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Tracing Post-depositional Processes at Mesolithic Occupation Sites in Central Sudan: View from the Site of Sphinx (SBK.W-60) at Jebel Sabaloka

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A B S T R A C T

Mesolithic archaeology in central Sudan, since its very beginnings in the 1940s, has had to deal with the bad state of preservation and the absence of visible stratification at prehistoric sites. This has constituted a major problem not only for the field research itself, but particularly for the subsequent evaluation and interpretation of the findings.

This paper is concerned with the field observations and findings made in the 2014 field campaign of the mission of the Czech Institute of Egyptology in their excavation of Trench 5 at the Mesolithic site of Sphinx (SBK.W-60) at Jebel Sabaloka in central Sudan. We describe and discuss the particular mechanisms of the varied post-depositional N-transformations that were encountered in a marked intensity during the fieldwork, their effect on the original anthropogenic deposits, and the consequences this has for the methodology and strategies of archaeological excavation.

We argue that the stratigraphic excavation method should always constitute the ultimate basis of an archaeological excavation. However, there are sites and situations in which this may turn out to be an ideal that is entirely or partly impossible to achieve. For this reason it is paramount that the traditional method of stratigraphic excavation should be undertaken in conjunction with other, *parallel* procedures. In this paper, we present those that we resorted to in 2014 for the excavation of Trench 5.

1. Introduction

Since its very beginnings in the 1940s, Mesolithic archaeology in central Sudan has had to repeatedly deal with the bad state of preservation and the absence of visible stratification at the sites under exploration where not “a hearth, post-hole, or other trace of any building could be distinguished” and where archaeological deposits appeared as “grey sand of varying firmness, with varying distribution of sherds, stone and shell fragments &c., completely unstratified” (Arkell 1949, 4). This has constituted a major problem not only for the field research itself (*e.g.*, Caneva 1983a, 11, 15; Caneva *et al.* 1993; Haaland, Magid 1995, 22), but even more so for the subsequent evaluation and interpretation of the findings that are only rarely derived from *in situ* features or layers of the Mesolithic age (for the latter see Arkell 1953, 4, 97 for Shaheinab and Qoz; Adamson *et al.* 1974 for Tagra; and Clark 1989 for Shabona).

A new discussion on this subject has recently been opened with the presentation of the findings made in the framework of the Es Salha Project on the lower White Nile where original, undisturbed Mesolithic stratigraphies and varied *in situ* features have been detected to a much larger extent than at other sites (*e.g.*, Usai, Salvatori 2006; Salvatori 2012; Salvatori *et al.* 2014; Usai 2014). Nevertheless, this can be attributed

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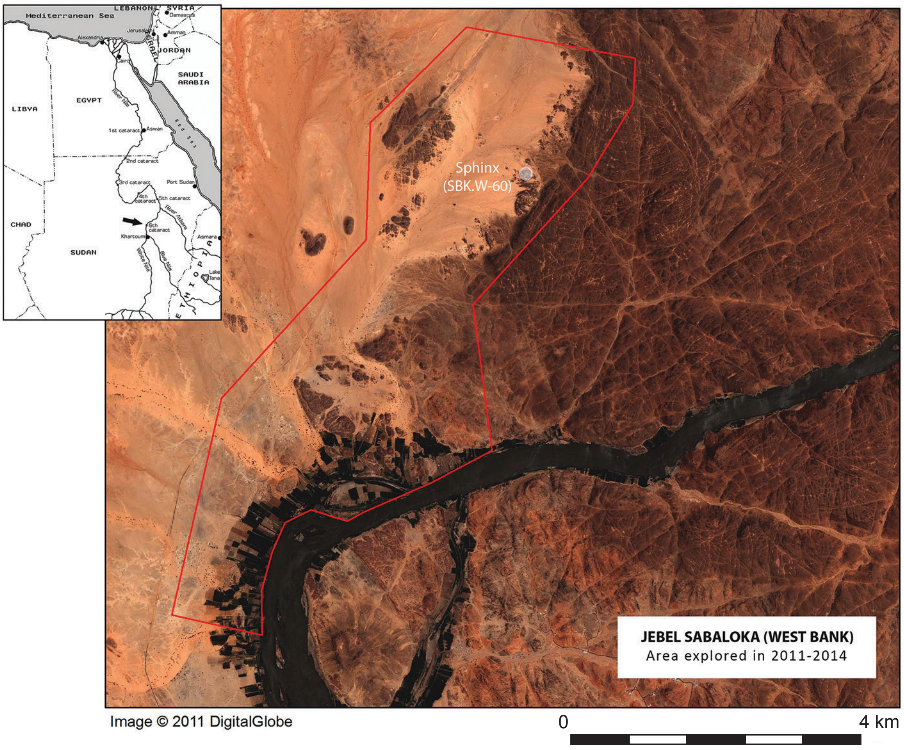

Figure 1. Jebel Sabaloka (West Bank) with the location of the site of Sphinx (SBK.W-60) (background: Google Earth 2011; map adapted from Adams 1977).

not only to the research methodology and strategies employed – in particular the stratigraphic excavation method (Usai, Salvatori 2006) – but also to their better state of preservation that might have been favoured by the specific character of the soils occurring in this area (*cf.* Vail 1982, 60; Williams *et al.* 1982; Zerboni 2011; 2014; Salvatori *et al.* 2011).

A better understanding of the preservation of the archaeological deposits, and of the possibilities and limits of traditional archaeological methods – together with their contingent adjustment or precision – in the conditions prevailing at the prehistoric sites at Jebel Sabaloka (West Bank) was one of the main aims set by the interdisciplinary expedition of the Czech Institute of Egyptology (Faculty of Arts, Charles University in Prague) for the exploration of the site of Sphinx (SBK.W-60) in 2014. In this paper, we draw attention not only to the main archaeological findings of the campaign, but also – and in particular – to the post-depositional processes studied in the course of exploration of Trench 5 and their effect on the present shape of archaeological situations in this region. We thus aim to contribute to a broader discussion on the possibilities and limits of traditional procedures of archaeological excavation through the stratigraphic method in central Sudan and, as the case may be, in northeast Africa.

1.1 Background and aims of the 2014 field campaign

The site of Sphinx is one of the core Mesolithic sites in the Czech research area. It is situated on top of one of the

Table 1. Jebel Sabaloka, Sphinx: AMS ^{14}C dates from Trenches 1 and 2 at the site of Sphinx, calibrated using OxCal 4.2 (Bronk Ramsey 2009) and according to the IntCal13 calibration curve (Reimer *et al.* 2013).

No.	Trench (sector)	Unit/ Feature	Material	Lab. No.	Age BP	Age cal. BC (95.4%)	Notes
1	2 (east)	B.4	*Unio elongatulus*	Poz-60411	8620±40	7725–7580	directly on the shoulder of the deceased
2	2 (centre/west)	B.5	*Unio elongatulus*	Poz-48347	8220±40	7355–7079	right next to the head (in front of the face)
3	2 (centre/east)	B.1	*Unio elongatulus*	Poz-60410	8160±40	7305–7061	directly on the tibia
4	2 (east)	B.4	ostrich eggshell	Poz-63005	8950±50	8276–7965	uncovering (cleaning) of the bones
5	2 (northwest)	B.3	ostrich eggshell	Poz-63004	8920±50	8269–7941	uncovering (cleaning) of the bones
6	2 (north/centre)	B.21	ostrich eggshell	Poz-63007	8690±50	7936–7591	uncovering (cleaning) of the bones
7	2 (centre/west)	B.5	ostrich eggshell	Poz-63006	8480±50	7592–7482	uncovering (cleaning) of the bones
8	2 (centre/east)	B.1	ostrich eggshell	Poz-63314	8340±40	7521–7312	uncovering (cleaning) of the bones
9	1	SU2	*Pila wernei*	Poz-58573	6220±40	5303–5057	remains of a pit/deposit of snails?
10	1	SU2	*Pila wernei*	Poz-58572	6180±40	5286–5002	remains of a pit/deposit of snails?

granite outcrops in the Rocky Cities landscape at the western outskirts of the Sabaloka Mountains (Figure 1). The slightly inclined occupation platform (940 m^2) extends over the uppermost part of the entire outcrop and is delimited on its perimeter by steep cliffs and large boulders (Figures 2–4). Other rocks and boulders allow the occupation platform to be divided into three parts: southern, central, and northern. The abundance of archaeological material that litters the present-day surface in all three parts of the site attest to an (intensive) occupation only by hunter-gatherers of the Early and Late Mesolithic period, *i.e.*, beginning in the late ninth and ending in the late sixth millennium BC (*cf.* Table 1). At the current stage of research, however, we are unable to comment on the issue of continuousness of the site's occupation over those millennia.

During the 2011 and 2012 field campaigns, four trenches (Trenches 1–4) of 23 m^2 in total were excavated at this site (see Figure 4). In Trench 2 (20 m^2) explored in the southern part of the occupation platform, 24 human skeletons were uncovered at a depth of *ca.* 50–120 cm below the present-day surface. In three burials of different stratigraphic dating, shells of Nile bivalves of the *Unio elongatulus* species (determination by L. Juřičková) were found directly on the shoulder of the deceased (B.4), in front of the face of the deceased (B.5), and directly on the tibia of the deceased (B.1). AMS ^{14}C dating of these shells, used evidently as grave goods (Table 1, nos. 1–3), places the burial activities in the southern part of the settlement platform at Sphinx tentatively within the 2nd half of the 8th millennium cal. BC (see also Suková, Varadzin 2012; Suková *et al.* 2014).[1]

The burials were situated in a homogenous, moderately-sorted silty loam of moderate-to-heavy compactness containing large amounts of clasts derived from the granitic rocks that form the background geology of the site. Despite various attempts, neither layers of primary sedimentation[2], nor anthropogenic layers or sunken features, could be recognized macroscopically or mechanically within this type of sediment (Figure 5). This was also the case with the burial pits, whose outlines could only be discerned in a few cases at the very base of the burials. This homogenous grey deposit contained a broad spectrum of finds common at Mesolithic settlements, such as pottery fragments, lithics, stone implements, mammal and fish bones, molluscs, bone industry, and varied artefacts for personal decoration made from bone, ostrich eggshell or shell (Suková, Varadzin 2012). Both artefacts and ecofacts as well as the very human remains had their surfaces covered by a thin layer of *kankar* (or duricrust, caliche hardpan) – a carbonaceous crust that occurs commonly in arid soils and is formed post-depositionally as a consequence of evaporation and subsequent precipitation of permeating solutions rich in

[1]In 2013 and 2014, altogether 8 samples of human bones and 3 samples of human teeth from the burials at Sphinx were tested for the presence of collagen for the purposes of direct dating of the anthropological material from Jebel Sabaloka by means of the AMS ^{14}C dating method. Whereas no collagen whatsoever was detected in the bone samples (this could have been given by the considerable age of the bones, their exposure to varied soil conditions in the course of contrasting Holocene climatic phases and, therewith, by complete bacterial decomposition), it was detected in the teeth samples, though, unfortunately, only in negligible amounts insufficient for a reliable direct dating of the human remains. For this reason, the burials from Sphinx themselves remain undatable – just as similar material from other Mesolithic sites in the Sudan (see Caneva 1983b; Haaland 1995; Honegger 2004; Usai 2014, 38–39; *cf.* Clark 1989 for the only directly dated Mesolithic burial from the Sudan). The determination of their age, therefore, must be necessarily based on the dating of the grave goods accompanying the deceased – in this case the shells of Nile bivalves (*cf.* Honegger 2004, 29, Table 1) – and a number of varied indirect evidence, including the character of the burial, dating of the material found in the fills of the graves, stratigraphic observations, state of preservation of the bones themselves, *etc.* (*cf.*, *e.g.*, Caneva 1983a, 21–28; Usai 2014, 39, note 5).

[2]From the hitherto observation it seems that the primary aggradation of the sedimentary record within this site's settlement platform encircled by granite boulders was caused mainly by degradation (through exfoliation/desquamation processes) of the surrounding rocks together with an aeolian input.

Figure 2. View from southeast of the southern part of the settlement platform at the site of Sphinx (photo L. Varadzin, 2014).

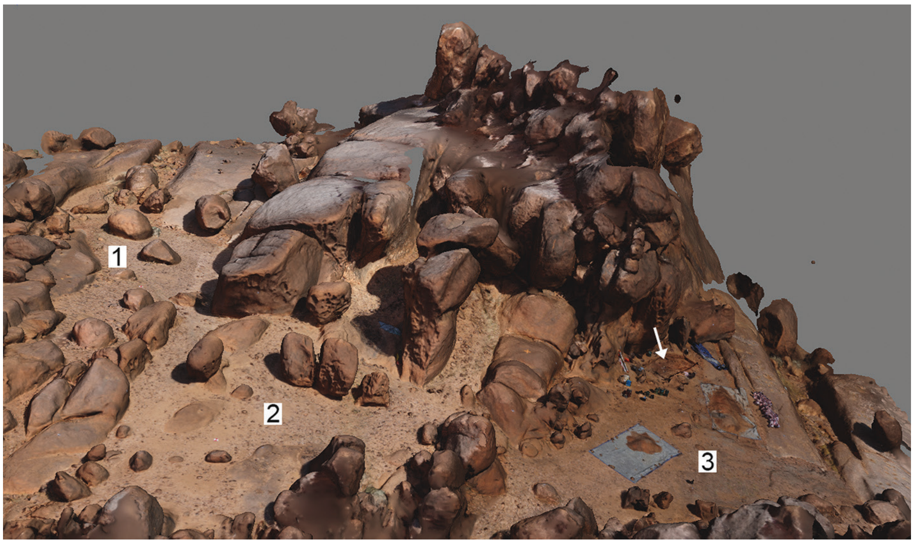

Figure 3. View from west of the settlement platform with its northern (1), central (2), and southern (3) parts; Trench 5 is indicated by an arrow (3D model based on KAP by J. Pacina, 2014).

carbonates (*cf.* Arkell 1949, 9; see also Zerboni 2011; Dal Sasso *et al.* 2014).

The diverse artefacts and ecofacts were also found in close contact with the bones of all of the uncovered and undisturbed human skeletons. Accordingly, although it was not possible to identify the grave pits, it is evident that the graves had been excavated in already deposited, and therefore earlier, settlement layers. The results of the AMS ^{14}C analysis of ostrich eggshell beads, undoubtedly deriving from a redeposited settlement layer and obtained upon uncovering (cleaning of) the bones in burials B.1, B.4, and B.5, always show an earlier date as compared with that obtained on the bivalves from the particular graves (see Table 1, nos. 1–4, 7, 8). Naturally, this does not mean that settlement activity might not have continued after the southern part of the settlement had begun to be used for burying. An occupation of the site during later phases of the Mesolithic period is, for what remains, indicated by the molluscs found in the central part of the occupation platform (in Trench 1 located *ca.* 35 m to the north of the southern part of the settlement with burials) and dated to the late 6th millennium cal. BC (Table 1, nos. 9, 10). For that reason, we cannot exclude that the burials laid in the southern part of the platform may have been overlaid by subsequent or even contemporary Mesolithic occupation.

Indeed, the interfering of the burials with one another and their rather not uncommon stratigraphic superimposition indicate perhaps the long-term character of the burial ground, containing burials of a number of generations. The absence of burials in test pits excavated in the northern (Trench 3; 1 m^2) and central (Trenches 1 and 4; each 1 m^2) parts of the settlement platform has led to the formulation of a hypothesis that the burial activities at the site were confined exclusively to the southern part of the settlement platform. The ascertained density of 1.2 burials per m^2 (24 burials in Trench 2 of 20 m^2) has justified an expectation of up to 400–450 individuals to have been buried in this part of the site (Suková, Varadzin 2012; Suková *et al.* 2014).

These considerations, together with the findings of the 2011 and 2012 field campaigns, had become the starting point for the formulation of the main issues and aims of further field research at this site in the autumn of 2014. These were: 1) to adjust the method of archaeological excavation to facilitate identification of settlement layers, contingent sunken settlement features and burial pits and determination of their stratigraphic relations; 2) to investigate the post-depositional processes that may have affected the original stratigraphic image of the site; 3) to elaborate the methods and procedures for the exploration of prehistoric sites in the geomorphologically and geologically specific area of Jebel Sabaloka (Almond, Ahmed 1993; see also Suková, Cílek 2012; Suková, Varadzin 2012); 4) to verify the extent of the burial ground in the southern part of the site of Sphinx and to secure further arguments for the dating of the burials; and 5) to collect further evidence for a better understanding of the former human activity at the site of Sphinx.

2. Methods

To address the above-mentioned issues, Trench 5 of 7.5 m^2 was excavated during the 2014 field campaign at the northeastern edge of the southern part of the occupation platform (*i.e.*, on the opposite side of the supposed burial ground as compared with Trench 2 – *cf.* Figure 4), right in front of a large, slightly overhanging granite boulder (*cf.* Figures 2–4). The excavation took altogether 18 working days of 8–10 hours each.[3] The trench was divided into seven squares of

[3]The field campaign lasted from 15th October till 4th November 2014. The research team consisted of: Aleš Bajer (sedimentologist, geologist), Murtada Bushara (inspector), Kristýna Kuncová (archaeobotanist – phytolith analysis), Lenka Lisá (sedimentologist, micromorphologist), Jon-Paul McCool (sedimentologist), Jan Novák (archaeobotanist – wood, charcoal), Jan Pacina (surveyor, GIS specialist), Adéla Pokorná (archaeobotanist – macro-remains), Petr Pokorný (palaeoecologist, biologist), Lenka Suková (research director, archaeologist), Ladislav Varadzin (field director, archaeologist), and four trainees – Safaa Ahmed Mohamed and Reemah Abdelrahim Kabbashi (National Corporation for Antiquities and Museums of the Sudan) and Hanaa Mohammed Hafiz and Huyam Mohammed Alamin (University of Bahri, Khartoum). The drivers and the cook of the expedition

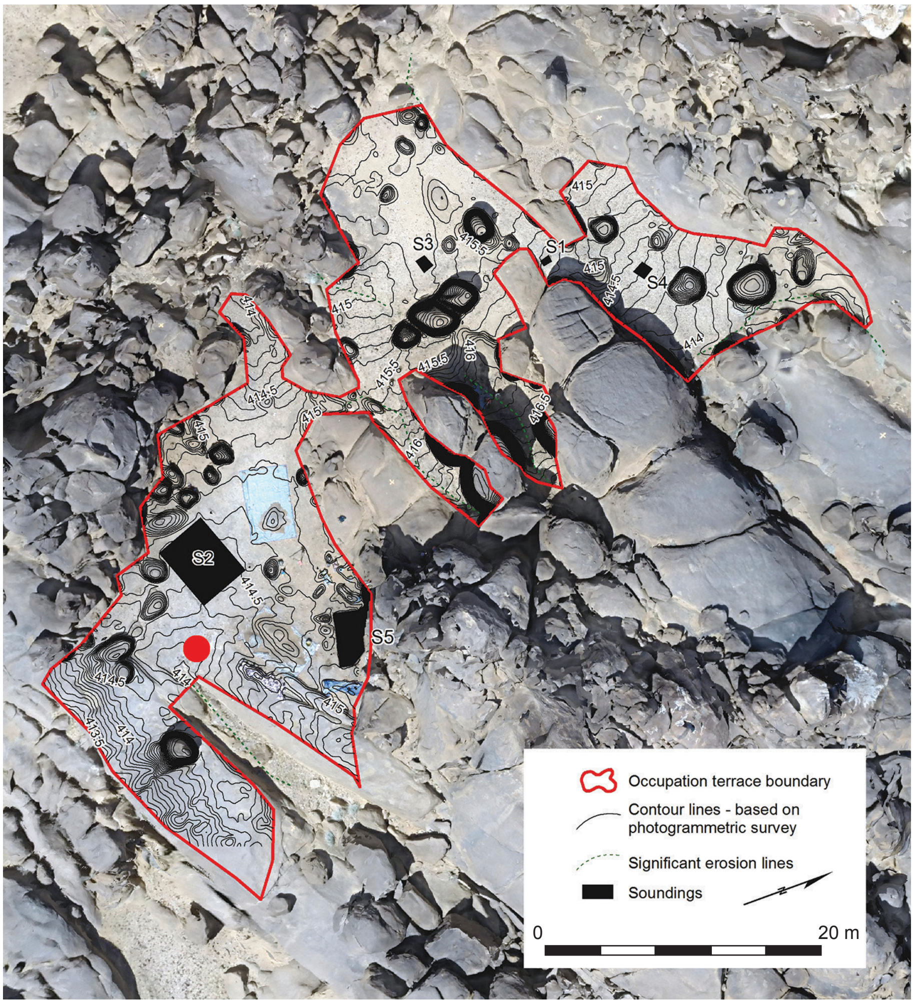

Figure 4. Contour plan overlaying an aerial photo of the site with the location of archaeological trenches (soundings) 1–5; the red circle shows the location of burial B.32 (author J. Pacina, 2014).

1×1 m (Squares A–G) and one of 0.5 m^2 (Square H).[4] First, the uppermost layer (SU1) forming a nearly continuous, 2–3 cm thick sedimentary cover, rich in archaeological finds datable to the Mesolithic period, was removed from the surface area of the delimited trench. Thereafter, exploration progressed in Squares B, D, and F only. Once we had become acquainted with the colour scheme and consistency of the deposits, the exploration was extended to the other squares and continued in the whole area of the trench. The excavation method involved a series of horizontal sections (mechanical units – MUs), 2–5 cm in thickness, cut within the confines of the 1×1 m squares and, within these, always only in line with what we considered to constitute possible stratigraphic units (SUs – layers or fills of features).[5] Colour, texture, and/or compactness (hardness) of deposits were taken into account to distinguish the individual units.

Once each successive mechanical unit within the confines of each supposed stratigraphic unit was removed, a detailed photographic, drawn, and textual documentation of the find situations was performed. For the purposes of more precise identification and documentation of the extent of individual parts of strata and to highlight the differences in their texture, compactness, and colour, the uncovered levels were sprayed by means of a water sprinkler and subsequently documented according to their uneven drying. Particular attention was paid to the vertical or inclined position of stones and artefacts that may indicate, *inter alia*, the presence of sunken features. Each uncovered level was surveyed and selected find situations were documented by means of stereophotography (*cf.* Figure 13). Visible signs of bioturbation (burrows and holes made by rodents and insects) were recorded, too.

The uncovered levels and find situations were studied by the geologists and sedimentologists who participated in the fieldwork. Common geoarchaeological approaches available in the field were employed, including the use of a portable magnetometer to obtain reference values of magnetic susceptibility, hydrochloric acid to ascertain the presence of

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were Osman Abdalla, Salih Muhammad Salih, and Mahmoud Almahi Altayeb of the Tumbus Tourism Co. Ltd.

[4]Squares G and H constituted a later extension to the southeast of the original 6 m^2 trench brought about by the necessity to explore in entirety the burials uncovered in the early phase of exploration at the edge of Squares E and F.

[5]In other words, the stratigraphic method was partly combined with what P. Barker refers to as "the planum method" (see Barker 1993, 108, 118, 146–148).

Figure 5. Trench 2 (2012) which contained 24 burials: homogenous grey silty loam without any traces of burial pits (photo A. Pokorná, 2012).

carbonates, and a magnifying glass to assess the roundness and sphericity of quartz grains to get a rough idea of the formation processes. The data obtained from the excavated trench were compared with similar proxy measured in the background geology. A series of geoarchaeological samples were taken from the uncovered find situations and stratigraphic units for the purposes of chemical, micromorphological and other analyses.

All excavated soil from Trench 5 was dry-sieved using a 4-mm mesh, always according to a particular mechanical unit within a particular stratigraphic unit. The coarse fraction was subsequently sorted for artefacts and ecofacts. Alongside this, about one third of the fine fraction under 4 mm obtained through the dry-sieving of individual contexts was flotated to secure charcoal and micro-charcoal and various botanical macro-remains (such as seeds, fruits, vegetative parts of plants, woods, *etc.*). Furthermore, prior to flotation of the selected contexts, the fine fraction was sampled for phytolith and pollen analyses.

In addition to this bulk sampling for archaeobotanical remains, direct sampling was resorted to where there was a possibility of uncovering accumulations of botanical material, especially in the course of exploration of the burials. In this case, samples of soil were taken from selected spots around or in the area of the skeletons (head, hands, abdominal area, feet, pelvic area, *etc.*) to ascertain and, as the case may be, to evaluate the presence of pollen grains, macro-remains, phytoliths, and other archaeobotanical finds that could constitute the remains of funerary offerings (*cf.* Sereno *et al.* 2008). Also, first samples were taken from the working surfaces of several upper and lower grinders to ascertain the presence and degree of preservation of starch grains and phytoliths. With selected bulk and specific botanical samples, the presence or absence of macro-remains, pollen grains, and phytoliths was tested already in the field laboratory established at the expedition's base camp.

During the 2014 field campaign, Kite Aerial Photography (KAP) and terrestrial photogrammetry were used to produce 3D models. KAP was used to create a complete 3D model (including Digitial Terrain Model and orthophoto) of the settlement and burial platform (Figures 3, 4, 17). A GoPro Hero 3+ camera was carried on the kite by a Picavet suspension (Verhoeven *et al.* 2009). The spatial resolution of the resulting data (DTM, orthophoto) at the site of Sphinx is 7 cm/pixel. The terrestrial photogrammetry was used to create 3D models of more detailed features (exposed boulders bearing cup marks, phases of excavation of Trench 5, and details of excavated burials; *cf.* Figure 13). The spatial resolution of the resulting data is much higher than with the KAP results – we used a camera with a larger chip and better optics (Sony NEX 7) and the distance between the camera and the object being photographed was in the order of several metres (rather than the 70 m altitude by KAP). The spatial resolution of the boulder with cup marks was *ca.* 1 mm/pixel (for further information see Pacina 2015). The 3D models were generated from conventional digital photographs using the PhotoScan software from Agisoft LLC and then following the process employed previously by authors working with close-range photogrammetry and image-based modelling for archaeological documentation (*e.g.*, Bitelli *et al.* 2004; Lerma *et al.* 2010; Verhoeven *et al.* 2012).

3. Field observations and findings of the 2014 field campaign

In the course of the excavation of Trench 5, altogether 18 types of deposits were differentiated and designated tentatively as

Figure 6. Trench 5 (prior to extension), one of the stages of excavation, view from northwest (photo L. Varadzin, 2014).

stratigraphic units. As in the 2012 field campaign, SU1 was reserved for the uppermost surface layer that constitutes a continuous sedimentary cover on the settlement platform and is composed of quite a noticeable amount of weathered granite rocks intermixed with numerous artefacts and ecofacts datable to the Mesolithic period. The remaining 17 deposits – or "stratigraphic units" (SU2–SU18) – were identified based on differences in colour, texture, and compactness of the deposits situated beneath SU1. Some of these were further subdivided, based on finer differences, into two (*e.g.*, SU9: A, B) to five (*e.g.*, SU11: A–E) subunits.

The most frequently encountered colours of deposits included red (*sienna*, *bordeau*) and grey (ranging from grey-white to dark grey to black), some of which verged on brown, green, or pink (Figures 6–12). The linear boundaries between the individual colours were sometimes clearly visible, but difficult to discern in other cases. From the point of view of texture, the deposits appeared rather homogeneous. Clasts of weathered granite constituted their coarse fraction, equating to 40%–60%; the remainder was formed by a fine dusty or silty matrix. Only SU9 differed from this composition, as it contained lenses of a dark-brown soil material that was not recorded elsewhere at the site.[6] The compactness of the deposits was quite variable, varying also within the same individual colour and texture. In several cases, it differed irrespective of the supposed presence of grave pits whose locations were subsequently estimated based on the position of the skeletons uncovered *in situ*. The individual types of sediments differed sometimes markedly and sometimes only slightly in their magnetic susceptibility, presence of carbonates tested by means of hydrochloric acid, or macroscopical presence of precipitated calcium carbonate adhering to the finds. A very strong representation of the (precipitated) carbonates was detected in SU11 rich in archaeological material and burials (see the grey-coloured unit in the lower and central part of Trench 5 in Figure 10), while no values whatsoever were shown for the crust SU15 (see the grey-coloured unit in the upper left corner of Trench 5 in Figure 10). Interestingly, the molluscs uncovered in the lower levels of SU15 were found to have been entirely decalcified! However, already in the course of the excavation it slowly became evident that at least some of the SUs did not correspond to the original strata and were rather the result of secondary post-depositional processes (*e.g.*, the extensive black sinuous – or trunk-like – formation, see Figures 9–12 and discussion below).

The excavated trench was found to contain 11 burials (B.25–B.31, B.33–B.36)[7] that concentrated in the southeastern and western part of Trench 5. The burials were located right above the bedrock at a depth ranging between 15–35 cm (southeastern part of the trench – B.25–B.31 on the large granite boulder; see Figures 12, 13) and 45–80 cm (western part of the trench – B.33–B.36; see Figures 12, 14). The deceased were laid in a more or less contracted position, head oriented mostly to the east or northeast (Figure 13). Some graves interfered with one another, which implies separate (successive) events of interment. Then again, four individuals (B.33–B.36), whose skulls were detected in the southwestern section of the trench, were laid one on top of the

[6]These facts could lead to the idea of a significantly different dating of SU9 (among the most recent from the stratigraphic point of view) as compared with the other units; however, there is no other evidence – for instance, in the form of more recent artefacts – that would render support to such thoughts.

[7]The numbers of the burials continue the sequence introduced in 2012 when altogether 24 burials were identified. In both field campaigns (2012, 2014), the numbering reflected the course of exploration, with the burials assigned numbers in the sequence in which they were recorded. In addition to the burials, several groups of loose human bones were uncovered in Trench 5 (just as in Trench 2 in 2012).

Figure 7. Trench 5 (after extension), one of the stages of excavation, view from northwest, feature F.1/14 below on the right (photo L. Varadzin, 2014).

other without cutting one another (see Figure 14).[8] Apparently, they had been interred at the same time into one and the same burial pit. Just as was the case with the burials explored in 2012, no funerary offerings accompanied the deceased uncovered in Trench 5. However, three shells of Nile bivalves (one *cf. Mutela* and two indeterminable due to fragmentation; determination by L. Juřičková), which can be considered to represent the likely remains of grave goods, were collected right behind the head of B.33 at the bottom of the grave with the quadruple burial (see Figure 14).[9] It is characteristic of Trench 5 that with the exception of SU7 that appears to have constituted the fill of B.25, none of the SUs corresponded to the supposed grave pits of the explored burials.

Furthermore, feature F.1/14, obviously of anthropic origin, was uncovered in the western part of Trench 5 at a depth of *ca.* 40 cm below the present-day surface and above burials B.33–B.36 (Figure 7). It was formed of medium-sized granite stones arranged in a semi-circle with a diameter of *ca.* 50 cm. Just as was the case with most of the burials explored in Trench 5, none of the differentiated stratigraphic units could be securely associated with this feature either. For this reason, it is impossible to state whether it was originally situated on the surface of the former terrain or in a pit.

Several hundreds of fragments of Mesolithic pottery (Incised Wavy Line, Dotted Wavy Line, Rocker Stamp), thousands of pieces of lithics (in addition to a large quantity of production waste, there were microliths on quartz as well as rhyolite pieces), nearly one hundred pieces of grinders – mostly broken and discarded upper as well as lower ones, and a small collection of other finds (bone implements, red and yellow pigment in raw form, mica, ostrich eggshell fragments and beads, *etc.*) were retrieved from Trench 5 through direct collection or through dry-sieving. In addition to artefacts, good-sized samples of ecofacts – animal bones, molluscs, and botanical finds – were obtained as well. Of particular significance with respect to understanding the subsistence is the confirmation of the presence of starch grains and phytoliths on the working surfaces of some of the grinders tested in the field laboratory.

Three more observations of significance for the aims set for the 2014 field campaign were made within or outside Trench 5. First, in an erosion line enlarged during heavy rain storms in 2013 and 2014 (Murtada Bushara, pers. comm., 2014), another human burial (B.32) was exposed on the surface by the southern edge of the southern part of the settlement platform (Figure 4). During the campaign, it was only recorded, but not investigated. Second, bands of horizontal weathering lines were noted to be running continuously across the lower parts of the granite boulders that delimit the outlines of, or outcrop within, all three parts of the settlement platform. The upper limits of these weathered and lighter-coloured zones, which were surveyed in all three parts of the site by means of a total station, ranged from 30 to 90 cm above the present-day terrain (Figure 15). Third, evidence of intensive bioturbation in the form of burrows or holes made by rodents but also insects was detected during the excavation of Trench 5.

4. Discussion

The 24 burials, uncovered in 2012 in Trench 2 at the western edge of the burial ground at Sphinx and tentatively dated to the Early Mesolithic (2nd half of the 8th millennium cal. BC; see Table 1, nos. 1–8) were supplemented in 2014 by 12 new burials showing the same state of preservation and

[8]The trench was extended locally in order to uncover the upper parts of the postcranial skeletons.

[9]The custom of placing shells of bivalves into graves by the head of the deceased has also been noted at Saggai (see Caneva 1983a, 24, Figure 10) and el-Barga (see Crèvecœur 2012, Figure 12).

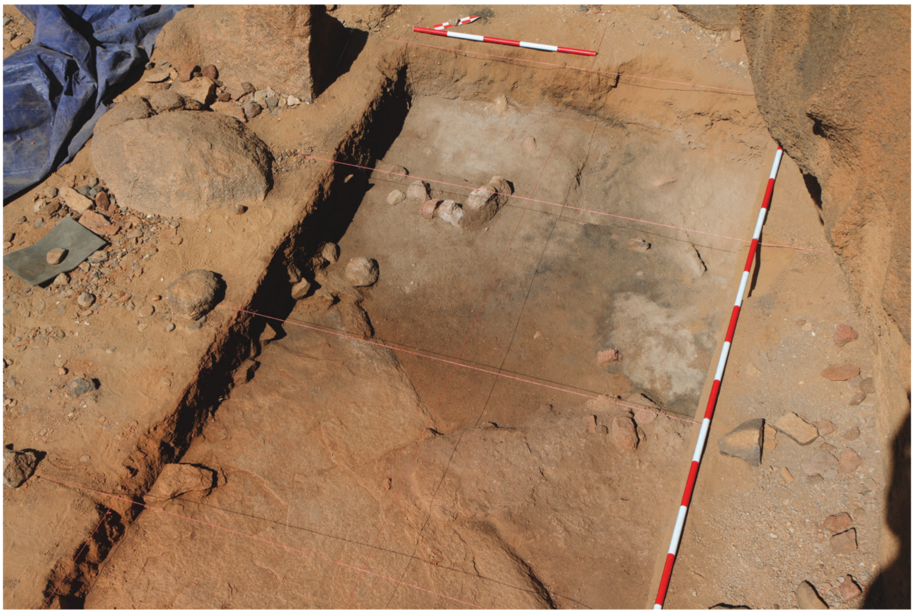


Figure 8. Trench 5, one of the stages of excavation, view from east (photo L. Varadzin, 2014).

Figure 9. Trench 5, one of the stages of excavation, view from southwest (photo L. Varadzin, 2014).

apparently governed by the same burial practices and rites. Just as at other pre-Neolithic burial grounds in the Sudan (in particular, Caneva 1983a; Haaland, Magid 1995; Fernández *et al.* 2003, 279; Honegger 2004; 2014), the cemetery at Sphinx is characterised by the isolated occurrence of grave goods, among which shells of bivalves constitute the only recurring element. The total number of burials so far known at Sphinx has thus increased to 36. With the location of the new graves at the northeastern (11 burials in Trench 5) and southern (1 burial revealed by surface erosion) edges of the southern part of the settlement platform, our hypothesis on the use of the entire southern part of the site for quite intensive burial activities has been given further support.

The density of the burials detected in Trench 5 (1.46 burials per m^2) has even exceeded the density of graves calculated on the basis of the exploration in 2012 (1.2 burials per m^2; see Suková, Varadzin 2012). These facts speak in favour of our estimate of the size of this site's burial ground equating to at least 400–450 deceased (*e.g.*, Suková *et al.* 2014). If this estimate is corroborated by further research, the site of Sphinx will constitute the largest pre-Neolithic hunter-gatherer necropolis so far known in North Africa (*cf.* Honegger 2014 for 41 Mesolithic burials at el-Barga in northern Sudan; Usai *et al.* 2010 for 68 /pre-/Mesolithic burials at Al Khiday in the lower White Nile region; Wendorf 1968 for at least 61 Final Palaeolithic burials at Jebel Sahaba in northern Sudan; and, for example, Sereno *et al.* 2008 for 17 hunter-gatherer burials at Gobero in Niger; for much smaller groups of, or disturbed, burials of presumably Mesolithic dating, see Arkell 1949 for Khartoum Hospital; Caneva 1983a for Saggai; Clark 1989 for Shabona; Haaland 1995 and Haaland, Magid 1995 for Damer and Aneibis at the Atbara Junction; and Fernández *et al.* 2003, 279 for the Blue Nile region). The evidence of a superimposition of burials, uncovered again in Trench 5,

Figure 10. Trench 5, one of the stages of excavation, view from southwest (photo L. Varadzin, 2014).

attests to a longer-term (multi-generational?) use of this part of the settlement platform for burying. Further excavation of the burial ground at Sphinx has undoubtedly extraordinary potential: not only from the point of view of understanding the thought-world of the complex hunter-gatherers of the Early Holocene period and their conception of landscape, into which a focal (ancestral?) burial ground established on a comparatively small and enclosed area (*cf.* Honegger 2004; 2014; Usai *et al.* 2010) had been incorporated, but also with a view to the information value of the analyses of the anthropological material.

Just as in the previous field campaign in 2012, the exploration of Trench 5 in the southern part of the site uncovered the remains of settlement activities that always fell, based on the tentative assessment of pottery and lithic finds, only within the Khartoum Mesolithic (generally 9th–6th millennia cal. BC) (see Suková, Varadzin 2012; Suková *et al.* 2014; and *cf.* Salvatori 2012). So far, no evidence of re-occupation during post-Mesolithic times has been brought to light through the hitherto research – both surface survey and excavation – in the southern (as well as in the central and northern) part of the settlement platform. In this respect, the site of Sphinx differs from most of the other Mesolithic sites in central Sudan whose situation on Pleistocene fluvial bars elevated above the alluvial plain (Marcolongo 1983; more recently Zerboni 2014) made them ideal locations for interment during the Meroitic (*ca.* 300 BC–350 AD), post-Meroitic (350–550 AD), Christian (550–1500 AD), and later periods (after 1500 AD). The establishment of cemeteries at these prehistoric mounds, often consisting of tumuli heaped from surface deposits, significantly devastated the earlier archaeological situations and distorted the original archaeological image of these prehistoric settlements (*e.g.*, Arkell 1949, 119–127; 1953, 91–96; Caneva 1983a; Caneva *et al.* 1993; Fernández *et al.* 2003, 283–284; Usai, Salvatori 2006; Salvatori 2012).

The apparent intactness of the Sphinx from later (post-Mesolithic) anthropic disturbances, together with the physical characteristics of the site constitutes an ideal precondition for the study of life and death at this site during the Mesolithic times. In this respect, for instance, the attestation of the presence of starch grains and phytoliths on the working surfaces of the grinders excavated in Trench 5 constitutes a finding of special significance that will hopefully help to address the issue of the representation of a vegetal component in the diet of the Mesolithic hunter-fisher-gatherers – one of the key issues of Sudanese prehistory (*cf.*, *e.g.*, Haaland 1995; critically Usai 2014; also Buckley *et al.* 2014).

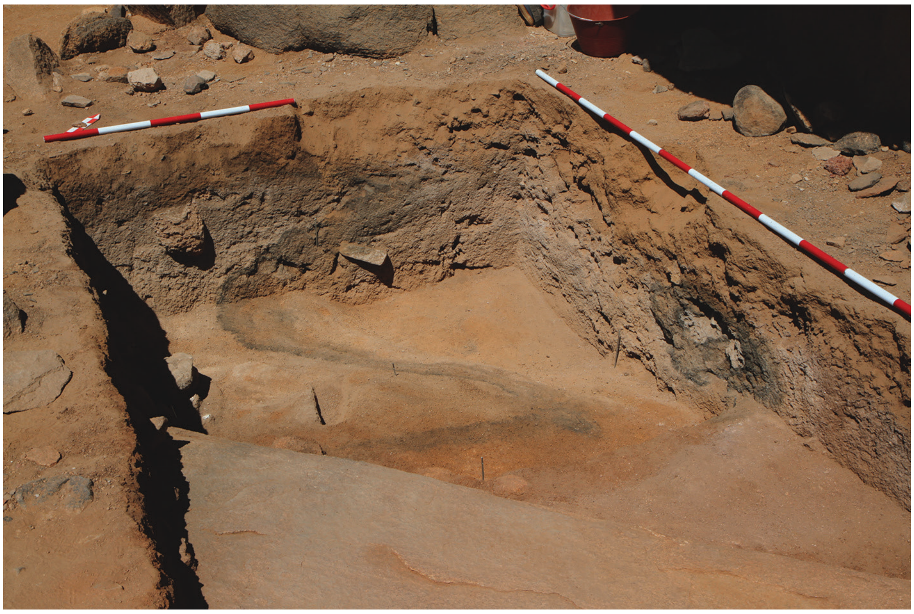
However, while anthropic disturbances during post-Mesolithic times appear to have avoided Sphinx, the site has not escaped post-depositional alteration through a number of non-cultural (physical and chemical) processes that are known to disturb artefact and site contexts in general (Schiffer 1987). What follows is a discussion of several interdependent (but still separable) N-transformations we identified and studied in the field in 2014.

4.1 Surface erosion

Wind erosion and deposition, together with colluvial processes, are the most common geological and climatic forces that act over long periods of time in deserts and semi-deserts (Shao 2008). The wind erosion is an interacting set of physical processes governed by many factors which can be broadly grouped into three categories: weather and climate (especially high winds and low precipitation), soil state (mineral composition, particle size characteristics, crusting and aggregation, and soil moisture), and also surface roughness (nonerodible soil aggregates, microtopography, and vegetation cover) (Shao, Leslie 1997).

In the case of the site of Sphinx, these phenomena played an important role in the primary natural aggradation of

Figure 11. Base of Trench 5, view from south (photo L. Varadzin, 2014).



the sediment on the platform as well as in the subsequent removal (or reduction) of the uppermost part of the deposits and in the transfer of finds that had once constituted part of the contingent stratigraphic units (layers, sunken features) situated in these deposits. During the climatically-favourable periods of the Early and Middle Holocene (*e.g.*, Kuper, Kröpelin 2006; Kröpelin *et al.* 2008), wind erosion and its impact on the site may have been reduced thanks to higher precipitation influencing the soil moisture, vegetation cover, and microtopography, which is quite special in the case of this site. With the onset of arid climate and decrease in humidity in the region during the Middle Holocene (Kuper, Kröpelin 2006; Kröpelin *et al.* 2008), the erosion must have begun to progress at a more rapid rate. The intensified and unobstacled wind action brought about the deflation of loose, fine-grained silt and sand particles and accumulation of the coarse fraction remaining from the deflated portions of the deposits. Through this selective erosion, the more or less consolidated layer of SU1, consisting of large accumulations of surface finds – both artefacts and ecofacts covered in most of the cases by a SiO_2 patina – and of noticeable amounts of weathered granite rocks, had formed at a new, lowered level of the terrain. Subsequently, due to its relative hardness, this consolidated surface, which to a certain extent can be regarded as constituting the incipient stage of a desert pavement (Williams, Zimbelman 1994), began to protect the underlying undisturbed deposits against further action of erosion, in particular the aeolian one.

This phenomenon is well known in arid environments of North Africa and beyond and has been already described several times at a number of archaeological sites (*e.g.*, Wainwright, Thornes 2004). However, it has always been difficult to determine the thickness of the deposits that had been removed (transferred) through the above-mentioned process, the fact of which has, naturally, an influence on the manner of evaluation of any particular site. So far, it has been assumed mostly on the strength of indirect indications that in central Sudan wind erosion might have removed up to one metre of the uppermost part of the deposits from the sites (*e.g.*, 20–30 cm based on sedimentological research at Saggai – see Caneva 1983a, 21, note 15; 4–6 feet at Shaheinab according to Arkell 1953, 1, 6; up to 1 m at Es Salha/Al Khiday according to Usai 2014, 39, note 5) (the issue of the action of water erosion, dependent on the steepness of slopes, is left aside for the time being). At the site of Sphinx, which is set within a granite outcrop, however, we command some unique direct evidence for this type of consideration: the bands of weathering lines – or more precisely weathering grades – that have been observed on the lower sections of the boulders delimiting or outcropping within the occupation platform.

From detailed observations in the field, the uppermost of the lines appears to be the relict of the highest level of the former surface of the terrain at the site with the highest probability of it being during the Early and Middle Holocene, *i.e.*, within the period of occupation of the platform in the Mesolithic period (see Figure 15). The measurements collected during the 2014 field campaign suggest that the former surface of the terrain had been situated as much as 90 cm higher as compared with the present day, with the difference decreasing to 30 cm as one approaches the edges of the settlement/burial platform.

As to the dating of the weathering lines, they certainly must have only formed to their fullest extent after the grave pits for burials B.25–B.31 in the southeastern part of Trench 5 had been excavated. These burials, uncovered merely 15–35 cm below the present-day surface, had been no doubt sunk originally from a higher level. The height of 37–40 cm above the present-day surface, at which we recorded the upper limit of the band of weathering lines on the granite boulder in the closest vicinity of Trench 5, could well correspond to the original height: one which would make the original depth of these burials equate to approximately 52–75 cm.

Figure 12. Base of Trench 5, view from north; A – location of burials B.25–B.29 (*cf.* Figure 13); B – burials B.33–B.35 (for detail, see Figure 14) (photo L. Varadzin, 2014).

As the weathering lines or grades could have formed only in connection with a gradual lowering of the surface of the terrain through wind and water erosion, unchained by the decreasing humidity of the climate in the region, and in consequence of the (chemical) reactions that must have occurred at the interface between the progressively lowering surface of the terrain and the surface of the rock, we regard the above-mentioned consideration as another indication for the Mesolithic dating of the burials in Trench 5. The unique documentation of the elevations of the bands of weathering lines, collected at Sphinx in 2014, allows for a reconstruction of the contour plan of the original surface of the Mesolithic settlement and burial ground during the climatically-more-favourable periods of the Early to Middle Holocene; this will subsequently serve as a tool for the inquiry into the occupation and activities at the site during the Mesolithic times as well as into post-depositional processes.

The main negative consequence of erosion for archaeological interpretations at this particular site, as well as in general, is the loss of stratigraphic information and original spatial contexts of finds within the affected upper portions of the deposits removed through deflation, as well as the loss of information on the original position of finds in consequence of their lateral movement through water erosion (colluvial processes) (*cf.* Figure 4 for the present erosion lines at the site). As the finds from SU1 probably do not correspond on the whole to their original place of deposition, as far as both vertical and horizontal position is concerned, they must be treated accordingly in subsequent evaluation. Thus, the surface finds from SU1 cannot be used to determine the relation between settlement and burial remains. However, the situation is different with the deposits situated below the level of SU1 where we can presuppose only a minimal affect from colluvial processes. This is evidenced by the finds in Trench 5 of feature F.1/14 and of intact burials B.25–B.31 and B.33–B.36 dated to the Mesolithic period, some of which were uncovered a mere few centimetres under SU1.

At present, it is this consolidated surface layer of SU1 that slows down surface erosion through wind and water action and thus protects the archaeological deposits situated below. Nevertheless, in isolated events of heavier rains – the present-day annual rainfall in Khartoum amounts to 175 mm (Williams *et al.* 2015, 2)[10] – that bring more water than the ground can absorb, the surface runoff through existing or new erosion lines can bring not only further dislocation of surface finds, but also mechanical damage of the surface layer and, eventually, activate further wind erosion. An illustrative example of this is the exposure of a human burial B.32 at the southern edge of the burial ground in consequence of the strong rains occurring in 2013 and 2014.[11]

4.2 Pedogenesis

In the course of the many millennia that elapsed between the Mesolithic period and the present, the site as well as the region as a whole has experienced contrasting climatic conditions (*e.g.*, Gasse 2000; Kuper, Kröpelin 2006; Kröpelin *et al.* 2008) that brought about a wide range of geochemical and biotic environments. In their scope, a broad array of pedogenetic processes has taken place, with each group impacting in its particular way the deposits preserved in defiance of the wind and water erosion under the accumulated coarse fraction constituting SU1.

[10]For the Mesolithic period, Arkell estimated a precipitation that amounted to at least three times that of his times (164 mm), *i.e.*, no less than 500 mm per year (Arkell 1949, 109–110).

[11]In this connection it is also important to note that archaeological excavation in general has an impact on the natural structure of the surface at any site and can also influence the rate or extent of deflation and erosion or alteration through water (for instance, by increasing water seepage). In every case, precautions against that happening should be made on completion of fieldwork and when backfilling the excavated trenches.

Figure 13. Burials B.25–B.29 uncovered in the southeastern part of Trench 5 on a large granite boulder ca. 15–35 cm below the present-day surface (orthophotography by J. Pacina, 2014).

Figure 14. Three skulls (nos. B.33–B.35) of the quadruple burial uncovered by the southwestern edge of Trench 5; note two of the three shells of Nile bivalves by the head of B.33 (photo L. Varadzin, 2014).

4.2.1 Geochemical processes

Several varied geochemical processes constitute an integral part of pedogenesis (Holliday 2004, 262). In Trench 5, a massive degree of chemical weathering and mobility of chemical compounds – especially manganese oxides, iron oxides, and carbonates – was ascertained within the sedimentary body. This can be demonstrated using several examples recorded in Trench 5. On the one hand, we registered a decalcification of some portions of stratigraphic units (in particular SU15), including the entire decalcification of shells of molluscs occurring in these deposits. On the other hand, at places that had little in common with the original stratigraphy we noted concentrations of particular chemical compounds that created formations of bright-coloured and banded zones. For instance, the precipitation of manganese across Trench 5, intensified obviously by the presence of the granite rock and, in particular, by its overhang above Trench 5, resulted in the formation of a black sinuous feature hemmed about and filled in with concentric lines and lenses of grey, pink, and white colours, as shown in its cross-section (*cf.* Figures 10, 11). Wherever the manganese concentrated (*e.g.*, Figures 7, 9, 10, 12), everything was coloured dark grey to black on the surface (for instance, human bones in burials B.27 and B.31, together with the underlying granite boulder,

Figure 15. Weathering lines on one of the boulders delimiting the "southern shelter" by the central part of the settlement platform (photo L. Varadzin, 2015).

pottery sherds, lithics, but also small clasts of weathered granite). This category also includes the formation of *kankar* through precipitation of calcium carbonate.

These processes result: a) in the change of colour of the sedimentary record, with some parts of the deposits acquiring the homogenising grey colour, and b) partially in the change of compactness of certain parts of the deposits – in the range from very hard/compact (they could be broken down only by using a heavy hoe) to loose. This occurs irrespective of the position of the original sunken features or layers and the contact lines (the interfaces) between them, as shown in the case of the supposed, but unidentifiable, grave pits.

The combination of these two results has brought about the following:

1) A change in the original character of the anthropic layers and sunken features, accompanied by the *obliteration of their boundaries and/or fills*. This can be illustrated using the example of feature F.1/14, which we would not have been able to identify without the presence of the stones laid out in a semi-circle, or the uncovered burials, whose grave pits could not, in most cases, be detected at all during excavation.
2) The disappearance of *layers of ash* (potassium carbonate) as a consequence of the mobilisation of carbonates.
3) The formation of *pseudo-layers* and *pseudo-features* that are clearly differentiated from their surroundings by their particular colour and compactness, but which have nothing to do with the former anthropogenic deposits. Their marked presence in Trench 5 (and their absence in Trench 2) can be explained by the close vicinity of the large granite boulder, whose slight overhang must have acted as a drip line, with the excess water accelerating and intensifying the chemical weathering and solution movement within the sedimentary body.
4) The formation of *kankar* (precipitated calcium carbonate) that was unevenly distributed throughout Trench 5 and noted mostly on the surfaces of skeletons, sherds, *etc.* As it is likely that this form of accumulation of calcium carbonate is related to the end of the Holocene humid phase (Williams *et al.* 2015, 11), and to dry environments in general, the finds covered by this precipitate (duricrust) probably date back to pre-Meroitic times (in this sense already Arkell 1949, 11–12; also *e.g.* Zerboni 2011; Dal Sasso *et al.* 2014). The radiocarbon dating of the burials uncovered in Trench 2 to the second half of the 8th millennium cal. BC (see Table 1, nos. 1–3) seems to correspond with this consideration well (see also Caneva 1983a, 21–28).

Although the apogee of these processes still falls within the Holocene humid phase in this part of Africa (in particular, prior to the 5th millennium cal. BC; see Kuper, Kröpelin 2006; Kröpelin *et al.* 2008), in the area of Sabaloka they also continue to operate to some extent in present times.

4.2.2 Biotic processes

Among the most common processes that have a considerable impact on the preservation of stratigraphies can be included mixing due to bioturbation by plant growth and by animal activity (Holliday 2004, 270). While the former can be supposed, although no evidence for it was ascertained during the excavation of Trench 5, the latter was not uncommon (*ca.* 15%–20% in the various parts of Trench 5) and occurred in varied forms. In addition to burrowing by animals such as rodents, bioturbation by insects was also established – both in the course of the excavation (the channels often extended as deep as the base of the trench) and in the subsequent sieving and flotation of the excavated deposits upon which desiccated bodies of insects (mostly ants and wasps), or their cocoons, were found.

The negative consequence of these processes consists in the following:

Figure 16. Recent observations at Jebel Sabaloka confirm the importance of insect vectors in the post-depositional introduction of plant materials into the archaeological layers: the photograph shows a collection of grass seeds around the entrance to an underground nest of ants (photo A. Pokorná, 2014).

1) The *homogenisation of a series of original anthropogenic deposits*, making the possibility of identifying stratigraphic units harder.
2) The *(downward) movement of artefacts and ecofacts* up to 4–5 cm in size through the deposits, causing the contamination of earlier layers and features.

We can associate these processes with most of the finds of fresh (uncharred) plant remains; these are extremely unlikely to be preserved since the Early and Middle Holocene and must be considered, for the time being, without direct radiocarbon dating of these finds, as relatively young intrusions possibly introduced into the cultural layers post-depositionally through the activity of these various animals.

Documented examples of this apparently date back to recent times; however, these biotic processes no doubt already began within the Mesolithic period. During the same period – more humid compared to recent times – we must also assume the action of earthworms (Holliday 2004, 274). Taking into account the above-stated findings, these processes must have been of a marked intensity.

5. Conclusion

The infamously bad preservation of prehistoric deposits, brought about by anthropic and/or natural disturbances, has constituted a constant challenge to archaeological excavation and for subsequent evaluation since the beginning of prehistoric research in central Sudan. In the case of the site of Sphinx at Jebel Sabaloka studied by the mission of the Czech Institute of Egyptology since 2011, the situation appears to have been made easier to some extent as the site has not suffered from any major anthropic reworking of deposits during post-Mesolithic times. However, it has not escaped an intensive post-depositional alteration through a number of non-cultural tranformations that are known to alter and, to a certain degree, also destroy the original artefact and site contexts.

Within this site, Trench 5 discussed in this paper constitutes rather an extreme example. For this reason, it is possible to use it to demonstrate the character and the possible degree of post-depositional N-transformations at prehistoric sites at Jebel Sabaloka and, to some degree, in arid environments in general. In the course of the exploration of Trench 5 it became evident that differences in colour and compactness (but not in texture, which varied only a little within Trench 5), on the basis of which stratigraphic units are most frequently differentiated and identified during archaeological excavations, were in the majority of cases rather the outcome of post-depositional processes that had taken place at the site. On the contrary, only a small number of the remains of true stratigraphic units of anthropic origin could be identified. And this is in spite of the fact that the original deposits, remaining after the action of surface erosion, have been preserved *in situ* at the site – as evidenced by the finds of eleven burials (B.25–B.31, B.33–B.36) and at least one possible settlement feature (F.1/14). All of this can be attributed in particular to the geochemical and biotic post-depositional processes that brought about the homogenisation of the cultural deposits, on the one hand, and the formation of pseudo-features and pseudo-layers on the other. The marked intensity of geochemical processes can be demonstrated by the entire decalcification of the mollusc shells in some parts of the trench. Furthermore, there is the disappearance of the layers of ash that we associate with a strong post-depositional mobilisation of chemical substances. However, these processes did not preclude at least partial preservation of some true stratigraphic units (*e.g.*, SU7, SU9). It is obvious

Figure 17. Jebel Sabaloka, Sphinx: 3D model of the granite outcrop on which the site is situated (KAP by J. Pacina, 2014).

that we are dealing with a series of particular processes, each one of which had, or still has, an impact of varied intensity and an apogee in a different period. These processes are given by a combination of the character of: the geological background of the site, georelief, dynamics and intensity of precipitation, changes of temperature, and intensity of solar radiation throughout the year, as well as by the action of animals (including insects). The synergic action of so many and so varied factors acting in conjunction implies that their effect at the site may be differing from one metre to the next.

Either way, the stratigraphic excavation method should certainly always constitute the ultimate basis of the archaeological excavation. Nevertheless, the example of Trench 5 shows that one must also allow for the contingent presence of pseudo-layers and pseudo-features that may be fully identified as such only after some time in the advanced stages of the exploration. For this reason, it is necessary to co-opt the traditional method of stratigraphic excavation by other, *parallel* procedures based on the mechanical cutting of the terrain through, if possible, fine, discreet, and precisely-localised levels. The latter should never, however, intervene with the excavation by contingent stratigraphic units (*i.e.*, mechanical units must always be subordinated to stratigraphic units). This should be accompanied by frequent production of detailed graphic and textual documentation of every level attained, and the finds uncovered therein. Throughout everything, special attention should be paid to movable finds in non-horizontal positions that may contribute – once all drawn plans from the various height levels have been superimposed over each other – to the reconstruction and indirect identification of other sunken features whose outlines and fills could not be detected by the naked eye, touch, or pressure directly during excavation. At the same time, the collection and recording of finds according to these subtle mechanical units and sectors in the trench may allow – already away from the site – the reconstruction of, at least hypothetically, the find assemblages corresponding hopefully to the original layers. Last, but not least, parallel study of the geological and geochemical properties of each individual site, which in the case of Jebel Sabaloka constitutes a peculiar task, is indispensable for an understanding of the formation and transformation processes. Without proper identification and critical assessment of these, it is impossible to exploit the information value of the studied archaeological site.

In this paper, the effect of post-depositional N-transformations was shown using the example of one trench at one site in the geologically-specific environment of Jebel Sabaloka. The stated findings in their *specific* form, therefore, cannot be schematically generalised for other prehistoric sites in central Sudan. On the other hand, the described *principles* and the degree of intensity of their effect on the image of such archaeological situations should contribute to the discussion on the possibilities and, equally, the limits of archaeological exploration in (semi-)arid environments in general.

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