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Why was the ancient city of Wad Ben Naga, Sudan, built of bricks? Geological evidence

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Abstract: Results of the first geological survey at the prominent archaeological site of Wad Ben Naga, Republic of the Sudan, are presented here. This study was carried out in order to determine provenance of the building material used in the royal city of the Kingdom of Meroe (ca. 300 BC to 350 AD). Two principal geological units crop out in the area: (1) the basement complex of Neoproterozoic age represented by granitic intrusions and associated dykes (aplites, pegmatites, microgranites and microdiorites) and (2) overlying horizontally bedded basal conglomerates of the Omdurman Formation (formerly referred to as the Nubian Sandstone Formation; probably of Cretaceous age). Both lithologies were apparently unsuitable for fine stonemason works and only used in the foundations of the ancient buildings. Columns, statues and altars found at the site were made from medium to coarse-grained sandstones from stratigraphically higher levels of the Omdurman Formation. However, they do not occur in the surroundings. This material had to be imported from distant sources which made the ancient architects to adopt bricks as the main building material. Possible sources of a sufficient quality stone are located approximately 20 km SE of Wad Ben Naga in the vicinity of the ancient settlements at Naga and Musawwarat es Sufra. Horizontally bedded sandstones and associated sediments of the Omdurman Formation form prominent extensive mesas there.
Key words: Sudan, Wad Ben Naga, geological mapping, material provenance

INTRODUCTION

Wad Ben Naga archaeological site is situated on the right bank of the Nile, approximately 130 km NE of Khartoum, the capital of the Republic of the Sudan (16.5560°N, 33.1806°E; Fig. 1). In 2009 the National Museum obtained a license for the archaeological survey of this locality that represents the southernmost royal city of the Kingdom of Meroe (ca. 300 BC to 350 AD). Remains of several buildings, including the royal palace and at least five temples, can be found here. Some of them have been known since the first half of the 19th century, although most of them have not been systematically studied so

far (for a review see Onderka & Dufková 2011). At present the procedure of addition of this prominent site to the UNESCO World Heritage List is in progress.

The aim of our pilot survey at the site was detailed geological mapping and the study of possible building material provenance. Information on local geology before the first field campaign was limited. The area is depicted on the Geological Map of the Sudan in the scale 1:2,000,000 from 1981 (Yassin et al. 1984). Also several papers on various geological aspects of surrounding areas (mostly the area of Sabaloka granitic intrusion, e.g. Küster et al. 2008, Shang et al. 2010, Lisá et al. 2012) have been published.

GEOLOGICAL SURVEY

The pilot geological survey at the site was carried out during the fifth archaeological excavation season in November 2012. The National Museum archaeological concession occupies an area of ca. 2 × 3 km. The partly built-up area is relatively flat, gently sloping from SE to NW towards the Nile, several wadis run in the same direction (Fig. 1). Most of the area is covered by gravel residue (desert pavement; however, ventifacts typical of the aeolian abrasion do not occur here very often); however, there are numerous small-scale outcrops that give a good image of local geology. Thicker alluvial deposits occur only in the bed of Wadi Kirbekan in the western part of the area and in the Nile valley (Fig. 1). Wadi deposits mostly consist of medium- to fine-grained sand, locally with higher proportion of quartz pebbles. On the other hand, the Nile flood plain deposits are predominantly muddy; their character is, however, significantly affected by intensive land use.

Two principal geological units crop out in the area: (1) basement coarse-grained granitoids and (2) overlying polymictic conglomerates.

Granitoids (locally biotitic; Fig. 2A, B) are accompanied by numerous small-scale dykes. They are mainly represented by microgranites, aplites, pegmatites, in the northern part of the area by microdiorites. They are predominantly of NW–SE strike. A larger dyke several hundreds of metres in length is situated in the south of the mapped area (NE–SW strike). Large numbers of quartz dykes appear all over the area.

Granitoids belong to the basement complex of Neoproterozoic age. Basement complex consists of high-grade metamorphic rocks of East African Orogen that was formed due to the assembly of ancient continents during Pan-African Orogeny (ca 850–550 My). Pan-African deformation was accompanied by intrusions of syn-orogenic and post-orogenic granitoids (for more details see Abdelsalam et al. 2003). Although there are no radiometric data from our area, we may infer the age of these granitoids from the data on the nearby Sabaloka granitoid intrusion. The results published by Küster et al. (2008) show rather uniform radiometric ages around 600 My indicative of post-collisional magmatism.

Granitoids are overlain by horizontally bedded polymictic conglomerates. They consist of well-rounded pebbles 1–2 cm in diameter (largest pebbles up to 4 cm; Fig. 2D). They are dominated by quartz, lithic fragments occur less frequently. Lithic fragments are represented by dark-coloured fine-grained rocks; surprisingly, fragments of the basement granitoids do not occur here. Conglomerates are mostly massive, indistinct cross-bedding can be found in some places (it dips generally westwards). Occurrence of a 4-m-long

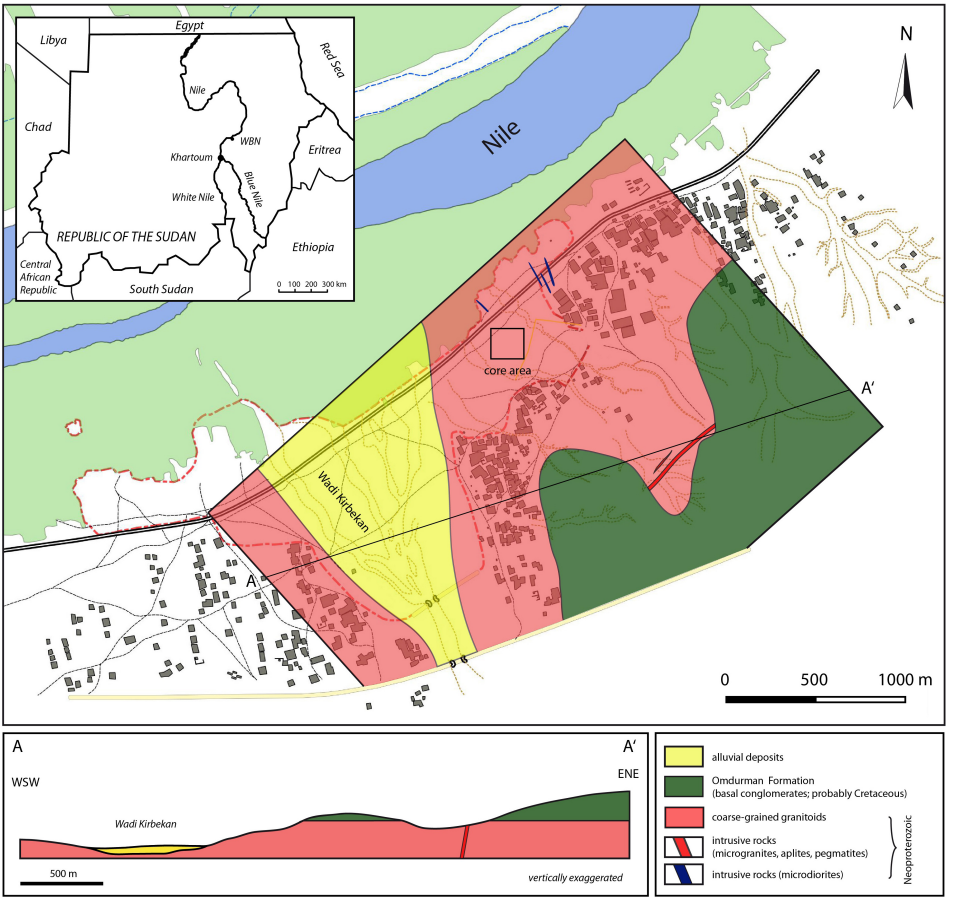

Fig. 1. Detailed geological map of Wad Ben Naga area. Dashed line indicates boundary of the National Museum archaeological concession. Core area includes the royal palace and adjacent building complex.

fossilized tree (Fig. 3) together with numerous scattered fossilized wood fragments was recorded in this unit. They probably belong to some gymnosperms (personal communication by J. Sakala, 2013). Rich fossil sites with petrified trees are well-known from other parts of the Sudan (e.g. north of Karima), they principally belong to the same stratigraphic unit (e.g. Giraud et al. 1992, Schrank 1992).

These conglomerates represent the base of the Omdurman Formation (previously referred as the Nubian Sandstone Formation), probably Cretaceous in age (Schrank & Awad 1990). This formation consists of several hundreds of metres thick sequence of mostly fluvial clastics that are widespread in North Africa (Egypt, Libya and Sudan). They were deposited in an extensive fluvial system running northwards to Tethys Ocean, which was fed by material from the exhumed basement rocks of Saharan Metacraton, Congo Craton and Arabian-Nubian Shield (Hussein 1992).

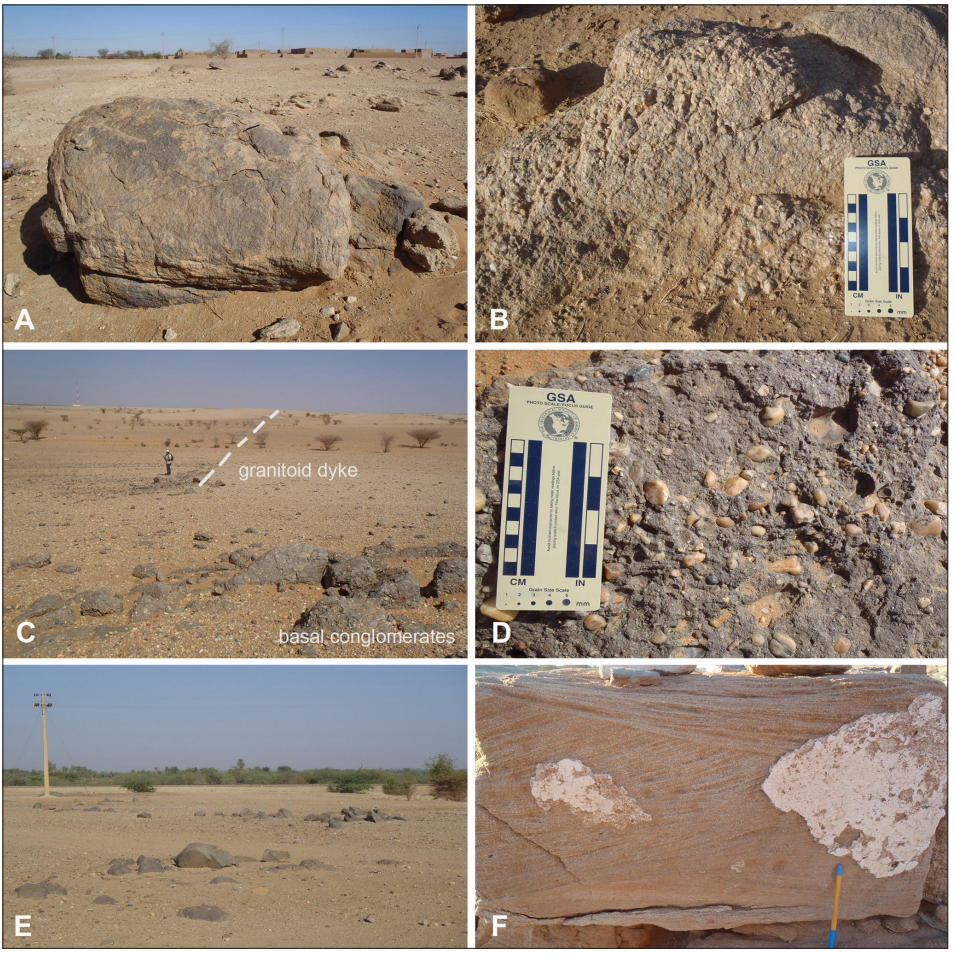

Fig. 2. A – outcrop of coarse-grained granitoids with typical exfoliation (data point 013; 16.5594°N, 33.1173°E); B – detail of coarse-grained granite (DP 005; 16.5900°N, 33.1871°E); C – contact between granitic dyke (in the background with the standing figure, dashed line indicates its strike) and the basal conglomerates of the Omdurman Formation (in the front; DP 008; 16.5259°N, 33.1183°E); D – detail of the basal conglomerate of the Omdurman Formation (DP 008); E – outcrop of the small-scale mafic dykes (microdiorites) in the northern part of the area (DP 002; 16.5858°N, 33.1887°E); F – block of cross-bedded coarse-grained sandstone used in the royal palace comes from the stratigraphically higher levels of the Omdurman Formation.

BUILDING MATERIAL USED IN THE ANCIENT SETTLEMENT AT WAD BEN NAGA

Local stone (granites, conglomerates) was apparently difficult to shape and thus not suitable for fine works and was used only in the foundations of the ancient buildings (mainly granites). Columns, altars and statues found at the site were made from medium to coarse-grained sandstones to arkosic sandstones from the stratigraphically higher levels of the

Fig. 3. Fossilized gymnosperm tree found in the basal conglomerates of the Omdurman Formation (length ca. 4 m; data point 011; 16.5418°N, 33.1242°E).

Omdurman Formation (Fig. 2F). However, they do not occur in the surroundings, therefore, they had to be imported from a distant source. Nearest occurrences are located ca. 15–20 km SE of Wad Ben Naga in the vicinity of the ancient settlements of Naga and Musawwarat es Sufra. Horizontally bedded sandstones and related clastics of the Omdurman Formation form prominent mesas there. These sites were visited during the field campaign; we made preliminary observations of the rocks cropping out there and compared them with the material used at Wad Ben Naga (extent of this stratigraphic unit can also be inferred from the geological map). The distance of a source of a sufficient quality stone can explain the fact that the majority of the ancient buildings were built of clay bricks and the stone was used only scarcely, while at the same time both above mentioned cities situated close to the source were built mostly of stone. However, the distribution of ancient quarries is still poorly known; some of them were reported in unpublished manuscripts (personal communication by Mohamed Saad, 2012).

CONCLUSIONS

Based on our detailed geological mapping of the archaeological site at Wad Ben Naga and a comparison with outcrops in adjacent areas, we have found that stone suitable as the building material were absent from the Wad Ben Naga area and that the nearest source of such stone was ca. 15–20 km far from the site. Therefore, most of the buildings were built of bricks and stone was used less frequently.

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