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A NOTE ON FREIBERGITE, PYRARGYRITE AND BOURNONITE FROM GRUDNO, LOWER SILESIA

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Abstract. The present paper discusses freibergite, pyrargyrite and bournonite from an ore vein in the vicinity of the polymetallic deposit Stara Góra. The identification has been based on the optical features, microhardness tests and electron microprobe analysis. Freibergite has not been so far described in Poland and pyrargyrite only once (at Kowary). The silver content in freibergite from Grudno is classified with the highest in the tetrahedrite group, being inferior only to that in the freibergites from the British Columbia.

In the eastern part of Góry Kaczawskie (the Kaczawskie Mountains) near Grudno there occurs an ore vein that has not been so far examined and is marked with the symbol Fe on Zimmerman's map (1929). Sulphide minerals occur there together with calcite in the Lower Cambrian limestones and also in silicified limestones and phyllites. A study of the sulphide minerals has demonstrated the presence of a.o. silver-rich tetrahedrite (freibergite), pyrargyrite and bournonite.

Three paragenetic assemblages can be distinguished that have been discussed comprehensively in a work of Paulo and Salamon (1973): 1) arsenopyrite, pyrite I, quartz; 2) sphalerite I, tetrahedrite, chalcopyrite I, pyrite II; 3) boulangerite, bournonite, pyrargyrite, galena, antimonite, sphalerite II, chalcopyrite II, arsenopyrite II, pyrite III, calcite. Morphologically they resemble assemblages known from Stara Góra (Manecki 1965), being at the same time conspicuous by the presence of numerous fine-grained intergrowths of sulphosalts.

The identification was principally based on microscopis observations in reflected light. Hardness measurements were performed using a PMT-3 microhardness tester. Reflectivity was measured in a non-serial apparatus consisting of microscope, selenium cell and galvanometer with a sensitivity of 10^{-9} Å. Galena served as a standard.

An analysis of the chemical composition of silver minerals and the occurring bournonite was performed on the CAMECA X-ray micro-

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analyser[1]. For Fe, As, Sb, Ag, Cu, Zn determinations pure metal standards were used. whereas galena was the standard for Pb and S. For Fe, S, As, Zn, Cu analysis the K_{α} line was used and for Sb, Ag, Pb — the L_{α} line.

The chemical composition was calculated using the formulae cited by Bojarski (1971), taking into account corrections resulting from the difference in atomic numbers as well as from absorption and fluorescence effects of radiation in the examined material. Considering the coincidence of the PbL_{α} and AsK_{α} analytical lines, the determined contents of these elements could be only roughly estimated.

Control of the chemical composition was made using spectral method. Complete separation being impossible, the material analyzed was inhomogeneous, consisting of two or more minerals. Both methods yielded compatible results.

T e t r a h e d r i t e (freibergite) is the common vein component. It shows slight differentiation of optical characteristics, this very likely reflecting the variations in the chemical composition. Tetrahedrite occurring in arsenopyrite fissures reveals a faint green tinge in oil and very likely corresponds to the intermediate member

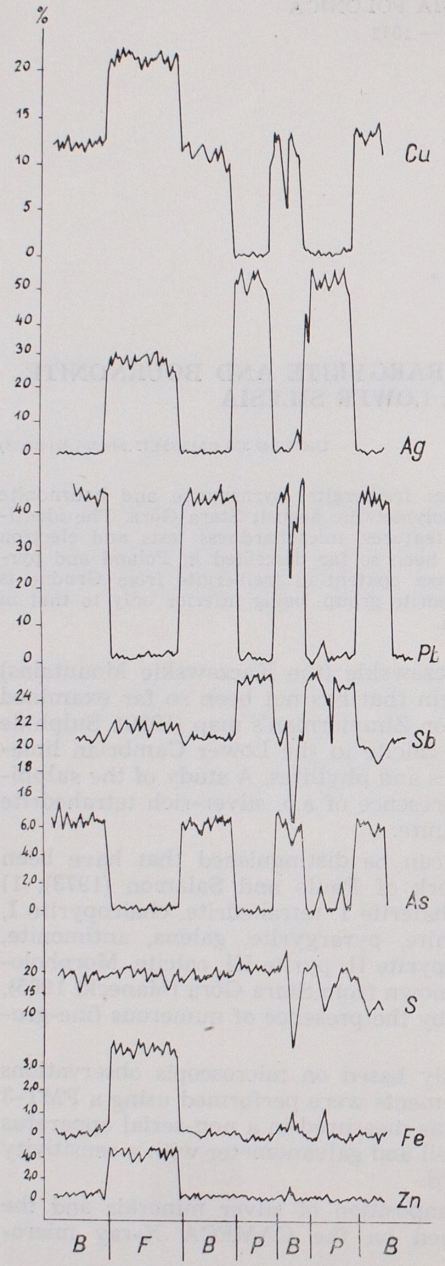

Fig. 1. Electron probe scan for Cu, Ag, Pb, Sb, As, S, Fe and Zn along the line $A — A'$ (Phot 2)
B — bournonite; F — freibergite; P — pyrargyrite

[1] The analysis was performed by P. Bolechała, M.Sc., eng.

of the tetrahedrite-tennantite isomorphous series. The variety encountered in the sulphosalt zone is olive-grey with yellow tinge in oil. According to Ramdohr (1960), this feature points to an antimony member, Ag-rich freibergite. R = 30,4 ± 1%, microhardness (VHN) = 198—261; the polishing hardness is smaller than that of sphalerite, equal to or greater than that of bournonite and greater than that of boulangerite or pyrargyrite. A roughly estimated chemical composition of the freibergite under study is presented in Table 1 and on diagram (Fig. 1). It corresponds to the formula:

$$Cu_{1.7}\ Ag_{1.0}\ Fe_{0.4}\ Zn_{0.3}\ Sb\ S_{3.2}$$

The presence of considerable As, Bi, Hg substitutions has been excluded by spectral analyses. The Ag content is very high, yielding only precedence to the freibergites from the British Columbia in Canada (Staples, Warren, 1946 *vide* Minerały 1960).

B o u r n o n i t e occurs predominantly in association with the two varieties of tetrahedrite, pyrargyrite and boulangerite. It has typical physical properties, R = 34 ±1%. The grains, as a rule, reveal polysynthetic twinning. The chemical composition is presented in Table 1. On account of the coincidence of the Pb and As analytical lines, there is an error involved in the determinations of these elements. The deviations from the composition of bournonite from other deposits are not however substantial.

P y r a r g y r i t e generally accompanies bournonite, forming hipidiomorphic grains. From other sulphosalts it is distinguished by grey-blue colouring, distinct bireflectance (in air R_1 = 32.2 ±1%, R_2 = 30.1 ±1%; in oil R_1 = 20.1 ±1%, R_2 = 18.4 ±1%), strong anisotropy with a dull yellow and grey-blue colour effect, and strong carmine red internal reflections cleary visible even without immersion. It yields readily to polishing, its relief being lower than that of boulangerite or bournonite. Microhardness (VHN) is 88—122.

T a b l e 1

Chemical composition determined by the electron-microprobe

Element	Freibergite	Pyrargyrite	Bournonite
Ag	22.66	56.77	—
Cu	22.82	—	11.84
Sb	25.62	25.98	20.79
Pb	—	—	43.91
As	—	—	5.02
Zn	4.14	—	—
Fe	4.90	—	—
S	21.28	16.92	20.88
Total	101.42	99.67	102.44

The approximate chemical composition of pyrargyrite under study is shown in Table 1 and on diagram (Fig. 1). It corresponds to the formula:

$$Ag_{2.9}\ Sb_{1.2}\ S_{2.9}$$

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FREIBERGIT, PIRARGYRYT I BURNONIT Z GRUDNA

Streszczenie

Opisano freibergit, pirargyryt i burnonit z żyły kruszcowej w okolicy złoża polimetalicznego Stara Góra. Identyfikację oparto na cechach optycznych, mikrotwardości i mikroanalizie elektronowej. Freibergit nie był dotąd stwierdzony w Polsce, obecność pirargyrytu zaważono w Kowarach. Zawartość srebra wefreibergicie z Grudna należy do najwyższych w grupie tetraedrytów, ustępując jedynie freibergitom z Kolumbii Brytyjskiej.

OBJAŚNIENIE FIGURY

Fig. 1. Wykres koncentracji Cu, Ag, Pb, Sb, As, S, Fe i Zn w profilu *A — A′* zaznaczonym na fot. 2.
B — burnonit, *F* — freibergit, *P* — pirargiryt

Анджей ПАУЛО, Витольд САЛЯМОН

ФРЕЙБЕРГИТ, ПИРАРГИРИТ И БУРНОНИТ ИЗ РАЙОНА ГРУДНО

Резюме

Описаны фрейбергит, пираргирит и бурнонит, находящиеся в составе рудной жилы в районе полиметаллического месторождения Стара-Гура. Определение основывается на оптических признаках, микротвердости и данных электронного микроанализа. Фрейбергит до сих пор в Польше не встречался, а пираргирит толко в Ковapax. Фрейбергит из Грудно-содержит самое большое количество серебра среди блеклых руд, уступая лишь фрейбергиту Британской Колумбии.

ОБЪЯСНЕНИЯ К ФИГУРЕ

Фиг. 1. График концентрации Cu, Ag, Pb, Sb, As, S, Fe, Zn в профиле *A — A′*, отмеченном на фото 2
B — бурнонит, *F* — фрейбергит, *P* — пираргирит

PLATE I (PLANSZA I, ТАБЛИЦА I)

Phot. 1. Pyrargyrite (*P*) and bournonite (*B*) replacing freibergite (*F*). Reflected light, immersion. Magn. × 320

Pirargyryt (*P*) i burnonit (*B*) zastępujący freibergit (*F*). Swiatło odbite, immersja. Pow. × 320

Пираргирит (*P*) и бурнонит (*B*), замещающий фрейбергит (*F*). Отраженный свет, иммерсия, увел. × 320

Phot. 2. Electron image of: freibergite (*F*), bournonite (*B*) and pyrargyrite (*P*). *AA'* — scanning line

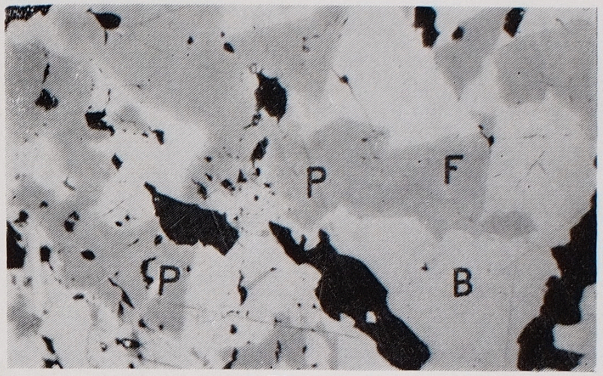
Obraz elektronowy absorpcyjny analizowanych minerałów: freibergitu (*F*), burnonitu (*B*), pirargyrytu (*P*). *AA'* — profil badawczy

Электронное абсорбционное изображение анализированных минералов: фрейбергита (*F*), бурнонита (*B*), пираргирита (*P*). *A—A'* — исследованный профиль

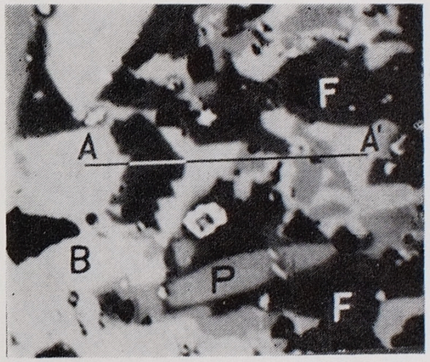
Phot. 3. Distribution of Pb

Rozmieszczenie

Распределение Pb



Phot. 1



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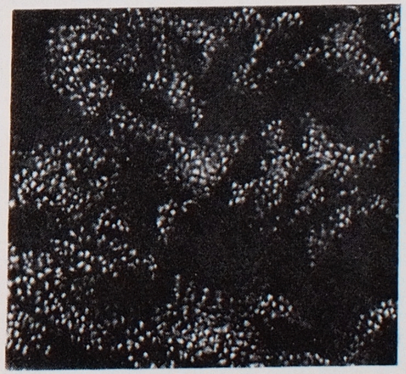

Phot. 3

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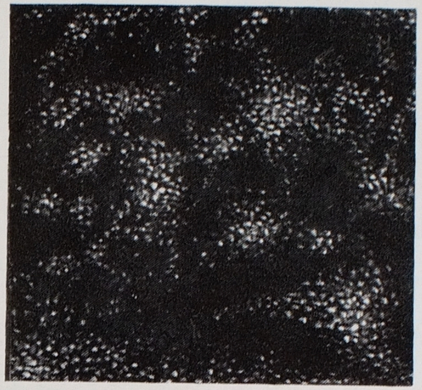
PLATE II (PLANSZA II, ТАБЛИЦА II)

Phot. 4. Distribution of Cu. Cu K_α image
Rozmieszczenie
Распределение

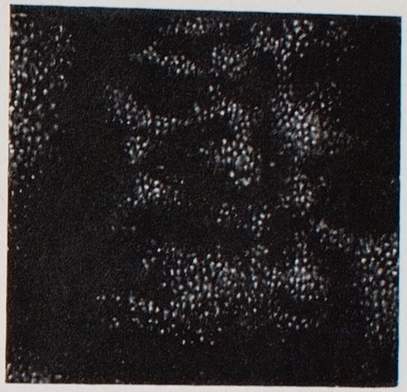
Phot. 5. Distribution of Ag. Ag L_α image
Rozmieszczenie
Распределение

Phot. 6. Distribution of Fe. Fe K_α image
Rozmieszczenie
Распределение

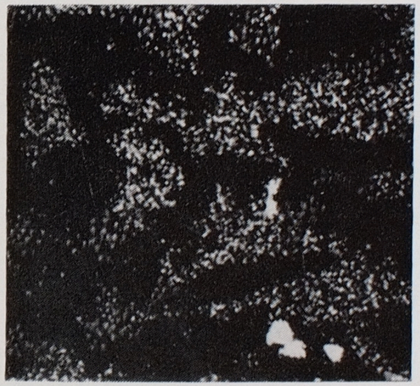
Phot. 7. Distribution of Sb. Sb L_α image
Rozmieszczenie Sb
Распределение Sb



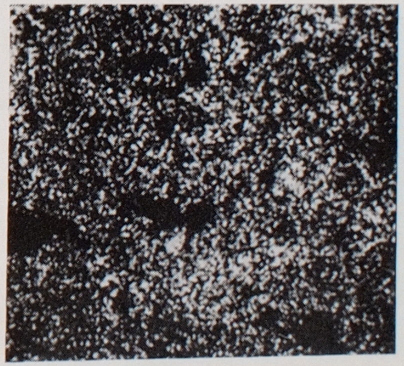
Phot. 4.



Phot. 5



Phot. 6



Phot. 7

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