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PRELIMINARY REPORT ON THE CAPE CROSS - UIS PEGMATITE FIELD*

by

M. Diehl

ABSTRACT

Numerous Sn- and Nb-Ta-rich pegmatite bodies are present in a NE-trending, approximately 20 km wide zone, consisting of schistose Damara metasediments and granites, in the area between Cape Cross and Uis. Structural analysis led to the recognition of the Cape Cross - Uis pegmatite field as a graben structure. Emplacement of stanniferous pegmatite bodies was structurally controlled by graben-related, en *echelon* Riedel-fractures. Three major pegmatite swarms, Uis, Strathmore and Karlowa, are located in clearly defined N-S trending, fracture-bounded zones. Significant Sn, Nb and Ta mineralization occurs in replacement units showing intensive albitization and greisenization.

Detailed mapping and structural analysis suggests a younger age than previously postulated for the mineralized pegmatites. A possible Jurassic - Cretaceous age of mineralization is discussed.

1. INTRODUCTION

The "Northern Tin Belt" of SWA/Namibia, as defined by Gevers and Frommurze (1929), forms a NE-trending zone extending from Cape Cross to an area north of Uis, near the Brandberg complex (Fig. 1). This area is more accurately described as the Cape Cross - Uis pegmatite field. This report presents some preliminary observations on the field relationships and structural setting of economically interesting stanniferous pegmatites in this area.

North-east of Henties Bay, highly metamorphosed rocks of the Tsaun Formation, Nosib Group, are exposed. Metasediments of Damaran age, belonging to upper and lower Swakop Group, consist of biotite-muscovite schist, quartz-feldspar schist, knotenschiefer, quartzite, calc-silicate, marble and tourmalinite. This succession is of eugeosynclinal character (Martin, 1980; for the plate tectonic setting see Miller, 1983) and the present lithotypes originated from regional metamorphism during the Pan-African.

Three major folding phases were active (Botha *et al*., 1974c). The metasediments were intruded by a suite of granites, representing syn- and late- to post-tectonic phases of igneous activity. Various types of granitoid rocks occur, but most are generally muscovite poor/biotite rich. Most of these granitoids belong to the Salem granite suite of Miller (1973) and Botha *et al*., (1974a). Predominant rock types are foliated biotite granites, two mica granites, tourmaline-garnet granites and unfoliated leucogranites. In addition a red biotite granite of the Sorris-Sorris type, as described by Martin (1965), is also recognized.

A wide range of syn- and post-tectonic pegmatites intruded the Damara sediments. These pegmatites have been prospected for Sn, Nb, Ta, Li, Be and REE since the early years of this country. Two tin mines are situated in the Northern Tin Belt: the Uis mine and the defunct Strathmore mine.

During late Jurassic to early Cretaceous the Damara metasediments were intruded by swarms of dolerite dykes and a dolerite cone sheet which occurs some 10 km north of Uis.

Igneous activity during the early Cretaceous is attested to by the alkaline to peralkaline granitic and gabbroic ring complexes of Brandberg, Messum and Cape Cross.

2. STRATIGRAPHY

Rocks of the Nosib and Swakop Groups occur in the area investigated. Descriptions of the stratigraphy are given by Gunter (1970), Koornhof (1970), Tordiffe (1970), Van Reenen (1970) and Botha *et al*. (1974b and c).

2.1 Nosib Group

Rocks of the Nosib Group occur in an area some 50 km ENE of Cape Cross (Fig. 1) and consist of a quartz-feldspar gneiss sequence with subordinate amphibolite and biotite-cordierite schist, granulite and conglomerate (Botha *et al*., 1974b). This sequence has been named the Tsaun Formation; it is characterized by high grade regional metamorphism of cordierite-amphibolite facies (Botha *et al*., 1974b). It is difficult to determine the exact stratigraphic position of the Tsaun Formation and Botha *et al*. correlated it with the Abbabis and Huab Complexes. A Nosib age of the Tsaun Formation (Botha, 1978) and correlation with the Khan and Naauwpoort Formations was suggested by Jacob and Kröner (1977). Structural investigations and detailed mapping show that the northern contact between Tsaun Formation and Khomas schist (including intrusive Damara

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granites) is of a tectonic nature. At the western contact Khomas schist and granites are downthrown against rocks of the Tsaun Formation by a significant N-S striking fault, along which intense brecciation occurred. Thin, concordant marble horizons are limited to the south-western portion of the Tsaun formation.

2.2 Swakop Group

Marbles of the Karibib Formation are usually exposed in inselbergs, that occur on the southern side of a NE-trending fault extending between Uis and the Atlantic Ocean.

Sediments of the Khomas Subgroup are widespread in the Cape Cross-Uis pegmatite field, and are highly deformed and metamorphosed (upper greenschist facies, Botha *et al*., 1974c). The Kuiseb Formation consists of a monotonous, schistose-quartzitic succession with interbedded marbles, calc-silicates and tourmalinites. The schistose sequence contains biotite schist, quartz-feldspar schist, muscovite schist and knotted schist (knotenschiefer). Botha *et al*. (1974c) estimated a total thickness of about 2 000 m for the Khomas sediments in this part of the Damara Orogen. Khomas schist occurs in a zone extending from NE of Uis to the Atlantic coast around Cape Cross (Fig. 1). Exposure is good in the north-eastern portion of this zone, but the rocks are increasingly covered by sand and calcrete towards the south-west.

2.3 Karoo Sediments

A small occurrence of greyish siltstone, located some 10 km south of Uis, is a relict of formerly more extensive Karoo sediments.

3. NON-PEGMATITIC INTRUSIVE ROCKS

3.1 Damaran Granites

Five major granite types, exhibiting a wide range in composition and age, are distinguished in the study area:

(i) greyish, coarsely-crystalline to porphyritic, foliated, biotite granite - syntectonic.
(ii) greyish-white, homogeneous, fine- to medium-grained, two mica granite - late to post-tectonic.
(iii) leucocratic, foliated and unfoliated tourmaline granites of aplitic character (some of them garnet-bearing) - late to post-tectonic.
(iv) greyish, homogeneous, fine- to medium-grained, two mica granite - post tectonic.
(v) red, medium- to coarse-grained, biotite granite (Sorris-Sorris granite) - post-tectonic.

3.2 Post-Karoo Ring Complexes

Three post-Karoo ring complexes occur along a north-east trending lineation parallel to the Cape Cross - Uis pegmatite field (Fig. 1). The Cape Cross and Messum complexes are respectively gabbroic and alkaline intrusions. The Brandberg complex consists of hornblende, aegirine, and arfvedsonite granites (Cloos and Chudoba, 1931).

3.3 Karoo dolerites

Karoo to post-Karoo intrusives also include numerous dykes of basaltic composition. These dolerite dykes are regarded as fracture fillings and feeders for basalt lava flows. The dykes have preferentially intruded N-S and NE-SW orientated faults and fracture zones, cross-cutting the fabric of sedimentary rocks. Olivine-, augite- and quartz-dole rites can be distinguished petrographically. A conspicuous cone-sheet, with sill-like portions, is present north of Uis. This is interpreted as a ring fracture (that was subsequently injected with doleritic magma), indicative of a deepseated igneous body.

Due to the preferred northerly orientation of dolerite dykes a relationship between Gondwanaland breakup and dolerite intrusion is postulated by Botha and Hodgson (1976).

4. STRUCTURAL GEOLOGY OF THE CAPE CROSS-UIS PEGMATITE FIELD

From detailed field investigations and use of Landsat imagery and aerial photographs the Cape Cross-Uis pegmatite field is interpreted as a graben structure, with typical wedge-block subsidence. Shoulder uplift is distinctly recognisable along a NE-trending lineament, representing the southern graben fault. In the central portion of the study area the southern graben fault cuts a reverse fault and downthrows Khomas schist against Karibib marble. Movement on the southern graben shoulder increases towards the SE, where Khomas schist is downthrown against metasediments of the Tsaun Formation. An isolated occurrence of Nosib metasediments and volcanics in this part of the Damara orogen is considered as an uplifted horst block. In the sand covered areas near the Atlantic Ocean, shoulder uplift of the graben is delineated by the outcrop of marble and a distinctive magnetic anomaly.

The northern graben fault is clearly recognisable only in the area NW of Uis, where the fault is marked by a highly weathered and kaolinized mylonite-zone in late tectonic granite, accompanied by a NE-striking and SE-dipping granite dyke. Recognition of the northern graben fault is complicated by lack of outcrop, but an indication of its position is given by a NE-trending drainage system.

The fabric of faults and joints related to graben formation during the Damara has been modified by later tectonic activity. In post-Damaran times the region was subjected to intensive block faulting, and NW-SE striking faults have displaced the graben into many seg-

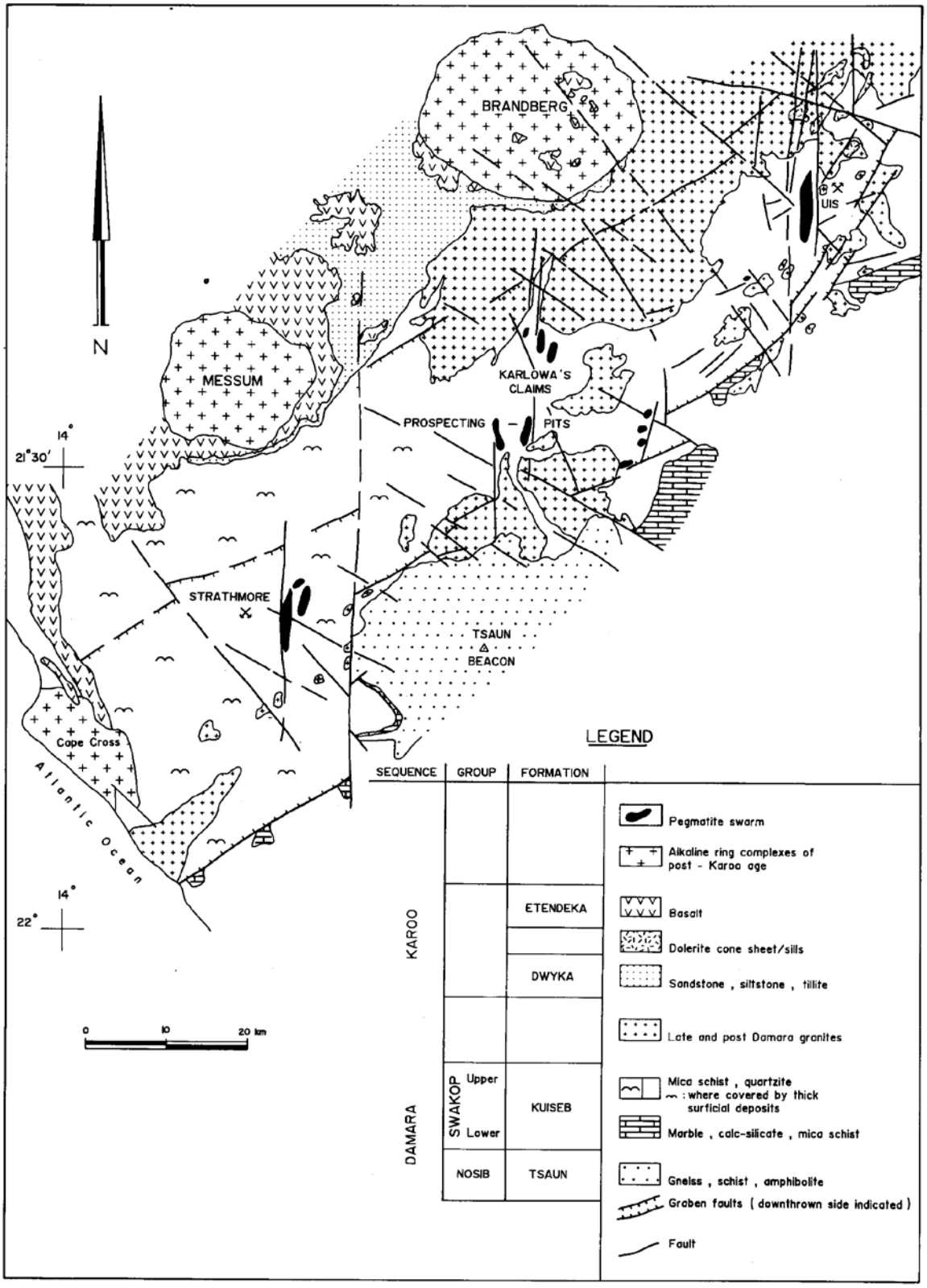

Fig. 1: Generalized geological map of the Cape Cross—Uis area.

ments. Moreover, the entire graben fault system was reactivated in Karoo and post-Karoo times. Post-tectonic Damaran granites which had intruded along zones of weakness were sheared and affected by temporary reactivation of the deep-seated faults. Open fractures and faults were filled by dolerite magmas and used as feeder dykes for lava flows.

The latest tectonic event, of Jurassic-Cretaceous age, resulted in N-S striking deep-seated tensional faults, some of which were subsequently intruded by dolerite. Faults with vertical movement are usually downthrown to the west, and may display brecciation. Strong movement took place along a prominent N-S trending fault in the Strathmore area, where Khomas schist and late-tectonic Damara granites were downthrown against the Tsaun Formation. Gossans and silicified breccias, with AI and Mn mineralization, are associated with these vertical faults. It is suggested that these faults are deep-seated and, consequently, enabled hydrothermal convection in post-Karoo times.

5. PEGMATITES

5.1 General

Numerous pegmatites, of varying composition, occur within the schistose zone (approximately 120 x 20 km) of the Cape Cross - Uis pegmatite field.

Four types of pegmatite can be distinguished mineralogically. A preliminary classification based on their index minerals/rare metal content is as follows:

(i) Cassiterite pegmatites
(ii) Niobium-tantalum-rich pegmatites (tantalite, columbite)
(iii) Lithium-rich pegmatites (amblygonite-spodumene-petalite)
(iv) Simple, quartz-feldspar-schorl pegmatites.

Types (i) and (ii) occur either as single, narrow (0.3 m - 3 m wide), dyke-like bodies with a north-easterly strike, or as swarms of large pegmatite bodies with an east-north-easterly strike. Types (i) and (ii) are unzoned. (The pegmatite mined at Uis is "typical of type (i)).

The majority of the cassiterite and niobium-tantalum-rich (Nb-Ta) pegmatites displays the effects of a characteristic phase of Li-Na-K mineralization (Von Knorring, 1985) and varying degrees of feldspar replacement by saccharoidal albite. Many albitized portions of the pegmatite bodies carry significant Sn and Nb-Ta mineralization. In pegmatite that is intensively albitized cassiterite and columbite-tantalite occur patchily as dark-brown to black grains, 0.1 - 0.5 cm in diameter.

Greisenized pegmatite occurs sporadically, forming distinct bands or schlieren of fine-grained altered rock with no preferential orientation. Within these greisens cassiterite may occur as bands up to 1 cm wide, with associated secondary, fine-grained quartz.

Type (iii): Many of the pegmatites of the Cape Cross - Uis pegmatite field contain significant amounts of lithium minerals. These may be classified as amblygonite, spodumene and petalite pegmatites in accordance with London and Burt (1982). Li-rich pegmatites, with well developed zoning and quartz cores, are exposed in the Strathmore area (e.g., Petalite Mine) and occur together with cassiterite pegmatites in a N-S trending swarm. Li-rich pegmatites, with spodumene as the dominant Li-mineral, are present in the central part of the study area (e.g., Karlowa claims).

Nb-Ta mineralization may occur in Li-rich pegmatites, concentrated in greisenized and albitized units. The Uis pegmatite swarm contains only a few distinct Li-rich pegmatites, but accessory petalite does occur in many of the cassiterite pegmatites.

Type (iv): In the Cape Cross-Uis pegmatite field small, schlieren-like, foliated, non-stanniferous pegma-

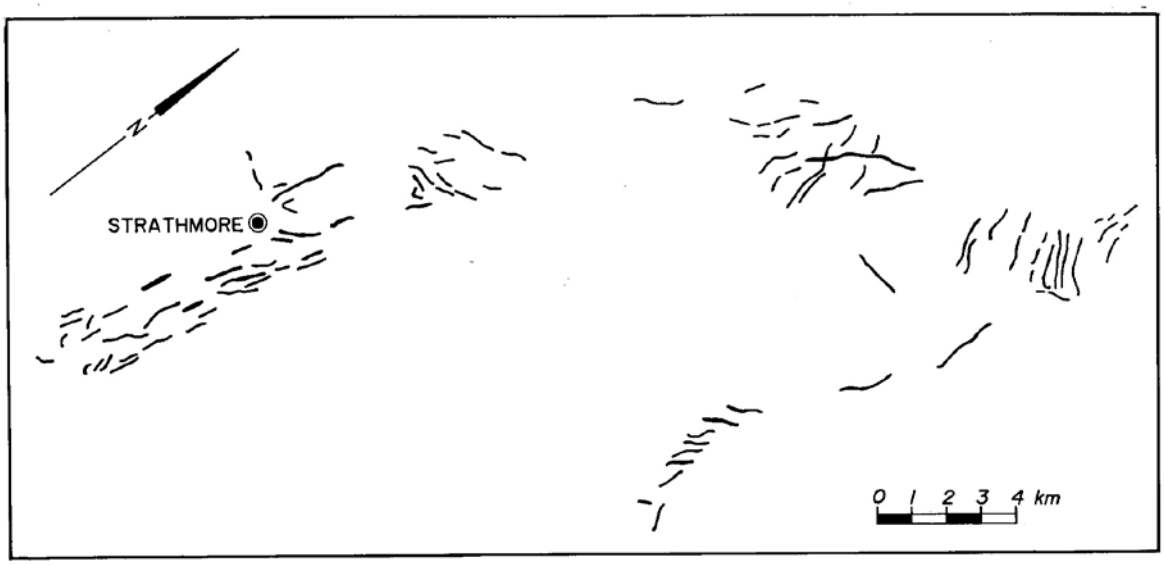

Fig. 2: Distribution of the Strathmore pegmatite swarms.

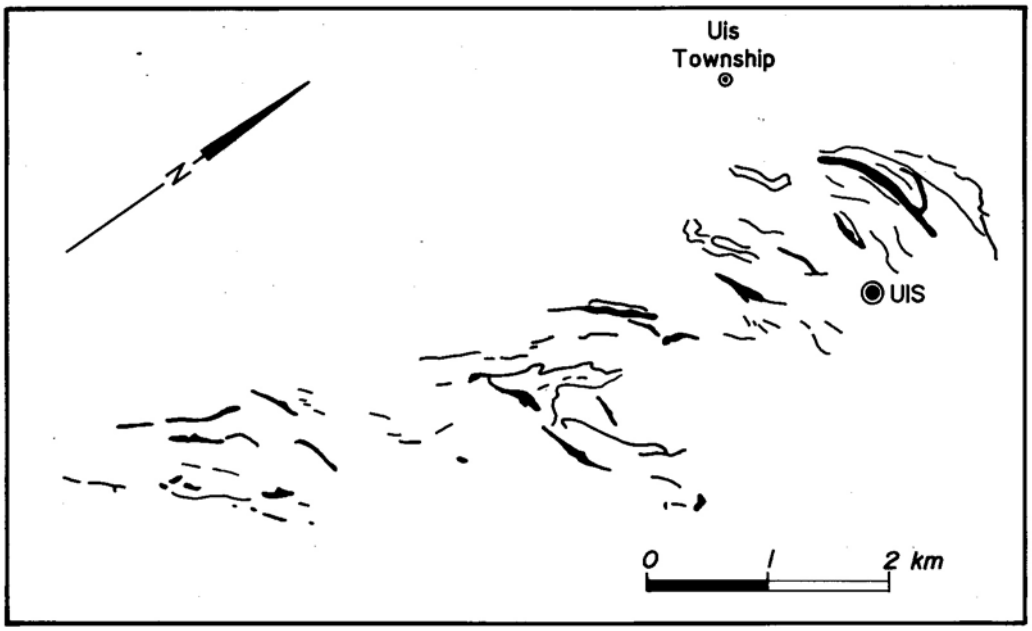

Fig. 3: Distribution of the Uis pegmatite swarms (after Grobler, 1980).

tite bodies are the most widespread. These are less fractionated than the other pegmatite types and consist of quartz, feldspar and schorl, with very small amounts of muscovite. Such pegmatites usually occur within Damaran granites and near their contacts with Khomas schist. In a few cases they are associated with secondary copper mineralization.

Another type of non-stanniferous pegmatite occurs as discordant arid concordant bodies in metasediments of the Tsaun Formation. The discordant pegmatite bodies are reddish in colour, unfoliated and consist essentially of quartz and microcline with accessory albite, muscovite (in many dykes also biotite), and magnetite. Cassiterite and Nb-Ta-rich pegmatites have not been found in the Tsaun Formation.

5.2 Structural Analysis of the Cassiterite and Nb-Ta-rich Pegmatites

Detailed mapping and structural investigations indicate that the occurrence of cassiterite and Nb-Ta-rich pegmatites is limited to a schistose, NE-trending graben zone from Cape Cross to Uis. Three main pegmatite swarms, viz. Uis, Strathmore and Karlowa (Fig. 2 and 3), have intruded pre-existing zones of weakness resulting from intensive block-faulting and shearing. Structural analysis of the pegmatite swarms illustrate the tectonic structure, especially in terrains of predominantly schistose rocks to be typical en *echelon* Riedel fractures. These occur in N-S striking zones and apparently acted as traps for pegmatitic melts. However, a number of isolated pegmatite bodies are situated parallel to the NE-trending tectonic fabric and dip towards the graben centre. These bodies cut across both the fabric and the foliation of the metasediments. North of the Karlowa swarm some pegmatite bodies have intruded anticlinal structures.

Structural analysis demonstrates that pegmatite swarms are located in significant, N-S orientated, fracture-bounded zones, within which pegmatite emplacement has been controlled by ENE-trending Riedel fractures.

With one exception, limited movement occurred along the N-S fractures, and it is suspected that they are of tensional origin. Many N-S fractures transgress dolerite dykes, indicating a post-Karoo age.

One N-S striking fault in the Strathmore area has a major vertical displacement. Khomas schist, on the western side of this fault, has been downthrown against older sediments of the Nosib Group. This fault also displaced dolerite dykes, thus attesting to post-Karoo movement.

5.3 Age of Pegmatites and Sn-Nb-Ta Mineralization

Cassiterite and Nb-Ta-rich pegmatites in the Cape Cross-Uis pegmatite field have been related to late- and post-tectonic Damaran granites by Koornhof (1970), Gunter (1970), Van Reenen (1970), Tordiffe (1970) and others.

Many of the cassiterite, Nb-Ta-rich and Li-rich pegmatites investigated in this study, specifically those well exposed in the Strathmore swarm, display mutually cross-cutting relationships with dolerite dykes.

Where dolerite transgresses a mineralized pegmatite body, the massive dolerite is completely altered and kaolinized to a soft, brownish mass, whereas dolerite emplaced in schist or in Damaran granites is fresh and unaltered. The contact between calc-silicate horizons and pegmatites may also exhibit intense alteration. There

are three possible interpretations for these features:

(i) Dolerite emplacement took place during consolidation of the pegmatites.

(ii) The pegmatite was emplaced after the dolerite, consequently reaction between the wallrocks and the pegmatitic liquids (melt) resulted in alteration of dolerite.

(iii) A late (hydrothermal?) phase has affected both intrusive rocks.

The first two interpretations would implify a Jurassic to Cretaceous age of the cassiterite, Nb-Ta-rich and Li-rich pegmatites, and would refute a genetic relationship with the late to post-tectonic Salem granitoid suite. The third interpretation suggests that post-Karoo (hydrothermal?) fluids, controlled by the N-S trending tectonic features, were responsible for late replacement processes in pre-existing pegmatites.

In a postulated case of a Jurassic-Cretaceous age the post-Karoo alkaline granites are most suitable as a possible source for cassiterite and Nb-Ta-rich pegmatites with well developed Li-Na-K phases. These post-Karoo alkaline granites exhibit A-type affinities, and Ginsburg *et al*. (1979) observed that many Li and Y, Nb, Be, F-enriched pegmatites occur in areas of anorogenic alkaline fractionation. Concerning the third hypothesis, Černý (1982) pointed out that the problem of an open or closed system of pegmatite crystallization is still under discussion, with alternatives ranging from strictly closed to open for late generation of mineralizing fluids. Finally, samples of different pegmatite bodies have been collected for age determination.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

Botha, B.J.V., Gunter, C.J., Koornhof, J.C., Schoeman, P.J., Tordiffe, E.AW. and Van Reenen, D.D. 1974a. Die Salemgranietgroep in die gebied tussen Uis en Kaap Kruis, Suidwes-Afrika. *Ann. geol. Surv. S. Afr*., **9**, 69-74.

Botha, B.J.V., Gunter, C.J., Schoeman, P.J. and Van Reenen, D.D. 1974b. Die voor-Damaragesteentes in die gebied suid van Brandberg, Suidwes-Afrika. *Ann. geol. Surv. S. Afr.*, **9**, 75-78.

Botha, B.J.V., Gunter, C.J., Koornhof, J.C., Schoeman, P.J., Tordiffe, E.A.W. and Van Reenen, D.D. 1974c. Die Sisteem Damara in die gebied tussen Uis en Kaap Kruis, Suidwes-Afrika. *Ann. geol. Surv. S. Afr*., **9**, 57-67.

Botha, B.J.V. and Hodgson, F.D.I. 1976. Karoo dolerites in north-western Damaraland. *Trans. geol. Soc. S. Afr*., **79**(2), 186-190.

Botha, P.J. 1978. *Die geologie in die omgewing van die benede-Omarurivier, Suidwes-Afrika*. Unpubl. M.Sc. thesis, Univ. Orange Free State, 157 pp.

Černý, P. (Ed.) 1982. *Petrogenesis of granitic pegmatites*. Short course Handb., Mineralog. Assoc. Canada, 8, 555 pp.

Cloos, H. and Chudoba, K. 1931. Der Brandberg. Bau, Bildung und Gestalt der jungen Plutone in Südwestafrika. *Neues Jb. Miner. Geol. Palaont., BeilBd*, **66B**, 1-130.

Gevers, T.W. and Frommurze, H.E. 1929. The tinbearing pegmatites of the Erongo Area, South West Africa. *Trans. geol. Soc. S. Afr.*, **32**, 111-149.

Ginsburg, A.I., Timofeyev, I.N. and Feldman, L.G. 1979. *Principles of geology of the granite pegmatites*. Nedra, Moscow, 296 pp.

Grobler, J.M. 1980. Tin-mining, Uis SWA. *Swaplan*, **9**, 1-3.

Gunter, C.J. 1970. *Die geologie van 'n gebied suid van Messum, Suidwes-Afrika*. Unpubl. M.Sc. thesis, Univ. Orange Free State, 116 pp.

Jacob, R.E. and Kröner, A. 1977. The stratigraphic position of supposed pre-Damara rocks in the Damara Belt south of the Brandberg, South West Africa. *Trans. geol. Soc. S. Afr*., **80**(2), 97-99.

Koornhof, J.C. 1970. *Die geologie van 'n gebied rondom Vis, Suidwes-Afrika*. Unpubl. M.Sc. thesis, Univ. Orange Free State, 85 pp.

London, D. and Burt, D.M. 1982. Lithium minerals in pegmatites, p. 99-133. *In*: Černý, P. (Ed.), *Petrogenesis of granite pegmatites in science and industry*. Short Course Handb., Mineralog. Assoc. Canada, **8**, 555 pp.

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

Martin, H. 1980. Geodynamic aspects of the intracratonic branch of the Damara Mobile Belt in Namibia. *In*: Closs, H., *et al*., (Eds), *Mobile Earth, IGP, Final Report of the Fed. Rep. of Germany*. H. Boldt, Boppard, 207-220.

Miller, R.McG. 1973. The Salem granite suite, South West Africa: genesis by partial melting of the Khomas schist. *Mem. geol. Surv. S. Afr*., **64**, 106 pp.

Miller, R.McG. (Ed.) 1983. The Pan African Damara Orogen of South West Africa/Namibia. *Spec. Publ. geol. Soc. S.Afr*., **11**, 431-515.

Tordiffe, E.A.W. 1970. *The geology of an area southeast of the Brandberg, South West Africa*. Unpubl. M.Sc. thesis, Univ. Orange Free State, 59 pp.

Van Reenen, D.D. 1970. *Die geologie van 'n gebied suid van Brandberg Suidwes-Afrika*. Unpubl. M.Sc. thesis, Univ. Orange Free State, 107 pp.

Von Knorring, O. 1985. Some mineralogical, geochemical and economic aspects of Lithium pegmatites from the Karibib-Cape Cross pegmatite field in South West Africa/Namibia. *Communs geol. Surv. SW Africa/Namibia*, **1**, 79-84.