

## Trace-element Analysis of Ancient Near Eastern Ceramics from the Mid-4<sup>th</sup> Millennium to 3<sup>rd</sup> Millennium BC.

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**Project Description.** This dataset contains trace-element data, descriptive information, and photographs for 1777 ceramic vessels from the ancient Near East analyzed as part of NSF Archaeometry award 1005945, *Support of Coordinated, Regional Trace-Element Studies at the OSU-RC*, between 2010 and 2014. The sample includes ceramic materials dating to the mid-4<sup>th</sup> millennium through 3<sup>rd</sup> millennium BC from Southern Mesopotamia, the Susiana Plain, Tell Brak, Jebel Aruda, Tell Hadidi, Tell Humeida, Nineveh, Godin Tepe, Kunji Cave, Tal-e Geser, Mamasani, the Kur River Basin, Yanik Tepe, Tepe Hissar, Sang-e Chakmaq, Tal-I Iblis, Tepe Yahya, Shar-I Sokhta, Bampur, and Makran (Table 1). Data on elemental composition were determined by instrumental neutron activation analysis (INAA) at the OSU Radiation Center's Archaeometry Lab, and consist of a suite of 31 elements (Al, As, Ba, Ca, Ce, Co, Cr, Cs, Dy, Eu, Fe, Hf, K, La, Lu, Mn, Na, Nd, Ni, Rb, Sc, Sm, Sr, Ta, Tb, Th, Ti, U, V, Yb, Zn), reported as parts-per-million (ppm) concentration values with associated uncertainties based on counting statistics.

Each artifact is given a unique lab identification number (INAA ID) which may be used to relate the trace-element data with descriptive information for each artifact and photos included in this dataset.

For each site, this dataset includes:

- (1) Trace-element data;
- (2) Sample descriptions;
- (3) Sherd photographs; and
- (4) Ceramic paste microphotographs.

A project summary (*NE Project Summary.pdf*; *NE Project Summary Figures.pdf*) is included to provide detailed information on project goals, methods, and results.

A complete list of files in this dataset may be found at the end of this document.

### Analytical Protocols:

**Sample selection.** Ceramic samples were selected for INAA analysis from 24 key sites (Table 1) stretching across Syria, Iraq, Iran, and western Pakistan, with the help of collaborating researchers. The geographic breadth of this sample was used to characterize the compositional signature of ceramic materials from across the Near East. These analyses will provide a comparative database for researchers examining ancient economic interactions between the lowlands of greater Mesopotamia, the highlands of the Iranian plateau, and along the inter-montane valleys of the Zagros mountains.

**Table 1.** INAA Sample for the Near East

<b>Site/Region</b>	<b>Project ID</b>	<b>Loaning Institution</b>	<b>Sample</b>
Mesopotamia	RC1901	Oriental Institute, Chicago	91
Tell Brak	RC1883	University of Michigan	96
Jebel Aruda	RC1941	Dutch Natl. Museum of Antiquities	76
Tell Hadidi	RC1989	Milwaukee Public Museum	36
Nineveh	RC1960	British Museum	21
Godin Tepe	RC1949	Royal Ontario Museum	86
Kunji Cave	RC1987	University of Michigan	95
<b>Susiana Plain</b>			
Abu Fanduweh	RC1845	Oriental Institute, Chicago	27
Khuzistan clays	RC1845	Oriental Institute, Chicago	9
<b>Ram Hormuz Plain</b>			
Tal-e Geser	RC1938	Oriental Institute, Chicago	76
<b>Mamasani Survey</b>			
	RC1988	University of Cambridge	100
<b>Kur River Valley</b>			
Late Banesh-Malyan	RC1845	Oriental Institute, Chicago	17
Sumner Survey	RC1911	Penn Museum	550
Ring scrapers (RS)	RC1911	Private	27
<b>Iranian Plateau</b>			
Yanik Tepe	RC1902	University College of London	12
Tepe Hissar	RC1912	Penn Museum	64
Sang-e Chakmaq	RC1912	Penn Museum	17
<b>Eastern Iran-Pakistan</b>			
Tal-I Iblis	RC1937	University of Georgia	26
Tepe Yahya	RC1959	Harvard Peabody Museum	225
Shahr-i Sokhta	RC1940	Palazzo Brancaccio & ISAO, Rome	91
Bampur	RC1959	Harvard Peabody Museum	8
Makran	RC1959	Harvard Peabody Museum	14

**Sample Preparation.** All ceramic samples were processed and analyzed at the OSU Archaeometry Lab. For most collections, each sample was photographed three times at the OSU Archaeometry Lab (interior, exterior, and profile), but in some cases, artifact photos were provided by participating institutions. A small portion of the sherd (ca. 1 x 2 cm) was then cleaned by removing surface pigments and contamination with a tungsten carbide burr or rotary file. This portion was removed, rinsed with de-ionized water and dried, before being pulverized in an agate mortar and pestle. Powdered sherd material was archived in glass scintillation vials. Finally, ceramic pastes were photographed on the fresh break at 50x, 100x, and 200x, using a digital fiberoptic microscope (see *Paste Photos* for each site).

**INAA Protocols and Analyses.** All ceramic samples were characterized for a suite of 31 major, minor and trace elements, through a protocol of two neutron irradiations in the OSU TRIGA reactor and multiple counts of gamma activity. To quantify elements with short half-life isotopes, approximately 250 mg of pulverized material was encapsulated in high-purity polyethylene vials, and delivered via pneumatic

tube to an in-core location with a nominal thermal neutron flux of  $10^{13} \text{ n} \cdot \text{cm}^{-2} \cdot \text{s}^{-1}$ . The 7-s irradiation was followed by two separate counts of resultant gamma activity, one after a 15-minute decay (for Al, Ca, Ti, and V) and a second count after 2-hr decay (for Dy, Mn, K, and Na); both counts were for 540 seconds using a 25-30% relative efficiency HPGe detector.

To quantify elements with intermediate and long half-live isotopes, sample materials were subjected to a 14-hr irradiation in the rotating rack of the reactor, a location which experiences a nominal thermal neutron flux of  $2.3 \times 10^{12} \text{ n} \cdot \text{cm}^{-2} \cdot \text{s}^{-1}$ . Again, two separate counts of gamma activity were acquired, the first count of 5000 s (live-time) began 6 days after the end of irradiation, while the second count for 10000 s followed a 4-week decay. These two counts provided data on As, La, Lu, K, Na, Sm, U, Yb, and Ba, Ce, Co, Cr, Cs, Eu, Fe, Hf, Nd, Ni, Rb, Sb, Sc, Sr, Ta, Tb, Th, and Zn, respectively. Element concentrations were determined via the direct comparison method; three replicates of the standard reference material NIST1633a (coal fly ash) and one of NIST688 (basalt) were utilized as standards. All data reductions were based on current consensus element libraries utilized by the Missouri University Research Reactor for archaeological materials (Glascock 1992, 2006).

**Provenance determination.** Reference groups representing one or more local compositional signatures have been established for most areas and sites examined, including Mesopotamia, the Syro-Tigridian highlands, the Susiana Plain, various valleys within the Zagros foothills, and far SE Iran. An overview of statistical methods and results are presented in *NE Project Summary.pdf* and *NE Project Summary Figures.pdf*. Final provenance determination of each artifact (based on current assessment) is indicated in the *Ceramic Database.xls* for each site.

#### Associated Files:

The Near Eastern ceramic dataset includes:

(A) A project summary and description:

*NE Project Summary.pdf*

(B) Figures for the project summary:

*NE Project Summary Figures.pdf*

(C) A map showing site locations:

*NE Project Map.pdf*

(D) Element library of values used for standard reference materials.

*NE\_Element\_library.xls*

(E) Values obtained for check-standards to be used for inter-lab calibrations.

*OSU-RC\_NearEast\_Stnds.xls*

(F) Trace-element data, artifact descriptions, and photographs organized by site.

For Mesopotamia, see the folder *OSU\_Mesopotamia.zip*.

This folder contains:

(1) Element concentrations in parts-per-million for each artifact:

*Uruk\_trace-element\_data.xls; Uruk\_trace-element\_data.csv*

(2) Metadata/sample descriptions:

*Uruk\_Ceramic Database.xls; Uruk\_Ceramic Database.csv*

(3) A contact sheet of sherd image thumbnails:

*Uruk Sherd Photo Index.pdf*

- (4) A contact sheet of ceramic paste photo thumbnails:  
*Uruk Paste Photo Index.pdf*
- (5) Exterior images of each artifact:  
*OSU-RC Mesopotamia Sherd Photos.zip*  
This folder contains 91 jpg images supplied by the Oriental Institute of Chicago. File-names specify INAA ID number and museum registration number (i.e. URUK\_001\_69953).
- (6) Ceramic paste photos of each artifact:  
*OSU-RC Mesopotamia Paste Photos.zip*  
This folder contains 185 ceramic paste micro-photographs taken with an incident light microscope at 50 and 100 power magnification. File-names specify INAA ID and magnification (i.e. URUK\_001\_50x).

For Godin Tepe, see the folder *OSU-RC\_GodinTepe\_Archive.zip*.  
This folder contains:

- (1) Element concentrations in parts-per-million for each artifact:  
*Godin Tepe INAA data.xls; Godin Tepe INAA data.csv*
- (2) Metadata/sample descriptions:  
*Godin Tepe Ceramic Database.xls; Godin Tepe Ceramic Database.csv*
- (3) A contact sheet of sherd image thumbnails:  
*Godin Tepe Artifact Photo Index.pdf*
- (4) A contact sheet of ceramic paste photo thumbnails:  
*Godin Tepe Paste Photo Index.pdf*
- (5) Exterior images of each artifact:  
*Godin Tepe Sherd Photos.zip*  
This folder contains 264 artifact images taken at the OSU Archaeometry Lab. File-names specify INAA ID number and interior, exterior, or profile view (e.g., GOT\_018\_EXT).
- (6) Ceramic paste photos of each artifact:  
*Godin Tepe Paste Photos.zip*  
This folder contains 172 ceramic paste micro-photographs taken with an incident light microscope at 50 and 100 power magnification. File-names specify INAA ID and magnification (e.g., GOT\_01\_50x).

For Jebel Aruda, see the folder *OSU-RC\_JebelAruda\_Archive.zip*.  
This folder contains:

- (1) Element concentrations in parts-per-million for each artifact:  
*Jebel Aruda INAA data.xls; Jebel Aruda INAA data.csv*
- (2) Metadata/sample descriptions:  
*Jebel Aruda Ceramic Database.xls; Jebel Aruda Ceramic Database.csv*
- (3) A contact sheet of sherd image thumbnails:  
*Jebel Aruda Sherd Photo Index.pdf*
- (4) A contact sheet of ceramic paste photo thumbnails:  
*Jebel Aruda Paste Photo Index.pdf*
- (5) Exterior images of each artifact:  
*Jebel Aruda Artifact Photos.zip*

This folder contains 132 artifact images taken by Emberling and Wright at the Dutch National Museum of Antiquities. File-names specify INAA ID number and interior, exterior, or profile view (e.g., JEB\_049\_ext).

- (6) Ceramic paste photos of each artifact:

*Jebel Aruda Paste Photos.zip*

This folder contains 152 ceramic paste micro-photographs taken with an incident light microscope at 50 and 100 power magnification. File-names specify INAA ID and magnification (e.g., JEB\_01\_50x).

For Nineveh, see the folder *OSU-RC\_Nineveh\_Archive.zip*.

This folder contains:

- (1) Element concentrations in parts-per-million for each artifact:

*Nineveh INAA data.xls; Nineveh INAA data.csv*

- (2) Metadata/sample descriptions:

*Nineveh Ceramic Database.xls; Nineveh Ceramic Database.csv*

- (3) A contact sheet of sherd image thumbnails:

*Nineveh Artifact Photo Index.pdf*

- (4) A contact sheet of ceramic paste photo thumbnails:

*Nineveh Paste Photo Index.pdf*

- (5) Exterior images of each artifact:

*Nineveh Artifact Photos.zip*

This folder contains 60 artifact images taken at the British Museum. File-names specify INAA ID number and interior, exterior, or profile view (e.g., NIN\_014\_profile).

- (6) Ceramic paste photos of each artifact:

*Nineveh Paste Photos.zip*

This folder contains 44 ceramic paste micro-photographs taken with an incident light microscope at 50 and 100 power magnification. File-names specify INAA ID and magnification (e.g., NIN\_001\_50x represents sample NIN\_001 taken at a magnification of 50x).

For Tell Hadidi, see the folder *OSU-RC\_TellHadidi\_Archive.zip*.

This folder contains:

- (1) Element concentrations in parts-per-million for each artifact:

*Tell-Hadidi INAA data.xls; Tell-Hadidi INAA data.csv*

- (2) Metadata/sample descriptions:

*Tell Hadidi Ceramic Database.xls; Tell Hadidi Ceramic Database.csv*

- (3) A contact sheet of sherd image thumbnails:

*Tell Hadidi Artifact Photo Index.pdf*

- (4) A contact sheet of ceramic paste photo thumbnails:

*Tell Hadidi Photo Index.pdf*

- (5) Exterior images of each artifact:

*Tell Hadidi Sherd Photos.zip*

This folder contains 108 artifact images taken at the OSU Archaeometry Lab. File-names specify INAA ID number and interior, exterior, or profile view (e.g., HDD\_014\_PRO).

- (6) Ceramic paste photos of each artifact:

*Tell Hadidi Paste Photos.zip*

This folder contains 108 ceramic paste micro-photographs taken with an incident light microscope at 50, 100, and 200 power magnification. File-names specify INAA ID and magnification (e.g., HDD\_001\_50x).

For Tell Brak, see the folder *OSU-RC\_TellBrak\_Archive.zip*.

This folder contains:

- (1) Element concentrations in parts-per-million for each artifact:

*Tell Brak INAA data.xls; Tell Brak INAA data.csv*

- (2) Metadata/sample descriptions:

*Tell Brak Ceramic Database.xls; Tell Brak Ceramic Database.csv*

- (3) A contact sheet of sherd image thumbnails:

*Tell Brak Sherd Photo Index.pdf*

- (4) A contact sheet of ceramic paste photo thumbnails:

*Tell Brak Paste Photo Index.pdf*

- (5) Exterior images of each artifact:

*Tell Brak Sherd Photos.zip*

This folder contains 291 artifact images taken at the OSU Archaeometry Lab. File-names specify INAA ID number and interior, exterior, or profile view (i.e. TBK\_049\_ext).

- (6) Ceramic paste photos of each artifact:

*Tell Brak Paste Photos.zip*

This folder contains 214 ceramic paste micro-photographs taken with an incident light microscope at 50 and 100 power magnification. File-names specify INAA ID and magnification (i.e. TBK\_01\_50x).

For Tell Humeida, see the folder *OSU-RC\_TellHumeida\_Archive.zip*.

This folder contains:

- (1) Element concentrations in parts-per-million for each artifact:

*Tell Humeida INAA data.xls; Tell Humeida INAA data.csv*

- (2) Metadata/sample descriptions:

*Tell Humeida Ceramic Database.xls; Tell Humeida Ceramic Database.csv*

- (3) A contact sheet of sherd image thumbnails:

*Tell Humeida Sherd Photo Index.pdf*

- (4) A contact sheet of ceramic paste photo thumbnails:

*Tell Humeida Paste Photo Index.pdf*

- (5) Exterior images of each artifact:

*Tell Humeida Artifact Photos.zip*

This folder contains 10 artifact images provided by the researcher.

- (6) Ceramic paste photos of each artifact:

*Tell Humeida Paste Photos.zip*

This folder contains 30 ceramic paste micro-photographs taken with an incident light microscope at 50, 100, and 200 power magnification. File-names specify INAA ID and magnification (i.e. TH\_01\_50x).

For Kunji Cave, see the folder *OSU-RC\_KunjiCave\_Archive.zip*.

This folder contains:

(1) Element concentrations in parts-per-million for each artifact:

*KunjiCave INAA data.xls; KunjiCave INAA data.csv*

(2) Metadata/sample descriptions:

*KunjiCave Ceramic Database.xls; KunjiCave Ceramic Database.csv*

(3) A contact sheet of sherd image thumbnails:

*Kunji Cave Sherd Photo Index.pdf*

(4) A contact sheet of ceramic paste photo thumbnails:

*Kunji Cave Paste Photo Index.pdf*

(5) Exterior images of each artifact:

*Kunji Cave Artifact Photos.zip*

This folder contains 211 artifact images taken by the OSU Archaeometry Lab.

(6) Ceramic paste photos of each artifact:

*Kunji Cave Paste Photos.zip*

This folder contains 213 ceramic paste micro-photographs taken with an incident light microscope at 50, 100, and 200 power magnification. File-names specify INAA ID and magnification (i.e. KC\_01\_50x).

Data from other sites will be uploaded as they become available.

## Citations

Adams, Robert McC.

1981 *of Cities: Surveys of Ancient Settlement and Land Use on the Central Floodplain of the Euphrates*. University of Chicago Press, Chicago.

Adams, Robert McC. and Hans J. Nissen.

1972 *The Uruk Countryside: The Natural Setting of Urban Societies*. University of Chicago Press, Chicago.

Algaze, Guillermo

1989 The Uruk expansion: cross-cultural exchange in early Mesopotamian civilization. *Current Anthropology* 30(5): 571-608.

2005 *The Uruk World System: The Dynamics of Expansion of Early Mesopotamian Civilization* (2<sup>nd</sup> edition). University of Chicago Press, Chicago. (Originally published 1993).

Glascok, Michael D.

1992 Characterization of archaeological ceramics at MURR by neutron activation analysis and multivariate statistics. In *Chemical Characterization of Ceramic Pastes in Archaeology*, edited by H. Neff, pp. 11-26. Prehistory Press, Madison, WI.

2006 *Tables for Neutron Activation Analysis* (6th Edition). Missouri University Research Reactor (MURR), Columbia.

Minc, Leah D.

2013 *Trace-Element Analyses of Near Eastern Ceramics: A Re-Evaluation of the Uruk Expansion and Interregional Ceramic Exchange in the Late 4th Millennium BC*. A preliminary report circulated to collaborators for analyses supported by NSF award 1005945: Support of Coordinated, Regional Trace-Element Studies at the OSU-RC.