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Petrology and geochemistry of the Karaj Dam basement sill: Implications for geodynamic evolution of the Alborz magmatic belt

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ABSTRACT

The northeastward subduction of the Neo-Tethyan oceanic lithosphere beneath the Iranian block produced vast volcanic and plutonic rocks that now outcrop in central (Urumieh–Dokhtar magmatic assemblage) and north–northeastern Iran (Alborz Magmatic Belt), with peak magmatism occurring during the Eocene. The Karaj Dam basement sill (KDBS), situated in the Alborz Magmatic Belt, comprises gabbro, monzogabbro, monzodiorite, and monzonite with a shoshonitic affinity. These plutonic rocks are intruded into the Karaj Formation, which comprise pyroclastic rocks dating to the lower–upper Eocene. The geochemical and isotopic signatures of the KDBS rocks indicate that they are cogenetic and evolved through fractional crystallization. They are characterized by an enrichment in LREEs relative to HREEs, with negative Nb–Ta anomalies. Geochemical modeling using Sm/Yb *versus* La/Yb and La/Sm ratios suggests a low-degree of partial melting of a phlogopite–spinel peridotite source to generate the KDBS rocks. Their low I_{Sr} = 0.70453–0.70535, εNd (37.2 Ma) = 1.54–1.9, and T_{DM} ages ranging from 0.65 to 0.86 Ga are consistent with the melting of a Cadomian enriched lithospheric mantle source, metasomatized by fluids derived from the subducted slab or sediments during magma generation. These interpretations are consistent with high ratios of ^{206}Pb/^{204}Pb = 18.43–18.67, ^{207}Pb/^{204}Pb = 15.59, and ^{208}Pb/^{204}Pb = 38.42–38.71, indicating the involvement of subducted sediments or continental crust. The sill is considered to have been emplaced in an environment of lithospheric extension due to the slab rollback in the lower Eocene. This extension led to localized upwelling of the asthenosphere, providing the heat required for partial melting of the subduction-contaminated subcontinental lithospheric mantle beneath the Alborz magmatic belt. Then, the shoshonitic melt generates the entire spectrum of KDBS rocks through assimilation and fractional crystallization during the ascent of the magma.

1. Introduction

Initiation of the north–eastward-dipping subduction of the Neo-Tethyan oceanic lithosphere beneath the south–southwestern border of the Turkish–Iranian high plateau was approximately contemporaneous with the closure of the Paleotethys in the south of Eurasia during the Late Permian–Early Triassic. This long-lasting period of subduction was followed by the collision of Arabia and Eurasia during the Tertiary Period. The protracted convergence of these two plates gave rise to the two main magmatic belts in Iran, which lie parallel to the present Bitlis–Zagros suture (Fig. 1), dating from the Jurassic to the Quaternary (Berberian and King, 1981; Berberian, 1983): (i) the Jurassic–Cretaceous Sanandaj–Sirjan magtmatic arc (SSMA) (Stöcklin, 1968; Azizi et al., 2011, 2014) and (ii) the Paleogene–Neogene Urumieh–Dokhtar magmatic assemblage (UDMA) and its counterparts, the Alborz magmatic belt (AMB), and the East Iran magmatic assemblage (EIMA) (Alavi, 1994, Fig. 1). The AMB is an important structural component of the Alpine–Himalayan range, situated 200–500 km north of the Bitlis–Zagros suture. It forms the easternmost portion of the Pontides arc-Lesser Caucasus-AMB belt in the Turkish–Iranian high plateau and includes the Damavand volcano, the highest peak in the Middle East.

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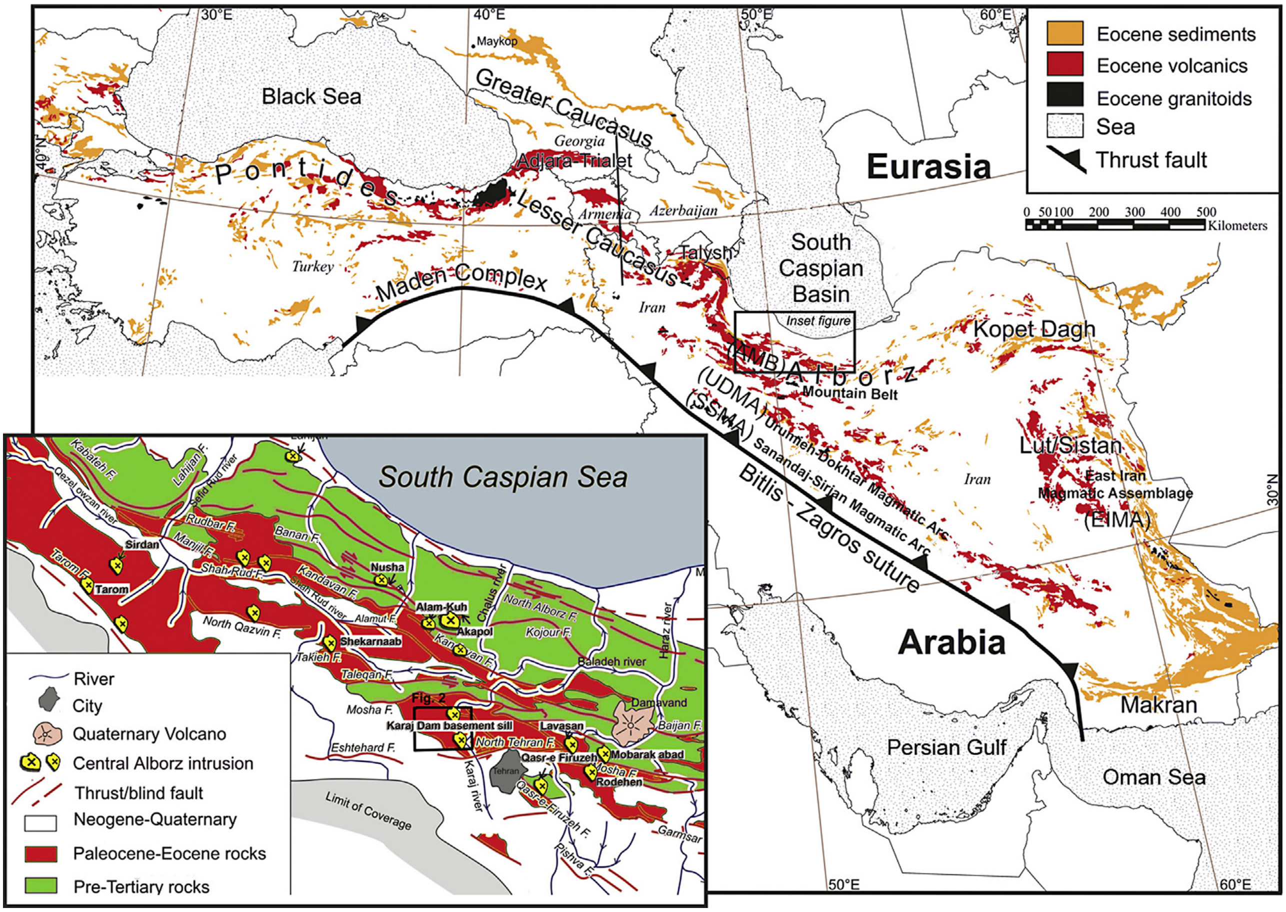

Fig. 1. Distribution of Eocene igneous and sedimentary rocks to the north of the Biltis–Zagros suture (after Vincent et al., 2005). The AMB is a narrow mountain range comprising a 100 km-wide active fold-and-thrust belt (Stöcklin, 1974; Axen et al., 2001) stretching from the northwestern border of Iran to the southern end of the Caspian Sea, terminating in the east at the border of Turkmenistan, and forming a barrier between the southern Caspian Sea and Central Iran. Inset figure: generalized geological structural map of Alborz, displaying the main geographic features and important plutons (after Rezaeian, 2008). The intrusions predominantly consist of: (1) calc-alkaline I-type granites (*e.g.*, the Lavasan and Ghasr-e-firoozeh granodiorites, the Akapol and Nusha granitoids, and the Tarom granodiorites); (2) high-K shoshonitic intrusions encompassing the gabbro–monzonite series (*e.g.*, the Mobarak Abad gabbro, the Karaj Dam basement sill (KDBS), the Shekarnaab monzogabbro, and the Rodehen igneous complex); and (3) intrusions of mafic alkaline composition that formed numerous igneous bodies in the Azerbaijan–Alborz magmatic belt.

One of the most significant events in the magmatic history of Iran was a widespread magmatic flare-up that occurred mainly in the UDMA and the AMB during the Eocene–Oligocene (Berberian and King, 1981; Verdel et al., 2011; Asiabanha and Foden, 2012). This phase of magmatism is characterized by rocks with intermediate compositions from calc-alkaline to pottasic affinity, which occur in an arc/back-arc system or extensional arc environment (Berberian, 1983; Kazmin et al., 1986; Hassanzadeh et al., 2004; Allen et al., 2003a,b; McQuarrie et al., 2003; Vincent et al., 2005; Agard et al., 2011; Verdel et al., 2011; Allen et al., 2013).

Much of the information available about the tectonics and the Cenozoic magmatism of the AMB has been derived mainly from studies into this phase of magmatism, and various scenarios and interpretations have therefore been proposed (*e.g.*, Stöcklin, 1968; Jung et al., 1976; Brousse et al., 1977; Berberian and King, 1981; Priestley et al., 1994; Dilek and Moores, 1999; Allen et al., 2003a,b; Davidson et al., 2004; Hassanzadeh et al., 2004; Vincent et al., 2005; Verdel et al., 2011; Asiabanha and Foden, 2012). Little information is available, however, about the dynamics of the subduction zone or zones, the characteristics of the subduction beneath the AMB, including orientation and dip, and the tectonomagmatic relation between the AMB and adjacent regions, (*e.g.* the northern part of Eastern Pontides arc, the Lesser Caucasus, *etc.*) or parallel trending arcs.

The well-exposed shoshonitic KDBS is an important intrusion among those emplaced during the Eocene-Oligocene magmatic phase (Fig. 1; inset figure) and contains a roughly complete sequence of high-K rocks (Maghdour-Mashhour, 2010). These rocks record the protracted history of the southern AMB, spanning from the evolution of their source region during the time of the first magmatism recorded in the AMB in the Late Cretaceous (Axen et al., 2001) to their late Miocene uplift and exhumation (Guest et al., 2006a,b). Despite their significance in the region, the geochemistry and geodynamics of the KDBS have remained poorly understood. Thus, a detailed study into this intrusion provides a unique opportunity to investigate various different scenarios for the tectonomagmatic evolution of the central Alborz. In this study, we present a detailed account of the rock types, mineral chemistry, and whole-rock geochemistry of high-K (shoshonitic) rocks of the KDBS for the first time and use these data to determine the petrogenesis and source region for this intrusive body. These data, in combination with the results from previous studies, are then used to deduce the nature of the tectonomagmatic regime and the geodynamics of the Alborz mountain range during the Cenozoic.

2. Geological setting and field relations

The formation of the AMB is generally interpreted to be due to the convergence of the Arabian and Eurasian plates.