Trans. geol. Soc. S. Afr., **80**, 97–99

THE STRATIGRAPHIC POSITION OF SUPPOSED PRE-DAMARA ROCKS IN THE DAMARA BELT SOUTH OF THE BRANDBERG, SOUTH WEST AFRICA*

by

R. E. JACOB[1] and A. KRÖNER[2]

ABSTRACT

The Tsaun Formation, a supposed pre-Damara basement unit in the Damara belt south of the Brandberg, comprises a metamorphosed sequence of banded gneisses, schists, calc-silicate rocks, amphibolites, marbles and metavolcanic rocks and is conformably overlain by marbles and schists of the Damaran Swakop Group. A re-evaluation of its lithology and stratigraphic position strongly indicates a correlation of this formation with the upper Nosib Group and not with the pre-Damara basement as previously suggested.

I. INTRODUCTION

Botha *et al.* (1975) have described a succession of gneisses and schists under the name "Tsaun Formation" from the eugeosynclinal portion of the Late-Precambrian Damara Belt (Fig. 1) which they interpreted as pre-Damara basement. They tentatively suggested a correlation with other basement rocks such as the Huab and Abbabis Complexes and concluded that the Tsaun succession resulted from high-grade pre-Damara metamorphism of a sedimentary assemblage (*op. cit.*, p. 78).

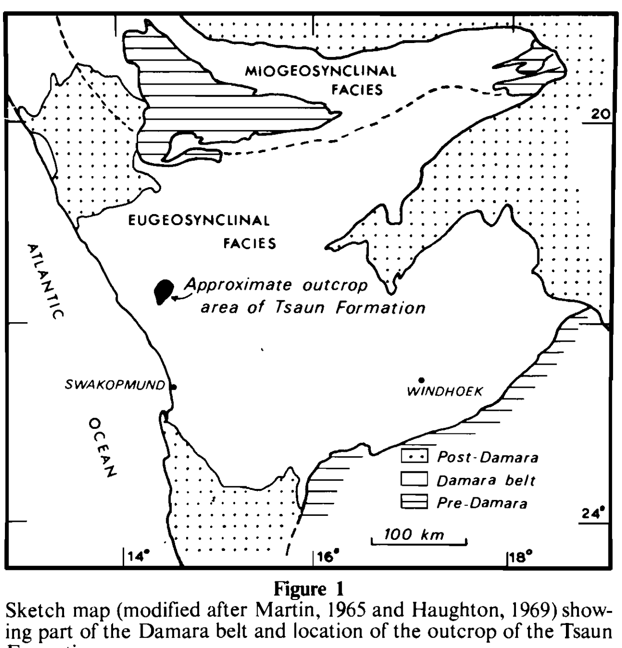

Figure 1

Sketch map (modified after Martin, 1965 and Haughton, 1969) showing part of the Damara belt and location of the outcrop of the Tsaun Formation.

The above interpretation implies that basement inliers do not only occur in the central and northern parts of the orogen (Martin, 1965) but also in those areas which could be regarded as some of the deeper parts of the original basin of deposition (judging from the extent of Khomas Subgroup-rocks) and, if correct, would give further support to the hypothesis that there may be continuous granitoid crust under the geosynclinal Damara cover. The stratigraphic position of the Tsaun Formation is therefore of considerable importance for any evolutionary model of the Damara belt and we have therefore re-examined these rocks during a reconnaissance survey as part of the South African Geodynamics Project.

*South African Geodynamics Programme, Publication No. 1

II. FIELD RELATIONSHIPS, LITHOLOGY AND PETROGRAPHY OF THE TSAUN ROCKS

Botha *et al.*'s (1975) description is based on detailed field-work of Gunther (1970), Schoeman (1970) and Van Reenen (1970) who mapped part of the Omaruru District south and south-west of the Brandberg. The Tsaun Formation is named after a prominent trigonometrical beacon in an otherwise featureless terrain.

Our examination concentrated on the contact between the Tsaun strata and the overlying rocks of the Khomas Subgroup of the Damaran Swakop Group (Table I) since Botha *et al.* (1975) suggest that a structural unconformity is present in places, although they describe an apparent conformity along the southern and south-western margin of the dome-shaped Tsaun outcrop.

Where seen, the basal Khomas metasediments consist of marble with thin bands of biotite schist and are lithologically similar to rocks of the Karibib Formation (the old upper Hakos Series) as described by Smith (1965) and Jacob (1974) from the central Damara belt (Table I). They are strongly foliated and contain a prominent NE-trending *b*-lineation. The underlying Tsaun strata show the same structural elements as the overlying Damaran rocks and there are numerous localities where a transitional contact between the two units is displayed. Usually this gradation is typified by a rapid alternation of biotite schist, marble and calc-silicate rock over a width of several metres as demonstrated in Fig. 2.

The Tsaun rocks consist of well-banded reddish to greenish gneisses and biotite schists in which amphibolites, marbles and calc-silicate lenses are frequently intercalated. Interbanding of coarse amphibolite with calc-silicate rocks was noted. A sequence of massive reddish quartz-feldspar rock which contains frequent pyrite and is more than 100 m thick was found to be intercalated in the above gneisses. These rocks are interpreted as felsic metavolcanics and strongly resemble the lava flows of the Naauwpoort Formation described by Miller (1972, 1974) from the lower Damara sequence farther north-east in the Summas Mountains (Table I).

The banded gneisses are the most common unit in the Tsaun succession. The layered appearance of these rocks is macroscopically prominent and individual bands are a few millimetres to several centimetres in width. The gneisses consist essentially of quartz, microcline and plagioclase in varying proportions resulting in pink to white colours in the different bands. In addition, ferromagnesian-mineral phases vary in abundance and proportion and serve to enhance the banded effect. Biotite is the most abundant of these but amphibole, clinopyroxene and epidote are also found. Where biotite is

TABLE I

Proposed stratigraphic position of Tsaun Formation inlier within the Damaran lithostratigraphy. The nomenclature incorporates new proposals submitted to the South African Committee for Stratigraphy.

			KHAN-SWAKOP AREA	AREA SOUTH OF BRANDBERG	SUMMAS MOUNTAINS	
DAMARA SUPERGROUP	SWAKOP GROUP	KHOMAS SUBGROUP	KUISEB Fm.	KUISEB Fm.	KUISEB Fm.	SWAKOP GROUP
DAMARA SUPERGROUP	SWAKOP GROUP	KHOMAS SUBGROUP	KARIBIB Fm.	KARIBIB Fm.	KARIBIB Fm.	SWAKOP GROUP
DAMARA SUPERGROUP	SWAKOP GROUP	KHOMAS SUBGROUP	CHUOS Fm.		CHUOS Fm.	SWAKOP GROUP
DAMARA SUPERGROUP	SWAKOP GROUP		Discordance		NAAUWPOORT Fm.	NOSIB GROUP
DAMARA SUPERGROUP	SWAKOP GROUP		DOME GORGE Fm.		NAAUWPOORT Fm.	NOSIB GROUP
DAMARA SUPERGROUP	Unconformity or conformable transition			Conformable transition	NAAUWPOORT Fm.	NOSIB GROUP
	NOSIB GROUP		KHAN Fm.	TSAUN Fm.	NAAUWPOORT Fm.	NOSIB GROUP
	NOSIB GROUP		ETUSIS Fm.			

particularly abundant the gneisses become quartzofeldspathic biotite schists whereas quartz-bearing amphibolites result from particular concentrations of amphibole. Coarser-grained, lenticular, migmatitic segregation lenses are concordantly developed in the gneisses and these contain quartz, feldspar, biotite, andradite garnet and epidote.

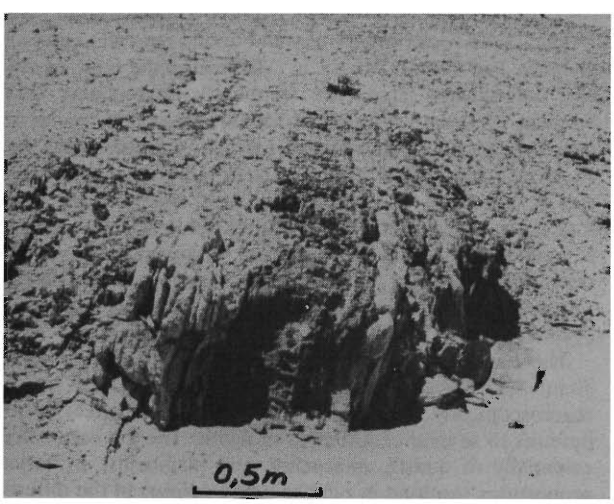

Figure 2
Transitional contact between schists of the Tsaun Formation (dark) and marble and calc-silicate rocks (light) of the Swakop Group. Locality: south-western margin of Tsaun inlier, about 20 km south-west of Tsaun beacon (see Fig. 1, Botha *et al.*, 1975).

Granoblastic-lobate to granoblastic-polygonal textures are exhibited in thin sections and there is generally evidence of retrogressive metamorphism. Xenoblastic quartz is a major phase, and crosshatch-twinned microperthitic microcline may constitute more than 50 per cent by volume. The plagioclase is oligoclase/andesine and is usually zoned, often exhibiting albite rims. Antiperthitic and myrmekitic textures are locally developed.

Brown to greenish-brown biotite is present in most samples and is normally partly retrogressed to chlorite. Amphibole occurs in two forms, as subidioblastic deep green hornblende, and as ragged pale blue-green actinolite along grain boundaries and replacing diopsidic clinopyroxene, which is present usually only in minor amounts. Pleochroic epidote is frequently encountered in certain of the gneiss layers and is associated with the uralitic amphibole. Accessory minerals in the banded gneisses include zircon, apatite, Fe-Ti oxide, calcite and, most frequently, sphene as idioblastic to irregular grains.

Intercalations of biotite schist consist of quartz, plagioclase, microcline and biotite with minor amounts of muscovite and, locally, pinitized cordierite, almandine garnet and sillimanite.

Calc-silicate rocks, intercalated within the gneisses, comprise strongly zoned calcic plagioclase, calcite, partly uralitized diopside and greenish-brown hornblende. Quartz is present in most, but not all, of the samples examined while sphene and epidote are the usual accessory minerals. Associated marble bands, up to several metres in thickness, vary in composition from relatively pure carbonate assemblages to those containing partly serpentinized forsterite, phlogopite, tremolite, chlorite and pleonaste.

The amphibolites in the Tsaun sequence are normally thin (a few metres and less), relatively coarse-grained and exhibit a strong foliation. They are composed of greenish-brown hornblende (individual grains are pale brown with patches of green), diopside and strongly zoned plagioclase with minor amounts of calcite and quartz and accessory Fe-Ti oxide, sphene and biotite.

The rocks interpreted here as metavolcanics are almost certainly those referred to as granulites by Botha *et al.* (1975), and possibly also those referred to as massive feldspathic quartzite by Enslin (1976, p. 11). They build low hills and weathered surfaces are brown to reddish-brown. From a distance the rocks appear to be massive but a distinct gneissic streaking is evident in hand specimens caused by slight variations in the proportions of the three essential constituents. These are quartz (20–35 per cent by volume), microperthitic microcline (20–60 per cent) and weakly zoned, partly saussuritized oligoclase (20–40 per cent). Microcline is generally more abundant than plagioclase. Muscovite is present only in very small amounts and biotite is a rare constituent. Zircon and rutile are common accessory minerals and a particularly abundant accessory is disseminated pyrite, which has oxidized in part to limonite.

III. COMPARISON WITH ROCKS OF THE NOSIB GROUP

The Tsaun rocks exhibit distinct similarities in the field and in thin section to rocks of the Nosib Group in the Khan-Swakop area, about 100 km to the south in the central Damara belt. Here the group is separated into two formations, a lower Etusis Formation and an upper Khan Formation (Nash, 1971; Jacob, 1974; see Table I). The Etusis Formation is generally psammitic in character and comprises conglomerates, quartzites, feldspathic quartzites, quartzofeldspathic paragneisses, banded quartz-microcline-plagioclase-hornblende-clinopyroxene gneisses, biotite schists, infrequent marble and, locally, felsic metavolcanic rocks (Jacob, 1974). The overlying Khan Formation is more calcic in character and consists essentially of migmatitic, banded quartz-microcline-plagioclase-hornblende-clinopyroxene gneisses in which the bands are less than one centimetre to several centimetres in width (Nash, 1971; Jacob, 1974). These bands normally consist of alternations of quartz-plagioclase-clinopyroxene and quartz-microcline-hornblende assemblages with transitional bands of quartz-microcline-hornblende-clinopyroxene. Quartz-feldspar-biotite, quartz-plagioclase and quartz-clinopyroxene-garnet assemblages as well as granitoid quartz-feldspar-garnet-epidote mobilizates also occur. Pebble bands, biotite-hornblende schists, biotite schists and ortho-amphibolite are locally developed. The accessory minerals of the banded gneisses include sphene, Fe-Ti oxide, apatite, allanite, scapolite and calcite.

The felsic metavolcanics of the Tsaun Formation strongly resemble and can also be compared with those of the Naauwpoort Formation, south-east and south of Welwitschia, described by Miller (1972, 1974). The Naauwpoort sequence consists largely of welded pyroclastic flows of K-rich alkali rhyolite, it is conformably overlain by rocks of the Swakop Group and has been included in the Nosib Group by Miller (1974). Metamorphism has produced "... a uniform light reddish-buff colour and monotonous arkose-like appearance that no longer bear any resemblance to felsitic or glassy textured volcanic rocks" (Miller, 1974, p. 363). In thin section the rocks are granoblastic and consist essentially of quartz and microcline with minor to accessory amounts of plagioclase, muscovite, biotite, ore, tourmaline, zircon and chlorite (Miller, 1972). Naauwpoort rocks are very similar in appearance to the Tsaun meta-volcanics and their correlation is a strong possibility.

IV. CONCLUSIONS

We conclude from the remarkable lithological similarity between the rocks of the Tsaun Formation and those mapped as Khan Formation (upper Nosib Group) in the central Damara belt (Nash, 1971; Jacob, 1974) as well as from the apparent conformable transition from Tsaun into Karibib strata that the former represents an equivalent of the upper Nosib sequence in the area south of the Brandberg (see Table I) and does not belong to a pre-Damara basement as proposed by Botha *et al.* (1975).

Our new interpretation receives support from a single discordant Pb^{207}/Pb^{206} zircon minimum age of 557 ± 30 Ma from a banded quartz-feldspar-biotite-hornblende gneiss of the Tsaun Formation (Dr A. J. Burger, pers. comm.) which is interpreted as reflecting the peak of Damaran metamorphism and invalidates Botha *et al.* (1975) conclusion of a high-grade pre-Damaran metamorphism in these rocks.

ACKNOWLEDGMENTS

The investigation forms part of the South African National Geodynamics Project financed by the Council for Scientific and Industrial Research.

REFERENCES

Botha, B. J. V., Gunter, C. J., Schoeman, P. J. and van Reenen, D. D. (1975). Die voor-Damaragesteentes in die gebied suid van Brandberg, Suidwes-Afrika. *Ann. geol. Surv. Dep. Min. S. Afr.*, (for 1971–72), **9**, 75–78.

Enslin, J. F. (1976). Report of the director of the Geological Survey for the year ended 31 December 1975. *Geol. Surv. S. Afr. Ann. Rep.*, 34 pp.

Gunter, C. J. (1970). *Die geologie van 'n gebied suid van Messum, Suidwes-Afrika.* M.Sc. thesis (unpubl.), University of the Orange Free State

Haughton, S. H. (1969). *Geological history of Southern Africa.* Geol. Soc. S. Afr., Johannesburg, 535 pp.

Jacob, R. E. (1974). Geology and metamorphic petrology of the Damara orogen along the lower Swakop River, South West Africa. *Precambrian Res. Unit, Univ. Cape Town, Bull.*, **17**, 185 pp.

Martin, H. (1965). *The Precambrian geology of South West Africa and Namaqualand.* Precambrian Res. Unit, Univ. Cape Town, 159 pp.

Miller, R. McG. (1972). *The geology of a portion of southern Damaraland, South West Africa, with particular reference to the petrogenesis of the Salem Granite.* Ph.D. thesis (unpubl.), Univ. Cape Town, 246 pp.

———— (1974). The stratigraphic significance of the Naauwpoort Formation of east central Damaraland, South West Africa. *Trans. geol. Soc. S. Afr.*, **77**, 363–367.

Nash, C. R. (1971). Metamorphic petrology of the SJ area, Swakopmund district, South West Africa. *Precambrian Res. Unit, Univ. Cape Town, Bull.*, **9**, 77 pp.

Schoeman, P. J. (1970). *Die geologie van 'n gebied noord van die Omarurudelta, Suidwes-Afrika.* M.Sc. thesis (unpubl.), Univ. Orange Free State.

Smith, D.A.M. (1965). The geology of the area around the Khan and Swakop Rivers in South West Africa. *Mem. Geol. Surv. S. Afr. (S.W.A. Series)*, **3**, 113 pp.

Van Reenen, D. D. (1970). *Die geologie van 'n gebied suid van Brandberg, Suidwes-Afrika.* M.Sc. thesis (unpubl.), Univ. Orange Free State.

[1] Department of Geology, Rhodes University, Grahamstown 6141.
[2] Department of Geosciences, University of Mainz, P.O. Box 3980. 65 Mainz, West Germany.

Accepted for publication by the Society on 7.6.1977.