INVESTIGATION ON EFFECTS OF CONTAMINATION IN SOUTH AMLASH INTRUSIONS, NORTHERN IRAN

Fatemeh Zaeimnia (1), Ali Kananian (1), Ramin Samadi (2)

(1) Faculty of Geology, College of Science, University of Tehran, Tehran, Iran. fzaeimnia@hotmail.com

(2) School of Geology, Faculty of Science, Azad University, Iran

Abstract

South Amlash gabbroic intrusions in Guilan provenance, which belong to south Caspian Sea ophiolite in north of Iran, mainly consists of layered and isotropic gabbro along with minor cumulative ultramafic rocks. Previous studies, by authors, suggested two different types of gabbros in this area, which are not recognizable by field study and their identification is only possible by the aid of precise microscopic studying as well as chemical analysis. Geochemical data indicates two distinct types of gabbros including sub-alkaline gabbros which are the dominant gabbros and the minor alkaline affinities gabbros. South Amlash sub-alkaline gabbros, are enriched in Th, K, Pb and Sr, but are depleted in Nb, Zr and Ti. These gabbros, by previous studies, represent Island Arc basalt signature and belong to South Caspian Sea Ophiolite complex. Enrichment of LREE with negative anomalies of Nb, Zr, and Ti in company with positive Pb anomalies in the sub alkaline gabbros is generally due to two processes: (1) crustal contamination and (2) partial melting of an enriched mantle source which is metasomatized by slab-derived fluid/melt. Based on Th/Yb ،Ta/Yb ،Nb/U ،Ta/U and Ce/Pb ratios, it seams that the metasomatization of the mantle by the slab-derived fluid is the main explanation for this topic. South Amlash alkaline gabbros croup out diffused bodies within Southern Caspian Sea Ophiolite. These gabbros composed of Plagioclase, Clinopyroxene and Apatite. Prior study by authors, show the alkaline signatures of these rocks and suggesting the origin of intra-plate ocean island type (OIB) for the magma. according to geochemical data, Nb positive anomaly, in spite of positive Pb anomaly, and high ratio Th/Yb and Ta/Yb and different ratios of Ta/U and La/Nb correlated with no crustal contamination in alkaline rocks of south of Amlash. These positive anomaly and high ratios of aforementioned elements attributed to enriched source such as OIB.

Key words: *Gabbro, sub-alkaline, alkaline, contamination, slab fluid, Amlash, Caspian sea, Iran.*

Introduction

The study area is located in the central Alborz range in Northern Iran and is exposed to an area that is located in the Southern Amlash city, in Guilan province, as a part of Gorgan-Rasht tectonic zone. The geology of the area is still poorly known, because of its location in rainy forest and dense topography. Geologically, the region is composed of Quaternary Caspian deposits (on the north) and mainly of Jurassic and Cretaceous volcanic rocks (Anells et al., 1975). Salavati (2000) reported "the Southern Caspian Sea Ophiolite (SCO)" in this region which includes typical ophiolites succession: Cumulate Ultramafic, Isotropic Gabbro, Layered Gabbro, Sheeted Dyke, and Pillow Lava. According to previous studies by authors (e.g., Zaeimnia 2009) the gabbroic rocks minerallogically and geochemically divided in two distinctive groups with two different origins: 1) Sub alkaline types which belong to the ophiolite suite and formed in an island arc region. Note that the layered gabbros and

cumulated ones show almost same geochemical signatures as sub-alkaline gabbros and according to prior studies they have same origin as sub-alkaline gabbros and belongs to ophiolite complex, thus due to shortage of place and complicated discussions, we omitted their conclusions; 2) Alkaline type gabbros outcrops occur along with the crustal part of this ophiolite complex and shows the characteristic of typical oceanic island basalt.
The goal of this research is survey of presence of some incompatible anomalies in both alkaline and sub-alkaline gabbros and investigation of possible involved process.

Discussion

Petrography

South Amlash sub-alkaline gabbros mainly consist of Plagioclase, Clinopyroxene and Olivine. Alkaline gabbros are included Plagioclase, titan-augit (clinopyroxen) and small euhedral apatite needle. No Orthopyroxene was found in both types of gabbros. Texturally, the rocks show medium grained, ophitic to sub-ophitic textures. Both types of gabbros are variably altered: in some samples plagioclase has been partially altered to sericite and the Clinopyroxene is altered to Uralite. Chlorite, epidote and zeolite are secondary phase in these rocks; however, alkaline rocks are fresher than others.

Geochemistry

Some samples were analyzed by ICP-MS at ALS Chemex in Canada. These gabbroic bodies are almost altered in the field. Most of the major oxides are known to be mobile during weathering and hydrothermal alteration. Therefore, the interpretation is based on the relatively immobile elements. In Nb/Y versus Zr/Ti diagram (Winchester and Floyd, 1976) most of them plot in the basaltic field; on the two separated sub alkaline and alkaline boundary (Fig.1). The rare earth element abundances of both types of gabbros show similar characteristics in term of a strong enrichment in LREEs relative to HREEs and almost flat HREEs pattern (Fig. 2a). All alkaline samples display positive Nb, Pb and Ti anomalies in primitive mantle-normalized pattern (Fig. 2b). Although the positive Pb anomaly and LREE enrichment of the south Amlash alkaline gabbros are consistent with crustal contamination, but, their low SiO_2 content (45-47 wt %) and particularly the lack of negative Nb anomaly strongly rule out a significant role of crustal contamination in their petrogenesis, because crustal material have lower Nb than those of mantle (Hoffmann, 1988).
These results are significantly different from those obtained for sub alkaline which is characterized by a negative Nb, Zr and Ti and positive Pb anomaly (Fig. 2c). These characteristics of sub alkaline gabbros generally result from two processes: (1) crustal contamination and (2) partial melting of an enriched mantle source metasomatized by slab-derived fluid. Although the exact recognition between these two processes needs isotopic data, we favor the latter explanation because of the following direct and indirect lines of evidence that argue against significant crustal contamination by whole rock chemistry data.
Th and Ta are two key elements that possess similar abundances in the asthenospheric mantle beneath the mid-ocean ridges (Pearce, 1991) and the ratio of Th/Ta in the MORB is close to unity. In subduction zones Th is more mobile and enriched in the overlying mantle wedge (Xia, et al., 2008), and thus the addition of a subduction-treated siliceous melt component is indicated by high Th/Yb ratio (Pearce and Stern, 2006; Koglin et al., 2009). Crustal

contamination may also increase Th/Yb ratios relative to that of Ta/Yb because of a higher abundance of Th relative to Ta in the crustal rocks (Aldanmaz et al., 2000). The Th/Yb against Ta/Yb plots in Fig. 3a show the MORB-OIB mantle trend for alkaline gabbros that the mantle source had no subduction component and that the resulting magmas was not affected by any significant crustal contamination. High ratios of both Ta/Yb and Th/Yb relative to N-MORB as given by sub alkaline gabbros, indicating either a greater subduction component or a greater crustal assimilation during evolution (Aldanmaz et al., 2000).

La/Nb ratio will separate subduction-modified asthenospheric sources since Nb is variably depleted in subduction-modified mantle and La is an indicator of enrichment processes, either is fluid-dependent via subduction or via asthenospheric metasomatism (Seghedi et al., 2004). Ba is soluble in aqueous slab-derived fluids, thus the Ba/Nb ratio against La/Nb plot is a useful diagram to show the effect of subduction material, therefore, in figure 3b, the alkaline gabbros plotted in OIB field whereas the sub alkaline gabbros follow subduction enrichment trend. Crustal contamination will produce rocks that show positive Nb anomalies and low La/Nb ratio (Yan and Zhao, 2008). The subduction component in the mantle can also be highlighted using the La/Nb vs. La diagram (Fig. 3c). The enriched Asthenospheric sources with subduction component (E) show rather enrichment in compared with the asthenospheric OIB-like ones (B) (Seghedi et al., 2004) and show the Nb depletion as a result of involving of subduction components in mantle source. In fig. 3c, the alkaline rocks plot in OIB field whereas sub alkaline gabbros show a source which was affected by subduction components.

Fig. 5 shows Ti vs. La/Nb and Ti/Hf vs. La/Ta variation diagrams for the Sub alkaline and alkaline gabbros (Temizel and Arslan, 2008). The alkaline gabbros plot close to OIB field and sub alkaline gabbros, as it's expected, follow the trends named Slab Zone Metasomatism (SZM) which show parental magma derived from an enriched source, probably mixing with slab fluids.

Nb/U, Ta/U and Ce/Pb ratios are sensitive indexes for crustal contamination (Hofmann, 1988). The Nb/U, Ta/U and Ce/Pb ratios in south Amlash alkaline rocks are 35-53, 2.9-3.5 and 9.6-14, respectively. These values are lower than those of the crust (Nb/U= 12.1, Ta/U= 1.1 and Ce/Pb= 4.1; Taylor and McLennan, 1995) and are similar to those of the MORB and OIB (Nb/U= 47, Ta/U= 2.7, and Ce/Pb= 25; Hofmann, 1988) and their Sr concentrations (550-1200 ppm) are higher than that of the upper continental crust (350 ppm; Taylor and McLennan, 1995). In addition, the Cr (20-60 ppm) and Ni (8-48 ppm) abundances of the analyzed samples are much lower than those of continental crust (Cr= 185 ppm, Ni= 105 ppm; Taylor and McLennan, 1995). These geochemical signatures of south Amlash alkaline rocks are free of crustal contamination and therefore they can be used to constrain the characteristics of original mantle source and deep chamber process.

Since South Amlash Sub alkaline gabbros have Nb/U= 6-10, Ta/U=0.6-0.4 and Ce/Pb= 0.7-1.2 which are lower than these ratios of crust, it could be a reason to reject the crustal contamination roll in present anomalies.

Conclusion

The south Amlash intrusion bodies can be divided into two main groups on the basis of their mineralogy and major-trace element characteristics. These are: (1) the sub alkaline gabbros; (2) alkaline gabbros. The sub alkaline gabbros minerallogically have plagioclase, clinopyroxene and olivine and according to previous studies by authors are a part of ophiolite suite which was reported by Salavati in this region. They are enriched in LILE and LREE relative to the HFSE (negative Ti and Nb anomalies) and they show an island arc rocks signatures that formed above a subduction zone. We interpret their incompatible elements anomalies as evidence for enrichment of the magma source by a subduction component. The presence of this subduction component is well illustrated by multielement patterns ratio plots; and by the Th/Yb vs. Ta/Yb ratio plot in which the sub alkaline rocks display a consistent displacement from the mantle trend towards higher Th/Yb values. According to some incompatible elements ratios such as Th/Yb and Nb/La it's seems that they have been affected by no (or a bit) crustal contamination. In conclusion, sub alkaline gabbros evolved from a parental magma derived from a source affected by subduction components.

The alkaline gabbros include plagioclase, clinopyroxen and small needle of apatite. In general, they show OIB-like trace element patterns characterized by enrichment in LILE and LREE. Unlike the sub alkaline gabbros the alkali samples have positive Nb anomalies. This indicates that they are formed in an enriched source such as OIB, and the source region for the alkali gabbros carries no crustal component.

Figures

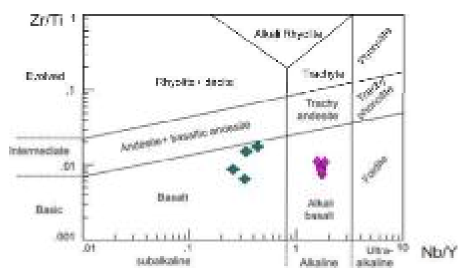

Figure 1: Zr/Ti vs. Nb/Y diagram of Winchester and Floyd (1977), Stars: Sub alkaline gabbros, diamonds: alkaline gabbros.

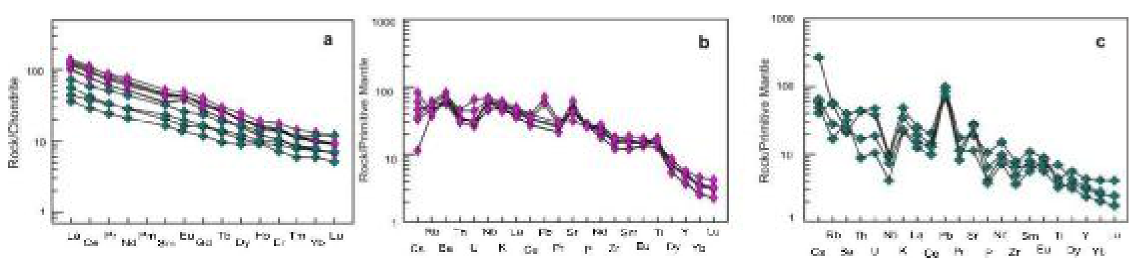

Figure 2: a) Chondrite-normalized REE diagram, b) Primitive-mantle-normalized spider diagrams for b) alkaline gabbros, c) sub-alkaline gabbros (Sun and McDonough, 1982). Symbols as in Fig. 1.

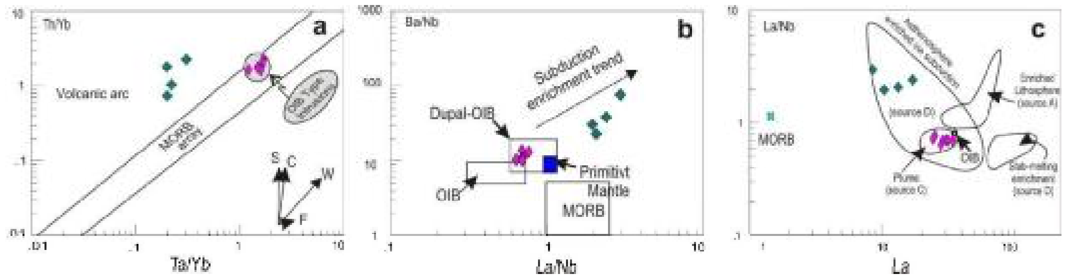

Figure 3:a) Ba/Nb vs. La/Nb plots Primitive mantle, Dupal-OIB, OIB and MORB are from Sun and McDonough (1989) and Le Roux (1986), respectively; b) Th/Yb vs. Nb/Yb plot. the MORB–OIB array of Pearce and Peate (1995), c) La/Nb vs. La diagram MORB and OIB after Sun and McDonough (1989); Symbols as in Fig. 1.

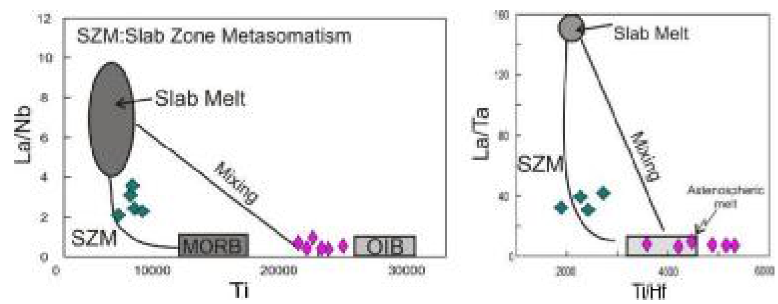

Figure 4: Ti vs. La/Nb and Ti/Hf vs. La/Ta variation diagrams (Temizel and Arslan, 2008). Symbols as Fig. 1.

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