Fluid inclusion and sulfur stable isotope evidence for the origin of the Ahangran Pb-Ag deposit

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Introduction

The Ahangaran Pb-Ag deposit is located in the Hamedan province, west Iran, 25 km southeast of the city of Malayer . . The deposit lies in the strongly folded Sanandaj-Sirjan tectonic zone, in which the ore bodies occur as thin lenses and layers. The host rocks of the deposit are Early Cretaceous carbonates and sandstones that are unconformably underlain by Jurassic rocks. Ore minerals include galena, pyrite, chalcopyrite, pyrrhotite and supergene iron oxide minerals. Gangue minerals consist of barite, dolomite, chlorite, calcite and quartz. The mineralization occurs as open-space fillings, veins, veinlets, disseminations, and massive replacements. Alteration consists of silicification, sericitization, and dolomitization. In this study, we carried out studies of mineralogy, microthermometry of fluid inclusions and sulfur isotopes to determine the source of sulfur and the physico-chemical conditions of formation.

Materials and methods

Seventy samples of different host rocks, alteration, and mineralization were collected from surface outcrops and different tunnels. Twenty of the samples were prepared for mineralogical studies at Tarbiat Modarres University in Tehran and 25 for petrological studies at the University of Bu-Ali Sina. Fluid-inclusion studies were done on 5 samples of quartz and calcite at Pouya Zamin Azin Company in Tehran using a Linkam THM 600 model heating-freezing stage (with a range of -196 to 480ºC). The accuracy and precision of the homogenization measurements are about ±1°C. Salinity estimates were determined from the last melting temperatures of ice, utilizing the equations by Bodnar and Vityk (1994) and for CO$_2$ fluids using equations by Chen (1972). Nine samples of sulfides and barite were crushed and separated by handpicking under binocular microscope and powdered with agate mortar and pestle. About one gram of each sample was sent to the Stable Isotope and ICP/MS Laboratory of Queen's University, Canada for sulfur isotope analysis. The sulfur isotopes in sulfides and sulfates were run on a Thermo Finnigan Delta Plus XP IRMS mass spectrometer. The analytical uncertainty for δ^{34}S is ±0.2‰.

Results and Discussion

The main types of fluid inclusions in quartz and calcite are as follows: I: dominant liquid + less vapor (L+V); II: dominant vapor + less liquid (V + L); III: liquid + vapor+ CO$_2$ (L+V+CO$_2$)(L+V)); IV: CO$_2$ (L+V); V: liquid + vapor + sylvite (L+V+Sy). Homogenization temperatures of primary fluid inclusions indicate that mineralization occurred at temperatures ranging from 130 to 320 °C (ave., 200°C) and their salinites range from 10 to 15 wt % NaCl equiv. The temperatures and salinities of the mineralizing fluids of the Ahangaran deposit are similar to the Irish type Zn-Pb deposits, and suggest a similar origin. The δ^{34}S values of pyrite and galena are within the range of -25.5 to +11.6 ‰ and -6.3 to -8.5 ‰, respectively and for barite are in the range of 26 to 27.2 ‰. These values indicate that the δ^{34}S$_{H2S}$ values of fluids in that deposited the pyrite and galena are within the range of -6.4 to-2.9 ‰ and 9.4 to 27.9 ‰, respectively. The δ^{34}S values of marine sulfate were 13 to 20 ‰ during the Cretaceous (Hoefs, 2009). The δ^{34}S values of barite are near to that of marine sulfate in the Cretaceous which indicate that the sulfate of the barite may have a marine

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origin. On the other hand, the $\delta^{34}S_{H2S}$ values of galena lie within a narrow range, suggesting that the main source of sulfur may be from thermochemical sulfate reduction (TSR).

References
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