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Evidence for Paleocene–Eocene evolution of the foot of the Eurasian margin (Kermanshah ophiolite, SW Iran) from back-arc to arc: Implications for regional geodynamics and obduction

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ABSTRACT

The nature and significance of the Kermanshah ophiolite (Zagros Mountains, Iran), traditionally identified as one of the remnants of the Peri-Arabic ophiolite system obducted onto Arabia in the Late Cretaceous, is reinvestigated in this study. We assess the geochemistry of magmatic rocks from two distinct areas: the Kamyaran Paleocene–Eocene arc and the so-called Harsin–Sahneh ophiolite complex. Volcanic rocks associated with Triassic to Liassic sediments display a clear alkali signature, whereas the Paleocene volcanic rocks show a geochemical signature similar to that of tholeiitic back-arc basin basalts. The presumed ophiolitic gabbros of the Harsin–Sahneh complex and some of the associated dykes that intrude harzburgites or gabbros also have a back-arc basin signature. Eocene volcanics, gabbros and dykes intruding the harzburgites display clear low to medium-K calc-alkaline signatures with variable negative Nb, Ta, and Ti and positive Sr, Ba, Th, and U anomalies. Field relationships and geochemical evidence indicate that the Eocene magmatic rocks were intruded into a mantle substratum close to the ocean–continent transition. The geochemistry of magmatic rocks from Paleocene to Eocene suggests that an Eocene arc was constructed in a Paleocene back-arc basin along the Eurasian continental margin. In the Kermanshah region this magmatic activity, which extended further to the northwest into Turkey, coincided with a marked slowing down of the convergence of Arabia with Eurasia. Furthermore, it occurred after the Mesozoic Sanandaj–Sirjan magmatism had ceased but before the development of the Tertiary Urumieh–Dokhtar magmatic arc. We tentatively relate this transient magmatic activity to a slab retreat and a back-arc extension at the Eurasian continental margin.

1. Introduction

The geodynamic evolution of the Tethyan realm is dominated by the existence of long-lived, active subduction zones to the north, beneath Eurasia, resulting in the detachment and northward migration of continental fragments from the Gondwana (Agard et al., 2011; Dercourt et al., 1986; Guillot et al., 2003; Ricou, 1994; Sengor et al., 1988; Stampfli and Borel, 2002). An example of one of these continental fragments is the Central Iranian block, which collided with Eurasia in the Lower to Middle Triassic (Saidi et al., 1997; Sengor, 1990; Stampfli and Borel, 2002). Oceanic subduction beneath the active margin of Central Iran continued from the Upper Triassic to the Oligocene until the Tertiary collision of Arabia with Eurasia. Evidence of this active subduction is preserved as magmatic arcs within the overriding plate, *i.e.*, the Sanandaj–Sirjan arc formed in the Mesozoic and the Urumieh–Dokhtar arc in the Tertiary (Omrani et al., 2008). These remnant arcs are found along a suture zone running along the present-day Main Zagros Thrust (MZT; *e.g.*, Agard et al., 2005 and references therein).

This protracted convergence was, however, affected by a significant obduction event across the whole Neotethys, from Turkey to the Himalayas (Coleman, 1971; Ricou, 1971), which was coeval with major geodynamic changes (Agard et al., 2006; Monié and Agard, 2009). Extensive ophiolitic thrust nappes were obducted onto the Arabian platform from Oman to Turkey (Fig. 1) in the Campanian–Maastrichtian, following the inception of oceanic detachment at ~100–95 Ma (Agard et al., 2007; Coleman, 1981; Hacker, 1994; Thuizat et al., 1981; Whitechurch et al., 1984). Irrespective of the internal structure of the ophiolites, the organisation of the ophiolite-bearing nappe pile, thrust onto the Gondwanian margin is almost identical to that of the Arabian

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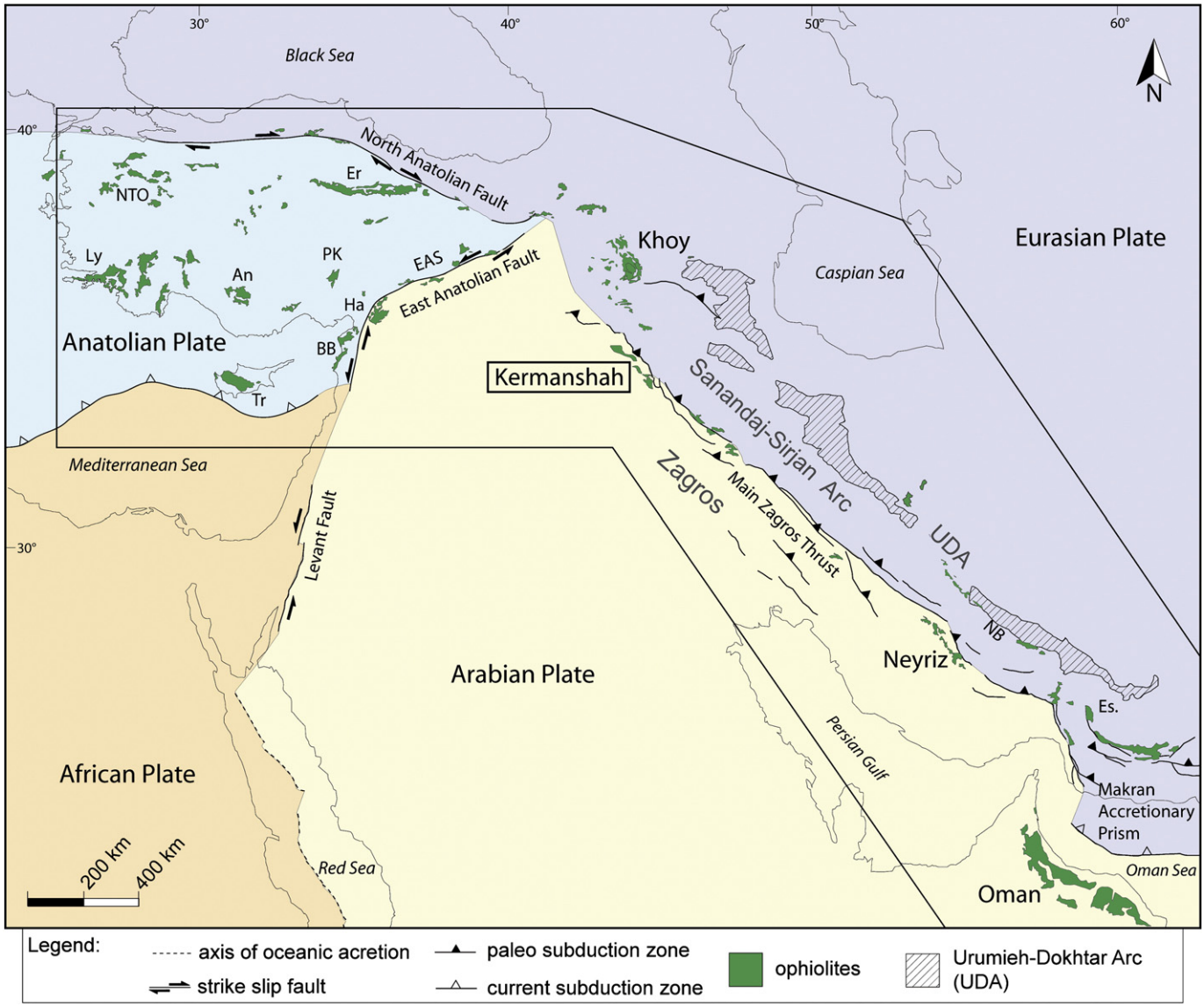

Fig. 1. Simplified tectonic map showing the Eurasian, African and Arabian Plates, the major continental sutures and subduction zones (represented, respectively, with black and white triangles), and allochtonous regions containing ophiolites (green). NTO: Northern Tauric ophiolites; Ly: Lycian ophiolite; An: Antalya ophiolite; Tr: Troodos ophiolite; Me: Mersin ophiolite; PK: Pozanti–Karsanti ophiolite; Er: Erzincan ophiolite; ETO: Eastern Tauric ophiolites; Ha: Hatay ophiolite; BB: Baër–Bassit ophiolite; NB: Nain–Baft ophiolite; Es: Esfandegheh ophiolite.

plate (Ricou, 1971). Within the nappes the bottom of the pile consists of radiolarian-bearing and continental slope sediments from a basin at the foot of the deepest part of the continental margin. These radiolarian-bearing nappes are often overlain by exotic blocks composed mainly of volcanic rocks and sedimentary reef formations of Triassic age, representing offshore seamounts from the most distal part of the southern margin of the Tethys. Ophiolitic nappes, often underlain by metamorphic soles, overlie this structural pile. These ophiolites were all thrust onto the Arabian platform over a detrital flysch basin containing blocks sheared off the advancing nappes.

In contrast to the Oman ophiolite, however, both the Neyriz and Kermanshah ophiolites, located in Iran along the MZT (Fig. 1) are affected by collision and differ markedly from the classic ophiolite sequence recognised in Oman. In the Kermanshah (NW Zagros) ophiolite, Braud (1970, 1987) identified two distinct components, an obduction-related part and a Tertiary arc (Harsin and Kamyaran, respectively). Ghazi and Hassanipak (1999) later suggested that these are both components of the Kermanshah ophiolite. The Neyriz ophiolite (SE zagros), which is intimately associated with huge pieces of marble and contains only a limited amount of oceanic crust (Hall, 1981; Jannessary, 2003; Ricou, 1976), was interpreted to have formed in an ocean–continent transition zone of the Gondwanian margin (Jannessary, 2003).

This paper focuses on the petrology and geochemistry of the Kermanshah ophiolite as one important key element of the Peri-Arabic ophiolite system between Oman and Turkey. Interpretation of the different magmatic systems emplaced through time in this composite so-called ophiolite, is tentatively interpreted in terms of kinematic changes during Tethyan convergence.

2. Geological setting

2.1. Zagros convergence and ophiolite remnants in the crush zone

The geodynamic context of the Zagros orogeny has been investigated by a number of workers (Agard et al., 2005, 2011 and references therein; Hatzfeld et al., 2003; Hessami et al., 2001; Lacombe et al., 2007), and only