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Radiocarbon dating of speleothems from the Rössing cave, Namib desert, and palaeoclimatic implications

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ABSTRACT. About 2 km west of the Rössingberge in the Namib desert at about 340 m above sea level, a small cave system with stalactites, stalagmites, flowstone, popcorn and other sinter formations was investigated in 1978 and 1981. Speleothems have been formed since the Tertiary. As the cave is within a small catchment area, the speleothems reflect changing palaeohydrological and palaeoclimatological conditions in the Namib desert in the vicinity of the cave rather than those of the escarpment in the east.

According to the C14 dates, the climate after 41 500 BP can be divided into five phases. Until about 25 500 BP rather humid conditions prevailed as cave sinter was formed. Afterwards the climate remained dry in the study area. As from 19 000 BP, the interior of South West Africa also became arid.

INTRODUCTION

Some questions of the Late Quaternary climatic evolution in the Namib desert will be discussed briefly. During recent years many scientists have tried to find evidence for or against the penetration of hypothermal (Glacial Maximum) winter rainfall in the Namib. According to Rust and Schmidt (1981), for example, winter rainfall penetrated as far north as 20 $^{\circ}$S during the last pleniglacial. Van Zinderen Bakker (1983a, b), on the other hand, argued that winter rainfall never extended so far north during the Late Quaternary. His pollen study indicates that the climatic conditions at Sossus vlei had not changed since at least 18 000 BP. Vogel (1982) concluded from dates obtained by him on silt, calcretes, and one wood sample taken at Homeb on the Kuiseb River, that the last humid period in the Namib desert ended about 28 000 BP.

About 2 km west of the Rössingberge (14 $^{\circ}$ 48' E, 22 $^{\circ}$ 31,5' S) at 338 m above sea level, a small cave with a variety of speleothems reflects the climatic evolution in the vicinity of the Rössingberge in the central Namib desert. Two Th230/U234 dates of speleothems exceeding 300 000 yr support the geomorphic evidence that the cave and the oldest sinter formation might be of Tertiary origin. In this paper attention is focused on the Late Quaternary only.

Speleothems from arid zones can be considered as "closed systems" with respect to carbon isotopes. Therefore, such samples are most suitable for C14 dating. The calibration uncertainty of the date is about ± 1000 years. In spite of this C14 ages seem to be more reliable than those of any other samples from the Namib desert, such as calcretes or fluviatile sediments which are often changed diagenetically.

THE CAVE AND PERIODS OF SPELEOTHEM FORMATION

The cave is situated in a narrow belt of calcareous rocks that emerges a few metres above the old Namib desert surface within a natural catchment area of a few km^2 (Fig. 1). Thus, the growth of speleothems was determined by the local precipitation in the vicinity of the cave on the western slopes of the Rössingberge rather than by that from the escarpment in the east.

The cave consists of three chambers situated parallel to the NNW/SSE direction of the folded rocks in the Namib. The chambers are about 10-20 m beneath the surface. Their widths range from a few metres to about 15 m, their lengths from about 10-25 m. The height of the chambers changes from several decimetres to c. 3 m.

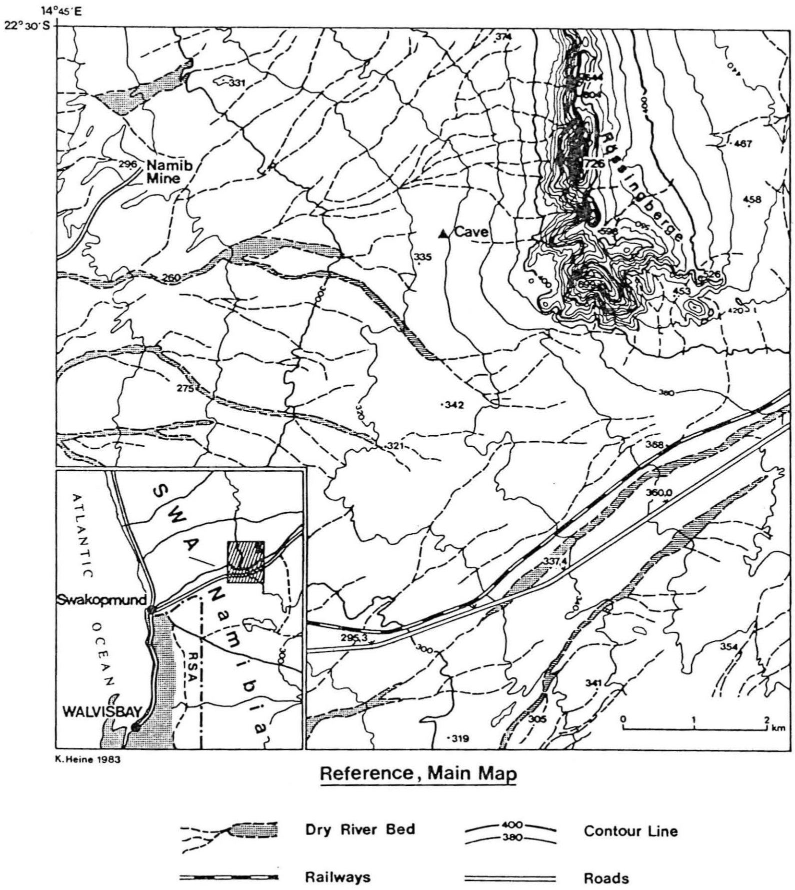

Figure 1. Map of the study area.

According to the geomorphologic situation the cave was formed by lime solution or erosion during pre-Pleistocene times. Only a few points in the cave display cave deposits as stalactites, stalagmites, flowstone, and popcorn. At present, the cave appears to be completely dry though drops of seeping water have been observed during extremely wet years.

In the northern part of the cave, a huge stalagmite (Fig. 2) stands beneath a big fissure which allowed fine aeolian sands from the Namib desert to enter the cave together with the dripping water. They are found in between the youngest flowstone layers (Fig. 2) surrounding the eastern and southern flanks of the stalagmite.

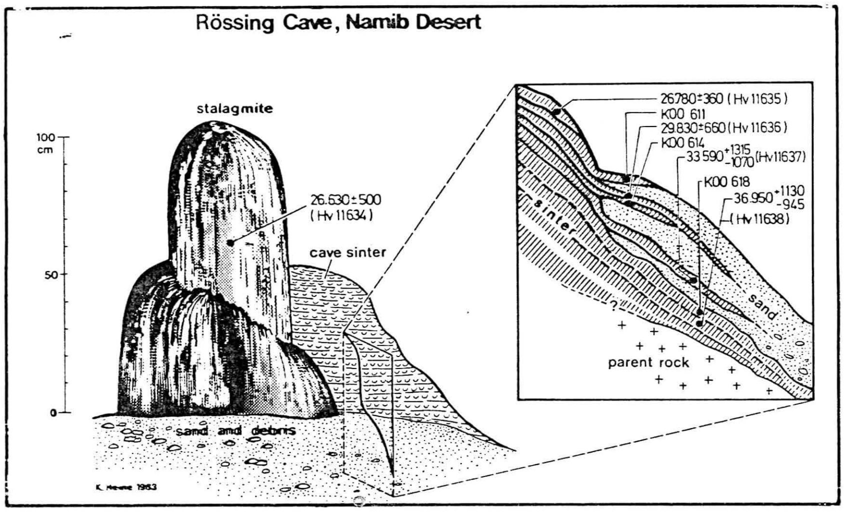

Figure 2. Speleothem morphology and sampling points for isotope analyses in the Rössing cave.

The conventional C14 ages of the uppermost flowstone layers (Fig. 2) range from 37 000 - 26 800 BP. The speleothems, formed until about 35 000 BP, consist of massive calcite deposits. Later on, sand horizons are intercalated. The conventional C14 dates of speleothem samples from other places in the cave (Table 1) also show that sinter formations terminated at 26 500 BP. This holds true also for the popcorn deposits consisting of irregularly alternating light and dark layers of aragonite and calcite. Their formation began before 41 000 BP. The outer part of a unique stalactite curtain yielded a date of 37 000 BP.

Only conventional C14 dates have been discussed up to now. It has been known, however, since the method for C14 dating of speleothems was introduced by Franke (1951) and proved to be applicable (Franke et al. 1958), that a "reservoir correction" of at least -1000 years is necessary to obtain actual ages. Labeyrie et al. (1967) even found a correction value of up to -3500 years for uncovered areas. However, as we do not know the geoecologic, pedologic and sedimentologic situation in the Namib desert around 30 000 BP, we accept Vogel's (1982) correction value of -1000 years for our geochronological evaluation. This does not exclude that the resulting time scale may have to be shifted further on by up to -2500 years. In this case, the end of speleothem formation might have coincided with the date of 23 000 BP obtained from wood found in silts at Homeb (Vogel 1982).

Table 1. Conventional C14 ages, C14 content (pmc) and δC13 values (‰) from speleothems of the Rössing cave in the Namib desert.

Hv	KOO	substance	RC age (years BP)	RC content (pmc)	δC13 (‰)
11634	610	stalagmite	26 630 ± 500	3.6 ± 0.2	-5.4
11635	613	flowstone	26 780 ± 360	3.6 ± 0.2	-7.9
11636	612	flowstone	29 830 ± 660	2.4 ± 0.2	-3.6
11637	616	flowstone	33 590 ± 1200	1.4 ± 0.2	-4.0
11638	619	flowstone	36 950 ± 1040	1.0 ± 0.1	-5.0
11639	621	stalactite curtain	37 000 ± 1700	1.0 ± 0.2	-6.8
11640	622	cave popcorn	41 500 ± 1280	0.6 ± 0.1	-5.3
9909	162	cave popcorn	29 700 ± 1360	2.5 ± 0.4	-4.5
9910	162a	cave popcorn	26 700 ± 540	3.6 ± 0.2	-5.7
9489	162(1)	cave popcorn	26 530 ± 920	3.7 ± 0.4	-2.0

PALAEOCLIMATIC IMPLICATIONS

Our results of radiometric datings together with sedimentologic observations at the sampling sites in the Rössing cave yield a rather differentiated picture of the Late Quaternary evolution of the climate in the Namib desert (Heine 1982). Various phases can be distinguished for the Middle Weichselian pluvial and other phases occurring up to the present. Once dates of the time before 41 000 BP become available, it will be possible to elongate the sequence by counting phases backwards:

PHASE 5: 40 000-34 000 BP

At the end of this phase, the Last Weichselian pluvial with compact sinter formation terminated within the Namib desert. Missing sand inclusions indicate that a closed plant cover might have existed. In view of the popcorn formation, the humidity must have been higher than later on. Various wall coatings may date back, however, to the Early Quaternary or even to the Tertiary.

PHASE 4: 34 000-27 000 BP

This phase is the beginning of the aridification in the central Namib. At least three noticeable climatic fluctuations occurred during which more humid conditions were replaced by more arid ones and vice versa. This is indicated by intercalating sand layers which account for a more windy climate and probably not completely closed plant cover. However, it was still humid enough for formation of compact sinter. This phase coincided with the calcrete formation on the 40 m terrace along the Kuiseb River (Vogel 1982) which lasted from 33 000 to 28 000 BP.

PHASE 3: c. 27 000-25 500 BP

Humid conditions predominated once more and compact sinter without aeolian sand inclusions was formed. It is not known whether this was due to decreasing wind activity or once more to a completely closed plant cover in the Namib desert. The humidity dropped drastically at the end as popcorn formation ended. Phase 3 and 4 may be identical. During this phase the rainfall intensity in the interior increased and pebble deposits from the 40 m terrace of the Kuiseb River were removed (Vogel 1982).

PHASE 2: 25 000-19 000 BP

From this time onwards the Namib desert remained dry. No further sinter formation occurred in the Rössing cave. However, according to Heine (1982) the interior of SW Africa was more humid than it was after 19 000 BP. In the Kuiseb valley, dunes started to block the river bed and vlei silt was deposited. At the end of this phase the aridification of the Namib desert was complete (Van Zinderen Bakker 1983a, b).

PHASE 1: after 19 000 BP

According to our own data from the Rössing cave as well as the results of other publications mentioned already, major climatic fluctuations no longer occurred. The Namib desert and the eastern escarpment remained under arid conditions contrary to the assumption by Rust and Schmidt (1981) that the area between 22 and 23 °S had been humid during the last Pleniglacial.

One of the most important findings of our study is that one has to be careful not to transpose chronostratigraphic sequences from one area to another as different palaeoclimatic events might have been responsible. Therefore, correlations between, for instance, different South African stratigraphies and their comparison with the marine oxygen isotope record can only make sense if at least the palaeogeographical situations are taken into account. Hence, our chronology of the climatic evolution within the Namib desert can be of regional importance only. Owing to the long history of the Rössing cave since the Tertiary, this cave with its speleothems seems to be one of the most suitable places for reconstructing the palaeoclimatic evolution of the Namib desert near 22° 30'S.

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