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Mineralization and leaching process in the Jian copper deposit, northeastern Fars province: Application of petrography and stable isotopes

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Introduction

One of the first principles in the formation of a reserve is mineralogical, construction and mineral textures studies and investigation of paragenetic relations in the ore minerals. In addition, to petrographic studies, isotopic investigates have wide applications in economic geology. In general, copper isotope variability in primary (high temperature) mineralization forms a tight cluster, in contrast to secondary mineralization, which has a much larger isotope range. A distinct pattern of heavier copper isotope signatures is evident in supergene samples, and a lighter signature characterizes the leached cap and oxidation-zone minerals. This relationship has been used to understand oxidation–reduction processes (Hoefs, 2009). Also for a better understanding of the origin of the Jian Cu deposit, this research focuses on the origin and composition of the fluid and elucidation of its evolution during the mineralization process. In order to achieve this end, field observations, vein petrography, microthermometry of fluid inclusions and stable isotope analyses of veins and minerals were investigated. The present study also compares high and low temperature sulfide samples in an attempt to document and explain diagnostic δ^{65}Cu ranges in minerals from the Jian deposit.

Materials and methods

The samples were taken from different depths to measure Cu isotope variations within each reservoir. Mineralogical composition was determined using X-ray diffractometry. In addition, chromatographic separation was carried out on all samples (except for native Cu samples) in a clean lab and was conducted as outlined in Mathur et al. (Mathur et al., 2009). These samples were measured into a Multicollector Inductively-Coupled-Plasma Mass Spectrometer (MC-ICPMS, the Micro mass Isoprobe at the University of Arizona) in low resolution mode using a microconcentric nebulizer to increase sensitivity for the samples with lower concentrations of copper. Preparation and analysis of quartz for oxygen isotopes was performed using the standard techniques detailed by Clayton and Mayeda (Clayton and Mayeda, 1963). Fluid inclusions were extracted for δD measurement from quartz samples selected as far as possible to avoid late inclusions. The methods were standard and similar to those published in Fallick et al. (Fallick et al., 1987). Stable isotope analysis for oxygen and hydrogen isotopes was undertaken at the isotope geochemistry laboratory, University of Queensland.

Results

δ^{65}Cu values for analyzed samples range from -0.45 to +0.49 ‰ in the secondary copper minerals (malachite). The δ^{18}O values for analyzed quartz samples, collected from different quartz veins of the Jian deposit, fall in a narrow range varying from +15.8 to +18.4‰ (avg. +16.7‰) for type A veins and +16.6 to +17.9‰ (avg. +17.2‰) for type B veins. The δ^{18}O values of the fluids calculated from the Jian quartz samples range from +7.6 to +10.7‰ (avg. +9.1 ‰) for type A veins and +4.7 to +5.1‰ (avg. +4.9 ‰) for type B veins. The δD values of the fluid inclusions hosted by quartz samples range from -33.1 to -

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41.2‰ (avg. -37.6‰) for type A and -52.3 to -54.9‰ (avg. -53.1‰) for type B veins.

Discussion

Based on mineralization style and structures, Th, salinity and composition of fluid inclusions, stable isotope systematics, timing of the mineralization with respect to deformation and metamorphism, host rocks, ore and gangue minerals, the Jian deposit can be classified either as a metamorphogenic or mesothermal Cu-bearing quartz deposit. Precipitation of secondary Cu^{+}-sulfide minerals from the Cu^{+} complexes present in this fluid would result in sulfide minerals with low copper isotopic variations (-0.45 to +0.49‰) in the Jian copper deposit. This could explain why a low variation in the isotopic composition of Cu is observed in a horizontal plane. Isotopically, mineralization is most probably the result of varied isotopic fractionation processes including low copper leaching, Cu^{+} to Cu^{2+} oxidation-reduction reactions, and fluid-mineral fractionations. Oxygen and hydrogen isotope compositions suggest that the main metallization occurred from a metamorphic dehydration in type A veins. These sulfide-bearing quartz veins are interpreted as a small-scale example of redistribution of mineral deposits by metamorphic fluids. This study suggests that mineralization at Jian is interpreted as metamorphogenic in style, probably related to a deep-seated mesothermal system.

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