Chemie der Erde xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Chemie der Erde

journal homepage: www.elsevier.de/chemer

Geochemistry and petrogensis of the Eocene back arc mafic rocks in the Zagros suture zone, northern Noorabad, western Iran

Fatemeh Nouri[a,*], Yoshihiro Asahara[b], Hossein Azizi[c], Koshi Yamamoto[b], Motohiro Tsuboi[d]

[a] Geology Department, Faculty of Basic Sciences, Tarbiat Modares University, Tehran, Iran
[b] Department of Earth and Environmental Sciences, Graduate School of Environmental Studies, Nagoya University, Nagoya 464-8601, Japan
[c] Mining Department, Faculty of Engineering, University of Kurdistan, Sanandaj, Iran
[d] Department of Applied Chemistry for Environment, School of Science and Technology, Kwansei Gakuin University, Sanda 669-1337, Japan

ARTICLE INFO

Article history:
Received 5 February 2017
Received in revised form 6 June 2017
Accepted 12 June 2017

Keywords:
Zagros orogeny
Neo-Tethys
Extensional basin
Metasomatized mantle
Sr-Nd isotope ratios

ABSTRACT

The northern Noorabad area in western Iran contains several gabbro and basalt bodies which were emplaced along the Zagros suture zone. The basalts show pillow and flow structures with amygdaloidal textures, and the gabbroic rocks show massive and foliated structures with coarse to fine-grained textures. The SiO_2 contents of the gabbros and basalts are similar and range from 46.1–51.0 wt.%, and the Al_2O_3 contents vary from 12.3–18.8 wt.%, with TiO_2 contents of 0.4–3.0 wt.%. The Nb concentrations of some gabbros and basalts are high and can be classified as Nb-enriched arc basalts. The positive $\varepsilon Nd(t)$ values (+3.7 to +9.8) and low $^{87}Sr/^{86}Sr_{(initial)}$ ratios (0.7031–0.7071) of both bodies strongly indicate a depleted mantle source and indicate that the rocks were formed by partial melting of a depleted lithospheric mantle and interaction with slab fluids/melts. The chemical composition of trace elements, REE pattern and initial $^{87}Sr/^{86}Sr$-$^{143}Nd/^{144}Nd$ ratios show that the rocks have affinities to tholeiitic magmatic series and suggest an extensional tectonic regime over the subduction zone for the evolution of these rocks. We propose an extensional tectonic regime due to the upwelling of metasomatized mantle after the late Cretaceous collision in the Harsin-Noorabad area. These rocks can be also considered as Eocene back arc magmatic activity along the Zagros suture zone in this area.

1. Introduction

The Iranian plateau is a tectonically active region within the Alpine-Himalayan orogenic belt. It contains a number of continental fragments that have been welded together along a suture zone of oceanic character from the Early Paleozoic to Late Tertiary. Stöcklin and Nabavi (1972) divided the Iranian plateau into eight segments (Fig. 1) including Zagros fold-thrust belt, Sanandaj-Sirjan, Urmia-Dokhtar magmatic arc, central Iran, Alborz, Kopeh Dagh and eastern Iran. Amongst the microcontinents, some oceanic crust and island arc such as Proto-Tethys, Paleo-Tethys and Neo-Tethys are preserved. The main remnant of the Neo-Tethys oceanic crust is Zagros ophiolite that is developed in the Zagros suture zone in the west of Iran and southern part of Turkey (Şengör, 1987; Alavi, 1994; Azizi and Moinevaziri, 2009; Paul et al., 2010; Wrobel Daveau et al., 2010; Azizi et al., 2011a,b; Azizi et al., 2013; Saccani et al., 2013; Whitechurch et al., 2013; Shafaii Moghadam and Stern, 2015). In the last three decades, many researchers have been interested in the Zagros suture zone (Buday, 1980; Delaloye and Desmons, 1980; Desmons and Beccaluva, 1983; Ghazi and Hassanipak, 1999; Alavi, 2004; Shafaii Moghadam et al., 2009; Allahyari et al., 2010; Shafaii Moghadam and Stern, 2011; Ali et al., 2013; Ali and Aswad, 2013; Saccani et al., 2013; Whitechurch et al., 2013; Azizi et al., 2013; Allahyari et al., 2014; Aswad et al., 2014; Saccani et al., 2014; Ao et al., 2016; Shafaii Moghadam and Stern, 2015; Nouri et al., 2016) and have suggested various tectonic regimes for some parts on the ophiolites in the Zagros orogeny such as supra-subduction origin, plume, MORB sources, oceanic island basalt (OIB) and island arc to back arc tectonic settings. Although many studies have examined the magmatic activity of the Zagros orogenic belt in western Iran, no detailed information has been reported on the Harsin dismembered ophiolite in the Zagros Mountains prior and during the collision of the Arabian and Iranian Plates.

In the Zagros suture zone, the Biston-Avoraman block (BAVB), which is similar to the Arabian plate and probably contains Precambrian basement (Şengör, 1987; Jassim and Goff, 2006; Okay et al.,

* Corresponding author.
E-mail address: F.nourisandiani@gmail.com (F. Nouri).

http://dx.doi.org/10.1016/j.chemer.2017.06.002
0009-2819/

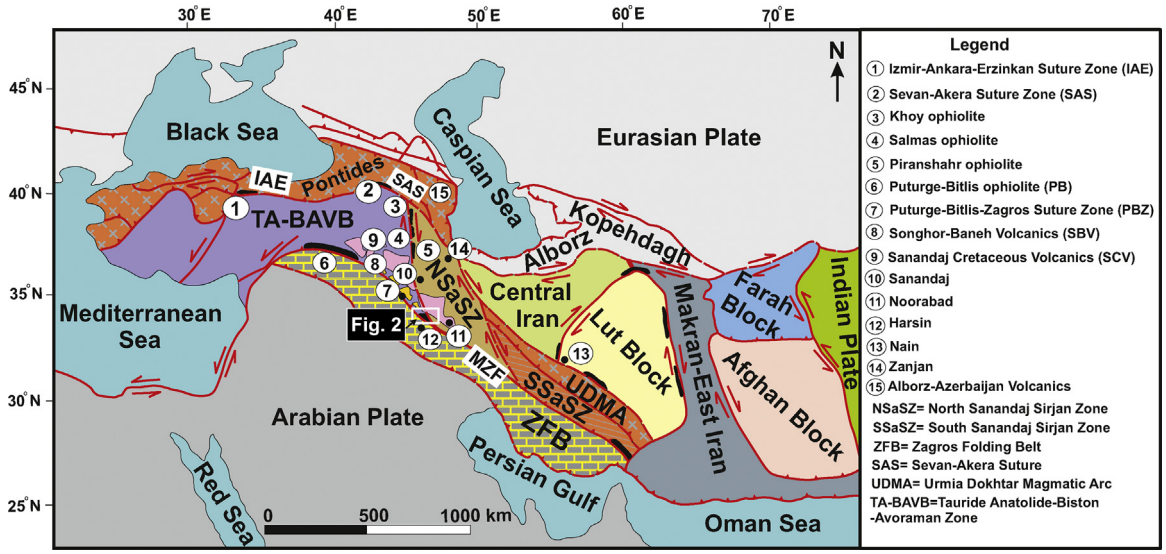

Fig. 1. Simplified geological map of the eastern Turkey and Iranian Plateau (modified from Nouri et al., 2016).

2008; Azizi et al., 2013), is squeezed between the Sanandaj-Sirjan zone in the east (Azizi and Moinevaziri, 2009; Azizi et al., 2011a,b; Azizi et al., 2015a,b; Azizi et al., 2016) and Arabian Plate in the west (Fig. 1). The BAVB now underlies a tall cliff in the Kermanshah area referred to as Biston Mountains. Several researchers concluded that thick limestone sequences were deposited in Arabian passive margin on an epi-continental basement (Ricou et al., 1977; Braud, 1978; Kazmin et al., 1986; Stampfli et al., 1991; Pillevuit et al., 1997; Shahidi and Nazari, 1997; Karimi Bavandpur and Hajihoseini, 1999; Mohajjel et al., 2003; Vergés et al., 2011). Jassim and Goff (2006) concluded that the BAVB, TA (Tauride Anatolide) and Hawasina blocks were a fragment of Arabian Plate in the Neo-Tethys Ocean. In addition, Wrobel Daveau et al. (2010) regarded the BAVB as fragment of the Arabian Plate that was squeezed between the Iranian and Arabian Plates and suggested that an upwelling mantle plume had a major role in separating the BAVB from the Arabian Plate. The same scenario was suggested by Azizi et al. (2013) and Nouri et al. (2016). Detailed discussion of the geodynamic of the BAVB by Jassim and Goff (2006) was based on the assumption that the BAVB underwent the same evolution as the TA block in southern Turkey and the Hawasina block in Oman. Given this situation, correlation between the TA block and the BAVB will clear up the relationships among the BAVB, TA block and Arabian Plate.

In addition, the TA block initially belonged to the Arabian Plate but separated from this continent during the Triassic Era (Okay, 2008). Monod et al. (2003) reported Ordovician glacial deposits in the TA block overlain by a huge volume of Mesozoic carbonate rocks (Okay, 2008). The radiometric dating of the TA basement yielded an age of 550 Ma (Okay et al., 2002). To the south, in the Biston area along the Iran-Iraq border, the basement is not exposed and is perhaps hidden under a large volume of Triassic-Jurassic carbonate deposits. Good correlation of Triassic and younger sedimentary rocks in the Biston area with those in the TA block lead us to believe that this zone is a segment of the Arabian Plate even without a report of Precambrian basement similar to that of the TA block in southern Turkey.

The Zagros ophiolite in the west of Iran and southern Turkey has been separated by the Tauride Anatolide – Biston Avoraman microcontinental block (Fig. 1). The Izmir-Ankara-Erzinkan suture zone (IAE) (Okay and Tüysüz, 1999) or the Northern Neo-Tethys remnant (Şengör and Yilmaz, 1981) is a junction between the Eurasian Plate and Tauride Anatolide block (Fig. 1). The south suture zone, which is situated between the Arabian Plate in the south and the Tauride Anatolide block in the north, is known as the Pütürge–Bitlis–Zagros (PBZ) suture zone (Okay and Tüysüz, 1999; Yilmaz and Özel, 2008). Recent reports by Azizi et al. (2013) and Nouri et al. (2016) have designated two parallel ophiolite zones in the Kermanshah–Harsin area which match with the IAE and PBZ suture zones in the northern and southern Tauride Anatolide block in Turkey, respectively (Fig. 1).

In this study, we report new geochemical and isotopic data from the Harsin-Noorabad mafic bodies, which have been considered to be part of the Cretaceous ophiolite before this study (Ghazi and Hassanipak, 1999; Allahyari et al., 2012; Saccani et al., 2013; Kiani et al., 2015; Tahmasbi et al., 2016). The petrogenesis and tectonic setting of these rocks are poorly constrained because geochemical and isotopic data remain scarce and only regional studies have been carried out on the area under investigation (Shahidi and Nazari, 1997). We discuss the significance and implication of these data in describing the heterogeneous lithology and geological makeup of the Neo-Tethys oceanic crust that is exposed in the Zagros suture zone. In this paper, we focus on the earlier suture zone and development of back arc magmatism in the Eocene after Late Cretaceous collision between Arabian Plate and BAVB block. Then, we show the connection of these rocks to the extensional tectonic regime over the subduction such as a back arc basin tectonic regime.

2. Regional geology and field relations

The Harsin-Noorabad area is situated in western Iran along the Zagros suture zone. The oldest rocks are Biston sedimentary rocks (Fig. 2) which were epi-continental facies (Shahidi and Nazari, 1997) and were thrusted over Cretaceous or younger unites.

Cretaceous ophiolite mélange is a main component of the igneous bodies and includes ultramafic, gabbro and rarely basaltic rocks (Fig. 2). Clear separation of the rocks is difficult because they are deformed and mixed with sediments. In most part, dynamic deformations have affected the entire ophiolite complex which occur as irregular blocks or bands within Eocene and Miocene unites. The ophiolite complex occurs as tectonic slices in fault contact with Eocene complex and thrusted over Quaternary deposit due to young activities of Zagros fault (Fig. 2). Allahyari et al. (2010) suggested that these rocks were formed in the middle oceanic ridge with tholeiitic composition.

The Eocene mafic-sedimentary complex (Fig. 2) is the focus of this paper and is mostly different from Cretaceous ophiolite.

Please cite this article in press as: Nouri, F., et al., Geochemistry and petrogensis of the Eocene back arc mafic rocks in the Zagros suture zone, northern Noorabad, western Iran. Chemie Erde - Geochemistry (2017), http://dx.doi.org/10.1016/j.chemer.2017.06.002