Mineralogical and Geochemical characteristics of metamorphic halo of Yazd Magmatic rocks(central Iran)

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Abstract

Intrusive masses of Yazd area are out- cropped in south- west of Yazd. These granitoid bodies seems to be younger than the surrunding metamorphosed rocks, particularly the lower cretaceous limestones, probably related to oligo- miocene ages. The most volumetric abundances of igneois rocks are Granodiorite, Granite, Quartz Monzo- Diorite, Quartz- Diorite, and in a lesser amount: Tonalite, Quartz- Syenite and Syeinite. From geochemical point of view, The amount of SiO_2, K_2O and CaO contents, in different points of intrusive bodies are variable, and Ba, K, Rb enrichment, Nb, Sr, Ti depletion could be seen. Plot of results on Spider diagrams show this matter. The Granitic intrusives of Yazd area are geochemically I- type granite. From economical potential point of view, Mineralization of Marbel, Skarn, Fe, Cu, Pb, Zn and non- metallic minerals such as kaolinite are considerable. Geothermobarometry of minerals of rocks, from metamorphic haloes of these masses indicates thermal conditions of 600-650^{0}c and pressures 1.5-2 kb.

Key words: *Yazd area, granitoid bodies, Geothermobarometry, metamorphic haloes,*

Introduction

In propose of, careful mineralogy and geochemical studies of metamorphic halo, and determination of P-T conditions of skarn formation, intensive, deep Sampling and field works considerations are made. Then, 8 samples of skarnic rocks for X.R.F method are selected. Some 12 more similar samples are selected and studied by X.R.D method. In addition, component minerals of some skarn are studied by Electron Probe Micro Analysis method (EPMA) [New Brownswick university, Canada, 1998].

Petrography and mineralogy

Yazd granitoids are coarse and fine graines. They consist of ellipsoidal and spherical dark xenoliths. Acidic and doleritic daykes, veins of aplite and pegmatite are seen within the granites(Darvish Zadeh, 1992). On the basis of modal classification and Q-P diagram (Debon & Lefort, 1988), rocks of the area are mainly: Granodiorite, Granite, Quartz- Monzodiorite, Quartz- Diorite, and to a lesser amount are Tonalite, Syenite and Quartz- Syenite (Fig.1).

Minerals of intrusive rocks are of: Quartz, Plagioclase (ab, olig and ands), Or and mica (Biotite, and to a lesser amount Muscovite). Minor mineral constituents of these rocks are of apatite, zircon (as biotite inclusions) Sphene, Tourmaline, spinel (Hereynite). hematite and magnetites. as mentioned earlier minerals of skarn types of the metamorphic halo were analyzed by EPMA, which are described as following:

Amphiboles in skarn from metamorphic- halo coexist with Diopside, Andradite- Grossular, phlogopite and forsterite and tremolite. Photomicrograph No. 1 shows a thin section of a skarn rock. According to diagrams confirmed by the IMA (Subcomission in International Mineralogical Association) and commission inrelation to the new minerals and nomination (CNMMN) [after: Leake, E. B.,1997], Amphiboles with in the skarn are of calcic type (Tremolite, Actinolite) which is shown in Fig. 2. Table 1 shows EPMA results of some amphiboles from contact metamorphism halo.

Pyroxenes in rocks of metamorphic halo are of diopside and augite types. aegirine- augite pyroxene in some more sodic magmatic rocks is found, According to minerals nomination presented by Morimoto (1988) the pyroxenes are of calcic type (Diopside, Augite), (Fig.3).

The microprobe results of two pyroxenes are presented on table 2.

Olivine in skarnic rocks of contact metamorphic halo, basaltic- andesite and basalts of the studied area is seen, one of this mineral which is related to the skarn from Yazd intrusine body (Sample No. ghc_{24}) is analysed by EPMA method, which is forsterite.

Magmatic rocks of the area, both Volcanic and plutonic rocks are free of Garnet, but skarns consists of it. One of this garnet is analysed by EPMA, the result is shown which is andradite type.

Metamorphic halo

In contact of Yazd magmatic rocks with other surrounding materials, different types of metamorphic rocks Such as: metamorphic tuffs, crystalline limestones, silica bearing limestones and dolomitic marbles, and more important than the others, skarns, were found.

In addition to the above matters, diagrams of Garrels & Mackenzie (1972) and Herron, 1988, after Rollinson (1993), are used. With these respects, the protolithe of most rocks of the area are carbonates, and with a lesser amount arkose, Fe- bearing sandstonev shales, litharenites and sub- litharenites.

The garnets consist of grossular and andradite (Zarei, 1998). Near by to Ader- Bolandan village and towards the plutonic mass, firstly silica bearing calcareous and dolomitic marbles, then grossular, andradite, tremolite and calcite, and finally in the nearest locality of the skarn to the plutonic body, diopside, and garnet are seen, which by being away from the igneous body, The only mineral which could be observed is garnet, which, it is being disappear gradually.

The propose of geothermobarometry is to determine P and T conditions which a rock is formed under it (Bucher & Frey, 1994).

Discussion and Conclusions

With regard to field works studies, it is indicated that the Yazd magmatic rocks are intruded within the limestones.

Therefore they are younger than them. Strong evidences to confirm this matter comes from the occurrence of skarn formation and metamorphism processes on to the limestones. Petrographic evidences show that metamorphism phenomena including recrystallization of limestones and tuffs, results to the formation of marbles and a type of metasomatism leading to skarn. Paragenesis of different minerals, could be seen, in the area, from the most far part of the halo to the nearest part of the intrusive bodies, which the most important facies with in

them are hornblende- hornfelse and pyroxene- hornfelse. The pyroxene- hornfelse facies of the area confirms the high intensity of metamorphism grade.

General conclusions are as the following:

1-Physical and chemical contact between the Yazd magmatic rocks and Cretaceous limestones results to metamorphism of the limestones and in particular skarn formation phenomena, and also some chemical contaminations in plutonic bodies.

2- With regard to diagrams of Garrels & Mackenzie (1972) and Herron (1988), protolithe of the metamorphic rocks of the area are mostly limestones and dolomitic limestones with silica Fe impurities, and also to a lesser amount arkose and arenite.

3- The most principle minerals of the skarnic rocks are: Fo, Di, Grt (Andr.), Phi., Scap, Trem, Act, Talc and serp, which talc and serpentine are the indicators of low grade metamorphism wherras, forsterite and diopside indicate high grade metamorphism.

4- According to EPMA studies, micas are biotite and phlogopite in metamorphic rocks.

5- With regard to paragenesis of: Calcite+ diopside+grossular+andradite+quartz the intensity of metamorphism is on the limit of pyroxene- hornfelse facies.

6- Geochemical analysis, microscopic studies, X.R.D. studies and geothermobarometry works on garnet- pyroxene and elinopyroxene- amphibole indicate a temperature- pressure range of 600- 650^{oC} and 1.5-2 kbar for metamorphism.

7- From economical potential point of view, intrusive masses of the area are valuable.

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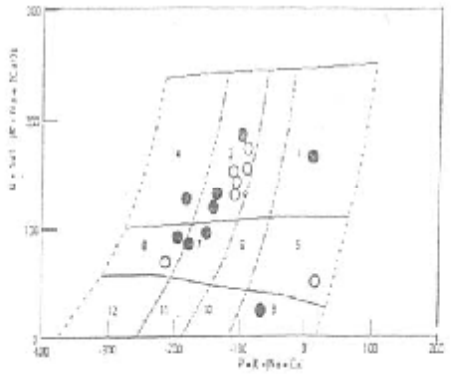


Fig1 : Q – P diagram, Debon & Lafort (1988), Showing plot of igneous rocks of studied area.
1– Granite 2– Granodiorite 4– Tonalite 5– Quartz – Syenite 7– Quartz – Monzo – Diorite
8– Quartz – Diorite 9– Syenite

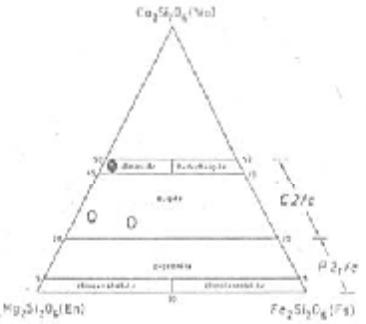


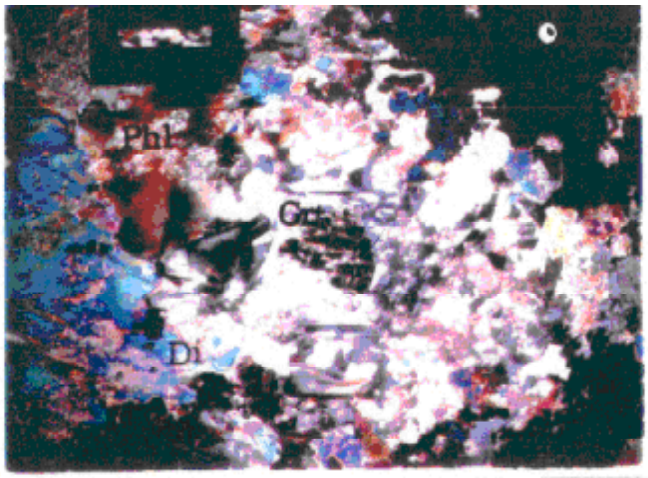
Fig2 : Field of Ca, Mg, Fe CPX, according to accepted names by Morimoto, 1988, Am. Mineral Mag., No. 52, PP. 535 – 550.

● : Diopside (Di) ○ : Augite (Aug)

Photomicrograph 2: Showing phlogopite, augite and epidote crystals in skarnic rocks of metamorphic halo, length of marker is 5^{mm}. phlogopite=Phl Aug=augite Epi=epidote

Table 1: Showing, chemical analysis of amphiboles by EPMA method. Cations calculation is on the basis of 24 oxygens. Amphiboles are related to skarn from metamorphic halo.

Amphibole	Tremolite			Actinolite		
No	gk_{17}			gk_{17}(incl)		
Oxides	(Wt)%	Cations		(Wt)%	Cations	
SiO_2	57/73	Si	8	55/73	Si	7/9660
TiO_2	0/11	Al^4	—	0/08	Al^4	0/034
Al_2O_3	1/71	Al^6	0/289	1/9	Al^6	0/284
FeO_t	1/88	Ti	0/008	4/74	Ti	0/009
MnO	0/14	Fe	0/221	0	Fe	0/567
MgO	23/24	Mg	4/892	22/7	Mg	4/838
CaO	13/58	Mn	0/017	13/67	Mn	0
Cr_2O_3	0/06	Ca	2/055	0/04	Ca	2/097
Na_2O	0/34	Cr	0	0/38	Cr	0
K_2O	0/14	Na	0/093	0/12	Na	0/103
F	0	K	0/025	0	K	0/026
Cl	—	F	0	—	F	0
Total	98/93	Cl	—	99/36	Cl	—



Photomicrograph 1: Showing Crystals of Di., Phl., and Grt. with in the skarnic rocks of metamorphic halo, Length of marker is 5mm Di=diopside Phl=phlogopite Grt=garnet

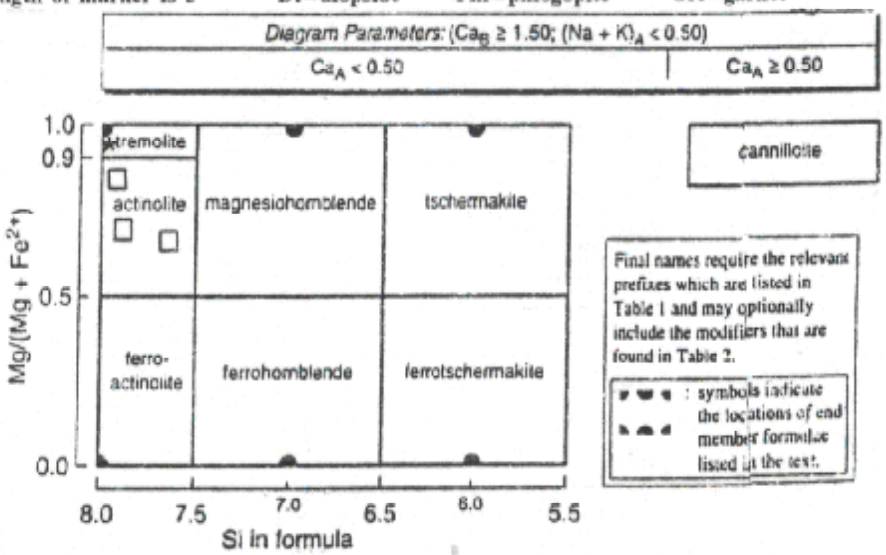


Fig. Classification of calcic amphiboles (Leake, E. B., 1997, Canad., Min., Mag., No. 35, pp 219 – 233) On the basis of this diagram, as it is seen, amphiboles are of tremolite – actinolite types:

● : Tremolite □ : Actinolite

Table 2: Showing EPMA results of two pyroxenes from skarnic rocks. Cations calculation is on the basis of 6.O.

Pyroxene	Diopside			Augite		
No	AD_{34}			gk_{17}		
Oxides	(Wt)%	Cations		(Wt)%	Cations	
SiO_2	53/46	Si	1/95	56/45	Si	1/998
TiO_2	0/12	Al^4	0/004	0/07	Al^4	0/002
Al_2O_3	0/09	Al^6	0	2/5	Al^6	0/102
Cr_2O_3	0	Cr	0	0/08	Cr	0/002
FeO_t	1/28	Fe	0/039	3/77	Fe	0/111
MnO	0/18	Ti	0/004	0/06	Ti	0/002
MgO	19/21	Mg	1/043	22/6	Mg	1/194
CaO	25/58	Mn	0/007	13/38	Mn	0/002
Na_2O	0	Ca	0/999	0/7	Ca	0/509
K_2O	0	Na	0	0	Na	0/049
Total	99/92	K	0	99/61	K	0
	Wo = 48			28/06		
	En = 50/12			65/82		
	Fs = 2			6/12		