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Hydrothermal Evolution of the Giant Cenozoic Kadjaran porphyry Cu-Mo deposit, Tethyan metallogenic belt, Armenia, Lesser Caucasus: mineral paragenetic, cathodoluminescence and fluid inclusion constraints

Samvel Hovakimyan (1,2), Robert Moritz (1), Rodrik Tayan (2), and Hervé Rezeau (1)

(1) Department of Earth Sciences, University of Geneva, Rue des Maraîchers 13, CH-1205 Genève, Switzerland (samvel.hovakimyan@unige.ch), (2) Institute of Geological Sciences of the Armenian National Academy of Sciences, 0019 Yerevan, Republic of Armenia

The Lesser Caucasus belongs to the Central segment of the Tethyan metallogenic belt and it is a key area to understand the metallogenic evolution between the Western & Central parts of the Tethyan belt and its extension into Iran. Zangezur is the most important mineral district in the southernmost Lesser Caucasus. It is a component of the South Armenian block, and it was generated during the convergence and collision of the southern margin of the Eurasian plate and the northern margin of the Arabian plate, and terranes of Gondwana origin (Moritz et al., in press). The Zangezur ore district consists of the Tertiary Meghri-Ordubad composite pluton, which is characterized by a long-lasting Eocene to Pliocene magmatic, tectonic and metallogenic evolution. It hosts major porphyries Cu-Mo and epithermal Au – polymetallic deposits and occurrences, including the giant world class Kadjaran porphyry Cu-Mo deposit (2244 Mt reserves, 0.3% Cu, 0.05% Mo and 0.02 g/t Au).

The Kadjaran deposit is hosted by a monzonite intrusion (31.83±0.02Ma; Moritz et al., in press). Detailed field studies of the porphyry stockwork and veins of the different mineralization stages, their crosscutting and displacement relationships and the age relationship between different paragenetic mineral associations were the criteria for distinction of the main stages of porphyry mineralization at the Kadjaran deposit. The economic stages being: quartz- molybdenite, quartz-molybdenite-chalcopyrite, and quartz-chalcopyrite. The main paragenetic association of the Kadjaran porphyry deposit includes pyrite, molybdenite, chalcopyrite, bornite, chalcocite, pyrrhotite, covellite, sphalerite, and galena.

Recent field observations in the Kadjaran open pit revealed the presence of epithermal veins with late vuggy silica and advanced argillic alteration in the north-eastern and eastern parts of the deposit. They are distributed as separate veins and have also been recognized in re-opened porphyry veins and in stockwork. One of them is the east-west-oriented 6th vein zone in the northern part of the deposit, which contains quartz-molybdenite veins and late quartz-galena-sphalerite veins. This is interpreted as a telescoping between porphyry and epithermal environments. It is supported by microscopic studies of mineral paragenesis, which reveal the presence of enargite and tennantite-tetrahedrite, luzonite, sphalerite, and galena, generally in a gangue of quartz, followed by a late carbonate and gypsum stage.

On-going fluid inclusion studies are being carried out on quartz samples from the different mineralization stages. Five types of fluid inclusions were distinguished according to their nature, bubble size, and daughter mineral content: vapor-rich, aqueous-carbonic, brine, polyphase brine and liquid-rich inclusions.

Cathodoluminescence images from the porphyry veins reveal four generations of quartz. Molybdenite and chalcopyrite are associated with two different dark luminescent quartz generations, which contain typical brine, aqueous-carbonic and vapour-rich H_2O fluid inclusions, with some of them coexisting locally as boiling assemblages. Epithermal veins are mainly characterized by liquid-rich H_2O fluid inclusions.

Microthermometric studies of fluid inclusions reveal a major difference in homogenisation temperatures between the early quartz-molybdenite- chalcopyrite stage (Thtotal between 360^0 and 425^0C) and the late quartz-galena-sphalerite vein stage (Thtotal 300-270^0C), which is attributed to the transition from a porphyry to an epithermal environment in the Kadjaran deposit.