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Geology, alteration, mineralization, Geochemistry, fluid inclusion, petrology, petrogenises and U-Pb zircon dating of diorite dykes in the Robaie copper area (South of Damghan)

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Introduction

The Robaie copper area is located 95 kilometers South of Damghan in the Semnan province. The study area has coordinates between 54˚30′37″to 54˚30′42.71″ latitude and 35˚22′29.41″ to 35˚23′47.54″ longitude. Geotectonically, the study area is located in the central Iran and in the northern part of the Torud-Chahshirin volcanic-plutonic belt (Houshmandzadeh et al., 1978). The Torud-Chahshirin volcanic-plutonic belt is a Tertiary magmatism in central Iran which is composed of volcanic rocks with dominant andesite composition and granodiorite intrusive with dominant diorite composition (Fard et al., 2001). Torud-Chahshirin volcanic-plutonic belt has created a favorable geological situation for base metals such as copper, lead, zinc, gold, silver and other precious and base metals, such as the Robaie copper area, Chah Messi (Cu±Pb-Zn; Imamjome et al., 2009), Kuh-Zar (Cu-Au; Rohbakhsh et al., 2018) and other instances. The main objective of this study is geology, petrography, U-Pb zircon dating and Sr-Nd isotope and also alteration, mineralization, geochemistry and fluid inclusion in the study area.

Materials and methods

60 samples were collected from the study area. Petrographic studies were done on 40 thin sections. Mineralization and paragnesis of the system were studied based on 10 polished-thin sections and 6 polished sections. The measurements were conducted on a Linkam THMSG 600 at the Ferdowsi University of Mashhad. REE (ICP-MS method-ACME Laboratory in Vancouver, Canada) elements were analyzed for 3 samples of diorite dykes. Eight sampels for geochemistry and four samples for fire assay were analyzed at the Zar Azma Company. U-Pb dating in zircon of diorite dyke was conducted by the ICP-MS method in the Arizona LaserChron Center. Sr and Nd isotopic compositions were determined at the Laboratório de Geologia Isotópica da Universidade de Aveiro, Portugal.

Results

The geology of the area is dominated by volcanic rocks (andesite and trachyandesite), which were intruded by diorite dykes. Alteration zones are propylitic, argillic, sericitic and carbonate. The Copper deposit in the study area occurs as ore veins situated along fault zone with NS-SW trending. Vein thickness varies from 1-5m. Vein thickness varies from 1-5m. The primary minerals are chalcopyrite, pyrite and chalcocite, covellite, bornite, malachite, azurite, hematite, goethite and limonite are secondary minerals. The amount of

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Cu is between 0.01 to 5.6 % and amount of Ag, Sb, Pb, Zn, As elements is low. The homogenization temperature (T_h) values ranged from 165 to 300 ^oC. Salinities of ore-forming fluids ranged from 7 to 16 wt. % NaCl equivalents. Diorite dykes in the Robaie area have characteristics of enrichment in LREE versus HREE, enrichment of LILE and depletion in HFSE. The initial $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ ratios of biotite-hornblende diorite are 0.705664 and 0.512486, respectively. The εNdI value is -1.7. In the εNdI versus initial $^{87}Sr/^{86}Sr$ diagram diorite dykes of the Robaie area plot to the right part of the mantle array. The mean age of diorite dyke is 50.49±0.49 Ma. Therefore, the U-Th-Pb zircon dating indicates that diorite dyke formed in the early Eocene (Ypresian) era.

Discussion

Diorite dykes originated from mantle-derived magmas. The parental melt would have originated in a non-depleted mantle source. Isotopic data from diorite dykes show that subduction source with contamination to continental crust. In tectonic setting diagrams (Pearce et al., 1984) diorite dykes plot on the fields of the volcanic arc granites (VAG). In the Dy/Yb vs. Dy system (Shaw, 1970) diorite dykes of Robaie area were formed by 15-20% partial melting of spinel-phlogopite lherzolite. According to Yh/Yb vs. Ta/Yb (Pearce et al., 1984) and Ba/La vs. Th/Nd diagrams (Shaw, 1970) diorite dykes were formed from slab-drive fluid in the active continental margins.

Fluid inclusions data of the Robaie area manifest that the ore-forming fluids were medium to low temperature and medium to low salinity. The pressure determined for the Robaie area was approximately < 10 MPa, which is equivalent to a depth of approximately < 1 km assuming lithostatic pressure. Fluid inclusion studies indicate that there is a positive correlation between homogenization temperature and fluid salinity, similar to the process of fluid mixing. The decrease in salinity has been the most important factor in the precipitation of copper in the area. All of evidence shows that mineralization in the Robaie area is of epithermal type deposit.

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