# A chronology of fluvial dynamics of the Hoanib River, NW-Namibia, based on optically stimulated luminescence dating.

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## Introduction

In the context of climatic change monsoon-affected desert-margin areas belong to the geomorphologically most sensitive environments on earth. The eastern margin of the Namib Desert, Northwestern Namibia, is characterized by the Great Escarpment with rivers draining the semi-arid highlands to the east, across the hyper-arid Namib desert down to the Atlantic Ocean in the west (**fig. 1**). In the same direction a prominent hygric gradient of ~20 mm mean annual precipitation per 10 km decreases from the semi-arid highlands (> 250 mm/a) to the hyperarid northern Namib Desert.

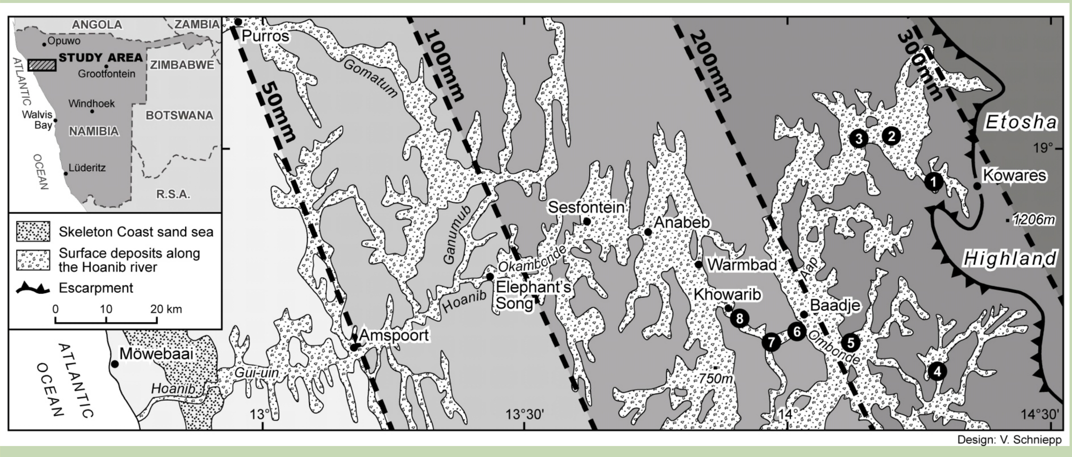

**Fig. 1:** ***The Hoanib River catchment in northwestern Namibia. The study concentrates on the upper catchment area down to the lower end of the Khowarib Gorge. The sampling locations are indicated with numbers 1- 8.***

Fine-grained, predominantly silty sediments covering large areas of the valleys and basins along the river courses are excellent archives storing information on past environmental changes (**fig. 2**). Even though the sediments may possess loessic features they are waterlain. Apart from this, their genesis is still controversialy debated.

**Fig. 2:** ***View to the ephemeral Nguruvai-Aap river near locality-3 (see fig. 1). Note the greyish deposits of complex-I below the brownish sediment-complex-II.***

Nowadays most authors do not dispute a fluvial origin, although subordinate occurances of limnic deposits are observed. Among those stating alluvial deposits, the point of debate is whether to address the sediments as slack-water (i.e. flash-flood) deposits (e.g. HEINE 2004) or river-end deposits (e.g. RUST 1999). These geomorphogenetic interpretations are of vital importance, as they imply completely opposing palaeo-environmental conditions. While flash-flood deposits are a consequence of increased monsoonal rainfall and severe flooding, river-end deposits point to increased aridity with receiving streams not having the capacity to carry the sediment load to their outlets at the Atlantic coast but terminating endorheicly upstream. Based on detailed geomorphological surveys and sedimentological analyses EITEL et al. (2005) showed that the Amspoort Silts in the Lower Hoanib Valley are such aridity-denoting river-end deposits. In our opinion also wide-spread occurences of fine-grained alluvial sediments in the Upper Hoanib drainage basin have to be similarly (re-)interpreted.

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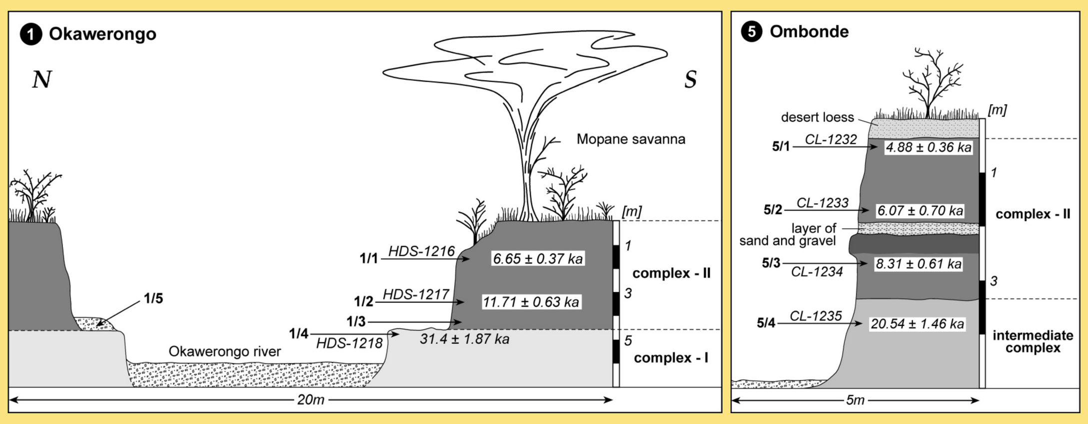
## Sediments and stratigraphy

The well laminated fine-grain structure of the deposits indicates low-energy runoff of the rivers during sedimentation. Complete covering of the basin and valley bottoms excludes repeated high-energy slackwater-deposition, which would be confined to distinct backflood positions. Typically, the sediments are divided into a basal light to greyish coloured complex-I (‚silt member 1', Heine 2004), and a younger brownish complex-II, with an 'intermediate complex' sometimes intercalated between the two (**fig. 3**, **fig. 4**).



**Figs. 3 + 4:** ***Sketches and ages of the exposed layers at locality 1 on the Okawerongo-Nguruvai-Aap River (northern Hoanib catchment, see fig. 1) and at locality 5 on the Otjovasandu-Ombonde River (southern Hoanib catchment).***

Hydromorphic bleaching of complex-I sediments (see **fig. 2**), indicating a high groundwater table, apparently occured before complex-II was deposited. A pedogenetic calcrete on top of complex-I (**fig. 5**) reveals that fluvial aggradation was succeeded by a period of soil formation with subsoil carbonate precipitation and a subsequent period of aridification leading to the exhumation of the subsoil horizon so that a hardpan could evolve. Gullying of complex-I points to a following period of fluvial erosion under more humid conditions. As the intermediate complex is made up from repeatedly reworked material of complex-I, more variable runoff than during the deposition of complex-I is likely. After the deposition of complex-II palaeoenvironmental conditions changed completely and the Hoanib River deeply eroded the formerly deposited river-end deposits along its thalweg. Intermediately, coarse grain, sandy and gravelly material forming a prominent 4-m terrace along the river course was deposited (**fig. 6**). At present the conditions in the highlands east of the Namib Desert are too humid for significant fluvial sediment accumulation. Erosional processes prevail resulting in progressive terrace consumption.

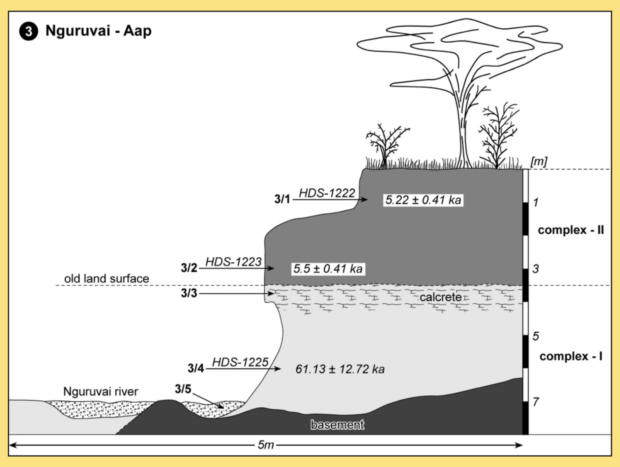


**Fig. 5:** ***Sketch and ages of the exposed layers at locality 3 on the Okawerongo-Nguruvai-Aap River (northern Hoanib catchment, see fig. 1).***

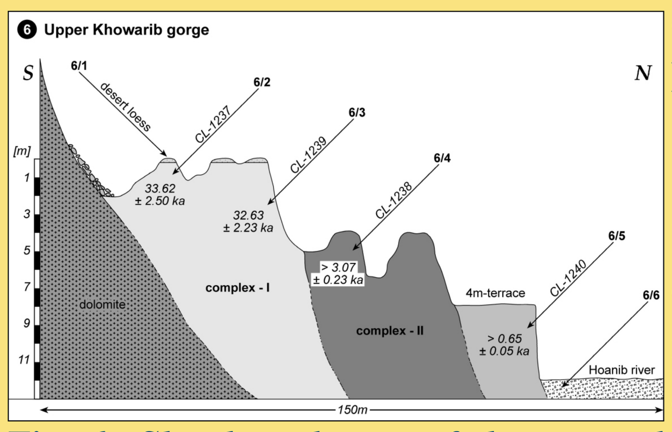


**Fig. 6:** ***Sketch and ages of the exposed layers at locality 8 in the Khowarib Gorge (upper Hoanib river, see fig. 1).***

## Luminescence dating

In arid areas providing only little organic material and limited possibilities to apply radioacrbon dating, luminescence dating often proves to be an indispensible chronometric technology to gain the palaeoenvironmental information from the sedimentary archives. In geomorphology optical stimulated luminescence (OSL) dating is a means, to determine the time when a sediment grain was last exposed to daylight, before it was effectively shed from any further light impact. Thus the time may be dated, when a sediment was last reworked before it was definitely covered in a sediment sink. We applied a blue-stimulated single aliquot regeneration (B-OSL SAR) protocol to coarse-grain quartz separates (125-212 µm) (**fig. 7**), an IR-stimulated (IRSL) SAR protocol to coarse-grain potassium-feldspar, an IRSL multiple-aliquot additive (MAA) protocol as well as a post-IRSL B-OSL protocol to polymineral fine-grains (4-11 µm) (Murray & Wintle 2000, Lang et al. 2003, Banerjee et al. 2001).

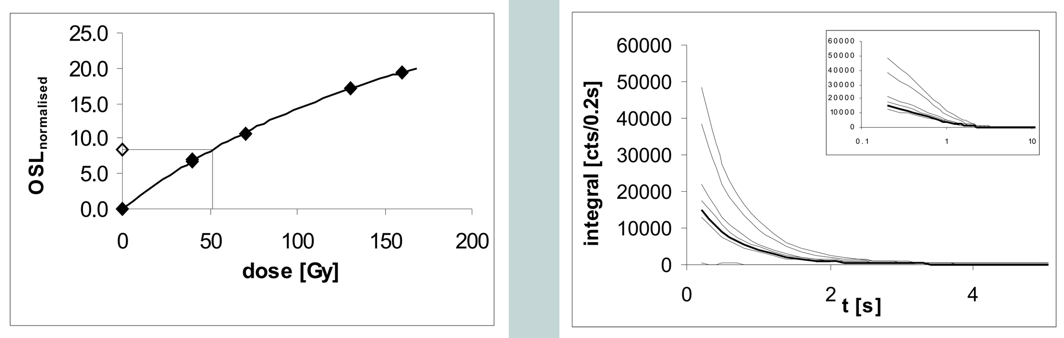


**Fig 7:** ***DE-determination for one aliquot of sample HDS-1220 using a B-OSL single-aliquot regenerative (SAR) protocol. B-OSL-shinedowns (left) and regenerative growth curve (right).***

The waterlain samples give indication of insufficient bleaching prior to deposition. However, dating results from modern sediments around Amspoort are in agreement with independend $^{14}$C-ages, showing that remnant doses from earlier depositional cycles may account for only up to a few decades to a few centuries of age-overestimation (Eitel et al. 2005). For older Holocene and late-Pleistocene deposits, ages cluster in definite periods including those from luminescence based chronologies established for neighbouring watersheds like the Hoarusib, Khumib and Kuiseb River drainages (Srivastava et al. 2004, 2005; Bourke et al. 2003). Results are compiled in **fig. 8**.

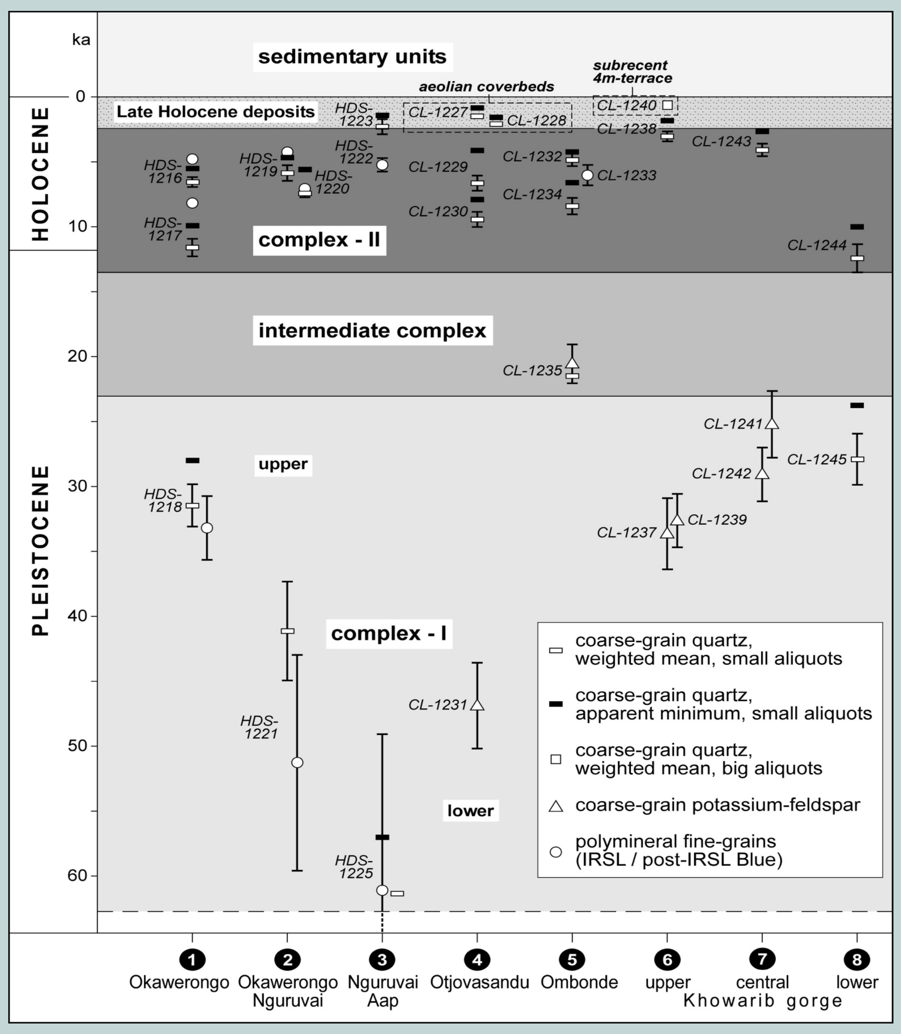


**Fig. 8:** ***Luminescence based chronology of Upper Hoanib valley sediments. Apart from the aeolian samples CL-1227 and CL-1228 and fluvial sample CL-1240, all samples were collected from typical river-end deposits.***

## Conclusions for the palaeoenvironment

Drier conditions favourable for river-end sedimentation in the Upper Hoanib valley prevailed ~60-40 ka and ~34-24 ka. During the Last Glacial Maximum (LGM) fluvial dynamics apparently ceased completely due to arid conditions. River-end deposits are documented from the latest Pleistocene to the mid-Holocene, when the climate was more humid than before the LGM but drier than at present. Due to increased runoff after ~3 ka the Hoanib River re-eroded older deposits forming deep channels. During the Little Ice Age (LIA), coarse-grain material was deposited along the Upper Hoanib, while river-end sedimentation produced the Amspoort Silt formation further downstream, pointing to slightly drier conditions than at present.

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