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Study of REE behaviors, fluid inclusions, and O, S stable Isotopes in Zafar-abad iron skarn deposit, NW Divandarreh, Kordestan province

Mehrdad Barati* and Meisam Gholipoor

Department of Geology, Bu-Ali Sina University, Hamedan, Iran

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Introduction

The Zafar-abad iron ore deposit, situated in the NW part of Divandarreh (lat. 36°01'14" and long. 46°58'22"). The ore body is located on the northern margin of the Sanandaj-Sirjan igneous metamorphic zone. The Zafar-abad Fe-skarn deposit is one of the important, medium- size mineral deposits in western Iran.

REE patterns of skarn magnetite were among others studied in Skarn deposit by (Taylor, 1979) Hydrothermal alteration and fluid-rock interaction significantly affect total contents of REE and their patterns in fluids. Moreover, fractionation of REE by chemical complication, adsorption effects and redox reactions are characteristic processes determining REE behavior during crystallization.

Stable isotope data for oxygen and sulfur have been widely used with great success to trace the origin and evolution history of paleo-hydrothermal fluids of meteoric, magmatic, and metamorphic.

Materials and methods

The present study investigates REE and stable Isotope geochemistry of magnetite and pyrite in Zafar-abad deposit and temperature of trapped fluid inclusions based on geothermometry analysis. In order to study the major, trace and REE compositions of Zafar-abad magnetite, twelve samples were collected from surface of ore exposures. The emphasis during sampling was on ores with primary textures.

Discussion

The Zafar-abad district is situated in Mesozoic and Cenozoic sedimentary, meta-sedimentary and meta-igneous rocks in Sanandaj-Sirjan igneous metamorphic zone. Sedimentary sequences dominantly composed of calcareous and conglomerate rocks. Various meta-sedimentary rocks are intercalated with the sedimentary rocks, and comprise biotite and muscovite-rich schist, calc-schist, calc-silicate rock. Several distinct ductile tectonic fabrics have been identified around the Zafar-abad deposit. The main ore body at Zafar-abad is in the form of a roughly horizontal, discordant, lens to tabular-shaped body plunging 10° NW, where it appears to interfinger with meta-sedimentary and fragmental wall-rock. The thickness of the ore body is 25 to 35 m with 40 m wide and around 130 m in elongate.

The chondrite normalized REE distribution pattern of Zafar-abad magnetite shows V shape. The analyzed samples display similar patterns. The average $(La/Yb)_{cn}$ ratio of 6.8 indicates a high degree of fractionation. The fractionation is more pronounced in HREE part of diagram, where the average $(Gd/Yb)_{cn}$ ratio is 1.07, whereas the average $(La/Sm)_{cn}$ ratio in the LREE part of the diagram is only 5.9. This indicates that the REE content in Zafar-abad magnetite is not affected by hydrothermal alteration. The ΣREE content varies between 2.09 and 15.02 ppm with an average of 8.4 ppm. These REE values are equal to those reported for the type of Skarn- type iron deposits (Bowman et al., 1985).

Other features include pronounced negative Eu and Ce and positive Pr and Gd anomalies.

Six purified magnetite samples used for Isotope Studies and $\delta^{18}O$ values are measured in them. The units of results are permil (‰) relative to SMOW for oxygen. The $\delta^{18}O$ values content varies between -5.93 and -0.28 ‰ with an average of -2.26 ‰. Considering that the magnetites formed at two stages (Meinert, 1995), the first one about 370 °C, and the second one about 240°C which is a reasonable guess bearing in mind that they are associated with intrusive and extrusive

*Corresponding author’s email: barati@basu.ac.ir

granitoids, then the fluid from which they formed, would yield $\delta^{18}O$ values that range from 4.1 to 8.1 ‰ which will fall in the boundary of magmatic water box and hence provide further support for a mixed magmatic and meteoric origins of Zafar-abad magnetite deposit.

In the Zafar-abad deposit, sulfur isotope composition was studied on six pyrite samples. The $\delta^{34}S$ values for this mineral in Zafar-abad vary from +1.2 to +1.9 ‰, with an average value of +1.61‰. Zafar-abad isotopic temperatures have been determined from the $\delta^{34}S$ values in pyrite. This temperature range is from 204 to 350°C.

Fluid inclusion studies illustrate the presence of two different types of hydrothermal fluids at Zafar-abad iron deposit. The earliest hydrothermal fluid with high salinity (11 to 49 wt % NaCl equiv) and high temperature (> 320°C) had a magmatic origin. This magmatic fluid moved upward to shallower levels, and its temperature subsequently decreased.

The meteoric water circulated in the peripheral parts of magnetic lens and layers this water moved inside the earth and after interaction with magmatic water, the magmatic fluid gradient decreased and then produced a mixture of magmatic and meteoric fluid with salinity of 15 to 25 wt % NaCl equiv.

Results

Geochemistry and REE studies indicate that the iron has magmatic origin and the REE content in Zafar-abad magnetite is not affected by hydrothermal alteration. The ΣREE content indicate Skarn-type for this deposit.

The $\delta^{34}S$ values of pyrite at Zafar-abad ranging from +1.2 to +1.9‰ that suggest a predominant magmatic origin for sulfur. The $\delta^{18}O$ values of magnetite at Zafar-abad ranging from between -5.93 and -0.28 ‰ with an average of -2.26‰ that suggest the magnetites formed at two stages.

Fluid inclusion studies show the presence of two hydrothermal fluids at Zafar-abad deposit. The fluid 1, originated from high temperature and pressure magma. The fluid 2, is a mixture of magmatic fluid with meteoric water which has low temperature and salinity, these fluids were responsible for genesis of ore body.

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