Astronomy and Landscape in Ancient Egypt:
Challenging the Enigma of the Minor Step Pyramids

Juan Antonio Belmonte¹, Mosalam Shaltout² and Magdi Fekri³

The minor step pyramids integrate a coherent group of seven monuments distributed along Egyptian geography with a series of common characteristics that make them different and peculiar to other buildings of similar typology. The purpose of these pyramids is a matter of dispute among Egyptologists and most proposals could be interpreted as sad examples of vox nihil. On the contrary, our archaeoastronomical study of the monuments would suggest that minor step pyramids were built at certain locations and with peculiar orientations that might relate them to the preliminary stages and consolidation, during the reign of king Snefru, of two master creations of early dynastic Egypt, the civil calendar and the star religion later appealing at the Pyramid Texts.

Minor step pyramids (hereafter MSPs) have been an archaeological enigma since they were discovered in the 19th Century (1) and especially after they were identified as a coherent group by the seminal work of Günter Dreyer and Werner Kaiser (2). As Mark Lehner recently argued, the purpose of these small pyramids is a mystery (3), with almost as many hypotheses to explain them as researchers have dealt with the problem.

MSP are seven buildings scattered from south to north along the Nile (fig. 1), at the island of Elephantine ①, near Naga el Ghoneimiya ②, to the south of Edfu, at El Kula③, a short distance north of Kom el Ahmar, close to Naqada®, near Nubt, the ancient city of the god Seth, at Sinki ④, a few kilometres south of Abydos, at the cemetery associated to the Zawiyet el Mayitin ⑤, 10 Km south of El-Minya and the only one at the east bank of the river, and at Seila ⑥, in the heights of Gebel el-Rus, a low chain of hills separating the Oasis of El-Fayum and the desert landscapes descending to the Nile valley. El Kula (fig. 1a) is the best preserved of the monuments where most of their common characteristics can be elucidated: small stones of some 60x100 cm, square base of some 35 cubits, three steps (except for Zawiyet el Mayitin, which could have had four, or Seila that for sure had four) and the absence of any associated chamber that could help to identify them as tombs or cenotaphs. However, they differ in their orientation, the quid of our question. A topic we will come back soon.

Three of them have been excavated and partially restored, Elephantine (4), Sinki (5) and Seila (6). El Ghoneimiya and Naqada are little more than a hill of pebbles and sand but still a few layers are visible. The excavations at Seila identified a chapel at the eastern side of the MSP where a few important discoveries pointed towards king Snefru (ca. 2575 B.C.; 7) as the most probable builder of this particular monument. However, the works at Elephantine discovered a building that has been interpreted as an administrative building of the 3rd Dynasty and, within that context, the excavators found a stone cone with the name of king Huni written on its base in a cartouche (4). This finding has been related to the MSP on site and consequently the pyramid has tentatively been assigned to the reign of Huni. The little differences between Seila and the rest of MSPs has made that several scholars (3), including some of the excavators of the monuments, tend to accept an earlier construction by Huni of most MSPs but of Seila which would have been constructed by Snefru in the first stages of his reign. However, Andrzej Ćwiek (8), in a most elucidating paper on the topic, has completely rejected that idea and has assigned all MSPs to the reign of Snefru. Aidan Dobson (9) is of the same opinion. The excavations of Sinki (5) revealed a fascinating aspect of the architecture of MSPs, since the mud-brick ramps of construction where found still in situ (fig. 2a), pointing to the fact that this particular pyramid was left unfinished at its second step, while most of the other MSPs were finished (certainly Seila and El Kula) or almost completed.

As we have argued, the purpose of these building is still an enigma with bizarre explanation from the lunatic fringe (10), to serious speculations that would make of MSPs cenotaphs for the ka or queens at her homelands, archaic benbens, i.e. the predecessor of 5th Dynasty solar temples (5), or local symbols of royal power at important cities of the country (3). We have not mentioned so far that MSPs were located

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at or nearby the location of some of the most important capitals of the ancient provinces of Upper Egypt during the Old Kingdom, Abu Elephantine), Behedet (Edfu), Nekhen (El Kula), Nubt (Naqada) and This-Abydos (Sinki). Zawiyet el Mayitin was also located at ancient Hebenu. Only Seila breaks this rule but it is located at bird-eye view of Meidum, where Snefru was building his first tomb in the form of a huge step pyramid. Ćwiek (8) has analyzed the majority of these proposals, rejecting most of them or re-interpreting the symbolic aspect, proposing on a firm basis that MSPs would be a sort of local sanctuaries built under Snefru for the royal cult; an effort that would be abandoned (hence the unfinished character of Sinki) once most of the energies of the Old Kingdom Egyptian society was diverted to the construction of huge pyramids by Snefru himself and his successors.

A clever alternative explanation related to the geographical location of MSPs has been that proposed by Rolf Krauss (private communication). This idea has to do with the following data:

<table>
<thead>
<tr>
<th>From–to</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elephantine–El Ghoneimiya</td>
<td>ca. 105 Km,</td>
</tr>
<tr>
<td>Elephantine–El Kula</td>
<td>ca. 130 Km,</td>
</tr>
<tr>
<td>El Ghoneimiya–El Kula</td>
<td>ca. 25 Km,</td>
</tr>
<tr>
<td>El Kula–Naqada</td>
<td>ca. 120 Km,</td>
</tr>
<tr>
<td>Naqada–Sinki</td>
<td>ca. 130 Km,</td>
</tr>
<tr>
<td>Sinki–Zawiyat el Mayitin</td>
<td>ca. 280 Km (splitting at Asyut; ca. 150+130 Km),</td>
</tr>
<tr>
<td>Zawiyet el Mayitin–Seila</td>
<td>ca. 130 Km (nearest point at the river),</td>
</tr>
<tr>
<td>Seila–Athribis*</td>
<td>ca. 130 Km,</td>
</tr>
</tbody>
</table>

where the distance between consecutive MSPs is presented. An additional monument at Athribis (see fig. 1), identified only by ancient reports (11), has sometimes been included in the group although its pertinence is unlikely (8). Krauss noticed *that with one exception, the small pyramids are situated at distances of about 150 Km, along the Nile, i.e. the distance which is covered by the Nile flooding when it flows at a velocity of about 6 Km. per hour.* Accordingly, he suggests the idea that the small pyramids could mark the progress of the high flood in full-day intervals, beginning at Elephantine. Actually, the distance is a little bit shorter (close to 12 Iteru or 126 Km, 12) and there are exceptions to the rule as the case of El Ghoneimiya, or problems like the distance between Seila and the river (more than 10 Km) or the inexistence of certain monuments which, however, could have stand near Asyut, another important provincial capital. At least, from our point of view, the hypothesis sounds reasonable for MSPs ①, ②, ③ and ⑤ and could be connected with the ideas we are now going to analyze and discuss.

For the last few years, the authors have been involved in the Egyptian-Spanish Mission for the Archaeoastronomy of ancient Egypt with the objective, among many others, of measuring the orientation of as many ancient monuments as possible. We have already obtained substantial results on the temples (13, 14, 15) that has convinced us that ancient Egyptian shrines were orientated according to local landscape, understanding landscape in its most broader meaning, including both the terrestrial (topographic) and celestial (astronomical) aspects. Of course MSPs were part of our interest since we were most intrigued by their enigmatic character and we wanted to check if archaeoastronomy could help to challenge the mystery. Our data are presented in Table 1. In our first campaign, we measured Elephantine and our data agreed with previous reports. Zawiyet el Mayitin was measured in the second campaign with slightly different data. However, it was in our 3rd campaign at Seila when we were astonished with an almost perfect cardinal orientation, while previous report (2, 3) offered a completely wrong value of 12° NW. This demonstrated the necessity for accurate local measurements of most of ancient Egyptian monuments that was used as the central idea for the creation of this project. Finally, the rest of the monuments were measured in our last (5th) campaign so far, in December 2006.

We want to clearly stress that in our project we were not seeking extreme-precision alignments. Bearing this in mind, and considering the rough state of preservation of MSPs (with the possible exception of El Kula), we obtained our measurements using high precision compasses, correcting for local magnetic declination (16), and clinometers. These instruments permit a theoretical ⅛° precision for both kinds of measurements. However, owing to various considerations, an error of at least ⅛° in both azimuth and angular height is probably nearer to reality. As the first author has discussed elsewhere (17), we can affirm without fear of being grossly in error that, for the latitudes of Egypt, a precision of ⅛° is perhaps the best we can expect in solar or very bright star observations near the horizon and, in the case of fainter stars, the errors in estimating the azimuth can range from that value to several degrees. According to our own
experience, we consider our data to be of good enough quality to pursue the study of the orientation of MSPs.

Figure 3 presents a schematic diagram of the orientation of MSPs, complementary to Table 1. The first topic we can analyze is the Nile hypothesis, as discussed in our earlier works (Papers 1 to 3). With the exception of Elephantine, the other six monuments have a side almost parallel to the river. Actually, the average value of the difference (Δ) for these six pyramids is of \( \frac{1}{2}° \pm 1\frac{1}{2}° \). Hence, our immediate conclusion would be that MSPs are orientated according to the Nile course. However, our experience has shown that the answer is not always so simple. It is precisely the exception to the rule, Elephantine, which offered the first challenge giving an extremely interesting alternative astronomical theory. The perpendicular axis of the pyramid (fig. 3 and Table 1) is orientated to a declination \(-16\frac{1}{4}°\) that corresponds to sunrise at Wepet Renpet (Egyptian New Year’s Eve) ca. 2570 B.C., with an interval of \( \pm 30 \) years due to our estimated error of \( \frac{1}{2}° \) for the declination. We have proposed elsewhere (18) that solar observations at the summer solstice at Elephantine might have permitted to establish the duration of the year at nearly 365 days a century or so earlier. Now, at the beginning of the reign of Snefru (7), the wandering character of the Egyptian civil calendar had moved the beginning of the year to a different date and the king might have decided to build a commemorative monument to this fact, that perhaps could serve as a new tool (a gnomon?) to check the actual duration of the civil year, similarly to other monuments of the king, and his direct successors, with peculiar astronomical behaviours (19).

Fascinated by this possibility, we have analysed the presumable astronomical connotations of the rest of pyramids with promising results. MSPs can be divided in two groups according to their orientation (see fig. 3). One group is that formed by those monuments with cardinal or quarter-cardinal orientations, as defined in Paper 3, El Ghoneimiy, El Kula, Sinki and Seila. In this case, a close N-S direction was first established that will be the axis of symmetry of the pyramid (cardinal) or this will be obtained by rotating the axis by \( 45° \) (quarter cardinal). Another group is formed by Elephantine, Naqada and Zawiyet el Mayitin where the orientation is far from this simple rule. We will discuss this group first.

After Elephantine, Naqada offers another curious alternative (see Table 1). Here, the perpendicular direction would be that of the rising of Sirius (Sopdet) in the centuries around 2820 B.C. or, most interesting, 2500 B.C. if the heliacal rising phenomenon is considered (Sirius need to reach an angular height of at least \( 2° \) in that case). The first author has defended (18) that the heliacal rising of Sirius (Peret Sopdet) was not crucial for the creation of the civil calendar but that it would have soon become important (presumably during the 4th Dynasty) as the harbinger of the real flooding, once Wepet Renpet has significantly departed from the arrival of the waters, due to the wandering nature of the calendar. Finally, Zawiyet el Mayitin (see Table 1 and fig. 3) offers a curious orientation to sunset at the winter solstice (\( \delta \) of the centre of the sun disk near \(-24°\) during the reign of Snefru), one of the most conspicuous astronomical orientations of ancient Egyptian sacred structures across time and space (15, 20). Hence Naqada and El Mayitin also offer connections to time keeping and the proposed questioning process of the civil calendar, supporting the result of Elephantine. Surprisingly, these findings would also connect our ideas with that of Krauss and the arrival of the flooding at the time of the summer solstice and the helical rising of Sirius.

The other group of four MSPs also offers a very suggestive alternative to the prosaic Nile orientations. Indeed, the N-S direction was determined in the four cases with a precision (\( 3\frac{1}{2}°, 1\frac{1}{4}°, 3\frac{1}{4}° \) and \( 0° \)) that can hardly be ascribed to chance. The axis of El Ghoneimiy (fig. 4) was orientated to a chain of hills located at the northern horizon. The lowest declination star of the asterism of the Plough (or Big Dipper), corresponding to the Egyptian constellation of Meskhetyu (21), Merak, was precisely slightly hidden at these hills at the time of Snefru (fig. 5a, for the seeking of coherency, we will centre all our following analysis in the date 2570 B.C.). Meskhetyu is mentioned in the Pyramid Texts (hereafter PTs, 22) like the “imperishable” group of stars per excellence, the Imperishable Stars being one of the various celestial destinies of the soul of the king after death. Meskhetyu, normally represented as a bull’s foreleg, was also identified as one of the celestial adzes used in the ubiquitous ceremony of the Opening of the Mouth, when the mummy of the dead was brought back to life (21). The other adze might be identified with the Small Dipper (Ursa Minor, 23). As a matter of fact, the area between El Ghoneimiy and El Kula was ca. 2570 B.C. the region of Egypt where Meskhetyu ceased to be circumpolar and the location and orientation of these MSPs, one cardinal and the other quarter-cardinal, might perhaps reflect this fact.

This idea could be confirmed for the next pyramid of the group, Sinki. The authors are now defending the idea, that will be published elsewhere (20), that the location of the earliest royal necropolis at Umm el Qab, in the desert area of Abydos and about 10 Km to the north of Sinki, was related to the fact that Umm
el Qab was the last spot of Egypt where *Meskhetyu* was circumpolar at the period of formation of the Egyptian state (ca. 3000 B.C.). However, another possibility is just the opposite, that *Meskhetyu* became important for the royal star religion, later stressed in the PTs or in other funereal ceremonies, precisely because it was circumpolar at the royal necropolis. Whatever the two alternatives is the true one, the location of Sinki close to the royal field and with an orientation so similar, although worse, to that of El Kula (see Table 1 and fig. 5b) clearly includes it within the same line or reasoning (Sinki was perhaps left unfinished because it did not fit so well the requirements of the new developing star mythology).

The last MSP of the group is Seila. In Paper 2 we already discussed the case of this fascinating monument and we still keep the idea that it might have been the first pyramid (not necessarily the first monument) to be cardinally orientated through the simultaneous lower transit observation of a couple of stars of *Meskhetyu* (see fig. 5d), idea that the first author proposed and defended first for some of the larger pyramids (24), apart from being constructed at a very peculiar latitude for solar illumination effects (19, 25). Once more the connection with *Meskhetyu* and the origins of the star religion justify the sensibleness of our arguments. At the light of these new discoveries, we would support the idea that precise N-S alignments should have been obtained through stellar observations, although there have been quite reasonable alternative proposals dealing with solar procedures (26).

To finish our line of argument connecting MSPs with important aspects of ancient Egyptian astronomy and culture, we will come back shortly to the three pyramids not belonging to the cardinal and quarter-cardinal group. El Mayitin was located at a very peculiar spot, that where the lowest culmination of Polaris (αUMi) was tangent to the horizon (see fig 5c; as a general rule, stars are invisible until they reach an angular height close to its apparent magnitude. αUMi has a visual magnitude of 2.5 and would be invisible until it reaches an h~2½º) and hence, the Small Adze (if it ought be identified with the Small Dipper), would cease to be circumpolar when travelling south ca. 2570 B.C. The parallelism with the location of the pair PLICATEichel—Sopdet and the Big Adze (*Meskhetyu*) is appealing. It is also worth mentioning that *Sopdet* is the astronomical object more frequently mentioned by its proper name in the PTs (22, 27). Finally, it is important to stress that the star religion of the PTs was partly conceived either simultaneously or once the civil calendar was already in operation since the 5 above the year (the “epagomenal” days, heralding Wepet Renpet in the Egyptian calendar) are mentioned there in one occasion. In summary, all seven MSPs (Elephantine is less clear) could be connected to a certain aspect of the star religion as later shaped in the PTs written in the walls of the pyramids two centuries later.

Consequently, our study relating astronomy and landscape has shown that MSPs were built at certain geographical locations and with challenging orientations that would be strongly correlated with two important aspect of ancient Egyptian culture that were being developed at the moment of their construction: the civil calendar and the star religion. Our proposal would agree with the sacred character and temporal adscription (the early reign of Snefru, who ought to be reputed to have started the construction of at least 12 pyramids) of these monuments as proposed by Ćwik 8) and might also agree with certain geographical properties, as discovered by Krauss, at least for MSPs 6, 8 and 9, and specially for the pyramids of Elephantine and Naqada, whose orientations could be connected to special events of the Egyptian time-keeping system such as Wepet Renpet and Peret Sopdet, respectively, and indeed with the arrival of the Flooding (expected at Elephantine and announced by Sopdet).

Peculiar celestial configurations of *Meskhetyu*, and perhaps of the Small Adze, would define the sites where four of the MSPs were erected as well as their orientation. The observation of yet another configuration would have offered at Seila the first sacred Egyptian building ever accurately orientated to the cardinal directions (probably with the nearby gigantic step pyramid of Meidum). This will easily connect with the idea of (step) pyramids as stairs to the celestial realm and especially to the area surrounding the Pole where the “imperishable” stars per excellence, those of *Meskhetyu*, were turning endlessly. In we are right, the minor step pyramid should not be seen anymore as an unsolved enigma but rather as peculiar links of a chain of monuments built for centuries in ancient Egypt for the major glory of their kings, both in this and the afterlife, and hence for preserving the concept of Maat in ancient Egyptian society.

References and Notes

10. Simply type “Small or Minor Step Pyramids” at any Internet finder.
12. The *Iteru* was the larger unity of length of ancient Egyptians (10.5 km), consisting of 20,000 royal cubits. The number 12 has strong calendrical meanings.
16. Magnetic alterations are not expected in Egypt, where most of the terrain is limestone and sandstone. In any case, the MSPs were mostly measured along their four faces, and from both sides, checking for possible alterations. Our own experience after four years of extended fieldwork and cross-checking of previous data supports this idea.
20. J. A. Belmonte, M. Shaltout, M. Fekri and N. Miranda, *J. Hist. Astron.* 39 (2008), submitted. In that paper, we show that alignments to winter solstice sunrise, where present in Egypt along all her history and in different geographical areas.
28. We wish to express our acknowledgement to our colleague Dr Zahi Hawass for his strong support of the Archaeoastronomy Mission as Director of the Supreme Council of Antiquities. We also express our gratitude to the various inspectors, guides and escorts who join us during the fieldwork; they were very kind and helpful. This work is partially financed under the frame of the projects P310793 “Arqueoastronomía” of the IAC, and AYA2004-01010 “Orientatio ad Sidera” of the Spanish MEC.
TABLE 1: Orientation data on the seven minor step pyramids of Egypt. After the name, latitude (L) and longitude (l) are presented. Then it shows azimuth ($a_N$), angular height ($h_N$) and the corresponding declination ($\delta_N$) for the pyramid face closest to north (as in Fig. 3), angular distance from due-north for the course of the Nile on site ($\Delta$), and some additional orientating data (as presented in Fig. 3). The last column presents a sketch of the corresponding archaeoastronomical interpretation, as discussed in the text.

The asterisks stand for special values of $h$.

<table>
<thead>
<tr>
<th>Pyramid</th>
<th>L (º')</th>
<th>l (º')</th>
<th>$a_N$ (º)</th>
<th>$h_N$ (º)</th>
<th>$\delta_N$ (º)</th>
<th>$\Delta$ (º)</th>
<th>$a_\ast$ (º)</th>
<th>$h_\ast$ (º)</th>
<th>$\delta_\ast$ (º)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elephantine</td>
<td>24/06</td>
<td>32/54</td>
<td>343</td>
<td>0</td>
<td>60½</td>
<td>46</td>
<td>73</td>
<td>2</td>
<td>16½</td>
<td>$-16\frac{1}{2}^{\circ}\pm\frac{3}{4}^{\circ}$ is the declination of sunrise at Wepet Renpet ca. 2570±30 B.C.</td>
</tr>
<tr>
<td>Ghoneimiya (South Edfu)</td>
<td>24/56</td>
<td>32/50</td>
<td>3½</td>
<td>2</td>
<td>66½</td>
<td>12½</td>
<td></td>
<td></td>
<td></td>
<td>Lower culmination at the horizon of Merak ca. 2570 B.C.</td>
</tr>
<tr>
<td>El Kula</td>
<td>25/08</td>
<td>32/44</td>
<td>316¼</td>
<td>0</td>
<td>40½</td>
<td>$-8\frac{1}{4}$</td>
<td>1½</td>
<td>2*</td>
<td>66½</td>
<td>Similar to the upper case; but with quarter cardinal orientation.</td>
</tr>
<tr>
<td>Naqada</td>
<td>25/58</td>
<td>32/44</td>
<td>24½</td>
<td>0½</td>
<td>55</td>
<td>114½</td>
<td>0</td>
<td>2*</td>
<td>$-22\frac{1}{4}$</td>
<td>$-22\frac{1}{4}^{\circ}\pm\frac{3}{4}^{\circ}$ and $-21\frac{1}{4}^{\circ}\pm\frac{3}{4}^{\circ}$ are the $\delta$ of Sopdet ca. 2820±220 and 2500±220 B.C., respectively.</td>
</tr>
<tr>
<td>Sinki</td>
<td>26/09</td>
<td>31/58</td>
<td>318¾</td>
<td>0</td>
<td>42</td>
<td>$-8\frac{3}{4}$</td>
<td>3¾</td>
<td>0</td>
<td>63</td>
<td>Similarly orientated as El Kula. Early member of the quarter cardinal family.</td>
</tr>
<tr>
<td>Zawiyet el Mayitin</td>
<td>28/03</td>
<td>30/50</td>
<td>331¾</td>
<td>0B</td>
<td>50½</td>
<td>$-4\frac{1}{4}$</td>
<td>241½</td>
<td>0½</td>
<td>$-24\frac{1}{4}$</td>
<td>Winter solstice sunset? Last point of Egypt where UMi (the Small Adze?) is circumpolar ca. 2570 B.C.</td>
</tr>
<tr>
<td>Seila</td>
<td>29/23</td>
<td>31/03</td>
<td>0</td>
<td>0</td>
<td>60</td>
<td>$-2$</td>
<td></td>
<td></td>
<td></td>
<td>One of the first buildings with cardinal orientation. 1st use for a pyramid of the simultaneous meridian transit of Phecda and Megrez ca. 2570 B.C.</td>
</tr>
</tbody>
</table>
**Fig. 1.** Map of Egypt showing the location of the 7 MSP along the course of the Nile. The location of the now lost Athribis pyramid is also marked.
Fig. 2. Images of a couple of fine examples of minor step pyramids—hereafter MSP—. (a) Top: the three-step pyramid of El Kula, the best preserved of all MSPs. (b) Below: the pyramid of Sinki, near Abydos. This monument was left unfinished. Notice the mud-brick construction ramps still attached to the sides of the pyramid.
Fig. 3. Schematic diagram of the orientation of the 7 MSPs, numbered from south to north. For each of the seven monuments, the image shows the name and latitude, its closest orientation (azimuth) towards north and the corresponding declination (thick black arrow), the approximate flow of the Nile on site (dot-line arrow) and the azimuth and declination of some additional important astronomical orientations as discussed in the text (thin arrow). The pyramid of Seila was almost surely built by Snefru while that at Elephantine has been assigned on tiny evidence to his predecessor Huni.
Fig. 4. One of the few preserved stone layers still visible at the eastern side of the MSP at El Ghoneimiya. It is orientated towards a distant hill with an angular height of some 2°. This was the first location in Egypt where the constellation of Meskhetyu (the Plough) ceased to be circumpolar when travelling south ca. 2570 B.C.
Fig. 5. Different celestial configurations of the “imperishable” asterism of Meskhetyu (the Plough or Big Dipper) and other circumpolar constellations as seen from the location of four MSPs, ca. 2570 B.C. Lower transit of Merak (βUMa), and hence of Meskhetyu, for El Ghoneimiya (a) and Sinki (b); lower transit of Polaris (αUMi), in the asterism of the Small Dipper (presumably the Small Adze), in the case of Zawiyet el Mayitin (c); and, finally, simultaneous meridian transit of Phecda (γUMa) and Megrez δ (UMa), signalling almost accurately due-north in the case of Seila (d).