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Discriminating productive and barren porphyry copper deposits in the southeastern part of the central Iranian volcano-plutonic belt, Kerman region, Iran: A review

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ABSTRACT

The Kerman Cenozoic magmatic arc (KCMA), located on the southeast of the Central Iranian volcano-plutonic belt, hosts some world class porphyry copper deposits. Temporally, the deposits overlap with the Alpine–Himalayan collision, which has some key implications for the existence or lack of copper mineralization during orogenic arc system development. Transition from normal calc-alkaline arc magmatism in the Eocene-Oligocene (Jebal Barez-type) to adakite-like calc-alkaline magmatism (Kuh Panj-type) in the mid-late Miocene-Pliocene reflects the onset of collision between the Afro-Arabian and Eurasian plates in the Kerman Cenozoic arc segment. The aim of this review is to determine the role of Cenozoic magmatic events in the development of economic to sub-economic porphyry copper mineralization in the southeastern parts of the Central Iranian volcano-plutonic belt. In order to discriminate between the various magmatic systems (KCMA) involved in that development, a geochemical investigation is carried out using samples collected from all important deposits in the region (this study) and previous published data by earlier researchers in this region. It is evident from these data that the collisional Neogene Kuh Panj porphyry suite is distinctly more evolved than the pre-collisional Eocene-Oligocene Jebal Barez granitoids, with relative enrichments in incompatible elements, Sr/Y (>55), and La/Yb (>20), slightly positive Eu anomalies ($Eu_n/Eu^* \approx 1$), and depletions in HFSE, with $[La/Sm]_n \approx 4.6–6.6$ and $[Dy/Yb]_n \approx 1.0–2.0$, and relatively non-radiogenic Sr isotope signatures ($^{87}Sr/^{86}Sr = 0.7042–0.7047$). In contrast, Jebal Barez granitoids exhibit low Sr/Y (<21) and La/Yb (<9) ratios, negative Eu anomalies ($Eu_n/Eu^* \approx 0.5$), and enrichment in HFSE and radiogenic Sr isotope signatures ($^{87}Sr/^{86}Sr = 0.7053–0.7075$). The temporal along with lithogeochemical and isotopic changes, reflect a progressive transfer of the melting zone from the juvenile mafic lower crust (garnet–free amphibolite) into garnet–amphibolite. This transfer is the result of compressional stress along with tectonic shortening during Eocene-Oligocene (~30–35 km crustal thickness) to mid-late Miocene (~45–55 km thick or 12–15 kbar). The absence of volcanism, under prevailing compressional conditions (mid-late Miocene-Pliocene), prevented the escape of SO_2 from the adakite-like, sulfur-rich, highly oxidized magmas ("closed porphyry systems"), which allowed formation of several world-class to giant mineral deposits. Volcanic activity during formation of the subvolcanic Eocene-Oligocene porphyries allowed development of "open porphyry systems", which, in turn to partial outgassing of volatiles, and therefore, far less significant mineral deposits.

Contents

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1. Introduction

Porphyry Cu systems relating to continent–continent collision are exposed within many orogenic belts worldwide (e.g., Qu et al., 2001; Hou and Cook, 2009; Richards, 2009). High heat flow, resulting from collisional orogeny and associated crustal thickening, translithospheric shearing, and lithospheric mantle thinning, are regarded as the main causes for hydrothermal mineralization in the orogenic systems (Groves and Bierlein, 2007). Several tectonic models for porphyry Cu mineralization within collisional orogenic belts are proposed by various authors, summarized by Pirajno (2009). Numerous giant and large-size porphyry Cu deposits have been identified in collisional settings, such as east China (e.g., Pan and Dong, 1999; Hou et al., 2007; Yang et al., 2012, 2013), Tibet (e.g., Hou et al., 2003; Chung et al., 2005; Hou and Cook, 2009; Hou et al., 2011) and western Asia (e.g., Hezarkhani et al., 1999; Calagari, 2004; Cooke et al., 2005; Zarasvandi et al., 2007; Shafiei et al., 2009; Richards et al., 2012; Asadi et al., 2013a,b).

All known porphyry copper deposits in Iran occur within the Cenozoic Urumieh–Dokhtar magmatic belt (e.g., McInnes et al., 2003; Shafiei et al., 2008, 2009; Hou et al., 2011; Richards et al., 2012), and are particularly widespread in the southeastern arc segment (Fig. 1), the so-called Kerman Cenozoic magmatic arc (KCMA; Shafiei et al., 2009). The KCMA in Iran (western Asia) is located on the western boundary of the central Iranian block and associated with calc-alkaline intrusive rocks (stocks) in the Urumieh–Dokhtar magmatic belt (Fig. 1; Hezarkhani, 2006a; Zarasvandi et al., 2007). This belt was first interpreted by Dewey et al. (1973) as an Andean-type Cordilleran arc system within the collisional Alpine–Himalayan orogenic belt, reflecting subduction and collision of the Afro-Arabian plate with Eurasia.

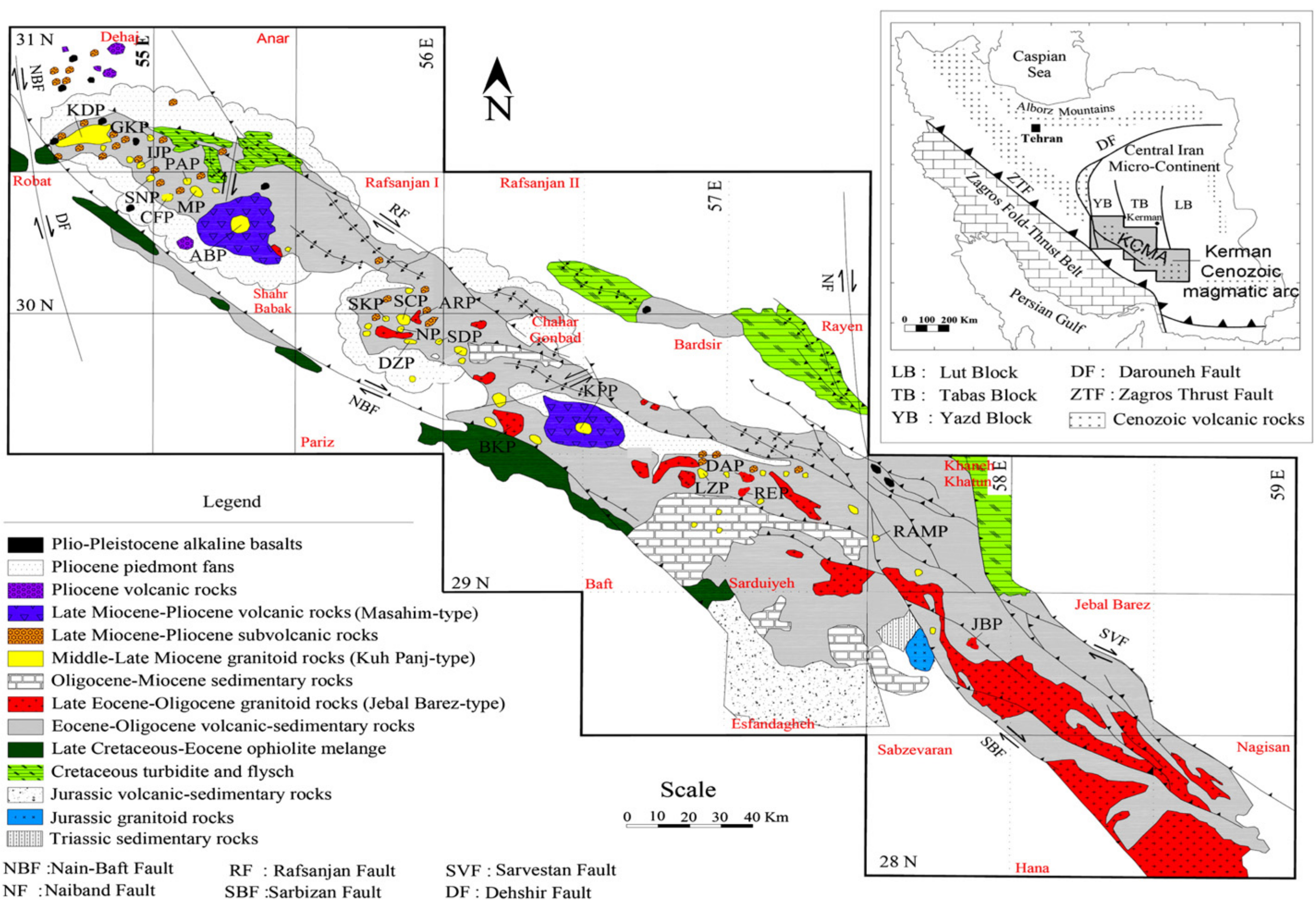

Fig. 1. Simplified geological map of the Kerman Cenozoic magmatic arc (KCMA) and location of major porphyry Cu deposits and prospects (compiled from Dimitrijevic, 1973; Saric and Mijalkovic, 1973; Dercourt et al., 1986; Emami et al., 1993, Samani, 1998; Shafiei et al., 2009). Abbreviations used: Deposits and Prospects: SCP: Sarcheshmeh porphyry, SKP: Sar Kuh porphyry, ABP: Abdar porphyry, DAP: Dar Alu porphyry, DZP: Darreh Zar porphyry, CFP: Chah Firuzeh porphyry, MP: Meiduk porphyry, PAP: Parkam porphyry, JBP: Jebal Barez porphyry, REP: Reagan porphyry, ARP: Archandor porphyry, SDP: Saridune porphyry, GKP: God-e-Kolvary prospect, IJP: Iju prospect, KDP: Kader prospect, KPP: Kuh Panj prospect, LZP: Lalleh Zar prospect, NP: Now Chun prospect, RAMP: Razi Abad-Madin prospect, and SNP: Serenu prospect. Faults: DF: Dehshir fault, RF: Rafsanjan fault, NBF: Nain–Baft fault, SBF: Sarbizan fault, NF: Nayband fault, SVF: Sarvestan fault. Inset: KCMA: Kerman Cenozoic magmatic assemblage, LB: Lut block, TB: Tabas block.