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Magnetic susceptibility anisotropy as a predictive exploration tool of metasomatic iron oxide deposits: Example from the Panj-Kuh iron ore body, NE Iran

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ABSTRACT

The Panj-Kuh iron deposit, hosted by Late Eocene igneous rocks in north of central Iran, is associated with a syenitic intrusive body. Magnetic fabric investigations indicate that the Panj-Kuh pluton was emplaced within a sinistral shear zone. Corridors of sheared and metasomatized rocks show that the shear zone was active after emplacement of the pluton and in the final steps of crystallization. The sheared rocks allowed for circulation of hydrothermal fluids during cooling of the magma and caused the pervasive Na–Ca alteration. The ferrimagnetic phase in fresh syenite is mostly euhedral or subhedral magnetite, and is observed adjacent to, or as inclusion in biotite and pyroxene. Anisotropy of magnetic susceptibility (AMS) in the fresh syenite is due to preferred shape orientation of magnetite grains. In Na–Ca altered syenites, magnetite has reduced or has been totally absorbed. The alteration results in decreased bulk susceptibilities (Km) and higher anisotropy degrees (P%), accompanied by changes in the shape of magnetic susceptibility anisotropy ellipsoid. This study of the Panj-Kuh pluton suggests that AMS can be used for mapping lithology and hydrothermal alteration types. Since various types of hydrothermal alteration create, transform or destroy ferrimagnetic minerals in a mineralized system, susceptibility measurements aid mapping of igneous rock type, alteration zoning and mineralization. Integrating petrography, magnetic mineralogy, bulk magnetic susceptibility and preferred orientations of principal axes of the AMS in fresh and altered rocks can be used to generate predictive magnetic exploration models for metasomatic iron oxide deposits.

1. Introduction

Anisotropy of magnetic susceptibility (AMS) is a useful petrofabric tool that is often used to quantify the magnetic fabric in granitoidic rocks from different tectonic settings (e.g. Tarling and Hrouda, 1993; Bouchez, 1997), in order to correlate the shape and orientation of the magnetic ellipsoid with tectonic strain and emplacement processes (e.g. Archanjo et al., 1995; Martin-Hernandez et al., 2004; Sadeghian et al., 2005). In the undeformed state, AMS defines grain-shape anisotropy for magnetite and expresses crystallographic control on magnetic properties for other minerals (Tarling and Hrouda, 1993). Thus, the orientation-distribution of a dominant mineral is inferred from the AMS of a rock (Borradaile and Henry, 1997). The spectrum of post-emplacement processes include mineral changes associated with hydrothermal alteration, metamorphism or tectonic activity can modify the AMS signal related to flow. Several workers have recognized the evidence for post-emplacement hydrothermal alteration in various igneous intrusions of contrasting tectonic settings (Torsvik et al., 1983; Lapointe et al., 1986; Nakamura and Nagahama, 2001; Just et al., 2004). There are, however, very few investigations focused on the influence of hydrothermal alteration and brittle deformation on magnetic fabrics during mineralization. Gunn and Dentith (1997) reviewed magnetic responses associated with mineral deposits and showed how magnetic survey data could be used for identifying favorable locations of ore bodies. Clark (1999) reviewed the magnetic petrology of intrusive igneous rocks and discussed exploration implications for intrusion-related mineral deposits. Sizaret et al. (2003) and Nomade et al. (2000) applied the AMS method to investigate flow direction of an aqueous fluid in which crystals are formed. Xu et al. (2003) indicated that changes in magnetic fabrics of tectonites, which had underwent hydrothermal alteration during gold mineralization in the Xiaoban gold-bearing shear zone in Fujian province, China, were dependent on type of host rock, deformation and hydrothermal fluid. Clark et al. (2004) developed the concept of predictive magnetic exploration model for porphyry copper and copper-gold deposits, including associated skarn deposits and intrusive-related breccia-hosted Au deposits, as

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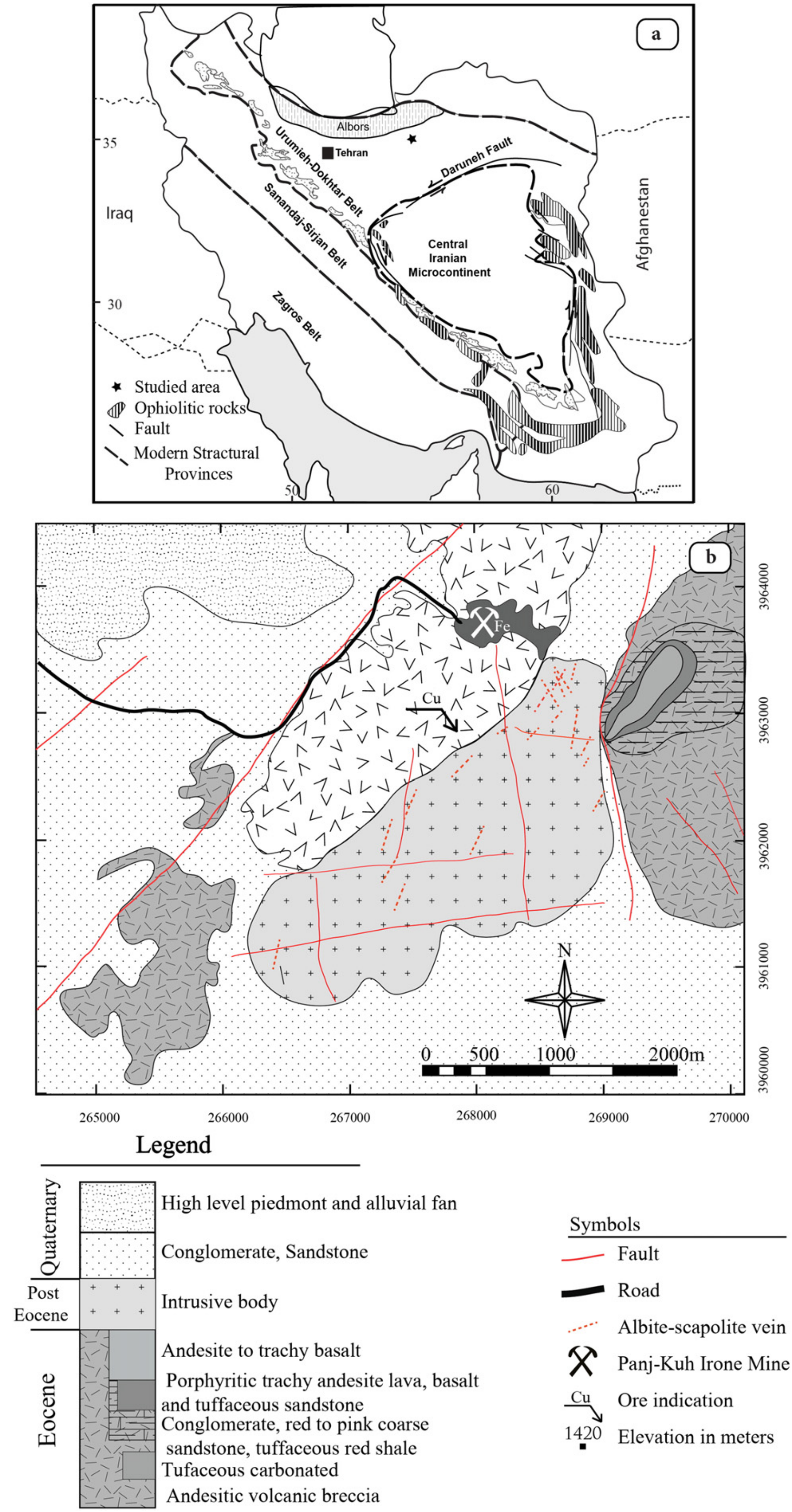

Fig. 1. a) Geological sketch map of Iran (compiled from Alavi, 1994; Berberian, 1981). b) Simplified geological map of Panj-Kuh.