The geomorphological evidence for the Early Dynastic origins of the Great Sphinx of Giza: a response to Drs Lehner and Hawass

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Having examined the weathering and erosion of the limestones that were exposed by the excavation of the Great Sphinx, this author has previously concluded that whilst the Sphinx is a product of the Pharaonic culture, its excavation pre-dates the 4th Dynasty Pyramids at Giza. Although space here prevents the repeating of detailed arguments leading to this conclusion, the following pages will revisit a number of relevant issues in the context of criticism that has been presented by Dr Mark Lehner and Dr Zahi Hawass in their publication, Giza and the Pyramids (2017: 58-61).

When presenting their criticism, Lehner and Hawass refer to only one of a number of articles published by this author on this subject. The article that Lehner and Hawass cite (Reader 2014) was an exploration of the iconography of the sphinx and did not address geological issues in detail. This apparent lack of familiarity with the full range of published material may explain why on a number of occasions in their rebuttal, Lehner and Hawass suggest that certain issues have been ignored. For example, they state 'Reader ignores the fact that the southeasterly sloping lower beds of Member II, which show the greatest erosion, are not exposed at the eastern end of the ditch' (2017: 59). Rather than having ignored the distribution of the various limestone units, however, these issues have been explored at length (Reader 1997; 2001; 2002; 2005; 2006; 2006a). As shown on figure 1, contrary to the view expressed in Lehner and Hawass (2017: 59), the lower beds of the Member II limestones are exposed in the eastern end of the Sphinx enclosure, with unit i extending for some distance across the enclosure floor (Lehner 1991: figs 4.4 and 4.5).

There is also an issue with the way in which Lehner and Hawass generalise about the degraded state of the limestones within the Sphinx enclosure. The Member II strata are the most widespread of three exposed limestone Members (Reader 1997), extending along the southern and western walls of the enclosure (fig. 1), as well as being exposed across most of the body of the Sphinx. As will be explored in more detail below, the Member II

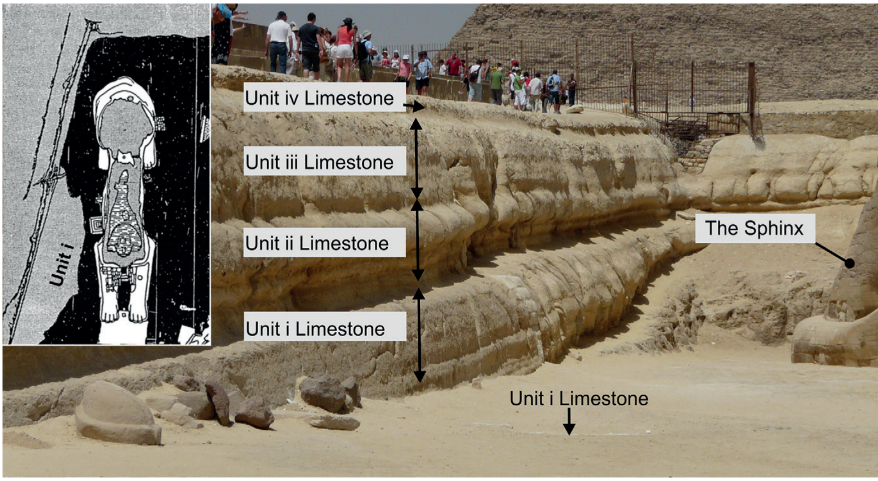

Figure 1: The Member II limestones, looking west along the southern wall of the Sphinx enclosure. It is evident from this view that the south easterly dip of the Member II strata causes the lowest unit (unit i) to dip below the enclosure floor. Although unit i is not exposed in the most easterly walls of the enclosure, as the extract from fig. 4.4 of Lehner's PhD thesis shows (inset), unit i is exposed across the eastern floor of the enclosure.

strata exposed along the western enclosure walls have a rounded and more intensely degraded morphology that is not apparent elsewhere. This distribution is considered to be particularly significant when attempting to determine when the excavation of the Great Sphinx took place.

A context for an Early Dynastic Great Sphinx

In their rebuttal, Lehner and Hawass note that extensive quarrying was required to construct the Great Sphinx and that 'nowhere else in Giza – or anywhere in Egypt – do we see this scale of stonework in the Early Dynastic, before the 3rd dynasty step pyramids' (2017: 59). In making this statement, Lehner and Hawass are implying that the Great Sphinx could not be a product of the Early Dynastic Period as suggested by this author's interpretation of the geological evidence, because the ancient Egyptians had not mastered the ability to quarry and move large volumes of stone at such an early time.

Lehner and Hawass' statement, however, is not consistent with what is currently understood regarding construction in the Early Dynastic Period and also appears to contradict statements they have made elsewhere in Giza and the Pyramids. As Lehner and Hawass discuss (2017: 72), the tombs of two early 2nd Dynasty pharaohs (Hetepsekhemwy and Ninetjer) at Saqqara took the form of extensive underground rock-cut galleries, the construction of which involved significant quarrying and tunnelling (Lacher 2008; Lacher-Raschdorff 2014). The volume of limestone bedrock removed for the construction of these early 2nd Dynasty royal tombs, however, will have been dwarfed by the quarrying required for the construction of the Gisr el-Mudir at Saqqara. The Gisr el-Mudir is a largely stone-built walled enclosure which lies to the south-west of the Step Pyramid, with the enclosed space covering an area approximately twice that of the Step Pyramid enclosure. As Lehner and Hawass confirm, the Gisr el-Mudir is generally regarded as having been built in the 2nd Dynasty (Lehner and Hawass 2017: 72).

Surrounding Netjerikhet's 3rd Dynasty Step Pyramid enclosure is a feature known as the Dry Moat which is generally understood to be a trench some 6 m deep and 40 m wide, excavated in the limestone bedrock (Swelim 1988). The Dry Moat may have served as a quarry during the construction of the Step Pyramid (Reader 2017); however, given that a number of 2nd- and early 3rd Dynasty features have been found in the area enclosed by the Dry Moat (Reader 2017; Welc 2008), it is possible that this little understood feature may predate the Step Pyramid. Of particular interest is a pair of 27 m deep rock-cut trenches in the south of the Dry Moat (Swelim 2006). Quarrying would have been impractical from such deep and narrow excavations and given that the locations of these trenches are remarkably close to the entrances to the early 2nd Dynasty tombs of Hetepsekhemwy and Ninetjer, an early 2nd Dynasty date has been suggested for their construction (Dodson 2017; Reader 2017).

Given what is known from just one site – Saqqara – Lehner and Hawass' view that the ancient Egyptians had not mastered the ability to quarry and move large volumes of stone before the beginning of the 3rd Dynasty, is clearly not supported by available evidence. When considering whether my proposed Early Dynastic date for the excavation of the Great Sphinx fits the established context for large-scale stone working in ancient Egypt, it is also important to consider that the Great Sphinx is unique. No other free-standing, rock-cut monument was constructed during the Pharaonic era. As a result, it is difficult to associate the Great Sphinx with any specific trend in monument building in ancient Egypt.

The degradation of the Great Sphinx

Irrespective of when the Great Sphinx was originally excavated, from the outset it will have been subject to a range of processes of weathering and erosion. As explored in detail elsewhere, these processes will have included chemical weathering, the daily heating and cooling of the exposed limestones as the sun rises and sets and abrasion by wind-blown sand. All these processes will have played a role in the degradation of the Great Sphinx, contributing to the form seen today. As previously discussed at length, however (for example Reader 2001), there is one particular feature of the degradation within the Sphinx enclosure that is not consistent with the action of these processes: this is an evident distribution in the intensity of degradation within the Sphinx enclosure, with the rounded, most heavily degraded exposures lying along the western enclosure walls (figs 2 and 3).

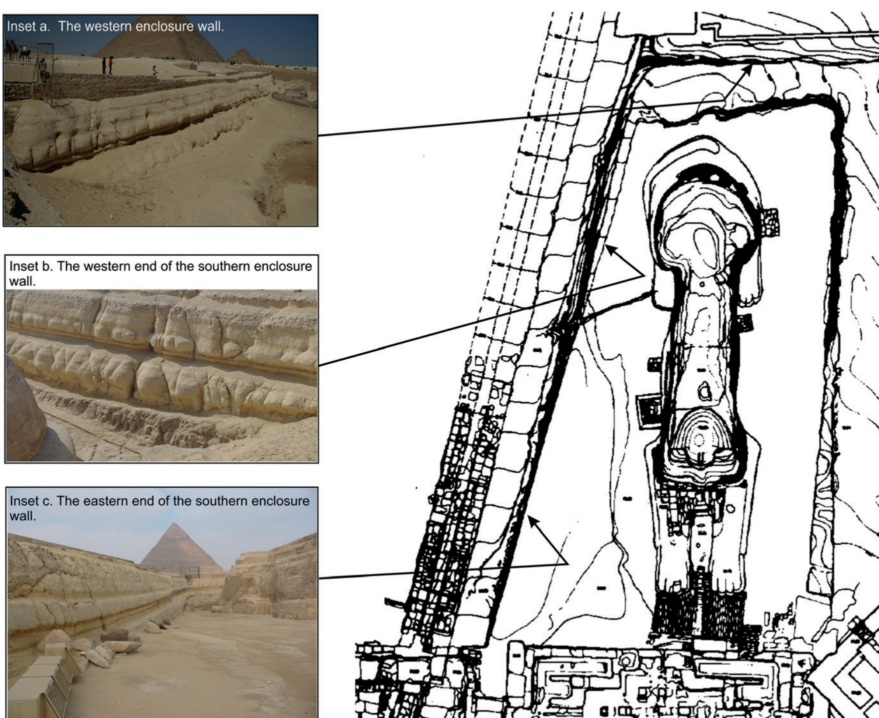

Figure 2: The varying degradation of the walls of the Sphinx enclosure, with the more intense degradation evident along the western exposures.

I consider that this spatial distribution is the result of an additional process, the destructive effects of which have been identified at a number of ancient sites in Egypt including the Giza necropolis (Reisner 1931: 44). This process is often referred to as run-off and occurs when heavy rainfall saturates the ground surface, leading to surplus water discharging downslope. This discharge can have significant erosive potential.

After considering the potential influence of run-off on the Sphinx enclosure in my earliest papers, I first applied the concept of the flow net to the issue in 2006 (Reader 2006; 2006a). Flow nets can be used to model the way in which topography (shown as orange contours and referred to as equipotentials in fig. 4) influences surface water or groundwater in the vicinity of a particular feature, with the spacing of flow lines (shown as blue arrows on fig. 4), indicating the relative intensity of the resulting flow. Although Lehner and Hawass consider that I have ignored ‘the fact that the

Figure 3: Looking east along the southern wall of the Sphinx enclosure, it is evident that the western end of the enclosure (foreground) has been degraded to a greater extent than the eastern end (background).

bedrock slopes south, away from the Sphinx ditch, as well as east, towards it' (2017: 59), it is clear from the manner in which topography has been modelled on figure 4, that I have taken full account of the slope of Giza plateau when assessing the behaviour of run-off in the vicinity of the Sphinx.

As figure 4 shows, the topography of the area surrounding the Sphinx causes the flow lines to draw closer together as they approach the western wall of the enclosure. These close flow lines indicate an increase in flow intensity in this area and correspond with the area of intense degradation along the western enclosure wall. The absence of flow lines at the eastern end of the southern enclosure wall (the area adjacent to the valley temple and Sphinx temple) suggests that only low intensity flow will have reached this area. The pair of widely spaced flow lines intercepting the western end of the southern enclosure wall suggest that flow intensity along this exposure increased towards the west. Once again, the distribution of flow lines along the southern enclosure wall is consistent with the distribution of more intense degradation evident within the Sphinx enclosure (fig. 3).

I consider that the correlation between the areas of more intense flow indicated by the flow net and the distribution of the more heavily degraded exposures within the Sphinx enclosure, confirms the role that run-off has played in the degradation of the Great Sphinx.

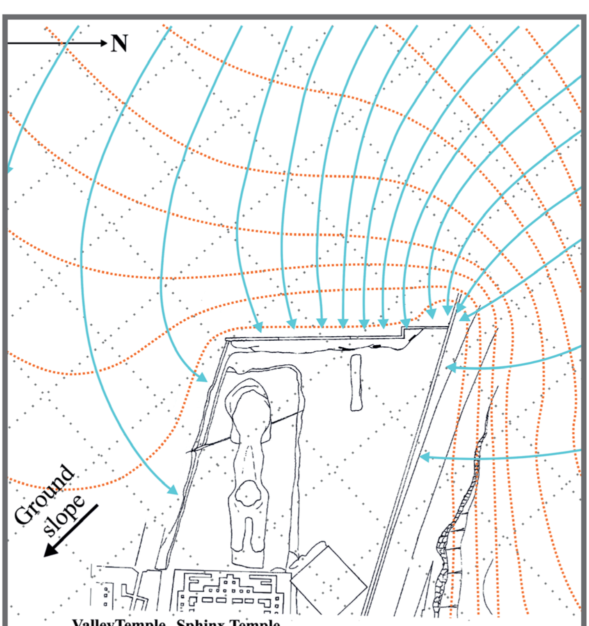

Figure 4: Flow net for the Sphinx enclosure (equipotentials in orange, flow lines in blue).

Quarrying to the west of the Sphinx enclosure

The flow net presented as figure 4 does not give the full picture however, as it does not take account of a feature located some 20 m to the west and upslope of the Sphinx enclosure: an area of ancient quarrying. Prior to this quarrying, run-off from occasional rain storms at Giza will have been able to discharge into the Sphinx enclosure in the manner shown on figure 4, scouring the western walls and leading to the development of the areas of rounded and more intense degradation that are so evident today. Once quarrying began, however, run-off will have discharged into the quarry basin and will not have been able to reach the downslope areas in which the Sphinx enclosure lies. The erosion of the western walls of the Sphinx enclosure by run-off therefore, requires the Great Sphinx of Giza to be older than the adjacent quarry and for this reason, the history of quarrying at Giza becomes hugely significant.

Lehner and Hawass suggest that I attributed the area of ancient quarrying to the west of the Sphinx enclosure to the reign of Khufu (2017: 59, 'Reader's main argument is as follows […] it was Khufu's workmen who quarried the bedrock west of the Sphinx'). If, as explained above, the erosion of the Sphinx enclosure by run-off took place before this quarrying began, it follows that the Great Sphinx must pre-date the activities of Khufu at Giza.

I was not the first, however, to suggest that this quarry was excavated during the reign of Khufu. As Lehner describes (1985: fig. 3c item C12 and the accompanying text for C12), there is clear archaeological evidence to support such an attribution, with material excavated from between a pair of masonry walls in the base of the quarry containing 'mud seal impressions bearing the name of Cheops [Khufu]' (Lehner 1985: item B9). The evidence recovered from the base of this quarry establishes a date not only for the masonry walls but also for the quarry in which they sit. In Giza and the Pyramids, however, Lehner and Hawass attempt to preserve the conventional date for the construction of the Great Sphinx by revising the date of this quarry, suggesting that its excavation can be attributed to the later reign of Khafre (2017: 59). In contrast to the well-reasoned attribution to Khufu that was presented in Lehner's 1985 paper, however, Giza and the Pyramids offers little more than opinion to support this revised position.

Even if the dating evidence presented by Lehner in his 1985 paper is set aside and it is accepted that the quarrying to the west of the Sphinx enclosure was undertaken during the reign of Khafre as suggested by Lehner and Hawass (2017: 59), this does not significantly alter the conclusion that the Great Sphinx pre-dates the 4th Dynasty. This is because available data suggests that rainfall was experienced only infrequently in Egypt in the Pharaonic period (Peacock and Maxfield 1997: 183, item 45), occurring at Giza in the Old Kingdom perhaps only a couple of times each century. Given the likely frequency of run-off events, even if the improbable scenario that the Great Sphinx was excavated at the very start of Khafre's reign and the adjacent quarrying took place at the end of his reign is accepted, this gives a limited period of less than 30 years during which run-off events could have affected the Sphinx enclosure (Baines and Malek 1980: 36). Evidence will be presented below to demonstrate that such restricted timescales will not have been sufficient for the development of the more intense erosion of the western walls of the Sphinx enclosure.

Modern rainfall

Having examined the case for erosion by run-off, Lehner and Hawass go on to consider other factors that they consider may have led to the degradation of the Sphinx enclosure and which in their view, do not require any revision of the conventional attribution of the Sphinx to Khafre. They present an extensive discussion of conditions within the Sphinx enclosure that they have encountered following modern rainfall events at Giza. I will address their observations in some detail shortly, however I consider that the conditions existing at Giza today will have little bearing on those that existed for most of the history of the Great Sphinx. In the modern era, the Sphinx has been completely cleared of sand, something that is known to have happened only occasionally in antiquity (for example during the reign of Thutmose IV, see Lehner and Hawass 2017: 476), a modern asphalt road has been built immediately to the north of the Sphinx enclosure, a masonry wall has been built along the western and northern limits of the enclosure and the broader environs of the Sphinx have been subject to extensive archaeological investigation, which has involved the re-distribution of large volumes of sand and accumulated debris. Together, these modern features and activities will have significantly altered the surface hydrology of this part of the Giza plateau, resulting in hydrological conditions today that will differ significantly from those that existed in the pre-modern era. When Lehner and Hawass state that they have observed water washing over the western side of the 'Sphinx ditch' (2017: 59), they appear not to have considered the potential significance of these modern changes.

I have previously referred to a letter written by Karl Lepsius (Reader 2014), which describes a severe rainfall event witnessed at Giza in 1843 (Lepsius 1853: 53-4). Lepsius' account is important because it largely pre-dates the modern interventions that influence current hydrological conditions at the site. Furthermore, from a surface hydrology perspective, conditions on site in 1843 will not have been significantly different from those that prevailed throughout the preceding centuries or even millennia. Lepsius' account of the rainfall event he witnessed is, therefore, likely to be the nearest to reconstructing a pre-modern major rainfall event at Giza and its consequences for the Great Sphinx.

Lepsius' account describes a brief but severe rain storm that led to the development of high-energy run-off capable of washing away tents and equipment, including iron crow-bars. Yet despite the ferocity of this event, within a short distance of washing through Lepsius' encampment, the high-energy run off was brought to a halt and formed a 'lake in a hollow behind the Sphinx' (Lepsius 1853: 53-4). It is with some evident relief that Lepsius confirms that the lake 'fortunately had no outlet', an indication that run-off failed to reach the Sphinx and that no damage was caused to the monument.

Given Lepsius' description, the hollow in which the 'lake' formed cannot have been the sand-filled Sphinx enclosure. A short distance upslope of the Sphinx enclosure, however, is the quarry worked by Khufu (Lehner 1985: fig. 3c item C12), which is separated from the Sphinx enclosure by an unquarried section of limestone bedrock (which Lehner and Hawass refer to as a 'bedrock bridge', see 2017: 59). This unquarried bedrock is the only feature in this area of Giza that will have been robust enough to bring the high-energy run-off described by Lepsius to a halt. The most likely location, therefore, for the 'lake' described by Lepsius is the sand-filled eastern section of the Khufu quarry and with this identification, Lepsius' account provides clear testimony that under the conditions of surface hydrology that existed in 1843 (and were likely to have existed throughout the preceding centuries) even high-energy run-off was unable to reach the Sphinx enclosure. I was not aware of Lepsius' letter when, in the late 1990s, I first reached my conclusions on the impact of quarrying on the surface hydrology of the Giza necropolis. Lepsius' account, however, confirms the conclusions reached independently and corroborates the view that the excavation of the Great Sphinx pre-dates the adjacent quarrying activity.

In order to understand the impact of run-off on the limestones exposed at the Sphinx, it is necessary to consider the competing influences at play. As Lehner and Hawass correctly state, run-off can be generated from 'any and all sized catchments' (2017: 59); however, if run-off from small catchments is considered, there are a number of important factors that need to be addressed. For example, given the presence of a modern wall running along the top of the western Sphinx enclosure, the western catchment will be limited to the sloping face of the enclosure together with the small area between the top of the excavated face and the base of the modern wall. Although this small catchment will generate some run-off, this will have little energy and relatively little erosive potential. This conclusion appears to be supported by Lehner and Hawass when discussing a rainfall event of 25 February 2010 (2017: 60). Their figure 4.13 illustrates accumulations of loose sand at the foot of the western wall of the Sphinx enclosure, which are crossed only by 'little channels' (Lehner and Hawass 2017: 60), consistent with the action of low-energy run-off. A high-energy event, such as that described by Lepsius, is more likely to have washed this sand away. For rainfall such as that encountered on 25 February 2010 to have led to the significant erosion that is evident, it will have been necessary for the western walls of the Sphinx enclosure to have been exposed to repeated low-energy run-off events over prolonged periods of time. Such a scenario is not supported by the available evidence, which suggests that once cleared, the Sphinx enclosure rapidly fills with wind-blown sand (Lehner and Hawass 2017: 477).

The other issue that Lehner and Hawass explore by reference to their figure 4.13 is the nature of the joints and fissures that run through the Member II limestones. They correctly state that these discontinuities are 'not primarily features of surface erosion' and attribute their origin to 'other forces, perhaps tectonic [which] created them in geological ages past' (2017: 60). Their suggestion, however, that these features are more prevalent in the west of the Sphinx enclosure (Lehner and Hawass 2017: 60: 'They happen to be more numerous in the bedrock of the western Sphinx ditch'), is not correct and neglects both the tectonic origins of these features as well as the post-tectonic development that these joints have undergone.

Given their tectonic origins, these sub-vertical discontinuities are distributed relatively evenly throughout the limestones at Giza (Gauri 1984: 39) and therefore, are present along the full length of the Sphinx enclosure walls as well as cutting through the body of the Sphinx. Following the excavation of the Sphinx, all the exposed discontinuities will have been subject to sub-aerial processes including chemical weathering and abrasion by wind-blown sand. As discussed in previous publications (e.g. Reader 1997: fig. 3), it is considered that the action of these sub-aerial processes has led to relatively moderate degradation of the exposed joints, such as that visible along the eastern end of the southern enclosure wall (fig. 2, inset c). In a relatively small area such as the Sphinx enclosure, however, the factors that affect the intensity of these sub-aerial processes (factors including air temperature, humidity etc.) will not vary to any significant extent. Weathering and erosion by sub-aerial processes cannot therefore account for the more marked degradation of the joints exposed along the western walls of the enclosure.

As modelled by the flow net presented as figure 4, however, prior to Khufu's quarrying at Giza, high-energy run-off discharging into the Sphinx enclosure, will have scoured the joints and fissures exposed along the western enclosure walls, leading to these discontinuities being cut back deeply into the exposed face. When the deep scouring of the exposed joints was combined with the high-energy erosion of the strata between the discontinuities, this led to the development of the heavily rounded features that are present in the west of the Sphinx enclosure (fig. 5). Despite the presence of numerous joints and fissures exposed along the eastern enclosure walls, localised rounded features such as that shown on figure 5 are not evident in the eastern part of the Sphinx enclosure or along exposed sections of the body of the Sphinx.

Figure 5: Heavy rounded degradation in the west of the Sphinx enclosure. The exposed limestones are naturally divided into blocks by sets of nearly vertical joints. Deep erosion of the joints by surface run off has led to the development of rounded features such as this example.

Given these considerations, although the presence of rounded features of degradation along the western walls of the Sphinx enclosure cannot be readily explained by the action of chemical weathering or abrasion by wind-blown sand (either acting alone or in combination), they can be readily explained by the action of high-energy run-off discharging from the higher areas of the Giza plateau. As discussed above however, such high-energy run-off was only able to reach the Sphinx enclosure before the large-scale quarrying undertaken during the reign of Khufu.

Discussion and conclusions

I fully accept the view of Lehner and Hawass that modern rainfall such as the event encountered on 25 February 2010 will generate run-off, which will discharge into the Sphinx enclosure (Lehner and Hawass 2017: 60). The important distinction to note, however, is that as a result of modern interventions at the site, particularly the wall built along the northern and western limits of the enclosure, the relevant catchments will be limited in size. As a result of these limited catchments, modern run-off will have relatively low energy.

Lehner and Hawass appear to agree with my interpretation that the 'lake' Lepsius observed behind the Sphinx formed within an area of ancient quarrying ('This hollow would be the quarry west of the Sphinx', Lehner and Hawass 2017: 60). This reinforces my conclusion that run-off from the higher reaches of the Giza plateau will have been intercepted by the 4th Dynasty quarry and was therefore, unable to reach the Sphinx enclosure. With the quarry intercepting high-energy run-off from the wider Giza plateau, in the period following the 4th Dynasty quarrying, only low energy run-off from the areas immediately surrounding the Sphinx will have discharged over the enclosure walls.

The key issue, therefore, appears to be whether the low energy run-off that has been experienced since the 4th Dynasty quarrying will have been sufficient to lead to the degradation that is evident within the Sphinx enclosure, particularly the more intense, rounded degradation that characterises the western enclosure walls (fig. 5). As Lehner and Hawass correctly observe, 'Running water could not erode the western Sphinx ditch if sand filled it' (2017: 60), irrespective of the energy associated with a particular run-off event. Given that once cleared, the Sphinx enclosure appears to rapidly re-fill with sand (Hawass 1998: 21-34), the 'windows of opportunity' for erosion by low-energy run-off would appear to be few and relatively brief.

Lehner and Hawass also appear to suggest that the extant degradation can be attributed to processes other than run-off. It is true that the Member II strata is 'always eroding through other processes' and that 'efflorescing salts are the culprit' (2017: 60). However, as I have explored in previous papers, these chemical weathering processes will act in a relatively uniform manner along any given exposed bed and even the influence of factors such as diurnal temperature ranges, fail to explain the variations in degradation that can be seen within the Sphinx enclosure. In the context of a single limestone stratum (for example Member II, unit ii – see fig. 1), Lehner and Hawass fail to explain how the effects of chemical weathering would be greater in the west of the Sphinx enclosure than in the east.

Figure 6: Chisel marks on the entrance to a Late Period tomb excavated into the western Sphinx enclosure wall.

Perhaps most telling, however, is the evidence presented by a series of tombs that have been cut into the western Sphinx enclosure wall. These tombs, which include the 26th Dynasty tomb of Ptahardais (c. 664 to 525 BC; Porter and Moss, 1974: plan VI and p. 291) are some 2,500 years old and once excavated will have had the same frequency and duration of exposure as the adjacent western enclosure wall. According to Lehner and Hawass, the more intense degradation of the western Sphinx enclosure 'does not require centuries or millennia to have taken place' and can be expected to occur over a 'few generations' (2017: 60). Lehner and Hawass' model for the degradation of the Sphinx and Sphinx enclosure, however, does not account for the extensive preservation of ancient tool marks along the rock-cut entrances to these Late Period tombs (fig. 6).

The survival of tool marks on these tomb entrances can be explained in the context of high-energy run-off. Unlike the limestones exposed along the adjacent western wall of the Sphinx enclosure, these Late Period tombs were excavated long after Khufu's quarrying at the site and have therefore been exposed only to the low-energy run-off that has been experienced since, together with sub-aerial processes including chemical weathering and abrasion by wind-blown sand. Having not been exposed to the more erosive conditions of high-energy run-off that existed before the reign of Khufu, these tomb cuttings are far less heavily degraded when compared with the adjacent walls of the Sphinx enclosure.

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