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MINERALS OF THE BISMUTHINITE-AIKINITE SERIES FROM RĘDZINY (WESTERN SUDETES)

Abstract: Signs of a rich, hydrothermal polymetallic mineralization are finding at the Rędziny dolostones quarry located in a distance of several hundred meters of the Karkonosze granite intrusion. Using electron microprobe (WDS mode) the authors have identified minerals of the bismuthinite-aikinite series occurring within arsenopyrite-quartzo-chlorite veins. Position of the samples belonging to the series was evaluated from the equation $n_{aik} = 25[(x + y)/2]$. In Rędziny, the most common phases of bismuthinite-aikinite series are their end-members as well as friedrichite, hammarite, lindströmite, krupkaite, paarite, salzburgite and gladite. They are associated with other Pb, Bi(Sb), Cu and Ag sulphosalts, galena, sphalerite, chalcopyrite, ikunolite and bismuth.

Keywords: bismuthinite-aikinite series, chemical composition, Rędziny

INTRODUCTION

Minerals of the bismuthinite-aikinite series, most often have been found in paragenesis with other bismuth minerals. They form a group of 11 species, distinguished on the basis of structural changes associated with dominant substitution within this group, i.e. Cu + Pb = $\square$ + Bi. The essential equation of this division, (Cu + Pb)/2 + Bi = 8, gives the following general formula for the compositions of the whole series: $Cu_xPb_yBi_{8-0.5(x+y)}S_{12}$, where the *x* value should be equal to *y*, and both can change continuously between 0 and 4. From this, x = y = 4 for the theoretical composition of aikinite $Cu_4Pb_4Bi_4S_{12}$, and x = y = 0 for bismuthinite $Cu_0Pb_0Bi_8S_{12}$, i.e. Bi_2S_3. The position of a mineral phase belonging to the bismuthinite-aikinite series can be evaluated from the equation $n_{aik} = 25[(x + y)/2]$ (Makovicky, Makovicky 1978; Topa *et al.* 2002), where for aikinite n = 100, while for bismuthinite n = 0. The Bi_2S_3-PbS-Cu_2S ternary diagram proposed by Harris and Chen (1976) is the most satisfactory.

The paper presents characteristics of the minerals of the bismuthinite-aikinite series from Rędziny as a supplement to the occurrence and genesis of sulphosalts in the E envelope of the Karkonosze granite intrusion.

GEOLOGICAL SETTING

The deposit of dolomitic marbles in Rędziny, localized within the schist series of the Kowary-Czarnów unit (Kozdrój 2003, Mazur 2003) as a result of Hercynian movements has been fragmented into several parts, separated by schist zones of NNW-SSE trending. These zones favoured migration of hydrothermal solutions derived form the nearby Varsican intrusion of the Karkonosze granite. The various ore minerals crystallized from

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hydrothermal fluids. Besides dominating arsenopyrite and cassiterite, the list of minerals includes chalcopyrite, pyrite, pyrrhotite, sphalerite, galena, various Pb, Bi(Sb), Cu and Ag sulphosalts, and others. Primary sulphide mineralization has been affected by hipergenic alterations, resulting in a wealth of secondary minerals, described in earlier papers (Gołębiowska, Pieczka 1998; Gołębiowska 2003; Parafiniuk, Domańska 2002; Pieczka *et al.* 2004).

In Rędziny, species belonging to the bismutinite-aikinite series are associated with other Pb, Bi(Sb), Cu and Ag sulphosalts, galena, sphalerite and chalcopyrite within large arsenopyrite-quartz-chlorite accumulations. Bismuthinite was also found as small inclusions in another, lower-temperature association with chalcopyrite, ikunolite and bismuth.

METHODS OF INVESTIGATIONS

Optical observations in the reflected light were carried out using an OLYMPUS BX-12 microscope. Chemical compositions of the minerals were established at the Inter-Institute Analytical Complex for Minerals and Synthetic Substances of the Warsaw University. A Cameca SX-100 electron microprobe operated in the WDS mode under the following conditions: excitation voltage 15 kV, beam current 20 nA, peak count-time 20 s, background time 10 s. Determination of the position of mineral species within the bismuthinite-aikinite series was based on microprobe analysis. In the case of the phases close in their chemical composition, e.g. hammarite and emilite, full identification will only be possible after carrying out X-ray diffraction in microareas.

RESULTS AND DISCUSSION

The aikinite-krupkaite species occur in the arsenopyrite-quartz-chlorite veins with sphalerite, stannite and chalcopyrite, within a polymetallic association composed mainly of Pb, Bi(Sb), Cu and Ag sulphosalts. The members of this series are most often localized in the outer parts of these aggregates, where they form anhedral grains with sizes up to 100 μm. The central parts are filled with elongated laths of giessenite and gustavite, less frequent berryite, irregular grains of felbertalite and galena. The aikinite-krupkaite species show in the reflected light a delicate yellowish tint and weak bireflectance. Graphic and lamellar intergrowths of aikinite-krupkaite with fine-grained galena, bournonite and Ag-tetrahedrite, resembling exsolution or decomposition products of an earlier Bi-bearing phase, were also observed. A similar type of aikinite grains, however seldom co-occurring with galena, was mentioned in polymetallic veins of the Wojcieszów area (Manecki 1965), while in Miedzianka aikinite occured as small aggregates within chalcopyrite grains in association with sphalerite, chalcocite and bismuth (Zimnoch 1978).

In the polymetallic veins of Rędziny another type of aikinite can also be found, occurring in the form of large grains reaching 1 mm and associated with a slightly different association (chalcopyrite, bismuth, Bi sulphides). In the outer parts of such aikinite grains as well as in their fractures were found tiny inclusions of bismuthinite, ikunolite and bismuth with sizes not exceeding 10 μm. These grains represent intermediate members between friedrichite and gladite. The latter reveal whiter shades of grey in BSE images, what is directly associated with a larger content of Bi at the expense of Cu and Pb (smaller n_{aik} values).

The results of chemical analyses in microareas were recalculated according to the formula (Cu + Pb)/2 + Bi = 8, while classification was based on their n_{aik} values (Fig. 1).

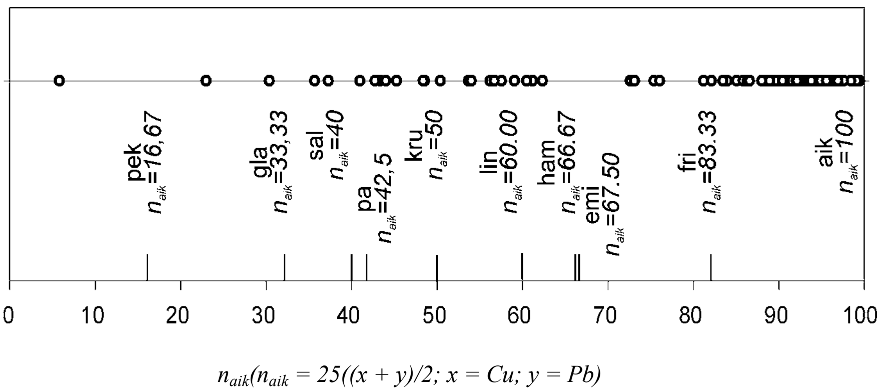

Fig. 1. Position of the species of the bismuthinite-aikinite series from Redziny determined by their n_{aik} values (aik-aikinite, fri-friedrichite, emi-emilite, ham-hammarite, lin-lindströmite, kru-krupkaite, pa-paarite, gla-gladite, pek-pekoite)

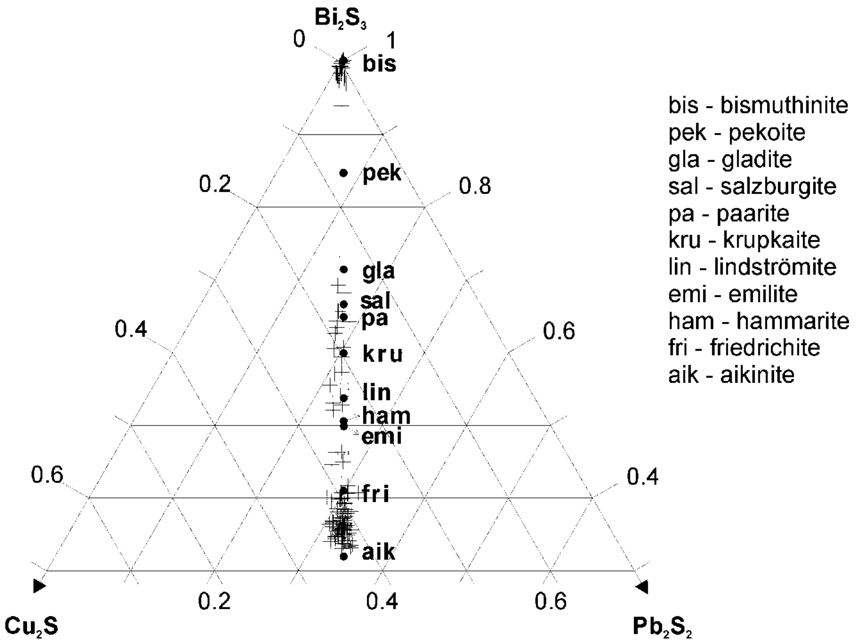

Fig. 2. Compositions of bismuthinite-aikinite series from Rędziny.

Pure aikinite with n_{aik} = 100 is very rare; the most frequent are the phases with n_{aik} <99 close to theoretical aikinite, simultaneously slightly enriched in Bi and plotting in the field between aikinite and friedrichite (Fig. 2). A less frequent group is represented by mineral phases with the compositions intermediate between friedrichite and hammarite (or emilite) and between lindströmite and gladite. The phases with n_{aik} <30, i.e. those between gladite and pekoite, have not almost been found (Fig. 1,2). Of the minor components, traces of Fe

(<0.0X apfu) substitute for Cu, of Sb (<0.0X apfu) for Bi, and of Se (<0.0X apfu) for S. The bismuthinite found is almost chemically pure, only with small admixtures of Cu and Pb (n_{aik} = 0 to 2.0).

Thermochemical conditions of crystallization of the aikinite-bismuthinite species from Rędziny have been evaluated by Pieczka *et al.* (2005). The species occurring in the outermost parts of the polymineral aggregates of sulphosalts with giessenite, felbertalite and lilianite crystallized at temperatures close to 330-320°C, while those from the assemblage with bismuth, ikunolite, bismuthinite and chalcopyrite around 270-260°C.

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