



## On the Waterfront: Canals and Harbors in the Time of Giza Pyramid-Building

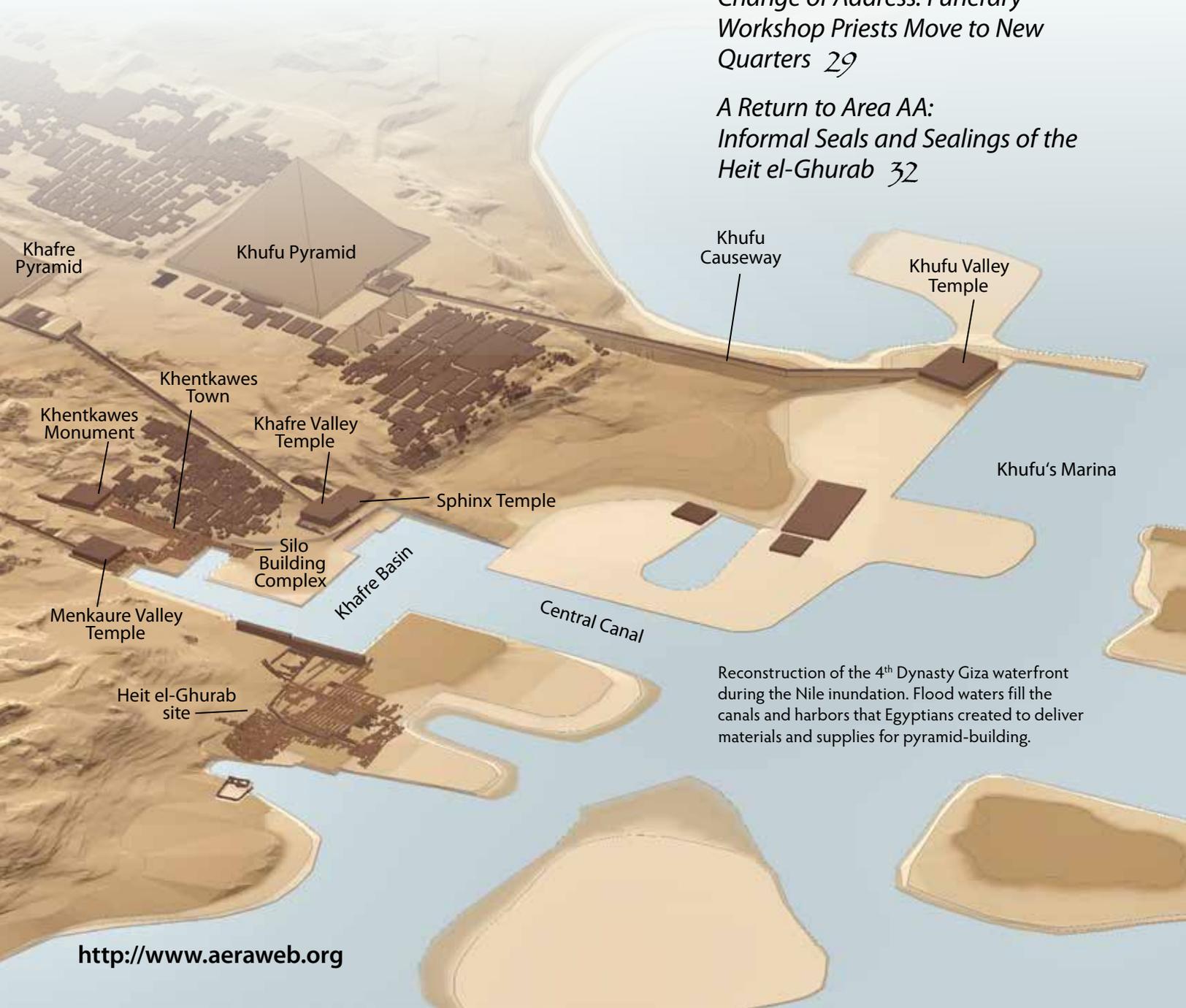
*A reconstruction of the Giza water transport  
infrastructure engineered by 4th Dynasty Egyptians 14*

*Construction Hub to Cult Center:  
Re-purposing, Old Kingdom Style 2*

*Did Egyptians Use the Sun to Align  
the Pyramids? 24*

*Change of Address: Funerary  
Workshop Priests Move to New  
Quarters 29*

*A Return to Area AA:  
Informal Seals and Sealings of the  
Heit el-Ghurab 32*



Reconstruction of the 4<sup>th</sup> Dynasty Giza waterfront during the Nile inundation. Flood waters fill the canals and harbors that Egyptians created to deliver materials and supplies for pyramid-building.



## Construction Hub to Cult Center: Re-purposing, Old Kingdom Style

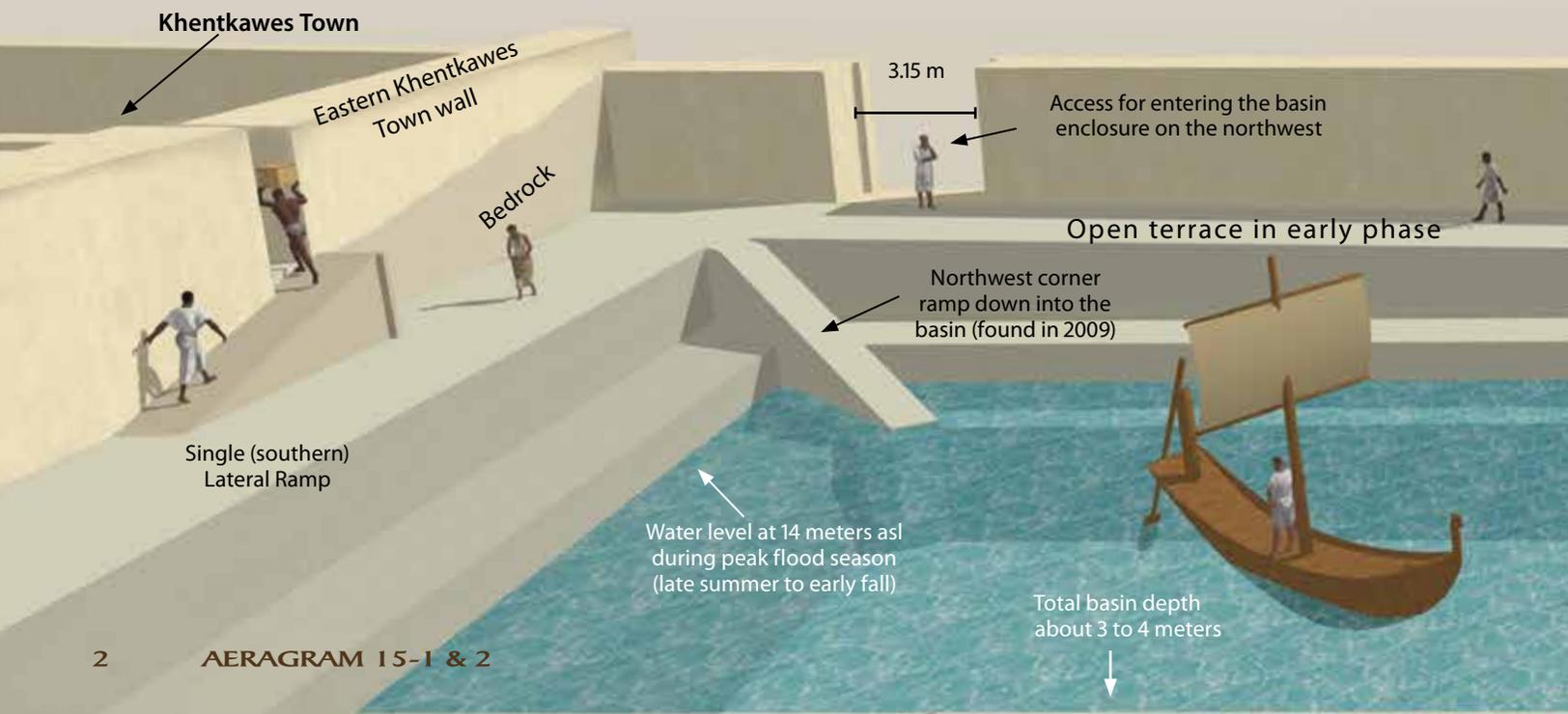
Some 4,400 years ago the Giza Plateau hummed with construction on the pyramid complex for king Menkaure, last of the Giza pyramid-builders, and on the monumental tomb of the queen mother Khentkawes I. When Menkaure died prematurely, his successor, Shepseskaf, hastily completed Menkaure's pyramid temples and built for Khentkawes a town adjoining Menkaure's valley temple on the north.

Over the last five years the AERA team uncovered the northern end of a basin east of the Khentkawes Town (κκτ).<sup>1</sup> Menkaure's workers first used the basin to deliver building material. Later, probably as part of Shepseskaf's works, they re-purposed the basin to serve the memorial foundation of Khentkawes. The earlier use of the basin during construction came into focus during Field Season 2014. In contrast, the role of the Lost City (or Heit el-Ghurab) site as a "back room" for

pyramid-building has been emerging since AERA began work there in 1988.

### Waterway and Basin

In order to move massive stone blocks and other supplies, ancient engineers dredged a waterway from the Nile to the eastern front of the Khafre Valley Temple and Sphinx (see article starting on page 14). Later, they extended the waterway south and then west to the front of Menkaure's valley temple, taking advantage of their deep quarrying of the bedrock at the mouth of the wadi between the Moqqatam and Maadi Formation outcrops (shown on page 21). Off this channel, they dug a spur north, creating the basin east of the Khentkawes Town.



Using abundant limestone quarry debris, workers terraced the basin perimeter and cased the edges with mudbrick sloping steeply on the west and standing vertically on the north and east. At 26.6 meters (87 feet) wide, the basin was just large enough for small boats to deliver goods and turn around. In both corners (northwest and northeast) we found traces of ramps that allowed people to offload material and carry it to the upper terrace.

### East and West Banks: A Construction Hub

Soon after builders completed the basin, they added on the east and west mudbrick buildings enclosed by massive walls, connected by an enormous mudbrick wall on the north. At this point thick mudbrick enclosure walls framed the basin.

The builders founded the western buildings along a high bedrock terrace, flush along an old quarry edge. In 2006 and 2007 we discovered that these buildings predated the later Khentkawes Town. Shepseskaf's masons incorporated them into the "foot" of the L-shaped town. During Menkaure's time these buildings must have housed people who administered deliveries of building supplies.

On the lower eastern bank, Menkaure's masons built a mudbrick enclosure that extends east beyond our excavations. On the north they connected the eastern and western enclosures with an enormous mudbrick wall spanning the 4-meter (13 feet) drop in elevation from the upper bedrock terrace to the east bank. Wide doorways through the northern wall at its western and eastern ends gave access to the upper basin terrace (Terrace 1). On the west, another doorway, marked by a limestone pivot socket, gave access into the upper buildings. From this thresh-

old, the Southern Lateral Ramp sloped down 2 meters against the bedrock face onto Terrace 1. On the east bank, a doorway, also marked by a limestone pivot socket, opened through the enclosure wall of the lower complex.

We know little about the early interior of the east bank enclosure, the pre-Silo Building Complex. In small excavations down to its earliest levels we found burnt walls and ashy floors—traces of baking. At this point in time, bread and beer probably went to construction workers and administrators. Grains and other supplies could have arrived by boat during the inundation season, when workers off-loaded onto the waterfront terraces.

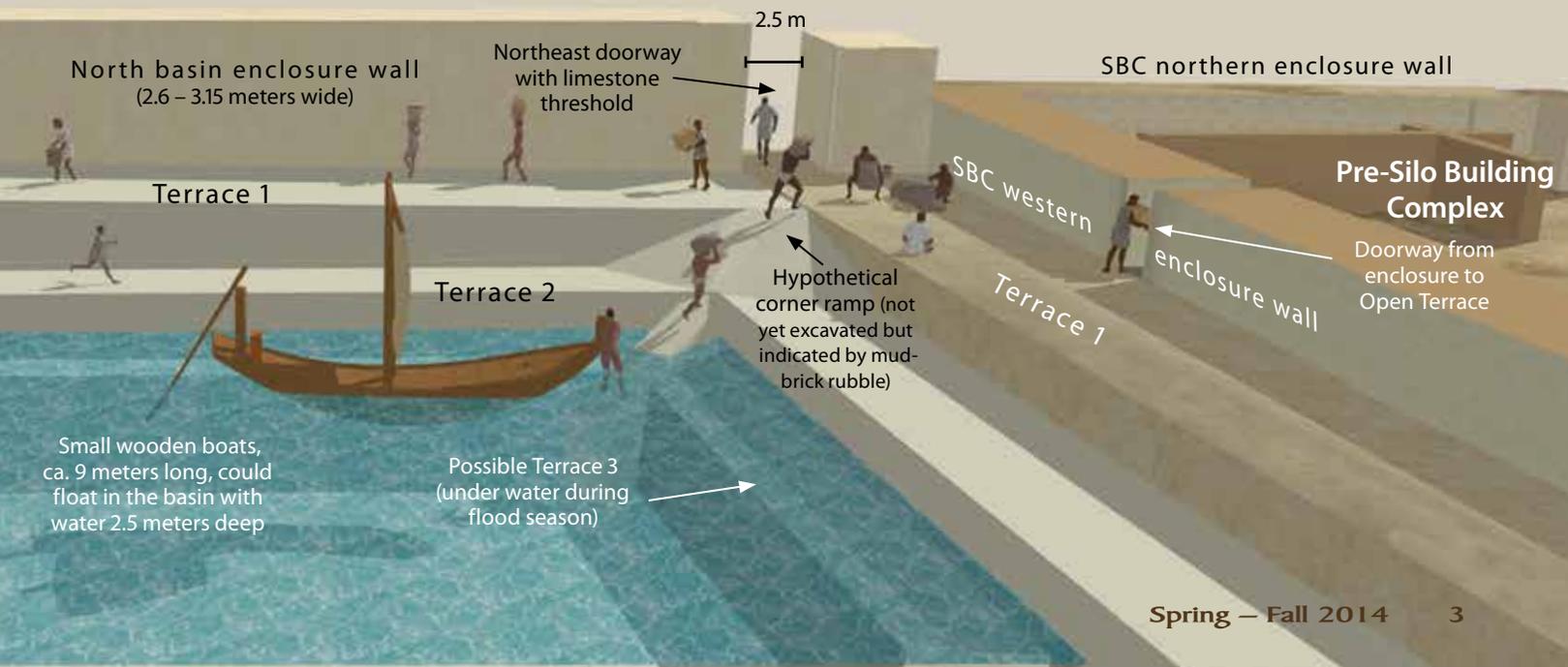
### Change on the Basin Banks

During the three or four years when Shepseskaf's masons completed Menkaure's pyramid temples, they built the town for the queen mother Khentkawes on the upper bedrock terrace. They incorporated Menkaure's administrative buildings into the eastern and southern end of the town.

At the top of the Southern Lateral Ramp they narrowed the eastern entrance to create the threshold for a causeway corridor, 1.6 meters (5.2 feet) wide and 150 meters (492 feet) long, running west up the slope to the queen's chapel in her monumental tomb.

The builders added a Northern Lateral Ramp complimenting the one on the south, but sloping down from the causeway threshold to a corridor raised about half a meter above Terrace 1 (see pages 4–5). To access the terrace, they constructed a set of stairs descending from an opening in the corridor wall.

"Snapshot" of a 3D model of the early phase of the Silo Building Complex, basin, and approach to Khentkawes Town. Most of this is based on archaeological evidence, but wall heights are estimates.



The terraces, stairs, and lateral ramps on the west side of the basin made a fitting ascent to the queen's monument and upper town. Generations later, builders crafted in limestone similar lateral and angled ramps and terraces at the front of the valley temple of the pyramid complex of Pepi II, last king of the 6<sup>th</sup> Dynasty.

The new walled corridor turned east to run above Terrace 1 along the northern side of the basin. By adding an accretion against the face of the northern enclosure wall, the builders made the corridor 1.6 meters wide, intending it to be a continuation of the queen mother's causeway that ran straight to the enclosure on the east bank. The accretion closed off the wide western access through the northern enclosure wall. But the builders left the eastern access, to this day marked by a broad limestone threshold.

### Community Cult Center and Commissary

During the 5<sup>th</sup> Dynasty, builders created the "Silo Building Complex" (SBC) within the eastern enclosure, named for its most distinguishing feature, a set of five round silos, which must have stored grain.

Fifth-Dynasty masons may have renewed storage, baking, and brewing facilities that began as early as Menkaure, when the goods might have gone to work gangs, guards, and officials. Once Khentkawes connected her causeway corridor to the eastern enclosure, bread, beer, and other goods were siphoned to her monument, before reverting to the staff now attached to her memorial service.

When they built the SBC as we know it, 5<sup>th</sup> Dynasty workers took down the thick western wall of the older enclosure to the level of Terrace 1. This left open to the basin the interiors of the rooms they added, or modified, on the western side of the enclosure. Alongside the remains of the old enclosure wall they erected small brick pillars to support a light roof. The result: a shaded portico opening into the bright light of the open basin,

a configuration we see in Middle Kingdom house models, ground plans, and temples.

Because the builders left the lowest half meter of the old enclosure wall flush with Terrace 1, one had to step down into the shaded western rooms of the SBC. In the northwestern corner of the SBC, they carved a slope into the base of the old enclosure wall, just opposite where the queen's causeway corridor ended from its run along the north side of the basin. This makeshift ramp allowed porters to carry bread and beer as offerings from the bakeries in the SBC directly up the corridor, thence to the Northern Lateral Ramp, and via the causeway through the upper town directly to the queen's chapel.

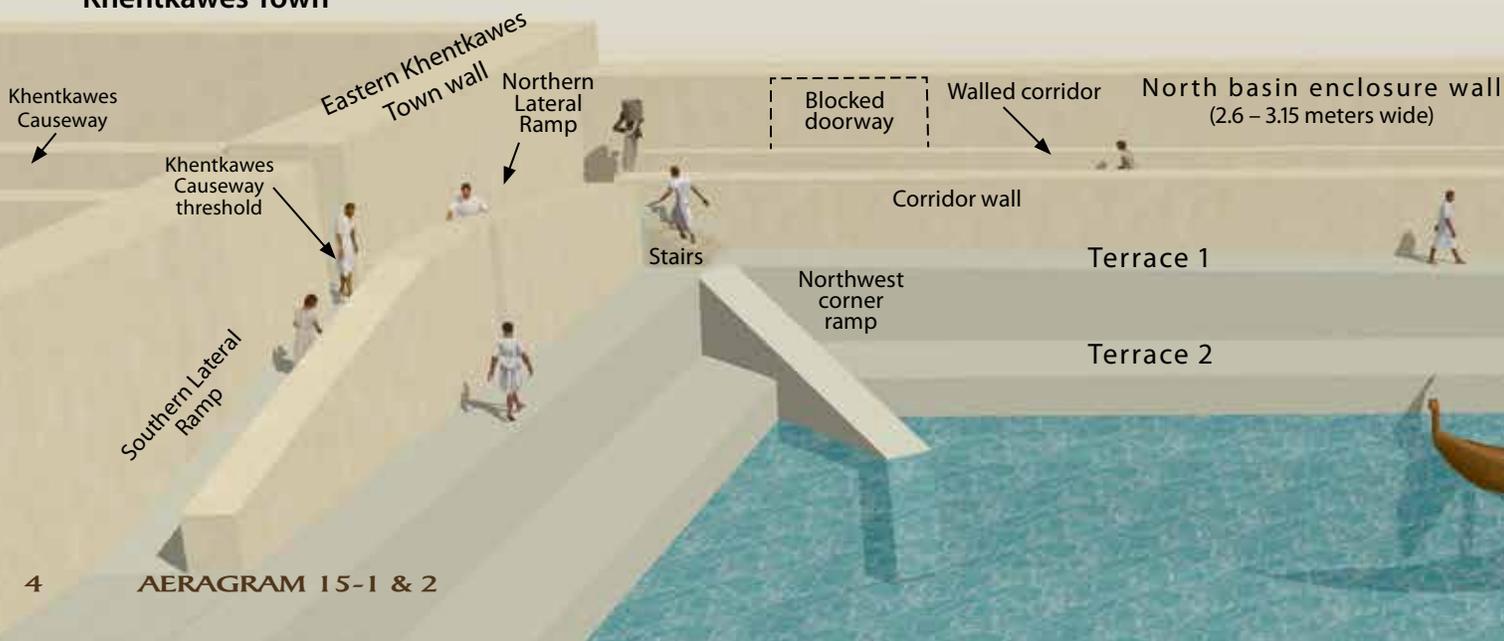
The final SBC included the five silos, long open chambers for baking and possibly brewing, and an overseer's residence with its own kitchen, sleeping chambers, and audience hall.

### A Tale of Two "Cities" and Transformation

The early Menkaure/Khentkawes basin and its settlements east and west offer a strikingly different narrative than the Lost City site. Authorities founded both installations to support pyramid-building. But the Lost City came down when construction ceased, while the Menkaure/Khentkawes Valley Complex metamorphosed into a pyramid town devoted to the royal cults. Why did the two sites meet different fates? As they say in real estate: "location, location, location."

While the early Menkaure/Khentkawes construction hub lay within the sacred mortuary precinct, the Lost City sat on profane ground farther southeast, too far to provide offerings of a smaller scale production than required for pyramid work crews and too far to house priests. But located adjacent to a sizable harbor close to the Nile (see article starting on page 14), it was ideal for receiving, housing, and processing vast quantities of material, supplies, and people arriving by water. Moreover, the expansive low desert allowed the "Lost City" settlement to sprawl as needed to accommodate a wide range of facilities and

### Khentkawes Town



activities on an industrial scale—craft workshops, grain silos, warehouses, officials residences, slaughterhouses, stockyards, and even, for its time, part of a royal mortuary workshop.

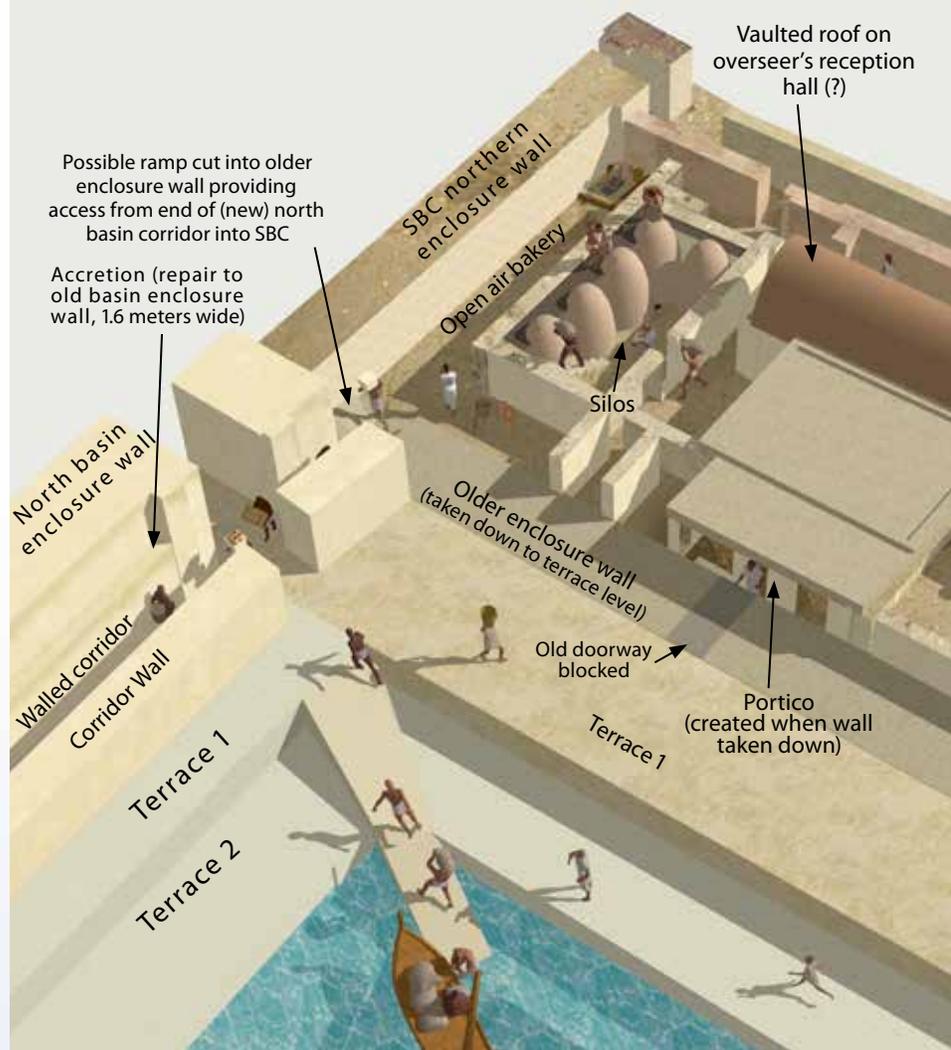
The early Menkaure/Khentkawes settlement, hemmed by quarry walls, mortuary temples, tombs, a canal, basin, and the southern wadi, had little room to expand. The builders intended it to serve as a management base close to the construction projects, akin to the present-day mobile office trailers at construction sites.

At the same time the builders must have designed it with a post-construction purpose in mind. They readily converted the basin frontage to serve royal cults. Moreover, the care and investment they put into the basin complex suggests they intended to use it long-term.

This tale of two cities and transformation includes the relocation of certain residents of the Lost City to the revamped Menkaure/Khentkawes complex. As people abandoned and dismantled the Lost City, Menkaure’s purification priests, who had staffed the Royal Mortuary Workshop (*Wabet*—literally “purification place”), moved to the SBC with Shepseskaf’s blessing (see article on pages 29–31).

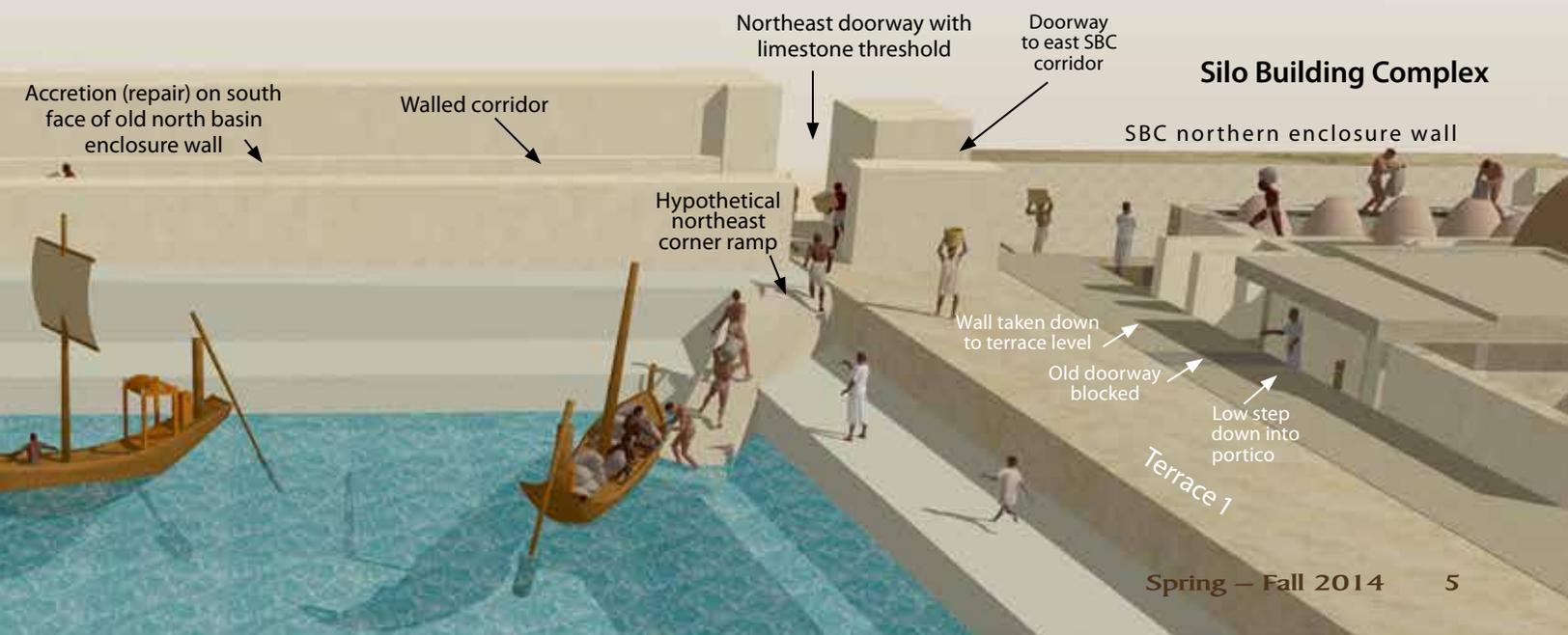
~Mark Lehner and Wilma Wetterstrom

1. “Valley Complex for a Queen,” *AERAGRAM* Vol. 10-2, pages 7–9, 2009; “KKT-E+: The Buried Basin and the Town Beyond,” *AERAGRAM* Vol. 12-1, pages 10–13, 2011; and “The Silo Building Complex: A Fifth Dynasty Production Facility,” *AERAGRAM* Vol. 13-2, pages 6–9, 2012. All back issues of *AERAGRAM* are available for free download at our website: aeraweb.org.



Closeup of the SBC and northeast corner of the basin. When the Egyptians took down the western enclosure wall of the SBC, they built support walls and columns for the roof of the adjacent rooms, creating a portico fronting onto a pool (basin) like we see in many models, albeit mostly of the Middle Kingdom. The vaulted roof is based on F. Arnold’s reconstruction of the Khentkawes Town houses in “Die Priesterhäuser der Chentkaues in Giza, Staatlicher Wohnungsbau als Interpretation der Wohnvorstellungen für einen Idealmenschen,” *Mitteilungen des Deutschen Archäologischen Instituts Abteilung Kairo*, Band 54, pages 1–18, 1998.

“Snapshot” of a 3D model of the late phase of the Silo Building Complex, basin, and approach to Khentkawes Town. Most of this is based on archaeological evidence, but the wall heights are estimates.



# Return to Memphis: MRFS 2014

We returned to the field in September—just three months after closing down our 2014 spring excavations at Giza—to carry out the 10<sup>th</sup> session of our joint field school with the American Center for Research in Egypt (ARCE), providing archaeological training for inspectors of the Egyptian Ministry of Antiquities. We resumed work at ancient Memphis (modern Mit Rahina) as the Mit Rahina Field School 2014 (MRFS 2014) in order to analyze material that our 2011 field school\* excavated in the Kom el-Fakhry settlement, the earliest known part of the vast ancient Egyptian capital of Memphis (see sidebar, next page).

This year's four-week program provided advanced training for students in pottery analysis and archaeological illustration, with an eye towards producing a series of publication-ready articles. The six inspectors in this session included four students in ceramics (Rodayna Bayoumy, Rehab Ahmed, Aisha Mohamed, and Walid Abd el-Bary) and two in archaeological illustration (Mahmoud Nour el-Din Mohamed and Abd el-Ghany Abd el-Rahman Mohamed). The students, selected from a pool of applicants with previous experience in one of these two subject areas, came from the Delta, Luxor, Saqqara, and Qena areas.

MRFS 2014 represented a joint project under the overall direction of Dr. David Jeffreys, Senior Lecturer at University College London and Director of the Egypt Exploration Society's (EES) Survey of Memphis, and Dr. Mark Lehner of AERA. AERA Co-Field Director Ana Tavares oversaw the fieldwork.

\*For more on the 2011 Mit Rahina Field School, see our previous *AERAGRAM* articles: "New Cycle, New Site: The Mit Rahina Field School," Vol. 12-2, pages 18–19, 2011; and "Memphis, A City Unseen: Joint AERA-ARCE-EES Beginners Field School Excavates Oldest Part of Egypt's Ancient Capital City," Vol. 13-1, pages 2–7, 2012. All back issues of *AERAGRAM* are available for free download at our website: [aeraweb.org](http://aeraweb.org).

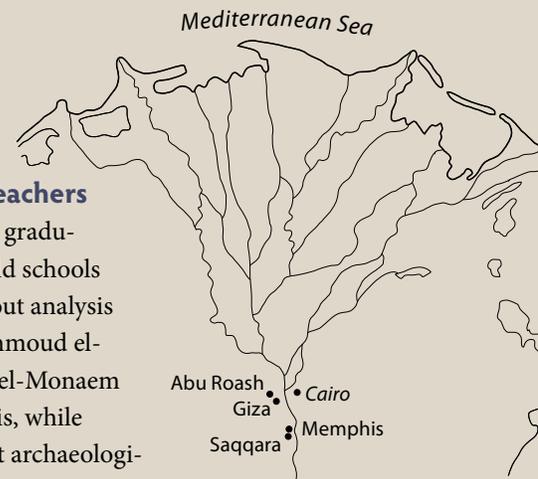
## Students Turned Teachers

We are proud that four graduates of our previous field schools taught and/or carried out analysis during MRFS 2014. Mahmoud el-Shafey and Sherif Abd el-Monaem taught ceramics analysis, while Yaser Mahmoud taught archaeological illustration. Rasha Nasr el-Mageed, archaeozoologist, analyzed the animal bone and prepared a preliminary report. All four are veteran teachers in our field schools. When they needed help this season they could turn to their former teachers from the 2011 AERA-ARCE Field School, via Skype: Dr. Teodozja Rzeuska and Dr. Sabine Laemel, ceramicists; William Schenck, archaeological illustrator; and Dr. Richard Redding, AERA archaeozoologist.

## Hands-on Training

The AERA-ARCE Field School adheres to the tenet that students jump right into basic archaeological documentation and analysis of any site or period. Such flexibility allows Ministry Inspectors to handle sites of all sorts, sizes, and periods in their day-to-day responsibilities. The challenges of a multi-period site such as Memphis are perfect for gaining such a range of practical experience.

*(continued on page 8)*



Students practice drawing skills in the Egypt Exploration Society's (EES) workroom at Memphis during September's Mit Rahina Field School session. Photo by Sayed Salah.

A busy day during the 2011 MRFS excavations at Kom el-Fakhry with students and staff hard at work uncovering and documenting residential compounds dating to the Middle Kingdom. View to the southeast. Photo by Yaser Mahmoud.



## Memphis, Manf, Kom el-Fakhry, or Mit Rahina? All of the above!

The ancient site of Memphis, or *Manf* in Arabic, is actually a palimpsest of overlapping, scattered ancient settlements and monuments, as well as modern towns and villages. Strategically located at the boundary between Upper and Lower Egypt, it served as the administrative capital of Egypt for much of the Pharaonic period and was a preeminent city of the ancient world. As such, it has drawn steady attention as a population center over millennia of ancient and modern history.

The site consists of multiple settlement mounds, also known as tells or *koms*, of which Kom el-Fakhry is but one. The modern village of Mit Rahina partially covers Kom el-Fakhry. All told, it is thought that the settlement ruins span six square kilometers (2.3 square miles), making it one of the largest ancient settlement sites in the Nile Valley.

According to ancient sources, Memphis was founded around 2990 BC by the 1<sup>st</sup> Dynasty king Menes, uniter of Upper and Lower Egypt. As noted, it saw varied occupation throughout much of the Pharaonic period and into Graeco-Roman times. Ptolemy supposedly brought the body of Alexander the Great to Memphis for embalming in the great Temple of Ptah, just east of Kom el-Fakhry. The Byzantine and Coptic period occupations were once important, but they are now poorly understood. During the Islamic period, the location of Memphis was once again discussed in 13<sup>th</sup> and 14<sup>th</sup> Century sources. Modern cartographic and archaeological investigations began in the 17<sup>th</sup> and 18<sup>th</sup> centuries, perhaps most notably by Napoleon's *Description de l'Égypte* team.

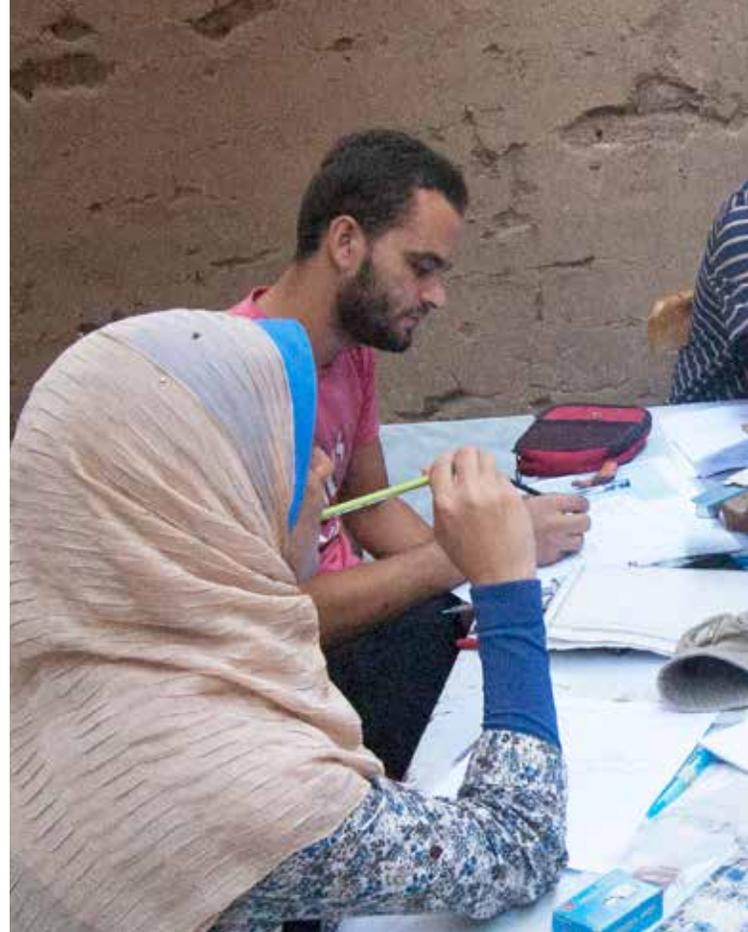


## OUR SINCEREST THANKS

The 2011 and 2014 MRFS sessions were greatly enriched by the stalwart presence of Dr. David Jeffreys (shown here leading a tour of the ruin field of Memphis last September; photo by Sayed Salah), who as Director of the EES's Survey of Memphis brings over 30 years experience working at this important ancient site. We are exceptionally grateful for his support and encouragement, as well as the collegial spirit of the Survey team, during the last five years.



Illustration student Mahmoud Nour el-Din completes a drawing of a bread mold base. Photo by Sayed Salah.



(continued from page 6)



Illustration instructor Yaser Mahmoud (at left, in striped shirt) teaches students how to draw the profile of a ceramic sherd. Photo by Ana Tavares.



Ceramics student Rodayna Bayoumy reconstructs the stance of a rim sherd in order to estimate its diameter as part of the recording process. Photo by Sayed Salah.

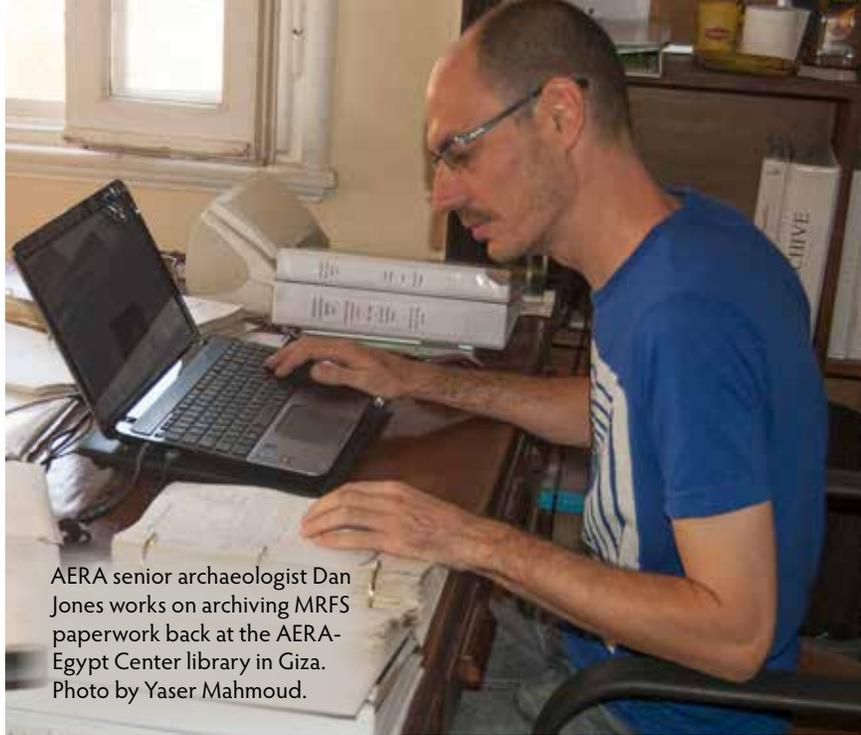
For example, although the 2011 excavations largely focused on the Middle Kingdom (c. 1980–1760 BC) residential compounds, some of the ceramics excavated in 2011 are a mixture of this period with earlier Old Kingdom (c. 2543–2120 BC) ceramics. The older pot fragments were most likely reused with Old Kingdom deposits as building material during the construction of the Middle Kingdom structures. The presence of both Old and Middle Kingdom ceramics and clay sealings offers students the chance to familiarize themselves with material culture from a range of periods.

Mahmoud, Sherif, and Yaser spent a few days reviewing the basics before jumping into more advanced issues, integrating student training with the publication goals of the season. By choosing objects and pottery crucial to the publication, and by training students in the preparation of publisher-ready drawings, the teachers show students the importance of prompt publication of archaeological work and time-saving tips and techniques for facilitating the process.

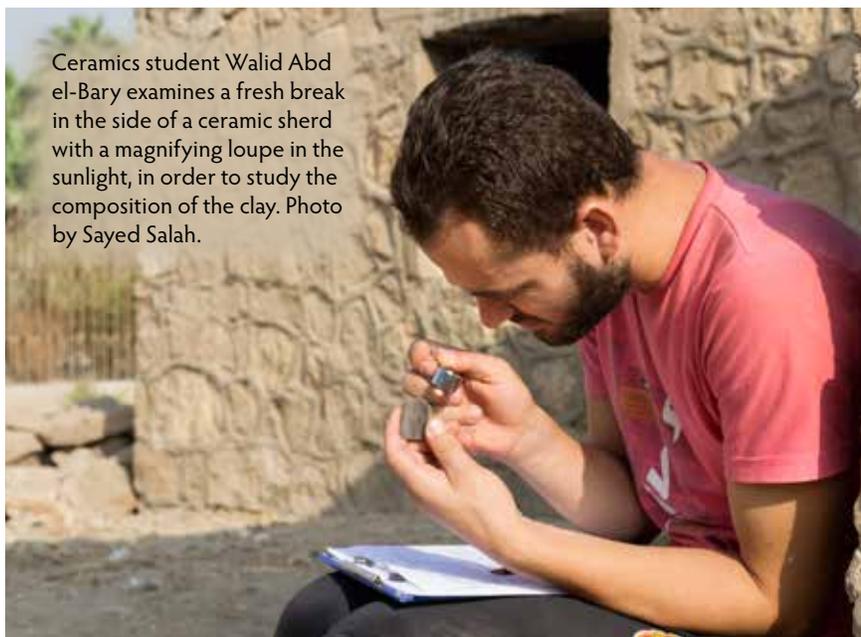
Ana lectured on object typologies and recording techniques, while Giulio Lucarini, Research Fellow at the McDonald Institute for Archaeological Research, spoke with students about the study of microscopic residues on ground stone tools. Drs. Joanne Rowland and Geoffrey Tassie (both of Freie Universität, Berlin) presented a hands-on session with lithic tools.



Ceramics instructor Sherif Abd el-Monaem (at center) holds an outdoor session with his students in the courtyard of the EES workshop. Photo by Ana Tavares.



AERA senior archaeologist Dan Jones works on archiving MRFS paperwork back at the AERA-Egypt Center library in Giza. Photo by Yaser Mahmoud.



Ceramics student Walid Abd el-Bary examines a fresh break in the side of a ceramic sherd with a magnifying loupe in the sunlight, in order to study the composition of the clay. Photo by Sayed Salah.

### Publication Goals

In addition to the further training of our students, MRFS 2014 also aimed to produce a report on the history and archaeology of Kom el-Fakhry and a full preliminary report of the 2011 excavations. Ministry of Antiquities Inspectors Hanan Mahmoud, Rabee Eissa, Essam Shehab, and Ashraf Abd el-Aziz, all of whom have taught in the AERA-ARCE Field Schools and worked with AERA as team archaeologists since completing their own field school training, worked on a preliminary site report based on the Data Structure Report they wrote in 2011 as Area Supervisors, in collaboration with AERA senior archaeologists Daniel Jones and Freya Sadarangani.

Separate articles on the 2011 material culture are also in the works, to be illustrated in part by student drawings from this season. Mahmoud and Sherif will prepare their work on the ceramics; Yaser is preparing an article on the clay sealings; and Ana and Ministry Inspector Nagwan el-Hadedi are writing up a report on the objects.

### Our Thanks!

The MRFS 2014 was made possible by an ARCE award from the Antiquities Endowment Fund and a generous donation from Dr. David Jeffreys, as well as an AERA cost-share from other donors. As always, we are grateful to the officials of the Ministry of Antiquities for their support and help.



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FROM THE AMERICAN PEOPLE

**EGYPT**

The AERA Mit Rahina Field School 2014 was made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents of this article are the responsibility of AERA and do not necessarily reflect the views of USAID or the United States Government. Funding was provided through an American Research Center in Egypt (ARCE) USAID grant.



# Season 2015: Doing Science at Giza

Thomas Huxley (aka Darwin's Bulldog) once described the process of science as "the slaying of a beautiful hypothesis by an ugly fact." Every season at the Lost City (or Heit el-Ghurab) settlement we start with beautiful hypotheses, and we look for those ugly facts. This season we start with one beautiful hypothesis and a basketful of ideas. Our beautiful hypothesis is that the Standing Wall Island area of the site is a large corral with two rooms on the northern edge for slaughtering cattle—a hypothesis presented in a previous issue of *AERAGRAM*.<sup>1</sup> The basketful of ideas is about the production of bread and beer. We believe brewing was associated with bread-baking and carried out extensively at the Lost City, although to date we have found no definitive evidence of brewing.

## Bread and Beer

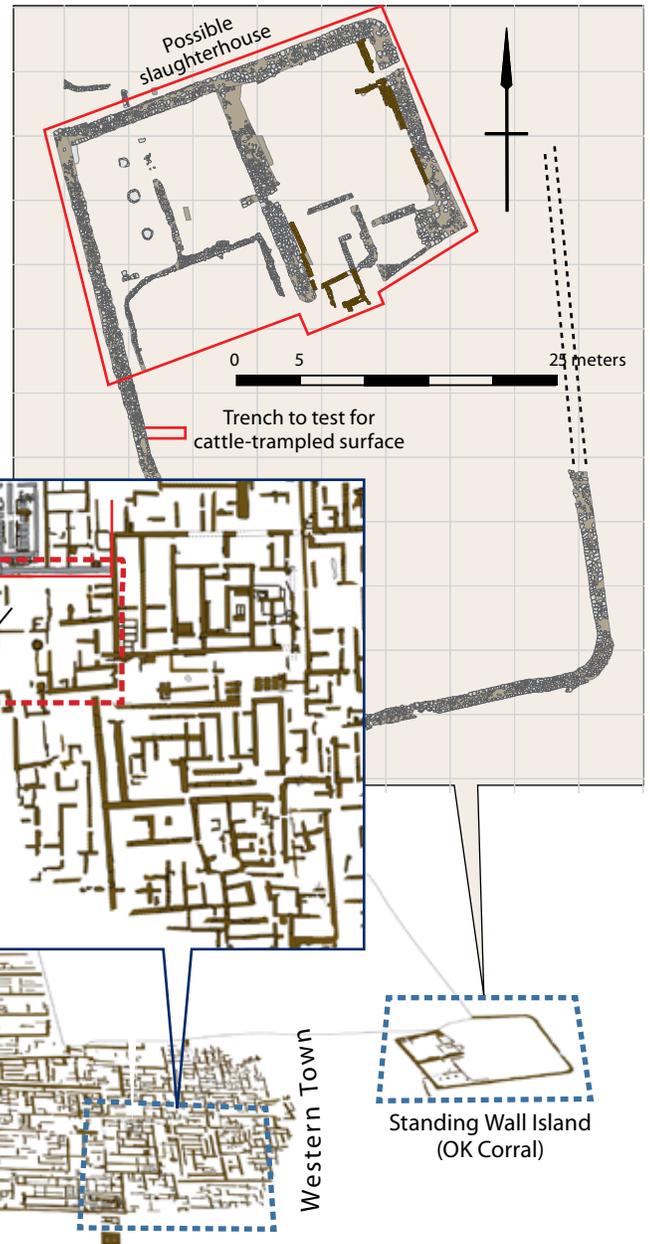
Bread and beer were the staples of the ancient Egyptian diet through all ranks of society from the pharaoh down to the lowliest peasant. At home and away Egyptians relied on bread and beer for sustenance. Workers serving the king on royal projects received bread and beer as rations. After passing on to the Afterlife, Egyptians "consumed" bread and beer offerings.

Thus, it is no wonder that we have found remains of bakeries throughout the Lost City site. Curiously, however, we have recovered no unequivocal traces of breweries, but we are not alone on that score.

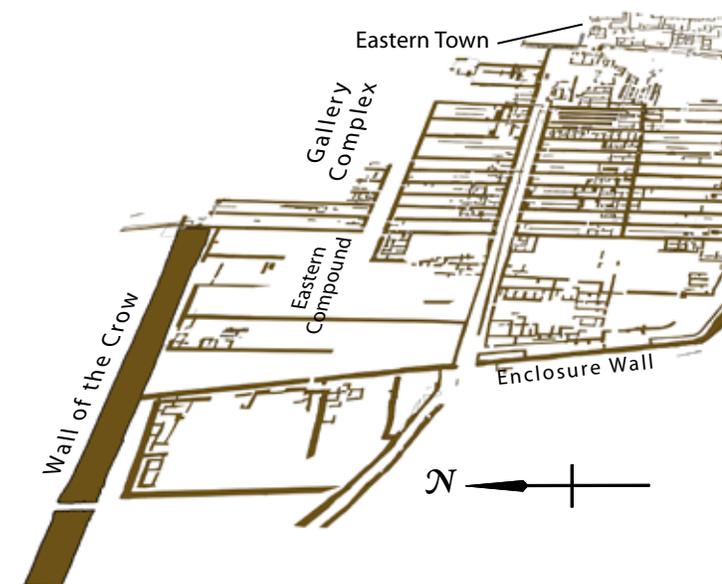
Breweries have been positively identified at only three sites in Egypt, all from the Predynastic period. They consist of clusters of large vats in crude kiln-like installations. Grain was apparently steeped in water in the vats. No such breweries have been found in later period sites, although brewing was depicted in tomb reliefs and paintings and in models. The kiln-like installations were apparently abandoned, but vats would still have been used to steep grains. Models and reliefs show steps in the

brewing process, but no kiln-like facilities. Rather, they depict brewing side by side with bread-baking. For example, one of the wooden models from Meketre's Middle Kingdom tomb contains a bakery and a brewery separated by a partition, with a doorway between them.<sup>2</sup>

Although tomb art was stylized and cannot necessarily be taken at face value, it seems likely that bakers and brewers worked near each other as they would have used nearly the same set of ingredients and may have shared some of them:



Map of the Lost City site highlighting the two areas the AERA team will excavate during the 2015 field season, Area AA South and Standing Wall Island. Note that the overall map is oriented with north to the left.



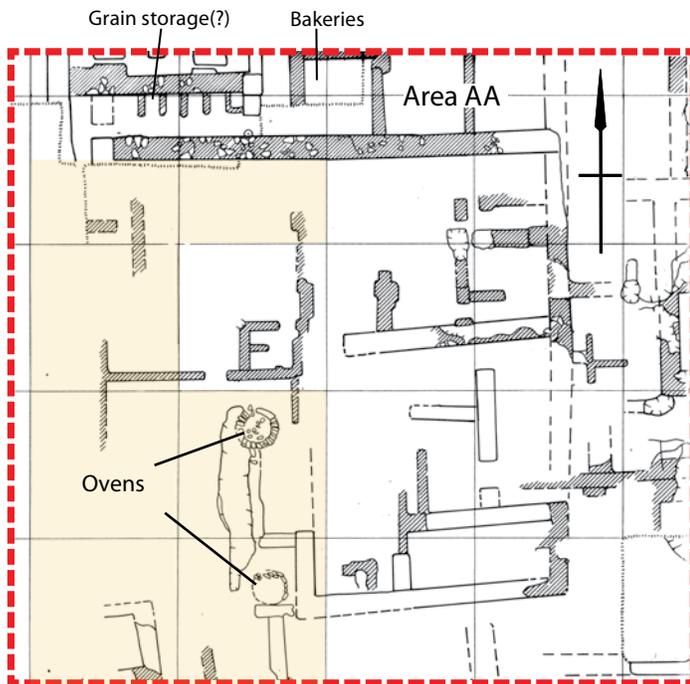


Above: This scene from Ti's 5<sup>th</sup> Dynasty tomb at Saqqara depicts several steps in the brewing process. The workers on the far left are filtering cereal hulls out of the mash (a mixture of grains and water in which cereal starch is converted to sugar). One man pours water over the mash, washing the wort (liquid to ferment) through a sieve into a large vessel. The men to the right appear to be pressing the dregs to extract the last of the wort. On the far right a worker pours beer from a spouted vessel into beer jars, while the other worker seals the jars. After Epron, L., F. Daumas, G. Goyon, and P. Montet, *Le tombeau de Ti: dessins et aquarelles*, I. Cairo: l'Institut Français d'Archéologie Orientale, 1939, plate lxvi.

Left: Area AA South. The 5-meter squares highlighted in orange are our target excavation areas, where we hope to find traces of a brewery. The two circular features might be ovens.

Menkaure (see pages 29–31). Here we found abundant evidence of a bakery producing two types of bread and a storeroom with pedestals probably used to support bins of grain and other products (see page 32).

If bakers and brewers worked in close proximity, we may find traces of a brewery in our target excavation squares. In 2005 we mapped two burned circles, possibly ovens, outlined in mudbricks here. Viewed from the top they resemble the vat emplacements in a Predynastic brewery at Tell el-Farkha on the Delta.<sup>3</sup> As we investigate the circular features and surrounding area, we do not expect to find the kiln-like installations seen in Predynastic sites, but rather, more subtle traces of brewing. In addition to emplacements where coarsely ground grains may have been cooked in vats of water, evidence of brewing would include sherds of the vessels used in brewing, such as the ones depicted in the brewery scene in Ti's tomb above. An assortment of pots were required to make beer: water jars, vats for heating grains, vats for soaking crushed sprouted grains, vessels for the liquid filtered out of the soaked grains, beer jars for storage and distribution, and possibly large storage jars for sprouting the grains. Since all of these ceramics were multi-functional, they alone do not signify a brewery. But an assemblage of broken ceramics encompassing this range of vessels would be suggestive, particularly if burned residues of barley adhered to any of the vat sherds. Among the charred plant remains we recover from ashy contexts, we might find high proportions of barley rachis fragments (pieces of the cereal head



- \* yeast, essential for fermenting beer and leavening bread
- \* grains, mainly emmer for bread, and primarily barley for beer, but both were used in baking and brewing
- \* sprouted grains, necessary for beer and sometimes added to bread

In addition, brewers and bakers would both have needed fuel, hearths/ovens, water, access to grain stores, and space to work.

### Exploring South of Area AA

Our quest for the elusive breweries takes us into the southwest corner of the Lost City settlement to an area that we know only from the tops of its walls. We exposed and mapped them in 2004 and 2005 while scraping down to the ruin surface as part of a major drive to capture the footprint of this district. Our map gives us an idea of what might lie below, but much is still buried and yet to be discovered.

Just to the north of our 2015 target excavation squares (highlighted in orange on the map above) lies Area AA, which we have partially excavated. We believe it was a production and storage center associated with the funerary workshop of



Above: Photo of the Standing Wall Island (swi) area of the Heit el-Ghurab site, also referred to as the Old Kingdom (OK) Corral, taken from a tower with a view to the southwest. On the right are the two enclosures that we believe were abattoirs. The area to the left, enclosed in a stone wall, is the pen where we believe cattle were held. For a sense of scale, note the two people standing along the western wall.

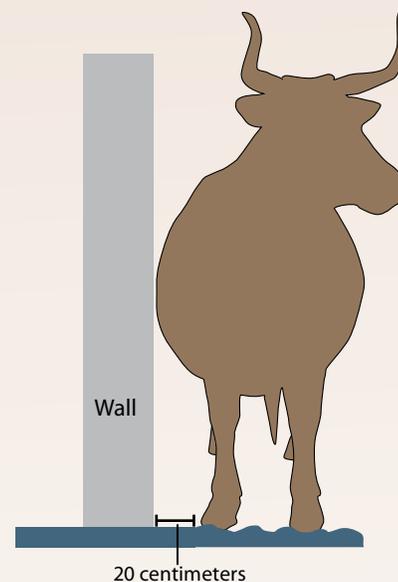
stem) or burned clumps of barley hulls. These clumps would have been filtered out of the mash (a mixture of crushed grains steeped in water) after the mashing process was completed. During mashing, cereal starch is converted to sugar, resulting in a product that can be fermented.

### Where is the Beef?

Based on the distribution of bone, cattle were consumed all across the site. But many Egyptologists believe beef was the prerogative of the well-to-do and a special treat for the masses, served on feast days and other celebrations. Indeed the cattle bone remains show the highest percentages in “elite” districts of the town, where their meat was almost exclusively from cattle. Still, other areas have yielded plenty of cattle bone as well, although the percentage of “lesser” meats, such as sheep, goat, and pig, are proportionately higher. Cattle meat still dominates the diet even in the galleries where workforces might have stayed. Faunal analyst Richard Redding estimated that 11 cattle and 37 sheep/goats were slaughtered everyday to supply part of the protein needs of the inhabitants. But one young bull provides 8 to 10 times the meat of a sheep or goat. So, the 11 to 37 ratio translates into a 2.4:1 ratio of cattle meat to sheep-goat meat.

The livestock consumed at Heit el-Ghurab almost certainly were provisioned by the crown. The ancient Egyptian administration maintained special estates, most likely in the Nile Delta, to raise cattle, sheep, and goats. The surplus from these herds would have been driven or ferried to the Heit el-Ghurab, but where they entered was a mystery. For years we tried to find the

Right: When a cow stands in an enclosure, its hooves come no closer than about 20 centimeters (almost 9 inches) from the wall because of its girth. If the corral in swi was indeed a holding pen for cattle, our trench should reveal compacted strata next to the wall and more disturbed ones out beyond 20 centimeters.



entry point and finally, in 2011, we discovered what we believe was a 4<sup>th</sup> Dynasty stockyard. Located at the southern end of the settlement, it

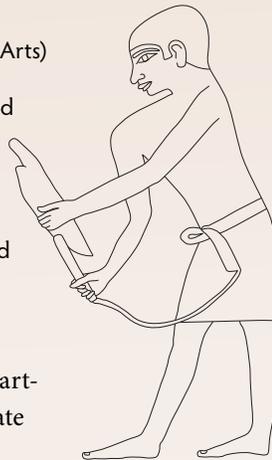
consists of one large enclosure and two smaller ones (shown in the photo above). We named the area Standing Wall Island in 2004 when we uncovered only the northern portion. But in 2011 we dubbed it the OK (Old Kingdom) Corral and proposed that it was a holding pen and slaughterhouse for cattle. This season we will test these hypotheses.

### Exploring an Abattoir

Our planned excavation trenches will focus on the enclosures at the north end and the west wall of the large corral. If animals were slaughtered in these enclosures, we should find evidence of butchering. This would include large ring stones for tethering the animals, like those found in an abattoir at Abusir, and flint tools for slaughtering and dismembering the cattle. We would certainly expect to find debris from sharpening those tools (shown in the tomb relief on the facing page). In the large corral we expect to find compacted strata against the wall where the animals' hooves could not tread because of their



Above: In this relief from the 5<sup>th</sup> Dynasty Offering Chapel of Sekhemankhptah at Saqqara (now at the Boston Museum of Fine Arts) butchers remove the forelimb of a cow. The butcher on the right sharpens his flint knife using a tool attached to his belt, as detailed in the drawing at right. The butcher presses the sharpening tool against the blade near the edge and then pushes outward causing small flint flakes to chip off and collect on the ground in front of him. Our team will be looking for such sharpening flakes in the SW1 as one indication of butchering. Photo by Richard Redding taken in the Boston Museum of Fine Arts.



torsos' girth (illustrated in the diagram on the left). But starting at about 20 centimeters out from the walls, the substrate would have been constantly torn up by hooves.

The obvious evidence of cattle one might expect in a holding pen would be dung. But it is likely that this valuable commodity was carried away in antiquity. Cattle dung, mixed with straw, was used widely as fuel for heating and cooking, and it was also sometimes added to mudbricks.

~Richard Redding and Wilma Wetterstrom

1. Redding, R., "The OK Corral: Standing Wall Island Mystery, Solved," *AERAGRAM* Vol. 12-1, pages 2-5, 2011. All back issues of *AERAGRAM* are available for free download at our website: [aeraweb.org](http://aeraweb.org).
2. Metropolitan Museum of Art, Model Bakery and Brewery from the Tomb of Meketre, Accession Number: 20.3.12. Online collections: <http://www.metmuseum.org/collection/the-collection-online/search/544258?rpp=30&pg=1&ft=meketre&pos=5>.
3. Adamski, B., and K. Rosińska-Balik, "Brewing Technology in Early Egypt, Invention of Upper or Lower Egyptians?" In *The Nile Delta as a centre of cultural interactions between Upper Egypt and the Southern Levant in the 4<sup>th</sup> millennium BC*. *Studies in African Archaeology* 13, pages 23-36, 2014.

## Season 2015: Training

This coming season we are looking to Egypt's future as much as its ancient past. Once again we will be training young Egyptian archaeologists with the goal of empowering them to preserve their own cultural heritage. They will be studying side by side with international students in a new program, AERA Field Training (AFT). For the first time since we launched our field school 10 years ago, we are opening it to non-Egyptians, with the permission of the Ministry of Antiquities. Through a partnership with the American University in Cairo, AFT will offer our international students eight course credits.

Twelve Egyptians, all inspectors with the Ministry of Antiquities, will participate in the program. Support for their training comes from an Antiquities Endowment Fund grant, which we competed for and were awarded last spring. Administered by the American Research Center in Egypt, the program is financed by USAID.

During the eight-week AFT program the students will work in teams on one of our 2015 area operations (described in the previous article), while learning how to excavate and record a site, archive their data, and prepare an excavation report. For one week they will put aside their trowels in favor of microscopes and calipers in the Giza field lab for an introduction to pottery, stone tools, animal bone, plant remains, and objects analysis.

By bringing together Egyptian and international students in the AFT, we hope to promote cultural exchange and understanding.

## AERAGRAM

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# On the Waterfront: Canals and Harbors in the Time of Giza Pyramid-Building *by Mark Lehner*

*In AERAGRAM 14-1<sup>1</sup> Mark Lehner presented a new side of the Heit el-Ghurab site: “The Lost Port City of the Pyramids.” The settlement was not only the base for Giza pyramid-construction, but also a major port on the Nile during that time. In that article Mark laid out a diverse set of archaeological evidence supporting the idea that the community was a port. But he did not address how this seemingly landlocked settlement was linked to the Nile. Here, he takes up that problem by examining the evidence of water transport infrastructure—canals, harbors, basins, and marinas—buried under the present-day floodplain along the base of the Giza Plateau. Working with archaeological evidence, traces of ancient landscape features, samples of sediments from deeply-buried surfaces, and best guesses and inferences, he develops a model of Giza’s Old Kingdom canals, harbors, and Nile channel.*

Every year, rain in the African Lakes Plateau and Ethiopian Highlands sends a colossal wave of water through the Nile basin. In Egypt, before engineers dammed the Nile at Aswan, the water rose 7 meters (23 feet) from its lowest level in the river channel. The Nile wave inundated the valley, usually not by overflowing its banks, but through outlets in the levees, filling natural and artificial catchments. For six to eight weeks, water stood 1.5 to 2 meters (4.9 to 6.6 feet) in the basins as clay and silt—disintegrated East African mountain material—settled, enriching the floodplain for highly productive farming.

The Giza Pyramid-builders planned a critical role for the Nile flood’s 7-meter lift when they engineered the floodplain into the greatest river port of its time, including the so-called Workers’ Town or Lost City site (*Heit el-Ghurab* [HeG] in Arabic). To deliver stone and other materials, they dug canals and basins into the floodplain as ambitiously as they quarried the high plateau and built pyramids, tombs, and temples. Today their waterways lie buried under the landscape, and the Nile now flows against the eastern side of the valley, 8 kilometers (5 miles) from the Giza Plateau. So how can we find traces of the 4<sup>th</sup> Dynasty water transport infrastructure?

## Looking Underground in Three Dimensions

Four and a half millennia of Nile floods and episodic hard rains washing sand and gravel out of desert wadis (gullies)

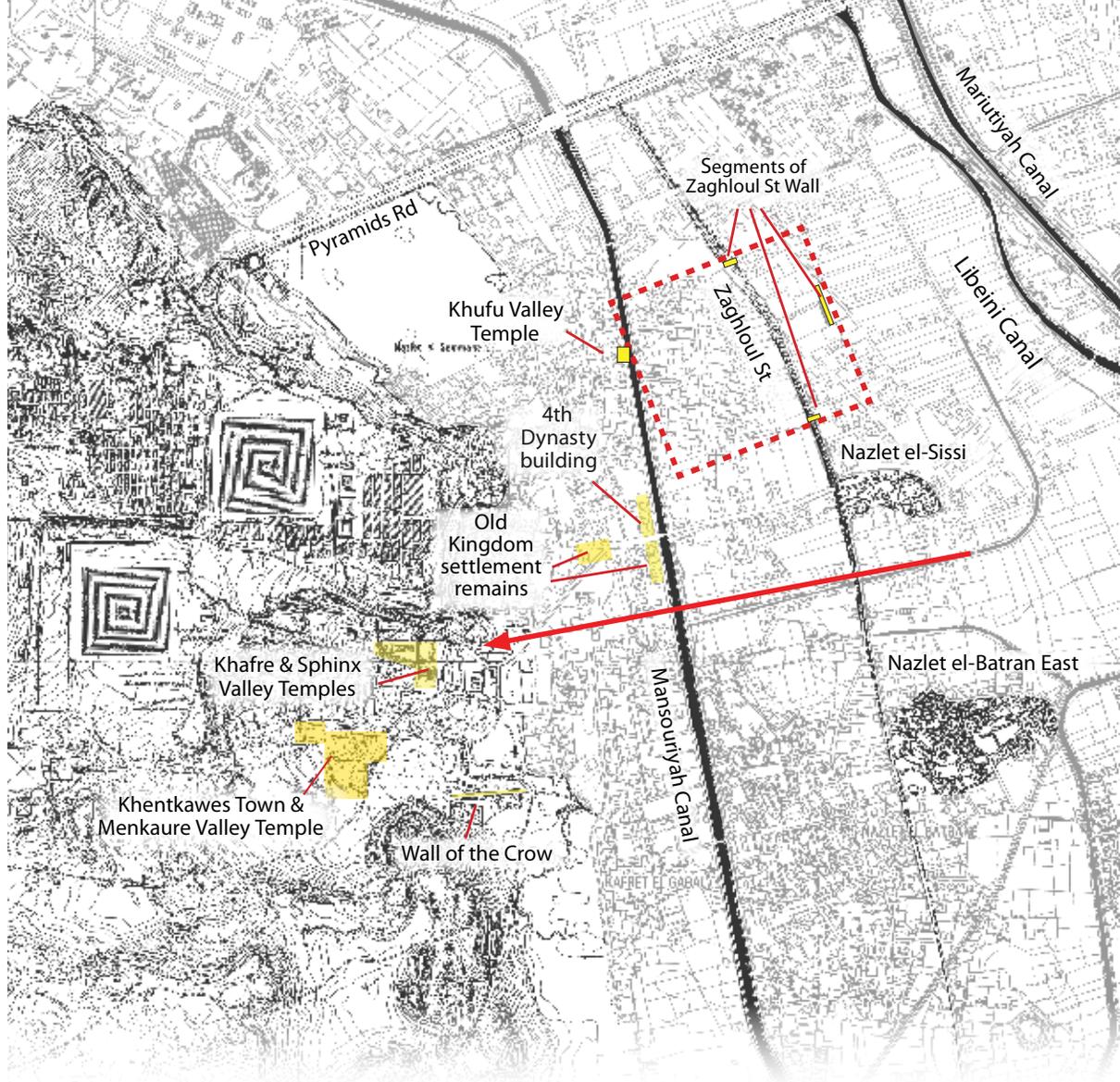
In the Nile floodplain near Zaghoul Street (shown in the map on the facing page) a massive limestone and basalt wall was uncovered in 1994 during excavations for a high-rise building. Two other sections of the wall turned up in a contractor’s trench for a waste water pipe cut along Zaghoul Street. The basalt and limestone match the material in Khufu’s upper pyramid temple, valley temple, and causeway, indicating that the Zaghoul Street wall was part of the Khufu complex. We propose that the wall enclosed a basin fronting the Khufu Valley Temple (discussed on page 18.) The “barricade” at the end of the trench is a contractor’s form for pouring a building foundation. The dense concentration of development on the floodplain at the foot of the Giza Plateau (clearly seen in the map on the facing page) poses a challenge for anyone trying to reconstruct the deeply buried Old Kingdom floodplain. Photo by Mark Lehner.

buried the Old Kingdom floodplain under 4 to 5 meters (13 to 16+ feet) of clay, silt, sand, and gravel.\* Over the last century, after the Aswan dams restrained the annual inundation, the modern city spread across the Giza floodplain, a sprawl already underway in 1977, as captured in the map on the right.

\* Broad wadis delimit the Giza Plateau north and south. A central wadi that separates the Moqqatam Formation from the Maadi Formation debouches north of the Wall of the Crow. See figure on page 21.



Portion of a 1:5,000 map showing the pyramids and the floodplain at the foot of the Giza Plateau. The map was produced for the Egyptian Ministry of Housing and Redevelopment by photogrammetry in 1977. It shows contour lines and all structures present at the time (but is slightly modified here to reduce busyness). The proposed Old Kingdom Nile channel follows the course of the Libeini Canal, a relic Nile channel. The hypothesized ancient basin canal that delivered materials to the Giza Plateau runs through the gap between the two highlighted settlement mounds, Nazlet el-Sissi and Nazlet el-Batran East. The proposed Khufu harbor or marina is outlined with a dotted red line. Shown in yellow are buried Old Kingdom architectural elements and some of the sites and features mentioned in the article.



With all these obstacles, what can we know about the Old Kingdom floodplain? Three sources offer clues:

- ◆ Vestiges of ancient features in modern surface contours
- ◆ Ancient features encountered through excavation
- ◆ Sediments retrieved through deep drilling

**Flood Parameters.** The 4<sup>th</sup> Dynasty engineers took advantage of the river's dynamics to make harbors and canals deep enough year-round for small boats with shallow drafts, and during the inundation's 7-meter swell, for heavy cargo boats with deep drafts. To tap a nearby western Nile branch, they had to breach the river's formidable bank, up to 200 meters broad and 4 meters high.

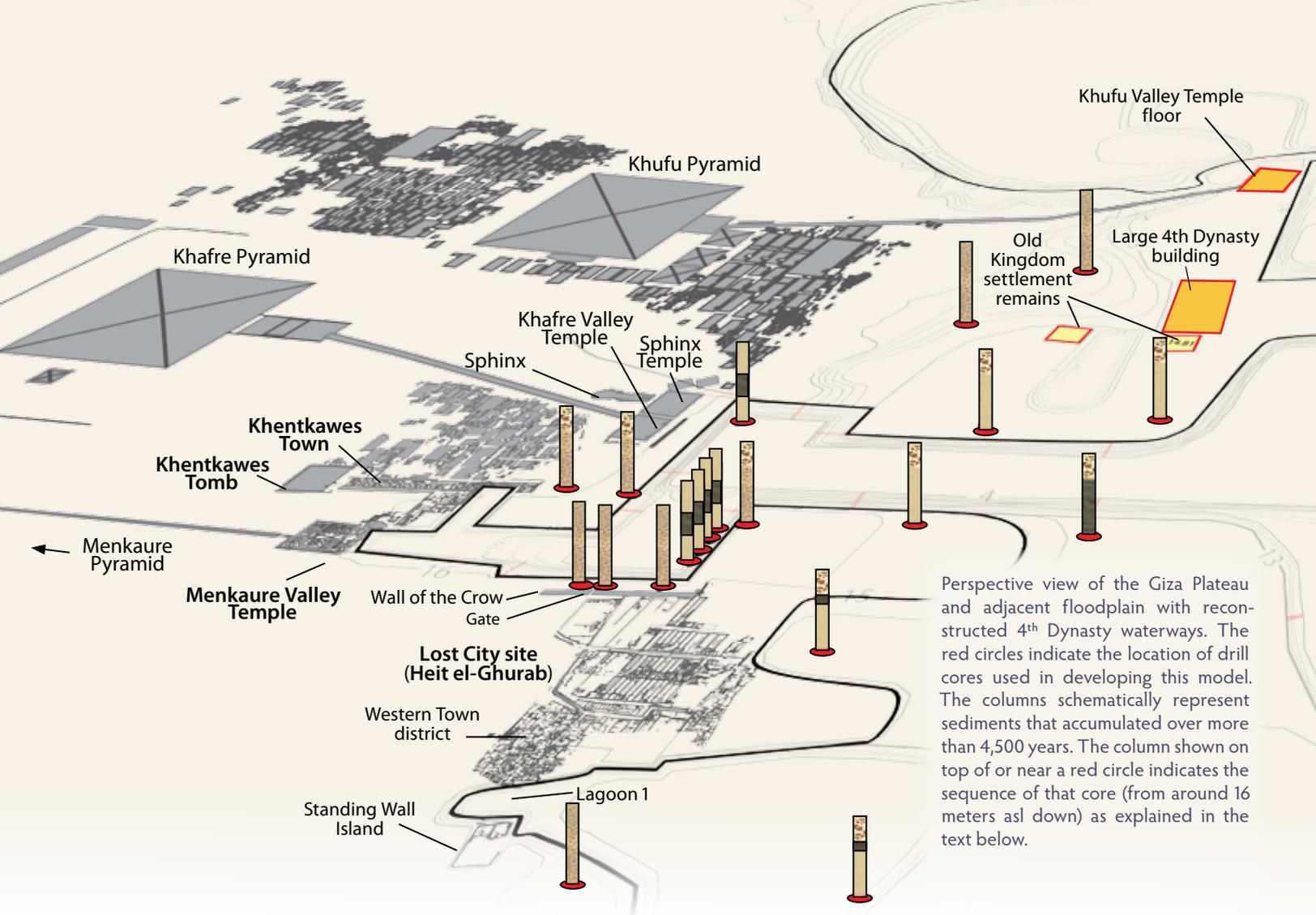
**Horizontal Coordinates.** Using the sources listed above, we can identify the location of ancient waterways and harbors on the landscape. Modern surface contours and an ancient channel suggest the course of an Old Kingdom Nile channel. Fourth-Dynasty structures discovered through excavation set boundaries for canals and harbors and serve as benchmarks for floodplain and riverbank levels. Sediment cores pulled from

deep in the floodplain provide sections of solid silt and clay, which filled abandoned water courses, and riverbank sand and gravel on which 4<sup>th</sup> Dynasty people built their settlements.

I used a topographic map of Giza produced by photogrammetry in 1977 for the Egyptian Ministry of Housing and Redevelopment (shown above) to locate features and drill cores. I drafted 4<sup>th</sup> Dynasty topography as an overlay.

**Vertical Coordinates: 72 Pin Pricks and the Elephant.** As I located features on the landscape's horizontal plane, I also placed them vertically; that is, set their shape, depth, and elevation. I rendered waterways and harbors from top to bottom in contour lines with values in meters above sea level (asl).

Data came from sediment cores. In the late 1980s, an American British consortium (AMBRIC) drilled 72 boreholes before they installed a sewage system east of the Giza Plateau. With great accuracy, they mapped and logged each drill core for different sediments, their depth below surface, and elevation with respect to sea level. For reconstructing an ancient Nile landscape—the buried elephant—the AMBRIC boreholes are mere pinpricks. Fortunately, the logs show high contrast



Perspective view of the Giza Plateau and adjacent floodplain with reconstructed 4<sup>th</sup> Dynasty waterways. The red circles indicate the location of drill cores used in developing this model. The columns schematically represent sediments that accumulated over more than 4,500 years. The column shown on top of or near a red circle indicates the sequence of that core (from around 16 meters asl down) as explained in the text below.

between sand or gravel and silt or clay. In working with these sediment cores I ignored the sequence from around 16.00 to 16.50 meters asl up, on an assumption (founded on evidence) that these are post-Old Kingdom.

Old Kingdom structures furnished benchmarks. For example, I set the Nile flood height at 1 meter below the elevation of the Khufu Valley Temple pavement, assuming its builders would want it to stay dry during the inundation. The flood height in turn led me to the elevation of the floodplain. Before the Aswan dams, at flood peak the water stood on average 1.5 meters above the floodplain.

In the sediment cores, I took very deep and solid clay and silt as the fill of former river channels and artificial basins. The Nile would not deposit clay and silt within its active channel; it splayed this fine material over the floodplain to either side during the inundation. But once the river cut a new course, the old channel filled with clay and silt from the annual flood and, east of the wadis, with sand and gravel. Here, the natural sequence, un-dredged, should show sand interleaved with silt and clay.

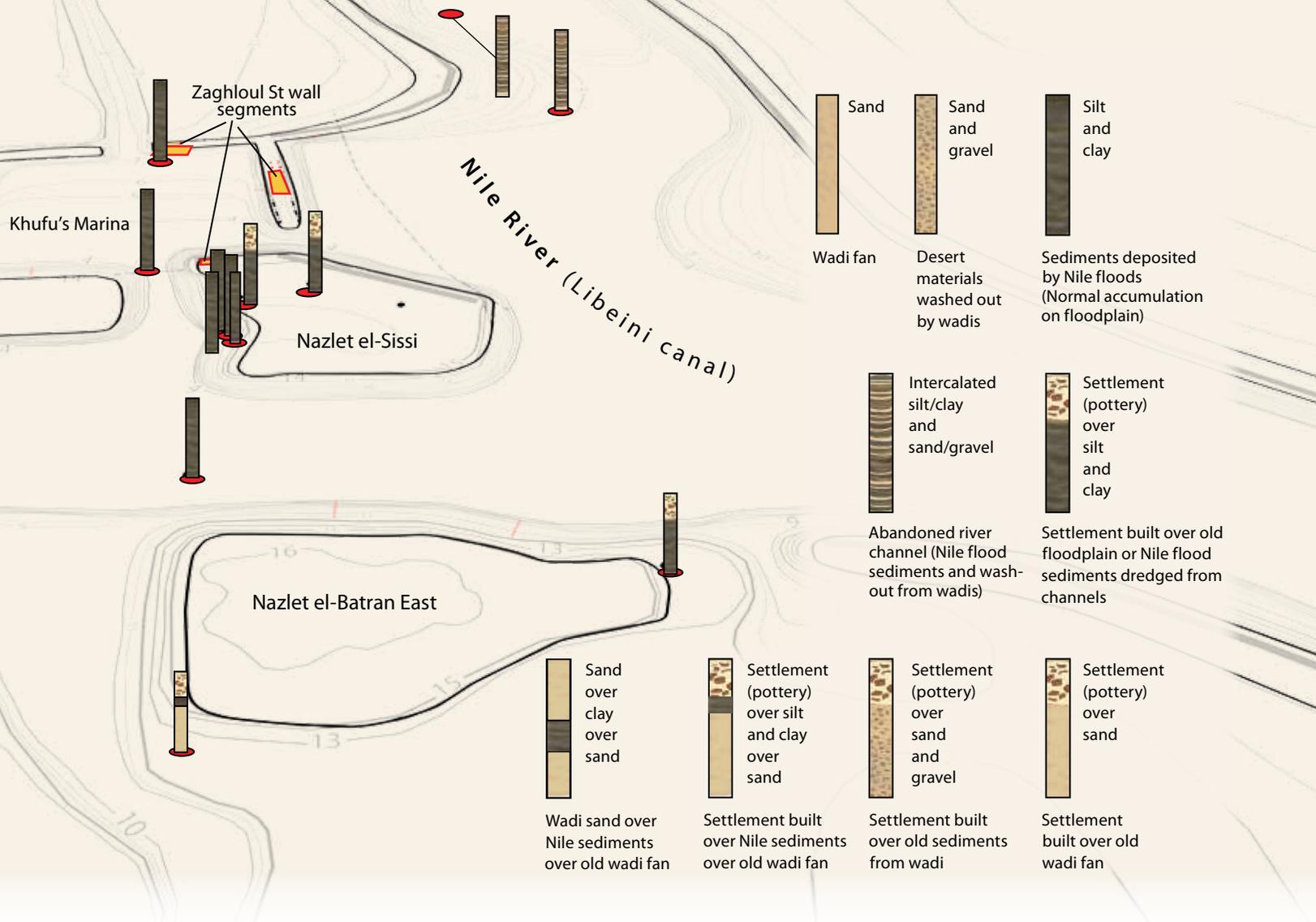
With this combination of benchmarks, traces of ancient landscape surfaces, and Nile dynamics, along with informed guesswork and insights gleaned from modern water transport

infrastructure, I developed the model of the floodplain that I offer here.

### Reconstructing the Nile Channel

The Nile has meandered across its floodplain for thousands of years. Its course during the Old Kingdom is the greatest unknown for reconstructing the 4<sup>th</sup> Dynasty Giza floodplain. Most scholars who have studied the question believe a Nile channel passed close to the western side of the valley during the Old Kingdom. Was this the trunk channel or a smaller tributary, like the Bahr Youssef through Middle Egypt? David Jeffreys and Judith Bunbury proposed the Nile branched around the traditional capital, Memphis, south of Giza, leaving two or more major channels like today's Rosetta and the Damietta, which split just north of Cairo.<sup>2</sup>

Old Nile Channel. Most agree that the old Libeini Canal marks a former west Nile channel. Along the Libeini, from Saqqara to Abu Roash (see map on page 8), modern surface contours show the linear scar of a broader ancient channel. Along this line, I placed my Nile channel. How wide to make it? Imagining that the pyramid-builders required a major channel to introduce stone and timber weighing many tons, I chose a width of 500



meters, the same width as today's Nile (without seasonal variation) at the latitude of Cairo.

We can assess hypothesized Nile channels and other landscape features near Giza against the AMBRIC cores (shown schematically above) along with others taken by AERA teams and other researchers. The AMBRIC borehole cores along the course of the Libeini show the composition we would expect in an abandoned river channel: very deep and solid silt and clay, or, east of the wadi mouths, interleaved silt and sand. The depth of the silt and clay layers allows us to locate the bottom of the old channel. Two boreholes nearly 20 meters (66 feet) deep in the Libeini just east of the pyramids reached the bottom of clay on sand and gravel, which I take to be the riverbed, at depths ranging from 1.93 to 4.83 meters asl. I contoured the channel bottom accordingly, more than 10 to 13 meters (33 to 43 feet) deep, within range of the modern Nile trunk channel at 10 to 14 meters deep.

### Khufu's Marina

Long gone, except for its pavement and massive limestone block foundation, Khufu's valley temple stood on the low desert about 400 meters (0.25 miles) from the edge of the Giza

Plateau. AMBRIC hit the basalt pavement of the valley temple in a trench along the Mansouriyah Canal. Nearly 500 meters east, in another trench along Zaghoul Street, they encountered two segments of a limestone wall, 400 meters apart (shown in map on page 15). Then, in 1994, a 70-meter long segment of a massive wall of limestone and basalt turned up a little farther east in excavations for a high-rise building (photo on page 14). The basalt and limestone match the material in Khufu's upper pyramid temple, causeway, and valley temple, indicating that the Zaghoul Street wall was part of his design. The three sections and the Khufu Valley Temple pavement define an enclosure 400 meters north to south by 475 meters east to west, or 190,000 square meters (over 2,045,000 square feet). On the basis of these structures, I reconstructed a protected marina—a port for small craft in contrast to a harbor, which can handle large ships and cargo freighters.

South of the Khufu Valley Temple site, the AMBRIC trench along the Mansouriyah Canal reportedly cut through Old Kingdom settlement at elevations between 14.59 and 14.86 meters asl, and then thick mudbrick walls lined with limestone around 100 meters apart, evidently the northern and southern

walls of a large building. This structure further delimited the extent of Khufu's Marina.

**Elevation of the Old Kingdom Floodplain.** Though fragmentary, the 4<sup>th</sup> Dynasty remains serve as benchmarks for the elevation of the Old Kingdom floodplain. The Zaghoul Street Wall foundations lie at 15 meters asl and the platform of the Khufu Valley Temple at 14.50 meters asl. Wanting to keep the temple dry during the annual inundation, its builders, as noted above, would have founded it at least a meter above the floodwater, which in the last centuries rose on average 1.5 meters above the lowest valley land, bringing us to 12 meters asl for the floodplain.

**Depth of the Marina.** The AMBRIC cores taken within the hypothetical enclosure area show very deep, solid clay and silt bottoming out at 7.29 meters asl on the north and 4.10 meters asl on the south. As with the river channel, I took the bottom of the clay/silt in the AMBRIC cores as the guide for setting the depth of this harbor. The result is a bottom that slopes down 3 meters from north to south.

The low side of this basin lies as deep as the deepest bottom of the reconstructed river channel. If, as in previous centuries, low water (early to midsummer) lay 5 meters below the floodplain (12 minus 5 = 7 meters asl), then the water in the basin was only at 2 to 0 meters depth, and in the deepest parts of the adjacent Nile channel, it was only 3 meters deep. But during the inundation peak, at 13.50 to 14.00 meters asl, water would fill the basin nearly to its brim, lapping up against the Zaghoul Street dikes and the Khufu Valley Temple.

**Opening Up the Marina North and East.** Since this enclosed basin would have needed an escape for high water to drain, I included an outlet on the north side. The escape canal corresponds to a south to north line of corings that show deeper clay and silt, including ones north of the reconstructed Khufu basin.

The western river bank—or levee—of my western Nile channel, standing 2 to 3 meters above the floodplain, would have dammed the marina on the east, rendering it a cul-de-sac, difficult to fill and drain. I, therefore, opened the basin to the Nile channel, leaving a long eastern

stretch of the Zaghoul Street Wall on a dike or berm 11 meters high.

Would this have been realistic? Could the ancient Egyptians have cut a transverse opening through the Nile levee and constructed the berm? Could they dredge a basin down to low water depth? It would have been a prodigious task, indeed, but within the capabilities of the Giza pyramid-builders. After all, they cut the limestone bedrock more than 10 meters deep for the foundation of the Khafre Pyramid. Elsewhere on the Giza Plateau they quarried three times deeper. As for the berm, it is about the height of the stone Wall of the Crow—10 meters—at the north edge of the Heit el-Ghurab settlement.

For another example of ancient Egyptian building prowess, we can look to the monumental Sadd el-Kafara dam in the Wadi Gerawi, southeast of Helwan.<sup>3</sup> The 4<sup>th</sup> Dynasty dam, built of rubble encased with ashlar masonry, rose 14 meters, spanned more than 100 meters, and was 98 meters thick at the base. My proposed berm would be built of soil, a less demanding task than stoneworking.



The South Side of the Marina. Just south of the enclosure, a cluster of AMBRIC core drillings around the mound of the present day village of Nazlet el-Sissi showed solid clay and silt down to 4.10 meters asl and more. We understand this as sediments left by floodwater filling a deep channel. Here I drew a southern inlet for the Khufu Marina.

Where I placed the opening of the inlet to the hypothetical Khufu Marina, a core showed solid clay and silt down to 4.10 meters asl. Four other boreholes along the west side of the Nazlet el-Sissi mound, along the line of the suggested inlet or channel, produced nearly solid clay and silt to elevations below 4 meters asl.

Cores taken just to the east, tight around the Nazlet el-Sissi mound, showed thick bands with pottery from 13.38 to 15.65 meters asl on interleaved clay and sand, or on solid clay and silt down to 3.13 meters asl. Taking the pottery as a signature of settlement, these cores suggest this part of the 4<sup>th</sup> Dynasty port community was built partly upon an undisturbed natural clay/sand sequence, and partly on Nile sediments dredged from the ancient waterway. The pottery lies in the same elevation range

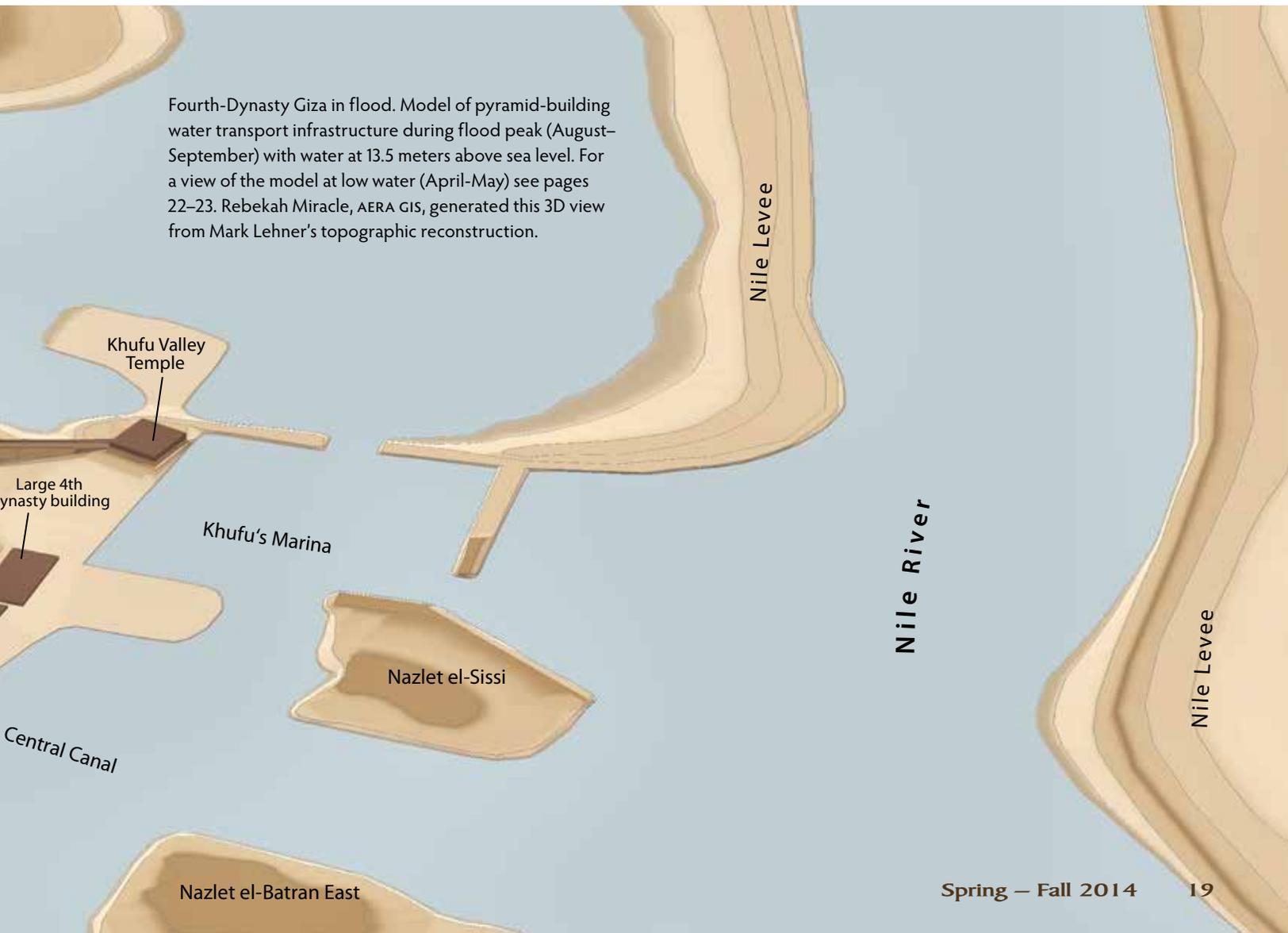
as the Zaghloul Street wall segments, the Khufu Valley Temple, and pottery and settlement in the Mansouriyah AMBRIC trench.

**Gateway Settlements:  
Outposts at the Entrance to Khufu's Basin**

Two village mounds stand out in early photographs of Giza during the flood. They may tell of long-term settlement on ancient high ground. Nazlet el-Sissi rose like an island above the inundation water, while its companion village mound to the south, Nazlet el-Batran East,<sup>†</sup> was surrounded by water on three sides.

These two mounded settlements remind me of the twin villages erected on spoil heaps at the entrance to the great Birket Habu basin, excavated by 18<sup>th</sup> Dynasty pharaoh Amenhotep III on the west bank of Luxor (see image on next page). The mounded villages at Giza may have originated as outposts at the entrance to another artificial basin.

<sup>†</sup> Nazlet el-Batran "East" is my designation. The east mound is a satellite of the main village of Nazlet el-Batran strung out linearly to the west and south.



Fourth-Dynasty Giza in flood. Model of pyramid-building water transport infrastructure during flood peak (August–September) with water at 13.5 meters above sea level. For a view of the model at low water (April–May) see pages 22–23. Rebekah Miracle, AERA GIS, generated this 3D view from Mark Lehner's topographic reconstruction.

Birket Habu basin at Malqata, near Luxor. While excavating the basin for the New Kingdom pharaoh Amenhotep III, workers heaped up spoil mounds in two rows on the west and linear berms on the northeastern and southwestern ends. Two mounds flank the channel-like entrance, 730 meters wide, which appears to have simply opened onto the floodplain. The modern villages of el-Beirat and Naga Ramla el-Alqata occupy the corner mounds flanking the channel. A similar pattern is seen in the two mounds flanking the central canal basin in the reconstructed floodplain at Giza. Image by Google Earth.



The low ground between them extends westward directly toward the Sphinx and Khafre Valley Temple. Its linearity and reach hint at a large, buried canal basin. In the parlance of water transport infrastructure, a canal basin is a wide waterway that allows boats to moor and unload cargo onto perimeter wharves without impeding other traffic, leaving room for turning around.

### Central Canal Basin

For confirmation of a canal basin debouching between the twin village mounds, I looked to the deep core drillings. An AMBRIC core taken south of the marina inlet and midway between the mounds yielded solid clay from elevation 12.01 meters asl—our 4<sup>th</sup> Dynasty floodplain level—down to 3.81 meters asl, equal to our river channel bottom. Centuries of Nile floods had filled an ancient cut with clay.

I placed the western end of the hypothesized channel near the front of the Sphinx Temple based on two findings. About 68 meters east of the temple, a 1980 Ministry of Irrigation core drilling brought up clay-stained limestone fragments from 10.73 to 7.73 meters asl and concentrated clay down to 3.74 meters asl—again, equal to the bottom of my contoured Nile channel. The drill bit seemed to grind on a hard rocky edge. The waterway could not have extended more than 20 meters further west. A few months earlier, archaeologists of the Giza Antiquities Inspectorate excavated through sand down to a smooth bedrock terrace at 15.93 meters asl. Under the sand, the terrace

slopes gently down to the east, evidently to a steep drop—the bedrock end of the basin.

To delimit the width of the canal I looked to AMBRIC boreholes that yielded pottery at predictable Old Kingdom levels—around 14 to 16 meters asl. On the north side of the hypothetical channel, two cores produced pottery at 14.86 and 14.77 meters asl, respectively. With evidence of settlement at these locations, the canal basin bank could not have run north of these points.

To the south, settlement indicators in three boreholes give a higher southern bank that slopes down to the east, from 16.30 to 13.75 meters asl. The pyramid-builders may have raised the southern flank as a spoil bank with sand and gravel from their original dredging of the central wadi mouth. Upon that bank, they founded the Lost City site, extending the settlement south of the major delivery zone and alongside their deeply dredged canal basin.

### A T-Shaped Basin

At its western end the canal basin was most likely T-shaped. The bedrock edge indicated by the 1980 Ministry of Irrigation borehole lies farther north than the north side of the canal delimited by the drill cores showing pottery (=settlement), giving us the northern end of the T's crossbar. This was the major conduit up onto the plateau and to the platforms of the Khufu and Khafre Pyramids.

Drill cores showing settlement delimit the west and east edges of the crossbar of the basin and its extension to the south.

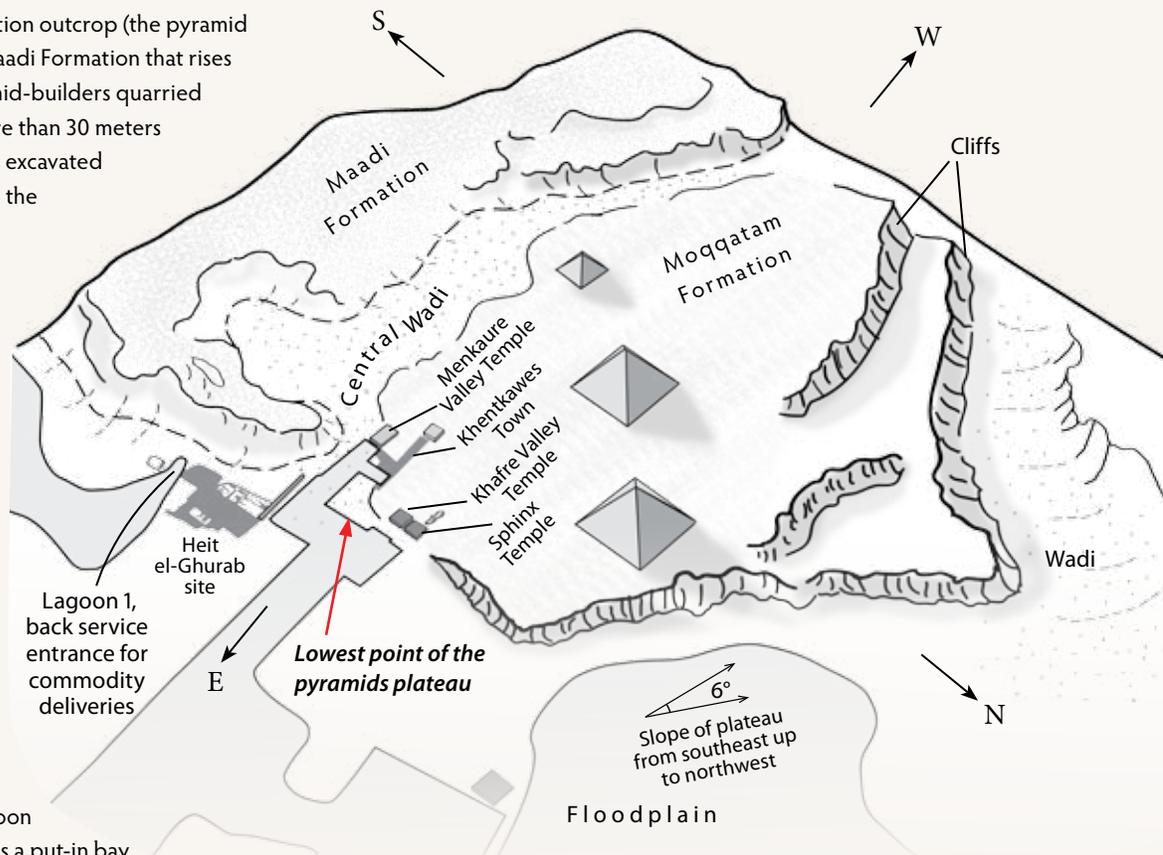
The western side would lie between the bedrock terrace east of the Sphinx Temple and the 1980 borehole and, to the south, it would lie east of an AERA drill core that showed settlement at 15.56 meters asl.

The east side of the crossbar is delimited by an AMBRIC drill core that hit settlement remains at 16.50 to 16.02 meters asl—roughly the level of the HeG site, which lies 100 meters south. Like the HeG site, the settlement layer rested on sand nearly solid to the bottom of the borehole. Only 30 meters to the west, at the eastern side of the tourist bus parking lot, four 2011 boreholes hit concentrated clay and silt at 7.57 to 9.57 meters asl. Assuming this is Nile sediment at the bottom of a basin, the eastern basin edge has to run between these four boreholes and AMBRIC’s drill core.

The southern end of the basin must lie a little more than 30 meters north of the Wall of the Crow. In 2004–2005 we cleared a 4<sup>th</sup> Dynasty terrace of compacted limestone debris over deep natural wadi sand and gravel for a distance of 30 meters north of the wall. North of the gate in the Wall of the Crow the terrace stands at 16.30 meters asl and slopes gently down to the east and north. If the northern edge of the terrace drops into the basin, we just missed it.

## From Builders’ Port to Temple Harbor

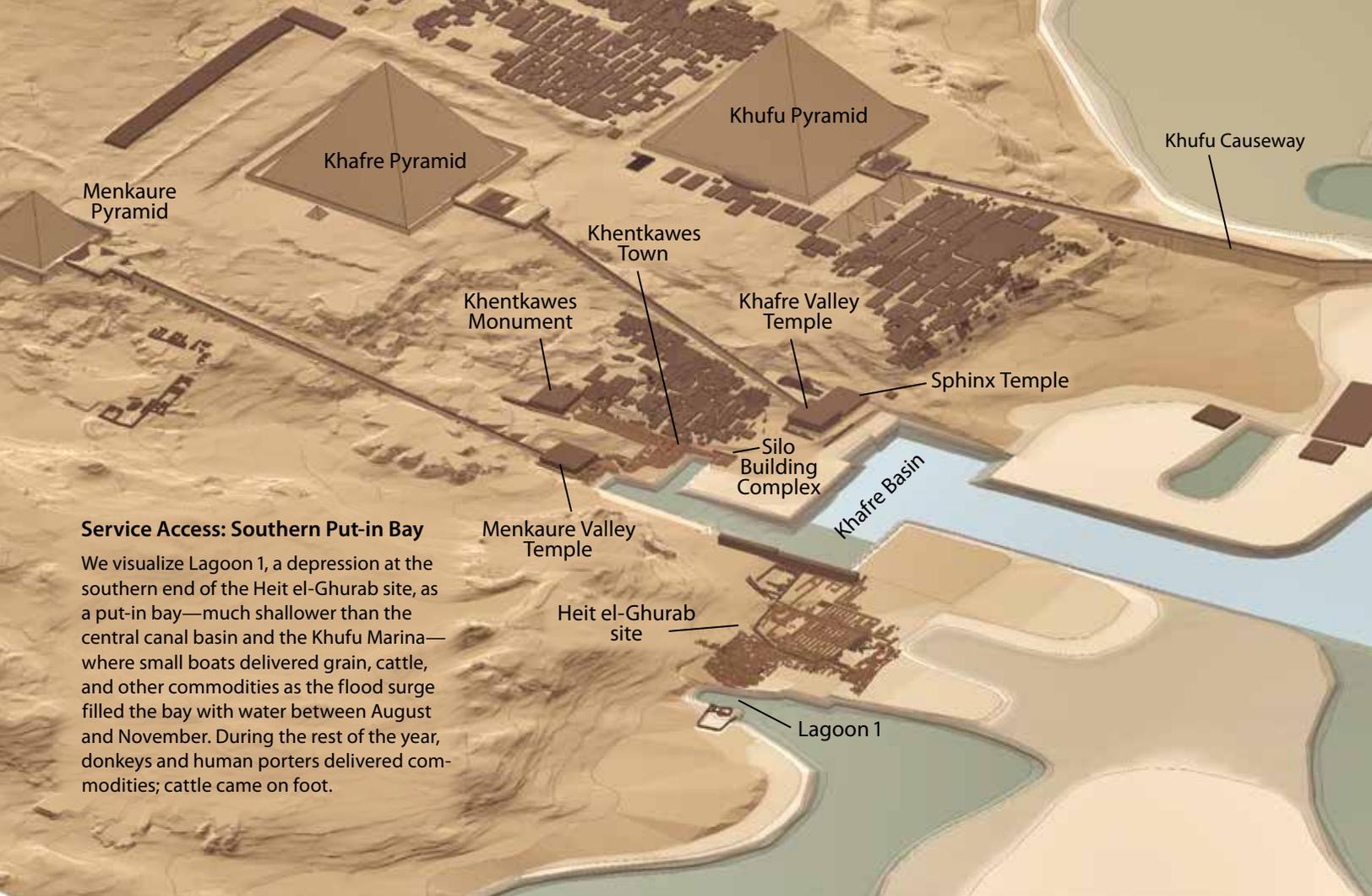
Broad wadis frame the Giza Plateau on the north and south. A central wadi separates the Moqqatam Formation outcrop (the pyramid plateau proper) from the southern Maadi Formation that rises west of the Heit el-Ghurab site. Pyramid-builders quarried the bottom and sides of this wadi more than 30 meters deep. East of this wadi they must have excavated a harbor and delivery basin deep into the natural sequence of the floodplain. While furnishing a solid base for giant pyramids, the Moqqatam Formation tilts at 6° northwest to southeast into the central wadi. This lowest point of the pyramids plateau offered the only practical way to get heavy stone and timber up to the pyramid platforms. The central canal basin served as the major construction harbor for large cargo ships, even in the time of Khufu, who made a separate valley temple marina. Khafre and Menkaure later transformed the western end of the canal basin into marinas fronting their valley temples. We visualize Lagoon 1 at the southern Heit el-Ghurab site as a put-in bay where small boats delivered grain and cattle and other commodities.



## Giza’s Back Bay and the Khentkawes Basin

Toward the end of the 4<sup>th</sup> Dynasty, engineers extended the southern end of the T-shaped basin westward, reaching for the Menkaure Valley Temple and Khentkawes Town, where they dredged a split to create two basins perpendicular to each other. We have excavated one of them, the northern end of the Khentkawes Basin (described on pages 2–5), fronting the town attached to the monumental tomb of the late 4<sup>th</sup> Dynasty queen Khentkawes. The other branch ends at the Menkaure Valley Temple. We cannot be certain of this split because it lies under a modern cemetery, but it is very likely that the retaining wall and slope at the front of Menkaure Valley Temple drops into the western end of the basin.

The late 4<sup>th</sup> Dynasty Egyptians could not dredge this back bay as deeply as the main Giza waterways and harbors, which their predecessors cut into the soft floodplain alluvium. Now they extended far into the low desert and base of the bedrock plateau. In our core drillings across the northern end of the Khentkawes basin we hit the deepest bedrock at 11.37 meters asl. The basin may reach greater depths to the south, beyond our clearing. I contoured the bottom of the western extension and the two basins to step up east to west from 7 to 11 meters asl.



**Service Access: Southern Put-in Bay**

We visualize Lagoon 1, a depression at the southern end of the Heit el-Ghurab site, as a put-in bay—much shallower than the central canal basin and the Khufu Marina—where small boats delivered grain, cattle, and other commodities as the flood surge filled the bay with water between August and November. During the rest of the year, donkeys and human porters delivered commodities; cattle came on foot.

With the annual flood peaking at 13.50 to 14 meters asl, these back bay basins would fill to a depth of 2.5 to 3 meters, deep enough for small boats, but only during flood season. The basins would remain dry at the time of low water—7 meters asl.

**The Back Bay Canal**

The extension to the back bay basins would probably have run from the southern end of Khafre’s T-shaped basin more or less due west to the Menkaure Valley Temple. However, we have neither drill cores nor excavation data for confirmation since the area in question lies, as noted above, under a modern cemetery. Still, the most plausible route seems to be straight west off the end of the T-shaped basin.

I modeled the south bank of the canal projecting due east following the line of the causeway corridor along the southern side of the Menkaure Valley Temple. Near the western end of the Wall of the Crow, I jogged the southern edge of the canal from due east to run parallel to the Wall of the Crow, an orientation slightly north of east.

For the north bank, I extended a line from the north side of the Menkaure Valley Temple to the T-shaped basin, orienting it not due east, but on the same alignment as the Wall of the Crow, 5.5° to 6° north of due east. This bank is at the same time

the southern edge of a terrace that supports the Silo Building Complex, which we excavated between 2011 and 2014. The complex extends farther east beyond our clearing, but perhaps no farther than the edge of the basin extending south from in front of the Sphinx Temple and Khafre Valley Temple.

**Delivering the Water**

The central canal basin shares the counterclockwise orientation of the Wall of the Crow, which is shared by all other 4<sup>th</sup> Dynasty structures at Giza, except for the pyramids, their temples, and the mastaba cemeteries east and west of the Khufu Pyramid. Nile water would have to flow into my central canal basin from a slight northeast to southwest angle. If the western Nile channel followed the course of the old Libeini Canal, with its big bend located at the latitude of the HeG site, it would have delivered Nile water directly into the basin mouth between the two mounded settlements. Water would have flowed straight from the Nile channel to the front of the Sphinx, 2.5 kilometers (1.6 miles) west. From here to the north, the bend set the Nile channel onto a counterclockwise orientation (southeast to northwest) that determined the orientation of most of the 4<sup>th</sup> Dynasty infrastructure at Giza.



### Conclusions: Exploratory Problem-Solving

Does my model of the Giza pyramid-builders' water transport infrastructure accurately capture how they engineered the floodplain? Let's consider the indisputable elements.

We can be certain that some sort of great enclosure, defined at least in part by stonewalls or dikes, stretched 500 meters (0.31 miles) east of the Khufu Valley Temple. The Zaghoul Street wall segments and the Khufu Valley Temple pavement give benchmarks above which normal Nile floodwater did not rise. Farther south, evidence points assuredly to a long, broad, and very deep channel leading straight toward the Sphinx and Khafre Valley Temple, with two settlements flanking its access on the east. Certainly, the HeG site bordered this broad delivery zone on the south. To the west, we found the northern end of an artificial basin fronting the Khentkawes complex. Nile water would have to reach this basin from the north and east, if it indeed held water.

While these pieces of the puzzle are firmly in our grasp, a major element remains unknown: the specifics of the Nile during the Old Kingdom. We do not know its course or size, whether the main trunk or a subsidiary channel flowed closest to Giza. In addition, we lack drill core data and other informa-

tion that could complete the waterfront at the foot of the Giza Plateau, such as in the area just east of the Khufu Marina.

But these lacunae are not cause for rejecting the model. Indeed, the purpose of my modeling exercise has been heuristic, aimed at problem-solving and discovery, making use of what I have at hand. My model almost certainly does not perfectly capture the 4<sup>th</sup> Dynasty waterfront, but this exploratory process has offered insights into how the Giza pyramid-builders may have turned Giza into a major port on the Nile.

1. Lehner, M., "The Lost Port City of the Pyramids," *AERAGRAM* Vol. 14-1, pages 2–7, Spring 2013. All back issues of *AERAGRAM* are available for free download at our website: [aeraweb.org](http://aeraweb.org).

2. Bunbury, J. M., and D. Jeffreys, "Real and Literary Landscapes in Ancient Egypt," *Cambridge Archaeological Journal* 21:1: pages 65–75, 2010.

3. Garbrecht, G., and H.-U. Bertram, *Der Sadd-el-Kafara, Die älteste Talsperre der Welt (2600 v. Chr.)*, Mitteilungen Heft 81, Braunschweig: Technischen Universität Braunschweig. Leichtweiss-Institut für Wasserbau, 1983.

# Did Egyptians Use the Sun to Align the Pyramids?

by Glen Dash, Glen Dash Foundation for Archaeological Research

The Egyptians aligned pyramids of the 4<sup>th</sup> Dynasty, including the Great Pyramid of Khufu and its neighbor Khafre, to cardinal points with amazing accuracy.\* The casing of the Great Pyramid is aligned to true north to within 4 minutes of arc, better than 1/15 of 1 degree. For the most part, scholars who have written on the issue have concluded that the Egyptians must have used the stars to achieve such accuracy. Wrote one, “[I]t is nearly impossible to attain such a high precision using solar methods.”<sup>1</sup>

Martin Isler, an American illustrator and sculptor, disagreed. Though not formally trained as an archaeologist, Isler had earned professional recognition for his studies on the methods the Egyptians had used to work and move stone.<sup>2</sup> On the issue of pyramid alignments, Isler argued that the Egyptians could have used a technique known as the “Indian Circle Method,” thought to have been pioneered on the Asian subcontinent.<sup>3</sup>

In this article, I put the Indian Circle method to the test. I find that, with one critical modification, the method works, and *is* capable of yielding results sufficiently accurate to account for the alignment of the pyramids’ casings.

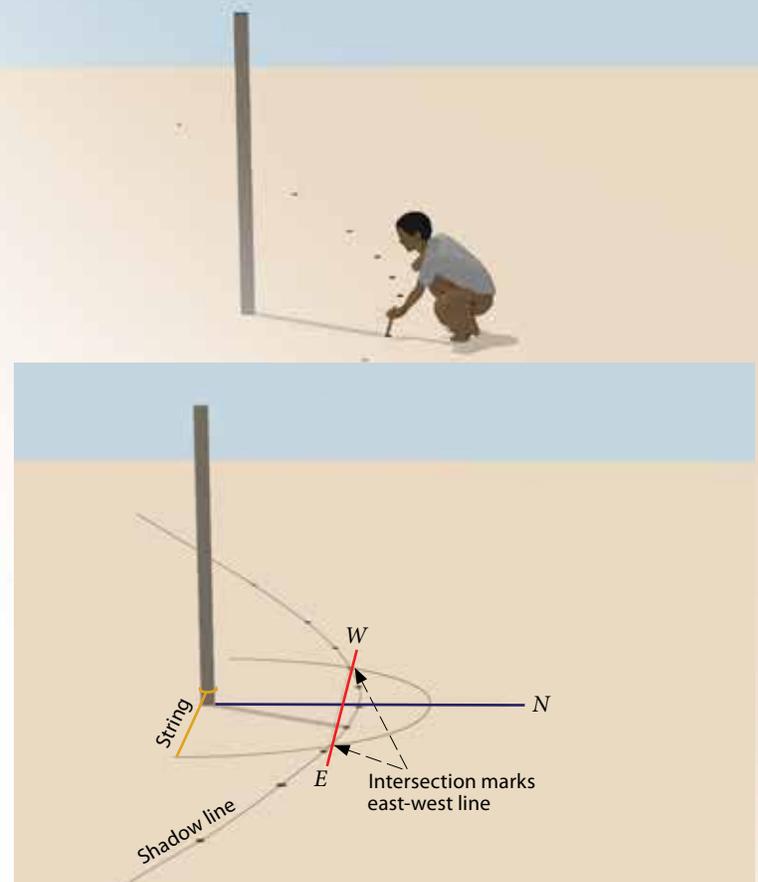
The Indian Circle method is illustrated in the figure on the right. An observer starts by setting a rod vertically in the ground. The rod is known as a *gnomon*, Greek for “one who knows.” As the day passes, the shadow produced by the gnomon is tracked by the observer, who marks its position on the ground every few minutes, eventually producing a curve called the shadow line. At the end of the day, the observer fixes a string to the base of the rod and draws a circle that intersects the shadow line at two points. In theory, a line drawn through those two points will run exactly east-west.

I tested the Indian Circle method at my home in Pomfret, Connecticut, in mid-summer near the solstice when the sun was high in the sky and shadows sharp. Because the ground around my house was uneven, I built a raised wooden platform with a horizontal surface for projecting the gnomon’s shadow, (see facing page, upper left). I attached the gnomon’s supporting post to the platform’s south side along its midline. For convenience, I wanted to start the test around eight in the morning. At that time, however, the sun was almost due east, so I needed to shift the position of the gnomon’s tip slightly to the north

of the platform’s southern edge so its shadow would fall on the platform. I did this by bolting a short length of 2-by-4 to the supporting post and attaching the gnomon’s tip to it as shown on the facing page, upper right. I constructed the gnomon’s tip out of a 1.25-inch (3.18 centimeters) diameter dowel rod and capped it with a rounded wooden half ball. I used the shadow cast by the dowel rod and half ball to track the movement of the sun. In all, the entire gnomon stood 6 foot, 11 inches (2.11 meters) above the platform’s surface. I also threaded a quarter-inch (6.4 millimeters) metal pin into the top of the gnomon’s tip. I used the metal pin to anchor the string I used to draw the circle around the gnomon at the completion of the tests.

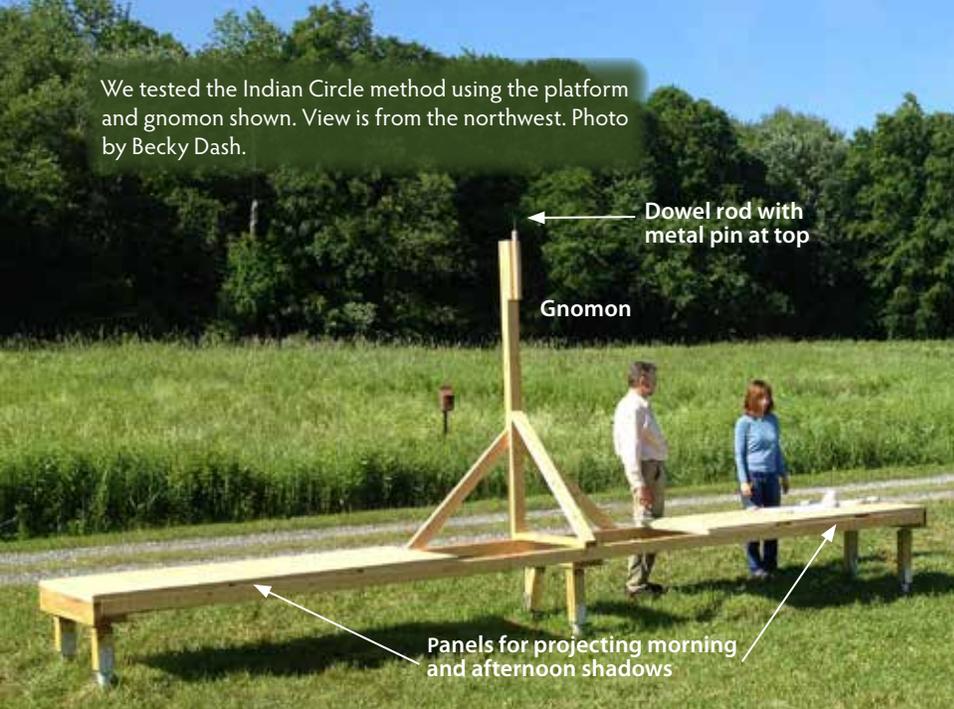
For the Indian Circle method to work well, the gnomon’s shadow must be projected onto a level surface. As I discussed in “North by Northwest: The Strange Case of Giza’s Misalignments” in a recent issue of *AERAGRAM* (Spring 2012), an east-to-west slope to the surface will cause a clockwise rotation of the results. I used a spirit level to verify that the platform was reasonably level.

## The Indian Circle Method

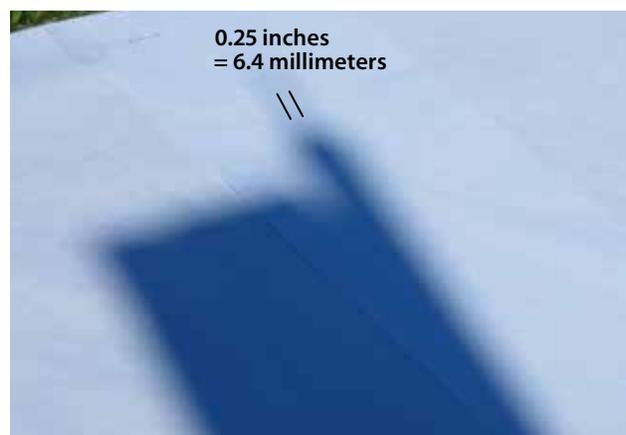


\*For more on this topic, see Glen’s previous *AERAGRAM* articles: “North by Northwest: The Strange Case of Giza’s Misalignments,” Vol. 13-1, pages 10–15, 2012; “New Angles on the Great Pyramid,” Vol. 13-2, pages 10–19, 2012; and “How the Pyramid Builders May Have Found Their True North,” Vol. 14-1, pages 8–14, 2012. All back issues of *AERAGRAM* are available for free download at our website: [aeraweb.org](http://aeraweb.org).

We tested the Indian Circle method using the platform and gnomon shown. View is from the northwest. Photo by Becky Dash.



At top, a close up of the gnomon tip. Below, the gnomon's shadow. Photos by Glen Dash.

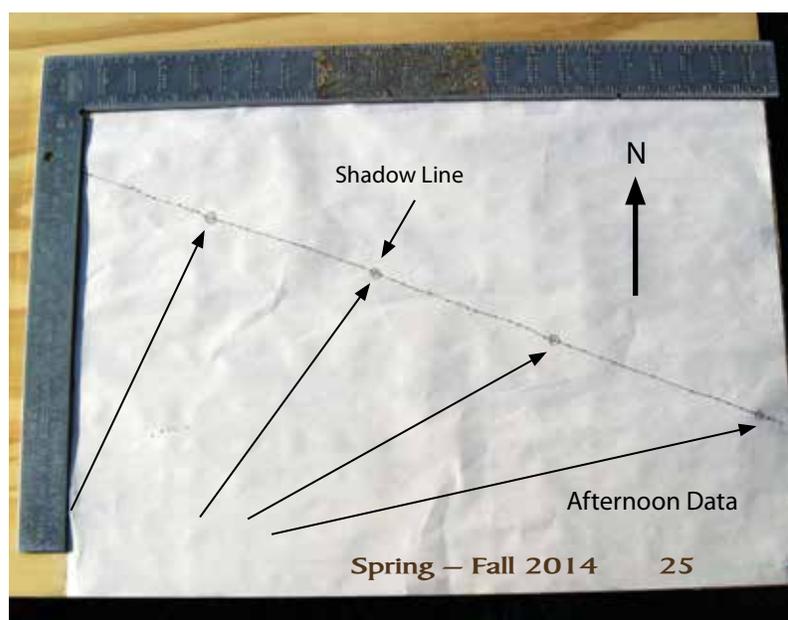
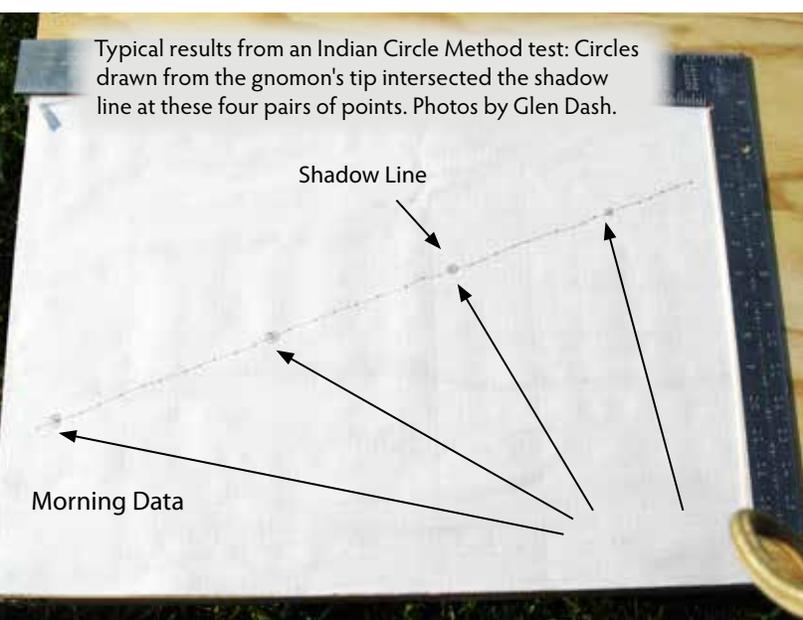


Indian Circle method tests in progress. The tests were filmed by a team from the History Channel's show "The Universe." Photo by Becky Dash.



The figure above shows the shadow produced by the gnomon during the tests. I found that it took two people to efficiently record the shadow's position. At left, Dr. Joan Dash marks the location of the shadow while I view it from about 1 meter away. The two of us would agree on a location every minute or so, when Joan would mark the agreed location on the quarter-inch (6.4 millimeter)-ruled graph paper. We could time a minute interval simply by watching the shadow's movement. We found that we only needed to take data for about an hour in the morning and an hour in the afternoon to complete the test. The figures below show a typical set of results.

Typical results from an Indian Circle Method test: Circles drawn from the gnomon's tip intersected the shadow line at these four pairs of points. Photos by Glen Dash.



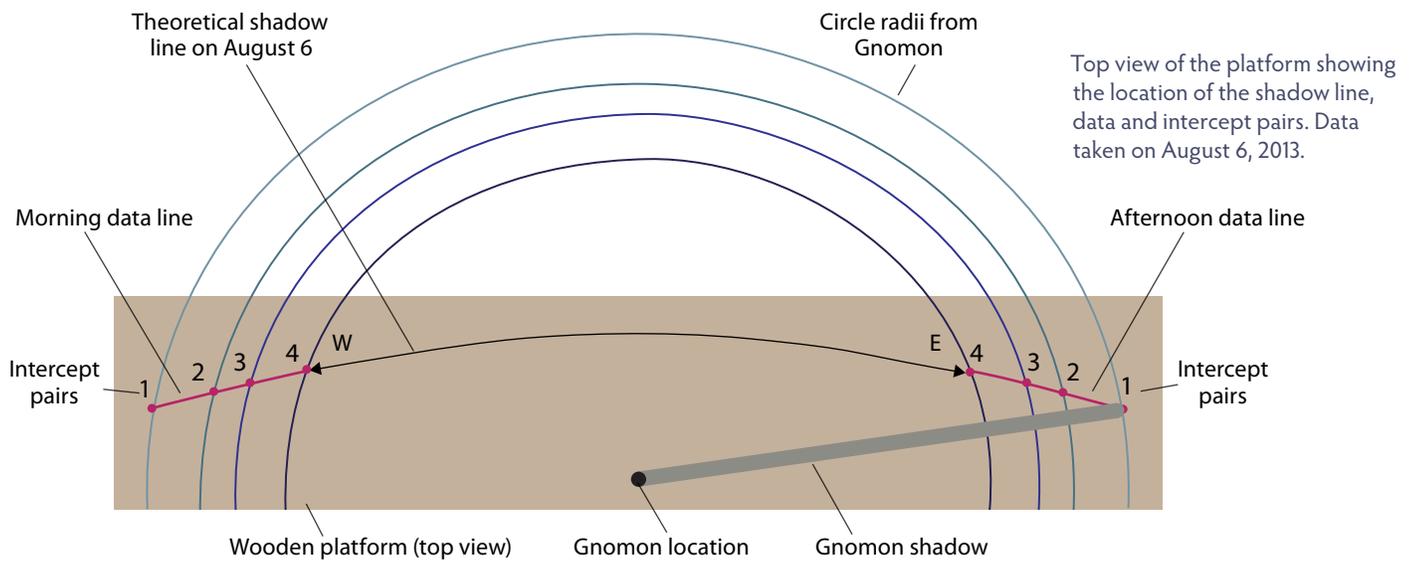


Drawing the circle. After the shadow line is established, a string is pulled from the top of the gnomon and matched with the shadow line on one side of the platform (a). The length of the line is then fixed and pulled over to the other side of the platform (b and c). The string is matched to the line there (d). The two points where the string and the line intersect should run straight east-west. Photos by Becky Dash.

In the Indian Circle method, the next step is to attach a string to the gnomon's base and use it to draw an intersecting circle with the shadow line. For the method to work well, however, the circle must be precisely centered on the part of the gnomon which produced the shadow. If I drew the circle from the base of the rod, as Isler had proposed, the gnomon would have to be set perfectly straight and vertical, something which is difficult to do using only the tools the Egyptians had. Therefore, I modified the technique by drawing our string from the top of the gnomon instead of the bottom (see figures a-d, this page). I threaded the string over the metal pin I inserted at the top of the dowel rod, and drew it out to a point on the afternoon data. I chose a point on the afternoon's data where the shadow line ran smooth. I marked the exact point where the string touched the shadow line on the string. I then pulled the string over to the morning's data and marked the location where the point I marked on the string matched the morning's data. I repeated the process four times and circled the four sets of intersecting points.

Prior to the test, I had set up a total station and aligned it with true north.<sup>†</sup> Now, using the total station, I measured the four sets of points and determined the true angle of the lines running through them (top figure, next page; table 1).

<sup>†</sup> I used a Topcon GPT-3005LW reflectorless total station. I set a permanent control monument and placed the total station over it. To locate the meridian, I focused the total station's telescope on Polaris and recorded the time to the second. I used the US Naval Observatory (USNO) Multiyear Interactive Computer Almanac (MICA) Version 2.2.1 to identify the azimuth of Polaris at that moment and loaded that information into the total station. I then focused the total station on a second star, Kochab, and noted the time. The total station's readout of Kochab's azimuth matched the USNO data for the star to within 10 seconds of arc. Thus, the total station was calibrated and could be used to record the horizontal angle (azimuth) of any given point from that location with that accuracy.



**Table 1: Error Off True East-West Produced by the Indian Circle Method**

| Intersecting Pair | Clockwise Angle off Due East-West       |
|-------------------|---|
| 1                 | -3 minutes, 26 seconds (-0.057 degrees) |
| 2                 | -4 minutes, 34 seconds (-0.076 degrees) |
| 3                 | -1 minute, 26 seconds (-0.024 degrees)  |
| 4                 | +50 seconds (0.014 degrees)             |
| Average           | -2 minutes, 9 seconds (-0.036 degrees)  |

Test performed on August 6, 2013.

The average error was 2 minutes and 9 seconds, about 1/28 of a degree, better than the 3 minute 38 second alignment of the Great Pyramid’s casing.<sup>4</sup> Three of the four lines ran just north of east, exhibiting a counterclockwise rotation from straight east-west (a clockwise rotation is denoted by a positive sign in the table). Data taken later in the morning and earlier in the afternoon were more accurate, probably because the sun was higher in the sky and the shadows sharper.

While this method might have sufficed, it does take some practice to reliably identify where the shadow falls. To make things easier, I tried using an angled block of wood as a “shadow definer” (figure below). The block, covered in white paper,



Joan Dash illustrates the use of an angled block as a shadow definer. Photo by Becky Dash.

**Table 2: Error Off True East-West Produced by the Indian Circle Method Using an Angled Block as a Shadow Definer**

| Intersecting Pair | Clockwise Angle off Due East-West       |
|-------------------|---|
| 1                 | No measurable error                     |
| 2                 | -3 minutes, 17 seconds (-0.055 degrees) |
| 3                 | -4 minutes, 58 seconds (-0.083 degrees) |
| 4                 | -6 minutes, 54 seconds (-0.115 degrees) |
| Average           | -3 minutes, 47 seconds (-0.063 degrees) |

Test performed on June 19, 2013.

was angled at 50 degrees so it would be more or less perpendicular to the rays of the sun during the test. While the angled block did make the shadow’s tip easier to see, it produced its own set of errors which became greater later in the morning and earlier in the afternoon (table 2).

Other cultures also used solar gnomons to perform such tasks as tracking the time of the day or the passing of the seasons.<sup>5</sup> Some used sophisticated shadow definers. To test the limits of the Indian Circle method, I used one described in the *Yuan Shih*, a history of the Chinese Yuan Dynasty.<sup>6</sup> It consists of a copper leaf with a pinhole in its center. The pinhole acts as a lens, focusing the image of the gnomon.<sup>7</sup> I made our shadow definer by drilling a 1/16-inch (1.6 millimeters) hole in a 6.75 × 5 inch (17.1 × 12.7 centimeter) sheet of copper, which I angled at 50 degrees to best catch the rays of the sun. I mounted it on a 19-inch-high (48.3 centimeters) wooden frame (top right, next page). The shadow definer produced a well-focused image of the gnomon’s tip, so well-focused, in fact, that I could clearly see the quarter-inch diameter rod rising above the wooden dowel. I decided to track the sun by aligning the tip of the metal pin with the top of the image of the sun, and marked that location on the paper every minute or so. The results were impressive (table 3). The average error was just 19 seconds of arc or about 1/180 of a degree, close to what I can expect to achieve with a modern total station.

**Table 3: Error Off True East-West Lines Produced by the Indian Circle Method Using a Pinhole as a Shadow Definer**

| Intersecting Pair | Clockwise Angle off Due East-West |
|-------------------|-----------------------------------|
| 1                 | No measurable error               |
| 2                 | 36 seconds (0.010 degrees)        |
| 3                 | No measurable error               |
| 4                 | 39 seconds (0.011 degrees)        |
| Average           | 19 seconds (0.005 degrees)        |

Test performed on May 30, 2013.

My tests showed that the Egyptians could have aligned the casing of the Great Pyramid to cardinal points using the Indian Circle method. The method is best performed near the summer solstice when the sun is high in the sky, providing sharp shadows. It requires an observer to track the motion of the sun for an hour or so in the morning and again in the afternoon. Using a string attached to the tip of the gnomon, the observer then draws a circle, identifying two points of intersection which will run east-west. While workable, the method requires a keen eye, and the Egyptians may have found that a “shadow definer,” such as an angled block of wood, helps. On the other hand, had the Egyptians used the pinhole shadow definer described by the Yuan Dynasty Chinese, their results might have been even better.

The Egyptians of the Old Kingdom left us only scant records regarding the methods they might have used to align their great monuments. Therefore, I cannot say with any certainty that the Egyptians actually used the sun to align the casing of their pyramids with cardinal points. However, I can definitely say that they could have done so, and needed only the tools they had at hand: wood, rope, copper, and stone.

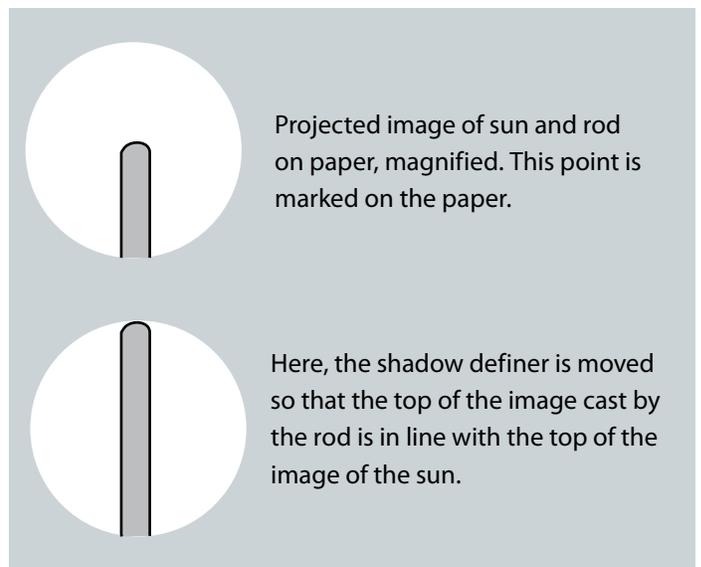
*The author would like to thank Juan Antonio Belmonte for his review of this article and his comments.*

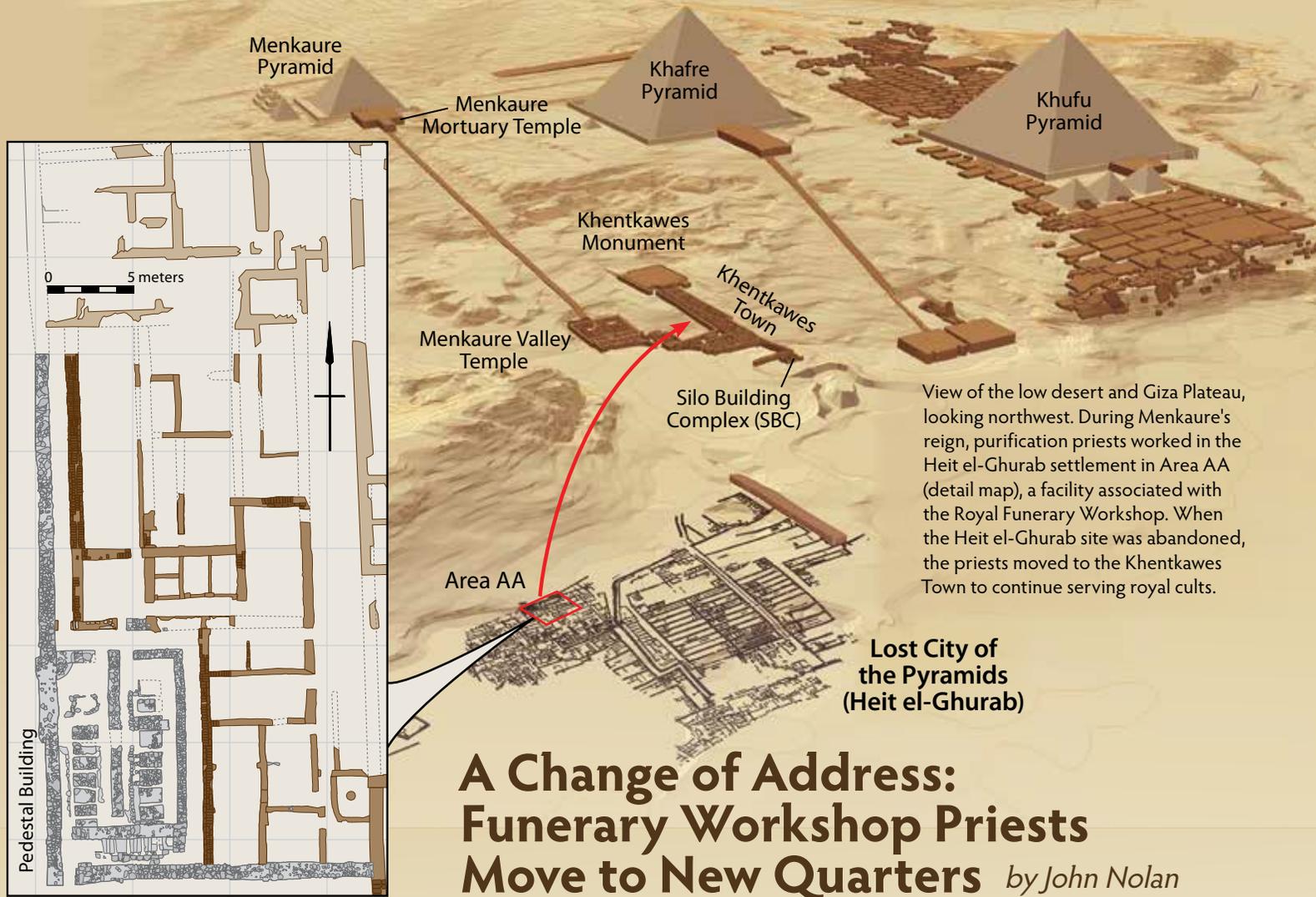
1. Magli, G., *Architecture, Astronomy, and Sacred Landscape in Ancient Egypt*, New York: Cambridge University Press, page 90, 2013.
2. Arnold, D., *Building in Egypt*, New York: Oxford University Press, page 104, 1991.
3. Isler, M., “An Ancient Method of Finding and Extending Direction,” *Journal of the American Research Center in Egypt*, Vol. 26, (pages 191–206), page 197, 1989.
4. Dash, G., “New Angles on the Great Pyramid,” *AERAGRAM* Vol. 13-2 (2012), page 16.
5. Isler, M., *Ibid.*, pages 197–98.
6. The primary reference on the Chinese use of solar gnomons and shadow definers is J. Needham, *Science and Civilization in Ancient China*, Cambridge, 1959, pages 296–99. For its use generally among traditional peoples, see E. C. Krupp, *Echoes of Ancient Skies: The Astronomy of Lost Civilizations*, New York: Dover, pages 47, 58–61, 1994.
7. Isler, M., *Ibid.*, page 198.



Above: A pinhole punched in a copper sheet acts as a shadow definer. In our tests, the shadow definer was able to produce an image so sharp that we could see the rod projecting from the gnomon's tip. This aid would have allowed the Egyptians to resolve a true east-west line to within a minute or so of arc.

Below and bottom: The copper plate with a 1/16-inch pinhole projected onto the paper below. Photos by Glen Dash.





View of the low desert and Giza Plateau, looking northwest. During Menkaure's reign, purification priests worked in the Heit el-Ghurab settlement in Area AA (detail map), a facility associated with the Royal Funerary Workshop. When the Heit el-Ghurab site was abandoned, the priests moved to the Khentkawes Town to continue serving royal cults.

**Lost City of the Pyramids (Heit el-Ghurab)**

## A Change of Address: Funerary Workshop Priests Move to New Quarters *by John Nolan*

In past issues of *AERAGRAM*, I have reported on the clay sealings from AERA's excavations at Giza and the insights they give us about Pyramid Age Egypt.\* Here I look at a particularly noteworthy collection of clay sealings from Area AA of the Lost City of the Pyramids. They offer remarkable insights into three different issues: the organization of priests in a funerary workshop, the emerging Egyptian bureaucracy, and the connections between the Lost City and Khentkawes Town, specifically the transfer of priests to the Khentkawes Town when the Lost City ceased operations.

### Priests of the Lost City

In 2007 the AERA sealings team of Ali Witsell, Foy Scalf, Elise MacArthur, and myself registered and studied over 870 sealing fragments from Area AA. We discovered that 201 of these sealing pieces bore impressions made by a limited number of cylinder seals. Working methodically with these clay fragments, we matched up all the overlapping impressions and were able

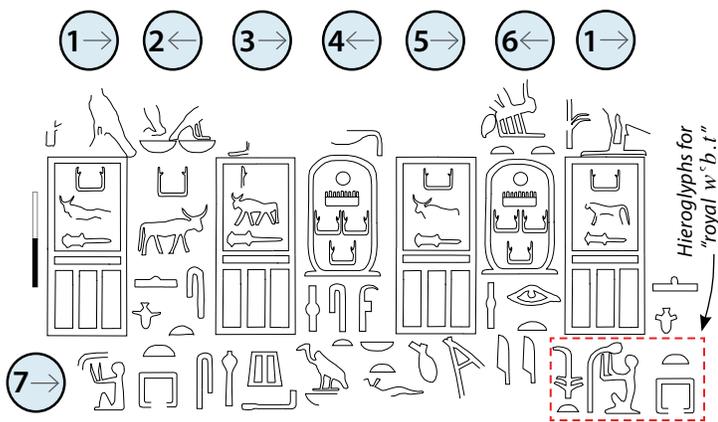
to reconstruct most of the original inscriptions on the cylinder seals that impressed the clay.† One reconstruction is shown on page 30. In this way we determined that these 201 clay sealings had been impressed by just 12 cylinder seals. Furthermore, the titles carved on these cylinder seals belonged to just two groups of people. The owners of four of the reconstructed seals were purification priests of the king and an additional seven seal bearers worked in the Royal Funerary Workshop. One single seal apparently bore two titles connected with both groups. Complicating our efforts to reconstruct these seals, the hieroglyphic writings of both “Purification priest” and “Royal Funerary Workshop” use the same hieroglyph, , which stands for the root  $w^{\circ}b$ , meaning “to be pure.” While both  $w^{\circ}b$ -priests and the  $w^{\circ}b.t$  as a funerary workshop (which produces “pure” goods for burials) have long been known to Egyptologists, the Area AA Official Seals‡ imply for the first time a close functional and administrative relationship between these two hitherto separate institutions.

*Purification Priest Seals.* The seven seals belonging to the purification priests bear the simple title “Assistant Royal

\*“Sealings from Giza, Globes of Mud with Stories to Tell,” *AERAGRAM* Vol. 2-1, pages 4–6, 1998; “Impressions of the Past: Seals and Sealings from Pottery Mound,” (with A. Pavlick), *AERAGRAM* Vol. 9-1, pages 2–4, 2008; “Fifth Dynasty Renaissance at Giza,” *AERAGRAM* Vol. 13-2, pages 6–9, 2012; “A Small Clay Label, a Bundle of Linen, and an Ancient Economic Network,” *AERAGRAM* Vol. 14-2, page 19, 2013. All back issues of *AERAGRAM* are available at our website, [aeraweb.org](http://aeraweb.org), for free download.

†We describe this process in *AERAGRAM* Vol. 9-1, pages 2–4, Spring 2008.

‡“Official” refers to a category of seals in contrast to official in a generic sense. These seals bore the Horus name of the king who issued the seal, his epithets, as well as the titles of the official to whom it was given.



The transliteration and translation of one reconstructed theoretical seal from Area AA. The arrows adjacent to the column numbers indicate the direction in which the text is meant to be read. The odd numbered columns are the names of the king; the even and number 7 are the titles of the cylinder seal owner.

- 1 *Hr: K3-ḥt*  
Horus: Bull-bodied,
- 2 *šḥtp-ib Nb.ty: K3*  
Favorite of the Two Ladies: Bull,
- 3 *Hr: K3-ḥt*  
Horus: Bull-bodied,
- 4 *Šmś(w) wd [Bik] nwb Mn-k3.w-R<sup>c</sup>*  
Who follows the command of the Golden [Falcon]:  
Menkaure,
- 5 *[Hr:] K3-ḥt*  
[Horus]: Bull-bodied,
- 6 *ir.ti wd(.w) Ny-šw.t-Bi.ty Mn-k3.w-R<sup>c</sup>*  
Who executes the command of the King of Upper and  
Lower Egypt Menkaure,
- 7 *šḥd ḥry(w)-<sup>c</sup> w<sup>c</sup>.b.t ny-šw.t Nḥb.t nb.t=f mry[.t]*  
The Inspector of the Assistants of the Royal Funerary  
Workshop, called(?), "Nekhbet, beloved of Coptus, is  
His Mistress" (?).

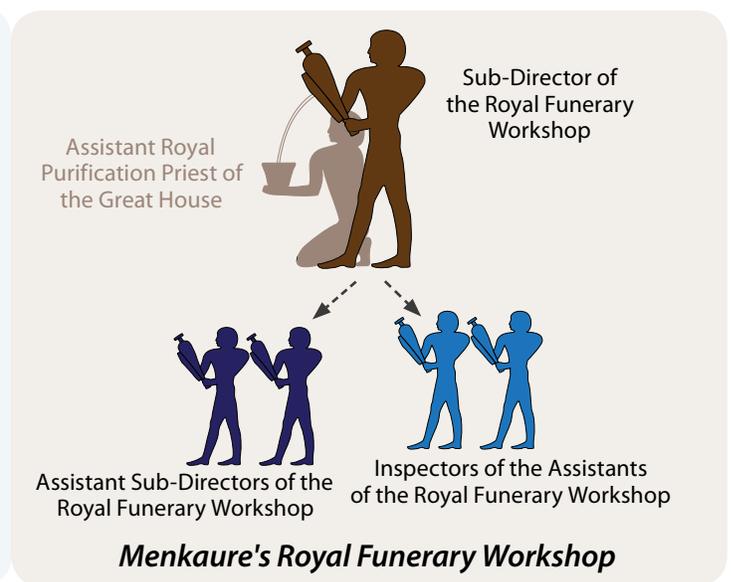
Purification Priest,” suggesting that there was no hierarchy among them. None of them was more important than the others. Each had equal status and stature to the other members of the group. However, the lone reconstructed seal that had titles belonging to both the Royal Funerary Workshop as well as the purification priests stands out as an exception. This seal owner was an “Assistant Royal Purification Priest of the Great House.” The additional reference to the “Great House” sets this special official apart from the other purification priests who left behind sealings at Area AA.

*Royal Funerary Workshop Seals.* In contrast to the seals of the purification priests, the titles on the four seals belonging to the Royal Funerary Workshop show a more hierarchical organization. Two of the seals belonged to Assistant Sub-Directors of the Royal Funerary Workshop while the other two, perhaps of higher rank, were Inspectors of the Assistants of the Royal Funerary Workshop.

Once again, however, the lone reconstructed seal with titles belonging to both groups stands out. This special seal bears the title “Sub-Director of the Royal Funerary Workshop.” Not only does this official, as we saw earlier, hold a unique position among the Assistant Purification Priests, he also seems to head the organization of the Royal Funerary Workshop at Area AA.

### “Seal of the Storehouse”

These twelve Official Seals give only part of the story. Impressions made by a very different kind of cylinder seal were also found among the sealings from Area AA. These cylinder seals were carved following a different set of complex rules than those used for Official Seals. The complexity and range



Titles found on reconstructed cylinder seals from Area AA offer insights into how Menkaure’s purification priests and his funerary workshop were organized and administered. One individual with two titles, “Assistant Royal Purification Priest of the Great House” and “Sub-Director of the Royal Funerary Workshop,” apparently oversaw both the purification priests (on the left) and headed up the funerary workshop organization (on the right). The purification priests seemed to be equal in rank, but the funerary workshop was apparently hierarchically organized.

of variation in the layout of these seals have led us to call them “informal,” meaning that they are not bound by the strict format that governs the arrangement of carvings on Official Seals.

AERA Epigrapher Ali Witsell, in an ongoing study of these informal sealings (see pages 32–34), has isolated an emerging seal type that may mark an important development in the Egyptian concept of bureaucracy. Among the 239 informal sealings from Area AA, Ali has pieced together potentially eight separate seals that seem to bear the label “seal of the storehouse.” The use of this label on a seal is unprecedented in the development of Egyptian seals. Most known Egyptian seals belong to a person. They either bear the name of the reigning king and the title or titles of the seal bearer, or simply the name and titles of the seal bearer with no royal names. Even the title or titles that lack a personal name on Official Seals seem to identify a given individual. Take for instance the single seal mentioned above whose owner served both as the “Assistant Purification Priest of the Great House” as well as the “Sub-Director of the Royal Funerary Workshop.” The combination of these two different spheres of activity on a single seal seems to identify the roles of a unique man. Even though Official Seals never name the owner of the seal—only the king he served—they belonged to individual people and did not represent impersonal cogs in the administrative machine.

The seals of the storehouse, on the other hand, do not appear to belong to any single individual. The inscriptions might identify the king who owns the storehouse or the name of the commodity stored there, or even show pictures of granaries containing barley and wheat, but they do not bear personal names or other administrative titles. They appear to belong to the “storehouse” itself!

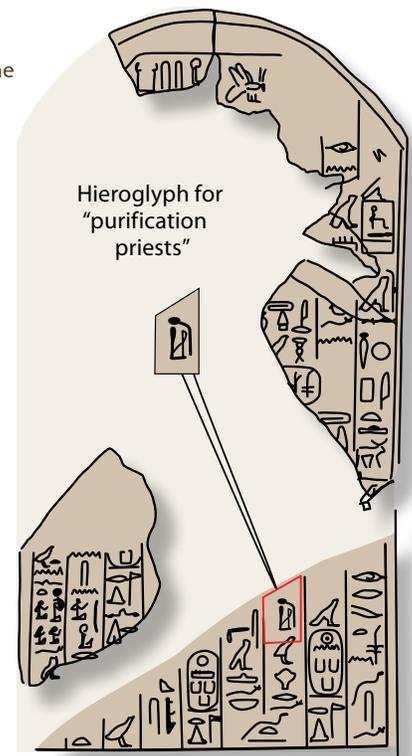
This development appears to be an early example of bureaucratic abstraction that is unusual for Old Kingdom Egypt. One other possible early example might be a few Early Dynastic Period cylinder seals that some scholars claim to be labels for vineyards in the Nile Delta, but this interpretation remains controversial and other interpretations are possible. Thus the “seals of the storehouse” from Area AA in the 4<sup>th</sup> Dynasty are among our earliest clear examples of bureaucratic thinking from ancient Egypt.

### Purification Priests Post-Lost City

Following Menkaure’s death and the completion of his mortuary complex, the Lost City settlement was abandoned and partially dismantled, leaving us to wonder what happened to the residents. Now that we can identify some of the people working in Area AA as Menkaure’s purification priests, we believe we can place this group of residents on the Giza Plateau after the demise of the Lost City.

An important clue to their whereabouts comes from a royal decree issued by Menkaure’s successor, Shepseskaf. Found

The badly damaged stone slab with Shepseskaf’s decree establishing permanent offerings of food for “purification priests” in the cult of Menkaure so that they “may be secure forever.” After H. Goedicke, *Königliche Dokumente aus dem alten Reich*, Wiesbaden: Otto Harrassowitz, 1967, Abb. 1.



on a badly damaged and incompletely preserved stone slab in Menkaure’s mortuary temple, the decree established permanent offerings of food for “purification priests” in the cult of Menkaure so that they “may be secure forever” (see above). Shepseskaf issued this edict in his first or second year on the throne, when he was already busy finishing Menkaure’s temples and building the adjacent Khentkawes Town (see map on page 29). Aside from one seal dating back to the reign of Khafre, all of the seals from Area AA were carved in the reign of Menkaure. It seems reasonable that the “Assistant Purification Priests” mentioned in the seals are precisely the “purification priests” of Menkaure endowed by Shepseskaf in his decree and, therefore, were among the first residents of the Khentkawes Town and Menkaure Valley Temple in the twilight of the 4<sup>th</sup> Dynasty.

In sum, the sealings from Area AA are crucial for our understanding of the connection between the Lost City and the Khentkawes Town. They also offer insight into the world view of the ancient Egyptians as the last of the great pyramids at Giza was under construction. The 12 reconstructed “formal” seals from Area AA show the close association of the cult of the living king with the royal workshop charged with producing grave goods and offerings for royal and noble burials. Despite this closeness, however, these two groups of officials—those working in the Royal Funerary Workshop and the royal purification priests—were organized in very different ways. Mixed in with the sealings made by these important priests and administrators are fragments that had been sealed by storehouse seals, possibly from all over Egypt, given their numbers. In addition, these storehouse seals may be the earliest examples of buildings owning seals, a milestone in Egyptians’ understanding of bureaucracy.

# A Return to Area AA: Informal Seals and Sealings of the Heit el-Ghurab *by Ali Witsell*

Much of the information AERA has presented regarding the 4<sup>th</sup> and 5<sup>th</sup> Dynasty Giza clay sealings has focused on one particular type of cylinder seal used extensively at the Lost City, or Heit el-Ghurab (HeG), and Khentkawes Town (κκτ) sites. We call these “Official” seals, or “formal” in our own AERA nomenclature, in part because they provide titles and dates for officials and, as such, are valuable for understanding bureaucratic development. But Official Seals are evidence of only one of several different seal carving traditions recorded at the HeG and κκτ sites through the impressions left behind on clay sealings—small pieces of clay applied to all sorts of containers and closures and impressed with a seal, much like wax sealings used in the past for letters and documents.

Here I introduce the other end of the spectrum, the “informal” seals and sealings. The informals come to the fore now because they may be especially abundant in our 2015 excavations, offering further opportunity to learn about what they sealed and how they were used. One of our 2015 operations, AA South, will be adjacent to a former hot spot for informal sealing finds, Area AA, which we believe encompasses a storage and production facility associated with the Royal Funerary Workshop. In the early 1990s and in 2006–7 we recovered large quantities of informal sealings in and around this area and may do so this season as well.

## The Formal-Informal Continuum

Not only are Official Seals formal because of the administrative titles they provide, but they also adhere to strict patterning conventions that divide the available space of the cylinder

(example on page 30) resulting in a predictable form that makes Official Seals easy to pick out of the corpus and classify. These stand in stark contrast to those seals that we call “informals”—the term we use to refer to the somewhat amorphous soup that encompasses the remaining cylinder and stamp seals and sealings in our corpus.

At Giza, we find informals in lower numbers than formals, and they cover a greater variety of types, subject matter, and carving quality, making their classification more difficult. Rather than follow the strict patterning seen in the formal seals, informal seals can follow common patterns or have no pattern at all. It is generally thought that the artists carving the formal seals were master craftsmen, working in a style or canon either dictated or approved by the king. The artists producing the informal seals may not have been bound by the same constraints, working in assorted materials for a variety of clients, with a freer reign that may have inspired more variation.

At their most basic level, informal seals typically display graphical designs, commonly consisting of animal or geometric motifs. But these can range from simple geometric net or crisscross patterns (above) to elaborate animal forms in *tête-bêche* arrangements (head-to-head or head-to-tail), laid out in demarcated panels or haphazardly encompassing the entire cylinder surface. Sometimes panels of hieroglyphs are included, but hieroglyphs can also be used as space fillers or dividers without any grammatical meaning. Suffice it to say, the number one rule with informals is to expect the unexpected!

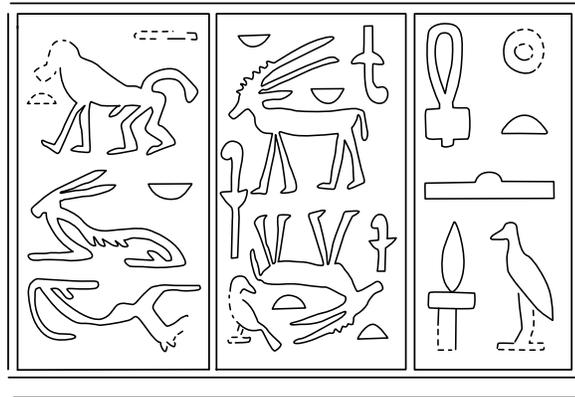
## One-offs vs. a Cache

The majority of the sealings we find are “one-offs,” meaning we only have one representative of the seal that produced the clay impression—we call this the “theoretical” seal. Say you have ten jigsaw puzzles featuring ten animals with distinctive markings, but no box top to give you the overall image you are attempting to construct. Finding one or two pieces of a tiger’s stripes could help you determine which puzzle you are assembling, but without finding more pieces, you won’t have much

Pedestals in the southern corridor of the Pedestal Building, Area AA, during excavation in 2006 (shown on the map on page 29). The beer jars below, shown *in situ*, may have been used to collect grain stored above. Photo by Mark Lehner.



A simple crosshatched “informal” cylinder seal from HeG.



By carefully examining and recording the traces left on the clay, as well as the character and placement of the signs, we can determine whether or not one sealing might be a match or duplicate to another and therefore part of the same “theoretical” or reconstructed seal. Through the process of collating 34 duplicate sealings from Area AA, such as the two sealing fragments showing parts of the same baboon, above, our reconstruction of “Theoretical B” (at right, not to scale) emerged. In this example and the two shown below in the sidebar, note the common pattern of one or two demarcated panels of hieroglyphs in combination with panels of animals, most often shown in tête-bêche arrangement. At Giza, foot-to-foot tête-bêche is common.

luck seeing the whole tiger. Sealing analysis can be just such a numbers game—the more impressions from one seal we can identify, the more of our puzzle we can assemble.

Formal sealings are much like those tiger stripes—easy to spot—but with only a few pieces, difficult to assemble into a whole image. Due to the complexities of classifying informals, as well as the often fragmentary condition of sealings, a cache of sealings in an undisturbed context can be a real boon to our analysis. And no place at HeG has produced such an exciting corpus of informal sealings as Area AA—in terms of number of sealings, variety of subject matter, and quality of preservation.

### But Who, What, and When?

Area AA is essential to our understanding of not only the administrative role of the formal seals (as seen in the preceding article), but for the informals as well, due to their relatively large numbers there. Because Official Seals include the name of the king who reigned when they were carved they can be extremely valuable as chronological evidence. Thus when formals are found with informals (which most often have no

inherent dating evidence themselves), the formals can serve to date the usage of certain informal patterns, motifs, or carving styles (see sidebar below). The narrow timespan represented at the HeG site—approximately 50 years dating to the reigns of Khafre and Menkaure—makes this corpus the perfect time capsule with which to narrow down the stylistic and chronological development of the informals. Because both types were found in the same archaeological contexts, AA could be key to disentangling how these different classes of seals might have been used together in the daily functioning of the site.

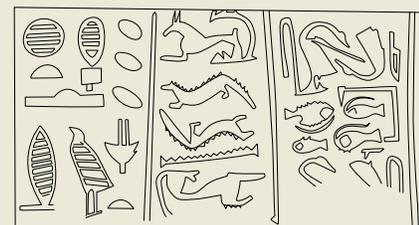
But who or what do these various informal seals represent? In the Near East—birthplace of cylinder seal technology and home to the majority of scholarly work dealing with seals and sealings—the classifying hallmarks of the pattern and motif variety present in the informals might be interpreted as the markers of specific seal workshops or geographic regions, different social classes, or even the public vs. private business activities of the same type of individual. We are just beginning to address these issues in the Giza corpus; AA is our best starting place thus far.

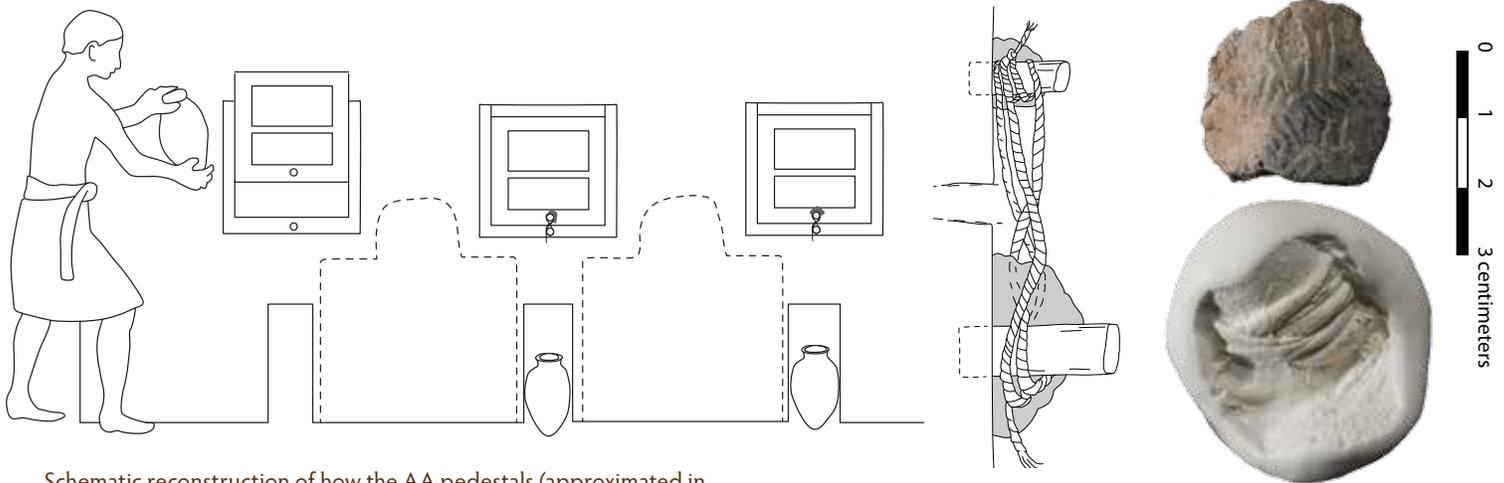
## The Importance of Archaeological Context: Other Seals of the Storehouse

Fortunately we are not working in the dark as we move towards the larger classification of the informals corpus. Cylinder and stamp seals excavated at other sites or in museum or private collections can serve as useful hallmarks. However, some of these examples come from early excavations with uncertain stratigraphy, or were bought on the art market and are thus entirely divorced from their archaeological context. This makes them essentially useful only as beautiful art pieces. They are helpful as we hone in on common patterns, motifs, and trends, but of limited use as chronological or social markers because they can no longer be studied in association with their surroundings. Theoretical seals reconstructed from sealings or intact seals excavated from secure dated archaeological contexts—such as Area AA’s Theoretical B and the 5<sup>th</sup> Dynasty Khentkawes example from Abusir at left— can, in turn, help fasten the larger corpus of undated pieces to their proper places in the development of Egyptian cylinder and stamp seals.

Seal of unclear date and provenance, purchased by the Wilbour Fund of the Brooklyn Museum, acc. no. 44.123.29. After P. Kaplony, *Die Rollsiegel des Alten Reichs*, Brussels: Fondation Égyptologique Reine Élisabeth 1981, pl. 155: 24.

Seal excavated from the 5th Dynasty Pyramid Complex of Khentkawes at Abusir. After M. Verner, *Abusir III, The Pyramid Complex of Khentkaus*, Prague, Universitas Carolina Pragensis, 1995, pl. 25: 126/A/80.





Schematic reconstruction of how the AA pedestals (approximated in dashed lines) might have worked with wooden bin and sliding door superstructures on top, and peg and string exterior closures. Such an arrangement—based in part on Old and Middle Kingdom tomb reliefs and wooden models—would help explain the large numbers of peg and string sealings found in the AA area. Drawing by Becky Witsell.

Right: An informal peg and string sealing from the HeG site. The obverse side (on top) shows a herringbone pattern. Below is a Sculpey impression of the reverse or back, showing a twine-wrapped peg. Photo by Jason Quinlan. The drawing to the left shows how the closure might have worked. Drawing by Ali Witsell.

### A Seal of the Storehouse

As John Nolan indicated in the preceding article, AA finally provided us with enough puzzle pieces to narrow in on a specific type of informal seal at Giza. By piecing together 34 separate duplicates from Area AA, we were able to reconstruct our most complete informal theoretical cylinder seal to date. Known as “Theoretical B,” it is an example of a seal labeled as a “seal of the storehouse” (see page 30). By researching seals from other sites and collections (see below), we now see that this seal type was an important piece of the sealings story across multiple sites in the region during the reigns of Khafre and Menkaure. At HeG, not only do I believe there are eight different seals of the storehouse represented in just the AA collection alone, but site-wide, I think we might have as many as two dozen different storehouse seals represented.

But why is that important? What does it mean for our understanding of the people responsible for using these seals? Are these storehouses located on site, perhaps within the AA area? Are they out at rural sites, shipping their goods in via Giza’s harbor to feed the pyramid-building engine? Perhaps both? Two of our best clues for answering these questions are the backs of the sealings and the sealings’ findspots on site.

### Area AA: The “Back Story” and the Pedestals

Although a cylinder seal is undoubtedly informative, a sealing impressed by that seal can provide more information than the seal alone. Because the clay is first pressed against the item it is sealing—say a ceramic jar neck or a door peg—before it is impressed on the opposite side by a seal, each side of the sealing has its own story to tell.

The backs of both the “Theoretical B” informals and many of the formal sealings indicate that these AA seals secured peg and string closures, a type of mechanism possibly associated with the curious pedestals shown in the photo on page 32.<sup>1</sup>

Based on parallels from Old and Middle Kingdom tomb reliefs and wooden models, as well as archaeological examples of similar sealings,<sup>2</sup> the sketch above shows how a bin system with sliding door closures incorporating peg and string sealings might have functioned with the pedestals.

Both the high number of “Theoretical B” sealings recovered from AA and the architectural nature of their backs suggest that the seal owner (or person responsible for its usage) most likely worked nearby. Sealings with backs bearing architectural impressions such as wooden door frames, plaster, or mudbrick are less likely to be shipped into a site than sealings from transportable objects like jars, increasing the likelihood that these sealings were produced on site.

Our ability to successfully reconstruct both formal and informal theoretical seals from the AA deposits, in addition to the cohesive story of their peg and string backs, argue for a correlation between architecture and findspot. This suggests to us that although we have both formal and informal types of seals at play in the AA area, they may be participating side by side in the same sorts of administrative activities—an exciting prospect. In the case of the AA pedestals, perhaps this includes opening and closing wooden granary bins to collect grain rations for distribution to the seal owner.

We are only beginning to study this group of sealings in depth. It is my hope that our 2015 work in this area and further study of this unique corpus from AA—and the Giza informals as a whole—might help us further understand the variety we find in Old Kingdom seals and sealings. Stay tuned!

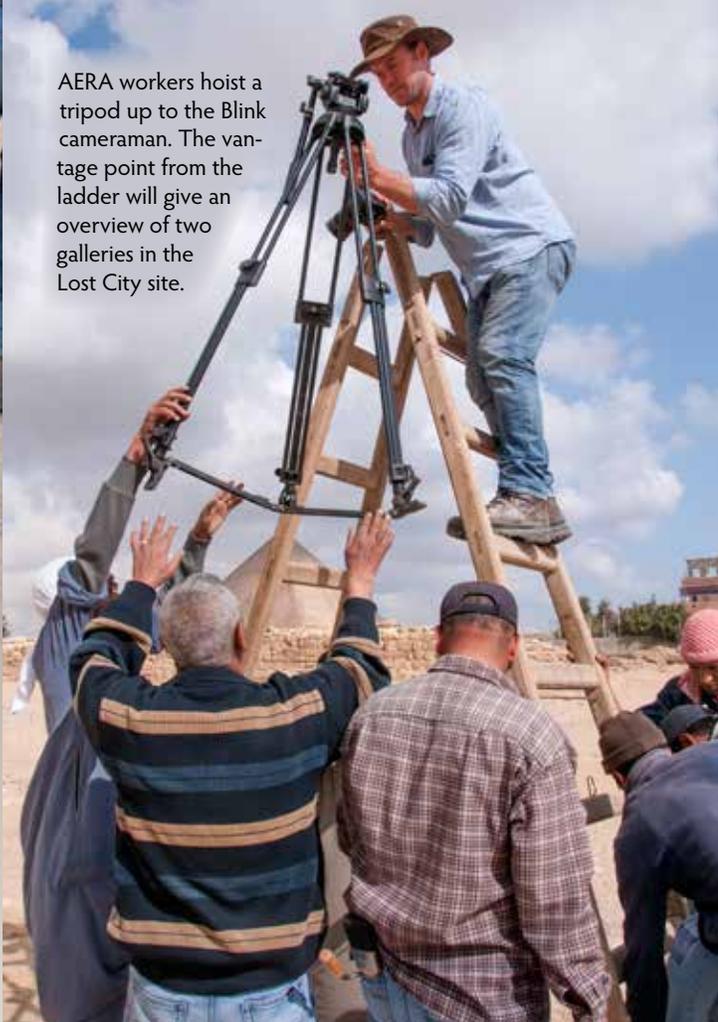
1. Lehner, M., M. Kamel, and A. Tavares, “Area AA and the Pedestal Building,” In *Giza Occasional Papers* 3, Boston: Ancient Egypt Research Associates, pages 65–77, 2009.

2. Smith, S. T., “The Transmission of an Egyptian Administrative System in the Second Millennium B.C.: Sealing Practice in Lower Nubia and at Kerma,” In *Administration in Ancient Societies*, ed. by P. Ferioli, E. Fiandra, and G. G. Fissore, Torino: Scriptorium, pages 67–85, 1996.

AERA Co-Field Director Mohsen Kamel reveals a blocked entrance as the Blink cameraman films. Photos by Mark Lehner.



AERA workers hoist a tripod up to the Blink cameraman. The vantage point from the ladder will give an overview of two galleries in the Lost City site.



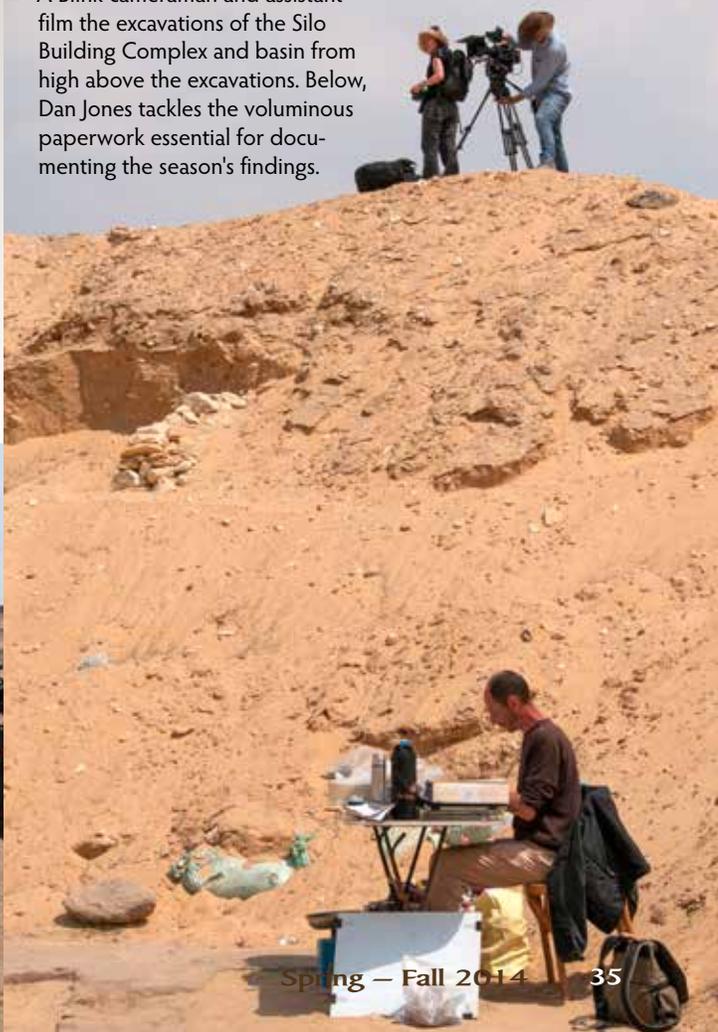
## Lost City Site and AERA in “Secrets: Great Pyramid”

Last April as we excavated in the Silo Building Complex, we paused to help London-based Blink Films shoot a television program about building the Great Pyramid, a topic that might seem exhausted. Yet the Blink film introduced a fresh window on how Egyptians built a 50-story high structure. A French team working at Wadi al-Jarf on the Red Sea coast discovered a port of Khufu and a papyrus journal and accounts of the stone transport for building the Great Pyramid. In the film AERA President Mark Lehner and the head of the French mission, Pierre Tallet, appraise the 4,500-year-old diary, which gives an eyewitness account of the monument's construction.<sup>1</sup>

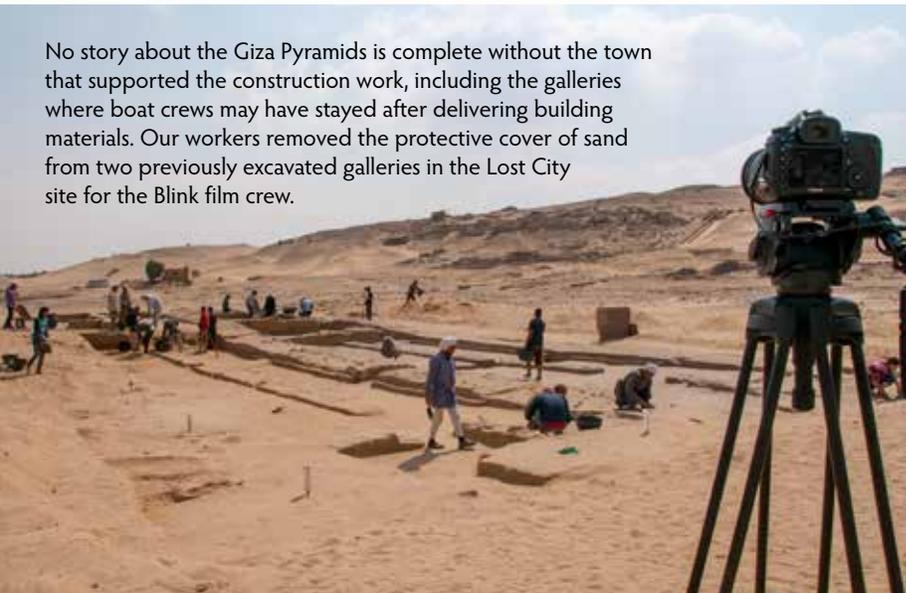
The film is shown on the Smithsonian Channel in the US (<http://www.smithsonianchannel.com/sc/web/series/1003102/secrets/3412162/great-pyramid#did-a-megalomaniac-build-the-great-pyramid>). In the UK the film airs as “Treasures Decoded: The Great Pyramid” on More4 (<http://www.channel4.com/programmes/treasures-decoded/episode-guide>).

1. Tallet, P., and G. Marouard. “The Harbor of Khufu on the Red Sea Coast at Wadi al-Jarf, Egypt,” *Near Eastern Archaeology* 77 (1), pages 4–14, 2014.

A Blink cameraman and assistant film the excavations of the Silo Building Complex and basin from high above the excavations. Below, Dan Jones tackles the voluminous paperwork essential for documenting the season's findings.



No story about the Giza Pyramids is complete without the town that supported the construction work, including the galleries where boat crews may have stayed after delivering building materials. Our workers removed the protective cover of sand from two previously excavated galleries in the Lost City site for the Blink film crew.



# Prickly Protection: Sailing in a Hedgehog Boat

This season we had a rare glimpse of ancient Egyptian popular beliefs with the discovery of a fragment of a model *Henet* boat from our 2014 Silo Building Complex (SBC) excavations (see article on pages 2–5). A *Henet* boat had a prow shaped as a hedgehog head, such as is depicted below from an Old Kingdom private tomb at Saqqara. The ancient Egyptians imbued hedgehogs with magical properties. They used hedgehog-shaped amulets and models for personal protection.<sup>1</sup>

In tomb reliefs, we see the *Henet* sailing boat traveling in a pilgrimage voyage together with a papyrus rowing boat called *Shabet*. They are, respectively, the night and day solar barques for the tomb owner's daily journeys through the heavens during the Afterlife. They may also represent private pilgrimages to real, sacred locations. We can tell the direction of travel as the *Henet* boat leads when traveling south with sails unfurled to catch the northerly breeze, corresponding to the owner's nighttime journey, and the *Shabet* boat leads when rowing north with the Nile current, meant to represent the daytime journey.

People dedicated small models of *Henet* boats at temples of local deities,<sup>2</sup> such as the goddess Satet in the island of Elephantine, or near royal mortuary temples, as in Sneferu's valley temple at Dashur. The Giza model (below, at left) might have been dedicated at (or near) the Khafre Valley Temple, which lies just to the north of last season's excavation area.

Eventually it was broken and the prow was discarded with other material into the SBC.

This boat model is unusual as it is the only known example made of limestone. Most other *Henet* boat pieces are quite schematic—small plaques made of faience with the boats shown in relief—although an exquisite pottery example was found at Tell Ibrahim Awad<sup>3</sup> in the eastern Delta. The Giza *Henet* model is also the largest example so far, most likely originally 28 centimeters (11 inches) in length, but now broken and measuring 13.9 centimeters (5.47 inches). The hedgehog head is nicely carved on its right side, but only roughly sketched on the left.

The Giza *Henet* model is a reminder of popular cults carried out around the pyramids and mortuary temples. Hedgehog boats offer a charming glimpse of the close, magical relationship the ancient Egyptians had with the natural world.

~ Ana Tavares

1. von Droste zu Hülshoff, V., *Der Igel im alten Ägypten*, Hildesheim: Gerstenberg Verlag, 1980.

2. Hamilton, J., "Henet-ships and Hedgehogs: Votive offerings from the Temple of Satet, Elephantine," Paper given at the Classics and Ancient History postgraduate conference, University of Sydney, 2013.

3. van Haarlem, W. M., "A Remarkable 'Hedgehog Ship' from Tell Ibrahim Awad," *Journal of Egyptian Archaeology*, Vol. 82, 1996, pages 197–198.

## "Sailing to the Good Places Among the Honored Ones"

*skd.t r ṯsw.t nfr(.w) t m ṯm<sup>3</sup>hw*

Relief from the tomb of Niankhkhnum and Khnumhotep at Saqqara, early 5<sup>th</sup> Dynasty. Drawing after A. M. Moussa and H. Altenmüller, *Das Grab des Nianchchnum und Chnumhotep*. Deutsches Archäologisches Institut, Abteilung Kairo. Mainz: von Zabern, 1997, Abb. 16. Translation (above) and transliteration (at left) provided by John Nolan. Photo by Ali Witsell.





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