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THE OORLOGSENDE PORPHYRY MEMBER, SOUTH WEST AFRICA/ NAMIBIA: ITS AGE AND REGIONAL SETTING

by

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ABSTRACT

The age of 1094 $^{+18}_{-20}$ m.y. of the Oorlogsende Porphyry (Area 2120) supports correlation with the Nückopf Formation, an equivalent of the Sinclair Sequence. The rocks form a tectonic sliver, and their position suggests that the southern Damara thrust belt continues into the Epukiro area. Dependent on whether the Kgwebe formation in Botswana is considered coeval with either the Eskadron Formation (Witvlei area, Gobabis District) or with the Nückopf Formation of central South West Africa/Namibia, the correlation of the Ghanzi Group in Botswana with only the Nosib Group or with both the Eskadron Formation and the Nosib Group of South West Africa/Namibia is implied.

UITTREKSEL

Die ouderdom van 1094 $^{+18}_{-20}$ m.j. van die Oorlogsendeporfier (Gebied 2120) steun korrelasie met die Formasie Nückopf, 'n ekwiwalent van die Opeenvolging Sinclair. Die gesteentes vorm 'n tektoniese wig en hul posisie dui aan dat die suidelike Damara-oorskuiwingsone in die Epukiro-gebied voortsit. Afhanklik daarvan of die Formasie Kgwebe in Botswana as gelyk oud beskou word met óf die Formasie Eksadron (Witvleigebied, Distrik Gobabis) óf die Formasie Nückopf van die sentrale Suidwes-Afrika/Namibië, word die korrelasie van die Groep Ghanzi in Botswana met alleen die Groep Nosib, of met albei die Formasie Eskadron en die Groep Nosib van Suidwes-Afrika/Namibië aangedui.

1. INTRODUCTION

The Oorlogsende Porphyry, exposed in eastern South West Africa/Namibia, occurs about halfway between the outcrops of similar rocks near Witvlei and in northwestern Botswana (Fig. 1). It forms isolated outcrops along the sandcovered, northeastern extension of the tectonic zone underlain by pre-Damaran rocks that fringes the thrust-faulted southern margin of the Damara Orogen. Aeromagnetic surveys indicate that faulting (thrusting?) was as extensive in this area as further to the south-west. Correlations are complicated by sand cover, lack of exposed contacts and faulting and must rely on radiometric age determinations. On the basis of age and composition, the porphyry is considered to be part of the Nückopf Formation, an equivalent of the upper Sinclair Sequence. Formerly, it was included in the Skumok Formation (Schalk 1961; Geological Map of South West Africa 1963; Martin 1965), a name that is now obsolete.

2. OCCURRENCE AND DESCRIPTION OF THE ROCKS

Several isolated outcrops of feldspar-quartz porphyry occur over a distance of 9 km in the Epukiro Omuramba and its tributaries in Hereroland East (Area 2120; 21°25'S, 20^{0}15'E), halfway between the Red Line and Oorlogsende (Fig. 2). The nearest site to lend a name is Oorlogsende, a deserted cattle-post situated about 8 km to the east of the easternmost porphyry outcrop. No rock type other than the porphyry is exposed.

The porphyry is a massive, hard, grey to black rhyolitic rock with a light brownish weathered crust. Weathered surfaces reveal an ubiquitous, steeply dipping flow banding, defined by straight to undulating or crumpled lamellae, some millimetres thick. About 20 per cent of the rock consists of phenocrysts, 1 to 2 mm across, predominantly of zoned pink feldspar and some light-grey quartz. Many feldspar phenocrysts are broken along planes aligned at a high angle to the long axis of the crystals. Locally, pyrite cubes up to 5 mm across are also present. The microcrystalline matrix is dark grey.

The porphyry, considered to be a tuffaceous ignimbrite, is unmetamorphosed, but displays an intense fracture cleavage in many places, mainly aligned in a NE-SW direction; the dip varies mostly around vertical. In many cases, the cleavage is parallel to the flow banding.

The uppermost portions of the exposures are disintegrated by weathering and pass into scree, up to 5 m thick, which also contains pieces of vein quartz. The scree is cemented by calcrete and subordinate silcrete, and is overlain by sandy cavernous silcrete of the Kalahari Sequence.

Porphyry of the same appearance as that near Oorlogsende was struck in boreholes through cover of Kalahari, all situated south-west of the surface outcrops: along the Red Line (Fig. 2), on farm, 832 (north-western Rietfontein Block, Area 2120CA) and on farm Islaverda 432 (Area 2119DB) (Fig. 1). The north-eastern continuation is not known; it would fall within zone 9 of the Aeromagnetic Interpretation Plan of the Herero-

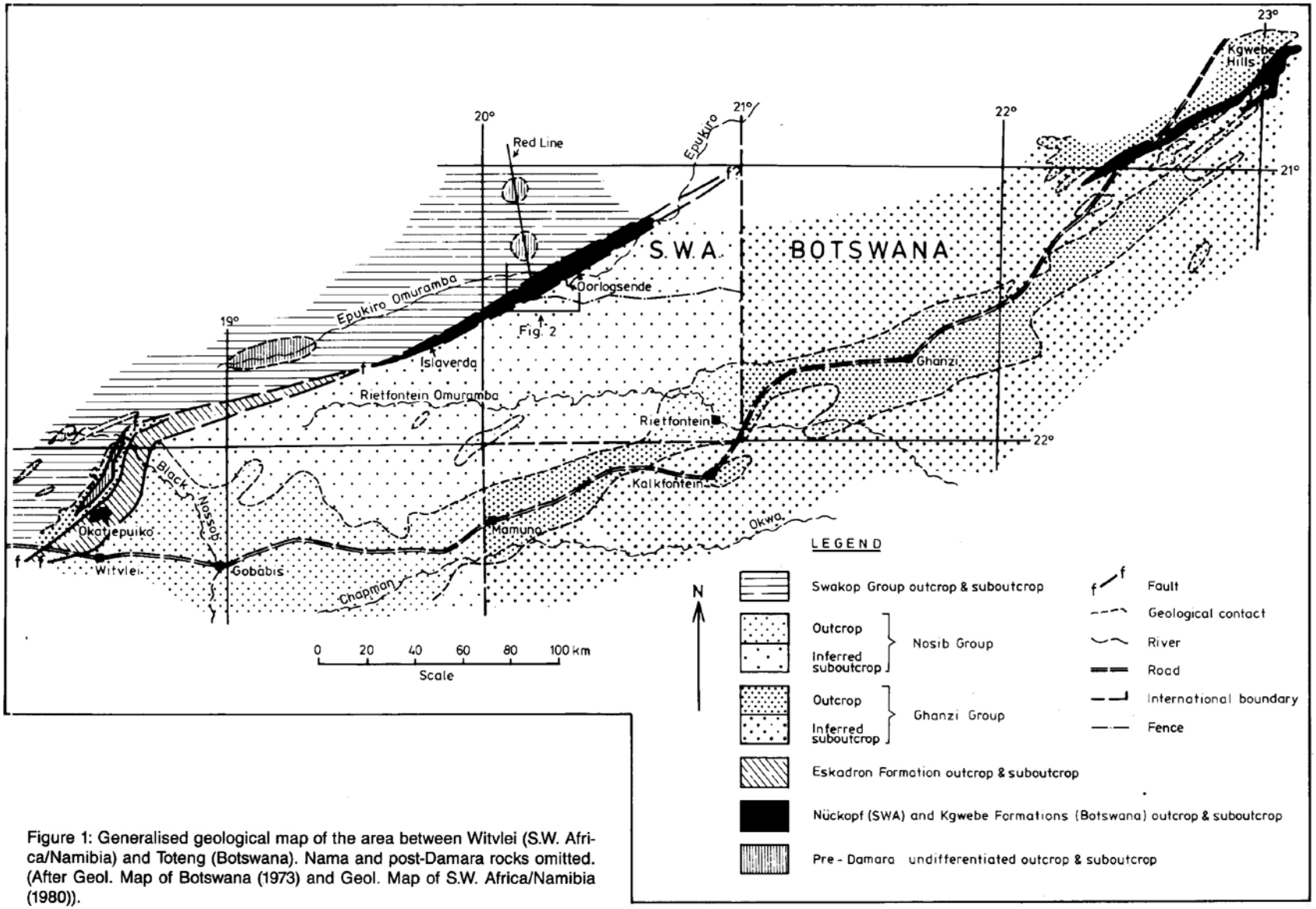

Figure 1: Generalised geological map of the area between Witvlei (S.W. Africa/Namibia) and Toteng (Botswana). Nama and post-Damara rocks omitted. (After Geol. Map of Botswana (1973) and Geol. Map of S.W. Africa/Namibia (1980)).

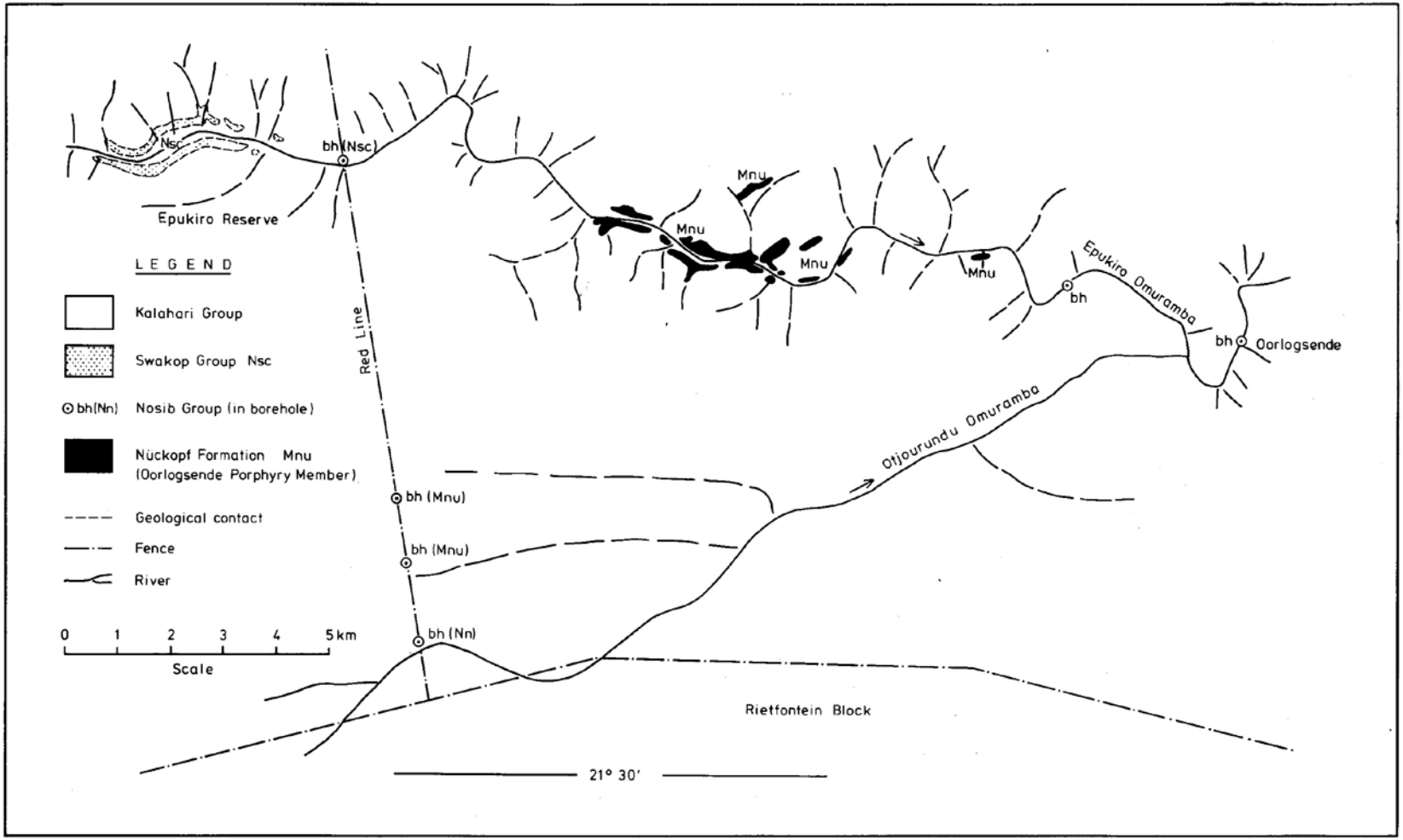

Figure 2: Position of the outcrops of the Oorlogsende Porphyry.

land Block (Köstlin 1978), which contains several horizons and can be traced to the Botswana border (Fig. 1). From the scant data available, it would appear as if the porphyry is confined to a belt more than 60 km long but possibly only a few kilometres wide.

In the north-west, the Oorlogsende Porphyry seems to be bounded by rocks of the lower Swakop Group, although there is a distance of 7 km between outcrops of the two successions. A phyllitic succession occurs to the south-east of the porphyry. This is known only from boreholes and was tentatively correlated with the Duruchaus Formation of the Nosib Group (Geological Map of South West Africa/Namibia, 1980); still further to the south-east, quartzites of the Kamtsas Formation (Nosib Group) occur. Being of pre-Damara age and occurring between two stratigraphically and structurally distinct domains of the Damara Sequence, the Oorlogsende Porphyry is believed to form a thrust sheet similar to those which are abundant in the better exposed areas further to the south-west between Dordabis and the Gamsberg; this interpretation suggests that the southern Damara thrust belt continues into the Epukiro area.

3. ANALYTICAL PROCEDURE AND PRESENTATION OF DATA

Seven samples of the Oorlogsende Porphyry were collected along the Epukiro Omuramba for age determination (WHG 25, OE 1 to OE 6); of these OE 3 and OE 5 had to be omitted on account of insufficient zircon content.

Crushed rock samples were processed following procedures outlined by Oosthuyzen and Burger (1973) in order to obtain zircon concentrates. Following Krogh (1973), sample dissolution was carried out in high-pressure, teflon-lined steel capsules, and lead and uranium analyses were made off rhenium filaments in an AEI MS503 mass spectrometer. Lead isotope ratios for common lead corrections for calculating isotopic ages were taken from equations used by Stacey and Kramers (1975). The accuracy of measurements of U and Pb is better than one per cent; sample sizes were in excess of 100 mg and both lead and uranium blanks were low enough to obviate the need for blank corrections; further details are given in Schoch *et al*. (1975, p. 98).

The discordant U-Pb data (Table 1) are presented on a concordia plot (Wetherill *et al*., see Doe 1970). A least-squares cubic calculation (York 1966) yielded a concordia-age of $1094\ ^{+18}_{-20}$ m.y. (Fig. 3). The Wendt-York method (Brooks *et al*. 1968; York 1966) was employed to construct a discordiagram. Ratios were accorded different weights ranging from 100 per cent at concordance to zero at the point of origin. The intercept of the best straight line was given at 95 per cent confidence level. An age of $1\ 094\ ^{+18}_{-20}$ m.y. is suggested (Fig. 3).

Zircons were mostly stubby, euhedral crystals with numerous inclusions (Figs. 4 and 5). Analyses of total WGH 25 population revealed a rather high uranium concentration, slightly high $^{207}Pb/^{206}Pb$ ages, but a grossly

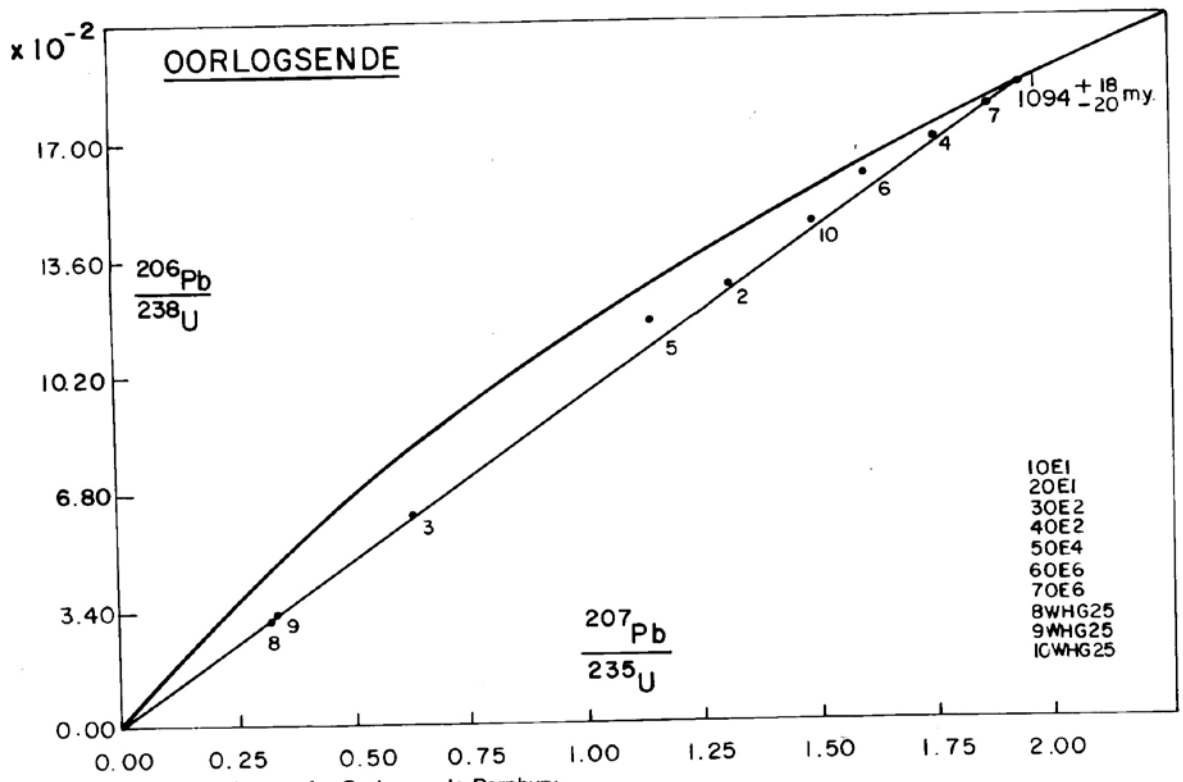

Figure 3: Discordia diagram for Oorlogsende Porphyry.

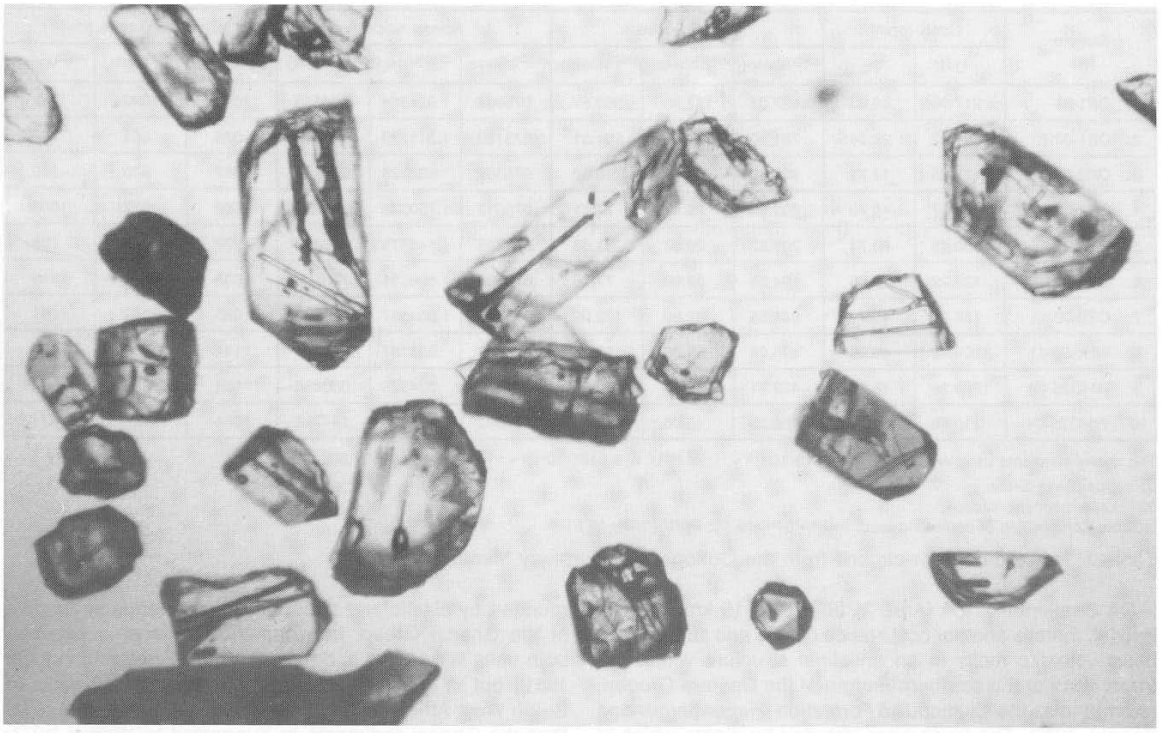

Figure 4: Zircon crystals from WGH 25. Note variety of inclusions as well as metamict (dark) crystals.

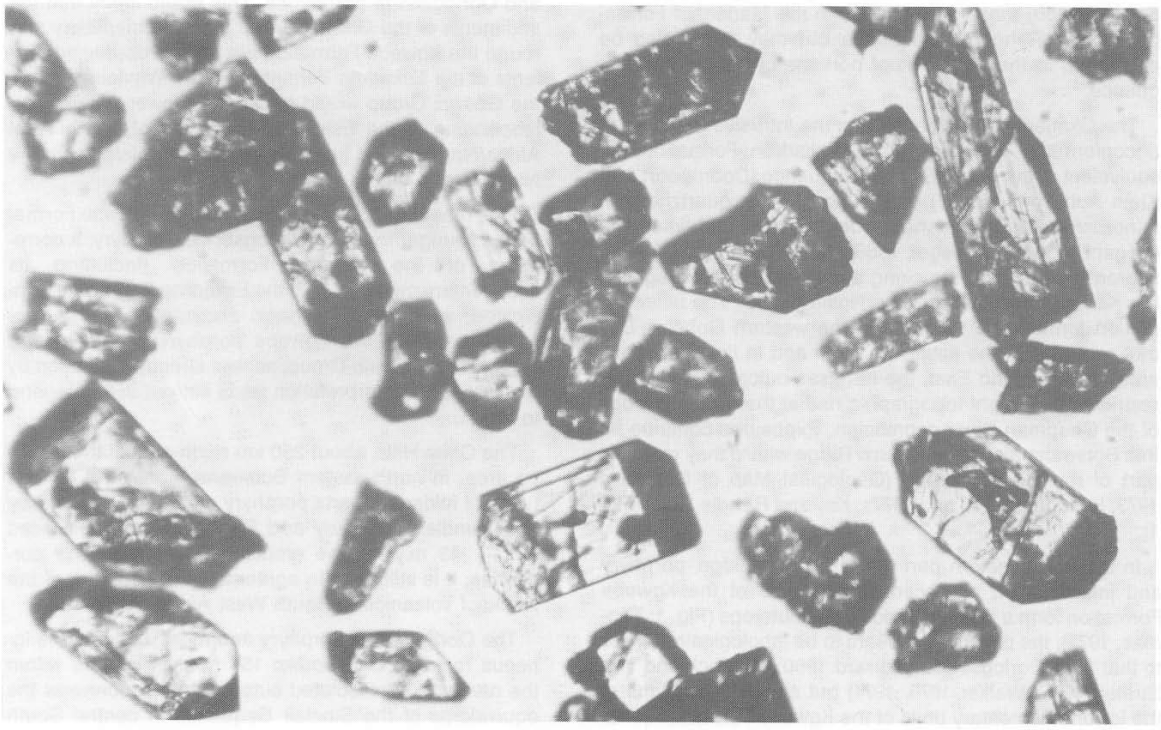

Figure 5: Zircon crystals from OE 1. Again a variety of inclusions rather similar to WGH 25.

discordant age pattern. A lesser magnetic fraction with less inclusions and metamict crystals, however, yielded an age similar to the OE samples.

4. DISCUSSION AND REGIONAL IMPLICATIONS

The age of 1 094 $^{+18}_{-20}$ my of the Oorlogsende Porphyry (Fig. 3) supports its correlation with and inclusion as a member in the Nückopf Formation, for which a number of age determinations, ranging between 1 010 and 1 232 m.y. are available (South African Committee for Stratigraphy, 1980).

The question arises whether confirmation of the stratigraphic position of the Oorlogsende Porphyry could help to elucidate correlation problems concerning successions in eastern South West Africa/Namibia and north-western Botswana.

On Okatjepuiko 154 (Area 2218), some 15 km north of Witvlei, there is another occurrence of acid and subordinate basic volcanic rocks in an anticlinal structure within the thrust zone at the southern margin of the Damara Orogen, referred to as the Okatjepuiko Formation (Hegenberger and Seeger, 1976). The lavas were intruded by diorite which is 1154 ± 30 m.y. old (one point determination; Burger and Walraven, 1979, p. 207); this is also the age of the Nückopf Formation. The lavas which, in contrast to the diorite, are intensively sheared, are therefore probably older than the Nückopf Formation. On the Geological Map of South West Africa/Namibia (1980) and according to Hegenberger and Seeger (1980) these are included in the Marienhof Formation of the Rehoboth Sequence but they could also be equivalent to the pre-Nückopf portions of the Sinclair Sequence.

The Okatjepuiko Formation and the intrusive diorites are unconformably overlain by the Eskadron Formation, an equivalent of the upper Sinclair Sequence (Doornpoort and Klein Aub Formations?) consisting of thick quartzite with minor intercalations of shale, conglomerate and limestone (Hegenberger and Seeger, 1980). To the south-east the Eskadron Formation abuts along a major thrust zone against the Kamtsas Formation of the Nosib Group. The latter formation forms large outcrops in the western Gobabis District, whereas in the eastern portion and in the Rietfontein area of Hereroland East, the Kamtsas outcrops are mainly restricted to a slight topographic rise at the northern slope of the Chapman River depression. Exposures continue far into Botswana along the Ghanzi Ridge where they make up part of the Ghanzi Group (Geological Map of Botswana 1973; Litherland 1977 and 1977a; Key and Rundle 1981) (Fig. 1).

In the north-eastern part of the Ghanzi Ridge, porphyry and interstratified arenaceous sediments of the Kgwebe Formation form a number of scattered outcrops (Fig. 1; Thomas, 1973); the porphyry appears to be lithologically similar to that from Oorlogsende (Gerrard 1960; Boocock and Van Straten 1962; Walker 1973, 1974) but contains xenoliths of the lower sedimentary units of the Kgwebe Formation (Thomas 1973). The outcrops of the Kgwebe Formation are surrounded by clastic and subordinate calcareous sediments of the Ghanzi Group, however, the relationship between both units still seems to be uncertain (see Key and Rundle 1981), but in accordance with the corresponding rocks in South West Africa/Namibia, the porphyry is probably older than the Ghanzi sediments as suggested by Walker (1973) who observed that the Ghanzi rocks rest with apparent conformity upon the Kgwebe Formation.

A minimum age of 821 ± 43 m.y. of the Kgwebe porphyry (Key and Rundle 1981) can be interpreted in two ways:

a) It does not rule out a contemporaneity of the Kgwebe

Sample No.	Conc. (ppm)		Isotopic ratios			Atomic ratios			Calculated ages (my)		
	U	Pb	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{206}Pb$	$^{207}Pb/^{238}U$	$^{206}Pb/^{238}U$	$^{207}Pb/^{206}Pb$	$^{207}Pb/^{238}U$	$^{206}Pb/^{238}U$
1. OE1-01	217.96	46.63	1497.01	127.95	365.57	.075967	1.931364	.184618	1094	1092	1092
2. OE1-02	191.92	28.94	781.40	73.00	201.31	.075199	1.311770	.126672	1074	851	769
3. OE2-01	177.25	12.72	922.50	83.89	226.38	.075508	.636226	.061186	1082	500	383
4. OE2-02	186.27	45.40	202.99	29.47	77.11	.075017	1.750375	.169436	1069	1027	1009
5. OE4-02	360.75	60.74	208.87	29.06	81.85	.071705	1.146973	.116156	978	776	708
6. OE6-01	123.22	28.55	194.55	28.60	77.06	.073684	1.608581	.158528	1033	974	949
7. OE6-02	188.01	40.71	644.53	62.99	172.99	.075650	.1864557	.178980	1086	1069	1061
8. WHG25-01	1209.38	45.28	576.04	59.06	158.12	.077887	.328197	.030599	1144	288	194
9. WHG25-02	1209.38	46.54	439.41	48.15	130.58	.077253	.324325	.030486	1128	285	194
8. WHG25-04	210.88	38.85	385.28	43.08	114.81	.074841	1.491823	.144748	1064	927	871

The decay constants used are: $\lambda^{238}U = 1{,}5513 \cdot 10^{-10}\ \gamma^{-1}$; $\lambda^{235}U = 9{,}8485 \cdot 10^{-10}\ \gamma^{-1}$; $^{238}U/^{235}U = 137{,}88$.

01. Composite zircon

02. Less magnetic fraction

Isotopic Composition of correcting lead: Pb^{206}/Pb^{204}; 16.90; Pb^{207}/Pb^{204}: 15.51

Table 1: Isotopic data for zircons from the Oorlogsende Porphyry Member.

and Oorlogsende porphyries. This would imply that the sediments of the Ghanzi Group which immediately surround the Kgwebe Formation are most probably equivalents of the Eskadron Formation of the Witvlei area and the Ghanzi Group would comprise a lower portion corresponding to the Eskadron Formation of South West Africa/Namibia and an upper portion correlated with the Nosib Group there.

b) On the other hand, if the porphyry of the Kgwebe Formation is younger than the Oorlogsende Porphyry, a correlation of the Kgwebe Formation (including its sedimentary member) with the Eskadron Formation is indicated, whereas the Ghanzi sedimentary rocks (believed to overlie the Kgwebe porphyry) would belong entirely to the Nosib Group, as was already supposed by Walker (1973). Interpretation (a) is set out in the legend to Fig. 1.

The Goha Hills, about 250 km north-east of the Kgwebe area, in north-eastern Botswana, consist of several types of feldspar-quartz porphyry and minor felsite (Key and Rundle 1981). Key and Rundle (1981) considered 981 ± 43 m.y. as the emplacement age of the porphyries; it is still quite in agreement with the age of the Nückopf volcanics in South West Africa.

The Oorlogsende Porphyry and most probably the igneous rocks of Okatjepuiko 154 near Witvlei lie within the narrow belt of isolated outcrops which connects the equivalents of the Sinclair Sequence in central South West Africa (see South African Committee for Stratigraphy 1980, p. 391) with those in north-eastern Botswana and confirm Key and Rundle's (1981, p. 64) assumption of a continuous Irumide Belt trending in a NE-SW direction through southern Africa. Southward-directed thrusting during the Damara orogeny resulted in imbrication of the southern margin of the Damara Belt and its foreland. Equivalents of the Sinclair Sequence occurring in central Namibia form tectonic slivers within the imbricated zone; the same must also be assumed for the Oorlogsende Porphyry and for isolated outcrops in Botswana.

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