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Classification of Granitoids from the Golpayegan Area on the Basis of the Tectonic Setting

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Abstract: Granitoid masses of the Golpayegan area from structural zones classification are considered within the Sanandaj-Sirjan zone. According to tectonic settings of granitoids various patterns are used for tectonic discrimination of granitoids. Based on geological, lithological and petrological evidences and also major and trace elements chemistry, various discrimination plots are applied. Based on Shand's index, most studied samples plot within the field of Continental Collision Granitoids (CCG) field. By utilizing the multication diagram of R_1-R_2, the granitoids samples from north of the Varzaneh and the Saeid-Abad often fall into the syn-collision field and few fall into the late orogenic field. Considering geochemical patterns and trace element-SiO_2 plot, these granitoids are mostly syn-collisional granites (syn-COLG) and volcanic Arc Granites (VAG). The relationship between the evolution of the Neo-Tethys and the magmatic events include geochemical studies, fabric elements and radiometric dating of the mylonitic granites in the Golpayegan area will be guide in the studied area. The main objective of this study is to evaluate the tectonic setting of granitoids from north of the Golpayegan, which can help to determine the geodynamic environment of the area and ultimately the Sanandaj-Sirjan Zone. The results indicate that granitoids of the Golpayegan are mostly CCG or syn-COLG types that were formed at the end of orogenic events synchronous with the end of deformations and collision of the Arabian plate with the Iranian plate at the Paleocene.

Key words: Tectonic setting, discrimination granitoids, Golpayegan area

INTRODUCTION

In this study, the granitoids from north of the Golpayegan consist of mylonitic granite from north of the Varzaneh and monzogranite and alkali feldspar granite from north of the Saeid-Abad village. These masses based on structural analysis were solely investigated by Saba (2000) and base on radiometric dating were studied by Rachidnejad-Omran (2002) and Moritz *et al.* (2006).

There are different ideas about the closure time of the Neo-Tethys in the southwest of Iran. Berberian and King (1981) believed that the Neo-Tethys Ocean was closed by the end of Cretaceous (60-70 Ma). But (Mohajjel *et al.*, 2003) believe that Continental collision in the Sanandaj-Sirjan Zone reached a climax in the Miocene after opening of the Red Sea and the Gulf of Aden. In this study, we present new geochemical data of the granitoids from the Golpayegan area to constrain magma sources and evolution, to determine the tectonic setting of the granitoids in the Sanandaj-Sirjan Zone and to shed light on this period of the Alpine history and related magmatism in Iran.

GEOLOGICAL SETTING

The Zagros fold and thrust belt of SW-Iran is one of the continental collision zones. This orogenic belt (Fig. 1) consists of four NW-SE trending parallel zones: (1) Urumieh-Dokhtar Magmatic Assemblage, (2) Sanandaj-Sirjan Zone, (3) High Zagros and (4) Zagros Simply folded belt (Alavi, 1994).

The Permian-Triassic extension is then produced the oceanic crust of the Neo-Tethyan basin to the northeast of the present High Zagros Belt (Ricou, 1994). The subduction process started in the late Jurassic (Stampfli and Borel, 2002). According to Mohajjel and Fergusson (2000), the Sanandaj-Sirjan Zone of western Iran is a metamorphic belt (green schist-amphibolites), that was uplifted during Late Cretaceous continental collision between the Afro-Arabian continent and the Iranian micro continent and extends for 1500 km along strike from the northwest Sanandaj, to the southeast Sirjan in the western part of Iran and has a width of 150-200 km (Fig. 1).

Upper Cretaceous greenschist metamorphism and felsic granitoid plutons along the Sanandaj-Sirjan mark the

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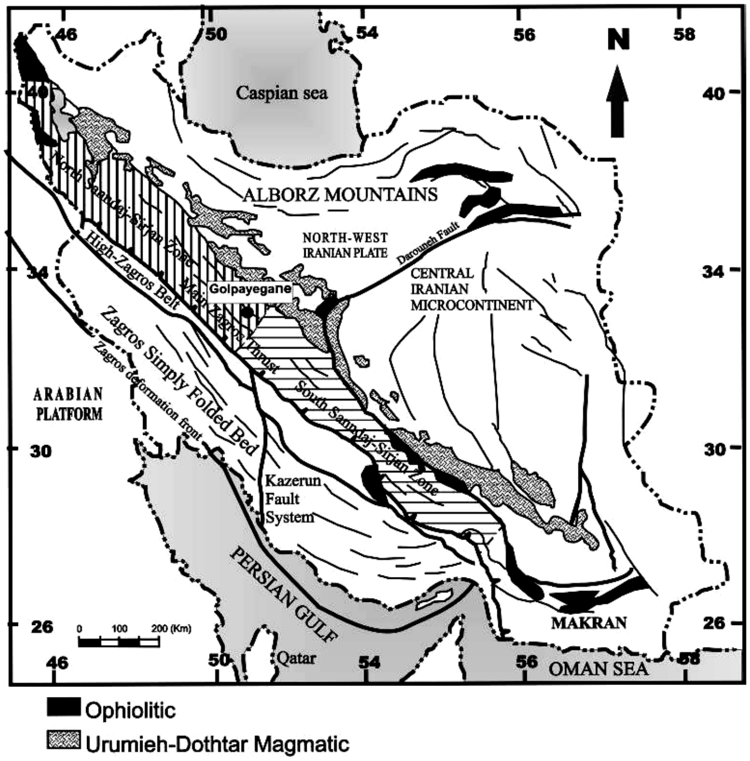

Fig. 1: Main tectonic units of Iran and location of the study area in the Sanandaj-Sirjan zone

continuation of subduction of Neo-Tethys along the western margin of the Sanandaj-Sirjan after the suturing of an intra-Neo-Tethyse Oceanic island arc to Arabia (Ghasemi and Talbot, 2005). After collision, the Arabian margin has shortened by distributed thickening of the continental lithosphere. Collision is thought to have occurred in the late Oligocene-early Miocene, followed by continental shortening (Navabpour *et al*., 2007).

The studies area, consist of mylonitic granites which have outcrop in the north of Varzaneh and monzogranites which have outcrop in Saeid-Abad (Ghydo) in the northeast of Golpayegan, based on classification of sedimentary structural zones, these are located within Sanandaj-Sirjan Zone. The area is located at latitudes of 33°, 34′ to 33°, 40.5′ and longitudes of 50°, 16.5′ to 50°, 32.5′. In the Golpayegan area, due to the presence of oriented pressure occurring during crystallization of the north of the Varzaneh area, the final crystallization product of the resulted melts (from sediments containing quartz and feldspar) is mylonitic granite (Fig. 2). In this regard, if oriented pressure is weak or absent, we could justify that typical granite is formed (Barker, 1990).

The most important deformational occurrence in the Sanandaj-Sirjan Zone and the studied area is related to continental collision between the Afro-Arabian continent and the Iranian micro continent in Late Cretaceous to Tertiary time (Berberian and King, 1981). According to filed relations the mylonitic granites in the north of Varzaneh are Late Cretaceous-Paleocene (phase Laramid) and fabric elements in this phase are significantly present in shear zones and can be observed in the form of shear foliation in mylonitic granites in the north of Varzaneh (Saba, 2000).

Rachidnejad-Omran (2002) obtained whole-rock and biotite K-Ar ages between 57.1±0.9 for monzogranite (Ghydo), 60±0.9 Ma for mylonitic granite (Varzaneh) and 64.2±1.2 for a dioritic and mylonitic dyke (Sfajerd) emplaced in the metamorphic complex north of the Golpayegan and, therefore, proposed a Paleocene age for these intrusions (Fig. 2).

The overlapping $^{40}Ar/^{39}Ar$ ages of biotite and amphibole at 54.85±1.00 and 54.64±1.66 Ma, respectively, from the granodiorite intrusion in the north of Sfajerd, indicate rapid cooling of this intrusion and represent a lower estimate of the intrusion age of the granodiorite, Based on the available age determinations, argon loss may be attributed to the emplacement of the early Eocene granodioritic intrusions at about 54 to 55 Ma (Moritz *et al*., 2006).

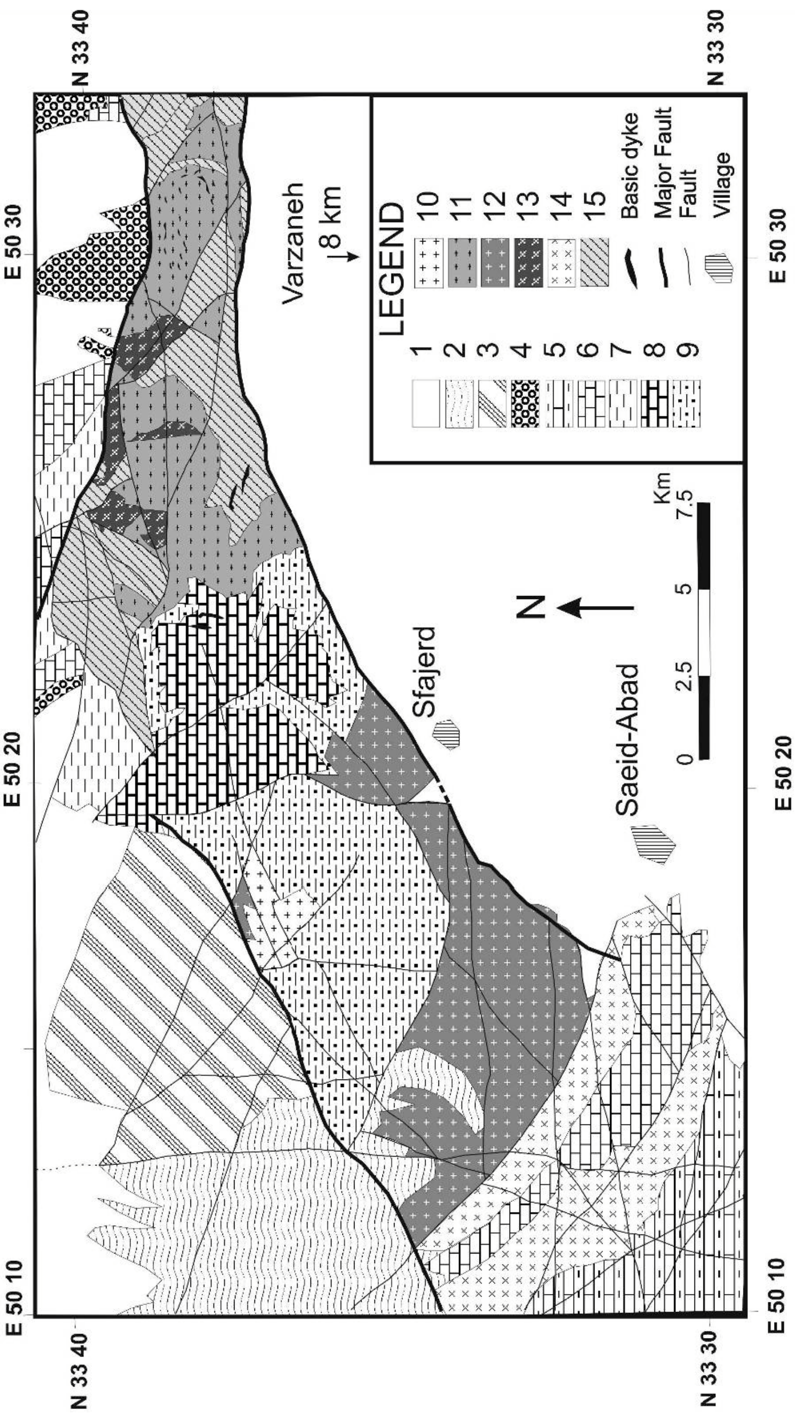

Fig. 2: Geological map of the area under study (the northeast of the Golpayegan). 1: Recent alluvium, 2: Alluvial terraces, 3: Banding sandstone (Eocene), 4: Sandstone and conglomerate (Eocene), 5: Calcareous shale, Marl, Limestone (U. Cretaceous), 6: Orbitolina limestone (L. Cretaceous), 7: Shale (Jurassic), 8: Marble (Mesozoic), 9: Garnet muscovite schist (Mesozoic), 10: Monzogranite (Paleocene), 11: Mylonitic granite (Paleocene), 12: Syente, Syenodiorite (Paleocene), 13: Mylonitic basic rocks (Paleocene), 14: Trachyte Cretaceous and 15: Meta-dacite, Meta-andesite, Meta-rhyolite (Mesozoic)

MATERIALS AND METHODS

For geochemical analysis of major and trace elements of collected field samples, the methods of X-Ray fluorescence (XRF), Neutron Activation Analysis (NAA) and Inductively Coupled Plasma Emission Spectrometry (ICP-MS and ICP-AES) were used. Ten mylonitic granite samples from the Varzaneh area were analyzed by XRF Method in which ten oxides of major elements and 22 trace elements and two monzogranite samples were analyzed by NAA Method. Three alkali feldspar granites from the Saeid-Abad area were also analyzed by the ICP-emission spectrometry for major elements and for trace and rare earth elements, ICP-mass spectrometry (Perkin-Elmer Elan 600) was used.

RESULTS AND DISCUSSION

In this research, the tectonic discrimination of granitoid masses was obtained by using chemical analysis. These granitoids are in the form of small and large masses which are intruded within a metamorphic complex of Barrovian type (medium temperature and pressure) and in some cases have caused contact metamorphism in adjacent rocks. These granitoids are sub-alkaline and calc-alkaline type and continental crust origin granitoids. Table 1 and 2 show the geochemical analyses of the granitoids from north of the Golpayegan. These granitoides have SiO_2 values of meanly 70%. In order to study the tectonic environments of granitoids from the Golpayegan, the suggested steps of Maniar and Piccoli (1989) were used which is a flow chart (continuous plan) for discrimination of granitoids. In each step, the composed location of granitoid samples are discussed by related diagrams.

First step: In order to determine the tectonic situation of granitoids, weight percentage diagram of K_2O versus SiO_2 plot was used (Fig. 3). As described in Fig. 3, the oceanic plagiogranites are separated from other granitoids and from 14 studied sample, only one sample plot within oceanic plagiogranite zone.

Second step: In order to distinguish groups I (CCG, CAG and IAG), group II (RRG and CEUG) and group III (POG), weight percentage diagrams of Al_2O_3 versus SiO_2, FeO (T)/ [FeO (T) + MgO] versus SiO_2 and also FeO (T) + MgO versus CaO were used. Based on above diagrams, most of the studied samples are placed within group I (CAG + CCG + IAG) (Fig. 4a-d).

Based on weight percentage diagrams of Al_2O_3 versus SiO_2, the granites of the northeast of the

Table 1: XRF major element (wt. %) and trace element (ppm) analyses of the sample from the mylonitic granitoids of the Varzanch area

Sample	A-1	A-10	A-13	A-6	A-9
SiO_2	71.660	71.180	74.500	72.220	71.780
TiO_2	0.240	0.151	0.245	0.230	0.338
Al_2O_3	14.510	16.790	15.170	24.530	14.260
Fe_2O_3	0.505	0.570	0.390	0.860	0.950
FeO	0.500	0.570	0.580	0.860	0.950
MnO	0.010	0.010	0.010	0.010	0.010
MgO	0.864	0.404	1.310	0.445	0.603
CaO	0.300	1.570	0.760	1.000	1.100
Na_2O	3.170	4.541	4.582	2.069	2.608
K_2O	6.450	2.910	1.110	5.510	5.920
P_2O_5	0.043	0.085	0.097	0.110	0.123
Cr_2O_3	0.015	0.014	0.022	0.022	0.020
Total	98.322	98.86	99.836	97.956	98.179
Ba	2071	639	110	924	879
Rb	66	78	44	192	188
Sr	66	543	422	68	102
Ga	17	18	20	16	20
Nb	10	3	11	10	14
Hf	14	12	11	9	12
Zr	211	73	196	139	170
Y	44	11	40	63	64
Cr	100	98	151	149	133
Ni	232	10	347	11	219
Co	1	0	1	3	4
V	16	20	21	18	22
Cu	8	4	8	3	6
Pb	0	12	0	9	0
Zn	16	36	13	19	16
F	192	170	60	82	367
Cl	38	24	88	169	273
S	5	6	5	8	11
La	41	0	28	1	15
Ce	84	0	48	15	18
Nd	60	0	29	11	25
Sm	14	0	17	15	11
Samples	M-4-1	O-2	O-4	T-5-1	T-G
SiO_2	73.020	75.3000	73.790	67.340	70.960
TiO_2	0.293	0.0092	0.004	0.392	0.367
Al_2O_3	14.260	14.4200	15.250	15.010	14.320
Fe_2O_3	0.980	0.2290	0.330	1.830	1.430
FeO	0.980	0.2290	0.330	1.220	1.430
MnO	0.010	0.0000	0.000	0.050	0.050
MgO	1.031	0.2830	0.009	1.184	0.594
CaO	0.830	1.4900	0.950	1.340	1.940
Na_2O	3.164	4.8500	3.210	2.581	2.382
K_2O	1.280	0.1900	5.040	4.350	5.320
P_2O_5	0.112	0.0740	0.123	0.216	0.171
Cr_2O_3	0.023	0.0200	0.015	0.015	0.023
Total	100.012	97.1090	99.050	95.648	98.670
Ba	637	34	365	232	374
Rb	126	5	179	253	236
Sr	114	170	115	121	128
Ga	20	15	22	19	17
Nb	12	10	33	20	24
Hf	10	5	2	10	14
Zr	169	14	31	172	190
Y	47	0	59	60	67
Cr	155	135	103	103	156
Ni	282	308	224	21	18
Co	2	0	1	5	5
V	30	11	10	40	32
Cu	9	4	9	5	22
Pb	3	2	34	18	33
Zn	19	11	14	42	94

Table 1: Continued

Total	100.012	97.109	99.05	95.648	98.67
F	651	323	279	236	389
Cl	69	251	253	339	141
S	25	8	5	9	8
La	5	0	5	14	46
Ce	1	0	0	0	93
Nd	9	0	5	8	18
Sm	3	6	2	3	12

Table 2: ICP-MS and NAA majar element (wt. %) trace and rare earth elements (ppm) analyses of the gamitoids from the north of Golpayegan area

Samples	A-14	DA-6	DA-8	MA-9	T-G
SiO_2	71.100	73.65	73.560	68.72	72.500
TiO_2	0.284	0.06	0.140	0.20	0.280
Al_2O_3	13.891	13.82	13.970	17.45	14.510
Se_2O_3	1.484	0.10	1.460	1.35	1.545
FeO	1.484	1.00	1.460	1.36	1.545
MnO	0.013	0.03	0.030	0.05	0.050
MgO	1.094	0.13	0.140	0.41	0.960
CaO	0.630	0.86	0.520	1.21	1.133
Na_2O	3.464	3.92	3.310	6.63	3.316
K_2O	6.348	4.15	4.470	1.12	3.829
P_2O_5	0.137	0.33	0.210	0.26	0.170
LOI	-	1.00	0.600	1.10	-
Cr_2O_3	0.003	0.001	0.002	0.002	0.003
Total	100	100.04	100.02	100	100
Ba	186.00	39.00	67.90	106.60	185.00
Rb	167.00	260.20	238.00	37.40	2.17
Sr	198.00	28.00	43.90	205.90	225.00
Ss	2.03	23.30	10.40	1.40	14.68
Ga	-	23.50	20.10	15.00	-
Tl	-	0.10	0.10	0.10	-
Ta	1.00	4.80	2.00	1.00	1.74
Nb	-	8.10	13.30	6.00	-
Hf	6.00	1.80	3.60	4.40	4.09
Zr	-	61.60	101.40	136.10	-
Y	-	10.00	18.30	19.10	-
Th	23.02	3.20	10.00	11.90	24.37
U	1.04	1.10	2.80	3.10	2.14
Cr	22.00	7.00	14.00	14.00	18.00
Ni	-	7.10	16.30	12.30	-
Co	13.00	1.10	3.00	4.90	5.00
Sc	5.13	3.00	4.00	5.00	7.00
V	21.71	5.00	15.00	30.00	28.31
Cu	620.00	11.20	29.40	13.00	650.00
Pb	-	5.70	9.00	2.00	-
Zn	276.00	3.00	12.00	5.00	68.00
Di	-	1.20	0.30	0.30	2.63
Cd	2.63	0.10	0.10	0.10	330.00
Sn	290.00	9.00	6.00	3.00	6.04
W	5.91	5.80	5.40	5.20	4.00
Mo	4.00	0.90	2.00	1.20	-
Be	-	2.00	6.00	4.00	-
Ag	-	0.10	0.10	0.10	0.10
Au	0.11	5.40	0.70	1.40	-
Hg	-	0.01	0.01	0.01	4.53
As	4.41	8.80	14.70	4.70	-
Se	-	0.50	0.50	0.50	0.25
Sb	0.22	0.40	0.70	0.30	49.68
La	20.90	7.70	14.60	23.20	90.04
Ce	4.20	13.70	30.70	47.30	-
Pr	-	1.49	3.00	4.65	7.66
Nd	6.81	5.20	11.10	17.20	6.85
Sn	3.44	1.20	2.20	3.40	1.08
Eu	0.28	0.18	0.21	1.06	-
Gd	-	1.19	2.35	3.02	0.99
Tb	0.81	0.27	0.48	0.56	4.45

Table 2: Continued

Total	100	100.04	100.02	100	100
Dy	4.85	1.59	2.70	3.36	-
Ho	-	0.29	0.54	0.63	-
Er	-	0.98	1.72	1.76	-
Tm	-	0.15	0.26	0.26	1.32
Yb	3.19	1.10	1.64	1.54	0.30
Lu	0.61	0.17	0.23	0.24	

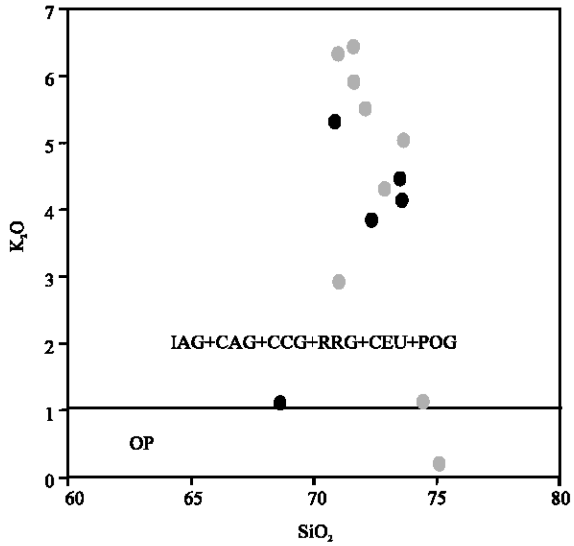

Fig. 3: K_2O versus SiO_2 (Maniar and Piccoli, 1989). Distinction between oceanic plagiogranites from north of the Golpayegan area and granitoids from other environments

Golpayegan are placed within group III which are Post Orogenic Granite (POG) and also within group I limits. This means that, this diagram can not distinguish these two groups.

On the other hand, it is not possible to separate these two groups from each other. It should be mentioned that, the diagram related to [FeO (T) + MgO]/CaO changes, the presented percentage values are not related to results of chemical analysis, there for, in order to calculate the above values, first the values for A, C and F should be calculated from following relations and be converted to percentage, from to be able to use for diagrams.

$$C = CaO \quad F = FeO\ (T) + MgO \quad A = Al_2O_3 - Na_2O - K_2O$$

Based on the above findings and geological, petrological and geochemical evidences, the granitoids of the northeast from the Golpayegan are mostly CCG which during an orogenic event were intruded as they were deformed.

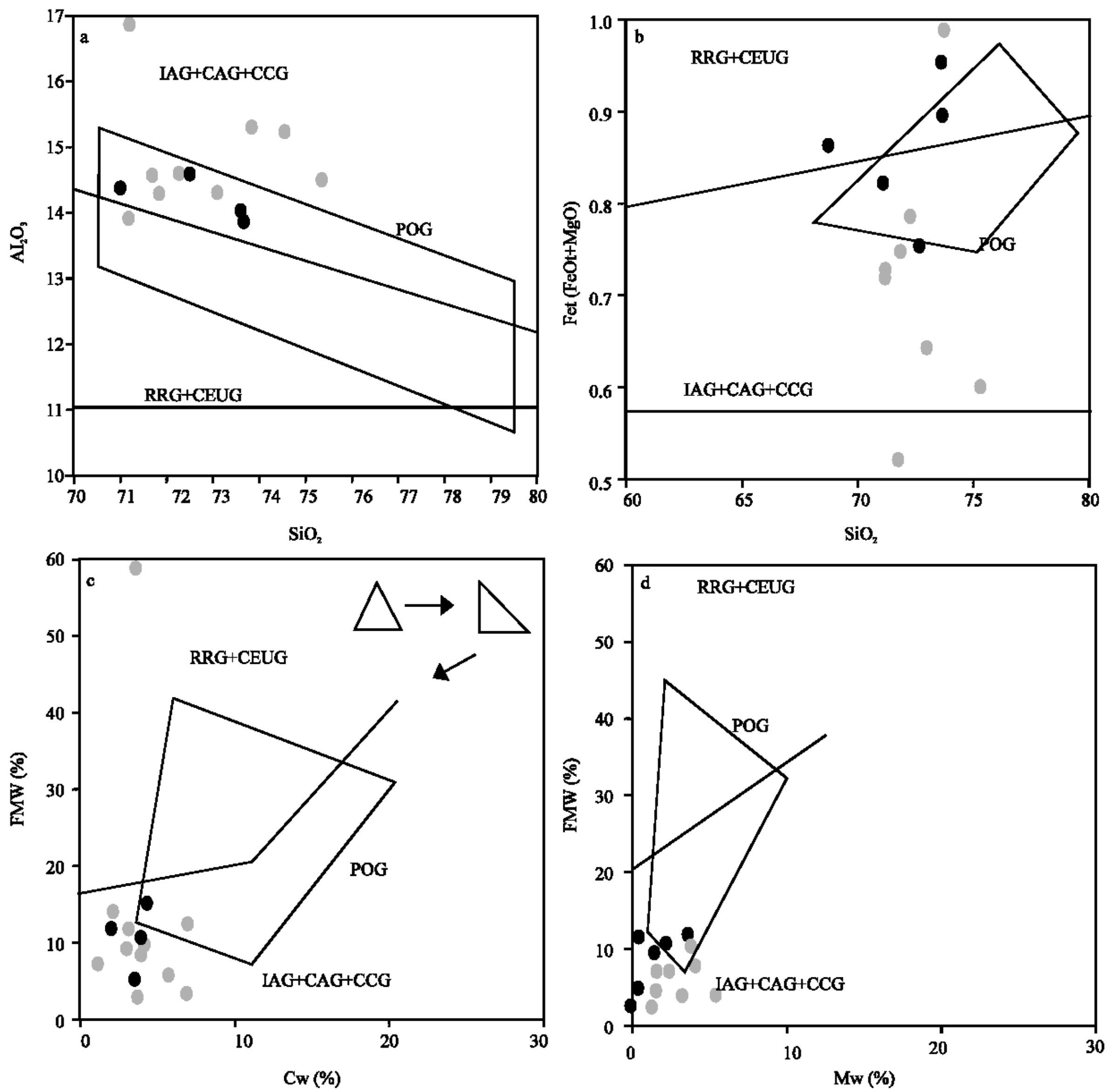

Fig. 4a-d: Discrimination between group I (IAG + CAG + CCG) and group III (POG) from Maniar and Piccoli (1989). Based on the plots studied samples, the granitoids from north of Golpayegan area were located within group I

For classifying of these granitoids according to their tectonic settings, various patterns for determining the tectonic environments were used. For the tectonic discrimination of granitoids the plots of Maniar and Piccoli (1989), Shand's index of Maniar and Piccoli (1989) and the multication diagram R_1-R_2 of Batchelor and Bowden (1985), were used. Based on geological, lithological and petrological evidences and also major and trace elements chemistry, various discrimination plots were applied.

The Shand's index is another way to determine the types of granitoids (Maniar and Piccoli, 1989). For the related diagram molar ratio of Al_2O_3/ (Na_2O + K_2O) versus Al_2O_3/ (CaO + Na_2O + K_2O) was used. The studied samples are plotted in the field of CCG and peraluminous granitoids (Fig. 5). In this Figure only the CCG are highly peraluminous (A/CNK>1.15). Similarly, only the IAG, CAG and OP are highly metaluminous (A/NK>1.4) and only the RRG and CEUG are considerably peralkaline (Maniar and Piccoli, 1989).

Another way to determine the types of granitoids is diagram R_1-R_2 (Batchelor and Bowden, 1985). Based on multication diagram of R_1-R_2, the discrimination plots of granitoids samples from north of Varzaneh and Saeid-Abad fall in to the within syn-collision field and the rest fall in to the late orogenic field (Fig. 6).

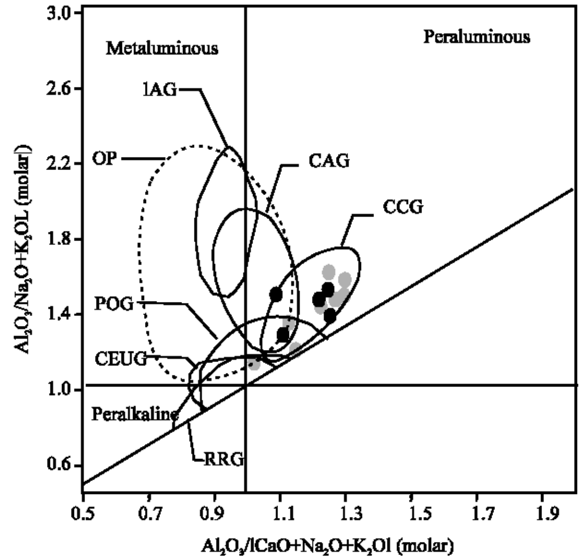

Fig. 5: Shandõs index (Maniar and Piccoli, 1989). The studied samples are mostly placed in Continental Collision Granite (CCG) and peraluminous limits

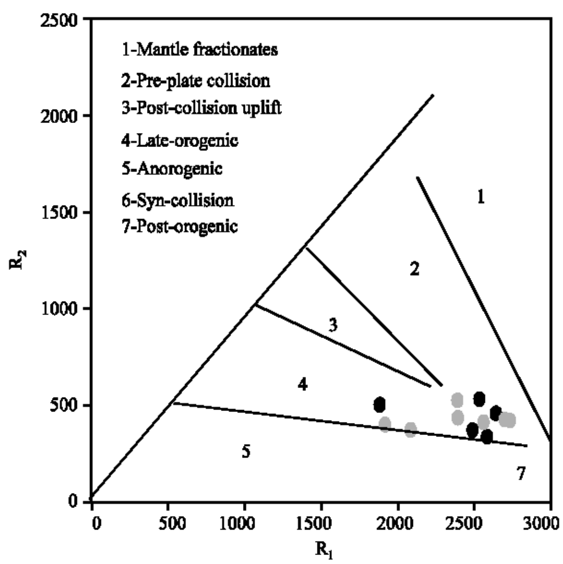

Fig. 6: Based on milication diagram of R_1-R_2, (Batchelor and Bowden, 1985). Granitoids of area were often located within syn-collision

Figure 7 describes, the modes of granitoid rocks from different tectonic environments, as fields (for clarity) in QAP diagram (quartz-alkali feldspar-plagioclase normalized to 100%). Streckeisen (1976) nomenclature is also strictly followed. The studied samples are often fall into the Continental Collision Granite (CCG) and island arc granitoids (IAG) fields in (Fig. 7).

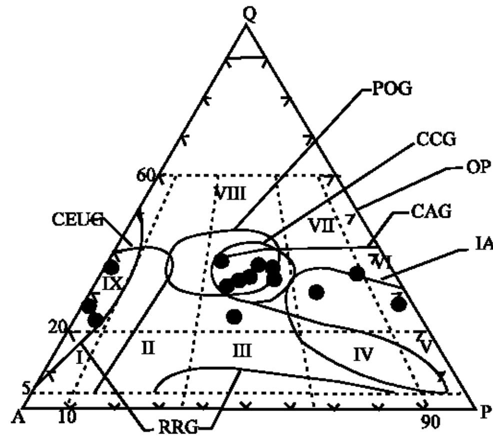

Fig. 7: Modal quartz (Q)- alkali feldspar (A)-plagioclase (P) ternary plot (Maniar and Piccoli, 1989). Granitoids of area were often located within continental collision granitoids and island arc granitoids. IAG = Island arc granitoids, CAG = Continental arc granitoids, CCG = Continental collision granitoids, POG = Post-orogenic granitoids, RRG = Rift-related granitoids, CEUG = Continental epeirogenic uplift granitoids, OP = Oceanic plagiogranites. I = Quartz alkali syenite; II = Quartz syenite; III = Quartz monzonite; IV = Quartz monzodiorite; V = Quartz diorite; VI = Tonalite, Trondhjemite; VII = Granodiorite; VIII = Granite; XI = Alkali granite

According to a preliminary study conducted by Pearce *et al.* (1984) the concentration of trace elements versus SiO_2 from 600 collected granite samples shows that, the elements of Hf, Zr, Sm, Ce, Ta, Nb, K, Ba, Rb, Yb and Y can effectually discriminate granitoids in relation to different tectonic settings. These factors were used to distinguish the tectonic environments of granites in two sets of diagrams based on variations of Nb, Y, Rb and Ta, Yb, Rb

Lack of relative mobility of these elements would make them to be more useful for identification of the tectonic environment for granitoids. For classifying of granitoids from the north of Golpayegan area, based on trace elements analysis two discrimination diagrams were used (Fig. 8a, b). In with regards to, elements of Rb, Y and Nb were selected as very effective indicators of ORG, WPG, VAG and syn-COLG (Pearce *et al.*, 1984). The results obtained from the samples show that, these granites are mostly VAG and syn-COLG type. It should be mentioned that, on these diagrams, it is not possible to distinguish post-orogenic granitoids (POG) from volcanic arc granitoids (VAG) and syn-collision granitoids (syn-COLG).

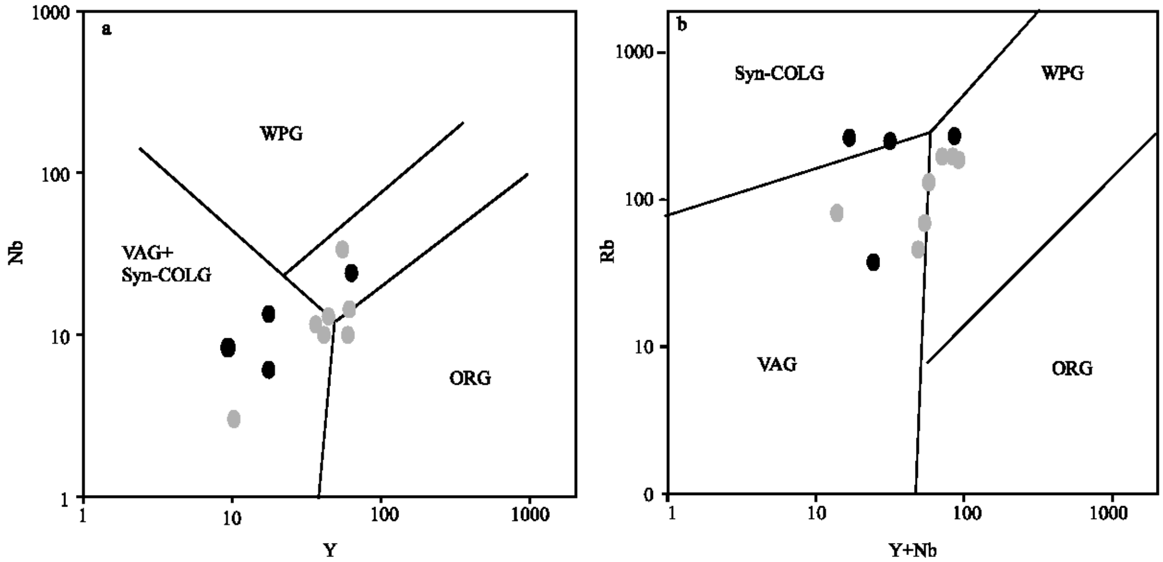

Fig. 8a: Nb versus Y, b. Rb versus Y + Nb diagrams (Pearce *et al.*, 1984). Granitoids of area were often located within VAG and Syn-COLG limits Syn-COLG = Syn-Collision granites, WPG = Within plate granites, VAG = Volcanic arc granites, ORG = Oceanic ridge granites

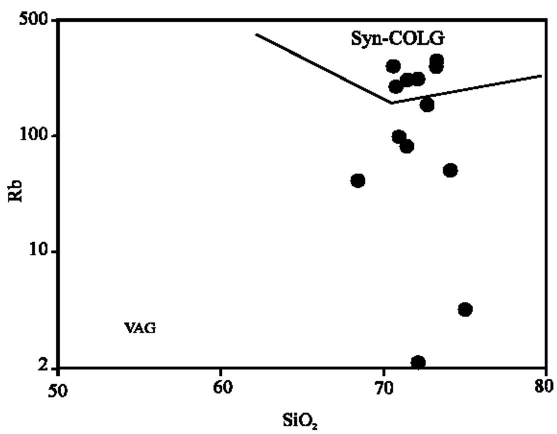

Fig. 9: SiO_2 variation diagram versus Rb (Pearce *et al.*, 1984). Granitoids of area were often fall into the within volcanic arc granitoids (VAG) and syn-collision granitoids (Syn-COLG) fields

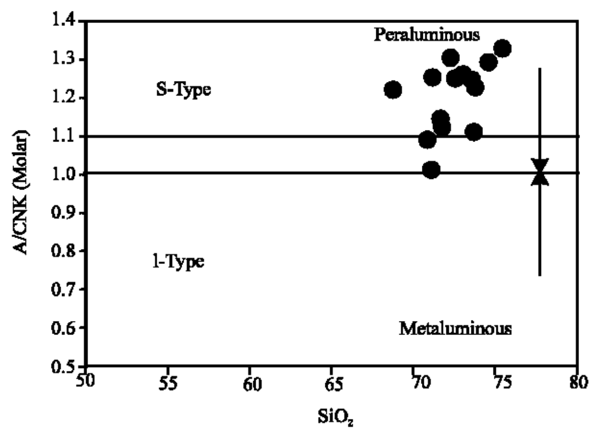

Fig. 10: Based on diagram $Al_2O_3/(CaO + Na_2O + K_2O)$ versus SiO_2, the studied samples are plotted in the field of S-Type in the sense of Chappell and White (1974)

The results, obtained by studying the diagram of Rb versus SiO_2 changes which could distinguish VAG and syn-COLG from each other, show that, granitoids of the study area are mostly syn-COLG and few are VAG (Fig. 9), which supports the diagrams of Pearce *et al.* (1984).

For determining the origin of mylonitic granites, the molecular A/CNK versus SiO_2 diagram is used. Based on this diagram (Chappell and White, 1974), the studied samples are plotted in the field of S-Type (Fig. 10).

Diagrams of normalized trace elements like spider diagrams (related to normalized granitoids related to Chondrite, primitive mantle, upper crust, lower crust, continental crust and ocean ridge granite) were used to interpret the evolution steps of differentiation processes and also the origin of mylonitic granite in north of Varzaneh.

About the origin of mylonitic granites, the results indicate that, although there are some evidences about the digestion of host rocks, but negative anomalies of Nb in normalized multi-element diagrams (spider diagrams) in mylonitic granite of Varzaneh is one of the suitable indexes to determine the continental rocks, which could show the participation of crust in magmatic processes (Fig. 11).

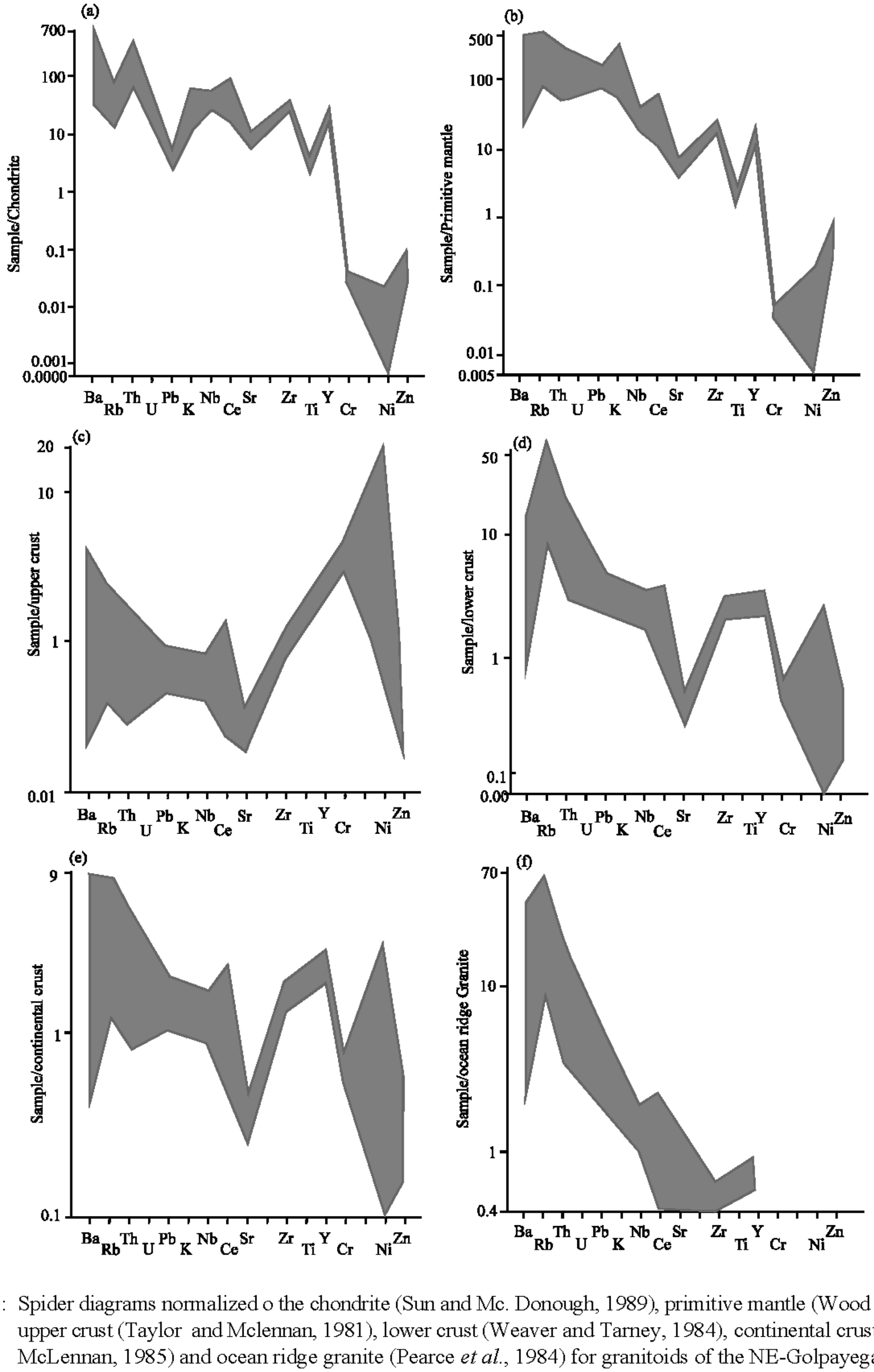

Fig. 11: Spider diagrams normalized o the chondrite (Sun and Mc. Donough, 1989), primitive mantle (Wood *et al*., 1979), upper crust (Taylor and Mclennan, 1981), lower crust (Weaver and Tarney, 1984), continental crust (Taylor and McLennan, 1985) and ocean ridge granite (Pearce *et al*., 1984) for granitoids of the NE-Golpayegan area

Recent geochemical studies, fabric elements and radiometric dating of the mylonitic granites in the Golpayegan area indicate that emplacement of granitic rocks in the Sanandaj-Sirjan Zone and along the Arabian plate margin occurred as the result of continental collision at the Paleocene.

CONCLUSION

- Based on the major-element chemistry discriminated scheme of Maniar and Piccoli was used to distinguish granitoid rocks. By considering the compositional situation of studies samples, the granitoids from north of the Golpayegan (the Varzaneh mylonitic granites and monzogranites from north of the Saeid-Abad) often fall into the CCG type and plot within composition range of peraluminous rocks.
- By using the multication of R1-R2 (presented by Batchelor and Bowden) which is used to distinguish the tectonic environments of granitoids and also by considering the compositional situation of studied samples, the granitoids from the north of Golpayegan are often fall into the within CCG zone and some fall into the near POG.
- Based on QAP diagram and by overlaying the equivalent classification of Maniar and Piccoli on it, the results indicate that, the studied granitoids plot within the field of CCG and some others are within IAG.
- By using the trace-element chemistry (presented by Pearce *et al*. (1984), the granitoids of studied area plot within the field of CCG and VAG.
- About the origin of mylonitic granites, the results indicate that, negative anomalies of Nb in spider diagrams in mylonitic granite of Varzaneh is one of the suitable indexes to determine the continental rocks, which could show the participation of crust in magmatic processes.
- The results indicate these granitoids are mostly CCG or syn-collision types that are formed at the end of orogenic events synchronous with the end of deformations and collision of the Arabian plate with the Iranian plate at the Paleocene.

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