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Palynological evidence for vegetation patterns in the Transvaal (South Africa) during the late Pleistocene and Holocene

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ABSTRACT

Palynological evidence relating to the nature of Late Quaternary vegetation types and plant migrations in the Transvaal is briefly summarized. It is suggested that, after an early temperate, relatively moist phase and a subsequent relatively dry phase lasting until about 25 000 yr B.P., a vegetation-type with ericaceous elements developed. It resembled belts presently occurring above the treeline and was possibly widespread over the plains of the Transvaal during the last glacial maximum period. In the central parts of the province, warm semi-arid savanna subsequently expanded during the early Holocene and was followed by a more broad-leafed type of woodland in the late Holocene. This change probably resulted from slightly wetter and, at times, also slightly warmer and cooler conditions.

RÉSUMÉ

PREUVE PALYNOLOGIQUE DE L'EXISTENCE DE TYPES DE VÉGÉTATION AU TRANSVAAL (AFRIQUE DU SUD) PENDANT LA DERNIÈRE PÉRIODE DU PLÉISTOCÈNE ET L'HOLOCÈNE

La preuve palynologique relative à la nature des migrations de plantes et des types de végétation à la fin du Quaternaire, au Transvaal est brièvement résumée. Il est suggéré qu'après une phase d'abord tempérée et relativement humide et ensuite une phase relativemant sèche perdurant jusqu'à environ 25 000 ans B.P., un type de végétation avec des éléments éricacés se développa. Il ressemblait aux étages qui se rencontrent actuellement au dessus de la ligne des arbres et étáit sans doute étendu sur les plaines du Transvaal durant l'apogée de la dernière période glaciaire. Dans les parties centrales de la province, des savannes chaudes semi-arides s'étendirent ensuite durant le début de l'Holocène et furent suivies par un type de forêt claire à feuilles plus larges. Ce changement résulta probablement de conditions légèrement plus humides et, à certains moments, aussi de conditions légèrement plus chaudes et plus froides.

INTRODUCTION

The purpose of this paper is to reconstruct the vegetation pattern of the Transvaal during the Late Quaternary by means of results obtained from pollen analyses of spring and other deposits and to assess the possible implications concerning migration and evolution. Marked climatic changes are reported to have occurred all over the world during the Pleistocene period and it is believed that, as elsewhere, these events had a major influence on the composition of the vegetation in Southern Africa. Up to now we have very little evidence of the nature of the Late Pleistocene vegetation types in the interior of the subcontinent. The important pollen diagram from Florisbad in the Orange Free State (Van Zinderen Bakker, 1957) which shows a change from a more karroid to grassland vegetation during the Late Pleistocene, is at present difficult to interpret in view of new age determinations (Rightmire, 1978) which show that the deposits are much older than previously believed. The pollen diagram from Aliwal North, Cape Province (Coetzee, 1967) only represents the terminal Pleistocene and early Holocene vegetation which developed after the amelioration of the full 'glacial' climate. Except for the oldest zone, the reconstructed vegetation does not differ widely from the present type which is transitional between karoo shrubland and grassland.

The framework for the present reconstruction was derived from pollen cores from organic and peat deposits of which the Wonderkrater thermal spring site, situated in the bushveld savanna of the low central plateau in the Transvaal (Fig. 1), is the most important. Details concerning the vegetation at Wonderkrater and large-scale pollen diagrams are presented by Scott (1982a). In the present paper, only idealized pollen diagrams (Figs 3 & 4) and a brief summary, compiled from data of four pollen profiles, are presented in order to demonstrate more clearly, changes in the environment. Supporting data from other sites in the region such as Rietvlei, Moreletta River, Scot, and Tate Vondo (Fig. 1), are

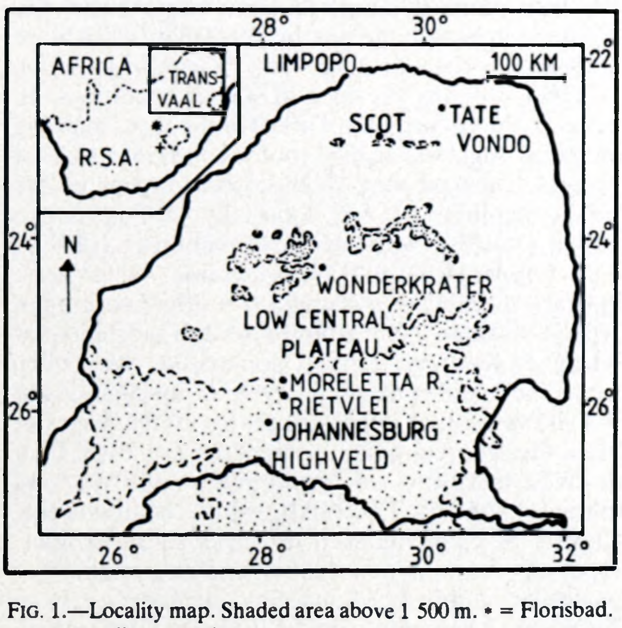

FIG. 1.—Locality map. Shaded area above 1 500 m. • = Florisbad. + = Aliwal North.

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also mentioned briefly. A study of the physiography, the climate and vegetation together with the results of 25 modern surface pollen samples from various vegetation types serve as a basis for the palaeoecological reconstructions (Scott, 1982a). The fossil pollen types and their significance in these reconstructions are described by Scott (1982b).

The pollen was extracted from the organic and peat deposits by means of standard palynological techniques mainly employing digestion in 10% KOH and mineral separation with $ZnCl_2$-solution (S.G. ±2). Eighteen relevant ^{14}C age determinations of various deposits were carried out by Dr J. C. Vogel of the CSIR, Pretoria.

THE POLLEN EVIDENCE AND INTERPRETATIONS

Micrographs of the most important indicator taxa are presented in Fig. 2. The pollen diagrams (Figs 3 & 4) from Wonderkrater show the regional pollen (A) which is made up of important AP (arboreal pollen) and NAP (non-arboreal) in the so-called pollen sum (Faegri & Iversen, 1964) and the total pollen composition (B) which consists largely of local elements. The regional palaeoenvironmental conclusions are based on the former and the percentage values mentioned below refer only to the pollen sum.

The earliest pollen zone (W1 in Fig. 3) which formed earlier than 30 000 yr B.P. consists of pollen assemblages differing widely from those produced by the present woodland type which falls within the area of Acocks's (1953) Sourish Mixed Bushveld (veld type 19). In total, the AP (arboreal pollen) is higher than in the present spectra. AP-taxa which are of importance are *Podocarpus* (≤34%), Oleaceae (≤14%) and Combretaceae (≤15%), whereas the modern pollen sum has lower AP-values consisting mainly of Combretaceae (≈6%), *Euclea* (≈6%), Tarchonantheae (≈ 5%) and relatively high numbers of NAP, especially Compositae (≈ 50%). Zone W1 is therefore thought to represent a relatively more mesic woodland on the plains and the high numbers of *Podocarpus* suggest that the montane forests in the nearby Waterberg were more extensive. The presence of *Kiggelaria* pollen (≤23%) supports the idea of wetter conditions. In general, the occurrence of small numbers of macchia elements suggests slightly cooler conditions than at present. The next zone (W2) shows a gradual decline in the numbers of AP, especially in *Podocarpus* pollen (≤10%), whereas Tarchonantheae (≤18%) and Capparaceae (≤14%) increase. This zone appears to indicate a change to a drier more open type of savanna. Zone W3 represents a short interval when *Podocarpus* (56%) dominated the pollen sum. The significance of this event is not clear. Zone W4 shows another important change in the diagram. Here the arboreal pollen content is even lower than in W2, consisting of *Podocarpus* (≤10%) and *Myrica* (≤26%). The NAP, which is important, consists of elements such as various Compositae, especially *Stoebe*-type (≤26%), and also smaller but persistent numbers of macchia elements such as Ericaceae, *Passerina* and *Cliffortia*. The reconstructed vegetation compares best with present types occurring above the treeline in the Drakensberg at altitudes of more than 1 000 m higher than Wonderkrater (1 100 m altitude). Therefore an average cooling of around 5–6°C is suggested. This cold phase corresponds with the last glacial maximum period recorded roughly between 28 000 and 14 000 yr B.P. elsewhere in the world.

The suggested lowering of vegetation zones by about 1 000 m would imply that cool open grassland or shrubland must have occupied most of the plateau above ±1 000 m. Preliminary findings from Pretoria and Venda also provide tentative support for a lowering in the vegetation belts such as is suggested by Zone W4 and may help to show that open vegetation was widespread. In those from Pretoria, open grassland or shrubland pollen with *Stoebe*-type and small numbers of indicators like Ericaceae and *Passerina* are recorded in current palynological studies of stream deposits in the Moreletta River (Fig. 1). Although no age for these layers is available, they are likely to be of Late Pleistocene or early Holocene age as they belong to the lower section of a ±50 cm layer of gray clay underlying a 20 cm peat layer with terminal age of ±5 220 yr B.P. (Verhoef, 1972). Spectra suggesting fairly open vegetation are also recorded from peats of ±2 m depth at Tate Vondo in Venda. Grass pollen is dominant and other NAP includes Ericaceae and *Passerina*. The AP consists mainly of *Podocarpus*, and also of some Combretaceae and *Myrica*. The results of current ^{14}C dating will help to determine the age of these spectra. Although it is not certain at this stage whether a vegetation type from above the treeline is represented, these results together with the data from the Moreletta River could eventually support those from Wonderkrater and help to demonstrate that the lowering of the treeline in the Late Pleistocene was quite widespread. Open vegetation could have extended as far north as Zambia in the present miombo woodland of 1 400 m altitude where there is tentative evidence for a more open vegetation in the form of a 22 000 yr old pollen sequence (Livingstone, 1971). This 5 m profile is dominated by grass pollen and below 0,5 m depth has fair numbers of *Podocarpus*, *Olea* and *Myrica* as the main AP component and shrubs such as Ericaceae and *Cliffortia* as NAP. Livingstone is, however, understandably cautious about his interpretation of this profile and did not provide a definite vegetational reconstruction.

At the end of the Pleistocene, climatic amelioration took place while Zone W5 at Wonderkrater was deposited (Fig. 4). The NAP, especially Chenopodiaceae (≤48%), is still very prominent, but there is a marked reduction in the percentages of macchia types while semi-arid woody elements reappear. The spectra of Zone W5 seem to represent an open dry savanna. During the next zone (W6), the Capparaceae (≤21%) and Tarchonanthaeae (≤25%) expand, while *Podocarpus* and Proteaceae pollen grains virtually disappear from the sequence. Very similar modern pollen spectra are recorded from the present warm Kalahari Thornveld (Acocks, 1953, veld type 16) of which the nearest small patch occurs

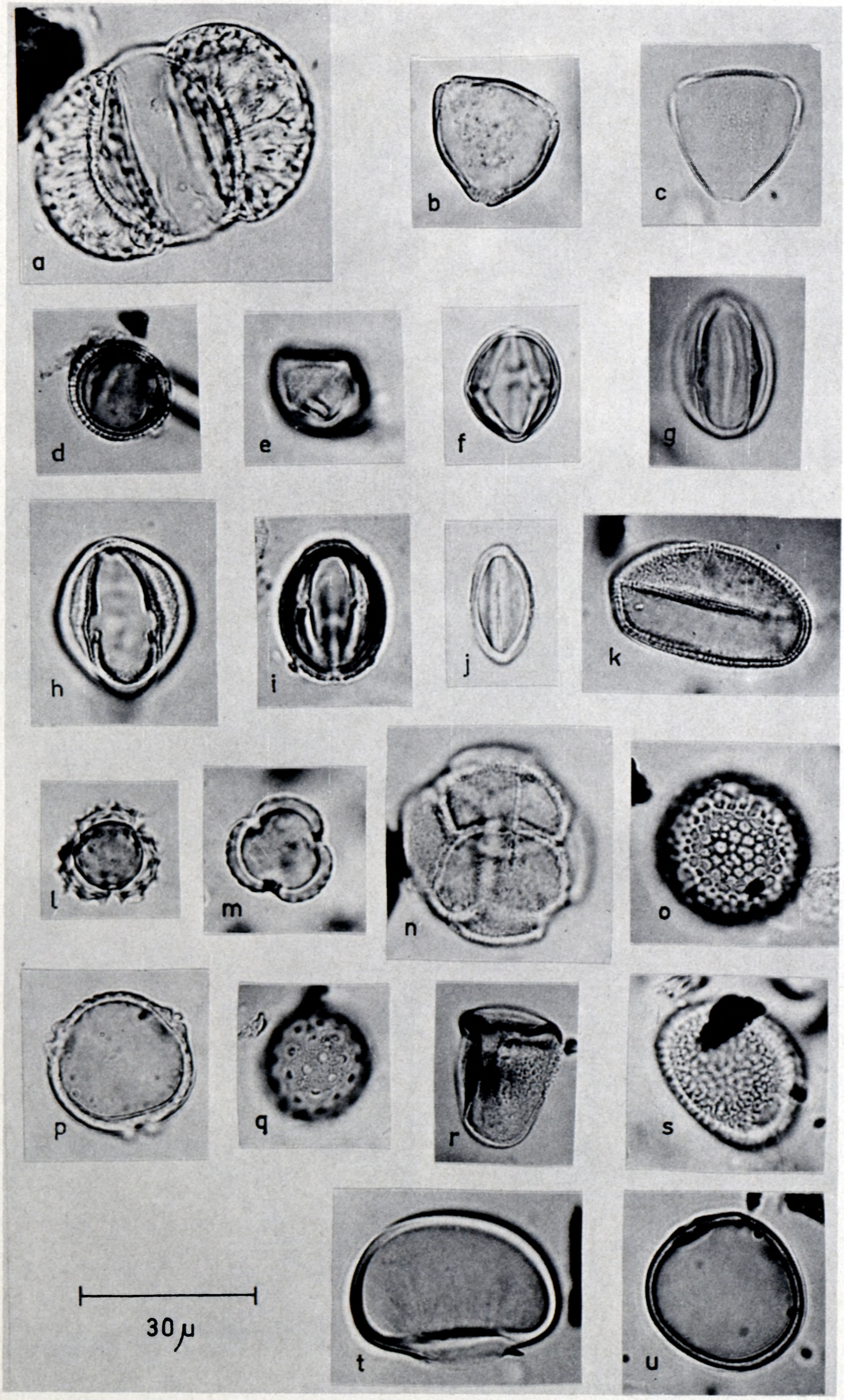

FIG. 2.—Some important fossil palynomorph types from Quaternary deposits in the Transvaal: a, *Podocarpus;* b, *Myrica;* c, Proteaceae; d, Oleaceae; e, *Burkea;* f, *Euclea;* g, Combretaceae; h, *Spirostachys;* i, Tarchonantheae; j, Capparaceae; k, Liliaceae; l, Compositae; m, *Stoebe*-type; n, Ericaceae; o, *Passerina;* p, *Cliffortia;* q Chenopodiaceae; r, Cyperaceae; s, *Typha;* t, Fern-spore; u, Gramineae.

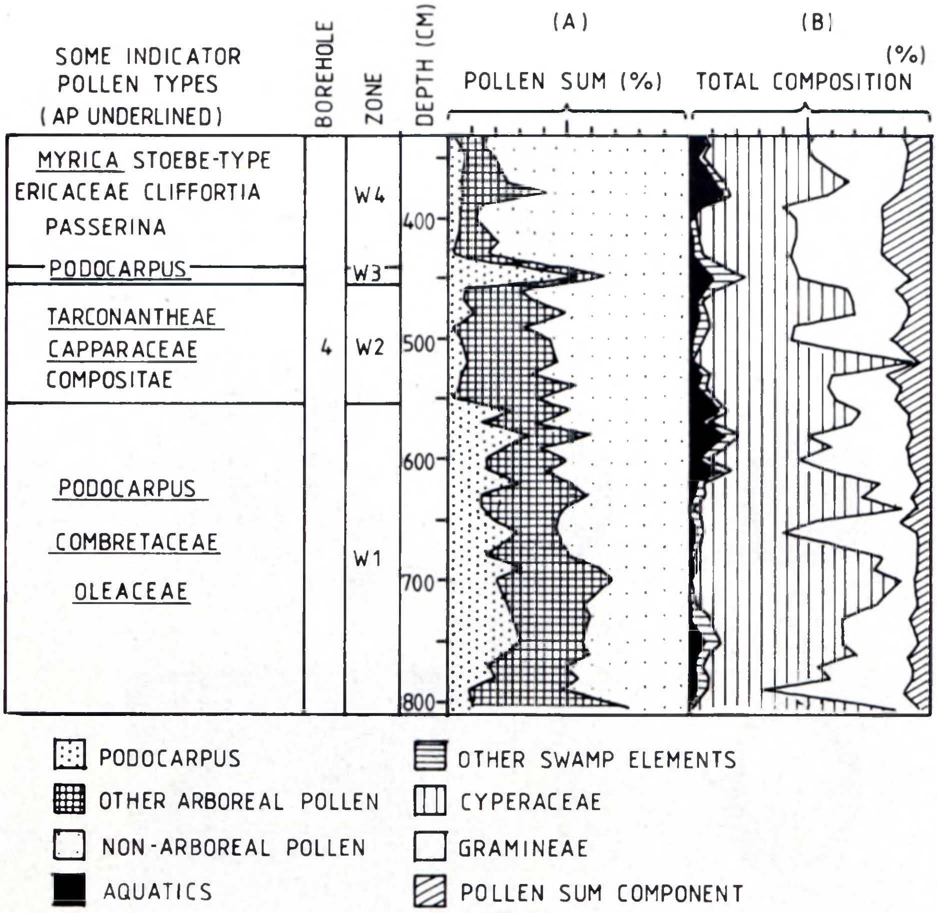

FIG. 3.—Pollen diagram of Late Pleistocene peat deposits from Wonderkrater (adapted from Scott, 1982a).

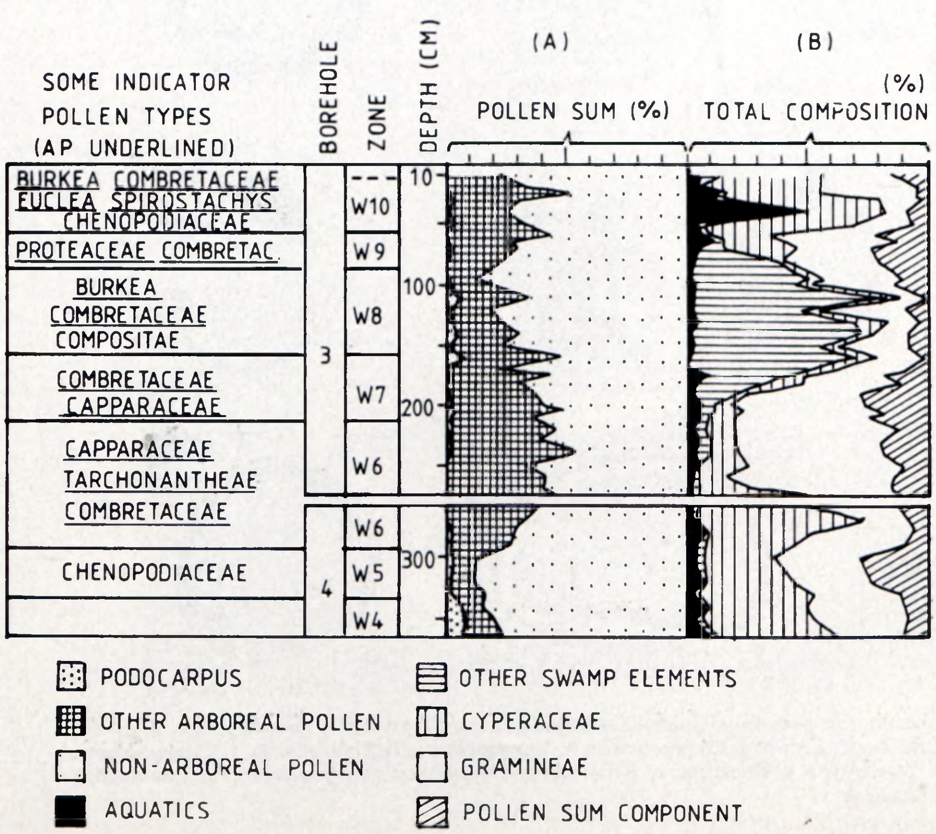

FIG. 4.—Pollen diagram of Late Pleistocene and Holocene peat deposits from Wonderkrater (adapted from Scott, 1982a).

about 100 km SSW of Wonderkrater around Pienaarsrivier Station. It is therefore possible that a similar kind of bushveld occupied a wider area and reached as far north as the foot of the Waterberg. In the next zone (W7), Combretaceae (≤18%) become important, whereas the Capparaceae and Tarchonantheae decline somewhat. Oleaceae and Proteaceae also return in small numbers and support the conclusion of a swing to slightly wetter conditions. In the next zone (W8), the AP shows a decline while NAP, especially Compositae (≤89%), becomes prominent. These spectra show a resemblance to modern surface pollen samples from upland woodland types and therefore possibly represent a more open, slightly cooler vegetation. The same kind of change also occurs around this time in a pollen sequence from the north of the Soutpansberg at 'Scot' (Scott, 1982). In the next zone (W9), bushveld pollen increases again and Combretaceae (≤16%) and Proteaceae (≤12%) become prominent. Comparison of these spectra with a surface spectrum from just north of Warmbad representing Sour Bushveld (Acocks, 1953, veld type 20) and dominated by *Faurea saligna,* shows strong similarities and suggests that it again became warmer, while slightly more humid conditions than at present still persisted. It is possible that this zone is coeval with an event recorded in the southern Transvaal highveld when a temporary expansion of the woodland occurred over the northern parts of the plateau at Rietvlei (Scott & Vogel, in preparation). However, this expansion might also have occurred earlier, coinciding, perhaps, with the deposition of the slightly mesic Zone W7 or W6b at Wonderkrater. Current ^{14}C-dating of the Rietvlei profile will throw more light on this occurrence. The nearby Moreletta River pollen sequence (in preparation), however, suggests that a marked increase in the trees of the region occurred some time after 5 220 B.P. The present savanna at Wonderkrater seemed to have developed in the youngest zone (W10) during the last 1 000 yr B.P., although there are signs that *Burkea* (≤25% pollen) was temporarily more important during this phase. The only evidence for human presence is found in the form of traces of *Zea* pollen late in the development of Zone W10.

DISCUSSION

It can be concluded that large-scale migrations of the vegetation types as suggested by pollen evidence were caused by climatic oscillations. It is difficult to estimate to what extent vegetation units migrated as a whole, but it seems likely that at certain times when new conditions arose, new combinations of species were present. For instance, Zone W2 combines elements like Capparaceae, Tarchonantheae and Combretaceae, with fair numbers of *Podocarpus* and smaller numbers of *Myrica, Kiggelaria* and macchia pollen. It is believed that the past environment in this case required a combination of temperature and moisture conditions (probably within the cooler temperate, dry sub-humid range) with a particular wind, frost and seasonal rainfall pattern which probably does not occur anywhere in Southern Africa at present. In view of the persistent oscillating nature of climatic conditions, it also seems reasonable to hypothesize that a vegetation type like the grassland with macchia-type shrubs suggested by Zone W4, was a more important part of the Quaternary scenery in Southern Africa than at present. Similarly, it will possibly be shown in future that other ecosystems like the karoo or fynbos vegetation types were more extensive during certain periods in the past. The expansion of karoo in the Pleistocene has in fact already been suggested by the pollen diagram from Florisbad in the O.F.S. (Van Zinderen Bakker, 1957).

In conclusion, the Late Quaternary record in the Transvaal seems to show a constantly migrating vegetational system but, as far as evolution of new taxa is concerned, no sign of it can be detected palynologically over this relatively short time interval. The method can, by its nature, not show evolutionary changes in plants, but only the appearance or disappearance of pollen taxa in the fossil record. Evolution of new pollen taxa only becomes noticeable over a longer time sequence ranging into the Tertiary. The modern macchia in the Cape Province evolved during the Tertiary together with the considerable and more lasting cooling of the climate in the Miocene (Coetzee, 1978). Before this cooling, the vegetation in the Transvaal region must also have been more tropical, but at this stage any fossil evidence of its nature is lacking.

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