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Front cover. Stone slab A3 used as a paving slab in Temple 4, Qasr Ibrim, showing Taharqa and Amun (photograph courtesy of F. Aldsworth).

Above. Frontal scan of lion head, Naga (Kroeper and Perzlmeier 2022, fig. 21, © Naga Project, 3-D scans by TrigonArt BauerPraus GbR).

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Interregional Linkage Investigations in Northern Kordofan (InterLINK). Report on the first project phase (2017-2022).

Jana Eger-Karberg and Tim Karberg¹

Introduction

The University of Münster (WWU) is participating in the DFG Priority Programme 2143 ‘Entangled Africa’ with its own sub-project based in the Sudanese federal state of Northern Kordofan. The ‘InterLINK - Interregional Linkage Investigations in Northern Kordofan’ project of the ‘Old Sudan’ Research Unit at WWU explores possible connections between the ancient and medieval cultures of the Nile Valley and their nearer and more distant neighbours to the west. The question to be investigated is whether and to what extent states such as the Napatan and Meroitic empires or the medieval states of Makuria or Alwa reached beyond to their western periphery, and what contacts with the early cultures of Kordofan, Darfur and the Chad Basin were established in the process. In the context of this research, the Kushite and Nubian cultures are understood not only as Nile cultures oriented on an imaginary north-south axis, but also as ‘Sudanese’ Sahel cultures that were integrated into an east-west axis of cultural and economic exchange processes.

The ‘Interregional Linkage Investigations in Northern Kordofan’ project was inaugurated at the University of Münster (WWU) in 2017. A preliminary campaign was funded by a WWU research prize awarded to Angelika Lohwasser in 2016.² Since 2018, the project has been funded by the German Research Foundation (DFG) as part of the priority programme ‘Entangled Africa’.³ Two field campaigns have been conducted so far: the preliminary campaign in autumn 2017, and the first regular campaign in autumn 2018. A third campaign was started in spring 2020 but had to be stopped due to the pandemic, and the team left Sudan before starting in the field. A second attempt, planned for autumn 2021, was again stopped while the team was already in Sudan in October 2021. Therefore, the focus of the project was temporarily shifted to satellite data analysis.

A summary report on the research activities of the first phase of the project (the two field campaigns as well as investigations based on satellite data analysis) is presented here. Until now, almost 1500 archaeological sites have been discovered and investigated based on satellite data, and 25 of them were comprehensively studied and investigated on the ground (Figure 1).⁴

2017 preliminary campaign

During the autumn 2017 campaign, the focus was on the middle Wadi Melek and the area around Jebel al-Ain and Jebel Nagashush. The Jebel al-Ain was already visited during a short trip by the authors in 2011 during their participation in the University of Cologne expedition at Gala Abu Ahmed in the Wadi Howar region,⁵ resulting in the discovery of a Christian Nubian (presumably monastic) building complex at the western pediment of the Jebel al-Ain,⁶ this region was re-visited and several sites identified by satellite imagery analysis were investigated on the ground, including different cemeteries and *hafirs*. These water harvesting installations are similar both in their layout and their placement in the landscape to *hafirs*

¹ Both authors are based in the Research Unit ‘Old Sudan’/Institute for Egyptology and Coptology, University of Münster.

² The authors express their gratitude to Angelika Lohwasser for the opportunity to use parts of the prize fund for the preliminary field campaign of the InterLINK project.

³ <https://www.dainst.blog/entangled-africa/en/home>.

⁴ Comprehensive preliminary reports (in German) were published in *Der antike Sudan/MittSAG*: Eger and Karberg 2019; Eger and Karberg 2020; Eger-Karberg and Karberg 2021.

⁵ The authors express their gratitude to Friederike Jesse, lead researcher of the Cologne excavations at Gala Abu Ahmed, for giving permission for this trip during the excavations.

⁶ Eger 2011; concerning the suggested identification of this area with the Land of ʿTariʿ of medieval sources, cf. Eger 2019.

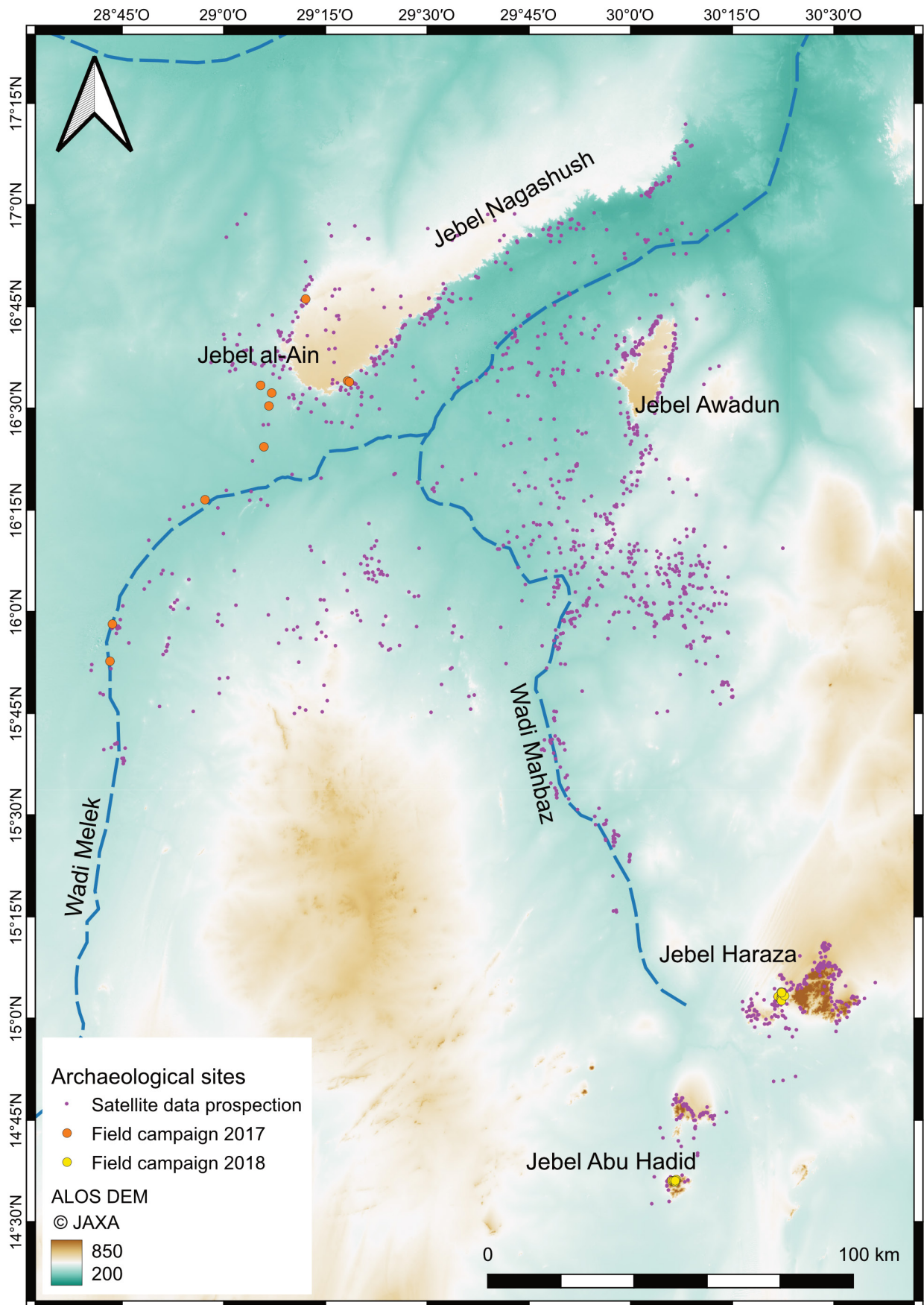


Figure 1. Archaeological sites investigated by satellite data analysis and ground survey. Background topographical data based on ALOS DEM (© JAXA).

from the Butana and Keraba, which are often dated to the Meroitic period (Hinkel 2015, 115-117). In addition, a cemetery with a mixed grave structure, two smaller settlement sites and a combined site with wells, settlement remains, and graves, were also investigated.

Graveyard WM 02

This cemetery is located on the western high flutter terrace of Wadi Melek south of Jebel al-Ain. It is characterised by a remarkable diversity of tomb superstructures. Based on preliminary observations, there also seems to be a long timespan of use. This is currently still based on analogies to cemetery structures in other parts of Sudan, for example the Bayuda, and needs to be verified by further research.

The cemetery has a total of 42 well preserved tomb superstructures. These can be roughly divided into three categories: relatively steep-sided, top-rounded ‘sugarloaf tumuli’; round, flat tumuli, and box graves. A functional, cultural and/or chronological differentiation between the steep-walled and the flat tumuli is not yet possible on the basis of the observations made so far. However, it is noticeable that the steep-walled type of tumuli superstructures show similarities with grave forms from further south, i.e. at Zankor⁷ and Abu Sufyan.⁸ The flat tumuli, at first glance, show certain similarities with grave forms that also occur in the Nile Valley; however, the grave superstructure patterns are so indistinct that it remains unclear whether there are indications of a cultural transfer or merely coincidental parallel developments. However, the question of a cultural transfer from the Nile Valley and its immediate surroundings can be answered quite clearly in the case of the box graves. This typical Christian burial form is quite characteristic and well documented in both the Nile Valley and the Bayuda. Thus, at least for the Christian-influenced medieval period, it can be assumed that certain elements of material culture spread from the Nubian Nile Valley to the middle Wadi Melek.

Hafirs WM03 and JA02

Within the investigation area, 51 *hafirs* have so far been recorded on satellite imagery (Figure 2). Two were surveyed in detail during the 2017 field campaign. Their identification as *hafirs* is clear due to their shape and position within the landscape (Figures 3 and 4). Pottery collected around them was chronologically unspecific and therefore the date of these *hafirs* remains undetermined. Nevertheless, the erosion of the hafir walls as well as their location in an area where the use of *hafirs* as water harvesting installations proves inefficient under recent ecological and climatic conditions might indicate the significant age of these constructions. Modern *hafirs* are found in more southern parts of Northern Kordofan with more rainfall (Hinkel 2015, 55-59). In the direct vicinity of the hafir, radar satellite imagery revealed the remains of former drainage channels (*khors*), which are today covered by aeolic sand accumulations and do not contain floating surface water anymore but seem to be still active as groundwater aquifers (cf. below and Figure 5).

Habitation site JA05

The settlement site of Bir al-Ain on the southern pediment of the eponymous Jebel al-Ain has been known since 1904 (Gleichen 1905, 211), and was briefly mentioned by Friedrich Hinkel (Hinkel 1979, 154-155). He, however, describes only very indifferently ‘round hut remains’ and a wall. Additionally, Hinkel mentions a metal cross found ‘in the vicinity’ of these round hut remains (Hinkel 1979, 155; SNM 7769).

Due to the cursory archaeological information available about this settlement site, it was decided to survey it in some detail and to produce a detailed site plan (Figure 6). It turned out that the site consists of several buildings of different structure, partly built on the plain, partly on a slope. The settlement

⁷ See further, Gratien *et al.* 2013, 58.

⁸ See further, Gratien *et al.* 2013, 36-37.

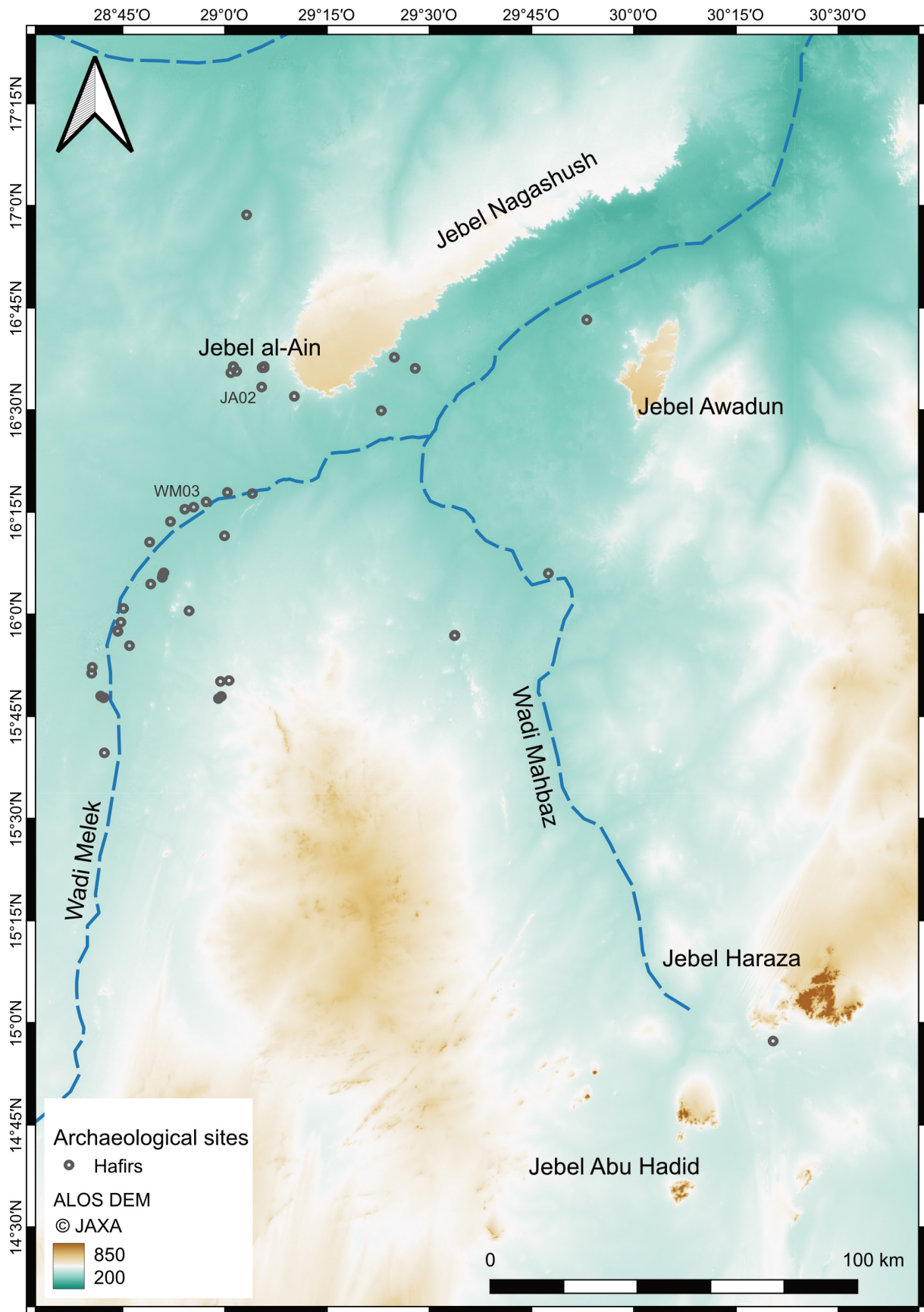


Figure 2. Distribution of *hafirs* in the survey area. Background topographical data based on ALOS DEM (© JAXA).

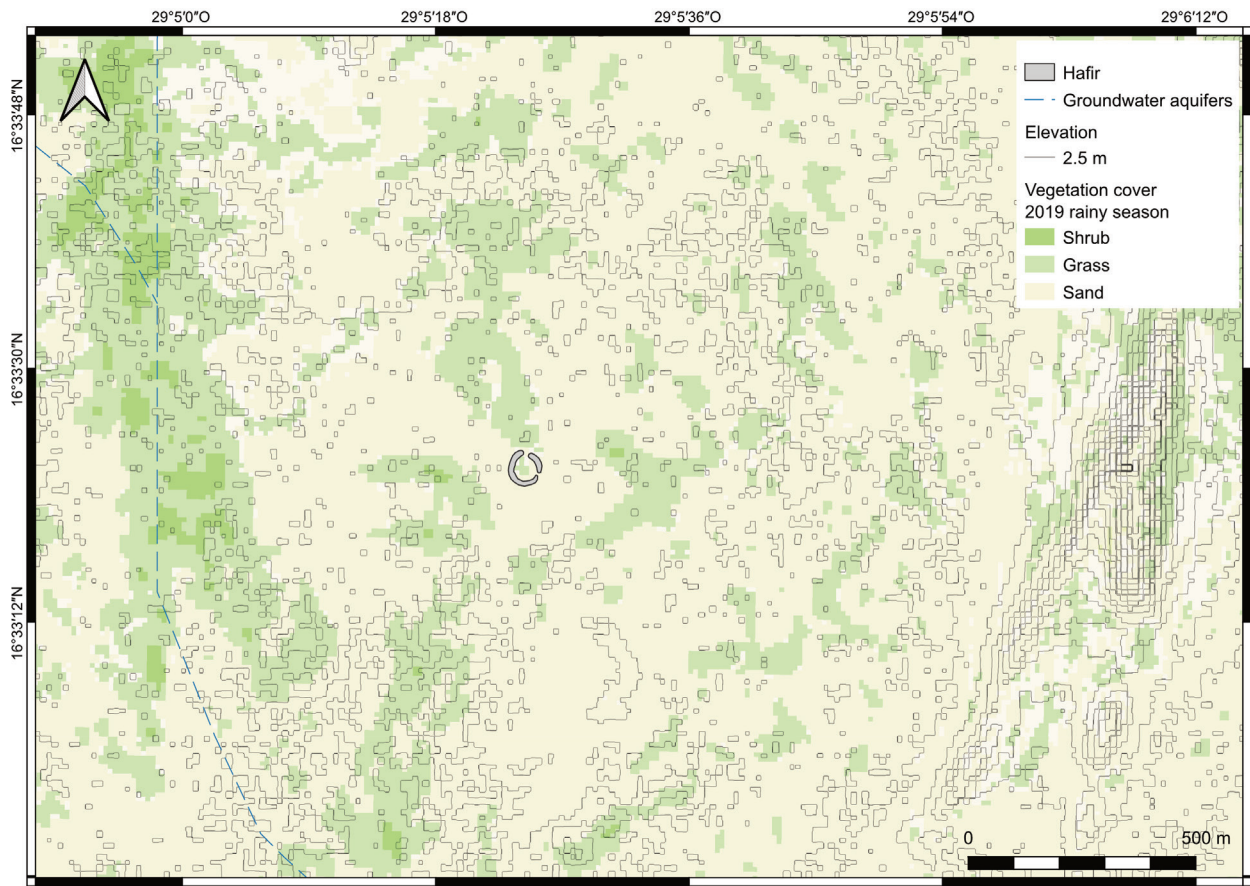


Figure 3. *Hafir* JA02 west of Jebel al-Ain. Terrain model based on TerraSAR/TanDEM-X WorldDEM 12m, tile TDM1_DEM__04_N16E029_DEM. Vegetation cover classified using NVDI based on ESA Copernicus programme Sentinel 2 A MSI multispectral data (stack T35QQU_20190827T082609). Groundwater aquifer mapping based on ESA Copernicus programme Sentinel 1 B radar data (radargram s1b-iw-grd-vh-20200605t035555-20200605t035620-021893-0298d0-002).



Figure 4. *Hafir* JA02 in the field (photo by J. Eger-Karberg).



Figure 5. *Hafirs*, vegetation cover, and groundwater aquifers at the southwestern pediment of Jebel Nagashush. Vegetation cover classified using NVDI based on ESA Copernicus program Sentinel 2 A MSI multispectral data (stack T35QQU_20190827T082609). Groundwater aquifer mapping based on ESA Copernicus program Sentinel 1 B radar data (radargram s1b-iw-grd-vh-20200605t035555-20200605t035620-021893-0298d0-002). For map symbols, cf. Figure 3.

remains consist of isolated round huts, often on slopes; round hut clusters grouped together by kraal-like connecting walls to form building complexes, often on flatter plateaus at the upper part of the jebel slope; and remains of buildings with rectangular ground plans, mostly in the area of the Jebel Pediment. The different building types (both in terms of building design and their location in the terrain) suggest that a certain chronological depth of settlement development is represented here. However, a functional differentiation of the individual buildings also seems possible.

The jebel bay around which the settlement is grouped is dominated today by a well system that is evidently fed by an aquifer that drains water collecting on the summit plateau, concentrated by a khor formation. The construction of a massive transverse valley wall, which closed off parts of the settlement area, does not give an impression of a defensive structure for the settlement itself, but more suggests the idea of regulating access to the water resources available. No archaeological material on the surface was directly connected with the well, and therefore its dating is still undetermined. Analysis of the terrain (using TerraSAR/TanDEM-X WorldDEM 12m digital elevation data)⁹ concluded that the drainage basin of the aquifer feeding this well is limited to the nearby southern plateau areas of the Jebel al-Ain, and so only during rather favourable ecological and climatic conditions could a capacity of the well sufficient to

⁹ The DEM was made available to the authors by the German Aerospace Center (DLR). The authors express their gratitude to Gunther Schreier and Thomas Busche for their manifold support.

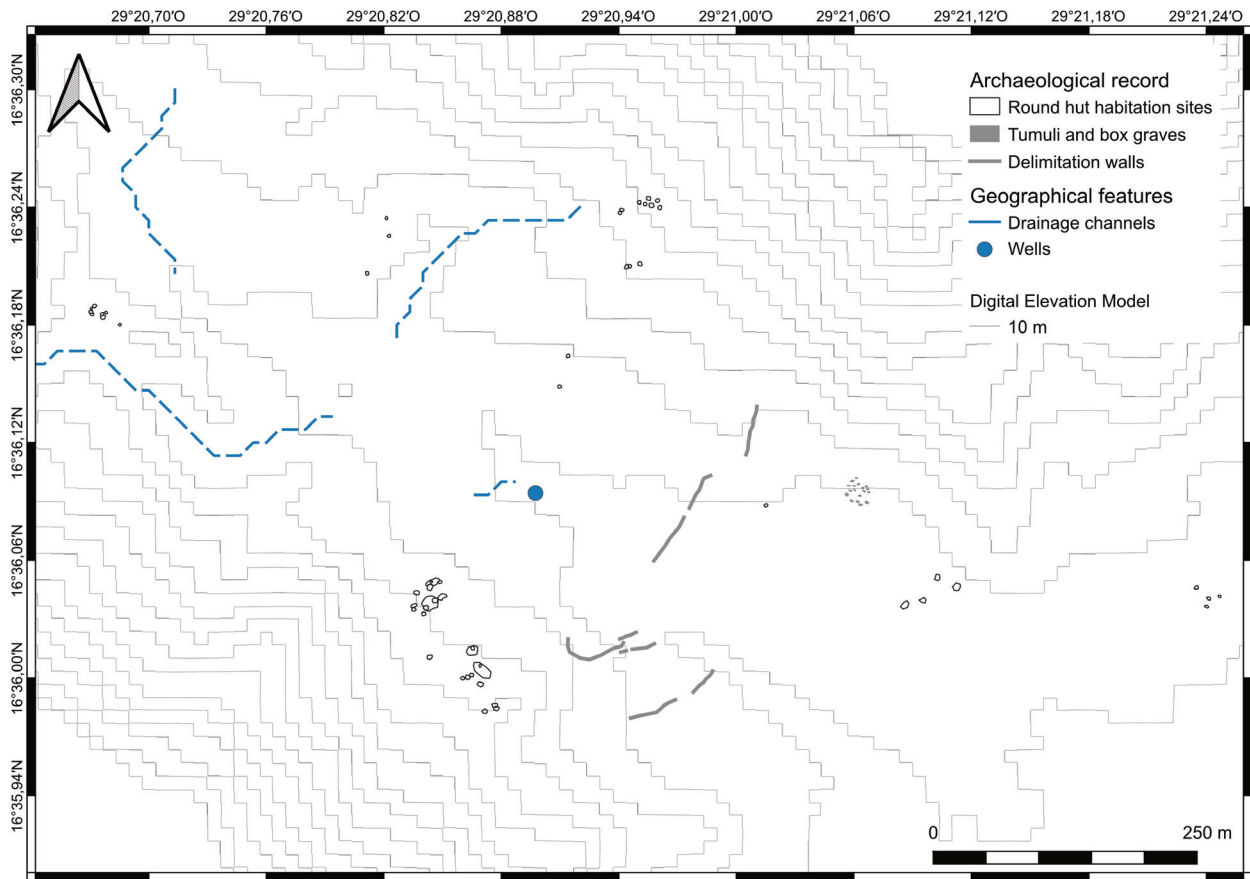


Figure 6. Settlement of Bir al-Ain with well and drainage channels. Terrain model based on TerraSAR/TanDEM-X WorldDEM 12m, tile TDM1_DEM__04_N16E029_DEM. Drainage modelling based on terrain model using SAGA 'Channel Network and Drainage Basins' 1.0 tool.

support a larger settlement be assumed.¹⁰

Evidence for the absolute chronology of the site is sparse so far. Within the settlement itself, no distinctive surface finds could be recovered that would allow for a more precise chronological classification. The only chronological indication so far is a small cemetery of box graves in the immediate vicinity of the settlement. This type of grave is usually associated with the Christian-influenced Nubian Middle Ages. This might correlate with the abovementioned find of a cross described by Hinkel, and the observation that the water supply of the settlement relied on rainfall in the vicinity, indicating a possible denser population only in eras with more favourable ecological conditions than today. Such favourable conditions can, for example, be assumed for the time of the so-called 'Medieval Climate Anomaly' according to actual palaeoclimatic models.¹¹

2018 field campaign

A field campaign investigating the area around the Jebel Haraza and the Jebel Abu Hadid was conducted in autumn 2018. Although the InterLINK project in its current funding phase focuses primarily on the northern area of the study area, an initial survey was carried out to clarify possible historical interaction routes as well as cultural and political-administrative entanglements with neighbouring areas.

Habitation sites JAH01 – JAH05

From satellite data, an extensive abandoned settlement site was identified, consisting of several habitation

¹⁰ For modelling the drainage, the tool 'Channel Network and Drainage Basins' from the SAGA (System for Automated Geoscientific Analysis) toolbox was used (cf. Conrad *et al.* 2015).

¹¹ Diaz *et al.* 2011, 1487; Nash *et al.* 2016, 9.

cores as well as terraced areas on slopes above the actual settlement areas (Figure 7). The settlement sites are grouped around a khor that forms the main drainage channel of Jebel Abu Hadid. This favourable situation could have been the cause of the past concentration of intensified agriculture and settlement.

The terraces delimit relatively small areas on the slopes and clearly served agricultural purposes. A dating of both the terraces and the round hut settlements below them is not yet possible, but the heavily eroded condition of the installations indicates a pre-modern age of the installations.

Further considerations concern the reasons for the construction agricultural terraces. Terraced fields are currently not used in the mountains of eastern North Kordofan between Jebel Abu Hadid and Jebel Haraza (unlike, for example, in present-day Darfur) (Hale 1966). Whether climatological or socio-economic factors caused the abandonment of terrace farming will be investigated in more detail in the future work of the InterLINK project in close cooperation with other projects participating in the priority programme 'Entangled Africa'.

Habitation sites JHZ01 – JHZ07

On the western slope of Jebel Haraza, another larger number of settlement cores were documented, here consisting of round huts, some of which stand alone and some of which are connected by walls to form kraal-like clusters. As at the Jebel Abu Hadid, they are accompanied by numerous abandoned, partly heavily eroded agricultural terraces on the slopes above the settlement cores (Figures 8 and 9). Despite the considerable size of the settlement cluster, the surrounding landscape - in contrast to the conditions observed at Jebel Abu Hadid - is not a particularly favourable area.

A massive transverse valley wall is also of interest. This is located away from the main settlements and extends on both sides up into the slopes of the surrounding hills. It has both a passage in the form of a simple gate, which is still crossed by a path, and another opening through which a small khor can flow through the barrier. The purpose of this wall is as yet unclear. Fortification can be ruled out, however, as the wall delimits a valley basin without any settlement remains. This section of the valley is also not a favourable area, at least under recent conditions. Instead, the numerous round hut settlement cores and agricultural terraces are situated outside the demarcated area. Despite the uncertain function, however, at least the concept of closing off a wide valley basin with a massive but not fortified wall is reminiscent of the transverse valley wall at Bir al-Ain (see above).

As at Jebel Abu Hadid, the dating of the extensive settlement cluster at Jebel Haraza remains unclear. That the region was used by people in the Middle Ages and that there were at least sporadic contacts with the Nile Valley is shown by the presence of a few box graves at a small cemetery in the far west of the settlement cluster: Site JHZ01 (Figure 8). However, the connection with the other parts of the site cluster, especially regarding dating, is still unclear.

Satellite data analysis

During the COVID-19 pandemic, when archaeological investigations were to a large extent restricted to work on the computer, satellite data analysis became a major focus of the project. Methodologically, satellite data analysis was conducted by optical evaluation of panchromatic satellite imagery, supervised and unsupervised semi-automatic classification analysis of multispectral satellite data, and classification of raw and processed data from radar satellites (for a detailed description of the methodological approaches, cf. Karberg and Eger-Karberg in press):

Settlements and palaeo-lakes on the pediments of the central Jebel Nagashush

In the high-resolution panchromatic satellite image, a number of settlements (predominantly round huts) can be observed along a specific area at the pediment of Jebel Nagashush, concentrated in this area, thus

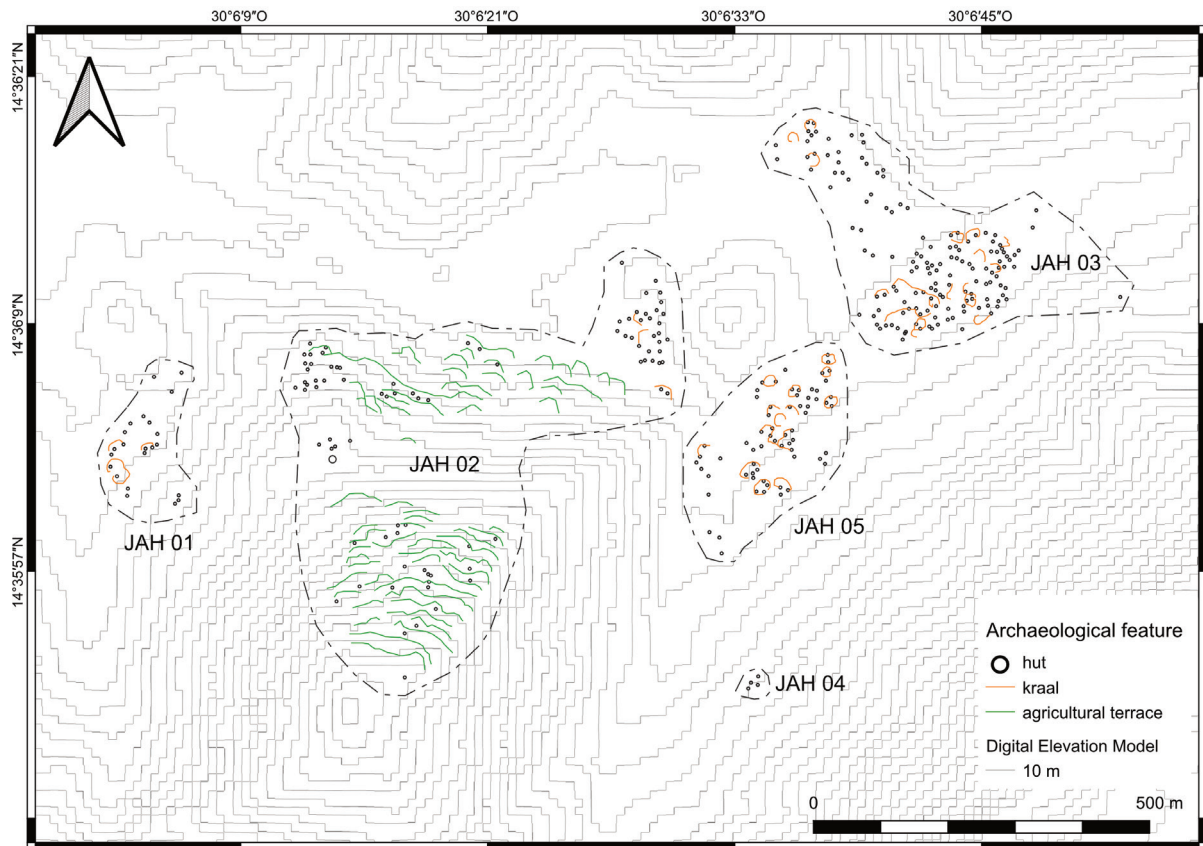


Figure 7. Settlement sites and agricultural terraces at Jebel Abu Hadid. Terrain model based on TerraSAR/ TanDEM-X WorldDEM 12m, tile TDM1_DEM_04_N14E030_DEM.

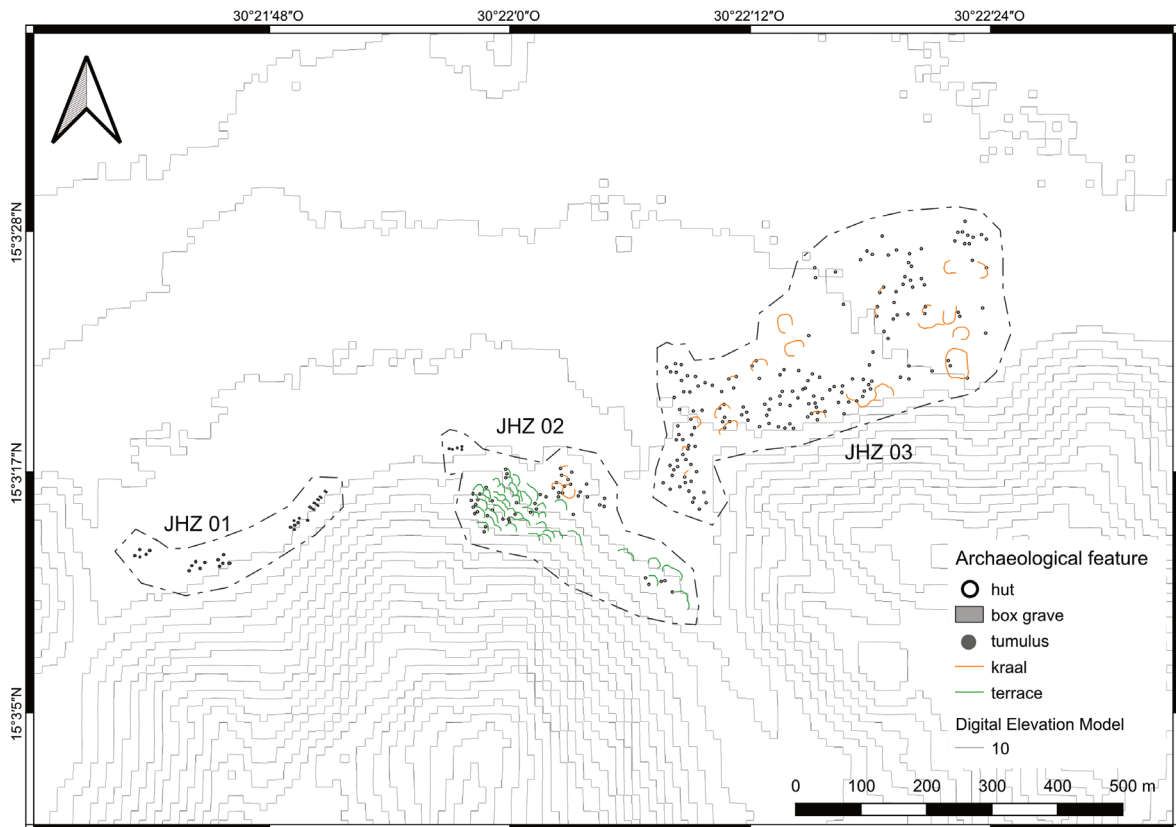


Figure 8. Settlement sites and agricultural terraces at Jebel Haraza. Terrain model based on TerraSAR/ TanDEM-X WorldDEM 12m, tile TDM1_DEM_04_N15E030_DEM.



Figure 9. Remains of agricultural terraces on the slope of Jebel Haraza (photo by T. Karberg).

forming a settlement zone that can be clearly distinguished from the surrounding area. Elevation profiles of the area derived from the abovementioned TerraSAR/TanDEM-X WorldDEM reveal both the location of settlement remains in the terrain relief and nearby landscape elements relevant to settlement. The settlement is located on a slope, but away from larger drainage channels. The fact that the slope was chosen, which in itself is a terrain situation that impedes settlement, indicates that the flatter area below the slope pediment was less suitable for settlement activity at this time, probably due to soil moisture. That the immediate vicinity of the khors, located from about 700 m to the east, which drain downslope from the summit plateau in the direction of palaeolakes, was apparently avoided, also favours dating the settlement to a pluvial period.¹²

Two areas in the immediate vicinity of this settlement are to be identified as palaeo-lakes. Multispectral analysis of Sentinel 2 A satellite images reveals a spectral profile of this surfaces resembling the spectroscopic signature of carbonates (in particular CaCO_3 , typical for limnic sediments).¹³ In the wider vicinity, limnic sediments were already observed by the geographers Pachur and Altmann (Pachur and Altmann 2006, 252-253). Nevertheless, the palaeo-lake remains discovered in the investigation area of the InterLINK project exceed that of of Pachur and Altmann by far.

Sub-surface palaeo-khors

Satellite data analysis enabled the mapping of former drainage channels (*khors*), which are today covered by aeolic sand.¹⁴ Some of these former surface *khors* are still active as subterranean groundwater aquifers,

¹² From the satellite data, no absolute chronology for the settlement chamber and palaeo-lakes at Jebel Nagashush can be derived directly. Nevertheless, archaeological and geological soundings by an expedition of Freie Universität Berlin at a palaeo-lake near Jebel Tageru, at a comparable geographical latitude roughly 250km west of the Jebel Nagashush, indicate at least sub-pluvial conditions until approximately 2000 BC (Hoelzmann *et al.* 2010). Similar ecological conditions are to be assumed for the Jebel Nagashush area.

¹³ For this spectral classification, data from the US Geological Survey Spectral Library was used (Kokaly *et al.* 2017).

¹⁴ Concerning the general applicability of satellite-based radar data for the discovery of sub-surface structures under dry and soft sand accumulations, cf. Germer 2001; Pachur and Altmann 1997.

but since they do not drain surface water anymore and are covered by sand, they are invisible on the surface (and in optical satellite imagery as well). The use of radar satellite data proved to be a reliable method to map these former khors. Cross-referencing with vegetation indices derived from multispectral satellite imagery taken during ecologically particularly favourable time periods (i.e. during the 2020 rainy season) indicates which of these paleo-khors are still active as groundwater aquifers, since the increased soil moisture along these aquifers is indicated by above average vegetation density. For the specific arid conditions of the survey area with significant activity of aeolic dunes, this combined method (classification of C- and L-band radar data, i.e. from the ESA Sentinel 1 A and B satellites, with vegetation cover and density analysis from multispectral satellite imagery using the Normalised Vegetation Difference Index NVDI, Tucker *et al.* 2005) proved very reliable to identify and map formerly ecologically favoured landscape zones which can be cross-referenced with archaeological material.¹⁵

Mapping of palaeo-khors revealed macro-drainage from the plateau of the Jebel Nagashush northwards to Wadi Howar (probably explaining the existence of small local ecologically favoured zones and wells, i.e. at the fortress of Gala Abu Ahmed, Eger-Karberg and Karberg 2021), but also drainage at a micro level providing landscape contexts for archaeological features, especially hydraulic installations like *hafirs* and wells.

Conclusions

The first phase of the InterLINK project added much data to our knowledge of the archaeology and landscape history of Northern Kordofan. Transdisciplinary approaches combining archaeological and geo-scientific questions and methods proved very useful in reconstructing the socio-economic and ecological background of the area, and its role as a border and contact zone between riverine Nubia and sub-Saharan Africa, especially during the Medieval period. The integration of the project into the priority programme 'Entangled Africa' enabled close cooperation with other archaeological projects working in the wider vicinity (not only in Sudan, but for example also in Chad), and with natural scientific projects dealing with climate history and palaeobotany. We hope to continue this highly integrated research strategy during the second phase of the project and the whole priority programme.

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¹⁵ Other approaches, as for example applied under the riverine conditions of the Nile delta (Ullmann *et al.* 2020), provided no reliable results under the climatic and soil conditions of Northern Kordofan.

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