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RADIOCARBON CHRONOLOGY OF LATE QUATERNARY LAKES IN THE KALAHARI, SOUTHERN AFRICA

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SUMMARY

Some radiocarbon dates concerning the late Quaternary development of the southern Kalahari and the Ngami-Makgadikgadi area are given. The southern Kalahari is characterized by pluvial conditions during the last glacial maximum (ca. 19,000 to 12,000 yr b.p.) and relatively arid conditions during the Holocene and before ca. 19,000 yr b.p.. A very high lake level in the Makgadikgadi depression occurred during ca. 30,000 to 19,000 yr b.p.; here the last glacial maximum was arid; a second pluvial period with less high lake levels is dated ca. 12,000 yr b.p.. Minor fluctuations of the Makgadikgadi lake level eventually occurred during the Early Holocene. The preliminary chronostratigraphy is shown in table 1.

ZUSAMMENFASSUNG

Einige ^{14}C-Daten zur spätquartären Entwicklung der südlichen Kalahari und des Ngami-Makarikari-Gebietes werden vorgestellt. Die südliche Kalahari wird durch pluviale Bedingungen während des letzten Hochglazials (ca. 19 000 bis 12 000 B.P.) und durch relativ aride Bedingungen während des Holozäns und vor ca. 19 000 B.P. charakterisiert. In der Makarikari-Depression bestand ein sehr hoher Seespiegel während ca. 30 000 bis 19 000 B.P.; hier war das letzte Hochglazial arid; eine zweite pluviale Phase mit weniger hohem Seespiegel wird auf ca. 12 000 B.P. datiert. Geringere Fluktuationen des Makarikari-Seespiegels gab es vermutlich im Frühholozän. Eine vorläufige Chronostratigraphie wird in Tabelle 1 wiedergegeben.

The recent increase in observational evidence for late Quaternary moist periods in North Africa, East Africa, Arabia, and Australia (ROGNON & WILLIAMS 1977, BUTZER et al. 1972, GASSE 1977, McCLURE 1976, BOWLER 1975), derived largely from dating and analysis of lake sediments, has been accompanied by little attention on fossil lake beds in the Kalahari of southern Africa, although fossil lakes have long been known to exist in the Kalahari region (PASSARGE 1904, JAEGER 1939, LANCASTER 1974). The results of a preliminary attempt to establish the age of a series of late Quaternary sediments and fluvial deposits in the Kalahari region are reported here.

The Kalaharian zone is situated on a plateau generally more than 1,000 m above sea level in Botswana, eastern South West Africa (Namibia), and north western Transvaal, stretching from the Okavango River in the north to close to the Orange River in the Republic of South Africa in the south (Fig. 1). It is flat or gently undulating, with sand dunes more frequently occurring in the south west. The true Kalahari os a huge sand-filled basin (DE VOS 1975). The zone is semi-arid. Rain-

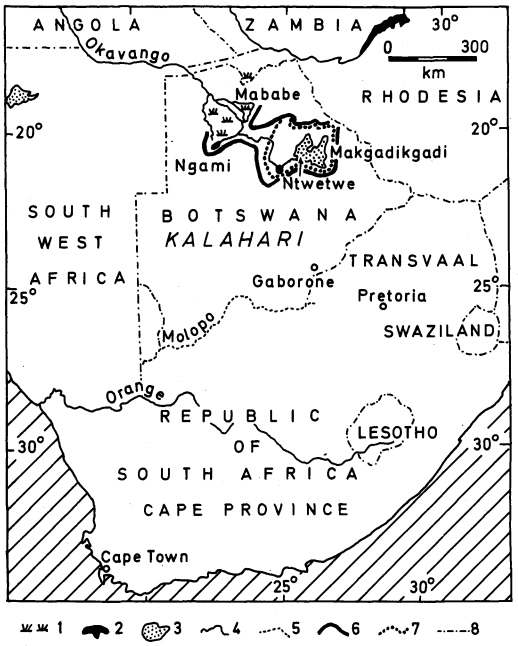

Fig. 1: Location map of places mentioned in the text. 1, Swamp; 2, Lake; 3, Pan; 4, Perennial river; 5, Valley with episodical run-off; 6, Fossil lake shore during the most extensive late Quaternary transgressive phase; 7, Minor fossil lake shore; 8, International border.

fall is erratic, confined mainly to the period November to April and decreasing from about 500 mm annually in the north and east to about 200 mm in the south west. From 22° latitude southward the zone is dry grasland and savanna, recieving only little and unreliable rainfall (DE VOS 1975, DIEM 1977). The summer climate is dry and continental. Scarcity of surface water and poor soils are the main limiting factors to vegetative growth (COLE & BROWN 1976). Ground waters in the northern Kalahari are directly, and in some cases rapidly, recharged by rain (VERHAGEN et al. 1974). Surface water is available in only a few areas for a short time after the rains, when it collects in pans or shallow depressions. These pans play an important role in the ecology of the area (DE VOS 1975).

Lacustrine deposits are associated with spring tufas and other related deposits, paleosols, aeolian and alluvial deposits and hold the key to the late Quaternary geomorphological and climatic evolution of the area. The lacustrine deposits consist of calcareous and sometimes fossiliferous marls, clays, and silts and sometimes contain snails and shells. Morphological, stratigraphical, and palaeontological criteria indicate the presence of two main generations of lake beds in the Ngami-Okavango-Makgadikgadi region. The older lake may on one or more occasions have formed a very large and continuous body of water with the Okavango-Mababe-Ngami depression (GREY & COOKE 1977), estimated to have been about 60,000 km^2 in area. Aeolian sands antedate the sediments of the younger lake. The 'contouring' of the slopes of dunes of the Ntwetwe pan in the Makgadikgadi is believed to have been caused by the retreating waters of the younger lake that flooded the pan after the formation of the dunes (GROVE 1969).

In the southern Kalahari the fossil bearing fluvial deposits of the Molopo River are underlain by aeolian sands; modern dune sands of light colour cover the fluvial sediments of the valleys, whereas the sand ridges of the neighbouring areas show the bright red colour which is characteristic of the Kalahari dunes.

Radiocarbon dating of the lake beds from the Ngami-Makgadikgadi basins and of the fluvial sediments of the Molopo supports the hypothesis that two main periods of high water level occurred in the northern and middle Kalahari during the late Quaternary whereas the southern Kalahari is characterised by only one pluvial period (Table 1). In the tropical part of the Kalahari the dates place the first pluvial lake between 31,000 (or older) and 19,000 yr b.p., and the different stages of the second pluvial lake between ca. 12,000 and 9,000 yr b.p. (and younger). An arid period between ca. 19,000 and 12,000 yr b.p. separates the two pluvial lakes. In the subtropical southern part of the Kalahari as well as in the Cape province (VAN ZINDEREN BAKKER 1976) the period between ca. 19,000 and 12,000 yr b.p. shows fairly wet climatic conditions (pluvial).

Table 1: THE MAIN STAGES IN THE LATE QUATERNARY EVOLUTION OF THE NGAMI-MAKGADIKGADI BASINS AND THE MOLOPO RIVER VALLEY

Ngami-Makgadikgadi basins (19° - 21°S)				Molopo River valley (ca. 27°S)			
^{14}C Age (yr b.p.)	Sedimentary facies		Humidity	^{14}C Age (yr b.p.)	Sedimentary facies		Humidity
	aeolian sand and calcrete	alternating lake levels	alternating from wetter to drier		aeolian sand	sand ridges (dunes)	very dry with wet intervals
C- 8,720±95 (Hv 8383) C- 9,390±80 (Hv 8378)	calcrete	high lake levels (920 m strand lines?)	wetter				?
M 11,920±$^{1630}_{1270}$ (Hv 8367)	lacustrine sediments		wet/ very wet				?
C+ 13,275±110 (Hv 8380) C+ 14,300±190 (Hv 8386) C+ 14,620±90 (Hv 8381)	Dune sand, fluvial sand near the Okavango delta	low lake level	dry	Mf 12,480±220 (Hv 8372) Mf 15,580±350 (Hv 8368)	fluvial deposits (sand, silt, clay) gravel	perennial river	wet
M 19,170±660 (Hv 8366) L 20,835±355 (Hv 8365) 20,990±1100 (+) L 24,330±270 (Hv 8364) M 25,910±$^{1210}_{1000}$ (Hv 8371) L 27,050±450 (Hv 8379) M 27,350±550 (Hv 8370) L 30,250±520 (Hv 8382) C+ 31,750±500 (Hv 8387)	lacustrine sediments (chalk, marl, silt, clay)	very high lake level (946 m shoreline?)	very wet		aeolian sand	sand ridges (dunes)	? dry
	?		?				?

(+) High Makgadikgadi lake level dated by A.T. Grove, see ref. 17 and ref. 1, p. 306.
L Lacustrine chalk, indicating high lake level.
M Mollusca, indicating high lake level and/or fresh water supply.
Mf Mollusca, indicating a perennial river.
C- Calcrete without fossil calcite fragments.
C+ Calcrete with fossil calcite fragments; the ^{14}C determination does not represent the true age of the calcrete formation

The preliminary chronostratigraphy (Table 1) confirms the assumption that the major environmental changes along the temperate and tropical margins of the Kalahari seem to be in phase with the variations in precipitation and evaporation in North and East Africa as well as in Arabia and Australia. Variations in temperature seem to be synchroneous worldwide; variations in humidity depend on a shifting of the climatic belts during the late Quaternary and therefore do not occur synchroneously in various regions of southern Africa. In the Kalaharian zone, as in North and East Africa, Arabia, Australia, and Mexico (HEINE 1974, 1977), we have to distinguish between the following periods with different climatic conditions: (1) the high glacial period (19,000 to 12,000 yr b.p.) characterised by a cool and arid climate in the northern, western, middle, and eastern Kalahari and a cold and humid climate (winter rains) in the southern Kalahari, (2) the interstadial period ($\geq$ 31,000 - 19,000 yr b.p.) and the late Pleistocene/early Holocene (12,000 - 9,000 yr b.p.), both periods are characterised by pluvials in the Kalahari, and (3) the postglacial period (< 9,000 yr b.p. = Holocene) with a warm and semihumid climate (tropical summer rains) in the northern, western, middle, and eastern Kalahari and a warm and semi-arid climate (subtropical anticyclone) in the southern Kalahari.

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