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Peridotites from the Khoy Ophiolitic Complex, NW Iran: Evidence of mantle dynamics in a supra-subduction-zone context

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A B S T R A C T

The Khoy Ophiolitic Complex as a part of the Tethyan ophiolites is exposed in the northwestern part of the Iranian-Azerbaijan province, extending to the Anatolian ophiolites in southeastern Turkey. Petrography, geochemistry and microstructural studies of the residual mantle sequence in the Khoy Ophiolitic Complex provide important information about the degree of partial melting and deformation in the oceanic mantle lithosphere. Ultramafic tectonites dominantly composed of lherzolite and clinopyroxene-bearing harzburgite (TiO_2 = 0.012–0.024 wt.%; Al_2O_3 = 1.36–1.81 wt.%). Chondrite-normalized rare-earth-element patterns are characteristically U-shaped. These peridotites can be divided into two types: (1) type 1 peridotites with Al-rich spinels (Cr number of 0.16–0.26, and Mg number of 0.64–0.76), resembling the fertile abyssal peridotites, supposed to have originated as the residue from <15% partial melting and mid-ocean ridge (MORB) magma extraction; (2) type 2 peridotites, representing characteristics of the depleted abyssal or supra-subduction-zone peridotites, with Cr-rich spinels (Cr number of 0.31–0.60 and Mg number of 0.51–0.72). This type of peridotite has undergone >20% partial melting, followed by segregation of basaltic magmas. Microstructural fabrics of olivine grains in peridotites highlight a sequence of dislocation creep on the (0 1 0) [1 0 0] slip system, plus subsidiary slip along the (0 0 1) [1 0 0] slip system. These systems, as well as coarse and fine-grained porphyroclastic textures, indicate deformation at high temperatures of ~1000–1250 °C. The observed subsidiary (0 0 1) [1 0 0] slip system is considered to have been triggered by elevated H_2O activity, and that deformation phases took place in a wet subduction-related environment. The geochemical and microstructural data suggest that the mantle sequence of the Khoy Ophiolitic Complex is consistent with a supra-subduction-zone environment in relation to a slow-spreading back-arc basin.

1. Introduction

The Tethyan ophiolites in the Alpine-Himalayan orogenic system are exposed along curvilinear suture zones, bounding a series of continental fragments of Gondwana. The geochemical signature of these Tethyan ophiolites changes from MORB-like in the Alps-Apennines in the western Mediterranean to supra-subduction-zone ophiolites in Cyprus, Turkey, Iran and Tibet in the east (Dilek et al., 2008).

Iranian ophiolites have long been the subject of research, because they represent important elements for reconstruction of the geodynamic evolution of the Tethyan ophiolite belt. The tectonic history of Iran began with detachment of the Mega-Lhasa block, including the Central Iranian block, from Gondwana during Permian to Triassic time (Ricou, 1994; Sengor and Natal'in, 1996). This block traveled to the north, pulled by the subduction of the Paleo-Tethys Ocean under the Eurasian plate, and pushed by the creation to the south of the Neo-Tethyan oceanic lithosphere. The collision of the Central Iranian block with the Eurasian block took place in Middle Triassic time during the early Cimmerian orogenic phase. As soon as the continental collision between the Mega-Lhasa block and Eurasia had been accomplished, the subduction of the Neo-Tethys began south of the Central Iranian block in Late Triassic to Early Jurassic time.

The Khoy Ophiolitic Complex, as a part of the Iranian Mesozoic ophiolites, is at the northwestern corner of the Iranian-Azerbaijan province, extending to the southeastern ophiolites of Turkey (Fig. 1).

The existence of two ophiolitic complexes of different ages has been documented in the Khoy area on the basis of isotopic ^{40}K–^{40}Ar dating and geochemical signatures (Khalatbari jafari et al., 2003). The first, the Late Cretaceous ophiolitic complex, is known as the *Western Khoy Ophiolitic Complex*, whereas the second, the Early

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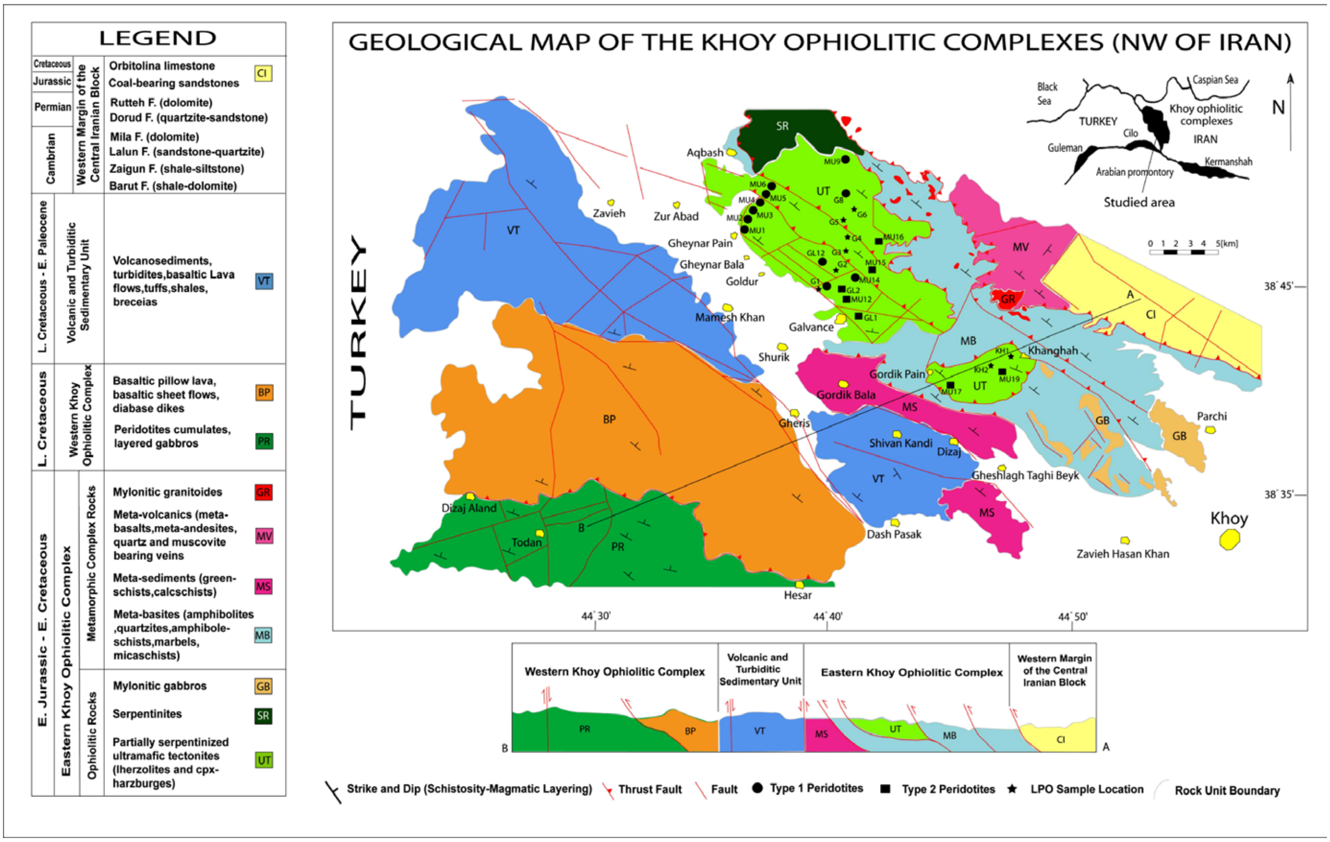

Fig. 1. Simplified geological overview map of the Khoy area, northwestern Iran, showing distribution of the ophiolitic complexes. Modified after Khalatbari Jafari et al. (2004).

Jurassic to Early Cretaceous meta-ophiolitic complex, is defined as the *Eastern Khoy Ophiolitic Complex* (Fig. 1).

A comparison between the Eastern Khoy Ophiolitic Complex and the other Middle Eastern and Asian supra-subduction-zone ophiolites (e.g. Cyprus, Turkey, Iran, Oman, Pakistan and Tibet) reveals geological evidence that suggests a tectonic link among them (Lensch et al., 1977; Pearce, 1980; Alabaster et al., 1982; Pearce et al., 1984; Lippard et al., 1986; Robinson and Malpas, 1990; Siddiqui et al., 1996; Dilek et al., 1999; Aitchison et al., 2000; Batanova and Sobolev, 2000; Robertson, 2000; Sachan, 2001; Ishikawa et al., 2002; McDermid et al., 2002; Hebert et al., 2003; Malpas et al., 2003; Manava et al., 2004; Azizi et al., 2006; Parlak et al., 2006; Tamura and Arai, 2006; Khan et al., 2007).

Various interpretations have been suggested for the evolution of the Khoy ophiolitic complexes. Hassanipak and Ghazi (2000), on the basis of the geochemistry of the basaltic sequence (MORB type), maintained that the Khoy ophiolites were generated along a mid-oceanic ridge. Khalatbari Jafari et al. (2004) documented that the Eastern Khoy Ophiolitic Complex was in fact a metamorphosed subduction complex progressively thickened throughout the trench. This metamorphic complex is composed essentially of amphibolites and slices of oceanic lithosphere of an Early to Late Jurassic age. Azizi et al. (2006), on the basis of geochemistry and petrogenesis of the metamorphic rocks, inferred that the Khoy ophiolites originated in an oceanic back-arc basin. This back-arc basin then was obducted over the island arc tholeiitic and calc-alkaline rocks of the adjacent arc system during the Late Cretaceous. However, the critical materials that reflect the supra-subduction-zone setting have not been discovered in the mantle sequence, and therefore detailed petrological studies of the peridotites are necessary.

Peridotites from the supra-subduction-zone environments can provide important information on melt generation and melt-mantle interaction above the subduction zones, contributing to our understanding of the original tectonic setting of ophiolite complexes, and helping our understanding of crustal accretion in the arc-basin systems (Pearce et al., 2000).

For the first time we describe in detail the petrography, geochemistry and microstructure of the upper mantle peridotites from the Eastern Khoy ophiolitic complex. Thus the aims of the present paper are: (1) to review the geochemical and petrological characteristics of the peridotites in the Eastern Khoy Ophiolitic Complex, (2) to establish the deformation mechanisms of ultramafic rocks on the basis of textural and petrofabric data and (3) to reconstruct a geodynamic environment for the evolution of the Eastern Khoy Ophiolitic Complex.

2. Geological setting and field observations

The Khoy ophiolites were studied by Ghorashi and Arshadi (1978) and Radfar et al. (1993) during geological mapping and stratigraphic investigations. Detailed lithologic, petrographic and geochemical studies, as well as reconstructions of eruptive environments of the lavas in the Khoy ophiolites, were conducted recently by Khalatbari Jafari et al. (2004).

The area under investigation is occupied by the western continental margin of the Central Iranian block, the Eastern Khoy Ophiolitic Complex, a volcanic-turbiditic sedimentary unit, and the Western Khoy Ophiolitic Complex (Fig. 1).

The western margin of the Central Iranian block is composed of basal Precambrian to Cambrian strata, disconformably overlain by Permian sediments. These Paleozoic strata are tectonically overlain by Jurassic and Early Cretaceous sediments, and finally by Miocene to Pliocene–Quaternary deposits (Khalatbari Jafari et al., 2003). On