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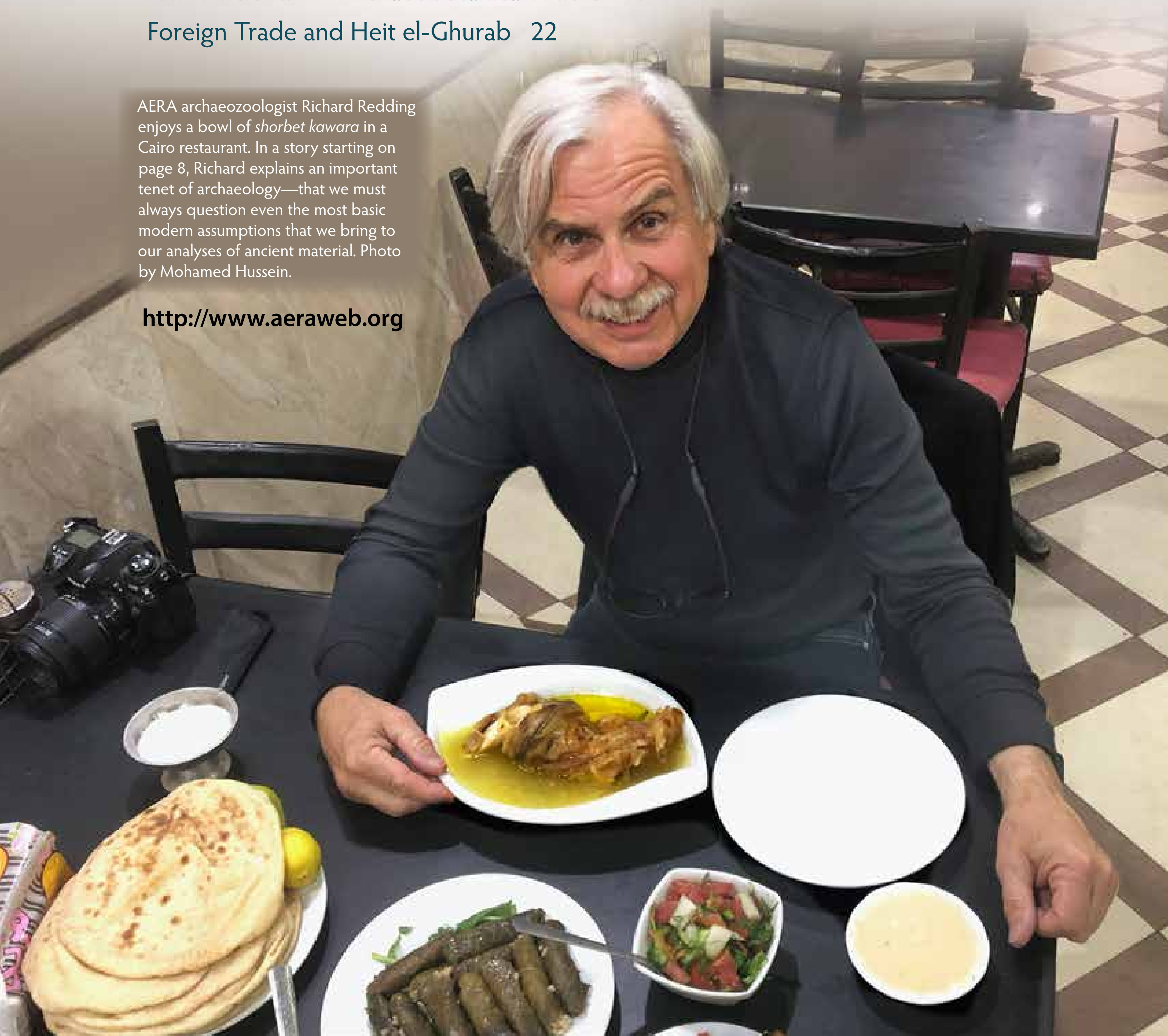
Tales from the Lab

In Memoriam



AERA archaeozoologist Richard Redding enjoys a bowl of *shorbet kawara* in a Cairo restaurant. In a story starting on page 8, Richard explains an important tenet of archaeology—that we must always question even the most basic modern assumptions that we bring to our analyses of ancient material. Photo by Mohamed Hussein.

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In Memoriam

The year 2019 was one of profound losses for AERA. Within the span of just four devastating months, from August through November, we lost three dear members of our family and team. First was the passing of major AERA donor and friend, David H. Koch, a benefactor crucial to AERA's success and growth through his decades of financial support and constant encouragement. Second, we lost Glen Dash—team member, close friend, board member, Giza scholar, and donor. Lastly, we were stunned by the sudden loss of Rabea Mohamed Shehat, a beloved AERA family member and AERA-Egypt Center constant. We feel these losses still. Here, AERA Director Mark Lehner relates his thoughts on Glen and Rabea and a few words about what they meant—and continue to mean—to our team.

Glen Dash: 1953–2019

My dear friend, colleague, team member, supporter, and valued AERA board member Glen Dash passed away on Thursday, September 19, 2019. I learned of his death in the first hours of the morning on September 23, while in transit from Cairo back to Boston, where I hoped to see Glen again soon.

Only five months earlier I had been working with Glen at the Sphinx as part of the Return to the Sphinx Viewing Project (RSVP) under the direction of Dr. Zahi Hawass. The project saw us back at the Sphinx, 30 years after Zahi and I had worked there at the launch of our careers, to take one last intensive look through geophysical and state-of-the-art survey and to bring together all the information about the Sphinx that had accumulated in the 40 years since we worked there in 1977–1978. Glen made this project possible through his support and participation.

I first met Glen in a small photography darkroom in the basement of the Harvard Semitic Museum (now Harvard Museum of the Ancient Near East), on loan to me as a working space and office when I was Research Associate at the museum in 1993. Glen and his wife, Joan, and daughter, Rebecca, joined us in the field at the turn of the millennium, as we began to peel back sand and rubbish to unveil and salvage part of a heretofore "Lost City of the Pyramids." The Dash team did geophysical survey ahead of our excavations. (It was Glen's survey that tells us that the Royal Administrative Building extends a good 150 meters under a modern soccer field from where we excavated its northern end.)

Glen joined the AERA board as an active "doer" and "donor." As Secretary of the board for many years, Glen offered unofficial legal counsel, kept AERA in compliance with state and federal nonprofit regulations, and helped me run our board meetings properly following Robert's Rules of Order.

Through the years, Glen made it possible for AERA to keep up with computers. He not only bought new computers for individual AERA team members, for the AERA Boston office publications department, and for the AERA-Egypt Center, in 2017 he made possible for our IT Director, Midou (Mohamed Saied) to purchase and install a 16- (now 40-) terabyte server, which allowed us to store all field data that AERA collects. With the server at home in the AERA-Egypt Center, more than ten users at a time can access it from anywhere in the world.[1] Midou exclaimed at when he installed it, "this was not only a new server, it was an entire new system upgrade."

Over the last several years, Glen took an increasing interest in the "mapping" part of the Giza Plateau Mapping Project (GPMP). The GPMP gave birth to all our research and salvage excavations and our archaeological training programs. Research and training excavations, and analysis of the settlement and material culture of the people who built the pyramids, took over our budgets, agendas, and our original goals to map the whole Giza Plateau. But Glen kept our focus on the pyramids themselves, especially the Great Pyramid—the very reason-for-being of the human and cultural remains that now so occupied us.

We began gathering together all the maps of monuments, sites, and features of the Giza Plateau we had surveyed and drawn, often stone by stone, by hand at large scales (the Sphinx, Sphinx Temple, Khafre Valley Temple, Khufu Upper Temple, Khufu boat pits, Khafre Pyramid corners, and of course the sites of the Heit el-Ghurab, Menkaure Valley Temple, and Khentkawes Town and Monument). Meanwhile, Glen analyzed the unpublished data from the survey of the Great Pyramid that California Department of Transportation surveyor David Goodman and I did in 1984. Glen plotted the results of that data for a most recent statement on the much-discussed size and orientation of the Great Pyramid.[2]

Glen especially impressed me with his precision when he tracked down Flinders Petrie's points from when that "father of Egyptian archaeology" surveyed the Great Pyramid and Giza Plateau in 1880–1881. The 26-year old Petrie, trained as a professional, surveyed Giza by triangulation from fixed points called "stations," because the surveyor "occupies" the points by setting a survey instrument, like a transit or theodolite, directly and precisely over them. In an ingenious way, Petrie made his points very small, to minimalize damage to the stone surfaces, and un-erasable. He marked each exact point with a pencil lead set in baby-blue plaster that filled a 0.15-inch (3.81-millimeter) diameter hole drilled 1 to 1.5 inches (2.54 to 3.81 centimeters) deep. How could we have any hope of finding points smaller than a thimble over the immensity of the pyramid plateau? Glen managed.

At the southwest corner, the Great Pyramid's giant foot pointed us to three of Petrie's tiny blue holes. To find Petrie's other points, Glen basically used Petrie's data to retro-locate his points in terms of our GPMP coordinates. At the foot of the pyramid, or on top of an ancient mastaba tomb far to the west, I was amazed to be looking at little pencil-thin blue spots, so conscientiously placed by Petrie 135 years earlier, and so meticulously retrieved by Glen Dash. Would that our survey markers had fared so well!

Glen wrote about his re-tracking of Petrie's points and much more.[3] He described how the ancient Egyptians used the sun to find true north to lay out their pyramids and temples;[4] why so many of their gigantic, non-pyramid structures (like the whole of the HeG site, the Wall of the Crow, the Khentkawes Town and Monument, and the quarry channels) twist slightly west of north;[5] and his specialty, geophysical survey.[6] He left an impressive record, now often cited in professional publications, through our *AERAGRAM* annals.

During the 2012 field season, Glen directed a joint Glen Dash Foundation Survey (GDFS)-AERA team to survey our own precise, pinpoint locations for major features of all three major pyramid complexes, queen's pyramids, mastaba tombs, and the Sphinx with a Total Station and the GPMP coordinate system. The idea was to geo-rectify our own and any other maps of the Giza Necropolis. With Glen's support and AERA's permissions from the Ministry of Antiquities, the 2012 survey included the first new data on the base of the Khufu Pyramid since the Goodman and Lehner survey of 1984. Glen, Joan, and Rebecca Dash worked with AERA surveyors Mohamed Abd el-Baset and Amr Zakaria team to establish closed-loop surveys for the Khufu Pyramid. They took Total Station points on the remnants of Khufu's builders' original lines—what is left of the pyramid baseline in the casing, and the platform upon which the casing sits.[7]

Glen Dash enjoys the view from the top of the Great Pyramid, while the GPS unit (not shown in photo), which he and his team carried up, interacted with satellites in order to precisely locate a brass plug, Station E1, on the World Geodetic System (WGS) 84 reference ellipsoid. This station in the Survey of Egypt control grid, and the Great Pyramid coordinates, had originally been located in an older model of the earth that was displaced by the more accurate ellipsoid adopted by the WGS in 1984. Photo by Sayed Salah.

In 2015, Glen Dash followed up with a survey by this team and professional surveyor Joel Paulson to establish *the* standard reference survey for the base of the Great Pyramid. After the team documented and surveyed the points, Glen used a standard statistical method known as linear regression analysis to "best-fit" lines to the data and to provide estimates for the pyramid corners. Rather than giving definitive discrete values for the lengths of the sides, he provided ranges within which the corners might have fallen, with greater or lesser probabilities. It was apparent in 2015 that what remained of the original builders' lines (about 28% of the original casing and platform) were not what they were in 1984. They are subject to constant weathering from natural elements and tourist traffic. Any future survey could only establish another set of probabilities, on even less of the original lines. This is why Glen's survey, and his publications of it,[8] including in the prestigious *Journal of Egyptian Archaeology*,[9] will remain definitive.

But Glen wasn't done with the Great Pyramid. He saw something in the surveys that still needed fixing. We actually were lacking good coordinates for the position of the Great Pyramid on the planet. When Glen put the published coordinates for the top of the Great Pyramid in Google Earth, the pyramid jumps more than 180 meters west of where it actually is. As Glen so clearly explained, "The reason for the discrepancy is that our model of the Earth has changed." The Great Pyramid coordinates are based on an old "Helmert" ellipsoid, not the much more accurate ellipsoid adopted by the World Geodetic System (WGS) in 1984. To make the fix, Glen and surveyor Joel Paulson needed to climb to the top of the pyramid.

With Ministry of Antiquities permission, on February 26, 2018, Glen and Joel, along with Glen's daughter Rebecca, her husband Eric Sperber, and AERA Overseer Sayed Salah, climbed to the truncated top of the Great Pyramid to place a Global Positioning System (GPS) on a brass plug, Station E1. The official Survey of Egypt placed this "first order" (of accuracy) station (under the Helmert ellipsoid) as a kind of lynchpin in the official Egyptian survey control network. Glen wrote about his climb, and his experience at the top. It was the best of days. While the GPS unit interacted with unseen satellites, "to precisely locate Station E1 on the WGS 84 reference ellipsoid and restore its integrity within the Survey of Egypt control grid," the survey members enjoyed expansive views in all direction and took pictures. Glen was thrilled to ascend the Great Pyramid. He said that he could not ask for a better milestone to mark turning age 65 than to set the pyramid in its proper place![9]

That same season, 2018, we started working together at the Sphinx with Zahi Hawass on the RSVP. Glen once again made it possible for Ashraf Abd el-Aziz and Amr Zakaria to work with us, now to survey and map all the features cut into the

The 2015 GDFS team, which surveyed the base of the Great Pyramid. Top row from left: Glen Dash, Joan Dash, Joel Paulson, Amr Zakaria, Midhat Mahmoud Abu Shahien, and Mohamed Abu Shnaf Ramadan. Bottom row from left: Mohamed Abd el-Baset, Rebecca Dash Sperber, Rida Abd el-Aziem Shalaan, and Ashraf Abd el-Aziz. Photo by Mark Lehner.

Glen Dash and Mohamed Abd el-Baset ponder over Petrie Station B on the north side of the Khafre Pyramid Temple. Photo by Mark Lehner.

Glen Dash examines values shown on the Total Station screen and compares them with figures in Mark Lehner's notebook from the Lehner-Goodman survey in 1984. Photo by Mark Lehner.

bedrock floor around the Sphinx, something I had not finished in my own survey of the Sphinx from 1979 to 1983. Prior to this, in 2015, after Joel Paulson and Glen Dash surveyed the Great Pyramid baselines, Glen supported Ashraf and Amr's survey of all the features cut into the bedrock floor around the Great Pyramid. They continued to survey the pyramid floor during March–April 2016.[10] As of his passing, Glen and I were still analyzing the patterns we could see in all the marks in the floor around the Great Pyramid, virtual footprints of the builders' leveling and layout operations. In 2018, as Ashraf and Amr cleaned the Sphinx floor and mapped its features, Glen and his team, with Sara Ahmed from the office of Zahi Hawass, completed a ground-penetrating radar (GPR) survey of the baseline of the Sphinx's leonine body, from the ground to a height of about 1.2 meters. Glen's analysis will be forthcoming, as we will ensure.

For the 2019 season of the RSVP, Glen, Rebecca, Eric, and Sara focused on the Sphinx Temple in early March. They used GPR to survey an area of gigantic laid-in blocks in front of the southeastern corner of the Sphinx Temple. I told Glen that I have witnessed streams of water after a hard rain disappear down seams between the blocks. Glen seemed unimpressed with the GPR results there, although it is clear the seams open up and extend deep down. He seemed most impressed with the GPR results in the southern end of the court of the Sphinx Temple where he outlined with small stones an area of anomalous readings. A mutual friend and colleague told me at Glen's memorial service that he had spoken of being perplexed by the data from the Sphinx Temple. We are still looking into the data he left us.

During that last time working together at Giza, Glen said he was happiest and most at peace when working in Egypt. Glen's last email to me, on August 25, 2019, expressed appreciation for a tribute I had written to David Koch. Not long before that I saw Glen with Fran Dilks at one of our usual lunches in the Stockyard Restaurant right across the Mass Pike from the AERA Boston office. We caught up on fieldwork, the analysis of the data from the Sphinx and Sphinx Temple. As always, Glen offered counsel on pending AERA state and federal filings, insurance issues, and board requirements. As always, we talked about potential fieldwork for the next season in early 2020. And as always, Glen was a good friend, in whom I

Joel Paulson and Glen Dash examine the top edge of intact casing stones on the southern side of the Great Pyramid. Photo by Mark Lehner.

sometimes confided personal as well as work issues. All of us at AERA miss Glen, as board member, team member, benefactor, and friend. I miss his calm and careful counsel. We hope our publications of the work that he made possible will honor his memory and contributions to AERA's growth and accomplishments.

1. "16 Candles for 16 Terabytes: Celebrating the New Giza Server," *AERAGRAM* 18-1, page 13, Spring 2017. Available for free download at aeraweb.org, as are all issues of our newsletter except the latest one.

2. Dash, G., "New Angles on the Great Pyramid," *AERAGRAM* 13-2, pages 10–19, Fall 2012.

3. Dash, G., "Finding those Indelible Marks Flinders Petrie Left on the Giza Plateau," *AERAGRAM* 18-1, pages 14–17, Spring 2017.

4. Dash, G., "Did the Egyptians Use the Sun to Align the Pyramids?" *AERAGRAM* 15-1 & 2, pages 24–28, Spring–Fall 2014; "Solar Alignments at Giza," *AERAGRAM* 12-2, pages 3–8, Fall 2011.

5. Dash, G., "North by Northwest: The Strange Case of Giza's Misalignments," *AERAGRAM* 13-1, pages 10–15, Spring 2012.

6. Dash, G., "Giza Ground Truth: Magnetic Anomaly Survey," *AERAGRAM* 4-1, pages 9–11, Fall 2000; "Seeing Beneath the Surface," *AERAGRAM* 7-1, pages 1–3, 6–10, Spring 2004.

7. Lehner, M., "GPMP Full Circle," *AERAGRAM* 13-1, pages 16–19, Spring 2012.

8. Dash, G., "The Great Pyramid's Footprint, Results from Our 2015 Survey," *AERAGRAM* 16-2, pages 8–14, Fall 2015.

9. Dash, G., and J. Paulson, "The 2015 Survey of the Base of the Great Pyramid," *Journal of Egyptian Archaeology* 102, pages 186–195, 2016.

10. Dash, G., "Where in the World is the Great Pyramid?" *AERAGRAM* 19-1, pages 16–20, Spring 2018.

11. Lehner, M., "Scanning by Eye and Experience: In Search of the Human Hand that Built the Great Pyramid," *AERAGRAM* 17-1 & 2, pages 20–23, Spring–Fall 2016.

Rabea Mohamed Shehat: 1963–2019

With great shock and sorrow, I learned on arising the morning of November 5, 2019, in Giza that Rabea Mohamed Shehat, a beloved member of the AERA-Egypt family and staff, passed away early that morning in his room at the center.

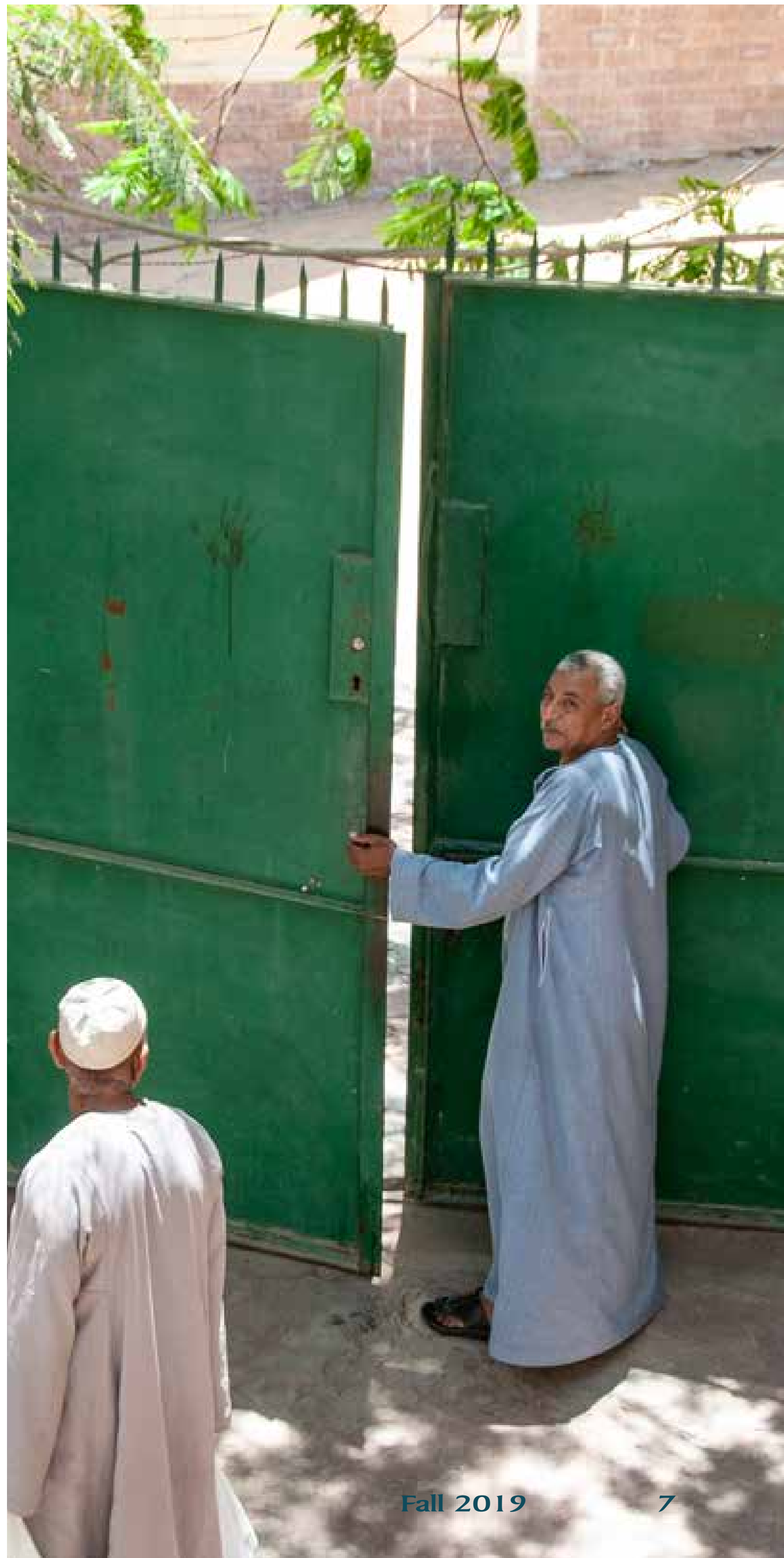
It was comforting that a number of the AERA family were there, at the AERA-Giza Center, with me that morning—Dr. Mohsen Kamel, AERA-Egypt Executive Director; Fran Dilks, AERA Development Coordinator; and Sayed Salah, AERA Egypt Manager and Overseer of Workers. All of us were very close to Rabea.

Rabea joined the AERA team at Giza in 2005 as one of the *faani* (literally, "artistic") excavators from the Upper Egyptian town of Qift who have been known for their skills in archaeology for more than a century. Rabea worked as a skilled excavator each season until 2009, when we purchased the villa and property that became our center in Giza. Rabea stopped working as an excavator, as he became an essential full-time member of the AERA-Egypt staff that hosted teams and field schools in a growing community of archaeologists for the last eleven years. He brought the same patience and care to his support of life and work at the AERA-Egypt Center as he did when he so skillfully excavated, stratum by stratum. Off-season, when we lacked a full-time cook, Rabea would often make breakfast, lunch, or dinner for those of us in Giza on off-season business. Rabea was a good cook. He made a great chicken and rice, but his lentil soup was outstanding.

Most important, Rabea was a calm and gentle soul, a presence that helped alleviate the stress and tension that comes with fieldwork and from more than a dozen adults packed together in one place during an intensive two or three months of exhausting outdoor work in the dirt. In his quiet way, Rabea had a positive effect on team members, old and new. Many who expressed their sorrow and condolences for Rabea's passing affirmed that he helped build a feeling of a second

home during their stays in the AERA villa. Greg Viessman, who joined the team for the first time during Season 2019, expressed it well: “While I only knew Rabea for two months and we were separated by a language barrier, he helped make the villa feel like home for me while I was there and always had a smile on his face. For my first time out of the country and not knowing what to experience, having Rabea greet us at the gate or even helping me order food on a Friday night gave me comfort. I will surely miss him.”

A dear and important a member of the AERA family in Cairo, Rabea will be sorely missed by all of us.



Shorbet Kawara: An Enlightenment

Your assumptions are your windows on the world. Scrub them off every once in a while, or the light won't come in.

~ Isaac Asimov

One of the greatest problems in scientific thought is that sometimes assumptions start to become givens, almost laws. During my 51 years in studying faunal remains from archaeological sites, I have developed a system of recording and study that reflects many of my assumptions.

One of my assumptions has been that the distal limb elements of animals—what I called the "non-meat-bearing bones," i.e., the podials, metapodials, and phalanges (see diagram on page 10)—are not of interest to humans and were discarded in slaughter. I use the relative occurrence of "non-meat bearing bones," which would have been thrown away near the butchering site, to "meat-bearing bones" to see if slaughter was local. Over representation of "meat-bearing bones" would suggest that packages of meat were being brought to the area of the site where the fauna was recovered.

It took only an instant for one of the underlying assumptions of my system—my view of the way people behaved in the ancient world—to collapse, when I was introduced to *shorbet kawara*.

In early March 2018 the AERA field laboratory started to receive materials from the excavation of the Kromer Dump site, an ancient trash midden that was dense with material discarded from two 4th Dynasty sites, including most likely our flagship Heit el-Ghurab site.[1] The animal bone was coming into the laboratory in such large quantities that the site crew put the bone in black rubber buckets, *muktafs* (produced from old tires), that we use on site to move dirt (photo facing page, top left). Too much bone was coming out of the excavation to fit into the plastic bags we normally use.

While my two students, Mohamed Hussein and Mohamed Raouf, and I were laying out and sorting the contents of one of the *muktafs*, Mark Lehner came to the lab, and I told him the Kromer Dump fauna was unlike anything we had seen at Giza. It was filled with shafts of distal limb bones, many of them my "non-meat-bearing bones." I was puzzled. Mark turned to my students and asked them what they thought. They looked at each other and said, in unison, "*Shorbet kawara!*"

Shorbet Kawara

Shorbet kawara is a stew or soup made from the feet of cattle, sheep, or goats. It is very popular in Egypt at present and is considered a hearty meal (photo on cover). The dish is high in calories, 519 kilocalories per 100 grams of soup; high in protein, 20 grams per 100 grams; and high in fat, 65.5 grams per 100 grams.[2] Because it includes boiled collagen, shorbet kawara is high in amino acids, including glycine, proline, and glycosaminoglycans (GAGs). The bone marrow contained in the distal metapodials and the phalanges releases healthy fats: omega 3—an anti-inflammatory—and linoleic fatty acids. This makes shorbet kawara an ideal food for individuals engaged in heavy labor. The Egyptian National Soccer team has a meal of shorbet kawara before matches.

Bones that I had always assumed were waste from slaughter, and not part of the subsistence of the residents whose garbage we were recovering, were actually an important component of the diet. Instead of an indication of butchery or disposal, these "non-meat-bearing bones" may indicate status and occupation. Perhaps a perfect diet for laborers who moved the stones to

Last spring, AERA's celebratory end-of-season meal for our 80 workmen was a large stew similar to shorbet kawara, consisting of 20 kilos of beef, 10 kilos of potato and onion, and 5 kilos of tomatoes. It is a hearty meal for hard workers. Photo by Sayed Salah.

Below: A *muktaf* full of the shafts of distal limb bones recovered from the Kromer Dump site. Photo by Richard Redding.

Above: Dr. Richard Redding and students (from left) Mohamed Hussein and Mohamed Raouf discuss the faunal remains—shafts of distal limb bones—coming into the AERA field lab from the Kromer Dump site. Photo by Mark Lehner.

build the pyramids. It was time to revisit the archaeological faunal data from Heit el-Ghurab.

Gallery Diet Puzzle

The Heit el-Ghurab (HeG) site, is a diverse settlement in which we have identified several functional areas. One of these is a series of barracks for workers that we refer to as the Gallery Complex[2] (see map on page 13). AERA has mapped three sets of galleries as part of our uncovering the "footprint" of the city and has excavated two adjacent galleries, Galleries III.3 and III.4. We have described and discussed the excavation of the galleries in three previous issues of *AERAGRAM*.[3] I have analyzed the faunal remains from the two galleries and have described the diet as the lowest status one of any area of the HeG. It has the highest dependence on sheep and goats of any area. A high level of cattle consumption characterizes the higher status diets. The fish fauna of the galleries focuses on the least desirable taxa.[4] This work was done in 2002 (GIII.4) and 2012 (GIII.3) and, fortunately, I recorded all the descriptive data I could think of, and all my data was placed in the AERA archive.

What has always puzzled me is that the galleries contained cattle bones in any quantity. While the ratio of sheep-goat[3] to cattle bone fragments in the galleries favors sheep-goats at 7.4:1, a steer/cull/heifer provides 184 kilograms (406 pounds) of edible product while a sheep-goat provides only 15 kilograms (33 pounds). Based on these data, sheep-goats are providing only 38% of the mammal-sourced meat consumed in the galleries. So, are cattle really contributing more edible product to the occupants of the galleries than sheep-goats? I have explained this to my colleagues as an example of how important cattle were to the HeG and to the Old Kingdom economy in general.

A New Paradigm

But, this new paradigm of the utility and value of the distal limb elements has caused me to closely re-examine the fauna from the Galleries. Could shorbet kawara be an explanatory tool? What would the consumption of shorbet kawara look like in the archaeological record? It is likely they were not eating shorbet kawara as it is served in the restaurants of Cairo, but were some of the workers at Giza consuming the distal non-meat bearing bones?

Evidence of the consumption of a shorbet kawara-like dish would be the occurrence of tarsals, carpals, metapodials, and phalanges in numbers beyond what might be expected. If whole animals—cattle, sheep, or goats— are slaughtered and consumed at a site, then distal bone fragments will compose 66% of the limb bone fragments at a site. This percentage is simply based on bone counts and reflects that more distal limb elements are found in the body than elements in the upper limbs that have the large muscle masses. The higher the percentage of distal limb element fragments is, the more likely the residents are eating a shorbet kawara-like dish.

I have argued in several publications that the residents of the Heit el-Ghurab were consuming mostly stews—concoctions of meat, fish, and vegetables all thrown in a large pot. Illustrations of cooking in the Old Kingdom almost exclusively show cuts of meat simmering in a large pot. The only exception is the duck, which is usually shown being grilled. Stews are the most efficient way to feed large numbers of people at once, stretch ingredients, and effectively access the marrow and fat in animal bones. A stew focused on the more distal limb elements would deliver to workers involved in heavy labor the positive benefits of shorbet kawara.

Cattle vs. Sheep

Cattle in the galleries are represented by 217 fragments of bones. In this sample 90.1% of the limb bone fragments are from shorbet kawara elements. This is an astonishingly high percentage of these elements. But we need to check the sheep-goat data. Do they tell us the same story? Could some other explanation account for the bias? In the sample of sheep-goat limb bone fragments from the galleries, 68% of the fragments are shorbet kawara elements. This is very close to the expected 66% if whole animals are being butchered and consumed. So, we have no evidence of specialized consumption of shorbet kawara elements in the sheep-goat sample.

If we go back to the unexpectedly high number of cattle in the galleries sample, it is not the bones that are enclosed in large leg muscles. I identified only two humerus fragments and two ulna fragments and found no scapulae, pelvis, or femur fragments. I did identify four distal tibia fragments, but these are sometimes included in shorbet kawara. The distal, shorbet kawara-type bones that were recovered do not carry large amounts of meat, but are enclosed in tendons and cartilage and include marrow. The sample of sheep-goat is composed of the expected mix of meat-bearing and distal, non-meat bearing elements, so whole animals were being consumed.

The ratio of sheep-goat to cattle bones from the galleries multiplied by the EP (Edible Product) is not a real measure of the relative contribution to the diet of sheep, goats, and cattle. Cattle are contributing much less to the diet in amount of meat than the numbers suggest, as they are providing *primarily* shorbet kawara elements to the stews consumed in the galleries. So, although cattle are contributing much less meat they are contributing shorbet kawara elements that yield calories, fat, protein, amino acids, and chondroitin, which are perfect for supporting heavy labor.

Enlightenment

The enlightenment in this story is not simply shorbet kawara. It is the value of distal limb elements that has caused me to totally rethink the meaning of the distribution of body parts and explanations for the patterns we observe. This story provides three important lessons.

First, we are all, sometimes, blinded by our assumptions. We need to re-examine them constantly and check the data for patterns that call our assumptions into question.

Second, we are often blinded by our cultural experiences. I have another story to illustrate this point. In 2006 I was in China teaching archaeozoology at Jinan University. We were sorting material and I found a series of cattle vertebrae all held together by soil. I told the students this was important because it meant that the vertebrae were still held together by cartilage and ligaments when they were discarded. They looked surprised and engaged in a discussion among themselves. Finally, my Chinese archaeological colleague explained that the students were expressing amazement that the people from the site were so wealthy they could throw away food. I had no experience eating lower limbs of animals (I have now!) and other ligaments and tendons; I assumed they were waste. This was, as we say in science, a bad assumption. AERA has done much to diversify our research team and this is one of the rewards. By bringing in multiple cultures we expand our explanatory world. Lastly, the third lesson is the value of AERA's effort to record all of the data when analyzing the material culture excavated, no matter if it is directly related to our current inquiries, and archiving these data for future research. This is a core research value and something that is a strength of AERA.

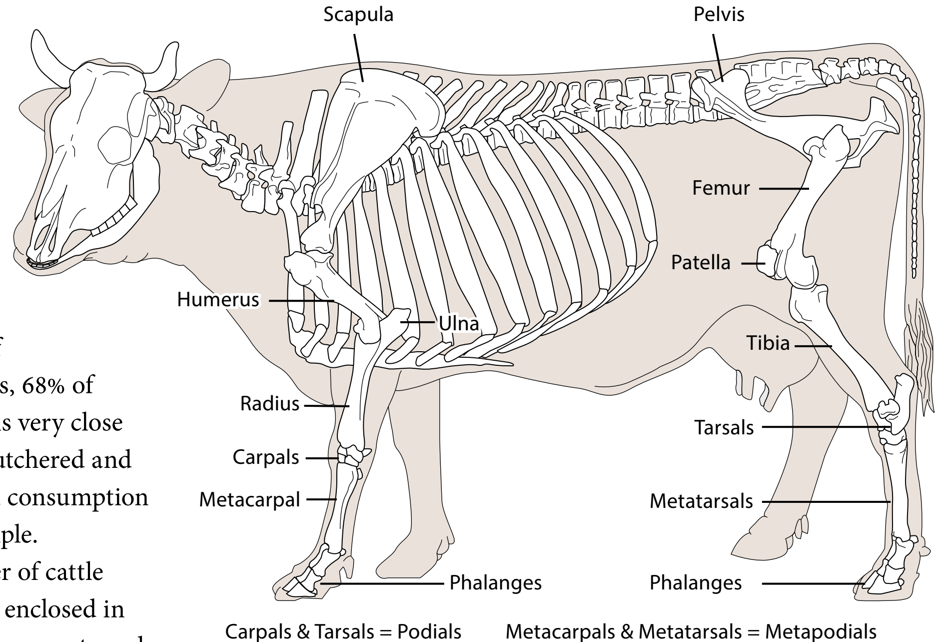


Diagram showing the skeletal elements in a cow mentioned in the text. © 1996 ArcheoZoo.org/Michel Coutureau (Inrap), Vianney Forest (Inrap). After Barone (Robert). *Anatomie comparée des mammifères domestiques, Tome I Ostéologie - atlas.* Paris: Vigot, plate 7, page 22, 1976.

1. Witsell, A.,"Kromer 2018: Basket by Basket," *AERAGRAM* 19-1, pages 2–9, Spring 2018. Available for free download at aeraweb.org.

2. Pellett, P. L., and S. Shadarevian, *Food Composition Tables for Use in the Middle East*, Beirut: American University of Beirut, 2013.

3. "A Gallery Unveiled," *AERAGRAM* 6-1, pages 4–5, Fall 2002.

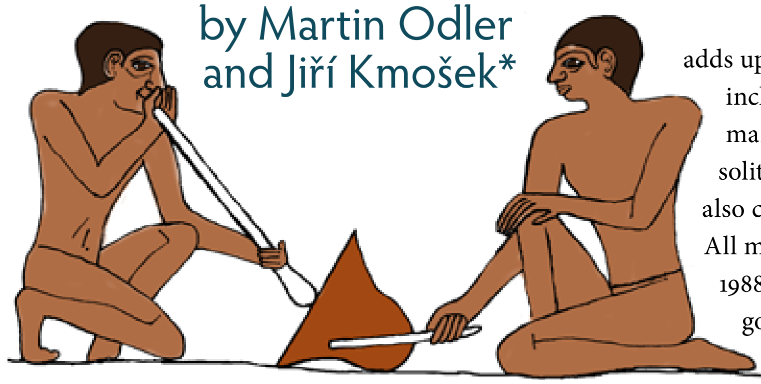
"Double-Decker Dorm? Reconstructing the Galleries," *AERAGRAM* 11-2, pages 7–9, Winter 2011.

"The Gallery Complex Gives Up Some of Its Secrets," *AERAGRAM* 16-1, pages 12–16, Spring 2015.

4. How do we assess desirability? One way is to look at the fish taxa we have at the site and then see what their relative value is in the fish markets of Cairo. The most expensive fish is the Nile perch (*Lates niloticus*) and the least expensive fish is the Nile catfish (*Clarias garepinus*). Also, a study by M. Babiker of Nile fish used the nutritional value, appearance, color, texture, and taste of the flesh to develop a ranking of desirability. The Nile perch was ranked first and the Nile catfish was ranked 17th of 20 taxa. Babiker, M. M., "Dietary Nile Fishes: A Reclassification According to Nutritional Merit," *Sudan Notes and Records* 62, pages 161–170, 1981.

Copper at Giza: the Latest News

by Martin Odler and Jiří Kmošek*



There is only one Giza, the largest excavated site of the Old Kingdom. Giza provides the basis of our archaeological knowledge of the period, only slowly being complimented by excavations on other sites. While early large-scale excavations focused on pyramids and other tombs, more recent excavation uncovered areas where ancient workmen actually lived. Thus, both ends of the past reality are represented, real lives of the Old Kingdom people, but also their eternal homes—tombs—with the objects destined to be used in the afterlife.

Information available at Giza holds the keys to many questions about past Egyptian lives. One of them, which we are trying to answer in an ongoing project, is about Old Kingdom procurement, use, and discard of copper. We apply modern scientific analytical techniques to uncover more information about this topic, long neglected in Egyptian archaeology. Many studies were done in the past, including on the material from Giza,[1] but these were all case studies of small groups of material. A systematic approach is what is needed now and in the future.

Many Questions, First Answers: Results of the Current Research

Copper was the most important metal of Old Kingdom Egypt, the Early Bronze Age. Oddly enough, the ubiquitous material of this age in the ancient Near East was not copper alone, but a specific alloy of copper with another chemical element, arsenic. More about the material below, but if your immediate thought was that arsenic is toxic … indeed, it is. But small doses are not lethal, and an addition of just a few percent of arsenic to copper causes the material to be harder, very similar in properties to the later-used tin bronze.

The main task of our project in Giza is to find out how local copper production and artifacts fit into this wider picture. In April 2019, archaeologist Martin Odler visited the AERA field lab at Giza and surveyed the available material, which had been recovered from AERA excavations. The so-called "industrial waste," including copper fragments, slag from the production processes, fragments of the smelting vessels (crucibles), adds up to more than 250 bags, including large bags with many fragments, but also solitary fragments and, finally, also copper artifacts themselves. All material excavated since 1988 is available and gives us good information about the amount of the metallurgical remains from the uncovered archaeological structures and deposits. It may seem to be not that much, but this is actually the largest known corpus of the metallurgical remains from the Old Kingdom in the whole of Egypt.

The 4.D17x Copper Workshop

The most important part of the corpus was found in the workshop denoted 4.D17x situated in the back chamber of Gallery III.8 at the Heit el-Ghurab (HeG) site (see sidebar, next page). Bread molds were used as crucibles for melting the copper, and probably also producing small items, such as needles and fishhooks. This is no coincidence, as bread molds were used for copper production in the Old Kingdom town of Buhen (Nubia), and such use of a bread mold is depicted in a tomb relief in Saqqara, in the tomb of Niankh-khnum and Khnumhotep (shown above). Special molds for the production of copper objects dating from the Old Kingdom are known only from Buhen.[2] Larger tools were cast as copper slabs, and later formed by hammering and annealing (repeated heating and cooling of the metal) to its final shape and function. Smaller objects, such as those produced in the 4.D17x workshop, were most probably shaped from cast metal rods, again going through processes of hammering and annealing.

Samples for Study

From the material at hand, 23 samples were selected, representing the layers of workshop 4.D17x and scattered slag pieces from other areas of HeG, as well as from the Kromer Dump site (KRO) and the Khentkawes Town (KKT)[3] (see table, page 17). These samples were documented and packed for

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Above: Copper-working scene in the tomb of Niankh-khnum and Khnumhotep at Saqqara shows a man holding a large bread mold at an angle (with sticks?), while another man uses a blow pipe to heat whatever is inside the bread mold. Redrawn after *Das Grab des Nianchchnum und Chnumhotep. Old Kingdom Tombs at the Causeway of King Unas at Saqqara*, Archäologische Veröffentlichungen, Deutsches Archäologisches Institut, Abteilung Kairo 21, by A. Moussa and H. Altenmüller, Mainz am Rhein: Philipp von Zabern, 1977, Plate 63, detail.

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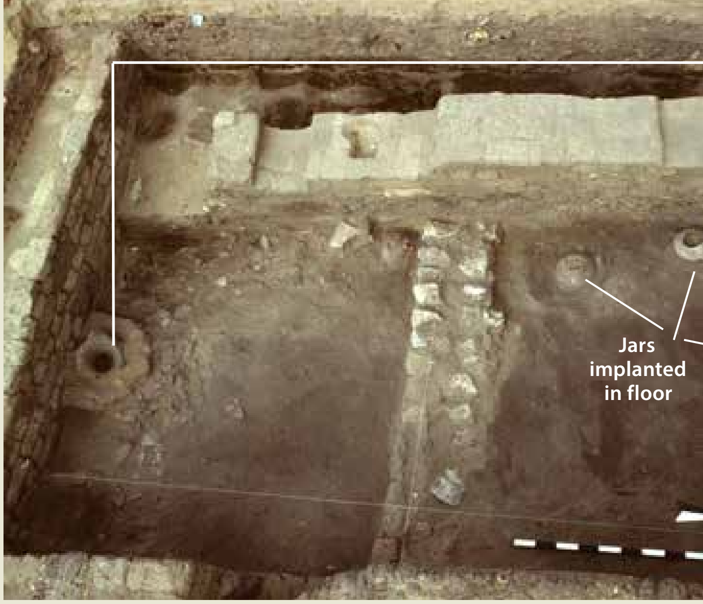
The 4.D17x Copper Workshop

Map of Heit el-Ghurab showing the location of the 4.D17x copper workshop. Map by Rebekah Miracle, AERA GIS.

Left: A copper needle and copper fishhook. The eye of the needle is at the bottom. Photos by Yukinori Kawae.



Above: Square 4.D17x, the copper workshop. North is to the right. Insets: the two bread molds used as crucibles. Note the three large jars implanted in the floor. Photos by Mark Lehner.

AERA uncovered the workshop in 1998 at Heit el-Ghurab while excavating in an area we later discovered was part of the Gallery Complex, a large block of long galleries. In Square D17 (later renamed 4.D17 when we extended our original grid), we discovered walls scorched by a hearth and bright orange deposits nearby. We suspected the hearth had been used for copper working, as many fragments of copper slag turned up in the heavy fraction from flotation samples collected here. In the hopes of uncovering more evidence of copper working, we expanded the excavation diagonally into the adjoining square, which we designated D17x.

Our efforts were rewarded. Here, in a chamber roughly 2 × 4 meters, copper-working appears to have been the principal activity, as indicated by abundant traces of

Square 4.D17x (outlined with red dotted line) during excavations in 1998. The man on the right is excavating through the uppermost floor. Note the hearth in the northeast corner and the three jars that were discovered embedded in the upper floor layer. View to the north. Photo by Mark Lehner.

metallurgy. Two unusual hearths consisting of bread molds had been plastered in place against the walls of the chamber, one at the center of the south wall, the other, in the north-east corner. They were held in place by “collars” of large sherds and mud that had been hard-fired like redbrick from the heat.

The bread mold hearths had been used as crucibles to hold molten metal. Small bits of corroded green copper were embedded in the bread mold walls. We found pieces of spouts and little clay tubes that would have been used to blow air into the “furnace,” as well as sherds vitrified by the heat. Copper slag was scattered through the ashy dirt fill and in the floor deposits.

Metal workers probably made small implements, such as the copper fishhook and thin copper needle we found here. Once the tools were heated in the bread mold crucibles for pounding, they could have been quickly cooled by dunking them in water in the large jars implanted in the floor (the so-called process of annealing).

(continued from page 11)

transport to the laboratory of the Institut français d’archéologie orientale (IFAO) in Cairo, which possesses all the necessary equipment for preparing the metallographic cross-sections from the samples and metallographic microscopes for their study. The transfer of samples was kindly allowed and enabled by the Ministry of Tourism and Antiquities. This research at Giza is part of a wider research framework.

Restarting Archaeometallurgy in Modern Egypt

The IFAO supported our project “Restarting Archeometallurgy in Modern Egypt, action spécifique no. 19463” in both 2019 and 2020. The principal investigators of this project are the authors of this article: archaeologist Martin Odler, and an archaeometallurgist, Jiří Kmošek. With our joint expertise, the project is attempting to demonstrate the feasibility of the scientific study of metals in Egypt. It is focused especially on the 3rd and 2nd millennia BC, the Early and Middle Bronze Age, gathering data on ancient copper from different missions working in Egypt, with our base at the Czech Institute of Egyptology, Faculty of Arts, Charles University, Prague, and its Egyptian concession at the Abusir pyramid and cemetery field south of Giza, where the initial corpus was examined.

As already mentioned, systematic effort is needed, as the past case studies focused on a limited number of artifacts and the “big picture” is still lacking. Another problem is that not all currently used methods are available in Egypt, and the export of samples is theoretically possible, but legally extremely difficult. Therefore, we are trying to apply the range of available methods in Egypt on the material currently found there, comparing these results with more fine-grained methods used on the samples from provenanced Egyptian and Nubian objects in the museums abroad (see below). This will allow us to pursue research and produce comparable results both in Egypt and outside of Egypt.

Lab Work

In November 2019, Jiří Kmošek prepared cross-sections from the Giza samples (photo, next page, second from top) and all were studied under the microscope and analyzed

In the AERA field lab Martin Odler photographs the samples of metallurgical remains that he prepared for transport to the Institut français d’archéologie orientale (IFAO) lab in Cairo. Photo by Mark Lehner. (Samples shown in photo on page 14, top.)

with a portable X-ray fluorescence spectrometer Bruker Tracer III-SD, one of the most precise (and most expensive) machines for this type of research. The spectrometer gives information (spectra) about the chemical composition of the analyzed material (photo, facing page and page 16). A cross-section cuts the sample in half; the polished sample cut thus enables us to examine the internal structure of the metallurgical remains (photos, page 15). The spectra (page 16), together with the observations of the sections under the microscope, produced the first solid results about the type of material worked in 4th Dynasty Giza. They revealed smelting/melting and probably also alloying slag fragments, and fragments of crucibles, almost all with small prills (metallic globular particles), composed of copper, arsenical copper, and extremely high arsenical copper. These preliminary results will be further studied and compared with other material.

Enigmatic Arsenical Copper

The use of arsenical copper for tools and weapons of the Old Kingdom was confirmed long ago by a range of independent studies on the objects from Egypt in the collections of several museums: the Ashmolean Museum, Oxford, by Hugh McKerrell in the 1970s; the Louvre, Paris, by Félix Michel in the 1960s and 1970s; and the British Museum, London, by Michael Cowell in the 1980s.[4] But it seems that many Egyptologists did not notice, or even internalize this fact in their research, and arsenical copper remained a rather mysterious material of ancient Egypt, until quite recently.

Experimental work on arsenical copper by Heather Lechtman, professor at MIT, demonstrated how it compared with tin bronze: the two metals "may be used interchangeably for specific functions within rather broad alloy ranges: ≈ 2–7 weight-percent arsenic; ≈ 2–7 weight-percent tin."[5] Thus, this less-known, but widely used material, offered similar practical properties as would later tin bronze. Even in the Old Kingdom, tin bronze was not completely foreign to ancient Egyptians, as the earliest tin bronze objects—vessels—occurred already in the Early Dynastic Period. But arsenical copper was the material of choice for tools and weapons before the end of the Middle Kingdom. This was almost all that we knew until recently.

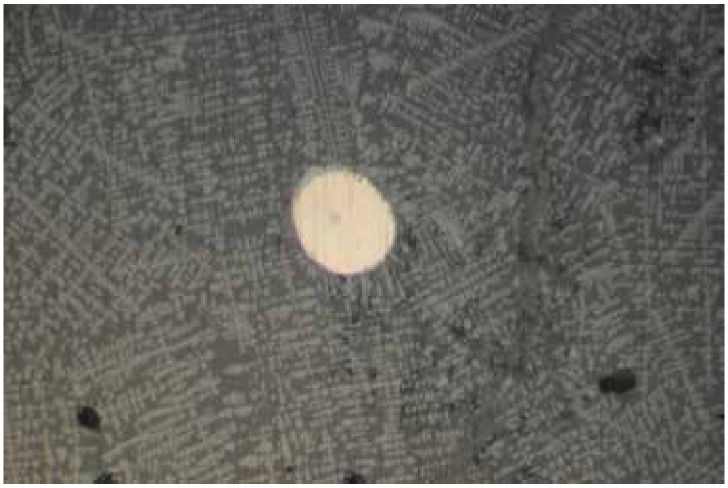
Two articles, published in August 2018 in the *Journal of Archaeological Science*, tackled the questions of the provenance and use of

From top down: The copper samples set for transport. Note only a small amount of the sample is needed for analysis.

In the IFAO lab, mounted cross-section samples prepared for X-ray fluorescence analysis and microscopy.

For safety reasons, Jiří Kmošek covers the sample for X-ray fluorescence analysis.

Jiří Kmošek analyzes the sample with the portable X-ray fluorescence spectrometer. Photos by Martin Odler.



Microstructure of an iron-rich compact slag fragment with a micrometer-size bright arsenical copper prill in the center, as documented by the metallographic microscope. Photo by Jiří Kmošek.

Jiří Kmošek documents the samples under a metallographic microscope. Photo by Martin Odler.

copper in Early Dynastic and Old Kingdom Egypt. The papers were the result of the project of the Czech team (led by Martin Odler and Jiří Kmošek)[6] and a Belgian team (led by Frederik Rademakers and Georges Verly),[7] both independently working on Egyptian material from the two museums, the former on the artifacts from the Egyptian Museum of Leipzig University, the latter on the material in the Royal Museum of Art and History, Brussels. Following the current focus on provenance and chemical composition, both studies identified the prevailing use of arsenical copper. Concerning the origins of copper, a rather surprising evaluation of the lead isotope results points to the main ore source areas in the Eastern Desert and the Sinai Peninsula. Some researchers supposed that a high quantity of copper in Old Kingdom Egypt was coming from the Early Bronze Age copper "factory" at Khirbet Hamra Ifdan (in Wadi Feynan, contemporary Jordan), but not a single piece has yet been demonstrated to have come from there. However, only about 60 artifacts were analyzed in both studies (and they were the hard-earned results of projects running for several years!), thus we might still be missing Feynan copper.

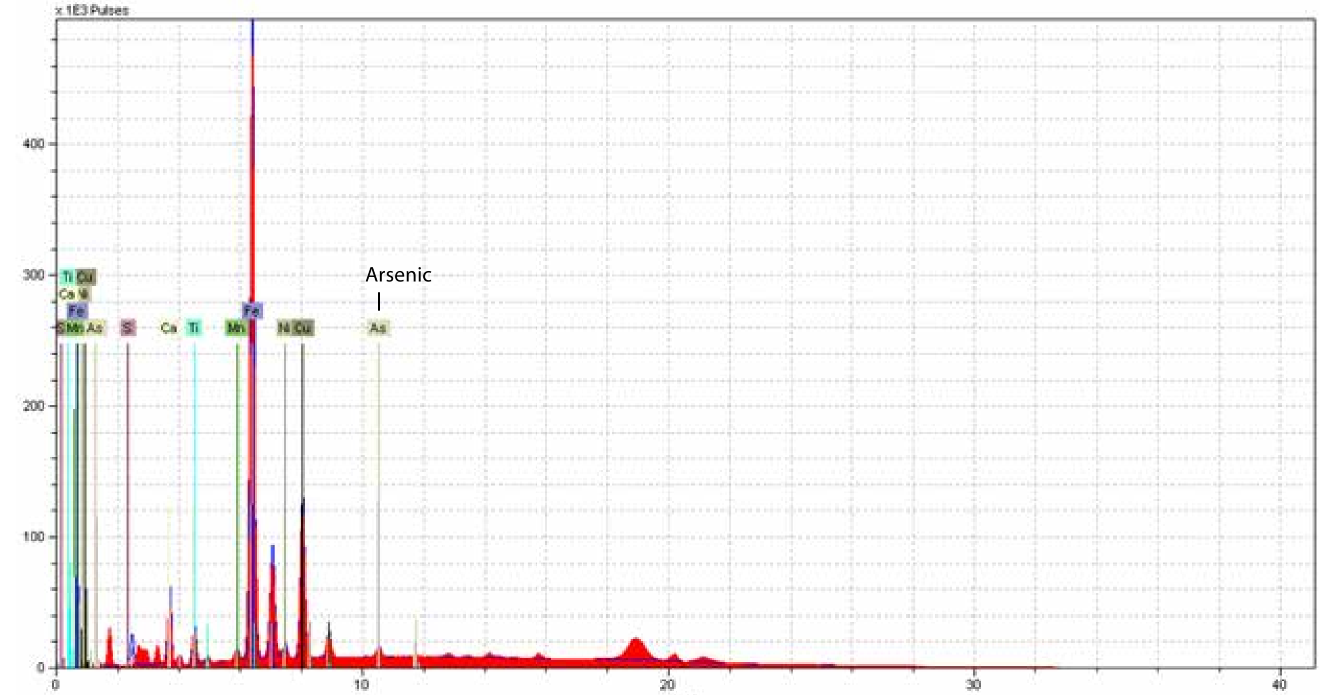
The research of the Czech team also sought further knowledge of the microstructure of the metals and their practical properties.[8] Among the studied assemblage were artifacts from Giza, West Field, where the German mission, led by Georg Steindorff, worked a century ago. We found that the contents of arsenic oscillates in the materials used and that hardness was achieved mainly by hammering the objects into the final shape. Full-size functional tools were, of course, harder than the model tools, which prevail in the known Old Kingdom archaeological contexts. The main difference between full-size functional tools and the model tools is in the amount of arsenic present, the working hypothesis being that the models might have been produced from already recycled material. Nevertheless, the studies of models demonstrated that they were produced by craft operations very similar to the production of full-size tools.[9]

As for the tool kits represented, among the model tools are especially blades of the artisan tool kit: chisels, adzes, axes, and saws. Moreover, often these models involved also razors and needles, besides a range of copper vessels. Full-size tools are much scarcer and thus less frequently analyzed, but one important corpus of artisan tools was found in the Menkaure Valley Temple and is now in the Museum of Fine Arts, Boston. In the 6th Dynasty, full-size mirrors became popular in burial equipment. More on these tools and their analyses can be found in Martin Odler's *Old Kingdom Copper Tools and Model Tools*.[10]

The Old Kingdom is also remarkable for the absence of metal blades of weapons. We know from the iconographic sources that such weapons must have existed, but because of social and religious rules and practices, they were not deposited amongst the burial equipment. Much more metal weaponry is preserved from the First Intermediate Period and Middle Kingdom.

Future Prospects

The project is to be continued in 2020 or in 2021, as the international and local situation will allow. We would like to study more fragments and artifacts from Giza with the help of portable X-ray fluorescence, in order to gain information about the composition of all fragments, selecting more to be studied as samples, with an eventual objective to publish this important material. We plan to analyze selected samples in detail by using the scanning electron microscope equipped with an EDS (Energy Dispersive Spectroscopy) analyzer, in order to get exact information about the composition of specific microstructural phases and metallic copper or arsenical copper prills. Even a tiny bit of a copper prill or slag can give vital information under the microscope, thus it is important to collect everything. Giza is the most important site for the 4th Dynasty. It must also be considered one of the most significant copper-processing centers in the heart of the Egyptian



Analyzed elemental spectrum of one of the samples. The horizontal axis is kiloelectron volts (keV), a unit of energy used in diagnostic radiography. Different elements have different characteristic energy values. The vertical axis reflects count rate (cps), the number of counts for each analyzed element per second. The concentration of the analyzed elements is then calculated from the area of the individual peaks.

state, based on the number of the known copper-processing workshops.

Only a handful of copper-processing workshops are known from 3rd millennium BC Egypt and Nubia (e.g., at Buhen, Elephantine, Edfu, and el-Kab). Three of them were identified in Giza. The workshop excavated by Abdel-Aziz Saleh in 1971–1972,[11] located south-east of the Menkaure mortuary temple, was the most complex, yet it is also the least known, as only a single, not very detailed, report was published on the results of the excavations. Later on in the 1970s, indications of metallurgical activity were found in the trash midden of 4th Dynasty settlement debris excavated by the team of Austrian archaeologists led by Karl Kromer.[12] And the third workshop was identified in HeG, in Square 4.D17x, as already mentioned. Saleh's work might deserve revisiting in the future, as it is most probably the largest copper-processing facility in the area. Paradoxically, we currently know much more about the smaller installations.

Kromer's material is being enriched currently by the recent excavations in and around his original trenches.[13] Part of the material excavated in 1970s was brought to Austria and ended up in the collection of the Institute of Prehistory at the University of Vienna. Among the objects were also the archaeometallurgical remains and copper artifacts, already being studied by our Czech team.

Since the range of methods available in Egypt is rather limited now, the projects there ought to be complemented by the more detailed analyses of the objects in the museum and university collections. The results of the research of Kromer's material, deposited in Austria, will be published soon. Right now we can say that the tools found were made of arsenical copper (including needles and fish-hooks) and the copper itself came either from the Eastern Desert or Sinai, Feynan being again absent.

1.Maddin, R., T. Stech, J. D. Muhly, and E. Brovarski, "Old Kingdom Models from the Tomb of Impy: Metallurgical Studies," *Journal of Egyptian Archaeology* 70 (1), pages 33–41, 1984.

2. O'Connor, D. B. *The Old Kingdom Town at Buhen*, Excavation Memoir/ Egypt Exploration Society 106, London: Egypt Exploration Society, 2014.

3. The Kromer Dump is a huge midden of trash discarded from two 4th Dynasty sites. The sample in the study was in a garbage layer that probably came from a site near where the Menkaure Valley Temple was later built. See Witsell, A.,"Kromer 2018: Basket by Basket," *AERAGRAM* 19-1, pages 2–9, Spring 2018. Available for free download at aeraweb.org.

The Khentkawes Town includes residences that once housed priests serving the cult of Queen Khentkawes and structures that may have been used during the time that the Menkaure Valley Temple was being built.

4. Michel, F., "Analyse de quarante miroirs appartenant au Département des Antiquités égyptiennes du Musée du Louvre," *Annales (Laboratoire de recherche des musées de France)* 23, pages 34–46, 1972.

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5. Lechtman, H., "Arsenic Bronze: Dirty Copper or Chosen Alloy? A View from the Americas," *Journal of Field Archaeology,* 23 (4), page 506, 1996.

6. Kmošek, J., M. Odler, M. Fikrle, and Y. V. Kochergina, "Invisible Connections. Early Dynastic and Old Kingdom Egyptian Metalwork in the

Table showing results of analysis for each sample.

IFAO sample number	AREA	YEAR	DESCRIPTION	WEIGHT (Grams)	MATERIAL DETERMINED BY XRF
12732	D17x	1999	vitrified pottery fragment	5.4	vitrified ceramic sherd with no added fluxes or metal
12733	D17x	1998	vitrified pottery fragment	3.4	vitrified ceramic sherd with no added fluxes or metal
12734	D17x	1998	vitrified pottery fragment	3.6	vitrified ceramic sherd with small arsenical copper prills
12735	D17x	1998	slag nodules	0.5	silica rich slag fragment with arsenical copper prills
12736	D17x	1998	vitrified pottery fragment/ crucible	6	vitrified ceramic sherd with arsenical copper prills
12737	D17x	1998	slag fragment	3.3	iron-rich slag fragment with completely corroded arsenical copper prills
12738	D17x	1998	slag fragment	2.4	iron-rich compact slag fragment with small arsenical copper prills
12739	D17x	1998	slag fragment	1.5	silica-rich compact slag fragment with small arsenical copper prills
12740	KRO	2018	slag fragment	0.9	slag fragment with small arsenical copper prills
12741	SWI	2018	copper mineral	1.5	copper mineral with high portion of iron
12742	KKT	2008	slag fragment	0.4	silica-rich compact slag fragment with small arsenical copper prills
12743	AA-S	2015	slag fragment	1.2	silica-rich compact slag fragment with small arsenical copper prills
12744	WD	2005	slag fragment	0.5	iron-rich compact slag fragment with small arsenical copper prills (in photo, page 15)
12745	WD	2005	vitrified pottery fragment/ crucible	1.1	vitrified ceramic sherd with arsenical copper prills
12746	SWI	2016	clinker	7.2	iron mineral with high portion of calcium and silica
12747	EOG	2005	burnt soil	8	burnt soil with no singularity
12748	RAB	2002	charred coal	2.8	porous charred coal with high portion of iron, sulphur, and calcium
12749	D17x	1998	slag fragment	0.6	silica-rich compact slag fragment with corroded arsenical copper prills
12750	D17x	1998	slag fragment	0.8	silica-rich compact slag fragment with no metallic prills
12751	D17x	1998	slag fragment	0.3	iron-rich compact slag fragment with small arsenical copper prills and copper sulphides
12752	D17x	1998	slag fragment	4.4	iron-rich compact slag fragment with small arsenical copper prills
12753	D17	1997	slag fragment	2.4	silica-rich compact slag fragment with big arsenical copper prills
12754	TBLF	1998	vitrified pottery fragment	2.8	vitrified ceramic sherd with no metallic prills

Egyptian Museum of Leipzig University," *Journal of Archaeological Science* 96, pages 191–207, 2018.

7. Rademakers, F. W., G. Verly, L. Delvaux, and P. Degryse, "Copper for the Afterlife in Predynastic to Old Kingdom Egypt: Provenance Characterization by Chemical and Lead Isotope Analysis (RMAH Collection, Belgium)," *Journal of Archaeological Science* 96, pages 175–190, 2018.

8. Kmošek et al. 2018, see footnote 6.

Kmošek, J., M. Odler, T. Jamborová, Š. Msallamová, K. Šálková, and M. Kmoníčková, "Archaeometallurgical Study of Copper Alloy Tools and Model Tools from the Old Kingdom Necropolis at Giza," In *Old Kingdom Copper Tools and Model Tools*, 1st edition, edited by M. Odler, Archaeopress Egyptology 14. Oxford: Archaeopress, pages 238–248, 2016.

9. Maddin et al. 1984, see footnote 1; Kmošek et al. 2016, see footnote 8.

10. Odler, M., *Old Kingdom Copper Tools and Model Tools* (With Contributions by Jiří Kmošek, Ján Dupej, Katarína Arias Kytnarová, Lucie Jirásková, Veronika Dulíková, Tereza Jamborová, Šárka Msallamová, Kateřina Šálková and Martina Kmoníčková) 1st edition, Archaeopress Egyptology 14. Oxford: Archaeopress, 2016.

11. Saleh, A.-A., "Excavations Around Mycerinus Pyramid Complex," *Mitteilungen des Deutschen Archäologischen Instituts, Abteilung Kairo* 30, pages 131–154, 1974.

12. Kromer, K., *Siedlungsfunde aus dem frühen alten Reich in Giseh: Österreichische Ausgrabungen* 1971–1975. Vienna: Österreichische Akademie de Wissenschaften, 1978.

13. See footnote 3.

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Am I Ancient? Solving Archaeobotanical Riddles From a 4th Dynasty Municipal Dump by Claire Malleson

In 2018 AERA excavated an ancient trash dump in the desert high up on the Giza Plateau. First dug in the 1970s by Karl Kromer, the midden was filled with demolition debris and garbage from two Old Kingdom sites: probably the Heit el-Ghurab (HeG) settlement and possibly a king's road house that once stood near the location where Menkaure later built his valley temple.[1] Below, Claire Malleson, AERA archaeobotanist, discusses a problem encountered at dry sites, including this midden (designated KRO). Under very dry conditions, plant remains are preserved in a desiccated state and may not look terribly ancient. How do you tell if they are really ancient and not recent contaminants that may have snuck into the site?

Most of AERA's work takes place in settlement sites, particularly Heit el-Ghurab, so we're usually excavating detritus left behind in the ruins of abandoned buildings. But at the KRO trash midden, we are dealing with the equivalent of a municipal dump—a treasure trove for most material culture specialists. My students often ask me what is the most exciting thing I've found, expecting to hear about mummies or gold. But my reply every time is "ancient garbage!" In the case of KRO, I have to add, "if it really is ancient." And that is the riddle I have been trying to solve as I study the KRO plant remains. Interpreting them is proving to be especially complicated, as this very dry site has yielded desiccated materials that could be modern. In cases like these, our interpretations must be closely tied to site history, stratigraphic markers, and clues from other categories of material culture.

Modern Intruders

Unlike, say, pottery or stone, modern plant materials can readily make their way into ancient deposits. Indeed, there are cases of seeds found in "sealed" features in stratigraphic excavations—presumed to be ancient—that have turned out to be recent as determined by radiocarbon dating. Many seeds are tiny, so they can "travel down," shuffled along by insects, worms, and rain. Wind can also blow plant materials into deposits. One Egyptian spring *hamseen* sandstorm could easily cause chaos in this respect, and there have been millennia of storms since the KRO garbage was first dumped. At very dry sites this can be a problem as the recent intruders persist in the site sediments.

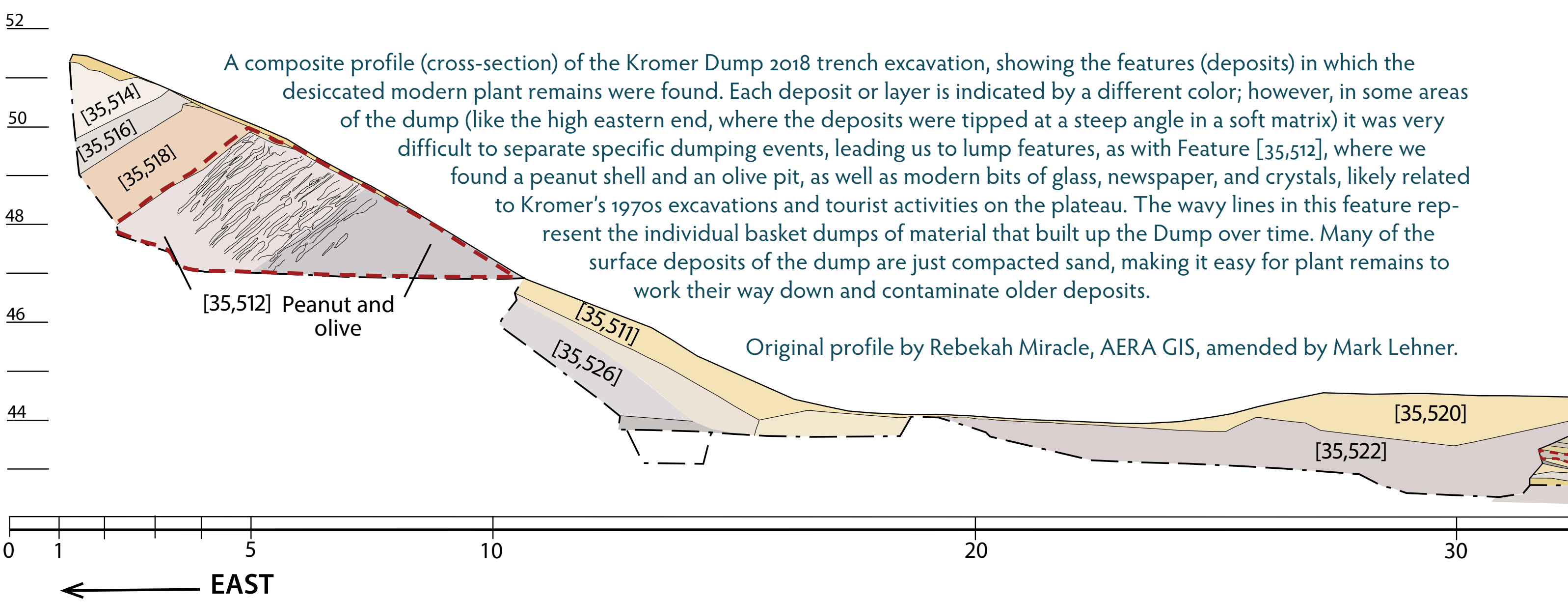
At moist sites, such as HeG—which lies close to the water table and was exposed to high Nile floods—these modern contaminants decompose readily, as organic material does not last long in moist environments. If they are very recent arrivals, they are easily identified as such. Only charred or carbonized materials are preserved in damp sites (see sidebar, page 20).

But at KRO we found both desiccated and carbonized plant materials. We expected that some of the former would be modern, since the chance for recent contamination is high here. The site is exposed, not deeply buried, and the soils and sand are very loose, so small seeds could easily travel into the archaeological layers. And at the KRO site, we must be ever cognizant that Kromer and his team excavated here over many seasons—in some of the exact areas of our recent trenches—surely leaving some remnants of their presence behind.

How to Sort Out the Modern From the Ancient

The Easy Cases. Ancient plant specimens are often readily identified by their darker color. They are more friable too, but not always. How do we decide, modern or ancient?

Archaeobotanical trainee Essam Ahmed Soliman found many un-charred sesame seeds (*Sesamum indicum*) in one or two samples. Because we know that sesame was not common in Egypt until Roman times and was probably not introduced



A composite profile (cross-section) of the Kromer Dump 2018 trench excavation, showing the features (deposits) in which the desiccated modern plant remains were found. Each deposit or layer is indicated by a different color; however, in some areas of the dump (like the high eastern end, where the deposits were tipped at a steep angle in a soft matrix) it was very difficult to separate specific dumping events, leading us to lump features, as with Feature [35,512], where we found a peanut shell and an olive pit, as well as modern bits of glass, newspaper, and crystals, likely related to Kromer's 1970s excavations and tourist activities on the plateau. The wavy lines in this feature represent the individual basket dumps of material that built up the Dump over time. Many of the surface deposits of the dump are just compacted sand, making it easy for plant remains to work their way down and contaminate older deposits.

Original profile by Rebekah Miracle, AERA GIS, amended by Mark Lehner.

Photos, at right: *Modern or Ancient?* The KRO Dump site has provided us with a mixed bag of datable material culture, both ancient and modern. Some—such as 1930s Eastman Kodak film packaging shown in **1** (from Feature [35,511]), cigarette packs, bullets, beer cans, and fragments of china teacups—are easy to identify, and are clear signposts to proceed with caution regarding dating the archaeological features in which they were found. Fragments of newspaper (**2**) were found in Feature [35,512], along with our olive pit and dessicated peanut shell. But others—most especially finds of common Egyptian organics—are less clear, like two masses of fiber (**3**, possibly wool) from Feature [35,516], believed to be an ancient deposit. The high and dry elevation of the KRO site has led to remarkable organic preservation, including cordage and textiles that are clearly ancient (**4**, **5**), occurring throughout the section. We must take all finds into account while telling the story of how the KRO Dump came to be. Photos by Mark Lehner.


1


2


3


4


5

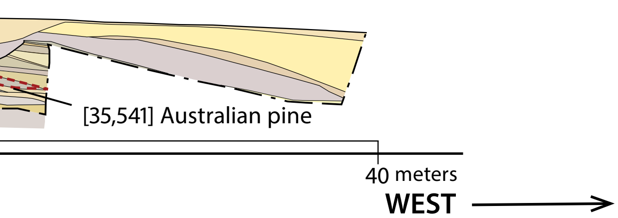
much before that, we asked how they may have ended up in our samples. A quick check showed that the culprit was the sacks we use to transport and store our soil samples—they come from a bakery. The sesame seeds had gotten trapped in the bags and mixed with our samples. That riddle was easy to solve!

Another example was a desiccated peanut shell (*Arachis hypogaea*) from Feature [35,512]—a feature low in the crater that Kromer's excavations left, but deep in the original layering (stratigraphic sequence). As peanuts are also a recent introduction to Egypt, we knew it could not be ancient, and modern glass and newspaper (photo 2 at right) were also found in this feature. The shell might have blown into the layers during Kromer's excavations in the 1970s (perhaps from a break-time snack) or found its way into this layer of debris during a sandstorm.

We also found small desiccated *Casuarina* "pine cones" in some well-sealed layers at the west end of the trench (Feature [35,541]). The common name of *Casaurina*, Australian pine, suggests that it might be a newcomer in Egypt, although common names are not always reliable indicators of a plant's origins. However, in this case, the majority of *Casuarina* species are native to Australia, the others, to Southeast Asia. These trees commonly grow in Egypt today, but were certainly not present in ancient Egypt. However, this species grows today on the HeG site, so it's not inconceivable that the cones could have worked their way into the layers at the KRO Dump.

The Hard Cases. But it is not always so simple. Lots of plants that grow in Egypt today were also present in ancient Egypt, so it is much harder to determine if the desiccated remains are ancient. In a situation like this, it is especially important to look for clues provided by stratigraphy or other classes of material culture.

In the thick eastern layers at KRO, filled with ceramics and bone, we found much more desiccated and charred cereal-



ON PLANT PRESERVATION AND TAPHONOMY IN EGYPT

Plants are preserved in archaeological contexts in four different ways: by charring, desiccation, waterlogging, and mineralization. At Giza, we have both **charred** (burnt) and **desiccated** (dried) remains. Indeed, the arid climate of Egypt makes it one of the few places in the world where ancient plants are often preserved by desiccation.

Just as with archaeological remains of any sort, the term "taphonomy" is used to describe the study of the processes—both natural and those due to human action—that affected the preservation of archaeobotanical materials after they were deposited. Perhaps most important in the case of the Heit el-Ghurab (HeG) and Kromer Dump (KRO) sites are: a) the presence or absence of water, and b) the disturbance of an original context and its destructive effects on fragile remains, like plants.

At the lower elevations of the Giza Plateau, at the HeG, Khentkawes Town, or the Menkaure Valley Temple, plant remains are most often present as waste leftover from cooking and baking. They are preserved because they were burned as fuel and charred (that is, not reduced to ash). Although the materials may be distorted as a result of heating, they often retain morphological features that allow us to identify them. The remains do not decompose, as charring converts the organic components to chemically stable compounds that are not subject to bacterial decay.

Which plant parts are preserved depends on the temperature of the fire, the duration of burning, and the amount of oxygen present: an open fire destroys more than an enclosed oven does. Smaller seeds that drop to the base of a fire tend to survive better, as do tougher, denser seeds or fruit stones. Fragile plant parts are more likely to be totally destroyed by a fire, such as flowers and leaves. When a fire was "finished," or an oven full of ash, ancient people cleaned this ash away and dumped it around the settlement, further damaging or destroying delicate items. To add to the problem, modern conditions also affect charred plants: repeated wetting and drying is detrimental, as are modern plant roots penetrating archaeological sites—both of which occur at HeG due to a fluctuating watertable. However, it all depends on context. The samples from House E in Khentkawes Town (photos at right, top)—from a sealed, undisturbed ash layer under silos—are a rare example of how amazingly well preserved in situ charred plant remains can be.*

Desiccated plant materials did not come into contact with water and over time lost moisture. At very dry sites, where we find desiccated plant remains, much of the waste left by the inhabitants is likely to be preserved, including even fragile elements, such as fine hairs. But items carried away by the wind, eaten by scavengers, or trampled would be long gone. And at the KRO Dump site, dry and high on the plateau, we are more likely to find dessicated plant remains untouched by water, save for what sparse rain may have fallen on the open dump deposits.

*Malleson, C., "Weeds and Seeds: On the Trail of Ancient Egyptian Agriculture," *AERAGRAM* 14-1, pages 22–23, Spring 2013.

Charred remains of barley (top photo) and emmer spikelet forks (bottom) from the 3rd millennium BC House E of Khentkawes Town. Photos by Claire Malleson.

Desiccated remains of barley (top photo) and emmer (bottom) from an early 2nd millennium BC context at Elephantine. Photos by Claire Malleson; courtesy of the German Archaeological Institute, Cairo.

processing waste (emmer wheat and barley chaff) than in the shallower (lower) western layers (see cross-section). This dearth of plant remains in the west may be a result of water settling in the lower, "bowl" of the Kromer area, causing more of the desiccated plants to decompose in the samples from the western side of the trench. But because Egyptians stopped growing emmer by the Greco-Roman period, we can be sure this is all ancient. Finding lots of both charred and dessicated specimens in the samples puts us on much firmer footing in identifying these plant remains as Old Kingdom in date. Barley, on the other hand, is still grown in Egypt now, but because it is a very common find in archaeobotanical samples throughout post-Paleolithic Egyptian sites, and because we found charred barley chaff in almost all the KRO features (as well as some dessicated barley in the higher eastern layers), I can feel secure in identifying this as ancient.

I also found a lot of desiccated *Rumex* (dock) and *Eleocharis* (rush) seeds. Both species are common field weeds in Egypt today, so the seeds *might* be modern, but I also found charred specimens. The two species are extremely common in Old Kingdom sites, so I can be more confident that they are ancient.

The Hardest Case: Olive (Olea Europaea) Stones. Charcoal specialist Rainer Gerisch identified olive wood from the HeG—the oldest evidence of olive in Egypt.[2] It was probably packed around jars of olive oil imported from the Levant. In 2012 I identified a charred fruit stone fragment, found in one of the galleries at HeG, as olive. But the identification is uncertain.[3,4] It flies in the face of the accepted view that olive fruits were not grown in Egypt or imported until much later, the 18th Dynasty.[5] However, an olive stone was found at Memphis dating to the 13th Dynasty, pushing the earliest date for olives back to the Second Intermediate Period.[6] Though unlikely, the possibility that Egyptians were importing olives in the Old Kingdom should not be entirely discounted.

At KRO, I found one complete and two halves of a desiccated olive stone, as well as one tiny charred fragment that might be olive The desiccated stone felt "fresh," and the interior was exceptionally well preserved. All the specimens came from Feature [35,512], where modern glass and newspaper were also found, as well as the peanut shell. I immediately concluded that the olive stones could not be ancient. These specimens could be tourist garbage, or perhaps remnants from the 1970s excavations. The exterior surfaces are unusually smooth (above, right), as if they had rolled, bounced, and blown across the sand a long way, perhaps after being discarded by tourists. (Compare the photos of a KRO olive specimen with those from Ptolemic El-Hibeh, above, right). Still, even though the KRO olive stones seem suspect, we should keep an open mind.

The only way to be certain that the KRO olive stones are ancient would be to test them with AMS (accelerated mass spectrometry) radiocarbon dating. This technique has revolutionized many archaeobotanical studies. But AMS dating is not yet available in Egypt. If it were, would we have the KRO specimens dated? With all (expensive) high-level scientific analyses, we must ask: what would the results contribute to our knowledge of the past that we do not already know, or cannot learn using other methods? AMS is usually used to answer a specific question. If the Kromer olive stones were AMS-dated and proved to be from the Old Kingdom, what would this tell us? We know that olive oil was imported during the Old Kingdom (see page 22). It would be interesting to discover that a few fruits were also imported at this time. Various lines of evidence from our excavations point towards the possibility that olive oil, and perhaps also olive fruits, were not just reserved for the "elite" classes in Egypt. Given the presence of the very clearly modern plant remains in the samples, I have to remain skeptical about the desiccated olive, but, the presence of what might be a charred olive fragment, alongside all the other evidence for olives in 4th Dynasty Giza is undoubtedly exciting.

Above, left: An olive pit from the Kromer site, interior and exterior. Note the light color and fresh appearance. The outside of the pit is smooth, possibly as a result of being tumbled across the desert by the wind. Photos by Claire Malleson. Compare it with the two desiccated Ptolemaic period olive stones, exterior and interior, on the right, from the El-Hibeh site in Middle Egypt. Note the pronounced ridges on the exterior. The surface of the interior is dull, and the ridge, on the right, is degraded. Photos by Wilma Wetterstrom.

The KRO Dump and its fascinating material culture are a reminder of the importance of gathering all available information from a deposit; looking for cues from all corners. It is crucial that all our lab specialists take each other's findings into account as they analyze their material, as well as understanding the stratigraphic interpretations of our excavation team. We have much to learn from the KRO material and its unusual taphonomic history.

1. "Kromer in Context: Biography of an Ancient Dump," *AERAGRAM* 19-2, pages 2–13, Fall 2018.

2. Gerisch, R., W. Wetterstrom, and M. A. Murray, "Egypt's Oldest Olive," *AERAGRAM* 9-2, page 3, Fall 2008.

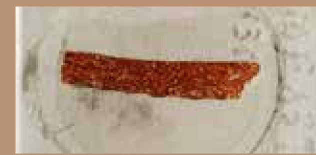
3. Malleson, C., "Egypt's Oldest Olive Pit at the Lost City of the Pyramids," *AERAGRAM* 13-2, page 24, Fall 2012.

4. Malleson, C., "Egypt's Earliest Olive Pit Reconsidered: A Case of Mistaken Identity?" *AERAGRAM* 14-1, page 23, Spring 2013.

5. Newton, C., J.-F. Terral, and S. Ivorra, "The Egyptian Olive (*Olea europaea* subsp. *europaea*) in the Later First Millennium BC: Origins and History Using the Morphometric Analysis of Olive Stones," *Antiquity* 80, pages 405–414, 2006.

6. Murray, M. A., "Fruits, Vegetables, Pulses, and Condiments," *Ancient Egyptian Materials and Technology*, edited by P. T. Nicholson and I. Shaw, Cambridge: Cambridge University Press, page 614, 2000.

Foreign Trade and Heit el-Ghurab *by Karin Sowada*



Left: Karin Sowada examining a Combed Ware jar at the Museum of Fine Arts, Boston (photo by Inês Torres). Above left: Section of a fragment of vat HeG69608 (next page, top), showing inclusions in the clay visible to the naked eye (photo by Jason Quinlan). The white speckles are pieces of limestone, the smaller light brown sub-rounded pieces are quartz sand. Above right: A pottery thin-section ready for examination under a microscope.

For years Dr Anna Wodzińska (University of Warsaw) has been a regular member of the AERA team, responsible for study of the many thousands of pottery fragments from the Heit el-Ghurab (HeG) settlement site. Over that time she discovered, mingled with daily life vessels, 24 pottery pieces from a special type of imported two-handled jar that was first identified at Giza over 100 years ago. The type is known as "Combed Ware" owing to the distinctive incisions on the surface. The marks are thought to imitate basketry, but also have the added benefit of roughing up the surface, making the large jars easier to handle.

The jars contained exotic liquids, like resins and oils, obtained by Egyptian royal maritime trade expeditions and were the primary trade container of the 3^{rd} millennium BC. The original contents were likely used by the royal house, with empty jars then given as gifts to high officials for their loyal service. As a result, the jars were not ordinarily seen by the average Egyptian, but rather circulated through the "royal economy" before usually ending up as elite burial equipment. Similar vessels are known from elite tombs at other Old Kingdom sites, including Saqqara, Abusir, Dahshur, Abu Rawash, and Abydos.

Noted among the HeG settlement material were two fragments of large Combed Ware basins or vats, an imported type never before seen in Egypt. Such vessels in the Levant would be ordinarily used for food preparation or associated with the production of oils, such as olive oil. Their presence at the settlement may represent importation of specific contents that did not require sealing inside a jar, followed by secondary use in food preparation.

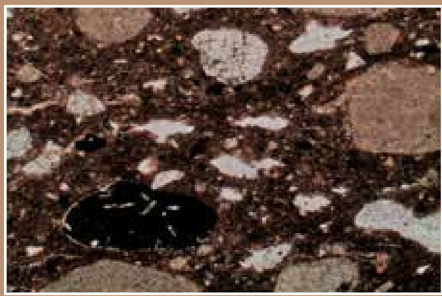
Identifying the contents of the jars is still a work in progress, but it's likely they contained mixtures of different organic compounds, such as resin from coniferous trees like cedar, and plant oils such as olive oil. The Egyptian royal court would have used these preparations in funerary and temple rites and other activities. As a result, Combed jars were prized for their contents and the symbolism of what they represented: access to royal grace and favor. The shape was even imitated in Egyptian clay as a form of status display. As mentioned, finding fragments of these sturdy containers at HeG also indicates that occasionally the jars were passed on to officials in the "company town" of the Giza pyramid builders, where they were likely used for storage.

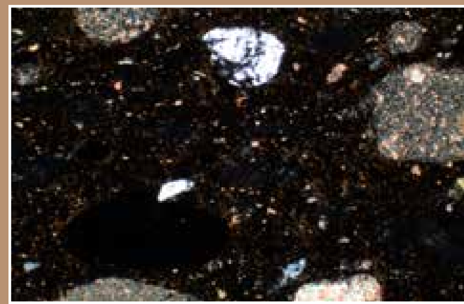
Combed Ware Origins

For decades, the origin of the jars has been guesswork. Much of the scholarly literature assumes they came from Byblos, owing to the city's role as Egypt's main trade partner.

My recent collaborative study with Dr. Mary Ownby (University of Arizona) and Dr. Wodzińska of samples from the HeG settlement and ten pieces from the Giza tombs, the latter housed in the Museum of Fine Arts, Boston, finally established the origin of the vessels. Most importantly, the results confirmed the destination of Egypt's foreign trade networks during the 4^{th} Dynasty.

Our study used the technique of thin-section petrography. This method involves embedding small pottery fragments in resin blocks, cutting a thin slice off each block, placing the slice on a glass slide, and examining each one with two different types of light using an optical microscope. Dr. Ownby identi-





Left: Thin-section of vat HeG69608 (right) at plane-polarized light (PPL), 100× magnification. Right: Thin-section at cross-polarized light (XPL), 100× magnification. Thin-sections show decomposing limestone as light brown inclusions, quartz as white inclusions, and shale fragments as black inclusions. Micrographs by Mary Ownby.

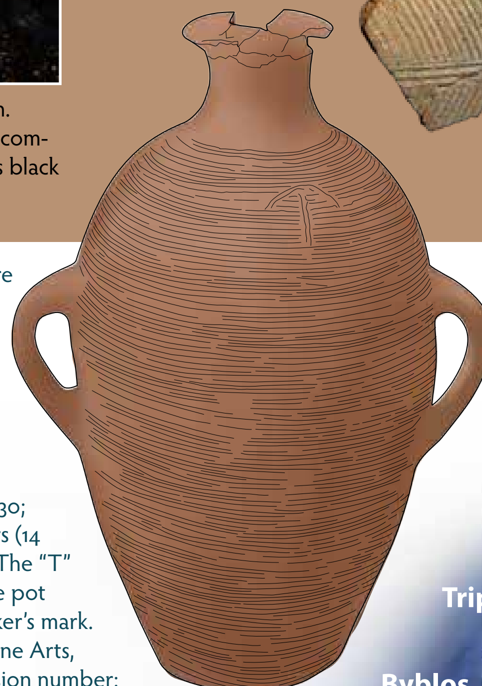
Rim of a vat from HeG Reg. 69608 (photo by Anna Wodzińska)

fied the type of rocks and minerals in the clay and compared them to the geology of the Middle East using geological maps. Such maps are used by the mining industry, for example, to understand the presence of rock and mineral types in a given location, materials from which ancient and modern clays are sourced.

The results revealed that all the sampled vessels were made in northern Lebanon between Beirut and Tripoli. This also includes the ancient city of Byblos. Other production centers may have been working with Byblos to supply products to the Egyptian state. The petrography results point to a major shift in Egyptian commodity acquisition networks by the 4^{th} Dynasty. The wide geographical scope of Early Dynastic exchange routes dissipated in favor of a focus by the Egyptian state on northern Lebanon. The need for very efficient transport mechanisms and procurement networks based on the trade in cedar wood fueled these changes, with Byblos as the likely key supply node.

Samples from the HeG made a significant contribution to the results by greatly increasing the scale of available data and providing key information about the royal economy. As a result, the trade relations of Egypt's great kings of the Pyramid Age are now more fully understood.

Read and download on Open Access: "The Petrography of Levantine Combed Vessels from Early Old Kingdom Giza," by K. Sowada, M. Ownby, and A. Wodzińska in *Levant, 2019*. https://doi.org/10.1080/00758914.2019.1664197



Combed Ware two-handled jar. Drawing based on a photo of a jar from the Western Cemetery at Giza, Pit G 4630; 36 centimeters (14 inches) high. The "T" incised on the pot may be a maker's mark. Museum of Fine Arts, Boston accession number: 19.1456.

Dr. Karin Sowada is a Future Fellow in the Department of Ancient History at Macquarie University. The work was funded by an Australian Research Council Grant FT170100288 and conducted in collaboration with AERA and with the permission of the Egyptian Ministry of Tourism and Antiquities.

Resurrecting Menkaure's Statutes

Fragment of travertine toes from AERA's 2019 fieldwork (about 4.3 centimeters [1.7 inches] at the widest point), and a *maktaf* of travertine stone fragments from the 2019 AERA MVT excavations. Photos by Mark Lehner.

In 1908 and 1910 George Reisner excavated the Menkaure Valley Temple (MVT), where he discovered multiple Old Kingdom statuary masterpieces, including dyad and triad statues featuring Menkaure and fashioned in dark diorite (or greywacke) stone, and several life-size statues of the king fashioned from alabaster.[1, 2] Along with complete pieces, Reisner found many small fragments of alabaster that likely belonged to statues that were casualties of vandalism (see photo below).[3] During 2019 we carried out our fourth field season in the MVT, focusing on the southwestern quadrant, where Reisner discovered some statue fragments. We thought that we might discover more—and indeed we did—far more than we expected.

Emmy Malak, AERA objects analyst, was soon inundated with *maktaf*s and *schwal*s (baskets and sacks) full of travertine fragments (sometimes called alabaster, Egyptian alabaster, or calcite). So many, in fact, that we quickly had to revise our normal process of sending everything up to the lab, and instead devise an on-site sorting method. Working quickly to sort out the piles, Emmy separated the worked/shaped fragments from stone chips, and then further sorted the worked/shaped stones by identifiable features: stones with flat worked surfaces and/or with corners, stones with curved surfaces, and stones with incised/inscribed surfaces. As for the unworked and chipped travertine stones, we weighed, recorded, and placed them together in schwals, just in case a reconstruction of a statue might be possible in the future.

Separating the grain from the chaff, as it were, it became obvious that many of the pieces were indeed from broken statues, likely of the same sorts that Reisner found. Emmy found that several bore partial incised hieroglyphs—including letters (*f*, *nb* or *t*, possibly a *nbty* from one of the king's titles) and the top portions of cartouches with a *ra* sign (the sun disc), likely bearing Menkaure's name. Additional identifiable fragments included three fragments of toes. Emmy dug into the daunting task: recording, measuring, describing, and photographing the identifiable fragments.

We plan to return to the MVT in Spring 2020, and will keep trying to piece fragments together, as well as record and catalog all the identifiable statue bits, including those of diorite, like the dyad and triads. Stay tuned for our next *AERAGRAM* issue, where we will have a fuller report by Emmy, including more exciting finds from AERA's Spring 2020 return to the MVT.

1. Reisner, G., *Mycerinus, The Temples of the Third Pyramid at Giza*, Cambridge, MA: Harvard University Press, 1931.

2. Friedman, F. D., "Broken, Buried—and (Often) Bewildering," *AERAGRAM* 20-1, pages 10–15, Spring 2019.

3. "Return to the Menkaure Valley Temple," *AERAGRAM* 20-1, pages 2–8, Spring 2019.

A 1910 expedition photo by Mohammedani Ibrahim, George Reisner's site photographer, showing piles of travertine fragments on the left edge of the trench in the MVT causeway's eastern end. Photo C2320_NS, courtesy Museum of Fine Arts, Boston.

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