Phantom crystals of pyrite from the Yuzhna Petrovitsa deposit, Madan ore field, Bulgaria

Фантомни кристали на пирит от находище Южна Петровица, Маданско рудно поле, България

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Introduction

The relatively rare phenomenon “phantom crystal” is typically referred to transparent minerals such as quartz, calcite, fluorite, barite, and others for cases when crystal outlines are visible embedded within comparatively large host crystals. “Phantom” is a special case of crystal zoning closely related to fluctuation, gradual or abrupt changes in the chemical composition, pH-Eh, and P-T conditions of the surrounding medium that cause interruption in the continuity of crystal growth. The latter may be followed by partial dissolution of the crystal or/and be accompanied by deposition of other minerals coating the crystal faces. The continuation of crystal growth seals the internal part of the crystal, and in case of essential optical (chemical) difference of the internal and external parts of the crystal or due to presence of phase inclusions between them, the internal part becomes visible as “phantom”. Generally, the crystal habits of the “phantom” and host crystal are different and can be used for crystallogenetic interpretations (Kostov, Kostov, 1999). In opaque minerals, the phenomenon “phantom crystal” can be observed on polished sections in optical and scanning electron microscope as different zones outlined within internal part of the crystal.

During detailed inspection of a collection of pyrites from the Yuzhna Petrovitsa deposit (Madan ore field, Bulgaria) deposited in the “Earth and Man” National Museum – Sofia, one of the coauthors of the present report (Zh. Janakieva) discovered an interesting case of phantom crystals of pyrite visible both in polished sections of the mineral and macroscopically in its druses. First results of the investigation of these pyrites are reported in the present short communication. The investigation is performed using binocular optical microscope, polarized light microscope Leitz Orthoplan Pol (reflected light) and scanning electron microscope ZEISS SEM EVO 25LS with EDAX Trident analytical system.

Anatomy of pyrite crystals

The material studied is presented by pyrite druses sampled from a cavity in the vein wall hosted by migmatized gneisses of the Rhodopean metamorphic complex (Yuzhna Petrovitsa deposit). Pyrite crystals are well faced and with size ranged from 3 to 20 mm. Clear signs of dissolution and corrosion are the most important features of the studied pyrite that allow us to consider the pyrite crystals as composite crystals. This finding is well illustrated in Fig. 1. Each of the composite crystals consists of octahedral {111} “phantom” crystal enclosed in the rounded outer pyritohedral-like form. It is shown that the outer pentagon-dodecahedral

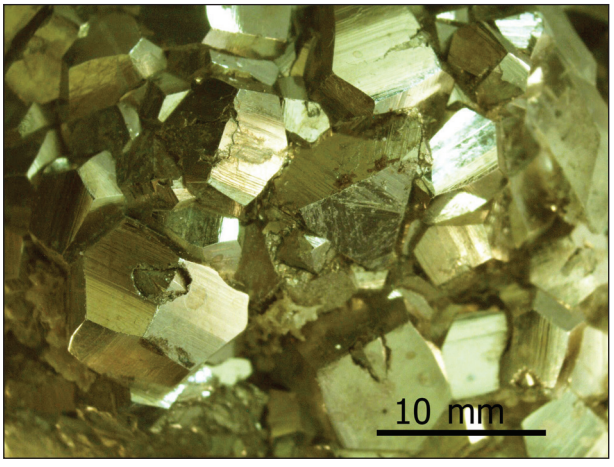

Fig. 1. Pyrite druse. Each of pyrite crystals shows signs of dissolution and consists of octahedral {111} “phantom” and rounded external {210}+{211} forms. Optical microscope image.

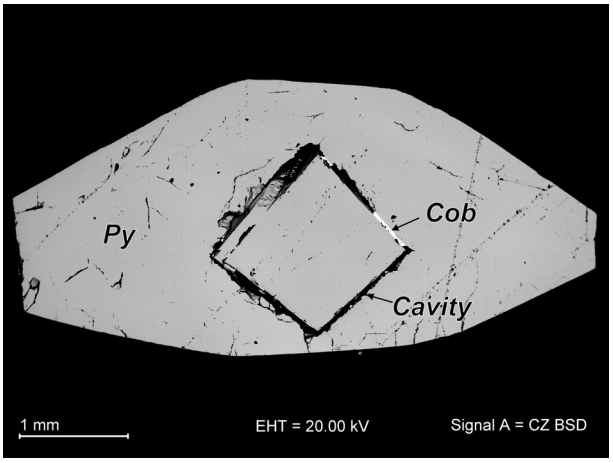

Fig. 2. Polished section of composite crystal of pyrite nearly perpendicular to [100] direction; "phantom" is located in the central part of the composite crystal; *Cob*, cobaltite; *Py*, pyrite. BSE image.

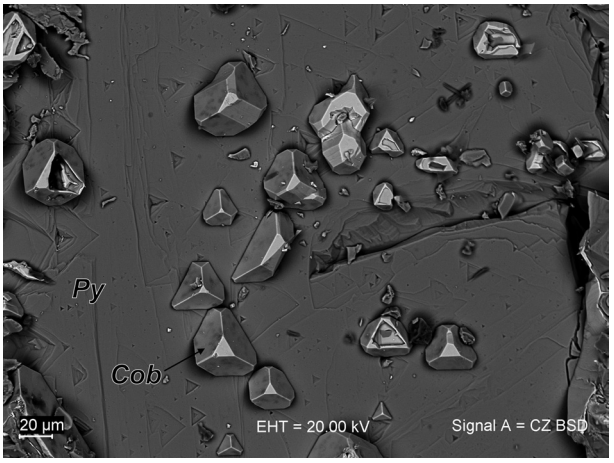

Fig. 3. {111} surface of the "phantom" crystal sporadically covered by strongly oriented cobaltite microcrystals; *Cob*, cobaltite; *Py*, pyrite. BSE image.

(pyritohedral)-like form in fact is a combination of two forms {210} (pyritoherdon) and {211} (tetragon trioctahedron). The striking fact established by us is that the space (10–50 to 100 μm in width) in-between the internal (phantom) and external parts of the composite crystals is nearly empty and sporadically occupied by micrometric crystals of cobaltite (Figs. 2, 3) or relics of Co-rich pyrite. This construction is not firm and under applied physical impact it destroys giving well-faced octahedral crystal (phantom) and pieces of the outer mantle. Such a type octahedral crystal is shown in the center of Fig. 1.

SEM investigation (Fig. 3) shows that there is no principle differences between any of two opposite {111} surfaces belonging to the "phantom" and outer pyrite mantle, respectively. In both cases the dissolution (etching) pictures and the strongly oriented cobaltite microcrystals are the same. Besides cobaltite, the {111} pyrite surfaces sporadically are covered by microcrystals of quartz, chlorite and galena. Detailed study of the composite crystals of pyrite using electron backscatter diffraction (EBSD) shows that the all their parts are strongly crystallographically oriented each to other and evidences for epitaxial growth of the cobaltite over the pyrite and autoepitaxial growth of the pyrite itself.

It is found that chemically the pyrite is not homogeneous and demonstrates growth zoning with variable concentration of Co (from 0.3 to 6.0 wt%). It is shown that the enriched in Co zones of pyrite are partially or completely dissolved giving rise to the formation of gaps within the composite crystal and to epitaxial crystallization of cobaltite. Some of the crystals demonstrate several consecutive zones of dissolution. Detailed analysis of the projections of different zones outlined in series of polished sections show that the real crystallogenetic evolution of pyrite forms is more complex. The generalized scheme of evolution of the composition and crystal form of the studied pyrite is following:

$$\{111\}_{\text{phantom}} \rightarrow \{111\}_{\text{Co-rich pyrite zone}} \rightarrow \{111\} \rightarrow \{211\} \rightarrow \{210\}+\{211\}.$$

Conclusion

In the present short communication, the authors reports the first data on the specific anatomy of composite pyrite crystals from the Yuzhna Petovitsa deposit (Madan ore field). Although the data are of preliminary character, they allows one to suggest that the crystallization and dissolution of the studied composite crystals of pyrite was accomplished during the deposition of two first successional ore parageneses typical for the Madan Pb-Zn deposits (according to Kolkovski and Dobrev, 2000): (1) quartz-pyrite and (2) galena-quartz. Intensive dissolution of the Co-rich pyrite zones most probably took place at the time of formation of galena-quarts paragenesis.

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