NEYITE,* A NEW SULPHOSALT FROM ALICE ARM, BRITISH COLUMBIA

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ABSTRACT

Neyite, $Pb_7Bi_6(Cu, Ag)_2S_{17}$, is a new sulphosalt mineral which occurs as needles and acicular aggregates in late vuggy quartz veins with pyrite, galena, sphalerite, chalcopyrite, aikinite, cosalite, and tetrahedrite. These veins are later than the quartz-molybdenite veins of the Lime Creek molybdenum deposit which is located near Alice Arm, B.C., some 500 miles northwest of Vancouver, B.C. The mineral is lead grey in colour with a bright metallic lustre and Prussian blue tarnish on exposure, it is brittle with a conchoidal fracture, and has a hardness of 2.5 with a specific gravity of 7.02. Rotation photographs and Weissenberg resolutions of the zero and first layer lines with [010] as the rotation axis showed monoclinic symmetry ($C2/m$) and gave: $a = 37.5 \pm 0.1$ Å, $b = 4.07 \pm 0.01$ Å, $c = 41.6 \pm 0.1$ Å, $\beta = 96.8° \pm 0.3°$. Cell content (Z) is 8. Strongest lines of the x-ray powder diffraction pattern are: 3.72 (10), 3.51 (10), 2.92 (10), 2.04 (6), 2.27 (5), 2.08 (4). Reactions to standard etch tests are given. Brief comment is made on other Pb-Bi-Cu sulphosalts of similar occurrence and on attempts to synthesize some of these sulphosalts. The mineral is named for C. S. Ney, District Manager for Kennco Explorations (Western) Ltd. who was in charge of early exploration of the Lime Creek molybdenite deposit.

INTRODUCTION

Sulphosalts were first recognized in the Lime Creek molybdenum stockwork deposit in 1960. The property, now in production under the name of British Columbia Molybdenum Limited, is located at the newly incorporated town of Kitsault, B.C. near the old community of Alice Arm, some 500 miles northwest of Vancouver.

The mineral is named for C. S. Ney, Exploration District Manager for Kennco Explorations (Western) Ltd. who was geologist-in-charge during early exploration of the Lime Creek molybdenum deposit when the new mineral was discovered. Approximately 100 pounds of neyite-bearing material is preserved at the Department of Geology, University of British Columbia, Vancouver, B.C.

OCCURRENCE

An outcropping quartz vein in Patsy Creek immediately south of the main molybdenite deposit contains vugs several inches across with

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abundant crystal aggregates from which studies could be made. The vugs are lined with sparse amounts of a soft, lead grey, prismatic sulphosalt embedded in quartz and projecting into the vugs. These veins were formed later than the main quartz-molybdenite vein stage. Initial tests indicated that the mineral contains lead, bismuth and copper, but the *x*-ray pattern did not fit any for known mineral of this general composition, such as aikinite, benjaminite and rezbanyite. Three other Pb-Bi-Cu sulphosalts, gladite, hammarite, and lindstromite, have been described but without *x*-ray data.

The unknown sulphosalt, later shown to be a new mineral, occurs in close association with pyrite, galena, yellow-green sphalerite, small amounts of chalcopyrite, aikinite, cosalite, tetrahedrite, and molybdenite, and extremely sparse, macroscopically indistinguishable grains, of a second Pb-Bi-Cu sulphosalt. This latter mineral has been described by Kingston (1968) who named it nuffieldite.

Two other unidentified Pb-Bi-Cu sulphosalts have been found in sparse amounts in British Columbia. One of these is from the Cariboo Gold Quartz Mine (a cosalite locality), the other from a quartz vein near Castlegar. The Castlegar occurrence was discovered by Prof. H. V. Warren who noted long thin prismatic crystals resembling cosalite associated with magnetite, pyrite, pyrrhotite, and chalcopyrite.

Physical Properties

The unknown sulphosalt (here called neyite) occurs in late-forming, crosscutting quartz veins both in vugs and intimately intergrown with quartz. In vugs the mineral has grown as an aggregate of prismatic to bladed crystals with stepped surfaces on the broad faces. A characteristic yellow, and eventually Prussian blue tarnish is developed on most of the exposed faces in the vugs. Most of the embedded material occurs as masses of small intergrown crystals and grains along crystallographic planes of quartz. The vuggy material is intergrown with euhedral yellow and yellowish green sphalerite crystals, small euhedral pyrite cubes, and a small amount of chalcopyrite. A few of the long prismatic aggregates are curved as if they had been twisted after growth. Aikinite was identified in some samples. It is similar to neyerite, but is distinctly more yellowish in colour.

Neyite is lead grey in colour. Untarnished crystals have a bright metallic lustre. It is extremely brittle and breaks with a flat conchoidal fracture. Its hardness is about 2.5 and six measurements of specific gravity with a Berman balance averaged 7.02. The mineral does not transmit light through thin edges when mounted in oil.

Polished Section Study

Mounted crystal fragments polish to a smooth homogeneous surface which appear galena-white in reflected light but has a distinctly light tan colour when seen against galena. Reflection pleochroism is not perceptible but the anisotropism is moderate with polarization colours light grey, yellow-green, light reddish-brown to grey-black. Under crossed nicols the mineral consists of solid coarse mosaics with optically continuous areas up to 1 mm^2. Crossed nicols reveal no evidence of twinning. The Talmage hardness is C.

Reactions to the standard etch reagents are as follows, HNO_3—tarnishes black with slight effervescence; HCl—develops a slight brown tarnish; KCN, $FeCl_3$, KOH—are all negative; $HgCl_2$—develops a slight tarnish; and aqua regia—effervesces and stains dark.

Galena, sphalerite, chalcopyrite, and aikinite were observed in direct contact with neyite.

X-ray Crystallography

Single crystal photographs were made using a thin unterminated needle. Individual crystals have dimensions of 0.1 mm × 0.1 mm × 3 mm length. Largest crystal group is 2 mm × 2 mm × 3 mm. The rotation photograph and the Weissenberg resolutions of the zero and first layer lines, with [010] as the rotation axis showed monoclinic symmetry and gave: $a = 37.5 \pm 0.1$ Å, $b = 4.07 \pm 0.01$ Å, $c = 41.6 \pm 0.1$ Å, $\beta = 96.8° \pm 0.3°$, where the $\pm$ limits are estimates of outer bounds of error.

The systematically missing spectra, *hkl* when $h + k$ is odd, conform to the space-groups $C2$, Cm, or $C2/m$.

From the volume of the monoclinic cell (V = 6304 $Å^3$) and the measured specific gravity (G = 7.02), the molecular weight of the cell content is M = 26657.

Composition and Cell Content

The chemical composition of neyite was determined by blowpipe and microchemical tests, qualitative spectrographic analyses and a standard chemical analysis. H. V. Sharples of Coast-Eldridge Limited, Vancouver, made a chemical analysis on a gram of the purest picked material (Table 1). The spectrographic analysis did not show the presence of any element(s) other than those indicated in the analysis. Because of the close similarity in physical properties of neyite, cosalite, aikinite, and

TABLE 1. ANALYSIS AND CELL CONTENT

	1	2	3	4	5	6
Pb	41.76	0.4244	0.002048	54.60	56	42.95
Bi	36.62	0.3722	0.001781	47.47	48	37.14
Cu	2.84	0.0289	0.000454	12.10	16	3.77
Ag	1.52	0.0154	0.000143	3.82		
S_2	15.65	0.1591	0.004961	132.3	136	16.14
TOTAL	98.39	1.0000				100.00

1. Analysis by H. V. Sharples.
2. Analysis reduced to unity.
3. Atomic proportions.
4. Number of atoms in unit cell obtained by multiplying the values under 3 by the molecular weight, 26657.
5. Ideal cell content.
6. Analysis calculated for $7PbS.3Bi_2S_3.Cu_2S$.

nuffieldite, it was necessary to make numerous x-ray powder photographs to confirm the identity of the material used for analysis.

The indicated cell content from Table 1 is:

$$Pb_{56}Bi_{48}(Cu, Ag)_{16}S_{136} = 8 \times [7PbS \cdot 3Bi_2S_3 \cdot (Cu, Ag)_2S]$$

which gives the calculated specific gravity 7.16 for a Cu:Ag ratio of 4:1. The calculated specific gravity for $8 \times [7PbS \cdot 3Bi_2S_3 \cdot Cu_2S]$ is 7.11.

Neyite gives a complicated and somewhat diffuse x-ray powder pattern. Table 2 gives the data with indexing (assuming holohedral symmetry) to a d spacing of 2.04 Å.

THE Pb-Bi-Cu-SULPHOSALTS

The individual mineral species containing lead, bismuth, copper and silver are:

Aikinite	$2PbS \cdot Bi_2S_3 \cdot Cu_2S$
Hammarite	$2PbS \cdot 2Bi_2S_3 \cdot Cu_2S$
Lindstromite	$2PbS \cdot 3Bi_2S_3 \cdot Cu_2S$
Gladite	$2PbS \cdot 5Bi_2S_3 \cdot Cu_2S$
Rezbanyite	$4PbS \cdot 5Bi_2S_3 \cdot 2Cu_2S$
Neyite (Alice Arm #1)	$7PbS \cdot 3Bi_2S_3 \cdot (Cu, Ag)_2S$
Benjaminite	$2PbS \cdot 2Bi_2S_3 \cdot (Cu, Ag)_2S$
Nuffieldite (Alice Arm #2)	$10PbS \cdot 5Bi_2S_3 \cdot 2Cu_2S$
Cariboo Unknown	Pb,Bi,Cu,Ag,S
Castlegar Unknown	Pb,Bi,Cu,(Ag?)S

TABLE 2. *X*-RAY POWDER DATA

$7PbS \cdot 3Bi_2S_3 \cdot (Cu, Ag)_2S$

Monoclinic, $C2/m$; a = 37.5 Å, b = 4.07 Å, c = 41.6 Å, β = 96.8°; Z = 8

I	*d*(meas)Å	*hkl*	*d*(calc)Å	*I*	*d*(meas)Å	*hkl*	*d*(calc)Å
1	6.15	600	6.21			$\overline{14}.0.3$	2.67
½	3.97	112	3.96	3	2.66	915	2.67
10	3.72	10.0.0	3.72			$\overline{5}.1.11$	2.66
		$\overline{5}13$	3.51			718	2.65
10	3.51						
		512	3.49			$\overline{13}.1.1$	2.35
		$\underline{5}13$	3.41	½	2.34	$\underline{12}.0.10$	2.35
3	3.39	$\underline{6}.0.11$	3.40			$\underline{10}.0.15$	2.35
		10.0.4	3.38			$\underline{13}.1.3$	2.34
		$\underline{10}.0.5$	3.25			7.1.12	2.28
3	3.24	$\underline{5}16$	3.25	5	2.27	13.1.3	2.27
		$\overline{7}11$	3.24			1.1.15	2.26
		$\underline{7}10$	3.23			$\underline{15}.1.2$	2.09
		$\overline{5}17$	3.13	4	2.08	$\underline{9}.1.15$	2.08
1	3.12	10.0.6	3.12			$\overline{2}.0.20$	2.08
		4.0.12	3.11			$\underline{18}.0.0$	2.07
		$\underline{5}16$	3.10			$\overline{11}.1.14$	2.05
		$\overline{7}17$	2.92	6	2.04	$\underline{5}.1.16$	2.04
10	2.92	$\underline{8}.0.10$	2.92			020	2.04
		$\overline{1}.1.10$	2.91				

I	*d*	*I*	*d*	*I*	*d*	*I*	*d*
1	1.969	½	1.613	3	1.373	½	1.217
3	1.848	½	1.558	2	1.331	½	1.192
3	1.784	½	1.506	3	1.315	1	1.033
3	1.746	4	1.461	1	1.287	1	1.012
½	1.670	½	1.402	½	1.252		

Aikinite has been fully described. Hammarite, lindstromite and gladite, rare minerals from Gladhammar, Sweden, were described by Johansson (1924) but without *x*-ray data. Padera, Bouska, and Pelikan (1955) have revised the formula of rezbanyite from $3PbS \cdot 5Bi_2S_3 \cdot Cu_2S$ to that given above, with *x*-ray diffraction data but no cell dimensions. Nuffield (1953) gives cell dimensions and *x*-ray powder data for benjaminite, and Mintser (1967) has given the above composition. Kingston (1968) gave the above composition for nuffieldite. The last two minerals listed above occur in very small amounts, but *x*-ray and optical data are available. The *x*-ray diffraction data are given below in the hope that they may be recognized by others elsewhere (Tables 3 and 4).

SYNTHETIC PRODUCTS

Direct dry fusions of the constituent elements were made, in evacuated silica glass tubes, of compositions corresponding to aikinite, hammarite,

TABLE 3. *X*-RAY POWDER DATA*
Pb-Bi-Cu-Ag Sulphosalt, Cariboo Gold Quartz Mine, Wells, B.C.

I	*d*	*I*	*d*	*I*	*d*	*I*	*d*
1	4.53	5	2.75	6	2.04	½	1.473
½	4.15	½	2.67	3	1.969	½	1.447
3	3.92	½	2.54	1	1.918	2	1.412
5	3.65	1	2.46	½	1.831	1	1.386
10	3.45	½	2.38	½	1.824	1	1.332
3	3.24	3	2.32	5	1.752	1	1.295
5	3.02	1	2.27	½	1.684	2	1.245
4	2.90	3	2.16	1	1.506	1	1.160

*UBC 2898 Cu/Ni.

TABLE 4. *X*-RAY POWDER DATA*
Pb-Bi-Cu-(Ag?) Sulphosalt, near Castlegar, B.C.

I	*d*	*I*	*d*	*I*	*d*	*I*	*d*
1	4.05	4	3.01	4	2.13	2	1.333
1	3.66	4	2.91	6	2.06	2	1.301
10	3.40	3	2.79	½	2.01		
½	3.21	½	2.33	1	1.964		
3	3.10	3	2.27	4	1.757		

*UBC 3483 Fe/Mn.

lindstromite, gladite, rezbanyite and neyite. All fusions formed readily but only the melt of rezbanyite gave a homogeneous product. The aikinite fusion gave an *x*-ray powder pattern identical to that of the natural mineral plus a few extra lines. The hammarite fusion gave a pattern whose lines could all be accounted for by bismuth and aikinite. The lindstromite and gladite fusions gave similar unknown patterns plus lines due to bismuth. The rezbanyite fusion gave a pattern, many of the lines of which agree closely with those given by Padera (1955), for the natural mineral.

Syntheses corresponding to the composition of neyite, both with and without silver, were made; these gave identical powder patterns which are different from those of the natural mineral. A fusion of a small quantity of neyite gave an inhomogeneous product. A powder pattern of a small hump on the melt gave a pattern identical to that of the rezbanyite fusion but the main regulus gave an unknown pattern.

It is hoped that many of the problems connected with this complex group of minerals will be resolved with publication of data on the Gladhammar minerals by Professor Wickman and his associates.

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