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LATE QUATERNARY DEVELOPMENT OF THE KUISEB RIVER VALLEY AND ADJACENT AREAS, CENTRAL NAMIB DESERT, SOUTH WEST AFRICA/NAMIBIA, AND PALAEOCLIMATIC IMPLICATIONS

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With 3 figures

SUMMARY

A chronology of climatic change in the central Namib desert may be reconstructed, based upon geomorphological and stratigraphical relationships and absolute dating of fluvial sequences, and upon speleothem development and dating. Correlation of events between the Kuiseb valley and Rössing Cave reveals the following pattern of Late Quaternary palaeoenvironments:

(1) Wetter than today from >40,500 to 34,000/33,000 BP,
(2) Alternating arid/windy and moist from 34,000/33,000 to 27,000 BP,
(3) Between 27,000 and 25,500 BP wetter than today,
(4) Since 25,500 BP arid (with several short periods of somewhat moister conditions locally, during the Holocene).
(5) Extremely arid since 600/500 BP.

DIE JUNGQUARTÄRE ENTWICKLUNG DES KUISEBTALES UND ANGRENZENDER GEBIETE, ZENTRALE NAMIB, SÜDWESTAFRIKA/NAMIBIA, UND PALÄOKLIMATISCHE FOLGERUNGEN

ZUSAMMENFASSUNG

Für die zentrale Namib kann eine Chronologie der Paläoklimate rekonstruiert werden, wenn nicht allein die geomorphologischen und stratigraphischen Beziehungen und absoluten Datierungen der fluvialen Abfolgen, sondern darüber hinaus Höhlensinterbildung und -datierung hinzugezogen werden. Die Korrelierung der Ereignisse des Kuisebtales mit denen der Rössing-Höhle erlaubt folgende Aussagen:

(1) Feuchter als heute von >40,500 bis 34,000/33,000 BP,
(2) Alternierend arid/windig und feucht von 34,000/33,000 bis 27,000 BP,
(3) Zwischen 27,000 und 25,500 BP feuchter als heute,
(4) Seit 25,500 arid (mit einigen kurzen holozänen Perioden mit etwas feuchteren Bedingungen, jedoch nur von lokaler Bedeutung).
(5) Extrem arid seit 600/500 BP.

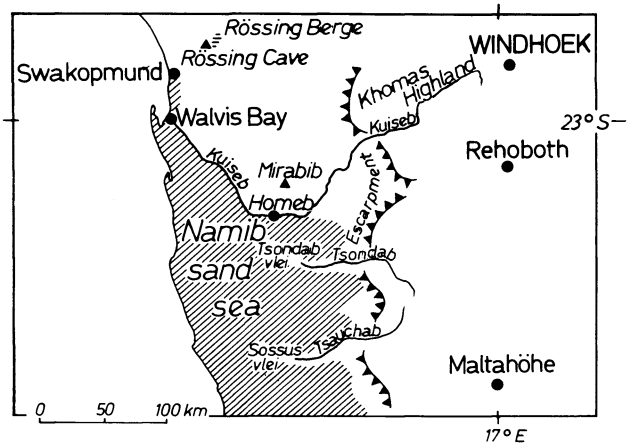

Fig. 1: The central Namib desert

1. INTRODUCTION

The landforms and sediments of the Kuiseb valley (Fig. 1) have been used to reconstruct Late Quaternary palaeoclimates of the Namib desert (Marker 1977, Ollier 1977, Marker & Müller 1978, Hövermann 1978, Rust & Wienecke 1974, 1980, Vogel 1982, Ward 1982). The Kuiseb has its headwaters far outside the Namib desert, however, so that the geomorphological and sedimentary evidence from the Kuiseb valley may not provide the best basis for palaeoclimatic reconstructions of the Namib desert. Evidence for Late Quaternary variations in precipitation are derived from speleothems in a small cave near the Rössing Berge, about 100 km north of the Kuiseb valley. In conjunction with the Kuiseb sedimentary sequence, the speleothem record can be used for palaeoclimatic reconstructions. The correlation of both chronostratigraphies provide a preliminary scheme of the Late Quaternary climatic history of the central Namib.

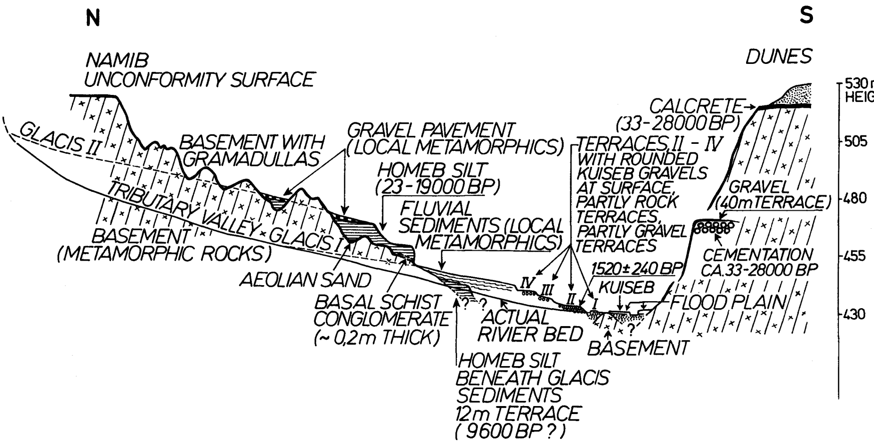

Fig. 2: Schematic cross-section of the Kuiseb river valley near Homeb

2. THE KUISEB RIVER VALLEY

In the course of a project to date geomorphological features, and hence to reconstruct the Late Quaternary climatic history of the Namib desert, isotopic and radiometric analyses have been undertaken by Vogel (1982) on the silt sediments and related deposits in the Kuiseb river canyon at Homeb (Fig. 2).

Radiocarbon dates, presented by Vogel (1982), indicate that carbonate cementation of pebble conglomerate (40 m terrace) and pedogenic calcrete formation took place between 33,000 and 28,000 BP. The calcrete development represents a phase of relatively humid and windy conditions. Observations in the eastern Namib indicate that, in siliceous substrates, calcretes are only formed by allochthonous (eolian) inputs (Blümel 1982); humid conditions (up to ca. 600 mm rainfall?) lead to the formation of the Ca-horizon by infiltration; more arid phases (up to < 100 mm) cause diagenesis and macro-structural changes (Blümel 1982, Netterberg 1978). Thus the calcrete formation phase between 33,000 and 28,000 BP may document alternating "humid" and arid conditions.

A cycle of incision which resulted in the gradual removal of the pebble beds of the 40 m terrace may have lasted from about or somewhat before 28,000 until about 25,000 BP (Vogel 1982). This cycle of incision was caused by an increase in rainfall intensity either in the headwater area or in the Namib or in the whole Kuiseb drainage system.

Radiocarbon dating indicates that the Homeb silt beds were deposited between ca. 23,000 and 19,000 BP (Vogel 1982). At this stage the climate must have been arid,

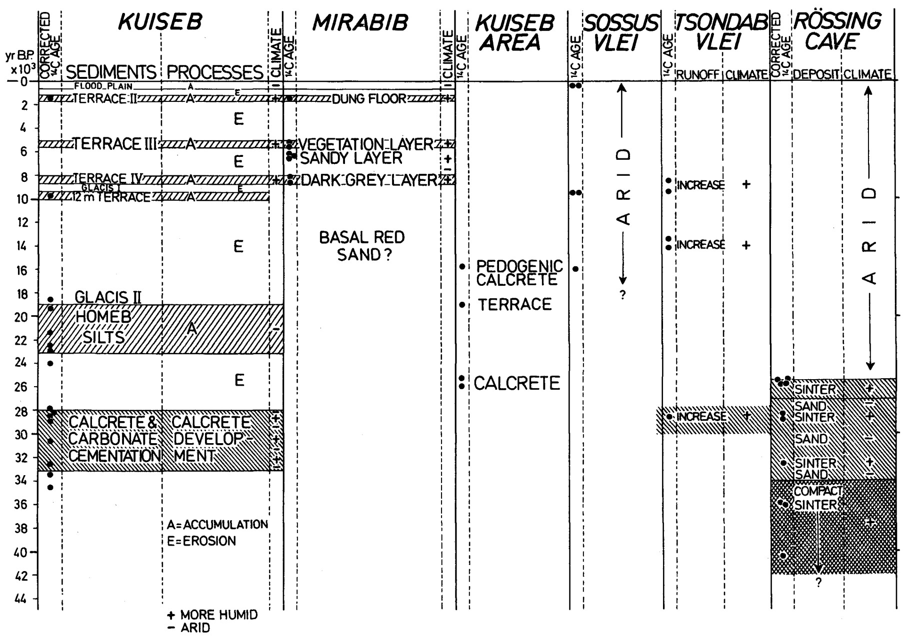

Fig. 3: Late Quaternary sequences for the central Namib desert. (See Vogel 1982 for the Kuiseb, Sandelowsky 1977 for Mirabib, Besler 1980 for the Kuiseb area calcretes, van Zinderen Bakker 1984 for Sossus vlei, Lancaster 1984 for Tsondab vlei, Heine and Geyh 1984 for the Rössing Cave)

because sedimentation took place without in situ alteration except for aeolian deposition (Hövermann 1978). Subsequent to 19,000 BP and after the development of glacis II the silt infilling of the valley was more or less completely removed; in the course of this degradation some of the silt was possibly redeposited as the 12 m terrace (Vogel 1982). After the deposition of the 12 m terrace (ca. 9600 BP?) glacis I was formed.

During the Holocene four small Kuiseb terraces accumulated or were developed as rock terraces. In terrace II a horizon of wood fragments and seeds were dated (1520 ± 240 BP, Hv 9882). The terrace gravels derived from the gramadullas document intensive slope activity (debris formation, see Hövermann 1978). The phase of terrace II formation was more humid than today.

3. CORRELATION OF THE KUISEB SEQUENCE WITH ADJACENT AREAS

Correlation of the radiocarbon-dated Kuiseb sediments with the environmental changes reconstructed at the Mirabib Hill Shelter (Sandelowsky 1977) shows a good agreement of the last moist phase about 1500 BP (Fig. 3). The Mirabib dung floor and terrace II were formed at the same time. Kuiseb terraces III and IV may be tentatively correlated with the other moist phases at the Mirabib archaeological site. This indicates at least three Holocene moist phases in the central Namib: 1500 BP, 5000—5500 BP and 8200—8400 BP. If the date of the accumulation of the 12 m terrace is correct (see Vogel 1982), then the phase between ca. 10,000 and 8000 BP was characterised by alternations of "humid" (moister) and arid conditions, as indicated by the stratification of silt with local schist gravels in the 12 m terrace.

At the Tsondab vlei an increase in runoff occurred about 28,000 BP (Lancaster 1984). The Tsondab and Tsauchab radiocarbon dates for vlei silts of 8640 and 9500 BP suggest (Lancaster 1984) an early Holocene period of increased moisture.

The preliminary results of palynological studies on the central Namib desert (Sossus vlei) are described by van Zinderen Bakker (1984). This study concludes that the northern part of the Namib erg did not receive significantly more rainfall over the last ca. 18,000 years and that the Tsondab and Tsauchab rivers were blocked by dune invasion prior to 18,000 BP (van Zinderen Bakker 1984).

4. THE SPELEOTHEMS OF THE RÖSSING CAVE

Significant conclusions may be drawn from the above data only by comparison with the dates from the Rössing Cave speleothems (Heine & Geyh 1984). The results of radiometric dating together with sedimentological observations at the sampling sites, yield a more eventful record of the Late Quaternary evolution of the climate in the central Namib desert. Various phases can be distinguished for the Middle Weichselian and the time until present (Heine & Geyh 1984). Phase 5 (> 40,500—34,000 BP, Fig. 3) was a "humid" phase with a closed plant cover in the central Namib desert; compact sinter formation as well as popcorn development indicate moist condition in the cave. Phase 4 (34,000—27,000 BP) was the beginning of the aridification in the central Namib. At least three marked climatic fluctuations occurred with alternating arid and more humid conditions. This is indicated by a sequence of sinter and sand layers. Phase 4 corresponds with the phase of calcrete formation and carbonate cementation in the Kuiseb river valley. During phase 3 (ca. 27,000—25,500 BP) moister conditions again dominated. From phase 2 onwards (25,500—19,000 BP), arid conditions prevailed in the central Namib desert. No further sinter formation occurred in the Rössing Cave. In the Kuiseb valley the Homeb silts were accumulated. There is no evidence, according to the Rössing Cave data, that during phase 1 (after 19,000 BP) the central Namib desert experienced other than arid climates.

5. DISCUSSION

Data from southern Africa suggests that relatively humid climatic conditions prevailed between >40,000 and 34,000/33,000 BP not only in the central Namib desert, but also in the interior of southern Africa (Heine 1982, Cooke & Verstappen 1984). The Kuiseb river sediment sequences and incision cycles do not provide information on this pluvial phase, which is well documented only by the Rössing Cave speleothems (Heine & Geyh 1984).

According to the Kuiseb valley sequences, the last phase of moister conditions in the central Namib desert ended about 28,000 BP (Vogel 1982). It should be pointed out that the phase of calcrete and carbonate cementation in the Kuiseb valley between 33,000 and 28,000 BP correlates with the phase of alternating sinter and sand deposition in the Rössing Cave between 34,000 and 27,000 BP. This phase, therefore, must have been characterised by alternating arid and "humid" stages (Heine 1985).

The fluvial record of the Kuiseb after 28,000 BP is not susceptible to palaeoclimatic interpretation. The evidence from the Rössing Cave speleothems suggests, however, that incision of the Kuiseb subsequent to 28,000 BP was caused not only by increasing rainfall intensity in the interior of SWA/Namibia, as assumed by Vogel (1982), but also by higher precipitation in the central Namib desert; the last time compact sinter formation took place in the Rössing Cave occurred between 27,000 and 25,500 BP (Heine & Geyh 1984).

Evidence from the Rössing Cave speleothems, the pollen record from Sossus vlei (van Zinderen Bakker 1984) and the palynological study of Pleistocene cores from Walvis Ridge off SWA/Namibia (Caratini & Tissot 1982) suggests that since 25,500 BP, periods of fluvial activity in the Kuiseb valley near Homeb imply variations in rainfall intensity in the headwaters rather than in the Namib desert itself. Thus the Homeb silt beds do not reflect local climatic changes.

At least four minor phases of moister conditions in the central Namib during the Holocene are documented by the three radiocarbon dated organic horizons of the Mirabib Hill Shelter and the set of small Holocene terraces of the Kuiseb river. Since about 500 BP evidence for greater aridity in the Namib desert comes from a variety of sources, such as the Mirabib Site (Sandelowsky 1977, Brain & Brain 1977) and Sossus vlei where about 600—550 BP *Acacia* trees died and deflation of vlei sediments started.

6. CONCLUSIONS

A chronology of palaeoclimates for the central Namib desert may be constructed, based upon geomorphological and stratigraphical relationships and absolute dating of fluvial sequences, and also upon speleothem development and dating. Correlation of events between the Kuiseb valley and Rössing Cave reveals the following patterns of Late Quaternary palaeoenvironments:

(1) During the Late Pleistocene, the available dated evidence for the central Namib desert shows that the phase from >40,500 BP to 34,000/33,000 BP was considerably wetter than today.
(2) During the period 33,000 to 27,000 BP calcrete development and the interbedding of aeolian sand and flowstone in cave sediments indicate alternating arid/windy and moist periods. This phase is characterised by unique climatic conditions on all continents.
(3) After a short moist phase between 27,000 and 25,500 BP the central Namib desert remained predominantly arid until today.
(4) Several short periods with somewhat moister conditions occurred during the Holocene. It should be emphasised that the climate in the central Namib desert has fluctuated since ca. 25,500 about a generally arid mean, becoming drier in the last five centuries.
(5) Incision and aggradation cycles of the Kuiseb river (terraces, glacis, sediments) are not suitable for a reconstruction of Late Quaternary palaeoclimates. Only the calcretes and carbonate cementations may be interpreted in connection with the speleothems. This accords with observations from the Sahara (Hagedorn 1980).

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REFERENCES

Besler, H., 1980: Die Dünen-Namib: Entstehung und Dynamik eines Ergs. Stuttgarter geogr. Studien 96, Stuttgart. Selbstverlag Geogr. Inst. Univ.

Blümel, W. D., 1982: Calcretes in Namibia and SE-Spain. Relations to Substratum, Soil Formation and Geomorphic Factors. Catena Suppl. 1, 67—82.

Brain, C. K. and V. Brain, 1977: Microfaunal remains from Mirabib: Some evidence of paleoecological changes in the Namib. Madoqua 10 (4), 285—293.

Caratini, C. and C. Tissot, 1982: Palynological Study of Pleistocene Sediment Cores from Walvis Ridge. Palaeoecology of Africa 15, 227.

Cooke, H. J. and H. Th. Verstappen, 1984: The landforms of the western Makgadikgadi basin in northern Botswana, with a consideration of the chronology of the evolution of Lake Paleo-Makgadikgadi. Z. Geomorph. N. F. 28 (1), 1—19.

Hagedorn, H., 1980: Fluvial processes in the Sahara. Palaeoecology of Africa 12, 115—123.

Heine, K., 1982: The main stages of the Late Quaternary evolution of the Kalahari region, southern Africa. Palaeoecology of Africa 15, 53—76.

Heine, K., 1985: Preliminary reconstruction of the Late Quaternary climatic history of the central Namib desert, SW Africa, based on new ^{14}C dates. In press.

Heine, K. and M. A. Geyh, 1984: Radiocarbon Dating of Speleothems from the Rössing Cave (Namib Desert) and Palaeoclimatic Implications. In press.

Hövermann, J., 1978: Formen und Formung in der Pränamib (Flächen-Namib). Z. Geomorph. N. F., Suppl. Bd. 30, 55—73.

Lancaster, N., 1984: Palaeoenvironments in the Tsondab valley, central Namib Desert. Palaeoecology of Africa 16, 411—419.

Marker, M. E., 1977: Aspects of the geomorphology of the Kuiseb River, South West Africa. Madoqua ser. II (10), 199—206.

Marker, M. E. and D. Müller, 1978: Relict vlei silts of the middle Kuiseb River valley, South West Africa. Madoqua ser. II (11), 151—162.
Netterberg, F., 1978: Dating and correlation of calcretes and other pedocretes. Transactions Geol. Soc. S. A. 81, 379—391.
Ollier, C. D., 1977: Outline geological and geomorphic history of the Central Namib Desert. Madoqua ser. II (10), 207—212.
Rust, U. and F. Wienecke, 1974: Studies on gramadulla formation in the middle part of the Kuiseb River, South West Africa. Madoqua ser. II (3), 5—15.
Rust, U. and F. Wienecke, 1980: A reinvestigation of some aspects of the evolution of the Kuiseb River valley up-stream of Gobabeb, South West Africa. Madoqua ser. II (12), 163—173.
Sandelowsky, B. H., 1977: Mirabib — an archaeological study in the Namib. Madoqua 10 (4), 221—283.
Van Zinderen Bakker, E. M., 1984: A Late- and Post-Glacial Pollen Record from the Namib Desert. Palaeoecology of Africa 16, 421—428.
Vogel, J. C., 1982: The age of the Kuiseb river silt terrace at Homeb. Palaeoecology of Africa 15, 201—209.
Ward, J. D., 1982: Aspects of a suite of Quaternary conglomeratic sediments in the Kuiseb valley, Namibia. Palaeoecology of Africa 15, 211—216.

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