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GEOCHEMISTRY AND PETROGENESIS OF PLUTONIC MASSES IN NORTH OF SONQOR (WEST OF IRAN)

GEOQUÍMICA E PETROGÊNESE DE MASSAS PLUTÔNICAS NO NORTE DE SONQOR (OESTE DO IRÃ)

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Resumo
A pesquisa possui como área de estudo um quadrilátero localizado no oeste do Irã e ao norte da cidade de Sonqor, na província de Kermanshah. Esta área de cerca de 155 km^2 está situada entre as longitudes 47°40’E e 47°52’E e as latitudes 35°N e 35°04’N. Nesta faixa, as rochas intrusivas são gabivino olivino, gabro, diorito de gabro, diorito, monzonita, sinito alcalino, diorito de quartzo, monzodiorito de quartzo, monzonito de quartzo, sinito alcalino de quartzo, tonalita, granodiorito, granito e granito alcalino, que passaram por um processo de injeção de minérios de ferro durante o cretáceo resultando em metamorfismo de contato entre as rochas, criando áreas de corneana no local do contato. Para a pesquisa realizada foram coletadas amostragens das rochas ígneas da área para análise. Assim, foram obtidas 90 seções finas das amostras que foram preparadas e após a análise da petrografia, 24 amostras foram selecionadas para experimentos geoquímicos. A análise de XRF foi realizada em 9 amostras e a ICP e fusão alcalina foram realizadas em 15 amostras. De acordo com estudos geoquímicos e petrológicos, os magmas que formam essas rochas ígneas intrusivas são de uma região e, devido à diferenciação magmática ou à cristalização fracionária, eles se referem a materiais basálticos a ácidos. A interpretação dos diagramas de sílica alcalina das rochas estudadas está classificada na série de tolita, alcalina-alcalina, alcalina-alcalina, rica em potássio e séries shoshoníticas. Com base em diagramas tectono-magmáticos, as amostras deste quadrilátero têm uma natureza de metaalumina e granitóides presentes na faixa de granitos de ilhas de arco, granitoides de arco continental e granitoides de colisão continental. A composição mineralógica e química das rochas ácidas da região mostra que os granitos deste estudo são do tipo I.
Palavras-Chave: Geoquímica, Petrogênese, Plutonic, Sonqor, Irã.

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ABSTRACT

The study area is a quadrilateral that is in west of Iran and north of Sonqor city of Kermanshah province. This area is 155 km2 between eastern longitude 47˚ and 40 ′ to 47˚ and 52 ′ and northern latitudes 35˚ and 00 ′ to 35˚ and 04 ′. In this range, the intrusive rocks are Olivine gabbro, gabbro, gabbro diorite, diorite, monzonite, alkaline sinite, quartz diorite, quartz monzodiorite, quartz monzonite, quartz alkaline sinite, tonalite, granodiorite, granite and alkaline granite, they were injected in the iron ores of cretaceous which has resulted in contact metamorphism and created hornfels at the site of contact. After comprehensive sampling of all required igneous rocks and according to the thesis objectives, 90 thin sections were prepared and after petrography, 24 samples were selected for geochemical experiments. XRF analysis were performed on 9 samples and ICP and alkaline fusion were performed on 15 samples. According to geochemical and petrological studies, the magmas forming these intrusive igneous rocks are from one region and because of magmatic differentiation or fractional crystallization, they from basaltic to acidic terms. According to the alkaline-silica diagrams, the studied rocks are in the range of tolite, calk-alkaline, potassium-rich calk-alkaline, and shoshonitic series. Based on tectono-magmatic diagrams, samples of this quadrilateral have a meta-alumina nature and granitoids are in the range of arc islands granites, continental arc granitoids and continental collision granitoids. The mineralogical and chemical composition of the acidic rocks in the area show that the granites in this study are type I.

Keywords: Geochemistry, Petrogenesis, Plutonic, Sonqor, Iran.

INTRODUCTION

Kermanshah province in located in the west of Iran, with an area of 24640 square kilometers and located between eastern longitude 45˚and 20 ° and 39″ to 48 ° and 01′ and 58″ and northern latitude 33˚ and 37′ and 08″ to 35˚ and 17′ and 08″. Kermanshah province is a mountainous area that lies between the Iranian plateau and the Mesopotamian Plateau and is covered by the Zagros Mountain Peak and Highlands. The Zagros Mountains within the province have emerged as a series of parallel mountain ranges and highland plains have formed between them, forming the bed of important Zagros crossings (Zadmehr et al., 2019; Yazdi et al., 2019 a; Nazemi et al., 2019). The studied intrusions were injected into the Sanandaj-Sirjan metamorphic belt. Their injections are from the Cretaceous to the late Eocene and early Oligocene (Ghadimi and Khavari., 2019; Khodami, and Kamali Shervedani., 2019; Yazdi et al., 2019 b).

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RESEARCH PURPOSES

- Field operations including sampling taking oriented geological samples of geological phenomena and the preparation of thin sections.
- Investigating the mineralogical variations of different rock types in different masses and exposure of the region and discovering the genetic relationship of these rocks.
- XRF and ICP.MS analysis selections after petrographic studies.
- Data analysis from field and laboratories.
- Investigation of changes in acidity and basicity of plutonic rocks in different masses.
- Investigation of quantitative elemental changes and oxides of some elements in various samples.
- Study of geochemical changes of elements and some of their compounds based on international standard charts.
- Summarizing all quantitative, qualitative and laboratory data.

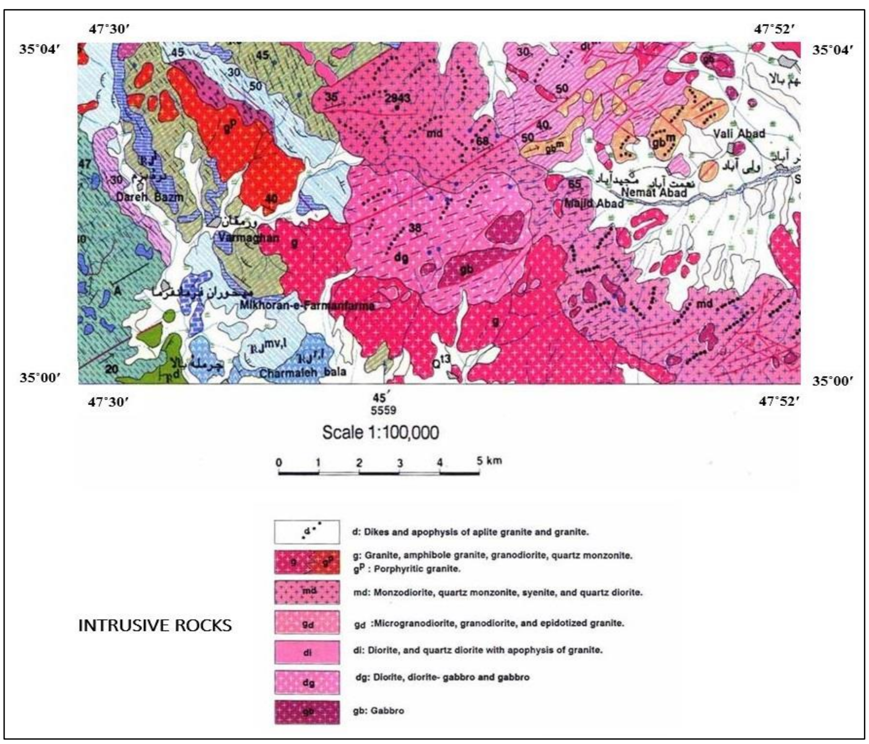

Figure 1: Geological map of 1: 100000 Qorveh.
Source: Ministry of mines and metals and Geological survey of Iran (1999)

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PETROGRAPHY

Petrographic study of the rocks within the range of study indicates different ranges of igneous rocks. The rocks in this quadrilateral are classified according to the Streckeisen classification (1974 - 1980) as: Olivine gabbro, gabbro, diorite gabbro, diorite, monzonite, alkaline sinite, quartz diorite, quartz monzodiorite, quartz monzonite, quartz alkaline sinite, tonalite, granodiorite, granite and alkaline granite. The red points representing the rocks of the study area are plotted on the QAP triangle (Figure 2).

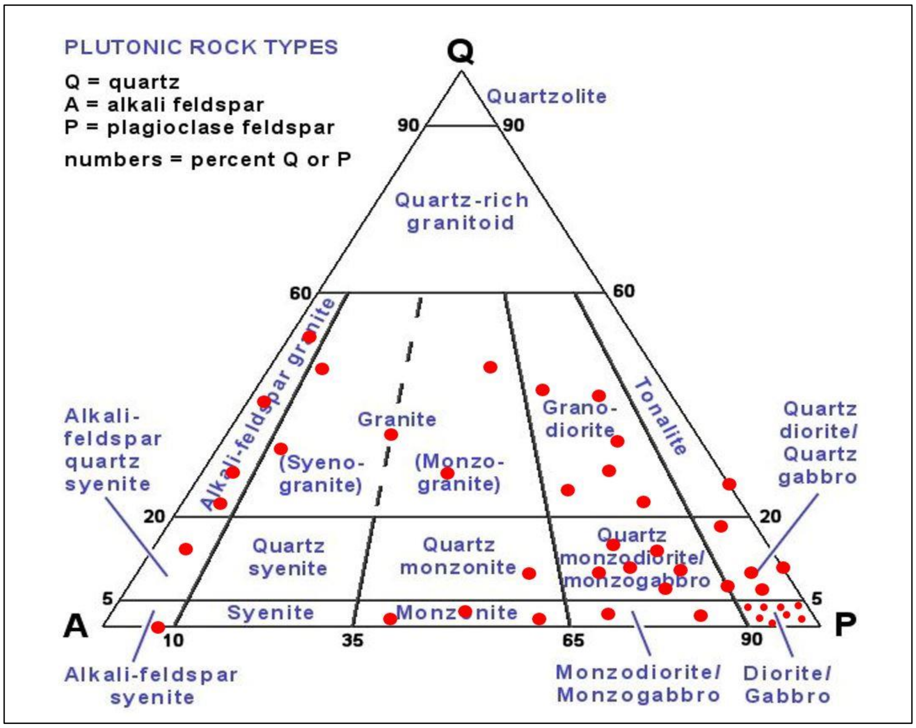

Figure 2: Studied rocks plotted on the Streckeisen 1974 diagram.
Source: (Streckeisen 1974)

Olivine Gabbro: The texture of these rocks is granular from medium-grain to coarse-grained. In some samples the texture is pegmatoidic. The plagioclases of these olivine gabbros have anorthite values of An 50 to An 66. Clinopyroxen types are augite and Mg/(Mg+Fetotal) varies from 0.60 to 0.84 . Biotite is found in small quantities and shows a second level red interference color. The olivines in these rocks are colorless, shapeless and lacking in cleavage, showing late interactive second series colors. A considerable amount of irregular cracks are seen in thin sections.

- **Diorite gabbro**: The composition of this rock varies between diorite and gabbro, in which the plagioclases have about 50% anorthite. Textures are granular and of medium type, coarse grained and pegmatoidic. The principal constituents of diorite gabbros are plagioclase, augite, hornblende and opaque.
- **Diorite**: Medium-grain texture. The principal constituents of these diorites are plagioclase, hornblende and augite and its minor minerals are orthos, quartz, opaque and biotite.
- **Monzonite**: In monzonites the percentage of alkaline feldspar is equal to plagioclase. The fine-grained, medium-grained, cumulus, and porphyry granular textures are visible in different specimens. In porphyry monzonites, plagioclase crystals are coarse. The principal constituents are oligoclase and andesine plagioclase, orthoclase and hornblende and its minor minerals are biotite and opaque.
- **Alkaline Sinite**: The principal constituent of this rock is sodium rich and highly perthite microcline. Another important characteristic of syenites is their high sodium and potassium levels. Orthoclase, microcline, oligoclase and albite are the most important feldspars that form these alkaline synenites. There is no quartz in these samples.
- **Quartz diorite**: The principal constituents of quartz diorite are plagioclase and hornblende. The great amount of plagioclases in all specimens are all automorphic with parallel twining, and high alteration. Minor minerals of quartz diorites are quartz, microcline, augite and biotite. Quartz minerals are present in all samples among other crystals in very small amounts and in small sizes.
- **Quartz Monzodiorite**: The texture is medium to fine-grained in various samples. Principal constituents are plagioclase, hornblende and augite.
- **Quartz Alkali Sinite**: The difference between these samples and that of the syenites is the addition of a small percentage of quartz along with other constituent minerals found in the center of the study area with medium grain texture. Orthose,

microcline, plagioclase and quartz are well visible in xpl and hornblende, biotites, apatite and opaque minerals are visible in ppl.

- **Granodiorite**: The granular texture consists of quartz, oligoclase and sometimes andesine plagioclase, orthoclase and microcline alkali feldspars, muscovite, and iron and magnesium minerals such as biotite and hornblende.
- **Granite**: The texture of these granites varies between coarse-grained, graphic and myrmecitic. The principal constituents of the granites are quartz, orthos, microcline, plagioclase and biotite. Quartz is amorphous and in small to large sizes, they are fillers between minerals. Orthos present in the samples are cloudy and semi-automorphic. In one sample, peritonitis orthosis has been seen (due to the simultaneous growth of potassic and sodic alkali feldspars at low temperatures and in two separate phases but in each other).

DETECTION OF GRANITE TYPES IN THE STUDIED AREA

The granites of type S and I are compared with each other (Table 1).

S	*I*
1 - Low sodium content, usually Na_2O ‹3.2% 2 - The range of changes is mainly acidic 3 - Normal corundum value is greater than one percent 4- mole ratio is Al_2O_3 / (Na_2O +K_2O +CaO) › 1.1 5- $(Sr87 / Sr86)_I$ › 0.807 6 - Contains muscovite 7 - Contains monazite, ilmenite, garnet and sillimanite	1 - Sodium content is relatively high, usually Na_2O ›3.2% 2 - Wide ranges of composition from mafic to acidic 3 - Corundum is less than one percent 4 - mole ratio is Al_2O_3 / (Na_2O+ K_2O+ CaO) ‹ 1.1 5- $(Sr87 / Sr86)_I$ ‹ 0.807 6 - Contains mafic hornblende and xenolith 7 - Contains sphinx, magnetite and alanite

Table 1: Comparison of S and I granites
Source: Chapel & White (1974)

Considering the above figure and given that the samples in the study range, based on the results of the chemical analysis of the major oxides, contain Na2O › 3.2%, as well as the range of variations from acidic to alkaline, and that by calculating the minerals of the rocks under study, the corundum content is less than 1%, and also by molar ratio that is Al2O3 / (Na2O + K2O + CaO) ‹ 1.1 , and according to the results of microscopic studies, the samples under study have

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high levels of hornblende, contain levels of magnetite and alanite and lack muscovite, monazite, garnet and silimanite , hence it can be concluded the studied granites are I type.

GEOCHEMISTRY

For chemical rock naming, determination of magma crystallization conditions and melting processes, 24 samples were chemically analyzed and results obtained from sample analysis using related software such as Ig Pet, GCD Kit, Min Pet, Petrographic and etc. was processed, debated and reviewed.

The results of chemical analysis are shown in the following tables and diagrams (Tables from 2 to 5):

sample	*SiO_2*	*Al_2O_3*	*BaO*	*CaO*	*FeTotal*	*FeO*	*Na_2O*	*Fe_2O_3*	*K_2O*	*Na_2O+ K_2O*	*MgO*	*MnO*	*P_2O_5*	*TiO_2*
D102	51.73	15.31	0.052	14.157	8.887	5.50994	2.52	3.37706	0.6	3.12	7.694	0.198	0.177	1.179
D103	52.266	20.17	0.052	10.97	9.78	5.6724	4.15	4.1076	0.337	4.487	3.95	0.147	0.147	2.266
D104	63.279	16.36	0.052	7.15	5.69	2.7881	5.515	2.9019	2.688	8.203	3.22	0.085	0.232	1.222
D105	64.608	15.97	0.052	6.036	6.143	2.9484	5.345	3.1943	2.869	8.214	2.62	0.053	0.2869	1.349
D109	50.18	12.77	0.052	15.65	10.287	6.3779	2.136	3.9090	0.248	2.384	9.094	0.207	0.134	1.3584
D111	55.49	1728	0.052	15.005	8.11	4.7849	3.95	3.3251	0.0847	4.0347	3.25	0.095	0.127	0.497
D112	57.212	16.14	0.052	7.63	10.83	6.3897	4.49	4.4403	1.47	5.96	4.265	0.2116	0.38	1.788
D115	58.16	15.65	0.052	6.526	11.85	6.0435	4.67	5.8065	1.83	6.5	3.14	0.2108	0.3057	2.288
D116	59.04	16.11	0.052	8.83	8.68	5.0344	4.7649	3.6455	0.35	5.1149	3.45	0.168	0.62	2.646
D117	60.937	15.518	0.052	7.11	9.247	4.8084	5.197	4.4385	1.02	6.217	3.79	0.18	0.34	1.8
D121	74.48	15.584	0.063	1.1139	2.11	0.844	4.544	1.266	5.569	10.113	0.43	0.1576	0.0945	0.5
D122	58.824	17.6	0.052	7.35	8.6	4.386	4.9	4.214	1.679	6.579	4.14	0.053	0.22	1.265
D124	58.23	16.29	0.052	67.1	10.63	5.5276	4.33	5.1024	1.479	5.809	3.746	0.188	0.3358	1.93
D125	48.85	13.45	0.052	8.33	12.43	7.5823	2.47	4.8477	0.659	3.129	14.4	0.216	0.278	1.89
D126	52.95	16.87	0.052	11.89	8.969	5.4710	3.05	3.49791	0.7999	3.8499	7.06	0.166	0.197	0.99

Table 2: Correction for Loss On Ignition (L.O.I)

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sample	*SiO_2*	*Al_2O_3*	*Fe_2O_3*	*CaO*	*Na_2O*	*MgO*	*Mno*	*P_2O_5*	*TiO_2*	*k_2O*
D42	54.27	15.37	9.67	8.04	3.48	4.95	0.141	0.161	1.179	1.67
D60	55.18	15.39	10.57	7.19	3.51	3.52	0.183	0.251	2.266	1.42
D44	53.28	15.39	10.37	8.68	2.89	6.34	0.153	0.156	1.222	0.71
D69	54.67	16.87	7.78	8.43	3.29	6.27	0.149	0.261	1.349	0.8
D31	69.66	15.34	3.28	2.45	4.71	0.28	0.062	0.039	1.3584	2.68
D45	59.42	16.27	8.25	5.48	4.59	1.26	0.165	0.373	0.497	1.98
D34	69.33	15.34	1.53	2.15	3.75	0.63	0.022	0.113	1.788	5.61
D41	65.57	18.32	1.67	2.01	5.84	0.42	0.021	0.067	2.288	4.86
D49	54.24	15.42	7.68	7.4	6.61	4.87	0.129	0.121	2.646	2.01

Table 3: Correction for Loss On Ignition (L.O.I)

sample	*Ap*	*Tn*	*Hm*	*Cs*	*Ol*	*Hy*	*Di*	*Kp*	*Ne*	*Lc*	*An*	*Ab*	*Or*	*C*	*Q'*
D102	0.419	2.894	3.377	0	0	6.072	28.241	0	0	0	28.691	21.324	3.546	0	2.19
D103	0.348	5.563	4.108	0	0	6.173	7.907	0	0	0	35.412	35.116	1.992	0	1.754
D104	0.55	3	2.902	0	0	1.614	13.82	0	0	0	11.945	46.666	15.885	0	6.199
D105	0.68	3.312	3.194	0	0	2.101	9.545	0	0	0	11.109	45.228	16.955	0	10.17
D109	0.317	3.335	3.909	0	0	5.057	36.982	0	0	0	24.524	18.074	1.466	0	1.374
D111	0.301	0	3.325	0	5.673	0	0	0	2.398	0	73.613	28.997	0.051	1694.432	0
D112	0.9	4.389	4.44	0	0	7.159	7.472	0	0	0	19.543	37.993	8.687	0	7.251
D115	0.724	5.617	5.806	0	0	5.629	4.728	0	0	0	16.335	39.516	10.815	0	9.223
D116	1.469	6.496	3.646	0	0	5.344	7.009	0	0	0	21.535	40.319	2.068	0	11.604
D117	0.805	4.419	4.438	0	0	5.55	8.392	0	0	0	16.001	43.976	6.028	0	10.56
D121	0.224	0	1.266	0	0	1.071	0	0	0	0	4.909	38.45	32.911	0.282	23.974
D122	0.521	3.105	4.214	0	0	6.865	7.435	0	0	0	21.069	41.462	9.922	0	5.61
D124	0.795	0	5.102	93.897	6.539	0	0		19.849	12.652	20.644	0	0	0	0
D125	0.658	4.64	4.848	0	7.378	21.998	7.208	0	0	0	23.666	20.9	3.894	0	0
D126	0.467	2.43	3.498	0	0	8.826	18.895	0	0	0	29.978	25.808	4.727	0	2.687

Table 4: Normative mineralization calculation of studied samples

sample	*Q*	*Or*	*Ab*	*An*	*Ne*	*Di*	*Hy*	*Ol*	*Hm*	*Tn*	*Pf*	*Ru*	*Ap*
D42	7.251	9.869	29.447	21.385	0	10.387	7.514	0	9.67	2.894	0	0	0.381
D60	11.971	8.392	29.701	22.043	0	3.187	7.29	0	10570	5.563	0	0	0.595
D44	9.406	4.196	24.454	26.923	0	8.456	11.872	0	10.37	3	0	0	0.37
D69	8.219	4.728	27.839	28.9	0	5.074	13.265	0	7.78	3.312	0	0	0.618
D31	26.449	15.838	39.855	11.9	0	0	0.697	0	3.28	0	0	1.359	0.092
D45	14.045	11.701	38.839	17.943	0	3.951	1.307	0	8.25	1.22	0	0	0.883
D34	21.138	33.153	31.731	8.454	0	0	1.569	0	1.53	1.039	0	1.365	0.268
D41	8.281	28.721	49.416	9.419	0	0	1.046	0	1.67	0.081	0	2.256	0.159
D49	0	11.878	45.283	6.467	5.769	15.753	0	3.383	7.68	0	4.505	0	0.287

Table 5: Normative mineralization calculation for samples with XRF analysis.

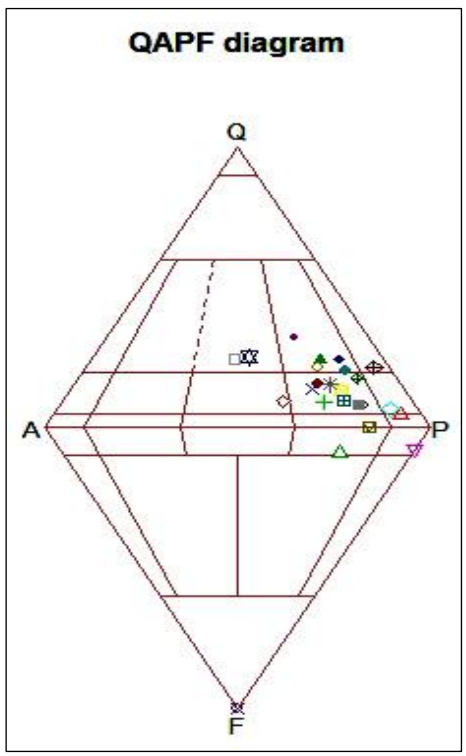

Figure 3: QAPF diagram (Streckeisen 1974) for silica-saturated plutonic igneous rocks.
Source: (Streckeisen 1974)

According to the results of the chemical analysis, the under study rocks include gabbro diorite, granodiorite, granite, quartz monzonite and quartz monzo gabbro diorite.

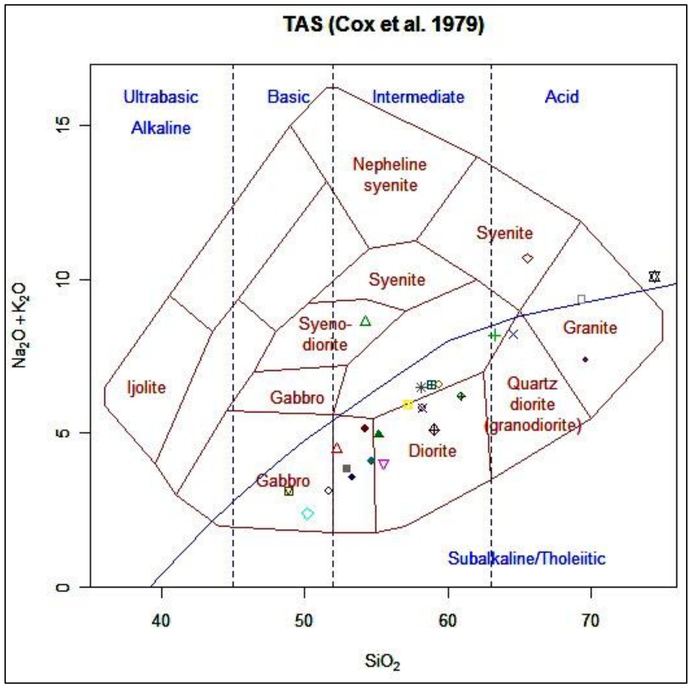

Figure 4: Si_2O-Na_2O+K_2O plot TAS
Source: Cox *et al* (1979)

According to TAS (Cox et al, 1979) for plutonic rocks, samples D49, D41 and D34 are in alkaline range and the rest of samples are in sub alkaline and tolite range.

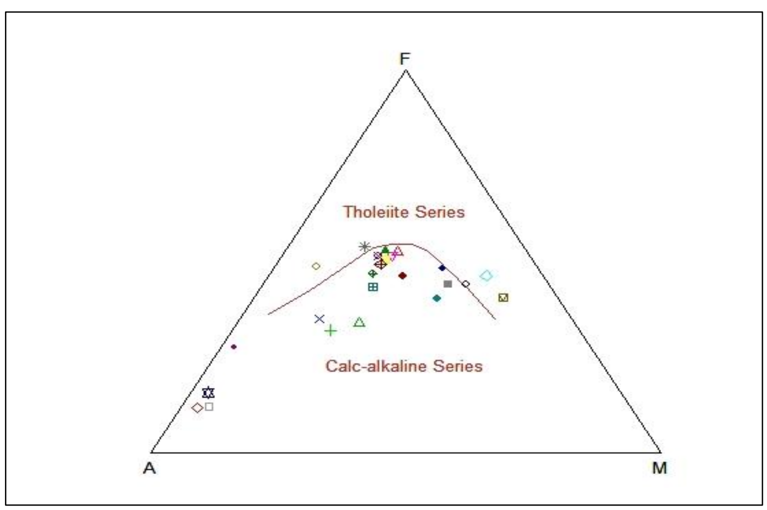

Figure 5: AFM plot
Source: Irvine and Baragar (1971)

According to the AFM diagram, most of the samples are in the calk- alkaline series and a few are in the toleitic series.

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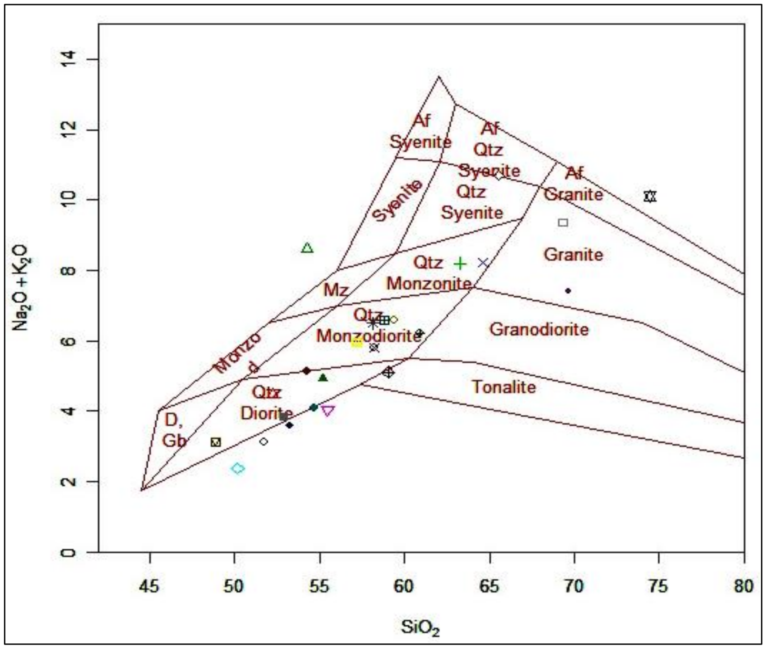

Figure 6: SiO_2 - $Na_2O + K_2O$ plot TAS
Source: Middlemost (1994)

As shown by TAS alkaline silica graph (Middlemost, 1994) for plutonic rocks, samples D111, D109, D102, D49 and D121 are out of the chart range, samples D31 and D34 are in the granite area, samples D104 and D105 in the quartz monzonite area, sample D115 is in the tonalite area, samples D60, D112, D115, D117, D122 and D124 are in the quartz monzonite area and the rest of the samples are in the quartz diorite zone.

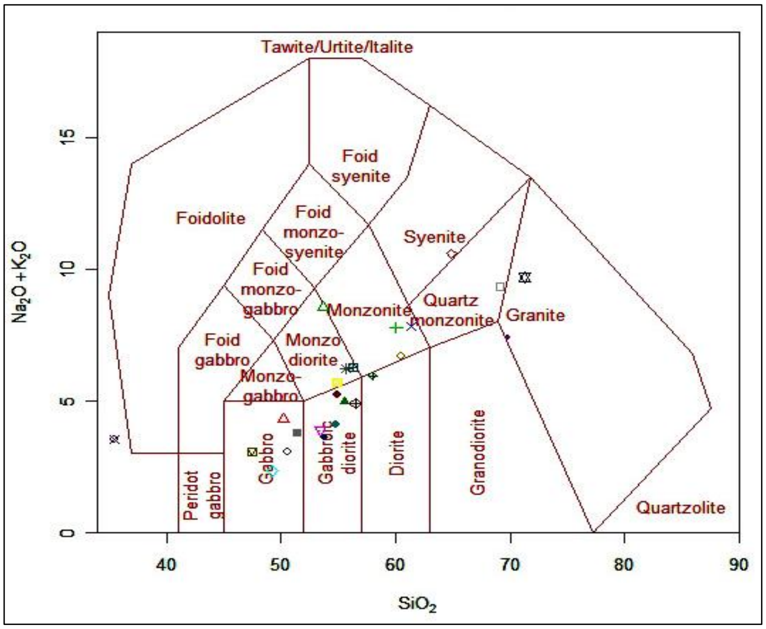

Figure 7: SiO_2 - $Na_2O + K_2O$ plot
Source: Middlemost (1985)

From the matching of plutonic sample data on TAS alkaline silica aggregate (Middlemost, 1985) for plutonic rocks, the studied samples are stretched from gabbro to granite range.

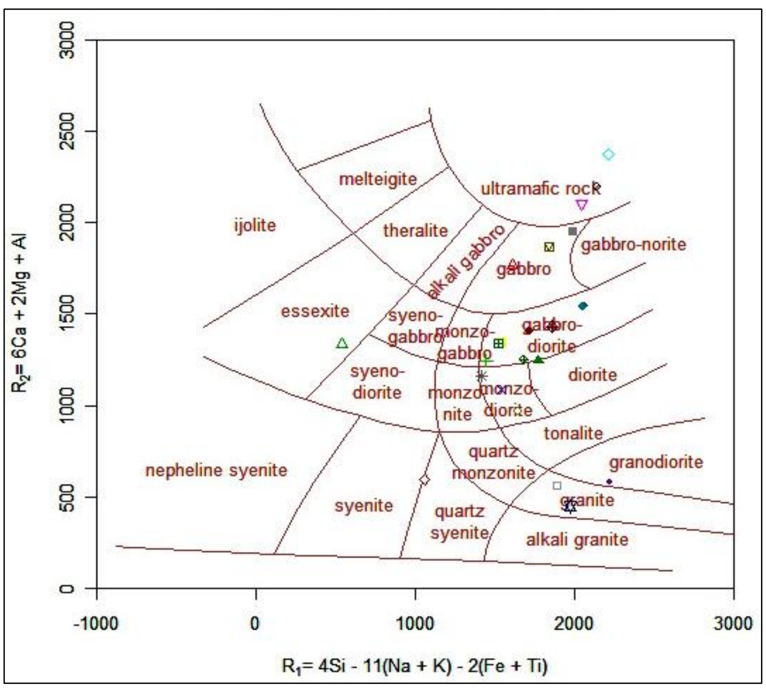

Figure 8: R_1-R_2 plot
Source: De la Roche *et al.* (1980)

D34 and D121 in granite, D31 in granodiorite, D41 in quartz sinite, D115 in monzodiorite, D49 in ESSEEXITE, D109 and D121 in ultramafic rocks D125, D103 D126, are located in the gabbro section and the rest of the samples in the gabbro diorite area.

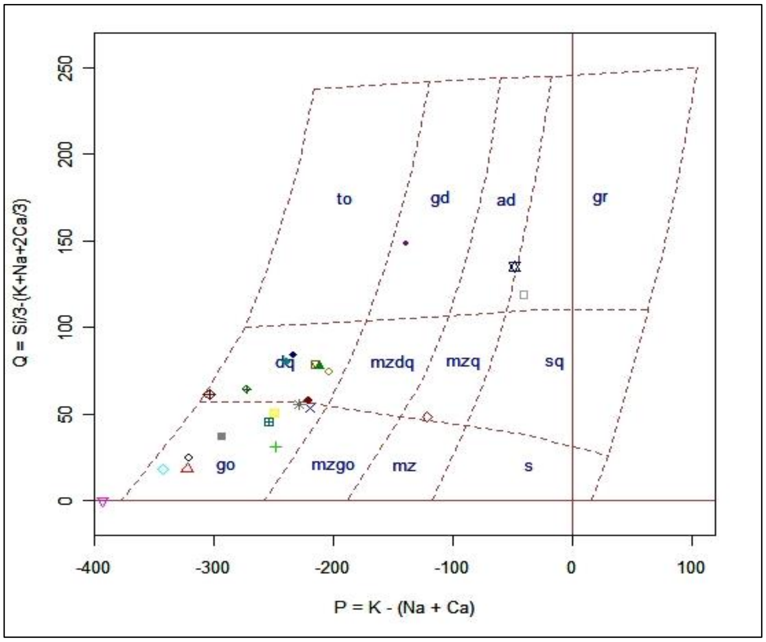

Figure 9: P-Q plot
Source: Debon & Le Fort (1983)

In the figure (P, Q1983 Debon and Lee Fort), sample D34 is in the granite area, sample D121 in the granite and adamlite area, sample D41 in the quartz monzonite area, samples D115, D102, D69, D60, D42 and D117 in the quartz diorite range and the rest of the samples are in the Gabbro range.

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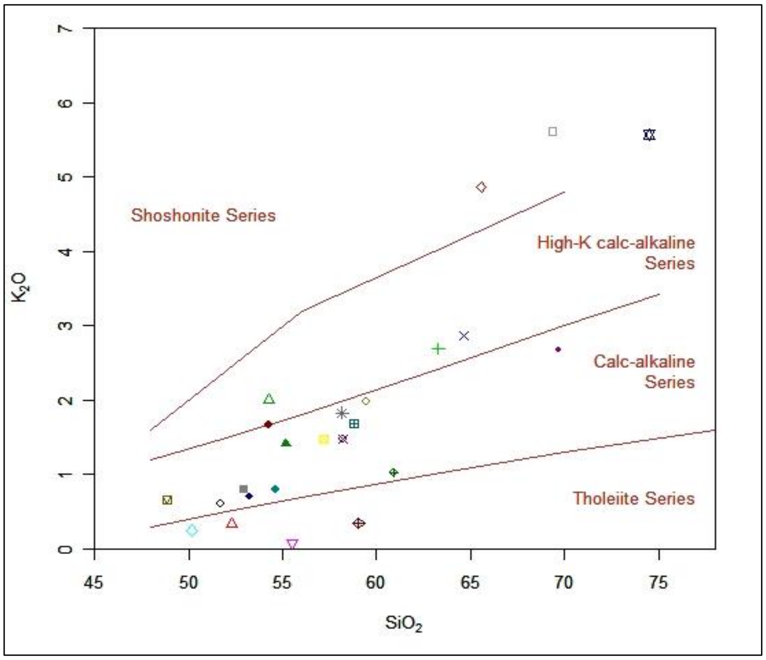

Figure 10: SiO_2 - K_2O plot
Source: Peccerillo & Taylor (1976)

According to the Peccerillo & Taylor 1976 diagram, samples D34, D41, and D121 are in the shoshoniitic series, samples D109, D111, D115, and D116 are in the toilet series; samples D42, D49 and D103 are in the high potassium calk-alkaline region. And the rest of the studied samples are in the calk-alkaline series. Potassium-rich rocks and the shoshonitic series are present in places where the Benioff Seismic Zone is deep or seen in areas where locally extensional tectonics is prevalent (Middlemost, 1987). These rocks also appear only in continental regions and have not been found in oceanic crusts.

Conclusion

According to field of study conclusions, the following results were obtained:

Plutonic masses were studied in the north of Sonqor in Kermanshah province and between Varmaqan in the east of the study area and Vali Abad to the west of the study area. The study area contains olivine gabbro, gabbro, diorite gabbro, diorite, monzonite, Alkaline syenite, quartz diorite, quartz monzodiorite, quartz monzonite, quartz alkaline sinite, tonalite, granodiorite, granite and alkaline granite.

These stones are light to medium in color (leucocrat to mesocrat) in hand specimen with little alteration. The principal constituents of these rocks are quartz, orthos, and plagioclase, and biotite, zircon, apatite, and opaq minerals are the minor minerals. In monzodiorite and quartz monzodiorite, in addition to the above minerals, clinopyroxene minerals such as augite and amphibole minerals such as hornblende exist too.

Severe chloritization and apacitization in biotite, sericitization and kaolinitization in plagioclase and kaolinitization in orthoses in granites and granitoids have occurred in great volumes.

Based on the results of delineated graphs such as Middlemost (1985) based on (Na_2O + K_2O) / (SiO_2), Cox et al. (1979) based on (Na_2O + K_2O) / (SiO_2) as well as Middlemost (1994) based on (Na_2O + K_2O) / (SiO_2) and Debon & Le Fort (1983) based on the Q / P plot and normative calculations of the samples, it is concluded that the rocks classified by the CIPW method include: gabbrodiorite, monzodiorite, granite, granodiorite and syenites and all show genetic dependence.

It seems that the magmas of all the plutonic rocks in the region appear to have a common origin caused by magmatic differentiation and fractional crystallization and differ from intermediate to acidic terms. All granites in this study are **I** type.

Two-dimensional diagrams of Irvine and Baragar were used to determine the magmatic series of plutonic rocks. The following results were obtained: Most of the samples were sub-alkaline with a calk-alkaline nature.

Peccerillo and Taylor's,1976 diagram, based on the K_2O to SiO_2 ratio, plots these rocks in three sections: calk-alkaline, potassium-high calk-alkaline and shoshonite. Conclusion of Maniar and Piccoli ,1989 diagrams is that the samples are of meta-alumina type and they have high percentages of aluminum. Based on the above results, it is concluded that the constructive magma of the plutonic rocks is calk-alkaline with a high percentage of aluminum. To illuminate the chemical and geochemical properties of these plutonic rocks and the genetic relationships, Harker's chemical reaction charts and differentiation index (D.I) were used.

Harker's diagrams ,1909 are plotted on the basis of major oxide changes of plutonic rocks of the region in ratio with silica, and the following results were obtained:

The abundance of Al_2O_3 in the less acidic and acidic terms is approximately equal but increases in the intermediate acidic terms, increased plagioclase crystallization is the main reason. The slope of the Fe_2O_3 diagram decreases from lower acidic to acidic terms which is mainly due to the presence of this element in amphibole, augite and magnetite minerals. The

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presence of Ca in the structure of augite and calcic plagioclase has caused CaO to be much higher in the less acidic term than the acidic term. The increase of Na_2O from basic terms to acidic terms indicates that the early magma was initially poor in Na, but after crystallization of calcic plagioclases and augite and the depletion of Fe,Ca and Mg , Na levels increased in left over magma. The abundance of potassium in the rocks of the area indicates irregularities, potassium is a strong hydromagmatophilic element and due to its high ionic radius, in the late stages of magma evolution it is consumed in acidic rocks and enters the feldspar mineral lattice, thereby its amount from less acidic rocks to acidic rocks is associated with increased irregularity. The curve slope of the MgO diagram relative to SiO_2, descends from less acidic to acidic terms because of magnesium consumption in amphibole and augite minerals formation. The high abundance of TiO_2 in the plutonic rocks indicates a downward trend towards acidic terms.

Examination of major elements oxidation diagrams in relative to the differentiation index (D.I) showed that partial crystallization of amphibole, augite, and calcic plagioclase caused magma to be depleted of iron, magnesium and calcium, and with increasing magmatic crystallization, the amount of elements such as sodium increased.

Based on tectonomagmatic positioning diagrams of the Maniar & Piccoli 1989, our samples are in the post-orogenic granitoids (POG) range.

The basic magmas in the study area are of mantle origin, which as acidic magmas originate from these basic magma fractionation and crustal contamination.

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