Pyrite and chalcopyrite as minerals-vectors toward porphyry-epithermal systems
Пирит и халкопирит като минерали-вектори за порфирно-епитермални системи

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Key words: LA-ICP-MS, minerals-vectors, porphyry-copper deposits, epithermal gold deposits.

Introduction
Based on examples from the Central Srednogorie of Bulgaria the recent study presents preliminary results of using trace elements in common sulphide minerals such as pyrite (Py) and chalcopyrite (Cp) to vector toward porphyry and epithermal gold systems. Chalcophile element association Cu, Zn, As, Mo, Cd, Sn, Sb, Te, Hg, Tl, Pb, and Bi is feature typical for both minerals (Py and Cp) in addition to direct ion exchange S ↔ Se, Te. Py and Cp also contain Au-Ag nanoparticles and other mineral micro inclusions (Cook et al., 2014). Although the wide accepted models (Sillitoe, 2010) the complicated anatomy and geochemistry of porphyry and epithermal systems explains the limited number of studies testifying the trace elements in ore minerals as geochemical vectors and pathfinders for porphyry and epithermal mineralization.

Elatsite, Medet, Asarel, Tsar Asen and Vlaykov Vrah porphyry-copper deposits (PCD) are significant examples for well developed “A”, “B” and “D” veins (Fig. 1a–c). The latter “D” veins are also characteristic for the epithermal gold deposits (Chelopech, Krasen, Radka and Elshitsa) in the Panagyrishite ore region (Popov et al., 2012) underlying the porphyry-epithermal deposits genetical link with specific magmatic centers.

Results and discussion
Pyrite and chalcopyrite from “B” and “D” type veins in addition to Mo-bearing veins have been studied by means of LA-ICP-MS (Perkin-Elmer ELAN DRC spectrometer with New Wave UP193FX LA device) for the purpose of discriminating the trace-elements vectors and pathfinders from porphyry toward epithermal environment (Figs. 2 and 3).

Cobalt, Ni, As, Se and Te are the most abundant in “B” type pyrite in Elatsite, Medet and Asarel, with concentrations that are highly variable (Fig. 2). Co is ranging from 0.17 to 2582 ppm, Ni from 1.4 ppm to 37 ppm and As from 0.1 to 10290 ppm. Se varies from 34.4 to 393.3 ppm, while Te is ranging from 1.1 to 16.8 ppm. Ti, Cr and Mn occur in both Py and Cp in variable concentrations most commonly between 5.2 and 87.5 ppm, but due to inclusions of magnetite and rutile in some cases contain up to 0.36% of all three elements. Au is low in “B” type Py except in Asarel where is between 0.2 and 28 ppm possibly due to electron micro inclusions. Pd in “B” type Cp from the studied PCD is low variable between 4.8 and 10.5 ppm, as well as Co (0.4–15.7 ppm). Ni and Se (Fig. 3) are low at Medet (2–33 ppm) and higher at Elatsite and Asarel (>190 ppm). The Re content in molybdenite from Elatsite varies from 2041 to 3140 ppm.

Conclusions
The recent study provides a preliminary basis to determine trends and vectors towards potential mineralized porphyry-epithermal centres as follows:
**Ag, Se and Ge** in “B” type pyrite increase, towards HS mineralisation and decrease towards PCD centre;

- **Bi** in “B” type pyrite increase towards deeper PCD centre and decrease towards shallower HS mineralisation;

- trend for Se increasing in “B” type pyrite and Pd decreasing in “B” type chalcopyrite from Elatsite to Medet and Asarel has also been observed explaining shallower “epithermal” mineralisation style in the upper parts of Asarel PCD;

- Ni and Co decrease from “B” to “D” type pyrite and also from porphyry towards HS mineralisation.

**Acknowledgments:** This work is supported by the Sofia University Scientific Research Fund, Grant 175/2015. Thanks are due to Dr. D. Dimitrova, Geol. Institute, BAS for providing LA-ICP-MS analyses.

**References**

