A prehistoric grinding stone quarry in the Egyptian Sahara

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In 2007, the first reported grinding stone quarry in the interior of Egypt’s Western Desert was found by the north scarp of the Kharga depression. It can be tentatively dated to Holocene prehistory, within the moist phase that lasted from ca. 8,500 to 5,300 BC, or slightly later. In this period, the climate was humid enough to support foraging and pastoralist cultures and thus grinding stones were needed to process vegetable matter, perhaps also mineral pigments. The discovered quarry is small, yet thousands of relatively standardised, flattish and oval, lower grinding stones were produced from the silicified sandstone, in particular with the aid of flint hammerstones. Since the quarry is located beyond major Holocene prehistoric occupation sites, it is interpreted as having been exploited in an organised way, by groups of people that regularly visited the place, and possibly also created rock art close by.

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The discovery

Anyone who has been trekking in the Sahara has seen the large numbers of grinding stones strewn on the desert floor at long-forgotten occupation sites (Fig. 1). Most of them are remains from a specific time in history – the early to middle Holocene wet phase, between roughly 8,500 and 5,300 BC (Kuper & Kröpelin 2006; all dates in this paper are calibrated), when the Sahara was green as a savannah and thus could sustain widespread human occupation. The Kharga Oasis – a huge depression, featuring the largest of the string of oases in Egypt’s Western Desert – also supported extensive Holocene prehistoric occupation before the rains diminished and people withdrew to the Nile Valley, or clustered around the little water left in the oasis, even until today.

The grinding stones in Kharga and elsewhere in the Western Desert (or more broadly the Eastern Sahara) normally consist of a big, flattish oval lower stone and a small, roundish upper stone, which can be moved with one or two hands to grind seed and other vegetable matter, perhaps also mineral pigments. Of course, there is quite some variation in typology, as well as in the materials from which the grinding stones were made. The most frequent stone encountered is silicified sandstone, which is a fairly abundant rock in Kharga and the Western Desert.

With all these grinding stones scattered throughout the area, the question arises: Where are the quarries? Were the grinders just procured in an ad hoc manner from the nearest patch of silicified sandstone, or rather as part of organised exploitation?

Until recently, no one had an answer to these questions. Not until Dirk Huyge and the present author, while participating in the American University in Cairo’s 2007 North Kharga Oasis Survey (NKOS), started following a string of very peculiar, crude flint hammerstones on a Pleistocene alluvial terrace towards the north scarp of the Kharga depression (Fig. 2 and 3). The hammerstones were clearly produced from pebbles and small boulders of poor, greenish flint that had been deposited on the terrace back in the Pleistocene. Associated with the hammerstones were often a few inexplicable fragments of brown silicified sandstone; obviously minor work of some kind had been going on.

We followed the hammerstones up the terrace and, at one point, Dirk wished to do something more in line with his interests, so he left to examine nearby rock art
Fig. 1. Collection of broken, oval lower and roundish upper grinding stones at the early-middle Holocene occupation site by Umm el-Dbabid in Kharga. Scale is 15 cm long. Photo: Per Storemyr.

Fig. 2. Heading along an alluvial terrace towards the north scarp of the Kharga depression: Dirk Huyge looking for artefacts. Photo: Per Storemyr.
Fig. 3. A depot of flint hammerstones on the alluvial terrace with views south over the Kharga depression. Photo: Per Storemyr.

Fig. 4. The grinding stone quarry by the north scarp: a work area lined with broken slabs. Scale is 15 cm long. Photo: Per Storemyr.
sites, leaving me to my exploration, the stone and quarries. I continued tracking the hammerstones, in the hope of finding a reason for their presence. After three kilometres, I found the explanation. As I looked up from a group of hammerstones, a plateau overlooking the terrace caught my attention. I walked up and suddenly found myself in a wonderful grinding stone quarry (Fig. 4), full of blanks of oval lower grinders and fragments of the flint hammerstones. They had been used as tools to work the grinding stones!

Regional archaeological context

This grinding stone quarry is the first to be reported from the interior of Egypt’s Western Desert, and there are probably several more awaiting discovery. This is because of the widespread use of grinders in occupation sites on the vast floor of the Kharga depression, which is about 180 km long, 50–80 km wide, and situated some 200 km west of the Nile Valley (Fig. 5 and 6). The occupation sites are usually related to playa and spring mound deposits, several of which have been investigated by the few expeditions that have worked here since the beginning of the 20th century. However, as compared to the Dakhla Oasis immediately to the west, Kharga has been relatively poorly investigated with regard to characterisation, distribution and chronology of prehistoric archaeological sites, although NKOS has been working to rectify this since 2000.

The chronology of human occupation suggested by Caton-Thompson (1952), based on work in the 1930s, is still in use and has generally been corroborated by later expeditions (see overview in Wiseman 1999). Due to the arid conditions, there was hardly any human presence in the later parts of the Pleistocene. However, with the onset of sparse Holocene rains around 8,500 BC (Kuper & Kröpelin 2006), occupation greatly intensified. Caton-Thompson (1952) divided the early-middle Holocene at Kharga in the Bedouin Microlithic, roughly corresponding to the Epipalaeolithic of the Nile Valley (ca. 9,000–5,000 BC), and the Peasant Neolithic, chronologically matching the Neolithic (ca. 5,000–4,000 BC)/Predynastic (ca. 4,000–3,000 BC) periods along the Nile. Later, the Kharga Oasis Prehistoric Project introduced the roughly corresponding Midauwara and Baris cultural units in Kharga, which also correspond with the Masara and Bashendi units in the Dakhla Oasis (Kleindienst et al. 2002, 2009).

Generally, for the southern Western Desert and corresponding areas bordering the Nile in Upper Egypt and Lower Nubia, there is hardly evidence of a Neolithic economy in the terms known from the Fertile Crescent. Rather, in the early to middle Holocene, the region was characterised by highly mobile peoples roaming the vast terrain following the seasonality of the sparse rains, occupying favourable niches, such as playa environments, for shorter and longer periods. Though highly disputed, cattle domestication may have started already in the 8th millennium BC (Nabta Playa); widespread herding of sheep and goat was certainly introduced by ca. 6,000 BC. Thus, throughout the early and middle Holocene hunting was still a dominant activity. Likewise, there was no farming, but systematic gathering of wild plants (tubers, fruits, grass seeds), which implies that we are probably not looking at use of grinding stones for domesticated grain before the 5th millennium BC, or even later. Cultivation or trade in cereals can perhaps be associated with the emerging complex societies in the Nile Valley. Thus, in general terms, the region supported foraging peoples that became combined pastoralists and foragers over the millennia after ca. 6,000 BC. As the climate deteriorated from ca. 5,000 BC, people migrated to the few oases with permanent ground water supply, but mainly to the Nile Valley (see, for example, Wendorf & Schild 2001, Riemer 2008, Gatto 2011, Briois et al. 2012).
From ca. 3,000 BC, at the beginning of the Pharaonic period, Kharga got a position as an outpost of the new state and for long-distance desert travel, as well as for mineral exploitation (in particular for alum, see Lucas & Harris 1962:257–259, Shortland et al. 2006). The oasis still held this position 3,000 years later and by then it formed part of the southern Roman frontier, still highly visible in the form of a very impressive string of fortresses in the northern part of the oasis. Today, Kharga features a bustling little town at the centre of the depression and is easily reached by highways connecting to the Nile Valley and the other oases in the Western Desert.

Though the grinding stone quarry described in this paper is the first one reported from Kharga and the Western Desert, it is not entirely isolated in terms of similar, prehistoric and later quarries in this part of Egypt. Large flint quarries are known at the Refuf pass (Fig. 6) at the eastern scarp of the Kharga depression (Caton-Thompson 1952:187–194). In nearby regions, massive grinding stone production is known in Aswan, from the Late Palaeolithic through the Roman period (Roubet 1989, Bloxam et al. 2007). Small-scale production is also known 400–500 km farther north, in the Faiyum (Heldal et al. 2009). Moreover, from other parts of the Sahara and Sub-Saharan Africa there are reports of quern factories and grinding stone quarries dating to various periods, some of which continued to be used until the present. Examples include sites in Niger/South Algeria (Hugot 1968:484, Milburn 1983), the Lake Chad region (Connah 1981:25–55, Connah & Jemkur 1982:41, Garba 1997:39), Ghana (Ratz & Flight 1974) and Darfur in the Sudan (Haaland 1995:164–166).

Local context: environment, archaeology and geology

The grinding stone quarry was found and surveyed (but not excavated) upon exploration of the northern part of the Kharga depression, about 40 km northwest of present-day Kharga town (Fig. 6–8). This area, dubbed “Split Rock” (Fig. 9) by NKOS, is located 18 km west of a major Holocene prehistoric site and the Roman fortress at Umm el-Dababib. It is also along a major ancient desert route, called Darb Ain Amur, heading due west to Dakhla Oasis (e.g. Beadnell 1909, Ikram & Rossi 2006). Situated by the foothills of the scarp, Split Rock lies in a landscape of low sandstone hills at the edge of lower-lying land with Pleistocene-Holocene playa deposits.

Some archaeological features by Split Rock have probably been washed away by Holocene flash floods, but the area still features camps and water depots of Roman and later dates, as well as numerous rock art panels discovered by NKOS, dating from the early-middle Holocene to the Islamic period (Ikram 2009). Also, there are some stone circles that may represent...
the remains of (prehistoric?) huts or tents. A landmark of a mountain, conical in form with a flat peak, overlooks the site at the northern scarp.

One kilometre to the northwest of Split Rock is a low valley with extensive Pleistocene alluvial deposits, forming terraces, partially downcut by Holocene flash floods. They are gently sloping within the sandstone area, from higher limestone terrain at the northern scarp, and representing earlier drainage from the basins to the north of the Kharga depression. It was on one of these terraces (Fig. 2) that we found dozens of scattered workings of small blocks of silicified sandstone associated with hammerstones and debitage of flint, as well as small depots of hammerstones. Three kilometres to the north, we find the largest quarry, on a small sandstone plateau on the eastern fringe of the valley (Quarry 1). In addition to this quarry and the workings along the terrace, there are at least three other, smaller quarries (Quarry 2–4) in the vicinity (Fig. 8).

Geologically, the Kharga grinding stone quarries are situated within the upper portion of the Taref formation of the late Cretaceous (Turonian, ca. 90 mya) (Fig. 7) (on the geology of Kharga, see Ball 1900, Beadnell 1909, Hermina 1990).
extensive sequence of Cambrian to late Cretaceous sandstone, siltstone, marls and sporadically limestone, which is widespread in North Africa, Arabia and parts of the Near East. Its sandstone members have been of great importance as ancient building stone, especially in Upper Egypt (e.g. Harrell & Storemyr 2009). Thinner and thicker, ferruginous and silicified, hard horizons are common in the Nubian sandstone and were exploited for tools throughout the Stone Age. Likewise, such horizons were much sought after for procurement of grinding stone and, in Ancient Egypt, ornamental stone of various kinds, particularly from the extensive quarries at Aswan (cf. Heldal & Storemyr 2007, Heldal 2009).

More specifically, the upper part of the Taref formation is interpreted by Hermina (1990) as consisting of cross-bedded beach dune deposits, with occasional interbeds of clay and shale. Field observations and examinations of samples with a hand lens indicate that the exploited deposits consist of medium-grained, very quartz-rich sandstone of whitish to brownish and reddish colours, the latter a result of the presence of oxidised iron compounds. Typically, relatively resistant, silicified layers are presently forming the top of plateaus and small hills, often in the form of a layer of broken-up blocks and slabs. However, contrary to many other areas with similar sandstone in the region, silicification...
has not been particularly invasive; it seems very patchy and has not contributed to complete filling of the pores of the originally rather friable and porous sandstone. Thus, a main reason for using this sandstone must have been that it very easily splits into slabs.

As for the flint hammerstones, they are derived from the Tertiary limestones on top and to the north of the Kharga north scarp. Hard, silicified cobbles of limestone, common on the alluvial terraces in the area, are also derived from these limestones (cf. Hermina 1990).

The quarries

The largest quarry is about 65 m long and 30 m wide, totalling slightly more than 2,000 m$^2$ (Fig. 4 and 10–11). Before quarrying began, the plateau must have featured cracked blocks and thick slabs, which easily split into thinner slabs along the bedding plane of the rock – a natural feature that was taken advantage of in the quarrying process. There are few larger blocks left, as practically all have been exploited, implying that the quarry plateau is a jumble of thousands of broken slabs and discarded grinding stone roughouts. One gets the impression that a group of larger blocks at the southern edge of the quarry, overlooking the alluvial terraces in the valley, were deliberately left. This is because the blocks are visible from below and could have been used as a marker of the quarry.

On closer inspection, many shallow, circular depressions, with a diameter of roughly 1–2 m, lined with slabs and coarse stone fragments were observed (Fig. 4). These are interpreted as work areas. There is very little fine debitage since, after loosening the slabs from larger blocks, it was only necessary to trim them along the edges in order to produce the desired lower grinding stone roughouts. The quarry is littered with such discarded, oval roughouts that broke perpendicular to the long axis during the production process. Measurement and interpretation of a selection of 10,  

Table 1. Dimensions of a selection of oval rough-outs from Quarry 1.

<table>
<thead>
<tr>
<th>Stone no.</th>
<th>Max. length, interpreted (cm)</th>
<th>Max. width (cm)</th>
<th>Max. thickness (cm)</th>
<th>Comment</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>&gt;30</td>
<td>23</td>
<td>4</td>
<td>Broken</td>
</tr>
<tr>
<td>2</td>
<td>&gt;34</td>
<td>30</td>
<td>5.5</td>
<td>Broken</td>
</tr>
<tr>
<td>3</td>
<td>35</td>
<td>25</td>
<td>6.5</td>
<td>Partially broken</td>
</tr>
<tr>
<td>4</td>
<td>35</td>
<td>ca. 27</td>
<td>5.5</td>
<td>Partially broken</td>
</tr>
<tr>
<td>5</td>
<td>ca. 39</td>
<td>30</td>
<td>ca. 5</td>
<td>Broken</td>
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<tr>
<td>6</td>
<td>&gt;27</td>
<td>23.5</td>
<td>ca. 5</td>
<td>Broken</td>
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<tr>
<td>7</td>
<td>&gt;30</td>
<td>33</td>
<td>ca. 6.5</td>
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<tr>
<td>8</td>
<td>&gt;27</td>
<td>28</td>
<td>ca. 7</td>
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<tr>
<td>9</td>
<td>38</td>
<td>28</td>
<td>&gt;4</td>
<td>Broken</td>
</tr>
<tr>
<td>10</td>
<td>&gt;30</td>
<td>34</td>
<td>9</td>
<td>Broken</td>
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<tr>
<td>Mean</td>
<td>&gt;32.5</td>
<td>ca. 28</td>
<td>ca. 5.8</td>
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mainly broken roughouts (Table 1) indicates that the grinding stones were rather standardised, with an average length of more than 33 cm (probably in the order of 40–50 cm), an average width of slightly less than 30 cm and an average thickness of about 6 cm. In addition to these oval, flat roughouts, two thicker, longish oval forms (ca. 35 cm x 18 cm) were found. Moreover, one small, flat circular stone and an egg-shaped stone were observed, both probably intended to be used as handstones (upper, active grinding stones or rubbers) (Fig. 12).

It is obvious that flint hammerstones collected and partially shaped on the wadi terrace were used as tools in the production process (Fig. 12F). However, in addition to about 20 scattered locations with flint fragments, probably from hammerstones that broke, only three complete hammerstones were actually observed in the quarry; two relatively large (ca. 15 cm diameter) and one small (ca. 8 cm diameter). Moreover, a couple of hard, white (silicified) limestone cobbles were also found in the quarry; as mentioned above these are common on the nearby alluvial terraces and most likely were brought to the quarry to be used as hammerstones.

Quarry 2 is located on a slightly more elevated plateau, about 150 m north of Quarry 1 (Fig. 8 and 11). It is smaller than Quarry 1 (roughly 20 m x 20 m), but displays the same general characteristics, except that there are several remaining blocks that have not been completely exploited. Moreover, at least six flint hammerstones with a diameter of 8–14 cm were found. Some of the remaining blocks display a few marks of hammering on the top, indicating that this was one of the methods applied for loosening slabs from the blocks.

Quarry 3 is rather an exploratory project than a true quarry. It is located on another small plateau 120 m to the north of Quarry 2 and features slightly different sandstone than in the two former quarries. The stone is reddish-brown, rather compact, but less silicified and less prone to splitting along the bedding plane than the others. One flint hammerstone was found, but generally this site has produced only few grinding stone roughouts.

The same can be said of Quarry 4, which is located at the head of the low valley, about one km to the north of Quarry 3. The sandstone is slightly harder, but otherwise similar to that found in Quarry 3. No tools were found here, and no clear grinding stone roughouts, but quite a lot of smaller, broken sandstone blocks, probably indicating that this was a place for procuring handstones.

There are several other areas with silicified sandstone along the valley, especially at the western flank, but none of them seem to feature ancient quarries. The sandstone is generally hard, has very dark desert varnish, breaks up in slabs and seems suitable for grinding stone procurement. There might be reasons, unknown to us, other than stone quality as to why these resources were not put in use.

Workings on the alluvial terrace

Quarry 4 marks the northern limit of the presence of stone artefacts on the alluvial terrace in the valley, an area of highly scattered workings that stretches for more than 3 km down towards Split Rock with its ancient camps and rock art (Fig. 8). A rough estimate indicates that there are 100 to 200 workings of small blocks of mainly reddish silicified sandstone in this area. Silicified sandstone blocks appear to have been transported from the head of the valley as a result of previous river drainage and deposited together with other debris, including significant amounts of the
greenish flint used as hammerstones in the quarries (and on the terrace).

The individual silicified sandstone workings are very limited (often only 1 m x 1 m) and rarely feature clear roughouts of lower grinding stone slabs (Fig. 13). It would seem that they were mainly used for the procurement of handstones. Flint fragments can usually be found within and beside the workings, but such fragments are also located away from broken silicified sandstone blocks. In such cases, it is likely that they represent trimming of flint cobbles to usable hammerstones. However, also natural, unworked flint cobbles were used as hammerstones, as indicated by their presence in the quarries, but also in at least five depots on the terrace (Fig. 3). Such areas may contain 5 to 15 flint cobbles, each with a diameter of about 10–15 cm. The flint is porous and sometimes cracked, and cannot be used for finer tools. However, it is evidently suited for use as solid hammerstones.

There is a well-worn path along the entire length of the terrace, apparently linking to Darb Ain Amur, which passes Split Rock and environs. It is unclear whether it is a foot and/or donkey path and whether it is ancient or recent, but it is possible that it is related to grinding stone procurement. One tethering stone was found on the terrace and at the extreme southern edge is a complete, used reddish oval grinding stone measuring ca. 39 cm x 27 cm x 3.5 cm; in other words of a dimension resembling the roughouts in the quarries. It is unclear how it ended up here, but it is likely derived from camps by the nearby Split Rock and environs, in which there are a few similar used grinding stones.

No ceramic was found in the quarries, their surroundings, or on the terraces. Likewise, there were no signs of shelters, stone circles and hearths, indicating camps or resting places. Such features would presumably have been easy to spot and, given the topography by the quarries, it is unlikely that they would have been washed away by flash flood here. Erosion by flash flood is, however, important in the surroundings of Split Rock.

Methods and volumes of extraction
Quarrying took advantage of the fact that blocks and larger slabs easily split into thinner slabs along the bedding plane of the rock (Fig. 14). Some layers could thus simply be removed by hand. Nevertheless, there must have been a means of undertaking splitting, especially when the sounder cores of larger blocks were exploited. No wedging tools (e.g. longish, hard stone) were found in the quarries and thus a means of loosening slabs would have been to knock carefully on top of the block with a larger hammerstone until the slab was released. In this way, the blocks would have been peeled off from above. However, it is reasonable to suggest that levers and wedges of wood and/or bone were also used. Since the rock easily splits, fire-setting would not have been necessary to break it. Fire-setting was a very common method used in traditional quarrying of silicified sandstone (and other stone). In the context of grinding stone production, good examples can be found in the extensive quarries in Aswan (Heldal & Storemyr 2007), in the Lake Eyre region in Australia (McBryde 1997) and in Kintampo in Ghana (Rahtz & Flight 1974).
When a suitable slab was obtained, it must have been roughly shaped in situ, probably using the smaller flint hammerstones. According to the relatively large chipping marks at the edges of roughouts, the stone is rather brittle and fairly easy to form. There is a large body of evidence of the use of hammerstones of similar size and for similar purposes in the grinding stone quarries in Aswan, although here the grinding stones have a different general form than in Kharga (they are boat-shaped, see Heldal & Storemyr 2007).

The number of grinding stones extracted is difficult to determine. One way of obtaining an estimate would be to assume that the plateau of Quarry 1 was covered with virgin sandstone blocks before the quarrying commenced, for example one block of 0.25 m³ in each square metre. If assuming that only two usable grinding stones were obtained from each block, the number of produced stones would have been in the order of 4,000. Adding 800 stones from Quarry 2 and assuming that Quarry 3 and 4, as well as the workings on the terrace would have yielded a total of 100–200 stones, a grand total would be 5,000. This is probably a very conservative estimate, but it might indicate a range: 100 or 1,000 produced grinding stones are clearly too few; 20,000 are probably too many.

Use of grinding stones in Khargan occupation sites

A few fragments of used, lower basin grinding stones were spotted among the campsites in the environs of Split Rock. They are generally made from fine-grained reddish silicified sandstone, not unlike the one described above, and their dimensions would seem to correspond to the roughouts present in the quarries. Since they are found in visible Roman and later contexts, as judged from ceramics on the surface, it may be speculated whether they were reused in these periods, though it cannot be entirely excluded that they were actually produced at such a late stage. Conversely, since excavations were not undertaken, such sites may hide small-scale occupation from earlier periods.

It is clear that flat, oval basin grinding stones are primarily found in Holocene prehistoric contexts associated with playas in Kharga, as they are e.g. at Nabta Playa (Wendorf & Schild 2001) and elsewhere in the Eastern Sahara. One of many examples in Kharga is the playa occupation sites located about 5 km to the south of Umm el-Dabadib and 18 km to the east of Split Rock. This site is dated to 7,600–6,100 BC (Hassan & Holmes 1985, cf. Caton-Thompson 1952) and features large amounts of lower grinding stones and smaller oval handstones (Fig. 1). All the lower stones are typical oval basin grinding stones, made from silicified sandstone and usually fine-grained and light reddish to yellowish in colour, although dark-coloured specimens also occur. Their dimensions are, according to own observations, approximately 30 to 50 cm in length, 22 to 35 cm in width and 2 to 5 cm in thickness (though many are very thin due to heavy use). Oval to egg-shaped and circular flat handstones are also made from silicified sandstone; they range in colour from very dark to light yellow and are 10 to 15 cm in diameter. Although the colour and hardness of some of the stones matches those in our quarries, it is unclear whether they can be regarded as the source. In this connection, it should be stressed that no attempt at provenance studies, including petrographic analyses, has yet been undertaken.

Most of the used grinding stones at Umm el-Dabadib have well-prepared, smooth edges and surfaces (Fig. 1) and thus have been subject to a significant amount of finishing as compared to the roughouts in the quarries. Since no secondary work areas were found in the quarries, it thus seems clear that finishing was undertaken at occupation sites/campsites. This is in accordance with observations of grinding stone production processes in nearby regions, from the Late Palaeolithic (e.g. Roubet 1989) to the present (e.g. Haaland 1995:164–166). Furthermore, many of the used lower grinding stones have numerous, easily visible small peck marks. In modern contexts in the Sudan, this is explained by Haaland (1995:169) as a means of roughening the surface in order to ease the grinding process.

It must be recalled that grinding stones often have been used for grinding mineral matter, such as ochre, of which there is abundant evidence in the Nile Valley; from the Late Palaeolithic at Kubbaniya (Wendorf & Schild 1989:799), via the Epipalaeolithic at Elkab (Vermeersch 1978) to the Pharaonic period at Aswan (own observations at the island of Elephantine). However, Caton-Thompson (1952), who investigated numerous Holocene occupation sites in Kharga, did not report any grinding stones with stains of mineral matter. Moreover, none of the grinding stones investigated by the present author in 2007 showed any sign of stained surfaces. All this is somewhat curious, since it is anticipated that ochre would have been among the minerals exploited in the Kharga region (own observations; see also Beadnell 1909:221). However, at the moment we have to conclude that the bulk of
the grinding stones observed were probably used to process wild plants.

**Dating the quarries**

Due to the lack of ceramics and other diagnostic artefacts, as well as charcoal from hearths and fire-setting, the grinding stone quarries cannot be securely dated. Considering the use of similar grinding stones in Kharga, it can thus initially be proposed that they may range in age from the early Holocene to the post-Roman period. However, there are some indications that a fairly early date is most likely.

First, as mentioned above, it seems that large, flat oval basin grinders like those produced in the quarries were predominantly used in the Holocene prehistoric period; in Kharga, this would mean the early to middle Holocene (ca. 8,500 to ca. 3,000 BC). Second, in the Pharaonic and later periods (ca. 3,000 BC onward), some pottery was usually left in Egyptian quarries (according to own observations of dozens of quarries), though the situation in Kharga is, of course, different from the Nile Valley. Third, the colour and thickness of desert varnish in Quarry 1 and 2 would point to an early date. There is very dark varnish on exposed fragments that were broken during the quarrying process, which indicates that they have been influenced by fairly humid conditions over prolonged periods of time (cf. Liu & Broecker 2007, see also Cremaschi 1996). This would again speak for a use of the quarry before or during the onset of climate deterioration from ca. 5,000 BC (Kuper & Kröpelin 2006, Bubenzer & Riemer 2007). Moreover, weathering and aeolian activity (sand blasting) have sometimes thoroughly worn down originally sharp edges of broken stones.

Importantly, artefacts of the reddish sandstone in the small quarries (3 and 4), as well as on the nearby alluvial terrace, have less varnish than what is the case in Quarry 1 and 2. There are several possible explanations, one of which would be that the quarries simply are younger. However, it is more likely that the red stone, which appears less silicified, is more friable and thus more prone to sand blasting than the stone in Quarry 1 and 2. This could imply that varnish formation has simply not taken place. Sand blasting is particularly extreme along the alluvial terrace, due to the prevailing northerly winds that sweep down the valley from the scarp.

In this connection, it must also be stressed that the grinding stone implements found at occupation sites do not have much desert varnish. However, most have been buried in playa silts for long periods of time, surfacing again due to deflation (removal of material from the surface by wind action).

**Discussion**

Silicified sandstone suitable for grinding stone procurement has a wide distribution in the Kharga depression. Patches of such stone, associated with special layers in the sandstone or with faulting were observed on many hills and ridges during our extensive field walks. At some places, faint traces of stone working could also be seen. However, the deposits of silicified sandstone by the north scarp seem to be of the few that contain fair quality material that very easily splits into larger slabs. This might be one of the reasons that quarrying was undertaken here; yet it is very likely that the quarry discussed here is only the tip of the iceberg, and that more grinding stone quarries exist. This makes it difficult to interpret the organisation of procurement. Moreover, at the moment we have limited knowledge of the distribution of sites where grinding stones were used (but see Caton-Thompson 1952, Wendorf & Schild 1980, Hassan & Holmes 1985, Mandel & Simmons 2001), and no knowledge of the provenance of the grinding stones that have actually been spotted.

From other contexts, there is evidence for a wide variety of procurement strategies. Ethnographic evidence from the Darfur region in the Sudan, for example, indicates that grinding grain was (and is) an activity particular to women and even that each woman undertaking such activity had her own quarry where she procured roughouts, bringing them back to the village for final shaping and use (Haaland 1995). In Aboriginal Australia, grinding was also a female activity, but it was the men who went on often long expeditions to special quarries to procure roughouts. Such expeditions had the character of ritual journeys, following Dreaming Tracks, for which several groups would come together. Moreover, grinding stones were part of long-distance exchange networks, implying that they might end up thousands of kilometres away from their origin (McBryde 1997). Ritual journeys for procurement of other stone resources are a well-known phenomenon, for example related to Neolithic axe production in Britain and elsewhere in Europe (e.g. Bradley & Edmonds 1993, Bradley 2000). In addition, ritual activity related to procurement of stone tools sometimes included the production of rock art, with one of the best examples coming from
 Aboriginal Australia and involving silicified sandstone (Taçon 1991).

Considering the closest currently known grinding stone quarries to Kharga, evidence from the extremely extensive production areas on the West Bank of the Nile at Aswan indicates that in the Late Palaeolithic such procurement took place right beside the seasonal occupation sites in Wadi Kubbaniya (Roubet 1989, Wendorf & Schild 1989, Bloxam et al. 2007). Throughout the Pharaonic period, production at Aswan reached truly enormous proportions and grinding stone was traded throughout Egypt.

With regard to trade and exchange, although not involving any specific quarry location, Mahmoud & Bard (1993) implied that grinding stones found in Predynastic contexts in the Naq Hammadi region in Upper Egypt were derived from at least 150 km away in the Eastern Desert. They used their findings as a further indication of the long distance exchange networks that certainly existed between the Nile Valley and the adjacent deserts between 4,000 and 3,000 BC. The only other grinding stone production site known in Egypt is located in the Faiyum, where it is spatially and temporally connected to Old Kingdom quarries for elite objects (gypsum vases at Umm es-Sawan, Heldal et al. 2009). However, it is not unlikely that the use of this quarry may have a history that goes back to the Faiyum Neolithic (cf. Caton-Thompson & Gardner 1934), in which case people would have had to walk 10 to 20 km from occupation sites to obtain the stone.

These examples might aid in building hypotheses about the organisation of grinding stone procurement in Kharga. Although we have little knowledge of the wider context of procurement in this area, the grinding stone quarries by the north scarp and their specific context provide some important clues and ideas:

- Based on the evidence of intensive quarrying in Quarry 1 and 2, the presence of work areas in the quarries and the procurement of special, local flint hammerstones for the exploitation, production must be regarded as organised and not an ad hoc activity undertaken whenever a grinding stone was needed. The procurement of rather standardised formats lends support to this supposition.
- Although the quarries cannot be accurately dated, there are indications that they should be placed at some time in the early to middle Holocene, most likely before the onset of climate deterioration (before ca. 5,000 BC).
- There is no evidence indicating that the peoples exploiting the resource lived right beside it.
However, the presence of stone circles and, additionally, relatively late campsites in the environs of Split Rock could indicate that this might have been a preferred place to camp during periods of grinding stone extraction. In this particular area, given its topography, flash floods might have washed away earlier remains of ephemeral campsites, but probably not all traces of potentially extensive occupation sites.

- The presence of Holocene prehistoric and later rock art in this area is intriguing (Fig. 15). It is not unthinkable that it was actually made by the peoples exploiting the grinding stone quarries. However, other reasons for rock art creation are, of course, also possible, including the good water catchment in the area (see also further remarks below).

- The later campsites and rock art in the environs of Split Rock are evidently connected to the major desert route of Darb Ain Amur. It is likely that this route has a history that goes far back. Moreover, there are well-worn paths leading to or passing the grinding stone quarries, perhaps heading towards the significant depressions north of Kharga. This might indicate that the quarries are in fact located in an area where desert routes met.

Before trying to formulate hypotheses of organisation, one needs need to get a grip on the longevity of the quarries. Above, it was inferred that a conservative estimate of production would be 5,000 roughouts brought away from the quarries. We do not know for how long a lower stone would last in use, but from modern analogies (with sandstone grinders) three years might be a rough estimate (Haaland 1995:169). Thus, assuming that a group of 10 families needed to renew their stock of 10 grinding stones every 3 years, they would have needed 100 stones in the course of 30 years. A quarry producing 5,000 stones would then have lasted for some 1,500 years. If 100 families used the quarry it may still have lasted for 150 years. However, if 5,000 produced roughouts is a too conservative estimate, and we should rather think in terms of 20,000 stones, then the quarry might have lasted for as much as between 750 years (100 families) and 6,000 years (10 families).

We have no knowledge of the size of the Holocene prehistoric population in Kharga and can only use such estimates to illustrate that a seemingly small quarry, which may initially look as if it was exploited over a short period of time only, might have a history spanning hundreds, perhaps even thousands of years. In such a perspective, it would be natural that the site acquired meaning and significance for those who returned regularly, just as the grinding stone quarry sites in Aboriginal Australia mentioned above.

Thus, a simple model of organisation could involve relatively small groups of people that regularly, perhaps following seasonal patterns of movement, walked from the Kharga Holocene occupations sites associated with playas and spring mounds, up to several dozens of kilometres from the quarries, for the purpose of acquiring grinding stone. The travel might have had the character of a short, ritual journey and may or may not have involved meeting with other groups, exchange, as well as performance of rituals, some of which may have involved production of rock art. A similar situation with regard to Prehistoric rock art close to grinding stone quarries is found at Aswan, but it is yet very difficult to positively associate rock art creation with quarrying since there are so many other archaeological features in the same area (Storemyr 2009) – just as is the case by the environs of the Kharga grinding stone quarries. This model should not exclude the possibility that more ad hoc procurement, in particular involving handstones, was undertaken at suitable outcrops closer to occupation sites.

Whether it is possible to place the grinding stone quarries within more extensive procurement and exchange networks, involving e.g. the Nile Valley, is doubtful, but should perhaps not be entirely excluded. However, the available evidence does not allow any inferences at this stage of research.

**Conclusion**

The quarry for production of mainly lower basin grinding stones discovered by the north scarp of the Kharga depression – the first in the Western Desert of Egypt – may at first glance look small and insignificant. However, observations and estimates indicate that thousands of grinding stones were produced here in Holocene prehistory and that procurement was undertaken in an organised way. The context of the quarry, including its location beyond main, known occupation sites, near the major desert route of Darb Ain Amur and its possible association with rock art production, points to strategies involving groups of people that regularly walked up here to procure roughouts to be trimmed to finished grinding stones at occupation sites up to several dozens of kilometres away.
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