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Long View (41RB112): Data Recovery of Two Plains Village Period Components in Roberts County, Texas, Volume 2

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Long View (41RB112): Data Recovery of Two Plains Village Period Components in Roberts County, Texas, Volume 2

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**Long View (41RB112): Data Recovery
of Two Plains Village Period Components
in Roberts County, Texas
Volume II**

By:

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Table of Contents of Volume II

APPENDIX A	RADIOCARBON ASSAY RESULTS.....	677
APPENDIX B	41RB112 SEDIMENT SAMPLE PHYTOLITH ANALYSIS.....	707
B.1	Phytoliths	709
B.2	Sample Processing	709
B.3	Data.....	712
B.3.1	Sand Fraction.....	712
B.3.2	Silt Fraction-Phytoliths.	714
B.4	Discussion.....	744
B.4.1	Agriculture—Corn, Beans, and Squash.....	744
B.4.2	Off-Site Surface Control Soil	747
B.4.2.1	Surface Soil Burned Phytolith Incidence	747
B.4.2.2	Surface Soil Seasonality Profile	747
B.4.3	Component A - Pithouse 1 and Associated Features:	752
B.4.3.1	Pithouse 1 Soil Seasonality Profile.....	752
B.4.3.2	Pithouse 1 Burned Phytolith Incidence	752
B.4.3.3	Pithouse 1 Food Processing	753
B.4.4	Component B - Swale between Components A and C	753
B.4.4.1	On-site Control Soil Seasonality Signature and Burned Phytolith Incidence:	753
B.4.5	Component C - Pithouse 2 Feature 6 and Associated Features:	753
B.4.5.1	Pithouse 2 Soil Seasonality Profile.....	753
B.4.5.2	Pithouse 2 Burned Phytolith Incidence	755
B.4.5.3	Pithouse 2 Food Processing	756
B.4.6	Phytolith preservation	756
B.5	Summary.....	756
B.5.1	Controls	756
B.5.2	Comparison of Pithouse 1 and Pithouse 2.....	758
B.6	Results and Conclusions of Phytolith Data from the Long View Site (41RB112)	759
B.7	Acknowledgements	765
B.8	References	765
APPENDIX C	PLANT REMAINS FROM THE LONG VIEW SITE: 41RB112	767
C.1	Introduction	769
C.2	Laboratory Method.....	769
C.2.1	Laboratory Procedures	769
C.2.1.1	Disturbance Indicators	769
C.3	Identifications	769
C.4	Quantifying and Reporting	770
C.5	Results	770
C.5.1	Wood	771
C.5.2	Food Remains	771
C.5.3	Component A.....	771
C.5.4	Component C.....	772

	C.5.4.1 Nonfeature Botanical Remains	774
C.6	Discussion	774
	C.6.1 Components A and C	774
	C.6.2 Regional Comparison	774
	C.6.2.1 Maize from 41RB112	775
	C.6.2.2 Squash	775
	C.6.2.3 Beans	775
	C.6.2.4 Mesquite	775
	C.6.2.5 Cheno-Am	776
	C.6.2.6 Prickly pear	776
	C.6.2.7 Wood Types	776
C.7	Summary and Conclusion	777
C.8	References	777
APPENDIX D STARCH ANALYSIS OF THE LONG VIEW SITE		793
D.1	Introduction to Starch Grain Analyses	795
D.2	Understanding The Relationship Between Residues And Artifacts	797
D.3	Methods	798
D.4	Results and Discussion	798
	D.4.1 Component A	799
	D.4.1.1 Ceramic Sherds	799
	D.4.1.2 Ground Stone Tools	804
	D.4.1.3 Burned Rocks	804
	D.4.1.4 Chipped Stone Tools	804
	D.4.1.5 Control Sediment Sample	804
	D.4.2 Component C	804
	D.4.2.1 Ceramic Sherds	804
	D.4.2.2 Ground Stone Tools	805
	D.4.2.3 Burned Rocks	805
	D.4.2.4 Chipped Stone Tools	805
	D.4.2.5 Control Sediment Sample	805
	D.4.3 Interesting Patterns in the Archaeobotanical Assemblages	805
	D.4.3.1 Ceramic Sherds	805
	D.4.3.2 Plant Use and Occurrence of Remains	806
D.5	Conclusions	807
D.6	References Cited	807
APPENDIX E SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS AND ELEMENTAL ANALYSIS OF TWO SHELL BEAD ARTIFACTS FROM THE LONG VIEW SITE (41RB112), CANADIAN RIVER VALLEY, NORTH WESTERN TEXAS		811
E.1	Introduction	813
E.2	Analysis and Instrumentation	813
E.3	Discussion	814
	E.3.1 The Jemez Mountains and the Sierra de los Valles	814
	E.3.2 Source Provenance Discussion	815

Page

E.4	Shell Beads	815
E.5	References Cited	816

**APPENDIX F ANALYSIS OF PLAINS VILLAGE SITE CERAMICS FROM THE PANHANDLES
OF TEXAS AND OKLAHOMA823**

F.1	Introduction	825
F.2	Methods	825
	F.2.1 Qualitative Thin Section Analysis	825
	F.2.2 Paste Groups	825
	F.2.3 Observational Conventions and Glossary	825
	F.2.4 Paste Groups	828
F.3	Tempering Agents	828
	F.3.1 Minor Minerals	828
F.4	Results	836
	F.4.1 Ceramic Temper List	836
	F.4.2 Experimental Fired Clay Sample Analysis	836
F.5	General Observations and Comparisons	849
F.6	Conclusions	854
F.7	References Cited	854

**APPENDIX G NEUTRON ACTIVATION ANALYSIS OF CERAMIC AND CLAY SAMPLES
FROM SOUTHERN PLAINS VILLAGE SITES IN OKLAHOMA AND TEXAS . . .857**

G.1	Introduction	859
G.2	Sample Preparation	859
	G.2.1 Irradiation and Gamma-Ray Spectroscopy	859
	G.2.2 Interpreting Chemical Data	860
G.3	Results	862
	G.3.1 Comparison to the MURR Master Database	862
	G.3.2 Compositional Groups	863
	G.3.3 Sample Pairs	863
	G.3.3.1 Small Groups	863
	G.3.3.2 Large Groups	864
	G.3.3.4 Unassigned Samples	872
G.4	Clays and Raw Materials	872
G.5	Conclusions	877
G.6	References Cited	877

**APPENDIX H MICROSCOPIC USE-WEAR AND RESIDUE ANALYSES OF STONE TOOLS
FROM 41RB112, ROBERTS COUNTY, TEXAS895**

H.1	Introduction	897
H.2	Methods	897
H.3	Results from Component A	897
	H.3.1 Beveled Knives	898
	H.3.2 Bifaces	898
	H.3.3 Cobble	898

	Page
H.3.4 Drill	898
H.3.5 Edge-Modified Flakes	898
H.3.6 Point Base	898
H.3.7 Scrapers	898
H.4 Results from Component C	907
H.4.1 Beveled Knife	907
H.4.2 Biface.....	907
H.4.3 Drill and Drill base	907
H.4.4 Edge-Modified Flakes	907
H.4.5 Scraper.....	907
H.5 Discussion.....	907
H.5.1 Woodworking	907
H.5.2 Hide Processing/Butchery	907
H.5.3 Starchy Plants	913
H.5.4 Beveled Knives	913
H.6 Conclusions	913
H.7 References Cited.....	913
 APPENDIX I A GEOPHYSICAL INVESTIGATION AT 41RB112: A MIDDLE CERAMIC PERIOD ARCHEOLOGICAL SITE LOCATED IN ROBERTS COUNTY, TEXAS ..	 917
I.1 Introduction	919
I.2 Site Setting and Field Conditions	919
I.3 Survey Design and Technical Parameters	919
I.3.1 Magnetic Field Gradient	919
I.3.2 Electrical Resistance	920
I.3.3 Ground Penetrating Radar (GPR)	920
I.4 Geophysical Survey Results.....	922
I.4.1 Summary Images.....	923
I.4.2 Geophysical Imagery Overlaid on Site Map.....	923
I.5 Geophysical Survey Interpretations	927
I.5.1 Area A –Initial Resistance Survey Interpretations.....	935
I.5.2 Area C – Initial Resistance Survey Interpretations	935
I.5.3 Additional Interpretations	935
I.6 Conclusions and Recommendations	935
 APPENDIX J PALEOENVIRONMENTAL ANALYSIS OF DIATOMS IN DAUB, AND BURNED ROCK SAMPLES FROM THE LONG VIEW ARCHEOLOGICAL SITE (41RB112), ROBERTS COUNTY, TEXAS	 943
J.1 Introduction	945
J.2 Methods	945
J.3 Results	946
J.4 Discussions.....	946
J.4.1 Component C.....	946
J.4.2 Component A	958
J.5 Reconstruction of Aquatic Paleoenvironment	959

Page

J.6	Conclusions	960
J.7	References	961

APPENDIX K	NAGPRA INVENTORY FOR SITE 41RB112 (CSJ: 0490-04-037), ROBERTS COUNTY, TEXAS	967
K.1	Introduction	969
K.2	Project Location	969
K.3	Site Description	969
K.4	Human Interment Descriptions and Context	970
	K.4.1 Feature 7	970
	K.4.2 Feature 22	973
K.5	Forensic Anthropologists Description of Inventory of Human Remains for Features 7 and 22	974
K.6	Cultural Assignment of Area C in Site 41RB112	978
	K.6.1 Southern Plains Village Tradition	978
	K.6.2 Association of Interment Features with Rest of the Late Prehistoric Component.	979
K.7	Vertical Distributions of Cultural Features and Associations with the Late Prehistoric Component of 41RB112.	979
K.8	Summary of Results	980
K.9	References Cited.	980

APPENDIX L	ASSESSMENT OF 41RB112, ROBERTS COUNTY, TEXAS INTERIM REPORT ..	983
L.1	Introduction	986
	L.1.1 Introduction	986
	L.1.2 Site Location	987
	L.1.3 Site Background	988
L.2	Methods	990
L.3	Geoarcheological Evaluations	995
	L.3.1. Introduction	995
	L.3.2 Physiographic Setting	995
	L.3.3 Methods	996
	L.3.4 Results	996
	L.3.4.1 Area A.	996
	L.3.4.2 Area B.	997
	L.3.4.3 Area C.	998
	L.3.5 Discussion	998
L.4	Archeological Results	1000
	L.4.1 Introduction	1000
	L.4.2 Cultural Features	1000
	L.4.2.1 Feature 1	1000
	L.4.2.2 Feature 2	1001
	L.4.2.3 Feature 3	1001
	L.4.2.4 Feature 4	1003
	L.4.2.5 Feature 5	1003

	Page
L.4.2.6 Feature 6	1005
L.4.2.7 Feature 7	1005
L.4.2.8 Structure 1	1007
L.4.3 Material Classes and Frequencies	1010
L.4.3.1 Lithic Debitage	1010
L.4.3.2 Chipped Stone Tools	1012
L.4.3.3 Ceramic Sherds	1014
L.4.3.4 Faunal Bone	1018
L.4.3.5 Mussel Shell	1018
L.4.3.6 Charcoal	1018
L.4.3.7 Ground Stone Tools	1019
L.4.3.8 Burned Clay	1019
L.4.3.9 Terrestrial Gastropods	1019
L.4.3.10 Burned Rocks	1019
L.4.3.11 Bone Tools	1019
L.4.4 Age of Cultural Deposits	1020
L.4.5 Horizontal Patterning Detected	1021
L.5 Summary, Conclusions, and Discussions	1022
L.5.1 Summary	1022
L.5.2 Conclusions	1024
L.5.3 Discussions	1026
L.6 Recommendations	1028
L.7 Data Recovery Plan	1028
L.7.1 Introduction	1028
L.7.2 Site Function	1029
L.7.3 Paleoenvironmental Issues	1029
L.7.4 Cultural Historical	1030
L.7.5 Subsistence Issues	1031
L.7.6 Technology Issues	1034
L.7.7 Mobility, Trade, and Interaction Issues	1035
L.7.8 Social Implications	1036
L.7.9 Field Approach	1037
L.8 References Cited	1039
Appendix L-1:	1045
Appendix L-2:	1047
Appendix L-3:	1056
APPENDIX M TXDOT CHIPPED STONE PROTOCOL VERSION 2.1	1061
APPENDIX N TXDOT CERAMIC PROTOCOL, VERSION 2.0	1097
APPENDIX O METRIC AND NONMETRIC DATA FOR ARTIFACTS FROM LONG VIEW (41RB112)	1123

Page

APPENDIX P	STABLE ISOTOPE RATIO ANALYSES	1179
APPENDIX Q	POTTERY DATA FROM OTHER PLAINS VILLAGE SITES	1183
Q.1	Introduction	1185
APPENDIX R	QUARTZ OPTICAL DATING REPORT: LONG VIEW SITE, TEXAS	1213
APPENDIX S	NAGPRA INVENTORY OF TWO INDIVIDUALS RECOVERED FROM 41RB112 - AREA C, ROBERTS COUNTY, TEXAS	1255
S.1	Introduction	1257
S.2	Bioarcheological Context	1257
S.3	Results	1257
S.3.1	Individual 1, 41RB112 – TRC Feature 7.	1257
S.3.1.1	Introduction	1257
S.3.1.2	Minimum Number of Individuals (MNI): One Individual . . .	1257
S.3.1.3	Sex: Female	1257
S.3.1.4	Age: Older Adult	1257
S.3.1.5	Cultural Affiliation: Native American	1258
S.3.1.6	Trauma and Pathology	1258
S.3.1.7	Summary.	1258
S.3.2	Individual 2, 41RB112 – TRC Feature 22	1259
S.3.2.1	Introduction	1259
S.3.2.2	Minimum Number of Individuals (MNI): One Individual . . .	1259
S.3.2.3	Age: Adult	1260
S.3.2.4	Sex: Indeterminate	1260
S.3.2.5	Affiliation: Native American	1261
S.3.2.6	Taphonomy	1261
S.3.2.7	Summary.	1261
S.4	References Cited.	1261

List of Figures of Volume II

Figure B-1.	Silt/clay removal.	711
Figure B-2.	Clay removal.	711
Figure B-3.	Crucibles containing silt fractions ready for ashing in the muffle furnace to remove organic materials.	712
Figure B-4.	Clean dried sand fraction of surface control soil sample 25 (control sample from pristine prairie on south side of Canadian River)..	714
Figure B-5.	Dry sand fractions of samples 1 through 12.	715
Figure B-6.	Dry sand fractions of samples 13 through 24.	716
Figure B-7.	Two views of a charred maize kernel fragment present in the sand fraction from the floor of pithouse 1 (a-external surface, b- internal surface; recovered from sample 3)..	717
Figure B-8.	Snail shells and shell fragments from 41RB112.	717
Figure B-9.	Two snail shell fragments (41RB112).	718
Figure B-10.	Phytolith growing season plot of summed normalized short cell phytolith data.	726
Figure B-11.	Ratio of bulliform phytolith counts to short cell phytolith counts (data from Tables B-3 through B-6).	728
Figure B-12.	Representative weathered bulliform phytoliths.	730
Figure B-13.	Commelinaceae seed phytolith.	731
Figure B-14.	Unusual phytolith form(s) recovered from three soil samples:	732
Figure B-15.	41RB112 possible tracheid elements from the ashy stain Feature 24 on the floor of pithouse 2 Feature 6, eastern end (sample 24).	732
Figure B-16.	Various views of example fiber residues recovered from soil samples during phytolith processing (plus one Rocky Mountain juniper control fiber).	733
Figure B-17.	Honey mesquite (<i>Prosopis glandulosa</i>).	734
Figure B-18.	Honey mesquite small limb phytoliths (thermally ashed samples, neutralized with HCl)—calcium oxalate crystals, and crystal-bearing fibers.	735
Figure B-19.	Honey mesquite tree phytoliths—spheres and crystalline material.	736
Figure B-20.	Honey mesquite tree fibers (after thermal ashing to 530°C and hydrochloric acid treatment).	737
Figure B-21.	Rocky Mountain juniper (<i>Juniperus scopulorum</i>).	738
Figure B-22.	Rocky Mountain juniper phytoliths from small limbs.	739
Figure B-23.	Rocky Mountain juniper phytoliths prepared from leaves.	740
Figure B-24.	Rocky Mountain juniper phytoliths and crystalline fiber residues prepared from berry-like cones.	741
Figure B-25.	Several generally rectangular phytoliths recovered from Rocky Mountain juniper leaves.	742
Figure B-26.	Large disk-shape or rondel phytoliths; possible <i>Zea mays</i> phytoliths.	743
Figure B-27.	Representative cross-shaped phytoliths from the bottom of the basin heating element Feature 5 (sample 10).	745
Figure B-28.	Phytoliths bearing some features similar to those of cucurbit phytoliths.	746
Figure B-29.	Variety of phytoliths recovered from Buffalo Gourd (<i>Cucurbita foetidissima kunth</i>) reference specimen (Sudbury 2007:35).	747
Figure B-30.	Other amorphous particles (obsidian).	748
Figure B-31.	Sponge spicule sections from the Long View site.	749
Figure B-32.	Other representative miscellaneous amorphous particles recovered from the floor of	

	Page
pithouse 1.	750
Figure B-33. Other representative miscellaneous amorphous particles recovered from the floor of pithouse 2.	751
Figure D-1. Starch remains recovered from sampled artifacts.	803
Figure E-1. Generalized stratigraphic relations of the major volcanic and alluvial units in the Jemez Mountains (from Gardner et al. 1986).	815
Figure E-2. Niobium (Nb) versus Yttrium (Y) biplot of the archaeological specimens and source standards from Cerro Toledo Rhyolite (Cerro Toledo and Rabbit Mountain), Jemez Mountains, New Mexico.	816
Figure E-3. A qualitative scan of shell bead (#580-1) showing presence of calcium, the major component of marine shell.	821
Figure E-4. A qualitative scan of shell bead (#1032-10) showing presence of calcium, the major component of marine shell.	822
Figure F-1. Basalt with pyroxene crystals.	851
Figure F-2. Bone temper particle.	851
Figure F-3. Granule-sized grain of composite quartz.	852
Figure F-4. Orthoclase feldspar grains.	852
Figure F-5. Granitic rock A.	853
Figure G-1. Bivariate plot of chromium and cerium showing the separation of the four groups with only two samples.	867
Figure G-2. Bivariate plot of chromium and iron showing groups 3 and 11.	868
Figure G-3. Bivariate plot of chromium and calcium showing the separation of group 6.	869
Figure G-4. Bivariate plot of iron and hafnium showing the separation of group 4.	870
Figure G-5. Bivariate plot of iron and sodium showing the separation of group 12.	871
Figure G-6. Bivariate plot of chromium and barium showing the separation of group 1.	873
Figure G-7. Bivariate plot of cesium and calcium showing the separation of group 2.	874
Figure G-8. Bivariate plot of hafnium and thorium showing the separation of group 7.	875
Figure G-9. Scatter plot of the number of NAA ceramic samples/site against the percent of unassigned samples.	876
Figure G-10. Bivariate plot of barium and hafnium showing the general similarity of the clay and ceramic samples.	876
Figure H-1. Results from Component A.	900
Figure H-2. Results from Component A.	901
Figure H-3. Results from Component A.	902
Figure H-4. Results from Component C.	903
Figure H-5. Results from Component C.	904
Figure H-6. Results from Component C.	905
Figure H-7. Four beveled knife 768-11, Component A; a and b) polish and striations; c) wood fragment; d) hard/high silica polish from movement in haft.	906
Figure H-8. Edge-modified flake 1031-11, component A; a) wood fragment; b) bark cells; c) wood fragment; d) hard/high silica polish.	908
Figure H-9. Edge-modified flake 593-10, Component C; a and d) raphides and plant tissue; b) hard/high silica polish; c) striations; e) starch grain under x-polarized light, original magnification 500x, approx. 5 Mm in diameter.	910
Figure H-10. Edge-modified flake 599-10, Component C; a and c) striations and hard/high silica polish; b) gymnosperm wood tissue, arrow indicates bordered pits.	911
Figure H-11. Scraper 1233-10, Component C; a and b) striations and soft polish; c) hair with cuticle.	912

Figure I-1.	Location of the geophysical survey areas at 41RB112.....	921
Figure I-2.	Geophysical survey results from Area A.....	924
Figure I-3.	Magnetic field gradient and electrical resistance survey results from Area C.	925
Figure I-4.	GPR survey results from Area C.....	926
Figure I-5.	Magnetic field gradient imagery presented on site map of Area A.....	928
Figure I-6.	Electrical resistance imagery (left) presented on site map of Area A.	929
Figure I-7.	Magnetic field gradient imagery presented on site map of Area C.....	930
Figure I-8.	Electrical resistance imagery (left) presented on site map of Area C.	931
Figure I-9.	Detail depicting GPR imagery from 10 to 20 cmbs presented on site map of Area C.	932
Figure I-10.	Detail depicting GPR imagery from 30 to 40 cmbs presented on site map of Area C.	933
Figure I-11.	Detail depicting GPR imagery from 55 to 65 cmbs presented on site map of Area C.	934
Figure I-12.	Electrical resistance survey interpretations from Area A.	936
Figure I-13.	Electrical resistance survey interpretations from Area C.	937
Figure I-14.	GPR survey interpretations from Area C.	938
Figure I-15.	Magnetic field gradient survey interpretations from outside ROW near Area A.	940
Figure I-16.	Magnetic field gradient survey interpretations from outside ROW near Area C.	941
Figure J-1.	Photomicrographs of selected diatoms.....	955
Figure J-2.	Photomicrographs of selected diatoms.....	956
Figure J-3.	Photomicrographs of selected diatoms.....	957
Figure K-1.	Overall map of Area C at the southern end of the Long View site (41RB112) showing the positions of the individual features identified.....	971
Figure K-2.	Plan view of Feature 7 showing the upper caliche rock layer covering a human burial..	972
Figure K-3.	East profile of Feature 7 showing position of caliche rocks in relation to surface and underlying burial site.....	973
Figure K-4.	Plan view of Feature 7 (containing individual 1) showing upper caliche rock layer (19 to 53 cmbs).	974
Figure K-5.	Plan view of Feature 7 (containing individual 1) showing underlying caliche slabs and uppermost reaches of human remains.....	975
Figure K-6.	Plan view of Feature 7 (containing individual 1) showing lower reaches of interment.	976
Figure K-7.	Plan view of Feature 22, which contains parts of individual #2.....	977
Figure K-8.	Edge modified tool fashioned from freshwater mussel shell associated with Feature 22..	978
Figure K-9.	Vertical distributions of cultural features in the northern portion of Area C, 41RB112....	981
Figure L-1.	Project location.	987
Figure L-2.	Overview of 41RB112 on rise in Canadian River valley (view south).....	988
Figure L-3.	Plan map of site 41RB112, Area A and the northern part of Area B.....	992
Figure L-4.	Plan map of site 41RB112, Area B and the northern part of Area C.	993
Figure L-5.	Plan map of site 41RB112, the southern part of Area C.....	994
Figure L-6.	Geomorphic summary of stratigraphy observed at 41RB112.....	999
Figure L-7.	Profile drawing of Feature 1.	1002
Figure L-8.	Feature 1 in roadcut.....	1002
Figure L-9.	Profile of Trench A1 showing deposits in Area A.....	1004
Figure L-10.	Plan view and profile of Feature 3.	1004
Figure L-11.	Plan view and profile of Feature 4.	1006
Figure L-12.	Profile of Feature 5.	1006
Figure L-13.	Profile drawing of Feature 6.	1008
Figure L-14.	South wall of C-7 showing profile of Feature 6.	1008
Figure L-15.	Feature 7 in Trench C-1, view to the northwest.	1009

Page

Figure L-16. Profile of Trench C-1 indicating location of Feature 7 and Area C deposits.	1009
Figure L-17. Structure 1, probable western edge of house foundation in Area C.	1011
Figure L-18. Profile of fireguard Trench C-2 showing deposits in Area C.	1012
Figure L-19. Profile of vertical rock in unit C-10 as part of Structure 1.	1013
Figure L-20. Selected stone tools from 41RB112.	1015
Figure L-21. Selected ceramic sherds from Area A.	1017
Figure L-22. Selected ceramic sherds from Area C.	1017
Figure L-23. Fragment of ground stone tool #48-10.	1021
Figure L-24. Burned tip of bison bone tool.	1022
Figure L-25. Proposed target area in Area C for data recovery excavations.	1041
Figure L-26. Proposed target area in Area A for data recovery excavations.	1042
Figure Q-1. Map of regions and sites from which pottery sherds were analyzed.	1185
Figure Q-2. Sherds from Buried City Complex, Courson B, 41OC27 used in technical analyses. ...	1188
Figure Q-3. Sherds from Courson D, 41OC29, in Buried City used in the technical analyses.	1190
Figure Q-4. Sherds from Kit Courson, 41OC43 in Buried City Used in Technical Analyses.	1191
Figure Q-5. Sherds from Stamper, 34TX1 in Oklahoma Panhandle Used in Analyses.	1192
Figure Q-6. Sherds from 34TX31 McGrath Site, in the Oklahoma Panhandle area used for instrumental neutron activation analysis.	1194
Figure Q-7. Sherds and clays from Two Sisters, 34TX32 in the Oklahoma Panhandle used in technical analyses.	1195
Figure Q-8. Sherds from Roy Smith, 34BV14 in Oklahoma Panhandle used in technical analyses. ...	1197
Figure Q-9. Sherds from Alibates Ruins 28, 41PT11 in the Antelope Creek Phase Core Area used in technical analyses.	1198
Figure Q-10. Sherds from 41HC6, Roper Site, in the Antelope Creek Core Area used for instrumental neutron activation analysis.	1200
Figure Q-11. Sherds of Alibates Creek Ruin 22, 41HC23, in the Antelope Creek Core Area used in the technical analyses.	1202
Figure Q-12. Sherds from Cottonwood Creek, 41HC141, in the Antelope Creek Phase Core Area used in the technical analyses.	1204
Figure Q-13. Sherds from Indian Springs 41RB81, used in technical analyses.	1206
Figure Q-14. Sherds from Whistling Squaw 41RB108 and Three Toes, 41RB110, used in technical analyses.	1208
Figure Q-15. Sherds from Hank's House, 41RB109 in M-Cross Ranch used in technical analyses. ...	1210

List of Tables of Volume II

Table B-1.	41RB112 Sediment Samples.....	710
Table B-2.	41RB112 Sediment Sample Textures.	713
Table B-3.	Soil Sample Phytolith Counts, Samples 1 Through 6 (41RB112).	719
Table B-4.	Soil Sample Phytolith Counts, Samples 7 Through 12 (41RB112).	720
Table B-5.	Soil Sample Phytolith Counts, Samples 13 Through 18 (41RB112).	722
Table B-6.	Soil Sample Phytolith Counts, Samples 19 Through 25 (41RB112).	723
Table B-7.	Percent Burned Short Cell Phytoliths in Each Soil Sample Scanned.	727
Table B-8.	Normalized Percent Short Cell Phytoliths in Seasonality Groupings	752
Table B-9.	Component A Pithouse 1 Floor Samples—Percent Burned Short Cell Phytolith Morphotypes.	754
Table B-10.	Component A Basin Heating Elements (Features 8, 10, and 11) and Storage Pit (Feature 13)—Percent Burned Short Cell Phytolith Morphotypes.	754
Table B-11.	Unidentified Function Feature from Component A—Percent Burned Short Cell Phytolith Morphotypes (Sample 8), and Component B—Percent Burned Short Cell Phytolith Morphotypes (Sample 9).	755
Table B-12.	Feature 6 (Pithouse 2 floor) Percent Burned Short Cell Phytolith Morphotypes.	757
Table B-13.	Feature 6 (Pithouse 2) Construction Fill, Percent Burned Short Cell Phytolith Morphotypes.	757
Table B-14.	Basin Heating Elements (Features 5 and 16), Ash Deposit (Feature 24), Storage Pit (Feature 23), and Dump (Feature 20)—Percent Burned Short Cell Phytolith Morphotypes.	760
Table B-15.	Soil Sample Phytolith Counts - Pithouse 2 Floor Samples (41RB112).	761
Table B-16.	Soil Sample Phytolith Counts – Pithouse 2 Construction/Roof Fall (12, 15, 18, and 19), Eolian Fill (14) and Off-Site Control (25)] Samples (41RB112).	763
Table C-1.	Flotation Sample Summaries.	779
Table C-2.	Contents of the Flotation Samples.	782
Table C-3.	Contents of the Macrobotanical Wood Identification/ (14C) Samples.	788
Table C-4.	Presence Values at 41RB112..	792
Table C-5.	Presence Value or Density of the Most Abundant Plant Resources from Components A and C.	792
Table C-6.	Regional Comparison of Presence Values of Plant Remains.	792
Table D-1.	Starch Remains from the Long View Site.	799
Table D-2.	Analysis of Starch Remains from Rim Verses Body Sherds.	807
Table E-1.	Elemental Concentrations for the Archaeological Specimens and the USGS RGM-1 Standard.	819
Table F-1.	Petrography Data on Individual Sherds.	829
Table F-2.	Paste Group Descriptions.	837
Table F-3.	Identified Tempering Agents.....	845
Table F-4.	Data Concerning the Clays Examined from the General Region.	850
Table F-5.	Paste Groups and Scales of Interaction.....	855
Table G-1.	Breakdown of Compositional Group by Region/Site.	865
Table H-1.	Frequency of Tool Types in Sample.	898
Table H-2.	Summary of Results from Long View Site (41RB112), Component A.	899
Table H-3.	Summary of Results from Long View Site (41RB112), Component C.	909
Table J-1.	Provenience of 41RB112 Samples Submitted for Diatom Analysis.....	947

	Page
Table J-2. Diatoms Recovered from 41RB112.	948
Table J-3. Ecological Characteristics of Diatoms from Site 41RB112.	951
Table K-1. Inventory of Nonhuman Materials Recovered from Feature 7.	977
Table K-2. Inventory of Nonhuman Materials Recovered from Feature 22.	978
Table K-3. Summary of Results.	981
Table L-1. Summary of Feature Data from 41RB112.	1013
Table L-2. Radiocarbon Samples and Results from 41RB112.	1023
Table L-3. Cultural Materials from Area B.	1024
Table L-4. Cultural Materials from Area A.	1025
Table L-5. Cultural Materials from Area C.	1025
Table L-6. Study Units and Data Sets to Address Questions.	1032
Table L-2-1. Flotation Sample Summaries, Presented by Unit and Level.	1053
Table L-2-2. Contents of the Seven Flotation Samples.	1053
Table L-2-3. Contents of the Macrobotanical (14C) Samples.	1054
Table L-2-4. Presence Values at 41RB112 and Other Late Prehistoric Sites.	1055
Table Q-1. List of Sites and Sherds from Surrounding Areas Used for Technical Analyses.	1186
Table Q-2. Selected Data on Sherds from Courson B, 41OC27 at Buried City Used in Petrography and Instrumental Neutron Activation Analysis.	1189
Table Q-3. Selected Data on Sherds from Courson D, 41OC29 Used for Petrography and Instrumental Neutron Activation Analysis.	1190
Table Q-4. Selected Data on Sherds from Kit Courson, 41OC43 Used in Petrography and Instrumental Neutron Activation Analysis.	1191
Table Q-5. Selected Data on Sherds from Stamper 34TX1 Used in Petrography and Instrumental Neutron Activation Analysis.	1193
Table Q-6. Selected Data on Sherds from 34TX31, McGrath Site Used in Technical Analyses.	1194
Table Q-7. Selected Data on Sherds from Two Sisters, 34TX32 Used for Petrography and Instrumental Neutron Activation Analysis.	1196
Table Q-8. Selected Data on Sherds from Roy Smith, 34BV14 Used in Petrography and Instrumental Neutron Activation Analyses.	1197
Table Q-9. Selected Data on Sherds from Alibates Ruins 28, 41PT11, Used for Petrography and Instrumental Neutron Activation Analysis.	1199
Table Q-10. Selected Data on Sherds from 41HC6, Roper Site Used for Petrography.	1201
Table Q-11. Selected Data from Sherds of Alibates Creek Ruin 22 41HC23 Used for Petrography and Instrumental Neutron Activation Analysis	1203
Table Q-12. Selected Data on Sherds from Cottonwood Creek, 41HC141 Used for Instrumental Neutron Activation Analysis.	1205
Table Q-13. Selected Data on Sherd from Indian Springs 41RB81, Used for Petrography and Instrumental Neutron Activation Analysis.	1207
Table Q-14. Selected Data on Sherd from Whistling Squaw 41RB108 and Three Toes 41RB110, Used for Petrography and Instrumental Neutron Activation Analysis.	1209
Table Q-15. Selected Data on Sherds from Hank's House, 41RB109, Used for Petrography and Instrumental Neutron Activation Analysis.	1211
Table S-1. Available Metric Data from Individual 1 following Buikstra and Ubelaker (1994) and Urcid (1992).	1259
Table S-2. Description of Feature 22 Bag Contents.	1260
Table S-3. Inventory of Additional Bags of Bone from 41RB112.	1262
Table S-4. Dental measurements for 338-002-2	1263

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APPENDIX A

RADIOCARBON ASSAY RESULTS

Prepared for:

**TRC Environmental Corporation
505 East Huntland Drive, Suite 250
Austin, Texas 78752**

Prepared by:

**Alexander Cherkinsky, Ph.D.
The University of Georgia
Center for Applied Isotope Studies
120 Riverbend Road
Athens, Georgia 30602-4720**

and

**Darden Hood
Beta Analytic Inc.
4985 S.W. 74 Court
Miami, Florida 33155**

March 2011

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FROM: Darden Hood, Director (mailto:mailto:dhood@radiocarbon.com)

(This is a copy of the letter being mailed. Invoices/receipts follow only by mail.)

August 10, 2005

Dr. James Abbott
Texas Department of Transportation
Cultural Resource Management
Environmental Affairs Division
125 East 11th Street
Austin, TX 78701
USA

RE: Radiocarbon Dating Results For Samples RB112/31-4-2A, RB112/31-7-1, RB112/34-7-2,
RB112/62-7A, RB112/120-4-3A, RB112/133-4-A, RB112/164-7-1, RB112/167-7-1

Dear Jim:

Enclosed are the radiocarbon dating results for eight samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses went normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice is enclosed. Please, forward it to the appropriate officer or send VISA charge authorization. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Dr. James Abbott

Report Date: 8/10/2005

Texas Department of Transportation

Material Received: 7/6/2005

Sample Data	Measured Radiocarbon Age	$^{13}\text{C}/^{12}\text{C}$ Ratio	Conventional Radiocarbon Age(*)
Beta - 206557 SAMPLE : RB112/31-4-2A ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1260 to 1310 (Cal BP 690 to 640) AND Cal AD 1370 to 1380 (Cal BP 580 to 570)	680 +/- 40 BP	-23.0 o/oo	710 +/- 40 BP
Beta - 206558 SAMPLE : RB112/31-7-1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 460 to 480 (Cal BP 1480 to 1470) AND Cal AD 520 to 650 (Cal BP 1430 to 1300)	1460 +/- 40 BP	-23.3 o/oo	1490 +/- 40 BP
Beta - 206559 SAMPLE : RB112/34-7-2 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1000 to 1170 (Cal BP 950 to 780)	940 +/- 40 BP	-23.2 o/oo	970 +/- 40 BP
Beta - 206560 SAMPLE : RB112/62-7A ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1260 to 1310 (Cal BP 690 to 640) AND Cal AD 1370 to 1380 (Cal BP 580 to 570)	690 +/- 40 BP	-24.0 o/oo	710 +/- 40 BP
Beta - 206561 SAMPLE : RB112/120-4-3A ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1290 to 1410 (Cal BP 660 to 540)	380 +/- 40 BP	-9.7 o/oo	630 +/- 40 BP

Dr. James Abbott

Report Date: 8/10/2005

Sample Data	Measured Radiocarbon Age	¹³ C/ ¹² C Ratio	Conventional Radiocarbon Age(*)
Beta - 206562 SAMPLE : RB112/133-4-A ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1260 to 1310 (Cal BP 690 to 640) AND Cal AD 1360 to 1390 (Cal BP 590 to 560)	690 +/- 40 BP	-24.4 o/oo	700 +/- 40 BP
Beta - 206563 SAMPLE : RB112/164-7-1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1280 to 1400 (Cal BP 670 to 550)	630 +/- 40 BP	-23.6 o/oo	650 +/- 40 BP
Beta - 206564 SAMPLE : RB112/167-7-1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 660 to 790 (Cal BP 1290 to 1160)	1260 +/- 40 BP	-23.0 o/oo	1290 +/- 40 BP

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23:lab. mult=1)

Laboratory number: **Beta-206557**

Conventional radiocarbon age: **710±40 BP**

2 Sigma calibrated results: **Cal AD 1260 to 1310 (Cal BP 690 to 640) and
(95% probability) Cal AD 1370 to 1380 (Cal BP 580 to 570)**

Intercept data

Intercept of radiocarbon age
with calibration curve: **Cal AD 1290 (Cal BP 660)**

1 Sigma calibrated result: **Cal AD 1270 to 1300 (Cal BP 680 to 650)**
(68% probability)

References:

Database used

INTCAL98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, *Radiocarbon* 40(3), pxii-xii

INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et. al., 1998, *Radiocarbon* 40(3), p1041-1083

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

498 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.3;lab. mult=1)

Laboratory number: Beta-206558

Conventional radiocarbon age: 1490±40 BP

2 Sigma calibrated results: Cal AD 460 to 480 (Cal BP 1480 to 1470) and
(95% probability) Cal AD 520 to 650 (Cal BP 1430 to 1300)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 580 (Cal BP 1360)

1 Sigma calibrated result: Cal AD 540 to 620 (Cal BP 1410 to 1320)
(68% probability)

References:

Database used

INTCAL98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii

INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.2:lab. mult=1)

Laboratory number: Beta-206559

Conventional radiocarbon age: 970±40 BP

2 Sigma calibrated result: Cal AD 1000 to 1170 (Cal BP 950 to 780)
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1030 (Cal BP 920)

1 Sigma calibrated results: Cal AD 1020 to 1050 (Cal BP 930 to 900) and
(68% probability) Cal AD 1100 to 1140 (Cal BP 850 to 810)

References:

Database used

INTCAL98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xii

INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et al., 1998, Radiocarbon 40(3), p1041-1083

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A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24;lab. mult=1)

Laboratory number: **Beta-206560**

Conventional radiocarbon age: **710±40 BP**

2 Sigma calibrated results: Cal AD 1260 to 1310 (Cal BP 690 to 640) and
(95% probability) Cal AD 1370 to 1380 (Cal BP 580 to 570)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1290 (Cal BP 660)

1 Sigma calibrated result: Cal AD 1270 to 1300 (Cal BP 680 to 650)
(68% probability)

References:

Database used

INTCAL98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii

INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-9.7;lab. mult=1)

Laboratory number: **Beta-206561**

Conventional radiocarbon age: **630±40 BP**

2 Sigma calibrated result: Cal AD 1290 to 1410 (Cal BP 660 to 540)
(95% probability)

Intercept data

Intercepts of radiocarbon age

with calibration curve:

Cal AD 1310 (Cal BP 640) and

Cal AD 1370 (Cal BP 580) and

Cal AD 1380 (Cal BP 570)

1 Sigma calibrated result: Cal AD 1300 to 1400 (Cal BP 650 to 550)
(68% probability)

References:

Database used

INTCAL98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, *Radiocarbon* 40(3), pxi-xii

INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et. al., 1998, *Radiocarbon* 40(3), p1041-1083

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.4;lab. mult=1)

Laboratory number: Beta-206562

Conventional radiocarbon age: 700±40 BP

2 Sigma calibrated results: Cal AD 1260 to 1310 (Cal BP 690 to 640) and
(95% probability) Cal AD 1360 to 1390 (Cal BP 590 to 560)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1290 (Cal BP 660)

1 Sigma calibrated result: Cal AD 1280 to 1300 (Cal BP 670 to 650)
(68% probability)

References:

Database used

INTCAL 98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii

INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.6:lab. mult=1)

Laboratory number: **Beta-206563**

Conventional radiocarbon age: **650±40 BP**

2 Sigma calibrated result: Cal AD 1280 to 1400 (Cal BP 670 to 550)
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1300 (Cal BP 650)

1 Sigma calibrated results: Cal AD 1290 to 1320 (Cal BP 660 to 630) and
(68% probability) Cal AD 1350 to 1390 (Cal BP 600 to 560)

References:

Database used

INTCAL 98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, *Radiocarbon* 40(3), pxi-xii

INTCAL 98 Radiocarbon Age Calibration

Stuiver, M., et al., 1998, *Radiocarbon* 40(3), p1041-1083

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23:lab. mult=1)

Laboratory number: Beta-206564

Conventional radiocarbon age: 1290±40 BP

2 Sigma calibrated result: Cal AD 660 to 790 (Cal BP 1290 to 1160)
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 700 (Cal BP 1250)

1 Sigma calibrated result: Cal AD 680 to 770 (Cal BP 1270 to 1180)
(68% probability)

References:

Database used

INTCAL98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, *Radiocarbon* 40(3), pxi-xiii

INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et. al., 1998, *Radiocarbon* 40(3), p1041-1083

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322

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The University of Georgia

Center for Applied Isotope Studies

RADIOCARBON ANALYSIS REPORT

March 11, 2011

Dr. Jim Abbott
Environmental Affairs Division
Texas Dept. of Transportation
125 E. 11th St.
Austin, TX 78701

Dear Dr. Abbott

Enclosed please find the results of ^{14}C Radiocarbon AMS analyses and Stable Isotope Ratio $\delta^{13}\text{C}$ analyses for the samples received by our laboratory on February 16, 2011.

UGAMS#	Sample ID	Material	$\delta^{13}\text{C},\text{‰}$	^{14}C age, years BP	$\pm$
8456	41RB112,349-008-1d	ceramic sherd	-21.7	940	25
8457	41RB112,308-008-19	ceramic sherd	-29.1	21550	70
8458	41OC29 #346-4d	ceramic sherd	-18.2	1340	25
8459	41RB81, #291	ceramic sherd	-16.5	1120	25

The surface of the sherds was ground off and the interior material was crushed to powder and treated with 5% HCl at the temperature 80°C for 1 hour, then it were washed and with deionized water on the fiberglass filter and rinsed with diluted NaOH to remove possible contamination by humic acids. After that the sample was treated with diluted HCL again, washed with deionized water and dried at 60°C. The cleaned sample was combusted at 900°C in evacuated/sealed quartz ampoule in the present CuO.

The resulting carbon dioxide was cryogenically purified from the other reaction products and catalytically converted to graphite using the method of Vogel *et al.* (1984) Nuclear Instruments and Methods in Physics Research B5, 289-293. Graphite $^{14}\text{C}/^{13}\text{C}$ ratios were measured using the CAIS 0.5 MeV accelerator mass spectrometer. The sample ratios were compared to the ratio measured from the Oxalic Acid I (NBS SRM 4990). The sample $^{13}\text{C}/^{12}\text{C}$ ratios were measured separately using a stable isotope ratio mass spectrometer and expressed as $\delta^{13}\text{C}$ with respect to PDB, with an error of less than 0.1‰. The quoted uncalibrated dates have been given in radiocarbon years before 1950 (years BP), using the ^{14}C half-life of 5568 years. The error is quoted as one standard deviation and reflects both statistical and experimental errors. The date has been corrected for isotope fractionation.

Sincerely,

Dr. Alexander Cherkinsky

RADIOCARBON CALIBRATION PROGRAM*

CALIB REV6.0.0

Copyright 1986-2010 M Stuiver and PJ Reimer

*To be used in conjunction with:

Stuiver, M., and Reimer, P.J., 1993, Radiocarbon, 35, 215-

230.

Annotated results (text) - -

Export file - cl4res.csv

41RB112,349-008-1d

UGAMS-8456

ceramic sherd

Radiocarbon Age BP 940 +/- 25

Calibration data set: intcal09.14c

% area enclosed cal AD age ranges

Reimer et al. 2009
relative area

under

probability

distribution

68.3 (1 sigma)	cal AD 1035- 1051	0.206
	1081- 1127	0.569
	1135- 1152	0.225
95.4 (2 sigma)	cal AD 1029- 1156	1.000

41RB112,308-008-19

UGAMS-8457

ceramic sherd

Radiocarbon Age BP 21550 +/- 70

Calibration data set: intcal09.14c

% area enclosed cal AD age ranges

Reimer et al. 2009
relative area

under

probability

distribution

68.3 (1 sigma)	cal BC 24055- 23708	1.000
95.4 (2 sigma)	cal BC 24230- 23444	1.000

41OC29 #346-4d

UGAMS-8458

ceramic sherd

Radiocarbon Age BP 1340 +/- 25

Calibration data set: intcal09.14c

% area enclosed cal AD age ranges

Reimer et al. 2009
relative area

under

probability

distribution

68.3 (1 sigma)	cal AD 655- 680	1.000
95.4 (2 sigma)	cal AD 646- 708	0.917
	747- 765	0.083

41RB81, #291

UGAMS-8459

ceramic sherd

Radiocarbon Age BP 1120 +/- 25

Calibration data set: intcal09.14c

Reimer et al. 2009

% area enclosed under	cal AD age ranges	relative area probability
distribution		
68.3 (1 sigma)	cal AD 894- 903	0.144
	914- 969	0.856
95.4 (2 sigma)	cal AD 881- 988	1.000

References for calibration datasets:
 PJ Reimer, MGL Baillie, E Bard, A Bayliss, JW Beck, C Bertrand, PG Blackwell,
 CE Buck, G Burr, KB Cutler, PE Damon, RL Edwards, RG Fairbanks, M Friedrich,
 TP Guilderson, KA Hughen, B Kromer, FG McCormac, S Manning, C Bronk Ramsey,
 RW Reimer, S Remmele, JR Southon, M Stuiver, S Talamo, FW Taylor, J van der Plicht, and CE Weyhenmeyer (2009), Radiocarbon 51:xxx-yyy.

Comments:
 * This standard deviation (error) includes a lab error multiplier.
 ** 1 sigma = square root of (sample std. dev.^2 + curve std. dev.^2)
 ** 2 sigma = 2 x square root of (sample std. dev.^2 + curve std. dev.^2)
 where ^2 = quantity squared.
 [] = calibrated range impinges on end of calibration data set
 0* represents a "negative" age BP
 1955* or 1960* denote influence of nuclear testing C-14

NOTE: Cal ages and ranges are rounded to the nearest year which may be too precise in many instances. Users are advised to round results to the nearest 10 yr for samples with standard deviation in the radiocarbon age greater than 50 yr.

RADIOCARBON ANALYSIS REPORT

December 2, 2010

Dr. Jim Abbott
Environmental Affairs Division
Texas Dept. of Transportation
125 E. 11th St.
Austin, TX 78701

Dear Dr. Abbott

Enclosed please find the results of ¹⁴C Radiocarbon AMS analyses and Stable Isotope Ratio $\delta^{13}\text{C}$ analyses for the samples received by our laboratory on November 8, 2010.

UGAMS#	Sample ID	Material	$\delta^{13}\text{C}, \text{‰}$	¹⁴ C age, years BP	±
7822	41RB112,131-7-1	char.plant	-9.4	580	20
7823	41RB112,266-7-1	char.plant	-9.2	590	20
7824	41RB112,300-7-1	char.plant	-9.9	570	20
7825	41RB112,331-7-1	char.plant	-8.6	570	25
7826	41RB112,455-7-1a	char.plant	-11.0	530	25
7827	41RB112,470-7-1a	char.plant	-10.0	610	20
7828	41RB112,625-7-1	char.plant	-10.3	580	20
7829	41RB112,641-2-1a	collagen	-8.0	630	25
7830	41RB112,643-7-1a	char.plant	-10.0	590	25
7831	41RB112,1032-7-1	char.plant	-12.5	500	25
7832	41RB112,1064-7-1a	char.plant	-9.9	510	20
7833	41RB112,1074-7-1a	char.plant	-12.7	510	25
7834	41RB112,1080-7-1	char.plant	-10.6	510	25
7835	41RB112,1093-7-1a	char.plant	-11.4	480	20
7836	41RB112,1116-7-1	char.plant	-9.8	480	25
7837	41RB112,1128-4-1a	char.plant	-11.3	480	20
7838	41RB112,1164-7-2	char.plant	-11.3	490	25
7839	41RB112,1164-7-3	char.plant	-9.9	590	25
7840	41DL436.TxDOT#1	charcoal	-25.3	390	25
7841	41DL436.TxDOT#2	charcoal	-24.3	1090	25

The charcoal sample was treated with 5% HCl at the temperature 80°C for 1 hour, then it were washed and with deionized water on the fiberglass filter and rinsed with diluted

NaOH to remove possible contamination by humic acids. After that the sample was treated with diluted HCL again, washed with deionized water and dried at 60°C. The cleaned sample was combusted at 900°C in evacuated/sealed quartz ampoule in the present CuO.

The bone was cleaned by wire brush and washed, using ultrasonic bath. After cleaning, the dried bone was gently crushed to small fragments. The crushed bone was treated with 1N HCl at 4° for 24 hours. The residue was filtered, rinsed with deionized water and under slightly acid condition (pH=3) heated at 80°C for 6 hours to dissolve collagen and leave humic substances in the precipitate. The collagen solution is then filtered to isolate pure collagen and dried out. The dried collagen was combusted at 575°C in evacuated/sealed Pyrex ampoule in the present CuO. The resulting carbon dioxide was cryogenically purified from the other reaction products and catalytically converted to graphite using the method of Vogel *et al.* (1984) Nuclear Instruments and Methods in Physics Research B5, 289-293. Graphite $^{14}\text{C}/^{13}\text{C}$ ratios were measured using the CAIS 0.5 MeV accelerator mass spectrometer.

The sample ratios were compared to the ratio measured from the Oxalic Acid I (NBS SRM 4990). The sample $^{13}\text{C}/^{12}\text{C}$ ratios were measured separately using a stable isotope ratio mass spectrometer and expressed as $\delta^{13}\text{C}$ with respect to PDB, with an error of less than 0.1‰.

The quoted uncalibrated dates have been given in radiocarbon years before 1950 (years BP), using the ^{14}C half-life of 5568 years. The error is quoted as one standard deviation and reflects both statistical and experimental errors. The date has been corrected for isotope fractionation.

If the dates are to be published, please quote the UGAMS numbers, as it identifies our laboratory as having produced the dates.

If we can be of further assistance, or you wish to discuss these results, please do not hesitate to contact me.

Sincerely,

Dr. Alexander Cherkinsky

RADIOCARBON CALIBRATION PROGRAM*
CALIB REV6.0.0
Copyright 1986-2010 M Stuiver and PJ Reimer
*To be used in conjunction with:
Stuiver, M., and Reimer, P.J., 1993, Radiocarbon, 35, 215-230.

Annotated results (text) - -
Export file - cl4res.csv

41RB112. 131-7-1
UGAMS-7822
charred plant
Radiocarbon Age BP 580 +/- 20
Calibration data set: intcal09.14c # Reimer et al. 2009
% area enclosed cal AD age ranges relative area
under
distribution probability

68.3 (1 sigma)	cal AD 1321- 1349	0.691
	1391- 1405	0.309
95.4 (2 sigma)	cal AD 1309- 1361	0.677
	1386- 1412	0.323

41RB112, 266-7-1
UGAMS-7823
charred plant
Radiocarbon Age BP 590 +/- 20
Calibration data set: intcal09.14c # Reimer et al. 2009
% area enclosed cal AD age ranges relative area
under
distribution probability

68.3 (1 sigma)	cal AD 1317- 1353	0.790
	1389- 1400	0.210
95.4 (2 sigma)	cal AD 1305- 1364	0.737
	1384- 1408	0.263

41RB112, 300-7-1
UGAMS-7824
charred plant
Radiocarbon Age BP 570 +/- 20
Calibration data set: intcal09.14c # Reimer et al. 2009
% area enclosed cal AD age ranges relative area
under
distribution probability

68.3 (1 sigma)	cal AD 1324- 1345	0.583
	1393- 1408	0.417
95.4 (2 sigma)	cal AD 1313- 1358	0.593
	1387- 1416	0.407

41RB112, 331-7-1			
UGAMS-7825			
charred plant			
Radiocarbon Age BP 570 +/- 25			
Calibration data set: intcal09.14c			
% area enclosed		cal AD age ranges	# Reimer et al. 2009 relative area
under			
distribution			probability
68.3 (1 sigma)	cal AD 1322- 1348		0.579
	1392- 1410		0.421
95.4 (2 sigma)	cal AD 1308- 1361		0.598
	1386- 1419		0.402
<hr/>			
41RB112, 455-7-1a			
UGAMS-7826			
charred plant			
Radiocarbon Age BP 530 +/- 25			
Calibration data set: intcal09.14c			
% area enclosed		cal AD age ranges	# Reimer et al. 2009 relative area
under			
distribution			probability
68.3 (1 sigma)	cal AD 1402- 1429		1.000
95.4 (2 sigma)	cal AD 1324- 1345		0.131
	1393- 1437		0.869
<hr/>			
41RB112, 470-7-1a			
UGAMS-7827			
charred plant			
Radiocarbon Age BP 610 +/- 20			
Calibration data set: intcal09.14c			
% area enclosed		cal AD age ranges	# Reimer et al. 2009 relative area
under			
distribution			probability
68.3 (1 sigma)	cal AD 1304- 1326		0.417
	1343- 1365		0.401
	1384- 1394		0.182
95.4 (2 sigma)	cal AD 1298- 1371		0.792
	1378- 1400		0.208
<hr/>			
41RB112, 625-7-1			
UGAMS-7828			
charred plant			
Radiocarbon Age BP 580 +/- 20			
Calibration data set: intcal09.14c			
% area enclosed		cal AD age ranges	# Reimer et al. 2009 relative area
under			
distribution			probability
68.3 (1 sigma)	cal AD 1321- 1349		0.691
	1391- 1405		0.309
95.4 (2 sigma)	cal AD 1309- 1361		0.677
	1386- 1412		0.323

41RB112, 641-2-1a
 UGAMS-7829
 collagen
 Radiocarbon Age BP 630 +/- 25
 Calibration data set: intcal09.14c # Reimer et al. 2009
 % area enclosed cal AD age ranges relative area
 under
 probability
 distribution
 68.3 (1 sigma) cal AD 1297- 1317 0.383
 1354- 1389 0.617
 95.4 (2 sigma) cal AD 1288- 1329 0.405
 1340- 1396 0.595

41RB112, 643-7-1a
 UGAMS-7830
 charred plant
 Radiocarbon Age BP 590 +/- 25
 Calibration data set: intcal09.14c # Reimer et al. 2009
 % area enclosed cal AD age ranges relative area
 under
 probability
 distribution
 68.3 (1 sigma) cal AD 1315- 1355 0.762
 1389- 1401 0.238
 95.4 (2 sigma) cal AD 1301- 1367 0.723
 1382- 1411 0.277

41RB112, 1032-7-1
 UGAMS-7831
 charred plant
 Radiocarbon Age BP 500 +/- 25
 Calibration data set: intcal09.14c # Reimer et al. 2009
 % area enclosed cal AD age ranges relative area
 under
 probability
 distribution
 68.3 (1 sigma) cal AD 1416- 1435 1.000
 95.4 (2 sigma) cal AD 1406- 1444 1.000

41RB112, 1064-7-1a
 UGAMS-7832
 charred plant
 Radiocarbon Age BP 510 +/- 20
 Calibration data set: intcal09.14c # Reimer et al. 2009
 % area enclosed cal AD age ranges relative area
 under
 probability
 distribution
 68.3 (1 sigma) cal AD 1414- 1430 1.000
 95.4 (2 sigma) cal AD 1406- 1439 1.000

41RB112, 1074-7-1a		
UGAMS-7833		
charred plant		
Radiocarbon Age BP	510 +/- 25	
Calibration data set:	intcal09.14c	# Reimer et al. 2009
% area enclosed	cal AD age ranges	relative area
under		
distribution		probability
68.3 (1 sigma)	cal AD 1412- 1432	1.000
95.4 (2 sigma)	cal AD 1398- 1444	1.000
41RB112, 1080-7-1		
UGAMS-7834		
charred plant		
Radiocarbon Age BP	510 +/- 25	
Calibration data set:	intcal09.14c	# Reimer et al. 2009
% area enclosed	cal AD age ranges	relative area
under		
distribution		probability
68.3 (1 sigma)	cal AD 1412- 1432	1.000
95.4 (2 sigma)	cal AD 1398- 1444	1.000
41RB112, 1093-7-1a		
UGAMS-7835		
charred plant		
Radiocarbon Age BP	480 +/- 20	
Calibration data set:	intcal09.14c	# Reimer et al. 2009
% area enclosed	cal AD age ranges	relative area
under		
distribution		probability
68.3 (1 sigma)	cal AD 1425- 1440	1.000
95.4 (2 sigma)	cal AD 1416- 1445	1.000
41RB112, 1116-7-1		
UGAMS-7836		
charred plant		
Radiocarbon Age BP	480 +/- 25	
Calibration data set:	intcal09.14c	# Reimer et al. 2009
% area enclosed	cal AD age ranges	relative area
under		
distribution		probability
68.3 (1 sigma)	cal AD 1423- 1441	1.000
95.4 (2 sigma)	cal AD 1413- 1447	1.000
41RB112, 1128-4-1a		
UGAMS-7837		
charred plant		
Radiocarbon Age BP	480 +/- 20	

Calibration data set: intcal09.14c	# Reimer et al. 2009
% area enclosed cal AD age ranges	relative area
under	
	probability
distribution	
68.3 (1 sigma) cal AD 1425- 1440	1.000
95.4 (2 sigma) cal AD 1416- 1445	1.000

41RB112, 1164-7-2
UGAMS-7838
charred plant
Radiocarbon Age BP 490 +/- 25
Calibration data set: intcal09.14c

% area enclosed cal AD age ranges	# Reimer et al. 2009
under	relative area
	probability
distribution	
68.3 (1 sigma) cal AD 1420- 1438	1.000
95.4 (2 sigma) cal AD 1410- 1445	1.000

41RB112, 1064-7-3
UGAMS-7839
charred plant
Radiocarbon Age BP 590 +/- 25
Calibration data set: intcal09.14c

% area enclosed cal AD age ranges	# Reimer et al. 2009
under	relative area
	probability
distribution	
68.3 (1 sigma) cal AD 1315- 1355	0.762
	1389- 1401
	0.238
95.4 (2 sigma) cal AD 1301- 1367	0.723
	1382- 1411
	0.277

41DL436, TxDOT#1
UGAMS-7840
charcoal
Radiocarbon Age BP 390 +/- 25
Calibration data set: intcal09.14c

% area enclosed cal AD age ranges	# Reimer et al. 2009
under	relative area
	probability
distribution	
68.3 (1 sigma) cal AD 1448- 1492	0.859
	1602- 1612
	0.141
95.4 (2 sigma) cal AD 1442- 1522	0.793
	1574- 1584
	0.016
	1590- 1624
	0.192

```

41DL436, TxDOT@2
UGAMS-7841
charcoal
Radiocarbon Age BP 1090 +/- 25
Calibration data set: intcal09,14c # Reimer et al. 2009
% area enclosed cal AD age ranges relative area
under
distribution probability
68.3 (1 sigma) cal AD 899- 919 0.345
949- 988 0.655
95.4 (2 sigma) cal AD 893- 997 0.967
1004- 1012 0.033

```

References for calibration datasets:

PJ Reimer, MGL Baillie, E Bard, A Bayliss, JW Beck, C Bertrand, PG Blackwell,
CE Buck, G Burr, KB Cutler, PE Damon, RL Edwards, RG Fairbanks, M Friedrich,
TP Guilderson, KA Hughen, B Kromer, FG McCormac, S Manning, C Bronk Ramsey,
RW Reimer, S Remmele, JR Southon, M Stuiver, S Talamo, FW Taylor, J van der Plicht, and CE Weyhenmeyer (2009), Radiocarbon 51:xxx-yyy.

Comments:

* This standard deviation (error) includes a lab error multiplier.
** 1 sigma = square root of (sample std. dev.^2 + curve std. dev.^2)
** 2 sigma = 2 x square root of (sample std. dev.^2 + curve std. dev.^2)
where ^2 = quantity squared.
[] = calibrated range impinges on end of calibration data set
0* represents a "negative" age BP
1955* or 1960* denote influence of nuclear testing C-14

NOTE: Cal ages and ranges are rounded to the nearest year which may be too precise in many instances. Users are advised to round results to the nearest 10 yr for samples with standard deviation in the radiocarbon age greater than 50 yr.

*Consistent Accuracy . . .
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Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

April 28, 2011

Dr. James Abbott
Texas Department of Transportation
Cultural Resource Management
Environmental Affairs Division
125 East 11th Street
Austin, TX 78701
USA

RE: Radiocarbon Dating Results For Samples 41RB112 LRSSD2, 41RB112 LRUD1

Dear Dr. Abbott:

Enclosed are the radiocarbon dating results for two samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice has been sent previously. Please, forward it to the appropriate officer or send VISA charge authorization. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Digital signature on file

BETA ANALYTIC INC. DR. M.A. TAMERS and MR. D.G. HOOD	4985 S.W. 74 COURT MIAMI, FLORIDA, USA 33155 PH: 305-667-5167 FAX: 305-663-0964 beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. James Abbott

Report Date: 4/28/2011

Texas Department of Transportation

Material Received: 4/15/2011

Sample Data	Measured Radiocarbon Age	¹³ C/ ¹² C Ratio	Conventional Radiocarbon Age(*)
Beta - 297506 SAMPLE : 41RB112 LRSSD2 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (organic sediment): acid washes 2 SIGMA CALIBRATION : Cal BC 1440 to 1360 (Cal BP 3390 to 3310) AND Cal BC 1350 to 1310 (Cal BP 3300 to 3260)	2970 +/- 30 BP	-16.4 o/oo	3110 +/- 30 BP
Beta - 297507 SAMPLE : 41RB112 LRUD1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (organic sediment): acid washes 2 SIGMA CALIBRATION : Cal AD 650 to 720 (Cal BP 1300 to 1230) AND Cal AD 740 to 770 (Cal BP 1210 to 1180)	1300 +/- 30 BP	-24.0 o/oo	1320 +/- 30 BP

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the ¹⁴C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby ¹⁴C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured ¹³C/¹²C ratios (delta ¹³C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta ¹³C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta ¹³C, the ratio and the Conventional Radiocarbon Age will be followed by ***. The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-16.4:lab. mult=1)

Laboratory number: **Beta-297506**

Conventional radiocarbon age: **3110±30 BP**

2 Sigma calibrated results: **Cal BC 1440 to 1360 (Cal BP 3390 to 3310) and**
(95% probability) Cal BC 1350 to 1310 (Cal BP 3300 to 3260)

Intercept data

Intercept of radiocarbon age
with calibration curve: **Cal BC 1400 (Cal BP 3350)**

1 Sigma calibrated result: **Cal BC 1420 to 1380 (Cal BP 3370 to 3330)**
(68% probability)

References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24;lab. mult=1)

Laboratory number: **Beta-297507**

Conventional radiocarbon age: **1320±30 BP**

2 Sigma calibrated results: **Cal AD 650 to 720 (Cal BP 1300 to 1230) and
(95% probability) Cal AD 740 to 770 (Cal BP 1210 to 1180)**

Intercept data

Intercept of radiocarbon age
with calibration curve: **Cal AD 670 (Cal BP 1280)**

1 Sigma calibrated result: **Cal AD 660 to 690 (Cal BP 1290 to 1260)**
(68% probability)

References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

October 25, 2011

Dr. James Abbott
Texas Department of Transportation
Cultural Resource Management
Environmental Affairs Division
125 East 11th Street
Austin, TX 78701

RE: Radiocarbon Dating Results For Samples 41RB112 60 2a, 41RB112 60 2b, 41RB112 305 1a,
41RB112 940 1a, 41RB112 940 1b, 41RB112 1021 1a, 41RB112 1047 1a

Dear Dr. Abbott:

Enclosed are the radiocarbon dating results for seven samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

Note that one of the samples (41RB112 60 2b, Beta-307380) does not have a Measured Radiocarbon Age and $^{13}\text{C}/^{12}\text{C}$ Ratio reported. This is because the sample was too small to do a separate $^{13}\text{C}/^{12}\text{C}$ ratio and AMS analysis. The only available $^{13}\text{C}/^{12}\text{C}$ ratio available to calculate a Conventional Radiocarbon Age was that determined on a small aliquot of graphite. Although this ratio corrects to the appropriate Conventional Radiocarbon Age, it is not reported since it includes laboratory chemical and detector induced fractionation.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice is enclosed. Thank you for your prior efforts in arranging payment. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Digital signature on file

BETA ANALYTIC INC. DR. M.A. TAMERS and MR. D.G. HOOD	4985 S.W. 74 COURT MIAMI, FLORIDA, USA 33155 PH: 305-667-5167 FAX: 305-663-0964 beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. James Abbott

Report Date: 10/25/2011

Texas Department of Transportation

Material Received: 10/12/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 307379 SAMPLE : 41RB112 60 2a ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (bulk sherd organics): acid washes 2 SIGMA CALIBRATION : Cal BC 40 to 10 (Cal BP 1990 to 1960) AND Cal BC 0 Cal AD 80 (Cal BP 1950 to 1860)	1950 +/- 30 BP	-24.1 o/oo	1960 +/- 30 BP
Beta - 307380 SAMPLE : 41RB112 60 2b ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (soot): acid washes 2 SIGMA CALIBRATION : Cal AD 1410 to 1450 (Cal BP 540 to 500) COMMENT: The original sample was too small to provide a 13C/12C ratio on the original material. However, a ratio including both natural and laboratory effects was measured during the 14C detection to calculate the true Conventional Radiocarbon Age.	NA	NA	490 +/- 30 BP
Beta - 307381 SAMPLE : 41RB112 305 1a ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (soot): acid washes 2 SIGMA CALIBRATION : Cal AD 1300 to 1370 (Cal BP 650 to 580) AND Cal AD 1380 to 1410 (Cal BP 570 to 540)	510 +/- 30 BP	-19.9 o/oo	590 +/- 30 BP
Beta - 307382 SAMPLE : 41RB112 940 1a ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (bulk sherd organics): acid washes 2 SIGMA CALIBRATION : Cal AD 1300 to 1360 (Cal BP 640 to 590) AND Cal AD 1380 to 1420 (Cal BP 570 to 530)	470 +/- 30 BP	-19.1 o/oo	570 +/- 30 BP

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by ***. The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

BETA ANALYTIC INC.	4985 S.W. 74 COURT
	DR. M.A. TAMERS and MR. D.G. HOOD	MIAMI, FLORIDA, USA 33155
		PH: 305-667-5167 FAX:305-663-0964
		beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. James Abbott

Report Date: 10/25/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 307383 SAMPLE : 41RB112 940 1b ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (soot): acid washes 2 SIGMA CALIBRATION : Cal AD 1410 to 1450 (Cal BP 540 to 500)	370 +/- 30 BP	-18.2 o/oo	480 +/- 30 BP
Beta - 307384 SAMPLE : 41RB112 1021 1a ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (soot): acid washes 2 SIGMA CALIBRATION : Cal AD 1420 to 1450 (Cal BP 530 to 500)	360 +/- 30 BP	-18.9 o/oo	460 +/- 30 BP
Beta - 307385 SAMPLE : 41RB112 1047 1a ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (bulk sherd organics): acid washes 2 SIGMA CALIBRATION : Cal AD 730 to 740 (Cal BP 1220 to 1210) AND Cal AD 770 to 900 (Cal BP 1180 to 1060) Cal AD 920 to 940 (Cal BP 1030 to 1010)	1110 +/- 30 BP	-20.4 o/oo	1190 +/- 30 BP

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the ¹⁴C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby ¹⁴C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured ¹³C/¹²C ratios (delta ¹³C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta ¹³C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta ¹³C, the ratio and the Conventional Radiocarbon Age will be followed by "as". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.1;lab.mult=1)

Laboratory number: Beta-307379

Conventional radiocarbon age: 1960±30 BP

2 Sigma calibrated results: Cal BC 40 to 10 (Cal BP 1990 to 1960) and
(95% probability) Cal BC 0 Cal AD 80 (Cal BP 1950 to 1860)

Intercept data

Intercepts of radiocarbon age

with calibration curve: Cal AD 30 (Cal BP 1920) and
Cal AD 40 (Cal BP 1920) and
Cal AD 50 (Cal BP 1900)

1 Sigma calibrated results: Cal AD 10 to 10 (Cal BP 1940 to 1940) and
(68% probability) Cal AD 20 to 70 (Cal BP 1930 to 1880)

References:

Database used

INTCAL09

References to INTCAL09 database

Heaton, et al., 2009, Radiocarbon 51(4):1151-1164, Reimer, et al., 2009, Radiocarbon 51(4):1111-1150,
Stuiver, et al., 1993, Radiocarbon 35(1):137-189, Oeschger, et al., 1975, Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=N/A:lab. mult=1)

Laboratory number: **Beta-307380**

Conventional radiocarbon age: **490±30 BP**

2 Sigma calibrated result: Cal AD 1410 to 1450 (Cal BP 540 to 500)
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1430 (Cal BP 520)

1 Sigma calibrated result: Cal AD 1420 to 1440 (Cal BP 530 to 510)
(68% probability)

References:

Database used

INTCAL09

References to INTCAL09 database

Heaton, et.al., 2009, Radiocarbon 51(4):1151-1164, Reimer, et.al., 2009, Radiocarbon 51(4):1111-1150,
Stuiver, et.al., 1993, Radiocarbon 35(1):137-189, Oeschger, et.al., 1975, Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-19.9;lab. mult=1)

Laboratory number: **Beta-307381**

Conventional radiocarbon age: **590±30 BP**

2 Sigma calibrated results: **Cal AD 1300 to 1370 (Cal BP 650 to 580) and
(95% probability) Cal AD 1380 to 1410 (Cal BP 570 to 540)**

Intercept data

Intercepts of radiocarbon age
with calibration curve: **Cal AD 1320 (Cal BP 630) and
Cal AD 1340 (Cal BP 610) and
Cal AD 1390 (Cal BP 560)**

1 Sigma calibrated results: **Cal AD 1310 to 1360 (Cal BP 640 to 590) and
(68% probability) Cal AD 1390 to 1400 (Cal BP 560 to 540)**

References:

Database used

INTCAL09

References to INTCAL09 database

Heaton, et.al, 2009, Radiocarbon 51(4):1151-1164, Reimer, et.al, 2009, Radiocarbon 51(4):1111-1150,
Stuiver, et.al, 1993, Radiocarbon 35(1):137-189, Oeschger, et.al, 1975, Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-19.1:lab, mult=1)

Laboratory number: Beta-307382

Conventional radiocarbon age: 570±30 BP

2 Sigma calibrated results: Cal AD 1300 to 1360 (Cal BP 640 to 590) and
(95% probability) Cal AD 1380 to 1420 (Cal BP 570 to 530)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1400 (Cal BP 550)

1 Sigma calibrated results: Cal AD 1320 to 1350 (Cal BP 630 to 600) and
(68% probability) Cal AD 1390 to 1410 (Cal BP 560 to 540)

References:

Database used

INTCAL09

References to INTCAL09 database

Heaton, et.al., 2009, Radiocarbon 51(4):1151-1164, Reimer, et.al., 2009, Radiocarbon 51(4):1111-1150,

Stuiver, et.al., 1993, Radiocarbon 35(1):137-189, Oeschger, et.al., 1975, Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-18.2:lab. mult=1)

Laboratory number: **Beta-307383**

Conventional radiocarbon age: **480±30 BP**

2 Sigma calibrated result: Cal AD 1410 to 1450 (Cal BP 540 to 500)
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1430 (Cal BP 520)

1 Sigma calibrated result: Cal AD 1420 to 1440 (Cal BP 530 to 510)
(68% probability)

References:

Database used
INTCAL09

References to INTCAL09 database

Heaton, et.al., 2009, *Radiocarbon* 51(4):1151-1164, Reimer, et.al., 2009, *Radiocarbon* 51(4):1111-1150,
Stuiver, et.al., 1993, *Radiocarbon* 35(1):137-189, Oeschger, et.al., 1975, *Tellus* 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, *Radiocarbon* 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-18.9;lab. mult=1)

Laboratory number: Beta-307384

Conventional radiocarbon age: 460±30 BP

2 Sigma calibrated result: Cal AD 1420 to 1450 (Cal BP 530 to 500)
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1440 (Cal BP 510)

1 Sigma calibrated result: Cal AD 1430 to 1450 (Cal BP 520 to 500)
(68% probability)

References:

Database used

INTCAL09

References to INTCAL09 database

Heaton, et al., 2009, Radiocarbon 51(4):1151-1164, Reimer, et al., 2009, Radiocarbon 51(4):1111-1150,
Stuiver, et al., 1993, Radiocarbon 35(1):137-189, Oeschger, et al., 1975, Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-20.4;lab. mult=1)

Laboratory number: Beta-307385

Conventional radiocarbon age: 1190±30 BP

2 Sigma calibrated results: Cal AD 730 to 740 (Cal BP 1220 to 1210) and
(95% probability) Cal AD 770 to 900 (Cal BP 1180 to 1060) and
Cal AD 920 to 940 (Cal BP 1030 to 1010)

Intercept data

Intercepts of radiocarbon age
with calibration curve: Cal AD 830 (Cal BP 1120) and
Cal AD 840 (Cal BP 1110) and
Cal AD 870 (Cal BP 1080)

1 Sigma calibrated result: Cal AD 780 to 890 (Cal BP 1170 to 1060)
(68% probability)

References:

Database used
INTCAL09

References to INTCAL09 database

Heaton, et.al., 2009, Radiocarbon 51(4):1151-1164, Reimer, et.al., 2009, Radiocarbon 51(4):1111-1150,
Stuiver, et.al., 1993, Radiocarbon 35(1):137-189, Oeschger, et.al., 1975, Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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APPENDIX B

41RB112 SEDIMENT SAMPLE PHYTOLITH ANALYSIS

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B.1 Phytoliths

Phytoliths, inorganic siliceous residues that form in plant cells, frequently mirror parent cell shape. Phytoliths become a mineral particle in soil when plants decay. Thus, to the extent that plant cell architecture is unique to a given species, phytolith morphology provides a mechanism whereby the plant origin of the phytolith can potentially be determined. For most grasses (Poaceae), the subfamily that produced a short cell phytolith is readily discernible from the phytolith's morphology. Many other botanical species also produce phytoliths; information about their morphology is gradually being gleaned from studies of new reference specimens. A more detailed overview was recently released (Sudbury 2011a:2-14).

Phytoliths are persistent in the soil, often surviving for tens of thousand of years, and provide evidence of past landscape and environmental conditions. Phytoliths may even enter the geological record and have been recovered in fossils. All silica is soluble—even quartz—but at a very low solubility rate; in cases where soil pH is high (basic), the rate of phytolith dissolution is enhanced which affect phytolith's survival. In addition to being soluble under certain conditions, phytoliths are also mobile as are all soil components. Thus, when exposed on the soil surface, phytoliths are prone to movement and redeposition, whether by erosive runoff during rain events, by flooding or redeposition by wind erosion. Another movement mechanism is when phytoliths are intentionally moved—such as by harvesting a crop; phytoliths also be relocated when they are deposited in animal droppings.

B.2 Sample Processing

Twenty-four sediment samples and one control surface soil sample from the Late Prehistoric Long View site (41RB112) were received for phytolith analysis (Table B-1). Due to the relatively small sample size (~30 g), the samples were transferred directly to the sample processing containers without preliminary sieving. The samples were oven dried, cooled, and weighed. Next, the samples were then vigorously agitated in 5 percent Calgon solution for 24 hours to disaggregate the clays. After the appropriate settling time, the combined silt

and clay fractions were repeatedly decanted from the sand fraction (2.65 g/cm³, > 50 microns) until only the sand fraction remained (Figure B-1 shows the sample suspensions at the beginning of the decanting procedure). As a result of this separation procedure, lower density sand-size particles (i.e., including large phytoliths) tend to be included in the decanted silt/clay fraction. Once the silt/clay fractions (which contain the phytoliths) were completely decanted, the clean sands were oven dried and weighed (Table B-2).

Next, the combined silt-clay components were re-suspended and the silt fraction allowed to settle for a time calculated based on a 2 micron particle size and 1.60 g/cm³ density. Once the settling interval was completed, the suspended clay fractions were removed by siphoning off the upper portion of the solution (Figure B-2). This procedure (suspending in water, settling the silt particles, and removing the suspended clay) was repeated until all of clay was removed leaving behind the silt fraction (i.e., after the settling interval, the liquid phase above the silt was clear indicating clay removal was complete).

Next, the silt fractions were quantitatively transferred to crucibles (Figure B-3) and ashed in a muffle furnace at 530°C to remove the organic material (Sudbury 2011b:44). Carbonates were removed from the ashed silt fractions by adding 10 percent hydrochloric acid (Ibid. 46-47). Once effervescence ceased, the silts were quantitatively transferred to preweighed 50 ml centrifuge tubes, repeatedly rinsed with water, centrifuged, and the aqueous phase removed until the acid had been diluted and eliminated. The isolated silt fractions were oven dried and weighed. With the sand and silt fraction weights, the soil sample texture can be determined (Table B-2).

Heavy aqueous zinc bromide solution (2.35 g/cm³) was added to the dry silts which were then frequently agitated; after disaggregating, the samples were centrifuged resulting in the biogenic silica fraction (including phytoliths) floating away from the heavier matrix on top of the zinc bromide solution (ibid. 255). The phytoliths were decanted to clean tubes, and the remaining original silt residue repeatedly remixed with fresh zinc bromide solution, centrifuged, and the phytoliths harvested until no

Table B-1. 41RB112 Sediment Samples.

Sample Number	Component	Unit	Depth (cmbs)	Sample Label	Feature Number	Weight (g)	Class
MQ11-1	A	Cutbank	57-61	1278-4-1a	1	30.8	sediment
MQ11-2	A	N700 E515	56-59	1164-4-11a	1	31	sediment
MQ11-3	A	N700 E515	56-59	1164-4-7a	1	31	sediment
MQ11-4	A	N699 E512	30-40	1116-4-1a	8 W 1/2	30.1	sediment
MQ11-5	A	N698 E511	31-53	1080-4-1a	10	30.8	sediment
MQ11-6	A	N696 E511	50-60	1032-4-1c	11	31.1	sediment
MQ11-7	A	N695 E513/514	59-61	1014-4-5b	13	30.4	sediment
MQ11-8	A	N699 E514	20-30	1128-4-1a	-	30.8	sediment
MQ11-9	B	B-1	92-96	77-4-1a	-	31.5	sediment
MQ11-10	C	Cutbank	32-36	120-4-4a	5	30.2	sediment
MQ11-11	C	N500 E 497	71-73	1284-4-1a	6	30.7	sediment
MQ11-12	C	N500 E 497	66-68	1282-4-1a	6	31.1	sediment
MQ11-13	C	C-7	60-64	139-4-1a	6	30.7	sediment
MQ11-14	C	Col-3 Z 3	25-30	C-3 Zone 3 Spl 6	6	38	sample 6
MQ11-15	C	Col-3 Z 4	65-70	C-3 Zone 4 Spl 14	6	32	sample 14
MQ11-16	C	Col-3 Z 5	78-83	C-3 Zone 5 Spl 17	6	32	sample 17
MQ11-17	C	Col-3 Z 5	83-87	C-3 Zone 5 Spl 18	6	36	sample 18
MQ11-18	C	Col-7 Z 7	33-38	C-7 Zone 7 Spl 8	6	31	sample 8
MQ11-19	C	Col-7 Z 9	38-44	C-7 Zone 9 Spl 9	6	32	sample 9
MQ11-20	C	Col-7 Z 5	44-51	C-7 Zone 5 Spl 10	6	35	sample 10
MQ11-21	C	N492 E501	50-59	472-4-1a	16	30.8	sediment
MQ11-22	C	N480 E500	40-50	234-4-1a	20	30.3	sediment
MQ11-23	C	N482 E501	87-90	331-004-2b	23	31.6	sediment
MQ11-24	C	N499 E497	40-48	644-4-1a	24	30.1	sediment
MQ11-25	NA	Surface	2-4	1281-4a	Control	37	sediment

Figure B-1. Silt/clay removal.

Sediment samples in water in the original mixing containers (250 ml glass jars with Teflon®-lined lids, front row). After the sand fractions settle, the suspended silt and clay fractions (front row) are decanted away from the sand into the two-liter settling containers (back row).

Figure B-2. Clay removal.

After allowing the silt fraction (> 2 microns, < 1.60 g/cm³) from the back row of bottles in Figure B-1 to settle for three days, the upper solution containing the suspended clay fraction (< 2 microns) was siphoned off of the silt fraction sediment and stored in another 2-liter bottle. Re-suspension and settling of the mixture in the original 2-liter bottle was repeated until the smaller particle size clay fraction was removed from the silt fraction. The silt was next processed further to recover the soil phytoliths. After additional settling, the isolated clay fractions for each sample are dried and retained.

more phytoliths were recovered. Then the pooled phytoliths were centrifuged to remove any residual clay carried over in the decants; once the phytoliths were demonstrated to be clay-free they were transferred to a clean centrifuge tube and water was added to the phytolith solution to lower the solution density to $< 1.50\text{g/cm}^3$ causing the phytoliths to sink and form a pellet when centrifuged. The phytolith pellet was washed repeatedly until the zinc bromide had been removed (the copious aqueous rinses were filtered and concentrated to recover the zinc bromide for reuse). The phytoliths were then transferred to pre-weighed and prelabeled 4 dram vials, dried, and the phytolith recovery determined. The phytolith soil concentrations (weight % in soil) are reported in Table B-2. The soils' high sand concentration resulted in the phytolith concentrations (i.e., a component of the silt fraction of soil) being relatively low.

Next, a portion of the dried phytolith fraction was mounted on microscope slides using Canada balsam and allowed to cure prior to examination (Sudbury 2011b:50-51). The specimen slides were scanned via microscopy at 500x and the short cell phytoliths in the fields of view tabulated by their morphology (Tables B3 through 6). The slides were then rescanned taking photographs of additional specimens of interest that were not observed during the formal particle count scans.

B.3 Data

B.3.1 Sand Fraction

Figures B-4 through B-6 show pictures of the dried sand fractions after silt and clay removal (isolated during the procedure shown in Figure B-1). These images enable comparison of the amount of organic debris present in the sand fractions (charcoal, roots, and other organic matter). Looking at the full size images also provides an idea of other detail such as sand grain size variation; for instance, the larger image presented for sample 25 shows that the sand grain size in the surface control sample is poorly sorted (Figure B-4). The color difference between sand samples is real and may reflect difference in burial conditions (Sudbury 2011b:148-149) or the source of parent material. The charcoal which floated to the surface before drying may also impact observed shading or coloration.

Prior to transferring the clean sands to storage containers, they were placed in a Petri dish and examined via stereo-microscopy. Charcoal fragments were common, and bone and burned bone fragments were noted in some samples. The most noteworthy observations included part of a maize kernel (Figure B-7), a small jaw fragment with a multi-rowed set of teeth (probably reptilian (Figure B-8), and several snail shells and shell fragments (Figures B-9 though B-10).

Figure B-3. Crucibles containing silt fractions ready for ashing in the muffle furnace to remove organic materials.

Table B-2. 41RB112 Sediment Sample Textures.

Sample Number	Excavation Unit	Oven-dried Soil Wt (g)	Sand %	Silt %	Soil Texture	Phytoliths Wt % Soil
MQ11-1	Cutbank	30.42	66.90%	16.20%	Sandy Loam	0.08%
MQ11-2	N700 E515	30.62	70.60%	14.80%	Sandy Loam	0.14%
MQ11-3	N700 E515	30.82	75.10%	11.50%	Sandy Loam	0.07%
MQ11-4	N699 E512	29.8	69.30%	16.20%	Sandy Loam	0.09%
MQ11-5	N698 E511	30.13	66.40%	17.80%	Sandy Loam	0.11%
MQ11-6	N696 E511	30.47	60.80%	20.40%	Sandy Clay Loam	0.12%
MQ11-7	N695 E513/514	29.65	58.10%	22.80%	Sandy Clay Loam	0.09%
MQ11-8	N699 E514	30.46	74.30%	17.40%	Sandy Loam	0.16%
MQ11-9	B-1	30.87	48.50%	33.50%	Loam	0.10%
MQ11-10	Cutbank	29.43	62.50%	18.70%	Sandy Clay Loam	0.35%
MQ11-11	N500 E 497	30.16	72.00%	11.10%	Sandy Loam	0.08%
MQ11-12	N500 E 497	30.41	69.20%	10.30%	Sandy Clay Loam	0.05%
MQ11-13	C-7	29.93	50.50%	18.90%	Sandy Clay Loam	0.05%
MQ11-14	Col -3 Zone 3	35.33[1]	80.60%	15.80%	Loamy Sand	0.24%
MQ11-15	Col -3 Zone 4	29.83	65.80%	11.90%	Sandy Clay Loam	0.06%
MQ11-16	Col -3 Zone 5	30.11	58.40%	16.60%	Sandy Clay Loam	0.04%
MQ11-17	Col -3 Zone 5	34.19	59.50%	16.80%	Sandy Clay Loam	0.11%
MQ11-18	Col -3 Zone 7	29.5	74.60%	9.40%	Sandy Loam	0.13%
MQ11-19	Col -3 Zone 9	30.07	71.00%	10.60%	Sandy Loam	0.08%
MQ11-20	Col -3 Zone 5	33.73	69.30%	12.40%	Sandy Loam	0.07%
MQ11-21	N492 E501	30.02	68.70%	12.90%	Sandy Loam	0.07%
MQ11-22	N480 E500	29.89	81.10%	8.30%	Loamy Sand	0.08%
MQ11-23	N482 E501	28.95	73.50%	10.30%	Sandy Loam	0.05%
MQ11-24	N499 E497	29.41	71.90%	9.80%	Sandy Loam	0.12%
MQ11-25	Surface Control	33.22	80.20%	12.90%	Loamy Sand	0.22%

[1] One piece of sandstone gravel (1.11 grams) was removed from sample MQ11-14 after extraction, and the original dried sample weight corrected for the gravel removal.

Figure B-4. Clean dried sand fraction of surface control soil sample 25 (control sample from pristine prairie on south side of Canadian River).

B.3.2 Silt Fraction-Phytoliths.

The observed phytolith morphology counts are in Tables B-3 through B-6. The first twelve phytolith types—all of the short cell phytolith morphotypes—are representative of the three basic “seasonality” types of Poaceae (grasses). Seasonality is a simplified way of summarizing the optimal growth conditions under which certain plants thrive; these differences are based on the cellular architecture of the plant which are due in part to differences in the metabolic machinery of the plants. Thus, plants that grow well in a cool moist environment (the Pooidaceae subfamily of grasses, later referred to herein as “poooids”) do not thrive in a hot or dry environment as they are basically unable to conserve their internal moisture during in hot weather conditions. These plants grow well in northern climates, but do occur locally in shaded or moist environments—including in riparian settings. In general, the poooids are the plants that show the first green in the spring and the last green in the fall—they do well in the cooler weather. The other two subfamilies contributing short cell phytoliths to the soil record are the chloridoid subfamily (Chloridoideae), which thrive in hot dry environments, and the panicoid subfamily (Panicoideae) which do well in hot environments but have a somewhat greater moisture requirement than the chloridoids. The chloridoids are the major component of the shortgrass prairies while the panicoids are the major species present in the tallgrass prairies; mixedgrass prairies are a blend of

the two prairie types in the zone where they intersect and overlap. The poooids are present in their niche in all three prairie zones—normally in relatively low concentration (depending on the environmental setting).

The short cell morphotype counts for these samples are in Tables B-3 through B-6; the raw counts are the top twelve phytolith forms listed. The three seasonality groupings (described above) of these twelve forms are summed and normalized in the lower section of each table. The short cell morphology reflects the plant’s cellular architecture and thus the short cell morphotypes can be assigned to (and are representative of) a specific seasonal Poaceae subfamily. The tables are also color-coded for ease of navigation (chloridoids (C_4 , hot and dry) are red, poooids (C_3 , cool and moist) are blue, and the C_4 panicoids are green (C_3 and C_4 refer to the specific metabolic cycle which the plants employ). The rest of the phytolith forms listed in the tables are not short cells, but are other morphotypes which were observed in the same microscopic fields of view during the counting procedure. Bulliform phytoliths, sometimes called motor cells, occur most frequently in C_4 plants and enable the plants to curl their leaves in the hot weather in order to conserve plant moisture. Noting the relatively high bulliform phytolith counts in some samples, the total bulliform to short cell phytolith ratios also calculated and are located at the bottom of the tables. The ratios of charcoal fragments to bulliform phytoliths and to

Figure B-5. Dry sand fractions of samples 1 through 12.

Sample 1 (from cutbank profile, base of pithouse 1), sample 2 (from profile wall, floor of pithouse 1), sample 3 (from floor of pithouse 1), sample 4 (inside west half of small basin heating element), sample 5 (southwest part of broad heating element, Feature 10), sample 6 (inside heating element, Feature 11), sample 7 (bottom of small storage pit, Feature 13), sample 8 (ashy stain next to heating element Feature 10), sample 9 (lower part of thickened A horizon, in shallow swale between Components A and C), sample 10 (bottom of basin heating element Feature 5), sample 11 (pithouse 2 floor, Feature 6), and sample 12 (lower portion of construction fill on top of floor, Feature 6).

Figure B-6. Dry sand fractions of samples 13 through 24.

Sample 13 (north wall profile inside and on floor of pithouse 2, Feature 6), sample 14 (upper end of eolian fill on top of construction fill towards western side of pithouse 2, Feature 6), sample 15 (middle of earthen construction fill inside pithouse 2, western side, Feature 6), sample 16 (upper part of pithouse 2 floor below earthen construction fill, western side, Feature 6), sample 17 (bottom of pithouse 2 floor, western side), sample 18 (earthen construction fill near center of pithouse 2, Feature 6), sample 19 (pithouse floor, upper, near center of pithouse 2, Feature 6), sample 20 (pithouse floor near center of pithouse 2, Feature 6), sample 21 (bottom of basin heating element with burned maize cobs, Feature 16), sample 22 (bottom of heating element with burned maize cobs, Feature 20), sample 23 (inside, bottom of storage pit, Feature 23), and sample 24 (ashy stain on floor of pithouse 2, Feature 6 eastern end).

Figure B-7. Two views of a charred maize kernel fragment present in the sand fraction from the floor of pithouse 1 (a-external surface, b- internal surface; recovered from sample 3).

Figure B-8. Snail shells and shell fragments from 41RB112.

A and B: two views of specimen from the profile wall of the floor of pithouse 1 (sample 2). C: specimen from the floor of pithouse 1 (sample 3). D and H shell fragments from the lower part of the thickened A horizon between pithouses 1 and 2 (sample 9). The 2 mm scale bar applies to all snail specimens.

Figure B-9. Two snail shell fragments (41RB112).

Shell fragments from the lower portion of the construction fill above the floor of pithouse 2, Feature 6 (sample 12). The 2 mm scale bar applies to all specimens.

Table B-3. Soil Sample Phytolith Counts, Samples 1 Through 6 (41RB112).

	Soil 1	Soil 2	Soil 3	Soil 4	Soil 5	Soil 6
Phytolith Morphology						
Keeled	20	17	12	16	26	28
Conical	22	26	25	21	43	57
Pyramidal	14	18	19	15	12	21
Crenate	10	7	8	4	6	6
Saddle, squat	32	32	34	29	34	22
Saddle, tall	82	90	102	50	45	56
Stipa	5	-	-	2	5	1
Lobate, Simple	4.5	3.5	1	2	1	2
Lobate, Panicoid	20	30	17	17.5	56	38.5
Lobate, Pan'd (compound)	-	-	-	-	-	1
Cross, Panicoid (<12 um)	2	1	3	1	2	1
Cross, Panicoid (>12 um)	6	4	1	1	7	2
Maize Rondel	1	-	-	-	-	1
Dicot, knobby	1	1	-	3	-	1
Spiny spheroid	6	2	5	7	3	3
WWW, Schlerid	2	-	-	3	3	4
Diatom	-	1	-	1	1	2
Sponge spicule	2	-	-	1	-	3
Trichome, Hair Cells	31	14	3	5	18	12
Bulliform, square	38	30	40	37	58	41
Bulliform, rectangular	125	74	45	44	98	86
Bulliform, keystone	43	13	18	48	28	34
Bulliform, Y-shaped	10	8	7	8	6	19
Bulliform, other	180	100	205	171	99	164
Elongate, smooth	7	10	11	5	13	8
Elongate, sinuous	8	9	7	9	4	26
Elongate, castillate	10	7	9	6	5	7
Elongate, spiny	-	-	-	-	-	-
Other Misc. Forms	-	-	-	-	-	-
Charcoal	63	18	39	48	51	84
Possible Pinaceae tracheid elements ?	-	-	-	-	-	-
Sedges	2	3	3	5	6	7
Saddle Imposters	5	6	13	1	7	3
Large Discs	9	3	5	5	11	14
Spore	-	1	-	3	-	-

Table B-3. Soil Sample Phytolith Counts, Samples 1 Through 6 (41RB112) (cont.)

	Soil 1	Soil 2	Soil 3	Soil 4	Soil 5	Soil 6
Phytolith Morphology						
Total Short Cell Counts:	218.5	228.5	222	158.5	237	236.5
Pooids (cool season)	66	68	64	56	87	112
Chloridoids (hot dry)	114	122	136	79	79	78
Panicoids (warm moist)	38.5	38.5	22	23.5	71	46.5
Normalized Short Cells (%)						
Pooids	30.2	29.8	28.8	35.3	36.7	47.3
Chloridoids	52.2	53.4	61.3	49.8	33.3	33
Panicoids	17.6	16.8	9.9	14.8	30	19.7
Total Bulliforms	396	225	315	308	289	344
Ratio Bulliform:Short Cells	1.81	0.98	1.42	1.94	1.22	1.45
Ratio Charcoal:Bulliform	0.16	0.08	0.12	0.16	0.18	0.24
Ratio Charcoal:Short Cells	0.29	0.08	0.18	0.3	0.22	0.36

Table B-4. Soil Sample Phytolith Counts, Samples 7 Through 12 (41RB112)

	Soil 7	Soil 8	Soil 9	Soil 10	Soil 11	Soil 12
Phytolith Morphology						
Keeled	2	14	1	22	26	18
Conical	10	23	6	66	34	29
Pyramidal	4	15	4	5	15	20
Crenate	1	3	-	3	14	8
Saddle, squat	4	44	6	21	24	22
Saddle, tall	6	67	13	30	60	9
Stipa	-	5	-	18	4.5	9
Lobate, Simple	0.5	3.5	1.5	9	5	4
Lobate, Panicoid	7.5	27	1	62	16.5	27
Lobate, Pan'd (compound)	-	1	-	-	-	-
Cross, Panicoid (<12 um)	-	3	-	31	4	6
Cross, Panicoid (>12 um)	-	1	-	16.5	2	3
Maize Rondel	-	-	-	-	-	-
Dicot, knobby	-	-	-	-	-	-
Spiny spheroid	1	2	-	-	2	6
WWW, Schlerid	-	-	-	-	5	1
Diatom	-	1	-	-	-	-

Table B-4. Soil Sample Phytolith Counts, Samples 7 Through 12 (41RB112) (cont.)

	Soil 7	Soil 8	Soil 9	Soil 10	Soil 11	Soil 12
Phytolith Morphology						
Sponge spicule	2	1	1	-	-	-
Trichome, Hair Cells	5	11	6	3	14	28
Bulliform, square	17	38	70	7	34	58
Bulliform, rectangular	52	103	94	4	80	178
Bulliform, keystone	31	48	45	-	26	47
Bulliform, Y-shaped	7	5	2	23	6	6
Bulliform, other	120	188	334	4	161	320
Elongate, smooth	1	4	2	6	9	20
Elongate, sinuous	1	7	2	4	10	24
Elongate, castillate	1	5	2	2	8	16
Elongate, spiny	-	-	-	-	-	1
Other Misc. Forms	-	-	-	-	-	-
Charcoal	67	57	40	10	66	74
Possible Pinaceae tracheid elements ?	-	-	-	-	-	-
Sedges	3	6	5	8	6	1
Saddle Imposters	-	9	-	1	13	5
Large Discs	4	15	-	16	5	1
Spore	1	1	-	-	-	-
Total Short Cell Counts:	35	206.5	32.5	283.5	205	195
Pooids (cool season)	17	55	11	96	89	75
Chloridoids (hot dry)	10	111	19	51	84	71
Panicoids (warm moist)	8	40.5	2.5	136.5	32	49
Normalized Short Cells (%)						
Pooids	48.5	26.6	33.8	33.9	43.4	38.5
Chloridoids	28.6	53.8	58.5	18	41	36.4
Panicoids	22.9	19.6	7.7	48.1	15.6	25.1
Total Bulliforms	227	386	545	38	307	609
Ratio Bulliform:Short Cells	6.49	1.85	16.77	0.13	1.5	3.12
Ratio Charcoal:Bulliform	0.3	0.15	0.07	0.26	0.21	0.12
Ratio Charcoal:Short Cells	1.91	0.28	1.23	0.04	0.32	0.38

Table B-5. Soil Sample Phytolith Counts, Samples 13 Through 18 (41RB112).

	Soil 13	Soil 14	Soil 15	Soil 16	Soil 17	Soil 18
Phytolith Morphology						
Keeled	2	34	10	-	2	21
Conical	6	90	10	4	3	25
Pyramidal	-	24	5	4	6	1
Crenate	-	3	3	-	1	9
Saddle, squat	5	70	5	3	2	23
Saddle, tall	4	101	8	5	3	32
Stipa	1	13	5	1	-	4.5
Lobate, Simple	1	-	4	-	-	3.5
Lobate, Panicoid	-	3	27.5	5	-	74.5
Lobate, Pan'd (compound)	-	--	2	-	-	2
Cross, Panicoid (<12 um)	1	1	-	-	-	7
Cross, Panicoid (>12 um)	-	0.5	3	-	-	14
Maize Rondel	-	-	-	-	-	-
Dicot, knobby	-	-	-	-	-	2
Spiny spheroid	2	1	7	7	5	6
WWW, Schlerid	-	2	-	-	-	1
Diatom	-	1	3	-	-	2
Sponge spicule	1	-	6	2	-	2
Trichome, Hair Cells	1	11	30	4	4	8
Bulliform, square	12	30	46	11	13	16
Bulliform, rectangular	28	54	127	61	39	50
Bulliform, keystone	16	21	58	32	29	9
Bulliform, Y-shaped	1	1	-	5	-	26
Bulliform, other	80	114	409	194	163	61
Elongate, smooth	1	4	5	1	1	2
Elongate, sinuous	10	1	12	4	4	8
Elongate, castellate	3	6	7	6	8	3
Elongate, spiny	-	-	-	-	-	3
Other Misc. Forms	-	-	-	-	-	-
Charcoal	72	15	122	77	75	27
Possible Pinaceae tracheid elements ?	-	1	-	-	-	16
Sedges	1	-	-	-	-	-
Saddle Imposters	1	4	1	2	1	-
Large Discs	-	1	1	2	-	-
Spore	-	1	-	-	-	-

Table B-5. Soil Sample Phytolith Counts, Samples 13 Through 18 (41RB112) (cont.)

	Soil 13	Soil 14	Soil 15	Soil 16	Soil 17	Soil 18
Phytolith Morphology						
Total Short Cell Counts:	20	339.5	82.5	22	17	230.5
Pooids (cool season)	8	151	28	8	12	70
Chloridoids (hot dry)	9	171	13	8	5	55
Panicoids (warm moist)	3	17.5	41.5	6	0	105.5
Normalized Short Cells (%)						
Pooids	40	44.4	33.9	36.3	70.6	30.3
Chloridoids	45	50.4	15.8	36.4	29.4	23.9
Panicoids	15	5.2	50.3	27.3	0	45.8
Total Bulliforms	137	220	640	303	244	162
Ratio Bulliform:Short Cells	6.85	0.65	7.76	13.77	14.35	0.7
Ratio Charcoal:Bulliform	0.53	0.07	0.19	0.25	0.31	0.17
Ratio Charcoal:Short Cells	3.6	0.04	1.48	3.5	4.41	0.12

Table B-6. Soil Sample Phytolith Counts, Samples 19 Through 25 (41RB112).

	Soil 19	Soil 20	Soil 21	Soil 22	Soil 23	Soil 24	Soil 25
Phytolith Morphology							
Keeled	20	11	45	22	6	8	17
Conical	35	12	42	42	7	16	41
Pyramidal	20	3	14	16	4	11	11
Crenate	6	6	4	2	-	4	2
Saddle, squat	41	21	61	68	1	15	47
Saddle, tall	126	36	115	102	3	29	99
Stipa	9	3	5	5	1	1	8
Lobate, Simple	3	3	1.5	2	1	1	1
Lobate, Panicoid	60.5	41.5	13	9.5	4.5	53	6
Lobate, Pan'd (compound)	-	-	-	-	-	-	-
Cross, Panicoid (<12 um)	17	7	3	-	1	2	-
Cross, Panicoid (>12 um)	17	9	1	-	1	5	-
Maize Rondel	-	-	-	-	-	-	-
Dicot, knobby	-	1	-	1	-	1	-
Spiny spheroid	2	2	-	2	2	3	-

Table B-6. Soil Sample Phytolith Counts, Samples 19 Through 25 (41RB112) (cont.)

WWW, Schlerid	-	-	-	4	1	3	6
Diatom	2	1	-	11	-	1	7
Sponge spicule	-	2	-	-	-	-	1
Trichome, Hair Cells	11	13	11	10	1	4	11
Bulliform, square	8	13	25	13	16	8	12
Bulliform, rectangular	32	34	37	36	33	26	46
Bulliform, keystone	13	18	30	33	15	5	10
Bulliform, Y-shaped	2	2	7	1	-	1	8
Bulliform, other	94	80	145	134	85	44	74
Elongate, smooth	15	9	14	4	9	20	3
Elongate, sinuous	8	6	11	11	17	13	4
Elongate, castillate	16	10	7	10	9	2	4
Elongate, spiny	2	-	2	7	-	2	1
Other Misc. Forms	-	-	-	-	-	-	-
Charcoal	27	34	26	23	62	14	8
Possible Pinaceae tracheid elements ?	-	35	-	-	-	9	-
Sedges	2	2	-	6	-	1	2
Saddle Imposters	9	1	6	8	1	1	-
Large Discs	5	-	6	1	1	-	-
Spore	-	-	-	1	-	-	-
Total Short Cells:	354.5	152.5	304.5	268.5	29.5	145	232
Pooids (cool season)	81	32	105	82	17	39	71
Chloridoids (hot dry)	167	57	176	170	4	44	146
Panicoids (warm moist)	106.5	63.5	23.5	16.5	8.5	62	15
Normalized Short Cells (%)							
Pooids	22.9	21	34.5	30.6	57.6	26.9	30.6
Chloridoids	47.1	37.4	57.8	63.3	13.6	30.3	62.9
Panicoids	30	41.6	7.7	6.1	28.8	42.8	6.5
Total Bulliforms	149	147	244	217	149	84	150
Ratio Bulliform:Short Cells	0.42	0.96	0.8	0.81	5.05	0.58	0.65
Ratio Charcoal:Bulliform	0.18	0.23	0.11	0.11	0.42	0.17	0.05
Ratio Charcoal:Short Cells	0.08	0.22	0.09	0.09	2.1	0.1	0.03

total short cells were also calculated in an effort to assess phytolith stability and preservation.

The normalized seasonality data for the twelve short cell phytolith morphologic types (see Tables B-3 through B-6) grouped by subfamily are plotted in Figure B-11. These three seasonality groupings are:

1. pooids which are the are cool season grasses (keeled, conical, pyramidal, and crenate phytoliths),
2. chloridoids which are the hot dry season grasses (squat and tall saddle phytoliths), and the
3. panicoids which are the hot season grasses with higher moisture requirements than the chloridoids (simple lobate, panicoid lobate, panicoid polylobate [i.e., compound lobate], and panicoid cross phytoliths [the *Stipa* biloboates are also included in this category]).

These soil samples are culturally derived; thus, rather than the term phytolith seasonality forms in this report meaning climatic seasonal variation over the millennia, it simply refers to the climatic condition under which the plant(s) grew. Thus for instance, pooids would generally represent spring or fall vegetation, or vegetation growing along waterways. Gathering activities conducted in different select portions of the ecosystem would likely result in various botanical species being introduced to the site.

The burned phytolith incidence of the twelve phytolith short cell forms was calculated yielding percent burned phytolith ratios (Table B-7). Bulliform phytoliths actually occur in the leaves of most grasses; however, they are more concentrated in C₄ plants as the bulliform cells are actively involved in conserving plant water in hot environments through the mechanism of active leaf curling (i.e., the plant actively reduces the amount of leaf surface area exposed to the sun during hot weather). Thus bulliform cells help and enable C₄ plants to thrive in a hotter drier environment. Although bulliform cells are most abundant in C₄ plants, the total number of bulliform cells contributed by panicoids with their much greater biomass is likely much larger than a comparable number of chloridoid plants—even though both subfamilies are C₄ plants. The ratio of total bulliform cell counts to total short cell counts

(see Tables B-3 through B-6) shows considerable variation in concentration between samples (Figure B-12). This variability is felt to reflect dissolution of short cell phytoliths due to high soil pH in some portions of the archeological site.

Of the twenty-five soil samples analyzed, seven samples have bulliform phytolith counts present at a ratio higher than five times the short cell phytolith content (Figure B-12; see Tables B-3 through B-6). Most interestingly, without exception, these seven samples are the same samples with the lowest short cell phytolith counts (Figure B-11 legend; see Tables B-3 through B-6). The on-site control (sample 9) from the swale between Components A and C has the highest observed relative bulliform concentration. The relative bulliform concentration in the modern off-site surface sample is low (sample 25). This data suggests that some phytolith dissolution is occurring at certain areas of the site which is selectively lowering the relative short cell phytolith count. The presence of carbonates in the soil under the pithouses indicates a basic soil pH; phytoliths are known to dissolve when the soil pH is too high (Piperno 2006:8, 22).

The explanation of the elevated bulliform concentration in the other six samples noted above is enigmatic. The two samples from the bottom of storage pits (sample 7, Feature 13 and sample 23, Feature 23) may indicate that the pits were preferentially used to store species with a higher bulliform content; bulliforms are more concentrated in C₄ species (chloridoids and/or panicoids) as these species contain the specialized cells which enable leaf curling that allows plants to conserve water in hot weather.

The bulliform concentration in the pithouse 1, storage pit Feature 13 is higher than any of the pithouse 1 floor samples (samples 1 through 3) or other related samples (samples 4 through 6 and 8). This could indicated high bulliform content plants were stored in the pit. Alternatively, the contributing botanicals could have been used to line or otherwise prepare the storage pit. The variable and at times extensive weathering observed in the site's bulliform sample (Figure B-13) suggests that the environmental conditions in some soil samples were such that phytolith preservation is poor.

Figure B-10. Phytolith growing season plot of summed normalized short cell phytolith data.

The particle counts for samples 7 [bottom of small storage pit, Feature 13], 9 [lower part of thickened A horizon in swale between Components A and C], 13 [north wall profile inside and on floor of pithouse 2, Feature 6], 15 [middle of earthen construction fill inside pithouse 2, western side, Feature 6], 16 [upper part of pithouse 2 floor below earthen construction fill, western side, Feature 6], 17 [bottom of pithouse 2 floor, western side, Feature 6], and 23 [inside, bottom of storage pit, Feature 23] were extremely low and thus have poorer reliability than the other samples as far as climatic indicators. The modern control surface soil is sample 25. Component A samples are 1 through 8, sample 9 is Component B, and samples 10 through 24 are from Component C. Other sample origin information is: soil sample 1 (from cutbank profile, base of pithouse 1, Feature 1), sample 2 (from profile wall, floor of pithouse 1), sample 3 (from floor of pithouse 1), sample 4 (inside west half of small basin heating element, Feature 8), sample 5 (southwest part of broad heating element, Feature 10), sample 6 (inside heating element, Feature 11), sample 8 (ashy stain next to heating element Feature 10), sample 10 (bottom of basin heating element Feature 5), sample 11 (pithouse 2 floor, Feature 6), and sample 12 (lower portion of construction fill on top of floor, Feature 6), sample 14 (upper end of eolian fill on top of construction fill towards western side of pithouse 2, Feature 6), sample 18 (earthen construction fill near center of pithouse 2, Feature 6), sample 19 (pithouse floor, upper, near center of pithouse 2, Feature 6), sample 20 (pithouse floor near center of pithouse 2, Feature 6), soil sample 21 (bottom of basin heating element with burned maize cobs, Feature 16), sample 22 (bottom of heating element with burned maize cobs, Feature 20), and sample 24 (ashy stain on floor of pithouse 2, Feature 24 in Feature 6 eastern end).

Table B-7. Percent Burned Short Cell Phytoliths in Each Soil Sample Scanned.

Soil Sample Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Morphology / Percent Burned													
Keeled													
Conical		7.70%						8.70%		9.10%	2.90%		
Pyramidal										20.00%		5.00%	
Crenate										33.30%			
Saddle, squat													
Saddle, tall	1.20%		2.00%										
Stipa								20.00%		5.60%			100%
Lobate, Simple										5.60%		25.00%	100%
Lobate, Panicoid	12.50%	6.70%	5.90%	11.40%	13.40%	2.60%	46.70%	20.40%		16.90%	15.20%	14.80%	
Lobate, Panicoid (cmpd)													
Cross, Panicoid (<12 μ)	50.00%		33.30%					33.30%		32.30%	50.00%	33.30%	
Cross, Panicoid (>12 μ)										33.30%		33.30%	

Soil Sample Number	14	15	16	17	18	19	20	21	22	23	24	25
Morphology / Percent Burned												
Keeled					4.80%							
Conical						2.90%		2.40%		14.30%	12.50%	
Pyramidal											9.10%	
Crenate					11.10%							
Saddle, squat						2.40%						
Saddle, tall							2.80%					
Stipa						11.10%						
Lobate, Simple								66.70%				
Lobate, Panicoid		12.70%	10.00%		3.40%	11.60%	14.50%				15.10%	16.70%
Lobate, Panicoid (cmpd)												
Cross, Panicoid (<12 μ)	100.00%				14.30%	11.80%	14.30%	33.30%				
Cross, Panicoid (>12 μ)						5.90%					40.00%

Figure B-11. Ratio of bulliform phytolith counts to short cell phytolith counts (data from Tables B-3 through B-6).

Well preserved and poorly preserved bulliform specimens were intermixed in the soils. Perhaps most significant is the specimen shown in Figure B-13U; the upper half of this rectangular bulliform is in pristine condition while the lower half is totally missing; one interpretation of this specimen would be that the phytolith protruded from a ped surface and the half exposed to ground water movement was dissolved. The ratio of charcoal to short cell phytolith count is also somewhat increased for the same seven samples (see Tables B-3 through B-6). This observation suggests that the smaller particles may be disappearing over time in an unfavorable soil environment whereas the larger particles with a smaller surface to volume ratio (i.e., bulliform phytoliths) take longer to dissolve (i.e., a large ice cube melts more slowly than a small ice cube). The bulliform phytoliths show evidence of weathering and partial dissolution (Figure B-13), but portions of bulliforms remain in the soil and are recoverable and countable whereas many of the smaller short cell phytoliths were apparently completely dissolved thus resulting in an artificially environmentally-induced low short cell phytolith count which is what is observed in the counts for some soil samples.

The key to understanding the soil samples in pithouse 2, Feature 6 in Component C with the higher/more

abundant relative bulliform content may hinge on the description provided for soil sample 14 (“upper end of eolian fill on top of construction fill towards western end of pithouse”). Once the structure was compromised, the exposed part of the abandoned pithouse would potentially develop a new botanical signature as degradation continued. The area would be a low spot, which would tend to concentrate the little bit of available water, and the effects of that higher water concentration in this local micro-environment could potentially have altered relative phytolith preservation. The higher bulliform ratio concentration samples in pithouse 2 tend to cluster on the west side of the structure which may suggest that this was the area available for vegetative growth [or selective dissolution] during the eolian period (sample 15 [middle of earthen construction fill inside pithouse 2, western side], 16 [upper part of pithouse 2 floor below earthen construction fill, western side], and 17 [bottom of pithouse 2 floor, western side], with sample 13 [north wall profile inside and on floor of pithouse 2] being the outlier from this interpretation. The other two slightly elevated bulliform soil samples (samples 11 [pithouse 2 floor] and 12 [lower portion of construction fill on top of floor], were also floor-related pithouse 2 samples; they had slightly elevated bulliform ratios of 1.5 percent and 3.1 percent). An alternative explanation

for the relative high bulliform concentration in these two samples is that the bulliform-rich botanical species may have been used in pithouse 2 construction, maintenance, and/or for sustenance; bulliforms are more abundant in the C₄ grasses (on a plant by plant basis, panicoids would presumably be favored as the source over chloridoids as the panicoids have much more biomass).

Sedge (Cyperaceae) phytoliths and sections of sponge spicules (Porifera) were also recovered (see Tables B-3 through B-6); no sponge gemmoscleres were observed in the slides. Sedges produce distinctive phytoliths, and frequently grow in wetland areas. The proximity to the creeks and local drainage system explains their presence at the site; they may have been actively gathered for use, or incidental (animal droppings, eolian deposit). Sponges live in water; when they die their microscopic skeletal support network (spicules) are released into the environment. Freshwater sponge spicules are made of biogenic silica (as are phytoliths)—so, they may be recovered in soil phytolith isolates. Complete spicules are gradually chipped, broken, and weathered as they are transported downstream with the sands [or blown as part of the dust]. Thus, fresh pristine spicules (such as those accidentally transported to the site when water was hauled for cooking or drinking) are suggestive of a local sponge population. At the other extreme, weathered spicules can and do occur in soil and sands, and can be transported, deposited, and redeposited by water and/or wind. In the process of this movement, the spicules collide repeatedly with other particles and they begin to show visible signs of abrasion and weathering (i.e., literal “sandblasting”) (Sudbury 2011c). Such weathered spicules occur at the site, but they are redeposited rather than representing an extant local sponge population. Sedges would have been transported to the site rather than growing on the site. Sponge spicules sections were present in the local environment without human intervention. Gemmoscleres (special spicules formed during the resting or dormant phase in the sponge’s life cycle) were not recovered at the site.

Several other distinctive phytolith forms were noted: one specimen of a Commelinaceae seed phytolith was found (Figure B-14). This was tentatively

identified as being a member of the Commulina genera (Yost personal communication) of which there are four species native to the USA: *C. dianthifolia*, *C. diffusa*, *C. erecta*, and *C. virginica* (Yost 2011). Several very distinctive examples of phytoliths exhibiting characteristics of a sedge (raised central area) but exhibiting a large jig-saw puzzle piece type edge were recovered (Figure B-15); the botanical source of these phytoliths remains unknown.

In the formal sample particle counts for short cell phytolith frequency (see Tables B-3 through B-6), possible tracheid phytoliths were in the soil sample phytolith isolates from pithouse 2, Feature 6 floor samples 14, 18, 20, and 24 (Figure B-16) [all four of these soils have what is interpreted as good short cell preservation (see Figure B-12)]. During the formal counts, no tracheid specimens of this morphology were observed in Components A and B samples (samples 1 through 10) or in the off-site control sample (sample 25). In the rescans of the specimen slides looking for additional particles of interest, photographs were taken of all observed similar possible tracheid elements; those total particle counts [based on photographs] are:

soil 11: 1 example (pithouse 2 floor, Feature 6),
soil 13: 1 example (north wall profile inside and on floor of pithouse 2),
soil 19: 1 example (pithouse floor, upper, near center of pithouse 2),
soil 17: 2 examples (bottom of pithouse 2 floor, western side),
soil 18: 9 examples (earthen construction fill near center of pithouse 2),
soil 15: 11 examples (middle of earthen construction fill inside pithouse 2, western side),
soil 24: 26 examples (ashy stain on floor of pithouse 2, Feature 6 eastern end),
soil 16: 36 examples (upper part of pithouse 2 floor below earthen construction fill, western side), and
soil 20: 82 examples (pithouse floor near center of pithouse 2).

Again, during these additional scans no specimens of this phytolith type (fragments or whole) were observed in the samples from Components A or

Figure B-12. Representative weathered bulliform phytoliths.

A through C and Q: sample 7 (bottom of small storage pit, Feature 13); D: sample 8 (ashy stain next to heating element Feature 10); E and F: sample 9 (control between Components A and C); G through K, R through S: sample 12 (lower portion of construction fill pithouse 2, Feature 6); L, T: sample 15 (middle of earthen construction fill western side, Feature 6); M through O, U through V: sample 16 (upper part of pithouse 2 floor below fill western side Feature 6), and P: sample 17 (bottom of pithouse 2 floor, western side of Feature 6).

Figure B-13. Commelinaceae seed phytolith.
Soil sample 20 (pithouse floor near center of pithouse 2, feature 6)

B—these phytoliths only occurred in Component C soils.

In Bozarth's paper reporting the Pinaceae blocky bordered pit tracheid elements, the control conifer specimens examined were more northern species: balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), black spruce (*Picea mariana*), jack pine (*Pinus banksiana*), and larch (*Larix laricina*) (Bozarth 1993:98). These tracheid elements with bordered pits were reported as common in jack pine (18 percent) and less common in white spruce at (1 percent) (ibid.). In an effort to identify the botanical source of the phytoliths illustrated in Figure B-16, phytoliths from reference specimens of honey mesquite (*Prosopis glandulosa*, Figures B-18 through B-21), Rocky Mountain juniper (*Juniperus scopulorum*, Figures B-22 through B-26), common juniper (*Juniperus communalis*), eastern redcedar (*Juniperus virginiana*), ponderosa pine (*Pinus ponderosa*), limber pine (*Pinus flexilis*), Douglas-fir (*Pseudotsuga* sp.), lodgepole pine (*Pinus contorta*), subalpine fir (*Abies lasiocarpa*), Piñon pine ("twoneedle pinon" *Pinus edulis*), and blue spruce (*Picea pungens*) were isolated and examined [when available, samples were ashed and mounted (with and without hydrochloric acid treatment) from cones, seeds, needles, small limbs, and bark shavings from limbs greater than 1 inch]. Phytoliths were also prepared from cottonwood (*Populus* sp.), hackberry (*Celtis* L.), pecan (*Carya illinoensis*), and quaking aspen (*Populus tremuloides*). To date, the botanical source(s) of the phytoliths in Figure B-16 remains unidentified; they were not observed in these reference specimens. The most similar

appearing phytoliths were observed in Rocky Mountain juniper (see Figure B-26), but they do not match the unknown specimens in Figure B-16. The specimen illustrated in Figure B-25N, P, and R is a narrow ribbon-like specimen, but differs in that it is crystalline rather than amorphous (the Figure B-16 specimens are amorphous) and they do not have the same surface detail.

The other unusual particles observed in the soil sample phytolith isolates are thought to be remains of plant fibers (see examples in Figure B-17). Perhaps the most striking feature observed in these fibers besides the crystallinity is the incised, X, or cross-hatched pattern that is most visible in the specimens B-17A, F3, and F5. A similar appearance is visible in Figure B-25T observed in the Rocky Mountain juniper control sample. However, as positive identification of the unknown fibers in Figure B-17 is currently not possible as we are current unable to excluded fibers that occur in other plants not yet examined.

Large flat disk-shape phytoliths, also referred to as rondels, were observed in a number of soil phytolith isolate slides; these specimens were further evaluated to determine if they originated from *Zea mays* (Piperno 2006: Figure 2. *Zea*, p. 49). A number of specimens of this general type of rondel are illustrated in Figure B-27. The disk-shaped rondels with appropriate upper surface contour or ornamentation when examined three dimensionally are classified as originating from *Zea mays* cobs. Those meeting the three dimensional morphologic criteria described by Pearsall, Chandler-Ezell, and Chandler-Ezell (2003) were specimens in

Figure B-14. Unusual phytolith form(s) recovered from three soil samples:
A: sample 18 (earthen construction fill near center of pithouse 2, Feature 6), B: sample 20 (pithouse floor near center of pithouse 2), and C: sample 24 (ashy stain on floor of pithouse 2, Feature 6 eastern end). The bar scales are 20 microns.

Figure B-15. 41RB112 possible tracheid elements from the ashy stain Feature 24 on the floor of pithouse 2 Feature 6, eastern end (sample 24).

Images Q and U are side (edge) views, K is an angle view, and the other shots are planar views. The 20 (A) and 50 (R) micron scales apply to all images. Many of these specimens—over 100 microns long—would normally be left in the sand fraction (> 50 microns) by the standard separation procedure as it appears in the literature.

Figure B-16. Various views of example fiber residues recovered from soil samples during phytolith processing (plus one Rocky Mountain juniper control fiber).

A, B: Soil sample 7 (bottom of small storage pit, Component A); C: control Rocky Mountain juniper cone fiber; D Soil sample 6 (inside heating element, Component A); E Soil sample 15 (middle of earthen construction fill inside pithouse, Component C); F and G: soil sample 23 (inside bottom of storage pit). Grey background photographic images are illuminated via polarized light; black backgrounds are via crossed polars, and reddish backgrounds are crossed polars with $\frac{1}{4}$ wave plate in place (yellow fiber change to blue color occurs by rotating the specimen stage 90°).

Figure B-17. Honey mesquite (*Prosopis glandulosa*).

A: Part of mesquite specimens as received from Mike Quigg (1-large branch, 2-small limb, 3-smaller limb with thorns, 4-petiole, 5-leaves, and 6-seed pod). B: seed pod (1), seeds removed from pod (2), and seed components (3; see D). C: thorns and accompanying stem section (visible in A3). D: seed components (row 1-intact seeds, 2-seed, 3-seed coats). E: eight samples before ashing (1-seeds [D2], 2-seed coats [D3], 3-seed pod husk [legume pericarp], 4-leaves [A5], 5-small limbs [A2], 6-petioles [A4], 7-thorns [C], and 8-limb section at base of thorns [C]). F: samples after ashing [1-8 the same as E; crucible #9 was added as there was additional room available in the muffle furnace; #9 contains bark sections from the larger limb [A1]]. In most samples in F, the white ash contains a significant amount of carbonate. Slides were prepared from the ash as shown. Part of the ash was later treated with hydrochloric acid to remove the carbonates; after rinsing and drying, the remaining residue was also mounted on slides for examination.

Figure B-18. Honey mesquite small limb phytoliths (thermally ashed samples, neutralized with HCl)—calcium oxalate crystals, and crystal-bearing fibers.

A through B: Imaged show profusion of calcium oxalate crystals from the small limbs. C through F: four views of example crystals (F was rotated 90° from E). G through J: four views of fiber containing oxalate). A, C, G-polarized light; D, H-crossed polars, B, E, F, I, J-crossed polars with quarter-wave plate).

Figure B-19. Honey mesquite tree phytoliths—spheres and crystalline material.

A through M: spherical phytoliths. N through AG: phytoliths associated with crystalline materials. Mesquite leaves: A through J, O through S; Mesquite petioles: K through N, T through X. Mesquite seed coat: Y through Z [also note the specimen in Figure B-21:H through K]; and Mesquite seed pod husk [legume pericarp]: AA through AG. The leaves had an abundance of variable size spherical phytoliths (A through J); specimen J is interesting in that a crystal appears to be growing out of a large sphere; the crystal also present in N (see same specimen in T). The petioles also had a few spheres (K through N); N actually appears to be co joined spheres with a crystal forming at the juncture. Two-part particles were also noted with a base or outer portion of biogenic silica and a central crystalline material. The series O through R shows one complete set of images (O: polarized light, P: crossed polars; Q through R crossed polars with quarter wave plate) [the remaining images (S through AG) just show the final quarter wave plate view]. There is considerable variation in crystalline material size and shape; the particles in the seed coat and pod husk (legume pericarp) tend to be larger. AA looks similar—but does not contain the crystalline component. V looks like a small sphere with a central crystal.

Figure B-20. Honey mesquite tree fibers (after thermal ashing to 530°C and hydrochloric acid treatment).

A through K: from seed coat [Figure B-20D3]; L through T: from husk of seed pod ([legume pericarp] note variable scales; polarized, cross polarized, and quarter wave plate images as described previously [one view missing in the A through C series; images G, K, and O rotated and reoriented for easier visualization]).

Seed Coat: A through C: fiber showing crystalline component after ashing and HCl treatment. The tracheid element shown in D through G is much larger and has a mesh-like appearance. In the H through K series, a different crystalline component (or mixture) is present as evidenced by the color change in I and J. The upper circular particle is a spherical particle practically identical to the one shown in Figure B-22Y suggesting this form may be common in Mesquite seed coats. Pod Husk (legume pericarp): three different fibers illustrated (L through O, P, and Q through T). P is a complete fusiform-shaped fiber with the same evidence of crystallinity. The specimen in L through O is similar in composition to that observed in A through C. The specimen in Q through T has a different composition based on color difference. Identity of the crystalline components, at least some of which are presumed to be calcium oxalate-related, remains to be determined.

Figure B-21. Rocky Mountain juniper (*Juniperus scopulorum*).

A: Trees sampled on the east edge of Estes Park, Colorado (specimens provided courtesy of Bud Hampton; view to the SE) [top of a Douglas-fir visible in the background]; B: example small limb to be processed; C: small limb fragments (larger diameter pieces were split so they would ash more quickly); D: berry-like seed cones (A-narrow, not fully filled out; B-plump). E. Crucibles loaded ready for the furnace (A-leaves; B-plump seed cones, C-seed cone stems; D-small limb sections, and E-narrow seed cones), and F. same composition as image E after ashing at 530°C. Specimen slides were prepared from the ash as shown. Part of the ash was later treated with hydrochloric acid to remove the carbonates; after rinsing and drying, the remaining residue was also mounted on slides for examination.

Figure B-22. Rocky Mountain juniper phytoliths from small limbs.

A through H: small spheres (the specimen in G and H contains a central crystalline component); I through P: narrow phytolith border around crystalline center. Q through X: four views of two “wispy” crystalline fibers; and Y through AB: representative view of crystalline nature of two fibers. Images A through X all prepared at the identical scale. These microscopic specimens were prepared from the small limbs shown in Figure B-17C through thermal ashing (530°C), HCl treatment, and mounting in Canada Balsam.

Figure B-23. Rocky Mountain juniper phytoliths prepared from leaves.

A through D: Spherical phytoliths; E through N: crystals associated with phytolith bases; O through R: pure isolated crystals (longer specimens were observed); S through X: images of four fibers (specimens S, U, and W are images of one fiber); T, V, and X are cross polars images of 3 additional sections of fibers at the same magnification).

Figure B-24. Rocky Mountain juniper phytoliths and crystalline fiber residues prepared from berry-like cones.

A through E: spherical phytoliths; F: possible spherical phytolith; G through K: crystals from cells or associated with phytoliths; L: pure crystalline material; and crystalline residue from three apparent plant fibers (M, O, Q, and S; N, P, and R; and T, U, V, and W).

Figure B-25. Several generally rectangular phytoliths recovered from Rocky Mountain juniper leaves.

Although superficially similar, the morphology of these specimens is not the same as those recovered from the soil samples Figure B-16. Specimen A through D is from the ashed leaf sample; and the three specimens in E through G are from the seed-like cones.

Figure B-27A, D, E, G, H, and I (see also Piperno 2006:204). This phytolith originated from maize cobs. The other specimens in Figure B-27 are from non-*Zea Poaceae* species. Cross-shaped Panicoid phytoliths or cross-bodies (Piperno 2006:49) occur in a number of morphologic subtypes; Type 1 specimens wider than 12.57 microns are considered to have originated from maize leaves (ibid.: 45-65). A selection of cross-shaped phytoliths from 41RB112 is shown in Figure B-28; the bar scale with each images is 12.5 microns long. The phytoliths in A through O are wider than 12.5 microns and thus are considered to be indicative of maize leaves (specimen P is borderline in width). The remaining specimens are narrower than the criteria and thus are automatically felt to have originated from other Poaceae species.

The second criterion is the variant type; of the 8 variants, variant one is type that originates from maize (ibid. 200). Of the specimens in Figure B-28A through P, C through E are clearly variant 1 whereas J, L, and N through P are not variant 1; the remaining specimens (A, B, G through I, K, and M) are probably variant 1 (i.e., *Zea mays*). These specimens, from a sample of a basin heating element (Feature 5), clearly record that maize was present and that nonmaize Poaceae were also present. However, the non-maize species may have been harvested for other uses, or simply employed as tinder. Thus, Feature 5 (sample 10) contained both maize cob phytoliths (see Figure B-27) and maize leaf phytoliths (Figure B-28). Some, but not all of the crosses are burned (Figure B-28).

Another common resource was the cucurbits, which also produce distinctive spherical scalloped phytoliths (Bozarth 1986, 1987; Piperno 2006:65-71, 205-206). Phytoliths with either the correct size or general textural appearance from 41RB112 are illustrated in Figure B-29. As cucurbit species were domesticated, their phytoliths gradually increased in size (Piperno 2006:67). For easy reference Figure B-30 shows six cucurbit phytoliths prepared from a reference specimen of Buffalo Gourd (*Cucurbita foetidissima kunth*). Past literature generally shows pristine phytoliths; however, the range shown in Figure B-30 is much more realistic—from classic

to pretty rough looking. Part of the difficulty in interpreting the 41RB112 cucurbit data in Figure B-29 is the issue with phytolith preservation at the site (see bulliform Figure B-13). A number of the phytoliths are too small to meet the published identification criteria (Figure B-29A through C, E, P, and Q and probably G and J). [To my knowledge, the phytolith size in immature cucurbits has not been studied or reported—that worthwhile investigation is currently being planned. The effect of environmental differences on cucurbit size and degree of silicification has been noted (Bozarth 1987:612.) Clearly, none of the remaining larger

Figure B-26. Large disk-shape or rondel phytoliths; possible *Zea mays* phytoliths.

A (sample 1, pithouse 1), B (sample 4, basin heating element, Feature 8), C-E (sample 6, heating element, Feature 11), F (sample 8, ashy stain), G-I (sample 10, basin heating element, Feature 5), J (sample 12, top of floor in pithouse 2, Feature 6), K (sample 14, eolian on top of pithouse 2, Feature 6), L-M (sample 18, earthen construction fill in pithouse 2, Feature 6), N-O (sample 19, floor of pithouse 2, Feature 6), and P (sample 21, basin heating element, Feature 16).

specimens are pristine cucurbit specimens compared to Figure B-30A. The specimens in Figure B-30H, L, N, O, and possibly R appear to be somewhat flattened (i.e., not spherical) which likely excludes them from being classified as cucurbit phytoliths. In Figure B-29I, R, and T may be cucurbit phytoliths; appearance and potential preservation issues make it impossible to tell for certain; thus, the question of phytolith evidence for cucurbits at the site currently remains unanswered.

Obsidian debitage can be included in phytolith preparations (Sudbury 2011b:18). Some small microchips or micro-flakes were prepared by jostling thin-edged obsidian flakes together in a Ziploc bag; three of the resulting modern obsidian fragments are shown in Figure B-31A through B-31C; visible conchoidal fractures were generally not produced by this method. The specimens in Figure B-31D through I were recovered from the construction fill above the floor of pithouse 2. Specimens D, H, and I are felt to be phytoliths. The very large odd specimen (G) and the smaller specimen with trace evidence of conchoidal fracture (F) are felt to be obsidian microchips or flakes generated during the site occupation. The specimen shown in B-31E is indeterminate. An important consideration is that in areas and eras with volcanic activity (or if redeposition of volcanic debris occurs onto the site)—one cannot visually distinguish between volcanic ash particles and obsidian micro-chips.

No complete spicules or gemmoscleres were observed. The recovered spicule fragments are all illustrated in Figure B-32. Specimens varied from pristine (Figure B-32A) to very heavily weathered Figures B-32K and B-32L (and everything in between). A few statospores were observed while processing these soil samples. Also, a crystalline material with low birefringence and a variety of crystal habits in was observed in most of these soil samples; an effort to identify this material and its significance is ongoing (an example of the hexagonal habit is in see Figure B-17D2 and B-17D3). A small number of the unidentified particles observed in this study that were recovered from the two pithouse floors are illustrated in Figures B-33 through B-34.

B.4 Discussion

B.4.1 Agriculture—Corn, Beans, and Squash: Images of phytoliths representing these three major crops are in the literature.

Corn or maize (*Zea mays*) phytoliths are present in these samples from both cobs (see Figure B-27) and from leaves (see Figure B-28) (Pearsall 1978; Pearsall, Chandler-Ezell, and Chandler-Ezell 2003; Piperno 2006:45-65, 200-204). Distribution data of the large variant 1 cross bodies (which indicate maize leaves) at the site is in Tables B-3 through B-6. That data, along with incidence of burned cross body phytoliths (see Table B-7), is briefly discussed in the following subsections.

Beans (*Phaseolus* sp.) are generally most easily recognized by their silicified plant hair cells (Bozarth 1986:58, 64; Bozarth 1990:100). No phytolith evidence of beans was observed in the soil samples analyzed from 41RB112.

Cucurbits produce distinctive large scallop-surfaced roughly spherical phytoliths (Bozarth 1986:58, 60, 65 through 66; Bozarth 1987; Piperno 2006:65-71, 205-206). A number of candidate particles were observed in these samples (see Figure B-29, phytoliths from a reference botanical specimen are in Figure B-30). In addition to some phytoliths in Figure B-29 being undersized, the larger specimens generally do not have the optimal expected surface appearance (i.e., see Figure B-30A). Those issues, coupled with the confounding issue of the variable and at times heavy phytolith weathering/dissolution problem (Figure B-13), renders positive identification of any of these specimens as cucurbit phytoliths impossible. Bozarth (1987:611) notes that some phytoliths in his cucurbit reference collection were less distinctive due to their shallow scallops. He also noted significant variation in size and degrees of silicification based on environmental factors (ibid. 612). Piperno (2006:67-69) indicates that cucurbits from domesticated plants are much larger than those from wild plants. It is possible that some if not all of the larger phytoliths in Figure B-29 are actually bulliform phytoliths with heavy edge weathering—or some or all may be cucurbit phytoliths. Positive identification of

Figure B-27. Representative cross-shaped phytoliths from the bottom of the basin heating element Feature 5 (sample 10).

The specimens wider than 12.57 microns (Specimens A through O) are likely from *Zea mays* whereas those narrower than 12.57 microns are felt to be crosses from non-*Zea Poaceae* sources (i.e., non-domesticated native grasses (specimens P through AD; with P being on the borderline between the two size categories). All images are the same scale; the scale bar is 12.5 microns. Specimens B, D, K, M, P, S, AC and AD are heavily burned; specimens A, G through J, L, N, O, Q through S, X, and AB appear to be lightly charred. Images taken during rescan of entire slide looking for morphological forms of interest.

Figure B-28. Phytoliths bearing some features similar to those of cucurbit phytoliths.

A and B: Sample 1 (based of pithouse 1); C: Sample 2 (wall profile, floor of pithouse 2, Feature 6); D: Sample 3 (floor of pithouse 1); E: Sample 5 (southwest part of broad heating element, Feature 10); F: Sample 9 (lower part of thickened A horizon in shallow swale between Component A and Component C (control)); G through H: Sample 10 (pithouse 2 floor, Feature 6), I: Sample 12 (lower portion of construction fill on top of pithouse 2 floor); J: Sample 13 (north wall profile inside and on floor of pithouse 2); K through M: Sample 15 (middle of earthen construction fill inside pithouse 2, western side); N: Sample 16 (upper part of pithouse 2 floor below earthen construction fill, western side); O: Sample 17 (bottom of pithouse 2 floor, western side); P through Q: Sample 19 (pithouse 2 floor, upper, near center of pithouse); R: Sample 20 (pithouse 2 floor, near center of pithouse); S: Sample 21 (bottom of basin heating element Feature 16 with burned maize cobs); and T: Sample 25 (control surface soil).

**Figure B-29. Variety of phytoliths recovered from Buffalo Gourd (*Cucurbita foetidissima* kunth) reference specimen (Sudbury 2007:35).
Bar scales are 10 microns.**

cucurbits at 41RB112 is not currently possible from the available phytolith record.

Starch analysis was not performed on these samples.

B.4.2 Off-Site Surface Control Soil (sample 25: soil in pristine prairie on south side of Canadian River)

B.4.2.1 Surface Soil Burned Phytolith Incidence

The only burned short cell phytolith type present in the off-site surface control soil sample was the warm moist panicoid lobate variety at a 16.7 percent burned phytolith specimen incidence (see Table B-7, sample 25). As any panicoid (the major Poaceae biomass) from the prior growing season would be a potential fuel source, it is probable that this burned phytolith value represents an approximation of the

site area's environmental background fire incidence. This background fire value would not be expected to necessarily carry over to specific habitation features which would be strongly influenced by human activity.

B.4.2.2 Surface Soil Seasonality Profile

The phytolith signature is predominantly hot dry weather chloridoid phytoliths (Table B-8; see Figure B-11). The signature is very similar to that of bottom of heating element Feature 20 with burned maize cobs (sample 22), and similar to the on-site control (sample 9).

Phytolith seasonality data from modern soils at several area upland sites is shown for comparative purposes (Table B-8 [data from Beaver and Roger Mills Counties, Oklahoma Sudbury 2011b:120]). The Bull Creek site (34BV176), an upland shortgrass prairie (SG), is far removed from water,

Figure B-30. Other amorphous particles (obsidian).

A through C: Obsidian micro-flakes produced in the lab for comparative analysis. D through I: specimens observed in the phytolith isolate from lowest part of construction fill above the floor of pithouse 2, Feature 6 (Sample 12). D, H, and I appear to be of plant origin (I also contains a bulliform phytolith (above) and a keeled phytolith (below)). F and G are felt to be obsidian micro-flakes; F shows traces of conchoidal fracture, and G is very large and unlike any plant material that I have previously encountered. The originating source of specimen E is indeterminate.

Figure B-31. Sponge spicule sections from the Long View site.

A and B: sample 1 (from cutbank profile, base of pithouse 1); C: sample 4 (inside west half of small basin heating element); D and E: sample 6 (inside heating element); F and G: sample 7 (bottom of small storage pit); H: sample 8 (ashy stain next to heating element Feature 10); I: sample 9 (lower part of thickened A horizon in swale between Components A and C); J: sample 14 (upper end of eolian fill on top of construction fill towards western side of pithouse 2); K: sample 13 (north wall profile inside and on floor of pithouse 2); L: sample 16 (upper part of pithouse 2 floor below earthen construction fill, western side); M through O: sample 15 (middle of earthen construction fill inside pithouse 2, western side); P and Q: sample 18 (earthen construction fill near center of pithouse 2); R: sample 19 (pithouse floor, upper, near center of pithouse 2); S and T: sample 20 (pithouse floor near center of pithouse 2); and U through W: sample 25 (off-site surface control).

Figure B-32. Other representative miscellaneous amorphous particles recovered from the floor of pithouse 1.

A through F and H through M: sample 1 (from cutbank profile, base of pithouse 1); O through X: sample 2 (from profile wall, floor of pithouse 1); and G and Z through AI: sample 3 (from floor of pithouse 1). Specimen N is a bulliform phytolith, and specimens V and W are likely phytoliths of tree origin.

Figure B-33. Other representative miscellaneous amorphous particles recovered from the floor of pithouse 2.

A through Y: sample 20 (pithouse floor near center of pithouse 2); Z through AD: sample 11 (pithouse 2 floor); AE through AG: sample 16 (upper part of pithouse 2 floor below earthen construction fill, western side); and AH through AJ: sample 17 (bottom of pithouse 2 floor, western side). All specimens are amorphous; Z could conceivably be obsidian; the remaining specimens are all thought to be phytoliths. Specimens I through X are likely blocky forms associated with trees. All of these specimens have information potential—once their botanical origin is identified.

so it is not directly comparable to the current 41RB112 setting, and the phytolith seasonality data does not match. Although also an upland setting, the mixedgrass prairie (MG) phytolith seasonality signature for Dempsey Divide is similar to that obtained at 41RB112. The difference in phytolith signatures between upland and alluvial settings in the same prairie area has been addressed (Sudbury 2011b:179-187).

B.4.3 Component A - Pithouse 1 and Associated Features:

- soil sample 1: from cutbank profile, base of pithouse 1
- soil sample 2: from profile wall, floor of pithouse 1
- soil sample 3: from floor of pithouse 1
- soil sample 4: inside west half of small basin heating element, Feature 8
- soil sample 5: southwest part of broad heating element, Feature 10
- soil sample 6: inside heating element, Feature 11
- soil sample 7: bottom of small storage pit, Feature 13
- soil sample 8: ashy stain next to heating element Feature 10

B.4.3.1 Pithouse 1 Soil Seasonality Profile

The phytolith signatures of two of the three pithouse floor samples (samples 1 and 2) are remarkably similar. The other pithouse floor sample (sample 3) shares the same cool season pooid concentration, but has higher hot dry chloridoid and lower warm moist panicoid concentrations; the phytoliths assemblage of one pithouse floor sample (sample 3) is more similar to the on-site control (sample 9; see Figure B-11). The actual phytolith signatures

of the three basin heating elements (samples 4, 5, and 6) are different with heating element 11 (sample 6) and storage pit Feature 13 (sample 7) being most similar (see Figure B-11). Heating element Feature 8 (sample 4) had a high hot dry chloridoid content and low warm moist panicoid content, whereas the three seasonality forms are roughly equal in heating element Feature 10 (sample 5). In heating element Feature 11 (sample 6), the pooid content was elevated at the expense of the panicoid concentration. The cool season pooid concentration was uniform in heating elements 8 and 10 (samples 4 and 5), whereas heating elements 10 and 11 (samples 5 and 6) exhibited relatively constant hot dry chloridoid concentrations. The ashy stain (sample 8) is generally dissimilar from the other samples in Component A. If the grasses used in this area were being gathered as fuel, they would be collected once dried (i.e., off-season). However, if the grasses were gathered for food use or other applications they would likely be gathered near the end of the growing season.

B.4.3.2 Pithouse 1 Burned Phytolith Incidence

The composition of two of the three pithouse samples' burned phytolith short cell signatures (samples 1 and 3) are very similar, likely indicating a similar activity area whereas that of sample 2 is different (Table B-9). Sample 2 also had a higher phytolith concentration (see Table B-2), less charcoal, and fewer bulliform phytoliths than the other two samples (see Table B-3). However, sample 2's short cell phytolith seasonality signature was very similar to sample 1, whereas sample 3 had a higher hot dry chloridoid component (seasonal difference, i.e., hot dry weather, or different targeted biomass collection source) at the expense of the warm moist panicoids (see Figure B-7). The

Table B-8. Normalized Percent Short Cell Phytoliths in Seasonality Groupings (ibid.).

	41RB112	Bull Creek SG	Dempsey Divide MG
Pooids	30.60%	10.10%	26.80%
Chloridoids	62.90%	82.20%	66.70%
Panicoids	6.50%	7.70%	6.40%

noticeably high burned small panicoid cross content observed in samples 1 and 3 may be associated with specific processing activities (Table B-9).

Interestingly, the only burned phytolith form in this area's basin heating elements was the tall saddle form of hot and dry chloridoid phytoliths; the same form was also the only one observed in the related storage pit but at a much higher normalized concentration (Table B-10). No burned warm moist panicoid phytoliths were observed in the storage pit or heating elements although they were relatively concentrated in soil samples 1 and 3. In the ashy stain from Component A (sample 8), a variety of burned phytolith forms were present (Table B-11). The forms in sample 8 appear to be a blend of what was observed in samples 1 through 3 (see Table B-9) with an additional form (*Stipa*) also being present.

B.4.3.3 Pithouse 1 Food Processing (maize, beans, cucurbits)

Large warm moist panicoid cross-bodies indicative of maize were observed in the formal particle counts for all samples in Component A except for the storage pit Feature 13 (sample 7; see Tables B-3 and B-4). One broken charred maize kernel was also recovered (see Figure B-7). No absolute definitive evidence of *Phaseolus* or *Cucurbits* was observed. The variations in burned phytolith incidence (see Tables B-9 through B-11) may be indicative of variations in activity areas, food processing, and/or season of use (i.e., tinder-gathering of available dry biomass).

B.4.4 Component B - Swale between Components A and C (On-site Control sample 9: lower part of thickened A horizon, in shallow swale)

B.4.4.1 On-site Control Soil Seasonality Signature and Burned Phytolith Incidence:

This on-site control soil had a relatively elevated bulliform component, and also shows evidence of extensive bulliform weathering (see prior discussion in the data section and see Figure B-13E and B-13F) which indicates the likelihood of some phytolith preservation/dissolution issues in the area and at

the site. This sample's charcoal content is also somewhat elevated (see Table B-4)—especially compared to the off-site control sample (sample 25; see Table B-6). No burned short cell phytoliths were observed in the formal scans of this phytolith isolate (see Table B-11). This sample's climatic signature (see Figure B-7) is generally most similar to the floor of pithouse 1 (sample 3), bottom of heating element with burned maize cobs, Feature 20 (sample 22), and off-site control soil (sample 25).

B.4.5 Component C - Pithouse 2 Feature 6 and Associated Features:

soil sample 10: bottom of basin heating element Feature 5

soil sample 11: pithouse 2 floor

soil sample 12: lower portion of construction fill on top of floor

soil sample 13: north wall profile inside and on floor of pithouse 2

soil sample 14: upper end of eolian fill on top of construction fill towards western side of pithouse 2

soil sample 15: middle of earthen construction fill inside pithouse 2, western side

soil sample 16: upper part of pithouse 2 floor below earthen construction fill, western side,

soil sample 17: bottom of pithouse 2 floor, western side

soil sample 18: earthen construction fill near center of pithouse 2

soil sample 19: pithouse floor, upper, near center of pithouse 2

soil sample 20: pithouse floor near center of pithouse 2

soil sample 21: bottom of basin heating element with burned maize cobs, Feature 16

soil sample 22: bottom of heating element with burned maize cobs, Feature 20

soil sample 23: inside, bottom of storage pit, Feature 23

soil sample 24: ashy stain on floor of pithouse 2, Feature 6 eastern end

B.4.5.1 Pithouse 2 Soil Seasonality Profile

The most striking thing about the set of ten pithouse samples (soil samples 11 through 20, Tables B-12 and B-13) from Component C is the very high

Table B-9. Component A Pithouse 1 Floor Samples—Percent Burned Short Cell Phytolith Morphotypes.

Soil Sample Number	1 [F1]	2 [F1]	3 [F1]
Field Sample Number	1278-4-1a	1164-4-11a	1164-4-7a
Percent Burned			
Keeled			
Conical		7.7	
Pyramidal			
Crenate			
Saddle, squat			
Saddle, tall	1.2		2
Stipa			
Lobate, Simple			
Lobate, Panicoid	12.5	6.7	5.9
Lobate, Panicoid (compound)			
Cross, Panicoid (<12 μ)	50		33.3
Cross, Panicoid (>12 μ)			

Table B-10. Component A Basin Heating Elements (Features 8, 10, and 11) and Storage Pit (Feature 13)—Percent Burned Short Cell Phytolith Morphotypes.

Soil Sample Number	4 [F8]	5 [F10]	6 [F11]		7 [F13]
Field Sample Number	1116-4-1a	1080-4-1a	1032-4-1c		1023-4-2b
Percent Burned					
Keeled					
Conical					
Pyramidal					
Crenate					
Saddle, squat					
Saddle, tall	4	16.7	1.8		58.3
Stipa					
Lobate, Simple					
Lobate, Panicoid					
Lobate, Panicoid (cmpd)					
Cross, Panicoid (<12 μ)					
Cross, Panicoid (>12 μ)					

Table B-11. Unidentified Function Feature from Component A—Percent Burned Short Cell Phytolith Morphotypes (Sample 8), and Component B—Percent Burned Short Cell Phytolith Morphotypes (Sample 9).

Soil Sample Number	8 [-]	9 [-]
Field Sample Number	1128-4-1a	77-4-1a
Percent Burned		
Keeled		
Conical	8.7	
Pyramidal		
Crenate		
Saddle, squat		
Saddle, tall		
Stipa	20	
Lobate, Simple		
Lobate, Panicoid	20.4	
Lobate, Panicoid (compound)		
Cross, Panicoid (<12 μ)	33.3	
Cross, Panicoid (>12 μ)		

cool season pooid content in floor of the pithouse (sample 17, with no panicoids present at all (see Figure B-11). Likewise interesting, eolian fill on top (sample 14) has a very low warm moist panicoid content although the hot dry chloridoid and cool pooid components are somewhat more balanced. The next lowest panicoid content was observed in north wall of pithouse next to floor (sample 13) and then the pithouse floor (sample 11). Conversely the panicoid content was relatively high in earthen construction fill and on the floor (samples 15, 18, and 20). This variation in distribution would likely require active intentional plant gathering and/or specific activity areas within the structure, and/or could potentially reflect changing seasons during occupation as alternate resources came into use. Contributing to the difficulty in interpreting these large concentration jumps is knowing whether the botanicals were being gathered dry for use as fuel, near the end of the growing season as a food resource, or for various other applications.

The two outside heating elements, Features 16 and 20 (samples 21 and 22) have elevated hot dry

chloridoid concentrations and very low warm moist Panicoid concentrations while the storage pit (sample 23) has the lowest chloridoid concentration observed in this sample suite (see Figure B-11) and the second highest cool season pooid content. All of these assemblage variations presumably indicate different activity areas and/or processing activities as well as possible seasonal variations. Interestingly, the phytolith seasonality signature of bottom of heating element with burned maize cobs, Feature 20 (sample 22) and the control soil (sample 25) are practically identical (see Figure B-11).

B.4.5.2 Pithouse 2 Burned Phytolith Incidence

Another striking point is the very high percent of burned specimens of some phytolith forms—for instance the burned frequencies of *Stipa* and simple lobate in the north wall profile inside and on floor of the pithouse (sample 13) were 100 percent (Table B-12). The concentration of burned crosses in the pithouse floor, lower part of the construction fill, and north wall next to floor (samples 11, 12, and

14) is also fairly high (Tables B-12 and B-13). At the other end of the spectrum, there were no burned phytoliths observed in the middle of the earthen construction fill and the western side of the pithouse floor (samples 15 and 17). The western side of the pithouse floor (sample 17) as pointed out above as being anomalous due to the very high pooid content—indicating that they gathered cool season botanicals, but interestingly no pooids show up as burned (also, this sample had a low total short cell count [possible phytolith preservation issues]). The lower part of the construction fill and of the earthen construction fill near the center of the pithouse (samples 12 and 18) have a large variety of burned short cell forms and are the only two samples besides that from the bottom of the basin heating element of Feature 5 (sample 10) which produced both large (maize) and small (wild Poaceae) burned panicoid cross bodies.

In looking at the associated features in Component C, Feature 5 basin heating element (sample 10) has the most different burned phytolith short cell forms of any soil sample evaluated in this study including three of four cool pooid forms and four of the five warm moist panicoid forms (Table B-13). It also has a relatively elevated panicoid concentration that looks similar to middle of the earthen construction fill on the western side (sample 15, see Figure B-11). This has a lower variety of burned forms but has the highest burned simple lobate panicoid concentration observed in these samples except for the north wall near the floor (sample 13). The storage pit Feature 23, (sample 23) only contained burned conical phytoliths whereas the heating element Feature 20 (sample 22), joins the site's control sample (sample 9), the earthen construction fill on the western side (sample 15), and the floor on the western side of the pithouse (sample 17) in having no burned phytoliths present.

In contrasting Components A and C, 6 out of 8 (75 percent) samples from Component A have burned hot dry chloridoid forms (at low concentrations), whereas only 2 out of 13 (15 percent) samples from Component C have burned hot dry chloridoid phytoliths.

B.4.5.3 Pithouse 2 Food Processing (maize, beans, cucurbits)

Maize cross-bodies were observed in 11 out of 15 soil sample phytolith counts (see Tables B-4 through B-6) or 73 percent of the pithouse 2 samples versus 88 percent of the pithouse 1 samples. However, the formal particle counts of the pithouse 2 samples showed burned maize cross-bodies in four soil samples from pithouse 2 (see Tables B-12 and B-13) versus none in pithouse 1 (see Tables B-9 through B-11). The crosses in Figure B-22 are all from the bottom of a heating element Feature 5 (sample 10), which also had the highest large cross phytolith count at the site (see Tables B-3 through B-6), and which also had the greatest variety of burned phytolith forms encountered (see Table B-13). No cucurbit phytoliths were positively identified, and no bean silicified hair cells were observed.

B.4.6 Phytolith preservation

Phytolith preservation (due to dissolution) was apparently poor in some 41RB112 samples (see prior discussions regarding bulliform phytoliths, relatively low short cell counts, and potential soil pH-related phytolith dissolution). In the past, while processing basic soils with high charcoal concentration, apparent phytolith preservation problems were observed (Sudbury 2007:16-18, 23-24). One theory regarding a mechanism whereby this may occur is related to aluminum's stabilizing/protective effect on phytoliths; when charcoal lowers the soil aluminum concentration in the vicinity of phytoliths; the phytoliths lose that protective function and become more susceptible to dissolution (ibid.). The presence of carbonates in the soil profile at 41RB112 indicates a basic pH which is one potential reason that variation in the bulliform: short cell count ratio occurred across the site (i.e., due to selective more rapid dissolution of the smaller short cell phytoliths).

B.5 Summary

B.5.1 Controls

The off-site control (sample 25) and on-site control (sample 9) have somewhat similar seasonality profiles based on short cell morphotypes, while

Table B-12. Feature 6 (Pithouse 2 floor) Percent Burned Short Cell Phytolith Morphotypes.

Soil Sample No.	11	13	16	17	20
Field Sample Number	1284-4-1a	139-4-1a	C-3 Zone 5 Spl 17	C-3 Zone 5 Spl 18	C-7 Zone 5 Spl 10
Percent Burned:					
Keeled					
Conical	2.9				
Pyramidal					
Crenate					
Saddle, squat					
Saddle, tall					2.8
Stipa		100			
Lobate, Simple		100			
Lobate, Panicoid	15.2		10		14.5
Lobate, Pan'd (cmpd)					
Cross, Pan'd (<12 μ)	50				14.3
Cross, Pan'd (>12 μ)					

Table B-13. Feature 6 (Pithouse 2) Construction Fill, Percent Burned Short Cell Phytolith Morphotypes.

Soil Sample No.	12	14	15	18	19
Field Sample Number	1282-4-1a	C-3 Zone 3 Spl 6	C-3 Zone 4 Spl 14	C-7 Zone 7 Spl 8	C-7 Zone 9 Spl 9
Percent Burned:					
Keeled				4.8	
Conical					2.9
Pyramidal	5			6.7	
Crenate					
Saddle, squat					2.4
Saddle, tall					
Stipa					11.1
Lobate, Simple	25				
Lobate, Panicoid	14.8			3.4	11.6
Lobate, Pan'd (cmpd)					
Cross, Pan'd (<12 μ)	33.3	100		14.3	11.8
Cross, Pan'd (>12 μ)	33.3				5.9

the seasonality signature of the bottom of a heating element Feature 20 (sample 22) is even more similar to the off-site control (sample 25, see Figure B-7). In addition to slight difference in subfamily seasonality group concentrations, these three soil samples vary noticeably in their burned phytolith component content. The on-site control (sample 9) and Feature 20 (sample 22) had no burned phytoliths while off-site control sample (sample 25) had a low rate of burned panicoid phytoliths (16.7 percent, see Table B-7).

B.5.2 Comparison of Pithouse 1 and Pithouse 2

Burned tall saddle phytoliths are present in 6 of 8 pithouse 1 samples. For the three pithouse floor samples, the seasonality signature of samples 1 and 2 is most similar, whereas the burned phytolith signature (suggesting similar activity) was most similar for samples 1 and 3. The greatest variety of burned phytoliths is in sample 8 (the ashy stain next to a heating element). The three pithouse floor samples have a strong chloridoid signature averaging 55.6 percent chloridoid (see Table B-3) with sample 3 being the highest individual value of the set. Heating element Feature 5 (samples 6) and storage pit Feature 13 (sample 7) show a stronger Pooid signature while the southwest part of broad heating element Feature 10 (sample 5) has the highest panicoid component observed in pithouse 1.

The sample suit from pithouse 2 is more complex (see Tables B-4 through B-6 and B-12 through B-16). The two floor-related samples 11 and 13 have very similar seasonality signatures (see Tables B-4 and B-5) but dissimilar burned phytolith signatures (see Table B-12). The bottom of the pithouse floor (sample 17) has zero panicoid component [and no burned phytoliths], whereas the soil sample near the center of the pithouse (sample 20) has the highest panicoid content of any floor sample (1, 2, 3, 11, 13, 16, 17, and 20). The bulliform cell short cell ratio is elevated for samples 13 (north wall profile inside and on floor of pithouse), 16 (upper part of pithouse floor below earthen construction fill, western end), and 17 bottom of pithouse floor, western side), and to a lesser extent 11 (pithouse floor) (Table B-15) suggesting the likelihood of enhanced dissolution of short cell phytoliths in those areas.

Two of the construction fill/roof debris, the lower portion of construction fill on top of floor (sample 12) and the middle of earthen construction fill inside pithouse, western side (samples 15) also have elevated relative bulliform counts (Table B-16). Water collecting in and percolating through the structure post abandonment would potentially have a negative impact on phytolith preservation. In addition to basic soil pH from the underlying Ogallala formation, ash deposits in the structure could also contribute to the detrimental pH impact on phytolith preservation posthabitation.

The higher relative warm moist panicoid concentration in the roof debris/fill (samples 15 and 18, and to a lesser extent 12 and 19) likely indicates incorporation of panicoid plants in roof construction. Panicoid plants have a significantly greater biomass than the chloridoid plants making panicoids more suitable for use in construction and roofing. The equally high panicoid concentration in the pithouse floor near center of pithouse (sample 20) may be residual from roof fall debris sloughing off and moving into that zone. This localized higher central panicoid concentration support's the geoarcheologist's central smoke hole interpretation.

In contrast to the phytolith preservation issues encountered in some feature samples, the phytolith preservation in the eolian sample covering pithouse 1 is good (see Table B-16) and matches that of the off-site control soil sample 25. Both samples have similar low warm moist panicoid content, and an elevated hot dry chloridoid content. The cool pooid content in the eolian deposit over the pithouse (sample 14) is higher than that of the off-site control (sample 25)—possibly because the soil in the buried pithouse is more fertile and/or holds more soil moisture thus better supporting pooid growth.

The chloridoid component recovered in the pithouse 2 floor samples (see Table B-15) is lower than the chloridoid concentration found in pithouse 1 (see Table B-3). The pithouse 1 sample values are much more in line with the chloridoid concentration in the off-site environmental control samples in Table B-16 (sample 25 - the off-site control, and sample 14 which is the top of the eolian fill) which indicates a hotter drier environment during the

occupation of pithouse 1. The sample from pithouse 2 floor may be incomplete due to apparent soil pH/ phytolith dissolution issues. However, the evidence available indicates that the climate when pithouse 1 was occupied was warmer than during the earlier occupation of pithouse 2. Of course, duration of occupation and specific activities taking place inside the pithouses may alter the deposited phytolith record. The chloridoids may have been introduced by any number of means including naturally as part of the dust infiltrating the pithouse, carried in as part of a gathered plant material, tracked in, or shed from individuals or clothing. The higher frequency of burned chloridoids in pithouse 1 samples versus pithouse 2 suggests that chloridoids were either more numerous in the environment, actively gathered, and/or may suggest a season of occupation if the occupation was temporary.

If pithouse 1 supported a long-term habitation, the 3 to 4 cm thick pithouse floor soil samples analyzed do not enable resolution of the upper layer of floor dust present and thus the phytoliths deposited at the time the occupation ended. Assuming that pithouses 1 and 2 were occupied and utilized in a similar fashion, the floor phytolith signature in the later pithouse 1 does show the environment was generally hotter/drier than during the occupation of neighboring pithouse 2.

B.6 Results and Conclusions of Phytolith Data from the Long View Site (41RB112)

The botanical phytolith seasonality signature of the off-site control soil sample (sample 25) from a pristine prairie context on May 18, 2005 is most similar to the Dempsey Divide mixedgrass prairie control sample included in this discussion. Alluvial settings may distort the signature due to the presence of different species—particularly increasing the number of C_3 grass species and tree-related phytoliths.

Soil textural types were determined; all but one sample contained more than 50 percent sand.

The soil phytolith concentration was at the low end of what I have experienced in the past (in part due to the high sand content and also due to

apparent phytolith preservation issues). The on-site control soil from a buried A horizon in the swale between the two components (sample 9) had less than half the phytolith concentration of the off-site control soil (sample 25). The only sample phytolith concentration higher than the off-site control soil was the upper end of eolian fill on top of construction fill towards western side of pithouse 2 (sample 14), which was post-occupation and thus potentially spared phytolith stability issues related to the occupation.

The sample phytolith seasonality plot (see Figure B-11), bulliform:short cell plot (Figure B-12), and the percent burned short cell phytoliths data Table B-7 are useful interpretative tools to help integrate the phytolith results with other site data.

Maize was present in Components A and C. Evidence of beans was absent in both components, and the cucurbit evidence was indeterminate.

Although charcoal was somewhat elevated in the on-site control sample (sample 9), no burned short cell phytoliths were observed. Additionally no large panicoid crosses or maize cob bodies (ruffle-topped rondels) were recovered from the control soil (sample 9). Likewise no beans or cucurbits were indicated. Phytolith preservation in this site area was apparently poor, likely at least in part due to presumed basic soil pH and the tendency of low ground to hold more moisture.

The discussions regarding sample signature similarities (e.g. seasonality indicators and charred phytolith incidence) provides clues about feature usage, food processing, related activity areas, and also implied seasonal information.

One interpretation of the burned hot dry season chloridoid phytoliths from pithouse 1 heating elements is that they indicate use during fall through early spring seasons. Assuming dry biomass was used in heating elements as tinder, the exclusive presence of burned hot dry saddle shaped chloridoid phytoliths in the three heating elements associated with pithouse 1 (see Table B-10) potentially suggests seasonal usage. However, the much higher concentration of burned saddles in the storage

Table B-14. Basin Heating Elements (Features 5 and 16), Ash Deposit (Feature 24), Storage Pit (Feature 23), and Dump (Feature 20)—Percent Burned Short Cell Phytolith Morphotypes.

Soil Sample Number	10 [F5]	21 [F16]	24 [F24]	23 [F23]	22 [F20]
Field Sample Number	120-4-4a	472-4-1a	644-4-1a	331-004-2b	234-4-1a
Percent Burned					
Keeled					
Conical	9.1	2.4	6.3	14.3	
Pyramidal	20		9.1		
Crenate	33.3				
Saddle, squat					
Saddle, tall					
Stipa	5.6				
Lobate, Simple	5.6	66.7			
Lobate, Panicoid	16.9		15.1		
Lobate, Panicoid (cmpd)					
Cross, Panicoid (<12 μ)	33.3	33.3			
Cross, Panicoid (>12 μ)	33.3		40		

Table B-15. Soil Sample Phytolith Counts - Pithouse 2 Floor Samples (41RB112).

	Soil 11	Soil 13	Soil 16	Soil 17	Soil 20
	Floor	N. wall profile	Below fill	Floor bottom	Floor, center
Phytolith Morphology					
Keeled	26	2	-	2	11
Conical	34	6	4	3	12
Pyramidal	15	-	4	6	3
Crenate	14	-	-	1	6
Saddle, squat	24	5	3	2	21
Saddle, tall	60	4	5	3	36
Stipa	4.5	1	1	-	3
Lobate, Simple	5	1	-	-	3
Lobate, Panicoid	16.5	-	5	-	41.5
Lobate, Pan'd (compound)	-	-	-	-	-
Cross, Panicoid (<12 um)	4	1	-	-	7
Cross, Panicoid (>12 um)	2	-	-	-	9
Maize Rondel	-	-	-	-	-
Dicot, knobby	-	-	-	-	1
Spiny spheroid	2	2	7	5	2
WWW, Schlerid	5	-	-	-	-
Diatom	-	-	-	-	1
Sponge spicule	-	1	2	-	2
Trichome, Hair Cells	14	1	4	4	13
Bulliform, square	34	12	11	13	13
Bulliform, rectangular	80	28	61	39	34
Bulliform, keystone	26	16	32	29	18
Bulliform, Y-shaped	6	1	5	-	2
Bulliform, other	161	80	194	163	80
Elongate, smooth	9	1	1	1	9
Elongate, sinuous	10	10	4	4	6
Elongate, castillate	8	3	6	8	10
Elongate, spiny	-	-	-	-	-
Other Misc. Forms	-	-	-	-	-
Charcoal	66	72	77	75	34
Possible Pinaceae tracheid elements ?	-	-	-	-	35
Sedges	6	1	-	-	2
Saddle Imposters	13	1	2	1	1
Large Discs	5	-	2	-	-

Table B-15. Soil Sample Phytolith Counts - Pithouse 2 Floor Samples (41RB112) (cont.)

	Soil 11	Soil 13	Soil 16	Soil 17	Soil 20
	Floor	N. wall profile	Below fill	Floor bottom	Floor, center
Phytolith Morphology					
Spore	-	-	-	-	-
Total Short Cell Counts:	205	20	22	17	152.5
Pooids (cool season)	89	8	8	12	32
Chloridoids (hot dry)	84	9	8	5	57
Panicoids (warm moist)	32	3	6	0	63.5
Normalized Short Cells (%)					
Pooids	43.4	40	36.3	70.6	21
Chloridoids	41	45	36.4	29.4	37.4
Panicoids	15.6	15	27.3	0	41.6
Total Bulliforms	307	137	303	244	147
Ratio Bulliform:Short Cells	1.5	6.85	13.77	14.35	0.96
Ratio Charcoal:Bulliform	0.21	0.53	0.25	0.31	0.23
Ratio Charcoal:Short Cells	0.32	3.6	3.5	4.41	0.22

Table B-16. Soil Sample Phytolith Counts – Pithouse 2 Construction/Roof Fall (12, 15, 18, and 19), Eolian Fill (14) and Off-Site Control (25)] Samples (41RB112).

	Soil 12	Soil 15	Soil 18	Soil 19	Soil 14	Soil 25
	Top of floor	Middle fill, W	Center	Fill	Eolian fill	Control soil
Phytolith Morphology						
Keeled	18	10	21	20	34	17
Conical	29	10	25	35	90	41
Pyramidal	20	5	1	20	24	11
Crenate	8	3	9	6	3	2
Saddle, squat	22	5	23	41	70	47
Saddle, tall	9	8	32	126	101	99
Stipa	9	5	4.5	9	13	8
Lobate, Simple	4	4	3.5	3	-	1
Lobate, Panicoid	27	27.5	74.5	60.5	3	6
Lobate, Pan'd (compound)	-	2	2	-	--	-
Cross, Panicoid (<12 um)	6	-	7	17	1	-
Cross, Panicoid (>12 um)	3	3	14	17	0.5	-
Maize Rondel	-	-	-	-	-	-
Dicot, knobby	-	-	2	-	-	-
Spiny spheroid	6	7	6	2	1	-
WWW, Schlerid	1	-	1	-	2	6
Diatom	-	3	2	2	1	7
Sponge spicule	-	6	2	-	-	1
Trichome, Hair Cells	28	30	8	11	11	11
Bulliform, square	58	46	16	8	30	12
Bulliform, rectangular	178	127	50	32	54	46
Bulliform, keystone	47	58	9	13	21	10
Bulliform, Y-shaped	6	-	26	2	1	8
Bulliform, other	320	409	61	94	114	74
Elongate, smooth	20	5	2	15	4	3
Elongate, sinuous	24	12	8	8	1	4
Elongate, castellate	16	7	3	16	6	4
Elongate, spiny	1	-	3	2	-	1
Other Misc. Forms	-	-	-	-	-	-
Charcoal	74	122	27	27	15	8
Possible Pinaceae tracheid elements ?	-	-	16	-	1	-
Sedges	1	-	-	2	-	2
Saddle Imposters	5	1	-	9	4	-

Table B-16. Soil Sample Phytolith Counts – Pithouse 2 Construction/Roof Fall (12, 15, 18, and 19), Eolian Fill (14) and Off-Site Control (25)] Samples (41RB112) (cont.)

	Soil 12	Soil 15	Soil 18	Soil 19	Soil 14	Soil 25
	Top of floor	Middle fill, W	Center	Fill	Eolian fill	Control soil
Phytolith Morphology						
Large Discs	1	1	-	5	1	-
Spore	-	-	-	-	1	-
Total Short Cell Counts:	195	82.5	230.5	354.5	339.5	232
Poooids (cool season)	75	28	70	81	151	71
Chloridoids (hot dry)	71	13	55	167	171	146
Panicoids (warm moist)	49	41.5	105.5	106.5	17.5	15
Normalized Short Cells (%)						
Poooids	38.5	33.9	30.3	22.9	44.4	30.6
Chloridoids	36.4	15.8	23.9	47.1	50.4	62.9
Panicoids	25.1	50.3	45.8	30	5.2	6.5
Total Bulliforms	609	640	162	149	220	150
Ratio Bulliform:Short Cells	3.12	7.76	0.7	0.42	0.65	0.65
Ratio Charcoal:Bulliform	0.12	0.19	0.17	0.18	0.07	0.05
Ratio Charcoal:Short Cells	0.38	1.48	0.12	0.08	0.04	0.03

pit Feature 13 (sample 7; Table B-10) causes one to wonder if this saddle usage was actually food preparation related, or alternatively if some residue from the elements was transferred to the pit. However, if the burned saddle phytoliths represent a byproduct of food processing, a fall activity is implied.

The assemblage in pithouse 2 Feature 6 was denser (e.g., more maize phytoliths, larger variety of burned phytolith morphologic types) which may indicate a more intense occupation, longer occupation, and/or more routine year-round activity areas.

The climate during the occupation of pithouse 1 appears to have been hotter than during pithouse 2.

All recovered sponge spicules were fragmentary and most had visible surface abrasion and occasional end-rounding which suggests mechanical movement and redeposition (i.e., via eolian and/or alluvial processes). No sponge gemmoscleres (the dormant or resting phase of sponges) were recovered. This evidence suggests that local sponge debris was not incidentally transported to the site via water-hauling activities, but is rather present as a natural environmentally-introduced soil component. Although the site was in close proximity to two creeks, there is no indication that extant sponge spicules were intentionally conveyed to the site at the time of occupation. A small number of statospores (formerly called Chrysophyte cysts) were also recovered. Recent information and illustrations regarding these particle types is available (Sudbury 2011c).

Obsidian was noted to be present, but not exhaustively investigated.

Both control soil samples were excellent additions to the sample inventory.

By carefully examining the soil fractions eliminated during the phytolith isolation procedure, additional important data was recovered (e.g., maize, teeth, and snail shells were recovered in the sand fraction).

Not sieving the soils in this study helped to preserve materials that would have otherwise been lost. In addition to the maize, jaw fragment, and snail shells,

it is likely that the large tracheid elements that were recovered (see Figure B-16) would have been lost or significantly reduced in size had the samples been sieved as dictated by normally recommended and published laboratory protocols.

Integration of this phytolith data with the other analyses should help contribute to a better understanding of the site and the human behaviors.

A number of botanical reference specimens were processed seeking to identify unknown phytoliths and other particles encountered in this project. This substantial effort was specifically directed at identifying the source of the phytoliths illustrated in Figure B-16 which may be part of the pithouse roofing materials (and/or fuel, or from other applications). To date, these phytoliths have not been identified.

Additional reference specimen acquisition, analysis, and experimental work are ongoing to help answer unresolved issues encountered during this project.

B.7 Acknowledgements

Bud Hampton and Mike Quigg generously provided samples of reference botanical specimens analyzed in the course of this study. Various suggestions and comments about specimen identification issues were generously provided by Calla McNamee, Barbara Winsborough, Chad Yost, Kent Buehler, Steve Bozarth, Mary Gard, and Debby Pearsall.

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APPENDIX C

PLANT REMAINS FROM THE LONG VIEW SITE: 41RB112

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C.1 Introduction

This report presents the analysis of flotation and macrobotanical samples from the Long View site. Thirty-four flotation samples totaling 566.7 liters were examined in this study. An additional 114 macrobotanical samples were submitted for identification. The flotation effort averaged 15.1 liters-per-sample. Sample sizes varied widely from 0.7 liters to 82.0 liters in volume. The contents of 16 features were collected for the analysis; among them were two pithouses, Features 1 and 6, along with 14 associated pits, hearths, dumps, and rock alignments or clusters. Macrobotanical (wood identification) samples were submitted from a few other features, including Feature 18, a pithouse of unknown dimensions, Feature 31, a dump, and Structure 1, a rock alignment.

The samples were recovered from two Late Prehistoric Plains Village period components of slightly different age, each with a pithouse. The analysis examined 11 flotation samples from Component A and 23 samples from Component C. The report describes the botanical contents by area, and then compares the two areas. The data will be utilized to assess the nature and condition of the plant remains within these components and to describe for plant production and utilization, and local environmental conditions.

C.2 Laboratory Method

Two types of samples are examined in the current study – flotation samples and macrobotanical samples. Flotation is a method of recovering organic remains from archeological sediments by using water to separate heavy and soluble inorganic particles from plant parts and small animal bone. The material floating to the surface is called the light fraction, and this is caught on a fine mesh screen or strainer. The material that sinks to the bottom is the heavy fraction and it is also caught on a fine mesh screen. Most of the soil including clay and silt is suspended in water, passes through the screens, and is discarded.

C.2.1 Laboratory Procedures

The analysis follows standard archeobotanical laboratory procedures. The light fraction of each

flotation sample is passed through a nested set of screens of 4-mm, 2-mm, 1-mm, and 0.450-mm mesh and examined for charred material that is separated for identification. Carbonized wood from the 4-mm and 2-mm screens (smaller pieces are seldom identifiable) is separated in a 25-piece grab sample and identified. Care is taken to select representative materials from both levels (cf. Diehl 2003:213; Huckell 2002:645; Miksicek 1994:243). If the sample contains more than 25 fragments, all the material is scanned and separated into taxonomic categories, and the volume and weight of each taxon or wood type is recorded.

Charred material caught on all of the sieve levels, including the bottom pan, is scanned for floral parts, fruits, seeds, and other potentially edible plant parts such as agave or maize fragments, and these plant parts are counted and examined for identification. Screen- or point-collected macrobotanical samples (radiocarbon samples, etc.) are also sorted, identified, and weighed to the nearest 0.1 g.

C.2.1.1 Disturbance Indicators

Sample content may be affected by various physical and biological disturbance factors, including insect or small mammal activity, and plant root growth. In an effort to assess this impact, the amount of roots, insect parts, termite pellets, gastropods, rodent fecal pellets, and other biological material is estimated. These amounts are reported on a scale of 1 to 25 (+), 25 to 50 (++), and over 50 fragments or units (+++).

C.3 Identifications

Due to the rapid decomposition of plant material in soils, only carbonized seeds and wood fragments are considered to be a part of the archeological sample. Identification of carbonized wood is accomplished by using the snap technique, examining the transverse, radial, and tangential surfaces at 8 to 45 power with a binocular dissecting microscope, and comparing the material to reference specimens in the Shumla Archeobotanical Services herbarium. The anatomy of some woods is so similar that identification to species or even genus is not possible. For this reason I combine some taxa into wood types. All identifications in the “type” category represent identifications to the taxon level indicated by the

name of the type. For example, willow (*Salix* sp.) and cottonwood (*Populus* sp.), both members of the Salicaceae or willow family, have been placed in an artificial category, Salicaceae (cottonwood/willow). The wood of mesquite and acacia, all members of the legume family (Fabaceae), are also difficult to distinguish. Mesquite usually can be separated from other woody members of that family, but in cases where this is a problem, the material is assigned to the Prosopis-Acacia or mesquite/acacia-type.

Many plants of the two genera *Chenopodium* (goosefoot) and *Amaranthus* (pigweed or amaranth) produce seeds that are quite similar and difficult to separate, especially when carbonized or partially decomposed. They also have similar growth habits and economic uses. When seeds are recovered that could be identified to either genus, the term “cheno-am” is used (cf. Adams 1994:177).

Because most goosefoot and pigweed seeds are black, it is sometimes difficult to distinguish between modern and potentially archeological specimens. Carbonized (and therefore most likely archeological) cheno-am seeds (achenes) usually are swollen with exudate appearing along an equatorial seam of the fruit coat. The modern material is usually shiny and lacks distortion or any other evidence of heat modification.

C.4 Quantifying and Reporting

The results are presented as counts and weights, and are summarized in terms of presence value and seed/fruit density. Presence value or presence value is defined as the percentage of all analyzed samples, both productive (with seeds) and unproductive (wood charcoal only or no charcoal), in which a particular taxon is present. I have used this method to evaluate the occurrence of the major food plant resources identified in the samples. Presence value provides a means of determining how widespread a taxon is throughout the samples recovered from a site. For example, if mesquite pod fragments were noted in 5 of 20 samples, the presence value is 25 percent. Presence value is not an indication of the abundance of a taxon within a site. There may be one unit (e.g., seed or fruit fragment) of the taxon in each of the 5 samples, or 100; regardless, the presence value remains at 25 percent.

Seed density, taxa per liter, and total charred plant weight per sample provide a measure of sample richness. For the purposes of measuring seed density the term “seed” refers to seeds, fruits and other edible plant parts. In current the study seed refers to maize cob fragments including cupules and kernels, squash rind fragments, and seeds. Density is determined by dividing the number of carbonized seeds and fruit fragments, and other edible plant parts by the volume of the flotation samples from which they were sorted (Miksicek 1994:250). Taxa per liter describes the number of identifiable taxa including wood types, recovered from flotation samples and averaged by the total volume of flotation samples recovered from a site. In addition the total weight of the charred plant material is provided for each sample. These three values provide a good measure basis for comparing the productivity of samples among sites. In turn, they provide an indirect indicator of preservation encountered at a site, and give us an idea of the formation processes operating within the site context. For example, high densities of edible seeds usually signal a sample drawn from a primary context, such a storage feature or a processing locale, and this is useful for describing the function of the feature containing the remains.

C.5 Results

I will begin the description of the results with an overview of the archeobotanical record, after which I will describe the botanical assemblages of the two components separately. Table C-1 summarizes flotation sample volume, seed density, seed taxa abundance, total charcoal weight, and disturbance indicators. Tables C-2 and C-3 present the identifications and counts of material recovered from the flotation and macrobotanical samples. Table C-4 contains presence values of the plant food resources.

Modern contaminants, primarily roots, were noted in moderate to abundant quantities in all of the flotation samples. Roots were present in all of the samples, insect chitin occurred in samples from Features 5, 6, 8, 9, 10, and 11. Uncarbonized seeds were recovered from 11 samples. Over fifty cheno-am seeds or achenes were observed in samples from Feature 6. *Juniperus* sp. (cedar) seeds were recovered from Feature 4, Asteraceae (sunflower

family) seeds from Features 9, 12, and 16, grass seed from Feature 6, *Mollugo* sp. (carpetweed) from Feature 26, and a single prickly pear seed from Feature 5. The uncarbonized seeds provide an impression of the modern local vegetation as well as an indication of the degree of disturbance at the site. The abundance of roots, insect chitin, and frequency of uncarbonized seeds probably reflects a combination of shallowly buried deposits, deposits affected by shrink-swell clay soils, and/or deposits disturbed by insect and burrowing mammal activity.

All the samples contained charcoal, and total charcoal weights ranged from low to relatively abundant, varying from <0.1 g two samples to 9.7 g in a samples from Feature 26. Seed density was relatively high for an open site in Texas. Only one flotation sample lacked seeds, and seed density in productive samples ranged from 0.25 seeds/liter in 34-4a (Feature 3) to a high of 8.75 seeds in 62-4a, Feature 4. Seed taxon density varies from 0 in the unproductive sample to 1.43 taxa/liter in 120-4-5a (Feature 5), a basin-shaped hearth.

C.5.1 Wood

Carbonized wood is more abundant than maize cob fragments and seeds. Over 904 fragments weighing 34.3 g were examined and identified from the flotation samples. I also identified an additional 691 charred wood fragments weighing 45.9 g from the macrobotanical samples. Seven wood types and the indeterminate category were noted in the samples. Identified wood types were mesquite, juniper, rose family-type, willow/cottonwood-type, oak, elm family, and pine/juniper-type.

Both juniper and mesquite were utilized extensively as fuel and as structural elements in the region. The rose family wood type includes *Prunus* sp., sand plum, chokecherry, or mountain mahogany. The elm family wood type includes elm and hackberry. Pinaceae wood type is a collective wood type that may or may not include either juniper or pine. The wood from the Long View site is probably juniper, but the fragments are small and riddled with holes (from termites or rootlets), so I can't positively assign all of them to the genus *Juniperus*.

C.5.2 Food Remains

The remains of six food plant taxa were noted in the samples: maize cob fragments, kernels, and cupules, squash rind, common bean, cheno-am seeds, hackberry nutlets, and mesquite seeds. Maize fragments were the most widespread and abundant of the food plant remains at the site. A total of 393 maize fragments were recovered from 34 flotation samples, a presence value of 94.1 percent. An additional 17 maize fragments are present in the macrobotanical samples. Each feature in this study contains maize fragments.

Although other resources occurred in much smaller quantities, their presence is no less significant. Cultigens include beans and squash. Squash rind was recovered in 8.8 percent of the samples, and a single bean cotyledon was noted in a sample from Feature 16. Squash rind is present in Features 4, 6 and 9.

Mesquite seeds are present in 11.8 percent of the samples, seven from Feature 6, two from Feature 4, and one from Feature 12. Cheno-am seed were recovered from Features 4, 6, and 9. A juniper seed from Feature 21, a prickly pear seed from Feature 6, and a hackberry nutlet from Feature 5 to round out the edible plant parts tally.

Maize is abundant in many samples. Interestingly, both cupule/cob fragments and kernels were common. Kernels, though not as abundant as the cupule fragments, occurred in many samples in which maize appeared. A total of 246 cupule fragments were counted in the flotation samples, along with 140 kernels or kernel fragments.

C.5.3 Component A

Component A encompasses a pithouse, Feature 1, and 10 associated features. These features include three basin-shaped hearths, four trash dumps, two hearths, and a storage pit. I examined flotation and macrobotanical samples from each of these features with the exception of Feature 15, a dump. A single macrobotanical sample was submitted for identification from Feature 15.

Feature 1 is a pithouse with a 250 cm diameter and a depth of 30 cm. Two flotation samples, 18 liters

and 36 liters each, along with seven macrobotanical samples, were examined. Evidence of termite activity was abundant in the samples.

Although one sample was recovered from the western half and one from the eastern half of the feature the botanical contents are comparable. Juniper or pine family wood type is present in four of the seven macrobotanical samples, and rose family wood, possibly sand plum, in two of the samples. Each sample contains maize cupules and kernels but there is no other evidence of cultigens or other food plants. Juniper and mesquite are the most abundant identifiable wood types. Maize fragment density in the sample from the eastern half of the pithouse is roughly twice that of the western half.

Feature 3 is a basin-shaped hearth measuring 34-by-40 cm in plan view and 11 cm deep. I examined a 4.0 liter flotation sample from this feature and found the charred plant material to be reduced, weighing less than 0.1 g. It contains a single maize kernel, and some indeterminate hardwood and juniper wood. The two macrobotanical samples from the feature yielded cottonwood/willow-type, mesquite, and juniper wood.

Feature 4 is a small basin-shaped hearth about 28 cm wide and about 15 cm deep. The single sample processed from this context contains considerable evidence of food remains, including a cheno-am seed, a squash rind fragment, 27 maize cupules, 3 kernels, and 2 mesquite seeds. The seed density measures 8.75 seeds/liter – the highest in the project. Both juniper and mesquite wood were also noted in these samples.

A 20 liter flotation sample was examined from Feature 8, a hearth measuring 30 cm by 12 cm deep. The single macrobotanical sample from this feature is juniper wood. Rose-family type wood is present in the flotation sample, along with six maize cupules.

Feature 9 is a shallow basin-shaped hearth, 25 cm in diameter and 9 cm deep. The contents of the 3 liter flotation sample include are comparatively taxa rich and include cheno-am seeds, squash rind, and maize cupules and kernels. Seed density is 3.67 parts/liter, one of the highest readings in the project. Mesquite wood is most abundant, followed by juniper.

Feature 10 is a dump measuring 75 cm wide and 22 cm deep. It was sampled with a very large 41 liter flotation sample from which I recovered two maize kernels. Juniper and oak are by far the most abundant wood types in the sample. Mesquite wood and thorns, and a few fragments of elm-family wood are also present.

Feature 11 is a small hearth 25 cm wide and 14 cm deep. It was sampled with a 5.5 liter flotation sample. Maize cupules and kernels were recovered in the sample along with juniper and mesquite wood.

Feature 12 is a dump, 70 cm wide and 39 cm deep. The flotation sample examined from this feature was 23 liters in volume. I noted both mesquite seed and maize fragments. Wood types were diverse and included juniper, mesquite, cottonwood/willow and oak.

Feature 13 is a storage pit, 75 cm in diameter and 39 cm deep. Two flotation samples of 15 and 17 liters volume were examined. The contents include eight maize cupules and three kernels. The wood types are diverse, including juniper, mesquite, rose-family-type and cottonwood/willow-type. One of the two macrobotanical samples from this feature contains juniper wood, the other contains a small fragment of burned bone.

C.5.4 Component C

Component C consists of a single pithouse that measured 380-by-280 cm along with 19 associated features. These features include a rock alignment labeled Structure 1, post holes, rock clusters, hearths, dumps, and an ash dump. In addition to the pithouse, six of these features were sampled for botanical remains.

Feature 5 is a basin hearth measuring 75 cm wide and 20 cm deep. Excavators noted that this hearth was disturbed by rodent burrowing and contained fresh grass culm fragments. Five flotation samples were analyzed from Feature 5, and they contained 1 maize cob fragment, 30 cupules, and 26 kernels. Over 30 ml of juniper charcoal dominated the wood assemblage. Mesquite wood charcoal was recovered in relatively minute quantities. A single macrobotanical sample from the bottom of Feature 5

contains additional maize cupules and kernels.

Feature 6 is a pithouse, a much larger structure than the one in Area A. Perhaps because of this the flotation effort was substantial; ten flotation samples totaling 140.5 liters were examined from this feature. An additional 40 macrobotanical samples were submitted for identification.

Maize was relatively abundant; six cob fragments, 50 cupules, and eight kernels were counted in the flotation and macrobotanical samples. Most of the material was too fragmented to determine row number, but one of the cob fragments from macrobotanical sample 669-7-2 is from a 10 row cob. Other evidence of plant use recovered from Feature 6 includes a squash rind, cheno-am seed, prickly pear seeds, and mesquite seeds.

Juniper wood is by far the most abundant of the wood types in the pithouse fill. In the flotation samples, juniper fragments outnumber the next most abundant material (mesquite) by a 4:1 ratio. Juniper is also the most abundant wood type in the macrobotanical samples – by a ratio of over 12:1. Although other wood types were present, including mesquite, rose family (mountain mahogany or sand plum), oak, cottonwood/willow, and elm (hackberry or elm), juniper likely made up the major vertical components of the house structure.

Feature 16 is a large basin-shaped hearth measuring 130 cm across and 30 cm deep. It was sampled with two outsized flotation samples of 82 liters and 78 liters, and one very small 2 liter sample. Maize cupules (N = 56) and kernels (N = 57) are present in nearly equal quantities. A common bean cotyledon, a relatively rare occurrence in open archeological sites in the Southern Plains, was noted from 470-4b.

Four wood types, juniper, mesquite, cottonwood/willow, and rose family were noted in the samples. Juniper fragments are far more numerous than the other wood types.

Feature 18 is a “ghost” pithouse of undetermined size. No flotation samples were submitted from this context, however, six wood identification samples from this area were examined. These macrobotanical

samples were identified as juniper, rose family, and oak.

Feature 21 is a large, shallow hearth measuring 100 cm diameter and 5 cm deep. A single 19 liter flotation sample was submitted for analysis. Maize cupules, kernels, and glumes were recovered from the sample. A single juniper seed was the only noncultigen noted. Wood charcoal is sparse; less than 0.1 g juniper wood and rose family wood is present in the flotation sample. The single macrobotanical sample is identified as rose-family wood.

Feature 23 is a small storage pit from which two flotation samples of 5 liters volume each were submitted. Maize is represented by 20 cupule fragments, three kernels, and one glume. Wood types are juniper and mesquite. As in most of the other features, juniper is by far the most abundant of the wood types.

A single 9 liter flotation sample was submitted from Feature 26, a basin-shaped hearth. Maize kernels, cupules, and glumes are present in this sample. A fragment of knobby tissue bears explanation. This is a lignified part of a stem, usually found around the base of the plant. It is common in many types of plants, including corn and sunflowers which are herbaceous annuals but also in perennial plants such as yuccas. Often adventitious roots, such as prop roots in corn, emerge from this area of the plant.

The wood charcoal is dominated by juniper. Oak and mesquite are also present, however, in much smaller quantities. The 45 ml total of juniper charcoal was the single largest concentration of wood charcoal in the flotation samples from this site.

Feature 29 is a hearth from which a single 21.5 liter flotation sample was submitted for analysis. Wood charcoal was not abundant; it contained a large quantity of soot and flecks, but little identifiable charcoal. Maize was evenly divided between cupules and kernels. A few juniper and oak fragments comprised the wood assemblage in the flotation sample. A single macrobotanical sample was identified as rose family wood.

C.5.4.1 Nonfeature Botanical Remains

Fifty-one macrobotanical samples were identified from contexts outside of features. These were point-collected or picked from archeological screens, and therefore this is a somewhat arbitrary selection of samples. Nevertheless, the wood types noted in these nonfeature carbonized wood samples were quite similar to the material from the features. Juniper is by far the most abundant wood, occurring in 35, or 69 percent, of the samples. Mesquite is present in only four samples, rose family (sand plum or mountain mahogany) in six samples, and elm family in two samples. This is a pattern that is quite similar to the wood types recovered from the pithouses and the heating features.

C.6 Discussion

In the following discussion I present a comparison of sample contents from the two components, A and C, followed by comparison with other sites in the region. A discussion of the Long View site maize follows, along with an ethnobotanical discussion of the major edible plant resources. The discussion concludes with a consideration of the wood types and their uses at the site.

C.6.1 Components A and C

Component A and C are represented by pithouse occupations separated by few hundred meters in space and a few decades in time. How do the plant remains compare from these two occupations? Table C-5 compares plant resource presence values and density from the two components.

A look at the present values of the plant resources indicates that the two are quite similar. Maize presence value is very high, approaching 100 percent. These settlements were obviously invested in farming, and the less commonly occurring squash rind and common beans (at least at Component A) occur with maize, indicating association of the three pillars of Native American cultigens. Beans are underrepresented in open sites most likely because they are soaked in water and boiled, preparation that does not invite carbonization, critical for preservation in open sites (Munson et al. 1971).

The evidence for gathered plant use is not as abundant or widespread in either component. There were no dense concentrations of wild plant remains, such as caches or storage pits, at either component. However, the evidence we do have suggests that gathered plants compare favorably between the two components. Mesquite is present in both components, as is cheno-am. Only one occurrence each of prickly pear (three seeds in one sample) and juniper (one seed) were recovered from Component C, and none from Component A. One seed from each of these species is not enough information upon which to base a comparison, but recovery of wild plant remains from open sites is dependent on the place and manner in which they were processed. However, it is clear that the occupants invested in agriculture and continued to gather wild plant resources to supplement the cultigens.

It is quite likely that juniper was the wood of choice for structural material and fuel. Although juniper and mesquite occurred in roughly the same number of samples, much more juniper was recovered from both areas. Samples from Component A contain an average of 0.012 g/L juniper charcoal but only 0.003 g/L mesquite charcoal. Another way to express this is that juniper charcoal was four times more abundant in samples from Component A. Likewise, in Area C juniper density is 0.091 g/L and mesquite is 0.005 g/L. In Component C juniper wood density is 18 times greater than mesquite wood density. In both components juniper is by far the most intensively utilized wood type.

Therefore, in terms of cultigens, the two components are quite similar. Both were invested in a maize-based agricultural economy. In terms of wild gathered plant resources, both occupations supplemented the maize, squash, and beans with wild gathered plants. These included mesquite, prickly pear, juniper berries, and cheno-ams at a minimum. The most heavily utilized wood for structures and fuel was juniper. All other wood types, including mesquite, oak, willow, elm, and rose family (sand plum and mountain mahogany), were present in the samples, but far less abundant.

C.6.2 Regional Comparison

Table C-6 compares presence value of the plant food resources at 41RB112 to other sites in the region.

At 94.1 percent, maize presence value is higher at the Long View site than at other site analyzed. The Lonker site in the panhandle of western Oklahoma is at least comparable with a maize presence value of 83 percent. Cheno-am is also much more widespread at the Lonker site and missing from the other two sites (Lintz 1984, 1986).

The low values at Landergin Mesa, especially considering the flotation effort, may be due to poor preservation brought on by a lack of burning at the site or post deposition processes such as deflation of the archeological deposits. Another possibility is that the investment in maize production was lower at Landergin Mesa. The maize presence values at Hank's House, viewed in light of the higher sunflower values, suggest that some years maize production may have been low and reliance on gathered plant resources much higher. At any rate, the data indicate that the Long View site economy focused on maize-based food production, supplementing the cultigens with wild plant resources. Squash and beans would have been interplanted with the maize. Wild plants from Long View include cheno-am, mesquite, and prickly pear. Given the wide variation of presence values, it is possible that annual variation in harvests forced the settlements practice a mixed economy, relying on plant production when possible and falling back on gathering wild plants when necessary.

C.6.2.1 Maize from 41RB112

Although maize presence value is high in samples from both components, the density of maize fragments is quite low – 0.55 fragments-per-liter. The low maize density probably has resulted from the use history and postdepositional conditions at the site. In other words, conditions of preservation are not the best. Storage features were emptied before abandonment, and all burning occurred after abandonment as well. I am emphasizing preservation conditions because maize kernels are more delicate than cupules; cupules are quite resistant to extreme weathering conditions. Yet despite the low density, maize kernels are surprisingly prevalent in the botanical assemblage. In fact, the density of maize cupules is 0.32 fragments-per-liter and that of kernels is 0.22 fragments-per-liter. Another way to express the kernel/cupule relationship is that maize kernels comprise about 40 percent of the maize assemblage.

Maize can be stored either in kernel form, usually in pots or pits, or on the cob, often in separate surface structures. In either case, cobs are often recycled as fuel and are recovered in greater numbers from archeological heating features. Kernels, however, would not be as abundant in most heating features or living surfaces unless they are being stored separately from the cobs, perhaps under the floor of the pithouse or in nearby pits, and prepared (ground) in close proximity to the pithouses. Far more observations will be required to elaborate on maize storage and preparation methods, but the abundance of kernels in the samples is a noteworthy occurrence.

C.6.2.2 Squash

Fragments of squash rind were noted in three samples. Squash rind is recognized by the arrangement of its cells in cross-section. The outer edge of the rind is covered by thin epidermis with several layers of thick-walled cells just beneath, and more layers of large and roughly isodiametric, thin walled cells to the inside (Cutler and Whitaker 1961). Although squash rind has not been commonly noted from sites along the Canadian River, its presence in the current study is not surprising. There have been very few flotation samples processed from sites in the region, and it was only a matter of time before squash rind appeared. The squash rind was recovered from two small hearths Features 4, and 9, and from Feature 6, a pithouse.

C.6.2.3 Beans

The single cotyledon of a common bean recovered from Feature 16 constitutes a rare find at open sites. Beans are not often recovered, because they are soaked in water and boiled before preparation. Plant resources need to be carbonized to survive in open sites, which mean that plants that are exposed directly to fire or coals, such as parching mesquite beans before pounding them, have a better chance of preservation. This carbonized specimen measured 8.2-by-5.1 mm, for a length-width ratio of 1.6, typical of carbonized *Phaseolus vulgaris* specimens (Wagner 1986:126).

C.6.2.4 Mesquite

Mesquite seeds provide proxy evidence for the consumption of mesquite flour. Mesquite pods or

legumes consist of the outer exocarp and mesocarp that surrounds several woody endocarps that contain the seeds. Mesquite flour is produced when the ripe, brownish bean pod is pounded in a mortar and pestle until it is reduced to a sticky mass which is further dried and pounded. The woody endocarps, and the seeds, are separated from the flour and then discarded. For this reason the seeds and endocarps along with a few small pod fragments are the most commonly encountered parts recovered from archeological sites. The rest has been reduced to flour (Rea 1997; Russell 1908).

C.6.2.5 *Cheno-Am*

Cheno-am type refers to *Chenopodium* sp. (goosefoot) and *Amaranthus* sp. (pigweed) seeds. These are actually achenes, which are fruits composed of a seed encased in a small, hard, pericarp. An achene has the overall appearance of a small seed. Although leaves are seldom preserved in open archeological sites, both the young leaves and the ripened seeds of goosefoot and pigweed would have provided a food source. The seed may be considered proxy evidence for the use of the plant in all its forms.

At least five and perhaps six species of *Amaranthus* grow in the study area. *Amaranthus palmeri* and *A. powellii*, however, is the species most often mentioned in ethnography, primarily because its distribution includes the entire desert southwest where so many ethnographic studies were conducted. Both the seeds and the young leaves were collected and consumed. Ripe seeds were usually harvested by shaking the heads into a basket or threshing the seed heads and beating them over a blanket using a stick (Castetter and Bell 1951). The leaves are rich in plant protein and would have been boiled in a skin or simply steamed over hot rocks.

Amaranthus palmeri, carelessnessweed, is an aggressive plant of open and disturbed spaces. The leaves contain iron, calcium, and niacin as well as vitamins A and C (Hodgson 2001). The Pima ate seeds of the plant after parching them or parching and grinding them into flour (Curtin 1984).

Although there are several species of goosefoot growing in the region, *Chenopodium berlandieri* (common lamb's quarter) is the one most prominently

mentioned in ethnography and its uses are similar to the others. The leaves of common lamb's quarter are very high in calcium and vitamin A (Hodgson 2001). Because some of the leaves contain concentrations of nitrates which are toxic, most ethnographies note that the young leaves were collected, and some were carefully leached (i.e., the Tarahumara: Pennington 1963). The Yavapai harvested the seeds in a manner similar to amaranth, then parched them on hot coals and ground them into flour (Gifford 1936).

Cheno-am seeds are seldom recovered from the ephemeral hunter-gatherer archeological sites of Texas. By contrast, they occur fairly frequently in more intensively occupied sites in the Southwest. This is probably due to the fact that the seeds are small and are often recovered from heating or storage facilities within the confines of a pithouse or pueblo contexts, all of which provide a better environment for concentrating seeds and preserving them. It stands to reason, then, that the Canadian River region with Late Prehistoric pithouse and surface structures occupied by agriculturalists should be an area from which cheno-am seeds are recovered.

C.6.2.6 *Prickly pear*

Prickly pear seeds were noted in one sample. The most common species in the area is *Opuntia macrorhiza* which produces a red, edible fruit. Each fruit contains an abundance of seeds, which are hard and resistant to deterioration if they are carbonized. This is the first occurrence of prickly pear from a Plains Village site of which I am aware. The Plains Apache ate the fruit when ripe, but did not collect and process it as a major source of carbohydrates. It is recorded as snack food (Jordan 2008:67)

C.6.2.7 *Wood Types*

Selection of wood for structures and for fuel is similar to that found at other Plains Village sites. As noted in Table C-2, juniper is most abundant wood type at the Long View site. Other wood types, including mesquite, willow/cottonwood, elm family, and rose family wood are present. A quick comparison to another Plains Village site just to the east, Hank's House, shows many similarities. Hank's House is one of the best studied (botanically) Plains Village structures in the region. It is a burned structure that

has identifiable vertical parts, including central roof supports, wall posts, and roof components of willow/cottonwood withes, and indiagrass. Both the large central roof supports and the wall posts were constructed of juniper wood. Juniper made up 90 percent of the smaller roof components, and willow/cottonwood and elm comprised the rest of the wood. The robust indiagrass was probably the primary roofing material (Texas Beyond History). Thus, the wood signature of the pithouses at the Long View site is quite similar to that of Hank's House.

C.7 Summary and Conclusion

The analysis of 34 flotation samples and 114 macrobotanical samples provides an understanding of plant production and procurement at two Late Prehistoric pithouse components. The samples were collected from 16 features including three pithouses and associated hearths, storage pits, and dumps. Maize presence value was very high at 94.1 percent, indicating that these settlements invested heavily in plant production.

Three maize cob fragments were examined and found to be 10 row maize. Evidence of squash in the form of rind and a single common bean cotyledon also was recovered from the samples. Maize kernels accounted for 40 percent of the total maize assemblage. Cupules are more resistant to postdepositional attrition, and are often far more abundant than kernels. The recovery of maize kernels in greater than usual numbers may indicate that the kernels were stored separate from the cob and parched inside or adjacent to houses before being ground into meal.

The botanical assemblages of Component A and Component C are very similar. Both have very high presence values for maize, both have squash rind, and both contained very similar wood types. Mesquite seeds identified in the samples indicate that the pods were collected, processed for meal, and consumed. Prickly pear seeds occurred in one sample, another indication that wild plant gathering augmented plant production.

The pithouses were constructed of the same raw materials and utilized the same fuel types. Most of the pithouse structure was built with juniper

wood. Willow/cottonwood probably was utilized for weaving among the juniper roof supports. Wood recovered from hearths was also primarily juniper. Smaller amounts of mesquite, elm, and rose family wood were also recovered from the samples.

A regional comparison among four sites, Long View, Hank's House, Landergin Mesa, and the Lonker site, shows that Long View has by far the highest maize presence value. Long View also had lower wild plant presence values and no sunflower seeds. This may be an artifact of preservation, a year where rainfall patterns favored maize production, a local trend, or a regional trend. The archeobotanical assemblage from the Long View site indicates that both components practiced a mixed economy that emphasized plant production, but still relied on wild plant gathering. The woody taxa identified at the site indicate that juniper was then, as now, the dominant woody plant on the landscape.

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Table C-1. Flotation Sample Summaries.

Component	Catalog No.	Feature	Provenience, Level	Sample Volume (L)	Light Fraction Vol (ml) and Wt (g)	Insect Parts (ip), roots (r), rodent pellets (rp), termite pellets (tp)	Uncharred (modern) seeds	Number of charred seed taxa	Seed taxa density (seeds/liter)	Total charred seeds or maize fragments	Density seeds/liter	Total charcoal (grams)
A	1164-4-1b	1 E 1/2	N700 E515, 50-60 cm	36	145; 27.4	r+++, tp++, ip+	0	1	0.03	8	0.22	0.7
A	1164-4-2b	1 W 1/2	N700 E515, 50-60 cm	18	170; 98.9	r+++, tp+, ip+++	0	1	0.06	10	0.56	0.5
A	34-4a	3	Trench A-1, 39-51 cm	4	62 ml, 14.8 g	r++	0	1	0.25	1	0.25	0.1
A	62-4a	4	A-5, Level 6, 50-66 cm	4	66 ml, 13.4 g	r++	Juniper (2)	4	1	35	8.75	0.6
A	1116-4b	8	N699 E512, 40-50 cm	20	78; 41.8	r+++, tp+, ip+++	0	1	0.05	6	0.3	<.1
A	1028-4b	9	N696 E511, 20-30 cm	3	20; 6	r++, tp+, ip+	Asteraceae 3	3	1	11	3.67	0.2
A	1080-4b	10	N698 E511, 31-53 cm	41.5	290; 109	r+++, tp+, ip+++	0	1	0.02	2	0.05	0.8
A	1032-4b	11	N696 E511, 50-60 cm	5.5	54; 19.7	r+++, tp+, ip+++	0	1	0.18	4	0.73	1.4
A	1125-4b	12	N699 E513, 30-55 cm	23	98; 21.1	r+++	Asteraceae (3)	1	0.04	9	0.39	1.4
A	1014-4-1b	13	N695 E513/514, 45-55 cm	17	220; 30.9	r+++, tp++, ip++	0	1	0.06	9	0.53	0.5
A	1014-4-3b	13	N695 E513/514, 65-75 cm	15	310; 80.4	r+++, tp+, ip+++	0	1	0.07	2	0.13	0.1
C	120-4-2b	5	Cutbank, 23-40	10	478; 236.0	r+++, tp+++, ip+	0	2	0.2	31	3.1	4.9

Table C-1. Flotation Sample Summaries (cont.)

Component	Catalog No.	Feature	Provenience, Level	Sample Volume (L)	Light Fraction Vol (ml) and Wt (g)	Insect Parts (ip), roots (r), rodent pellets (rp), termite pellets (tp)	Uncharred (modern) seeds	Number of charred seed taxa	Seed taxa density (seeds/liter)	Total charred seeds or maize fragments	Density seeds/liter	Total charcoal (grams)
C	120-4-3a	5	General, Cutbank 30-40 cmbs	2	30 ml, 5.0 g	r +++	Prickly pear (1)	1	0.5	13	6.5	0.2
C	120-4-4a	5	Cutbank, bottom, 32-36 cm	1.5	24 ml, 4.1 g	r +, ip +	0	0	0	0	0	<.1
C	120-4-5a	5	Cutbank, bottom, 35-40 cm	0.7	15 ml, 2.8 g	r +++	0	1	1.43	2	2.86	0.6
C	120-4-6a	5	Cutbank, bottom, 36-42 cm	3.5	40 ml, 5.7 g	r ++	0	1	0.29	13	3.71	0.3
C	1231-4-1b	6	N499 E496, 50-60 cm	15	99; 25.4	r+++, tp++	0	1	0.07	2	0.13	0.3
C	132-4a	6	Bottom, C-7, Lvl 6, 50-60 cm	11	145 ml, 25.2 g	r +++, ip ++	Cheno-am (25+)	2	0.18	22	2	0.9
C	133-4c	6	C-7, 60-70 cm	31	92; 31.2	r+++, tp+, ip+++	Poaceae (1)	1	0.03	1	0.03	0.2
C	574-4b	6	N498 E495, 70-80 cm	16	110; 28.7	r+++, tp+++	0	2	0.13	8	0.5	1
C	582-4b	6	N498 E496, 65-70 cm	3.5	28; 3.7	r+++, tp+	Cheno-am (8)	1	0.29	1	0.29	0.1
C	584-4b	6	N498 E496, 70-80 cm	14	130; 21.6	r++, tp+, ip+	0	1	0.07	1	0.07	0.7
C	591-4b	6	N498 E497, 40-50 cm	15	152; 24.6	r+++, tp++, ip++	Cheno-am (5)	6	0.4	6	0.4	0.9
C	595-4b	6	N498 E497, 64-72 cm	10	210; 55.3	r+++, tp+, ip+++	0	1	0.1	5	0.5	3.4

Table C-1. Flotation Sample Summaries (cont.)

Component	Catalog No.	Feature	Provenience, Level	Sample Volume (L)	Light Fraction Vol (ml) and Wt (g)	Insect Parts (ip), roots (r), rodent pellets (rp), termite pellets (tp)	Uncharred (modern) seeds	Number of charred seed taxa	Seed taxa density (seeds/liter)	Total charred seeds or maize fragments	Density seeds/liter	Total charcoal (grams)
C	597-4b	6	N498 E497, 70- 80 cm	15	89; 19.7	r+++, tp+++	Cheno-am (11)	3	0.2	10	0.67	0.6
C	625-4-1b	6	N499 E495, 60- 70 cm	10	90; 9.8	r+++, tp++	0	1	0.1	1	0.1	0.2
C	451-4b	16	N491 E501, 40- 50 cm	82	720; 300.3	r+++, tp+, ip+++	0	1	0.01	40	0.49	0.5
C	453-4b	16	N491 E501, 50- 59 cm	2	224; 119.1	r+++, ip+++, gp++	Asteraceae (1)	1	0.5	17	8.5	2.3
C	470-4b	16	N492 E501, 40- 50 cm	78	210; 79.4	r+++, gp+, ip+	0	2	0.03	57	0.73	1.8
C	474-4-1b	21	N492 E501, 50- 60 cm	19	179; 64.1	r+++, ip++	0	2	0.11	17	0.89	0.1
C	328-4-1b	23	N482 E501, 70- 82 cm	5	270; 40.9	r+++, tp+	0	1	0.2	6	1.2	0.3
C	328-4-2b	23	N482 E501, 70- 82 cm	5	32; 6.0	r+++, tp++, ip+++	0	1	0.2	18	3.6	0.6
C	294-4b	26	N482 E499, 47- 50 cm	9	180; 50.7	r+++, tp++	Mollugo (2)	1	0.11	17	1.89	9.7
C	300-4b	29	N482 E499, 70- 80 cm	21.5	69; 16.9	r+++	0	1	0.05	26	1.21	0.3

Table C-2. Contents of the Flotation Samples.

Component	Cat No.	Feature No.	Taxon	Common	Part	Count	Vol (mL)	Wt (g)
A	1164-4-1b	1 E 1/2	Indeterminate	NA	Wood	25	--	0.5
A	1164-4-1b	1 E 1/2	Juniperus sp.	Juniper	Wood	18	--	0.2
A	1164-4-1b	1 E 1/2	Zea mays	Maize	Cupule	6	--	<.1
A	1164-4-1b	1 E 1/2	Zea mays	Maize	Kernel	2	--	<.1
A	1164-4-2b	1 W 1/2	Indeterminate	NA	Wood	7	--	<.1
A	1164-4-2b	1 W 1/2	Juniperus sp.	Juniper	Wood	13	--	0.4
A	1164-4-2b	1 W 1/2	Monocot	NA	Stem	1	--	<.1
A	1164-4-2b	1 W 1/2	Prosopis sp.	Mesquite	Wood	8	--	0.1
A	1164-4-2b	1 W 1/2	Zea mays	Maize	Cupule	7	--	<.1
A	1164-4-2b	1 W 1/2	Zea mays	Maize	Kernel	3	--	<.1
A	34-4a	3	Indeterminate	NA	Wood	2	--	<.1
A	34-4a	3	Juniperus sp.	Juniper	Wood	10	--	<.1
A	34-4a	3	Zea mays	Maize	Kernel	1	--	<.1
A	62-4a	4	Cheno-am	Goosefoot or Pigweed	Seed	2	--	<.1
A	62-4a	4	Cucurbita sp.	Squash	Rind	1	--	<.1
A	62-4a	4	Indeterminate	NA	Wood	9	--	0.2
A	62-4a	4	Juniperus sp.	Juniper	Wood	19	--	0.1
A	62-4a	4	Prosopis sp.	Mesquite	Seed	2	--	<.1
A	62-4a	4	Prosopis sp.	Mesquite	Wood	12	--	0.1
A	62-4a	4	Zea mays	Maize	Cupule	27	--	0.1
A	62-4a	4	Zea mays	Maize	Kernel	3	--	<.1
A	1116-4b	8	Rosaceae	Rose family wood type	Wood	1	--	<.1
A	1116-4b	8	Zea mays	Maize	Cupule	6	--	<.1
A	1028-4b	9	Cheno-am	Chenopodium or Amaranthus	Seed	3	--	
A	1028-4b	9	Cucurbita sp.	Squash	Rind	3	--	<.1
A	1028-4b	9	Indeterminate	NA	Wood	3	--	<.1
A	1028-4b	9	Juniperus sp.	Juniper	Wood	4	--	<.1
A	1028-4b	9	Prosopis sp.	Mesquite	Wood	14	--	0.1
A	1028-4b	9	Zea mays	Maize	Cupule	4	--	<.1
A	1028-4b	9	Zea mays	Maize	Kernel	1	--	<.1
A	1080-4b	10	Indeterminate	NA	Wood	4	--	<.1
A	1080-4b	10	Juniperus sp.	Juniper	Wood	31	--	0.6

Table C-2. Contents of the Flotation Samples (cont.)

Component	Cat No.	Feature No.	Taxon	Common	Part	Count	Vol (mL)	Wt (g)
A	1080-4b	10	Prosopis sp.	Mesquite	Wood	1	--	<.1
A	1080-4b	10	Prosopis sp.	Mesquite	Thorn	1	--	<.1
A	1080-4b	10	Quercus sp.	Oak	Wood	14	--	0.2
A	1080-4b	10	Ulmaceae	Elm Family Wood	Wood	3	--	<.1
A	1080-4b	10	Zea mays	Maize	Kernel	2	--	<.1
A	1032-4b	11	Indeterminate	NA	Wood	13	--	0.4
A	1032-4b	11	Indeterminate	NA	Wood	13	--	0.4
A	1032-4b	11	Juniperus sp.	Juniper	Wood	15	--	0.2
A	1032-4b	11	Juniperus sp.	Juniper	Wood	15	--	0.2
A	1032-4b	11	Prosopis sp.	Mesquite	Wood	5	--	0.1
A	1032-4b	11	Prosopis sp.	Mesquite	Wood	5	--	0.1
A	1032-4b	11	Zea mays	Maize	Cupule	4	--	<.1
A	1032-4b	11	Zea mays	Maize	Cupule	4	--	<.1
A	1125-4b	12	Indeterminate	NA	Wood	7	--	0.5
A	1125-4b	12	Juniperus sp.	Juniper	Wood	19	--	0.9
A	1125-4b	12	Prosopis sp.	Mesquite	Wood	12	--	<.1
A	1125-4b	12	Prosopis sp.	Mesquite	Seed	1	--	--
A	1125-4b	12	Quercus sp.	Oak	Wood	4	--	<.1
A	1125-4b	12	Salicaceae	Cottonwood/ willow	Wood	2	--	<.1
A	1125-4b	12	Zea mays	Maize	Cupule	8	--	<.1
A	1125-4b	12	Zea mays	Maize	Kernel	1	--	<.1
A	1014-4-1b	13	Indeterminate	NA	Wood	10	--	0.1
A	1014-4-1b	13	Juniperus sp.	Juniper	Wood	12	--	0.3
A	1014-4-1b	13	Prosopis sp.	Mesquite	Wood	1	--	<.1
A	1014-4-1b	13	Quercus sp.	Oak	Wood	6	--	0.1
A	1014-4-1b	13	Salicaceae	Cottonwood/ willow	Wood	3	--	<.1
A	1014-4-1b	13	Zea mays	Maize	Cupule	7	--	<.1
A	1014-4-1b	13	Zea mays	Maize	Kernel	2	--	<.1
A	1014-4-3b	13	Indeterminate	NA	Wood	25+	4	<.1
A	1014-4-3b	13	Prosopis sp.	Mesquite	Wood	3	--	<.1
A	1014-4-3b	13	Rosaceae	Rose family wood type	Wood	4	--	<.1

Table C-2. Contents of the Flotation Samples (cont.)

Component	Cat No.	Feature No.	Taxon	Common	Part	Count	Vol (mL)	Wt (g)
A	1014-4-3b	13	Salicaceae	Cottonwood/ willow	Wood	3	--	<.1
A	1014-4-3b	13	Zea mays	Maize	Cupule	1	--	<.1
A	1014-4-3b	13	Zea mays	Maize	Kernel	1	--	<.1
C	120-4-2b	5	Celtis sp.	Hackberry	Nutlet	1	--	<.1
C	120-4-2b	5	Juniperus sp.	Juniper	Wood	25+	30	4.9
C	120-4-2b	5	Zea mays	Maize	Cupule	12	--	<.1
C	120-4-2b	5	Zea mays	Maize	Kernel	17	--	<.1
C	120-4-3a	5	Juniperus sp.	Juniper	Wood	19	--	0.1
C	120-4-3a	5	Prosopis sp.	Mesquite	Wood	5	--	<.1
C	120-4-3a	5	Zea mays	Maize	Cupule	8	--	0.1
C	120-4-3a	5	Zea mays	Maize	Kernel	5	--	<.1
C	120-4-4a	5	Juniperus sp.	Juniper	Wood	6	--	<.1
C	120-4-5a	5	Indeterminate	NA	Wood	3	--	0.1
C	120-4-5a	5	Juniperus sp.	Juniper	Wood	19	--	0.3
C	120-4-5a	5	Prosopis sp.	Mesquite	Wood	6	--	0.1
C	120-4-5a	5	Zea mays	Maize	Cob fragment	1	--	0.1
C	120-4-5a	5	Zea mays	Maize	Kernel	1	--	<.1
C	120-4-6a	5	Indeterminate	NA	Wood	1	--	<.1
C	120-4-6a	5	Juniperus sp.	Juniper	Wood	17	--	0.2
C	120-4-6a	5	Zea mays	Maize	Cupule	10	--	<.1
C	120-4-6a	5	Zea mays	Maize	Kernel	3	--	<.1
C	1231-4-1b	6	Juniperus sp.	Juniper	Wood	18	--	0.2
C	1231-4-1b	6	Prosopis sp.	Mesquite	Wood	3	--	<.1
C	1231-4-1b	6	Quercus sp.	Oak	Wood	7	--	0.1
C	1231-4-1b	6	Zea mays	Maize	Cupule	1	--	<.1
C	1231-4-1b	6	Zea mays	Maize	Kernel	1	--	<.1
C	1231-4-1b	6	Cucurbita sp.	Squash	Rind	1	--	<.1
C	132-4a	6	Juniperus sp.	Juniper	Wood	25	--	0.6
C	132-4a	6	Prosopis sp.	Mesquite	Seed	2	--	<.1
C	132-4a	6	Prosopis sp.	Mesquite	Wood	14	--	0.2
C	132-4a	6	Zea mays	Maize	Cupule	18	--	0.1
C	132-4a	6	Zea mays	Maize	Kernel	2	--	<.1
C	133-4c	6	Indeterminate	NA	Wood	4	--	<.1

Table C-2. Contents of the Flotation Samples (cont.)

Component	Cat No.	Feature No.	Taxon	Common	Part	Count	Vol (mL)	Wt (g)
C	133-4c	6	Juniperus sp.	Juniper	Wood	17	--	0.1
C	133-4c	6	Prosopis sp.	Mesquite	Wood	2	--	<.1
C	133-4c	6	Zea mays	Maize	Cupule	1	--	<.1
C	574-4b	6	Juniperus sp.	Juniper	Wood	25	--	0.8
C	574-4b	6	Opuntia sp.	Prickly pear	Seed	3	--	--
C	574-4b	6	Prosopis sp.	Mesquite	Wood	11	--	0.2
C	574-4b	6	Rosaceae	Rose family wood type	Wood	2	--	<.1
C	574-4b	6	Zea mays	Maize	Cupule	3	--	<.1
C	574-4b	6	Zea mays	Maize	Kernel	2	--	<.1
C	582-4b	6	Juniperus sp.	Juniper	Wood	9	--	0.1
C	582-4b	6	Prosopis sp.	Mesquite	Wood	4	--	<.1
C	582-4b	6	Zea mays	Maize	Kernel	1	--	<.1
C	584-4b	6	Indeterminate	NA	Wood	5	--	<.1
C	584-4b	6	Juniperus sp.	Juniper	Wood	26	--	0.6
C	584-4b	6	Quercus sp.	Oak	Wood	3	--	<.1
C	584-4b	6	Ulmaceae	Elm Family Wood	Wood	6	--	0.1
C	584-4b	6	Zea mays	Maize	Cupule	1	--	<.1
C	591-4b	6	Indeterminate	NA	Wood	6	--	0.3
C	591-4b	6	Juniperus sp.	Juniper	Wood	14	--	0.3
C	591-4b	6	Prosopis sp.	Mesquite	Thorn	1	--	<.1
C	591-4b	6	Rosaceae	Rose family wood type	Wood	6	--	0.2
C	591-4b	6	Salicaceae	Cottonwood/ willow	Wood	5	--	<.1
C	591-4b	6	Zea mays	Maize	Cob frag	1	--	0.1
C	591-4b	6	Zea mays	Maize	Cupule	3	--	<.1
C	591-4b	6	Zea mays	Maize	Kernel	2	--	<.1
C	595-4b	6	Indeterminate	NA	Wood	21	--	0.1
C	595-4b	6	Juniperus sp.	Juniper	Wood	25+	23	3.3
C	595-4b	6	Zea mays	Maize	Cupule	5	--	<.1
C	597-4b	6	Cheno-am	Chenopodium or Amaranthus	Seed	1	--	<.1
C	597-4b	6	Juniperus sp.	Juniper	Wood	24	--	0.5
C	597-4b	6	Prosopis sp.	Mesquite	Wood	11	--	0.1

Table C-2. Contents of the Flotation Samples (cont.)

Component	Cat No.	Feature No.	Taxon	Common	Part	Count	Vol (mL)	Wt (g)
C	597-4b	6	Prosopis sp.	Mesquite	Seed	2	--	--
C	597-4b	6	Zea mays	Maize	Cupule	7	--	<.1
C	625-4-1b	6	Juniperus sp.	Juniper	Wood	14	--	0.2
C	625-4-1b	6	Zea mays	Maize	Cupule	1	--	<.1
C	451-4b	16	Indeterminate	NA	Wood	7	--	0.1
C	451-4b	16	Juniperus sp.	Juniper	Wood	6	--	0.1
C	451-4b	16	Prosopis sp.	Mesquite	Wood	14	--	0.3
C	451-4b	16	Salicaceae	Cottonwood/ willow	Wood	2	--	<.1
C	451-4b	16	Zea mays	Maize	Cupule	14	--	<.1
C	451-4b	16	Zea mays	Maize	Kernel	26	--	<.1
C	453-4b	16	Juniperus sp.	Juniper	Wood	25+	21	2.2
C	453-4b	16	Rosaceae	Rose family wood type	Wood	5	--	0.1
C	453-4b	16	Zea mays	Maize	Cupule	8	--	--
C	453-4b	16	Zea mays	Maize	Kernel	9	--	--
C	470-4b	16	Indeterminate	NA	Wood	9	--	0.4
C	470-4b	16	Juniperus sp.	Juniper	Wood	33	--	0.6
C	470-4b	16	Phaseolus vulgaris	Common bean	Cotyledon	1	--	--
C	470-4b	16	Prosopis sp.	Mesquite	Wood	8	--	0.2
C	470-4b	16	Zea mays	Maize	Cupule	34	--	0.5
C	470-4b	16	Zea mays	Maize	Kernel	22	--	0.1
C	474-4-1b	21	Juniperus sp.	Juniper	Wood	25+	8	<.1
C	474-4-1b	21	Juniperus sp.	Juniper	Seed	1	--	<.1
C	474-4-1b	21	Rosaceae	Rose family wood type	Wood	3	--	<.1
C	474-4-1b	21	Zea mays	Maize	Cupule	8	--	<.1
C	474-4-1b	21	Zea mays	Maize	Kernel	6	--	<.1
C	474-4-1b	21	Zea mays	Maize	Glume	2	--	<.1
C	328-4-1b	23	Indeterminate	NA	Wood	7	--	<.1
C	328-4-1b	23	Juniperus sp.	Juniper	Wood	22	--	0.2
C	328-4-1b	23	Prosopis sp.	Mesquite	Wood	2	--	0.1
C	328-4-1b	23	Zea mays	Maize	Cupule	3	--	<.1
C	328-4-1b	23	Zea mays	Maize	Glume	1	--	<.1
C	328-4-1b	23	Zea mays	Maize	Kernel	2	--	<.1

Table C-2. Contents of the Flotation Samples (cont.)

Component	Cat No.	Feature No.	Taxon	Common	Part	Count	Vol (mL)	Wt (g)
C	328-4-2b	23	Indeterminate	NA	Wood	20	--	0.4
C	328-4-2b	23	Juniperus sp.	Juniper	Wood	5	--	0.1
C	328-4-2b	23	Prosopis sp.	Mesquite	Wood	4	--	<.1
C	328-4-2b	23	Zea mays	Maize	Cupule	17	--	0.1
C	328-4-2b	23	Zea mays	Maize	Kernel	1	--	<.1
C	294-4b	26	Indeterminate	NA	Wood	9	--	0.4
C	294-4b	26	Indeterminate	NA	Knobby tissue	6	--	<.1
C	294-4b	26	Juniperus sp.	Juniper	Wood	25+	45	7.8
C	294-4b	26	Prosopis sp.	Mesquite	Wood	9	--	0.2
C	294-4b	26	Quercus sp.	Oak	Wood	8	--	1.3
C	294-4b	26	Zea mays	Maize	Kernel	11	--	<.1
C	294-4b	26	Zea mays	Maize	Cupule	4	--	<.1
C	294-4b	26	Zea mays	Maize	Glume	2	--	<.1
C	300-4b	29	Indeterminate	NA	Wood	7	--	0.1
C	300-4b	29	Juniperus sp.	Juniper	Wood	10	--	0.1
C	300-4b	29	Quercus sp.	Oak	Wood	3	--	0.1
C	300-4b	29	Zea mays	Maize	Cupule	13	--	<.1
C	300-4b	29	Zea mays	Maize	Kernel	13	--	<.1

Table C-3. Contents of the Macrobotanical Wood Identification/ (14C) Samples.

Component	PNUM	Feature	Provenience	Taxon	Common	Part	Count	Weight (g)
A	1114-7-1	1	E699 N512, 30-40	Juniperus sp.	Juniper	Wood	5	0.1
A	1140-7	1	E699 N515, 50-60	Indeterminate	NA	Wood	4	0.1
A	1160-7	1	E700 N515, 30-40	Juniperus sp.	Juniper	Wood	3	0.2
A	1162-7	1	E700 N515, 48	Rosaceae	Rose Family Wood	Wood	9	1
A	1164-7-3	1	E700 N515, 58	Rosaceae	Rose Family Wood	Wood	2	0.1
A	31-4-2a	1	62-64 cm	Juniperus sp.	Juniper	Wood	3	<.1
A	31-7-1	1	52 cm	Pinaceae	Pine-Juniper Family	Wood	2	<.1
A	34-7-1	3	T A1, 39-51 cm	Salicaceae	Cottonwood/willow-type	Wood	6	0.1
A	34-732	3	Trench 1, 36 cm	Juniperus sp.	Juniper	Wood	10	0.5
A	34-732	3	Trench 1, 36 cm	Prosopis glandulosa	Mesquite	Wood	16	0.5
A	34-7-2	3	Trench 1, 36 cm	Salicaceae	Cottonwood/willow-type	Wood	7	0.4
A	1116-7-1	8	E699 N512, 40-50	Juniperus sp.	Juniper	Wood	9	0.8
A	1019-7-1	13	E695 E513/514, 33-55	Juniperus sp.	Juniper	Wood	8	0.5
A	1021-7-1	13	E695 E514, 50	Burned bone				
A	860-7	15	N679 E511, 30	Juniperus sp.	Juniper	Wood	8	0.4
A	1005-7	-	N695 E511, 38	Rosaceae	Rose Family Wood	Wood	4	0.3
A	1031-7	-	E696 N511, 50-60	Juniperus sp.	Juniper	Wood	8	0.8
A	1059-7	-	E697 N512, 50-60	Prosopis sp.	Mesquite	Wood	18	0.5
A	1062-7-1	-	E697 N513, 25-35	Ulmaceae	Elm Family Wood	Wood	8	1.2
A	1078-7-1	-	E698 N511, 20-30	Juniperus sp.	Juniper	Wood	7	0.3
A	1107-7	-	E699 N511, 30-40	Juniperus sp.	Juniper	Wood	2	0.4
A	1193-7-1	-	E702 N513, 20-30	Rosaceae	Rose Family Wood	Wood	6	0.1
A	27-7-1	-	Cutbank Surface	Prosopis sp.	Mesquite	Wood	6	0.1
A	43-7-1	-	A-2, 30-40 cm	Juniperus sp.	Juniper	Wood	2	<.1
A	52-7-1	-	A-4, 50 cm	Juniperus sp.	Juniper	Wood	1	<.1
A	59-7-1	-	A-5, 25 cm	Rosaceae	Rose Family Wood	Wood	9	0.3
A	62-7-1	-	A-5, 50-60 cm	Juniperus sp.	Juniper	Wood	4	<.1
A	62-7-1	-	A-5, 50-60 cm	Quercus sp.	Oak	Wood	2	<.1
A	694-7	-	N665 E509, 30-40 cm	Juniperus sp.	Juniper	Wood	3	0.1
A	701-7	-	N665 E511, 20-30 cm	Juniperus sp.	Juniper	Wood	1	0.1
A	704-7	-	N666 E509, 20-30 cm	Juniperus sp.	Juniper	Wood	1	0.1
A	71-7-1	-	A-6, 40-50 cm	Juniperus sp.	Juniper	Wood	1	0.4
A	749-7	-	N668 E512, 20-30	Indeterminate	NA	Wood	4	0.1
A	790-7	-	N671 E511, 23 cm	Ulmaceae	Elm Family Wood	Wood	2	0.2
A	813-7	-	N673 E509, 20-30 cm	Juniperus sp.	Juniper	Wood	5	0.1

Table C-3. Contents of the Macrobotanical Wood Identification/ (14C) Samples (cont.)

Component	PNUM	Feature	Provenience	Taxon	Common	Part	Count	Weight (g)
A	814-7	-	N673 E509, 30-40 cm	Juniperus sp.	Juniper	Wood	7	1.1
A	852-7	-	N678 E511, 10-20	Indeterminate	NA	Wood	2	0.2
A	854-7-2	-	N678 E511, 20-30	Juniperus sp.	Juniper	Wood	2	0.2
A	865-7	-	N680 E511, 30-40	Juniperus sp.	Juniper	Wood	3	0.2
A	872-7-1	-	N682 E511, 20-30	Rosaceae	Rose Family Wood	Wood	2	<.1
A	907-7-1	-	N688 E513, 24	Juniperus sp.	Juniper	Wood	6	1.2
A	922-7-1	-	N690 E512, 20-30	Juniperus sp.	Juniper	Wood	1	0.1
A	961-7-1	-	N693 E512, 30-40	Juniperus sp.	Juniper	Wood	1	0.1
A	999-7	-	N695 E511, 30-40	Rosaceae	Rose Family Wood	Wood	2	<.1
C	115-7	NA	C-4, 30 cmbs	Juniperus sp.	Juniper	Wood	7	0.1
C	119-7	NA	C-5, 30-40 cmbs	Juniperus sp.	Juniper	Wood	18	0.2
A	30-7-1	NA	Cutbank, 63 cm	Juniperus sp.	Juniper	Wood	2	0.1
A	38-7-1	NA	A-1, 28 cmbs	Flecks	NA	NA	--	--
A	43-7-1	NA	A-2, 33 cmbs	Juniperus sp.	Juniper	Wood	14	0.1
C	435-7-1	5	N490 E501, 30-40	Juniperus sp.	Juniper	Wood	11	0.4
C	120-4-3	5, bottom	30-40 cmbs	Juniperus sp.	Juniper	Wood	21	0.2
C	120-4-3	5, bottom	30-40 cmbs	Prosopis glandulosa	Mesquite	Wood	2	<.1
C	120-4-3	5, bottom	30-40 cmbs	Zea mays	Maize	Kernel	10	0.3
C	120-4-3	5, bottom	30-40 cmbs	Zea mays	Maize	Cupule	2	<.1
C	1266-7-1	6	N500 E496/497	Quercus sp.	Oak	Wood	1	<.1
C	1266-7-11	6	N500 E496/497	Indeterminate	NA	Wood	3	<.1
C	1266-7-3	6	N500 E496/497	Juniperus sp.	Juniper	Wood	3	<.1
C	1266-7-4	6	N500 E496/497	Indeterminate	NA	Wood	2	<.1
C	1266-7-5	6	N500 E496/497	Juniperus sp.	Juniper	Wood	3	0.1
C	1266-7-7	6	N500 E496/497	Prosopis sp.	Mesquite	Wood	4	0.1
C	1266-7-8	6	N500 E496/497	Juniperus sp.	Juniper	Wood	2	<.1
C	1267-7-10	6	N499 E496/497	Juniperus sp.	Juniper	Wood	1	<.1
C	1267-7-11	6	N499 E496/497	Juniperus sp.	Juniper	Wood	4	0.3
C	1267-7-12	6	N499 E496/497	Zea mays	Maize	Cupule	10	--
C	1267-7-15	6	N499 E496/497	Juniperus sp.	Juniper	Wood	3	<.1
C	1267-7-19	6	N499 E496/497	Juniperus sp.	Juniper	Wood	2	<.1
C	1267-7-21	6	N499 E496/497	Prosopis sp.	Mesquite	Wood	4	<.1
C	1267-7-23	6	N499 E496/497	Juniperus sp.	Juniper	Wood	7	0.1
C	1267-7-24	6	N499 E496/497	Ulmaceae	Elm Family Wood	Wood	6	0.2
C	1267-7-25	6	N499 E496/497	Ulmaceae	Elm Family Wood	Wood	1	0.1
C	1267-7-26	6	N499 E496/497	Juniperus sp.	Juniper	Wood	2	<.1

Table C-3. Contents of the Macrobotanical Wood Identification/ (14C) Samples (cont.)

Component	PNUM	Feature	Provenience	Taxon	Common	Part	Count	Weight (g)
C	1267-7-28	6	N499 E496/497	Juniperus sp.	Juniper	Wood	2	0.3
C	1267-7-29	6	N499 E496/497	Juniperus sp.	Juniper	Wood	2	<.1
C	1267-7-5	6	N499 E496/497	Indeterminate	NA	Twig	2	<.1
C	1267-7-7	6	N499 E496/497	Juniperus sp.	Juniper	Wood	3	<.1
C	1267-7-9	6	N499 E496/497	Prosopis sp.	Mesquite	Wood	4	<.1
C	128-7	6	C-7, 30-40 cmbs	Juniperus sp.	Juniper	Wood	11	0.3
C	539-7	6	N497 E497, 27-32	Juniperus sp.	Juniper	Wood	12	0.3
C	541-7	6	N497 E497, 40-50	Juniperus sp.	Juniper	Wood	28	1.6
C	574-7	6	N498 E495, 70-80	Juniperus sp.	Juniper	Wood	7	0.3
C	582-7	6	N498 E496, 60-70	Juniperus sp.	Juniper	Wood	9	1
C	591-7	6	N498 E497, 40-50	Indeterminate	NA	Wood	5	0.6
C	601-7	6	N498 E498, 40-50	Juniperus sp.	Juniper	Wood	9	0.6
C	621-7	6	N499 E495, 40-50	Rosaceae	Rose Family Wood	Wood	10	0.5
C	631-7-1	6	N499 E496, 21-31	Indeterminate	NA	Wood	5	0.1
C	631-7-1	6	N499 E496, 21-31	Juniperus sp.	Juniper	Wood	6	0.2
C	641-7	6	N499 E497, 30-40 cm	Juniperus sp.	Juniper	Wood	25+	4.3
C	643-7-2	6	N499 E497, 40-50 cm	Juniperus sp.	Juniper	Wood	25+	4.2
C	658-7	6	N500 E496, 30-40 cm	Juniperus sp.	Juniper	Wood	7	0.2
C	660-7	6	N499 E496, 40-50 cm	Juniperus sp.	Juniper	Wood	10	0.7
C	660-7	6	N499 E496, 40-50 cm	Ulmaceae	Elm Family Wood	Wood	4	0.1
C	669-7-2	6	N500 E497, 40-55 cm	Juniperus sp.	Juniper	Wood	16	1.1
C	669-7-2	6	N500 E497, 40-55 cm	Zea mays	Maize	Cob frag	5	0.2
C	133-4-a	6, bottom	C7, 60-70 cm	Juniperus sp.	Juniper	Wood	1	<.1
C	284-7-2	18	E481 N501, 79-81	Juniperus sp.	Juniper	Wood	11	0.4
C	308-7-1	18	E482 N500, 70	Indeterminate	NA	Wood	6	0.3
C	310-7	18	E482 N500, 70-80	Rosaceae	Rose Family Wood	Wood	8	3.7
C	312-7	18	E482 N500, 80-90	Rosaceae	Rose Family Wood	Wood	6	2.4
C	323-7-1	18	N482 E501, 53	Juniperus sp.	Juniper	Wood	4	0.1
C	325-007	18	N482 E501, 60-70	Quercus sp.	Oak	Wood	4	0.5
C	455-7-3	21	N491 E501, 60-70	Rosaceae	Rose Family Wood	Wood	13	1.2
C	300-7-2	29	E482 N499, 70-80	Rosaceae	Rose Family Wood	Wood	11	1.3
C	349-7	31	N484 E496, 70	Juniperus sp.	Juniper	Wood	6	0.3
C	114-7-1	-	C-4	Indeterminate	NA	Wood	7	<.1

Table C-3. Contents of the Macrobotanical Wood Identification/ (14C) Samples (cont.)

Component	PNUM	Feature	Provenience	Taxon	Common	Part	Count	Weight (g)
C	119-007	-	C-5	Juniperus sp.	Juniper	Wood	22	0.7
C	119-007	-	C-5	Prosopis sp.	Mesquite	Wood	2	0.1
C	165-007	-	C-10	Juniperus sp.	Juniper	Wood	3	<.1
C	172-007	-	E474 N494, 10-20	Juniperus sp.	Juniper	Wood	1	0.1
C	177-7	-	E478 N500, 50-60	Juniperus sp.	Juniper	Wood	5	0.1
C	178-7-1	-	E478 N500, 60-70	Juniperus sp.	Juniper	Wood	1	0.1
C	196-007	-	E479 N499, 61	Juniperus sp.	Juniper	Wood	4	<.1
C	292-007-2	-	E482 N499, 30-40	Juniperus sp.	Juniper	Wood	3	0.3
C	297-007	-	E482 N499, 60-70	Juniperus sp.	Juniper	Wood	8	0.3
C	343-7	-	N483 E500, 65-80	Juniperus sp.	Juniper	Wood	17	0.7
C	358-7	-	E485 N499, 30-40	Juniperus sp.	Juniper	Wood	6	0.7
C	396-7	-	N487 E500, 40-50	Juniperus sp.	Juniper	Wood	18	0.4
C	407-7	-	N489 E493, 50-60	Burned bone				
C	421-7	-	N489 E501, 20	Juniperus sp.	Juniper	Wood	5	0.1
C	425-7	-	N490 E494, 28	Prosopis sp.	Mesquite	Wood	2	0.1
C	429-7	-	N490 E495, 20-30	Rosaceae	Rose Family Wood	Wood	5	0.1
C	547-7	-	N497 E500, 10-20	Juniperus sp.	Juniper	Wood	3	0.1
C	153-7	NA	C-9, 37 cmbs	Indeterminate diffuse porous	NA	Wood	5	0.1
C	153-7	NA	C-9, 37 cmbs	Juniperus sp.	Juniper	Wood	2	<.1
C	164-7-1	Structure 1	C10, 19 cm	Indeterminate hardwood	NA	Wood	6	<.1
C	166-7-1	Structure 1	C-10	Juniperus sp.	Juniper	Wood	5	0.3
C	167-7-1	Structure 1	C10, 34 cm	Juniperus sp.	Juniper	Wood	4	0.1

Table C-4. Presence Values at 41RB112.

Taxon	Common	Part	Total number of flotation samples	Samples Present	Presence Value (Ubiquity)
Cucurbita	Squash	Rind	34	3	8.8 percent
Cheno-am	Goosefoot or Pigweed	Seed	34	3	8.8 percent
Prosopis sp.	Mesquite	Seed	34	4	11.8 percent
Zea mays	Maize	Cupule, kernel, cob fragment	34	32	94.1 percent
Juniperus sp.	Juniper	Seed	34	1	2.9 percent
Phaseolus sp.	Common Bean	Cotyledon	34	1	2.9 percent
Celtis sp.	Hackberry	Nutlet	34	1	2.9 percent
Opuntia sp.	Prickly pear	Seed	34	1	2.9 percent

Table C-5. Presence Value or Density of the Most Abundant Plant Resources from Components A and C.

	Component A Presence Value	Component C Presence Value
Maize cupules – Presence Value	90.9 percent	87.0 percent
Maize kernels – Presence Value	81.8 percent	73.9 percent
Overall Maize – Presence Value	90.9 percent	87.0 percent
Common Bean – Presence Value	0.0 percent	4.3 percent
Squash Rind – Presence Value	18.2 percent	4.3 percent
Mesquite Seed – Presence Value	18.2 percent	8.6 percent
Cheno-am Seed – Presence Value	18.2 percent	4.3 percent
Juniper Seed – Presence Value	0	4.3 percent
Prickly Pear – Presence Value	0	4.3 percent
Juniper Wood Mass – Density	2.9 g (0.012g/L)	23.3 g (0.091 g/L)
Mesquite Wood Mass – Density	0.5 g (0.003 g/L)	1.4 g (0.005 g/L)

Table C-6. Regional Comparison of Presence Values of Plant Remains.

Taxon	Landergin Mesa (n=40)	Lonker Site (n=6)	Hank's Site (n=22)	41RB112 (n=34)
Maize	3 percent	83 percent	13.6 percent	94.1 percent
Goosefoot/Pigweed	3 percent	83 percent	4.5 percent	8.8 percent
Mesquite	--	--	--	11.8 percent
Sunflower	--	83 percent	36.4 percent	--

APPENDIX D

STARCH ANALYSIS OF THE LONG VIEW SITE

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D.1 Introduction to Starch Grain Analyses

Archaeobotanical investigators are constantly seeking new methods by which previously unobtainable data can be recovered. Among archaeologists who work in regions characterized by the poor preservation of organic remains, the analyses of starch granules have proven particularly useful in accessing the residues of starchy root and tuber crops that have previously been invisible in the archaeological record (Bryant 2003; Coil et al. 2003; Fullagar et al. 1998; Hall et al. 1989; Iriarte et al. 2004; Loy et al. 1992; Pearsall et al. 2004; Perry 2001, 2002, 2004, 2005, 2007; Perry and Quigg 2011a, 2011b; Perry et al. 2006, 2007, 2010; Piperno and Holst 1998; Piperno et al. 2000). These residues have proven to be tenacious survivors in harsh climates, and their preservation on the surfaces of lithic tools that were used in the processing of starch-bearing plants occurs consistently in archaeobotanical investigations (Iriarte et al. 2004; Pearsall et al. 2004; Perry 2001, 2002, 2004, 2005, 2007, 2010; Perry and Quigg 2011a, 2011b; Perry et al. 2006, 2007; Piperno and Holst 1998; Piperno et al. 2000).

Investigations of the starchy remains of plant foods on the surfaces of archaeological lithic tools began with simple analyses using chemical reagents that identified the residues in question as plant-derived storage starch (Bruier 1976) rather than animal tissue. Within the last fifteen years, however, archeologists have been successfully employing morphological criteria to identify plant taxa. The methods are almost identical to those used in the analysis of phytolith microfossils.

Just as different plants produce characteristically shaped leaves, flowers, and seeds, different genera and species make starch grains that are distinctive to and diagnostic for each taxon. The anatomical features that distinguish the starch of one species of plant from another have been noted by botanists (e.g., Denniston 1904; MacMasters 1964; Reichert 1913), and their methods have been expanded by archaeobotanists who are now able even to distinguish wild from domesticated species in some plant families (Iriarte et al. 2004; Pearsall

et al. 2004; Perry 2001, 2002, 2004; Piperno et al. 2000). Basic physical features that are comparable between modern reference specimens and archeological samples can be viewed using a light microscope and include gross morphological features such as shape and faceting, the location of and appearance of the hilum, and presence and patterning of lamellae (Iriarte et al. 2004; Loy 1994; Pearsall 2004; Perry 2004; Piperno and Holst 1998; Piperno et al. 2000). Fissuring and other internal patterning have also proven to be useful criteria for identification. The successful identification of starch granules relies upon the viewing of each granule in three dimensions to gain an accurate assessment of its morphological features.

Because starch granules differ morphologically between plants, their distinctive characteristics can often allow identification to the level of genus or species in archeological samples (e.g., Iriarte et al. 2004; Pearsall et al. 2004; Perry 2001, 2002, 2004, 2005, 2007; Perry et al. 2006, 2007; Piperno and Holst 1998; Piperno et al. 2000). The method has proven particularly useful in identifying the remains of plant tissues that would not usually be preserved as macroremains, such as the remnants of root and tuber crops (Bryant 2003; Coil et al. 2003; Fullagar et al. 1998; Hall et al. 1989; Iriarte et al. 2004; Loy et al. 1992; Pearsall et al. 2004; Perry 2001, 2002, 2004, 2005; Piperno and Holst 1998; Piperno et al. 2000). This role of starch analysis as a tool for revealing the significance of plant foods in the archaeobotanical record also adds to our understanding of the pre-contact significance of starchy seed crops like maize (*Zea mays*).

In a citation of preliminary results from an ongoing study, the archeological remains of maize starch have been extracted from 2,000-year-old obsidian artifacts from the Honduran site of Copán (Haslam 2003, 2004). The starchy residues of maize were also successfully recovered and identified from a migmatite milling stone from Cueva de los Corrales 1 in Argentina (Babot and Apella 2003). In this case, the grinding stone was found to have multiple purposes, including the grinding of burnt bone, presumable for a non-food purpose. Starch analyses of ground stone artifacts from Real Alto have supported previously published phytolith studies

that indicate the great antiquity of maize in Ecuador, and its role in subsistence during the Formative period (Pearsall et al. 2004). Seventeen examined artifacts from Real Alto yielded concentrations of maize starch granules ranging from one to more than ten granules per sampled tool. Other Neotropical studies have resulted in the recovery of more complex assemblages of starches.

Archeologists have recovered starch granules from maize, beans (*Phaseolus* sp.), and Canna from the Los Ajos mound complex in Uruguay (Iriarte et al. 2004). Maize starch granules were reported from three ground stone tools including one mano and two milling stone bases. Concentrations of maize starches ranged from two to eleven granules on tools from contexts dating from 3,600 years before present to about 500 years before present (Iriarte et al. 2004: supplementary information). The starch data were combined with phytolith evidence and, together, these results introduce compelling evidence for the early development of a mixed subsistence economy in this region of South America. In other regions of the Neotropics, starch analysis has been an essential tool in defining similar subsistence patterns that included the exploitation of root and tuberous food plants.

Starch granules of maize, manioc (*Manihot esculenta*), both wild type and domesticated yams (*Dioscorea* spp.), and arrowroot (*Maranta arundinacea*) have been recovered from edge ground cobbles and grinding stone bases collected from the Aguadulce rock shelter as well as the sites of Monagrillo, La Mula, and Cerro Juan Diaz in Panama (Piperno and Holst 1998; Piperno et al. 2000). Edge ground cobbles are characterized by faceting that is hypothesized to have resulted from the processing of root crops against larger grinding stone bases (Ranere 1975), and the analyses of the residual remains of plant tissues supports this hypothesis. However, the use of the milling stones does appear to have been more complex than previously believed. Maize remains were recovered from all twelve artifacts that bore starch (Piperno et al. 2000). The numbers of starch granules of maize per artifact ranged from one to twenty-five per artifact. Two starch granules of arrowroot occurred on a single artifact, manioc starch granules were

recovered from three artifacts (one, five, and eight granules), and yam starch granules were found on the surfaces of three of the artifacts (two, three, and sixteen granules) (Piperno et al. 2000). These investigations resulted in the recovery of the oldest evidence for root and tuber crop cultivation in the Neotropics, with radiocarbon dates spanning from 5,000 to 7,000 years before present.

Starch granules of maize, yams, and arrowroot have also been recovered from twelve flake and three ground stone tools collected from Pozo Azul Norte 1 and Los Mangos del Parguaza in Venezuela (Perry 2001, 2002, 2004, 2005). These sites date from the middle first century A.D. to contact. As in the above-cited set of studies, maize remains were recovered from every examined artifact and ranged in number from two to fifty-one per artifact. Additionally, four granules of yam starch were recovered from two flake tools, four flake tools yielded four granules of guapo (*Myrosma* sp.) starch, and seven starch granules from arrowroot were collected from five tools, one of which was a ground stone artifact. These findings were significant in that five of the examined artifacts were chosen for study due to their hypothetical function as microlithic grater flakes from a manioc specific grater board. The evidence indicated a more complex function of these tools that did not include the processing of manioc.

More recent investigations have led to the recovery of direct evidence for contact between the highland Peruvian Andes and the lowland tropical forest to the east (Perry et al. 2006). This contact and interaction had been a significant component of Andean theory for decades, but direct evidence had been elusive until starch microfossils of arrowroot were collected from both sediment samples and lithic tools at the mid-elevation site of Waynuna (Perry et al. 2006). Further, the discovery and cataloging of a microfossil will allow for the recovery and understanding of the origins and subsequent dispersals of chili peppers (Perry et al. 2007), plants whose histories are poorly understood due to the lack of preservation of macroremains in the archaeobotanical record. Remains of these plants have been successfully recovered throughout the Americas from ceramic sherds, lithic tools, and sediment samples dating from 6250 B.P. to European contact.

D.2 Understanding The Relationship Between Residues And Artifacts

Early work on starch remains from Panamanian sites used stepwise analysis to support the direct association between starchy residues on tools and the tools' use (Piperno et al. 2000). These studies demonstrated that starch grains were not present in sediments adhering to stone tools or on unused parts of the lithics, but they did occur in the cracks and crevices of the tools on used surfaces, thus indicating that the residues were the result of the tools' use and not environmental contamination. Similar experiments have been undertaken independently by other researchers, and the results were equivalent.

In a study of obsidian artifacts recovered from an open air site in Papua New Guinea, the frequency of starch granules recovered from stone artifacts was compared to that present in the soil matrix immediate to the tool (Barton et al. 1998). The frequency of starch granules was found to be much higher on used artifacts than in the surrounding soil. Thus, the conclusion was drawn that the tools were not contaminated by environmental starch sources. Further, use-wear analyses were used in combination with the soil and starch analyses to assess the degree of association of starchy residues with the used surfaces of tools (Barton et al. 1998). The researchers found that, indeed, the occurrence of starch granules was highly correlated with obsidian tools that bore use-wear and was not correlated with unused tools.

In a study of starch residues occurring on stone pounding tools from the Jimmum site in north central Australia, the starch forms in soil samples were compared to those extracted from the artifacts (Atchison and Fullagar 1998). It was found that, although starch granules did occur in the soil matrices surrounding the tools, they were of different size and shape than those present on the pounding stones, and, therefore, are probably not from the same plant source. This result was interpreted as evidence that the tools had not been contaminated by soil-borne starches.

Another method for assessing whether or not starch residues are culturally deposited involves the analysis of control samples from non-cultural

contexts surrounding a site. If different types of starches, or different concentrations of starches, or no plant residue whatsoever are recovered from the control samples than are recovered from the artifacts undergoing testing, then one can be more secure that the residues are the remains of prehistoric food processing (Brieur 1976).

In addition to the study of association of microfossils with tool use, experimentation with processing methods has also been undertaken. In Argentina, a researcher replicated ancient Andean methods of food processing and found that each different process resulted in diagnostic damage to starch granules in plant tissues including potato tubers (*Solanum tuberosum*) and quinoa seeds (*Chenopodium* spp.) (Babot 2003). Modern plant materials were subjected to freeze-drying, dehydration, roasting, charring, desaponification (a process particular to the preparation of quinoa), and grinding. It was found that fragments of starches that would probably otherwise be identified as unknowns or non-starches are actually damaged starches. Further, with careful analysis, researchers can link damage patterns with processing techniques (Babot 2003). Experimentation with various cooking techniques has resulted in similar conclusions: cooked starches are identifiable as such, and different cooking techniques yield different patterns of damage (Henry et al. 2009).

Recent work at the Pipeline, Pavilion, and Corral sites in Texas have demonstrated the utility of starch grain analysis in understanding the function of burned rocks in archeological contexts (Perry 2010; Perry and Quigg 2011a; Quigg et al. 2010). Here, the analysis of burned rocks yielded starch grains that bore clear damage from boiling and secured the function of many burned rocks as boiling stones used for the cooking of wildrye. The analysis of other artifacts from the sites yielded wildrye starches bearing damage from grinding, thus indicating that the grain was probably milled into flour prior to cooking (Perry 2010; Perry and Quigg 2011a; Quigg et al. 2010).

Archaeobotanists have focused their energies upon honing their methods toward the effective recovery of and identification of residual starch granules

to understand plant use and processing. Studies have resulted in an impressive assemblage of various suites of starchy food plants, both wild and domesticated, raw and cooked. At this juncture in time, more studies are being undertaken and starch remains are being successfully recovered. What we now lack are baseline data as to how and why different plant materials may or may not adhere to stone tools. Thus, we are not yet able to understand issues such as intensity of use based upon numbers of recovered grains, or the history of a tool based upon the numbers of species of plants recovered from its surface. Linda Perry has obtained funding and will be performing experiments over the next year in the hopes of gaining an understanding of these issues.

D.3 Methods

One hundred six samples were chosen for analysis. The samples included 39 ceramic sherds, 17 ground stone artifacts, 20 burned rocks, 28 chipped stone tools, and two sediment samples for controls. All artifacts were collected and bagged separately without washing. Washing is a traditional step in the collection and curation of artifacts, but it will remove some of the residues that are of interest to archeologists.

All artifacts were placed in clean, metal beakers and were covered with filtered water. The beakers were then set aside for ten minutes to soak in the hope that this step would loosen the microfossils and allow for a better extraction. At this point, the beakers were placed in a sonic bath for ten minutes to shake the microfossils loose from the artifacts. The artifacts were removed from the beakers and the surfaces were rinsed with filtered water that was collected in the same effluent vessel.

The effluent from the cleaning was allowed to settle overnight, then the settled material was centrifuged for ten minutes at 1,000 RPM to pellet out the solids. The solid materials were then subject to a heavy liquid flotation using cesium chloride (CsCl) at a density of 1.8 g/cm³ to separate the starch grains from the sediment matrix.

The material collected from the flotation was rinsed and centrifuged three times with filtered water to

ensure that the CsCl was completely removed from the solution. At this point, the pellet from the final centrifugation was placed on a clean glass slide with a small amount of water/glycerin solution.

Slides were scanned with a Zeiss Universal compound microscope for polarized light at 200x, and identifications were made at 400x using standard methods. Digital images were captured at 800x magnification using a Micropublisher 3.3 camera and software.

D.4 Results and Discussion

The starchy remains of maize (*Zea mays*), grasses from the tribe Triticeae (lenticular in the table), cheno-ams (*Chenopodium* spp. and *Amaranthus* spp.), and several yet unidentified types were recovered from the artifacts (Table D-1, Figure D-1). The morphological features of the lenticular starch grains indicate that at least some, if not all, of the lenticular starches are derived from little barley (*Hordeum pusillum*), though some may be from seeds of wildrye (*Elymus* spp.). For the purposes of simplification in the report, the lenticular assemblage as a whole will be referred to as little barley. In the data table, the cheno-ams are noted with a presence/absence designation rather than a starch grain count for the following reason. These plants produce very tiny starch grains ranging in size from a single micron to about four microns in maximum length, and the starches occur in archaeobotanical assemblages in small aggregates of anywhere from tens to hundreds of component starch grains rather than in single, separate grains. A count, therefore, would not be useful in assessing the use of the plants at the site.

There are at least three types within the unidentified starches that are of distinctive form and that are certainly identifiable. Comparative work continues to identify these unknowns, and right now there are tentative identifications of starches from the bulbs of plants within the lily family (cfl in Table D-1) and those from the seeds (as opposed to pods) of mesquite (cfm in Table D-1). Another appears to be from some type of wild grass, but this identification is tentative.

D.4.1 Component A

D.4.1.1 Ceramic Sherds

The ceramic sherds were excellent sources of starchy remains from the pithouse in Component A. Of 27 sampled sherds, 19 yielded starch grains. Among the assemblage were maize, little barley, cheno-ams, and several unknowns. Additionally, damaged

starches were recovered, and the processing techniques recognized in the record include both grinding and gelatinization. The entire assemblage indicates that at least some of the little barley was ground into flour prior to cooking in the vessels, and the vessels were most certainly used for cooking with some sort of aqueous medium that would allow for the gelatinization.

Table D-1. Starch Remains from the Long View Site.

“Cf” indicates a tentative identification. Note: in the unidentified column, cfl is a tentative lily identification, cfm is mesquite, and small is possible cheno-am or wild grass. F = Feature number, V = Vessel number or letter, PR = parched, GD = ground, GL = gelatinized, X = damage of unidentified origin present in the sample, unless in the Total column where X indicates the presence of any damage in the sample.

Sample #	Artifact Type	Provenience Component / Feature	Maize	Cf. Maize	Damaged maize	Lenticular	Damaged Lenticular	Cheno-Am	Unknown	Unidentified Damaged	Total
Component A											
Ceramics											
1162-8-1	Body Sherd	A F1	3			3				X	6X
1021-8-1	Body Sherd	A F13		1	X						1X
2-8-4	Body Sherds VA	A Surf				6	GL				6X
11-8-7	Pipe Frag	A	5		PR	48	GD		5	GL	58X
58-8-1	Rim sherd VA	A							1	GL	1X
979-8-1	Body sherd VA	A									0
762-8-2	Body sherd VB	A									0
1135-8-1	Rim sherd VH	A									0
2-8-5	Rim sherd	A Surf	2			40			1	GL	43X
39-8-1	Body sherd	A									0
779-8-1	Corded sherd	A				2					2
809-8-1	Body sherd	A				1					1
940-8-1	Body sherd	A				1					1
961-8-1	Body sherd	A									0
1042-8-1	Body Sherds	A				1	GD		6 cfl		7X
1044-8-1,2	2 Rim sherds	A				2	GD	X			2X
1047-8-1	Rim sherd	A				6			2 cfl		8
1106-10	Mod body sherd	A	1			1					2
1113-8-2	Body sherd	A				2	GL				2X

Table D-1. Starch Remains from the Long View Site (cont.).

Sample #	Artifact Type	Provenience Component / Feature	Maize	Cf. Maize	Damaged maize	Lenticular	Damaged Lenticular	Cheno-Am	Unknown	Unidentified Damaged	Total
1120-8-2	Body sherd	A				2					2
1128-8-2	Body Sherd	A	3			5	GD		2 cfm		10X
1138-8-1	Body sherd	A									0
1151-10	Pipe frag	A	1			2	GL				3X
1160-8-1	Body sherd	A									0
1168-10	Spindle whorl	A				1					1
1195-8	Body Sherd/pipe	A	2			4			5 cflm		11
1198-8-1	Body sherd	A									0
Ground Stone											
48-10	Mano frag	A				33			5	X	38
709-10	Edge Ground pebble	A	3			45	GD		4		52X
772-11	Metate frag	A	1			1		X			2X
783-10	Metate frag	A				50+	GD	X	55+small		55X
1056-10	Abrader	A				1			1		2
1110-10	Metate frag	A							1		1
Burned Rocks											
1135-3-2b	Burned Rock	A F1				4					4
1032-3-1b	Burned Rock	A F11									0
985-3-1b	Burned Rock	A F13	1			2	X				3X
800-3-1b	Burned Rock	A F14									0
855-3-1b	Burned Rock	A F15									0
692-3-1b	Burned Rock	A	10		X	3				GL	13X
697-3-2b	Burned Rock	A	3			1				GL	4X
821-3-1b	Burned Rock	A	9			34	GL				43X
821-3-2b	Burned Rock	A	1			5					6
836-3-1b	Burned Rock	A				1			1 cfl		2
857-3-1b	Burned Rock	A				1					1
1031-3-1b	Burned Rock	A	1			7					8
1176-3-1b	Burned Rock	A							5 cfl		5
Chipped Stone											
1047-11	Mod flake	A F10	2						3		5
704-12	Edge mod flake	A							1		1
752-11	Mod flake	A									0

Table D-1. Starch Remains from the Long View Site (cont.).

Sample #	Artifact Type	Provenience Component / Feature	Maize	Cf. Maize	Damaged maize	Lenticular	Damaged Lenticular	Cheno-Am	Unknown	Unidentified Damaged	Total
775-10	Scraper	A				2	GD		1		3X
780-10	Biface	A				2					2
798-10	Scraper	A									0
819-11	Spokeshave	A									0
1004-11	Scraper	A									0
1009-10	Mod flake	A									0
1036-11	Mod flake	A									0
1080-10	Mod flake	A				1					1
1084-10	Hammerstone	A				2					2
1106-12	Uniface	A	1	1		X	clump				2X
Sediment											
1014-4-5a	Sediment	A F13									0
Component C											
Ceramics											
643-8-1	Body Sherd residue	C F6								PR, GL	X
153-8-2	Base sherd V1	C				3			2 cfl		5
177-8-1	Body Sherd V1	C	1			16			3 cfl	GL	20X
308-8-1	Rim sherd V1	C	7			3	X		2		12X
308-8-2	Rim sherd V1	C	24			2			3	GL	29X
308-8-3	Rim sherd V1	C				3	X		1 clump		4X
342-8-9	Body Sherd resd V1	C F18		1		1					2
635-8-1	Rim sherd V2	C F6				1	GL				1X
349-8-1c	Body Sherd V3	C F31	3		X					X	3X
350-8-1	Body sherd V3	C F31				20					20
335-8-1	Body Sherd residue	C	1		X	1				PR, GL	2X
1233-8-1	Body Sherd residue	C				1				GL	1
Ground Stone											
629-12	Mano frag	C F6						X			X
643-12	Abrader	C F6							2		2
671-10	Metate frag	C F6							1		1
1229-11	Mano	C F6				1					1
1229-12	Metate frag	C F6									0

Table D-1. Starch Remains from the Long View Site (cont.).

Sample #	Artifact Type	Provenience Component / Feature	Maize	Cf. Maize	Damaged maize	Lenticular	Damaged Lenticular	Cheno-Am	Unknown	Unidentified Damaged	Total
1231-11	Metate frag	C F6				1			1		2
351-10	Mano	C F30							1		1
191-10	Mano	C	4		X			X			4X
292-10	Metate frag	C							3		3
545-10	Abrader	C							4 small		4
1260-10	Abrader	C									0
1261-10	Metate frag	C							1		1
Burned Rocks											
586-3-2b	Burned Rock	C F6									0
583-3-3b	Burned Rock	C F6	1						1 cfl		2
643-3-11b	Burned Rock	C F6							2 cfm		2
643-3-12	Burned Rock	C F6									0
1229-3-3b	Burned Rock	C F6	3			3		X	1		7X
234-3-1b	Burned Rock	C F20				1					1
234-3-2b	Burned Rock	C F20	8			18	PR		6 cflm		32X
Sediment											
331-4-1a	Sediment	C F23									0
Chipped Stone											
120-11	Mod core frag	C F5				2					2
637-10	Mod flake	C F6									0
639-11	Mod flake	C F6									0
639-12	Mod flake	C F6									0
643-10	Scraper	C F6									0
1229-16	Mod flake	C F6									0
449-10	Mod flake	C F16							1 small		1
468-10	Mod flake	C F16				1			1	X	2X
192-10	Mod flake	C	1			2		X			3X
357-12	Mod flake	C	1		1	1			1	GD	4X
379-10	Mod flake	C	2			1					2
432-10	Mod flake	C									0
577-10	Mod flake	C									0
697-10	Biface	A									0
Totals			105	3	4	405	17	7	134	14	687

Figure D-1. Starch remains recovered from sampled artifacts.

A is Maize starch from Area A “pipe fragment” 11-8-1. B is a lenticular starch grain from the same artifact displaying the edge indentations characteristic of little barley. C is an unidentified starch grain, possibly from a member of the lily family, from Component A sherd #1042-8-1. D is a tiny cheno-am starch grains in a large cluster. The arrow indicates a single grain on the edge of a smaller clump from Component C mano #191-10. The scale bar is 20 microns, and all photomicrographs are of equivalent magnification.

Interestingly, the only occurrence of cheno-am starch on a ceramic vessel at the Long View site occurs here in a rim sherd (#1044-8-1,2). The presence of such tiny starches on the rim may indicate they are more likely to survive at the top of the liquid level in the vessel than in a lower, immersed section.

Several sherds were from features and/or single vessels. The sherd from Feature 1 (#1162-8-1) yielded both maize and little barley starch grains, while the sherd from Feature 13 (#1021-8-1) contained starches from maize, some of which were damaged by unknown processing.

Three sherds from Vessel A were analyzed, and two (#2-8-4 and #58-8-1) yielded the starchy remains of little barley. Gelatinized starches indicate this vessel was used for the cooking of plant foods in an aqueous medium. The sherds from Vessels B and H (#762-8-2 and #1135-8-1) yielded no starches.

A few specialized sherds were also analyzed. The pipe fragment (#1151-10) contained both maize and little barley starches, some of which were gelatinized by heating in the presence of water. This finding may indicate a different use of the original vessel or object than that originally presumed by the excavators. The spindle whorl, or perforated sherd,

yielded a single starch grain from little barley. This starch could be a remnant of the original use of the vessel prior to its breakage and repurposing of the sherd. There was a fragment of plant tissue with circular-bordered pits on the sherd, but I found no cotton fibers. Unfortunately, circular-bordered pits are not particularly diagnostic as they occur in vascular tissues throughout plants.

D.4.1.2 Ground Stone Tools

All six ground stone artifacts from Component A yielded the starchy remains of plant foods. Included in the assemblage were the remains of maize, little barley, cheno-ams and several as yet unidentified starches. Notably, maize starches were relatively rare and did not show any grinding damage in any sample, and little barley dominated the assemblage occurring on all but one examined tool (#1110-10). Grinding damage was noted in the little barley assemblage on two artifacts (#709-10 and #783-10).

One metate fragment (#783-10) had unusually good preservation, and the recovered starches included the small component (see Table D-1) of the little barley starch assemblage. Starches of little barley occur as large, lenticular forms that preserve quite well, and relatively tiny, somewhat spherical forms that rarely occur in archaeobotanical assemblages. It is unclear why the small component survived on this artifact and not on others, but the phenomenon may indicate some process that could be of interest.

D.4.1.3 Burned Rocks

Thirteen burned rocks from Component A were examined, and ten yielded the starchy remains of plant foods. Little barley starches occurred commonly, and maize starches more sporadically throughout the assemblage. The exception to this pattern is a single burned rock (#692-3-1b) with more maize than little barley at ten and three grains, respectively. Whether or not the occurrence of more starch grains from one species indicates a more intensive use is unknown. Experimental work can clarify this issue.

Damaged starches occurred on the rocks, and gelatinization damage from heating in the presence of water was noted on three samples (#692-3-1b, #697-3-2b, and #821-3-1b). Despite a somewhat

widespread assumption that the introduction of pottery into the region ended the practice of cooking with boiling stones, this pattern of starch damage is identical to that recovered from the earlier Pavilion site in the Texas panhandle where boiling stones were the dominant means of preparing food (Perry and Quigg 2011). It is possible that the stones were used for cooking with either ceramic vessels or with other containers made of more perishable materials.

D.4.1.4 Chipped Stone Tools

The assemblage of chipped stone tools from Component A yielded small numbers of starch grains, and a little more than half of the samples, 7 of 13, yielded plant remains. Little barley occurs most commonly in the samples followed by cheno-ams and then maize. One scraper (#775-10) yielded gelatinized starch, an indicator of cooking. It is possible that this tool was used either to process cooked plant foods, or it was employed in the cleaning of other tools that had been used to heat plant foods in the presence of water.

D.4.1.5 Control Sediment Sample

The control sediment contained no starch remains. Thus, the starches recovered from this area can be assumed to be culturally derived and associated with the use of the artifacts.

D.4.2 Component C

D.4.2.1 Ceramic Sherds

All twelve ceramic sherds from Component C yielded starch grains. The remains of maize, little barley, and several unknowns were recovered, and damage from processing including grinding and cooking in the presence of water were noted. As in Component A, it appears that the vessels were used for the cooking of plant foods including little barley flour. Unlike in Component A, two of the sherds yielded unidentified starches that appear to have been parched, or heated without water (#643-8-1 and #335-8-1).

Sherds from three distinct vessels were analyzed. Vessel 1 yielded starchy remains from maize, little barley, and unidentified plants. The three rim sherds from Vessel 1 (#308-8-2) yielded the largest quantity of maize starches of any sample of any artifact from

the entire site. The rim sherd from Vessel 2 (#635-8-1) was not as prolific a producer of plant remains yielding only a single grain of little barley. Vessel 3, like Vessel 1, contained the remains of both maize and little barley, and unidentifiable processing damage was noted in the assemblage. Vessels 1 and 2, in contrast, yielded starches that were clearly gelatinized by cooking in the presence of water.

The pipe fragment from Component C (#11-8-1) yielded a large number of starch grains from maize and little barley, some of which were damaged by parching and grinding. Gelatinization, or cooking in the presence of water, was also noted in starches that had become too distorted to identify. This small sherd yielded one of the largest assemblages of starch grains of any artifact from Long View, and, with the evidence for cooking taken into account, may not be a pipe fragment, but a sherd from a cooking vessel.

D.4.2.2 Ground Stone Tools

Nine of the ten ground stone artifacts from Component C yielded starch remains. The numbers, however, are quite small when compared with those from the artifacts in Component A. It is not known if the difference is one of preservation conditions or one of intensity of use. Like in Component A, the assemblage of plant remains from the ground stone artifacts includes maize, little barley, cheno-ams, and unidentified starches.

While there appear to be differences between the samples from Feature 6 and Feature 30, it is difficult to assess if they are meaningful because of the small sample size. Maize and cheno-am starches did not occur on the single ground stone tool from Feature 30, but did occur on two from Feature 6. Otherwise, the assemblages are consistent with one another.

Three abraders were included in this assemblage, and two (#545-10 and #643-12) yielded tiny starch grains, one assemblage of which is clearly derived from cheno-ams. The hypothetical use of these tools is to abrade wood for arrow shafts. The microbotanical analyses do not support this hypothesis, as no woody tissues were recovered from the artifacts. It is possible that these grooved stones were used to harvest seed heads from the tops of stems.

D.4.2.3 Burned Rocks

Five of the seven burned rocks from Component C yielded the starchy remains of plants and one (#243-3-2b) contained evidence for parching, or heating in the absence of water. Like in the ground stone assemblage, the numbers of starch grains are fewer than those in Component A. Further, while the burned rocks from Component A appear to have been employed as boiling stones, no gelatinized starches were recovered from those in Component C. Evidence of parching, however, was recovered.

D.4.2.4 Chipped Stone Tools

In comparison with the other classes of artifacts that were sampled for starch remains, like in Component A, the chipped stone tools from Component C yielded fairly small quantities of plant remains, and fewer than half the samples, 5 of 14, yielded starches at all.

Generally speaking, the plant assemblage follows that recovered from other classes of artifacts with maize, little barley, cheno-am, and unidentified starches occurring through the samples. Little barley occurs most commonly followed by maize and then cheno-ams. When considered with the assemblage from Component A, the vast majority of chipped stone tools with starchy remains are simple modified flakes followed by a core, a scraper, a uniface, and a bifacial tool. These tools may have been used to harvest or scrape grain from the stalks or cobs of plants.

D.4.2.5 Control Sediment Sample

The control sediment contained no starch remains. Thus, the starches recovered from this area can be assumed to be culturally derived and associated with the use of the artifacts.

D.4.3 Interesting Patterns in the Archaeobotanical Assemblages

D.4.3.1 Ceramic Sherds

The relatively large numbers of sherds analyzed for this study allow for an analysis of the reliability of rim sherds verses body sherds for the recovery of starch remains. While there have not been any

experiments published at this time, it is generally believed that residues will accumulate at the top of a vessel where the surface of the liquid occurs. This “bathtub ring” of residue would, at least hypothetically, contain more starch grains than the lower levels of the vessel would.

To examine this hypothesis, sherds that were positively identified as either body or rim types were grouped, and both the frequency of recovery of starch remains and the numbers of starch grains were examined. While rim sherds occur less frequently in archeological assemblages than body sherds do, and, therefore, the sample size of rim sherds is much smaller than that of body sherds, an interesting pattern does emerge when the data are analyzed (Table D-2). Rim sherds are not only more likely to produce identifiable starchy residues, they also yield more than two times the numbers of starch grains per sherd.

Further analysis of sherds in future studies will assist in testing the hypothesis that rim sherds are better producers of starchy residues. In the meantime, researchers with limited budgets of time and/or funds may wish to maximize results by including all rim sherds in the analyzed samples.

D.4.3.2 Plant Use and Occurrence of Remains

The majority of plant remains in the starch record also occur in the macrobotanical record. These plants include maize and the cheno-ams. There are two interesting trends in the archaeobotanical data, however, that merit further discussion. First, while lenticular starches from little barley dominate the starch assemblage, they are absent from the macrobotanical record. Little barley starches with distinctive grinding damage were also recovered from the site. Second, maize occurs commonly in the macrobotanical record, but is rare on both ground stone tools and ceramic sherds in the starch assemblage. Maize starches with unidentifiable damage were recovered, but none that were clearly processed by grinding were found. I will discuss the barley first.

There are two major possible scenarios that could explain the lack of little barley in the macrobotanical

record. It could simply be a consequence of the recovery method. The macrobotanical analyst, however, indicates that the screen in the bottom of the flotation tank was of small enough mesh to capture these seeds. Therefore, it is also possible that the patterning of botanical residues explains the use of the plant at the site.

The starchy remains of barley occur on grinding stones, and lenticular starch grains with grinding damage occur in some of the ceramic cooking vessels. If the grain was typically ground prior to cooking, there would be little chance for intact grains to become accidentally charred, deposited on site, and preserved in the archaeobotanical record. While it is difficult to argue for the absence of evidence being evidence of absence, in this case the preponderance of data indicate a preference for using little barley as a source of flour at the Long View site.

The remains of maize, in contrast, occur in a pattern that is almost the opposite of that of the little barley starches. Maize starch occurs rarely on grinding stones, and is common only in a single ceramic vessel, #1 from Component C. It is the experience of the author that when maize is used for flour at a site, the remains are ubiquitous and dominate the assemblage. I have seen this pattern in southwestern U.S. sites as well as several in South America.

Thus, maize may not have been ground for flour at the site, but may have been prepared in other ways, such as popping. The thick body of Vessel 1 would allow it to withstand the high heat necessary for popping maize, and the constricted rim would catch most wayward flying kernels and keep them in the vessel. The popcorn hypothesis is further supported by the types of maize starch recovered at the site. Angular forms typical of a hard endosperm were present, and the rounded forms found in floury endosperm were absent. Popcorns have hard endosperm and little to no floury endosperm, while flour corns have the opposite distribution.

In sum, the distribution of the remains of these two important crop plants in this manner may indicate that the indigenous grains continued to be used for flour even after the introduction of maize into the region. While this is just one site, the data do present

Table D-2. Analysis of Starch Remains from Rim Verses Body Sherds.

Columns indicate the numbers of sherds analyzed, percentages of analyzed sherds that yielded starch grains, and the average numbers of grains per sherd.

	# Rim	Rim %	Rim #s	# Body	Body %	Body #s
Component A	5	80	13.5	18	67	4.25
Component C	4	100	11.5	8	88	7.57
Combined	9	89	12.5	26	73	5.47

an interesting hypothesis that the first maize to enter the area may have been popcorn.

D.5 Conclusions

The major plant foods being exploited at the site were little barley, maize, cheno-ams, and a few as yet unidentified taxa. With the exception of the little barley, the starch record is supplemented by the data from the macrobotanical analysis.

The starch record provides evidence for the harvesting or scraping of grain and seed crops with chipped stone tools, the grinding of little barley and cheno-ams with ground stone artifacts, and the cooking of the flour in ceramic vessels in an aqueous medium, possibly with boiling stones in Component A.

The maize from the Long View site appears to be popcorn. This conclusion is drawn from the distribution of the starch grains in the artifact assemblage as well as the consistent appearance of hard endosperm types and lack of floury morphologies.

In sum, indigenous plants, including little barley, appear to have been used for food at the Long View site and these native plants were supplemented by the exotic maize, possibly in the form of popcorn.

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APPENDIX E

SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS AND ELEMENTAL ANALYSIS OF TWO SHELL BEAD ARTIFACTS FROM THE LONG VIEW SITE (41RB112), CANADIAN RIVER VALLEY, NORTH WESTERN TEXAS

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E.1 Introduction

The analysis here of 49 obsidian artifacts from the Long View Site indicates that they were all produced from the Cerro Toledo Rhyolite obsidian source in the Valles Caldera, Jemez Mountains, and northern New Mexico. The two bead samples are comprised nearly entirely of calcium (calcium carbonate) based on the qualitative analysis.

E.2 Analysis and Instrumentation

All archaeological samples are analyzed whole. The results presented here are quantitative in that they are derived from “filtered” intensity values ratioed to the appropriate x-ray continuum regions through a least squares fitting formula rather than plotting the proportions of the net intensities in a ternary system (McCarthy and Schamber 1981; Schamber 1977). Or more essentially, these data through the analysis of international rock standards, allow for inter-instrument comparison with a predictable degree of certainty (Hampel 1984).

The trace element analyses were performed in the NSF Geoarchaeological XRF Laboratory, Department of Anthropology, University of California, Berkeley, using a Thermo Scientific *Quant’X* energy dispersive x-ray fluorescence spectrometer. The spectrometer is equipped with a ultra-high flux peltier air cooled Rh x-ray target with a 125 micron beryllium (Be) window, an x-ray generator that operates from 4-50 kV/0.02-1.0 mA at 0.02 increments, using an IBM PC based microprocessor and WinTrace™ 4.1 reduction software. The spectrometer is equipped with a 2001 min⁻¹ Edwards vacuum pump for the analysis of elements below titanium (Ti). Data is acquired through a pulse processor and analog to digital converter. This is a significant improvement in analytical speed and efficiency beyond the former Spectrace 5000 and *QuanX* analog systems (see Davis et al. 2011; Shackley 2005). For samples over 10 mm in smallest diameter, a 8.8 mm tube collimator is used. If the samples are smaller, a 3.5 mm tube collimator is substituted to concentrate emitted x-rays into a smaller pattern (see Shackley 2011).

For Ti-Nb, Pb, Th elements the mid-Zb condition is used operating the x-ray tube at 30 kV, using a 0.05 mm (medium) Pd primary beam filter in an air path

at 200 seconds livetime to generate x-ray intensity K α_1 -line data for elements titanium (Ti), manganese (Mn), iron (as FeT), cobalt (Co), nickel (Ni), copper, (Cu), zinc, (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), niobium (Nb), lead (Pb), and thorium (Th). Not all these elements are reported since their values in many volcanic rocks is very low. Trace element intensities were converted to concentration estimates by employing a least-squares calibration line ratioed to the Compton scatter established for each element from the analysis of international rock standards certified by the National Institute of Standards and Technology (NIST), the U.S. Geological Survey (USGS), Canadian Centre for Mineral and Energy Technology, and the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994). Line fitting is linear (XML) for all elements but Fe where a derivative fitting is used to improve the fit for iron and thus for all the other elements. When barium (Ba) is acquired, the Rh tube is operated at 50 kV and 0.5 mA in an air path at 200 seconds livetime to generate x-ray intensity K α_1 -line data, through a 0.630 mm Cu (thick) filter ratioed to the bremsstrahlung region (see Davis et al. 1998). Further details concerning the petrological choice of these elements in North American obsidians is available in Shackley (1988, 1990, 1995, 2005; also Mahood and Stimac 1991; and Hughes and Smith 1993). A suite of 17 specific standards used for the best fit regression calibration for elements Ti- Nb, Pb, and Th, include G-2 (basalt), AGV-2 (andesite), GSP-2 (granodiorite), SY-2 (syenite), BHVO-2 (hawaiiite), STM-1 (syenite), QLO-1 (quartz latite), RGM-1 (obsidian), W-2 (diabase), BIR-1 (basalt), SDC-1 (mica schist), BCR-2 (basalt), TLM-1 (tonalite), SCO-1 (shale), all US Geological Survey standards, NBS-278 (obsidian) from the National Institute of Standards and Technology, BE-N (basalt) from the Centre de Recherches Pétrographiques et Géochimiques in France, and JR-1 and JR-2 (obsidian) from the Geological Survey of Japan (Govindaraju 1994).

For the two bead samples, a qualitative scan of the Low Zc x-ray spectrum was acquired to determine the presence of calcium (Appendix). The instrument is operated at 12 kV and 1.98 mA for 12 to 34 live seconds.

The data from the WinTrace software were translated directly into Excel for Windows and into SPSS for statistical manipulation (Table O-1). In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run (Table O-1). RGM-1 is analyzed during each sample run for obsidian artifacts to check machine calibration (Table O-1). Source assignments made by reference to source data at Berkeley and Shackley (1995, 2005).

E.3 Discussion

Before a discussion of the source provenance of the samples, a short discussion of the Jemez Mountains sources is in order. Following this is a short discussion of the samples proper.

E.3.1 The Jemez Mountains and the Sierra de los Valles

A more complete discussion of the archaeological sources of obsidian in the Jemez Mountains is available in Shackley (2005:64-74). Distributed in archaeological contexts over as great a distance as Government Mountain in the San Francisco Volcanic Field in northern Arizona, the Quaternary sources in the Jemez Mountains, most associated with the collapse of the Valles Caldera, are distributed at least as far south as Chihuahua through secondary deposition in the Rio Grande, and east to the Oklahoma and Texas Panhandles through exchange. And like the sources in northern Arizona, the nodule sizes are up to 10 to 30 cm in diameter; El Rechuelos, Cerro Toledo Rhyolite, and Valles Rhyolite (Valles Rhyolite derived from the Cerro del Medio dome complex) glass sources are as good a media for tool production as anywhere. Until the recent land exchange of the Baca Ranch properties, the Valles Rhyolite primary domes (i.e., Cerro del Medio) have been off-limits to most research. The discussion of this source group here is based on collections by Dan Wolfman and others, facilitated by Los Alamos National Laboratory, and the Museum of New Mexico, and recent sampling of all the major sources courtesy of the Valles Caldera National Preserve (VCNP; Shackley 2005; Wolfman 1994).

There are at least four eruptive events in the last 8.7 million years that have produced the four chemical

groups in the Jemez Mountains (Figure O-1).

The earliest is the Bear Springs Peak source, part of Canovas Canyon Rhyolite that is dated to about 8.7 mya, firmly in the Tertiary (Kempter et al. 2004; Figure O-1 here). This source is a typical Tertiary marekanite source with remnant nodules embedded in a perlitic matrix. It is located in a dome complex including Bear Springs Peak on Santa Fe National Forest and radiating to the northeast through Jemez Nation land (Shackley 2009a). While the nodule sizes are small, the glass is an excellent media for tool production and has been found archaeologically at Zuni and in secondary deposits as far south as Las Cruces (Church 2000; Shackley 2009a).

The second relevant eruptive event that produced artifact quality obsidian is the El Rechuelos Rhyolite. This source, present as one sample here, is what I consider the best media for tool production of the group. It dates to about 2.4 million years ago, and nodules at least 10 cm in diameter are present in a number of domes north of dacite Polvadera Peak, the incorrect vernacular name for this source. El Rechuelos has eroded through the Rio Chama into the Rio Grande and has also been found in alluvium into southern New Mexico (Church 2000).

About 1.4 mya, the first caldera collapse occurred in the Jemez Mountains, called Cerro Toledo Rhyolite, the obsidian used to produce the stone artifacts in this assemblage (Figure O-2). This very large event produced the Bandelier Tuffs and spread ash flows many kilometers into the area and horizontally southwest from what is now Rabbit Mountain and the Cerro Toledo domes to the east. These large ash flow sheets are responsible for the great quantity of Cerro Toledo obsidian that is present in the Quaternary Rio Grande alluvium all the way to Chihuahua (Church 2000; Shackley 2005, 2010). While Cerro Toledo Rhyolite is present in the Rio Grande alluvium, many of these artifacts are very angular with abundant spherulites suggesting that the obsidian was originally procured at the primary source.

The second caldera collapse, that produced the Valles Rhyolite member of the Tewa Formation, called Valles Rhyolite here, occurred around one

Figure E-1. Generalized stratigraphic relations of the major volcanic and alluvial units in the Jemez Mountains (from Gardner et al. 1986).

Note the near overlapping events at this scale for the Cerro Toledo and Valles Rhyolite members, and the position of Cerro Toledo Rhyolite at the upper termination of the Puye Formation.

million years ago and created most of the geography of the current Valles Caldera. A number of rhyolite ring domes were produced on the east side of the caldera, but only Cerro del Medio produced artifact quality obsidian. Indeed, the Cerro del Medio dome complex produced millions of tons of artifact quality glass, and is the volumetrically largest obsidian source in the North American Southwest challenged only by Government Mountain in the San Francisco Volcanic Field. This source was apparently preferred by Folsom knappers, as well as those in all periods since. While Cerro Toledo probably appears in archaeological contexts in New Mexico sites with greater frequency, it is likely because it is distributed in secondary contexts. Valles Rhyolite (Cerro del Medio), present as one sample here importantly does not erode outside the caldera, and had to be originally procured in the caldera proper (Shackley 2005). While Valles Rhyolite is often present in Texas Panhandle sites, it is absent in this collection.

E.3.2 Source Provenance Discussion

Most of these artifacts analyzed produced from Cerro Toledo Rhyolite exhibit angular cortex when present and abundant spherulites. This is typical of much of the Cerro Toledo Rhyolite obsidian at the source, but secondary deposits of this obsidian are typically water worn and the spherulites absent due to frequent breaking and release in the stream basin. This suggests to me that the cores used to produce these artifacts were originally procured at the primary domes either Cerro Toledo or Rabbit Mountain, nearly 500 linear kilometers west of the Long View site. Also, I noticed that both the translucent and opaque black varieties are present in the assemblage indicating that there were at least two cores used to produce this debitage or any artifacts from those cores.

E.4 Shell Beads

A qualitative scan of the two beads (one fragment) was used to detect the potential presence of calcium,

Figure E-2. Niobium (Nb) versus Yttrium (Y) biplot of the archaeological specimens and source standards from Cerro Toledo Rhyolite (Cerro Toledo and Rabbit Mountain), Jemez Mountains, New Mexico.
All measurements in parts per million (ppm).

the major component of marine shell (Krinsley and Bieri 1959; Appendix here, Figures O-3 and O-4). Carbon, the other element in the compound calcium carbonate is not detectable with XRF. These two beads are certainly shell, and likely marine shell beads.

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**Table E-1. Elemental Concentrations for the Archaeological Specimens and the USGS
RGM-1 Standard.**
All measurements in parts per million (ppm).

Sample	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
32	519	10985	200	10	59	173	92	Cerro Toledo Rhy
48	508	10471	201	8	60	172	90	Cerro Toledo Rhy
73	525	10878	216	10	67	175	97	Cerro Toledo Rhy
683	599	11919	241	10	71	181	100	Cerro Toledo Rhy
686	499	10426	204	9	60	165	93	Cerro Toledo Rhy
692	481	10249	202	10	64	170	95	Cerro Toledo Rhy
697	452	10097	192	10	60	166	92	Cerro Toledo Rhy
698	489	10247	205	9	64	172	95	Cerro Toledo Rhy
700	507	10717	209	8	65	175	102	Cerro Toledo Rhy
701	501	10539	208	8	58	168	92	Cerro Toledo Rhy
702	457	10111	192	9	61	166	88	Cerro Toledo Rhy
708	494	10506	196	8	62	168	87	Cerro Toledo Rhy
731	495	10237	204	9	63	178	97	Cerro Toledo Rhy
765	505	10487	203	8	59	170	89	Cerro Toledo Rhy
799	482	10203	202	9	64	167	99	Cerro Toledo Rhy
843	496	10622	209	8	67	177	98	Cerro Toledo Rhy
845	486	10326	203	8	60	164	99	Cerro Toledo Rhy
888	602	12118	213	8	58	165	89	Cerro Toledo Rhy
905	507	10496	208	8	66	181	101	Cerro Toledo Rhy
935	501	10451	200	9	67	167	95	Cerro Toledo Rhy
955	519	10846	220	11	67	171	98	Cerro Toledo Rhy
961	485	10230	203	11	61	165	91	Cerro Toledo Rhy
964	522	10620	198	8	62	162	88	Cerro Toledo Rhy
965	472	10159	188	8	60	156	87	Cerro Toledo Rhy
972	491	10187	202	8	65	169	99	Cerro Toledo Rhy
977	454	10253	186	12	53	164	87	Cerro Toledo Rhy
979	491	10462	206	10	63	171	95	Cerro Toledo Rhy
981	492	10301	196	9	62	164	95	Cerro Toledo Rhy
983	499	10321	209	8	62	173	95	Cerro Toledo Rhy
988-1	511	10655	205	8	63	168	93	Cerro Toledo Rhy
988-2	482	10262	199	8	63	167	93	Cerro Toledo Rhy
998	513	10518	204	8	59	167	90	Cerro Toledo Rhy
1004	537	11252	223	11	69	176	95	Cerro Toledo Rhy
1005	484	10063	204	9	64	171	100	Cerro Toledo Rhy
1014	524	10779	208	9	60	165	92	Cerro Toledo Rhy
1016-1	489	10417	202	11	62	169	89	Cerro Toledo Rhy
1016-2	490	10469	200	10	67	164	92	Cerro Toledo Rhy
1021	501	10204	204	8	62	170	96	Cerro Toledo Rhy

Table E-1. Elemental Concentrations for the Archaeological Specimens and the USGS RGM-1 Standard (cont.).

All measurements in parts per million (ppm).

Sample	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
1026	618	12242	227	9	64	169	89	Cerro Toledo Rhy
1039	474	9934	198	8	64	163	93	Cerro Toledo Rhy
1040	485	10349	205	11	62	167	91	Cerro Toledo Rhy
1061	488	10328	210	8	61	174	101	Cerro Toledo Rhy
1084	500	10322	202	8	61	164	93	Cerro Toledo Rhy
1087	454	9973	189	10	58	159	91	Cerro Toledo Rhy
1110	482	10201	199	9	61	173	94	Cerro Toledo Rhy
1116	474	10379	199	8	60	164	87	Cerro Toledo Rhy
1125	618	12065	212	9	57	152	87	Cerro Toledo Rhy
1126	527	10476	211	11	67	168	97	Cerro Toledo Rhy
1251	540	11098	202	10	65	173	97	Cerro Toledo Rhy
RGM1-S4	296	13165	148	108	26	218	8	Standard
RGM1-S4	268	13173	148	107	23	215	8	Standard

APPENDIX

Spectral analysis of two bead samples showing large Ca peak. Elements Ar and Te artifacts of the analysis in path.

Figure E-3. A qualitative scan of shell bead (#580-1) showing presence of calcium, the major component of marine shell.

Figure E-4. A qualitative scan of shell bead (#1032-10) showing presence of calcium, the major component of marine shell.

APPENDIX F

ANALYSIS OF PLAINS VILLAGE SITE CERAMICS FROM THE PANHANDLES OF TEXAS AND OKLAHOMA

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F.1 Introduction

A petrographic analysis was performed on 86 ceramic sherds and 11 clay/sediment samples from 16 excavated sites in the Texas and Oklahoma panhandles in 2011. The primary analytic method was qualitative thin section analysis, which identified the paste traits and rocks and minerals present. The principal research questions regarded source localities of clays and ceramic resources, the geographic scale of earthenware ceramic production, and the identification of ceramic trade and transport. Findings are intended to provide clearer reconstructions of the Plains Village period of the southern High Plains.

F.2 Methods

F.2.1 Qualitative Thin Section Analysis

The principal method of the analysis is the identification of rock fragments, minerals and paste structures following the approach to ceramic petrographic analysis pioneered in archeology by Shepard (1942, 1976). Chayes' (1949) method of point-counting thin section particles and materials was modified by making visual estimates of proportions of mineral bodies by reference to a set of visual standards of percentage coverage of observational fields (Folk 1951; Terry and Chilingar 1955). This procedure approximated the results of point counting, deemed prohibitively time-consuming on this larger scale of analysis. The method is also qualitative as opposed to quantitative. National Petrographic Service, Inc., of Houston, Texas, prepared the thin sections. The thin section preparation included impregnation with blue resin, staining for carbonates and feldspars, on an uncovered 27 x 46 mm slide, which also had a reference number etched into it. The microscopic analysis was performed at the Texas Archeological Research Laboratory, microscopy lab, on an Olympus BH-2 stereographic polarizing microscope with a rotating stage.

Recorded attributes of the ceramic thin sections included the ceramic fabric matrix, or paste; pore space, or voids; color and isotropy of the matrix; and all discrete bodies of rock fragments or minerals. Additional information such as grain size range and angularity (Powers 1953) was written on the record

page for potential future reference. The Wentworth (1922, 1933) particle size classification scale is used throughout this study.

An additional component of the research was experimental and comparative rather than strictly analytic. A sample of local and regional clay sources was collected for comparison with aboriginal ceramics. Local tempering material was ground and added to the clays in known volumes. The mixed samples were fired to known temperatures, either 450°C or 650°C. By this design, variables of clay, tempering agent, and two firing temperatures were available for comparison with the prehistoric ceramics. The mixed and fired clays were ground and prepared for thin sections so that the comparisons could be made petrographically at the same 100X magnification as the prehistoric thin sections. The comparative observations are reported in section F.5.2.

F.2.2 Paste Groups

Paste groups are based on the properties of ceramic pastes identified in the thin sections. Upon completion of the microscopy, paste groups were defined in the studied sections from the observed traits. Of primary importance were paste color and isotropy, followed by tempering agents and their abundance, pore space and minor minerals and bodies resident in the paste. Because paste groups are based in technology and ceramic resources, they allow wider intersite comparisons with paste groups likewise defined on a petrological basis. Paste groups may or may not match groupings identified on a typological basis.

F.2.3 Observational Conventions and Glossary

Granular rock fragments were common components of the sections. The rock minerals commonly comprise granite (quartz, feldspars and biotite), but as these rocks are commonly reduced in size as part of the ceramic manufacturing process, the rocks were designated Rock A, Rock B, etc, their petrology termed granitic rather than granite. The particles in the thin sections lacked standard dimensions that would affirmatively determine their rock classifications, so it was thought better to avoid unsupportable assumptions about petrogenesis.

Additional terms and concepts are explained in the following glossary. Most of the terms refer to the mineral and particle terms used on Table F-1 and in following sections and state how the terms are used throughout this study. Additional terms provide useful background for using and understanding these petrographic data.

1. **Paste and matrix.** Used interchangeably here, a ceramic **paste** is the mix of ceramic ingredients, usually used to describe the material before firing. A ceramic **matrix** is the body of ceramic materials as it exists stably after firing; sometimes this context of the term excludes the solid particles.

2. **Matrix density.** An optical measure of the paste useful for comparisons. Matrix density is a description of the apparent solidity of the paste material in the microscopic view and the consistency of its coverage of the ceramic material of the thin section. Any ceramic matrix appears interrupted to varying degrees by the voids and aplastic inclusions of the section. The greater the interruptions the lower the density. The descriptions used in this study, from high to low density, are massive, very dense, dense, moderate, light, thin and minimal.

3. **Isotropy and Isotropism.** Literally, the same response or reaction. **Isotropic** minerals respond to transmitted light in the same way through the crystal. Light propagates through them equally without obstruction. **Anisotropic** minerals inhibit or obstruct the passage of light through them in different directions. These differences stem from properties of the crystalline structure. Anisotropic minerals on the microscope stage shift in appearance from light to dark or from one color to another and back again when the microscope stage is rotated through a few degrees. Isotropic minerals under cross-polarized light remain dark and undeviating through all degrees of rotation. This distinction is a simple dichotomous test of difference in ceramic clay pastes, and it was recorded for the collection. On the tables and in the text, plane-polarized light is denoted by ppl, and cross-polarized light is denoted by xpl.

4. **Voids/pores.** Any and all gaps in the ceramic material. They are responsible for the trait of porosity in earthenware ceramics and have a complex relationship to permeability. High porosity may yield low permeability; conversely, a pattern of few pores (low porosity) communicating regularly with the surface of the ceramic may produce high permeability. Voids derive ultimately from the physico-chemical interactions of clays in a ceramic matrix and take final form in the cooling phase of the ceramic firing sequence (Shepard 1976:125-130). In the Roberts County collection they appear in the thin sections most commonly as jagged strips aligned parallel to the edges of the sherd. Few of them communicate with the edges. Typically the jagged strips may extend to lengths of 0.4 to 0.5 mm within the paste. They may also assume irregular shapes.

5. **Aplastic inclusions.** Any solid particle in a ceramic matrix. Includes minerals, rocks, plant and animal parts.

6. **Common Quartz.** Single-grain quartz, having many sources. Also called monocrystalline quartz.

7. **Composite Quartz.** Multiple-grain quartz, having a distinct suture pattern where the grains are joined in the composite. Composite quartz usually has origins in the formation of igneous rocks or from coming under the effects of metamorphism. Also called polycrystalline quartz.

8. **Resident quartz and residents.** Resident quartz is present, or residing, in the clay material naturally, before collection. This applies to any mineral naturally occurring in a deposit. In an earthenware clay paste the residents most commonly are silt-, very fine sand- or fine sand-sized particles. As used here, resident quartz is the silt-, fine sand- or fine sand-sized fraction of quartz in the section. Larger-sized fractions of common quartz or composite quartz are reported separately. They may be the same mineralogically, but have entered the clay as additives.

9. **Iron opaques.** A common mineral form of iron is **hematite**; the mineral is isotropic, or dark and opaque, under plane-polarized light (ppl) and cross-polarized light (xpl). **Ferrous hematite** has iron ions with a valence of ++, while **ferric hematite** has a valence of +++; both forms are isotropic.

10. **Feldspars.** Feldspars are the most common family of minerals forming volcanic rocks other than quartz. Feldspars are divided fundamentally between plagioclase and alkali feldspars on the basis of proportions of calcium (**plagioclase**) or sodium and potassium (**alkali feldspars**) attached to the silicate molecule (Deer, Howie and Zussman 1980:281-284). Plagioclase, or **plag**, is the common term for several closely related minerals. Common alkali feldspars, or **K-spar**, are **orthoclase**, **microcline** and **sanidine**. The specific feldspar formed is determined by temperature and pressure and the relative abundance of calcium, sodium and potassium in the magma. Feldspars are stable after formation and also form as alteration products in surface rocks. They are the most common mineral in sands after quartz.

11. **Granite and Granular rocks.** Granite is a granular igneous rock composed of varying conjoined minerals in crystals, or grains, each potentially ranging from 1 to 5 mm in overall size. A common combination of minerals in granite is alkali feldspar, quartz, biotite, and other micas. These always take the form of discrete grains joined together, hence the term granular rocks. They have wide variations in their composition and environments of formation. See above for naming conventions and cautions in naming granular rocks.

12. **Basalt.** A non-granular, or **aphanitic**, igneous rock. Also called an **extrusive**, or lava, these rocks form by cooling from hot, liquid lavas extruded onto the earth's surface from volcanic vents or fissures. The mass of the material is called the **groundmass**, within which crystals form, called **phenocrysts**. In basalt, these phenocrysts are necessarily various feldspars, but other crystals may form

in the groundmass as well, notably pyroxene. **Rhyolite** is another aphanitic rock, of differing composition; its phenocrysts are commonly quartz, pyrite and others.

13. **Igneous.** Born in fire. Igneous rocks form a very large class of rocks and minerals derived from magma in magma chambers deep within the earth. Their compositions vary immensely, depending on the mix of elements in the magma chamber and the circumstances of their cooling and solidifying after flowing out or being expelled from the chamber. A basic distinction of igneous rocks is whether they are cooled slowly within the earth, or **intrusive** (granites and other granular rocks); or cooled rapidly at the earth's surface, or **extrusive** (basalt and other aphanitic rocks). In the collection, extrusive volcanic rocks other than basalt and rhyolite are denoted as AVRFA, B, etc. **Volcanics** and **volcanic rock fragments** are synonyms used freely here, although technically volcanics are limited to extrusive igneous rocks. Igneous rocks, including granular rocks and related minerals, are typical members of the regional unconsolidated deposits, notably the widespread Ogallala Formation (Frederick, Chapter 6.0 this study). They reflect cycles of erosion wherein they were eroded from the outcrops in which they were formed and redeposited as materials in alluvial and other deposits throughout the region. Altogether, they are common constituents of the regional earthenware ceramics.

14. **Muscovite, biotite, and chlorite.** These are all members of the mica family. They have platy structure and are very common in nature and readily distinguished in plane-polarized and cross-polarized light. They are considered igneous because they form in granitic rocks as they cool from magmas. They also form as accessory minerals in rocks as they begin to erode and as companion minerals and residents in clays formed from volcanic rocks. Their many environments of formation readily explain their common occurrence (Deer, Howie and Zussman 1980:193-216). In thin sections

they are easily identified by higher value color and by cylindrical, rod-like and spicule shapes. As residents they may be visible in medium silt sizes (very small).

15. **Pyroxenes.** Pyroxene denotes a family of similar minerals commonly occurring in granular igneous rocks such as those observed in the Roberts County collection (Hurlbut and Klein 1977:371-376). They are silicates structured with ferromagnesian minerals, especially iron and magnesium. They are taxonomically similar to the amphiboles but with significant crystallographic differences.

16. **Carbonates.** A large class of rocks and minerals formed largely by various forms of calcium carbonate. **Calcite** is one mineral form of calcium carbonate. **Limestone** describes a large sub-family of carbonates, formed under marine conditions from shells and casts of marine animals and calcium carbonate derived from them. Caliche is calcium carbonate formed variously in soils and other deposits on dry land.

17. **Bone.** Crushed bone used to temper ceramics produces distinctive pastes. Bone material is readily identified because it retains its pore structure, the Haversian canals, no matter how small the particle. Bone is also isotropic, appearing black and featureless in xpl. In general, bone applied to ceramics is from large vertebrates; finer taxonomic distinctions may be discernible with future technological research.

F.2.4 Paste Groups

The defining characteristics of the paste groups identified here are:

1. Paste traits
2. Tempering agents
3. Minor minerals resident or residual in the original clay.

The significant paste traits recorded in the collection are:

- Color in plane (ppl) and cross-polarized light (xpl)
- Isotropism
- The general amount, or apparent density, of the ceramic paste in the optical view.

Given the unreliability of taking Munsell color readings through microscope optics, all the color terms listed here are the conventional colors known to the analyst, reported as consistently as possible. Isotropism refers to the general optical property of light passing through a mineral, as defined above. Clay particles are too small to see at most optical magnifications lower than those of the scanning electron microscope. Distinguishing isotropism is a simple dichotomous test to identify differences in mineralogy of clay minerals, otherwise difficult to address on an optical, thin section basis. The general amount of ceramic paste, termed here matrix density, is in comparison to the voids and solid particles that share its field of view. When voids and particles are few, the matrix appears continuous and dense. Larger amounts of voids and particles interrupt the continuity of the paste and give it a thin, intermittent or streaked appearance. Categorizing matrix density is therefore a way of comparing clay paste mixtures and firing characteristics. Terms used here to describe the general appearance of the paste are massive, very dense, dense, moderate, medium, light and thin on a scale from greatest amount of paste to least.

F.3 TEMPERING AGENTS

Tempers, or tempering agents, are solid particles (aplastic inclusions) mixed into ceramic pastes to buffer thermal shock in firing. The temper allows the vessel to survive the firing without cracking, warping or shattering. The identification of the tempering agents in the collection follows the arguments of Rice (1987). In essence, the largest particles in the section in comparison to other resident particles and minor minerals comprise the tempering agent or agents.

F.3.1 Minor Minerals

Minor minerals are so termed because they are generally the smallest aplastic inclusions in the ceramic paste and do not usually serve tempering

Table F-1. Petrography Data on Individual Sherds.

Site/Sample No.	Paste Group	Paste Attributes					Quartz		Igneous										Hematite	Granular Rocks			Carbonates		Meta morphic	Bone					
		Matrix Color (plain-polarized light)	Matrix Color (cross-polarized light)	Isotropy	Voids (%)	Matrix Density	Quartz Resident (%)	Quartz Common (%)	Quartz Composite (%)	Chert (%)	Plagioclase (%)	Orthoclase (%)	Microcline (%)	Basalt (%)	Basalt/pyrx (%)	Pyroxene (%)	Rhyolite (%)	Biotite (%)	Muscovite (%)	Iron Opaques (%)	Rock A (%)	Rock B (%)	Rock C (%)	AVRF (%)	VRFB ₂ (%)	Limestone (%)	Caliche (%)	Schist (%)	Bone (%)	Unknown/Rare (%)	
RB112																															
RB112 1223-8-1	A	dk. Red-brown	black	iso	1	massive		5-7	1-3		1-2	1-3							1	tr.						1-2					
RB112 1119-8-1	A	medium brown	reddish brown	iso	few	massive		7-10	1-2		1	1								2-3						tr.	tr.				
RB112 2-8-6	B	reddish-brown	golden brown	aniso	15	dense		3-5	1-2	1-2	1-2	3-5						tr.	tr.	2-5											
RB112 1140-8-1	B	greenish brown	golden brown	aniso	few	massive		3-5	1		1-2		1-2					tr.	1	3-5						1	2-3				
RB112 1175-8-1	B	yellow-brown	reddish brown	aniso	few	massive		5-7		tr.		1-2						1-2	1-2	1-2											
RB112 1135-8-1	C	dark brown	black	iso	5-7	dense	5-7	7-10	3-5	1-2	1-2		3-5	tr.						1-2	1-2	tr.	3-5		2-3			tr.			
RB112 998-8-1	C	dark brown	black	iso	5-7	dense	5-7	7-10	3-5	1			3-5	tr.						1-2	1-2	tr.									
RB112 1066-8-1	C	dark brown	black	iso	15-20	moderate		5-10	5-7	1-2	1-2		3-5	tr.						1-2	3-5		3-5						tr.		
RB112 1036-8-1	C	dark brown	black	iso	5-7	dense	5-10	7-10	3-5	1-2	1-2	1-2	3-5	tr.						1-2	1-2		3-5		2-3			tr.			
RB112 405-1	I	reddish black	black	iso	10	moderate	7-10	3-5		2-3	1-2				3-5	1-3				2-5					tr.	2-3					
RB112 628-1	I	reddish-brown	blackish-brown	iso	10	dense	3-5		tr.		tr.	tr.			5-10	tr.				1-2								1-2			
RB112 338-6	I	medium brown	dk. golden brown	iso	5	moderate	5-7	3-5	1-2		3-5				10-15	3-5				1-2							tr.	2-3			
RB112 349-1	I	yellowish-brown	black	iso	7-10	dense		3-5	tr.						10-15	1-2				1-2							tr.	3-5			tr. ⁸
RB112 639-3	I	reddish-brown	v.dk. Reddish-brown	iso	3-5	dense	10-15			1-2					20-25											1-2					
RB112 259-2	EE	greenish brown	golden brown	aniso	5-10	dense	3-5	2-3	1-2	tr.	1-2	tr.		tr.		1-2	3-5	2-3	1-2	1-2						1-2	tr.	tr.			

Table F-1. Petrography Data on Individual Sherds. (cont.)

Site/Sample No.	Paste Group	Paste Attributes					Quartz			Igneous										Hematite	Granular Rocks				Carbonates		Meta morphic	Bone			
		Matrix Color (plain-polarized light)	Matrix Color (cross-polarized light)	Isotropy	Voids (%)	Matrix Density	Quartz Resident (%)	Quartz Common (%)	Quartz Composite (%)	Chert (%)	Plagio clase (%)	Ortho clase (%)	Microcline (%)	Basalt (%)	Basalt/pyrx (%)	Pyroxene (%)	Rhyolite (%)	Biotite (%)	Muscovite (%)	Iron Opaques (%)	Rock A (%)	Rock B (%)	Rock C (%)	AVRF (%)	VRFB ² (%)	Limestone (%)	Calcite (%)	Schist (%)	Bone (%)	Unknown/Rare (%)	
RB112 362-8-1	FF	lt. tannish-gray	medium gray	iso	20	light	25	2-3	1	1-2	1-2	1-2			10-15			1	1	1-2						1-2					
RB112 468-8-4	FF	lt. tannish-gray	medium gray	iso	20	light	25	2-3	1		1-2	1-2			10-15			1	1	1-2						1-2					
RB112 303-8-1	GG	lt. tannish-gray	golden brown	aniso	10-15	moderate	25	2-3	1	1-2	1-2	1-2			10-15			1	1	1-2						2-3					
RB112 1206-8-1	HH	lt. green	lt. greenish gold	aniso	few	massive		1-2						5-7				3-5	1-2	3-5											
RB112 643-1	II	deep reddish-brown	reddish black	iso	10-15	dense	5-7	2-3		1-2			tr.	3-5		tr.			3-5								tr.	1-2			1-2 ³
PT11																															
PT11 28-A8-60	J	yellowish-brown	golden brown	aniso	10	moderate	5-10	2-3	1-2	2-3	1-2					1-2				1-2							1-2				
PT11 28-?-71	A	black	black	iso	5-10	dense	5-10	1-2	1-3	1-2	1-2														tr.		3-5				
PT11 28-7-73	A	greenish black	black	iso	5-7	dense	10-15	5-7	1-2	1-2	1-2									1-2							3-5				
PT11 28-A2-8	I	reddish-brown	black	iso	15	moderate	15-20		1	1	1-2	tr.			2-3	2-3	1											1-2			
PT11 28-A2-R3	K	reddish-brown	reddish black	iso	15	moderate	5-10	1-2	1-2		1-2					1-2		3-5	3-5		2-3										1-2 ⁴
PT11-28-A21	J	medium brown	golden brown	aniso	5-10	very dense	5-7	1-2	1-2	1-2									3-5								tr.				
HC23																															
HC23 R2/3	A	reddish-brown	gray-black	iso	10	dense	5-10	2-3	2-3	1-2	1-2					1					1-2										
HC23 3c7	A	greenish brown	gray-green	iso	3-5	dense	20		3-5		1-2									1-2							1-2				

Table F-1. Petrography Data on Individual Sherds. (cont.)

Site/Sample No.	Paste Group	Paste Attributes					Quartz			Igneous										Hematite	Granular Rocks					Carbonates			Meta morphic	Bone	
		Matrix Color (plain-polarized light)	Matrix Color (cross-polarized light)	Isotropy	Voids (%)	Matrix Density	Quartz Resident (%)	Quartz Common (%)	Quartz Composite (%)	Chert (%)	Plagio clase (%)	Ortho clase (%)	Microcline (%)	Basalt (%)	Basalt/pyrx (%)	Pyroxene (%)	Rhyolite (%)	Biotite (%)	Muscovite (%)	Iron Opaques (%)	Rock A (%)	Rock B (%)	Rock C (%)	AVRF (%)	VRFB ² (%)	Limestone (%)	Calcite (%)	Caliche (%)	Schist (%)	Bone (%)	Unknown/Rate (%)
HC23 R2/13	A	yellowish-brown	deep grayish brown	iso	3-5	dense	3-5	5-7	5-7										1-2		1-3						tr.				
HC23 R2/15	I	lt. reddish-brown	dk. Reddish-brown	aniso	5	dense	3-5	3-5			1				5-7					2-3							1				
RB81																															
RB81 156	E	medium brown	gray-black	iso	3-5	dense	10-15	3-5	1-2	1-2									1								2-3		5-7		
RB81 291/124.1	E	grayish brown	black	iso	5-7	dense		tr.								tr.														5-10	
RB81 374-2/1240	F	yellow-brown	golden brown	aniso	3-5	light	25			1-2						1-2				1-2										5-7	
RB81 505/123.9	F	deep red-brown	black	iso	5	thin	7-10	1-2								1		1												7-10	
RB81 381/124.8	F	red brown	brownish-black	iso	7-10	thin	25	2-3		3-5	1-2					1-2			1	1-2										3-5	
RB81 374/123.8	G	golden-brown	deep golden brown	aniso	5-7	dense	5-7			1-2	1-2			1-2														3-5		5-7	
RB81 370	H	yellow-brown	golden brown	iso	10	moderate	5-10				1-2				5-7													2-3		5-7	
RB81 492	H	tan	greenish-gray	iso	3-5	dense	5-10			1-2	1-2				5-7	1		1-2										2-3		5-7	
RB81 374-1/124.0	I	red brown	reddish black	iso	5-7	dense	5-7	2-3		1-2	1-2				5-7													1-2			
RB108																															
RB108 /WP6	L	golden brown	black	iso	5-7	dense	2-3							2-4		tr.	1-2		tr.												
RB109																															

Table F-1. Petrography Data on Individual Sherds. (cont.)

Site/Sample No.	Paste Group	Paste Attributes					Quartz			Igneous										Hematite	Granular Rocks				Carbonates			Meta morphic	Bone			
		Matrix Color (plain-polarized light)	Matrix Color (cross-polarized light)	Isotropy	Voids (%)	Matrix Density	Quartz Resident (%)	Quartz Common (%)	Quartz Composite (%)	Chert (%)	Plagio clase (%)	Ortho clase (%)	Microcline (%)	Basalt (%)	Basalt/pyrx (%)	Pyroxene (%)	Rhyolite (%)	Biotite (%)	Muscovite (%)	Iron Opaques (%)	Rock A (%)	Rock B (%)	Rock C (%)	AVRF (%)	VRFB2 (%)	Limestone (%)	Caliche (%)	Schist (%)	Bone (%)	Unknown/Rare (%)		
RB109 E3/WP1	B	medium brown	golden brown	aniso	2-3	dense	1-2	1-2	1-2	tr.	1-2	1-2	1-2			tr.		1					tr.									
RB109 E3/WP2	D	dk. red-brown	dk. red-brown	iso	5-10	moderate	3-5	5-7			2-3		2-3					1-2		tr.	tr.					tr.						
RB109 5/WP5	L	lt. golden-brown	dk. golden brown	aniso	2-3	dense	3-5							5-7				3-5		3-5							tr.					
RB109 17/WP4	L	grayish brown	dk. Gray-brown	iso	few	dense	3-5	2-4	2-4	tr.				5-7				1-2		1-2												
RB109 21/WP3	L	lt. reddish-brown	lt. reddish-brown	iso	10-15	dense	5-7	2-3						5-10				1-2		tr.							1					
RB110																																
RB110 12/WP8	D	reddish-brown	gray-brown	iso	10-15	thin		2-3	2-3		2-3		2-3					1-2	1-2	1							tr.					
RB110 13/WP7	D	dk. red-brown	dk. red-brown	iso	12-15	moderate	5-10		3-5		1-2	1-2	3-5							1-3									1-3			
RB110 37WP9	DD	golden-brown	dk. brown	aniso	3-5	dense		1-2						3-5												tr.					5-10	
OC27																																
41OC27 355-2	M	greenish brown	black	aniso	5-10	minimal	5-10	3-5	1-2	1-2	2-3							1	1	2-3						tr.						
41OC27 386	M	medium brown	golden red-brown	iso	15	moderate	10-15	5-10	1-2	2-3	1-2								tr.	1								1-2				
41OC27 216	M	dk. red-brown	black	iso	5-7	light	5-10	3-5		1	2-3	1-2							1	tr.												
41OC27 378-310	M	reddish black	black	iso	10	light	7-10	3-5		1	3-5					1				1-2	tr.											
41OC27 556-8	H	lt. yellowish-brown	golden brown	aniso	10	moderate	5-10	1-2	1-2						3-5	1-2			1	1-2						tr.		tr.			5-7	

Table F-1. Petrography Data on Individual Sherds. (cont.)

Site/Sample No.	Paste Group	Paste Attributes					Quartz			Igneous										Hematite	Granular Rocks					Carbonates			Meta morphic	Bone	
		Matrix Color (plain-polarized light)	Matrix Color (cross-polarized light)	Isotropy	Voids (%)	Matrix Density	Quartz Resident (%)	Quartz Common (%)	Quartz Composite (%)	Chert (%)	Plagio clase (%)	Ortho clase (%)	Microcline (%)	Basalt (%)	Basalt/pyrx (%)	Pyroxene (%)	Rhyolite (%)	Biotite (%)	Muscovite (%)	Iron Opaques (%)	Rock A (%)	Rock B (%)	Rock C (%)	AVRF (%)	VRFB ² (%)	Limestone (%)	Calcite (%)	Caliche (%)	Schist (%)	Bone (%)	Unknown/Rare (%)
41OC27 462-70	L	reddish-brown	gold-red-black	aniso	10	moderate	15-20	3-5	3-5	1-2	2-3			3-5		tr.			tr.								tr.				
41OC27-243	E	grayish-green	dk. Greenish gray	iso	5-7	v. dense		1-2		1	1-2								1	1								1-2		2-3	
41OC27 383	E	reddish black	black	iso	10-15	moderate	3-5	5-7	1	1-2	tr.									1					1-2					2-3	
41OC27 256-57	N	dk. brown	reddish brown	aniso	10	dense	5-10	10-15	1	1-2	2-3				2-3	2-3				1											
OC29																															
41OC29 343-22	O	reddish-brown	dk. reddish-brown	iso	5-7	moderate	15	1-2	1-2	tr.	2-3	tr.							1-2		1				1 ⁵			1-2			
41OC29 346-4	P	brownish gray	gray	iso	5	massive	3-5	1-2		1	1-2	1-2			5-7	1-2				1								1-2			
41OC29 338-07	M	dk. red-brown	gold, deep red	aniso	5-10	thin	10-15	3-5	3-5	3-5	3-5								tr.	1-2								tr.			poss. Halite
41OC29 338-1	M	dk. yellowish-red	golden brown	aniso	5-7	dense	15	1-2	2-3	1-2	1-2					1			1	1-2											
OC43																															
41OC43 65-310	R	med. Yellowish-brown	black	iso	3-5	thin	10-15	1-2	1	1	2-3			3-5		1				1-2						tr.		tr.			
41OC43 325.7	Q	reddish-brown	black	iso	20	massive	10-12		3-5	1-2					2-3	1			1	1				tr. ⁶			1				
34BV14																															
34BV14-302	Z	blackish brown	black	iso	0.03	thin	25	3-5			1																	1			Qtz=tr

Table F-1. Petrography Data on Individual Sherds. (cont.)

Site/Sample No.	Paste Group	Paste Attributes					Quartz			Igneous										Hematite	Granular Rocks				Carbonates			Meta morphic	Bone	
		Matrix Color (plain-polarized light)	Matrix Color (cross-polarized light)	Isotropy	Voids (%)	Matrix Density	Quartz Resident (%)	Quartz Common (%)	Quartz Composite (%)	Chert (%)	Plagio clase (%)	Ortho clase (%)	Microcline (%)	Basalt (%)	Basalt/pyrx (%)	Pyroxene (%)	Rhyolite (%)	Biotite (%)	Muscovite (%)	Iron Opaques (%)	Rock A (%)	Rock B (%)	Rock C (%)	AVRF (%)	VRFB ² (%)	Limestone (%)	Calcite (%)	Schist (%)	Bone (%)	Unknown/Rare (%)
34BV14-364	AA	reddish-brown	golden red-brown	aniso	10	dense		1-2	tr.						2-3	1-2								2-3				3-5		
34BV14-71	AA	yell. Reddish brown	golden red-brown	aniso	10	dense		1-2	tr.						2-3	1-2								3-5				3-5		
34BV14-438	BB	medium brown	golen red	aniso	15	thin	25	1-2		1	1-2				2-3			1	1	1-2										
34BV14-427	BB	greenish gray	golden green	aniso	10	light	25-30	1-2							3-5													3-5		
34BV14-600	BB	greenish gray	golden green	aniso	15	thin	25-30	1-2			2-3				3-5	1-2				1								3-5		
34BV14-580	CC	gray green	black	iso	25	thin	20	2-3	1-2	tr.	tr.				1-2					1-2										1-2
34TX1																														
34TX1-155	M	greenish brown	dk. Brown	aniso	5	moderate	5-10	3-5		3-5	2-3		tr.			1-2				tr.								1-2		
34TX1-10	M	lt. reddish-brown	dk. red-brown	iso	5	moderate	5-7	3-5		1-2	1-2					1-2				1										tr.
34TX1-407	T	yell. Reddish brown	golden brown	aniso	10	dense	5-7	2-5	2-5	2-3									1-2			tr.				1		2-3		
34TX1-377	T	med.brown	med. brown	iso	5	dense	3-5	2-3	3-5	2-3	1-2								1-2	1	tr.							1		
34TX1-408	O	yellow-brown	golden brown	aniso	10	dense	3-5		3-5	2-3	2-3					tr.			1-2	tr.	1-2	1-2						2-3		tuff=tr
34TX1-14	U	reddish-brown	reddish brown	iso	5	moderate	10-15		1-3	2-3	1-2	2-3	tr.	1-2		tr.		1		5						tr.				tr. ⁹
34TX31																														
34TX31-175.2	S	yellowish-brown	golden brown	aniso	10-15	dense	15	2-3	2-3	1	1-2				2-3	1-2				tr.				tr.						tr.

Table F-1. Petrography Data on Individual Sherds. (cont.)

Site/Sample No.	Paste Group	Paste Attributes					Quartz		Igneous										Hematite	Granular Rocks				Carbonates			Meta morphic	Bone			
		Matrix Color (plain-polarized light)	Matrix Color (cross-polarized light)	Isotropy	Voids (%)	Matrix Density	Quartz Resident (%)	Quartz Common (%)	Quartz Composite (%)	Chert (%)	Plagio clase (%)	Ortho clase (%)	Microcline (%)	Basalt (%)	Basalt/pyrx (%)	Pyroxene (%)	Rhyolite (%)	Biotite (%)	Muscovite (%)	Iron Opaques (%)	Rock A (%)	Rock B (%)	Rock C (%)	AVRF (%)	VRFB ² (%)	Limestone (%)	Calcite (%)	Caliche (%)	Schist (%)	Bone (%)	Unknown/Rare (%)
34TX31-74	S	brownish gray	golden brown	aniso	5	dense	25-30		1-2						3-5				tr.					tr.							
34TX31-175.1	Q	black	reddish black	iso	7-10	dense	3-5	2-3	3-5						3-5	1-2											1-2				
34TX32																															
34TX32-44	V	lt. reddish-brown	reddish brown	iso	5	moderate	25-30		5-7																						
34TX32-21	V	med. reddish-brown	golden red-brown	aniso	5	moderate	15-20		3-5	1-2	1-2					tr.				1-2								1			
34TX32-53	K	med. reddish-brown	red-brown	aniso	10	dense	12-15		5-7		1-2					1		1	1		5-7										
34TX32-285-2	W	greenish gray	dk. gray-brown	aniso	20	dense	2-5	5-10		1-2	1			1		1															
34TX32-285-1	X	brownish black	black	iso	20	dense		5-7	5-7			3-5				1			1-2									1-2			
34TX32-284	Y	black	black	iso	10	minimal	30	tr.											tr.											5-7	

1. Numbers and number ranges are estimates of percentage coverage of visual field. Tr. = trace is less than 1%.
2. Volcanic rock fragment B - rare in collection
3. Possibly organic material.
4. Possibly chlorite.
5. Pink groundmass with deteriorated plagioclase xtals and pyroxene. Temper classes here have pebble-sized grains.
6. Black groundmass with muscovite rod phenocrysts.
7. Section exceptional for pebble-sized particles.
8. Sandstone fragment.
9. Hornblende

functions. The potter may or may not be aware of the nature and presence of the particles. They may or may not be clay residents, or naturally occurring minerals in clay and sedimentary deposits. Minor minerals in the following descriptions are listed together regardless of mineral family or class. Resident minerals are those judged by the analyst as resident in the original clay, but minor minerals may have other, indeterminable, origins.

F.4 Results

Table F-1 presents the data and results of the petrographic analysis of the collection. Notes on the unknown and unique particles and some of the shorthand used on the table are presented at the bottom. The table is followed by the paste group descriptions, Table F-2, in turn followed by the ceramic temper list, Table F-3, and the fired clay sample analysis in Table F-4.

The paste groups show pattern and diversity within the Plains village region. Eleven of the paste groups are shared among two or more sites or site clusters. These common paste groups are considered further below (section F.6) in terms of the scales of interaction implied by their sharing. Four of the paste groups have at least two sherd members from the same site whose pastes are so distinctive and similar that they probably came from the same vessel or ceramic batch. The first paste group is Paste Group J, with common members PT11-28-A21 and PT11-28-A8-60. The pastes in each have distinctive red clay lumps, the same quartz temper and minor minerals. The red clay lumps are identical to those in fired clay sample RB81-C26. The clay in the sherds very likely came from or very close to the source locality of RB81-C26. Paste Group T has common sherds 34TX1-377 and 34TX1-407. They both have similar amounts of composite quartz temper with large muscovite drapes over the quartz grains. This is a very unusual mineral combination and most likely resulted from the crushing of a single unusual rock to temper a paste batch. This paste batch formed the vessels that ultimately produced the sherds. Paste Group V contains sections 34TX32-44 and 34TX32-21. The sherds were tempered with granule and pebble-sized composite quartz and otherwise had low diversity and numbers of minor and resident minerals except for abundant resident silt-sized

quartz. The great disparity in grain sizes between the tempering agent and all other particles, and with the same mineralogy, suggests that the sherds came from the same paste batch, and very likely the same vessel. Paste Group AA includes very similar sherds 34BV14-364 and 34BV14-71. The sherds share the same basalt with pyroxene temper and an altered volcanic rock fragment temper and all other resident and minor minerals in similar proportions. The two sherds are very likely pieces from the same vessel.

F.4.1 Ceramic Temper List

The tempers of the collection are usually singled out for each thin section as they have a critical function in ceramics and in defining paste groups. Table F-3 is a useful analytic tool for the collection.

F.4.2 Experimental Fired Clay Sample Analysis

The experimental fired clay analysis is reported in Table F-4. Collectively, the fired clay collection showed that most clays and ceramic materials that might be gathered from stream deposits and open dry land exposures have fresh, terrigenous, poorly sorted yet abundant particles in silt, fine sand and medium sand sizes. This is consistent with the Holocene history of the region (Chapter 6.0 this study). Actual clays varied from less than five percent up to 30 percent. Some of the samples showed granular rock fragments, either resident or added as temper (added tempering agents were collected from the immediate area around Long View); these rocks may have been convenient co-located temper sources for the rock-tempered paste groups. Two samples had distinctive iron-rich red clay lumps, 34TX32-420 and RB81-C26. 34TX32-420 seemed not to have observable contributions to the Oklahoma panhandle paste groups, but the source deposit of sample RB81-C26 appears to have contributed red clay lumps to sections PT11-28-A8-60 and PT11-28-A21. These two sections form Paste Group J.

Sample Blue Creek contains abundant added basalt particles, described as local scoria. The sediment/clay came from Blue Creek in Hutchinson County, a northern tributary of the Canadian River, now flowing into the flood pool of Lake Meredith. The

Table F-2. Paste Group Descriptions.

Paste Group	Defining Traits	Sherds	Sites	Notes
	<u>Rock and Mineral Tempers</u>			
A	Medium brown paste, isotropic.	RB112 1223-8-1, RB112 1119-8-1	RB-112	Minimal inclusions, simple paste.
			HC-23	
	Massive matrix, few voids, small particles.	HC23 R2/3	PT-11	
	Temper: quartz in minimal med. sand sizes.	HC23 3c 7		
	Minor feldspars and some carbonate.	HC23 R2/13		
		PT11 28-71		
		PT11-28-7-73		
B	Reddish or yellowish-brown paste, anisotropic.	RB112 2-8-6	RB-112	Abundant volcanic minerals, but no basalt.
	Matrix moderate or massive, voids variable.	RB112 1140-8-1	RB-109	
	Temper small amounts of quartz and orthoclase.	RB112 1175-8-1		
	Abundant small feldspars, micas and ferrous opaques (minor minerals).	RB109 E3/WP1		
C	Matrix dense, dk brown and isotropic.	RB112 1135-8-1	RB112	Heavily volcanic, basalt incidental, not temper.
	Voids variable, but commonly outline solid particles.	RB112 998-8-1		One piece of schist (metamorphic) in one section.
	Multiple tempers, quartz, microcline feldspar, granular rock frags (Rock A, Rock C).	RB112 1066-8-1		
	Minor minerals heavily volcanic.	RB112 1036-8-1		
	Carbonate minor or absent.			
D	Matrix dk reddish brown and isotropic.	RB110 12/WP8	RB110	Common quartz/feldspar tempered paste group.
	Voids variable and common.	RB110 13/WP7	RB109	Schist in RB110 13/WP7 is not a temper.
	Temper quartz and various feldspars.	RB109 E3/WP2		
	Resident minerals volcanic but not abundant.			
	Carbonate rare.			

Table F-2. Paste Group Descriptions (cont.)

Paste Group	Defining Traits	Sherds	Sites	Notes
J	Reddish brown paste, anisotropic, w/ red clay masses or lumps, distinctive.	PT11-28-A21	PT11	The red clay lumps are identical to those in sediment sample RB81 C26.
	Medium and coarse sand quartz temper.	PT11-28-A8-60		
	Minimal minerals and carbonate.			
K	Deep reddish brown paste, moderate, isotropic or anisotropic.	PT11-28-A2-R3	PT11	
	Common voids in aligned strips.	34TX32-53	34TX32	
	Temper granular rock (Rock A) and composite quartz, coarse and granule.			
	Minor minerals common volcanics, esp. micas.			
	No carbonate.			
M	Greenish to reddish brown paste, isotropic or anisotropic, light to moderate.	OC27 355-2	OC-27	One large halite (evaporite) xtal in OC29 338-07.
	Voids abundant w/ irregular shapes and strips.	OC27 386	OC-29	Muscovite drapes on composite quartz on 34TX-1 sections.
	Temper common quartz and small amounts of plagioclase.	OC27 216	34TX-1	
	Minor minerals volcanic.	OC27 378-310		
	Little or no carbonates.	OC29 338-07		
	Abundant silt-sized resident quartz.	OC29 338-1		
		34TX1 10		
		34TX1 155		
O	Moderate reddish brown isotropic paste w/ irregular voids surrounding particles.	OC29 343-22	OC-29	Heavily volcanic section/paste group.
	Multiple tempers, mainly common and composite quartz and very little (tr.-1%) granitic rock (Rock A) and AVRFS.	34TX1 408	34TX1	Median grain size is coarse sand, largest is pebble.
	Minor minerals volcanics, carbonate.			
	No hematite.			

Table F-2. Paste Group Descriptions (cont.)

Paste Group	Defining Traits	Sherds	Sites	Notes
T	Paste is med. yellowish brown, dense, slightly anisotropic w/ irregular voids.	34TX1-377	34TX1	
	Distinctive temper: composite quartz w. large muscovite drapes.	34TX1-407		
	Minor minerals volcanic, and trace of granitic rock (rocks A and B).			
	Carbonate common.			
V	Reddish-brown dense isotropic or anisotropic paste w/ few small irregular voids.	34TX32-44	34TX32	
	Temper granule and pebble-sized composite quartz.	34TX32-21		
	Minor minerals few volcanic minerals.			
	Dense resident quartz.			
	Some carbonate.			
W	Greenish gray-brown anisotropic dense paste w/ many long strip voids.	34TX32-285-2	34TX32	
	Temper common quartz up to granule size.			
	Minor minerals volcanic.			
	No carbonate.			
X	Brownish black and black, isotropic and moderate paste w/ common voids.	34TX32-285-1	34TX32	
	Temper common and composite quartz and orthoclase feldspar in granule sizes.			
Z	Dark brown to black moderate isotropic paste w/ few irregular voids.	34BV14-302	34BV14	
	Temper common quartz.			
	Resident quartz is the dominant particle, superabundant.			
	Plentiful carbonates.			
	Few minor minerals.			

Table F-2. Paste Group Descriptions (cont.)

Paste Group	Defining Traits	Sherds	Sites	Notes
EE	Paste greenish brown to golden greenish brown and anisotropic, dense w/ few voids in long strips that surround particles.	RB112 259-2	RB112	Unique in collection for rhyolite temper.
	Temper rhyolite.			
	Minor minerals—trace of basalt w/ pyroxene, probably incidental companion to rhyolite; volcanics and carbonate.			
	<u>Bone Tempers</u>			
E	Paste med, brown to black and isotropic.	RB81-156	RB81	
	Voids irregular and outline particles.	RB81-291/124.1	41OC27	
	Temper bone up to coarse sand and granule sizes.	OC27-243		
	Minor minerals volcanics and carbonate particles and drapes.	OC27-383		
F	Paste yellowish red-brown to black, isotropic or anisotropic.	RB81 374-2/124.0	RB81	Notable for two obvious clay types, both containing bone.
	Temper bone in two kinds of clay, both red and lumpy.	RB81 505/123.9		
	Few minor minerals.	RB81 381/124.8		
G	Dense paste, lt. golden brown to deep golden brown and anisotropic.	RB81 374/123.8	RB81	Similar to Paste Group F, but with carbonates and anisotropic paste.
	Voids irregular and few.			
	Bone temper in two clays.			
	Basalt incidental and small grains, other volcanics minor.			
	Some carbonates.			
Y	Black, isotropic, minimal paste w/ few voids.	34TX32-284	34TX32	Almost unique paste.
	Temper bone up to coarse sand size.			
	Packed-in, superabundant resident quartz.			
	Few other minerals, no carbonates, no pyroxene			

Table F-2. Paste Group Descriptions (cont.)

Paste Group	Defining Traits	Sherds	Sites	Notes
	<u>Bone and Basalt Tempers</u>			
H	Paste tan or yellow-brown, moderate to dense and isotropic.	RB81-370	RB-81	
	Voids irregular.	RB81-492	OC-27	
	Co-tempers bone and basalt to coarse sand sizes.	OC27-556-8		
	Minor minerals abundant resident quartz, few others.			
	Carbonate variable amounts and forms			
CC	Paste gray-green to black, thin, isotropic.	34BV14-580	34BV14	
	Voids copious, oriented strips and bodies.			
	Temper bone and basalt w/ pyroxene xtals.			
	Minor minerals few volcanics.			
	Resident silt-sized quartz is dominant particle.			
	No carbonates.			
DD	Paste golden-brown to dark brown, anisotropic and very dense w/ few irregular void strips.	RB110-37-WP9	RB110	Paste notable for having few minor minerals.
	Temper bone and basalt up to granule sizes.			
	Trace of carbonates.			
	<u>Basalt Tempers</u>			
I	Paste red-brown, isotropic or anisotropic, and dense.	RB81-374-1/124.0	RB-81	Basic basalt tempered group.
	Voids irregular.	HC-23-R2/15	HC-23	
	Temper basalt with pyroxene xtals w/in the basalt particles.	PT11-28-A2-8	PT-11	
	Minor minerals few, carbonates few particles.	RB112-405-1	RB-112	
		RB112-628-1		
		RB112-338-1		
		RB112-349-1		
		RB112-639-3		

Table F-2. Paste Group Descriptions (cont.)

Paste Group	Defining Traits	Sherds	Sites	Notes
N	Paste dark brown and reddish-brown, anisotropic and dense.	OC27-256-57	OC-27	
	Voids large, common and irregular.			
	Temper multiple—basalt w/ pyroxene xtals, common quartz and plagioclase feldspar.			
	Few minor minerals.			
	No carbonate.			
P	Very dense brownish-gray paste, isotropic, w/ few irregular voids that do not surround particles.	OC29-346-4	OC-29	Similar to Group I but w/ more minor minerals and some carbonate.
	Temper basalt w/ pyroxene and common quartz.			
	Minor minerals various feldspars, some carbonate.			
Q	Very dense reddish-brown to black isotropic paste w/ abundant voids in jagged strips.	OC43-325.7	OC-43	Similar to Paste Group N, but composite quartz, not common quartz.
	Temper basalt w/ pyroxene xtals and composite quartz.	34TX-31-175.1	34TX-31	
	Resident quartz abundant.			
	Other minor minerals rare.			
	Carbonate particles only.			
S	Paste yellowish and brownish gray to gray, dense, anisotropic w/ abundant irregular and strip voids.	34TX31-74	34TX-31	Similar to Group N, but no plagioclase.
	Temper basalt w/ pyroxene xtals and common and composite quartz.	34TX31-1752		
	Minor minerals volcanics, a trace of AVRFS.			
	No carbonate.			

Table F-2. Paste Group Descriptions (cont.)

Paste Group	Defining Traits	Sherds	Sites	Notes
AA	Paste yellowish to golden-brown, dense, anisotropic w/ few irregular voids.	34BV14-364	34BV14	
	Temper basalt w/ pyroxene xtals and an AVRf.	34BV14-71		
	Resident silt-sized quartz is dominant particle in the section.			
	Minor minerals pyroxene derived from basalt and composite quartz.			
BB	Paste med brown to golden-red, anisotropic and thin; voids copious oriented strips.	34BV14-438	34BV14	
	Temper basalt w/ pyroxene xtals.	34BV14-427		
	Minor minerals copious resident quartz in silt sizes, carbonate, few volcanics.	34BV14-600		
FF	Paste lt. tannish gray to med gray, thin, isotropic, abundant irregular voids.	RB112-362-8-1	RB112	
	Temper basalt w/ pyroxene xtals.	RB112-468-8-4		
	Abundant resident quartz.			
	Abundant minor minerals, volcanic and carbonate.			
GG	Paste lt. tannish gray to golden-brown, anisotropic.	RB112 303-8-1	RB112	
	Voids common and irregular.			
	Temper basalt w/ pyroxene xtals.			
	Abundant minor minerals, silt-sized quartz and volcanics, carbonate.			
L	Golden-brown, dense, isotropic and anisotropic paste.	RB108 /WP6	RB-108	
	Voids numerous wide strips.	OC27-462-70	OC-27	
	Temper basalt w/o pyroxene xtals.	RB109 5/WP5	RB-109	
	Minor minerals rare biotite and hematite.	RB109 17/WP4		
		RB109 21/WP3		

Table F-2. Paste Group Descriptions (cont.)

Paste Group	Defining Traits	Sherds	Sites	Notes
R	Yellowish or reddish brown to black, thin, isotropic w/ abundant oriented strip voids.	OC43 65-310	OC-43	
	Temper basalt w/o pyroxene xtals.			
	Minor minerals quartz, volcanics, hematite and a trace of carbonates.			
U	Reddish-brown anisotropic or isotropic paste, dense, w/ irregular voids.	34TX1-14	34TX-1	
	Temper basalt w/o pyroxene xtals and some composite quartz.			
	Minor minerals volcanic.			
	No carbonates.			
HH	Paste lt. green to lt. greenish gold, anisotropic, massive.	RB112 1206-8-1	RB112	Unique in collection for restricted numbers of particles and deteriorated look.
	Voids few oriented strips and bodies.			
	Temper basalt w/ deteriorated plagioclase feldspar xtals.			
	Few other minor minerals.			
II	Paste dark red, dense and isotropic.	RB112-643-1	RB112	Unique in collection for diverse minerals and common unknown particle, possibly bone, other organic?
	Voids few jagged strips.			
	Temper basalt w/o pyroxene and varying amts of plagioclase phenocrysts.			
	Minor minerals feldspar, chert, carbonates.			
	Notably rounded chert may be alluvial marker.			
	Unknown B is unknown material, layered, common in the section, organic[?]			

Table F-3. Identified Tempering Agents.

Site and Section	Paste Group	Temper
RB112 1223-8-1	A	Common quartz
		Composite quartz
		Orthoclase feldspar
RB112 1119-8-1	A	Common quartz
RB112 2-8-6	B	Common quartz
		Orthoclase feldspar
RB112 1140-8-1	B	Common quartz
RB112 1175-8-1	B	Common quartz
		Orthoclase feldspar
RB112 1135-8-1	C	Common quartz
		Composite quartz
		Microcline feldspar
		Rock C
RB112 998-8-1	C	Common quartz
		Composite quartz
		Rock A
RB112 1066-8-1	C	Common quartz
		Composite quartz
		Rock A
		Rock C
RB112 1036-8-1	C	Common quartz
		Composite quartz
		Microcline feldspar
		Rock C
RB112 405-1	I	Common quartz
		Basalt w/pyroxene
RB112 628-1	I	Basalt w/pyroxene
RB112 338-6	I	Basalt w/pyroxene
RB112 349-1	I	Basalt w/pyroxene
RB112 639-3	I	Basalt w/pyroxene
RB112 259-2	EE	Common quartz
		Rhyolite
RB112 362-8-1	FF	Composite quartz
		Basalt w/pyroxene
		Limestone
		Orthoclase feldspar
RB112 468-8-4	FF	Composite quartz
		Basalt w/ pyroxene
		Limestone
		Orthoclase feldspar

Table F-3. Identified Tempering Agents (cont.)

RB112 303-8-1	GG	Basalt w/ pyroxene
		Orthoclase feldspar
RB112 1206-8-1	HH	Basalt w/pyroxene
RB112 643-1	II	Basalt w/pyroxene
PT11-28-A8-60	J (red clay lumps)	Common quartz
		Chert
PT11-28-A-21	J (red clay lumps)	Common quartz
		Composite quartz
		muscovite
PT11 28-?-71	A	Composite quartz
PT11-28-7-73	A	Composite quartz
PT11 28-A2-8	I	Basalt w/pyroxene
PT11 28-A2-R3	K	Rock A
		Muscovite
		Biotite
		Chlorite
HC23 R2/3	A	Common quartz
		Composite quartz
		Rock A
HC23 3c7	A	Composite quartz
HC23 R2/3	A	Common quartz
		Composite quartz
		Rock A
HC23 R2/15	I	Basalt w/pyroxene
RB81-156	E	Bone
RB81 291/124.1	E	Bone
RB81 374-2/124.0	F	Bone
RB81 505/123.9	F	Bone
RB81 381/124.8	F	Bone
RB81 374/123.8	G	Bone
RB81 370	H	Bone
		Basalt w/pyroxene
RB81 492	H	Bone
		Basalt w/pyroxene
RB81 374-1/124.0	I	Basalt w/pyroxene
RB108 /WP6	L	Basalt
RB109 E3/WP1	B	Composite quartz
		Rock C
RB109 E3/WP2	D	Common quartz
		Rock A

Table F-3. Identified Tempering Agents (cont.)

RB109 5/WP5	L	Basalt
RB109 17/WP4	L	Basalt
RB109 21/WP3	L	Basalt
RB110 12/WP8	D	Common quartz
		Composite quartz
		Plagioclase feldspar
		Microcline feldspar
RB110 13/WP7	D	Composite quartz
		Schist
RB110 37WP9	DD	Bone
		Basalt
OC27 355-2	M	Common quartz
		Composite quartz
		Plagioclase feldspar
OC27 386	M	Common quartz
		Composite quartz
		Plagioclase feldspar
OC27 216	M	Common quartz
		Orthoclase feldspar
OC27 378-310	M	Common quartz
		Plagioclase feldspar
OC27 556-8	H	Bone
		Basalt w/pyroxene
OC27 462-70	L	Basalt
OC27 243	E	Bone
OC27 383	E	Bone
OC27 256-57	N	Basalt w/pyroxene
		Plagioclase feldspar
OC29 343-22	O	Rock A
		Rock D
		Common quartz
		Composite quartz
OC29 346-4	P	Basalt w/pyroxene
OC29 338-07	M	Common quartz
		Composite quartz
OC29 338-1	M	Common quartz
		Composite quartz
OC43 65-310	R	Basalt

Table F-3. Identified Tempering Agents (cont.)

OC43 325.7	Q	Basalt w/pyroxene
		Composite quartz
34BV14 302	Z	Common quartz
34BV14 364	AA	Basalt w/pyroxene
		Aphanitic volcanic rock frag
34BV14 71	AA	Basalt w/pyroxene
		Aphanitic volcanic rock frag
34BV14 438	BB	Basalt w/pyroxene
34BV14 427	BB	Basalt w/pyroxene
34BV14 600	BB	Basalt w/pyroxene
34BV14- 580	CC	Bone
		Basalt w/pyroxene
34TX1 155	M	Common quartz
34TX1 10	M	Common quartz
34TX1 407	T	Composite quartz
34TX1 377	T	Composite quartz
34TX1 408	O	Composite quartz
		Rock A
		Rock B
34TX1 14	U	Composite quartz
		basalt
34TX31 175.2	S	Common quartz
		Composite quartz
		Basalt w/pyroxene
34TX31 74	S	Composite quartz
		Basalt w/pyroxene
34TX31 175.1	Q	Common quartz
		Composite quartz
		Basalt w/pyroxene
34TX32 44	V	Composite quartz
34TX32 21	V	Composite quartz
34TX32 53	K	Composite quartz
		Rock A
34TX32 285-2	W	Common quartz
34TX32 285-1	X	Common quartz
		Composite quartz
		Orthoclase feldspar
34TX32 284	Y	Bone

added basalt contains the common plagioclase feldspar rods and spicules contributing to the composition of all basalts; however, the Blue Creek sample also has large, well-formed crystals of pyroxene within the basalt grains. Basalt with pyroxene is a temper in paste groups I, N, P, Q, S, AA, BB, CC, FF and GG (Figure F-1). These paste groups are distributed throughout the study region. This finding offers hope that source localities may be discovered simply by fieldwork that identifies basalt with pyroxene co-located with exploitable clay deposits.

F.5 General Observations and Comparisons

This large collection, from sites dispersed across the Texas and Oklahoma panhandles on the Southern High Plains, reflects in its petrological assemblage the diversity of the wide geographic region. Thirty-five paste groups were identified in the collection, falling within four temper classes: crushed minerals and rock fragments (other than basalt), basalt, bone, and bone and basalt. Mixed and multiple tempers are common. Several of the paste groups are shared among two or more widely dispersed sites, suggesting the operation of regional trade and transport in ceramics. Sedimentological analysis of ten sediment samples from streams and on-site soils matched characteristics of resident minerals in the ceramic pastes. In the case of the Blue Creek clay sample, its resident basalt particles with pyroxene crystals match tempers in ceramic pastes from several sites.

Interregional connections and influences are more difficult to assess. The paste groups contain bone temper (Figure F-2) and crushed mineral (Figures F-3 and F-4) and rock tempers (Figure F-5). This variety shows technological diversity, with some interregional similarities.

Comparisons with previous petrographic work are illustrative of the heterogeneous nature of the regional ceramic tradition. In the Texas panhandle, Reese-Taylor (1991) studied a collection of six sherds from prehistoric sites and two sediment samples from the Palo Duro Reservoir in Hansford County in extreme northern Texas panhandle, about 80 km to the north of Long View. She defined four paste groups in the

collection, which included Borger Cordmarked and plainwares. The paste groups included one bone-tempered paste in a cordmarked sherd, two sand-tempered pastes in three plainwares, and one sand and basalt-tempered paste in two cordmarked sherds (Reese-Taylor 1991:H-9 to H-11). The two sand-tempered pastes had dense matrixes, quartz, feldspar and carbonates (dolomite), and particle shapes varied from subrounded to angular. The pastes contained a small amount of hematite, but were entirely lacking in biotite. Although the paste groups contained varying amounts of feldspar, the groups altogether bear little resemblance to the Potter County paste groups. Interestingly, Reese-Taylor (1991:H-2) conducted petrological analysis of two surface sediment samples collected from two nearby localities. The aplastic inclusions ranged in size from fine sand to coarse sand and were rounded to subrounded in shape. The principal mineral component was quartz sand, from 78 percent to 86 percent of the totals. The samples also contained minor amounts of feldspar, carbonate (calcite), clinopyroxene and a trace of woody organic matter (Reese-Taylor 1991:H-2). These sediments are very dissimilar to the Potter County sherds.

Lintz and Reese-Taylor (1997) conducted a small (n = 22 sherds), petrographic study of mostly decorated ceramics from the Canadian River drainage and northward with sites along Wolf Creek, an eastward flowing tributary of the Canadian River. They made comparisons with a ceramic sample from the Central Plains-Nebraska, well outside the region. The relevant findings are that ceramic sources with naturally resident biotite, quartz, alkali feldspars and occasionally occurring pyroxene, hematite, carbonates and volcanic rock fragments are widespread through the region. Ceramic pastes made with these materials and additional crushed granitic rock temper are similarly common (Lintz and Reese-Taylor 1997:288-295; Table 3).

Robinson (2010) established paste groups on nine prehistoric sherds from three sites on the BLM Landis Property along West Amarillo Creek in western Potter County, in the Canadian River drainage. The three paste groups defined on sherds all contained crushed granitic rock tempering agents, the rocks commonly comprised 22 to 30 percent quartz, 1.5 to 3.9 percent microcline feldspar, and 3.5 to 10.4

Table F-4. Data Concerning the Clays Examined from the General Region.

Sample Label	Textural Maturity	Mineral Maturity	Sorting	Clay Notes	Major Resident Minerals	Minor Minerals	Comments	Temper Added
Blue Creek Clay	Immature	immature	poor	>15%, aniso ¹ , gold to brown	basalt (VRF) irregular, v-ang, contains large pyroxene xtals in addition to plag feldspar	common qtz, 1-2%; caliche and ferrous opaques <1%	basalt with pyroxene is signature; found in several paste groups.	50% local scoria
Long View 41RB112 Ogallala	Immature	immature	poor	>5% clay	common qtz; plag and microcline feldspars	caliche, biotite ferrous opaques, pyroxene		25% local sandstone
Long View RB112 Clay C-Alluvial	submature	immature	poor	5% clay	ang common and composite qtz, coarse sand sizes; plagioclase, orthoclase and microcline feldspars	caliche, limestone, ferric opaques, biotite, chert, insect egg case	Qtz entirely fine sand and larger, no silt-sized. Sample lacks pyroxene and muscovite	50% local sandstone
Indian Springs RB81 Clay	submature	immature	poor	<5%, aniso, gold to brown	composite and common qtz, plagioclase feldspar, carbonate cement	muscovite, chlorite, pyroxene; no chert	Distinctive red clay lumps up to coarse sand size.	no temper added
Government Canyon Clay	Immature	immature	poor	>5% clay	coarse sand-sized composite Qtz, muscovite, plag feldspar, qtz/plag granular rock frags,	ferrous opaques, caliche drapes on qtz	granular rock frags probably Rock A in several paste groups.	50% local sandstone
Hank's - A RB109, Clay WP-C10	submature	immature	poor	<5% clay	common qtz up to v. coarse sand size, 12-15% plagioclase feldspar	caliche, ferrous opaques, chert		50% local sandstone
Hank's-ARB109, Clay CI alluvial	submature	immature	poor	<5% clay	copious common qtz in medium sand sizes, abundant carbonate	<1% plagioclase feldspar, no other feldspar, few large biotite lathes, ferrous opaques, pyroxene, no chert	pronounced carbonate cement on many particle clusters.	25% local sandstone
Buried City Clay WC-C1	Immature	immature	poor	30% clay, very dense	abundant common and composite qtz, bimodal silt and coarse sand sizes, plag feldspar up to coarse sand size, 5%	chert, iron opaques, muscovite, biotite, hornblende, all <2%	A few grains of Rock A---qtz, plag and biotite.	25% local sand
Buried City Clay WC-C3	Immature	immature	poor	>5% clay, aniso, gold to reddish brown	abundant common qtz and a few composite qtz grains up to granule size	chert, iron opaques, muscovite, plagioclase feldspar and caliche, all <2%		no temper added
Two Sisters daub 34TX32-363	submature	immature	poor	1-2% clay	common qtz 40-50%, chert 2-3%, plagioclase feldspar 1-2%, AVRF 1-2%	carbonate particles, muscovite, pyroxene, all trace	Distinctive for high proportions of qtz and other minerals	Daub
Two Sisters Clay 34TX32-420	Immature	immature	poor	20-30% clay, dense	granular rock frag (Rock A--composite Qtz, muscovite rods and some plag feldspar) up to coarse sand size; plag feldspar up to coarse sand size; muscovite rods up to coarse sand size	ferrous opaques; pyroxene up to coarse sand chunks; iron-rich red clay lumps; no chert	red clay lumps found in multiple paste groups, as well as Rock A.	25% local sandstone

Figure F-1. Basalt with pyroxene crystals.

Basalt is the purplish darker material, and pyroxene crystals are the lighter masses within the basalt. Paste Group I. Section RB112- #639-3. 8.5X. Photograph by P. Matchen.

Figure F-2. Bone temper particle.

Bone may occur as large as coarse sand size. Section 34TX32-#284. 8.5X. Photograph by P. Matchen

Figure F-3. Granule-sized grain of composite quartz.

Rounded dark grain of hematite to right of quartz. Section 34TX32-#44. 8.5X. Photograph by P. Matchen

Figure F-4. Orthoclase feldspar grains.

Paste Group X. Section 34TX32-#285-1. 8.5X. Photograph by Paul Matchen.

Figure F-5. Granitic rock A.

Composite minerals join along minute fracture lines. Small dark masses are biotite formed along fractures. Section RB112- #1066-8-1. 8.5X. Photograph by P. Matchen.

percent biotite. Biotite was also a common resident in the natural clays and sediments entering the ceramic pastes (Robinson 2010:839-840). These granitic rock pastes compare closely with the Lintz and Reese-Taylor (1997) paste groups, although they are temporally and typologically distinct from one another. The three Landis Property paste groups compare closely with paste groups C, K, O and T; and one sherd in Paste Group D (RB109 E3/WP2) in the current study. These paste groups have common representative sherds from the Roberts County and Potter County (41PT11) sites.

An additional petrographic study of panhandle ceramics (Robinson n.d.) provides direct and closely comparable ceramic data. The study focused on the Borger Cordmarked type, and was designed to conduct thin section analysis on one Borger Cordmarked sherd each from ten Texas panhandle Plains Village sites in Roberts, Hutchinson, Ochiltree and Hemphill counties. The boundaries of these counties lie athwart or near the Canadian River drainage. Reanalysis of their ceramic attribute data by the original analyst

shows that six of their ten pastes, 60 percent, can be related to paste groups defined in this study. Four bone-tempered sherds were identified, and two of them, the sherds from RB-73 and HH-19, are closely similar to Paste Group E. Sherd RB-39 fits within Paste Group B, characterized by mixed minerals. Sherd RB-40 is also a mixed mineral specimen that fits well with Paste Group D. Sherd RB-48 is tempered with granitic rock fragments that correspond closely with Paste Group C. A single basalt-tempered sherd was identified (without pyroxene crystals), from RB-64, and it appears to be a variant of Paste Group II. The remaining four sherds of the study have pastes of differing combinations of igneous minerals and bone temper (Robinson n.d.).

The finding of shared paste groups addresses the larger issues of cultural connections, communication and trade, and transport of goods and people. Shared paste groups, even comparing a single sherd to another, offer, at a minimum, the potential to establish the scales of interaction among sites and people. Precise determination of the nature of

cultural interactions certainly requires statistically balanced data sets and information from full artifact assemblages; however, initial attempts at establishing these scales of interaction and information flow with current data are worthy, and they may motivate more comparative work. Table F-5 below is clearly one such initial attempt; it shows distances between site clusters and localities having shared paste groups. The distances are map-measured straight-line kilometers between the sites and localities; they are highly approximate. The codes in the shared areas column are the county trinomial codes or the site number. The county code by itself indicates the site cluster in that county, not any single site. The topography column describes the nature of the landscape requiring transit to connect the site localities; it is a “relative difficulty” measure. Table F-5 breaks down the interaction implied by eleven shared paste groups described on Table F-2.

The results of this initial “scales of interaction” seem intuitive, that nearby interaction is stronger than long distance dealings, but that long distance exchanges nevertheless took place. The more remarkable finding may be that long distance interaction between the Canadian and Beaver (North Canadian) river valleys was conducted with ceramics at all. It is possible to suggest that the ceramics moving the greatest distances over the roughest terrain were moved by reasons of trading relations rather than ordinary functional transport. These longer distance paste groups are A (96 km), K (160 km), M (74 km), O (74 km) and Q (74 km). These paste groups lacked anything observable in their technology to indicate greater fitness for trading over distance. Further, Paste Group A showed sharing over short and intermediate distances as well as long distance. This shows no preparation for exceptional distance movement and also perhaps alternative mechanisms for ceramic movement. Trade, however, remains a common and viable explanation, although it is not firmly established in this case at this time. Additional ceramic petrography would be useful in advancing research in this important topical area.

F.6 Conclusions

This petrographic analysis of larger ceramic data sets has begun to identify more detailed intersite connections among panhandle Plains Village sites.

Continuing work may eventually isolate the exact nodes of the network and the connecting routes between the nodes. The current work has established that pastes of pottery wares common to two or more site clusters were a feature of the cultural network. The mechanisms of transport may have been trading relations or direct movement. Potters from several sites may have used desirable clay resource localities. Exclusive or restricted use of the localities is not suggested by these data, although the control of resource localities may be a viable research topic.

Interactions among site clusters along the Canadian River valley are the strongest, as would be expected. The finding of interaction between the Canadian River, Wolf Creek and Beaver River valleys is less expected, given the greater distance and necessary transit of High Plains terrain by foot. The apparent lack of transit along the Beaver River drainage (between the Texas County and Beaver County sites in two adjacent Oklahoma counties) may be a function of smaller data sets from those sites, or the sites may have been part of a relatively more isolated hinterland of the cultural network.

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Table F-5. Paste Groups and Scales of Interaction.

Paste Group	Shared Areas	Distance (km)	Topography
A	RB-HC23	64	Along Canadian R. drainage
	HC23-PT11	36	Along Canadian R. drainage
	RB-PT11	96	Along Canadian R. drainage
B	RB109-RB112	20	Across minor drainages
D	RB109-RB110	8-Jul	Across flat interflaves
K	PT11-34TX32	160	Across all drainages and interflaves
M	OC-34TX1	74	Across all drainages and interflaves
O	OC-34TX1	74	Across all drainages and interflaves
E	RB-OC	31	Across flat interflaves
H	RB-OC	31	Across flat interflaves
I	RB81-HC23	50	Along Canadian R. drainage
	HC23-PT11	50	Along Canadian R. drainage
	PT11-RB112	57	Along Canadian R. drainage
Q	OC-34TX1	74	Across all drainages and interflaves
L	RB-OC27	31	Across flat interflaves
	RB108-RB109	8-Jul	Across flat interflaves

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APPENDIX G

NEUTRON ACTIVATION ANALYSIS OF CERAMIC AND CLAY SAMPLES FROM SOUTHERN PLAINS VILLAGE SITES IN OKLAHOMA AND TEXAS

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G.1 Introduction

This report describes the preparation, analysis, and interpretation of 112 pottery samples, 9 clay samples, and 6 daub samples from the northern Texas and Oklahoma panhandles. The ceramic samples are from 13 Plains Village sites spread out across approximately 15,000 square kilometers. Initial investigation suggested a possible link with previous samples analyzed from the Central Plains; however this connection consists of only one possible match and is only briefly discussed in this report. The current samples are closely related to previous samples analyzed for Holly Meier as part of her 2007 thesis. Ms. Meier analyzed samples from one of the same sites as this study (Alibates Ruin 28 – 41PT11) and also included two other sites (Landergin Mesa – 41OL2 and 41PT109) to the southwest. We have also added six ceramic samples and nine clay samples previously analyzed for TRC from the same region in 2008 and 2010 (Quigg et al. 2011). The interpretation presented here combines the Meier (assigned HAM) and TRC (assigned TRC) samples into a single dataset containing 193 ceramic samples and 48 clay, daub, and other raw material samples.

Within the 193 ceramic sample we have identified 13 compositional groups, although four of the groups include only a pair of samples each and only three of the groups contain ten or more samples. The groups show strong distributional patterns according to the five geographic clusters of sites suggesting a strong correlation with production areas. Overall there are 31.4 percent of the samples unassigned, and this appears closely related to the sampling strategy. For the two regions with the most samples, there are only 21.9 percent unassigned, and the three regions with an average of only five samples per site the unassigned samples account for 55.4 percent of the samples. More extensive sampling of the under-sampled areas in the study may assist in identifying additional compositional groups. Of the four sites with 25 or more samples only 18 percent of the samples are unassigned.

The research questions are primarily focused on the large-scale identification of region-specific ceramic production patterns and on the small-scale examination of ceramic production in two specific

components of the Long View site (41RB112). The patterns of compositional group distribution strongly support the identification of regional production signatures, and there is even differentiation in the compositional signatures at the two components of the Long View site. The following report describes the preparation, analysis, and interpretation of the samples.

G.2 Sample Preparation

Pottery samples were prepared for INAA using procedures standard at MURR. Fragments of about 1 cm² were removed from each sample and abraded using a silicon carbide burr in order to remove glaze, slip, paint, and adhering soil, thereby reducing the risk of measuring contamination. The samples were washed in deionized water and allowed to dry in the laboratory. Once dry, the individual sherds were ground to powder in an agate mortar to homogenize the samples. Archival samples were retained from each sherd (when possible) for future research. Clay and other raw material samples were prepared in a similar manner but with the addition of a brief firing prior to grinding and weighing.

Two analytical samples were prepared from each source specimen. Portions of approximately 150 mg of powder were weighed into clean high-density polyethylene vials used for short irradiations at MURR. At the same time, 200 mg of each sample was weighed into clean high-purity quartz vials used for long irradiations. Individual sample weights were recorded to the nearest 0.01 mg using an analytical balance. Both vials were sealed prior to irradiation. Along with the unknown samples, Standards made from National Institute of Standards and Technology (NIST) certified standard reference materials of SRM-1633a (coal fly ash) and SRM-688 (basalt rock) were similarly prepared, as were quality control samples (e.g., standards treated as unknowns) of SRM-278 (obsidian rock) and Ohio Red Clay (a standard developed for in-house applications).

G.2.1 Irradiation and Gamma-Ray Spectroscopy

Neutron activation analysis of ceramics at MURR, which consists of two irradiations and a total of

three gamma counts, constitutes a superset of the procedures used at most other NAA laboratories (Glasco 1992; Neff 1992, 2000). As discussed in detail by Glascock (1992), a short irradiation is carried out through the pneumatic tube irradiation system. Samples in the polyvials are sequentially irradiated, two at a time, for five seconds by a neutron flux of $8 \times 10^{13} \text{ n cm}^{-2} \text{ s}^{-1}$. The 720-second count yields gamma spectra containing peaks for nine short-lived elements aluminum (Al), barium (Ba), calcium (Ca), dysprosium (Dy), potassium (K), manganese (Mn), sodium (Na), titanium (Ti), and vanadium (V). The samples are encapsulated in quartz vials and are subjected to a 24-hour irradiation at a neutron flux of $5 \times 10^{13} \text{ n cm}^{-2} \text{ s}^{-1}$. This long irradiation is analogous to the single irradiation utilized at most other laboratories. After the long irradiation, samples decay for seven days, and then are counted for 1,800 seconds (the “middle count”) on a high-resolution germanium detector coupled to an automatic sample changer. The middle count yields determinations of seven medium half-life elements, namely arsenic (As), lanthanum (La), lutetium (Lu), neodymium (Nd), samarium (Sm), uranium (U), and ytterbium (Yb). After an additional three- or four-week decay, a final count of 8,500 seconds is carried out on each sample. The latter measurement yields the following 17 long half-life elements: cerium (Ce), cobalt (Co), chromium (Cr), cesium (Cs), europium (Eu), iron (Fe), hafnium (Hf), nickel (Ni), rubidium (Rb), antimony (Sb), scandium (Sc), strontium (Sr), tantalum (Ta), terbium (Tb), thorium (Th), zinc (Zn), and zirconium (Zr). The element concentration data from the three measurements are tabulated in parts per million

G.2.2 Interpreting Chemical Data

The analyses at MURR, described above, produced elemental concentration values for 32 elements in most of the analyzed samples. Nickel concentrations were below detection limits in a large number of the samples and thus this element was eliminated from the dataset. Arsenic, antimony and titanium were not particularly reliable in this dataset and were also eliminated from the further analysis. Calcium levels in many samples are high enough (1-4 percent) to justify a calcium adjustment (Cogswell et al. 1998:64; Steponaitis et al. 1988), however, the calcium is not derived from the addition of calcium-based tempers

(i.e. bone, shell, limestone...) and thus most likely represents chemical variability in the clays. An initial analysis using calcium corrected data found little patterned variation. The data maintained better patterned variability without a calcium adjustment and this report only described the unadjusted data.

Statistical analysis was carried out on base-10 logarithms of concentrations on the remaining 28 elements. Use of log concentrations rather than raw data compensates for differences in magnitude between the major elements, such as iron, and trace elements, such as the rare earth or lanthanide elements (REEs). Transformation to base-10 logarithms also yields a more normal distribution for many trace elements.

The interpretation of compositional data obtained from the analysis of archaeological materials is discussed in detail elsewhere (e.g., Baxter and Buck 2000; Bieber et al. 1976; Bishop and Neff 1989; Glascock 1992; Harbottle 1976; Neff 2000) and will only be summarized here. The main goal of data analysis is to identify distinct homogeneous groups within the analytical database. Based on the provenance postulate of Weigand et al. (1977), different chemical groups may be assumed to represent geographically restricted sources. For lithic materials such as obsidian, basalt, and cryptocrystalline silicates (e.g., chert, flint, or jasper), raw material samples are frequently collected from known outcrops or secondary deposits and the compositional data obtained on the samples is used to define the source localities or boundaries. The locations of sources can also be inferred by comparing unknown specimens (i.e., ceramic artifacts) to knowns (i.e., clay samples) or by indirect methods such as the “criterion of abundance” (Bishop et al. 1992) or by arguments based on geological and sedimentological characteristics (e.g., Steponaitis et al. 1996). The ubiquity of ceramic raw materials usually makes it impossible to sample all potential “sources” intensively enough to create groups of knowns to which unknowns can be compared. Lithic sources tend to be more localized and compositionally homogeneous in the case of obsidian or compositionally heterogeneous as is the case for most cherts.

Compositional groups can be viewed as “centers of mass” in the compositional hyperspace described by the measured elemental data. Groups are characterized by the locations of their centroids and the unique relationships (i.e., correlations) between the elements. Decisions about whether to assign a specimen to a particular compositional group are based on the overall probability that the measured concentrations for the specimen could have been obtained from that group.

Initial hypotheses about source-related subgroups in the compositional data can be derived from non-compositional information (e.g., archaeological context, decorative attributes, etc.) or from application of various pattern-recognition technique to the multivariate chemical data. Some of the pattern recognition techniques that have been used to investigate archaeological data sets are cluster analysis (CA), principal components analysis (PCA), and discriminant analysis (DA). Each of the techniques has its own advantages and disadvantages which may depend upon the types and quantity of data available for interpretation.

The variables (measured elements) in archaeological and geological data sets are often correlated and frequently large in number. This makes handling and interpreting patterns within the data difficult. Therefore, it is often useful to transform the original variables into a smaller set of uncorrelated variables in order to make data interpretation easier. Of the above-mentioned pattern recognition techniques, PCA is a technique that transforms from the data from the original correlated variables into uncorrelated variables most easily.

PCA creates a new set of reference axes arranged in decreasing order of variance subsumed. The individual PCs are linear combinations of the original variables. The data can be displayed on combinations of the new axes, just as they can be displayed on the original elemental concentration axes. PCA can be used in a pure pattern-recognition mode, i.e., to search for subgroups in an undifferentiated data set, or in a more evaluative mode, i.e., to assess the coherence of hypothetical groups suggested by other criteria. Generally, compositional differences between specimens can be expected to be larger for

specimens in different groups than for specimens in the same group, and this implies that groups should be detectable as distinct areas of high point density on plots of the first few components. It is well known that PCA of chemical data is scale dependent (Mardia et al. 1979), and analyses tend to be dominated by those elements or isotopes for which the concentrations are relatively large. This is yet another reason for the log transformation of the data.

One frequently exploited strength of PCA, discussed by Baxter (1992), Baxter and Buck (2000z), and Neff (1994, 2002), is that it can be applied as a simultaneous R- and Q-mode technique, with both variables (elements) and objects (individual analyzed samples) displayed on the same set of principal component reference axes. A plot using the first two principal components as axes is usually the best possible two-dimensional representation of the correlation or variance-covariance structure within the data set. Small angles between the vectors from the origin to variable coordinates indicate strong positive correlation; angles at 90 degrees indicate no correlation; and angles close to 180 degrees indicate strong negative correlation. Likewise, a plot of sample coordinates on these same axes will be the best two-dimensional representation of Euclidean relations among the samples in log-concentration space (if the PCA was based on the variance-covariance matrix) or standardized log-concentration space (if the PCA was based on the correlation matrix). Displaying both objects and variables on the same plot makes it possible to observe the contributions of specific elements to group separation and to the distinctive shapes of the various groups. Such a plot is commonly referred to as a “biplot” in reference to the simultaneous plotting of objects and variables. The variable inter-relationships inferred from a biplot can be verified directly by inspecting bivariate elemental concentration plots. [Note that a bivariate plot of elemental concentrations is not a biplot.]

Whether a group can be discriminated easily from other groups can be evaluated visually in two dimensions or statistically in multiple dimensions. A metric known as the Mahalanobis distance (or generalized distance) makes it possible to describe

the separation between groups or between individual samples and groups on multiple dimensions. The Mahalanobis distance of a specimen from a group centroid (Bieber et al. 1976, Bishop and Neff 1989) is defined by:

$$D_{y,x}^2 = [y - \bar{X}]' I_x [y - \bar{X}]$$

where y is the $1 \times m$ array of logged elemental concentrations for the specimen of interest, $\bar{X}$ is the $n \times m$ data matrix of logged concentrations for the group to which the point is being compared with $\bar{X}$ being its $1 \times m$ centroid, and I_x is the inverse of the $m \times m$ variance-covariance matrix of group $\bar{X}$. Because Mahalanobis distance takes into account variances and covariances in the multivariate group it is analogous to expressing distance from a univariate mean in standard deviation units. Like standard deviation units, Mahalanobis distances can be converted into probabilities of group membership for individual specimens. For relatively small sample sizes, it is appropriate to base probabilities on Hotelling's T^2 , which is the multivariate extension of the univariate Student's t .

When group sizes are small, Mahalanobis distance-based probabilities can fluctuate dramatically depending upon whether or not each specimen is assumed to be a member of the group to which it is being compared. Harbottle (1976) calls this phenomenon "stretchability" in reference to the tendency of an included specimen to stretch the group in the direction of its own location in elemental concentration space. This problem can be circumvented by cross-validation, that is, by removing each specimen from its presumed group before calculating its own probability of membership (Baxter 1994; Leese and Main 1994). This is a conservative approach to group evaluation that may sometimes exclude true group members.

Small sample and group sizes place further constraints on the use of Mahalanobis distance: with more elements than samples, the group variance-covariance matrix is singular thus rendering calculation of I_x (and D^2 itself) impossible. Therefore, the dimensionality of the groups must somehow be reduced. One approach would be to eliminate elements considered irrelevant or

redundant. The problem with this approach is that the investigator's preconceptions about which elements should be discriminate may not be valid. It also squanders the main advantage of multielement analysis, namely the capability to measure a large number of elements. An alternative approach is to calculate Mahalanobis distances with the scores on principal components extracted from the variance-covariance or correlation matrix for the complete data set. This approach entails only the assumption, entirely reasonable in light of the above discussion of PCA, that most group-separating differences should be visible on the first several PCs. Unless a data set is extremely complex, containing numerous distinct groups, using enough components to subsume at least 90 percent of the total variance in the data can be generally assumed to yield Mahalanobis distances that approximate Mahalanobis distances in full elemental concentration space.

Lastly, Mahalanobis distance calculations are also quite useful for handling missing data (Sayre 1975). When many specimens are analyzed for a large number of elements, it is almost certain that a few element concentrations will be missed for some of the specimens. This occurs most frequently when the concentration for an element is near the detection limit. Rather than eliminate the specimen or the element from consideration, it is possible to substitute a missing value by replacing it with a value that minimizes the Mahalanobis distance for the specimen from the group centroid. Thus, those few specimens which are missing a single concentration value can still be used in group calculations.

G.3 Results

The compositional groups, assessment of the clay samples, correlation with descriptive data, and plans for further research are discussed below. The list of samples, group assignments, and location information for the ceramic samples are provided in Appendix G-1, and the clay samples in Appendix G-2.

G.3.1 Comparison to the MURR Master Database

The new TRC samples were compared to the MURR master database containing almost 90,000 previously analyzed ceramic and raw material

samples. The comparison was based on a Euclidian search distance between each sample and all samples in the master database. Reasonably close matches (Euclidian distances of less than 0.012) were found for a number of samples from the same area submitted by Holly Meier (2007) as well as samples from the Central Plains submitted by Robert Hoard and Anne Cobry. We began the analysis for compositional groups using a database including all of the TRC, Meier, Hoard, and Cobry samples. A number of compositional groups were identified in this dataset and it was readily apparent that the TRC and Meier data was not compositionally similar to the Central Plains samples. The main Central Plains Group (redefined in this project as Group 5) was very similar to the group identified in previous studies of the Central Plains data, with one sample from the current study included. Sample TRC609 (284a) from 34TX32 has a 7 percent probability of membership in the Central Plains Group (Group 5, based on a Mahalanobis distance calculation) and is tentatively assigned to this group. The probability is too low to be certain of long-distance exchange between the Southern and Central Plains, but this does suggest the possibility. With the exception of TRC609 there was no overlap between the preliminary compositional group assignments of the samples from the two regions, we have conducted the remainder of the interpretation using only the TRC and Meier samples from the Southern Plains.

G.3.2 Compositional Groups

All of the compositional groups in this study were identified by visual analysis of bivariate elemental plots of the ceramic samples. Some groups represent clusters of samples that remain very tight in most elemental combinations, while other groups represent clusters in only a limited number of bivariate plots. Statistical validation of small compositional groups using Mahalanobis distance calculations is possible in some studies using a subset of the principal components, but these data do not separate well in PC space, and thus PCs are not useful for statistical tests. Only two groups include enough samples to conduct Mahalanobis distance calculations and this was used to further refine the groups initially defined in bivariate plots. The groups were formed without any regard to archeological site or region and represent unbiased groups. The resulting

distribution of groups by region (Table G-1) strongly supports regional production patterns. The clay samples were compared to the compositional groups and are discussed separately.

The large number of sites with very few samples makes a strictly site-based analysis difficult. The sites have been divided into five regions based on local geography and geology. The five regions and their respective sites are listed in Table G-1.

The compositional groups fall into three broad categories: 1) pairs of samples that consistently plot together; 2) small groups with three to eight samples; and 3) large groups containing ten or more samples. The compositional groups are discussed according to these three categories below.

G.3.3 Sample Pairs

Groups 8, 9, 10, and 13 all consist of only two samples that consistently plot together in bivariate plots (Table G-1). There are no appropriate statistical tests to validate the pairs, but the two samples in each group are all from the same site. These may represent fragments from the same chemically-unique vessels or perhaps underrepresented production recipes. Group 8 consists of two samples from the Roy Smith site (34BV14) and is most readily separated from the other samples in high concentrations of iron and low cesium. Group 9 is from the Cross Bar site (41PT109) samples defined by Meier and these samples show elevated concentrations of terbium and ytterbium. Group 10 samples are both Meier samples from Alibates 28 (41PT11), and are very chemically distinct, with low concentrations of chromium and cerium. Group 13 includes two samples from the Pavilion site (41PT245) sampled by TRC in 2008. Group 13 samples have elevated levels of most rare earth elements. Figure G-1 shows all of the pair groups, and in particular, the separation of Groups 8, 10, and 13.

G.3.3.1 Small Groups

Five groups (Groups 3, 4, 6, 11 and 12) have between three and eight samples each (Table G-1). These groups were identified through visual inspection of bivariate plots and are too small for any statistical validation. Many of the groups

are distinct in only a few plots, yet they represent restricted spatial distributions – suggesting they are valid representations of spatially differentiated raw material chemical variation.

Group 3 included four samples, all submitted by Meier from the Alibates Ruin 28 site (41PT11). The four samples in the group are extremely similar in chemistry and so they were considered a separate group, even though they are generally similar to the large Group 7 that is primarily from the region surrounding the Antelope Creek sites. Figure G-2 shows how tight this group is, even though it is difficult to show clear separation from some of the larger groups.

Group 11 consists of three samples, all from the Indian Springs site (41RB81). There are only a total of nine samples from this site, and three fall into this unique group, two are assigned to other groups, and four are unassigned. A more extensive sample from this site would help to determine if the Group 11 samples represent rare unique chemistry or an under-sampled local production signature. This group is shown in Figure G-2.

Group 6 includes five samples, four of which are from two sites in the Antelope Creek phase (ACP) region (Alibates Ruin 28 [41PT11] and Cross Bar [41PT109]). The remaining sample is from the Two Sisters site (34TX32). Figure G-3 shows the separation of this group.

Six of the seven members of Group 4 are from the Long View site and the seventh sample is from Antelope Creek Ruin 22 (41HC23). The samples in this group exhibit relatively high concentrations of iron, and a plot of iron and calcium (Figure G-4) shows the separation of this group. Given the concentration of this group at the Long View site (41RB112), it seems likely that this is, or is very near, the location of production. There are not enough samples to confidently attribute this to a particular area of the site.

Group 12 is one of the more questionable groups in the study. The samples were left unassigned for most of the analysis, but they did separate by low sodium concentrations (Figure G-5). Sodium is

susceptible to post-depositional changes and even modern sample contamination, however, the group includes samples from four sites in two regions and from both the TRC and Meier projects. The group is similar in composition to Group 7 in both composition and geographic distribution.

G.3.3.2 Large Groups

The smallest of the large groups, Group 1, contains ten samples, nine of which are from the Long View site. The samples exhibit high concentrations of chromium and barium (Figure G-6). Interestingly, 9 of the 10 samples in Group 1 from the Long View site are from Component C, and none are from Component A. Although the samples are small, this may indicate a production recipe unique to Component C. One additional group member is from the nearby site of Indian Springs.

Group 2 includes 29 samples, 15 of which are from the Long View site. Nine of the 15 samples are from Component A, and only 2 are from Component C. This is nearly the opposite pattern as Group 1, suggesting that Group 2 may have been produced in Component A while Group 1 was produced in Component C. An alternative scenario is that occupants in the different components of the site (Component A is roughly 70 years older than Component C) had different ceramic procurement patterns. The Group 2 samples were initially separated as a tight cluster in a plot of cesium and calcium (Figure G-7). The group was slightly modified by membership probabilities based on Mahalanobis distance calculations.

Group 7 was initially part of a large cluster of remaining samples after the other compositional groups were established that revealed very little obvious groupings. We began to remove individual samples that were clear outliers in individual bivariate plots. After about 15 samples were removed, a large cluster was apparent in a plot of hafnium and thorium. This group was further refined using Mahalanobis distance probabilities (Appendix G-3) that resulted in a slightly less visually-distinct group seen in Figure G-8.

The group membership probabilities presented in Appendix G-3 require further explanation.

Table G-1. Breakdown of Compositional Group by Region/Site.

Region abbreviations: **ACP** = Antelope Creek Phase sites located in the Canadian River Valley; **LVR** = Sites near the Long View Site; **LVS** = Long View Site; **NCR** = North Canadian River Area in the Oklahoma Panhandle; and **WBC** = Wolf Creek/Buried City sites just north of the Long View site.

Region/Site	1	2	3	4	5	6	7	8	9	10	11	12	13	out	Unas	Grand Total
ACP Total		3	4	1		4	51		2	2		7	2	1	28	105
Alibates 28 – 41PT11		3				2	15			2		2		1	9	34
Antelope Creek 41HC23				1			4					1				6
Corral - 41PT186															3	3
Cottonwood - 41HC141							1								2	3
Cross Bar - 41PT109			4			2	11		2			4			2	25
Landergin Mesa -41OL2							17								8	25
Pavilion – 41PT245													2		1	3
Roper - 41HC6							3								3	6
LVR Total	1	3									3	1			10	18
Hank's Area A 41RB109		1													1	2
Hank's Area B 41RB109															1	1
Hank's Area E - 41RB109		2														2
Indian Springs - 41RB81	1										3	1			4	9
Three Toes Area A 41RB110															3	3
Whistling Squaw 41RB108															1	1
LVS Total	9	15		6											2	32
Long View Component A		12		2											1	15
Long View Component C	9	3		4											1	17
NCR Total		4			1	1	5	2							10	23
McGrath – 34TX31		1													2	3
Roy Smith – 34BV14		2						2							3	7
Stamper – 34TX1		1					4								1	6
Two Sisters – 34TX32					1	1	1								4	7

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WBC Total		4													11	15
Courson B – 41OC27															9	9
Courson D – 41OC29		3													1	4
Kit Courson – 41OC43		1													1	2
Grand Total	10	29	4	7	1	5	56	2	2	2	3	8	2	1	61	193

Figure G-1. Bivariate plot of chromium and cerium showing the separation of the four groups with only two samples.

Only members of Groups 8, 9, 10, and 13 are individually plotted and labeled. The other compositional groups are shown with the ellipses only. The unassigned samples are individually plotted. Ellipses represent a 90% confidence level for membership in the group.

Figure G-2. Bivariate plot of chromium and iron showing groups 3 and 11. Only members of Groups 3, 4, 6, 11, and 12 are individually plotted. The large compositional groups are shown with the ellipses only. Ellipses represent a 90% confidence level for membership in the group.

Figure G-3. Bivariate plot of chromium and calcium showing the separation of group 6. Only members of Groups 3, 4, 6, 11, and 12 are individually plotted. The large compositional groups are shown with the ellipses only. Ellipses represent a 90% confidence level for membership in the group.

Figure G-4. Bivariate plot of iron and hafnium showing the separation of group 4. Only members of Groups 3, 4, 6, 11, and 12 are individually plotted. The large compositional groups are shown with the ellipses only. Ellipses represent a 90% confidence level for membership in the group.

Figure G-5. Bivariate plot of iron and sodium showing the separation of group 12. Only members of Groups 3, 4, 6, 11, and 12 are individually plotted. The large compositional groups are shown with the ellipses only. Ellipses represent a 90% confidence level for membership in the group.

Mahalanobis distance probabilities are best when the number of samples in the groups is at least double the number of variables in the dataset, and the closer the number of samples and variables, the more the probability of membership for unrelated samples are inflated. Thus, a few additional elements (Al, Nd, Dy, and U) were eliminated to help improve the statistics for Group 2 since it only has 29 members. The Group 2 samples are easily separated from the members of Group 7 with only a few exceptions. Most of the other compositional groups and unassigned samples have high probabilities of membership in Group 2, but this is a function of probability inflation due to the low number of samples in Group 2. One interesting note is the high probability of membership in Group 7 for the samples in Group 10. Group 10 is also from ACP, and if the two Group 10 samples were not so closely related (perhaps even from the same vessel) then they would be reasonable members of Group 7. The unassigned ceramics and raw material samples are discussed below.

While we had questions about the interpretive validity of Group 7, the spatial pattern of the samples confirmed its separation. Fifty-one of the 56 members of this group are from sites in the Antelope Creek phase (ACP) region, and the remaining five samples are from the North Canadian River (NCR) region. It is surprising that the near Long View (LVR), Long View site (LVS), and Wolf Creek/Buried City (WBC) site do not have a single member of Group 7. The limited distribution of Group 7 as well as many of the other groups suggests fairly limited inter-regional ceramic exchange between occupants of the five regions.

G.3.3.4 Unassigned Samples

One sample from Alibates Ruin 28, 41PT11 (HAM060) was removed from the dataset early in the analysis because it was clearly different in a number of elemental concentrations. It did not have any close matches to other samples in the MURR master database that might offer an explanation of long-distance exchange, so at this point it is not possible to offer any further interpretation of this sample.

The remaining unassigned samples represent what is left after all apparent clusters were removed. Unsuccessful attempts were made to use principal

component and hierarchical analysis to identify any additional compositional groups. The spatial pattern of the unassigned samples is perhaps one of the most interesting and informative aspects of this entire study. There are unassigned samples from every region and all but Antelope Creek Ruin 22 (41HC23), but the pattern is far from even and there is a strong correlation between sampling intensity and the percentage of unassigned samples. Figure G-9 shows the relationship between the number of samples/site for a region and the percent of unassigned samples. The overall percentage of unassigned samples (31 percent) is in line with general expectations for ceramic NAA projects, particularly, but it might be possible to dramatically reduce the percentage with more intensive sampling of the regions and sites with less than 10 samples per site. Small unique clusters representing production recipes from the currently under-sampled sites might emerge from the scatter of unassigned samples. This pattern of unassigned samples is very informative about ideal sampling strategies and reaffirms the interpretative limitations of studies with samples spread too thin over many sites, regions, temporal periods, or other factors.

G.4 Clays and Raw Materials

The clay and raw material samples include a mix of raw clays, 6 daub and 9 clays with temper mixes, and clays from feature walls and floors. The clays were initially separated from the ceramic samples while compositional groups were established. Unfortunately the clay and raw material samples showed little patterned match with any of the ceramic compositional groups. The clay samples are generally similar to the ceramics samples, suggesting a general regional similarity. The only element with a consistent difference between the clays and ceramics is barium, and we do not have a good explanation for this difference (Figure G-10).

The only group large enough for meaningful group membership probability calculation using Mahalanobis distance calculations is Group 7. As shown in Appendix G-3, only one clay sample has a membership probability in Group 7 of more than 1 percent, and that is a daub sample from the Long View site. This seems like an unlikely indicator of location of production because there is not a single

Figure G-6. Bivariate plot of chromium and barium showing the separation of group 1. Only members of Groups 1, 2, 7, and the unassigned samples are individually plotted. Ellipses represent a 90% confidence level for membership in the group.

Figure G-7. Bivariate plot of cesium and calcium showing the separation of group 2. Only members of Groups 1, 2, 7, and the unassigned samples are individually plotted. Ellipses represent a 90% confidence level for membership in the group.

Figure G-8. Bivariate plot of hafnium and thorium showing the separation of group 7. Only members of Groups 1, 2, 7, and the unassigned samples are individually plotted. Ellipses represent a 90% confidence level for membership in the group.

Figure G-9. Scatter plot of the number of NAA ceramic samples/site against the percent of unassigned samples.

Figure G-10. Bivariate plot of barium and hafnium showing the general similarity of the clay and ceramic samples.

sample in Group 7 from the Long View site or any of the adjacent sites and the probability of membership in Group 4 is only 4 percent.

Each of the ceramic compositional groups was individually compared to all of the clay and raw material samples and there were no consistent matches. This in no way does not rule out the use of any specific clay in the manufacture of any of the ceramics, nor does it link any ceramic compositional group to a particular clay source. The strong spatial patterning of the compositional groups indicated numerous localized production locations, but not the use of specific raw materials. We have the capability to analyze clays and tempers separately and then mathematically mix them in different concentrations. This can be a more productive method of linking raw materials with specific compositional groups and perhaps future sampling would attempt this.

G.5 Conclusions

This study includes 193 ceramic samples and 48 clay, 6 daub, and other raw material samples combined from new and previous TRC projects (Quigg et al. 2010) and the samples previously analyzed for Holly Meier (2007). The entire dataset was reinterpreted and we have identified 13 compositional groups. Only one of the groups (Group 2) had widespread distribution across multiple regions, while the twelve remaining groups all showed spatially restricted distributions, often limited to a single region or even site. This distribution clearly demonstrates that region-specific production signatures are detectible. Limited patterns, even at the intra-site level, are possible, but further sampling should be undertaken to confirm these patterns.

The unassigned sample distribution provides an excellent example of the importance of large samples in conducting ceramic NAA. The regions with a high number of samples and/or few sites had the less than half the percentage of unassigned samples as the regions with few samples per site. Additional sampling from the LVR, NCR, and WBC may reveal a number of additional compositional groups and increase our understanding of ceramic production and exchange in the Southern Plains.

Acknowledgments

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**Appendix G-1. Descriptive Information and Compositional Group Assignments
for Ceramic Samples.**

Note, HAM samples are from Holly A. Meier (2007) analysis of three Antelope Creek phase sites. TRC numbers are those submitted by TRC Environmental.

<u>ANID</u>	<u>Comp.</u>	<u>Alt ID/Lot # PNUM</u>	<u>Region</u>	<u>Site No.</u>	<u>Type</u>
HAM001	3		ACP	41PT109	Borger Cord Marked, 2004-9-1
HAM002	7		ACP	41PT109	Borger Cord Marked, 2004-9-2
HAM003	7		ACP	41PT109	Borger Cord Marked, 2004-9-3
HAM004	7		ACP	41PT109	Borger Cord Marked, 2004-3-1
HAM005	7		ACP	41PT109	Borger Cord Marked, 2004-18-1
HAM006	6		ACP	41PT109	Borger Cord Marked, 2004-12-1
HAM007	7		ACP	41PT109	Borger Cord Marked, 2004-8-1
HAM008	12		ACP	41PT109	Borger Cord Marked, 2004-6-1 rim
HAM009	7		ACP	41PT109	Borger Cord Marked, 2004-1-2
HAM010	12		ACP	41PT109	Borger Cord Marked, 2004-1-1
HAM011	9		ACP	41PT109	Borger Cord Marked, 2004-U15 L5
HAM012	7		ACP	41PT109	Borger Cord Marked, 2004-U16 5- 1/2
HAM013	Unas		ACP	41PT109	Borger Cord Marked, 2004-U16 5-4
HAM014	9		ACP	41PT109	Borger Cord Marked, 2004-U16 6-1
HAM015	12		ACP	41PT109	Borger Cord Marked, 2004-U16 L1 base
HAM016	6		ACP	41PT109	Borger Cord Marked, 2004-U17 7-8
HAM017	Unas		ACP	41PT109	Borger Cord Marked, 2004-U17 7-5
HAM018	7		ACP	41PT109	Borger Cord Marked, 2004-U17 7-1
HAM019	7		ACP	41PT109	Borger Cord Marked, 2004-U21 91 neck
HAM020	7		ACP	41PT109	Borger Cord Marked, 2004-U22 10-1
HAM021	7		ACP	41PT109	Borger Cord Marked, 2004-U22 11-1
HAM022	12		ACP	41PT109	Borger Cord Marked, 2004-U25 14-1
HAM023	3		ACP	41PT109	Borger Cord Marked, 2004-U25 12-2
HAM024	3		ACP	41PT109	Borger Cord Marked, 2004-U25 12-1
<u>HAM025</u>	<u>3</u>		<u>ACP</u>	<u>41PT109</u>	<u>Borger Cord Marked, 2004-U25 12-4/5</u>
HAM026	7		ACP	41OL2	Borger Cord Marked, 416-1 rim
HAM027	Unas		ACP	41OL2	Borger Cord Marked, 416-1
HAM028	Unas		ACP	41OL2	Borger Cord Marked, 78-5
HAM029	7		ACP	41OL2	Borger Cord Marked, 82-6
HAM030	7		ACP	41OL2	Borger Cord Marked, 86-15
HAM031	7		ACP	41OL2	Borger Cord Marked, 96-1 rim
HAM032	7		ACP	41OL2	Borger Cord Marked, 114-1 shoulder
HAM033	7		ACP	41OL2	Borger Cord Marked, 99-11 shoulder
HAM034	Unas		ACP	41OL2	Borger Cord Marked, 108-1 shoulder
HAM035	Unas		ACP	41OL2	Borger Cord Marked, 90-1 shoulder
HAM036	7		ACP	41OL2	Borger Cord Marked, 90-1
HAM037	7		ACP	41OL2	Borger Cord Marked, 90-1 rim

Appendix G-1. Descriptive Information and Compositional Group Assignments for Ceramic Samples. (cont.)

Note, HAM samples are from Holly A. Meier (2007) analysis of three Antelope Creek phase sites. TRC numbers are those submitted by TRC Environmental.

<u>ANID</u>	<u>Comp.</u>	<u>Alt ID/Lot # PNUM</u>	<u>Region</u>	<u>Site No.</u>	<u>Type</u>
HAM038	7		ACP	41OL2	Borger Cord Marked, 97-1
HAM039	7		ACP	41OL2	Borger Cord Marked, 97-1
HAM040	7		ACP	41OL2	Borger Cord Marked, 112-3
HAM041	Unas		ACP	41OL2	Borger Cord Marked, 112-3
HAM042	Unas		ACP	41OL2	Borger Cord Marked, 63-4
HAM043	Unas		ACP	41OL2	Borger Cord Marked, 147-1
HAM044	7		ACP	41OL2	Borger Cord Marked, 157-1,
HAM045	7		ACP	41OL2	Borger Cord Marked, 243-1
HAM046	Unas		ACP	41OL2	Borger Cord Marked, 243-1
HAM047	7		ACP	41OL2	Borger Cord Marked, 243-1
HAM048	7		ACP	41OL2	Borger Cord Marked, 182-1
HAM049	7		ACP	41OL2	Borger Cord Marked, 182-1
<u>HAM050</u>	<u>7</u>		<u>ACP</u>	<u>41OL2</u>	<u>Borger Cord Marked, 178-2 rim</u>
HAM051	7		ACP	41PT11	Borger Cord Marked, 28,A2-52/2
HAM052	7		ACP	41PT11	Borger Cord Marked,28 A2-52/2
HAM053	7		ACP	41PT11	Borger Cord Marked, 28 A2-37a/3
HAM054	Unas		ACP	41PT11	Borger Cord Marked, 28 A2-37a/3
HAM055	10		ACP	41PT11	Borger Cord Marked, 28 A2-8/3
HAM056	7		ACP	41PT11	Borger Cord Marked, 28 A2-8/3
HAM057	10		ACP	41PT11	Borger Cord Marked, 28 A2-8/4
HAM058	Unas		ACP	41PT11	Borger Cord Marked, 28 A1-18-R2/2
HAM059	Unas		ACP	41PT11	Borger Cord Marked, 28 A1-18-R2/3
HAM060	Unas		ACP	41PT11	Borger Cord Marked, 28 A1-18-R2/4
HAM061	7		ACP	41PT11	Borger Cord Marked, 28 A5-R32/1 rim
HAM062	12		ACP	41PT11	Borger Cord Marked, 28 A5-R32/1
HAM063	7		ACP	41PT11	Borger Cord Marked, 28 A5-R32/3
HAM064	7		ACP	41PT11	Borger Cord Marked, 28 A5-R32/3
HAM065	6		ACP	41PT11	Borger Cord Marked, 28 RM5/1
HAM066	6		ACP	41PT11	Borger Cord Marked, 28 RM5/1
HAM067	2		ACP	41PT11	Borger Cord Marked, 28 A1-14-R1/1,2
HAM068	7		ACP	41PT11	Borger Cord Marked, 28 A1-14-R1/2
HAM069	7		ACP	41PT11	Borger Cord Marked, 28 A1-14-R1/3
HAM070	7		ACP	41PT11	Borger Cord Marked, 28 A1-14-R1/2
HAM071	7		ACP	41PT11	Borger Cord Marked, 28 A1-14-R1/4
HAM072	Unas		ACP	41PT11	Borger Cord Marked, 28 A1-10/3
HAM073	7		ACP	41PT11	Borger Cord Marked, 28 A1-10/3
HAM074	Unas		ACP	41PT11	Borger Cord Marked, 28 A1-10/1 rim

**Appendix G-1. Descriptive Information and Compositional Group Assignments
for Ceramic Samples. (cont.)**

Note, HAM samples are from Holly A. Meier (2007) analysis of three Antelope Creek phase sites. TRC numbers are those submitted by TRC Environmental.

<u>ANID</u>	<u>Comp.</u>	<u>Alt ID/Lot # PNUM</u>	<u>Region</u>	<u>Site No.</u>	<u>Type</u>
HAM075	Unas		ACP	41PT11	Borger Cord Marked, 28 A1-10/2
TRC429	Unas	401-008-1	ACP	41PT245	Redware, polished, granitic temper, hematite
TRC430	13	340-008-1	ACP	41PT245	Plain, very thin, granitic temper with feldspar
TRC431	Unas	343-008-1	ACP	41PT186	Corrugated, crushed rock temper, no feldspar
TRC432	Unas	FS 68.1	ACP	41PT186	Cordmarked, smoothed over, thin-4.5 mm
TRC433	13	341-008-1	ACP	41PT245	Plain, polished, quartz temper, thin-4.5 mm,
TRC527	Unas	443-8-1	ACP	41PT186	Plain, thin, crushed quartz temper
TRC528	2	E3a/WP-1	LVR	41RB109	Smoothed, fingernail impressed
TRC529	2	E3a/WP-2	LVR	41RB109	Cordmarked, fingernail impressed
TRC530	2	21a/WP-3	LVR	41RB109	Cordmarked, from upper house, structure 1
TRC531	Unas	17a/WP-4	LVR	41RB109	Cordmarked, from Feature 2, bell pit
TRC532	Unas	5a/WP-5	LVR	41RB109	Cordmarked, from trash/burrow pit B-1
TRC533	Unas	?a/WP-6	LVR	41RB108	Cordmarked, Feature 4 deep pit
TRC534	Unas	13a/WP-7	LVR	41RB110	Cordmarked, from Feature 5
TRC535	Unas	12a/WP-8	LVR	41RB110	Cordmarked, smoothed over, house 1
TRC536	Unas	87 37a/WP-9	LVR	41RB110	Cordmarked, faint, shallow, thick,
TRC537	Unas	291a/124.1	LVR	41RB81	Cordmarked, obliterated, thick
TRC538	11	381a/124.8	LVR	41RB81	brushed? very distinct lines, thick
TRC539	12	347a 309/123.8	LVR	41RB81	Cordmarked, distinct, deep
TRC540	Unas	370a	LVR	41RB81	Cordmarked, smoothed over, thick
TRC541	1	374-1a/124.0	LVR	41RB81	Cordmarked,
TRC542	11	374-2a/124.0	LVR	41RB81	Cordmarked, linear thin marks
TRC543	Unas	492a	LVR	41RB81	Cordmarked, thick polished, obliterated
TRC544	11	505a 123.9	LVR	41RB81	brushed? Structure 1, Linear marks,
TRC545	Unas	156a	LVR	41RB81	Cordmarked, narrow obliterated
TRC555	2	1140-008-1b	LVS	41RB112	Cordmarked, Vessel A collared rim
TRC556	2	1175-008-1b	LVS	41RB112	Plain, Vessel B thin obliterated
TRC557	4	1206-008-1b	LVS	41RB112	Plain, Vessel C red import
TRC558	2	1119-008-1b	LVS	41RB112	Cordmarked, Vessel D
TRC559	2	1223-008-1b	LVS	41RB112	Cordmarked Vessel E partial obliterated
TRC560	2	998-008-1b	LVS	41RB112	Cordmarked, Vessel F hand molded
TRC561	2	1066-008-1b	LVS	41RB112	Cordmarked, Vessel G rim impressed
TRC562	2	1135-008-1b	LVS	41RB112	Cordmarked, Vessel H thick black
TRC563	2	1036-008-1b	LVS	41RB112	Cordmarked, Vessel I overlapping marks
TRC564	2	2-008-6b	LVS	41RB112	Cordmarked, Vessel J fine sand
TRC565	1	362-008-1b	LVS	41RB112	Cordmarked, Vessel 1 body, thick
TRC566	4	349-008-1b	LVS	41RB112	Cordmarked, Vessel 3 body/rim, thick

Appendix G-1. Descriptive Information and Compositional Group Assignments for Ceramic Samples. (cont.)

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<u>ANID</u>	<u>Comp.</u>	<u>Alt ID/Lot # PNUM</u>	<u>Region</u>	<u>Site No.</u>	<u>Type</u>
TRC567	1	259-008-2b	LVS	41RB112	Cordmarked, Vessel 2 rim indistinct
TRC568	2	405-008-1b	LVS	41RB112	- , Vessel 4 small, plain rim
TRC569	1	338-008-6b	LVS	41RB112	Cordmarked, Vessel 1 rim thick
TRC570	1	628-008-1b	LVS	41RB112	Cordmarked, Vessel 5 rim, obliterated
TRC571	1	639-008-3b	LVS	41RB112	Corn Cob impressed, Vessel 6, body
TRC572	4	643-008-1b	LVS	41RB112	Cordmarked, Vessel 1 thick black, body
TRC573	1	303-008-1b	LVS	41RB112	Cordmarked, Vessel 1 base, very thick
<u>TRC574</u>	<u>2</u>	<u>468-008-4b</u>	<u>LVS</u>	<u>41RB112</u>	<u>Cordmarked, Vessel 7 body obliterated</u>
TRC575	Unas	243a	WBC	41OC27	Cordmarked, thick, obliterated
TRC576	Unas	462-70a	WBC	41OC27	Cordmarked, narrow marks, pinched rim
TRC577	Unas	256-57a	WBC	41OC27	Cordmarked, narrow marks, thick decorate rim
TRC578	Unas	383a	WBC	41OC27	Cordmarked, broad shallow marks, upper house
TRC579	Unas	386a	WBC	41OC27	Corn Cob impressed, distinct, thick, S. trash pit
TRC580	Unas	355-2a	WBC	41OC27	Cordmarked, narrow marks nail impressed plain lip
TRC581	Unas	216a	WBC	41OC27	Cordmarked, lines? Smoothed, Feature 7A pit
TRC582	Unas	556-8a	WBC	41OC27	Cordmarked, rounded rim, shallow marks F-4,
<u>TRC583</u>	<u>Unas</u>	<u>398-310a</u>	<u>WBC</u>	<u>41OC27</u>	<u>Cordmarked, upper house, thin</u>
TRC584	Unas	346-4a	WBC	41OC29	Cordmarked, narrow distinct marks, F-A3 thick
TRC585	2	343-22a	WBC	41OC29	Corn Cob impressed, thick, big & lots temper
TRC586	2	338-01a	WBC	41OC29	Polished, plain, tool pinched/collared rim
<u>TRC587</u>	<u>2</u>	<u>338-07a</u>	<u>WBC</u>	<u>41OC29</u>	<u>Polished plain, thin</u>
TRC588	2	325.7a	WBC	41OC43	Cordmarked, shallow & narrow marks, residue
<u>TRC589</u>	<u>Unas</u>	<u>65-310a</u>	<u>WBC</u>	<u>41OC43</u>	<u>Cordmarked, broad and distinct marks</u>
TRC590	8	71a	NCR	34BV14	Cordmarked, thick, narrow marks, smoothed
TRC591	Unas	427-a	NCR	34BV14	Cordmarked, rim, smoothed over
TRC592	2	600a	NCR	34BV14	Cordmarked, thin, very distinct marks
TRC593	Unas	580a	NCR	34BV14	Cordmarked, thin & shallow marks
TRC594	2	438a	NCR	34BV14	Cordmarked, smoothed over, narrow, distinct
TRC595	Unas	302a	NCR	34BV14	Cordmarked, smoothed over, ?grog
<u>TRC596</u>	<u>8</u>	<u>364a</u>	<u>NCR</u>	<u>34BV14</u>	<u>Cordmarked, narrow marks, shallow</u>
TRC597	Unas	74a	NCR	34TX31	Cordmarked, broad distinct marks
TRC598	Unas	175.1a	NCR	34TX31	Cordmarked, smoothed over, crusted residue
<u>TRC599</u>	<u>2</u>	<u>175.2a</u>	<u>NCR</u>	<u>34TX31</u>	<u>Cordmarked, well defined marks</u>
TRC600	Unas	10a	NCR	34TX1	Cordmarked, rim, deep, distinct marks
TRC601	2	14a	NCR	34TX1	Plain, rim right angle to neck, black exterior
TRC602	7	155a	NCR	34TX1	Cordmarked, rim, narrow & shallow marks
TRC603	7	377a	NCR	34TX1	Cordmarked, rim, narrow & shallow marks,

**Appendix G-1. Descriptive Information and Compositional Group Assignments
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Note, HAM samples are from Holly A. Meier (2007) analysis of three Antelope Creek phase sites. TRC numbers are those submitted by TRC Environmental.

<u>ANID</u>	<u>Comp.</u>	<u>Alt ID/Lot # PNUM</u>	<u>Region</u>	<u>Site No.</u>	<u>Type</u>
TRC604	7	407a	NCR	34TX1	Cordmarked, rim, vertical, distinct marks
<u>TRC605</u>	<u>7</u>	<u>408a</u>	<u>NCR</u>	<u>34TX1</u>	<u>Cordmarked, thin body, deep & narrow marks</u>
TRC606	Unas	21a	NCR	34TX32	Cordmarked, body smoothed over,
TRC607	6	44a	NCR	34TX32	Cordmarked, body, obliterated
TRC608	7	53a	NCR	34TX32	Cordmarked, body, distinct, shallow marks
TRC609	5	284a	NCR	34TX32	Cordmarked, body obliterated
TRC610	Unas	285-1a	NCR	34TX32	Cordmarked, body, partially smoothed over
TRC611	Unas	285-2a	NCR	34TX32	Cordmarked, body, smoothed over
<u>TRC612</u>	<u>Unas</u>	<u>363a</u>	<u>NCR</u>	<u>34TX32</u>	<u>Daub, floor Room 1B</u>
TRC613	7	3c-7	ACP	41HC23	Cordmarked, vertical rim, flat
TRC614	7	5I/45	ACP	41HC23	Cordmarked, vertical rim, round
TRC615	7	7A	ACP	41HC23	Cordmarked, vertical rim, round
TRC616	7	R2/3	ACP	41HC23	Cordmarked, body, distinct marks
TRC617	4	R2/15	ACP	41HC23	Cordmarked, base, obliterated marks
<u>TRC618</u>	<u>12</u>	<u>R2/13</u>	<u>ACP</u>	<u>41HC23</u>	<u>Cordmarked, obliterated, flat neck rim</u>
TRC619	Unas	104.1	ACP	41HC141	Cordmarked flat rim, distinct marks
TRC620	Unas	109.3	ACP	41HC141	Cordmarked, rim shallow marks
<u>TRC621</u>	<u>7</u>	<u>111.4</u>	<u>ACP</u>	<u>41HC141</u>	<u>Cordmarked, collared round rim</u>
TRC622	Unas	542	ACP	41HC6	Cordmarked, collared rim obliterated
TRC623	Unas	543	ACP	41HC6	Cordmarked, collared rim, red interior
TRC624	Unas	544	ACP	41HC6	Cordmarked, collared rim, red interior
TRC625	7	545	ACP	41HC6	Cordmarked, round rim
TRC626	7	546	ACP	41HC6	Cordmarked, rim
<u>TRC627</u>	<u>7</u>	<u>547</u>	<u>ACP</u>	<u>41HC6</u>	<u>Cordmarked, rim</u>
TRC628	7	28-A8-42	ACP	41PT11	Cordmarked, round rim, obliterated
TRC629	7	28-A8-16	ACP	41PT11	Cordmarked, distinct marks, mica
TRC630	2	28-A6-92	ACP	41PT11	Cordmarked flat rim narrow distinct
TRC631	7	28-A3-21	ACP	41PT11	Cordmarked, rim angled, obliterated
TRC632	Unas	28-?-71	ACP	41PT11	Cordmarked, body obliterated marks
TRC633	out	28-A2-R3	ACP	41PT11	Cordmarked, body rough black exterior
TRC634	Unas	28-?-73	ACP	41PT11	Cordmarked, body, shallow distinct
TRC635	12	28-A8-60	ACP	41PT11	Cordmarked, body, smoothed over
<u>TRC636</u>	<u>2</u>	<u>28-A2-8</u>	<u>ACP</u>	<u>41PT11</u>	<u>Cordmarked, plain imperfections</u>
TRC644	2	684-8-1	LVS	41RB112	Cordmarked, unassigned vessel
TRC645	1	629-8-1	LVS	41RB112	Cordmarked, Vessel 5 Rim
TRC646	1	308-8-6a	LVS	41RB112	Cordmarked, Vessel 1 body
TRC647	Unas	2/8/2004	LVS	41RB112	Cordmarked, Vessel A

**Appendix G-1. Descriptive Information and Compositional Group Assignments
for Ceramic Samples. (cont.)**

Note, HAM samples are from Holly A. Meier (2007) analysis of three Antelope Creek phase sites. TRC numbers are those submitted by TRC Environmental.

<u>ANID</u>	<u>Comp.</u>	<u>Alt ID/Lot # PNUM</u>	<u>Region</u>	<u>Site No.</u>	<u>Type</u>
TRC648	1	308-8-2	LVS	41RB112	Cordmarked, Vessel 1 Rim
TRC649	4	350-8-1	LVS	41RB112	Cordmarked, Vessel 3 body
TRC650	4	118-8-1	LVS	41RB112	Cordmarked, Vessel 3 base
TRC651	2	762-8-1	LVS	41RB112	Plain, Vessel B
TRC652	Unas	697-8-1	LVS	41RB112	Cordmarked, unassigned vessel
TRC653	2	405-8-12	LVS	41RB112	Cordmarked, Vessel 4
TRC654	2	973-8-1	LVS	41RB112	Cordmarked, Vessel E
TRC655	4	1034-8	LVS	41RB112	Cordmarked, Vessel C

**Appendix G-2. Descriptive Information and Compositional Group Assignments for
Clay Samples.**

Note, HAM samples are from Holly A. Meier (2007) analysis of clays from near three Antelope Creek phase sites. TRC numbers are those submitted by TRC Environmental.

<u>ANID</u>	<u>Alt ID/Lot # PNUM</u>	<u>Material</u>	<u>Site Name</u>	<u>Site No. (comments)</u>
HAM076		Clay	Alibates	41PT11
HAM077		Clay	Alibates	41PT11
HAM078		Clay	Alibates	41PT11
HAM079		Clay	Alibates	41PT11
<u>HAM082</u>		<u>Clay</u>	<u>Alibates</u>	<u>41PT11</u>
HAM083		Clay	Landergin Mesa	41OL2
HAM084		Clay	Landergin Mesa	41OL2
HAM085		Clay	Landergin Mesa	41OL2
HAM086		Clay	Landergin Mesa	41OL2
<u>HAM087</u>		<u>Clay</u>	<u>Landergin Mesa</u>	<u>41OL2</u>
HAM088		Clay	Cross Bar	41PT109
HAM089		Clay	Cross Bar	41PT109
<u>HAM090</u>		<u>Clay</u>	<u>Cross Bar</u>	<u>41PT109</u>
HAM091		Clay Floor		41PT109
HAM092		Clay Floor		41PT109
HAM093		Clay Floor		41PT109
HAM094		Clay Floor		41PT109
<u>HAM095</u>		<u>Clay Floor</u>		<u>41PT109</u>
HAM096		Clay		
HAM097		Clay		
HAM098		Clay		
HAM099		Clay		
HAM100		Clay		
<u>HAM101</u>		<u>Clay</u>		
TRC379		Clay	Pipeline	41PT185, West Amarillo Creek
TRC380		Clay	Big Blue Creek	North of Lake Meredith
TRC381		Clay	Pipeline	41PT185/C West Amarillo Creek
TRC382		Clay	Wildcat Bluff N.C.	West side of Amarillo
TRC383		Clay	Big Blue Creek Pot	Alvin Lynn's replicate Borger pot
TRC434		Clay	Corral	41PT186 West Amarillo Creek
TRC435		Sandy Loam	Off-site	West Amarillo Creek, Scout camp
TRC436		Clay	Pavilion	41PT245 West Amarillo Creek
<u>TRC437</u>		<u>Clay</u>	<u>Off-site</u>	<u>West Amarillo Creek, Scout camp</u>
TRC546	C1a	Clay	Hank's, 41RB109A	Area A, cutbank, 25% sand, 650 C
TRC547	WP-C10a	Clay	West pasture	41RB109, 50% sand, 650°C
TRC548	Cza	Clay	Indian Springs	41RB81, Wilkens 1, no temper

Appendix G-2. Descriptive Information and Compositional Group Assignments for Clay Samples. (cont.)

Note, HAM samples are from Holly A. Meier (2007) analysis of clays from near three Antelope Creek phase sites. TRC numbers are those submitted by TRC Environmental.

<u>ANID</u>	<u>Alt ID/Lot # PNUM</u>	<u>Material</u>	<u>Site Name</u>	<u>Site No. (comments)</u>
TRC549	WC-C1a	Clay	Buried City	41OC26, cutbank 25% sand, 450°C
TRC550	WC-C3a	Clay	Buried City	41OC26, No temper, 650°C
TRC551	BC-Ca	Clay	Blue Creek	N. Lake Meredith 50% scoria, 650°C
TRC552	Gc-Ca	Clay	Government Canyon	Roberts Co. 50% sands, 650°C
TRC553	OCa	Clay Ogallala	Long View	41RB112 25% sands, 650°C
TRC554	C-Aa	Buried A	Long View	N. of 41RB112 50% sands, 450°C
<u>TRC637</u>	<u>420a</u>	<u>clay</u>	<u>Two Sisters</u>	<u>N of 34TX32, 25% sandstone, 650°C</u>
TRC638	1229-5a	Daub	Long View	41RB112, F6 pithouse
TRC639	294-5a	Daub	Long View	41RB112, Area C
TRC640	1235-5a	Daub	Long View	41RB112, F6 pithouse
TRC641	1140-5-4a	Daub	Long View	41RB112, F1 pithouse
TRC642	1113-5-2	Daub	Long View	41RB112, F1 pithouse
TRC643	1012-5-1	Daub	Long View	41RB112, F13 Area A

**Appendix G-3. Group Membership Probabilities Based on a Mahalanobis Distance Calculation
 Using a Subset of the Elemental Data.**

GROUP CLASSIFICATION USING MAHALANOBIS DISTANCE

Using the transformation matrix:
 and the following variables: Na K Ca Sc V Cr Mn Fe Co Zn Rb Sr Zr Cs Ba La Ce
 Sm Eu Tb Yb Lu Hf Ta Th

Membership probabilities (%) for samples from the group: Group 2
 Probability for each sample calculated after removal from original group.

ANID	g2	g7	Best Group
HAM067	6.78	0.00	g2
TRC528	94.27	0.07	g2
TRC529	94.83	0.01	g2
TRC530	26.16	0.00	g2
TRC555	78.58	0.00	g2
TRC556	95.36	0.01	g2
TRC558	19.86	0.00	g2
TRC559	66.15	0.00	g2
TRC560	56.70	0.00	g2
TRC561	73.60	0.00	g2
TRC562	31.92	0.01	g2
TRC563	62.62	0.03	g2
TRC564	60.16	0.00	g2
TRC568	34.16	0.00	g2
TRC574	15.09	0.00	g2
TRC585	79.67	0.00	g2
TRC586	22.98	0.01	g2
TRC587	43.93	0.03	g2
TRC588	0.75	0.00	g2
TRC592	59.77	0.00	g2
TRC594	22.79	0.00	g2
TRC599	5.58	0.00	g2
TRC601	84.07	0.00	g2
TRC630	49.43	6.16	g2
TRC636	89.78	0.00	g2
TRC644	32.79	0.00	g2
TRC651	89.95	0.01	g2
TRC653	32.22	0.00	g2
TRC654	14.68	0.00	g2

Membership probabilities (%) for samples from the group: Group 7
 Probability for each sample calculated after removal from original group.

ANID	g2	g7	Best Group
HAM002	2.50	79.84	g7
HAM003	2.61	51.68	g7
HAM004	13.42	90.46	g7
HAM005	0.20	56.42	g7
HAM007	13.49	99.94	g7
HAM009	26.43	76.79	g7
HAM012	0.94	86.06	g7
HAM018	0.12	90.26	g7
HAM019	0.83	22.41	g7
HAM020	1.46	62.49	g7

**Appendix G-3. Group Membership Probabilities Based on a Mahalanobis Distance Calculation
Using a Subset of the Elemental Data (continued)**

HAM021	10.17	68.16	g7
HAM026	1.63	12.17	g7
HAM029	0.39	27.20	g7
HAM030	0.09	50.07	g7
HAM031	0.74	95.27	g7
HAM032	0.54	62.30	g7
HAM033	0.96	73.55	g7
HAM036	0.62	75.41	g7
HAM037	0.23	74.78	g7
HAM038	0.59	88.23	g7
HAM039	0.34	80.92	g7
HAM040	0.41	92.67	g7
HAM044	0.53	57.71	g7
HAM045	0.11	34.33	g7
HAM047	0.12	83.02	g7
HAM048	0.47	74.72	g7
HAM049	0.32	44.39	g7
HAM050	0.45	15.95	g7
HAM051	2.99	6.57	g7
HAM052	38.12	0.71	g2
HAM053	9.03	11.53	g7
HAM056	0.24	11.41	g7
HAM061	1.85	13.45	g7
HAM063	1.87	10.96	g7
HAM064	5.36	29.90	g7
HAM068	0.44	39.00	g7
HAM069	0.24	16.07	g7
HAM070	0.51	8.40	g7
HAM071	2.29	90.19	g7
HAM073	1.93	1.04	g2
TRC602	18.83	5.18	g2
TRC603	17.35	21.35	g7
TRC604	4.50	58.43	g7
TRC605	5.07	1.40	g2
TRC608	21.20	12.73	g2
TRC613	20.81	94.37	g7
TRC614	8.67	97.36	g7
TRC615	36.13	81.15	g7
TRC616	6.93	59.56	g7
TRC621	6.97	55.57	g7
TRC625	1.73	9.80	g7
TRC626	1.43	71.36	g7
TRC627	14.07	93.09	g7
TRC628	13.29	21.25	g7
TRC629	6.51	51.01	g7
TRC631	0.91	18.98	g7

Membership probabilities (%) for samples from the group: g1
Probability for each sample calculated after removal from original group.

ANID	g2	g7	Best Group
TRC541	2.45	0.00	g2
TRC565	15.47	0.00	g2
TRC567	0.55	0.00	g2
TRC569	3.72	0.00	g2
TRC570	9.41	0.00	g2

**Appendix G-3. Group Membership Probabilities Based on a Mahalanobis Distance Calculation
 Using a Subset of the Elemental Data (continued)**

TRC571	7.45	0.00	g2
TRC573	2.09	0.00	g2
TRC645	42.36	0.00	g2
TRC646	13.32	0.00	g2
TRC648	24.19	0.00	g2

Membership probabilities (%) for samples from the group: g10
 Probability for each sample calculated after removal from original group.

ANI D	g2	g7	Best Group
HAM055	10.01	98.92	g7
HAM057	25.44	84.65	g7

Membership probabilities (%) for samples from the group: g11
 Probability for each sample calculated after removal from original group.

ANI D	g2	g7	Best Group
TRC538	0.25	0.00	g2
TRC542	0.37	0.00	g2
TRC544	0.17	0.00	g2

Membership probabilities (%) for samples from the group: g12
 Probability for each sample calculated after removal from original group.

ANI D	g2	g7	Best Group
HAM008	4.70	0.65	g2
HAM010	6.67	0.00	g2
HAM015	2.96	0.00	g2
HAM022	6.70	0.00	g2
HAM062	1.13	0.00	g2
TRC539	1.60	0.42	g2
TRC618	0.44	0.24	g2
TRC635	0.38	0.00	g2

Membership probabilities (%) for samples from the group: g13
 Probability for each sample calculated after removal from original group.

ANI D	g2	g7	Best Group
TRC430	0.11	0.00	g2
TRC433	0.08	0.00	

Membership probabilities (%) for samples from the group: g3
 Probability for each sample calculated after removal from original group.

ANI D	g2	g7	Best Group
HAM001	0.48	0.00	g2
HAM023	0.22	0.02	g2
HAM024	0.18	0.17	g2
HAM025	0.15	0.03	g2

Appendix G-3. Group Membership Probabilities Based on a Mahalanobis Distance Calculation Using a Subset of the Elemental Data (continued)

Membership probabilities (%) for samples from the group: g4
Probability for each sample calculated after removal from original group.

ANID	g2	g7	Best Group
TRC557	1. 01	0. 00	g2
TRC566	10. 65	0. 00	g2
TRC572	7. 56	0. 00	g2
TRC617	1. 49	0. 00	g2
TRC649	11. 64	0. 00	g2
TRC650	1. 18	0. 00	g2
TRC655	0. 53	0. 00	g2

Membership probabilities (%) for samples from the group: g5
Probability for each sample calculated after removal from original group.

ANID	g2	g7	Best Group
TRC609	3. 83	0. 03	g2

Membership probabilities (%) for samples from the group: g6
Probability for each sample calculated after removal from original group.

ANID	g2	g7	Best Group
HAM006	8. 50	5. 87	g2
HAM016	8. 27	15. 76	g7
HAM065	0. 26	0. 00	g2
HAM066	0. 46	0. 00	g2
TRC607	58. 41	0. 09	g2

Membership probabilities (%) for samples from the group: g8
Probability for each sample calculated after removal from original group.

ANID	g2	g7	Best Group
TRC590	2. 12	0. 00	g2
TRC596	17. 20	0. 00	g2

Membership probabilities (%) for samples from the group: g9
Probability for each sample calculated after removal from original group.

ANID	g2	g7	Best Group
HAM011	0. 03	0. 00	
HAM014	0. 06	0. 00	

Membership probabilities (%) for samples from the group: outleir
Probability for each sample calculated after removal from original group.

ANID	g2	g7	Best Group
HAM060	0. 32	0. 00	g2

Membership probabilities (%) for samples from the group: clay

**Appendix G-3. Group Membership Probabilities Based on a Mahalanobis Distance Calculation
 Using a Subset of the Elemental Data (continued)**

Probability for each sample calculated after removal from original group.

ANID	g2	g7	Best Group
HAM076	0.02	0.00	
HAM077	7.03	0.01	g2
HAM078	0.01	0.00	
HAM079	0.53	0.00	g2
HAM080	0.00	0.00	
HAM081	0.00	0.00	
HAM082	1.04	0.00	g2
HAM083	0.29	0.00	g2
HAM084	0.11	0.00	g2
HAM085	0.02	0.00	
HAM086	0.68	0.01	g2
HAM087	1.03	0.00	g2
HAM088	1.22	0.00	g2
HAM089	19.13	0.00	g2
HAM090	0.76	0.00	g2
HAM091	5.41	0.00	g2
HAM092	1.73	0.00	g2
HAM093	0.43	0.00	g2
HAM094	7.10	0.00	g2
HAM095	4.18	0.00	g2
HAM096	0.59	0.00	g2
HAM097	0.79	0.27	g2
HAM098	7.78	0.00	g2
HAM099	0.20	0.00	g2
HAM100	0.54	0.00	g2
HAM101	0.35	0.00	g2
TRC379	1.55	0.00	g2
TRC380	0.47	0.00	g2
TRC381	0.21	0.03	g2
TRC382	1.80	0.00	g2
TRC383	0.73	0.00	g2
TRC434	6.21	0.11	g2
TRC435	1.12	0.00	g2
TRC436	0.48	0.00	g2
TRC437	8.56	0.00	g2
TRC546	1.04	0.00	g2
TRC547	6.50	0.00	g2
TRC548	1.13	0.00	g2
TRC549	4.62	0.00	g2
TRC550	1.00	0.00	g2
TRC551	4.84	0.00	g2
TRC552	31.70	0.00	g2
TRC553	0.46	0.00	g2
TRC554	1.76	0.00	g2
TRC637	0.97	0.00	g2
TRC638	2.77	4.94	g7
TRC639	51.09	0.00	g2
TRC640	3.88	0.00	g2
TRC641	7.99	0.00	g2
TRC642	29.20	0.00	g2
TRC643	11.02	0.10	g2

Membership probabilities (%) for samples from the group: unassigned

**Appendix G-3. Group Membership Probabilities Based on a Mahalanobis Distance Calculation
Using a Subset of the Elemental Data (continued)**

Probability for each sample calculated after removal from original group.

ANID	g2	g7	Best Group
HAM013	5.02	0.00	g2
HAM017	0.61	0.06	g2
HAM027	0.12	0.00	g2
HAM028	0.50	0.00	g2
HAM034	0.36	0.10	g2
HAM035	0.32	0.00	g2
HAM041	0.52	0.53	g7
HAM042	0.69	6.01	g7
HAM043	0.14	0.00	g2
HAM046	0.23	0.15	g2
HAM054	10.00	0.15	g2
HAM058	3.95	1.67	g2
HAM059	3.26	0.00	g2
HAM072	8.09	0.03	g2
HAM074	3.21	3.83	g7
HAM075	0.30	0.03	g2
TRC429	0.08	0.00	
TRC431	2.04	0.00	g2
TRC432	2.91	0.00	g2
TRC527	4.81	0.09	g2
TRC531	10.27	0.07	g2
TRC532	3.42	0.00	g2
TRC533	29.43	0.00	g2
TRC534	0.16	0.00	g2
TRC535	6.86	0.00	g2
TRC536	1.65	0.00	g2
TRC537	2.33	0.07	g2
TRC540	8.13	0.00	g2
TRC543	7.82	0.00	g2
TRC545	8.66	0.01	g2
TRC575	4.10	1.10	g2
TRC576	23.20	0.76	g2
TRC577	30.47	0.07	g2
TRC578	5.60	0.00	g2
TRC579	66.64	0.15	g2
TRC580	12.72	0.68	g2
TRC581	0.11	0.00	g2
TRC582	15.41	0.00	g2
TRC583	29.48	0.01	g2
TRC584	14.82	0.00	g2
TRC589	86.47	0.00	g2
TRC591	71.20	0.00	g2
TRC593	75.22	0.00	g2
TRC595	6.71	0.27	g2
TRC597	10.22	0.02	g2
TRC598	2.87	0.00	g2
TRC600	5.70	0.56	g2
TRC606	16.41	1.40	g2
TRC610	14.70	0.54	g2
TRC611	3.10	0.10	g2
TRC619	4.36	4.55	g7
TRC620	0.15	0.00	g2
TRC622	0.35	0.03	g2
TRC623	2.94	0.08	g2

**Appendix G-3. Group Membership Probabilities Based on a Mahalanobis Distance Calculation
Using a Subset of the Elemental Data (continued)**

TRC624	2. 26	0. 25	g2
TRC634	0. 57	0. 00	g2
TRC647	3. 85	0. 10	g2
TRC652	36. 85	0. 53	g2

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APPENDIX H

MICROSCOPIC USE-WEAR AND RESIDUE ANALYSES OF STONE TOOLS FROM 41RB112, ROBERTS COUNTY, TEXAS

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July 2011

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H.1 Introduction

Long View (41RB112) is a Plains Village period site with two horizontally separate components (A and C) that are similar to one other another, but differ slightly in age (Component A is ca. 495 B.P. cal; Component C is ca. 560 B.P. cal). A sample of 52 stone artifacts was provided for microscopic functional analysis. Artifacts for this analysis were minimally handled and unwashed. Artifacts usually had one area of a surface that had been cleaned for the purposes of labeling, but were otherwise unwashed. The samples for the two components are similar in size and frequency of artifact types (Table H-1). For both components, edge-modified flakes are the most frequent tool type followed by scrapers.

H.2 Methods

The methods used here are a combination of microscopic residue and use-wear analysis that follow the protocol of Hardy et al.:

All artifacts were examined with an Olympus BH microscope under bright-field incident light at magnifications ranging from 100 to 500 diameters. All wear patterns and residues were photographed using a Nikon Coolpix 995 digital camera, and their location on the surface was recorded on a line drawing of the artifact. Identifications of residues were made by comparison with published materials and a comparative collection of experimental stone-tool replicas (Brunner and Coman 1974; Catling and Grayson 1982; Beyries 1988; Anderson-Gerfaud 1990; Hoadley 1990; Fullagar 1991; Teerink 1991; Hather 1993; Hardy 1994; Brom 1986; Kardulias and Yerkes 1996; Williamson 1996; Hardy and Garufi 1998; Pearsall 2000; Haslam 2004; Dove et al. 2005; Fullagar et al. 2006). Residue recognition was the primary goal of the analysis; therefore, no special procedures were conducted to clean the tools for the sake of rendering use-wear patterns more visible. While this procedure may limit the use-wear information obtained, it serves to maximize the residues observed (Hardy and Garufi 1998; Hardy et al. 2001; Hardy 2004). Potentially identifiable residues include plant (plant tissue, plant fibers, starchy residue, epidermal cell tissue, wood, raphides, phytoliths, resin) and animal tissues (muscle tissue, collagen, fat, bone/antler, blood,

hair, and feathers) (Hardy et al. 2001; Lombard 2004; Wadley et al. 2004). Distribution of residues and use-wear on the artifact surface were used to help demonstrate use-relatedness and to identify use-action (Hardy and Garufi 1998; Hardy et al. 2001; Lombard 2004).

Use-wear patterns recorded included edge damage (microflake scars, edge rounding), striations, and polishes. These were used to help identify use-action (Odell and Odell-Vereecken 1980; Mansur-Franchomme 1986). Due to the potential overlap of polishes produced by different materials, use-wear polishes were categorized as either “soft” or “hard/high silica” (e.g., Newcomer et al. 1986, 1988; Moss 1987; Bamforth 1988; Hurcombe 1988; Bamforth et al. 1990; Grace 1990; Fullagar 1991; Shea 1992). Soft polish often results from processing animal tissue such as skin and meat. Hard/high-silica polish is produced when processing soft plants with high silica content, such as reeds and grasses, and wood, bone/antler, and tilling soil. The amount of time a tool was used, silica content of the processed material, and presence of water are all factors that can influence polish formation (Fullagar 1991; Hardy 2004). A combination of residue and use-wear analysis can provide complementary and corroborative information, potentially producing more accurate results than either technique used alone (Hardy 1998; Hardy and Kay 1998; Hardy et al. 2001; Rots and Williamson, 2004). (Hardy et al. 2008:651-2)

One deviation from these methods is that all residues were photographed with a Dino-Lite DinoEyepiece Digital USB Camera and DinoCapture 2.0 software. One further modification involves the identification of starch grains. Since small starch grains 5 µm or less in size, can be confused with other small particles (Haslam 2006; Loy 2006), the identification of grains at this site through reflected light alone is viewed as probable or possible. Extraction and analysis with other techniques is advised.

H.3 Results from Component A

The sample for Component A consisted of 27 artifacts, 21 (77.7%) of which showed evidence of use (Table H-2). The majority of tools were associated with working wood (wood residues associated with hard/high silica polish) or other hard or high silica plant

Table H-1. Frequency of Tool Types in Sample.

Tool Type	Component A (n=27)	Component C (n=25)
Beveled Knife	4 (14.8%)	1 (4%)
Biface	1 (3.7%)	3 (12%)
Cobble	1 (3.7%)	0
Drill	1 (3.7%)	2 (8%)
Drill Base	0	2 (8%)
Edge-modified flake	12 (44.4%)	11 (44%)
Point Base	2 (7.4%)	0
Scraper	6 (22.2%)	5 (20%)
Uniface	0	1 (4%)

materials (undiagnostic plant tissue associated with hard/high silica polish). Based on the presence of striations and edge damage (but no hard/high silica polish or residues), several artifacts were used on a hard material but no more specific identification is possible. Other activities include hide processing and/or butchery with some artifacts used on an unknown soft material (possibly hide or meat). See Table H-2 for a complete summary and Figures H-1 through H-6 for a visual summary.

H.3.1 Beveled Knives

Three of the four beveled knives in the sample were used to cut wood. Two of these show evidence of being hafted (abraded ridges on both surfaces, confined to the proximal half of the tool. One of these was used for cutting, while the other was used for boring (as evidenced by striations perpendicular to the tool edge near the tip, Figure H-7). The third beveled knife was also used on wood but showed no signs of hafting. The final knife was also unhafted, but was used on a soft material.

H.3.2 Bifaces

The one biface was used to cut hard/high silica material. Based on the high frequency of woodworking in the sample, wood is the most likely source of this use-wear.

H.3.3 Cobble

The one cobble in the sample has an area of added residue on one surface. The residue is orange-red in appearance but amorphous in texture. No specific identification was possible.

H.3.4 Drill

A broken tip of a drill showed no evidence of use. It is possible that it broke during manufacture.

H.3.5 Edge-Modified Flakes

Two-thirds (8 of 12) of the edge-modified flakes appear to have been used. Of these, 7 were used on wood, hard/high silica material, or unidentified hard material (Figure H-8). One of the seven was hafted and used for boring hard/high silica material. The final used flake was hafted and used for scraping hide).

H.3.6 Point Base

One point base showed no signs of use. It may have broken during the manufacturing process.

H.3.7 Scrapers

Scrapers in the sample (n=6) were evenly divided in terms of use. Two were used on wood or hard/high silica plant, two were used on hide or other soft material (both hafted), and two were of unknown use (one was missing the distal end and appeared to have snapped while in a haft).

Table H-2. Summary of Results from Long View Site (41RB112), Component A.

Artifact #	Tool Type	Function
2-10	Biface	Cutting hard/high silica material
22-10	Scraper	Scraping hard/high silica plant
45-10	Edge-modified flake	Scraping hard/high silica plant
692-10	Fresno base	Cutting hard/high silica material
755-10	Edge-modified flake	Scraping wood
768-10	Beveled knife	Hafted, cutting wood
768-11	Beveled knife	Hafted, boring wood
768-12	Beveled knife	Cutting wood
768-13	Beveled knife	Cutting soft material
768-14	Scraper	Hafted, scraping soft material
786-11	Scraper	Unknown/unused
857-10	Edge-modified flake	Hafted, scraping hide
859-10	Scraper	Scraping hide, possibly hafted
883-10	Scraper	Snapped in haft
911-10	Edge-modified flake	Light polish, unknown use
933-10	Edge-modified flake	Unknown/unused
943-10	Drill	Unknown use
948-10	Edge-modified flake	Scraping hard material
1004-10	Edge-modified flake	Cutting wood
1031-10	Edge-modified flake	Cutting wood
1051-11	Edge-modified flake	Hafted, boring hard/high silica material
1145-10	Edge-modified flake	Unknown/unused
1152-10	Edge-modified flake	Unknown/unused
1194-10	Edge-modified flake	Cutting hard/high silica
1216-10	Point base	Unknown/unused
1042-10	Scraper	Scraping wood
1147-10	Edge ground stone	Additive residue, unknown origin

Figure H-1. Results from Component A.

Figure H-2. Results from Component A.

Figure H-3. Results from Component A.

Figure H-4. Results from Component C.

Figure H-5. Results from Component C.

Figure H-6. Results from Component C.

Figure H-7. Four beveled knife 768-11, Component A; a and b) polish and striations; c) wood fragment; d) hard/high silica polish from movement in haft.

H.4 Results from Component C

The sample for Component C included 25 tools. Of these, 19 (73.1%) were used. As with Component A, wood working and hide working were the predominant activities (Table H-3). One artifact exhibited starch grains, raphides, and plant tissue which likely derives from processing desert succulents (see below).

H.4.1 Beveled Knife

A beveled knife tip exhibits soft polish as well as hair and skin fragments and was used in butchery. It is impossible to tell if it was hafted or handheld since the other end has snapped off.

H.4.2 Biface

Both bifaces in the sample appear to have been handheld and used to whittle wood.

H.4.3 Drill and Drill base

One drill has striae perpendicular to the long axis of the tool near the tip and wood residues. The other drill tip shows no signs of use. One drill base shows evidence of hafting while the other bears no signs of use.

H.4.4 Edge-Modified Flakes

Edge-modified flakes served a variety of purposes, including boring hard/high silica material, scraping wood, scraping starchy plant, and cutting both plant and animal by the same tool. These functions are evenly divided with no one function predominant for this type of artifact. See Figures H-9 and H-10 for individual examples.

H.4.5 Scraper

Of the four scrapers examined, two were used for woodworking with neither being hafted (Figure H-11). The other two were used on hide and unknown soft material respectively, both handheld.

H.5 Discussion

H.5.1 Woodworking

Woodworking is attested to in both samples by the presence of wood residues, hard/high silica polish,

edge damage and striations. In two cases, one from component A and one from C, it was further possible to identify the wood being worked as gymnosperm due to the presence of bordered pits (Hardy and Garufi 1998; Hoadley 1990; Figure H-10). Wood residues are potentially identifiable to species, but must have diagnostic anatomical parts available in the appropriate plane to do so. Most diagnostic criteria are best viewed in a radial, tangential, or cross-sectional plane of the wood. While these cuts are quite easy to make in a laboratory, processing wood with a stone tool more often cuts through these planes at oblique and varied angles, making species specific identification rare on archeological specimens (Hardy 2009).

The patterns suggested by the evidence here is one of extensive woodworking using a variety of actions, including scraping, whittling and boring. The evidence is very similar between the two components and suggests that similar woodworking activities took place at both.

H.5.2 Hide Processing/Butchery

Evidence for hide processing (soft polish and hair fragments) as well as butchery is found in both components on a variety of hafted and unhafted tool types. In one case, a hair fragment preserves the cuticle (Figure H-11) which can be species specific. Scale patterns of the cuticle do vary by species. However, the scale patterns vary on a single individual depending on what type of hair (guard hair, underhair) and as you move from root to tip on an individual hair (Teerink 1991). This hair has scales with a transversal orientation, irregular wave pattern, smooth margins, and distant placement. This type of scale pattern could be found on numerous places on different species (for example, a similar scale pattern to this one can be found on base of a guard hair from deer as well as near the distal end of a guard hair of a marten). In practice, numerous hairs from different parts of an animal are needed to make a definitive species identification (Hardy 2009). Thus, although the scale pattern could come from deer (a commonly represented species at the site), the evidence is insufficient to make a confident identification.

Figure H-8. Edge-modified flake 1031-11, component A; a) wood fragment; b) bark cells; c) wood fragment; d) hard/high silica polish.

Table H-3. Summary of Results from Long View Site (41RB112), Component C.

Artifact #	Tool Type	Function
95-10	Edge-modified flake	Cutting hide
101-10	Edge-modified flake	Unknown/unused
174-10	Drill	Boring wood
202-12	Drill base	Unknown/unused
210-11	Edge-modified flake	Boring hard/high silica material
231-11	Drill	Hafted drill base
242-10	Beveled knife tip	Slicing meat/butchery
246-10	Biface	Cutting hard/high silica material
256-10	Edge-modified flake	Scraping wood
352-10	Scraper	Hafted, scraping soft material
417-10	Biface	Whittling wood
466-10	Scraper	Scraping wood
466-11	Edge-modified flake	Unknown/unused
589-12	Uniface	Hafted, scraping hide
593-10	Edge-modified flake	Cutting starchy plant
593-11	Edge-modified flake	Cutting hard material
599-10	Edge-modified flake	Whittling wood
643-18	Edge-modified flake	Unknown/unused
646-12	Biface	Whittling wood
648-15	Drill	Unknown/unused
1233-10	Scraper	Scraping hide
1270-11	Edge-modified flake	Cutting plant and animal
1270-12	Edge-modified flake	Light polish, unknown use
1273-10	Scraper	Scraping soft material
1287-10	Scraper	Scraping wood

Figure H-9. Edge-modified flake 593-10, Component C; a and d) raphides and plant tissue; b) hard/high silica polish; c) striations; e) starch grain under x-polarized light, original magnification 500x, approx. 5Mm in diameter.

Figure H-10. Edge-modified flake 599-10, Component C; a and c) striations and hard/high silica polish; b) gymnosperm wood tissue, arrow indicates bordered pits.

Figure H-11. Scaper 1233-10, Component C; a and b) striations and soft polish; c) hair with cuticle.

H.5.3 Starchy Plants

One edge-modified flake (593-10) from Component C (Figure H-9) has raphides, plant tissue and possible starch grains. These residues are consistent with tools used to process desert succulents such as agave, sotol, or yucca. This type of processing has previously been identified at several archaic sites in Texas (Sobolik 1996; Piperno 1998; Hardy 2010). Processing of desert succulents may also have been an activity in Component C of the Long View site.

H.5.4 Beveled Knives

Beveled knives have a particular form of retouch which has been suggested as an adaptation for heavy-duty cutting and a reduction in resharpening (Brown et al. 1982:56). Previous microwear analysis on this tool type has been interpreted as cutting through “yielding substances” (Creel 1991:44). Furthermore, there are common associations between bison, beveled knives, and scrapers after the Late Archaic (Creel 1991). While this association might suggest a specialized function for these tools related to bison processing, the evidence from the Long View sites suggests a more varied use. Beveled knives at Long View show evidence for being hafted and unhafted and used on both wood and hide or butchery tasks.

H.6 Conclusions

Residue and use-wear analyses of the two components of the Long View site have provided evidence that both fits with other archeological evidence at the site and that is not otherwise represented archeologically. Butchery and hide working are both attested to on numerous artifacts which is no surprise given the faunal remains at the site. Woodworking is also very common in both samples. This would certainly have been a common activity in the past, but we rarely have wooden artifacts preserved. Microscopic residue analysis provides a means of actually observing traces of this activity. Finally, in Component C, one edge-modified flake suggests the processing of desert succulents. Aside from this one difference, the two components appear to reflect a similar range of activities in terms of tool use.

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APPENDIX I

A GEOPHYSICAL INVESTIGATION AT 41RB112: A MIDDLE CERAMIC PERIOD ARCHEOLOGICAL SITE LOCATED IN ROBERTS COUNTY, TEXAS

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I.1 Introduction

Archaeo-Physics, LLC was contracted by TRC Environmental Corporation - Austin to conduct a geophysical investigation at 41RB112, an archeological site located in Roberts County, Texas. Geophysical methods were used to evaluate two areas of the site that prior to archeological mitigation during the summer of 2006. The objective of this investigation was to identify geophysical anomalies and patterning that indicated the presence of archeological features or landscape modifications associated with the Middle Ceramic period occupation of the site.

Several geophysical methods were employed during the investigation, including magnetic field gradient, electrical resistance, and ground penetrating radar (GPR). Fieldwork was conducted over the period of 8 to 12 August, 2006.

I.2 Site Setting and Field Conditions

Site 41RB112 lies about 4 km north of the Canadian River on high ground midway between the river and the high valley rim. Soil at the site consists of a sandy loam of the Mobeetie-Veal-Potter soil association. Two areas of the site were investigated. These were designated Area A and Area C. A survey grid was established over Areas A and C on 8 August by the TRC field supervisor, Paul Matchen. This survey grid encompassed the right-of-way (ROW) corridor that was the subject of the archeological mitigation, as well as portions of the adjacent pasture (Figure I-1). The ROW varied from about 6- to 10-m-wide.

Grasses with sideoats grama dominated ground cover at Areas A and C. Ground cover did not pose an obstacle to geophysical data collection. The ROW had been significantly disturbed by construction of a fireguard, which consisted of a bladed area about 4- to 5-m-wide that had the topmost 0.4 m or so removed. While this fireguard did not pose an obstacle to geophysical data collection, it did have a significant impact on the survey results (see results section below).

The ROW was bounded on the west by a barbed wire fence, with iron gates and iron fence posts. This wire fence created significant signal clutter in

the magnetic field gradient survey results. A second older fence existed within the ROW. This fence was removed by Courson Oil and Gas employees prior to the geophysical investigation. Fence staples and wire fragments associated with this fence were located using a metal detector and removed prior to the geophysical investigation, also by Courson Oil and Gas employees. Unfortunately not all of the metal fragments associated with this fence were found, and these remaining fragments created significant signal clutter in the magnetic field gradient survey results.

The weather during the geophysical fieldwork was extremely hot and dry, with high temperatures ranging from 100 to 105 degrees Fahrenheit. This created some difficulty during fieldwork, as the GPR transmitter overheated and failed. Unfortunately this equipment malfunction required shipment of the GPR to the manufacturer for repair, thereby causing us to terminate the GPR survey before we would have liked.

I.3 Survey Design and Technical Parameters

I.3.1 Magnetic Field Gradient

Magnetic field gradient survey was conducted over approximately 2,900 square meters at Area A. The magnetic field gradient survey coverage at Area C was slightly smaller, with a total area of 2,700 square meters total having been surveyed. At both Area A and Area C, magnetic survey was conducted within the project ROW and in areas directly adjacent to, but outside the ROW (see Figure I-1). There are two reasons that magnetic survey was performed outside the ROW.

1. By extending the survey area to relatively undisturbed areas outside of the ROW, it was possible to better understand the natural signal response due to heterogeneity in geology or soils at the site, and to better understand and identify nonarcheological signal clutter associated with the metal fence, metal trash, and fireguard within the ROW.
2. Survey of undisturbed areas outside of the ROW allowed us to examine the nature and

characteristics of magnetic anomalies that are thought to be archeological in origin. A better understanding of the signal response from archeological features in relatively undisturbed areas makes it easier to identify archeologically significant signal within the heavily disturbed ROW.

The magnetic field gradient data were collected using a Geoscan Research FM256 fluxgate gradiometer. The FM256 has two fluxgate sensors, separated by 0.50 m. The recorded data are the difference between the two sensors (the vertical magnetic gradient). The instrument was operated in the 0.1 nT sensitivity range. Data were collected at relatively high-resolution data sample densities in transects spaced at 0.50 m, with eight samples per meter along each transect (overall data sample density = 16 samples per m²). Magnetic data transects were collected in a zigzag manner, meaning the first data transect was collected from south to north, the second data transect was collected north to south, and so on. Magnetic field gradient data are presented in units of nanoTeslas (nT) in this report by convention. Multiplication by two is required to convert to SI units for the magnetic field gradient (nT/m). Processing of magnetic data included:

- A zero mean traverse filter, which compensates for defects caused by instrument drift and sensor orientation (heading error). Data exceeding a threshold value were excluded from the transect mean value calculation.
- Lowpass filtering to suppress small scale noise and enhance the detectability of cultural patterning.
- Interpolation to a uniform number of data points in both the x and y directions.
- Clipping the data range used to construct imagery in a manner that would best display cultural features.

I.3.2 Electrical Resistance

Electrical resistance survey was conducted over 520 square meters at Area A, and 460 square meters at Area C (Figure I-1). All electrical resistance survey data were collected within the project ROW. A Geoscan Research RM15 resistance meter operated in twin electrode configuration was used

to perform the resistance survey. Resistance survey was conducted using a mobile probe spacing of 0.5 m resulting in a nominal depth of investigation of approximately 0.5 m. The resistance survey at Area C used potential of 40 V, a current of 1 mA, and an integration time set to medium (this is related to the number of data values that are averaged for each recorded value).

These same settings were utilized at Area A, unfortunately the Area A results suffered from a higher signal noise level than the results from Area C. The reduced data quality may have been related to the extremely dry conditions that existed during the resistance survey, although it is not clear why Area C results were acceptable when Area A results were not. In any case – Area A was surveyed a second time in an effort to obtain higher quality data. Much more acceptable electrical resistance results were obtained during this second survey, which used a potential of 100 V, a current of 0.1 mA, and an integration time set to slow (more readings were averaged for each recorded value).

Electrical resistance data at both Areas A and C were collected using a transect spacing of 0.5 m, with 2 samples per meter along each transect (overall data sample density = 4 samples per m²). Resistance data transects were collected in a zig-zag manner. The resistance survey data in this report are reported in units of relative resistance (Ω).

Resistance survey data processing included:

- Removal of extreme statistical outliers.
- Interpolation to uniform sample densities in the x and y directions.
- Lowpass filtering to suppress small scale noise and enhance the detectability of cultural patterning.
- Highpass filtering (10 m radius) to suppress large-scale geologic variation and to enhance the visibility of small low-contrast anomalies.
- Clipping the data range used to construct imagery in a manner that would best display cultural features.

I.3.3 Ground Penetrating Radar (GPR)

After the magnetic field gradient and electrical resistance surveys were completed a systematic

Figure I-1. Location of the geophysical survey areas at 41RB112.

survey by GPR was undertaken. The GPR survey was to cover the same areas as the electrical resistance survey, but would include areas outside of the ROW as well. Regions outside the ROW were to be surveyed for the same reasons as the magnetic field gradient survey – namely to understand how disturbance within the ROW might affect the GPR signal response, which in turn would help us identify signal that may be archeological in origin. Unfortunately the GPR equipment overheated and failed before complete survey coverage was obtained.

Nine hundred (900) square meters of GPR survey coverage were obtained prior to this failure however (Figure I-1). These data were collected using a pulseEKKO 1,000 ground penetrating radar operating at a center frequency of 450 MHz. The data transect interval was 0.5 m, trace interval (stepsize) was 0.05 m (overall data sample density = 40 GPR traces per m²). Each GPR trace consisted of data points within a 100 nanosecond time window, data are recorded every 0.2 nanoseconds within this window, resulting in 500 data points per trace. GPR data transects were collected in a unidirectional manner, from south to north.

The radar wave propagation velocity was estimated at 0.1 m/ns. This is a typical value for sandy loams, however it should be noted that the velocity is an estimate and was not calculated using common-midpoint (CMP) analysis as the GPR failed before a common-mid-point velocity analysis could be conducted. The GPR survey was designed to facilitate “time slice” analysis. Time slice analysis calculates the average amplitude of the reflected radar signal within various time windows for display as plan view maps. The approximate depth of these time windows was calculated using the estimated reflected wave propagation velocity of 0.1 m/ns. The GPR data are presented in units of microVolts (µV). The processing methods applied during the construction of the GPR time slices are as follows:

- Each data transect was cropped to a length of 30 m.
- A constant time gain was applied.
- DEWOW signal saturation correction was used to remove unwanted inductive low

frequency components.

- A low pass filter (3 data points) operating in the time domain was used to suppress high frequency noise.
- A highpass background subtraction filter (401 trace window) was used to remove horizontal banding and enhance dipping events.
- Data were converted from wavelets with both positive and negative components to a monopulse wavelet with all positives (average enveloped amplitude).
- An estimated wave velocity of 0.1 m/ns was used to construct time slices.
- Time slice data were interpolated down in the x-direction from 20 samples per meter to 16 samples per meter and up in the y-direction to 16 samples per meter.
- A spatial lowpass filter (2 data point radius) was used to suppress small-scale noise and enhance the detectability of cultural patterning.

I.4 Geophysical Survey Results

The results of geophysical surveys of archeological sites are generally presented graphically. This is done because anomalies of cultural origin are usually recognized by their pattern, rather than by the intensity of their signal response (or numeric value). When rendered graphically, we can better recognize cultural and natural patterns and visualize the physical phenomena causing the detected anomalies. Patterning in the geophysical data can be caused by a number of different phenomena including archeological features, modern disturbance (for example agricultural plowing, construction of fireguards, construction of fences, etc...), and natural changes in soils or geology.

The results of the geophysical investigation at 41RB112 are first summarized using a number of different processing and display methods. By presenting several different views of each data set we can more fully understand the nature and characteristics of the geophysical response.

Next, the results from each area will be presented in conjunction with a detailed map of the site. This map (created by TRC personnel during the geophysical investigation) depicts the location of previously

excavated units and trenches (which may or may not create their own signal response), fences, fencepost holes from the fence that was removed, the fireguard, and other physical features. A careful comparison of the geophysical data and the map data can help us recognize signal clutter associated with disturbance of the site, which in turn may help us identify signal associated with archeological features.

I.4.1 Summary Images

The geophysical survey results from Area A are summarized in Figure I-2. In the top row of Figure I-2 are three magnetic field gradient grey-scale images (black = positive data, white = negative data). These three images were created from the same data set, but are displayed using different data ranges. The leftmost image is cropped at ± 10 nT, which allows us to view the relative intensity of magnetic signal from Area A. The middle and rightmost magnetic images in Figure I-2 were cropped at ± 3 nT and ± 1 nT respectively. Cropping the magnetic data to a more narrow range allows us to view increasingly subtle detail within the magnetic data, but causes us to lose our perspective on the relative intensity of the magnetic anomalies. To fully understand the magnetic field gradient imagery it is important to view the data at a number of different contrast levels.

The electrical resistance data from Area A are displayed in a similar fashion, with low, medium, and high contrast images created from the same processed data set (see middle row of images in Figure I-2). In the three leftmost electrical resistance images, resistance values greater than the mean value of the data set are displayed in black, while values less than the mean value are displayed in white. Sometimes it is useful to reverse the shading scheme of the display, and/or colorize a range of data. For example, the rightmost electrical resistance image in Figure I-2 is presented with data greater than the mean in white, less than the mean in black, and very low resistance data displayed in red.

The final row of images in Figure I-2 depicts the electrical resistance data after high-pass filtering. High-pass filtering is a processing method that tends to reduce large-scale signal variation due to natural changes in soil or bedrock geology, while increasing the visibility of relatively subtle signal associated with

archeological features. Once again, several different views of the high-pass filtered resistance data are presented. On the left are three images representing low, medium, and high contrast views of the high-pass filtered data. On the right is a medium contrast view, but with a reversed shading scheme.

The geophysical survey results from Area C are summarized in Figures I-3 and I-4. Figure I-3 presents the magnetic field gradient survey imagery in much the same manner as was done for Area A. Once again, data are clipped to create several different levels of contrast, and color schemes are reversed to provide alternate views of the resistance data. High-pass filtered resistance data are again presented, as are non high-pass filtered data.

The complete GPR survey results from Area C are presented in Figure I-4. A total of 21 average amplitude depth slice images were created. Each of these images represents the average amplitude of reflected radar waves within a 10 cm window (note: time data were converted to estimated depth using a radar wave velocity of 0.1 m/ns). The estimated depth range in centimeters below surface (cmbs) is given above each image. Each GPR image is clipped at ± 4 standard deviations from the mean value. Data greater than the mean are depicted in shades of black, while data less than the mean are depicted in shades of white. GPR data collection over the western 1/3 of the 30-by-30 m grid was completed on Friday August 11th. The site received approximately 3 to 5 cm of rain late in the evening on the 11th. This rain significantly changed the conductivity and dielectric properties of the soil. GPR survey resumed on Saturday the 12th and survey over the remainder of the 30-by-30 m grid was completed before the GPR broke down. The change in soil conductivity and dielectric properties is readily visible in the GPR imagery, with the much better depth of penetration occurring in the dry soil conditions prior to the rainstorm (see western 1/3 of most images).

I.4.2 Geophysical Imagery Overlaid on Site Map

In the next series of figures the geophysical survey results are combined with a detailed map of 41RB112. Presenting the data in such a manner helps

Figure I-2. Geophysical survey results from Area A.

Figure I-3. Magnetic field gradient and electrical resistance survey results from Area C.

Figure I-4. GPR survey results from Area C.

us identify anomalous signal that may be caused by modern disturbance, such as fence posts or backfilled excavation units. The location of excavation units and trenches from previous archeological are depicted as green rectangles. The locations of fence posts removed prior to the geophysical investigation are indicated with small yellow or black circles.

Figure I-5 presents the magnetic field gradient image (medium contrast version) from Area A with a site map overlaid on top of the image. In Figure I-6 medium contrast versions of both the non high-passed and high-passed filtered electrical resistance survey results from Area A are presented side by side.

Figure I-7 depicts the magnetic field gradient image (medium contrast version) from Area C with a site map overlaid on top of the image. In Figure I-8 medium contrast versions of both the non high-pass filtered and high-pass filtered electrical resistance survey results from Area C are presented side by side.

A representative sample of the GPR survey imagery from Area C is presented with a site map overlay in Figures I-9, I-10, and I-11. Figure I-9 presents GPR data from 10 to 20 cmbs, Figure I-10 from 30 to 40 cmbs, and Figure I-11 from 55 to 65 cmbs. Complete GPR survey results can be viewed in Figure I-4.

A careful examination of Figures I-5 through I-11 reveals significant magnetic signal clutter associated with the current fence. Magnetic signal clutter was also created by small fragments of fence, wire, and fence staples left behind after removal of the fence inside the ROW (in spite of many hours spent searching for and removing metal fragments using a metal detector). Magnetic clutter caused by the existing fence was worse in Area A due to the presence of two large iron gates.

Significant magnetic signal clutter was also observed in the vicinity of some of the previously excavated units (i.e. observe signal in the vicinity of Test Units A2 and A5 in Figure I-5). This signal clutter is probably due to iron nails left in the units. These nails may have defined the corners of the excavation units. Previously excavated units that did

not contain iron nails tended to show up as induced magnetic lows (negative anomalies), probably due to redistribution of the highly magnetic A horizon magnetic minerals (i.e. observe signal in the vicinity of Test Unit A1 in Figure I-5 and Test Units C3, C5, C6, and C11 in Figure I-7).

A large vertical iron spike anchoring a transmission line guy wire caused the extremely intense magnetic signal observed just to the west of the ROW in Figure I-7. This signal is visible to the west of the previously excavated Test Unit C10 in Figure I-7.

Soil disturbance associated with construction of a fireguard inside the ROW had a significant impact on the electrical resistance survey results, with resistance values much lower inside the fireguard than outside (see Figures I-6 and I-8). Some previously excavated units created significant electrical resistance signal clutter. Field observations seemed to suggest that those excavation units containing plastic sheeting had the strongest and most variable signal response (i.e. see signal in the vicinity of Test Unit C7 in Figure I-8).

I.5 Geophysical Survey Interpretations

Interpretation of survey data must be a cooperative process involving both archeological geophysicists and archeologists that are familiar with the specific cultural context of the site being studied. An understanding of the geological and geomorphological context of the survey area is also very important.

In areas that have been surveyed with more than one type of instrument, the results of the different surveys should be carefully compared. Correlations between data sets (or lack of correlation) can be as important as either data set by itself to our interpretation of the site.

The interpretations offered in this report are to be considered preliminary, as they represent only the initial interpretations of the geophysical surveyor. Review by archeologists familiar with the cultural context of the site and the range of expected feature types and intrasite patterning may result in different or elaborated interpretation. Testing these initial interpretations will be of great benefit. Verification

Figure I-5. Magnetic field gradient imagery presented on site map of Area A.

Figure I-6. Electrical resistance imagery (left) presented on site map of Area A.
The Image on the Right is Created from the Same Data Set, but After High-pass Filtering.

Figure I-7. Magnetic field gradient imagery presented on site map of Area C.

Figure I-8. Electrical resistance imagery (left) presented on site map of Area C.
The Image on the Right is Created from the Same Data Set, but After High-pass Filtering.

Figure I-9. Detail depicting GPR imagery from 10 to 20 cmbs presented on site map of Area C.

Figure I-10. Detail depicting GPR imagery from 30 to 40 cmbs presented on site map of Area C.

Figure I-11. Detail depicting GPR imagery from 55 to 65 cmbs presented on site map of Area C.

(or refutation) of preliminary interpretations and insights into feature composition and geology can allow us to revise or elaborate our interpretations, and to do so with greater confidence.

Magnetic field gradient survey results within the ROW were seriously compromised by heavy site disturbance and GPR survey results were only obtained over a small portion of the ROW, therefore the initial interpretations focused solely on the electrical resistance survey results. These interpretations were provided to TRC within one week of completion of geophysical fieldwork.

I.5.1 Area A –Initial Resistance Survey Interpretations

The initial electrical resistance survey interpretations from Area A are presented in Figure I-12. Four anomalies were identified as having the highest probabilities of representing archeological features. These anomalies were labeled 1 through 4 and are described in Figure I-12. Several additional resistance anomalies were also identified and described in Figure I-12.

I.5.2 Area C – Initial Resistance Survey Interpretations

The initial electrical resistance survey interpretations from Area C are presented in Figure I-13. Three anomalies were identified as having the highest probabilities of representing archeological features. These anomalies were labeled 1 through 3 and are described in Figure I-13. Several additional resistance anomalies were also identified and described in Figure I-13.

I.5.3 Additional Interpretations

Although only partial coverage of the ROW was obtained during the GPR survey, several interesting linear patterns are visible in the time-slice imagery. Possible interpretations of the GPR imagery from approximately 30 to 40 cmbs and 55 to 65 cmbs are presented in Figure I-14. The linear patterning highlighted in Figure I-14 could represent the outlines of structures or other buried features, or could also represent more ephemeral phenomena such as subtle soil changes associated with foot trails, or perhaps lines of small post molds external to major features.

The magnetic field gradient data from inside the ROW was dominated by signal clutter associated with modern disturbance, making it impossible to identify the relatively subtle signal typically created by prehistoric archeological features in this region. However, several interesting magnetic anomalies were observed just outside the ROW. Magnetic field gradient anomalies of possible interest in Area A are highlighted in Figure I-15. In Figure I-15 the three relatively strong bipolar anomalies (those anomalies with strong black and white components) appear to represent areas that retain some magnetic remanence and may indicate burnt structures or other burnt features such as a hearth. It is also not uncommon for individual burnt artifacts to create strong bipolar signal – perhaps a burnt metate or other large stone artifact. One of the anomalous regions highlighted in Figure I-15 contains weakly positive (dark) signal, which is typical of induced phenomena and may be indicative of a region containing magnetically enhanced soils. The parallel linear magnetic anomalies in the southern portion of Figure I-15 probably represent a modern road or trail, although it is possible that this signal represents a linear archeological feature, a road, or a trail associated with the prehistoric occupation of the site.

Significant magnetic anomalies from outside the ROW near Area C are presented in Figure I-16. A dashed yellow circle outlines three bipolar anomalies, again these anomalies appear to retain some magnetic remanence and may be associated with burned archeological features. The two northernmost bipolar magnetic anomalies appear to be “connected” by a weak arching magnetic anomaly. The southernmost bipolar magnetic anomaly is very intense and may be caused by a modern ferrous iron fragment, although a cursory search with a metal detector did not identify any near surface metal objects.

I.6 Conclusions and Recommendations

The geophysical investigation of 41RB112 has identified several anomalies and/or anomalous patterns that may identify the locations of buried archeological features. Unfortunately heavy disturbance within the project ROW has significantly increased the uncertainty of our interpretations.

Figure I-12. Electrical resistance survey interpretations from Area A.

Figure I-13. Electrical resistance survey interpretations from Area C.

Figure I-14. GPR survey interpretations from Area C.
Time-slice Imagery from 30 to 40 cmbs (bottom) and 55 to 65 cmbs (top).

The magnetic field gradient survey results from Areas A and C were compromised by signal clutter associated with wire fencing and other modern metal fragments within the ROW. Just outside the ROW (to the west), several magnetic anomalies are observed at both Areas A and C. These anomalies are consistent with magnetic anomalies from Middle Ceramic period features on other sites surveyed in this region and suggest that buried features extend to the west of the ROW. Several previously excavated units show up in the magnetic survey results as magnetic field gradient lows. These lows are induced magnetization anomalies, probably related to the mixing and redistribution of highly magnetic A horizon soils within the backfilled units.

The electrical resistance results were not affected by wire fences or metal fragments, but they were sensitive to soil disturbance associated with the construction of the fire break, as well as soil disturbance associated with fence and telephone pole construction. A careful comparison of the magnetic anomalies identified in Figures I-12 and I-13 with excavation plan maps should determine which anomalies were associated with modern disturbance, and which were caused by buried archeological

features. The electrical resistance survey results may also provide data useful in understanding the soil formation processes at this site. For example, high resistance regions (dark areas) exist in the southern portions of both Areas A and C (see the non high-pass filtered images in Figures I-6 and I-8). These relative resistance highs may identify deposits of coarser grained windblown sand.

The GPR survey results were impacted by modern soil disturbance and the presence of metal fragments. Once again, a careful comparison of the GPR anomalies identified in Figure I-14 with excavation plan maps should determine which, if any, of these anomalous reflections were caused by buried archeological features.

A final detailed comparison of excavation plan maps with the geophysical imagery is highly recommended. Such a comparison will allow us to improve our interpretations of the data, and to better identify signal that was created by site disturbance. This would improve our interpretation of future surveys, especially surveys in heavily disturbed environments such as found at 41RB112.

Figure I-15. Magnetic field gradient survey interpretations from outside ROW near Area A.

Figure I-16. Magnetic field gradient survey interpretations from outside ROW near Area C.

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APPENDIX J

PALEOENVIRONMENTAL ANALYSIS OF DIATOMS IN DAUB, AND BURNED ROCK SAMPLES FROM THE LONG VIEW ARCHEOLOGICAL SITE (41RB112), ROBERTS COUNTY, TEXAS

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J.1 Introduction

The purpose of this study is to investigate the possibility of using the ecological preferences of individual diatom species preserved in the surface coating on burned rocks, in construction material (sediment) and in daub associated with the Long View archeological site, 41RB112, to provide a paleoenvironmental description of the aquatic environment and contextual information about possible construction practices. Diatoms are unicellular, photosynthetic algae distinguished by the possession of a silica cell wall. They can be found living in a wide variety of natural and man-made terrestrial and aquatic habitats, including seeps, wet walls, dry and damp soil, springs, streams, creeks, sloughs, lakes, rivers, ponds, marshes, lagoons, estuaries, bays, and oceans. Many, if not most, are cosmopolitan: found in many parts of the world under similar environmental conditions, and many species have predictable environmental requirements and pollution tolerances that directly effect diatom species composition.

Diatoms are the most taxonomically diverse and well-studied algal group found in streams. A large and growing body of information exists on the range of ecological tolerance of many common taxa. Large diatom data sets from various parts of the world have shown that living diatom communities provide reliable analogs for estimates of past salinity, conductivity, depth, trophic (nutrient) level, pH, habitat, seasonality, and (indirectly) climate. Published autecological information about individual species form the general basis for interpretation of the diatom assemblage found during this study. Since diatoms are sensitive to so many physical and chemical parameters, and are often found in large numbers in sedimentary deposits, they are well-suited for use in paleoenvironmental reconstruction.

Aquatic diatoms include free-floating planktonic (lives suspended in the water column) species, and benthic species associated with sediment, microbial mats, drifting mats of filamentous algae, and rooted vegetation on the floor of a stream or lake. Motile benthic forms glide through mud, and others are firmly attached to macrophytes or larger algae, rocks, sand, mollusks, turtles and fish. Related to the benthic

diatoms, in terms of overlapping habitats, are the aerial diatoms commonly found living exposed to air and adapted to damp or dry habitats. Aerial diatoms are occasionally found in small numbers in aquatic diatom assemblages, such as those found in overbank deposits, if they have been washed into the water and transported with the aquatic diatoms during a flood.

This report presents the results of a diatom paleoenvironmental analysis of 18 samples, including burned rock or cook stones (rocks used as heating elements for boiling foods), daub, and construction fill material (Table J-1). Site 41RB112 is on the Southern Great Plains, in the northern part of Roberts County, Texas. The Long View site is located below the caprock between two small creeks, Dugout and Sourdough creeks, both of which flow southward from the Ogallala Formation, into the Canadian River a short distance to the south of the Long View site. The site is a Plains Village dated at about 535 B.P. cal (cal A.D.1425) for Component A and 390 B.P. cal (A.D. 1360) for Component C. Local geology consists of Holocene alluvial sediments along streams and Mio-Pliocene Ogallala sediments exposed on the rest of the land surface. By ca. 390 to 535 B.P., the approximate age of the material, the diatom flora consisted of extant species, and ecological studies of modern lake and stream systems are directly applicable.

J.2 Methods

Daub and sediment samples were cleaned of organic material and soluble minerals in preparation for microscopic analysis by boiling first in hydrogen peroxide and then in nitric acid. Burned rocks were gently scraped to remove the organic coating. This dry material was first wetted with distilled water and examined under the microscope and then processed in the same manner as the daub. The oxidized, decalcified material was rinsed repeatedly until a pH of about seven was reached. A few drops of the cleaned material was air-dried onto 22-by-22 mm cover glasses and mounted onto glass slides using NAPHRAX® a synthetic resin with a high index of refraction, developed to aid in resolving the details of diatom cell wall morphology. Two slides for each sample were scanned at 600x and all diatom cells were counted. Taxonomic determinations were done at 1500x.

J.3 Results

Diatoms were found in all but 3 of the 18 samples (83 percent). The diatoms encountered during this investigation, with their authorship, are tabulated on Table J-2. A total of 1,163 diatom cells, representing 49 diatoms identified to species and another 6 identified to the genus level were recorded from the 15 diatomaceous samples. As can be seen from Table J-2, the number of diatoms in any one sample varied from 1 to 741. The most common species, in order of abundance, are *Aulacoseira distans* (Ehrenberg) Simonsen and closely related forms, including *A. cf. subarctica* (O. Müller) Haworth and *A. cf. distans*, a very finely punctate form, (604 cells, all found in the daub), *Amphora pediculus* (Kützing) Grunow (124 cells), *Denticula kuetzingii* Grunow (49 cells), *Gomphonema lateripunctatum* Reichardt and Lange-Bertalot (55 cells), *Eolimna minima* (Grunow) Lange-Bertalot (45 cells), *Synedra ulna* (Nitzsch) Ehrenberg (39 cells), *Cocconeis placentula* Ehrenberg and varieties (34 cells), *Delicata delicatula* (Kützing) Krammer (32 cells), *Achnanthisidium minutissimum* (Kützing) Czarnecki (21 cells), *Hantzschia amphioxys* (Ehrenberg) Grunow (23 cells), and *Reimeria sinuata* (Gregory) Kociolek and Stoermer (15 cells). The remaining taxa are represented by numbers ranging from 1 to 10 cells. In the daub and sediment samples the diatoms were heavily diluted by insoluble residues consisting of clay, quartz and other mineral grains. The diatoms in the burned rock scrapings were diluted with organic material and sediment. The kinds of diatoms include both freshwater and aerial species. Available autecological information about specific taxa is provided on Table J-3. Sources of ecological information include Porter (2007), Haworth (1988), Camburn and Charles (2000), and many others that are included in the list of references. A total of 37 diatom species identified during this investigation are illustrated on plates J-1 through J-3. Some diatoms were oriented in a way that made it impossible to photograph well, and these are not illustrated.

J.4 Discussions

The samples represent two separate time intervals (listed as Component C and Component A on Table J-1). There are 8 samples from each component. Both components include samples of daub and burned rock, and in addition there were two pithouse

construction fill sediment samples from Component C. These two areas and the three kinds of samples from these areas (daub, sediment and burned rock) are discussed separately.

J.4.1 Component C

A total of 946 cells were found in Component C, and of these 747 were found in daub, 7 in the sediment and 192 on the burned rocks. The two daub samples were variable in the numbers of diatoms they contained. Daub sample 195-005 was the most diatomaceous sample and 741 cells were counted. The diatoms in this sample are a combination of aquatic, benthic species typical of those found in a small, shallow, alkaline, eutropic (nutrient rich), hard-water stream; and aquatic, planktonic and benthic forms that live in low-nutrient, low conductivity, shallow, acid-water lakes, bogs and reed swamps. The most common of the lacustrine forms include a group of closely related taxa in the *Aulacoseira distans* complex, now recognized as several separate but difficult to distinguish species, including smaller numbers of a finely punctate form referred to as *Aulacoseira cf. distans*. One other centric diatom found in very small numbers, *Aulacoseira granulata* (Ehrenberg) Simonsen, is not related to the other *Aulacoseira* species and has a different ecology. The other diatoms in the sample are species found in the shallow areas of lakes and in streams. Sample 643-005-2 contained only five cells of *Aulacoseira distans*.

No diatoms were recorded from sample 1288-004-7 of the construction fill from above the floor of the pithouse, but the other sediment sample, 1289-004-13, contained seven diatoms. Two cells were *Aulacoseira distans*, one was *Hantzschia amphioxys*, one was *Pinnularia viridis* var. *minor* Cleve, two were fragments of *Pinnularia*, and one was a *Stauroneis* sp. fragment. *Hantzschia* could have come from either a fossil or more recent source. The *Pinnularia viridis* and *Stauroneis* sp. are found in low alkalinity habitats similar to *Aulacoseira distans* and could be the same age as the *Aulacoseira*.

The presence of these planktonic diatoms in the daub and sediment contrasts with the kinds of diatoms found in the burned rock samples of Component

Table J-1. Provenience of 41RB112 Samples Submitted for Diatom Analysis.

Component	PNUM	Unit N	Unit E	Depth (cmbs)	Feature No.	Sample Type	Summary
C	195-005	479	499	51-60		Daub	Most diatomaceous
C	234-3-1a	480	500	40-50	20	BR	Some diatoms
C	234-3-2a	480	500	40-50	20	BR	Some diatoms
C	586-3-4a	498	496	80-90	6	BR	No diatoms
C	643-005-2	499	497	47	6	Daub	Some diatoms
C	643-3-11a	499	497	50-60	6	BR	No diatoms
C	1288-004-7	498	496	29-33	6	Sediment (Daub)	No diatoms
C	1289-004-13	498	495		6	Sediment (Daub)	Some diatoms
C	1256-003	485	495	30		BR	Many diatoms
A	697-3-2a	665	510	15		BR	Some diatoms
A	800-3-1a	672	509	40-50	14	BR	Some diatoms
A	855-3-1a	678	611	23-26	15	BR	Some diatoms
A	836-3-1a	675	509	20-30		BR	Many diatoms
A	956-005-2	693	511	31		Daub	Some diatoms
A	985-3-1a	694	513	41-45	13	BR	Some diatoms
A	1032-3-1a	696	511	50-60	11	BR	Some diatoms
A	1031-3-1a	696	511	50-60		BR	Some diatoms
A	1160-005	700	515	30-40	1	Daub	Many diatoms

Table J-2. Diatoms Recovered from 41RB112.

	195-005	234-3-1a	234-3-2a	586-3-4a*	643-005-2	643-3-11a*	1288-004-7*	1289-004-13	1256-003	697-3-2a	800-3-1a	855-3-1a	836-3-1a	956-005-2	985-3-1a	1032-3-1a	1031-3-1a	1160-005	Total
Component	C	C	C	C	C	C	C	C	C	A	A	A	A	A	A	A	A	A	
Sample type	daub	rock	rock	rock	daub	rock	sediment	sediment	rock	rock	rock	rock	rock	daub	rock	rock	rock	daub	
<i>Achnantheidium minutissimum</i> (Kützing) Czarnecki	8								7				6						21
<i>Achnantheidium biasolettianum</i> (Grunow) Round & Bukhtiyarovia									1										1
<i>Amphora cf. montana</i> Krasske	2																		2
<i>Amphora pediculus</i> (Kützing) Grunow	118		4						2										124
<i>Anomooneis</i> sp.														1					1
<i>Aulacoseira distans</i> (Ehrenberg) Simonsen	430				5			2						3				122	562
<i>Aulacoseira cf. distans</i> (Grunow) Krammer	40																		40
<i>Aulacoseira granulata</i> (Ehrenberg) Simonsen									1									1	2
<i>Aulacoseira</i> sp.					1														1
<i>Aulacoseira cf. subarctica</i> (O. Müller) Haworth																		2	2
<i>Bacillaria paradoxa</i> Gmelin	2																		2
<i>Cocconeis placentula</i> Ehrenberg	23								1				7						31
<i>Cocconeis placentula</i> var. <i>euglypta</i> (Ehrenberg) Grunow	1																		1
<i>Cocconeis placentula</i> var. <i>lineata</i> (Ehrenberg) Van Heurck	2																		2
<i>Delicata delicatula</i> (Kützing) Krammer									32										32
<i>Denticula kuetzingii</i> Grunow	2								47										49
<i>Diadesmis confervacea</i> Kützing			1																1
<i>Diploneis oblongella</i> (Naegeli) A. Cleve-Euler									5										5

Table J-2. Diatoms Recovered from 41RB112 (cont.)

	195-005	234-3-1a	234-3-2a	586-3-4a*	643-005-2	643-3-11a*	1288-004-7*	1289-004-13	1256-003	697-3-2a	800-3-1a	855-3-1a	836-3-1a	956-005-2	985-3-1a	1032-3-1a	1031-3-1a	1160-005	Total
Component	C	C	C	C	C	C	C	C	C	A	A	A	A	A	A	A	A	A	
Sample type	daub	rock	rock	rock	daub	rock	sediment	sediment	rock	rock	rock	rock	rock	daub	rock	rock	rock	daub	
<i>Encyonema silesiacum</i> (Bleisch) D.G. Mann	2								1										3
<i>Eolimna minima</i> (Grunow) Lange-Bertalot	45																		45
<i>Epithemia argus</i> (Ehrenberg) Kützing																		1	1
<i>Eunotia</i> sp.	2																		2
<i>Fragilaria parasitica</i> (W. Smith) Grunow									1										1
<i>Geissleria cf. paludosa</i> (Hustedt) Lange-Bertalot & Metzeltin	1																		1
<i>Gomphonema lateripunctatum</i> Reichardt & Lange-Bertalot									55										55
<i>Gomphonema micropus</i> Kützing																	2		2
<i>Gomphonema parvulum</i> (Kützing) Kützing													2						2
<i>Hantzschia amphioxys</i> (Ehrenberg) Grunow		1						1	3		2				12		2	2	23
<i>Luticola mutica</i> (Kützing) D.G. Mann										2					3				5
<i>Navicula cryptocephala</i> Kützing	2																		2
<i>Navicula ingenua</i> Hustedt			1																1
<i>Navicula kotschyi</i> Grunow	6																		6
<i>Navicula libonensis</i> Schoeman																2			2
<i>Navicula sanctaecrucis</i> Østrup	4																		4
<i>Nitzschia amphibia</i> Grunow	4								1										5
<i>Nitzschia fonticola</i> Grunow													1						1
<i>Nitzschia sinuata</i> var. <i>delognei</i> (Grunow) Lange-Bertalot									10										10
<i>Nitzschia</i> sp.	1																		1

Table J-2. Diatoms Recovered from 41RB112 (cont.)

	195-005	234-3-1a	234-3-2a	586-3-4a*	643-005-2	643-3-11a*	1288-004-7*	1289-004-13	1256-003	697-3-2a	800-3-1a	855-3-1a	836-3-1a	956-005-2	985-3-1a	1032-3-1a	1031-3-1a	1160-005	Total
Component	C	C	C	C	C	C	C	C	C	A	A	A	A	A	A	A	A	A	
Sample type	daub	rock	rock	rock	daub	rock	sedi-ment	sedi-ment	rock	rock	rock	rock	rock	daub	rock	rock	rock	daub	
<i>Pinnularia borealis</i> Ehrenberg		2													1				3
<i>Pinnularia viridis</i> var. <i>minor</i> Cleve								1											1
<i>Pinnularia</i> sp.	1							2	1			1						1	6
<i>Placoneis elginensis</i> (Gregory) Cox			2																2
<i>Planothidium lanceolatum</i> (Brébisson) Grunow	5												1						6
<i>Planothidium lanceolatum</i> ssp. <i>dubium</i> (Grunow) Lange-Bertalot	1																		1
<i>Reimeria sinuata</i> (Greg.) Kociolek & Stoermer	11		2															2	15
<i>Sellaphora seminulum</i> (Gregory) Mann	5																		5
<i>Sellaphora stroemii</i> (Hustedt) Kobayasi									2										2
<i>Stauroneis</i> sp.								1											1
<i>Staurosira construens</i> Ehrenberg	8												10						18
<i>Staurosira construens</i> var. <i>venter</i> (Ehrenberg) Hamilton			4										1						5
<i>Staurosirella martyi</i> (Héribaud) Morales & Manoylov	1																		1
<i>Synedra ulna</i> (Nitzsch) Ehrenberg	8								5				26						39
<i>Tabellaria flocculosa</i> (Roth) Kützing	1																		1
<i>Tabularia fasciculata</i> (Agardh) Williams & Round	1												1						2
<i>Tryblionella apiculata</i> Gregory	4																		4
Total	741	3	14	-	6	-	-	7	175	2	2	1	55	4	16	2	4	131	1163

*No diatoms found

Table J-3. Ecological Characteristics of Diatoms from Site 41RB112.

<i>Achnantheidium minutissimum</i> (Kützing) Czarnecki	Aquatic, benthic, epiphytic and epilithic, eurytrophic, sometimes an indicator of low total nitrogen (TN) and total phosphorous (TP), but also appears to prefer a nitrogen and/or phosphorous-enriched environment, β -mesosaprobous, tolerates high organic bound nitrogen (OBN), sensitive to nutrients and organic enrichment, tolerates continuously high concentrations of oxygen, pH indifferent, fresh-brackish salinity, chloride optimum low, non-motile, abundant in bright sun on travertine in a film of flowing water, an early colonizer in newly established habitats
<i>Achnantheidium biasolettianum</i> (Grunow) Round & Bukhtiyarovia	Aquatic, benthic, epilithic, non-motile
<i>Amphora cf. montana</i> Krasske	Aquatic, benthic, eutrophic, indicator of high TN and TP, β -mesosaprobous, tolerates high OBN and continuously high oxygen concentrations, alkaliphilous (pH at least 7), fresh-brackish water
<i>Amphora pediculus</i> (Kützing) Grunow	Aquatic, benthic, littoral zone, eutrophic, indicator of high TN and TP, β -mesosaprobous, tolerates high OBN, sensitive to organic enrichment, fairly high oxygen tolerance, alkaliphilous, fresh-brackish water, on rocks and moss in springs, in surf zone and other high-energy environments
<i>Anomooneis</i> sp.	Aquatic, benthic, epiphytic
<i>Aulacoseira distans</i> (Ehrenberg) Simonsen	Aquatic, planktonic, in acidic, very soft waters with 0 to low alkalinity, low total phosphate, pH 4.4-6.3, dystrophic (nutrient-poor, brown, peaty water) to oligotrophic, non-motile, characteristic of alpine and northern regions, also reported as benthic, halophobous, pH up to about 7, peaty water, clear, cold water, glacial lakes
<i>Aulacoseira cf. distans</i> (very finely punctate form)	Aquatic, planktonic, in acidic, very soft waters with 0 to low alkalinity, low total phosphate, pH 4.4-6.3, oligotrophic, non-motile, characteristic of alpine and northern regions, also reported as benthic, halophobous, pH up to about 7, peaty water, clear, cold water, glacial lakes
<i>Aulacoseira granulata</i> (Ehrenberg) Simonsen	Aquatic, planktonic and benthic, in large, and shallow, mesotrophic- highly eutrophic lakes and rivers, dominant in shallow lakes, oligohalobous, alkaliphilous, β -mesosaprobous, tolerates turbid water, medium conductivity, alkaliphilous, pH around 8-8.5, found in sodium-rich water, not nitrogen fixing, indicator of high TN and TP, tolerates OBN, tolerates moderate oxygen saturation, fresh-brackish water, non-motile
<i>Aulacoseira</i> sp.	Aquatic
<i>Aulacoseira cf. subarctica</i> (O. Müller) Haworth	Aquatic, cool water, meroplanktonic (spends an important part of its life on the bottom, and is stirred up in boreal forest lakes, seems to be confined to higher latitudes, in large, deep lakes and small, shallow lakes, negatively correlated with TN and TP concentrations, oligotrophic and meso-eutrophic, declines with increasing nutrient concentrations, moderately low conductivity and alkalinity, acidophilic-circumneutral (pH 5.6-7.0)
<i>Bacillaria paradoxa</i> Gmelin	Aquatic, planktonic, (and benthic?) eutrophic, indicator of high TN and TP, α -mesosaprobous, tolerant to OBN, somewhat tolerant to nutrient and organic enrichment, tolerates low oxygen saturation, pH indifferent, brackish water, non-motile
<i>Cocconeis placentula</i> Ehrenberg	Aquatic, benthic, epiphytic, epipsamic, eutrophic, indicator of high TN and TP, β -mesosaprobous, tolerant to organically bound N, sensitive to nutrient and organic enrichment, tolerates moderate oxygen saturation, alkaliphilous, fresh-brackish water, non-motile, high calcium optimum
<i>Cocconeis placentula</i> var. <i>euglypta</i> (Ehrenberg) Grunow	Aquatic, benthic, attached, not nitrogen fixing, eutrophic, indicator of high TN and TP, β -mesosaprobous, tolerant to OBN, sensitive to nutrient and organic enrichment, tolerates moderate dissolved oxygen saturation, alkaliphilous, fresh-brackish water, chloride optimum low, non-motile
<i>Cocconeis placentula</i> var. <i>lineata</i> (Ehrenberg) Van Heurck	Aquatic, benthic, attached, not nitrogen fixing, eutrophic, indicator of high TN and TP, β -mesosaprobous, tolerant to OBN, sensitive to nutrient and organic enrichment, tolerates moderate dissolved oxygen saturation, alkaliphilous, fresh-brackish water, chloride optimum low, non-motile

Table J-3. Ecological Characteristics of Diatoms from Site 41RB112 (cont.)

<i>Delicata delicatula</i> (Kützing) Krammer	Aquatic, benthic, attached, epiphytic, oligotrophic, indicator of low total and organic nitrogen and phosphorus, oligosaprobous, sensitive to nutrient and organic enrichment, high oxygen concentrations, alkaliphilous, fresh water, less than 100 mg/l chloride, less than 0.2ppt salinity, non-motile, also regularly occurs in wet places, carbonate buffered, high conductivity water, tropical to subarctic, on wet rocks and in oligotrophic, slightly alkaline lakes and running waters
<i>Denticula kuetzingii</i> Grunow	Aquatic, benthic, mesotrophic, low TP indicator, β -mesosaprobous, intolerant to organically bound N, oxygen tolerance always high, alkaliphilous, fresh-brackish water, specific conductance and chloride optimum low, motile
<i>Diadsmis confervacea</i> Kützing	Aquatic, benthic, motile, mesotrophic, high TP indicator, α -mesosaprobous, requires periodic elevated concentrations of OBN, tolerates moderate dissolved oxygen saturation, pH indifferent, brackish-fresh water
<i>Diploneis oblongella</i> (Naegeli) A. Cleve-Euler	Aquatic, benthic, motile, low TP indicator, oligosaprobous, generally intolerant to OBN, sensitive to nutrient and organic pollution, tolerant of always high oxygen saturation, alkaliphilous, fresh-brackish water
<i>Encyonema silesiacum</i> (Bleisch) D.G. Mann	Aquatic, benthic, tolerant to a wide range of nutrients, low TN and TP indicator, $\pm$ -mesosaprobous, tolerant to OBN, sensitive to nutrient and organic enrichment, tolerates moderate oxygen concentrations, pH around 7, fresh-brackish water, low specific conductance optimum, low chloride optimum, non-motile
<i>Eolimna minima</i> (Grunow) Lange-Bertalot	Aquatic, benthic, non-motile, eutrophic, high TN and TP indicator, α -meso/polysaprobous, requires periodic OBN, most tolerant to nutrient and organic enrichment (pollution), polysaprobic- tolerant of extremely degraded conditions, tolerates low oxygen saturation, alkaliphilous, fresh-brackish water, chloride optimum low
<i>Epithemia argus</i> (Ehrenberg) Kützing	Aquatic, benthic, epiphytic and epilithic, capable of fixing dissolved atmospheric nitrogen, mesotrophic, oligosaprobous, less tolerant to organic and nutrient pollution, alkaliphilous, fresh-brackish water, non-motile
<i>Eunotia</i> sp.	Aquatic, benthic, epiphytic
<i>Fragilaria parasitica</i> (W. Smith) Grunow	Aquatic, benthic, not capable of fixing dissolved atmospheric nitrogen (not nitrogen fixing), mesotrophic-eutrophic, β -mesosaprobous, generally intolerant to OBN, oxygen tolerance always high, alkaliphilous, fresh-brackish water, non-motile
<i>Geissleria cf. paludosa</i> (Hustedt) Lange-Bertalot & Metzeltin	Aquatic and aerial- intermittently wet places like <i>Carex</i> swamps and in the supralittoral of various waters with average electrolyte content
<i>Gomphonema lateripunctatum</i> Reichardt & Lange-Bertalot	Aquatic, benthic, in irrigation water on moss, in a flowing channel, associated with travertines, on moss in springs
<i>Gomphonema micropus</i> Kützing	Aquatic, benthic, epiphytic, not nitrogen fixing, eutrophic, β -mesosaprobous, tolerant to OBN, oxygen tolerance fairly high, alkaliphilous, fresh-brackish water, non-motile
<i>Gomphonema parvulum</i> (Kützing) Kützing	Aquatic, benthic, epiphytic, not nitrogen fixing, eutrophic, indicator of high TN and TP, α -mesosaprobous, requires periodic elevated concentrations of OBN, polysaprobic-most tolerant of pollution and degraded conditions, tolerates low oxygen, circumneutral pH, fresh-brackish water, chloride optimum low, non-motile
<i>Hantzschia amphioxys</i> (Ehrenberg) Grunow	Aerial, on rocks, in damp mud and dry soil, also in sand and in the upper littoral zone in fresh and brackish water of lakes and streams, tolerates a wide range of physical and chemical conditions, becomes frequent only upon rewetting after drought, not nitrogen fixing, indifferent to a wide range of nutrients, high TP indicator, α -mesosaprobous, tolerant to OBN, somewhat tolerant to nutrient and organic enrichment, dissolved oxygen tolerance fairly high, circumneutral pH, fresh-brackish water, chloride optimum low, benthic, motile

Table J-3. Ecological Characteristics of Diatoms from Site 41RB112 (cont.)

<i>Luticola mutica</i> (Kützing) D.G. Mann	Aerial, sometimes aquatic, in soils and crusts, benthic, tolerates a wide range from oligotrophic to eutrophic water, in fresh and brackish water, in estuaries, springs, streams, rivers, swamps, hot springs, bogs and saline lakes, indifferent to salt, temperature and water current, not nitrogen fixing, eutrophic, indicates high TN, α -mesosaprobous, tolerant to OBN, somewhat tolerant to nutrient and organic enrichment, oligosaprobic, oxygen tolerance always high, circumneutral pH, brackish-fresh water, chloride optimum low, benthic, motile
<i>Navicula cryptocephala</i> Kützing	Aquatic, benthic, not nitrogen fixing, wide range of tolerance to nutrients, indicator of high TN and TP, α -mesosaprobous, tolerant to OBN, sensitive to nutrient and organic enrichment, tolerates moderate oxygen saturation, alkaliphilous, fresh-brackish water, low chloride optimum, non-motile
<i>Navicula ingenua</i> Hustedt	Aquatic, benthic, not nitrogen fixing, indicator of high TN and TP, specific conductance optimum low, chloride optimum high, motile
<i>Navicula kotschy</i> Grunow	Aquatic, benthic, not nitrogen fixing, low TP indicator, oligosaprobous, oxygen tolerance always high, alkaliphilous, fresh-brackish water, motile, calcium optimum high
<i>Navicula libonensis</i> Schoeman	Aquatic, benthic, not nitrogen fixing, somewhat tolerant to nutrient and organic enrichment, specific conductance optimum high, chloride optimum low, motile
<i>Navicula sanctaecrucis</i> Østrup	Aquatic, benthic, not nitrogen fixing, indicator of high TP, specific conductance optimum high, chloride optimum high, motile, calcium optimum high
<i>Nitzschia amphibia</i> Grunow	Aquatic, benthic, and opportunistically planktonic, epipelagic, in mud of freshwater lakes and streams, oligohalobous but tolerates higher salt content of different ionic ratios, fresh-brackish water, alkaliphilous to alkalibiontic, pH optimum 8.5, tolerates slight fluctuations in osmotic pressure, eurythermal and can live in hot springs, indicator of high TN and TP, requires periodic elevated concentrations of OBN, eutrophic, somewhat tolerant to nutrient and organic enrichment, non-motile, sometimes occurs in wet, places that are not submerged, not nitrogen fixing, α -meso/polysaprobous, tolerates moderate oxygen saturation, alkaliphilous, fresh-brackish water
<i>Nitzschia fonticola</i> Grunow	Aquatic, benthic, not nitrogen fixing, mesotrophic-eutrophic, indicator of high TN and TP, β -mesosaprobous, tolerant to OBN, sensitive to nutrient and organic enrichment, tolerates fairly high oxygen concentrations, alkaliphilous, fresh-brackish water, non-motile
<i>Nitzschia sinuata</i> var. <i>delognei</i> (Grunow) Lange-Bertalot	Aquatic, benthic, not nitrogen fixing, mesotrophic-eutrophic, low phosphorous optimum, β -mesosaprobous, intolerant to OBN, tolerates high oxygen saturation, alkaliphilous, (range of 4.91-9.45 with mean of 7.82), fresh-brackish water, low chloride optimum, motile
<i>Nitzschia</i> sp.	Aquatic
<i>Pinnularia borealis</i> Ehrenberg	Aerial, not nitrogen fixing, oligotrophic-mesotrophic, β -mesosaprobous, tolerant to OBN, somewhat tolerant to nutrient and organic enrichment, tolerates very high oxygen concentrations, circumneutral pH, fresh-brackish water, benthic, found in habitats such as rocks, walls, soil, moss, also in rivers and lakes, motile
<i>Pinnularia viridis</i> var. <i>minor</i> Cleve	Aquatic and aerial, benthic, not nitrogen fixing, wide range of tolerance to nutrients, β -mesosaprobous, tolerant to OBN, tolerates moderate oxygen concentrations, circumneutral pH, fresh-brackish water, low specific conductance optimum, low chloride optimum, motile
<i>Pinnularia</i> sp.	Aquatic
<i>Placoneis elginensis</i> (Gregory) Cox	Aquatic, benthic, not nitrogen fixing, eutrophic, β -mesosaprobous, tolerant to OBN, sensitive to nutrient and organic enrichment, tolerates fairly high dissolved oxygen saturation, alkaliphilous, fresh-brackish water, low chloride optimum, motile
<i>Planothidium lanceolatum</i> (Brébisson) Grunow	Aquatic, benthic, not nitrogen fixing, eutrophic, indicator of high TN and TP, α -mesosaprobous, tolerant to OBN, somewhat tolerant to nutrient and organic enrichment, α -mesosaprobous-polysaprobous, tolerates moderate oxygen saturation, alkaliphilous, fresh-brackish water, low chloride optimum, non-motile, inhabits depressions and crevices on sand grains

Table J-3. Ecological Characteristics of Diatoms from Site 41RB112 (cont.)

<i>Planothidium lanceolatum</i> ssp. <i>dubium</i> (Grunow) Lange-Bertalot	Aquatic, benthic, epiphytic, not nitrogen fixing, eutrophic, indicator of high TN and TP, α -mesosaprobous, tolerant to OBN, somewhat tolerant to nutrient and organic enrichment, α -mesosaprobous-polysaprobous, tolerates moderate oxygen saturation, alkaliphilous, pH 7.2, fresh-brackish water, low chloride optimum, non-motile
<i>Reimeria sinuata</i> (Gregory) Kociolek & Stoermer	Aquatic, benthic, not nitrogen fixing, epipellic or epiphytic in slowly running water, oligohalobous, pH indifferent, mesotrophic-eutrophic, low TN and TP, β -mesosaprobous, tolerant to OBN, sensitive to nutrient and organic enrichment, tolerates high oxygen concentrations, oligosaprobic-sensitive to nutrient and organic pollution, circumneutral pH, fresh-brackish water, low chloride optimum, non-motile
<i>Sellaphora seminulum</i> (Gregory) Mann	Aquatic, benthic, motile, not nitrogen fixing, eutrophic, indicator of high TN and TP, α -mesosaprobous-polysaprobous, requires periodic elevated concentrations of OBN, very tolerant to nutrient and organic enrichment, tolerance of oxygen low, circumneutral pH, fresh-brackish water
<i>Sellaphora stroemii</i> (Hustedt) Kobayasi	Aquatic, benthic, indicator of low TN and TP, tolerates always high oxygen, alkaliphilous, fresh-brackish water, low chloride optimum, motile
<i>Stauroneis</i> sp.	Aquatic, benthic
<i>Staurosira construens</i> (Ehrenberg) Williams & Round	Aquatic, benthic, not nitrogen fixing, mesotrophic-eutrophic, β -mesosaprobous, generally intolerant to OBN, sensitive to nutrient and organic enrichment, oligosaprobic, tolerates always high oxygen, alkaliphilous, fresh-brackish water, low chloride optimum, non-motile
<i>Staurosira construens</i> var. <i>venter</i> (Ehrenberg) Hamilton	Aquatic, benthic, not nitrogen fixing, mesotrophic-eutrophic, β -mesosaprobous, tolerant to OBN, sensitive to nutrient and organic enrichment, tolerates always high oxygen, alkaliphilous, fresh-brackish water, non-motile
<i>Staurosirella martyi</i> (Héribaude) Morales & Manoylov	Aquatic, benthic in sand, not nitrogen fixing, low conductivity, circumneutral to alkaliphilous pH, low chloride optimum, non-motile
<i>Synedra ulna</i> (Nitzsch) Ehrenberg	Aquatic, benthic and opportunistically planktonic, epiphytic, not nitrogen fixing, indifferent to a wide range of nutrients, low TN and TP optimum, α -mesosaprobous-polysaprobous, tolerant to OBN, somewhat tolerant to nutrient and organic enrichment, tolerant of extremely degraded conditions, moderate oxygen tolerance, alkaliphilous, fresh to slightly brackish water, epiphytic, moderate conductivity, eutrophic water, oligohalobous, low chloride optimum, non-motile
<i>Tabularia fasciculata</i> (Agardh) Williams & Round	Aquatic, benthic, not nitrogen fixing, eutrophic, high TN indicator, α -mesosaprobous, tolerant to OBN, tolerates moderate oxygen concentrations, alkaliphilous, brackish water, high specific conductance, chloride optimum high, non-motile
<i>Tabellaria flocculosa</i> (Roth) Kützing	Aquatic, benthic and planktonic, epiphytic, attached to floating leaves, not nitrogen fixing, low conductivity and chloride and sulfate optimum, non-motile, low calcium optimum, pH about 6-6.6, acidiphilous, tolerant of a wide range of oligotrophic to eutrophic waters without discernable preference, favored by low nutrient concentrations, sensitive to pollution, β -mesosaprobous, fresh water
<i>Tryblionella apiculata</i> Gregory	Aquatic, benthic, not nitrogen fixing, high TN and TP indicator, α -mesosaprobous, alkalibiontic, high specific conductance, motile, high calcium optimum

Figure J-1. Photomicrographs of selected diatoms.

Figure J-2. Photomicrographs of selected diatoms.

Figure J-3. Photomicrographs of selected diatoms.

C. There were no *Aulacoseira* species in any of the burned rock samples. Burned rock sample 234-3-1a contains two diatom species, both of them aerial mud forms. Sample 234-3-2a contains 6 stream species. No diatoms were found in sample 586-3-4a or sample 643-3-11a.

Burned rock sample 1256-003 was the second most diatomaceous sample examined, with 167 cells representing 17 species, all characteristic of a shallow, alkaline, hard-water stream. Many of these species are epiphytic (attached to plants) and grow attached to submerged vegetation. There were few aerophilic (soil) species. These aquatic species were probably attached to submerged or emergent aquatic vegetation that was pulled up and cooked. Those plants harvested from a stream or marshy area would be expected to contain aquatic diatoms as a tenaceous biofilm or algal mat that coats exposed roots, stems and leaves.

J.4.2 Component A

A total of 217 diatom cells were found in the samples of Component A, of which 135 diatoms were found in the 2 samples of daub. Sample 956-005-2 contained 3 cells of *Aulacoseira distans* and one fragment of another diatom. Sample 1160-005 contained 122 *Aulacoseira distans*, 3 *Aulacoseira granulata* and another 4 benthic species found in alkaline, hardwater streams.

There were 82 diatom cells in the six burned rock samples but the numbers varied substantially. As in Component C, there were no *Aulacoseira* species in the burned rocks. In 697-3-2a there is one species, *Luticola mutica* (Kützing) D. G. Mann, an aerial form. Another aerial diatom, *Hantzschia amphioxys*, was found in sample 800-3-1a. There was only one diatom fragment found in sample 855-3-1a. Burned rock sample 836-3-1a was more diatomaceous with 9 benthic stream taxa. There were three diatoms in sample 985-3-1a, all aerial forms. Sample 1032-3-1a had one benthic stream species only. Sample 1031-3-1a had one aerial form and one benthic stream species. The aerial species are found on mud that is frequently rewetted and could have become attached to the wet rocks when they were discarded after use. *Hantzschia* is most abundant on freshly wetted surfaces and the cooking rocks may

have been discarded in a depression that retained moisture. Another possibility is that the vegetable matter being cooked was of a kind that grew in areas that were seasonally marshy or moist where *Hantzschia* would be found in the mud at the base of the growing plants. Rainfall at the site would also have contributed to the growth of the aerial species.

The differences between Component C and Component A are primarily in the numbers of diatoms found in the samples. There is no evidence of a significant change in the paleoenvironment. Because the diatoms are heavily diluted with sediment, differences in the absolute numbers are in part an artifact due to the vagaries of sampling daub, sediment and burned rock coatings and should not be interpreted as ecologically significant. Some rocks, for example, may have been used more frequently than others and accumulated a thicker rind or coating on the surface. The kind of food being cooked would also play a role in what kinds of diatoms are found and part of the variability could be related to seasonal differences in when various kinds of vegetables became available. Also, when vegetation forms a dense canopy, such as in a stand of cattails or tall rushes, sunlight reaching the sediment surface is substantially reduced and the kinds of diatoms that can grow on the plants are those adapted to low light settings. Many of the aquatic diatoms found during this study are epiphytic, meaning that there was at least some aquatic vegetation, either submerged or emergent. The stream was probably shallow and flow moderately slow to avoid washing away the sediment and any vegetation. The substrate would have had to contain sufficient sediment to support the growth of rooted aquatic vegetation. Depth probably fluctuated at least seasonally. Dead and decomposing plants release soluble organic substances into the environment such as dissolved organic carbon, nitrogen and phosphorous that contributes to algal growth.

When water was collected from the stream for cooking, some diatoms would have been included with the water. Food, especially roots that would have had dirt on them may have been washed in the stream prior to cooking, and drifting filaments of green or blue-green algae encrusted with diatoms, could very easily have been caught up on the food.

There is often a diatom coating on mollusks and diatoms could become dislodged during the cooking process. Physical contact with the food being cooked, and the particles that fall to the bottom of the cooking vessel, as well as diatoms from the stream water used in the cooking process are the most likely mechanisms for incorporating aquatic diatoms onto the rock coating. Diatoms would have become dislodged during cooking and settled to the bottom of the cooking vessel with the rocks. Since the rocks were wet after use aerial diatoms living on the ground surface could have become attached to the rocks. Diatoms on the rocks would not live through the heating of the rocks but the dead cells would have remained. It is difficult to distinguish between recently living cells and ones that have been dead for a while once they have been cooked since the criteria for recently dead is the presence of cellular contents and these seem to degrade or disappear entirely with cooking. Heating the rocks might have dried the surface coating tighter onto the rock by removing the water, if it did not totally incinerate the coating. These processes could easily account for the variations in the numbers of diatoms found on the different rocks, and the kinds of diatoms found. If the rocks were not collected from the stream in the first place the only reasonable way that large numbers of aquatic diatoms could have selectively become attached to the cooking rocks is during the cooking process. This implies an anthropogenic influence on the burned rocks.

J.5 Reconstruction of Aquatic Paleoenvironment

The source area of potential diatomaceous material found at the site includes the area covered by the small drainage basin of the two intermittent streams near the site that flow into the Canadian River a couple of kilometers to the south. According to the Texas Commission on Environmental Quality the present Canadian River Basin is characterized as semi-arid and virtually treeless, with deciduous timber only along the fringes of the streams. Canadian River water contains elevated chloride, sulfate and total dissolved solids due in part to a natural brine artesian aquifer near the Texas-New Mexico border that seeps into the river as well as regional dissolution of Permian salts. The chemistry of water feeding the streams bordering the site is

influenced by the presence of silt, clay, caliche and limestone pebbles in the overlying Ogallala.

Reconstruction of paleoenvironment is based on the ecological characteristics of modern diatoms. The aquatic diatoms found during this investigation are divided into two distinctly different paleoecological environments. The burned rocks contain species found in meso-eutrophic water (moderate nutrient concentrations) with an alkaline pH (above pH 7) and at least slightly elevated ion concentrations suggesting that the water had a moderate to high conductivity. The diatoms indicate that chloride salinity was not abundant in the stream water so the conductivity (total ion concentration) probably represents primarily carbonate and sulfate ions. The diatoms are typically found in shallow, hard-water streams, and around the edge of ponds, attached to vegetation, sand, mud, pebbles or rocks. Their habitats can overlap with those of the aerial diatoms that might have been living on the damp mud of stream banks or on the occupation floor where the wet rocks were discarded after use. The preponderance of meso-eutrophic species suggests that there could have been nitrate and phosphate enrichment possibly associated with decaying vegetation, the grazing of large mammals and/or prairie fires (natural or human induced). Anthropogenic influences that commonly affect water quality at occupation sites include increased runoff associated with land clearing and farming, and contaminated runoff due to use of latrines and other domestic activities.

In contrast to the material extracted from the surface coating on the burned rocks, the daub samples and one of the sediment samples contained a group of diatoms belonging to the *Aulacoseira distans* complex, typical of a shallow, lacustrine-palustrine (marsh, swamp or bog) environment that contained cool, acidic, dilute, low-conductivity water. The detailed taxonomy of these forms at the species and varietal level is difficult to confirm with the light microscope alone, but the ecological characteristics of the group are very similar. The presence of *A. distans* and its relatives has been used to infer a low pH in lakes due to cool episodes associated with low weathering rates, decreased in-lake alkalinity production, shorter retention times and lower amounts of dust deposition (Lotter et al. 2010).

Some of the benthic diatoms found in the daub and sediment samples tolerate a wide range of ecological conditions but four forms: *Tabellaria fenestrata* (Roth) Kützing, *Staurosirella martyi* (Héribaud) Morales and Manoylov, *Pinnularia viridis* var. *minor* Cleve and *Stauroneis* sp. are typical of the low conductivity, acid-water lakes where *Aulacoseira* species are found. Another diatom found in the daub, *Epithemia argus* (Ehrenberg) Kützing, found in daub sample 1160-005, is an alkaliphil that prefers nutrient-rich, hard to slightly brackish water and is not part of the low alkalinity component.

Local environmental conditions determine the nature of seasonal succession of the diatom population. In seasonal or small streams, local rainfall, base flow velocity, and stream geomorphology are responsible for flow volume, flood disturbance, substrate size and nutrient concentrations. These factors, in turn, affect the rate and nature of diatom colonization and thus the kinds of diatoms present and the degree of succession possible. For example, crevices on loose, unconsolidated sand grains support a limited diatom flora that includes *Planothidium lanceolatum* (Grunow) Lange-Bertalot, *Staurosirella martyi*, and *Amphora pediculus* (Round 1981). On the other hand, submerged plants support large numbers of attached, epiphytic species. There is a definite seasonality and seasonal succession in the appearance of various diatom species, with some species common in the spring and others later in the year. Also diatoms replace each other as physical and chemical conditions change. Initial colonization at the beginning of the growing season by small, firmly attached epiphytic diatoms such as *Achnanthes minutissimum* and *Cocconeis placentula* is followed by slower growing, more upright, colonial and motile species as a habitat becomes more mature and differentiated, and temperature, nutrients and conductivity increase. In small, seasonal streams, particularly those dependent on local rainfall for recharge, succession may be only partial, with early colonizing species remaining although in lower numbers. No definitive statement can be made as to the time of year represented by the various samples.

J.6 CONCLUSIONS

The surface coatings on the burned rocks contain diatoms that are typically found in a temperate,

shallow, slightly too definitely alkaline, moderately high conductivity, eutrophic stream, in contrast to those found on the daub pieces. There were no oligotrophic (nutrient poor) diatoms such as are found in an acidic bog or marsh with very low conductivity. The modern soils in the area are classified as moderately alkaline throughout the area according to the soil survey of Roberts County.

The daub samples are distinct from the burned rock samples in that they contain two different kinds of diatoms. One group includes several related *Aulacoseira* species that dominate the assemblage, as well as *Tabellaria fenestrata*, *Staurosirella martyi*, *Pinnularia viridis* var. *minor* and *Stauroneis* sp. all diatoms that are found in cold-water, low alkalinity, oligotrophic, acid-water lakes. The other group includes taxa that are typical of a small, temperate, shallow, alkaline, eutrophic stream. These results suggest that the daub was made from clay dug from an ancient bog, reed swamp or shallow lake deposit that represents a very different paleoenvironment than the present-day streams near the site. The climate would have been cool and wet enough to support a permanent wetland such as a marsh. *Aulacoseira distans* has been found in the Pliocene Ogallala Formation (Selva 1976) and has been reported from many other fossil freshwater lacustrine deposits as well. It occurs in modern habitats characterized as cool, acidic, low nutrient, low alkalinity lakes and bogs (Haworth 1988; Camburn and Charles 2000). A sample of the soil from the south wall below the pithouse at 78 to 80 cmbs, that is thought to be Ogallala in age, was examined for evidence of similarity with the other samples. Unfortunately no diatoms were found in this soil.

The hard-water stream species may have been incorporated into clay exposed along a stream bank at the time when it was used as daub. This could occur as a result of incision into an older bog deposit by a younger stream. None of these cold, acid-water species were found in the burned rock samples reinforcing the interpretation that they came from a different paleoenvironment than that of the streams near the site. An alternative mechanism that would incorporate alkaline stream diatoms into older bog sediments is if the bog material was excavated

during pithouse construction and dampened with creek water in order to use it as daub.

There were more diatom valves found in the daub, sediment and burned rock samples from Component C than from the daub and burned rock samples in Component A. This is difficult to interpret due to the vagaries of the sampling process. One possibility is that, particularly in sample 195-005, in Component C, aquatic plant material was intentionally incorporated into the daub during construction. All the stream diatoms in this sample can found living in the benthic, epiphytic habitat, attached to or associated with vegetation. The stems of submerged macrophytes such as *Equisetum*, *Phragmites* and the leaves of *Nuphar*, *Nymphaea*, *Ranunculus*, *Ceratophyllum* (Round 1981) and many other submerged and emergent plants and large algae are often coated with a thick, sticky, algal biofilm that includes abundant extracellular mucopolysaccharides in the form of mucilage pads, stalks, sheaths, filaments, and tubes produced by the diatoms (and other algae). Motile diatoms leave behind a slime trail of the same material when they move around. On mature plants this biofilm thickens, incorporates particles and forms a crust. When biofilm dries it contracts and may be an effective binding agent for the daub, particularly if grasses were unavailable.

Further investigations should include collections of modern diatom material from the streams in the area to provide local material for a comparison between present day and paleo-water conditions. Additional material from Ogallala sediments in the area should be examined to assist in verifying the age of the *Aulacoseira* species. Experiments to determine what happens to coatings on rocks during the heating and cooking process of various foods could provide insights into the composition and survival of organic surface coatings on these rocks with repeated use.

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Winsborough, B. M.	brackish	1000-5000	1.8-9.0
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	Oxygen requirements continuously high (about 100% saturation) fairly high (above 75% saturation) moderate (above 50% saturation)		
	Trophic state (growth promoting substances such as nitrate and phosphate, often from animals) oligotrophic- nutrient poor mesotrophic-moderate nutrient concentrations eutrophic- nutrient rich eurytrophic- indifferent to nutrients		
Glossary of terms used (after Van Dam et al. 1994; Round 1981; Porter 2007):			
pH			
acidobiontic (optimal occurrence at pH <5.5)			
acidophilous (mainly occurring at pH <7)			
circumneutral (mainly occurring at pH-values about 7)			
alkaliphilous (mainly occurring at pH >7)			
alkalibiontic (exclusively occurring at pH >7)			
indifferent (no apparent optimum, tolerates a wide pH range)			
Salinity			
	Cl- (mg/L)	Salinity (%)	
fresh	<100	<0.2	
fresh brackish	<500	<0.9	
brackish fresh	500-1000	0.9-1.8	
	Conductivity the concentration of dissolved salts (electrolytes), made up of cations calcium, magnesium, sodium and potassium, and anions bicarbonate, sulphate and chloride		
	Substrate epilphytic- attached to plants or other algae epilithic- on rocks epipellic- in mud aerial- habitats that are not submerged, such as soil, moss, wet walls and boulders aquatic- submerged		

Saprobity (organic pollution, harmful substances)

	Oxygen saturation (%)	BOD ₅ ²⁰ (mg/L)
oligosaprobous	>85	<2 low amounts of organic enrichment, clean water
B-mesosaprobous	70-85	2-4 somewhat degraded conditions, rich in diatoms and green algae
a-mesosaprobous	25-70	4-13 degraded conditions, preponderance of diatoms and some algae
cyanobacteria, tolerant		13-22 highly degraded conditions, cyanobacteria and a few diatoms
a-meso-/polysaprobous	10-25	
polysaprobous	<1	>22 extremely degraded conditions, very polluted, few algae

List of Diatoms in Microphotographs in the Plates.

Plate	Fig.	Name	Size	Mag.	PNUM
J-1	1	<i>Staurosirella martyi</i> (Héribaud) Morales & Manoylov	width 4µm, length 9µm	x1000	195-005
J-1	2	<i>Tabularia fasciculata</i> (Agardh) Williams & Round	width 6µm, length 16µm	x1000	195-005
J-1	3	<i>Aulacoseira distans</i> (Ehrenberg) Simonsen	width 7µm, height 2.5-3µm	x1000	195-005
J-1	4	<i>Aulacoseira cf. subarctica</i> (O. Müller) Haworth	width 7µm, height 12µm	x1000	1160-005
J-1	5	<i>Aulacoseira distans</i> (Ehrenberg) Simonsen	diameter 7µm	x1000	195-005
J-1	6	<i>Aulacoseira distans</i> (Ehrenberg) Simonsen	diameter 13µm	x1000	195-005
J-1	7	<i>Aulacoseira cf. subarctica</i> (O. Müller) Haworth	diameter 13µm	x1000	195-005
J-1	8	<i>Aulacoseira distans</i> (Ehrenberg) Simonsen	width 14µm, height 4µm	x1000	195-005
J-1	9	<i>Aulacoseira cf. subarctica</i> (O. Müller) Haworth	diameter 10µm	x1000	195-005
J-1	10	<i>Aulacoseira cf. subarctica</i> (O. Müller) Haworth	width 12µm, height 5µm	x1000	195-005
J-1	11	<i>Aulacoseira cf. distans</i> (Ehrenberg) Simonsen (fine striae)	width 10µm, height 2µm	x1000	195-005
J-1	12	<i>Aulacoseira distans</i> (Ehrenberg) Simonsen	width 7µm, height 4µm	x1000	195-005
J-2	13	<i>Eolimna minima</i> (Grunow) Lange- Bertalot	width 3µm, length 7µm	x1000	195-005
	14	<i>Encyonema silesiacum</i> (Bleisch) D.G. Mann	width 5µm, length 16µm	x1000	195-005
J-2	15	<i>Stauroneis</i> sp. (fragment)	width 18µm	x1000	195-005
J-2	16	<i>Cocconeis placentula</i> var. <i>euglypta</i> (Ehrenberg) Grunow	width 10µm, length 16µm	x1000	195-005
J-2	17	<i>Cocconeis placentula</i> var. <i>lineata</i> (Ehrenberg) Van Heurck (focus on lower valve)	width 12µm, length 19µm	x1000	195-005
J-2	18	<i>Cocconeis placentula</i> var. <i>lineata</i> (Ehrenberg) Van Heurck (same specimen as 17, focus on upper valve)	width 12µm, length 19µm	x1000	195-005
J-2	19	<i>Hantzschia amphioxys</i> (Ehrenberg) Grunow (partial valve)	width 8µm	x1000	985-3-1a

List of Diatoms in Microphotographs in the Plates.

J-2	20	<i>Amphora pediculus</i> (Kützing) Grunow	width 6µm, length 8µm	x1000	195-005
J-2	21	<i>Reimeria sinuata</i> (Greg.) Kociolek & Stoermer	width 6µm, length 19µm	x1000	195-005
J-2	22	<i>Bacillaria paradoxa</i> Gmelin	width 4µm	x1000	195-005
J-2	23	<i>Luticola mutica</i> (Kützing) D.G. Mann	width 5µm, length 11.5µm	x1000	985-3-1a
J-2	24	<i>Aulacoseira granulata</i> (Ehrenberg) Simonsen	width 11µm	x1000	195-005
J-2	25	<i>Pinnularia viridis</i> var. <i>minor</i> Cleve	width 15µm, length 85µm	x400	1289-004-13
J-2	26	<i>Nitzschia sinuata</i> var. <i>delognei</i> (Grunow) Lange-Bertalot	width 5µm, length 17µm	x1000	1256-003
J-2	27	<i>Synedra ulna</i> (Nitzsch) Ehrenberg (partial valve)	width 4.5µm	x400	836-3-1a
J-2	28	<i>Staurosira construens</i> var. <i>venter</i> (Ehrenberg) Hamilton	width 4µm, length 5.5µm	x1000	234-3-2a
J-3	29	<i>Nitzschia amphibia</i> Grunow	width 4µm, length 13µm	x1000	195-005
J-3	30	<i>Navicula kotschy</i> Grunow	width 5µm, length 16µm	x1000	195-005
J-3	31	<i>Navicula sanctaerucis</i> Østrup	width 9µm, length 23µm	x1000	195-005
J-3	32	<i>Delicata delicatula</i> (Kützing) Krammer	width 5µm, length 26µm	x1000	1256-003
J-3	33	<i>Synedra ulna</i> (Nitzsch) Ehrenberg (partial valve)	width 5µm	x400	836-3-1a
J-3	34	<i>Denticula kuetzingii</i> Grunow	width 5µm, length 29µm	x1000	1256-003
J-3	35	<i>Planothidium lanceolatum</i> (Brébisson) Grunow	width 4µm, length 10.5µm	x1000	195-005
J-3	36	<i>Diploneis oblongella</i> (Naegeli) A. Cleve-Euler	width 7µm, length 17µm	x1000	1256-003
J-3	37	<i>Gomphonema lateripunctatum</i> Reichardt & Lange-Bertalot	width 6µm, length 31µm	x1000	1256-003
J-3	38	<i>Pinnularia borealis</i> Ehrenberg	width 7µm, length 31µm	x1000	234-3-1a
J-3	39	<i>Cocconeis placentula</i> Ehrenberg	width 14µm, length 21µm	x1000	836-3-1a
J-3	40	<i>Achnanthisidium minutissimum</i> (Kützing) Czarnecki	width 2µm, length 8µm	x1000	1256-003
J-3	41	<i>Nitzschia fonticola</i> Grunow	width 3µm, length 19µm	x1000	836-3-1a
J-3	42	<i>Tabularia fasciculata</i> (Agardh) Williams & Round	width 3µm, length 45µm	x1000	836-3-1a
J-3	43	<i>Diadesmis confervacea</i> Kützing	width 6µm, length 16µm	x1000	234-3-2a
J-3	44	<i>Placoneis elginensis</i> (Gregory) Cox	width 6µm, length 21µm	x1000	234-3-2a
J-3	45	<i>Planothidium lanceolatum</i> ssp. <i>dubium</i> (Grunow) Lange-Bertalot	width 4µm, length 15µm	x1000	836-3-1a

List of Diatoms in Microphotographs in the Plates.

J-3	46	<i>Gomphonema parvulum</i> (Kützing) Kützing	width 5µm, length 20µm	x1000	836-3-1a
J-3	47	<i>Staurosira construens</i> var. <i>venter</i> (Ehrenberg) Hamilton	width 5µm	x1000	836-3-1a

APPENDIX K

NAGPRA INVENTORY FOR SITE 41RB112 (CSJ: 0490-04-037), ROBERTS COUNTY, TEXAS

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Texas Antiquities Commission Permit No. 3721
TxDOT Scientific Services Contract No. 57-902 SA003**

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K.1 Introduction

During August through November 2006 a data recovery program was conducted by archeologists from TRC Environmental Corporation (TRC) at 41RB112, the Long View site. These cultural resource investigations were necessitated to mitigate the development impacts by the planned state highway widening program proposed by the Texas Department of Transportation (TxDOT). The proposed roadway rehabilitation program will directly impact a narrow north-south section of prehistoric site 41RB112 along the western side of the current roadway. These cultural resource investigations were part of the responsibilities of TxDOT under the National Historic Preservation Act (NHPA) of 1966, as amended through 1992 (PL-89-665; 80 Stat. 915; 16 U.S.C. § 470 et seq.).

This prehistoric site appears to represent two horizontally separated, distinct and mostly Plains Village period occupations (Area A and Area C) in Roberts County, located towards the eastern side of Texas panhandle (Figure K-1). During the data recovery excavations in Area C at the southern end of the Long View site (41RB112), two human interments were encountered. Upon encountering the first interment TRC archeologists notified personnel in the Environmental (ENV) Affairs Division of TxDOT. After receiving instruction to proceed with the removal, the first interment was carefully hand-excavated and soon after a second interment was encountered and carefully excavated. These interments were designated in the field as cultural Features 7 and 22, respectively. Following the field investigations the interments were transported to TRC archeological laboratory in Austin, Texas for temporary storage and kept under lock and key until further examined as required under the Native American Graves Protection and Repatriation Act (NAGPRA).

K.2 Project Location

The Long View site is located within the Canadian River valley about 5.6 kilometers (km; 3.5 miles) north of the Canadian River in Roberts County. Roberts County is towards the eastern side of the Texas panhandle and part of the broader Southern High Plains section of the Great Plains

physiographic province (Fenneman 1931). The broad Canadian River valley topography below the escarpment is gently rolling with high ground, ridges and knolls between broad, shallow creek drainages flowing parallel to one another from the valley wall southward into the Canadian River. The Long View site is buried in sandy loam near the southern end of a north to south ridge about mid-way between the Canadian River and the high valley rim to the north. Two Canadian River tributaries, Sourdough Creek, approximately 550 meters (m) to the east, and Dugout Creek, approximately 1,100 m to the west of site 41RB112 have headwaters in the Tertiary Ogallala Formation caprock along the valley rim to the north. Currently both creek valleys contain quantities of wind blown sand, sand sheets, and sand dunes along their margins.

K.3 Site Description

The Long View site was along the western side of the highway as a roughly 250- to 260-m-long by 10- to 15-m-wide area, which contained two major concentrations of cultural materials within the top meter of sandy deposits. The area of potential affect (APE) through the Long View site was bounded on the west by a new right-of-way fence and on the east by a steep road cut above the highway. This long north-south section also included a mechanically bladed fireguard that has disturbed the natural prairie. It is roughly 4- to 5-m-wide and roughly 20 to 30 centimeters (cm) deep, and generally parallels the highway for kilometers. It is not known when this fireguard was first bladed and/or how often it has been bladed multiple times over the years.

The northern end (Area A) encompasses a section of land that extends roughly 70 m north to south over the entire APE, which is roughly 9- to 10-m-wide at this location. This area includes about 4 to 5 m of undisturbed natural prairie and a 4- to 5-m-wide by 20- to 30-cm-deep mechanically stripped fireguard that abuts the eastern edge of the new right-of-way fence line. Cultural materials lie across the entire width of the 10-m-wide area of potential affect. The materials include chipped stone tools, ground stone tools, bone tools, cord marked and painted pottery sherds, animal bones (at least bison, turtle and deer bones), burned rocks, mussel shells, charcoal, part of a pit house, basin hearths, storage pit, and

discard piles. The plant remains documented from the current analyses include at least mesquite beans, squash, maize, juniper, mesquite, and cottonwood/willow. Thus far, the four radiocarbon results indicate the occupation(s) occurred over a period between roughly 710 B.P. to 1490 B.P. These ages indicate possible cultural use during the Woodland and Plains Village periods.

Immediately south of Area A, and in the central part of the site is Area B, which is some 100 m north to south and covers an area that is a couple of meters lower in elevation than adjacent areas to the north or south. This area is nearly void of any sign of cultural material.

Immediate south of Area B and in the southern part of the site is Area C, which extends another 80 to 90 m north to south and is a variable 8- to 10-m-wide. This area contains diverse types of cultural materials including chipped stone tools, ground stone tools, cordmarked pottery sherds, burned rocks, animal bones, and recognized clusters of cultural materials labeled as features. Cultural features identified in Area C include a semisubterranean pit/post frame structure (Feature 6), a possible pithouse (Feature 18), one cairn above a human interment (Feature 7), one human cremation (Feature 22), at least four basin hearths (Features 5, 16/21, 26, and 29), a small storage pit (Feature 23), at least eight discard/dump areas (Features 2, 19, 20, 24, 25, 27, 30, and 31), one large post mold (Feature 17), and a number of small post holes in the vicinity of Features 6 and 18. One other feature, a partially buried 15-m-long rock alignment labeled Structure 1, is visible near the surface along the new right-of-way fence line. The plant remains documented thus far include corn/maize, juniper, mesquite, and cottonwood/willow.

Four radiocarbon dates on wood charcoal were obtained during the National Register Eligibility assessment phase from Area C. Their ages range from 630 to 1290 B.P. with three dates clustered around 660 B.P. The oldest date of 1290 B.P. was obtained from charcoal at 34 cm below surface (bs) below the rock alignment, Structure 1, observed near the surface. No diagnostic cultural material was recognized, which may support this early age. Washita, Harrell, and Fresno arrow points have

been recovered and the remainder of the cultural assemblage of stone and bone tools, cord marked ceramic sherds, animal bones, burned rocks, and the structural features identified all appear to support at least one Plains Village occupation.

One exception to the recognized Plains Village occupation is possibly the partially buried rock alignment, Structure 1 that is partially visible on the surface. This stone alignment is partially buried by recent wind blown sand that is probably less than 200 years old.

The focus of the remainder of this discussion is on two human interments (Features 7 and 22) that were recovered from the southernmost area, Area C.

K.4 Human Interment Descriptions and Context

K.4.1 Feature 7

Feature 7 was discovered during National Register eligibility assessment (Quigg et al. 2005) within Trench C-1. At the time of discovery, only the top of the caliche rock concentration was exposed within a 30-cm-wide hand-excavated trench that went over this rock concentration. As the trench was being excavated the excavator dug up over the caliche rocks and down the other side without moving the rocks or exposing the entire concentration, or digging under the rocks. This rock cluster was encountered about 160 cm east of the rock alignment, Structure 1. It was nearly centered along the north to south axis of Structure 1 and along the very western edge of the mechanically bladed fireguard. This fireguard was a roughly 4- to 5-m-wide by 20- to 30-cm-deep area that removed the natural prairie grasses. This disturbance was created by a road grader between the TxDOT road cut on the east and the adjacent private property fence line on the west.

At the time of discovery the caliche rock concentration measured about 1 m north to south and extended at least 30 cm east to west across Trench C-1, with rocks extending into the east and west trench walls. The visible part of the cluster consisted of at least 19 irregularly shaped caliche cobbles that ranged in size from 9 to 17 cm in diameter. The tops

Figure K-1. Overall map of Area C at the southern end of the Long View site (41RB112) showing the positions of the individual features identified.

of the rocks were encountered at about 20 cmbs in an Ap2 horizon. This soil zone is a dark grayish brown (10YR 4/2) sandy loam with irregular, linear, and ephemeral bands of pale brown (10YR 6/3) and brown (10YR 5/3) sandy loam. The rocks appeared to rest in or slightly below these bands, which are thought to be derived from the adjacent bladed fireguard. This rock feature is near the top of an Ab horizon, a brown (10YR 4/3) sandy loam with slight charcoal flecking in the area (Figures K-2 and K-3).

Subsequently, this rock feature was entirely excavated during the data recovery phase. Hand-excavations in a 2-by-2 m wide block excavated in four quadrants (labeled N493/E495, N493/E496, N494/E495, and N494/E496) revealed the rock cluster to be ovate in outline and measured about 100 cm north to south by 80 cm east to west (see Figure K-2). A second layer of caliche rocks was discovered immediately under the first layer of rocks. One of the rocks in the second layer was quite large, roughly 45 to 50 cm in diameter. The eastern edge of the rock cluster appeared to have been partially disturbed through the blading of the fireguard as it was nearly straight along the buried margin of the fireguard. Human bones were partially exposed at the north end of the

rock cluster, and at that time it became clear that we were dealing with a cairn burial (Figures K-4, K-5 and K-6). Below the rocks a previously dug pit became visible at about 30 cmbs and this contained the majority of what appeared to be a single adult human interment (Figure K-5).

The pit contained slightly darker colored sediments from the surrounding sediments and measured roughly 100 cm north to south by 70 to 80 cm east to west and was dug to about 70 cmbs (Figure K-3). The matrix in the pit was a brown (10YR 5/3) clay loam with no calcium carbon nodules present. The pit extended into the gray clay and reddish sands of the lower Ogallala Formation sediments.

The body was positioned mostly in the southeastern quadrant of the pit (Figure K-6). The individual was discovered in a flexed position with the knees pulled up to the chest. The body was laid on its right side with the projected head positioned to the south. During the excavation, portions of the skull were recovered from the northern edge of the rocks, whereas the upper extent of the post cranial skeleton lay on the southern end of the pit. The odd location of the cranial bones supports the idea that

Figure K-2. Plan view of Feature 7 showing the upper caliche rock layer covering a human burial.

Figure K-3. East profile of Feature 7 showing position of caliche rocks in relation to surface and underlying burial site.

this interment was disturbed by a road grader during the blading of the fireguard. No grave offerings, possessions, or any sign of cultural materials were observed or present with the skeletal remains (Table K-1). The four units excavated around the top of this rock cluster yielded no identifiable cultural remains, with only a few pieces of caliche rocks present in the NW corner of N494 E497 besides the 62 that covered the interment.

K.4.2 Feature 22

This feature was discovered about 1 m east of the new right-of-way fence and about 1 m south of the power pole in unit 489N 494E towards the southwestern edge of Area C (Figure K-1). Feature 22 was discovered under the southern part of the stone alignment, Structure 1, and recognized in level 7, between 60 and 70 cmbs, in a sandy loam matrix. It was designated a feature after a loose cluster of intensively burned and partially calcined long bone and rib fragments were identified. These bones were

concentrated in an area about 50 cm north to south by roughly 60 cm east to west. No soil staining or pit encompassing the burned bones was observed upon excavation (Figure K-7).

A minimum of 16 bone fragments or partial elements were observed and plotted, with a number of smaller, less than 3-cm-long, burned and calcined fragments in amongst the larger fragments. None of the collected pieces are longer than about 13 cm in length. A number of the elements were at a 40 to 60 degree angle. Of the roughly 16 plotted fragments or elements 12 were intensively burned to a black and calcined state. At least four plotted bone pieces appeared unburned. These include; one nearly complete unburned possible human patella, one unburned probable deer axis, one distal radius section of an apparent bison, and one unburned possible human metapodial. One 8 cm diameter caliche rock and an edge-modified tool, fashioned from a complete mussel shell valve, were within this

Figure K-4. Plan view of Feature 7 (containing individual 1) showing upper caliche rock layer (19 to 53 cmbs).

loose cluster of mostly calcined bones (Figures K-7 and K-8). The outer edge of the valve appears to be smoothed through use. A tiny chunk of charcoal was also detected in between the charred bones. A small, less than two liter sample, of sediment was collected from around some of the burned bones.

No lithic debitage, pottery sherds, formal stone tools, or other cultural remains were recovered from this 10-cm-thick level encompassing Feature 22 (Table K-2). No in situ burned area such as a hearth was observed at this location.

This feature appears to be a secondary deposition of cremated human bones mixed with other nonhuman bones and a couple of other items. The bones appear

to represent mostly fragments of human long bones. Since we did not observe any in situ burning, which would have significantly reddened the earth or created an ash deposit, these materials are thought to have been placed at this location following their intentional burning at another location.

K.5 Forensic Anthropologists Description of Inventory of Human Remains for Features 7 and 22

Drs. M. Kate Spradley and Michelle D. Hamilton of the Forensic Anthropology Center at Texas State University (FACTS) performed an inventory of the human remains recovered from Features 7 and 22, recovered from Area C, at the southern end of 41RB112 (see Appendix S). The inventory

Figure K-5. Plan view of Feature 7 (containing individual 1) showing underlying caliche slabs and uppermost reaches of human remains.

identified a single human individual is represented by the materials from each of Feature 7 and Feature 22 (Individual 1 in Feature 7 and Individual 2 in Feature 22). Interpretations derived by the forensic anthropologists regarding these individuals are summarized below.

Individual 1 (represented in Feature 7) is an older adult female, whose remains are only 30 percent complete. Trauma is evident on the individual in the form of ante mortem phalangeal trauma. Specifically the tip of one finger on the right hand appears to have been amputated and damage to an adjacent finger is also apparent. Pathological

Figure K-6. Plan view of Feature 7 (containing individual 1) showing lower reaches of interment.

indicators suggest arthritic conditions consistent with an older individual. Osteometric measurements are consistent with those of a Native American. It is not possible, however, to determine the cultural affiliation of this individual.

Individual 2 (represented in Feature 22) is an adult of unknown sex, whose remains are only 10 percent complete. Trauma is present in the form of post

mortem thermal damage. A majority of the remains from this individual exhibit this trauma, with the exception of three elements (patella, hand, and foot fragments). Individual 2 was also interpreted as a Native American. Due to the incomplete, burned and fragmentary nature of the remains, however, no further assessment of cultural affiliation was possible.

Table K-1. Inventory of Nonhuman Materials Recovered from Feature 7.

Recovered Materials	Unit, Depth	Count	Total Weight
Caliche Rocks	493N495E; 493N496E; 494N495E; 494N496E; 20- 50 cmbs**	62	104 kg*

* kg = kilograms, ** cmbs = centimeters below surface

Figure K-7. Plan view of Feature 22, which contains parts of individual #2.

Figure K-8. Edge modified tool fashioned from freshwater mussel shell associated with Feature 22.

Table K-2. Inventory of Nonhuman Materials Recovered from Feature 22.

Material	Unit, Depth	Length	Width	Thickness	Weight
Edge Modified Tool Fashioned from Freshwater Mussel Shell (n=1)	481N494E; 71 cmbs***	87 mm*	39 mm	13 mm	14.2 g**
Sediment sample #1	489N494E; 60-70 cmbs				473.9 g
Charcoal Sample #1	489N494E; 60-70 cmbs				0.3g
Charcoal Sample #2	485N493E; 60-70 cmbs				1.9g

* mm = millimeters, ** g = grams, *** cmbs = centimeter below surface

K.6 Cultural Assignment of Area C in Site 41RB112

The Late Prehistoric period begins in the southern Plains at the end of the Late Woodland period (A.D. 900/1000) and lasts until the point of European contact in that region around A.D. 1500. Recent studies have further defined characteristics of cultural groups in the early part of this period (Drass 1997). Generally, there is a marked subsistence change from a less sedentary settlement pattern focusing primarily on bison hunting in the Late Woodland period to a farming-based village pattern that is supplemented by bison hunting and wild plant collection (Drass 1997:11-12; Drass and Baugh 1997). In contrast, evidence from the latter part of the Late Prehistoric period suggests population

decreases and more reliance on bison hunting and trade of bison products (Drass 1997:17). However, much is still to be learned about the cultural transition from the Late Prehistoric period to the Protohistoric period (A.D. 1450-1700).

K.6.1 Southern Plains Village Tradition

The Southern Plains Village tradition appears in the Late Prehistoric period of the southern Plains at approximately A.D. 800 to 1500 (Drass 1997:11). This tradition encompasses scattered groups of farmers/hunters that reside in the central and western parts of the southern Plains. Settlement types include small to large farming settlements, kill sites (primarily bison, but also other large game animals), temporary processing camps, and isolated settlements (i.e., field houses,

homesteads, and so forth). Subsistence economies vary from mainly horticultural to mainly hunting and gathering. Farming is accomplished through the establishment of settlements close to fertile soil and reliable sources of water. As a result, many farming communities are found along rivers and tributary systems (Brooks 1989:75; Brooks 2004). Maize, beans, and squash are the main cultigens in the region. As for hunting, large mammals in the Cross-Timbers, upland grasslands, and breaks regions, such as bison, deer, and antelope, are procured. In fact, evidence suggests that bison are economically exploited not only for food but for bones and hides, among other things. Bones were crushed to expose the marrow which was consumed. Hides were made into clothes, components for house construction, and containers. These bison products were consumed, traded to other groups, or stored for later use. The processing of bison was important enough that the remains of carcasses and their products tend to dominate archaeological settings in this region (Brooks 1989:75; Drass 1997:43; Brooks 2004).

K.6.2 Association of Interment Features with Rest of the Late Prehistoric Component

It is evident that Features 7 and 22 have definable spatial boundaries, both horizontally and vertically, in the Holocene deposits within Area C, 41RB112 (Figures K-2 and K-8). Given this, it can be argued that each feature is a self-contained deposit, which represents a single event, and does not intrude upon other contained deposits (features) in Area C. This being the case, we have considered only those materials found within each discrete feature as directly associated with the corresponding interment. Furthermore, the artifacts recovered within other discrete features identified are not considered to be directly associated with the human interments described in this report. Reasons for this stance not only hinge upon spatial parameters of extant features, but also on their perceived function (e.g., cooking, food processing, shelter, etc.). This does not discount the fact that Features 7 and 22 were within the same general deposits as the other cultural features documented in Area C.

K.7 Vertical Distributions of Cultural Features and Associations with the Late Prehistoric Component of 41RB112

Features 7 and 22 are clearly within the boundaries of Area C, the southern end of site 41RB112 (see Figure K-1). Much of cultural material recovered from Area C is currently viewed as representing materials reflecting a semi-sedentary prehistoric occupation of the Plains Village period at roughly 660 B.P. based on three clustered radiocarbon dates.

There are no cultural materials other than the human bodies in Features 7 and 22 that would directly link these two individuals to a particular archeological assemblage, complex or phase, and definitely not to a known historical group. Thus, at this time, one cannot assign cultural affiliation to these two individuals, nor place these two interments at the same time as the general camp debris recovered across Area C. The absence of funeral or diagnostic objects in the interment coupled with the lack of direct radiocarbon dates for these two features makes it impossible to assign these two human interments to any specific group or age. At present, one cannot confidently say that they reflect either historic or prehistoric features.

Comparison of the vertical position of Feature 7 with other identified cultural features in the vicinity indicates that it is definitely above, although only slightly, the other cultural features (Figure K-9). These other features generally reflect camping activities by Plains Village populations. The discovery of this cairn burial in the camp indicates the burial was not part of the general camp site activities, as it represents a completely different activity. Generally, burials of a particular group are placed away from the campsite and on a high promontory point. In similar other Southern Plains Village sites, specifically in the Antelope Creek phase, Lintz (1986:164) states that “the burials occur “inside” architectural units (N = 24), in exterior midden areas (N = 12), or at cemetery plots located 50 to 100 m away from architectural features (N = 8). He goes on to say the general pattern at Antelope Creek sites “clearly reflects the encroachment of cemetery areas over abandoned structures and sites. If the individual in Feature 7

was a member of the Plains Village population that occupied this specific village, the body would have most likely been interred outside this village and away from this particular spot, or potentially buried in or below the pithouse structure (Feature 6).

The majority of features identified in Area C, with the exception of Features 7 and 22, are directly related to camp site activities, with widely scattered debris associated with camping activities including chipped and ground stone tools, cord marked pottery, lithic debitage, cooking features and discard areas. None of these types of cultural materials are directly associated with Feature 7. If the body was entered during the occupation of this particular camping event, surely one or more of these cultural items would have been intentionally or unintentionally interred with the body. Therefore, no direct association to the surrounding camp debris can be construed for the human interment at Feature 7. As an indication of multi use of this one particular spot is the rock alignment, Structure 1. This alignment is partially visible near the current ground surface and occurs relatively high in the profile, and definitely higher than the other buried features. This stone alignment is partially buried by recent windblown sand that is probably less than 200 years old. Therefore, this rock alignment is likely of historic age, and has no direct linkage to the prehistoric campsite and associated material remains below it.

The vertical position of Feature 22 is definitely below Feature 2, 5, 6, 7, and 16/21, as depicted in Figure 7. Features 2, 5, and 16/21 are on the same east to west horizontal position in Area C and should represent the similar depositional conditions. The lower vertical position of the human interment represented in Feature 22 indicates it was probably not associated with the other camping associated features. Features 2, 5, 6, and 16/21 are thus likely older than Feature 22. In support of the burial representing a completely different event is the fact that a complete mussel shell valve was recovered with the interment. Across the rest of Area C only an occasional tiny fragment of mussel shell was observed. One of the radiocarbon dates on wood charcoal from outside of Feature 22 yielded an assay of 1290 B.P. This is much older than the three

clustered dates associated with the more general camping features and debris. This dated piece of wood charcoal was obtained from 34 cmbs below the stone alignment and only a couple of meters north of Feature 22. Given the sandy nature of the deposits around Feature 22 and the rock alignment, coupled with the observed turbation in these deposits, it is possible that this early single date might be associated with the deeper and apparently older feature.

K.8 Summary of Results

This document has demonstrated that Features 7 and 22, found during the data recovery excavations at Area C- 41RB112, each contain the remains of a single human individual that was intentionally interred. Data has been presented from field investigations and laboratory analyses that present inventories of human remains and associated grave materials. In addition, attempts have been made to establish the cultural affiliation, timeframe, and spatial extent of each interment. A summary table is provided below with the resulting determinations presented in this report (Table K-3).

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Figure K-9. Vertical distributions of cultural features in the northern portion of Area C, 41RB112.

Table K-3. Summary of Results.

Internment	Cultural Affiliation	Identification	Associated Materials	Affiliation of Associated Materials
Individual 1	Native American	Older Adult Female	62 caliche rocks covering interment	Clearly determined
Individual 2	Native American	Adult of unknown age or sex	Edge-Modified Tool Fashioned from freshwater mussel valve Two charcoal samples One sediment sample Non-human femur fragments Non-human vertebra	Clearly determined

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APPENDIX L

ASSESSMENT OF 41RB112, ROBERTS COUNTY, TEXAS INTERIM REPORT

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EXECUTIVE SUMMARY

In June 2004, G. Dennis Price staff archeologists from the Environmental (ENV) Affairs Division of the Department of Transportation (TxDOT) in Austin conducted a linear archeological survey of about a 9.7 km (6 mile) section (38.7 ha or 96 ac) for a proposed rehabilitation and widening of a state highway in Roberts County from the North Canadian River bridge to the Ochiltree County line in far northeastern Texas panhandle. That investigation consisted of surface inspection of the existing right-of-ways. One buried prehistoric site, 41RB112, was detected. Upon discovery, two shovel tests were excavated within the existing right-of-way on the western side of the state highway, in an area adjacent to where additional right-of-way will be obtained. One shovel test yielded quantities of and diverse cultural remains. Mr. Price recommended testing this site to determine its eligibility for listing on the National Register of Historic Places (NRHP) and as a State Archeological Landmark (SAL).

In February 2005, Mr. Quigg from the Cultural Resources Department of TRC Environmental Corporation's (TRC's) Austin, Texas, office and Dr. James Abbott of the ENV Affairs Division of TxDOT in Austin visited the site to discuss and plan the eligibility assessment investigation strategies for site 41RB112. Further inspection revealed additional cultural materials roughly 130 m south of the initial discovery local. This clustered material was included as part of site 41RB112. The addition of that cluster of cultural material increased the length of 41RB112 from about 60 m north to south to nearly 270 m north to south along the proposed development zone.

In May 2005, TRC's archeologists conducted archeological testing for a NRHP and SAL eligibility assessment investigation at site 41RB112. This investigation was conducted under TxDOT Scientific Services Contract No. 573XXSA006 and Texas Antiquities Permit No. 3721. The assessment of the long, narrow area of potential effect (APE) previously identified was accomplished by means of excavating 28 hand-excavated 1-by-1 m units (totaling 16.8 m³), the hand-excavation of four trenches (totaling nearly 32 linear meters), and the

cleaning and inspection of 28 m of road cut. These investigations determined the cultural materials clustered at the northern and southern ends of the site with nearly 110 m of noncultural bearing deposits between the two concentrations. An existing 4-m-wide mechanically bladed fireguard parallels the existing fence line throughout the length of the APE and has disturbed much of the near surface materials in that zone. The opposite, eastern side of the highway was investigated through the excavation of six 50-by-50 cm shovel tests and surface inspection.

The northern cluster or cultural component (Area A) yielded three cultural features, including at least one broad basin shaped pit in the top of the road cut profile, two small dark stained hearth features, and a limited but diverse assemblage of chipped and ground stone tools, ceramic sherds, a few burned rocks, mussel shell, faunal bone, and organic materials associated with the cultural features. These cultural remains indicate an intense occupation(s) that reflects generalized camping and processing activities at this end of the site at about 710 B.P.

The southern cluster or cultural component (Area C) yielded four cultural features, including a 12-m-long rock alignment that is probably part of a house structure, a large, deep basin shaped storage pit or pithouse below the northern edge of the rock alignment, one medium size hearth feature, and a buried cluster of flat lying caliche cobbles. These features were associated with diverse cultural materials including chipped and ground stone tools, ceramic sherds, burned rocks, mussel shell, faunal bone, and organic materials. These clustered cultural remains indicate an intense occupation(s) that reflects generalized habitation and processing activities at this end of the site between 630 and 700 B.P.

The middle and slightly lower section of 41RB112 (Area B) yielded almost no cultural remains and limited areas of much deeper Holocene deposits. The upper 30 to 50 cm of these sandy deposits is highly turbated.

Based on the results from the hand-excavations and various collections conducted to date, it is apparent that the two ends (Areas A and C) of site 41RB112

in TxDOT's proposed APE contain well-defined cultural components in the top 50 cmbs. Each end appears to represent habitation remains from single occupation episodes with potential structures, restricted to a narrow time period between 630 and 710 B.P. Various rodent and natural disturbances have vertically displaced some small objects within the sandy deposits, but the limited time period involved reduces this impact.

The collected chipped and ground stone tools, bone tools, lithic debitage, mussel shell, faunal bone, charcoal, and other cultural materials, including various sediment samples are temporarily curated at TRC's laboratory facilities in Austin, Texas. Following completion of analyses, these materials will be permanently curated at the Panhandle-Plains Historical Museum in Canyon, Texas.

The northern (Area A) and southern (Area C) ends of site 41RB112 have yielded significant information and the potential to yield further significant information pertinent to answering questions concerning local and regional prehistory under NRHP Criterion D. Therefore, Areas A and C of site 41RB112 are recommended as eligible for listing on the NRHP and for designation as an SAL. If these areas cannot be avoided during the road widening, TRC recommends that the northern and southern ends (Areas A and C) of site 41RB112 lying within the existing and proposed new right-of-way, be targeted for a mitigation excavation program before any earth-disturbing construction activities. The eastern side of the highway yielded almost no cultural materials. The eastern side proposed for development across the roadway from 41RB112 is a noncontributing member and TRC recommends no further work on that side.

L.1 Introduction

L.1.1 Introduction

This interim report describes the findings and interpretations of an archeological assessment program implemented at prehistoric site 41RB112. Following the presentation of the data and recommendations, this report also provides a brief data recovery plan for proceeding forward. Site

41RB112, the Long View site, lies within the narrow existing and proposed right-of-way on the western side of the highway in the Roberts County, in the northeastern Texas panhandle (Figure L-1). The Texas Department of Transportation (TxDOT) is proposing to rehabilitate and widen about a 9.7 km (6 mile) long section (38.7 ha or 96 ac) extending from the North Canadian River bridge northward to the Ochiltree County line.

In June 2004, G. Dennis Price, staff archeologists of the Environmental (ENV) Affairs Division of TxDOT in Austin, conducted a linear archeological survey of the existing right-of-way that parallels the planned expansion area and discovered this site. Cultural materials including cordmarked ceramic sherds, lithic debitage, chipped stone tools; mussel shells, bone fragments, and burned rocks were discovered eroding from a 60-m-long north to south section of road cut and in one of two shovel tests. These materials were exposed on the surface in backdirt from rodent activity in the existing right-of-way and eroding out from the top 50 cm of the road cut. Mr. Price recommended testing this site to determine its eligibility for listing on the National Register of Historic Places (NRHP) and as a State Archeological Landmark (SAL).

In February 2005, Mr. Quigg from the Cultural Resources Department of TRC Environmental Corporation's (TRC's) Austin, Texas, office and Dr. James Abbott of the ENV Affairs Division of TxDOT in Austin visited the site to discuss and plan the eligibility assessment investigation strategies for site 41RB112. Further inspection revealed additional cultural materials roughly 130 m south of the initial discovery local. This clustered material was included as part of site 41RB112. The boundaries of the site were extended from about 60 m north to south to nearly 270 m north to south.

In May 2005, TRC archeologists conducted an archeological assessment of site 41RB112 to evaluate the eligibility for inclusion in the NRHP and/or for designation as a SAL per the requirements of Sections 106 and 110 of the National Historic Preservation Act (NHPA) and other related legislation. This TRC assessment was conducted under TxDOT Scientific Services Contract No. 573XXSA006

Figure L-1. Project location.

(Work Authorization No. 57317SA006) and Texas Antiquities Committee Permit No. 3721.

L.1.2 Site Location

Site 41RB112 lies about 4 km (2.5 miles) north of the Canadian River in Roberts County, part of the Texas panhandle region of Southern High Plains section of the Great Plains physiographic province (Fenneman 1931). The west to eastward flowing Canadian River has cut through the Ogallala Formation that caps the red Permian beds below and composes the High Plains across the Texas panhandle (Spearing 1991). The site is buried in sandy loam, the Mobeetie-Veal-Potter soil association (Wyrick 1981) on high ground/knoll mid-way between the Canadian River and the high valley rim to the north (Figure L-2). The broad Canadian River valley topography is gently rolling with high ground/knolls between broad, shallow creek drainages flowing parallel to one another from the valley wall southward into the Canadian River. These tributaries include Sourdough Creek, about 550 m to the east, and Dugout Creek, about 1,100 m to the west. Both creeks headwater at

the Tertiary Ogallala Formation caprock along the valley rim to the north. The Mobeetie and Veal soils are throughout the immediate area and consist of deep, well-drained, loamy soils across these rolling lands. The Potter series consists of very shallow, loamy soils on uplands, which are more prominent along the southern sloping edge of this upland setting (Wyrick 1981).

Roberts County has a continental climate that is characterized by rapid changes in temperature, marked extremes, and large temperature ranges both daily and annually (Haragan 1978). Summers are generally hot with temperatures that average about 26 degrees Celsius (78 degrees Fahrenheit [F]) with the average daily maximum temperature of 33 degrees Celsius (92 degrees F). Winters vary between mild and cold, with average temperatures about five degrees Celsius (37 degrees F). Annual precipitation is 53.3 cm (21 inches) with nearly 70 percent coming during April through September, throughout the growing season (Wyrick 1981). About 43 percent of the average annual precipitation

Figure L-2. Overview of 41RB112 on rise in Canadian River valley (view south).

falls during a three-month period from May through July (Haragan 1978). The sun shines about 80 percent of the time in summer (Wyrick 9181). At least 164 frost-free days occur yearly.

Native vegetation is dominated by grasses with sideoats grama (*Boutelous curtipendula*) and blue grama (*Boutelous gracilis*) grasses in the loamy soils. Sideoats grama and little bluestem (*Schizachyrium scoparium*) occur on the steep and broken areas. The bottomlands and sandy areas are normally covered in switchgrass (*Panicum virgatum*), sand bluestem (*Andropogon Hallii*), indianguass (*Sirgastrum avenaceum*), and little bluestem. The Mobeetie soils generally reveal about 60 percent tall and mid grasses, 30 percent short grasses, five percent forbs and five percent woody vegetation. Woody vegetation includes yucca (*Yucca* sp), and sagebrush (*Artemisia*), shinners oak (*Quercus harvardi*), skunkbush (*Rhus aromatica*), and Mormon tea (*Ephedra antisyphilitica*). Forbs includes catclaw (*Acacia* sp), sensitive brier (*Schrankia willd*), dotted gayfeather (*Liatris* sp),

prairie clover (*Petalostemum* sp), bush sunflower (*Simsia calva*), dalea (*Dalea formosa*), heath aster (*Aster* sp), pitchersage (*Sarracenia*), western ragweed (*Ambrosia psilostachya*), and bundleflower (*Melanthium virginicum*) (Wyrick 9181). If the range is overgrazed, blue grama and buffalograss (*Buchloe dactyloides*) increase quickly to replace the tall and mid grasses. Many of the spring areas and the streams flowing from them, often contain cottonwood (*Populus deltoides*), willows (*Sakix nigra*), salt cedars (*Tamarix aphylla*), plum (*Prunus angustifolia*) thickets, grapevines (*Vitus* sp), and rushes (*Eleocharis* sp) (Brune 1981).

L.1.3 Site Background

Site 41RB112 was discovered June 17, 2004 by G. Dennis Price during a linear archeological survey of about a 9.7 km (6 mile) section (38.7 ha or 96 ac) proposed for rehabilitation and widening of the highway from the North Canadian River bridge to the Ochiltree County line. His investigation consisted of surface inspection of the existing right-of-way surface and exposures. Cultural materials including

cordmarked ceramic sherds, lithic debitage, chipped stone tools, mussel shells, bone fragments, and burned rocks were discovered eroding from a roughly 60-m-long section of road cut on the western edge of SH 70. At that location Mr. Price hand-excavated two shovel tests, a 50-by-50 cm shovel test (ST 1) and a 30-by-30 cm shovel test (ST 2). These two shovel tests were in the natural prairie of the existing right-of-way, about a 4-m-wide section between the road cut and the existing fence line. Shovel test 1 was excavated on top of the road cut above the roadway and generally above the apparent highest density of cultural materials that had eroded out of the road cut. Fill was dry screened through 6.4 mm (1/4 inch) hardware cloth. That shovel test yielded four fragments of cordmarked pottery, one small fragment of daub, six small bone fragments, seven flakes of Alibates, one piece of gypsum, flecks of charcoal, and three fragments of burned rock. All this material appeared to come from a single cultural zone between about 17 and 40 cm below surface (bs). Shovel test 2 was excavated 15 m south of ST 1. No cultural materials were recovered from ST 2. The sediment profile includes sandy loam to about 50 cmbs overlying a calcium carbonate rich C horizon.

The observed and collected cultural materials were exposed on the natural prairie surface in backdirt from rodent activity along a 4-m-wide natural grassed surface between the edge of the road cut and the existing fence line, and from the erosional and slumping deposits of the top 50 cm of the 3-m-tall road cut. The cultural materials included 14 cordmarked sherds with 13 body and one rim sherd. All appeared to be sand tempered. The rim sherds exhibit a folded over lip with two rows of horizontal fingernail impressions forming an 11-mm-wide band. Below that band the sherd is cordmarked. Chipped stone tools include two biface fragments, one of Alibates and one of petrified wood. Lithic debitage includes five flakes. Two quartzite burned rocks were also recovered. Bone fragments include a large tooth enamel section from a bison. Fragments of mussel shell were also collected. Mr. Price interpreted the materials as representing the Antelope Creek phase. He recommended testing this site to determine its eligibility for listing on the NRHP and SAL.

Dr. Jim Abbott of TxDOT's Environmental Affairs Division, and the first author visited site 41RB112 on February 24 and 25, 2005, to view the site first hand and discuss and plan a field strategy for the archeological assessment program described in this interim report. The site area was walked and the eastern side of the highway, opposite the discovered cultural materials, was also walked. During that time the western road cut was carefully scrutinized and then a short 2.5-m-long section opposite ST 1 was cleaned and inspected. What appeared to be a broad basin shaped pit of cultural origin was discovered in the top 50 to 60 cm of the vertical exposure (see Feature 1 below for full description). Sparse cultural materials including a partially burned bone fragment, a few small chunks of charcoal, a mussel shell fragment, a flake, and a burned rock, were observed within this basin. About 200 m south of this basin, a roughly 10 to 12-m-long linear arrangement of roughly 20 to 30 head size, carbonate cemented cobbles was barely exposed in the grasses. This rock alignment was about one m west of the 4-m-wide fireguard that parallels the current fence line (see Structure 1 below for description). This rock alignment may represent part of a prehistoric house structure. Inspection of the area around that rock alignment, specifically the bladed fireguard, revealed more cultural materials including burned rocks, chert debitage, a hafted drill, cordmarked pottery sherds, but very few other large cobbles. This cluster of cultural materials south of the original discovery was added to the more northern cluster and the site boundaries were expanded to include these cultural materials. A low swale lacking any visible cultural materials lies between the northern and southern clusters.

Between the time of the site visit in February and the start of the TRC fieldwork in May, TxDOT had purchased the new right-of-way and fenced that new section through the site area. This new fence provides the exact boundary of the development zone. The expanded new right-of-way was not quite as wide as initially thought in February and the cultural materials are within a very narrow zone that is between 8- to 10-m-wide. That APE also includes the 4-m-wide mechanically bladed fireguard.

L.2 Methods

During the TRC archeological investigations at site 41RB112 in May 2005 the following methods were employed for the purpose of assessing NRHP and SAL eligibility.

Initially, this long narrow north to south segment (varying from about 8 to 10-m-wide by 270-m-long) of site 41RB112 was subdivided into three sections, Areas A, B, and C to designate the different topographic settings and the cultural concentrations across the site. Area A encompasses the northern end and covers roughly a 60-m-long section that crosses a low rise. Area A contains a concentration of cultural materials in the vicinity of a cultural feature (Feature 1) exposed in the road cut. Area B, immediately south of Area A, is slightly lower in elevation, crossing a low saddle area that lacks significant quantities of cultural material, at least based on the surface observation during the initial site visit. Area B extends for about 120 m to an arbitrary boundary where the land begins to rise. Area C, immediately south of Area B, is at the southern end of the site centered over a low rise that exhibits a surface rock alignment and clustered cultural materials. Area C extends for about 90 m southward with the southern end sloping down to the south off the rise.

The initial step in the investigation was the location of the cultural materials exposed on the surface across the APE. Six crewmembers lined up across the narrow right-of-way and walked the entire 270 m length of the projected site area. Pin flags were used to mark each and every piece of cultural material observed. This included the road cut edge along the eastern side of the APE. The observed cultural materials were identified and mapped on an overall site map, with the ceramic sherds, stone and bone tools collected individually. These cultural items were placed in individual plastic bags with individual artifact tags. The more general materials such as lithic debitage, burned rocks, mussel shell fragments, and bone fragments were collected by class by the three different designated areas.

TRC personnel used the existing road cut exposure to locate buried cultural features in the most efficient manner without destroying large surface areas. Some

28 m of exposed Holocene deposits, generally the upper 50 to 60 cmbs of the road cut, was hand faced/cleaned in selected localities of Areas A and C. In Area A, a nearly 15-m-long section that included the area encompassing the broad basin labeled as Feature 1 was cleaned. This section was carefully inspected, cultural materials noted and collected, and a profile completed. In Area C, a nearly 13-m-long section 6.5 m directly east of the rock alignment was cleaned and inspected. Feature 5 was detected in this area.

Four hand-dug trenches, about 25- to 30-cm-wide, were completed, two each in Areas A and C. Two hand-dug trenches, Trench A-1 and Trench C-1, were completed along the edges of the fireguard. These two trenches, 9 and 8-m-long respectively in a north to south direction were dug in anticipation of locating buried cultural features. Trench A-1 was dug along the eastern edge of the fireguard about 5 m due west of Feature 1 observed in the road cut. Cultural materials including Feature 3 were encountered during the trench excavation and observed in the trench walls. Photographs were taken and a profile was drawn of Trench A-1. Trench C-1 was dug on the western edge of the fireguard about 1.5 m directly east of the rock alignment in Area C. A cluster of natural caliche rocks (Feature 7) was encountered during the digging of this trench. The trench was photographed and the profile drawn. Two other hand-dug trenches, Trench A-2 and Trench C-2, were completed perpendicular (east to west) across the fireguard in Areas A and C. These two trenches were used to examine the depth of the fireguard in the two areas where cultural materials were concentrated to determine the potential for cultural materials to remain below the bladed fireguard.

A total of 28 individual 1-by-1 m units, 16.8 m³, were hand-excavated across the APE and the sediments were screened. These investigations were scattered across all three areas of the site with eight units each in Areas A and B, and 11 units in Area C. The test units were numbered sequentially for each area and were preceded by the Area designation, i.e., A-1 for the first unit in Area A. These units were distributed opportunistically at the judgment of the Principal Investigator to provide broad coverage

and information from across the long area relevant to site structure and content; integrity, feature and nonfeature contexts, and to identify areas for potential mitigation. Units were excavated in 10 cm arbitrary levels until calcium carbonate nodules dominated the last level or sterile deposits were encountered. The vertical measurements were taken from below surface (bs) using a string and line level. The depth of the units varied from 42 cm in A-8 to 115 cmbs in B-2. The sediments from the hand-excavations of 1 m units were screened through 6.4 mm (¼ inch) hardware cloth. When sizable pieces of cultural material were encountered in situ during the excavations, these items were piece plotted on the excavation level records and the bottom elevation of the object was recorded. An excavation level form was completed for each hand-excavated and screened level. Recognized cultural materials were placed in resealable plastic bags by excavation unit and level, class of material, appropriately labeled with field tags in each bag, and returned to the laboratory in Austin for processing and analysis.

When multiple pieces of cultural material were in a cluster, these clusters were designated as cultural features. Once features were encountered, the excavation and recording methods changed in order to collect more observations and data for interpretations. With small features, the feature was isolated from the rest of the level for more precise excavation and documentation. In most instances the internal matrix of the small features was removed and bagged without screening for more refined screening/flotation in the laboratory. The small features were cross sectioned at least once to expose the profile. The feature was drawn in plan view and profile, photographs were taken, and a feature form was completed that documented the size, shape, and various construction elements. The large features, Features 1 and 6 plus Structure 1, were handled differently because of their greater size and lack of complete excavation.

A hand-operated Oakfield coring device was used to remove 16 small diameter cores (2 cm) across a gridded area between the Feature 1 basin in the road cut and Feature 3 in Trench A-2, and next to Unit A-5. This coring apparatus provides a 2-by-24 cm open core that can be examined. This coring was

implemented to investigate the possible continuation and the location of the basin observed in the road cut. As the cores were retrieved the sediment colors were recorded on a form and the presence or absence of cultural materials was noted. The depth of the cores ranged from 14 to 74 cmbs.

A site plan map was drawn. The surface artifacts, 1-by-1 m units, the faced/cleaned sections, the hand-excavated trenches and profiled areas, and other relevant locational data were drawn on the map (Figures L-3, L-4, and L-5). A more detailed assessment of the rock alignment was recorded on the Area C map, in addition to the location of the surface cultural materials, position of the identified features, and other relevant data in that immediate area.

Selected units from each of the three areas had one wall of the unit profiled. In some instances small sediment samples were collected from these walls. Potentially these could be used for a variety of analysis including phytolith or isotope investigations.

Artifacts classified as burned rock were mostly counted and weighed in the field by size classes with selected samples from various levels and units returned to the laboratory for potential analysis and assessment. Bulk sediments for fine-screening and/or flotation in the laboratory were collected from selected features and context. Macrobotanical, charcoal, and other samples were collected from recognized features and other contexts during excavations. General sediment samples from selected units in the three areas were also collected.

The opposite side of the highway, the eastern side of the roadway opposite the areas revealing the cultural materials was also investigated. Five 50-by-50 cm shovel tests were excavated and the sediments from those screened through 6.4 mm hardware cloth.

Once in the laboratory various methods were employed to further assess specific data sets. The collected lithic debitage, mussel shells, and bone were hand-washed, sorted, and counted in the laboratory. Selected stone and bone artifacts and most ceramic sherds were not washed to help preserve

Figure L-3. Plan map of site 41RB112, Area A and the northern part of Area B.

Figure L-4. Plan map of site 41RB112, Area B and the northern part of Area C.

Figure L-5. Plan map of site 41RB112, the southern part of Area C.

cultural residues that may still be adhering to their surfaces. Selected sediments samples from across the three areas were sent to different specialists. Six sediment samples were selected and sent to Dr. Steve Bozarth to determine the presence/absence of phytoliths (Appendix L-1). Eight samples, seven charcoal pieces and one maize kernel were selected and sent for radiocarbon dating. These eight samples were submitted to TxDOT who forwarded them to Beta Analytic for dating. About 27 liters of sediment from four features, Features 3, 4, 5, and 6, plus eight individual charcoal chunks were sent to Dr. Phil Dering for flotation and macrobotanical identifications (Appendix L-2).

The TRC geoarcheologist, Grant Smith documented and characterize the Holocene deposits from various excavation units, trench exposures, and the road cut exposures following the hand-excavations.

L.3 Geoarcheological Evaluations

L.3.1. Introduction

Geomorphic investigations of archeological site 41RB112 were conducted to determine the late Quaternary depositional record, the nature of soil/paleosol horizons, and the relationship of these soil/sediment units to cultural materials discovered. The site location is on bedrock-controlled uplands about 4 km (2.5 miles) north of the Canadian River. Deposition in this area appears to be a combination of alluvial slope wash and eolian accumulation. The eolian deposition is the most dominant, the result of sandy sediments being transported from alluvial drainages to the west and south and being baffled from the air stream by the grassland vegetation. The sediments are near the crest of a hill, however, and some slope wash, particularly in swales such as Area B, is to be expected.

Before the geomorphic investigations, the site had already been subdivided into the three areas based on the visible terrain and presence of archeological materials exposed on the surface. Area A, the northernmost of the areas, was on a gentle rise and exhibited cultural materials/features on the surface and in the roadway cut. Area B, in the center, was a swale between the two high areas and lacked cultural

materials on the surface. Area C is the highest elevation hilltop locale within the site boundaries and exhibited cultural materials on the surface. Due to depositional and pedological differences these areas are described individually.

L.3.2 Physiographic Setting

The study area is located in the High Plains section of the Great Plains physiographic province (Fenneman 1931). The High Plains are generally described as a relatively flat lying fluvial plain that stretches from mountains on the west to the Central Lowland on the east. The sediments in this area are primarily composed of alluvial stream deposits (gravel, sand, and silt) and occasional lacustrine sediments (silt to clay) that were deposited during late Tertiary time. These deposits are often collectively referred to as the "Tertiary Mantle".

In the immediate study area the bedrock is composed of sandstone of probable fluvial origin. On the east side of the road cut an isolated lens of organic-rich sandstone about 2-m-thick and 20-m-wide may represent a Tertiary age playa fill or some other organic rich setting that was conducive to sand collection. Other sandstone outcropping in the road cut has a vuggy appearance suggestive case hardening, probably a result of salt leaching when this sandstone was previously exposed on the surface. In addition, some of the sandstone appears to be capped by a thin stringer of quartz and quartzite-rich gravel (one piece of schist was also observed). This material is often over 2 m below the present ground surface and below the cultural levels. It is possible that the quartzite was used for tools; in fact some pieces observed on the surface appear battered. The depth of this material below the current surface suggests that it is more likely that these materials were collected where they were weathering out of the hillside, but it is possible that other means were used to procure the quartzite (e.g. excavation) though no evidence to support this practice was observed. All of the sandstone underlies and pre-dates the cultural occupation of the area and is primarily of interest as a sediment source for eolian and alluvial reworking.

L.3.3 Methods

The intent of the geoarcheological investigations was to determine the stratigraphic integrity of the known archeological site and ascertain its potential to contain intact strata with in situ cultural materials or paleoenvironmental data. Criteria used in the evaluation of the sites included defining site extent, determining the nature and depth of subsurface deposits, and evaluating their areal distribution.

On the 17th and 18th of May, 2005 the geoarcheological aspects of the site were investigated through open archeological test units, road cut exposures, and shovel test pits. Field descriptions follow standard sedimentologic and pedogenic procedures established by Birkeland (1984), Birkeland et al. (1991), Gile et al. (1966), Krumbein and Sloss (1963), Reineck and Singh (1980), the Soil Survey Staff (1962, 1975), and Waters (1992). Field investigations were recorded on geoarcheologic/geomorphic field forms and the locations of described exposures were recorded relative to previously mapped features or points of interest on the site.

L.3.4 Results

The three topographical areas had unique soil/sediment profiles that reflect differences in accumulation and cultural impacts. For this reason, each area is described individually and then the discussion focuses on interpreting the soil/sediment record from these areas and the differences between them. The profiles observed in all three areas are summarized in Figure L-6.

L.3.4.1 Area A

Area A is at the northern margin of the site and is notable for the charcoal stained features/sediments exposed in the roadway cut profile and in hand-excavations. The natural profile of the area will be discussed first and then deviations from that profile compared to that observed in clearly cultural areas are made.

The uppermost unit in Area A (Unit 1) consisted of ca. 7 cm of brown (10YR 5/3, dry) sandy loam. This sandy loam is massive and has a weak reaction to dilute hydrochloric acid. Due to the lack of

visible carbonates within the profile, this reaction is probably a result of calcareous parent material as opposed to in situ pedogenic accumulation. In some locales this unit exhibits a weak color banding that swirled. This banding is thought to be due to mechanical scraping and compaction and not due to natural depositional processes. For this reason, the upper unit in Area A is considered an Ap horizon, though in less disturbed areas it might be appropriate to consider it the A1 horizon. One anomaly observed in Area A is that the surficial sediments appeared to be less compact closer to the roadway cut and more compact as one moved towards the field to the west. The reason for this is not entirely clear but it may have to do with mechanical disturbances associated with the construction of the road or bioturbation, such as insects burrowing into the recently exposed sediments. The sediment texture does not appear to change significantly between these areas.

Below the Ap horizon is a ca. 24-cm-thick unit of brown (10YR 5/3, dry) sandy loam that appears slightly darkened by humic material (Unit 2). In much of the area, this unit exhibits a very weak, medium, subangular blocky structure but this is probably due to mechanical compaction. With respect to the roadway exposure, this unit could be considered an A2 horizon or possibly even an Ab horizon. The Ab designation is problematic since the burial of the unit appears to be a recent phenomenon associated with mechanical activity and not a natural event that might reflect a change in depositional regime and/or climate. In fact a shovel test away from the roadway disturbance indicated only a single ca. 15 cm humic horizon that is still the surficial A horizon. So while the roadway cut may be considered to have an A1/A2 or Ap/Ab soil the true natural record for the area appears to only record a single surficial A horizon.

The third unit in the roadway cut of Area A consists of ca. 14 cm of pale brown (10YR 6/3, dry) sandy loam with a weak, medium, subangular blocky structure. This unit tends to be near the clay rich side of sandy loam and appears to have developed on the weathered surface of the underlying 2Bk horizon. Due either to weathering on the older exposed paleosol or due to eluviation after it was subsequently buried, this unit appears transitional between the underlying sandy clay loam and the overlying sandy

loam. Visible carbonates are present in Unit 3 but they are not as strong as in the underlying 2Bk horizon. The carbonate masses in the unit appear to be decomposing remnants of carbonates observed in the underlying unit. All of this evidence seems to suggest a welded soil horizon that began as a Bk horizon and is now progressing towards either a weaker expression of a Bk horizon or a Bw horizon. For this reason, the designation of Bk→Bw is used (after Birkeland 1984:11). The relative proximity of this unit to the surface and exposure to organic acids from the overlying A horizon suggest the eventual removal of visible carbonates, though that is most likely a very long term process.

The basal unit observed in Area A (Unit 4) consists of 50+ cm of light brown (7.5YR 6/4, dry) sandy clay loam. Along with the redder color, the moderate, medium, subangular blocky structure of this unit makes it quite distinct within the profile. The unit violently effervesces when tested with dilute hydrochloric acid and about 25 percent of its volume is composed of medium to large, irregularly shaped carbonate filaments. This degree of carbonate development is considered a Stage II accumulation (after Gile et al. 1966; Birkeland 1984). Within the American Southwest, such accumulations are typically associated with paleosols dating to the Pleistocene (Machette 1985). This soil/sediment unit therefore probably pre-dates human occupation of the area.

There are a few major differences between the soil/sediments observed in the natural portion of the road cut exposure and that observed in association with cultural materials. The most notable difference is the absence of Unit 3 (the Bk→Bw horizon). In the cultural areas the A2 horizon goes deeper and approaches 40 cm in thickness. Charcoal flecking also increases in this area. The initial interpretation is that some form of depression was excavated through the Bk→Bw horizon and to the surface of the 2Bk horizon. The resulting "A horizon" material within this area is therefore probably humically enriched cultural fill. The boundary between the natural sediments and the culturally stained sediments is diffuse and difficult to clearly define, partially because the color between them is very similar. Even the charcoal flecking is diffuse across this

boundary. The color differences between this fill and the natural A horizon, however, make it very difficult to distinguish a clean break between the cultural and noncultural areas. This diffuse boundary between cultural and noncultural sediments makes it difficult to clearly define where cultural organic input stops.

L.3.4.2 Area B

The roadway cut exposure in the swale of Area B is similar to that observed in Area A in many ways, especially in the upper two units (Figure L-3). The biggest difference is that the B horizon is thicker (ca. 40-cm-thick) and appears to be developed in sandy sediments that are eolian and/or slope wash in origin. Unit 3 in this area is designated as a Bk horizon instead of the Bk→Bw horizon observed in thinner sediments to the west. It is possible that the Bk horizon sediments observed in Area B are also derived from the underlying 2Bk horizon, but the thicker sediment profile helps separate the different properties of the pedogenic horizons.

A very major difference in the soil/sediment profile was observed in the hand-excavated units about 6 m to the west. In this area the A2 horizon suddenly approached 1 m in thickness (compared to the ca. 20 cm thickness observed in the road cut profile). The reasons for such a dramatic change over so short a distance are not clear. No evidence that this is a culturally excavated feature was apparent; in fact most of Area B is noted for its dearth of cultural materials compared to Areas A and C. The best natural explanation for such a thick profile of humic material relates to the geomorphic position of Area B. This area is a swale near the top of a hillslope, with a gentle depression progressing from this area down the hillside. There currently is not any surface expression that suggests that this area is a defined drainage, but it is possible that in the past a channel existed in this area. Area B may have been at the head of this drainage and served as a collection area for humic material washing in from the adjacent high points. Subsequent in filling and eolian accumulation may have buried this channel and muted its expression on the hillside. While it appears subdued now, this area may have been a much more pronounced drainage in the past.

If Area B was such a drainage and collection area, it may have been favorable for either natural or planted vegetative resources. This is very speculative but it may help further understand the cultural occupations observed to the north and south. Such an area would not, however, appear suitable for long-term occupation; a conclusion that would appear to be in agreement with the general lack of cultural materials in this area.

L.3.4.3 Area C

Two exposures observed in Area C displayed very different results. The roadway cut yielded a profile very similar to the roadway cut exposures observed in Area B and Area A (A1/A2/Bk/2Bk; Figure L-6) that is interpreted similarly. A profile near the crest of the hilltop and just west of the fireguard berm yielded a very different profile (hilltop exposure, Figure L-6).

The hill top exposure occurs just west of the fireguard and in an area noted for rock alignments and cultural features. It exhibits two Ap horizons that are considered to be disturbed push from the fireguard and extend to a depth of 23 cmbs. Below the disturbed units is a ca. 14-cm-thick grayish brown (10YR 5/2, dry) sandy loam unit that is organically stained unit and is considered an Ab horizon. This Ab horizon is in direct association with some of the cultural materials and features in the area, so some of the staining may be due to cultural organic sources.

Below the Ab horizon is an 11+ cm-thick unit of reddish brown (5YR 5/4, moist) clay that is unique to any other profiles observed on the site. This unit has moderate, medium, prismatic soil structure and also displays common, thin, clay cutans on ped faces. Considering the uniqueness of the unit and the nearby cultural materials, a natural question is whether the clay is in situ or if humans brought it to the site. Considering the clay cutans and intact soil structure, this unit appears to be natural in origin. Clay brought in by humans would tend to have such characteristics destroyed. Instead, this clay unit appears to be a 2Bt horizon that caps the more ubiquitous 2Bk horizon observed elsewhere on the site. It is a fairly common soil horizon sequence in well-developed soils to have a Bt horizon overlying a Bk horizon. Due to erosion of the area, however,

it appears that the hilltop crest is the only place in which soil horizon is preserved.

L.3.5 Discussion

The soil/sediment units observed at site 41RB112 exhibit a relatively straightforward upland stratigraphy. The basal 2Bk and 2Bt horizons are the remnants of an older paleosol, probably Pleistocene in age, that pre-dates human occupation of the site and probably that of North America. The sediments in which this paleosol developed may be even older, possibly Tertiary in age. Erosion of this Pleistocene paleosol resulted in only a small remnant of the 2Bt horizon being preserved and partial erosion of the 2Bk horizon over much of the study area. Subsequently, it appears that Holocene eolian and alluvial slope wash sediments began to collect in the area. Given the geomorphic location, it is likely that this sediment accumulation occurred gradually as grass baffled sand from the air stream and wash on the hillside helped was sediments from higher locales. Any pedogenic development that may have occurred during the accumulation, however, appears to have been minimal or has been overprinted because the current soil profiles do not appear overthickened. Where the sediments were thicker the A horizon and Bk horizon both appear to have developed in the Holocene eolian/alluvial sediments. Where accumulation was less, B horizon development extended into the older 2Bk horizon sediments that may have been weathered during previous exposure. The A horizon that developed on these sediments appears to be the current surface soil in the adjacent pasture. Only because of mechanical disturbances associated with the fireguard berm and/or road construction does this A horizon appear buried in some of the profiles. The cultural materials in the area appear to be largely associated with this A horizon or are intrusive into the underlying Bk or 2Bk horizons.

Due to the long-term, static accumulation of sediments in this upland locale, defining time for the soil/sediment units becomes problematic. As opposed to fluvial locales that may be subject to more frequent episodes of flooding and soil development, relatively static uplands are not particularly good at preserving smaller scale climatic episodes. Since the A horizon on the site is still present at the surface

Figure L-6. Geomorphic summary of stratigraphy observed at 41RB112.

and subject to humic enrichment, any radiocarbon dates from this unit would probably yield a relatively young age. Considering the hilltop environment, this A horizon may have started developing two or three thousand years ago (just to throw out a possible age and not an age estimate based on some more tangible evidence) but a radiocarbon date of the humates would probably indicate that it was 100 B.P. or something similar. As a result, all of the sediments from the Bk horizon up could represent deposition throughout the Holocene or maybe only deposition during the past 1,000 years or so. Based on data available from site 41RB112, a more accurate age determination cannot be made.

The question then turns to regional chronologies that may provide some guideline. Holliday (1985) has proposed that the most substantial eolian depositions on the High Plains were deposited between 6000 and 4500 B.P., between 3000 and 2000 B.P. and also in recent times. If we use this as a baseline measure, eolian deposition at 41RB112 probably post-dates 6000 B.P. A more specific age is very much limited by the depositional and pedological record at this specific site.

L.4 Archeological Results

L.4.1 Introduction

This chapter presents the results of the archeological assessment investigations within TxDOT's proposed narrow development zone at site 41RB112. The concentrations of cultural debris recognized in the field and that have been designated as cultural features are presented and discussed below in Section 4.2. The classes and frequencies of recovered cultural material including those materials collected during the initial site discovered by Mr. Price are presented in Section L.4.3. Finally, Section L.4.4 provides the radiocarbon ages for the buried cultural component targeted during this assessment program.

L.4.2 Cultural Features

Seven clusters of cultural material were assigned feature numbers in the field. One of those assigned areas (Feature 2) did not yielded sufficient evidence to remain a feature following further excavations. A rock alignment was labeled as a possible structure,

but was not assigned a feature number. Each is discussed below.

L.4.2.1 Feature 1

Feature 1 appears as a relatively large, roughly 250-cm-wide basin exposed in the upper 60 cm of the roadway cut in Area A at the northern end of the site (Figures L-3, L-7 and L-8). Shovel test 1, dug and screened by Mr. Price was located just over 2 m west in the natural prairie of the current right-of-way. his 50-by-50 cm test yielded 23 pieces of cultural material between the surface and 50 cmbs. A 4-m-long section of the roadway cut directly east of ST 1 was cleaned and examined. In that cleaned section the bottom part of a basin came to light (Figure L-8). The basin was dug into the lower pale yellow (5YR 7.3) calcium carbon layer making the lower part relatively distinguishable. The deepest part of the basin was about 65 cmbs. The interior of the basin was a yellowish brown (10YR 5/4) sandy loam with an occasional piece of cultural material towards or near the bottom. The top part of the basin disappeared or faded into the lower part of the current A horizon and was not distinguishable. The northern edge of the basin was not distinguishable as it rose towards the surface. However, the bottom part of the northern section was above a pale olive (5YR 6/3) matrix. The southern edge was badly disturbed by at least two visible rodent holes. South of the rodent holes the questionable lower pit boundary gradually angled toward the surface, but again become part of the A horizon. The lower part of the interior basin yielded at least two chunks of charcoal; one partially burned and pointed bone fragment, two small mussel shell fragments, and two small burned rock fragments. No oxidation rim, charcoal staining, clay lining, or other visible characteristic was observed along the bottom edge of this basin.

A piece of juniper charcoal was extracted from the matrix sample collected from inside near the bottom of the basin between 62 and 64 cmbs. This piece yielded a $\delta^{13}\text{C}$ (-23.0‰) corrected AMS date of 710 ± 40 B.P. (Beta-206557). A second piece-plotted chunk of pine/juniper charcoal from 52 cmbs inside the basin yielded a $\delta^{13}\text{C}$ (-23.3‰) corrected AMS date of 1490 ± 40 B.P. (Beta-206558). These two dates are some 780 radiocarbon years apart. It is unusual that two burned events this far apart are

represented inside the base of this feature. I suggest that one of the dates is not dating the actual use period of this feature. Based on the other radiocarbon dates obtained from this site (see below), it is interpreted that the older date is unacceptable and not dating this particular cultural event. A possible explanation of the age discrepancy between the two samples is that the older result represents much older dried wood used during the much later occupation (Smiley 1985).

Based on soil core probing in the natural prairie immediately west of the roadcut and the excavation of nearby Unit A-5, the remaining part of this basin may not extend more than 1 m back (west) from the exposed roadcut. Therefore, potentially very little of this basin may remain.

The function of this broad basin is not clear at the present time. Diverse cultural remains were recovered from the surface, roadway cut, and hand-excavations in the immediate vicinity of this basin. Cultural materials recovered include cordmarked sherds, pinched rims sherds, Alibates, obsidian and opalite flakes, burned rocks, mussel shell fragments, tiny bone fragments, and a reworked Washita point. Two small hearth features (Features 3 and 4) were discovered buried about 1.5 m and 4.5 m west of the exposed basin. This broad basin may represent part of a large storage basin that became filled with limited quantities of cultural material from adjacent activities. Alternately, it may represent the edge of an excavated pithouse used as living quarters. If enough of Feature 1 still remains, further excavations will hopefully help determine the function of Feature 1.

L.4.2.2 Feature 2

During the hand-excavation of Unit C-5 in Area C, a few chunks of charcoal and a small bone fragment appeared clustered in a limited area of roughly 20 to 15 cm in diameter. This charcoal was about 22 cmbs along the northern edge of C-5. This cluster was assigned Feature 2 but further excavation yielded no other materials. In addition, no basin or sediment discoloration was observed under or around the charcoal chunks. As a result, the feature status of this deposit was rescinded. It is possible that the charcoal recovered was associated with Feature 5, 60 cm to the northwest. Three small chunks of

questionable daub, 14 tiny pieces and one 12-cm-long burned rock, one Alibates flake, and four bone scraps were recovered from this same 10 cm level. Matrix containing the charcoal chunks was collected for flotation.

L.4.2.3 Feature 3

Feature 3 was discovered during the hand-excavation of Trench A-1 along the eastern edge of the fireguard in Area A (Figures L-3 and L-9). This north to south trench was about 11-m-long, 25- to 30-cm-wide, and situated 5 m west of Feature 1 exposed in the road cut. A concentration of charcoal chunks was first observed between 40 and 50 cmbs in the eastern side of the trench during the cleaning of the profile. The western side of the trench exhibited a small charcoal stained feature about 39 cmbs. Unit A-8, a 1-by-1 m unit was established over the remaining western section of the charcoal stain and investigated. Most of Unit A-8 was inside the bladed fireguard and much the original ground appeared removed by the fireguard. It is likely that some of the top part of this charcoal stain was previously removed by blading the fireguard, whereas the eastern side was removed during Trench A1 excavation. A bison long bone fragment was located just to the south of the charcoal stained area and two bison teeth were roughly 250 cm to the north in the trench profile. An unusual plain exterior sherd (#74-8) was recovered from Unit A-8, but it is not clear if it was inside this hearth feature.

Feature 3 appeared to be the partial remains of a small hearth with a shallow basin. The plan view of the western part exhibited irregular margins that were extensively disturbed by rodent activity (Figure L-10). The interior of the hearth exhibited a gray (5YR 5/1) matrix, whereas the exterior matrix was a brown (10YR 5/3) sandy loam. A few small charcoal chunks were visible across the top surface as it became exposed. The top of the hearth as encountered in our excavations was roughly 45 cm north to south and the remaining western part was 18 cm east to west. In profile the stained matrix appeared as a shallow basin about 8- to 9-cm-deep with gently sloping sides. The lower boundary exhibited considerable turbation by small insects creating a 3- to 4-cm-wide band of poorly defined basin margin. No oxidation rim or charcoal concentration was

Figure L-7. Profile drawing of Feature 1.

Figure L-8. Feature 1 in roadcut.

visible in the profile. No burned rocks, flakes, or other cultural materials were observed in the dark matrix. The top of the stain was at 39 cmbs with the bottom at about 48 cmbs with the turbated matrix extending to about 51 cmbs. Feature 3 appears to lie vertically within the detected occupation zone in Area A and is therefore, associated with diverse occupational materials including Features 1 and 4.

About five liters of matrix, the majority of the contents of the basin remaining in Unit A-8 were bagged in anticipation of flotation in the laboratory. A chunk of charcoal was extracted from the stained matrix for radiocarbon dating. This piece of juniper charcoal yielded a $\delta^{13}\text{C}$ (-23.2‰) corrected AMS date of 970 ± 40 B.P. (Beta-206559). About four liters of feature matrix were sent to Dr. Phil Dering for flotation and identification of the macrobotanical remains. This processed sample contained considerable evidence of food remains, including a cheno-am seed, a squash rind fragment, 27 maize cupules, 3 kernels, and 2 mesquite seeds. Both juniper and mesquite wood were also noted in these samples (Appendix L-2).

L.4.2.4 Feature 4

Feature 4 consisted of a small basin hearth discovered near the middle of Unit A-5 in Area A (Figure L-3). It was situated about 1.5 m southwest of Feature 1 in the road cut. The top of the cultural deposit (the actual 'top' has probably been disturbed) was encountered at 49 cmbs. It first appeared as stained matrix in a circular pattern. A few chunks of charcoal, a small bone fragment, an opalite flake, and small areas of baked clay were present across the top of the dark grayish brown (10YR 4/2) stained ashy matrix. The circular stain was about 30 cm in diameter and quite flat across the top (Figure L-11). Most of the margins, except the northern quarter were a very dark brown (7.5YR 2/2) ashy matrix. A few small chunks of caliche were just outside the stained margins. The profile revealed a steep sided basin that was about 15-cm-deep. The matrix from this basin was bagged for laboratory flotation. Feature 4 is about 10 cm below the present surface than Feature 3 but it appears to be within the same occupation zone. Therefore, Feature 4 appears associated with diverse occupational materials including Features 1 and 3.

About four liters of matrix were sent to Dr. Phil Dering for flotation and identification of the macrobotanical remains. This floated sample contained a single maize kernel and some juniper charcoal (Appendix L-2). A chunk of wood charcoal removed from the collected matrix was sent for dating. This piece of wood charcoal from 50 to 60 cmbs yielded a $\delta^{13}\text{C}$ (-24.0‰) corrected AMS date of 710 ± 40 B.P. (Beta-206560).

L.4.2.5 Feature 5

Feature 5 consisted of a basin hearth eroding from the top of the road cut at the southern end in Area C (Figure L-5). This hearth was exposed about 50 cm east of Unit C-5 and nearly 7 m east of the north to south rock alignment. This basin was not obvious in the weathered, eroded road cut, but once a fresh vertical cut was made 4 to 5 cm back into the bank it became distinguishable. A profile was drawn and the exposed cross section was photographed (Figure L-12). Extensive rodent runs, some quite fresh or recent with grass, and others older and not as distinct went through this hearth. Visible rodent holes were identified on the northern and southern edge and one very obvious recent run through the middle of the feature. These rodent disturbances created difficulty in distinguishing the feature margins. In general terms, the hearth exhibited a shallow basin with ill-defined lateral margins and a blurred indistinguishable top. The basin was not lined and did not exhibit an oxidation rim. The top northern edge exhibited characteristics that might indicate materials had been raked or pulled out in that direction, but the rodent activity may be a contributing to this interpretation. The top edge was estimated to be about 22 cmbs in the dark brown (10YR 4/3) sandy loam A horizon with limited color distinction. If this proposed depth is roughly accurate then the basin was originally about 20-cm-deep. The dimensions of Feature 5 were measured at 75 cm north to south and at least 30 cm east to west.

During the hand-excavation at least three 5 cm diameter burned rocks were encountered along the southern margin. These burned rocks represented three different types of material, which included quartzite, caliche caprock, and sandstone. One quartzite burned rock exhibits the hackeled edges of a boiling stone. A base of a triangular point

Figure L-9. Profile of Trench A1 showing deposits in Area A.

Figure L-10. Plan view and profile of Feature 3.

(#120-10) was also present near the burned rocks. The basin was filled with an ashy dark brown (10YR 4/3) sandy loam matrix that contained moderate flecks and chunks of charcoal, a few tiny burned and unburned bone fragments, and the occasional flake. Mottling was evident with spots of light colored matrix that may be tiny burned clay lumps. No visible oxidation rim was present along the bottom edge. Most of the matrix fill was placed in five-gallon bags for flotation in the laboratory.

A charred maize kernel removed from the collected matrix was sent for radiocarbon dating. This maize piece yielded a $\delta^{13}\text{C}$ (-9.7‰) corrected AMS date of 630 ± 40 B.P. (Beta-206561). Roughly 7.7 liters of basin matrix were submitted to Dr. Dering for flotation and macrobotanical identification. The floated matrix contained 1 maize cob fragment, 18 cupule fragments, and 9 kernels. Juniper and mesquite wood charcoal were noted in the samples as well (Appendix L-2). The large fraction also yielded a variety of items including a tiny burned and unburned bone splinters, tiny 1.5-mm-long burned fish vertebrae, and at least two flakes (Appendix L-2).

The small cluster of charcoal in Unit C-5, initially assigned Feature 2, may be associated with Feature 5. Also a single caliche burned rock resting on charcoal in the southeastern maizeer of Unit C-5 may also be associated with this hearth.

L.4.2.6 Feature 6

Feature 6 consists of a deep pit recognized from observations made in the hand-excavation of Unit C-7 in Area C (Figure L-5). The pit was not completely excavated and therefore, only limited information is currently available. It was initially recognized by a color change in the matrix at about 30 cmbs. At that level the floor of Unit C-7 revealed a distinctive color change in the matrix with the eastern half revealing a lighter matrix (10YR 4/3) with scattered pieces of charcoal present compared to the slightly darker terms, the hearth exhibited a shallow basin with ill-defined lateral margins and a blurred indistinguishable matrix (10YR 4/4) that lacked charcoal in the western side. This feature fill/matrix consisted of scattered flecks and chunks of charcoal as well as abundant fine mottles of brown (10YR 4/3) sandy loam. As the excavations

proceeded downward, the north to south demarcation line between the two colors shifted eastward across the unit. In the floor of level 4, ca 40 cmbs a third zone became visible along the western margin. This zone was a 10 to 15 cm north to south band of dark yellowish brown (10YR 4/4) with calcium carbonates. However, this third zone was just barely visible at about 50 cmbs along the western edge. The feature fill/matrix base was indistinguishable from the bottom of this unit at about 85 cmbs in the eastern wall. The pit edges were visible in the eastern, southern, and northern walls of Unit C-7 (Figures L-13 and L-14). Between about 52 and 62 cmbs along the western edge of the pit were at least seven burned rocks and two large bison bone fragments (a maxillary section and a rib). The pit is over a meter in length north to south, a minimum of 80 cm east to west, and over 55+ cm in depth. It appears to have been originally dug from the possible living surface between 14 and 30 cmbs, but the initial starting elevation is not clear. The dark brown A horizon is quite similar in color to the upper pit matrix. The lower edge of the pit has suffered from extensive insecturbation causing a blending of the matrix and a blurring of the precise lower boundary. This pit is definitely cultural but its function is not clear at this time.

From level 5, (40 cmbs) and deeper, the pit matrix was bagged without screening. This matrix was recovered for fine-screening or flotation in the laboratory. About 11 liters of pit matrix were submitted to Dr. Dering for flotation and macrobotanical identification. This single sample contained 2 mesquite seeds, 18 maize cupules, and 2 maize kernels (Appendix L-2).

A chunk of charcoal, identified as juniper, from a bag of unfloted matrix collected from 60 to 70 cmbs was sent for radiocarbon dating. This piece yielded a $\delta^{13}\text{C}$ (-24.4‰) corrected AMS date of 700 ± 40 B.P. (Beta-206562).

L.4.2.7 Feature 7

Feature 7 was not fully excavated; therefore, most details are currently unknown. Feature 7, recorded in Trench C-1 (Figure L-5), consists of a cluster of flat caliche rocks. This cluster lies about 120 cm east of the rock alignment, Structure 1. This cluster

Figure L-11. Plan view and profile of Feature 4.

Figure L-12. Profile of Feature 5.

was nearly centered along the north to south rock alignment and about 1 m east of the alignment. It measures about 1 m north to south and extends at least 30 cm east to west. The later dimension is limited by the width of Trench C-1 with rocks extending into both trench walls. This cluster consists of at least 19 irregularly shaped caliche cobbles that range in size from 9 to 17 cm in diameter (Figure L-15). The tops of the rocks were encountered at about 20 cmbs in an Ap2 horizon (Figure L-16). This soil zone is a dark grayish brown (10YR 4/2) sandy loam with irregular, linear, and ephemeral bands of pale brown (10YR 6.3) and brown (10YR 5/3) sandy loam. The rocks appear to rest slightly below these bands, which are thought to be derived from the bladed fireguard. This rock feature is near the top of an Ab horizon, a brown (10YR 4/3) sandy loam with slight charcoal flecks and chunks. Its function is not known and speculations range from part of the rock rubble belonging to the possible structure, possible wall remains of Structure 1, or even a possible cairn covering a burial. Only complete excavation will provide the necessary data to interpret this cluster of rocks.

L.4.2.8 Structure 1

A linear, north to south alignment of caliche rock is visible at the southern end in Area C (Figure L-5). This alignment is 1+ m west of the deeply bladed, 4-m-wide north to south fireguard that extends 6.5 m west of the current right-of-way fence, is about 7.5 m west of the road cut, and about 1.5 m east of the new right-of-way fence (Figure L-17). The rocks comprising this alignment are deeply buried with only the top one-third of the rock visible, and roughly 20 to 30 cm in diameter. At least 45 to 65 rocks are visible in at least a 10-m-long segment. The alignment is not perfectly straight with some rocks slightly displaced to one side or the other. Often a smaller rock is east or west of a larger rock. Some smaller rocks are barely visible south of this alignment and may be a continuation of the more visible alignment, which would extend this alignment another 2 to 3 m. The rocks are irregular shaped pieces of caliche caprock with only one or two that appear potentially vertical. A power pole was inserted about 25 cm west of the alignment towards the southern end and three larger rocks were placed at the surface around the pole. These three rocks

appear to have been removed from the alignment as gaps in the alignment are nearby. This partially buried alignment is postulated as the western wall of a structure. However, no east to west lines of rock were detected. Trench C-1 was hand-excavated about 120 to 130 cm east of main concentration of exposed rocks along the very western edge of the fireguard. This trench was about 8-m-long and roughly 25-cm-wide, paralleling the rock alignment (Figures L-16 and L-17). It was anticipated that this trench might expose some indication of east to west rock alignments and/or detect the occupation floor associated with the potential structure. A cluster of smaller rocks, each about 10 to 15 cm in diameter, was encountered in the trench and they were left in situ (see Feature 7 above). Feature 7 may be related to this possible structure or may reflect some other aspect of the occupation.

The 4-m-wide fireguard that parallels the rock alignment and is less than 1 m west of the old right-of-way fence, appears to have been mechanically bladed a number of times and is roughly 30- to 40-cm-deep. Only about four sizable caliche rocks were observed along the eastern margin of the fireguard. These four larger rocks appear to have been displaced by the blading of the fireguard. The lack of other large rocks for the other potential walls of Structure 1 creates doubt as to the function of the observed rock alignment.

Trench C-2 was hand-excavated perpendicular to the fireguard about 9 m north of the northern end of the alignment (Figure L-4). In that location the fireguard was bladed to about 40-cm-deep, but did not totally remove the lower part of the brown (10YR 4/3) sandy loam A horizon (Figure L-18). This fireguard appears to have removed roughly a 4-m-wide by 30- to 40-cm-deep zone of cultural materials, including part of the potential structure. If cultural materials such as storage pits or postholes/molds are associated with this structure, many of these are potentially still present below the fireguard.

In support of the possible cultural association and function as a part of a structure, diverse cultural materials were exposed in the adjacent fireguard, and recovered from five 1-by-1-m units hand-excavated in the immediate vicinity. Unit C-7, at the

Figure L-13. Profile drawing of Feature 6.

Figure L-14. South wall of C-7 showing profile of Feature 6.

Figure L-15. Feature 7 in Trench C-1, view to the northwest.

Figure L16. Profile of Trench C-1 indicating location of Feature 7 and Area C deposits.

northern end of the alignment and immediately east of the observed rocks in this alignment, yielded a number of smaller caliche rocks buried just east of the surface exposed rocks at about 6 to 8 cmbs and three flakes. At about 20 to 30 cmbs a pit (Feature 6) larger than the excavation unit was encountered and may represent a large storage pit below the structure. Unit C-10, located at the eastern edge of the alignment yielded cultural materials and more buried caliche rocks in the top 20 cm (Figure L-19). Bone fragments, charcoal, small caliche caprocks, and a few Alibates flakes were recovered. Most of the cultural materials were between 8 and 18 cmbs with a few scattered pieces below that to about 39 cmbs.

A chunk of unidentifiable wood charcoal, piece plotted from 19 cmbs in the northeastern quadrant in C-10 yielded a $\delta^{13}\text{C}$ (-23.6‰) corrected AMS date of 650 ± 40 B.P. (Beta-206563). A second chunk of charcoal, identified as juniper, from 34 cmbs of this same unit and directly below the above dated charcoal yielded a $\delta^{13}\text{C}$ (-23.0‰) corrected AMS date of 1290 ± 40 B.P. (Beta-206564). Here again, the age difference is considerable, some 640 radiocarbon years. As currently interpreted no cultural materials were recovered that might represent this earlier age. Five of the previous reported six radiocarbon dates above reflect an age range closer to the younger of these two samples. Currently, it is interpreted that the 1290 B.P. age is unacceptable for the more obvious cultural event. This may again represent a piece of older wood used at a much later time.

Also in Area C three other units, C-5, C-6, and C-11 were hand-excavated along a narrow strip of natural prairie immediately east of the fireguard and east of the rock alignment (Figure L-17). These units also yielded cultural materials that consist of ceramic sherds, burned rocks, charcoal, a hearth (Feature 5) in the road cut, bone fragments, and flakes, mostly from the Ab horizon.

In summary, these seven cultural features and one possible structure are divided nearly equally between the northern (Area A) and southern (Area C) ends of the site. Features 1, 3, and 4 were in the northern area. Features 5, 6, 7, and the structure were in the southern area. All features are associated with

very similar, but diverse cultural materials discussed below (Table L-1). Areas A and C reflect intense cultural activities, probably at two slightly different times, but apparently by similar groups of people. Areas A and C are spatially separated by nearly 120 m of Area B, in which almost no cultural materials and no cultural features were detected.

L.4.3 Material Classes and Frequencies

The following sections present the different classes of cultural materials recovered from the natural surface, the exposed surface of the previously bladed fireguard, the exposed road cut, the 28 hand-excavated 1-by-1-m units, and the hand-excavated trenches. The discussions include the counts and some initial observations on selected individual pieces. The recovered cultural materials appear to have generally come from the A horizon and varied in depth over about 30 cm. A specific living floor/occupation surface was not visible or detected in any of the excavations or profiles.

L.4.3.1 Lithic Debitage

The hand-excavations of 16.8 m³ combined with surface collections from the bladed fireguard yielded 278 pieces of lithic debitage. The debitage includes at least 75 percent Alibates and 25 percent nonAlibates based on quick visual identifications. A few pieces are identified as quartzite; many chunks of opalite are present, with at least three small pieces of obsidian (#32-1, #48-1, and #73-1). All three small obsidian pieces came from Area A, one out of the backdirt of Trench A-1, one from the surface northwest of A-6, and the other from Unit A-3 at 35 cmbs. The debitage collected from the surface (mostly the exposed fireguard), includes roughly 76 pieces. About 63 percent is Alibates, 28 percent is opalite, and 9 percent is other materials. One Alibates flake measures 64-mm-long and exhibits no cortex indicating a high probability that it came from a quarry source and not the river gravels. At least one 20-mm-long quartz pebble exhibits negative flake scars and is indicative of a cultural piece. The exterior is rounded implying it came from stream gravels.

In Area C the lithic debitage is mostly of Alibates (at least 83 percent) with about nine percent quartzite,

Figure L-17. Structure 1, probable western edge of house foundation in Area C.

Figure L-18. Profile of fireguard Trench C-2 showing deposits in Area C.

and eight percent other materials. No opalite flakes/chunks were identified from Area C. This is in stark contrast with Area A where at least 25 percent of the debitage is opalite.

Alibates material most often comes from quarry sources at Lake Meredith some 90 km upstream from 41RB112. There the Alibates comes from ledges of Alibates dolomite, which is part of the Permian-age-Quartermaster formation (Shaeffer 1958; Boyd 1987; Spearing 1991; Bowers and Reaser 1996). The dolomite has been partially replaced by silica solution to form chert. Some Alibates may have been collected from the actual quarry sources, whereas some may have come from the Canadian River gravels (Wyckoff 1989). The presence of white opalite was also expected and is considered locally available since it is available in the Ogallala Formation that caps the region (Lintz 1998). This material is generally very blocky with numerous internal fractures and not of a high quality for knapping. A few pieces of high quality, fine-grained quartzites are present. These also can be considered locally available, most likely in the river gravels.

L.4.3.2 Chipped Stone Tools

The hand-excavations and surface collections yielded a very limited chipped stone assemblage that includes nine formal chipped stone tools, including two triangular unnotched projectile points classified as Fresno arrow points, one reworked Washita arrow

point, at least four biface fragments, and two formal scrapers. The informal stone tools include a variety of items of different shapes and sizes labeled as edge-modified flakes. At least 17 pieces exhibit some tiny flake scars along the very lateral edges and these are classified as edge-modified tools. Below the formal tools are briefly discussed.

The Washita point (#23-10) was collected from the slumping road cut deposits immediately below Feature 1 at the northern end. This side-notched point is of dark gray quartzite and definitely reworked. This complete specimen exhibits a tip that was very short compared to the relatively long basal edge indicating the tip had been reworked. This point measures 14-mm-long, by 12.8-mm-wide at the base, and is 2.7-mm-thick.

A complete triangular Fresno point (#145-10) was recovered from 30 to 40 cmbs in C-8. This is a nearly clear piece of chalcedony or possibly translucent Alibates dolomite (Figure L-20). The distal section has been reworked into a sharp point and is now slightly asymmetrical. It measures 21.2-mm by 13.6-mm-by 3.5-mm-thick.

The base and midsection of a triangular Fresno point (#120-10) was recovered 22 cmbs near the top of the fill inside hearth Feature 5. This point was manufactured on a thin flake that exhibits minimal retouch along the margins with the dorsal face

Figure L-19. Profile of vertical rock in unit C-10 as part of Structure 1.

Table L-1. Summary of Feature Data from 41RB112.

Feature No.	Feature Type	Feature Size (cm)	Unit No.	Depth (cmbs)	Conventional Age (B.P.)	Charcoal Present	Lithic Debitage	Mussel Shell	Burned Rock	Tools Present
1	Basin	250 wide, 30 deep	Area A, roadcut	30-64	710 ± 40, 1490 ± 40	Chunks	yes	yes	yes	yes
2	Not a feature		C-5	22-30	NA	Chunks				
3	Basin Hearth	35 x 40, 11 deep	Trench A-1	32-50	970 ± 40	Chunks	none	none	none	1 edge-modified
4	Basin Hearth	28 x 28, 15 deep	A-5	49-65	710 ± 40	Chunks	none	none	none	none
5	Basin Hearth	75 wide, 20 deep	Area C, roadcut	22-42	630 ± 40	Chunks	yes	none	yes	Fresno
6	Deep pit	100+ wide, 55+ deep	C-7	30-85	700 ± 40	Chunks	?	none	yes	mano
7	Rock Cluster	100 x 30+	Trench C-1	22 to 25	NA	none	none	none	none	none
Structure 1	Rock Alignment	1200 long	Area C	78-16	650 ± 40	Chunks	yes		yes	biface scraper

exhibiting the ripple lines of the original flake. This specimen measures 22.1-mm-long by 16.9-mm-wide by 2.4-mm-thick. It was manufactured from a dark Alibates flake.

An Alibates biface (#2-10) was broken during use. This piece was recovered from the surface in Area A. It is an elongated form with use along the margins.

A petrified wood biface fragment (#2-11) also appears to have broken during use. This piece came from the surface of Area A.

An opalite piece is a questionable biface fragment (#42-12) since this material is difficult to flake. This is a small section and is difficult to define with certainty. This specimen came from 20 to 30 cmbs in A-2.

A fragment of a biface (#90-10) was collected from the fireguard surface inside Structure 1. The material is presently not identifiable. It exhibits a use break indicating it was probably discarded following its breakage.

A broken side scraper (#22-10) with two worked edges was recovered from the surface of the fireguard in Area A. This scraper was manufactured from Alibates.

A complete end and side scraper (#103-10) of Alibates was collected from the surface just south of Structure 1. This scraper is relatively thin, lacks a dulled edge, and still appears functional (Figure L-20).

These nine formal chipped stone tools were nearly equally divided between Areas A and C. The dominance of Alibates used to manufacture tools is characteristic of the Antelope Creek phase populations. The Alibates quarry is near Late Meredith near the heartland of Antelope Creek sites but Alibates pieces also are present in and recovered from the Canadian River gravels down stream from the quarry.

L.4.3.3 Ceramic Sherds

A total of 105 sherds have been recovered thus far. The surface sherds from Area A reveal a broad range in thickness from 2.9 to 7.9 mm, even though nearly all of the 77 sherds are cordmarked. This

range of thickness either reveals extensive variation in individual vessel wall thickness or that multiple vessels were present. Three sherds collected from the road cut in Area A were relatively large (over 40 mm) and are the largest pieces from the site. The largest sherd measures about 68.9-mm-across. These and the smaller sherds from the surface in Area A exhibit cordmarked exteriors, some smoothed over, and some plainware sherds (Figure L-21). The cord impressions were often created with fine, tight cordage. These sherds appear to have mostly rounded sand temper. The interiors are smooth and lack striations or major blemishes. Over 50 percent of the sherds were recovered from the hand-excavations, with 47 sherds from Unit A-5. Some sherds are a brown color (#2-18) whereas others are blackened (#2-17) with burned organic residues. One-body sherd (#2-17) exhibits two intentional fingertip size indentations on the exterior, but do not push the clay through to the interior or create raised areas on the interiors. These indentations look identical to that one indentation observed below the rim sherd #2-13. Although the two sherds do not appear to refit, they do appear to represent a similar decorated vessel and probably the same vessel. Area A yielded a rim sherd decorated by pinched areas with fingertip indentations plus a second rim with a small part of the neck and shoulder that represent at least two different vessels.

In Area C, 17 sherds were recovered from one unit, seven pieces from 30 to 40 cmbs, and another ten from 40 to 50 cmbs in Unit C-9. Most sherds are relatively thick cord-marked pieces (Figure L-22). All but one or two sherds from Unit C-9 are thicker than sherds from Area A. These thicknesses range from 7.4 to 10.1 mm, with a single sherd yielding up to 2.5 mm differences in thickness. One sherd (#153-10) was extremely thick (14.1 to 17.5 mm) and represents a sherd from near the very bottom of a vessel (see below). The largest single sherd measures 54.1 mm across. Seven thick cordmarked sherds were recovered from the fireguard surface in the immediate vicinity of Unit C-9. The interior surfaces are relatively smooth with shallow deviations and a few striations with a few temper particles visible. These sherds are also thicker than those from Area A, and appear to be mostly sand tempered. One longitudinally split sherd exhibits

Figure L-20. Selected stone tools from 41RB112.

a nearly black interior core with angular pieces of temper up to 2 mm in diameter. This temper appears to represent a crushed rock. Most of the interior cores are quite mottled with blacks and brown colors with a very thin layer of dark brown color immediately under the gray exterior.

One unusual sherd (#12-8) exhibits two black painted bands (Figure L-21h). It was collected from the surface of the fireguard in Area A. This is a small triangular sherd about 19-mm-by-13.7-mm-by-5.6-mm-thick. The dark paint is on the exterior surface and appears as two black parallel lines, one of which is about 7-mm-wide. The unpainted section between the two lines is also a line about 4.3-mm-wide and is the brown color of the natural sherd. This is a nonlocal sherd that looks like a Rio Grande Glaze ware without the glaze (Boyd p.c. 2005). The temper is unlike those of the cordmarked sherds.

Sherd #74-8 is also unusual in that it lacks cord marking on the exterior (Figure L-21e). This

piece was recovered from next to hearth Feature 3 between about 40 to 50 cmbs in A-8. This 30.5 mm diameter sherd has a slightly convex exterior that is smooth and a light gray color. It is 4.5- to 4.8-mm-thick with two colors evident in the core. A reddish color is present towards the outer half with a gray color towards the interior side. The core is quite homogeneous with sand temper. The interior is slightly concave and relatively smooth. It does not appear similar to other cord-marked interiors. This piece may be from a nonvessel, possibly a pipe bowl or something similar.

Sherd #11-10 is a slightly curved piece that looks more like a section of a pipe (Figure L-21). This sherd was recovered from the surface of the fireguard in Area A. The exterior is partially covered in calcium carbonate adhering to a very smooth and well-finished polished surface that is a light brown color. The exterior is convex across the width and concave longitudinally with both broken lateral edges facing the interior. The interior is not well

finished, is irregular, but mostly concave, and does not appear polished. The interior core is brown on the outer margin with a gray color on the interior half with small fine temper particles visible. The broken edge exhibits considerable variations in the thickness. The parallel lateral edges vary from 4.9- to 7.2-mm-thick. The sherd measures 43.9-mm-by-28.6-mm-by-roughly 5.5-mm-thick. This sherd is unlike any of the cordmarked sherds and more closely resembles pieces from the Southwest. This is considered a nonlocal sherd.

Another specimen (#2-15) from the surface of Area A also is an unusual in shape and may be a side section of a ceramic pipe bowl or some unusual appendix to a vessel (Figure L-21g). It is similar in overall shape to sherds #10-11. This piece exhibits light colored exterior and interior surfaces, which is a light coating of calcium carbonate. Under the carbonate layer is a well finished, possibly polished brown surface that is quite similar to sherd #11-10. The exterior is convex across the width. The interior is concave, relatively smooth but not as well finished as the exterior. The two broken lateral edges are visible on the interior side creating an elongated appearance. The broken edges exhibit fine rounded sand grain temper in a fine-grained matrix. The temper is similar to sherd #10-11 with fine particles in a two tone colored matrix. The core matrix towards the exterior is a light brown, whereas the matrix closest to the interior is gray. The piece measures 25.8-mm-wide, 33-mm-long, 4-mm-tall, with a thickness that varies from 4.1 mm to 5.7 mm. This piece is similar to #10-11 and is also considered nonlocal and probably from the Southwest.

A rim sherd (#58-10) was recovered from 14 cmbs in A-5. This short section is about 3-cm-long and exhibits a thickened lip, which is pinched on the exterior. The interior of the rim is rounded and smooth, much lighter in color than the exterior lip.

A second rim sherd (#2-13) was collected from the surface of Area A and refits to the above rim sherd (#58-10). This piece reveals a 31-mm-long section of rim that exhibits a thickened lip (8.5 to 9.5 mm side) on the exterior that is pinched (Figure L-21c). Below the 11.1- to 12.2-mm-tall pinched section is the nearly vertical body with well-preserved fine

cord-marked impression right to the lip. About 18 mm below the lip is a shallow finger-tip size depression that does not push out the interior.

A sherd from the surface of Area A (#2-14) is a small rim section that also exhibits the entire width of the neck area below the rim and the start of the shoulder. This sherd is very similar to the sherds (#46-8) from A-3, but has the rim still attached. The short 15-mm-long rim is slightly thickened (6.2 to 7.2 mm) with a rounded and smooth interior juncture but the exterior part is damaged. Below the rim, the neck extends about 35 mm to the shoulder that flares outward. The exterior is covered with a black organic residue over the cord-marked finish. The interior surface is smooth, slightly irregular, and exhibits small sand temper. The core matrix also exhibits rounded sand temper.

At least one massive sherd (#153-10) is thick enough to represent the bottom or near bottom of a large vessel (Figure L-22a). This piece was recovered from 42 cmbs in Unit C-9 in Area C. It measures 59.7-mm-by-53.6-mm-by-14.1 to 17.5-mm-thick. The slightly concave interior exhibits a thin darkened layer that penetrates at least 2-mm-deep towards the center of the core matrix. This interior surface is quite smooth and well finished with a couple of thin, shallow striation lines visible. The lightly colored, convex exterior is smoothed over cordmarked with many irregular pits and irregularities. The temper appears as rounded grains of sand. A number of slightly thinner cordmarked sherds were recovered from this same unit, and the adjacent fireguard surface, and may be part of this same vessel (see above).

Two sherds that fit together (#46-8) were recovered from 19 cmbs in A-3 and represent the lower neck and shoulder area (Figure L-21a). This shoulder is slightly curved outward, thickens slightly towards the body, and exhibits a very fine, tight cordmarked exterior. The neck area is thinner and nearly vertical. The interior is very smooth and black with tiny striations parallel to the rim. The interior core is a brown color and appears tempered with sand.

In summary, the ceramic assemblage is quite diversified for a relatively small sample. Although cordmarked sherds represent about 96 percent of the

Figure L-21. Selected ceramic sherds from Area A.

Figure L-22. Selected ceramic sherds from Area C.

assemblage, the other four percent consists of at least four sherds considered nonlocal and likely from the Southwest. These four sherds include one painted sherd, and three plain surface sherds with two of those that might be pipe fragments. The paste and temper of the four nonlocal sherds is quite similar and may reflect a similar origin. Another important aspect of this ceramic assemblage is the high frequency of decorated rim and neck sherds, which are not often recovered even in large assemblages. Decorated rims, are not common in the core Antelope Creek sites at Late Meredith, but are more common in the Buried City assemblages. Also unusual is the thickness of the cordmarked sherds from the southern end (Area C), which are on the average much thicker than those in the northern end (Area A). These thick sherds are often assumed to represent Woodland events. This assemblage provides an opportunity to gain a greater understanding of the complexity of ceramic technology and variations within Antelope Creek populations.

L.4.3.4 Faunal Bone

The vertebrate assemblage consists of 209 small, mostly unidentifiable bone fragments. Very few pieces could be identified to element and even fewer to species. Cortical wall thickness of a few of the fragments indicates at least two sizes of animals are represented, that of bison and a deer/antelope size. No fetal elements or small rodent size animals were identified.

Bison long bone fragments were observed in Units A-8, C-4, C-6, C-7, C-9, and C-10. One upper right maxillary section of a bison was recovered from 59 cmbs inside and along the western wall of Feature 6 in C-7. This maxillary section contains three molars and one pre-molar still intact in the bone. The style of the third molar is not in wear, whereas the two styles of molars one and two are worn to a loop. This tooth wear pattern reflects a mature animal greater than four years old that was possibly killed during the spring season. Two other bison teeth (#33-2) were recovered from 30 cmbs in the eastern profile of Trench A-1.

Based on only a few identifiable pieces, bison is present and represented by a rib, maxillary section, upper teeth, and a distal metapodial fragment. These

few elements imply much of the carcass was brought to this site for further processing.

A deer/antelope size ungulate is represented by one burned astragalus. This nearly complete astragalus was recovered from 0 to 10 cmbs in C-11. The only other identifiable bone was a small fragment of a turtle carapace (#108-2) from Unit C-2.

In general the bone preservation appears to be relatively good, lacking extensive root etching and weathering. However, the bones are quite fragmentary with only three species currently identified. More bone may be expected in cultural pits and other features.

L.4.3.5 Mussel Shell

Nineteen small, broken pieces of thin mussel shell valves were encountered scattered throughout the investigations. Fragments were observed along the eroding roadcut profile of Feature 1, in the fireguard, and on the natural surface from rodent disturbances. Nearly 90 percent of the pieces were recovered from Area A. Only a couple of the pieces have parts of the hinge represented and these potentially may be identifiable to species. If identifiable species can be recovered this might provide information of the nearby water sources.

L.4.3.6 Charcoal

No obvious charcoal lens, large pockets of charcoal, or burned posts were observed during these investigations. Small scattered pieces of wood charcoal were observed in many of the excavated units and in the identified features in Areas A and C. The three excavated hearth features, Features 3, 4, and 5 all yielded flecks and small chunks of identifiable charcoal within their ashy matrix, but no thick lenses of charcoal. Scattered chunks of charcoal were also observed in pit Features 1 and 6. Beside the charcoal from the feature matrix at least 42 samples of charcoal were collected from Areas A and C. Thus far, Dr. Dering has identified juniper, mesquite, and cottonwood/willow (Appendix L-2). Seven individual wood charcoal pieces were selected and sent for radiocarbon. These pieces included six pieces of juniper and one piece of unidentifiable hardwood (Appendix L-2).

L.4.3.7 Ground Stone Tools

Five stone objects are considered ground stone tools and include four manos and one apparent hammerstone. These are individually presented below.

One complete granite mano (#21-10) was recovered from the western edge of the bladed fireguard in Area A. It measures 106.2-mm-by-97.9-mm-by-57.1-mm. One face is convex and highly smoothed and polished, whereas the opposite face is convex (roughly 3.5-mm-deep) with many small pits and a small section of high polish near the margin. The lateral edges are rough and pitted with at least one flake scar present. This was probably a multifunctional tool from grinding and pounding.

A small fragment of a sandstone mano (#48-10) was recovered from 30 cmbs in A-3. This fragment reveals two very flat faces; with one partially polish and the other relatively rough (Figure L-23). It measures 50.0-mm-by-30.8-mm-by-23.1-mm.

One haft of a probable mano (#132-10) was recovered from 50 to 60 cmbs C-7 near the bottom of Feature 6 in Area C. This is a quartzite piece that apparently broke during use. It exhibits one flat face and one lateral edge still present. It measures 150-mm-long by 52-mm-wide. The ends appear slightly rounded and this piece may have also functioned as a hammerstone. This broken mano was associated with a couple of large bison bones, and a few burned rocks along the western edge inside the large pit Feature 6.

A fourth specimen (#89-10) appears to be a quartzite hammerstone. It was recovered from the surface of the disturbed fireguard inside Structure 1. It is complete, ovate in shape with light battering on both ends that exhibit tiny flake scars. The rest of the cobble surfaces are water worn smooth with calcium carbonate still adhering to about 25 percent of the surfaces. This piece measures 100.3-mm-by-55.6-mm-by-38.7 mm.

A fifth ground stone specimen, a probable mano (#165-10), came from 23 cmbs in C-10. This fragment represents about a quarter of relatively

thin rock that exhibits a very smooth and regular curved outer edge. One face is flat with a few pits across its surface and is partially covered in calcium carbonate. The junction between the flat face and convex outer edge is abrupt and well-defined. The other face has been removed and exhibits an irregular broken surface.

The recovery of at least four pieces of ground stone from both ends of the site indicates plant-processing activities. This may have been directed towards domesticated plants such as maize. The presence of maize in each of the sampled features is extremely high and the ground stone tools support agricultural practices and processing of plants here.

L.4.3.8 Burned Clay

A few small pieces have been labeled as burned clay but these are so small and may represent pieces of pottery. A few pieces were also labeled as daub, but again their small size hinders identification of their true nature and function. One piece of a triangular shaped daub about 2-cm-across came from the initial TxDOT ST 1 in Area A.

L.4.3.9 Terrestrial Gastropods

No snail shells were recovered from these investigations.

L.4.3.10 Burned Rocks

Burned rocks were scattered across Areas A and C with no detected clusters to imply a burned rock feature. The largest piece was just less the 12 cm in diameter with most pieces in the 3 to 7 cm size range. At least three different material types are represented and include caliche caprock, opalite, quartzite, and at least a couple of unidentifiable pieces. In Area C nearly 67 percent of the burned rocks were caliche, with some 27 percent quartzite, and another 6 percent other materials. In Area A three materials, caliche, sandstone, and quartzite are equally represented in the assemblage.

L.4.3.11 Bone Tools

Only two small fragments of bone appear to have been worked and or used as tools. A very fragmented section of a bone awl (#20-10) was recovered from the western edge of the fireguard in Area A. This

piece exhibits a burned black interior with a thin gray colored 1- to 2-mm-thick rim on the exterior. The very distal tip is missing but a roughly 16-mm-long section just before the tip is rounded and smooth, and tapers to what would have been a fine point.

A short bison long bone fragment (#31-10) exhibits a burned (blackened) distal end that tapers to a dull pointed end with rounded lateral edges (Figure L-24). The outer surface of the blackened area is partially smoothed/polished. This piece measures about 41.6-mm-long, 11.9-mm-thick and 9.8-mm-wide. This piece was recovered at 44 cmbs near the bottom and inside pit Feature 1. The rounding appears intentional and therefore, represents some type of pointed, heat-hardened bone instrument.

L.4.4 Age of Cultural Deposits

Eight samples were selected for radiocarbon dating to gain an initial understanding of the age of the investigated features and assess their potential association. Four wood charcoal samples were selected from Area A including two from pit Feature 1, one each from hearth Features 3 and 4. Three wood charcoal and one maize kernel from Area C were sent for dating. The maize kernel came from hearth Feature 5, one charcoal sample came from inside the deep pit Feature 6, and two pieces of charcoal came from two different levels in C-10 located just inside the western margin of Structure 1. These later two pieces were assumed to be associated with Structure 1 and provide an indication of its age.

The eight-radiocarbon results obtained indicate an 860 year time span for the material dated across this site (Table L-2). Upon closer examination of the results it appears that five of the eight (63 percent) obtained radiocarbon dates cluster in a very narrow 80 year period between 630 and 710 B.P. or a two sigma calibrated range from A.D. 1260 to 1410. The three older ages are at least 250 years older and outside the range of the five clustered ages. These three older ages do not cluster and represent some 520 years of time. In the case of the very oldest assay, at 1490 B.P., the dated charcoal came from excellent intact context inside Feature 1 and directly associated with a second piece of charcoal that dated to 710 B.P. Since the younger of the two dated samples from Feature 1 clusters with four

other radiocarbon results from this site, it is the older assay that is believed not representative of this cultural event. This provides a clue that all three of the older assays may be reflecting ages that are older than the cultural events represented by the material remains, which reflect an Antelope Creek event(s). In the most recent overview of Antelope Creek phase, Brooks (2004) indicates the ages of Antelope Creek occupations are roughly between 750 to 450 B.P. (A.D. 1200 and 1500). Therefore, the three older assays of 970, 1290, and 1490 B.P. appear beyond the currently accepted age range for Antelope Creek occupations. In addition, no artifacts were recovered that clearly corroborate occupations at these early dates.

The three older and age dispersed radiocarbon assays were derived from Areas A and C and may reflect factors other than multiple occupational events. Radiocarbon results can be misleading (Schiffer 1986 and Smiley 1985). Smiley (1985:34-45) lists 17 sources of error in radiocarbon dating and argues for quantification and control for the bias in dating. He discusses historic sites in northeastern Arizona that when radiocarbon dated, yielded dates about 150 years older than their known ages. The differences between the ages of the five clustered assays and three older nonclustered ages may be potentially explained by the use of old, dried deadwood as fuel in campfires. Here, juniper wood was most often dated and is known to live longer and preserve better after death than softer and more rapidly decaying hackberry or cottonwood trees. The single date obtained from charred maize may be the most reliable date for determining the age of the cultural occupation since this cultigen is commonly found at sites of this age. It also has a very short growing period compared to tree wood.

Setting aside the three older assays for the moment let us consider the five clustered ages only. The three youngest assays of 630, 650, and 700 B.P. are all from cultural features at the southern end (Area C) of the site. The two slightly older assays of 710 and 710 B.P. are both from the northern end (Area A). Although these five assays overlap at the two-sigma range the current data (including the artifact assemblages) hints at two separate cultural events that are very close in time.

Figure L-23. Fragment of ground stone tool #48-10.

If more radiocarbon dating is conducted for this site it is recommended that maize or some other annual plant part (i.e., seeds) be used to date these occupations. Dating annuals should provide a greater control on the timing of these closely spaced cultural events by minimizing the potential for old wood problems that might be occurring. The greater control is desired since it is apparent that the occupations represented at either end of this site (Areas A and C) appear to represent the same or similar cultural manifestations albeit slightly different events. Dating annual plant parts would help narrow the timing of the occupation(s) and potentially help determine which of the events occurred first.

L.4.5 Horizontal Patterning Detected

Major differences were detected in the horizontal patterning of the types and quantities of some classes of cultural materials between the three areas. Very limited cultural materials were recovered from the 120-m-long Area B (Table L-3) and reflect no significant cultural activities in that area. Areas A and C yielded clustered cultural materials and differences in the types and quantities of materials. Area A yielded over twice the number of pieces of lithic debitage and nearly three times the number of ceramic sherds than Area C, even though the linear section of Area C is 1.5 times as long (Tables L-4 and L-5). Nearly 99 percent of the opalite pieces were collected from Area A with the rest from Area

C. All three pieces of obsidian were recovered from Area A, just west of Feature 1. However, the burned rocks were nearly five times more frequent in Area C than Area A. The more frequent burned rocks in Area C may be accounted for by the nearly twice the area in C and the more excavation units.

The two triangular Fresno points were from Area C, whereas the one Washita point was recovered from Area A. Area A and C each yielded a well-made scrapers manufactured from Alibates, fragments of bifaces, Alibates edge-modified flakes, and pieces of ground stone tools. Both bone tools were recovered from Area A.

Fragmented bison remains have been identified from Areas A and C. The identifiable pieces of bison bones came from pit Features 1 and 6 in Areas A and C respectively. The fragmented bones were in nearly equal numbers in Area A (N = 108) and Area C (N = 99), whereas only two tiny fragments were in Area B. The deer/antelope and turtle carapace were both from Area C. In Area A Unit A-5 yielded the most bone fragments (N = 85) in that area. In Area C Units C-5, 7, 9, and 10 had more bones than the other units in that area.

The majority and thinner cordmarked sherds, plus the three plainware body sherds and one painted sherd were recovered from the fireguard surface and the road cut in Area A. At least three separate vessels

Figure L-24. Burned tip of bison bone tool.

are represented in Area A. One of the vessels in Area A lacks the usual cord-marked exterior. One cord-marked vessel in Area A exhibits a decorated rim, with a pinched lip, and shallow depressions in the vertical neck area. The other vessel in Area A is a possible trade vessel as it exhibits a smooth exterior surface with painted black lines. Unit A-5 yielded nearly 48 percent of the sherds recovered from Area A, implying a concentration in that area. At least one very thick bottom sherd, and body sherds that are thicker than most of those from Area A, came from Area C. The thicker cordmarked sherds, including the one very thick basal sherd, were all from Area C. Unit C-9 yielded nearly 63 percent of the thick sherds from Area C, possibly indicating a pot drop in that vicinity.

The skewed distribution of opalite, obsidian, the ceramic vessel differences, burned rocks, plus differences in the point types, are clues to indicate that Areas A and C represent two separate events. However, it is also possible the skewed material frequencies from the two areas reflect different tasks conducted in these two areas during the same occupation.

Within Area A Unit A-5 yielded the greatest quantity of cultural material and small hearth Feature 4. This unit was the closest excavated unit to the 2.5-m-wide basin (Feature 1) observed in the road cut profile.

Feature 1 was only about 2 m from Unit A-5. Unit A-2 was the second highest producing unit in Area A. Overall, the significant frequency differences in the materials recovered from the individual units indicate a definite horizontal pattern across the area, implying a very limited use period. The northern edge of this cultural concentration is defined by the absence of materials from A-7. The southern end is not as well-defined as materials are still evident in A-1.

In area C Units C-9 and C-10 yielded the greatest amounts of material. Interestingly C-10 was on the east edge of the rock alignment and C-9 was southeast of the alignment. Two moderately productive units, C-5 and C-6 yielded similar amounts of materials, and were also along the very eastern edge of the APE. The current distribution pattern indicates that that about 8 m from the rock alignment the frequency of cultural materials drops off dramatically.

L.5 SUMMARY, CONCLUSIONS, AND DISCUSSIONS

L.5.1 Summary

Before the planned road rehabilitation and widening of the highway along a 9.7 km (6 mile) section north of the Canadian River, TxDOT archeologist G.

Table L-2. Radiocarbon Samples and Results from 41RB112.

Catalog No.	Unit No.	Depth (cmbs)	Feature No.	Material Dated	Wgt. (g)	Beta Lab. No.	Measured Age	13C/12C Ratio (‰)	Conventional Age (B.P.)	2 Sigma Calibration Range
31-4-2a	Cutbank	62-64	1	charcoal	0.1	206557	680 ± 40	-23	710 ± 40	AD 1260-1310 AD 1370-1380
31-7-1	Cutbank	52	1	charcoal	0.1	206558	1460 ± 40	-23.3	1490 ± 40	AD 460-480, AD 520-650
34-7-2	Trench A1	36	3	charcoal	0.5	206559	940 ± 40	-23.2	970 ± 40	AD 1000-1170
62-7a	Unit A-5	50-60	4	charcoal	0.1	206560	690 ± 40	-24	710 ± 40	AD 1260-1310 AD 1370-1380
120-4-3a	Cutbank	30-40	5	maize	0.1	206561	380 ± 40	-9.7	630 ± 40	AD 1290-1410
133-4-a	Unit C-7	60-70	6	charcoal	0.1	206562	690 ± 40	-24.4	700 ± 40	AD 1260-1310 AD 1360-1390
164-7-1	Unit C-10	19	Structure 1	charcoal	0.1	206563	630 ± 40	-23.6	650 ± 40	AD 1280-1400
167-7-1	Unit C-10	34	Structure 1	charcoal	0.1	206564	1260 ± 40	-23	1290 ± 40	AD 660-790

Dennis Price conducted a cultural resource survey of the right-of-way in June 2004. Mr. Price identified the presence of a buried prehistoric site (41RB112) in the APE along the western side of the highway. He saw potential for this site to contain significant cultural information and recommended testing this site to determine its eligibility for listing on the NRHP and as a SAL per the requirements of Sections 106 and 110 of the National Historic Preservation Act and other related legislation.

In May 2005, TRC archeologists, under a TxDOT Scientific Services Contract No. 573XXSA006 (Work Authorization No. 57317SA006) and Texas Antiquities Committee Permit No. 3721, conducted an archeological assessment of site 41RB112. The field investigations were structured to evaluate the eligibility of 41RB112 for inclusion in the NRHP and for designation as a SAL.

The TRC field assessment investigations involved the surface collection and mapping of cultural materials exposed on the surface from the APE, the hand-excavation of 28 1-by-1 m units (totaling 16.8 m³), the hand-excavation of four trenches (totaling nearly 32 linear meters), and the cleaning and inspection of 28 m of road cut. The narrow and nearly 270-m-long north to south APE was divided into three areas (A, B, and C) for management

purposes based on topography and observed cultural materials.

These investigations resulted in the documentation significant cultural materials in the form of scattered occupational debris around well-defined cultural features in two (Areas A and C) of the three areas. Seven buried cultural features and one partially buried possible structure were identified. These features are nearly equally divided between Areas A and C with no cultural features identified in Area B. These investigations not only document the presence of intact buried cultural features but also document diverse cultural materials and organic remains in direct association with these features. The cultural materials recovered include a total of 854 pieces, with over 82 percent from subsurface context. The materials include lithic debitage ($N = 274$), bone fragments ($N = 219$), mussel shell fragments ($N = 41$), burned rock fragments ($N = 183$), ceramic sherds ($N = 104$), and various stone and bone tools ($N = 33$). Also recovered were some 42 charcoal samples plus other macrobotanical remains from floated feature matrix that include charred wood, cultigens, and wild plant remains. The diverse cultural assemblage indicates multiple tasks were conducted around the cultural features identified in Areas A and C. Area A yielded about 57 percent of the material remains, whereas Area C yielded nearly 44 percent. Area B

yielded less than one percent of the cultural debris ($N = 11$). These investigations determined that the cultural materials were clustered in Areas A and C with nearly 110 m of noncultural bearing deposits (Area B) between the two concentrations. Eight radiocarbon assays, four each from Area A and C yielded a time span of some 860 years for the material dated. Five clustered ages fall in an 80 year period from 630 to 710 B.P. and appear to represent the clusters of cultural materials in Areas A and C. The cultural assemblages recovered from these two areas support these five clustered ages. Three apparent outliers at 970 B.P., 1290 B.P., and 1490 B.P. are suspect and may be from old wood used in cultural fires or represent something besides the documented components. No cultural materials recovered reflect these earlier times creating doubt as to their documenting the current assemblages.

In summary, the investigated parts of Areas A and C of 41RB112 contain single occupations in the top 50 cm of the sandy loam Holocene soils that date to the Plains Village period from about 630 to 710 B.P. Areas A and C each contains at least three cultural features in association with diverse cultural remains that include good organic preservation. In addition, each occupation represents a very narrow time period associated with the Southern Plains Village tradition.

The opposite, eastern side of the highway was investigated through surface inspection and the

excavation of six 50-by-50 cm shovel tests. These shovel tests and observations documented the presence of only a few scattered pieces of cultural material.

L.5.2 Conclusions

Site 41RB112 is a very important site since it contains what appears to be two horizontally discrete areas that have time specific materials with the potential to contribute further information towards understanding the local and regional prehistory, specifically for the Plains Village tradition. Areas A and C may represent individual habitation localities that indicate Antelope Creek phase occupations during a narrow radiocarbon dated period of 80 years from 630 to 710 B.P. based on five tightly clustered assays.

In Area A the presence of a nearly 250-cm-wide by some 30- to 40-cm-deep basin with sparse artifacts near the bottom potentially represents a subterranean habitation structure or a large storage pit. The two identified hearth features (Features 3 and 4) combined with the moderate frequency of lithic debris, the faunal remains, the presence of burned rocks and ceramic sherds, and stone tools all support multiple tasks relating to the habitation of this location. Both hearth features yielded charred food remains (cultigens) and indicate the presence of at least maize, squash, and cheno-ams. Preservation of macrobotanical remains is good to excellent. The

Table L-3. Cultural Materials from Area B.

Units	Flakes	Bones	Mussel Shells	Burned Rocks	Ceramic Sherds	Tools	Feature Numbers
B-1	-	-	-	-	-	-	-
B-2	-	-	-	-	-	-	-
B-3	-	-	-	-	-	-	-
B-4	-	-	-	1	1	-	-
B-5	-	-	-	-	-	-	-
B-6	-	-	-	-	-	-	-
B-7	7	2	-	-	-	-	-
B-8	-	-	-	-	-	-	-
Totals	7	2	-	1	1	-	-

Table L-4. Cultural Materials from Area A.

Units	Flakes	Bones	Mussel Shells	Burned Rocks	Ceramic Sherds	Tools	Feature Numbers
A-1	15	2	1	-	10	-	
A-2	32	10	2	22	7	2 EM	
A-3	5	-	1	-	2	1 mano	
A-4	8	4	3	-	-	1 EM	
A-5	50	85	5	1	19	1 EM	4
A-6	5	5	1	1	2	-	
A-7	-	-	-	-	-	-	
A-8		-	-	-	-	1 EM	3
Unit Totals	115	106	13	24	40	6	2
Surface	54	8	3	1	30	1 scraper, 2 biface, 7 EM, 1 mano, 1 awl, 1 point	
Other	22	15	1	6	7	1 awl	1
Totals	191	129	17	31	77	20	3

EM = Edge modified flake

Table L-5. Cultural Materials from Area C.

Units	Flakes	Bones	Mussel Shells	Burned Rocks	Ceramic Sherds	Tools	Feature Numbers
C-1	-	-	-	2	-	-	-
C-2	2	1	-	7	-	-	-
C-3	-	-	-	7	-	-	-
C-4	3	7	-	3		-	-
C-5	6	20	-	3	3	1 EM	-
C-6	1	9	-	22	-	-	-
C-7	9+	2+	-	8	-	1 mano	6
C-8	12	-	2	8		1 point	-
C-9	14	14		5	17		
C10	17	34		11		1 mano	Structure
C-11	2	1		6			
Unit Totals	66	88	2	82	20	4	2
Surface	12	2		56	1	1 scraper, 1 hammer, 2 biface, 4 EM	
Other	2			14	6	1 point	5, 7
Totals	80	90	2	152	27	13	5

EM = Edge modified flake

general depth of deposits of most of the cultural material lies between 20 and 40 cmbs, the horizontal distribution of material classes, plus the intact nature of the features and associated cultural assemblage indicate these two areas reflect a single occupational event. Single events are rare regardless of what time period is involved. Therefore, Area A through the presence of diverse cultural remains provides a great opportunity to learn specific details about human behavior at one point in time at this particular location. This event has suffered only minor disruption throughurbation, which has caused some vertical displacement of some smaller artifacts. The initial four radiocarbon dates from Area A indicate a potential period of occupation occurred between 710 and 1490 B.P. However, the oldest two dates at 970 and 1490 B.P. appear older than the associated cultural assemblage and may reflect old wood problems. The two youngest dates from Features 1 and 4, both at 710 B.P. may be more accurately reflecting when this specific occupation occurred. The lithic debris, dominated by Alibates dolomite with moderate frequencies of local opalite, limited pieces of nonlocal obsidian, combined with the cordmarked pottery sherds and the Washita projectile point all reflect an occupation during the Plains Village period. Most data collected indicates an Antelope Creek occupation, but the lack of stone architecture could be cause for some to question this assignment, especially if Feature 1 is surmised to be a pithouse.

In Area C the rock alignment indicates a possible structure, and the associated cultural assemblage would support that as a habitation structure at which diverse activities were conducted. Both Features 5 and 6 yielded well-preserved macrobotanical remains, which include maizcob and kernel fragments, along with at minimum mesquite and juniper wood. The diverse cultural assemblage including points, bifaces, scrapers, bone, ceramic sherds, and macrobotanical remains represent a very narrow occupation period within the Plains Village period. The initial four radiocarbon dates from Area C range in age from 630 to 1290 B.P. and document the probable use period. However, one outlier date of 1290 B.P. is some 590 years older than the other three clustered assays and may not reflect the age of this cultural event. More likely this cultural

event occurred at about 630 to 700 B.P. based on the three clustered dates. The combination of the three-clustered radiocarbon dates, the recovered artifact assemblage, and the possible architectural remains are interpreted to reflect an Antelope Creek phase event. The thick cordmarked ceramic pottery recovered is not the typical thin wall vessel type normally associated with Antelope Creek sites. However, thick cordmarked body sherds tempered with fine sand were also recovered from Buried City (Hughes 1991), Roy Smith (Schneider 1969), and at Spring Canyon (Duffield 1964). At present, the association of the thicker sherds with the rest of the recovered material assemblage implies this vessel is part of the Antelope Creek assemblage.

The initial seven flotation samples encompassing 26.7 liters of matrix from four features contained small quantities of wood charcoal, a significant amount of maize remains, a squash rind, and seeds of mesquite and cheno-am. Evidence of bioturbation included roots, insect parts, and uncarbonized seeds, but the former activities did not significantly reduce or displaced the archeobotanical record. The recovery of four edible plant food taxa from such a limited flotation effort is a clear indication that further excavation 41RB112 has excellent potential for adding to our knowledge of plant production and wild plant utilization in the Canadian River region.

L.5.3 Discussions

A number of Plains Village manifestations have been identified across the southern Plains region such as Antelope Creek phase, Buried City complex, Apishapa phase, Zimms complex, Odessa phase, Custer and Turkey Creek phases, etc., and all have generally similar artifact assemblages and the presence of architecture. However, slight differences in the material assemblages and architecture have been used to assign sites to the different cultural manifestations often without a clear understanding of the broader picture of cultural diversity. A number of the named Plains Village manifestations have not received the deserved attention in the last 20 to 30 years and much of the previous information is quite poorly reported or spotty. Much remains to be learned about Plains Village manifestations, especially those in the Texas panhandle (i.e., Antelope Creek phase and Buried City complex) where few sites have been

thoroughly investigated and reported. In a recent summary of the Antelope Creek phase Brooks (2004) stated, "It should be clear from this overview that vast areas of the Antelope Creek phase are poorly understood or not understood at all." Consequently, Areas A and C of 41RB112, which represent two separate Antelope Creek phase occupational events, provide a significant opportunity to address many unanswered questions concerning this phase and time period.

If Feature 1 represents a pithouse or subterranean habitation structure this would be a very significant discovery and reason to question the Antelope Creek phase assignment to Area A. Currently only a few Antelope Creek sites have yielded subterranean habitation structures (i.e., Two Sisters, Stamper, and probably Alibates Ruin 28 Unit II [Lintz p.c. 2005]; potentially Structure A at Medford Ranch [Duffield 1964]). However, the recently investigated Hank site (Boyd and Wilkens 2001) a few kilometers to the east, the earlier occupations at Buried City just to the northeast have pithouses (Brosowski p.c. 2005), and the Zimms complex (Drass et al. 1987) in western Oklahoma (Drass 1998), all have subterranean houses with wood post walls. The Zimms complex and Buried City complex are roughly contemporaneous with the Antelope Creek phase. Therefore, the understanding of the nature of Feature 1 and the associated material assemblage is important in assigning this specific occupation to a particular cultural manifestation. The presence of decorated rim and neck sherds on cordmarked pottery from Area A is also outside the norm for Antelope Creek sites and may indicate the borrowing of traits, population integration, and/or human variations by the maker of these vessels. Decorated rims are more frequent in the Buried City assemblages (Hughes and Hughes-Jones 1987; Hughes 1991). Trade was definitely being conducted at this time, and specifically by the occupants of Area A, since the obsidian recovered is definitely nonlocal and probably came from northern New Mexico. The few plain surface sherds recovered from Area A may also indicate trade/exchange since plainwares are more common in Plains Village manifestations to the east (i.e., Zimms complex; [Drass 1998], Buried City complex [Hughes 1991]), although some 25 percent of the ceramic assemblage from the McGrath site

in the Oklahoma panhandle also yielded plainware (Lintz 1976), and are not the typical finish for Antelope Creek.

The concentration of cultural debris in Area C appears to reflect a completely separate event than the activities identified in Area A. Although the rock alignment in Area C is similar to the use of rocks in the construction of Antelope Creek structures, it does not exhibit the more characteristic vertical slabs that dominate the majority of Antelope Creek structures in the core area (Lintz 1986). Structure 1 exhibits irregular shaped caliche cobbles. Large caliche rocks were also used in some structures at Buried City (Hughes and Hughes-Jones 1987; Hughes 1991). The lack of other apparent wall sections, stone alignments, or additions connected to this one alignment is disturbing and cause for further evaluation and interpretation. However, cultural materials reflecting a broad range of activities related to habitation surround this alignment and support the interpretation that this is part of a habitation structure.

The thick cordmarked sherds that were clustered a few meters east of the rock alignment may appear to some as an indication of a Woodland event. However, similar thick cordmarked sherds have been recovered from at least three other Antelope Creek phase sites. Although these thick sherds do not appear to be the majority at any one site, they appear to be a small percentage of a number of village assemblages. At Roy Smith, 10 mm cordmarked sherds were recovered from the main structure (a continuous room block), which yielded a number of radiocarbon dates on charcoal dating between 700 to 730 B.P. (Schneider 1969:177). These ages are nearly identical to the five clustered dates obtained from 41RB112.

The presence or 71.4 percent ubiquity value of the plant food resources at 41RB112 is quite high compared to other Antelope Creek sites. This high ubiquity value indicates that maize-based food production was likely an important economic endeavor at his site and potentially in the region. Squash and cheno-ams were identified and are very infrequent at other Antelope Creek phase sites. In fairness, most of the early excavated Antelope

Creek sites were not subjected to much flotation/macrobotanical analyses, therefore it is not clear how frequent these important food resources may have been in other excavated Antelope Creek phase sites. Recently, Boyd (2005) has argued for a greater role for agricultural practices among Antelope Creek populations. Part of his support comes from the recent investigations at four West Pasture sites a short distance to the east to 41RB112. At least Hank's site in West Pasture has yielded considerable evidence for maize.

Both Areas A and C represent horizontally separate areas/assemblages of the Southern Plains Village at 41RB112 and are assigned to Antelope Creek phase. If Feature 1 in Area A and the rock alignment in Area C are both determined to represent habitation structures, then this site will provide a unique opportunity to investigate the reasons why two different types of structures can be linked to the same cultural manifestation at what appears to be the same time period. Regardless what the features end up representing, it will be interesting to discuss why the apparent use of this specific landform by the different Antelope Creek populations at about the same time.

L.6 RECOMMENDATIONS

Parts of site 41RB112, specifically Areas A and C within the APE have yielded diverse classes of cultural material associated with intact cultural features that date to an 80 year period between 630 and 710 B.P. during the Plains Village period based upon the five clustered radiocarbon assays. Preservation is good across most of these two areas with bone, charcoal, and other organic remains recovered both inside and outside cultural features. The presence of intact cultural features that represent a number of concentrated activities in direct association with diverse classes of cultural material and datable remains indicate that the AEP has yielded and has further potential to yield more information important to prehistory specifically to this Plains Village period in this immediate region and across a broader southern Plains landscape. Therefore, TRC recommends that Areas A and C within 41RB112 are eligible for listing on the NRHP under Criterion D and warrants designation as an SAL.

TRC also recommends that these two areas within the APE be targeted for large block mitigation excavations before any further development activities. Area B contained very minimal cultural materials, lacked the diverse classes of materials recovered from Areas A and C, and also lacked cultural features. Area B does not contain sufficient cultural material to contribute to addressing the broader questions at 41RB112. TRC does not recommend Area B as eligible for the NRHP under Criterion D and this part of site 41RB112 does not warrant designation as an SAL. However, limited trenching or sampling may be warranted in Area B to contribute information towards understanding Areas A and C.

L.7 Data Recovery Plan

L.7.1 Introduction

If TxDOT and the THC concur that the investigated section of 41RB112, specifically Areas A and C that contain the remains of mostly buried cultural materials that appear to represent separate, single episodes of use during a very limited time period, possibly as few as 80 radiocarbon years, are eligible for inclusion in the NRHP and for designation as an SAL, TRC proposes that the APE in Areas A and C of TxDOT's right-of-way be targeted for data recovery before any construction activity.

The recovery of diverse data sets (i.e., probable house remains, intact hearth features, deep pit features, remains of cooking activities [ceramic sherds and burned rocks], food processing tools [formal chipped and ground stone tools], subsistence remains (faunal bone, mussel shells, and floral remains [including maize and squash]), and recognition of concentrated activity areas within the APE combined with a relatively short radiocarbon dated occupation period, provide a rare opportunity to investigate a relatively poorly understood period – the Antelope Creek phase of southern Plains prehistory in Texas. Brooks (2004), as Lintz (1984, 1986) discussed before him, states that most of the work conducted on the Antelope Creek phase sites occurred before the refinement of our data recovery techniques. Much of the early work was conducted without adequate provenience controls and major

classes of cultural debris were not systematically collected or collected at all. Often only samples of the faunal and floral remains were collected. Many times screening was not conducted and flotation was not often performed. Therefore, many aspects of the Antelope Creek culture are poorly understood even though many Antelope Creek sites have been excavated. Some aspects are not known at all because there has been a general lack of detail in the reporting, with most artifacts poorly described and poorly illustrated. There is a desperate need for more intensive artifact descriptions and analyses, detail descriptions of houses and features, and more technical analyses. Brooks (2004:331) states that many questions remain unanswered concerning the origin of these people, their way of life, and ultimately, their disappearance from the Southern High Plains. The Antelope Creek sites have received little or no intensive study since 1986 when Lintz tried to delineate the factors underlying the architecture, community and settlement patterns of Antelope Creek through summarizing the old, existing chronology, characterizing the settlement patterns and masonry structures, from previously excavated sites in the core Antelope Creek area around Lake Meredith.

Table L-6 provides a broad overview of the potential study units that could be profitably addressed through excavation of major block areas; subsequent analyses of the data recovered, and detailed reporting of the recovered data sets from site 41RB112. Brief discussions of various study units are presented below to address the broad theme of “the emergence of social complexity in the Southern High Plains region of northwestern Texas”. Following a discussion of each study unit, some specific questions are presented. A proposed operational strategy for obtaining classes of material and other important data sets from 41RB112 necessary to address many of the questions proposed is presented below.

L.7.2 Site Function

Lintz (1986) indicates there are many different types of architectural structures within the Antelope Creek phase. He links these to potential functional differences but also sees social, temporal, and spatial factors contributing to some differences. He divides

the sites into six groupings based on the complexities observed in the structural remains. These include simple and complex subhomesteads, simple and complex homesteads, simple and complex hamlets. He attempts to determine function by examination of associated artifacts recovered from each of these site types. Lintz (1986) encountered many problems that dealt primarily with sample size for divisions, and the poor reporting nature of the existing database. He concluded that a wide range of different activities was conducted at subhomesteads, homesteads, and hamlet sites. In general, he concluded that the two simple subhomesteads sites are thought to be short-term fieldhouse sites subservient to other homesteads or hamlets. In the final analysis he concluded that most sites appear to be self-sufficient in most endeavors. Lintz (1986) also discovered that the greatest density of trade goods and religious goods (i.e., pipes) occurred at the hamlet sites. He also sees some general changes (i.e., room sizes and numbers of roof supports) in the main residential units that are linked to time differences, the “Early” and “Late” subphases. Although some interpretations were derived during Lintz’s study, the limitation of working primarily from lack of controlled excavations and the fact that only 13 of 110 sites have been dated indicates many functional, temporal, and spatial trends still need to be resolved.

- What are the specific functions of features?
- Are specific types of structures related to specific functions?
- Are specific activity areas present that reflect individual tasks?
- Does this single component that currently reveals a diverse material assemblage reflect general homestead activities or specialized function?
- Can group structure be interpreted from the cultural assemblage and/or site structure?
- Does the site function and or site structure relate to a regional pattern with Antelope Creek phase or to some other complex?

L.7.3 Paleoenvironmental Issues

In general, the climate conditions in the Texas panhandle region between about 400 to 800 B.P. has not been well established. Most previous

environmental studies provide very broad interpretations of the climate and often generalize that no significant changes occurred over the last 4000 years. Although most of the available data has limitations, the general consensus is that between about 1000 and 2000 B.P. the conditions were generally wetter than today (Schultz and Rawn 1978; Hall and Lintz 1984; Hall 1988, 1990; Holliday 1995). Further east in central Oklahoma and central Texas, Hall (1990) documented the development of the Copan Soil in many valleys during a period of slow sedimentation and a regionally moister climate. The Copan Soil ranges in age from ca. 1000 to 1900 B.P. (Hall 1990). Increased precipitation in the region would increase spring discharge as the water tables rose. Potentially this would increase discharge and cause local cutting and filling in the local draws. In east-central Texas grass pollen spikes have been linked to alluvial pedogenesis (Bousman 1998). If correct in this association, then dry grassy intervals are associated with alluvial landscape stability, at least in that area.

At about 1000 B.P. the conditions changed, since the Copan Soil did not continue to aggrade. It is believed that the area became dryer (Hall 1988, 1990; Holliday 1995). This dry condition coincided with an episode of channel incision of valley floors (Hall 1988, 1990). Hall (1990) sees this to be a very brief period of less than 200 years. How dry has not been adequately determined. Hall (1988) documents alluvial stability by the presence of a weakly developed A horizon (the Delaware Creek paleosol) that has been dated to about 650 to 400 B.P. This buried soil represents a slowing of valley sedimentation but it is unclear if this represents a moist period (Hall 1988). Holliday (1995) sees an increase in effective moisture around 500 B.P. at least in the Lubbock area. The Apache soil began to form about 450 B.P. at Lubbock Lake (Holliday 1995). Lintz (1986) suggested future research should involve the reconstruction of environmental conditions, specifically the timing, intensity, duration, and periodicity of any fluctuations. Understanding the paleoclimate will provide the foundation in which to interpret the human behaviors and possible responses to the environment. Since little has been done in the Texas panhandle to address these environmental concerns, Lintz's suggestion remains valid today.

The amount of precipitation in the region and the amount of discharge from springs is significant to the human populations in this region because humans were apparently conducting some agricultural activities. The amount of surface moisture would significantly influence the agricultural practices and crop yields.

- Does the environmental evidence from 41RB112 provide additional evidence to evaluate hypotheses regarding increased or decreased moisture conditions?
- Did these environmental conditions influence the availability and/or distribution of bison and other large food animals, thereby influencing the agricultural practice?
- Was it too dry for dry land agriculture during the 400-year period between 400 and 800 B.P. or were crops being irrigated?
- Did climate changes postulated for this period have an effect on the agricultural productivity and/or the foraging capacity of the peoples?
- Did climate changes cause population centers to change locations, increase trade, and/or change subsistence patterns.

L.7.4 Cultural Historical

Plains Village complexes/phases are distinguished by slight differences in settlement patterns, subsistence economies, house variations, artifact assemblage characteristics, trading patterns, and geographical distribution. Antelope Creek sites generally resemble other Southern Plains village manifestations, but are generally distinguished based on architecture characteristics, specifically the use of slabs for foundations of structures. A number of Plains Village manifestations are in the vicinity of 41RB112 (i.e., Zimms, Buried City [Hughes 1991], Odessa [Brosowske 2004]) and proper assignment of 41RB112 is critical to understanding broader regional interactions and settlement patterns.

The current characterization of the Antelope Creek phase is primarily based on the analysis of excavated sites from a limited part of the Canadian River valley near the Alibates quarries at Lake Meredith and a cluster of sites along the North Canadian River in Texas County, Oklahoma. Site 41RB112 is roughly

80 km from the main cluster of sites near the Alibates quarries, some 60 to 70 km from a cluster of sites in the Oklahoma panhandle, and only some 30 km from the Buried City complex materials along Wolf Creek in Ochiltree County.

In general, decorated rims and necks of cordmarked ceramics are rare in Antelope Creek sites. However, decorated cordmarked ceramics constitute a much higher percentage in the Buried City assemblages. The Buried City materials were incorporated into the Antelope Creek phase by Lintz (1986) and others. However, recently Brosowske (2005) has now assigned Buried City to the newly defined Odessa phase situated slightly to the north and east in Oklahoma. Brosowske (2005) has linked the Buried City materials to the Odessa phase based on similarities of material assemblages and the presence of pithouses. However, he states that the pithouses at Buried City predate the earliest stone foundations there. The pithouse dates are about 700 to 520 B.P. (A.D. 1250 to 1380) or similar to Lintz's Early Phase of Antelope Creek. Brosowske (2005) indicates that the pithouses were the original house form at Buried City and that stone foundation structures were a later development. Consequently, there is some question as to what the relationships are between these manifestations and what groups are associated with other groups. Potentially, Feature 1 at 41RB112 is a possible pithouse and potentially similar to those at Buried City. The potential Structure 1 in Area C at 41RB112 is a rock foundation, which indicates Area C might have close affiliations with Buried City or Antelope Creek phase.

Lintz (1986) states that the Antelope Creek phase is one of the best radiocarbon dated cultural manifestations in the Southern Plains. At least 58 radiocarbon dates were available by 1986 and a few more dates have been obtained since that time. Most dates were derived from wood charcoal and the MASCA tree ring corrections factor narrows the broader range down to 300 years between 750 and 450 B.P. (A.D. 1200 to 1500). However, these phase dates were derived from only about 35 percent of the investigated Antelope Creek sites and most individual dates were obtained on samples from poorly understood context. Lintz discusses an "Early" and "Late" subphase to this short 300-year

period. The "Early" subphase dates the first half of this period from about 600 to 750 B.P., whereas the "Late" subphase dates from 450 to 600 B.P. Lintz (1986) sees changes occurring through these two subphases and attributes some detected changes to cultural responses to regional environmental changes. Seven radiocarbon dates mostly on maize are currently available for the Odessa Yates site and range from 390 to 720 B.P. (A.D. 1284 to 1476; Brosowske 2005).

- Can the two cultural events in Areas A and C at site 41RB112 be dated to narrow time periods that coincide with the "Early" and/or "Late" subphases and if so, how are their time differences manifested in the broader cultural assemblages and features.
- Which cluster of Antelope Creek sites, those at Lake Meredith, the Oklahoma panhandle, or Buried City, best correspond in time to the materials from 41RB112?
- Do the projectile point forms/point attributes or other tool forms provide support for time differences between Areas A and C?
- Can a time progression of the occupations be documented in Areas A and C at 41RB112 and reflect the use of this landform by similar groups over a period of time?
- Is there a time division between 41RB112 and the other sites in the region, and if so how it is manifested?
- What accounts for the Antelope Creek phase materials dating some 100 years later than most other Plains Village sites to the east?

L.7.5 Subsistence Issues

This general village period is considered to have been a time during which bison were present across vast areas of the southern plains (Baugh 1986) and bison remains have been previously excavated in Antelope Creek sites (Duffield 1970) and from adjacent Plains village manifestations (Baugh 1986; Brosowske 2004). In general, the faunal collection from the early-excavated Antelope Creek sites have not been adequately described or discussed (less than 50 percent of the sites, Lintz personal communication, July 2005) with a few exceptions (i.e., Duffield 1970; Keller 1975; DeMarcay 1986; Duncan 2002; Lintz 2003). Sometimes the presence

Table L-6. Study Units and Data Sets to Address Questions.

Study Units	Geoarch.	Arch.
1. Landscape Development/Age		
Development of deposits	X	
Soil characterization	X	
2. Site Integrity Assessment (Vertical Patterning)		
Features, structures, and materials by depth		X
Features, structures, and material clarity		X
3. Site Function/Structure		
Feature types, structures, and material associations		X
Artifact classes (burned rocks, mussel shells, tools, lithic debitage) and concentrations		X
Horizontal clarity across areas		X
Stratigraphic clarity		X
4. Paleoenvironmental /Ecological		
Floral and faunal remains		X
Wood cell structure analysis on mesquite wood		X
Phytolith preservation		X
Isotopes from sediments and bones		X
5. Cultural History		
Radiocarbon dating (floral, faunal, burned rock, ceramic)		X
Projectile point typology and tool assemblage characterization		X
Architectural variations		X
6. Subsistence/Ecological		
Vertebrate faunal remains (e.g., mammals, birds, fish)		X
Invertebrate faunal remains (e.g., mussel shells)		X
Macrobotanical identification (features and nonfeatures)		X
Burned rock lipid residue		X
Isotope values from burned rocks, human and animal bones		X
7. Technologies		
Hunting technology (tools, strategies, processing, consumption)		X
Agricultural technology (growing, collecting, processing, storage)		X
Cooking technology (burned rocks, ceramics, features, etc.)		X
Building technology (storage pits, houses, etc.)		X
8. Mobility and Trade Issues		
Comparative tool forms (e.g., points, style, variation, processing tools)		X
Exotic stones (e.g., obsidian, nonlocal cherts; marine shells)		X
Stone tool assemblage characteristics		X
Neutron activation analysis on tool stone for trading patterns		X
Ceramic characterization across the region trading and exchange, populations		X

Table L-6. Study Units and Data Sets to Address Questions (Cont.).

9. Social Implications/Patterns	
Burial practices and status of individuals	?
Patterning of structures and features in sites	X
Trade networks for status or control	X
X = Data Present ? = Unknown/Potentially	

of bison is only reflected in the bone tool assemblage through bison scapula hoes and tibia digging sticks. Duffield (1970) argues that the dependence on bison declines after about 650 B.P. (A.D. 1300), whereas Lintz (1986) argues for increase in bison procurement after that time. Part of the Antelope Creek economy was based on hunting other game resources (i.e., small game, turtles, fish, possibly bird) as well as deer and antelope (Duffield 1970; Keller 1975; Lintz 1986; Duncan 2002; Lintz 2003). Even mussel shells appear to have provided part of the diet with a small cluster of shells just outside “Hank’s House” (Boyd and Wilkens 2001).

Horticultural activities also contributed food during this period, although the evidence of charred maize at sites is limited (i.e., Keller 1975; Dean 1986; Duncan 2002; Lintz 2003). Contributing to the very limited evidence has been the lack of systematic studies of macrobotanical remains from the excavated Antelope Creek sites (Lintz 1986). Consequently, the relative importance of each food item or classes of food (meat verses plants and wild verses cultivated) and scheduling of use of various resources has been difficult to determine. Lintz (1984, 1986) postulates that these peoples were primarily dependent on maize horticulture and bison hunting, supplemented by variable quantities of wild plants and small game. However, Lintz (1986) sees the intensification of drought conditions during that period as adversely affecting the economic base, thus increasing the reliance on bison.

Human skeletal remains from 29 individuals from five sites along the Canadian River and assigned to the Antelope Creek phase were chemically studied by Habicht-Mauche et al. (1994) to investigate the relative significance of certain classes of food resources consumed. The results of trace elements

and stable carbon isotope analyses provide diverse information, but the study was inconclusive in determining the change of bison in the diet over time. The nitrogen isotope analysis indicates statistically significant differences in the diets of males and females. The carbon isotopes indicate about 90 percent of the diet consisted of C₄ plant and animal products. It was not possible to determine the relative importance of bison hunting verses maize agriculture (Habicht-Mauche et al. 1994). However, Habicht-Mauche et al. (1994) concluded that maize was not very important to the Antelope Creek populations. Duncan (2002) conducted a “diet breath and site catchment analysis of a single Antelope Creek site and also concluded that maize agriculture was not very important to the overall diet.” The larger debate thus centers on the role of agriculture within the broader Plains Village societies. Boyd (2005) recently addressed this issue and argues for a greater role of maize than many before him have given credit and stresses its importance cannot be dismissed based on assumed environmental conditions and other poorly founded assumptions.

- Do the faunal remains from 41RB112 represent a single or multiple seasons of occupation?
- Do the subsistence resources at 41RB112 indicate bison were available and/or exploited during this time period? If so, do the subsistence practices reflect seasonal variation in their availability or exploitation of bison?
- What percentage of the total diet does the subsistence resources, such as the terrestrial fauna, flora, agricultural corps, and fresh water mussels, reflect?
- Does the diverse subsistence assemblage reflect a stress-related diet?
- Do cultivated crops or wild plants primarily

dominate the plant food products?

- Does the subsistence data indicate a change in hunting strategies at this site compared to other Antelope Creek Sites?

L.7.6 Technology Issues

In general, the currently available artifact assemblages from Antelope Creek sites reflect a focus on hunting and processing animal parts through the presence of chipped stone tools such as stone arrow points, bifaces, end scrapers, and drills. However, possible agricultural related tools such as bison scapula holes and tibia digging sticks, hammerstones, manos, and metates are present in limited numbers. The frequency and distribution of these later artifacts is in question at many of the excavated Antelope Creek sites, thus it is not clear where the focus was directed. Use-wear on bison scapula tools and tibia digging sticks revealed that wear on many of the scapula tools indicates they were probably not agricultural hoes as many have assumed, but probably used as spatulas for mixing and applying adobe for house building (Huhnke 2001 cited in Boyd 2005). The broader assemblage is very representative of Plains Village societies and reflects great diversity of tasks.

Most stone tool assemblages from the core Antelope Creek sites reflect the use of Alibates agatized dolomite with minimal imported or nonlocal material. Even the Antelope Creek sites in the Oklahoma panhandle have yielded high percentages (80 to 100 percent) of Alibates. However, other Plains Village manifestations to the east reflect a range of other raw materials as well as Alibates. Alibates is considered local since the main quarry sources are further west along the Canadian River near Late Meredith. Some Alibates may have been collected from river gravel deposits downstream from the source area (Wyckoff 1989). Much less frequent here are other local materials that include various quartzites, petrified wood, and opalite.

The ceramic assemblage in Antelope Creek sites is dominated by undecorated Border cordmarked sherds. However, very limited information is available concerning the ceramic industry, as it was not an area of study by Lintz in 1986. Since that time Lintz and Reese-Taylor (1997) conducted

a petrographic study on a small sample (N = 22) of cordmarked rim sherds from the core Antelope Creek sites and compared them to a few sherds from Buried City and a site in central Nebraska. Collared and noncollared cordmarked rims were analyzed. The results indicate the Antelope Creek phase sites in the Canadian River valley are typically tempered with igneous materials, whereas most of the Buried City complex sherds, the collared sherds from Cottonwood Creek, and most of the collared sherds from the Roper site are tempered with sedimentary materials. The noncollared rim sherds are made from igneous material pastes. The results indicate two distinctly different ceramic paste technologies. The collared rim sherds from the sites in the Canadian River valley have stronger shared paste characteristics with the nearby Buried City complex than with the noncollared rim sherds from the same sites (Lintz and Reese-Taylor 1997). The Stamper site also has some decorated rim sherds (Lintz 2004). Sand is the dominant temper in these sherds. The Odessa phase consists of high percentages (greater than 50 percent) of decorated rim sherds on cordmarked bodies. The decorations vary considerably with most common elements being pinched and impressed designs along the upper half of the rim. The exterior surfaces were most often smoothed over cordmarked with some plain exteriors. The Odessa site sherds exhibit sand or sand combined with bone or scoria (Brosowske 2005). Brosowske (2005) also points out that thick, greater than 15 mm cordmarked sherds have been recovered from Buried City in good context with well-dated Middle Ceramic materials. In a comparison of ceramic sherds between Buried City and Alibates Ruin 28, Hughes (2002) determined that the Borger Cordmarked sherds from Alibates Ruin 28 were similar in thickness and overall size to cordmarked sherds from Buried City. However, the two assemblages differed in temper, rim form, decoration, and surface finish. Thus, there is an interesting variability exhibited in the ceramic assemblages and this should provide a fruitful avenue of study.

Architectural characteristics of the houses in the southern Plains Village sites are an extremely important aspect of phase assignment, but there are considerable variations in the structures. The typical

Antelope Creek house has a stone slab foundation with stones set vertically, that may be supplemented with horizontal slabs, vertical posts, or adobe blocks (Lintz 1986). Rooms may be circular, rectangular, or square. These rooms may be isolated or in multiroom blocks in excess of 20 contiguous rooms forming large villages. Some of the larger rectangular structures were often built in shallow pits with elaborate features such as depressed central channels, central hearths, interior roof supports, eastward extended passage ways, raised platforms recessed or projecting from the center of the west wall. Despite the extensive analyses conducted by Lintz in 1986, the overall structure of the settlement pattern is still poorly understood.

- Does the stone tool assemblage reflect the intensive use and recycling of individual tools?
- Was the Alibates material used in these occupations mostly from local gravel sources or from the main quarry source at Lake Meredith?
- Does the ground stone tool assemblage reflect a general (various plants) or specific type of food processing (maize grinding) technology?
- Does the absence of burned rock features at 41RB112 represent a change in cooking technology from the previous periods, or just a selected process of cooking certain food products?
- Are animal resources cooked in the same manner as plant resources?
- Does the ceramic assemblage from 41RB112 best reflect associations with the core Antelope Creek sites at Lake Meredith or other Plains Village manifestations to the north and east?
- From which directions do the ceramic vessels appear to have arrived from or were they made locally on site?
- Do the differences in the tempers used and vessel forms reflect functional, individual, or cultural differences?
- Do the differences in burned rock material types, sizes, and/or shapes reflect different cooking technologies or foods cooked?
- Does the type of cooking technology, the use of ceramic vessels, reflect specific seasonal

use of plants and/or resource processing techniques?

- Do the Fresno and Washita points reflect different backgrounds of the groups that occupied this site or a specific killing instrument for specific types of resource?
- Does the lithic debitage reflect a broad range of knapping activities such as core and biface reduction, tool resharpening, and tool maintenance?
- Do the architectural differences reflect seasonal conditions, some social structure, individual preferences, resource availability, or some other uniting factor?
- Are stone artifacts dominated by local or nonlocal cherts? If nonlocal does this reflect a different technology from the locally made objects?
- Are stone tools produced on-site? If so, is there a distinct pattern of tool production between Areas A and C?

L.7.7 Mobility, Trade, and Interaction Issues

Lintz (1986) discusses intercultural exchange in the Antelope Creek cultural system. He detected three areas of material differences and suggests these are related to intercultural exchange. These areas include food sharing based on disproportionate kinds of bone elements at various sites, the presence of abundant Alibates cherts at Antelope Creek sites in the Oklahoma panhandle, and extensive number of spindle whorls recovered from one site (Medford Ranch).

Southwestern trade goods that are thought to have originated in the Middle Rio Grande district of New Mexico reflect intercultural exchange. The goods include painted and glazed pottery, obsidian, turquoise, and marine shells. Lintz (1986) following Baugh (1982) suggests that the Antelope Creek populations were providing Alibates chert, bone tools, and bison products in exchange for the Southwestern goods. There are also some indications that trade goods were not treated in the same manner. Shell and turquoise jewelry are frequently found with burials. The obsidian and trade ceramics were often scattered around the site and may have been more utilitarian. Lintz (1991) reveals that most

of the smaller settlements yielded very few trade ceramics with the majority recovered from the larger settlements. Lintz (1986, 1991) interprets his data to indicate that Southwestern trade goods were limited in sites that date before 600 B.P. (A.D. 1350), but settlements dating after 600 B.P. had abundance of exotic goods. Here at 41RB112 the three obsidian pieces and the probable Southwestern sherds were from Area A and dated to roughly 700 B.P.

It does not appear that previous researchers have discussed group interactions between Plains Village groups through examination of the different types of cordmarked ceramic vessels at sites or between the different groups. It is possible that the women manufacturing the different vessels were moving about the different regions, and/or phases/complexes and producing their own style of vessels with their individualize decorations on the vessels. The rims from most Antelope Creek sites are generally straight or slightly flaring and undecorated, but decorated or collared rims appear in various sites in different frequencies.

- What evidence exists for widespread trade and interaction during the 41RB112 occupation(s) that may be similar to other sites in the region?
- Does this valley setting combined with the cultural material assemblage reflect the use of the Canadian River valley as an east-to-west transportation corridor for Southwestern goods?
- Are lithic resources (specifically Alibates) being procured from local gravels or brought in from the primary quarry sources near Lake Meredith as part of this trade route?
- Are nonlocal lithic resources present in the assemblage and, if so, where were these resources from and how did they move or arrive at this site (e.g., via direct procurement versus trade)?
- Does the raw material from which the formal tools were manufactured indicate movements across the broad region?
- Did trade, mobility, or population interactions intensify during this period compared to the previous period?
- Do the variations detected in the ceramic

assemblage reflect contact or interactions with other Antelope Creek groups or Plains Villagers?

- Does the higher frequency of trade goods at a few villages support the idea of trade centers?

L.7.8 Social Implications

Burials ($N = 47$) have been recovered from at least nine Antelope Creek phase sites (Lintz 1986). Most burials were single interments, semiflexed, in shallow pits placed in abandoned structures or hill top deposits. There are rare instances of multiple burials with at least one known cemetery (Big Blue Creek) and potentially a second (the Footprint site; Lintz 1986). Most often burials were not placed in any formal pattern or orientation. Stones representing a cairn about 1 m in diameter covered some 64 to 87 percent of the burials (Lintz 1986). Most often the burials lacked associated artifacts; however, those that did contained what have interpreted as utilitarian objects (Lintz 1986). The lack of grave goods has been interpreted as a lack of status differentiations among the population (Lintz 1986). Lintz (1986) states that none of the site reports indicate clear evidence of violent deaths. Lintz goes on to state that much of the cultural dynamics were caused by population pressures due in part from climate deterioration and population growth.

In an alternative perspective, trade relationships with the Southwest may have impacted Plains Village societies. Brosowske (2005) suggests that a few local leaders became enterprising leaders and were the stimulus for promoting trade, establishing trade centers, and encouraged economic intensification. These actions led to changes in the social system at Antelope Creek settlements. The nitrogen isotope analysis on a small sample of human remains indicates statistically significant differences in the diets of males and females (Habicht-Mauche et al. 1994). This seems to reflect different food consumption patterns, but it is not obvious what those differences are at this time.

- If there were internal pressures and/or warfare, where were all the bodies buried?
- What do the grave goods with selected individuals tell us about the social structure?
- Why were people buried in old house

structures and not in planned cemeteries?

- Is there support for status differences among the population or between sexes?
- Are the cairn burials found in some sites truly Antelope Creek burials or some subsequent population?

L.7.9 Field Approach

To obtain the most comprehensive data to address these and other research questions, the following outline is presented for a data recovery plan.

First, before any further excavations and well before the proposed hand-excavations, TRC proposes that a geophysical investigation (resistance and/or magnetic) be conducted across Areas A and C within the APE including the bladed fireguard in those areas. Geophysical surveys have recently been used on a few Plains Village sites (i.e., Odessa Yates and Buried City) with positive results in identifying buried cultural features (Brosowske 2005). We believe this approach will direct the archeologists to specific locations and provide approximate sizes of buried features to insure that these important aspects of this site are detected and excavated even though some may lie below the bladed fireguard or outside the proposed block excavation limits. The early detection of buried features will help guide the subsequent hand-excavations. TRC proposes to conduct the geophysical studies across an area of about 500 to 600 m² in Area A that is all within the APE and encompasses the disturbed fireguard on the western side and the natural prairie on the eastern side. Also TRC proposes to conduct the same geophysical studies across an area of about 200 to 300 m² in Area C that is all within the APE and encompasses the disturbed fireguard near the middle of the APE with some natural prairie on either side. Once the geophysical fieldwork has been completed, the field data manipulated, the results and discussions concerning the detected anomalies will be presented to TRC archeologists to incorporate the findings into the data recovery plan. This step needs to be completed well in advance of the proposed archeological fieldwork to facilitate the planning of the subsequent hand-excavations.

This data recovery plan proposes to obtain data to address the above proposed questions through two

large-area block excavations at site 41RB112. The hand-excavations in these blocks will be directed towards Areas A and C that retain the entire sediment profile outside the fireguard scraping. The use of blocks will enable the detection of spatial patterning of features, artifacts, etc., and facilitate the recovery of cultural assemblages directly associated with the identified cultural features. It is proposed that two linear blocks totaling 205 m² be hand-excavated, about 112 m² in Area A (Figure L-25) and about 93 m² block in Area C at each end of the site (Figure L-26). These proposed hand-excavations will be within a 1-by-1 m grid system across and around identified cultural features and target associated cultural materials lying between 0 and 50 cmbs. If cultural materials and cultural features appear to be quite limited towards the margins of either of the blocks, then some hand-excavations may be redirected towards more productive areas. In Areas A and C the roughly 30-cm-deep fireguard has removed the upper portion of the occupation zone, perhaps half of the vertical deposits. However, the geophysical survey will undoubtedly detect some pit features or other anomalies that extend below the current fireguard surface and those will also be targeted for hand-excavations. Therefore, we are estimating roughly 10 m² will be dug in the existing fireguard to target those anomalies.

A grid of contiguous 1-by-1 meter squares will be laid out within each block area to provide horizontal control over the targeted component. Hand-excavations will then be conducted to remove and screen the sediments from the individual 1-by-1 m units. It is proposed that 10 cm arbitrary levels be used to control the vertical recovery. It is anticipated that five levels (i.e., 50 cm) would be excavated in each unit to ensure complete capture of the targeted cultural component unless the sterile underlying C horizon is encountered before that depth. An excavation level record will be completed for each hand-excavated level. The hand-excavated matrix will be dry screened through 6.4 mm (¼ in) hardware cloth. Cultural materials, such as lithic debitage, stone tools, faunal bone, mussel shell, charcoal, and burned rock, will be collected and placed in resealable plastic bags, and labeled according to the appropriate provenience. Although the vertical nature of the cultural materials is generally known,

vertical depths of many of the larger burned rocks and other larger specimens would be piece-plotted during the hand-excavations. This selective piece-plotting will contribute towards the documentation of the vertical depth of the occupation zone or event(s) and help determine the level from which pit features were originally excavated. The horizontal provenience of the larger pieces of lithic debitage, stone tools, and larger pieces of burned rocks will be mapped to allow spatial patterning and associations to be investigated. This type of plotting will allow horizontal maps to be developed to address site structure, activity areas, and other behavioral patterns.

When clusters of cultural material are encountered, these clusters will be designated as cultural features, they will be hand-excavated, and documented with greater precision. Following careful exposure using hand tools in and around the material concentration, the feature will be photo-documented, mapped in plan and profile views, and measured, and observations made on the context, integrity, and associations of burned rocks and other cultural items. Artifacts and samples (i.e., charcoal, burned rocks, and matrix) from within the feature will be collected. Feature components (i.e., sediment matrix, burned rocks) and sample localities will be drawn in plan and or profile views. Recovered cultural debris from features will be bagged and appropriately labeled separately from the materials collected from the general 10 cm excavation level(s) in which the feature occurs. The only envisioned exception to this rule would be burned rocks, which will primarily be sorted into four size categories, counted and weighed by size category, material typed, and then discarded in the field. Samples of burned rocks will be retained for further detailed analyses. Unscreened feature sediment matrix will be collected, bagged, and appropriately labeled for potential flotation or fine screening in the laboratory. A feature form will be completed for each recognized feature to provide primary data concerning the nature of feature construction and content.

Two complete vertical columns of matrix samples from the excavated Areas A and C will be collected for potential specialized analyses, such as soil texture, stable carbon and nitrogen isotope, and

phytolith analyses. The nature of the stratigraphy and the nature and extent of potential disturbance will influence the selection of sample column localities. Column matrix samples will be collected from thin (<3 cm) horizontal layers.

If possible, a sample of recognized stone tools will not be handled, upon discovery in the field. These selected tools will be carefully bagged and labeled immediately so as not to contaminate them by handling in the laboratory. These tools will not be washed or otherwise processed. A sample of these tools will be selected for high-powered use-wear and/or residue analyses. These analyses will potentially increase the information return and contribute to a broader understanding of the human behavior represented by the analyzed tools and allow specific tool function and activities to be determined.

Scattered burned rocks will be documented in the field with only a small percentage collected and returned to the laboratory for further analyses. It is anticipated that a suite of analyses will be conducted on burned rocks that will enable researchers to address issues relating to cooking technologies and practices, feature function, and subsistence practices. A subset of the collected burned rock sample will be curated following analyses.

A sample of natural cobbles, including both chert and nonchert-bearing pieces, will be collected from exposed gravel lenses along the adjacent two creek valleys next to 41RB112. These natural rock samples will be used to compare and contrast with the cultural materials collected from the site occupations. This collection and comparison will contribute information to address the lithic resource procurement, exploitation, possible trade, and other procurement practices.

It is also suggested that natural clay samples from the adjacent creek valleys and the Canadian River be collected. These can be used in analyses to facilitate addressing whether or not ceramic vessels were locally manufactured or brought in from other areas.

Special attention will be directed towards finding and collecting macrobotanical remains. Individual pieces encountered during general level excavations,

and/or specific features will be collected and bagged. It is also anticipated that the matrix collected and processed from identified features will yield macrobotanical remains. The collected macrobotanical items from identified features, structures, and nonfeatures will be identified to enable studies of species present at the time of the occupation. The identified macrobotanical items will also contribute to a broader understanding of the local environment and the selection processes involved in gathering fuel woods and targeted subsistence resources. If sufficient mesquite wood is identified, it would be advantageous to conduct wood-structure analyses to contribute to our understanding of the moisture conditions during the period of tree growth. Identification of plant species will also help to assess seasonal use of the site. In anticipation of the presence of the mesquite wood structure analysis, the sampling of dead mesquite wood (branches) in the vicinity of 41RB112 would provide a comparison sample to establish and document the present moisture conditions in the area.

Bulk sediment, macrobotanical, C-14, fine-screen, flotation, and other samples will be collected from recognized features and other selected contexts during excavations. Samples shall be collected as needed according to the PI/PA judgment with the primary goals of identifying the data content, placing site deposits in a chronological framework, addressing subsistence issues, and paleoenvironmental conditions.

The stone and bone tools, ceramic sherds, lithic debitage, mussel shells, bone, charcoal, and other cultural materials will be collected, washed, sorted, and counted. If large quantities of lithic debitage or mussel shell are recovered then only selected samples of the bulk debitage and mussel shell will be proposed for curation. If large quantities are not recovered then all the lithic debitage and mussel shell will be curated. All formal and informal tools recognized, ceramic sherds, charcoal, bone, and other cultural materials will be curated.

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Figure L-25. Proposed target area in Area C for data recovery excavations.

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Appendix L-1:

Assessment of Phytoliths Isolated from 41RB112

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The following six sediment samples from 41RB112 were processed for phytoliths: #31-4-2b, Feature 1, 62 to 64 cm; #66-4, Unit A-5, 36 cmbs; #77-4-1a, Unit B-1, 92 to 96 cmbs; #135-4a, Unit C-7, 20 to 24 cmbs; #139-4a, Unit C-7, 60 to 64 cmbs; and #141-4a, Unit C-7, 80 to 84 cmbs.

Phytoliths were isolated from 5-gram samples using a procedure based on heavy-liquid (zinc bromide) flotation and centrifugation. This procedure consists of five basic steps: 1) removal of carbonates with dilute hydrochloric acid; 2) removal of colloidal organics, clays, and very fine silts by deflocculation with sodium pyrophosphate, centrifugation, and decantation through a 7- μ filter; 3) oxidation of sample to remove organics; 4) heavy-liquid flotation of phytoliths from the heavier clastic mineral fraction using zinc bromide concentrated to a specific gravity of 2.3; 5) washing and dehydration of phytoliths with butanol; and 6) dry storage in 1-dram vials.

A representative portion of each phytolith isolate was mounted on a microscope slide in immersion oil under a 22-by-40 mm cover glass and sealed with clear nail lacquer. Each slide was then scanned with a petrographic Zeiss microscope at a magnification of 625X.

Phytoliths were adequately preserved in all samples. C₃ and C₄ grass phytoliths, as well as arboreal phytoliths, were found in all six samples. Therefore, phytolith analysis at 41RB112 would provide interpretable paleoenvironmental and archaeological data.

Appendix L-2

Assessment of Macrobotanical Remains from 41RB112

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INTRODUCTION

Seven flotation samples totaling 26.7 liters were examined in this study. The flotation effort averaged 3.8 liters-per-sample. Sample size varied widely from 0.7 liters to 11.0 liters in volume. The contents of four features were collected for the analysis, including three hearths, Features 3, 4, and 5, and one large pit, Feature 6. Because Feature 6 was not completely excavated it is not fully described and its function has yet to be determined.

LABORATORY METHODS

Flotation

Flotation is the process by which organic remains, primarily charred plant fragments, are recovered from archeological sediments using water as the separating agent. The samples from 41RB112 were processed using a simple screen and swirl technique by pouring the sample into a 5-gallon water-filled bucket. The sample is stirred gently with a narrow metal rod and rocked back and forth. The heavy material, consisting of large clasts, some bone, and occasionally heartwood charcoal or nut charcoal, falls to the bottom of the bucket, and the lighter material, including most of the plant material, both carbonized and uncarbonized, floats to the surface. The floating material is directed onto a 0.375 mm screen, a mesh small enough to catch the smallest seeds. This floating material is called the light fraction. The material that sinks to the bottom, termed the heavy fraction, is passed through a 1mm stainless steel screen. Both fractions are tagged and slowly dried before they are examined in the laboratory. Flotation recovery was tested in two samples using 50 poppy seeds, and 94% of the poppy seeds were recovered.

Laboratory Procedures

The analysis follows standard archeobotanical laboratory procedures. The light fraction of each flotation sample is passed through a nested set of screens of 4 mm, 2 mm, 1 mm, and 0.450 mm mesh and examined for charred material that is separated for identification. Carbonized wood from the 4 mm and 2 mm screens (smaller pieces are seldom identifiable) is separated in a 25-piece grab sample and identified. Care is taken to select representative materials from

both levels (cf. Diehl 2003:213; Huckell 2002:645; Miksicek 1994:243). If the sample contains more than 25 fragments, all the material is scanned and separated into taxonomic categories, and the volume and weight of each taxon or wood type is recorded.

Charred material caught on all of the sieve levels, including the bottom pan, is scanned for floral parts, fruits, seeds, and other potentially edible plant parts such as agave or maize fragments, and these plant parts are counted and examined for identification. Screen- or point-collected macrobotanical samples (radiocarbon samples, etc.) are also sorted, identified, and weighed to the nearest 0.1-g.

Disturbance Indicators

Sample content may be affected by various physical and biological disturbance factors, including insect or small mammal activity, and plant root growth. In an effort to assess this impact, the amount of roots, insect parts, termite pellets, gastropods, rodent fecal pellets, and other biological material is estimated. These amounts are reported on a scale of 1 to 25 (+), 25 to 50 (++), and over 50 fragments or units (+++).

Identification

Due to the rapid decomposition of plant material in soils, only carbonized seeds and wood fragments are considered to be a part of the archeological sample. Identification of carbonized wood is accomplished by using the snap technique, examining the transverse, radial, and tangential surfaces at 8 to 45 power with a binocular dissecting microscope, and comparing the material to reference specimens in the Shumla Archeobotanical Services herbarium. The anatomy of some woods is so similar that identification to species or even genus is not possible. For this reason I combine some taxa into wood types. All identifications in the "type" category represent identifications to the taxon level indicated by the name of the type. For example, willow (*Salix* sp.) and cottonwood (*Populus* sp.), both members of the Salicaceae or willow family, have been placed in an artificial category, Salicaceae (cottonwood-willow). The wood of mesquite and acacia, all members of the legume family (Fabaceae), are also difficult to distinguish. Mesquite usually can be separated from other woody members of that family, but in cases

where this is a problem, the material is assigned to the *Prosopis*-*Acacia* or mesquite/acacia-type.

Many plants of the two genera *Chenopodium* (goosefoot) and *Amaranthus* (pigweed or amaranth) produce seeds that are quite similar and difficult to separate, especially when carbonized or partially decomposed. They also have similar growth habits and economic uses. When seeds are recovered that could be identified to either genus, the term “cheno-am” is used (cf. Adams 1994:177).

Because most modern goosefoot and pigweed seeds are black, it is sometimes difficult to distinguish between modern and potentially archeological specimens. Carbonized (and therefore most likely archeological) cheno-am seeds (achenes) usually are swollen with exudate appearing along an equatorial seam of the fruit coat. The modern material is usually shiny and lacks distortion or any other evidence of heat modification.

Quantifying and Reporting

The results are presented as counts and weights, and are summarized in terms of presence value and seed/fruit density. Presence value or ubiquity is defined as the percentage of all analyzed samples, both productive (with seeds) and unproductive (wood charcoal only or no charcoal), in which a particular taxon is present. I have used this method primarily to evaluate the occurrence of the major food plant resources identified in the samples. Presence value provides a means of determining how widespread a taxon is throughout the samples recovered from a site. For example, if mesquite pod fragments were noted in five of 20 samples, the presence value is 25%. Presence value is not an indication of the abundance of a taxon within a site. There may be one unit (e.g. seed or fruit fragment) of the taxon in each sample, or 100 in each sample, the presence value remains at 25%.

Seed density, taxa per liter, and total charred plant weight per sample provide a measure of sample richness. For the purposes of measuring seed density the term “seed” refers to seeds, fruits and other edible plant parts. In the current study the term seed refers to maize cob fragments including cupules and

kernels, squash rind fragments, and seeds. Density is determined by dividing the number of carbonized seeds and fruit fragments, and other edible plant parts by the volume of the flotation samples from which they were sorted (Miksicek 1994:250). Taxa per liter describes the number of identifiable taxa including wood types, recovered from flotation samples and averaged by the total volume of flotation samples recovered from a site. In addition the total weight of the charred plant material is provided for each sample. These three values provide a good measure basis for comparing the productivity of samples among sites. In turn, they provide an indirect indicator of preservation encountered at a site, and formation processes operating within the site context. For example, high densities of edible seeds usually signal a sample drawn from a primary context, such a storage feature or a processing locale, and this is useful in describing the function of the feature containing the remains.

Results and Discussion

The overview in Table L-2-1 summarizes flotation sample volume, seed density, seed taxa abundance, total charcoal weight, and disturbance indicators. Tables L-2-2 and L-2-3 present the identifications and counts of material recovered from the flotation and macrobotanical samples. Table L-2-4 contains presence values of the plant food resources.

Modern contaminants, primarily roots, were noted in moderate to abundant quantities in all of the flotation samples. Roots were present in all of the samples, insect chitin occurred in samples from Features 5 and 6. Uncarbonized seeds were recovered from three of the samples. Over two-dozen cheno-am seeds or achenes were observed in the sample from Feature 6. *Juniperus* sp. (cedar) seeds recovered from Feature 4, and a single prickly pear seed from Feature 5. The uncarbonized seeds provide an impression of the modern local vegetation as well as an indication of the degree of disturbance at the site. The abundance of roots, insect chitin, and frequency of uncarbonized seeds probably reflects a combination of shallowly buried deposits, deposits affected by shrink-swell clay soils, and/or deposits disturbed by insect and burrowing mammal activity.

Wood

Carbonized wood was slightly more abundant than maize cob fragments and seeds. A total of 167 fragments weighing slightly over 2.0-g were noted in the flotation samples. Only two wood types and the indeterminate category were noted in the samples. Identified wood types were mesquite and juniper, both of which were utilized extensively as fuel and as structural elements in the region. The macrobotanical samples contained more juniper and mesquite wood, as well as some willow-cottonwood wood type. Pinaceae wood type is a collective wood type that may or may not include either juniper or pine. The wood from 41RB112 is probably juniper, but the fragments are small and riddled with holes, so I can't positively assign them to the genus *Juniperus*.

Food Remains

The remains of four food plant taxa were noted in the samples: maize cob fragments, kernels, and cupules, squash rind, cheno-am seeds, and mesquite seeds. Maize fragments were the most widespread and abundant of the food plant remains at the site. A total of 79 maize fragments were recovered from five samples, a presence value of 71.4%. Three of the four features sampled by the flotation samples contained maize fragments.

Although other resources occurred in much smaller quantities, their presence is no less significant. Mesquite was the second most widespread plant resource, occurring in 28.6% of the samples. Four mesquite seeds were noted, two each from Features 4 and 6. A single cheno-am seed was recovered from Feature 4. Squash rind also was noted from Feature 4.

Maize was both common and abundant in the samples. It was recovered from 71.4% of the flotation samples, and was by far the most abundant of the plant food taxa. Interestingly, both cupule/cob fragments and kernels were common. Kernels, though not as abundant as the cupule fragments, occurred in every sample in which maize appeared. Additionally, maize kernels and cupules occurred in a macrobotanical sample collected from the bottom of Feature 5.

Mesquite seeds provide proxy evidence for the consumption of mesquite flour. Mesquite pods or legumes consist of the outer exocarp and mesocarp that surrounds several woody endocarps that contain the seeds. Mesquite flour is produced when the ripe, brownish bean pod is pounded in a mortar and pestle until it is reduced to a sticky mass, which is further dried and pounded. The woody endocarps, and the seeds, are separated from the flour and then discarded. For this reason the seeds and endocarps along with a few small pod fragments are the most commonly encountered parts recovered from archeological sites. The rest has been reduced to flour (Rea 1997; Russell 1908).

Cheno-am type refers to *Chenopodium* sp. (goosefoot) and *Amaranthus* sp. (pigweed) seeds. These are actually achenes, which are fruits composed of a seed encased in a small, hard, pericarp. An achene has the overall appearance of a small seed. Although leaves are seldom preserved in open archeological sites, both the young leaves and the ripened seeds of goosefoot and pigweed would have provided a food source. The seed may be considered proxy evidence for the use of the plant in all its forms.

At least five and perhaps six species of *Amaranthus* grow in the study area. *Amaranthus palmeri* and *A. powellii*, however, is the species most often mentioned in ethnography, primarily because its distribution includes the entire desert southwest where so many ethnographic studies were conducted. Both the seeds and the young leaves were collected and consumed. Ripe seeds were usually harvested by shaking the heads into a basket or threshing the seed heads and beating them over a blanket using a stick (Castetter and Bell 1951). The leaves are rich in plant protein and would have been boiled in a skin or simply steamed over hot rocks.

Amaranthus palmeri, carelessnessweed, is an aggressive plant of open and disturbed spaces. The leaves contain iron, calcium, and niacin as well as vitamins A and C (Hodgson 2001). The Pima ate seeds of the plant after parching them or parching and grinding them into flour (Curtin 1949).

Although there are several species of goosefoot growing in the region, *Chenopodium berlandieri*

(common lamb's quarter) is the one most prominently mentioned in ethnography and its uses are similar to the others. The leaves of common lamb's quarter are very high in calcium and vitamin A (Hodgson 2001). Because some of the leaves contain concentrations of nitrates, which are toxic, most ethnographies note that the young leaves were collected, and some were carefully leached (i.e., the Tarahumara: Pennington 1963). The Yavapai harvested the seeds in a manner similar to amaranth, then parched them on hot coals and ground them into flour (Gifford 1936).

Cheno-am seeds are seldom recovered from the ephemeral hunter-gatherer archeological sites of Texas. By contrast, they occur fairly frequently in more intensively occupied sites in the Southwest. This is probably due to the fact that the seeds are small and are often recovered from heating or storage facilities within the confines of pithouse or pueblo contexts, all of which provide a better environment for concentrating seeds and preserving them. It stands to reason, then, that the Canadian River region with Late Prehistoric pithouse and surface structures occupied by agriculturalists should be an area from which cheno-am seeds are recovered.

A single fragment of squash rind was noted in the seven samples. Squash rind is recognized by the arrangement of its cells in cross-section. The outer edge of the rind is covered by thin epidermis with several layers of thick-walled cells just beneath, and more layers of large and roughly isodiametric, thin walled cells to the inside (Cutler and Whitaker 1961). Although squash rind has not been commonly noted from sites along the Canadian River, its presence in the current study is not surprising. There have been very few flotation samples processed from sites in the region, and it was only a matter of time before squash rind appeared. The squash rind was recovered from Feature 4, a small hearth.

Feature Descriptions

Four features examined in this study include three hearths and a large pit of unidentified function. Feature 3 was a small, shallow basin hearth about 45-cm-wide and 8 to 9-cm-deep with gently sloping sides. The sample analyzed from Feature 3 contained a single maize kernel and some juniper charcoal. Feature 4 also was a small basin-shaped

hearth about 30-cm-wide and about 15-cm-deep. The single sample processed from this context contained considerable evidence of food remains, including a cheno-am seed, a squash rind fragment, 27 maize cupules, 3 kernels, and 2 mesquite seeds. Both juniper and mesquite wood were also noted in these samples.

Feature 5 was a basin hearth measuring 75-cm-wide and 20-cm-deep. Excavators noted that this hearth was disturbed by rodent burrowing and contained fresh grass culm fragments. Four samples were analyzed from Feature 5, and they contained 19 maize cob and cupule fragments and 9 kernels. Juniper and mesquite wood charcoal were noted in the samples as well.

Feature 6 was a large pit that contained a few pieces of burned rock, a couple of bison bones, and scattered charcoal. Although this pit was not completely excavated, the exposed part revealed a depth from 40 to 50 cm, and in plan view it measured over a meter along the north/south axis and at least 80 cm on the east/west axis. A single 11.0 liter sample from the western edge at 40 to 50 cmbs in this feature contained 2 mesquite seeds, 18 maize cupules, and 2 maize kernels.

Presence Value

Table L-2-4 compares presence value/ubiquity of the plant food resources at 41RB112 to other sites in the region. At 71.4%, maize ubiquity indicates that maize-based food production was likely an important economic endeavor in the region. Squash would have been interplanted with the maize. Cheno-ams appeared at the Lonker Site in western Oklahoma, but have not been reported from other sites in the region (Lintz 1984; 1985).

Conclusions

The seven flotation samples from 41RB112 contained small quantities of wood charcoal, a significant amount of maize remains, squash rind, and seeds of mesquite and cheno-am. Although evidence of bioturbation included roots, insect parts, and uncarbonized seeds, the activity did not seem to reduce or displace the archeobotanical

record significantly. The recovery of four edible food taxa from such a limited flotation effort is a clear indication that further excavation 41RB112 has excellent potential for adding to our knowledge of plant production and wild plant utilization in the Canadian River region.

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Table L-2-1. Flotation Sample Summaries, Presented by Unit and Level.

Catalog Number	Feature Number	Provenience, Level	Sample Volume (L)	Light Fraction Volume (ml) and Weight (g)	Insect Parts (ip), Roots (r), Rodent Pellets (rp), Termite Pellets (tp)	Uncharred (modern) Seeds	Number of Charred Seed Taxa	Seed taxa density (seeds/liter)	Total Charred Seeds or Maize Fragments	Density Seeds/Liter	Total Charcoal (grams)
34-4a	3	Trench A-1, 39-51 cm	4	62 ml, 14.8 g	r ++	0	1	0.25	1	0.25	0.1
62-4a	4	A-5, Level 6, 50-66 cm	4	66 ml, 13.4 g	r ++	Juniper (2)	4	1	35	8.75	0.6
120-4-3a	5	General, Cutbank 30-40 cmbs	2	30 ml, 5.0 g	r +++	Prickly pear (1)	1	0.5	13	6.5	0.2
120-4-4a	5	Cutbank, bottom, 32-36 cm	1.5	24 ml, 4.1 g	r +, ip +	0	0	0	0	0	<.1
120-4-5a	5	Cutbank, bottom, 35-40 cm	0.7	15 ml, 2.8 g	r +++	0	1	1.43	2	2.86	0.6
120-4-6a	5	Cutbank, bottom, 36-42 cm	3.5	40 ml, 5.7 g	r ++	0	1	0.29	13	3.71	0.3
132-4a	6	Bottom, C-7, Lvl 6, 50-60 cm	11	145 ml, 25.2 g	r +++, ip ++	Cheno-am (25+)	2	0.18	22	2	0.9
+ = 1 to 25, ++ = 25 to 50, +++ = over 50 fragments or units											

Table L-2-2. Contents of the Seven Flotation Samples.

Catalog Number	Feature Number	Taxon	Common	Part	Count	Wt (g)
34-4a	3	<i>Zea mays</i>	Maize	Kernel	1	<.1
34-4a	3	<i>Juniperus</i> sp.	Juniper	Wood	10	<.1
34-4a	3	Indeterminate	NA	Wood	2	<.1
62-4a	4	Cheno-am	Goosefoot or Pigweed	Seed	2	<.1
62-4a	4	<i>Cucurbita</i> sp.	Squash	Rind	1	<.1
62-4a	4	<i>Prosopis</i> sp.	Mesquite	Seed	2	<.1
62-4a	4	<i>Zea mays</i>	Maize	Cupule	27	0.1
62-4a	4	<i>Zea mays</i>	Maize	Kernel	3	<.1
62-4a	4	Indeterminate	NA	Wood	9	0.2
62-4a	4	<i>Juniperus</i> sp.	Juniper	Wood	19	0.1
62-4a	4	<i>Prosopis</i> sp.	Mesquite	Wood	12	0.1
120-4-3a	5	<i>Zea mays</i>	Maize	Cupule	8	0.1
120-4-3a	5	<i>Zea mays</i>	Maize	Kernel	5	<.1
120-4-3a	5	<i>Juniperus</i> sp.	Juniper	Wood	19	0.1
120-4-3a	5	<i>Prosopis</i> sp.	Mesquite	Wood	5	<.1
120-4-4a	5	<i>Juniperus</i> sp.	Juniper	Wood	6	<.1
120-4-5a	5	<i>Juniperus</i> sp.	Juniper	Wood	19	0.3
120-4-5a	5	<i>Prosopis</i> sp.	Mesquite	Wood	6	0.1
120-4-5a	5	Indeterminate	NA	Wood	3	0.1
120-4-5a	5	<i>Zea mays</i>	Maize	Cob fragment	1	0.1

Table L-2-2. Contents of the Seven Flotation Samples (Cont.).

Catalog Number	Feature Number	Taxon	Common	Part	Count	Wt (g)
120-4-5a	5	<i>Zea mays</i>	Maize	Kernel	1	<.1
120-4-6a	5	<i>Zea mays</i>	Maize	Cupule	10	<.1
120-4-6a	5	<i>Zea mays</i>	Maize	Kernel	3	<.1
120-4-6a	5	<i>Juniperus</i> sp.	Juniper	Wood	17	0.2
120-4-6a	5	Indeterminate	NA	Wood	1	<.1
132-4a	6	<i>Zea mays</i>	Maize	Cupule	18	0.1
132-4a	6	<i>Zea mays</i>	Maize	Kernel	2	<.1
132-4a	6	<i>Prosopis</i> sp.	Mesquite	Seed	2	<.1
132-4a	6	<i>Prosopis</i> sp.	Mesquite	Wood	14	0.2
132-4a	6	<i>Juniperus</i> sp.	Juniper	Wood	25	0.6

Table L-2-3. Contents of the Macrobotanical (14C) Samples.

Catalog Number	Feature Number	Provenience, Level	Taxon	Common	Part	Count	Wt (g)
30-7-1	NA	Cutbank, 63 cm	<i>Juniperus</i> sp.	Juniper	Wood	2	0.1
31-4-2a	1	62-64 cm	<i>Juniperus</i> sp.	Juniper	Wood	3	<.1
34-7	3	Trench A-1, 39-51 cm	Salicaceae	Cottonwood/willow-type	Wood	6	0.1
34-732	3	Trench A-1, 36 cm	<i>Juniperus</i> sp.	Juniper	Wood	10	0.5
34-732	3	Trench A-1, 36 cm	<i>Prosopis</i> sp.	Mesquite	Wood	16	0.5
34-732	3	Trench A-1, 36 cm	Salicaceae	Cottonwood/willow-type	Wood	7	0.4
37-7-1	1	52 cm	Pinaceae	Pine-Juniper Family	Wood	2	<.1
38-7-1	NA	A-1, 28 cmbs	Flecks	NA	NA	--	--
43-7-1	NA	A-2, 33 cmbs	<i>Juniperus</i> sp.	Juniper	Wood	14	0.1
115-7	NA	C-4, 30 cmbs	<i>Juniperus</i> sp.	Juniper	Wood	7	0.1
119-7	NA	C-5, 30-40 cmbs	<i>Juniperus</i> sp.	Juniper	Wood	18	0.2
120-4-3	5, bottom	30-40 cmbs	<i>Juniperus</i> sp.	Juniper	Wood	21	0.2
120-4-3	5, bottom	30-40 cmbs	<i>Prosopis</i> sp.	Mesquite	Wood	2	<.1
120-4-3	5, bottom	30-40 cmbs	<i>Zea mays</i>	Maize	Kernel	10	0.3
120-4-3	5, bottom	30-40 cmbs	<i>Zea mays</i>	Maize	Cupule	2	<.1
128-7	6	C-7, 30-40 cmbs	<i>Juniperus</i> sp.	Juniper	Wood	11	0.3
133-4-a	6, bottom	C-7, 60-70 cm	<i>Juniperus</i> sp.	Juniper	Wood	1	<.1
153-7	NA	C-9, 37 cmbs	Indeterminate diffuse porous	NA	Wood	5	0.1
153-7	NA	C-9, 37 cmbs	<i>Juniperus</i> sp.	Juniper	Wood	2	<.1
164-7-1	Structure 1	C-10, 19 cm	Indeterminate hardwood	NA	Wood	6	<.1
167-7-1	Structure 1	C-10, 34 cm	<i>Juniperus</i> sp.	Juniper	Wood	4	0.1

Table L-2-4. Presence Values at 41RB112 and Other Late Prehistoric Sites.

Taxon	Landergin Mesa (n=40)	Lonker Site (n=6)	Hank's Site (n=22)	41RB112 (n=7; 26.7 liters)	Longview Site (n=1)	41OC29 (n=8; 22 liters)
Maize	3%	80%	13.60%	71.40%	100%	100%
Goosefoot/ Pigweed	3%	80%	4.50%	14.20%		
Mesquite	--	--	--	28.40%		
Sunflower	--	80%	36.40%	--		

Appendix L-3:

Artifact frequency and distributions at 41RB112

TRC CULTURAL RESOURCES PROGRAM																													
ARTIFACT FREQUENCY DISTRIBUTION - TEST PIT SUMMARY																													
SITE NUMBER: 41RB112								TESTING DATES: May 2005								CREW CHIEF: M Quigg								Page: 1 of 3					
Test Pit: A-1								Test Pit: A-2								Test Pit: A-3													
Excavator: Cody								Excavator: Cody								Excavator: Rowe													
CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T						
0-10	0	0	0	0	0	0	0	0-10	0	2	0	0	0	0	0	0	0-10	1	0	0	0	0	0	0					
10-20	8	2	1	0	5	0	0	10-20	4	1	0	0	2	0	0	0	10-20	0	0	0	0	2	0	0					
20-30	7	0	0	0	0	4	0	20-30	21	6	2	20	2em/5	0	0	0	20-30	1	0	0	0	0	0	0					
30-40	0	0	0	0	1	0	0	30-40	6	1	0	2	0	2	0	0	30-40	3	0	1	0	1mano	0	0					
40-50	0	0	0	0	0	0	0	40-50	1	0	0	0	0	0	0	0	40-50	0	0	0	0	0	0	0					
50-60	0	0	0	0	0	0	0	50-60	0	0	0	0	0	0	0	0	50-60	0	0	0	0	0	0	0					
60-70								60-70									60-70												
TOTAL	15	2	1	0	6	4	0	TOTAL	32	10	2	22	2	2	0	0	TOTAL	5	0	1	0	2	0	0					
Test Pit: A-4								Test Pit: A-5								Test Pit: A-6													
Excavator: Matras								Excavator: Rowe								Excavator: Cody													
CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T						
0-10	0	0	0	0	0	0	0	0-10	0	0	0	0	0	0	0	0	0-10	0	1burned	0	0	0	0	0					
10-20	0	0	0	0	0	0	0	10-20	10	3	1	0	1rim/2em	0	0	0	10-20	0	0	0	0	0	0	0					
20-30	1	2	1	0	0	0	0	20-30	12	53	4	1	0	9	0	0	20-30	0	0	0	1	1	0	0					
30-40	6	2	2	0	1em	0	0	30-40	24	26	0	0	0	3	0	0	30-40	4	4	0	0	1	0	0					
40-50	1	0	0	0	0	0	0	40-50	4	3	0	0	feat4/6	0	0	0	40-50	1	0	1	0	0	0	0					
50-60								50-60	0	0	0	0	0	0	0	0	50-60	0	0	0	0	0	0	0					
TOTAL	8	4	3	0	1	0	0	TOTAL	50	85	5	1	0	12	0	0	TOTAL	5	4	1	1	2	0	0					
Test Pit: A-7								Test Pit: A-8								Test Pit: B-1													
Excavator: McGuire								Excavator: Rowe								Excavator: LaBuddle													
CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T						
0-10	0	0	0	0	0	0	0	0-10	Gone							0-10	0	0	0	0	0	0	0	0	0				
10-20	0	0	0	0	0	0	0	10-20								10-20	0	0	0	0	0	0	0						
20-30	0	0	0	0	0	0	0	20-30								20-30	0	0	0	0	0	0	0						
30-40	0	0	0	0	0	0	0	30-40	0	3	0	0	1em	feat3	0	0	30-40	0	0	0	0	0	0	0					
40-50	0	0	0	0	0	0	0	40-50									40-50	0	0	0	0	0	0	0					
50-60	0	0	0	0	0	0	0	50-60									50-60	0	0	0	0	0	0	0					
60-70								60-70									60-70	0	0	0	0	0	0	0					
70-80								70-80									70-80	0	0	0	0	0	0	0					
80-90								80-90									80-90	0	0	0	0	0	0	0					
90-100								90-100									90-100	0	0	0	0	0	0	0					
100-110								100-110									100-110	0	0	0	0	0	0	0					
TOTAL	0	0	0	0	0	0	0	TOTAL	0	3	0	0	1	0	0	0	TOTAL	0	0	0	0	0	0	0					

L=Lithics; B=Bone; S=Shell;
BR=Burned Rock; CE=Ceramic;
CH=Charcoal; T=Tools, EM = Edge
modified flake

For each test pit, tabulate artifact frequency (from field catalog) by artifact class (columns) and depth (rows). Use zero (0) for none. Use final column under each test pit for other artifacts. Use "+" for items present (per level notes) but not counted. Note counts which include a temporal diagnostic with "****". Note bottom of each test pit with a heavy horizontal line. Circle entire level for a test pit if a feature is present. Attach additional sheets as needed.

TRC CULTURAL RESOURCES PROGRAM																								Page: 2 of 3	
ARTIFACT FREQUENCY DISTRIBUTION - TEST PIT SUMMARY																									
SITE NUMBER: 41RB112								TESTING DATES: May 2005								CREW CHIEF: M Quigg									
Test Pit: B-2								Test Pit: B-3								Test Pit: B-4									
Excavator: Rowe								Excavator: Hammond								Excavator: McGuire									
CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T		
0-10	0	0	0	0	0	0	0	0-10	0	0	0	0	0	0	0	0-10	0	0	0	0	0	0	0		
10-20	0	0	0	0	0	0	0	10-20	0	0	0	0	0	0	0	10-20	0	0	0	0	0	0	0		
20-30	0	0	0	0	0	0	0	20-30	0	0	0	0	0	0	0	20-30	0	0	0	0	0	0	0		
30-40	0	0	0	0	0	0	0	30-40	0	0	0	0	0	0	0	30-40	0	0	0	0	0	0	0		
40-50	0	0	0	0	0	0	0	40-50	0	0	0	0	0	0	0	40-50	0	0	0	0	0	0	0		
50-60	0	0	0	0	0	0	0	50-60	0	0	0	0	0	0	0	50-60	0	0	0	0	0	0	0		
60-70	0	0	0	0	0	0	0	60-70	0	0	0	0	0	0	0	60-70	0	0	0	0	0	0	0		
70-80	0	0	0	0	0	0	0	70-80	0	0	0	0	0	0	0	70-80									
80-90	0	0	0	0	0	0	0	80-90								80-90									
90-100	0	0	0	0	0	0	0	90-100								90-100									
100-110	0	0	0	0	0	0	0	100-110								100-110									
TOTAL	0	0	0	0	0	0	0	TOTAL	0	0	0	0	0	0	0	TOTAL	0	0	0	0	0	0	0		
Test Pit: B-5								Test Pit: B-6								Test Pit: B-7									
Excavator: Matras								Excavator: Hammond								Excavator: McGuire									
CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T		
0-10	0	0	0	0	0	0	0	0-10	0	0	0	0	0	0	0	0-10	0	0	0	0	0	0	0		
10-20	0	0	0	0	0	0	0	10-20	0	0	0	0	0	0	0	10-20	4	0	0	0	0	0	0		
20-30	0	0	0	0	0	0	0	20-30	0	0	0	0	0	0	0	20-30	1	2	0	0	0	0	0		
30-40	0	0	0	0	0	0	0	30-40	0	0	0	0	0	0	0	30-40	2	0	0	0	0	0	0		
40-50	0	0	0	0	0	0	0	40-50	0	0	0	0	0	0	0	40-50	0	0	0	0	0	0	0		
50-60	0	0	0	0	0	0	0	50-60	0	0	0	0	0	0	0	50-60									
60-70	0	0	0	0	0	0	0	60-70								60-70									
TOTAL	0	0	0	0	0	0	0	TOTAL	0	0	0	0	0	0	0	TOTAL	7	2	0	0	0	0	0		
Test Pit: B-8								Test Pit: C-1								Test Pit: C-2									
Excavator: Rowe								Excavator: Matras								Excavator: Batten									
CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T		
0-10	0	0	0	0	0	0	0	0-10	0	0	0	0	0	0	0	0-10	0	0	0	0	0	0	0		
10-20	0	0	0	0	0	0	0	10-20	0	0	0	0	0	0	0	10-20	2	1	0	0	0	0	0		
20-30	0	0	0	0	0	0	0	20-30	0	0	0	1	0	0	0	20-30	0	0	0	6	0	0	0		
30-40	0	0	0	0	0	0	0	30-40	0	0	0	1	0	0	0	30-40	0	0	0	1	0	0	0		
40-50	0	0	0	0	0	0	0	40-50	0	0	0	0	0	0	0	40-50	0	0	0	0	0	0	0		
50-60	0	0	0	0	0	0	0	50-60								50-60	0	0	0	0	0	0	0		
60-70	0	0	0	0	0	0	0	60-70								60-70									
TOTAL	0	0	0	0	0	0	0	TOTAL	0	0	0	2	0	0	0	TOTAL	2	3	0	7	0	0	0		
L=Lithics; B=Bone; S=Shell; BR=Burned Rock; CE=Ceramic; CH=Charcoal; T=Tools								For each test pit, tabulate artifact frequency (from field catalog) by artifact class (columns) and depth (rows). Use dash (-) for none. Use final column under each test pit for other artifacts. Use "+" for items present (per level notes) but not counted. Note counts which include a temporal diagnostic with ***. Note bottom of each test pit with a heavy horizontal line. Circle entire level for a test pit if a feature is present. Attach additional sheets as needed.																	

TRC CULTURAL RESOURCES PROGRAM																							
SITE NUMBER: 41RB112												TESTING DATES: May 2005								CREW CHIEF: M Quigg			
Test Pit: C-3												Test Pit: C-4								Test Pit: C-5			
Excavator: Coke												Excavator: Marie								Excavator: Batten			
CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T
0-10	0	0	0	0	0	0	0	0-10	0	0	0	0	0	0	0	0-10	0	0	0	0	0	0	0
10-20	0	0	0	4	0	0	0	10-20	0	1	0	0	3	0	0	10-20	2	1	0	0	0	0	0
20-30	0	0	0	1	0	0	0	20-30	1	7	0	0	0	0	0	20-30	1	4	0	1	3db/3sh	0	0
30-40	0	0	0	2	0	0	0	30-40	1	0	0	0	0	0	0	30-40	3	15	0	2	1em	x	0
40-50	0	0	0	0	0	0	0	40-50	0	0	0	0	0	0	0	40-50	0	0	0	0	0	0	0
50-60	0	0	0	0	0	0	0	50-60								50-60							
TOTAL	0	0	0	7	0	0	0	TOTAL	2	8	0	0	3	0	0	TOTAL	6	20	0	3	0	0	0
Test Pit: C-6												Test Pit: C-7								Test Pit: C-8			
Excavator: Batten												Excavator: LaBuddle								Excavator: Marie			
CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T
0-10	0	0	0	0	0	0	0	0-10	3	0	0	1	0	0	0	0-10	0	0	0	2	0	0	0
10-20	1	1	0	1	0	0	0	10-20	1	1	0	0	rubble	0	0	10-20	1	0	0	1	0	0	0
20-30	1	0	3	0	0	0	0	20-30	3	0	0	0	feat6	0	0	20-30	4	0	2	1	0	0	0
30-40	0	6	0	18	0	0	0	30-40	2	0	0	0	0	x	0	30-40	2	0	0	0	0	0	1pt#145
40-50	0	1	0	0	0	0	0	40-50	?	?	?	0	0	x	0	40-50	2	0	0	2	0	x	0
50-60	0	0	0	0	0	0	0	50-60	?	5	?	3	0	0	1mand	50-60	2	0	0	2	0	x	0
60-70								60-70	?	4	?	4	0	x	0	60-70	1	0	0	0	0	x	0
70-80								70-80								70-80	0	0	0	0	0	0	0
TOTAL	2	8	3	19	0	0	0	TOTAL	9	10	0	8	0	0	0	TOTAL	12	0	2	8	0	0	0
Test Pit: C-9												Test Pit: C-10								Test Pit: C-11			
Excavator: Coke												Excavator: Marie								Excavator: Coke			
CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T	CMBS	L	B	S	BR	CE	CH	T
0-10	5	0	0	0	0	0	0	0-10	2	15	0	2	0	0	0	0-10	0	0	0	1	0	0	0
10-20	2	1	0	0	0	x	0	10-20	3	18	0	6	0	x	0	10-20	1	0	0	5	0	0	0
20-30	1	0	0	3	0	0	0	20-30	10	1	0	3	0	x	1Gstone	20-30	1	0	0	0	0	0	0
30-40	2	5	0	2	2	9	0	30-40	2	0	0	0	0	x	0	30-40	0	0	0	0	0	0	0
40-50	2	8	0	0	0	8	0	40-50								40-50							
50-60	2	0	0	0	0	x	0	50-60								50-60							
190-200								190-200								190-200							
TOTAL	14	14	0	5	2	17	0	TOTAL	17	34	0	11	0	0	0	TOTAL	2	2	0	6	0	0	0

L=Lithics; B=Bone; S=Shell;
BR=Burned Rock; CE=Ceramic;
CH=Charcoal; T=Tools

For each test pit, tabulate artifact frequency (from field catalog) by artifact class (columns) and depth (rows). Use dash (-) for none. Use final column under each test pit for other artifacts. Use "*" for items present (per level notes) but not counted. Note counts which include a temporal diagnostic with "**". Note bottom of each test pit with a heavy horizontal line. Circle entire level for a test pit if a feature is present. Attach additional sheets as needed.

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APPENDIX M

TXDOT CHIPPED STONE PROTOCOL VERSION 2.1

Prepared by:

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Chipped Stone Analytical Protocol

TxDOT Archeological Studies Program

This protocol specifies the observations to be made with respect to chipped-stone artifacts during fieldwork and analysis. It is TxDOT's position that data should be collected with problem-oriented research in mind, but that is not to say that it needs to be used in the context of the study that it is collected in - just that it needs to be systematically reported so that future researchers have access to the data for the purposes of developing innovative research designs. The specific observations included within this protocol have been selected because they have proven valuable for addressing important questions of prehistory, and because they can be feasibly accomplished in most laboratory settings within a reasonable time frame. The implementation of this protocol will not undermine the collection of additional data so long as the need for additional data can be justified with respect to specific research needs. We recognize that reasonable disagreement is possible with respect to those choices.

The following discussion of procedures is designed as a guide for using the data coding key that is part of the TxDOT chipped stone protocol. Data coding is important to the process of recording standardized observations within the proposed state-wide database that will facilitate inter-site comparisons and allow researchers to more readily address regional-scale research questions. It is TxDOT's intent that this protocol be used when analyzing any form of chipped stone tool or core. This portion of the protocol does not address the analysis of groundstone tools or chipped stone non-tools (e.g. symbolic forms).

I. Taxonomy

The artifact taxonomy presented here has been designed as a means to record various levels of analytical data for each specimen, and to move beyond a strict reliance on static artifact names and types. It is hoped that this taxonomy will help identify technological traditions and preferences of technique within and between groups, landscapes, regions, and periods. Taxonomic classification of stone tools will also provide the eventual database with greater analytical potential.

1. Technology

Technology, as used here, relates to the suite of techniques used to produce a lithic implement. The primary distinction at this level is between (1) chipped-stone, and (2) groundstone, although minor categories may be considered. This will be used to separate lithic artifacts at the broadest analytical level. TxDOT anticipates the development of a groundstone protocol in 2009.

2. Group

At the next lower taxonomic level, lithic objects classified as chipped stone (non-debitage) may be separated into two distinct groups. The first group is *Tools*, and includes objects that represent or were intended for (in the case of performs) direct functionality. The second group is *Non-tools*, representing objects of indirect functionality (ex. cores), or objects of an instructional, symbolic or artistic nature (ex. Early Archaic multi-notched lithics). For the purposes of this protocol, only those artifacts grouped as chipped-stone tools are considered.

3. Subgroup

Tool subgroup identifies the primary technique of manufacture. Chipped-stone tools are classified into one of three subgroups: (1) simple detachment-based; (2) complex detachment-based; and (3) core-based. Detachment-based tools are derivative of larger cores. Simple detachment-based tools are classified as either blades or flakes, and are used with modest to no modification following detachment. Complex detachment-based tools undergo substantial modification prior to use. Such tools most commonly originate as macro-flakes or macro-blades detached from a sizable core. The form is then reduced through bifacial or unifacial percussion and, unlike simple detachment-based tools, proceeds through several identifiable reduction stages prior to use. Core-based tools are constructed from material cores (most often in the form of tabular or nodular cobbles) rather than detachments. Such tools are reduced through bifacial or unifacial percussion and proceed through several identifiable reduction stages prior to use. Differentiating between core-based and complex detachment-based tools may not be possible. Complex detachment-based tools can often only be distinguished from core-based tools when they retain characteristics of their origin. These may include a remnant bulb of percussion, striking platform, or (more typically) identifiable ventral surface.

4. Class

A tool class identifies the general form of the tool with implicit information relevant to understanding the techniques of manufacture. For simple detachment-based tools, classes include flakes and blades. For both complex detachment-based tools and core-based tools, classes include bifaces and non-bifaces.

5. Subclass

The subclass of a tool provides additional information with respect to its class, often related to the degree to which the producer adhered to a predetermined manufacturing template. A subclass also encodes implicit information relevant to understanding the degree of expediency with which the tool was crafted. Tools classified as either flakes and blades are sub-classified as either modified or unmodified. Such tools are sub-classified as modified when additional stages of manufacture are required following their initial detachment prior to their use. Sequent flake unifaces, end scrapers, drills, and backed blades are a few examples of modified simple detachment-based tools.

Tools classified as either bifaces or non-bifaces are sub-classified as either formal or informal. If tools fit within a standardized, pervasive, recognizable morphology, they are considered formal as the producer is presumed to have been following a traditional manufacturing template. Unique tool forms that (typically) appear more expedient in design are considered informal.

6. Type

A tool's type identifies aspects of its use. Complex detachment-based and core-based tools should be typed according to their function. Function should be determined through use-wear analysis using the methods and observations outlined below. Some examples of biface tool types include projectiles, adzes, choppers, and knives. Examples of non-biface tool types include scrapers, adzes, and gouges.

Simple detachment-based tools sub-classified as modified flakes should also be typed according to their function (ex. burin, drill, graver, etc.). Simple detachment-based tools sub-classified as unmodified flakes should only be typed as expedient. Simple detachment-based tools sub-classified as unmodified blades should be typed according to their morphology. Common unmodified blade types include dihedral and polyhedral varieties. Simple detachment-based tools sub-classified as modified blades should be typed according to modification form (ex. backed, stemmed, etc.).

7. Subtype / Identity

The identity of a tool form (its subtype) corresponds to how it is commonly identified within the classical typological system. Thus, a projectile may be identified as Angostura, Bell, Clovis, Dalton, Ensor, etc. For tools classified as flakes and blades, the appropriate identity will most often be “not applicable” (an exception would be a Clovis blade).

Figure 1: Artifact taxonomy for chipped stone tools based on technological attributes and reduction characteristics.

Figure 2: Artifact taxonomy for chipped stone objets with primarily non-utilitarian, symbolic purpose.

Figure 3: Taxonomy for chipped stone cores. These are not tools, but rather the objective piece from which tool forms are extracted.

II. Metric Information

8. Max length

Record the maximum observed length of the tool form to the nearest whole millimeter. Do not project or estimate unrepresented portions of the tool form. Using calipers, take this measurement directly from the tool.

9. Max width

Record the maximum observed width of the tool form to the nearest whole millimeter. Do not project or estimate unrepresented portions of the tool form. Using calipers, take this measurement directly from the tool.

Figure 4: Metric measurements recorded directly from tool.

10. Max thickness

Record the maximum observed thickness of the tool form to the nearest whole millimeter. Do not project or estimate unrepresented portions of the tool form. Using calipers, take this measurement directly from the tool.

11. Weight

Record the weight of the tool to the nearest whole gram.

12. Edge angle

The edge angle of the tool should be recorded as an average measure along the used margin of the form. This should be recorded to the nearest 5° interval. Measurements should be made using a goniometer and recorded directly from the tool. Some extrapolation is acceptable where the edge has been blunted from use and the original angle can be determined.

Figure 5: Edge angle can be recorded with the use of a goniometer. As the exact angle may vary across the length of the use edge, it is sufficient to record edge angle to the nearest 5° increment.

III. Attributes

13. Stage

Linear reduction models assist in determining the stage of manufacture an artifact reached within an idealized trajectory. Linear reduction models provide a framework for understanding the functional and behavioral relationships among related sets of artifacts (Collins 1975; Goode 2002; Patterson 1977, Shafer 1983, 1985; Sollberger 1977; Tsirk 1979), and are typically based on theoretical abstractions or on experimental replication (Crabtree 1966). Classifying tools in accordance with a linear reduction scheme allows for a more precise study of manufacturing concerns, and it provides a conceptual model for determining the degree of morphologic variation that finished trajectories may be expected to exhibit. When assessing trait or design variability, it will be most productive to compare finished tool forms that have not been extensively remodeled through recycling efforts. The criteria for determining stage of manufacture used in this work closely follow that of Black et al. (1997).

Five stages in the life cycle trajectory of tools are recognized in this protocol: (1) initial package reduction, (2) blank preparation, (3) preform shaping and thinning, (4) final edge trimming and sharpening, and (5) rejuvenated forms. Assessing manufacturing stage is not a wholly objective enterprise (Goode 2002). Lithic reduction is a linear process, and its separation into discrete units of activity is necessarily subjective. Also, the fragmentary nature of some artifacts, the retention of trace amounts of surface cortex on finished forms, and variability in production patterns due to raw material variability and individual skill all contribute to the occasional difficulty in assigning production stage. However, observing this process in stepwise fashion provides a useful proxy measure for detecting potentially important variations in the organization of lithic resource exploitation.

The first stage of the linear reduction model, *initial package reduction*, reflects the beginning steps of tool manufacture and includes preliminary reduction efforts such as cortex removal, mass thinning, and initial shaping. At this stage, objective pieces typically retain some cortex on one or both faces and reduction is dominated by hard-hammer percussion. Tool forms in their initial production stage are generally irregular in outline, exhibit unrefined edges, and do not provide an indication of the intended manufacturing trajectory. However, tools may be employed as crude “choppers” even at this early stage (Goode 2002: 36). Most expedient tool forms will be assigned to this reduction stage.

The second category, *blank preparation*, is characterized by the production of a less generalized form with a limited set of possible final trajectories. Tool forms in this stage of manufacture, called “blanks” (Crabtree 1972), typically exhibit little if any cortex, although completed tools may exhibit traces of cortex on occasion. As blanks, tools receive further reduction of mass through thinning, which is accomplished with some hard-hammer, but primarily soft-

hammer percussion. Blanks require refinement of lateral margins, which may appear sinuous on bifacial forms. Incipient stems may be initially observed at this stage.

The third category, *preform shaping and thinning*, is characterized by the artisan's full commitment toward a single or very limited number of morphological forms, producing what is commonly called a "preform" (Crabtree 1972b). Preforms exhibit a significant reduction in thickness when compared to blanks, and soft-hammers are used almost exclusively for purposes of reduction. Cortex is rare on these late stage forms. Artifacts categorized as preforms approximate their final design and generally lack only refinement of lateral edges and minor facial thinning. Edges are nearly straight and exhibit minor sinuosity. This is the final stage of production to use direct percussion.

The fourth category, *final edge trimming and sharpening*, includes artifacts that are very near or have reached the end stage of their manufacture. Tools within their final production stage require minor reduction along their margins, which is accomplished exclusively through pressure flaking and indirect percussion. Notching, edge grinding, and final stem preparation are completed at this stage. Artifacts having reached their end stage presumably represent tools that were discarded (often due to breakage), cached, lost, or otherwise abandoned. Finished forms require no additional production efforts, and commonly exhibit use-related edge modification (use-wear). Edges have not been remodeled through refurbishing efforts.

The final category, *rejuvenated forms*, describes artifacts that exhibit pronounced edge retouch or remodeling, a marked reduction in size, or evidence of adaptation to a secondary production trajectory in response to failure or discontinuation of the initial tool form. Tool rejuvenation and other forms of recycling provide important information regarding the perceived value of the resource.

00. [Indeterminate]	03. [Preform]
01. [Initial Reduction]	04. [Final Stage]
02. [Blank]	05. [Rejuvenated]

Figure 6: In the illustration above, "retouched" and "fractured segments" are generally represented by Stage 5 (rejuvenated forms) in the TxDOT Chipped Stone Analytical protocol. However, it should be noted that "fractured segments" will often be identified as belonging to a preform of finished tool, and should be categorized appropriately. The final category, "recycled flakes," would be difficult to identify as deriving from an original formal tool in most instances, and many objects of this character would be included in the lithic assemblage as debitage. Such objects should only be identified as rejuvenated forms when the analyst is certain that a precursor form existed.

Figure 7: In the reduction sequence to the right, "stage one: blank" and "stage two: edged biface" each would be classified under Stage 2 (blank preparation) of the TxDOT Chipped Stone Analytical protocol. Similarly, "stage three: thinned biface" and "stage four: preform" would be classified as Stage 3 (perform shaping and thinning) under the TxDOT Chipped Stone Analytical protocol. The "stage five" shown here relates to Stage 4 of the TxDOT protocol.

14. Portion

A significant number of tools are recovered in a fragmentary state and it is important to record the portion represented. Identify partial forms as "fragments" when too little of the tool remains to determine what part of the tool is represented. As it is occasionally difficult to determine whether a piece corresponded to a proximal or distal segment, even when it was clear that one or the other is represented, an "indeterminate" category has been included.

00. [Indeterminate]	06. [Proximal]
01. [Complete]	07. [Lateral edges missing]
02. [Distal]	08. [Fragment]
03. [Distal-medial]	09. [Barb / shoulder]
04. [Medial]	10. [Ear / tang]
05. [Proximal-medial]	11. [Stem]

Figure 8: Chipped stone tools are more often discovered in a broken state. Recording the portion of the tool that was recovered is necessary for adding context to metric measurements.

15. Failure / Discard

Determining the reason why a particular tool form was discarded is seldom a straightforward endeavor. Oftentimes such a determination cannot be made at all. However, where a cause of discard can be determined, valuable insights regarding production specialization and standardization, raw material conservation, use context, and cultural ideology may be gleaned.

The context of tool discard can be identified as production-related, use-related, and incidental. Production-related discard occurs when tools are discarded during manufacture as the result of technical mistakes or material deficiencies. Use-related discard can result from stress or impact fractures, excessive dulling, material exhaustion, use-loss, or caching. Tool forms may also be lost unintentionally. Each mode of discard will have distinct implications for the likelihood of artifact recovery.

Several factors are also known to complicate determinations of discard cause. Secondary tool modification and material recycling may complicate determinations of failure, as can patina development. Excessive thermal alteration can also present an obstacle for assessing the probable cause of original discard as it is often difficult to determine the point at which the object was altered. Artifacts can be subjected to excessive heat following their discard, as when

affected by modern or ancient surface fires. The over-firing of raw material blanks or preforms may also have contributed to fire-damage.

Production-related Discard

Several authors have previously described snap or bending fractures (Crabtree 1972:60; Whittaker 1994:213; and Tsirk 1979:84). This fracture results when the lithic material is subjected to bending forces that exceed the material's elastic limits. Snap fractures often occur during tool production due to the knapper's failure to provide the objective piece with adequate support as it is reduced. In so doing, vibrations radiate throughout the tool form with each percussive strike, causing a fracture at the point where the elasticity of the material can no longer absorb the vibrations (Whittaker 1994: 213). Bending fractures can also occur quite commonly as the result of tool use. Use derived bending fractures manifest as lateral truncations that often display a rolled or lipped edge along one side of the termination (Shafer 1985: 283). When a rolled lip is observed, it often indicates that the tool was subjected to excessive torque during use. Snap fractures may also derive from material flaws, such as cavities or crystalline inclusions, which cause disharmony in the radiation of percussion waves through the material, or simply produce areas of weak structural integrity (see discussion of material flaws below). Step and hinge fractures present analogous difficulties for tool production or recycling, and while morphologically distinct, they are formed through similar circumstances. They are treated as a single category of failure in this protocol. A step fracture happens when the outward force is too great causing the flake to bend to the point of breaking. This is typically caused by hitting the core with a motion that is too fast which pulls the flake way faster than the propagation through the core; thus causing the snap to occur (Crabtree 1972: 92; Whittaker 1994: 109). Step fractures are similar to snap fractures with regard to the fracture mechanics of brittle solids in that they result in the truncation of material due to the unchanneled dispersion of percussive force. Hinge fractures occur when inadequate percussive force is applied to reduction efforts, preventing the flake from traveling the desired distance (Whittaker 1994: 109). However, rather than the flake being prematurely truncated as in step fractures, hinge fractures are characterized by the full termination of the flake. This termination occurs earlier than the intended point of egress, producing a rounded or blunt break and a disproportionate distribution of material mass that impedes further reduction efforts (Crabtree 1972: 68). Further reduction efforts often produce stacked step fractures or continued hinging, resulting in the inability to further reduce medial areas or to rejuvenate worn-out tool forms (Whittaker 1994: 109). Although they are morphologically dissimilar, the causes of hinge and step fractures, as well as the ensuing impediments for material reduction, are nearly equivalent (Whittaker 1994: 109). While step and hinge fractures often occur in the production of stone tools, they may also occur through tool use. Flakes may be inadvertently removed when tools come into contact with other materials as they are used in various tasks. Regardless of the trajectory stage, step and hinge fracture present a challenge to future reduction efforts, and may necessarily result in discard.

Failure and discard may also occur during reduction and rejuvenation efforts as the result of platform loss. The loss or collapse of a workable striking platform is often the consequence of improper reduction techniques or unanticipated fractures that leave no viable surface on which to strike and remove a desirable flake. Platform loss can occur during efforts to remove excessive mass from the medial areas of cores, preforms, and recycled tools, and may result in the inability to remove a desired mass without compromising the dimensional requirements of the desired trajectory.

Material flaws generally manifest as mineral inclusions or cavities that differ compositionally from the package material. Irregular cleavage planes constitute another material obstacle that can impact the success of manufacturing efforts. When encountered, these flaws can produce anomalous fractures that complicate or preclude further reduction efforts. Common material flaws include macrocrystalline quartz, calcite, or fossil inclusions, as well as solution cavities and thermally-induced fractures. Production failures resulting from unanticipated thermally-induced fractures should be classified as “excessive heat” rather than “material flaw.”

Cotterell and Kamminga (1979) describe overshoot (*outrépassé*) failures as those that result from the application of excessive percussion force, and which cause the fracture path to dive into the objective piece and remove more than the intended mass. Such fractures often occur during the bifacial thinning of blanks and preforms, or in the removal of blades from prepared cores. While failures of this type are most frequently observed during primary production, they may also occur during rejuvenation efforts. Discard will generally be motivated by excessive medial thinning or unrecoverable compromise of the objects design.

Perverse fractures, as defined by Crabtree (1972b: 82), are a spiral or twisting break that initiates at the point of percussion and follows through the object, causing its segmentation. In terms of causation, perverse fractures are the result of a hair-line fracture that resulted from a previous blow. The spiral perverse fracture picks up the old fracture thus resulting in failure. These differ from snap/bending fractures as they are not the result of excessive vibration, but result from a poor choice of striking angle and/or percussion force (as well as a bit of bad luck) that results in the plane of fracture traveling through rather than across the objective piece.

When more than one failure trait is expressed by an artifact, record the most significant cause for failure. For example, if a snap fracture resulted during production due to a fossil or crystalline quartz inclusion within the material, record material flaw as the cause of failure. In conjunction with other features of the assemblage, this information may potentially reveal preference patterns in raw material usage vis-à-vis specific tool classes, correlations between tool forms and discard patterning, and idiosyncratic differences in production skill.

Use-related Discard

Stone tools may be lost in their use-context in myriad ways. Points attached to an errant arrow may be lost or broken; as well they may be carried off embedded in game that was not subsequently subdued. Tools can also be continuously curated and used to the point of material exhaustion. Objects may also be cached in the process of ritual activity, such as when placed in burials. The motives for use-related discard may only be definitively discerned in a limited number of cases. Points with distal spalling, perhaps combined with a stress fracture above the hafting element, may be understood to have suffered an impact fracture. Tools recovered within a burial context may be identified as cached. Heavily recycled forms that cannot practically be further reduced through percussion or pressure flaking to yield an acute edge angle may be identified as exhausted tools. However, complete forms with light or no use-wear are commonly recovered at sites in contexts that do not explicitly indicate caching. When a discard motivation is ambiguous, “indeterminate” should be selected among the alternatives provided below.

Incidental Discard

Incidental discard includes actions that removed objects from their systemic context by means other than manufacturing error, caching, or use (see Schiffer 1972), such as through dropping or misplacing them. However, this category of discard is a theoretical construct, the objective identification of which cannot be systematized. Thus, it is not included as an analytical option for assessing discard.

00. [Indeterminate]	04. [Hinge / step]	08. [Excessive heating]
01. [Snap / end shock]	05. [Overshot (outrépasse)]	09. [Exhausted]
02. [Impact / bending]	06. [Material flaw]	10. [Cached]
03. [Perverse]	07. [Platform loss]

Figure 9: These terminations are often observed on bifacial blanks and preforms that were discarded in the process of manufacture. For the purposes of the protocols, step and hinge fractured are recorded as a single category of failure as the result in a very similar obstruction to the knapper.

Figure 10: These terminations illustrate additional failures that may render the objective piece unusable or incapable of further reduction and recycling.

16. Alteration (choose dominant form)

Material alteration addresses the transformation of structural and compositional properties that occurs as the result of natural and cultural processes. Natural processes include chemical and mechanical weathering, often resulting in patina or material decay. Thermal alteration is an example of material alteration through cultural processes.

An accurate assessment of thermal alteration is often inhibited by artifact size, patina formation, and unfamiliarity on the part of the researcher with some of the lithological variability expressed by select raw materials. Lithic raw materials typically undergo significant and detectable lithological changes with prolonged exposure to heat. Such changes are often desirable and may be deliberately generated by tool producers through controlled firing. Heat-treated materials may be more easily worked by the artisan as the process renders low-quality materials more knappable (albeit while making them more brittle and decreasing their durability).

The identification of heat-treated materials brings culture process and the details of economic activity to the fore. Nonetheless, it is frequently difficult to distinguish purposefully treated materials from those that were incidentally burned. Incidental firing occurred in antiquity through controlled vegetation burns, as well as the occasional burning of middens or other cultural deposits. Historic-age and modern incidental firing may have resulted from burning off surface vegetation when preparing land for cultivation of pasture.

Lithic assemblages often exhibit other forms of material alteration that can obscure the study of raw material properties. The most common of these is the development of a weathering rind that is often identified as a white patina. The rind may be semi-translucent to opaque and is typically less than 3mm in thickness. The development of a yellow to reddish brown “stain” may also develop on lithic artifact surfaces in iron-rich soils. The chemical processes that lead to the development of black (often dark blue) patinas is not completely understood. They most often occur in inundated deposits. Carbonate deposits and pigment staining occur rarely, the former being most common in coastal areas and the latter more common in ritual contexts.

00. [Indeterminate]	03. [Black patina]	06. [Carbonate build-up]
01. [Thermal]	04. [Oxide staining (yellowing)]	99. [Other]
02. [White patina]	05. [Pigment staining]	

17. Edge morphology (D & L & R)

Please indicate the shape of the working edge of the tool. Measuring from a line strung between edge termini, an edge is characterized as very convex if the distance from the cord to the maximum outward projection of the edge is greater than or equal to 5mm. Similarly, an edge is considered convex if the distance from the cord to the maximum outward projection of the edge is between 4.9mm and 2mm. Edges are considered straight if the maximum inward or outward projection of the edge from the cord is no more than 1.9mm. An edge is considered concave if the distance from the cord to the maximum inward projection of the edge is between 4.9mm and 2mm. An edge is characterized as very concave if the distance from the cord to the maximum inward projection of the edge is greater than or equal to 5mm. An edge is considered recurved if the maximum outward projection of the edge from the cord is greater than or equal to 2mm, and the maximum inward projection of the edge from the cord is also greater than or equal to 2mm.

00. [Indeterminate]	03. [Convex]	06.. Very Convex
01. [Straight]	04. [Recurved]	07. Very Concave
02. [Concave]	05. [Serrated]	99. [Not applicable]

Figure 11: Edge morphology has its greatest utility in characterizing projectile points, darts, and knives.

18. Flake scar pattern

Flake scars are the impressions that remain on the face of a flaked stone artifact which are produced by the detachment of flakes during tool manufacture. The pattern of flake removal may offer important insights relating to the distribution of design templates and techniques of manufacture, as well as offer a means by which to observe variability in production design at different spatial scales.

- 00. [**Indeterminate**] a flaking pattern cannot be determined.
- 01. [**Collateral**] a flaking style that is characterized by parallel flakes emanating from opposing edges which meet in the center of the blade, forming a median ridge.
- 02. [**Horizontal transverse**] a flaking style that is characterized by horizontal, parallel flake scars emanating along one edge, traveling across the face of the blade, and terminating at the opposing edge.
- 03. [**Oblique transverse**] a flaking style that is characterized by long, diagonal, parallel flake scars emanating along one edge, traveling across the face of the blade, and terminating at the opposing edge.
- 04. [**Random**] flake removals do not reflect an aesthetic template in their distribution or alignment.
- 99. [**Not applicable**] (expedient flake tools are one form of tool that will not exhibit a flake scar pattern).

Figure 12: Patterns of flake removal in edge construction, potentially related to flaking technique, tool function, aesthetic display, and social identity.

19. Edge construction type

Edge construction type references the location and form of preparatory edge construction on the objective piece. There are a variety of ways in which an edge may be constructed on a chipped stone object. The most basic choice is between bifacial and unifacial constructions. Such choices carry implications for accurately assigning tools to a subgroup, distinguishing between techniques used during production, assessing the foci of use, and determining the angle of the resulting edge. Variability may also occur among subtypes, potentially alluding to differences in raw material access, tool function, or nuances of social identity. For example, while the lateral margins of some Perdiz points are bifacially constructed, others exhibit unifacially beveled edges. The constructed working edge(s) of a tool may be characterized using the following descriptions:

00. [Indeterminate]	08. [Unifacial-bilateral]
01. [Bifacial-distal]	09. [Unifacial-unilateral]
02. [Bifacial-bilateral]	10. [Unifacial-distal-bilateral]
03. [Bifacial-unilateral]	11. [Unifacial-distal-unilateral]
04. [Bifacial-distal-bilateral]	12. [Unifacial-circumferential]
05. [Bifacial-distal-unilateral]	13. [Other]
06. [Bifacial-circumferential]	99. [Not applicable]
07. [Unifacial-distal]	

20. Proximal edge grinding

- ☐ Not Observed
- ☐ Observed

IV. Wear Patterning

The following use-wear observations can be made macroscopically using an 18-20X jeweler's loop, and is considered low-power magnification. Low-power magnification is assumed to imply magnification between 18x-power and 100x-power. This portion of the protocol has not been designed for high-power magnification and Scanning Electron Microscopy. Use-wear characterization using low-power magnification has been shown to successfully identify the range of motion an object was used in, and, to a lesser degree, the hardness of the contact material. High-power magnification is generally needed to accurately identify contact material and detect finer details of object use. The low-power use-wear characterization advocated here will find its greatest utility in quantifying the presence or absence of use, identifying the area of use on a specific piece, and in identifying variability in use among specific artifact types and subtypes. The use-wear categories described below are not mutually exclusive – tools may exhibit more than one form of wear.

Edge modification is not always the product of material use. Other natural and cultural processes, such as trampling and archeological excavation, have been shown to produce edge modification similar to that developed through actual use (McBrearty, et al. 1998; Shea and Klenck 1993; Tringham, et al. 1974). Such processes obviously affect the recognition of some patterns of wear more than others, and may be particularly relevant for detecting true use-wear on simple detachment-based tools. Distinguishing use-derived flake terminations along the lateral margins of tools is perhaps the most equivocal functional assessment; although Odell and Odell-Vereecken (1980) state that the patternlessness of such incidental attrition is detectable and, thus, can be distinguished from actual use-wear with a high level of accuracy. Tools may exhibit a form of polish in deflationary zones derived from aeolian processes, and may exhibit battered edges within fluvial deposits. Given the possibility that edge modification derived from trampling or other processes, “attrition” use wear should only be record for artifacts that exhibit both a distinct, clustered pattern of edge alteration and worn or polished facets in the area of proposed use. While this undoubtedly underestimates the actual amount of use-wear exhibited throughout the assemblage, it substantially increases the accuracy with which positive determinations were made.

The degree of expedient tool use within an assemblage provides one means by which the level and importance of material conservation may be evaluated. Regions characterized by a scarcity of utilitarian lithic raw materials have been shown to exhibit higher levels of material recycling. Careful attention to and recording of use-wear may also provide important information related to spatial and temporal variability expressed within tool classes, types and subtypes.

21. Flaking attrition

Material mass is often removed from the working edge of a tool during the process of use. Much of this attrition is in the form of small flake removals that typically exhibit feathered or stepped terminations. Accurate recording of use-derived attrition requires an analyst to distinguishing these removals from trimming flakes that are detached along a tool's edge in the final preparation stage prior to use. Use-derived attrition can often be distinguished from preparatory trimming as it creates a more obtuse edge angle in the area of use than is expected based on observing edge characteristics elsewhere on prepared, but unused portions of the tool. Use-derived attrition may also remove areas of polish that have developed along tool margins, which may also produce sharper facets that contrast in the area of use with more polished and rounded facets.

Data is coded to record the presence and location of flaking attrition as its distribution on a tool form is a significant indication of tool function. Observations shall be recorded as follows:

00. [Not present] Use if flaking attrition is not observed.
01. [Bifacial-distal] Use if the working edge of a tool is located along the distal margin and attrition is observed on each face (dorsal and ventral).
02. [Bifacial-bilateral] Use if both lateral margins exhibit use-derived attrition and the attrition has resulted in removals on both faces.
03. [Bifacial-unilateral] Use if only one lateral margin (left or right) exhibits use-derived attrition and the attrition has resulted in removals on both faces.
04. [Bifacial-distal-bilateral] Use if both lateral margins and the distal margin exhibit use-derived attrition and the attrition has resulted in removals on both faces. This option will be select if one of the lateral margins exhibits unifacial attrition.
05. [Bifacial-distal-unilateral] Use if only one lateral margin (left or right) and the distal margin exhibit use-derived attrition and the attrition has resulted in removals on both faces.
06. [Bifacial-circumferential] Use if the lateral margins along the entire circumference of the tool form exhibit use-derived attrition and the attrition has resulted in removals on both faces.
07. [Unifacial-distal] Use if the distal margin exhibits use-derived attrition and the attrition is observed on only one face.
08. [Unifacial-bilateral] Use if both lateral margins exhibit use-derived attrition and the attrition has resulted in removals on only one face.
09. [Unifacial-unilateral] Use if only one lateral margin (left or right) exhibits use-derived attrition and the attrition has resulted in removals on only one face.
10. [Unifacial-distal-bilateral] Use if both lateral margins and the distal margin exhibit use-derived attrition and the attrition has resulted in removals on only one face.
11. [Unifacial-distal-unilateral] Use if only one lateral margin (left or right) and the distal margin exhibit use-derived attrition and the attrition has resulted in removals on only one face.
12. [Unifacial-circumferential] Use if the lateral margins along the entire circumference of the tool form exhibit use-derived attrition and the attrition has resulted in removals on only one face.
13. [Unifacial-bilateral-oppositional] This form of attrition is most typically found on tools used as drills or awls. Use if both lateral margins exhibit use-derived attrition and the attrition has resulted in removals along the opposing margins of each face.
14. [Other] Use if none of the above apply and enter a description in the text box provided.

Figure 13: Examples of lateral edge flaking attrition. (A) bifacial-unilateral; (B) unifacial-unilateral; (C) platform abrasion and (likely) post-depositional removals.

22. Crushing

23. Smoothing

Crushing and smoothing describe the form of wear attained through battering, grinding, or polishing. The tool is typically blunted through battering or abrasion against a hard contact material in the process of use. Crushed working surfaces may be a normally achieved trait with little effect of tool utility, such as with hammerstones. Alternatively, crushed surfaces may be an undesired consequence of use and material attrition that necessitates edge resharpening. Smoothing is typically the result of intensive abrasion and is commonly observed on tools used for grinding, polishing, or burnishing (uncommon among chipped-stone tools). Once identified, the distribution of this wear should be recorded using one of the following descriptions:

- 00. [Not present] Use if attrition through crushing or smoothing is not observed.
- 01. [Distal]
- 02. [Distal-lateral]
- 03. [Unilateral]
- 04. [Bilateral]

- 05. [Facial Smoothing]
- 06. [Facet Smoothing]
- 07. [Circumferential]
- 08. [Primary Proximal]
- 09. [Secondary Proximal]

24. Polish

The use-wear category “polish” describes lustrous areas on the tool, typically located at the distal or lateral margins, but occasionally noted on medial surfaces. Record polish as “shallow” when it is restricted to within 5mm of an edge. Define polish as “deep” when it extends beyond 5mm from the edge of its origin.

The origin of polish is not well understood despite having been the subject of generous scholarly attention (Odell 2001). Research into the nature of use-polish is generally focused either on the patterns of polish formed on stone tools as the result of a specific set of activities (cf. Aoyama 1999; Keeley 1977, 1980; Semenov 1964), or on the genesis and composition of polish itself (Fullagar 1991; Grace 1996; Odell 2001). In controlled studies where specific tool forms were utilized in a defined set of prescribed behaviors, researchers have had considerable success in correlating patterns of polish distribution and composition with the specific activities that generated its development. However, studies have also shown that a diverse set of activities may produce virtually identical patterns of use-polish (Lewenstein and Walker 1984). Researchers have also found that specific patterns of polish development do not correlate well with isolable tasks on multifunctional tools (Clark 1988). It is perhaps best to consider that the form of the tool, the raw material used in its manufacture, and the patterns of wear (in any form) observed will provide a range of functional possibilities and limitations for how the tool was used in a particular cultural and techno-environmental setting.

Three processes other than primary contact during use may cause the development of a lustrous sheen, and they should not be recorded as use-derived polish. The first, hafting polish, develops through secondary, use-associated contact. Hafting polish is formed through the tools contact with a hafting element or fastening material. Hafting polish, when present, will typically manifest on both lateral and medial surfaces nearer the proximal end of a tool. Hafting can also be associated with worn, ground, or otherwise blunted lateral margins. Evidence for hafting should be nominally recorded separately from use-wear (see #26 below).

The second process that inhibits the detection of use-derived polish is thermal alteration. In extreme cases, lithic material will become vitrified through over-exposure to heat, producing a lustrous sheen that covers the surface of the artifact and resembles use-derived polish. Grinding, the third process, is a specialized manufacturing technique that results in the development of a luster across the ground surface. The luster forms through the extensive abrasion required in the production process rather than from use.

00. [Not present] Use if use-derived polish is not observed.
01. [Shallow distal <5mm]
02. [Deep distal >5mm]
03. [Shallow lateral <5mm]
04. [Deep lateral >5mm]
05. [Unifacial-medial]
06. [Bifacial-medial]
07. [Bipolar]
08. [Proximal]

Figure 14: Patterns of polish formation and distribution related to use wear. The formation of polish is dependent on the nature of the tool construction material, nature of the contact material, and duration of use.

25. Etching / pitting

Etching and pitting refer to striations or small cavities produced through abrasive contact (Semenov 1964). As with polish, such markings may occasionally derive from production techniques, although this is generally only a concern for tool forms featuring ground or pecked and ground bits. Etching and pitting are better studied microscopically. The macroscopic techniques used in this study are useful for detecting moderate to deep scarring and abrasion that are characteristic of working soils with a significant sand content, but they may have less utility in detecting wear left from working in clayey soils. Striations (etching) may be located along either the distal or lateral margins of the tool. When located at the distal margin they most often run perpendicular to the edge. The extent to which they proceed from the distal margin across the face of a tool can provide some measure of how far the tool penetrated into a contact material. When located along the lateral margins striations more typically run parallel the edge. Striations may be created through quarrying, soil working, planing, polishing, grinding, or any extended lateral movement across a hard or abrasive surface.

00. [Not present] Use if attrition through etching or pitting is not observed.	05. [Unifacial-medial]
01. [Shallow distal <5mm]	06. [Distal-medial]
02. [Deep distal >5mm]	07. [Circumferential]
03. [Shallow lateral <5mm]	08. [Medial-bifacial]
04. [Deep lateral >5mm]	09. [Bipolar]

Figure 15: Development of lateral scars (or striations) developed on the working edge of the tool derived from abrasive and repeated contact between the tool form and contact material.

26. Hafting evidence

Hafting may be identified through lateral edge dulling toward the proximal end of the tool form, polish along the proximal lateral margins and proximal facial facets, and the residual presence of a masticate such as asphaltum. Note the presence or absence of this evidence.

- ☐ Not Observed
- ☐ Observed

V. Raw Material

27. Lithology

The lithologic character of raw materials should be identified to the best, most accurate extent reasonable. The lithic analyst should specifically identify materials only to the extent that they are certain that the information provided is accurate. The most common raw materials have been coded for use. Materials not included in the list provided should be coded as “other” and specifically identified in the text field provided.

01. Unidentified Silex	12. Silicified Limestone	23. Silt-stone
02. Microcrystalline Quartz	13. Quartzite	24. Obsidian
03. Macrocrystalline Quartz	14. Novaculite	25. Manning Fused Glass
04. Chalcedony	15. Rhyolite	26. Ironized sandstone
05. Jasper	16. Basalt	27. Unidentified Sedimentary
06. Chert	17. Serpentine / Greenstone	96. Unidentified Sedimentary
07. Chert-Chalcedony Blend	18. Steatite (soap stone)	97. Unidentified Igneous
08. Dolomite	19. Granite	98. Unidentified Metamorphic
09. Agatized dolomite	20. Marble	99. Other
10. Fossilized Wood	21. Gneiss	
11. Limestone	22. Schist	

28. Source identification

The source areas provided below represent those commonly identified in available literature, but the list is by no means exhaustive (see Banks 1990; Turner and Hester 1999). The identification of lithic raw material source is intended to provide a means to address issues of resource mobilization. However, many issues exist in accurately identifying source areas. For example, Uvalde Gravels contain a good amount of Edwards Chert. The raw material source area should be

identified to the most accurate level possible without unsupportable speculation. It is expected that raw material source areas will not generally be identifiable.

In general, raw material sourcing is assessed using visual identification for chert, chalcedony, and quartzite artifacts as chemical characterization studies have not been reliable in determining source areas. Successful identification of specific resource outcrops is often impossible, but some confidence regarding the general can be gained by matching artifacts (formal tools and debitage) to geological samples taken from individual resource outcrops (ex. Edwards, Alibates, Maravillas, Ogallala). Relevant criteria to consider in matching archaeological materials to geological samples include lithology, material hardness, relative grain size, color, the presence or absence of banding and other irregularities, and the presence and composition of micro-fossils and other inclusions (cf. Morrow 1994). In most instances, determining the area of procurement depends on artifact mass as only large pieces will retain enough compositional character to distinguish between geographically discrete resource areas.

00. Unidentifiable	11. Markely Conglomerate
01. Alibates (Llano Estacado)	12. Pisgah Ridge
02. Antlers Formation	13. Rio Grande Gravels
03. Burro Mesa (Trans-Pecos)	14. Tecovas Formation (cherts and jaspers)
04. Bexar County chert	15. Yegua Gravels (quartzite and petrified wood)
05. Callahan Divide	16. Uvalde Gravels
06. Caballos Mountain	17. Catahoula
07. Central Mineral Region (Llano Uplift)	97. Unidentified local
08. Georgetown Cherts	98. Unidentified regional
09. Edwards Chert	99. Unidentified exotic
10. Manning Fused Glass	100. Other

VI. Projectile point data

29. Point Class

00. Not Applicable	02. Side Notched	04. Triangular
01. Corner Notched	03. Stemmed	05. Lanceolate

30. Point Data**Table 1: Shaded rows have automatically populated data and should not be manually entered.**

	Corner Notched	Side notched	Stemmed	Triangular	Lanceolate	Measurement	Description
	X	X	X	X	X	point length	same as question #8 above
	X	X	X	X	X	point width	same as question #9 above
	X	X	X	X	X	point ratio	Tool width divided by tool length
30a.	X	X	X	X	X	blade length (L)	
29b.	X	X	X	X	X	blade length (R)	
30c.	X	X	X	X	X	base/stem length or basal inflection	
30d.	X	X	X			base/stem width	
30e.	X	X	X		X	neck thickness	
30f.	X	X	X		X	neck width	May be the same as #30d in stemmed forms, and the same as #9 in Lanceolate forms.
30g.	X	X				notch depth (L)	
30h.	X	X				notch depth (R)	
	X	X				notch ratio	Average notch depth divided by width of point
	X	X	X	X	X	base to blade ratio (length)	29e divided by 30a
	X	X	X			base to blade ratio (width)	29f divided by 30b
	X	X	X			base/stem ratio	0 (indeterminate), 1 (short; <= 0.7), 2 (proportionate; >0.7 & <1.3), 3 (long; >=1.3)
30i.	X	X	X			base form	0 (indeterminate), 1 (convex), 2 (straight), 3 (concave), 4 (notched), 5 (pointed), 6 (bulbar)
30j.			X			stem form	0 (indeterminate), 1 (contracting), 2 (parallel), 3 (expanding), 4 (asymmetrical)
30k.				X	X	distal base form	0 (indeterminate), 1 (convex; >=1mm), 2 (straight; <1mm & >1mm), 3 (concave; <-1mm)
30l.			X		X	lateral base/stem form	0 (indeterminate), 1 (contracting), 2 (parallel), 3 (expanding – exhibits tangs), 4 (asymmetrical)
30m.	X	X	X	X	X	blade curvature (L)	0 (indeterminate), 1 (very convex; >=5mm), 2 (convex; <5mm & >=2mm), 3 (straight; <2mm & >2mm), 4 (concave; <=-2mm), 5 (recurved; <-2mm & >2mm)
30n.	X	X	X	X	X	blade curvature (R)	0 (indeterminate), 1 (very convex; >=5mm), 2 (convex; <5mm & >=2mm), 3 (straight; <2mm & >2mm), 4 (concave; <=-2mm), 5 (recurved; <-2mm & >2mm)
30o.	X	X	X			shoulder angle (L)	
30p.	X	X	X			shoulder angle (R)	
30q.			X			shoulder junction	0 (indeterminate), 1 (curved), 2 (angular), 3 (straight)
30r.				X		base angle (L)	
30s.				X		base angle (R)	
	X	X	X	X	X	index of symmetry	

TXDOT PROTOCOL FOR DEBITAGE ANALYSIS

Research Methods: Debitage

There is a great deal of information that may be gained from the study ofdebitage in archaeological assemblages, and researchers have debated the utility of various classes of information, as well as their situational applicability, accuracy, and level of efficiency (Ahler 1989; Andrefsky 1998; Baumler and Downum 1987; Johnson 1989; Magne 1989; Sullivan and Rossen 1985). The analytical process described here provides a useful synthesis of attribute analysis and mass analysis that captures the maximum amount of critical basic data for large collections within a workable time frame while allowing a wide range of research questions to be addressed.

Within this protocol, no linear measurements are recorded for individual artifacts (i.e. flake length, width, thickness, and curvature; platform angle, width, and thickness). Such measurements rarely lend themselves to addressing important or innovative research questions. They also require a large amount of time to collect when analyzing sizable collections and this time investment is invariably unwarranted when assessed against the amount of useful information returned.

Metric Attributes (Number and Weight)

In the interest of analytical efficiency, there is also no good reason to weigh individual flakes. Counts and weights will be assessed for artifact groupings (analytical assemblages) that are created through the analytical process.

Minimum Number of Nodules (MNN)

An assessment of MNN is designed to record the minimum number of individual packages of raw material (nodules) that contributed to a specific analytical assemblage. This may be relevant for determining the number/volume of tools produced, the number of individuals participating in the production activity, raw material preferences, or the degree of deflation, comingling, or disturbance reflected in the assemblage being analyzed. This assessment should be based on observations of raw material type and material properties, and may be augmented through the use of ultraviolet fluorescence. Analysts should consider the effects of differential patination and thermal alteration on observable raw material features when assessing MNN. Analysts should favor lumping over splitting in determining MNN (additional nodules should only be recorded when flakes within an analytical assemblage can not have been derived from the same source package).

Form (Completeness –flake vs. frag vs. shatter)

Sullivan and Rozen (1985:759) have advocated using the analytical categories “complete flake”, “broken flake”, “flake fragment”, and “debris” for the study of flake assemblages, and have illustrated the tendency for each to be represented in different proportions at various stages of manufacture (see also Baumler and Downum 1987). There are many variables that undermine the utility of this approach. Landscapes used for pasture or cultivation, particularly in near-surface deposits, are highly susceptible to trampling and to disturbance by agricultural machinery. Either agent will distort the ratio of complete to broken flakes in such contexts. The movement of artifacts in vertic soils or within contexts characterized by erosion and re-deposition, root disturbances, and ancient cultural disturbances such as area maintenance (to name only a few) are equally likely to affect this ratio. Interpreting manufacturing stage through the percentage of whole vs. broken flakes requires preservation of integrity, in both individual specimens and the original composition of the assemblage, with little post-depositional alteration. Due to the rarity of such an occurrence, the interpretive worth of the categories advocated by Sullivan and Rozen find their greatest utility when used with experimental assemblages.

This protocol does not require that only those flakes within an assemblage that retain a striking platform (whole and proximal flakes) be included for data collection and analysis. While this would reduce spurious data produced through post-depositional processes, distal flake fragments may be excluded from analyses by most statistical packages.

Size-grade Analysis

Sort all debitage by size-grade using nested sieves with 1-inch, ¾-inch, ½-inch, and ¼-inch apertures. Size-grade analysis offers an alternative to taking standard metric measurements of maximum flake length, width, thickness (cf. Andrefsky 1998: 96-100) that substantially increases the efficiency with which large samples may be studied (Ahler 1989). When combined with supplementary data, such as the percentage of dorsal cortex present and platform type, size-grade analysis provides researchers with valuable information regarding production trajectory, the method and organization of raw material procurement, technology of production, production efficiency, and the level of material curation (Ahler 1989; Baumler and Downum 1987; Behm 1983; Bradbury and Franklin 2000).

01.	[1-inch sieve]	03.	[1/2-inch sieve]
02.	[3/4-inch sieve]	04.	[1/4-inch sieve]

Cortex Percent

Perhaps the most common use of cortex observations in debitage analysis is for assessing the stage of manufacture represented by the flake assemblage. Researchers commonly use one of two models of assigning meaning to the percentage of cortex present. The first uses the relative amount of cortex present on each flake to place the individual piece within a linear reduction model, under the assumption that only flakes produced during the initial phases of tool manufacture will exhibit a high percentage of dorsal cortex. Andrefsky (1998:111) refers to this as the “triple cortex” approach, and it can be recognized by the identification of *primary*, *secondary*, and *tertiary* (or *interior*) flakes. As researchers Sullivan and Rozen (1985:756-757) have pointed out, however, there is little standardization among those employing the triple cortex approach, such that the flakes designated as *primary* may be required to have as much as 100 percent dorsal cortex or be permitted to exhibit as little as 50 percent. Similarly, the percentage of dorsal cortex required to identify a *secondary* flake ranges between 100 and 0 percent depending on the researcher, while the percentage of dorsal cortex required for the identification of a *tertiary* flake ranges from between 0 and 25 percent (Sullivan and Rossen 1985:757). As a significant number of *tertiary* flakes -which are often regarded as evidence of final stage manufacture- are produced in the initial phases of core reduction, the traditional classification of debitage into primary, secondary, and tertiary flakes has very little analytical worth.

Ahler (1989:90) has pointed out that the presence of cortex in a lithic waste assemblage, as well as the utility of information gleaned from its study, will vary according to the nature of the raw material, how it was quarried, the reduction technology employed, and the stage of manufacture represented by the assemblage. Also, the presence of cortex at any reduction stage is dependent on the initial presence of cortex prior to reduction (Andrefsky 1998:113-114). The nature of raw material outcrops, the method of quarrying employed, and the technology of production affects the viability of using cortex percent as an indicator of production stage. Even under the best of circumstances, cortex percent may only provide data relevant to broadly distinguish early reduction stages from later stages (Mauldin and Amick 1989:71). Debitage is able to more accurately inform reduction stage and artifact class when classified according to size, percentage of cortex represented, and platform type. The following size categories should be used for classifying debitage.

Cortex Percentages

00.	[0%]	02.	[26-50%]	04.	[76-100%]
01.	[1-25%]	03.	[51-75%]

Figure 16: The graphic above illustrates both a quantifiable and a qualitative means by which to measure or estimate the amount of remnant dorsal cortex on a lithic flake.

Platform Type

The striking platform of a flake is the point of contact where the percussor initiated the flake detachment. The morphology of the platform can yield valuable information pertaining to the stage of manufacture represented by the flake, which in turn reflects the presence, character, and organization of activity areas. Platform morphology can also inform production technology (Andrefsky 1998).

Platform types should be recorded as indeterminate, cortical, flat, complex, abraded, faceted, multifaceted, and rejuvenated (cf. Andrefsky 1998:93-96). Cortical platforms are those that retain some amount of unmodified cortex, and are generally attributable of early production stages. Cortical flakes also generally, but do not necessarily, exhibit dorsal cortex beyond the platform. Flat striking platforms exhibit a smooth, un-faceted striking surface. Flakes detached from unidirectional cores generally exhibit flat platforms (Andrefsky 1998:94), although flakes with flat striking platforms may also be produced in the early stages of bifacial core reduction. Faceted striking platforms exhibit one or more facets, reflecting the removal of previous flakes from the same general area. Although researchers have had some success in determining manufacturing stage using facet counts (Mauldin and Amick 1989; McNany 1988), time constraints and unresolved ambiguity in directly correlating facet count with manufacturing stage in an uncontrolled archeological sample undermine the desirability of including this finer resolution. A simple distinction between single-faceted platforms and multifaceted platforms is advocated in this protocol. Flakes that exhibit bifacial mass removal, often referred to as bifacial thinning flakes, are categorized as having complex platforms. Abraded platforms are those that exhibit attrition caused by purposeful edge preparation procedures. Such platforms are generally rounded or ground in appearance, and often exhibit multiple tiny step fractures. Marginal abrasion is a common practice for preparing a striking platform, and serves as a method of altering the direction of percussor force, which produces a more

predictable flake removal (Andrefsky 1998:96; Whittaker 1994). Abraded platforms are produced in all phases of tool manufacture, but are more common in later stages of production. Finally, rejuvenated platforms reflect tool resharpening and often display remnant use wear along a focal margin. Assemblages dominated by rejuvenated platforms indicate tool maintenance rather than tool production.

Indeterminate identifications generally result from poorly represented (fractured) or wholly absent platforms, or from poor resolution caused by heavy patina. To be clear, it is not desirable to record platform width and thickness or the number of facets present on the dorsal surface of flakes. These attributes are not efficiently recorded through mass analysis procedures, and the information they provide may be ascertained through other means, such as multivariate analysis incorporating the percentage of dorsal cortex present with flake size and platform type.

- 00. [indeterminate]
- 01. [cortical] flakes with cortex observed on striking platforms are produced in the initial stage of package reduction.
- 02. [flat] a single facet, caused by characterizes the striking platform.
- 03. [faceted] two facets are observed on the platform. Assemblages dominated by flakes with double faceted platforms are generally produced in early stage blank production.
- 04. [multifaceted] multiple facets are observed on the platform. Assemblages dominated by flakes with multifaceted platforms are generally produced through work on later stage preforms.
- 05. [abraded] the platform exhibits ground margins
- 06. [complex] complex platforms are bifacial.
- 07. [rejuvenated] rejuvenated platforms are indicative of recycling and will typically exhibit worn edges and remnant polish.
- 08. Missing

Platform Type	Platform Description	Illustration
missing	Flakes are defined as having missing striking platforms if they are flake fragments or shatter that are missing the proximal segment of the flake that includes the point of fracture initiation.	
cortical	Flakes with cortex observed on striking platforms are generally produced in the initial stage of package reduction.
flat	A single facet, caused by a single previous flake removal, characterizes this type of striking platform. Flat (single faceted) platforms are common in early stages of decortification, and are common to blade manufacture when combined with notably abraded edges.
dihedral-faceted	A surface having or formed by two intersecting faces. Assemblages dominated by flakes with double faceted platforms are generally produced in early stage blank production.
multifaceted	Multiple facets are observed on the platform but only along one face of the object. Light abrasion may or not be present. Assemblages dominated by flakes with multifaceted platforms are generally associated with later stages of biface reduction but can also be present in early stage biface reduction.
abraded	Abraded platform exhibit grinding that may obliterate facet ridges and/or exhibit platform edge smoothing/rounding visible to the naked eye or under low power magnification. Heavily abraded platforms are often "dull" or smooth to the touch. Abraded platforms serve to strengthen a platform edge allowing for the application of greater force loads thus increasing successful flake propagation and decreasing platform failure by crushing or collapse.
complex	Complex platforms exhibit pressure or light percussion scars on the proximal-dorsal flake surface originating from the platform edge. These scars are typically associated with precision platform preparation (i.e., isolation and orientation) of late stage bifaces where manufacturing failure rates increase proportional to width to thickness ratios.

rejuvenated	Rejuvenated platforms are indicative of recycling and will typically exhibit worn edges and remnant polish.
indeterminate	In some instances, the platform type will not be determinable even when the striking area is present. This is typically caused by crushing of the platform at the instant of production, or by post-depositional weathering.	

Figure 17: 10-20x magnification (hand lens or loop) is recommended for viewing platforms on debitage in the ¼ - ½ inch size grades.

Thermal Alteration

Thermal alteration is used here to describe the process of purposefully subjecting lithic materials to a heat source as a means to affect raw material properties. Lithic raw materials typically undergo significant and detectable lithological changes with prolonged exposure to heat. Such changes are often desirable and may be deliberately generated by tool producers through controlled firing. Heat-treated materials may be more easily worked by the artisan, thus rendering low-quality materials more useful (albeit while making them more brittle and decreasing their durability).

An accurate assessment of thermal alteration is often inhibited by artifact size, patina formation, the production of comparable attributes through incidental fire exposure, and unfamiliarity on the part of the researcher with the lithological variability expressed by select raw materials in their natural state. The identification of heat-treated materials can bring culture process and the details of economic activity to the fore. For example, the presence of thermal alteration in combination with an assessment of platform type and cortex representation can indicated the trajectory stage at which the objective piece was heat-treated. Nonetheless, it is frequently difficult to distinguish purposefully treated materials from those that were incidentally burned. Given the inherent difficulty with distinguishing between materials were purposefully heat-treated (cultural process) as opposed to fire-affected (incidental alteration resulting from both natural and cultural processes), debitage should be recorded as thermally altered, not altered, or indeterminate with regard to alteration conservatively and through incorporation of ancillary data. Identifying alteration on pieces with insufficient mass is unreliable, and so all small-sized debitage that is not minimally captured by a ½-inch mesh sieve should be recorded as indeterminate. If a piece has been determined to be altered its context and association should be considered (e.g. if other artifact classes for the same context similarly burned the piece is more likely to have been incidentally fire affected).

- 00. [indeterminate]
- 01. [thermal alteration observed]
- 02. [thermal alteration not observed]

Analytical Process

By combining the above attributes into criteria lists and then recording the number and aggregate weight of flakes that fit a given set of criteria, this system allows for numerous unique attribute combinations for all debitage within a given provenience. This system works efficiently for large volumes of material and produces an easily queried database.

First, flakes from a given provenience should be sorted by raw material or individual package where it is obvious that the assemblage represents the reduction of separate material packages and such packages are distinctly identifiable. Uniquely identifiable raw material groupings will represent distinct analytical assemblages within each provenience. Next, for each separate package group, sort whole and proximal flakes by size within a given spatial context. Following this, inspect flakes within the 1-inch and ¾-inch sieve size groups for evidence of use-wear (use-derived edge modification is unlikely to be reliably reflected on smaller flakes and they should not be evaluated for possible use). Remove utilized flakes for analysis under the chipped-stone tool protocol. Next, within each size group, sort flakes according to whether or not they are thermally altered (this step will not be performed for the two smallest size groups). Sort flakes within each alteration group (or size group if not separated by alteration) according to the amount of dorsal cortex that is present. From each of the cortex groups, sort flakes by platform type. Finally, count and record the total number of flakes in each of these final groupings and collectively weigh them in grams (round to the nearest gram) and record the MNN for the grouping.

Data derived from formal tool and debitage analyses are complementary. Each data set provides a more informed perspective on the other. Individually, however, each data set may make a distinct contribution with respect to illuminating a particular set of cultural processes and behaviors.

material	period	Size grade	cortex	platform	thermal alteration	edge modification
00 – indeterminate	01 – early Paleo	01 – 1”	00 – 0%	00 - indeterminate	00 - no	00 - absent
01 – local	02 – late Paleo	02 - ¾”	01 - 1-25%	01 - cortical	01 - yes	01 - present
02 – regional	03 – general Paleo	03 - ½”	02 – 26-50%	02 - flat	02 - indeterminate	
03 – exotic	04 – early Archaic	04 - ¼”	03 – 51-75%	03 - faceted.		
	05 – middle Archaic		04 – 76-100%	04 - abraded		
	06 – late Archaic			05 - complex		
	07 – transitional Archaic / early Ceramic			06 - rejuvenated		
completeness	08 – general Archaic			Metrics <ul style="list-style-type: none"> record number within each final grouping record aggregate weight of final group 		
01 – complete	09 – late Prehistoric					
02 – broken	10 – Historic (general)					
03 – fragment	11 – Historic (Spanish)					
04 - debris	12 – Historic (French)		General Period		Regions (from T.B.H.)	
	13 – Historic (Mexican)		01 – Paleo Indian		1. Plateaus and Canyonlands	
	14 – Historic (Texas Republic)		02 – Archaic		2. South Texas Plains (Rio Grande)	
	15 – Historic (Confederate)		03 – Late Prehistoric		3. Mountains and Basins	
	16 – Historic (1870-present)		04 – Historic		4. Prairies and Marshlands	
	17 – General Historic				5. Rolling Plains	
					6. Timbers and Prairies	
minimum number of individual nodules					7. Pinewoods	
					8. High Plains	

TAXONOMY

1. Technology:
2. Group:
3. Subgroup:
4. Class:
5. Subclass:
6. Type:
7. Identity:

METRIC INFO / Measurements

8. Max length (mm):
9. Max width (mm):
10. Max thickness (mm):
11. Weight (g):
12. Edge angle (working edge averaged to nearest 5°):

ATTRIBUTES

13. Stage
 00. Indeterminate
 01. Initial reduction
 02. Early stage forming
 03. Late stage perform
 04. Finished product
 05. Recycled
14. Portion
 00. Indeterminate
 01. Complete
 02. Distal
 03. Distal-medial
 04. Medial
 05. Proximal-medial
 06. Proximal
 07. Lateral edges missing
 08. Fragment
 09. barb / shoulder
 10. ear / tang
 11. stem
15. Failure
 00. Indeterminate
 01. Snap / end shock
 02. Impact / bending
 03. Perverse
 04. Hinge / Step
 05. Overshot (outrepasse)
 06. Material flaw
 07. Platform loss
 08. Excessive heating
 09. Exhausted
16. Alteration
 00. None observed
 01. Thermal
 02. White patina
 03. Black patina
 04. Oxide staining (yellowing)
 05. Pigment staining
 06. Carbonate build-up
17. Edge Morphology [17a=L; 17b=R]
 00. Indeterminate
 01. Concave
 02. Convex
 03. Recurved
 04. Serrated
18. Flake Scar Pattern
 00. Indeterminate
 01. Collateral
 02. Horizontal transverse
 03. Oblique transverse
 04. Random
 99. Not Applicable

19. Edge Construction Type
 00. Indeterminate
 01. Bifacial – distal
 02. Bifacial – bilateral
 03. Bifacial – unilateral
 04. Bifacial – distal – bilateral
 05. Bifacial – distal – unilateral
 06. Bifacial – circumferential
 07. Unifacial – distal
 08. Unif – bilat – conforming
 09. Unif – bilateral – opposing
 10. Unifacial – unilateral
 11. Unif – distal – bilateral-conform
 12. Unif – distal – bilateral-opp
 13. Unifacial – distal – unilateral
 14. Unifacial – circumferential
 15. Other
 99. Not applicable
20. Proximal edge grinding
 - ☐ Not observed
 - ☐ Observed

WEAR PATTERNING (macroscopic)

21. Flaking
 00. Not present
 01. Bifacial – distal
 02. Bifacial – bilateral
 03. Bifacial – unilateral
 04. Bifacial – distal – bilateral
 05. Bifacial – distal – unilateral
 06. Bifacial – circumferential
 07. Unifacial – distal
 08. Unifacial – bilateral - conform
 09. Unifacial – bilateral - opposing
 10. Unifacial – unilateral
 11. Unif – distal – bilateral-conform
 12. Unif – distal – bilateral-opposing
 13. Unifacial – distal – bilateral
 14. Unifacial – distal – unilateral
 15. Unifacial – circumferential
 16. Other
22. Crushing
 00. Not Present
 01. Distal
 02. Distal – lateral
 03. Unilateral
 04. Bilateral
 05. Facial smoothing
 06. Facet smoothing
 07. Circumferential
 08. Primary proximal
 09. Secondary proximal
23. Smoothing
 00. Not Present
 01. Distal
 02. Distal – lateral
 03. Unilateral
 04. Bilateral
 05. Facial smoothing
 06. Facet smoothing
 07. Circumferential
 08. Primary proximal
 09. Secondary proximal
24. Polishing
 00. Not present
 01. Shallow distal (<5mm)
 02. Deep distal (>5mm)
 03. Shallow lateral (<5mm)
 04. Deep lateral (>5mm)
 05. Unifacial medial
 06. Bifacial medial
 07. Bipolar
 08. Proximal

26. Etching / Pitting
 00. Not present
 01. Shallow distal (<5mm)
 02. Deep distal (>5mm)
 03. Shallow lateral (<5mm)
 04. Deep lateral (>5mm)
 05. Unifacial medial
 06. Distal medial
 07. Circumferential
 08. Medial bifacial
 09. Bipolar
27. Hafting evidence
 - ☐ Not observed
 - ☐ Observed
 - ☐ Not Applicable

RAW MATERIAL

28. Lithology
 01. Unidentified Silex
 02. Microcrystalline Quartz
 03. Macrocrystalline Quartz
 04. Chalcedony
 05. Jasper
 06. Chert
 07. Chert-Chalcedony Blend
 08. Dolomite
 09. Agatized dolomite
 10. Fossilized Wood
 11. Limestone
 12. Silicified Limestone
 13. Ortho-Quartzite
 14. Meta-Quartzite
 15. Novaculite
 16. Rhyolite
 17. Basalt
 18. Serpentine / Greenstone
 19. Steatite (soap stone)
 20. Granite
 21. Marble
 22. Gneiss
 23. Schist
 24. Silt-stone
 25. Obsidian
 26. Manning Fused Glass
 27. Ironized sandstone
 96. Unidentified Sedimentary
 97. Unidentified Igneous
 98. Unidentified Metamorphic
 99. Other
29. Major Sources
 00. Unidentifiable
 01. Alibates (Llano Estacado)
 02. Antlers Formation
 03. Burro Mesa (Trans-Pecos)
 04. Bexar County chert
 05. Callahan Divide
 06. Caballos Mountain
 07. Central Mineral Region (Llano Uplift)
 08. Georgetown Cherts
 09. Edwards Chert
 10. Manning Fused Glass
 11. Markely Conglomerate
 12. Pisgah Ridge
 13. Rio Grande Gravels
 14. Tecovas Formation (cherts and jaspers)
 15. Yegua Gravels (quartzite and petrified wood)
 16. Uvalde Gravels
 17. Catahoula
 97. Unidentified local
 98. Unidentified exotic
 99. Other

Questions for Middle-Level and High-Level Theory Using Debitage Data

*** Many of these questions can be best or only answered with respect to complementary data from other material classes.**

QUESTIONS

1. What is being produced? (biface, blades, expedient flakes, points, etc... may be identified by class or type).
2. What techniques were used in its production? (bifacial reduction, prismatic core, bipolar reduction, channel flaking, etc...).
3. What part of the production process is represented by the available assemblage? (stage in trajectory).
4. What function was the objective piece meant to serve? (this deduction is generally only possible when waste can be related to finished products with observable use-wear, or production failures of known function)
5. How many were being made? (flake-to-tool ratios are inherently spurious without diagnostic flakes and researchers should be cautious when addressing this issue; raw material type differences may be valuable in establishing a minimum number objects produced)
6. Who was making it? (age, gender, and social status are typically central to this issue, and the question may be best addressed –if it is indeed possible to do so- with respect to the context and composition of deposit, and its association with identified activity areas)
7. How many people were involved in creating the assemblage and what was their relationship? (this assumes that the waste actually has the meaning that we assign to it and that variation in flaking is not the result of an ancillary feature in the manufacturing process such as raw material type and quality)
8. Is this where the constituent components of the assemblage originally entered the archeological record? (the integrity of deposit should be considered with respect to natural and cultural transformation processes, including disturbances and patterns of refuse disposal)
9. Was the product for immediate use? (consider degree of material curation, production stage, environmental setting, and degree of expediency in tool design)
10. Was the material easy to come by? (consider the local availability of the raw material, as well as the degree of material curation and conservation observed in the relative percentage of use-wear observed on flakes, and the degree to which tools are recycled)
11. Was the raw material easy to use? (this assessment of raw material quality may be addressed through error rates and thermal alteration, but also in consideration of the amount of material mass that remains when expended tools are discarded)

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APPENDIX N

TXDOT CERAMIC PROTOCOL, VERSION 2.0

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TxDOT Ceramic Standards and Guidelines

Version 2.0 (3/11/10)

Subject to Revision

(Please include date and version used in Research Design)

The purpose of the Ceramic Standards and Guidelines is to gain a better understanding of the ceramic universe in Texas. At the time of this writing these Standards and Guidelines apply only to prehistoric and/or indigenous early historic period ceramics (i.e. wares produced by Native Americans that post-date European contact, such as those found in Spanish missions, etc.). Standards and Guidelines for non-indigenous historic-era ceramics are currently being developed by TxDOT.

After reviewing ceramic studies conducted in Texas TxDOT archeologists recognized that a fundamental problem in ceramic analyses was the absence of standardization primarily in terms of sampling and the application of the same analytical techniques to all sherds in a specific sample. Thus, the need for these standards and guidelines is based on the paucity of statistical sampling and precise application of specific analytical techniques, both of which contribute significantly to our ignorance concerning the potential information available from prehistoric ceramics in Texas. In terms of Section 106, our ignorance may constitute negligence in terms of our ability to evaluate historic properties based on specific criteria. The significance of defining the chemical composition of ceramics and sourcing clays through combinations of INAA, ICP, petrography, and stylistic analyses lies in their potential for contributing to our understanding of stylistic, technological, and chemical parameters of pottery manufacture and their associations with various historic ethnic groups as well as prehistoric socio-cultural identities throughout the region (Cecil 2001, 2004, 2007; Cecil and Neff 2006).

To summarize, there is little in the current state of affairs that will facilitate or speed us towards defining (geophysically) specific ceramic types/wares and/or sources in the State of Texas. Therefore, we propose to define the ceramic universe by:

- observing and documenting variability in plastic and aplastic elements of ceramic artifacts in order to determine the range of variation.
- building a comparative database to curate and learn from these efforts.

Statistical sampling (as opposed to selective sampling on a whim) of ceramic collections from sites is required. Research designs and reports must indicate how diversity and frequency has been sampled for. Sampling strategies may differ by site and assemblage and may be determined based on professional expertise and/or specific knowledge. Recognizing that all things are not equal, the precise details of the sampling will be determined on a case by case basis in consultation with TxDOT archaeologists. However, the strategy adopted shall be cited and supported in the report unless this is an entirely new sampling strategy (unlikely). Once the sample is selected the same series of specific analysis will be conducted on all sherds in the sample.

This methodology emphasizes the integration of both statistical sampling and standardization of a suite of analytical techniques applied in order to construct a comparative data base. This data base will include thin sections, photographs, and a record of the petrographic analysis, INAA and/or ICP analysis, and the results of any analyses conducted on clay sources in the surrounding area. The intent is to code these various data so that we can simply query the database and observe statistical and locational distributions of various elements and combinations of various elements discovered in these analyses in order to generate testable hypotheses. Thus, these guidelines are intentionally designed to make comparative analysis possible.

Implementing multivariate statistical analyses of data resulting from such analyses also has significant potential for addressing research questions at both the local (site) and regional (state) levels. For example, if multivariate statistical analysis of the INAA results from site-specific ceramics indicates that they were produced locally it is

likely that these vessels were produced, used, and discarded at the site. Therefore, it may be possible to significantly narrow the geographic distributional range of specific ceramic groups.

There will be no ceramic studies in lieu of or as a substitute for the standard required documentation listed in Table 1 below. Additional studies may be permitted and some of these are covered in the guidelines, however these are subject to review by TxDOT archeologists. The table below covers required standards of documentation as well as some optional guidelines for documentation and analysis.

The primary intent is to define the geophysical ceramic universe in Texas so we can understand what we are actually dealing with. Technical Experts must familiarize themselves with these types of documentation and analysis (TxDOT strongly suggests contacting the University of Missouri Research Reactor (MURR, Michael D. Glascock, director of the Archaeometry Laboratory).

The suite of analytical techniques can be broken down into two primary groups one is based on measurements and visual observations of the sherd and the other focuses primarily on chemical composition studies of various materials in the sherd.

Therefore, thin sections of ceramics will be required in order to conduct petrographic analysis of each sherd in a sample. Petrographic analysis must be conducted by competent analysts and it is the responsibility of the Technical Expert to evaluate, ascertain, and present their competency to TxDOT prior to conducting analysis. The Technical Expert shall also be responsible for determining the appropriate geo-chemical compositional analysis conducted (e.g. Instrumental Neutron Activation Analysis (INAA) or Inductively Coupled Plasma–Mass Spectrometry (ICP-MS) or some combination of the two) and communicating the reasons for this selection to TxDOT archeologists. This requires the Technical Expert to familiarize themselves with various analytical techniques. In addition, the Technical Expert shall have to communicate with TARL as well as CAR in order to learn how to prepare samples for curation.

The chemical composition of Texas ceramics (and by extension, the raw clays from which they were made) is quite diverse throughout the region (Taff 2006). Therefore, these data sets are crucial to determining patterns of production, mobility, and trade as well as social, economic, and political identity and interaction.

Towards that end TxDOT Standards and Guidelines require that sherds from the site be submitted for INAA (see INAA Protocols below). Implementing multivariate statistical analyses of data resulting from such analyses also have the potential to address research questions at local (site), area, and regional scales.

After careful consideration TxDOT has decided not to pursue the INAA analysis of local (site) clays in conjunction with other ceramic analyses detailed in the Ceramic Standards and Guidelines. Currently there are a number of issues concerning where and how these types of samples should be collected and what they might mean. Until such time that we have a better grasp of raw clay sampling TxDOT prefers to simply analyze ceramics. Nevertheless, it is acknowledged that this line of investigation has the potential to one day address the question of whether the ceramics recovered at a specific site were produced locally. TxDOT recommends Technical Experts carefully consider how, why, and where clay sampling would be conducted prior to discussing the possibility of conducting clay sampling in an investigation. For example, TxDOT generally finds that there is little sense in collecting clay samples more than half an hour walking distance from the site. The rationale here is that no self-respecting hunter-gatherer would willingly carry lumps of clay more than half an hour. Due to the significant variation of raw materials throughout the state of Texas, TxDOT recommends conducting petrographic analysis on ceramics before collecting clay samples from the site and/or the vicinity. Petrographic analysis should give some clue as to the range of available plastic (coarse-grain as opposed to fine-grained clay, etc.) that were used in the production of pottery and, thus, provide some guidance for collecting similarly structured samples. TxDOT also recommends consulting a geomorphologist prior to collecting clay samples and having them work in cooperatively with the petrographic analyst.

Beyond the scale of the immediate locale, the chemical compositional data from site specific ceramics and clays may one day be added and compared to existing compositional data from other similar ceramic types. Some of these data is already available through the Central Texas Ceramics Project (CTCP), a joint undertaking of the Texas Archeological Research Laboratory and a number of public and private agencies (Taff 2006). Comparison of the site specific INAA data with this larger body of data has the potential to shed light on a number of issues, from whether or not groups were sharing clay sources to how ceramics were being moved within and between different areas as well as reveal patterns of vessel movement and production across the region. In time INAA conducted on samples of clays from throughout the region may contribute significantly to our understanding of the raw clay universe. However, TxDOT is not pursuing this specific line of inquiry at this time.

In addition, consultants that anticipate conducting ceramic analyses are strongly advised to familiarize themselves with the known universe of Texas ceramics. For example, at least 72 pottery types were identified in Texas by 1962 (Suhm and Jelks) and there are almost certainly more types out there. The number of pottery types alone indicates significant variation in ceramics across the region and it is unlikely that many archaeologists working in Texas are even aware of this diversity.

Glossary of Terms (Rice 1987 Pottery Analysis)

- 1. Rim** --also known as the orifice or mouth opening, this area is frequently the place of greatest elaboration and provides the measurement for vessel diameter when the whole vessel does not exist. Diameters in ceramic reports typically report rim diameters. A rim can be straight (the rim/lip does not curve in or out), inverted (rims tend to curve inward), or everted (rims tend to curve outward).
- 2. Neck**--a restriction of the opening of the vessel beginning above the point of maximum diameter of the body (shoulder) to the top of the rim (lip).
- 3. Shoulder**--begins at the point of maximum diameter and does not significantly reduce the orifice opening relative to the body. They typically join the body at an angle and these sherds are curved.
- 4. Body**--portion between the rim (or shoulder) and the base that includes the maximum diameter of the vessel or region of greatest enclosed volume.
- 5. Base**--underside of a vessel touching the surface it rests on during normal use.
- 6. Appendages** (including flanges, ridges, handles, etc.--usually added to the wall of a fully shaped vessel rather than being part of the wall and its contours. They typically run around the circumference of the vessel.
- 7. Vessel Group**— Despite its ubiquitous use in the literature, the term “vessel group” is not necessarily self-explanatory and it is rarely defined within the context of any given report. The term “vessel group” is defined here as a single sherd or group of sherds that archeologists infer was once a constituent element in a single ceramic vessel. For example, 32 sherds of the same ware or type, of varying gross metric morphology (i.e. rim, body, neck, shoulder, base, and/or appendage sherds), excavated in good context in close proximity to each other (perhaps a meter or less) within a specific component at an archaeological site may be inferred to represent a pot break (which may also be classified as a feature). Together these sherds represent a single vessel. Whenever and wherever possible, sherds shall be assigned to a vessel group. One may also infer that even a single sherd at an archaeological site constitutes a sample of a group of sherds that were once a vessel. Such an inference should also include the sherd as a part of its own vessel group. Similarly, it is also possible that a number of completely different sherds (with respect to provenience, gross metric morphology, and type/ware) may be recovered from the same component at a site and that these sherds could, individually, constitute a single vessel group each.

TABLE 1. Required Documentation and Analysis (Standards) and Optional Documentation and Analysis (Guidelines)

CERAMICS	STANDARDS <u>Required</u> Documentation & Analysis	GUIDELINES <u>Optional</u> Documentation & Analysis
Rim Sherds	<p><i>Color Measurements:</i> describe the color of the interior surface, the exterior surface, and the core color of sherds using a Munsell Soil Color Charts.</p> <p><i>Counts by:</i></p> <ul style="list-style-type: none"> • Excavation unit/feature context • Decorative method or attributes • Construction method (e.g. coil breaks, paddle-and-anvil) • Established typologies/wares (e.g. Leon Plain, Holly Fine, Goose Creek, El Paso Brown ware), citing the relevant source <p><i>For vessels and complete rims (interior, lip through to shoulder) record:</i></p> <ul style="list-style-type: none"> • Rim profiles <p><i>Surface treatment</i></p> <p><i>Temper description</i></p> <p><i>Minimum Vessel Counts or Estimated Vessel Equivalents by contextual units</i> (e.g. middens, houses), by attribute/type.</p> <p><i>Compositional Analyses:</i> Petrography (NOTE: this will require thin sections) INAA Photographs and/or digital images of samples (to be curated with collection and/or relevant records if sherd is destroyed for analysis)</p>	<p><i>Measurements:</i> Length, Width, Mean thickness, Weight, Mouth circumference Interior residue analysis</p> <p><i>Minimum vessel counts</i> Measurements Vessel size or circumference Vessel profiles</p> <p><i>Estimation of firing temperature</i></p>
Neck and/or Shoulder Sherds	<p><i>Color Measurements:</i> describe the color of the interior surface, the exterior surface, and the core color of sherds using Munsell Soil Color Charts.</p> <p><i>Counts of each by:</i></p> <ul style="list-style-type: none"> • Excavation unit/feature context • Decorative method or attributes • Construction method (e.g. coil breaks, paddle-and-anvil) • Established typologies/wares (e.g. Leon Plain, Holly Fine, Goose Creek, El Paso Brown ware), citing the relevant source <p><i>Surface treatment</i></p> <p><i>Temper description</i></p> <p><i>Minimum Vessel Counts or Estimated Vessel Equivalents by contextual units</i> (e.g. middens, houses), by attribute/type</p> <p><i>Compositional Analyses:</i> Petrography (NOTE: this will require thin sections) INAA Photographs and/or digital images of samples (to be curated with collection and/or relevant records if sherd is destroyed for analysis)</p>	<p><i>Measurements:</i> Length, Width, Mean thickness, Weight, Mouth circumference Interior residue analysis</p> <p><i>Estimation of firing temperature</i></p>
Body Sherds	<p><i>Color Measurements:</i> describe the color of the interior surface, the exterior surface, and the core color of sherds using a Munsell Soil Color Charts.</p>	<p><i>Measurements:</i> Length, Width, Mean thickness, Weight, Mouth circumference Interior residue analysis</p>

	<p><i>Counts of each by:</i></p> <ul style="list-style-type: none"> • Excavation unit/feature context • Construction method (e.g. coil breaks • Established typologies/wares (e.g. Leon Plain, Holly Fine, Goose Creek, El Paso Brown ware), citing the relevant source <p><i>Surface treatment</i> <i>Temper description</i> <i>Minimum Vessel Counts or Estimated Vessel Equivalents by contextual units</i> (e.g. middens, houses), by attribute/type</p> <p>Compositional Analyses: Petrography (NOTE: this will require thin sections) INAA Photographs and/or digital images of samples (to be curated with collection and/or relevant records if sherd is destroyed for analysis)</p>	<p><i>Estimation of firing temperature</i></p>
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Implications and Middle Range Theory: The types of data gleaned from the standards and guidelines in the table above have the potential to address a number of issues pertaining to production, use, exchange, mobility, and socio-cultural identity ranging from the local to the regional level. Furthermore, many of these questions are specifically relevant to Texas archaeology. For example, many archaeologists have suggested large-scale human migration occurred during the Late Prehistoric II. However, we have barely scratched the surface in terms of clay sourcing. Thus, it remains to be seen whether the geographic extent of the ceramics is substantially larger than the production sphere or core area where the tradition is based. Similarly, if ceramics from sites outside of the Classic Toyah area (e.g. “Shared Toyah Area” ala Johnson [1994]) exhibit increasingly high percentages of nonlocal source clays it may suggest a distinction between areas of domestic use and a broader economic sphere.

With respect to the local, in terms of the domestic mode of production at least one recognized characteristic of hunter-gatherer society is the inter-community signature of an endogamous linguistic group evidenced by very similar practices, technologies, materials, and decoration. This can be particularly apparent with respect to the distribution of ceramics corresponding to several community/band territories that together comprise a marriage/linguistic/culture group. For example, a hypothesis might posit that if a large sample of remarkably similar ceramics from several adjacent and contemporaneous residential sites are locally produced, locally utilized, and locally discarded, then the distribution of the raw materials utilized in the production should correlate with the distribution of an endogamous linguistic group. INAA results evidencing strong intra-assemblage commonality would, in part, support such a hypothesis. Alternatively, the distribution of ceramics far beyond the point of production suggests other mechanisms were at work.

Below is an example of various concepts and techniques used by a TxDOT Technical Expert to develop the ceramic analysis portion of a data recovery research design for the Toyah component at Site 41KM226:

Social Underpinnings of ceramic technology- Leslie Cecil PhD

To help develop a fine-grained view of Toyah material culture and possible diverse social differences in time and space, it is necessary to more systematically and completely analyze their pottery. By examining the stylistic and technological characteristics of a specific type of pottery, we will be able to infer differences in manufacturing recipes and potting traditions thus “seeing” subdivisions in space and time.

The existence of the variability within the stylistically- and technologically-based pottery groups are a result of the social processes. This variation allows the archaeologist to study materials such as clay and mineral

inclusions and patterns of pottery manufacture as practice. As such, the patterns of manufacture are not merely “‘added on’ in order to signal group identity,” but are choices made by the potter “by which a sense of group identity is formed and transformed as being coeval with and identical to the process by which a sense of technique is formed and transformed” (Dietler and Herbich 1998:247). Potters, as well as other members of a society, may continually construct and reconstruct their identity by creating and recreating their social structures through daily activities such as pottery manufacture (Giddens 1984:17).

As a daily activity, pottery manufacture becomes a social activity when the choices made during the manufacturing process are examined as a social phenomenon. The patterns of manufacture (choices) are made in a specific manner, under the umbrella of the local or community social structure, and reproduced. As such, patterns of manufacture may be reproduced without the potter being fully cognizant of the set of established and mediated “rules” or operational sequences (Lechtman 1977; Lemonnier 1992). For example, a clay source may be continually used without question because one social group does not have access to clay sources in another territory or because it is customary to use that source. “These dispositions of choice and perceptions in the domain are interwoven with similarly formed patterns of choice and perceptions in the domain of social relations and cultural categories in ways that evoke and reinforce each other such that they come to be perceived as ‘natural’” (Dietler and Herbich 1998:246). Therefore, clusters of pottery traits (stylistic, mineralogical, and chemical), together with other clusters of material culture (e.g., drills, grinding stones, hearths, and beads) are compatible with specific social structures (i.e. Toyah) and they reflect the social identity and history of Toyah culture (Arnn 2007; Black 1986; Collins 2004; Johnson 1994; Kelly 1947a; Prewitt 1981; Ricklis 1994; Suhm and Jelks 1962; Turner and Hester 1999).

Technological and decorative variability results from the relationships between form and decorative elements and the patterns people produce through various behaviors. When creating material objects, the producer may have many choices (operational sequences) to make. The objects reflect the social and cultural constructs that underlie and direct her/his actions, and subtle differences in a choice (e.g., matter, energy, motor patterns, etc.) can influence the social representation of material culture (Lechtman 1977:6; Lemonnier 1992:23, 1993: 9). Therefore, both the material and the process of manufacture contribute to an object’s style as much as does the surface decoration because technological acts are embedded in a symbolic system that reflects social reality and indigenous knowledge. It is the combination of choices “defined by these relationships that is stylistic in nature” (Lechtman 1977:6). Thus, the integration of behavioral events at each level of manufacture defines technological style, which is “recognizable by virtue of its repetition which allows us to see the underlying similarities in the formal arrangements of the patterns of [manufacturing] events” (Lechtman 1977:7).

An object’s technological style reflects technological acts that are also embedded in a symbolic system that embodies social reality and indigenous knowledge that is “translated by, among other things, implicit or explicit classification of the materials treated, of the processes brought into play, of the means and tools employed, and of the results obtained, without speaking of the presentation of the actor’s roles” (Lemonnier 1986: 160). Thus, style is a technological aspect of social production and mental schemes that need not carry directly observable meaning, and can be learned and transmitted from generation to generation (Lechtman 1977:6, 1993; Lemonnier 1993:3).

By combining the choices available from the technological and stylistic realms, one can better understand “emic behavior based upon primarily etic phenomena of nature” (Lechtman 1977:7). This type of analysis is possible because the social representations behind the technological style presented on material culture are the perspectives of the producer toward the raw materials that are used, “the attitudes of cultural communities towards the nature of the technological events themselves,” and the attitudes of the community towards the end product (Lechtman 1977:10, 1988:369). However, to fully understand the technological and stylistic realms, we must conduct a synchronic and diachronic analysis of the design elements and the transformation and social representations that permeate beyond the material world (Lemonnier 1992:3).

Different technological styles may be developed and operate synchronically, but they will not be perpetuated unless the technological style is compatible “with the natural environment and with the state of technological

systems at the time of creation” (Lemonnier 1993:12). Because choices are arbitrary from a technological point of view, technological styles are a result of accommodation rather than alteration. As such, the new style has to fit into an already existing structure of social meaning and practices, and the object needs to be able to be interpretable by those within the social group as well as by those from “competing” social groups to be perpetuated in a culture (Lemonnier 1992:18, 1993:14). As a result of a new technology having to fit into an already existing system, some choices will impinge on the transformation of technological systems. A technology also may not appear in society because it is not “in fashion” or does not look like something that already exists (Lemonnier 1989: 166). If this happens, some innovations will not be reproduced and will never be seen by the cultural group at large because selective pressures at the individual and community levels always exist that decide what will represent social structures, such as power, ancestry, and identity (Lemonnier 1993:15). On the other hand, it is possible to have many different stylistic schema representing the same social group because there is “no necessary or unique correspondence between the expression of a socially defined technical aim and the physical objects and actions that a given culture use to perform its function” (Lemonnier 1993:16). Therefore, the resulting technological style is the “source of precise information about the history of its own manufacture” (Lechtman 1994:5).

The theory of technological style permits us to suggest that: 1) technological and stylistic choices have a social context; 2) technology and style are social reproductions of a specific society; 3) some technological and stylistic choices were more compatible with the study society than others; 4) technology affects style; and 5) compatible choices tend to reinforce intra-group social identity and/or regional identities.

Even a seemingly simple hypothesis, such as Toyah ceramics are produced and used locally, must address a number of inferences, almost all of which are suggested in the theory of technological style. Furthermore, even if such a hypothesis is wrong, either because the results of the analysis could be inconclusive or contradict the hypothesis, the data would still be available and organized for future comparative analyses.

Data and Sampling Strategies for Ceramics

Stylistic Analysis—Type-Variety Classification

The first level of study will consist of a typological analysis using the type-variety system (Smith et al. 1960). This hierarchical system uses a series of categories in descending inclusiveness to organize levels of variability in archaeological pottery. Many sherds in Texas are typically classified as to ware and type. For purposes of studying technological and stylistic attributes, it is particularly useful to consider pottery at the ware level because this level of classification conveys information about geographical location and manufacturing traditions (Cecil 2001; Rice 1982: 50). Some pottery wares, such as bone-tempered plain ware, can be categorized based on their inclusions (e.g., bone temper and other rocks and minerals). Other pottery types may reflect difference in surface treatment. Types may “reflect the interplay of both covert individualness and covert culturalness. . . that the pottery type is telling us of the subconscious ceramic value orientations of both the culture and the individual. . . (Gifford 1976:32). Therefore, pottery types may reflect cultural integration and possible interactions. Thus, examining the pottery at the ware and type levels has the potential to provide additional information concerning specific technological styles and identities.

While the type-variety system is the primary method for pottery classification, we recognize that there are many assumptions and problems with this kind of classificatory system. First, pottery types do not necessarily correspond to different cultural affiliations, potter’s knowledge, potter’s capacity, or accidents of production (Shepard 1956:317). Second, many archaeologists magnify slight differences and unnecessarily define new pottery types (Ball 1982; Rice 1976). This is a result of archaeologists not adhering to the original classification rules. Finally, a strict use of the type-variety system often leads to misclassification of sherds that come from the same vessel. Because of differences in firing over the surface or a vessel, uneven erosion patterns due to deposition or placement of decoration on a vessel, sherds from the same vessel may appear as two distinct types (Demarest 1986). While there are limitations to this descriptive methodology, it is the commonly-used schema by which Texas archaeologists discuss ceramics and as long as the researchers understand these limitations, type-variety analysis of a ceramic sample can be fruitful.

As part of the classification procedure, information will be recorded concerning color measurements, degree of dark coring, form dimensions (such as rim diameter), estimation of firing temperature, and surface treatment/decoration. Digital photographs of all sherds will be taken as part of the classificatory analysis. Additionally, digital images will be taken of the sherds used for destructive analysis after they have been sampled. Therefore, we will have a before/after record of all excavated sherds. These images will be placed in a database that will be accessible to researchers.

Color Measurements

Color measurements will describe the color of the interior surface, the exterior surface, and the core color of the sherds with the use of the Munsell Soil Color Charts. These colors are important to record because they may infer variation within ceramic traditions as well as the degree of quality control of the manufacturing process. By establishing different color patterns, if they exist, it may be possible to distinguish technological behaviors and stylistic identifiers. These patterns will be inferred through richness, evenness, and heterogeneity indices (Bobrowsky and Ball 1989: formula 3; Pielou 1969:233, Simpson 1949).

Core Colors

Paste colors visible in cross-sections may show distinctive colors resulting from a combination of paste constituents and firing conditions. Fully oxidized vessels or sherds contain no organic matter and have a uniform cross-section color. On the other hand, a dark-colored core may result from a lack of primary removal of carbon by oxidation (dark core), or deposition of carbon from a reducing atmosphere. Core colors resulting from paste components and original firing will be measured with published charts and recorded (Cecil 2001:Figure 2). The resulting nominal values will allow for statistical analyses of measurements of central tendency (mean), measurements of variation (standard deviation and range), and correlation coefficients for the sample.

Form dimensions

Various sherds will be measured and vessel forms (e.g., bowls and jars) determined in order to suggest possible changes in technological, functional, and stylistic attributes. By measuring the diameter of rim sherds that comprise more than 10 percent of the total rim diameter of a vessel, we will be better able to demonstrate variation in vessel size of a given ceramic group and/or form. Measurements of central tendency (mean) and measurements of variation (standard deviation and ceramic ware/type will aid in the determination of technological choices.

Estimation of firing temperature

Refiring procedures provide insight into the original firing conditions and original clay colors. By estimating the original firing temperature, information on time, temperature, and atmosphere characteristics of the pottery firing are provided. When refiring sherds at a temperature of 800° C, one is able to arrive at “a general picture of the variability in the kinds of clays the prehistoric potters used” (Rice 1987: 344). As a result of such analyses, a researcher can ask questions such as: 1) are particular clays used for particular vessels? 2) are different firing procedures used for different clays?, and 3) does dark coring result from an abundance of organics or is it attributable to another cause?

With sherds that are large enough to allow for this type of analysis, six small pieces (approximately .5 cm) of each sherd will be placed in an electric kiln with a constant atmosphere and pressure. The temperature will be set at 275°C and the sherds “soaked” at that temperature for 15 minutes. This temperature drives off atmospheric water that may have accumulated in the pores. After 15 minutes, the temperature will be set to 550°C and the sherds soaked for 15 minutes after that temperature is reached. After the soaking period, one sherd piece will be removed from the electric kiln and placed in an electric drying oven set at 40° C. This process will be repeated at 600° C, 650° C, 700° C, 750° C, and 800° C. After all of the sherd pieces have cooled, we will compare the broken pieces from the different firing temperatures to the original sherd to estimate at what temperature and atmosphere the sherd might have been originally fired. In cases where sherds were fired below 550° C, the procedure described above will be repeated, but at lower temperatures: 300°C, 400° C, and 500° C.

Surface Treatment and Decoration

When possible, surface treatment and decoration will be described. The most common surface treatment is often brushing, which can be visually and microscopically detected because the Toyah brushed/scraped the clay while it was plastic thus leaving drag marks. The drag marks were caused when grit or harder inclusions are dragged across the surface. The length of the brushings can be determined because the grains that were brushed remain at the end of the drag. In addition to brushing, polishing; engraving; incising; punctating; and slipping or washing (self-slipped) is known to occur. These surface treatments will be described and illustrated when appropriate in order to compare stylistic attributes to technological characteristics.

Technological Analysis—Mineralogical/Petrographic Analysis

Petrographic analysis of clays and pottery is the second essential step of this project that will identify variability of the samples as well as manufacturing recipes and potting traditions. Petrographic analysis allows for the identification of naturally occurring versus culturally added inclusions to a clay body because of the differences in inclusion size and sorting (shifting of temper ingredients, or levigating of the clay) (Childs 1989; Orton et al. 1993; Williams et al. 1954). This determination can be accomplished by analyzing potential clay sources and pottery. Differences in mineral composition and character between clays and sherds reflect human behavior and the choices made during pottery manufacture. Additionally, when sherds cannot be assigned to a specific typology (described above), petrography can distinguish more subtle technological characteristics that may have been important to particular groups of people, but were not detectable by the archaeologist's eye (Childs 1989:24; Robinson 2005; Steponaitis et al. 1988).

Petrographic analysis has been adapted from geological techniques of analysis for the study of soils and rocks and is useful for archaeological ceramics because, to a large extent, geological sources differ enough across regions to allow for comparison of different clays (Blatt 1992). These methods are applicable to pottery analysis because pottery can be regarded as a metamorphosed sedimentary rock due to the composition of a sherd consisting of clastic grains imbedded in a clay matrix which has been transformed to "rock" through the process of firing (Bishop et al. 1982; Rice 1987:376). Understanding these basic principles of geology plus other principles of optical mineralogy, allow the description of pottery pastes and clays.

Additionally, petrographic analysis can be used to establish technological characteristics within the ceramic samples because petrographic analysis aids in the classification of sherds into specific categories (Childs 1989:24; McIntyre and McGregor 1982; Skokan and Perttula 1998). This aspect of petrography is most helpful when a sherd or vessel cannot be assigned to a typology based on surface decoration, vessel form, or rim diagnostics (Shepard 1956:165). We anticipate that the above situation will arise most frequently when sherds are not decorated (i.e. Leon Plain) and because the variability within pastes may be undetectable with a 10X hand lens. As a result, paste characteristics (clay matrix and inclusions) will be examined to establish possible differences between technological styles.

Once a sherd or vessel is assigned to a ceramic group, we can develop additional behavioral information from a classification based on petrography because petrography can answer process-oriented questions from a diachronic or synchronic perspective (Carr 1990; Cecil 2001; Childs 1989). It is possible to create a time series that models shifts in technological characteristics such as paste and temper characteristics (Braun 1985; Carr 1990; Cecil 2001).

The most common geological method of determining the quantity of minerals in a thin section (quantitative data) is point counting. Point counting determines the number of different minerals along a predetermined area (for example, 10 mm) of the length and width of the section (Stoltman 1989). Analysis will entail point counting of minerals and pores along transects of the thin-section as is a generally accepted ceramic and geological methodology. As part of the point counting procedure mineral size, shape, roundness, and frequency will also be recorded to provide qualitative and quantitative data by which to infer manufacturing recipes. After completing the point counting of minerals and pores, the investigator will convert the frequency data to percentages based

on the actual counts and the percentages examined by ternary diagrams to aid in the identification of various pottery technological styles (i.e. slipped, burnished, etc.).

Although petrographic analysis is important to this research design, there are some limitations. Thin-sectioning may not produce the full mineralogical composition of a pottery sample due to sampling error and because the method of producing thin-section slides involves grinding and polishing of the sample (Orton et al. 1993). In addition to problems with sample preparation, petrographic analysis alone cannot determine the type of clay mineral in the sherd because of the refractive characteristics of clay minerals. Because of these limitations, petrography will be combined with neutron activation analysis (INAA) to obtain a more comprehensive data set of clays and tempers.

Technological Analysis—Chemical Analysis

Although petrography can identify the different minerals and culturally added temper to the clay, petrography cannot determine differences in clay sources and it cannot detect trace and rare earth elements that are often used to distinguish chemical composition groups. Because the determination of different manufacturing traditions is essential to any long term anthropological ceramic study, INAA will be used to identify the variability in chemical signatures that will indicate differences in clay resources and/or recipes of the ceramics sampled. Thus, by combining the strengths of petrography and INAA, we can obtain results that predict regional identities and possible exchange activities because variability informs archaeologists about choices in technology and resources that are essential to understanding the regional population.

A number of analytical techniques (e.g., x-ray fluorescence and inductively coupled plasma mass spectroscopy) can be used to determine the chemical composition of pottery, but none have the ease of sample preparation and fewer errors due to laboratory procedures as INAA. We propose to use INAA because it has been proven to be a very valuable analytical tool for determining distribution patterns of ceramics in Texas and worldwide (Bishop 2003; Bishop and Rands 1982; Bishop et al. 1982; Blackman and Bishop 2007; Boyd et al. 2002; Creel et al. 2002; Descantes et al. 2004; Neff et al. 1994; Nichols et al. 2002, 2006).

Neutron Activation Analysis

INAA samples shall be submitted to the University of Missouri Research Reactor (MURR, Michael D. Glascock, director of the Archaeometry Laboratory), and prepared employing standard INAA and MURR procedures (Bishop et al. 1982; Glascock 1992) unless an alternative facility is explicitly discussed with and approved by TxDOT and is named in the work authorization. MURR will then analyze the thirty-three standard elemental concentrations with several multivariate pattern recognition techniques (e.g., base 10 transformation of the elemental concentrations, principal component analysis, and Mahalanobis distances). The goal of INAA is to distinguish compositionally homogenous groups within the database of analytical samples that may reflect geographically restricted zones. Thus, INAA data will ultimately be combined with the typological, stylistic, and petrographic data previously attained to create technological style groups.

Cluster Analysis

Like most published cluster analyses in archaeometry, the type of cluster analysis utilized should be hierarchic agglomerative (Baxter and Buck 2000:705). In this type of analysis, individual specimens are treated as unique groups at the outset and are successively merged until they form one cluster. The criteria for merging groups are based on one of several clustering algorithms; in this study, the clustering algorithm that will be typically utilized is average linkage. The average linkage algorithm takes account of group structure by defining dissimilarity as the average distance between all pairs of points, or one in each cluster (ibid.). The results of cluster analysis are presented as a dendrogram showing clusters and the level of dissimilarity at which they merge (Baxter and Buck 2000:707).

Inspection of dendrograms can be a useful method for identifying preliminary groups within compositional data but this process is typically quite subjective (Baxter and Buck 2000:707; Glascock 1992:17). The interpretation of results from cluster analysis is further complicated by the fact that clustering algorithms can impose an artificial structure on a set of data (Baxter 1995:166). Ultimately, other statistical pattern recognition techniques

must be used to confirm or refine groups suggested by cluster analysis (Baxter and Buck 2000:707; Glascock 1992:17).

Principal Components Analysis

Principal components analysis (PCA) is a powerful statistical technique that can be used to evaluate the coherence of groups suggested by cluster analysis, though it works equally well as a pattern-recognition technique in its own right. PCA transforms a data set by creating new, uncorrelated variables termed principal components. The first principal component created incorporates the greatest variance within the original data set, the second principal component comprises the second-most variance, and so on.

When PCA is used to discern groupings within a given set of data, these principal components are typically plotted against each other in two or three-dimensional space (Baxter and Buck 2000:702). In many cases, the resulting plot will reveal structures within the data that are difficult or impossible to perceive using other methods, with groups evident on the plot as areas of high point density (Neff and Glascock 2002:5).

According to Baxter and Buck (2000:702), another way of looking at PCA is that it approximates the distances between individual specimens in low-dimensional space. The quality of this approximation can be assessed by the percentage of variation subsumed by the primary principal components. The first two principal components frequently account for more than 50% of the variance in a given data set, with the first four principal components often incorporating 80% (Baxter 1995; Baxter and Buck 2000:702).

Discriminant Analysis

Discriminant analysis differs from both cluster analysis and PCA in that it cannot be used to discover groups or patterns in an undifferentiated set of data. This multivariate statistical technique uses previously defined groupings such as those determined through cluster analysis or PCA to confirm the assignment of specimens to different groups. As Baxter and Buck note (2000:709), the manner in which discriminant analysis works is similar to PCA. Both techniques create new variables from a previously existing set, but in the case of discriminant analysis variables termed discriminant functions are created to maximize the separation between existing groups. The probability that an individual specimen belongs to a given group is calculated by determining its distance from the group mean using the discriminant functions.

Occasionally the discriminant analysis will determine that a specimen has been misclassified; in this case an alternate group assignment is suggested. This ability to reclassify cases makes discriminant analysis a powerful tool for linking additional specimens not included in initial analyses to existing groups (Baxter and Buck 2000:711; Glascock 1992:18).

Mahalanobis Distance

The data obtained from INAA are often highly correlated, presenting a unique challenge for pattern-recognition techniques such as cluster analysis. To use an example, it has been demonstrated that the average linkage cluster analysis of highly correlated data can result in the appearance of multiple clusters where in fact only one exists (Baxter and Buck 2000:707-708). Given this situation, many analyses of ceramic compositional data utilize statistical techniques that employ a measurement known as Mahalanobis distance (Baxter and Buck 2000:709; Glascock 1992:17; Neff and Glascock 2002:5).

Mahalanobis distance takes the correlations between element concentrations in a given group into account when formulating probabilities of group membership; for a multivariate group the Mahalanobis distance of a group member to the group centroid is analogous to the standard deviation from a univariate mean (Neff and Glascock 2002:5). Unfortunately, the use of Mahalanobis distance requires that the group size numbers at least one greater than the number of variables used to calculate the probability of group membership (Glascock 1992:19). Ideally, the group size will be many times the number of variables considered (Baxter and Buck 2000:717; Glascock 1992:19; Harbottle 1976). Given that neutron activation analysis of ceramic artifacts can yield element concentrations for up to 33 elements, these requirements for group size are often not met. One method of dealing with the issue of group size-to-variable ratios is to base the Mahalanobis distance calculations on

principal components. This method presents an objective criterion for lowering the group size requirement (Baxter and Buck 2000:717; Glascock 1992:19).

Effect of Bone and Shell Temper on INAA Results

The predominance of bone and shell temper in Texas ceramics presents a problem for INAA in terms of determining the effect of the calcium present in the bone or shell on the overall chemical composition of the ceramic paste. Laser ablation ICP-MS analyses undertaken on two Toyah sherds submitted to MURR by the Texas Archaeological Research Laboratory (Neff and Glascock 2002) indicated that the majority of elements within these two samples were present in similar amounts in the bone temper and the clay matrix. The chief exception to this trend was the element calcium, which was found to be present in the bone temper at concentrations approximately six times that of the ceramic paste. Given these results, it was clear that the addition of bone temper had the effect of diluting the concentrations of other elements in the paste.

The large quantities of calcium in the bone temper and its dilutive effect on the measured quantities of other elements within the paste requires that a mathematical formula be utilized to correct the concentrations reported by the neutron activation analysis. Fortunately, previous work with neutron activation analysis of Mississippian pottery containing shell temper (Cogswell et al. 1998; Steponaitis et al. 1996) resulted in the introduction of a formula that can serve as an approximate correction for calcium dilution resulting from the addition of either shell or bone to ceramic paste. This formula requires some adjustment depending on whether bone or shell is present but, nevertheless, can be used to correct the elemental concentrations for bone and shell tempered sherds. The correction formula should be employed when the total frequency of calcium is 25% or higher.

Of course another solution to this problem is to simply conduct laser ablation ICP-MS analyses on samples containing bone and/or shell temper agents or aplastics.

CODED CERAMIC ATTRIBUTE FORM (Incomplete)

TAXONOMY

1. Vessel:
2. Sherd:
3. Raw Clay:

CONSTRUCTION METHOD

4. Coil
5. Paddle and Anvil

METRIC INFORMATION

Measurements

6. Max length (mm):
7. Max width (mm):
8. Mean thickness (mm):
9. Weight (g):
10. Mouth Circumference
11. Neck Circumference

SURFACE TREATMENT ATTRIBUTES

Exterior Finish

12. Smoothed
13. Floated
14. Streaky polish
15. Lustrous/Polished
16. Eroded, indeterminate

Interior Finish

17. Smoothed
18. Floated
19. Streaky/polished
20. Lustrous/polished
21. Eroded/indeterminate

Exterior Scoring

22. Absent
23. Individual
24. Multiple
25. Eroded/indeterminate

Interior Scoring

26. Absent
27. Individual
28. Multiple
29. Eroded/indeterminate

FIRING PRODUCTION ATTRIBUTES

Core/Surface Color and Firing Temperature

30. Interior/Exterior same color w/ dark core
31. Exterior dark
32. Interior dark
33. No Change (primarily one color through whole sherd profile)

Fire-Clouding Present on Heat Contact Surface

34. Present
35. Absent
36. Eroded, indeterminate

VESSELS

General Vessel Form

- 1 - Bowl
- 2 - Jar
- 3 - Other
- 9 - Unknown/Unidentified

Specific Vessel Form

- 10 - Unidentified Bowl
- 11 - Inverted Rim Bowl
- 12 - Direct Rim Bowl
- 13 - Everted Rim Bowl
- 20 - Unidentified Jar
- 21 - Inverted Rim Jar

- 22 - Direct Rim Jar
- 23 - Everted Rim Jar
- 30 - Other Forms
- 99 - Unidentified

Vessel Shape

- 10 - Inverted Rim Bowl
- 11 - Direct Rim (Vertical) Bowl
- 12 - Direct Rim (Outcurved) Shallow Bowl
- 12 - Everted Rim (Outcurved) Shallow Bowl
- 13 - Plato
- 20 - Inverted Rim Neckless Jar
- 21 - Direct Rim Neckless Jar
- 22 - Direct Rim Necked Jar
- 23 - Everted Rim Necked Jar
- 30 - Other Forms

RIM DESCRIPTION

Rim Lip Form:

- 1 - Flat
- 2 - Pointed
- 3 - Round
- 4 - Beveled Interior
- 5 - Beveled Exterior

Rim Wall Curvature:

- 1 - Direct
- 2 - Incurved (Inverted)
- 3 - Slight Outcurved (Everted)
- 4 - Outcurved (Everted)

Rim Wall Form:

- 1 - Straight
- 2 - Contracting
- 3 - Expanding
- 9 - Indeterminate

Rim Arc:

- 1 - Concave
- 2 - Straight
- 3 - Convex
- 9 - Indeterminate

End-Point Tangent: Use "tangentometer" to calculate end-point (vessel wall) tangent (also known as rim angle)

Orifice Diameter and Rim %: Use concentric circle diagram to calculate orifice diameter and percentage of rim present.

RIM ATTRIBUTES/RSI MEASURES

Width of Rim: Measure of rim width in mm from tip to tip

Lip Thickness: Measure at 2mm below lip

Rim Thickness: Measure at 5mm below lip

Upper Rim Wall Thickness: Measure at 10mm below lip

(Lower Rim Wall Thickness: Measure at 15mm below lip

If not present (rim too small) - leave blank. Measure to .00 mm.

DECORATION METHOD/ATTRIBUTES

1. Finish
 00. Not present
 01. Burnished
 02. Slipped
 03. Brushed
 04. Other
2. Patterns
 00. Not Present
 01. Geometric
3. Punctated
 00. Not present

THIN SECTION FORM

Inclusions	Size Range Very Fine (up to .1 mm) Fine (.1-.25 mm) Medium (.25-.5 mm) Coarse (.5-1 mm) Very Coarse (over 1 mm)	Frequency and Percentage Abundant Common Sparse Rare	Degree of Sorting Very Poor Poor Fair Good Very Good	Roundness High Sphericity Very Angular Angular Low Sphericity Sub-Angular Sub-Rounded Rounded Well-Rounded	Point Count

INAA PROTOCOL

The protocol for selecting ceramic samples for Instrumental Neutron Activation Analysis is completely dependant upon the research question being addressed. Within the scope of a particular research question, however, the selection process is a relatively straightforward series of steps as outlined below. This protocol is based on the assumption that sample selection is to be done for the collection, or set of collections, from a single site.

Generally, the first series of steps involves definition of the sample pool within each collection, and the second series of steps relates to selection and documentation of the specimens to be analyzed.

Defining the Set of Potential Samples

The first step in the protocol is determining how many pottery vessels are represented by the collection. Unless the research question specifically requires information on intravessel variability, it is assumed that there will be no reason to have more than one sample per vessel. The research question will determine which vessels or vessel batches will be sampled, but the critical issue is avoiding the duplication of samples from a single vessel.

Sample Selection, Removal, and Documentation

An individual vessel may be whole or essentially so, or it may be represented by only one or a few sherds. If represented by sherds, it is presumed that the identification of a vessel batch will be made on the basis of attributes such as paste and temper characteristics, vessel form, finish, and decoration. Provenience data may also be relevant.

Once the vessels or vessel batches to be sampled have been identified, the sample to be submitted must be selected. In either case, an effort should be made to avoid, if practical, portions of a vessel or sherd that have labels, particularly if PVA or other material has been applied as a base for the ink label.

Sampling a Whole Vessel

If the vessel is whole or essentially so, the sample is most reasonably taken from an inconspicuous place on the bottom of the vessel. A solid sample may be removed or a powdered sample removed; the decision will depend on a variety of factors including possible exhibit potential of the vessel, thickness of the vessel, etc. It is most likely that a powder sample will be preferred, thereby preserving the basic structural integrity and appearance of the vessel. If so, the outer surface must be removed using a sapphire file or diamond tip on a rotary tool. Then, scrape off or remove by the same means about 200 mg of powder onto laboratory paper, and place in a vial. The vessel should be photographed prior to and preferably after removal of the sample.

Sampling a Vessel Batch of Sherds

If a vessel is represented by more than one sherd, there are a number of options for selecting the actual sample. One option is to identify a single sherd large enough to provide the 200 mg minimum sample (once all surfaces have been removed and discarded). Generally, base or lower body sherds, or those with the fewest decorative/shape characteristics, are preferable. An archive specimen would be another sherd demonstrably from the same vessel, preferably a sherd that possesses as many vessel characteristics as possible.

Sampling a Single Sherd

Alternatively, the sample may be taken from a sherd large enough to leave an archive fragment; this approach has the advantage of leaving an archive specimen unequivocally from the same vessel. Either way, an archive specimen will be available for future examination and analysis. The sample may be removed from the sherd using an electric rotary cutting tool with a

polyglass reinforced cutting blade. Of, if the sherd is large enough, the sample may be snapped off with pliers or other tool, if the metal edges are wrapped in tape to protect the sherd section to be archived. The main drawback to the latter method is that the sherd may crumble when snapped.

Sampling a Raw Clay Source

If a raw clay sample is to be analyzed, the appropriately documented sample may be collected in a vial or plastic bag; an archive sample from exactly the same location should be kept.

Archiving and Documentation

All specimens will be described and photographed prior to sample removal; these documents will be part of the project archives, with appropriate cross-referencing in individual site/collection files. An example of a sample documentation form is attached. Archive specimens should be individually labeled and packaged. The documentation form should indicate any previous laboratory processing that might affect the chemical composition of the sample; an example would be the use of acid to remove carbonate.

For each sample, the following information, as a minimum, should be recorded in an electronic datafile that will accompany the samples to the reactor laboratory:

1. Unique INAA sample identification number
2. Site number (if applicable) or other designation such as collection name
3. Site location, including state, county, and location in either UTM or latitude and longitude (decimals rather than degrees, minutes, and seconds, so that the data can be more readily used in GIS analyses). The location should be noted as approximate or exact.
4. Intrasite provenience
5. Original specimen or lot number
6. Ceramic type, if applicable. Use the formal type name, including formally named varieties
7. Other descriptive information as appropriate. For example, a vessel batch may have been given a batch number previously; this should be recorded along with the name of the analyst who assigned the vessel batch numbers.
8. Other relevant analyses, including petrographic.
9. Facility where archive specimen is, or will be, curated.

Sample Preparation and Submission of Sample

Each sherd or raw clay sample to be analyzed should be placed in its own separate plastic bag with a tag bearing its unique INAA sample number. Typically, no further preparation is necessary. Unless other arrangements are made, the laboratory performing the analysis usually will process the sample according to its own requirements including removing exterior surfaces of the sherd, measuring, powdering, etc.

In addition to providing an electronic datafile to the laboratory, a print copy with list of samples and documentation data should be sent along with the group of samples to be analyzed.

INAA Sample Documentation

SAMPLE# _____ Date Submitted _____

Sample Type: _____ Sherd _____ Raw clay

Site#/collection name _____ Lot# _____

Sherd type: _____ body _____ rim _____ base

Sherd thickness _____ mm

Assoc. of sherd with vessel group: _____ single sherd of _____ (#in vessel group).
_____ refit sherd of _____ (# in vessel group).

Vessel form of sherd group _____

Analytical Group# _____ (classification by _____)

Style/type _____

Sherd exterior decoration/treatment _____

Sherd paste characterization, inclusions/temper:

Method of Sample Removal:

_____ cut with Dremel Tool _____ snapped with pliers _____ other

Petrographic analysis? Date _____ by _____

Digital photo # _____

Location of parent sherd: _____

Location of primary collection (institution, etc.) _____

Sketch of sherd
with sample location marked:

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APPENDIX O

METRIC AND NONMETRIC DATA FOR ARTIFACTS FROM LONG VIEW (41RB112)

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January 2012

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Table O-1.

Lithic Points

Area	A	A	A	A	A	A	A	A
PNUM	23	692	707	727	752	786	804	805
CAT NUM	10	10	10	10	10	10	10	10
Type	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point
Type 2	Washita	Fresno	Fresno	Fresno	Washita	Washita	Fresno	Fresno
Lithology	Ortho-Quartzite	Agatized dolomite	Agatized dolomite	Chert	Agatized dolomite	Agatized dolomite	Jasper	Jasper
Sourcing		Alibates	Alibates		Alibates	Alibates	Tecovas	Tecovas
Weight	0.4	1.6	0.5	0.7	0.3	0.6	0.6	1.3
Max Length	14.1	19.3	11.7	16.4	8.9	22.1	19.6	22.3
Max Width	12.8	17.9	13.1	16.1	11.7	12.2	12.7	14.4
Max Thickness	2.7	3.8	2.6	3.2	2.6	2.8	3	4.8
Point Ratio	0.90780141844		1.1196581197	0.98170731707	1.3146067416	0.5520361991	0.64795918367	0.64573991031
Stage	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product
Portion	Complete	Proximal-medial	Proximal-medial	Proximal-medial	Proximal	Complete	Complete	Fragment
Failure / Discard								
Alteration				Thermal	Thermal		Thermal	Thermal
Edge Angle 1	50	35	n/a	30	n/a	35	30	35
Edge Angle 2	55	30	n/a	35	n/a	35	30	n/a
Edge Angle 3	n/a	35	n/a	n/a	n/a	n/a	n/a	n/a
Edge Angle 4								
Edge Morphology Distal	Point						Point	
Edge Morphology Proximal	Straight	Recurved	Concave	Concave	Concave	Concave	Concave	Convex
Edge Morphology Lateral 1	Indeterminate	Recurved	Straight	Straight		Straight	Convex	Recurved
Edge Morphology Lateral 2	Indeterminate	Convex	Recurved	Straight		Straight	Straight	
Flake Scar Pattern	Random	Marginal pressure	Random	Random	Random	Random	Random	Random
Edge Construction 1	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 2	Bifacial-unilateral	Bifacial-proximal	Bifacial-unilateral	Bifacial-unilateral		Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 3	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral		Bifacial-unilateral	Bifacial-unilateral	
Edge Construction 4								

Table O-1.

Lithic Points

Area	A	A	A	A	A	A	A	A
PNUM	822	844	971	988	1009	1051	1051	1061
CAT NUM	10	10	10	10	11	10	11	10
Type	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point
Type 2	Fresno	Fresno	Washita	Possible Fresno	Washita	Washita		Washita
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	0.5	0.9	0.2	0.6	1.4	0.9	0.5	0.5
Max Length	15.4	24.6	8.8	18.5	21.8	26.5	15.3	17.6
Max Width	10.5	14.7	11.3	10.7	15.6	13.4	10.8	13.9
Max Thickness	3.4	3.5	2.3	2.7	3.8	2.9	2.9	2.5
Point Ratio	0.68181818182	0.59756097561	1.2840909091			0.50566037736	0.70588235294	
Stage	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product
Portion	Complete	Fragment	Proximal	Distal-medial	Proximal-medial	Complete, broken in two	Medial	missing tip
Failure / Discard								
Alteration		Thermal				Thermal		Thermal
Edge Angle 1	40	35	n/a	35	35	30	35	n/a
Edge Angle 2	45	30	n/a	35	35	35	30	n/a
Edge Angle 3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Edge Angle 4								
Edge Morphology Distal	Point			Point				
Edge Morphology Proximal	Concave	Indeterminate	Concave		Concave	Concave		Concave
Edge Morphology Lateral 1	Convex	Indeterminate		Straight	Straight	Straight	Straight	Straight
Edge Morphology Lateral 2	Convex	Convex		Straight	Straight	Straight	Straight	Straight
Flake Scar Pattern	Random	Random	Random	Random	Random	Random	Random	Random
Edge Construction 1	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 2	Bifacial-unilateral	Bifacial-unilateral		Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 3	Bifacial-unilateral	Bifacial-unilateral			Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 4								

Table O-1.

Lithic Points

Area	A	A	A	C	C	C	C	C
PNUM	1216	1269	1270	145	152	175	180	182
CAT NUM	10	12	10	10	10	10	10	10
Type	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point
Type 2	Fresno-like	Fresno	Harrell	Possible Fresno	Fresno		Fresno	Possible Washita
Lithology	Chalcedony	Agatized dolomite	Agatized dolomite	Chert-Chalcedony Blend	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing		Alibates	Alibates		Alibates	Alibates	Alibates	Alibates
Weight	0.7	0.9	0.6	0.8	0.3	0.2	0.4	0.5
Max Length	16.9	20.4	23.5	21.3	8.6	12	7.9	16.1
Max Width	15.9	14.7	13	13.6	15.4	9.1	14.7	11.7
Max Thickness	3.6	3.2	2.6	3.5	2.6	2.6	3.3	2.9
Point Ratio		0.72058823529	0.55319148936	0.63849765258	1.7906976744	0.75833333333	1.8607594937	0.72670807453
Stage	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Late Stage Preform
Portion	Proximal-medial	Proximal-medial	Complete	Complete	Proximal	Distal	Proximal	Medial
Failure / Discard								Indeterminate
Alteration		Thermal	Thermal			Thermal	Thermal	Thermal
Edge Angle 1	35	35	35	40	40	35	35	30
Edge Angle 2	45	40	35	40	n/a	30	25	40
Edge Angle 3	30	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Edge Angle 4								
Edge Morphology Distal				Point		Very Convex		Indeterminate
Edge Morphology Proximal	Concave	Concave	Concave	Straight	Concave		Straight	
Edge Morphology Lateral 1	Indeterminate	Straight	Straight	Recurved	Convex	Straight	Straight	Convex
Edge Morphology Lateral 2	Recurved	Straight	Straight	Recurved		Straight	Straight	Convex
Flake Scar Pattern	Random	Random	Random	Random	Random	Random	Random	Random
Edge Construction 1	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 2	Bifacial-proximal	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 3	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral		Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 4								

Table O-1.

Lithic Points

Area	C	C	C	C	C	C	C	C
PNUM	193	200	200	204	206	210	224	236
CAT NUM	10	10	12	10	10	10	10	10
Type	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point
Type 2		Washita	Washita	Fresno	Fresno	Fresno	Fresno	
Lithology	Chert	Agatized dolomite	Agatized dolomite		Agatized dolomite	Agatized dolomite	Agatized dolomite	Chert-Chalcedony Blend
Sourcing		Alibates	Alibates		Alibates	Alibates	Alibates	
Weight	0.7	0.7	0.7	1	0.6	0.7	0.3	0.4
Max Length	18.9	20.1	20.6	20.2	19.4	12.4	11.1	20.5
Max Width	13	15.5	13.9	14.4	12.4	19	14.5	9
Max Thickness	2.7	3.4	2.9	3.8	2.2	2.6	3.2	2.6
Point Ratio	0.68783068783	0.77114427861	0.67475728155	0.71287128713	0.63917525773	1.5322580645	1.3063063063	0.43902439024
Stage	Finished Product	Rejuvenated/Repaired	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product
Portion	Distal	Complete	Complete	Proximal-medial	Proximal-medial	Proximal	Proximal	Fragment
Failure / Discard								
Alteration	Thermal	Thermal			Thermal			
Edge Angle 1	30	40	40	35	30	40	35	30
Edge Angle 2	30	45	40	35	25	40	30	n/a
Edge Angle 3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Edge Angle 4								
Edge Morphology Distal	Point	Point	Very Convex					
Edge Morphology Proximal		Concave	Concave	Concave	Concave	Concave	Straight	
Edge Morphology Lateral 1	Straight	Straight	Indeterminate	Straight	Straight	Convex	Straight	Convex
Edge Morphology Lateral 2	Straight	Straight	Recurved	Straight	Straight	Convex	Straight	
Flake Scar Pattern	Random	Random	Random	Random	Random	Random	Random	Random
Edge Construction 1	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 2	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	
Edge Construction 3		Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	
Edge Construction 4								

Table O-1.

Lithic Points

Area	C	C	C	C	C	C	C
PNUM	281	291	301	360	368	373	410
CAT NUM	10	11	11	10	10	10	11
Type	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point
Type 2	Fresno	Washita	Fresno		Possible Washita	Harrell	Harrell
Lithology	Agatized dolomite	Agatized dolomite	Chert-Chalcedony Blend	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates		Alibates	Alibates	Alibates	Alibates
Weight	0.5	0.7	0.6	0.2	0.9	0.8	0.6
Max Length	17.9	21.2	20.3	12.1	26.4	21.8	17.6
Max Width	10.2	15.3	13.2	11.8	13.6	12.4	12.8
Max Thickness	2.7	2.4	2.5	2.3	2.8	3	2.6
Point Ratio	0.56983240223	0.72169811321	0.65024630542	0.97520661157	0.51515151515	0.56880733945	0.72727272727
Stage	Finished Product	Rejuvenated/Repaired	Finished Product	Indeterminate	Rejuvenated/Repaired	Finished Product	Finished Product
Portion	Nearly Complete	Nearly Complete	Complete	Proximal-medial	Complete	Proximal-medial	Complete *
Failure / Discard							
Alteration					Thermal	Thermal	
Edge Angle 1	35	35	35	25	30	40	35
Edge Angle 2	35	35	40	n/a	35	35	35
Edge Angle 3	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Edge Angle 4							
Edge Morphology Distal	Very Convex	Point	Very Convex		Point		Point
Edge Morphology Proximal	Concave	Concave	Convex	Convex	Straight	Concave	Concave
Edge Morphology Lateral 1	Straight	Straight	Straight	Indeterminate	Straight	Straight	Convex
Edge Morphology Lateral 2	Straight	Convex	Convex		Convex	Straight	Convex
Flake Scar Pattern	Random	Random	Random	Random	Random	Random	Random
Edge Construction 1	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 2	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 3	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral		Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 4							

Table O-1.

Lithic Points

Area	C	C	C	C	C	C	C	C
PNUM	449	451	460	464	510	510	589	589
CAT NUM	12	10	10	11	10	12	10	11
Type	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point
Type 2		Fresno	Harrell	Fresno	Washita	Washita	Harrell	Washita
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Chert
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	
Weight	0.3	0.6	0.5	0.2	0.9	1.1	0.6	0.2
Max Length	13.2	17.7	20.1	10.5	21.9	27.6	26.8	9.7
Max Width	11.3	14.6	11.6	12.4	14.3	13.4	12.8	16.2
Max Thickness	2.2	2.5	2.6	2.1	3.4	3.5	2.6	2.2
Point Ratio	0.85606060606	0.82485875706	0.57711442786	1.180952381	0.65296803653	0.48550724638	0.4776119403	1.6701030928
Stage	Finished Product	Finished Product	Finished Product	Finished Product	Rejuvenated/Repaired	Finished Product	Finished Product	Finished Product
Portion	Distal	Complete	Complete	Proximal	Nearly Complete	Nearly Complete	Lateral edge(s) missing	Proximal
Failure / Discard								
Alteration							Thermal	
Edge Angle 1	35	30	35	30	45	45	30	n/a
Edge Angle 2	35	35	35	30	40	40	30	n/a
Edge Angle 3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Edge Angle 4								
Edge Morphology Distal	Point	Very Convex	Point			Very Convex	Point	
Edge Morphology Proximal		Concave	Concave	Concave	Concave	Recurved	Concave	Concave
Edge Morphology Lateral 1	Convex	Convex	Straight	Straight	Convex	Concave	Convex	
Edge Morphology Lateral 2	Straight	Recurved	Straight	Concave	Concave	Straight	Convex	
Flake Scar Pattern	Random	Random	Random	Random	Random	Random	Random	Random
Edge Construction 1	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 2	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	
Edge Construction 3		Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	
Edge Construction 4								

Table O-1.

Lithic Points

Area	C	C	C	C	C	C	C
PNUM	595	626	648	669	1262	1269	1269
CAT NUM	10	10	14	11	10	10	11
Type	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point	Projectile Point
Type 2	Possible Fresno	Fresno	Possible Washita		Fresno	Washita	Fresno
Lithology	Agatized dolomite	Jasper	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Tecovas	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	1.2	0.6	0.7	0.3	1.3	0.9	2.3
Max Length	23.7	15.6	25.8	9.2	23.5	27.3	27.1
Max Width	16.3	13.9	13.4	9	18.5	13.3	16.3
Max Thickness	3.2	2.6	2.8	2.1	3.6	3.3	5.3
Point Ratio	0.68776371308	0.89102564103	0.51937984496	0.97826086957	0.78723404255	0.48717948718	0.60147601476
Stage	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product
Portion	Complete	Proximal-medial	Distal-medial	Medial	Complete	Nearly Complete	Complete
Failure / Discard							
Alteration		Thermal			Thermal		Thermal
Edge Angle 1	35	35	35	35	40	35	50
Edge Angle 2	35	40	30	30	40	35	45
Edge Angle 3	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Edge Angle 4							
Edge Morphology Distal	Point		Point		Point	Point	Point
Edge Morphology Proximal	Recurved	Convex			Straight	Concave	Straight
Edge Morphology Lateral 1	Convex	Recurved	Convex	Indeterminate	Straight	Straight	Convex
Edge Morphology Lateral 2	Convex	Convex	Convex	Indeterminate	Straight	Straight	Convex
Flake Scar Pattern	Random	Random	Random	Random	Random	Random	Random
Edge Construction 1	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 2	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 3	Bifacial-unilateral	Bifacial-unilateral			Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 4							

Table O-2.

Lithic Bifaces

Area	A	A	A	A	A
PNUM	2	2	3	697	733
CAT NUM	10	11	11	10	10
Type	Bifacial tool of unknown function	Bifacial tool of unknown function	Bifacial tool of unknown function	Bifacial tool of unknown function	Bifacial tool of unknown function
Type 2					
Lithology	Agatized dolomite	Jasper	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Niabrara	Alibates	Alibates	Alibates
Weight	21.3	28.6	5	12.3	0.6
Max Length	62.9	57.1	17.4	32.3	10.3
Max Width	32.4	43.3	28.9	29.4	12.3
Max Thickness	13.1	11	7.9	10.9	4.5
Point Ratio		0.75831873905	1.6609195402		1.1941747573
Stage	Finished Product	Finished Product	Finished Product	Indeterminate	Finished Product
Portion	Distal-medial	Distal-medial	Fragment	Fragment	Distal
Failure / Discard				Indeterminate	
Alteration	Thermal				
Edge Angle 1	60	40	40	55	40
Edge Angle 2	55	35		60	40
Edge Angle 3	60				
Edge Angle 4					
Edge Morphology Distal	Convex	Convex			Convex
Edge Morphology Proximal					
Edge Morphology Lateral 1	Straight	Convex	Convex	Serrated	Convex
Edge Morphology Lateral 2	Convex			Straight	Convex
Flake Scar Pattern	Random	Random	Random	Steep abrupt percussion	Random
Edge Construction 1	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 2	Bifacial-distal	Bifacial-unilateral		Unifacial-unilateral ventral side	Bifacial-unilateral
Edge Construction 3	Bifacial-unilateral				Bifacial-unilateral
Edge Construction 4					

Table O-2.

Lithic Bifaces

Area	A	A	A	A	A	A
PNUM	768	768	768	768	780	852
CAT NUM	10	11	12	13	10	10
Type	Four-beveled biface	Beveled knife	Four-beveled biface	Beveled knife	Bifacial tool of unknown function	Bifacial tool of unknown function
Type 2	Beveled knife		Beveled knife			
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Chert	Jasper
Sourcing	Alibates	Alibates	Alibates	Alibates		Niabrara
Weight	17.6	25.5	9.9	23.3	13.2	0.6
Max Length	76.6	64.9	71.9	56.4	44.3	14.1
Max Width	26.2	34.6	17.9	44.3	36.7	10.4
Max Thickness	8.7	8.5	7.6	8.7	7.5	4.2
Point Ratio						0.73758865248
Stage	Finished Product	Finished Product	Finished Product	Finished Product	Indeterminate	Finished Product
Portion	Complete	Distal-medial	Complete	Distal-medial	Fragment	Distal
Failure / Discard	Exhausted		Exhausted		Indeterminate	
Alteration	Thermal					
Edge Angle 1	65	55	70	70	45	40
Edge Angle 2	65	60	70	65		50
Edge Angle 3	65		70			
Edge Angle 4	70		60			
Edge Morphology Distal						Convex
Edge Morphology Proximal						
Edge Morphology Lateral 1	Recurved	Recurved	Recurved	Straight	Convex	Convex
Edge Morphology Lateral 2	Recurved	Straight	Recurved	Convex		Convex
Flake Scar Pattern	Random		Random	Random		Random
Edge Construction 1	Patterned resharpening	Bifacial-unilateral	Patterned resharpening	Bifacial-unilateral	Unifacial-unilateral	Bifacial-unilateral
Edge Construction 2		Bifacial-unilateral		Bifacial-unilateral		Bifacial-unilateral
Edge Construction 3						Bifacial-unilateral
Edge Construction 4						

Table O-2.

Lithic Bifaces

Area	A	A	A	A	A
PNUM	854	857	863	1106	1271
CAT NUM	10	10	10	11	10
Type	Bifacial tool of unknown function	Bifacial tool of unknown function	Bifacial tool of unknown function	Bifacial tool of unknown function	Bifacial tool of unknown function
Type 2			Beveled Edge		
Lithology	Opalite	Agatized dolomite	Agatized dolomite	Jasper	Agatized dolomite
Sourcing		Alibates	Alibates	Tecovas	Alibates
Weight	2.7	6.8	1.1	2.5	8.4
Max Length	24.9	37.6	14.5	21.2	35.7
Max Width	26.6	15.7	17.5	16	25.1
Max Thickness	6	1.7	4.4	7.2	7.6
Point Ratio	1.0682730924		1.2068965517	0.75471698113	0.70308123249
Stage	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product
Portion	Medial	Complete	Medial	Distal-medial	Distal-medial
Failure / Discard					
Alteration	Thermal	Thermal	Thermal		
Edge Angle 1	50	55	60	55	50
Edge Angle 2		45		55	55
Edge Angle 3					
Edge Angle 4					
Edge Morphology Distal				Point	Point
Edge Morphology Proximal					
Edge Morphology Lateral 1	Indeterminate	Convex	Straight	Straight	Convex
Edge Morphology Lateral 2		Recurved		Convex	Convex
Flake Scar Pattern	Random	Marginal pressure	Bifacial Beveled edge	Random	Random
Edge Construction 1	Bifacial-unilateral	Unifacial-unilateral-ventral side	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 2		Unifacial-unilateral-dorsal side		Bifacial-unilateral	Bifacial-unilateral
Edge Construction 3					
Edge Construction 4					

Table O-2.

Lithic Bifaces

Area	C	C	C	C	C
PNUM	90	200	242	246	265
CAT NUM	10	11	10	10	11
Type	Bifacial tool of unknown function	Bifacial tool of unknown function	Beveled knife	Bifacial tool of unknown function	Bifacial tool of unknown function
Type 2	With Spokeshave				
Lithology	Jasper	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Niabrara	Alibates	Alibates	Alibates	Alibates
Weight	8.7	2	3.1	5.8	12.2
Max Length	42	22.7	25	27.7	28.4
Max Width	27.1	19.3	22.8	27.6	29.3
Max Thickness	12.5	7.9	6.6	8.1	11.5
Point Ratio	0.64523809524	0.85022026432			1.0316901408
Stage	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product
Portion	Distal-medial	Complete	Distal-medial	Distal-medial	Distal-medial
Failure / Discard					
Alteration					
Edge Angle 1	45	45	50	70	60
Edge Angle 2	45		55	55	55
Edge Angle 3	55			60	
Edge Angle 4					
Edge Morphology Distal	Very Convex		Point	Convex	Convex
Edge Morphology Proximal					
Edge Morphology Lateral 1	Convex	Indeterminate	Recurved	Convex	Convex
Edge Morphology Lateral 2	Recurved		Convex	Straight	Convex
Flake Scar Pattern	Marginal percussion	Marginal percussion		Random	Marginal percussion
Edge Construction 1	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 2	Bifacial-unilateral		Bifacial-unilateral	Bifacial-distal	Bifacial-unilateral
Edge Construction 3	Bifacial-unilateral			Bifacial-unilateral	Bifacial-unilateral
Edge Construction 4					

Table O-2.

Lithic Bifaces

Area	C	C	C
PNUM	417	646	648
CAT NUM	10	12	20
Type	Bifacial tool of unknown function	Bifacial tool of unknown function	Bifacial tool of unknown function
Type 2		possible distal graver modification	Beveled Edge
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates
Weight	8.8	45.7	1.8
Max Length	36.6	69.1	25.9
Max Width	27.1	53.4	22.7
Max Thickness	9.6	15.3	2.9
Point Ratio			0.87644787645
Stage	Finished Product	Finished Product	Finished Product
Portion	Indeterminate	Distal-medial	Distal-medial
Failure / Discard			
Alteration		Thermal	
Edge Angle 1	70	65	40
Edge Angle 2	55	25	45
Edge Angle 3	50	60	
Edge Angle 4			
Edge Morphology Distal	Convex	Very Convex	Point
Edge Morphology Proximal			
Edge Morphology Lateral 1	Convex	Recurved	Convex
Edge Morphology Lateral 2	Recurved	Recurved	Convex
Flake Scar Pattern	Random	Random	Beveled
Edge Construction 1	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 2	Unifacial-distal	Unifacial-distal	Unifacial-unilateral
Edge Construction 3	Unifacial-unilateral	Bifacial-unilateral	
Edge Construction 4			

Table O-3.

Lithic Scrapers

Area	A	A	A	A	A
PNUM	22	688	768	771	775
CAT NUM	10	10	14	10	10
Type	Scraper	Scraper	Scraper	Scraper	Scraper
Type 2	Side scraper		End/Side scraper	Turtleback Scraper w/ Graver Mod	End Scraper
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Jasper
Sourcing	Alibates	Alibates	Alibates	Alibates	
Weight	6.5	2.8	9.8	4.4	2
Max Length	32.6	24.5	41.2	28.2	10.9
Max Width	22.6	21.8	31.9	17.5	26.1
Max Thickness	6.4	5	6.9	9.3	7.2
Point Ratio		0.88979591837		0.62056737589	
Stage	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product
Portion	Distal-medial	Medial	Complete	Complete	Distal
Failure / Discard	Perverse				
Alteration	Thermal		Thermal	Thermal	
Edge Angle 1	70	60	60	65	55
Edge Angle 2	60	40	75	50	
Edge Angle 3			60	65	
Edge Angle 4				70	
Edge Morphology Distal			Convex		Convex
Edge Morphology Proximal					
Edge Morphology Lateral 1	Convex	Straight	Convex	Not Applicable	
Edge Morphology Lateral 2	Convex	Convex	Convex	Not Applicable	
Flake Scar Pattern	Marginal pressure	Marginal pressure	Marginal pressure (lateral), steep abrupt percussion (distal)	Steep abrupt percussion	Steep abrupt percussion
Edge Construction 1	Unifacial-unilateral	Unifacial-unilateral	Unifacial-unilateral-dorsal side	Unifacial-unilateral	Unifacial-distal dorsal side
Edge Construction 2	Unifacial-unilateral	Unifacial-unilateral	Unifacial-distal	Unifacial-unilateral	
Edge Construction 3			Bifacial-unilateral	Unifacial-unilateral	
Edge Construction 4				Unifacial-unilateral	

Table O-3.

Lithic Scrapers

Area	A	A	A	A	A	A	A
PNUM	775	786	796	798	836	859	883
CAT NUM	12	11	10	10	10	10	10
Type	Scraper	Scraper	Scraper	Scraper	Scraper	Scraper	Scraper
Type 2		End/Side scraper			Turtleback Scraper	End/Side scraper	
Lithology	Agatized dolomite	Other	Agatized dolomite	Agatized dolomite	Jasper	Agatized dolomite	Agatized dolomite
Sourcing	Alibates		Alibates	Alibates	Niabrara	Alibates	Alibates
Weight	0.6	8.4	1.2	3	2	4.7	7.5
Max Length	9.8	22.7	14.4	18.8	21.3	29.4	30.6
Max Width	11.7	28.2	13.5	28.7	10.3	22.8	26.3
Max Thickness	5.2	10.7	6.6	4.8	8.5	5.5	7.9
Point Ratio	1.193877551		0.9375		0.48356807512		
Stage	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Indeterminate
Portion	Medial	Complete	Medial	Fragment	Complete	Proximal-medial	Proximal-medial
Failure / Discard							
Alteration		Thermal	Thermal				
Edge Angle 1	65	75	60	60	65	85	60
Edge Angle 2						65	65
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal		Convex		Convex		Convex	
Edge Morphology Proximal		Convex				Straight	
Edge Morphology Lateral 1	Indeterminate	Convex	Convex		Not Applicable	Convex	Convex
Edge Morphology Lateral 2		Convex				Convex	Convex
Flake Scar Pattern	Marginal percussion	Steep abrupt percussion	Marginal pressure	Steep abrupt percussion	Steep abrupt percussion	Steep abrupt percussion	
Edge Construction 1	Unifacial-unilateral	Bifacial-circumferential	Unifacial-unilateral	Unifacial-unilateral dorsal side	Unifacial-unilateral	Unifacial-circumferential	Bifacial-unilateral
Edge Construction 2							Unifacial-unilateral
Edge Construction 3							
Edge Construction 4							

Table O-3.

Lithic Scrapers

Area	A	A	C	C	C	C
PNUM	1004	1042	103	352	643	1233
CAT NUM	11	10	10	10	10	10
Type	Scraper	Scraper	Scraper	Scraper	Scraper	Scraper
Type 2	End Scraper		End/Side scraper	Convex end scraper	End/Side scraper	
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Jasper
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Tecovas
Weight	3.8	16.7	9.5	4.8	11.3	10.2
Max Length	27.1	51.9	40.1	31.5	39.2	31.9
Max Width	26.7	29.2	26.6	23.8	26	33
Max Thickness	7	11.7	7.1	6.8	9.7	9.3
Point Ratio			0.66334164589			
Stage	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product	Finished Product
Portion	Complete	Complete	Complete	Complete	Complete	Proximal-medial
Failure / Discard						
Alteration	Thermal	Thermal		Thermal	Thermal	Thermal
Edge Angle 1	65	70	60		60	70
Edge Angle 2		50	60	65	60	65
Edge Angle 3		70	60		60	
Edge Angle 4		65				
Edge Morphology Distal	Convex	Convex	Convex	Convex	Very Convex	
Edge Morphology Proximal		Convex				
Edge Morphology Lateral 1	Recurved	Convex	Convex	Convex	Convex	Convex
Edge Morphology Lateral 2	Concave	Convex	Indeterminate	Straight	Serrated	Convex
Flake Scar Pattern	Steep abrupt percussion	Steep abrupt percussion	Steep abrupt percussion	Steep abrupt percussion	Steep abrupt percussion	Steep abrupt percussion
Edge Construction 1	Unifacial-distal dorsal side	Unifacial-circumferential dorsal side	Unifacial-unilateral	Unifacial-unilateral	Unifacial-unilateral dorsal side	Unifacial-unilateral
Edge Construction 2	Unifacial-unilateral dorsal side		Unifacial-unilateral	Unifacial-distal	Unifacial-distal dorsal side	Unifacial-unilateral
Edge Construction 3	Other		Unifacial-unilateral	Unifacial-unilateral	Unifacial-unilateral dorsal side	
Edge Construction 4						

Table O-3.

Lithic Scrapers

Area	C	C
PNUM	1273	1287
CAT NUM	10	10
Type	Scraper	Scraper
Type 2		End/Side scraper
Lithology	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates
Weight	5.2	5.8
Max Length	27.6	20.6
Max Width	27.2	27.5
Max Thickness	6.9	8.2
Point Ratio		
Stage	Finished Product	Finished Product
Portion	Complete	Complete
Failure / Discard		
Alteration	Thermal	
Edge Angle 1	60	75
Edge Angle 2		70
Edge Angle 3		75
Edge Angle 4		
Edge Morphology Distal	Convex	Convex
Edge Morphology Proximal	Convex	
Edge Morphology Lateral 1	Convex	Convex
Edge Morphology Lateral 2	Convex	Convex
Flake Scar Pattern	Steep abrupt percussion	Steep abrupt percussion
Edge Construction 1	Bifacial-circumferential	Unifacial distal dorsal side
Edge Construction 2		Unifacial unilateral dorsal side
Edge Construction 3		Unifacial unilateral dorsal side
Edge Construction 4		

Table O-4.

Lithic Drills

Area	A	A	A	A	C	C	C	C	C
PNUM	42	810	819	943	174	202	231	254	648
CAT NUM	12	10	10	10	10	12	11	10	15
Type	Drill	Drill	Drill	Drill	Drill	Drill	Drill	Drill	Drill
Type 2		w/ modified edge	w/ modified edges						
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Chalcedony	Jasper	Jasper	Jasper	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates		Tecovas	Tecovas	Tecovas	Alibates
Weight	1.9	0.9	4.2	0.2	0.8	4.2	3.1	2.5	0.4
Max Length	14.1	13.7	19.3	11	27.3	26.8	24.7	21.5	17.5
Max Width	23.4	19.2	31.7	10.6	7.6	24.2	22.4	16.6	6.3
Max Thickness	7.4	4.3	9	2.5	3.6	6.3	6.5	6.9	4.5
Point Ratio	1.6595744681	1.401459854	1.6424870466					0.77209302326	
Stage	Finished Product	Recycled	Recycled	Finished Product	Finished Product	Indeterminate	Finished Product	Finished Product	Finished Product
Portion	Medial	Indeterminate	Medial	Complete	Distal-medial	Proximal	Proximal	Fragment	Distal
Failure / Discard		Perverse	Indeterminate						
Alteration		Thermal							
Edge Angle 1	65	60	60	45	70				70
Edge Angle 2	60			35	60				70
Edge Angle 3				50					
Edge Angle 4									
Edge Morphology Distal					Point				Point
Edge Morphology Proximal				Straight			Indeterminate		
Edge Morphology Lateral 1	Indeterminate	Indeterminate	Indeterminate	Concave	Straight		Indeterminate		Straight
Edge Morphology Lateral 2	Concave	Indeterminate		Concave	Straight		Indeterminate		Straight
Flake Scar Pattern	Random	Marginal pressure	Marginal pressure		Invasive pressure		Marginal pressure	Random	Collateral
Edge Construction 1	Bifacial-unilateral	Unifacial-unilateral	Unifacial-unilateral	Bifacial-circumferential	Bifacial-unilateral		Indeterminate		Bifacial-unilateral
Edge Construction 2	Bifacial-unilateral	Unifacial-unilateral			Bifacial-unilateral		Indeterminate		Bifacial-unilateral
Edge Construction 3									
Edge Construction 4									

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	2	3	3	14	16	17	18
CAT NUM	12	12	13	10	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Day Creek	Alibates
Weight	22.8	1.1	0.5	4.4	27.91	13.9	6.1
Max Length	60.53	17.89	11.38	31.92	54.94	50.7	29.42
Max Width	49.16	17.13	16.09	23.62	61.96	33.6	29.06
Max Thickness	9.68	3.24	3.28	6.44	13.47	12.18	7.31
Point Ratio							
Stage							
Portion	Complete	Distal-medial	Medial	Complete	Proximal-medial	Complete	Medial
Failure / Discard							
Alteration							Thermal
Edge Angle 1							
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1							
Edge Morphology Lateral 2							
Flake Scar Pattern							
Edge Construction 1							
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	19	36	38	42	42	45	51
CAT NUM	10	10	10	10	11	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	1.8	1.2	1.9	1.6	2.8	6.4	1.5
Max Length	21.14	18.94	20.48	19.34	22.99	29.06	18.01
Max Width	28.56	20.55	17.51	15.47	28.72	34.2	23.39
Max Thickness	4.14	3.15	5.16	5.7	4.95	6.5	5.03
Point Ratio							
Stage						Finished Product	
Portion	Distal-medial	Proximal-medial	Distal-medial	Distal-medial	Distal-medial	Complete	Distal-medial
Failure / Discard							
Alteration						None observed	
Edge Angle 1						45	
Edge Angle 2						50	
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1						Convex	
Edge Morphology Lateral 2						Serrated	
Flake Scar Pattern						Marginal pressure	
Edge Construction 1						Unifacial-unilateral	
Edge Construction 2						Unifacial-unilateral	
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	51	51	51	51	58	58	74
CAT NUM	11	12	13	14	11	12	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Chalcedony	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates		Alibates
Weight	1.1	7.5	1.3	1.4	6.7	2	4.6
Max Length	27.45	31.17	30.1	16.48	40.9	20.34	26.67
Max Width	17.94	35.21	19.19	17.09	28.86	26.12	30.11
Max Thickness	2.67	7.85	3.18	4.32	8.64	4.48	6.57
Point Ratio							
Stage							
Portion	Proximal-medial	Distal-medial	Medial	Medial	Complete	Distal-medial	Distal-medial
Failure / Discard							
Alteration							Carbonate build-up
Edge Angle 1							
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1							
Edge Morphology Lateral 2							
Flake Scar Pattern							
Edge Construction 1							
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	692	693	693	697	703	704	707
CAT NUM	11	10	11	10	10	12	11
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Edge Modified Flake with Graver Modification	Generalized modified flake tool of unknown function
Type 2						Multi-point Graver	
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Jasper	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates		Alibates	Alibates
Weight	4.6	0.6	1	2.8	0.3	5.9	3.4
Max Length	38.31	10.47	12.82	16.7	11.03	52.5	28
Max Width	23.36	17.5	25.41	29.73	11.58	22.6	29.36
Max Thickness	9.04	3.46	3.55	4.82	2	6.9	5.69
Point Ratio							
Stage						Finished Product	
Portion	Complete	Medial	Distal-medial	Medial	Medial	Complete	Proximal-medial
Failure / Discard							
Alteration			Thermal			Thermal	
Edge Angle 1							
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal						Point	
Edge Morphology Proximal							
Edge Morphology Lateral 1							
Edge Morphology Lateral 2							
Flake Scar Pattern							
Edge Construction 1						Snap or radial break with superimposed retouch	
Edge Construction 2						Other	
Edge Construction 3						Bifacial-unilateral	
Edge Construction 4						Unifacial-unilateral	

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	708	713	718	719	719	719	719
CAT NUM	10	10	10	10	11	12	13
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Ortho-Quartzite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates		Alibates	Alibates	Alibates	Alibates	Alibates
Weight	0.6	3.2	1.2	11.3	1.5	1	0.8
Max Length	11.41	14.95	18.17	49.04	19.19	12.37	8.14
Max Width	12.33	24.94	25.65	30.51	13.96	23.57	15.63
Max Thickness	7.59	6.85	2.82	7.77	4.95	5.59	6.36
Point Ratio							
Stage							
Portion	Medial	Medial	Medial	Complete	Medial	Medial	Medial
Failure / Discard							
Alteration							
Edge Angle 1							
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1							
Edge Morphology Lateral 2							
Flake Scar Pattern							
Edge Construction 1							
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	723	723	734	735	739	743	750
CAT NUM	10	11	10	10	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	0.7	0.4	0.7	3.2	1.8	4.5	0.2
Max Length	10.99	12.52	10.33	35.15	20.97	25.27	16.23
Max Width	11.2	11.81	19.69	28.45	28.44	27.3	6.86
Max Thickness	5.73	3.16	4.44	3.84	3.42	6	1.86
Point Ratio							
Stage							
Portion	Medial	Medial	Medial	Proximal-medial	Proximal-medial	Medial	Medial
Failure / Discard							
Alteration							
Edge Angle 1							
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1							
Edge Morphology Lateral 2							
Flake Scar Pattern							
Edge Construction 1							
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	751	751	752	754	755	755	758
CAT NUM	10	11	11	10	10	11	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	1.7	1.4	2.3	2.3	5.5	2.7	6.4
Max Length	18.38	25.09	24.5	23.29	24.6	24.43	27.76
Max Width	14.05	17.66	26.8	21.11	37.3	21.34	22.38
Max Thickness	5.8	3.96	3.6	6.47	8.1	6.09	10
Point Ratio							
Stage			Finished Product		Indeterminate		
Portion	Medial	Proximal-medial	Complete	Complete	Indeterminate	Proximal-medial	Medial
Failure / Discard					Perverse		
Alteration			Thermal		Thermal		
Edge Angle 1					45		
Edge Angle 2					60		
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1			Convex		Convex		
Edge Morphology Lateral 2					Concave		
Flake Scar Pattern			Marginal edge nibbling		Marginal pressure		
Edge Construction 1			Unifacial-unilateral dorsal side		Unifacial-unilateral		
Edge Construction 2					Bifacial-unilateral		
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	765	768	768	772	775	776	777
CAT NUM	10	15	16	10	11	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Uniface	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	2.5	0.5	0.7	1.1	1.1	1	2.2
Max Length	20.4	11.44	9.71	10.33	15.9	17.15	17.11
Max Width	21.09	9.46	12.7	18.74	10.1	16.28	27.64
Max Thickness	6.48	5.73	4.84	4.94	8.2	3.71	4.43
Point Ratio					0.63522012579		
Stage					Finished Product		
Portion	Proximal-medial	Medial	Medial	Medial	Fragment	Medial	Medial
Failure / Discard							
Alteration							
Edge Angle 1					50		
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1					Indeterminate		
Edge Morphology Lateral 2							
Flake Scar Pattern					Marginal percussion		
Edge Construction 1					Unifacial-unilateral		
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	778	779	780	786	786	787	790
CAT NUM	10	10	11	12	13	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Uniface
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Jasper	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates		Alibates	Alibates	Alibates	Alibates
Weight	0.8	1.2	0.9	1.5	1.2	1.4	2.9
Max Length	14.12	13.93	12.69	16.68	13.53	17.27	14.5
Max Width	10.37	21.12	13.37	16.01	16.18	18.32	28.9
Max Thickness	5.23	4.18	8.28	5.89	4.33	5.58	5.7
Point Ratio							1.9931034483
Stage							Finished Product
Portion	Medial	Medial	Medial	Medial	Medial	Proximal-medial	Medial
Failure / Discard							
Alteration							
Edge Angle 1							45
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1							Indeterminate
Edge Morphology Lateral 2							
Flake Scar Pattern							Marginal pressure
Edge Construction 1							Unifacial-unilateral
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	794	802	809	814	819	827	834
CAT NUM	10	10	10	10	11	10	11
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Spokeshave	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Jasper	Agatized dolomite	Agatized dolomite	Jasper	Agatized dolomite	Chert
Sourcing	Alibates	Tecovas	Alibates	Alibates		Alibates	
Weight	15.5	22.4	0.4	1.1	11.8	2.4	4.6
Max Length	43.18	43.51	21.09	10.45	21.1	13.73	27.62
Max Width	44.52	38.47	7.25	14.04	34.6	27.4	26.83
Max Thickness	9.26	15.19	3.23	5.26	12	6.36	5.94
Point Ratio							
Stage					Finished Product		
Portion	Proximal-medial	Proximal-medial	Medial	Medial	Complete	Medial	Distal-medial
Failure / Discard							
Alteration						Thermal	
Edge Angle 1					60		
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1					Very Concave		
Edge Morphology Lateral 2							
Flake Scar Pattern					Steep abrupt percussion		
Edge Construction 1					Unifacial-distal dorsal side		
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.
Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	852	867	876	877	880	908	911
CAT NUM	11	10	10	10	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							Edge-bite flake with modified
Lithology	Agatized dolomite	Agatized dolomite	Jasper	Silicified Limestone	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates			Alibates	Alibates	Alibates
Weight	0.4	0.6	2.4	0.9	0.6	0.8	1.7
Max Length	13.49	13.67	16.23	8.36	13.75	11.19	19.1
Max Width	17.58	10.38	22.33	31.96	10.37	16.56	18.8
Max Thickness	3.38	7.14	7.48	3.91	3.18	4.06	3.8
Point Ratio							
Stage							Finished Product
Portion	Distal-medial	Medial	Medial	Medial	Medial	Distal-medial	Complete
Failure / Discard							
Alteration							
Edge Angle 1							55
Edge Angle 2							50
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							Convex
Edge Morphology Lateral 1							Concave
Edge Morphology Lateral 2							
Flake Scar Pattern							Marginal pressure
Edge Construction 1							Bifacial proximal
Edge Construction 2							Unifacial-unilateral-ventral side
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	917	929	929	933	936	939	947
CAT NUM	10	10	11	10	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Uniface	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2	edges		Beveled Edge				
Lithology	Dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Jasper	Agatized dolomite	Chert
Sourcing	Day Creek	Alibates	Alibates	Alibates		Alibates	
Weight	13	0.2	1.1	8.1	3.1	2.5	6.5
Max Length	51.37	8.31	16.3	39.4	32.84	15.28	43.61
Max Width	34.28	9.34	14.6	34.4	22.11	28.33	27.94
Max Thickness	8.75	2.35	3.5	5.4	7.14	5.92	5.62
Point Ratio			0.89570552147				
Stage			Finished Product	Finished Product			
Portion	Complete	Distal-medial	Medial	Indeterminate	Complete	Medial	Complete
Failure / Discard							
Alteration				Thermal			
Edge Angle 1			40				
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1			Straight	Convex			
Edge Morphology Lateral 2				Concave			
Flake Scar Pattern			Unifacial Beveled edge				
Edge Construction 1			Unifacial-unilateral				
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	948	963	972	976	1004	1005	1005
CAT NUM	10	10	10	10	10	10	11
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Jasper	Agatized dolomite
Sourcing		Alibates	Alibates	Alibates	Alibates		Alibates
Weight	29.5	1	1.4	0.8	17.6	3.4	0.5
Max Length	61.7	20.39	20.19	14.76	68.2	26.82	11.65
Max Width	41.7	14.5	19.96	13.27	35.7	28.31	22.66
Max Thickness	12.63	3.88	4.11	5.39	7.4	5.53	2.13
Point Ratio							
Stage	Initial Reduction				Finished Product		
Portion	Complete	Proximal-medial	Proximal-medial	Medial	Complete	Complete	Distal-medial
Failure / Discard							
Alteration	None observed						
Edge Angle 1	63				60		
Edge Angle 2	63				65		
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1	Straight				Recurved		
Edge Morphology Lateral 2	Convex				Concave		
Flake Scar Pattern	Sleep abrupt percussion				Marginal percussion		
Edge Construction 1	Unifacial-unilateral						
Edge Construction 2	Unifacial-unilateral						
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	1006	1009	1010	1012	1013	1014	1031
CAT NUM	10	10	10	10	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Uniface	Generalized modified flake tool of unknown function	Utilized flake used to cut/drill/scrape	Generalized modified flake tool of unknown function
Type 2				Beveled Edge			
Lithology	Agatized dolomite	Chert-Chalcedony Blend	Agatized dolomite	Jasper	Chalcedony	Agatized dolomite	Agatized dolomite
Sourcing	Alibates		Alibates	Tecovas		Alibates	
Weight	1.7	3.6	0.2	0.8	7.9	0.7	7
Max Length	33.18	29	8.16	20	29.9	11.58	55.54
Max Width	14.7	24	10.58	10.1	37.12	23.06	32.3
Max Thickness	4.39	5.6	1.47	5	7.11	2.45	4.45
Point Ratio				0.505			
Stage		Finished Product		Finished Product			Initial Reduction
Portion	Distal-medial	Complete	Medial	Medial	Proximal-medial	Medial	Complete
Failure / Discard							
Alteration	Thermal	Thermal			White patina		None observed
Edge Angle 1		45		55			30
Edge Angle 2		40					40
Edge Angle 3							40
Edge Angle 4							60
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1		Convex		Convex			Convex
Edge Morphology Lateral 2		Convex					Straight
Flake Scar Pattern		Marginal pressure		Unifacial Beveled edge			Marginal edge nibbling
Edge Construction 1		Unifacial-unilateral dorsal side		Unifacial-unilateral			Unifacial-unilateral
Edge Construction 2		Unifacial-unilateral dorsal side					Unifacial-unilateral
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	1034	1034	1035	1036	1036	1039	1040
CAT NUM	10	11	10	10	11	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Uniface	Generalized modified flake tool of unknown function	Graver	Spokeshave
Type 2							with Edge Modification
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Silicified Sandstone	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates		Alibates	Alibates	Alibates
Weight	2.4	1.5	8.1	0.8	1.8	3.1	2.9
Max Length	32.02	16.32	44.83	17.6	24.3	14.8	14.7
Max Width	21.81	20.09	31.87	16.9	22	29.7	23.7
Max Thickness	3.54	5.58	7.21	3.7	3.7	9	7
Point Ratio				0.96022727273		2.0067567568	1.612244898
Stage				Finished Product	Finished Product	Finished Product	Finished Product
Portion	Distal-medial	Medial	Complete	Distal-medial	Complete	Complete	Complete
Failure / Discard							
Alteration		Thermal			Thermal	Thermal	Thermal
Edge Angle 1				30		65	50
Edge Angle 2				30		55	
Edge Angle 3						65	
Edge Angle 4							
Edge Morphology Distal				Convex		Indeterminate	Concave
Edge Morphology Proximal							Convex
Edge Morphology Lateral 1				Convex	Straight	Convex	
Edge Morphology Lateral 2				Convex	Convex	Convex	
Flake Scar Pattern				Random	Marginal edge nibbling	Random	Invasive pressure
Edge Construction 1				Unifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral	Bifacial-unilateral
Edge Construction 2				Unifacial-unilateral	Unifacial-unilateral dorsal side	Bifacial-unilateral	Indeterminate
Edge Construction 3				Unifacial-unilateral		Bifacial-unilateral	
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	1043	1045	1047	1047	1051	1051	1057
CAT NUM	10	10	11	12	11	12	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Opalite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates		Alibates	Alibates	Alibates	Alibates
Weight	1.3	3.2	5.1	0.7	11	1.7	1.5
Max Length	20.8	16.74	38.4	14.62	25.25	17.5	25.89
Max Width	20.44	31.64	20.9	16.04	50.43	30.55	15.24
Max Thickness	3.31	6.05	8.7	3.68	9.81	2.58	3.14
Point Ratio							
Stage			Finished Product		Initial Reduction		
Portion	Distal-medial	Proximal-medial	Complete	Distal-medial	Complete	Medial	Distal-medial
Failure / Discard							
Alteration			Thermal		None observed		
Edge Angle 1					65		
Edge Angle 2					50		
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1			Serrated		Straight		
Edge Morphology Lateral 2			Straight		Convex		
Flake Scar Pattern			Marginal retouch				
Edge Construction 1			Unifacial-unilateral dorsal side				
Edge Construction 2			Indeterminate- unilateral				
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	1061	1066	1071	1072	1080	1084	1089
CAT NUM	11	10	10	10	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Hammerstone	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Ortho-Quartzite	Jasper	Rhyolite	Rhyolite	Agatized dolomite
Sourcing	Alibates	Alibates					Alibates
Weight	1.8	1.8	6.7	6	19	249	2.1
Max Length	23	14.31	30.17	38.66	65.3	88.6	19.72
Max Width	18.75	25.4	18.12	24.6	38.6	48.8	30.96
Max Thickness	4.15	3.7	16.81	7.49	10.1	43.1	4.33
Point Ratio							
Stage					Finished Product	Finished Product	
Portion	Medial	Medial	Complete	Distal-medial	Complete	Complete	Proximal-medial
Failure / Discard							
Alteration						Thermal	
Edge Angle 1							
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal						Straight	
Edge Morphology Proximal						Convex	
Edge Morphology Lateral 1					Recurved		
Edge Morphology Lateral 2							
Flake Scar Pattern					Marginal edge nibbling	Hard hammer percussive scarring	
Edge Construction 1					Unifacial-unilateral		
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	1091	1096	1104	1106	1106	1111	1114
CAT NUM	10	11	10	12	13	11	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Unifacial tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Day Creek	Alibates	Alibates	Alibates	Alibates
Weight	4.1	2.1	13.9	1.4	0.8	0.7	1
Max Length	36.39	14.55	33.52	26.9	12.9	11.05	13.14
Max Width	26.94	24.25	48.78	13.1	16.25	22.22	13.31
Max Thickness	5.35	6.01	8.94	6.3	2.57	3.98	4.15
Point Ratio							
Stage				Finished Product			
Portion	Complete	Medial	Distal-medial	Fragment	Medial	Medial	Proximal-medial
Failure / Discard				Perverse			
Alteration				Thermal	Thermal		
Edge Angle 1				40			
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1				Convex			
Edge Morphology Lateral 2							
Flake Scar Pattern				Invasive percussion			
Edge Construction 1				Unifacial-unilateral			
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	1135	1135	1137	1140	1144	1145	1147
CAT NUM	10	11	10	10	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Unifacial tool of unknown function	Boiling Stone
Type 2							
Lithology		Agatized dolomite	Agatized dolomite	Opalite	Agatized dolomite	Jasper	Quartzite
Sourcing		Alibates	Alibates		Alibates	Niabrara (Smoky Hill)	
Weight	8.6	2.3	4.6	51.5	1.4	5.2	140
Max Length	40.61	19.83	28.61	50.47	30.42	32.5	74.1
Max Width	31.42	24.83	20.8	67.44	13.95	29.2	51.3
Max Thickness	5.79	4.69	9.09	29.47	4.25	7.8	25.9
Point Ratio							
Stage						Indeterminate	Finished Product
Portion	Proximal-medial	Proximal-medial	Proximal-medial	Complete	Complete	Indeterminate	Complete
Failure / Discard						Perverse	
Alteration	Thermal						Thermal
Edge Angle 1						55	
Edge Angle 2						55	
Edge Angle 3						65	
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1						Convex	
Edge Morphology Lateral 2							
Flake Scar Pattern						Random	
Edge Construction 1						Unifacial-unilateral	
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	A	A	A
PNUM	1152	1155	1162	1170	1193	1194	1270
CAT NUM	10	10	11	10	10	10	11
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							possible graver modification
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	3.9	0.5	4	0.4	0.5	3.9	14
Max Length	18.8	8.3	23.79	13.23	8.43	35.5	48.6
Max Width	25.9	15.36	27.49	17.77	20.26	25	38.2
Max Thickness	7.9	2.78	6.63	1.7	4.05	3.7	8.8
Point Ratio							
Stage	Finished Product					Finished Product	Finished Product
Portion	Complete	Medial	Proximal-medial	Medial	Medial	Medial	Complete
Failure / Discard	Material flaw					Hinge / Step	
Alteration						Thermal	Thermal
Edge Angle 1						55	
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal	Convex						
Edge Morphology Proximal							
Edge Morphology Lateral 1						Convex	
Edge Morphology Lateral 2							
Flake Scar Pattern	Marginal edge nibbling					Marginal pressure	Marginal edge nibbling
Edge Construction 1	Unifacial-distal					Unifacial-unilateral-ventral side	Unifacial-circumferential
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	A	A	A	A	C	C	C
PNUM	1270	1272	1272	1272	93	95	101
CAT NUM	12	11	12	13	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Graver	Core fragment with modified edge
Type 2						with modified edges	
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	1.9	4.5	0.5	1.1	1.5	7	18.2
Max Length	31	23.7	15.96	18.15	15.11	27.2	34.8
Max Width	18.4	31.25	15.15	21.23	22.13	21	38.6
Max Thickness	4.3	7.22	1.77	3.78	5.06	14.5	14
Point Ratio							
Stage	Finished Product					Rejuvenated/Repaired	Recycled
Portion	Complete	Proximal-medial	Medial	Medial	Medial	Complete	Indeterminate
Failure / Discard							Material flaw
Alteration	Thermal						Thermal
Edge Angle 1	65					70	75
Edge Angle 2	65					70	
Edge Angle 3	50					65	
Edge Angle 4						20	
Edge Morphology Distal	Recurved					Point	Recurved
Edge Morphology Proximal							
Edge Morphology Lateral 1	Convex					Indeterminate	
Edge Morphology Lateral 2	Convex					Serrated	
Flake Scar Pattern	Marginal edge nibbling					Steep abrupt percussion	Invasive percussion
Edge Construction 1	Unifacial-unilateral					Bifacial-unilateral	Unifacial-distal
Edge Construction 2	Bifacial-distal					Unifacial-unilateral	
Edge Construction 3	Unifacial-unilateral						
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C	C	C
PNUM	102	119	120	120	144	151	161
CAT NUM	10	10	10	11	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Core Fragment with Modified Edges	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Jasper	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Tecovas	Alibates	Alibates	Alibates
Weight	1.2	2.6	1.1	20.6	1.6	0.1	0.3
Max Length	19.25	20.02	18.33	60.3	24.17	7.02	19.37
Max Width	18.8	21.49	25.78	26.8	23.54	8.81	14.52
Max Thickness	3.71	6.2	2.7	16.3	4.77	1.44	2.3
Point Ratio							
Stage				Finished Product			
Portion	Proximal-medial	Proximal-medial	Distal-medial	Complete	Proximal-medial	Medial	Medial
Failure / Discard							
Alteration		Thermal		Thermal			
Edge Angle 1							
Edge Angle 2				65			
Edge Angle 3				60			
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1							
Edge Morphology Lateral 2							
Flake Scar Pattern				Marginal edge nibbling			
Edge Construction 1				Bifacial-unilateral			
Edge Construction 2				Bifacial-unilateral			
Edge Construction 3				Bifacial-unilateral			
Edge Construction 4				Other			

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C	C	C
PNUM	166	185	185	192	194	196	196
CAT NUM	11	10	11	10	10	10	11
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Chert	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates		Alibates	Alibates	Alibates
Weight	1.3	2.3	2.6	0.8	5.1	0.9	1.5
Max Length	12.55	12.19	18.25	19.2	28.6	15.82	26.05
Max Width	21.13	26	19.39	15.6	24.76	21.64	19.61
Max Thickness	4.83	7.4	12.14	2.6	8.28	2.81	3.74
Point Ratio							
Stage				Finished Product			
Portion	Proximal-medial	Distal-medial	Medial	Indeterminate	Proximal-medial	Medial	Distal-medial
Failure / Discard							
Alteration							
Edge Angle 1							
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1				Convex			
Edge Morphology Lateral 2				Convex			
Flake Scar Pattern				Marginal edge nibbling			
Edge Construction 1				Unifacial-unilateral ventral side			
Edge Construction 2				Unifacial-unilateral ventral side			
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C	C	C
PNUM	202	202	205	210	216	223	231
CAT NUM	10	11	10	11	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates		Alibates	Alibates	Alibates
Weight	1.3	0.9	0.2	2.7	5.4	0.1	0.6
Max Length	22.31	9.54	12.29	40.2	30.26	10.54	9.81
Max Width	16.91	17.84	8.22	18.06	21.32	9.94	22.01
Max Thickness	3.76	5.41	3.65	3.15	9.61	2.82	3.81
Point Ratio							
Stage				Initial Reduction			
Portion	Medial	Medial	Medial	Complete	Proximal-medial	Medial	Medial
Failure / Discard							
Alteration		Thermal	Thermal	None observed			
Edge Angle 1				35			
Edge Angle 2				45			
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1				Convex			
Edge Morphology Lateral 2				Convex			
Flake Scar Pattern				Marginal edge nibbling			
Edge Construction 1				Unifacial-unilateral			
Edge Construction 2				Unifacial-unilateral			
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C	C	C
PNUM	251	256	265	288	291	292	301
CAT NUM	10	10	12	10	10	11	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	0.2	19.7	1.2	2.6	3.5	0.7	0.8
Max Length	5.6	43.2	18.78	26.86	28.09	15.18	15.34
Max Width	11.01	42	16.77	27.91	37.09	20.95	12.12
Max Thickness	6.52	12.5	4.55	4.28	3.82	2.56	3.67
Point Ratio							
Stage		Finished Product					
Portion	Medial	Complete	Medial	Proximal-medial	Proximal-medial	Distal-medial	Proximal-medial
Failure / Discard							
Alteration			Thermal				
Edge Angle 1		65					
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1		Convex					
Edge Morphology Lateral 2							
Flake Scar Pattern		Marginal pressure					
Edge Construction 1		Unifacial-unilateral					
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C	C	C
PNUM	308	321	323	338	357	357	364
CAT NUM	10	10	10	10	11	12	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Jasper	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Chert	Agatized dolomite
Sourcing	Tecovas	Alibates	Alibates	Alibates	Alibates		Alibates
Weight	3.2	0.4	0.2	0.5	0.3	1	5.1
Max Length	14.86	12.69	9.83	16.3	9.77	11.3	29.1
Max Width	27.62	10.18	15.83	12.6	16.22	23.3	29.97
Max Thickness	7.72	1.79	2.39	2.59	2.2	4.4	6.54
Point Ratio							
Stage						Finished Product	
Portion	Proximal-medial	Medial	Medial	Proximal-medial	Medial	Distal	Proximal-medial
Failure / Discard							
Alteration							
Edge Angle 1						60	
Edge Angle 2						40	
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1						Convex	
Edge Morphology Lateral 2						Recurved	
Flake Scar Pattern						Marginal pressure	
Edge Construction 1						Unifacial-unilateral	
Edge Construction 2						Unifacial-unilateral	
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C	C	C
PNUM	366	372	375	379	399	406	419
CAT NUM	10	10	10	10	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	2.1	1.6	0.5	1.5	2.2	4	0.7
Max Length	20.95	19.72	10.38	32	23	25.82	13.72
Max Width	15.02	23.3	16.39	18.1	26.42	20.45	13.35
Max Thickness	7.36	4.7	2.83	2.7	4.48	6.39	2.53
Point Ratio							
Stage				Finished Product			
Portion	Medial	Proximal-medial	Medial	Complete	Proximal-medial	Proximal-medial	Medial
Failure / Discard							
Alteration				Thermal			
Edge Angle 1							
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1				Straight			
Edge Morphology Lateral 2				Recurved			
Flake Scar Pattern				Marginal edge nibbling			
Edge Construction 1				Unifacial-unilateral ventral side			
Edge Construction 2				Unifacial-unilateral ventral side			
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C	C	C
PNUM	425	432	436	445	449	464	466
CAT NUM	10	10	10	10	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	1.9	9.6	4.3	4.4	1	0.9	1.8
Max Length	12.73	34.7	25.75	19.08	17.3	19.08	17.1
Max Width	25.5	33.4	37.75	23.51	18.2	16.13	25.7
Max Thickness	5.41	8	7.72	8.75	3.2	2.73	3.4
Point Ratio							
Stage		Finished Product			Finished Product		Finished Product
Portion	Proximal-medial	Complete	Proximal-medial	Proximal-medial	Complete	Proximal-medial	Complete
Failure / Discard							
Alteration							
Edge Angle 1					45		45
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1		Straight			Straight		
Edge Morphology Lateral 2		Convex					Convex
Flake Scar Pattern		Marginal edge nibbling			Marginal pressure		Marginal pressure
Edge Construction 1		Unifacial-unilateral ventral side			Unifacial-unilateral		Unifacial-unilateral-dorsal side
Edge Construction 2		Unifacial-unilateral ventral side					
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C	C	C
PNUM	466	468	508	510	517	523	530
CAT NUM	11	10	10	11	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Uniface	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2		Possible side scraper					
Lithology	Chert	Agatized dolomite	Agatized dolomite	Meta-Quartzite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing		Alibates	Alibates	Ogallala	Alibates	Alibates	Alibates
Weight	1.4	3.9	4.6	4.6	2.7	2.8	2.5
Max Length	15.3	33.9	36.3	27.41	36.46	19.71	23.79
Max Width	25.2	25.1	19.6	25.59	17.7	20.35	15.83
Max Thickness	3.7	4.6	7.1	8.65	6.3	6.94	8.17
Point Ratio			0.53994490358				
Stage	Indeterminate	Finished Product	Finished Product				
Portion	Fragment	Lateral edge(s) missing	Indeterminate	Proximal-medial	Complete	Distal-medial	Medial
Failure / Discard		Indeterminate					
Alteration	Thermal						
Edge Angle 1	50	60	55				
Edge Angle 2		50					
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1	Convex	Convex	Convex				
Edge Morphology Lateral 2		Convex					
Flake Scar Pattern	Marginal edge nibbling	Steep abrupt percussion	Marginal pressure				
Edge Construction 1	Unifacial-unilateral	Unifacial-unilateral ventral side	Unifacial-unilateral				
Edge Construction 2		Bifacial-unilateral					
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C	C	C
PNUM	545	576	577	582	589	589	589
CAT NUM	10	10	10	12	12	13	14
Type	Abrader	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Unifacial tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2	Formal Bifacial Abrader						
Lithology	Sandstone	Agatized dolomite	Agatized dolomite	Agatized dolomite	Other	Agatized dolomite	Agatized dolomite
Sourcing		Alibates	Alibates	Alibates		Alibates	Alibates
Weight	11.2	3.4	6.9	7.6	6.2	0.1	0.5
Max Length	30.4	27.11	33.7	33.47	35.6	8.13	16.01
Max Width	25.6	28.43	24.3	32.04	27	18.71	15.29
Max Thickness	14.7	6.59	8.6	6.93	6.9	1.69	2.53
Point Ratio							
Stage	Finished Product		Recycled		Finished Product		
Portion	Fragment	Complete	Complete	Proximal-medial	Complete	Medial	Medial
Failure / Discard			Perverse				
Alteration			Thermal		Thermal		
Edge Angle 1			70				
Edge Angle 2			45		50		
Edge Angle 3					50		
Edge Angle 4							
Edge Morphology Distal					Convex		
Edge Morphology Proximal							
Edge Morphology Lateral 1			Convex		Convex		
Edge Morphology Lateral 2			Convex		Convex		
Flake Scar Pattern					Random		
Edge Construction 1			Unifacial-unilateral retouch		Platform faceting and retouch		
Edge Construction 2			Bifacial-unilateral		Bifacial-unilateral		
Edge Construction 3					Unifacial-unilateral		
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C	C	C
PNUM	589	591	593	593	599	612	613
CAT NUM	15	10	10	11	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	0.7	1.6	14.1	3.3	6	0.1	6.2
Max Length	17.18	31.65	56.4	34.6	24	11.45	35.45
Max Width	12.24	18.82	32.3	27.5	37.5	9.2	27.76
Max Thickness	4.11	2.69	8.8	4.8	8.1	1.62	6.51
Point Ratio							
Stage			Finished Product	Early Stage Forming	Finished Product		
Portion	Proximal-medial	Medial	Complete	Proximal-medial	Complete	Medial	Proximal-medial
Failure / Discard				Perverse			
Alteration			Thermal				
Edge Angle 1			55	55	50		
Edge Angle 2				50	45		
Edge Angle 3					50		
Edge Angle 4							
Edge Morphology Distal					Straight		
Edge Morphology Proximal							
Edge Morphology Lateral 1				Convex	Convex		
Edge Morphology Lateral 2				Straight	Convex		
Flake Scar Pattern			Marginal pressure	Marginal pressure	Marginal pressure		
Edge Construction 1			Unifacial-unilateral	Unifacial-unilateral	Unifacial-unilateral-dorsal side		
Edge Construction 2				Unifacial-unilateral	Unifacial-unilateral-ventral side		
Edge Construction 3					Unifacial-unilateral-ventral side		
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C	C	C
PNUM	613	615	619	626	639	639	641
CAT NUM	11	10	10	10	11	12	10
Type	Generalized modified flake tool of unknown function	Spokeshave	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Jasper	Agatized dolomite	Agatized dolomite	Agatized dolomite		Agatized dolomite
Sourcing	Alibates	Tecovas	Alibates	Alibates	Alibates		Alibates
Weight	1	6.7	0.2	0.5	7.4	4.6	1.4
Max Length	16.9	20.4	10.27	14.7	44.3	24.7	24.51
Max Width	20.02	30.3	10.44	12.89	23.4	35	19.47
Max Thickness	3.44	7.7	1.51	3.04	6.9	6.6	3.64
Point Ratio		1.4852941176					
Stage		Finished Product			Finished Product	Finished Product	
Portion	Distal-medial	Complete	Proximal-medial	Medial	Complete	Complete	Proximal-medial
Failure / Discard							
Alteration				Thermal	Thermal	Thermal	
Edge Angle 1		65					
Edge Angle 2		60					
Edge Angle 3		60					
Edge Angle 4							
Edge Morphology Distal		Concave					
Edge Morphology Proximal							
Edge Morphology Lateral 1		Serrated			Recurved	Convex	
Edge Morphology Lateral 2		Serrated			Recurved		
Flake Scar Pattern					Marginal edge nibbling	Marginal edge nibbling	
Edge Construction 1		Unifacial-unilateral			Unifacial-unilateral dorsal side	Unifacial-circumferential	
Edge Construction 2		Bifacial-unilateral			Unifacial-unilateral dorsal side		
Edge Construction 3		Bifacial-unilateral					
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C	C	C
PNUM	641	643	643	643	643	646	646
CAT NUM	11	11	17	18	19	10	11
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Uniface	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2					with Edge Modification		
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	10.3	1	3.1	2.3	0.6	0.7	1.3
Max Length	44.32	33.47	36.71	37	16.1	19.4	29.91
Max Width	27.98	12.67	37.42	21.9	13.8	17.92	19.31
Max Thickness	9.17	2.11	5.38	4.1	3.4	2.27	2.85
Point Ratio					0.85714285714		
Stage				Finished Product	Indeterminate		
Portion	Lateral edge(s) missing	Medial	Complete	Complete	Indeterminate	Proximal-medial	Complete
Failure / Discard							
Alteration					Thermal		
Edge Angle 1							
Edge Angle 2					30		
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal					Very Convex		
Edge Morphology Proximal							
Edge Morphology Lateral 1				Concave	Convex		
Edge Morphology Lateral 2					Convex		
Flake Scar Pattern				Marginal edge nibbling	Marginal pressure		
Edge Construction 1				Unifacial-unilateral-ventral side	Unifacial-unilateral		
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C	C	C
PNUM	648	648	648	648	648	648	648
CAT NUM	10	11	12	18	19	21	22
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	2.8	5	0.5	2.5	0.5	8.1	1
Max Length	20.57	46.76	16.26	29.73	17.11	30.36	23.03
Max Width	25.99	29.67	14.51	22.79	11.8	35.79	11.21
Max Thickness	5.55	6.82	3.29	3.52	2.86	9.81	3.99
Point Ratio							
Stage							
Portion	Proximal-medial	Complete	Complete	Medial	Proximal-medial	Complete	Medial
Failure / Discard							
Alteration							
Edge Angle 1							
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1							
Edge Morphology Lateral 2							
Flake Scar Pattern							
Edge Construction 1							
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C	C	C
PNUM	655	656	667	669	675	1229	1229
CAT NUM	10	10	10	10	10	14	15
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function
Type 2							
Lithology	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite	Agatized dolomite
Sourcing	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates	Alibates
Weight	1.1	2	1	2.4	0.2	0.5	15.5
Max Length	14.06	23.28	18.15	30.95	7.72	22.42	41.36
Max Width	20.23	23.23	17.71	21.56	13.76	14.15	36.74
Max Thickness	6.14	4.42	3.51	4.71	2.18	2.82	9.49
Point Ratio							
Stage							
Portion	Medial	Proximal-medial	Proximal-medial	Proximal-medial	Medial	Proximal-medial	Complete
Failure / Discard							
Alteration	Thermal						
Edge Angle 1							
Edge Angle 2							
Edge Angle 3							
Edge Angle 4							
Edge Morphology Distal							
Edge Morphology Proximal							
Edge Morphology Lateral 1							
Edge Morphology Lateral 2							
Flake Scar Pattern							
Edge Construction 1							
Edge Construction 2							
Edge Construction 3							
Edge Construction 4							

Table O-5.

Lithic Informal Tools

Area	C	C	C	C	C
PNUM	1229	1233	1245	1260	1268
CAT NUM	16	11	10	10	10
Type	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Generalized modified flake tool of unknown function	Abrader	Generalized modified flake tool of unknown function
Type 2				Informal Unifacial Abrader	
Lithology	Jasper	Agatized dolomite	Agatized dolomite	Sandstone	Agatized dolomite
Sourcing	Tecovas	Alibates	Alibates		Alibates
Weight	15.8	1.4	0.5	30.2	0.7
Max Length	51.8	17.93	12.19	54.4	12.81
Max Width	36	22.05	17.5	33.5	17.62
Max Thickness	10.7	4.63	2.43	13.9	2.86
Point Ratio					
Stage	Finished Product			Finished Product	
Portion	Complete	Proximal-medial	Medial	Indeterminate	Medial
Failure / Discard					
Alteration					
Edge Angle 1					
Edge Angle 2					
Edge Angle 3					
Edge Angle 4					
Edge Morphology Distal					
Edge Morphology Proximal					
Edge Morphology Lateral 1	Recurved				
Edge Morphology Lateral 2	Recurved				
Flake Scar Pattern	Marginal edge nibbling				
Edge Construction 1	Bifacial-unilateral				
Edge Construction 2	Unifacial-unilateral ventral side				
Edge Construction 3					
Edge Construction 4					

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APPENDIX P

STABLE ISOTOPE RATIO ANALYSES

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June 2011

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List of Bone Isotope Samples with Results

Site No.	Site Name	Area	PNUM	Unit N	Unit E	Depth (cmbs)	Feature No.	Bone Element	Weight (g)	Geochron Lab. No.	$\delta^{13}\text{C}$ (‰) Results	$\delta^{15}\text{N}$ (‰) Results
41RB112	Long View	A	799-002	672	509	40-50	-	vertebrae	18.1	120269	-9.8, -9.8**	6.6
41RB112	Long View	A	1012-2-2	695	513	35	13	bison frag	10.9	120270	-8.9	3.7
41RB112	Long View	A	60-2-1	A-5	-	30-40	-	bison frag	15.2	120271	-9.1	3.1
41RB112	Long View	A	737-002	668	511	40-50	-	bison frag	8.8	120272	-8.6	5.4, 7.4**
41RB112	Long View	A	1185-002-2	701	515	40	-	bison frag	8.4	120273	-8.6	4.4
Component A Average											-9.0	4.64
41RB112	Long View	C	194-2-1	479	499	47	-	bison frag	22.0	120274	-9.6	5.7
41RB112	Long View	C	520-2-5	496	500	40-50	-	bison frag	26.0	120275	-9.9	5.5
41RB112	Long View	C	349-2-6	484	496	60	31	bison frag	25.0	120276	-9.3	6.2
41RB112	Long View	C	572-2-1a	498	495	60-70	6	Radius	22.0	120277	-8.2	5.8
41RB112	Long View	C	580-2-1a	498	496	50-60	6	bison frag	24.0	120278	-8.0	5.5
Component C Average											-9.0	5.74

** Duplicate analysis on separate aliquots of the original sample.

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APPENDIX Q

POTTERY DATA FROM OTHER PLAINS VILLAGE SITES

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Q.1 Introduction

In an attempt to determine how the two Long View component ceramic assemblages compare to other Plains Village pottery in the surrounding region and possibly identify manufacturing localities, TRC with the approval of TxDOT, solicited pottery samples from 15 excavated sites in four surrounding regions to pursue the same two technical analyses performed on the Long View samples. The selected regions and sites within those regions include: 1) four sites in the Antelope Creek phase core area (i.e., Alibates Ruin 28, Antelope Creek Ruin 22, Cottonwood Creek and Roper) around Lake Meredith roughly 85 km to the southwest; 2) four sites from the M-Cross Ranch (i.e., Hank's, Indian Springs, Three Toes and Whistling Squaw) about 10 km to the east; 3) three Buried City complex sites (i.e., Courson B and D,

and Kit Courson) in Wolf Creek valley about 35 km to the northeast; and 4) the four excavated Antelope Creek phase sites (i.e., McGrath, Roy Smith, Stamper and Two Sisters) in the central Oklahoma panhandle roughly 75 km to the north (Figure Q-1).

These ceramic assemblages were sought to provide a broad regional coverage immediately surrounding the Long View site and provide a variety of vessel finishes and styles from adjacent Plains Village sites. These areas have yielded excavated ceramic assemblages from which to obtain the necessary samples. The individual sites provide a wide range of conditions and structures that might relate to a broader understanding of individual potters, groups of populations, and conditions in these regions. A significant factor that contributed to what specific sherds were analyzed was the individuals

Figure Q-1. Map of regions and sites from which pottery sherds were analyzed.

and institutions housing the various ceramic assemblages, willingness to allow destructive analysis. In the case of the four central Oklahoma sites the rare decorated rim sherds, especially the collared rims were not allowed to be subjected to destructive analyses. Therefore, the samples other than the 32 Long View site samples were biased and judgmentally selected by other archeologists. Doug Boyd provided the sherds from M-Cross Ranch, Scott Brosowske provided the sherds from the Buried City sites, Richard Drass with the approval of Don Wyckoff selected the 16 sherds from the 3 Oklahoma sites (Roy Smith, McGrath and Stamper) housed at the Sam Noble Museum of Natural History, Marjy Duncan of the Archeological Survey

of Oklahoma selected the 8 sherds and 1 clay sample from the Two Sister site housed at the Oklahoma Archeological Survey, and Jeff Indeck, Chief Curator at the Panhandle-Plains Historic Museum in Canyon, Texas was kind enough to provide the sherds from the 4 Antelope Creek phase sites in their collections. In total 80 sherds and 8 clay samples were procured and analyzed either by petrography or instrumental neutron activation (INA; Table Q-1).

The following tables and figures present a site by site and sherd by sherd documentation of the sherds used in the two technical analyses. A total of 97 samples, which included 86 sherds and 11 clays, were subjected to petrographic analysis, which was

Table Q-1. List of Sites and Sherds from Surrounding Areas Used for Technical Analyses.

Site Name	Site Number	No. of Sherds Analyzed	No. of Clay Samples	References
Buried City Complex Sites in Wolf Creek Valley				
Courson B	41OC27	9	1	Eyerly 1907a; Moorehead 1931; D. Hughes and Hughes-Jones 1987; D. Hughes 1991; Brosowske 2005
Courson D	41OC29	4	1	Eyerly 1907a; Moorehead 1931; D. Hughes and Hughes-Jones 1987; D. Hughes 1991; Brosowske 2005
Kit courson	41OC43	2		Eyerly 1907a; Moorehead 1931; D. Hughes and Hughes-Jones 1987; D. Hughes 1991; Brosowske 2005
Four Antelope Creek Phase Sites In the Oklahoma Panhandle				
Stamper	34TX1	6	1	Watson 1950; Baerreis and Bryson 1966; Lintz 2003a, 2003b, 2003c, 2004
McGrath	34TX31	3		Lintz 1976
Two Sisters	34TX32	7		Lintz 1979; Duncan 2004, 2006
Roy Smith	34BV14	7		Schneider 1969
Antelope Creek Phase Core Area Sites				
Alibates Ruin 28	41PT11	9		Studer 1942; Baker and Baker 2000; Krieger 1946; Lintz 1986
Antelope Creek Ruin 22	41HC23	6		Baker and Baker 2000; Holden 1930; Lowrey 1932; Krieger 1976; Lintz 1986
Cottonwood Creek Ruin	41HC141	3		Holden 1929; Lintz 1986, 1997
Roper	41HC6	6		Lintz 1986
M-Cross Ranch Sites				
Indian Springs	41RB81	9	1	Cruse 2007; Boyd 2008
Whistling Squaw	41RB108	1	1	Boyd 2008
Hank's	41RB109	5	1	Boyd 2008; Boyd and Wilkens 2001
Three Toes	41RB110	3		Boyd 2008

conducted by David Robinson. This includes 10 sherds from Component A and 10 from Component C at the Long View; 13 sherds from 4 different sites on the M-Cross Ranch; 15 sherds from 3 different sites from the Buried City complex; 22 sherds from 4 Antelope Creek phase sites in the Oklahoma panhandle; and 17 shreds from 4 Antelope Creek phase sites in the core area. Parts of these exact same sherds were used for the INA analysis.

A total of 129 samples (112 sherds, 11 tempered clays, and 6 daub) were subjected to INA conducted

at the Missouri University Research Reactor (MURR) under the direction of Michael Glascock and Jeff Ferguson. These included 32 sherds, 6 daub, and 3 tempered clays from Long View Components A and C, 18 sherds from M-Cross Ranch, 15 sherds from Buried City, 23 sherds from the 4 Antelope Creek phase site in the Oklahoma panhandle, and 24 sherds from the 4 Antelope Creek phase sites in the core area. Besides the sherds, clay samples were also submitted for INA, 2 from Buried City, 2 from M-Cross Ranch, 1 each from Blue Creek, Government Canyon, and Two Sisters.

Figure Q-2. Sherds from Buried City Complex, Courson B, 41OC27 used in technical analyses.

Table Q-2. Selected Data on Sherds from Courson B, 41OC27 at Buried City Used in Petrography and Instrumental Neutron Activation Analysis.

PNUM	Ceramic Ware / Type	Exterior Surface	Portion	Thickness (mm)	Macroscopic Temper	Interior Surface	Lip Characteristic	Lip Decoration	Rim Wall Direction	Rim Form	Rim Decoration	MURR No. *	Chemical Group **	Petrographic group ***
216	Cordmarked	partially obliterated cordmarks	body	1.9-5.4	rounded sand	irregular smooth	N/A	N/A	N/A	N/A	N/A	TRC 581	UN	M, quartz + plagioclase
243	Cordmarked	obliterated cordmarks	body	7.5-10.5	fine sand	wiped smooth	N/A	N/A	N/A	N/A	N/A	TRC 575	UN	E, bone + sand
256-57	Cordmarked	thin, deep vertical cords	rim	3.8-5.0	sand	very smooth	rounded	thickened collared	direct	straight	thickened rim, collared, punctates	TRC 577	UN	N, basalt, pyroxene, quartz
355-2	Cordmarked	partially obliterated cordmarks	rim	9-11.4	fine sand	smoothed irregular	narrow rounded	none	direct	straight	narrow, shallow cordmarked	TRC 580	UN	M, quartz + plagioclase
383	Cordmarked	obliterated cordmarks	body	7.4-10.4	sand	smooth	N/A	N/A	N/A	N/A	N/A	TRC 578	UN	E, bone + sand
386	-	Corn Cob impressed	body	7-9.1	sand	irregular	N/A	N/A	N/A	N/A	N/A	TRC 579	UN	M, quartz + plagioclase
398	Cordmarked	partially obliterated narrow cords	body	3.9-5.4	sand	smooth	N/A	N/A	N/A	N/A	N/A	TRC 583	UN	M, quartz + plagioclase
462-70	Cordmarked	thin deep vertical cords	rim/ neck	5.1-7.1	fine sand	smooth	rounded	none	incurved	straight	pinched rim, fingernail punctates	TRC 576	UN	L, basalt, pyroxene
556-8	Cordmarked	partially obliterated cordmarks	rim	5.6-7.4	fine sand	smooth	narrow rounded	none	direct	straight	none	TRC 582	UN	H, bone + basalt

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** Petrographic results; UN = Unassigned, N/A = data not applicable

Figure Q-3. Sherds from Courson D, 41OC29, in Buried City used in the technical analyses.
(Note, the 346-04 body sherd was from a pithouse and was directly radiocarbon dated).

Table Q-3. Selected Data on Sherds from Courson D, 41OC29 Used for Petrography and Instrumental Neutron Activation Analysis.

Petrographic Group ***	Chemical Group **	MURR No. *	Rim Decoration	Rim Form	Rim Wall Direction	Lip Decoration	Lip Characteristic	Interior Surface	Macroscopic Temper	Thickness (mm)	Portion	Exterior Surface	Ceramic Ware / Type	PNUM
M, quartz, plagioclase	2	TRC 586	tool pinched collar rim	straight	direct	none	rounded	smooth	sand	4.8-5.1	rim	Plain	Cordmarked	338-01
M, quartz, plagioclase	2	TRC 587	N/A	N/A	N/A	N/A	N/A	smooth	sand	3.7-5.2	body	polished	Plain	338-07
O, multiple tempers	2	TRC 585	N/A	N/A	N/A	N/A	N/A	irregular bumpy	lots coarse sand	10.5-13.2	body	bumpy, corn cob impressed?	Cordmarked	343-22
P, basalt, pyroxene, quartz	UN	TRC 584	N/A	N/A	N/A	N/A	N/A	smooth	fine sand	7.8-11.3	body	deep, narrow cordmarks	Cordmarked	346-4

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** Petrographic results;
UN = Unassigned, N/A = data not applicable

Figure Q-4. Sherds from Kit Courson, 41OC43 in Buried City Used in Technical Analyses.

Table Q-4. Selected Data on Sherds from Kit Courson, 41OC43 Used in Petrography and Instrumental Neutron Activation Analysis.

PNUM	Ceramic Ware / Type	Exterior Surface	Portion	Thickness (mm)	Macroscopic Temper	Interior Surface	Lip Characteristic	Lip Decoration	Rim Wall Direction	Rim Form	Rim Decoration	MURR No. *	Chemical Group **	Petrographic Group ***
065/310	Cordmarked	shallow, thick cords	body	5.4-6.1	fine sand	very smooth	N/A	N/A	N/A	N/A	N/A	TRC 589	UN	R, basalt, pyroxene
325.7	Cordmarked	very shallow, narrow cords	body	4.3-5.7	fine sand	smooth	N/A	N/A	N/A	N/A	N/A	TRC 588	2	Q, basalt, pyroxene, quartz

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** Petrographic results;
UN = Unassigned, N/A = data not applicable

Figure Q-5. Sherds from Stamper, 34TX1 in Oklahoma Panhandle Used in Analyses.

Table Q-5. Selected Data on Sherds from Stamper 34TX1 Used in Petrography and Instrumental Neutron Activation Analysis.

PNUM	Ceramic Ware / Type	Exterior Surface	Portion	Thickness (mm)	Macroscopic Temper	Interior Surface	Lip Characteristic	Lip Decoration	Rim Wall Direction	Rim Form	Rim Decoration	MURR No. *	Chemical Group **	Petrographic Group ***
10	Cordmarked	deep, wide cordmarks	rim	6.84-8.71	crushed rock	smooth irregular	flat	none	outcurved/everted	straight	none	TRC 600	UN	M, quartz + plagioclase
14	Plain	irregular-plain	rim	5.15-7.48	fine sand	smooth bumpy	narrow rounded	none	direct	irregular	none	TRC 601	2	U, basalt + pyroxene
155	Cordmarked	shallow, narrow vertical cordmarks	rim	4.14-6.42	mica sand	striated smooth	sloped	cordmarked	direct	straight	cordmarked	TRC 602	7	M, quartz + plagioclase
377	Cordmarked	shallow, narrow vertical cordmarks	rim/neck	5.31-8.72	sand	smooth, divots	flat	cordmarked	direct	straight	cordmarked	TRC 603	7	T, distinct temper, muscovite drapes
407	Cordmarked	deep narrow vertical cordmarks	rim	4.70-6.70	mica sand	smooth, striated	flat	none	direct	straight	none	TRC 604	7	T, distinct temper, muscovite drapes
408	Cordmarked	shallow, narrow, smoothed over cordmarks	body	3.25-5.47	mica sand	smooth, striated	N/A	N/A	N/A	N/A	N/A	TRC 605	7	O, multiple tempers

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** Petrographic results; UN = Unassigned, N/A = data not applicable

Figure Q-6. Sherds from 34TX31 McGrath Site, in the Oklahoma Panhandle area used for instrumental neutron activation analysis.

Table Q-6. Selected Data on Sherds from 34TX31, McGrath Site Used in Technical Analyses.

PNUM	Ceramic Ware / Type	Exterior Surface	Portion	Thickness (mm)	Macroscopic Temper	Interior Surface	Lip Characteristic	Lip Decoration	Rim Wall Direction	Rim Form	Rim Decoration	MURR No. *	Chemical Group **	Petrographic Group ***
175.1	Cordmarked	obliterated cordmarks	rim	5.10-7.00	crushed rock sand	very smooth	narrow rounded	none	outcurved/everted	straight	plain	TRC 598	UN	Q, basalt+pyroxene + quartz
175.2	Cordmarked	cordmarked	body	-	-	-	N/A	N/A	N/A	N/A	-	TRC 599	2	S, basalt+pyroxene + quartz
74	Cordmarked	deep wide cordmarks	body	7.08-9.13	sand +	smooth	N/A	N/A	N/A	N/A	N/A	TRC 597	UN	S, basalt+pyroxene + quartz

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** Petrographic results;
UN = Unassigned, N/A = data not applicable

Figure Q-7. Sherds and clays from Two Sisters, 34TX32 in the Oklahoma Panhandle used in technical analyses.

Table Q7. Selected Data on Sherds from Two Sisters, 34TX32 Used for Petrography and Instrumental Neutron Activation Analysis.

PNUM	Ceramic Ware / Type	Exterior Surface	Portion	Thickness (mm)	Macroscopic Temper	Interior Surface	Lip Characteristic	Lip Decoration	Rim Wall Direction	Rim Form	Rim Decoration	MURR No. *	Chemical Group **	Petrographic Group ***
21	Cordmarked	smoothed over cordmarks	body	6.3-7.8	sand	smooth	N/A	N/A	N/A	N/A	N/A	TRC 606	UN	V, granular quartz
284	Cordmarked	mostly obliterated cordmarks	body	4.8-7.2	shell	smooth	N/A	N/A	N/A	N/A	N/A	TRC 609	5	Y, bone, sand, quartz
285-1	Cordmarked	smoothed over cordmarks	body	4.8-5.9	sand	bumpy, smooth	N/A	N/A	N/A	N/A	N/A	TRC 610	UN	X quartz + feldspar
285-2	Cordmarked	smoothed over cordmarks	body	6.3-7.5	sand	smooth	N/A	N/A	N/A	N/A	N/A	TRC 611	UN	W, quartz
44	Cordmarked	obliterated cordmarks	body	6.1-9.5	sand	bumpy	N/A	N/A	N/A	N/A	N/A	TRC 607	6	V, granular quartz
53	Cordmarked	shallow cordmarks	body	7.2-8.7	sand	cracked	N/A	N/A	N/A	N/A	N/A	TRC 608	7	K. granular rock

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** Petrographic results;
 UN = Unassigned, N/A = data not applicable

Figure Q-8. Sherds from Roy Smith, 34BV14 in Oklahoma Panhandle used in technical analyses.

Table Q-8. Selected Data on Sherds from Roy Smith, 34BV14 Used in Petrography and Instrumental Neutron Activation Analyses.

PNUM	Ceramic Ware / Type	Exterior Surface	Portion	Thickness (mm)	Macroscopic Temper	Interior Surface	Characteristic Lip	Lip Decoration	Rim Wall Direction	Rim Form	Rim Decoration	MURR No. *	Chemical Group ***	Petrographic Group ***
302	Cordmarked	shallow, smoothed over cordmarks	body	6.11-7.08	grog sand	smooth	N/A	N/A	N/A	N/A	-	TRC 595	UN	Z, quartz temper
364	Cordmarked	partially obliterated narrow cords	body	8.98-9.72	bone	smooth	N/A	N/A	N/A	N/A	N/A	TRC 596	8	AA, basalt + pyroxene
427	Cordmarked	smoothed over cordmarks	rim	4.36-5.74	bone	smooth	rounded	none	direct	straight	N/A	TRC 591	UN	BB, basalt + pyroxene
438	Cordmarked	shallow, smoothed over cordmarks	body	6.75-7.50	sand/ bone	smooth	N/A	N/A	N/A	N/A	-	TRC 594	2	BB, basalt + pyroxene
580	Cordmarked	shallow thin cordmarks	rim/ neck	4.36-5.34	fine sand	smooth	N/A	N/A	direct	straight	N/A	TRC 593	UN	CC, bone + basalt temper
600	Cordmarked	shallow, thin cordmarks	body	3.90-4.50	fine bone	smooth	N/A	N/A	N/A	N/A	N/A	TRC 592	2	BB, basalt + pyroxene
71	Cordmarked	narrow cords, partially obliterated	body	9.16-9.69	bone	bumpy	N/A	N/A	N/A	N/A	N/A	TRC 590	8	AA, basalt + pyroxene

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** Petrographic results; UN = Unassigned, N/A = data not applicable

Figure Q-9. Sherds from Alibates Ruins 28, 41PT11 in the Antelope Creek Phase Core Area used in technical analyses.

(Note, sherds A8-16 and A8-42 use in petrographic study by Lintz and Reese-Taylor 1997).

Table Q-9. Selected Data on Sherds from Alibates Ruins 28, 41PT11, Used for Petrography and Instrumental Neutron Activation Analysis.

PNUM	Ceramic Ware / Type	Exterior Surface	Portion	Thickness (mm)	Macroscopic Temper	Interior Surface	Lip Characteristic	Lip Decoration	Rim Wall Direction	Rim Form	Rim Decoration	MURR No. *	Chemical Group **	Petrographic Group
28-?-71	Cordmarked	partially obliterated, wide cordmarks	body	5.5-8.4	crushed rock	very smooth	N/A	N/A	N/A	N/A	N/A	TRC 632	UN	A, quartz, feldspar
28-?-73	Cordmarked	shallow, indistinct, narrow, overlapping cordmarks	body	2.7-3.6	sand	smooth, divot	N/A	N/A	N/A	N/A	N/A	TRC 634	UN	A, quartz, feldspar
28-A2-8	Plain	striation, imperfections	body	4.5-6.6	fine sand	very smooth	N/A	N/A	N/A	N/A	N/A	TRC 636	2	I, basalt, pyroxene
28-A2- R3	Corn Cob Impressed	rough	body	4.7-6.1	-	-	N/A	N/A	N/A	N/A	N/A	TRC 633	OUT	K, granular rock
28-A3-21	Cordmarked	wiping, obliterated cordmarks	rim	6.8-7.9	crushed rock	smooth	beveled exterior	none	direct	straight	none	TRC 631	7	J, quartz sand
28-A8-16	Cordmarked	well defined, narrow cordmarks angled	rim	3.7-6.3	mica, sand	wiped bumpy	narrow rounded	obliterated cordmarked	incurved inverted	straight	none	TRC 629	7	***quartz = 65.7% alkali feldspar = 22.9%, granite 11.4% mica 0.03%
28-A8-42	Cordmarked	obliterated cordmarks	rim	5.5-7.1	crushed rock	smooth	beveled exterior	none	direct	straight	none	TRC 628	7	***quartz = 62.5% alkali feldspar = 3.1%, granite 25% mica 6.3%
28-A8-60	Cordmarked	partially smoothed cordmarks	body	4.5-5.8	sand	bumpy	N/A	N/A	N/A	N/A	N/A	TRC 635	12	J, quartz sand
28-A6-92	Cordmarked	narrow, shallow distinct vertical cordmarks	rim	4.1-6.2	sand	very smooth	flat	bumpy	direct	straight	none	TRC 630	2	***quartz = 55.9% alkali feldspar = 17.7%, granite 17.7% biotite 2.9%

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** Petrographic results from Lintz and Reese-Taylor 1997:293;
UN = Unassigned, N/A = data not applicable

Figure Q-10. Sherds from 41HC6, Roper Site, in the Antelope Creek Core Area used for instrumental neutron activation analysis.

(Note these same six sherds were used in a petrographic study by Lintz and Reese-Taylor 1997).

Table Q-10. Selected Data on Sherds from 41HC6, Roper Site Used for Petrography.

PNUM	Ceramic Ware / Type	Exterior Surface	Portion	Thickness (mm)	Macroscopic Temper	Interior Surface	Lip Characteristic	Lip Decoration	Rim Wall Direction	Rim Form	Rim Decoration	MURR No. *	Chemical Group **	Petrographic Group ***
542	Cordmarked	partially obliterated cordmarks	rim	3.3-7.5	mica fine sand	bumpy smooth	narrow, rounded	none	inverted	collared, wedge	cordmarked	TRC 622	UN	quartz = 62.5%, granite = 37.5%, biotite 1.0%
543	Cordmarked	partially smoothed over cordmarks	rim	4.0-6.9	fine sand	very smooth	rounded	none	incurved/ inverted	collared, thickened	cordmarked collared	TRC 623	UN	quartz = 80.7%, alkali feldspar = 15.4%, biotite 3.8%
544	Cordmarked	partially smoothed over cordmarks	rim/neck	4.0-9.7	fine sand	very smooth	narrow rounded	none	direct	collared, thickened	cordmarked collared	TRC 624	UN	quartz = 84.6%, alkali feldspar = 15.4%, biotite 1.0%
545	Plain	horizontal wiping striations	rim	4.9-5.8	sand	smooth	rounded	cord impressed	outcurved/ everted	expanded	none	TRC 625	7	quartz = 72.1%, alkali feldspar = 11.1%, granite 16.7%
546	Cordmarked	partially obliterated cordmarks	rim	5.2-6.9	sand	wiping smooth	polished rounded	none	direct	straight	none	TRC 626	7	quartz = 88.8%, alkali feldspar = 11.1%, biotite 0.06%
547	Plain	irregular possible plain	rim	5.2-6.2	sand	-	N/A	N/A	N/A	N/A	N/A	TRC 627	7	quartz = 99.8%, alkali feldspar = 0.06%, granite 0.06%

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** petrographic results from Lintz and Reese-Taylor 1997:293; UN = Unassigned, N/A = data not applicable

Figure Q-11. Sherds of Alibates Creek Ruin 22, 41HC23, in the Antelope Creek Core Area used in the technical analyses.

Table Q-11. Selected Data from Sherds of Alibates Creek Ruin 22 41HC23 Used for Petrography and Instrumental Neutron Activation Analysis

PNUM	Ceramic Ware / Type	Exterior Surface	Portion	Thickness (mm)	Macroscopic Temper	Interior Surface	Lip Characteristic	Lip Decoration	Rim Wall Direction	Rim Form	Rim Decoration	MURR No. *	Chemical Group **	Petrographic Group
3c-7	Cordmarked	shallow, broad cords	rim	3.96-6.5	crushed rock	smooth	flat	N/A	N/A	straight	N/A	TRC 613	7	A, crushed rock & mineral
5I/45	Cordmarked	narrow partially, obliterated cordmarks	rim/neck	4.5-7.66	sand	smooth	slopes rounded	none	direct	straight	none	TRC 614	7	***quartz = 74.9% alkali feldspar = 16.7%, granite = 4.2% carbonate = 4.2%
7A-20-2	Cordmarked	shallow cordmarks	rim/neck	5.1-9.1	crushed rock	smooth	flat	none	direct	straight	none	TRC 615	7	***quartz = 74.9% granite = 21.9% carbonate = 3.1%
R2/13	Cordmarked	obliterated cordmarks	rim/neck	4.1-7.5	mica, sand	very smooth	narrow flat	none	direct	straight	none	TRC 618	12	A, crushed rock & minerals
R2/15	Cordmarked	obliterated cordmarks	base	9.3-12.8	fine sand	smooth, divot	N/A	N/A	N/A	N/A	N/A	TRC 617	4	I, basalt with pyroxene
R2/3	Cordmarked	broad distinct cordmarks	body	4.8-5.4	crushed rock	smooth	N/A	N/A	N/A	N/A	N/A	TRC 616	7	A, crushed rock & minerals

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** Petrographic results from Lintz and Reese-Taylor 1997:293;
UN = Unassigned, N/A = data not applicable

Figure Q-12. Sherds from Cottonwood Creek, 41HC141, in the Antelope Creek Phase Core Area used in the technical analyses.

(Note, these same three sherds used in petrographic analysis by Lintz and Reese-Taylor 1997)

Table Q-12. Selected Data on Sherds from Cottonwood Creek, 41HC141 Used for Instrumental Neutron Activation Analysis.

PNUM	Ceramic Ware / Type	Exterior Surface	Portion	Thickness (mm)	Macroscopic Temper	Interior Surface	Lip Characteristic	Lip Decoration	Rim Wall Direction	Rim Form	Rim Decoration	MURR No. *	Chemical Group **	Petrographic Group ***
104.1	Cordmarked	distinct narrow cordmarks	rim	5.1-6.3	fine sand	very smooth	wiped rounded	none	direct	straight	none	TRC 619	UN	quartz = 79.5% alkali feldspar 12.8% granite = 5.1% mica 2.6%
109.3	Cordmarked	shallow cordmarks, poor pattern	neck	3.0-5.1	sand	very smooth	-	-	outcurved/ everted	straight	none	TRC 620	UN	quartz = 63% alkali feldspar 14.8% granite = 22.2%
111.4	Cordmarked	shallow narrow distinct cordmarks	rim	2.2-10.3	crushed rock	smooth	narrow rounded	N/A	direct	thickened straight	cordmarked collared	TRC 621	7	quartz = 85% alkali feldspar 5% mica 10%

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** Petrographic results from Lintz and Reese-Taylor 1997:293;
UN = Unassigned, N/A = data not applicable

Figure Q-13. Sherds from Indian Springs 41RB81, used in technical analyses.

Table Q-13. Selected Data on Sherd from Indian Springs 41RB81, Used for Petrography and Instrumental Neutron Activation Analysis.

PNUM	Ceramic Ware / Type	Exterior Surface	Portion	Thickness (mm)	Macroscopic Temper	Interior Surface	Lip Characteristic	Lip Decoration	Rim Wall Direction	Rim Form	Rim Decoration	Comments	MURR No. *	Chemical Group **	Petrographic Group ***
156	Cordmarked	well defined, narrow cordmarks	neck	5.75-8.87	sand	smooth	N/A	N/A	N/A	N/A	N/A	pithouse	TRC 545	UN	E, bone temper
291/124.1	Cordmarked	thick, obliterated cordmarks	base	10.3-11.0	bone	very smooth	N/A	N/A	N/A	N/A	N/A	-	TRC 537	UN	E, bone temper
347/369/123.8	Cordmarked	deep, well defined distinct cords	body	9.6-9.9	grog	wiped smooth	N/A	N/A	N/A	N/A	N/A	-	TRC 539	12	G, bone temper
370	Cordmarked	shallow, thick, narrow well defined	body	8.71-9.50	fine sand	smooth	N/A	N/A	N/A	N/A	N/A	-	TRC 540	UN	H, bone & basalt temper
374-1/124.0	Cordmarked	irregular, smoothed cords	body	6.2-7.8	?	smooth	N/A	N/A	N/A	N/A	N/A	-	TRC 541	1	I, basalt temper
374-2/124.0	Cordmarked	deep, well defined narrow	body	8.0-8.9	grog	very smooth	N/A	N/A	N/A	N/A	N/A	-	TRC 542	11	F, bone temper
381/124.8	Cordmarked	deep, distinct cords	body	7.9	bone +	very smooth	N/A	N/A	N/A	N/A	N/A	-	TRC 538	11	F, bone temper
492	Cordmarked	polished obliterated cordmarks	base	13.41-14.1	bone + sand	smooth	N/A	N/A	N/A	N/A	N/A	thick base	TRC 543	UN	H, bone & basalt temper
505/123.9	Cordmarked	deep, well defined narrow	rim	8.5	grog	very smooth	N/A	N/A	N/A	N/A	N/A	-	TRC 544	11	F, bone temper

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** Petrographic results; UN = Unassigned, N/A = data not applicable

Figure Q-14. Sherds from Whistling Squaw 41RB108 and Three Toes, 41RB110, used in technical analyses.

Table Q-14. Selected Data on Sherd from Whistling Squaw 41RB108 and Three Toes 41RB110, Used for Petrography and Instrumental Neutron Activation Analysis.

PNUM	Ceramic Ware / Type	Exterior Surface	Portion	Thickness (mm)	Macroscopic Temper	Interior Surface	Lip Characteristic	Lip Decoration	Rim Wall Direction	Rim Form	Rim Decoration	MURR No. *	Chemical Group **	Petrographic Group ***
?/WP-6	Cordmarked	smoothed over deep cordmarks	body	4.2-5.3	very fine sand	smooth	N/A	N/A	N/A	N/A	N/A	TRC 533	UN	L, basalt temper

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** Petrographic results; UN = Unassigned, N/A = data not applicable

PNUM	Ceramic Ware / Type	Exterior Surface	Portion	Thickness (mm)	Macroscopic Temper	Interior Surface	Lip Characteristic	Lip Decoration	Rim Wall Direction	Rim Form	Rim Decoration	Comments	MURR No. *	Chemical Group **	Petrographic Group ***
12/WP-8	Cordmarked	smoothed over cordmarks	body	7.8-9.8	sand	-	N/A	N/A	N/A	N/A	N/A	brown core	TRC 535	UN	DD, bone & basalt temper
13?/WP-7	Cordmarked	obliterated cordmarks, faint lines across sherd	body	6.0-6.8	fine sand	very smooth	N/A	N/A	N/A	N/A	N/A	Fea. 5	TRC 534	UN	D, quartz temper
87/37/WP-9	Cordmarked	faint, shallow cordmarks	body	10.3-12.1	fine sand	bumpy	N/A	N/A	N/A	N/A	N/A	black core	TRC 536	UN	D, quartz temper

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** Petrographic results; UN = Unassigned, N/A = data not applicable

Figure Q-15. Sherds from Hank's House, 41RB109 in M-Cross Ranch used in technical analyses.

Table Q-15. Selected Data on Sherds from Hank's House, 41RB109, Used for Petrography and Instrumental Neutron Activation Analysis.

PNUM	Ceramic Ware / Type	Exterior Surface	Portion	Thickness (mm)	Macroscopic Temper	Interior Surface	Lip Characteristic	Lip Decoration	Rim Wall Direction	Rim Form	Rim Decoration	Comments	MURR No. *	Chemical Group **	Petrographic Group ***
17/WP-4	Cordmarked	smoothed over cordmarks, shallow, wide cordmarks	body	5.0-5.3	sand	very smooth	N/A	N/A	N/A	N/A	N/A	gray core	TRC 531	UN	L, Basalt + pyroxene
21/WP-3	Cordmarked	prominate, wide, shallow, overlapping cordmarks	body	5.0-6.9	sand	smooth	N/A	N/A	N/A	N/A	N/A	-	TRC 530	2	L, Basalt + pyroxene
5/WP-5	Cordmarked	shallow unclear cordmarks	body	6.0-7.1	sand	-	N/A	N/A	N/A	N/A	N/A	-	TRC 532	UN	L, Basalt + pyroxene
E3/WP-1	Cordmarked	smoothed over cordmarks	upper body below rim	5.8	sand	-	N/A	N/A	N/A	N/A	finger nail impressed	thick shoulder, reconstructed, same vessel as WP-2	TRC 528	2	B, quartz temper
E3/WP-2	Cordmarked	obliterated cordmarks	base	2.6-3.6	sand	-	N/A	N/A	N/A	N/A	finger nail impressed	reconstructed, same vessel as WP-1	TRC 529	2	D, quartz temper

* = TRC submission No. to University of Missouri; ** Chemical Group assigned by Missouri; *** Petrographic results; UN = Unassigned, N/A = data not applicable

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APPENDIX R

QUARTZ OPTICAL DATING REPORT: LONG VIEW SITE, TEXAS

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March 2011

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Quartz Optical Dating Report

15th March, 2011

Longview Site, Texas, USA

Abstract: Optical luminescence dating (OSL) at both the single aliquot and grain level was applied to coarse quartz grains extracted from fourteen samples taken from at or within vicinity of the Longview site, Texas, USA. Whilst all samples responded acceptably to OSL measurement, most were very young for this technique. Additionally analysis of sample replicates indicated some samples had appreciable palaeodose scatter which are taken to indicate partial bleaching prior to burial or post-depositional disturbance. Whilst efforts have been made to mitigate the effects of this and ages have been calculated, results for these samples should be treated with some caution. Most samples returned very young ages which appear to increase in antiquity with depth. Best estimates of the samples burial age range from 100 ± 20 years through to $>38 \pm 2.4$ ka.

1. Introduction: Fourteen samples in opaque PVC tubing from at or within the vicinity of the Longview site, Texas, USA were submitted for OSL dating by Dr. Charles Frederick. All luminescence work was carried out at the Sheffield Centre for International Drylands Research (SCIDR) luminescence laboratory. The samples are assumed not to have been exposed to sunlight during sampling or transportation to the laboratory. Upon arrival, each sample was allocated a Sheffield laboratory number (Table 1). This report provides a brief summary of the procedures employed and results obtained for samples.

In order to derive an optically stimulated luminescence (OSL) age both the palaeodose (De - the amount of absorbed dose since the sample was buried) and the dose rate (the estimated radiation flux for the sedimentary bodies) have to be determined. Aitken (1998) gives a detailed explanation of both these parameters. To calculate an age, the palaeodose (expressed in Grays) is divided by the annual dose rate (Grays/yr). An inherent assumption in these age calculations is that the sediment was fully reset or 'bleached' by exposure to sunlight during the last transport event or whilst *in situ* prior to burial and that no post-depositional sediment disturbance has occurred. As part of this investigation, efforts have been taken to establish if these sediments have been bleached prior to burial or disturbed by, for example, bioturbation. As the OSL signal measured at the single aliquot level of measurement is an average of ~2000 grains the true distribution of De values may be masked. This is of particular significance in heterogeneously dosed samples (e.g. poorly reset/bleached) in which grains with a high De signal will dominated the signal at the expense of grains containing a true burial De. The De of grains recently exhumed and bleached due to bioturbation (referred to as zero-dosed grains) are also masked at the single aliquot level. Measurement of the accumulated dose from individual grains obviates this problem. As a result some samples, which based on field evidence (as observed by Dr Frederick) may have undergone bioturbation, were selected for single grain analysis. The remainder underwent single aliquot analysis.

Table 1. Sample descriptive data.

Lab No.	Field Reference	Latitude (° N)	Longitude (°W)	Altitude (m)	Sampling Depth (cm below surface)
LRUD					
Shfd10166	LRUD-3	36° 01'	100° 51'	847	30
Shfd10165	LRUD-2	36° 01'	100° 51'	847	60
Shfd10164	LRUD-1	36° 01'	100° 51'	847	120
LRSSD					
Shfd10167	LRSSD-1	36° 00'	100° 51'	790	60
Shfd10168	LRSSD-2	36° 00'	100° 51'	790	110
Shfd10169	LRSSD-3	36° 00'	100° 51'	790	180
Shfd10170	LRSSD-4	36° 00'	100° 51'	790	260
Shfd10171	LRSSD-5	36° 00'	100° 51'	790	310
A1					
Shfd10172	A1-1	36° 00'	100° 51'	822	20
C2					
Shfd10173	C2-1	36° 00'	100° 51'	822	50
Shfd10174	C2-2	36° 00'	100° 51'	822	20
Shfd10175	C2-3	36° 00'	100° 51'	822	90
C4					
Shfd10176	C4-1	36° 00'	100° 51'	822	30
Shfd10177	C4-2	36° 00'	100° 51'	822	80

2. Dose Rate Analysis: Naturally occurring potassium (K), thorium (Th), rubidium (Rb) and uranium (U) are the main contributors of dose to sedimentary quartz. The concentrations of these elements were determined by inductively coupled plasma mass spectrometry (ICP) at SGS laboratories Ontario Canada (Table 2). Elemental concentrations were converted to annual dose rates using data from Adamiec and Aitken (1998), Marsh et al. (2002), and Aitken (1998). This took into account attenuation factors relating to sediment grain sizes used, density and palaeomisture. It has been assumed that the samples formed part of a thick homogeneous unit with no gamma contribution (other than from cosmogenic sources) being received by the samples from other unsampled sedimentary units. Attenuation of dose by moisture used the present-day moisture values as measured in the laboratory, with a $\pm 3\%$ error to incorporate seasonal and longer-term fluctuations in moisture which the samples may have endured since burial (Table 2). The contribution to dose rates from cosmic sources were calculated using the expression published in Prescott and Hutton (1994; Table 2). It is noted that four samples were collected from less than 50 cm from the ground surface where the cosmic attenuation is non-linear and with both a hard and soft component. As a result the cosmic component of the dose rate for these samples will be an under-estimation.

The dose rates calculated are based on analyses of the sediment sampled at the present day. This assumption is only valid if no movement and/or reprecipitation of the four key elements has taken place since sediment burial and the adjacent sediments to those sampled had similar dose rates. Further analysis would have to be undertaken to establish whether the latter is true and if radioactive disequilibrium is present in the dose rate.

Table 2. Summary of results – Dosimetry related data.

Lab Code	U (PPM)	Th (PPM)	Rb (PPM)	K (%)	D _{cosmic} ⁺ (Gy/ka)	Moisture (%)	Dose rate [†] (Gy/ka)
LRUD							
Shfd10166	0.93	2.4	60.8	2.1	0.236 ± 0.012	0.6	2.675 ± 0.144
Shfd10165	0.92	2.4	56.7	1.9	0.229 ± 0.011	0.5	2.451 ± 0.129
Shfd10164	0.87	2.2	58.5	1.9	0.219 ± 0.011	0.6	2.436 ± 0.130
LRSSD							
Shfd10167	0.95	2.0	54.8	1.8	0.224 ± 0.011	0.4	2.354 ± 0.124
Shfd10168	1.08	2.3	54.9	1.9	0.210 ± 0.010	0.5	2.487 ± 0.131
Shfd10169	0.93	1.9	52.7	1.7	0.210 ± 0.010	0.4	2.231 ± 0.117
Shfd10170	1.03	2.1	53.5	1.8	0.195 ± 0.010	0.1	2.347 ± 0.125
Shfd10171	1.23	2.6	58.1	2.0	0.164 ± 0.08	0.7	2.590 ± 0.138
A1							
Shfd101724	1.77	5.3	68.4	2.1	0.238 ± 0.012	1.6	3.037 ± 0.147
C2							
Shfd10173	1.65	4.2	72.4	2.3	0.231 ± 0.012	1.2	3.188 ± 0.162
Shfd10174	1.78	5.0	70.4	2.2	0.238 ± 0.012	1.2	3.187 ± 0.157
Shfd10175	1.63	4.1	67.8	2.2	0.231 ± 0.012	1	3.084 ± 0.156
C4							
Shfd10176	1.78	5.5	70.5	2.2	0.235 ± 0.012	1.3	3.216 ± 0.158
Shfd10177	1.62	4.3	72.8	2.4	0.229 ± 0.011	1.2	3.282 ± 0.169

+ Cosmic dose is calculated as a linear decay curve at depths below 50 cm. Above this depth, errors in calculation may lead to an under-estimation of the cosmic dose contribution.

† Total Dose is attenuated for grain size, density and moisture.

Palaeodose Determination: The samples were prepared under subdued red lighting following the procedure to extract and clean quartz outlined in Bateman and Catt (1996). Prepared aliquots of the samples were taken from within a maximum size range of 125-250 µm to ensure sufficient material for measurements. All samples then underwent measurement either at the single aliquot or single grain level. For the single aliquot measurements, prepared quartz was mounted onto 9.6 mm diameter disks for measurement. The purity of the quartz extract was checked using infrared stimulated luminescence and minimal feldspar contamination was seen. All OSL measurements were carried out using an upgraded DA-15 Risø luminescence reader fitted with blue LEDs for stimulation. OSL was measured through a Hoya-340 filter in placed in front of the photomultiplier tube. Samples were dosed using a calibrated ⁹⁰strontium beta source. All samples were analysed using the single aliquot regenerative (SAR) approach (Murray and Wintle 2000, 2003), in which an interpolative growth curve is constructed using data derived from repeated measurements of a single aliquot which has been given various laboratory irradiations (Figure 1a and 1b). The last irradiation dose replicated the first to check if sensitivity changes cause by repeated measurement of the same aliquot had been correctly monitored and corrected for by the SAR protocol. All aliquots where the ratio of first and last dose

point exceeded $\pm 10\%$ of unity were excluded from further analysis. As rangefinder measurements indicated that (a) many samples were very young and (b) many of the samples suffered from relatively high recuperation compared to the natural, prior to OSL measurement all samples underwent an IR bleach to remove any low level feldspar contribution. At the end of each SAR cycle a hot bleach of 220°C for 40s was also added. Both these additions were successfully adopted by Cunningham and Wallinga (2010). The most appropriate preheat temperature for each sample was derived experimentally using a dose recovery test with a range of preheat temperatures (after Murray and Wintle, 2003). As Figure 2 shows the 160°C for 10 s preheat recovers the 10 Gy dose within errors and has recycling ratios within $\pm 10\%$.

Figure 1: Examples of single aliquot and single grain OSL data (a) OSL decay of naturally acquired signal for sample Shfd10168 measured at the single aliquot level; (b) Single aliquot SAR growth curve for sample Shfd10168; (c) OSL decay of naturally acquired signal for sample Shfd10166 measured at the single grain level and (d) Single grain SAR growth curve for sample Shfd10166. Note red lines in (a) and (c) indicate block of data used as OSL signal and green lines indicate block of data used as OSL background. Red lines in (b) and (d) indicate where naturally acquired OSL signal intercepts with SAR growth curve (and associated uncertainties) from which the naturally acquired dose can be calculated.

For single grain level measurements grains were mounted in $300\mu\text{m}$ pits with 100 pits per 9.6 mm aliquot. A focussed 532 nm Nd:YVO₄ laser provided the stimulation and luminescence detection was through a Hoya U-340 filter. All samples were then measured in an identical method to that used for standard aliquots although the stimulation time was much short to reflect the much lower OSL signal contained within individual grains (Figure 1c and d). With all single grain OSL analysis many grains exhibit insufficient OSL signal to be utilised and/or are too poorly behaved for the De to be accurately measured. De values from individual grains were only accepted they exhibited an OSL signal measurable above background, good growth with dose, recycling within 20% of unity and the error on the test dose used within the SAR protocol was less than 20%. Most samples analysed as part of this study were had lower than average numbers of acceptable grains compared to those measured (recovery rate) requiring many 1000's of grains to be measured in order to obtain $\sim 30+$ De's of acceptable quality.

Figure 2. Results of Dose recovery test on Shfd10165 used to determine appropriate preheat for SAR protocol. (a) Results of different preheat temperatures in recovering a ~10 Gy beta radiation dose; (b) recycling ratio of different preheats.

4. Sedimentary bleaching behaviour: The effects of incomplete bleaching of the sediment during the last period of transport or exposure *in situ* can be profound. Typically, poorly bleached sediments retain a significant level of residual signal from previous phases of sedimentary cycling, leading to inherent inaccuracies in the calculation of a palaeodose value. By plotting the replicate data for each sample as a probability density function some assessment of whether older or younger material has been included in the sample measurements can be made (Figure 3). In principle a well bleached unpost-depositionally disturbed sample should have replicate palaeodose (De) data which is normally distributed and highly reproducible (See Bateman *et al.* 2003, Fig 3; Bateman *et al.* 2007a). Where post-depositional disturbance or incomplete bleaching prior to sample burial has occurred skewing of this distribution may occur and/or replicate reproducibility may be lower (Bateman *et al.* 2007a; Bateman *et al.* 2007b). In the case of poorly bleached material skewing should be evident with a high De tail (e.g. Olley *et al.* 2004).

As Figure 3 and Table 3 (see also appendix) shows, De distributions for the samples varied. For samples Shfd10165, Shfd10168, Shfd10170 and Shfd10171 over-dispersion (OD) values were low and distributions were unimodal (once outliers falling outside 2 standard deviations of the mean are excluded). Based on these measurements these samples are assumed to have been sufficient exposed to sunlight prior to burial (resetting the OSL 'time clock') and not bioturbated. The exception to this at the single aliquot level was sample Shfd10164 which was scattered and skewed perhaps indicating incomplete resetting prior to burial for this sample. Many of the samples measured at the single grain level had high OD and appreciable numbers of zero-dose grains (i.e. grains which have recently been exhumed and returned to depth by, for example, bioturbation (see Heimsath 2002; Bateman *et al.* 2007b). This is taken to indicate that the deposits had undergone some bioturbation since deposition. If it is assumed that the single grain measurements result in the true distributions of De, in order to try and overcome incorporating disturbed/antecedent De signals and try to isolate a burial OSL ages, the De values were statistically analysed using the finite mixture model (Roberts *et al.* 2000). This model attempts to extract the different multiple components contained within the De distributions. Results from this (excluding any component representing less than 10% of data as per Bateman *et al.*

Figure 3: Examples of combined probability density functions for both single aliquot and single grains showing degree of inter-aliquot scatter. Also plotted are individual grain De (black) and the unweighted mean De (red).

2010) are shown in Table 4. For disturbed samples it has been argued that the dominant peak (that incorporating the results of the most number of grains) relates to the true burial age and other minor peaks represent either post-depositional disturbance or incomplete bleaching (Bateman *et al.* 2007). The indistinct nature of many of the De components displayed for these samples makes such assumptions difficult to apply. As such ages for all De's found within the samples have been calculated along with the relative proportion of the data found within each De component (Table 4). Whilst ages have been calculated this uncertainty should be borne in mind and appropriate caution used when using the ages for site interpretation.

Table 3a. Summary Single Grain Palaeodose (De) data.

Lab Code	Field Ref.	Depth (cm)	Grains measured	Usable Grains	OD* (%)	Zero-Dosed Grains (%)	Skewness
LRUD							
Shfd10166	LRUD-3	30	1600	43	56	16	11.22
LRSSD							
Shfd10167	LRSSD-1	60	1300	32	92	22	19.18
Shfd10169	LRSSD-3	180	1500	31		23	2.52
A1							
Shfd10172	A1-1	20	1900	22		18	0.97
C2							
Shfd10173	C2-1	50	2800	51	132	2	7.97
Shfd10174	C2-2	20	2800	31	139	13	0.00
Shfd10175	C2-3	90	1400	34	100	0	0.67
C4							
Shfd10176	C4-1	30	2100	37	154	19	9.03
Shfd10177	C4-2	80	1400	51	140	2	-2.03

* OD (over-dispersion) is a function which indicates the level of data falling outside a normal distribution which would be expected for well-bleached undisturbed sediment. It cannot always be calculated where there are significant numbers of zero-dosed grains. The latter also affects the reliability of the skewness calculation.

Table 3b. Summary Single Aliquot Palaeodose (De) data.

Lab Code	Field Ref.	Depth (cm)	Aliquots measured	Usable Aliquots	OD (%)	Skewness
LRUD						
Shfd10165	LRUD-2	60	24	18	26	3.04
Shfd10164	LRUD-1	120	24	21	63	2.00
LRSSD						
Shfd10168	LRSSD-2	110	23	20	8	-0.02
Shfd10170	LRSSD-4	260	24	23	28	5.49
Shfd10171	LRSSD-5	310	24	22	16	4.91

Table 4. Results of Finite Mixture modelling of the single grain De data to extract multiple components for each sample. Dominant De and age derived from it highlighted in bold.

Lab Code	Field Ref.	Depth (cm)	FMM component ^a	De (Gy)	Proportion of grains (%)	Dose rate [†] (Gy/ka)	Age (years)
LRUD							
Shfd10166	LRUD-3	30	1	1.20 ± 0.11	97	2.675 ± 0.144	450 ± 50
LRSSD							
Shfd10167	LRSSD-1	60	1	0.24 ± 0.05	20	2.354 ± 0.124	100 ± 20
			2	1.03 ± 0.14	76	2.354 ± 0.124	440 ± 60
Shfd10169	LRSSD-3	180	1	0.61 ± 0.08	80	2.231 ± 0.117	270 ± 40
			2	1.66 ± 0.47	19	2.231 ± 0.117	740 ± 210
A1							
Shfd1004724	A1-1	20	1	0.54 ± 0.26	12	3.037 ± 0.147	180 ± 90
			2	1.56 ± 0.14	88	3.037 ± 0.147	510 ± 50
C2							
Shfd10173	C2-1	50	1	2.18 ± 0.16	70	3.188 ± 0.162	680 ± 60
			2	4.89 ± 0.63	19	3.188 ± 0.162	1530 ± 200
			3	19.16 ± 1.54	11	3.188 ± 0.162	6000 ± 580
Shfd10174	C2-2	20	1	1.31 ± 0.14	63	3.187 ± 0.157	410 ± 50
			2	5.11 ± 0.67	14	3.187 ± 0.157	1600 ± 210
			3	31.06 ± 2.27	24	3.187 ± 0.157	9750 ± 710
Shfd10175	C2-3	90	1	25.27 ± 2.86	11	3.084 ± 0.156	8190 ± 1020
			2	48.65 ± 4.62	21	3.084 ± 0.156	15770 ± 1550
			3	117 ± 14.3	24	3.084 ± 0.156	37780 ± 4660
			4	199 ± 16.8	35	3.084 ± 0.156	64710 ± 5450
C4							
Shfd10176	C4-1	30	1	1.28 ± 0.35	64	3.216 ± 0.158	400 ± 110
			2	2.61 ± 0.65	25	3.216 ± 0.158	810 ± 200
				9.27 ± 1.05	11	3.216 ± 0.158	2880 ± 330
Shfd10177	C4-2	80	1	1.75 ± 0.03	10	3.282 ± 0.169	530 ± 30
			2	127 ± 4.3	81	3.282 ± 0.169	38750 ± 2400

^a only component representing more than 10% of De data are reported.

[†] Total Dose is attenuated for grain size, density and moisture.

Table 5. Ages for samples which underwent De measurement at the single aliquot level

Lab Code	Field Ref.	Depth (cm)	De (Gy)	Dose rate [†] (Gy/ka)	Age (years)
LRUD					
Shfd10165	LRUD-2	60	0.95 ± 0.02	2.451 ± 0.129	390 ± 20
Shfd10164	LRUD-1	120	1.95 ± 0.09*	2.436 ± 0.130	800 ± 60
LRSSD					
Shfd10168	LRSSD-2	110	0.26 ± 0.02	2.487 ± 0.131	100 ± 20
Shfd10170	LRSSD-4	260	0.82 ± 0.02	2.347 ± 0.125	350 ± 20
Shfd10171	LRSSD-5	310	0.96 ± 0.02	2.590 ± 0.138	370 ± 20

* Based on Finite mixture modelling due to high OD and skewed data

5. Age Calculation and Conclusions: Ages are quoted in years from the present day (2011) and are presented with one sigma confidence intervals which incorporate systematic uncertainties with the dosimetry data, uncertainties with the palaeomoisture content and errors associated with the De determination. Tables 4 and 5 shows the final OSL age estimates. Aliquot and grain-specific data for each sample are included in appendix 1. The data presented showed many of the samples had appreciable De scatter (due to bioturbation, beta heterogeneity and/or partial bleaching), whilst efforts have been made to mitigate the impact of this, ages may still incorporate a partial bleach or post-depositional disturbance signature and should be treated with due caution. Nearly all samples had very low De values and therefore very low antiquities. The best estimate of ages for the LRUD site range from 390 ± 20 (Shfd10165) to 800 ± 60 years (Shfd10164). The best estimates of ages for the LRSSD site range from 100 ± 20 (Shfd10168) to 370 ± 20 years (Shfd10171). The best estimate of ages for the C2 site range from 410 ± 50 (Shfd10174) to 8190 ± 1020 years (Shfd10175). The best estimate of ages for the C4 site range from 400 ± 110 (Shfd10176) to 38750 ± 2400 years (Shfd10177). There would appear to be some concordance of these OSL ages with respective inter and intra site and stratigraphy although the validity of the OSL ages should be further tested with the associated radiocarbon dates, associated stratigraphy and archaeology found at the sites.

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Appendix 1

Single aliquot and single grain data and plots for the Longview site and associated areas, Texas, USA.

Sample specific data including:-

- list of De's derived from individual grains/aliquots
- calculated statics for De distribution (Skewness, kurtosis and sorting)
- calculated means based on a range of statistical models including Finite Mixture Modelling (FMM)
- histogram plot of distribution of De within a sample
- probability density plot (curve) with ranked De data (black points) and probability mean (uppermost red point).

Field Code: LRUD-1
Lab Code: Shfd10164
Aliquot Size: Single Aliquot

Site: Longview Site
Texas, USA

Aliquot	Palaeodose (Gy)	error
1	2.536	0.097
2	1.815	0.063
3	3.051	0.102
4	2.409	0.102
5	16.702	0.628
6	3.407	0.136
7	14.615	0.492
8	4.448	0.146
9	7.835	0.258
10	2.073	0.097
11	1.942	0.063
12	1.431	0.049
13	5.027	0.161
14	2.151	0.073
15	5.718	0.185
16	4.623	0.146
17	2.005	0.073
18	6.731	0.224
19	1.942	0.083
20	4.161	0.151
21	2.842	0.097
22	2.102	0.088
23	3.003	0.122
24	5.363	0.175

De Distribution	All Data	Minus Outliers
Skewness	2.00	-0.11
Kurtosis	5.18	-0.36
Median	3.03	2.84
Sorting	0.62	0.30

	De (Gy)	error
Minimum	1.43	0.05
Maximum	16.70	0.63
N	24	

Unweighted		
	All Data	Minus Outliers
Mean (Gy)	4.50	3.28
SD	3.84	1.51
SE	0.78	0.31
N	24	21

Weighted		
	All Data	Minus Outliers
Mean (Gy)	2.45	2.38
SD	1.30	1.51
SE	0.26	0.33
N	24	21

Probability		
	All Data	Minus Outliers
Mean (Gy)	2.56	2.52
SD	1.09	1.01
SE	0.22	0.22
N	24	21

Central Age Model		
	All Data	Minus Outliers
Mean (Gy)	3.56	2.98
SD	0.46	0.29
OD (all data)	63.18%	43.14%
N	24	21

Finite Mixture Modelling				
Component	Mean De (Gy)	Error	Proportion	
1	1.950	0.085		36%
2	2.910	0.167		22%
3	4.850	0.226		25%
4	7.17	0.627375		9%
5	15.61	1.172311		8%

Field Code: LRUD-1
Lab Code: Shfd10164
Aliquot: Single
Size: Aliquot

Site: Longview Site
Texas, USA

Distribution minus selected aliquots

Field Code: LRUD-2 Site: Longview Site
 Lab Code: Shfd10165 Texas, USA
 Aliquot Size: Single Aliquot

Aliquot	Palaeodose (Gy)	error
1	0.993	0.044
2	0.983	0.039
3	1.066	0.039
4	0.930	0.039
5	0.842	0.039
6	2.224	0.078
7	1.173	0.044
8	0.759	0.034
9	0.983	0.034
10	1.056	0.044
11	0.881	0.044
12	0.949	0.044
13	2.171	0.073
14	0.876	0.034
15	0.954	0.044
16	0.925	0.034
17	0.959	0.039
18	0.993	0.039
19	0.993	0.044
20	0.930	0.058
21	0.930	0.049
22	0.891	0.044
23	0.745	0.034
24	0.715	0.034

De Distribution	All Data	Minus Outliers
Skewness	3.04	-0.02
Kurtosis	7.42	-0.10
Median	0.95	0.95
Sorting	0.23	0.05

	De (Gy)	error
Minimum	0.72	0.03
Maximum	2.22	0.08
N	24	

Unweighted		
	All Data	Minus Outliers
Mean (Gy)	1.04	0.95
SD	0.37	0.06
SE	0.08	0.01
N	24	18

Weighted		
	All Data	Minus Outliers
Mean (Gy)	0.95	0.95
SD	0.23	0.08
SE	0.05	0.01
N	24	18

Probability		
	All Data	Minus Outliers
Mean (Gy)	0.95	0.95
SD	0.15	0.08
SE	0.03	0.02
N	24	18

Central Age Model		
	All Data	Minus Outliers
Mean (Gy)	1.00	0.95
SD	0.08	0.06
OD (all data)	26.07%	4.44%
N	24	18

Field Code: LRUD-2
Lab Code: Shfd10165
Aliquot: Single
Size: Aliquot

Site: Longview Site
Texas, USA

Field Code: LRUD-3 Site: Longview Site
 Lab Code: Shfd10166 Texas, USA
 Aliquot Size: Single grain

Grain	Palaeodose (Gy)	error
1	0.005	1.160
2	1.115	0.289
3	0.567	0.638
4	0.491	0.324
5	0.578	0.324
6	0.020	0.613
7	1.206	0.476
8	1.454	0.654
9	0.056	1.003
10	0.132	3.065
11	1.079	0.643
12	0.532	0.659
13	7.149	1.561
14	0.846	0.370
15	-0.345	0.963
16	1.733	0.547
17	0.117	0.253
18	-0.334	0.360
19	1.388	0.811
20	0.162	0.167
21	0.233	0.426
22	1.915	0.689
23	1.282	0.441
24	0.927	0.557
25	-0.177	0.593
26	-1.110	0.588
27	0.866	0.669
28	1.930	1.409
29	-1.307	1.262
30	0.972	0.613
31	0.318	1.234
32	1.455	0.784
33	-0.429	0.686
34	1.240	0.545
35	1.319	0.311
36	1.739	0.590
37	0.563	0.387
38	0.369	0.732
39	0.252	0.360
40	1.843	0.732
41	1.073	0.568
42	1.577	1.045
43	1.091	0.360

Field Code: LRUD-3
Lab Code: Shfd10166
Aliquot Size: Single grain

Site: Longview Site
Texas, USA

	De (Gy)	error
Minimum	0.00	0.59
Maximum	7.15	1.56
N	43	

De Distribution	All Data	Minus Outliers
Skewness	11.22	0.10
Kurtosis	19.86	-1.26
Median	0.85	0.71
Sorting	0.71	0.69

Unweighted		
	All Data	Minus Outliers
Mean (Gy)	0.92	0.77
SD	1.16	0.64
SE	0.18	0.10
N	43	42

Central Age Model		
	All Data	Minus Outliers
Mean (Gy)	1.22	0.55
SD	0.18	75.61
OD (all data)	56.14%	
N	43	42

Weighted		
	All Data	Minus Outliers
Mean (Gy)	0.65	0.64
SD	0.62	0.64
SE	0.09	0.10
N	43	42

Probability		
	All Data	Minus Outliers
Mean (Gy)	0.78	0.78
SD	0.61	0.60
SE	0.09	0.09
N	43	42

Finite Mixture Modelling

Component	De	error	Proportion
1	1.20	0.11	97%

Field Code:	LRSSD-1	Site:	Longview Site
Lab Code:	Shfd10167		Texas, USA
Aliquot Size:	Single grain		

Grain	Palaeodose (Gy)	error
1	0.719	0.299
2	-1.105	0.456
3	1.130	0.395
4	0.821	2.376
5	0.978	0.831
6	1.338	0.583
7	0.958	0.735
8	1.099	0.669
9	0.552	0.780
10	1.485	0.740
11	1.419	1.348
12	1.479	0.618
13	0.375	0.370
14	0.836	0.811
15	0.983	0.395
16	1.110	0.274
17	1.125	0.841
18	0.294	0.552
19	1.373	2.052
20	-0.263	0.573
21	0.978	0.390
22	0.481	0.258
23	-0.086	0.324
24	-0.522	0.659
25	16.634	2.726
26	0.203	0.233
27	-0.137	0.350
28	0.208	0.051
29	0.263	0.106
30	0.223	0.086
31	-0.061	0.294
32	-0.446	0.507

Field Code: LRSSD-1
Lab Code: Shfd10167
Aliquot Size: Single grain

Site: Longview Site
Texas, USA

	De (Gy)	error
Minimum	0.00	0.29
Maximum	16.63	2.73
N	32	

De Distribution	All Data	Minus Outliers
Skewness	19.18	-0.01
Kurtosis	29.76	-1.48
Median	0.77	0.72
Sorting	0.48	0.44

Unweighted		
	All Data	Minus Outliers
Mean (Gy)	1.16	0.66
SD	2.87	0.52
SE	0.51	0.09
N	32	31

Central Age Model		
	All Data	Minus Outliers
Mean (Gy)	0.87	0.72
SD	0.21	0.13
OD (all data)	92.36%	54.58%
N	32	31

Weighted		
	All Data	Minus Outliers
Mean (Gy)	0.28	0.28
SD	0.33	0.53
SE	0.06	0.09
N	32	31

Probability		
	All Data	Minus Outliers
Mean (Gy)	0.62	0.61
SD	0.62	0.54
SE	0.11	0.10
N	32	31

Finite Mixture Modelling				
Component	Mean De (Gy)	Error	Proportion	
1	0.24	0.05	20%	
2	1.03	0.14	76%	
	16.60	3.69	4%

Field Code: LRSSD-2 Site: Longview site
 Lab Code: Shfd10168 Texas, USA
 Aliquot Size: Single Aliquot

Aliquot	Palaeodose (Gy)	error
1	0.273	0.049
2	0.273	0.058
3	0.238	0.049
4	0.238	0.039
5	0.195	0.024
6	0.258	0.015
7	0.238	0.034
8	0.224	0.015
9	0.287	0.024
10	0.336	0.034
11	0.273	0.024
12	0.307	0.024
13	0.273	0.015
14	0.287	0.024
15	0.273	0.039
16	0.287	0.049
17	0.238	0.034
18	0.287	0.039
19	0.238	0.049
20	0.258	0.024
21	0.224	0.039
22	0.175	0.024
23	0.258	0.024

De Distribution	All Data	Minus Outliers
Skewness	-0.02	0.15
Kurtosis	0.68	-1.00
Median	0.26	0.27
Sorting	0.12	0.08

De (Gy)	error
Minimum	0.18
Maximum	0.34
N	23

Unweighted	All Data	Minus Outliers
Mean (Gy)	0.26	0.26
SD	0.04	0.02
SE	0.01	0.00
N	23	20

Weighted	All Data	Minus Outliers
Mean (Gy)	0.26	0.26
SD	0.07	0.06
SE	0.01	0.01
N	23	20

Probability	All Data	Minus Outliers
Mean (Gy)	0.26	0.26
SD	0.07	0.07
SE	0.01	0.02
N	23	20

Central Age Model	All Data
Mean (Gy)	0.26
SD	0.06
OD (all data)	8.28%
N	23

Field Code:	LRSSD-2	Site:	Longview site
Lab Code:	Shfd10168		Texas, USA
Aliquot Size:	Single Aliquot

Field Code: LRSSD-3 **Site:** Longview Site
Lab Code: Shfd10169 **Texas, USA**
Aliquot Size: Single grain

Grain	Palaeodose (Gy)	error
1	0.329	0.162
2	1.039	0.618
3	0.228	0.177
4	0.481	0.258
5	-0.608	0.998
6	0.740	0.360
7	2.619	1.034
8	0.679	0.400
9	0.476	0.649
10	-0.380	0.137
11	0.091	0.198
12	0.284	1.074
13	1.449	0.638
14	1.262	0.557
15	-0.253	0.643
16	0.137	0.117
17	0.304	0.370
18	0.512	0.152
19	-1.626	0.775
20	0.233	0.502
21	1.601	0.532
22	-0.046	0.334
23	-0.005	0.461
24	0.567	0.223
25	0.020	0.304
26	0.719	0.096
27	1.545	1.312
28	1.429	2.315
29	-0.020	0.258
30	0.573	0.177
31	0.441	0.208

Field Code: LRSSD-3
Lab Code: Shfd10169
Aliquot Size: Single grain

Site: Longview Site
Texas, USA

	De (Gy)	error
Minimum	0.00	0.46
Maximum	2.62	1.03
N	31	

De Distribution	All Data	Minus Outliers
Skewness	2.52	0.23
Kurtosis	2.30	0.43
Median	0.44	0.32
Sorting	0.98	0.68

Unweighted		
	All Data	Minus Outliers
Mean (Gy)	0.57	0.43
SD	0.63	0.44
SE	0.11	0.08
N	31	28

Central Age Model		
	All Data	Minus Outliers
Mean (Gy)	0.49	0.40
SD	81.82	74.70
OD (all data)		
N	31	28

Weighted		
	All Data	Minus Outliers
Mean (Gy)	0.39	0.37
SD	0.32	0.44
SE	0.06	0.08
N	31	28

Probability		
	All Data	Minus Outliers
Mean (Gy)	0.41	0.38
SD	0.39	0.33
SE	0.07	0.06
N	31	28

Finite Mixture Modelling				
Component	Mean De (Gy)	Error	Proportion	
1	0.61	0.08	80%	
2	1.66	0.47	19%

Field Code: LRSSD-4 Site: Longview Site
 Lab Code: Shfd10170 Texas, USA
 Aliquot Size: Single Aliquot

Aliquot	Palaeodose (Gy)	error
1	0.803	0.034
2	0.866	0.029
3	0.735	0.029
4	0.754	0.029
5	0.939	0.034
6	0.842	0.034
7	0.837	0.039
8	0.725	0.029
9	0.808	0.039
10	0.793	0.034
11	0.788	0.034
12	0.930	0.034
13	0.808	0.034
14	0.822	0.034
15	0.784	0.029
16	3.197	0.097
17	0.842	0.034
18	0.784	0.029
19	0.852	0.034
20	0.866	0.034
21	0.944	0.039
22	0.754	0.034
23	0.915	0.039
24	0.871	0.034

De Distribution	All Data	Minus Outliers
Skewness	5.49	-0.02
Kurtosis	23.13	-0.61
Median	0.83	0.82
Sorting	0.07	0.07

De (Gy)	error
Minimum	0.73
Maximum	3.20
N	24

Unweighted	All Data	Minus Outliers
Mean (Gy)	0.93	0.83
SD	0.49	0.06
SE	0.10	0.01
N	24	23

Weighted	All Data	Minus Outliers
Mean (Gy)	0.83	0.82
SD	0.19	0.09
SE	0.04	0.01
N	24	23

Probability	All Data	Minus Outliers
Mean (Gy)	0.82	0.82
SD	0.11	0.08
SE	0.02	0.02
N	24	23

Central Age Model	All Data	Minus Outliers
Mean (Gy)	0.87	0.83
SD	0.08	0.06
OD (all data)	27.92%	6.32%
N	24	23

Field Code:	LRSSD-4	Site:	Longview Site
Lab Code:	Shfd10170		Texas, USA
Aliquot Size:	Single Aliquot

Field Code: LRSSD-5 Site: Longview Site
 Lab Code: Shfd10171 Texas, USA
 Aliquot Size: Single Aliquot

Aliquot	Palaeodose (Gy)	error
1	0.915	0.039
2	0.930	0.039
3	0.925	0.034
4	0.968	0.029
5	1.012	0.044
6	1.051	0.039
7	0.944	0.049
8	0.930	0.039
9	0.934	0.034
10	0.993	0.044
11	0.949	0.034
12	0.968	0.034
13	1.032	0.039
14	0.895	0.044
15	0.998	0.034
16	0.934	0.039
17	0.959	0.044
18	0.959	0.044
19	1.003	0.039
20	0.920	0.044
21	1.066	0.039
22	0.978	0.044
23	2.073	0.068
24	0.993	0.039

De Distribution	All Data	Minus Outliers
Skewness	4.91	-0.02
Kurtosis	22.04	-0.42
Median	0.96	0.96
Sorting	0.04	0.04

De (Gy)	error
Minimum	0.90
Maximum	2.07
N	24

Unweighted	All Data	Minus Outliers
Mean (Gy)	1.01	0.96
SD	0.23	0.04
SE	0.05	0.01
N	24	22

Weighted	All Data	Minus Outliers
Mean (Gy)	0.98	0.96
SD	0.15	0.07
SE	0.03	0.01
N	24	22

Probability	All Data	Minus Outliers
Mean (Gy)	0.97	0.96
SD	0.09	0.08
SE	0.02	0.02
N	24	22

Central Age Model	All Data
Mean (Gy)	1.00
SD	0.07
OD (all data)	15.65%
N	24

Field Code: LRSSD-5 Site: Longview Site
 Lab Code: Shfd10171 Texas, USA
 Aliquot Size: Single Aliquot

Field Code: A1-1 **Site:** Longview Site
Lab Code: Shfd10172 **Texas, USA**
Aliquot Size: Single grain

Grain	Palaeodose (Gy)	error
1	1.880	0.390
2	0.451	0.400
3	2.042	0.243
4	1.302	0.456
5	0.887	0.552
6	1.520	0.284
7	1.626	0.841
8	0.314	0.765
9	1.991	1.013
10	1.201	0.765
11	-0.922	0.882
12	0.502	0.223
13	1.839	0.502
14	1.444	0.456
15	0.517	0.476
16	1.196	0.198
17	1.834	0.380
18	0.456	0.258
19	1.175	0.643
20	-0.339	0.593
21	-0.370	0.887
22	-0.385	0.299

Field Code: A1-1
Lab Code: Shfd10172
Aliquot Size: Single grain

Site: Longview Site
Texas, USA

	De (Gy)	error
Minimum	0.00	0.59
Maximum	2.04	0.24
N	22	

De Distribution	All Data	Minus Outliers
Skewness	0.97	0.97
Kurtosis	-1.46	-1.38
Median	1.19	1.20
Sorting	0.73	0.67

Unweighted		
	All Data	Minus Outliers
Mean (Gy)	1.01	1.06
SD	0.72	0.70
SE	0.15	0.15
N	22	21

Central Age Model		
	All Data	Minus Outliers
Mean (Gy)	1.01	1.01
SD	193.99	194.88
OD (all data)		
N	22	21

Weighted		
	All Data	Minus Outliers
Mean (Gy)	1.05	1.06
SD	0.66	0.70
SE	0.14	0.15
N	22	21

Probability		
	All Data	Minus Outliers
Mean (Gy)	1.05	1.09
SD	0.65	0.65
SE	0.14	0.14
N	22	21

Finite Mixture Modelling				
Component	Mean De (Gy)	Error	Proportion	
1	0.54	0.26	12%	
2	1.56	0.14	88%

Field Code:	C2-1	Site:	Longview Site
Lab Code:	Shfd10173		Texas, USA
Aliquot Size:	Single grain		
Grain	Palaeodose (Gy)	error	
1	0.319	0.345	
2	16.137	1.885	
3	2.969	0.714	
4	49.957	5.082	
5	1.991	0.426	
6	0.324	0.461	
7	1.013	1.125	
8	5.928	1.023	
9	3.678	0.000	
10	13.285	1.054	
11	2.163	0.436	
12	1.550	0.279	
13	-0.035	1.338	
14	1.652	0.187	
15	2.098	0.410	
16	3.111	0.902	
17	0.000	1.201	
18	16.887	1.865	
19	3.689	0.714	
20	2.630	0.588	
21	7.478	0.649	
22	3.065	0.542	
23	2.640	0.993	
24	4.616	1.713	
25	22.283	0.000	
26	15.028	1.363	
27	4.580	1.545	
28	2.163	0.725	
29	0.578	1.257	
30	2.239	0.410	
31	1.986	2.062	
32	0.005	0.000	
33	2.361	0.866	
34	2.174	0.882	
35	0.882	0.502	
36	2.528	0.532	
37	1.317	0.841	
38	0.466	1.135	
39	3.835	0.284	
40	1.794	0.562	
41	2.265	0.512	
42	5.619	1.626	
43	2.619	1.044	
44	3.410	0.542	
45	2.711	0.309	
46	1.839	0.841	
47	5.092	1.383	
48	1.414	0.218	
49	2.650	0.902	
50	0.334	0.187	
51	0.892	0.573	

Field Code: C2-1
Lab Code: Shfd10173
Aliquot Size: Single grain

Site: Longview Site
Texas, USA

	De (Gy)	error
Minimum	0.00	1.20
Maximum	49.96	5.08
N	49	

De Distribution	All Data	Minus Outliers
Skewness	7.97	-0.05
Kurtosis	25.80	0.05
Median	2.26	2.16
Sorting	0.80	0.31

Unweighted		
	All Data	Minus Outliers
Mean (Gy)	4.37	2.13
SD	7.73	1.39
SE	1.10	0.20
N	49	42

Central Age Model		
	All Data	Minus Outliers
Mean (Gy)	2.49	1.78
SD	0.51	0.36
OD (all data)	132.22%	115.58%
N	49	42

Weighted		
	All Data	Minus Outliers
Mean (Gy)	0.01	0.01
SD	0.06	1.39
SE	0.00	0.21
N	49	42

Probability		
	All Data	Minus Outliers
Mean (Gy)	2.30	2.10
SD	2.09	1.01
SE	0.30	0.16
N	49	42

Finite Mixture Modelling				
Component	Mean De (Gy)	Error	Proportion	
1	2.18	0.16	70%	
2	4.89	0.63	19%	
3	19.16	1.54	11%

Field Code: C2-2 Site: Longview Site
 Lab Code: Shfd10174 Texas, USA
 Aliquot Size: Single grain

Grain	Palaeodose (Gy)	error
1	0.066	1.029
2	3.861	1.348
3	0.203	0.659
4	27.705	5.578
5	26.250	2.057
6	5.133	0.000
7	0.684	0.719
8	0.826	0.826
9	2.361	0.704
10	2.543	1.236
11	0.735	0.380
12	1.429	0.522
13	31.484	3.673
14	0.000	0.877
15	27.304	1.439
16	0.633	0.182
17	0.654	0.182
18	1.571	0.400
19	-0.132	0.578
20	0.851	1.338
21	-0.066	0.750
22	1.302	0.400
23	1.069	0.811
24	20.768	1.804
25	1.606	0.628
26	1.373	0.370
27	-0.182	0.542
28	2.255	1.079
29	1.733	0.400
30	6.536	1.525
31	63.729	4.606

Field Code: C2-2
Lab Code: Shfd10174
Aliquot Size: Single grain

Site: Longview Site
Texas, USA

	De (Gy)	error
Minimum	0.00	0.88
Maximum	63.73	4.61
N	31	

De Distribution	All Data	Minus Outliers
Skewness	0.00	-0.01
Kurtosis	7.55	3.40
Median	1.43	1.07
Sorting	1.31	0.17

Unweighted		
	All Data	Minus Outliers
Mean (Gy)	7.57	1.50
SD	14.18	1.62
SE	2.55	0.29
N	31	25

Central Age Model		
	All Data	Minus Outliers
Mean (Gy)	3.42	1.71
SD	1.00	0.30
OD (all data)	139.20%	61.90%
N	31	25

Weighted		
	All Data	Minus Outliers
Mean (Gy)	5.13	5.13
SD	0.06	1.62
SE	0.00	0.32
N	31	25

Probability		
	All Data	Minus Outliers
Mean (Gy)	1.39	1.10
SD	2.88	0.89
SE	0.52	0.18
N	31	25

Finite Mixture Modelling				
Component	Mean De (Gy)	Error	Proportion	
1	1.31	0.14	63%	
2	5.11	0.67	14%	
3	31.06	2.27	24%

Field Code: C2-3 Site: Longview Site
 Lab Code: Shfd10175 Texas, USA
 Aliquot Size: Single grain

Grain	Palaeodose (Gy)	error
1	239.50	27.92
2	201.14	11.53
3	50.09	8.30
4	195.05	20.88
5	113.49	21.82
6	163.69	10.55
7	148.90	31.58
8	100.05	16.62
9	46.04	9.31
10	9.38	1.95
11	19.95	1.88
12	1.63	1.19
13	111.45	12.23
14	58.21	9.11
15	86.77	8.83
16	59.09	10.33
17	46.67	8.78
18	40.48	4.54
19	51.00	6.33
20	116.55	14.72
21	28.69	2.01
22	131.41	23.84
23	30.45	4.80
24	214.24	42.09
25	181.16	38.17
26	22.90	5.92
27	146.81	22.34
28	328.50	51.31
29	161.47	23.24
30	164.27	27.58
31	2.37	2.19
32	242.97	23.15
33	225.52	43.21
34	123.78	25.09

Field Code: C2-3
Lab Code: Shfd10175
Aliquot Size: Single grain

Site: Longview Site
Texas, USA

	De (Gy)	error
Minimum	1.63	1.19
Maximum	328.50	51.31
N	34	

De Distribution	All Data	Minus Outliers
Skewness	0.67	0.21
Kurtosis	-0.32	-1.17
Median	112.47	111.45
Sorting	0.69	0.66

Unweighted		
	All Data	Minus Outliers
Mean (Gy)	113.64	107.13
SD	82.87	74.80
SE	14.21	12.83
N	34	33

Central Age Model		
	All Data	Minus Outliers
Mean (Gy)	78.45	75.19
SD	13.82	13.21
OD (all data)	100.32%	98.44%
N	34	33

Weighted		
	All Data	Minus Outliers
Mean (Gy)	17.28	17.22
SD	27.99	74.80
SE	4.80	13.02
N	34	33

Probability		
	All Data	Minus Outliers
Mean (Gy)	82.41	81.23
SD	68.54	67.41
SE	11.76	11.73
N	34	33

Finite Mixture Modelling				
Component	Mean De (Gy)	Error	Proportion	
1	1.84	1.16	5%	
2	9.12	2.43	4%	
3	25.27	2.86	11%	
4	48.65	4.62	21%	
5	116.56	14.31	24%	
6	199.53	16.78	35%

Field Code: C4-1 Site: Longview Site
 Lab Code: Shfd10176 Texas, USA
 Aliquot Size: Single grain

Grain	Palaeodose (Gy)	error
1	0.785	0.152
2	0.248	1.155
3	1.839	0.659
4	10.468	1.044
5	6.237	1.662
6	1.084	0.421
7	1.120	0.345
8	-0.167	1.322
9	0.284	0.578
10	0.000	0.000
11	0.218	0.370
12	1.403	0.410
13	0.735	0.704
14	1.890	0.785
15	1.707	0.395
16	2.878	0.826
17	1.282	0.421
18	2.017	0.932
19	1.971	0.198
20	3.298	0.122
21	1.414	0.294
22	0.491	0.719
23	0.400	0.223
24	1.181	0.578
25	-0.466	0.902
26	2.695	0.350
27	1.718	1.383
28	2.397	0.593
29	9.353	0.486
30	1.013	0.436
31	1.373	0.309
32	0.689	1.424
33	-1.105	0.730
34	-0.020	0.542
35	-0.243	0.279
36	0.593	0.537
37	-0.466	0.654

Field Code: C4-1
Lab Code: Shfd10176
Aliquot Size: Single grain

Site: Longview Site
Texas, USA

	De (Gy)	error
Minimum	0.00	0.00
Maximum	10.47	1.04
N	37	

De Distribution	All Data	Minus Outliers
Skewness	9.03	0.06
Kurtosis	7.52	-0.39
Median	1.12	1.05
Sorting	0.98	0.53

Unweighted		
	All Data	Minus Outliers
Mean (Gy)	1.70	1.08
SD	2.34	0.92
SE	0.38	0.15
N	37	34

Central Age Model		
	All Data	Minus Outliers
Mean (Gy)	1.24	0.98
SD	0.38	0.30
OD (all data)	154.07%	144.07%
N	37	34

Weighted		
	All Data	Minus Outliers
Mean (Gy)	0.00	0.00
SD	0.06	0.93
SE	0.00	0.16
N	37	34

Probability		
	All Data	Minus Outliers
Mean (Gy)	0.00	0.00
SD	0.06	0.06
SE	0.01	0.01
N	37	34

Finite Mixture Modelling				
Component	Mean De (Gy)	Error	Proportion	
1	1.28	0.35	64%	
2	2.61	0.65	25%	
3	9.27	1.05	11%

Field Code:	C4-2	Site:	Longview Site
Lab Code:	Shfd10177		Texas, USA
Aliquot Size:	Single grain		
Grain	Palaeodose (Gy)	error	
1	123.779	25.090	
2	115.474	12.621	
3	53.124	8.613	
4	284.802	29.387	
5	141.375	27.005	
6	27.629	15.783	
7	106.942	15.144	
8	191.561	15.281	
9	148.509	35.097	
10	193.856	22.729	
11	91.651	13.989	
12	75.813	10.893	
13	112.135	12.388	
14	145.961	16.720	
15	91.413	5.989	
16	65.228	9.292	
17	66.074	6.881	
18	277.020	30.755	
19	138.092	8.826	
20	201.218	38.223	
21	109.602	17.095	
22	115.474	12.621	
23	53.124	8.613	
24	141.375	27.005	
25	27.629	15.783	
26	106.942	15.144	
27	191.561	15.281	
28	148.509	35.097	
29	193.856	22.729	
30	91.651	13.989	
31	55.982	23.367	
32	2.341	52.551	
33	16.994	62.244	
34	208.731	33.187	
35	139.647	21.386	
36	88.251	11.456	
37	138.477	16.740	
38	136.405	10.316	
39	163.577	14.156	
40	171.730	28.434	
41	62.680	30.294	
42	0.157	0.699	
43	-0.491	0.973	
44	1.743	0.491	
45	0.324	0.461	
46	1.013	1.125	
47	5.928	1.023	
48	3.678	0.000	
49	13.285	1.054	
50	2.163	0.436	
51	1.550	0.279	

Field Code: C4-2
Lab Code: Shfd10177
Aliquot Size: Single grain

Site: Longview Site
Texas, USA

	De (Gy)	error
Minimum	0.00	0.97
Maximum	284.80	29.39
N	51	

De Distribution	All Data	Minus Outliers
Skewness	-2.03	-2.03
Kurtosis	-0.40	-0.67
Median	106.94	99.30
Sorting	0.74	0.71

Unweighted		
	All Data	Minus Outliers
Mean (Gy)	98.94	95.22
SD	74.93	70.78
SE	10.49	9.91
N	51	50

Central Age Model		
	All Data	Minus Outliers
Mean (Gy)	62.73	60.65
SD	13.05	12.75
OD (all data)	140.18%	140.04%
N	51	50

Weighted		
	All Data	Minus Outliers
Mean (Gy)	3.68	3.68
SD	0.06	70.78
SE	0.00	10.01
N	51	50

Probability		
	All Data	Minus Outliers
Mean (Gy)	13.95	13.78
SD	40.65	40.12
SE	5.69	5.67
N	51	50

Finite Mixture Modelling				
Component	Mean De (Gy)	Error	Proportion	
1	1.75	0.03	10%	
2	4.20	0.54	5%	
3	13.88	2.39	4%	
4	127.18	4.30	81%

APPENDIX S

NAGPRA INVENTORY OF TWO INDIVIDUALS RECOVERED FROM 41RB112 - AREA C, ROBERTS COUNTY, TEXAS

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April 2009

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S.1 Introduction

On April 2, 2009, a representative from the archeological consulting firm TRC Environmental Corporation (Austin) delivered two small boxes of fragmentary human remains to the Department of Anthropology at Texas State University-San Marcos for osteological analysis on behalf of their client, the Texas Department of Transportation (TxDOT). The analysis was required under the Native American Graves Protection and Repatriation Act (NAGPRA), and the final report was requested by April 7, 2009. The osteological investigation was conducted by Drs. Kate Spradley and Michelle Hamilton of the Forensic Anthropology Center at Texas State (FACTS).

S.2 Bioarcheological Context

The remains are from a Plains Village archeological site (possible Antelope Creek culture) from the panhandle region of Texas (site designation 41RB112). Archeological information suggests the human remains date to the Late Prehistoric period (approximately 600 B.P.), based on recovery context and associated surrounding occupation sites. The remains are representative of two separate adult individuals:

- Individual 1 was damaged prior to archeological investigation by a road grader in the midst of constructing a fire break. The partial skeletal remains were found in a semi-flexed position, are fragmentary and poorly preserved, and represent less than an estimated 30% of the total skeleton.
- Individual 2 appears to have been a cremation, with the majority of bones displaying evidence of thermal damage. The majority of the remains are calcined and fragmentary, and represent less than an estimated 10% of the total skeleton.

S.3 Results

The fragmentary and incomplete nature of the remains largely precludes osteometric data and measurement collection, although some measurements were possible on Individual 1 (see report). The results of the osteological analysis are as follows, and are further detailed in the appended report.

S.3.1 Individual 1, 41RB112 – TRC Feature 7

S.3.1.1 Introduction

The box labeled Feature 7 contained multiple foil-wrapped bones and Zip-loc type plastic bags. Each foil pouch and plastic bag from the box representing Feature 7 was opened, inspected, and brushed free of adhering soil matrix. Bone taphonomy, including patina and wear present on all human skeletal elements, is typical of an extended earthen burial. The skeletal elements are light brown in color with some root etching and adherence.

S.3.1.2 Minimum Number of Individuals (MNI): One individual

As depicted on the skeletal inventory, no repeated bone elements were recovered from Feature 7. All remains are adult in age and do not present overlapping morphological indicators of varying age ranges. Additionally, all elements that were utilized for sex estimation point toward a single sex represented. Based on archeological recovery records, burial context, and observations of the elements present, the MNI from Feature 7 is determined to likely represent one individual.

S.3.1.3 Sex: Female

Sex was estimated using gross visual and metric techniques. The pelvis is the most effective indicator of sex in the human skeleton, and the fragmentary pelvic morphology visible for Feature 7 includes an ischiopubic ramus and a portion of a pubic symphyseal face that are small and narrow. These characteristics are suggestive of female. Although the long bones exhibit rugose muscle attachment sites, the overall size of these bones (especially the right radius and ulna) is gracile. A fragment of the occipital is present, and the nuchal area of the cranium displays slight muscle markings and no visible external occipital protuberance. The mandible displays a pointed mental eminence. Taken together, these characteristics are all suggestive of female for Individual 1.

S.3.1.4 Age: Older Adult

Skeletal age at death is determined via a detailed

multifactoral approach utilizing macro- and microscopic changes in selected bone structures. Certain bones or bone features are target elements for assessing age and include dental maturation, long bone growth, epiphyseal closure, and articular joint morphology. The age of these skeletal remains was estimated by observing root development, epiphyseal closures, degenerative changes to the skeleton, and morphology of the pubic symphysis. The observable indicators of age are all suggestive of an older adult individual. The remains representing Individual 1 are adult. No unfused epiphyses or epiphyseal lines are present and the single molar recovered has a tooth root that is fully developed. The observable pubic symphyseal fragments exhibit porosity, densification (worn flat), and shows osteoarthritic lipping around the visible face, all suggestive of an older adult. Further observable degenerative changes are apparent on the majority of joint surfaces. The glenoid cavity of the scapula exhibits pitting on the articular surface and slight lipping on the margins of the articular surface. Of the ten individual fragmentary thoracic and lumbar vertebral bodies present, all have evidence of moderate to severe osteoarthritic lipping. Further, a minimum of three wedge fractures (compression fractures) are present on the vertebral bodies, likely resulting from bone loss associated with old age (osteoporosis). Osteoarthritic lipping is also present on the majority of right hand and foot bones.

All of the observed degenerative changes with the observations of the pubic symphysis characterize this individual as an older adult. By recent forensic standards this individual would be considered 55+ years of age, although given the differences in activity patterns and lifeways between prehistoric and modern populations, the age estimation of Individual 1 is given simply as “older adult.”

S.3.1.5 Cultural Affiliation: Native American

Burial context, archeological data, biological indicators, and overall taphonomic appearance all point towards a general prehistoric “Native American” determination with regards to cultural and biological affiliation. Based on the incomplete and fragmentary nature of the remains, further assessment with reference to specific tribal or

population affiliation is not possible. Specific biological indicators of Native American affiliation include the following. One tooth is present, the mandibular right second molar (# 31), and is intact with complete root development, dentine exposure, and moderate calculus build up. Occlusal tooth wear is moderate (Stage 4/5), and the patterning and degree is consistent with prehistoric hunter-gatherer populations (Smith 1984). Due to the fragmentary nature of the remains, only a limited number of postcranial elements were available for measurement (Table S-1). The subtrochanteric portion of the femur has a platymetric index of 74, also consistent with Native American (Gilbert and Gill 1990). The muscle attachment sites on the long bones are rugose and consistent with rigorous habitual activities.

S.3.1.6 Trauma and Pathology

Evidence of antemortem trauma that occurred during Individual 1’s lifetime include injury to the right hand, with damage and atrophy of the distal portion of one proximal phalanx (suggestive of an amputated fingertip), and fusion of one proximal and intermediate phalanx (finger and fingertip) which may be related to the traumatic incident which caused the atrophied phalanx. Evidence of antemortem pathology includes thoracic and lumbar vertebral bodies with evidence of moderate to severe osteoarthritic lipping, and a minimum of 3 wedge fractures (compression fractures) likely resulting from bone loss associated with old age (osteoporosis). All other trauma observed on the remains appears consistent with postmortem damage.

S.3.1.7 Summary

The remains from Feature 7 likely represent one single adult individual. Morphological indicators that can be used to assess sex and age indicate that Individual 1 is an older adult female. No assessments for cultural affiliation beyond “Native American” can be made as a result of the fragmentary and incomplete nature of the remains.

SEX: Female Indeterminate

AGE: Older Adult

STATURE: Indeterminate

Table S-1. Available Metric Data from Individual 1 following Buikstra and Ubelaker (1994) and Urcid (1992)

DESCRIPTION MEASUREMENT IN MM

Scapula glenoid cavity breadth = 24 (left side)
 Scapula glenoid cavity height = 32 (left side)
 Mesosternum length = 95 (left side)
 Sternebra 1 width = 25 (left side)
 Sternebra 3 width = 28 (left side)
 Humerus max diameter midshaft = 21 (left side)
 Humerus min diameter midshaft = 15 (left side)
 Femur subtrochanteric anterior / posterior diameter = 31 (left side)
 Femur subtrochanteric medial / lateral diameter = 23 (left side)
 Femur anterior / posterior diameter at midshaft = 21 (left side)
 Femur medial / lateral diameter at midshaft = 29 (left side)
 Femur maximum vertical diameter of head = 42 (left side)
 Femur maximum horizontal diameter of head = 41 (left side)
 Femur minimum vertical diameter of neck = 27 (left side)
 Tibia anterior / posterior diameter at nutrient foramen = 31 (right side)
 Tibia medial / lateral diameter at nutrient foramen = 19 (right side)
 Tibia circumference at nutrient foramen = 70 (right side)
 Calcaneus maximum length = 77 (right side)
 Calcaneus middle breadth = 43 (right side)

** The osteometrics presented in Table 1 incorporate all the standard osteometric data outlined in Buikstra and Ubelaker (1994). However, the manual compiled by Urcid (1992) provides additional osteometric measurements that are used by the Smithsonian Institution.*

TRAUMA: Antemortem phalangeal trauma
 postmortem thermal damage

CULTURAL AFFILIATION: Prehistoric Native American; specific tribal affiliation undetermined
 Prehistoric Native American; specific tribal affiliation undetermined.

Texas State (FACTS) identification number that was placed inside each bag of shell, charcoal, and bone after analysis. Table S-2 contains a description of the contents of each bag for Feature 22.

S.3.2.2 Minimum Number of Individuals (MNI): One individual

S.3.2 Individual 2, 41RB112 – TRC Feature 22

S.3.2.1 Introduction

The box labeled Feature 22 contains 27 plastic Zip-loc type plastic bags containing material recovered from within the archeological feature. Of these 27 bags, 1 bag contains an identification card for the entire box, 1 bag contains shell, 2 bags contain charcoal fragments, and 23 bags contain bone and associated soil matrix. Because each bag did not contain a unique identification number, each bag was assigned a Forensic Anthropology Center at

Based on the inventory (Table S-2), no repeated bone elements were recovered from Feature 22. Due to the fragmentary nature of the remains, collection of osteometric data was not possible. Further, all recovered remains are adult and do not present morphological indicators of varying age ranges. The majority of remains exhibit thermal damage with the exception of the hand and foot bones and patella. Based on observations of the elements present, the MNI from Feature 22 is estimated to be one individual.

S.3.2.3 Age: Adult

The incomplete, burned, non-diagnostic, and fragmentary nature of the remains makes age assessment difficult. However, the remains are all adult based on overall size and morphology, and lack of unfused epiphyses or epiphyseal lines.

S.3.2.4 Sex: Indeterminate

The incomplete, burned, non-diagnostic, and fragmentary nature of the remains makes sex assessment difficult. There are no observable indicators of sex on any of the remains.

Table S-2. Description of Feature 22 Bag Contents.

BAG Number, Contents, and Conditions

- 001 Unsided human femur (shaft fragment), associated unidentifiable bone fragments, femoral shaft exhibits thermal damage associated fragments all exhibit thermal damage
- 002 Right human patella, no thermal damage
- 003 Right human scapula (glenoid cavity portion), thermal damage
- 004 Unsided human ulna (shaft fragment), thermal damage
- 005 Left human scapula (spine fragment), associated unidentifiable bone fragments, thermal damage to all elements
- 006 Unsided human ulna (shaft fragment), associated unidentifiable bone fragments, thermal damage to all elements
- 007 Right human 3rd metacarpal (proximal portion), associated unidentifiable bone fragments, metacarpal does not exhibit thermal damage, associated fragments all exhibit thermal damage
- 008 Unsided, unidentifiable bone fragments, thermal damage
- 009 Right human 2nd metacarpal, no thermal damage
- 010 Unsided, unidentifiable bone fragments, thermal damage
- 011 Left human femur (proximal portion), thermal damage
- 012 Left (?) human femur (shaft fragment), thermal damage
- 013 Right human tibia (shaft fragment), thermal damage
- 014 Left human rib, thermal damage
- 015 Unsided human navicular fragment, unsided human rib fragment, associated unidentifiable bone fragments, navicular does not exhibit thermal damage, rib and all fragments exhibit thermal damage
- 016 Unsided human femur (shaft portion), associated unidentifiable bone fragments, thermal damage to all elements
- 017 Unsided human fibula (shaft fragments), associated unidentified bone fragment, thermal damage to all elements
- 018 Unsided human ulna (shaft fragment), thermal damage
- 019 Non-human femur fragments No thermal damage
- 020 Unsided human rib fragments Thermal damage
- 021 Right human 2nd cuneiform, associated unidentifiable bone fragments, cuneiform does not exhibit thermal damage, all other fragments exhibit thermal damage
- 022 Bivalve shell, no thermal damage
- 023 Charcoal fragments, N/A
- 024 Charcoal fragments, N/A
- 025 Human interproximal foot phalanx, associated unidentifiable bone fragments
Phalanx does not exhibit thermal damage, associated fragments exhibit thermal damage
- 026 Non-human vertebra No thermal damage,
- 027 Site label ID tag N/A

S.3.2.5 Affiliation: Native American

Burial context, archeological data, biological indicators, and overall taphonomic appearance all point towards a general prehistoric “Native American” determination with regards to cultural and biological affiliation. Based on the incomplete, burned, and fragmentary nature of the remains, further assessment with reference to specific tribal or population affiliation is not possible.

S.3.2.6 Taphonomy

The observable thermal damage on the bone fragments indicates that fire exposure occurred postmortem (Symes et al. 2008).

S.3.2.7 Summary

The remains from Feature 22 likely represent one single adult individual. There are no morphological indicators that can be used to assess sex, age, or cultural affiliation beyond “Native American”. The pattern of thermal damage present on the remains indicates postmortem exposure to fire.

Sincerely,

April 7, 2009

M. Kate Spradley, PhD Date

Assistant Professor

Director, Forensic Anthropology Research Facility

Texas State University-San Marcos

April 7, 2009

Michelle D. Hamilton, PhD Date

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Addendum to the NAGPRA Inventory of Two Individuals Recovered from 41RB112-Area C, Roberts County, Texas (2009) by Drs. Kate Spradley and Michelle Hamilton

By Daniel J. Wescott, Ph.D.

Date: December 6, 2011

In 2009, Drs. Kate Spradley and Michelle Hamilton of the Forensic Anthropology Center at Texas State (FACTS) conducted an osteological analysis of two burial features from the Long View site (41RB112) in Roberts County, Texas for TRC Environmental Corporation (TRC). Spradley and Hamilton (2009) concluded that the partial skeleton from Feature 7 represented a single older adult female. The remains from Feature 22, on the other hand, most likely represented a single adult, but the bones were too fragmentary to assess age, sex, or cultural affiliation.

On November 15, 2011, TRC shipped additional bones (seven small bags containing very small bone and teeth fragments) from the Long View site (41RB112) to FACTS for analysis. The new bones

were discovered in association with Feature 18 and possibly Feature 7. The purpose of this addendum is to inventory the additional bones and determine if they could be associated with the remains previously analyzed. The osteological investigation was conducted by Dr. Daniel Wescott of FACTS. An inventory of the content of the seven bags presented for analysis is provided in Table S-3. Additional information and discussion of the remains follows.

Feature 18

338-002-2: Human teeth

1. Human, left, deciduous, maxillary canine. Root development is complete with apical closure but no evidence of crown attrition.
2. Human maxillary premolar crown. The crown formation is nearly complete. This tooth would not have erupted at the time of death.
3. Human premolar crown. The crown formation is greater than 50%. This tooth would not have erupted at the time of death.
4. Also present are six root and enamel fragments probably representing a deciduous molar and an unerupted permanent incisor crown.

338-02: bone fragments

1. Four small nonhuman bone fragments with discoloration due to thermal alteration. The

fragments include 1 articular surface and 3 shaft fragments.

2. Three small, undiagnostic trabecular bone fragments. Species is unknown.

Summary

Feature 18 likely represents a single human child and associated heat altered animal bone fragments. Assuming the teeth described above are from the same individual, then they represent and approximately 2 to 5 year old child. Apical closure of the deciduous canine occurs at approximately 3 years of age. Crown development of the premolars begins as early as 2 years of age with complete crown formation and early root development by approximately 5 years (Ubelaker 1989).

Possible Feature 7

400-002-1: The right 1st metacarpal fragment of an adult human.

482-002: Contains an undiagnostic trabecular bone fragment and a possible large animal vertebral articular facet.

162-002: Eleven very small possible cranial fragments.

163-002: Three small cranial fragments.

1.30 mm long x 25 mm wide x 5.5 mm thick

2.18.8 mm long x 18.8 wide x 4.0 thick

3.14.3 mm long, 12.2 mm wide, and 4.4 mm thick

Table S-3. Inventory of Additional Bags of Bone from 41RB112.

Feature #	PNUM	Bag Inventory
18	338-002	1 left deciduous canine, 1 left premolar crown, 1 unsided premolar crown, six enamel and root fragments of a deciduous molar and permanent incisor crown
18	338-002-2	4 small nonhuman, heat altered bone fragments, 3 undiagnostic trabecular bone fragments
7?	400-002-1	1 Right first metacarpal distal fragment
7?	482-002	1 possible large animal vertebral articular facet, 1 undiagnostic trabecular bone fragment
7?	162-002	11 very small cranial fragments
7?	163-002	3 small human cranial fragments
7?	164-002-2	1 human tibia shaft fragment, 2 human undiagnostic long bone fragments, 9 small human cranial fragments, and numerous small undiagnostic bone fragments

Table S-4. Dental measurements for 338-002-2

Tooth	Mesiodistal dia.¹	Faciolingual dia.²	Crown height³	Root length⁴
Left deciduous canine	6.8	5.9	5.6	13.4
Left 1 st premolar	7.2	9.8	6.4	N/A
Premolar	6.5	7.7	5.3	N/A

¹mesiodistal diameter: maximum width of the crown in the mesiodistal plane

²faciolingual (buccolingual) diameter: maximum diameter of the crown perpendicular to the mesiodistal plane

³crown height: distance from the occlusal surface to the cemento-enamel junction (CEJ)

⁴root length: distance from the CEJ to the apex of the root

164-002-2: This bag contains a human tibia shaft fragment (42.2 mm long and 20.9 mm wide), two undiagnostic long bone fragments, nine very small human cranial fragments, and 21 very small undiagnostic bone fragments.

Summary

The bones from Feature 7 primarily represent the cranium, right thumb, and a tibia midshaft. Previous analysis of skeletal remains from Feature 7 indicates that an older adult female was buried in this location (Spradley and Hamilton 2009). While the remains analyzed are not inconsistent with an adult female, at least one of the bones from the additional bones is not from this individual. The inventory by Spradley and Hamilton (2009) indicates that most of the cranium was missing, so the additional cranial fragments could be from the same older adult female. However, the right first metacarpal was present for the older individual. Therefore, the presence of a right first metacarpal in the new material represents a duplication of elements and suggests that bones of at least two individuals are represented in Feature 7.

Conclusions

Bone and teeth fragments from Feature 18 and possibly Feature 7 of 41RB112 were presented for examination. The remains of Feature 18, assuming they belong to the same individual, consists of deciduous and developing permanent teeth of an approximately two to five year old child. Additional bone fragments from Feature 18 are most likely nonhuman. The bones from Feature 7 include primarily cranial, hand, and leg bones. The presence of the distal end of the first metacarpal indicates

a duplication of this element from previously analyzed remains suggesting the presence of at least two individuals.

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