1 Regional and Deposit geology

The Zartorosht gold deposit, southern Sanandaj-Sirjan metamorphic belt, southeastern Iran, is hosted in highly strained, greenschist facies, late Paleozoic metabasalt and schist (Fig. 1). The orebodies are broadly parallel to the regional east-west-oriented normal faults, and the discordant mineralization comprises thick quartz-sulfide vein sets, small quartz-carbonate-sulfide veinlets, and enclosing hydrothermally altered host rocks.

2 Hydrothermal Alteration

Textures and crosscutting relationships in gold-bearing
veins indicate two stages for the gold-related hydrothermal event. The minor Stage I gold-bearing veins contain transparent quartz and pyrite. These are overprinted by the main Stage II gray gold-bearing quartz-ankerite-muscovite-chalcopyrite-sphalerite-galena ± albite ± chlorite ± epidote ± fuchsite ± epidote assemblage.

3 Alteration Geochemistry

Mass balance calculations indicate average net mass gain and losses of major oxides in the altered zones were about 10 to 30 g/100 g, mainly owing to the loss of K₂O, Na₂O, CaO, P₂O₅, and MgO, and addition of SiO₂, Fe₂O₃, CO₂, and H₂O, which implies very high water-rock ratios. Gold is mainly associated with enrichments of As, Ag, Sb, Zn, Pb, Cu, S, Mo, Te, and W, and depletion of Co, Cr, Ni, Rb, and Sr. Rare earth elements also exhibit a depletion in the alteration zones (Fig. 2). These results are consistent with the elemental mass balance calculations using the isocon method that shows that the degree of mass and volume depletion systematically increases during alteration. A decrease of the element abundances, as well as mass and volume during alteration processes, may imply a general decrease of the element activities in hydrothermal fluids during the formation of the alteration zones.

Stage II gray quartz δ¹⁸Ofluid values range from 8.7 to 11.5 per mil, δDfluid values calculated from chlorite is about -35 per mil, and the temperatures for Stage II mineral deposition obtained from quartz-chlorite fractionation range from 235° to 365°C. Calculated δ¹⁸Ofluid and δ¹³C compositions of Stage II auriferous carbonate veins ranging between 6.5 and 10 per mil, and from -3.8 to -11.5 per mil, respectively, indicate high water/rock ratios and temperatures generally greater than 250°C. Sulfur isotope compositions in gold-bearing veins (-8.0 to +3.0 per mil) are not inconsistent with a metamorphic source of sulfur.

The alteration geochemistry, estimated mass changes, and isotopic data show that the Zartorosht gold deposit was formed by a large and focused volume of reduced to neutral pH hydrothermal fluid that had a δ¹⁸O of 8.7 to 11.5 per mil at a temperature greater than 280°C. The δ¹⁸O-enriched fluid isotope composition suggests derivation from either metamorphic or mixed metamorphic and magmatic fluid (Fig. 3). Lithogeochemistry and stable isotope data indicate that hydrothermal system evolved under high water/rock ratios. Therefore, temperature of hydrothermal alteration assemblages together with stable isotope geochemistry can provide early discrimination of this type of hydrothermally altered, gold mineralizing system and can potentially assist subsequent exploration vectoring.