Petrology, geochemistry and tectonic setting of intrusive massives of Baft ophiolitic – melange, Southeast of Kerman, Iran

Malihe Golestani

M.Sc. in Petrology, Shahid Bahonar University of Kerman, Iran

* Corresponding Author: golestani_m59@yahoo.com

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Abstract

Baft ophiolitic – mélange belt is a part of the ophiolite melange belt of central Iran whose genesis is considered as an environment related to Tethys subduction at Upper Cretaceous. Major part of intrusive masses of Baft ophiolitic – melange form gabbros with the inequigranular texture fine to coarse and pegmatitic, plagiogranites also with inequigranular general texture have been developed within the isotropic gabbros as local small masses or vein and or these have been injected as relatively thick veins within the dolerite dikes. Plagiogranites are located mainly in the range of volcanic arc and syncollision, and gabbros are located in the range of calc alkaline arc basalts. Based on the REE distribution pattern normalized according to chondrite plagiogranites indicate relatively similar pattern with gradual changes in the concentration of REE that indicates these rocks is syngenetic. The LREE enrichment shows that granites are related to suprasubduction zone that originally has been formed from island arc tholeiitic series or calk–alkaline series. Relative enrichment with almost flat pattern especially in part HREE, can be related to the shallow depth of partial melting for magma production of these rocks and or participation of amphibole in their formation, therefore consideration of hornblende gabbro and or amphibolitic source rock seems more logical for at least plagiogranites that are specifically enriched in HREE. In gabbros also the REE pattern normalized based on chondrite follow trend almost flat along with an enrichment slight increase of LREE elements in comparison with HREE that is indicating similar origin of gabbroic samples. According to the existence of defined differences in the content and pattern of REE in most samples of plagiogranite and gabbros of Baft ophiolitic–mélange–acid phase derivation from the gabbros does not seem plausible at least in template of partial melting for most samples of plagiogranite. Since the content of REE in the Baft plagiogranites is not higher than gabbros and even in one of samples this amount is lower than gabbros level, therefore acid phase derivation is not also plausible for most samples in the template of fractionation process. However, due to the field interconnected part of plagiogranitic with the part of doleritic in Baft ophiolitic–mélange–it is possible that fractional crystallization of basic rocks doleritic that is accompanied with pyroxene and plagioclase separation be able to produce plagiogranitic magma with features of volcanic arc similar to that of what is seen in the Baft area.

Keywords: Plagiogranite, Gabbro, Fractional Crystallization, Subduction Zone, Baft Ophiolitic–Mélange, Kerman.

1– Introduction

Iranian ophiolites are part of the eastern Tethys, that are important due to the unique geographic location joining the Middle East and other Asian ophiolites (e.g. Pakistan and Tibet) to the Mediterranean and

Carpathianophiolites (e.g. Troodos, Greek and Eastern European) (Hassanipak and Ghazi, 2000). Iran ophiolites may be divided into two groups by their age: the Paleozoic ophiolite with lower frequency and Mesozoic ophiolites with higher frequency (Arvin and Robinson, 1994). Most of the ophiolitic complexes of Iran are seriously cluttered and units could not be separated and identified. Also intense and advanced alteration is seen in this disorganized collection.

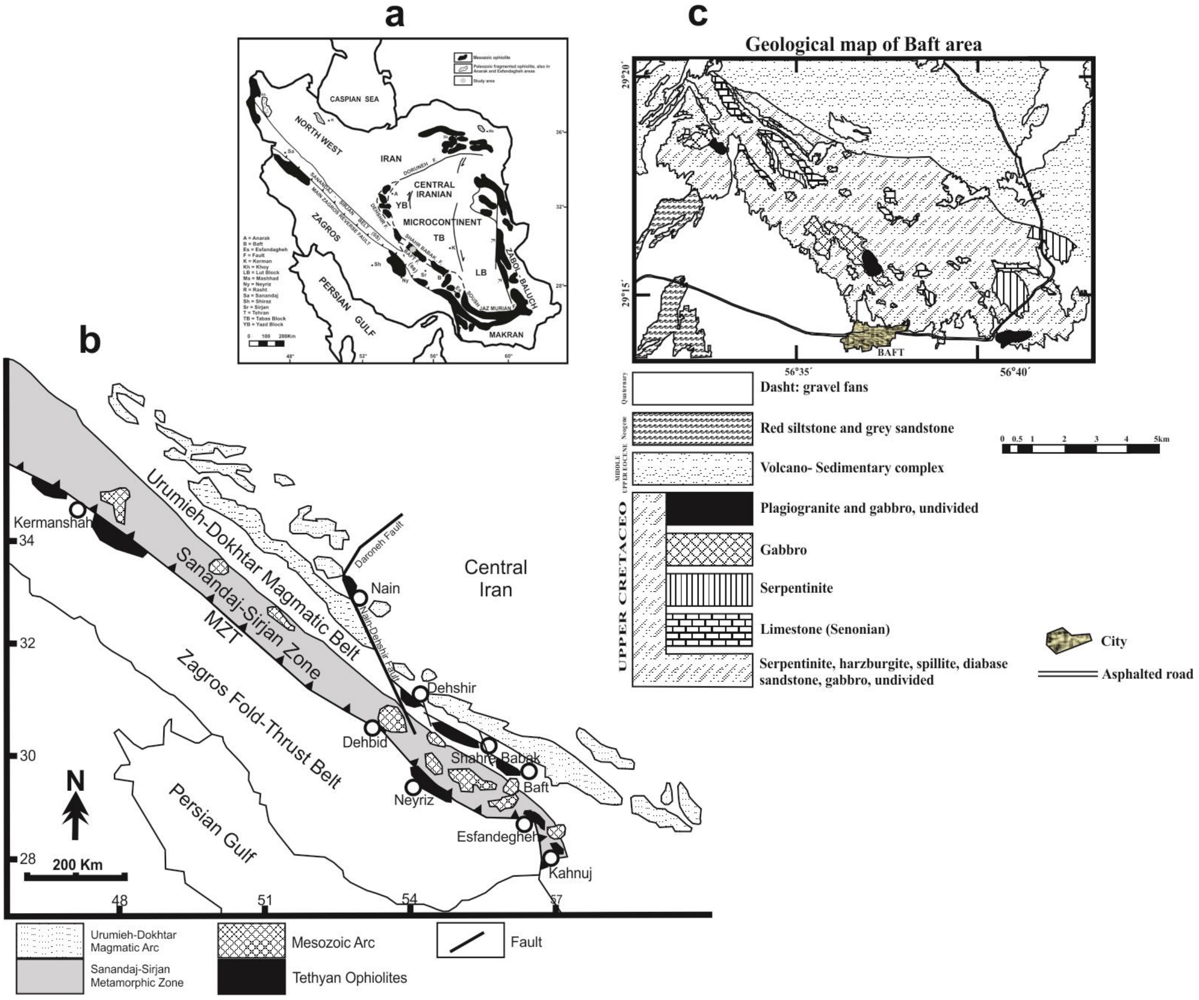

Figure 1a) The situation of Baft ophiolite-melange in Iran (Shojaat et al., 2003). b) Tectonic position of Baft ophiolite-melange (Shafaii Moghadam et al, 2009). c) Location of the study area at 1:100000 geological map of Baft (Srdic et al., 1972).

In general, the Iranian ophiolites can be divided into two ophiolitic belts 1: Zagros ophiolite–radiolarite belt 2: annular ophiolites belt (all ophiolite surrounding the central Iran are called annuluses that surround the central and east sub–continent of central Iran (Stocklin 1974)). This Ophiolitic belt includes Ophiolite melange of the Sabzevar, north of Torbat–E–Heidarieh, South of Birjand, East of Iran, north of Makran, South and South West of Kerman, Naini and Makoo–Khoy. Ophiolite melange of south and southwest of Kerman extends from northwest of Esfandaghe to Hajiabad area by the approximate length of 360 km and a width of 4 to 15 kilometers (Fig. 1). Baft ophiolite melange is a part of this the ophiolitic belt. Basically Baft ophiolites are chased at two parts: 1) In the Southern–South East of Baft and 2) In the northwest of Baft sheet. These two sections are exposed along with strike–slip faults Dehshir–Baft. The north–northwest direction of the Baft Ophiolites reaches to the Shahr–e Babak Ophiolites whereas its south – Southeast direction ends to the Dareh Pahn Ophiolites and then Ophiolites Esfandaghe. This sequence is the complete sequence of ophiolitic with tectonical contact surfaces, Sediment and injection which consists of tectonized – serpentini harzburgites, gabbro, dolerite dikes, pillow lava, limestone, tuff, keratophyre and chert. Intrusion major part of Baft ophiolite melange is gabbros of black to grayish. These rocks are exposed to the region with relatively significant volume. Plagiogranites are seen as veins, small, scattered outcrops and with less frequently associated with gabbros and dolerite dykes in the region. The area of this study is approximately 150 square kilometers in the north of Baft city and is located in 150 km southwest of Kerman province between geographical coordinates of 15 º 29 to 20 º 29 north latitude and of 31 º 56 to 43 º 56 east longitudes. In this paper it has been tried to specify tectonic setting of forming these masses, plagiogranitic phase petrogenesis and correlation with gabbroic phase by studying on the intrusive member of the Baft ophiolite melange.

2– Plagiogranites and gabbros field relations

These rocks are hololeucocratic and with the general texture of inequigranular general texture. The plagiogranites are seen mainly in the north, northwest and east of the study area. Plagiogranites of the north of the region have been developed as local small masses or vein (with a thickness of 0/5 to 20 cm) within altered isotropic gabbros. Plagiogranites of the northwest of the region are exposed mostly as local small masses (The average diameter of four meters) with high crushing and high–intensity alteration within crushed isotropic gabbros and finally plagiogranites of the east of the region are injected into the dolerite dykes as relatively thick veins (up to a diameter of 1/5 m) (Fig. 2a).

Isotropic gabbros (various sizes from small to large) are observed with the fine to coarse and pegmatitic inequigranular texture (Fig. 2b). These rocks are different in terms of color index so that they are generally melanocratic and less leucocratic and mesocratic. Sometimes in some parts of north of Baft gabbroic masses because of fractionation process a gradual conversion of the melanocratic gabbros to leucocratic is seen which leads to the formation layered gabbros. Layer thickness in this type of the gabbros is about 2 to 10 cm.

Pegmatite gabbros are injected into other rocks including dolerites and gabbros mostly as sheath with vein clear boundary and transitional (Fig. 2c). The boundary between plagiogranites and gabbros, dolerite dykes of the area is clear. In some cases the injection of plagiogranites into gabbros and especially dolerite dykes causes the enclosing of their parts as xenoliths or expanding of plagiogranite veins within it (Fig. 2d). These xenoliths are semi–angular or perfectly angular. In some cases, injection of acidic phase is applied along with fractures and joints in the dolerites so that the veins be relatively parallel.

3– Petrography of Baft ophiolitic – melange intrusive masses

The mineral assemblage of plagiogranites includes the main minerals plagioclase, quartz, sodic feldspar (Fig. 2e) and accessory mineral biotite, hornblende and opaque minerals. Alteration of the intensity plagiogranite that leads to the forming of secondary minerals such as epidote, kaolinite, zoisite, chlorite, sphene, tremolite – actinolite, and sericite, ranges relatively from low–to–high. Plagioclase crystals show polysynthetic and pericline twinning and zoning. The sodic feldspar crystals include up to about 55 percent of the volume of samples. Sometimes these crystals are formed as a halo around the plagioclase and have created a texture similar to anti–rapakivi.

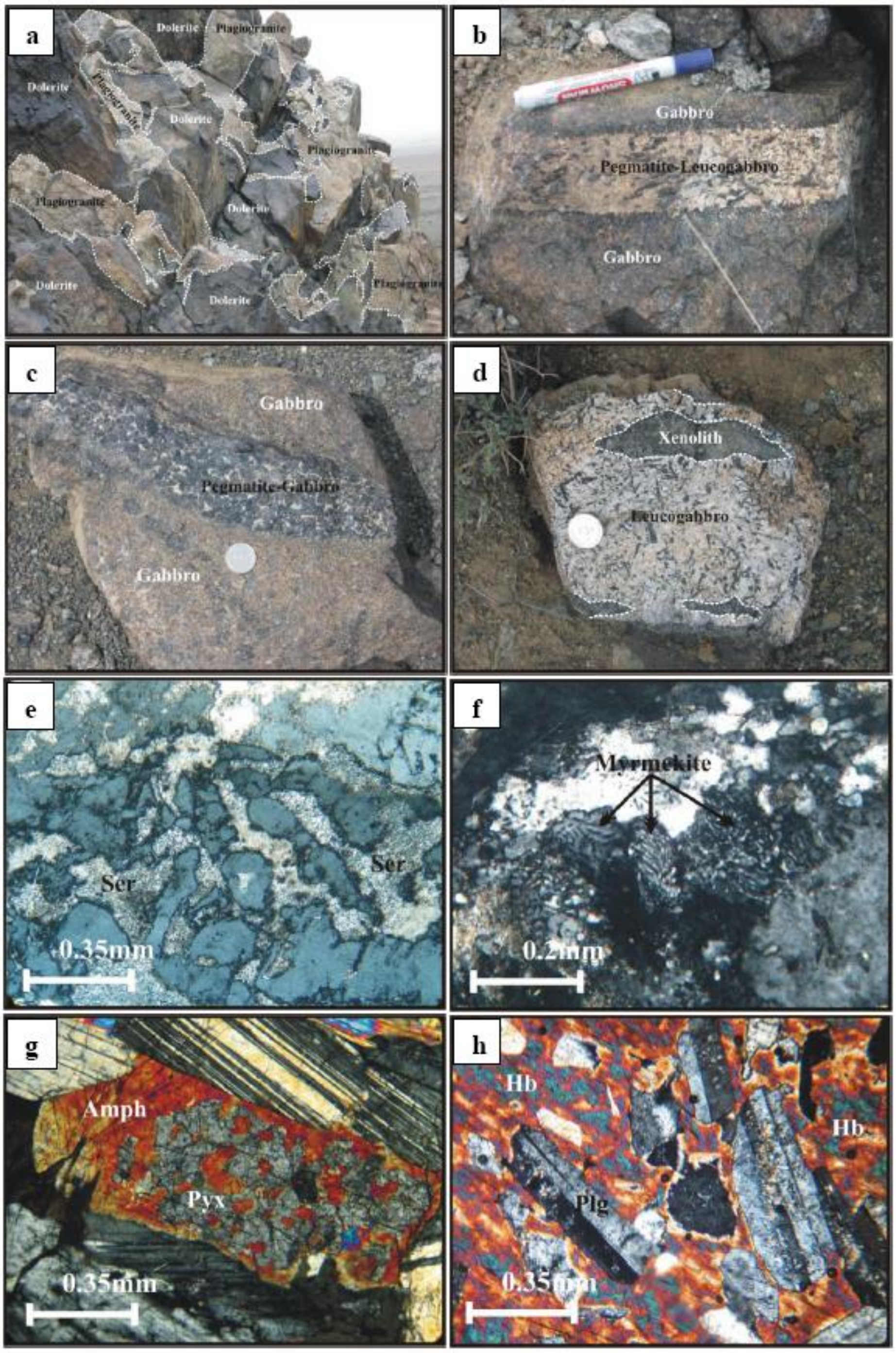

Figure 2a) Injecting acidic phase within dolerite dykes in the eastern part of Baft area. b) Pegmatite-leucogabbro with a clear border in the north of Baft gabbroic massif. c) Pegmatite-gabbro in gabbros with the inequigranular texture in the Baft ophiolite melange, in a sheath form. d) Gabbroic xenoliths within late leucogabbro in the gabbroic massif of north of Baft. e) Intense sericitic process of sodic feldspar (albite?) in granophyric (light, XPL). f) Myrmekitic texture resulting from vermiform growing of quartz with sodic feldspar in plagiogranite (light, XPL). g) Conversing of pyroxene to amphibole in gabbro (light, XPL). h)

Poikilitic texture in the form of inclusion of plagioclase crystals by secondary hornblende in gabbro (light, XPL).

It seems that all the sodic feldspar crystals do not have primary sources and at least are partly formed as the result of the influx sodic solutions to stone and expense of plagioclase (Ahmadipour and Rostamizadeh, 2012). The quartz varies from 35 to 60 percent in these rocks. Quartz crystals are seen as individuals and intergrowth with albite in these rocks. Eutectic intergrowth of quartz with sodic feldspar is often of the granophyric type and rarely of the micrographic type and is just seen in some examples. The general texture of the area plagiogranites is inequigranular hypidiomorph granular and shearing, granophyric, micrographic, myrmekitic (Fig. 2f), sieve and zoning textures are considered as sub–textures in these rocks. In some plagiogranites of the area, the granophyric texture is so developed that all rocks are composed of this intergrowth. Alkali feldspar in granophyres is typically of the albite type that has changed to sericite from moderate to extreme degree. A mineral assemblage of gabbros includes main minerals plagioclase (45 to 80%) and pyroxene (18 to 50%) that mainly have converted completely or slightly to secondary amphibole (Fig. 2g) with accessory minerals are olivine and opaque (less than 5 percent). Hornblende, albite, sericite, kaolinite, prehnite, chlorite, tremolite–actinolite, zoisite, sphene, epidote, zeolite and serpentine form gabbros secondary minerals. The general texture of the area gabbros is hypidiomorphic granular. Ophitic, subophitic, corona textures (in the form top growth of secondary hornblende on pyroxene) and poikilitic texture (in the form of inclusion plagioclase by amphibole) (Fig. 2h) are evident in the samples. Most gabbros have endured an incipient metamorphism so that in most cases the rock has converted to an assemblage of amphibole and Na–plagioclases, thus in this case with preservation of igneous texture, the meta–gabbro term can be applied to them. Pegmatitic gabbros are very similar to the gabbros in terms of volume percent of minerals and mineralogical characteristics and their main constituent minerals are plagioclase and the secondary amphibole in which the presence of secondary amphibole is the result of the alteration of pyroxene such as gabbros in these rocks.

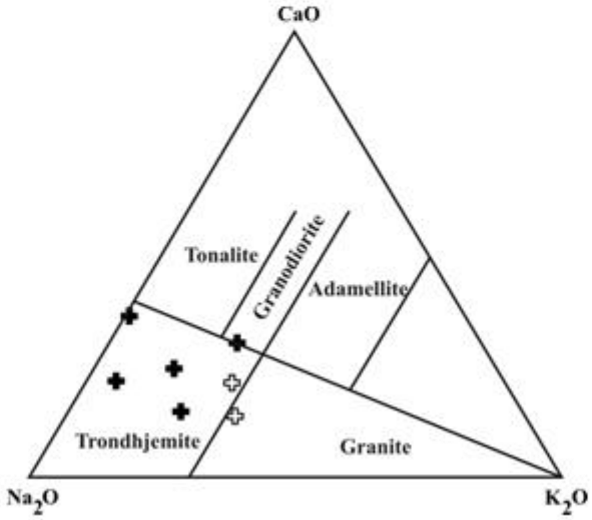

Figure 3) The situation in samples of acidic masses of Baft ophiolite-melange on the CaO-Na$_2$O-K$_2$O diagram (after Glikson, 1979) (Solid plus sign = Granite, Hollow plus sign = Graniten.a).

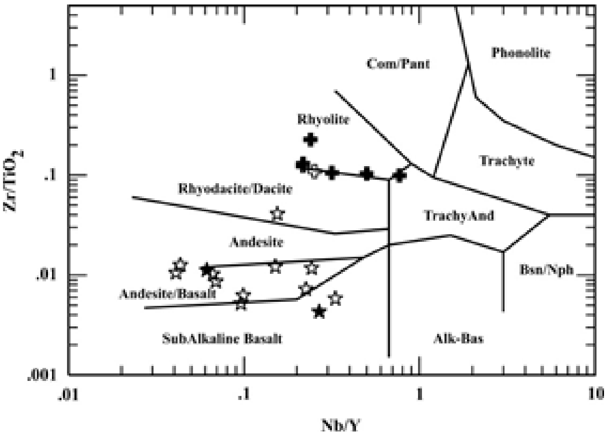

Figure 4) The situation in samples of Baft ophiolitic-melange intrusive masses On the Zr/TiO2

Vs Nb/Y diagram (Winchester and Floyd, 1977) (Solid plus sign = Granite, Hollow plus sign = Graniten.a, Solid star = Gabbro, Hollow star = Gabbron.a).

4– Geochemical characteristics and tectonic setting of plagiogranites and gabbros

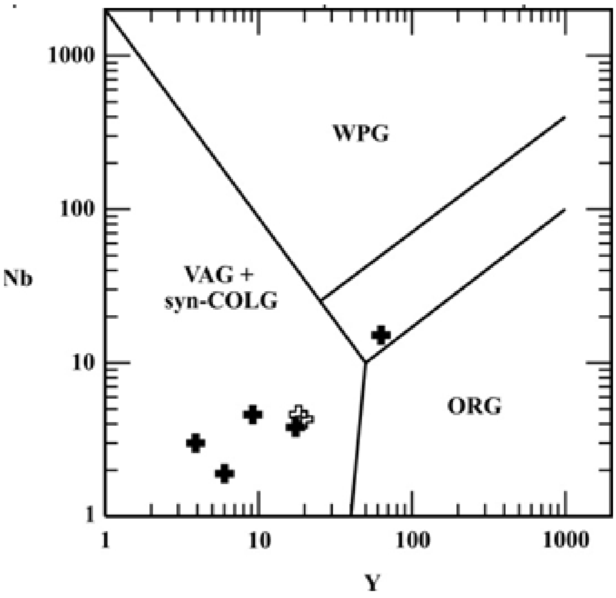

Figure 5) Nb-Y diagram for the recognition of the tectonic setting of Baft ophiolite-melange plagiogranites (Pearce et al., 1984).

At first in order to geochemical classification of the studied plagiogranites, their compositions (Table 1) are ploted on the CaO–Na_2O–K_2O diagram (Glikson, 1979) that the acid samples of study area are mainly in the range trondhjemite, only one sample is located on the border trondhjemite and granodiorite also one sample is located in the granite range (Fig. 3).

Based on Zr/TiO_2 Vs Nb/Y diagram (Winchester and Floyd, 1977) the area rocks are mainly located in the ranges of rhyolite, basalt and andesite basalt (Fig. 4).

To identify the tectonic setting of plagiogranites the Nb–Y diagram was used (Pearce *et al.,* 1984), according to which, Baft ophiolite melange plagiogranite samples are located within the range of the volcanic arc and syncollision, whereas the BA–6 sample are placed in the range overlaps of oceanic ridge and inter–plate granites and of course with more tendency toward the range of the oceanic ridge granites (Fig 5). Comparing the spider diagram Baft ophiolite melange plagiogranites with global patterns (Pearce *et al.,* 1984, Fig 6) indicates that the BA–6 sample has the most similarity with the pattern of oceanic ridge granites (ORG) that this main point is clearly evident by paying attention to a different focus situation LIL elements and especially depletion K_2O and Rb in comparison with enrichment Th and Be with the non–depletion or a relative enrichment in HFS elements.

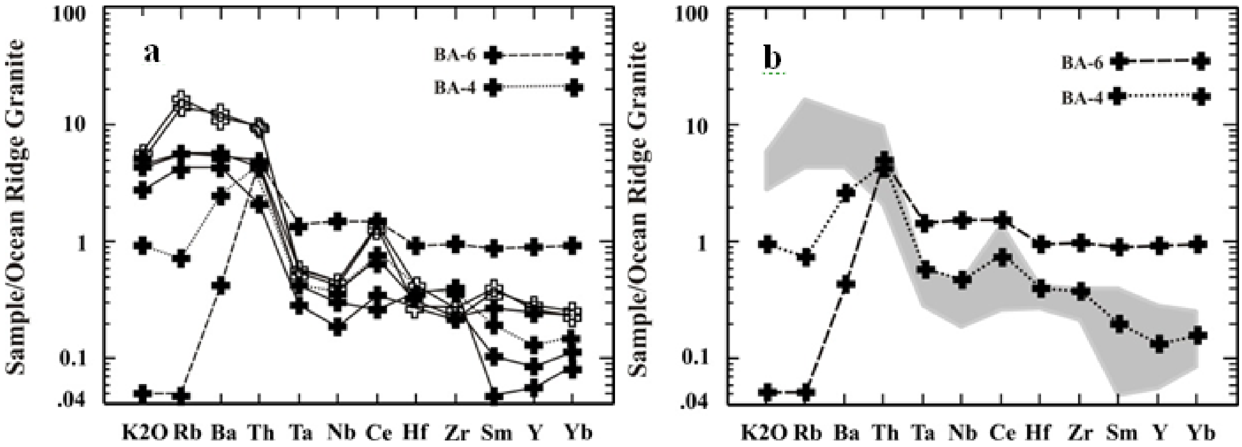

Figure 6) Spider diagram of normalized Baft ophiolite–melange plagiogranites based on oceanic ridge granites (Pierce et al, 1984). In figure a all sample are shown and in figure b for the detection of differences, samples BA-6 and BA-4 have been shown independently and shaded areas are related to the rest of the samples.

The BA–4 sample shows a pattern between ORG granites and volcanic arc granites (VAG), while the rest of samples have a very similar pattern VAG (preferably from Jamaica) that this problem is especially characterized by the relatively harmonious enriched LIL elements and the absence of negative anomalies in Ba with HFS elements depletion.

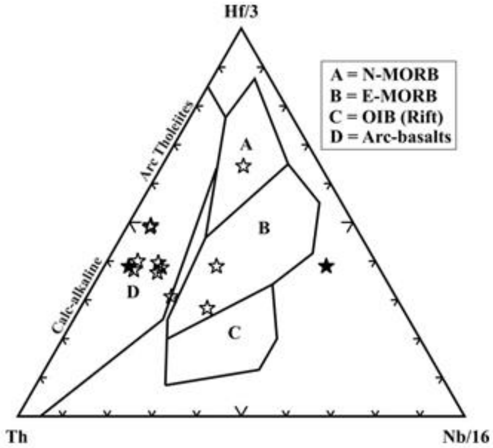

Figure 7) The situation in samples of Baft ophiolitic-melange gabbroic on the diagram recognition of tectonic setting (Wood, 1980).

To determine the tectonic terrain of gabbros the Th–Hf/3–Nb/16 triangular diagram was used (Wood, 1980). Accordingly, most gabbroic samples are located in calc–alkaline arc basalts range (Fig 7).

The distribution of some gabbroic samples in the other ranges is probably due to the role of metasomatic processes in changing the elementary grade on the rocks.

To examine the effects of subduction zone fluids on the geochemical characteristics of plagiogranite samples of Baft ophiolite – melange are used binary diagrams of Rb vs. Rb/Nb (Fig. 8a) and Ba vs. Ba/Nb (Fig. 8b) proposed by Christiansen and Keith (1996). As it is clear in the figures at the sample BA–6 the lowest effect of the subduction zone is seen, but toward BA–4 the effect of subduction zone fluids is increased to some extent and finally in other samples Subduction zone characterizations are evident and they reach, their maximum.

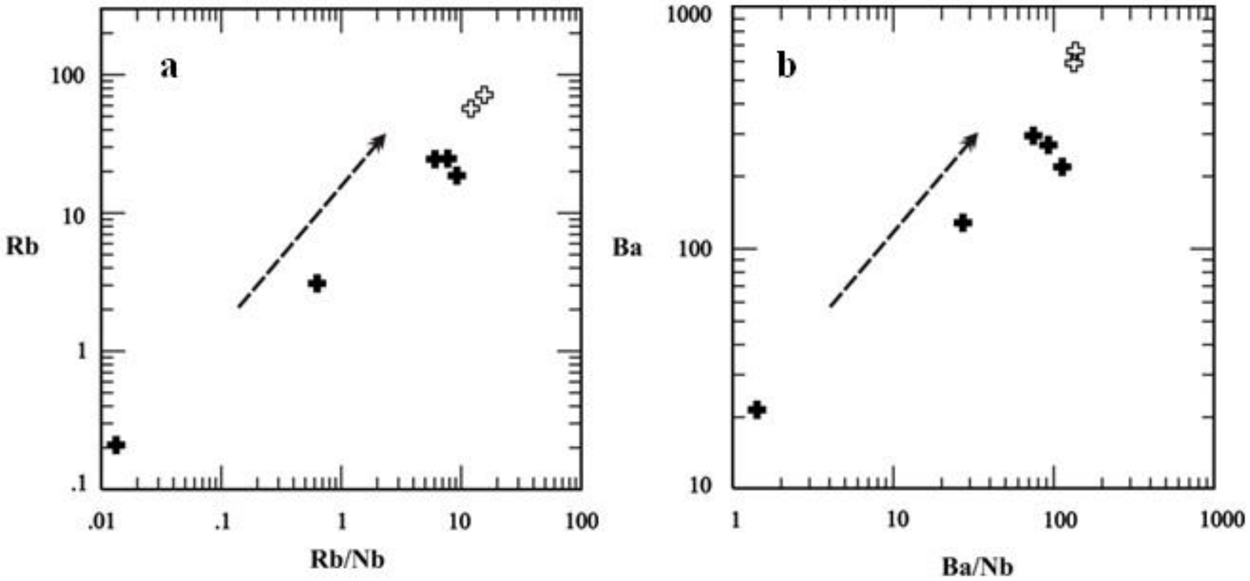

Figure 8): The impact of subduction zone on the development of plagiogranite rocks of Baft ophiolite–melange. The flash direction shows the increasing level of components intercommunity associated with subduction zone fluids (After Christiansen and Keith, 1996).

Based on what has been discussed it seems that plagiogranites of Baft ophiolite–melange show the dual nature of geochemical characteristics so that their geochemical characteristics are variable from plagiogranites type of oceanic ridge to the development types in the seduction zone. Such features can often happen in the suprasubduction zone, as it has also been reported in other suprasubduction ophiolite complexes of the world such as the Oman (Rollinson, 2009) and the Troodos in Cyprus (Floyd *et al*., 1998).

5– Petrogenesis

Several mechanisms have been proposed for the origin of plagiogranites by various researchers that (Flagler and Spray, 1991) have been listed as follows: a) sodic metasomatism of the potassium–bearing differentiated acidic phases, 2– immiscibility between iron–rich acidic and basic magmas under dry conditions, 3– fractionation basic sub–alkaline magma at low pressure and 4– amphibolite anatoxin or basaltic crust under hydrous conditions. Between the mentioned four theories, the first and the second mechanisms are no longer supported with regard to the contradictions that exist in the world of natural systems and the focus is on the third and the fourth theories now.

In order to investigate the origin and role of partial melting or crystal fractionation in form of plagiogranites the chondrite normalized REE distribution patterns have been used (Sun and Mc Donough, 1989) (Fig 9a). In this diagram the differentiated trend with enrichment in LREE (La–Sm) can be determined and HREE (Gd–Lu) have an almost flat trend. These samples contain variable amounts of Eu anomalies. Any way what clear is that the amount of anomalies in relatively plagiogranites of Baft ophiolites–mélange is small and cannot be indicative of very different conditions of melting or fractionation in different samples .With the exception of BA–6, other samples have relatively similar patterns with gradual changes in concentration of REE that can prove the cogenetic of these rocks. It should be noted that the increase of enrichment LREE elements in comparison with HREE is of the geochemical characteristics that are usually present at granites related to that of suprasubduction zone that have been the origin of island arc toleitic series or the series of calc–alkaline (Pearce *et al.*, 1984).

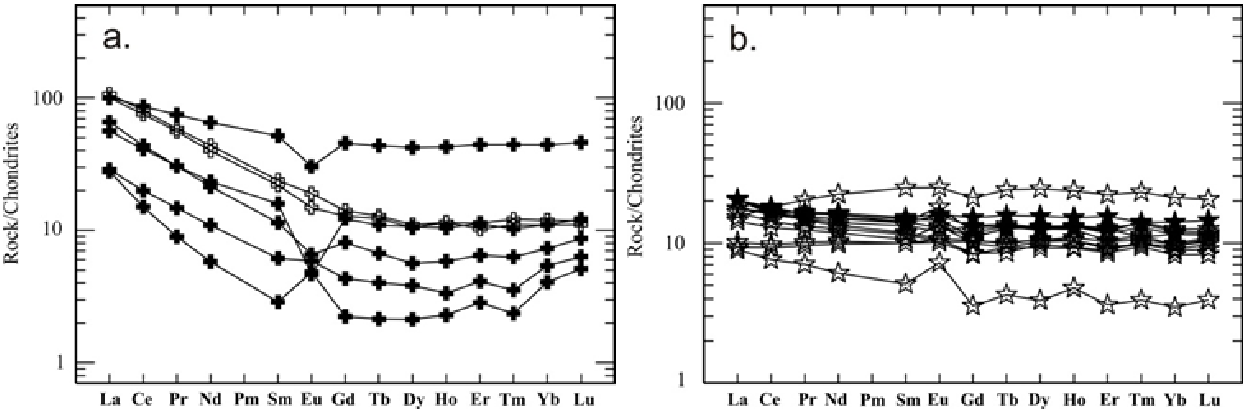

Figure 9a) REE pattern of Baft ophiolite–melange plagiogranites normalized based on chondrite. b) REE pattern of Baft ophiolite–melange gabbros normalized based on chondrite (Sun and Mc Donough, 1989) (Solid plus sign = Granite, Hollow plus sign = Graniten.a, Solid star = Gabbro, Hollow star = Gabbron.a).

But BA–6 is richer in terms of the abundance of REE than the other samples and in this figure it is the highest model. However, the relative flat pattern with a rather enrichment of the HREE can be related to produced magma by shallow depths of partial melting of these rocks (Rapp *et al*., 1991) or association of amphibole in their formation (Lopez–Escobar, 1974 & Gao *et al*., 2009), because if amphibole involved melting during partial melting with regard to its ability to maintenance of the REE particular heavy, its amount will increase in the produced magma and hence may seem more logical considering the hornblendegabbro or amphibolite source rock for at least plagiogranites that are richer of HREE clearly. Also on the gabbros the chondrite normalized REE patterns (Sun and Mc Donough, 1989) (Fig 9b) are following the almost flat trend, with a slight increase of LREE enrichment relative to HREE which implies the similar origin of the gabbro samples. Weak positive Eu anomaly in some samples is due to accumulation of plagioclase in these rocks.

Low values of LIL elements in the OR type in comparison with other species must be related to low concentration of these elements in the origin of these granites, Because of this type is usually occurring by fractionation of MORBs derived from the depleted upper mantle or partial melting of basalts. The non–accompanying of metal mineralization with this type also comes back to the depleted nature of MORB. The Existence of some features of type I in some plagiogranite samples of Baft ophiolite–melange should be related to their formation setting. Such features typically occur associated with subduction zones in which the dual role of fluids in displacement trace elements cause the appearance of negative anomalies in elements such as Nb along with increasing amount of LIL elements. Therefore, it seems that plagiogranites of Baft ophiolite–melange must have been occurred from a similar origin to depleted MORB in the subduction zone. Such a situation is usually seen in developed plagiogranites in subduction zones. Related to the plagiogranites origin in ophiolitic complexes it can be concluded that with regard to the specified differences in the content and pattern of REE most plagiogranite and gabbros of Baft ophiolitic–melange samples, acidic phase derivation of the gabbros at least in the form of partial melting does not seem probable for most plagiogranite samples, in particular, based on the Dilek and Thy (2006) model to develop acidic magmatic from melting a basic–metabasic rocks about 10–20% of the rock partial melting is required and in this case, if the basic–metabasic rock has a relatively flat pattern such as those seen in the Baft of gabbros in the case plagiogranite rock produced by crystallization acid magma should have the pattern with steep slope with the amount of $(La/Yb)_n$ is greater than 10.

Meantime, if garnet be present in the source rock (eclogite facies) in this case even more intensive REE slope of the pattern will be also there. Since the pattern of REE of Baft gabbros is relatively flat and the amount of $(La/Yb)_n$ plagiogranites of Baft is in the limit of 0/52–9/19 at an average of 5/72, therefore, considering the partial melting origin of gabbros for these acidic rocks does not seem reasonable. But about the derivation of gabbros from plagiogranites in the fractionation process it can be said that it has now been proved that melt plagiogranite can also occur due to the intense fractionation of a basaltic magma in dry conditions or under water saturation (Dilek and Thy, 2006). Berndt *et al* (2005) expressed that even if partial melting of a basaltic origin similar to MORB be involved in the production of plagiogranite magmas again, a significant amount of fractional crystallization is required for the development of features such as low amount elements Fe, K and Ti in plagiogranites. However, according to Dilek and Thy studies (2006) to develop a magma plagiogranite from a basic magma, an intense fractionation (approximately 70%) is required and in this case it is expected that REE content in the produced acidic magma will be increased specifically. While in most Baft plagiogranites the amount of REE is not greater than the gabbros and even perhaps in one of the samples this amount is less than gabbros. Of course fractional relationship cannot be rejected completely, because similar pattern of REEs of at least one of the samples that has quite different features from the other samples is undeniable with gabbroic member.

Table 1) Representative chemical analysis of major oxides and trace elements found in gabbros and plagiogranites of Baft ophiolite-melange (Analyses samples Bt06- Bt07 prepared by Shafaii Moghadam et al., 2013).*

SAMPLE	**BA-1 Granite**	**BA-2 Granite**	**BA-3 Granite**	**BA-4 Granite**	**BA-5 Gabbro**	**BA-6 Granite**	**BA-7 Gabbro**	**BT07-18 Graniten.a**	**BT07-20 Graniten.a**	**BT06-34 Gabbron.a**
SiO_2	76.40	76.50	76.60	77.40	46.80	76.30	50.40	77.30	74.70	52.04
Al_2O_3	12.55	11.90	12.95	12.60	17.35	11.40	15.05	12.48	13.00	14.73
Fe_2O_3	1.34	0.93	1.57	1.59	11.00	3.81	10.00	1.72	2.57	10.45
CaO	1.27	2.18	1.84	1.60	12.95	2.59	10.05	1.01	1.53	8.41
MgO	0.18	0.34	0.33	0.49	7.64	0.51	7.24	0.28	0.35	6.62
Na_2O	5.61	3.36	4.65	5.50	2.01	4.61	2.99	4.06	3.75	3.72
K_2O	1.81	1.75	1.12	0.37	0.09	0.02	0.18	2.36	2.00	0.67
Cr_2O_3	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.03	n.a	n.a	n.a
TiO_2	0.10	0.23	0.15	0.20	0.97	0.24	0.85	0.10	0.14	0.85
MnO	0.03	0.02	0.04	0.04	0.19	0.08	0.16	0.04	0.05	0.17
P_2O_5	0.03	0.02	0.02	0.02	0.15	0.03	0.08	0.07	0.10	0.07
SrO	<0.01	0.05	0.02	0.02	0.03	0.01	0.02	n.a	n.a	n.a
BaO	0.03	0.03	0.03	0.01	0.01	<0.01	<0.01	n.a	n.a	n.a
LOI	0.87	2.05	0.87	0.39	0.88	0.56	1.96	0.50	0.59	1.35
Total	**100.00**	**99.40**	**100.00**	**100.00**	**100.00**	**100.00**	**99.00**	**99.92**	**98.77**	**99.08**
Ag	<1	<1	<1	<1	<1	<1	<1	n.a	n.a	n.a
Ba	284.00	267.00	216.00	125.50	41.20	21.20	34.30	578.92	630.74	90.08
Ce	25.10	9.20	12.20	26.70	10.30	52.80	10.70	46.23	49.28	9.79
Co	1.90	2.10	2.10	2.90	43.40	7.40	39.70	n.a	n.a	n.a
Cr	10.00	10.00	10.00	20.00	90.00	10.00	210.00	4.19	3.42	229.18
Cs	0.41	0.29	0.23	0.07	0.11	0.03	0.06	0.52	0.54	0.18
Cu	7.00	6.00	<5	7.00	105.00	12.00	45.00	n.a	n.a	n.a
Dy	2.70	0.54	0.97	1.43	3.28	10.70	3.96	2.66	2.81	3.29
Er	1.86	0.47	0.68	1.07	2.10	7.33	2.57	1.88	1.69	2.00
Eu	0.27	0.28	0.34	0.38	0.92	1.76	0.93	0.86	1.10	0.70
Ga	12.20	9.20	12.70	12.50	16.80	15.60	16.40	n.a	n.a	n.a
Gd	2.52	0.46	0.89	1.66	2.69	9.35	3.12	2.63	2.89	2.73
Hf	2.80	3.30	2.50	3.50	0.70	8.30	1.70	2.45	2.82	1.49
Ho	0.59	0.13	0.19	0.33	0.73	2.41	0.86	0.65	0.65	0.75
La	13.30	6.60	6.80	15.60	4.80	23.70	4.80	23.65	25.28	4.87
Lu	0.31	0.13	0.16	0.22	0.29	1.17	0.37	0.30	0.28	0.32
Mo	<2	<2	<2	<2	<2	<2	<2	n.a	n.a	n.a
Nb	3.80	3.00	1.90	4.60	4.80	15.10	1.30	4.29	4.61	1.36
Nd	10.90	2.70	5.10	10.00	7.00	30.40	7.60	18.63	20.47	6.55
Ni	7.00	11.00	5.00	13.00	63.00	<5	64.00	n.a	n.a	65.72
Pb	167.00	96.00	45.00	1480.00	188.00	175.00	844.00	12.23	13.22	0.10
Pr	2.91	0.85	1.40	2.90	1.46	7.10	1.55	5.30	5.54	1.41
Rb	23.00	23.20	17.50	2.90	1.20	0.20	2.00	67.06	55.42	9.41
Sm	2.43	0.44	0.94	1.75	2.14	7.92	2.33	3.36	3.65	2.03
Sn	<1	<1	1.00	1.00	1.00	1.00	1.00	n.a	n.a	n.a
Sr	44.50	419.00	136.50	154.00	226.00	124.50	220.00	124.27	177.18	300.56
Ta	0.30	0.30	0.20	0.40	0.30	1.00	0.10	0.38	0.41	0.08
Tb	0.41	0.08	0.15	0.25	0.49	1.63	0.59	0.46	0.48	0.51
Th	3.50	3.99	1.66	3.63	0.07	3.89	0.82	7.84	7.66	0.66
Tl	<0.5	<0.5	<0.5	0.50	<0.5	0.60	<0.5	n.a	n.a	n.a
Tm	0.26	0.06	0.09	0.16	0.28	1.13	0.36	0.31	0.28	0.36
U	0.97	0.92	0.36	0.65	0.07	1.12	0.20	1.93	2.46	0.17
V	<5	18.00	10.00	16.00	327.00	<5	280.00	n.a	3.15	315.48
W	<1	1.00	1.00	<1	<1	<1	<1	6.58	6.90	0.86
Y	17.50	3.90	6.00	9.20	17.90	63.10	21.20	19.82	18.27	20.51
Yb	1.88	0.69	0.92	1.24	1.97	7.52	2.40	2.03	1.86	2.14
Zn	38.00	33.00	26.00	790.00	107.00	42.00	353.00	n.a	n.a	n.a
Zr	78.00	137.00	95.00	124.00	25.00	327.00	57.00	74.41	91.64	51.99

However, regarding the interconnected field of plagiogranite part with dolerite in Baft ophiolite melange, it is possible that fractional crystallization of doleritic basic rocks which is accompanied with separation pyroxene and plagioclase can produce plagiogranite magmas with characteristics of the volcanic arc similar to what's seen in the Baft area that Of course, certainty this issue requires detailed geochemical studies on dolerite phase and comparison with its data with plagiogranite phase. Of course as already mentioned although in several papers the originating of plagiogranite phase from the amphibolite (For example (Flagler and Spray, 1991)) is considered, in about most plagiogranites of Baft area , it seems that this hypothesis is not very logical because the content of HREE is relatively low in most samples belonging to the plagiogranite phase in this area, however, REE patterns of one of the samples (BA–6) is so that can be consistent with origin of partial melting of amphibolite source.

According to Arvin and Robinson (1994) the absence of the gabbroic accumulations in Baft ophiolitic sequence refers to the lack of continuous and large magma chamber below spreading axis of Baft, and there ophiolitic complex is formed in a transformation ridge probably and as a result conversion thetransform fault to a subduction zone replacement has occurred during the changes related to plates motion. Modeling transformation ridge refers to forming ophiolite in a narrow ocean basin that has separated the Sanandaj–Sirjan sub–continent from central Iran block. The ophiolite has been replaced with the central Iran sub–continentas as a result of oblique subduction of the African–Arabia plate towards Eurasia (Babaie *et al.*, 2001).

6– Conclusions

Based on what has been discussed it seems that all the plagiogranites of Baft do not have the same origin, so that the geochemical characteristics of the dominant samples are consistent with their derivation in the form fractional crystallization of a basic magma that possibly has been the creator of dolerite dykes in the area. But at least one of the samples has quite different geochemical characteristics that reinforces its derivation from partial melting of gabbroic hornblende or amphibolite–phase. It should be noted that the existence of different origins for plagiogranites of an ophiolitic complex is not a far–fetched matter, thus such a situation has also been proposed for the plagiogranites of Oman area now (Rollinson, 2009).

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