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خصوصیات کانی‌شناسی و ژئوشیمیایی توده نفوذی خضرآباد (شمال غرب تفت)

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چکیده: توده نفوذی خضرآباد در شمال غرب تفت رخنمون دارد. به نظر می‌رسد این توده نفوذی از سنگهای دگرگونی اطراف و به ویژه از سنگهای آهکی در برگیرنده به سن کرتاسه زیرین جوانتر باشد و احتمالاً دارای سن الیگو- میوسن است. فراوانترین سنگهای توده نفوذی عبارتند از گرانودیوریت، گرانیت، کوارتزمونز و دیوریت، کوارتزدیوریت و به مقدار کمتر تونالیت، کوارتزسیینیت و سیینیت. ضمناً کلیه سنگها غنی‌شدگی از عناصر Rb, K, Ba و تهی‌شدگی از Nb, Sr, Ti را نشان می‌دهند.

از نظر زمین شناسی اقتصادی کانی‌سازی مرمر، اسکارن، آهن - مس - سرب – روی و کانی‌های غیرفلزی نظیر کائولینیت قابل ملاحظه است. ژئوترموبارومتری کانی‌های تشکیل دهنده این توده گرانیتوئیدی، دمای ۸۱۰ تا ۹۸۵ درجه سانتی‌گراد و فشار ۲٫۴۳ تا ۶٫۲ کیلوبار را نشان می‌دهد .

واژه‌های کلیدی: *گرانیتوئید، گرانیت، دیوریت، کانی‌سازی، ژئوترموبارومتری.*

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Mineralogical and Geochemical characteristics of "Khezr-Abad pluton" NW of Taft, Iran.

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Abstract: Khezr-Abad pluton is cropped out in North-West of Taft. This granitoid seems to be younger than the surrounding metamorphosed rocks, particularly the lower cretaceous limestones and probably is implaced during Oligo-Miocene. The most volumetric abundances of the igneous rocks are: granodiorite, granite, quartzmonzo-diorite, quartz-diorite, and in a lesser amount tonalite, quartz-syenite and syenite. All granitoid rocks show Ba, K, Rb enrichment, and Nb, Sr, Ti depletion.

From the economical potential point of view, mineralization of marble, Fe-Cu-Pb-Zn skarn and non-metalic minerals such as kaolinite are considerable.

Geothermobarometry of rock forming minerals of this pluton indicates temperature of 810- 985 ˚C and pressures of 2.43 – 6.2 kilobars (kbar).

Keywords: *Granitoid, Granite, Diorite, Mineralization, Geothermo-barometry.*

1. Introduction

Khezr-Abad pluton is situated in Nw of Taft (Central Iran), With a 53˚:30´ to 54˚:20´eastern longtitude and 31˚:30´ to 31˚:52´ northern latitude (Fig. 1).

With respect to existance of younger plutonic rocks (eg. Khezr-Abad) than shir-kuh pluton in central Iran, the aim of this study is to indicate: relative ageing, chemical compositions and geothermobarometry of related rocks and minerals.

Granitoid rocks were intruded into volcanic rocks (Eocene) and cretaceous limestones (Taft Formation). With respect to the metamorphosed cretaceous limestones and skarn formation, the age of the plutonism of the area are younger than Cretaceous and Eocene (Oligo-Miocene). On the basis of structural sedimentary units division of Iran [1], the pluton is located within the central-Iran zone.

Using discriminant diagrams of Maniar&Piccoli [2], granitoids could be generally divided into three groups: 1-CCG [1], CAG[2] and IAG[3] 2-RRG[4] and CEUG[5], and 3-POG[6].

With this respect the granitoids are post-orogenic and syn-orogenic. From the economical point of view, mineralization of marbles, Fe-Cu-Pb-Zn skarn and non-metalic minerals such as kaolinite are mentionable. Pegmatites in relation to the plutonic rocks are rare with lack of economical value.

2. Method of Study

In order to undertake, mineralogical and geochemical studies and determination of pressure and temperature (P&T) conditions of pluton, dense sampling and field works considerations were made and 17 samples of plutonic rocks were selected for major and trace elements analyses by XRF. In addition, some component minerals of plutonic rocks studied by Electron Probe Micro Analysis method (EPMA)[*] [at New Brownswick university, Canada, [1998]], and on this basis, P-T conditions of crystallization was estimated. P-T conditions of plutonic emplacement also were calculated, using different geothermobarometers.

[1] Continental collosion Granitoids
[2] Continental Arc Granitoids
[3] Island Arc Granitoids
[4] Rift - related Granitoids
[5] Continental Epirogenic Uplift Granitoids
[6] Post Orogenic Granitoids
[*] Name and conditions of instrument:
JEOL superprobe 733 Wavelength Dispersive Spectroscopy (WDS).
Beam current, 10 mA, 15 Kev, Count time, 60 seconds.

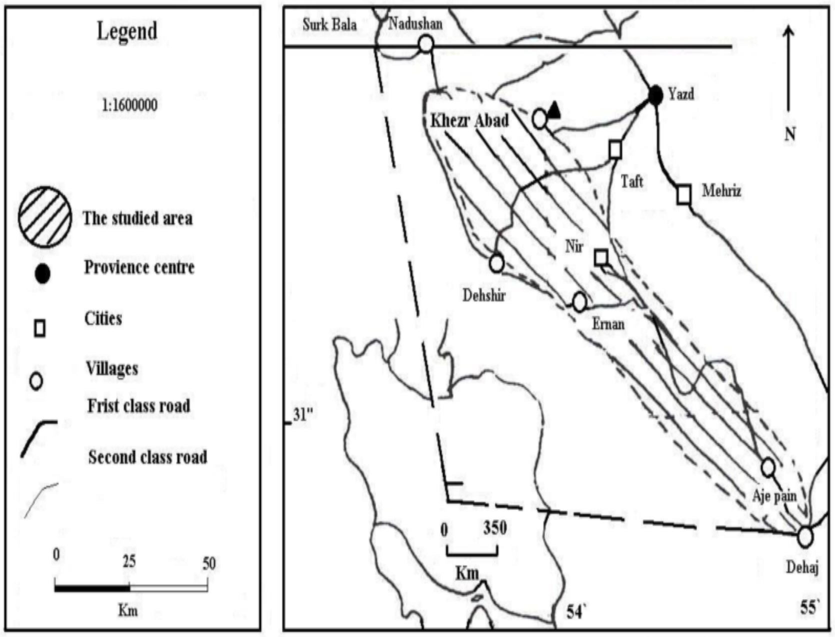


Fig. 1 Geographical position of granitoid of Khezr-Abad (NW, Taft, central Iran). ▲: Khezr-Abad

3. Petrography and Mineralogy

Khezr-Abad pluton consist of different ellipsoidal and spherical dark xenoliths, acidic and doleritic daykes, veins of aplite and pegmatite were seen within the granites. Small volcanic masses such as dacite, rhyodacite doms, trachytic and andesitic tuffs and lavas and rarely basaltic-andesite in contact with granites and close to the faults (particularly Dehshir–Baft fault with a trend of NW-SE) are reported. The granitoid rocks under study in area are, granodiorite, granite, quartz monzo-diorite, quartz-diorite, and in a lesser amount tonalite, quartz-syenite and syenite.

Texture of granitoid rocks are granular, granophyric (graphic), perthite, anti-perthite and sieve textures. The graphic textures indicate eutectic or cotectic crystallization of quartz and alkali-feldspars. Table 1 shows chemical analysis of plutonic rocks.

Table 1 Chemical analysis of plutonic rocks of Khezr-Abad by XRF method. Oxides (wt%), traces (ppm).

Oxides/ No.Sample	SiO_2	Al_2O_3	CaO	K_2O	Fe_2O_3	FeO	Na_2O	MgO	TiO_2	P_2O_5	MnO	Total
gk1	69.10	13.89	2.85	3.84	1.88	1.26	3.61	1.3	0.38	0.11	0.064	98.31
gk8	67.65	13.89	3.38	3.51	1.9	1.2	3.47	1.38	0.4	0.125	0.061	96.96
gk12	66.54	13.97	3.55	3.68	2.00	1.52	3.46	1.42	0.45	0.141	0.07	98.8
gk14	58.24	15.13	6.37	1.94	2.41	5.52	3.98	3.65	0.86	0.26	0.19	98.55
gk18	68.63	13.96	3.53	3.69	1.99	1.53	3.46	1.42	0.44	0.143	0.086	98.86
gk22	74.77	13.08	0.26	3.86	0.86	-	4.88	0.28	0.18	0.114	0.008	98.29
gk25	62.39	15.25	3.37	8.21	1.99	1.18	2.96	1.39	0.49	0.173	0.088	97.49
gkc17	69.15	13.87	2.86	3.88	1.89	1.26	3.60	1.29	0.39	0.114	0.063	98.37
AD6	56.10	13.73	7.38	2.26	2.49	6.13	2.67	4.16	0.99	0.265	0.169	96.34
AD10	74.06	13.57	0.84	6.13	0.98	-	3.20	0.22	0.08	0.027	0.013	99.12
AD12	73.29	13.28	0.86	2.96	1.69	0.74	4.44	0.57	0.19	0.064	0.024	98.10
AD14	62.12	15.94	5.31	2.90	2.04	2.74	3.16	2.04	0.54	0.16	0.084	97.04
AD15	60.38	15.82	6.5	2.28	2.36	4.2	3.49	3.31	0.81	0.26	0.128	99.54
AD26	59.7	13.98	7.18	2.11	2.37	4.81	2.71	3.04	0.81	0.21	0.124	97.04
AD27	62.1	14.57	5.65	2.91	2.24	3.86	2.93	2.92	0.7	0.185	0.112	98.08

Table 1(cont.)

AD39	AD37
57.65	58.47
14.46	13.76
6.12	10.12
2.73	6.87
2.54	2.21
5.72	3.29
2.92	1.18
3.86	1.78
1.01	0.67
0.25	0.159
0.16	0.186
97.42	98.66

Table 1 (cont.)

AD14	AD12	AD10	AD6	gkc17	gk25	gk22	gk18	gk14	gk12	gk8	gk1	Trace.E/ No.sample
152	65	56	141	136	157	105	145	175	144	126	137	**Zr**
290	106	48	296	173	280	25	195	200	199	183	175	**Sr**
103	130	188	94	150	193	110	131	125	134	138	146	**Rb**
11	7	21	20	16	16	9	18	15	18	14	18	**Pb**
58	23	13	108	31	30	10	42	73	41	36	32	**Zn**
33	6	4	40	7	15	1	9	19	8	0	8	**Cu**
5	3	4	9	10	4	0	11	10	10	0	10	**Ni**
40	84	28	49	46	11	14	44	83	44	50	45	**Ce**
34	27	20	28	29	8	28	8	43	9	17	31	**Nd**
51	48	39	56	48	42	32	38	71	37	46	48	**Nb**
965	144	142	618	390	467	661	675	761	671	351	388	**Cl**
19	44	57	31	52	19	22	37	25	36	36	50	**La**
8	24	41	7	16	5	22	14	7	13	11	17	**Th**
114	183	0	390	119	131	460	395	650	405	44	114	**F**
91	29	16	175	56	58	12	59	123	58	59	55	**V**
70	6	81	34	102	8	0	66	41	68	62	103	**Cr**
431	155	60	341	503	960	269	523	299	525	460	499	**Ba**

Table 1 (cont.)

AD15	167	328	87	23	81	12	12	57	14	55	515	36	10	350	122	59	497
AD26	142	321	66	22	73	37	9	42	21	54	864	13	7	771	160	21	406
AD27	150	278	93	19	71	26	9	61	17	45	755	18	9	737	132	67	408
AD37	175	255	177	100	96	27	3	84	33	49	210	15	11	685	112	18	632
AD39	143	315	116	14	84	9	7	37	27	60	560	33	11	321	141	17	352

On the basis of modal classification [3] and Q-P diagram [4], rocks of the area are mainly granodiorite (gk14, gk18, AD10, AD12, AD14, AD15, AD26, AD27), granite (gk1, gk22, gkc17), quartz-monzodiorite (gk12), quartz-diorite (gk25, AD22), and to a lesser amount tonalite (gk 8), syenite (AD37) and quartz-syenite (AD39) (Figs. 2 and 3).

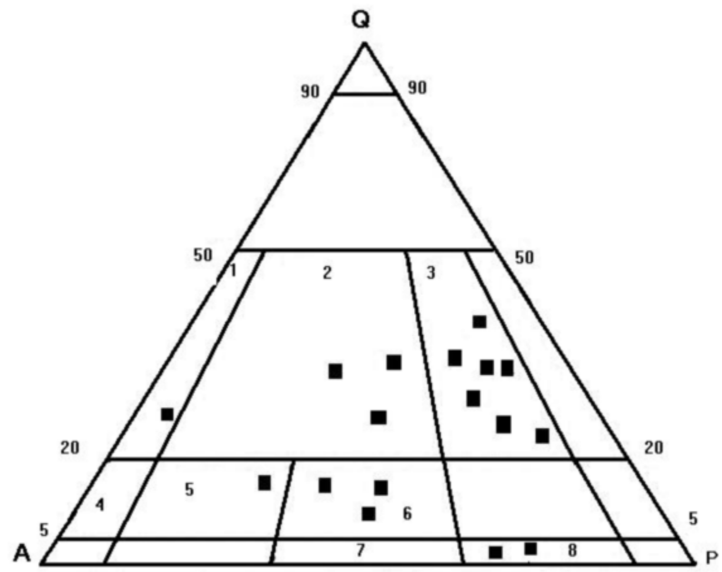


Fig 2 Streckeisen diagram (1982) Showing plot of igneous rocks of the studied area.
1- Alkali feldspar granite 2- Granite 3- Granodiorite
5- Quartz-syenite 6- Quartz-monzonite 8- Monzo- diorite

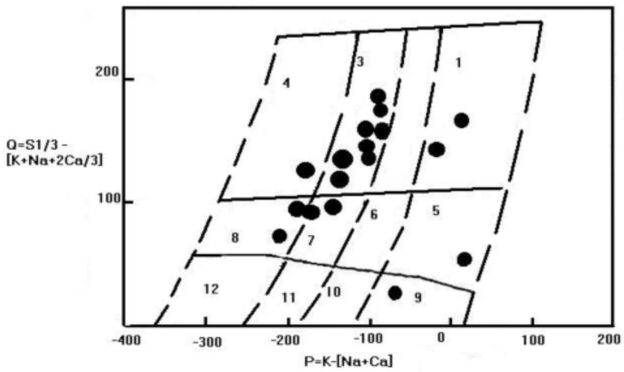


Fig. 3 Q-P diagram after Debon& Lefort [4], Showing plot of igneous rocks of the studied area. 1- Granite, 3- Granodiorite, 4- Tonalite, 5- Quartz-syenite, 7- Quartz-monzo diorite, 8- Quartz-diorite, 9- Syenite.

Minerals of intrusive rocks are quartz, plagioclase (albite, oligoclase and andesine), orthoclase, pyroxene, amphibole and mica (biotite and to a lesser amount muscovite). Minor mineral constituents of these rocks are apatite, zircon (as inclusions in biotite), sphene, tourmaline, spinel (hercynite), hematite and magnetite. The above minerals are firstly distinguished under the microscope, then by XRD method and finally by EPMA method which are described as the following.

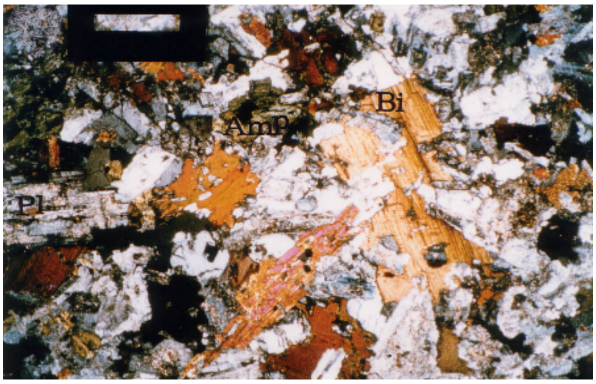
3.1. Pyroxenes

Pyroxenes in plutonic rocks are of diopside and augite types. Aegirine-augite pyroxene in some more sodic magmatic rocks are found. According to minerals nomenclature presented by Morimoto [5], the pyroxens are of calcic type (diopside, augite), (Fig. 4). Table 2 shows chemical analysis of pyroxenes. Photomicrograph No. 1 shows a microscopic view of minerals in a granitic rock of the area.

Table 2 Representatives of pyroxene minerals.

Rock	Mineral	SiO_2	TiO_2	Al_2O_3	MgO	CaO	Cr_2O_3	MnO	FeO_t	Na_2O	K_2O	F	Cl	Total
Gk17	CPX	56.45	0.07	2.5	22.6	13.38	0.08	0.06	3.77	0.7	0	-	-	99.61
AD34	CPX	53.46	0.12	0.09	19.21	25.58	0	0.18	1.28	0	0	-	-	99.92
Gk14	CPX	50.45	1.56	6.98	16.09	11.41	0.14	0.43	11.2	1.64	0	-	-	99.9

GK14, GK17: Granodiorite AD34: Quartz–monzodiorite



Photomicrograph 1 showing amphibole, biotite and plagioclase crystals in granitoid rocks. Length of marker is 5 mm. Amphibole= Amp, Biotite= Bi, Plagioclase= PL.

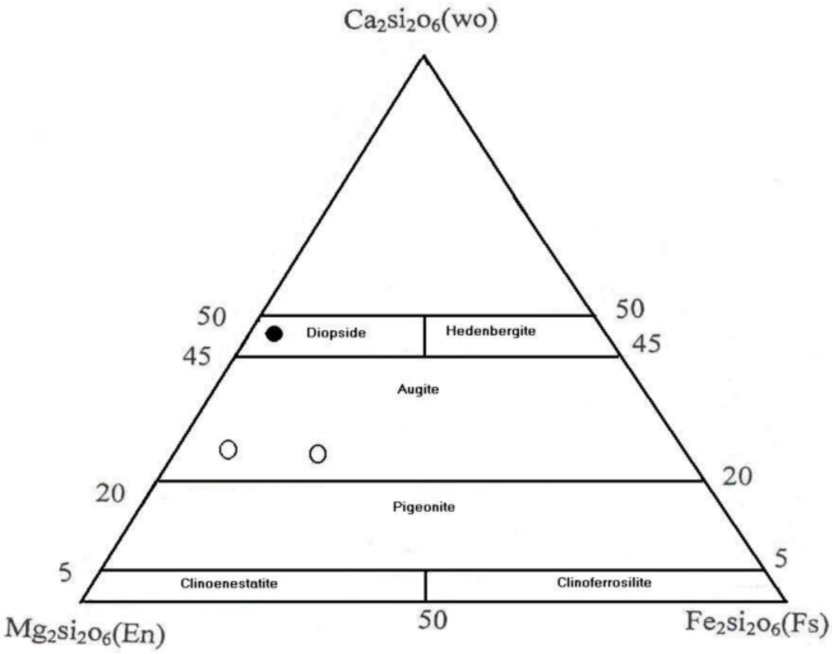
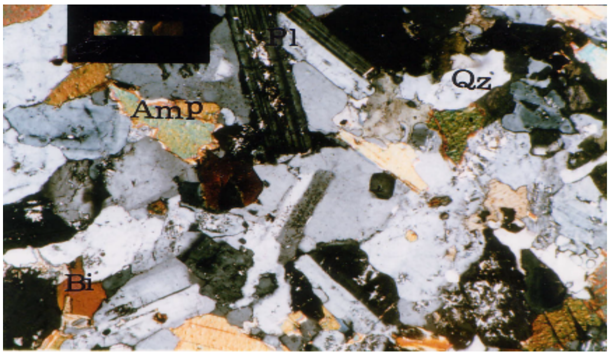


Fig. 4 Field of Ca , Mg and Fe CPX, according to ref. **[5]**.

3.2. Amphiboles

Amphiboles in granitoid rocks coexist with pyroxene (augite), plagioclase, mica (biotite), orthoclase and oxides. Amphiboles in these rocks are actinolite (in granodiorite and granite), edenite (in andesite), and magnesiohornblende (in granodiorite and quartz-diorite) types. Photomicrograph No. 2 shows a view of a thin section of a plutonic rock.



Photomicrograph 2 showing crystals of amphibole, biotite, plagioclase and quartz within the granitoid rocks. Length of marker is 5 mm. Amphibole= Amp, Biotite= Bi, Plagioclase= Pl, Quartz= Qz.

According to Leake [6], amphiboles within the granitoid rocks are mainly of calcic type, actinolite, edenite, magnesiohornblende which is shown in Fig. 5. Table 3 shows EPMA results of some amphiboles from granitoid rocks of Khezr-Abad.

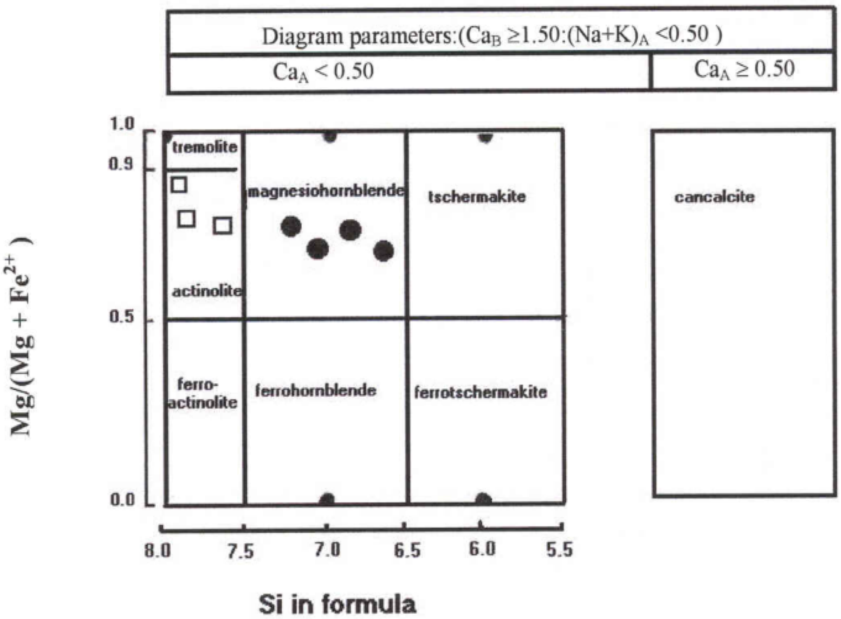


Fig. 5 Classification of calcic amphiboles (after Leake, [6]). Amphiboles are of actinolite and magnesiohornblende types.

• In granodiorite and quartz-diorite (AD14, AD22).

□ In granodiorite and granite (gk18, gk1).

Table 3 Chemical analysis of amphiboles by EPMA method. Cations calculation is on the basis of 23 (O, F, Cl).

Amphibole	Actinolite			Actinolite			Magnesiohornblende			Magnesiohornblende		
No	**Gk$_l$**			**gk$_{18}$**			**AD$_{14}$**			**AD$_{22}$**		
Oxides	**(wt) %**	**Cations**		**(wt) %**	**Cations**		**(wt) %**	**Cations**		**(wt) %**	**Cations**	
SiO_2	54.01	S I	7.921	51.9	S i	7.757	47.13	S i	7.3	48.34	S i	7.29
T_1O_2	0.29	A14	0.079	0.53	A14	0.243	0.38	A14	0.69	1.02	A14	0.706
$A1_2O_3$	8.3	A16	1.349	7.48	A16	1.069	7.54	AI'	0.66	8.81	A16	0.85
FeO_t	11.41	Ti	0.032	13.52	Ti	0.059	16.18	Ti	0.43	15.32	Ti	0.115
MnO	1.19	Fe	1.393	0.92	Fe	1.689	0.91	Fe	2,09	0.89	Fe	1.93
MgO	10.66	Mg	2.328	11.07	Mg	2.463	11.91	Mg	2.74	11.85	Mg	2.65
CaO	10.68	Mn	0.147	11.29	Mn	0.107	11.25	Mn	0.12	11.3	Mn	0.11
Cr_2O_3	0.01	Ca	1.675	0.01	Ca	1.806	0.1	Ca	1.86	0.01	Ca	1.82
Na_2O	1.5	Cr	0.001	0.81	C r	0.001	1.39	C r	0.012	1.41	Cr	0.011
K_2O	0.38	Na	0.423	0.49	Na	0.233	0.44	N a	0.409	0.19	Na	0.411
F	0.28	K	0.07	0.31	K	0.089	MI	K	0.085	0.12	K	0.036
Cl	0.09	F	0.123	0.09	F	0.143	0.09	F	0.149	0.05	F	0.057
Total	98.8	C 1	0.022	98.42	C 1	0.022	97.63	C 1	0.023	99.31	C 1	0.012

3.3. Micas

Micas in the magmatic rocks of the area are brown biotites and within the metamorphic rocks (skarns) are phlogopite. These are confirmed by EPMA analysis. Biotites and phlogopites show a wide range of variations in Al and Mg contents, Al_2O_3 (wt %) variations are from 15.38% in biotite to 18.16% in phlogopite, MgO also varies from 6.14% in biotite to 25.25% in phlogopite. The results of four selected samples from biotite are presented in Table 4.

Table 4 EPMA results of biotite from the granitoid rocks. Cations calculation is based on 23 (O , F, Cl).

Mica	**Biotite**			**Biotite**			**Biotite**			**Biotite**		
No	**gk$_l$**			**gk$_{18}$**			**AD$_{14}$**			**AD$_{22}$**		
Oxides	**(wt) %**	**Cations**		**(wt) %**	**Cations**		**(wt) %.**	**Cations**		**(w t) %**	**Cations**	
SiO_2	35.41	Si	5.855	35.08	Si	5.877	35.47	Si	5.861	36.4	Si	5.99
TiO_2	2.73	$A1^4$	2.145	1.82	$A1^4$	2.123	2.72	Al^4	2.139	3.23	$A1^4$	2.01
Al_2O_3	17.41	Al^6	1.235	17.13	Al^6	1.258	17.27	Al^6	1.218	15.38	Al^6	0.96
FeO_t	20.57	Ti	0.338	24.05	Ti	0.231	22.21	Ti	0.337	19.87	Ti	0.396
MnO	0	Fe	2.843	0.72	Fe	3.371	0	Fe	3.069	0	Fe	2.732
MgO	7.94	Mn	0	6.14	M n	0.101	7.02	Mn	0	9.65	Mn	0
CaO	0	Mg	1.948	0	Mg	1.530	0	Mg	1.728	0	Mg	2.366
Na_2O	0	Ca	0	0.3	C a	0	0	Ca	0	0	Ca	0
K_2O	9.94	Na	0	9.81	N a	0.101	9.86	Na	0	9.74	Na	0
F	1.28	K	2.087	1.92	K	2.093	1.35	K	2.066	1.21	K	2.039
C1	0.09	F	0.666	0.74	F	1.016	0.02	F	0.705	0.05	F	0.623
BaO	0.26	C1	0.0248	0	C1	0.211	0.38	C 1	0.0055	0.25	C1	0.0138
Total	95.63	Ba	0.0159	97.71	Ba	0	96.3	Ba	0.023	95,78	Ba	0.0158

3.4. Plagioclases

Magmatic rocks of the area , both volcanic and plutonic include plagioclases. Quartz is the first and plagioclase is the second in the order of abundances in both volcanic and plutonic rocks of the area. Seventeen plagioclases are analysed by EPMA. The result is shown in Table 5. Plagioclases are oligoclase to andesine in the acidic and intermediate rocks and labradorite in the basic rocks.

Plagioclases have been analysed from core to rim. Some of them showing oscillatory and reverse zoning, which may be as a result of variations in physical conditions (variations in partial pressure of water vapour (H_2O) and temperature [7]. In some cases anorthite content of plagioclase decrease from core to rim, but suddenly increase in rim. This may be occur as a result of variations in chemical composition of magma. Increasing of Ca content of magma may be occur as a result of assimlation of limestone by magma during rising to the surface.

Table 5 EPMA results of plagioclases from granitoid rocks. Cations calculation is based on 32 Oxygens.

Plagioclase		**Oligoclase**	**Oligoclase**	**Andesine**	**Andesine**	**Oligoclase**	**Oligoclase**	**Oligoclase**	**Oligoclase**	**Andesine**	**Andesine**
No		gk_1	gk_1	gk_{18}	gk_{18}	gk_{18}	gk_{18}	AD_{14}	AD_{14}	AD_{22}	AD_{22}
Oxides		(c)	(r)		(c 1)	(C2)	(r)	(c)	(r)	(c)	(r)
SiO_2		60.95	62.23	60.06	56.3 1	60.8	60.38	61.64	61.25	58.87	60.24
TiO_2		0	0	0	0	0	0	0	0	0	0
Al_2O_3		24.69	24	25.73	27.12	24.31	25.43	24.76	24.79	27.55	25.55
FeO_t		0.08	0.09	0.17	0.15	0	0.09	0.06	0.08	0.21	0.19
MgO		0	0	0	0.06	0	0	0	0	0	0
CaO		5.12	4.53	6.29	8.01	4.79	5.91	5.19	5.09	8.95	6.41
Na_2O		8.36	8.75	7.67	7.48	8.91	7.93	8.63	8.52	6.14	7.82
K_2O		0.35	0.47	0	0.17	0.32	0.38	0.17	0.36	0.15	0.11
Total		99.55	100.1	99.92	99.32	99.13	100.1	100.5	100.1	101.9	100.3
cations											
Si		10.87	11.036	10.844	10.204	10.902	10.737	10.887	10.873	10.337	10.696
Al		5.188	5.006	5.476	5.793	5.133	5.325	5.162	5.185	5.702	5.337
Fe		0.01	0.01	0.022	0.0217	0	0.0128	0.0088	0.011	0.03	0.027
Mg		0	0	0	0.015	0	0	0	0	0	0
Na		2.894	3.003	1.768	2.61	3.084	2.716	2.952	2.923	2.09	2.69
Ca		0.975	0.852	1.215	1.546	0.916	1.122	0.977	0.96	1.678	1.216
K		0.0857	0.106	0	0.0217	0.071	0.085	0.038	0.081	0.033	0.023
Mol percent	**Ab**	7118	75.82	59	62.48	75.75	69.23	74.41	73.74	54.98	68.46
	An	24.65	21.52	41	37	22.5	28.60	24.63	24.22	44.15	30.95
	Or	2.17	2.67	0	0.52	1.75	2.17	0.96	2.04	0.87	0.59

3.5. Feldspars

Basically feldspars are of a series of solid solutions between $KAlSi_3O_8$ and $NaAlSi_3O_8$ with a little amount of $CaAl_2Si_2O_8$. In general anorthite content is less than 5% for a composition between $Or_{100}Ab_0$ to $Or_{60}Ab_{40}$, but in Na end-members it is a little higher. Alkali feldspars also like plagioclase is a main constituent of granitoid rocks. Alkali feldspars are of orthoclase, microcline and albite type. Six samples of feldspars were analysed by EPMA, which are presented in Table 6.

Table 6 EPMA results of alkali feldspars from plutonic rocks . Cations calculation is based on 32 Oxygens.

Alkali feldspar	**orthoclase**	**microcline**	**Albite**	**orthoclase**	**orthoclase**	**orthoclase**
No	gk_1	gk_{18}	gk_{18}	Gk_{18}	AD_{14}	AD_{22}
Oxides		**(1)**	**(2)**	**(3)**		
SiO_2	64.02	65.32	67.3	63.9	63.1	63.25
TiO_2	0.07	0	0	0.09	0	0
$A1_2O_3$	19.22	19.11	21.11	18.87	18.14	18.27
FeO_t	0.05	0	0	0.08	0,04	0.12
MgO	0	0	0	0.07	0.06	0.06
CaO	0.66	0	0.49	0.6	0.52	0.83
Na_2O	3.11	1.59	10.01	3.4	2.55	3.68
K_2O	12.61	14.32	1.26	12.75	12.81	12.94
BaO	0	0	0	0.28	0.53	0.07
Total	100.19	1	100.17	100.04	97.85	99.3
	Cations					
Si	11.779	11.937	11.774	11.787	11.902	11.785
AI	4.158	4.118	4.3 52	4.102	4.012	4.01
Fe	0.0076	0	0	0.011	0.0062	0.0179
Ti	0.0088	0		0.012	0	0
Mg	0	0	0	0.018	0.015	0.015
Na	1.106	0.560	3.396	1.197	0.929	1.321
Ca	0.121	0	0.095	0.110	0.104	0.165
K	2.942	3.338	0.284	2.994	3.06	3.069
BaO	0	0	0	0.011	0.038	0.005
Mol. percent Or	70.57	85.63	7.52	69.61	74.76	67.38
Mol. percent Ab	26.53	14.37	89.96	27.83	22.70	29.00
Mol. percent An	2.90	0	2.52	2.56	2.54	3.62

3.6. Oxides

Oxide minerals of magmatic rocks consist of ilmenite, magnetite, hematite, corundum, spinel and ulvospinels. In order to do geothermometry the results indicate that they contain some geikielite ($MgTiO_3$) and with a lesser amount pyrophanite ($MnTiO_3$) , Table No. 7.

Table 7 EPMA results of oxides from granitoid rocks. Cations calculation is based on 6 Oxygens for ilmenite and 32 Oxygens for magnetite.

Iron oxide	Mag.	Mag.	Mag.	Mag.	Ilm.	Ilm.	I1m.	I1m.
No	Gkl	Gk_{18}	AD_{14}	AD_{22}	Gk_1	Gk_{18}	AD_{14}	AD_{22}
Oxides								
TiO_2	2.8	10.74	2.41	0.34	50.15	49.29	47.9	49.12
SiO_2	0.03	0	0.07	0.04	0.02	0.05	0	0
FeO_t {FeO	28.3	77.86	26.73	30.69	38.8	37 .78	38.96	39.25
Fe_2O_3	68.12	6.21	69.09	68.28	3.67	4.98	2.31	2.08
Cr_2O_3	0.09	0.43	0.19	0.07	0.05	0.05	0.07	0.05
$A1_2O_3$	0.1	2.02	0.09	0.07	0	0.31	0.19	0.1
V_2O_3	0.38	0	0.28	0.29	0.16	0.24	0.12	0.09
MnO	0.25	0.22	0.91	0.26	7.22	6.21	7.14	7.09
MgO	0.06	2.14	0.04	0.04	0.12	1.45	3.23	2.14
CaO	0	0.12	0	0	0.05	0.09	0.08	0.05
Total	100.13	99.74	99.81	100. 8	100.32	100.42	100	99.97

cations

Ti	0.626	2.899	0.546	0.077	1.905	1.856	1.821	1.842
Si	0.0087	0	0.02	0.012	0.001	0.0025	0	0
Fe {Fe^{2+}	7.034	23.453	6.77	7.88	1.643	1.582	1.647	1.638
Fe^{3+}	15.251	0.261	15.74	15.77	0.139	0.186	0.085	0.078
Cr	0.0214	0.129	0.043	0.016	0.002	0.0019	0.0028	0
Al	0.35	0.865	0.032	0.025	0	0.018	0.01	0.059
V	0.089	0	0.065	0.07	0.0064	0.0096	0.0048	0.0036
Mg	0.026	1.146	0.018	0.018	0.0088	0.106	0.243	0.159
Mn	0.0626	0.064	0.218	0.066	0.306	0.263	0.305	0.297
Ca	0	0.043	0	0	0.0027	0.0048	0.0043	0.0026

4. Geothermobarometry

The propose of geothremobarometry is to determine pressure and temperature (P&T) conditions of formation of rock [8]. During the past twenty years, laboratory experiments, thermodynamical models, calcultions, and analytical works by EPMA have provided a better situation to understand the P-T conditions of formation of minerals. One of the methods to indicate pressure of mineral crystallization in plutonic rocks is hornblende geobarometry [9]. According to this method, using this formula, p (±3 kbar) = -3.92 + 5.03 Al^T , hornblendes in calc-alkalic rocks were crystallized under pressure of 2.28-6.33 kbar in the khezr-Abad pluton. The above calculated results are compared with results obtained by method of Johnson& Rutherford [10] , using the formula, P (±0.5 kbar) = -3.46 + 4.23 Al^T, where Al^T is the total aluminum content reported as cations per 23 Oxygens formula unit. Typical hornblendes of dioritic rocks and other intermediate calc-alkaline rocks have a relative amount of X= Mg/(Mg+Fe) close to 0.5, such a hornblendes have 1.5 Al atom in formula unit based on 23 Oxygens [11].

The above mentioned factor in hornblende bearing rocks of the studied area varies between 0.56-0.57 indicating and confirming calc-alkaline characteristics of them. To indicate pressure and temperature conditions of minerals and magmatic crystallization can be used Ab and An fractions of plagioclases and Ab and Or fractions in alkali-feldspars. In this order the following formulas and method were used [12, 13]:

$KD= X^{pl}{}_{ab}\,(ab+an)/X^{kf}{}_{ab}(ab+or)$

$Lnp= 11.2\ LnKD-12.3$

$T^{\circ C}= 2080/(LnKD-0.091\ Lnp+ 1.16)$

$$P=\exp\ \{[\frac{LnKD-\left(2080/T+1.16\right)}{0.091}]\}$$

According to the above method, the temperatures of 900–920 °C are obtained for Khezr-Abad intrusive rocks. The magmatic pressure conditions for Khezr-Abad intrusive are 2.43 to 5.58 kbar. In addition to the above method, the method of Haselton et.al. [12] , also is used.

$$T^{\circ C}=\frac{\left|\left(x^{kf}{}_{or}\right)^2\left(18810+17030X^{Kf}{}_{ab}+0.346p\right)-\left(X_{an}^{PI}\right)^2\left(28230-39520X_{ab}^{PI}\right)\right|}{10.3\left(X_{or}^{kf}\right)^2+8.314Ln[\left(X_{ab}^{PI}\right)^2(2-X_{ab}^{PI}/X_{ab}^{kf}]}$$

With this respect the temperaturs of 810 to 867 °C are calculated for crystallization of feldspars of intrusive rocks. In addition to the thermometers mentioned above plagioclase-liquid geothermometry method also is used to identify magmatic condition temperatures.

4.1. Plagioclase-liquid geothermometry

This method is based on the equilibrium between the two phases. These two phases are rim of plagioclase crystal and the remaining liquid surrounding it. The calculated temperatures using this method are in the order of 805 to 837 °C .

5. Physical conditions of crystallization in granitic magmas

By study of chemical composition of clinopyroxenes and amphiboles, it is possible to find out the amount of water vapour pressure and approximate percentage of water in magmas [14, 15, 16, 17 and 18].

On the basis of tetrahedral Al amounts in amphiboles against silica content of rock (Fig. 6), in addition to conditions of variations of water vapour pressure, magmatic amphiboles of Island-Arcs and continental active margins are recognizable from each other. According to (Fig. 6) magmatic amphiboles of the studied area are originated from magmas of continental active margins.

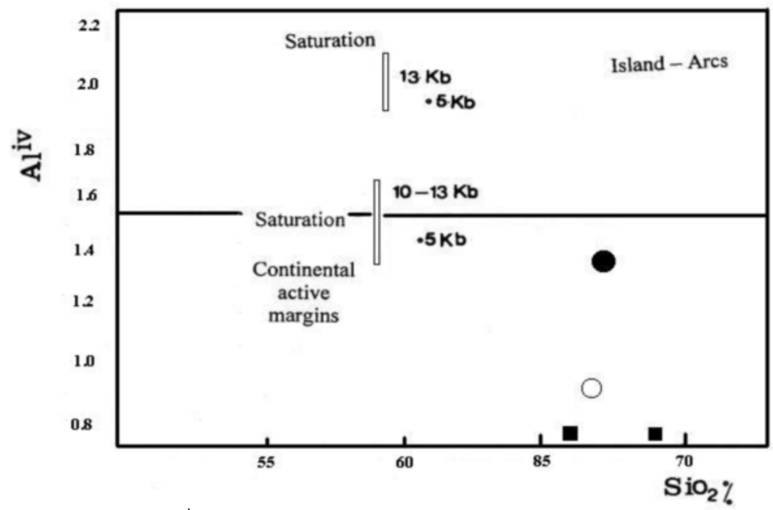


Fig. 6 Limit of [Al^{iv}] = 1.5 allows which amphiboles and therefore magmas of Island arcs are being recognaized from amphiboles and magmas of continental active margins (the case in the study area) [18]. Open bars showing range of variations of syntetic amphiboles under, pressures of 5 kbar [14].

o: Quartz-diorite. ■ : Granite. • : Granodiorite.

6. Discussion and conclusions

Plutonic rocks of Khezr-Abad are intruded into the Taft limestones. Strong evidence to confirm this matter comes from the occurence of skarn formation in the limestones. Petrographic evidence show that metamorphic phenomena including recrystallization of limestones and tuffs, results in formation of marbles and skarn. Electron microprobe studies of minerals show that Fe-Mg minerals (pyroxene, amphibole, micas) are Mg rich.

Temperature and pressure indentification of plutonic rocks emplacement are based on different methods. The obtained temperatures and pressures are from 810 – 867 °C and 2.43 to 5.58 kbars respectively.

General conclusions are as the following:

1- With respect to petroghraphy, the studied granitoids show a wide varieties, ranging from diorite to alkali-granite, indicating differentiation process in generation of the rocks .
2- The host-rocks were cretaceous limestones, and have changed to skarn. Main minerals of the skarn are diopside, garnet (andradite), phlogopite, scapolite, talc and serpentine.

3- Known textures in magmatic rocks are granular, granophyric (graphic), perthite, anti-perthite and sieve textures. The graphic textures indicate eutectic or cotectic crystallization of quartz and alkali-feldspars .
4- The essential minerals of granitoids consist of quartz, plagioclase (albite, oligoclase and andesine), orthoclase, mica (biotite and with a lesser amount muscovite). Plagioclases show zoning. This phenomen indicates rapid depressing and thermodynamical and chemical variations of crystallization environment .
5- Textural (perthite and granophyric), mineralogical (zoned texture of plagioclases), chemical (range of SiO_2 variations), low K/Na ratio, high Ca content, lack of aluminum minerals and muscovite evidences, and the presence of intermediate therms such as diorite and granodiorite all suggest a nature for the granitoids .
6- The results of EPMA analyses of pyroxenes show that they are high calcic, and of augite and diopside types.
7- On the basis of $Mg/(Mg + Fe^{2+})$ and Si, amphiboles of magmatic rocks are magnesiohornblende and actinolite.
8- According to EPMA studies, micas are biotite in plutonic rocks and phlogopite in metamorphic rocks .
9- Plagioclases in plutonic rocks are mostly oligoclase - andesine , and alkali feldspars are orthoclase, microcline or perthitic orthoclase or microcline and albite.
10- With regard to $X^{pl}{}_{ab}$ (ab + an) ratios, it is suggested that rocks were crystallized at moderate to low depths of the crust .
11- Geochemical analysis and geothermobarometry studies indicate a pressure and temperature of 2.43-5.5 kbars and 810–867 °C respectively.
12- With respect to broad presence of perthite and anti-perthite textures and plagioclase-liquid geothermobarometry studies, the water vapour pressure in the intrusive masses are probably 1 to 2 kbar .
13- Plot of Al^{iv} against SiO_2 on the diagram shows that amphiboles of magmatic rocks of the studied area related to magmas of continental active margins .

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