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Arc-magmatism and subduction history beneath the Zagros Mountains, Iran: A new report of adakites and geodynamic consequences

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ABSTRACT

The Zagros Mountains were formed by convergence between Eurasia and Africa/Arabia. Compared to the wealth of recent studies on the external Zagros fold and thrust belt, the internal Sanandaj–Sirjan and Urumieh–Dokhtar magmatic arcs (SSMA, UDMA) remain poorly studied, despite being some of the best-preserved active margins within the greater Alpine–Himalayan convergent system.

We focus on the key geodynamic constraints provided by the subduction-related magmatism of the upper plate, which shifted ~300 km inward from the SSMA to the UDMA at the end of the Mesozoic. Major and trace element data show that all studied magmatic rocks display the characteristics of subduction-related calc-alkaline magmas. Rare-earth element (REE) systematics for Mesozoic (SSMA) and Eocene (UDMA) volcanic and plutonic rocks suggest a similar mantle wedge source. In contrast, major and trace element data for volcanic rocks postdating the Late Miocene reveal a typical adakitic signature along part of the UDMA. The amphibole and SiO_2-rich (59–72 wt.%) Zagros adakites have very low Y and HREE contents.

Adakitic magmas are likely to result from the melting of mafic material at depth (i.e., subducted oceanic crust from the slab and/or earlier obducted ophiolites) under unusually high temperature thermal conditions, in response to the regional-scale thermal re-equilibration accompanying collision or, to slab break-off. The fact that the distribution of these adakites is spatially restricted to the central parts of the UDMA (i.e. 200–300 km along strike) supports the slab break-off hypothesis, as do preliminary tomographic images. The timing of this event is coeval with slab-break-off below southern Turkey, which supports the view that slab detachment propagated laterally in the Neotethyan slab, both to the west (Turkey) and to the south (Iran), during the last 10–5 Ma.

1. Introduction

The Zagros Mountains are part of the Alpine–Himalayan orogenic belt and, result from the closure of the Neotethyan ocean between Arabia and Eurasia (e.g., Ricou et al., 1977; Dercourt et al., 1986, 1993; Sengor et al., 1988; Agard et al., 2005). Collision in the Zagros has recently been studied in terms of geophysics, kinematics and neotectonics (Talebian and Jackson, 2002, 2004; McQuarrie et al., 2003; Vernant et al., 2004; Molinaro et al., 2004, 2005a Meyer et al., 2005; Mouthereau et al., 2006; Agard et al., 2006, 2007).

Little is known, however, about the long-lasting magmatic activity (>150 m.y.) of the two presumably subduction-related arcs trending parallel to the Main Zagros Thrust (Fig. 1), namely, the Mesozoic Sanandaj–Sirjan (SSMA) and the Tertiary to Plio-Quaternary Urumieh–Dokhtar magmatic arcs (UDMA).

Despite abundant exposures of igneous rocks in both the SSMA and the UDMA (Fig. 2a), few studies are available (Berberian and Berberian, 1981; Berberian et al., 1982; Shahabpour, 2005; Ahmadi Khalaji et al., 2007) and no geochemical data have been acquired on a regional scale to better constrain the subduction history of Zagros.

Arc magmatism provides useful insights into mantle or crust melting processes in subduction zones (e.g., Pearce et al., 1990; Davidson, 1996; Macdonald et al., 2000), and in the case of Zagros, it should also help to solve some first-order geodynamic problems, such as:

(1) The shift of ~300 km of subduction-related magmatism from the Mesozoic SSMA to the Tertiary UDMA. Does this result from a change in subduction processes (e.g., a change in slab dip; Berberian and Berberian, 1981) or from the existence of two distinct subduction zones?

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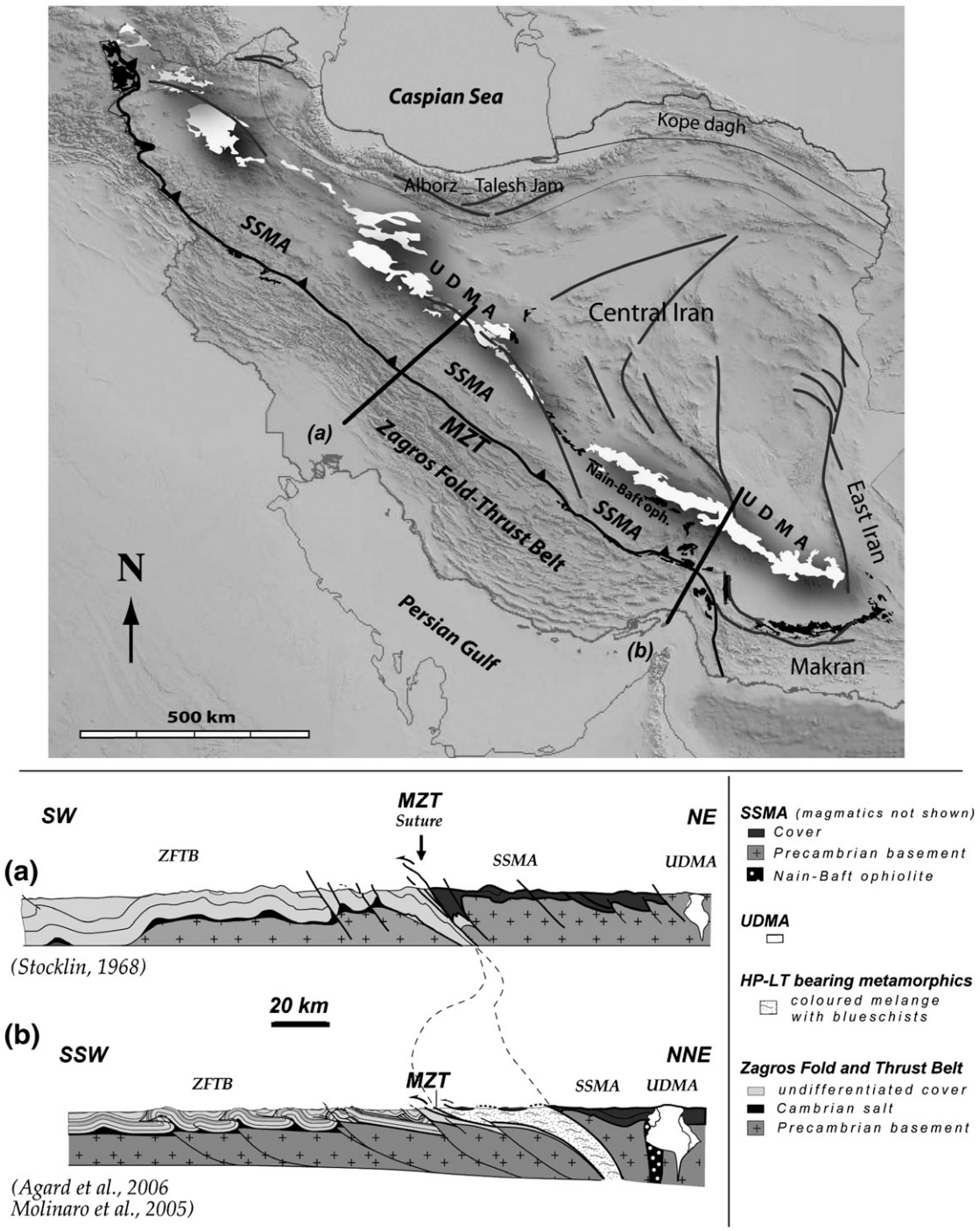

Fig. 1. Simplified structural map of Iran with two cross-sections (a: after Stöcklin, 1968; b: after Agard et al., 2006; Molinaro et al., 2005a,b) outlining the suture zone of Zagros. MZT: Main Zagros thrust; SSMA: Sanandaj–Sirjan magmatic arc; UDMA: Urumieh–Dokhtar magmatic arc. Note that Nain–Baft ophiolites and high-pressure low-temperature metamorphic rocks are only found in the southern Zagros.

(2) The geochemical nature and significance of the recent, Upper Miocene to Plio-Quaternary magmatic activity postdating the onset of collision (c. 25 Ma; Agard et al., 2005).

This paper presents petrological, major and trace element geochemical data from a reconnaissance study of the Sanandaj–Sirjan and Urumieh–Dokhtar magmatic arcs in an attempt to answer these questions and help understand the convergence history across Zagros. As part of this study we report the first occurrence of adakites in the central Zagros and discuss their geodynamic significance.

2. Geological setting and magmatic record of convergence

The protracted convergence history between Arabia and Eurasia (c. >150–0 Ma) comprised a long-lasting period of subduction followed by collision during the Tertiary. The suture zone between the two plates