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Structural controls on the localization of Cu deposits in the Kerman Cu metallogenic province of Iran using geoinformatic techniques

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ABSTRACT

The Sarcheshmeh area is located in the Kerman Cu metallogenic province (KCMP) in the southeastern part of the Uramia-Dokhtar magmatic arc in Iran. The Sarcheshmeh contains numerous Cu deposits making it ideal for the study on the structural controls in the magmatic arc. The study area is cut by major (first-order) and minor (second-order) faults, and contains different types of Cu occurrences, which have been here studied using geoinformation techniques (GiT), which consist of remote sensing techniques, GIS analyses and careful field investigations. The outcome of this study has confirmed that the Cu mineralization in KCMP is structurally controlled in faults. On a regional scale, the major faults (together with their second-order splays) form a braided fault pattern containing predominantly SE-trending faults. On a local scale, the main faults together with their splays form a rhombohedral pattern, which is due to a transtensional deformation related to the formation of pull-apart basins along the KCMP. This tectonic regime prepared the suitable environment for the ascent and final emplacement of felsic plutons in a broad linear zone trending SE. The Cu mineralization and accompanying alteration zones are hosted by the second-order faults.

1. Introduction

Most porphyry copper deposits are formed during igneous activity associated with subduction and post-subduction tectonic settings (Richards, 2003; Richards et al., 2001; Sawkins, 1990; Shafiei et al., 2008; Sillitoe, 1972, 1993, 1997; Sillitoe and Perello, 2005; Sutherland-Brown, 1976; Titley, 1982; Tosdal and Richards, 2001; USGS, 2008). In these tectonic settings, mineralization is genetically associated with felsic to intermediate magmatism as near vertical cylindrical stocks emplaced at depths of 1–4 km in the crust (Sillitoe, 1972; USGS, 2008). Richards (2003) concluded that magmatic ascent driven primarily by buoyancy forces is dominantly a fracture-controlled phenomenon in the north Chile and therefore, trans-lithospheric, orogen-parallel, strike-slip structures serve as primary controls on the magma emplacement.

Porphyry copper deposits are structurally controlled (Richards, 2003; Zengqian et al., 2003; Berger et al., 2003; Padilla-Garza et al., 2001). Zarasvandi (2004) proposed that the Darre Zerreshk and Ali Abad copper deposits, which are located in the Yazd area in the northwestern part of the Kerman Copper Metallogenic Province (KCMP), are genetically related to a plutonic complex containing dioritic and granitic rocks. This composite pluton is structurally controlled in a pull-apart basin formed along the Dehshir Fault, which is a dextral strike-slip fault. Safari (2013) identified a genetic relationship between the local structures and copper occurrences in the Sarcheshmeh area. Similarly, other researchers have concluded analogous genesis for the Himalayan Yulong porphyry Cu belt (e.g. Zengqian et al., 2003), the Escondida porphyry Cu deposits in north Chile (e.g. Padilla-Garza et al., 2001; Richards, 2003; Richards et al., 2001) and the Comstock Lode in Nevada (e.g. Berger et al., 2003).

Abbaszadeh and Hezarkhani (2011) identified hydrothermal alteration zones associated with the porphyry copper mineralization in the Rabor area of Kerman, Iran, using the Spectral Feature Fitting (SFF) method on ASTER satellite data. Similarly, Beiranvand Pour and Hashim (2012) have used spectral mapping methods to distinguish sericitic and argillic alteration zones in the Sarcheshmeh and Meiduk areas of Iran. These alteration zones surround discontinuous to extensive zones of propylitization on a regional and district-scale associated with copper deposits.

Deformation in magmatic arcs is expressed in a variety of ways, including pure and simple shears. The nature of the shears is largely controlled by the post-magmatic geological history of terrains (USGS, 2008), which is commonly associated with transpressional and/or transtensional settings (e.g. Harding, 1973; Krantz, 1995; Sanderson and Marchini, 1984; Wilcox et al., 1973). Such settings form suitable environments for the localization of porphyry Cu deposits within the magmatic arcs (Hollings et al., 2004; Richards, 2003; Titley, 1993; USGS, 2008; Zengqian et al., 2003).

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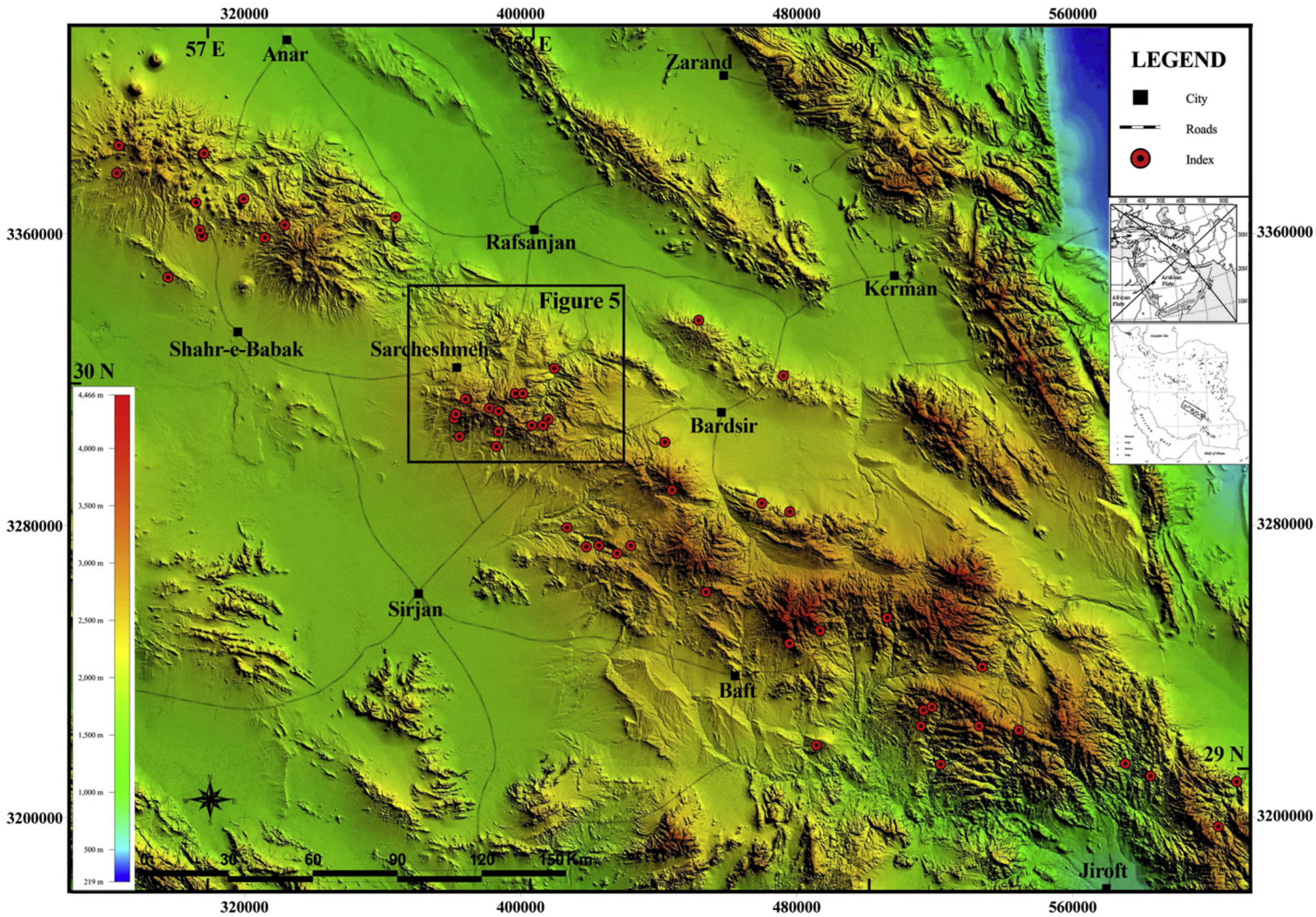

Fig. 1. Geographical position and access roads in the Kerman Copper Metallogenic Province and Sarcheshmeh area (defined as a rectangular labeled as Fig. 6). The location of study area is defined by the two simplified insets in the right corner of figure (after Lotfi et al., 1993; Safari et al., 2011). Note that this province is located at an elevation of over 2000 m (refer to height scale in side bar). The position of the copper deposits are denoted as red circles.

In this research, KCMP has been selected as a case study for an investigation of the structural controls on Cu mineralization. KCMP is one of the most significant Cu mineralization provinces in Iran containing approximately 300 Cu deposits and occurrences with at least 20 porphyry type Cu deposits (Ghorbani, 2002, 2013). This province is ~300 km long and 30–45 km wide, and is situated in the southern part of the Uramia-Dokhtar Volcanic Belt (UDVB) in central Iran.

The Sarcheshmeh area is located in the KCMP region and contains Cu mineralization that is spatially located between fault zones, making it an ideal area to investigate for this study. These investigations have utilized geoinformation technology (GiT) such as Geographic Information System (GIS) and Remote Sensing (RS) in combination with field investigations. These field investigations combined with statistical analysis form an invaluable tool in studying Cu deposits (Pirasteh et al., 2008), which are related to faults of various scales and plutonic bodies. This contribution discusses the findings of this study.

2. Tectonic setting and general geology

The Iranian copper belt is ~2000 km long and consists of over 100 Cu deposits extending from Azerbaijan in the northwest to Sistan and Baluchistan (Ghorbani, 2013). The Cu mineralization in the belt forms zones that trend 130°–140° parallel to the Sanandaj-Sirjan Metamorphic belt. The UDVB is a remnant element of the Afro-Arabian plate subducted beneath the Iranian micro-plate during the Jurassic to Cretaceous, followed by oblique collision and suturing during the Miocene (Alavi, 1994; Berberian and King, 1981; Hosseini et al., 2010; Sarkarinejad et al., 2008; Shafiei, 2010; Stocklin, 1968).

The UDVB is a NW–SE linear intrusive–extrusive complex that consists of an upper Cretaceous–Eocene mafic to felsic volcano-sedimentary complex intruded by Oligocene to Miocene granites, stocks and dykes (Boomeri et al., 2010; Hosseini et al., 2010; (Alavi, 1994; Kirkham and Dunne, 2000; Walker and Jackson, 2002; McInnes et al., 2003; Shahabpour, 2005; Barzegar, 2007). The region was succeeded by collisional and post-collisional magmatism forming adakitic and alkaline rocks during the Pliocene–Quaternary (Ghadami et al., 2008).

The host rocks of the porphyry Cu deposits in UDVB are shallow-level plutonic complexes that are characteristic of magmatic arcs. They were emplacing in a magmatic arc at a convergent plate margin, as is the case for other parts of the world, such as Andean Cu province (e.g. Ghorbani, 2013; Sillitoe, 1997; Titley, 1982; Sawkins, 1990).

The KCMP is one of the most significant Cu provinces in the UDVB. The province extends from Dehaj in north of Shahr-Babak (30° 37′ 04″ N, 54° 52′ 05″ E) to Sarduyieh in east of Baft (29° 14′ 13″ N, 57° 28′ 27″). The main mines in Dehaj-Sarduyieh belt include the giant Sarcheshmeh Cu deposit and the Meiduk, Darre Zar, Nowchun, Dar Alu and Seridun deposits (Fig. 1). Hydrothermal alteration in the belt is associated with three stages of primary mineralization in the form of veins and veinlets (Asadi et al., 2013).

The Sarcheshmeh deposit is hosted by the Sarcheshmeh Granite, which consists of a granodiorite porphyry stock intruded by fine-grained monzonite porphyry and several porphyritic dykes. Other