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Mineralization and trace element distribution in pyrite using EMPA in exploration drill holes from Cheshmeh Zard gold district, Khorasan Razavi Province, Iran

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Introduction

Pyrite is the most abundant sulfide mineral in low sulfidation ore deposits. Experimental studies have shown that low-temperature (<150°C) pyrite that formed rapidly is more likely to be fine-grained and framboidal in shape compared to pyrite crystals that formed more slowly and at a higher temperature (> 200°C) from hydrothermal or metamorphic fluids (Butler and Rickard, 2000). Framboidal pyrite mostly occurs in sedimentary environments, though it could also form during metamorphism and hydrothermal alteration (Scott et al., 2009). The pyrite formed tends to be enriched in various trace elements such as Au and As. For this study we have combined the geology, alteration, mineralization with recent studies of the description of the deposit from core logging and underground mapping and geochemistry in the CheshmehZard gold district and also investigated the compositional variation and textural differences between pyrite types. This study is based on the results of our alteration and mineralization mapping and detailed logging of 1937.8 m of drill core.

Materials and Methods

Geology, hydrothermal alteration and mineralization were examined in drill holes along several cross sections. Host-rock alteration minerals and veins were determined for 11 samples using standard X-ray diffraction (XRD) and *X-ray fluorescence spectrometry (XRF)* techniques. Polished sections were studied by reflected light microscopy and backscattered electron images (BSE). In this study, the trace-element composition of pyrite samples from the Au-III vein system was obtained using electron microprobe analyzer (EMPA) data. All analyseswere carried out at the department of Materials Engineering and Physics of the University of Salzburg in Austria. The EMPA measurements and BSE imaging were made using a JXA-8600 electron microprobe. Spot analyses of 30 pyrite grains from CheshmehZard are given in Table 1.

Results

The study area is located in the north of Khorasan Razavi Province 45 km to the south of Neyshabour. The area near CheshmehZard could become important as a site of economically significant gold mineralization. Six gold-bearing vein systems were recognized east of Arghash. The estimated resources are about 2 million metric tons of potential ore with an average of 1.9 g/t Au (Samadi, 2001;Ashrafpour et al., 2012). Multiple intrusive events are recognized in the region including Precambrian to post-Oligocene-Miocene igneous rocks (Alaminia et al., 2013a). This includes the Arghash diorite pluton, upper Cretaceous granitoids (minor diorite, mainly quartz monzodiorite and granodiorite), early Eocene granite and several lamprophyre and small intrusions of quartz monzodiorite porphyries. Volcanicsinclude andesite, dacite, pillow basalt and tuffs. Sedimentary rocks are conglomerate and minor limestone. Gold veins are hosted by intermediate to silicic volcanic rocks, tuffs, granite, granodiorite, and conglomerate. Veins consist of calcite and quartz. The main alteration zones mapped at the surface and underground are

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sericite-quartz-pyrite-calcite, withsilicified, propylitic, argillic, and carbonate zones.

The mineralization associated with sericiticalteration and silicificationoccurs asveinlets and disseminated in the propylitic zone. Gangue minerals are quartz, chalcedony, calcite, adularia, illite, and kaolinite. Mineralization occurs as veinlets, breccia filling and disseminated. The veinlets are comprised of pyrite, arsenopyrite, minor chalcopyrite, sphalerite, galena, magnetite and hematite. Pyrite is the main sulfide mineral in the hypogene ore. Samples were collected with the objective of studying the pyrite in the Au (III) vein systems. All samples were therefore pyrite rich. The paragenesiswas determined to show four stages of mineralization based on the following microscopic observations: 1. an initial pyrite veinlet stage with associated quartz, chlorite, epidote. Pyrite is fine to medium grained, anhedral and gold-poor. 2. a second pyritic stage (polymetallic sulfide stage) contains pyrite, chalcopyrite, galena, sphalerite, quartz and chalcedony, minor adularia and arsenopyrite. 3. An As-bearing pyrite stage with sericite, chalcedony and quartz. The pyrite isframboidal.. 4. Finally, a carbonate-dominated stage. The pyrite is euhedral to anhedral and coarse grained. The Au concentration in Stages 2 and 3 pyrite is higher than that in Stage 4 pyrite.

Conclusions

The gangue mineral assemblages of carbonate, chlorite, quartz, and minor sericite and potassium feldspar in the ore-forming process of the CheshmehZard gold district suggest that the pH value of the hydrothermal fluids was near neutral to slightly acid (approximately 4.5 to 5.3 under 250 to 300 °C and 1 kbar conditions) and that gold would be transported mainly as $Au(HS)_2^-$ (Stefansson and Seward, 2004). Three types of pyrite based on the chemical composition have been investigated: As- bearing pyrite, Ti-V - bearing pyrite and pure or barren pyrite. EMPA analyses of the pyrite in gold veins show maximum concentrations of As (3.62 wt.%), Ti (3.91 wt.%) and V (0.53 wt.%) respectively. The occurrence of the gold is usually associated with arsenian pyrite and Ti-V - bearing pyrite. Veinlets of the Py1 coexisting with arsenopyrite and gold Py2 implies the substitution of sulfur by arsenic. Gold precipitated under relatively reducing conditions in framboidal pyrite. Py3 formed prior to barren pyrite (IV).

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