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NIOBIUM AND TANTALUM MINERALS

by

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ABSTRACT

Various minerals of niobium and tantalum are fairly common in many South West African pegmatites whose age ranges from pre-Damaran (Warmbad area) to Damaran (Karibib - Cape Cross - Omaruru area) and Post-Karoo (Erongo area). A number of those minerals and their mode of occurrence are described.

UITTREKSEL

Verskeie minerale van niobium en tantalum is taamlik volop in baie Suidwes-Afrikaanse pegmatiete waarvan die ouderdom wissel van voor-Damara (Warmbadgebied) tot Damara (Karibib - Kaap Kruis - Omaruru gebied) en Na-Karoo (Erongogebied). ‘n Aantal van hierdie minerale en die aard van hul voorkomste word beskryf.

1. INTRODUCTION

The elements niobium (Nb) and tantalum (Ta) are closely associated in nature and are the two most characteristic rare-metal accessories in granite pegmatites, forming a large number of exotic minerals.

As major constituents in the mineral columbite-tantalite, these elements were also discovered in that mineral, although for a long time there was uncertainty regarding the true identity of niobium (columbium) and tantalum, largely due to the great similarity of their chemical properties.

Apart from granite pegmatites, the elements are also prominent in some alkali granites, e.g. the Nigeria-Niger alkali granite province, in a number of geochemically similar mineralised alkali gneisses in Egypt and Uganda (Von Knorring, 1971), and in alkaline complexes proper - nepheline syenites and nepheline syenite pegmatites and, as far as Nb is concerned, in numerous carbonatites.

Quantitatively these various groups of alkaline rocks carry the bulk of extractable Nb and Ta mostly in the form of accessory columbite-tantalite in various pyrochlore-group minerals, or other oxide or silicate minerals of niobium.

In the granite pegmatites, however, the Nb - Ta minerals occur often in larger concentrations and, as far as Ta is concerned, the granite pegmatites and especially the Li bearing ones constitute the only economic source of this important rare element.

2. NIOBIUM AND TANTALUM MINERALIZATION IN THE PEGMATITES OF SOUTH WEST AFRICA/NAMIBIA

Minerals of Nb and Ta have been known for a long time in the Namibian pegmatites and have been first recovered in connection with tin-mining operations, and subsequently with the mining of Li and Be minerals.

The early tin miners often overlooked the minerals of Nb and Ta or had a great difficulty in separating them from the tin. Consequently all cassiterite concentrates were contaminated with columbite-tantalite. Perhaps one of the best accounts on the occurrence of Nb and Ta minerals is that given by Frommurze *et al.* (1942) in the Explanation of Sheet No. 79 (Karibib, SWA).

These authors noted, that tantalite is generally associated with cassiterite in the stanniferous pegmatites and shows preference for feldspar-rich portions of the pegmatites, viz. the intermediate zone marginal to the quartz core - in zoned pegmatites they also noted that much of the feldspar is albitized to a white, fine-grained mineral (sugary albite) where the tantalite is developed. In addition to columbite-tantalite other Nb-Ta minerals may be found in the pegmatitic replacement units consisting of sugary albite or in the bladed variety of albite, known as cleavelandite and also in pods and schlieren of muscovite or lithian micas.

At Sandamap tin pegmatite, for instance, the Ta mineral microlite occurs together with cassiterite in a lithian mica-cleavelandite unit.

In the present pegmatite belt Nb-Ta mineralisation is principally associated with:

- numerous pegmatites, usually Li-bearing, in the Karibib area;
- pegmatites, many Sb and Li-bearing, connected with the Erongo granite intrusions;
- extensive tin pegmatites, partly Li-bearing, south and west of Brandberg (the Uis-Strathmore pegmatite field).

Outside the present area, Ta minerals have been successfully mined in the Tantalite Valley region south of Warm bad, Karasburg District.

2.1 Pegmatitic Minerals of Niobium and Tantalum

In the present pegmatite field the following minerals of Nb and Ta have been observed:

Columbite	Manganotantalite
Manganocolumbite	Tapiolite
Ferrocolumbite	Wodginite

Tantalite Microlite

Columbite $(Fe,Mn)(Nb,Ta)_2O_6$ is the commonest member of the Nb-Ta minerals in those pegmatites as it is also in other parts of Africa. It occurs frequently in tabular, prismatic crystals with well-developed crystal faces, submetallic lustre and has a dark-brown to almost black streak in some varieties. The chemical composition varies greatly - Nb and Ta may range from about 33 to 75 and 2 to 50 per cent respectively. The analyses 1-4 of columbites (Table 1) show little variation as they come from the same mineralized area. The specimen from Sandamap 64, however, shows a rather different composition. Substitution of Wo for Nb-Ta in the columbite structure seems to be compensated by the incorporation of Ti as seen in analyses 1-4 (Table 1). Minor amounts of Sc, Y, rare-earths, Zr, Sb and U may be also present.

Manganocolumbite $(Mn,Fe)(Nb,Ta)_2O_6$, (Table 2) is a type mineral of the Karibib Li-rich pegmatites, and is found as black, tabular, striated crystals, with vitreous to submetallic lustre and yellowish-green to dark-brown streak. It may be distinguished from other columbite-tantalites by the intense pink to purple colour of the borax bead when fusing the mineral.

Manganocolumbite is distinctly black in colour, in contrast to manganotantalite which is often red to brown. The Fe content of the present manganocolumbites is low and frequently lower than in corresponding manganotantalites (Table 4, analyses 16-19), hence the black colour may be caused by the much higher Nb contents in the manganocolumbites.

The Mn content is exceptionally high, a typical feature of this late stage mineral, in the highly fractionated Li pegmatites of the region. The content of trace elements is generally low, but there are exceptions, especially regarding Wo and Ti in some cases.

	1	2	3	4	5	
Nb_2O_5	69.11	66.94	66.92	61.10	42.21	%
Ta_2O_5	4.67	7.52	10.11	16.57	38.96	%
MnO	6.53	8.01	7.12	6.88	8.05	%
FeO	13.63	12.34	12.91	13.13	9.76	%
CaO	-	-	0.08	0.20	-	%
Y_2O_3	0.03	-	-	-	-	%
Sc_2O_3	-	0.03	-	0.05	-	%
TiO_2	1.80	1.85	0.63	0.73	0.52	%
ZrO_2	0.39	-	0.15	0.26	0.12	%
SnO_2	0.11	0.15	0.02	0.24	0.44	%
WO_3	2.83	3.61	1.29	1.51	-	%
U_3O_8	0.27	-	0.07	0.07	-	%
	99.37	100.45	99.30	100.74	100.06	%

Table 1: Chemical composition of columbite

1. Columbite, Okongava Ost 72, Karibib District
2. Columbite, Cement dam on Okongava Ost 72, Karibib District
3. Columbite, Etiro 50, Karibib District
4. Columbite, Okatjimukuju 55, Karibib District
5. Columbite, Sandamap 64, Karibib District

	6	7	8	9	10	
Nb_2O_5	57.67	53.59	50.35	35.29	34.67	%
Ta_2O_5	20.89	27.76	29.57	44.10	47.36	%
MnO	17.91	18.34	19.04	18.54	16.44	%
FeO	1.14	0.25	0.27	0.07	0.66	%
CaO	0.23	-	-	-	-	%
Y_2O_3	-	-	-	-	-	%
Sc_2O_3	-	0.06	-	-	0.10	%
TiO_2	0.28	0.14	0.16	0.00	0.28	%
ZrO_2	-	0.19	-	0.16	0.21	%
SnO_2	0.18	0.24	0.18	-	0.25	%
WO_3	0.68	-	0.14	-	-	%
U_3O_8	0.07	0.12	-	-	0.12	%
	99.05	100.69	99.53	98.16	100.09	%

Table 2: Chemical composition of manganocolumbite

6. Mangancolumbite, Helicon 2 on Okongava Ost 72, talite Karibib District
7. Manganocolumbite, Rubicon on Okongava Ost 72, Karibib District
8. Manganocolumbite, Albrechtsh6he on Ptn. Karlsbrunn of Kaliombo 42, Karibib District
9. Manganocolumbite, Daheim 106, Karibib District
10. Manganocolumbite, Okatjimukuju 72, Karibib District

The analytical results in numerous Nb-Ta minerals of the region have shown, that manganocolumbite, occurring in a variety of Li pegmatites, is more common than had been expected.

Ferrocolumbite $(Fe, Mn)(Nb,Ta)_2O_6$ is a rather rare mineral occurring mostly in non-Li pegmatites or in Li-free units of Li pegmatites. It is found as black, platy crystals with a submetallic lustre and has a reddish-brown streak. Ferrocolumbite can be distinguished from other columbitetantalites by its characteristic leaf-green colour when the mineral is fused with borax.

In the present pegmatite belt, ferrocolumbites have been found in Li-poor pegmatites from the Brandberg - Cape Cross field and from Spitzkoppe.

The trace elements Ti, Sn and Wo are generally enriched in the ferrocolumbites showing the regional trend or a close association with a particular mineralisation, e.g. the relatively high Sb content of the ferrocolumbite from the Strathmore tin field (Table 3, analysis 12).

Tantalite $(Fe,Mn)(Ta,Nb)_2O_6$, This group includes rare members of the columbite-tantalite series with Ta predominating over Nb, while Fe and Mn are of intermediate magnitude (Table 3, analyses 13-15).

Tantalite is usually observed in Li-poor pegmatites but occasionally it also occurs in Li-rich pegmatites, as e.g. the present ones.

The colour of tantalite is generally black but when the Ta content is high as in the Ricksburg occurrence, the colour is red-brown and in appearance this tantalite is identical to manganotantalite. Tantalite has been observed in disseminated grains in late, Fe-rich muscovite replacement units at Viljoen's claim, Okongava

	11	12	13	14	15	
Nb_2O_5	62.41	53.16	29.37	24.66	9.59	%
Ta_2O_5	13.13	24.05	53.56	55.94	76.11	%
MnO	4.76	3.95	9.64	9.21	7.17	%
FeO	15.19	14.87	9.63	6.88	7.62	%
CaO	0.12	0.04	-	-	-	%
Y_2O_3	-	-	-	-	-	%
Sc_2O_3	0.05	-	-	-	-	%
TiO_2	1.07	1.75	0.09	1.42	0.12	%
ZrO_2	0.21	0.46	0.19	0.54	-	%
SnO_2	0.30	0.88	0.00	0.00	0.08	%
WO_3	2.00	0.43	0.26	0.66	-	%
U_3O_8	0.05	0.10	0.05	0.25	-	%
	99.29	99.69	100.09	99.56	100.69	%

Table 3: Chemical composition of ferrocolumbite and tantalite

11. Ferrocolumbite, Klein Spitzkoppe 70, Damaraland
12. Ferrocolumbite, Strathmore area near Cape Cross, Swakopmund District
13. Tantalite, Viljoen's pegmatite on Okongava Ost 72, Karibib District
14. Tantalite, Ptn. Dernburg of Karibib 54, Karibib District
15. Tantalite, Ptn. Ricksburg of 0kakoara 43, Karibib District

Ost 72, and in pockets intergrown with microlite and manganoapatite in a Li pegmatite on Ptn, Ricksburg of Okakoara 43.

The content of the common trace elements is rather low.

Manganotantalite $(Mn,Fe)(Ta,Nb)_2O_6$. Members of the columbite-tantalite series with Ta and Mn in excess of Nb and Fe have been classified as manganotantalites. They are more widespread than the tantalites and may be regarded as type minerals of Ta mineralization in the highly fractionated Li pegmatites.

In contrast to the columbites which are mostly opaque, the manganotantalites are commonly translucent and of a characteristic golden-brown to red colour. Colour and translucency are, however, variable, depending primarily on the amount of Fe and Nb present, but some trace elements or other physical factors may also have a great influence on the colour.

The present manganotantalites come mainly from the highly mineralized pegmatites of the Karibib area (Table 4, analyses 16-19).

Economic amounts of manganotantalite have been noted in a number of pegmatites in the Karibib area.

Tapiolite (Fe) (Ta, $Nb)_20_6$, tetragonal with a trirutile structure, is a comparatively rare mineral of Ta and has been noted in only two localities, namely on Etiro 50 and Ptn. Mon Repos of Navachab 58 in the Karibib area, where it was recovered from the eluvium.

Generally tapiolite is occurring in Li-poor pegmatites but in places it is closely associated with the Li pegmatites, although it may occur in the Li-poor units of these. Chemically, the mineral is Ta- and Fe-dominant although it is not excluded that some Mn-rich va-

	16	17	18	19	20	21	
Nb_2O_5	21.25	8.85	3.70	3.69	3.13	3	%
Ta_2O_5	63.30	75.18	80.89	81.37	83.05	74	%
MnO	12.91	14.64	13.15	13.12	2.48	10	%
FeO	1.78	0.10	1.38	1.46	11.54	0	%
CaO	-	-	0.01	-	-	-	%
Y_2O_3	0.01	-	-	-	-	-	%
Sc_2O_3	0.16	0.17	0.23	-	-	-	%
TiO_2	0.37	0.76	0.23	0.24	0.16	0	%
ZrO_2	-	0.35	0.08	-	-	-	%
SnO_2	0.12	0.08	0.07	0.12	0.15	13	%
WO_3	-	0.10	-	-	-	-	%
U_3O_8	0.01	0.33	-	-	-	-	%
	99.91	100.46	99.74	100.00	100.51	100	%

Table 4: Chemical composition of Nb - Ta minerals

16. Manganotantalite, Ptn. Dernburg of Karibib 54, Karibib District
17. Manganotantalite, near homestead on Tantalite Valley, Umeis 110, Karasburg District
18. Manganotantalite, Ptn. Mon Repos of Navachab 58, Karibib District
19. Manganotantalite, Okongava Ost 72, Karibib District
20. Tapiolite, Etiro 50, Karibib District
21. Wodginite, Meyer's Camp on Okatjimukuju 55, Karibib District

Analysis 17 is representative of some of the manganotantalites. from Tantalite Valley, which are black in colour in spite of the low Fe and Nb contents.

rieties may be found. Tapiolite is commonly altered to a secondary microlite, which may completely envelop the mineral - it is rather poor in trace elements.

Wodginite, $(Ta,Nb,Sn,Mn,Fe)_{16}O_{32}$ structurally differs from the orthorhombic columbites-tantalites by being monoclinic. This rather rare Ta mineral has been observed in great abundance in a cleavelandite-muscovite unit marginal to the quartz core in a pegmatite on Okatjimukuju 55, near Karibib. It forms yellowish-brown to brown, darkrimmed, sphenoidal crystals and aggregates up to some

25 mm in size. The yellowish, clear portions of the crystals are almost free of Fe and the mineral represents the Sn-bearing, Mn-rich end-member of the wodginite series (Table 4, analysis 21) with the composition $Mn_4(Sn,Ta)_4Ta_8O_{32}$. So far no other Ta minerals than wodginite have been noted at this locality.

It appears from experimental work that wodginite is formed under fO_2 conditions distinctly higher than those characteristic for the stability of columbite-tantalite (Foord, 1982).

It is interesting to note, that in a Li pegmatite closeby, a tantalian cassiterite was observed in the lepidolite unit and not wodginite.

Microlite $(Ca,Na,U)_2(Ta,Nb,Ti)_2(O,OH,F)_7$, the Ta end-member of the pyrochlore-microlite series, is an important source of Ta and has been observed in numerous Li pegmatites in SWA/Namibia. Because of its

small size, irregular form, multiplicity of colours and dispersed nature, microlite is often camouflaged in the host mineral matrix and may be overlooked.

Commonly a small amount of microlite is seen associated with, or replacing other, Ta minerals and only rarely are larger concentrations of the mineral found in specific zones of Li pegmatites. Microlite is mostly disseminated in sugary albite, cleavelandite, lithian mica or in more complex albite-spodumene-lithium mica units.

Being a (F,OH)-bearing mineral, microlite belongs to the last minerals to crystallize and is therefore often noted in the latest micaceous replacing units, and frequently closely associated or replacing the quartz core of the pegmatites.

The chemical composition of microlites is highly valuable as the microlite structure can accommodate a large number of elements.

The Ta content is usually high, up to 79 per cent Ta_2O_5; in highly uraniferous varieties, the Ta content is generally much lower.

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