

GPMP Full Circle

Thanks to the inspiration and support of the Glen Dash Foundation, we have come full circle, returning to the mapping of major Giza Plateau monuments for the first time since David Goodman and I laid out the basic survey control in 1984. That year we initiated the Giza Plateau Mapping Project (GPMP), aspiring to produce a comprehensive topographic and archaeological map of the plateau and its monuments. As the acronym for our project was the GPMP for years, many people still write asking for exact coordinates on the corners of the three large pyramids and precise positions of temples, tombs, and major walls (see page 19).

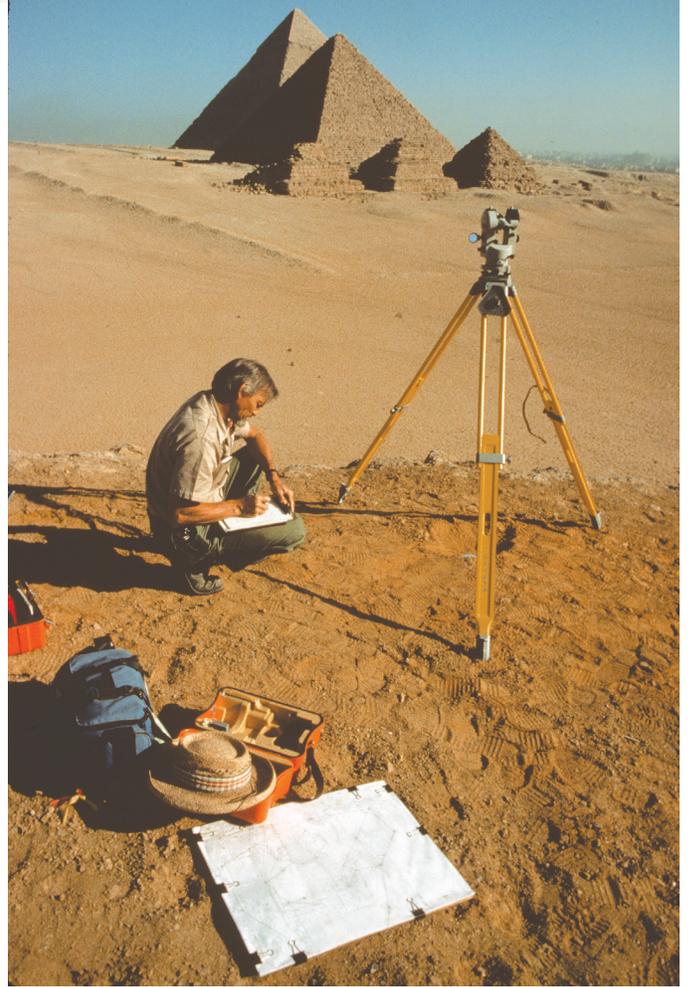
Point of Beginning

David, longtime senior surveyor for the California Highway Department, directed us as we set and measured control points on a closed loop traverse around the entire Giza Plateau. We intended to produce the overall map with aerial photogrammetry—stereoscopic pairs of photographs from which 3-D elevations and contour lines could be plotted showing shapes and forms of the landscape. Before LIDAR (Light Detection and Ranging, laser scanning) and widespread use of GPS (Global Positioning System), David's protocol was the professional way to set control for surveying a map of such a large area. David plotted the flight lines on the best existing maps for overlapping photo pairs. But we never obtained permission for the aerial photography.

So the best maps of Giza, and most of the other pyramid sites from Abu Roash to Dahshur, remained a 1:5,000 series produced in 1977 by aerial photogrammetry for the Egyptian Ministry of Housing and Reconstruction (MHR). These map sheets show the surface contours at one-meter intervals as of 1977. In 1991 Peggy Sanders at the Computer Lab of the Oriental Institute, University of Chicago, digitized, under my guidance, the contour lines from the two MHR map sheets that covered the Giza Plateau.

In overall maps of the Giza Plateau that we have since published, the locations of the "Lost City," the Khentkawes Town, and the Menkaure Valley Temple are precise. But the positions of pyramids, temples, and tombs on the high plateau are based on the MHR map sheets, maps prepared by the major excavators of the first half of that century—George Reisner, Hermann Junker, Selim Hassan—and other published sources. Except for the MHR maps, the other maps have no vertical information (spot heights or contours).

Our maps, like most maps, reconstruct neat, highly schematic outlines of the ancient monuments from ruins on the ground. For example, in our maps the Menkaure causeway,



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1984: the beginning of the Giza Plateau Mapping Project. David Goodman records survey data for the control network that he and Mark Lehner set up across the Giza Plateau.

straight and bold, is a graphic reconstruction that does not exist as far as we know for much of the distance between the Menkaure Upper Temple and the Valley Temple.

Busy: Lost City and Field Schools

Over the years, it would have been easy for our surveyors to satisfy numerous requests for exact coordinates of the pyramids—once we decided where the original corners were, corners that have not existed for thousands of years (see page 19).

But we got busy. We salvaged, excavated, and mapped the urban sprawl of the Lost City and conducted nine field schools, all of which took us away from locating precise points on pyramids. As I have explained to many petitioners, our mapping project became less about the exact relations between pyramids, the Sphinx, tombs, and temples, and more about adding major missing components to the archaeological map of Giza—principally, the settlements where people lived while building and servicing the great necropolis.

In fact, in 1984–85 David Goodman and I did survey the base points of the Khufu Pyramid. We did not publish the survey, but used the corner points, marked with brass plugs (see page 19) to calculate a center for the Khufu Pyramid and define it as N100,000 and E500,000, setting the values for the GPMP grid. And over the years, we have used the GPMP grid to survey

and hand-map many other features of the Giza Necropolis. With this season's work we now pull together many years of disparate maps.

Giza Plateau Parts: Mapping Here and There

Through the years, the GPMP survey control network has provided invaluable points for establishing a local grid over the entire Giza Plateau and for locating any feature to great accuracy in terms of the grid. The GPMP survey control was indispensable for recording the remains of the Lost City and for teaching best standard practice in archaeological excavation and recording.

In addition to mapping our own sites with great precision and detail, we have mapped sites for Dr. Zahi Hawass and the Supreme Council of Antiquities (now Ministry of State for Antiquities): the AMBRIC trenches that hit the foundations of the Khufu causeway (1991), the remains of the Upper Temple of the Khufu Pyramid (1995), the Khufu satellite pyramid (1995), the pyramids of Khufu's queens (1995), the eastern Khufu boat pits (1995), the area east of the Khafre Valley Temple (2002), the Menkaure causeway ramp (2004), and the construction ramp along the southern wall of the Western Cemetery (2005).

We mapped some of these features by measuring many points with Total Station survey instruments. We mapped others by hand, as we do our excavation squares, by offset measures from datum lines strung between grid control points. My pre-GPMP hand-mapping included the Sphinx, Sphinx Temple, and Khafre Valley Temple, where I used my own local grid and control points. These facsimile maps represent reality on the ground. Most of the resulting maps are at very large scales: 1:20, 1:50, and 1:100. They all have many spot heights with respect to meters above sea level.

GPMP and GIS: A Layered Archaeological Map of Giza

Now, as part of the Glen Dash Foundation Survey (GDFS), in collaboration with the Boston Museum of Fine Arts/Harvard University Giza Archives Project directed by Peter Der Manuelian, we are bringing all of our survey data and hand-drawn maps together with maps of previous missions into one single map in our Geographic Information System (GIS). When finished, it will encompass a large percentage of the archaeological map of Giza—the initial goal of the GPMP.

In 1984 neither David Goodman nor I dreamt of AERA owning our own GIS. Thanks to Farrah Brown, Camilla Mazzucato, and Rebekah Miracle developing and growing our own Giza GIS since 2005, the newly comprised overall map is itself layered like a stratified archaeological tell. We can turn on and off the various layers: older maps, the Ministry of Housing and Reconstruction maps, our own survey points, as well as plot the distributions of anything from fish bone (in the settlements) to titles (tomb texts and clay sealings).

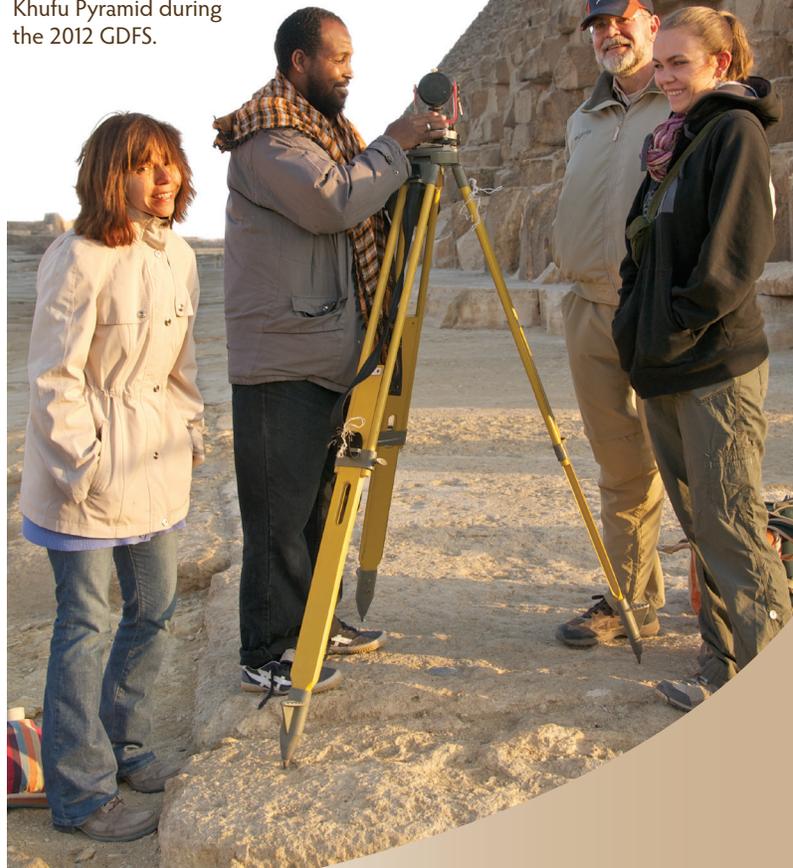
With support from the Glen Dash Foundation, Rebekah Miracle, AERA GIS director, visited the Boston office in 2011. Together we assembled all of our survey points and hand-maps of features, sites, and monuments for Rebekah to subsume this decades of data harvest into the best compilation and map of Giza that exists.

And finally, after so many years, during Season 2012 we aimed our Total Stations on the major monuments, capturing additional points to geo-rectify the pyramids, temples, causeways, and major tombs as we also maintain our survey control network. In February, Joint Field Director Mohsen Kamel and I spent several mornings with the 2012 survey team: Surveyor Mohammed Abd el-Basat, Apprentice Surveyor Amer Zakaria, Assistant Surveyor Mohamed Hilmy, Documentation Recorder and Photographer Yaser Mahmoud, and Assistant Photographer Osama Hassan.

We reconnoitered each major pyramid, temple, causeway, and tomb to decide where best to take points on what we believe to be original builders' lines. As the team subsequently carried out the survey, they gave each point (of thousands) a number and documented it with a photograph, description, and date. Team members sketched each corner and wrote notes on where and why they took particular points.

In the third week of February, Glen, Joan and Becky Dash and James Bishop joined the survey team, working to establish closed loop surveys for the Khufu Pyramid and Sphinx for greater confidence and accuracy. The Dash Survey team took hundreds of points

Joan, Glen, and Becky Dash with surveyor Mohammed Abd el-Basat next to the Khufu Pyramid during the 2012 GDFS.



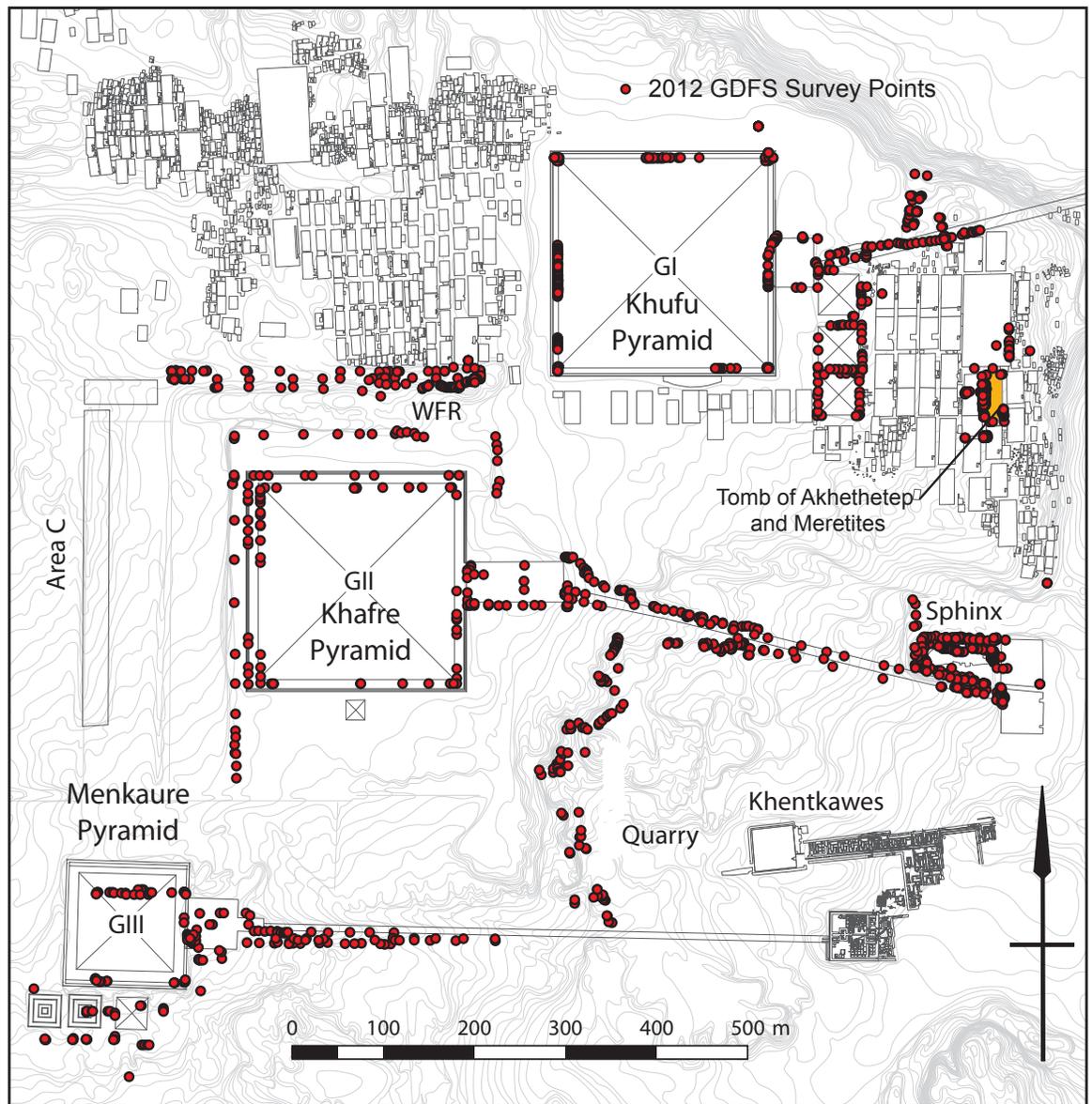
Mark Lehner

with a Total Station on the remnants of Khufu's builders' original lines, allowing precise coordinate and distance measurements with an infrared beam.

We thank the Glen Dash Foundation for bringing us back to our point of beginning (as surveyors call the opening and closing point of a traverse loop), and look forward to contributing to a new and comprehensive map of the ancient Giza Necropolis.

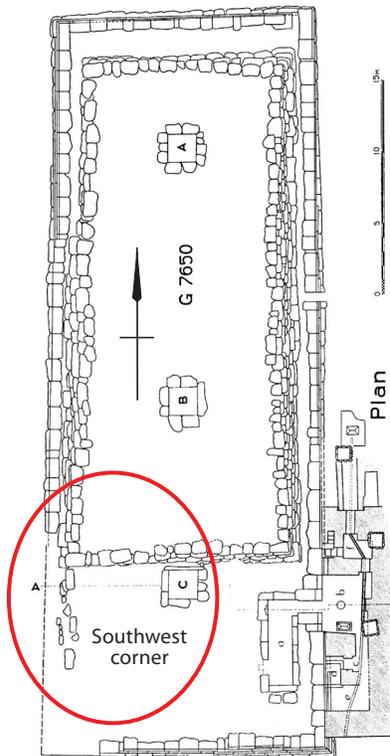
~ Mark Lehner

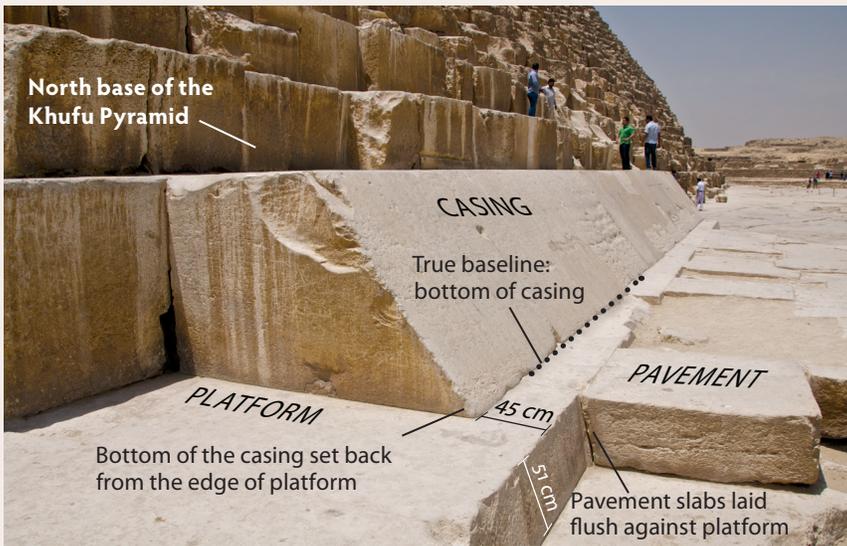
Right: Survey points taken by the 2012 Glen Dash Foundation Survey Project, shown in red. The 2012 survey reveals a need to shift southward the Menkaure Pyramid (GIII), temple, and causeway. WFR stands for Western Field Ramp, an ancient construction embankment along an unfinished colossal stone wall. Map prepared by Rebekah Miracle, AERA GIS.



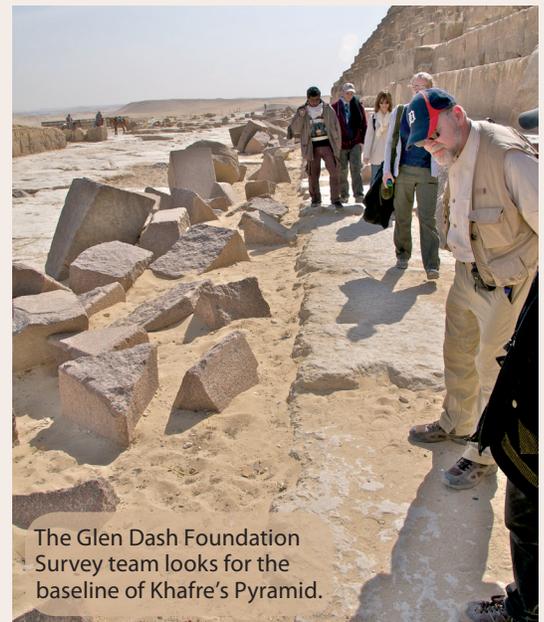
Left: George Reisner's map of mastaba G7650, the 4th Dynasty tomb of Akhethetep and Meretites in the Eastern Cemetery at Giza, marked in yellow on the map above. From G. A. Reisner, 1942, *A History of the Giza Necropolis*, Vol. 1, Cambridge: Harvard University Press, page 47, fig. 9.

Below: Recent photo of G7650. View to the northeast. The dashed line on the photo shows the extrapolated southwest corner. When Reisner mapped the tomb, the southwest corner and portions of the west and south sides were already gone. View to the northeast. Photo by Yaser Mahmoud.





Mark Lehner



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The Glen Dash Foundation Survey team looks for the baseline of Khafre's Pyramid.

Corner Conundrum: A Mapping Mantra

If we had clear-cut lines and corners, we could give precise coordinates for the pyramids to those who believe this is meaningful in terms of the builders' intentions. But, could the builders have measured distances to an accuracy of millimeters or centimeters over hundreds of meters, given sighting by eye without our telescopic instruments and challenges such as the stretch and sag of a rope?

Maps are by nature abstractions based upon assumptions, estimates, and interpretations. Mapmakers transform complicated physical realities into neat lines. Maps of the Giza Necropolis represent pyramids, tombs, and temples with clean rectangles, features that ceased to exist centuries ago and in some cases never existed as such.

Khufu's Great Pyramid is a good example. First, the original finished corners, and most of the original baselines, are missing completely. When David Goodman and I surveyed the Khufu Pyramid in 1984, we took measurements from points marked with bronze plugs at three of the corners. The people who set the plugs must have meant them to mark the corners, which they would have established by extrapolating from patches of *in situ* masonry in the foundation platform. Or they may have extrapolated from the line of the platform still visible in the bedrock floor. But this extrapolated line was *not* the baseline of the pyramid. As shown in the photo above, the bottom of the casing, set back from the upper edge of the platform, became the true baseline. But of the original 921.44 meters of this baseline only 54.44 meters remains, less than 6%. Most of this is near the centers of the sides, which makes extrapolations far less accurate than if we had segments closer to either end. With most of the original builders' lines gone, the baseline and dimensions of the Great Pyramid are now our own extrapolation.

When we read of the cosmic significance that some authors place on the exactitude of the Great Pyramid dimensions, we should bear in mind that the original builders' lines are reconstructed from less than 6% of the base.

Mapping the baseline of Khafre's pyramid is no easier. Petrie, who in 1881–82 surveyed the Giza pyramids according to professional stan-

dards of his time, went into the issue: what do we take as the baseline?*

It turns out that Khafre's builders created the baseline of his pyramid simply as a vertical cut in the foot of the bottom course of casing stone, which was granite, so that the slope of the pyramid met the top surface of the pavement of the court surrounding the pyramid. Khafre's builders' custom-cut the natural limestone base underneath the casing to bring the granite blocks flush at the top (it was easier to cut away the limestone than the much harder granite). Only four casing blocks remain in place: two side by side at the far western end of the southern side and another pair near the center of the northern side. We therefore need to take as the baseline the outer edge of the emplacement cuttings, or socle, for the missing casing stones.

The builders never finished making the baseline of the Menkaure Pyramid, as we know from trenches dug into the debris covering most of the base. They shaved the tops of the lowest casing course even and flush, while leaving the bottoms at different levels, accommodating the slope and irregularity of the rough foundation. Maybe they intended, like Khafre's builders, to trim the baseline by cutting a vertical, lower face into the bottom of the slope of the casing blocks. Since they never completed this task, there is no straight and square baseline. Recently the Giza Inspectorate excavated through the debris at the western end of the northern side and showed that Menkaure's builders set the lowest casing here down into a trench cut into bedrock, several meters wide and 1.70 meters deep! We do not know the exact location of the corners, still embedded in debris, but like the pyramids of Khufu's queens, the base footprint is almost certainly a trapezoid.

Mastaba tombs (Arabic for "bench") look like flat-topped, stretched-out pyramids with sloping sides, and they present similar issues. During the Glen Dash Foundation Survey, "Where's the corner?" became a mapping mantra, and even "Where's any good stretch of straight [builders'] line?" For those theorists who demand high precision for pyramid points, we wondered, just what is the point?

*W. M. F. Petrie. 1883. *Pyramids and Temples of Giza*. London: Field and Tuer, pages 96–99.