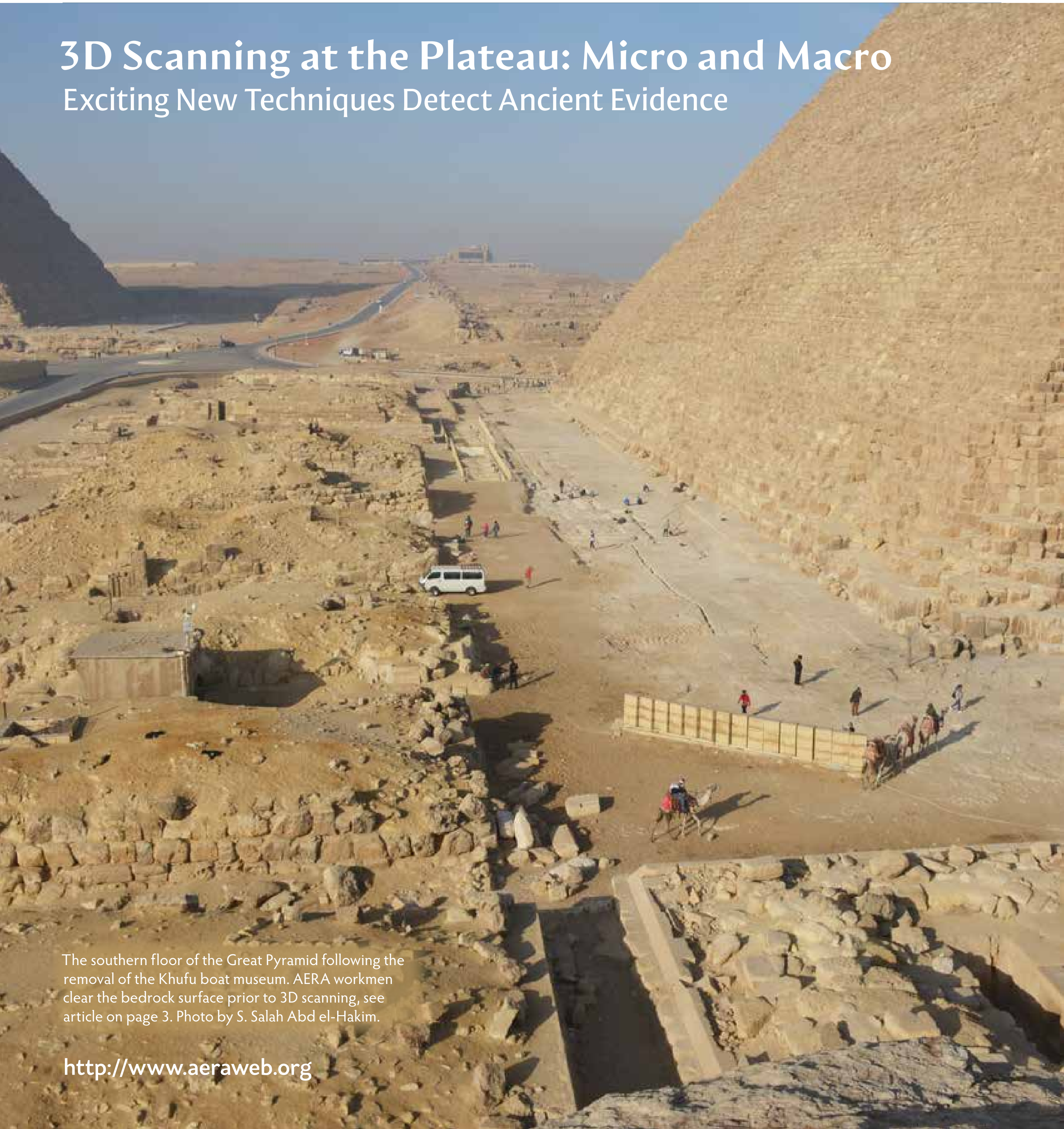
AERAGRAM
ANCIENT EGYPT RESEARCH ASSOCIATES
Groundbreaking Archaeology
VOL. 25 NOS. 1&2
Spring–Fall 2024
ISSN 1944-0014

3D Scanning at the Plateau: Micro and Macro

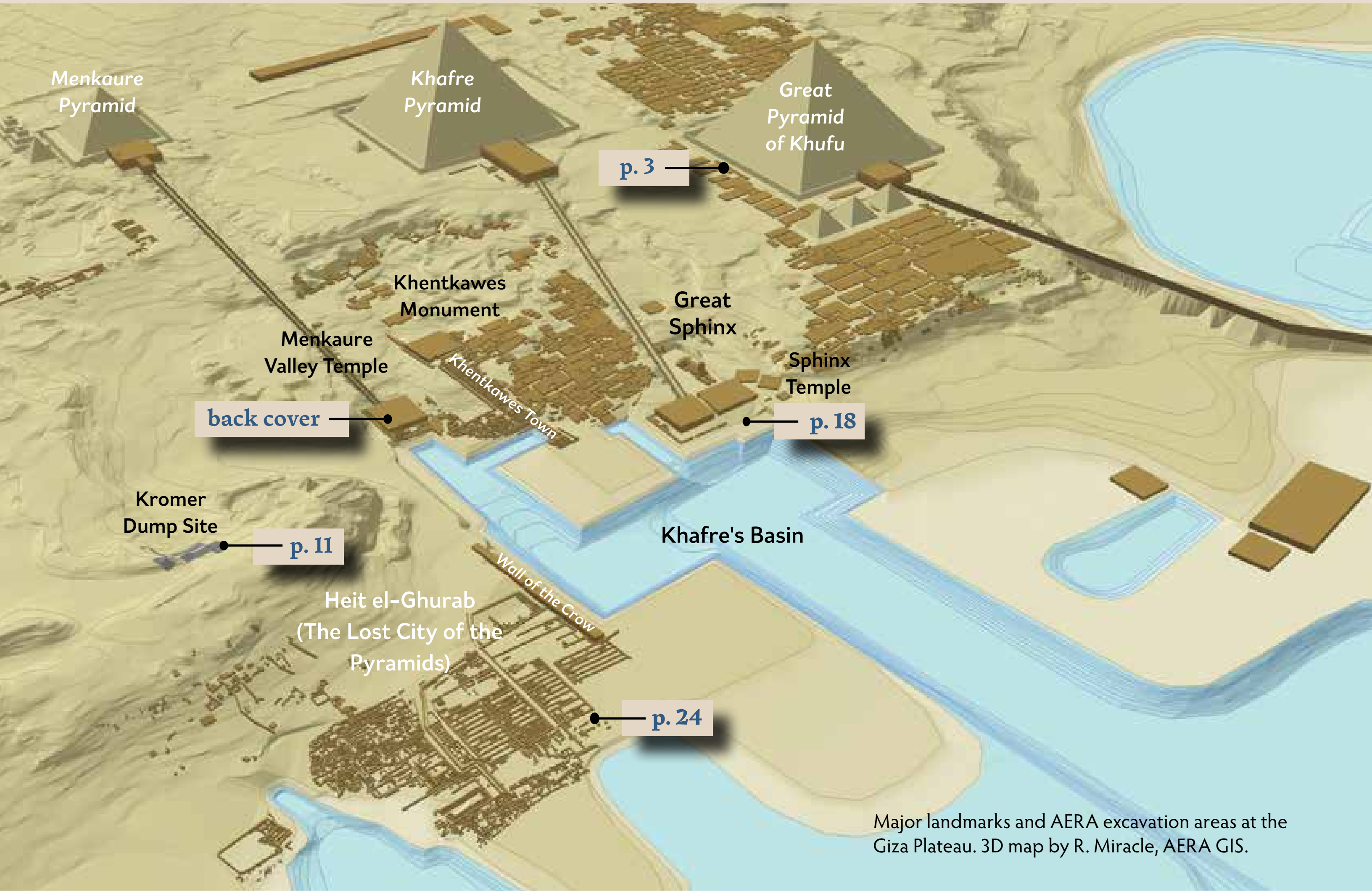
Exciting New Techniques Detect Ancient Evidence



The southern floor of the Great Pyramid following the removal of the Khufu boat museum. AERA workmen clear the bedrock surface prior to 3D scanning, see article on page 3. Photo by S. Salah Abd el-Hakim.

http://www.aeraweb.org

Inside this Issue of *AERAGRAM*:



Major landmarks and AERA excavation areas at the Giza Plateau. 3D map by R. Miracle, AERA GIS.

Dear Friend of AERA,

I'm pleased to present AERAGRAM 25-1&2, a double issue focused on 3D scanning and survey with applications both big and small. AERA partnered with Dr. Søren Sindbæk of Aarhus University in Denmark for last season's work, laser scanning on both the macro level—the southern bedrock floor of the Great Pyramid of Khufu—and on the micro level, working to capture minute detail in clay sealings from the Kromer Dump site. ***See pages 3 and 11.***

On ***page 19***, the Glen Dash Foundation for Archaeological Research discusses their 2019 radar survey and what their findings mean for our understanding of the engineering that went into the Sphinx Temple.

AERA textile specialist Sarah Hitchens and clay sealings specialist Ali Witsell discuss the now-invisible world of textiles at the Heit el-Ghurab site, from traces left behind on sealing backs, see ***page 24.***

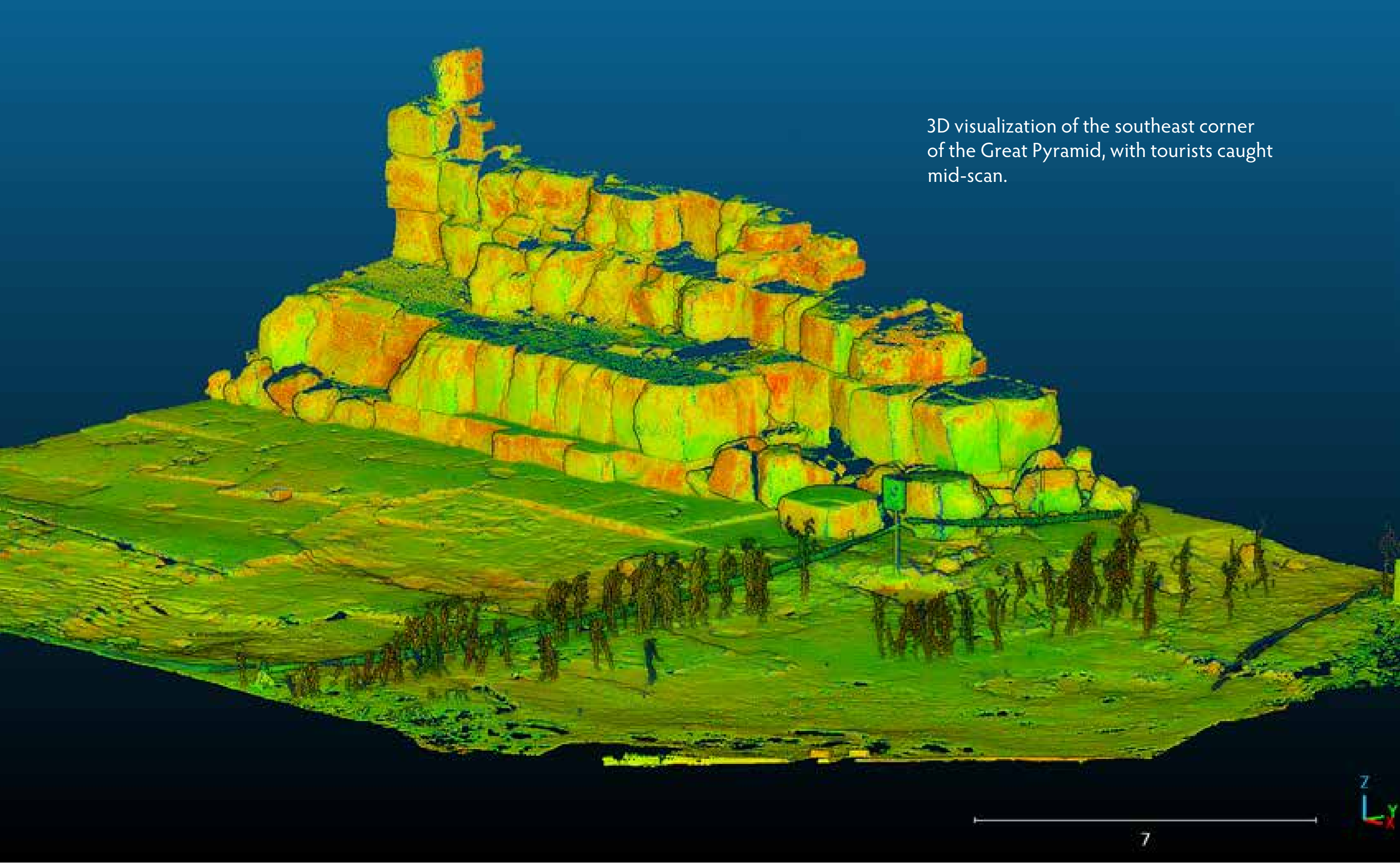
On ***page 31***, we say a big thank you to Dr. Wilma Wetterstrom, former AERA archaeobotanist and Art and Science Editor, for her decades of work and dedication to AERA.

I encourage you to read my remembrances of dear friends and board members Ann Lurie and Bruce Ludwig, along with an update on our celebration of the life of Richard Redding, without whose support AERA would not be what it is today. See ***pages 35–39.***

And lastly, on the ***back cover***, AERA lithicist Samar Mahmoud Ibrahim presents our Artifact of the Issue—a rare sickle blade from the Menkaure Valley Temple.

I thank you for making all our work possible. We carry out every field season because you are there for us. Please stay with us as we continue our journey of exploration.

With gratitude,
Mark Lehner



3D visualization of the southeast corner of the Great Pyramid, with tourists caught mid-scan.

THE LASER'S EDGE

The Great Pyramid South Floor Survey

by Søren Sindbæk and Mark Lehner

For decades, visitors to the Giza Plateau would visit one of the world's most famous boats—the eastern wooden boat of Khufu, builder of the Great Pyramid—more or less in its original setting. One of seven buried boats meant to provide for Khufu and his queens in the afterlife, in 2021 it was disassembled and moved from the southern side of his pyramid to the new Grand Egyptian Museum (GEM), just north of the pyramids on the plateau. The reassembled boat had been on display in a museum built directly over the pit where its disassembled pieces were found in 1954. After the eastern boat and its twin, just to the west, went to the GEM, the Ministry of Tourism and Antiquities (MoTA) removed the old museum infrastructure, exposing the bedrock surface underneath, which had never been mapped in detail. At the end of 2022, AERA received permission to survey this area, the southern floor of the Great Pyramid.

Construction Evidence Left Behind

But very few of those same visitors have taken note of a constellation of simple rock-cut features carved into the bedrock floor around all sides of the pyramid. These traces bear witness[1] to a building process entirely unprecedented, when Khufu came 4,500 years ago to build his Great Pyramid.

Unlike his predecessors, Khufu placed his giant pyramid on a carefully prepared base carved into the bedrock of the Middle Eocene Moqattam Formation, formed from sea sediments 50 million years ago. These bedrock marks (see photo, page 4) include remnants of quarry channels, sockets for big wooden levers that the builders used to maneuver heavy stones into place, complex jigsaw patterns of emplacements for court pavement slabs, small holes for wooden props that helped the masons set the slabs, and a long series of large holes in lines parallel to the pyramid base that may have

Left: A view south, down the steps of the Great Pyramid, showing the area of Khufu's southern boat pits. On the left, the former museum housing his assembled eastern boat; on the right, the buildings cover the western boat pit, where a Japanese team worked to document and conserve a second boat. All of this infrastructure has now been removed, uncovering the southern floor of the pyramid and making it available for survey.

Below: Dan Jones documents the myriad bedrock marks left in front of one of Khufu's queens' pyramids, GI-a. Photos by M. Lehner.

served for survey stakes that carried reference lines as builders constructed the base of this giant pyramid with unprecedented accuracy.

When they finished the pyramid, the builders laid a thick limestone pavement[2] over the court that surrounded the pyramid, thus covering their tracks. When stone robbers stripped the pyramid of the fine Tura limestone of its outer casing, including court pavement, these backstage builders' marks lay revealed, but ignored. (Only patches of the pavement now remain on the north and west side of the pyramid, along with a smaller patch on the east.)

Back in 2015–2016, AERA team members Ashraf Abd el-Aziz and Amr Zakaria surveyed the bedrock surface on the east, west, and north sides of the pyramid as part of the Glen Dash Foundation Survey. They used a Total Station (a combined theodolite and electronic distance measurer) to map almost 2,900 postholes, lever sockets, leveling blocks, and channels that Khufu's builders left in the rock floor along the north, west, east, and part of the south side of the Great Pyramid (see blue lines on plan, page 9).

Boats Moved, Floor Uncovered

But due to the boat museum on the southern side, Amr and Ashraf mapped only a small part of the southern floor. This area remained covered with immense piles of limestone debris from robbing the pyramid's outer casing[3] until 1954, when it was first cleared by excavations led by Kamal el-Mallakh, which led to the discovery of the two large pits, cut into the southern floor as part of

Laser scanning surveying in progress at the south pavement of the Great Pyramid, view to the west. Photo by M. Lehner.

the original pyramid complex, for Khufu's cedar ships. Between 1961 and 1982, the museum was built above the eastern pit to house the magnificent re-assembled boat (see photo, page 4). In 2011, a Waseda University team led by Sakuji Yoshimura opened the western pit and began a project to retrieve and conserve the disassembled pieces of the second boat.[4, 5] Much of the southern floor around the western pit was covered by facilities to retrieve and conserve the boat (see photo, page 4). When this work was completed, MoTA transferred both cedar boats—the western one in pieces, and the eastern one, intact and complete in a specially constructed truck—to the GEM, where the two boats will be together on display.

Now came the opportunity to survey the Great Pyramid floor by cleaning and mapping the entire 270 square meters of the hitherto-inaccessible south side of the pyramid (see photo above). As testimony to the long period with limited access, the area along this side has been exposed to rather minimal wear, and arguably comprises the best-preserved traces of the footprint from the process of constructing the Great Pyramid.

In late 2021, AERA sent out an appeal to friends and supporters to help us accomplish this work. The response came immediately from one of AERA's newest collaborators, Professor Søren Michael Sindbæk of Aarhus University in Denmark. He had teamed up with us to study clay sealings using advanced, high-resolution 3D scanning (see article, page 11), and he proposed a simple idea for the pyramid survey: why not use a laser scanner? His team had successfully used laser scanning to record minute traces in the complex stratigraphy of excavations of Viking urban sites,[6] and he was convinced that the technique would be imminently suitable to the task at hand.

Precision Building, Precision Scanning

The Great Pyramid was constructed with an extraordinary degree of precision that even today requires a high level of survey to capture accurately. William Matthew Flinders Petrie (1853–1942), who completed a groundbreaking survey of the Great Pyramid in 1881–1882, famously noted that "in order to understand what kind of precision the ancients aimed at, our errors in examining their work must be so small as to be insignificant by the side of their errors."[7] Or as he also put it, "the joiner needs a better straight edge than the bricklayer."

With a laser scanner (see photo above), we could record a detailed 3D record of millions of points of the surface, rather than simply take Total Station points to outline features, as is typically done in archaeological surveys. In this way we would capture and secure a permanent, accurate 3D record of the Great Pyramid builders' marks. Søren's team had built an expertise to work with scanners in archaeological sites. They volunteered for the task.

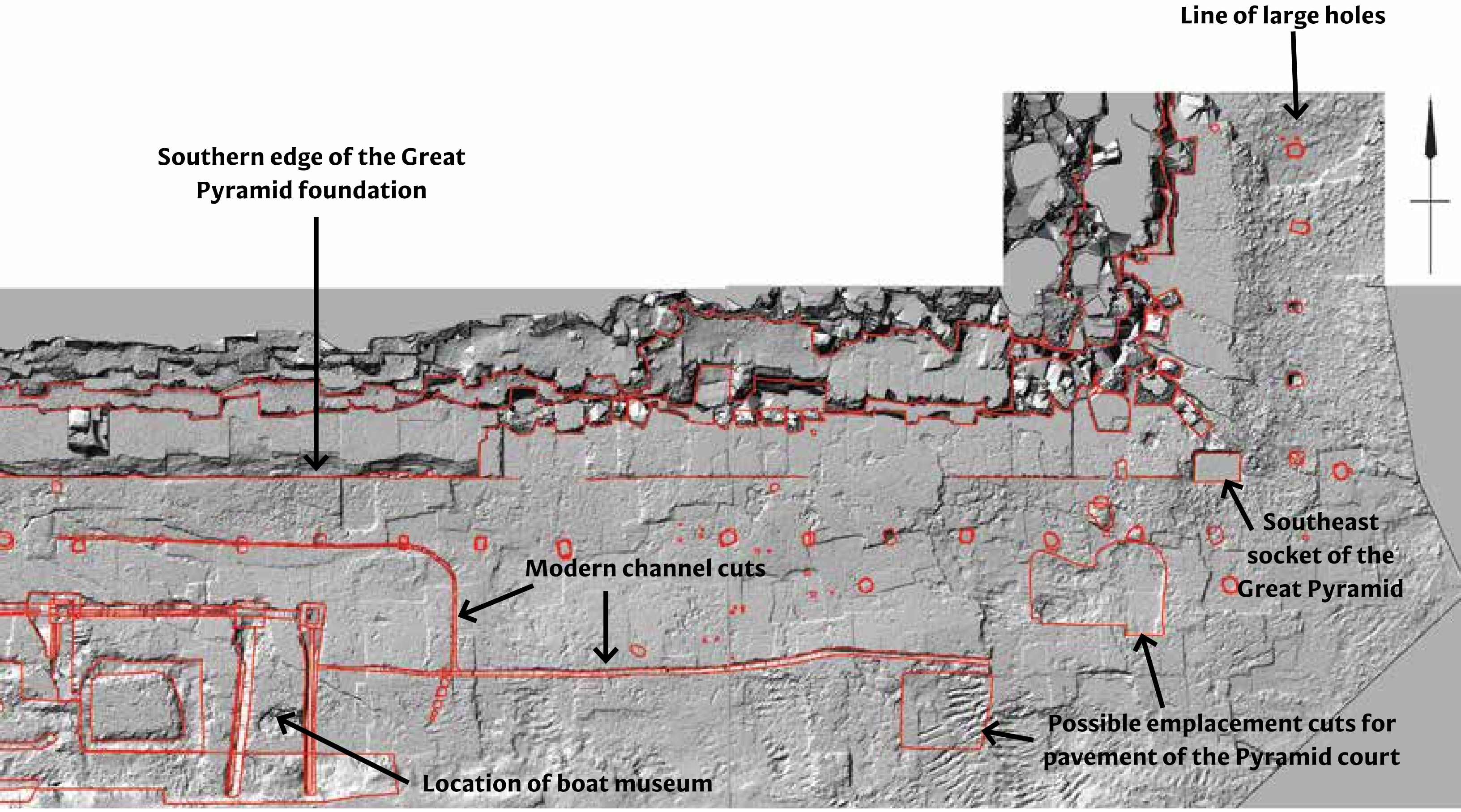
A team of AERA's workmen, led by Rais Sayed Salah Abd el-Hakim, slowly make their way along the bedrock in front of the southern face of the Great Pyramid, sweeping away dust and debris to uncover the surface prior to scanning. Photo by S. Saleh Abd el-Hakim.

AERA invited the Danish team to join us for the 2024 winter season. The Danes arrived on January 8th with their scanning station. Before the survey began, AERA's team of workers led by Sayed Salah Abd el-Hakim, had meticulously cleared the southern floor. This was the first time that the area had been scrubbed clean to bedrock in modern times.

Over the next two weeks, AERA's Danish team members scanned their way over the newly uncovered surfaces. Working with Ashraf Abd el-Aziz, we registered a total of 170 never-before-recorded features at the foot of the Great Pyramid, including lever sockets, rock-cut holes, and deep emplacements for limestone pavement pieces, in addition to modern features from the foundations of the museum building.

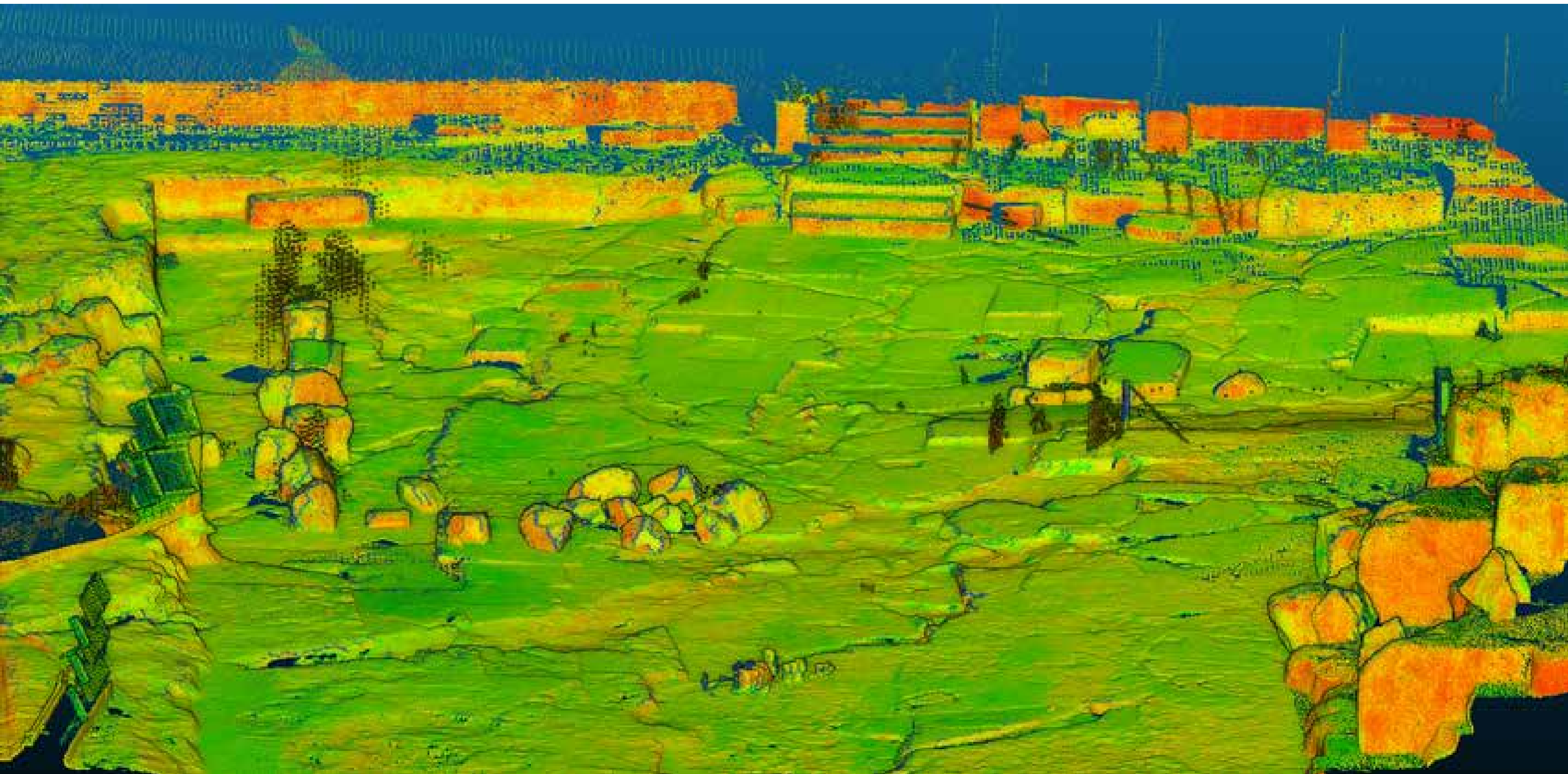
The survey data preserves a record of the exact shape of each of these features, together with those recorded previously, in an accurate model. The survey also enables us to visualize just how precisely the pyramid builders were able to level the bedrock to a horizontal plane at the foot of the pyramid. One particularly impressive example of their skill is the gentle, almost

The Danish scanning team, from left to right: Kirstine Haase, Claus Feveile, Lene Lund Feveile, Sarah Croix, Søren Michael Sindbæk, and Sarah Skytte Qvistgaard. Photo by S. Saleh Abd el-Hakim.



Above: A basic visualization of a section of the processed laser survey, rendered with an artificial "hill-shadow" shading. This is overlain by the shape files of various features recorded during the survey, like postholes, lever sockets, and emplacements for now-missing limestone pavement pieces. The southern edge of the Great Pyramid shows at the top of the image. Below it, vague traces of the edge of the pyramid platform are visible. In the lower part of the picture, a modern feature is conspicuous: a channel cut for electric cables for a previous installation of the Pyramid Sound & Light show.

Below: Visualizations of the raw data for the southwestern corner of the Great Pyramid court, view to the southwest. During further processing, we will delete accidental features, such as the outline of people visible along the edge of the scannings, or the top of the Khafre Pyramid, which happened to be captured in thin outline in one scanning.



Sarah Skytte Qvistgaard and Dr. Sarah Croix set up the laser scanner at the Great Pyramid. The Trimble SX10 scanning total station combines automated total station positioning with band scanning using a rotating prism telescope. Photo by S. Saleh Abd el-Hakim.

imperceptible, gradual drop of level along the middle of the pavement towards the corners. This "impluvium" was presumably made to allow rainwater to run off the court pavement. With laser scanning we can visualize this minute and highly controlled landscape sculpting, which is barely visible to the naked eye on site (see pseudo-color map, page 9).

From the data we can also more easily analyze the alignment of features, including what are the most conspicuous, yet enigmatic, features. Along the whole perimeter of the pyramid runs a row of regularly spaced, large holes parallel to the pyramid base. The builders plugged many of these holes with stone blocks and mortar before the pavement was put in. One might think that the pyramid building site had been fenced in, but this is hardly what the holes were intended for.

Lehner has suggested that the holes were cut as sockets for a system of wooden posts that were designed to carry a thin rope that could have assisted the builders in taking accurate measures for setting the pyramid platform. With the new survey data from the well-preserved south side, we will now be able to test this hypothesis.

Future Plans

There is a wealth of new detail to be explored and explained in our virtual record of the Great Pyramid building site. This is an exploration, which is just commencing now, but the level of new detail has opened new paths. The results beg the question as to where else laser scanning might give us new eyes. It is, after all, a unique and universally significant monument in history. There is only one Great Pyramid.

The traces recorded on the southern floor may be unassuming compared to the giant monuments that surround them; yet they are some of our best evidence for the process by which the ancient Egyptians managed to plan and engineer a monument of unprecedented size and precision. For now, the survey has secured for posterity a permanent record of bedrock features along some of the best surviving parts of the Great Pyramid building site. It has taken us to the edge of a new understanding of the level of precision that Khufu's builders put into both the pyramid platform and the construction of the Great Pyramid, and how they achieved it.

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1. For more, see M. Lehner, 2021, "Sculpting Bedrock on the Scale of Acres," *AERAGRAM* 22, pages 11–19.

2. Z. Hawass, M. Lehner, and D. Jones, 2020, "The Great Pyramid Temple Project," *AERAGRAM* 21-1&2, pages 11–19.

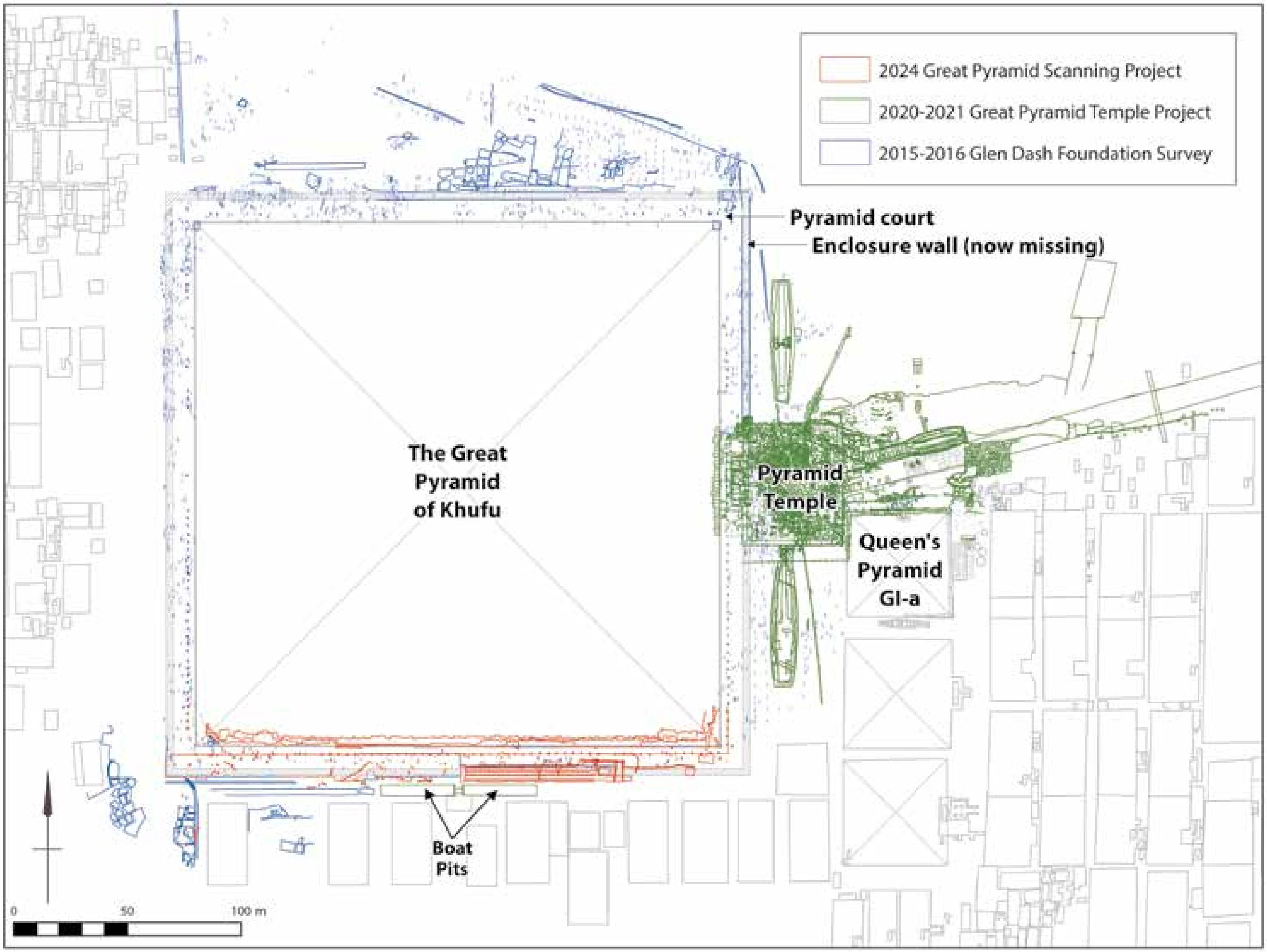
3. N. Jenkins, 1980, *The Boat beneath the Pyramid: King Cheops' Royal Ship*, London: Thames and Hudson.

4. S. Yoshimura and H. Kurokochi, 2013, "Brief Report of the Project of the Second Boat of King Khufu," *Journal of Ancient Egyptian Interconnections* 5(1), pages 85–89.

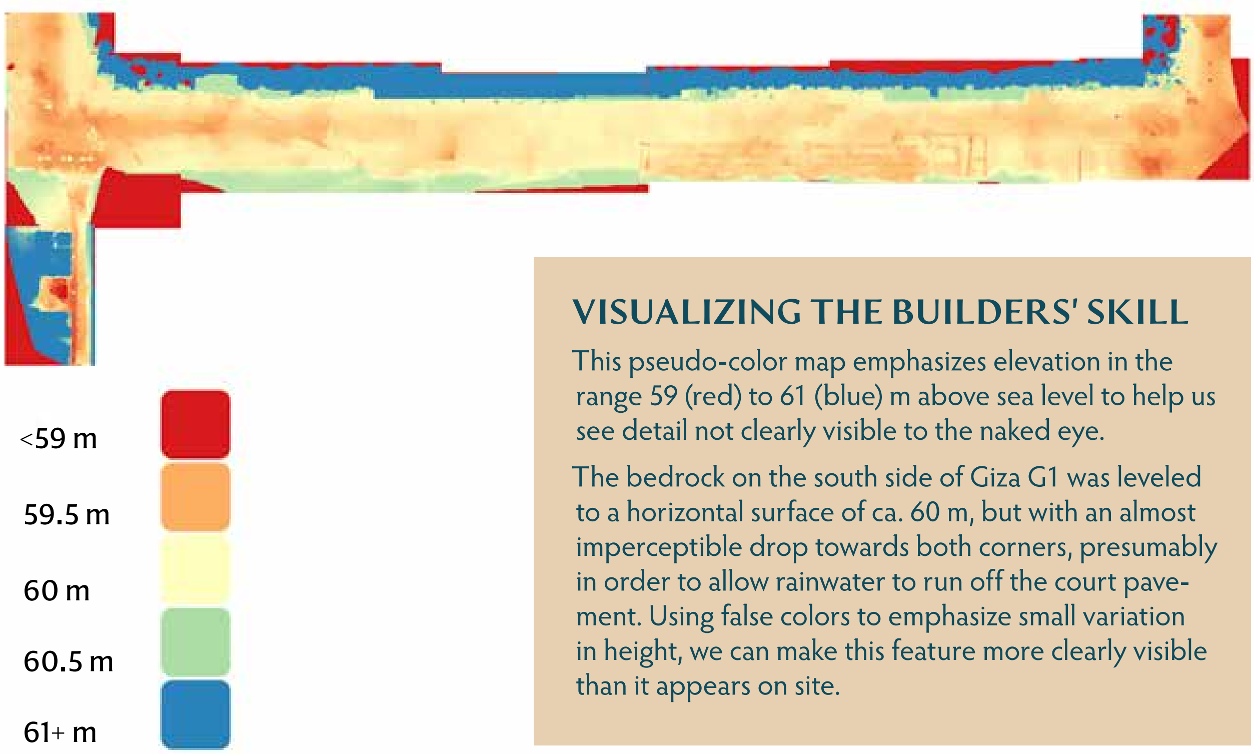
5. H. Kurokochi and S. Yoshimura, 2015, "Report of the Activity in 2015, Project of the Solar Boat," *Journal of Egyptian Studies* 22, pages 5–14 (Japanese with summary in English).

6. S. Croix, P. Deckers, C. Feveile, M. Knudsen, S. S. Qvistgaard, S. M. Sindbæk, and B. Wouters, 2019, "Single Context, Metacontext, and High Definition Archaeology: Integrating New Standards of Stratigraphic Excavation and Recording," *Journal of Archaeological Method and Theory* 26, pages 1591–1631.

7. W. M. Flinders Petrie, 1992 reprint, *Ten Years Digging in Egypt 1881–1891*. London: The Religious Tract Society.



Above: A plan of all the lever sockets, rock-cut holes (some of which may be postholes), limestone and quarry blocks, quarry channels, drains, court lines, foundation blocks, temple columns, boat pits, basalt pavements, causeway blocks, and modern features that AERA has recorded since 2015. Plan by R. Miracle, AERA GIS.



VISUALIZING THE BUILDERS' SKILL

This pseudo-color map emphasizes elevation in the range 59 (red) to 61 (blue) m above sea level to help us see detail not clearly visible to the naked eye.

The bedrock on the south side of Giza G1 was leveled to a horizontal surface of ca. 60 m, but with an almost imperceptible drop towards both corners, presumably in order to allow rainwater to run off the court pavement. Using false colors to emphasize small variation in height, we can make this feature more clearly visible than it appears on site.

Help Us Fill Our People Pyramid

The Return of the AERA Archaeology Field School

We need YOUR help! We are pleased to announce that we have been asked by the Egyptian Ministry of Tourism and Antiquities (MoTA) to relaunch our Archaeological Field School at the Lost City of the Pyramids.

Since their inception, AERA's Field Schools have trained over 390 MoTA archaeologists in the best practices of scientific archaeology. Our field school program empowers Egyptian archaeologists in the study of their heritage by equipping them with the skills to excavate, record, analyze, and publish material throughout Egypt. Our graduates have pursued advanced degrees, managed archaeological projects, taken leading positions in the MoTA, and taught in AERA Field Schools and MoTA training centers.

The Beginners Field School will excavate craft production areas located along the Lost City's southern harbor, including Egypt's oldest-known faience production area, copper-working facilities, and an alabaster workshop. Over an eight-week intensive excavation season, students will work with professional archaeologists to learn how to document and preserve information—written, drawn, digital, and photographic. Students will also work in the Giza Field Lab to learn about people's lives from animal bones, plant remains, clay sealings, pottery, and artifacts. After excavation is over, students will learn to archive data and write reports.

These same students will then return for the Advanced Field School to receive in-depth training in a concentrated area of interest—advanced excavation, archaeological illustration, ceramics analysis, survey, osteoarchaeology (the study of human remains), archaeozoology (the study of ancient animal bone), or archaeobotany (the study of plant remains).

Your tax-deductible donation supports education and world cultural heritage at one of Egypt's most iconic locations. It is an investment in the future of Egyptian archaeology. A safe online donation can be made by scanning the QR code here, or to donate by check, please send it payable to AERA at 26 Lincoln Street, Suite 5, Boston MA 02135 USA.

Help us fill our people pyramid! It takes a team of people to train, feed, house, and transport a field school team. As we raise funds, we will fill in members of the team.

THE DATA'S IN THE DETAILS

3D Micro-Scans of Giza Clay Sealings Show the Promise of Using Technology to Bridge Distance and Time

by Ali Witsell and Søren Sindbæk

As we have discussed previously in our newsletter, it is often the case that AERA's lab specialists are working in a time crunch, trying to capture as much data as possible in the very finite time we have available during the season. We primarily use photography and drawings to record our data, but inevitably find that the photographs we were so certain captured some essential detail fall terribly short once we get home. This is regularly the case for clay sealings, one of AERA's main categories of small finds from our excavations and an important dataset for reconstructing the complexity of Old Kingdom society and the administration that built the Giza pyramids.

Sealings are small bits of clay used in tandem with cordage or string as a locking system to hold ancient items like jars, bags, bins, documents, and doors closed. This clay would then be impressed with a cylinder or stamp seal that represented a claim of responsibility on the part of the seal owner for the contents of the locked item. The front side bears the seal impression; the back side an impression of the surface that was sealed, be it clay, wood, leather, plaster, or papyrus. During the Old Kingdom, these seals were regularly carved with the job titles of the seal owner, as well as the name of the pharaoh under whom they served, making them a more precise dating tool than most of the material culture we recover. Seals and sealings can, in a way, be almost as identifiable as a fingerprint. When we can match a ***duplicate***—multiple sealings impressed by the same seal—from one area to a duplicate in another area, it means that in some way these two areas are related through the ancient work of this single seal. It is our job as archaeologists to figure out how.

As informative as sealings can be, they are equally frustrating to work with. Details are often smeared by a hasty cylinder roll at the end of the day, or stamped into uneven, poorly prepared, and badly levigated clay. Many are broken into small pieces. The average sealing fragment from our excavations measures only 2–3 cm across, and the hieroglyphic elements can be just millimeters in size. They are also very multi-dimensional, with information on every surface. Static photographs are never quite enough—you always wish for one more angle, or two or three. A 3D scan you could rotate and study at home would be even better.

A very small fragment of a clay sealing recovered from AERA's HeG excavations. Tiny but mighty, it has two hieroglyphs—just millimeters in size—from one of the names of Menkaure, builder of the third pyramid at Giza. Photo by A. Witsell.

So in addition to Søren Sindbæk's work 3D scanning Giza's monuments (see article on page 3), he offered, and we gladly accepted, his help in running a trial project micro-scanning some of the sealings excavated at Giza. But first we needed to choose just the right dataset. One of our current research topics and a bit of lucky geography made the answer obvious.

Kromer and KRO vs. HeG: Familiar but Different

In 2018, AERA opened excavations[1] in an area adjacent to but with an unclear association to the Heit el-Ghurab (HeG) site. Originally excavated over five seasons in the 1970s by Karl Kromer, an Austrian prehistorian, the site was a bit of an enigma (see maps, pages 2, 16). Located up in the desert over the rocky ridge running along the western side of HeG, it had no standing archi-

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Above, left: Kromer's drawing of a seal impressed by Seal 1 of HeG (K. Kromer, 1978, *Siedlungsfunde aus dem frühen Alten Reich in Giseh*). Right: A reconstruction of Seal 1, owned by a royal scribe of Khafre who likely worked in House Unit 1 at HeG (see map, page 17). Drawing by J. Nolan.

tecture, but plenty of broken bits of architecture. It had literal mounds of Old Kingdom material culture familiar to AERA's specialists, but somehow just a bit out of step. AERA sealings specialist John Nolan thought he recognized one of Kromer's sealings as a duplicate to his own "Seal 1" (see image at right) that he had pieced together[2] from over 100 HeG duplicates. Seal 1 is the most well-represented seal that we know was in use at Giza during the Old Kingdom and belonged to a royal scribe of Khafre who worked in House Unit 1 of HeG (see map, page 17). But Kromer only published an impressionistic drawing with no photograph.[3] The titles and epithet strings on this type of seal are very repetitive—"similar" is just not enough to prove a match.

In the late 1970s, Kromer passed the main work of the publication of his sealings corpus to Peter Kaplony, who at the time was finishing a compilation of all known Old Kingdom seals and sealings. Kaplony saw many of the pieces in person and illustrated them with line drawings. While his compilation is a tremendous resource, line drawings of sealings without accompanying photographs must still be considered interpretations. They don't always capture the weight of the carving, the exact alignment of signs, the arched toes of a crocodile, the graceful curve of a falcon's head and back—all the little things that can cinch a clear match. In Kaplony's line drawings, we saw many motifs and title strings familiar from HeG examples, but without seeing at least photos, it would be irresponsible to say definitively that the same seals were used in both sites.

But with our 2018 return to the Kromer area, we had hopes of finding duplicates we could study in person ourselves. Our work in KRO suggests that the site is a large, open-air demolition dump of the Old Kingdom. (Our area code for this work is "KRO," vs. the full "Kromer" to designate his original work.) We did indeed retrieve several hundred sealings and sealing-related objects, including two duplicate sealings that proved that Seal 1 was indeed active in both HeG and whichever building or site produced the Kromer trash.

But we also found new pieces that proved the KRO trash included discarded sealings made by officials at the highest levels of Khafre's administration, including mentions of his pyramid complex, the royal guard of the palace, scribes of royal documents and the king's writing case, and numerous priests. We knew many of these types of officials from HeG, but not dating to Khafre. While the main footprint of HeG dates to Khafre and his son, Menkaure, most of the datable HeG sealings belong to Menkaure. The Kromer/KRO sealings only date to the time of Khafre and his father, Khufu. But with so many examples of Seal 1 from HeG, it was still possible to argue that its owner could have worked at other sites on the plateau, not just HeG. So where did all the KRO trash come from, carted basket by basket up into the desert? We have a theory. The stratigraphy in KRO indicates at least some of it came from the direction of HeG. We suspect that the KRO debris comes from a clean-out of HeG during an expansion in the time of Khafre, and that perhaps the unexplored lower level of HeG may date to Khufu. But to really prove it, we need more data and a lot more detail.

Enter Søren and the Vienna Test Run

Søren had prior success using his micro-scanning methodology on Viking-era moldmade jewelry. After seeing Mark Lehner lecture on the importance of sealings to AERA's work, he approached Mark about potentially trying it at the lab in Giza. But a trial run

Søren tests the scanner on one of Kromer's sealings at the University of Vienna. Photo by S. Sindbæk.

closer to home was preferable, especially before lugging precision equipment through airports and customs, on planes, and up to a dusty lab on the plateau with an uncertain power supply.

Luckily for us, a portion of Kromer's original finds are now housed at the Institut für Urgeschichte und Historische Archäologie at the University of Vienna, not far from Søren's homebase at Aarhus University in Denmark. We thank Mark Lehner for arranging this trip, with the generous permission of Dr. Alois Stuppner, and the kind assistance of curator Cordula Engeljehringer, both of the University of Vienna.

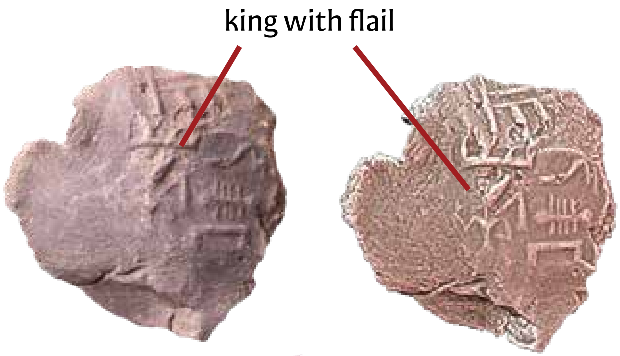
In four days in February 2023 Søren scanned over 170 sealing fragments and sealing-related objects from Kromer's finds in Vienna. Smaller pieces often took less than five minutes to process and on the best day he was able to complete 80 scans. The scans were captured using a Shining AutoScan-DS-MIX (see image below)—a blue-light scanner that can create highly detailed scans of small objects in under 30 seconds, which can then be converted into 3D models. Unlike a conventional desktop 3D scanner, it operates with a very high resolution and precision. It has a scanning area of 100 × 100 × 75 mm and an accuracy of ≤10 µm, meaning it can match the most detailed scanning currently used for high-precision tasks such as dental work or quality inspection. This enables it to capture the fine details present on clay sealings and other small finds.

The 3D scans can then be used to make accurate high-resolution images of the objects, images that can be stored and shared (see sealing images below). The scans can be processed in standard open-access software such as Meshlab, where they can be visualized using a variety of filters to highlight details and processed to compare multiple scans. The scans can also form the basis of advanced image processing and eventually, perhaps, AI techniques such as automated image recognition.

To Giza and the Lab

Søren's images immediately proved highly valuable and we proceeded with arranging a full session in Giza. Before launching in with his team on the Khufu Pyramid scanning project (see article, page 3), Søren trained AERA sealings team member Ellie Westfall to operate the scanner and she set to work. Ellie was able to scan over 300 pieces in the lab, including the majority of the KRO impressed sealings.

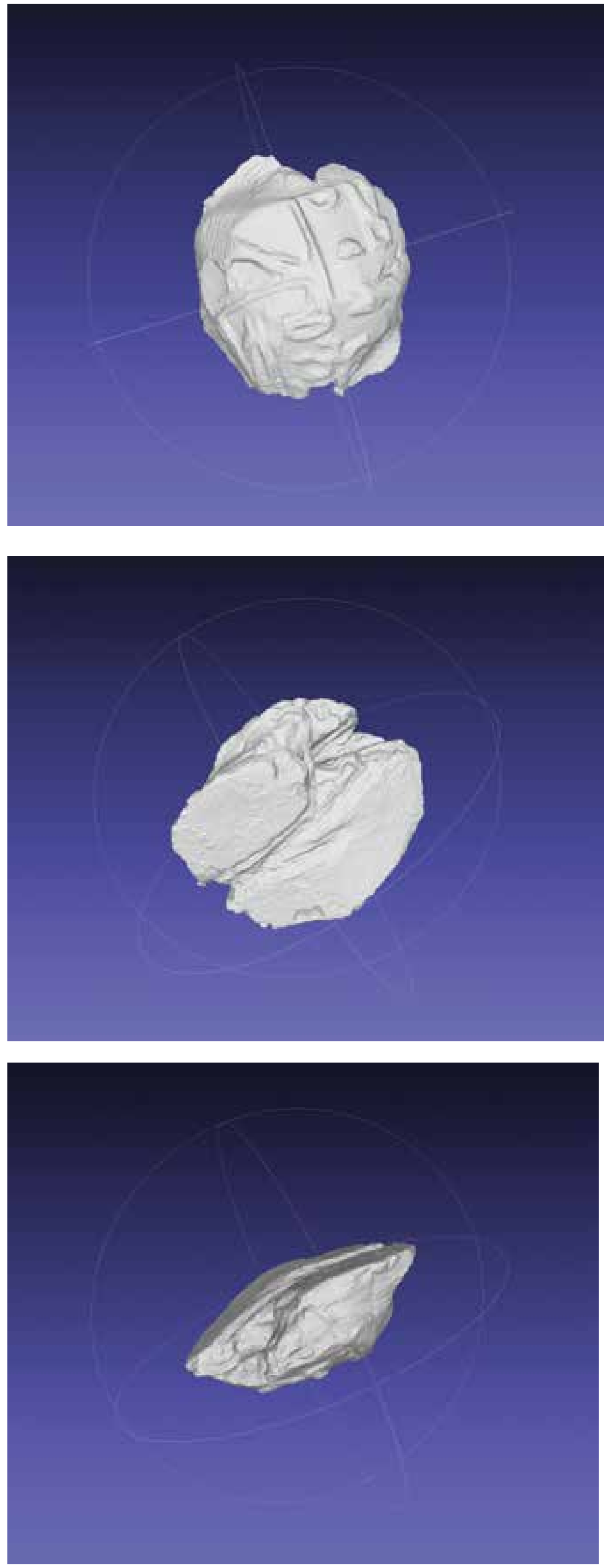
Above: High-resolution images (not to scale) prepared from the 3D KRO scans. Below: Ellie explains the scanning process while working in the Giza Field Lab. Photo by M. Lehner.



More data in the details. SN5848, excavated in our 2018 KRO work, has two rolls from a cylinder seal that mentions the *setep za*, or royal palace guard. It also has a motif related to the king's *heb sed* festival, celebrating his royal jubilee, showing the king wearing the crown of Lower Egypt, with a flail over his left shoulder and the *mekes*, a document case, held in his right hand and extended in front of him. On the left: A perfectly lovely photograph of SN5848, but on the right, an image produced from the 3D scan of the same sealing, showing much more detail than the photograph. Note especially the additional detail on the king's body.

Benefits to 3D Scans

A good illustration of the quality of the scans is the fact that fingerprints preserved in the clay, of which there are many, often clearly come through. While there will always be a place for traditional photography for sealing recording, the 3D scans pack in a lot more detail (see comparison images above). The data capture is simply superb and the ability to rotate a sealing, change shading, and provide raking light to bring out details is an absolute game-changer, especially when you have old, inadequate photos and are not able to consult the sealing itself. This applies to details on both the fronts and the backs of the sealings. The screenshots at right show the manipulation of the raw scan of a small document sealing from various angles.



Above: Screenshots of a raw 3D scan being turned in Meshlab. This allows us to check details from any angle and look for things missed in standard photography. At left: An old photograph of the same sealing. Images by A. Witsell.

Theoretical Visualization: The “Son of Wadjet” Seal

Beyond the superb data capture and detail that the 3D scanning provides, this methodology allows us to digitally peel apart separate impressions from the same sealing, superimpose and move them around, and make a blended illustration of what the full theoretical seal might have looked like. We have reconstructed this new theoretical seal, currently called “Son of Wadjet,” from four sealings excavated in the Kromer Dump, three by Kromer and one by AERA in 2018. The multi-colored image below is a blend of those four, shown at right. Wadjet was a cobra goddess of Lower Egypt, known for her role in protecting the king and mothers in childbirth.

This seal belonged to a purification priest during the reign of Khafre who served as an assistant of the royal *wabet*, the royal mummification workshop responsible for the preparation of the pharaoh’s body for burial. At the HeG site, sealings related to these priests are overwhelmingly found in Area AA (see map, page 17).

Vienna 1186

SN5855

Vienna 1005

Vienna 1143

Transliteration and Translation of the “Son of Wadjet” Theoretical Seal from KRO:

1. Nbtj wsr m ḫʿ.f-rʿ ḥknw ḥḏt dšrt

2. ḥrw wsr-jb zꜣ wꜣḏt

3. [nswt bjt] ḫʿ.f-rʿ jrt wḏ(w) rʿ nb [ẖrjw?]-ʿ wʿbt nswt

4. ḥrw wsr-jb sn Mnwj (?)*

5. Nswt bjt ḫʿ.f-rʿ [...] mr[y] ẖnm [...] rr

6. [*ḥrw*] *wsr-jb* (APIS BULL/RUNNING KING MOTIF)

1. The one who is strong through the two ladies, Khafre, the one who praises,

2. Horus User-ib, the son of Wadjet,

3. [The King of Upper and Lower Egypt] Khafre, the one who makes the commands every day, [assistant?] of the royal wabet,

4. Horus User-ib, brother (?) of the two Mins* (?)

5. The King of Upper and Lower Egypt Khafre [...] the beloved of Khnum [...],

6. [Horus] User-ib (APIS BULL/RUNNING KING MOTIF)

**The reading and meaning of this group is unclear, but based on positioning it would seem to be a royal epithet.*

Transliteration and translation by V. Almansa-Villatoro and B. Hainline; 3D scans by S. Sindbæk and E. Westfall; blended illustration by S. Sindbæk; line drawing by A. Witsell. Illustrations not to scale.

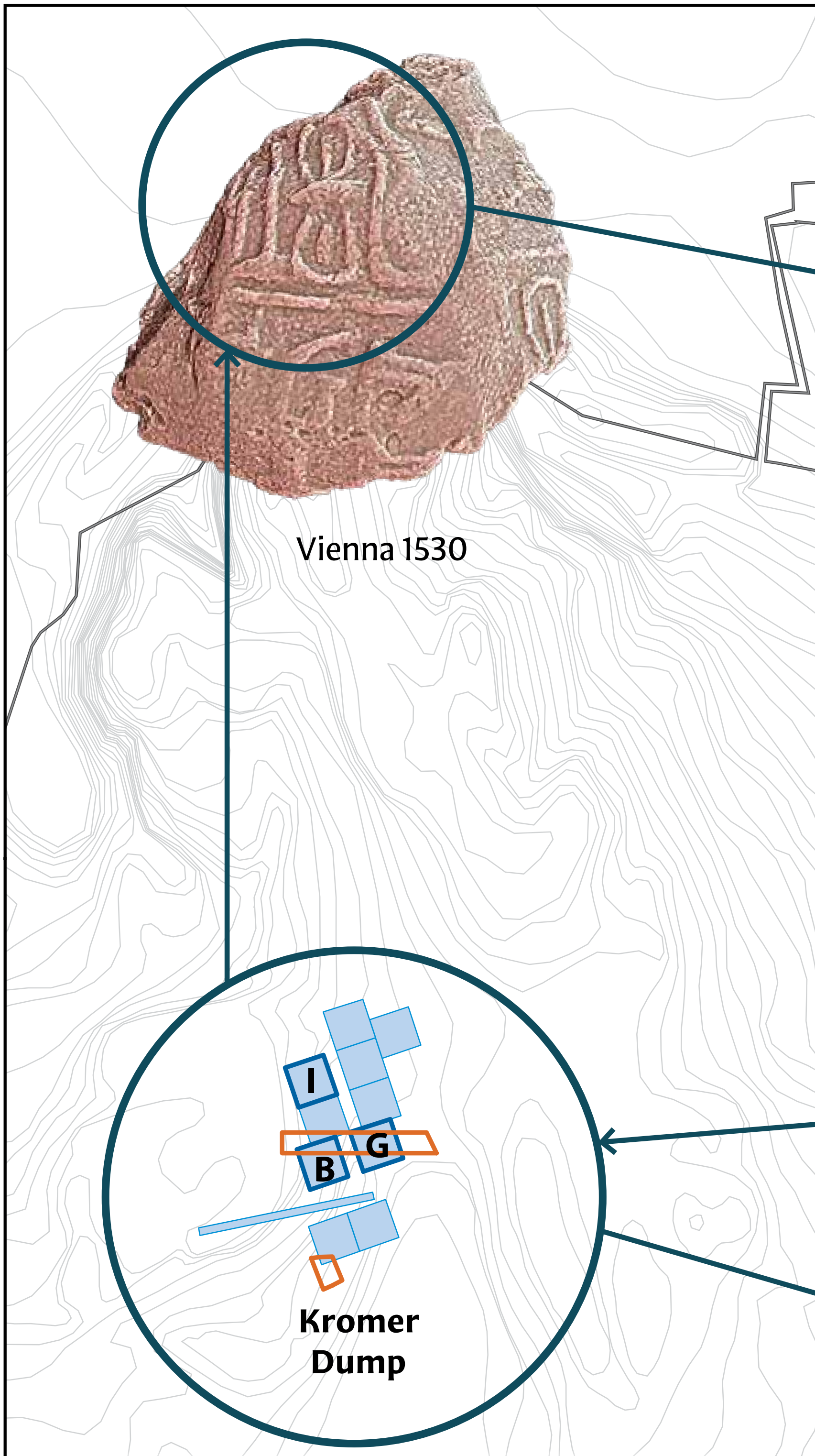
On the Hunt for Pictures Small and Big

Now that we could work with 3D copies of both Vienna's pieces and our own, the importance of the KRO sealings to our larger research question regarding the origin of the KRO trash became apparent. Thanks to Søren and Ellie's 3D scanning in Vienna and Giza, we have the detail necessary to confirm matches between the Kromer Dump (in blue at right) and three separate areas of HeG.

We already knew that sealings from one of Khafre's royal scribes from House Unit 1 were present in both areas (Seal 1). But we have now found a KRO match to a second seal, with two duplicate sealings found in Area East of Galleries (EOG)—sealing Vienna 1530 shown at right and its matches in SN3014 and SN4959. And we now know SN6859 (see lower righthand corner, page 17) from Enclosure 1 (E1) near the Royal Administrative Building is a match to Vienna 1420a, found by Kromer. Both of these areas are craft-working areas, EOG for faience and E1 for stone. These matches strengthen our argument that KRO represents a clean-out of the entire HeG site, rather than just one small section, during a city expansion in Khafre's reign. Lastly, what about Khufu? The KRO Dump produced the Khufu sealings that HeG has not. These matches are a tantalizing link to Khufu's still-missing pyramid town and the massive walls lurking in HeG's lower level that we have yet to investigate in-depth.

Future Plans

This work shows the benefit of a fresh look and new technology to find precious small details and answer big questions using legacy data recovered and recorded in the past. It also illustrates how we can merge collections that are geographically distant through technological advances. A big story can be told from such small, unassuming puzzle pieces—sitting on a dusty shelf at Giza, matched to others, excavated more than 50 years ago and transported a continent away—all waiting patiently to have their full story told.



Top: A processed image from Søren's 3D scan of Kromer's sealing 1530 (found in his Quads B-G, but now in Vienna) matched to AERA sealings SN3014 and SN4959, both found in EOG in 2005–2006. It is an informal design that includes birds, a lizard, and a figure-eight motif. **At right:** A processed image from Søren's 3D scan of Kromer's sealing 1420a (also from B-G and now in Vienna) matched to AERA sealing SN6859, excavated in 2023 in E1. It features delicately carved birds, a crocodile, and various quadrupeds.

1. A. Witsell, 2018, "Kromer 2018: Basket by Basket," *AERAGRAM* 19-1, pages 2–11. See also M. Lehner, 2018, "Kromer in Context: Biography of an Ancient Dump," *AERAGRAM* 19-2, pages 2–13.

2. J. Nolan, 2010, "Mud Sealings and Fourth Dynasty Administration at Giza," Ph.D. dissertation, University of Chicago.

3. K. Kromer, 1978, *Siedlungsfunde aus dem frühen Alten Reich in Giseh: Österreichische Ausgrabungen 1971–1975*, Vienna: Österreichischen Akademie der Wissenschaften, plate 38:1.

3D scan images by Søren Sindbæk, sealing photos by Ali Witsell and Sarah Hitchens; Map by Rebekah Miracle, AERA GIS.

THE RETURN TO THE SPHINX VIEWING PROJECT

Once More with an Old Friend

by Zahi Hawass and Mark Lehner

Both of us spent a good part of our early careers at the Great Sphinx of Giza. For us the Sphinx was a key that led to wider understandings of the Giza Pyramids Plateau.[1] We started together on the SRI International Science and Archaeology Project in 1977–1978, which included a geophysical survey of the Sphinx floor. Mark went on to work on the ARCE (American Research Center in Egypt) Sphinx Project, directed by James Allen, between 1979–1983.[2, 3] Zahi oversaw the major conservation of the Sphinx in the 1990s.[4] By 2018 we had moved on to excavations of the Workers Tombs and the Lost City of the Pyramids, and excavations and field schools at Saqqara, Memphis, and Luxor. But we felt we had left tasks undone at our old friend. Specific tasks, and one final go at overall survey.

So, we conceived the ***Return to the Sphinx Viewing Project*** (RSVP, *répondez s'il vous plait*, that is, respond, if you please). We wanted to respond one last time to the Sphinx's invitation to investigate its mystery.

More prosaically, we aimed to collect all information stemming from investigations at or on the Sphinx over the prior 45 years, much of which remains unpublished, including:

1) Geophysical survey of the Sphinx by projects that published no reports or only very brief preliminary reports;
2) Holes investigators drilled in the floor of the Sphinx, some exploratory, others to test for the quality of the limestone bedrock and the level and quality of the ground water;
3) Features cut into the bedrock floor, from modern channels for electrical cables to postholes and lever sockets left by original Sphinx builders.

We directed two seasons of RSVP fieldwork.[5] ***Season 2018***, from February 28 until March 29, saw us with workers removing drift sand and scrubbing clean the entire bedrock floor around the 72-meter-long lion body (as we had done several times in our careers). Ashraf Abd el-Aziz and Amr Zakaria, our intrepid survey team who mapped builders' marks around the floor of the Great Pyramid in 2015–2016, did the same for the Sphinx. ***Season 2019***, from February 26 until April 1, focused on the Sphinx Temple and the area immediately east. Now we employed 25 workers to clean the floor inside the Sphinx Temple so Amr and Ashraf could map all the ancient and modern cuts in the bedrock floor. Dr. Yukinori Kawae led a team from Nagoya, Kansai, and Nagasaki Universities to produce a laser scanning and photogrammetry survey of the Sphinx and Sphinx Temple.

During our two seasons Glen Dash directed team members from the Glen Dash Foundation for Archaeological Research (GDFAR)and Zahi's office to carry out a ground-penetrating radar survey of what lay below the bedrock floor of the Sphinx and Sphinx Temple. The radar survey team consisted of Glen Dash, Rebecca Dash Sperber, Eric Sperber, Joel Paulson, and Sara Ahmed. Dean Goodman assisted Rebecca Sperber in the post-survey processing and analysis of the GDFAR data.

As we launched the RSVP, we told the GDFAR team how in our earlier work, following on torrential rain, we witnessed streams of water flow across the bedrock southeast floor of the Sphinx, spill down the steps and down the corridor between the Sphinx Temple and Khafre Valley Temple, and then disappear in a crevasse that opened in the terrace just east of the temples. Here, out in front of the Sphinx Temple southeast corner, and the Khafre Valley Temple northeast corner, ancient builders fitted huge limestone blocks into what must have been a gap in the natural bedrock. Where did the water flow away to? The following article is a report from the GDFAR team.

1. M. Lehner and Z. Hawass, 2017, *Giza and the Pyramids: The Definitive History,* Chicago: The University of Chicago Press.

2. M. Lehner, 1991, "The Archaeology of an Image: The Great Sphinx of Giza," Ph.D. dissertation, Yale University.

3. M. Lehner, 2002, "Unfinished Business: The Great Sphinx – Why It Is Most Probably that Khafre Created the Sphinx." *AERAGRAM* 5/2, pages 10–15.

4. Z. Hawass, 1998, *The Secrets of the Sphinx: Restoration Past and Present,* Cairo: University of Cairo Press.

5. AERA, 2019, "Return to the Sphinx Viewing Project," *AERA Annual Report* 2018–2019, pages 8–9.

WHERE THE WATER DISAPPEARS

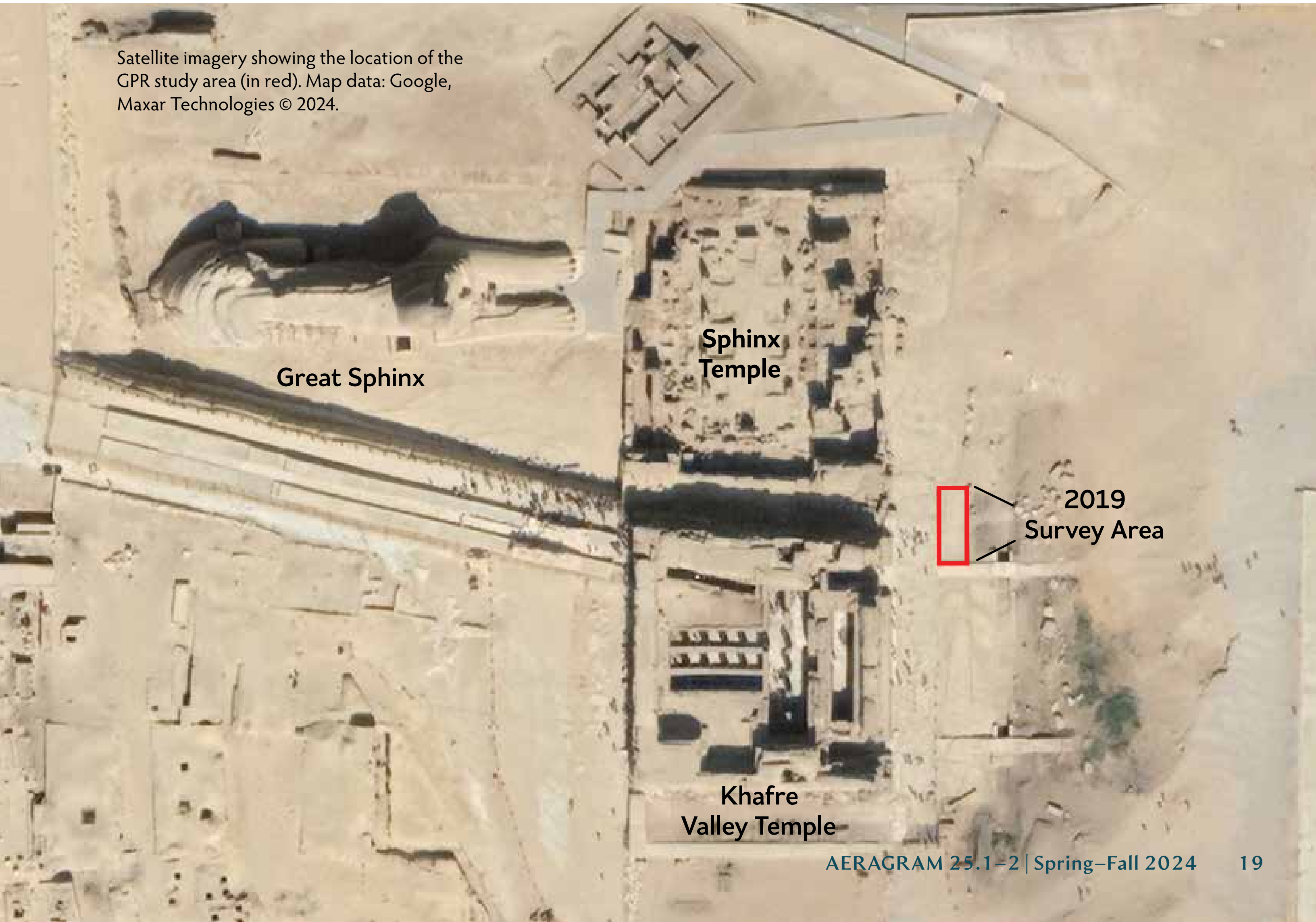
A Ground-Penetrating Radar Survey near the Great Sphinx of Giza

by Rebecca D. Sperber, Dean Goodman, Mark Lehner, and Glen Dash

Over the years, Mark Lehner and Zahi Hawass have noted a location near the Sphinx Temple where the water would "disappear" after hard rains on the Giza Plateau. From the surface, this area looks like a series of adjoining large blocks (see photo on page 20). These blocks were presumably used to level the ground around the Sphinx Temple, a common building practice of the ancient Egyptians. It was assumed that these blocks were sitting directly on the bedrock, as the bedrock can be easily visualized within the Sphinx Temple just a few meters away. However, the evidence of water traveling underground here made us wonder, could there be more man-made features hidden beneath these giant blocks?

In 2018 and 2019, the Glen Dash Foundation for Archaeological Research (GDFAR), worked with AERA and Zahi, to conduct a ground-penetrating radar (GPR) of the Sphinx and Sphinx Temple (see image below). GPR uses radar pulses to produce images of the subsurface and is used to investigate underground features in a minimally invasive way. (For definitions and more technical information on how the GPR survey was conducted, see the sidebar on page 22). One task was to investigate why after the rain a stream of water would disappear down a crevasse in front of the southeast corner of the Sphinx Temple.

Our GPR survey results showed two interesting patterns. Approximately 1 meter below the surface, we

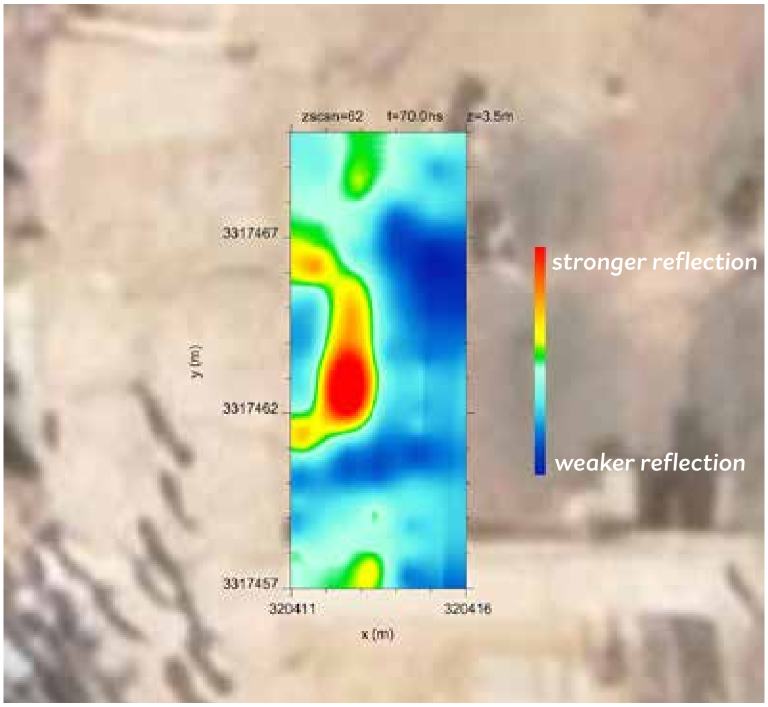


Satellite imagery showing the location of the GPR study area (in red). Map data: Google, Maxar Technologies © 2024.

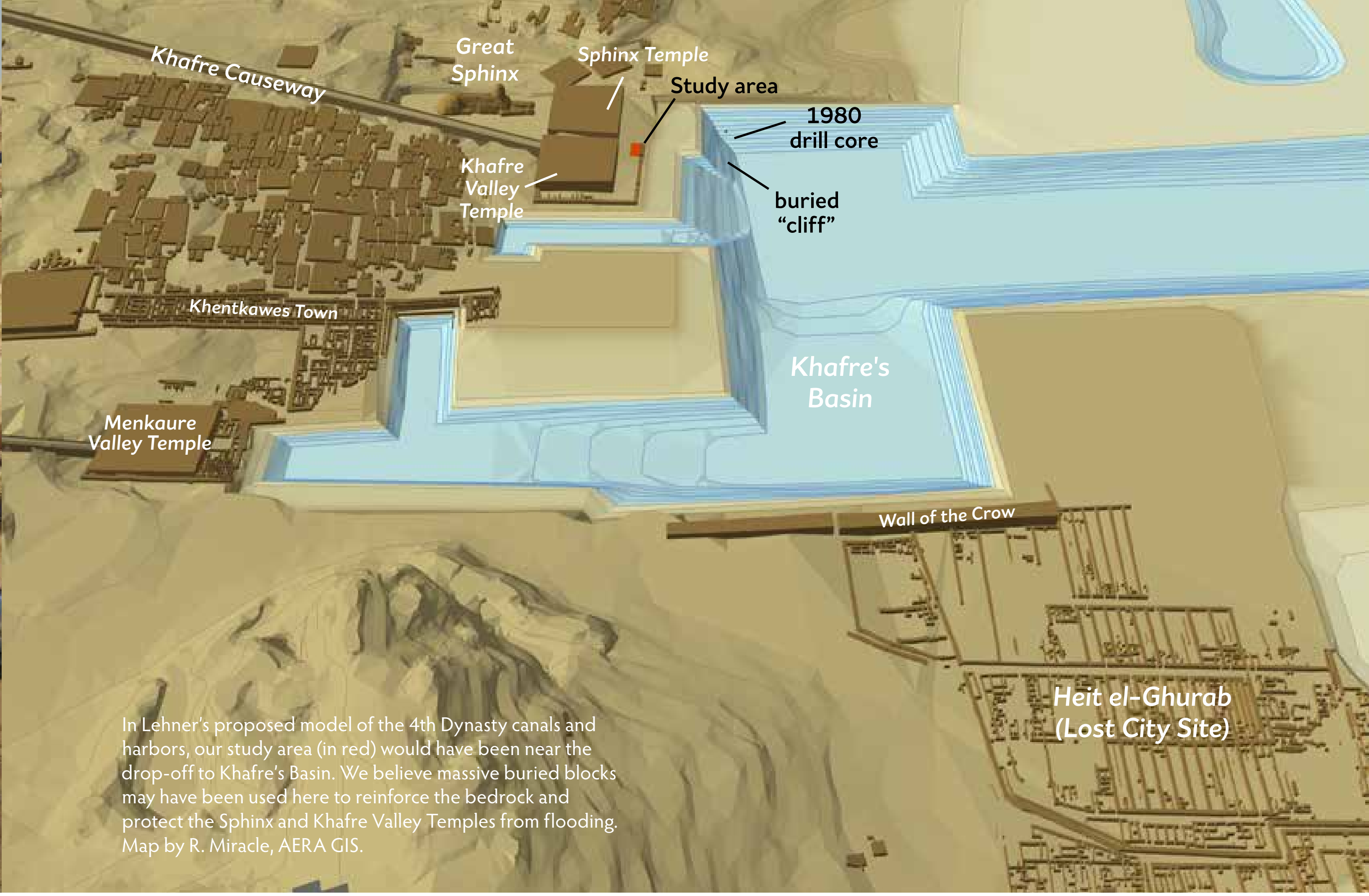
A view of the study area from the southeast with the Sphinx in the background. White dashed lines show the approximate size and shape of some of the large blocks visible on the surface. View to the northwest. Photo by G. Dash.

found a uniform reflection indicating the presence of man-made features. The uniformity of this reflection appears to confirm that the surface is made of quarried blocks that the ancient builders placed to create an even surface. Below this, though, are deeper reflections that appear to form right angles extending down as much as 4 meters below the surface (see image at right). As these deeper reflections appear to be narrow, they are unlikely to indicate the formation of an underground tunnel. We believe they are more likely a deeper layer of supporting blocks of a uniform size.

These results support our hypothesis that the surface blocks do not sit directly on bedrock, but instead a built-up substructure rests underneath them. This indicates a massive feat of engineering, but one that was well within the capabilities of the ancient Egyptians. After all, the Giza pyramid builders cut the limestone bedrock more than 10 meters deep for the foundation of the Khafre Pyramid. Why was so much work put into leveling and reinforcing the ground here? We believe it is because it is located very near where an ancient harbor once stood.



A depth slice 3.5 meters below the surface shows reflections forming right angles (in yellow). This indicates the possible presence of man-made objects buried beneath the surface blocks.



In Lehner's proposed model of the 4th Dynasty canals and harbors, our study area (in red) would have been near the drop-off to Khafre's Basin. We believe massive buried blocks may have been used here to reinforce the bedrock and protect the Sphinx and Khafre Valley Temples from flooding. Map by R. Miracle, AERA GIS.

When Zahi Hawass excavated the bedrock terrace in front of the Sphinx Temple in 1980, he found the surface sloped down to the east.[1] Core drillings further east showed a 12-meter drop-off in the bedrock levels, indicating the presence of a steep buried "cliff" (see plan above). Just above the bottom of the hole, the core drill pulled up fragments of Aswan granite. Zahi and Mark suggested the buried "cliff" was actually once an ancient quay used for docking boats at the front of Khafre's valley complex and that the imported granite, similar to what was used to clad the Sphinx and Khafre Valley Temples, may have fallen off an ancient transport barge and come to rest at the bottom of the deep basin.[2]

If this area was in fact a harbor in ancient times, the ancient builders may have reinforced the bay against the bedrock with large adjoining blocks. The limestone on the Giza Plateau has areas of lesser-quality stone and fissures, so the ancient builders may have strengthened and reinforced the bedrock with harder limestone blocks to prevent water from entering the fissures below the base of the temple. If so, this shows the thought and planning that the ancient Egyptians had not only with building above the surface, but with the engineering below as well.

While our survey results indicate the existence of an engineered substructure beneath the surface blocks, this can only be confirmed through direct observation. Due to the presence of the large platform stones, the best option would be an endoscopic observation, where a small flexible camera is used to examine below the surface. However, this could also pose a challenge with the level of debris and sand present. We hope our results will prompt more investigation into this area and further research into how the ancient Egyptians built their massive waterways from the substructure up.

1. Z. Hawass, 1997, "The Discovery of the Harbors of Khufu and Khafre at Giza," in *Études sur l'ancien empire et la nécropole de Saqqara dédiées a Jean-Philippe Lauer,* edited by C. Berger and B. Mathieu, Montpellier: Universite Montpellier III, pages 245–56.

2. M. Lehner and Z. Hawass, 2017, *Giza and the Pyramids,* page 211. London: Thames & Hudson Ltd. See also M. Lehner, 2020, "Merer and the Sphinx," in *Guardian of Ancient Egypt: Studies in Honor of Zahi Hawass*, Vol. II, ed. by J. Kamsin, M. Bárta, S. Ikram, M. Lehner, and M. Megahed, Prague: Charles University, pages 896–99.

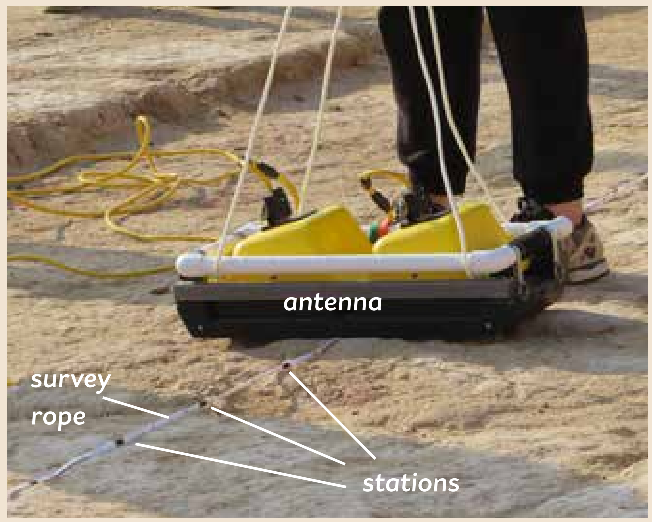
How Was Our Remote Sensing Project Conducted?

In March of 2019, the Glen Dash Foundation for Archaeological Research (GDFAR) conducted a ***ground-penetrating radar*** (GPR) survey near the Sphinx Temple to attempt to identify any subsurface structures. GPR is a minimally invasive geophysical survey method that uses radar pulses to detects changes in soil and sediment types. A transmitter emits radio frequency energy into the ground as an antenna is moved across a surface, measuring the variation in the amount of time it takes for the signal to be reflected back to the surface. The variation in the signal's travel times can then be analyzed to give information on the depth, geometry, and material types of subsurface features. Abrupt breaks in the continuity of reflections are considered a possible indication of human intervention.

The GDFAR team used a Sensors and Software DV III pulseEkko radar transmitter with a 500 MHz shielded antenna. The survey was conducted using a point-by-point method of data acquisition for deep radar penetration. We used survey ropes laid on the ground and marked at regular intervals, generally 0.25 meters apart. Each mark is known as a ***station***.

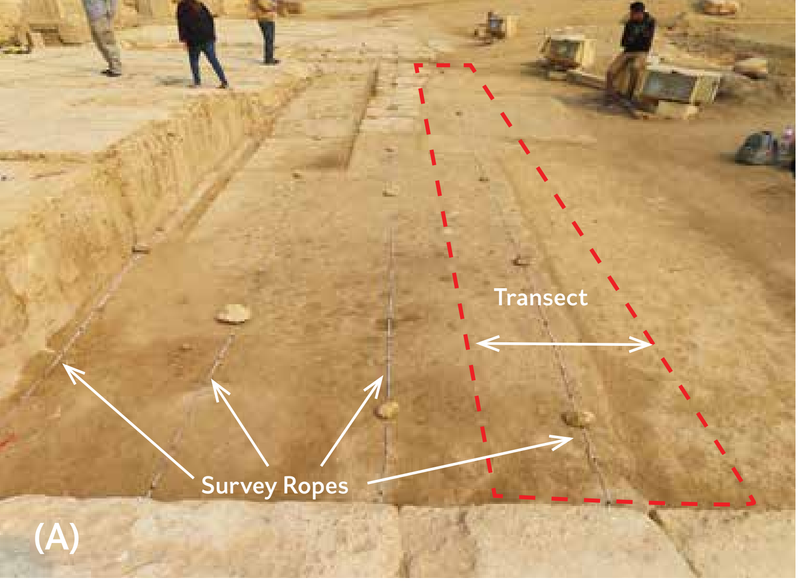
To survey along a given line, which we call a ***transect***, an antenna handler starts by placing the antenna on the first station on the survey rope. A radar operator then triggers the radar on each station, and the radar records pulse echoes. Once a recording is finished, the antenna handler then moves the antenna to the next station along the transect. The process is continued until the transect is completed. Once completed, a second transect, usually parallel to the first, can be started.

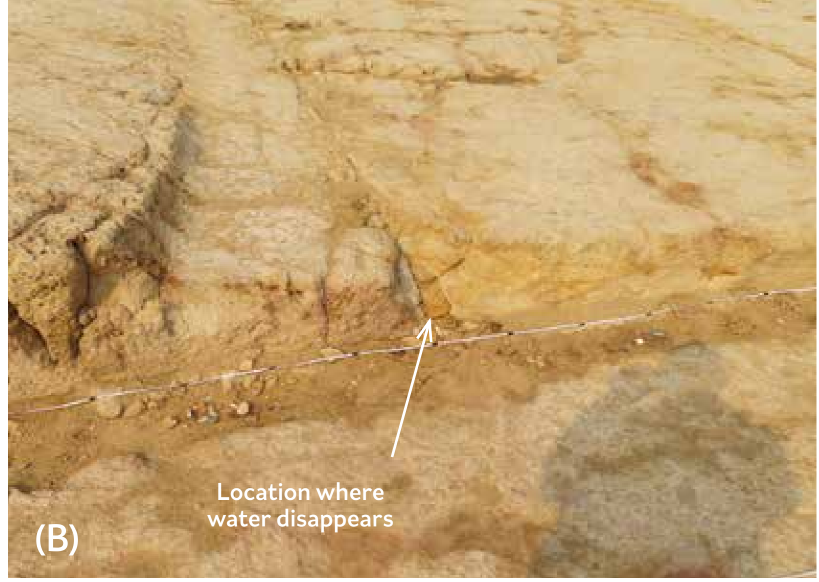
Once the radar data is collected, it is displayed in an image called a ***radargram***. Each radargram represents the data from a single transect. The horizontal axis of each radargram identifies the distance along the transect and along the vertical axis is the time/depth. We can also map the data volumetrically. ***Volumetric analysis*** is the computer analysis of multiple axes to create a 3D image for interpretation. To do this, we used Geophysical Archaeometry Laboratory's GPR-Slice, Version 7.0. GPR-Slice allows us to see, in 3D, where reflections are coming from and to produce images of the subsurface at selected depths. These ***depth slices*** show horizontal time slices of the soil parallel to the surface (see bottom image, page 23).



In the point-by-point method of scanning, stations are marked on a rope with black tape. The antenna is then placed over a station and a measurement is taken. The measurement takes between 10 and 20 seconds. When finished, the antenna is moved to the next station. Photos by G. Dash.

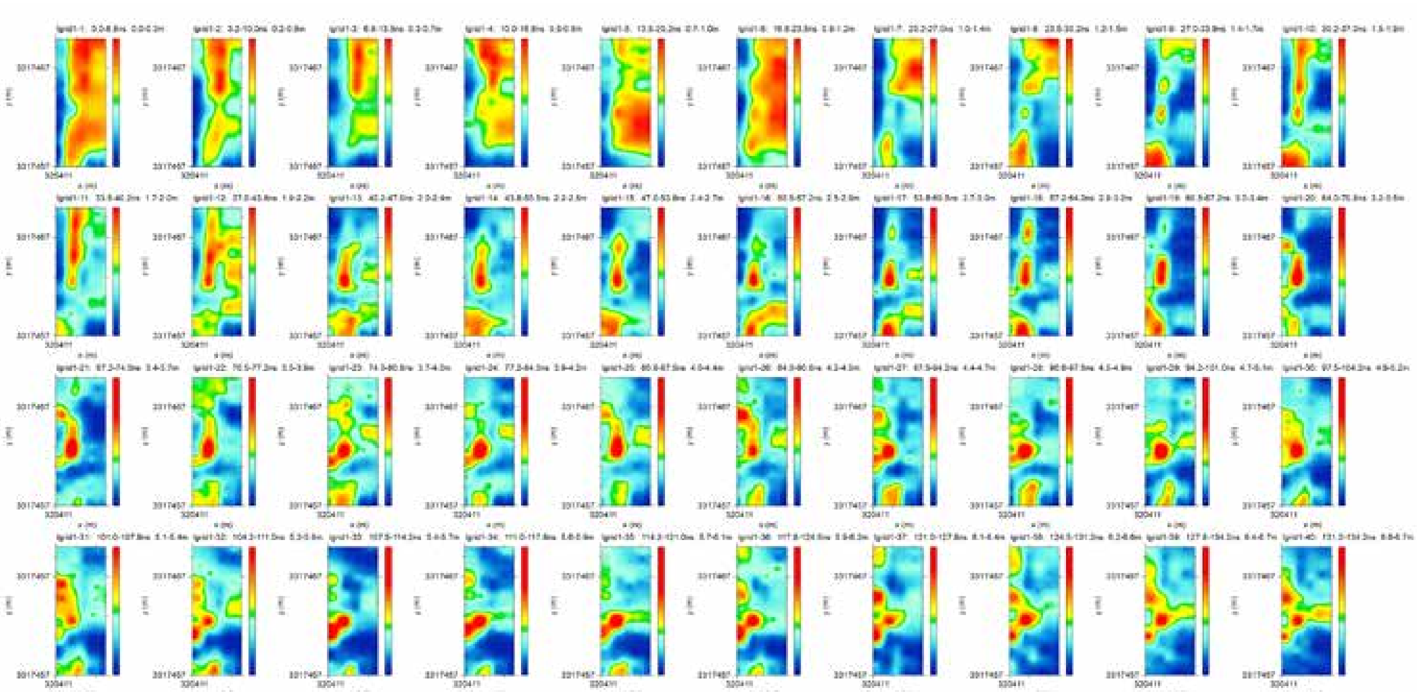
Our work was conducted under the direction of Dr. Zahi Hawass, former Minister of Antiquities, and Dr. Mark Lehner of AERA. It was performed by Glen Dash, Rebecca Sperber, Eric Sperber, and Sara Ahmed Abdel Aziz. We were assisted in this effort by our inspector, Mahmoud Abd El-Aleem Hakel of the Ministry of Antiquities. Ashraf Abdel Aziz and Amr Zakaria conducted topographic surveys on behalf of AERA.





Above: (A) The study area after being divided into transects with survey ropes, (B) The location where Mark and Zahi saw runoff disappearing. Photos by G. Dash.

Below: Each image below shows an approximately 0.4-meter thick slice of soil running parallel to the surface of our study area, descending from surface level (upper left) to 6.7 meters deep (bottom right). Areas shown in red, orange, and yellow exhibit relatively strong to moderate radar reflections respectively, while areas shown in blue exhibit little or no reflection. Note that a strong reflection is seen approximately 1 meter below the surface (top row, sixth image from left) and uniform reflections forming right angles are seen extending 4 meters deep. The 3.4–3.7-meter depth slice (third row down on the left) most clearly shows these right angles, which may indicate the presence of a second layer of buried blocks.



AERAGRAM

Volume 25, Numbers 1–2 · Spring–Fall 2024

Executive Editor: Dr. Mark Lehner
Managing Editor: Alexandra Witsell
Editor, GIS Director: Rebekah Miracle

AERAGRAM is published by AERA, Ancient Egypt Research Associates, Inc., a 501(c) (3), tax-exempt, nonprofit organization. Previous copies of this newsletter are available for free download at our website, https://aeraweb.org.

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26 Lincoln St. Ste. 5, Boston, MA 02135 USA

A VIEW OF THE BACK

A Pilot Study of Textile Impressions on Giza's Clay Sealings

by Sarah Hitchens and Ali Witsell

For AERA's study of Old Kingdom Egypt, one of our main sources of evidence of administrative activity are clay sealings—unassuming small bits and blobs of clay impressed by a cylinder or stamp seal that bore the hieroglyphs, official titles, and decorative motifs that identified the seal's owner. The use of a person's seal to secure the contents of a jar, document, or door implies their acknowledgment of their responsibility for its contents, much like a wax seal on a 19th-century letter. At AERA's flagship Heit el-Ghurab (HeG) site, sealings number in the thousands, and are our main source of linguistic evidence.

We often speak in this newsletter of the front impressions of sealings, also called the ***obverse***, the portion of the clay impressed by the seal and the side that bore that important data left behind. However, the back impression of the clay, or the ***reverse***, is often just as important a source of data as the front and is, unfortunately, regularly overlooked. Here we find the tell-tale evidence of the physical surfaces—wood, papyrus, ceramic, plaster—onto which the clay was pressed. From these, we make inferences as to what type of item or what bit of architecture was sealed; whether it was something portable, like a document or jar, or immovable, like a peg-and-string mechanism that locked a door frame or a sliding bin door. Along with the remains of walls, roofs, and ceilings (their homographic cousin), clay sealing backs are an important tool for reconstructing the built environment of ancient Egypt.

In fact, for a site like HeG, which suffers from a repeated wet-and-dry cycle due to a high and fluctuating water table, impressions in clay may be the only evidence we have of certain classes of organic material, like wood, grasses, leather, papyrus, feathers, hair, or textiles. Due to Egypt's arid climate, many dry desert sites have produced rich quantities of organic finds, including fabric. Unfortunately for us, HeG is not one of these sites.

In the absence of preserved textiles, we rely on other forms of indirect evidence, such as manufacturing tools, tomb iconography, and impressions on pottery, plaster, or clay in order to study ancient textiles. In this article we discuss the results of an exploratory study of clay sealing backs from HeG and what they might tell us about textile use or even their manufacture at Giza during the Old Kingdom.

Above: The front (obverse, on left) and back (reverse, on right) sides of three clay sealings from the HeG site. Top: A jar sealing with textile and twine impressions, incised in hieratic with a stylus; middle: a small document sealing with a papyrus back impression, impressed by a cylinder seal; bottom and right: a stamp seal impression on basketry, with a polymer clay impression to show detail of the basket weave preserved on the reverse.

Above: Middle Kingdom linen bag from Lahun, Egypt. At the neck, it was cinched tightly and then sealed (see the highlighted, small dark clay mass). Although dating later in time, the same process and materials were used at the HeG site during the Old Kingdom. Photo courtesy of the Petrie Museum, University College London.

Giza Sealings and Textiles

Indeed one of the most common physical surfaces we see in the Giza sealings are textile impressions. For HeG, this usually implies one of two functional types of sealing: a jar or a bag. In the case of a ***jar sealing***, a scrap of textile would be stretched taut over the mouth of a jar, then twine, cordage, or strapping would be wrapped around the rim or lip of the jar to secure the textile in place (see photos at right). The clay would then be pushed into the spot where the sealer both started and stopped wrapping their twine, so as to secure both the initial and final pass of twine, as well as the passes in between. The same basic twine process would be used for a ***bag sealing*** as well (see photo above), however, in this case, the entire bag would be made from textile or leather, rather than just a small scrap. Although it can be difficult to discern between a bag or a textile-wrapped jar, if the size of the sealing fragment is large enough, the diameter of the twine can serve as a hint. The smaller and tighter the circles of twine, the more likely it is that the clay may have sealed a bag. We can also use the behavior of the textile or textile folds as a clue. Sometimes we can see the smooth convex surface of the ceramic jar under the textile weave, rather than the dynamic folding and wadding of a bag.

Above: Ancient textile-wrapped ceramic and stone jars on display at the Cairo Museum, Tahrir Square. The wrapping or cinching string is visible in the carination of the jar, under the lip. Note the variety and coarseness of the textiles displayed. Photos by and courtesy of D. Jeřábek.

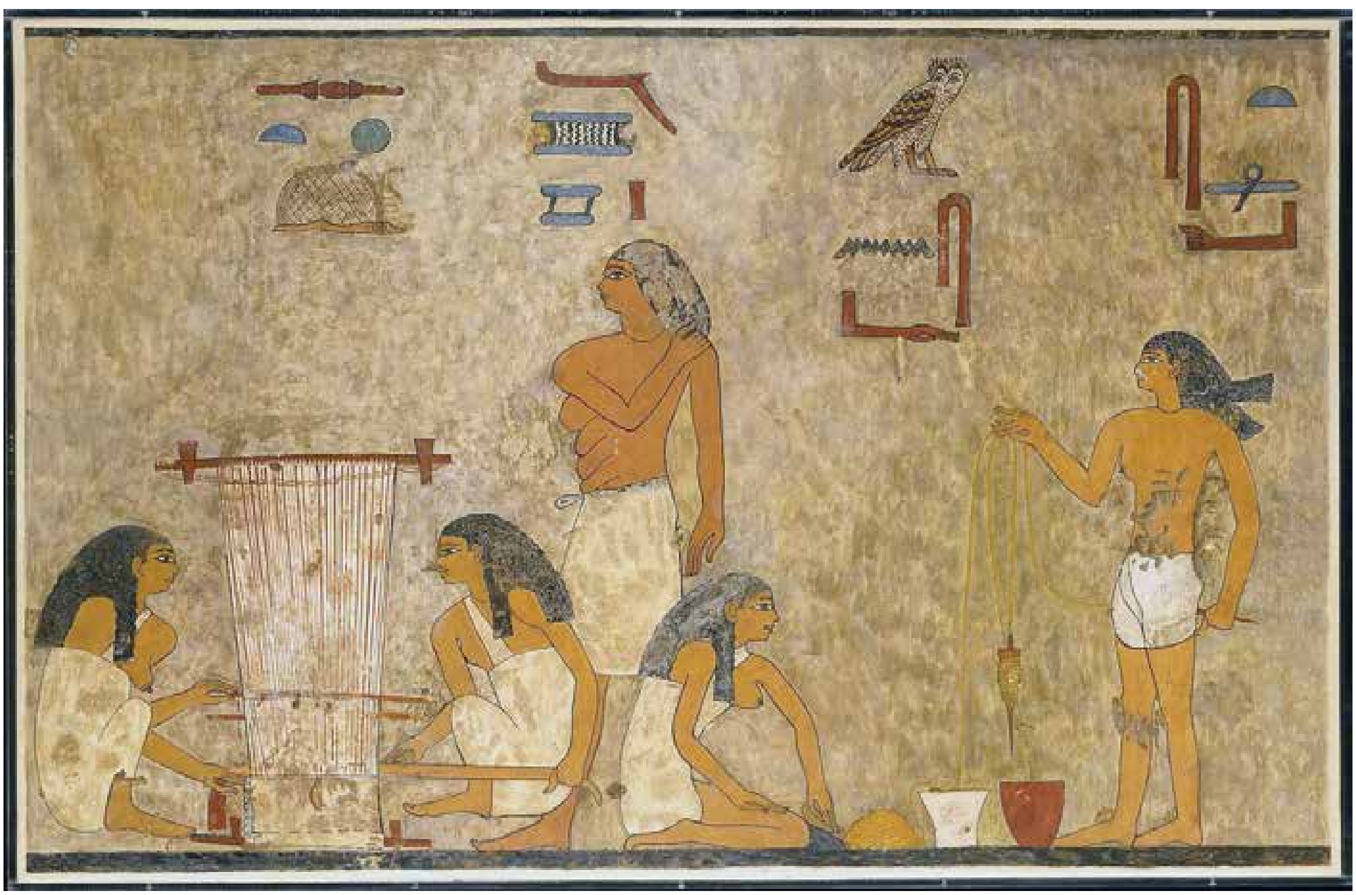
Raw Materials

At Giza, we find all make and manner of raw materials impressed in sealings. The textiles can be beautifully woven—small, tight, crisp as the day they were woven—or unraveling at the edges, a loose weave that seems it could barely hold the jar's contents safe. Over time, we have seen the gauge of our wrapping materials settle into five basic categories based on caliber: thread (a single thread), string (ca. 1–2 mm), twine (ca. 3–4 mm), cordage (5 mm–1 cm), and rope (+1 cm). Sometimes the fastening material is also clearly woven, with straps of textile used as twine, or carefully twisted plant-based cordage, and sometimes we see strapping of leather or what looks like raw grasses or papyrus. When registering a sealing in the lab, we make notes about our impressions of the size and appearance of the wrapping, but a proper study of the composition and construction of Giza's cordage needs a specialist of its own and would be a welcome addition to future study at AERA.

The Pilot Study

For this initial pilot study, [1, 2] we chose 28 clay sealings with textile back impressions. We selected for clarity of impression and variety of impressed material, including different types of woven cloth and cordage. We chose sealings from different areas of the HeG, as well as from the nearby Menkaure Valley Temple (MVT; see map page 2). Most date to the 4th Dynasty. Hundreds more sealings with textile impressions lie in our corpus, and it is our hope to include additional impressions and broaden out this study to include basketry and matting, in addition to cordage.

It is illegal to remove archaeological objects from Egypt. So, we have to find a way to take the impressions home to microscopes we don't have available in the Giza Field Lab. We press the sealing backs into worked polymer clay (see page 27) to create positive casts of the negative impressions that were left in the clay. Sarah Hitchens, AERA textile specialist, took the casts

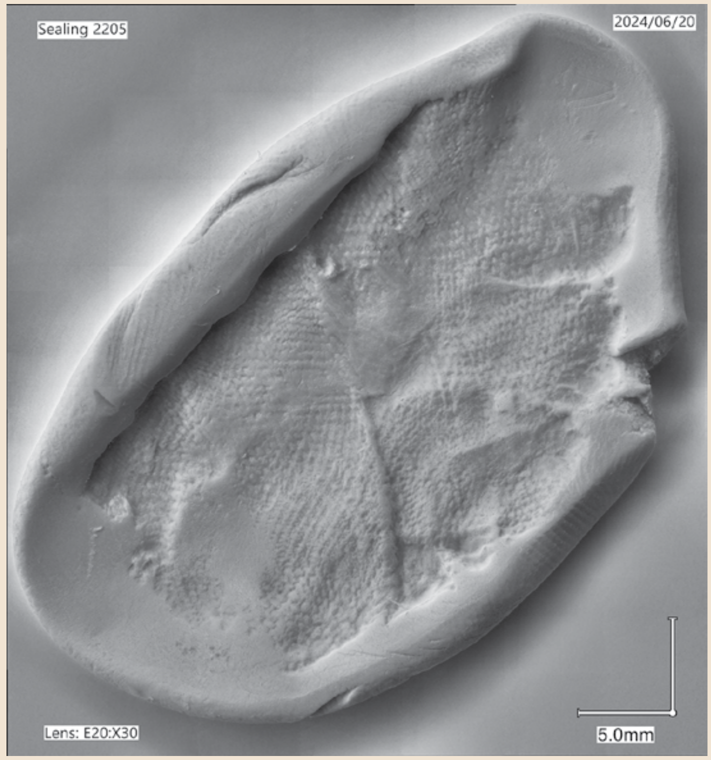


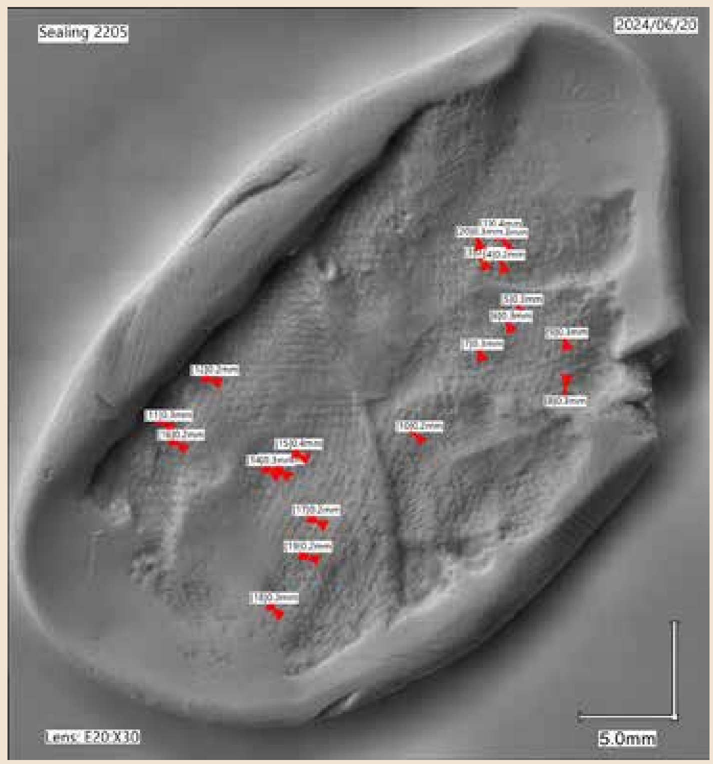
1931 facsimile painting by Norman de Garis Davies, director of the Metropolitan Museum of Art's Graphic Egyptian Expedition, showing a tomb scene from the Middle Kingdom tomb of Khnumhotep at Beni Hasan. The woman kneeling in the center is splicing and twisting individual lengths of flax together to create the individual yarns that the woman standing on the right is plying together with a drop spindle. The women on the left are weaving on a ground loom. Courtesy of the Metropolitan Museum of Art, via a Creative Commons Zero license.

Studying Sealing 2205

We excavated Sealing 2205 in the Eastern Town of the Heit el-Ghurab site. It was incised by a stylus rather than being impressed by a seal. The reverse side has a dynamic textile impression. The broad curving shape of the back surface, as well as the wide diameter suggested by the shape of the clay, indicates that this sealing was likely placed at the mouth of a jar that had been covered with a scrap of textile—we call these ***indirect jar*** sealings. These differ from a ***direct jar*** sealing, where the clay would have been applied directly to the pottery or stone surface itself.

The polymer clay impression we made of its lower surface is shown below. In the field, when specialized equipment might not be available, using polymer clay can help us quickly study and document details that might not be clear or visible to the eye; this is in part because it can help our brains flip the impression from a negative to a positive.





Above: Micro-photographs of Sealing 2205 taken by Sarah in Liverpool, the bottom photo has individual thread measurements marked.

Above, left: Front and back photos of Sealing 2205, taken by John Nolan; not to scale. Left: The polymer clay impression of the back surface we made in the Giza Field Lab, before being taken to Liverpool for study; photo and impression by Ellie Westfall.

to the University of Liverpool and analyzed them under a special Keyence microscope. She captured micro-photographs of the impressions using Shadow Effect Mode, which allowed her to most effectively manipulate the light cast across the surface, making individual details pop out clearly.

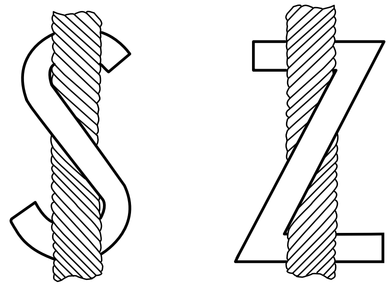
Micro-Measurements

For understanding ancient Egyptian textile and weaving industries—one of their most elementary structures of everyday life—we want to know if the impressions come from fine, medium, or coarse fabrics. Were the weaves open or closed, the fabrics thick or thin? You wouldn't use a very fine, light gauzy fabric to hold flour. A very thick and coarse textile may had a more utilitarian function, like a flour sack.

So, as Sarah peered through her microscope, deep into fabric patterns, she recorded the density of threads and measured their diameters—another example of an AERA team member mapping the archaeology of Giza at micro-scales (see article on 3D micro-scanning of sealings, page 11). She looked for evidence of how the thread spinner worked, that is, the direction they turned the thread, also known as the ***spin/twist direction***. Some of the impressions had enough detail to indicate that the threads overall behaved as S-plied—meaning that individual threads were twisted together in a clockwise direction so that the threads slant in the same direction as the middle stroke of an S (see drawing, upper right). This is in keeping with what we know of other Old Kingdom Egyptian examples.[3]

Sarah measured the ***thread size*** and found it ranged in diameter from 0.2–1.3 mm, with an average of 0.47 mm. She tallied ***thread counts***—or the number of threads (or yarns) woven into one square centimeter of fabric. The S1-thread counts (see definitions and illustration on page 29) ranged from 12–46 yarns per cm^2, with an average of 22.9 yarns per cm^2. The S2-thread counts ranged from 6–22 yarns per cm^2, with an average of 12.6 cm^2. The thread counts showed that the majority of the textiles used here were S1-dominant, with four being roughly balanced. This is also in line with other Old Kingdom textile samples.

While this was a small study, we are pleased to learn we are exactly where we should be. Overall, the textile imprints showed that tabby-woven, S1- or warp-dominant textiles with S-plied threads (see definitions and illustration on page 29) were used at HeG. This is typical in Old Kingdom textiles. In this pilot study,



S-spun thread *Z-spun thread*

Drawings after H. M. Behery, 2010, "Yarn Structural Requirements for Knitted and Woven Fabrics," In C. Lawrence (ed.), *Advances in Yarn Spinning Technology*, Sawston: Woodhead, pages 155–89.

it was not possible to discern the fiber content from which the textiles were woven—wool vs. flax or linen—but the majority of the Pharaonic textiles thus far discovered in Egypt have been made from linen,[3] so this is what we would expect from future study.

Why Is This Important?

Building out from these very small, seemingly unimportant details, we can use this data for larger comparison. We can compare textiles from HeG and MVT to other sites to get a general idea of the textiles being produced at a given time. As for textiles and sealings, with enough samples, we can see if the ancient Egyptians used different seals with different textiles, and see if any patterns appear across the site. The direction they turned their thread, the kind of fiber they used, and decoration provide clues as to whether a textile was produced "locally" within a specific area, or if it came from far away.

The Role of Kromer

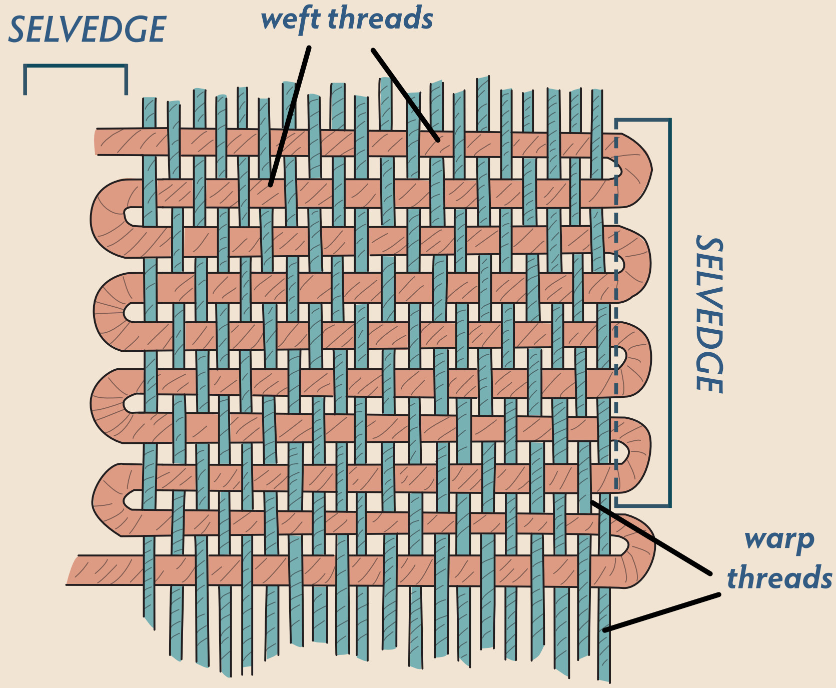
Although it is true that the HeG site is poor in organic remains, this does not mean that AERA specialists do not have the opportunity to study organics. In 2018, we returned[4] to an area west of the HeG site that lies high on the plateau and has remained much dryer over the millennia. This deposit—called the Kromer Dump (KRO) after Karl Kromer, its original excavator—is a series of open-air trash middens filled with debris dating to the time of Khufu and Khafre, builders of the first and second pyramids at Giza (see map, page 2).

Because it is higher in elevation and the soils much sandier, we recovered more organic material than we normally encounter at HeG, including fragments of wood, textile, twine and cordage, reed, and animal hair (see photos, page 30). Kromer himself even recovered a fragment of inscribed papyrus. KRO gives us the chance to see what is missing from our study of Old Kingdom daily life and is the next frontier for our study of textiles.

A CLOSER LOOK: TEXTILE TERMINOLOGY

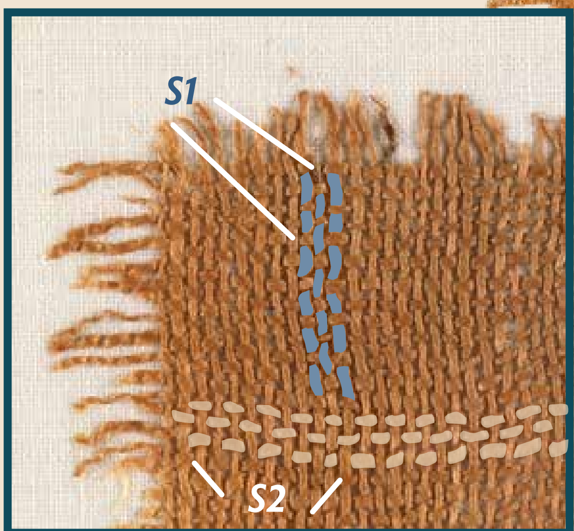
HOW TO READ TEXTILES

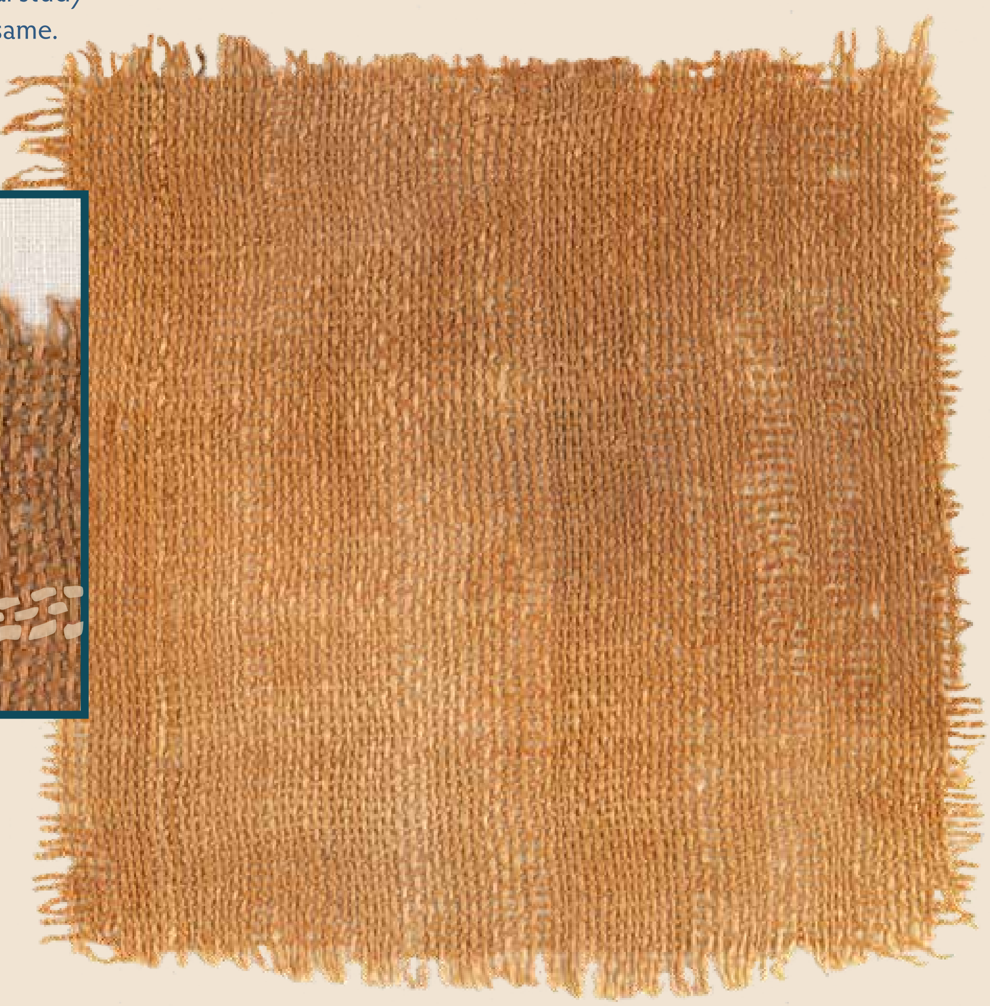
In a loom-woven piece of ***tabby-*** or ***plain-weave*** textile where the edges (***selvedge***) are intact, the ***warp*** (vertical) and ***weft*** (horizontal) threads or yarns form right angles and a criss-cross pattern.



To describe a fragment where the edges are missing and warp/weft is unclear, such as those likely used in the Giza sealings, the analyst chooses one direction to be called ***S1 (System 1)***, for the warp threads, and ***S2*** for the weft threads. ***S1-dominant*** means there are more warp threads present in a fragment and ***balanced*** means that the number of threads in the S1 and S2 systems are equal or fairly equal in number.

Thus far, most Old Kingdom linen textiles have proven to be S1-dominant. Our initial study indicates the HeG textiles were the same.





5th Dynasty fragment of tabby-weave or plain-weave linen from the burial chamber of King Unas, Saqqara. This linen is S-twisted. Metropolitan Museum, 90.5.42. Photo courtesy of the Metropolitan Museum thanks to a Creative Commons Zero license.

Future Plans

This exploratory study helped test a methodology with which to study material that was once very prevalent at the site but no longer survives in the archaeological record due to Giza's high groundwater table. Our analysis revealed that daily life at HeG was flush with a variety of textiles, from fine to more coarse, used not just as clothing, but also as bags or for covering and wrapping ceramic jars at Giza. All the textiles studied were tabby-woven and ranged from closed to more open, looser weaves. The casts show that twine/cordage as well as torn strips of cloth were used to wrap around and secure the vessels sealed by the clay.

Despite the overall small size of the textile impressions we studied, these impressions are a valuable tool we can use to study textiles at Giza. The potential to study organic materials at the micro-level—even if just fleeting impressions in clay—adds to our understanding. We look forward to future opportunities to broaden our study and understanding of the now-invisible organic material culture at the pyramids.

Above: Photographs of organic material culture recovered from AERA's 2018 excavations at the Kromer Dump, high on the plateau to the west of HeG. Here we found many organic remains that are missing from the often-soggy remains of HeG, including fragments of textile and cordage like those we see impressed in the sealings. Photos by M. Lehner and S. Hitchens.

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1. The methodology used here is based on articles published by Agata Ulanowska as well as that set down by the Centre for Textile Research in Copenhagen.

These include: A. Ulanowska, 2020, "Textile Uses in Administrative Practices in Bronze Age Greece: New Evidence of Textile Impressions from the Undersides of Clay Sealings," in M. Bustamante-Álvarez, E. H. Sánchez López, and J. Jiménez Ávila (eds.), *Purpureae Vestes VII. Textiles and Dyes in Antiquity. Redefining Ancient Textile Handcraft. Structures, Tools and Production Processes*, Granada: University of Granada, pages 413–24.

A. Ulanowska, 2022, "Investigating Relations between Textile Production and Seals and Sealing Practices in Bronze Age Greece: A Presentation of the New 'Textile and Seals' Project Database," in A. Ulanowska, K. Grömer, I. Vanden Berghe, and M. Öhrman (eds.), *Ancient Textile Production from an Interdisciplinary Perspective. Interdisciplinary Contributions to Archaeology*, Cham: Springer, pages 295–317. https://doi.org/10.1007/978-3-030-92170-5_17.

E. B. Andersson Strand and M. L. Nosch (eds.), 2015, *Tools, Textiles and Contexts: Investigating Textile Production in the Aegean and Eastern Mediterranean Bronze Age,* Oxford: Oxbow.

2. See also R. Laurito, 2024, "Making Visible the Invisible: The Case Study of Clay Sealings from Arslantepe (Turkey)," In U. Mannering, M.-L. Nosch, and A. Drewsen (eds.), *The Common Thread: Collected Essays in Honour of Eva Andersson Strand*, Turnhout: Brepols, pages 107–13.

3. G. Vogelsang-Eastwood, "Textiles," In *Ancient Egyptian Materials and Technologies*. Cambridge: Cambridge University Press, pages 268–98, 2000.

4. A. Witsell, 2018, "Kromer 2018: Basket by Basket," *AERAGRAM* 19-1, pages 2–11. See also M. Lehner, 2018, "Kromer in Context: Biography of an Ancient Dump," *AERAGRAM* 19-2, pages 2–13.

*Sarah wishes to thank Jordan Poole for assistance in using the Keyence microscope. Ali thanks David Jeřábek for allowing the use of his Cairo Museum imagery.

TO WILMA, WITH THANKS!

A Well-Deserved Retirement Leaves a Big Hole in AERA's Team

by Mark Lehner and Claire Malleson

This summer saw the well-deserved retirement of Dr. Wilma Wetterstrom—AERA's longest-serving employee outside of Mark Lehner. Although she began her AERA tenure in 1988 as an archaeobotanist at Giza, she retired as Art and Science Editor of AERA's publication department, leaving a huge hole in our team. Here Mark and Claire Malleson, AERA's current archaeobotanist, reflect on Wilma's impact on both AERA and the field of archaeobotany.

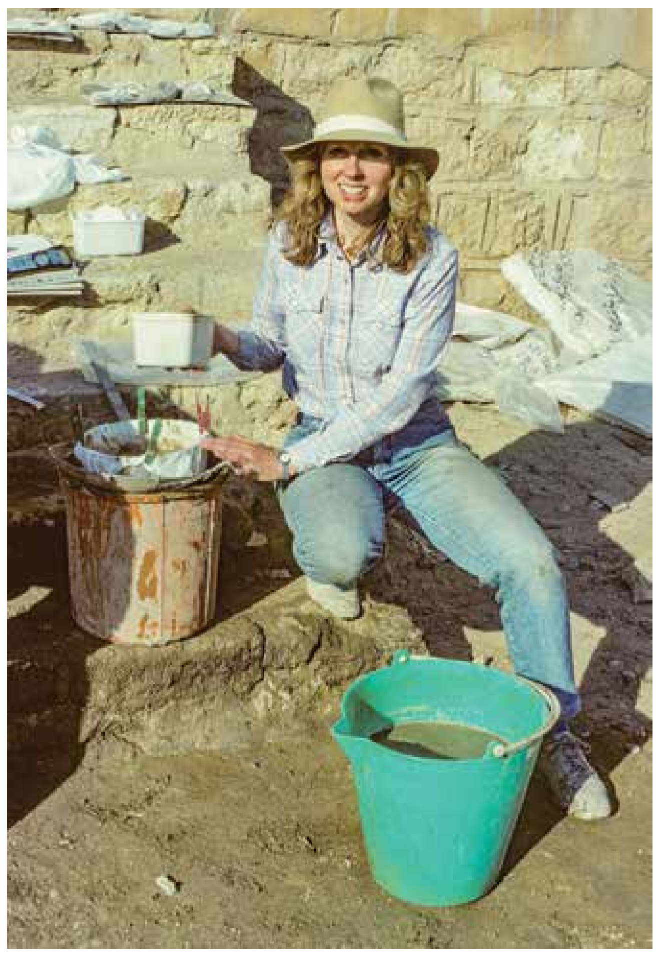
Tenure with AERA

It was 1988, my last year in grad school at Yale when AERA Board member and donor Bruce Ludwig brought me the opportunity to present a proposal for him and David Koch to fund an excavation at the Giza Pyramids. Our purpose: to find and explore a Lost City of the Pyramids, on the site we now call Heit el-Ghurab (HeG), Arabic for "Wall of the Crow," the name of the stone wall that borders on the northwest. I wanted an interdisciplinary team for "settlement archaeology," who would explore where people who built the pyramids lived 4,500 years ago (ca. 2,500 BC). I wanted to know how they lived and worked. For example, what did they eat?

For that question, I needed someone who could retrieve and identify ancient plant remains—an archaeobotanist. Peter Lacovara, a friend and at that time a grad student at the University of Chicago, told me to call Wilma Wetterstrom. "You'll get along well with Wilma," Peter said. "Like you she's an old hippie." While our births predated Peter's by a number of years, neither Wilma nor I were that old at that time. But we are both "boomers," members of the post-World War II "youth bulge."

I knew that Wilma, a Research Associate at the Harvard Botanical Museum, worked at Tell Leilan in Syria with one of my Yale professors, Harvey Weiss. Wilma, always the happy camper, was happy to sign on to our ambitions for Giza. Our first season, 1988–89, she captured ancient plant parts through a process called bucket flotation (photo at right), a quick and slapdash way of separating her research material from the soil we removed that season.

In high desert sites, like Tutankhamen's tomb, for example, plants will survive for thousands of years by drying out, but not at HeG. Because the 4,500-year-old settlement ruins perch only a meter above ground water at HeG, plant parts simply rotted away, into the moist soil. But, if people burnt plant parts in hearths, ovens, and bakeries, they survived as charcoal. If, after we find them, those charred parts do not crush into a powder, botanists can see their structure—stems, chaff, and whole grains of wheat and barley, even flowers of field weeds. But first they must get them out of the dirt. When they pour the dirt into water, charred plant parts survive and float to the surface, where team members

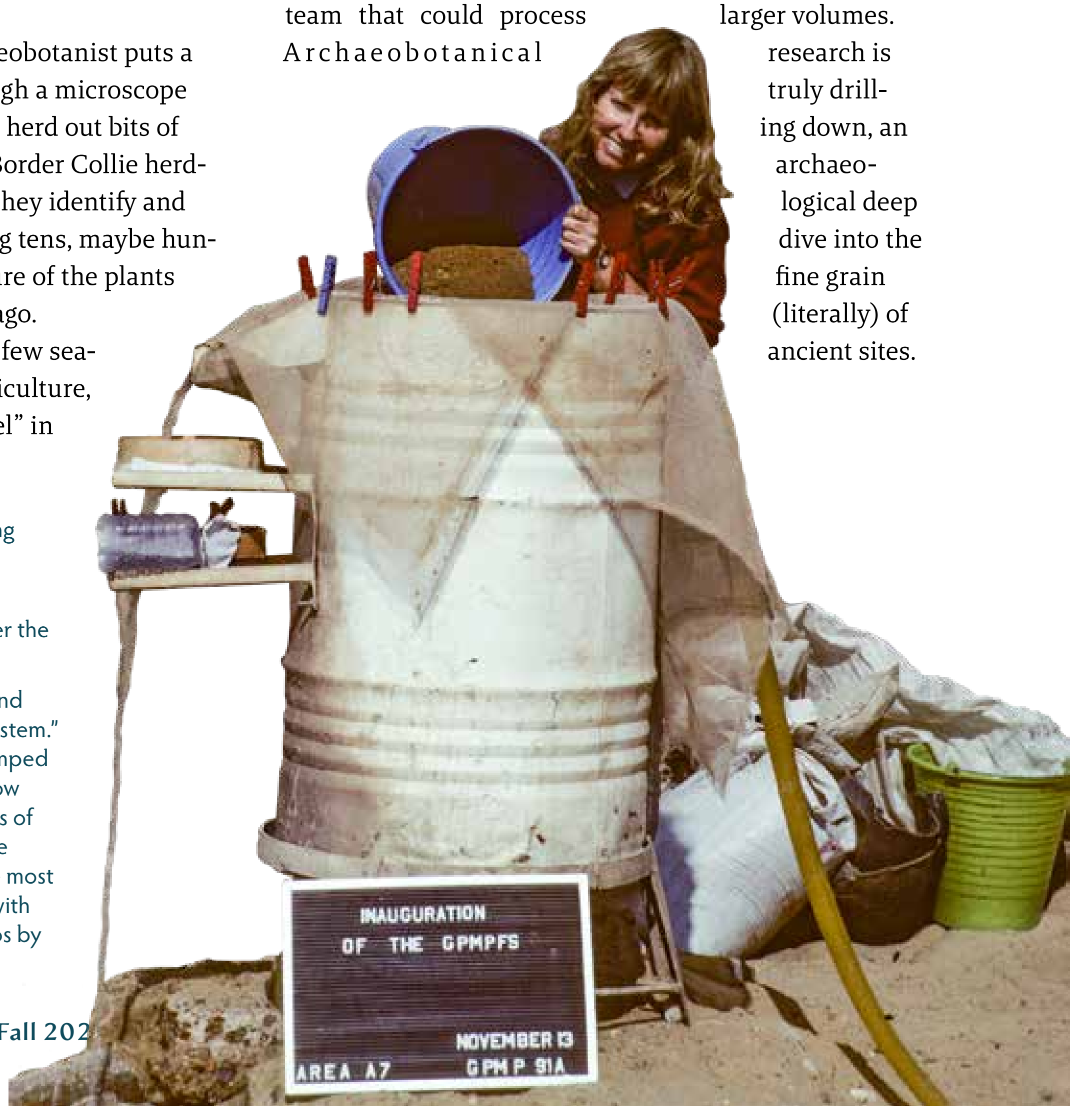


Wilma during GPMP's first field season, 1988–89, using a small bucket and sieve system to retrieve plant remains from excavated soils. Photo by M. Lehner.

skim them off the top or capture them from the sinking dirt in various size meshes, down to fine cheesecloth (photo above). The combined sample is now a black muck, which team members hang to dry in little cheesecloth pouches.

When the muck dries, the archaeobotanist puts a sample in a petri dish. Peering through a microscope they use a fine needle or tweezers to herd out bits of stem, seeds, and field weeds, like a Border Collie herding sheep. With the patience of Job, they identify and count each component, accumulating tens, maybe hundreds or thousands, to obtain a picture of the plants that people partook of, so very long ago.

This is what Wilma did our first few seasons. From bucket to big-picture agriculture, Wilma reconstructed the "people fuel" in the economic engine that built the giant pyramids. By her second season with AERA (1991a), Wilma moved beyond her buckets and constructed a large, barrel-flotation machine (photo below). She began to train a team that could process larger volumes. Archaeobotanical research is truly drilling down, an archaeological deep dive into the fine grain (literally) of ancient sites.



Top, left: Wilma and Mark discuss her drying cheesecloth sacks of ancient plant remains recovered from flotation.

Top, right: Wilma separating a sample under the microscope.

Right: Wilma during the 1991 field season and the "Inauguration of the GPMP Flotation System." With this more advanced set-up, dirt is dumped into the top of the drum and a continual flow of water washes the sample through a series of smaller and smaller sieves in order to isolate different types of material for analysis. The most lightweight plant remains float at the top, with heavier material being caught below. Photos by M. Lehner.

Wilma has always loved plants. She would wander into fields where she focused another lens (now a camera, photo below) on living examples of the crops and weeds whose burnt bits she so cared for and counted. Each of those tiny black seeds could have flowered into one of nature's elegant designs. Is that why Wilma loves visual expression and display as communication?

Wilma is an artist who specialized in communicating information. We share a belief that if a scholar or scientist cannot talk or write about their research in conversational prose that anyone can follow, they may not understand it themselves. We agree that it is not an easy task to boil down ideas before writing. It's the challenge of any writer. We believe in "the lifelong challenge of perfecting the craft of writing." Through the years, we have slashed at each other's prose like samurai. We joke that when it is time for us to sit all day in rocking chairs, we will still be quibbling about commas.

Wilma brought to AERA skills in both written and visual communication. She honed her skills by taking courses at the Museum of Fine Arts, Boston (now the School of the Museum of Fine Arts at Tufts University). She became an adept InDesign user. She happily took up the challenge of AERA being a publishing house as well as an archaeological project. In 1996 we conceived and produced the first installment of *AERAGRAM*. We tried to keep our research current in *Giza Reports* and *Giza Occasional Papers*. It's been hard to keep up with those monographs. (We plan to catch up.) But thanks to Wilma, working with AERA Publications Manager Ali Witsell and AERA GIS Director Rebekah Miracle, *AERAGRAM* has reported on every season since 1996 (and the early issues include lookbacks at 1988–1995).

In those early years, Wilma and I were without office. We met in the Biolab cafeteria—now the Biolounge—at Harvard to plan how best to tell the story of our last field season, to inform our supporters and help raise funds for the next phase of research. Thanks to Wilma, *AERAGRAM* tracked AERA's growth, from the Biolabs to our Boston office (which Wilma found for us). She leaves a legacy, a foundation for building a future for AERA. ***-M. Lehner***

Contribution to Archaeobotany

In the 1980s there were only a tiny handful of archaeobotanists working in Egypt (a situation that has not changed that much). Wilma was perhaps the only specialist who worked at multiple sites, and until the

mid-1990s she was leading the systematic investigations of plant remains recovered via sampling at settlement sites across Egypt. Importantly, she also worked on archaeobotanical samples from elsewhere, including Jordan, Syria, Kenya, Madagascar, and Spain. Her research in almost all cases has focused on agriculture, most particularly on the transitions from gathering (wild plants) to farming (cereal cultivation).

Wilma's earliest work as an archaeobotanist was based in the US, at Prehistoric Arroyo Hondo Pueblo, New Mexico. The materials from the site were the focus of her 1976 doctoral dissertation on links between diet, environment, and population. Two years later, in 1978, she became one of the first archaeobotanists to employ flotation—the method used to recover small plant remains from archaeological sites—in Egypt, at Naqada. She pushed to publish systematically, producing a full scientific report on her analyses, and setting a benchmark for all future archaeobotanical work in Egypt. Her main research interest was the agricultural history of ancient Egypt, from hunter-gather activities to the development of simple horticulture and eventually the intensive agriculture that helped build the pyramids that AERA studies.

In 1981 she joined the University of Michigan expedition to the southern Fayum, where Robert Wenke was leading a team (including AERA's Richard Redding) investigating prehistoric sites. At that time, virtually nothing was known about the archaeobotany of hunter-gatherer communities in northeast Africa, so Wilma was able to gain more insights into the plant collecting strategies used prior to the introduction of formal cereal agriculture from western Asia.

In 1984 and 1986 she worked once again with Robert and Richard at the Old Kingdom site of Kom el-Hisn in the western Delta. Wilma and Richard worked closely together and developed an integrated study of agricultural strategies based on the faunal and botanical remains. They looked specifically at the relationship between arable farming, animal husbandry, and the use of agricultural byproducts in ancient daily lives.

In 1988 Wilma founded the archaeobotanical work for AERA at Giza. She implemented a program of flotation for recovery of plant remains from the very first excavations in Area C ("Petrie's Barracks," to the west of the Khafre Pyramid), and Area A (Heit el-Ghurab). A summary of her results—AERA's first report on plant remains—was published in 2001. There she found large quantities of emmer wheat glume bases—the tough chaff that holds the grains together. These have to be removed before emmer is ground into flour, which requires vigorous pounding of the grain spikelets. The resulting chaff was used for various purposes, and became preserved via charring either because it had been incorporated into dung fuel (used as animal fodder and surviving digestion, or added as temper to dung cakes), or thrown directly onto fires probably as tinder. Her inference in that report was therefore that the barracks may have been supplied with dung cakes. These results contrast sharply with the plant remains we find at Heit el-Ghurab, which has very little cereal chaff present, allowing us to make inferences about differing patterns of provisioning to the two work sites/communities. Wilma was succeeded at Giza by Mary Anne Murray (in 1995), then myself (in 2012), making this (we think) the longest running archaeobotanical research anywhere in the world. ***-C. Malleson***

In her retirement, Wilma hopes to make great botanical strides in both her garden and her research, including publishing her results from AERA's early excavations in Area C. While she is missed daily in AERA, we look forward to working with her again, this time as an author, in the near future.

***Mabruk*, Wilma!**

Wilma Wetterstrom and Claire Malleson in 2017. Photo by S. Dilks.

HEARTFELT GOODBYES TO DEAR FRIENDS

Remembrances of Bruce, Ann, and Richard

by Mark Lehner

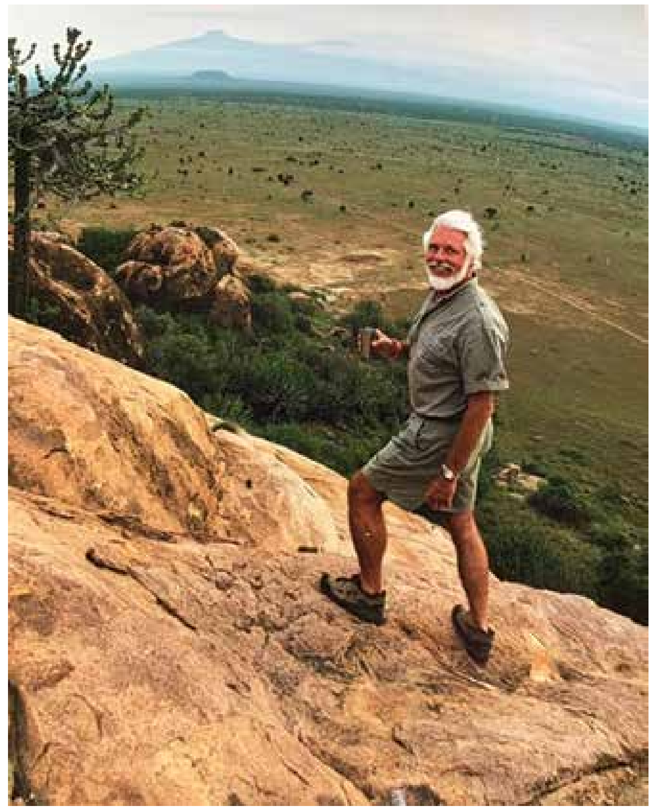
We at AERA have suffered many profound losses in the past two years. It is with deep sadness that we report here that AERA lost two major longtime supporters, board members, and dear friends during 2024—Bruce Ludwig and Ann Lurie. We also provide an update on the legacy of Dr. Richard Redding, whose death we reported in the last issue of *AERAGRAM*.

Bruce Ludwig

Bruce died October 25th of last year. He was my long-time personal friend, a founding friend of AERA, and one of the original AERA board members. I have recently been writing about my 1986 survey, mapping, and study of the builders' marks in the floor off the northwest corner of the Khafre Pyramid. That's where Bruce first found me. Looking larger than life, and a little like Kenny Rogers, he walked up in cowboy boots to where I was kneeling on the bedrock floor, drawing post holes. Before I knew it, I was staying in his home in Hancock Park, Los Angeles. He woke me up at 6 am my first morning after arriving. Before even a drop of coffee, I found myself speaking to assembled real estate brokers at the local office of Caldwell Banker. I gave my spiel, clicking a carousel of Kodachrome slides, to investment bankers, real estate brokers, and architects. After a merciful coffee, he took me to an architectural firm on Sunset Boulevard, the Jerde Partnership. Jon Jerde, and then Janice Jerde, became some of my best friends. Jon passed away in 2015. Janice remains a dear friend and an AERA board member.

Bruce was a member of the first AERA board. He joined with Jon, and Matthew (McCauley), my best friend since 1974, and founding AERA board member, for our earliest formal meeting, four guys in jeans, meeting in front of Jon's drafting table. Bruce was the link to several of AERA's major supporters. Without Bruce, there might not have been an AERA.

Although Bruce was an institutional and fiduciary realtor by trade, he traveled extensively in Egypt and published many books with his life-long mate, Carolyn, on the history and religious heritage of churches in Old Cairo and Egypt. He was passionate about ancient history and culture, conservation and the environment, serving as Trustee for the American University in Cairo, the Trust for African Rock Art, and the Amboseli Trust for Elephants, while also being on the board or advisory councils for the National Geographic Society, the Petra National Trust, the Institute for Human Origins, and the Planetary Coral Reef Foundation.



Above: Bruce in Africa. Photo by and courtesy of his daughter Pamela Hearn.

I last saw Bruce in what was the old Nile Hilton (now Ritz Carlton) in 2020. He and Carolyn were just getting out of Egypt before airports closed for Covid. But I last talked to Bruce only a few months before he passed. He had the chance to say how much he loved the AERA work, and how proud he was of what the AERA team has accomplished. We had the chance to say we loved each other. (Two machos, we'd never said that before).

I will really miss Bruce. Having lost two dear board members in 2023, Richard and Bruce, I will honor them and their contributions by trying my best to sustain AERA's unique work and to pass it onto a younger generation. Bruce is survived by Carolyn and their two children and two grandchildren.

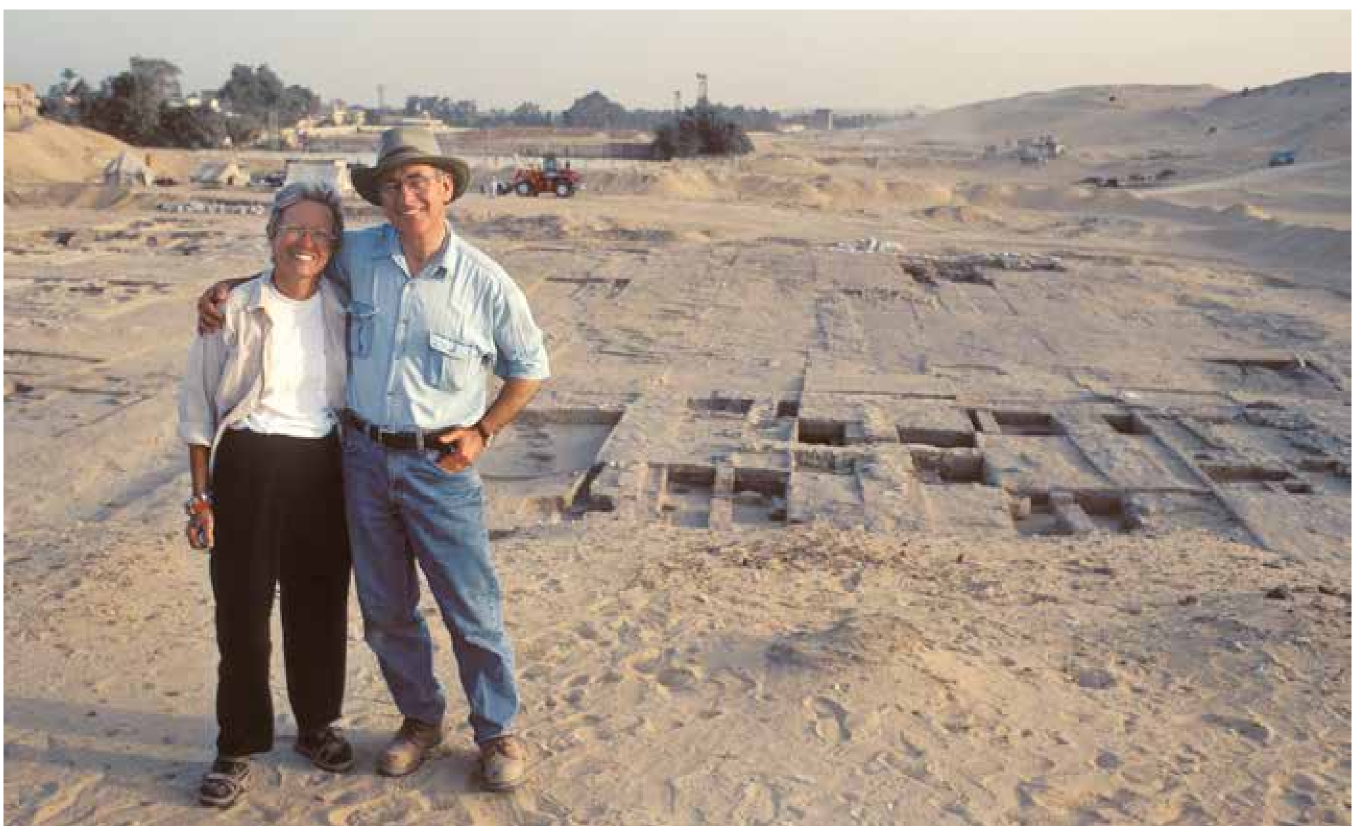
Ann Lurie

Ann died June 24th of this year. Without Ann, AERA would not be who we are, nor would we have accomplished what we have accomplished. As I was able to tell Ann more than once, she made an archaeologist's dream come true. She made it possible for the AERA team to find the Lost City of the Pyramids. I owe much of my career to Ann. Ann and her husband, Mark Muheim, became my good friends.

When Ann visited our Lost City site in 1999, we had already backfilled our 1998 excavation trenches. I was unable to show her the ancient walls, copper shops, workers' houses, and bakeries that Ann's support helped us find in 1997 and 1998. All that she could see, south of the gigantic stone Wall of the Crow and the Giza Pyramids on the horizon, were rolling piles of sand and modern debris. Ann asked, "What would it take to find the whole of what's under here?" What would it take to clear, map, and salvage as much as we could of the Lost City? When we told her in budgetary terms, Ann challenged us to launch a major initiative. She offered to match all other major donations to ensure we recover as much as possible of the ancient pyramid city. And so, we kicked off our Millennium Project, which would go on to save the footprint of a pyramid city over an area of ten football fields between 1999 and 2004. Ann joined the AERA board and served until her untimely passing.

In 2008 Ann challenged us again, this time to launch a capital campaign that would make it possible for AERA to acquire its own home base and center in Giza where we could keep our rich archive, house our team, and teach our field schools. Again, Ann challenged AERA's major donors. She offered to match their contributions to our capital campaign, if over and above their prior contributions to AERA's annual research and training programs. All the while, Ann sustained her own annual major support of our excavations and field schools to train young Egyptian archaeologists in the best of scientific archaeology.

Below: Mark and Ann Lurie at the Heit el-Ghurab site during a visit around the time of the Millennium Project, when Ann's generosity helped us secure the main footprint of this important Old Kingdom pyramid town. The world would not know what it does about the Old Kingdom without Ann. Photo by T. Hill.



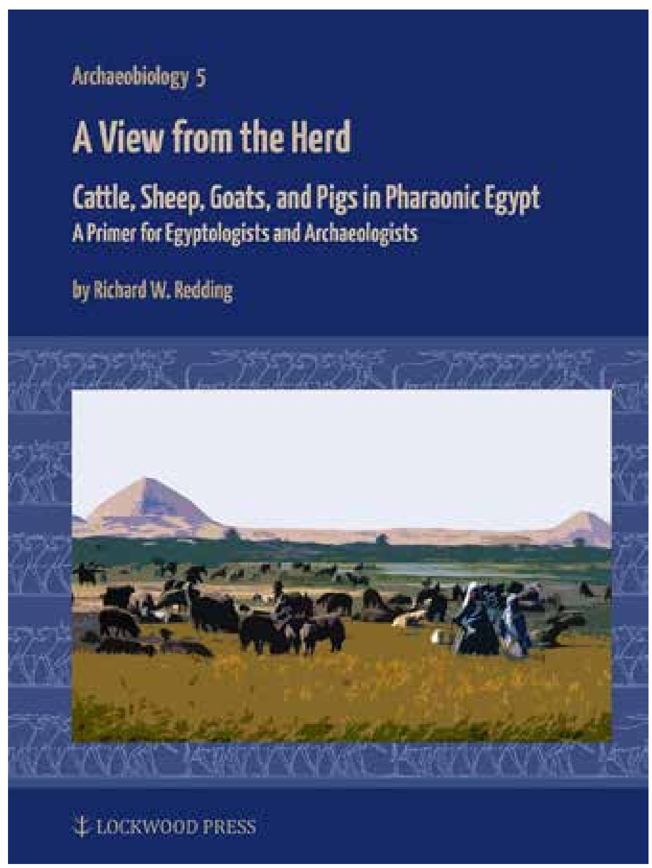
Ann has not left this world. She remains in the many fine works she made possible at the University of Michigan, Northwestern University, the Ann and Robert H. Lurie Children's Hospital of Chicago, and many other health, education, social services, and arts projects around the world. I encourage you to read about all that Ann made possible—both the New York Times and the Chicago Sun Times had excellent obituaries. I am so honored that Ann chose AERA as one recipient of her extraordinary philanthropy. Ann is survived by her husband Mark Muheim, her six children, 16 grandchildren, and Mark's two sons.

Richard Redding

In the last AG,[1] we reported on the devastating loss of one of our core team members, Dr. Richard Redding, AERA's archaeozoologist and our dear friend. We are pleased to give an update on contributions to his legacy, both inside and outside of AERA. Richard first joined Mark in 1989 in the field, then was a regular presence every year from 1995 until 2023. He served not only on AERA's board, but also as our Chief Research Officer and led AERA's field lab for many years. His sudden loss is still keenly felt at AERA. In February, we held an informal gathering of friends and colleagues at the AERA villa in Giza—a joyous celebration of his life and work with many bringing photos of their time with Richard to share (image at right). At the same time, Cheri Alexander, Richard's wife, announced her donation of his fantastic bone reference collection to AERA (see text on pages 38–39, explaining the importance of this gift).

We are also thrilled to report that Richard's final book, submitted in manuscript form just before his untimely death, was finished by family and colleagues and is now available for purchase. *A View from the Herd: Cattle, Sheep, Goats, and Pigs in Pharaonic Egypt. A Primer for Egyptologists and Archaeologists* will be a seminal work for those interested in archaeozoological research for years to come. It was printed just in time for a workshop in Richard's remembrance held in April at the 2024 89th Annual Meeting of the Society for American Archaeology in New Orleans. The workshop—titled "Breaking the Mold: A Consideration of the Impacts and Legacies of Richard W. Redding"—was attended by Richard's wife, Cheri Alexander, and daughter, Alexis, as well as many friends and colleagues.

1. M. Lehner, 2024, "In Memoriam: Richard Redding," *AERAGRAM* 24–1&2 (Spring–Fall 2023), pages 29–31.



Top: A former student remembers Richard at our February gathering. Below: The cover of Richard's last book, *A View from the Herd*, now available from Lockwood Press.

Richard's Boxed Menagerie:
Teaching Students with Hands-On Learning

Richard Redding's family generously donated his study collection to AERA, gathered over decades of fieldwork. A reference collection such as this is crucial for learning the basic skill of comparison—teaching students how to identify bones found during excavation, one piece at a time. Richard's consists of dozens of skeletons of the modern amphibian, bird, fish, and mammal species of Egypt—along with ancient samples of hippopotamus, crocodile, and even leopard. Many of us at AERA have fond memories of Richard returning from a trip to the butcher or fish market, putting his flesh-eating beetles to work in skeletonizing boxes around the back of the villa; those beetles doing their part to build this superb teaching collection and help Richard's students start their own collections, as well. He regularly loaned the collection to colleagues in Cairo, but most recently it has been used at the villa by Dr. Johanna Sigl of the Commission for Archaeology of Non-European Cultures to train students from the Archaeological Science study program of Ain Shams University in Cairo. We know Richard would be thrilled that the collection continues to serve its purpose and is being used to train a whole new generation of archaeozoologists.

Top: Dr. Richard Redding surrounded by animal bones, ancient and modern, in his corner of the AERA Field Lab, where he was happiest training students in archaeozoology. Photo by M. Lehner.

Above: Richard demonstrates the importance of a reference collection, showing a side-by-side comparison of the same bone to make an identification. In the foreground is the new modern specimen, compared to the dark, ancient bone next to it. Photo by A. Witsell.

Above: Richard's former students Mohamed Hussein Ahmed (foreground) and Mohamed Raouf Badran (background) consult Richard's study collection in the white cardboard boxes on the tables while identifying ancient bone in the Giza Field Lab. At right: They begin their own reference collections at the villa by filleting fresh fish from the market, careful not to damage the fragile bones. Once the majority of the flesh was removed, the fish were boxed with flesh-eating beetles to finish the skeletonizing process. Photos by R. Redding.

Below, left: Some of the fish specimens from Richard's animal bone collection in labeled boxes in the Giza Field Lab. Photo by A. Witsell.

Below, right: In the library of the AERA villa, Dr. Johanna Sigl trains archaeological science students from Ain Shams University in Cairo using Richard's collection. Photo by S. Saleh Abd el-Hakim.

Artifact of the Issue: Lithic 577.1—Out of Time, Out of Place?

Early Neolithic farmers developed the sickle blade—one of the earliest and most remarkable farming tools. They set these thin rectangular pieces of flint into straight or curved pieces of wood or bone to make sickles for cutting cereal grasses, plants they used for livestock fodder, and reeds for their matting.

Buried beneath the Menkaure Valley Temple (MVT), AERA archaeologists discovered a sickle blade with coarse serrations. Such coarsely serrated sickle blades date back to the 6th to 4th millennia BC and are older than later, finely serrated ones. Many Neolithic sites in Egypt including Fayum, Merimde Beni-salame, El Omari, and Maadi, as well as Badari and Naqada, had bifacial, finely serrated blades. The coarsely serrated ones were less common. They are also uncommon at 3rd millennium sites, like Giza.

Knappers—people who made flint tools—crafted sickle blades by breaking long flint blades into smaller segments, and then pushing off smaller, thinner flakes along one or both edges by pressing with a pointed tool. This "pressure flaking" resulted in a coarse, tooth-like edge, ideal for cutting thick, tough plant stalks. Experimental studies have demonstrated that coarse-serrated sickles were particularly effective for harvesting fully ripe domesticated cereals, especially when compared to blades that are not serrated. They were also more suitable for cutting dry cereal stems (***culms***), rather than half-green stems with high moisture content. The durability of these blades made them perfect for cutting thick and tough culms of plants, including domesticated cereals, wild reeds, and sedges.

We found the fragment presented here—Lithic Number 577.1—during Season 2024 in an extensive dump of degraded mudbrick outside the temple. On top of this dump, in the late 6th Dynasty, people built a small glacis to protect the west temple wall against rainwater. We do not know when a knapper made this particular blade, but it must be much older than the Pyramid Age, or Old Kingdom. People may have reused the blade and brought it to the MVT from elsewhere.

The important thing about sickle blades is that they indicate that people were farming for themselves, rather than being supplied with grain by government authorities. AERA has excavated a handful of other sickle blades at Giza. We also found sickle blades high on the plateau when we excavated the so-called Workers' Barracks west of the Khafre Pyramid. And we found one in the northern courtyard of the Royal Administrative Building, so we know Egyptians were using sickle blades during the time of the pyramids. But sickle blades with such pronounced serration are rare, and much older than the pyramids.

Above: Front and back sides of Lithic Number 577.1, a bifacial sickle blade fragment from the Menkaure Valley Temple; shown at true scale. Photos by Amel Eweida.

Below: A mid-5th millennium Neolithic wooden sickle (with ancient blade fragments added for modern display), found at a granary site (Silo 52) in the Fayum, Kom K. Shown at 1:2 scale. Photo courtesy of the Petrie Museum, University College London.

I feature this artifact because it is an unusual find for the Giza Plateau, and for AERA, and because it is Neolithic in origin. Its presence is a reminder that even a landscape as large and imposing as the Old Kingdom Pyramids at Giza did not just spring up overnight, nor exist in a vacuum. People were at the plateau, living and farming long before the 4th Dynasty Egyptians built the Giza Pyramids. This sickle blade was as far removed in time from ancient inhabitants of the MVT and the Heit el-Ghurab site (a.k.a. the Lost City of the Pyramids) as we are today from the time of Cleopatra.

~ Samar Mahmoud Ibrahim
AERA Lithicist