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TETRAHEDRITE IN BRECCIA OF ORDOVICIAN ROCKS  
FROM ZAWIERCIE, SOUTHERN POLAND – PRELIMINARY REPORT

**Abstract:** Tetrahedrite was found as minor but important constituent of polymetallic (arsenopyrite, pyrite, chalkopyrite, sphalerite, galena) ore mineralization, in breccia of Ordovician rocks from RK-2 borehole in Zawiercie. It occurs in the form of inclusions in chalcopyrite and galena. Stoichiometrically, it shows excess of As + Sb and deficit of other metals and sulphur and contains up to 6 wt. % of Ag (argentian tetrahedrite).

**Keywords:** tetrahedrite, breccia, polymetallic mineralization, silver, Zawiercie area.

#### INTRODUCTION

The tetrahedrite-tennantite series minerals are commonly known as the *fahlore* or *fahlerz* minerals. Natural tetrahedrites are described by chemical formula  $A_{10}B_2C_4D_{13}$ , where A=Cu, Ag; B=Cu, Fe, Zn, Hg, Cd, Pb; C= Sb, As, Bi, Te; D= S, Se. This formula, though complicated, is stoichiometric. Its mineralogical significance derives, in part, from the fact, that in many deposits they are the major, or one of the essential source of silver.

The occurrence of minerals of these series along the borders of Małopolska and Upper Silesian Blocks was mentioned several times in literature. In the Myszków area, the occurrences of inclusions of tennantite and tetrahedrite in chalcopyrite from black molybdenite-bearing quartz veins and in sphalerite of polymetallic association, were mentioned (Ślósarz 1994; Podemski 2001). Górecka (1978) and Harańczyk (1985) suggested the possibility of silver admixture in tetrahedrites in the Zawiercie region.

#### METHODS OF INVESTIGATION

Ore-microscopic examinations of thin sections and polished specimens were carried out in transmitted and reflected light using Neophot and Amplival microscopes. Chemical composition of individual mineral phases was defined by means of scanning electron microscopy SEM (JEOL 5410) equipped with an energy dispersive spectrometer EDS Voyager 3100 (NORAN) with the accelerating voltage 20 kV. According to the “standardless” procedure of calculation the data were normalised to atomic percentage.

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## GEOLOGICAL SETTING

In RK-2 borehole, located in Zawiercie, several zones of tectonic breccia were encountered. One of them, drilled at the depth of 1119 m occurs within the Ordovician limestones and is 1 m thick. The clasts forming breccia range in size from several mm up to several cm. They are dominated by brass-coloured and metallic luster clasts, composed of ore minerals constituting 90% of their volume. Fine quartz crystal and small amounts of carbonate minerals form the rest part of these rock clasts. Apart from the clasts mentioned above, there are also lithic fragments, having beige colouration and in some parts they are olive-grey. They are built of very finely crystallized quartz, light micas and carbonate minerals.

The clasts are cut by minute veins (0.X mm thick) of transparent quartz. The quartz veinlets are in turn cut by minute veinlets of younger generation containing beige-brown carbonates, which protrude outside the clasts and merge with cement.

Breccia cement consists of quartz and carbonates and grows radially on clasts. Fine milky quartz crystal forms the first rim around the clasts. After the growth of this mineral, subsequent tectonic event took place, which caused the break-up of the clasts. This was followed by crystallization of beige-brownish carbonate, representing siderite-sideroplesite, having subhedral form. It overgrows quartz as rhombic crystals, exhibiting a weak zonation in composition at margins. Subsequently, the crystallization and recrystallization of transparent quartz took place, frequently in the form of euhedral crystals. The last mineral in this sequence is light, transparent calcite, filling existing free spaces.

## ORE MINERALIZATION

Ore mineralization in the discussed breccia zone is massive, disseminated and vein-type in character. Pyrite and arsenopyrite occur in ore-dominated clasts. Mutual quantitative relationship of both minerals is variable. One of them frequently dominates quantitatively over the other.

**Pyrite** forms subhedral, sometimes euhedral crystals from 0,X up to 2 mm in size. It occurs as aggregates in association with arsenopyrite and often contains gangue rock inclusions. Pyrite aggregates occurring in lithic rock clasts are overgrown by fine quartz crystal. No pyrite was found in cement.

**Arsenopyrite**, forming crystals from 0,0X to 0,Xmm in size, is often the main mineral in ore-dominated clasts. There are so many crystals of this mineral inside the clasts that they are mutually intergrown and form massive mineralization. It does not contain any other mineral inclusions. In lithic rock clasts arsenopyrite is disseminated and occurs in the form of complex multiple twins. Individual crystals are prismatic in habit, and in cross-section perpendicular to the elongation of the prism, rhombic in shape. In veinlets of transparent quartz disseminated arsenopyrite prisms are present. The cement contains fine arsenopyrite crystals, 0,0X mm in size, occurring within quartz and carbonate grains. They are probably originated from very small clasts, in which the primary gangue rock was altered by cement-forming minerals.

**Sphalerite** forms individual anhedral crystals in the cement, where it also occurs as small inclusions in chalcopyrite. In many sphalerite grains chalcopyrite exsolutions were recorded.

**Chalcopyrite** fills minute fissures in pyrite. It was found in patches, where it is accompanied by sphalerite in lithic clasts, in neighbourhood of pyrite grains. Moreover, it occurs as anhedral crystals in the cement filling spaces between quartz or/and siderite-sideroplesite grains, in association with sphalerite, Cu sulphosalts and galena.

In the cement **galena** frequently fills interstitions in quartz and Fe carbonate crystals. It replaces chalcopyrite and overgrows its crystals.

So far the Bi minerals were not found in these paragenesis, although Bi telluride was identified lately in lower situated breccia complex.

#### TETRAHEDRITE

Cu-sulphosalts form anhedral inclusions, from 5 to 30  $\mu\text{m}$ , rarely up to 60  $\mu\text{m}$  in size, occurring most often in chalcopyrite. Their small (5-20 $\mu\text{m}$ ) inclusions are met in galena too. Locally, close to Cu-sulphosalt grains, small blebs of native antimony (5-10 $\mu\text{m}$ ) were identified in chalcopyrite.

All the so far examined fahlore have chemical composition of tetrahedrites. Sb/Sb+As ratio in them ranges between 0.74 and 0.96 (Fig. 1). The substitution of Ag in these tetrahedrites varies from 2.4 to 6.0 wt.%, and some grains, showing higher Ag content, can be named – “argentian tetrahedrite”. The relation Ag/Ag+Cu vary from 0.04 to 0.11. Positive correlation of Sb and Ag was not determined. The Zn content (0.7 to 4.1 wt. %) is somewhat lower than of Ag and the proportions Zn/Zn+Fe vary from 0.15 and 0.4. The Fe content displays considerably higher variation, from 2.2 to 8.8 wt. %. Bi content is variable and the maximum of measured amount is 0.6 wt. %. The composition of the tetrahedrites studied if considered in terms of atomic percentages metal:semimetal:sulfur (i.e., Cu+Ag+Fe+Zn:As+Sb:S) are semimetal-rich and sulfur-deficient relative to ideal  $\text{Cu}_{12}\text{Sb}_4\text{S}_{13}$  stoichiometry.

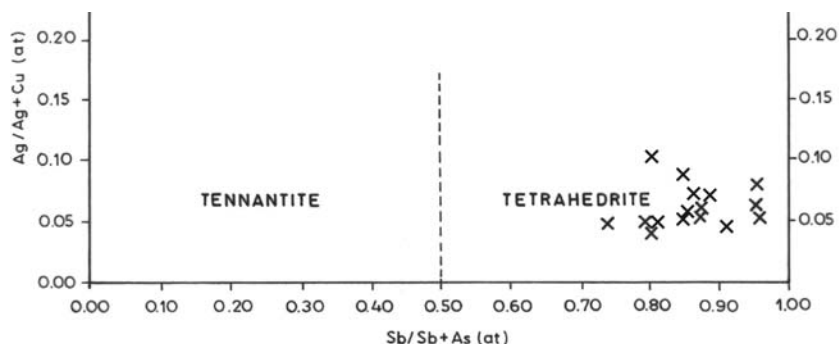


Fig. 1. Chemical variations of tetrahedrites from Zawiercie as a function of Ag/(Ag+Cu) versus Sb/(Sb+As).

## CONCLUSIONS

The Cu sulphosalts occur in minor amounts in the examined rocks. They represent only one member of the fahlore series – tetrahedrite, containing 2.4 to 6.0 wt.% Ag. The varieties distinctly enriched in silver should be called “argentian tetrahedrite”.

In the rock studied the ore minerals were deposited in two main stages, connected with tectonic events. The first pre-tectonic stage took place before the brecciation of rock and gave rise to massive pyrite-arsenopyrite mineralization, replacing the lithic material of rock. Arsenopyrite precipitated also in minute quartz veins cutting this rock.

The second syntectonic stage was connected with the crystallization of breccia cement. The mineral succession was as follows: quartz, siderite-sideroplesite, ore minerals and calcite. Tetrahedrite occurs in mineral assemblage composed of sphalerite, chalcopyrite and galena, inside the two latter minerals. These minerals are usually precipitated from acidic, saline mineralizing fluids in the temperature range 200 to 400° C and over a wide range of redox conditions.

Palaeozoic ore deposits at the boundary of Małopolska and Upper Silesia Blocks is of porphyry copper-molybdenum-tungsten type. Sulphosalts of the tennantite-tetrahedrite series often occur in the formation of porphyry-type copper deposits. The presence of arsenopyrite and lack of molybdenite indicate different origin of the mineralization studied – it is probably related with earlier impulses of fluid hydrothermal activity in this region. Despite Ag-enrichment of these tetrahedrites, their low content and negligible thickness of mineralized zones, indicate them as no potential source of silver.

ACKNOWLEDGMENTS: This work was supported by the Jagiellonian University's BW-27 Grant and by KBN grant No 2PO4D 005 26.

## REFERENCES

- GÓRECKA E., 1978: Mineralizacja polimetaliczna w utworach paleozoicznych rejonu Zawiercia. *Prace Inst. Geol.*, 83: 163-169.
- HARAŃCZYK C., 1985: Paragenezy mineralne w złożach Krakowidów i ich pokrywy. *Pocznik PTG*, 53/1-4: 91-126.
- PODEMSKI M., 2001. Palaeozoic porphyry molybdenum-tungsten deposit in the Myszków area, Southern Poland. *Polish Geological Institute – Special Papers*, 6: 1-88.
- ŚLÓSZARZ J., 1994: Charakterystyka mineralogiczna okruszczenia miedziowo-molibdenowo-wolframowego. *Przewodnik 65 Zjazdu Polskiego Towarzystwa Geologicznego w Sosnowcu. Pr. Nauk. UŚL.* 1431: 196-202.