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A GEOMORPHOLOGICAL STUDY OF THE GIZA NECROPOLIS, WITH IMPLICATIONS FOR THE DEVELOPMENT OF THE SITE*

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There are a number of features of weathering and erosion within the enclosure surrounding the Great Sphinx of Giza that suggest the action of flowing water. That this erosion is not uniformly distributed is consistent not with erosion by rainfall per se *but by rainfall run-off—an erosive agent that is known to have been experienced at Giza until the late Fifth Dynasty. When the spatial relationship of various features within the Giza necropolis is considered, the extant erosion indicates that the Sphinx may pre-date the reign of Khufu, the builder of the first Giza pyramid. The existence of pre-Fourth Dynasty development at Giza can be inferred from this—support for which is provided by a number of archaeological finds excavated from the site.*

KEYWORDS: EGYPT, GIZA NECROPOLIS, SPHINX TEMPLE, EARLY DYNASTIC, GEOMORPHOLOGY, DEGRADATION

INTRODUCTION

In 1992, a Boston University Professor of Geology, Robert M. Schoch, published a paper which concluded that the Great Sphinx of Giza was carved at a time between 5000 and 7000 BC (Schoch 1992). This conclusion was reached following a study of the degradation of the body of the Sphinx and adjacent exposures. Schoch stated that the 'rolling and undulating vertical profile to the weathered rocks' was attributable to 'precipitation-induced weathering'.

A summary of the chronology of Ancient Egypt (to the end of the Fourth Dynasty) is given as Table 1. The Sphinx is conventionally attributed to the Fourth Dynasty pharaoh, Khafre (2520–2494 BC) and, unsurprisingly, Schoch's early date has not received wide acceptance. Schoch's work has also been criticized by a number of geologists—notably K. L. Gauri (Gauri *et al.* 1995)—who have offered alternative interpretations of the degradation of the Sphinx in support of its generally accepted Fourth Dynasty construction. Gauri *et al.* (1995) provides a summary of many of the features of degradation that are present along the body of the Sphinx and adjacent exposures, attributing these features to the combined effects of chemical weathering and subsurface groundwater movement.

The current paper shows that these processes, although significant, are unable to account for all of the features of degradation that are present within the Sphinx enclosure. It reviews the geology, geomorphology and surface hydrology of the Giza necropolis and proposes a revised sequence of development for the site. In this way, it is possible to reconcile the geological and archaeological evidence while placing the construction of the Sphinx within the context of Dynastic Egypt.

THE GEOLOGY OF THE SPHINX

The geology of the Upper Mokattam Limestones, from which (and on which) the Giza necropolis was constructed, has been described at length by others (Gauri, 1981, 1984;

* Received 4 January 2000, accepted 3 July 2000.

Table 1 *A summary of the chronology of Ancient Egypt up to the end of the Fourth Dynasty*

Period	*Dynasty*	*Approximate dates*	*Significant reigns*	*Approximate reignal dates*
Late Pre-dynastic	0	3200–3000 BC	Ka	–
			Scorpion	–
Early Dynastic Period	1	3000–2800 BC	Narmer	–
			Aha	–
			Djet	–
			Djer	–
			Merneith	–
			Den	–
			Anedjib	–
			Semerkhet	–
			Qaa	–
	2	2800–2650 BC	Hetepsekhemwy	–
			Nebra	–
			Ninetjer	–
			Peribsen	–
			Khasakhem(wy)	–
	3	2650–2575 BC	Netjerikhet (Djoser)	–
			Sekhemkhet	–
			Khaba	–
			Sanakht	–
			Huni	–
Old Kingdom (Dynasties 4–8)	4	2575–2465 BC	Sneferu	2575–2551 BC
			Khufu	2551–2528 BC
			Djedfre	2528–2520 BC
			Khafre	2520–2494 BC
			Menkaure	2490–2472 BC
			Shepseskaf	2472–2465 BC

Choudhory *et al.* 1990). The original ground surface at Giza has been controlled by the southeasterly dip of the strata (5–7°), with the Sphinx occupying a position at the low lying, eastern edge of the plateau. Detailed geological mapping of the Sphinx enclosure, undertaken by Gauri (1984), has led to the exposed strata being divided into three members, as shown in Figure 1. The lowest is the Member I strata, consisting of a massive and durable reefal limestone, exposed across much of the base of the Sphinx enclosure and forming the lowest lying parts of both the body of the Sphinx and the western enclosure walls. The upper body of the Sphinx, and the upper part of the adjacent exposures to the south and west, consist of the overlying Member II strata, a cyclothemic series of seven fine-grained limestone units which, generally, become more durable towards the top of the sequence. Of these seven units, units 1 to 6 have been further divided into two sub-units, the lowest of which consists of a less durable, marly rock and is identified by the Roman numeral i. The upper more durable sub-unit is identified by the Roman numeral ii. The head and neck of the Sphinx are carved from perhaps the only Member III exposure at Giza which, on the basis of durability, has also been divided into two sub-units.

The durability of the Upper Mokattam Limestones is controlled by two intrinsic properties of the rock—the pore size distribution and the salt content of the pores (Gauri *et al.* 1995)—with

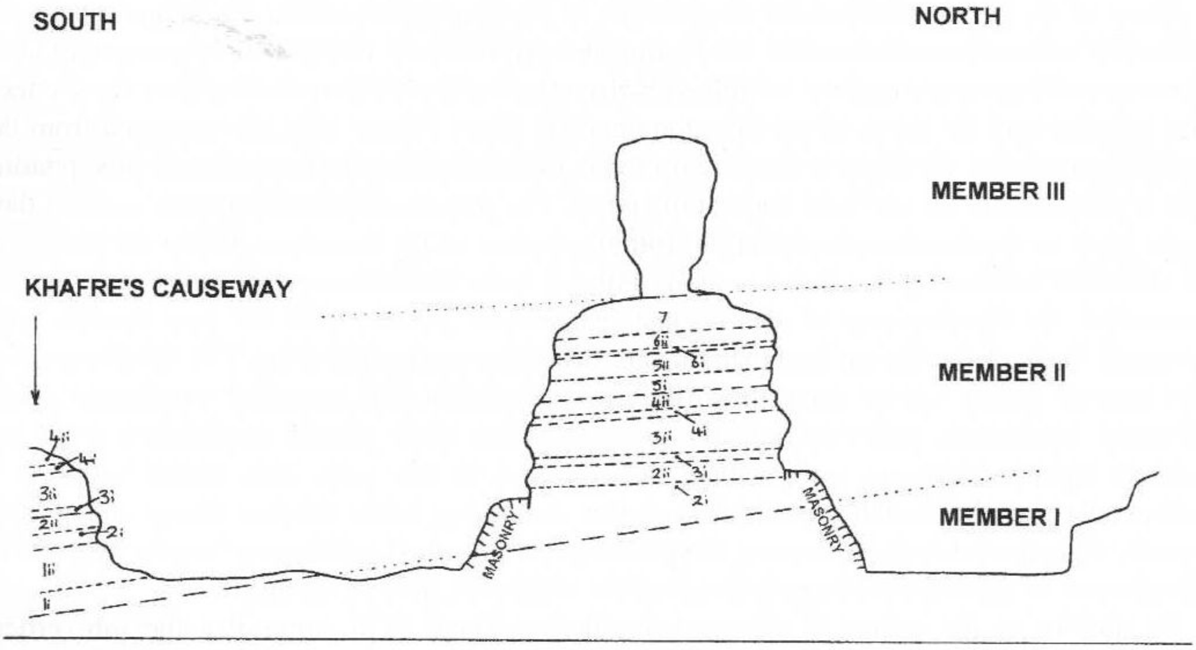

Figure 1 *A geological section of the Sphinx and Sphinx enclosure (after Gauri).*

durability influencing the development of sub-vertical discontinuities within the strata. The exposed rock is cut by two sets of irregularly spaced, near-vertical, intersecting joints which, although well developed in the more durable strata, become less distinct in the softer units.

DEGRADATION OF MEMBER II STRATA WITHIN THE SPHINX ENCLOSURE

Of the three members of the Upper Mokattam Limestone, much of the debate on the age of the Sphinx has concentrated on the degradation of the Member II strata, which are best represented and most widely distributed within the Sphinx enclosure. Examination of this stratum has established that the degradation present is characterized by three principal features:
(1) sub-horizontal degradation—parallel with the bedding plane;
(2) sub-vertical degradation—across the bedding plane;
(3) receded strata at the top of the exposures.
On the basis of the distribution of these features, a marked variation in the nature and intensity of degradation within the Sphinx enclosure can be identified. Much of the body of the Sphinx and the eastern end of the southern exposure exhibit comparatively moderate degradation, typified by sub-horizontal degradation and limited erosion of the upper strata of the enclosure walls. However, by comparison of the same units at different locations within the Sphinx enclosure (see Gauri 1984; Figures 3A and 3C), it can be seen that in the west, the degradation of the enclosure walls becomes more intense, with deeply incised sub-horizontal features and an increased frequency of sub-vertical degradation features. In places the sub-vertical features combine in a dendritic pattern, indicating that even minor discontinuities in the exposed strata have been exploited. This distribution in the intensity of degradation has not been recognized by Gauri *et al.* (1995), who state that 'the vertical profiles of the strata of the Sphinx on all four sides as well as those on the south and west walls of the enclosure are rounded and exactly similar'. With respect to the age of the Sphinx, this distribution is considered to be particularly significant.

Gauri *et al.* (1995) attribute the degradation of the limestones within the Sphinx enclosure primarily to the effects of chemical weathering and exfoliation in which dew, forming at night on the exposed limestone, removes soluble salts from the surface of the rock. Capillary forces draw this solution into the pores of the limestone matrix, where further salts are dissolved from the internal pore walls. As daytime temperatures rise, the solution begins to evaporate, precipitating salt crystals within the confined neck of the pores. The pressure that these crystals exert as they grow leads to stress-induced exfoliation from the surface of the limestone. Under the processes of chemical weathering that Gauri *et al.* describe, it is the bedded nature of limestones that has controlled the development of the vertical degradation profile, with the less durable units receding further from the cut face than the interbedded more durable strata. The development of this vertical profile can be seen, therefore, to be consistent with chemical weathering of the stratified limestones. However, the development of the more intense degradation along the western Sphinx enclosure walls cannot be explained in this way. This lateral variation is independent of the bedding, with degradation becoming more intense along, rather than across, the exposed beds. Likewise, the processes of chemical weathering cannot explain the distribution of sub-vertical degradation features within the Sphinx enclosure.

In addition to the effects of chemical weathering, Gauri *et al.* argue that the sub-vertical degradation features are the result of solution widening of joints by pre-Pliocene groundwater. A number of the most significant sub-vertical features, exposed along the western enclosure walls, have been plotted in Figure 2. By measuring the orientation of these exposed joints and then extrapolating their axes across the Sphinx enclosure, it can be demonstrated that a number of these joints pass through the body of the Sphinx. On the basis of the joint distribution and alignment shown in Figure 2, any solution-widened joints, exposed by excavation of the western enclosure walls, would be expected to have a corresponding expression across the excavation on the adjacent body of the Sphinx. However, in unit 3ii (exposed on both the western enclosure walls and the rump of the Sphinx—just above the restorative masonry) it is evident that this expected distribution is not present—no significant sub-vertical degradation features can be identified on the rump of the Sphinx. This indicates that these sub-vertical degradation features cannot be interpreted as solution-widened joints.

It is concluded, therefore, that the features of degradation within the Sphinx enclosure are the result of a more complex degradational history than that proposed by Gauri *et al.* and, to investigate this further, it is necessary to reconsider the climatic and other conditions that have been experienced at Giza.

AN ALTERNATIVE INTERPRETATION OF THE DEGRADATION OF THE SPHINX

Although arid conditions have dominated the dynastic period of Egyptian history, wetter periods are known to have been experienced, with the current arid conditions not becoming fully established until the late Fifth Dynasty (*c.* 2350 BC; Butzer 1971). The rainy conditions of *c.* 5000–7000 BC, to which Schoch attributed the degradation of the Sphinx, will have been separated from these later arid conditions by a transitional phase, during which increasingly arid conditions will have been interrupted by occasional, probably seasonal rains. Flood damage to Menkaure's valley temple (Reisner 1931) attests to the fact that, even during the late Old Kingdom, rainfall run-off was a significant agent of erosion at Giza.

Given the topography of the site, rainfall run-off from the Giza plateau will have discharged towards the lower lying areas in the east, with the erosive potential of this discharge depending, amongst other things, on the size of the available catchment. Given the east–west orientation of

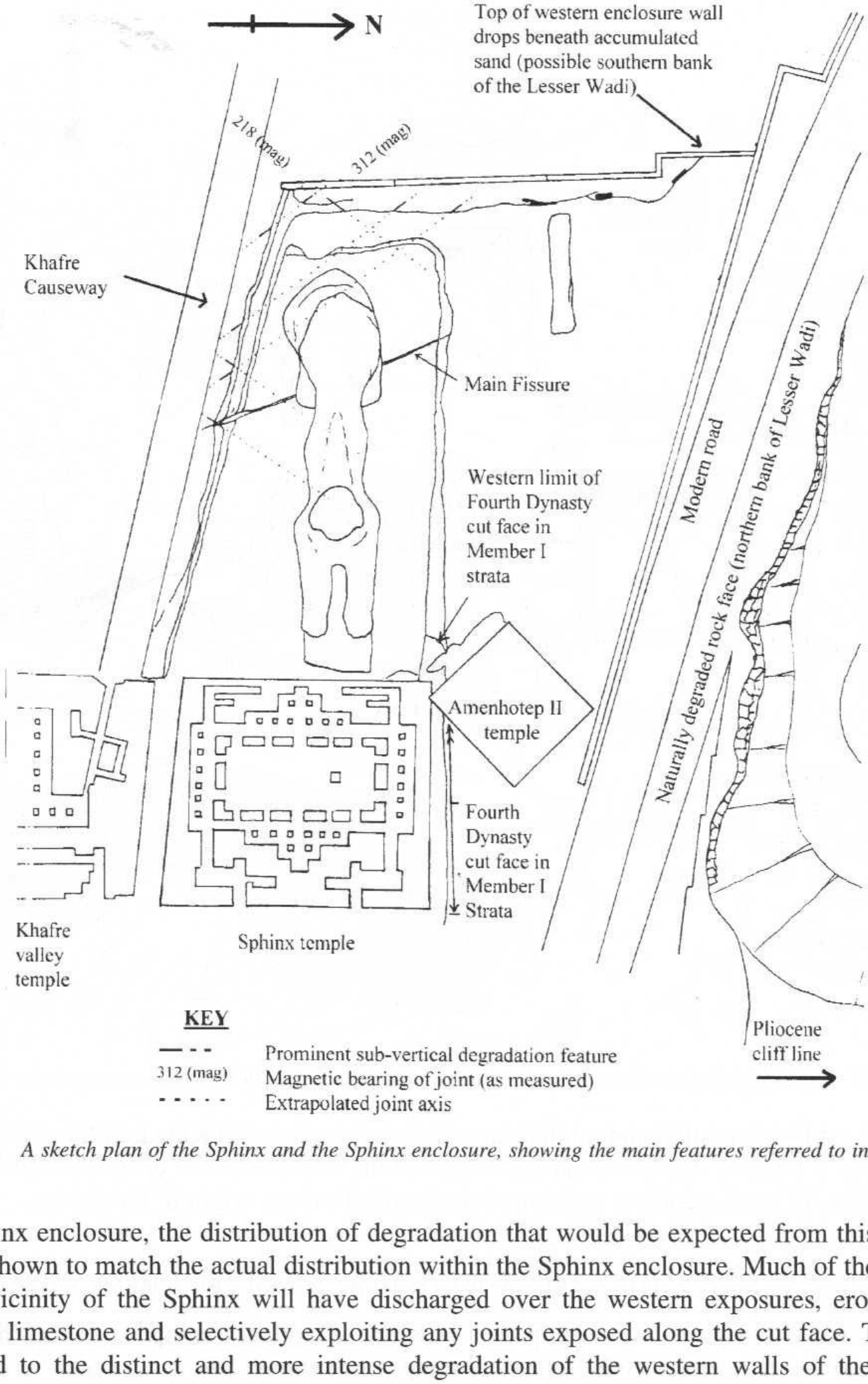

Figure 2 *A sketch plan of the Sphinx and the Sphinx enclosure, showing the main features referred to in the text.*

the Sphinx enclosure, the distribution of degradation that would be expected from this run-off can be shown to match the actual distribution within the Sphinx enclosure. Much of the run-off in the vicinity of the Sphinx will have discharged over the western exposures, eroding the exposed limestone and selectively exploiting any joints exposed along the cut face. This will have led to the distinct and more intense degradation of the western walls of the Sphinx enclosure. The body of the Sphinx will have generated little run-off itself and will have been isolated from run-off from the plateau by the surrounding excavation. Consequently, the generally more intense degradation and sub-vertical features that are particularly characteristic of erosion by run-off will not have developed on the limestones exposed across the Sphinx itself. However, as both the reconstructed climate of the period and the archaeological record indicate,

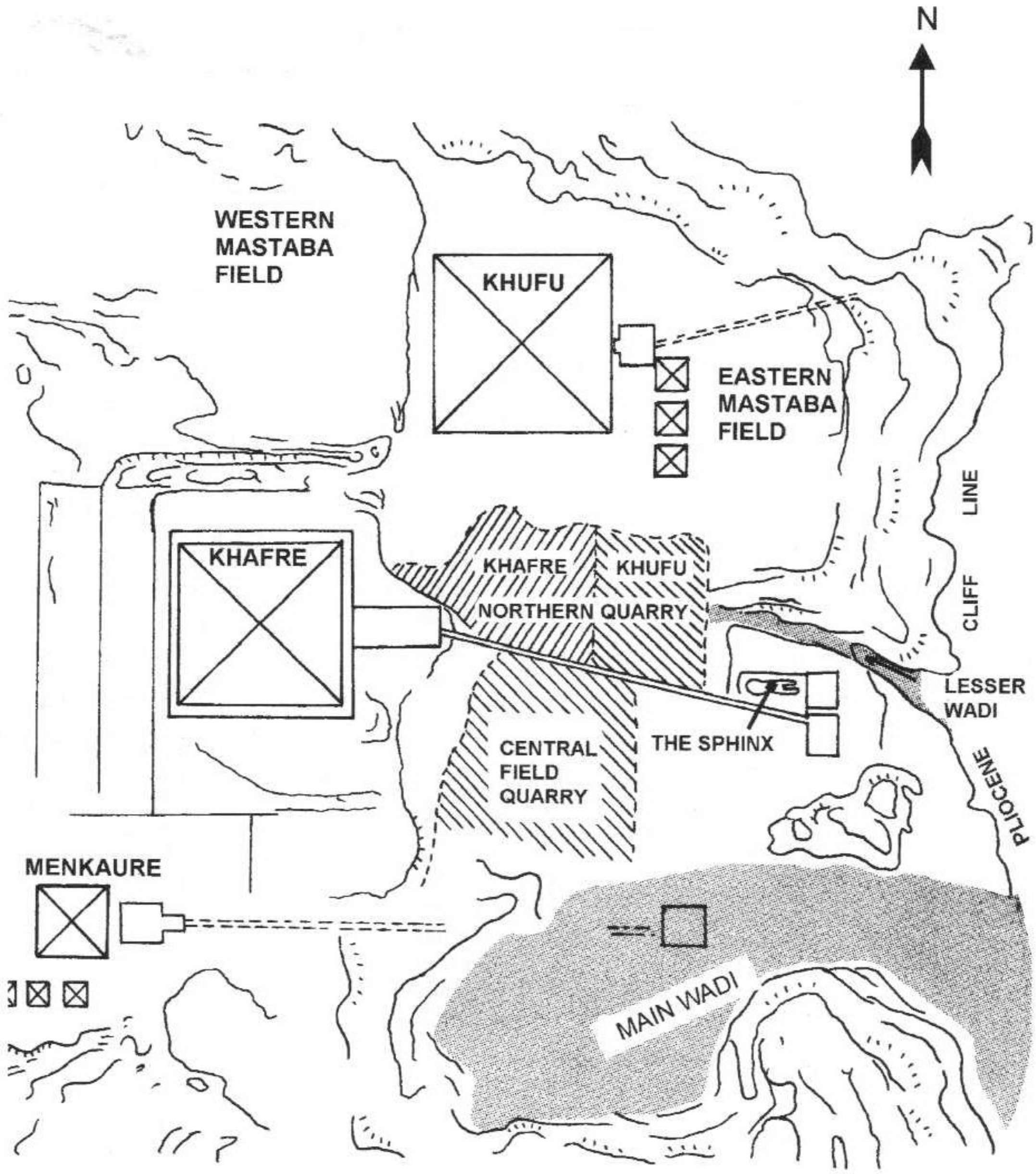

Figure 3 *A sketch plan of the Giza necropolis, showing the extent of Fourth Dynasty quarrying (after Lehner).*

Giza was subject to rainfall and rainfall run-off during the late Old Kingdom (Fourth and Fifth Dynasties). It follows, therefore, that the erosion of the western Sphinx enclosure walls by run-off does not, in itself, require a revision to the Fourth Dynasty origin of the Sphinx.

LEHNER'S MODEL FOR EARLY FOURTH DYNASTY DEVELOPMENT AT GIZA

Lehner (1985a) modelled the development of Khufu's mortuary complex, paying particular attention to the temporary works (quarries, ramps, accommodation, etc.) which were a vital element of the construction programme. Significant to the current discussion is a quarry, located to the west of the Sphinx and to the north of Khafre's causeway (Fig. 3). The position of this quarry can be identified today by a low depression in the surface of the plateau, filled with accumulations of windblown sand. Archaeological excavation in the eastern end of this quarry has identified a pair of closely spaced, parallel walls, built from rough masonry faced with clay

(Saleh 1974). These walls have a general north–south alignment and show a slight slope up towards the cemetery to the east of Khufu's pyramid. Given their location and orientation, these features have been interpreted by Lehner as part of a construction ramp used during the development of Khufu's mortuary complex. This date has been confirmed by mud seal impressions, bearing the name of Khufu, which were found between the walls.

From the earliest phase of Khufu's development, this quarrying will have disrupted the surface hydrology of the site, with the open excavation intercepting any run-off from the higher plateau in the west and preventing its discharge towards the area of the Sphinx. Although worked during the reign of Khufu, Lehner has argued that the quarry was extended to the west during the reign of Khafre. As these additional areas of quarrying were opened up across the plateau, mud brick from construction ramps and large volumes of chippings from the working of masonry may have been deposited in the earliest, worked-out areas. It is not clear how quickly windblown sand then accumulated over this construction debris; however, the surface hydrology of the backfilled quarry will have been very different from that of the intact limestone plateau that preceded it.

Rainfall run-off will only be generated when the surface and immediate subsurface become saturated. Given the fine-grained nature of the limestones and the presence of relatively impermeable marly horizons within the Member II strata that form the surface of the plateau, saturation is likely to be achieved under comparatively moderate rainfall conditions. By contrast, the higher permeabilities of the unconsolidated windblown sand, within the abandoned quarries, will require significantly more extreme rainfall conditions before the subsurface reaches saturation. It is unlikely that rainfall experienced at Giza will have been of sufficient intensity to generate run-off from the backfilled quarry. Even if such extreme conditions were encountered, however, for rainfall run-off to have been generated and to have reached the Sphinx enclosure, a number of additional requirements would have to be satisfied. First, unless the backfill and accumulated sand reached the level of the unworked limestone that surrounds the quarry, any run-off that was generated will have been prevented from discharging towards the Sphinx by the eastern quarry face. For any post-Khufu erosion to have taken place, therefore, it would be necessary for the quarried areas to have been backfilled to the original level of the plateau before the end of the Fifth Dynasty (i.e., before the onset of the present arid conditions). Second, if backfill had reached the level of the adjacent, unquarried areas, discharge towards the Sphinx would then depend on a suitable pattern of surface drainage across the quarry backfill.

In the conventional sequence of development, the excavation of the Sphinx postdates the construction of Khufu's pyramid and the working of the associated quarries. However, the erosion surfaces within the Sphinx enclosure show that the western enclosure walls in particular, were exposed to significant rainfall run-off. This could only have occurred if the excavation of the Sphinx enclosure was undertaken some time before Khufu's quarrying began, when rainfall over the more elevated areas of the Giza plateau was able to run off a substantial catchment, gathering momentum before finally discharging into the enclosure.

THE SPHINX TEMPLE

A study of the distribution of fossils within the Upper Mokattam Limestones at Giza has established that the masonry used to construct the Sphinx temple was quarried from within the Sphinx enclosure (Lehner 1985b). This indicates that the Sphinx enclosure and Sphinx temple were probably built at the same time which, given the proposed relative dating for the Sphinx discussed above, suggests that the Sphinx temple may also pre-date Khufu's development of the site.

Figure 4 *Fourth Dynasty excavation in Member I limestones.*

Although there is evidence for Fourth Dynasty construction of the Sphinx temple (Lehner and Hawass 1994), this relates to activity associated with the northern wall of the temple which, together with the southern temple wall, has been shown to form part of a second phase of Sphinx Temple construction (Ricke 1970). Ricke did not speculate on the period of time that separated the Fourth Dynasty activity from the earlier construction: however, on the basis of degradation of the Member I limestones exposed within the Sphinx enclosure, it is evident that the two operations were undertaken under different conditions of weathering and erosion and were probably, therefore, separated by a significant period of time.

To the immediate north of the Sphinx temple, an excavation has been made into the durable Member I strata. This excavation begins at a point aligned with the eastern face of the temple and extends westward to a position opposite the north forepaw of the Sphinx (Fig. 2). Dated to the Fourth Dynasty by Lehner *et al*. (1980), this excavated face was probably cut to facilitate the extension of the northern temple wall described by Ricke and exhibits remarkably little degradation (Fig. 4). By contrast, the same Member I beds, exposed beyond the western limit of the Fourth Dynasty excavation, are more intensely degraded (Fig. 5). The western limit of the Fourth Dynasty excavation is marked by an abrupt change in the intensity of degradation, a feature that provides a strong indication of a later excavation into an existing cut face.

The more heavily degraded Member I beds beyond the Fourth Dynasty excavation must, therefore, have been exposed to more aggressive conditions of degradation. Such conditions are considered to have prevailed at Giza before the working of quarries during the reign of Khufu. It is concluded that the Sphinx temple was originally built before the Fourth Dynasty and that parts of the foundations and the walls of the first building phase were reused when the Sphinx temple was incorporated into Khafre's Fourth Dynasty mortuary complex.

Figure 5 *Member I limestones immediately west of the Fourth Dynasty excavation shown in Figure 4.*

EVIDENCE FOR PRE-FOURTH DYNASTY ACTIVITY AT GIZA

Additional evidence, outside the scope of the present paper, suggests that a number of other features, including Khafre's causeway and part of Khafre's mortuary temple may, like the Sphinx, pre-date the Fourth Dynasty development of the site. Archaeological evidence in support of early activity at Giza is provided by a number of artefacts that have been recovered on and around the site. Mortensen (1985) discusses four ceramic jars, reportedly found in the late 1800s 'at the foot of the Great Pyramid' (the exact location has not been recorded). When these jars were first found, the Pre-dynastic period of Ancient Egyptian history was little understood and, given the accepted Fourth Dynasty context of the Giza site, the jars were assumed to be of the Fourth Dynasty. Mortensen, however, has re-assessed these jars and considers them to be typical of the late Pre-dynastic Maadi period. Given that the jars were found intact, Mortensen has also argued that they were from a burial rather than a settlement site. Emery (1961) makes reference to the discovery of a large but much destroyed royal monument, believed to be the tomb of the consort of Uadji (Djet) from the First Dynasty ('Mastaba V'; Petrie 1907). Further evidence of Early Dynastic associations with Giza includes two inscribed bowls bearing the name of the first king of the Second Dynasty, Hotepsekhemui (Hetepsekhemwy) (Reisner 1931), found in Menkaure's pyramid complex, and jar sealings bearing the name of a later Second Dynasty king, Neteren (Ninetjer) (Petrie 1907). 'Covington's Tomb' ('Mastaba T'; Petrie 1907) provides evidence of Giza's continued use into the Third Dynasty.

The survival of pre-Fourth Dynasty artefacts within the Giza necropolis has to be considered in the context of the Fourth Dynasty development. In general terms, the Fourth Dynasty land use of the site consisted either of areas of quarrying or construction. These are both rather destructive activities, which may have necessitated the removal of earlier structures and the disposal of the resulting 'site clearance' debris. This debris may have been deposited in the base of worked-out quarries or in other known areas of dumping, outside the area of construction. In the mid-1970s, an Austrian Egyptologist, Karl Kromer, investigated one such area of debris, some 1 km south of the Great Pyramid. Within the fill, Kromer reported finds from the Late Predynastic, the First, Second and Fourth Dynasties (Kromer 1978). Kromer's work has been criticized by Butzer (1982); however, Butzer did not question the age of the finds but only Kromer's interpretation, suggesting that the stratigraphy of the excavation site was more complex than Kromer had reported. Others have criticized the age attributed to the finds, but while the age of ceramics, stone tools, and so on may remain contentious, most people do accept the jar sealings that were excavated as being Early Dynastic (Friedman 1999, personal correspondence). It is generally agreed, however, that the material encountered during Kromer's excavation, including the Early Dynastic artefacts, represented material that had been cleared from the site of the pyramids and dumped at the excavation site (Butzer 1982).

The work of both Mortensen and Kromer has demonstrated, therefore, that there is evidence for pre-Fourth Dynasty activity at Giza. Although most of the pre-Fourth Dynasty artefacts found at Giza have been recovered from outside the Fourth Dynasty necropolis, it can be argued that the mechanism by which this earlier material was removed from its original position and deposited elsewhere is widely understood and generally accepted.

CONCLUSIONS

When considered in terms of the hydrology of the site, the distribution of degradation within the Sphinx enclosure indicates that the excavation of the Sphinx and the original construction of the Sphinx temple, pre-date Khufu's early Fourth Dynasty development at Giza. The close association of the Sphinx and Sphinx temple with other features may indicate a more widespread early development of the site, which may have its origins in the late Pre-dynastic period. At this early time, Giza may have achieved some local significance, with the principal focus of veneration being the prominent outlier from which the Sphinx was later to be carved. Perhaps resembling the head or face of a lion, this outlier faced east towards the rising sun and, as such, may have been linked to sun worship, justifying its own cult temple. On the basis of the known development in the use of stone masonry in Ancient Egypt, the excavation of the Sphinx and the construction in stone of the earliest part of the Sphinx Temple are tentatively placed at some time in the latter half of the Early Dynastic Period. In the Fourth Dynasty, the site of the established cult centre was selected by Khufu for the construction of his pyramid complex. In this way, the Sphinx enclosure and Sphinx temple became an integral part of this large Old Kingdom necropolis, the building of which absorbed or erased much of the evidence for earlier activity.

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COMMENTS ON 'A GEOMORPHOLOGICAL STUDY OF THE GIZA NECROPOLIS, WITH IMPLICATIONS FOR THE DEVELOPMENT OF THE SITE'

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The pyramids at Giza continue to grip the public's imagination in a way that no other archaeological site anywhere in the world is capable of doing. Therefore it is perhaps unsurprising that this appetite is fed by a large number of books and publications on every conceivable aspect of the Giza site and its monuments. These books range from the scholarly treatises published by groups such as the Giza Plateau Mapping Project, through more popular texts written by respected Egyptologists (such as Lehner's *The complete pyramids*) to the more fanciful bestselling creations detailing secret chambers, lost civilizations, fabulous treasures and conspiracies of silence. This latter group of 'creative' writings means that in some areas it can be difficult to publish even well constructed academic papers, if they argue against the current status quo. This is especially true if you are, first, writing about the Giza plateau and, second, not conventionally trained in an established Egyptology department. Colin Reader and 'A geomorphological study . . . ' fall into both of these categories, but his work is well argued and certainly of sufficient merit to warrant more than the usual stony silence. However, Reader should be aware that the burden of proof very much lies with him. On such a high-profile and important site, he will have to prove his argument 'beyond reasonable doubt' in order for it to be accepted.

The evidence for Reader's argument is drawn from geological interpretations of weathering patterns in and around the Sphinx enclosure. The presence of sub-vertical degradation elements in the walls of the Sphinx enclosure is not in doubt; and it is certainly true, as Reader points out, that they are more abundant at the western end and comparatively rare at the eastern end and on the Sphinx itself. However, their interpretation is a more complex matter. Reader argues against the theory of Gauri *et al.* (1995) that the sub-vertical features are caused by solution widening of joints by groundwater movement. He believes that such a process would not account for the relative abundance of the features on the western wall. However, the western wall faces east and gets the sun full on throughout the morning, whereas the southern wall faces north and is therefore relatively shaded from the sun. The two walls are therefore exposed to different temperature profiles and different microclimates, which Reader should address as another possible cause of differential weathering. Reader's view is that rainfall run-off is a more likely cause. His argument would be considerably strengthened if he had been able to cite evidence that demonstrates unequivocally that this is the case. This could be accomplished relatively easily if, for example, if he could locate other equivalent sub-vertical features that have developed in local wadis or monuments as a result of flash floods and show that these are morphologically identical to those in the Giza area. Similarly, Reader would advance his case if he could show the absence of these features on post-Fifth Dynasty buildings that lie in areas that are geographically vulnerable to run-off.

If one accepts the interpretation that the sub-vertical features are run-off derived, as seems likely, then one must look further at the quarries. The critical points are their dating and the implications of the nature and timing of their fill. If the quarry to the north of the Khafre's causeway is later than the reign of Khufu, then run-off from the catchment area into the Sphinx enclosure and subsequent degradation is possible, and the date of the Sphinx enclosure does not have to be changed. Interestingly, Lehner's map (1997, 230) marks this quarry as 'Khafre's quarry?', suggesting at least that there might be some doubt as to the date. If a small amount of mining was carried out in Khafre's reign, but the majority is later, then run-off would still be likely and this would also 'reconcile the geological and archaeological evidence'. If all of this quarry *is* of Khafre's reign, then Reader states that it is 'unlikely' that the rain of the period was of sufficient intensity to run off the backfilled quarry, even if it was completely full of debris. Again, this is Reader's opinion, and it is not supported by comparative data about the flow of water over such terrain. One is just left with a series of questions: What volume of water in what period of time would be needed to flow over a quarry full of sand? How big a thunderstorm would that represent: a 100-year event, or a 1000-year event? How many storms would be necessary to cause the observed degradation: one, ten, one hundred? What does that say about how much earlier than the pyramids he proposes the Sphinx enclosure to be? Stadelmann (2000) is very definitely of the opinion that the Sphinx dates to Khufu's reign. Would this be sufficiently early to give sufficient rainfall run-off?

In conclusion, it seems possible that the degradation features are caused by rainfall run-off as Reader describes; but without comparative information, 'possible' is as far as one can go. Without more information about the quarries, one is forced into either accepting the geology and therefore problematizing the archaeology, or rejecting some part of the geological interpretation in favour of the strong archaeological and contextual information in favour of the conventional dating. The lack of comparative information from other sites on degradation, water flow and storm damage means that Reader falls short of 'beyond reasonable doubt' and, in the end, the verdict has to be that his case is 'not proved'.

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COMMENT ON C. D. READER, 'A GEOMORPHOLOGICAL STUDY OF THE GIZA NECROPOLIS, WITH IMPLICATIONS FOR THE DEVELOPMENT OF THE SITE'

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From his study of the geomorphology of the Giza plateau, and in particular of the Sphinx and its enclosure, Reader concludes that the Sphinx was first excavated, and the Sphinx Temple first built, some time before the Fourth Dynasty. According to the orthodox Egyptological view, the Giza plateau did not achieve prominence until the reign of Khufu, second king of the Fourth Dynasty, the Sphinx and its temple being created as part of the master-plan of Khufu's second successor, King Khafra. In recent years, many popular books have suggested that the Sphinx is much older than the conventional view allows. In contrast to some of the more sensationalist works of this genre, Reader takes a refreshingly scientific approach to the question. He shows himself ready to engage with—rather than reject out of hand—the Egyptological arguments. However, although Reader's hypothesis is not inherently impossible, a consideration of the archaeological and Egyptological evidence suggests that it is unlikely, at least on the basis of the data currently available.

Reader correctly notes that there is evidence—albeit scanty—for activity at Giza before the Fourth Dynasty. The four pottery vessels found near the Great Pyramid in the nineteenth century, discussed by Mortensen (1985), belong to the Pre-dynastic ceramic tradition of Lower (northern) Egypt, sometimes called the Maadi cultural complex (cf., Wilkinson 1996, 5). Sites—both settlements and cemeteries—yielding material of this type have been excavated throughout the Memphite region, indicating a fairly dense occupation during the middle of the fourth millennium BC (Rizkana and Seeher 1987–90; Debono and Mortensen 1988; Habachi and Kaiser 1985). Although most of the sites are situated on the east bank of the Nile (notably Maadi itself, Heliopolis South, Wadi Digla and es-Saff) there are recent indications that the west bank too was used for settlement and/or burial in the Pre-dynastic period. Excavations within the modern settlement of Giza for the Cairo Waste-Water Project uncovered a number of pottery vessels of the 'Maadi cultural complex' (David Jeffreys, personal communication), confirming that Giza witnessed at least a limited degree of activity long before the Fourth Dynasty.

Be that as it may, there is a marked hiatus in the archaeological record of some six centuries between these scanty remains and the next indication of activity at Giza. Petrie's 'Mastaba V', dated to the reign of King Djet in the early First Dynasty (*c.* 2900 BC), is the earliest evidence for construction at Giza and the first edifice with royal associations to be built at the site (Petrie 1907). It was most probably constructed for Djet's wife or mother (Wilkinson 1999, 73–4). Another Early Dynastic tomb, dated by seal-impressions to the reign of King Nintejer in the early Second Dynasty (*c.* 2700 BC), has also been excavated at Giza (Petrie 1907, 7; Wilkinson 1999, 85), while 'Covington's Tomb' is dated to the Third Dynasty (*c.* 2600 BC). These three tombs, one from each of the first three dynasties, comprise the sum total of pre-Fourth Dynasty construction at Giza. While they do indicate a minimal level of activity—even royal activity—in the area in Early Dynastic times, they do not suggest that Giza was anything more than a peripheral site in the great Memphite necropolis prior to the reign of Khufu. (As Reader notes, inscribed stone bowls bearing the name of the Second Dynasty King Hetepsekhemwy were found in the pyramid temple of Menkaura's pyramid complex, but such re-use of 'heirlooms' in kings' mortuary complexes is a well attested practice throughout Egyptian history, and in particular during the early dynasties (Wilkinson 1999, 84).)

Of course, the intensity of construction on the Giza plateau during the Fourth Dynasty may well have obliterated remains of earlier activity. However, given also the intensity of archaeological investigation at Giza over the past hundred years, it is perhaps telling that so few indications of pre-Fourth Dynasty activity have been discovered to date. In the absence of more compelling archaeological evidence, the hypothesis that the Giza plateau was a significant site prior to the early Fourth Dynasty must remain unproven.

As for Reader's suggestion that the prominent outlier, from which the Sphinx was later to be carved, may have been linked to sun worship in the Early Dynastic period, the Egyptological evidence is very firmly against such a theory. The study of Early Dynastic religion is in its infancy, but the available evidence indicates that sun worship did not become significant within the ruling élite until the Third Dynasty at the earliest, and was not wholeheartedly adopted into royal theology until the early Fourth Dynasty. The earliest, fleeting reference to the sun as a deity is found at the end of the Second Dynasty (*c.* 2700 BC), on a seal-impression of King Peribsen (Wilkinson 1999, 293). (The name of the early Second Dynasty king, Nebra, seems to refer to the sun as a heavenly body rather than as a deity.) In the reign of King Netjerikhet (builder of the Step Pyramid at Saqqara), at the beginning of the Third Dynasty, one of the most senior members of the ruling élite was a man called Hesira, whose name means 'praised of Ra [the sun god]'. This indicates that worship of the sun god, at least as a personal deity, was beginning to gain ground within the highest echelons of Egyptian society (Wilkinson 1999, 293). The earliest building at Heliopolis—later the principal cult centre of the sun god Ra—dates to the same reign; however, it does not even seem to be dedicated to the sun god but, rather, to the group of nine deities (ennead) worshipped at Heliopolis in connection with the primary creation myth of Egyptian theology. This suggests that sun worship was still far from being established as a major tenet of state religion. Only with the accession of King Djedefra, Khufu's successor, were the name of the sun god and the title 'son of Ra' incorporated into the royal titulary (Quirke 1990). Hence, Reader's suggestion that sun worship was established at Giza in the Early Dynastic period is not supported by the available evidence, and seems highly improbable.

In conclusion, the evidence for pre-Fourth Dynasty activity at Giza is very limited indeed, and the evidence for sun worship before the Fourth Dynasty even scantier. It is not impossible that the Sphinx and its temple pre-date the reign of Khufu, and future excavations may indeed yield evidence to support such a theory. But, at present, the archaeological and historical data available to Egyptologists strongly support the orthodox view that major construction at Giza, including the Sphinx and its temple, did not begin until the reign of Khufu in the early Fourth Dynasty.

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A RESPONSE TO COMMENTS ON 'A GEOMORPHOLOGICAL STUDY OF THE GIZA NECROPOLIS, WITH IMPLICATIONS FOR THE DEVELOPMENT OF THE SITE'

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The comments of Drs Shortland and Doherty focus on the geomorphological aspects of 'A geomorphological study . . . ' and, while many of the key observations do not appear to be in dispute, a number of issues are raised in relation to whether the more intense degradation of the western enclosure walls is indeed the result of erosion by rainfall run-off. Shortland and Doherty suggest that other processes of weathering and erosion may be responsible for the formation of these more intense features of degradation.

During research for the paper, to establish whether erosion by rainfall run-off was the only process that could explain the observed features, the potential influence of a number of agents of weathering and erosion were considered. These included chemical weathering, the abrasive nature of windblown sand and, as Shortland and Doherty suggest, the aspect of the various exposures within the Sphinx enclosure. Aspect can greatly influence certain processes of degradation: however, it is considered that aspect has not had a dominant influence on the degradation of the Sphinx. Although the more intensely degraded east-facing, western enclosure wall is exposed to direct sunlight throughout the morning, so too is the 'chest' of the Sphinx. Unlike the western enclosure wall, however, the east-facing 'chest' of the Sphinx does not exhibit the intense and characteristic degradation of the western enclosure wall.

The sub-vertical features and smoothed, rounded strata of the western enclosure walls are considered to be typical of erosion by rainfall run-off. Similar features can be identified on a number of rock-cut tombs at Giza. Those observed to date are located mainly in the south of the central field area; for instance, the mastaba of Kai (Hassan 1941), close to what, before ancient quarrying, was probably the northern bank of the Main Wadi (Fig. 3 in 'A geomorphological study . . . '). The distribution and morphology of these features has yet to be fully assessed and is one of a number of objectives set for further work.

Of interest also are a number of Late Period (26th Dynasty) tombs cut into the western wall of the Sphinx enclosure (see Plan IV; Porter and Moss 1974). These tombs are in the same hydrogeological setting as the Sphinx and are cut into some of the most intensely degraded beds exposed along the western enclosure wall. Limited inspection to date has shown that, despite being exposed to chemical weathering, abrasion by windblown sand, and so on for some 2600 years, the portals of a number of these tombs still show tool marks made during their excavation.

Shortland and Doherty make no mention of what may be the most significant evidence in support of an early Sphinx—the Fourth Dynasty cutting to the north of the Sphinx Temple. The relatively unweathered state of this cut face, when compared with the heavy degradation of the same limestone beds beyond the western limit of the cutting and the abrupt rather than transitional change in the degradation, leaves little doubt that this is a late excavation into an older cutting.

Shortland and Doherty also question the dating of the quarry that lies immediately to the west of the Sphinx and has such a significant impact on the date at which the monument was excavated. Lehner's qualified attribution of this quarry to Khafre (Lehner 1997, 230) is not known to be supported by any datable finds from within the quarry. By contrast, as Saleh (1974) and Lehner (1985) indicate, the attribution of the eastern section of this quarry to the reign of Khufu is supported by artefacts, excavated from within the now backfilled quarry, which bore Khufu's cartouche.

The effect of materials of different permeabilities is also questioned—particularly whether, after quarrying, replacement of the stratified and fine-grained limestones with coarser unconsolidated construction debris and windblown sand would have the marked effect on the generation of rainfall run-off that has been suggested. Establishing the permeability of the materials by a programme of *in situ* testing has been identified as an additional area of future work, if the necessary permissions can be obtained. Even with this data, however, the derivation of values for the intensity of rainfall that would generate run-off from these two materials would be problematic. This would be compounded by the lack of rainfall data for the period in question (the ancient records of Nile flood levels would not provide the necessary data).

It is a fundamental concept of geomorphology, however, that sands will have greater permeability than fine-grained soils or rocks, such as marly limestones and will, therefore, be less likely to generate run-off. This is not to preclude run-off from the backfilled quarries, but does make it far less likely. It is, therefore, difficult to reconcile the intense degradation of the western Sphinx enclosures with relatively infrequent run-off occurring during the geologically brief interval between the conventional Fourth Dynasty construction of the Sphinx (the reign of Khafre—*c.* 2520–2494 BC) and the onset of the present arid conditions in the late Fifth Dynasty (*c.* 2350 BC).

By contrast to the comments of Shortland and Doherty, the comments made by Dr Wilkinson focus on the Egyptological case put forward in 'A geomorphological study . . .'. Wilkinson refers to the work of Mortensen and provides further evidence for late Pre-dynastic activity in the Giza area. Wilkinson then suggests a hiatus for almost six centuries before the construction of a First Dynasty mastaba at a peripheral location to the south of the Giza necropolis. However, Wilkinson does not refer to the excavations undertaken by Kromer, who concluded that the only hiatus present may have been during the Third Dynasty.

Despite some of Kromer's interpretation being criticized, two conclusions are generally accepted:

(1) that Kromer encountered Early Dynastic artefacts within the dumped material that he excavated;

(2) that the excavated material had been removed from the area of the pyramids, presumably to allow the Fourth Dynasty development to proceed.

Kromer's work, therefore, constitutes the most direct evidence that there was development at Giza throughout most of the Early Dynastic period, providing a context for a pre-Fourth Dynasty Sphinx. At no point in 'A geomorphological study . . . ' is it argued that the pre-Fourth Dynasty solar cult complex at Giza was anything other than a site of local importance, nor it is argued that any link to royalty or to Ra, the sun god, was established before the Fourth Dynasty. In considering the case for the pre-Fourth Dynasty site at Giza being a site of sun worship, Wilkinson argues that the Egyptological evidence is firmly against such a theory. However, As Wilkinson himself points out, references to the sun as a deity are known from the Early Dynastic Period. Wilkinson has also argued that certain architectural elements of Early Dynastic royal funerary structures may have been oriented east to face the rising sun (Wilkinson 1999, 237), an alignment shared with the proposed Early Dynastic solar-cult complex at Giza.

Interestingly, Dr Edwards appears to have been in little doubt regarding the cultic significance of the sun, its duality and links with the iconography of the lion: 'In Egyptian mythology the lion often figures as the guardian of sacred places. How or when this conception first arose is not known *but it probably dates back to remote antiquity*. Like so many other primitive beliefs, it was incorporated by the Priests of Heliopolis into their solar creed, the lion being considered the guardian of the gates of the underworld on the eastern and western horizons' (Edwards 1993; 122—my italics). The concepts outlined here by Edwards fit particularly well with the role of the Sphinx, the Sphinx Temple and other early features of the Giza Plateau that have been discussed in the paper.

As stated earlier, there are a number of avenues of research that require further attention. As all of the work undertaken for this study is self-funded, no dates for this further work can presently be set. However, the evidence presented by the geology and geomorphology—particularly the contrast in degradation that can be observed in a number of places within the Sphinx enclosure—is considered to present difficulties for the conventional age of the Sphinx. While it is accepted that, given the Egyptological status quo, the 'burden of proof' rests with the geomorphological argument, it is also suggested that this debate can never fully progress until Egyptologists engage the detailed issues raised in 'A geomorphological study . . . '.

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