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The Gilf Kebir and Lower Wadi Howar: contrasting Early and Mid-Holocene environments in the Eastern Sahara

In this paper I will focus on two localities: the Gilf Kebir which is situated in the center of the Eastern Sahara, and the Lower Wadi Howar and its southeastern periphery (Fig. 1). The following results evolved from several field seasons carried out within two projects: the multidisciplinary B.O.S. Project of Cologne University and the Quaternary Geology Section of the Berlin-based Joint Research Project "Arid Areas". Though most of the evidence presented here is geological, the palaeoclimatic impact upon human activity and some geoarchaeological aspects will also be mentioned.

The sandstone plateau of the Gilf Kebir is situated at 23°N in the southwestern corner of Egypt and thus in the hyperarid core of the Eastern Sahara with an estimated annual rainfall of below 5 mm. During the Terminal Pleistocene one of the box canyons on the eastern side – Wadi el Bakht – had been dammed up some 12 km below the valley head by a huge blocking dune which caused the accumulation of thick playa deposits during the first half of the Holocene. The importance of this locality was stressed by McHugh (1980: 65) when he wrote: "This locale has outstanding potential for contributing to the study of the late prehistoric palaeoenvironments and cultural adaptation in the area".

An outcrop in the gorge breaching the former dune barrier gives an excellent insight into the sequence of sedimentary processes. It shows the eolianite components of the fossil dune consisting of consolidated cross-bedded sand striking about north-south corresponding to the trade winds, and the impounded playa deposits which are over 8 m thick at this site near the former playa lake shore. Mapping of the surface deposits revealed that these pelitic still-water sediments extend over some 65,000 km^2 (Kröpelin 1987). They consist of thin alternating layers of alluvial sand and silty-clayey deposits which were charcoal-dated at 8,700 B.P. at the base and around 5,000 B.P. at the top (Fig. 2). Only the top layer,

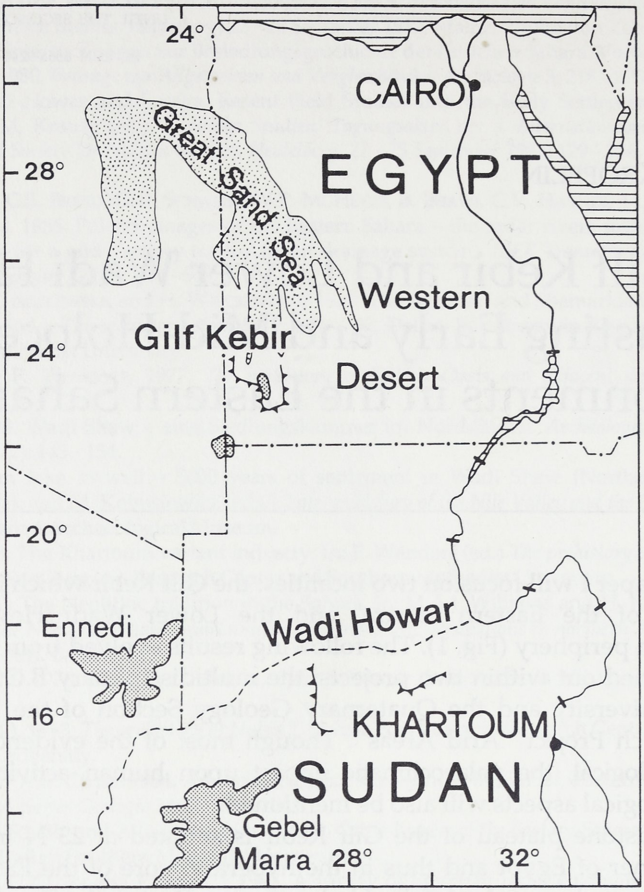

Fig. 1. Sketch map of the Eastern Sahara.

dated firmly from 6,000 to 5,000 B.P. by several dates, has a thickness of more than 1 m, while 77% of the strata are less than 2 cm thick, with an average thickness of only 14 mm (Kröpelin 1989). Grain size analyses show the high clay fraction of the playa layers which are built up by clastic silicate mud deposits including detritic kaolinite (Pachur and Röper 1984). A characteristic structural feature are load casts which occur at the basal sides of the sand layers. These pressure marks are important for the argument that the sand layers, which probably have been flooded from the slopes, have been deposited on the still water-saturated playa mud. These sandy red beds have been consolidated by iron oxides and mechanically infiltrated clay minerals during succeeding playa lake phases (Kröpelin 1989).

The 89 pelitic strata occur in a period between approximately 9,000 to 5,000 B.P. indicating short-lived rainpools containing water for weeks or months at most fed by about four heavy rainfalls per 100 years (Fig. 2; Kröpelin 1987). Such rainfall distribution is characteristic of arid climates.

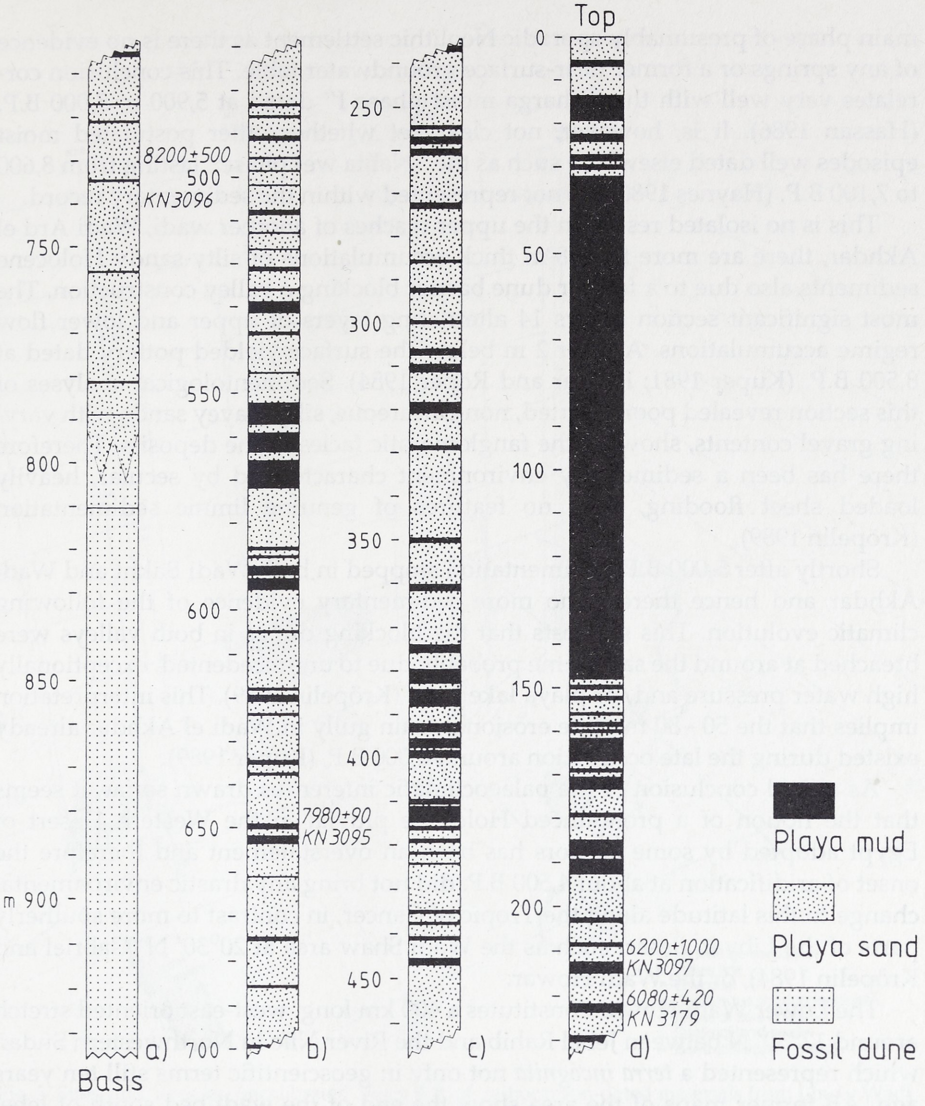

Fig. 2. Wadi Bakht, Gilf Kebir. Stratigraphy of section 82/13 with radiocarbon ages of charcoal in uncalibrated years B.P.

Only between 6,000 and 5,000 years B.P. did conditions tend toward moderate aridity with an estimated maximum rainfall of 100 mm (Kröpelin 1987). These inferences have been corroborated by charcoal identifications yielding only species still forming part of the modern Saharan flora (Neumann 1987) and lie significantly below the earlier estimates of 200 - 800 mm/yr by McHugh (1974: 13) which he based on the normal ecological requirements of the giraffe, ostrich, oryx and domestic cattle depicted by rock art. According to numerous radiocarbon dates (Kuper 1989), this millennium also seems to represent the main phase of presumably sporadic Neolithic settlement as there is no evidence of any springs or a former near-surface groundwater table. This conclusion correlates very well with the "Kharga moist phase I" dated at 5,900 to 5,000 B.P. (Hassan 1986). It is, however, not clear yet whether other postulated moist episodes well dated elsewhere such as the "Nabta wet phase" lasting from 8,600 to 7,100 B.P. (Haynes 1980) are not represented within the sedimentary record.

This is no isolated result. In the upper reaches of another wadi, Wadi Ard el Akhdar, there are more than 8 m thick accumulations of silty-sandy Holocene sediments also due to a former dune barrier blocking a valley construction. The most significant section shows 14 alternating layers of upper and lower flow regime accumulations. A layer 2 m below the surface yielded pottery dated at 8,500 B.P. (Kuper 1981; Pachur and Röper 1984). Sedimentological analyses of this section revealed poorly sorted, non-calcareous, silty-clayey sands with varying gravel contents, showing the fanglomeratic facies of the deposits. Therefore there has been a sedimentary environment characterized by secular, heavily loaded sheet flooding, with no features of genuine limnic sedimentation (Kröpelin 1989).

Shortly after 5,000 B.P. sedimentation stopped in both Wadi Bakht and Wadi Akhdar and hence there is no more sedimentary evidence of the following climatic evolution. This suggests that the blocking dunes in both valleys were breached at around the same time probably due to unprecedented, exceptionally high water pressure and/or playa lake level (Kröpelin 1989). This interpretation implies that the 50 - 80 m wide erosional main gully in Wadi el Akhdar already existed during the late occupation around 4,000 B.P. (Kuper 1989).

As a final conclusion of the palaeoclimatic inferences drawn so far, it seems that the notion of a pronounced Holocene pluvial in the Western Desert of Egypt adopted by some authors has been an overstatement and therefore the onset of aridification at about 4,500 B.P. did not bring any drastic environmental change to this latitude along the Tropic of Cancer, in contrast to more southerly parts of the Libyan desert such as the Wadi Shaw area at 20°30′ N (Gabriel and Kröpelin 1984), or the Wadi Howar.

The Lower Wadi Howar constitutes a 400 km long, west-east oriented stretch around 17°30′ N between Jebel Rahib and the River Nile in Northwestern Sudan which represented a *terra incognita* not only in geoscientific terms still ten years ago. All former maps of the area show the end of the wadi bed south of Jebel Rahib (Fig. 3). During several field seasons in the last few years, however, we could verify earlier speculations on an eastward connection to the Nile during the Tertiary (Newbold 1924), and interpretations of Landsat imagery (Meissner and Schmitz 1983). Ample evidence was found that the Lower Wadi Howar drained parts of this 400 km wide, now extremely arid region with an estimated average rainfall below 40 mm/year, as late as mid-Holocene (Kröpelin 1990a; Pachur and Kröpelin 1987). The Wadi Howar joined the Nile between the third and fourth cataract some 30 km northwest of Ed Debba, opposite to the site of the early Christian, Makourian capital Old Dongola on the east bank of the Nile (Jakobielski 1970; Krzyżaniak 1968; Michałowski 1966; 1970).

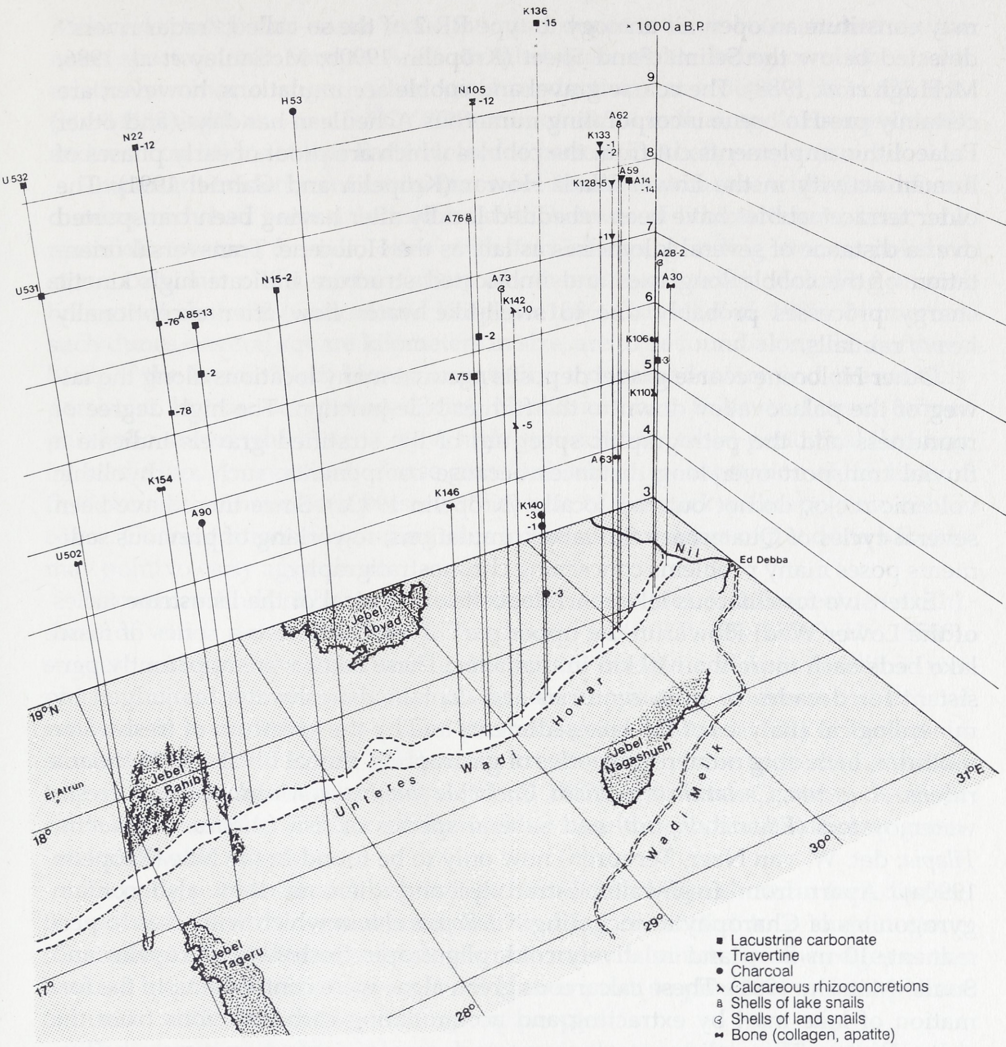

Fig. 3. Sites and ages in uncalibrated years B.P. of radiocarbon-dated materials from Lower Wadi Howar. Vertical time-scale is isometric.

While interpretation of Landsat imagery suggests a uniform fluvial origin of the valley, ground work showed narrowly interlocked sedimentary environments of various fluvial and lacustrine stages dating back at least until the late Tertiary. So far some 300 sites, sections and backhoe trenches have been recorded which allow a spatially and chronologically differentiated reconstruction of the palaeoriverine environment during the late Quaternary (Kröpelin 1993).

Fluvial high velocity deposits occur as 9 m thick and several hundred meters wide cobble terraces within braided inset channels in the bedrock valley which may constitute an open-air analogy to type RR-2 of the so-called "radar rivers" detected below the Selima Sand Sheet (Kröpelin 1990b; McCauley *et al.* 1986; McHugh *et al.* 1988). The coarse gravel and cobble accumulations, however, are certainly pre-Holocene incorporating numerous Acheulean handaxes and other Palaeolithic implements cut from the cobbles which are proof of early phases of human activity in the Lower Wadi Howar (Kröpelin and Gabriel 1991). The older terrace cobbles have been rebedded locally after having been transported over a distance of several kilometres as late as the Holocene. Transversal orientation of the cobble long axes and imbricated structure indicate high kinetic energy processes probably due to swell-like water flow after exceptionally heavy rainfalls.

Other Holocene coarse gravel deposits occur at many locations along the talweg of the palaeovalley down to the former Nile-junction. The high degree of roundness and the petrographic spectrum of the stratified gravels indicate a fluvial transport over long distances because components, such as rhyolithic volcanic rocks, do not outcrop locally (Kröpelin 1990a). Since there have been several cycles of Quaternary fluvial accumulations, reworking of previous sediments poses many problems concerning chronostratigraphy.

Extensive fossiliferous lake marl deposits are typical of the lacustrine facies of the Lower Wadi Howar in the upper part of which there is a series of fossil lake beds each more than 10 km in diameter. These lakes were apparently persistent for decades or even centuries and contained freshwater, as judged by mineralogical analyses of the lake sediments and by the spectrum of freshwater molluscs, including numerous species of gastropods, fluvial bivalves *(Aspatharia rubens, A. arcuta, Caelatura aegyptiaca, Corbicula fluminalis, Mutela nilotica),* freshwater oysters *(Etheria elliptica)* and several species of fish *(Alestes, Synodontis, Tilapia;* det. W. van Neer, Tervuren) now only to be found in the Nile (Kröpelin 1990a). Apart from freshwater ostracodes and diatoms, they also contain gyrogonites of Charophytes including *Nitellopsis obtusa* which witnesses to permanent, 10 m deep and relatively cold, oligotropic freshwater (Kröpelin and Soulié-Märsche 1991). These calcareous green algae were contributing to the formation of lake marl by extracting and accumulating carbonate ions from the groundwater. The sediments also contain bones of large savanna and amphibious mammals such as elephant, rhinoceros and hippopotamus which have been dated to between 6,325 and 3,825 B.P. (Kröpelin 1993). The diversity and widespread distribution of the specimens are proof of a water-course surrounded by a highly developed savanna ecosystem providing animals with optimal living conditions (Pachur and Kröpelin 1987). Worth mentioning is the skeleton of an apparently drowned human in lake marls dated to 5,640 ± 70 B.P. (Hv-14434).

Sandy alluvium, silicate muds and subhydric soils give evidence of tens of kilometers wide marsh environments. Their thickness is considerable, not even 4.5 m deep backhoe trenches reaching their base. To find out about seasonal changes in the weather, the oxygen isotope ratios within the shells of individual

Melanoides tuberculata snails from the mud deposits have been studied on the mass spectrometer. Sample A 62 revealed quite stable living conditions with relatively minor changes in biological productivity at around 8,585 ± 135 B.P. (Hv-14432) with the low $\delta\ ^{18}O/PDP$ ratio of –8.5% indicating "extremely cool" and wet conditions at that Early Holocene period (P. Abell, pers. comm.).

Important evidences of a very favorable human habitat are widespread fossil dunes which had been stabilized by a thick cover of lithic artefacts, lithic raw materials, pottery, burials, often with furnishings, grinding stones, polished stone axes, microliths, and a variety of other cultural debris including animal bones and charcoal (Gabriel and Kröpelin 1986; Gabriel *et al.* 1985). Numerous such dunes, several square kilometers in size, are to be found along the northern bank of the Lower Wadi Howar suggesting a quasi-sedentary and presumably persistent human occupation during Neolithic times. In several cases former parabolic dunes which stand for a high groundwater table, periodical flooding by wadis, and/or relatively dense grass or herbaceous vegetation at the time of first occupation have been preserved because of the thick anthropogenic debris cover. Concentrations of grinding sites in the surroundings of the dune habitats may point to early agriculture.

Numerous finds of bones of domesticated cattle (det. J. Boessneck, Munich), some of which dated to 5,350 ± 275 and 3,915 ± 210 B.P. (Hv-15589, Hv-15588), suggest widespread cattle herding during the Middle and Late Neolithic wet phase. Several former watering places are supporting evidence. Additional evidence is provided by so-called "pierres à gorge" (Morel 1982) or "tethering stones" (Pachur and Röper 1984) which are thought to have been used either as trap stones for large savanna game (Morel 1982), or to hinder grazing domestic cattle from straying (Pachur 1982); in either case they indicate sufficient grassland and water supply.

Recently published rock engravings from South Libya show, in fact, domesticated cattle with a rope around the hind leg connected to a shaped stone (Castiglioni *et al.* 1986). Hundreds of grave mounds which line the edges of the braided inset channels of Lower Wadi Howar point to presumably later phases of human settlement perhaps of C-group peoples.

The concept of the Wadi Howar being an indicator of a significant shift in the rainfall regime of the Eastern Sahara is based on the field evidence that its lower course was not an exotic river sustained by rainfall in the mountainous source area of the Jebel Marra or Meidob Hills but that it was fed by substantial local rainfall. Supplementary proxy data support this statement. Along the wadi banks – as for example in the environs of an only recently discovered, presumably Meroitic or Christian fortress, some 110 km away from the Nile (Kröpelin 1993; Kuper 1988), there are erosional relics of more than 100 m wide travertines testifying to extensive spring horizons. Some of these apparently annually laminated calcareous sinter deposits were dated at 8,355 ± 180 B.P. (Hv-15580, Hv-15578; Kröpelin 1993). Due to their geomorphological position they must have been fed by infiltrated local rainfall. Other evidences are up to 80 cm thick iron-crusts that formed at the groundwater interface in the near vicinity of the wadi high above the talweg, pointing to a significantly higher groundwater table during the Early and Mid-Holocene wet phase (Pachur and Kröpelin 1987).

Figure 3 gives an overview of the radiocarbon dates currently available from the Lower Wadi Howar with their distribution between 9,300 and 2,075 B.P. Synchronous occurrence of individual sedimentary events of fluvial or lacustrine nature cannot be inferred from these dates. In an order of magnitude of centuries, however, there is increasing evidence of a fully developed and uninterrupted amphibian and savanna ecotope between 17° and 18° N during the entire Early and Mid-Holocene, during which parts of the large, now extremely arid region of "Western Nubia" drained into the Nile *via* the Lower Wadi Howar. Since the indicators of increased palaeorainfall culminate in the Lower Wadi Howar region, there is conclusive evidence of a distinct gradient of decreasing palaeohumidity from here northwards to the Gilf Kebir, a distance of some 600 km. Therefore, the tropically induced Holocene shifting of the northern fringe of the palaeo-Sahel, which was subject to important oscillations, has apparently never passed beyond 22° N which coincides with the present political border between Egypt and Sudan.

These conclusions are in agreement with other workers using different approaches (Gabriel 1986; Haynes 1987; Haynes and Mead 1987; Neumann 1989; Pachur *et al.* 1987; 1990; Pachur and Kröpelin 1989). However, in spite of the increasing evidence on the palaeoclimate of the Eastern Sahara during the last 10,000 years there still is a dearth of data concerning a reliable, detailed and regionally differentiated chronology of palaeoclimatic events, and thus wide scope for interpretation.

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