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Phase II Investigations at Prehistoric and Rock Art Sites, Justiceburg Reservoir, Garza and Kent Counties, Texas Volume II

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Phase II Investigations at Prehistoric and Rock Art Sites, Justiceburg Reservoir, Garza and Kent Counties, Texas Volume II

Authors

Douglas K. Boyd, James T. Abbott, William A. Bryan, Colin M. Garvey, Steve A. Tomka, and Ross C. Fields

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**PHASE II INVESTIGATIONS AT PREHISTORIC
AND ROCK ART SITES,
JUSTICEBURG RESERVOIR,
GARZA AND KENT COUNTIES, TEXAS**

VOLUME II

by

Douglas K. Boyd

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and

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**REPORTS OF INVESTIGATIONS, NUMBER 71
TEXAS ANTIQUITIES COMMITTEE PERMIT NUMBER 712**

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VOLUME II

by

Douglas K. Boyd
James T. Abbott
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Steve A. Tomka
and
Ross C. Fields

with Contributions by

Linda Scott Cummings
Charles D. Frederick
John G. Jones
Michael L. Marchbanks
J. Michael Quigg
Steve W. Tweedy
and
Richard W. Yerkes

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REPORTS OF INVESTIGATIONS NO. 71

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Lubbock, Texas

by

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Consulting Archeologists
Austin, Texas

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TEXAS ANTIQUITIES COMMITTEE PERMIT NO. 712

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- CHAPTER 3: Objectives and Methods
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Series Technical Editor: Linda Nance Foster

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APPENDIX A: Geomorphic Backhoe Trench Descriptions

James T. Abbott

INTRODUCTION

This appendix describes the stratigraphic and pedogenic characteristics of each trench excavated during subsurface geomorphic reconnaissance conducted as part of the testing phase at Justiceburg Reservoir. Seventy-seven trenches were excavated during the course of the project. The overall results and interpretations of the geomorphic phase of the investigation are presented in Chapter 4.

The data presented in this appendix are based on field descriptions of the sediment columns exposed by the trenches. The neutral term "zone" was adopted to allow both stratigraphic and pedogenic variation in sediment columns to be described under the same nomenclature. For each zone, the depth, thickness, texture, structure, consistence, reactivity with dilute HCl, color, and nature of the contact with the next lower unit were noted. All depths were recorded relative to the present ground surface. Texture was estimated according to the guidelines presented by Birkeland (1984). Structure, consistence, and boundary determinations follow Olson (1976) and the Soil Survey Staff (1951). Dilute HCl was used to determine reactivity and thus suggest relative carbonate content. Color was recorded using a Munsell soil color chart and denotes dry color except where noted.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
BACKHOE TRENCH 1		
1	0-7	Fine sand; massive; loose; reddish brown (5YR 4/4); strongly calcareous; gradual boundary; numerous grass roots.
2	7-50	Fine sand; massive; soft; reddish brown (5YR 4/4); strongly calcareous; clear boundary; numerous grass roots.
3	50-98	Fine sandy loam to silty loam; very weak coarse subangular blocky; soft to slightly hard; reddish brown (5YR 4/4); strongly calcareous; clear boundary; contains abundant Ca and Na precipitate filaments on ped faces.
4	98-105	Fine sandy loam to loam; moderate medium subangular blocky; firm; reddish brown (5YR 4/3); strongly calcareous; clear boundary; contains abundant Ca and Na precipitate filaments on ped faces.
5	105-247	Silty loam grading to loamy fine sand with depth; moderate to weak subangular blocky; reddish brown (5YR 5/4); strongly calcareous; clear boundary; contains abundant Ca and Na precipitate filaments on ped faces.
6	247-260	Gravelly coarse sand; massive to weakly crossbedded; very friable; reddish brown (5YR 5/4); strongly calcareous; contains well-rounded small siliceous pebbles.
Comments: This trench consists of approximately 1 m of eolian sand overlying Double Mountain Fork alluvium. Minor amounts of debitage and burned and abraded sandstone were recovered from the upper 0.5 m of the eolian deposits.		
BACKHOE TRENCH 2		
1	0-12	Fine sand; massive; loose; strong brown (7.5YR 4/6); moderately calcareous; gradual boundary; numerous grass roots.
2	12-71	Fine sand; massive to very weakly crossbedded; soft; strong brown (7.5YR 4/6); moderately calcareous; gradual boundary; numerous grass roots.
3	71-157	Fine sand; massive; soft; strong brown (7.5YR 4/6); strongly calcareous; clear to gradual boundary; contains some whitening due to Ca and Na precipitation, but few well-developed filaments exist on ped faces.
4	157-177	Loamy fine sand; massive; soft to slightly hard; reddish brown (5YR 4/4); strongly calcareous; gradual to diffuse boundary; suggestion of slight organic enrichment.

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
5	177-263	Silty loam grading to loamy fine sand with depth; weak sub-angular blocky; reddish brown (5YR 5/4); strongly calcareous; clear boundary; contains abundant Ca and Na precipitate filaments on ped faces; contains dispersed small siliceous pebbles.
6	263-280	Gravelly medium to coarse sand; massive; loose; reddish brown (5YR 5/4); strongly calcareous; contains well-rounded small siliceous pebbles.
Comments: This trench consists of approximately 1.6 m of eolian sand overlying Double Mountain Fork alluvium. No artifacts were recovered.		
BACKHOE TRENCH 3		
1	0-257	Fine sand; massive; loose to soft; strong brown (7.5YR 4/6); moderately calcareous; clear boundary; numerous grass roots in upper 2 m.
2	257-400	Loamy fine sand to sandy loam; massive to weak subangular blocky; yellowish red (5YR 4/6); strongly calcareous; contains abundant Ca and Na precipitate filaments on ped faces in upper unit that decrease dramatically with depth.
Comments: This trench consists of approximately 2.6 m of eolian sand overlying Double Mountain Fork alluvium. Channel sediments were not reached. No artifacts were recovered. Trench was not entered due to instability.		
BACKHOE TRENCH 4		
1	0-41	Fine sand; massive; loose; brown (7.5YR 4/4); strongly calcareous; clear boundary; numerous grass roots; weak organic enrichment.
2	41-90	Fine sand; massive; loose; brown (7.5YR 5/4); strongly calcareous; abrupt gently dipping boundary; occasional grass roots.
3	90-370	Loamy fine sand; massive to very weak subangular blocky; soft; yellowish red (5YR 4/6); strongly calcareous; diffuse boundary; contains abundant Ca and Na precipitate filaments on ped faces that decrease with depth.
4	370-390	Silty loam to silty fine sand; weak to moderate coarse sub-angular blocky; yellowish red (5YR 4/6); strongly calcareous; gradual boundary; contains infrequent Ca and Na precipitate filaments on ped faces.

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
5	390-400	Gravelly silty loam; massive; soft; yellowish red (5YR 4/6); strongly calcareous; contains well-rounded small siliceous pebbles. Comments: This trench consists of approximately 1 m of eolian sand overlying Double Mountain Fork alluvium. Burned sandstone, mussel shells, and lithic debitage were recovered from multiple levels at 1.3-1.8 m. No surfaces were discernible in association with fire-cracked rock features, suggesting occupation of a rapidly aggrading floodplain.
BACKHOE TRENCH 5		
1	0-96	Fine sand; massive; loose; light brown (7.5YR 6/4); strongly calcareous; clear to abrupt gently dipping boundary; numerous grass roots; weak organic enrichment in upper 20 cm.
2	96-250	Fine sand; massive; loose; brown (7.5YR 5/4); strongly calcareous. Comments: This trench contains eolian sands of two different ages separated by a truncation surface. The trench proved highly unstable below 2.5 m and excavation was discontinued. No artifacts were recovered.
BACKHOE TRENCH 6		
1	0-20	Fine sand to gravelly fine sand; massive; soft; strong brown (7.5YR 4/6); strongly calcareous; gradual boundary; eolian sand reworked by slopewash.
2	20-100	Gravelly loamy sand; massive; loose to soft; brown (7.5YR 4/4); strongly calcareous; clear boundary; contains infrequent Ca and Na precipitate filaments on ped faces; mixed overbank fines and slopewash.
3	100-157	Coarse sandy gravel; crossbedded; loose to soft; reddish brown (5YR 4/4); strongly calcareous; crossbedded channel gravels to 5 cm diameter resting on sandstone bedrock.
BACKHOE TRENCH 7		
1	0-70	Fine sand to loamy fine sand; massive; soft; strong brown (7.5YR 4/6); strongly calcareous; abrupt boundary; underlain by intact sandstone. Comments: Overbank alluvium with a little siliceous and sandstone gravel incorporated by sheetwash.

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
BACKHOE TRENCH 8		
1	0-12	Fine sand to loamy fine sand; massive; soft; brown (7.5YR 4/4); strongly calcareous; clear to gradual boundary; abundant grass roots.
2	12-84	Loamy fine sand to sandy loam; massive; soft to slightly hard; brown (7.5YR 5/4); strongly calcareous; gradual boundary; common filamental Ca and Na precipitate; occasional dispersed small siliceous gravels; occasional grass roots.
3	84-108	Sandy loam; weak medium subangular blocky; slightly hard to hard; yellowish red (5YR 4/6); strongly calcareous; clear to abrupt erosional boundary with lag gravels; contains abundant Ca and Na precipitate filaments on ped faces and few small CaCO ₃ nodules.
4	108-198	Sandy clay loam to sandy clay; strong medium angular blocky; very hard; reddish brown (5YR 4/4); very strongly calcareous; diffuse boundary; contains abundant nodular CaCO ₃ to 2 cm diameter.
5	198-208	Sandy to silty clay loam; medium subangular blocky; hard; yellowish red (5YR 4/6); strongly calcareous.
		Comments: Holocene alluvium overlying a strongly developed, truncated soil of Pleistocene age.
BACKHOE TRENCH 9		
1	0-15	Fine sand; massive; loose to soft; strong brown (7.5YR 4/6); strongly calcareous; gradual boundary; abundant grass roots.
2	15-78	Sandy loam; massive; soft; reddish brown (5YR 4/4); strongly calcareous; clear boundary.
3	78-108	Clay loam to sandy clay loam; strong small to medium angular blocky; hard to very hard; reddish brown (2.5YR 4/4); very strongly calcareous; contains abundant nodular CaCO ₃ to 2 cm diameter.
		Comments: Holocene alluvium overlying a strongly developed, truncated soil of Pleistocene age. A fragment of historic window glass was recovered from the surficial horizon.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
BACKHOE TRENCH 10		
1	0-15	Fine sandy loam to loamy fine sand; massive; soft; strong brown (7.5YR 4/6); strongly calcareous; gradual boundary; abundant grass roots; contains abundant Ca and Na precipitate filaments on ped faces.
2	15-60	Sandy clay loam; strong medium subangular blocky; hard to very hard; yellowish red (5YR 4/6); strongly calcareous; clear boundary; contains abundant nodular CaCO ₃ to 2 cm in diameter; contains siliceous and sandstone gravels dispersed in the matrix and in thin subhorizontal stringers.
3	60-118	Coarse sandy gravel; massive to low-angle crossbedded; loose to weakly cemented; dark reddish brown (5YR 3/3); strongly calcareous; contains low-angle crossbedded siliceous and sandstone gravels and medium to coarse sand.
BACKHOE TRENCH 11		
1	0-19	Loamy fine sand; massive; very soft; reddish brown (5YR 4/4); strongly calcareous; clear to abrupt boundary; numerous grass roots; weak organic enrichment.
2	19-210	Gravelly sandy loam; very weak subangular blocky; soft; dark reddish brown (5YR 3/4); strongly calcareous; diffuse boundary; contains siliceous and sandstone gravels.
3	210-315	Silty loam to fine sandy loam; massive; soft; dark reddish brown (5YR 3/4); strongly calcareous; gradual boundary; fines with depth.
4	315-440	Fine sandy loam to silty loam; massive; soft; dark reddish brown (5YR 3/4); strongly calcareous.
		Comments: Trench not entered below 3 m.
BACKHOE TRENCH 12		
1	0-17	Fine sand to loamy fine sand; massive; friable; dark brown (7.5YR 3/4); strongly calcareous; clear boundary; numerous grass roots; weak organic enrichment.
2	17-131	Loamy fine sand to gravelly loamy fine sand; massive; soft; yellowish red (5YR 4/6); strongly calcareous; gradual to diffuse boundary; occasional grass roots.

APPENDIX A: GEOMORPHIC BACKHOE TRENCH DESCRIPTIONS

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
3	131-174	Gravelly loamy fine sand; massive; soft; yellowish red (5YR 4/6); strongly calcareous; gradual boundary; contains siliceous and sandstone gravels.
4	174-211	Gravelly medium sand; massive; soft; yellowish red (5YR 4/6); strongly calcareous; gradual boundary; gravels occur suspended in matrix and in gravel stringers.
5	211-228	Gravelly coarse sand with loamy clay drapes; crossbedded; loose; reddish brown (5YR 5/4); strongly calcareous.
Comments: Cultural materials recovered include burned and abraded sandstone.		
BACKHOE TRENCH 13		
1	0-20	Fine sand to loamy fine sand; massive; friable; brown (7.5YR 4/4 moist); strongly calcareous; clear boundary; numerous grass roots; weak organic enrichment.
2	20-64	Loamy fine sand to silty fine sand; massive; soft to slightly hard; reddish brown (5YR 4/4); strongly calcareous; gradual to diffuse boundary; occasional grass roots; contains very few dispersed small siliceous pebbles.
3	64-160	Loamy fine sand; massive; soft; yellowish red (5YR 4/6); strongly calcareous; gradual boundary; contains some small dispersed siliceous and sandstone gravels.
4	160-221	Coarse sand; crossbedded; loose; light brown (7.5YR 6/4); strongly calcareous; clear to abrupt boundary; low-angle tabular crossbedding.
5	221-240	Fine sandy silt; massive; soft; reddish brown (5YR 5/4); strongly calcareous; contains common to abundant Ca and Na precipitate filaments.
BACKHOE TRENCH 14		
1	0-19	Loamy fine sand; massive; friable; dark brown (7.5YR 3/4 moist); strongly calcareous; clear boundary; numerous grass roots; weak organic enrichment.
2	19-41	Fine sandy loam; massive; soft to slightly hard; yellowish red (5YR 4/6); strongly calcareous; gradual boundary; occasional grass roots.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
3	41-62	Gravelly sandy loam; massive; soft; yellowish red (5YR 4/6); strongly calcareous; clear to gradual boundary; contains siliceous and sandstone gravels.
4	62-83	Sandy loam to gravelly sandy loam; massive to weak tabular bedded; soft to slightly hard; yellowish red (5YR 4/6); strongly calcareous; clear boundary; fines upward; common Ca and Na precipitate; matrix-supported small siliceous gravels.
5	83-92	Sandy loam to gravelly sandy loam; massive to weak tabular bedded; soft to slightly hard; yellowish red (5YR 4/6); strongly calcareous; clear boundary; fines upward; common Ca and Na precipitate; matrix-supported small siliceous gravels.
6	92-132	Sandy loam to silty loam; massive; soft to slightly hard; yellowish red (5YR 4/6); strongly calcareous; gradual boundary; common Ca and Na precipitate filaments; compaction decreases with depth.
7	132-190	Fine sandy loam; massive; soft to slightly hard; yellowish red (5YR 4/6); strongly calcareous; diffuse boundary; common Ca and Na precipitate filaments.
8	190-325	Sandy loam; massive; soft to slightly hard; yellowish red (5YR 4/6); strongly calcareous; clear boundary; contains horizontal gravel lenses.
9	325-400	Medium to coarse sand; massive to weakly crossbedded; loose; brown (7.5YR 5/4); strongly calcareous.
BACKHOE TRENCH 15		
1	0-3	Fine sand; massive; loose; strong brown (7.5YR 4/6); strongly calcareous; clear boundary; numerous grass roots; weak organic enrichment.
2	3-20	Loamy fine sand; massive; friable; dark brown (7.5YR 3/4 moist); strongly calcareous; clear boundary; occasional grass roots; organic enrichment.
3	20-52	Loamy fine sand; massive; soft; yellowish red (5YR 4/6); strongly calcareous; gradual boundary; slight organic enrichment.
4	52-220	Loamy fine sand to fine sand; massive; soft to very soft; reddish brown (5YR 5/5); strongly calcareous; gradual boundary.

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
5	220-290	Fine sand; massive; loose to very soft; light brown (7.5YR 6/4); strongly calcareous. Comments: Cultural materials recovered include burned sandstone and a ceramic sherd.
BACKHOE TRENCH 16		
1	0-19	Fine sand to loamy fine sand; massive; friable; strong brown (7.5YR 4/6); strongly calcareous; clear boundary; weak organic enrichment.
2	19-50	Sandy loam; massive; soft to slightly hard; brown (7.5YR 4/4); strongly calcareous; gradual to diffuse boundary; occasional small siliceous gravels; some organic enrichment.
3	50-131	Sandy loam; massive; soft to slightly hard; brown (7.5YR 4/5); strongly calcareous; clear to gradual boundary; few Ca or Na precipitate filaments; few to common small dispersed siliceous and sandstone gravels.
4	131-290	Silty loam to fine sandy silt; massive; friable; yellowish red (5YR 4/6); strongly calcareous; gradual boundary.
5	290-450	Laminated medium to fine sands and silts with occasional clay drapes; crossbedded; not sticky (sands and silts) to sticky (clays); yellowish red (5YR 4/6 wet); strongly calcareous. Comments: A lenticular ashy stain, probably a hearth, was observed in the north wall at 63-66 cm. Cultural materials recovered include burned sandstone. Trench not entered below 3 m.
BACKHOE TRENCH 17		
1	0-255	Gravelly fine sand to fine sandy loam; massive; soft; yellowish red (5YR 4/6); strongly calcareous; gradual boundary; contains siliceous and sandstone gravels dispersed in the matrix and in gravel stringers that dip gently downslope.
2	255-435	Silty fine sand to fine sandy loam; massive; friable; reddish brown (5YR 4/4); strongly calcareous; few dispersed siliceous gravels. Comments: Possible cultural materials recovered include bone and burned sandstone. Trench not entered below 3 m.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
BACKHOE TRENCH 18		
1	0-16	Fine sand; massive; friable; strong brown (7.5YR 4/6); strongly calcareous; clear boundary.
2	16-156	Gravelly fine sand; massive; soft; strong brown (7.5YR 4/6); strongly calcareous; clear boundary; contains siliceous and sandstone gravels; contact with underlying saprolitic sandstone bedrock is marked by hard sandstone slabs to 50 cm in diameter.
Comments: Cultural materials recovered include thermally fractured quartzite.		
BACKHOE TRENCH 19		
1	0-27	Loamy fine sand; massive; friable; brown (7.5YR 4/4); strongly calcareous; clear boundary; abundant grass roots.
2	27-86	Gravelly fine sand to gravelly sandy loam; massive; soft; reddish brown (5YR 5/4); strongly calcareous; clear boundary; contains siliceous and sandstone gravels.
3	86-168	Coarse sandy gravel; massive to weak tabular bedded; loose; reddish brown (5YR 4/4); strongly calcareous; abrupt boundary; channel gravels to 5 cm in diameter resting on sandstone bedrock.
BACKHOE TRENCH 20		
1	0-25	Fine sand to loamy fine sand; massive; friable; brown (7.5YR 4/4); strongly calcareous; clear boundary; weak organic enrichment; common grass roots.
2	25-98	Gravelly loamy sand; massive; soft; yellowish brown (10YR 5/4); strongly calcareous; clear to gradual boundary; few Ca or Na precipitate filaments; common small siliceous and sandstone gravels dispersed in matrix and in thin subhorizontal stringers.
3	98-150	Silty loam to fine sandy loam; massive; soft to slightly hard; brown (7.5YR 4/4); strongly calcareous; gradual boundary; few Ca or Na precipitate filaments; few small siliceous gravels.
4	150-410	Silty to loamy fine sands; massive; friable; reddish brown (5YR 4/6 moist); strongly calcareous.

APPENDIX A: GEOMORPHIC BACKHOE TRENCH DESCRIPTIONS

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
BACKHOE TRENCH 21		
1	0-35	Fine sand; massive; friable; brown (7.5YR 4/4); strongly calcareous; clear boundary; weak organic enrichment; common grass roots.
2	35-140	Gravelly loamy sand to gravelly fine sand; massive; soft; strongly calcareous; clear; common small siliceous and sandstone gravels dispersed in matrix; contains large sandstone slabs below 1 m.
3	140-205	Coarse sandy gravel; massive to weak tabular bedded; soft; reddish brown (5YR 4/4); strongly calcareous; primarily angular and subangular sandstone gravels.
		Comments: Cultural materials recovered include burned sandstone and minor amounts of debitage.
BACKHOE TRENCH 22		
1	0-20	Loamy fine sand; massive; friable; brown (7.5YR 4/4 moist); strongly calcareous; clear boundary; common grass roots.
2	20-78	Loamy fine sand; massive; soft; strong brown (7.5YR 4/6); strongly calcareous; gradual boundary; common filamental Ca and Na precipitate.
3	78-125	Loamy fine sand; massive; soft; brown (7.5YR 4/4); strongly calcareous; gradual boundary; common Ca and Na precipitate filaments on ped faces; organic enrichment.
4	125-250	Fine sand; massive to faint ripple laminated; very soft to loose; strong brown (7.5YR 4/6); strongly calcareous; clear to abrupt boundary.
5	250-435	Fine laminated sands and silty clays; ripple laminated sands with clay drapes; plastic; not sticky; reddish brown (5YR 4/4 moist and wet); strongly calcareous; channel sediments saturated below 4.1 m.
BACKHOE TRENCH 23		
1	0-40	Loamy fine sand; massive; friable; brown (7.5YR 4/4 moist); strongly calcareous; clear boundary; weak organic enrichment; common grass roots; few dispersed siliceous and sandstone gravels.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
2	40-175	Gravelly sandy loam; massive (matrix-supported gravel); soft; strongly calcareous; abrupt; common small siliceous and sandstone gravels dispersed in matrix; underlain by saprolitic sandstone.
		Comments: Possible cultural materials recovered include bone.

BACKHOE TRENCH 24

1	0-12	Loamy fine sand; massive; friable; brown (7.5YR 4/4 moist); strongly calcareous; clear boundary; weak organic enrichment; heavily turbated by chaining of mesquite.
2	12-28	Loamy fine sand; massive; friable; strong brown (7.5YR 4/6); strongly calcareous; gradual boundary; disturbed by vegetation clearing activities.
3	28-84	Loamy fine to medium sand; massive to weakly crossbedded; soft; strong brown (7.5YR 4/6); strongly calcareous; clear to gradual boundary.
4	84-143	Silty loam; massive; friable; yellowish red (5YR 4/6 moist); strongly calcareous; gradual boundary; lenticular ashy stain at upper contact.
5	143-183	Silty loam; massive; friable; reddish brown (5YR 4/4 moist); strongly calcareous; gradual boundary; contains dispersed charcoal flecks.
6	183-350	Silty loam to fine sandy loam; laminated; friable; reddish brown (5YR 4/4 moist); strongly calcareous; clear boundary.
7	350-435	Sandy clay; massive; plastic; not sticky; reddish brown (5YR 4/4 moist to wet); strongly calcareous; saturated below 4 m.

Comments: A lenticular ashy stain was observed in the side wall at 80-84 cm and may represent a shallow basin hearth. Possible cultural materials recovered include bison bone.

BACKHOE TRENCH 25

1	0-25	Silty clay loam; strong medium subangular blocky; hard dry, sticky wet; dark reddish brown (5YR 3/4); strongly calcareous; gradual boundary; moderate organic enrichment; contains common roots.
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APPENDIX A: GEOMORPHIC BACKHOE TRENCH DESCRIPTIONS

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
2	25-40	Silty clay loam; moderate medium subangular blocky; slightly hard to hard; reddish brown (5YR 4/4); strongly calcareous; clear boundary.
3	40-130	Clay loam; strong medium angular blocky; hard to very hard; dark reddish brown (5YR 3/2); strongly calcareous; gradual boundary; common filamental Ca and Na precipitate.
4	130-165	Sandy loam; massive to weak subangular blocky; soft to slightly hard; reddish brown (5YR 4/4); strongly calcareous; gradual boundary; common filamental Ca and Na precipitate.
5	165-220	Fine sandy to silty loam; weak subangular blocky; soft to slightly hard; brown (7.5YR 4/2); strongly calcareous; gradual boundary; abundant filamental Ca and Na precipitate; slight organic enrichment.
6	220-270	Sandy loam; massive; soft; reddish brown (5YR 4/4); strongly calcareous; clear boundary; contains flaggy sandstone fragments and siliceous gravels; contains sparse helicoidal mollusca; abundant filamental Ca and Na precipitate.
7	270-300	Medium sand; massive; soft; reddish brown (5YR 4/4); strongly calcareous.

Comments: Charcoal staining representing a possible cultural feature was observed at 90 cm.

BACKHOE TRENCH 26

1	0-34	Sandy loam to sandy clay loam; strong medium subangular blocky; hard; reddish brown (5YR 4/4); strongly calcareous; clear boundary; weak organic enrichment in upper 20 cm.
2	34-40	Sandy loam; massive to weak subangular blocky; slightly hard to hard; reddish brown (5YR 5/4); strongly calcareous; clear boundary; consists of a lenticular ashy stain at the contact between the overlying and underlying unit.
3	40-180	Fine sandy to silty loam; weak to moderate subangular blocky; hard; reddish brown (5YR 4/4); strongly calcareous; gradual boundary; moderate to abundant filamental Ca and Na precipitate.
4	180-201	Gravelly fine to medium sand; massive; soft to slightly hard; dark reddish brown (5YR 3/4); strongly calcareous; clear boundary.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
5	201-220	Sandy gravel; massive; soft; reddish brown (5YR 4/4); strongly calcareous; clast-supported siliceous gravels and sandstone slabs up to 40 cm in diameter.
Comments: Zone 2 may represent a basin hearth feature.		

BACKHOE TRENCH 27

1	0-33	Sandy loam to sandy clay loam; strong medium subangular blocky; hard; dark reddish brown (5YR 3/4); strongly calcareous; clear boundary; weak organic enrichment.
2	33-90	Gravelly sandy loam to gravelly sandy clay loam; massive to moderate angular blocky; hard; reddish brown (5YR 4/4); strongly calcareous; diffuse boundary; contains discontinuous gravel stringers of mixed siliceous and sandstone gravels; moderate to abundant filamental Ca and Na precipitate.
3	90-145	Gravelly sandy loam to gravelly clay loam; massive to moderate angular blocky; hard to very hard; reddish brown (5YR 4/4); strongly calcareous; clear boundary; contains discontinuous gravel stringers of mixed siliceous and sandstone gravels; few filaments of Ca and Na precipitate.
4	145-235	Gravelly sandy clay loam; moderate angular blocky; very hard; dark reddish brown (matrix 5YR 3/4; ped faces 5YR 3/3); strongly calcareous; clear to gradual boundary; thin argillans on ped faces.
5	235-270	Gravelly sand to gravelly sandy loam; massive to weak blocky; slightly hard; yellowish red (5YR 4/6); strongly calcareous; clear boundary.
6	270-330	Sandy loam to sandy clay loam; massive to weak subangular blocky; hard; reddish brown (5YR 4/4); strongly calcareous.

Comments: Charcoal staining representing a possible cultural feature was observed at 35 cm.

BACKHOE TRENCH 28

1	0-60	Sandy loam; weak subangular blocky; slightly hard; dark reddish brown (5YR 3/4); strongly calcareous; clear boundary; contains few small siliceous pebbles.
2	60-295	Sandy loam; weak subangular blocky; slightly hard to hard; reddish brown (5YR 4/4); strongly calcareous; diffuse boundary, contains siliceous gravels and sandstone flags; moderate filamental Ca and Na precipitate decreases with depth.

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
3	295-380	Sandy loam; massive; friable; strongly calcareous.
		Comments: Artifacts recovered include minor amounts of debitage.

BACKHOE TRENCH 29

1	0-7	Fine sand; single grain structure; loose; yellowish red (5YR 4/6); gradual boundary; strongly calcareous.
2	7-22	Fine sand; massive; soft; yellowish red (5YR 4/6); gradual boundary; strongly calcareous.
3	22-55	Medium to fine sand and sandy loam; massive (turbated); soft to slightly hard; yellowish red (5YR 4/6); clear boundary; strongly calcareous.
4	55-58	Coarse sand; massive; soft; strong brown (7.5YR 5/6); clear boundary; strongly calcareous; discontinuous lenticular deposit.
5	58-65	Medium sand; massive; soft; yellowish red (5YR 4/6); clear boundary; strongly calcareous; discontinuous lenticular deposit.
6	65-75	Medium sand; massive; soft; yellowish red (5YR 4/6); clear boundary; strongly calcareous.
7	75-80	Medium sandy loam; massive; soft to slightly hard; yellowish red (5YR 4/6); clear boundary; strongly calcareous; discontinuous lenticular deposit.
8	80-95	Gravelly coarse sand to sandy gravel; crossbedded; loose; yellowish brown (10YR 5/4); clear to abrupt erosional boundary; strongly calcareous; coarsens upward.
9	95-105	Medium to coarse sand; massive to weakly laminated; soft; yellowish red (5YR 4/6); clear boundary; strongly calcareous.
10	105-115	Sandy loam; massive; soft; yellowish red (5YR 4/6); clear boundary; strongly calcareous; discontinuous lenticular deposit.
11	115-125	Medium to coarse sand; massive; soft; yellowish red (5YR 4/6); clear boundary; strongly calcareous.
12	125-135	Gravelly loam; massive; soft; yellowish brown (10YR 5/4); clear boundary; strongly calcareous.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
13	135-185	Coarse sandy gravel; crossbedded gravels and sands; loose; yellowish brown (10YR 5/4); strongly calcareous.

Comments: Relatively recent fining-upward point bar deposits unmodified by pedogenic processes. Many zones are lenticular trough fills and lenses and do not continue across all of the exposure.

BACKHOE TRENCH 30

1	0-70	Fine sandy loam to silty loam; weak to medium subangular blocky structure; slightly hard; reddish brown (5YR 5/4); clear boundary; strongly calcareous; contains filamental carbonate; dispersed sandstone gravels; extensively bioturbated.
2	70-105	Fine sandy loam to silty loam; medium subangular blocky structure; hard; reddish brown (5YR 5/4); clear boundary; strongly calcareous; contains filamental carbonate; extensively bioturbated.
3	105-150	Fine sandy loam; weak to medium subangular blocky structure; friable; reddish brown (5YR 4/4 moist); clear boundary; strongly calcareous; bioturbated.
4	150-180	Sandy loam; massive; friable; reddish brown (5YR 4/4 moist); clear boundary; strongly calcareous; turbated.
5	180-220	Sandy loam; massive; friable; reddish brown (5YR 4/4 moist); clear boundary; strongly calcareous; turbated.
6	220-255	Sandy loam to silty loam; massive; friable; dark reddish brown (5YR 3/4 moist); clear boundary; strongly calcareous; turbated; contains dispersed charcoal flecks.
7	255-305	Sandy loam; massive; friable; reddish brown (5YR 4/4 moist); clear boundary; strongly calcareous; strongly turbated; contains dispersed charcoal flecks.
8	305-325	Sandy loam; massive; friable; reddish brown (5YR 4/4 moist); clear boundary; strongly calcareous; strongly turbated; contains dispersed charcoal flecks; contains small sandstone gravels.
9	325-395	Loamy medium to fine sand; massive; friable; reddish brown (5YR 4/4 moist); clear boundary; strongly calcareous; strongly turbated.

Comments: A quartzite core was recovered at 270 cm.

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
BACKHOE TRENCH 31		
1	0-55	Fine sandy loam to silty loam; massive to weak subangular blocky; slightly hard to hard; reddish brown (5YR 4/4); strongly calcareous; clear boundary; strong bioturbation.
2	55-200	Fine sandy loam to silty loam; weak subangular blocky; hard; reddish brown (5YR 4/4); strongly calcareous; gradual boundary; moderate filamental carbonate in matrix.
3	200-225	Fine sandy loam to silty loam; massive to weak subangular blocky; slightly hard to hard; reddish brown (5YR 4/4); strongly calcareous; clear wavy boundary.
4	225-245	Silty loam; massive; friable; reddish brown (5YR 5/4); strongly calcareous; gradual boundary; filamental Ca and Na dispersed in matrix; few small siliceous pebbles.
5	245-360	Fine sandy to silty loam; weakly laminated; friable; brown (7.5YR 4/4); strongly calcareous.

Comments: Cultural materials recovered include minor amounts of debitage and mussel shell. Trench not entered below 3 m.

BACKHOE TRENCH 32

1	0-28	Sandy clay loam; moderate subangular blocky; hard to very hard; reddish brown (5YR 4/4); strongly calcareous; clear to gradual boundary; moderate organic enrichment; contains common roots; contains a discontinuous 1-2-cm-thick lens of ash and charcoal from 5-10 cm; contains few small siliceous pebbles and tabular sandstone slabs.
2	28-95	Clay loam; strong angular blocky; hard to very hard; dark brown (7.5YR 3/2); strongly calcareous; gradual to diffuse boundary; abundant filamental Ca and Na precipitate on ped faces and along root traces; few thin argillans.
3	95-195	Gravelly sandy loam to loamy sand; massive to weak subangular blocky; soft to slightly hard; yellowish red (5YR 4/6); strongly calcareous; clear boundary; common matrix-supported siliceous and sandstone gravels; bioturbated.
4	195-255	Sandy gravels and coarse sands; crossbedded; reddish brown (5YR 4/4); strongly calcareous; clasts to 12 cm in diameter.

Comments: Recovered artifacts include minor amounts of debitage.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
BACKHOE TRENCH 33		
1	0-95	Fine sandy loam to silty loam; laminated; friable to firm; reddish brown (5YR 4/4) to yellowish red (5YR 4/6); strongly calcareous; clear boundary; multiple subhorizontal overbank packets; charcoal flecks occur in lenses at 60 and 80 cm.
2	95-115	Silty loam; massive (turbated); friable; yellowish red (5YR 4/6); strongly calcareous; gradual boundary.
3	115-200	Fine sand to loamy fine sand; massive (turbated); soft to loose; yellowish red (5YR 4/6); contains dispersed charcoal flecks; very strongly turbated by burrows and root traces.
BACKHOE TRENCH 34		
1	0-80	Fine sandy loam to silty loam; massive to weak subangular blocky; slightly hard; yellowish red (5YR 4/6); strongly calcareous; clear to abrupt boundary; very faint subhorizontal lamination.
2	80-204	Fine sandy loam to silty loam; moderate to weak subangular blocky with depth; hard to slightly hard with depth; reddish brown (5YR 4/4) to yellowish red (5YR 4/6) with depth; strongly calcareous; gradual boundary; few precipitate filaments; few siliceous gravels.
3	204-250	Fine sandy to silty loam; massive (turbated); soft to slightly hard; yellowish red (5YR 4/6); strongly calcareous; abrupt undulatory boundary.
4	250-290	Fine to medium sand; laminated; soft to loose; yellowish red (5YR 4/6); strongly calcareous.
BACKHOE TRENCH 35		
1	0-10	Loamy fine sand; massive; friable; brown (7.5YR 4/4 moist); strongly calcareous; gradual boundary.
2	10-45	Fine sandy loam to loamy fine sand; very weak subangular blocky; friable; reddish brown (5YR 4/4); strongly calcareous; gradual to diffuse boundary.
3	45-83	Sandy loam; massive to weak subangular blocky; soft to slightly hard; yellowish red (5YR 5/6); strongly calcareous; clear boundary.

APPENDIX A: GEOMORPHIC BACKHOE TRENCH DESCRIPTIONS

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
4	83-90	Sandy loam; massive; hard; very pale brown (10YR 8/3); very strongly calcareous; contains abundant nodular and interstitial carbonate.
BACKHOE TRENCH 36		
1	0-30	Sandy loam; weak subangular blocky; soft to slightly hard; brown (7.5YR 4/4); strongly calcareous; gradual boundary.
2	30-70	Sandy loam; moderate to strong subangular blocky; hard; dark brown (7.5YR 3/4); strongly calcareous; gradual boundary.
3	70-90	Sandy loam; very weak subangular blocky; slightly hard to hard; strong brown (7.5YR 4/6); strongly calcareous; gradual boundary.
4	90-108	Sandy loam; massive to weak subangular blocky; slightly hard to hard; brown (7.5YR 5/4); strongly calcareous; abrupt boundary.
5	108-120	Saprolitic sandstone bedrock with abundant pedogenic carbonate.
BACKHOE TRENCH 37		
1	0-8	Loamy fine sand; massive; friable; dark brown (7.5YR 3/4); strongly calcareous; gradual boundary.
2	8-60	Sandy loam; weak to moderate subangular blocky; slightly hard to hard; brown (7.5YR 4/4); strongly calcareous; diffuse boundary; contains few small siliceous gravels; slight organic enrichment.
3	60-120	Sandy loam; massive to weak subangular blocky; slightly hard to hard; strong brown (7.5YR 4/6); strongly calcareous; clear undulating boundary; contains abundant carbonate filaments and some small (<0.5 cm) carbonate nodules; contains dispersed subangular to subrounded sandstone gravels.
BACKHOE TRENCH 38		
1	0-15	Loamy fine sand; massive (turbated); friable; dark brown (7.5YR 3/4); strongly calcareous; clear to gradual boundary.
2	15-45	Sandy loam; massive to weak subangular blocky; slightly hard to hard; brown (7.5YR 4/4); strongly calcareous; gradual to diffuse boundary.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
3	45-120	Sandy loam; weak subangular blocky; slightly hard to hard; brown (7.5YR 4/4); strongly calcareous; gradual boundary; common carbonate filaments on ped faces.
4	120-140	Sandy loam; weak to moderate subangular blocky; slightly hard to hard; yellowish red (5YR 4/6); strongly calcareous; clear boundary; strongly turbated.
5	140-175	Sandy loam to loamy sand; massive; soft to slightly hard; brown (7.5YR 5/4); strongly calcareous; clear boundary; turbated.

BACKHOE TRENCH 39

1	0-15	Loamy fine sand; massive; friable; brown (7.5YR 4/4 moist); strongly calcareous; gradual boundary.
2	15-45	Sandy loam; massive to weak subangular blocky; slightly hard to hard; brown (7.5YR 4/4); strongly calcareous; gradual boundary; contains flecks and filaments of carbonate; heavily bioturbated.
3	45-80	Sandy loam; massive; soft to slightly hard; light gray (2.5Y 7/2); very strongly calcareous; contains abundant carbonate nodules; bioturbated.

BACKHOE TRENCH 40

1	0-20	Fine sandy loam; massive; slightly hard; brown (7.5YR 4/4); strongly calcareous; clear boundary.
2	20-43	Sandy loam to clayey sandy loam; strong medium angular blocky; very hard; dark yellowish brown (10YR 4/4); strongly calcareous; diffuse boundary; contains filaments of carbonate on ped faces.
3	43-165	Sandy loam; medium to weak subangular blocky; hard; strong brown (7.5YR 4/6) to yellowish red (5YR 4/6) with depth; abrupt undulatory boundary with underlying caliche; strongly calcareous; contains small carbonate nodules and filaments; contains few small siliceous gravels.

BACKHOE TRENCH 41

1	0-15	Sandy loam; massive to weak blocky; slightly hard; brown (7.5YR 4/4); strongly calcareous; gradual boundary.
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APPENDIX A: GEOMORPHIC BACKHOE TRENCH DESCRIPTIONS

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
2	15-70	Sandy clay loam; strong small angular blocky; very hard; dark reddish brown (5YR 3/4); strongly calcareous; gradual boundary.
3	70-210	Sandy loam; strong to moderate subangular blocky; hard; yellowish red (5YR 4/6); clear to abrupt boundary with underlying saprolitic sandstone and caliche; strongly calcareous; contains few small siliceous gravels.
BACKHOE TRENCH 42		
1	0-6	Fine sandy loam; massive; friable; brown (7.5YR 4/4 moist); strongly calcareous; clear to gradual boundary.
2	6-30	Sandy loam; massive to weak blocky; slightly hard; brown (7.5YR 4/4 moist); strongly calcareous; gradual boundary; few dispersed sandstone pebbles and (probably reworked) carbonate nodules.
3	30-70	Fine sandy loam to silty loam; massive; soft to slightly hard; strong brown (7.5YR 4/6); strongly calcareous; clear wavy boundary.
4	70-83	Fine sandy loam to silty loam; massive; soft to slightly hard; very pale brown (10YR 7/3); very strongly calcareous; contains abundant large carbonate nodules.
BACKHOE TRENCH 43		
1	0-15	Fine sandy loam; massive; soft; dark reddish brown (5YR 3/2); strongly calcareous; gradual boundary.
2	15-50	Sandy clay loam; strong small angular blocky; very hard; dark reddish brown (5YR 3/4); strongly calcareous; gradual to diffuse boundary.
3	50-130	Sandy clay loam; strong small subangular blocky; hard to very hard; reddish brown (5YR 4/4); strongly calcareous; clear wavy boundary.
4	130-155	Fine sandy loam to silty loam; massive; hard; very pale brown (10YR 7/4); very strongly calcareous; contains abundant large carbonate nodules.
BACKHOE TRENCH 44		
1	0-10	Loamy fine sand; loose to massive; very friable; dark brown (7.5YR 3/4 moist); strongly calcareous; gradual boundary.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
2	10-24	Loamy fine sand; massive; friable; dark brown (7.5YR 3/4 moist); strongly calcareous; abrupt boundary (probably defines base of zone disturbed by root plowing).
3	24-55	Fine sandy loam; strong small subangular blocky; soft; strong brown (7.5YR 4/6); strongly calcareous; clear boundary; contains carbonate filaments and small nodules.
4	55-70	Fine sandy loam to silty loam; massive; soft; very pale brown (10YR 7/3); very strongly calcareous; contains abundant large carbonate nodules.

BACKHOE TRENCH 45

1	0-30	Sandy loam; massive; slightly hard to hard; dark brown (7.5YR 3/4); strongly calcareous; gradual to diffuse boundary; few carbonate filaments on ped faces.
2	30-105	Sandy loam; massive to weak subangular blocky; slightly hard to hard; yellowish red (5YR 4/6); strongly calcareous; clear wavy boundary; contains few small carbonate nodules and abundant carbonate filaments; contains few sandstone gravels; bioturbated.
3	105-130	Fine sandy loam to silty loam; massive; soft to slightly hard; very pale brown (10YR 7/3); very strongly calcareous; contains abundant large carbonate nodules.

BACKHOE TRENCH 46

1	0-35	Gravelly sandy loam; massive; soft; reddish brown (5YR 4/4); strongly calcareous; clear boundary; contains dispersed siliceous gravels up to 5 cm in diameter.
2	35-70	Gravelly sandy loam; massive to weak subangular blocky; soft to slightly hard; yellowish red (5YR 4/6); strongly calcareous; gradual boundary; contains common to abundant siliceous gravels and sandstone flags; contains carbonate filaments that decrease with depth and oriented carbonate coats on gravels.
3	70-120	Coarse sandy gravel; massive; loose; reddish brown (5YR 4/4); very strongly calcareous; mixed clast and matrix support of predominantly siliceous gravels to 15 cm in diameter.

BACKHOE TRENCH 47

1	0-16	Sandy clay loam; medium subangular blocky; hard; dark reddish brown (5YR 3/4); strongly calcareous; gradual boundary.
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<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
2	16-118	Clay loam; strong small angular blocky; very hard; dark reddish brown (5YR 3/4); strongly calcareous; gradual to diffuse boundary; occasional carbonate nodules; thin clay films on many ped faces.
3	118-180	Sandy clay loam; small to medium subangular blocky; very hard to hard; reddish brown (5YR 5/4); strongly calcareous; abrupt wavy boundary with underlying caliche.
BACKHOE TRENCH 48		
1	0-7	Sandy loam to sandy clay loam; massive; friable; reddish brown (5YR 4/4); strongly calcareous; clear wavy boundary; strongly turbated.
2	7-12	Sandy clay loam; massive; friable to firm; reddish brown mottled with dark reddish brown (5YR 4/4 and 5YR 3/2); strongly calcareous; gradual boundary; strongly turbated zone of contact between Zones 2 and 4.
3	12-36	Clay loam; massive; firm; dark reddish brown (5YR 3/2); strongly calcareous; gradual boundary.
4	36-85	Clay to clay loam; strong medium to small angular blocky with depth; hard; dark reddish brown (5YR 3/3); strongly calcareous; common carbonate filaments.
BACKHOE TRENCH 49		
1	0-12	Silty clay loam to fine sandy clay loam; massive; firm; reddish brown (5YR 4/4); strongly calcareous; gradual boundary.
2	12-47	Sandy clay loam to clay loam; massive; firm; reddish brown mottled with dark reddish brown (5YR 4/4 and 5YR 3/4); strongly calcareous; gradual boundary; large, faint mottles.
3	47-77	Clay to clay loam; strong subangular blocky; hard; reddish brown (5YR 4/4); strongly calcareous; gradual boundary; slight organic enrichment.
4	77-115	Clay loam to clay; strong angular blocky; hard; dark reddish brown (5YR 3/3); strongly calcareous; gradual boundary; common carbonate filaments on ped faces.
5	115-135	Fine sandy to silty loam; massive; slightly hard; reddish brown (5YR 4/4); strongly calcareous; abundant carbonate filaments.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
BACKHOE TRENCH 50		
1	0-12	Fine sand to loamy fine sand; massive; friable; yellowish red (5YR 4/6); strongly calcareous; clear boundary.
2	12-40	Sandy loam; massive; friable; reddish brown (5YR 4/4 moist); strongly calcareous; diffuse boundary; contains slight organic enrichment.
3	40-218	Sandy loam; massive; soft; yellowish red (5YR 4/6, 5YR 4/4 moist); strongly calcareous; contains few dispersed siliceous gravels below 70 cm.
BACKHOE TRENCH 51		
1	0-30	Sandy loam; massive; friable; yellowish red (5YR 4/6); strongly calcareous; clear boundary; contains small siliceous gravels.
2	30-70	Clay; massive; very firm; dark reddish brown (5YR 3/2); strongly calcareous; gradual to diffuse boundary.
3	70-145	Clay to clay loam; massive to weak subangular blocky; very hard; yellowish red (5YR 4/6); strongly calcareous; common carbonate filaments and small nodules below 100 cm.
BACKHOE TRENCH 52		
1	0-25	Clay; massive; firm; dark reddish brown (5YR 3/3); strongly calcareous; clear to gradual boundary; heavily disturbed.
2	25-74	Clay; massive; very firm; dark reddish brown (5YR 3/3); strongly calcareous; clear to gradual boundary.
3	74-110	Clay; massive; very hard; reddish brown (5YR 4/4); strongly calcareous; few carbonate filaments and small nodules.
BACKHOE TRENCH 53		
1	0-35	Loamy fine sand; massive; friable; brown (7.5YR 4/4 moist); strongly calcareous; gradual boundary; few siliceous pebbles; weak organic enrichment.
2	35-95	Loamy fine sand; massive; friable; strong brown (7.5YR 4/6 moist); strongly calcareous; diffuse boundary; contains siliceous pebbles.

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
3	95-300	Gravelly loamy fine sand to gravelly sandy loam; massive; soft to slightly hard; yellowish red (5YR 4/6); strongly calcareous; contains matrix-supported siliceous and sandstone gravels dispersed in matrix and in steeply dipping stringers; contains flecks of carbonate above 2 m.
BACKHOE TRENCH 54		
1	0-32	Gravelly loamy fine sand; massive; friable; brown (7.5YR 4/4 moist); strongly calcareous; gradual boundary; few siliceous pebbles; weak organic enrichment; contains matrix-supported siliceous and sandstone gravels.
2	32-52	Loamy fine sand; massive; friable; yellowish red (5YR 4/6 moist); strongly calcareous; clear to abrupt boundary with underlying Permian bedrock; contains siliceous pebbles.
BACKHOE TRENCH 55		
1	0-7	Fine sand; single grain structure; loose; strong brown (7.5YR 4/6); strongly calcareous; clear boundary.
2	7-35	Silty fine sand to fine sandy loam; massive; friable; brown (7.5YR 4/4); strongly calcareous; gradual to diffuse boundary; contains weak organic enrichment; contains dispersed charcoal flecks and charred mesquite roots; common krotovina.
3	35-80	Loamy fine sand to fine sandy loam; massive; friable; reddish brown (5YR 4/4); strongly calcareous; clear wavy boundary; common soft carbonate nodules up to 0.5 cm in diameter; few to common krotovina.
4	80-102	Loamy fine sand to silty fine sand; massive; soft to slightly hard; reddish brown (5YR 4/4); very strongly calcareous; clear boundary; contains abundant large carbonate nodules and interstitial carbonate.
5	102-147	Silty fine sand; massive; soft; reddish brown (5YR 4/4); strongly calcareous; clear boundary; contains common large carbonate nodules and interstitial carbonate.
Comments: Artifacts recovered include minor amounts of debitage, ground stone, and burned sandstone.		

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
BACKHOE TRENCH 56		
1	0-40	Silty fine sand; massive; friable; reddish brown (5YR 4/4); strongly calcareous; gradual to diffuse boundary; slight organic enrichment.
2	40-72	Gravelly silty fine sand; massive; soft to slightly hard; reddish brown (approximately 4YR 4/4); strongly calcareous; clear boundary; contains few carbonate filaments; contains few dispersed sandstone pebbles.
3	72-112	Silty fine sand; massive; soft; reddish brown (5YR 4/4); very strongly calcareous; contains common small carbonate nodules and interstitial carbonate.
BACKHOE TRENCH 57		
1	0-40	Silty fine sand to loamy fine sand; massive; friable; brown (7.5YR 4/4); strongly calcareous; gradual boundary; slight organic enrichment; contains common small dispersed siliceous pebbles.
2	40-60	Silty loam to silty fine sand; massive to very weak large subangular blocky; soft; reddish brown (5YR 4/4); strongly calcareous; clear to gradual boundary; contains few carbonate filaments on ped faces.
3	60-80	Silty fine sand; massive; soft; reddish brown (5YR 4/4 to 5YR 4/5); very strongly calcareous; contains common small carbonate nodules and interstitial carbonate.
4	80-90	Loamy sand; massive; soft; reddish brown (5YR 4/6); very strongly calcareous.
		Comments: Burned sandstone and lithic debitage were recovered.
BACKHOE TRENCH 58		
1	0-40	Loamy fine sand to sandy loam; massive; friable; reddish brown (5YR 4/4 moist); strongly calcareous; gradual to clear boundary; heavily bioturbated.
2	40-65	Sandy loam to silty loam; massive; soft; brown (7.5YR 5/4); strongly calcareous; clear boundary.
3	65-100	Fine to medium sand; massive; very soft to loose; brown (7.5YR 4/4 to 7.5YR 5/4); strongly calcareous.

APPENDIX A: GEOMORPHIC BACKHOE TRENCH DESCRIPTIONS

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
BACKHOE TRENCH 59		
1	0-37	Silty fine sand to fine sandy loam; massive to weakly stratified; friable; reddish brown (5YR 4/4 mottled with 5YR 4/6 moist); strongly calcareous; clear to abrupt boundary; contains small siliceous gravels.
2	37-77	Clay to clay loam; massive to weak subangular blocky; firm moist, hard dry; dark reddish brown (5YR 3/4, 5YR 3/3 moist); strongly calcareous; diffuse boundary; contains abundant carbonate filaments.
3	77-120	Clay to clay loam; massive; hard; yellowish red (5YR 4/6); strongly calcareous; contains small dispersed siliceous pebbles.
BACKHOE TRENCH 60		
1	0-70	Gravelly fine sand to gravelly loamy sand; massive; friable; brown (7.5YR 4/4); strongly calcareous; abrupt boundary; contains abundant small siliceous gravels.
BACKHOE TRENCH 61		
1	0-53	Gravelly sandy loam; massive; friable; yellowish red (5YR 4/6 moist); strongly calcareous; abrupt boundary; contains abundant siliceous gravels in stringers and dispersed in matrix.
2	53-115	Gravelly clay loam; massive; firm; dark reddish brown (5YR 3/3); strongly calcareous; gradual to diffuse boundary; contains carbonate filaments; contains dispersed sandstone and siliceous gravels.
3	115-270	Gravelly clay loam to gravelly sandy clay loam; massive to very weak subangular blocky structure; soft to slightly hard; yellowish red (5YR 4/6); clear boundary with Permian bedrock; strongly calcareous; contains sandstone and siliceous gravels dispersed in matrix and in a distinct stringer at 225 cm.
BACKHOE TRENCH 62		
1	0-70	Loamy fine sand; massive; friable; reddish brown (5YR 4/4 moist); strongly calcareous; clear to abrupt boundary; contains dispersed sandstone and siliceous gravels; sandstone gravels are highly degraded.
2	70-135	Stratified sands and gravels; tabular and trough cross-bedding; loose; pinkish gray (5YR 6/2); contains krotovina.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
BACKHOE TRENCH 63		
1	0-37	Fine sand; massive; loose to extremely friable; brown (7.5YR 5/4 moist); strongly calcareous; gradual boundary; contains one distinct clay lamellae 0.5-1.0 cm thick at approximately 15 cm; heavily bioturbated.
2	37-250	Stratified fine to medium sands with silty laminae; gently to steeply dipping tabular crossbedding; loose to very friable; brown (7.5YR 5/4); contains numerous krotovina.
BACKHOE TRENCH 64		
1	0-212	Stratified silty loam with thin interbedded sands and clays; friable; reddish brown to yellowish red (5YR 4/4 to 5YR 4/6); strongly calcareous; clear to gradual boundary; contains multiple reactivation surfaces.
2	212-305	Stratified silty loam and fine to medium sands; subhorizontal tabular laminae; friable; reddish brown to yellowish red (5YR 4/4 to 5YR 5/4).
BACKHOE TRENCH 65		
1	0-50	Fine sandy loam to silty loam; massive; friable; reddish brown (5YR 4/4); clear boundary; strongly calcareous; extensively bioturbated.
2	50-57	Gravelly loam to gravelly sand; massive to weak tabular bedded; soft; reddish brown (5YR 4/4); clear boundary; strongly calcareous; contains coarse sand and very fine siliceous gravels.
3	57-65	Clay loam; massive; firm; dark reddish brown (5YR 3/2 to 5YR 3/3 moist); clear to gradual boundary; strongly calcareous; contains organic matter and dispersed charcoal flecks.
4	65-175	Clay loam to silty clay loam; massive to weak subangular blocky; hard; reddish brown (5YR 4/4); gradual to diffuse boundary; strongly calcareous; contains carbonate filaments and small soft nodules.
5	175-225	Clay loam; massive to weak subangular blocky; hard; dark reddish brown (5YR 3/3); clear boundary; strongly calcareous; strongly turbated; contains carbonate flecks and organic matter.

APPENDIX A: GEOMORPHIC BACKHOE TRENCH DESCRIPTIONS

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
6	225-260	Silty loam to silty clay loam; massive; slightly friable; reddish brown (5YR 4/4 moist); gradual to diffuse boundary; strongly calcareous; contains carbonate filaments.
7	260-320	Silty loam; weak horizontal lamination; friable; reddish brown (5YR 4/4 moist); strongly calcareous.
BACKHOE TRENCH 66		
1	0-30	Silty loam; massive; friable; reddish brown (5YR 4/4); clear wavy boundary; strongly calcareous.
2	30-110	Sandy loam to silty loam; massive; friable; reddish brown to yellowish red (5YR 4/4 to 5YR 4/6); gradual boundary; strongly calcareous; contains stringers of very fine siliceous gravels.
3	110-165	Gravelly sands, sands and silts; trough crossbedded; reddish brown to yellowish red (5YR 4/4 to 5YR 4/6); clear boundary; strongly calcareous; multiple lenticular fining upward fills.
4	165-205	Gravelly sandy loam; massive; friable/soft; reddish brown (5YR 4/4); abrupt boundary; contains small matrix-supported siliceous gravels.
5	205-215	Silt to silty loam; massive; soft to slightly hard; yellowish red (5YR 4/6); abrupt boundary; strongly calcareous.
6	215-265	Clay loam; medium subangular to angular blocky; slightly hard; dark reddish brown (5YR 3/3); gradual boundary; strongly calcareous; contains common carbonate filaments.
7	265-350	Clay loam; massive; slightly friable; reddish brown (5YR 4/4 moist); strongly calcareous; contains common carbonate filaments.
BACKHOE TRENCH 67		
1	0-6	Sandy loam; massive; soft; reddish brown (5YR 4/4); clear boundary; strongly calcareous; contains organic matter.
2	6-36	Fine sandy loam to silty loam; massive; friable; reddish brown (mottled 5YR 4/3 and 5YR 4/4 moist); clear to abrupt boundary; strongly calcareous; heavily turbated.
3	36-112	Silty loam to sandy clay loam; very weak subangular blocky; soft to slightly hard; yellowish red (5YR 4/6); strongly calcareous.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
BACKHOE TRENCH 68		
1	0-15	Fine sandy to silty loam; massive; soft; yellowish red (5YR 4/6); clear boundary; strongly calcareous.
2	15-20	Gravelly sand; massive; soft; yellowish red (5YR 4/6); clear boundary; strongly calcareous; lenticular.
3	20-105	Gravelly loam to gravelly clay loam; massive; soft to slightly hard; yellowish red (5YR 4/6); clear boundary; strongly calcareous; contains subangular sandstone and rounded siliceous gravels.
4	105-155	Gravelly clay loam; massive to weak subangular blocky; hard; reddish brown (5YR 4/4); strongly calcareous; contains large subangular sandstone gravels.
BACKHOE TRENCH 69		
1	0-40	Gravelly sandy loam; massive; very friable; reddish brown (5YR 4/4); strongly calcareous; clear boundary; contains dispersed siliceous and sandstone gravels.
2	40-46	Medium to coarse sand; massive; friable to loose; reddish brown (5YR 4/4); strongly calcareous; clear boundary.
3	46-56	Silty loam; massive; friable; yellowish red (5YR 4/6); strongly calcareous; clear boundary; faint horizontal lamination.
4	56-155	Silty loam to clayey silty loam; weak subangular blocky; friable to firm; reddish brown (5YR 3/4 to 5YR 4/4 with depth); strongly calcareous; gradual boundary; contains dispersed saprolitic sandstone pebbles; organic enrichment.
5	155-215	Loam to fine sandy loam; massive to weak subangular blocky; friable to firm; reddish brown (5YR 5/4); strongly calcareous; clear boundary.
6	215-240	Clay loam to silty clay loam; moderate to strong subangular blocky; firm; dark reddish brown (5YR 3/3); strongly calcareous; gradual boundary; organic enrichment.
7	240-280	Clay loam to silty clay loam; moderate to strong subangular blocky; firm; reddish brown (5YR 4/4); strongly calcareous; gradual boundary; common flecks of carbonate.

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
8	280-300	Silty to fine sandy loam; massive to weak subangular blocky; friable; dark reddish brown (5YR 3/4); strongly calcareous; common carbonate flecks; contains dispersed sandstone pebbles.
BACKHOE TRENCH 70		
1	0-20	Sandy clay loam; massive; firm; dark reddish brown (5YR 3/4); clear to gradual boundary; strongly calcareous.
2	20-120	Clay to clay loam; massive to weak blocky; very firm; dark reddish brown (5YR 3/2 moist); diffuse boundary; strongly calcareous; contains common carbonate filaments.
3	120-225	Clay to clay loam; massive; very firm; dark reddish brown (5YR 3/3 to 5YR 3/4); strongly calcareous; contains common carbonate filaments; moisture content increases with depth.
BACKHOE TRENCH 71		
1	0-40	Loamy fine sand to sandy loam; massive; friable; dark reddish brown (5YR 3/3); gradual boundary; strongly calcareous; contains dispersed small sandstone gravels; organic enrichment.
2	40-83	Loamy fine sand to sandy loam; massive; friable; dark reddish brown (5YR 3/4); clear boundary; strongly calcareous; contains small dispersed sandstone gravels.
3	83-115	Sandy clay loam; massive to weak subangular blocky; friable to firm; reddish brown (5YR 4/4 moist); gradual boundary; contains small matrix-supported sandstone gravels.
4	115-130	Sandy clay loam; massive to weak subangular blocky; slightly hard; dark reddish brown (5YR 3/4); clear boundary; strongly calcareous.
5	130-217	Sandy clay loam; massive to small subangular blocky; slightly hard; reddish brown (5YR 4/4); gradual boundary; strongly calcareous; contains common carbonate filaments; contains stringers of small sandstone gravels.
6	217-230	Silty loam to fine sandy loam; massive; soft to slightly hard; reddish brown (5YR 4/4); strongly calcareous.
BACKHOE TRENCH 72		
1	0-33	Loamy fine sand; massive; very friable; reddish brown (5YR 4/4); clear boundary; strongly calcareous.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
2	33-55	Fine sand; weak ripple lamination; very soft to loose; reddish brown (5YR 5/4); clear boundary; strongly calcareous.
3	55-96	Laminated sands and silts; multiple thin fining upward packets; friable to very friable; reddish brown (5YR 4/4 to 5YR 5/4 moist); clear wavy boundary.
4	96-170	Clay loam to gravelly clay loam; massive to weak subangular blocky; hard; reddish brown (5YR 5/4); gradual boundary; strongly calcareous.
5	170-195	Sandy loam; massive; friable; reddish brown (5YR 4/4); clear boundary; strongly calcareous.
6	195-210	Coarse sandy gravel; massive; loose; reddish brown (5YR 5/4); strongly calcareous; very small gravels.

BACKHOE TRENCH 73

1	0-12	Sandy loam; massive; friable; reddish brown (5YR 4/4); clear boundary; strongly calcareous.
2	12-69	Sandy loam; massive; friable; dark reddish brown (5YR 3/4 moist); gradual boundary; strongly calcareous.
3	69-192	Clay loam; massive to very weak subangular blocky; hard to very hard; reddish brown to yellowish red (5YR 4/4 to 5YR 4/6); strongly calcareous; contains small siliceous gravels.

BACKHOE TRENCH 74

1	0-50	Sandy loam; massive; friable; dark reddish brown (5YR 3/4 moist); gradual boundary; strongly calcareous.
2	50-133	Silty loam to clayey silty loam; large subangular blocky; slightly hard to hard; reddish brown (5YR 4/3); clear boundary; strongly calcareous; contains common carbonate filaments.
3	133-183	Clay loam; weak subangular blocky; hard to very hard; dark reddish brown (5YR 3/4); gradual boundary; strongly calcareous; contains common carbonate filaments.
4	183-305	Clay to clay loam; massive; firm; dark reddish brown (5YR 3/3 moist); strongly calcareous; contains carbonate flecks.

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
BACKHOE TRENCH 75		
1	0-30	Sandy loam; massive; friable; dark reddish brown (5YR 3/3 to 5YR 3/4 with depth; moist); gradual boundary; strongly calcareous; organic content decreases with depth.
2	30-70	Sandy clay loam; weak subangular blocky; hard; reddish brown (5YR 4/3); gradual boundary; strongly calcareous; contains few carbonate filaments.
3	70-300	Clayey sandy loam to sandy clay loam; massive to very weak horizontal stratification; friable; reddish brown (5YR 4/4 moist); strongly calcareous; contains carbonate flecks and filaments concentrated around 190 cm.
BACKHOE TRENCH 76		
1	0-33	Fine sand; massive to weak horizontal stratification; very soft; brown (7.5YR 4/4); clear to abrupt boundary; strongly calcareous.
2	33-200	Sandy loam to sandy clay loam (fines upward); massive to very weak subangular blocky; friable; reddish brown (5YR 3/4 moist); gradual boundary; strongly calcareous; abundant dispersed charcoal flecks in upper 10 cm of zone; contains common carbonate flecks below 160 cm; few bivalve mollusca.
3	200-265	Laminated sands and muds; lenticular bedding; friable; reddish brown (5YR 4/4 moist); strongly calcareous; underlain by coarse sandy gravel channel sediments.
BACKHOE TRENCH 77		
1	0-55	Silty sand to silty loam; massive (heavily turbated); friable; brown (7.5YR 4/4); abrupt boundary; strongly calcareous; root plow disturbance.
2	55-75	Fine sand with silty sand drapes; multiple thin crossbedded fining upward packets; very soft to loose; dark yellowish brown with reddish brown drapes (10YR 4/4; 5YR 4/4); abrupt boundary; strongly calcareous; coarsens upward.
3	75-140	Silty to clayey loam; massive to very weak blocky; soft to slightly hard; reddish brown to dark reddish brown (5YR 4/4 to 5YR 3/4); clear boundary; contains thin subhorizontal organic-rich drapes.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

<u>Zone</u>	<u>Depth Below Surface (cm)</u>	<u>Description of Zone</u>
4	140-165	Fine sandy loam to silty loam; laminated; soft to slightly hard; reddish brown (5YR 4/4); clear boundary; strongly calcareous.
5	165-195	Fine sand with silty drapes; multiple thin crossbedded fining-upward packets; very soft to loose; dark yellowish brown with reddish brown drapes (10YR 4/4; 5YR 4/4); clear boundary; strongly calcareous.
6	195-225	Gravelly sandy clay; massive; firm; dark reddish brown (5YR 3/3 moist); strongly calcareous; siliceous and limestone gravels.

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APPENDIX B: Magnetometer Surveys at 41GR323 and 41KT53

James T. Abbott

and

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INTRODUCTION

One aspect of the testing phase at Justiceburg Reservoir consisted of a preliminary investigation designed to assess the utility of magnetic prospection for locating buried features and activity areas within the boundaries of known sites. Portable proton magnetometers have been applied to archeological prospection with considerable success in other locations in Texas and elsewhere (e.g., Breiner and Coe 1972; Arnold and Kegley 1977; Weymouth 1979; Weymouth and Huggins 1985; Huggins et al. 1987). Magnetometry is not a viable method of archeological investigation in many site situations, however, because the magnetic characteristics of soils, sediments, and bedrock geology vary considerably from location to location, as do the effects of cultural features on the overall field (Breiner 1973:47). Substantial amounts of ferrous metal, electrical and telephone transmission lines, oil or gas pipelines, and electrical wiring preclude application in urban and suburban situations, while anomaly size, depth of burial, intensity of remanent magnetization, proximity to other cultural features, uniformity of background magnetization, machine sensitivity, and resolution of the survey all affect the detectability of archeological features in nonurban contexts. Therefore, the applicability of the technique must be assessed for each new broad geologic or cultural situation.

The bedrock geology of the Justiceburg Reservoir area consists of Triassic sandstones and mudstones of the Dockum Group overlying highly oxidized Permian mudstones and shales of the Quartermaster Formation (see Chapter 4). With the exception of some grayish green Dockum sandstone beds, all bedrock in the area is strongly rubified, suggesting a high iron content (Hurst 1977). Alluvial sediments derived from these formations are also typically quite red. The effect of the apparently high concentrations of iron in the site sediments and substrate on any magnetic patterning due to cultural phenomena was not known prior to the study. Therefore, a pilot study was undertaken to determine the applicability of the method to archeological questions at sites within the Justiceburg Reservoir project area. Two sites were selected for preliminary assessment of the utility of magnetic survey, 41KT53 and 41GR323. Magnetometer fieldwork was conducted August 29 through September 1, 1988, during which time three grid blocks were investigated. Several additional short feasibility transects over known cultural features at other sites were made in early October 1988.

THEORETICAL BACKGROUND

The earth is enveloped by a magnetic field similar in configuration to one surrounding a simple bar magnet. This field is composed of lines of magnetic force, or flux, that issue from the earth's magnetic poles (Fig. 61). The intensity of the magnetic field at any location is a function of the density of the lines of flux, and varies from approximately 25,000 gammas in the tropical latitudes to over 70,000 gammas at the magnetic poles.

The proton precession magnetometer is a portable instrument that provides a measure of the total magnetic field intensity independent of field orientation at a given location. The detector consists of a wire coil surrounding a bottle of fluid rich in hydrogen ions, such as water, kerosene, or decane. The nuclei of the hydrogen ions behave as small, spinning magnetic dipoles and precess about an axis parallel to the magnetic field of the

Figure 61. Magnetic field of the earth.

earth at a rate directly related to its intensity. Under normal conditions, the precession of individual protons in the fluid is out of phase. When a strong current is passed through the coil, however, a magnetic field is generated which temporarily polarizes the protons. After the current is eliminated, the protons resume precession in phase and generate a minute voltage signal in the coil. This signal is directly proportional to the total magnetic field intensity and is largely independent of the detector coil orientation. After a few seconds, the protons once again become out of phase and the signal fades (Breiner 1973; Steponaitis and Brain 1976).

The proton magnetometer measures the overall strength of the magnetic field at a given point in time and space. The total field strength is a composite of the earth's field strength and local permutations caused by induced (or viscous) and remanent magnetization of nearby objects. Induced magnetism refers to temporary alignment of magnetic particles

under the influence of the ambient field, where remanent magnetism refers to permanent, fixed alignment of magnetic particles independent of the ambient field. Of these two types of magnetization, remanent is the more important archeologically (Breiner 1973; Aitken 1974; Weymouth and Huggins 1985). The most significant form of remanent magnetism results from heating and is termed thermoremanent magnetism (TRM). Under normal conditions, the electron orbits of magnetic minerals contained within a substance are locked into randomly oriented alignments. However, when materials containing magnetic minerals are heated above the Curie point (approximately 700 °C), the electrons of the magnetic particles are thermally agitated and begin to rotate freely. As the material cools, the electron orbits tend to align with the magnetic field of the earth and, with further cooling, are locked in place. Heating to temperatures below the Curie point usually results in partial thermoremanent magnetization, resulting in a less pronounced but often still detectable overall magnetization of the material.

Thermoremanent magnetism allows the determination of the azimuth and inclination of the magnetic pole at the time that the material cooled and the orbits were frozen, and thus provides the basis of paleomagnetic and archeomagnetic dating (Eighmy 1980). In addition, this uniform alignment also tends to give the material strong magnetic properties that can produce dramatic signatures in magnetic surveys (Breiner and Coe 1972; Weymouth 1979; Weymouth and Huggins 1985).

Archeological magnetic surveys are designed to detect spatial anomalies due to localized phenomena (e.g., burned archeological features). Because all readings cannot be taken simultaneously, however, survey data also contain a temporal component that must be corrected. The magnetic field of the earth varies both on a fairly predictable daily basis (diurnal variation of up to several hundred gammas a day due to compression of the global field by the solar wind) and on a random short-term basis (micropulsations of 10-100 gammas at unpredictable intervals) (Breiner 1973; Knecht and Shuman 1985). To eliminate the effects of these variations, a second magnetometer typically is employed as a stationary recording base station. During processing, these base data are used to correct for diurnal drift in the field data.

Magnetic anomalies take the form of individual or groups of monopole or dipole sources. Monopoles are formed where the lines of flux converge upon a given point. As Breiner (1973) observes, most monopole sources are not truly monopolar, only bipolar sources of sufficient size that only one end of the local field is detected. Dipoles, similar in configuration to the earth's field as a whole, are more common archeological signatures. Typical dipole signatures consist of paired positive and negative anomalies which represent the warping of the ambient field around the source. Unless the object is shallowly buried, the position of the anomaly is usually offset from the position of the source in a direction related to the orientation and inclination of the ambient field.

The configurations of both monopolar and dipolar signatures vary enormously depending upon the size, magnetic intensity, depth, and orientation of the feature producing them and the latitude and orientation of transect lines. The strength of an anomaly as measured by a magnetometer varies as the inverse cube of its distance from the sensor. Thus, small features located near the ground surface typically produce a sharply defined peak with little areal extent, while large, deeply buried features result in a more extensive, gradual signature.

As a general rule, archeological anomalies are more intense than the surrounding matrix (Breiner 1973). With the exception of ferrous objects, burned and fired cultural materials with thermoremanent magnetic properties produce the strongest signatures. Other differences arise from strong variation in the magnetic susceptibility of site sediments. For example, humus-rich sediment is typically more magnetic than surrounding soil, allowing the identification of humus concentrations, filled pits, and the like. Walls and other structural elements may be constructed of highly magnetic materials, such as igneous rocks, and result in a positive anomaly, or they may displace a more highly magnetic soil and result in a negative anomaly. Continued displacement of surface soil by the movement of inhabitants can result in lower magnetism than surrounding soils affected by viscous magnetization (e.g., the gradual alignment of magnetic particles under ambient temperatures). If the subsurface composition of a site is complex, then the results of magnetic survey can be a confusing juxtaposition of superimposed anomalies that is impossible to interpret. At the other extreme, the contrast in magnetic susceptibility may be insufficient to indicate any anomalies at all, even in the presence of burned features.

METHODOLOGY

Two Geometrics G856X portable proton precession magnetometers were employed in this study. These instruments have a theoretical sensitivity of 0.1 gamma (although the practical sensitivity suggested by repeatability of readings is closer to 1.0 gamma), are capable of storing several thousand readings in an internal memory bank, and may be operated either in a field mode or in an automated base station mode.

The field instrument was operated by a two-person team; one placed the sensor while the other operated the instrument pack. Readings were taken on a 1-m grid at a sensor height of 75 cm. Grid locations were determined by stretching a fiberglass tape between paired points on opposite ends of survey transects. Survey grids were aligned to magnetic north, and all transects ran east-west. Corner points of the grids were marked with wooden survey stakes, while transect ends were marked with pin flags. To avoid magnetic interference caused by the metal pin flags, a 3-m cushion was used between the end of the transect and the first reading. Therefore, a 40x40-m survey grid was contained within a 40-m (N-S) by 46-m (E-W) staked rectangle and consisted of 1,681 (41 x 41) individual points.

The base station was located off-site in an untrafficked area and was set to record the diurnal field drift at 10-second intervals. After completion of each survey, the pin flags were removed, but the wooden corner stakes were left in place to allow relocation of anomalous areas for subsequent testing. The data were downloaded into a Macintosh personal computer, corrected for diurnal variation, and used to produce gray-scale intensity plots, transect profiles, and three-dimensional grid surface representations of the data. During subsequent hand testing of the sites, test units were located over a number of anomalies within each grid. An effort was made to investigate several different types of anomalies and negative areas in order to develop working models relating size and configuration to the cultural or natural materials causing the anomalies.

RESULTS

41KT53

This locality is a Late Prehistoric site situated on the western terrace and adjacent alluvial fan of Grape Creek approximately 2.3 km upstream from its confluence with the Double Mountain Fork of the Brazos River. Two survey grids were investigated within its boundary (see Fig. 32 and discussion in Chapter 5). This site was selected because ceramic sherds were recovered from the surface and a shovel test suggested the presence of a shallowly buried Late Prehistoric occupation.

Grid A was 40x40 m in size and was positioned to encompass sloping alluvial fan sediments and relatively level stream alluvium. The magnetometer results are depicted in Figure 62. This plot reveals that the stream alluvium (i.e., the northern half of the plot) has a higher degree of ambient magnetism and that a substantial amount of noise occurs. This noise is primarily manifested as east-west linear anomalies along the route of survey transects, indicating that the principal source was the presence of ferrous objects on the survey technicians, probably rivets and buttons on jeans. Unfortunately, due to time constraints, the survey was not repeated. To minimize the effect of the noise, the raw data were run through a simple mathematical filter that averaged the values of stations on adjacent lines. This filtering process did little to eliminate the apparent noise.

Due to the excessive noise apparent in the data, anomaly investigation in Grid Block A was limited to two test units (Table 71; see Fig. 62). Test Unit 8 (1x2 m) was located in the northwest quadrant on a fairly strong monopolar anomaly where several polychrome ceramic sherds had been collected from the surface. The excavation yielded a cluster of 57 additional ceramic sherds (Feature 5) and a concentration of charcoal and burned soil (Feature 2) at 5-40 cm. Test Unit 9 (1x1.5 m) was located over a moderately strong dipole on the eastern edge of the survey block. The unit was excavated to 30 cm, and no cultural materials were recovered.

TABLE 71
INVESTIGATED ANOMALIES IN MAGNETOMETER GRID A, 41KT53

Test Unit	Anomaly Type	Anomaly Orientation	Approximate Size (m)	Anomaly Magnitude (gammas)	Excavation Result
8	Monopole	n/a	1x2	19	ceramic cluster, charcoal and burned sediment at 5-40 cm
9	Dipole	N-S	1x2	7	No cultural materials

Figure 62. Plan view of magnetometer grid A, 41KT53.

Grid B, 30x30 m in size, was situated adjacent to the Grape Creek channel on an alluvial terrace. This survey revealed a number of anomalies of various sizes and configurations (Fig. 63). Two large positive anomalies were detected in the northwest and northeast corners, and a northwest-southeast-trending dipole occupies the southeastern quadrant. Additionally, several small discrete dipoles were identified in the north-central, south-central, and western sections of the grid. Test units were placed in a number of these locations (Table 72; see Fig. 63).

TABLE 72
INVESTIGATED ANOMALIES IN MAGNETOMETER GRID B, 41KT53

Test Unit	Anomaly Type	Anomaly Orientation	Approximate Size (m)	Anomaly Magnitude (gammas)	Excavation Result
1 & 7	Dipole	N-S	1x3	3.2	60-cm-diameter hearth, 32 flakes, 15 bone fragments, charcoal, burned clay at 10-15 cm
2	Dipole	N-S	1x2	1.2	Burned post, burned bone fragments, 3 flakes, and burned clay at 13-47 cm
3	Monopole	n/a	9x16	3.9	1 flake, 2 bone fragments
4	Monopole	n/a	2x2	3.2	Ceramic cluster, charcoal, debitage, burned bone fragments, burned sandstone at 18-25 cm
5	Dipole	E-W	1x2	1.2	7 ceramic sherds
6	None (Control Unit)	n/a	n/a	-2.0	1 ceramic sherd
BHT 32	Dipole	NE-SW	10x15	2.5	Channel gravels, no cultural materials

Figure 63. Plan view of magnetometer grid B, 41KT53.

Test Units 1 (1x2 m) and 7 (1x1 m) were contiguous units excavated at the location of a very distinct dipole in the north-central portion of the grid block. These units uncovered a scatter of burned bones, debitage, and burned clay around a clearly defined 60-cm-diameter, shallow basin, ash-filled hearth at ca. 10-15 cm. Test Unit 2 (1x1 m) was excavated in a moderate dipole at the south end of the block and revealed a burned post and associated debitage, burned bone fragments, and charcoal at 13-47 cm. Test Unit 3 (1x1 m) was located in a large monopolar anomaly (although a corresponding magnetic shadow could exist outside the boundary of the survey) in the northeast corner of the block and contained minor quantities of debitage and bones but no cultural features capable of causing the anomaly. This unit was located in a much coarser grained sediment than evidenced in the other units, and the anomaly is interpreted as the result of variation in the magnetic susceptibility of the sediments. Test Unit 4 (1x1 m) was located on a strong monopolar peak at the northwest end of the northwest-southeast-trending anomaly and revealed a concentration of 16 ceramic sherds (Feature 6), charcoal, and scattered sherds and debitage at 12-20 cm. Test Unit 5 (1x1 m) was excavated over an east-west-oriented dipole in the west-central portion of the block and yielded seven small sherds at 10-20 cm. Test Unit 6 (1x1 m) was excavated in a magnetic low as a control measure and yielded one small sherd. Additionally, a backhoe trench (1x7 m) was placed across the large northeast-southwest-trending anomaly in the southeast quadrant of the block, revealing a linear deposit of buried channel gravels at approximately 2 m.

41GR323

This is a Late Prehistoric site located in a large alluvial fan adjacent to Grape Creek approximately 0.9 km upstream from its confluence with the Double Mountain Fork of the Brazos. One 20x54-m magnetometer grid block survey was conducted on the southern margin of the site adjacent to a 2-m-high cutbank created where Grape Creek has migrated laterally into the alluvial fan (see Fig. 20 and discussion in Chapter 5). This locality was selected because artifacts and burned rock concentrations visible in the cutbank and on the beveled edge of the fan surface indicated a prehistoric occupation in the upper 50 cm of the deposit.

The magnetometer survey of this grid block revealed broad magnetic patterning but no small discrete dipoles (Fig. 64). With the exception of a moderately large monopole in the northwest corner of the grid, the magnetic intensity of the grid tends to decrease from the southeast to the northwest. Six test units were located within the grid in an attempt to identify the sources of the large anomalies (Table 73; see Fig. 64). Test Unit 1 (1x1 m) was located within the strong positive anomaly present in the southeast corner and yielded one flake in the uppermost 20 cm and a charcoal-rich zone at 55 cm. Test Unit 2 (1x1 m) was located on a 1-m-diameter anomaly in the center of the grid and contained no artifacts, although a charcoal-rich zone existed at 50-60 cm. Test Unit 3 (1x1 m) was located 4 m south-southwest of Test Unit 2 in the middle of a large monopolar anomaly. Debitage was recovered at 10-20 cm and 30-50 cm, and a burned zone was located at 60-70 cm. Test Unit 4 (1x1 m) was located in a low magnetic area near the western margin of the grid and yielded charcoal and sparse debitage. Test Unit 5 (1x1 m) was located in an area of neutral magnetism 5 m west-northwest of Test Unit 2. No artifacts were recovered. Test Unit 7 (1x1 m) was located in a positive anomaly at the northwest corner of the grid and yielded a single flake, a possible fire-cracked rock, and charcoal flecks from the upper 30 cm.

Figure 64. Plan view of magnetometer grid, 41GR323.

Additional Feasibility Investigations

In addition to the three grid block surveys, several small-scale informal investigations were conducted to aid in interpreting the existing grid data and to help predict the magnetic signals that could be expected from specific types of features. To examine the degree of thermoremanent magnetism characteristic of individual burned sandstone clasts, several readings were taken while holding a clast at varying distances from the sensor. The effect of a single burned clast proved to be very slight, resulting in a 3-5-gamma increase at a distance of 10 cm from the sensor and no difference at a distance of 1 m. To examine the general magnetic response of the area geology, a cross-valley transect of Grape Creek was measured (Fig. 65). The transect indicates that the various geologic formations and alluvial/colluvial units present in the Grape Creek valley are not distinguishable based on magnetic intensity.

To model feature signatures, small-scale transects were run across exposed burned rock features at three sites. One of these, a hearth (Feature 2 in Test Unit 6 at 41KT33), was

TABLE 73
INVESTIGATED ANOMALIES IN MAGNETOMETER GRID, 41GR323

Test Unit	Anomaly Type	Anomaly Orientation	Approximate Size (m)	Anomaly Magnitude (gammas)	Excavation Result
1	Monopole	n/a	8x20	2.7	1 flake*
2	Monopole	n/a	1x1	1.2	No cultural materials*
3	Monopole	n/a	8x12	2.7	5 flakes*
4	None (Control Unit)	n/a	n/a	-6.3	2 flakes, charcoal
5	None (Control Unit)	n/a	n/a	-1.8	No cultural materials
7	Monopole	n/a	n/a	-0.2	1 flake, charcoal

*Charcoal-rich sediment zone noted below 50 cm.

composed of burned sandstone in a sandy matrix and produced a very faint signal (approximately 1-gamma variation). The strength of this signal is near the threshold of detectability and, depending on the magnetic heterogeneity of the site sediments, may have been too weak in comparison with the surrounding background variation for the feature to have been identified. Better results were obtained from a surficial feature composed entirely of thermally fractured Potter chert at 41GR287 and from an exposed burned sandstone feature at 41GR323. The total variation attributable to these features was 3-7 gammas, which is in the same range of variation as the more intensely burned features detected at 41KT53.

In an attempt to determine the utility of the magnetometer for investigation of sites with a thicker overburden, transects were run over several sandstone-lined hearths in a sandy loam matrix exposed in the cutbank at site 41KT52. These hearths, ranging in depth from 75 to 100 cm, were not detected in the transects; however, subsequent readings made against the cutbank face revealed that the features are poorly magnetized and probably would not have been detectable even if they had been exposed at the surface. Localities where more deeply buried fired features in a clayey matrix are exposed in a cutbank are unknown, and therefore the detectability of deep features in this type of substrate was not tested.

Figure 65. Magnetic transect across lower Grape Creek valley.

SUMMARY AND CONCLUSIONS

The three grid block surveys and subsequent feasibility investigations clearly suggest that magnetometry has the potential to increase data recovery within the Justiceburg Reservoir study area. Two grids were investigated within the boundary of 41KT53. Grid A was located away from Grape Creek and encompassed stream alluvium and alluvial fan sediments. The stream alluvium exhibited a generally higher degree of ambient magnetism than the fan sediments, possibly reflecting a higher clay content. Due to a high degree of noise in the results, only two anomalies within the grid were investigated by hand testing. Both of these anomalies were relatively small strong dipoles. Only one detected cultural materials, consisting of a concentration of ceramic sherds.

Grid B was located adjacent to Grape Creek on stream alluvium. A number of anomalies of different sizes were detected. Five of these were investigated by hand testing, and one additional anomaly was investigated with a backhoe trench. One test unit was placed in a magnetically low area for control purposes. Magnetically significant cultural materials recovered include a well-defined hearth, a burned post, burned sandstone, burned earth, and several concentrations of ceramic sherds. Associated materials recovered include debitage and bones. All of the cultural materials were recovered from relatively small anomalies developed in clayey sediment. Several large anomalies proved to be geological in origin; one was attributed to a facies change to loamier sediment near the channel margin and the other to a deeply buried channel gravel deposit.

One grid was investigated within the boundary of 41GR323. No small discrete dipolar anomalies were detected. Although subsequent hand testing of several large monopolar anomalies yielded minor amounts of cultural materials, the magnetic patterning evidenced in the plot appears to be due to lateral textural heterogeneity and variation in a charcoal-enriched burned "horizon" located at approximately 50-75 cm.

Magnetometer transects were run over known features at several sites in order to assess their detectability. These transects were performed as field evaluations only and were not corrected for diurnal variation. Nevertheless, the range of variation in magnetic deviation observed at these sites was similar to that of features discovered in the grid blocks, suggesting that the proton magnetometer would be an effective tool for locating similar features in the subsurface.

In summary, the following statements can be made:

1. The strength of anomalies created by burned features appears to vary between approximately 1 and 7 gammas. While the majority of near-surface burned features are probably readily detectable, the magnetization of small features may be near the threshold of discrimination possible with the proton magnetometer, particularly in sandier sediments. Therefore, some weakly magnetized features may escape detection.

2. While detection of features in the upper 30-50 cm of site sediments appears good, too little information exists to evaluate the effective depth of magnetic prospection in the study area, and the detectability of features buried deeper than 50 cm is unknown.

3. Despite the high iron concentration suggested by a rubified appearance, the native sandstone and sandy sediment derived from this source appear to have a relatively low magnetic susceptibility. Individual clasts typically are poorly magnetized, and the magnitude of anomalies over fired features is not high.

4. Ceramic sherds and sherd clusters were detected as weak to moderately strong anomalies at several locations within Grids A and B at 41KT53. One of these anomalies exhibits a rotated dipolar signature, while both in situ features located in Grid B exhibit a dipole aligned with the magnetic field. It is likely that other dipoles that exhibit a significant deviation from north-south alignment also will represent materials fired at another location and transported in (e.g., ceramics, dump piles) rather than features fired in situ.

5. Anomalies with a large areal extent, manifested both as monopoles and broad dipoles, were detected in all three survey grids. In each case where the anomaly was investigated, the source proved to be geological, i.e., a buried channel, a facies change, etc. Cultural materials detected were limited to burned features and fired artifacts and were characterized by relatively localized anomalies. No architectural features, with the exception of a possible burned post, were detected.

This study demonstrates that magnetic survey has the potential to greatly increase the information return resulting from mitigation of the sites in the Justiceburg Reservoir project area. In particular, the utility of magnetic prospection has been demonstrated at 41KT53, and further use of the technique is warranted there; however, anomalies occur in a number of sizes and shapes, and the results of the preliminary investigation suggest that larger monopolar and dipolar anomalies are characteristic of noncultural variation in the

substrate. Therefore, unless the morphology of an individual anomaly strongly suggests an architectural feature, it is recommended that investigation of anomalies detected by the magnetometer should focus on small discrete dipoles.

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APPENDIX C: Chronometric Dating

J. Michael Quigg

INTRODUCTION

This appendix discusses the absolute dating undertaken during the Phase II investigations at Justiceburg Reservoir. The materials dated from prehistoric sites and geomorphic localities consist of charcoal, soil humates, bones, burned rocks, and ceramics. Fifty-nine radiocarbon and thermoluminescence samples were selected and sent to various laboratories. When possible, paired samples for thermoluminescence and radiocarbon dating were collected from archeological features. The lack of charcoal in features and sites limited this effort, however. The radiocarbon and thermoluminescence dating efforts are addressed separately below.

RADIOCARBON DATING

A total of 31 radiocarbon assays were undertaken on three materials: wood charcoal, bone, and soil humates. Charcoal has long been the preferred material for radiocarbon dating, but this approach is not without problems (e.g., Black 1986:146-155; Taylor 1987:44-47). For example, scattered charcoal from nonfeature contexts often yields questionable results; thus, this type of sample was not submitted for dating. Charcoal samples from nine features at six sites were submitted, although two were too small to be dated. In addition, a tenth feature at a seventh site was charcoal dated during the Phase I investigations.

Faunal remains were scarce at the open campsites investigated during this project and were not considered for dating. The tested faunal localities did yield sufficient quantities of bones for dating, however. Bone suffers from a loss of collagen (organic fraction) over time, varying between different depositional environments. Bone collagen does not suffer from any exchange phenomena, however, and cannot be altered by known natural mechanisms. It has been successfully utilized to provide acceptable dates (Taylor 1987:53-67). Collagen from seven individual elements from seven different localities was radiocarbon dated.

Geomorphic events and depositional units were dated by humates extracted from sediments or buried soils. Humate dating involves assays on fine organics bound to clay particles. In depositional settings, fine organic matter from both new and old carbon is deposited with the sediment, and an assay yields an approximate date of deposition. In soils, organic matter is produced continually at the surface and migrates downward. Dates on soils thus provide the mean residence age of the organic humates and a minimum age of the soil. Radiocarbon dating of humates at archeological sites has proven to be quite successful in recent years (see Haas et al. 1986:473-485; Collins et al. 1989) and is used extensively in geomorphic investigations (Birkeland 1984:150-152). Fifteen humate samples were dated during Phase II, and 11 were dated during the Phase I studies.

Carbon Isotope Corrections

Stable carbon isotope analysis was conducted on all of the samples processed during the Phase II investigations. Thus, the dates are corrected for variations in C-13 and C-12

resulting from fractionation of the isotopes during the three types of photosynthesis, i.e., C3 (Calvin and Benson 1948), C4 (Hatch and Slack 1966), and CAM (Osmond 1978). Fractionation is the selection for or against one of the stable carbon isotopes during the course of a chemical or physical reaction in photosynthesis (Taylor 1987:34-35, 120-123). The C-13/C-12 ratios are expressed as parts per thousand (ppt) deviation from the Peedee Belemnite (PDB) carbonate standard, a marine limestone from South Carolina, and are written as $\delta^{13}C$. As standard radiocarbon dates are calibrated for C3 plants, significant contributions of C4 or CAM plants to the organic fractions in soil humates or bones would result in dates that are too young. The $\delta^{13}C$ value is used to correct the radiocarbon date for the fractionation effect. Values for pure C3 plants range between -23 and -32 ppt, with an average of -26.5 ppt, while C4 species range between -9 and -16 ppt with an average of -12.5 ppt (Smith and Epstein 1971). CAM plants average -16.5 ppt. As bison or other herbivores consume various plants, there is a consistent metabolic process resulting in additional fractionation of the carbon isotopes. It has been shown that a "collagen enrichment" of about 5.1 ppt (Chisholm et al. 1982; Van der Merwe 1982) must be added to the negative $\delta^{13}C$ values when dealing with assays on herbivore bone collagen to accurately reflect the C3/C4 vegetation intake.

Laboratory Analysis

All of the humate assays, 11 from the Phase I investigations and 15 from the Phase II work, and one charcoal assay (Tx-5758) were performed by S. Valastro, Jr. at the Radiocarbon Dating Laboratory, The University of Texas at Austin. Age calculations are based on a 5,568-year half-life of C-14 and referenced to the year A.D. 1950. Seven bone and nine charcoal samples were dated by Geochron Laboratories Division, Krueger Enterprises, Inc., Cambridge, Massachusetts, under the supervision of Dr. H. Krueger. Age calculations are based upon the Libby half-life of 5,570-years for C-14 and are referenced to the year A.D. 1950. The pretreatment of the bone samples to obtain the necessary collagen gelatin, as discussed on the Geochron Laboratories dating reports, was as follows:

The insoluble residue from the bone apatite dissolution procedure was filtered and washed. It was then boiled in slightly acid distilled water to solubilize any collagen present. The broth was filtered through fiberglass and the filtrate was evaporated to dryness to recover collagen as bone gelatin. Rootlets, humic acids, and other contaminants would have been removed by the filter and discarded. The recovered bone gelatin was combusted and the carbon dioxide was recovered and used for the analysis.

Their pretreatment of the charcoal is slightly different and consisted of the following procedure.

The charcoal fragments were separated from any sand, silt, rootlets, or other foreign matter. The sample was then treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids and other organic contaminants. After washing and drying, the cleaned charcoal was combusted and the carbon dioxide was recovered for the analysis.

All of the Geochron Laboratories samples were counted in Sharp Low-Beta Counting Equipment, operated in anti-coincidence mode, using methane as a counting gas. Two counters have a nominal volume of 0.5 liter (0.25 g carbon), while two others have a nominal volume of 1.0 liter (1.0 g carbon at 1.0 atmosphere, or 2.0 g carbon at 2.0 atmosphere). Samples are normally counted under the optimum conditions indicated by the amount of carbon recovered from the sample. The recovered carbon varied from as high as 2 g to as low as 0.25 g from the bone samples, while the charcoal samples yielded 1.93 to 0.06 g of carbon. Samples yielding 1 to 2 g of carbon (GX-14416-G, GX-14417-G, GX-14418-G, GX-14419-G, GX-14422-G, and GX-14451) were counted for about 23 hours; those with between 0.25 to 1 g carbon (GX-14420-G, GX-14421-G, GX-14448, and GX-14453) were counted for ca. 46 hours; and those with less than 0.25 g carbon (GX-14447, GX-14449, GX-14450, and GX-14597) were counted for 66 hours (H. Krueger, personal communication 1989).

The sediment samples submitted to The University of Texas at Austin Radiocarbon Dating Laboratory were treated in the following manner:

Each sample was dried at 100°C, disaggregated, and spread over aluminum foil, and any visible rootlets were removed with tweezers. After sieving dry through 60-mesh screens, the rootlets and pebbles caught were discarded; this was repeated several times. Each sample was immersed in distilled [water] and stirred, and any floating rootlets were removed by decanting the liquid and/or skimming with a 100-mesh screen; this also was repeated. All material was passed through the 100-mesh screen, and anything less than 100-mesh was retained and treated with 0.2 N HCl, thus removing any intrusive carbonate. Each sample was boiled for an hour and digested overnight, ensuring carbonate removal. The HCl was cleared by distilled [water] and agitation. The sample was allowed to settle and the clear liquid decanted, immersed in 0.2 N NaOH solution, and boiled and digested.

The organic-soil residue was separated from the humic-acid fraction by filtering through a glass-fiber paper, with the organic residue retained and the humic-acid fraction collected in a vacuum flask. The organic residue was repeatedly reimmersed in 0.2 N NaOH and washed with distilled [water] until the humic-acid fraction was leached out. The residue was reacidified with 0.2 N HCl and boiled while the absorption of CO₂ from the atmosphere was prevented at the same time. HCl was removed and the same centrifuged, the liquid removed, and all was dried at 100°C. The humic-acid fraction was boiled to reduce its volume and acidified with concentrated HCl which precipitated the humic acid. This was allowed to settle and then was washed with distilled H₂O, centrifuged until the HCl cleared, and all dried at 100°C.

Both the organic residue and the humic-acid fraction were burned separately in a quartz-burning apparatus under a 1- μ m vacuum. Oxygen was passed through while being heated externally. Carbon dioxide and other gases were passed through a dry ice-acetone bath trap, heated in a copper oxide furnace, at 750°C, and scrubbed through four different solutions to remove any impurities.

CO₂ was reacted with lithium metal and the temperature raised from 500° to 1000°C, forming lithium carbide. This was hydrolyzed into acetylene. The acetylene was purified by screening through 19 N NaOH and through phosphoric acid, which was trimerized by a silicon-vanadium catalyst into benzene. The benzene was weighed in K-free vials. Liquid scintillation counting was performed by using Packard Tri-Carb Model 3002 and Beckman LS230 spectrometers for periods of 24 to 48 hr. [White and Valastro 1984:26, 28]

Results

It has long been known that a discrepancy exists between radiocarbon dates and calendric dates. Stuiver and Kra (1986) have presented a high resolution calibration curve for the period 9000 B.C. to A.D. 1950 based on tree ring dates. A computerized conversion process permits easy calibration, and the curve based on the 20-year record is used in presenting the Justiceburg Reservoir dates (Stuiver and Reimer 1986). Radiocarbon ages older than 9165 B.P. cannot be corrected using this calibration, however. A formula, $1.05 \times \text{C-14 age} + 470$ (Stuiver et al. 1986:971), is used for the three assays greater than 10,000 B.P. Problems also exist with dating very young samples as the amount of carbon in the atmosphere has undergone considerable change (Taylor 1987:35-38). Calibrations are provided where possible. Table 74 provides specific information on all of the radiocarbon samples, including 12 assays from the Phase I investigations (Blum 1989:88).

Discussion

The 41 radiocarbon results obtained to date indicate that the reservoir basin contains sediments dating as early as the late Pleistocene, ca. 14,600 years B.P. The three ages of 14,645, 13,647, and 11,831 B.P. from Geomorphic Locality 2 (GM-2) in the lower Grape Creek valley (Blum 1989:94-96) date a well-developed soil and a clay zone immediately above the soil. No cultural materials have been observed at this locality. Ten humate dates not associated with cultural remains span some 3,200 years between 4730 ± 70 B.P. and 1560 ± 50 B.P. Thirteen other dates associated with cultural materials span only the last 1,500 years. The oldest humate age associated with cultural materials, ca. 1400 B.P. (41GR303, Feature 7), plus a humate age of 1178 B.P. from 41GR303 and a charcoal date of 1070 B.P. from 41GR559, represent the early part of the Late Prehistoric period. Two charcoal samples, 720 and 759 B.P. from 41GR303 and 41GR559, document occupation during the middle part of the Late Prehistoric period. Six humate and charcoal samples from five sites represent the late portion of the Late Prehistoric period. These overlap the ages of the six bone collagen samples from the six faunal localities, which are restricted to the last 400 years.

THERMOLUMINESCENCE DATING

Most sites on the Southern Plains contain quantities of burned rocks, either in definable features or as scatters. If these materials could be dated, then they would provide a

valuable chronometric alternative to the sparse charcoal that occurs on many sites in the region. Because thermoluminescence dating has the potential to extract chronometric information from burned rocks, a pilot study of this technique was undertaken.

The principle of thermoluminescence dating centers on the release of light stored in the form of energy from an object after it was last heated. Small radioactive impurities (e.g., uranium and potassium) emit alpha, beta, and gamma radiation at specific rates that depend on the impurity content of the sample. Heating to ca. 450 °C (842 °F) causes the release of all stored energy, a zeroing effect, and then any accumulation of light energy after that point can be measured to arrive at an estimate of the elapsed time since heating. The thermoluminescence observed is a measure of the total dose of radiation to which an object has been subjected since that zeroing. The surrounding sediments contain these same radioactive particles and therefore must be accounted for, since gamma rays contribute significantly to the total dose rate of the nearby object. This necessitates the submission of small sediment samples retrieved adjacent to objects being dated to detect the natural dose rate.

Thermoluminescence dating has lacked widespread use in the New World and has concentrated on dating ceramics and Quaternary sediments (Aitken 1985). Burned rocks have not been used to a great extent for dating.

Laboratory Analysis

Thermoluminescence dating was performed by the TL Laboratory, Department of Archaeology, University of Durham, under the direction of Dr. Ian Bailiff. "Survey Dating" level procedures were recommended for this study of the Justiceburg Reservoir materials (Bailiff 1988:613-621). The Survey Test provides accuracy at a 68% level of confidence, which is the overall error based on the formulation given by Aitken (1985).

The TL Laboratory was provided with 26 burned rocks and 2 ceramic sherds, along with companion sediment samples, for thermoluminescence dating. Laboratory procedures included the following: (1) performing a dose plateau test to verify whether the cultural heating (called the zeroing event) was sufficient to erase all previously accrued radiation; (2) measuring the radioactivity level of the selected mineral and the companion sample; (3) selecting the mineral size fraction to be used; (4) assessing the burial depth (preferred to be greater than 50 cm below the surface); and (5) application of a correction process based upon the depth, the measured radioactivity of the burial medium, and thermoluminescence. Uncertainties about the various influences of the shallow burial depths of many samples and the correction process account for the high standard deviations.

Results

Table 75 presents the sample data, the results, and ages converted into years B.P. (1950) to enable comparison with Table 74. Eight samples were found to have unsatisfactory properties to allow age determinations; five are suspected to have insufficient heating, one is a carbonate rock, one has poor thermoluminescence characteristics, and one has insufficient thermoluminescence within the sample.

TABLE 74

RESULTS OF RADIOCARBON DATING

Lab No.	Provenience	Material	Uncorrected Age, B.P.	$\delta^{13}\text{C}$ Corrected Age, B.P.	$\delta^{13}\text{C}$ Value (ppt)	Calibrated Age, Intercepts, and 1-Sigma Range, B.P.
Tx-5758*	41GR484, Feature 1	charcoal	260 $\pm$ 70			431 (302) 0
Tx-5759*	BHT 5, 50 cm	humate	1750 $\pm$ 60			1730 (1697, 1646, 1635) 1578
Tx-5760*	41GR323, BHT 8, 140 cm	humate	810 $\pm$ 50			770 (720) 685
Tx-5761*	BHT 9, 140 cm	humate	4780 $\pm$ 60			5593 (5521, 5484) 5336
Tx-5762*	BHT 12, 50 cm	humate	520 $\pm$ 50			553 (536) 516
Tx-5763*	BHT 12, 130 cm	humate	860 $\pm$ 70			907 (768) 697
Tx-5764*	41GR568, BHT 13, 180 cm	humate	1910 $\pm$ 60			1929 (1868) 1815
Tx-5765*	41GR484, BHT 14, 100 cm	humate	1160 $\pm$ 60			1165 (1064) 989
Tx-5766*	41GR484, BHT 14, 150 cm	humate	1830 $\pm$ 70			1863 (1804, 1786) 1700
Tx-5767*	BHT 17, 50 cm	humate	740 $\pm$ 50			698 (680) 669
Tx-5796*	GM 2, 560-580 cm	humate	13,500 $\pm$ 280			14,645
Tx-5798*	GM 1, 90 cm	humate	4730 $\pm$ 70			5580 (5543, 5339) 5325
Tx-6222	41GR323, Feature 6	humate	130 $\pm$ 70	250 $\pm$ 70	-17.5	427 (299) 0
Tx-6223	BHT 16, 147-153 cm	humate	1580 $\pm$ 80	1690 $\pm$ 80	-17.9	1706 (1602, 1579) 1525
Tx-6224	BHT 16, 275-285 cm	humate	2570 $\pm$ 160	2650 $\pm$ 160	-19.9	2962 (2762) 2549
Tx-6225	BHT 22, 250-260 cm	humate	690 $\pm$ 110	770 $\pm$ 110	-19.4	780 (688) 660
Tx-6226	41KT53, BHT 25, 63-75 cm	humate	1100 $\pm$ 50	1280 $\pm$ 50	-15.0	1281 (1261) 1168
Tx-6227	41KT53, BHT 25, 160-175 cm	humate	2490 $\pm$ 70	2630 $\pm$ 70	-16.6	2788 (2756) 2742
Tx-6228	41KT151, BHT 30, 250-270 cm	humate	1990 $\pm$ 70	2090 $\pm$ 70	-18.3	2145 (2059) 1984
Tx-6229	BHT 40, 80-90 cm	humate	2620 $\pm$ 80	2770 $\pm$ 80	-15.4	2957 (2864) 2782
Tx-6230	BHT 65, 48-58 cm	humate	410 $\pm$ 60	510 $\pm$ 60	-19.2	552 (532) 510
Tx-6231	BHT 65, 205-215 cm	humate	1430 $\pm$ 50	1560 $\pm$ 60	-16.6	1526 (1487, 1420) 1395
Tx-6232	GM 2, 550-560 cm	humate	12,550 $\pm$ 940	12,670 $\pm$ 960	-16.6	13,647
Tx-6233	GM 2, 530-540 cm	humate	10,820 $\pm$ 180	10,960 $\pm$ 180	-17.0	11,831

*Dates obtained during Phase I (Blum 1989:88).

Table 74, continued

Lab No.	Provenience	Material	Uncorrected Age, B.P.	d13C Corrected Age, B.P.	d13C Value (ppt)	Calibrated Age, Intercepts, and 1-Sigma Range, B.P.
Tx-6294	41GR303, Feature 7	humate	1400 ± 60	1510 ± 60	-17.9	1504 (1396) 1340
Tx-6295	41GR303, Feature 8	humate	1150 ± 50	1250 ± 50	-18.6	1269 (1178) 1098
Tx-6296	41GR303, ET 91, 30-40 cm	humate	560 ± 70	700 ± 70	-16.7	688 (671) 575
GX-14416-G	41GR539, 141 cm	bison	*	205 ± 75	-9.7	770 (285) 0
		metatarsal				
GX-14417-G	41GR270, 75-87 cm	bison humerus	*	70 ± 110	-8.7	-
GX-14418-G	41GR249, 70 cm	bison radius	*	90 ± 115	-9.2	-
GX-14419-G	41KT69A, 33 cm	bison femur	*	<200	-9.8	-
GX-14420-G	41GR488, 114 cm	bison tibia	*	<200	-9.3	-
GX-14421-G	41KT69B, 12 cm	bison radius	*	<200	-8.6	-
GX-14422-G	41KT44, 78 cm	bison radius	152 ± 115	375 ± 115	-10.9	520 (473) 300
GX-14447	41GR546, Feature 2	charcoal	245 ± 210	275 ± 210	-23.4	1470 (307) 0
GX-14448	41GR559, Feature 3	charcoal	815 ± 190	855 ± 190	-22.7	960 (759) 660
GX-14449	41GR559, Feature 5	charcoal	1155 ± 210	1180 ± 210	-23.3	1300 (1070) 920
GX-14450	41KT52, Feature 1	charcoal	*	<200	-24.4	-
GX-14451	41KT53, Feature 1	charcoal	280 ± 80	295 ± 80	-24.2	473 (313) 288
GX-14452	41KT53, Feature 3	charcoal	-	too small	-	-
GX-14453	41KT53, Feature 4	charcoal	*	<200	-23.5	-
GX-14596	41GR515, Feature 2	charcoal	-	too small	-22.7	-
GX-14597	41GR303, Feature 5	charcoal	775 ± 195	810 ± 195	-22.9	930 (720) 568

*% modern >100

TABLE 75

RESULTS OF THERMOLUMINESCENCE DATING

Lab No.	Provenience	Material	Survey Date	Age B.P. (present = 1950)
Dur89TL 134-1	41GR287*, Feature 1	sandstone	suspected insufficient heating	-
Dur89TLqi 134-2BS	41GR287*, Feature 2	chert	1650 $\pm$ 730 B.C.	3600
Dur89TLqi 134-3AS	41GR291*, Feature 2	sandstone	3220 $\pm$ 1040 B.C.	5170
Dur89TLpfg 134-4AS	41GR303*, Feature 3	sandstone	4875 $\pm$ 1375 B.C.	6825
Dur89TLpfg 134-5AS	41GR303*, Feature 4	sandstone	4460 $\pm$ 1290 B.C.	6410
Dur89TL 134-6	41GR303*, Feature 7	sandstone	suspected insufficient heating	-
Dur89TLqi 134-7AS	41GR303*, Feature 8	sandstone	2200 $\pm$ 850 B.C.	4150
Dur89TLpfg 134-8AS	41GR359, Feature 2	chert	2790 $\pm$ 960 B.C.	4740
Dur89TLqi 134-9BS	41GR471*, Feature 1	sandstone	1360 $\pm$ 670 B.C.	3310
Dur89TL 134-10	41GR484*, Feature 2	sandstone	insufficient TL sample within material	-
Dur89TLqi 134-11BS	41KT33*, Feature 1	sandstone	2475 $\pm$ 895 B.C.	4425
Dur89TL 134-12	41KT33*, Feature 2	limestone	cannot date limestone	-
Dur89TLpfg 134-13BS	41KT53*, Feature 5	ceramic	A.D. 1805 $\pm$ 40	145
Dur89TLpfg 134-14BS	41KT53*, Feature 6	ceramic	A.D. 1770 $\pm$ 45	180
Dur89TL 135-1	41GR303*, Feature 5	sandstone	suspected insufficient heating	-
Dur89TLqi 135-2BS	41GR303, ET 91, 40 cm	chert	4100 $\pm$ 1200 B.C.	6050
Dur89TLpfg 135-3BS	41GR323*, Feature 6	sandstone	A.D. 110 $\pm$ 375	1840
Dur89TLqi 135-4BS	41GR323, Feature 7	sandstone	A.D. 470 $\pm$ 305	1480
Dur89TLpfg 135-5BS	41GR383*, Feature 2	sandstone	2645 $\pm$ 925 B.C.	4595
Dur89TLqi 135-6BS	41GR456*, Feature 3	sandstone	2545 $\pm$ 900 B.C.	4495
Dur89TLqi 135-7BS	41GR515, Feature 2	sandstone	1465 $\pm$ 690 B.C.	3415
Dur89TL 135-8	41GR546*, Feature 2	sandstone	suspected insufficient heating	-
Dur89TLpfg 135-9	41GR559*, Feature 5	sandstone	suspected insufficient heating	-
Dur89TLpfg 135-10AS	41GR559*, Feature 3	sandstone	A.D. 1470 $\pm$ 105	480
Dur89TLqi 135-11AS	41KT34*, Feature 1	sandstone	600 $\pm$ 520 B.C.	2550
Dur89TLqi 135-12BS	41KT49*, Feature 4	sandstone	A.D. 1125 $\pm$ 175	825
Dur89TL 135-13	41KT52*, Feature 1	sandstone	poor TL characteristics	-
Dur89TLqi 135-14AS	41KT53*, Feature 3	sandstone	850 $\pm$ 570 B.C.	2800

*Sample was also subjected to residue analysis (see Appendix G).

Discussion

The 20 dated thermoluminescence samples suggest human occupation in the reservoir basin over the last 6,900 years. As a group, these dates are much older than those obtained from the radiocarbon assays, especially if the two thermoluminescence dates on ceramics are excluded. The much greater mean age of the 18 burned rock thermoluminescence samples (3731 ± 1838 B.P.) compared to the 18 radiocarbon assays from cultural contexts (722 ± 490 B.P.) suggests substantial inconsistency between the two dating techniques. Although few paired samples were obtained, four sites did yield data allowing comparisons of radiocarbon and thermoluminescence dating (Table 76). At 41GR303, three thermoluminescence dates on burned rocks from feature and nonfeature contexts in Exploratory Trench 91 or Test Unit 1 are at least 5,000 years older than two radiocarbon dates on soil humates from these proveniences. The thermoluminescence date on rocks from Feature 8 at this site is ca. 2,950 years older than the humate radiocarbon date. At 41GR323, thermoluminescence dates on burned rocks from two roughly contemporaneous features in Test Unit 10 are ca. 1,200-1,550 years older than the radiocarbon date on soil humates from one of the features. A similar discrepancy occurs for the lower component at 41KT53, where the thermoluminescence date on burned rocks from Feature 3 is ca. 800 years older than the date suggested by two humate radiocarbon dates bracketing the cultural deposit. At only one site (41GR559) is the burned rock thermoluminescence date close to a radiocarbon date on charcoal from the same feature, and in this case the thermoluminescence date is ca. 300 years older than the radiocarbon date. In contrast to the assays on burned rocks, the two thermoluminescence dates on ceramics from 41KT53 are reasonably consistent with the two charcoal radiocarbon dates from comparable contexts, with all of the samples apparently dating to the last several hundred years (see Table 76).

Given the specific, as well as the general, disagreement between the thermoluminescence dates on burned rocks and the radiocarbon dates, it is surmised that one of the dating techniques, i.e., thermoluminescence dating of burned rocks, failed to yield reliable results. This conclusion is supported by the fact that the radiocarbon dates are consistent with the diagnostic artifacts recovered, as well as with the regional geomorphic data. In short, this technique appears to be of limited utility when applied to burned rock features in the project area. This is not the case with the ceramics, however. The samples submitted to date agree reasonably well with the radiocarbon dates and the known period of manufacture for these types. Thus, thermoluminescence dating of ceramics promises to be a useful chronometric tool in the Justiceburg Reservoir area.

TABLE 76
COMPARISON OF RADIOCARBON AND THERMOLUMINESCENCE DATES

	Calibrated Radiocarbon Age (Years B.P.)	Thermoluminescence Age (Years B.P.)
41GR303, ET 91/Test Unit 1	671 (30-40 cm)* 1396 (Feature 7, 101 cm)*	6050 (40 cm) 6825 (Feature 3, 30-60 cm) 6410 (Feature 4, 70-90 cm)
Test Unit 4	1178 (Feature 8, 80-95 cm)*	4150 (Feature 8, 80-95 cm)
41GR323, Test Unit 10	299 (Feature 6, 9-29 cm)*	1840 (Feature 6, 9-29 cm) 1480 (Feature 7, 9-29 cm)
41GR559, Test Unit 2	759 (Feature 3, 71-83 cm)	480 (Feature 3, 71-83 cm)
41KT53, upper component	200 (Feature 4, 18-25 cm) 313 (Feature 1, 13-47 cm)	145 (Feature 5, 10 cm)** 180 (Feature 6, 15 cm)**
lower component	1261 (BHT 25, 63-75 cm)* 2756 (BHT 25, 163-175 cm)*	2800 (Feature 3, 100-129 cm)

*Radiocarbon assays on soil humates; all others on charcoal.

**Thermoluminescence assays on ceramics; all others on burned rocks.

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APPENDIX D: Artifact Analysis

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and

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INTRODUCTION

The prehistoric artifacts recovered during the Phase II investigations are classed as chipped stones, battered stones, ground stones, other modified stone, ceramics, and burned rocks. The chipped, battered, and ground stones were analyzed and described by Tomka. The other modified stone (a pendant), ceramics, and burned rocks were analyzed and described by Boyd.

CHIPPED, BATTERED, AND GROUND STONES

This section describes and discusses the 3,520 chipped, battered, and ground stone artifacts recovered from 36 tested sites. Included are 23 projectile points, 52 bifaces, 1 perforator, 61 cobble tools, 164 unifaces, 110 cores, 203 edge-modified flakes, 35 hammerstones, 88 ground stone pieces, and 2,783 pieces of unmodified debitage (Table 77). A brief description of the objectives and methods of the analysis is followed by descriptions of the various artifact categories in general technological terms. A more specific discussion of three site groups, defined based on common temporal parameters, ends the chipped, battered, and ground stones section.

Objectives and Methods of the Analysis

The objectives of the chipped, battered, and ground stone artifact analysis were to (1) characterize the collection in technological and morphological terms, (2) define site use and function if possible, and (3) define temporal changes in lithic technology. To achieve the first objective, a large number of attributes were recorded for the various artifact categories. These attributes were chosen to describe the artifact in morphological terms and help define the stage of reduction and status or condition (Collins 1975) of the particular artifact. While all the tools were subjected to an equally comprehensive analysis, two levels of analysis were performed on the unmodified lithic debitage. The majority of the sites contained either mixed assemblages, were deflated and contained potentially mixed assemblages, or could not be assigned to temporal proveniences. The unmodified debitage from these sites received only limited analysis, consisting of the recording of four attributes. Eight sites could be assigned to one of three temporal units (late Archaic, Late Prehistoric I, and Late Prehistoric II), however. The debitage from these sites was the subject of a more extensive analysis consisting of the recording of eight attributes.

It was hoped that the analysis of the lithic tools and debitage from each site could provide clues to aid in understanding the use of the sites and their functions within the regional settlement pattern. The exploratory organic residue analysis coupled with high-powered microwear analysis on selected specimens have the potential to elucidate the types of activities carried out at the sites (see Appendixes E and G).

To investigate shifts in lithic reduction strategies and assemblage composition through time, all lithic artifacts were grouped into the above-mentioned three temporally defined categories. This was done primarily because the sample sizes for any particular

TABLE 77

LITHIC ARTIFACT CATEGORIES BY SITE

Sites	Arrow Points	Dart Points	Bifaces	Perforator	Cobble Tools	Unifaces	Cores	Edge- modified Debitage	Unmodified Debitage	Hammer- stones	Ground Stones	Totals
41GR207	-	-	-	-	-	1	-	4	30	1	-	36
41GR239	-	-	-	-	-	3	-	2	5	-	1	11
41GR286	-	-	-	-	-	-	-	-	10	1	-	11
41GR287	-	-	-	-	-	-	1	1	3	-	-	5
41GR291	4	1	9	-	7	19	8	17	311*	2	14**	392
41GR302	-	-	-	-	-	3	3	5	75	-	1	87
41GR303	-	-	7	1	11	30	22	38	486*	3	7	605
41GR323	1	-	1	-	3	5	4	15	124*	-	11	164
41GR327	-	-	1	-	1	6	6	5	30	7	-	56
41GR359	3	2	4	-	8	14	19	22	362	4	5	443
41GR374	-	-	-	-	-	-	1	3	5	-	-	9
41GR376	-	-	7	-	4	13	12	23	64	-	-	123
41GR378	-	-	-	-	-	-	-	1	4	-	-	5
41GR380	-	-	-	-	-	2	5	-	40	1	3	51
41GR381	-	-	2	-	2	4	3	3	22	2	1	39
41GR383	1	4	8	-	9	32	3	22	247	1	14	341
41GR456	1	1	3	-	2	5	2	9	170*	-	2	195
41GR467	-	-	-	-	-	-	-	-	13	-	-	13
41GR471	-	-	-	-	-	-	-	-	13*	-	9	22
41GR474	1	-	-	-	-	4	-	-	-	-	-	5
41GR483	-	-	-	-	-	-	-	-	1	-	-	1
41GR484	1	-	1	-	2	1	2	3	51	1	3	65
41GR512	-	-	-	-	-	-	-	-	1	-	-	1
41GR515	-	-	1	-	2	6	6	5	46	2	5	73
41GR539	-	-	-	-	-	-	-	-	1	-	-	1

Table 77, continued

Sites	Arrow Points	Dart Points	Bifaces	Perforator	Cobble Tools	Unifaces	Cores	Edge- modified Debitage	Unmodified Debitage	Hammer- stones	Ground Stones	Totals
41GR546	-	-	-	-	-	-	-	-	13*	-	-	13
41GR559	-	-	-	-	-	-	1	-	32*	2	-	35
41GR569	-	-	-	-	1	-	-	-	1	-	1	3
41KT33	-	2	2	-	7	7	4	11	198*	4	5	240
41KT34	-	-	5	-	1	4	3	6	103	3	2	127
41KT44	-	-	-	-	-	-	-	-	1	-	-	1
41KT49	-	1	-	-	1	2	2	4	79*	1	1	91
41KT51	-	-	-	-	-	3	-	2	65	-	-	70
41KT52	-	-	-	-	-	-	2	1	7*	-	1	11
41KT53	-	-	1	-	-	-	-	1	170*	-	2	174
41KT151	-	-	-	-	-	-	1	-	-	-	-	1
Totals:	12	11	52	1	61	164	110	203	2783	35	88	3520

*Includes microdebitage from flotation samples.

**Includes one ground kaolinite pendant.

site and any specific artifact type are not sufficiently large to permit meaningful patterns to be observed. It was hoped that the composition of the tool assemblages, in conjunction with debitage characteristics from sites of the same broad temporal units, could identify some similarities and differences in land-use practices through time.

Attribute Descriptions

The attributes recorded for the chipped, battered, and ground stone artifacts (Table 78) can be grouped under 17 headings: (1) raw material; (2) core characteristics; (3) nature of the core; (4) tool morphology; (5) fracture type; (6) manufacture problems; (7) size; (8) cortex characteristics; (9) working edge characteristics; (10) base, stem, and blade treatment; (11) reworking category; (12) heating category; (13) platform characteristics; (14) flake type; (15) dorsal scar count; (16) wear type; and (17) weight. Each of these groups consists of individual attributes. Brief descriptions of attribute definitions, the states that each attribute can assume, and the class of artifacts on which the attribute was recorded are given below. To retain consistency between research projects and to make results from different regions of Texas generally comparable, the same attributes and methods of recording were used as in an analysis of lithic materials from the Jewett Mine in east-central Texas (see Fields 1990).

Raw Material

Seventeen raw material types were defined following a preliminary inspection of the lithic artifacts from the project area. These are: (1) fine-grained Potter chert; (2) coarse-grained Potter chert; (3) fine-grained chert; (4) coarse-grained chert; (5) Ogallala quartzite; (6) unidentified quartzite; (7) milk white quartzite; (8) opalized caliche; (9) silicified wood; (10) miscellaneous; (11) Alibates agate; (12) Tecovas jasper; (13) non-local Cretaceous chert; (14) silicified caliche; (15) conglomerate quartzite; (16) sandstone; and (17) basalt.

Lithic resources of varying quality are abundant in the gravel deposits found on the uplands, canyon rims, and erosional remnants of the project area (Boyd 1989a:Fig. 23). A large portion of these Quaternary gravels are composed of pink, purple, and red quartzites derived from the Ogallala Formation. These materials range from small spherical pebbles to large elongated, and even flat biconvex, nodules. Small, milky to pure white quartzite pebbles also occur, but these may be derived from Triassic conglomerates (Boyd 1989a:126). Two other types of quartzites were identified in the archeological lithic collections, conglomerate quartzite and unidentified quartzite. The first appears to have formed from the metamorphosis of large quartzite crystals and has a highly lustrous appearance. The second is a very fine grained quartzite with grain sizes considerably smaller than those making up some of the fine-grained Potter chert specimens. Also contained in the Ogallala Formation are Potter chert nodules varying in diameter from ca. 8 cm to 20 cm or more. This material ranges in quality from extremely coarse nodules which can be split only with extreme force to very fine grained pieces which fracture relatively easily and predictably. Heat treatment improves the fracture quality of both types, but more improvement is seen in the fine-grained materials. Other less frequent lithic raw materials in the Quaternary gravels in the project area are silicified wood, opalized caliche, silicified caliche, and

TABLE 78

ATTRIBUTES RECORDED ON CHIPPED, BATTERED, AND GROUND STONE ARTIFACTS

Attribute Grouping/Artifact	Projectile Points	Bifaces	Perforators	Cobble Tools	Unifaces	Cores	Edge- modified Flakes	Unmodified Debitage	Hammer- stones	Ground Stones
RAW MATERIAL	X	X	X	X	X	X	X	X		X
CORE CHARACTERISTICS										
Core Type						X				
Removal Directionality						X				
No. of Platform Surfaces						X				
No. of Flake Removal Scars						X				
NATURE OF CORE										
Core Type	X	X								
Platform Remnant Type	X	X								
TOOL MORPHOLOGY										
Completeness	X	X			X					X
Outline Shape		X								
Transverse Cross Section	X	X								
Medial Ridge										X
FRACTURE TYPE	X	X								
MANUFACTURING PROBLEMS	X	X				X				
SIZE										
Maximum Length	X	X	X	X	X	X			X	X
Reconstructed Maximum Length	X									
Working Surface Maximum Length										X

Table 78, continued

Attribute Grouping/Artifact	Projectile Points	Bifaces	Perforators	Cobble Tools	Unifaces	Cores	Edge- modified Flakes	Unmodified Debitage	Hammer- stones	Ground Stones
Maximum Width		X	X	X	X	X			X	X
Working Surface Maximum Width										X
Maximum Thickness	X	X	X	X	X	X			X	X
Maximum Dimension Category							X	X		
Blade Length	X									
Blade Width	X									
Reconstructed Blade Width	X									
Base Width	X									
Reconstructed Base Width	X									
Neck Width	X									
Haft Length	X									
CORTEX CHARACTERISTICS										
Category					X					
Amount							X	X		
Presence/Absence								X		
Backing				X						
WORKING EDGE CHARACTERISTICS										
Flake Portion Modified					X					
Working Edge Location					X					
No. of Modified Edges							X			
Edge Shape					X		X			
Length of Edge Modification							X			
Edge Angle				X	X		X			
Face Angle					X		X			
Inferred Manner of Use							X			
BASE, STEM, AND BLADE TREATMENT	X									
REWORKING CATEGORY	X									

Table 78, continued

Attribute Grouping/Artifact	Projectile Points	Bifaces	Perforators	Cobble Tools	Unifaces	Cores	Edge- modified Flakes	Unmodified Debitage	Hammer- stones	Ground Stones
HEATING CATEGORY										
Nonheated	X	X	X		X	X	X	X		
Heated	X	X	X		X	X	X	X		
Heat Treated	X	X	X		X	X	X	X		
Indeterminate	X	X	X		X	X	X	X		
Stage Heated								X		
PLATFORM CHARACTERISTICS										
Cortex								X		
Grinding								X		
Faceting								X		
FLAKE TYPE					X		X	X		
DORSAL SCAR COUNT								X		
WEAR TYPE										
Polish										X
Grinding										X
Battering									X	X
Pecking										X
Macroscopic Striations									X	X
Microscopic Striations										X
Striation Directionality										X
Degree of Battering									X	
Wear Location									X	
Scar Count									X	X
Step Fracturing				X						
Edge Rounding				X						
WEIGHT									X	X

fine- and coarse-grained cherts. The coarse-grained cherts occur in the form of small (5-10 cm) lenticular nodules and range in color from dark gray to white or red. The fine-grained specimens also occur in the form of larger angular to globular pebbles. One specimen collected from the project area in Garza County is 14 cm long, although most specimens tend not to exceed 6 cm in maximum size. These cherts range in color from light gray to yellowish brown and darker gray, with all specimens encountered containing a variety of bands of lighter and darker colors. The large amount of swirling and banding, together with the lack of extremely fine grained, highly silicified materials, sets these specimens apart from the Cretaceous cherts. The latter are more highly silicified, are generally larger, and lack the swirling and narrow banding noted in the specimens collected from the project area. Also, the Cretaceous cherts contain dark brown, dark gray, and bluish gray colors that are not represented in specimens collected from within the project area. Alibates agate is mottled, multicolored, silicified dolomite originating in the Alibates Dolomite Lenticle of the Quartermaster Formation of Permian age. It occurs northeast of Amarillo and has a relatively limited, localized distribution. Tecovas jasper is somewhat similar to Alibates agate in broad visual characteristics. It originates from the Tecovas Formation of Triassic age. It is encountered in outcrops along the eastern escarpment from Quitaque to Palo Duro Canyon and northwest of Amarillo (Peterson 1988:90), but no outcrops of the Tecovas have been identified in the project area which is dominated by Triassic-age outcrops of the Trujillo Formation. Sandstone, a widely utilized raw material in the project area, occurs in abundance and forms the bluff edges in most of the reservoir area (Boyd 1989a:126). Triassic-age sandstones extend through a large portion of the region, including Palo Duro Canyon (Matthews 1969:23) and Mackenzie Reservoir (Hughes and Willey 1978:21). A dark gray to black, relatively coarse material is tentatively identified as basalt. Finally, any materials not falling within these types were grouped into a miscellaneous material category.

Based on the geomorphic history and the limited comparative collections of lithic raw materials from the project area, the following raw material types are considered to be local: (1) fine-grained Potter chert; (2) coarse-grained Potter chert; (3) Ogallala quartzite; (4) milk white quartzite; (5) fine-grained chert; (6) coarse-grained chert; (7) silicified wood; (8) opalized caliche; (9) silicified caliche; and (10) sandstone. The origins of the following material types are uncertain: (1) conglomerate quartzite; (2) basalt; (3) unidentified quartzite; and (4) miscellaneous materials. The following materials do not occur naturally in the project area: (1) Alibates agate; (2) Tecovas jasper; and (3) Cretaceous chert. Of these three, the Cretaceous cherts found to the south and southeast of the project area would be the closest sources, followed by the Tecovas jasper sources to the north and the Alibates agate source in the extreme northern part of the Texas Panhandle.

Core Characteristics

Four attributes are included in this group: (1) core type; (2) removal directionality; (3) number of platform surfaces; and (4) number of flake removals. Core type refers to the by-products of core reduction (flake, bipolar, or multipurpose), although the manner of core reduction is also considered. Flake removal directionality (unidirectional, bidirectional, opposed bidirectional, multidirectional, or indeterminate) was recorded to gauge the degree of systematic core reduction practiced by the prehistoric knappers. The number of platform surfaces refers to the surfaces of the core from which flake removals

were attempted. Three categories were distinguished: (1) corticate; (2) decorticate; and (3) total number of surfaces. The number of flake removals consists of the count of flake scars not resulting from platform crushing. Platform preparation scars 1-10 mm in length were excluded.

Nature of Core

Two attributes are included in this group: (1) core type; and (2) platform remnant type. Core type refers to the nature of the core used in the manufacture of bifacial artifacts (i.e., bifaces and projectile points). Three possible core types were defined: (1) cobble/pebble; (2) flake; and (3) indeterminate. The presence of cortex on both faces of a biface or unreduced corticate margins were considered indicative of cobble/pebble cores. Smaller bifaces with unreduced platform remnants and/or unreduced flake core ventral surface remnants are assumed to have been made from flake cores. Numerous bifacial artifacts that were substantially reduced and showed none of the characteristics described were classified as indeterminate core types. Platform remnant type refers to the presence or absence of a platform on projectile points made on flakes. It was recorded in three categories: (1) absent; (2) corticate; and (3) decorticate.

Tool Morphology

Four attributes are used to characterize tool morphology: (1) completeness; (2) outline shape; (3) transverse cross section; and (4) medial ridge. The completeness attribute is used to indicate complete specimens; proximal, medial, distal, and longitudinal fragments; triangular wedges; biface edges; and barbs. Completeness for tool categories other than bifaces and projectile points was recorded as simply complete or fragmentary. Outline shapes on bifacial artifacts were classified as (1) ovate, (2) triangular, (3) rounded, (4) bipointed, and (5) indeterminate. The following shape categories were utilized on ground stones and hammerstones: (1) rounded; (2) oval; (3) angular; (4) spherical; (5) ovate; (6) rectangular; and (7) unknown. The shape of incomplete specimens could be determined with certainty when only a small portion of the artifact was missing. Most fragments were classified as having indeterminate shapes. Three transverse cross-section categories were utilized in classifying bifacial artifacts: biconvex, planoconvex, and planoconcave. The following ground stone cross sections were recorded: (1) lenticular; (2) biconvex; (3) biconcave; (4) planoconvex; (5) planoconcave; (6) beveled; (7) tabular; and (8) indeterminate. The presence/absence of a medial ridge was recorded on ground stone specimens only. Such a ridge is the result of differential force distributions during the push and pull motions of the grinding stroke. The ridge is oriented perpendicular to the grinding motion and the striations indicative of use-wear.

Fracture Type

This attribute identifies the cause of fracture of incomplete specimens. Four types were distinguished: (1) use; (2) manufacture; (3) postdepositional; and (4) indeterminate. Some use-generated breaks and a large variety of manufacturing breaks have been reproduced

experimentally (Tomka 1986). Others are taken from studies of manufacture and use-generated tool failures (e.g., Muto 1971; Crabtree 1972; Callahan 1979; Johnson 1979, 1981; Odell and Cowan 1986). The diagnostic morphologies defined from these replications are the comparative bases used in identifying fracture causes on the archeological specimens. Break morphologies that share characteristics of more than one cause of fracture or were not experimentally replicated were assigned to an indeterminate category.

Manufacturing Problems

Six types of manufacturing problems were noted: (1) knots; (2) crushed edges; (3) hinge fractures; (4) coarse material inclusions; (5) old fracture lines; and (6) multiple problems. The presence of any of these problems on an artifact does not necessarily mean that the manufacturing process was abandoned due to the problem or that the artifact was not functional.

Size

Fourteen size measurements are included under this attribute: (1) maximum length; (2) reconstructed maximum length; (3) working surface maximum length; (4) maximum width; (5) working surface maximum width; (6) maximum thickness; (7) maximum dimension category; (8) blade length; (9) blade width; (10) reconstructed blade width; (11) base width; (12) reconstructed base width; (13) neck width; and (14) haft length. Maximum dimension categories consist of 10-mm-increment size classes ranging from 1-10 to 91-100 mm. Reconstructed maximum dimensions were recorded on incomplete specimens only when a small portion of the specimen was missing. Only measurements taken on complete specimens are used in the statistical manipulation of the data. Working surface length and width measurements were taken on complete ground stone specimens to calculate working surface area since differences exist between overall measurements and the extent of the working surface.

Cortex Characteristics

Four attributes were used to characterize the nature of cortex on lithic artifacts: (1) cortex category; (2) cortex amount; (3) cortex presence/absence; and (4) cortex backing. Cortex category was recorded as either primary, secondary, or tertiary. Cortex amount was recorded in 25% increments with the exception of the 0% and 100% groups. Cortex presence/absence is self-explanatory. The cortex backing attribute was recorded for cobble tools and is an indication of the character of the surface of the tool opposite the working edge.

Working Edge Characteristics

This group consists of eight attributes: (1) flake portion modified; (2) working edge location; (3) number of modified edges; (4) edge shape; (5) length of edge modification;

(6) edge angle; (7) face angle; and (8) inferred manner of use. The first and third attributes identify the location and number of modified edges on the artifact. On the other hand, working edge location refers to the edge of the tool employed as the work-performing surface. Edge shape refers to the shape of the working edge. The length of the edge modification is a measure of the extent of the working edge on an edge-modified flake. Edge angle measures the angle between the working edge and the ventral surface of the flake. Face angle, on a uniface, is the angle defined by the ventral and dorsal faces of the flake; on a bifacial artifact, it is the angle defined by the two faces. Edge and face angles are the same on edges employed in cutting or sawing tasks. The inferred manner of use, on the majority of the specimens, was determined by comparison with replicated use-wear on experimental tools in conjunction with diagnostic wear patterns described in the literature (Tringham et al. 1974; Keeley 1980; Yerkes 1987). The following use categories were identified: (1) cutting/sawing; (2) scraping; (3) multiple use (cutting/sawing and scraping); (4) boring; (5) engraving; and (6) indeterminate.

Base, Stem, and Blade Treatment

This attribute was recorded on projectile points. It has six values: (1) stem smoothing; (2) base smoothing; (3) blade beveling; (4) stem beveling; (5) serrating; and (6) base depth. The first five attributes were recorded as present or absent. Base depth measured in millimeters the concavity or convexity of a projectile point base. Concave bases received a positive number and convex bases a negative value, while the attribute was not recorded on straight bases.

Reworking Category

This attribute, recorded on projectile points as present/absent, gauges the degree of artifact maintenance. Two criteria were used to establish the presence of reworking on a specimen: (1) morphological asymmetry along the longitudinal or transverse cross section; and (2) changes in flake removal patterns along the length of the projectile point.

Heating Category

On all nondebitage lithic artifacts, as well as the less intensively analyseddebitage collections, heating was recorded as either present or absent. For the more intensively analyzeddebitage collections, this attribute was recorded as (1) nonheated, (2) heated, (3) heat treated, (4) indeterminate, and (5) stage heated (i.e., Collins and Fenwick 1974: 137).

To establish the potential to differentiate heat-treated from nonheated specimens, a limited series of heat treatment experiments was conducted. Fine-grained and coarse-grained Potter chert, Ogallala quartzite, and opalized caliche were subjected to 500° F temperatures for five hours in a gas oven. Examination of fresh flake scars on the thin specimens revealed the shine and luster characteristic of heat-treated specimens. The greatest degree of improvement was noticed in opalized caliche, followed by fine-grained

Potter chert. Some luster and a slight pinkish color change were also noted on coarse-grained Potter chert; however, the treatment did not improve substantially the flaking characteristics of the material. Because of the inherent luster of fresh surfaces on Ogallala quartzite specimens, no effects of heat treatment could be noted on these fragments.

Platform Characteristics

Three attributes were recorded to characterize striking platforms on unmodified lithic debitage: (1) cortex; (2) grinding; and (3) faceting. Cortex and grinding were recorded as either present or absent, while faceting refers to the number of platform facets.

Flake Type

Four flake types were distinguished: (1) complete; (2) proximal; (3) chip; and (4) chunk. Complete flakes retain both a striking platform and a feathered termination. Proximal fragments have only a platform. All medial and distal fragments were classified as chips. Angular debris lacking clear flake features was placed in the chunk category.

Dorsal Scar Count

This attribute identifies the number of flake removal scars on the dorsal surface of unmodified lithic debitage. Only flake scars that were not the secondary effect of platform crushing or platform preparation were included in the count.

Wear Type

The attributes in this group identify the type and degree of wear on ground stones, hammerstones, and cobble tools. The attributes are: (1) polish; (2) grinding; (3) battering; (4) pecking; (5) macroscopic striations; (6) microscopic striations; (7) striation directionality; (8) degree of battering; (9) wear location; (10) scar count; (11) step fracturing; and (12) edge rounding. The first seven of these attributes were recorded on ground stone artifacts only. Polish, grinding, battering, and pecking assumed the following values: (1) face one; (2) face two; (3) both faces; (4) margin(s); (5) ends; (6) face and margin; (7) ends and margin; and (8) absent. Only the presence or absence of macroscopic and microscopic striations was recorded. Striation directionality was recorded as (1) parallel to long axis, (2) perpendicular to long axis, (3) irregular, and (4) tangential to long axis. The degree of battering was recorded on hammerstones only; it consists of the following values: (1) slight; (2) moderate; (3) extensive; and (4) absent. The first category consists of battering covering an area of only 1 cm². Battering covering between 1-3 cm² was included in the second category, while battering over more than 3 cm² was considered extensive. Wear location describes the location of battering on a hammerstone: (1) end; (2) margin; (3) circumference; (4) face; and (5) combination. Scar count

was recorded on both the ground stone and hammerstone specimens. For the ground stones, it gauges the number of flake removals to shape the specimen or the flake removals from the specimen subsequent to a change in tool use (i.e., the use of a broken mano as a core). In the case of hammerstones, scar counts indicate the number of flake spalls from the working surface of the tool. These flake scars are unintentional removals and are assumed to indicate tool breakdown. Step fracturing is recorded on cobble tools and is indicative of the degree of working edge use in conjunction with the hardness of the worked material. It was recorded as a presence/absence attribute. Finally, edge rounding, also recorded only on cobble tools, is indicative of the degree of working edge wear. While some edge rounding similar to use-wear may result from platform preparation (i.e., of a core), the wear noted on these tool edges extends onto the two faces of the working edge. This distribution should not occur in the case of core platform preparation.

Weight

Weight was recorded to the nearest gram with an O'Hause Triple Beam Balance scale.

Artifact Descriptions

Phase II investigations at the 36 sites yielded 12 arrow points, 11 dart points, 52 bifaces, 1 perforator, 61 cobble tools, 164 unifaces, 110 cores, 203 pieces of edge-modified debitage, 35 hammerstones, 88 ground stones and 2,783 pieces of unmodified debitage. These categories are described below.

Arrow Points

Twelve arrow points were recovered from seven sites. Eight of these are from the surface, while the other four are from excavation units. Only two are complete, while five are proximal, one is medial, and three are distal fragments; one arrow point barb also was recovered. Ten specimens are of fine-grained chert, one is of Tecovas jasper, and one is of Cretaceous fine-grained chert. Only two specimens made of local fine-grained chert have been heat treated. Base and stem smoothing is absent on all complete specimens and proximal fragments. Similarly, none has a beveled blade or stem. Only two have serrated blades. No point exhibits a platform remnant, although two specimens retain a large portion of the bulb of percussion. Eight specimens have biconvex transverse cross sections; only three have planoconvex cross sections. Manufacturing problems in the form of unthinned knots are evident on 3 of the 12 points. The blade portions of three specimens appear to have been reworked. Seven fragments exhibit use-generated fractures. Two other points were broken in manufacture, and one specimen has an indeterminate fracture. Three of the use-broken arrow points are proximal fragments, possibly returned to the camp in shafts for retooling. The three distal fragments and single medial fragment with use breaks may have been incidentally returned to the camp inside kills or may have been broken accidentally at the camp. Four specimens are typed, five are untyped, and three are untypable distal fragments.

DEADMAN'S

The single specimen of this type, from 41GR291, is a distinctive barb fragment made of mottled yellowish brown Tecovas jasper. It is a narrow (7 mm) and thin (3 mm) barb which broke at the juncture of the neck and blade. The cause of the break cannot be determined. The barb is 17 mm long and recurves longitudinally toward the base of the point. This trait is characteristic of the Deadman's points recovered at Deadman's Shelter in Mackenzie Reservoir (Willey and Hughes 1978:Fig. 55).

GRANBURY

Two proximal fragments are classified as Granbury (Jelks 1962). Both are manufactured on locally available fine-grained chert flakes which still retain a portion of the untouched ventral surface of the parent flake. The two points have moderately convex bases lacking sharp angles at the basal corners. The blades are straight to slightly concave, and one specimen retains a portion of the unreduced bulb of percussion.

The more complete specimen (Fig. 66a), from 41GR383, has a reconstructed maximum length of 24 mm (actual length = 22 mm), a maximum width of 16 mm, and a maximum thickness of 4 mm. The second specimen, from 41GR359, is more fragmentary and has a maximum width of 19 mm, a maximum thickness of 5 mm, and a present length of 20 mm. The breaks on both specimens were generated during manufacture. This raises the possibility that the two specimens are preforms broken in manufacture as opposed to finished points. The two specimens are similar to the parker variety of the Granbury type found at the Kyle Site (Jelks 1962:Fig. 14) and at the Pecan Springs Site (Sorrow 1966:Fig. 13). Jelks (1962:79) encountered this variety primarily in the Austin Phase levels, together with Alba, Scallorn, and Young specimens. At the Pecan Springs Site, the type appears to co-occur with Alba, Bonham, Cuney, and Fresno arrow points (Sorrow 1966:Table 1). Granbury-like points recovered from Stratum 1 at 34GR51 in southwestern Oklahoma date to ca. A.D. 1430, much later than their occurrence at the Kyle Site (Leonhardy 1966:62).

SCALLORN

A single proximal fragment, from 41GR291, of locally available fine-grained chert is typed as Scallorn (Fig. 66b). It has a slightly expanding stem generated by corner notches. The barbs are moderate and slant downward. The blade edges are straight and regularly serrated. The base is straight and has a wedge-shaped longitudinal cross section. The fracture of the distal end appears to have been use generated. The specimen has an estimated length of 35 mm (actual length = 30 mm), a maximum blade width of 15 mm, and a maximum thickness of 4 mm. The haft is 7 mm long and has a base width of 9 mm and a neck width of 7 mm. The arrow point is similar in stem and base morphology to the coryell variety Scallorn points recovered from the Kyle Site (Jelks 1962:Fig. 13).

EXPANDING STEM, STRAIGHT BASE

Three expanding-stem, straight-base specimens were recovered. One is a complete arrow point, while two are proximal fragments. All are made of locally available fine-grained chert. The complete arrow point, from 41GR359, is a corner-notched specimen that appears

Figure 66. Chipped stone artifacts. (a) Granbury arrow point, 41GR383; (b) Scallorn arrow point, 41GR291; (c) expanding-stem, straight-based arrow point, 41GR291; (d) untyped medial arrow point fragment, 41GR291; (e) Marcos dart point, 41KT49; (f) perforator, 41GR303; (g) biface, 41KT53; (h) biface, 41KT34.

to have been side notched subsequent to blade reworking. The reworking substantially reduced the size of the barbs and generated a longitudinally asymmetrical blade outline. The stem is moderately expanding, and the base is straight and wedge shaped. The parent flake appears to have been heat treated. The point has a maximum length of 28 mm, a blade width of 11 mm, a reconstructed blade width of 14 mm, a base width of 13 mm, and a neck width of 9 mm. The haft is 7 mm long, and the specimen has a maximum thickness of 5 mm.

The larger of the proximal fragments, also from 41GR359, has cortex on one face and retains much of the ventral surface and bulb of percussion of the parent flake. It has relatively shallow corner notches and a straight base. The long blade is only slightly retouched, and the blade edges are convex. The striking platform of the parent flake seems to have been lateral to the proximal end of the point. Maximum length is 34 mm, reconstructed length is 39 mm, blade width is 15 mm, and base width is 10 mm. Neck width is 8 mm, haft length is 7 mm, and maximum thickness is 4 mm.

The third specimen, from 41GR291, is a small point with fractures on the distal end and stem barbs (Fig. 66c). The remainder of the stem indicates a strongly expanding, corner-notched stem and a straight to perhaps slightly concave base. The blade barbs are moderate to pronounced, and the relatively short blade edges are straight. The fracture morphologies are characteristic of use-generated failures. The distal end of the remaining blade has been reworked, suggesting that the blade and stem barb fractures derived from two distinct use episodes. The maximum length is 21 mm, the reconstructed length is 26 mm, and the blade width is 14 mm. The neck is 5 mm wide, the haft is 5 mm long, and the point is 4 mm thick.

These arrow points cannot be typed due to the degree of blade reworking on the complete specimen, the relatively little retouch in manufacturing the larger proximal fragment, and the broken nature of the smaller fragment. The points are similar in stem and base morphology to two untyped specimens from the County Line Site (Hughes and Willey 1978: Fig. 40c, d). Since the single Scallorn point recovered in the project area is from the same site as the smaller of the expanding-stem points and the stem forms are similar to those of Scallorn points from the Kyle Site (Jelks 1962), it is possible that these three points are Scallorns.

PARALLEL STEM, STRAIGHT BASE

A single complete arrow point made of fine-grained chert was recovered from 41GR474. The stem is relatively broad (8 mm) with rounded basal corners; the base is straight. One of the blade barbs was broken and subsequently reworked. The other barb is prominent and slightly downward slanting. The blade is triangular, and its straight edges exhibit considerable reworking. Some of the reworking flakes terminate in step fractures forming a small knot just above the neck of the projectile point. This specimen has been heat treated. It has a maximum length of 33 mm, a maximum blade width of 16 mm, and a reconstructed blade width of 19 mm. The haft is 11 mm long, and the maximum thickness is 5 mm.

The stem/base morphology is similar to Alba points recovered from the Kyle Site (Jelks 1962:Fig. 14). At that site, one of the two Albas was recovered from the Austin Phase levels while the second came from an intermediate zone between the Austin Phase and Toyah Phase materials.

UNTYPABLE FRAGMENTS

One medial and three distal fragments constitute this group. The medial fragment and two of the distal specimens are made of locally available fine-grained chert, while the third distal fragment is of Cretaceous chert. The medial specimen, from 41GR291, is a narrow, highly and regularly serrated blade fragment (Fig. 66d). The distal end break and the fracture of the stem at the neck are use related. The length of the fragment is 31 mm; it has a maximum blade width of 11 mm, a neck width of 4 mm, and a maximum thickness of 4 mm.

The larger of the distal fragments, from 41GR484, is a finely pressure flaked blade segment exhibiting a short burinlike scar originating from the tip and a use-related blade fracture. A portion of the ventral surface of the parent flake is visible on one face of the specimen. The fragment measures 15 mm in length. The second distal fragment, from

41GR456, measures only 10 mm in length and exhibits use-generated fractures. The third specimen, from 41GR323, is a short (15 mm) blade fragment broken at the juncture of the neck and blade. The break face has been reworked, making the specimen potentially reusable. Maximum blade width measures 13 mm, and both faces retain unretouched parent flake surfaces. It is 2 mm at its maximum thickness.

Dart Points

Eleven dart points and fragments were recovered from six sites. Eight were recovered from the surface, and three are from excavation units. Only two are complete, six are proximal, and three are medial fragments. Ten specimens are of locally available fine-grained chert, and a single medial fragment is of Cretaceous chert. Two have been heat treated, and an additional fragment has either been extensively heat treated or has suffered substantial postabandonment heat damage. Two proximal fragments exhibit substantial stem and base smoothing. Blade and stem beveling and serrations are not present on any of the dart points. None have platform remnants, but one proximal fragment retains a large portion of the ventral surface of the parent flake. This is the only specimen for which the nature of the core could be established. The projectile point made on this flake core has a planoconvex cross section, while the other 10 have biconvex cross sections. Manufacturing problems in the form of step and hinge fractures and collapsed platforms are present on three items. Reworking of the blade and/or blade barbs occurs on five dart points. Four of the nine fragments have use-generated fractures, one was broken in manufacture, and the fracture type could not be determined with certainty on the four remaining fragments. Three of the four use-broken specimens are proximal fragments, and the fourth is a medial segment. The single dart point broken in manufacture is also a proximal fragment. As in the case of the arrow point fragments, the frequencies of the break types on the dart point fragments seem to indicate a preponderance of hunting activities. Only one dart point, an expanding-stem, straight-based specimen, is typed. Two additional expanding-stem, straight-based specimens were recovered, together with three expanding-stem, concave-based and two expanding-stem, convex-based dart points. The remaining three are untypable medial fragments.

MARCOS

One expanding-stem, corner-notched specimen, from 41KT49, of locally available fine-grained chert has been typed as Marcos (Fig. 66e) (Suhm and Jelks 1962:209). The specimen has a broadly expanding stem formed by relatively shallow corner notches. The base is straight and basally thinned by a series of short pressure flakes which do not extend more than 9 mm beyond the base. The remaining blade segment (20 mm) is heavily retouched. It is probable that the projectile point was reworked into a drill which subsequently broke in use. The width of the base is 24 mm, the neck width is 18 mm, and the haft length is 12 mm. The maximum width of the reworked blade is 32 mm, and the point is 6 mm thick. The specimen is similar in stem and base morphology to points recovered from Fate Bell Shelter (Suhm and Jelks 1962:Plate 105a, b), as well as Marcos points recovered from Arenosa Shelter (Dibble 1967:Fig. 16a-c).

EXPANDING STEM, CONCAVE BASE

Three untyped specimens are in this group. All are of locally available fine-grained cherts. Two are complete, while the third is a proximal fragment with only a small portion of the distal end missing. One of the complete points, from 41KT33, and the proximal fragment, from 41GR359, have short (16-17 mm) but broad (19-18 mm) blades and shallow corner notches and small shoulders. The base (27 mm) on the proximal fragment expands beyond the maximum width of the blade (16 mm), while the two measures are equal (17 mm) on the complete specimen. The base is moderately concave on the proximal fragment and strongly concave to notched on the complete point. Similarly, the proximal specimen has a ground stem and base, while the complete point does not exhibit this trait. The blade edges on the proximal fragment and the complete specimen are straight to slightly convex. The two points are 6 and 7 mm thick.

The third point in this group, a complete specimen from 41GR383, has a narrow blade (16 mm) and base (14 mm) and relatively wide corner to side notches. The shoulders are moderate and upward slanting. This point has only a slightly concave base. It lacks stem and base grinding. Maximum neck width is 10 mm, and maximum thickness is 5 mm.

Based on stem and base form, it appears that each of these three points represents a distinct form. The other alternative is that the proximal fragment and the complete point from 41GR383 are variants of the same form and the complete point from 41KT33 is a distinct form. No typological affiliation can be suggested for these points.

EXPANDING STEM, CONVEX BASE

Two proximal fragments made of locally available fine-grained cherts are in this category. Both have moderately deep corner-notched stems. One, from 41KT33, consists of only the stem, while the second, from 41GR291, is missing a large portion of the blade. The stem fragment is moderately expanding and exhibits considerable base and stem smoothing. The break is an impact fracture. The maximum width of the base is 19 mm, while the neck is 12 mm wide. Some base thinning in the form of small (3 mm) regular pressure flakes is evident on both faces of the point. The maximum thickness of the point, at the neck break, is 5 mm. The second specimen is made on a flake core and exhibits only shallow marginal retouch along its ventral surface. Apparently, however, the point was functional given the impact-generated breaks noted on the stem and barbs. The expedient nature of the specimen is surprising since most dart points are viewed as relatively labor intensive and highly curated. The maximum width of the base is 18 mm, and the neck is 16 mm wide. The maximum thickness of the point is 5 mm. No typological assignment can be made for either point.

EXPANDING STEM, STRAIGHT BASE

Two proximal fragments with broad and slightly expanding stems are in this category. Both are made on locally available fine-grained cherts. The larger fragment, from 41GR359, retains a large portion of impact-fractured blade. The break face was subsequently unifacially reworked. The stem and blade barbs were broken as a result of impact, and the blade barbs have been reworked. The stem is slightly convex as a result of at least two episodes of reworking. Only the neck width can be obtained; it measures 18 mm. The specimen is 8 mm thick. The blade of the shorter proximal fragment, from 41GR383, is broken

tangentially to the long axis of the point; only one reworked blade barb is present. The break morphology could not be identified with certainty, although it appears to represent a postdepositional fracture. The base is broad (24 mm), and the neck is only slightly narrower (23 mm). The maximum thickness of the fragment is 9 mm. Reworking is not evident. The two specimens are too fragmentary to permit typological classification.

UNTYPABLE FRAGMENTS

Three medial fragments are in this group. One fine-grained chert specimen, from 41GR456, is heavily heat damaged and permits no further observations. The second medial fragment, from 41GR383, is of Cretaceous chert, but the cause of breakage cannot be identified. The third fragment, from 41GR383, is missing a small portion of the tip, broken as a result of impact. The break on the proximal end of the blade appears to have been generated postdepositionally. The fragment is 19 mm long and has a maximum thickness of 7 mm. All three appear to have been finished artifacts, and it is possible that they represent curated proximal specimens which were discarded or lost and broken in a depositional context.

Perforator

One specimen, manufactured of locally available, nonheated, fine-grained chert, is in this tool category; it is from 41GR303. It is a 58-mm-long, bifacially flaked blade fragment (Fig. 66f). The blade is 2 mm wide near the tip and 14 mm wide at the proximal end break. The break appears to have been use generated. The two edges of the diamond-cross-sectioned blade exhibit significant rounding extending 37 mm from the tip. The blade reaches a maximum thickness of 7 mm near the proximal break. It is not possible to establish whether the specimen was a large projectile point reworked into a drill or if it was specifically manufactured as a drill. The fragment does not allow the reconstruction of base morphology, and it is not known if the specimen was hafted.

Bifaces

Fifty-two complete (Fig. 66g) and fragmentary (Fig. 66h) bifaces were recovered from 14 sites (Table 79). Forty specimens (77%) were recovered from the surface; the remainder (23%) are subsurface finds. The twenty complete bifaces (38%) outnumber each of the fragment types. Distal fragments account for 19% of the collection, followed by proximal and medial fragments with 13% each. Edges and longitudinally split fragments are the next most abundant categories, making up 6% each. Only two wedges (4%) were recovered. Fine-grained chert obtained in the project area is the dominant raw material employed in biface manufacture. Thirty-four of the bifaces (65%) are made of this material. Seven (13%) are made of nonlocal Cretaceous fine-grained chert. Fine-grained Potter chert was used in the manufacture of five specimens (10%), while only three bifaces (6%) are made of opalized caliche. Three material types--coarse-grained Potter chert, Ogallala quartzite, and Tecovas jasper--are represented by only one specimen (2%) each.

TABLE 79

BIFACE ATTRIBUTES BY RAW MATERIAL TYPE

Attributes	Fine-grained Potter Chert		Coarse-grained Potter Chert		Fine-grained Chert		Ogallala Quartzite		Opalized Caliche		Tecovas Jasper		Cretaceous Chert		Totals
	#	%	#	%	#	%	#	%	#	%	#	#	#	%	
SITE															
41GR291	-	-	1	11	7	78	-	-	-	-	-	-	1	11	9
41GR303	1	14	-	-	5	71	-	-	1	14	-	-	-	-	7
41GR323	-	-	-	-	-	-	-	-	-	-	-	-	1	100	1
41GR327	-	-	-	-	-	-	-	-	-	-	-	-	1	100	1
41GR359	2	50	-	-	-	-	-	-	2	50	-	-	-	-	4
41GR376	1	14	-	-	3	43	-	-	-	-	1	14	2	29	7
41GR381	-	-	-	-	2	100	-	-	-	-	-	-	-	-	2
41GR383	1	13	-	-	6	75	1	13	-	-	-	-	-	-	8
41GR456	-	-	-	-	3	100	-	-	-	-	-	-	-	-	3
41GR484	-	-	-	-	1	100	-	-	-	-	-	-	-	-	1
41GR515	-	-	-	-	1	100	-	-	-	-	-	-	-	-	1
41KT33	-	-	-	-	2	100	-	-	-	-	-	-	-	-	2
41KT34	-	-	-	-	4	80	-	-	-	-	-	-	1	20	5
41KT53	-	-	-	-	-	-	-	-	-	-	-	-	1	100	1
Totals:	5	10	1	2	34	65	1	2	3	6	1	2	7	13	52
PROVENIENCE															
Surface	5	13	-	-	24	60	1	3	3	8	1	3	6	15	40
Subsurface	-	-	1	8	10	83	-	-	-	-	-	-	1	8	12
Totals:	5	10	1	2	34	65	1	2	3	6	1	2	7	13	52
COMPLETENESS															
Complete	4	20	-	-	12	60	1	5	1	5	-	-	2	10	20
Proximal	-	-	-	-	6	86	-	-	-	-	-	-	1	14	7

Table 79, continued

Attributes	Fine-grained Potter Chert		Coarse-grained Potter Chert		Fine-grained Chert		Ogallala Quartzite		Opalized Caliche		Tecovas Jasper		Cretaceous Chert		Totals
	#	%	#	%	#	%	#	%	#	%	#	#	#	%	
Medial	1	14	-	-	2	29	-	-	1	14	1	14	2	29	7
Distal	-	-	1	10	7	70	-	-	1	10	-	-	1	10	10
Wedge	-	-	-	-	2	100	-	-	-	-	-	-	-	-	2
Edge	-	-	-	-	2	67	-	-	-	-	-	-	1	33	3
Longitudinal	-	-	-	-	3	100	-	-	-	-	-	-	-	-	3
Totals:	5	10	1	2	34	65	1	2	3	6	1	2	7	13	52
HEATING															
Heated	4	21	1	5	8	42	-	-	3	16	-	-	3	16	19
Not heated	1	4	-	-	22	85	-	-	-	-	1	4	2	8	26
Indeterminate	-	-	-	-	4	57	1	14	-	-	-	-	2	29	7
Totals:	5	10	1	2	34	65	1	2	3	6	1	2	7	13	52
BIFACE SHAPE															
Ovate	3	25	-	-	6	50	1	8	-	-	-	-	2	17	12
Triangular	-	-	-	-	1	100	-	-	-	-	-	-	-	-	1
Rounded	1	25	-	-	3	75	-	-	-	-	-	-	-	-	4
Lanceolate	-	-	-	-	6	75	-	-	-	-	-	-	2	25	8
Indeterminate	1	4	1	4	18	67	-	-	3	11	1	4	3	11	27
Totals:	5	10	1	2	34	65	1	2	3	6	1	2	7	13	52
TRANSVERSE CROSS SECTION															
Biconvex	4	13	1	3	19	61	1	3	1	3	1	3	4	13	31
Planoconvex	-	-	-	-	9	64	-	-	2	14	-	-	3	21	14
Tabular	1	14	-	-	6	86	-	-	-	-	-	-	-	-	7
Totals:	5	10	1	2	34	65	1	2	3	6	1	2	7	13	52
NATURE OF CORE															
Cobble/pebble	2	18	-	-	9	82	-	-	-	-	-	-	-	-	11
Flake	-	-	-	-	1	50	1	50	-	-	-	-	-	-	2

Table 79, continued

Attributes	Fine-grained Potter Chert		Coarse-grained Potter Chert		Fine-grained Chert		Ogallala Quartzite		Opalized Caliche		Tecovas Jasper		Cretaceous Chert		Totals
	#	%	#	%	#	%	#	%	#	%	#	#	#	%	
Indeterminate	<u>3</u>	<u>8</u>	<u>1</u>	<u>3</u>	<u>24</u>	<u>62</u>	-	-	<u>3</u>	<u>8</u>	<u>1</u>	<u>3</u>	<u>7</u>	<u>18</u>	<u>39</u>
Totals:	5	10	1	2	34	65	1	2	3	6	1	2	7	13	52
MANUFACTURING PROBLEMS															
Knot	1	17	-	-	4	67	-	-	-	-	-	-	1	17	6
Coarse material inclusions	-	-	-	-	3	75	-	-	1	25	-	-	-	-	4
Multiple	2	33	1	17	3	50	-	-	-	-	-	-	-	-	6
Absent	<u>2</u>	<u>6</u>	<u>-</u>	<u>-</u>	<u>24</u>	<u>67</u>	<u>1</u>	<u>3</u>	<u>2</u>	<u>6</u>	<u>1</u>	<u>3</u>	<u>6</u>	<u>17</u>	<u>36</u>
Totals:	5	10	1	2	34	65	1	2	3	6	1	2	7	13	52
FRACTURE TYPE															
Use	-	-	-	-	5	63	-	-	1	13	-	-	2	25	8
Manufacture	1	6	1	6	12	71	-	-	1	6	-	-	2	12	17
Indeterminate	-	-	-	-	5	67	-	-	-	-	1	17	1	17	7
Absent	<u>4</u>	<u>19</u>	<u>-</u>	<u>-</u>	<u>12</u>	<u>62</u>	<u>1</u>	<u>5</u>	<u>1</u>	<u>5</u>	<u>-</u>	<u>-</u>	<u>2</u>	<u>10</u>	<u>20</u>
Totals:	5	10	1	2	34	65	1	2	3	6	1	2	7	13	52
MAXIMUM LENGTH (mm)															
Mean	58.0		-		47.4		49.0		43.0		-		52.5		
Standard deviation	10.4		-		16.9		-		-		-		6.4		
Minimum	44		-		28		-		-		-		48		
Maximum	69		-		95		-		-		-		57		
MAXIMUM WIDTH (mm)															
Mean	40.0		-		34.9		44.0		34.0		-		39.5		
Standard deviation	3.8		-		18.6		-		-		-		0.7		
Minimum	35		-		18		-		-		-		39		
Maximum	43		-		77		-		-		-		40		

Table 79, continued

Table 77, continued

Attributes	Fine-grained Potter Chert		Coarse-grained Potter Chert		Fine-grained Chert		Ogallala Quartzite		Opalized Caliche		Tecovas Jasper		Cretaceous Chert		Totals
	#	%	#	%	#	%	#	%	#	%	#	#	#	%	
MAXIMUM THICKNESS (mm)															
Mean	18.3		-		14.1		13.0		11.0		-			12.0	
Standard deviation	2.9		-		6.7		-		-		-			7.1	
Minimum	16		-		7		-		-		-			7	
Maximum	22		-		30		-		-		-			17	
EDGE ANGLE (°)															
Mean	64.8		-		63.0		68.0		39.0		-			51.0	
Standard deviation	11.2		-		10.2		-		-		-			18.4	
Minimum	55		-		48		-		-		-			38	
Maximum	80		-		78		-		-		-			64	

Noncultural gravels from the eastern (41GR327) and western (41GR381) ends of the project area were sampled for a comparative collection of naturally occurring raw materials. Considering only specimens greater than 5 cm in diameter, it is evident that quartzite and fine-grained chert predominate at one location, while quartzite, Potter chert, and fine-grained chert predominate at the other (Table 80).

TABLE 80
RAW MATERIAL TYPES FROM NONCULTURAL GRAVELS AT 41GR327 AND 41GR381

Raw Material Type	41GR327		41GR381	
	#	%	#	%
Quartzite	17	42	14	44
Fine-grained chert	17	42	6	19
Limestone	5	12	4	12
Potter chert	1	2	8	25
Unidentified	<u>1</u>	<u>2</u>	<u>-</u>	<u>-</u>
Totals:	41	100	32	100

Comparing these relative frequencies with the percentages of raw materials employed in the manufacture of the 52 bifaces shows a clear selection of the locally available, fine-grained chert sources over all other material types. Furthermore, the second most frequently used raw material is the nonlocal Cretaceous fine-grained chert. In total, 79% of the bifaces are made of the highest quality raw materials available.

The selection of these fine-grained cherts may be a product of at least two interacting goals: (1) the relative ease of manufacturing a biface (to completion) from fine-grained materials as opposed to coarse-grained materials; and (2) the reduced role of material grain size in the function of bifacial artifacts (i.e., cutting tools). The first question is addressed in discussing the rate of manufacturing problems and the second one in comparing the rate of raw material types used in the different tool categories. Twenty-six of the bifaces (50%) have neither been heated nor heat treated. Nineteen specimens (37%) have been heat treated, and heating could not be determined on seven items (13%). The goals of heat treatment (i.e., improvement of material quality) can be clearly seen in the frequency with which different material types were heat treated. For example, five of the six Potter chert bifaces (83%) were heat treated. All three of the opalized caliche bifaces (100%) were heat treated. On the other hand, only 8 of the 30 fine-grained chert specimens for which heating could be determined (27%) were heat treated. The general pattern is that the coarser grained materials tend to exhibit higher frequencies of heat treating.

Shape could be determined on only 25 of the 52 bifaces (48%). Twelve specimens (23%) are ovate shaped, 8 (15%) are lanceolate, 4 (8%) are rounded, and a single specimen (2%) is triangular. The majority (60%) have biconvex transverse cross sections. Fourteen (27%) are planoconvex, and only 7 (13%) are tabular in transverse cross section. Given that the majority of the bifaces passed through the initial edging stage (see Callahan 1979:18), the

nature of the core used can be determined on only a few specimens. Cobble/pebble cores were used in manufacturing 11 bifaces (21%), and 2 items (4%) were made on flake cores. The nature of the core used could not be determined for the remaining 39 bifaces (75%). Manufacturing problems were noted on 16 bifaces (31%). Six of these (38%) exhibit unthinned knots generated by hinge and/or step-fractured sequential flake removals. Another 6 (38%) have multiple manufacturing problems in the form of step and hinge fractures, crushed edges, and coarse material inclusions. The termination of biface reduction due to coarse material inclusions was noted on 4 of the 16 bifaces (25%). Some correlation exists between the quality of the raw material and the frequency of manufacturing problems. For example, four of six Potter chert (fine and coarse grained) bifaces (67%) have manufacturing problems. On the other hand, only 11 of 41 fine-grained local and nonlocal chert specimens (27%) exhibit manufacturing problems. Fracture cause could be determined on only 25 of the 32 incomplete bifaces (78%). Use-generated snap fractures account for 8 of these specimens (25%), while 17 bifaces (53%) were broken in manufacture. Based on the fracture analysis, it appears that only 8 of the incomplete bifaces (15%) are finished, while the remaining 44 specimens (85%) are unfinished or were broken prior to completion.

Assuming that biface thickness and edge angle correlate with reduction stage (see Callahan 1979 and Amick 1986), it is possible to gauge when during reduction the bifaces tended to be broken. The mean maximum thickness of the 20 complete specimens is 14.5 mm ($s = 5.9$; range = 7-30 mm). On the other hand, the mean maximum thickness of the broken specimens is 9 mm ($s = 4.5$; range = 4-28 mm). Significant differences also exist between the two groups in mean edge angle, with complete bifaces having a greater mean edge angle (61°) than incomplete specimens (51°). The two attributes indicate that incomplete specimens progressed further in the reduction sequence than complete specimens and, by implication, that the reduction of complete specimens was terminated early due to manufacturing problems which impaired thinning. The frequencies of the different manufacturing problems and fracture types indicate two aspects of biface discard during manufacture: (1) termination of a reduction process took place only when all alternatives at correcting a manufacturing mistake (e.g., hinged flake removal) were exhausted or the attempts generated even more problems (e.g., knots); and (2) the largest percentage of discarded bifaces were generated through manufacture as opposed to use. The latter point may also be an indication of the relatively long use life (Shott 1989) of bifaces (i.e., knives) considering that only 26% of the fragments were broken in use.

The maximum length of the 20 complete specimens ranges from 28 to 95 mm, with a mean of 50 mm ($s = 14.4$). Maximum width ranges from 18 to 77 mm, with a mean of 37 mm ($s = 14.5$). Maximum thickness ranges from 7 to 30 mm, and the mean is 14.5 mm ($s = 5.9$). Finally, complete biface edge angle ranges from 38° to 80° , with the mean being 61° . As noted above, this figure differs significantly from the mean edge angle (51° ; range = 20° - 75°) of the 32 incomplete specimens.

Cobble Tools

Sixty-one cobble tools (e.g., Fig. 67) were recovered from 15 sites (Table 81). Twenty-three of these tools (38%) are made of coarse-grained Potter chert. The next most often used raw materials are the Ogallala and unidentified quartzites, which together account for 25% of the collection. Fine-grained Potter cherts were used in making 11 cobble tools (18%), while fine- and coarse-grained cherts and the other raw material types

Figure 67. Cobble tools. (a) 41GR291; (b) 41KT33.

occur relatively infrequently. The two kinds of chert and the Ogallala and unidentified quartzites are combined due to the small samples of coarse-grained cherts ($n = 2$) and unidentified quartzites ($n = 4$). The apparent preference for coarse-grained Potter chert in the manufacture of the cobble tools may be the result of at least two interacting factors: (1) the functional requirements of the tools; and (2) raw material flaking characteristics. Given that heavy use is demonstrated by the wear on the edges of most cobble tools, it is possible that coarser grained materials were consistently chosen because they are more resistant to wear and damage. On the other hand, since coarse materials are more difficult to flake, the reduction of cores may have terminated more often early in the sequence, fortuitously generating cobble tools. Because the cobble tools were shaped to specific forms and their reduction proceeded beyond the tested cobble stage, however, it appears that the use of coarse-grained Potter chert is the product of the purposeful selection for this material type for this particular class of tools.

Five sites (41GR291, 41GR303, 41GR359, 41GR383, and 41KT33) yielded 69% of the cobble tool collection. An additional site contained 7% of the tools, while the remainder contained less than 5% each. Coarse-grained Potter chert dominates this tool class at most of the sites, followed by the Ogallala and unidentified quartzites and the fine-grained Potter chert specimens. The majority of the specimens (67%) are surface finds, while the remainder are from excavation units. A somewhat larger percentage of the fine-grained Potter chert specimens (45%) were found in excavation units than the coarse-grained Potter chert (30%). An even smaller percentage of the Ogallala and unidentified quartzite specimens (20%) came from the subsurface. It is difficult to determine whether these differences are due to geomorphic processes (e.g., differential burial and/or erosional exposure) or a general increase in the role of the artifact type through time.

Tools with one working edge dominate the assemblage (72%), while only 15 (25%) have two working edges. Two cobble tools (3%) have three or more edges that were employed in task performance. Seventy-five percent ($n = 61$) of the 81 working edges are convex (Table 82). Straight (10%) and concave (9%) edges are almost equally frequent, while irregularly

TABLE 81
COBBLE TOOL ATTRIBUTES BY RAW MATERIAL TYPE

Attributes	Fine-grained Potter Chert		Coarse-grained Potter Chert		Fine/Coarse- grained Cherts		Ogallala and Unidentified Quartzites		Silicified Wood		Conglomerate Quartzite		Misc.		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
SITE															
41GR291	2	29	3	43	1	14	-	-	-	-	1	14	-	-	7
41GR303	3	27	4	36	-	-	4	36	-	-	-	-	-	-	11
41GR323	1	33	1	33	1	33	-	-	-	-	-	-	-	-	3
41GR327	-	-	1	100	-	-	-	-	-	-	-	-	-	-	1
41GR359	2	25	-	-	-	-	4	50	-	-	1	13	1	13	8
41GR376	-	-	1	25	1	25	2	50	-	-	-	-	-	-	4
41GR381	-	-	1	50	1	50	-	-	-	-	-	-	-	-	2
41GR383	-	-	3	33	1	11	3	33	-	-	-	-	2	22	9
41GR456	-	-	2	100	-	-	-	-	-	-	-	-	-	-	2
41GR484	-	-	-	-	-	-	2	100	-	-	-	-	-	-	2
41GR515	1	50	1	50	-	-	-	-	-	-	-	-	-	-	2
41GR569	-	-	1	100	-	-	-	-	-	-	-	-	-	-	1
41KT33	2	29	3	43	1	14	-	-	1	14	-	-	-	-	7
41KT34	-	-	1	100	-	-	-	-	-	-	-	-	-	-	1
41KT49	-	-	1	100	-	-	-	-	-	-	-	-	-	-	1
Totals:	11	18	23	38	6	10	15	25	1	2	2	3	3	5	61
PROVENIENCE															
Surface	6	15	16	39	4	10	12	29	-	-	2	5	1	2	41
Subsurface	5	25	7	35	2	10	3	15	1	5	-	-	2	10	20
Totals:	11	18	23	38	6	10	15	25	1	2	2	3	3	5	61

Table 81, continued

Table 81, continued

Attributes	Fine-grained Potter Chert		Coarse-grained Potter Chert		Fine/Coarse- grained Cherts		Ogallala and Unidentified Quartzites		Silicified Wood		Conglomerate Quartzite		Misc.		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
NUMBER OF MODIFIED EDGES															
One	6	14	15	34	5	11	13	30	1	2	2	5	2	5	44
Two	4	27	7	47	1	7	2	13	-	-	-	-	1	7	15
Three or more	<u>1</u>	<u>50</u>	<u>1</u>	<u>50</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>2</u>
Totals:	11	18	23	38	6	10	15	25	1	2	2	3	3	5	61
EDGE ANGLE (°)															
Mean	86.4		85.1		73.3		82.7		-		77.5		74.5		
Standard deviation	13.6		12.9		21.5		18.3		-		4.0		9.2		
Minimum	68		62		54		60		-		74		68		
Maximum	110		120		115		125		-		83		81		
MODIFICATION LENGTH (mm)															
Mean	77.0		84.6		57.9		77.4		-		77.0		73.5		
Standard deviation	49.0		41.0		45.2		29.5		-		12.7		2.1		
Minimum	9		24		22		20		-		61		72		
Maximum	167		193		141		129		-		89		75		
MAXIMUM LENGTH (mm)															
Mean	78.2		87.1		65.8		83.6		-		89.3		98.0		
Standard deviation	34.3		30.9		28.9		16.6		-		9.0		22.6		
Minimum	30		30		38		53		-		80		82		
Maximum	122		168		110		113		-		98		114		

Table 81, continued

Table 317 continued

Attributes	Fine-grained Potter Chert		Coarse-grained Potter Chert		Fine/Coarse- grained Cherts		Ogallala and Unidentified Quartzites		Silicified Wood		Conglomerate Quartzite		Misc.		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
MAXIMUM WIDTH (mm)															
Mean	59.1		73.0		49.5		66.1		-		85.0		82.5		
Standard deviation	29.3		31.8		23.0		12.0		-		1.7		9.2		
Minimum	17		15		22		39		-		84		76		
Maximum	94		155		82		89		-		87		89		
MAXIMUM THICKNESS (mm)															
Mean	33.2		39.2		30.5		46.4		-		41.0		44.0		
Standard deviation	21.7		19.6		16.5		13.4		-		9.5		17.0		
Minimum	10		12		13		23		-		32		32		
Maximum	70		90		58		75		-		51		56		

TABLE 82
COBBLE TOOL WORKING EDGE ATTRIBUTES

	#	%		#	%
EDGE SHAPE			STEP FRACTURES		
Straight	8	10	Present	71	88
Concave	7	9	Absent	<u>10</u>	<u>12</u>
Convex	61	75	Totals:	81	100
Irregular	3	4			
Pointed	<u>2</u>	<u>2</u>			
Totals:	81	100			
EDGE ROUNDING			CORTEX BACKING		
Present	70	86	Present	50	62
Absent	<u>11</u>	<u>14</u>	Absent	<u>31</u>	<u>38</u>
Totals:	81	100	Totals:	81	100

shaped (4%) and pointed (2%) working edges are relatively infrequent. Of the 81 working edges, 50 (62%) are cortex backed, and 31 (38%) have no backing. Step fractures, occurring on both faces of the working edge, are present on 71 of the working edges (88%). No step fracturing is visible on 10 working edges (12%). The frequency of edge rounding due to intensive wear is similar to step fracturing. Eighty-six percent (n = 70) of the edges are rounded, while 14% do not exhibit rounding. It is notable that 89% of the edges with step fracturing are also rounded. On the other hand, 70% of the cobble tool edges with rounding do not exhibit step fracturing. The absence of step-fracture scars may be due to the relative softness of the materials being worked with these tools.

The mean edge angle for the 81 edges is 83° (s = 15.1; range = 54-125). Some minor differences exist between raw material types. Most notably, the locally available fine- and coarse-grained cherts have the lowest mean edge angle, while the coarser materials have consistently higher values (i.e., coarse-grained Potter chert and Ogallala and unidentified quartzites). Fine-grained Potter chert has the highest mean edge angle of all the raw material types. The mean length of edge retouch is smallest (58 mm) on the chert cobble tools and virtually identical (77 mm) on the fine-grained Potter chert, Ogallala and unidentified quartzites, and conglomerate quartzite. The mean length of edge retouch is greatest (85 mm) on the coarse-grained Potter chert tools.

The analysis of cobble tool maximum dimensions indicates that, in general, conglomerate quartzite, the miscellaneous materials, and coarse-grained Potter chert are the largest specimens. The cobble tools of Ogallala and unidentified quartzites and fine-grained Potter chert are somewhat smaller, but the tools of locally available fine- and coarse-grained chert are the smallest in size. Perhaps the low frequency of cobble tools manufactured of locally available chert is due not only to its brittle edge-keeping quality but also to the size limitations of the raw materials. This size difference between the

naturally occurring raw material types is illustrated in the collections of naturally occurring raw materials from the two lithic procurement sites sampled (see raw material type discussion).

Unifaces

One hundred and sixty-four unifacial artifacts were recovered from 20 sites. Fifty-four (33%) of these are end scrapers (Fig. 68a-b). Side scrapers (Fig. 68c-d) are the second most frequent type (18%), followed by end/side scrapers (Fig. 69) and gouges (Fig. 70) representing 15% and 13%, respectively, of the unifacial tool collection. Tools used in cutting tasks are not abundant (3%), while gravers are very infrequent (1%). The type of unifacial tool represented could not be determined on 7% of the collection. These specimens are small edge fragments that are sufficiently large to determine that they derived from unifacial tools but not large enough to categorize according to tool group. Ten percent ($n = 16$) of the collection is uniface rejuvenation fragments, comprising a relatively large percentage of the tools.

Figure 68. End and side scrapers. (a) End scraper, 41KT34; (b) end scraper, 41GR359; (c) side scrapers, 41GR291; (d) side scraper, 42KT31.

Figure 69. End/side scrapers. (a) 41GR303; (b) 41KT51; (c) 41GR302; (d) 41GR303.

Figure 70. Gouges. (a) 41GR303; (b) 41GR474; (c) 41GR303.

Table 83 shows the eight artifact types included in the uniface category by site, provenience, raw material, heating characteristics, flake type, completeness, cortex category, flake portion modified, working edge shape, and a series of metric attributes. It is evident that the three sites with the largest lithic collections contain the largest overall number of unifactes. Sites 41GR383, 41GR303, and 41GR291 have the highest number of unifactes in each of the eight categories. In each case, gouges and end scrapers are the dominant unifacial tool types. The two graters recovered cannot be seen as constituting a representative sample.

The fact that the majority of the unifactes from the project area (77%) are surface finds is discouraging; however, a number of interacting factors could generate such a pattern. It is possible that erosion and site deflation have exposed lithic tool assemblages from numerous episodes of site use. On the other hand, it is also possible that the abundance of unifacial tools on the surface is a partial reflection of the increase in the use of such tools during the late occupations of the project area. Finally, it is most probable that both geomorphic and behavioral factors have contributed to the pattern observed.

Fine-grained chert (45%) is the most frequently used raw material in the unifactes, followed by fine-grained Potter chert (23%) and Ogallala quartzite (13%). Unidentified quartzite (6%) and opalized caliche (4%) are infrequent. While the same ranking of raw material frequencies is noted within the individual unifacial tool categories, one significant difference can be noted. The most frequently used raw material for the end, side, and end/side scrapers is fine-grained chert. However, 64% of the gouges are manufactured of fine-grained Potter chert, a relatively coarse material. The next most frequently used raw material for gouges is silicified wood (14%), followed by Ogallala and unidentified quartzites in equal frequencies (9%), followed by opalized caliche (5%). These figures indicate a clear selection for fine-grained Potter chert in manufacturing gouges. Given that gouges are tools probably intended for heavy tasks (Hester et al. 1973; Chandler 1974) and that coarse-grained materials maintain edges longer than do fine-grained materials, it is probable that the selection of Potter chert for gouge manufacture reflects these elements of tool function and raw material quality. It is significant that, although Tecovas jasper is not a local raw material, two end scrapers were made of this material. Similarly, the low frequency of Cretaceous fine-grained chert illustrates some utilization of chert sources probably located south-southeast of the project area.

Almost half of the unifacial artifacts (46%) have not been heat treated. A slightly smaller percentage (38%) have been heat treated, while the attribute could not be determined on 16% of the unifactes. In most unifacial tool categories, nonheat-treated specimens outnumber heat-treated unifactes; however, the higher frequency of heat-treated specimens in the gouges is an exception to this. The high frequency of heat-treated gouges reflects the predominance of fine-grained Potter chert used in the manufacture of this tool type.

The majority of the unifactes are complete flakes (46%), while specimens made on chips are second in frequency (32%). Proximal fragments (5%) and chunks (2%) are infrequent. The type of flake fragment could not be determined on 15% of the collection. These figures are indicators of the flake blanks used in the manufacture of unifacial tools. On the other hand, the breakdown of uniface tool categories by completeness illustrates the number of complete and broken unifactes. These percentages reflect the effects of manufacture, rejuvenation, abandonment, discard, and postdepositional processes. That is, some of the complete unifactes may have been discarded due to their exhausted state, while others may

TABLE 83

UNIFACE ATTRIBUTES BY UNIFACE CATEGORY

SITE	End Scrapers		Side Scrapers		End/side Scrapers		Gouges		Cutting Tools		Gravers		Indeter- minate Edges and Fragments		Rejuve- nation Fragments		Totals	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
41GR207	-	-	-	-	-	-	1	5	-	-	-	-	-	-	-	-	1	1
41GR239	-	-	-	-	1	4	2	9	-	-	-	-	-	-	-	-	3	2
41GR291	6	11	3	10	3	13	2	9	-	-	-	-	1	8	4	25	19	12
41GR302	-	-	1	3	1	4	-	-	-	-	-	-	-	-	1	6	3	2
41GR303	11	20	3	10	4	17	5	23	1	20	1	50	4	33	1	6	30	18
41GR323	1	2	1	3	-	-	-	-	1	20	-	-	1	8	1	6	5	3
41HR327	4	7	-	-	1	4	-	-	1	20	-	-	-	-	-	-	6	4
41GR359	4	7	2	7	3	13	1	5	-	-	-	-	1	8	3	19	14	9
41GR376	3	6	5	17	4	17	-	-	-	-	1	50	-	-	-	-	13	8
41GR380	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1
41GR381	-	-	3	10	-	-	1	5	-	-	-	-	-	-	-	-	4	2
41GR383	15	28	4	14	4	17	6	27	1	20	-	-	2	17	-	-	32	20
41GR456	-	-	2	7	-	-	1	5	-	-	-	-	1	8	1	6	5	3
41GR474	-	-	-	-	2	8	1	5	-	-	-	-	-	-	1	6	4	2
41GR484	-	-	-	-	-	-	-	-	1	20	-	-	-	-	-	-	1	1
41GR515	2	4	3	10	-	-	-	-	-	-	-	-	1	8	-	-	6	4
41KT33	3	6	1	3	-	-	1	5	-	-	-	-	-	-	2	13	7	4
41KT34	3	6	-	-	-	-	-	-	-	-	-	-	-	-	1	6	4	2
41KT49	-	-	-	-	-	-	1	5	-	-	-	-	-	-	1	6	2	1
41KT51	-	-	1	3	1	4	-	-	-	-	-	-	1	8	-	-	3	2
Totals:	54	101	29	97	24	101	22	103	5	100	2	100	12	98	16	99	164	101

Table 83, continued

	End Scrapers		Side Scrapers		End/side Scrapers		Gouges		Cutting Tools		Gravers		Indeter- minate Edges and Fragments		Rejuve- nation Fragments		Totals	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
PROVENIENCE																		
Surface	44	81	24	83	20	83	21	95	4	80	1	50	5	42	8	50	127	77
Subsurface	<u>10</u>	<u>19</u>	<u>5</u>	<u>17</u>	<u>4</u>	<u>17</u>	<u>1</u>	<u>5</u>	<u>1</u>	<u>20</u>	<u>1</u>	<u>50</u>	<u>7</u>	<u>58</u>	<u>8</u>	<u>50</u>	<u>37</u>	<u>23</u>
Totals:	54	100	29	100	24	100	22	100	5	100	2	100	12	100	16	100	164	100
RAW MATERIAL																		
Fine-grained Potter chert	10	19	6	21	4	17	14	64	1	20	-	-	-	-	2	13	37	23
Coarse-grained Potter chert	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Fine-grained chert	22	41	15	52	12	50	-	-	3	60	2	100	7	58	12	75	73	45
Ogallala quartzite	11	20	3	10	4	17	2	9	-	-	-	-	1	8	-	-	21	13
Unidentified quartzite	5	9	1	3	2	8	2	9	-	-	-	-	-	-	-	-	10	6
Opalized caliche	1	2	1	3	-	-	1	5	-	-	-	-	2	17	1	6	6	4
Silicified wood	-	-	2	7	-	-	3	14	-	-	-	-	-	-	-	-	5	3
Tecovas jasper	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1
Cretaceous chert	1	2	1	3	1	4	-	-	-	-	-	-	2	17	1	6	6	4
Conglomerate quartzite	-	-	-	-	1	4	-	-	-	-	-	-	-	-	-	-	1	1
Basalt	<u>1</u>	<u>2</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>1</u>	<u>20</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>2</u>	<u>1</u>
Totals:	54	101	29	99	24	100	22	101	5	100	2	100	12	100	16	100	164	102
HEATING																		
Heated	20	37	10	34	9	38	10	45	3	60	-	-	5	42	5	31	62	38
Not heated	23	43	15	52	9	38	7	32	2	40	1	50	7	58	11	69	75	46
Indeterminate	<u>11</u>	<u>20</u>	<u>4</u>	<u>14</u>	<u>6</u>	<u>25</u>	<u>5</u>	<u>23</u>	<u>-</u>	<u>-</u>	<u>1</u>	<u>50</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>27</u>	<u>16</u>
Totals:	54	100	29	100	24	101	22	100	5	100	2	100	12	100	16	100	164	100

Table 83, continued

	End Scrapers		Side Scrapers		End/side Scrapers		Gouges		Cutting Tools		Gravers		Indeter- minate Edges and Fragments		Rejuve- nation Fragments		Totals	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
FLAKE TYPE																		
Complete	31	57	12	41	11	46	11	50	3	60	1	50	-	-	7	44	76	46
Proximal	-	-	5	17	-	-	1	5	-	-	-	-	1	8	1	6	8	5
Chip	17	31	9	31	10	42	1	5	-	-	1	50	6	50	8	50	52	32
Chunk	3	6	1	3	-	-	-	-	-	-	-	-	-	-	-	-	4	2
Indeterminate	3	6	2	7	3	13	9	41	2	40	-	-	5	42	-	-	24	15
Totals:	54	100	29	99	24	101	22	101	5	100	2	100	12	100	16	100	164	100
COMPLETENESS																		
Complete	31	57	15	52	18	75	21	95	4	80	-	-	-	-	4	25	93	57
Proximal	-	-	2	7	-	-	-	-	-	-	-	-	-	-	-	-	2	1
Medial	3	6	4	14	-	-	-	-	1	20	-	-	-	-	-	-	8	5
Distal	18	33	8	28	5	21	1	5	-	-	1	50	6	50	-	-	39	24
Wedge	-	-	-	-	-	-	-	-	-	-	-	-	1	8	-	-	1	1
Edge	-	-	-	-	-	-	-	-	-	-	1	50	4	33	12	75	17	10
Longitudinal	2	4	-	-	1	4	-	-	-	-	-	-	1	8	-	-	4	2
Totals:	54	100	29	101	24	100	22	100	5	100	2	100	12	99	16	100	164	100
CORTEX CATEGORY																		
Primary	16	30	5	17	3	13	2	9	-	-	1	50	2	17	1	6	30	18
Secondary	27	50	18	62	14	58	14	64	4	80	-	-	3	25	7	44	87	53
Tertiary	11	20	6	21	7	29	6	27	1	20	1	50	7	58	8	50	47	29
Totals:	54	100	29	100	24	100	22	100	5	100	2	100	12	100	16	100	164	100

Table 83, continued

	End Scrapers		Side Scrapers		End/side Scrapers		Gouges		Cutting Tools		Gravers		Indeter- minate Edges and Fragments		Rejuve- nation Fragments		Totals	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
FLAKE PORTION MODIFIED																		
Indeterminate	-	-	-	-	-	-	-	-	-	-	-	-	12	100	16	100	28	17
Distal end only	23	43	-	-	-	-	1	5	-	-	-	-	-	-	-	-	24	15
Proximal and distal ends	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Margins and ends	30	56	29	100	24	100	21	95	3	60	1	50	-	-	-	-	108	66
Margins only	-	-	-	-	-	-	-	-	2	40	1	50	-	-	-	-	3	2
Totals:	54	101	29	100	24	100	22	100	5	100	2	100	12	100	16	100	164	101
WORKING EDGE SHAPE																		
Straight	11	20	6	17	13	22	5	20	1	8	-	-	-	-	-	-	36	17
Concave	1	2	3	9	11	19	-	-	2	17	-	-	-	-	-	-	17	8
Convex	27	49	17	49	22	37	14	56	7	58	-	-	-	-	-	-	87	40
Irregular	16	29	8	23	13	22	6	24	2	17	-	-	-	-	-	-	45	21
Notched	-	-	1	3	-	-	-	-	-	-	2	100	-	-	-	-	3	1
Indeterminate	-	-	-	-	-	-	-	-	-	-	-	-	12	100	16	100	28	13
Totals:	55	100	35	101	59	100	25	100	12	100	2	100	12	100	16	100	216	100
EDGE ANGLE (°)																		
Mean	76.8		80.0		77.2		79.4		70.5		75.0		74.1		81.4			
Standard deviation	11.3		12.6		9.6		9.3		9.9		1.4		12.1		8.2			
Minimum	50		33		38		47		58		74		56		68			
Maximum	110		100		95		92		89		76		91		100			
FACE ANGLE (°)																		
Mean	60.1		62.8		55.7		67.9		58.6		59.0		55.3		73.7			
Standard deviation	17.5		17.1		15.3		10.4		22.5		8.5		16.3		9.2			
Minimum	25		22		22		45		24		53		25		53			
Maximum	97		90		96		89		89		65		77		92			

Table 83, continued

	End Scrapers		Side Scrapers		End/side Scrapers		Gouges		Cutting Tools		Gravers		Indeter- minate Edges and Fragments		Rejuve- nation Fragments		Totals	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
MAXIMUM LENGTH (mm)																		
Mean	43.7		56.3		54.7		64.2		47.5		27.5		24.1		22.6			
Standard deviation	13.3		19.4		17.2		15.6		12.8		6.4		7.5		9.7			
Minimum	25		24		25		40		30		23		12		7			
Maximum	68		84		86		96		57		32		37		43			
MAXIMUM WIDTH (mm)																		
Mean	43.4		44.5		44.0		47.8		33.0		24.0		22.8		22.3			
Standard deviation	12.2		15.9		8.5		7.2		6.8		9.9		8.0		9.7			
Minimum	19		31		33		38		26		17		12		8			
Maximum	76		82		64		64		41		31		37		44			
MAXIMUM THICKNESS (mm)																		
Mean	14.2		15.9		16.4		20.8		13.0		9.0		8.8		7.8			
Standard deviation	4.5		7.7		5.2		5.1		4.0		2.8		3.2		3.4			
Minimum	6		6		9		14		11		7		6		3			
Maximum	22		32		24		34		19		11		15		13			

have been lost. Still other incomplete unifaces may have been broken in manufacture, use, or rejuvenation, or as a result of postdepositional processes. The majority of the unifaces (57%) are complete tools. Distal fragments represent 24% of the unifaces, while tool edges occur in relatively high frequencies (10%). Medial (5%), longitudinal (2%), proximal (1%), and wedge-shaped (1%) fragments are infrequent. The breakdown of completeness by uniface category illustrates some differences. Gouges and cutting tools have the highest percentages of complete specimens. In the first instance, the high percentage is probably due to the thickness of the tools and the raw material used in gouge manufacture. For instance, all 22 gouges are thicker than 11 mm, while 30%, 45%, 21%, and 20% of the end, side, and end/side scrapers and cutting tools are less than 10 mm thick. The lower frequency of complete end and side scrapers may be a reflection of the type of blank used in tool manufacture and its relationship with force load during task performance. That is, because some of the end and side scrapers were manufactured on thin bladelike flake blanks, they may have been less resistant to heavy force loading during use. In addition, some experimental manufacture and resharpening of unifacial tools (end scrapers and thin gouges made on fine-grained Cretaceous chert) suggest that both types of activities can generate broken unifaces. Until experimental research is carried out to identify diagnostic break morphologies for a number of these causes, it will be difficult to address the role of raw material and force loading factors in breakage generation.

Unifaces made on secondary flakes and/or flake fragments are most frequent (53%), followed by tertiary flakes (29%) and primary flakes (18%). The relatively high frequency of secondary flakes among the gouges appears to be related to the high frequency of fine-grained Potter chert in this tool class. Given the difficulty of reducing this raw material, it is probable that most gouges were made of early-reduction secondary or primary flake blanks. The degree of modification exhibited by the unifaces is extensive. On 66%, the parent flake was modified both on its margins and distal end. The extensive retouch along the edges of unifaces reflects a combination of hafting requirements, perhaps some functional tool requirements, and the initial shape of the blank used in tool manufacture.

Convex edge shapes are most frequent in the uniface collection (40%). Irregularly shaped edges (21%) are next most frequent, followed by straight working edges (17%). Concave working edges are infrequent (8%), while notched edges occur only on one side scraper and the two graters. In all uniface tool categories, convex edges are dominant, although they represent the highest frequency among cutting tools. Irregularly shaped edges are the second most frequent edge shape among the different uniface categories. Straight edges are frequent on end/side scrapers, gouges, and end scrapers.

No notable differences occur between the unifacial tool categories in terms of edge angle. As expected, cutting tools have the most acute edge angles (70°). Side scrapers and gouges have the steepest edge angles (80°), followed by end/side scrapers and end scrapers (77°). Face angles are in all cases less than working edge angles and do not show notable differences between the various uniface tool categories.

The mean length for the complete specimens indicate that gouges are the longest unifaces (64 mm), followed by side scrapers (56 mm) and end/side scrapers (55 mm). End/side scrapers are somewhat larger than end scrapers (44 mm), while graters are the shortest (27 mm) unifacial tools. Similar patterns are seen in terms of maximum width among the six complete uniface tool categories. Gouges have the highest mean thickness (21 mm), followed by end/side scrapers (16 mm). Side scrapers, end scrapers, and cutting tools have similar mean thicknesses, while graters have the lowest mean thickness (9 mm). These differences

are a result of a number of interacting factors, including the cortex category of the blank from which the tools were manufactured and, more importantly, probable functional requirements of certain tool types as related to force loading during task performance. For instance, it is possible that the difference in thickness between gouges and side scrapers reflects energetic differences in the tasks for which the tools were used. Greater force expended in the performance of a task required thicker tools to avoid breakage during task performance. Thinner unifaces (i.e., end scrapers) may have been employed in lighter tasks in which tool breakage was minimal.

Table 84 is a breakdown of unifaces by raw material type, heating characteristics, and cortex category. Opalized caliche and fine-grained Potter chert have the highest percentages of heat-treated specimens (83% and 73%). Locally available fine-grained chert has the lowest frequency of heat treatment of all material types recovered in the project area. These figures suggest a pronounced attempt on the part of the prehistoric knappers to improve the flaking qualities of Potter chert.

The breakdown of raw material types by cortex category indicates some overall similarities between these materials. Secondary flakes dominate the assemblage, followed by tertiary and primary flakes. It is interesting, however, that opalized caliche and Cretaceous chert have the highest frequencies of tertiary flakes, while Ogallala quartzite, unidentified quartzites, and silicified wood have the lowest frequencies of tertiary flakes. These figures may represent the degree of ease of obtaining tertiary flakes large enough to serve as uniface blanks. That is, given the difficulty of reducing the coarse-grained materials, many of the tools made of these materials may have been on early-reduction, i.e., secondary, flake blanks. The fact that three of the six unifaces of Cretaceous chert are secondary is not surprising even considering that this material does not occur locally. Given that three of the six uniface specimens are end, side, and end/side scrapers that are relatively thick ($\bar{x}$ = 20 mm), the specimens were probably manufactured from large secondary flake blanks at the material sources and transported into the project area where they were utilized, rejuvenated, and subsequently discarded or lost.

The last portion of Table 84 presents the uniface raw material types by site. Two general patterns are evident: (1) at some sites, Potter chert (fine and coarse grained) and the quartzites greatly outnumber the local and nonlocal fine-grained chert specimens; and (2) at other sites, the local and nonlocal fine-grained cherts significantly outnumber the Potter chert and quartzites.

The 16 rejuvenation flakes and/or fragments recovered represent 10% of the overall unifacial tool category (see Table 83). These flakes and fragments are included in this category because they are diagnostic of rejuvenation and/or manufacture of unifacial tools. Three rejuvenation methods and a proximal thinning technique are exemplified by these specimens. Nine of the flakes (56%) are representative of uniface retouch Method C, three (19%) represent Method B, and one (6%) represents Method A (Shafer 1970:481-482, 484). In addition, three specimens (19%) derived from failed proximal end thinning attempts.

Cores

One hundred and ten cores and core fragments were recovered from 21 archeological sites (Table 85). Of these, 43% are of locally available fine- and coarse-grained cherts.

TABLE 84

UNIFACE ATTRIBUTES BY RAW MATERIAL TYPE

Attributes	Fine-grained Potter Chert		Coarse-grained Potter Chert		Fine-grained Chert		Ogallala Quartzite		Uniden- tified Quartzite		Opalized Caliche		Sili- cified Wood		Tecovas Jasper		Creta- ceous Chert		Conglo- merate Quartzite		Basalt		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
HEATING*																							
Heated	27	73	1	100	22	30	-	-	-	-	5	83	-	-	-	-	3	50	-	-	-	-	58
Not heated	5	14	-	-	49	67	-	-	-	-	1	17	4	80	2	100	2	33	-	-	2	100	65
Indeter- minate	5	14	-	-	2	3	21	100	10	100	-	-	1	20	-	-	1	17	1	100	-	-	41
Totals:	37	101	1	100	73	100	21	100	10	100	6	100	5	100	2	100	6	100	1	100	2	100	164
CORTEX CATEGORY*																							
Primary	5	14	-	-	14	19	5	24	4	40	-	-	1	20	-	-	-	-	-	-	1	50	29
Secondary	24	65	1	100	38	52	12	57	4	40	1	17	3	60	-	-	3	50	-	-	1	50	88
Tertiary	8	22	-	-	21	29	4	19	2	20	5	83	1	20	2	100	3	50	1	100	-	-	47
Totals:	37	101	1	100	73	100	21	100	10	100	6	100	5	100	2	100	6	100	1	100	2	100	164
SITE**																							
41GR207	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
41GR239	1	33	-	-	1	33	-	-	1	33	-	-	-	-	-	-	-	-	-	-	-	-	3
41GR291	2	11	-	-	13	68	1	5	2	11	-	-	1	5	-	-	-	-	-	-	-	-	19
41GR302	2	67	-	-	1	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
41GR303	8	27	-	-	10	33	6	20	1	3	2	7	1	3	1	3	1	3	-	-	-	-	30
41GR323	1	20	-	-	4	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5

Table 84, continued

Attributes	Fine-grained Potter Chert		Coarse-grained Potter Chert		Fine-grained Chert		Ogallala Quartzite		Uniden- tified Quartzite		Opalized Caliche		Sili- cified Wood		Tecovas Jasper		Creta- ceous Chert		Conglo- merate Quartzite		Basalt		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
41GR327	2	33	1	17	-	-	2	33	-	-	-	-	-	-	-	-	-	-	-	-	1	17	6
41GR359	1	7	-	-	9	64	1	7	2	14	-	-	1	7	-	-	-	-	-	-	-	-	14
41GR376	3	23	-	-	7	54	2	15	-	-	1	8	-	-	-	-	-	-	-	-	-	-	13
41GR380	-	-	-	-	1	50	1	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
41GR381	2	50	-	-	-	-	1	25	-	-	-	-	1	25	-	-	-	-	-	-	-	-	4
41GR383	11	34	-	-	7	22	5	16	4	13	-	-	1	3	1	3	1	3	1	3	1	3	32
41GR456	1	20	-	-	3	60	-	-	-	-	1	20	-	-	-	-	-	-	-	-	-	-	5
41GR474	1	25	-	-	3	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
41GR484	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
41GR515	-	-	-	-	6	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
41KT33	-	-	-	-	4	57	2	29	-	-	-	-	-	-	-	-	1	14	-	-	-	-	7
41KT34	1	25	-	-	2	50	-	-	-	-	1	25	-	-	-	-	-	-	-	-	-	-	4
41KT49	-	-	-	-	1	50	-	-	-	-	1	50	-	-	-	-	-	-	-	-	-	-	2
41KT51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	100	-	-	-	-	3
Totals:	37		1		73		21		10		6		5		2		6		1		2		164

*Column percentages

**Row percentages

TABLE 85

CORE ATTRIBUTES BY RAW MATERIAL TYPE

Attributes	Fine/ coarse- grained Potter Chert		Fine/ coarse- grained Chert		Ogallala, Unidenti- fied, and Milk White Quartzite		Opalized Caliche		Sili- cified Wood		Tecovas Jasper		Creta- ceous Chert		Sili- cified Caliche		Misc.		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
	SITE																		
41GR287	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	1
41GR291	2	25	6	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
41GR302	1	33	1	33	-	-	-	-	-	-	-	-	-	-	-	-	1	33	3
41GR303	3	14	13	59	1	5	3	14	1	5	1	5	-	-	-	-	-	-	22
41GR323	-	-	1	25	-	-	-	-	1	25	-	-	1	25	1	25	-	-	4
41GR327	-	-	1	17	5	83	-	-	-	-	-	-	-	-	-	-	-	-	6
41GR359	2	11	8	42	7	37	1	5	-	-	-	-	-	-	1	5	-	-	19
41GR374	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
41GR376	2	17	2	17	4	33	3	25	1	8	-	-	-	-	-	-	-	-	12
41GR380	1	20	2	40	2	40	-	-	-	-	-	-	-	-	-	-	-	-	5
41GR381	1	33	1	33	1	33	-	-	-	-	-	-	-	-	-	-	-	-	3
41GR383	-	-	2	67	-	-	-	-	-	-	-	-	-	-	-	-	1	33	3
41GR456	-	-	2	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
41GR484	-	-	2	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
41GR515	1	17	3	50	2	33	-	-	-	-	-	-	-	-	-	-	-	-	6
41GR559	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
41KT33	-	-	2	50	1	25	-	-	-	-	1	25	-	-	-	-	-	-	4
41KT34	-	-	-	-	1	33	1	33	-	-	-	-	-	-	1	33	-	-	3
41KT49	1	50	-	-	1	50	-	-	-	-	-	-	-	-	-	-	-	-	2
41KT52	2	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
41KT151	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	1
Totals:	17	15	47	43	27	25	8	7	3	3	2	2	1	1	3	3	2	2	110

Table 85, continued

TABLE 657 Continued

Attributes	Fine/ coarse- grained Potter Chert		Fine/ coarse- grained Chert		Ogallala, Unidenti- fied, and Milk White Quartzite		Opalized Caliche		Sili- cified Wood		Tecovas Jasper		Creta- ceous Chert		Sili- cified Caliche		Misc.		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
PROVENIENCE																			
Surface	8	12	35	53	12	18	6	9	2	3	1	2	-	-	1	2	1	2	66
Subsurface	<u>9</u>	<u>20</u>	<u>12</u>	<u>27</u>	<u>15</u>	<u>34</u>	<u>2</u>	<u>5</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>5</u>	<u>1</u>	<u>2</u>	<u>44</u>
Totals:	17	15	47	43	27	25	8	7	3	3	2	2	1	1	3	3	2	2	110
HEATING																			
Heated/heat-treated	10	63	4	25	-	-	1	6	-	-	-	-	1	6	-	-	-	-	16
Not heated	6	10	41	67	-	-	5	8	3	5	2	3	-	-	2	3	2	3	61
Indeterminate	<u>1</u>	<u>3</u>	<u>2</u>	<u>6</u>	<u>27</u>	<u>82</u>	<u>2</u>	<u>6</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>1</u>	<u>3</u>	<u>-</u>	<u>-</u>	<u>33</u>
Totals:	17	15	47	43	27	25	8	7	3	3	2	2	1	1	3	3	2	2	110
CORE TYPE																			
Flake	17	17	39	40	23	23	8	8	3	3	2	2	1	1	3	3	2	2	98
Bipolar	-	-	6	67	3	33	-	-	-	-	-	-	-	-	-	-	-	-	9
Multipurpose	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	1
Indeterminate	<u>-</u>	<u>-</u>	<u>2</u>	<u>100</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>2</u>
Totals:	17	15	47	43	27	25	8	7	3	3	2	2	1	1	3	3	2	2	110
CORE MORPHOLOGY																			
Flake	5	38	2	15	4	31	1	8	-	-	-	-	-	-	1	8	-	-	13
Lenticular nodule	1	6	10	56	7	39	-	-	-	-	-	-	-	-	-	-	-	-	18
Angular nodule	5	50	-	-	3	30	-	-	1	10	-	-	-	-	-	-	1	10	10
Lenticular fragment	1	10	2	20	7	70	-	-	-	-	-	-	-	-	-	-	-	-	10
Bifacial	1	13	2	25	1	13	3	38	-	-	1	13	-	-	-	-	-	-	8
On break face	1	7	7	47	5	33	1	7	-	-	-	-	-	-	-	-	1	7	15
Irregular	<u>3</u>	<u>8</u>	<u>24</u>	<u>67</u>	<u>-</u>	<u>-</u>	<u>3</u>	<u>8</u>	<u>2</u>	<u>6</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>3</u>	<u>2</u>	<u>6</u>	<u>-</u>	<u>-</u>	<u>36</u>
Totals:	17	15	47	43	27	25	8	7	3	3	2	2	1	1	3	3	2	2	110

Table 85, continued

Attributes	Fine/ coarse- grained Potter Chert		Fine/ coarse- grained Chert		Ogallala, Unidenti- fied, and Milk White Quartzite		Opalized Caliche		Sili- cified Wood		Tecovas Jasper		Creta- ceous Chert		Sili- cified Caliche		Misc.		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
MANUFACTURING PROBLEMS																			
Step/hinge removals	7	17	18	43	10	24	3	7	1	2	1	2	1	2	1	2	-	-	42
Platform collapse	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Coarse inclusions	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Old fracture lines	3	43	-	-	2	29	1	14	-	-	-	-	-	-	-	-	1	14	7
Multiple	2	7	18	60	4	13	2	7	2	7	1	3	-	-	-	-	1	3	30
Absent	5	17	9	31	11	38	2	7	-	-	-	-	-	-	2	7	-	-	29
Totals:	17	15	47	43	27	25	8	7	3	3	2	2	1	1	3	3	2	2	110
NUMBER OF FLAKE REMOVALS																			
1-5	7	17	10	24	18	44	2	5	1	2	1	2	-	-	1	2	1	2	41
6-10	7	18	18	46	6	15	4	10	1	3	-	-	-	-	2	5	1	3	39
11-15	1	7	9	64	3	21	-	-	1	7	-	-	-	-	-	-	-	-	14
16-20	-	-	5	63	-	-	2	25	-	-	1	13	-	-	-	-	-	-	8
21+	2	25	5	63	-	-	-	-	-	-	-	-	1	13	-	-	-	-	8
Totals:	17	15	47	43	27	25	8	7	3	3	2	2	1	1	3	3	2	2	110
REMOVAL DIRECTION																			
Unidirectional	7	19	12	33	14	39	-	-	-	-	1	3	-	-	1	3	1	3	36
Bidirectional	4	20	4	20	7	35	3	15	2	10	-	-	-	-	-	-	-	-	20
Multidirectional	6	12	28	56	5	10	5	10	1	2	1	2	1	2	2	4	1	2	50
Opposed bidirectional	-	-	3	75	1	25	-	-	-	-	-	-	-	-	-	-	-	-	4
Totals:	17	15	47	43	27	25	8	7	3	3	2	2	1	1	3	3	2	2	110

Table 85, continued

Attributes	Fine/ coarse- grained Potter Chert		Fine/ coarse- grained Chert		Ogallala, Unidenti- fied, and Milk White Quartzite		Opalized Caliche		Sili- cified Wood		Tecovas Jasper		Creta- ceous Chert		Sili- cified Caliche		Misc.	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
MAXIMUM LENGTH (mm)																		
Mean	65.9		39.7		70.6		52.8		56.0		45.0		40.0		65.7		65.5	
Standard deviation	27.9		13.2		18.7		15.2		11.5		14.1		-		11.9		29.0	
Minimum	25		25		43		31		45		35		-		52		45	
Maximum	136		88		102		79		68		55		-		74		86	
MAXIMUM WIDTH (mm)																		
Mean	48.1		31.6		54.2		43.4		30.3		35.0		30.0		49.0		50.0	
Standard deviation	23.9		10.0		14.4		15.7		9.1		11.3		-		19.2		14.1	
Minimum	21		16		19		27		20		27		-		27		40	
Maximum	116		64		74		75		37		43		-		62		60	
MAXIMUM THICKNESS (mm)																		
Mean	32.1		19.9		39.7		27.4		23.7		21.5		19.0		31.0		36.5	
Standard deviation	18.5		9.7		12.3		10.4		11.6		2.1		-		14.4		17.7	
Minimum	13		8		18		17		13		20		-		19		24	
Maximum	95		58		59		45		36		23		-		47		49	

Ogallala, unidentified, and milk white quartzites are the second most frequent materials (25%), followed by fine- and coarse-grained Potter chert (15%). Other locally available raw materials such as opalized caliche, silicified wood, and silicified caliche occur in low frequencies (7%, 3%, and 3%). Only two cores of Tecovas jasper (2%) and a single Cretaceous chert core (1%) were recovered.

Almost half of the cores (48%) were recovered from three sites: 41GR303, 41GR359, and 41GR376. The remaining 52% are distributed among 18 sites, with sample sizes ranging from 1% to 7% of the core collection. Keeping in mind that sample sizes are small for individual sites, two patterns are worth noting. First, as sample size increases, the number of raw materials represented also increases. Second, two general patterns of raw material type distributions are seen. Locally available cherts outnumber other raw materials at some sites; at others, locally available Potter chert and quartzite cores combined are more numerous than fine- and coarse-grained cherts. The first pattern appears to be related to intensity of occupation and also implies that a significant part of the site activities was related to lithic artifact manufacture. The relevance of the second pattern is discussed at some length later in this chapter in the section on raw material patterns in the lithic debitage.

As in the case of other artifact types, the majority of the cores (60%) are surface finds, although a substantial portion (40%) are from excavation units. A larger proportion of the Potter cherts and quartzites are from subsurface contexts than the fine- and coarse-grained cherts. Overall, the mean dimensions of the surface artifacts are less than the mean dimensions of the subsurface cores (mean length = 50.4, mean width = 40.4, mean thickness = 25.1 for surface artifacts; mean length = 59.5, mean width = 42.9, mean thickness = 29.1 for subsurface artifacts).

The majority of the cores (55%) have neither been heated nor heat treated. Heating characteristics could not be determined for 30% of the cores. Only 16 cores (15%) have been heat treated. This low percentage may reflect the stage of reduction at which raw materials were subjected to heat treatment. That is, it is not expected that thick cores containing a significant amount of cortex would have been heat treated. Potter chert cores may be exceptions to this. Given that the raw material is difficult to flake, it is possible that in order to obtain preforms or blanks, the cores were heat treated. Fifty-nine percent of the Potter chert cores have been heat treated. In contrast, only 9% of the fine- and coarse-grained chert cores have been heated or heat treated.

Flake cores constitute the bulk of the collection (89%), although 9 bipolar cores (8%) were also recovered. One core appears to have been split by a bipolar technique and subsequently flaked by direct percussion. The core type could not be determined on two core fragments. All of the Potter chert cores are flake cores, while 13% of the locally available chert and 11% of the quartzite cores are bipolar. The bipolar reduction method was used on relatively thin, lenticular, coarse-grained chert pebbles and the rounded to oval Ogallala quartzite pebbles.

Irregularly shaped angular cores are most common (33%). Lenticular nodules are also numerous, making up 16% of the collection. Cores on which flake removals were initiated from a break face on the nodule (e.g., split cobble) are relatively numerous (14%), as are large primary and/or secondary flake cores (12%). Cores on angular nodules and lenticular nodule fragments are less frequent (9%), and only 7% of the cores are bifacial specimens. Flake and angular nodule cores are the most common types among the Potter chert specimens,

while lenticular nodule and irregular angular cores are relatively abundant among the locally available chert cores. Bifacial cores are relatively evenly distributed among the raw material categories. The utilization of a fracture face as the core platform surface is most prevalent in the fine- and coarse-grained cherts and the quartzite specimens. The core morphologies within these raw material types probably represent the interaction of raw material quality constraints, material size, and the shape of the naturally occurring raw materials.

The number of flake removals per core ranges from 1 to 26, with a mean of 8. Nearly equal numbers of cores have less than 6 flake scars (37%) and 6-10 flake scars (35%). The numbers of cores with more than 10 flake removals steadily decrease until only 7% of the cores have 21 or more flake removals. The breakdown of flake removal numbers by raw material is also revealing in that 41% of the Potter chert specimens have 1-5 removals, while only 21% of the locally available cherts fall in this group. Even more notable, 67% of the quartzite cores have fewer than six flake removals. On the other hand, 21% of the local chert cores have 16 or more flake removals, while only 12% of the Potter chert specimens are in this class. Similarly, one of the two Tecovas jasper cores has more than 16 flake scars, and the single Cretaceous chert core is equally reduced (21 scars). These differences in the number of removals reflect varying degrees of reduction and are probably related to the quality of the raw material as well as to the relative abundance of the materials within the project area. For instance, 7 of 13 (54%) of the locally available chert specimens measuring between 16 and 30 mm in maximum length (the smallest size group) have more than 10 flake scars. On the other hand, none of the cores larger than 45 mm have less than five flake removals. In contrast, only one of four (25%) Potter chert cores measuring between 16 and 45 mm has more than 10 flake removals. Similarly, five of nine (56%) Potter chert cores larger than 61 mm in maximum length have only one through three flake removals. These figures indicate that fine- and coarse-grained chert cores were more extensively reduced than Potter chert specimens. This pattern is revealed in both the relative lack of tested fine- and coarse-grained chert cores and the high degree of reduction of chert nodules as opposed to Potter chert cores.

Another attribute somewhat related to the degree of core reduction but primarily indicative of the reduction strategy employed is removal directionality. Over two-fifths of the cores (45%) exhibit a multidirectional reduction strategy. One-third (33%) exhibit unidirectional flake removals, and 18% have bidirectional flake scars. Only four cores (4%) have opposed bidirectional flake scars, even though nine specimens were identified as bipolar. This discrepancy is due to the fact that five bipolar cores do not exhibit flake scars originating from opposing directions, but rather have crushing on the surface opposite the point of impact. Over one-half of the quartzite cores (52%) have unidirectional removals, and 41% of the Potter chert cores are unidirectional. Only 26% of the local chert cores have unidirectional removals. On the other hand, 60% of the local chert cores are multidirectional, while smaller frequencies of the quartzites (19%) and Potter chert cores (35%) are multidirectional. Three of the four opposed bidirectional cores are small chert nodules longitudinally split by a bipolar technique. The fourth is an oval quartzite pebble similarly split. The other raw material types appear to reflect primarily a multidirectional reduction approach, although a few unidirectional cores are also present. Overall, it appears that the reduction techniques employed are a result of constraints and factors related to the intended final products. Among these constraints are the flaking quality of the raw material, the size of the material, the relative frequency of the different material types, and the morphology of the natural materials. These factors, together with the intended product for which the flakes are produced, appear to have affected the degree of reduction of the materials and the reduction technique used.

The metric data from the core analysis indicate that, in general, the Ogallala, unidentified, and milk white quartzites are the largest specimens. Silicified caliche and Potter chert are somewhat smaller but similar in size, while opalized caliche and silicified wood are even smaller. The locally available fine- and coarse-grained cherts are the smallest cores, while the single Cretaceous chert core and the Tecovas jasper specimens are also small.

Edge-modified Flakes

A total of 203 edge-modified flakes were recovered from 23 sites (Table 86, Fig. 71). Seven of the 23 sites have relatively large collections, while the remainder have small samples. Because of the small numbers of coarse-grained Potter chert ($n = 1$) and coarse-grained chert ($n = 3$) in the collection, these categories are combined with the fine-grained categories of these material types. Fine-grained chert edge-modified flakes outnumber those of Potter chert and Ogallala quartzite at 20 sites; however, the collection of edge-modified flakes at a number of these sites is very small, and this pattern must be viewed with caution. The coarser raw materials (Potter chert and Ogallala quartzite) outnumber fine-grained cherts at only one site (41GR327). While nonlocal materials are relatively infrequent, it is interesting that all but two sites with Tecovas jasper specimens also contain Cretaceous cherts. This pattern may be an indication of the regional range of the populations inhabiting the sites. Silicified wood and opalized caliche specimens are relatively infrequent.

Figure 71. Edge-modified flakes. (a) 41GR378; (b) 41GR484; (c) 41GR323.

The vertical distribution of the edge-modified flakes indicates that 45% are surface finds, and the remaining 55% are from excavation contexts. The percentage of edge-modified flakes from subsurface contexts is higher than for any of the previously discussed tool categories. This is perhaps due to the higher frequency of downward migration of smaller sized artifacts (Gifford-Gonzalez et al. 1985); on the other hand, it may be due to the differential rate of exposure of edge-modified flakes as opposed to larger artifacts during deflation and erosion of the sites. Although no explanation is available at this time, it

TABLE 86
EDGE-MODIFIED FLAKE ATTRIBUTES BY RAW MATERIAL TYPE

Attributes	Fine/coarse-grained Potter Chert		Fine/coarse-grained Chert		Ogallala Quartzite		Opalized Caliche		Silicified Wood		Tecovas Jasper		Cretaceous Chert		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
SITE															
41GR207	2	50	2	50	-	-	-	-	-	-	-	-	-	-	4
41GR239	-	-	-	-	1	50	-	-	1	50	-	-	-	-	2
41GR287	-	-	1	100	-	-	-	-	-	-	-	-	-	-	1
41GR291	1	6	13	76	-	-	-	-	-	-	2	12	1	6	17
41GR302	-	-	5	100	-	-	-	-	-	-	-	-	-	-	5
41GR303	7	18	27	71	1	3	-	-	-	-	1	3	2	5	38
41GR323	-	-	9	60	1	7	-	-	-	-	3	20	2	13	15
41GR327	2	40	1	20	2	40	-	-	-	-	-	-	-	-	5
41GR359	2	9	17	77	-	-	1	5	1	5	1	5	-	-	22
41GR374	1	33	2	67	-	-	-	-	-	-	-	-	-	-	3
41GR376	2	9	14	61	-	-	1	4	-	-	4	17	2	9	23
41GR378	-	-	1	100	-	-	-	-	-	-	-	-	-	-	1
41GR381	1	33	2	67	-	-	-	-	-	-	-	-	-	-	3
41GR383	1	5	19	86	-	-	-	-	-	-	-	-	2	9	22
41GR456	-	-	7	78	-	-	-	-	-	-	1	11	1	11	9
41GR484	-	-	3	100	-	-	-	-	-	-	-	-	-	-	3
41GR515	1	20	3	60	-	-	-	-	-	-	1	20	-	-	5
41KT33	-	-	10	91	-	-	1	9	-	-	-	-	-	-	11
41KT34	2	33	4	67	-	-	-	-	-	-	-	-	-	-	6
41KT49	-	-	4	100	-	-	-	-	-	-	-	-	-	-	4
41KT51	-	-	1	50	-	-	-	-	-	-	-	-	1	50	2
41KT52	-	-	1	100	-	-	-	-	-	-	-	-	-	-	1
41KT53	-	-	1	100	-	-	-	-	-	-	-	-	-	-	1
Totals:	22	11	147	72	5	2	3	1	2	1	13	6	11	5	203

Table 86, continued

Attributes	Fine/coarse-grained Potter Chert		Fine/coarse-grained Chert		Ogallala Quartzite		Opalized Caliche		Silicified Wood		Tecovas Jasper		Cretaceous Chert		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
PROVENIENCE															
Surface	14	15	58	64	2	2	1	1	1	1	9	10	6	7	91
Subsurface	<u>8</u>	<u>7</u>	<u>89</u>	<u>79</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>4</u>	<u>4</u>	<u>5</u>	<u>4</u>	<u>112</u>
Totals:	22	11	147	72	5	2	3	1	2	1	13	6	11	5	203
HEATING															
Heated/heat treated	6	12	37	76	-	-	1	2	-	-	1	2	4	8	49
Not heated	7	6	93	86	-	-	1	1	2	2	2	2	2	2	108
Indeterminate	<u>9</u>	<u>20</u>	<u>17</u>	<u>37</u>	<u>5</u>	<u>11</u>	<u>1</u>	<u>2</u>	<u>-</u>	<u>-</u>	<u>10</u>	<u>22</u>	<u>5</u>	<u>11</u>	<u>46</u>
Totals:	22	11	147	72	5	2	3	1	2	1	13	6	11	5	203
FLAKE TYPE															
Complete	11	14	54	68	3	4	2	3	1	1	8	10	-	-	79
Proximal	4	8	39	76	2	4	1	2	-	-	3	6	2	4	51
Chip	3	6	39	78	-	-	-	-	-	-	1	2	7	14	50
Chunks/indeterminate	<u>4</u>	<u>17</u>	<u>15</u>	<u>65</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>1</u>	<u>4</u>	<u>1</u>	<u>4</u>	<u>2</u>	<u>9</u>	<u>23</u>
Totals:	22	11	147	72	5	2	3	1	2	1	13	6	11	5	203
CORTEX CATEGORY															
Primary	2	22	3	33	2	22	-	-	-	-	2	22	-	-	9
Secondary	7	8	69	83	2	2	-	-	1	1	2	2	2	2	83
Tertiary	<u>13</u>	<u>12</u>	<u>75</u>	<u>68</u>	<u>1</u>	<u>1</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>9</u>	<u>8</u>	<u>9</u>	<u>8</u>	<u>111</u>
Totals:	22	11	147	72	5	2	3	1	2	1	13	6	11	5	203

Table 86, continued

TABLE 63, continued

Attributes	Fine/coarse-grained Potter Chert		Fine/coarse-grained Chert		Ogallala Quartzite		Opalized Caliche		Silicified Wood		Tecovas Jasper		Cretaceous Chert		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
LENGTH CATEGORY															
1-10 mm	-	-	2	100	-	-	-	-	-	-	-	-	-	-	2
11-20 mm	2	3	58	91	-	-	-	-	-	-	3	5	1	2	64
21-30 mm	3	4	59	78	1	1	2	3	-	-	6	8	5	7	76
31-40 mm	8	29	14	50	-	-	1	4	-	-	2	7	3	11	28
41-50 mm	3	18	9	53	2	12	-	-	1	6	-	-	2	12	17
51-60 mm	1	17	3	50	1	17	-	-	-	-	1	17	-	-	6
61-70 mm	4	57	2	29	1	14	-	-	-	-	-	-	-	-	7
71+ mm	<u>1</u>	<u>33</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>1</u>	<u>33</u>	<u>1</u>	<u>33</u>	<u>-</u>	<u>-</u>	<u>3</u>
Totals:	22	11	147	72	5	2	3	1	2	1	13	6	11	5	203
NUMBER OF MODIFIED EDGES															
One	11	9	97	78	4	3	2	2	1	1	6	5	3	2	124
Two	11	16	44	63	1	1	1	1	1	1	5	7	7	10	70
Three or more	<u>-</u>	<u>-</u>	<u>6</u>	<u>67</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>2</u>	<u>22</u>	<u>1</u>	<u>11</u>	<u>9</u>
Totals:	22	11	147	72	5	2	3	1	2	1	13	6	11	5	203
INFERRED MANNER OF USE															
Sawing/cutting	10	10	76	73	4	4	-	-	1	1	6	6	7	7	104
Scraping	22	13	118	68	2	1	4	2	2	1	13	7	13	7	174
Boring	1	100	-	-	-	-	-	-	-	-	-	-	-	-	1
Engraving	<u>-</u>	<u>-</u>	<u>9</u>	<u>75</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>3</u>	<u>25</u>	<u>-</u>	<u>-</u>	<u>12</u>
Totals:	33	11	203	70	6	2	4	1	3	1	22	8	20	7	291

is interesting to note that while 61% of the fine-grained chert specimens are from the subsurface, only 36% of the Potter chert items are from the same context.

The analysis of raw material heating characteristics indicates the same pattern noted previously among other tool categories. In general, nonheated raw materials dominate the assemblage due primarily to the large frequency of fine-grained raw materials in the overall collection. The coarser grained raw materials (e.g., Potter chert) tend to be heated/heat treated more often than the finer grained raw materials (local fine-grained chert, Tecovas jasper, and Cretaceous chert). Based on the lack of differential luster (Collins and Fenwick 1974), it is likely that these heated specimens represent debitage removed from the surface of heat-treated artifacts as opposed to the heat treatment of flake blanks subsequently used in various expedient tasks.

Complete flakes dominate the assemblage (39%), followed by proximal fragments and chips at 25% each. A relatively small percentage of indeterminate chunk edge-modified flakes were also recovered. Because no differentiation was made during the analysis between the flake type used as an expedient tool and the completeness of the tool itself, it is not possible to determine the correlation between flake type and tool completeness. Consequently, it is also impossible to determine the ratio of use-related to manufacturing breaks in this tool class. Complete flakes dominate in each of the raw material categories. This suggests that complete flakes were purposely selected as blanks. However, the comparison of modification lengths on complete versus incomplete fine-grained chert edge-modified flakes suggests that this is not the case. The mean length of modification on complete flakes is 16 mm ($s = 8.5$), while that on incomplete flakes is 17 mm ($s = 10.1$). This pattern may be due to some of the flake fragments representing use-broken specimens.

Edge-modified tertiary flakes are the most common, although secondary flakes are also relatively frequent. Only a small number of primary flakes were employed as expedient tools. These differences may be indicative of at least one aspect of tool use and function, i.e., the more acute face angle of tertiary as opposed to secondary and primary flakes. This hypothesis is supported by the fact that the mean face angle on primary and secondary fine-grained chert edge-modified flakes is 47° ($s = 17.0$), while on tertiary flakes it is 37° ($s = 15.4$). These figures suggest that, rather than the presence or absence of cortex being a selection criteria for edge-modified flake blanks, perhaps more significant was the angle described by the two faces of the flake. It is notable that moderate percentages of the two nonlocal raw material types (Tecovas jasper and Cretaceous chert) occur in the form of primary and secondary flakes (31% and 18%). The presence of some primary and secondary flakes is somewhat surprising given the expectation that the farther a raw material was transported from the source, the less likely it is that debitage from its continued reduction will contain primary and/or secondary flakes. It is possible, however, that these edge-modified flake blanks were obtained from artifacts (i.e., large unifaces) made on secondary or even primary flakes outside of the project area and subsequently transported and further reduced or rejuvenated in the project area.

The analysis of the edge-modified flakes by length category indicates that overall the percentage of flakes increases between the smallest size category and the 21-30-mm category. Subsequently, the percentage of flakes in each larger size category gradually decreases. The same general trend is seen in the fine-grained chert edge-modified flake collection. The slightly different pattern seen among the Potter chert edge-modified flakes may be a reflection of the larger size of the parent raw materials from which the flake blanks were obtained. No edge-modified flakes on Cretaceous materials are larger than 50 mm, and only two Tecovas jasper specimens are in the size categories above 50 mm.

Flakes with a single modified edge are the most numerous (61%). Flakes with two modified edges are still relatively frequent (34%), while flakes with three modified edges are infrequent (4%). In total, 291 modified edges are present on the 203 edge-modified specimens. One-third (34%) of all the fine-grained chert specimens have two or more modified edges, while 50% of the Potter chert flakes fall in this group. On the other hand, 54% of the Tecovas jasper specimens and 73% of the Cretaceous chert flakes have two or more modified edges. These figures suggest a more intensive or repeated utilization of the highly silicified nonlocal materials than of the locally available types.

Edges used in scraping tasks are most numerous in this collection (60%), although cutting/sawing edges (36%) are also relatively frequent. Edges used in engraving tasks are infrequent (4%), and only one (0.3%) pointed edge was used in boring tasks. Edges used in scraping tasks outnumber all other uses in six of the seven material types, although a slightly higher percentage of the fine-grained local chert tools were used in sawing/cutting tasks than was the case with Potter chert flakes. Four of the six modified edges on Ogallala quartzite (67%) were used in sawing/cutting tasks. Although this is a small sample, the preponderance of sawing/cutting edges on Ogallala quartzite tools may indicate a relationship between tool use and raw material grain size (coarseness). It is possible that coarse raw materials such as quartzite perform more effectively in some cutting/sawing tasks involving certain (e.g., harder) materials. The abundance of fine-grained Potter chert specimens among the gouges is not mirrored in the edge-modified flakes in terms of edges used in scraping tasks. One possible explanation for this discrepancy may be the different material types worked by the two tool classes, or more probably the force loading necessary to perform tasks with gouges as opposed to edge-modified flakes.

The analysis of individual edge use by site indicates two general patterns (Table 87). Edges used in scraping tasks outnumber other uses at 17 of the 23 sites. Edges used in sawing/cutting tasks are more numerous than scraping edges at five sites. Edges used as engravers are most frequent at the site with the largest edge-modified flake collection (41GR303), and they occur in low frequencies at six other sites. The single boring tool is also from 41GR303.

The analysis of edge use by edge shape (see Table 87) indicates some distributional differences. For instance, a much larger percentage of sawing/cutting edges are straight, while more of the scraping edges are concave and irregular. On the other hand, almost equal percentages of sawing/cutting edges and scraping edges are convex. These differences suggest that tool edge shape may have been one selection factor in flake blank use or that use may have altered edge shape.

The breakdown of the length of edge modification by edge use also shows some interesting differences between the three categories with the largest samples (i.e., sawing/cutting, scraping, and engraving). The largest percentage of edge modifications in the shortest length category occurs among the engraving tools, followed by scraping and sawing/cutting tools. This pattern is not unexpected because working edges employed as engravers are relatively short (and pointed) and scraping edge contact with the worked material is relatively localized. In comparing the sawing/cutting and scraping tool edges, it is apparent that the former exhibit greater lengths of modification. On the other hand, edge modification lengths on specimens used in engraving tasks do not exceed 30 mm. Again, it is probable that these differences are derived from differences in the length of the contact between the tool edges and the worked materials. Because the contact of sawing/cutting edges parallels the long axis of the flake, use-generated wear is expected to

TABLE 87

EDGE-MODIFIED FLAKE ATTRIBUTES BY INFERRED MANNER OF USE

Attribute	Sawing/Cutting		Scraping		Engraving		Boring		Totals
	#	%	#	%	#	%	#	%	
SITE									
41GR207	-	-	6	100	-	-	-	-	6
41GR239	1	33	2	67	-	-	-	-	3
41GR287	-	-	1	100	-	-	-	-	1
41GR291	9	31	20	69	-	-	-	-	29
41GR302	4	57	3	43	-	-	-	-	7
41GR303	13	24	36	67	4	7	1	2	54
41GR323	8	42	10	53	1	5	-	-	19
41GR327	1	20	4	80	-	-	-	-	5
41GR359	6	21	22	79	-	-	-	-	28
41GR374	1	33	2	67	-	-	-	-	3
41GR376	19	49	18	46	2	5	-	-	39
41GR378	-	-	2	100	-	-	-	-	2
41GR381	2	50	1	25	1	25	-	-	4
41GR383	23	68	10	29	1	3	-	-	34
41GR456	3	25	7	58	2	17	-	-	12
41GR484	2	50	2	50	-	-	-	-	4
41GR515	7	100	-	-	-	-	-	-	7
41KT33	-	-	14	93	1	7	-	-	15
41KT34	4	44	5	56	-	-	-	-	9
41KT49	1	25	3	75	-	-	-	-	4
41KT51	-	-	4	100	-	-	-	-	4
41KT52	-	-	1	100	-	-	-	-	1
41KT53	-	-	1	100	-	-	-	-	1
Totals:	104	36	174	60	12	4	1	<1	291
EDGE SHAPE									
Straight	47	45	48	28	-	-	-	-	95
Concave	15	14	39	22	-	-	-	-	54
Convex	30	29	54	31	-	-	-	-	84
Irregular	12	12	29	17	-	-	-	-	41
Notched	-	-	1	1	-	-	-	-	1
Denticulate	-	-	3	2	-	-	-	-	3
Pointed	-	-	-	-	12	100	1	100	13
Totals:	104	100	174	101	12	100	1	100	291
LENGTH OF EDGE MODIFICATION									
1-10 mm	7	7	53	30	8	67	-	-	68
11-20 mm	50	48	80	46	2	17	1	100	133
21-30 mm	27	26	25	14	2	17	-	-	54

Table 87, continued

Attribute	Sawing/Cutting		Scraping		Engraving		Boring		Totals
	#	%	#	%	#	%	#	%	
31-40 mm	10	10	8	5	-	-	-	-	18
41-50 mm	5	5	4	2	-	-	-	-	9
51-60 mm	3	3	3	2	-	-	-	-	6
61+ mm	2	2	1	1	-	-	-	-	3
Totals:	104	101	174	100	12	101	1	100	291
EDGE ANGLES									
1-20°	1	1	-	-	-	-	-	-	1
21-40°	9	9	4	2	2	17	-	-	15
41-60°	27	26	15	9	3	25	-	-	45
61-80°	58	56	102	59	6	50	1	100	167
81-100°	9	9	53	30	1	8	-	-	63
Totals:	104	101	174	100	12	100	1	100	291

extend over a larger portion of the edge than in the case of scraping use, in which the tool edge moves perpendicular to the long axis of the flake and contact between the tool edge and the worked material is more limited.

The analysis of edge angle by inferred use indicates some interesting differences between the three groups. A larger percentage of the sawing/cutting tools have edge angles less than 60° in comparison to the tool edges used in scraping tasks. Similar percentages of edges in these two categories occur in the 61-80° category. On the other hand, a much larger percentage of scraping edges have angles of 81-100°. Edges used in engraving tasks have similar values and patterns to those seen among sawing/cutting edges. The one exception is that 17% of the edges used in engraving have angles of 21-40°, while only 9% of the sawing/cutting edges fall in this category. The differences between the use groups in terms of edge angle reflect differences in the manner of use and, consequently, wear formation.

Unmodified Debitage

A total of 2,783 unmodified lithic debitage specimens were collected from 34 sites. Of these, 127 are classified as microdebitage less than 5 mm in maximum dimension; all of these were recovered from flotation samples. The bulk of this section discusses only the results of the analyses performed on the 2,656 nonmicrodebitage specimens (Table 88). A brief discussion of the distribution of the microdebitage is presented at the conclusion of the section. With the exception of the frequency of these specimens by provenience, no analysis of the microdebitage was conducted.

In general, the sites with the largest tool collections also yielded the largest collections of lithic debitage. Sites 41GR303, 41GR359, 41GR291, 41GR383, 41KT33, 41GR456, 41GR323, 41KT53, and 41KT34 yielded 78% of the lithic debitage. Other sites individually

TABLE 88
UNMODIFIED LITHIC DEBITAGE ATTRIBUTES BY RAW MATERIAL TYPE*

Attribute	Potter Chert		Local Chert		Quartzite		Opalized Caliche		Silici- fied Wood		Alibates Agate		Tecovas Jasper		Creta- ceous Chert		Silici- fied Caliche		Misc.		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
SITE																					
41GR207	2	7	27	90	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
41GR239	1	20	1	20	-	-	-	-	-	-	1	20	-	-	-	-	-	-	2	40	5
41GR286	6	60	1	10	2	20	-	-	-	-	-	-	-	-	-	-	-	-	1	10	10
41GR287	-	-	2	67	-	-	-	-	1	33	-	-	-	-	-	-	-	-	-	-	3
41GR291	58	19	206	68	29	10	2	1	-	-	-	-	1	<1	2	1	3	1	3	1	304
41GR302	39	52	26	35	2	3	3	4	-	-	-	-	2	3	-	-	-	-	3	4	75
41GR303	175	37	200	42	62	13	10	2	4	1	-	-	7	1	7	1	-	-	7	1	472
41GR323	18	15	86	70	7	6	3	2	-	-	-	-	1	1	7	6	-	-	1	1	123
41GR327	19	63	4	13	7	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
41GR359	94	26	162	45	78	22	-	-	1	<1	5	1	1	<1	4	1	1	<1	16	4	362
41GR374	2	40	2	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	20	5
41GR376	7	11	24	38	16	25	-	-	-	-	-	-	1	2	14	22	-	-	2	3	64
41GR378	1	25	3	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
41GR380	16	40	11	28	10	25	-	-	-	-	-	-	-	-	-	-	-	-	3	8	40
41GR381	13	59	5	23	-	-	2	9	1	5	-	-	-	-	-	-	-	-	1	5	22
41GR383	50	20	152	62	18	7	3	1	1	<1	1	<1	8	3	1	1	2	1	11	4	247
41GR456	24	14	104	62	13	8	1	1	-	-	-	-	16	9	3	2	1	1	7	4	169
41GR467	3	23	7	54	3	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13
41GR471	-	-	10	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
41GR483	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	-	-	1
41GR484	-	-	40	78	2	4	-	-	1	2	-	-	1	2	6	12	-	-	1	2	51

*Does not include unmodified microdebitage.

Table 88, continued

Attribute	Potter Chert		Local Chert		Quartzite		Opalized Caliche		Silici- fied Wood		Alibates Agate		Tecovas Jasper		Creta- ceous Chert		Silici- fied Caliche		Misc.		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
41GR512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	-	-	1
41HR515	6	13	17	37	10	22	-	-	-	-	-	-	8	17	3	7	-	-	2	4	46
41GR539	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
41GR546	-	-	3	50	-	-	-	-	-	-	-	-	-	-	1	17	-	-	2	33	6
41GR559	7	32	10	45	2	9	-	-	-	-	-	-	1	5	-	-	-	-	2	9	22
41GR569	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
41KT33	34	19	118	66	12	7	1	1	-	-	-	-	2	1	11	6	-	-	-	-	178
41KT34	20	19	54	52	9	9	-	-	1	1	-	-	11	11	-	-	-	-	8	8	103
41KT44	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
41KT49	7	9	63	81	3	4	-	-	-	-	-	-	-	-	4	5	-	-	1	1	78
41KT51	-	-	50	77	-	-	1	2	-	-	-	-	-	-	14	22	-	-	-	-	65
41KT52	-	-	5	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
41KT53	2	2	86	79	4	4	-	-	-	-	-	-	1	1	15	14	-	-	1	1	109
Totals:	606	23	1480	56	290	11	26	1	10	<1	7	<1	61	2	94	4	7	<1	75	3	2656
MAXIMUM DIMENSION CATEGORY																					
1-10 mm	7	5	106	81	7	5	1	1	-	-	1	1	-	-	3	2	-	-	6	5	131
11-20 mm	235	16	961	67	101	7	18	1	4	<1	3	<1	31	2	55	4	4	<1	26	2	1438
21-30 mm	171	26	306	47	89	14	3	<1	2	<1	3	<1	21	3	26	4	2	<1	25	4	648
31-40 mm	73	33	76	35	37	17	4	2	1	<1	-	-	8	4	7	3	-	-	13	6	219
41-50 mm	56	50	22	20	23	21	-	-	3	3	-	-	1	1	2	2	1	1	3	3	111
51-60 mm	32	52	7	11	21	34	-	-	-	-	-	-	-	-	-	-	-	-	2	3	62
61+ mm	32	68	2	4	12	26	-	-	-	-	-	-	-	-	1	2	-	-	-	-	47
Totals:	606	23	1480	56	290	11	26	1	10	<1	7	<1	61	2	94	4	7	<1	75	3	2656

Table 88, continued

TABLE 63 continued

Attribute	Potter Chert		Local Chert		Quartzite		Opalized Caliche		Silici- fied Wood		Alibates Agate		Tecovas Jasper		Creta- ceous Chert		Silici- fied Caliche		Misc.		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
FLAKE TYPE																					
Complete	131	24	317	58	37	7	8	1	1	<1	1	<1	11	2	28	5	1	<1	7	1	542
Proximal	194	26	400	54	86	12	5	1	-	-	3	<1	18	2	19	3	3	<1	12	2	740
Chip	209	19	656	59	125	11	10	1	6	1	3	<1	20	2	43	4	2	<1	39	4	1113
Chunks	<u>72</u>	<u>28</u>	<u>107</u>	<u>41</u>	<u>42</u>	<u>16</u>	<u>3</u>	<u>1</u>	<u>3</u>	<u>1</u>	-	-	<u>12</u>	<u>5</u>	<u>4</u>	<u>2</u>	<u>1</u>	<u><1</u>	<u>17</u>	<u>7</u>	<u>261</u>
Totals:	606	23	1480	56	290	11	26	1	10	<1	7	<1	61	2	94	4	7	<1	75	3	2656
CORTEX																					
Present	160	28	234	40	96	17	1	<1	1	<1	3	1	26	4	16	3	1	<1	41	7	579
Absent	<u>120</u>	<u>19</u>	<u>388</u>	<u>60</u>	<u>68</u>	<u>11</u>	<u>6</u>	<u>1</u>	<u>3</u>	<u><1</u>	<u>4</u>	<u>1</u>	<u>22</u>	<u>3</u>	<u>12</u>	<u>2</u>	<u>3</u>	<u><1</u>	<u>19</u>	<u>3</u>	<u>645</u>
Totals:	280	23	622	51	164	13	7	1	4	<1	7	1	48	4	28	2	4	<1	60	5	1224
CORTEX PERCENT																					
0	153	18	541	65	53	6	11	1	1	<1	-	-	8	1	61	7	2	<1	6	1	836
1-50	73	28	151	58	26	10	3	1	-	-	-	-	2	1	3	1	-	-	2	1	260
51-99	47	36	63	48	15	11	2	2	1	1	-	-	-	-	2	2	-	-	1	1	131
100	<u>17</u>	<u>25</u>	<u>36</u>	<u>53</u>	<u>13</u>	<u>19</u>	-	-	<u>1</u>	<u>1</u>	-	-	-	-	-	-	-	-	<u>1</u>	<u>1</u>	<u>68</u>
Totals:	290	22	791	61	107	8	16	1	3	<1	0	0	10	1	66	5	2	<1	10	1	1295
CORTEX ON CHUNKS																					
Present	20	21	46	48	15	16	3	3	3	3	-	-	3	3	-	-	1	1	5	5	96
Absent	<u>16</u>	<u>39</u>	<u>21</u>	<u>51</u>	<u>4</u>	<u>10</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<u>41</u>
Totals:	36	26	67	49	19	14	3	2	3	2	0	0	3	2	0	0	1	1	5	4	137

Table 88, continued

TABLE 33, continued

Attribute	Potter Chert		Local Chert		Quartzite		Opalized Caliche		Silici- fied Wood		Alibates Agate		Tecovas Jasper		Creta- ceous Chert		Silici- fied Caliche		Misc.		Totals
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
PLATFORM CORTEX																					
Present	57	42	55	40	20	15	2	1	-	-	-	-	-	-	1	1	-	-	2	1	137
Absent	<u>134</u>	<u>24</u>	<u>327</u>	<u>59</u>	<u>34</u>	<u>6</u>	<u>6</u>	<u>1</u>	<u>1</u>	<u><1</u>	-	-	<u>7</u>	<u>1</u>	<u>37</u>	<u>7</u>	<u>1</u>	<u><1</u>	<u>3</u>	<u>1</u>	<u>550</u>
Totals:	191	28	382	56	54	8	8	1	1	<1	0	0	7	1	38	6	1	<1	5	1	687
PLATFORM GRINDING																					
Present	59	24	129	54	12	5	2	1	-	-	-	-	5	2	31	13	-	-	3	1	241
Absent	<u>132</u>	<u>30</u>	<u>253</u>	<u>57</u>	<u>42</u>	<u>9</u>	<u>6</u>	<u>1</u>	<u>1</u>	<u><1</u>	-	-	<u>2</u>	<u><1</u>	<u>7</u>	<u>2</u>	<u>1</u>	<u><1</u>	<u>2</u>	<u>1</u>	<u>446</u>
Totals:	191	28	382	56	54	8	8	1	1	<1	0	0	7	1	38	6	1	<1	5	1	687
PLATFORM FACET COUNT																					
One	104	25	225	54	38	9	4	1	-	-	-	-	6	1	32	8	-	-	4	1	413
Two	34	30	65	57	9	8	2	2	1	1	-	-	-	-	2	2	1	1	-	-	114
Three	36	37	52	54	5	5	1	1	-	-	-	-	1	1	1	1	-	-	1	1	97
More than three	<u>17</u>	<u>27</u>	<u>40</u>	<u>63</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	-	-	-	-	-	-	<u>3</u>	<u>5</u>	-	-	-	-	<u>63</u>
Totals:	191	28	382	56	54	8	8	1	1	<1	0	0	7	1	38	6	1	<1	5	1	687

contributed 3% or less of the collection. For presentation, the fine- and coarse-grained materials are combined in the Potter chert and local chert categories. Similarly, the Ogallala, milk white, unidentified, and conglomerate quartzite types are combined into one quartzite group. The miscellaneous material category contains the very few sandstone, basalt, and unidentified raw materials. The one notable trend in the raw materials which is obscured by this grouping is that, somewhat surprisingly, coarse-grained Potter chert debitage represents a higher percentage in the Potter chert debitage collection (32%) than anticipated. However, given the large number of cobble tools at many of the sites and the fact that these tools tended to be manufactured of coarse-grained materials (e.g., coarse-grained Potter chert), this high percentage may not be out of line.

Locally available cherts represent the most frequently employed raw material type (56%) followed by Potter chert (23%). The quartzite materials were the next most frequently used, followed by the nonlocal Cretaceous cherts. It is somewhat surprising that Tecovas jasper represents 2% of the debitage collection while all other material types constitute 1% or less. More-interesting patternings are evident in the breakdown of the raw material categories by site. Of the sites with debitage collections equal to or greater than 30 specimens, 11 sites (41GR207, 41GR291, 41GR323, 41GR383, 41GR456, 41GR484, 41KT33, 41KT34, 41KT49, 41KT51, and 41KT53) yielded more than 50% locally available cherts. Interestingly, five of these sites (41GR456, 41GR484, 41KT34, 41KT51, and 41KT53) also exhibit relatively large percentages of nonlocal Cretaceous chert and/or Tecovas jasper. Five of the remaining sites (41GR302, 41GR327, 41GR359, 41GR380, and 41GR381) with samples equal to or greater than 30 specimens have collections consisting of more than 50% locally available coarser grained raw materials (i.e., Potter chert, quartzites, silicified wood, silicified caliche). One additional site (41GR515) contains a relatively high percentage (17%) of Tecovas jasper debitage. To examine the factors generating these patterns, site locations within the project area were compared with the percentages of local chert and locally available coarser grained raw materials. Of the 11 sites with chert frequencies equal to or greater than 50%, 7 (64%) are located in the eastern end of the project area. Only four of these sites (41GR207, 41GR291, 41GR383, and 41GR456) are located at the western end of the project area. On the other hand, all five of the sites in which locally available coarse-grained materials dominate the collections are located in the western or central portion of the project area. An additional aspect that needs to be considered is the temporal affiliation of the sites with large local chert collections. Four sites (41GR323, 41GR484, 41KT51, and 41KT53) are assigned to the Late Prehistoric II period based on radiocarbon dates and artifacts. All of these sites are located at the eastern end of the project area, and each has a local chert percentage equal to or greater than 70%. These patterns suggest two competing explanations: (1) the presence of a chert source located in the eastern portion of the project area in the middle or upper portions of Grape Creek; or (2) a strong selection of locally available chert sources by Late Prehistoric II occupants of the project area. At the present time, it is impossible to identify which of these explanations contributes to the patterns observed. A more systematic sample of the raw materials available in noncultural contexts as well as from lithic procurement sites along an east-west transect in the project area is needed to weigh the role of the temporal and locational elements of the raw material procurement patterns.

The debitage maximum dimension data indicate that flakes in the 11-20-mm category dominate the collection (54%). Only 5% of the debitage is smaller than 11 mm, and the frequency of debitage decreases as size increases beyond 11-20 mm. While these patterns are not surprising, some interesting differences can be noted between raw material types. For instance, of the Potter chert and quartzite debitage, 38% falls in the 11-20-mm

category, and 11% is larger than 51 mm in maximum dimension. The size distribution of the locally available chert specimens is quite different; 65% falls in the 11-20-mm category, and only 1% is larger than 51 mm. This pattern probably reflects differences in the sizes of the naturally occurring raw materials. On the other hand, the Cretaceous cherts demonstrate a third size distribution pattern. The percentage of flakes in the 11-20-mm size range (59%) is higher than in the Potter chert and quartzite materials but somewhat lower than in the locally available cherts. Similar to the local chert raw materials, only 1% of the Cretaceous debitage is greater than 51 mm in maximum dimension. The Tecovas jasper debitage also shows a different size distribution pattern. One-half (51%) is 11-20 mm in size, and a relatively high 34% is in the 21-30-mm size category. No flakes measure greater than 51 mm.

Chips (distal and medial fragments) are the most abundant category (42%) in the collection, followed by proximal fragments (28%). Complete flakes are next in frequency (20%), while chunks are the least frequent (10%). Potter chert and the locally available cherts have equal frequencies of complete flakes (22%). On the other hand, the quartzites are comprised of only 13% complete flakes. The Cretaceous chert contains 30% complete flakes.

Two types of analyses were conducted on the 2,656 specimens collected (see Table 88). For 1,224 debitage pieces, only four attributes were recorded (raw material, maximum dimension, flake type, and cortex presence/absence). For the remaining 1,432 specimens, a more extensive list of attributes was recorded, including dorsal cortex percentage, platform cortex, platform grinding, platform facet count, and dorsal scar count. Of the 1,224 specimens in the limited analysis, 579 (47%) contain cortex. The remaining 645 flakes (53%) are tertiary specimens. Among the Potter chert specimens, 57% are secondary (corticate); a similar percentage (59%) of the quartzite specimens are secondary. The locally available cherts exhibit a different pattern; only 38% contain cortex, while the majority are tertiary (decorticate). Interestingly, the majority of the nonlocal raw material types (Cretaceous chert, Tecovas jasper, and Alibates agate) contain relatively high frequencies of corticate flakes (57%, 54%, and 43%). These frequencies suggest that some of the nonlocal materials were brought to the sites either in the form of corticate artifact types (e.g., unifaces or corticate cores) or in the form of tested nodules containing a large percentage of cortex. The second alternative seems unlikely, although not impossible. The transportation of artifacts such as unifaces made on large primary or secondary flakes is more likely given that such unifaces have been encountered in the survey collections from sites in the project area (Boyd 1989b).

Of the 1,432 pieces of unmodified debitage on which more-detailed study was conducted, 90% (n = 1,295) are complete flakes, proximal fragments, or chips. The majority of these (65%) are tertiary, while 20% contain 50% or less cortex. Ten percent of the remaining specimens have 51-99% cortex, and 5% are entirely cortex covered. Significant differences exist between the coarser versus finer grained and between the local versus nonlocal materials in the collection. For instance, only 52% of the Potter chert and quartzite debitage is tertiary, while 8% has 100% cortex. On the other hand, 68% of the locally available chert debitage is tertiary, and only 5% is entirely corticate. The Cretaceous and Tecovas jasper debitage differ from both of the preceding types. Ninety-two percent of the Cretaceous debitage is tertiary, and none of this raw material occurs as primary flakes. The Tecovas jasper debitage contains 80% tertiary flakes and no flakes with more than 50% cortex.

Of the 137 chunks that were part of the detailed lithic analysis, 70% contain cortex. The other 30% (n = 41) are decorticate. Corticate chunks outnumber decorticate specimens in all of the raw material types. It is not possible to interpret these breakdowns, other than the obvious fact that most of the chunks are the result of early reduction removals or are spalls generated as secondary removals during early reduction.

Platform cortex is present on 20% of the complete flakes and proximal flake fragments. The remainder have decorticate platforms. Considerable variation occurs between the different raw material types. Almost one-third (30%) of the Potter chert platform-bearing debitage has cortex, while 37% of the quartzite specimens fall in this category. Only 14% of the locally available chert platform-bearing flakes have corticate platforms, while only 3% of the Cretaceous platform flakes contain cortex. None of the seven Tecovas jasper platform flakes contain cortex. The platform cortex patterning in the nonlocal raw materials indicates that most of these materials were introduced into the project area as partially decorticate artifacts rather than as unreduced cores.

Over one-third (35%) of the platform flakes have ground striking platforms. The lowest percentages of ground platforms are among the coarser grained raw materials (quartzite, 22%; Potter chert, 31%). Among the locally available materials, chert has the highest frequency of ground platforms (34%), while the nonlocal raw materials (Tecovas jasper and Cretaceous chert) have 71% and 82% ground platforms. This high frequency of ground platforms suggests that these flakes were either removed following platform preparation during a manufacturing sequence or removed as rejuvenation flakes from edges which had become dulled by use. Because no microscopic wear analysis of these platforms was performed to establish the nature of the rounding, it is not possible to determine which of the two explanations applies; however, if the ground platform flakes were removed during manufacture, the resulting debitage should exhibit multifaceted striking platforms. On the other hand, the rejuvenation of dulled edges on tools such as unifaces and gouges should have generated platforms with single facets.

The analysis of platform faceting indicates that 60% of the platform flakes have single facets. An additional 17% have platforms with two facets, while only 14% have three and 9% have more than three facets. The distribution by raw material type again shows distinct patterns between coarse- versus fine-grained and between local versus nonlocal materials. Among the material types with sufficient sample sizes, the Potter chert platform flakes have the lowest frequency of single-faceted flakes (54%). Almost three-fifths (59%) of the locally available chert flakes with platforms have single facets, while 70% of the quartzite flakes are single faceted. These differences may indicate differences in manufacturing strategies, degrees of reduction within these three raw materials, or perhaps different rates of artifact rejuvenation among the different types of artifacts. That is, the high figures in the quartzites may suggest that few items were reduced greatly beyond the removal of blanks from cores. This is supported by the few formal artifacts in the collection made of this material type. However, a look at all the quartzite (all types of quartzites) artifacts collected from survey (Boyd 1989b:306) and testing indicates that 65% of the 77 specimens are unifaces, while choppers, bifaces, and projectile points comprise only 45%. These figures suggest that the high number of single-faceted platform flakes could have resulted from the manufacture and rejuvenation of the large number of unifaces made of this material.

The similar figures among the Potter chert and the locally available finer grained cherts may indicate that some unifacial tool rejuvenation and bifacial artifact manufacture

occurred with both material types. Of the artifacts collected during both survey and testing, 50% of the Potter chert and 54% of the locally available chert specimens are unifaces. That the percentage of unifaces made of local chert is higher than that made of Potter chert (54% versus 50%), while the percentage of single-faceted platform flakes of local chert is 5% higher than among Potter chert flakes (59% versus 54%), is intriguing. In contrast to these materials, 84% of the Cretaceous chert and 86% of the Tecovas jasper platform flakes are single faceted. The combined survey and testing artifact collection indicates that 40% each of the Cretaceous chert and the Tecovas jasper artifacts are unifaces, while bifaces and projectile points also contribute a significant proportion of the artifacts made of these materials. The single-faceted platform flakes of these non-local raw materials represent primarily rejuvenation, assuming that manufacture took place at the source area. In the case of locally available raw materials, some portion of the unifacial platform flakes represents manufacture and another portion derives from the rejuvenation of unifacial artifacts. If this scenario is correct, it suggests that unifaces made of Cretaceous chert were utilized until they were entirely worn prior to discard, producing a higher rate of unifacial rejuvenation flakes. Additionally, considering only the artifact types made of the same raw materials, the platform flake faceting patterns appear to suggest that unifaces were rejuvenated more consistently than bifaces and projectile points. This is suggested by the low frequency of multifaceted platform flakes in the debitage of Cretaceous chert and Tecovas jasper.

The analysis of the microdebitage was directed primarily toward the isolation of primary activity areas as opposed to secondary refuse disposal loci (Behm 1983; Baumler 1985; Clark 1986). Primary activity areas, under normal site maintenance activities, should contain a higher frequency of microdebitage than secondary refuse disposal concentrations (see Clark 1986 for exceptions). Microdebitage has a higher chance of escaping site maintenance activities than larger debitage specimens.

The distributional analysis of the 127 microdebitage specimens (Table 89) indicates that features contain an average of 9 specimens while levels not containing features have an average of only 2.4 specimens. This difference appears to support the assumption that features were loci where some lithic reduction activities were carried out. It does not, however, rule out the probability that such activities also took place away from burned rock features.

Hammerstones

Thirty-five complete and fragmentary hammerstones were recovered from 15 archeological sites (Table 90). The largest collection ($n = 7$, 20%) was obtained from 41GR327, while two other sites (41GR359 and 41KT33) each contained 11% ($n = 4$) of the overall collection. Two other sites (41GR303 and 41KT34) had three hammerstones each, while the remaining sites each contained only one or two items. All but one of the hammerstones are of quartzite. The majority (71%) are Ogallala quartzites, and an additional 26% are unidentified quartzite specimens. The single nonquartzite hammerstone is made of a basaltic material containing white macrocrystalline inclusions within a dark gray matrix.

The vertical distribution of the hammerstones indicates that 66% are from surface contexts, while the remaining 34% are from excavation units. As in the case of some other tool categories, there is a relatively strong distributional bias in favor of surface

TABLE 89
PROVENIENCE OF MICRODEBITAGE

Site	Test Unit	Feature	Level (cm)	Specimens
41GR291	1	-	15-20	5
	5	2	30-59	2
41GR303	5	5	5-23	13
	1	-	90-100	1
41GR323	10	6	20-27	1
41GR456	1	3	24-35	1
41GR471	2	1	33-38	3
41GR546	1	-	17-27	3
	1	1	25-35	1
	1	-	40-50	2
	1	-	60-70	1
41GR559	3	2	28-42	8
	3	-	59-71	2
41KT33	4	1	0-18	6
	6	2	2-28	14
41KT49	6/7	4	20-30	1
41KT52	1	1	96-113	2
41KT53	2	1	13-47	2
	2	-	25-35	2
	7	4	18-25	57
Total:				127

artifacts. There are at least two avenues to explain this bias, human behavior and geomorphic processes. One of the potential behavioral explanations is the tendency for larger and still functional artifacts to be consistently extracted from existing archeological deposits and hence moved up-profile, while smaller items or broken and discarded specimens are left in their depositional contexts (Schiffer 1972). This scenario would result in the accumulation of a large percentage of complete items on the surface, while the majority of the fragmentary items would be found in subsurface contexts. The effects of various geomorphic processes (e.g., burial and reexposure) are difficult to predict. If large artifacts were discarded on the same surfaces as all other artifacts within an assemblage, then they should have been found together with smaller artifacts when erosion or deflation reexposed the deposits. On the other hand, the exposure of these deposits by agents that can remove smaller artifacts could generate surface collections composed primarily of large artifacts (e.g., hammerstones and ground stones). The co-occurrence of smaller artifacts with larger ones should indicate neither differential reexposure of depositional surfaces nor differential transport of smaller artifacts. The predominance of larger artifacts in surface collections can indicate (1) upward recycling of functional artifacts during site reuse or (2) differential reexposure or transport (removal) of small artifacts. A final but not unlikely possibility is that a predominance of large artifacts such as hammerstones

and/or ground stones may actually indicate an increase in the use of these artifact classes through time, specifically in the latest occupations.

To explore some of these possibilities, the frequency of complete and fragmentary hammerstones was obtained by provenience. It was found that 71% of the complete specimens are from surface contexts, while only 43% of the fragmentary hammerstones are from the surface. Furthermore, among the complete hammerstones it was found that larger specimens tended to come more frequently from surface as opposed to subsurface contexts. For instance, 11 of 14 specimens (79%) larger than 80 mm in maximum length were surface finds. On the other hand, only 64% of the specimens between 50 and 79 mm in length were recovered from the surface. Similarly, three of the four hammerstone fragments smaller than 70 mm (75%) were recovered from excavation contexts, while two of three specimens larger than 70 mm (67%) were surface finds. It is possible that the fragmentary hammerstone specimens found on the surface actually represent the use and breakage of these specimens during the last occupation of the sites.

Rounded and oval hammerstones each compose 23% of the collection. Angular hammerstones (17%) are also relatively frequent, while ovate (11%) and spherical (9%) specimens are somewhat less frequent. The shape of six of the seven fragments could not be determined. Almost half of the hammerstones (46%) exhibit wear only on their ends, while an additional 26% have only marginally located wear. Two percussors (6%) exhibit wear around their entire circumference, and eight specimens (23%) have localized wear traces on the ends and the margins. Almost two-fifths of the hammerstones (37%) have only slight traces of wear. A somewhat smaller percentage (34%) have moderate wear, and a relatively high 29% are extensively worn. The percentages of extensive and moderate wear may indicate that hammerstones were highly curated. If this conclusion is correct, it may indicate that in areas rich with raw materials hammerstones do not represent expedient tool types. It suggests that hammerstones, as part of the personal gear of a flintknapper, were curated artifacts irrespective of the local abundance of appropriate raw materials. Macroscopic striations, which usually result from platform preparation and are located either on the margins or the face of the hammerstone, were noted on only 3 of the 28 complete specimens (11%). This low frequency is surprising given the high frequency of platform preparation, especially during bifacial reduction strategies (Sheets 1973). Because unifacial reduction techniques do not require such intensive platform preparation, it is possible that the low frequency of striations may represent the relatively low frequency of bifacial reduction at the sites in the project area.

The analysis of metric attributes on the complete hammerstones indicates that maximum length ranges from 50 to 104 mm ($\bar{x}$ = 77, s = 13.4). Maximum width ranges from 37 to 92 mm ($\bar{x}$ = 62, s = 14.0). Finally, maximum thickness ranges from 20 to 62 mm ($\bar{x}$ = 38, s = 10.9). The weight of the 28 complete hammerstones ranges between 61 and 669 g ($\bar{x}$ = 281, s = 172.9). Only one specimen (4%) weighs less than 100 g. Almost half (46%) weigh between 101 and 200 g, with only 11% falling between 201 and 300 g. Four specimens weigh between 301 and 400 g, and a second smaller peak, with 7 specimens (25%), occurs above 401 g. This bimodal weight distribution may be due to two factors: (1) the use of these hammerstones to flake different raw materials; and (2) the use of these hammerstones at different stages of reduction. For instance, informal experiments indicate that Potter chert and quartzite raw materials are relatively hard and that flake blanks can be removed effectively only using heavy hammerstones. All else being equal, a heavier hammerstone is needed to remove equal-sized flake blanks from Potter chert compared to fine-grained chert cores. On the other hand, the early reduction of bifaces requires larger flake removals and, by

TABLE 90
HAMMERSTONE ATTRIBUTES BY RAW MATERIAL TYPE

Attribute	Ogallala		Unidentified		Miscellaneous		Totals
	Quartzite		Quartzite				
	#	%	#	%	#	%	
SITE							
41GR207	1	100	-	-	-	-	1
41GR286	1	100	-	-	-	-	1
41GR291	1	50	1	50	-	-	2
41GR303	3	100	-	-	-	-	3
41GR327	6	86	1	14	-	-	7
41GR359	1	25	2	50	1	25	4
41GR380	1	100	-	-	-	-	1
41GR381	2	100	-	-	-	-	2
41GR383	-	-	1	100	-	-	1
41GR484	1	100	-	-	-	-	1
41GR515	2	100	-	-	-	-	2
41GR559	-	-	2	100	-	-	2
41KT33	3	75	1	25	-	-	4
41KT34	3	100	-	-	-	-	3
41KT49	-	-	1	100	-	-	1
Totals:	25	71	9	26	1	3	35
PROVENIENCE							
Surface	19	83	4	17	-	-	23
Subsurface	6	50	5	42	1	8	12
Totals:	25	71	9	26	1	3	35
COMPLETENESS							
Complete	19	68	9	32	-	-	28
Fragment	6	86	-	-	1	14	7
Totals:	25	71	9	26	1	3	35
SHAPE							
Rounded	4	50	4	50	-	-	8
Oval	7	88	1	13	-	-	8
Angular	4	67	2	33	-	-	6
Spherical	2	67	1	33	-	-	3
Ovate	3	75	1	25	-	-	4
Unknown	5	83	-	-	1	17	6
Totals:	25	71	9	26	1	3	35

Table 90, continued

TABLE 50, Continued							
Attribute	Ogallala Quartzite		Unidentified Quartzite		Miscellaneous		Totals
	#	%	#	%	#	%	
WEAR LOCATION							
End wear	11	69	5	31	-	-	16
Margin wear	5	56	3	33	1	11	9
Circumference	2	100	-	-	-	-	2
Combination	<u>7</u>	<u>88</u>	<u>1</u>	<u>13</u>	<u>-</u>	<u>-</u>	<u>8</u>
Totals:	25	71	9	26	1	3	35
DEGREE OF BATTERING							
Slight	10	77	2	15	1	8	13
Moderate	8	67	4	33	-	-	12
Extensive	<u>7</u>	<u>70</u>	<u>3</u>	<u>30</u>	<u>-</u>	<u>-</u>	<u>10</u>
Totals:	25	71	9	26	1	3	35
MACROSCOPIC STRIATIONS							
Present	3	100	-	-	-	-	3
Absent	<u>22</u>	<u>69</u>	<u>9</u>	<u>28</u>	<u>1</u>	<u>3</u>	<u>32</u>
Totals:	25	71	9	26	1	3	35
	(n = 19)		(n = 9)				
MAXIMUM LENGTH (mm)							
Mean	77.0		77.2				
Standard deviation	14.1		12.9				
Minimum	50		62				
Maximum	104		97				
MAXIMUM WIDTH (mm)							
Mean	61.3		63.3				
Standard deviation	13.3		16.1				
Minimum	37		44				
Maximum	81		92				
MAXIMUM THICKNESS (mm)							
Mean	35.7		43.2				
Standard deviation	10.0		11.6				
Minimum	20		24				
Maximum	54		62				

implication, larger (heavier) hammerstones than later reduction and/or resharpening removals. It is likely that both of these factors entered into consideration and conditioned the choice of hammerstones.

Support for the raw material aspect of this hypothesis is offered by the breakdown between degree of battering and weight. While only 67% of the hammerstones weighing 1-400 g have moderate to extensive battering, 86% of the hammerstones weighing more than 400 g fall in these two wear groups.

Another interesting aspect of hammerstone wear is the correlation between degree of wear and location of wear. On none of the eight hammerstones exhibiting slight battering does the wear extend around the circumference of the hammerstone nor on a combination of locations. On the other hand, of the 20 specimens with moderate and/or extensive battering, 10 (50%) exhibit wear either along the entire circumference or in a combination of locations such as both ends and the margins of the artifact.

Ground Stones

Eighty-eight ground stone items were recovered from 19 sites (Table 91, Figs. 72 and 73). One of these is a kaolinite pendant fragment from 41GR291. This specimen is not included in Table 91 and is discussed individually at the end of this section. Only two raw materials are represented in any frequency, Ogallala quartzite and sandstone. Because only one conglomerate quartzite item was found, this specimen is combined with the Ogallala quartzite sample. The single granitic specimen is discussed under the miscellaneous category. Four sites (41GR383, 41GR291, 41GR323, and 41GR471) yielded 54% of this ground stone collection. Smaller samples of between 6% and 8% of the collection were found at four other sites, while the remaining 11 sites yielded only 1-3% of the collection. Three-fifths of the collection is from the surface, with the remaining 40% being from excavated contexts. Sandstone specimens outnumber quartzite in both surface and subsurface contexts. A larger percentage of the quartzite ground stone pieces (76%) than the sandstone items (54%) are from surface contexts, however.

Equal percentages of the complete artifacts are in the two major raw material categories. In contrast, 80% of the fragmentary ground stone specimens are of sandstone and 20% are of quartzite. Furthermore, while almost equal percentages of the fragmentary specimens occur in surface (52%) and subsurface contexts (48%), the majority of the surface artifacts (78%) are complete. This disparity suggests that many of the complete ground stone specimens may have been recycled during reuse of the sites. On the other hand, fragmentary specimens appear to have been discarded and subsequently buried. The fragmentary surface ground stone specimens may represent items broken during the last occupations.

Angular specimens, generated from the fracture of complete ground stones, are the most common shape (43%) due partly to the high frequency of fragmentary ground stone specimens. Oval ground stone shapes are the second most frequent type (32%), while almost identical percentages are rectangular and rounded. Only 3% are ovate, and the shape of 7% could not be determined. Ground stones with biconvex transverse cross sections (47%) are the most frequent. Specimens with tabular cross sections are relatively frequent, making up 26% of the collection. Other cross section types are relatively infrequent. The breakdown of cross section shape among the raw material types indicates notable differences. Over

TABLE 91
GROUND STONE ATTRIBUTES BY RAW MATERIAL TYPE

Attribute	Ogallala and Conglomerate Quartzite		Sandstone		Miscellaneous		Totals
	#	%	#	%	#	%	
SITE							
41GR239	-	-	1	100	-	-	1
41GR291	6	46	7	54	-	-	13*
41GR302	1	100	-	-	-	-	1
41GR303	5	71	2	29	-	-	7
41GR323	2	18	9	82	-	-	11
41GR359	1	20	3	60	1	20	5
41GR380	2	67	1	33	-	-	3
41GR381	1	100	-	-	-	-	1
41GR383	1	7	13	93	-	-	14
41GR456	-	-	2	100	-	-	2
41GR471	1	11	8	89	-	-	9
41GR484	2	67	1	33	-	-	3
41GR515	1	20	4	80	-	-	5
41GR569	-	-	1	100	-	-	1
41KT33	1	20	4	80	-	-	5
41KT34	-	-	2	100	-	-	2
41KT49	1	100	-	-	-	-	1
41KT52	-	-	1	100	-	-	1
41KT53	-	-	2	100	-	-	2
Totals:	25	29	61	70	1	1	87
PROVENIENCE							
Surface	19	37	33	63	-	-	52
Subsurface	6	17	28	80	1	3	35
Totals:	25	29	61	70	1	1	87
COMPLETENESS							
Complete	13	48	13	48	1	4	27
Fragment	12	20	48	80	-	-	60
Totals:	25	29	61	70	1	1	87
SHAPE							
Rounded	2	33	4	67	-	-	6
Oval	15	54	13	46	-	-	28
Angular	2	5	35	95	-	-	37

*Does not include kaolinite pendant.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

Table 91, continued

Attribute	Ogallala and Conglomerate		Sandstone		Miscellaneous		Totals
	#	%	#	%	#	%	
Ovate	-	-	2	67	1	33	3
Rectangular	1	14	6	86	-	-	7
Indeterminate	5	83	1	17	-	-	6
Totals:	25	29	61	70	1	1	87
TRANSVERSE CROSS SECTION							
Lenticular	2	100	-	-	-	-	2
Biconvex	23	56	17	41	1	2	41
Biconcave	-	-	2	100	-	-	2
Planoconvex	-	-	10	100	-	-	10
Planoconcave	-	-	4	100	-	-	4
Beveled	-	-	5	100	-	-	5
Tabular	-	-	23	100	-	-	23
Totals:	25	29	61	70	1	1	87
WEIGHT							
1-500 g	14	27	36	71	1	2	51
501-1000 g	8	42	11	58	-	-	19
1001-1500 g	2	20	8	80	-	-	10
1501-2000 g	1	100	-	-	-	-	1
2001+ g	-	-	6	100	-	-	6
Totals:	25	29	61	70	1	1	87
LOCATION OF GRINDING WEAR							
One face	10	25	29	73	1	3	40
Both faces	15	33	30	67	-	-	45
Face and margins	-	-	2	100	-	-	2
Totals:	25	29	61	70	1	1	87
LOCATION OF POLISH WEAR							
One face	8	73	3	27	-	-	11
Both faces	14	82	3	18	-	-	17
Absent	3	5	55	93	1	2	59
Totals:	25	29	61	70	1	1	87
LOCATION OF BATTERING WEAR							
Margins	5	100	-	-	-	-	5
Ends	6	86	-	-	1	14	7
Face and margins	3	60	2	40	-	-	5
End and margins	2	100	-	-	-	-	2
Absent	9	13	59	87	-	-	68
Totals:	25	29	61	70	1	1	87

Table 91, continued

Attribute	Ogallala and Conglomerate Quartzite		Sandstone		Miscellaneous		Totals
	#	%	#	%	#	%	
NUMBER OF FLAKE SCARS							
One	4	40	6	60	-	-	10
Two or three	3	60	2	40	-	-	5
More than three	5	100	-	-	-	-	5
Absent	<u>13</u>	<u>19</u>	<u>53</u>	<u>79</u>	<u>1</u>	<u>1</u>	<u>67</u>
Totals:	25	29	61	70	1	1	87
LOCATION OF PECKING							
One face	3	8	33	92	-	-	36
Both faces	12	44	15	56	-	-	27
Absent	<u>10</u>	<u>42</u>	<u>13</u>	<u>54</u>	<u>1</u>	<u>4</u>	<u>24</u>
Totals:	25	29	61	70	1	1	87
MACROSCOPIC STRIATIONS							
Present	28	43	37	57	-	-	65
Absent	<u>13</u>	<u>20</u>	<u>52</u>	<u>79</u>	<u>1</u>	<u>1</u>	<u>66</u>
Totals:	41	31	89	68	1	1	131
MICROSCOPIC STRIATIONS							
Present	39	40	57	59	1	1	97
Absent	<u>2</u>	<u>6</u>	<u>32</u>	<u>94</u>	<u>-</u>	<u>-</u>	<u>34</u>
Totals:	41	31	89	68	1	1	131

nine-tenths (92%) of the quartzite specimens have biconvex transverse cross sections; the remaining 8% are lenticular. Lenticular cross sections do not occur among the sandstone specimens, although biconvex and tabular pieces are frequent. Planoconvex specimens are also found, with the remaining types constituting only small percentages. These cross section shapes represent a combination of ground stone use and the shape of the original nodule used in the manufacture of the tool.

The distribution of ground stone weights is somewhat bimodal. The largest number of specimens weigh 500 g or less, and the number of specimens decreases as weight increases. Only one specimen weighs 1,501-2,000 g. A smaller second peak exists in the larger-than-2,000-g group. Six specimens weigh more than 2,000 g. This distribution is conditioned by the function of these specimens as well as the degree of completeness of the tools.

Forty tools (46%) have unifacial grinding wear, 45 (52%) have bifacial wear, and 2 specimens (2%) have wear on the margins and the face. In total, 130 used faces occur on 85 mano, mano/hammerstone, and metate specimens. In addition, two pestles have wear on their margins and both faces. Polish resulting from tool use occurs on 28 specimens. Eleven of these (39%) have polish distributed on one face only while the other 17 (61%) have polish

Figure 72. Ground stones. (a) Mano, 41GR515; (b) mano/hammerstone, 41GR291.

Figure 73. Ground stones. (a) Metate, 41KT52; (b) pestle, 41GR471.

on two faces. Fifty-nine of the ground stone specimens (68%) show no polish on any of the work surfaces. The distribution of wear by raw material type shows that 93% of the specimens on which no polish was noted are of sandstone. On the other hand, 82% of the specimens with polish on both faces are of quartzite.

Battering wear occurs on 19 specimens. On seven of these (37%) battering is distributed on the ends of the tool. Five specimens (26%) have battering on the margins, and five also display battering on the face and margins. Finally, two specimens (11%) have battering on the margins and ends. Only 2 of the 61 sandstone specimens (3%) have battering, which is distributed on the margins and face. These two specimens are pestles. Sixteen of the quartzite specimens (64%) exhibit battering, and of these, 81% have wear on the end or margin, or both. The differential distribution of wear on the ground stones may be indicative of a number of factors, including functional differences as conditioned by raw material characteristics. The relative lack of battering on the sandstone specimens may indicate a specialized tool function focused on grinding without the need to crush the items being processed (e.g., small seeds). On the other hand, the high frequency of end and marginal battering on the quartzite specimens suggests that the tools were used in the grinding of a substance that necessitated crushing. Polish and battering can develop either independently or as part of the same task. That is, polish wear can result from the processing of a substance different from that which generated the battering along the margins and ends. While this is a likely possibility, ethnographic studies of groups using ground stones (Hard 1986; Mauldin and Tomka 1988) indicate that small one-handed ground stone specimens are used in tasks which often necessitate not only the grinding of a substance but its initial crushing on an anvil or basin metate (e.g., salt, condiment seeds). In addition, such manos tend to be used as hammers in bone crushing or seed breaking. Based on these examples and the distribution of polish and battering on the ground stones in this collection, it is likely that the quartzite specimens were relatively more versatile tools while the sandstone specimens were specialized grinding stones.

The number of flake scars on the surfaces of ground stone artifacts is also an indication of the manner of use. Over three-quarters of these tools (77%) do not contain flake scars. Of the 20 with flake scars, 50% have only one scar, and 25% each have two to three or more than three scars. The breakdown by raw material shows a significant difference between quartzite and sandstone specimens with 48% of the quartzite specimens having flake scars (five have more than three scars) and only 13% of the sandstone specimens having flake scars (none have more than three scars). These distributions indicate that quartzite specimens were more often employed as either hammerstones or grinding implements in tasks necessitating heavy crushing. On the other hand, the presence of battering and flake scars on the ends of manos may indicate that, following a use life as grinding stones, these specimens were reused as hammerstones in lithic reduction. The relative lack of flake scars on the sandstone specimens may indicate that this soft raw material may not be appropriate for use as a hammerstone in the reduction of coarser raw materials.

Pecking is often interpreted as reflecting use-surface refurbishing (Adams 1988:311). The pecking locations on the 87 ground stone specimens indicate that 72% have refurbished grinding surfaces. Thirty-six specimens (41%) have one pecked surface, and 31% (n = 27) have pecking on both work surfaces. The breakdown by raw material type indicates that 60% of the quartzite items have pecked work surfaces; of these, 80% have both surfaces refurbished. A higher percentage of the sandstone grinding stones (79%) have refurbished surfaces; 69% of these have only one pecked surface, and the remaining 31% are pecked on both surfaces.

Macroscopic striations were noted on 65 of the working surfaces (50%). A larger percentage of the quartzite specimens (68%) have macroscopic striations compared to sandstone (42%). An even larger percentage of the ground stone items (74%) have microscopic striations. Microscopic striations were noted on all but two of the quartzite working surfaces and 14% of the sandstone working surfaces.

The breakdown by tool type indicates that 40% are manos, 21% are metates, 5% are interpreted as mano/hammerstone combinations, and 2% are pestles (Table 92). Unfortunately, 32% of the items are so fragmentary that the manner of tool use could not be established clearly. Because of small sample sizes, distributions by site are difficult to interpret. Manos appear to be most numerous at the sites with the largest ground stone collections. On the other hand, 39% of the metate fragments are from a single site (41GR323). Each of the four mano/hammerstone specimens and the two pestles are from different sites. Of the 35 manos, almost equal numbers are made of quartzite and sandstone. All of the metates and pestles are of sandstone. None of the combination mano/hammerstones are of sandstone. Only three of the fragmentary specimens with unknown uses are of quartzite, with the remainder made of sandstone. No notable differences occur in the distribution of the different ground stone types by provenience. Twenty-one of the 27 complete specimens (78%) are manos, with an additional 11% consisting of combination mano/hammerstones. Only 2 of the 18 metates (11%) are complete.

Grinding wear is bifacial on 25 of 35 manos (71%) and unifacial on the remaining 29%. Two of the four manos/hammerstones (50%) are bifacial, and slightly more than half of the unknown function specimens (57%) have unifacial wear. On the other hand, only 33% of the metates were used bifacially. Polish wear on 18 manos occurs primarily on both faces of the tools (67%). The battering on 12 manos occurs mainly on the ends or margins, and 2 specimens have battering distributed on both locations. Three of the four mano/hammerstone tools (75%) have battering on the margins and the face of the tool, while the fourth has battering on the ends. More than twice the number of manos (54%) exhibit pecking on both working faces than on one face only (23%). Only 50% of the manos/hammerstones have pecked faces, while 78% of the metates have pecking wear. The majority of these metates (79%) have been unifacially pecked. Pecking is also prevalent on the fragments with unknown functions. Flake scars occur on 14 of the 35 manos (40%). While some of these specimens may have functioned also as hammerstones, it appears that the flake scars on these specimens were removed during the crushing of items as opposed to during the use of these tools as hammerstones. Only one of four mano/hammerstone specimens has flake scars, while two metates have single flake scars. These flake scars were removed in the process of shaping artifact outlines.

The distribution of ground stone weights indicates that the majority of the manos (46%) weigh 500 g or less and an additional 40% are between 501 and 1,000 g. Only five manos weigh more than 1,000 g. The 28 fragments with unknown functions have a similar weight distribution, suggesting that they may represent mano fragments. None of the mano/hammerstone specimens weigh more than 1,000 g. The metates have a wider distribution.

The mean working surface areas on the specimens with two working surfaces was obtained by dividing the total surface area by two. The distribution of the mean working surface area indicates that of the 26 working surfaces, 4 (15%) are between 33 and 55 cm². The majority (54%) have working surfaces between 51 and 100 cm². Only five items (19%) have working surfaces between 101 and 150 cm². The working surface size on one item is between 151 to 200 cm, and two other items have surface area sizes between 201 and 250 cm². While

TABLE 92
GROUND STONE ATTRIBUTES BY TOOL TYPE

Attribute	Mano		Mano/ Hammerstone		Metate		Pestle		Unknown		Totals
	#	%	#	%	#	%	#	%	#	%	
SITE											
41GR239	-	-	-	-	1	100	-	-	-	-	1
41GR291	11	85	-	-	-	-	-	-	2	15	13
41GR302	1	100	-	-	-	-	-	-	-	-	1
41GR303	5	71	1	14	-	-	-	-	1	14	7
41GR323	2	18	-	-	7	64	-	-	2	18	11
41GR359	1	20	1	20	1	20	-	-	2	40	5
41GR380	1	33	-	-	-	-	-	-	2	67	3
41GR381	1	100	-	-	-	-	-	-	-	-	1
41GR383	5	36	1	7	1	7	-	-	7	50	14
41GR456	-	-	-	-	1	50	1	50	-	-	2
41GR471	1	11	-	-	1	11	1	11	6	67	9
41GR484	1	33	1	33	1	33	-	-	-	-	3
41GR515	3	60	-	-	2	40	-	-	-	-	5
41GR565	-	-	-	-	-	-	-	-	1	100	1
41KT33	2	40	-	-	-	-	-	-	3	60	5
41KT34	-	-	-	-	2	100	-	-	-	-	2
41KT49	1	100	-	-	-	-	-	-	-	-	1
41KT52	-	-	-	-	1	100	-	-	-	-	1
41KT53	-	-	-	-	-	-	-	-	2	100	2
Totals:	35	40	4	5	18	21	2	2	28	32	87
RAW MATERIAL											
Ogallala quartzite	18	75	3	13	-	-	-	-	3	13	24
Sandstone	16	26	-	-	18	30	2	3	25	41	61
Conglomerate											
quartzite	1	100	-	-	-	-	-	-	-	-	1
Miscellaneous	-	-	1	100	-	-	-	-	-	-	1
Totals:	35	40	4	5	18	21	2	2	28	32	87
COMPLETENESS											
Complete	21	78	3	11	2	7	1	4	-	-	27
Fragment	14	23	1	2	16	27	1	2	28	47	60
Totals:	35	40	4	5	18	21	2	2	28	32	87
LOCATION OF GRINDING WEAR											
One face	10	25	2	5	12	30	-	-	16	40	40
Both faces	25	56	2	4	6	13	-	-	12	27	45
Face and margin	-	-	-	-	-	-	2	100	-	-	2
Totals:	35	40	4	5	18	21	2	2	28	32	87

Table 92, continued

Attribute	Mano		Mano/ Hammerstone		Metate		Pestle		Unknown		Totals
	#	%	#	%	#	%	#	%	#	%	
LOCATION OF POLISH WEAR											
One face	6	55	1	9	-	-	1	9	3	27	11
Both faces	12	71	2	12	-	-	1	6	2	12	17
Absent	<u>17</u>	<u>29</u>	<u>1</u>	<u>2</u>	<u>18</u>	<u>31</u>	<u>-</u>	<u>-</u>	<u>23</u>	<u>39</u>	<u>59</u>
Totals:	35	40	4	5	18	21	2	2	28	32	87
LOCATION OF BATTERING WEAR											
Margins	4	80	-	-	-	-	-	-	1	20	5
Ends	6	86	1	14	-	-	-	-	-	-	7
Face and margins	-	-	3	60	-	-	2	40	-	-	5
End and margins	2	100	-	-	-	-	-	-	-	-	2
Absent	<u>23</u>	<u>34</u>	<u>-</u>	<u>-</u>	<u>18</u>	<u>26</u>	<u>-</u>	<u>-</u>	<u>27</u>	<u>40</u>	<u>68</u>
Totals:	35	40	4	5	18	21	2	2	28	32	87
LOCATION OF PECKING											
One face	8	22	1	3	11	31	-	-	16	44	36
Both faces	19	70	1	4	3	11	-	-	4	15	27
Absent	<u>8</u>	<u>33</u>	<u>2</u>	<u>8</u>	<u>4</u>	<u>17</u>	<u>2</u>	<u>8</u>	<u>8</u>	<u>33</u>	<u>24</u>
Totals:	35	40	4	5	18	21	2	2	28	32	87
NUMBER OF FLAKE SCARS											
One	5	50	-	-	2	20	-	-	3	30	10
Two or three	5	100	-	-	-	-	-	-	-	-	5
More than three	4	80	1	20	-	-	-	-	-	-	5
Absent	<u>21</u>	<u>31</u>	<u>3</u>	<u>4</u>	<u>16</u>	<u>24</u>	<u>2</u>	<u>3</u>	<u>25</u>	<u>37</u>	<u>67</u>
Totals:	35	40	4	5	18	21	2	2	28	32	87
WEIGHT											
1-500 g	16	31	2	4	8	16	-	-	25	49	51
501-1000 g	14	74	2	11	1	5	-	-	2	11	19
1001-1500 g	3	30	-	-	5	50	1	10	1	10	10
1501-2000 g	1	100	-	-	-	-	-	-	-	-	1
2001+ g	<u>1</u>	<u>17</u>	<u>-</u>	<u>-</u>	<u>4</u>	<u>67</u>	<u>1</u>	<u>17</u>	<u>-</u>	<u>-</u>	<u>6</u>
Totals:	35	40	4	5	18	21	2	2	28	32	87

this distribution is not bimodal, it is interesting that there is a strong tendency for manos with a smaller work surface area to be made of quartzite while larger specimens are consistently of sandstone. To increase the sample size, the 21 specimens recovered during survey (Boyd 1989b) were added to this analysis. The distribution of work surface area by material type indicates that quartzite tools tend to have smaller work surface areas.

Conversely, the great majority of the specimens larger than 100 cm² (82%) are made of sandstone. In light of the more multifunctional nature of the quartzite manos, it is probable that these figures reflect both the size limitations of the quartzite materials that occur in the project area and the use of quartzite manos in hammering or crushing hard items on an anvil. On the other hand, the sandstone specimens appear to have been used as specialized grinding tools. Even though there is a lack of bimodality in the surface area distributions, it is proposed here that the ground sandstone tools were employed in relatively intensive grinding of large quantities of grains and/or seeds. On the other hand, the quartzite manos were utilized as grinders, crushers, and occasionally hammers in processing a wider array of materials. Given that Mauldin and Tomka's (1989) research indicates an increase in grinding surface area with increased grinding activity and quantity, the differentiation between the two raw material types may be indicative of more-intensive grinding of a specialized substance with the larger sandstone implements. This, in turn, suggests a relatively significant dependence upon plant resources.

Other Modified Stone

A fragment of a decorated pendant (Fig. 74), collected from the surface of 41GR291, was found in an eroded area without any contextual relationship to other artifacts or features. It is made of a very pure variety of white kaolinite, which was identified by the Mineral Studies Laboratory of the Bureau of Economic Geology, The University of Texas at Austin (see Appendix F).

Figure 74. Kaolinite pendant fragment, 41GR291.

The fragment measures 16x22 mm and is 1-5 mm thick; it has three broken edges and one beveled, notched edge. A portion of a round suspension hole exhibits slight wear under low-power magnification, indicating the top of the pendant. The faces have numerous faint unpatterned scratches or striations, representing incised decorations, abrasion wear, or both. The complete specimen was probably oval.

The pendant fragment is similar mineralogically to kaolinite from the Apache Canyon source area in Big Bend National Park, Brewster County, Texas. Apache Canyon is the only documented source of high-quality kaolinite in Texas, although others are suspected in western Texas and northern Mexico (Tom Alex, personal communication 1988). The similarities with the Apache Canyon source suggest a possible origin for the pendant but do not rule out other possibilities.

Temporal Changes in Lithic Technology at Justiceburg Reservoir

Three site temporal groupings were defined based on radiocarbon dates and artifact associations: Late Prehistoric II (ca. 1000 B.P.-evidence of European contact); Late Prehistoric I (ca. 2000-1000 B.P.); and late Archaic (ca. 4500-2000 B.P.). Eight sites yielded adequate artifact samples for comparative purposes. Four sites are assigned to the Late Prehistoric II period: 41GR323, 41GR484, 41KT51, and 41KT53. Two sites, 41GR291 and 41GR303, date to the Late Prehistoric I period, and two others, 41KT33 and 41KT49, are considered to be late Archaic. In studying temporal changes using the artifacts from these sites, it is important to realize the nature of the collections from these sites and how the collection methods may have affected the samples recovered. An additional source of bias in the record is the effect of local collectors systematically removing diagnostic artifacts. This bias is difficult to account for, although it is known that a number of local individuals have collected artifacts from sites in the project area.

The recovery of artifacts during site testing consisted of three methods: (1) general surface collections; (2) collection of all artifacts from surface collection units; and (3) subsurface test units. Collections of the first type tend to be biased against unmodified and edge-modified debitage and favor diagnostic and larger artifacts. The latter two methods should result in true representations of the proportions of artifacts present. Because sample sizes are generally small, all artifacts irrespective of collection method are included in the analysis below.

Table 93 illustrates the composition of the lithic artifact collections from each site in the three groups. This table also includes artifacts collected from these sites during the survey (Boyd 1989b). It appears that two groups of two sites each are contained in the Late Prehistoric II category. Sites 41GR323 and 41GR484 have relatively broad ranges of tool types, with the first site containing slightly larger proportions of unifaces, edge-modified flakes, and ground stones than the second site. Differences in collection techniques do not account for these slight differences in assemblage composition. Sites 41KT51 and 41KT53 appear to represent a distinct group characterized by low artifact diversity and the absence of cores, cobble tools, and hammerstones. It appears that these two sites may represent relatively short term occupations with narrow ranges of activities performed at the sites. The two Late Prehistoric I sites are similar to each other with only two notable differences. Site 41GR303 has no projectile points, and ground stones are slightly underrepresented. The highly diverse artifact assemblages from the two sites combined with the relatively large number of tools in each category suggest either longer term occupations, more numerous reoccupation episodes (with similar or different site functions), or occupations by larger units. The two late Archaic sites are similar to each other in terms of assemblage composition. In addition, they are similar to the first two Late Prehistoric II sites in terms of artifact diversity and the relative percentages of the various artifact classes.

TABLE 93
LITHIC ARTIFACT COLLECTIONS FROM SITES BY TIME PERIOD*

Artifact Type	Late Prehistoric II					Late Prehistoric I			Late Archaic			Totals
	41GR323	41GR484	41KT51	41KT53	Subtotals	41GR291	41GR303	Subtotals	41KT33	41KT49	Subtotals	
Arrow points	1	1	-	-	2	4	-	4	-	-	0	6
Dart points	-	-	-	-	0	1	-	1	2	2	4	5
Bifaces	1	1	-	1	3	9	9**	18	2	-	2	23
Unifaces	5	1	3	1	10	19	34	53	9	4	13	76
Cores	4	2	-	-	6	8	22	30	4	2	6	42
Edge-modified flakes	15	3	2	1	21	17	38	55	11	4	15	91
Cobble tools	3	2	-	-	5	8	11	19	7	1	8	32
Hammerstones	-	1	-	-	1	2	3	5	4	1	5	11
Ground stones	11	3	-	2	16	14	7	21	6	1	7	44
Unmodified debitage	<u>126</u>	<u>51</u>	<u>68</u>	<u>109</u>	<u>354</u>	<u>307</u>	<u>474</u>	<u>781</u>	<u>183</u>	<u>79</u>	<u>262</u>	<u>1397</u>
Totals:	166	65	73	114	418	389	598	987	228	94	322	1727

*Includes artifacts collected from the sites during the survey.

**Includes one drill.

The limitations of the testing phase data notwithstanding, these patterns suggest that late Archaic and Late Prehistoric I sites are relatively similar in function and/or occupation length. On the other hand, two slightly different groups of two sites each are noted in the Late Prehistoric II group. It is possible that these represent differences in site function, although other possibilities cannot be ruled out (e.g., occupation length, differences in numbers of occupants).

Table 94 illustrates a number of ratios for selected artifact classes within the three temporal groups. To derive these ratios, the collections from all the sites in each temporal group were combined. It is evident that the three groups are dissimilar in terms of all ratios. The Late Prehistoric II and late Archaic sites appear to be most alike in terms of the bifaces to projectile points ratio and the combined bifaces/unifaces to cobble tools ratio. On the other hand, the Late Prehistoric I and the late Archaic sites are most alike in terms of three ratios: bifaces/unifaces/cobble tools to edge-modified flakes; unmodified debitage to chipped lithics; and chipped lithic tools to ground stones. Similarities between the two Late Prehistoric groups exist in terms of the unifaces to bifaces and the cores to hammerstones ratios. Although these ratios are derived from small samples and are thus subject to numerous potential biases, some preliminary conclusions can be drawn to help direct future research in the project area. The low ratios of bifaces to projectile points in the late Archaic and the Late Prehistoric II sites suggest that hunting may have been a relatively important activity during these periods. The high ratio of bifaces to projectile points in the Late Prehistoric I sites suggests that hunting may have played a lesser role in the subsistence base. The low ratio of bifaces/unifaces to cobble tools during the late Archaic reflects the infrequency of bifaces and unifaces and the relative importance of cobble tools in the lithic tool assemblage. The moderate ratio in the Late Prehistoric II sites suggests that cobble tools may have played a significant role in the assemblage, perhaps as complementary elements of a hunting tool kit in the processing of prey (e.g., bone-breaking tools). The high ratio of bifaces/unifaces to cobble tools in the Late Prehistoric I sites suggests a reduction in the role of cobble tools. This reduction may parallel a concurrent reduction in the hunting aspect of the subsistence base. These interpretations, however, do not take into account the possibility that cobble tools functioned in the processing of wood rather than bone. The low ratio of bifaces/unifaces/cobble tools to edge-modified flakes in the Late Prehistoric II suggests that the expedient component of the assemblage was relatively important. The high ratio in the Late Prehistoric I indicates that formal tools were relatively more important than expedient tools during this period. A variety of factors such as increased mobility, greater time stress in the performance of activities, and changes in site function may account for the greater importance of expedient tools in the Late Prehistoric II. It is probable that the differences in this ratio are tied to the other shifts in land-use patterns between these two time periods noted in the other ratios already examined. The ratios of cores to hammerstones are a result of a number of interacting factors, including the degree of reduction of locally available materials, the degree of reduction of individual cores, and the degree of curation of hammerstones. The ratio of unmodified debitage to chipped lithics is highest for the Late Prehistoric II sites and lowest in the Late Prehistoric I sites. The ratio for the Late Prehistoric II sites is influenced by the high number of debitage specimens and low tool counts in the collections from 41KT51 and 41KT53; however, it may also indicate that, while lithic tool manufacturing activities were prominent at these sites, some of the tools manufactured were not discarded there. The low ratio in the Late Prehistoric I sites indicates occupations associated with the use of a large number of formal lithic tools and a large discard component. It may also indicate a relative decrease in some lithic tool manufacturing activities during this period. The low ratio of

TABLE 94
RATIOS AMONG SELECTED ARTIFACT CLASSES BY TIME PERIOD

Ratio	Late Prehistoric II	Late Prehistoric I	Late Archaic
Bifaces:Projectile Points	1.5:1	3.6:1	0.5:1
Unifaces:Bifaces	3.3:1	2.9:1	6.5:1
Bifaces/Unifaces:Cobble Tools	2.6:1	3.7:1	1.9:1
Bifaces/Unifaces/Cobble Tools: Edge-modified Flakes	0.9:1	1.6:1	1.5:1
Cores:Hammerstones	6.0:1	6.0:1	1.2:1
Unmodified Debitage:Chipped Lithics*	14.6:1	6.2:1	7.9:1
Chipped Lithic Tools**:Ground Stones	2.9:1	8.6:1	6.9:1

*Does not include edge-modified flakes.
**Includes edge-modified flakes.

chipped lithic tools to ground stones seen in the Late Prehistoric II may be a result of the higher degree of curation described above, or it may reflect the increased importance of plant resources in the diet. The high ratio of chipped lithic tools to ground stones in the Late Prehistoric I sites suggests that plant processing was relatively less important than in any other time period. This conclusion is somewhat contradictory to traditional reconstruction of Late Prehistoric I (e.g., Palo Duro Complex) subsistence patterns which, in the absence of bison, should be characterized by a heavy reliance on plant resources (Couzzourt 1985). Conversely, Late Prehistoric II (e.g., Garza Complex) subsistence patterns should contain a strong hunting component in response to the presence of bison in the region (Baugh 1986).

Given this contradiction, other factors were examined to seek an explanation of these patterns in the Justiceburg Reservoir data. As noted above, the ratio of chipped stone tools to ground stone tools suggests an important plant-processing component for the Late Prehistoric II occupations. On the other hand, the actual count of ground stone specimens for the two sites with Late Prehistoric I components is higher than that for the four sites in the immediately preceding period. While counts alone can be deceiving, it is perhaps these figures, as opposed to ratios of tools, which are a truer indication of subsistence pattern.

The pattern in complete ground stone tool surface area size by time period follows the pattern defined in the tool ratio analysis although sample sizes are extremely small. The mean working surface areas of late Archaic ($n = 2$) and Late Prehistoric II ($n = 2$) grinding implements (manos only) are 148 cm^2 and 150 cm^2 . In contrast, the mean area for the Late

Prehistoric I ($n = 8$) specimens is 77.5 cm^2 . If the relationship suggested by Mauldin and Tomka (1989) is correct, then these figures indicate a greater role for plant processing during the bison presence periods as opposed to the previously proposed absence periods. Larger samples of ground stones, specifically complete specimens, can help clarify the mix of plant and animal resources in the three time periods.

A total of 1,380 unmodified lithic debitage specimens are in the collections from the eight sites in the three temporal groups. Table 95 presents breakdowns for selected attributes by time period. One-quarter ($n = 348$) were collected from the four Late Prehistoric II sites, 56% ($n = 776$) from the two Late Prehistoric I sites, and 19% ($n = 256$) from the two late Archaic sites. Locally available cherts were utilized in similar frequencies in the Late Prehistoric II and late Archaic sites, but only slightly more than 50% of the debitage from the Late Prehistoric I sites is of these materials. The Late Prehistoric I debitage collection is composed primarily of coarser-grained materials such as quartzites and Potter chert. No Alibates agate debitage was encountered in any of the groups, and Tecovas jasper constitutes only 1% of the debitage in each temporal group. Cretaceous cherts represent 12% of the Late Prehistoric II debitage, while late Archaic sites contain 6% Cretaceous cherts. The lowest frequency of this material type (1%) occurs at the Late Prehistoric I sites. This distribution suggests decreased access to these materials during the Late Prehistoric I. It also may signal decreased mobility of groups utilizing the project area during the Late Prehistoric I period. Access to the broadest region appears to have occurred during the Late Prehistoric II period. Based on the present data, however, it is not possible to establish whether these patterns of nonlocal raw material usage represent the acquisition of these materials by direct access or by exchange.

Tertiary flakes (0% cortex) are most frequent in the Late Prehistoric II sites and least frequent in the Late Prehistoric I sites. On the other hand, primary flakes (100% cortex) are least frequent in the Late Prehistoric II sites and most frequent in the late Archaic sites. Flakes with corticate platforms are least common in the Late Prehistoric II debitage and most frequent at Late Prehistoric I sites. Platform grinding is most frequent in the late Archaic debitage and much less so in the Late Prehistoric I. Single-faceted platform flakes are most common among the Late Prehistoric II debitage and least frequent in the Late Prehistoric I collection. Platform flakes with three or more facets are most frequent in the late Archaic and Late Prehistoric I periods.

Two additional lines of evidence can help determine the role of uniface manufacture in the different time periods: (1) the frequency of single-faceted platform flakes among the tertiary flakes; and (2) the size distribution of complete single-faceted flakes. Analysis of the local and Cretaceous cherts shows that the lowest percentage (62%) of tertiary single-faceted platform flakes occurs in the late Archaic collection. The highest percentage (81%) is found in the Late Prehistoric II debitage, while the Late Prehistoric I collection is similar to the late Archaic materials (63%). Analysis of the distribution of single-faceted platform complete flakes by maximum dimension also shows similarities between the late Archaic and Late Prehistoric I collections of local and Cretaceous chert debitage. In both cases, 64% are less than 20 mm in maximum dimension. Conversely, 82% of the Late Prehistoric II single-faceted complete flakes are smaller than 20 mm. Experimental manufacture of unifacial scrapers conducted suggests that uniface manufacture and rejuvenation flakes tend to have single-faceted platforms, to be decorticate, and to be no larger than 20 mm, especially the rejuvenation flakes. These observations suggest that uniface manufacture was most prominent in the Late Prehistoric II period and had lesser but equal roles during the two preceding periods. In turn, this suggests that activities

TABLE 95
UNMODIFIED LITHIC DEBITAGE ATTRIBUTES BY TIME PERIOD*

Attributes	Late Prehistoric II		Late Prehistoric I		Late Archaic	
	#	%	#	%	#	%
RAW MATERIAL						
Potter chert	20	6	233	30	41	16
Local chert	262	75	406	52	181	71
Quartzite	13	4	91	12	15	6
Opalized caliche	4	1	12	2	1	<1
Silicified wood	1	<1	4	1	-	-
Tecovas jasper	3	1	8	1	2	1
Cretaceous chert	42	12	9	1	15	6
Silicified caliche	-	-	3	<1	-	-
Miscellaneous	3	1	10	1	1	<1
Totals:	348	100	776	100	256	100
CORTEX PERCENT						
0	249	78	425	60	155	67
1-50	34	11	174	25	34	15
51-99	23	7	72	10	23	10
100	12	4	35	5	19	8
Totals:	318	100	706	100	231	100
PLATFORM CORTEX						
Present	16	10	86	22	19	18
Absent	146	90	305	78	87	82
Totals:	162	100	391	100	106	100
PLATFORM GRINDING						
Present	89	55	82	21	62	58
Absent	73	45	309	79	44	42
Totals:	162	100	391	100	106	100
PLATFORM FACET COUNT						
One	123	76	211	54	61	58
Two	13	8	80	20	17	16
Three	13	8	61	16	17	16
More than three	13	8	39	10	11	10
Totals:	162	100	391	100	106	100

*Does not include debitage collected during survey.

connected with hide and/or plant processing were at their peak during the latest occupations. Based on the results of the microwear and residue analyses, it appears that the majority of the unifaces were utilized on meat and/or hides, suggesting that the high frequency of uniface rejuvenation flakes may be a reflection of the increased importance of hunting.

CERAMICS

One hundred and twenty-three ceramic sherds were recovered from five sites (Table 96). These sherds are classified into six groups; Types I and II are defined types, Types III and IV are similar to defined types, and Types V and VI are unidentified types. The classification of these sherds is tentative because of the small sample. A simple visual descriptive analysis of attributes was done using low-power (16x and 40x) magnification. Petrographic thin sections of a selected sample of sherds were made, and although they were not fully analyzed, a cursory examination does support the above ceramic classification.

Type I

Sixty-eight sherds of this type were recovered from two sites, 41KT51 and 41KT53. Fifty-seven sherds from a single vessel are from 41KT53 (Feature 5, Test Unit 8). A partial vessel was reconstructed from these sherds and 28 sherds recovered in 1987 (Fig. 75). Type I sherds from the 1987 sample were identified as Pecos Glaze Polychrome V, ca. A.D. 1600-1700 (see Boyd 1989b:356-357). Type Ia consists of all decorated sherds (slipped and/or glaze-painted surface decorations), and Type Ib consists of sherds identical in paste but with no surface decorations. Type Ib sherds could be from undecorated vessels or undecorated portions of vessels, or they could be weathered sherds that no longer have the original surface finish.

Description: Type I consists of 52 body sherds and 16 rim sherds. Body sherds range in maximum length from under 15 mm to over 50 mm and in thickness from 4 to 10 mm. Rim sherds are larger and range in maximum length from ca. 25 mm to over 65 mm and in thickness from 6 to 11 mm.

Construction: Type I is presumed to be coil-made, but the sherds exhibit no evidence of the construction method.

Paste: These sherds have a light red (10R 6/6) to yellowish red (5YR 5/6), fine- to coarse-grained paste which leaves a red streak. A light gray (2.5Y 7/0) core accounts for nearly 100% of the thickness of most sherds and leaves a gray carbon streak. The core thickness is variable on other sherds and constitutes the central 50-75% of some.

Temper: The temper was identified as Glorieta Sandstone, probably from the Pecos Pueblo area. It consists of well-rounded, fine-grained, clear glossy quartz, vitreous feldspar, and minor amounts of silver and gold mica. The clear quartz and white feldspar grains constitute ca. 30% of the paste and range in size from 0.25 to 1.0 mm but are dominantly ca. 0.5 mm. The mica flecks are smaller than 0.5 mm and constitute less than 5% of the paste.

TABLE 96
PROVENIENCE OF CERAMICS

Site No.	Provenience	Types							Totals
		Ia	Ib	II	III	IV	V	VI	
41GR291	Test Unit 1, 30-40 cm	-	-	-	-	1	-	-	1
	Surface	-	-	-	-	1	-	-	1
		0	0	0	0	2	0	0	2
41GR467	Backhoe Trench 15, 0-105 cm	0	0	0	0	1	0	0	1
41KT51	Test Unit 1, 0-10 cm	-	-	1	-	-	-	-	1
	Test Unit 2, 10-20 cm	3	1	2	-	-	-	1	7
	Test Unit 2, 20-30 cm	-	-	1	-	-	-	-	1
	Test Unit 3, 0-10 cm	-	-	1	-	-	-	-	1
	Surface	1	1	1	-	-	-	-	3
		4	2	6	0	0	0	1	13
41KT52	Surface	0	0	3	0	0	0	1	4
41KT53	Test Unit 1, 0-10 cm	-	3	-	-	-	-	-	3
	Test Unit 1, 10-15 cm	-	-	-	4	-	-	-	4
	Test Unit 2, 0-10 cm	-	-	-	1	-	-	-	1
	Test Unit 4, 10-20 cm	1	-	10	2	-	1	-	14
	Test Unit 4, Feature 6, 10-20 cm	-	-	16*	-	-	-	-	16
	Test Unit 5, 8-18 cm	-	1	5	-	-	1	-	7
	Test Unit 6, 0-10 cm	-	-	1	-	-	-	-	1
	Test Unit 8, Feature 5, 0-20 cm	57*	-	-	-	-	-	-	57
		58	4	32	7	0	2	0	103
GRAND TOTALS:		62	6	41	7	3	2	2	123

*Sherds used in reconstruction of vessels.

Finish: Type Ib sherds have no slip; the surface is obviously smoothed or polished on some sherds but appears to be unfinished or weathered on others. All Type Ia sherds have a pale brown (10YR 7/3 to 10YR 8/4), well-polished slip on the interior surface, and most are slipped on the interior and exterior surfaces. In addition to the slip, many of the sherds have a glaze-painted decoration on the interior and/or exterior. The decoration of the reconstructed vessel consists of both interior and exterior painted designs over the slip (see Boyd 1989b:Fig. 63). The interior is entirely slipped with a painted decoration consisting of horizontal parallel lines 17-45 mm below the rim within the shouldered portion of the vessel. The parallel painted lines are ca. 3-7 mm thick and consist of three black (7.5YR 2/10) lines and one red (10R 4/8) line. From the top, the lines are black, red, black, pale brown (unpainted slip), and black. The sherds closest to the bottom of the

Figure 75. Type I vessel form. (a) Reconstructed bowl profile, 41KT53; (b) Glaze E, Pecos Polychrome bowl form (from Honea 1973:85).

vessel have a worn or scarred slip, probably resulting from scraping out the contents of the vessel. There is no visible residue on the interior.

The exterior slip is the same as the interior, but the very bottom exterior of the bowl was not slipped. The bottom of the vessel appears to be smoothed or polished, but it does not have any visible residue or evidence of postmanufacture firing. The exterior glaze-painted decoration consists of angular and curved black lines from the top of the rim to ca. 60 mm below the rim. The vessel is not complete enough to determine the full design, but the decoration did not cover the entire rim. The exterior probably had four painted designs, one in each quarter of the bowl rim. Each design was separated by ca. 90 mm of unpainted slip. The black glaze paint has partially vitrified to a light green (5Y 5/2) color in some places.

Vessel Form: Four body sherds were recovered from a single test unit and two from the nearby surface at 41KT51. All are very small, and the vessel form could not be discerned. Sixty-two sherds were recovered from several proveniences at 41KT53. Small body sherds found in Test Units 1, 4, and 5 represent an unknown number of vessels of unknown form. The 57 sherds recovered from Test Unit 8, along with the 28 sherds recovered from the surface at the same provenience in 1987, appear to be from one vessel. A partial vessel was reconstructed from these 85 sherds (includes 16 rim sherds). The vessel is a large, shallow bowl (see Fig. 75) with an exterior rim diameter of 275-280 mm and an estimated depth of 90 mm. The bowl is slightly shouldered, with an inverted rim. The rim is the thickest portion of the vessel, being 10-11 mm thick at a point 13 mm below the rim. The vessel is 8 mm thick at the shoulder and thins toward the bottom. The thinnest sherds are

5 mm and are from near the bottom of the bowl. The bottom center of the vessel is missing and was probably ca. 4 mm thick.

Discussion: The reconstructed bowl from 41KT53 is of the same form as the Glaze E, Pecos Polychrome bowl illustrated by Honea (1973:85) and appears to have been well constructed. The maximum rim thickness varies from 10-11 mm, and there is no evidence that sherds broke along coil lines. In contrast to the construction is the carelessly painted decoration. Both the interior and exterior decorations are poorly executed linear designs. The painted lines vary considerably in thickness, and the edges are wavy due to the paint running. The designs appear to have been executed very hastily and without regard to appearance.

The vessel appears to be a storage or serving bowl. An organic residue sample taken from the interior 1-3 mm of a body sherd from the side of the bowl was determined to be probable plant (see Appendix G). A thermoluminescence date of A.D. 1805 $\pm$ 40 was obtained from a body sherd (see Appendix C, sample Dur89TLpfg 134-13BS).

Type II

Forty-one sherds of this type were recovered from three sites, 41KT51, 41KT52, and 41KT53 (see Table 96). Sixteen sherds from a single vessel were recovered from 41KT53 (Feature 6, Test Unit 4), and a partial vessel was reconstructed (Fig. 76). Sherds of this type collected from a shovel test in 1987 were identified as Pecos Faint Striated. This utilitarian ware is contemporaneous with Pecos Glaze Polychrome V, ca. A.D. 1600-1700 (see Boyd 1989b:357). There are many problems with visual identification of this type of plain ware (Habicht-Mauche 1987:181), and these sherds are extremely homogenous in all characteristics. Lacking a detailed petrographic analysis, it is impossible to determine if all of the sherds are truly Pecos Faint Striated or if some might be indigenous wares manufactured by similar or identical techniques. For now, Type II is considered to be a group of imported plain wares which is similar to and includes Pecos Faint Striated.

Description: Type II includes 36 body sherds ranging in maximum dimension from 8 to 50 mm and in thickness from 2 to 6 mm. Also included are five rim sherds, four of which are from the partial vessel found at 41KT53. The largest of these is ca. 30x30 mm, and they range in thickness from 4 mm along the rim edge to 7 mm at a point 15 mm below the rim. A single rim sherd from 41KT52 measures 20x25 mm and is 6-7 mm thick.

Construction: The method of construction is presumed to be coiling, but there is no evidence on these sherds.

Paste: These sherds have a grayish red (5R 5/2), fine- to coarse-grained paste which leaves a reddish to black streak. There is no distinct core, and the sherd interiors are dark gray to black throughout.

Temper: The temper of one of the Type II sherds recovered in 1987 was identified as Glorieta Sandstone from the Pecos Pueblo area (Boyd 1989b:357). The temper varies slightly in grain size from sherd to sherd, but the basic composition and texture are the same. The temper consists of ca. 30% rounded, clear to white quartz grains and white feldspar ranging in size from 0.25 to 1.0 mm and less than 5% silver or gold mica under 0.25 mm in size. Occasional sherds have slightly more or less of these various components.

Figure 76. Type II vessel form. (a) Reconstructed jar profile, 41KT53; (b) Pecos Faint Striated and Tierra Blanca Plain jar form (from Habicht-Mauche 1987:179, 182).

Finish: Most of these sherds are unfinished and have a rough surface texture on both the interior and exterior. Others exhibit various degrees of smoothing; many have prominent striations resulting from scraping. Some appear to be slightly smoothed on one surface, and five sherds have a very smooth interior surface.

Vessel Form: The single rim sherd from 41KT51 is probably from a small jar with an everted rim and squared lip, but the sherd is too small to determine its exact form. The partially reconstructed vessel from 41KT53 is a globular to slightly elongated jar (see Fig. 76). The rim is everted, and the lip is rounded. The jar has a maximum body diameter of 215 mm, and the rim diameter was probably similar.

Discussion: The Type II vessel from 41KT53 is similar to the globular jar form of the Pecos Faint Striated and the Tierra Blanca Plain types (Habicht-Mauche 1987:182). These two types are similar in vessel form, composition, construction, and surface finish. It is difficult, if not impossible, to differentiate between these two types on the basis of visual inspection.

The fire-smudged exterior and baked-on residue on the interior indicate that the vessel was a utilitarian cooking pot. An organic residue sample taken from the interior 1-3 mm of a body sherd from the side of the pot from 41KT53 was of indeterminate origin, while a sample from a Type II sherd from 41KT51 yielded plant residues (see Appendix G). A sherd from the vessel at 41KT53 submitted for thermoluminescence dating yielded a date of A.D. 1770 $\pm$ 45 (see Appendix C, sample Dur89TLpfg 134-14BS).

Type III

Seven sherds of this type were recovered from one site, 41KT53 (see Table 96). This type is unidentified, and the present sample is too small to allow confident identification; however, these few sherds are very similar to the Ocate Micaceous type described by Gunnerson (1969:26-27) and other varieties of Sangre de Cristo Micaceous wares (Baugh and Eddy 1987).

Description: The largest of these sherds is 14x17 mm; three are fragments lacking one surface. The largest sherd is 3-4 mm thick.

Construction: There are no identifiable coil breaks, and the surface finish has obliterated other traces of the method of construction.

Paste: These sherds have a homogenous, gray to dark gray (10YR 5/1 to 10YR 4/1), very fine to coarse-grained paste which leaves a grayish brown to black streak. The paste appears to be laminated in flakey layers parallel to the surface, and there is no apparent core discoloration.

Temper: These sherds contain a very fine grained sand and mica temper, although the sand could be a component of the clay. The sand is rounded-subangular clear quartz grains less than 0.1 mm in diameter, which can be seen only under magnification. These grains make up 10-15% of the paste. The mica consists of small silver flecks under 1 mm in diameter and makes up ca. 30% of the paste. The sand and mica are evenly mixed throughout, and the mica is visible on both surfaces.

Finish: Two sherds are scraped and/or smoothed on both surfaces and have parallel striations visible on the interior. All other sherds are slightly smoothed and have a rough texture and no apparent striations.

Vessel Form: Due to the small size of the sherds, no vessel form can be determined. These sherds represent an unknown number of vessels but could all be from a single vessel.

Type IV

Three sherds of this unidentified type were recovered from two sites, 41GR291 and 41GR467 (see Table 96). The sample is too small for any positive identification, but these sherds are similar to plain wares from southern New Mexico and western Texas, specifically the Jornada Mogollon types (Jornada, Roswell, and El Paso Brown, and Alma Plain) (Jelinek 1967:47-51). Similar sherds were recovered from the Deadman's Shelter Site in Swisher County, Texas, and may date to A.D. 200-900 (Willey and Hughes 1978:189).

Description: Two sherds are from 41GR291; one measures 14x14 mm and is 5 mm thick, and the other measures 13x16 mm and is 5 mm thick. A single sherd from 41GR467 measures 12x15 mm and is 7 mm thick.

Construction: These sherds exhibit no evidence of the method of construction.

Paste: These sherds have a medium- to coarse-grained, reddish gray (5YR 4/2) paste. Two sherds have no apparent core discoloration and leave a dark brown streak. One sherd from 41GR291 has a 3-mm-thick, dark gray core which leaves a dark brown streak.

Temper: The temper consists of angular to subangular fragments of feldspar and quartz of various colors, including white, red, gray, and brown. They vary in size up to 1.25 mm, constitute 30-40% of the paste, and are apparently derived from crushed igneous rocks.

Finish: The surfaces of these sherds are evenly smoothed without striations but are not highly polished. The surfaces are all light brown, except for the exterior surface of one sherd which is dark brown to black.

Vessel Form: These sherds are too small to determine vessel form, and a minimum of two vessels are represented. The two sherds from 41GR291 could be from the same vessel.

Type V

Two sherds of this type were recovered from one site, 41KT53 (see Table 96). This type is unidentified, and the sample is too small for positive identification. These sherds are similar to Type III but contain considerably less mica.

Description: One is a body sherd with no interior surface; it measures 21x29 mm and is 4 mm thick. The second is a small rim sherd measuring 13x15 mm and 5 mm thick.

Construction: These sherds exhibit no evidence of the method of construction.

Paste: These sherds have a fine-grained, yellowish brown (10YR 6/4) paste with no apparent core discoloration. The paste leaves a yellowish brown streak.

Temper: These sherds contain a very fine grained sand and mica temper. The sand consists of rounded to subangular grains of clear quartz less than 0.25 mm in size, which constitute 20-30% of the paste. Fine flecks of silver mica, less than 0.25 mm in size, constitute less than 5% of the paste. The temper is probably a micaceous sandstone, although some or all of this material could be a component of the clay.

Finish: The rim sherd has a smoothed or scraped finish with horizontal striations on both the interior and exterior. The body sherd has a rough exterior finish, and the interior surface is missing.

Vessel Form: The rim sherd is too small to determine vessel form, but it has a rounded lip and tapers from 5 to 1 mm in thickness. It may represent a slightly everted rim. The two sherds probably are from different vessels.

Type VI

Two sherds of this type were recovered from two sites, 41KT51 and 41KT52 (see Table 96). This type is unidentified, and the sample is too small for positive identification. These sherds are similar to Types III and V but do not contain mica in the temper.

Description: A small rim sherd from 41KT51 measures 9x13 mm and is 3 mm thick. A body sherd from 41KT52 measures 15x22 mm and is 3-4 mm thick.

Construction: These sherds exhibit no evidence of the method of construction.

Paste: The body sherd paste is yellowish brown (10YR 5/4) and leaves a brown streak. It has a 1-mm-thick reddened core discoloration along one surface which leaves a red streak. The rim sherd paste is dark brown (7.5YR 4/4) and leaves a dark brown streak. It has a 1-mm-thick black core which leaves a black streak.

Temper: This temper consists of very fine, rounded-subangular, clear quartz grains less than 0.25 mm in size. No mica is present. The temper is probably crushed sandstone, although some or all of the quartz could be a component of the clay.

Vessel Form: These sherds represent two different vessels but are too small to determine vessel form. The rim sherd has a rounded lip and tapers from 3 to 1 mm.

Petrographic Thin Sections

Petrographic thin sections of four sherds were made by the Thin Section Laboratory of the Bureau of Economic Geology, The University of Texas at Austin (Table 97). These samples were not subjected to full petrographic analysis (e.g., point counting or grain identification), and thus the mineralogical constituents and other characteristics of the sherds cannot be detailed; however, the following observations were made by Mark Wink of the Thin Section Laboratory after a cursory examination of the thin sections under a polarizing microscope. The sherds appear to represent three source areas. Samples 2 and 3 vary slightly but are homogeneous in grain size, shape, and concentration; they could be from the same clay/temper source. They appear to contain mainly well-sorted quartz and feldspar fragments and probably represent materials transported a considerable distance.

TABLE 97

PETROGRAPHIC THIN SECTION DATA

Sample No.	Site No.	Provenience	Ceramic Type
1	41GR291	Test Unit 1, 30-40 cm	IV
2	41KT53	1987 surface collection (Feature 5)	I
3	41KT53	Test Unit 4, Feature 6	II
4	41KT53	Test Unit 2, 0-10 cm	III

Samples 1 and 4 are quite different and represent two sources that are distinct from Samples 2 and 3. Sample 1 appears to contain mainly feldspar fragments that vary considerably in size, shape, and angularity. Some grains are very large and irregularly shaped. This sample also appears to contain small quartz grains. The sources of the feldspar and the quartz are probably different; the former was probably obtained from a primary source, while the latter may be a component of the clay. Sample 4 is somewhat similar to Samples 2 and 3 in that it appears to contain well-sorted quartz and feldspar. However, Sample 4 appears to have a different concentration of these materials and also has a considerable amount of elongated mica or biotite fragments. It is not apparent whether the mica/biotite is from the same source as the quartz and feldspar.

The preceding observations support the type classifications set forth above but do not replace a full petrographic analysis. If future ceramic investigations are to address the problems of distinguishing between the clay and temper components and defining the source areas of these components, then petrographic analytical techniques should be utilized.

BURNED ROCKS

Burned rocks were encountered in two contexts within prehistoric sites, in distinct features and scattered in excavations or on the surface. Feature-related burned rocks were too numerous to be systematically collected and analyzed, but those associated with particularly well defined features were analyzed in the field or collected and analyzed. These are discussed in the individual feature descriptions in Chapters 5 and 6 and are not considered here. The scattered burned rocks are described and analyzed in three categories: fire-cracked Potter chert and quartzite, heat-shattered chert, and burned sandstone and limestone (Table 98).

Fire-cracked Potter Chert and Quartzite

Intensive heating followed by rapid cooling of Potter chert and quartzite results in distinctive and easily recognized angular fracturing and blocky fragmentation (i.e., fire cracking) and slight discoloration (i.e., reddening) of the cortex. All fragments of fire-cracked Potter chert and quartzite were systematically collected from nonfeature contexts, test excavations, and surface collection samples and are considered to be scattered occupational debris dispersed from features. One critical assumption is that the scattered and feature-associated fire-cracked rocks represent a specific activity, presumably food preparation by stone boiling or stone-lined baking pit techniques. No hearths constructed of Potter chert and/or quartzite were observed. The inter- and intrasite distributions of scattered fire-cracked rocks should reflect the relative importance of these activities. The frequency of scattered fire-cracked rocks varies considerably between sites (Table 99). No fire-cracked rock features were observed at any of the four Late Prehistoric II sites, and few or no scattered fire-cracked rocks were recovered. The scarcity of fire-cracked rocks suggests a reduction or absence of specific activities (i.e., certain kinds of food processing). The Archaic and Late Prehistoric I sites have a higher fire-cracked rock/area ratio (0.404 ± 0.264) than do the Late Prehistoric II sites (0.004 ± 0.006). A simple nonparametric statistical test, the Mann-Whitney U Test, was applied to the data to test the null hypothesis that there is no difference in the fire-cracked rock/area ratio between

TABLE 98
SUMMARY OF SCATTERED BURNED ROCKS BY SITE

Site	Fire-cracked Potter Chert	Fire-cracked Quartzite	Heat- shattered Chert	Burned Sandstone	Burned Limestone
41GR239	2	-	-	-	-
41GR286	10	-	-	-	-
41GR291	34	3	2	2	-
41GR302	39	-	-	3	-
41GR303	43	3	7	6	-
41GR323	3	-	-	13	-
41GR327	17	-	-	-	-
41GR359	55	6	10	16	19
41GR374	3	-	-	-	-
41GR376	2	1	3	-	-
41GR378	4	-	2	1	-
41GR380	24	1	-	-	-
41GR381	10	1	-	-	-
41GR383	22	1	1	1	-
41GR456	4	-	6	11	2
41GR467	-	-	2	-	-
41GR471	1	-	-	1	-
41GR474	-	-	-	1	-
41GR484	-	1	1	-	-
41GR515	1	2	7	4	-
41GR546	-	-	7	-	-
41GR559	1	1	6	-	-
41GR569	-	-	-	1	-
41KT33	63	9	19	16	15
41KT34	114	3	3	33	4
41KT49	-	-	4	37	2
41KT51	-	-	2	1	-
41KT52	1	-	1	-	-
41KT53	-	-	21	-	1
Totals:	453	32	104	147	43

the two groups of sites. The p value, determined by the z score ($p = 0.0827$; $z = 1.71$), indicates that the null hypothesis can be rejected as false with a ca. 8% probability of being incorrect. The pattern indicated is one of significantly less scattered fire-cracked rocks in the Late Prehistoric II sites, which is tentatively interpreted as a reduction in stone boiling/baking activities. Hammett (1966:270) notes the use of baking pits and resulting middens and scattered fire-cracked rocks as a diagnostic Archaic phenomenon in southwestern Oklahoma.

TABLE 99
DATA ON SCATTERED FIRE-CRACKED POTTER CHERT
AND QUARTZITE AT SELECTED SITES

Site	Temporal Assignment*	Area (m ²)				Number of Scattered Fire-cracked Rocks	Ratio of Fire-cracked Rocks/Total Area
		Auger Tests	Test Units	Surface Collection Units	Total Area		
41GR291	LPI	1.7	6.0	60.0	67.7	37	.547
41GR303	LPI	-	5.0	100.0	105.0	46	.438
41GR323	LPII	0.8	10.0	236.6	247.4	3	.012
41GR383	LA/LPI	0.8	8.0	60.0	68.8	23	.334
41GR484	LPII	-	5.0	225.0	230.0	1	.004
41KT33	LA	-	7.0	78.5	85.5	60	.702
41KT49	LA	2.0	8.0	-	10.0	0	0
41KT51	LPII	-	3.0	40.0	43.0	0	0
41KT53	LPII	-	13.0	-	13.0	0	0

*LA = late Archaic (ca. 4500-2000 B.P.)

LPI = Late Prehistoric I (ca. 2000-1000 B.P.)

LPII = Late Prehistoric II (ca. 1000-400 B.P.)

Heat-shattered Chert

Cherts that are heat altered exhibit attributes ranging from slight discoloration and textural changes to angular fracturing and fragmentation, potlidding, crazing, and intense discoloration. Heat-shattered chert, which includes all intensively heated specimens not exhibiting flake attributes, was systematically collected during the Phase II investigations (see Table 98). No attempt was made to distinguish between heat shatter resulting from intentional or incidental heating of lithic debitage and fractured specimens resulting from heating of unmodified chert cobbles or fragments. It is unlikely that chert nodules were utilized to any significant extent in food processing. Suitable-sized cobbles are rare in the project area and were probably valued as lithic material, and the tendency of fine-grained chert to shatter when heated makes it a less favorable material than Potter chert or quartzite.

Burned Sandstone and Limestone

Evidence of heat alteration is more subtle in sandstone and limestone than in siliceous materials. The local limestone, found as small cobbles in the gravel outcrops, may exhibit angular fracturing and discoloration (reddening) if intensively heated; otherwise,

there may be no evidence of burning. Heat alteration of sandstone, which occurs throughout the project area, is even less obvious, and evidence of burning is limited to discoloration (reddening or blackening) of its interior. Slight heating is not visually evident, and even intensively heated specimens can be confused with some of the local varieties of sandstone. Contextual relationships (i.e., feature associations) are thus extremely important in identifying heat-altered sandstone and limestone.

Burned sandstone and limestone reflect cultural activities, but scattered specimens were not systematically collected because of the difficulty of identifying burned specimens. Also, the natural occurrence of sandstone fragments in almost all depositional environments compounded the problem of identification, and the sheer abundance of scattered burned and unburned sandstone made total collection or in-field analysis impractical. Samples of burned sandstone and all of the identifiable burned limestone were collected but were not analyzed further (see Table 98).

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APPENDIX E: Microwear Analysis of Selected Chipped Stone Tools

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INTRODUCTION

Twenty chipped stone tools retrieved from the proposed Justiceburg Reservoir near Lubbock, Texas, were examined for microwear traces. Eighteen of the tools had undergone chemical analysis for residues adhering to their surfaces prior to the microwear study. It was assumed that the tools represent a broad range of functions associated with plant and animal procurement and processing, and the following information was requested for each utilized edge: (1) portion of edge used; (2) type of material worked; (3) relative hardness of material worked; and (4) type and direction of motion.

METHOD OF MICROWEAR ANALYSIS

The functions of the 20 tools in the sample were determined by applying the method of microwear analysis developed by Lawrence H. Keeley (1980). This method involves the examination of distinctive "micropolishes," striations, and damage scars that form on the edges of chipped stone tools when they are used to perform specific tasks (boring, cutting, scraping, etc.) on certain types of materials (bone, shell, wood, hide, etc.). Because Keeley's method focuses on the micropolishes on stone tools that are best viewed under incidental light at magnifications between 100x and 500x, the technique is often referred to as the "high-power approach" and contrasted with the "low-power approach" of stereo-microscopy that uses reflected light and magnifications between 10x and 100x (Yerkes 1987: 114; Juel Jensen 1988:53-54).

The low-power techniques do not allow the analyst to discriminate between different types of worked materials (Odell 1982; Yerkes 1987; Juel Jenkins 1988). The only method that provides a means to that end is the high-power incident-light technique. Keeley's (1980) observations on the morphological and textural variation in microwear polishes have been "verified, extended, and adjusted" by researchers in Europe, Asia, Australia, and North America (Juel Jensen 1988:54). His method has been used in the analysis of chipped stone assemblages that span 1.5 million years of prehistory (Owen et al. 1984; Juel Jensen 1988).

Microwear analysis involves the examination of the edges of chipped stone artifacts to locate the area of the implement that was used, determine the method of use, and identify the material that was worked. This is done by matching the microwear traces on artifacts with the use-wear patterns on experimental chipped stone tools in a reference collection that contains replicas of prehistoric tools that were knapped from several different types of flint and chert (including some chert that had been thermally altered) and used for a variety of tasks, including piercing, cutting, scraping, drilling, and engraving antler, bone, hide, meat, ceramic, shell, stone, and wood items (Yerkes 1987). Artifacts and experimental tools are cleaned in solutions of detergent (Top Job) and 10% HCl and 10% KOH, and the microwear traces on the experimental tools are compared with wear patterns on the prehistoric implements.

RESULTS

The cleaning and microscopic examination of each of the tools in the sample took approximately two to three hours. The Potter chert cobble tool (41GR291) was too large to fit on the stage of the incident-light microscope and could only be examined with a stereo-microscope at magnifications between 6x and 50x. This tool showed no obvious wear traces.*

Virtually all of the tools in the sample seem to have been affected by natural and technological effects that modified their surfaces and edges (Keeley 1980:4-5). Thirteen of the tools have a bright sheen or luster on their surfaces that may have resulted from postdepositional mechanical or chemical processes, while 12 of the tools seem to have been abraded either during the manufacturing process or after they had been discarded (Table 100). One or two of the tools seem to have been thermally altered (heat treated), and one to three of the implements have technological and/or wear traces suggesting that they were hafted (edge-grinding, basal thinning, or wear traces that suggest that the base or stem of the tools were bound with leather or sinew).

Eight tools are made of coarse-grained cherts that have many crystalline inclusions. It is difficult to precisely determine the function of tools made of these raw materials, since the crystalline surface of the tool edges "glitters" under incidental light and obscures the wear traces. Recent work by Knutsson and Taffinder (1984-86) demonstrated that the same types of wear traces form on coarse-grained materials as on flint (hlleflint and porphyry from Sweden were used in their study), although they noted that more experiments are needed to document the full range of the use-wear traces. The variability in raw material and the high incidence of natural and technological modification in the samples made the microwear analysis more difficult and time consuming than anticipated.

Eleven of the 20 tools were utilized, although the specific materials worked could be identified in only 7 cases (see Table 100). Three of the utilized tools were made of coarse-grained raw material, and although they have patterns of edge damage or edge rounding that suggest that one was used as a graver/drill (41GR484) and two were used as scrapers (41GR303 and 41KT33), the wear traces were not developed to the extent that the specific worked material could be identified. Another tool (41GR378) has a snapped tip exhibiting the "hangnail" fracture that suggests that it had broken during drilling (Odell 1981); however, the microwear traces on the remaining portion of the implement were not extensive enough to allow an accurate determination of the precise material worked (it may have been antler, bone, or shell).

The remainder of the utilized tools were used in butchering or hide-processing activities. A side scraper (41KT51, Test Unit 1) and an edge-modified flake (41GR323) were used to cut and scrape fresh hide (or meat); a side scraper (41GR291, Test Unit 1), an end/side scraper (41GR303), and an end scraper (41KT34) were used to scrape dry hide; and two gouges (41GR474 and 41GR303, Exploratory Trench 91) were used to scrape fresh or dry hide.

*During the lithic analysis (see Appendix D), this tool was classified as a cobble tool based on the presence of step fracturing and edge rounding on four distinct edges.

FORM AND FUNCTION

The three bifaces in the sample were not used, and two of them seem to have been broken during manufacture. The drill or perforator was also apparently not utilized. Five of the eight scrapers in the sample were utilized, one to scrape and cut fresh hide or meat, three to scrape dry hide (one was also used to cut dry hide), and one to scrape an unknown material. Two of the three gouges were used; both served as scrapers and were probably used on hide. One cobble tool (unifacial retouch) was also used as a scraper, but the material worked could not be determined, and the other was not utilized. Edge-modified flakes seem to have been used as drills or gravers on unknown materials or for scraping and cutting fresh hide or meat.

In the case of the scrapers, the form and function of the utilized tools show a strong correlation. However, the microwear on the gouges, which are commonly classified as wood-working tools (Morse and Goodyear 1973), indicated that they were used as scraping tools.

TABLE 100
SUMMARY OF MICROWEAR ANALYSIS

Provenience	Sample	Thermally			Method of Use	Worked Material
		Abraded	Altered	Hafted		
41GR291						
Test Unit 1, 20-30 cm	side scraper	yes	no	no	scraping	dry hide?
Test Unit 5, 31-35 cm	cobble tool	no	no	no	no visible wear*	-
41GR302						
Test Unit 1, 20-40 cm, Feature 2	end/side scraper	yes	no	no	no visible wear**	-
41GR303						
Test Unit 4, 20-30 cm	drill	yes	yes	yes	no visible wear	-
Surface Collection Sample	end/side scraper	yes	yes	no	scraping	dry hide
	end/side scraper	no	no	no	scraping	unknown**
	gouge	no	no	no	no visible wear**	-
Exploratory Trench 91, 40 cm	gouge	no	no	?	scraping?	hide**?
41GR323						
Surface	edge-modified flake	no	no	no	scraping/cutting	fresh hide, meat
Surface Collection Sample 1	biface	yes	no	no	no visible wear	-
41GR359						
Test Unit 8, 0-10 cm	side scraper	no	no	no	no visible wear	-
41GR378						
Test Unit 2, 40-70 cm	edge-modified flake	no	?	?	drilling	unknown
41GR474						
Surface	gouge	no	no	no	scraping	hide**?
41GR484						
Test Unit 3, 0-10 cm	edge-modified flake	yes	no	no	drilling or graving	unknown**

Table 100, continued

Provenience	Sample	Thermally			Method of Use	Worked Material
		Abraded	Altered	Hafted		
41KT33						
Test Unit 6, 10-20 cm, Feature 2	cobble tool	yes	no	no	scraping?	unknown**
41KT34						
Auger Test 27	end scraper	yes	no	no	scraping/cutting	dry hide**
Test Unit 9, 0-20 cm, Feature 3	biface	yes	no	no	no visible wear	-
41KT51						
Test Unit 1, 20-30 cm	side scraper	yes	no	no	scraping/cutting	fresh hide, meat
Test Unit 2, 10-20 cm	end/side scraper	yes	no	no	no visible wear	-
41KT53						
Test Unit 4, 10-20 cm, Feature 6	biface	yes	no	no	no visible wear	-

*Too large for incident-light microscope stage; examined under stereomicroscope at 6x-50x.

**Coarse-grained crystalline rock; difficult to identify micropolishes.

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APPENDIX F: Mineralogical Analyses of Kaolinite
and Pictograph Pigments

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INTRODUCTION

This appendix details the mineralogical analyses of four samples of kaolinite and two samples of pictograph pigment. All of the samples were analyzed by x-ray diffraction (XRD) to determine the whole rock mineralogy (Table 101), and the pigment samples were analyzed for total organic carbon.

TABLE 101
MINERALOGICAL SAMPLES ANALYZED BY X-RAY DIFFRACTION

MSL* ID No.	Description	Provenience
88-1229	pendant fragment	41GR291, surface
88-1230	"smooth" stream gravel	Apache Canyon, Big Bend National Park
88-1231	"rough" stream gravel	Apache Canyon, Big Bend National Park
89-032	quarry source specimen	Apache Canyon, Big Bend National Park
89-033	red pictograph pigment	41GR426
89-034	black pictograph pigment	41GR437

*Mineral Studies Laboratory, Bureau of Economic Geology, The University of Texas at Austin

X-ray diffraction is a well accepted qualitative analytical method that determines, and to some degree measures, the minerals present in a rock sample. The x-rays are diffracted, or reflected at varying angles, by the crystalline structure of the minerals present. The angles of diffraction along with the intensity of the diffracted x-ray beam provide a unique pattern of information specific for each mineral. By viewing the graph, an experienced analyst can determine the minerals present with a detectability of one to two weight percent of the bulk material.

KAOLINITE ANALYSIS

One artifact and three mineral specimens suspected to be kaolinite were submitted for x-ray diffraction analysis. The artifact is a pendant fragment recovered from an archeological site in Garza County, and the three mineral specimens are from the Apache Canyon kaolinite source area in Big Bend National Park, Brewster County, Texas. The mineral samples were loaned by Park Archeologist Thomas C. Alex for comparative analysis.

Sample Preparation/Treatment

Each sample was filed with a steel file in order to produce enough fine powder for the sample holder of the x-ray diffractometer. All samples were measured under identical instrument conditions so relative differences in the analog results could be identified. This approach was taken to study the minerals present in the host material at minor levels in hopes of finding a unique mineralogy that would indicate the source of the artifact.

Results

All samples were found to be pure kaolinite with minute amounts of quartz, the only other mineral identified. The very low concentration of this mineral precludes its use to "fingerprint" the artifact and the possible source materials. All samples appear to be identical to the limit of detection for this analytical technique as currently practiced at the Mineral Studies Laboratory.

Recommendations

Trace element concentrations of these materials could aid in the matching of artifacts of this type with their source.

PICTOGRAPH PIGMENTS ANALYSIS

The two pigment samples submitted for x-ray diffraction analysis consist of "red" pigment from a pictograph at 41GR426 and "black" pigment from a pictograph at 41GR437. In addition, an analysis of total organic carbon was done for the black pigment sample; the red pigment sample was too small for this analysis.

Sample Preparation/Treatment

A concentrated fraction (high in the colored material) was ground in an agate mortar and pestle to a fine powder. Then an unoriented powder x-ray diffraction analysis was performed for each of three materials (host rock, black pigment, red pigment). The analytical data were recorded on the same graph for all samples. By doing this, the analyst can visually subtract the parts of the resulting graph that are due to the rock on which these materials were placed.

Results

The "red" pigment appears to be rust-stained quartz. There were no data from the x-ray analysis to indicate any minor minerals to cause the color. Under a low-power microscope, the specimen appears to be sand grains with a rustlike coating.

The "black" pigment, under the microscope, has grains of colored material that range from dark brown to green. A physical isolation, or concentration, was made of the green material, via the microscope, which was subsequently analysed by x-ray diffraction. The results are inconclusive, but a green mineral called "chromian dravite" of the tourmaline group is a possibility that is supported by the x-ray diffraction data. An analysis of the "slightly concentrated" black pigment for total organic carbon (TOC) indicates a TOC content of one weight percent. Further study might reveal this organic carbon to be associated with the pigment.

Recommendations

Further efforts in the examination of these materials could include: (1) chemical analysis; (2) trace element studies; or (3) examination and qualitative chemical analysis using scanning electron microscopy (SEM) with energy dispersive x-ray analysis (EDS). All of the above can be performed at the Mineral Studies Laboratory.

APPENDIX G: Organic Residue and Phytolith Analyses

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and

J. Michael Quigg

INTRODUCTION

This appendix describes two separate technical studies conducted to determine their feasibility for future use in the Justiceburg Reservoir region. The organic residue analysis examined 80 samples, primarily lithic artifacts and burned rocks from features. The phytolith analysis focused on 11 samples of sediments from cultural features.

ORGANIC RESIDUE ANALYSIS

Archeometry, the application of chemical and physical analyses to answer archeological questions, is becoming more prevalent in archeology. One application is the use of chemicals to extract microscopic organic residues from cultural materials to address topics such as artifact function, feature function, and subsistence practices. In the pilot study presented here, samples were obtained from 25 burned rocks (2 samples were taken from 1 rock), 7 unmodified flakes, 5 bifaces, 5 gouges, 5 end/side scrapers, 4 projectile points, 3 end scrapers, 3 edge-modified flakes, 3 cobble tools, 3 manos, 3 metates, 3 ceramic sherds, 2 side scrapers, 2 pestles, 2 mano/hammerstones, 1 drill, and 1 hammerstone. In addition, two sediment samples were analyzed.

The organic residues extracted from these samples are called lipids and are present in or derived from all living organisms. Kates (1986) defines lipids as substances that: (1) are insoluble in water; (2) are soluble in organic solvents such as chloroform and ether; and (3) contain long-chain hydrocarbon groups in their molecules. There are many types of lipids, including hydrocarbons, alcohols, aldehydes, glycerides, fatty acids, and sterols. Fatty acids, the focus of this analysis, have been studied taxonomically since the nineteenth century, and in 1934 Hilditch (referred to in Hamilton and Bhati 1987:109) proposed that fats could be used for a chemically based plant taxonomy. In 1963, Shorland (cited in Hamilton and Bhati 1987:109) stated that "although the data on the types and distributions of fatty acids do not provide an unequivocal guide to the classification of plants, many correlations of taxonomic significance have been apparent in spite of the small number of species examined up to now."

Lipids have been investigated in disciplines such as biology, geology, medicine, and food science. In the latter, fatty acids and sterols are used to determine the purity of foods and oils and to examine the rate of fat deterioration so that food rancidity can be deduced (Privett 1961; Aurand et al. 1987:224). Fatty acids have been used in medical studies to determine if relationships exist between lipids, various diseases, and other biological problems (Mayer 1968; Kanau and Holman 1977; Brisson 1981:101-103). Geology and geochemistry have used lipids to examine petroleum formation processes, organic constituents of fossils and rocks, and climatic and geological changes (Smith 1952; Van Vleet and Quinn 1976; Baroux et al. 1988).

A few examples show that lipid (particularly fatty acid) analysis has served to address archeological questions. Jaky et al. (1964) found olive oil to which "sweet water (honey or must) and vinegar was probably added" from a 1,800-year-old Roman vase. Using gas chromatography, Thornton et al. (1970) discovered "bog butter" in eight samples from Scotland. Through thin-layer chromatography, one of eight vessels from early Bronze Age Crete yielded unidentifiable animal residue (Bowyer 1972). Also using gas chromatography,

Condamin et al. (1976) analyzed the contents of ceramics to determine the presence of olive oil. Rottlander and Schlichtherle (1979) tested Neolithic pottery and discovered milk, fat, beef suet, oil of Cruciferae, and other food residues. Morgan et al. (1984) detected marine animal residues in three samples from a Thule midden matrix. A ceramic vessel from the southwestern Cape of South Africa yielded marine animal, perhaps seal, residue (Patrick et al. 1985). Recently, Hurst et al. (1989) identified cocoa in a vessel from the Maya site of Rio Azul.

Fatty acid nomenclature reflects both the carbon chain length and the number of double bonds. For example, the fatty acid C16:0 has 16 carbons within its chain and no double bonds, while C18:3 has 18 carbons and 3 double bonds. Three groups of fatty acids are distinguishable: (1) saturated fatty acids; (2) monounsaturated fatty acids; and (3) polyunsaturated fatty acids. Saturated fatty acids have no double bonds within their carbon chains (e.g., C12:0, C14:0, C16:0), monounsaturated fatty acids have one double bond (e.g., C16:1, C18:1, C20:1), and polyunsaturated fatty acids have two or more double bonds (e.g., C18:2, C18:3).

Animal fats tend to have large amounts of saturated fatty acids relative to polyunsaturated fatty acids, while plant fats exhibit the opposite pattern. Therefore, the percentage of saturated fatty acids provides one means to investigate the origins of organic residues on archeological specimens. Since monounsaturated fatty acids have high nondiagnostic concentrations in both plant and animal fats, they are not considered here.

Another approach commonly used in fatty acid studies, calculating ratios of polyunsaturated to saturated fatty acids, is not employed here because of its inability to deal mathematically with samples lacking saturated fats. Also, no attempt is made here to characterize or fingerprint individual samples based on the amounts of specific carbon chains, although this approach can result in more-confident interpretations than the calculation of simple percentages of saturated fatty acids (Marchbanks 1989).

Several problems with this kind of analysis are evident. Many tools were probably used for multiple purposes, as were ceramic vessels and cultural features, which could result in mixing of different fatty acids. In addition, the mechanisms by which organic residues can become deposited in archeological contexts are varied and poorly understood, and hence they are difficult to interpret in terms of artifact or feature function. For example, residues from features could reflect the materials that were processed or the fuels used, and residues from chipped stone tools may represent materials used in hafting as well as the materials that were processed with the tools. Also, modern residues could be added through handling, and there are a variety of sources of noncultural residues. The most significant problem, however, appears to be the degradation of some fatty acids over time. The limited experimentation done to date indicates that the total fatty acids present decreases and that different fatty acids change at different rates (Morgan et al. 1973; Rottlander 1985; Marchbanks 1989). For example, Marchbanks (1989) showed that the percentages of C16:0 and C18:0 increase over time while the percentages of C18:1, C18:2, and C20:0 decrease. These diagenetic changes are extremely important since they affect the calculation of the percentage of saturated fatty acids and hence the interpretability of the data. To lessen the influence of these changes, saturated fatty acids that are known to alter over time (C16:0, C18:0, and C20:0) have been excluded from the calculations of the saturated fatty percentages (leaving C12:0 and C14:0). Unfortunately, the same cannot be done for the polyunsaturated fatty acids since C18:2, which decreases through time, is one of the primary polyunsaturated fatty acids in most plants; C18:2 and C18:3 were used to

represent polyunsaturated fatty acids in the calculations presented in this study. Modern samples were analyzed using these same carbon chains. Because C18:2 is used, a shift to higher saturated fatty acid percentages is expected in the archeological samples compared to the modern ones.

Methods

Eighty nonwashed samples, stored in plastic bags, were prepared for lipid extraction in two different ways. On ceramics, manos, metates, and burned rocks, roughly 1 mm of the outer surface was removed and discarded to reduce potential contamination. Further grinding with a Dremel drill using a tungsten steel bit removed the sample to be analyzed. Chipped stones were not ground but were cleaned with sterile laboratory tissues prior to extraction. Sterile surgeon's gloves were used to handle the samples.

Fatty acids were extracted using either the conventional Soxhlet extractor or by soaking the item in an inert plastic container. Specimen size was the principal factor in determining which extraction process was employed, as the extraction thimble inside the Soxhlet extractor had a 150-ml capacity. A solvent consisting of a two to one mixture of methanol to chloroform was used to remove the lipids.

Recovered fatty acids were first converted into their methyl ester form. Next, a thin-layer plate separation isolated the desired fatty acids from the other lipids (see Marchbanks 1989). Approximately 0.5 to 1.0 microliter of diluted fatty acid solution was injected into the fused silica column of the gas chromatograph which separates organic compounds. A Hewlett Packard integrator, connected to the gas chromatograph, calculated and registered how long it took the fatty acids to come off the gas chromatograph, i.e., the retention time. Smaller carbon chains have lower retention times, and longer carbon chains have higher retention times. The retention times were standardized for all samples except two, which were analyzed on a different gas chromatograph column. When possible, known carbon chains were identified through commercial standards.

Results

The analysis of 14 modern plant and animal samples (mesquite, cedar elm, persimmon, live oak, black walnut, hackberry, Amaranthus, sorghum, prickly pear, wild onion, millet, sycamore, osage orange, and bison), together with published data on 5 modern animal samples (cow, sheep, goat, red deer, and reindeer), indicate that animal residues consistently contain higher percentages of saturated fatty acids than plant residues (Marchbanks 1989: 91-98). Modern plant residues range from less than 1% to 16%, while animal residues show a range from 48% to 96% saturated fatty acids (Fig. 77).

Figure 77 also shows the distribution of the archeological organic residue samples by the percentage of saturated fatty acids. Of the 80 samples analyzed (Table 102), 6 (5 burned rocks and 1 sediment sample) have been omitted from this discussion and from Figure 77 because they yielded small concentrations of residues (Area <15,000), which are suggestive of noncultural origins. Also omitted are one end/side scraper that was contaminated with lichen growth and one unmodified flake for which the saturated fatty acid percentage

Figure 77. Distributions of modern and archeological organic residue samples by percentage of saturated fatty acids.

could not be calculated. The raw data for these 80 samples are presented in Table 103. Using the distributions of the archeological samples and the modern samples as a guide, 72 archeological samples are placed into four interpretive groups: Group I, with saturated fatty acid percentages less than 25%; Group II, with values from 27% to 38%; Group III, with from 44% to 82%; and Group IV, with values greater than 82% (Table 104).

The 12 Group I samples (17%) have residues that originated from plants. These samples consist of three burned rocks, two metates, two manos, two unmodified flakes, one gouge, one ceramic sherd, and one end scraper. Group II contains 13 samples (18%) with values slightly higher than those for modern plants and less than those for modern animals. Because of the diagenetic changes noted above wherein saturated fatty acids increase at the expense of polyunsaturated acids over time, the Group II residues are interpreted as probably representing plants. These samples consist of eight burned rocks, one ceramic sherd, two metates, one end/side scraper, and one sediment sample associated with a gouge. Because the amount and rate of the diagenetic changes remain poorly known, the 35 Group III samples (49%) are interpreted conservatively as representing either plants or animals, or a mixture of the two. Consequently, the parent materials are indeterminate. The samples include specimens from all categories except manos and metates. Group IV, represented by 12 samples (17%), appears to represent residues that originated from animals. This group consists of three projectile points, one biface, one cobble tool, one side scraper, one gouge, two edge-modified flakes, two unmodified flakes, and one burned rock.

Plotting the sample types, e.g., bifaces, metates, burned rocks, etc., against the saturated fatty acid percentages reveals some interesting patterns (Fig. 78). Roughly half the samples have values between 44% and 82% and, as described above, are placed in an

TABLE 102
 ARCHEOLOGICAL ORGANIC RESIDUE SAMPLES

Sample Number	Description	Site	Provenience	Area	Saturated Fatty Acid Percentage	Interpretive Group
1	Burned rock	41GR287	Feature 2	1,952,000	51.5	III
2	Burned rock	41GR287	Feature 1	32,152	27.1	II
3	Mano	41GR291	Test Unit 5, 30-40 cm	49,428	16.0	I
4	Arrow point	41GR291	Test Unit 6, 10-20 cm	19,102	100.0	IV
5	Arrow point	41GR291	Surface	43,359	73.3	III
6	Side scraper	41GR291	Test Unit 1, 20-30 cm	850,280	95.6	IV
7	Unmodified flake	41GR291	Test Unit 1, 30-40 cm	27,365	100.0	IV
8	Cobble tool	41GR291	Test Unit 5, 31-35 cm	143,990	65.9	III
9	Mano/hammerstone	41GR291	Test Unit 5, 25-30 cm	1,491,800	57.4	III
10	Burned rock	41GR291	Feature 2	13,311	*	--
11	Biface	41GR291	Test Unit 1, 30-40 cm	473,260	67.6	III
12	End/side scraper	41GR302	Feature 2	1,315,800	57.4	III
13	Gouge	41GR303	Exploratory Trench 91, 40 cm	4,088,200	58.0	III
14	Sediment around gouge	41GR303	Exploratory Trench 91, 40 cm	147,210	35.8	II
15	Burned rock	41GR303	Feature 7	10,166	*	--
16	Burned rock	41GR303	Feature 3	35,515	47.6	III
17	Burned rock	41GR303	Feature 4	7,827	*	--
18	End/side scraper	41GR303	Surface Area B	2,159,800	46.7	III
19	Gouge	41GR303	Surface Area B	1,707,800	73.4	III
20	Gouge	41GR303	Surface Area B	2,002,100	46.8	III
21	Drill	41GR303	Test Unit 4, 20-30 cm	59,243	52.5	III
22	End/side scraper	41GR303	Surface Area B	3,144,300	35.0	II
23	Gouge	41GR303	Surface Area B	711,070	100.0	IV
24	Gouge	41GR303	Surface Area B	2,509,400	0.0	I

*Omitted from analysis because of low concentrations or inability to determine saturated fatty acid percentage.

**Specimen contaminated with lichen; omitted from analysis.

Table 102, continued

Sample Number	Description	Site	Provenience	Area	Saturated Fatty Acid Percentage	Interpretive Group
25	Burned rock	41GR303	Feature 5	155,040	27.1	II
26	Burned rock	41GR303	Feature 8	184,700	69.3	III
27	Biface	41GR323	Surface	62,437	57.6	III
28	Metate (hearthstone)	41GR323	Feature 7	98,730	31.8	II
29	Burned rock	41GR323	Feature 6	41,279	37.9	II
30	Mano/hammerstone	41GR359	Test Unit 5, 20-30 cm	1,889,300	62.6	III
31	Unmodified flake	41GR359	Test Unit 6, 0-10 cm	33,167	70.9	III
32	Arrow point	41GR359	Test Unit 6, 10-20 cm	23,862	100.0	IV
33	End scraper	41GR359	Test Unit 8, 0-10 cm	6,464,600	51.0	III
34	End/side scraper	41GR359	Surface	2,481,000	**	--
35	Edge-modified flake	41GR378	Test Unit 2, 40-70 cm	64,464	61.0	III
36	Metate	41GR383	Test Unit 8, 70-80 cm	93,854	13.8	I
37	Burned rock	41GR383	Feature 2	47,584	47.7	III
38	Burned rock	41GR383	Feature 1	49,944	34.1	II
39	Metate	41GR456	Feature 3	56,498	34.0	II
40	Pestle	41GR456	Feature 12	2,591,900	45.0	III
41	Burned rock	41GR456	Feature 3	76,157	20.9	I
42	Burned rock	41GR456	Feature 3	36,563	29.6	II
43	Mano	41GR471	Test Unit 2, 0-10 cm	38,997	20.1	I
44	Pestle	41GR471	Surface	1,136,100	52.0	III
45	Burned rock	41GR471	Feature 1	126,600	51.9	III
46	Hammerstone	41GR484	Feature 2	1,196,700	59.9	III
47	Metate	41GR484	Feature 2	43,716	0.0	I
48	Biface (burned)	41GR484	Backhoe Trench 67, 0-40 cm	48,002	79.2	III
49	Edge-modified flake	41GR484	Test Unit 3, 0-10 cm	1,430,500	90.1	IV
50	Burned rock	41GR484	Feature 1	9,349	*	--
51	Burned rock	41GR484	Feature 2	74,534	50.3	III
52	Burned rock	41GR546	Feature 2	3,916	*	--
53	Burned rock	41GR559	Feature 3	44,733	36.6	II
54	Burned rock	41GR559	Feature 5	70,329	31.5	II

Table 102, continued

Sample Number	Description	Site	Provenience	Area	Saturated Fatty Acid Percentage	Interpretive Group
55	Dart point base	41KT33	Test Unit 3, 10-20 cm	20,951	100.0	IV
56	Unmodified flake	41KT33	Test Unit 5, 0-10 cm	21,634	100.0	IV
57	Unmodified flake	41KT33	Test Unit 5, 0-10 cm	26,553	*	--
58	Unmodified flake	41KT33	Test Unit 5, 0-10 cm	35,771	0.0	I
59	Cobble tool	41KT33	Feature 2	58,387	100.0	IV
60	End scraper	41KT33	Surface	2,325,500	0.0	I
61	Unmodified flake	41KT33	Test Unit 5, 0-10 cm	40,100	0.0	I
62	Burned rock	41KT33	Feature 1	45,198	0.0	I
63	Burned rock	41KT33	Feature 2	68,025	32.0	II
64	Cobble tool	41KT34	Test Unit 5, 80-90 cm	988,710	50.9	III
65	End scraper	41KT34	Auger Test 27	1,426,100	80.5	III
66	Biface	41KT34	Feature 3	21,506	100.0	IV
67	Burned rock burned side)	41KT49	Feature 4	456,280	23.3	I
68	Burned rock (unburned side)	41KT49	Feature 4	51,725	87.9	IV
69	Side scraper	41KT51	Test Unit 1, 20-30 cm	756,360	64.9	III
70	Edge-modified flake	41KT51	Test Unit 2, 0-10 cm	18,724	100.0	IV
71	End/side scraper	41KT51	Test Unit 2, 10-20 cm	6,333,200	44.5	III
72	Ceramic sherd (Type II)	41KT51	Test Unit 2, 10-20 cm	152,550	20.2	I
73	Burned rock	41KT52	Feature 1	46,406	51.5	III
74	Biface	41KT53	Feature 6	3,698,700	53.0	III
75	Ceramic sherd (Type II)	41KT53	Feature 6	251,940	51.2	III
76	Ceramic sherd (Type I)	41KT53	Feature 5	109,350	34.8	II
77	Unmodified flake	41KT53	Test Unit 2, 0-10 cm	51,533	47.7	III
78	Burned rock	41KT53	Feature 3	38,663	61.9	III
79	Burned rock	41KT53	Feature 4	155,090	59.7	III
80	Sediment	nonsite	Alluvial terrace	10,556	*	--

TABLE 103 Raw Data for Archeological Organic Residue Samples

RETENTION TIME/ FATTY ACID	SAMPLE NUMBER									
	1	2	3	4	5	6	7	8	9	10
2.99	1.21	0.00	0.00	0.00	0.00	1.47	0.00	0.00	1.95	0.00
c 12:0	0.05	0.00	0.00	0.00	7.18	0.35	0.00	0.00	0.39	0.00
3.31	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
c 13:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.84	1.13	0.00	0.00	0.00	0.00	11.55	0.00	0.00	0.83	0.00
c 14:0	1.40	1.88	1.80	5.23	8.89	3.35	7.77	2.25	1.53	0.00
4.15	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00
4.27	0.13	0.00	0.00	0.00	0.00	1.56	0.00	0.00	0.00	0.00
4.39	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.20	0.00
4.46	0.00	2.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
c 15:0	0.13	0.00	1.10	0.00	1.03	0.25	0.00	0.00	0.18	0.00
4.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.98	0.00	0.00	2.70	0.00	0.00	0.23	0.00	0.00	0.00	8.96
5.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.12	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00
c 16:0	20.67	31.98	24.75	37.25	32.34	16.25	35.20	31.38	20.91	26.60
5.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
c 16:1	0.00	15.62	4.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.77	0.00	0.00	0.00	0.00	0.00	5.43	0.00	0.00	0.00	0.00
5.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00
5.98	0.00	0.00	2.11	0.00	3.35	0.00	1.83	0.00	0.00	0.00
6.15	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.00
6.20	0.00	32.88	19.67	14.79	0.00	0.00	4.58	2.01	0.54	25.61
c 17:0	0.33	0.00	0.00	0.00	0.00	0.80	0.00	0.83	0.34	0.00
6.80	13.30	0.00	0.00	0.00	0.00	28.84	0.00	4.72	14.19	0.00
7.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
c 18:0	48.07	10.53	7.53	23.09	23.68	26.66	22.15	52.80	45.69	7.24
8.69	0.26	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.29	0.00
c 18:1	0.00	0.00	26.10	19.64	17.67	0.47	28.47	4.43	0.54	31.58
c 19:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
c 18:2	0.00	5.05	4.06	0.00	5.85	0.00	0.00	0.00	0.18	0.00
11.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.15	0.28	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
c 18:3	1.37	0.00	5.39	0.00	0.00	0.17	0.00	1.16	1.24	0.00
15.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.6	8.50	0.00	0.00	0.00	0.00	0.63	0.00	0.00	7.03	0.00
c 20:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
c 22:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
c 20:1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
c 22:1	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.60	0.00
25.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHERS	2.65	0.00	0.00	0.00	0.00	0.62	0.00	0.42	0.90	0.00
% Saturated Fatty Acids	51.48	27.15	15.96	100.00	73.33	95.51	100.00	65.88	57.44	-

TABLE 103, continued

RETENTION TIME/ FATTY ACID	SAMPLE NUMBER									
	11	12	13	14	15	16	17	18	19	20
2.99	0.00	1.28	0.81	0.00	0.00	0.00	0.00	2.03	0.98	0.39
C 12:0	0.11	0.44	0.30	0.60	0.00	4.13	0.00	0.27	0.33	0.11
3.31	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.22	0.00	0.00
C 13:0	0.00	0.00	0.00	0.37	0.00	5.29	0.00	0.00	0.00	0.00
3.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00
3.84	0.00	0.00	0.00	17.19	0.00	0.00	0.00	0.00	0.00	0.00
C 14:0	2.11	0.06	0.09	4.27	0.00	3.12	0.00	0.00	0.00	0.00
4.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.27	0.00	0.25	0.50	0.76	0.00	2.35	0.00	0.48	0.37	0.00
4.39	0.00	0.09	0.08	2.01	0.00	0.00	0.00	0.00	0.00	0.09
4.46	0.29	0.00	0.00	0.00	0.00	6.59	7.26	0.00	0.00	0.00
C 15:0	0.36	0.22	0.12	1.78	0.00	0.00	0.00	0.10	0.12	0.12
4.76	0.00	0.10	0.04	0.00	0.00	0.00	0.00	0.00	0.12	0.15
4.98	0.22	0.33	0.00	1.93	0.00	6.07	0.00	0.00	0.00	0.23
5.03	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.18	0.23	0.00
5.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 16:0	41.90	6.38	8.35	15.01	46.46	21.84	44.78	4.01	3.83	4.46
5.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 16:1	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.09	0.00	0.00
5.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.77	0.00	6.24	5.44	0.00	0.00	0.00	0.00	5.91	5.18	3.25
5.93	0.00	0.00	0.00	6.69	0.00	0.00	0.00	0.00	0.00	0.00
5.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.15	0.00	0.00	0.09	0.00	0.00	0.00	16.99	0.00	0.00	0.00
6.20	0.00	0.37	0.27	2.57	9.60	0.00	0.00	0.00	0.00	0.32
C 17:0	0.67	0.11	0.29	0.70	0.00	0.00	0.00	0.13	0.12	0.13
6.80	0.50	0.00	0.22	0.00	0.00	0.00	0.00	0.28	0.36	0.00
7.22	0.00	0.69	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
C 18:0	51.24	8.55	18.87	4.17	26.44	11.82	19.31	9.36	6.14	7.51
8.69	0.00	0.07	0.28	2.86	0.00	0.00	0.00	0.04	0.00	0.00
C 18:1	0.20	2.02	0.09	26.97	17.50	4.14	11.67	0.40	0.79	0.50
C 19:0	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 18:2	0.00	0.37	0.04	6.96	0.00	7.96	0.00	0.07	0.12	0.05
11.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.15	0.00	0.89	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.37
C 18:3	1.06	0.00	0.24	1.76	0.00	0.00	0.00	0.24	0.00	0.08
15.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.6	0.00	2.37	3.12	0.00	0.00	0.00	0.00	0.98	0.19	3.21
C 20:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 22:0	0.00	0.00	0.06	1.82	0.00	0.00	0.00	0.00	0.00	0.00
23.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 20:1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 22:1	1.35	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHERS	0.00	68.59	59.63	1.38	0.00	26.70	0.00	75.22	81.12	79.05
% Saturated Fatty Acids	67.55	57.39	58.03	35.79	-	47.65	-	46.74	73.39	46.78

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

TABLE 103, continued

RETENTION TIME/ FATTY ACID	SAMPLE NUMBER									
	21	22	23	24	25	26	27	28	29	30
2.99	0.00	0.70	0.57	1.85	0.00	0.00	0.00	0.00	0.00	1.77
C 12:0	0.47	0.21	0.11	0.00	0.00	2.20	0.00	0.00	0.00	0.27
3.31	0.00	0.00	0.00	0.28	0.00	0.80	0.00	0.00	0.00	0.11
C 13:0	0.00	0.00	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.00
3.72	0.00	0.00	0.00	0.02	0.00	1.83	0.00	0.00	0.00	0.00
3.84	0.00	0.00	0.00	0.00	0.00	2.94	0.00	0.00	0.00	1.66
C 14:0	3.65	0.00	0.00	0.00	0.85	5.27	6.33	2.07	2.81	1.80
4.15	2.99	0.00	0.00	0.12	0.00	3.00	1.34	0.00	0.00	0.47
4.27	0.00	0.48	0.00	0.62	0.24	3.64	0.00	0.00	1.72	0.00
4.39	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
4.46	0.00	0.00	0.00	0.00	1.76	8.90	1.35	0.00	5.33	0.00
C 15:0	0.00	0.13	0.14	0.00	0.00	3.95	0.00	1.13	0.00	0.24
4.76	0.00	0.08	0.12	0.00	0.00	6.42	0.00	0.00	0.00	0.00
4.98	0.00	0.00	0.53	0.00	1.15	6.05	0.00	3.12	4.59	0.10
5.03	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.12	0.00	0.00	0.00	0.00	0.00	2.07	0.00	0.00	0.00	0.04
C 16:0	23.60	10.20	4.78	2.16	23.13	8.22	22.42	35.74	25.26	28.56
5.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 16:1	0.00	0.02	0.00	0.00	3.89	0.00	5.02	8.88	2.54	0.00
5.68	0.00	0.00	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00
5.77	0.00	4.92	0.00	8.10	0.00	0.00	0.00	0.00	0.00	0.00
5.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
5.98	0.00	0.00	0.00	0.00	0.55	0.00	2.77	0.00	0.00	0.00
6.15	0.00	0.07	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00
6.20	3.90	0.00	0.00	0.00	49.09	5.59	0.00	10.33	38.34	0.69
C 17:0	0.00	0.37	0.17	0.00	0.00	0.00	0.00	1.26	0.00	0.21
6.80	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	12.58
7.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 18:0	9.60	22.48	7.97	5.30	2.71	6.93	11.88	12.66	9.59	34.83
8.69	7.96	0.41	0.00	0.00	0.00	0.00	2.93	0.00	0.00	0.31
C 18:1	44.11	0.00	1.00	0.28	7.12	10.10	33.67	14.17	9.83	3.13
C 19:0	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 18:2	3.73	0.15	0.00	0.10	2.29	3.32	4.67	2.28	4.60	0.29
11.80	0.00	0.00	0.00	0.00	0.00	1.26	0.00	0.00	0.00	0.00
12.15	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77
C 18:3	0.00	0.25	0.00	0.20	0.00	0.00	0.00	2.16	0.00	0.94
15.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
19.6	0.00	1.58	0.00	0.00	0.00	1.09	0.00	0.00	0.00	7.58
C 20:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 22:0	0.00	0.00	0.00	0.08	0.00	0.00	0.00	6.19	0.00	0.00
23.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 20:1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 22:1	0.00	0.00	0.00	0.00	0.00	0.00	7.63	0.00	0.00	0.00
25.8	0.00	0.00	0.00	0.00	0.00	4.44	0.00	0.00	0.00	0.00
OTHERS	0.00	56.74	84.43	80.78	7.24	9.92	0.00	0.00	0.00	2.70
% Saturated Fatty Acids	52.48	34.98	100.00	0.00	27.05	69.25	57.52	31.77	37.88	62.61

TABLE 103, continued

RETENTION TIME/ FATTY ACID	SAMPLE NUMBER									
	31	32	33	34	35	36	37	38	39	40
2.99	0.00	0.00	0.86	1.66	0.00	0.00	0.00	0.00	0.00	2.73
C 12:0	1.28	0.00	0.35	0.00	0.00	0.00	0.21	0.87	0.00	0.00
3.31	0.00	0.00	0.15	0.29	0.00	0.00	0.00	0.00	0.00	0.10
C 13:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
3.72	0.00	0.00	0.00	0.01	0.00	0.00	0.00	1.92	0.00	0.47
3.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 14:0	7.84	8.59	0.00	0.00	4.13	2.57	3.21	3.72	1.61	1.57
4.15	0.00	1.35	0.00	0.00	0.00	2.80	0.00	0.00	0.00	0.00
4.27	0.00	0.00	0.54	0.39	0.00	0.00	0.00	0.00	0.87	0.00
4.39	0.00	0.00	0.06	0.00	0.00	0.00	0.00	3.23	0.00	0.00
4.46	0.00	0.00	0.00	0.00	0.00	0.00	1.66	0.00	0.00	0.00
C 15:0	4.88	4.10	0.14	0.14	2.84	1.06	0.00	1.35	1.15	0.07
4.76	0.00	0.00	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00
4.98	0.00	0.00	0.00	0.00	0.00	3.53	1.87	3.81	3.56	0.10
5.03	0.00	0.00	0.20	0.22	0.00	0.00	0.00	0.00	0.00	0.00
5.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 16:0	32.20	40.83	7.78	4.15	31.81	25.89	27.06	17.07	19.62	25.83
5.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 16:1	0.00	0.00	0.00	0.00	0.00	0.00	9.59	0.00	3.48	0.00
5.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.43	0.00
5.77	0.00	0.00	5.71	6.95	0.00	0.00	0.00	0.00	0.00	0.00
5.93	10.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.98	0.00	8.48	0.00	0.00	7.97	0.55	0.00	0.68	1.84	0.00
6.15	0.00	0.00	0.14	0.09	0.00	0.00	0.00	0.00	0.00	0.05
6.20	6.12	0.00	0.25	0.00	0.00	22.24	17.99	13.13	29.57	0.00
C 17:0	0.00	0.00	0.27	0.15	0.00	0.00	0.00	0.00	0.00	0.00
6.80	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 18:0	16.12	15.10	17.11	8.45	32.76	5.81	5.83	4.28	3.89	49.94
8.69	0.00	0.00	0.20	0.00	2.24	0.00	0.00	0.00	0.00	0.13
C 18:1	17.40	21.55	0.16	0.50	15.63	14.73	21.04	27.31	14.45	0.08
C 19:0	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.11
10.15	0.00	0.00	0.10	0.14	0.00	0.00	0.00	0.00	0.00	0.00
C 18:2	3.73	0.00	0.10	0.52	2.64	16.05	3.75	8.89	3.12	0.08
11.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.15	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.23
C 18:3	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	1.83
15.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.02	0.00	0.00
19.6	0.00	0.00	3.74	0.14	0.00	0.00	0.00	0.00	0.00	0.00
C 20:0	0.00	0.00	0.11	0.59	0.00	0.00	0.00	0.00	0.00	0.00
C 22:0	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00
23.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 20:1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 22:1	0.00	0.00	0.17	0.11	0.00	4.79	7.81	8.99	11.58	0.00
25.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHERS	0.00	0.00	60.82	75.32	0.00	0.00	0.00	0.72	3.84	16.52
% Saturated Fatty Acids	70.95	100.00	51.02	0.00	61.02	13.78	47.71	34.06	34.02	45.00

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

TABLE 103, continued

RETENTION TIME/ FATTY ACID	SAMPLE NUMBER									
	41	42	43	44	45	46	47	48	49	50
2.99	0.00	0.00	0.00	0.00	0.00	1.29	0.00	0.00	1.14	0.00
C 12:0	0.00	0.00	0.00	0.09	1.33	0.21	0.00	1.50	0.30	0.00
3.31	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.16	0.00
C 13:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.84	0.00	0.00	0.00	0.00	1.39	1.09	0.00	0.00	0.00	0.00
C 14:0	1.30	2.19	1.97	2.08	2.57	1.61	0.00	10.07	2.70	0.00
4.15	0.00	0.00	0.00	0.00	0.65	0.29	0.00	2.29	0.00	0.00
4.27	0.00	2.80	0.00	0.00	2.36	0.00	0.00	0.00	1.19	0.00
4.39	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00
4.46	0.00	0.00	0.00	0.00	6.64	0.00	0.00	0.00	0.45	0.00
C 15:0	0.82	0.00	0.00	0.16	2.84	0.22	0.00	3.04	0.23	0.00
4.76	0.00	0.00	0.00	0.00	3.78	0.00	0.00	0.00	0.00	0.00
4.98	2.06	0.00	0.00	0.00	6.76	0.00	6.50	0.00	0.00	11.73
5.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.12	0.00	0.00	0.00	0.00	2.35	0.05	0.00	0.00	0.00	0.00
C 16:0	24.63	24.62	18.90	31.39	14.21	29.86	29.19	26.97	15.03	42.42
5.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 16:1	2.56	0.00	3.12	0.32	1.75	0.00	0.00	0.00	0.05	0.00
5.68	0.78	0.00	0.00	0.00	1.09	0.00	0.00	0.00	0.00	0.00
5.77	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	3.39	0.00
5.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.98	1.10	0.00	2.52	0.19	0.85	0.28	0.00	7.68	0.00	0.00
6.15	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.32	0.00
6.20	33.85	28.56	22.67	0.00	16.14	0.00	9.40	0.00	0.00	0.00
C 17:0	0.00	0.00	0.00	0.83	0.00	0.22	0.00	0.00	0.84	0.00
6.80	0.00	0.00	0.00	0.61	0.81	11.05	5.59	0.00	16.35	0.00
7.22	0.00	0.00	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00
C 18:0	2.67	4.63	7.27	55.85	4.80	37.11	20.36	13.86	34.36	33.78
8.69	0.00	0.00	0.00	0.00	0.00	0.43	0.00	3.30	0.04	0.00
C 18:1	18.27	14.71	35.71	6.33	11.38	0.62	18.43	28.26	0.52	12.07
C 19:0	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.23	0.00
10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 18:2	4.92	5.23	7.85	0.75	3.62	0.17	5.87	3.04	0.00	0.00
11.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 18:3	0.00	0.00	0.00	1.26	0.00	1.05	0.00	0.00	0.33	0.00
15.16	0.00	0.00	0.00	0.00	2.65	0.22	0.00	0.00	0.00	0.00
19.6	0.00	0.00	0.00	0.00	0.00	7.26	0.00	0.00	1.23	0.00
C 20:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 22:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 20:1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 22:1	0.00	0.00	0.00	0.00	3.18	3.85	0.00	0.00	0.00	0.00
25.8	0.00	0.00	0.00	0.00	2.13	0.00	0.00	0.00	0.00	0.00
OTHERS	7.05	17.25	0.00	0.00	5.55	2.49	4.67	0.00	21.15	0.00
% Saturated Fatty Acids	20.93	29.56	20.06	51.98	51.89	59.86	0.00	79.18	90.11	-

TABLE 103, continued

RETENTION TIME/ FATTY ACID	SAMPLE NUMBER									
	51	52	53	54	55	56	57	58	59	60
2.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.37
C 12:0	0.35	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00
3.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
C 13:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
3.84	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00
C 14:0	3.13	0.00	10.06	4.34	5.00	7.65	0.00	0.00	2.64	0.00
4.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
4.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27
4.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.46	0.00	0.00	2.82	4.62	0.00	5.02	0.00	0.00	0.00	0.00
C 15:0	1.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
4.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.98	0.00	0.00	2.60	5.78	0.00	0.00	0.00	0.00	0.00	0.00
5.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
5.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 16:0	48.98	65.78	25.65	21.81	45.51	26.44	41.60	37.51	43.27	3.60
5.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 16:1	0.00	0.00	7.73	0.00	0.00	0.00	0.00	10.56	0.00	0.00
5.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.98	0.00	0.00	0.00	1.83	0.00	0.00	0.00	0.00	0.00	0.00
6.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
6.20	2.11	0.00	0.00	18.45	0.00	10.60	0.00	0.00	0.00	0.00
C 17:0	2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
6.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
7.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 18:0	19.57	34.22	7.97	10.48	27.15	10.11	26.40	15.82	45.36	8.63
8.69	0.00	0.00	0.00	0.00	0.00	0.00	2.10	5.01	0.00	0.00
C 18:1	2.59	0.00	15.63	17.11	22.34	40.19	18.45	25.71	8.73	0.14
C 19:0	0.00	0.00	3.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
C 18:2	0.00	0.00	17.44	9.73	0.00	0.00	0.00	5.40	0.00	0.11
11.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.15	0.00	0.00	6.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 18:3	3.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
15.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
C 20:0	10.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 22:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 20:1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 22:1	4.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHERS	0.98	0.00	0.00	4.04	0.00	0.00	11.45	0.00	0.00	83.53
% Saturated Fatty Acids	50.30	-	36.57	31.53	100.00	100.00	-	0.00	100.00	0.00

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

TABLE 103, continued

RETENTION TIME/ FATTY ACID	SAMPLE NUMBER									
	61	62	63	64	65	66	67*	68*	69	70
2.99	0.00	0.00	0.00	0.98	2.09	0.00	-	-	1.01	0.00
C 12:0	0.00	0.00	0.63	0.27	0.58	0.00	1.89	10.42	0.25	0.00
3.31	0.00	0.00	0.00	0.00	0.69	0.00	-	-	0.00	0.00
C 13:0	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
3.72	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
3.84	0.00	0.00	2.05	0.83	0.00	0.00	-	-	0.89	0.00
C 14:0	0.00	0.00	1.98	1.79	1.56	6.32	0.91	1.83	2.29	8.13
4.15	0.00	0.00	0.00	0.32	0.00	0.00	-	-	0.14	0.00
4.27	0.00	0.00	2.14	0.00	1.31	0.00	-	-	0.00	0.00
4.39	0.00	0.00	0.00	0.57	0.00	0.00	-	-	0.00	0.00
4.46	3.56	5.29	4.34	0.00	0.32	0.00	-	-	0.00	3.34
C 15:0	0.00	0.00	0.00	0.17	0.21	0.00	-	-	0.23	0.00
4.76	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
4.98	4.79	2.71	4.26	0.00	0.24	0.00	-	-	0.00	0.00
5.03	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
5.12	0.00	0.00	0.00	0.00	0.10	0.00	-	-	0.00	0.00
C 16:0	23.12	23.23	21.72	23.13	13.21	39.78	10.27	25.80	29.66	39.25
5.63	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
C 16:1	0.00	0.00	8.69	0.00	0.00	0.00	0.50	-	0.00	0.00
5.68	0.00	0.00	0.00	0.00	0.21	0.00	-	-	0.00	0.00
5.77	0.00	0.00	0.00	0.13	6.08	0.00	-	-	0.00	0.00
5.93	0.49	0.00	0.00	0.14	0.00	0.00	-	-	0.00	0.00
5.98	0.00	0.52	0.91	0.00	0.00	0.00	-	-	0.55	0.00
6.15	0.00	0.00	0.00	0.00	0.48	0.00	-	-	0.00	0.00
6.20	35.58	17.91	13.07	0.70	0.00	9.84	-	-	0.00	0.00
C 17:0	0.00	0.00	0.00	0.39	0.66	0.00	-	-	0.74	0.00
6.80	0.00	0.00	0.00	12.74	25.48	0.00	-	-	0.00	0.00
7.22	0.00	0.00	2.23	0.00	0.00	0.00	-	-	0.00	0.00
C 18:0	0.00	35.65	9.26	44.41	24.56	20.07	8.01	10.33	60.86	23.14
8.69	0.00	0.00	0.00	0.37	0.27	0.00	-	-	0.00	0.00
C 18:1	18.15	3.20	8.94	1.08	0.39	23.99	4.01	-	1.18	16.20
C 19:0	0.00	0.00	0.00	0.00	0.22	0.00	-	-	0.00	0.00
10.15	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
C 18:2	6.21	7.19	5.54	0.27	0.18	0.00	1.23	1.69	0.00	0.00
11.80	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
12.15	0.00	0.00	0.00	1.46	0.46	0.00	-	-	0.00	0.00
C 18:3	0.00	0.00	0.00	1.71	0.33	0.00	7.95	-	1.38	0.00
15.16	0.00	0.00	0.00	0.38	0.00	0.00	-	-	0.00	0.00
19.6	0.00	0.00	0.00	4.63	0.56	0.00	-	-	0.00	0.00
C 20:0	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
C 22:0	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
23.3	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
C 20:1	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
C 22:1	0.00	0.00	11.91	1.86	0.23	0.00	-	-	0.00	0.00
25.8	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
OTHERS	0.00	4.30	2.33	1.70	19.59	0.00	65.22	49.93	0.82	9.92
% Saturated Fatty Acids	0.00	0.00	32.00	50.85	80.54	100.00	23.39	87.85	64.87	100.00

* Samples analyzed using different gas chromatograph column; cannot be calibrated with other samples.

TABLE 103, continued

RETENTION TIME/ FATTY ACID	SAMPLE NUMBER									
	71	72	73	74	75	76	77	78	79	80
2.99	1.38	0.00	0.00	1.69	0.00	0.00	0.00	0.00	0.00	0.00
C 12:0	0.40	0.00	0.71	0.47	0.04	0.00	0.00	5.50	0.00	0.00
3.31	0.26	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00
C 13:0	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00
3.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.11	0.00
3.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.72	0.00
C 14:0	0.00	1.68	4.55	0.00	3.37	3.74	3.76	8.45	5.84	0.00
4.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.28	0.00
4.27	0.36	0.00	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00
4.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.56	0.00
4.46	0.00	1.71	4.59	0.08	0.00	0.00	0.00	0.00	9.94	0.00
C 15:0	0.17	2.77	0.00	0.13	2.11	2.06	0.00	2.77	0.00	0.00
4.76	0.05	0.00	0.00	0.08	0.00	0.00	0.00	0.00	7.23	0.00
4.98	0.19	1.19	8.08	0.00	0.00	0.00	0.00	0.00	6.44	0.00
5.03	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00
5.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01	0.00
C 16:0	6.59	20.48	34.68	4.15	32.85	35.67	19.30	30.97	7.42	38.48
5.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 16:1	0.00	10.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.93	6.07	0.00	7.09	8.55	0.00	0.00	0.00	0.00	0.00	0.00
5.98	0.00	0.00	0.00	0.00	1.14	4.96	0.00	4.37	0.00	0.00
6.15	0.08	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00
6.20	0.11	4.56	8.27	0.00	1.75	0.00	20.41	0.00	8.35	14.67
C 17:0	0.26	0.97	0.00	0.16	4.01	2.23	0.00	0.00	0.00	0.00
6.80	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 18:0	16.96	15.89	19.30	9.02	41.53	29.65	8.87	11.28	7.03	16.36
8.69	0.14	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
C 18:1	0.97	12.54	7.78	0.53	5.74	12.24	39.52	28.07	4.42	13.48
C 19:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.15	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	2.10	0.00
C 18:2	0.16	4.09	4.95	0.07	2.40	7.03	4.11	8.60	2.78	0.00
11.80	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 18:3	0.34	2.54	0.00	0.34	0.86	0.00	0.00	0.00	1.16	17.01
15.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.6	2.84	0.00	0.00	0.31	0.00	0.00	0.00	0.00	2.58	0.00
C 20:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 22:0	0.06	3.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23.3	0.00	5.68	0.00	0.00	0.00	0.00	0.00	0.00	3.23	0.00
C 20:1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 22:1	0.23	5.03	0.00	0.00	0.00	2.43	0.00	0.00	3.38	0.00
25.8	0.00	2.97	0.00	0.00	0.00	0.00	0.00	0.00	6.93	0.00
OTHERS	62.07	3.66	0.00	72.77	3.89	0.00	4.03	0.00	4.50	0.00
% Saturated Fatty Acids	44.52	20.21	51.52	53.01	51.15	34.76	47.75	61.88	59.71	0.00

TABLE 104
FREQUENCY OF ORGANIC RESIDUE SAMPLE TYPE BY INTERPRETIVE GROUP

Sample Type	Interpretative Group					Total No. of Samples
	I	II	III	IV	None	
Artifacts						
Projectile points	-	-	1	3	-	4
Bifaces	-	-	4	1	-	5
Drill	-	-	1	-	-	1
Cobble tools	-	-	2	1	-	3
End scrapers	1	-	2	-	-	3
Side scrapers	-	-	1	1	-	2
End/side scrapers	-	1	3	-	1	5
Gouges	1	-	3	1	-	5
Edge-modified flakes	-	-	1	2	-	3
Unmodified flakes	2	-	2	2	1	7
Hammerstone	-	-	1	-	-	1
Manos	2	-	-	-	-	2
Manos/hammerstones	-	-	2	-	-	2
Metates	2	2	-	-	-	4
Pestles	-	-	2	-	-	2
Ceramic sherds	1	1	1	-	-	3
Burned rocks	3	8	9	1	5	26
Sediment	-	1	-	-	1	2
Totals:	12	13	35	12	8	80

indeterminate origin category. Some classes, e.g., unmodified flakes, gouges, and burned rocks, have samples widely distributed on the graph, but a number of the classes have restricted distributions. Projectile points, bifaces, cobble tools, edge-modified flakes, and side scrapers have relatively high values suggesting some consistency in the use of chipped stone tools, presumably involving the processing of animals. In contrast, manos, metates, pestles, and ceramics consistently have relatively low values suggestive of use with plant resources.

Future Research Directions

While this pilot study has yielded promising results, several areas require additional work. For example, research needs to be conducted to document diagenetic changes in fatty acids over time, to expand the modern data base, to explore residue mixing, and to determine the quantities and types of residues that are archeologically significant. Some

Figure 78. Scattergram of saturated fatty acid percentage by sample type.

experimental research on these topics is in progress (Marchbanks 1989). Removing a thin outer layer from porous samples such as ceramics and burned rocks reduces problems with contamination and should be used when possible. Upon discovery, artifacts should be wrapped in aluminum foil, with the shiny side in, and placed in a bag without handling. Sterile gloves should be worn when handling the chipped stones, and they should not be washed.

PHYTOLITH ANALYSIS

The goal of the phytolith analysis reported here was to determine whether or not phytoliths are preserved in cultural features in the Justiceburg Reservoir area. Eleven samples were selected from four burned rock clusters, two slab-lined hearths, one unlined basin-shaped hearth, one bedrock mortar, one ceramic sherd cluster, and two nonfeature contexts at five sites, three located on terraces and one in the upland margin (Table 105). Environmental reconstruction was not attempted but is one of the strengths of phytolith analysis (Pearsall 1989:340).

TABLE 105
PHYTOLITH SAMPLES

Sample Number	Provenience	Feature Type
1	41GR383, Feature 1	Burned rock cluster
2	41GR383, Feature 2	Burned rock cluster
3	41GR456, Feature 12	Bedrock mortar hole
4	41GR456, Feature 3	Burned rock cluster
5	41GR456, outside Feature 3	--
6	41GR559, Feature 5	Burned rock cluster
7	41KT52, Feature 1	Slab-lined hearth
8	41KT53, Feature 3	Slab-lined hearth
9	41KT53, outside Feature 3	--
10	41KT53, Feature 4	Unlined basin hearth
11	41KT53, Feature 6	Ceramic sherd cluster

Phytoliths are formed in plants by the deposition of silica absorbed from ground water and occur in plant stems, leaves, and inflorescences. Woody plants and grasses produce phytoliths (Piperno 1986:35-40, 1988) which are deposited in the soil as the plants decay. These silica bodies are nearly indestructible, with a record extending back some 620,000 years in Nebraska (Fredlund 1986:12-21). Phytolith analysis is not without problems, however. Among the more enduring of these are the great variability in phytolith size and shape within individual plants and species, the difficulty of shape recognition, differential silica production within different parts of plants, the lack of phytoliths in some plants (Pearsall 1989:343), and the nascent state of the phytolith taxonomy (Rovner 1986; Piperno 1988; Pearsall 1989).

Twiss et al. (1969) identified three principal classes of short-cell grass phytoliths: festuroid, chloridoid, and panicoid. These, plus a long-cell elongate type and a class termed "Other," are used in this analysis. Festuroid phytoliths reflect moist habitats (Twiss et al. 1969) or moist climates and winter rainfall (Robinson 1982). Chloridoid phytoliths reflect warm and dry conditions (Twiss et al. 1969) or arid environments with summer rainfall and include the short and mid-range grasses (Robinson 1982). Panicoids are characteristic of warm, moist conditions (Twiss et al. 1969) or mesic grasslands with summer rainfall, such as the tall-grass prairie (Robinson 1982). The "Other" class includes long-cell epidermal appendages such as microhairs and recognized Ulmaceae (elm, hackberry) and Fagaceae (oak) phytoliths. The elongate class consists of undiagnostic phytoliths that occur in all grasses and are easily broken. Following Twiss et al. (1969), each principal class was subdivided into distinctive forms. Festuroid phytoliths were separated into circular, rectangular, elliptical, and oblong forms; chloridoid phytoliths were separated into chloridoid and thin chloridoid forms, and panicoid phytoliths were separated into dumbbell and cross forms. Elongate phytoliths were separated into smooth and spiny forms.

Methods

The extraction and isolation techniques used here are those discussed by Robinson (1982:121) and Piperno (1988). Phytoliths were screened into different sizes and viewed separately to reduce the possibility of large phytoliths covering small ones. At least 100 phytoliths per sample were recorded and tallied by class and shape using 450x or 750x magnification.

Results

In general, the "Other" class dominates the overall phytolith assemblage (45%) and all but one of the individual samples (Feature 6 at 41KT53). Within this class, nondiagnostic microhairs are by far the most frequent type (Table 106). The presence of some Ulmaceae phytoliths in all samples and Fagaceae types in over half probably indicates that hackberry and oak woods were used frequently to fuel fires in these features. Both taxa are present in the area today.

Festucoid phytoliths occur in similar frequencies in every sample and are the second most frequent class (27%), indicating a relatively high frequency of cool-season grasses. Chloridoid and elongate phytoliths occur in nearly equal quantities overall (11% and 13%) and are less than half as frequent as festucoid types. The low frequency of chloridoid phytoliths reflects the scarcity of short grasses. Panicoid phytoliths are quite infrequent, indicating very few tall grasses.

At two terrace sites (41GR456 and 41KT53), samples were analyzed from within and just outside features. In both instances, the samples outside produced more chloridoid phytoliths and fewer elongate, "Other," and festucoid phytoliths. One possible interpretation is that short grasses existed on the terraces, but the features involved the use of cool-season grasses. The presence of sparse nongrass phytoliths (Ulmaceae and Fagaceae) adjacent to the features may indicate feature cleaning or piling fuel sources, or it may reflect noncultural processes.

As expected, the bedrock mortar hole contained the least amount of woody plant indicators, Ulmaceae and Fagaceae phytoliths. Microhairs dominate (44%) the assemblage in this feature, with festucoid types also being relatively frequent (39%). It is difficult to interpret these results, but it could be that the cool-season grasses reflect the surrounding vegetation.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

TABLE 106
RESULTS OF PHYTOLITH ANALYSIS

Phytolith Type	Sample Number											Total No.
	1	2	3	4	5	6	7	8	9	10	11	
<u>Festucoid Class</u>												
Circular	5	10	13	9	5	10	8	4	5	9	12	
Rectangular	5	4	4	5	12	6	5	8	2	5	8	
Elliptical	7	-	5	3	15	-	-	5	2	5	3	
Oblong	<u>18</u>	<u>18</u>	<u>17</u>	<u>11</u>	<u>8</u>	<u>21</u>	<u>13</u>	<u>8</u>	<u>12</u>	<u>18</u>	<u>8</u>	
Totals:	35	32	39	28	40	37	26	25	21	37	31	351
<u>Chloridoid Class</u>												
Chloridoid	-	4	6	27	-	1	34	2	26	21	15	
Thin Chloridoid	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>2</u>	<u>-</u>	<u>5</u>	<u>-</u>	<u>2</u>	
Totals:	0	4	6	27	0	1	36	2	31	21	17	145
<u>Panicoid Class</u>												
Dumbbell	-	1	2	3	-	-	2	1	-	5	19	
Cross	<u>-</u>	<u>-</u>	<u>-</u>	<u>2</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>3</u>	
Totals:	0	1	2	5	0	0	2	1	0	5	22	38
<u>Elongate Class</u>												
Smooth	5	9	17	14	5	17	20	21	9	15	20	
Spiny	<u>-</u>	<u>-</u>	<u>-</u>	<u>1</u>	<u>-</u>	<u>1</u>	<u>1</u>	<u>5</u>	<u>2</u>	<u>1</u>	<u>6</u>	
Totals:	5	9	17	15	5	18	21	26	11	16	26	169
<u>Other</u>												
Ulmaceae	12	16	4	8	1	6	5	31	6	3	9	
Microhairs	47	57	44	23	57	49	37	33	46	55	16	
Fagaceae	<u>-</u>	<u>-</u>	<u>1</u>	<u>1</u>	<u>-</u>	<u>-</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>3</u>	
Totals:	59	73	49	32	58	55	43	66	53	61	28	577
Grand Totals:	99	119	113	107	103	111	128	120	116	140	124	1,280

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APPENDIX H: Assessment of Pollen Preservation
and Macrobotanical Analysis

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INTRODUCTION

This appendix describes two separate studies conducted as part of the testing phase at Justiceburg Reservoir. The first is an assessment of pollen preservation from selected feature and sediment samples, and the second is an analysis of macrobotanical remains from selected flotation, fine screen, and charred wood samples.

ASSESSMENT OF POLLEN PRESERVATION

Initial palynological investigations to determine the presence or absence of pollen were conducted on eight selected sediment samples. The submitted samples were believed to represent a broad range of settings and ages to investigate the utility of subsequent pollen studies in this project. The samples consist of one representing modern environmental conditions, five from archeological features or occupational zones at four sites, and two from a geomorphic locality representing a ca. 12,000-year-old soil and a younger clay zone above the soil.

Methods

Archeological sediment samples generally require a four-step extraction process. A prequantified sample of sediment, here 20 ml, is placed in a beaker where two Lycopodium spp. tracer spores are added. The spores are used to calculate concentration value and to verify that processor error was not a factor in pollen loss. The samples are next treated with concentrated hydrochloric acid to aid in the removal of carbonates and to dissolve the binding agent in the spore tablets. This material is next rinsed with distilled water, and the lighter fraction, including pollen, is isolated. The water is removed after the sediment settles, in preparation for the next phase of treatment.

The second phase of treatment is the removal of silicates with concentrated (70%) hydrofluoric acid. Approximately 50-75 ml of acid is added to the sediment, where it is allowed to work overnight. The acid is then thoroughly rinsed from the sediment with distilled water. The residue is next consolidated and placed in an ultrasonic separator for several minutes. The samples are then rinsed in preparation for the next treatment, that of heavy density separation. Here, zinc bromide (specific gravity 2.00) is used as a heavy density medium. The zinc bromide solution is added to the samples, and they are spun on a clinical centrifuge for about five to seven minutes. The lighter fraction is then removed and concentrated.

When a large amount of unwanted organic material is present in the samples, acetylation is employed. Here, a 9:1 solution of acetic anhydride to sulfuric acid is prepared and added to the dehydrated samples. This step aids in the removal of unwanted lipids, cellulose, hemicellulose, and lignins. This step was not necessary with the Justiceburg samples, which, following the heavy density separation, were rinsed with ethanol and transferred to a glycerine medium for analysis and storage. Analysis is performed with the use of a high-powered stereomicroscope, and identifications are confirmed through the use of the Texas A&M University reference collection.

Results

There is nearly complete loss of pollen from most samples (Table 107). Well-preserved pollen was noted in only two instances from 41KT53. One sample represented the modern environment at 2-4 cm below the surface, while the second represented a 300-year-old occupation situated in a clay matrix at 8-10 cm. It cannot be stated at present how long pollen is preserved in the Justiceburg region, but sites dating over the last 300-500 years at least can be targeted for future palynological studies.

TABLE 107
RESULTS OF THE PALYNOLOGICAL INVESTIGATIONS OF SELECTED SAMPLES

Sample No.	Provenience	Results
P-1	41GR291, Feature 2, Test Unit 5	Some pollen grains were noted but in a degraded state
P-2	41GR303, Feature 5, Test Unit 5	Poor preservation
P-3	41GR559, Feature 5, Test Unit 3	Poor preservation
P-4	41KT53, Feature 1 control, Test Unit 2, 8-10 cm	Good preservation
P-5	41KT53, Feature 4, Test Unit 7	Poor preservation
P-6	41KT53, Test Unit 2, modern environment, 2-4 cm	Good preservation
P-7	Geomorphologic Locality 2, column sample, 530-540 cm, ca. 10,000 B.P.	No fossil pollen but modern oak, sycamore, and thistle noted
P-8	Geomorphologic Locality 2, column sample, 550-560 cm, ca. 12,000 B.P.	No pollen

Although there is no pollen preserved in the sampled features, it is quite possible these were not full of pollen to begin with. Specific types of features, i.e., storage pits, may contain pollen, but many others may not.

Discussion

Factors influencing the preservation of pollen are many and include soil chemistry, moisture, and biological activity. Regions with relatively high pH values and seasonal cycles of wetting/drying are particularly hard on pollen grains since these conditions favor destructive fungal growth and facilitate bacterial degradation. West Texas is known for producing samples with low pollen concentration values, and it is usually only in rare situations that pollen is preserved in any quantity and valid counts can be achieved.

Archeologists generally must rely on macrobotanical analyses to gain information on paleoenvironment and prehistoric resource utilization, and these techniques would probably offer more information than pollen studies. Phytolith analysis, as well, could be useful in those sites where pollen is clearly not preserved.

It may be appropriate to submit additional pollen samples from certain strategic features, for example, burials or well-sealed units. For the most part, however, pollen analysis from these sites is of limited value. Further palynological investigation is probably not necessary due to the nearly complete loss of pollen from the samples.

MACROBOTANICAL ANALYSIS

Three fine-screen and 29 flotation samples from 16 archeological sites at Justiceburg Reservoir were examined for archeobotanical, malacological, and faunal remains. In addition, two additional charred wood fragments from features were submitted for identification. Relatively little archeobotanical work has been done in this area of West Texas. As a result, all studies are important in establishing the regional paleoenvironment as well as documenting prehistoric resource utilization. The assessment of pollen preservation presented in this appendix demonstrates that pollen is not well preserved, thus placing the burden of paleoenvironmental reconstruction on the macrofossil remains.

Methods

Archeobotanical analyses, including charcoal and seed analyses, generally follow a standardized procedure. For charcoal, clear transverse sections prepared by the snap method (Leney and Casteel 1975) were examined under a low-power stereomicroscope at magnifications of 5x to 50x. While radial and tangential sections generally allow for a finer degree of species resolution, the small size of most of the samples did not allow for such preparation. Seed and charcoal identifications were confirmed by reference materials housed in the Archeobotanical Laboratory in the Department of Anthropology at Texas A&M University.

All faunal remains were identified based on published keys and verified with comparative materials housed in the Zooarcheology Laboratory in the Department of Anthropology at Texas A&M University. Identifications of these remains are presented in Appendix J.

Results

A listing of all archeobotanical remains identified is presented (Table 108), and specific sample identifications are listed by site and provenience (Table 109). Identified charcoal samples were not quantified other than by a simple presence/absence listing. Seeds and fruits were counted, with the number observed listed in parentheses. Most of the seeds recovered are considered to be modern or intrusive, based on their noncharred characteristics. These seeds likely were introduced into the samples through contamination by surface material or introduced into the sediments by rodent or animal action. Charcoal is presumed to be largely of prehistoric origin. Two charred wood samples from features at 41KT53 were identified as Celtis. One specimen is from a burned post (Feature 1, Test Unit 7, 15-25 cm), and the second specimen is from the fill of an unlined basin hearth (Feature 4, Test Unit 7, 18-25 cm).

TABLE 108
ARCHEOBOTANICAL MATERIALS RECOVERED

Group	Scientific Name	Common Name
Trees	<u>Celtis</u> sp.	hackberry
	<u>Cornus</u> sp.	dogwood
	<u>Juniperus</u> sp.	juniper
	<u>Prosopis</u> sp.	mesquite
	<u>Quercus</u> sp.	oak
	<u>Rhus</u> sp.	sumac
	Rosaceae	rose family
	Salicaceae	willow family
Flowering Plants	<u>Allium</u> sp.	onion
	<u>Amaranthus</u> sp.	pigweed
	Asteraceae	aster family
	<u>Chenopodium</u> sp.	goosefoot
	Euphorbiaceae	spurge family
	<u>Helianthus annuus</u>	sunflower
	<u>Mollugo</u> sp.	carpetweed
	<u>Platyopuntia</u> sp.	prickly pear
	<u>Portulaca</u> sp.	purslane
Grasses	<u>Yucca</u> sp.	yucca
	Poaceae (formerly Graminae)	grass family

Discussion

Charcoal taxa encountered represent species present in the project area today, including Quercus (oak), Celtis (hackberry), Juniperus (juniper), and members of the Rosaceae and

TABLE 109

IDENTIFICATION OF ARCHEOBOTANICAL MATERIALS BY PROVENIENCE

Provenience	Botanical Remains	Sample Type
<u>41GR287</u>		
Test Unit 1, 0-10 cm, Feature 1	<u>Celtis</u> seed (1) <u>Juniperus</u> wood fragment* <u>Mollugo</u> seed (1)	flotation
<u>41GR291</u>		
Test Unit 1, 15-20 cm	<u>Chenopodium</u> fruit (38) <u>Juniperus</u> wood* <u>Quercus</u> wood*	flotation
Test Unit 1, 25-30 cm	<u>Chenopodium</u> fruit (86) <u>Juniperus</u> wood* unidentified hardwood*	flotation
Test Unit 5, 30-59 cm, Feature 2	<u>Chenopodium</u> fruit (6) <u>Juniperus</u> wood* <u>Juniperus</u> wood fragment unidentified hardwood* unidentified fruit fragment	flotation
<u>41GR302</u>		
Test Unit 1, 17-41 cm, Feature 2	unidentified seed coat (possibly <u>Quercus</u>)	flotation
<u>41GR303</u>		
Test Unit 1, 50-60 cm	none present	flotation
Test Unit 1, 90-100 cm	none present	flotation
Test Unit 5, 5-23 cm, Feature 5	<u>Chenopodium</u> fruit (1) <u>Juniperus</u> wood* <u>Juniperus</u> wood fragment <u>Quercus</u> wood*	flotation
<u>41GR323</u>		
Test Unit 10, 20-27 cm, Feature 6	<u>Amaranthus</u> (1) <u>Chenopodium</u> fruit (11) Euphorbiaceae seed (1) <u>Helianthus annuus</u> achenes (many) Poaceae caryopses (6) Rosaceae seed (1) unidentified wood* unidentified seed	flotation

*Charred materials

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

Table 109, continued

Provenience	Botanical Remains	Sample Type
<u>41GR383</u>		
Test Unit 8, 70-90 cm	<u>Juniperus</u> wood fragment <u>Portulaca</u> seed (1)	flotation
<u>41GR456</u>		
Test Unit 1, 24-35 cm, Feature 3	<u>Juniperus</u> wood* <u>Juniperus</u> wood fragment	flotation
<u>41GR471</u>		
Test Unit 2, 33-38 cm, Feature 1	<u>Celtis</u> seed (1) <u>Juniperus</u> wood* <u>Juniperus</u> wood fragment	flotation
<u>41GR484</u>		
Test Unit 4, 60-70 cm, Feature 2	<u>Chenopodium</u> fruit (4) <u>Juniperus</u> wood* <u>Portulaca</u> seed (1)	flotation
<u>41GR515</u>		
Test Unit 4, 46-63 cm Feature 2	<u>Juniperus</u> wood* <u>Juniperus</u> wood fragment	flotation
<u>41GR546</u>		
Test Unit 1, 17-30 cm	<u>Celtis</u> seeds (many) <u>Helianthus annuus</u> achene (1) <u>Juniperus</u> wood <u>Juniperus</u> seeds (many) <u>Platyopuntia</u> seeds (8) <u>Poaceae</u> caryopsis (1) <u>Prosopis</u> fruit fragments (many) <u>Prosopis</u> (?) spine (1) <u>Quercus</u> wood* <u>Rhus</u> seeds (4) unidentified hardwood* <u>Yucca</u> leaf fragment (1)	flotation
Test Unit 1, 30-40 cm	<u>Celtis</u> wood* <u>Celtis</u> seeds (many) <u>Juniperus</u> wood* <u>Juniperus</u> wood fragment <u>Juniperus</u> seeds (many) <u>Rosaceae</u> wood* unidentified hardwood*	fine-screen

Table 109, continued

Provenience	Botanical Remains	Sample Type
Test Unit 1, 25-35 cm, Feature 1	<u>Celtis</u> seeds (2) <u>Chenopodium</u> fruit (4) <u>Juniperus</u> wood* <u>Juniperus</u> seeds (2) Poaceae caryopsis (1) <u>Prosopis</u> fruit fragment (1) <u>Quercus</u> wood* Salicaceae wood* unidentified fruit fragment (1)	flotation
Test Unit 1, 20-40 cm, Feature 2	<u>Amaranthus</u> seed (1) <u>Celtis</u> seeds (13) <u>Chenopodium</u> fruits (14) <u>Helianthus annuus</u> achene (1) <u>Juniperus</u> wood* <u>Juniperus</u> seed (1) <u>Mollugo</u> seed (1) Poaceae caryopses (3) <u>Prosopis</u> fruit fragment (1) <u>Quercus</u> wood* unidentified hardwood* unidentified seed coats (4)	flotation
Test Unit 1, 40-50 cm	<u>Celtis</u> wood* <u>Celtis</u> seeds (many) <u>Juniperus</u> wood <u>Juniperus</u> seeds (5) <u>Prosopis</u> fruit fragment (1)	fine-screen
Test Unit 1, 50-60 cm	<u>Celtis</u> wood* <u>Celtis</u> seeds (many) <u>Cornus</u> seeds (2) <u>Juniperus</u> wood* <u>Juniperus</u> wood fragments <u>Platyopuntia</u> seed (1) Poaceae caryopsis (1) <u>Rhus</u> seeds (7) unidentified hardwood*	flotation
Test Unit 1, 60-70 cm	<u>Celtis</u> seeds (4) <u>Prosopis</u> fruit fragment (1) unidentified hardwood*	fine-screen
41GR559		
Test Unit 2, 71-83 cm, Feature 3	<u>Celtis</u> wood* <u>Celtis</u> seeds (8) <u>Quercus</u> wood*	flotation

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

Table 109, continued

Provenience	Botanical Remains	Sample Type
Test Unit 3, 28-42 cm Feature 2	<u>Celtis</u> wood* <u>Celtis</u> seeds (6) <u>Juniperus</u> wood* <u>Juniperus</u> wood <u>Prosopis</u> fruit fragments (2) unidentified seed fragment (1)	flotation
Test Unit 3, 59-71 cm	<u>Celtis</u> wood* <u>Celtis</u> seeds (6) <u>Chenopodium</u> fruit (1) <u>Juniperus</u> wood* <u>Mollugo</u> seed (1) Poaceae caryopsis (1) <u>Quercus</u> wood* unidentified hardwood*	flotation
<u>41KT33</u> Test Unit 4, 0-18 cm, Feature 1	<u>Allium</u> bulb fragments Asteraceae achene (1) <u>Chenopodium</u> fruit (9) Rosaceae seed (1) unidentified hardwood*	flotation
Test Unit 6, 2-28 cm, Feature 2	Asteraceae achenes (3) <u>Juniperus</u> wood* Poaceae caryopses (many)	flotation
<u>41KT49</u> Test Units 6 and 7, 20-30 cm, Feature 4	<u>Chenopodium</u> fruit (8) unidentified hardwood*	flotation
<u>41KT52</u> Test Unit 1, 96-113 cm, Feature 1	<u>Amaranthus</u> seed (1) <u>Chenopodium</u> fruit (3) <u>Juniperus</u> wood* <u>Portulaca</u> seeds (3)	flotation
<u>41KT53</u> Test Unit 2, 13-47 cm, Feature 1	<u>Celtis</u> wood* (very large quantity) <u>Chenopodium</u> fruit (2) <u>Mollugo</u> seeds (19)	flotation
Test Unit 2, 25-35 cm	unidentified hardwood*	flotation

Table 109, continued

Provenience	Botanical Remains	Sample Type
Test Unit 7, 18-25 cm, Feature 4	<u>Celtis</u> seeds (15) <u>Chenopodium</u> fruit (23) <u>Mollugo</u> seeds (9) Poaceae seed (1) unidentified hardwood* unidentified nut fragment* unidentified seeds (7)	flotation
Test Unit 12, 101-129 cm, Feature 3	<u>Quercus</u> wood* unidentified hardwood* unidentified fruit fragment (1)	flotation

Salicaceae families (rose and willow families). Additional definite paleobotanical materials were not encountered in the samples, as other materials are noncharred and probably intrusive.

Paleoenvironmental reconstructions cannot be attempted due to the small sample size. Prehistoric subsistence patterns, as well, cannot be discerned since economic materials other than firewood were not recovered. The preservation of carbonized materials, however, was excellent, and fossil seeds, if present in the archeological sediments, would likely be found. Future testing at Justiceburg Reservoir should concentrate on the macrofossil assemblages (including botanical, malacological, and faunal) rather than pollen. Phytoliths, as well, could prove to be of value in these sites and should be investigated.

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APPENDIX I: Phytolith and Pollen Analyses: A Feasibility Study

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INTRODUCTION

A total of nine stratigraphic and nine feature samples from Justiceburg Reservoir were analyzed for their phytolith content. Stratigraphic phytolith sampling provided samples from acultural strata for the purpose of interpreting paleoenvironmental conditions. Phytolith analysis in feature samples was to address subsistence activities and possibly contribute to interpretations of paleoenvironmental conditions. Previous phytolith sampling established phytolith preservation in this area. A test of six pollen samples was also made to establish preservation and interpretability of the pollen record. Two of these samples represent acultural strata, while the remaining four were collected from features. The combined evidence from the pollen and phytolith records provides a more thorough interpretation of the paleoenvironment.

METHODS

Extraction of phytoliths from these sediments was based on heavy liquid flotation. A 0.1 molar solution of sodium pyrophosphate was added to each sample to suspend the clays. The samples were rinsed thoroughly with distilled water in beakers to remove the clays. The samples were agitated following addition of the distilled water and allowed to stand for four hours. The supernatant was then poured off and discarded and the process repeated. Once most of the clays were removed, the silt- and sand-size fraction was dried. Two grams of the dried silts and sands were then mixed with sodium polytungstate (density 2.3) and centrifuged to separate the phytoliths, which will float, from the other silica, which will not. The organics present in the sample floated with the phytoliths. Phytoliths, in the broad sense, may include opal phytoliths and calcium oxalate crystals. Calcium oxalate crystals are formed by *Opuntia* (prickly pear cactus) and are retained, rather than destroyed, using this extraction technique. Calcium oxalate crystals are also produced by *Ulmaceae* and by *Valeriana*, a tuber noted at 41KT53. Any remaining clay floated with the phytoliths was removed by mixing with sodium pyrophosphate and distilled water. The organic fraction was destroyed at this phase in samples that appeared to have sufficient organics to impede the phytolith count. The samples were then rinsed with distilled water and then with alcohol to remove the water. After several alcohol rinses, the samples were mounted in Canada balsam for counting with a light microscope at a magnification of 500x.

The pollen was extracted using a chemical technique based on flotation, which is the standard preparation technique used in this laboratory for the removal of the pollen from the large volume of sand, silt, and clay with which they are mixed. This particular process was developed for extraction of pollen from soils where preservation has been less than ideal and pollen density is low. The technique was modified for use in conjunction with phytolith extraction. The dried silt and sand fraction, which also contained the pollen and organics, was used as the sample for pollen extraction. At this point, the clay had been removed using sodium pyrophosphate.

Hydrochloric acid (10%) was used to remove calcium carbonates present in the dried concentrate. Zinc bromide (density 2.0) was used for the flotation process. All samples received a short (10 minutes) treatment in hot hydrofluoric acid to remove any remaining inorganic particles. The samples were then acetolated for three minutes to remove any

extraneous organic matter. Distilled water washes were employed between the various acid treatments.

A light microscope was used to count the pollen to a total of 100 to 200 pollen grains at a magnification of 430x. Pollen preservation in these samples varied from good to poor. Comparative reference materials collected at the Intermountain Herbarium at Utah State University and the University of Colorado Herbarium were used to identify the pollen to the family, genus, and species level, where possible.

Pollen aggregates were recorded during identification of the pollen. Aggregates are clumps of a single type of pollen and may be interpreted to represent pollen dispersal over short distances or the actual introduction of portions of the plant represented into an archeological setting. Aggregates were included in the pollen counts as single grains, as is customary. Indeterminate pollen includes pollen grains that are folded, mutilated, and otherwise distorted beyond recognition. These grains are included in the total pollen count, as they are part of the pollen record.

DISCUSSION

The phytolith and pollen analyses consist of samples from 13 sites in Kent and Garza counties (Tables 110 and 111). Vegetation reported in the vicinity of the proposed Justiceburg Reservoir includes a juniper-mesquite assemblage on level to gently sloping uplands, the canyon-rim edge, and the valley slopes. The most common plants of this assemblage include juniper (Juniperus), agarita (Berberis), catclaw (Acacia), yucca (Yucca), prickly pear (Opuntia), cholla (Cylindropuntia), and Mormon tea (Ephedra). The vegetation common to alluvial floodplains and terraces bordering present stream channels is referred to as the mesquite-oldfield/terrace-floodplain association. Invader species are common in this area, and the most abundant include mesquite (Prosopis), prickly-poppy (Argemone), common sunflower (Helianthus), cholla (Cylindropuntia), and several grasses (Gramineae). The saltcedar/riparian assemblage along present stream channels is dominated by saltcedar (Tamarix), which is an introduced species from the Mediterranean. A more detailed list of the plants present in the Justiceburg Reservoir area is presented by Boyd (1989).

The object of this feasibility study was to evaluate the phytolith and pollen records for preservation and interpretability and to make recommendations for further sampling to complete interpretations of the paleoenvironment and subsistence base. Both the phytolith and pollen records are presented in diagram form (Figs. 79 and 80, Table 112). The samples have been ordered by radiocarbon age.

The stratigraphic phytolith record displays variations in quantities of grass phytoliths recovered. Festucoid, chloridoid, and panicoid grasses are all represented. In addition, elongate phytoliths, which are produced abundantly by most grasses, are very abundant throughout the record. Smooth and spiny elongate forms were combined on the diagram. Other grass phytoliths include prickles, which resemble nonsegmented hairs, and an elongate type typical of glumes. In addition, small quantities of phytoliths representing nongrasses were recorded and include Cyperaceae, Leguminosae, Opuntia, and anticlinal phytoliths. The irregular phytoliths are primarily triangular or pentagon-shaped, although a few are very irregular in shape. The last category of remains included in the phytolith record are diatoms and occur only in relatively recent samples (modern to 510 B.P.). These

TABLE 110

PROVENIENCE OF PHYTOLITH SAMPLES

Site No.	Feature No.	Radiocarbon Age B.P.*	Depth in cm or Feature Description	Phytoliths Counted
<u>Stratigraphic Samples</u>				
41KT53	-	Modern	2-4	300
41KT53	-	295 ± 80	8-10	300
BHT 65-1	-	510 ± 60	48-58	300
BHT 22	-	770 ± 110	250-260	100
BHT 25-1	-	1280 ± 50	63-75	300
BHT 65-2	-	1560 ± 60	205-215	200
BHT 30	-	2090 ± 70	250-270	300
BHT 25-2	-	2630 ± 70	160-170	300
GM 2	-	13,500 ± 280	560-580	300
<u>Features</u>				
41KT33	1	-	Fire-cracked rock cluster	100
41GR291	2**	-	Slab-lined hearth	100
41GR303	5	810 ± 195	Burned rock cluster	100
41GR303	7	1510 ± 60	Burned rock cluster	100
41GR303	8	1250 ± 50	Slab-lined hearth	50
41GR323	6	250 ± 70	Burned rock cluster	100
41GR484	2**	-	Slab-lined hearth	100
41GR546	2	275 ± 210	Slab-lined hearth	Insuff
41GR559	3	855 ± 190	Slab-lined hearth	100

*All radiocarbon ages are $\delta^{13}C$ corrected except for uncorrected age 13,500 ± 280.

**Ground stone tools were associated.

bodies are elliptical with straight ends and have single rows of dots along the longer sides.

Elongate phytoliths generally occur in greater abundance in the older samples. This is more noticeable in the stratigraphic record than in the samples from features. Elongate phytoliths are easily broken in the soil, and because each fragment is counted as an individual phytolith, soil movement that serves to break the phytoliths would also increase the apparent relative frequency of this type. Elongate phytoliths are of no aid in interpreting either paleoenvironmental conditions or the subsistence record because they are produced by all grasses.

TABLE 111
PROVENIENCE OF POLLEN SAMPLES

Site No.	Feature No.	Radiocarbon Age Corrected, B.P.	Depth in cm or Feature Description	Pollen Counted
<u>Stratigraphic Samples</u>				
BHT 30	-	2090 ± 70	250-270	200
BHT 25-2	-	2630 ± 70	160-170	200
<u>Features</u>				
41GR303	5	810 ± 195	Burned rock cluster	200
41GR484	2*	-	Slab-lined hearth	200
41GR546	2	275 ± 210	Slab-lined hearth	200
41GR559	3	855 ± 190	Slab-lined hearth	200

*Ground stone tools were associated.

Twiss (1987:181; see also Twiss 1980, 1983) has suggested that "grass-opal phytoliths serve as indicators of C3 and C4 pathways in grasses." The festucoid class of phytoliths is ascribed primarily to the Subfamily Pooideae, which are C3 grasses and occur most abundantly in cool, moist climates. However, Brown (1984) notes that festucoid phytoliths are produced in small quantity by nearly all grasses. Therefore, while they are typical phytoliths produced by the Subfamily Pooideae, they are not exclusive to this subfamily. Chloridoid phytoliths are found primarily in the Subfamily Chloridoideae, a warm-season C4 grass that grows in arid to semiarid areas and requires less available soil moisture. Chloridoid grasses are the most abundant in the American Southwest (Gould and Shaw 1983: 120). Panicoid phytoliths occur in warm-season or tall grasses that frequently thrive in humid conditions. The Subfamily Panicoideae are primarily C4 grasses. "According to Gould and Shaw (1983:110) more than 97% of the native US grass species (1,026 or 1,053) are divided equally among three subfamilies Pooideae, Chloridoideae, and Panicoideae" (Twiss 1987:181). Within the Subfamily Panicoideae, and more particularly within the Tribe Paniceae, the grasses are divided between C3 and C4. The species of *Panicum* are divided between C3 and C4 pathways. Twiss (1987:181) also notes that some members of the Subfamily Chloridoideae produce both bilobate (panicoid) and festucoid phytoliths.

Although some exceptions do exist, festucoid, chloridoid, and panicoid phytoliths are related to the photosynthetic pathways used by the majority of grasses. Fortunately, the exceptions occur in rare groups, many of which are restricted to specialized environments. The C4 grasses can be split into two groups: chloridoid and panicoid. Chloridoid phytoliths represent those grasses which are abundant in relatively warm and dry areas with low available soil moisture. Panicoid phytoliths occur in grasses which flourish in warm and more moist areas where the available soil moisture is higher [Twiss 1987:181].

Figure 79. Phytolith diagram. Asterisk (*) indicates uncorrected date; "T" indicates that the phytolith type was observed outside the regular count while scanning the remainder of the microscope slide.

From Twiss's (1987) review of phytoliths and photosynthetic pathways, we may conclude that the festuroid phytoliths are representative, primarily, of C3 grasses, while the chloridoid and panicoid phytoliths represent primarily C4 grasses. He suggests that the exceptions that occur are relatively minor and that a thorough identification and testing of local grasses for phytoliths are invaluable in answering questions concerning the local validity of the association of phytolith classes and photosynthetic pathways.

The phytolith record indicates a mixed environment with respect to the grasses. In the stratigraphic column, all three types are fairly well represented in the younger samples, although the phytolith record is dominated by panicoid phytoliths at 41KT53. This may represent an increase in the tall grasses in this area in the past several hundred years. Prior to 510 B.P., panicoid phytoliths are not noted in large quantities in the stratigraphic record. They occur in varying frequencies in the feature samples but usually not in great frequency, with the exception of Feature 3 at 41GR559 (855 B.P.).

Chloridoid and festuroid phytoliths vary throughout the samples, although they are both most abundant in the more recent stratigraphic samples, with the exception of one sample from BHT 30 (250-270 cm) with a radiocarbon age of 2090 B.P. This sample contained a large quantity of festuroid phytoliths.

Figure 80. Pollen diagram. "A" indicates the presence of aggregates which are counted as single grains; "T" indicates that the pollen type was observed outside the regular count while scanning the remainder of the microscope slide.

Cyperaceae phytoliths were recorded in three stratigraphic samples and are most abundant at BHT 22 (250-260 cm) which yielded a radiocarbon age of 770 B.P. Opuntia calcium oxylate crystals were recovered from one of the stratigraphic samples collected at GM 2, which yielded a radiocarbon age of 13,500 B.P. This is the oldest sample examined for phytoliths, and it contained evidence of phytolith and calcium oxylate preservation. This suggests that one may expect a good stratigraphic phytolith record from the project area. A phytolith typical of those produced in the leaves of Leguminosae, but also found in Ulmaceae, was recorded in BHT 25-2 (160-175 cm), which yielded a radiocarbon age of 2630 B.P. This sample is from the floodplain of Grape Creek where one would expect mesquite (Prosopis) to grow. These phytoliths have been recovered from mesquite leaves and pods and may be present in the soil as a result of mesquite growing in the area.

The lack of patterning in the phytolith record may be ascribed primarily to analysis of a limited quantity of samples (one or two) per site. A pattern of distribution of phytolith classes is much more likely to be detectable within a single stratigraphic column.

Recovery of phytoliths from nine features was minimal when compared with phytolith recovery from stratigraphic sediments. The majority of the phytoliths in the features are elongate and chloridoid types, although panicoid and festuroid phytoliths are also present. Elongate phytoliths are produced by all grasses and as such are undiagnostic. Chloridoid phytoliths represent short grasses that grow well in arid environments and are the most abundant of the identifiable grass phytoliths. In contrast, festuroid (humid grass) and panicoid (tall grass) phytoliths were observed less frequently. Calcium oxylate crystals were specifically sought in the feature samples as they may be present from Opuntia pads or Valeriana tubers. Two features contain a very few Opuntia-type calcium oxylate crystals, observed by scanning the entire slide, but no Valeriana-type crystals were recorded in any of the samples. Valeriana roots were collected at 41KT53, but no feature samples from that site were examined for phytoliths. The presence of Opuntia calcium oxylate crystals confirms the presence of prickly pear at the site and suggests that it may have been processed in Feature 3 (41GR559) and Feature 8 (41GR303). Radiocarbon ages reported for these features are 855 ± 190 B.P. and 1250 ± 50 B.P., respectively.

The features analyzed may have been used to prepare food, and several contained charcoal indicating that fires had been built. The phytolith record from the features examined contains evidence of some of the local grasses, particularly chloridoid grasses, but does not contribute to an understanding of subsistence activities in the Justiceburg Reservoir area.

It should be noted that while leaves of some plants (notably grasses) produce phytoliths, the edible portions (fruits and seeds) may or may not (Piperno 1988). Most of the edible foods of the American Southwest, such as Chenopodium and Amaranthus, do not appear to produce phytoliths. The grasses are siliceous but are not anticipated to contribute significantly to the phytolith record in features because the grass leaves produce more phytoliths than do the seeds and accompanying parts, such as the bracts. Other plants such as Opuntia (prickly pear cactus) and Valeriana (valerian) produce calcium oxylate crystals. It may be possible to identify processing activities involving prickly pear cactus from the pollen or even the macrofloral records, as well as from the phytolith record. It is highly unlikely, however, that Valeriana pollen would be recovered if the roots were processed. In cases where root crops are suspected to have been processed or utilized, it may be worthwhile to seek evidence in the phytolith record.

TABLE 112
POLLEN TYPES OBSERVED IN SAMPLES

Scientific Name

Common Name

ARBOREAL POLLEN:

<u>Abies</u>	Fir
<u>Acer negundo</u>	Boxelder
<u>Celtis</u>	Hackberry
<u>Juniperus</u>	Juniper
<u>Picea</u>	Spruce
<u>Pinus</u>	Pine
<u>Prosopis</u>	Mesquite
<u>Quercus</u>	Oak
<u>Salix</u>	Willow

NONARBOREAL POLLEN:

<u>Argemone</u>	Prickle-poppy
Cheno-ams	Includes amaranth and pigweed family
Compositae:	Sunflower family
<u>Artemisia</u>	Sagebrush
Low-spine	Includes ragweed, cocklebur, etc.
High-spine	Includes aster, rabbitbrush, snakeweed, sunflower, etc.
Other Compositae	Eroded Low- and/or High-spine
Liguliflorae	Includes dandelion and chicory
Cruciferae	Mustard family
<u>Ephedra</u>	Mormon tea
<u>Eriogonum</u>	Wild buckwheat
<u>Erodium</u>	Storksbill
<u>Euphorbia</u>	Spurge
<u>Galium</u>	Bedstraw
Gramineae	Grass family
Hydrophyllaceae	Waterleaf family
<u>Phacelia</u>	Spike phacelia
<u>Kallstroemia</u>	Kallstroemia
Labiatae	Mint family
Leguminosae	Legume or pea family
Liliaceae	Lily family
<u>Malva</u>	Mallow
Onagraceae	Evening primrose family
<u>Phlox/Abroonia</u>	Phlox/Sand verbena
Polemoniaceae	Phlox family
<u>Polygonum</u>	Knotweed
Rhamnaceae	Buckthorn family
Anacardiaceae	Sumac family

Table 112, continued

Scientific Name	Common Name
<u>Rhus aromatica</u>	Fragrant sumac
Rosaceae	Rose family
Saxifragaceae	Saxifrage family
Sax. <u>Philadelphus</u> -type	Mock orange
Solanaceae	Potato/tomato family
<u>Lycium</u>	Wolfberry
<u>Physalis</u>	Groundcherry
<u>Typha angustifolia</u>	Cattail
Umbelliferae	Parsley/carrot family

Six samples were selected for pollen analysis from the 18 analyzed for phytoliths. Four features and two stratigraphic samples were selected using radiocarbon ages and depth to select the stratigraphic samples. Older pollen samples were sought for this test, as it was felt that they had less chance of producing pollen than the very recent samples. The feature samples were selected at random. The object of this test was to establish whether or not pollen is preserved in the samples. It was also important to determine whether the pollen could be recovered and identified to produce an interpretable record.

The pollen record is very diverse, indicating that preservation is sufficient to recommend further analysis. The Compositae pollen display signs of abrasion in the ground, as the spines are frequently worn down. Therefore, distinction between Low-spine and High-spine Compositae was difficult. When this distinction could not be made, the pollen was placed in a category of "other Compositae." The diversity in the pollen record indicates that pollen preservation is relatively good in spite of the fact that "Indeterminate" pollen exceeded 10% in most of the samples.

The pollen record is comprised of long-distance transport of some of the conifer pollen (Abies, Pinus, and Picea) and local vegetation. Elements of the riparian communities along drainages are evident in the cf. Acer negundo (boxelder), Celtis (hackberry), Prosopis (mesquite), Typha angustifolia (cattail), and possibly Umbelliferae (parsley/carrot family), Hydrophyllaceae (waterleaf family), Phacelia (spike phacelia), and Liguliflorae (dandelion/chicory) pollen. Compositae pollen, which represents some of the smaller shrubs common in the juniper-mesquite assemblage of the uplands, dominates the pollen record. Broomweed, a composite, is noted in this association, as is Indian blanket and blackfoot. The pollen from all three plants is classified as High-spine Compositae.

The pollen record indicates that the local vegetation at the time of the various occupations included many of the same trees, shrubs, and forbs that are recorded in the area today and includes evidence of numerous plants in the vicinity of the sites that may have been exploited as food by the occupants. Stratigraphic fluctuations in frequencies of these pollen types will aid in identifying paleoenvironmental conditions through time in the project area. In addition, the pollen record may address elements of the local vegetation that were available for exploitation and possibly point to specific resources that were processed within individual features.

This study of pollen was small, and the purpose was to evaluate the potential of further studies. The data base is not large enough to interpret the subsistence base, but a discussion of plants represented in the pollen record that have documented uses in the ethnobotanical literature point to the potential for gathering plant resources as part of the subsistence base. These plants include Celtis, Juniperus, Prosopis, Chenopods, Cruciferae, Gramineae, Labiatae, Liliaceae, Polygonum, Solanaceae (including Lycium and Physalis), Typha, and Umbelliferae. Recovery of small quantities of pollen of these plants is not evidence that the plants were processed in the features but rather indicates their presence in the environment. With the possible exception of the Gramineae pollen in Feature 2 at 41GR484 and Feature 2 at 41GR546, pollen from these plants is not observed in sufficiently large frequencies to indicate definite processing. Pollen from plants that are insect pollinated, however, is usually present in very small quantities even when the edible portion of the plant was collected and processed.

A review of the ethnobotanical literature concerning specific utilization of these plants follows. The ethnobotanical literature provides evidence of the exploitation in historic times of numerous plants, both by broad categories such as greens, seeds, roots, and tubers, etc., and by specific example, i.e., seeds parched and ground into meal which was formed into cakes and fried in grease. Ethnographic sources document that with some plants the historic use developed and carried from the past. A plant with medicinal qualities very likely was discovered in prehistoric times, and the usage persisted into historic times. There is, however, likely to have been a loss of knowledge concerning the utilization of plant resources as cultures moved from subsistence to agricultural economies and/or were introduced to European foods during the historic period. Repetitive evidence of the exploitation of resources indicates a widespread utilization and strengthens the possibility that the same or similar resources were used in prehistoric times. The ethnobotanical literature serves only as a guide indicating that the potential for utilization existed in prehistoric times, not as conclusive evidence that the resources were used. Pollen, phytoliths, and macrofloral remains, when compared with the material culture (artifacts and features), become indicators of use.

Celtis (hackberry) fruits may be eaten raw, cooked, or dried. The thin pulp is tasty and sweet and attracts birds and small animals (Angell 1981:162-164). Juniperus berries were exploited ethnohistorically as both food and medicine, while the wood was used as a fuel and construction material. Juniper berries are an abundant crop and available into the winter. Gallagher (1977:28-29, 122) notes that juniper berries were an important food for the Apache. The berries were eaten fresh, boiled, pounded to form a kind of bread, or soaked and pounded to make a liquid drink. Goodwin (1935:62) also notes that juniper berries were a staple for the Apache. Smith (1974) reports that the northern Utes rubbed juniper berries with a mano to separate the seeds from the pulp. The pulp was then either eaten fresh or dried and ground on a metate. Harrington (1967:242-244) and Rogers (1980:18) note that the Rocky Mountain and High Plains juniper berries were collected in the late summer or fall and may have been eaten raw or cooked (boiled or roasted). Dried berries were stored for winter use, when they may have been ground into meal and used to make mush, cakes, or a beverage. The berries may also have been used to flavor meat (Harrington 1967:242; Angell 1981:96). Juniper berries are also used to make a decoction for use as a medicine (Densmore 1974; Gilmore 1977). The Gosiute used juniper both as firewood and as a construction material. Smaller juniper branches, as well as grass, were used as a covering on the floor, while juniper bark was used as thatching for winter lodges. Bark was also used to line pits where dried fruits were stored (Chamberlin 1964:372).

Prosopis (mesquite) wood is an important firewood in semidesert regions. Mesquite pods are noted to have been an important food source among the Indians. Kearney and Peebles (1960:402) observed that pinole was made from the long, sweet mesquite pods and served as a staple food for the Pima. Mesquite pods are described as an important food source among the ancient Pima, Papago, and other Native American groups from central Arizona (Castetter and Bell 1942:63; Curtin 1949).

Cheno-ams are a group of plants that include the goosefoot family (Chenopodiaceae) and pigweed (Amaranthus) and were exploited for both their greens (cooked as potherbs) and seeds. The greens are most tender in the spring when young but may be used at any time. The seeds were ground and used to make a variety of mushes and cakes. The seeds are usually noted to have been parched prior to grinding. Chenopodium and Amaranthus are both weedy annuals capable of producing large quantities of seeds. Atriplex, which occurs as both an annual herb and perennial shrub, may also be exploited for both its greens and seeds. Saltbush leaves have a salty taste and have been used as a seasoning. Saltbush seeds do not ripen until mid fall and may remain on the shrubs throughout the winter into the next growing season (Chamberlin 1964:366; Harrington 1967:55, 57, 71; Schopmeyer 1974; Gallagher 1977:12-16; Gilmore 1977:26; Rogers 1980:43, 66). The seeds may be harvested in the late summer and fall.

Several members of the Cruciferae (mustard) family are noted to have been exploited for their greens, which were used as potherbs, while the plant was young. In addition, seeds may have been parched, ground into flour, and used for making pinole, mush, bread, or to thicken soup (Harrington 1967:308; Rogers 1980:61). Cruciferae seeds ripen in the early summer.

Members of the Gramineae (grass) family, particularly Oryzopsis (Indian ricegrass), have been widely used as a food resource. Oryzopsis produces an abundant quantity of seeds, which were utilized by Native American groups, including the Gosiute (Chamberlin 1964:375). The seeds were often parched and ground into meal to make various mushes and cakes (Harrington 1967:322). Several other species of grasses are also noted to have been used for their seeds, and the young shoots and leaves may have been cooked as greens (Rogers 1980:32-40). Grass is also reported to have been used as a floor covering (Chamberlin 1964:372). Grass seeds ripen during the summer and fall.

Members of the Labiatae (mint) family are noted to have been used both as potherbs and as medicines. Monarda is a popular potherb among the Hopi and is dried for winter use. Poliomintha may be eaten raw or boiled and is also dried for winter use. Salvia is a valued medicine for epilepsy. Monarda is also used by the Tewa to flavor meat, and the dried plant is ground to a fine powder to be used medicinally for colds, headaches, and fever (Robbins et al. 1916:57-58; Whiting 1939:91). Mint leaves may be collected at any time during the growing season.

Both wild onion (Allium) and sego lily (Calochortus) fall within the approximate size range of Liliaceae pollen recovered. These plants are noted to have been frequently exploited by many Native American groups. Wild onion may be utilized as flavoring for stews or meats, boiled and eaten as a vegetable, or the juice used medicinally. Wild onions appear to have been used extensively in the past and were also dried and stored for future use (Yanovsky 1936; Harrington 1967:345-346; Hellson and Gadd 1974:100; Smith 1974:271; Gilmore 1977:19). Several parts of the sego lily are edible, including the greens, seeds, bulbs, and flowers. The bulbs constitute the most usable portion of the plant and were frequently boiled. They may also be stored for future use (Harrington 1967:159-161).

Several species of Polygonum are reported to have been used for their roots, which are starchy and may be roasted, and their leaves, which were used as potherbs and for seasoning. In addition, the seeds of several species of Polygonum may have been parched and ground into meal (Harrington 1967:196-198; Rogers 1980:84).

Members of the Solanaceae family, primarily Solanum and Physalis, were exploited for food. The berries of both plants are edible, as are the roots of Solanum. The tubers are noted to have been eaten raw, boiled, or baked. The berries of Solanum may be eaten raw or cooked, frequently with sweetening. The fruits of Physalis have a distinctive flavor and are also noted to have been used both raw and cooked (Harrington 1967:213, 259, 286).

Typha is a rich source of nutrients. Steward (1938) and Chamberlin (1964) note the utilization of cattail as food, and Harrington (1967) describes the use of both pollen and the seedlike fruits of cattail as food resources. The young pollen-producing flowers may be stripped from the spikes, or the pollen may be removed by shaking the mature flowers. The resulting flowers and/or pollen may be mixed with flour. Flour made from cattail roots, which are best harvested in the fall, is similar with respect to quantities of fats, proteins, and carbohydrates to flour obtained from wheat, rice, and corn (Harrington 1967).

Members of the Umbelliferae family, including but not limited to Cymopterus, Lomatium, and Pseudocymopterus, are noted to have been used. The roots, stems, and leaves of these plants may be used for food, seasoning, and medicine (Whiting 1939:86; French 1971; Colton 1974:305). Biscuit root (Cymopterus) produces an edible root that has been widely used on the Plains. The roots may be eaten raw or cooked (Harrington 1967:171-173).

Specific interpretation of the pollen record with respect to food items processed must wait for additional sampling on this project. Stratigraphic pollen records will provide data to add to the paleoenvironmental interpretations, as well as control data for the interpretation of the subsistence record. The stratigraphic samples will establish quantities or frequencies of pollen from plants that produce edible fruits and seeds that may be expected to occur naturally through transport of the pollen in the environment. Comparison of these control data with the frequencies recovered from features will assist in interpreting the subsistence record. It will, for instance, point to the importance of the recovery of very small quantities of pollen from plants that produce edible fruits, such as Lycium, Physalis, or Celtis, and will help to establish expected ranges for pollen such as Chenopods and Gramineae in the natural environment. Deviations from these ranges recovered in features will, then, take on significance with respect to the subsistence record.

SUMMARY AND CONCLUSIONS

Analysis of a limited number of phytolith and pollen samples from the Justiceburg Reservoir project has shown the utility of both data bases to the interpretation of the paleoenvironmental and subsistence records. The pollen record provides information concerning nongrasses in this diverse environment, while the phytolith record refines the grass record substantially. The phytolith record also provides information for comparison with C3/C4 pathway studies conducted during this project.

Phytolith recovery was more successful in the stratigraphic samples than in samples collected from feature fill. This is because phytoliths are produced in abundance in

silicified portions of plants, such as grass blades, which are not a part of the human diet. However, phytoliths may be of assistance in determining the use of certain root crops that produce calcium oxylate crystals, such as Valeriana. In addition, decomposition of prickly pear (Opuntia) pads in a feature would leave behind an identifiable calcium oxylate crystal.

Pollen, spores, and opal phytoliths have similar, rather low, specific gravities (less than 2.3) and are also of similar size (between 10 and 150 microns) and so tend to be transported together by wind and water. They also occur together in soil and sediment (Twiss 1987:186).

Phytolith analysis is a powerful tool that may be used to provide environmental data from stratigraphic columns where the probability is high that phytolith-producing plants, such as grasses, would have decayed in place. It may be used in concert with pollen analysis for paleoenvironmental interpretations, providing a detailed look at fluctuations in the grasses and identifying the presence of certain other opal phytolith-producing plants. When both records are preserved, it appears to be most effective to utilize both data bases for interpretation.

With some exceptions, however, features have a relatively low probability of yielding phytolith data that may assist the interpretation of the use of the feature. Large quantities of grass or sedge phytoliths may be represented in features, particularly if grasses or sedges were used to line pits. Evidence of roasting seeds or processing berries may be more readily obtained from either the pollen or macrofloral records, although testing continues to isolate identifiable phytoliths, calcium oxylate crystals, cells, or siliceous hairs that may identify edible plants or their fruits. Evidence of processing prickly pear may be expected from both the pollen and phytolith records, while evidence of processing root crops may be limited to the phytolith record in many cases, provided that the roots processed produce phytoliths. Mesquite produces a cell in both the leaf and pod that may become part of the phytolith record. This cell has been observed by the author in the leaves of other legumes and also in the leaves of Ulmaceae and as such is diagnostic only in areas where Ulmaceae does not grow. Its presence may serve in certain instances, however, to indicate use or processing of a legume. These cells were not observed in the features from this project, although one was recovered in a stratigraphic sample.

Future sampling strategies should include sampling for both pollen and phytoliths from all stratigraphic columns. A slightly larger soil sample will provide an adequate quantity for analyses of both data bases. In addition, a sufficient quantity of soil should be collected from the fill of the features to facilitate both pollen and phytolith analyses, should they be desired. At present, pollen analysis is recommended more strongly than phytolith analysis for features.

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APPENDIX J: Faunal Analysis

J. Michael Quigg

INTRODUCTION

Testing of faunal localities, open camps, geomorphic localities, and rockshelters at the proposed Justiceburg Reservoir yielded over 720 vertebrate and limited invertebrate faunal remains from excavations, cutbanks, and flotation of sediment samples. Sample sizes are limited, and discussions concerning site seasonality, dietary patterns, and butchering and processing techniques must await recovery of larger samples. The faunal remains are associated with occupations during the late Archaic and Late Prehistoric periods over the last 3,000 years. Faunal remains recovered by flotation or fine screening were identified by John G. Jones, Barry Baker, and Brian Shaeffer of Texas A&M University.

FAUNAL LOCALITIES

The eight faunal localities contributed the bulk of the materials on which detailed analysis was undertaken (Tables 113, 114, and 115). Many natural agencies and cultural practices account for the taphonomy of the bones, and these must be considered when interpreting these faunal localities. Cultural alterations involving skinning, dismembering, and transporting occur soon after death when the bone is still in a fresh or green state. Green bone versus dry bone alterations are generally detectable (Bonnichsen 1979; Morland 1983, 1984). The larger the assemblage, the more informative the results. The eight faunal localities yielded more than 138 identifiable elements which are analyzed by site, followed by a general discussion. The goals of the analysis were as follows: (1) to determine if the localities represent cultural events; (2) to identify the elements and species involved; (3) to determine the age and sex of the animals; and (4) to describe other pertinent data that may contribute to understanding these events.

41GR249

Ten identifiable elements were recovered and represent the right front leg and skull of a single bison (see Table 113). Most are lightly weathered and reveal drying cracks, deteriorating surfaces, bleached white edges, and various degrees of acid etching from rootlets. The ulna is broken into numerous pieces and is missing the olecranon process, but all breaks appear to be dry bone and therefore noncultural. The right mandible is in numerous fragments, while the left is nearly intact. Two phalanges, a radius, and the metacarpal are complete. When discovered, the front leg was in an articulated position. Examination of each element showed no signs of cultural alteration in the form of cut marks or green bone breaks.

The complete radius (530 g) was submitted for radiocarbon analysis and yielded a corrected age of 90 ± 115 B.P. (GX-14418-G; see Appendix C). The complete metacarpal was measured to determine the sex of this individual (see Table 115). Based on the ratio of transverse width/total length (Bedord 1974:194-240), this animal appears to have been a male. Measurements on the right mandible (see Table 114) indicate this bison was between five and six years old at the time of death (Reher 1973:93-94; Wilson 1980:94).

TABLE 113

BISON ELEMENT REPRESENTATION AT FAUNAL LOCALITIES

Site	Element	Comments
41GR249	1 hyoid, left mandible, right mandible*, 1 incisor, 1 fragmentary thoracic vertebra, right medial ulna, right radius#, right metacarpal, 1 1st phalanx, 1 2nd phalanx	male, age 5-6 years
41GR270	right mandible*, 2 dentition, 2 cervical vertebrae, 4 thoracic vertebrae, 1 lumbar vertebra, right scapula, 8 ribs, right humerus#, 1 carpal, right metacarpal*, left patella, left astragalus, 1 1st phalanx, 1 3rd phalanx	male, age 5-6 years
41GR310	4 skull fragments, 1 hyoid, 3 thoracic vertebrae fragments, 1 rib fragment, left humerus	sex and age unknown
41GR488	left mandible, right mandible*, 1 rib, right radius, left medial femur, right tibia#, 1 1st phalanx, 2 3rd phalanges	male, age 10 years
41GR512	1 cervical vertebra fragment, left proximal humerus	sex and age unknown
41GR539	1 sternum, 7 ribs, right ulna, right femur, right patella, right tibia, right astragalus, right calcaneum, 4 sesamoids, right metatarsal*#, 3 1st phalanges, 4 2nd phalanges, 4 3rd phalanges	male, age 6+ years
41KT44	left mandible, right mandible fragment*, 1 atlas vertebra, 3 cervical vertebrae, 3 thoracic vertebrae, 1 lumbar vertebra, right scapula, 10 ribs, left radius, right radius#, 2 carpals, right femur, 1 1st phalanx, 1 3rd phalanx	male, age 10-11 years

*Element used to determine sex.

#Element used for radiocarbon dating (see Appendix C).

Table 113, continued

Site	Element	Comments
41KT69A	3 thoracic vertebrae fragments, 2 sacral vertebrae fragments, 1 rib, right ulna fragment, 1 right carpal, left ilium fragment, right femur, right proximal tibia	sex and age unknown
41KT69B	1 sternum, 2 rib fragments, right ulna, right radius#, 5 right carpals, right metacarpal*, 1 2nd phalanx	male, age unknown

41GR270

Twenty-six nearly complete elements representing a single bison are identifiable (see Table 113). The mandible, scapula, humerus, and metacarpal represent the right side, while the left is represented by the patella, astragalus, and probably the two phalanges. Seven vertebrae and eight rib shafts are present. All elements display weathered surfaces, drying cracks, minor root etching, and numerous dry bone breaks along the margins.

The complete right humerus (1,130 g) was submitted for radiocarbon assay and yielded a corrected age of 70 ± 110 B.P. (GX-14417-G; see Appendix C). The sex, based on measurements of the metacarpal (Bedord 1974:194-240), is identified as male. All permanent teeth are erupted and in full wear, and the height of the mandible below M3 also indicates a male (see Table 114). As indicated by the position of the enamel base, the age at death appears to have been near 6 years, based on the bison at the Garnsey Site (Wilson 1980:90). Wear on the molars indicates a mature animal between 5.5 and 9.5 years in age, based on the mandibles at the Glenrock Site in Wyoming (Frison and Reher 1970:47). The enamel height of M1 (28 mm) falls within the average for animals between 5.4 and 6.4 years of age at the Wardell Site in Wyoming (Reher 1973:94). Therefore, the best age approximation appears to be between 5 and 6 years.

41GR310

The faunal remains are extremely fragmented with nearly 130 cancellous fragments and only 1 nearly complete bison humerus. The humerus was recovered from a cutbank downstream and across the creek at 165 cm below the surface. It lacks the proximal end, which was the portion exposed. This end reveals five green bone flake removals from the interior, however. Slight rounding of those edges appears to be from use and not exposure. This element represents an isolated bison bone tool with light rootlet etching, longitudinal drying cracks, and a lightly weathered surface.

TABLE 114
SELECTED METRIC AND NONMETRIC ATTRIBUTES ON
BISON MANDIBLES FROM FAUNAL LOCALITIES

Attribute	41GR249		41GR270		41KT44
	Left	Right	Left	Right	Left
Mandible height under					
M1	-	56	-	59	58
M2	-	64	-	68.5	69
M3	-	73	-	78	72
Height of M1	-	28	25.5	28	24
M2	-	23.8	-	25	23*
M3	-	22.2	-	20	27*
Base of enamel at M1	-	above	-	above	17.5
M2	-	below	-	below	-
M3	-	below	-	below	-
Style of M1	open	open	open	open	-
M2	open	elongated	open	elongated	-
M3	-	not visible	-	not visible	open
Length of tooth row	-	16.7	-	16.8	-
Number of foramina	-	1	-	1	-
Sex	-	male	-	male	male
Age in years	-	5-6	-	5-6	10-11

NOTE: All measurements are in millimeters; an asterisk (*) indicates measurement is estimated.

A single small fragment of a turtle carapace was recovered from Test Unit 2 at a depth of 30-63 cm below the surface but above the bone concentration. The remaining faunal materials came from Test Unit 1 at 120-132 cm below the surface. Identifiable fragments represent the skull, vertebrae, and a rib (see Table 113). The fragments, 1-6 cm in length, are dominated by vertebrae spine pieces and reveal dry bone breaks and surface weathering. Sixteen unidentifiable cancellous lumps are burned black. A single skull fragment reveals a cluster of four 1-cm-long cut lines. These remains appear to represent a single animal that was butchered and partially burned. The sizes of the vertebrae are indicative of a bison, although positive identification is not possible. Elements appropriate for aging and sexing are not represented.

TABLE 115
METRIC DATA FOR BISON METAPODIALS RECOVERED FROM FAUNAL LOCALITIES

	41GR249	41GR270	41GR539	41KT69B
Measurements*	Metacarpal	Metacarpal	Metatarsal	Metacarpal
1. Maximum length	198	209	248	205
2. Transverse width, proximal end	70.1	76	56	73
3. Transverse width, center	45.2	46.7	34	45.6
4. Transverse width, distal end	75	78	65	74
5. Anterior-posterior width, center	30.3	31.6	36.3	34.2
6. Anterior-posterior width, proximal, inner lobe	36.3	39.8	55.6	45
7. Anterior-posterior width, proximal, outer lobe	41.6	43	52.2	44.3
8. Anterior-posterior width, distal	35.8	40	35.6	39.6
9. Anterior-posterior width, minimum	26.9	30	30.3	27.6
10. Lateral-medial width, minimum	43.7	47	34	45.6
11. Transverse width (center)/ maximum length x 100	22.7	22.5	13.7	22.4

*Measurements (mm) are based on those used by Bedord (1974:199-240).

41GR488

The faunal remains from this site consist of numerous small rectangular splinters from unidentifiable long bones; badly weathered and fragmented elements representing a medial femur, radius, mandible, and tibia; and three complete phalanges (see Table 113). The tibia and phalanges are definitely bison, and therefore the fragmented remains are probably bison. The surfaces are so weathered that detection of cut marks is impossible. Dry bone breaks are so extensive that cultural alterations cannot be confirmed. Presently, it is not possible to state if this single bison has cultural associations.

The nearly complete right tibia (872 g) was submitted for radiocarbon assay and yielded a corrected age of less than 200 B.P. (GX-14420-G; see Appendix C). The fragmented mandible and isolated teeth do not permit accurate measurements, although the lower left teeth are extremely worn, with the M1 style worn to a loop and the M2 worn below M3. The M2 has no enamel at the posterior or anterior fossae. Tooth wear indicates an animal 10 to 11 years old based on comparisons with the bison at the Garnsey Site in New Mexico (Wilson 1980:94).

41GR512

Excavations yielded over 100 weathered bone fragments, with one weathered proximal humerus and fragments of a cervical vertebra (see Table 113). All are extensively weathered, with longitudinal drying cracks, flaking surfaces, dry bone breakage, and crushed edges. The left humerus is that of a bison, while the rest of the materials are of a similar-sized animal. A green bone spiral fracture appears on the neck of the proximal humerus just below the partially intact head. Rodent teeth marks were noted immediately above this fracture, but no sign of tool marks was detected.

Given the porosity of the proximal humerus, it was not submitted for radiocarbon assay. Identified elements are not sufficient for age or sex determination. The humerus and vertebra display fused ends indicating a mature animal. Given that vertebral fusion is one of the last to occur, the animal is probably older than 6 years. The butchered humerus in a nonarticular association with a vertebra indicates this animal was altered by man.

41GR539

Thirty identifiable elements are represented through the ribs, sternum, ulna, and the right hind leg (see Table 113). Most are complete, with the exception of the ribs which reveal dry bone fracture lines, crushed edges, and fractures. Bone surfaces are intact, although minor root etching is visible. The tibia and femur display numerous questionable small cut lines. Articulation of the tibia-patella-metatarsal-astragalus-calcaneum was observed in the field. One phalanx and one tarsal were collected during the survey (Westgate 1989:386). These elements represent a single bison that does not reveal conclusive butcher marks or human alteration. The articulated leg is supportive of a nonhuman agent of deposition.

The right metatarsal was used for radiocarbon assay, yielding a corrected age of 205 ± 75 B.P. (GX-14416-G; see Appendix C), and for sexing. Based on the measurements (see Table 115), the metatarsal represents a male. No indication of the age of the animal at death is present except for the fact that all epiphyseal caps have fused, thereby indicating a mature individual.

41KT44

Twenty-eight elements are identifiable, and numerous dry bone fragments are present (see Table 113). Even the identifiable elements are fragmented due to weathering. The left, right, and axial portions of one bison are represented. Bone surfaces are extensively weathered and flaky and reveal root etching. Drying cracks and dry bone crushing are present on many elements. A spiral-shaped removal from the distal end of a first phalanx, one spiral curved edge on the radius, and an apparent chop mark on the neck of a rib head represent green bone breaks assumed to have been caused by humans. The apparent articulation of a rib sequence adjacent to the pile of vertebrae, mandibles, atlas, scapula, and phalanges, coupled with a cluster of long bone fragments, suggests a butchering station.

The nearly complete right radius (376 g) was used for radiocarbon assay and yielded a corrected age of 375 ± 115 B.P. (GX-14422-G; see Appendix C). The right mandible was selected for aging and sexing (see Table 114). Tooth wear indicates a very old animal, as the M3 is fully erupted with a worn third cusp and a style that is worn in an open loop. The latter characteristics compare favorably with a 10-year-old bison at the Garnsey Site (Wilson 1980:94). The M1 has a tiny spot of the posterior fossa remaining, while the anterior fossa is obliterated, again indicating an animal older than 10.5 years based on animals at the Glenrock Site in Wyoming (Frison and Reher 1970:47). The mandible height of 72 mm below the M3 indicates a probable male, based on the Glenrock Site animals (Reher 1974:116-117).

41KT69

Twenty-three identifiable fragments and complete elements were recovered from two distinct sections of this site. The main portion of the site, Area A, yielded nine small weathered identifiable fragments from the cutbank and two identifiable elements from the excavations (see Table 113). These display surface deterioration and root etching. All parts of a bison appear represented. One rib fragment reveals a green bone fracture, while the remaining pieces have dry bone breaks. A single nonbison long bone fragment was recovered from the cutbank. Its cortical wall thickness indicates a small mammal. Most of the excavated materials are small long bone fragments with the exception of a proximal epiphyseal cap of a right tibia and a nearly complete right bison femur. The nature of the bone distribution along the terrace, coupled with the green bone break of the rib and the presence of at least two individuals, indicates this locality served as a processing and/or camping area.

The femur (424 g) was used to obtain a radiocarbon assay that yielded a corrected age of less than 200 B.P. (GX-14419-G; see Appendix C). No elements suitable for aging or sexing were available, although at least one immature and one mature animal are recognized from the fusion of the epiphyseal caps.

Faunal materials from a nearby erosional gully cutbank, Area B, represent the partial remains of a single bison as revealed by an articular section of the right front leg and the sternum (see Table 113). These elements are intact with minimal weathering on the surfaces and only minor drying cracks. There is no sign of alteration by man. The complete right radius (750 g) was submitted for radiocarbon assay and yielded a corrected age of less than 200 B.P. (GX-14421-G; see Appendix C). The metacarpal measurements (see Table 115) indicate this animal was a male. The age is unknown, but the articular surfaces are fused to the main shafts, indicating that it represents a mature individual.

Discussion of Faunal Localities

Four sites, 41GR310, 41GR512, 41KT44, and 41KT69A, appear to represent cultural activities, while the others appear to be natural. Each locality, with the exception of 41KT69A, indicates the presence of a single bison. Every sexed individual was a male greater than five years old. Given the abundant literature concerning solitary male bison (Haines 1970; Roe 1970; Hornaday 1971), it is not surprising that these single animals are mature males.

The cause of death of the animals at the noncultural sites is open to speculation. Only the animal at 41KT44 may have been old enough to die of natural causes. Many recovered elements at these locations are complete and could represent limited utilization of the animals by man once killed. These animals could have been killed and skinned and the bones defleshed without leaving evidence of human association.

The data indicate that bison were not taken in large numbers as in mass kills but support individual ambush techniques. At present, it is not known if this is due to the lack of bison in the area, an unfamiliarity with communal killing operations, or seasonal use of the valley. Thus far, only one site, 41KT79, reveals extensive butchered faunal remains that could help to address these questions (Bryan and Howard 1989:567; Westgate 1989).

OPEN CAMPSITES

The excavations at 14 of the campsites yielded a total of 255 vertebrate remains (Table 116); 80 of these were recovered through 1/4-inch screening procedures. Most pieces are small, weathered, unidentifiable, and root etched. Forty-two are burned. Few can be identified as to element and fewer yet to species. Therefore, general categories such as small, medium, or large mammal are used to provide an indication of the size of the animals represented when family, genus, or species could not be determined. The large mammals include bovids and most likely represent bison, medium mammals may include deer or antelope, while small mammals include rabbits, coyotes, and foxes.

Five flotation samples--one from Feature 5 at 41GR303, one from Feature 6 at 41GR323, one from Feature 1 at 41KT52, and two from Test Unit 2 and Feature 4 at 41KT53--yielded 176 tiny fragments, of which 16 are burned and 150 are calcined (see Table 116). These samples reveal a variety of resources, including eight turtle (Testudinata) fragments, five Rodentia phalanges, small and medium mammals, and numerous unknown pieces.

In general, vertebrate remains appear to be sparse in the open camps, which is probably best explained by the acidic soil. The relatively high frequency of vertebrates from 41KT53 is related to the fact that 157 are burned or calcined and recovered during flotation. This provides a biased look at what might have been available or utilized by the inhabitants.

ROCKSHELTERS

The two rockshelters, 41GR546 and 41GR559, yielded a total of 292 vertebrate remains (Table 117). Of these, 120 specimens were retrieved from the 1/4-inch screen. Surfaces of elements are well preserved and lacked root etching. Generally, the preservation is noticeably better in comparison to the open campsites. However, the green bone breaks observed on a few of the fragments cannot be assumed to indicate cultural processes as carnivores and other species can alter elements in this manner and are known to inhabit these rockshelters. The dryness of the bones caused numerous breaks which hamper identification and interpretation.

TABLE 116
VERTEBRATE FAUNAL REMAINS FROM OPEN CAMPSITES

Provenience	Description	Identification
41GR291		
Surface Collection Unit	1 tooth enamel fragment	medium mammal
41GR303		
Test Unit 4, 20-30 cm	3 articulated burned long bone fragments	medium mammal
30-40 cm	1 burned long bone fragment	small mammal
60-70 cm	1 long bone fragment	medium mammal
Test Unit 5, Feature 5, flotation, 5-23 cm	8 burned long bone fragments	medium mammal
41GR323		
Test Unit 10, Feature 6, flotation, 9-29 cm	3 unidentifiable fragments	medium mammal
41GR383		
Surface Collection Unit	1 unidentifiable weathered fragment	unknown
41GR456		
Test Unit 2, 50-60 cm	5 unidentifiable weathered fragments	unknown
41GR467		
Test Unit 1, 0-20 cm	1 unidentifiable root-etched fragment	unknown
70-80 cm	1 unidentifiable root-etched fragment	unknown
41GR468 (isolated find)		
Backhoe Trench 17, 0-110 cm	2 unidentifiable root-etched fragments	large mammal
41GR471		
Test Unit 1, 110-120 cm	1 burned long bone fragment	small mammal
41GR484		
Backhoe Trench 67, 0-40 cm	1 epiphyseal cap fragment 1 long bone fragment	medium mammal medium mammal
41GR515		
Test Unit 7, 160-180 cm	1 long bone fragment	medium mammal
41KT33		
Test Unit 1, 0-10 cm	4 unidentifiable burned fragments	medium mammal

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

Table 116, continued

Site	Description	Identification
41KT51		
Test Unit 2, 10-20 cm	1 distal 1st phalanx, 4 pieces, root-etched	large mammal
	7 unidentifiable fragments	unknown
	20-30 cm 8 unidentifiable root-etched fragments	unknown
41KT52		
Test Unit 1, Feature 1, flotation, 96-113 cm	1 unidentifiable calcined fragment	unknown
41KT53		
Test Unit 1, 0-10 cm	3 unidentifiable burned/calcined fragments	medium mammal
	1 bone flake off a long bone	medium mammal
Test Unit 2, 10-15 cm	3 burned long bone fragments	medium mammal
Test Unit 2, flotation, 25-35 cm	1 tooth fragment	small mammal
Test Unit 3, 0-20 cm	4 long bone fragments	large mammal
Test Unit 4, 10-20 cm	9 burned long bone fragments	medium mammal
	2 bone flakes off long bones	medium mammal
Test Unit 7, 0-10 cm 10-20 cm	1 unidentifiable fragment	medium mammal
	8 calcined long bone fragments	medium mammal
	2 burned long bone fragments	medium mammal
	1 vertebra cap	medium mammal
	2 calcined carapace fragments	Testudinata
	1 bone flake off a long bone	medium mammal
	1 unidentifiable fragment	unknown
Test Unit 7, Feature 4, flotation, 18-25 cm	8 burned carapace fragments	Testudinata
	148 unidentifiable calcined fragments	unknown
	1 calcined long bone fragment	Rodentia
Test Unit 11, 10-20 cm	5 phalanges	Rodentia
	2 halves of a chewed long bone	medium mammal

Only four fragments are assumed to be cultural because of their noticeable alteration through burning or cut marks. Three are burned long bone fragments from a medium-sized animal, probably a deer. A proximal metapodial shaft of a Canis sp. from 41GR559 reveals cut marks perpendicular to the long axis, indicating human action. As a group, these specimens testify to the use of small and medium-sized game by the inhabitants.

The Canis sp. remains from 41GR559 are relatively large. The measurements obtained on the one complete right maxillary premolar (Table 118) fall within the limits for modern wolf presented by Walker (1983:293). Most of these large canids have been shown by Walker and Frison (1982) to be a wolf/dog hybrid, however.

It is important to stress that the elements representing Leporidae, Geomyidae, and Cricetidae without cut marks or burning probably represent noncultural remains. There is

TABLE 117
VERTEBRATE FAUNAL REMAINS FROM ROCKSHELTERS

Provenience	Description	Identification
41GR546		
Test Unit 1		
0-17 cm	1 vertebra fragment	small mammal
	1 distal femur condyle fragment	small mammal
	2 long bone fragments	small mammal
17-30 cm	1 2nd phalanx	small mammal
	2 burned long bone fragments	medium mammal
	2 unidentifiable fragments	unknown
	1 maxillary tooth	Leporidae
17-30 cm, flotation	1 right proximal femur, 7 long bones	Cricetidae
	2 incisors, 26 fragments	Cricetidae
	2 unidentifiable burned fragments	small mammal
	1 burned vertebra	Serpentes
	1 burned long bone fragment	medium mammal
Feature 2, 20-40 cm, flotation	1 tooth and mandible fragment	Cricetidae
	4 long bone fragments	Cricetidae
	1 unidentifiable calcined fragment	medium mammal
30-40 cm	1 unidentifiable fragment	medium mammal
30-40 cm, fine screen	1 vertebra	Serpentes
	1 pelvis fragment	Cricetidae
	1 immature left distal femur fragment	small mammal
	9 long bone fragments	small mammal
	2 unidentifiable burned fragments	small mammal
40-50 cm	1 unidentifiable burned fragment	medium mammal
40-50 cm, fine screen	1 tooth fragment	Rodentia
50-60 cm, flotation	2 white eggshell fragments	unknown
	1 complete ulna	small Aves
41GR559		
Shovel Test 3		
0-10 cm	1 occipital foramen	Neotomae
10-20 cm	1 complete immature right femur	Cricetidae
60-70 cm	1 complete left calcaneus	Leporidae
	1 left proximal humerus fragment	Leporidae
	1 lower left 4th premolar, mandible fragment	Geomys sp.
	1 distal femur fragment	small Rodentia
	1 distal tibia fragment	small Rodentia
	1 long bone fragment	small Rodentia

Table 117, continued

Provenience	Description	Identification
Shovel Test 4		
40-50 cm	1 complete right maxillary premolar 4	<u>Canis</u> sp. hybrid
	1 complete right maxillary 2nd molar	<u>Canis</u> sp.
	4 teeth fragments	<u>Canis</u> sp.
	1 3rd phalanx	<u>Canis</u> sp.
	1 proximal right femur head, 1 shaft	<u>Canis</u> sp.
	17 long bone fragments	medium mammal
	2 distal metapodial shafts	Canidae
	1 proximal metapodial shaft with cut marks	Canidae
	3 fragments of tarsals	Canidae
Test Units 1 and 2		
Feature 6, 8-22 cm	2 rib heads with canine tooth holes	medium mammal
	1 left mandible, complete, 5.5-6.5 years	<u>Odocoileus</u> sp.
	1 left 1st premolar, maxillary	<u>Odocoileus</u> sp.
	4 rib head fragments	medium mammal
	1 long bone fragment	unknown
	1 rib head	medium mammal
	1 right maxillary tooth row	<u>Odocoileus</u> sp.
	1 left maxillary fragment, M2 M3	<u>Odocoileus</u> sp.
Test Unit 2		
0-14 cm	1 complete immature right femur	Cricetidae
14-24 cm	2 rib heads with canine tooth holes	medium mammal
	1 mandible, 1st molar fragment	<u>Geomys bursarius</u>
	1 acetabulum fragment	Rodentia
	2 incisors	Rodentia
	8 unidentifiable bone fragments	unknown
	1 left 2nd premolar, maxillary	<u>Odocoileus</u> sp.
24-53 cm	8 unidentifiable bone fragments	unknown
	1 distal right humerus	Leporidae
	1 proximal left femur	Cricetidae
Feature 3, 71-83 cm	1 vertebra	Serpentes
	1 lower right 1st molar	<u>Neotoma albigula</u>
	9 incisor fragments	small Rodentia
	5 mandible fragments	small Rodentia
	11 long bone fragments	small Rodentia
Feature 3, 71-83 cm, flotation	2 incisors	small Rodentia
	1 right upper 1st molar, 1 left 3rd molar	<u>Neotoma albigula</u>
	7 mandible and skull fragments	small Rodentia
	16 long bone fragments	small Rodentia
	2 tooth fragments	small Rodentia
Test Unit 3		
Feature 2, 28-42 cm, flotation	1 proximal right ulna	Cricetidae
	2 lower right molars	<u>Neotoma albigula</u>
	2 teeth fragments, 1 burned	Leporidae

Table 117, continued

Provenience	Description	Identification
59-71 cm, flotation	6 teeth fragments	small Rodentia
	7 unidentifiable burned fragments	small mammal
	6 unidentifiable fragments	small mammal
	63 unidentifiable fragments	small Rodentia
	1 upper 2nd molar	Canidae
	1 complete burned calcaneus	small Rodentia
	1 proximal radius fragment	small Rodentia
	3 long bone fragments	medium mammal
	11 unidentifiable fragments	small Rodentia
	9 unidentifiable burned fragments	small Rodentia
Feature 5, 72-80 cm	4 unidentifiable fragments	unknown

TABLE 118

SELECTED METRIC ATTRIBUTES OF THE CANID ELEMENTS FROM 41GR559

Complete right maxillary premolar*:	Greatest breadth	=	13.4 mm
	Length	=	24.1 mm
	Minimum breadth	=	9.5 mm
Proximal femur head*:	Maximum length	=	22.5 mm
	Maximum breadth	=	20.6 mm
Complete right maxillary M2*:	Maximum length	=	9.0 mm
	Maximum breadth	=	13.0 mm

*Measurements after Von den Driesch (1976:45).

no direct evidence that these were utilized by man in the rockshelters. They can be used to infer environmental conditions in the vicinity of the sites.

Twenty burned specimen were retrieved from the rockshelters; the majority were recovered from fine-screen and flotation samples (see Table 117). The burned specimens consist of three long bone fragments from a medium mammal, a snake vertebra, and five unidentifiable fragments from small and medium mammals from 41GR546. Other burned specimens include a calcaneus and nine unidentifiable fragments of a small Rodentia, a burned tooth fragment from a Leporidae, and seven unidentifiable small mammal fragments recovered from 41GR559. Again, these burned elements are considered cultural because they are altered. The remaining specimens from the fine screening may or may not be cultural. The inhabitants of both sites appear to have utilized both small and medium-sized mammals.

INVERTEBRATE REMAINS

Two general categories of shells, freshwater mussels (bivalves) and gastropods (snails), were recovered from test units and auger holes and are discussed below. The shell fragments from 1/4-inch screening were identified by Dr. Raymond W. Neck of the Texas Parks and Wildlife Department, while the sample of small snails retrieved during flotation and fine screening of selected sediment samples were identified by John G. Jones of Texas A&M University.

Freshwater Mussels

Most of the bivalves recovered are quite fragmentary, but two small fingernail clams (Sphaerium striatinum) and nine Unio declivus were identified (Table 119). Unio declivus is common on the High Plains today as it was throughout the Holocene (Raymond W. Neck, personal communication 1988). Its presence does not indicate permanent water but rather a small stream, likely intermittent, or perhaps a backwater slough. Young bivalves are parasitic to fish; thus, the presence of mussels implies that fish hosts were available at least long enough for the bivalves to migrate with them, perhaps eventually becoming concentrated as the water supply diminished. Mussels can survive for months in dry sediments but prefer a permanent pond or connection to a small water source. Given the present intermittent water supply, it appears the modern climate is similar to that of the immediate past.

It is unknown if these mussels were used as food as none show cultural modification, but the direct association of half of a bivalve with the hearth at 41KT52 implies cultural use. The frequency and clustering of mussels at archeological sites imply more than just random scattering. Mussels could have served as a seasonal food source or may have been gathered for the production of decorative items such as disk beads. There are, however, several noncultural situations that could explain the occurrence of limited quantities of shells in prehistoric sites. For example, raccoons, skunks, and various birds consume mussels and could leave the remains at archeological sites.

Gastropods

Screening of sediments at 11 sites yielded three identifiable types of snails, Succineidae or Catinella sp., Planorbella trivolvis, and Polygyra texasiana (Table 120). None of the snails appear burned or modified, and thus there is no evidence to associate these with the cultural materials. Their presence reflects certain habitats and possibly environmental conditions. The 47 terrestrial Succineidae/Catinella from 10 sites could not be separated without their soft parts. Succineidae generally prefer moist wooded areas (Allen and Cheatum 1961:299). The aquatic species, Planorbella trivolvis, represented by four specimens from Backhoe Trench 31 at 41KT51, prefers ponded to shallow, slow-moving water, while the terrestrial Polygyra texasiana recovered from 41GR323 (n = 1), 41GR359 (n = 1), 41GR456 (n = 2), and 41KT34 (n = 1) prefers a rocky, dry habitat and may be found in areas with limestone (Raymond W. Neck, personal communication 1988). One gastropod from 41GR456 is unidentifiable.

TABLE 119
DISTRIBUTION AND TYPE OF FRESHWATER MUSSELS

Provenience	Unidentifiable Fragments*	<u>Uniomorus</u> <u>declivus</u>	<u>Sphaerium</u> <u>striatinum</u>
<u>41GR291:</u>			
Surface	8	-	-
Auger Tests 10, 11, and 24	3	-	-
Test Unit 1, 0-40 cm	x	-	-
Test Unit 2, 10-20 cm	x	-	-
Test Unit 4, 0-20 cm	x	-	-
Test Unit 5, 0-40 cm	x	1	-
Test Unit 6, 10-20 cm	x	-	-
<u>41GR302:</u>			
Test Unit 2, 40-60 cm	x	-	-
<u>41GR303:</u>			
Test Unit 2, 20-40 cm	x	-	-
Test Unit 4, 0-85 cm	x	-	-
Test Unit 5, 23-33 cm	-	1	-
<u>41GR323:</u>			
Surface	-	-	1
Auger Test 7	x	-	-
Test Unit 6, 0-10 cm	x	-	-
Test Unit 9, 20-30 cm	x	-	-
Test Unit 10, 10-40 cm	x	-	-
<u>41GR359:</u>			
Surface	x	-	-
Shovel Test 4	x	-	-
Test Unit 6, 20-30 cm	x	-	-
<u>41GR383:</u>			
Surface	3	-	-
Auger Tests 4 and 11	x	-	-
Test Unit 2, 0-40 cm	x	-	-
Test Unit 3, 10-20 cm	x	-	-
Test Unit 7, 30-40 cm	x	-	-
Test Unit 8, 0-90 cm	x	1	-
<u>41GR456:</u>			
Auger Tests 4 and 11	x	-	-
Test Unit 1, 0-20 cm	x	-	-

*x indicates presence.

PHASE II PREHISTORIC INVESTIGATIONS, JUSTICEBURG RESERVOIR

Table 119, continued

Provenience	Unidentifiable Fragments	<u>Uniomerus</u> <u>declivus</u>	<u>Sphaerium</u> <u>striatinum</u>
Test Unit 2, 30-50 cm	x	-	-
Test Unit 3, 0-10 cm	x	-	-
Test Unit 6, 0-130 cm	x	-	-
Test Unit 7, 20-60 cm	x	-	-
<u>41GR474:</u>			
Backhoe Trench 4	x	-	-
<u>41GR484:</u>			
Surface	-	1	-
Test Unit 2, 30-50 cm	x	-	-
Test Unit 3, 10-40 cm	x	-	-
<u>41GR515:</u>			
Surface	x	1	-
Test Unit 1, 10-50 cm	x	2	-
<u>41GR559:</u>			
Test Unit 3, 38-59 cm	-	1	-
<u>41KT33:</u>			
Surface	x	-	-
Test Unit 1, 0-30 cm	x	-	-
Test Unit 6, 0-10 cm	x	-	-
<u>41KT34:</u>			
Auger Test 9	x	-	-
Test Unit 2, 30-40 cm	x	-	-
Test Unit 3, 60-70 cm	x	-	-
Test Unit 4, 20-80 cm	x	-	-
<u>41KT49:</u>			
Auger Test 25	x	-	-
<u>41KT51:</u>			
Backhoe Trench 31	-	-	1
Test Unit 3, 0-10 cm	x	-	-
<u>41KT52:</u>			
Backhoe Trench 28	x	-	-
Test Unit 1, Level 2, Feature 1	-	1	-

TABLE 120
DISTRIBUTION AND FREQUENCY OF TERRESTRIAL AND AQUATIC GASTROPODS

Site	Number of Specimens in 1/4-inch Screen	Number of Specimens in Flotation/Fine Screen*
41GR287	2	2
41GR291	2	21
41GR302	-	2
41GR303	6	18
41GR323	5	4
41GR359	3	-
41GR383	-	7
41GR456	8	2
41GR471	-	17
41GR484	-	10
41GR515	3	32
41GR546	1	18
41GR559	8	116
41KT33	-	6
41KT34	16	-
41KT49	-	1
41KT51	4	-
41KT52	-	3
41KT53	-	20
Totals:	58	279

*Gastropods identified by John Jones of Texas A&M University.

Flotation and fine screening yielded another 279 gastropods including 45 Succineidae, 108 Zonotidae, 122 Pupillidae, 1 Polygyridae, and 3 unidentifiable specimens from cultural contexts from various prehistoric sites (see Table 120). Their presence is assumed to be natural as there is no evidence to indicate otherwise. Succineidae and Zonotidae generally live in moist wooded areas, while the latter can tolerate seasonal drought (Allen and Cheatum 1961:301). Pupillidae have a wide ecological range and are thus not sensitive to specific environments. Six Pupillidae specimens are identified as Pupoides sp., a hardy gastropod that can inhabit arid situations as well as its preferred wooded habitat (Allen and Cheatum 1961:805; Neck 1987). The habitat information is consistent with the present environmental conditions of a mix of open grasslands and wooded sections.

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