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A NOTE ON STRATIFORM TOURMALINITES IN THE LATE PRECAMBRIAN KUISEB FORMATION, DAMARA SEQUENCE

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1. INTRODUCTION

Tourmaline associated with sedimentary and metamorphic rocks, igneous intrusions and hydrothermal ore deposits is well known from many localities in the Damara Province (Haughton *et al.*, 1939). This variety of tourmaline also includes minor occurrences within discordant veins, metamorphic replacement bodies, pegmatites, granites and breccia pipes. In contrast, conformable tourmaline-rich rocks in the Damara Province have only recently been described (Behr *et al.*, 1983; Badenhorst, 1987).

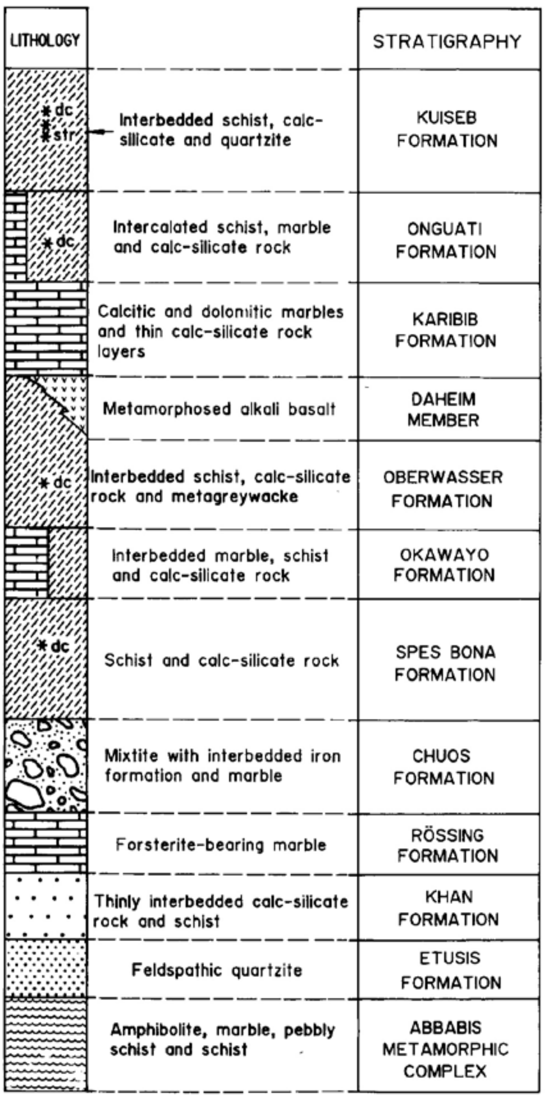

Fig. 1: A generalized stratigraphic column in the study area indicating with an * the position where tourmalinites were found. Dc stands for discordant tourmalinite veins and str for stratiform tourmalinites.

In this note, attention is drawn to stratiform tourmalinites that have, in spite of their abundance, only recently been recognized in the Swakop Group rocks of the Damara Sequence (Fig. 1). The tourmalinites occur in black or light brown, very fine-grained sediments that exhibit numerous small, delicate but well preserved sedimentary structures. These rocks are interpreted here as marine distal turbidite sequences. Most of the work was carried out at two localities - the Kohero/Ohere area, 30 km north-east of Omaruru and the Onguati/Krantzberg area, east of the Erongo Complex (Fig. 2). The term tourmalinite refers to stratabound lithologic units broadly concordant with their enclosing rocks and containing between 15 and 20 % or more tourmaline by volume (Slack *et al.*, 1984). Discordant tourmaline-rich assemblages associated with pegmatite intrusives and quartz veins are also described for comparison.

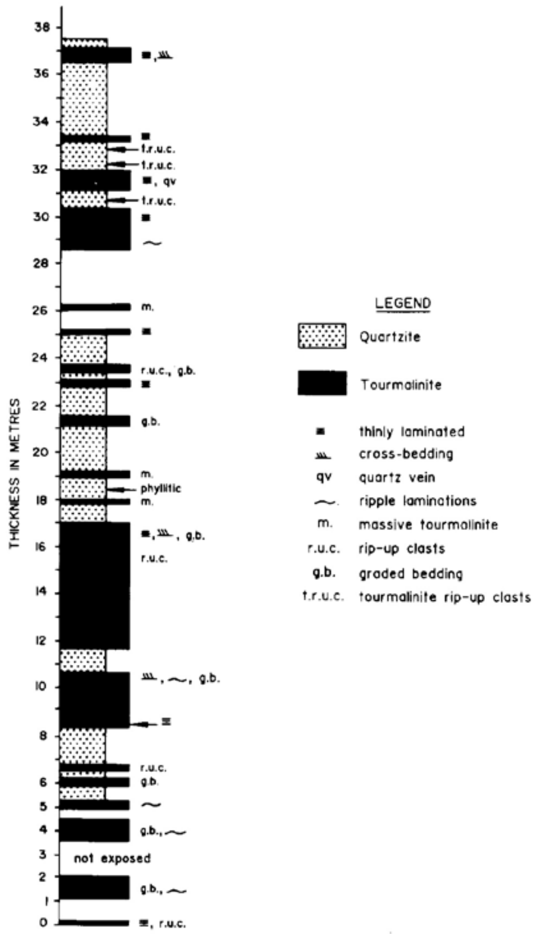

Fig. 2: A detailed stratigraphic profile on the farm Onguati 52 close to the Khan River indicating the type of sedimentary structures preserved in the tourmalinites.

2. OCCURRENCE

Tourmaline is found in all the schist units of the northern Central Zone and in the eastern part of the southern Central Zone (Fig. 1). However, it is most abundant in the higher levels of the Kuiseb Formation where it is closely associated with an increase in quartzitic material about one third up from the base of that unit.

The tourmalinites occur as stratiform units that retain their conformable shape in a multiply deformed and highly metamorphosed rock mass. They can mostly be traced along strike for kilometres, a feature that distinguishes them from other, generally non-stratified, occurrences of tourmaline-rich assemblages associated with metamorphic quartz veins and granite intrusions.

3. SEDIMENTARY STRUCTURES

Within the tourmalinite, partial Bouma sequences are common, and include abundant graded beds, one centimetre or less in thickness (Fig. 3). Characteristically, these beds grade from a quartz-rich base into a tourmaline-rich upper portion, where scheelite, pyrite and chalcopyrite are also concentrated. Pyrite and, to a lesser extent, chalcopyrite are commonly finely disseminated throughout these rocks. Rip-up clasts of tourmaline-rich layers and planar cross-bedding defined by tourmaline-rich laminae are common in these tourmalinites (Figs 3, 4 and 5). These rip-up clasts indicate that this part of the bed must have been clay during deposition, as do the small, delicate flame structures and load casts (Figs 6 and 7). Starved current ripples were also observed in the Onguati section.

4. COMPOSITION OF THE TOURMALINE

There is a difference in colour, texture and composition of the tourmalines contained in well-stratified tourmalinite, those occurring in tourmaline-rich assemblages associated with quartz veins and those in Damaran pegmatites. The tourmaline crystals in tourmalinite beds generally have an olive green to light brown colour (dravite) and do not show any zoning. However, in tourmaline-rich assemblages closely associated with quartz veins, the tourmaline is darker green to slate blue in colour (schorl) and is coarser grained (Fig. 8). Irregular zoning appears in the coarse-grained tourmaline crystals associated with the quartz veins (Fig. 9). This is distinct from the light to dark blue colours of the well-zoned iron-rich tourmalines (schorl) of the Damaran pegmatites and granites.

5. ORIGIN OF THE TOURMALINITES

Badenhorst (1987) suggested that the tourmalinites

Fig. 3: A polished rock slab of a tourmalinite from the farm Ohere 106 showing well preserved graded bedding and rip-up clasts of tourmalinite.

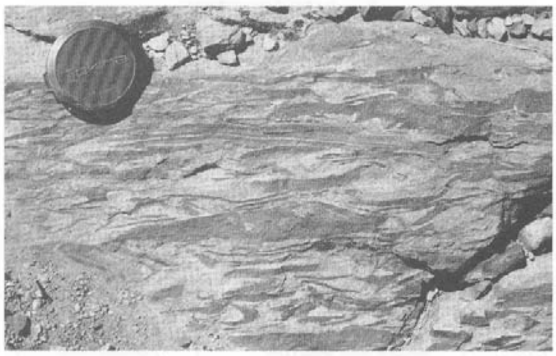

Fig. 4: Rip-up clasts of brown tourmalinite in a white feldspathic quartzite on the farm Onguati. 52.

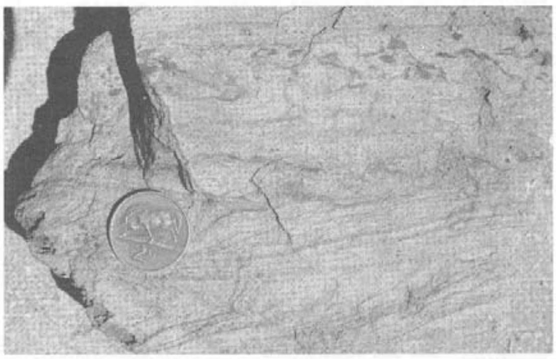

Fig. 5: Cross-bedding defined by tourmaline and rip-up clasts of tourmalinite in a feldspathic quartzite.

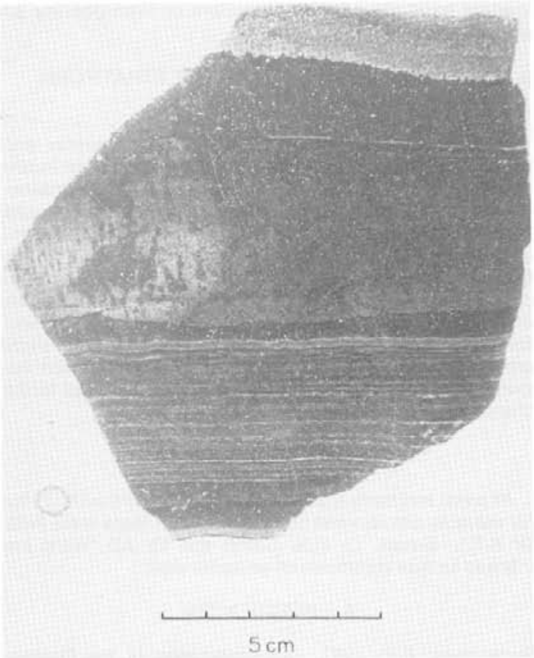

Fig. 6: Well preserved load casts and flame structures in a tourmalinite from farm Ohere 106. Note the irregular replacement by tourmaline confined to the thick bed.

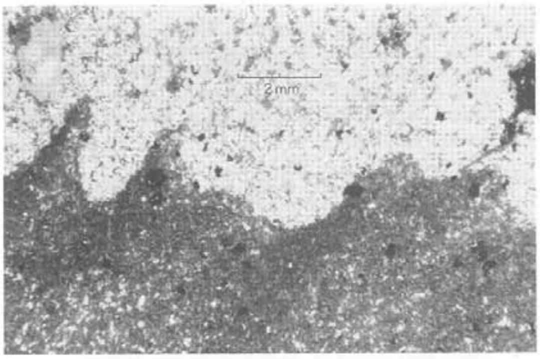

Fig. 7: A photomicrograph of flame structures in a tourmalinite from Ohere 106.

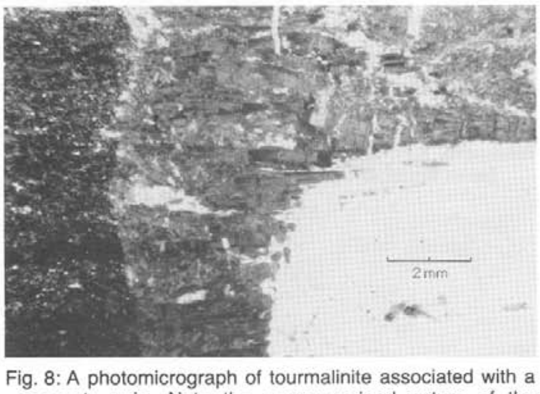

Fig. 8: A photomicrograph of tourmalinite associated with a quartz vein. Note the coarse-grained nature of the tourmaline crystals close to the vein.

contained in the Damara succession are exhalative in origin, but this interpretation poses a few problems. The sedimentary structures indicate that prior to metamorphism the tourmaline-rich portion of the layers was probably a boron-rich clay layer, rather than a sediment containing detrital tourmaline. Two possibilities there-

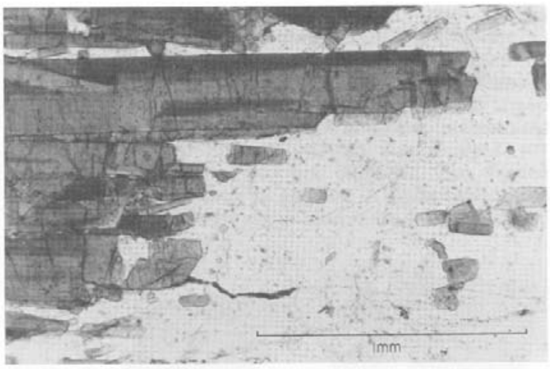

Fig. 9: A photomicrograph showing the irregular zoning of tourmaline associated with a quartz vein.

fore exist:

- these layers were deposited as a boron-rich detrital clay;
- the clay fraction of the layers was replaced at a later stage.

The boron values of 2 to 9 % (Table 1) suggest that there was an enrichment above the levels that could be reached by absorption and adhesion of boron into and onto the clay structure from both sea and fresh water to form a detrital tourmaline-rich clay (Wedepohl, 1978). Locally many large granitic plutons and pegmatites are closely associated with the tourmalinites, but their emplacement or any metamorphic remobilization was probably not responsible for all the replacement observed. This implies that the boron must have been in the clay at an early stage during deposition to account for the formation of the tourmaline-rich rip-up clasts.

TABLE 1: Whole-rock analyses of four tourmalinite samples associated with a quartz vein on the farm Kompaneno. Tour. 1 and Tour. 2 - quartz vein tourmalinite. Tour. 3 - typical fine-grained, black tourmalinite. Tour. 4 - tourmaline-rich schist away from any quartz vein.

	Tour. 1	Tour. 2	Tour. 3	Tour. 4
B %	5,96	6,60	9,75	1,95
B_2O_3 %	19,18	21,25	31,39	6,28
Li ppm	29	84	25	44
Cu ppm	n.d.	1 253	83	18
Pb ppm	6	15	n.d.	19
Znppm	n.d.	609	107	77
Sn ppm	335	63	45	n.d.
Wppm	n.d.	813	48	n.d.
Au*	5	7	n.d.	n.d.
Hg*	5	9	5	5

*Au and Hg contents in ppb

n.d. - not determined

On Kohero, the tourmaline crystals in a schist containing 20 to 50 % tourmaline are well aligned in the s_2 and s_3 foliation directions, suggesting that the tourmaline (and not only boron) was in the metasediment prior to the D_2 deformation phase. In this area, the D_2 phase coincides with the peak of metamorphism (Haack *et al.*, 1979) and therefore with the formation of the quartz veins. Accordingly, formation of the tourmalinite by selective replacement at any stage later than early diagnesis is difficult to envisage. That the replacement of clay by tourmaline is responsible for some of the tourmaline fractions is shown in Fig. 6, where tourmaline-rich portions occur in an irregular and incoherent way, but nevertheless are still confined-to a single layer. This implies an early diagenetic replacement of clay by tourmaline because tourmaline growth accompanying the formation of quartz veins usually destroys all sedimentary or metamorphic features and proceeds across sedimentary boundaries (Fig. 10). Metamorphic quartz-tourmaline replacement bodies usually only penetrate the country rock for just a few centimetres (Figs 10 and 11), or even tens of centimetres, depending on the thickness of the vein and probably also on the duration of fluid movement. In the Uis tin mine tourmalinization associated with a 5 to 7 m thick inclined pegmatite dyke has affected the country rock for only 3 to 4 cm from the pegmatite/metasediment contact and for 30 to 40 cm along cracks and fractures above the dyke.

Thus, in spite of many tourmalinites displaying late-stage metamorphic characteristics, a number of features also point towards early diagenetic replacement or even possibly an exhalative origin.

6. ECONOMIC IMPLICATIONS OF STRATIFORM TOURMALINITES

In general, only pyrite and traces of chalcopyrite and scheelite were observed in the tourmalinites, although locally abundant Cu-mineralization is associated with tourmaline-bearing quartz veins. In the latter, chalcopyrite, chalcosite and secondary Cu minerals can be seen in hand specimen, and whole-rock analyses show contents of 1,25 % Cu, 609 ppm Zn and 813 ppm WO_3 (Table 1). Although no cassiterite was seen in these tourmalinites, whole-rock analyses indicate values up to 335 ppm Sn (Table 1). Gold content is, however, below the limit of detection. In the study area, no massive sulphide is directly associated with the tourmalinite, but this may be a function of the distal facies character in such a system (e.g. Slack, 1982).

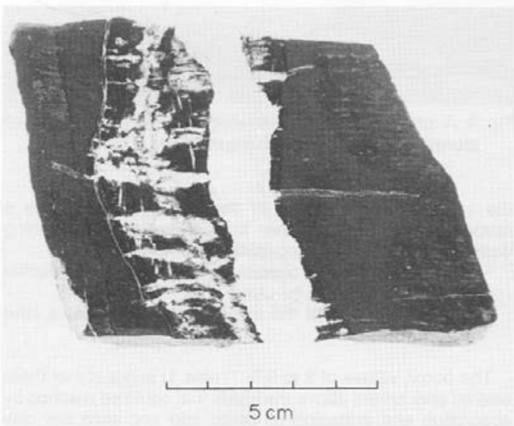

Fig. 10: Tourmalinization around a quartz vein. Note the complete destruction of sedimentary layering.

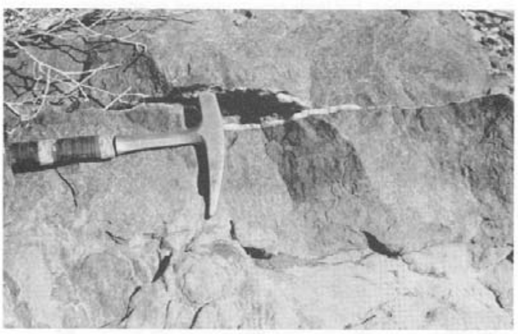

Fig. 11: Tourmalinization around a quartz vein. The country rock is only penetrated a few centimetres.

7. ACKNOWLEDGEMENTS

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8. REFERENCES

Badenhorst, F.P. 1987. Lithostratigraphy of the Damara Sequence in the Omaruru area of the northern Central Zone of the Damara Orogen and a proposed correlation across the Omaruru Lineament. *Communs geol. Surv. S. W. Africa/Namibia*, **3**, 3-8.

Behr, H.J., Ahrendt, H., Porada, H., Rohrs, J. and Weber, K. 1983. Upper Proterozoic playa and sabkha deposits in the Damara Orogen S.W. Africa/Namibia, 1-20. *In*: Miller, R.McG. (Ed.), *Evolution of the Damara Orogen of South West Africa/Namibia*. Geol. Soc. S. Afr. Spec. Publn, **11**, 515 pp.

Haack, U., Gohn, E. and Klein, J.A. 1980. Rb/Sr ages of granitic rocks along the middle reaches of the Omaruru River and the timing of orogenic events in the Damara belt (Namibia). *Contr. Miner. Petrol.*, **74**, 349-360.

Haughton, S.H., Frommurze, H.F., Gevers, T.W., Swellnus, C.M. and Rossouw, P.J. (1939). *The geology and mineral deposits of the Omaruru District, South West Africa*. Expl. Sheet 71, geol. Surv. S. Afr., 160 pp.

Slack, J.F. 1982. Tourmaline in Appalachian-Caledonian massive sulphide deposits and its exploration significance. *Trans. Instn Min. Metall.*, **91**, B81-B89.

Slack, J.F., Herriman, N., Barnes, A.G. and Plimer, I.A. (1984). Stratiform tourmalinites in metamorphic terranes and their geologic significance. *Geology*, **12**, 713-716.

Wedepohl, K.H. (Ed.), 1978. *Handbook of geochemistry*. Berlin, Springer-Verlag, v.11 /1, sec. 5.