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Petrography, mineral chemistry and geochemistry of post-ophiolitic volcanic rocks in the Ratouk area (south of Gazik, east of Iran)

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Introduction

Basaltic volcanoes are one of the volcanisms that have occurred in different parts of the world. The study of these lavas is important for petrologists, because they are seen in different tectonic settings and therefore diverse mechanisms affect their formation (Chen et al., 2007). Young volcanic rocks such as Quaternary basalts are one of latest products of magmatism in Iran that are related to deep fractures and active faults in Quaternary (Emami, 2000). The study area is located at 140km east of Birjand at Gazik 1:100000 geological map (Guillou et al., 1981) and have 60° 11' to 60° 15' 27" eastward longitude and 32° 33' 24" to 32° 39' 10" northward latitude. On the basis of structural subdivisions of Iran, this area is located in the northern part of the Sistan suture zone (Tirrul et al., 1983). Because of the importance of basaltic rocks in Sistan suture, this research is done with the aim of investigating the petrography and mineralogy of basaltic lavas, the nature of basaltic and intermediate magmatism and finally determination of tectonomagmatic regime.

Materials and methods

After field studies and sampling, 85 thin sections were prepared and carefully studied. Then ten samples with the lowest alteration were analyzed for major elements by inductively coupled plasma (ICP) technologies and trace elements were analyzed using inductively coupled plasma mass spectrometry (ICP-MS), following a lithium metaborate/tetraborate fusion and nitric acid total digestion at the Acme laboratories, Vancouver, Canada. Electron probe micro analyses of clinopyroxene and olivine were done at the Iranian mineral processing research center (IMPRC) by Cameca SX100 machine. X-ray diffraction analysis of minerals was done at the X-ray laboratory of the University of Birjand.

Results

In 60km south of GaziK at the east of the southern Khorasan province and the northern part of the Sistan suture zone, volcanic rocks with intermediate (Oligomiocene) and basic (Quaternary) compositions outcropped above ophiolitic units. Electron probe micro analyzer (EMPA) data indicated that clinopyroxene in basalt is diopside and olivine from chrysolite type with Mg# around 81-82 percent. The whole rocks geochemical data prove calc-alkaline and alkaline nature for andesites and basalts, respectively. Trace element patterns, especially for andesites show enrichment in Ba, K, Cs, Sr and Th, depletion in P, Nb, Ti and enrichment in LREE relative to HREE. Electron probe micro analyses of clinopyroxene in olivine basalt support alkaline nature and within plate tectonic setting for this rock. Thermobarometry of clinopyroxene in olivine basalt record crystallization conditions about 1200 °C and 6-10kbars.

Discussion

The origin of intraplate volcanism is diverse and not always well understood. Most intraplate volcanos have been attributed to (i) mantle plumes

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and hot spots, (ii) continental rift, (iii) back-arc extension and (iv) lithosphere delamination and thinning (Chen et al., 2007). Although volcanism at intraplate settings is less common than along mid-ocean ridges and subduction zones, it is of significant importance for both preventing geological hazards and understanding mantle geochemistry. It is believed that alkaline oceanic island basalts (OIB) are only derived from the asthenospheric mantle (Alici et al., 2002). However, the intracontinental alkaline magmas can be produced by partial melting of metasomatized mantle enriched in LREE and LILE (Upadhyay et al., 2006).

On the basis of trace element diagrams, Ratouk basaltic rocks placed within plate volcanic zone (WPVZ) and andesitic samples have been located within the active continental margin (ACM).

The studies that took place about young basaltic volcanism (Alishahi, 2012; Mollashahi et al., 2011; Ghasempour et al., 2011; Pang et al., 2012; Walker et al., 2009) have shown that the mechanisms of their occurrence are similar such that all of them have been formed in intraplate extensional environments and active fault zone and originated from enriched mantle or asthenosphere. Lithospheric thickness maps derived from the speed of shear waves show that the lithosphere is thin in east of Iran and volcanic activity has occurred along strike-slip faults (Walker et al., 2009). Therefore, according to other similar basaltic eruptions that have occurred in the Sistan suture zone, we can say that all of them are from the same origin and as a result of deep fractures within continental plates that provide conditions for the eruption of basaltic magma.

Andesitic units in the Ratouk area are located within the active continental margin and show similar characteristics to rocks of the Subduction Zone in terms of composition.

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