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Geology, mineralogy, structure and texture, geochemistry and genesis of the Golestan Abad iron oxide- apatite deposit (East of Zanjan)

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Introduction

Iron oxide-apatite deposits (IOA) are considered to be Kirune-type iron ores which have been formed during Proterozoic to Tertiary eras in different parts of the world. They usually have a connection with calc-alkaline volcanic rocks (Hitzman, 2000). Apatite occurs as a major constituent of these deposits which is accompanied with magnetite and some actinolite. One of the most important features of these deposits (Frietsch and Perdahl, 1995) is higher concentration of REEs.

There are some iron oxide-apatite deposits in the Tarom-Hashtjin magmatic-metallogenic belt, northwestern Iran. The Golestan Abad iron oxide-apatite deposit is one of the IOA deposits at the Tarom-Hashtjin belt which is located about 30 km east of Zanjan. The Golestan Abad deposit was studied during the exploration studies, but its geological characteristics, mineralogy, texture, geochemistry and genesis have not been studied yet.

Materials and methods

This research study can be divided into two parts that include field and laboratory studies. Field studies include recognition of different lithological units and mineralization zones along with sampling for laboratory studies. During field studies, 60 samples were selected for petrographical, mineralogical and analytical studies. Moreover, 12 thin sections and 15 thin-polished sections were used for petrographical and mineralogical studies. For geochemical studies, 6 samples from intrusive host rocks and 7 samples from mineralized zones were analyzed by XRF and ICP-MS methods at the Zarazma laboratory, Tehran.

Results

The Golestan Abad area is composed of Eocene volcano-sedimentary rocks of the Karaj Formation which have been intruded by quartz monzodiorite, pyroxene quartz monzodiorite and porphyritic quartz diorite intrusions. Based on petrographic studies, the pyroxene quartz monzodiorites have porphyritic and felsophyric textures and are composed of plagioclase, quartz, clinopyroxene, K-feldspar and hornblende phenocrysts set in a quartz-feldspatic groundmass. Quartz monzodiorites show porphyritic and felsophyric textures and composed of plagioclase, hornblende, quartz, K-feldspar and biotite. The quartz monzodiorite and pyroxene quartz monzodiorites have high-K calc-alkaline affinity and may be classified as metaluminous I-type granitoids. Primitive mantle-normalized (McDonough and Sun, 1995) trace elements diagrams for these granitoids indicate LILE enrichment along with negative HFSE and distinctive positive Pb

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anomalies. Chondrite-normalized (McDonough and Sun, 1995) REE patterns for these granitoids demonstrate LREE enrichment (high LREE/HREE ratio) and weak negative anomalies in Eu. These granitoids were formed in an active continental margin to post collisional tectonic setting.

Mineralization at the Golestan Abad occurs as lenses and vein-veinlets of iron oxide-apatite mainly within the quartz monzodiorite- pyroxene quartz monzodiorite intrusions. Stockwork ores occur in the footwall of the main veins. Mineralized lenses and veins have up to 300m length and 20m width. Hydrothermal alterations around the mineralized veins include silicification, calcic (actinolitization), argillic and propylitic. From a mineralogical point of view, this deposit is composed of magnetite, apatite, actinolite, pyrite and chalcopyrite as primary minerals, while hematite, covellite, goethite and gypsum were formed during supergene alteration. Mineralization textures in the Golestan Abad deposit include vein-veinlet, banded, massive, brecciated, disseminated, stockwork, replacement, relict and open space filling. Based on mineralogical and textural studies, 3 stages of apatite formation were distinguished which include: 1- coarse-grained idiomorphic apatite crystals within the magnetite matrix, 2- fine-grained apatite crystals as matrix of brecciated magnetites, and 3- coarse-grained idiomorphic apatite crystals within the actinolite-apatite veins which have been cut in the previous stages. Apatite crystals of the 3 mentioned stages have high concentrations of REE that include 0.98, 0.92 and 0.95%, respectively. Condrite-normalized (McDonough and Sun, 1995) REE patterns for 3 apatite generations demonstrate LREE enrichment with high LREE/HREE ratio and distinctive negative Eu anomalies.

Discussion

Similar REE patterns of apatite crystals and mineralized samples with host quartz monzodiorite-pyroxene quartz monzodiorite samples demonstrate a genetic link between iron oxide-apatite mineralization and granitoids. Furthermore, REE patterns of the Golestan Abad deposit are similar to other iron oxide-apatite deposits of the Tarom-Hashtjin metallogenic belt (Nabatian and Ghaderi, 2014; Mokhtari et al., 2017), and those of Central Iranian iron ores (Mokhtari et al., 2013). Finally, the REE patterns of the Golestan Abad deposit are similar with the REE patterns of the Kiruna-type iron ores (Frietsch and Perdahle, 1995). Totally, based on mineralogical assemblages, hydrothermal alteration, mineralization textures and geochemical characteristics, the Golestan Abad iron oxide- apatite deposit can be classified as the Kiruna-type iron ores.

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