Structural and Compositional Investigation of Pottery Samples from Guatemala

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1. Abstract

Purpose of investigation: The composition and characteristics of Mayan pottery samples from Guatemala was investigated.

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Analysis of samples: Samples were analyzed for metal content, mineral crystalline phases, elemental composition, particle size, and porosity. The samples were analyzed using scanning electron microscopy (SEM/EDX), FT-IR, ICP-OES, and powder X-ray diffraction (XRD).

Results: Investigations showed the samples contained aliphatic C-H, C-C, and C=O functional groups.

(a) EDX analysis show samples contained elements C (3.4 w/w%), O (54.8 w/w %), Mg (0.45 w/w%%), Al (7.25 w/w% %), Si (11.2 w/w% %), K (0.3 w/w%), Ca(21.3 w/w%), and trace amounts of Mn, Cu, S, Na, Ti.

(b) **ICP-OES** analysis further confirmed the composition of macrorelements Al, Ca, Fe, K, Mg, Na, P, S and microelements Ba, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Se, Zn, and V.

(c) XRD determined the major mineral crystalline phases in the samples were quartz, aluminite, alunogen, andalusite, borax, gypsum, hexahydrite, hornblende, laumontite, mirabilite, palygorskite M, talc, and vermiculite.

2. Objective of Study

- Pottery was used by natives for various purposes, such as cooking and storing food products.[1,2]
- During the processing of food, organic residues were left behind in the matrix of the unglazed pottery, and metals were contained in the matrix of the pottery.
- Analyzing the metal composition, crystalline structure, and porosity can determine what the pottery consist of.
- This study may provide a picture of early human life.

Figure 1: Representative pottery samples from Guatemala sites

3. Materials and Instrumentation

Methodology

I. Fourier Transform Infrared Spectroscopy (FT-IR)
II. Scanning Electron Microscopy/Energy Dispersive Spectroscopy (SEM/EDS)
III. Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)
IV. Powder X-Ray Diffraction (XRD)

Instrumentation

- Perkin Elmer Spectrum 100 FT-IR Spectrometer
- Hitachi S-2300 SEM
- JEOL-6100 SEM
- Bruker D8 XRD
- Dual view Thermo Scientific (USA) iCAP™ 7400 ICP-OES

4. Results

(a) DRIFTS (FT-IR)

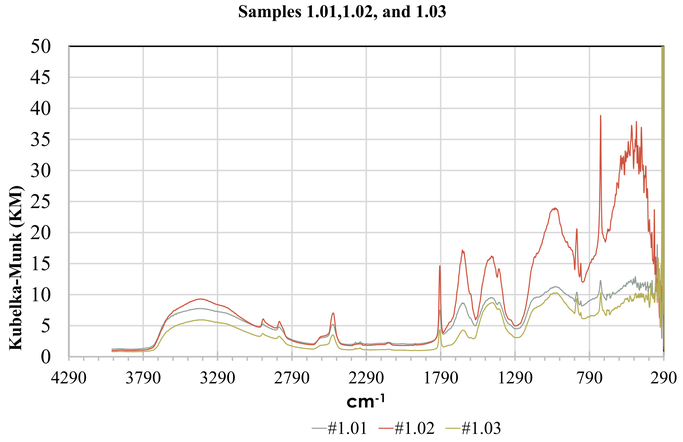

Figure 1: Representative DRIFTS (FT-IR) spectra of samples

References:

1. Kaners, A. A. Potted History of Japan. Nature, 2013, 496, 302–303.
2. Craig, O. E., Saul. H, Lucquin, A., Nishida, Y., Tache´, K., Clarke, L., Thompson, A., Altoft, D. T., Uchiyama, J., Ajimoto, M., Gibbs, K., Isaksson, S., Heron, C.P., & Jordan, P. Earliest Evidence for the Use of Pottery. Nature,2013, 496, 351-354.

4. Results (cont'd)

(b) XRD

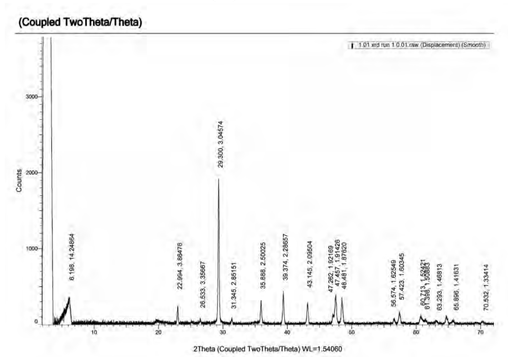

Figure 2: Representative XRD spectra

(c) EDX/ SEM

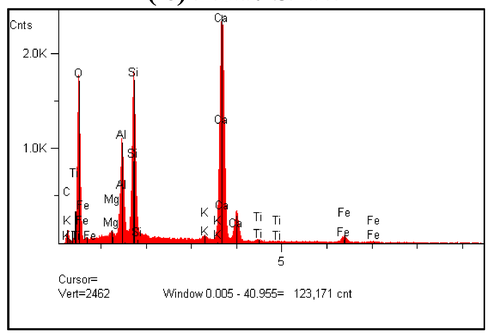

Figure 3: Representative EDS spectrum

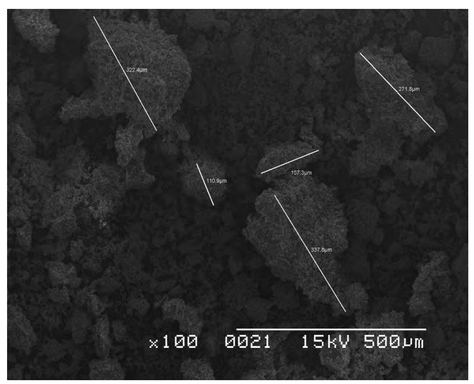

Figure 4: Representative SEM micrograph (particle range: 20 – 500 µm)

(d) ICP-OES Analysis

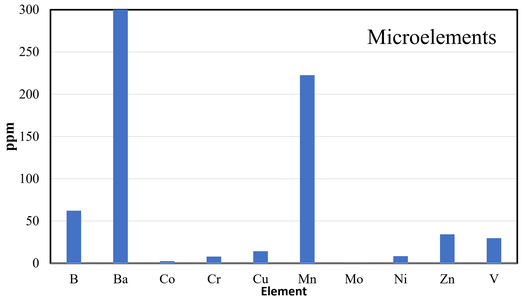

Figure 5: Micro-elements in pottery using ICP-OES

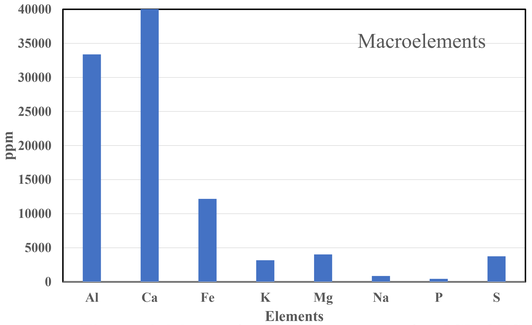

Figure 6: Macro-elements in pottery using ICP-OES

5. Conclusions

1. Samples 1.01-1.07, 1.09-1.12, and 1.14-1.23, 1.25-1.34, and 1.36-1.39 contain carbonyl (C=O) and aliphatic C-H groups. All the samples contain an O-H group.
2. The majority of samples contained trace (Ba, Cd, Co Cr, Hg, Mn, Mo Ni, Pb, Zn, V) and macroelements (Al, Ca, Fe, K, Mg, Na, P, and S).
3. Concentrations of the toxic elements (Cd (70 ppm), Cr (230 ppm), Hg (16-250 ppm), Ni (1600 ppm), Pb (400 ppm), and Zn (23,600 ppm)) are below USEPA ceiling limits.
4. The common crystalline structures in the pottery were quartz, aluminite, alunogen, andalusite, borax, gypsum, hexahydrite, hornblende, laumontite, mirabilite, palygorskite M, talc, and vermiculite 2M.
5. Sample were porous with particles sizes in the range ~20 - 500 µm.

6. Acknowledgments

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