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With kind regards

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# ARIDITY ALONG THE NAMIBIAN COAST

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## INTRODUCTION

The remarkable phenomenon of the occurrence of coastal deserts along the western shore of most continents has attracted the attention of scientists for a long time. These deserts are of a different nature, some are hyper-arid while others like the coastal region of western Australia are semi-arid. The age and origin of these deserts and their physical and biological characteristics have in recent years been the focus of much research of an interdisciplinary nature. The elongated Namib desert with a length of about 2 000 km and a width varying between 40 and 120 km, which stretches along the southwest African coast, is the subject of this treatise. Research in this peculiar desert has been stimulated by the Desert Ecological Research Unit, which runs a research station in the centre of the desert at Gobabeb under the directorship of Dr M K Seely. Many studies carried out here have been devoted to biological-geomorphological and geological aspects, while important work has been done on the origin and age of the desert. In this latter respect oceanographic studies, such as those conducted over 10 years along the N W African coast, have not yet received much attention. This research



is, of paramount importance as ocean sediments can provide long stratigraphic sequences of environmental changes and can be dated by different means. In deserts such sequences are practically non-existant (van Zinderen Bakker, this volume), while material for absolute dating can hardly be found. In the following considerations attention will especially be given to the oceanographic aspects of the Namib research and comparisons will be made between analogous situations along the southwest and northwest African coastline.

## GENERAL CLIMATIC CONSIDERATIONS

Since late Mesozoic times the coastal region of southwestern Africa mostly had a dry climate. It is generally accepted that semi-arid to arid conditions existed here as a consequence of atmospheric and oceanic influences. During the Mesozoic and early Cainozoic the palaeogeography of continents and oceans and also the topography differed considerably from the present situation. It would therefore be unrealistic to use actualistic principles to explain the coastal aridity which prevailed in those times. Oceanic research has shown that the Southern Ocean was then warm until the temperature dropped considerably at the Eocene-Oligocene boundary. After the origin of the Circum-Antarctic Current and the formation of the Antarctic Polar Front, respectively in the late Oligocene and early Miocene the scene was set for the gradual development of the present ocean circulation system. These developments depended on the evolution of the Antarctic ice sheet. Oxygen isotope palaeo-climatology and palaeomagnetic and isotopic dating of ocean sediments have during the last 12 years produced extremely important results which should not be ignored in explaining the climatic evolution of the Southern Hemisphere. Notwithstanding these recent findings the dating of several important events in the Antarctic region is still a matter of controversy. It has with Gramineae and Cyperaceae are found, while in depressions sebkhas covered with Chenopodiaceae occur. Such conditions will be typical for hypothermal periods with low sea-levels. Late Pliocene deposits with 37% Chenopodiaceae pollen could represent such conditions. Similar pollen spectra with high Chenopodiaceae percentages are known from sediments offshore of the Somalia and Arabian Deserts (Van Campo et al., 1982), the dry Palestinian coast (Rossignol, 1969) and the western Sahara (Agwu, 1979; Rossignol-Strick & Duzer, 1979; Agwu & Beug, 1982; Bonnefille et al., 1982).

The few arboreal pollen grains represent some woody vegetation as is at present found in the Namib along some wadis and which occurs further inland on the escarpment.

The fossil spectra studied so far indicate hyper-arid conditions along the northern coast of Namibia in Plio-Pleistocene times. It is, however, not possible to give any detailed indications on fluctuations in climate which may have occurred. Much pollen information calibrated with $^{18}O$ determinations and palaeomagnetic dating will be needed before the possible late-Cainozoic influence of the Benguela current on the local climate of the desert zone can be assessed.

DID THE SOUTHERN NAMIB RECEIVE MORE WINTER RAIN 18 000 B P?

Some questions of the late Quaternary climatic evolution in the southern Namib are discussed elsewhere (van Zinderen Bakker, ~~1983)~~ this volume) but one problem which has in recent years become a bone of contention will be briefly dealt with here.



As has already been mentioned the author advocated in 1967 the hypothesis that during hypothermal conditions (glacial maxima) the climatic belts shifted equatorward and he described this possibility further in a palaeoclimatic model for southern Africa in 1976. For the Namib it was surmised that cyclonic winter rainfall could during the last glacial maximum (c. 18 000 B P) fairly regularly penetrate as far north as about 24° S and would have covered the southern sand sea. This idea was mainly based on synoptic observations according to which rare winter rain at present penetrates the desert to about the same latitude. When the South Atlantic anticyclone weakens summer rainfall can at present reach the escarpment and the catchment area of the rivers that flow into the sand desert. Another consideration that has been taken into account in propounding the hypothesis has been that at Narabeb (23° 41' S) an old lake bed with an age of 210 000 to 240 000 years could not have remained undisturbed for so long if regular rainfall had occurred (Selby et al., 1979).

This northward penetration of winter rainfall in the Namib has since then remained a contentious point (van Zinderen Bakker, 1980). Tankard and Rogers (1978) describe dune plumes at the mouth of ephemeral rivers at 30° S as evidence for intensified atmospheric circulation during the late Pleistocene hypothermal and accept the coeval northward penetration of cyclonic rainfall. Rust (1981) described terraces along the Skeleton Coast (20° S) which he equates with humid periods, presumably of late Pleistocene age.

In their studies on the photosynthetic pathways and geographical distribution of grasses in Namibia Vogel et al. (1978) and Vogel (1978) mention that temperate $C_3$ grass genera only occur in Namibia in the southwestern district of Lüderitz which falls within the winter rainfall area. Precipitation as such does not seem to be an important factor for the occurrence of 18% of these grass species in this hyper-arid district. A significant point is that the growing season of these temperate species corresponds with the cooler winter months when water stress is not severe. This proxi data could indicate that in former cool-humid periods such grasses could have spread northward sothat their present distribution is of a refuge nature.

Recent determinations of the contribution of $C_3$ and $C_4$ plants to the food of zebra excavated in the Apollo II Cave 50 km north of the Orange River, however, reveals that compared with the present day the proportion of $C_3$-plants in the diet was 7 000, 20 000 and 70 000 years ago only slightly more than at present (Vogel, 1983). This evidence shows that the winter rainfall could not have extended appreciable further northward in former times. From his datings of the silts and calcretes at Homeb on the Kuiseb River Vogel (1982) also concludes that the last time that more humid conditions prevailed in the Namib Desert ended about 28 000 B P.

Recent pollen studies in the northern part of the sand sea show that about 18 000 B P at Sossus Vlei conditions must have been about the same as at present. From this data it can be inferred that during the last glacial maximum at least this part of the erg was not affected by more than normal rainfall (van Zinderen Bakker, ~~1983)~~ this volume)

It will take some time before this problem, which is of much palaeoecological and evolutionary interest, will be settled, but the balance is swinging towards dry conditions 18 000 BP,



IS THE NAMIB AN OLD DESERT?

This dramatic question has been posed several times in literature and it is not always clear whether the questioners have the age of the southern sand sea, of the biota or of the hyper-arid climate in mind. We will limit ourselves shortly to the last question. Looking at the long and varied geological history of the Namibia coast it is certain that many variations in its climate must have taken place since its separation from the South American plate. Desert conditions most-certainly have occurred several times and minor climatic variations can often have changed the palaeoenvironment of the region.

The origin of the present climatic regime is coupled with the evolution of the Antarctic ice sheet (van Zinderen Bakker, 1975). It is remarkable that parallel with changes in the Southern Ocean arid conditions developed along both the nortwestern and southwestern African coast in late Miocene times. Further back in time a synchronous development of the climates in these two regions may not have existed as the palaeogeographic position then differed substantially from the present. The Tethys Sea was still open to the West and the northwest Sahara was situated at lower latitudes. It is possible that the Canary Current originated after the gradual closing of the sea way between the North Atlantic and the Tethys in the earliest Miocene (Sarnthein _et al._, 1982). Some phases of strong cooling with lower sea levels, upwelling comparable with glacial regimes and stronger Trade Winds then caused desert conditions in the northwestern Sahara (_op cit._). The data of Siesser (1978, 1980) on the upwelling along the Namibian coast do not indicate all these changes along the Namib coast. ~~It is, however, remarkable that in~~ the ~~Early Oligocene desert conditions existed in the northwestern~~ Sahara (~~Diester-Haass & Chamley, 1980, Sarnthein et al., 1982) while Siesse~~r

The matter of the age of the desert biota is far more difficult to settle because of the problem of the dating of this origin. It is certainly possible that during the long time of climatic evolution biota adapted to arid conditions could in more mesic times have survived in certain arid and hyper-arid habitats (Endrödy-Younga, 1982). Such mesic conditions may not have existed in Pliocene times in the northern Namib (van Zinderen Bakker, this volume).

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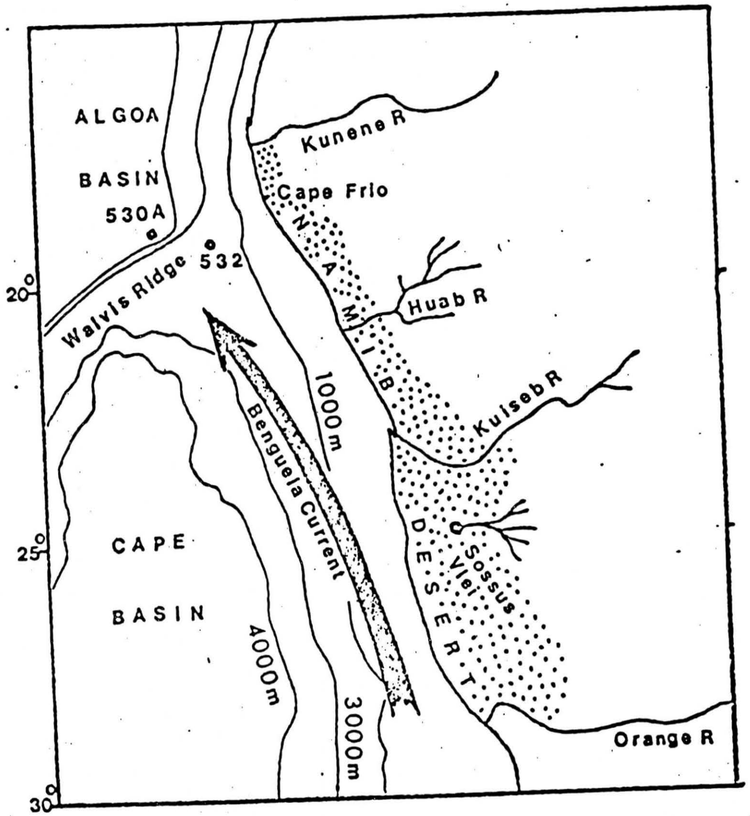


Figure 1. Locality map
Isobaths in metres.