*Journal of Ancient Egyptian Interconnections*

# Moving Archaeological Sciences Forward in Egypt

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Archaeological science—or the application of the chemical, physical, and environmental sciences, as well as computer and satellite technologies to ancient remains—has revolutionized the way archaeologists understand the past.[1] Scientific techniques allow archaeologists to ask new questions of data and gain novel perspectives of socio-economic practices, technology, health, diet, and the environment. Archaeologists have yet to explore the full potential of this research for many reasons, most of which relate to a limited awareness of labs in Egypt, difficulties transferring samples to local labs, and a lack of funding for scientific archaeology. Given the near prohibition of exporting samples to extant labs abroad, there is a strong need to develop archaeological science facilities and expertize in Egypt. The last decade has witnessed the development of new labs and increased collaborations between archaeologists and scientists, bringing exciting possibilities to the study of ancient Egypt.

Scientific analyses that can be conducted in the field with imported equipment are relatively common in Egypt. Geophysical surveys (e.g., magnetometery, geoelectric resistivity surveys, ground penetrating radar), conducted by both international and Egyptian teams, have provided valuable insight into the changing environment and settlement patterns at many sites in Egypt.[2] Likewise, portable X-ray fluorescence (XRF) enables materials characterization in the field, which allows archeologists to address a wide array of questions.[3] These analyses have greatly contributed to our understanding of ancient Egypt, but it is not possible to conduct tests in the field for most scientific techniques.

There are significant differences between ancient and modern materials that require labs to make special accommodations for archeological science. Archaeologists not only require access to facilities, but also collaborations with labs that have scientific protocols—or a written procedure for experiments—to analyze ancient materials. Several extant labs are particularly strong in analysis of mummies, as well as restoration and conservation. Computed tomography (CT) scanning of mummies at the Faculty of Medicine at Cairo University and DNA analysis of royal mummies at the Faculty of Medicine at Kasr al-Ainy Hospital have generated insight into larger historical questions regarding royal families.[4] Most museums in Egypt have done extensive work with conservation, and it is the major focus of archeological science education at Egyptian Universities. For example, the Grand Egyptian Museum (GEM) has a ground-breaking lab for restoration and conservation.

Finding suitable labs and collaborative scientists is a major challenge for archaeologists, although there are several viable options for some types of analyses. Ceramic petrography is a good example where the labs at the Institut français d'archéologie orientale (IFAO)[5] and the Centre d'études Alexandrines (CE Alex)[6] can prepare samples and cross polarizing microscopes are available for a fee.

The methods used to date materials, as well as address questions of ancient diet and health, environmental change, technological practices, as well as trade and interregional interactions, require physical and chemical analyses. Despite dating ancient materials being a priority for many archaeologists, there are few options in Egypt. The only facility available for dating organic materials is the radiocarbon (14C) lab at IFAO.[7] Other options are not

yet available in Egypt. This is particularly problematic for dendrochronology, which is only now developing utility for Egypt and can also inform on climatic events.[8]

Chemical characterization and residue analysis, often conducted on materials excavated decades ago from museum collections abroad, are particularly informative on trade networks between Egypt, the Near East, and the Mediterranean world. Isotope analysis measures changes related to ancient environments and diet that result from an organism's interaction with its environment. For example, isotope analysis conducted abroad on dental remains from recently excavated tombs in Tombos (Sudan) show that the people buried in Egyptian-style graves were raised in an environment different from that of Lower Nubia, suggesting these individuals were immigrants from Egypt.[9] Isotope analysis, unfortunately, is not currently being applied to ancient materials in Egypt.

There are many characterization analyses that are technically available but underutilized in Egypt, including: inductively coupled plasma-mass spectrometry (ICP-MS), gas chromatography mass spectrometry (GCMS), X-ray fluorescence (XRF), and scanning electron microscopy (SEM). Isotope analyses employ several types of mass spectrometry (e.g. multiple-collector inductively coupled plasma mass spectrometry [HR-MC-ICPMS] or Thermal Ionization Mass Spectrometry [TIMS]) that are also theoretically present in Egypt. Labs that have the requisite equipment include the National Research Center in Egypt[10] and several science faculties at Egyptian universities (e.g. Faculty of Agriculture and the Faculty of Geology, Cairo University), but they are rarely used because collaborations between these labs and archaeologists have not been formed. Further, many of them do not have protocols for analyzing ancient materials. For archaeological science to proceed in Egypt, archaeologists first need to forge the relationships with these labs so that they establish protocols for dealing with ancient remains.

While undertaking the archaeological sciences in Egypt seems prohibitively challenging, there are several positive changes on the horizon. This field is gaining more attention both in the academic community and the media, which can lead to awareness, and, hopefully, funding.[11] For instance, I am writing a series with *Nature Middle East* on archaeological science in the region that focuses attention on exciting research projects and the numerous challenges in the field.[12]

Additionally, several archaeologists and scientists are organizing conferences in Egypt on these matters. IFAO is hosting "Archaeometery: Another Point of View," a conference to be held on December 15, 2016, in Cairo,[13] which will explore the various scientific techniques used outside Egypt to examine the past. Also, in collaboration with IFAO, the American Research Center in Egypt (ARCE), the Egypt Exploration Society (EES), and the German Archaeological Institute (DAI), the Ministry of Antiquities (MOA) is organizing the Conference on the Science of Ancient Egyptian Materials and Technologies (SAEMT).[14] This international conference—to be held in Cairo on November 4–6, 2017—will bring together representatives from the MOA, international archaeology bodies, and both foreign and Egyptian archaeological scientists, as well as representatives from labs in Egypt for the first major meeting of its kind. It is valuable for archaeologists, even those who do not have scientific programs in their excavation, to attend such conferences in order to gain insights into the research potential of archaeological science and the mechanics of conducting such analyses in Egyptian labs. Only through collaboration can we explore the full range of potential with ancient Egyptian artifacts, and these conferences are a step forward to achieving this goal.

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[1] The author wishes to thank the following people for their valuable discussions on archaeological science in Egypt: Mennat-Allah El Dorry, Anita Quiles, Johanna Sigl, Abdelrahman Medhat, and Basaem Gehad.

[2] For example, geophysical surveys around Luxor have expanded on the ways the shifting Nile could affect the landscape and cult activities; see J.M. Bunbury, A. Graham, and M. Hunter, "Stratigraphic Landscape Analysis: Charting the Holocene Movements of the Nile at Karnak through Ancient Egyptian Time," *Geoarchaeology* 23.3 (2008): 351–373; J.K.Hillier et. al., "Monuments on a Migrating Nile," *Journal of Archaeological Science* 34 (2007): 1011–1015; and M. Ghilardi and M. Boraik, "Reconstructing the Holocene Depositional Environments in the Western Part of Ancient Karnak Temples Complex (Egypt): A Geoarchaeological Approach," *Journal of Archaeological Science 38* (2011): 3204–3216. Similar analyses in the Delta have also provided a wealth of information on settlement patterns and ancient water courses; for example, M. el Gamili et al., "Defunct Nile Branches Inferred from a Geoelectric Resistivity Survey on Samannud Area, Nile Delta, Egypt," *Journal of Archaeological Science 28* (2001): 1339–1348; and B. Pennington and R. Thomas, "Paleoenvironmental Surveys at Naukratis and the Canopic Branch of the Nile," *Journal of Archaeological Science: Reports* 7 (2016): 180–188.

[3] For example, one such study conducted XRF analysis

on mud bricks from a large, square enclosure at El-Hibeh found that sections of construction could be identified by bricks with different chemical compositions, which speaks to larger issues of work organization: V. L. Emery and M. Morgenstein, "Portable EDXRF Analysis of a Mud Brick Necropolis Enclosure: Evidence of Work Organization, El Hibeh, Middle Egypt," *Journal of Archaeological Science* 34 (2007): 111–122.

4 For a summary of such work, see Z. Hawass and S. Saleem, *Scanning the Pharaohs: CT Imaging of the New Kingdom Royal Mummies* (Cairo: AUC Press, 2016).

5 Web page: http://www.ifao.egnet.net/ifao/services/. Several scholars have used the IFAO lab to analyze materials from all over Egypt that further an understanding of trade and local production practices; for example, U. Hartung, E. C. Köhler, V. Müller, and M. F. Ownby, "Imported Pottery from Abydos: A New Petrographic Perspective," *Ägypten und Levante* 25 (2015): 295–333; and L. Peloschek, *Cultural Transfers in Aswan (Upper Egypt): Petrographic Evidence for Ceramic Production and Exchange from the Ptolemaic to the Late Antique Period*, PhD dissertation (Vienna 2015).

6 Web page: http://www.cealex.org/sitecealex/navigation/FENETR_NAVcealex_F.htm.

7 Web page: http://www.ifao.egnet.net/c14/.

8 P. P. Creasman, "Tree Rings and the Chronology of Ancient Egypt," *Radiocarbon* 56.4/*Tree-Ring Research* 70.3 (2014): S85–S92, doi: http://dx.doi.org/10.3959/1536-1098-70.3.85.

9 M. Buzon and G.J Bowen, "Oxygen and Carbon Isotope Analysis of Human Tooth Enamel from the New Kingdom Site of Tombos in Nubia," *Archaeometery* 52 (2010): 855–868.

10 Website: http://www.nrc.sci.eg.

11 For example, see Sonia Zakrzewski, Andrew Shortland, and Joanne Rowland, *Science in the Study of Ancient Egypt* (London: Routledge, 2015).

12 See M. Brand, "Piecing Together the Past Demands Forging Links in the Present," *Nature Middle East*, 10 October 2016, https://www.natureasia.com/en/nmiddleeast/article/10.1038/nmiddleeast.2016.184 (accessed 8 November 2016).

13 See: http://www.ifao.egnet.net/manifestations/#749.

14 See: http://www.saemt.com.