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Late Miocene K-rich volcanism in the Eslamieh Peninsula (Saray), NW Iran: Implications for geodynamic evolution of the Turkish–Iranian High Plateau

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ABSTRACT

Post-collisional volcanism in northwestern Iran is represented by the Saray high-K rocks including leucite-bearing under-saturated and leucite-free silica saturated rocks. We report Ar–Ar age data which constrain the age as ca. 11 Ma (late Miocene). Most of clinopyroxene phenocrysts from the volcanic rocks have complex oscillatory zoning, with high Ti and Al cores, low Ti and high Al mantled clinopyroxenes, grading into low Ti and Al outer rims. All the rocks are highly enriched in incompatible trace elements and have identical Sr–Nd–Pb isotopes. Enrichment in incompatible elements and other geochemical features for the Saray lavas suggest a metasomatized sub-continental lithospheric mantle (SCLM) as the magma source. The negative Nb–Ta–Ti anomalies for the Saray lavas compare with the features of subduction-related magmatism with negligible contamination with ancient crustal components. The highly radiogenic $^{87}Sr/^{86}Sr$ and $^{207}Pb/^{204}Pb$ isotopic values of the Saray lavas imply the involvement of slab terrigenous sediments and/or a continental lithosphere. Isotopically, the volcanic rocks define a binary trend, representing 5–8% mixing between the primary mantle and sediment melts. Our melting models suggest residual garnet in the source and are incompatible with partial melting of amphibole and/or phlogopite bearing lherzolites, although the complex geochemical features might indicate the result of mixing between melts produced by different sources or a homogenous melt passing through a compositionally-zoned mantle during multiple stages of partial melting and melt migration. The geochronological, geochemical and isotopic data for the Saray rocks suggest that these Late Miocene magmas were derived from a small degree of partial melting of subduction-metasomatized (subcontinental) lithospheric mantle source in a post-collisional setting.

1. Introduction

The northward migration of the Afro-Arabian plate caused subduction during the late Cretaceous to Miocene beneath the Iranian block, followed by collision between the Anatolian–Iranian and Arabian plates during middle to late Miocene (Berberian and King, 1981; Alici Sen et al., 2004; Chiu et al., 2013). This continental collision was accommodated by crustal shortening and thickening in eastern Anatolia and northwestern Iran (Sengor and Yılmaz, 1981; Temel et al., 1998; Alici Sen et al., 2004; Dilek et al., 2010). The northwestern Iran–eastern Mediterranean region (Turkish–Iranian High Plateau) is a tectonically active plateau between the converging Arabia and Eurasia. Cenozoic magmatic rocks occur extensively in the Turkish–Iranian High Plateau, northeast of the Bitlis–Zagros suture zone (Dilek et al., 2010) (Fig. 1). The temporal distribution of the magmatism in this region shows different phases of magma generation with distinct geochemical signatures mainly in the late Eocene, late Miocene and Plio–Quaternary (Dilek et al., 2010; Eyuboglu et al., 2010, 2011a,b,c,d,e, 2012, 2013a,b). Mantle-derived volcanic rocks with oceanic-island basalt (OIB)-like geochemical features with and/or without subduction fingerprints are commonly found in the Turkish–Iranian High Plateau (e.g., Aldanmaz et al., 2006; Dilek and Altunkaynak, 2009; Kheirkhah et al., 2009; Elitok et al., 2010; Allen et al., 2013).

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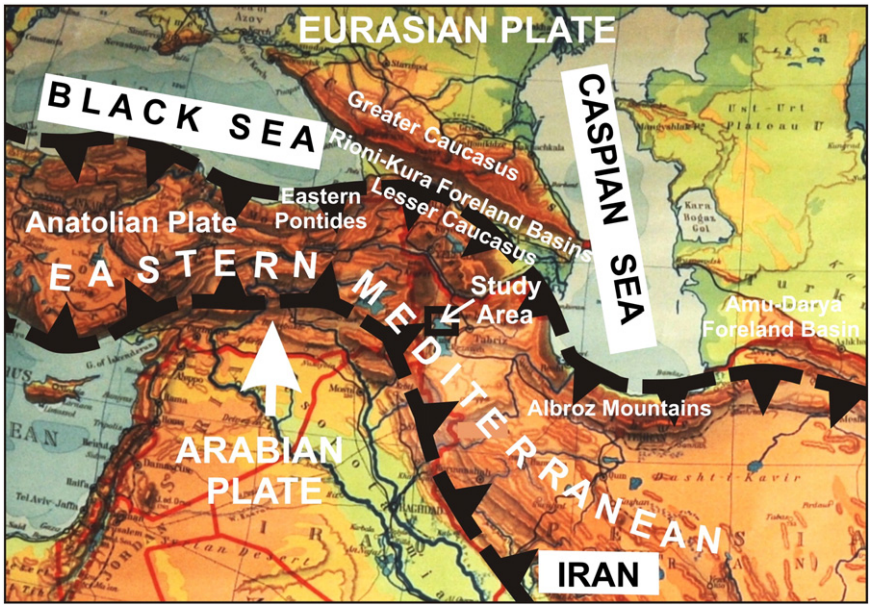

Fig. 1. Simplified tectonic map of the eastern Mediterranean–Persian Gulf region, showing the active plate boundaries and location of the eastern Pontides–Lesser Caucasus–Albroz magmatic arc.
Modified after Eyuboglu et al. (2012).

The late Miocene magmatic rocks with calc-alkaline and shoshonitic (or ultrapotassic) characteristics are found mainly along the UDMA (Chiu et al., 2013) and occur in the northern parts of the Turkish–Iranian High Plateau (Moine-Vaziri et al., 1991; Dilek et al., 2010; Eyuboglu et al., 2012). Plio-Quaternary magmatic rocks are represented by alkaline rocks with and/or without subduction overprints and by shoshonitic rocks in several regions of the UDMA, but mostly in NW Iran, in the Turkish–Iranian High Plateau (e.g., Keskin, 2003; Kheirkhah et al., 2009; Elitok et al., 2010; Eyuboglu et al., 2012; Allen et al., 2013).

The study area is situated between the Bitlis–Zagros Zone and eastern Pontides–Lesser Caucasus–Albroz magmatic arc. Although there is consensus on a northward subduction model for the geodynamic evolution of the Bitlis–Zagros Zone in the southern part of the study area, the evolution of the eastern Pontides–Lesser Caucasus–Albroz magmatic arc in the north is still controversial due to lack of systematic geological, geochronological and geochemical data. The most popular idea is the magmatic arc developed by the northward subduction of the Paleotethys oceanic lithosphere, which was situated to the south of the arc, until the Eocene (e.g., Adamia et al., 1977; Okay and Sahintürk, 1997; Dilek et al., 2010). An earlier interpretation by Sengor and Yılmaz (1981) proposed that Paleotethys was located to the north of the magmatic arc, and hence southward subduction operated from the Paleozoic until the Dogger, and that northward subduction occurred subsequently from the late Mesozoic until the Eocene. The third model includes those of Dewey et al. (1973), Bektaş et al. (1999), Chorowicz et al. (1998), Eyuboglu et al. (2006, 2007, 2010) and Eyuboglu (2010) who favor a southward subduction of the Tethys oceanic lithosphere, which was situated to the north of magmatic arc, continued uninterruptedly from the Paleozoic till the late Cenozoic.

Adakitic volcanism is minor in the region north of the Bitlis–Zagros suture zone in the northern and southern parts (e.g., Jahangiri, 2007; Omrani et al., 2008; Chiu et al., 2013). However, different pulses of magmatism are widespread in the Eastern Pontides–Lesser Caucasus and eastern Iranian–Azerbaijan regions, which have been correlated with the northward subduction of the southern Neotethyan Ocean (Yılmaz et al., 1997). These rocks vary in composition from calc-alkaline to alkaline/adakitic characteristics with temporal variations from Paleocene to Plio-Quaternary. The occurrence of magmatic rocks in the Eastern Pontides–Lesser Caucasus and eastern Iranian–Azerbaijan regions have posed important questions related to the geodynamic evolution of these regions. Recent comprehensive geological, geochemical, and geochronological studies (e.g., Dokuz, 2011; Eyuboglu et al., 2011a,b,c,d,e, 2012, 2013a, 2013b; Maden, 2013) on the Cenozoic magmatism revealed that the adakitic magmatism occurred in two different cycles in the eastern Pontides–Lesser Caucasus–Alborz magmatic arc. The first phase was during the late Paleocene–early Eocene and the second one during late Miocene. The origin of the late Paleocene–early Eocene adakitic rocks, which are well exposed in the southern part of the eastern Pontides orogenic belt, has been correlated to slab window processes in a southward subduction zone (Eyuboglu et al., 2011a,b,c,e, 2013a,b). The late Miocene adakitic rocks, which are well exposed in the eastern part of the eastern Pontides orogenic belt and also Caucasus, were generated by partial melting of the mafic lower crust after the collision between Lesser Caucasus and Greater Caucasus (Eyuboglu et al., 2012). These studies suggest that the slab break-off of the southward subducted oceanic lithosphere and inflow of hot asthenosphere into the mantle wedge caused partial melting of subduction-modified mantle wedge and led to the formation of Pliocene and Pleistocene alkaline magmatic rocks exposed along the northern edge of the eastern Pontides–Lesser Caucasus–Albroz magmatic arc (Eyuboglu et al., 2012).

Although several studies have highlighted the temporal and spatial aspects of magmatism in the Turkish–Iranian High Plateau, showing different pulses of magma generation mainly in the late Eocene, late Miocene and Plio–Quaternary and with distinct geochemical signatures, NW Iran has not been investigated in detail. A recent report shows that Late Eocene and Oligocene (ca. 38 to 23 Ma) shoshonitic to adakitic plutons (with an age progression from SE to NW) are common in NW–N Iran (Castro et al., 2013). It is important to trace the temporal distribution of the various pulses of magmatism and the triggering mechanisms in NW Iran, in order to evaluate the post-collisional magmatism in this region.

In this paper we present: 1) a detailed classification of the high-K volcanic rocks in the Eslamieh Peninsula (Saray) based on mineral and whole rock geochemical studies; 2) Ar–Ar dating of the rocks and 3) Sr–Nd–Pb isotope geochemistry. Based on the results, we evaluate the petrogenesis of the high-K rocks (leucite-free or leucite-bearing) and its implications on post-collisional magmatism in the late Miocene.