NATIONAL ENDOWMENT FOR THE HUMANITIES

DIVISION OF PRESERVATION AND ACCESS

Narrative Section of a Successful Application

The attached document contains the grant narrative of a previously funded grant application. It is not intended to serve as a model, but to give you a sense of how a successful application may be crafted. Every successful application is different, and each applicant is urged to prepare a proposal that reflects its unique project and aspirations. Prospective applicants should consult the NEH Division of Preservation and Access application guidelines at http://www.neh.gov/divisions/preservation for instructions. Applicants are also strongly encouraged to consult with the NEH Division of Preservation and Access staff well before a grant deadline.

Note: The attachment only contains the grant narrative, not the entire funded application. In addition, certain portions may have been redacted to protect the privacy interests of an individual and/or to protect confidential commercial and financial information and/or to protect copyrighted materials.

Project Title: Far from Home: Exploring the application of non-destructive XRF clay analysis for the provenience study of cuneiform tablets

Institution: University of Chicago

Project Director: Susanne Paulus

Grant Program: Research and Development

Far from Home: Exploring the application of non-destructive pXRF clay analysis for the provenance study of cuneiform tablets – Narrative

A Tier I NEH Research and Development Proposal

I. Significance

From about 3300 BC until about 100 AD, literate societies in the lands of western Asia, from western Iran, over Syria, Iraq to the Mediterranean, made written documents on clay tablets in cuneiform script. For more than 2000 years, cuneiform tablets were the dominant medium for recording, conveying and preserving written information, in Akkadian, Sumerian, and other ancient languages. Hundreds of thousands of these ancient documents survive in museums, academic, and private collections. Some cuneiform documents in modern museum and academic collections come from legal archaeological excavations, but hundreds of thousands come from illicit excavations, and many are now coming from looting and pillaging of known sites (Lawler 2005, 164-67, Reade 2017, 164-72). Unprovenanced[1] cuneiform clay tablets present a legal, ethical, and scholarly challenge for scholars, curators, law enforcement, and all concerned with the cultural heritage of the ancient Near East.

Since the 1800s, the European antiquities market has tolerated the looting of ancient Near Eastern artifacts (Reade 2017, 164-67). Since the early 1990s, the catastrophic developments in the region have encouraged the illegal excavation and sale of hundreds of thousands of tablets, reaching unprecedented levels during the 2003 Iraq War and the recent ISIS looting in Syria (Gibson 1997, Lawler 2005, Brodie 2008, 2011, Földi 2017). If the government and cultural authorities are successful in their efforts to confiscate and repatriate these tablets to their country of origin, it is vital that there be accurate and accepted criteria for identifying the source country. Establishing the object provenance is particularly important as a corrective to the practice of antiquities dealers involved in trafficking of the artifacts to mislabel the provenance of the tablets in efforts to obscure origins and to provide legal cover for the transaction.[2]

Identifying the provenance of a cuneiform tablet is no easy task, however. To the untrained eye, many tablets look indistinguishable. A careful study by cuneiformists[3] can often—but not always—identify their ancient origin, though not often their modern source. This project will explore a scientific methodology of provenance study based on the chemical composition of the clay as a useful tool that could benefit the scope and effectiveness of law enforcement efforts to seize and repatriate stolen tablets to their country of origin. Better locational evidence may lead to an increase in seizures and successful prosecutions of participants in the stolen antiquities trade, dampening the illicit art market effectiveness, and in turn, would disincentivize local looters thus protecting archaeological sites and contributing to regional security.

Beyond law enforcement and cultural heritage preservation, unprovenanced cuneiform tablets pose a severe problem for museum collections and scholars. Most museum collections with cuneiform tablets have a substantial amount of unprovenanced tablets legally acquired in the late 19th and early 20th century (Reade 2017, 164-67); by one estimate, some 300,000 to 400,000 unprovenanced tablets were housed in museum collections before 1990 (Lawler 2005). For example, of the around 6,500 tablets in the Oriental Institute Tablet Collection, only 35% were excavated and therefore have a secure provenance[4] while the remainder was either legally purchased or acquired as gifts.[5] For other collections, even significant academic or museum collections, the number of excavated tablets is significantly lower.[6] Unexcavated tablets in

[1] Provenance (or provenience) is the place of origin of an object, here read as the archaeological context in which an object was discovered. Unprovenanced tablets are looted artifacts without context.

[2] See for example (Brodie 2011, 126-27) for the "Barakat" tablets: paleographical study demonstrates that many of them likely come from one place and even one archive, yet dealers claimed they came from "Syria, Israel, Mediterranean, East Mediterranean, and Central Asia," see tab. 7.6. In the "Hobby Lobby Case," the tablets were claimed to originate in Israel, see the discussion by (Brodie 2017).

[3] "Cuneiformist" here refers the Assyriologists, Sumerologists, and other specialists working on languages and texts originally recorded in by cuneiform writing. .

[4] 2,289 cuneiform tablets derive from archaeological contexts.

[5] The Oriental Institute has a rigorous Acquisitions Policy in compliance with the UNESCO Convention of Means of Prohibiting and Preventing the Illicit Import, Export, and Transfer of Ownership of Cultural Property. https://oi.uchicago.edu/collections/oriental-institute-acquisitions-policy.

[6] Less than 1% of the over 30,000 tablets in the Yale Babylonian Collection come from excavations (numbers provided by Agnete Wisti Lassen, Associate Curator of the YBC at the Peabody Museum). Smaller collections, like the Charles L. Souvay Cuneiform Tablets Collection of the DePaul

museum collections often remain unknown to cuneiformists and hence unstudied,[7] as preliminary grouping by provenance and local archives is generally a precondition to raising the interest of cuneiformists.

Currently, the provenance of a cuneiform tablet without archaeological context only can be determined by internal criteria, beginning with a study of its content and any available acquisition history (Földi 2017, 8). A preliminary indication of provenance is suggested when a decipherment and edition of the tablet identifies toponyms (place names) and personal names; for many administrative and legal documents, archives and dossiers are reconstructed based on those criteria (Charpin 2010, 68-92, Baker 2004, 3-17).

This method has disadvantages and limitations. First, a separate study of every document is time-consuming. Even when a scholar encounters a small group of tablets acquired together, each of them must be studied separately and independently, as dealers regularly group together tablets from varying sources.[8] Second and ethically problematic, if the textual analysis is the only method to relocate unprovenanced material, it becomes a way for cuneiformists to justify their study and publication of illegal tablets (Westenholz 2010, Földi 2017, Owen 2009). The severe legal and ethical consequences of publishing looted antiquities remains an unresolved and divisive issue in cuneiform studies (Cherry 2014, Brodie 2016). Third, even this flawed method is not applicable for tablets with scholarly and literary tablets which lack prosopographical information[9] or for school tablets and other untypical tablets (Baker 2004, 5). Finally, identifying provenance from the internal criteria of place and personal names fails to forestall future harm: finding an ancient city name in the text does not reveal the modern name of the site, and thus no measures can be taken to prevent further looting.[10]

It is an important, therefore, for institutions, and governments concerned with cultural heritage and for archaeologists and cuneiform scholars to establish a valid non-textual method of establishing the provenance of cuneiform tablets. **The applicant proposes to explore and test the application of non-destructive geochemical clay analysis for the provenance study of cuneiform tablets**, a form of provenance study well-established in pottery analysis (Rice 2015, 342-49). The long-term goal is to establish a database of the material composition of cuneiform tablets (the "clay fingerprint") from different sites in the Near East. The database will allow scholars and law enforcement to associate unprovenanced tablets with a site of origin either by comparison with the composition of other tables or via data from systematic soil sampling from sites in the Near East. Such an endeavor will require collaboration between cuneiformists, conservators, archaeologists, geologists, and specialists of cultural heritage preservation.

Archaeology has deployed some methods for clay-artifact identification (Hunt 2017), of which portable energy dispersive X-ray fluorescence (henceforth pXRF) is especially attractive for the study of cuneiform tablets. pXRF analysis can provide data to support a meaningful clustering of clay objects based on their chemical composition (Holmqvist 2017) which, in comparison with soil samples from archaeological sites, may suggest conclusions about the provenience of the clay. Most importantly, pXRF is non-destructive, portable, and relatively less costly, all of which makes large-scale provenance studies feasible. While pXRF does not provide all the information available from destructive methods such as neutron activation analysis (Speakman et al. 2011), it nonetheless provides a source of data that can be used to characterize the chemical clay composition of cuneiform tablets, based on trace and major elements. In addition to pXRF, this study will explore the use of clay fingerprinting via laser-induced breakdown spectroscopy (LIBS), to explore the possibilities of another secondary, minimal-destructive method.

University Special Collections, often include only unprovenanced tablets (information courtesy of Morag Kersel, Associate Professor and Director of the Museums Studies Minor Program, DePaul University).

[7] 69% of the unprovenanced tablets in the Oriental Institute have not been published or even cited in any form, not even in such basic form as a catalogue.

[8] See (Földi 2017, 11-12) for an example of a unrelated tablets offered together as a single lot on the antiquities market.

[9] The study of colophons and of scholarly networks may provide some information; see (Robson 2014).

[10] The site of origin of the intensively studied Ur-III tablets from ancient Garšana and Iri-saĝrig, as well as the provenance of the Old Babylonian texts from Dūr-Abī-ešuḫ are still unknown (Földi 2017, 7). The same is true for the tablets of the Judea Exiles dating into the first millennium BC (Pierce and Wunsch 2014).

To make things more complicated, ancient places could change their names over time (Arkhipov 2014, Cancik-Kirschbaum and Ziegler 2018, 88). Scholars see Boivin, Dalley, Devecchi, and Paulus in (Paulus and Clayden forthcoming) discuss now whether the illegally excavated Old Babylonian texts from the ancient site of Dūr-Abī-ešuḫ (Van Lergerghe, Voet, and Hameeuw 2009), come from the same archive as the Sealand texts from Dūr-Enlil (Dalley 2009) and the Kassite texts from Dūr-Enlilē (van Soldt 2015). There is little hope to solve this problem philologically.

pXRF has been used successfully in previous studies to identify clusters of cuneiform tablets from the international correspondence found at the site of Tel el-Amarna in Egypt. Because these diplomatic letters were sent to Egypt from distant allies, scholars were able to establish that documents originating in Egypt from those coming in from Canaan (Levant), Ugarit (Syrian coast), Mitanni (central Syria), Hattusa (Turkey), and Babylonia (Southern Iraq). Tablets did indeed cluster according to their chemical signatures (Goren, Mommsen, and Klinger 2011). **However, it remains to determine whether pXRF can be employed successfully in geologically more uniform areas such as the alluvial plains of the Euphrates and Tigris rivers to pinpoint local clay sources.**

The use of pXRF to examine tablets from Iraq and Syria has had limited application in the past, and this study will refine and build on those experiences. A series of studies conducted by Watanabe et al. from 2009-15 showed promising clustering and broad distinctions among clay sources in Northern and Southern Mesopotamia, Turkey, and one site in Syria; no differentiation was possible among individual sites in southern Iraq (Uchida, Sasaki, and Watanabe 2011, Sterba et al. 2011, Uchida, Daiki, and Watanabe 2015).[11] These studies used devices which relied on fundamental parameters and a small calibration set of igneous rock samples which do not have the same elemental range of variation as clay samples (Uchida, Sasaki, and Watanabe 2011, 395, Uchida, Daiki, and Watanabe 2015, 180). Furthermore, they mixed archaeologically provenanced tablets with tablets for which provenance was ascribed based on the textual analysis (Uchida, Daiki, and Watanabe 2015).[12]

As a refinement, this proposed study will calibrate with reference standards appropriate to the sedimentary material in a manner which is replicable (Rowe, Hughes, and Robinson 2012, Speakman and Shackley 2013). The more extended testing period[13] will allow higher precision by taking multiple assays per tablet. Furthermore, it will allow adapting the method in response to intermediate results. The sample will include only securely archaeologically provenanced tablets in the Oriental Institute Tablet Collection for base studies. Finally, the applicant's expertise as a skilled cuneiformist will allow a careful distinction to be made between the relatively smaller number of tablets known to have circulated beyond their site of origin (letters, treaties, and documents of international trade) and the vastly more significant number of tablets produced and retained locally (economic and legal documents). If the proposed methods provide clear indications of provenance for tablets by compositional analysis, the results will be compared to textually-based provenance studies of cuneiform tablets. The results will illustrate the potential of the pXRF method for the field of cuneiform studies in general and build the basis for a constitutive project.

II. Background of the Applicant

The Oriental Institute (OI) was founded in 1919 with the goal to investigate in the broadest and deepest possible way the rise of civilization and the development of societies in the Ancient Near East. It is the oldest research institute of the University of Chicago. Its faculty and staff include broad variety scholars and specialists, and it has the technical and material capabilities needed for this study. Currently, the institution unites seven cuneiformists who specialize in different areas and periods, and five archaeologists specializing in the archaeology of Iraq, Iran, Turkey, Egypt, and Israel and Syria.

The tablet collection of the OI provides an ideal basis for conducting the project. More than one-third of the collection, over 2,200 tablets, were excavated by the OI and its affiliates and thus have secure provenance. Those tablets cover a wide variety of genres and periods and are therefore ideal for testing the proposed methodology. The remaining two-thirds of the tablets were legally acquired though without provenance; for 37% of this latter group of tablets, a possible provenance has been established based on textual criteria.

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[11] The team evaluated a selection of 540 clay tablets in the Yale Babylonian Collection in 2009-11, and another set of 94 clay tablets and bullae in the British Museum in 2013. C. Watanabe and M. Altaweel also sampled a selection of tablets from the Oriental Institute's Tablet Collection in 2014-15. The publication of the results is pending. Information provided by Mark Altaweel, Reader in Near East Archaeology, Institute of Archaeology London. The team agreed to exchange their results with the proposed project.

[12] The studies could for example not separate the clay source of the tablets from Nippur from that of the tablets from Adab (Uchida, Sasaki, and Watanabe 2011) (Uchida, Daiki, and Watanabe 2015).While the tablets from Nippur were excavated, the sample for Adab included only unprovenanced material. Information provided by Agnete Wisti Lassen (Yale Babylonian Collection, Peabody Museum of Natural History).

[13] The readings of Uchida, Sasaki, and Watanabe 2011, 394were done in a period five days.

The OI established a conservation laboratory in 1972 with professionally-trained conservators. The conservators are all highly trained specialists in archaeological conservation. The head of the laboratory would serve as the conservation consultant for the project.
The OI has experience in pXRF studies on pottery (Karacic and Osborne 2016) and cuneiform tablets. Lee Drake, the staff member for this project, currently conducts pXRF analysis of the cuneiform tablets from Persepolis (Iran) housed at the OI. He will also collaborate with the applicant on this project, providing the necessary equipment (handheld XRF and LIBS), data analysis software, and in-person training for the onsite procedures involved in the project. The proposed project will also collaborate with Edward Stratford whose ongoing project, "Mapping the Socio-Economic Geography of the Earliest Private Trade System," employs XRF analysis of cuneiform tablets from Turkey and has so far studied 2400 objects. Exchange of best practices, findings, and data between the projects will be beneficial for both.
The Oriental Institute has a well-documented and publicized stake in all aspects of cultural heritage preservation (Emberling and Hanson 2004, Stein et al. 2017). The Oriental Institute's Center for Ancient Middle Eastern Landscapes (CAMEL) provides experience in landscape-based cultural heritage preservation techniques and will be a vital partner for the future development of the proposed project. The cultural heritage component of this application will be developed further in cooperation with a fellow at the Museum Conservation Institute of the Smithsonian Institution, Katharyn Hanson. Her insights will be especially helpful in developing the next steps towards a large-scale project.

III. History, scope, and duration

The Tablet Collection of the Oriental Institute is well prepared to conduct this project. All tablets in the collection are now part of the KE EMu (Electronic Museum database). The entries include acquisition records for all tablets, provenance information if excavated, and information about the textual research and publications of those objects. The team is nearing completion of a systematic review of the conservation status of every object, crucial information for the selection of candidate tablets for the project according to the guidelines described below.
This project is conceptualized as a one-year pilot study to determine whether pXRF is a viable method for provenance study of cuneiform tablets and the extent to which it may be beneficial both from a collection's perspective and for cultural heritage preservation efforts. We will conduct pXRF readings from at least 600 tablets in the Oriental Institute collection; a subset will be tested using LIBS to investigate whether LIBS is a reliable additional resource. The results of this pilot project will be crucial in establishing the parameters of a follow-up project of provenance study for cuneiform tablets.

IV. Methodology and standards

Scientific methods of analysis (pXRF, LIBS) will be applied to a sample based both on archaeological information and on the results of a textual study by cuneiformists. For the analysis, the project uses scientific methods for clay analysis (pXRF and LIBS) according to accepted scientific standards; the tablets are selected based on the pool of specialized knowledge available only to cuneiformists. A feedback loop between the scientists analyzing the archaeometry results and the cuneiformists deciphering the texts will refine the method of testing and selecting candidate tablets.
In the first half of the project, the applicant will test securely provenanced, administrative clay tablets from different regions in Iraq to explore whether precise clustering according to provenance is possible. In the second half of the project, a selected group of Ur III-tablets, the most common unprovenanced administrative tablets,[14] will be tested.

Technologies

Energy dispersive X-ray fluorescence (ED-XRF) functions through exciting the inner electron shells of atoms to fluoresce characteristic lines; the intensity of the fluorescence corresponds to the quantity of that element in the analyte. In the past, this analysis has been conducted using destructive sample preparation to fit within laboratory equipment. Over the past two decades, however, miniaturization of x-ray tubes, the

[14] Many of the tablets belonging to the *Hobby Lobby Case* were identified as Ur III tablets likely from Irisagrig. https://www.washingtonpost.com/entertainment/museums/hobby-lobbys-illicit-artifacts-are-returned-to-their-iraqi-homeland/2018/05/02/3f59842a-4e44-11e8-84a0-458a1aa9ac0a_story.html?noredirect=on&utm_term=.301f739f6952.

development of lithium-ion batteries, and peltier-cooling of detectors have enabled handheld devices to detect elements ranging from sodium (atomic number 11) to uranium (92) (Bosco 2013). Portable, handheld XRF instruments now can be used non-destructively without sample preparation, making them ideal for the analysis of cultural heritage objects (Shugar and Mass 2012); however, the lack of sample preparations means that quantification is a challenge compared to traditional laboratory methods (Drake 2016). Accuracy comparable to traditional laboratory methods requires the use of reference standards appropriate to the matrix type (Speakman and Shackley 2013). This technique has resulted in strong provenance determination for obsidian artifacts (Rademaker et al. 2013, Brooks et al. 2018), which benefit from a) homogeneity and b) spatially circumscribed geochemical sources. The technique is more difficult for archaeological ceramic materials, which can involve complex mixtures of clays and other temper materials (Shepard 1976) as well as geochemical variation in the source that can preclude simple source assignment using non-destructive pXRF in the range of elements commonly detectable (Speakman et al. 2011). In some cases ceramics can be provenanced, though it is incumbent on the researcher to a) demonstrate the separation between geochemical sources, and b) determine diagnostic elements which distinguish between artifact types (Tykot 2016). Because cuneiform tablets require fine-grained clay types for writing (Taylor 2011, 5-7), they are more likely than other clay artifacts to be geochemically distinct. An pXRF study of tablets which had been previously examined using optical mineralogy (OM) and instrumental neutron activation analysis (INAA) showed a high potential for pXRF studies on cuneiform tablets (Goren, Mommsen, and Klinger 2011, Sterba et al. 2011).

Laser-induced breakdown spectroscopy (LIBS) functions by forming a plasma and recording light emitted from it. Different elements have different characteristic lines within the infrared, ultraviolet, and visible light wavelengths. As with pXRF, LIBS instruments have undergone miniaturization that enables handheld use. Unlike pXRF, LIBS is destructive as it requires the formation of plasma, although the damage is minimal and constrained to ~300 microns in diameter and ~20 microns deep, depending on the density of the sample. LIBS spectra also tend to be more complex; for example, Fe has two characteristic fluorescence lines in an pXRF spectrum, while in LIBS there are more than 18,000. The multitude of peaks may complicate quantitative analysis; it may directly compliment pXRF by providing a direct fingerprinting method for clays. Its inclusion in this study is primarily exploratory as this technique has not been widely adopted in archaeology, but pairing it with pXRF may provide an essential contribution from this study.

Specifics of Cuneiform Tablets

Clay tablets incised with cuneiform writing are complex objects. For the study proposed here, their fabrication, their original purpose, their content, and their provenance are known relevant factors; other criteria of which we are currently unaware may emerge. Cuneiform tablets are most frequently cuboid in shape with rounded edges. The size of the tablets varies, but most fit in the palm (Taylor 2011, 8). The project staff will perform for each tablet six readings (obverse, reverse, four edges) with both major and trace assays, yielding twelve assays per tablet.

The majority of cuneiform tablets was produced to record local bookkeeping matters, to keep the legal records of local families and institutions, or to train local scribes. It is likely that the raw material used for such local purposes would be locally sourced (Taylor 2011, 7, Reade 2017, 170) Ethno-archaeological studies in pottery production have shown that the majority of clay for pottery was acquired less than 1 km from the site of production (Rice 2015, 130-31).[15] Tablets are usually fabricated from fine clay, cleared from obstructing large stones and vegetation (Thickett and Odlyha 1999, Taylor 2011, Reade 2017, 169-70). Some tablets are made with a core (Taylor 2011, 11-12, 21-23), possibly from the recycled or different material, sheathed with a fresh layer of clay. The thickness of this layer can vary but is always higher than the penetrance depth of the analysis method proposed here. While our focus will be on undamaged tablet surfaces, as there is a substantial number of tablets with an exposed core in the collection, experimental

[15] A study of 26 cuneiform tablets from Tell Leilan with INAA (instrumental neutron activation analysis) in combination with soil sampling found a modest but significant match of sources and tablets (Blackman 2003).

core analysis will be done on a small scale. Tablets with flat or smooth uninscribed surfaces,[16] which are visually clean of incrustation or dirt (Goren, Mommsen, and Klinger 2011, 688) and have not received treatment of the surface, will be preferred. If unusual readings occur, the conservation history of the tablet(s) will be investigated.[17]

Project Phases

Phase 1: Training and protocol establishment

The goal for this phase is to establish a viable, high standard protocol for pXRF analysis of clay tablets and create a feedback circle which enables ongoing data interpretation and selection of new test material based on the appearing clustering. At the beginning of the phase, the project members will receive a three-day workshop and training about the potential and limits of the methodology, appropriate usage of the handheld XRF, and data interpretation. The training will also include data management and test readings.

The staff will establish a protocol for tablet selection, data mining, and interpretation based on the results.

Phase 2: Testing a group of securely provenanced tablets in the OI Tablet Collection

The goal of this phase is to establish whether pXRF is a reliable method to build clusters of cuneiform tablets excavated in Iraq and if those clusters are precise enough to distinguish between different areas or even close by sites. For this phase securely provenanced tablets will be sampled. The tablets are selected based on their find spots in different regions in Iraq: Adab and Nippur in the Southern alluvial plain between Euphrates and Tigris; Ishchali, Khafajeh, and Tell Asmar from the Diyala region; and Nuzi from the Kirkuk region. Selecting sites in a wide geographic range makes it likely that differences in the clay composition are visible while selecting tablets from sites in closer proximity permits to test how precise the clustering will be.[18] The staff will sample at least 40 tablets from each site from at least two successive time periods. The exact number will depend on the results obtained.[19]

Site (ancient name)	**Iraqi governorate**	**no. OI tablets available**	**Periods**
Bismaya (Adab)	Wasit	562	ED, OA, Ur III, IL, OB
Ishchali (Dūr-Rimuš, Neribtum)	Diyala	140	ED, IL
Khafajeh (Tutub)	Diyala	95	IL
Nuffar (Nippur)	Al Qadisiyah	1289	ED, OA, Ur III, IL, OB, MB
Tell Asmar (Ešnunna)	Diyala	78	OA, IL, OB
Yorghun Tepe (Nuzi)	At Ta'amim	101	MB

Tablets are recording legal and economic activities, as well as school tablets, which according to the working hypothesis were likely locally produced, will be selected first. Tablets which likely traveled from site to site (for example, letters) will be sampled in smaller numbers for comparison. For sites with tablets from more than one historical period, tablets from at least two consecutive periods will be selected to explore the influence of time on the grouping.

Phase 3: Reflection on the results, testing of new methods, and proposing alternative approaches

The goal of this phase is to react to the results obtained in phase 2 and establish a plan to move forward. The following type of questions need to be discussed: Does the clustering reflect our expectations? Are there viable explanations for unusual clay compositions? What roles do text type (administrative vs. other), period, and archeological site play? What are identifiable sources of contamination and how can they be avoided? Also, during this phase, the potential of LIBS as a more informative method will be explored. **If the clustering results correspond with the known provenance of the tablets**, the project will move to phase 4.

[16] For example on the edges or only partially inscribed reverse of the tablet.
[17] For a detail history of common conservation methods see (Reade 2017, 172-96).
[18] Nippur and Adab were selected as a previous study (Uchida, Sasaki, and Watanabe 2011) was unable to distinguish within those clusters.
[19] ED = Early Dynastic period (mostly ED IIIa and b, ca. 2600-2350 BC); OA = Old Akkadian (ca. 2350-2200 BC); Ur III = 3rd dynasty of Ur (ca. 2100-2000 BC); IL = Isin-Larsa (Early Old Babylonian period, ca. 2000-1800 BC); OB = Old Babylonian (ca. 1800-1550 BC); MB (Middle Babylonian, including Kassite, ca. 1550-1150 BC). Only periods with multiple tablets in the OI collection are mentioned here.

If a large-scale clustering occurs according to regions but not according to individual sites, the project will explore whether more precise clustering via LIBS is possible. If clustering by provenance is a result, the project will move to phase 4. The project will also explore the potential to trace crucial elements with micro-destructive methods, including microsampling on damaged tablets (Goren, Finkelstein, and Na'aman 2004, 4-20). Other possible methods of analysis may include but are not limited to Optical Mineralogy (OM), Instrumental Neutron Activation Analysis (INAA), and Scattered Petrographic Analysis (SPA). The staff will perform the microsampling at the Oriental Institute, and analysis will be accomplished at a variety of possible labs chosen by the consultants on this project. Additionally, tablets from other sites in the OI Tablet Collection will be tested, to explore where the limits of the method lie.

If the clustering is precise but does not reflect known provenance, the results will suggest that tablet production and movement for local administrative and legal texts are far more complicated than previously suggested. While such an outcome would controvert any precise provenance study of individual texts and change our assumptions about tablet production, it would demand to refocus the remainder of the project to understand better the mechanisms of tablet production and circulation.

Phase 4a: Application to unprovenanced tablets

The goal of this phase is to apply the developed method to a case study of unprovenanced tablets to further explore its potential. The test material will be a selection from the 3,500+ Ur III tablets in the OI Tablet Collection. Other than the 924 tablets from Adab and Nippur whose provenance is archaeologically secure, the OI acquired all tablets through purchase or gift without secure provenance. the or many, scholars have assigned a possible provenance by textual analysis (Hilgert 1998, Hilgert 2003). These inferred provenances are the ancient cities of Lagash, Drehem, Girsu, Umma, and Uruk.[20]

Site (ancient name)	**Iraqi governorate**	**no. OI Ur-III tablets available**	**mode of accession**	**mode of provenance attribution**
al-Hiba (Lagash)	Dhi Qar	3	1 excavation? 2 purchase/gift	study study
Bismaya (Adab)	Wasit	68	excavation	find spot
Drehem (Puzrish Dagan)	Al Qadisiyah	1119	purchase/gift	study
Nuffar (Nippur)	Al Qadisiyah	856	excavation	find spot
Telloh (Girsu)	Dhi Qar	393	2 excavations ? purchases/gift	study study
Umm al-Aqarib (Umma)	Dhi Qar	87	purchase/gift	study
Warka (Uruk)	Al Muthanna	528	purchase/gift	study
Unassigned		494	purchase/gift	n.a.

Comparing the results from the textual analysis with the clustering obtained via chemical clay analysis will allow insights into the precision of both methods and further elucidate the potential of non-textual provenance study. For example, will the unprovenanced texts from Puzrish Dagan will cluster near the texts from Nippur, as the location of the sites suggests? The results will allow predictions for other material from unknown sites and further highlight the potential of pXRF for provenance studies of cuneiform tablets.

Phase 4b: Dissemination and preparation of follow-up project

The goal of this phase is to define in close cooperation with our consultants and the members of the advisory board the requirements for a broad application of the methodology for museum collections and cultural heritage preservation. Firstly, this will include a determination of how best to locate the clay sources using old and new soil samples, and the potential of studying comparative materials such as ceramics and bullae. Secondly, the project members will determine the requirements to establish a comprehensive and accessible database of chemical clay composition which will be useful for curators, cultural heritage preservation, and scholars. This step will include a meeting of the PI and Katharyn Hanson at the Smithsonian Institution (Washington, DC) to discuss needs and possibilities. Thirdly, the project will make the established protocol

[20] The results confirm general trends visible in textual provenance study for Ur III texts as presented in the comprehensive database of Neo-Sumerian texts (BDTNS). http://bdtns.filol.csic.es/estadisticas_mapa_todos.php

as well as the results freely available in the form of publication on the OI website as well as in a peer-reviewed publication.

V. Workplan

Phase	**Timeline: Year 2019**												**2020**
	01	02	03	04	05	06	07	08	09	10	11	12	Beyond duration of Tier I
1: Training and protocol establishment	S C	S C											
2: Testing securely provenanced tablets		S	S	S	S	S							
3: Reflection on results, testing new methods						S C A	S C A	S C A					
4a: Testing unprovenanced Ur III tablets							S	S	S	S	S		
4b: Dissemination and preparation of follow-up project											S C A	S C A	Follow-up project if method promising
Reports for Evaluation													Peer-reviewed publication

Involved: S = Staff; C = Consultants; A = Advisory board

VI. Staff

Primary Staff

Dr. **Susanne Paulus** (10% cost share), Tablet Collection Curator at the Oriental Institute, Assistant Professor of Assyriology at the OI, the Department of Near Eastern Languages and Civilizations, and the College of the University of Chicago, will serve as Principal Investigator of the proposed project. In her capacity as Tablet Collection Curator, she is responsible for the management of the tablet collection, facilitates publication and research projects, manages the staff and volunteers, and leads its public engagement and outreach of the Tablet Collections. She works closely with the registration and conservation at the OI. Her scholarship investigates legal and economic texts from Southern Iraq. She has an interest in archive reconstruction, provenance studies, and the identification of ancient sites as well as the reconstruction of ancient topography. She teaches undergraduate and graduate classes with a focus on object-based inquiry. She currently oversees two Ph.D. theses.

As **PI** she will manage the proposed project and set its intellectual aims and methods. She will be the primary cuneiformist working on the project, responsible for the selection of the tablets and the historical interpretation of the results. She will lead the planning of the follow-up steps of the project, the publication of the results, and the dissemination efforts.

B. Lee Drake, Ph.D., Vice President of the Paleoresearch Institute and Adjunct Professor at the University of New Mexico, (contract), is an XRF specialist who has worked worldwide with archaeologists, agronomists, engineers, and nuclear physicists on developing mobile solutions for advanced analytical problems. Currently, he works as a collaborator with the Persepolis Fortification Archive Project at the OI and for Edward Stratford's project on the Old Assyrian trade at the Brigham Young University. He received his Ph.D. from the University of New Mexico with a focus on paleoclimatic reconstruction using stable isotopes and has since focused on non-destructive spectral analysis.

Lee Drake will provide an in-depth introduction to and training in pXRF and LIBS to the project team. He will conduct two three-day onsite workshops with the team and will help to establish the protocol for the analysis. He will be responsible for the principal archaeometric analysis of the data and will co-author publications resulting from the project. He will also provide the technical equipment (handheld XRF and LIBS units) and provide the necessary data analysis software to distinguish clay types geochemically.

A **Ph.D. student in Near Eastern Archaeology**, to be determined (500 hours), will conduct the pXRF readings on the tablets. There are several qualified students in the Ph.D. program of the Department of Near

Eastern Languages and Civilizations who can fulfill the role and would greatly profit from training in pXRF. The primary role of the graduate student will be to conduct the time-consuming pXRF readings and oversee transmission and management of the data. She or he will be involved actively in the development of the protocol, the interpretation of the data from an archaeological perspective, and will be a co-author on the publication of results.

Colton Siegmund, Assistant Curator of the Tablet Collection, and graduate student in Cuneiform Studies, Department of Near Eastern Languages and Civilizations, the University of Chicago, (200 hours), is responsible for conducting the daily business of the tablet collection. He will facilitate all object-based business for the project, including pulling the selected tablets, transferring them, and maintaining the related paperwork. On an intellectual level, he will assist in selecting suitable tablets and updating the catalog entries, and he will support the text-based research and co-author the resulting publications.

Consultants

Laura D'Alessandro, Head of the Conservation Laboratory, Oriental Institute, will consult on matters of tablet conservation and preservation. She has over 34 years of experience in the conservation of archaeological materials and is deeply knowledgeable about the Oriental Institute's tablet collection and its history.

Katharyn Hanson, Ph.D., Fellow, Smithsonian Institute's Museum Conservation Institute and Executive Director of The Academic Research Institute in Iraq (TARII), is a Mesopotamian archaeologist specializing in the protection of cultural heritage and will consult in this project on collaboration and interaction with the broader cultural heritage preservation field. She will also consult on developing this proposal into a follow-up project involving Iraqi cultural heritage practitioners and source clay from archaeological sites through the Iraqi State Board of Antiquities and Heritage, as well as how best to provide this information to Iraqi and US law enforcement.

Edward Stratford, Ph.D., Associate Professor at the Brigham Young University, is head of the "Mapping the Socio-Economic Geography of the Earliest Private Trade System" project which does pXRF studies on cuneiform tablets mainly from Turkey will consult on the development of best practices for pXRF studies on tablets. Furthermore, the project outlined here and his project will exchange data.

Advisory board

The advisory board supports the project with the breadth of scholarly knowledge available at the Oriental Institute. The advisory board members serve as additional consultants in cuneiform studies, archaeology, and cultural heritage preservation matters. They will provide feedback on the interim and final report, and crucially will advise on preparing the next step of the project, based on the results obtained.

Jean M. Evans, Ph.D., Chief Curator and Deputy Director, Oriental Institute Museum, Research Associate, Oriental Institute Museum.

McGuire Gibson, Professor of Mesopotamian Archaeology, Oriental Institute, University of Chicago.

James Osborne, Assistant Professor of Near Eastern Archaeology, Oriental Institute, University of Chicago.

Hervé Reculeau, Assistant Professor of Assyriology, Oriental Institute, University of Chicago.

Martha T. Roth, Chauncey S. Boucher Distinguished Service Professor, Oriental Institute, University of Chicago.

Gil Stein, Professor of Near Eastern Archaeology, Oriental Institute, Senior Advisor to the Provost for Cultural Heritage, University of Chicago.

Matthew Stolper, John A. Wilson Professor Emeritus of Assyriology, University of Chicago. Director of the Persepolis Fortification Archive Project, Oriental Institute.

Agnete Wisti Lassen, Ph.D., Associate Curator, Yale Babylonian Collection, Peabody Museum.

Christopher Woods, John A. Wilson Professor of Sumerology, Dept. of Near Eastern Languages and Civilizations, and the College, University of Chicago, Director of the Oriental Institute.

VII. Evaluation and sustainability

The OI is a research institution committed to the highest standards of rigorous scholarship. The OI's museum is committed to preserving its collections and to disseminating information. To secure rigorous

methodology and reliable results, the project will distribute its preliminary results in the form of an interim report after phase 2 to the members of the advisory board and solicit their feedback. After the conclusion of phase 4, the final report including methodology, data, and results will be made available and public on the OI website. The project staff also will submit the results to a peer-reviewed journal for publication.

The data, as well as the report, will become part of the OI's integrated database (IDB) containing all information about the tablets examined during this study. New information obtained during the study will be integrated directly. The OI's Integrated Database Project aims to provide public access to information about the diverse research and object-based collections managed and cared for by the OI via an online portal (http://oi-idb.uchicago.edu). For public access to information about the OI's collections, a public website portal was created and functional development to this "front end" will continue for the foreseeable future. The OI is committed to the long-term preservation of its digital assets, including its metadata. All metadata are stored in the integrated database run on a series of four multi-terabyte Storage Area Networks including the following servers: (b) (4) , (b) (4) , (b) (4) , and (b) (4) . These servers correspond with live and test versions of the internal client database and live and test versions of the online web database. These RAID-5, secure SAN with additional secure off-site backup at (b) (4) . All servers are maintained by the University of Chicago IT Services and are connected to two independent power grids.

The clay tablets used for this study will be conserved according to best practices of the field and in close cooperation with the head of the conservation department. All tablets are stored in individual, cushioned boxes, and kept in museum storage in a secure climate-controlled environment. The applicant is currently exploring possibilities to address ongoing conservation issues.

VIII. Intended audience

This project addresses at least three different audiences. The first group of stakeholders consists of curators and museums professionals in charge of collections housing cuneiform tablets. There are 15 such collections in the US alone currently represented in the Cuneiform Digital Library initiative.[21] Gaining additional information about tablet provenance is helpful for cataloging and promotes the timely publication of objects.

The second group of stakeholders consists of scholars of the languages and cultures of ancient Mesopotamia. The study's methodology will help with archival construction and advance our knowledge of the material components of cuneiform tablets. Scholarship has so far concentrated primarily on the textual content of those objects; this study will provide information on the materiality of the objects, such as information about locally-sourced clay. This study will provide crucial comparative material for scholars working on projects with similar goals outside of the Mesopotamian heartland. Furthermore, there is potential that this method can help in the future to locate sites identified within the cuneiform textual record as the place of origin but as yet unidentified on the ground. Finally, this study will help counter the arguments of some assyriologists in favor of publishing looted cuneiform tablets, arguments that cultural preservationists claim to encourage looting.

The third group of stakeholders includes cultural institutions and governments concerned with cultural heritage preservation. If the provenance of a tablet can be determined reliably, quickly, and scientifically with a portable device, the information given by dealers and owners trying to circumvent restrictions on the important and purchase of cuneiform tablets can be checked at key points of entry. International and US law enforcement will have a valuable tool in efforts to repatriate the seized cultural property to its country of origin.

Finally, if the fingerprinting of cultural objects via LIBS proves to be a promising approach, this method has possible applications beyond clay tablets with cuneiform writing and may be applied to ceramics in general. Museum collections and archaeological excavations could fingerprint their materials, which would then help to identify stolen or looted objects if they appear on the black market.

[2] (b) (4) . The list provided is likely incomplete.