Petrochemical characteristics of Neogene and Quaternary alkali olivine basalts from the western margin of the Lut Block, Eastern Iran

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Abstract

The Nayband strike-slip fault forms the western margin of the micro-continental Lut block in Eastern Iran. Neogene and Quaternary mafic volcanic rocks collected near Tabas, along the northern part of the fault (NNF), and further to the south, along the middle part of the fault (MNF), are within-plate sodic-series alkali olivine basalts with high TiO_2 and up to >16% normative nepheline. Their high MgO, Ni and Cr contents indicate that they crystallized from relatively primitive magmas, and La/Nb (0.5-0.65) and Nb/U (44-120) ratios, suggest that crustal contamination was not significant for these basalts. Their low La/Nb and Ba/Nb ratios are similar to oceanic island basalts (OIB) and unlike convergent plate boundary arc basalts (IAB). Normalized trace element patterns for these samples show enrichment in LREE relative to HREE. These alkali olivine basalts show limited variation in Sr, Nd and Pb isotopic values which all plot in the range of OIB, and overlap the EM-2 field. The data may be interpreted as indicating the participation of upwelling mantle asthenosphere and the deeper continental mantle lithosphere in the generation of these basalts, which formed by generally low, but variable degrees of partial melting. The small volume of melts that formed these basalts rose to the surface along the very deep Nayband strike-slip fault without significant interaction with the continental crust.

1. Introduction

The Iranian plateau occurs within a part of the active Alpine-Himalayan orogenic belt. This plateau includes the Lut block micro-plate, an extremely arid desert region in eastern Iran. The Lut block is largely covered by Neogene volcanic rocks. The focus of this paper is primitive mantle-derived Neogene/Quaternary alkali olivine basalts that have erupted along the Nayband fault along the western margin of the Lut block (Fig.1)

2. Results and discussion

The Neogene/Quaternary basalts erupted along the Nayband strike-slip fault are composed of dense black blocky masses. These basalts have mainly porphyritic texture with intergranular, subophitic and intersertal groundmass. The phenocrysts in samples from the northern part of

the Nayband fault (NNF) comprise 25-30 volume % of the rock, and include olivine (0.5-1.5mm in diameter) ± clinopyroxene (0.8-1 mm in diameter) ± plagioclase (1-1.5 mm in diameter). The phenocrysts of samples from middle part of the Nayband fault (MNF) comprise less than 20 volume % of the rock and include mainly of olivine (< 0.5 mm) and clinopyroxene (0.5-2 mm). Compositions of olivine phenocrysts from NNF samples range between Fo_{68} to Fo_{84} and from MNF samples range from Fo_{75} to Fo_{81}.

According to silica versus total alkali diagram (Fig. 2), the chemical composition of these rocks are mainly hawaiites, but also include basalts, trachyandesite and tephrite basanite. All samples plot in the alkali field. K_2O versus Na_2O (wt. %) and MgO versus TiO_2 diagrams show that these alkali rocks belong to Na-Series and high-Ti or very close to high-Ti alkali basalts. These samples are enriched in LREE relative to HREE, a feature typical of alkalic intraplate basalts (Fig. 3). Values of $(La/Yb)_N$ vary from 6.3–11.6 for northern part of Nayband fault and from 17.9- 20.4 for middle part of Nayband fault. Other characteristics, such as low La/Nb (0.5-0.65) and Ba/Nb ratios (6-13) are similar to oceanic island basalts (OIB) and unlike convergent plate boundary arc basalts.

The $^{87}Sr/^{86}Sr$ ratio of one MNF samples is 0.704592 and for NNF rocks this ratio ranges from 0.705312 to 0.705555 (Fig. 4). Hashemi et al. (2008) reported that the Sr isotopic composition of four Quaternary basalt and andesitic basalt from northern part of the Nayband fault (NNF) ranged from 0.705291 to 0.705777, and the newly determined values are within this range. The Nd isotopic composition of these samples ranges from ϵ_{Nd} = +0.94 to +1.76, similar to four samples analyzed by Hashemi et al. (2008), which range from +0.91 to +1.34. All samples are plotted on the right corner of the world sodic continental basalts field and also in the left side of the EM-2 field (Fig. 4). The Pb isotopic composition of these alkali basalts plotted above the Northern Hemispheric Reference Line (NHRL), in the EM- 2 and OIBs fields.

3. Conclusion

Based on the major and trace element compositions, the western Lut Neogene/Quaternary basalts are classified as within-plate sodic alkaline basalts. These alkali olivine basalts erupted along both the north and middle parts of the Nayband fault have been formed by generally low but variable degrees of partial melting of similar mantle source. These low-volumes, low-degree melts rose to the surface along the very deep Nayband strike-slip fault, which forms the western margin of the Lut block, without significant interaction with the continental crust. Trace elements and isotopic composition of theses lavas have been interpreted as indicating the participation of mantle asthenosphere and the continental mantle lithosphere, modifided by the addition of either subducted or delaminated continental components, in the generation of these magmas.

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Figure captions

Figure 1. Location of the Lut block and the study area along the Nayband fault. Distribution of Quaternary basalts are shown with red color, and sample locations from the northern (NNF) and middle (MNF) part of the fault are shown in green circles. Radiogenic age determination from NNF basalts after [1] and from MNF basalts after [2] and [3].

Figure 2. Geochemical division of rocks based on Na_2O+K_2O (wt.%) against SiO_2 (wt.%), from [4]. The dividing line between subalkaline and alkaline field is from [5]. Samples of previous study for NNF are taken from [6] and samples of previous study for MNF from [3] and [7].

Figure 3. Chondrite normalized multi-element for western Lut Quaternary basalts and also for average OIB and MORB, as shown in this figure, these lava show strong OIB-like characteristics. Normalization values chondrite from [8]. Average OIB from [9], MORB (N-type) from [10] and [9], average Makran arc from [11].

Figure 4. $^{143}Nd/ ^{144}Nd$ ratio versus $^{87}Sr/ ^{86}Sr$ comparing western Lut block samples (NNF and MNF). Base diagram from [12] and references therein, Sample are shown as open space triangular are taken from [6]. NW Iran/East Turkey boundary from [13], Damavand from [14], Western Anatolia from [15], Eastern Anatolia from [16] and Oman from [17].

Figure 1.

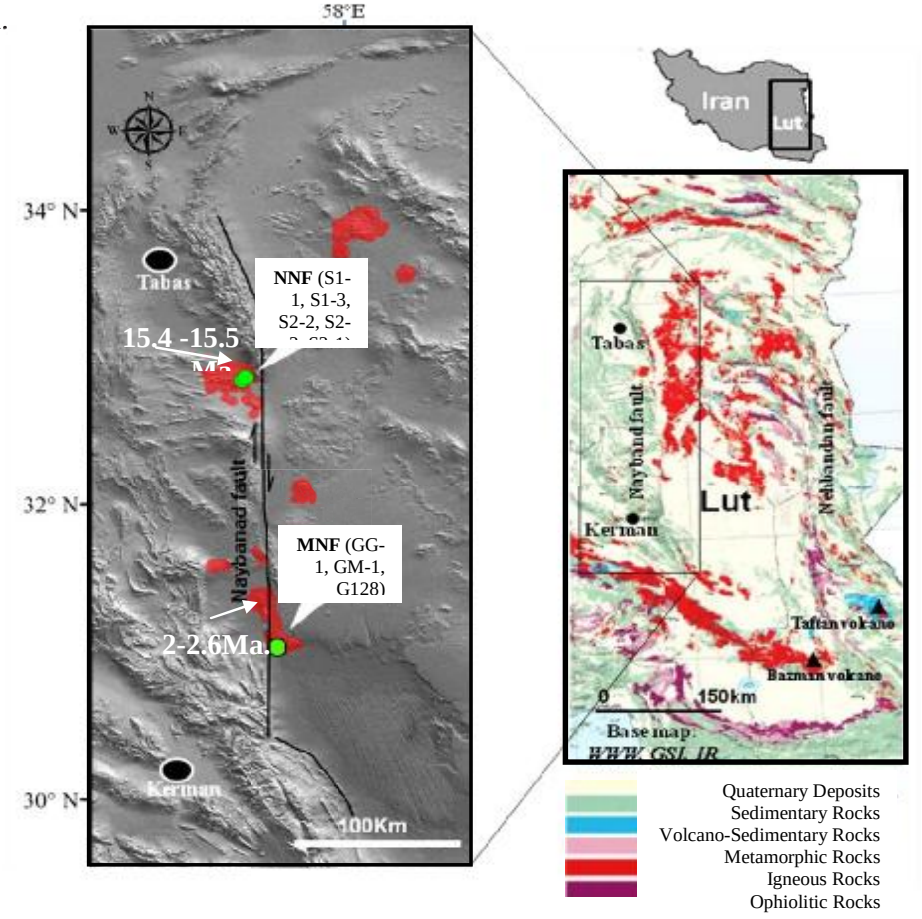
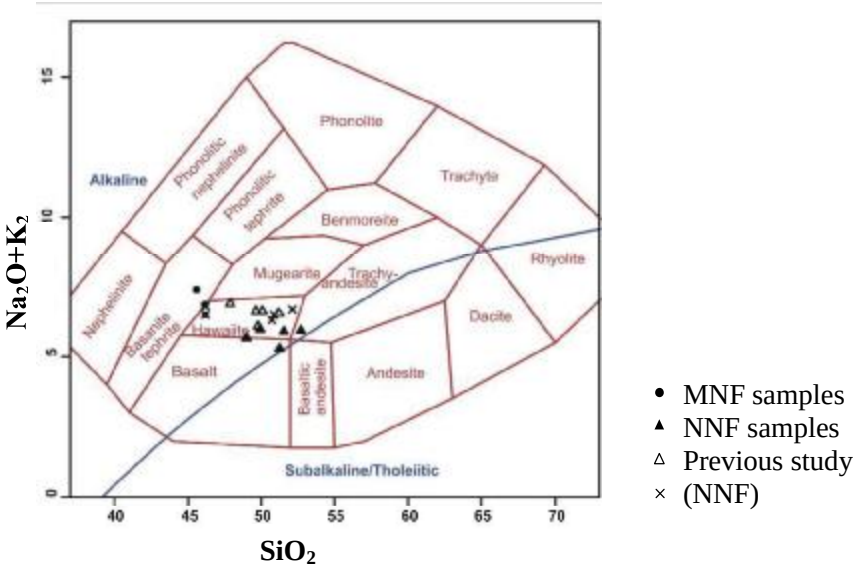


Figure 2.



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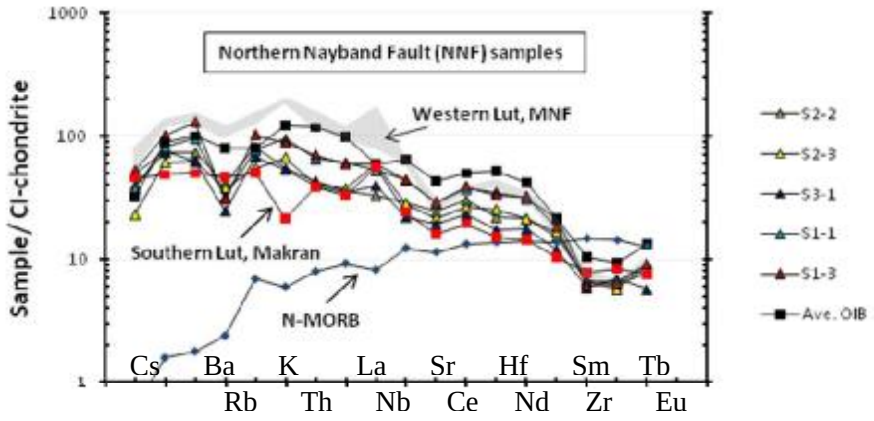

Figure 4.