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## KITKAITE (NiTeSe), A NEW MINERAL FROM KUUSAMO, NORTHEAST FINLAND

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### ABSTRACT

Kitkaite, NiTeSe, occurs in carbonate-bearing veinlets in Kuusamo, NE Finland associated with nickel and selenium mineralization. Kitkaite is trigonal,  $a=3.716\pm 0.005$  and  $c=5.126\pm 0.005$  Å, space group  $P\bar{3}m1$ ,  $Z=1$ , calculated density 7.19 gm/cc, measured density 7.22 gm/cc. The mineral is isostructural with melonite with which it forms a solid solution series.

Kitkaite is named in allusion to the river Kitka in the valley of which the mineral was found.

During prospecting work in 1961 in the valley of the Kitka river in Kuusamo, northeast Finland, a silver-white opaque mineral was encountered by a field group of the Outokumpu Company. The mineral could not be identified in the field. Therefore, and because of its interesting mode of occurrence in a zone of nickel and selenium mineralization, it was subjected to a closer study at the research laboratory of the Company. It was found that the mineral represents a new species with the chemical formula NiTeSe. In allusion to the locality of its discovery, the name kitkaite is suggested for the mineral.

As has been pointed out by Sindeeva (1964), minerals containing both selenium and tellurium as major elements have been unknown so far. Some selenium-bearing minerals have been reported with low tellurium contents, but the amount of the latter compared with that of selenium is so small that tellurium must be regarded merely as a minor element not essential to the mineral. Thus, *e.g.* in Shinkolobwe, according to Derriks and Vaes (1955), selenio-vaesite contains 19% Se and selenio-siegenite 11% Se, respectively, and only 0.30–0.55% Te. In addition, despite the fact that a complete solid solubility exists in the synthetic PbSe–PbTe series, no natural minerals have been reported, the compositions of which would be intermediate between clausthalite (PbSe) and

altaite (PbTe). The discovery of the mineral kitkaite to be described in the present paper and the fact that it forms a hitherto unknown series of solid solution with melonite ( $\text{NiTe}_2$ ) indicates that the supposed non-existence of SeTe minerals probably results merely from the scarcity of data available at present for the selenium and tellurium minerals.

The occurrence of kitkaite is intimately connected with a low-grade uranium and selenium mineralization in an albite diabase area, the geology of which has been briefly given by Vuorelainen *et al.* (1964). The mineralization is confined to albitite veins cutting the albite diabase. Kitkaite occurs in albitite in narrow carbonate-bearing fissure veinlets and is associated with clausthalite, hematite, selenian polydymite, selenian linneite and locally also with Ni-, Co- and Se-bearing pyrite. The identification of these minerals was made by powder diffraction pattern combined with a semi-quantitative *x*-ray fluorescence analyses on materials drilled out of the polished sections under a binocular microscope by using a sharp-pointed dental drill.

Kitkaite is often enveloped by a narrow crust of clausthalite which, sometimes, with selenian melonite forms a zone of myrmekite-like intergrowth around the kitkaite core. The selenian melonite was found to contain notably less selenium than kitkaite and the powder diffraction pattern indicates *d*-values for the lines that are only slightly smaller than those for pure melonite. Under the microscope, the color of the selenian melonite differs from that of kitkaite. Usually selenian melonite is slightly paler in color than kitkaite, but in some samples its color shows a reddish hue approaching that of an ordinary melonite.

Hematite commonly occupies the walls of the veinlets forming bunches of needles in random orientation and is clearly older than kitkaite and clausthalite. In some specimens kitkaite has been observed to replace calcite in association with clausthalite, penroseite and the new minerals sederholmite ( $\beta\text{-NiSe}$ ) and trüstedtite (cubic  $\text{Ni}_3\text{Se}_4$ ), (Vuorelainen *et al.*, 1964). In such cases the crystals of kitkaite are remarkably pure without their usual clausthalite envelope as is indicated by Fig. 1. The size of the kitkaite crystals ranges up to 5 mm.

As a matter of curiosity it may be mentioned that slightly outside the mineralized veinlets beautiful spherulites of selenian molybdenite are found ranging up to 1 mm. in size. In some cases the spherulites contain a grain of native gold as a nucleus. In one specimen, a crystal of paraganajuatite was found to occupy the center of the spherulite. *X*-ray fluorescence analyses made of the molybdenite from several samples indicate notable and varying contents of selenium. The most selenium-rich molybdenite analyzed contained 25.0% Se and only 0.067% Te with unit cell edges  $a = 3.20 \text{ \AA}$  and  $c = 12.54 \text{ \AA}$ . Another selenian molybdenite

sample contained 8.8% Se with  $a=3.175 \text{ \AA}$  and  $c=12.33 \text{ \AA}$ . This selenian molybdenite apparently corresponds to what Derriks and Vaes (1955) have described from Shinkolobwe and what they call a "variété sélénifère de la molybdénite." Due to the incorporation of selenium into the molybdenite structure, the cell edges found are longer than those for ordinary molybdenite approaching with increasing Se-content those of pure  $\text{MoSe}_2$  (James and Lavik, 1963).

Kitkaite is pale yellow in color. Under the microscope the mineral shows a distinct pleochroism from pale gray to pink or purple. Its reflec-

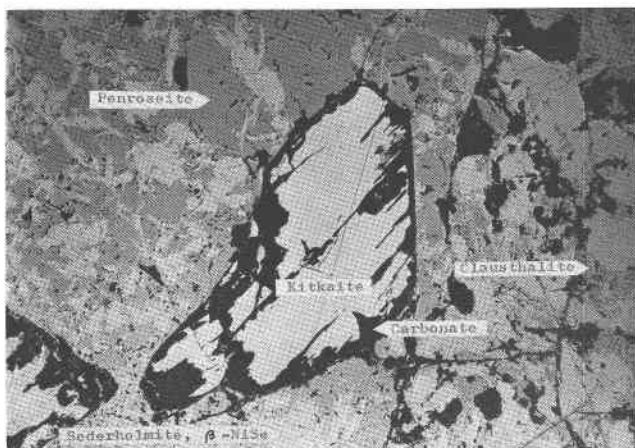


FIG. 1. Kitkaite replacing calcite in penroseite, clausthalite and sederholmite ( $\beta$ -NiSe) assemblage. Note the absence of the clausthalite envelope around kitkaite. Magnification 100 $\times$ .

tivity in air is 56% for green, 65% for yellow and 62% for red light. In immersion the corresponding values are 50%, 56% and 54%, respectively. Cleavage parallel to (001) is often visible. Sometimes kitkaite contains minute inclusions that are best seen on an etched surface. The inclusions are quite too tiny to give any lines in the powder pattern and, thus, have escaped identifications so far. No twinning, zonal texture nor internal reflections have been discerned. The hardness of kitkaite is 110 kg/sq. mm. A pycnometric specific gravity determination yielded a value of 7.22. The etching solvents recommended by Uytenbogaardt (1951) gave the following etch reactions for kitkaite: HCl, FeCl, KCN and KOH all negative;  $\text{HNO}_3$  positive with effervescence;  $\text{HgCl}_2$  positive with slow reaction inducing a brown tarnish.

For chemical analysis two samples marked A and B were prepared and are believed to be of high purity. The results of the analyses, together

TABLE I. CHEMICAL COMPOSITION OF KITKAITE FROM KUUSAMO, NE FINLAND

	Sample A		Sample B	
	Weight %	Unit cell	Weight %	Unit cell
Ni	22.42	1.01	23.33	1.06
Te	47.46	0.99	48.65	1.01
Se	30.22	1.01	27.58	0.93
S	—	—	0.43	0.04
Co	0.40	0.02	0.17	0.01
Cu	0.07	—	0.02	—
Bi	—	—	0.02	—
Ag	0.0005	—	0.005	—
Total	100.57		100.20	

with the calculated unit cell contents, are reproduced in Table I. As is indicated by the data of that table, the chemical composition of the mineral closely approaches the simple stoichiometric formula NiTeSe. The very slight departure from this formula may be caused by analytical errors or, by analogy to the deficiency in sulfur in some iron sulfide minerals, it could also be caused by a slight deficiency in Se and/or Te in the structure. The density calculated for the strictly stoichiometric

TABLE II. X-RAY POWDER DIFFRACTION DATA FOR KITKAITE  
FROM KUUSAMO, NE FINLAND  
Cu radiation, Ni filter, Si standard

hkl	int.	d <sub>obs.</sub>	d <sub>calc.</sub>
001	15	5.13	5.13
100	5	3.213	3.218
101	100	2.729	2.724
002	25	2.567	2.563
102	45	2.007	2.004
110	25	1.860	1.858
201	20	1.535	1.535
105, (112)	35	1.510	1.509
202	10	1.3638	1.3626
004	10	1.2811	1.2812
211, (104)	10	1.1832	1.1834
203	5	1.1717	1.1712
114, (301)	10	1.0559	1.0548
213, (302)	5	.9918	.9908
105	5	.9785	.9766

compound NiTeSe, *viz.* 7.19, is very close to the value measured for the natural kitkaite.

A series of *a*- and *c*-axis Weissenberg photographs prepared of kitkaite revealed the mineral to be trigonal or hexagonal with no systematic extinctions. The powder pattern prepared with a Philips Norelco diffractometer (Table II) agrees well with that of melonite with respect to the positions and intensities of the lines, except for a systematic shift of the lines corresponding to somewhat smaller unit cell edges. Accordingly, it is concluded that kitkaite is isostructural with melonite and is trigonal with a space group of  $P\bar{3}m1$ . The unit cell edges of kitkaite, calculated from powder pattern are  $a = 3.716 \pm 0.005 \text{ \AA}$  and  $c = 5.126 \pm 0.005 \text{ \AA}$  with a unit cell volume of  $61.3 \text{ \AA}^3$  and one formula weight in the unit cell. These unit cell dimensions agree with those obtained from the single crystal photographs.

A short while ago Yushko-Zakharova (1964) reported a new nickel mineral imgreite (NiTe) from the Monchegorsk region. Notwithstanding some similarities in their physical properties, kitkaite and imgreite seem to be two different species. Kitkaite is structurally isotype with melonite, whereas the powder pattern of imgreite clearly differs from that of melonite, as pointed out by Yushko-Zakharova. Also, their chemical compositions show dissimilarities. Kitkaite belongs to mineral type AX<sub>2</sub>, whereas imgreite is a typical AX-compound.

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