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Bedrock outcrop reserved from original plateau surface, location of GPMP Survey Point GCF1, north of Khentkawes monument, and the center of a great circle of quarrying (AERAGRAM 9-2: 15). Story on page 3.

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AERA's POB, a Unified Map, and a Quest

The articles by Glen Dash and Rebekah Miracle starting on the facing page and page 10, respectively, bring AERA back to our "point of beginning" (POB) in the Giza Plateau Mapping Project (GPMP). In survey, a POB is a mark at the location where wide-scale land survey starts. In the survey control network that David Goodman designed and set up for us at Giza in 1984, our POB was GP1 (Giza Plateau 1), a point on top of the *Gebel el-Qibli*, the "Southern Mount" of the Maadi Formation outcrop towering above our Lost City site on the southeast and the Khentkawes Town on the northwest.

David's polygon of precisely measured points allowed us to project across the Giza Plateau a theoretical grid, anchored at the center of the Great Pyramid and assigned the coordinate values East 500,000 and North 100,000. We linked this local grid to earth's latitude and longitude through measurements to a Survey of Egypt point at the top of the Great Pyramid. The GPMP grid allowed us to locate with our total stations any point on the plateau to an accuracy of millimeters.

With the coordinating, unifying GPMP grid, we pulled in plateau contours from previous surveys, added our own, and plotted grid square by grid square all the architecture of the Lost City, and, later, the Khentkawes Town. Rebekah reports how the grid, through a GIS (Geographical Information System), also unifies and coordinates not just survey and mapping data, but literally hundreds of thousands of points of information on ancient artifacts and bits of material culture.

In a larger sense, the GPMP is the POB of all that AERA has accomplished and become. That AERA's work began in broad site survey is not only, if I may say so, exemplary archaeological method; it allows us to carry on explorations of the questing sort that brought me to Giza in the first place.

Glen Dash reports on one of his own quests. Working in the Western Valley of the Kings in Luxor, he became intrigued with alignments between the Tomb of Ay in the valley and the Great Karnak Temple, and between both of them and the setting sun at summer solstice. Returning to Giza, he picked up on alignments between the summer solstice sunset and the pyramids that I had observed in my early years at Giza, before the GPMP. I could only guess if the ancient surveyors and builders really intended the gigantic configuration, a writing of the hieroglyph for *akhet*, "horizon" (a sun disk between two mountains) on the scale of acres. Using the GPMP control, Glen put the Giza solstice alignment to the test. He reports results here. His attention turned to a prominent bedrock outcrop (our point GCF1, seen on our cover) that might have been the ancient Egyptian surveyors' POB when they laid out the Giza Plateau for quarrying.

~ Mark Lehner

The summer solstice sunset viewed from the lower terrace in front of the eastern niche of the Sphinx Temple. Glen Dash's observation point OP1 (see pages 4–5) would have been on the roof—now missing—5 to 7 meters (16.4 to 23 feet) above this spot on the floor. Photo by Mark Lehner.

Solar Alignments of Giza *by Glen Dash*

The Giza temples provided for the worship of dead kings. But they may also have served the living as solar observatories.

With the end of the Sphinx Project in 1983, Mark Lehner had completed his hand-drawn-and-measured plans of the Sphinx, the Sphinx Temple, and the Khafre Valley Temple. In a 1985 article, he collected some of his thoughts and observations. One of those concerned the summer solstice, as viewed from a niche at the eastern end of the Sphinx Temple:

> At this time, and from this advantage, the sun sets almost exactly midway between the Khufu and Khafre Pyramids, thus construing the image of the akhet ("horizon") hieroglyph on a scale of acres. The effect is … best seen from the top of the Sphinx Temple colonnade, or an equivalent height to the east of the temple where the sand rises. … Even if coincidental, it is hard to imagine the Egyptians not seeing the ideogram. If somehow intentional, it ranks as an example of architectural illusionism on a grand, maybe the grandest scale.[1]

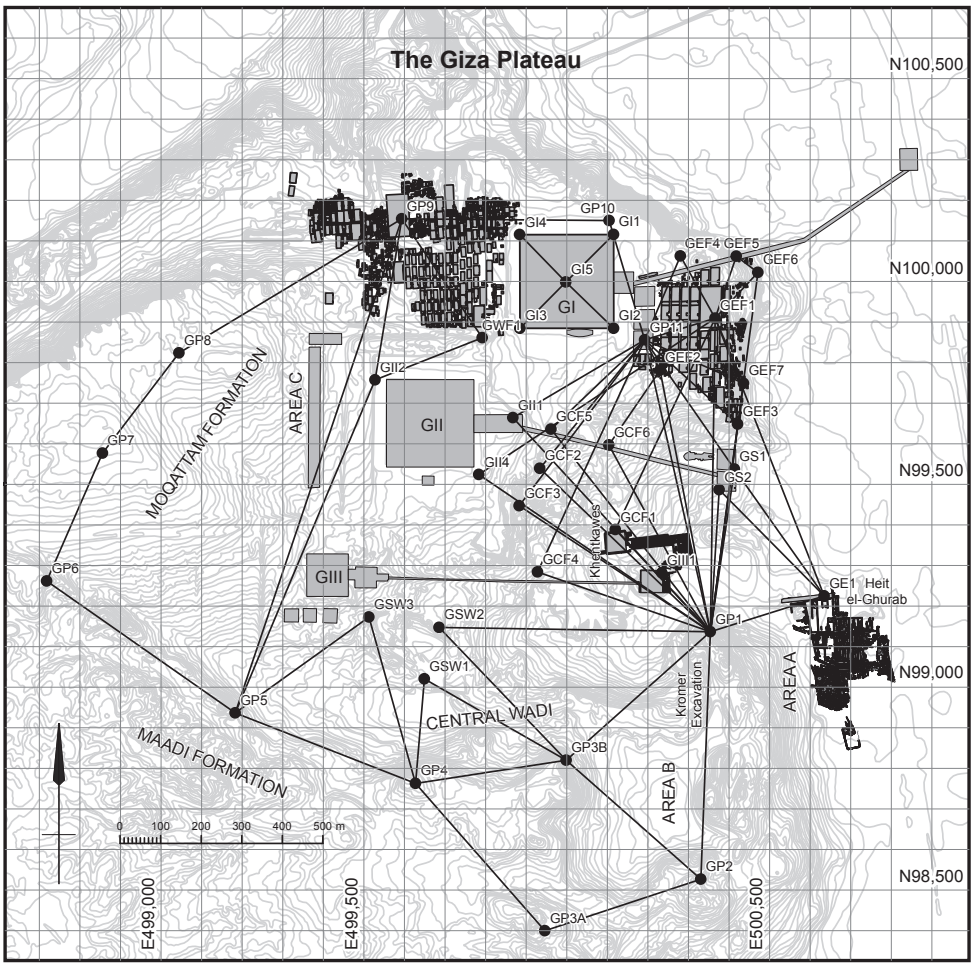
Indeed, the very name of the Sphinx suggests such an association. In the New Kingdom and perhaps before, the Sphinx was known by the name *Hor-em-akhet* or "Horus in the Horizon."

In the same paper, Lehner set forth the goals of a newly envisioned "Giza Plateau Mapping Project":

> In future seasons we would like to survey the Giza Plateau with the primary goal of producing a topographical map of a scale of 1: 1000. … The map is seen as a tool for a functional, spatial, and ecological study of the building of the Giza Necropolis, in addition to its purely descriptive value. It will be possible to check for the accuracy of the apparent alignments mentioned here.[2]

Within three years, that goal had been substantially achieved. The Giza Plateau Mapping Project (GPMP) had established a primary control grid on the plateau accurate to one part in 320,000 and oriented to true north to better than ten seconds of arc.[3]

This data, now combined with years of additional GPMP survey work, allows us to produce maps of unprecedented accuracy, and with them identify those places on the plateau where the Egyptians, by design or coincidence, might have observed the solstices (shown below, left). Our goal here is to test the hypothesis that Giza might have functioned not only as a funerary complex to serve the dead king, but also to serve the living Egyptians as a platform for observing the solstices. In ancient times, the winter solstice was celebrated throughout the Mediterranean as the time of the sun's birth. In Egypt, the summer solstice was associated with the return of the inundation.[4]



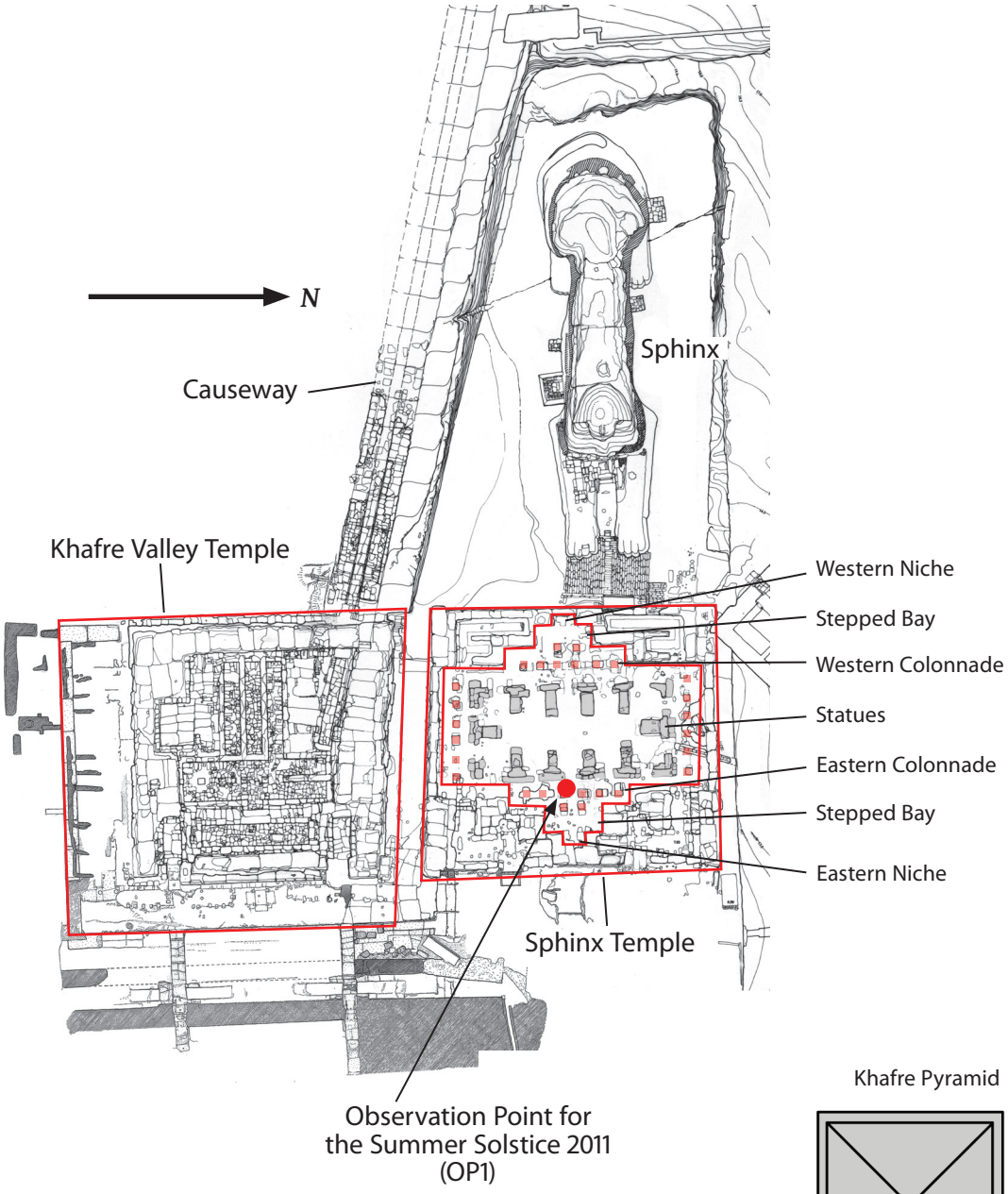
GPMP Map of the Giza Necropolis. To construct this map, AERA's principal surveyor David Goodman first laid in an outer, closed loop of eleven primary control monuments, GP1 through GP11, each serving for both horizontal and vertical (elevation) control. He surveyed these and established their positions relative to one another to an accuracy of better than one part in 320,000. He then established secondary control monuments, and their location relative to GP1 through GP11 using the transects shown. Finally, Goodman picked the center of the Khufu Pyramid as the origin of his map and assigned to it coordinates of North 100,000 meters and East 500,000 meters. Map prepared by Rebekah Miracle, AERA GIS.

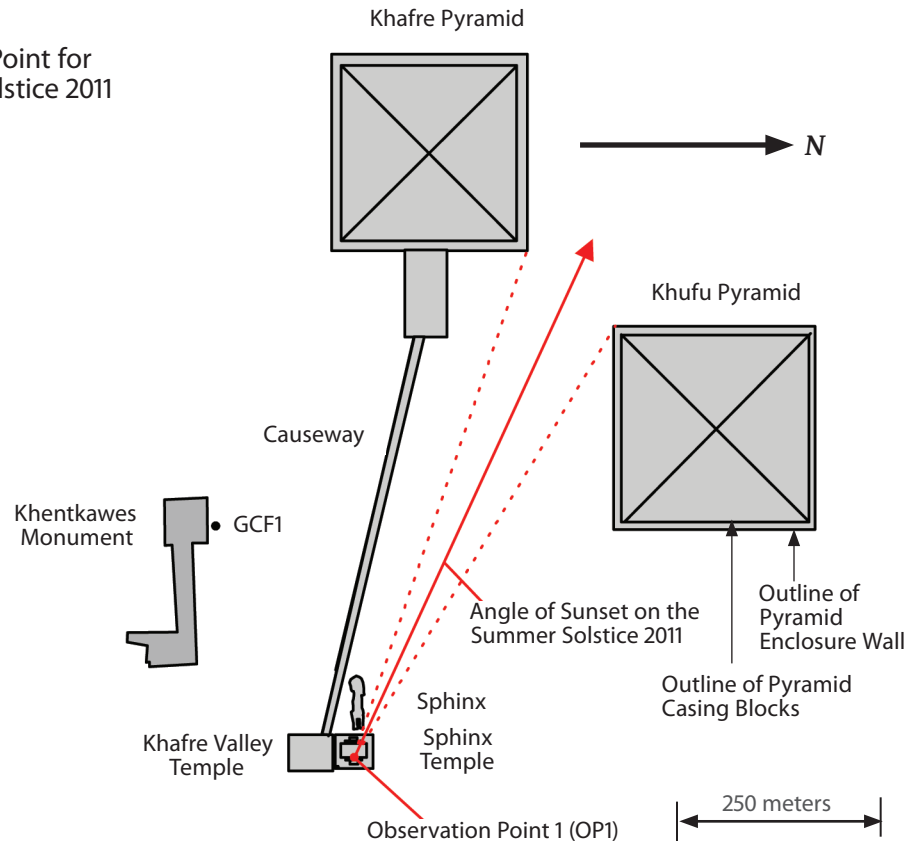
1. M. Lehner, "Giza, A Contextual Approach to the Pyramids," *Archiv für Orientforschung* 32 (1985): 139.

2. *Ibid.*, 147.

3. D. Goodman and M. Lehner, "The Survey: The Beginning," *Giza Reports, Volume 1,* M. Lehner and W. Wetterstrom, eds. (Boston: Ancient Egypt Research Associates, Inc, 2007), 97–98.

4. J. A. Belmonte, M. Shaltout, and M. Fekri, "Astronomy, Landscape and Symbolism: A Study of the Orientation of Ancient Egyptian Temples," *In Search of Cosmic Order,* 1st ed. J. A. Belmonte and M. Shaltout, eds. (Cairo: Supreme Council of Antiquities Press, 2009), 229.





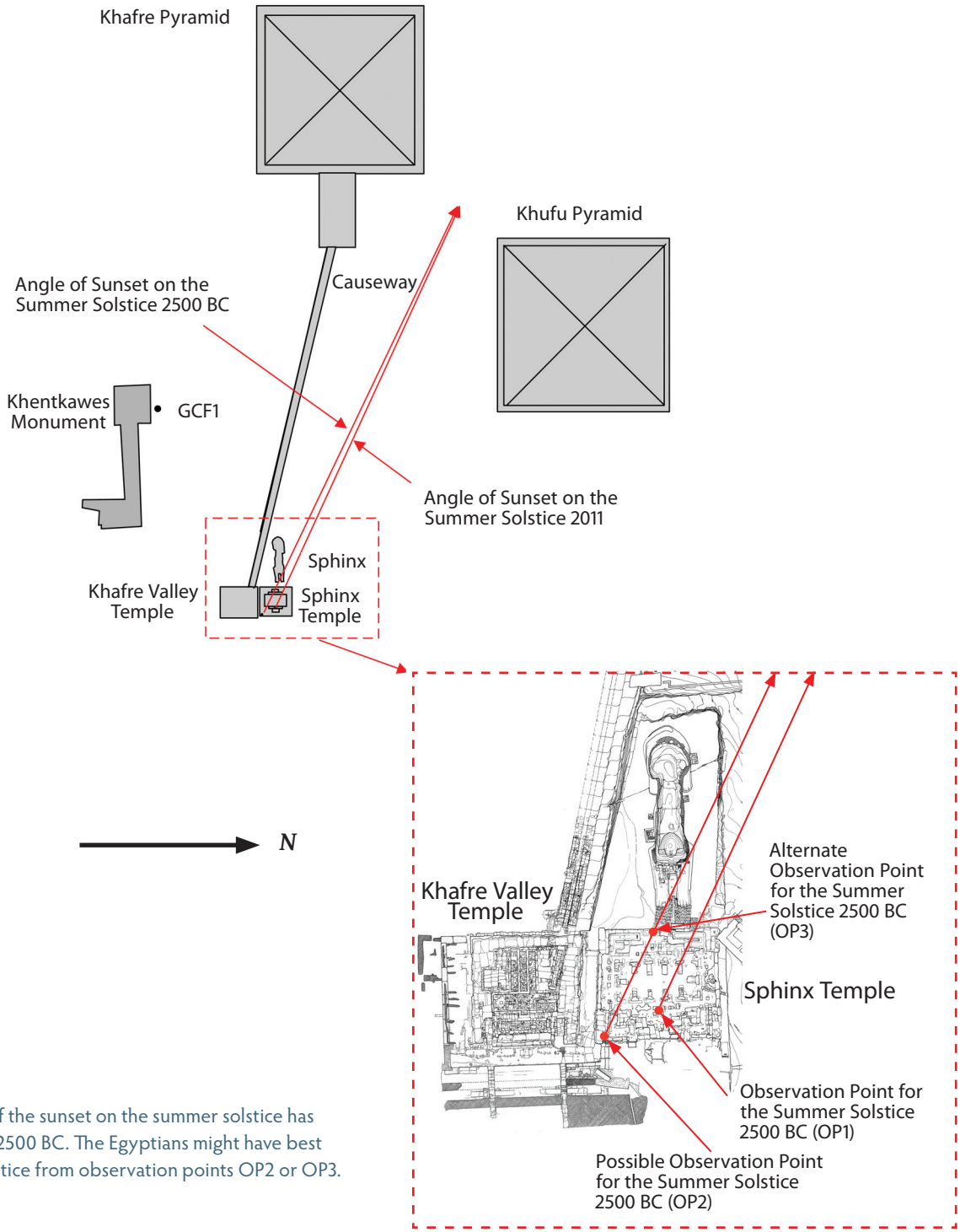
Above: Mark Lehner's map of the Sphinx Complex with key areas within the Sphinx Temple and an observation point (OP1) for the summer solstice.

Right: The sunset on the summer solstice can be seen today from the top of the eastern wall above the eastern colonnade, slightly east of observation point OP1, on the actual colonnade roof, now missing. From this vantage point, elevated several meters above the temple floor, the sun appears to set directly between the pyramids of Khafre and Khufu.

In exploring our hypothesis, we will start where Lehner observed the summer solstice, in the Sphinx Temple (facing page, top). Within the temple, twenty-four granite pillars surrounded a central courtyard which once contained ten to twelve colossal statues. Two additional pillars flanked niches set at the back of stepped east and west bays.[5] These niches flooded with light during the rising and setting of the sun on the equinoxes.

To test whether the colonnade above the eastern niche could have been intended as an observation point for the summer solstice sunset, we need to measure the angle of a ray drawn from there to a point directly between the pyramids of Khufu and Khafre (facing page, bottom). We draw rays from the colonnade (observation point OP1 on facing page, top) to the northeast corner of the Khafre Pyramid and the southwest corner of Khufu. Next, we draw a ray bisecting the two. The bisecting ray runs at an angle of 24.7 degrees north of true west, or, more properly stated, at an azimuth of 294.7 degrees clockwise of true north.

5. H. Ricke, "Der Harmachistemple des Chefren, Giseh," *Beiträge zur ägypischen Bauforschung und Altertumskund* 10 (1970): 1–43.



The direction of the sunset on the summer solstice has changed since 2500 BC. The Egyptians might have best viewed the solstice from observation points OP2 or OP3.

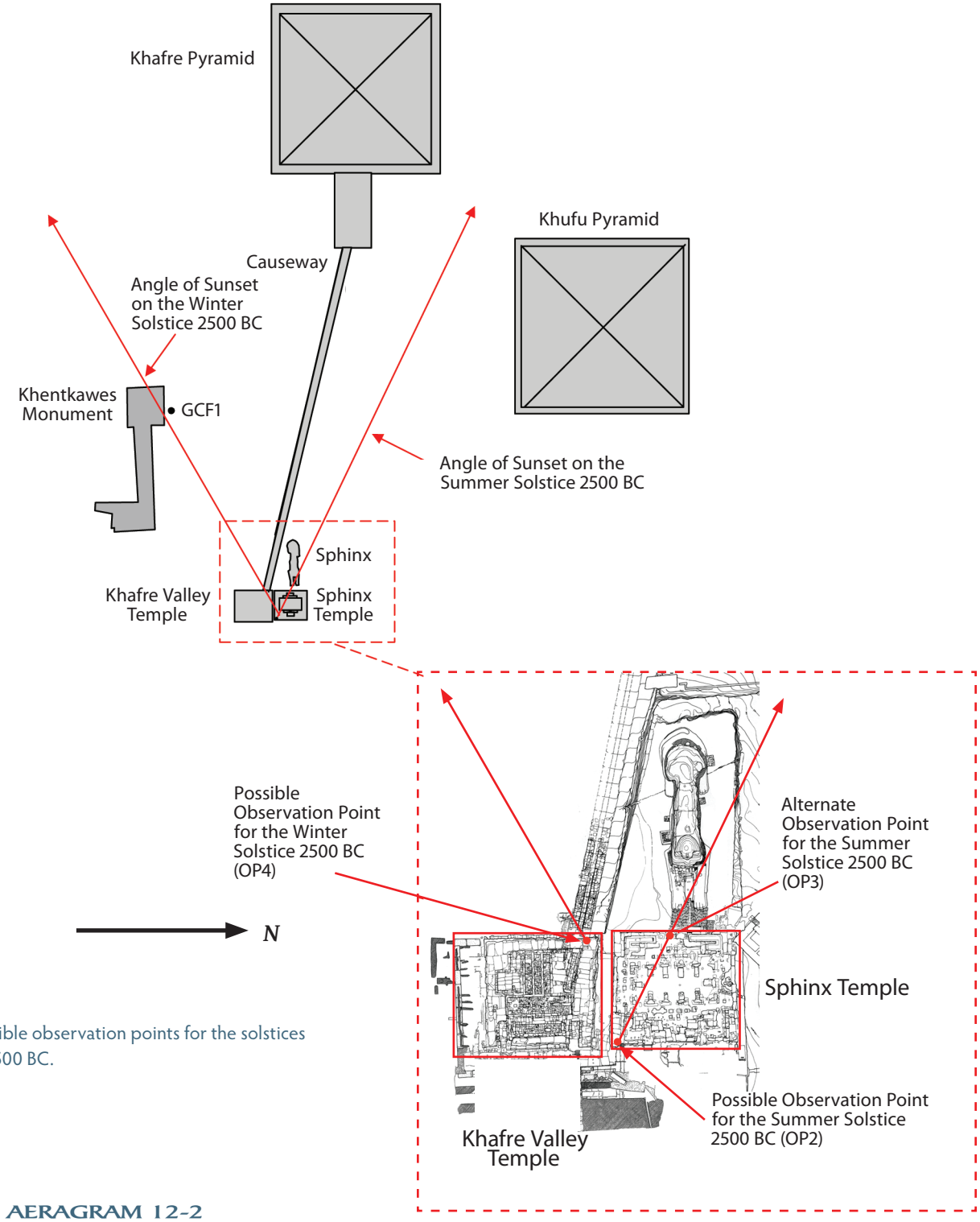
The predicted azimuth of the sunset on the summer solstice is 294.9 degrees, agreeing well with Lehner's observations.[6]

However, the position of the sunset has changed since 2500 BC due to changes in the Earth's obliquity, or tilt. Then, the sun set 0.6 degrees to the north, or at 295.5 degrees, a little more than one solar diameter away. The change causes us to consider the possibility that the priests stood elsewhere on the temple roof (shown in figure on previous page).

If we draw a ray from the Sphinx Temple to the center point between the pyramids at an angle of 295.5 degrees, we end up moving our observation point to OP2 in the figure on the previous page. The priests could have observed the sun setting on the solstice directly between the pyramids from this point, or from a vantage point near the center line of the Sphinx Temple at its western edge (OP3).

Indeed, had the Sphinx Temple been completed the priests could have observed both the summer and winter solstices from observation point OP2. The calculated azimuth of the sunset on the winter solstice in 2500 BC is about 240 degrees or 30 degrees south of due west. If we a draw a ray at this angle from OP2 to the south and west, it passes just to the north of

6. G. Dash, Solar Alignments of Giza, http://DashFoundation.org/SolarAtGiza.doc



Possible observation points for the solstices in 2500 BC.

Survey point GCF1 is located at the top of this prominent outcrop of Member III rock. The 4th Dynasty builders left this bedrock, and the bedrock forming the pedestal of the Khentkawes Monument, when they quarried stone for the pyramids. The northwest corner of the Khentkawes Monument shows at the far right. View to the east-northeast. Photo by Mark Lehner.

the Khentkawes monument and near GPMP control monument GCF1 (facing page). The bedrock knoll supporting GCF1, seen above and on the cover, is plainly visible from the Khafre Valley and Sphinx Temple complex today and, as it turns out, has a particular importance to our understanding of the history and geology of the plateau.

The surface layers of the Giza Plateau consist of alternately hard and soft members. We see this most clearly in the layering of the head and body of the Sphinx. A hard layer, know as Member I, supports the base of the Sphinx. The core of the Sphinx's body was cut from the softer Member II and has much eroded over time. Fortunately, the iconic head of the Sphinx was cut from the harder, topmost Member III and is well preserved. Before the pyramids were built, the surface of the southern portion of the plateau consisted mainly of Member III stone. A hard and uniform limestone, it was mostly quarried away. One place it does conspicuously remain, however, is at GCF1, where it lies, intact, beneath even older strata. The Egyptians may have used GCF1 as a control point; it has 360 degree views and good site lines. (Forty-five hundred years later, we did the same thing.) For the Egyptians, GCF1 could also have functioned as a fore sight for the winter solstice.

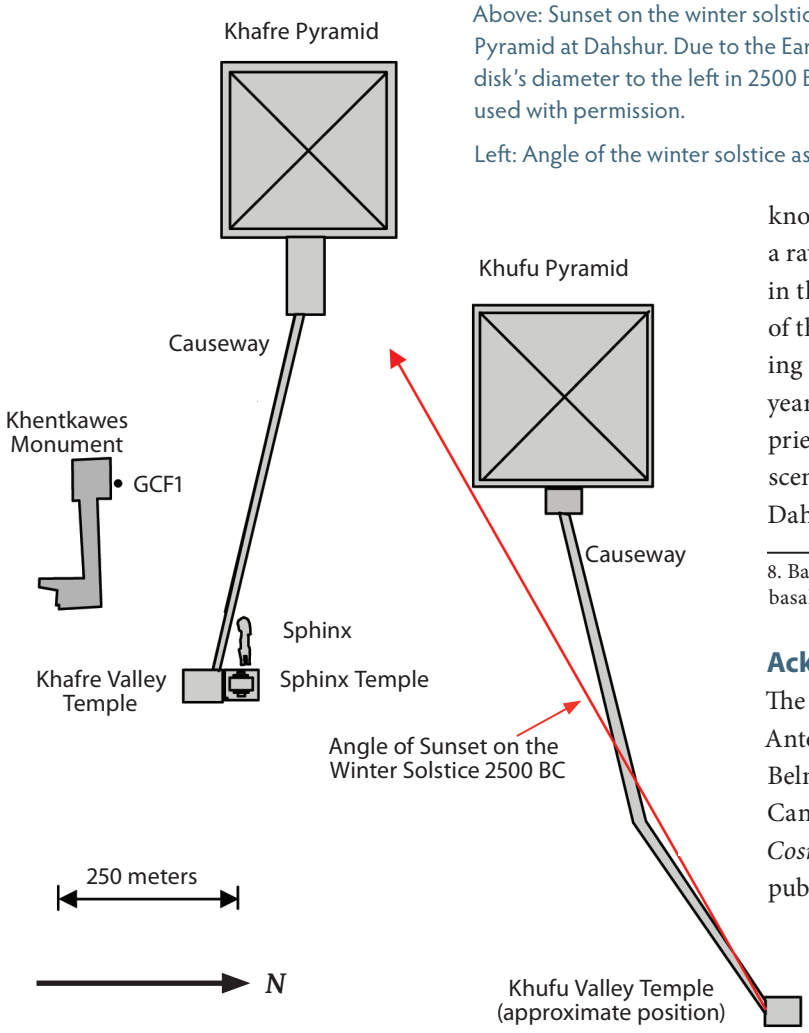
On the other hand, the Sphinx Temple was likely never finished, and the view from OP2 to the south and west may have been blocked by the taller Khafre Valley Temple. The priests might have better viewed the sunset from OP4 in the figure on the facing page, the point just above where the Khafre causeway enters the Valley Temple.

Thus far our discussion has been limited to the Khafre Pyramid complex. We find another possible alignment, however, between the Khufu Valley Temple and the Great Pyramid of Khufu. We draw inspiration from Juan Antonio Belmonte's observation of the winter solstice at Dahshur, where he found the sun setting at the northwest corner of the Bent Pyramid as viewed from its lower temple (next page, top).[7] While we do not

7. J. A. Belmonte, "The Egyptian Calendar: Keeping Ma'at on Earth," *In Search of Cosmic Order,* 1st ed. J. A. Belmonte and M. Shaltout, eds. (Cairo: Supreme Council of Antiquities Press, 2009), 98.

Above: Sunset on the winter solstice observed from the center line of the lower temple of the Bent Pyramid at Dahshur. Due to the Earth's changing tilt, the sun would have set a little more than one sun disk's diameter to the left in 2500 BC, clipping the pyramid's northwest corner. Photo by J. Belmonte, used with permission.

Left: Angle of the winter solstice as seen from the presumed position of the Khufu Valley Temple.



know the precise position of the Khufu Valley Temple, we draw a ray at an azimuth of 240 degrees from its presumed position[8] in the drawing on the left to the Great Pyramid. It clips a corner of the pyramid, in this case its southeast corner. Thus, standing on the Khufu Valley Temple on the winter solstice in the years before the pyramid of his son Khafre was built, Khufu's priests might have seen the sun set at a corner of the pyramid, a scene reminiscent of what his father's priests might have seen at Dahshur a generation before.

8. Based on the spot where the late 1980s AMBRIC Waste Water Project found a basalt pavement presumed to belong to the Khufu Valley Temple.

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