A LATE- AND POST-GLACIAL POLLEN RECORD FROM THE NAMIB DESERT

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INTRODUCTION

Pollen research in deserts meets with many problems as arid and warm conditions are not condusive to the preservation of sporomorphs so that pollen bearing deposits are very rare in hyper-arid regions. The comparison of the fossil pollen spectra with the present pollen rain has also proved to be difficult as the pollen production of the desert vegetation cannot easily be assessed in the traditional way by analysing surface soil samples. The ingenious method devised by Cour (1974) to collect pollen from dust on the desert surface has overcome this problem. He used gauze filters soaked with silicon oil and attached these to the back of a vehicle that stirs up the dust. Another serious obstacle for the explanation of pollen analytical results in deserts is the great scarcity of organic material which can be used for radiocarbon dating. Nevertheless, important pioneer work on pollen analysis in the Sahara has been done by Beucher (1970), Cour (1974), Schulz (1980) and Maley (1981).

The first results of palynological studies on the Namib Desert are described here. This research aims at assessing the climatic history and the possible age of this coastal desert. These problems are approached from two different angles. On the one hand, sediments occurring in valleys in the sand desert provide data on the late Quaternary, while deep sea cores taken off the coast of Namibia extend the pollen sequence further back and cover the late Cainozoic. In the present study, the late Quaternary sediments occurring in the Sossus Vlei, the endpoint of the Tsauchab River, are discussed (Fig.1). This river originates in the Naukluft and Tsaris mountains where its catchment area is approximately 750 km^2. The river has a length of roughly 150 km, the last 40 km of which traverse the sand sea of the southern Namib. The course of the Tsauchab has been blocked by high dunes several times and a number of depressions covered with white silt indicate the sites where water has been dammed up formerly. These pans are situated at different levels and their age should reveal the history of the river activity. With the assistance of some colleagues in 1975, a large hole was excavated on the east side of Sossus Vlei. A sequence of 11 layers of solid grey silt was uncovered. These layers

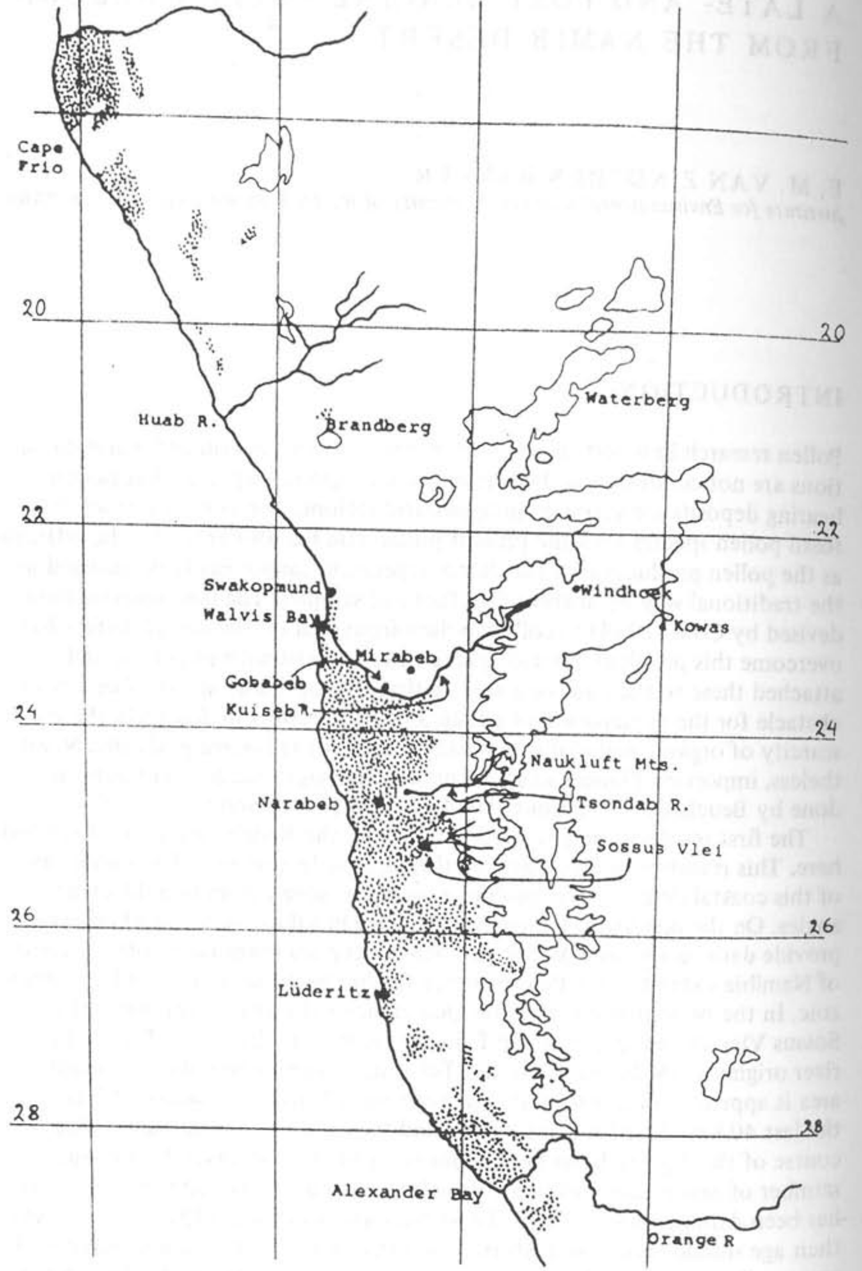

Figure 1. Locality map of the Namib Desert and adjacent areas.

had a thickness of 2-40 cm and were separated by red brown windblown sand. The silt mostly contained just enough pollen to count 300-500 grains per layer (Table 1).

THE NAMIB DESERT

The Namib Desert, which varies in width from 40-120 km and has a length of 2 000 km, can be divided into three sections (Giess 1971).

The Northern Namib stretches from the Kunene to the Huab River and consists of dunes and large areas covered with white sand on which a sparse vegetation occurs.

The Central Namib between the Huab and Kuiseb Rivers is a vast rocky plain with some isolated mountains. Near the coast succulent xerophytic undershrubs are found, while the gravel and sandy flats are often covered with widespread, white annual desert grasses which mostly belong to the genus *Stipagrostis.* The remarkable endemic *Welwitschia mirabilis* Hook.f. reaches its southern limit in this part of the desert.

The Southern Namib extends from the Kuiseb to the Orange River and roughly covers the coastal region between the 24th and 28th parallels. The northern part of the Southern Namib consists of a sand desert of about 320 km length and 120 km width. In the southern part, which receives more winter rainfall, a great variety of indigenous plant species, mostly succulents, occurs in the rocky hills and mountains.

To the east all three of these sections of the Namib merge into extensive grasslands dominated by *Stipagrostis ciliata* (Desf.) de Winter and *S.obtusa* (Del.) Nees (Giess 1971).

The erg of the Southern Namib is a real sand sea with linear dunes with a height of 50-150 m running roughly in a south-northerly direction (Lancaster 1982). This inhospitable region is delimited in the north by the ephemeral Kuiseb River, while some temporary rivers, like the Tsondab and Tsauchab further south, enter the sand sea from the escarpment to the east (Fig.1). Some of these rivers end in vleis where they have in the course of time deposited silty sediment layers. In former times, these rivers used to flow into the ocean but their water capacity became too limited to force their way through the dunes invading their valleys (Seely & Sandelowsky 1974, Vogel 1982). This can be proved by the configuration of the dunes west of the present end point of the rivers, the occurrence of river transported boulders, fresh seepage water and old river sediments in the now abandoned lower bed especially of the Tsondab River.

THE VEGETATION

It is important to give a short account of the present vegetation near the site in order to obtain an insight in the possible pollen production of the surround-

Table 1. Sossus Vlei pollen counts in percentages. NAP = Non-arboreal pollen; AP = Arboreal pollen.

Depth in cm	0	25	31	52-57	89-94	133-136	153-158	218-223	236-242	247-250	275-280	310-325
Lab. number	surface	5852	5851	5850	5849	5848	5847	5846	5845	5844	5843	5842
No. counted	300	200	250	300	300	300	300	300	300	500	200	200
NAP												
Chenopodiaceae/Amaranthaceae	46.3	40.5	46.8	26.3	45.0	54.7	52.7	25.7	30.6	80.8	54.5	34.0
Gramineae	15.0	10.5	4.8	12.3	8.0	1.3	2.7	18.3	7.0	1.4	6.0	10.5
Compositae	10.0	16.0	12.8	27.3	20.3	9.7	13.7	19.3	20.7	6.4	7.5	27.0
Acanthosicyos	9.7	1.5	15.2	2.3	19.7	7.0	5.7	2.3	1.0	4.0	9.0	0.5
Justicia	3.3	10.5	2.0	8.7	2.0	5.3	3.0		19.3	0.4	1.0	5.0
cf. *Hypoestes*	0.7			1.0								
Other Acanthaceae	0.3			0.3		1.3	1.0	0.7	0.7	0.8	1.0	0.5
Tribulus	3.7	2.0	2.0	3.3	2.7	3.3		0.7		0.4	1.0	0.5
Zygophyllum		1.5	0.4			1.7	0.7	2.0	4.0	0.4		3.0
Cyperaceae	1.0	1.0	0.4	0.7	0.3	2.0	0.7	1.0	1.0	0.2		2.0
Liliaceae	3.0	2.5	3.2	6.7	3.0	4.3	5.0	7.3	10.7	0.6	3.5	7.0
Labiatae				0.3		0.3						
Boraginaceae	1.0	3.5	2.8	4.6	2.7	1.0	4.3	5.6	0.3	2.0	3.5	0.5
Leguminosae	0.3	1.0	0.4	1.7	0.3		1.0			0.6	4.5	
Polygonaceae		1.0	0.4									
cf. *Geranium*	0.3					0.3		0.3				
Euphorbiaceae	0.3											
Cruciferae		1.5	1.2									
Amaryllidaceae						0.3						
Loranthaceae			0.4									
Nyctaginaceae									0.3			
Malvaceae									0.3			
AP												
Combretaceae	0.7	2.5		0.7	0.7	2.0	1.0	0.3	1.3		0.5	3.0
Acacia	2.3		0.4	2.7	1.3	0.3	0.3	1.6	2.0	4.4	1.0	1.5
Podocarpus												0.5
Pterolobium		0.5									0.5	
Oleaceae				0.3		0.7						
Celastraceae							0.3					
Myrica						0.3						
Spores			1.2		0.3			0.7		0.2	1.0	
Varia	2.0	4.0	6.0	0.3	3.6	4.0	8.0	4.0	1.0	1.4	0.5	4.5

ings. In the dunes near Sossus Vlei, vegetation is very sparse. In rare years with more than normal rainfall, the high dune slopes have a thin cover of widespread desert grasses, mainly *Stipagrostis namaquensis* (Nees) de Winter. Mr W.Giess from Windhoek kindly supplied the following list of plants he collected round Sossus Vlei on 29 June 1974:

Stipagrostis gonatostachys (Pilger) de Winter
Eragrostis spinosa (L.f.) Trin.
Brachiaria glomerata (Hackel) A.Camus
Monsonia ignorata Merxm. & Schreiber
Osteospermum microcarpum (Harvey) T.Norl. subsp. *microcarpum*
Cleome paxii (Schinz) Gild & Benedict
Hermannia minimifolia M.Holzhammer
Coronopus integrifolius (D.C.Sprengel)
Limeum fenestratum (Fenzl) Heimerl
Limeum viscosum (J.Gay) Fenzl subsp. *viscosum*
Amaranthus thunbergii Moq. (Rendle) Conert
Asthenatherum glaucum (Nees) Nevski var. *lasiophyllum*
Sesamum abbreviatum Merxm.
Galenia papulosa (Ecklon & Zeyher) Sonder

A much more varied vegetation has been described from the Mirabib Hill area in the Central Namib just north of the Kuiseb River (Robinson 1977).

On the escarpment to the east where the Tsauchab River originates in the Naukluft and Tsaris Mountains, a very great variety of endemic species is found. According to the map of Giess (1971), this vegetation forms a transition from the desert to the savanna and several woody genera like *Moringa, Adenolobus, Acacia, Commiphora* and *Euphorbia* are typical for this region.

In the Tsauchab river bed and around the vlei a denser concentration of vegetation occurs. The very wide valley in the higher part of the river course develops locally to a flood plain where the gravelly sand is covered with dense stands of *Stipagrostis fastigiata* (Hackel) de Winter, while locally some *Geigeria* species are found. Lower down, where the dunes narrow the valley, large specimens of *Acacia erioloba* E.Meyer festoon the dry river course. Extensive areas are here covered with small mounds of up to 2 m high. These miniature dunes are formed by windblown sand trapped in dense growth of *Salsola tuberculata* (Fenz ex Moq.) Schinz. On the side of the valley much larger young dunes accumulate around bushes of *Acanthosicyos horridus* Welw. ex Hook.f. In the river valley two plants are found widespread, viz. *Stipagrostis sabulicosa* (Pilger) de Winter and *Pechuel-Loeschia leubnitziae* (O.Kuntze) O.Hoffm. The following shrubs and small trees are found here: *Boscia foetida* Schinz, *Maerua schinzii* Pax, *Zizyphus mucronata* Willd. and *Hermannia minimifolia* M.Holzhammer.

DISCUSSION

The pollen spectra of the 11 silt layers and one surface soil sample are given in Table 1. The pollen which was trapped in the silt deposited during rare river floods represents the vegetation growing in and along the river valley and in the catchment area. Taking the low pollen production of the sparse desert vegetation into account, 'long-distance pollen' will have played a role in the composition of the assemblages.

In general, the spectra of Table 1 show a great resemblance. The non-arboreal pollen (NAP) is dominated by very high percentages (25.7-80.8 %) of Chenopodiaceae which indicates aridity. These high percentages can be explained by the overall presence of *Salsola tuberculata* (Fenz. ex. Moq.) Schinz on the countless little dines which are found in the river bed above the vlei. Compositae take the second place with 6.4-27.3 %, which also points to arid conditions and to transport and concentration of this sticky insectivorous pollen by water. *Geigeria* and *Osteospermum* spp. are probably mainly responsible for this pollen. Gramineae pollen must have originated from the many species of grass growing in the valley and occasionally on the dunes. *Acanthosicyos* pollen is present in all the samples and varies from 0.5-19.7 %. The large variation in the pollen percentages of all the plants indicates that the season of the floodings must have had a great influence on the pollen deposition.

Besides the already mentioned Chenopodiaceae and Compositae the following taxa in the pollen spectra are proof of arid conditions: *Tribulus, Zygophyllum,* Boraginaceae, Liliflorae and Acanthaceae. The small percentages of other 'NAP' pollen could be of local origin or have been transported from the catchment area of the river.

Among the arboreal pollen (AP), *Acacia,* which is present in 11 samples, could belong to *A.erioloba* E.Meyer which grows along the river course. Several of the other arboreal pollen types, which occur in very low percentages, may well indicate the influence of the mountain vegetation such as: *Combretum, Pterolobium,* Oleaceae, Celastraceae and *Myrica.*

The general composition of the fossil pollen spectra closely resembles that of the surface sample taken from the vlei. This indicates that arid conditions similar to today existed in the desert during the deposition of the silt layers. The intercalation of wind blown sand inbetween the silt layers shows that the surroundings remained arid during the whole timespan. The present situation is a close analogue to former conditions when precipitation on the escarpment or the margin of the desert caused a river flood which filled up the vlei in the otherwise arid desert. It would in this connection be very useful to have radiocarbon dates for the various silt layers as this would show the cyclicity of the rain periods. So far we only possess one date for the second lowest silt layer from a depth of 2.85 m, viz. 24 800 ± 320 BP (Pta-1859, Vogel & Visser 1981) which was kindly supplied by Dr J.C.Vogel. Comparisons with the dates of calcareous silts taken from depths of 0-5 and 5-10 cm respectively 9 460 ± 90 (Pta-1503) and 9 600 ± 90 (Pta-1599), suggests that the 10th silt layer at 2.85 cm depth is not 24 800 ± 320 but ca. 16 000 years old. This assumption is supported by the ^{13}C contents (ibid.)

The 11th silt layer at the bottom of the sequence at a depth of 3.25 cm may then be near 18 000 years old.

A large silt sample taken at 2.40 m depth was digested with HF and the residue of 0.3 g organic material gave a date of AD 1957 (Pta-1646). The sample appeared to contain fine recent rootlets which could have penetrated to the water table.

The conclusions which can be drawn from this data are firstly that the northern part of the sand sea did not receive significantly more rainfall over the last ca.18 000 years, which pleads against the penetration of more than usual winter rainfall in the erg (van Zinderen Bakker 1976).

A second conclusion could be that the Tsondab and Tsauchab Rivers were blocked by dune invasion prior to 18 000 BP. As several older vleis occur in the Tsauchab valley lower down these may show that the rivers did not have enough capacity during the arid period which, according to Vogel (1982), lasted from 23 000 to 19 000 BP. During this period, the Homeb silts accumulated. Floods caused by stronger precipitation on the escarpment from 19 000 BP onward, which gradually removed the Hobel silts, were, in the case of the Tsauchab, not strong enough to force their way through the dune barrier.

A third point which emerges from the data is the question of the nature of the precipitation which fell on the interior of SWA or on the escarpment from 19 000 BP onward. Is it perhaps possible that the South Atlantic anticyclone was at the time of low temperature situated on the coast and that its aridifying influence dominated the sand sea so that only orographic rain could fall on the more elevated region east of it? The solving of some problems therefore leaves us with other questions for future research. More vleis should be investigated and well-dated pollen sequences will be necessary in order to find acceptable explanations for these problems.

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