

ILMENORUTILE AND STRÜVERITE FROM PENIKOJA, SOMERO, SW FINLAND

JAAKKO SIIVOLA

Geological Survey of Finland, Otaniemi, Finland

ABSTRACT

This paper reports the occurrence of ilmenorutile (niobian rutile) and strüverite (tantalian rutile) in two specimens from the Penikoja pegmatite in Somero, SW Finland. One of the specimens contains strüverite as inclusions in pseudo-ixiolite, whereas the other specimen shows both ilmenorutile and strüverite in association with columbite. Microprobe analyses of the minerals concerned are presented.

Introduction

Several niobium and tantalum minerals from the Tammela—Somero pegmatite area in SW Finland have recently been described by Vormä (1965) and by Vormä and Siivola (1967). In conjunction with these studies a phase new to this pegmatite province was recorded. Subsequent examination of this phase proved it to represent partly ilmenorutile (niobian rutile) and partly strüverite (tantalian rutile). Because these two minerals have not previously been found in Finland and because they are in association with each other, their occurrence in the Penikoja pegmatite of the Somero commune will be reported in this paper.

The specimens

The following two specimens were available:
Specimen No. 4561. University of Helsinki collection, labelled as »Ainalite from Penikoja, Somero». The following minerals have been

identified: Cassiterite with pseudo-ixiolite inclusions and pseudo-ixiolite with strüverite and tapiolite inclusions. The strüverite grains measure up to 60 μ in length. Their shape is irregular and polishing hardness about the same as that of pseudo-ixiolite (Fig. 1). This sample, especially the pseudo-ixiolite phase, has formerly been studied by Vormä (1965).

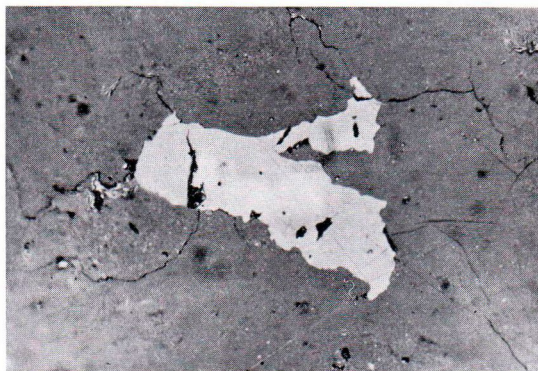


Fig. 1. Strüverite as an inclusion in pseudo-ixiolite. Nic. ||. Magnification 1070 x. Photo Erkki Halme.

Specimen No. 8810. Polished section collection of the Geological Survey of Finland, labelled as »Vorma -66, Penikoja, Somero». The specimen is a single crystal exhibiting the crystal form of rutile. The pyramidal faces (111) are well developed. A microscopic examination of the polished section in reflected light reveals the sample to consist of ilmenorutile and strüverite with some columbite as shown in Fig. 2. Small grains of cassiterite are also present. The columbite grains have uniform optical orientation in large areas of the microscope field of view. This fact probably indicates that the texture is caused by exsolution of columbite.

The optical properties of the ilmenorutile and strüverite studied are similar to each other showing a light creamy colour, weak bireflectivity and moderate anisotropy. Columbite and pseudo-ixiolite are brownish in colour and show more intense bireflectivity.

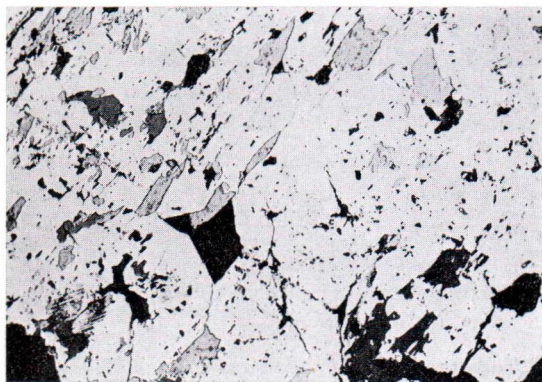


Fig. 2. Ilmenorutile-strüverite (white) with columbite (grey). Black areas are silicate minerals. Nic. ||. Magnification 220 x. Photo Erkki Halme.

Chemical composition

The chemical analyses (Tables 1 and 2) were performed by using an electron microprobe, model »Geoscan». Normally the analysing conditions were as follows: Accelerating voltage 25 kV, specimen current 60 μ A with probe diameter of approximately 1 μ . Sometimes an accel-

TABLE 1

Chemical composition of ilmenorutile and strüverite from Penikoja, Somero, SW Finland. Microprobe analyses.

	Specimen No. 4561 Strüverite	Specimen No. 8810		
		Ilmenorutile	Ilmenorutile	Strüverite
Ta ₂ O ₅	21 %	19 %	10 %	22 %
Nb ₂ O ₅	12	12	10	9
FeO	8	13	8	14
MnO	n.d.	tr.	n.d.	tr.
TiO ₂	55	53	66	48
SnO ₂	1	1	1	2
Total	97	98	95	95

Unit cell content based on O = 4.

Ta	0.19	0.17	0.09	0.21
Nb	0.18	0.18	0.14	0.14
Fe	0.22	0.36	0.21	0.42
Ti	1.40	1.35	1.59	1.30
Sn	0.013	0.013	0.012	0.028
Cation sum ..	2.003	2.073	2.042	2.098
(Fe, Mn)	1.18/2	2.06/2	1.82/2	2.4/2
(Nb, Ta)				
Nb/Ta	0.95	1.06	1.56	0.67

n.d.: not detected.

tr.: trace.

TABLE 2

Chemical composition of pseudo-ixiolite, columbite and cassiterite from Penikoja, Somero, SW Finland. Microprobe analyses.

	Pseudo-ixiolite Specimen No. 4561	Columbite Specimen No. 8810	Cassiterite	
			Specimen No. 4561	Specimen No. 8810
Ta ₂ O ₅	27 %	31 %	0.5 %	2 %
Nb ₂ O ₅	46	44	nd.	nd.
FeO	11	5	1	tr.
MnO	8	12	nd.	tr.
TiO ₂	4	3	0.5	tr.
SnO ₂	0.5	1	95	94
Total	96.5	96 ¹	97	96

¹) Average of two analyses.

n.d.: not detected.

tr.: trace.

erating voltage of 30 kV was used in determining the Ti-content in ilmenorutile and strüverite. Analysing crystals were LiF and Mica. The characteristic lines used were 1st order $K\alpha_1$ -line for Fe, Mn and Ti and 1st order $L\alpha_1$ -line for Nb, Sn and Ta. The following materials were used

as standards: ilmenite (taken as FeTiO_3), cassiterite (taken as 99.5 wt. % SnO_2), manganocolumbite (analysis published in: Vorma and Hoffman, 1965, p. 204, Anal. No. Rb 75/61) and synthetic TiO .

As is illustrated by Table 1, ilmenorutile and strüverite from the Penikoja pegmatite are characterised by high TiO_2 , Ta_2O_5 , Nb_2O_5 and FeO contents with minor SnO_2 . The low content of MnO is remarkable because the surrounding minerals are rich in it (Table 2). An X-ray single crystal oscillation and precession photographs of strüverite, sample No. 4561, give the following monorutile unit cell dimensions (uncalibrated, Mo $K\alpha$ -radiation): $a_0 = 4.62 \text{ \AA}$, $c_0 = 2.99 \text{ \AA}$ with $c_0/a_0 = 0.647$ (Vorma, 1965, oral commun.).

Table 2 summarises the chemical composition of pseudo-ixiolite, columbite and cassiterite found in the specimens studied. The pseudo-ixiolite and the columbite analysed are similar to each other in bulk composition. The cassiterite of specimen No. 8810 shows a fairly high tantalum content. The unit cell parameters of the pseudo-ixiolite No. 4561 have been given by Vorma (1965). The unit cell data for this mineral are summarised in Table 3. According to this table, (Fe, Mn, Ti, Sn): (Nb, Ta) = 1.36 : 2 with Nb : Ta = 2.84 : 1. Thus the analysis suggests the formula (Fe, Mn, Ti, Sn, Nb, Ta)_{4.06(7)}O₈ for this pseudo-ixiolite. The ratio $\text{Nb}_2\text{O}_5 : \text{Ta}_2\text{O}_5$ (in weight percent) in the pseudo-ixiolite No. 4561 is 1.7 : 1, not 18 : 1 as was erroneously given by Vorma (1965, p.

173). The error in the previously reported value of this ratio, determined by the X-ray fluorescence method, is apparently due to the very small amount of material examined.

Discussion

Černý *et al.* (1964) presented a thorough review of the ilmenorutile-strüverite series and established diagrammatically the range of variation in the chemical composition of this series. Plotting the compositions of Table 1 in the diagrams reproduced by these authors (*op. cit.*, Fig. 3 on p. 164 and Fig. 4 on p. 165) shows that the chemical composition of ilmenorutile and strüverite from Penikoja is in accordance with the general chemistry of these minerals. According to the classification scheme of Černý *et al.*, the Penikoja specimens studied in this paper should be included in the section of »inhomogeneous specimens» which consist of a monorutile type mineral in association with an orthorhombic columbite (or pseudo-ixiolite) rich in niobium and manganese.

In distinguishing between ilmenorutile and strüverite, or between niobian rutile and tantalian rutile, the limiting ratio is considered to be Nb/Ta = 1. As has been remarked by Lima de Faria and Quadrado (1966), the value for the a -parameter of the unit cell shows an increase along the sequence rutile — niobian rutile — tantalian rutile — tapiolite. Theoretically, the X-ray powder pattern could be used in estimating the Nb/Ta ratio in these minerals. In practice, however, more data correlating the a -parameter with the Nb/Ta ratio are desirable. In the Penikoja specimen No. 8810 (Table 1) both ilmenorutile and strüverite are present, the ratio Nb/Ta varying from 0.67 to 1.56. Thus, a presence of columbite exsolutions does not necessarily indicate that the monorutile phase contains niobium in excess over tantalum (*cf.* Černý *et al.*, p. 169). Because of the heterogeneous nature of specimen No. 8810, no detailed X-ray study was made of the specimen.

TABLE 3

Unit cell of pseudo-ixiolite No. 4561 from Penikoja, Somero, SW Finland.

	Unit cell content (from Table 2)	Cell parameters (Vorma, 1965)
Ta	0.63	$a = 5.72 \text{ \AA}$ $b = 4.72$ $c = 5.10$ $V = 137.7 \text{ \AA}^3$
Nb	1.79	
Fe	0.79	
Mn	0.58	
Ti	0.26	
Sn	0.017	
O	8	

In specimen No. 8810 especially the TiO_2 , Ta_2O_5 and Nb_2O_5 contents vary greatly. The differences in composition do not affect the optical properties. Therefore, domains of differing compositions cannot be distinguished from each other under the microscope. When the specimen surface is subjected to the electron beam of a microprobe, the image which is monitored by the backscattered electrons distinctly shows the variations in composition. The electron back-scattering power of the sample surface varies greatly as a function of the TiO_2 , Ta_2O_5 and

Nb_2O_5 contents. Thus a qualitative examination of this specimen proved the Nb, Ta-rich rutile phase to be very heterogeneous indeed. Once more, this fact reflects the varying conditions of crystallisation in the Penikoja pegmatite area in Somero, also shown by the common occurrence of disordered columbite.

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