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Bonchevite, $PbBi_4S_7$, a new mineral.

By IVAN KOSTOV, D.I.C., F.G.S.

Professor of Mineralogy, University of Sofia.

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Summary. In quartz-scheelite veins traversing rocks from the metamorphic complex in the Central Rhodopian mountains, a mineral was found closely resembling bismuthinite. Its composition is Bi 66.62 %, Pb 15.50 %, Cu 0.85 %, and S 16.71 %, corresponding to the formula $PbBi_4S_7$. It is orthorhombic, long prismatic to acicular with an axial ratio $a:b:c = 0.9004:1:0.3249$. Observed forms: {110}, {100}, {010}, and {011}. Sp. gr. 6.92. Hardness about $2\frac{1}{2}$. Displays a perfect cleavage along {100}. It is distinctly anisotropic. Strongest X-ray intensities: 3.50 Å. (10), 3.08 (8), 1.939 (8), 2.78 (6), 1.733 (6), 2.50 (5). The name is after the eminent Bulgarian mineralogist and petrographer G. Bonchev.

DURING a field practice carried out with students in the Central Rhodopian mountains in 1952, a mineral was found that according to some preliminary microchemical tests was thought to be tetradymite. Owing to certain engagements the mineral was not studied until last year when additional material was secured. Detailed investigations proved it a new mineral from the series Bi_2S_3 - $PbBi_2S_4$, to which was given the name *bonchevite* in honour of Academician Georghi Bonchev (Г. Бончев), former professor and founder of the Institute of Mineralogy and Petrography at the University of Sofia.

The mineral occurs in quartz veins cutting a metamorphic rock series, mainly gneisses and amphibolites, of unknown age, in close proximity to the so-called Yugovo granite. The latter is considered to be of Tertiary age. The mineral paragenesis includes as principal minerals scheelite, pyrite, and bonchevite with sparse zinblende and molybdenite. The gangue is exclusively milky quartz, locally enriched in calcite. White mica often develops along the selvages of the veins.

Morphology. The new mineral is found usually as acicular or long prismatic crystals and aggregates up to 2 cm. in size. Most of them are tectonically deformed (fig. 1). The crystals are apparently orthorhombic. On four crystals measured with the reflection goniometer angles of 48° and 18° were observed, corresponding to ϕ for $m\{110\}$ and ρ for $e\{011\}$



FIG. 1.

FIG. 1. Bonchevite crystals in milky quartz. $\times 20$.

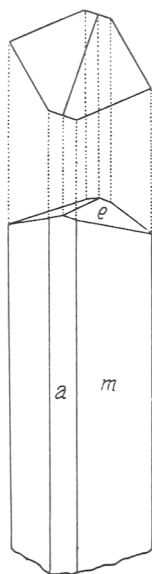


FIG. 2.

FIG. 2. Typical habit of bonchevite.

respectively. In addition the forms $a\{100\}$ and $b\{010\}$ have been recognized. Observed combinations were: $\{110\}\{011\}$, $\{110\}\{100\}\{011\}$ (fig. 2), and $\{110\}\{100\}\{010\}\{011\}$. The axial ratio as determined from the above angles is $a:b:c = 0.9004:1:0.3249$, which lies between those for bismuthinite ($0.9862:1:0.3498$) and galenobismutite ($0.8050:1:0.2828$). The faces $\{110\}$ are commonly striated along the c -axis.

Physical properties. A perfect cleavage apparently along $\{100\}$ is observed on most crystals. Otherwise the mineral shows an uneven or subconchoidal fracture; the crystals are very brittle. Hardness about $2\frac{1}{2}$. The density was determined on five samples using the method suggested by N. I. Rudenko and M. M. Vassilevski (1957); the mean value thus obtained is 6.92. The mineral is lead- to steely-grey with metallic lustre;

in polished sections it is weakly pleochroic and distinctly to strongly anisotropic. Several polished sections etched with HCl, HNO₃, and FeCl₃ failed to reveal any inhomogeneities (fig. 3). Very sporadic minute inclusions, most probably of native bismuth, are found in some sections.

Chemical composition. Carefully selected samples of the mineral have been analysed by N. Yordanov, Senior Assistant in Analytical Chemistry

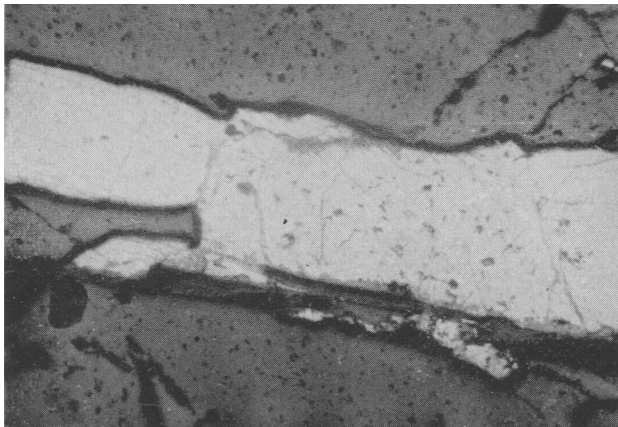


FIG. 3. Polished section of bonchevite showing cleavage and rims of weathered products. $\times 150$.

in the University of Sofia, firstly by using the polarograph in order to get a provisional idea about its composition and then by a tested analytical procedure in order to secure a complete separation of the bismuth from the lead. The results in all cases closely agreed. The complete analysis of the mineral gave the following percentages: Bi 66.62 %, Pb 15.50 %, Cu 0.85 %, S 16.71 %, total 99.68 %. The analysis corresponds almost exactly to the ideal formula $2\text{Bi}_2\text{S}_3 \cdot \text{PbS}$ or PbBi_4S_7 . Apart from lead, bismuth, copper, and sulphur, Ag, Zn, Cd, Sb, and Te have been detected spectrographically; the last element was also found by micro-chemical tests.

Rims of a weathering product, probably a bismuth carbonate, are found around some of the bonchevite crystals (fig. 3).

X-ray diffraction data. Powder patterns of bonchevite were recorded using a VEM 'TUR' M 60 apparatus and standard camera with copper radiation and nickel filter. All patterns proved to be identical. X-ray powder data of the best diffraction photograph are given in table I

(fig. 4) together with X-ray powder data of related minerals. The intensities are estimated visually.

The X-ray powder pattern of bonchevite is very similar to but not identical with that of the bismuthinite. As the only X-ray data of bismuthinite to hand were those by A. Harcourt (1942), several selected

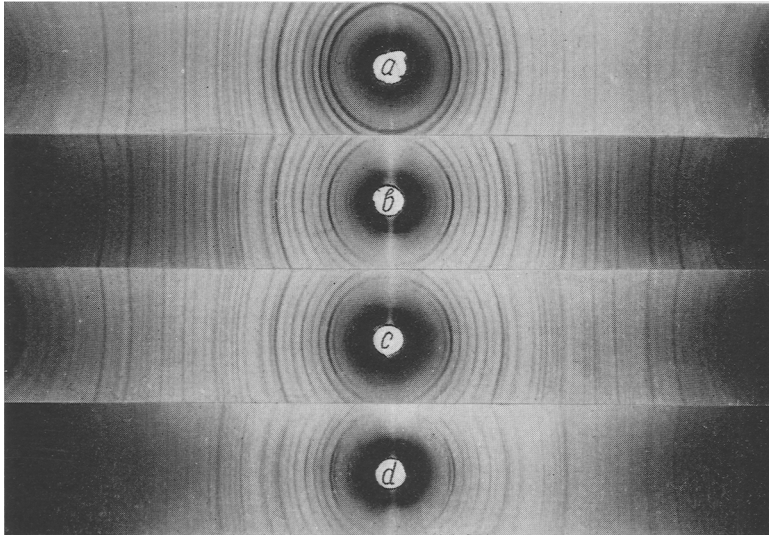


FIG. 4. X-ray powder photographs of bonchevite (a); bismuthinite from Telemarken, Norway (b); bismuthinite from Cerro de Chorolque, Bolivia (c); and galenobismutite from Falun, Sweden (d).

samples from two rich specimens from the mineral collection of the University of Sofia have been X-rayed for comparison, one labelled Bleka, Telemarken, Norway, the other Mina Coronacion, Cerro de Horolque, Bolivia. Semiquantitative spectrographic analyses of these bismuthinites revealed less than 1 % Pb. Their X-ray powder patterns are identical (see table I and fig. 4 *b* and *c*), but are different from that of the bismuthinite given by Harcourt. On the other hand, the X-ray patterns of the Norwegian and Bolivian bismuthinites differ distinctly from that of the bonchevite in the intensities and slight changes of the *d*-values of some lines. Thus:

bonchevite: $d = 3.50$ (10), 3.08 (8), 2.78 (6), 2.50 Å. (5).

bismuthinite: Norway: $d = 3.44$ (10), 3.03 (5), 2.76 (3), 2.48 Å. (7).

Bolivia: $d = 3.46$ (10), 3.06 (5), 2.76 (3), 2.47 Å. (7).

In addition there is the line 3.70 Å. in the powder pattern of bonchevite, lacking altogether in the X-ray patterns of the bismuthinites. This value is, however, met with in the X-ray powder data of galenobismutite as given by L. G. Berry (1940). Another specimen of galenobismutite from Falun, Sweden, X-rayed by the author for comparison, showed *d*-values agreeing well with those given by Berry (see table I). The differences between these X-ray patterns and that of bonchevite are, however, obvious. Having in mind the internal homogeneity of the crystals of the new mineral and the differences displayed by its X-ray patterns and crystallography it is logical to assume a new phase in the system Bi_2S_3 - PbBi_2S_4 rather than a mixture of these two 'end-members'.

Discussion. The system Pb-Bi-S was recently dealt with by A. R. Graham, R. M. Thompson, and L. G. Berry (1953) who obtained by hydrosynthetic experiments Bi_2S_3 , galenobismutite, PbS, and phase 2 = cannizzarite, redefining the latter as a mineral species on X-ray grounds, without giving for it any formula. Cannizzarite was described from the fumaroles on Vulcano, Lipari Islands, by Zambonini, de Fiore, and Carobbi (1925), who gave for it the formula PbBi_4S_7 , the same as that of bonchevite. In a revision of the chemical composition of cannizzarite Wolfe (1938) gives a formula $\text{Pb}_3\text{Bi}_5\text{S}_{11}$ and axial ratio $a:b:c = 0.8050:1:0.2828$. The latter, according to M. A. Peacock (Dana, 1944), corresponds to the axial ratio of galenobismutite and in Dana's 'Mineralogy' (7th edn) cannizzarite is considered to be identical with galenobismutite. It should be noted also that Wolfe's formula is with uncompensated charges, showing an excess of sulphur. As Carobbi's analysis agrees well with the composition of bonchevite it is possible that the specimens studied by Zambonini differed from those described by Wolfe and that the originally described cannizzarite was in fact identical with the mineral dealt with in this paper. The name cannizzarite as re-established by Graham, Thompson, and Berry refers, however, to a product which has an entirely different X-ray pattern, similar to that of the mineral X-rayed by Harcourt (see table I). This mineral (Harcourt's cannizzarite) again comes from the Lipari Islands.

Three more minerals have already been described in the series Bi_2S_3 - PbBi_2S_4 : ustarasite, $\text{PbBi}_6\text{S}_{10}$ (Saharova, 1955), chiviatite, $\text{Pb}_3\text{Bi}_8\text{S}_{15}$ (Rammelsberg, 1853), and rezbanyite, $\text{Pb}_4\text{Bi}_{10}\text{S}_{19}$ (Frenzel, 1883). For rezbanyite the formulae $\text{Pb}_2\text{Bi}_6\text{S}_{11}$ and $\text{Cu}_2\text{Pb}_3\text{Bi}_{10}\text{S}_{19}$ have also been suggested (Ramdohr, 1955; Koch, 1948; Padera, 1956), the last mentioned perhaps more becoming so far as the type mineral is concerned. The remaining two minerals are not firmly established as

definite species. With the rational ratio $\text{Bi}_2\text{S}_3:\text{PbS} = 2:1$, one could accept logically the mineral described in this paper as a well-defined new intermediate but not isomorphous member of the series $\text{Bi}_2\text{S}_3\text{-PbBi}_2\text{S}_4$ (Kostov, 1957).

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