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Mineralogy and electron microprobe studies of magnetite in the Sarab-3 iron Ore deposit, southwest of the Shahrak mining region (east Takab)

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Introduction

There is an iron mining complex called Shahrak 60 km east of the Takab town, NW Iran. The exploration in the Shahrak deposit (general name for all iron deposits of the area) started in 1992 by the Foolad Saba Noor Co. and continued in several periods until 2008. The Shahrak deposit is comprised of 10 ore deposits including Sarab-1, Sarab-2, Sarab-3, Korkora-1, Korkora-2, Shahrak-1, Shahrak-2, Shahrak-3, Cheshmeh and Golezar deposits (Sheikhi, 1995) with a total 60 million tons of proven ore reserves. The Fe grade ranges from 45 to 65% (average 50%). The ore reserves of these deposits are different. Sarab-3 ore deposit with 9 million tons of 54% Fe and 8.95% S is located at the northeast of Kurdistan and in the Sanandaj-Sirjan structural zone at the latitude of 36°20´ and longitude of 47°32´.

Materials and methods

Sixty thin-polished, polished and thin sections are made for the study of mineralogy and petrology, and among them six thin-polished sections were selected for EPMA (Electron Probe Micro Analysis) on magnetite and hematite. EPMA was performed using the Cameca Sx100 electron microprobe at the Iran Mineral Processing Research Center (IMPRC) with wavelength-dispersive spectrometers.

Results and discussion

Based on field observations and petrographic studies, lithologic composition of intrusion (Miocene age) ranges within the diorite-leucodiorite, monzodiorite-quartz monzodiorite, granodiorite-granite. With the intrusion of those igneous bodies into carbonate rocks of the Qom Formation, contact metamorphism was formed. The formation of Sarab-3 iron deposit occurred at the three stages of metamorphism, skarnification and supergene. Based on field geology of the deposit, it is composed of endoskarn, exoskarn including Fe ore±sulfides. At the metamorphic stage, after intrusion of intrusive bodies in carbonate rocks, recrystallization took place and marble was formed. With more crystallization of magma, evolved hydrothermal fluids intruded into host rocks. Skarnification occurred at the two stages of progressive and regressive. At the progressive stage, the reaction of fluids and host rocks turned to the formation of anhydrous calc-silicate minerals such as garnet and clinopyroxene. At the regressive stage with the change of physicochemical conditions like decreasing temperature, these minerals converted to hydrous silicates (tremolite-actinolite, epidote) and phyllosilcates (chlorite, serpentine, talk, and phlogopite). Also, minerals such as oxides (magnetite and hematite), sulfides (pyrite and chalcopyrite) and calcite were formed. At a late stage, with activations of fluids, quartz-calcite mineralized veins formed. At the supergene stage, the oxidation process leads to the formation of alteration minerals from the main mineralization. Although there are magnesian minerals in the skarn, its main composition is calcic. The shape of the deposit is lentoid to horizontal and in some

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places bed formed along with some alteration halos. The ore minerals include low Ti-magnetite (with an average of 0.02 wt % Ti), hematite and sulfide minerals such as pyrite, pyrrhotite and chalcopyrite. Magnetite is the most important mineral with disseminated, vein, open-space filling, aggregate, accumulation, island and cataclastic textures. The magnetite at Sarab-3 is generated in 2 stages: At the first stage, magnetite has mass to mosaic textures that indicate the first phase of deposition in the area and at the second stage magnetite is gray magnetites that are placed as narrow bands around hematite or on the primary magnetite. Hematite in the area is formed either as hypogene hematite with plate or blade texture that is formed before the formation of early magnetite or supergene hematite that itself is formed due to alteration and weathering of magnetite in the superficial and shallow part of the deposit. In the surface area of the deposit, ore minerals are strongly altered to mixtures of oxide and hydroxide minerals like hematite, limonite and goethite which changed the color of the ore body to yellow, deep orange, red and brown. Pyrites are the most important sulfide minerals in the area that are formed in five stages respectively, mass texture (Py1), Melnikovity (py2), vein-veinlet (py3), inclusion (py4), and mineralized veins (py5). Sericitization, calcitization, serpentinization, chloritization, epidotization, uralitization, argilitization, propylitization and actinolitizion are the important alterations in the area from which chloritization-epidotization and calcitization in the ore and propylitic and argilitization alteration in the plutonic rocks are dominant. The EPMA analytical results on 23 points on magnetite and hematite mineral suggest that the amounts of TiO_2 and V_2O_5 (0.03 wt % and 0.01 wt % in average, respectively) are low in contrast to MnO and Al_2O_3 (0.09 wt % and 1.59 wt % on the average, respectively). Therefore, it fits in the skarn ore deposit domain on Ni/(Cr+Mn) versus Ti+V and Ca+Al+Mn versus Ti+V discrimination diagrams of iron ore deposits (Dupuis and Beaudoin, 2011). High Mn in the rock samples of Sarab-3 may have resulted from the substitution of Fe by Mn in magnetite and hematite structure that can be a sign of hydrothermal skarn. Manganes, Al, Cu, Mg, and Ca show a negative correlation with Fe that may have resulted from the concentration and the substitution of these elements in tremolite-actinolite, epidote, chlorite, calcite, phlogopite and chalcopyrite. According to the chemistry of magnetite and plotting them on V_2O_5 versus TiO_2 and V_2O_5 versus Cr_2O_3 diagrams, it can be recognized that the samples of the Sarab-3 deposit resemble to exoskarn magnetite of Goto and endoskarn Karakaen deposit of Senegal. Mineralographical and geochemical evidence from ore, the occurrence of iron in contact with the carbonates and calc silicates such as garnet, pyroxene, secondary calcite, epidote and chlorite suggest iron skarn genesis for the Sarab-3 deposit.

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