



New Angles on the Great Pyramid 10

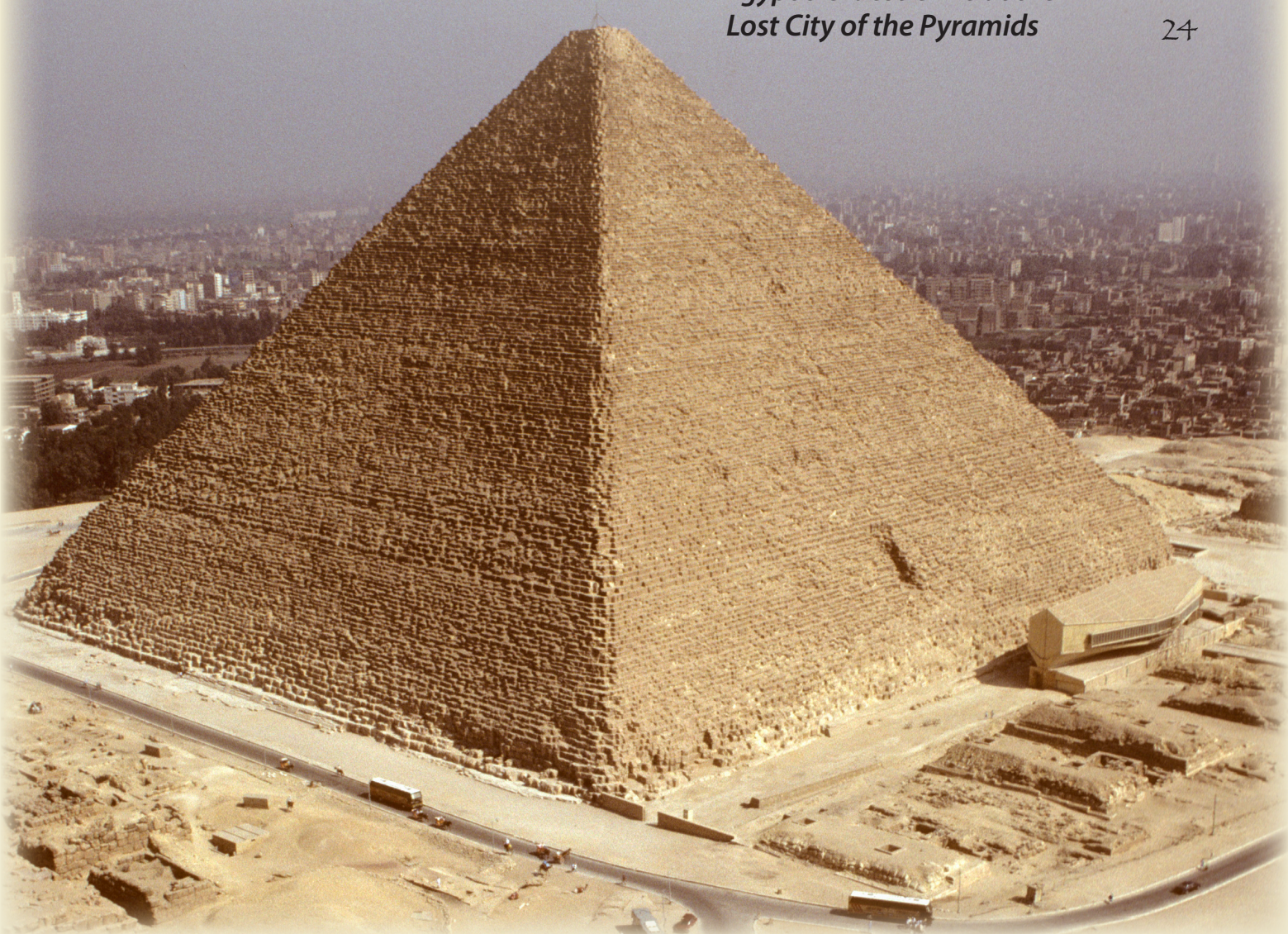
We publish for the first time estimates for the dimensions and orientation of the Great Pyramid, based on data that Mark Lehner and David Goodman collected in 1984–85.

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Fifth Dynasty Renaissance at Giza *by John Nolan*



4th Dynasty building boom. The view to the northwest from the top of the Gebel el-Qibli ridge takes in the great building projects carried out during this period. To the left just out of view lie the Menkaure Pyramid, temple, and queens' pyramids.

Over the last 25 years AERA has excavated the Lost City of the Pyramids, occupied during the 4th Dynasty when thousands labored to build the pyramids, tombs, and temples of Giza. When pyramid construction ended, kings moved to Saqqara to build their monuments, leaving Giza to the dead and the priests who served them. Our recent discoveries in the Khentkawes Town and Menkaure Valley Temple mark the return of royal attention in the middle of the 5th Dynasty. John Nolan, AERA Associate Director and epigrapher, opens a window onto Giza's transition and revival after the end of the 4th Dynasty.

Scrambling up the ridge called the Gebel el-Qibli west of the Lost City of the Pyramids—also called the Heit el-Ghurab site (HeG)—the entire panorama of Giza, chockablock with stone monuments, opens up at your feet. It's difficult to imagine that almost all of the structures you see before you were built in the span of just 90 years. Before Khufu started building the Great Pyramid, the Giza Plateau was a high desert outcrop where the Maadi geologic formation meets the Moqattam formation. Aside from several isolated tombs from the first few dynasties, the plateau was untouched.

Fourth Dynasty Building Boom

The next four generations of Egypt's rulers would oversee an explosion of construction at Giza. They raised three major pyramids with their associated temples, causeways, and valley temples, plus two satellite pyramids and six queens' pyramids. The Sphinx was carefully carved out of bedrock, while the blocks cut out from around its feline body were stacked up to make the Sphinx Temple. High up on the plateau, both to the west and east of the Great Pyramid, the overseer of works laid out several cemeteries, comprised of street after street of large stone mastaba cores. Each of these stripped-down tombs stood ready to be assigned to one of the king's officials, who would then case and decorate it as his house for eternity.

Toward the end of this intense period, the rich and powerful started building tombs in the quarries east of the Khafre Pyramid, creating the great Central Field burial ground.

End of the 4th Dynasty

During the 4th Dynasty the HeG settlement at the edge of the Giza Plateau was an important administrative and economic center, a command center for pyramid building. We have found evidence of a wide range of activities at the town, from food preparation, storage, construction, and crafts to high-level administration. We see indications of a vast spectrum of people from laborers to high administrators.

Some of the most striking information about the town comes from discarded clay sealings that had been used to secure containers, papyrus rolls, and doors. The clay was impressed while wet with cylinder seals that bear titles of the seal owner and the king he served. The titles on the sealings we have recovered belong to high officials, some of whom worked closely with the king's Prime Minister—the Vizier—and educated future officials in the king's household. Other sealings indicate that purification priests of the living king worked at the edge of the settlement in an outpost of the royal funerary workshop.

All of this activity appears to have stopped abruptly at the end of Menkaure's reign late in the 4th Dynasty. Several lines of archaeological evidence indicate that the settlement was delib-

erately dismantled and abandoned. Our clay sealings also suggest that there was virtually no activity after this point. Out of more than 5,000 clay sealings recovered from the site, only five belong to a king other than Khafre or Menkaure. All five date to the reign of Userkaf, the founding ruler of the 5th Dynasty.

When Menkaure died, workers were still finishing off his pyramid and its complex of temples and queens' pyramids. His successor, Shepseskaf, took up the work and finished these structures using a distinctive size and style of mudbrick.

We now believe Shepseskaf carried out an even larger project on the plateau by completing the mortuary complex of Queen Khentkawes as part of a single, massive construction effort. When he finished, Shepseskaf abandoned Giza, moved the royal house to South Saqqara, and began building his own funerary monument there.

Transition to the 5th Dynasty at Giza

With the end of the 4th Dynasty, major construction projects were completed, but Giza did not become a ghost town. A community of priests lived in the settlement at the foot of the Khentkawes monument, and teams of artists and craftsmen labored away on tombs in the Western and Central Cemeteries. As the owners of these tombs passed away, priests visited their tomb chapels and established cults for them. Even the spaces in between the great 4th Dynasty tomb cores gradually filled in with smaller mudbrick burials for minor officials and relatives. With the end of the large scale projects of the 4th Dynasty, Giza

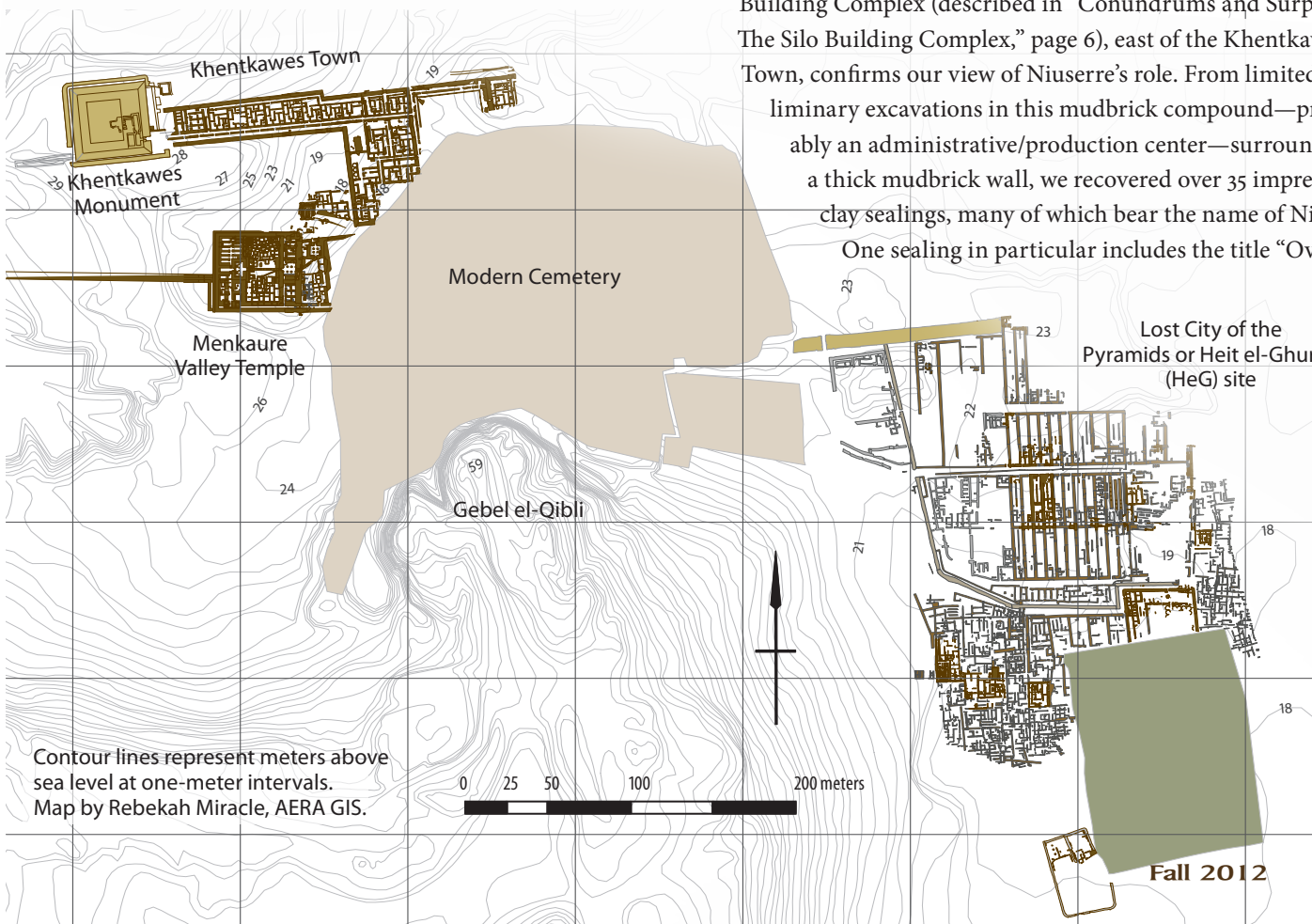
was a quieter place. Then after 45 subdued years, Giza was infused with new vitality.

Giza Revival

Our 2011 and 2012 excavations in the Menkaure Valley Temple revealed that sometime in the middle of the 5th Dynasty workers returned to the temple and refurbished the cult emplacements. In his excavations here over 100 years ago, George Reisner had noted some of this activity but did not single it out as an archaeological phase in its own right. We, however, felt it was significant enough to merit a discrete phase of its own.

Who was responsible for the refurbishment? Mark Lehner observes that the architecture of this phase includes massive corner constructions used in some of the walls of the Annex at the front of the valley temple and a small square chamber with a single, central column up in the mortuary temple, both innovations introduced in other temples during the reign of Niuserre, an important king who reigned (ca. 2402–2374 BC) in the middle of the 5th Dynasty. In addition, clay sealings and broken inscriptions discovered by Reisner throughout the pyramid complex bear the names of Khafre, Menkaure, and Shepseskaf, three of the last rulers in the 4th Dynasty, but no later kings until Niuserre, followed by almost every other king of the Old Kingdom. This evidence points to Niuserre as the driving force behind the resuscitation of the temple and the renewal of Menkaure's cult.

Evidence gathered from our 2012 excavations in the Silo Building Complex (described in "Conundrums and Surprises: The Silo Building Complex," page 6), east of the Khentkawes Town, confirms our view of Niuserre's role. From limited, preliminary excavations in this mudbrick compound—probably an administrative/production center—surrounded by a thick mudbrick wall, we recovered over 35 impressed clay sealings, many of which bear the name of Niuserre. One sealing in particular includes the title "Overseer

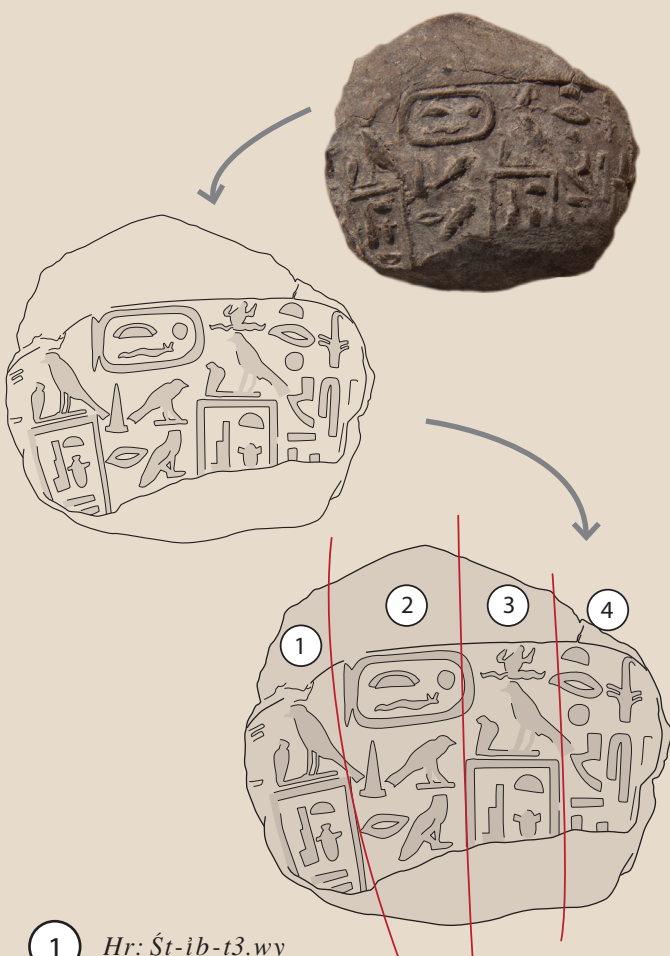


HOW TO READ A CLAY SEALING:

Right: Clay sealing found in the Silo Building Complex in 2012 that bears the Horus name of Niuserre: *Set-ib tawy*, "Favorite of the Two Lands." The Horus name (here highlighted in red), written inside a box topped by a falcon over a stylized "palace facade," indicates that Niuserre was alive at the time the cylinder seal was carved.



Below: Clay sealing found in the Silo Building Complex in 2012 that bears the title "Overseer of the Pyramid 'Great is Khafre.'" In all the line drawings presented here, a solid black line indicates a clear reading, gray shading indicates an interpretation based on the existing traces, and a dashed line represents a complete reconstruction. The transliterations and translations below correspond to the columns of text in the line drawing in bottom right, where red lines indicate the column text breaks. Photos by Yaser Mahmoud.



- 1 *Hr: Št-ib-t3.wy*
Horus: "Favorite of the Two Lands,"
- 2 *imy-r3 Wr-H^c=f-R^c ...*
Overseer of the Pyramid "Great is Khafre," ...
- 3 *Hr: Št-ib-[t3.wy]*
Horus: "Favorite of the Two Lands,"
- 4 *iry-ht-ny-šw.t šm3^c [wd^c-mdw ...]*
Custodian of the King's Property,
who makes right [the judgement ...]

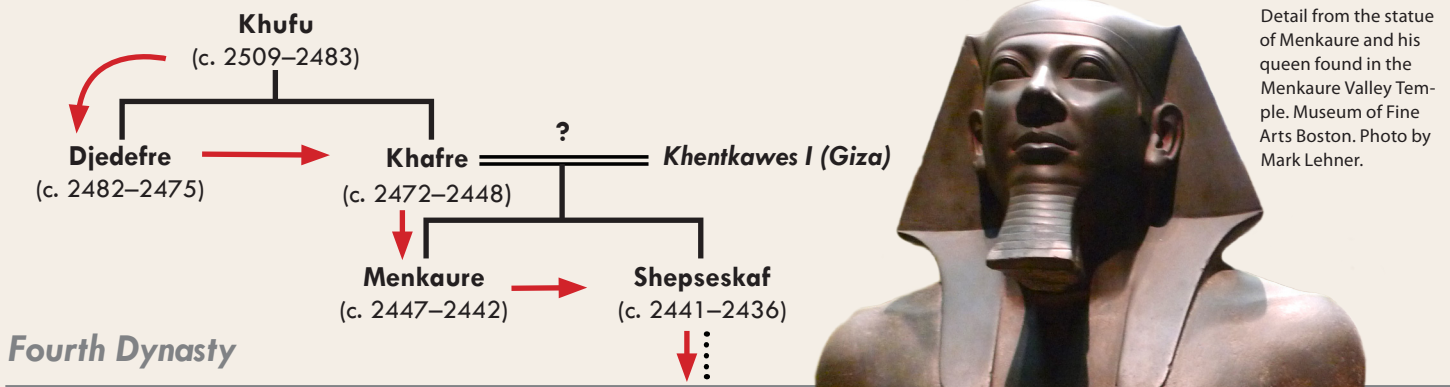
of the Pyramid 'Great is Khafre'" alongside Niuserre's name. This seal impression suggests that, at a minimum, Niuserre took an active interest in the administration of the old pyramid town that housed priests and others maintaining the cult of Khafre in his temple. Altogether the emerging evidence shows that Niuserre focused his attention on many of the same structures and institutions at the foot of the Giza Plateau as did his successor Shepseskaf at the end of the 4th Dynasty.

Niuserre Looks Back to Giza

Why was Niuserre interested in Giza? We turn to details of his reign for answers. After his father Neferirkare passed away Niuserre's older brother Raneferef became king. But, after ruling for just two years, Raneferef died unexpectedly. At this point, Shepseskare, Niuserre's cousin and a son of the old pharaoh Sahure, may have seized the throne. While little is known about Shepseskare's reign, he seems to have ruled long enough to level the site for his pyramid just north of Sahure's pyramid at Abusir, before he too died. After two ephemeral reigns and an apparent power struggle between two collateral lines of the royal family, Niuserre ascended to the throne.

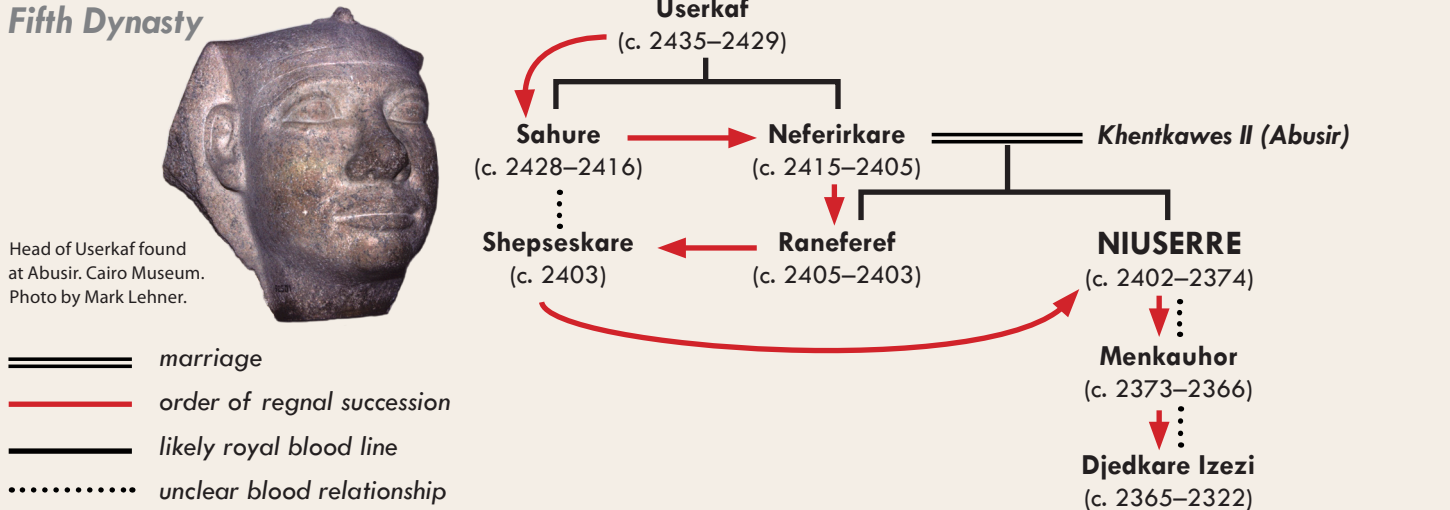
He set to work completing his brother Raneferef's funerary monument and made substantial changes to that of his mother, a woman named Khentkawes. Originally the temple attached to her pyramid at Abusir opened north into the larger pyramid complex of her husband, Neferirkare. Niuserre shifted its entrance to the east making it an independent cult. He also bestowed on his mother the title "Mother of Two Kings of Upper and Lower Egypt," mirroring—perhaps intentionally—the same title held by the earlier, 4th Dynasty queen also named Khentkawes, but buried under the large monument towering above the Khentkawes Town at Giza.* Taking over after a period of instability and perhaps judging that his grasp on power was shaky, Niuserre drew upon the obvious parallels between the name and title of his mother Khentkawes buried at Abusir and her earlier namesake at Giza. By revitalizing the cults of Khafre, Menkaure, and Khentkawes I at Giza, Niuserre hoped

* For more on the two queens named Khentkawes see "On the Cusp of a New Dynasty: Khentkawes and Userkaf" in *AERAGRAM* 11.2, Winter 2011, pages 10–12. All issues of *AERAGRAM* are available for free download at our website: aeraweb.org.



Fourth Dynasty

Fifth Dynasty



Proposed family relationships among the kings from Khufu through Djedkare Izezi. The relationships for the 4th Dynasty, especially that Menkaure and Shepseskaf might have been brothers and sons of Khentkawes I, are only hypothetical. The relationships for the 5th Dynasty agree with those on pages 64–65 in A. Dodson and D. Hilton, *The Complete Royal Families of Ancient Egypt*, London: Thames and Hudson, 2010. Year dates for the rulers largely follow E. Hornung, R. Krauss, and D. Warburton, *Ancient Egyptian Chronology*, Leiden and Boston: Brill, 2006.

to solidify his ties to the 4th Dynasty and at the same time to legitimize his own reign.

Repercussions

The revitalization of the cults had wider repercussions through the end of the 5th Dynasty. Giza, it appears, took on increased economic and religious prominence in the late 5th Dynasty. For example, the cults of both Khafre and Menkaure played important roles elsewhere in Egypt, as can be gleaned from papyrus documents discovered in the ruins of pyramid temples at Abusir, just north of Saqqara. These documents start in the reign of Niuserre's successor, Menkauhor, and continue into the 6th Dynasty. Scattered among the hundreds of pieces of papyrus were receipts of linen and textiles from the Menkaure Valley Temple. Another document identifies priests of Khafre as those who sealed the walkway that opened onto the truncated pyramid of Raneferef, indicating that they were among the most important priests in the Raneferef cult. These glimpses from the Abusir documents suggest that the royal temples at Giza, newly revitalized by Niuserre, played an important role in the economic and administrative life of the late 5th Dynasty.

At the same time, high officials like one named Rawer, who served Niuserre's father, chose to be buried in elaborate tombs

at Giza, as did two viziers of Djedkare Izezi—Seshemnefer III and Senedjemib Inty. Clearly, by the late 5th Dynasty Giza had once again become a prestigious burial ground for Egypt's upper classes. Niuserre's campaign of legitimization was apparently a great success.

As we digest the results of AERA's recent fieldwork and prepare for upcoming seasons in the Khentkawes Town and the Menkaure Valley Temple, it is clear that we are now moving into a dynamic historical period, not only for Giza, but for Egypt as a whole. With the passing of Menkaure, the royal focus shifted away from Giza for a few generations. The vibrant settlement at the HeG was dismantled and put to bed just as priests and their families moved into the newly-built structures around the Khentkawes monument and Menkaure Valley Temple. After some years, the royal gaze returned to Giza as a symbol of legitimacy. Niuserre, the unexpected king and witness to years of dynastic strife, emphasized the parallels between his rule and those of his predecessors at Giza by rebuilding their temples and revitalizing their cults. As we put together the evidence from the Khentkawes Town and the Menkaure Valley Temple and dig deeper into the Silo Building Complex, we hope to learn more about Niuserre and his successors.

Conundrums and Surprises: The Silo Building Complex



Above: The tops of silo walls begin to appear as excavators scrape the ruin surface. Beyond lies the basin and at its far side, approach ramps leading up to the Khentkawes Town. View to the west-northwest. Photo by Mark Lehner.

We launch each field season with ideas as to how the excavation might answer particular questions. But we do not know what we will find until we dig. This past season the Silo Building Complex yielded conundrums and surprises. We first exposed this mudbrick compound in 2011 while clearing to the east of the settlement dedicated to the cult of the 4th Dynasty Queen Khentkawes. The Silo Building Complex appeared to be an extension of the Khentkawes layout. But we discovered a more complicated and surprising story: a 5th Dynasty structure that may have served the cult of the 4th Dynasty king Khafre built inside an enclosure predating the Khentkawes Complex.

We launched the 2012 season eager to return to the Silo Building Complex (SBC), where we exposed and mapped the tops of walls in 2011 as part of our ongoing work at the Khentkawes Town. We had discovered a previously unknown eastern approach to the Khentkawes Town in 2009. This valley



Map 1: What was known of the Khentkawes Town and monument when AERA began work here in 2005 was based on the map published in S. Hassan, *Excavations at Giza, 1932–1933, Vol. IV*, Cairo: Government Press, 1943. Map 2: In 2009 AERA discovered an eastern approach to the settlement (2009 excavations in blue). In 2011 AERA teams cleared to the east (green). Map 3: In 2012 AERA excavated the Silo Building Complex (gold). Maps by Rebekah Miracle, AERA GIS.

complex, as we called it, included corridors, stairs, and ramps fronting on a deep basin, which was probably a harbor. But we had only captured the northwestern corner of the approach. The basin, flanked on the north by a thick mudbrick wall (the Northern Enclosure Wall) and corridor, continued east beyond our excavation.

2011: Khentkawes Complex Farther East?

In 2011 we resumed clearing and eventually located the eastern end of the Northern Enclosure Wall, corridor, and basin.* A massive wall—reduced to only a few centimeters—bordered the basin on the east. The corridor terminated in a niche in this massive wall.

Farther east beyond the Basin Enclosure Wall we exposed the Silo Building Complex, a compound with silos, small chambers, and a courtyard that extended beyond our clearing (2011 photo on facing page, top; map 2 on the right, center).

We were surprised to find that the Khentkawes Valley Complex extended so far east, but the SBC appeared to be an integral part of the layout, fronting on the basin. The niche could have been an access from the northern corridor through the Basin Enclosure Wall into the SBC. We proposed that goods and offerings were stored here and then carried through the niche, up the corridor and ramp, onto the Khentkawes causeway to the chapel, where they were offered to the deceased queen.

2012: Corner Conundrum

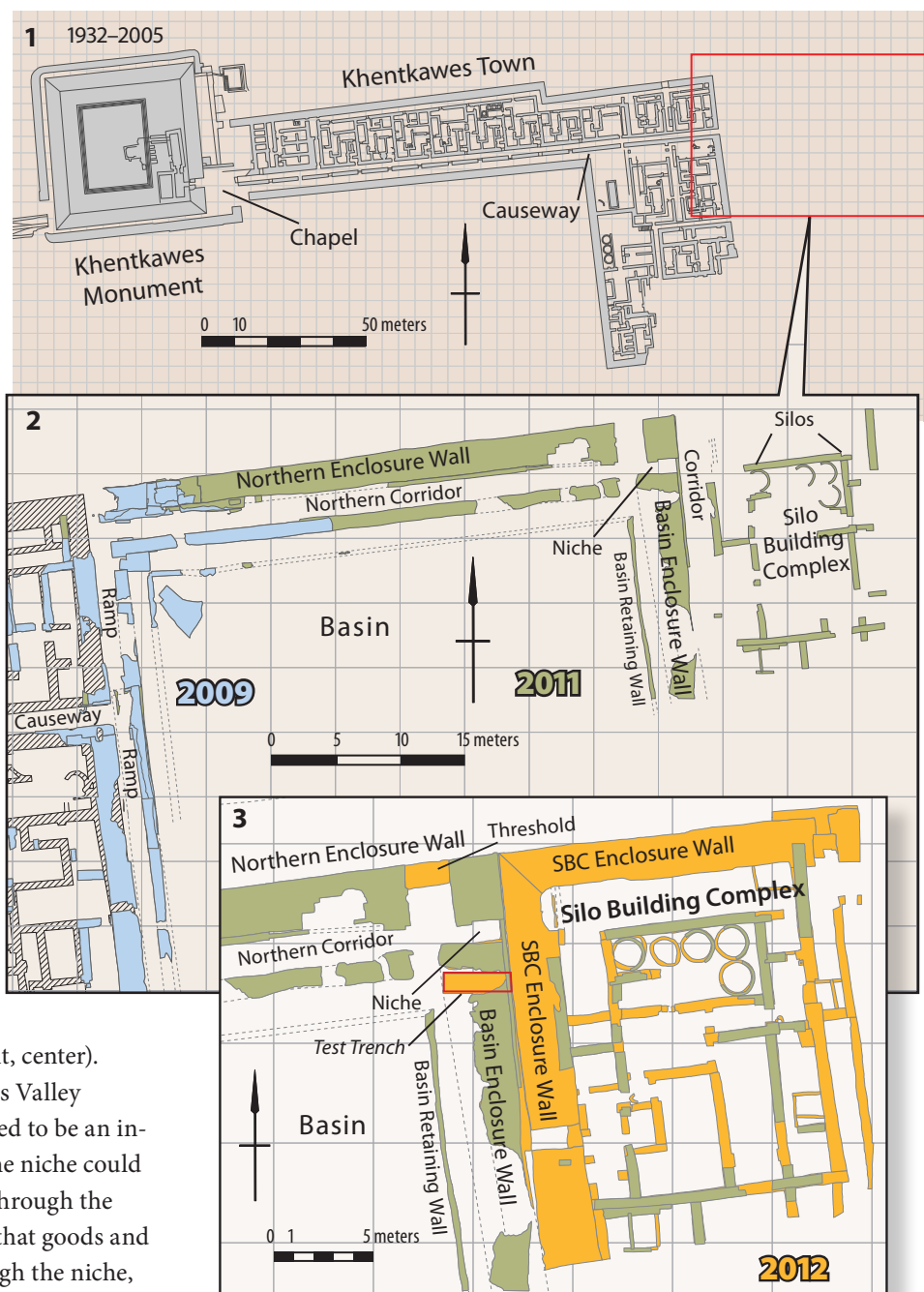
Our theory about the ties between the SBC and Khentkawes Complex began to collapse during the 2012 excavations when we literally ran into a wall—the top of a massive mudbrick wall, 2.62 meters thick (8.6 feet), lying right where we expected to find a corridor between the SBC and the Basin Enclosure Wall. Coming to a dead-end at this wall, the niche would not have

offered access from the corridor after all. Two thick enclosure walls stood back to back (facing page, bottom; map 3 above).

A connection between the SBC and Khentkawes seemed even more dubious when excavation supervisors Hussein el-Rikaby and Rabee Eissa discovered that the massive wall next to the SBC—the SBC Enclosure Wall—wrapped around the complex on the north. It formed a corner that opened out to the southeast and away from the Khentkawes Complex.

An Old Enclosure

To find out how the two sets of enclosure walls were related, we dug a test trench down into the traces of the badly eroded Basin Enclosure Wall and the bank of limestone debris on which it rested. The trench exposed the west face of the SBC Enclosure Wall and revealed that it was older than the Basin



* We first reported on the 2011 work and the SBC in *AERAGRAM* 12-1, Spring 2011, pages 10–13. All back issues of *AERAGRAM* are available for free download at our website: aeraweb.org.

Facing page: The Silo Building Complex at the end of the 2012 excavations. In the background the high water table floods the basin. At the far end of the basin a protective backfill layer covers the ramps and corridors. View to the north-northwest. Photo by Mark Lehner.

Enclosure Wall. We could clearly see a coating of plaster on the western face of the SBC Enclosure Wall, which would not have been there had it been built at the same time as the Basin Enclosure Wall or later. Moreover, the builders had piled limestone debris against the older wall, forming a bank upon which they laid the first course of the Basin Enclosure Wall.

At this point the SBC appeared to be older than the Basin Enclosure Wall, which we assumed was built for Khentkawes. Excavations revealed a more complex situation.

An Older Enclosure, a Younger Complex

As we slowly worked our way down through the mudbrick tumble filling the SBC we discovered from architectural evidence that the SBC compound was built *later* than its enclosure wall. The SBC walls on the west side were built up to the SBC Enclosure Wall. Someone had blocked an opening in that massive wall and built the SBC east of it. In addition, the bricks of the SBC walls are made of tan or yellowish marl desert clay, in contrast to the dark Nile silt bricks of the SBC Enclosure Wall. They are also smaller—three-quarters the size of the SBC Enclosure Wall bricks.

The SBC: A Production Center

Although our initial impression of the SBC as an extension of the Khentkawes Complex proved wrong, we were apparently right about it being a production-administrative facility, based on our few limited excavation trenches that reached only to the final occupation floor.

The five large mudbrick silos probably stored emmer wheat and barley. Production facilities occupied rooms on the north and east sides (C, A, O, N, M, and L), which were probably open to the sky (see map facing page, top). Ashy deposits, abundant bread molds and beer jars, as well as other evidence suggested bread-baking—and probably beer-brewing—on a large scale, as well as cooking.

Some activity scorched the walls of Room L and left black ash across the floor. Along with Room M, Room L most likely functioned as a bakery. Room N also displayed burned walls, probably as a result of cooking. A circular feature in the floor might have been a hearth, perhaps where workers heated beer mash. The feature could also have been a socket for a vat or for a mortar used with a pestle to break apart cereal spikelets in preparation for grinding.

Room A featured scorched walls and black ash fill as well as a large granite quern stone. Millers would have used it with a smaller hand stone to grind cereals into flour.

An official who administered the operation might have been quartered in the central SBC rooms. Room G perhaps served as the audience hall, where the official would have received visitors while seated in a niche defined by pilasters. He might have found private space in Room P, while H, Q, and V served as the kitchen.

Thrust into the 5th Dynasty

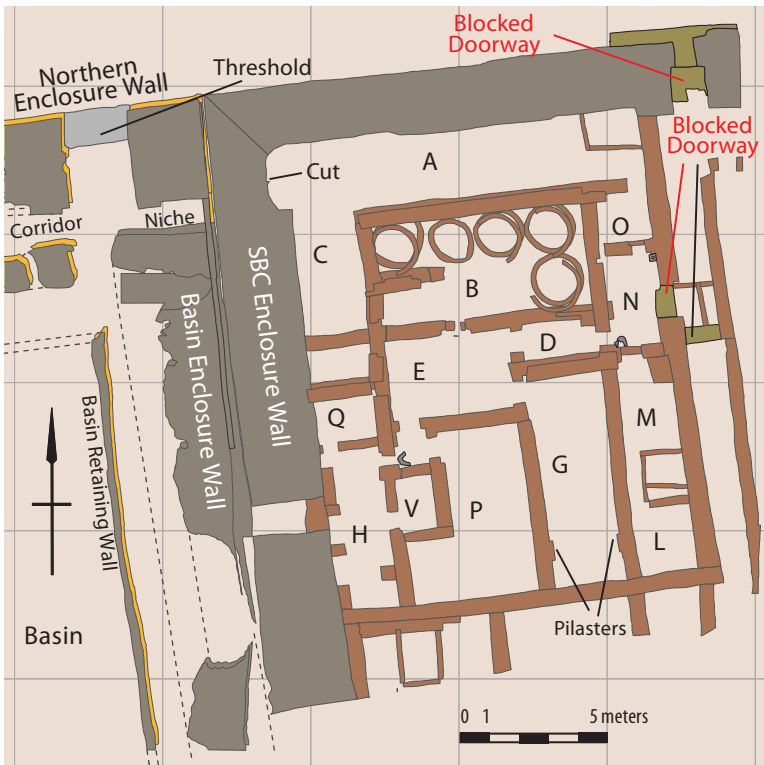
Our ceramics team first alerted us to a possible 5th Dynasty occupation when they began finding 5th Dynasty pottery coming out of the SBC. But the clincher for this later date came from discarded clay sealings bearing the Horus name of 5th Dynasty king Niuserre (described in the box on page 4).

Ancient Egyptians secured containers, papyrus rolls, and doors from unauthorized opening with clay sealings, which were impressed while still wet with a cylinder seal often bearing the seal owner's title and the Horus name



Right: 5th Dynasty storage and beer jars from the Silo Building Complex (far right). Photo by Yaser Mahmoud. Below: The northeast corner of the Khentkawes Valley Complex and the west side of the Silo Building Complex. View to the south-southeast.





Above: Detail map of the Silo Building Complex based on AERA 2012 excavations. Map by Rebekah Miracle, AERA GIS. Below: Workers excavate ashy layers in Room L, while in the background a worker and excavation supervisor Mohammed Fethi Mansour clear fill in Room M. Note the burned walls in Room L. View to the north. Photo by Mark Lehner.



of the king he served. We know that the seals represented on the SBC sealings were carved when Niuserre was king because the Horus name was used only when the king was alive. So the SBC most likely functioned during the reign of Niuserre, half a century after the Khentkawes Complex was built.

The sealings complement other evidence we uncovered of Niuserre’s presence on the plateau (described in the article “Fifth Dynasty Renaissance at Giza” starting on page 2). He may have retrofitted the SBC into the corner of the old mudbrick enclosure predating Khentkawes. But for whom was the older enclosure originally built?

Whose Cult?

Another sealing (shown on page 4) suggests an answer. It bears Niuserre’s Horus name along with the title: “Overseer of the Pyramid, ‘Great is Khafre,’” the name of the Khafre pyramid. The sealing suggests that the SBC was part of Khafre’s pyramid town and supported priests who maintained the cult of this 4th Dynasty king long after his death, during Niuserre’s reign (see chronology on page 5).

The massive walls around the SBC may have originally been built for Khafre’s cult before the Khentkawes Complex was conceived. The Khafre Temple, where the cult priests would have conducted their rituals, lies only about 70 meters (around 230 feet) to the northeast, although the enclosure seems to open to the southeast.

Fifth Dynasty Access Conundrum

Before we can verify that the SBC served the Khafre cult during the 5th Dynasty, we have to address a perplexing access issue. The northern entrance to the compound in which the SBC stands was blocked before the final occupation phase and the only access into SBC, through Room N, seems to have been completely sealed off as well (see map above, left).

How did people get in and out of the SBC? Perhaps the niche in the Basin Enclosure Wall was their entrée after all. If the SBC Enclosure Wall stood only at the height we found it—perhaps eroded or partially dismantled—people could have exited the niche and stepped across. The east side of the wall might have contained steps to facilitate access. We found a cut in the wall but did not have time to explore further.

An entrance on the west would connect the SBC with the Khentkawes Complex rather than the Khafre Valley Temple. Perhaps workers produced bread and beer for Khafre *and* Khentkawes. Niuserre seems to have revitalized the cult of Khafre and perhaps that of Khentkawes (his mother’s name-sake) as well.

We look forward to another excavation season with so much yet to learn about a 5th Dynasty occupation at the SBC and about the original structure in the enclosure wall. Much work lies ahead and probably more unexpected discoveries.



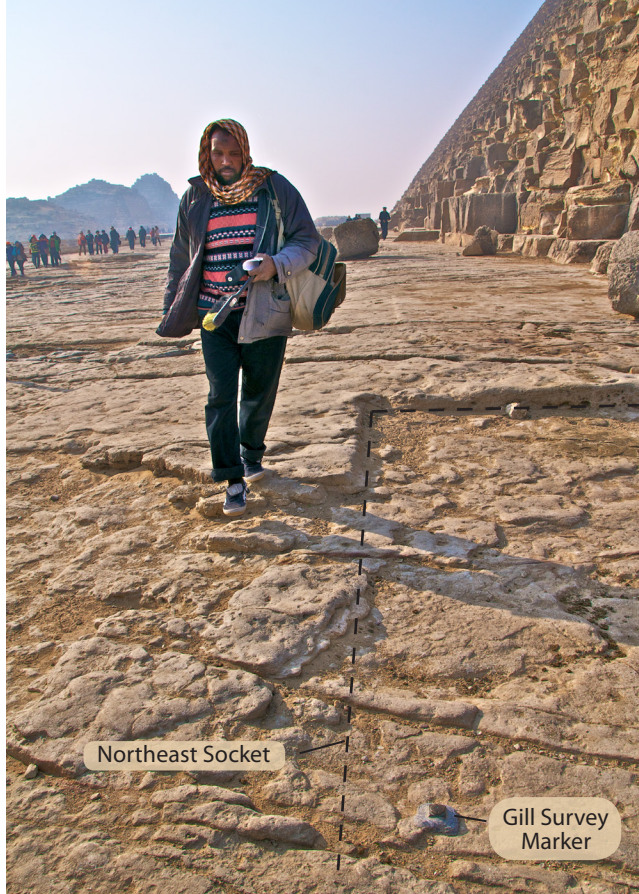
PLAN TOPOGRAPHIQUE DES PYRAMIDES ET DES ENVIRONS.

In 1984 Mark Lehner and David Goodman measured the elusive base of the Great Pyramid of Khufu. They followed in the footsteps of researchers, going back to the 17th century, who tried to determine the true dimensions of the pyramid—no easy task. Stripped of nearly all of its casing, the monument no longer has any corners, nor well-defined edges. Now, for the first time, we publish the Lehner-Goodman data with an analysis that gives the dimensions and orientation of the Great Pyramid.

No monument in the world has given rise to more speculation about its meaning than the Great Pyramid of Khufu. It has been said to encode “God’s unit of measurement”—the Pyramid inch—to physically represent the mathematical constant pi, and incorporate the Golden Section. Sir Isaac Newton thought it could be used to refine his theory of universal gravitation. All of these ideas, sensible or not, depended to one degree or another on knowing the exact size and orientation of the Great Pyramid. It is surprising then to find that there has been no final, definitive work on the subject. The reason is due, in large part, to the condition we find the Pyramid in today. We find scant traces of its original corners. The best we can do is to project their original positions from the fragmentary data that does remain. It has proven to

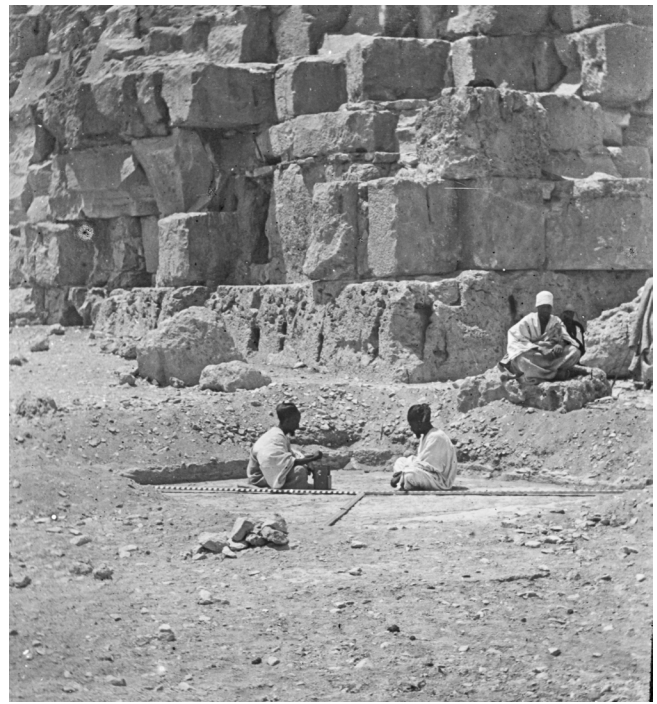
Above: Map of the Giza Plateau prepared by Napoleon’s expedition. *Description de l’Égypte, Antiquites Planches, vol 5. Pyramids de Memphis.* Plate 6, Plan Topographique des Pyramides et des Environs, 1809–17. Image courtesy of the Linda Hall Library of Science, Engineering & Technology. Right: David Goodman surveys in 1984 with a theodolite and electronic distance measuring device to establish the Giza Plateau Mapping Project grid, looking toward the Great Pyramid. View to the east-northeast. Photo by Mark Lehner.





Northeast Socket

Gill Survey Marker



The Northeast Corner Socket. Left: AERA Surveyor Mohammed el-Baset walks past the remains of the socket (dotted line). Right: The same corner socket was photographed by Piazza Smyth in 1865. Smyth photo © Photoarchive3D; courtesy of George Mutter and Bernard Fishman.

be a challenge. Of the original base, only 55 meters (180 feet) of what was once a casing baseline of 921 meters (3,022 feet) survives. Of the original platform baseline (as defined by its top, outer edge), only 212 meters (696 feet) of 924 meters (3031 feet) survives.

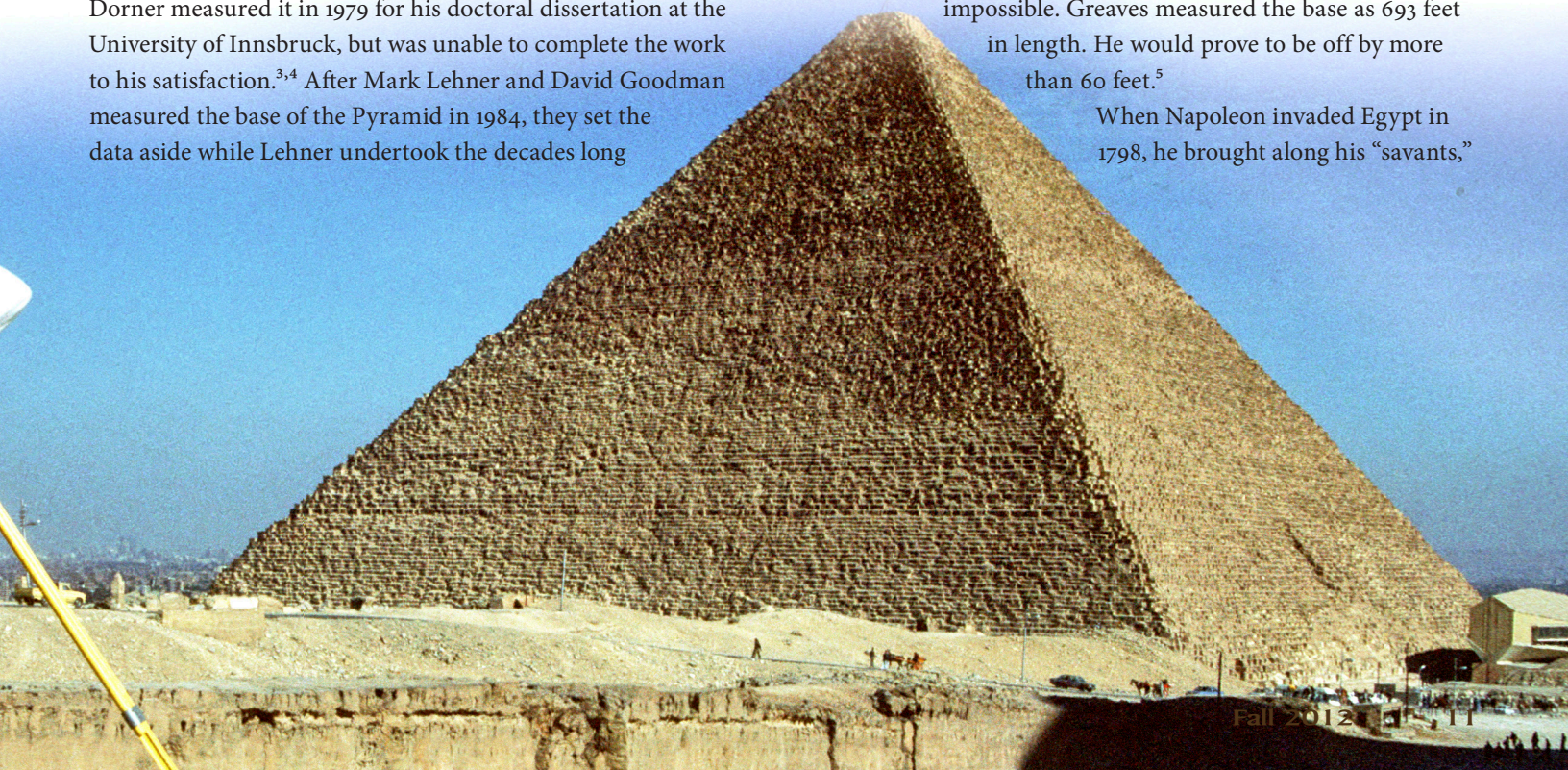
Flinders Petrie, the father of Egyptian archaeology, measured the base of the Great Pyramid from 1880 to 1882.¹ J. H. Cole, a surveyor with the Egyptian Ministry of Finance, made additional measurements, which he published in 1925.² Joseph Dorner measured it in 1979 for his doctoral dissertation at the University of Innsbruck, but was unable to complete the work to his satisfaction.^{3,4} After Mark Lehner and David Goodman measured the base of the Pyramid in 1984, they set the data aside while Lehner undertook the decades long

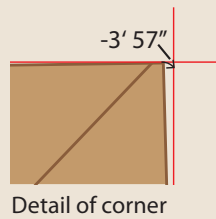
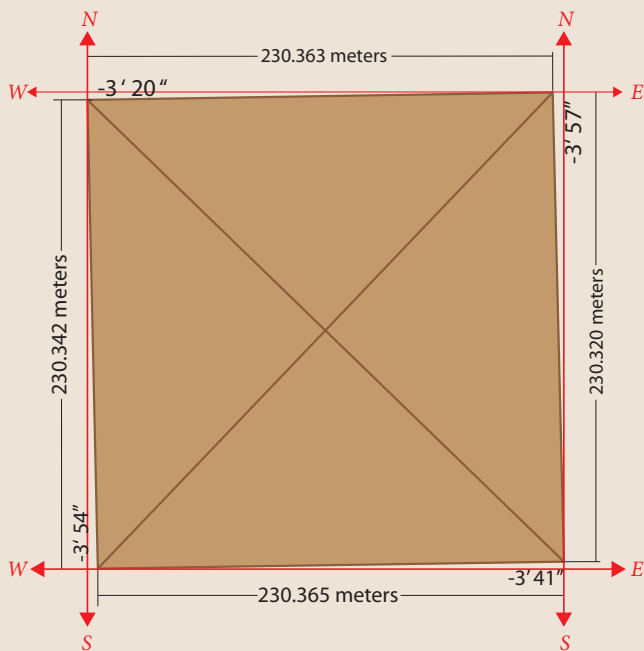
task of uncovering and mapping the Lost City of the Pyramids. I now return to it.

Pyramid Surveys: From Savants to the 1970s

John Greaves, Professor of Astronomy at the University of Oxford, made one of the first attempts in modern times to precisely measure the base of the Great Pyramid. However, upon his arrival in Egypt in 1638 he found the base covered in centuries-old debris. Accurate measurements were all but impossible. Greaves measured the base as 693 feet in length. He would prove to be off by more than 60 feet.⁵

When Napoleon invaded Egypt in 1798, he brought along his “savants,”





This drawing and table present Petrie's measurements of the sides of the Great Pyramid and the angles at which they deviate from the cardinal directions. The drawing exaggerates the angles in order to display them. Petrie found that each side was rotated slightly counterclockwise from cardinal points, as indicated by the minus sign.

PETRIE'S GREAT PYRAMID MEASUREMENTS

Side	Length (meters)	Angle
North	230.363	-3' 20"
East	230.320	-3' 57"
South	230.365	-3' 41"
West	230.342	-3' 54"
Average	230.348	-3' 43"

150 members of the "Commission of Arts and Sciences" to study and document sites throughout Egypt. Savant Edme-François Jomard assaulted the accumulated debris on the base of the Pyramid in Napoleonic style with a small army of Ottoman Turks. They cut through the overburden, uncovering two "sockets" off the northeast and northwest corners, one of which can be seen in the photos on the previous page. Jomard believed these sockets once held the very cornerstones of the Pyramid. To compute the Pyramid's orientation and size, he thought, one only needed to measure the relative positions of the socket's outermost corners.

Petrie's Measurements. Flinders Petrie, who arrived at Giza in 1880 to perform his measurements, disagreed with Jomard. By analyzing the Pyramid's angles, he determined that the true corners must have fallen somewhere inside the sockets. Petrie, at 27, had already gained recognition for his skills as a surveyor, even before winning lasting fame as an archaeologist.

By then, all four corner sockets had been found and exposed. Conveniently, Royal Astronomer and surveyor David Gill had preceded Petrie and in 1874 set bronze survey markers just inside the socket corners (shown in photo on previous page). Petrie, and almost every surveyor since, would use Gill's markers as control points.

Petrie found the north side of the Pyramid partially cleared of debris, revealing its ancient casing of smooth, white Tura limestone, seen in the photo on the facing page. The casing's outer surface, Petrie estimated, sloped at a mean angle of 51° and 52 minutes plus or minus 2 minutes. The casing once covered the entire Pyramid, requiring 21 acres of casing stones in all. Most of the casing had been carted away for building material centuries before. Originally it was supported by platform slabs set into bedrock, which Petrie found to be remarkably level.

At that time, however, most of the east, west, and south sides of the Pyramid still remained covered in debris. Petrie cut through the debris to find a section of well-preserved casing near the center of each side. He chose one point on each side and then measured their relative positions precisely.

Petrie then set out to calculate the size and orientation of the Pyramid by making a key assumption. He assumed that the corners of the Pyramid's casings fell on the "pyramid diagonals"—lines that connected the four socket corners to their opposing corner.

With that assumption and his measurements in hand, Petrie claimed he could calculate the length of the casing's baseline on each side and the orientation of each baseline relative to cardinal points using a complex geometrical argument.⁶ He found that each side was rotated slightly counterclockwise from cardinal points, as indicated by the minus sign in angle measurements shown above in the table and the stylized pyramid with Petrie's measurements. The maximum difference in length between any two sides, Petrie said, was just 4.5 centimeters (about 1.75 inches), and the corners of the casing formed nearly perfect right angles. The maximum deviation from a 90° angle at any corner was at the northeast corner, where it was just 37 seconds of arc (.01°)—about the angle subtended by a dime viewed from across a football field.

However, as noted, Petrie measured just one point on each side. Establishing a line, of course, requires at least two.

Cole's Lines. In the Pyramid's case, no lines would actually be measured until the 1920s, when J. H. Cole of the Computation Office of the Egyptian Ministry of Finance did so at the request of the German archaeologist Ludwig Borchardt. Cole laboriously cut through debris to expose several more points of the casing on each side. He chose the "best" two on each

COLE'S GREAT PYRAMID MEASUREMENTS

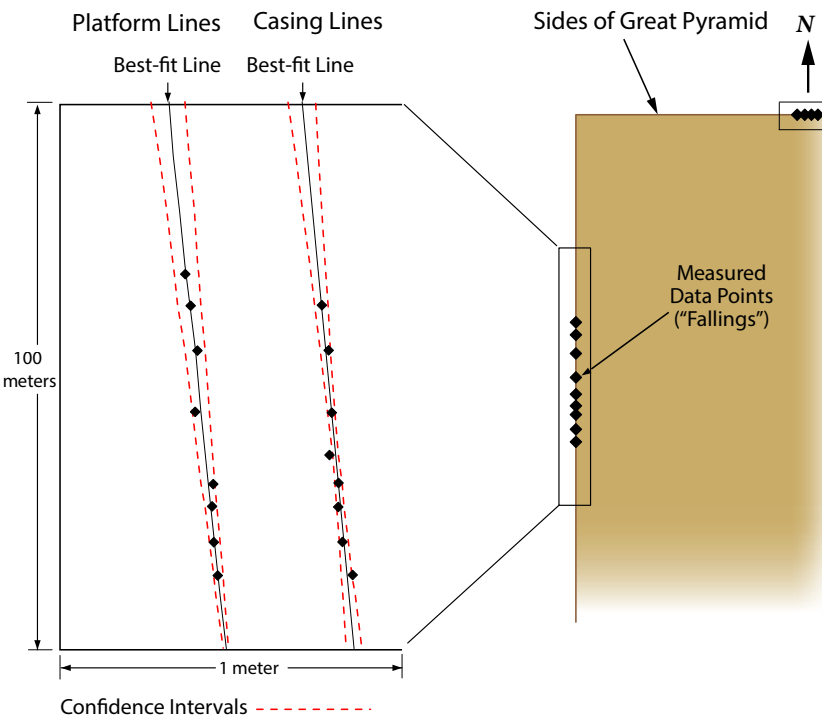
Side	Length (meters)	Angle
North	230.353	-2' 28"
East	230.391	-5' 30"
South	230.454	-1' 57"
West	230.357	-2' 30"
Average	230.364	-3' 06"

DORNER'S GREAT PYRAMID MEASUREMENTS

Side	Length (meters)	Angle
North	230.328	-2' 28"
East	230.369	-3' 26"
South	230.372	-2' 31"
West	230.372	-2' 47"
Average	230.360	-2' 48"



Casing and Platform Stones. Near the corner of the north side the angled casing stones sit upon platform stones. The lower, outer edge of the casing and the top, outer edge of the platform provide the best places to measure the Pyramid's lines. Petrie estimated the angle of the casing slope to be $51^{\circ} 52 \text{ minutes} \pm 2 \text{ minutes}$. Photo by Mark Lehner.



Lehner's Fallings. Mark Lehner mapped points near the middle of the east, west, and north side of the Great Pyramid where he found well preserved edges. We derive best-fit lines and confidence intervals for these. (The horizontal scale is exaggerated here to emphasize the angle.) The original corners can be located by extrapolation.

and measured their angle. His measurements for the Great Pyramid are shown in the table above.

The Pyramid was looking a little less perfect than what Petrie had determined. The maximum difference between any two sides, according to Cole, was 10 centimeters, about twice what Petrie had found. Its sides were also less square, with a deviation of about $3\frac{1}{2}$ minutes of arc ($.058^{\circ}$) at the northeast

corner, about six times what Petrie found. Cole did find Petrie correct in one respect; the corners of the casing seemed to fall on the Pyramid diagonals.

The Egyptian Government eventually cleared the entire base of the Pyramid, but there would be no additional surveys until decades later.

Dorner's Values. In 1979, when Josef Dorner surveyed the Great Pyramid for his doctoral dissertation, he was able to provide preliminary measurements for the Great Pyramid, as shown in the table above on the left.

The maximum difference between any two sides, according to Dorner, was 4.4 centimeters (almost 1.75 inches). The most askew of the right angles was 58 seconds ($.016^{\circ}$) from square on the northeast. While not as perfect a pyramid as Petrie had proposed, Dorner's findings were more in line with Petrie's than Cole's.

Lehner's Fallings

In 1984, Mark Lehner and David Goodman made a comprehensive survey of the base of the Pyramid. Goodman, a surveyor then with the California Department of Transportation, established the survey grids now used to map both the Giza Plateau and the Valley of the Kings. For this study, he first laid a survey line along each side of the Pyramid between the bronze survey markers left by Gill, to serve as a control. Lehner then walked along the survey lines, choosing points to measure. When he chose a point, Goodman recorded its distance from one of Gill's markers electronically. Goodman then sighted along the survey line using his theodolite's telescope.

Lehner laid a tape measure from the point he wished to measure to the survey line, while Goodman, who could see the tape measure in his telescope, recorded the distance between the two. Surveyors refer to these offset measures as “fallings.” At each station, Lehner carefully noted the condition of the edges of the casing and platform stones. Mapping those points where he found the top, outer edge of the platform stones or the lower edge of the casing stones well preserved, I can attempt to reconstruct the original lines of the Pyramid. While previous surveyors had concentrated only on the casing, Lehner measured the platform as well.

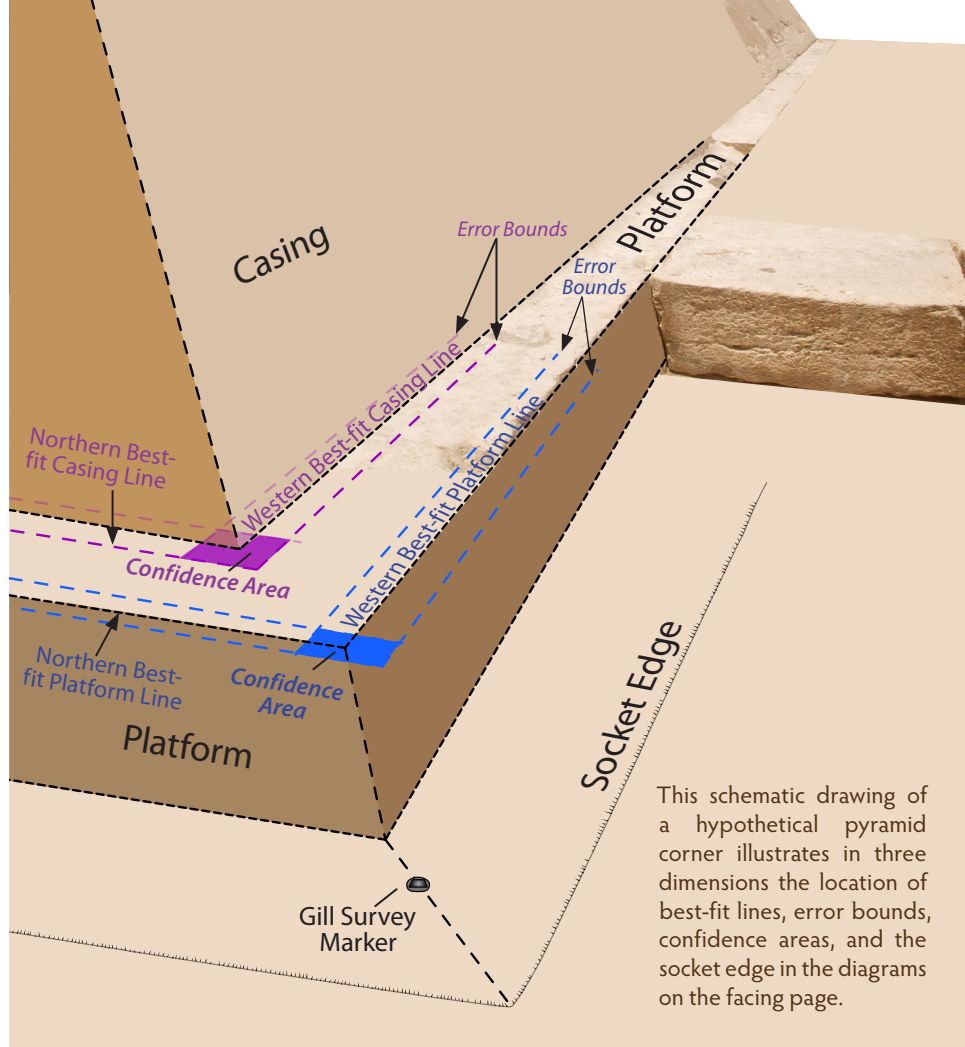
Analyzing the Lehner-Goodman Data

In order to analyze this data, I first need to place it on a master grid. The grid I will use is the Giza Plateau Mapping Project (GPMP) control network that was established by Lehner and Goodman in 1984 and 1985. It assigns every point on the plateau coordinates, like addresses for houses on a city map. The origin of the map lies at the calculated center of the Great Pyramid, and everything is measured from that point, in units of meters. For example, Gill’s bronze survey marker off the northeast corner of the Pyramid is at 115.802 meters north of the center of the Pyramid, and 115.607 meters to its east. By convention, surveyors do not work with negative numbers, so instead of making the center of the Great Pyramid point (0, 0), Goodman and Lehner arbitrarily assigned it a location of (N100,000, E500,000). That places the northeast Gill marker at “Northing” 100,115.802 and “Easting” 500,115.607. As designed, the GPMP system can be used to map features up to 100 kilometers south of the Pyramid, and 500 kilometers to its west, with unlimited range to its north and east.

Once the Lehner-Goodman data is converted to GPMP coordinates, I can use a standard statistical method known as linear regression analysis to “best-fit” lines to it. In the figure on page 13 (center left), I show best-fit lines for the casing and the platform on the west side of the Pyramid. My linear regression analysis not only generates best-fit lines, but margins of error as well, known as confidence intervals.

I have generated best-fit lines and confidence intervals for the north and east sides as well.* To derive corners, I need only

* The south side is too badly damaged to provide data useful for statistical analysis. However, since I am assuming that the original casing and platform corners fell on the diagonals, I can proceed without that data.

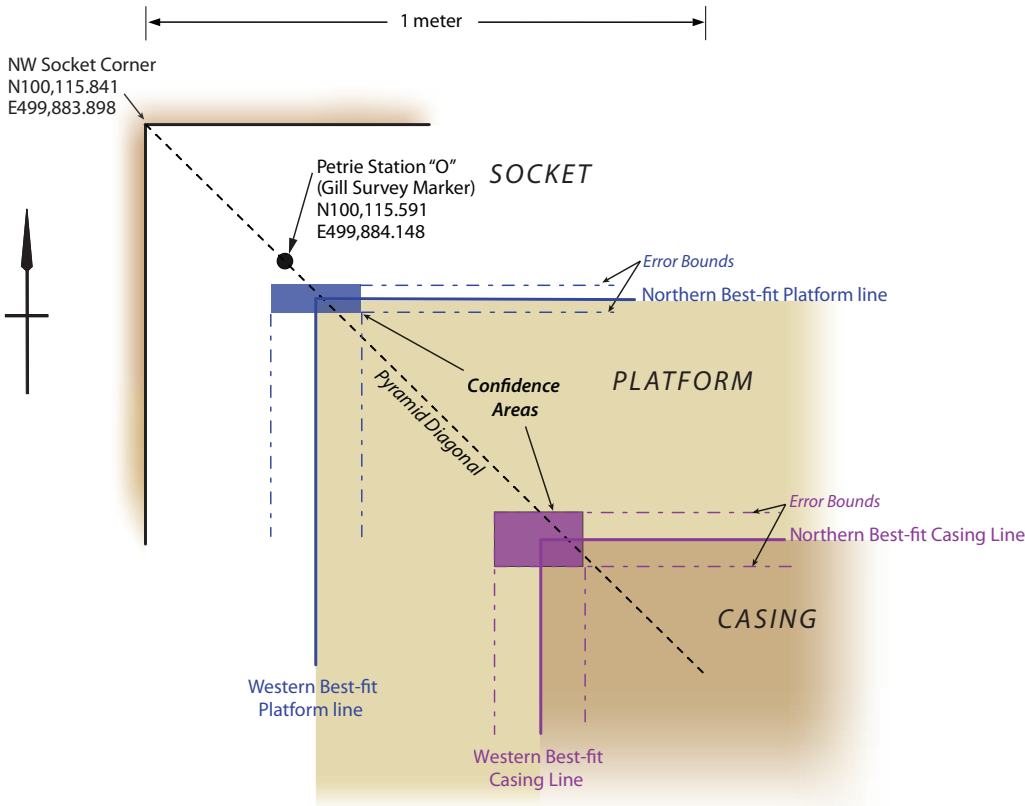


This schematic drawing of a hypothetical pyramid corner illustrates in three dimensions the location of best-fit lines, error bounds, confidence areas, and the socket edge in the diagrams on the facing page.

to extrapolate these lines to see where they cross. The figure on the facing page shows the situation at the northwest corner. Here, two sets of best-fit lines for the casing, and two for the platform, meet. Each line is accompanied by confidence intervals. Based on my measurements and assumptions, there is a 95% probability that the original casing and platform edges fell within the regions bounded by the dotted lines. For the casing, the error range, or “confidence area,” is approximately 16 by 9 centimeters (6.3 by 3.5 inches). For the platform, it is about 16 by 5 centimeters (6.3 by 2.0 inches).

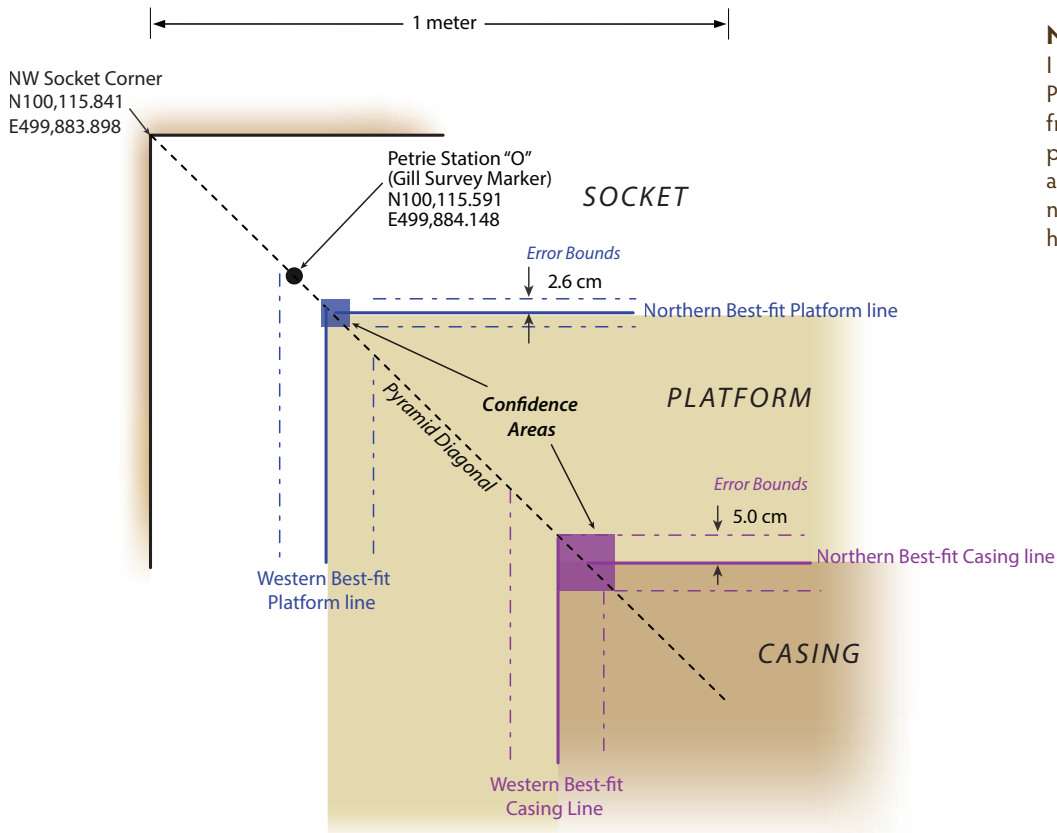
Is there a way to narrow this confidence area further? I can assume, as did Petrie and Cole, that all four corners of the platform and casing fell on the Pyramid’s diagonals (shown in the figure on the right). The locations of the Pyramid diagonals are well documented.† Since I only need the intersection of two lines to define a corner, and I am assuming that the casing and platform corners fell on the diagonal, I only need consider the intersection of either the northern casing and platform lines

† Petrie and Maragioglio and Rinaldi placed the northern socket corners in exactly the same locations. Compare Plate x in W. M. F. Petrie, *The Pyramids and Temples of Gizeh*, London: Field and Tuer, 1883, with Plate 2 in V. Maragioglio and C. Rinaldi, *L’Architettura Delle Piramidi Menfite Parte IV*, Rapallo, Tipografia Canessa, 1965.



The Northwest Corners

I can locate the corners from the intersection of the best-fit lines derived from the Lehner-Goodman data. Each line is surrounded by confidence intervals. (While the confidence intervals are, in fact, curved [hyperbolic] they appear straight over short distances.) There is a 95% chance that the original corners fell within the "confidence areas."



Narrowing the Range

I can use the intersection of the Pyramid diagonal, which extends from the socket corner to the approximate center of the Pyramid, and the northern best fit lines, to narrow the confidence areas. This helps to better locate the corners.

LEHNER-GOODMAN CASING CORNERS

Corner	Northing	Easting	Confidence Areas (meters)
Northeast	100,115.288	500,115.034	±.054
Southeast	99,885.006	500,115.262	±.093
Southwest	99,884.759	499,884.954	±.060
Northwest	100,115.095	499,884.645	±.050

LEHNER-GOODMAN PLATFORM CORNERS

Corner	Northing	Easting	Confidence Areas (meters)
Northeast	100,115.668	500,115.414	±.013
Southeast	99,884.484	500,115.785	±.031
Southwest	99,884.396	499,884.592	±.023
Northwest	100,115.522	499,884.217	±.026

with the diagonal, or the intersection of the western casing and platform lines with the diagonal. The northern lines have narrower confidence intervals and thus are better defined. Therefore, I will locate the northwest platform and casing corners at the intersections of the northern lines with the diagonal. The regions bounding their intersections are their confidence areas.

Applying the same procedure at all four of the Pyramid's corners, I can derive their locations. In the tables above I provide my best estimates for the original locations of the corners and their confidence areas. The largest of the confidence areas is at the southeast, but even there I can locate the casing corner to within ± 9.3 centimeters (3.7 inches).

I can also use this data to calculate the length of the Pyramid's sides and its angles. The Lehner-Goodman estimates for the casing lengths compared with that of Petrie, Cole, and Dorner are in the table on the right. Petrie's and Dorner's measurements fit comfortably inside the Lehner-Goodman ranges. Lehner-Goodman and Petrie differ in the mean of all four sides by only 1.8 centimeters (0.75 inches). One of Cole's measurements, however, falls outside the Lehner-Goodman ranges (in italics).

As for the angles, the Lehner-Goodman estimates are compared with that of Petrie, Cole, and Dorner in the

THE GREAT PYRAMID'S CASING LENGTHS IN METERS: LEHNER-GOODMAN, PETRIE, COLE, AND DORNER

Side	Lehner/Goodman			Petrie	Cole	Dorner
	Min	Mean	Max			
North	230.286	230.389	230.493	230.363	230.253	230.328
East	230.135	230.282	230.429	230.320	230.391	230.369
South	230.155	230.309	230.462	230.365	230.454	230.372
West	230.227	230.337	230.447	230.342	230.357	230.372
Average		230.329		230.348	230.364	230.360

THE GREAT PYRAMID'S CASING ANGLES: LEHNER-GOODMAN, PETRIE, COLE, AND DORNER

Side	Lehner/Goodman			Petrie	Cole	Dorner
	Min	Mean	Max			
North	-1' 19"	-2' 52"	-4' 25"	-3' 20"	-2' 28"	-2' 28"
East	-1' 12"	-3' 24"	-5' 36"	-3' 57"	-5' 30"	-3' 26"
South	-1' 24"	-3' 41"	-5' 58"	-3' 41"	-1' 57"	-2' 31"
West	-2' 58"	-4' 37"	-6' 14"	-3' 54"	-2' 30"	-2' 47"
Average		-3' 38"		-3' 43"	-3' 06"	-2' 48"

LEHNER-GOODMAN LENGTH AND ANGLES OF THE GREAT PYRAMID'S PLATFORM

Side	Length (meters)			Angle		
	Min	Mean	Max	Min	Mean	Max
North	231.157	231.196	231.236	-1' 35"	-2' 10"	-2' 45"
East	231.140	231.184	231.229	-4' 51"	-5' 31"	-6' 11"
South	231.138	231.193	231.248	-29"	-1' 18"	-2' 07"
West	231.076	231.126	232.176	-4' 50"	-5' 34"	-6' 18"
Average		231.175			-3' 38"	

table on the left. All the measurements fall within the Lehner-Goodman ranges except for the Dorner and Cole measurements on the west side.[‡]

Recalling that Lehner measured the platform as well, I include its lengths and angles in the table on the left. The platform extends outward from the casing by an average of 42.3 centimeters (16.7 inches) on each side. The casing does not run quite parallel to the platform. Although this difference is too small to illustrate in our figures, it is still significant and helps us to understand how the Pyramid was built. It might suggest, for example, that the Pyramid's builders were unsatisfied with the platform's original lines and chose to square things up a bit before finally dressing the casing down.

[‡] Dorner initially set his azimuth by measuring the angle of the casing on the north side with a WILD meridian telescope. He found the north side running at an angle of -3' 0." However, he rejected his own measurement in favor of Cole's: -2' 28." My analysis indicates he would have been better off not doing so. If he had accepted his own measurements, all his angles would change by -32" of arc. Not only would these revised angles fall within the Lehner-Goodman ranges, but they would be quite close to Petrie's values as well.

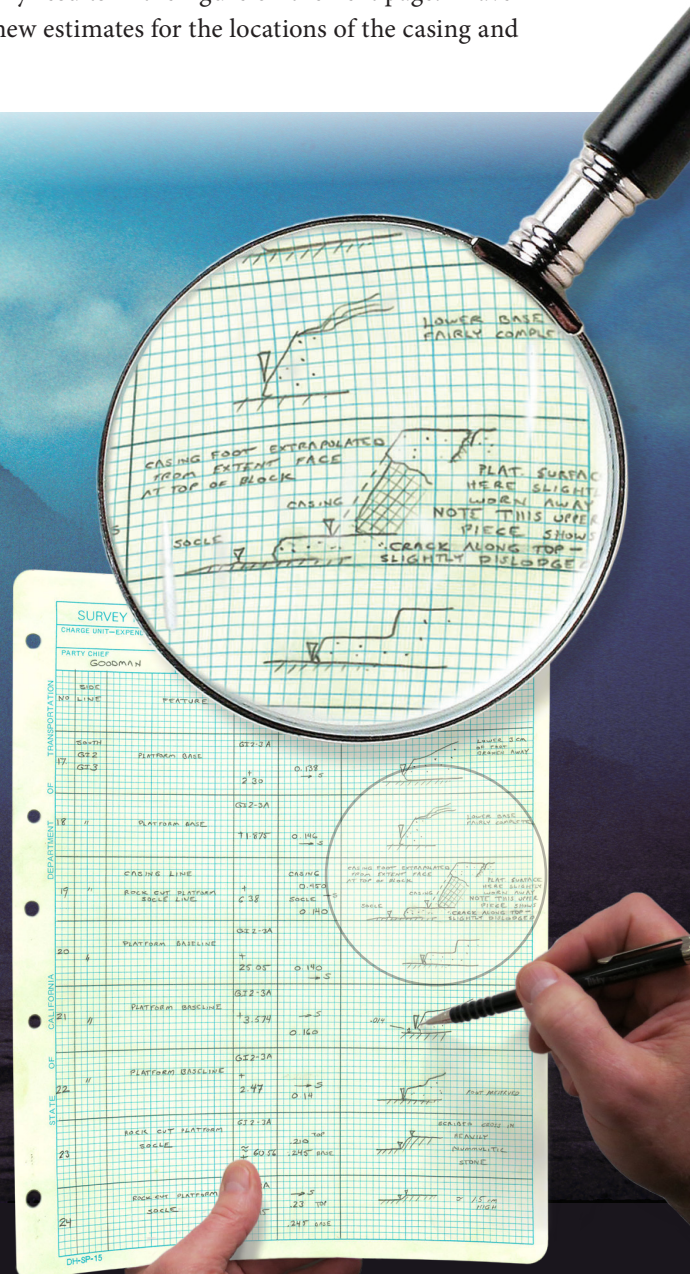
The South Side

In this analysis, I managed to compute the length and orientation of the base of the Great Pyramid without the benefit of data from its south side. I was able to do this because I assumed that the corners of both the casing and the platform fell on the socket diagonals. This was necessary because so little of the south survives. There, the top, outer edge of the platform is nowhere to be found. As for the casing, at one point 122.2 meters east of the southwest Gill marker, Lehner found that the casing once met the platform at N99,884.838 and E500,006.828. My model predicts that at that location the casing should have fallen at N99,884.889 and E500,006.889 plus or minus 0.075 meters. The casing does indeed fall within the range my model predicts. It is the only usable data point on the casing I have identified for the south side.

Conclusions

I gather my results in the figure on the next page. I have derived new estimates for the locations of the casing and

Lost in the fog of time: the exact size and orientation of the Great Pyramid (above left) and the Khafre Pyramid (above) are not certain because the corners are missing. Right: One of the Lehner-Goodman 1984 survey sheets recording their fallings on the south side of the Great Pyramid. The detail shows Lehner's sketches of the casing and platform at three points. The center sketch includes the comments: "Casing foot extrapolated from extant face at top of block." "Plat. surface here slightly worn away. Note this upper piece shows a crack along the top - slightly dislodged."



platform corners and provided error bounds (confidence areas). I can fix the locations of the platform corners to within 4 centimeters, and the casing corners within 10 centimeters.

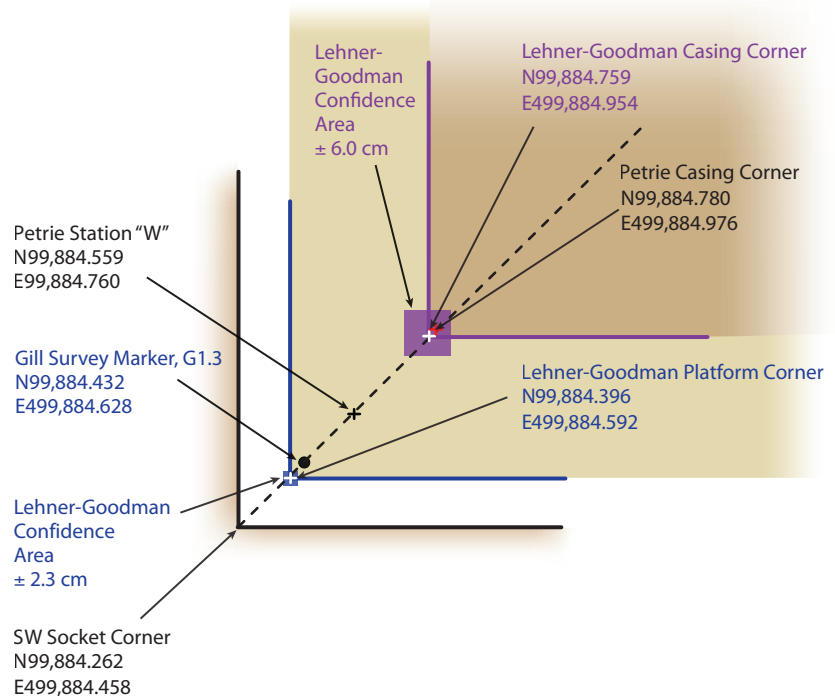
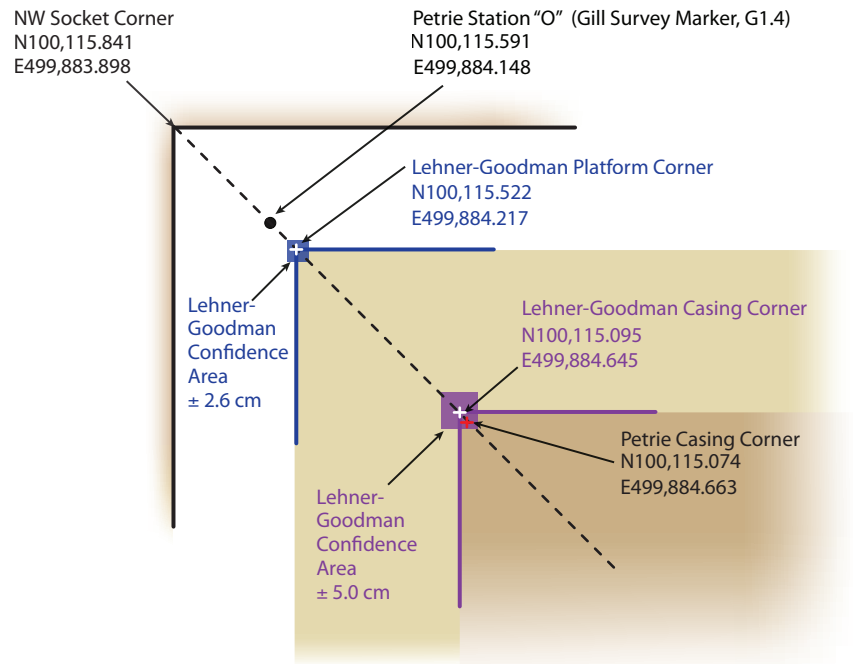
The mean of the Lehner-Goodman estimates for the casing corners are remarkably close to Petrie's. The largest deviation between the two is on the northwest and is less than 4 centimeters (1.6 inches).

ACKNOWLEDGEMENTS

I wish to thank the following people who aided me in the preparation of this article. Jeff Stefanik, a professional surveyor with CME Associates of Woodstock, CT, helped establish the protocol I used to complete my February 2012 survey of the Great Pyramid's base. Dr. Robert Craig of Bird Conservation Research, Inc., of Putnam, CT, provided me with valuable insight into the proper methods of statistical analysis needed to analyze the data. Glenn Harrison of Fairfield, CT, performed some of the statistical analysis and re-checked my calculations.

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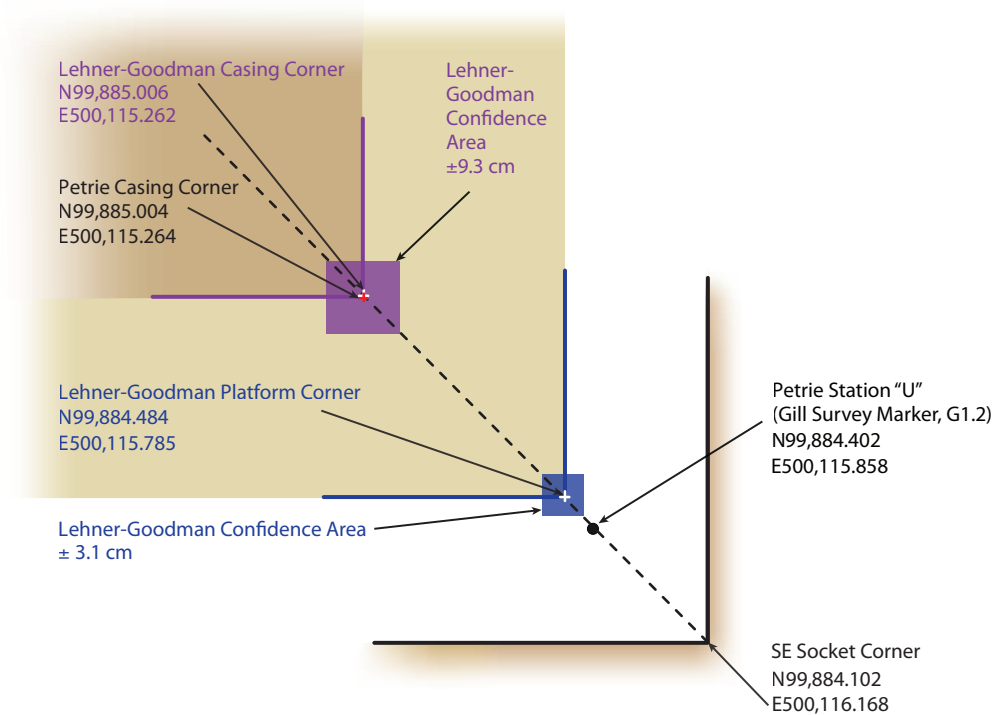
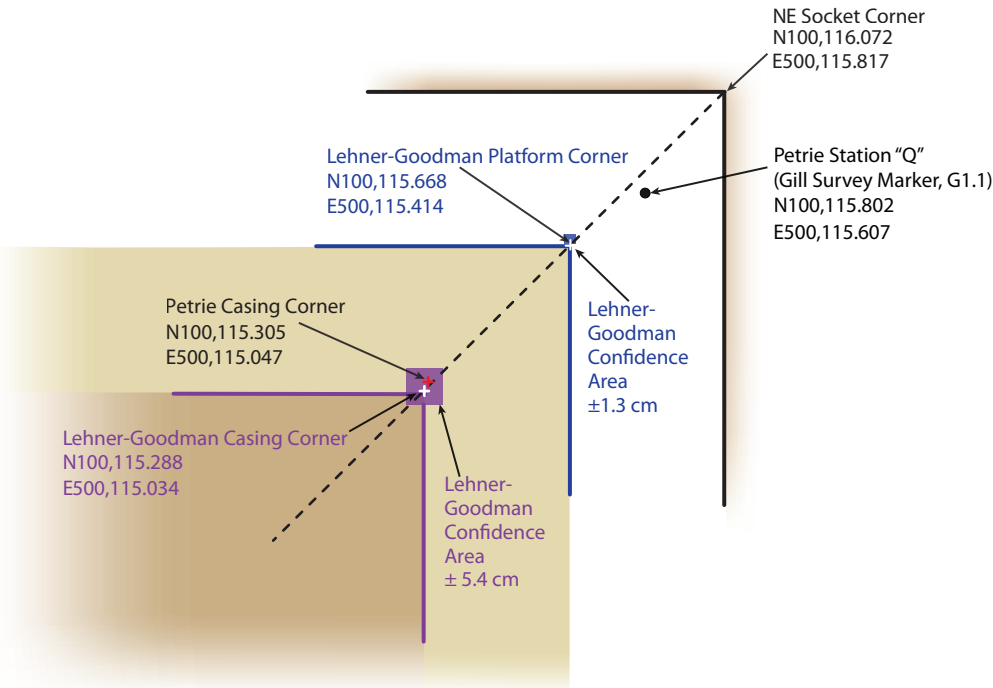




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Living on a Slope in the Town of Queen Khentkawes

by Ana Tavares, Hanan Mahmoud, and Essam Shehab

Walking around our reconstruction of House E in the town of Queen Khentkawes, Mohsen Kamel, AERA co-field director, exclaimed, “This is totally impossible!” Though we had been aware of the marked slope across the site since 2005 when we began recording the 4th Dynasty town of Queen Khentkawes (the Khentkawes Town or KKT), it was during the reconstruction of House E that the impractical slope of the floor surprised and puzzled us.* How did the inhabitants cope with the slope?

We reviewed the information from our excavation records as to whether the house builders tried to lessen or level the slope within certain rooms by spreading a bed of limestone gravel between the walls. We had to go on what was left after Selim Hassan excavated the entire town in 1932 and 75 years of subsequent decay and erosion. We found that the builders managed to keep brick courses horizontal and that they tried to compensate for slope within rooms but could not totally eliminate it.

Recording the Town: Mission Accomplished

This past spring, Essam Shehab and an all-Egyptian team cleared, surveyed, and mapped the last three houses on the west, bringing to completion the archaeological recording of the KKT that we began in 2005 (maps of KKT are shown on pages 3 and 7). With our meticulous methods, it took seven seasons to carefully document the town that Selim Hassan excavated in a single season. Hassan mapped at a scale of 1:200; we mapped at 1:20. We photographed and described every visible archaeological feature, including walls, deposits, and floors. Such careful mapping and recording allowed us to save information previously discarded or misunderstood. Our targeted excavations revealed the town’s original layout, development,

and longevity. We excavated House E in its entirety, finding out about the construction of the house. Finally, we protected the ancient remains with a mudbrick reconstruction over them.

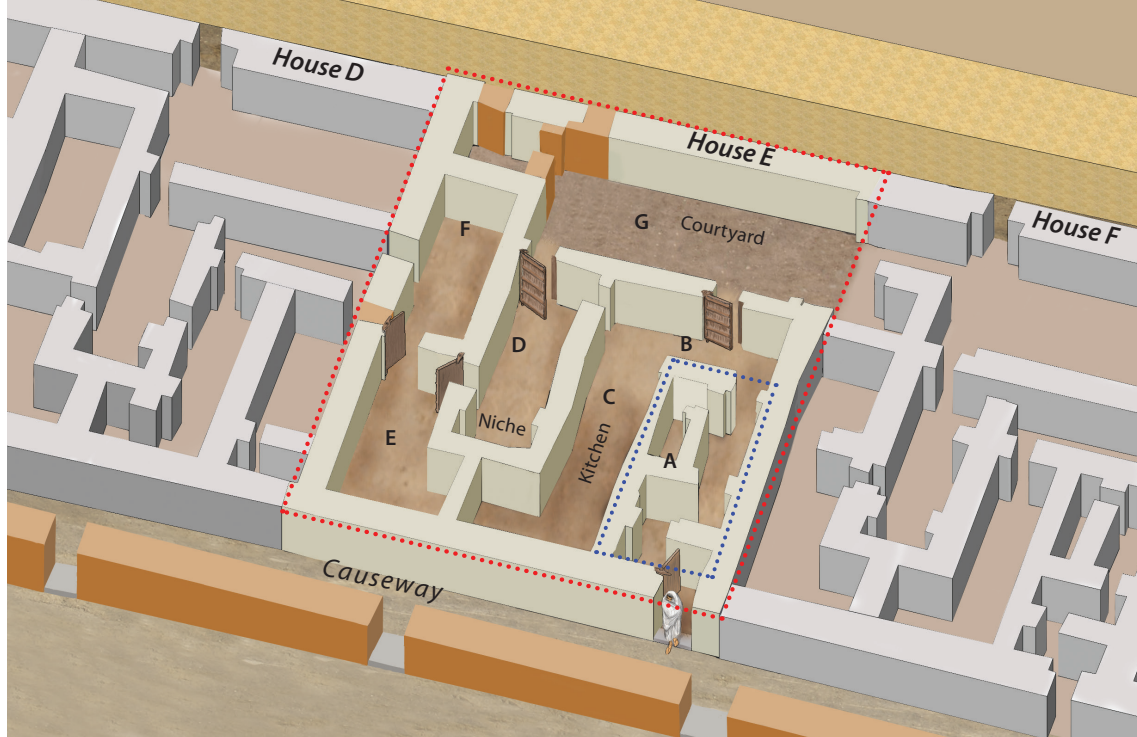
The work at KKT has radically altered our understanding of the town and brought to light many baffling features. We now know that the town was occupied over a long period of time, that there were various phases of rebuilding and a distinct phase of abandonment, and that the town functioned with a valley complex to the east. Puzzling features are changes in access and movement between different parts of the town and within house features, such as blocked rooms; how rooms were lit and ventilated; if they had upper floors; and, most startling, sloping floors, which are discussed below.

The Strange Case of the Sloping Town

A striking feature of the KKT is its unsuitable location. This priests’ town is positioned where it should be—near the funerary monument it serves—but the physical location presented substantial building problems. When the ancient Egyptians laid out new settlements on the level floodplain or relatively flat low desert, they required little preparation. This is the case at the Lost City of the Pyramids (also called Heit el-Ghurab), a city for housing the pyramid builders, which AERA has been excavating since 1988 to the southeast of the KKT site (both sites are shown in the map on page 3). Here many buildings, such as the galleries in the Gallery Complex—possibly used as barracks—and the Royal Administrative Building—a large compound with grain silos and evidence of crafts and administration—were laid down with little levelling or other preparations. These structures have hardly any foundations, with the brick walls being built directly on sand, sometimes in a shallow foundation trench, or upon older settlement deposits.

The area chosen by Khentkawes for her priests’ town stands in great contrast to the Heit el-Ghurab site. Khentkawes lived at the end of the 4th Dynasty when Giza had already been extensively quarried and built up during the earlier reigns of Khufu,

* Articles about our work at the Khentkawes Town have appeared in previous issues of our newsletter. *AERAGRAM* 9-2, Fall 2008, pages 8–11, presents an overview of our findings and results of the 2008 field season. *AERAGRAM* 10-2, Fall 2009, pages 10–13, describes the excavations of House E. *AERAGRAM* 12-1, Spring 2011, pages 16–18, discusses the House E conservation project. All back issues of *AERAGRAM* are available for free download at our website: aeraweb.org.



A well-appointed house: House E showing five elongated north-south spaces (A, C, D, E, and F), one transversal room (B) and an open courtyard (G). The size and layout of these modular houses, each approximately 189 square meters (2,034 square feet), reflects the high status of the inhabitants.

Facing page: The mudbrick reconstruction of House E highlights the slope across the site and within a single house (compare the man in the foreground left with the one standing in the entrance to the house, in the background on the right). The overall site slope is very marked and needs to be taken into account when reconstructing the ancient town. Because the ancient structures are badly eroded and the site is vast, the drop in levels is difficult to visualize. View to the east.

Khafre, and Menkaure. She built as her funerary monument a mastaba above a protruding block of limestone bedrock that remained from three generations of quarrying on a massive scale. Her tomb occupied a commanding position of the wadi and delivery area at the low, southeastern base of the Giza Plateau. Mark Lehner suggests this knoll was purposely left un-quarried and may have served as a surveyors' point for the building of the pyramids and adjacent valley temples.* The KKT is laid out east of the queen's monument, along the southern edge of the older quarries, on a broad quarry shelf, sloping down about 6° from northwest to southeast.

As Hassan published a plan with no elevations, this pronounced slope—a striking aspect of the settlement—went unnoticed. After the 1932 excavation the mudbrick ruins were left uncovered and eroded rapidly, further obscuring the contours. The causeway, 150 meters long (492 feet), drops from an elevation of 28.5 meters above sea level on the west, at the entrance of the Khentkawes chapel, to 18.5 meters above sea level at the doorway to the valley complex on the east, a slope of 1:15. In the “foot” of the town the builders compensated for the east-west drop by using debris to build up a terrace, but the north-south slope is almost as severe as that of the causeway, a 6-meter (19.7

feet) drop over a distance of 85 meters (279 feet). Although such drops in elevation can be dealt with easily in towns by terracing, or building individual structures at different levels accessible by stairs and ramps, the consequences are more conspicuous within individual houses.

Coping with Slope

The 1932 excavation removed occupation deposits and later floors. Ancient remodelling and severe erosion since the original excavation complicated the picture further. We were, however, able to recover the original modular plan of the houses. This consists of five elongated north-south spaces (A, C, D, E, and F), and one transversal room (B) leading to an open courtyard (G), on the north at the back of the house. House E measures 15.70 by 12 meters (51.5 by 39.8 feet), making it a substantial house with an area of 189 square meters (2,034 square feet). The house was entered from the southeast, into a rectangular space (A) subdivided by walls into a zigzag passage that allowed for increased privacy as one progressed through the house.

The bedrock of the KKT site provided a solid foundation for building. The problem, however, was that within the House E area the bedrock slopes down across the house (from northwest to southeast) by over 2 meters (6.6 feet). The builders compensated for this by building the main walls out from the lowest point and keeping brick courses horizontal by extending each successive course farther out than the preceding course. They then reduced the slope inside each room by placing a thick, uneven layer of limestone chips between the walls. The thickness of this layer is uneven because of the contour of the underlying bedrock, but always thicker at the south-southeast end of the rooms. Then they laid the floors above this layer. This, however, was not enough, and the long north-south rooms (particularly

* For more information about the quarrying around the monument see Mark Lehner's article "Khentkawes and the Great Circle of Quarrying" in *AERAGRAM* 9-2, Fall 2008, pages 14-15.

D and E) still had clearly sloping floors, as shown in the section drawing on the right. Despite previous excavations and subsequent site erosion, we were able to ascertain floor levels from thresholds and doorsockets, fragments of floor, and traces on wall plaster.

Slopes, Ramps, and Steps

When a drop in level is evident across other ancient Egyptian settlements, piecemeal solutions seem to have been adopted. At the Stone Village, a workmen's small hamlet at Amarna in Middle Egypt, a 7-meter (23 feet) drop across the village was not surmounted with terraces, but in a haphazard way by either building up floor levels with debris or cutting down into the marl desert clay.¹ Despite this, floor levels varied within houses and necessitated steps between rooms. A similar situation is clear at Deir el-Medinah, the village of the New Kingdom royal tomb builders at Thebes. Here floor levels varied from room to room, requiring much stepping up and down as the inhabitants moved through these houses. At Ayn 'Asyl in the Governors' Palace, dated to the 6th Dynasty, level floors were also not a priority. The floors were uneven from the start and were patched as they subsided, but no effective attempt was made to correct slope or evenness.²

Ramps, often with central shallow steps, are ubiquitous in formal Egyptian architecture. They allow access between terraces, courtyards, and rooms. The Egyptians obtained an increasing sense of privacy as one progressed through a building by raising the floor and lowering the ceiling. This is well attested in temple architecture but is also present in domestic architecture, for example, at Heit el-Ghurab in Gallery III.4* where the floor rises by a total of 1.18 meters from the entrance to the back rooms. In House E the rising floor was particularly noticeable on entering the house, through the narrow, ramp-like zigzag passage (Space A in the drawing on page 21). This liminal zone was a deliberate way of increasing privacy not only by restricting access but by creating a sense of disorientation as visitors entered from a bright street into a dark, twisting, and steep passage before arriving in the main rooms. However, once in the main house, the slope is mostly reversed because of the site topography. As one progressed into the more private rooms of the house (through C, D, E, and F) the floors slope down, not up. For example, in Room D the floor sloped by 60 centimeters over 6.30 meters (23.6 inches over 20.7 feet), as shown in the drawing on the right. That is a drop of 9.5 centimeters for each meter (that is 1:10.5). How did the inhabitants cope with this?

Staying Low

Why didn't the inhabitants consider these houses unusable



How did they cope? A north-south section through House E showing floor slopes of the mudbrick reconstruction, with floor elevations indicated in meters above sea level (asl). After excavation we buried the ancient house under a protective layer of sand and encased the upper part of walls with mudbrick. We then built a mudbrick replica of House E above the ancient house. Original floors were evident from the excavation of doorsockets, door sills, debris levelling layers, fragments of floor, and traces of junction between floors and wall plaster. The lower part of the walls is based on our mudbrick reconstruction. The upper part of the walls and roofing are based on a hypothetical reconstruction by Felix Arnold (F. Arnold, "Die Priesterhäuser der Chentkaues in Giza." *Mitteilungen des deutschen archäologischen Instituts, Kairo*, vol. 54, 1998, pages 2-18).

given the sloping floors? Ancient Egyptian furniture and life-style may provide a partial explanation. Many cultures, including modern cultures in the Middle East and Far East, prefer living with low furniture, and many activities are carried out sitting, kneeling, or squatting on the floor. This was the case in ancient Egypt, where inhabitants favored low furniture such as stools, chairs, and beds, ranging from the simplest stone and reed pieces to sophisticated wood furniture, inlaid and gilded. Wood suitable for making furniture was a rare commodity in Egypt, and modest households often used stone, reed, leather, and matting as an alternative. Although conditions at the Heit el-Ghurab site do not allow for the preservation of organic materials, we have found low tables and fragments of stools made of stone, like those on the facing page. For storage, the ancient Egyptians used boxes and baskets placed on the ground, or pottery jars partly buried in the floor, or placed on low stands. In the Heit el-Ghurab galleries we found low sleeping platforms, which, probably covered with a simple reed mat, served as beds. Those who have camped "roughing it" with sleeping bags on the ground and food cooking over a campfire or have lived in a traditional Middle Eastern or Japanese style will know that short-legged furniture, and generally living on the ground, lessens the problems with slope and unevenness, while high-legged furniture accentuates the need for level floors. The priests of the KKT Town would have used this type of low furniture, which lessens the problems of uneven or sloping floors.

Or, people ate, slept, and worked directly on the floor, probably on mats, using very little furniture. Old Kingdom tomb scenes show a great range of activities on the floor: traders in markets exchanging wares placed on the ground before them; in workshops craftsmen making artisanal goods as they kneel

* Gallery III.4 is described in *AERAGRAM* 6-1, 2002, pages 4-5.

or squat on a low brick; and scribes recording with a papyrus scroll stretched across their laps, in front of a low table or near chests and boxes for storing documents, scribal tools, and papyrus rolls, all resting on the floor. The scenes show, directly on the floor, ancient Egyptians playing board games, receiving guests, and enjoying musicians at banquets. Objects found at both the Heit el-Ghurab and KKT sites provide evidence for many of these activities. Living close to or upon the ground with low furniture may explain why a sloping floor may have been an inconvenient, but not insurmountable, obstacle to the inhabitants of the KKT houses.

More Questions than Answers

AERA's work at the town of Khentkawes has produced more questions than answers. The KKT priests' town was built in a difficult area. The ground slope was dealt with in a pragmatic, piecemeal manner, but builders could not compensate fully for the topography. Slope was particularly striking within individual houses. House size and layout were commensurate with the high status of the occupants, and yet inconvenient features such as sloping floors, were acceptable. Ancient Egyptian lifestyle and furniture may in part explain why living on a slope was tolerable. The excavation and reconstruction of House E has also highlighted other questions about light and ventilation, use of rooms, and flow of space. These questions are our driving motivation as we place the Khentkawes Town and its structures in the wider context of Egyptian urbanism and ancient Egyptian culture.

Structures of everyday life. Household furniture was mostly low; short-legged beds, chairs, tables, and stands complemented with mats and low stools. We have found limestone fragments of table-stands and stools at the Heit el-Ghurab site, similar to these three examples currently in the Petrie Museum, London (UC 16530, UC 16532, and UC 64713). Courtesy of the Petrie Museum.



Low furniture minimizes the problem of sloping or uneven floors. The chair, on display at the Metropolitan Museum of Art, New York, is from Dira Abu el-Naga, ca. 1550–1425 B.C., Thebes. The Met provides this information: "This low, wooden chair, with its straight back, legs carved in the form of a lion's legs, and mesh seat, is characteristic of chairs used by women in Egyptian wall paintings of banquet scenes. The chair is held together with pegs and dowels; the angle braces are carved from forked branches. The central slat in the back and a few minor repairs are modern, and the mesh seat has been restored following indications provided by remnants." "Tamarisk wood, reed. Overall: H. 58.8 cm (23 1/8 in); w. 43.3 cm (17 1/16 in); d. 47.5 cm (18 11/16 in) seat: H. 19.3 cm (7 5/8 in); w. 43.3 cm (17 1/16 in); d. 45.7 cm (18 in). 3/4 Left view. Rogers Fund, 1912 (12.182.28)." Photo Credit: image copyright The Metropolitan Museum of Art. Image source: Art Resource, NY Image Reference: ART403815, Image size: 4812 X 5002 px.

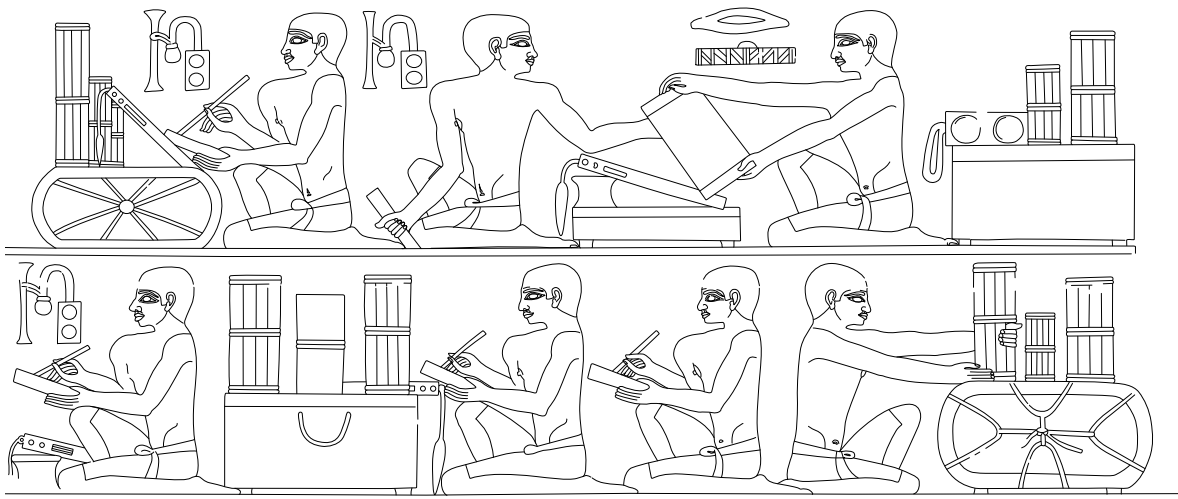


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1. A. Stevens, *Akhenaten's Workers, The Amarna Stone Village Survey, 2005–2009. Volume I: The Survey, Excavations and Architecture*, Excavation Memoir 100, London: Egypt Exploration Society and Amarna Trust, 2012, pages 23–68.
2. G. Soukiassian, Balat 6. *Le palais des gouverneurs de l'époque de Pépy II: Les sanctuaires de ka et leurs dépendances*, Cairo: Institut français d'archéologie orientale, 2002, pages 281–283.



Low living. Tomb scenes show a great variety of activities taking place while sitting on low furniture or directly on the floor. Here a scribal office depicted in the 5th Dynasty tomb of Ti at Saqqara, shows scribes kneeling on the ground, while working in front of low tables laden with writing equipment and boxes. After L. Épron, *Le Tombeau de Ti*, Cairo: Institut Français d'Archéologie Orientale, 1939.

Egypt's Oldest Olive Pit at the Lost City of the Pyramids

On the basis of archaeological evidence, Egyptologists say that olives first arrived in Egypt during the 18th Dynasty, and even then were a rare commodity. Egyptologists would never expect to find olives at an Old Kingdom site. Yet, this past season, AERA archaeobotanist Claire Malleson discovered two halves of a charred olive pit in an ashy sample from the Lost City of the Pyramids excavations.

The charred olive pit pieces turned up in Gallery III.3, one of the elongated structures in the middle of the Lost City of the Pyramids (also called the Heit el-Ghurab site, map on page 3), which may have served as a barracks.

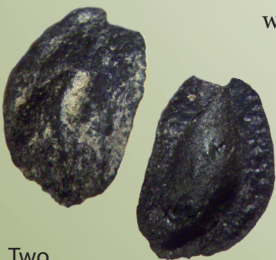
Prior to this discovery, the earliest finds are fragments from a context with a dubious 13th Dynasty date at Memphis, then capital of ancient Egypt. The most reliable early finds of olive come from the 18th Dynasty. The earliest evidence for cultivation of olives in Egypt dates to the reign of Ramesses III (20th Dynasty), but Egypt's climate does not suit olive growing.

We might reject our exceptionally early find as intrusive material from later periods, but the olive pit halves came from a sealed deposit with no evidence of later disturbance. So how do we account for this olive at 4th Dynasty Giza so much earlier than any other examples in Egypt?

Perhaps the olive came with a shipment of olive oil, which was imported from the Levant and Libya beginning as early as the 1st Dynasty. Levantine oil, scholars believe, was transported in vessels of combed ware, a hard ceramic named for the striations scratched in the clay before firing. We have found fragments of combed ware at the Lost City site, suggesting that olive oil might have been delivered to the settlement. It may have held olive oil for elite residents. Or, perhaps it was stored there before going to the Giza Necropolis, where it was placed in tombs as an offering. More than 50 complete combed jars have been found in the mastaba tombs of high officials.

The olive pit is not our first evidence of olive at the Heit el-Ghurab site. Since 2002 charcoal analyst Rainer Gerisch has found bits of charred olive twigs scattered throughout the settlement—the oldest olive wood in Egypt.* The twigs, probably prunings, may have come with shipments of olive oil from the Levant. The twigs could have been packing material around oil storage jars. Perhaps our olive pit traveled with these twigs? If the olive wood did

0 1 5 mm



Two halves of a charred olive pit found at the Lost City site. Photo by Claire Malleson.

*The olive wood finds are described in *AERAGRAM* 9/1, Fall 2008, page 3. All back issues of *AERAGRAM* are available for free download at our website: aeraweb.org.

indeed travel with combed storage jars, we can pin the source down more precisely. Our combed ware came from the area now within the modern country of Lebanon, most of it from a region between Beirut and Byblos, according to ceramicist Mary Ownby who determined its provenance through analysis of the clay.†

Rainer found the olive wood associated with bits of other Levantine woods, such as cedar, pine, and oak, suggesting yet another possible explanation for our olive pit. When Egyptian crews went to the Levant to fell trees for timber, they may have taken kindling for the return trip, a voyage as short as five days. Among the twigs and other material they picked up for their fires, a stray olive—perhaps a spoiled fruit—might have lurked. Since our specimens are charred we know that the olive ended up in a fire, although we cannot say if that was intentional.

Our olive specimen most likely arrived at Giza by accident, but we plan to consider other options, such as the possibility that someone attempted to import a live olive tree.

† M. F. Ownby, "The Importance of Imports: Petrographic Analysis of Levantine Pottery Jars in Egypt," *Journal of Ancient Egyptian Interconnections*, vol. 4:3, pages 23–29, 2012.





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