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Petrogenesis of Rabor-Lalehzar magmatic rocks (SE Iran): Constraints from whole rock chemistry and Sr-Nd isotopes

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ABSTRACT

The Urumieh-Dokhtar magmatic arc (UDMA) of Central Iran has been formed during Neotethyan Ocean subduction underneath Eurasia. The Rabor-Lalehzar magmatic complex (RLMC), covers an area ~1000 km^2 in the Kerman magmatic belt (KMB), SE of UDMA. RLMC magmatic rocks include both granitoids and volcanic rocks with calc-alkaline and adakitic signatures but with different ages.

Miocene adakitic rocks are characterd by relatively enrichmented in incompatible elements, high $(Sr/Y)_{(N)}$ (> 40), and $(La/Yb)_{(N)}$ (> 10) ratios with slightly negative Eu anomalies ($Eu_N/Eu^* \approx 0.9$), depletion in HFSEs, and relatively non-radiogenic Sr isotope signatures ($^{87}Sr/^{86}Sr$ = 0.7048–0.7049). In contrast, the Oligocene granitoids exhibit low Sr/Y (< 20) and La/Yb (< 9) ratios, negative Eu anomalies ($Eu_N/Eu^* \approx 0.5$), and enrichment in HFSEs and radiogenic Sr isotope signatures ($^{87}Sr/^{86}Sr$ = 0.7050–0.7052), showing affinity to the island arc rocks. Eocene volcanic rocks which crusscut the younger granitoid rocks comprise andesites and dacites. Geochemically, lavas show calc-alkaline character without any Eu anomaly ($Eu_N/Eu^* \approx 1.0$). Based on the geochemical and isotopic data we propose that melt source for both calc-alkaline and adakitic rocks from the RLMC can be related to the melting of a sub-continental lithospheric mantle (SCLM). Basaltic melts derived from a metasomatized mantle wedge might be emplaced at the mantle-crust boundary and formed the juvenile mafic lower crust. However, some melts fractionated in the shallow magma chambers and continued to rise forming the volcanic intermediate-mafic rocks at the surface. On the other hand, the assimilation and fractional crystallization in the shallow magma chambers of may have been responsible for the development of Oligocene granitoids with calc-alkaline affinity. In the mid-Late Miocene, following the collision between Afro-Arabia and Iranian block the juvenile mafic crust of UDMA underwent thickening and metamorphosed into garnet-amphibolites. Subsequent upwelling of a hot asthenosphere during Miocene was responsible for partial melting of thickened juvenile crust of the SE UDMA (RLM complex). The adakitic melts ascended to the shallow crust to form the adakitic rocks in the KMB.

1. Introduction

Calc–alkaline arc magmas are mostly generated from flux melting of mantle wedge peridotite above a downgoing slab, induced by fluids released from the subducting oceanic lithosphere (Chiaradia et al., 2004; Stern, 2011). Adakites area also common along the convergent plate margins (Castillo, 2006; Chiaradia et al., 2009; Chung et al., 2003; Defant et al., 2002; Kay and Kay, 2002; Yogodzinski and Kelemen, 1998). The term “adakite” is usable for intermediate to felsic rocks with high Sr/Y ratio (> 40) and low HREE (Yb < 1.8 ppm) values (Defant and Drummond, 1990). These geochemical features are interpreted to reflect the importance of garnet and/or amphibole and absence of plagioclase in magma sources (Martin, 1999). Such melt signatures can be produced in at least five ways: 1) subduction of young and hot slab (Defant and Drummond, 1990); 2) slab break off in a post–collisional setting (Castillo, 2006, 2012); 3) slab window processes linked to the ridge subduction (Eyuboglu et al., 2011a; Zhang et al., 2010; Zhang and Zhai, 2012), 4) partial melting of a thickened continental lower crust (Coldwell et al., 2011) and 5) hydrous (involving amphibole) and/or high pressure (involving garnet) crystal fractionation of a parent mafic magma (Chiaradia et al., 2009; Macpherson et al., 2006; Moyen, 2009; Muntener et al., 2001; Nandedkar et al., 2014; Rossetti et al., 2014). One of the best and recent active continental margins is the Urumieh-Dokhtar Magmatic Arc (UDMA) in central Iran, where the Neotethyan

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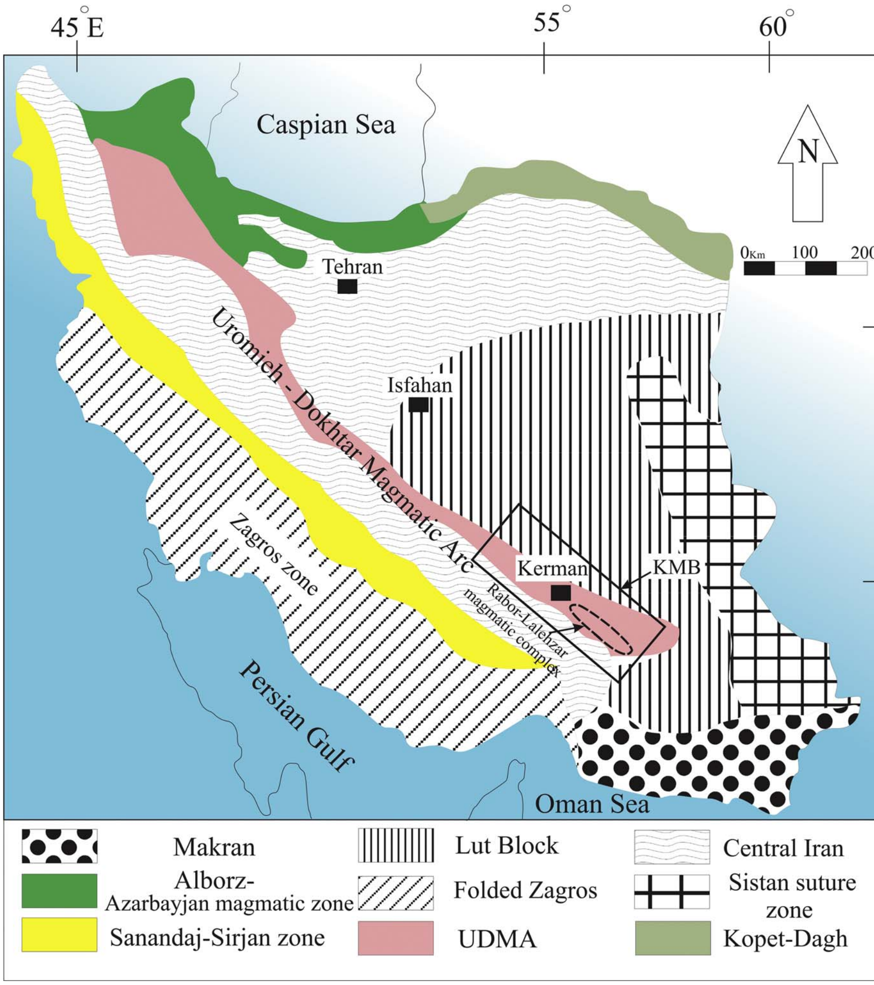

Fig. 1. Simplified regional geotectonic map showing some major geological-structural zones of Iran and location of Rabor-Lalehzar complex in south of UDMA (modified from Stocklin, 1968).

Oceanic lithosphere subducted beneath Iran during Cenozoic. The Cenozoic magmatism in Iran is mostly distributed in two belts (Fig. 1): (1) The Urumieh-Dokhtar magmatic arc with > 1700 km in length and NW–SE trend (Stocklin, 1968; Shahabpour, 2005). (2) The Alborz-Azarbaijan Belt, in N Iran, containing 800 km magmatic rocks with NW–SE and W–E directions (Stocklin, 1968; Nabavi, 1976).

The western end of this belt merges in the UDMA. Both magmatic belts show a major magmatism during whole of Cenozoic with a magmatic climax at Eocene time. The Kerman magmatic belt (KMB) in the SE parts of the UDMA contains widespread Paleogene-Neogene magmatic rocks and host most of the large Cu-Au deposits (Fig. 1). Most of the rocks in the KMB show calc-alkaline and shoshonitic signatures.

Mafic to acidic magmatism rocks and pyroclastic edifices are common and in some cases, show intercalations with the Paleogene sallow water sediments (limestones). Oligocene to Miocene

The suggested mechanisms for the formation of KMB is successive episodes of Neotethyan Ocean subduction beneath central Iran during Paleogene and subsequent continent-continent collision in Neogene (e.g., Stocklin, 1968; Berberian et al., 1982; Dercourt et al., 1986; Mohajjel et al., 2003; Agard et al., 2005). Adakitic rocks are the main components of the UDMA, especially in the KMB. Adakitic rocks are also common.

In Iran some adakitic Provinces were identified in some locations for instance NW of Alborz–Azarbaijan Belt (Jahangiri, 2007; Jamali and Mehrabi, 2015), in Central Iran in Isfahan area (Ahmadian et al., 2016), and in NE Iran (Mazhari, 2016; Shafaii Moghadam et al., 2016). These rocks are belived to trigger the main Cu-Au deposits in KMB (e.g., Asadi et al., 2014; Ayati et al., 2013; Shafiei et al., 2009; Zarasvandi et al., 2013, 2015; Mohammaddoost et al., 2017; Hosseini et al., 2017; Alirezaei et al., 2017 and others).

In this paper, we report for the first time the whole rock geochemical composition and Sr-Nd isotope ratios of granitoids and volcanic rocks from the RLMC (SE parts of KMB). The major goals of this contribution are (1) to understand the geochemical composition of igneous rocks from the KMB, (2) to understand the nature and origin of the Miocene adakitic rocks from the RLMC and (3) to understand the petrogenetic relationships between adakities and other non adakite granitoids and volcanic rocks.

2. Geological framework

2.1. Regional geology: Kerman Magmatic Belt (KMB)

The Kerman magmatic belt (KMB) comprise voluminous intrusive and extrusive rocks with mostly calc-alkaline in nature. Generally, the KMB contains two different types of igneous rocks: (1) barren Late Eocene - Oligocene granitoid and subvolcanic rocks (the Jebal Barez-type rocks) and (2) fertile mid-Late Miocene intrusive bodies (Kuh Panj-type rocks). Most porphyry Cu-Au mineralizations are related to the emplacement of mid-Late Miocene (Kuh Panj) granitoids, whereas most late Eocene–Oligocene (Jebal Barez) intrusions are barren without any Au-Cu mineralization (e.g., Dimitrijevic 1973; Shafiei et al., 2008).

The formation of adakitic and calc-alkaline rocks in KMB are attributed to three magmatic pulses in Tertiary: (1) Eocene–Oligocene (Ahmadian et al., 2009); (2) mid-Late Oligocene (Kirkham and Dunne, 2000; McInnes et al., 2005); and (3) mid-Late Miocene (Razique et al., 2007; Richards, 2012). Most scientists believe that adakitic magmatism occurred during Miocene (e.g., McInnes et al., 2005; Shafiei et al.,