

# Petrology and Geochemical Properties of the Granitoid Complex of Chahar-Gonbad, Southeast Iran

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## Abstract

The Chahargonbad batholite is located in Sirjan and southeast of magmatic zone of Urumieh-Dokhtar. The main volume of this rocks consisted of Granodiorite and Monzogranite, but it's also consists of Quartzdiorite, Tonalite and Syenogranite. They have allotrimorphic granular texture with subordinate porphyritic texture. Their enclaves consist of: xenoliths enclaves, microgranular mafic enclaves (Diorite to Quartzdiorite in composition) and autolite enclaves (Tonalite, granodiorite and monzogranite in composition). The Chahargonbad batholite rocks are also cut by different types of dykes which are mainly consisted of dykes and veins of pegmatic stage, microgranular dykes (andesit and andesit basaltic in composition) and microgranular dykes that are similar to mafic enclaves. Evidence shows that regional examples represent properties of granitoids type I. As well as, Granite of Granitoid body of this area has magnesium nature and shows the cordellarian granites features. Based on the tectonomagmatic environment determination diagrams, all samples from the Chahargonbad study area located in the arc island setting due to subduction and show the characteristic of active continental margin setting.

## Keywords

Petrology and Geochemical Properties Granitoid Complex, Southeast Iran

## 1. Introduction

Chahar Gonbad granitoid mass is situated in geographic longitudes (56°10' - 56°21') and latitudes (29°34' - 29°34') at 80 km distant from northeast of Sirjan

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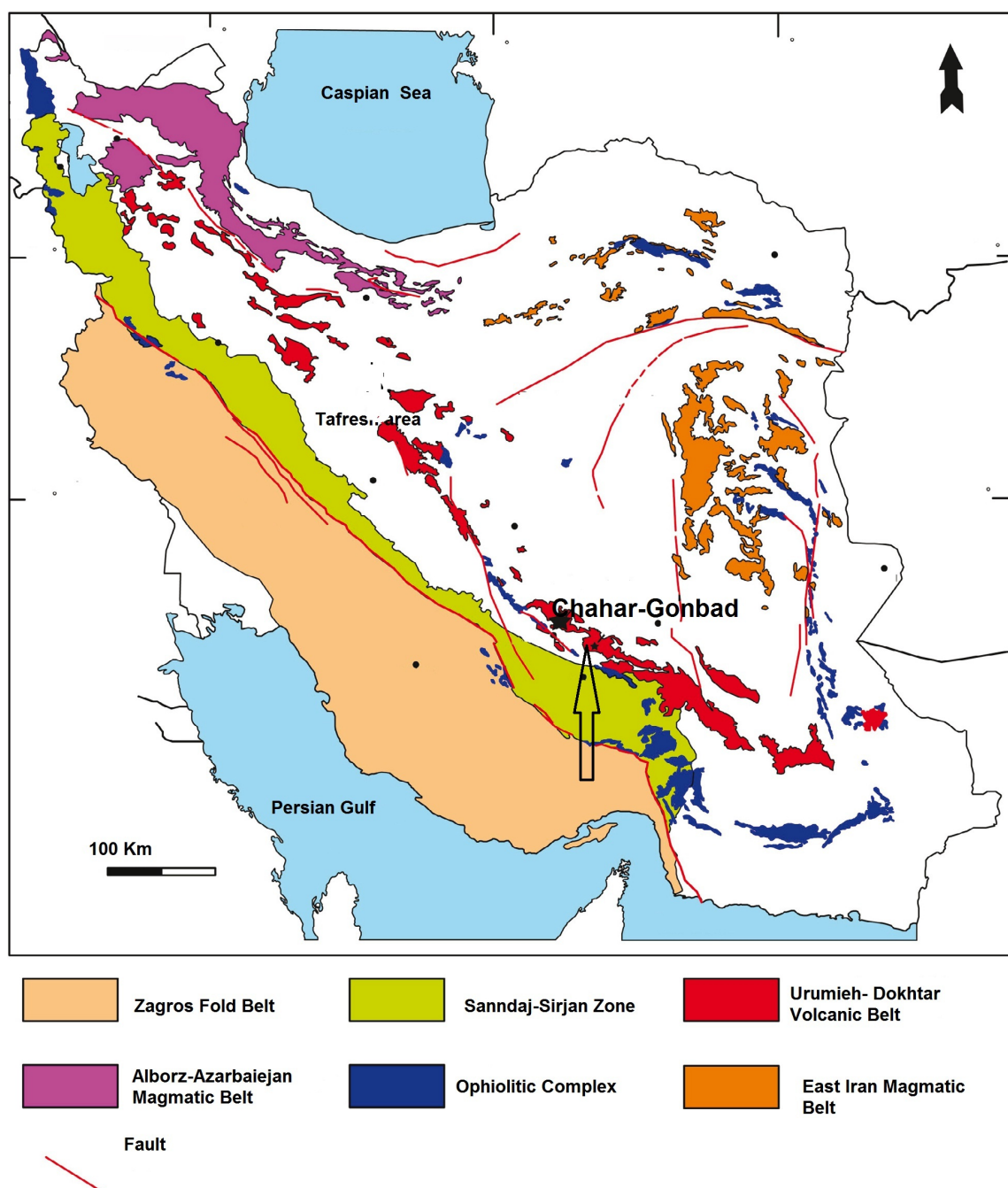
zone and 32 km at northwest of Belord county in Kerman province and with respect to structural-sedimentary divisions of Iran [1] and it is located at southeast of Uremia-Dokhtar magmatic belt [2]. Most of granitoids is composed of granitoid to granodiorite at southwest of Kerman and they are metaluminous and calc-alkaline [3]. The rocks which include this granitoid mass are Eocene volcanic-sedimentary complex that is the oldest rock unit in this zone and it is well visible at south and east of this region. Given the granitic rocks have only crossed Eocene rocks one can attribute these rocks at least to post-Eocene magmatism in terms of age where they have intrude and placed due to performance of Chahar Gonbad fault. Several dikes have crossed this plutonic mass where their array has also crossed Eocene volcanic-sedimentary complex as well. The studied rocks in Chahar Gonbad zone were divided into four groups of extrusive and intrusive igneous rocks, xenolith, and clastic igneous rocks. The extrusive igneous rocks are as follows: 1) andesite, 2) rhyolite, and 3) dolerite. Intrusive igneous rocks include i) diorite with quartz content, ii) tonalite, iii) granodiorite, and iv) granite (monzogranite and syenogranite). Rocks in xenolith groups and clastic igneous group of rocks comprise of tuffs. We will examine the evidences of magmatic evolution in granitoid rocks in this zone in the following. This study is intended to explore petrographic and geochemical evidences of magmatic evolution in granitoid rocks in Chahar Gonbad zone and determine tectonic environment of rocks in this zone.

## 2. Geostrategic

Tectonic factors in the westward and SW of Iran could be classified such 1) UDMC, 2) Sirjan-Sanadaj Region and 3) Zagros Fold-Thrust [4].

The UDMC includes Eocene-Quaternary plutonic and volcanic stones 4 km thicknesses and 50 km long [5]. But, the utmost of the magmatic action happened at Eocene which contains different of volcanic stones. However, Cretaceous parts were discernible in this region north too (Figure 1). The volcanic action was expelled in Upper Miocene and extended by Pliocene-Quaternary and identified by basaltic dacites and andesites as lava runs and heads and volcanic detritus flow. The emplacement age of these stones has not been delimited via geochronological period, however, according to stratigraphical investigations; the mentioned stones are fresher than Miocene. Apparently, the present volcanic action started in the late Miocene and extended by Pliocene. The UD volcanic stones have several, chemical, mechanical and petrological from acidic to primary and so creation conditions from continental to low marine depth. The acidic igneous masses were in sufficient associated via average till primary stones and frequently made because of continental shell melting [6].

Tafresh region is a section of the UDMC found in the center Iran. The UDMC is a portion of the Alpe-Himalayan orogenic belt and located within Arabian and Eurasian range in the same bias via Sirjan-Sanandaj changed region (Northwest, East south). The magmatic of the proposed belt is a debated issue, as some of the researchers [7] correlate it to the intracontinental cracks. Whereas other reserachers [8] [9] offer the subduction of the Neotethyan oceanic lithosphere



**Figure 1.** Schematic of Iran map, displaying the division of the main sedimentary and tectonic parts. The Urumieh-Dokhtar magmatic arc is of regularly Eocene-Miocene age, some of the other volcanic stones are older.

under the center Iran plate as the cause of the magmatic.

The principal purposes of the current research are to show geochemical aspects, as well as recognized area links of the Chahar-Gonbad complex, to characterize igneous magmatism, discover its main source and the tectonic situation in the Sirjan-Sanandaj District and to cast light on the Rocky history and associated magmatites in Iran. The information in the present work is essential for the recognition of the appearance of a subduction region in South-west of Iran over the Cenozoic.

### Context of Geological

The Chahar-Gonbad granitoid complex is located 80 km north east of Sirjan city, Kerman province, southeast of Iran, which lies between  $29^{\circ}34'N$  -  $29^{\circ}42'N$  and between  $56^{\circ}10'E$  -  $56^{\circ}21'E$  (Figure 1).

Chahar-Gonbad granitoids contain quartz diorite, Tonalite, synogranite, granodiorite and monzogranite. The granodiorites were extensive through the region and the largest interference in the region. They are white, gray to pinkish and commonly medium to coarse-grained stones and have a granular to porphyritic form presenting a plain Mineralogy: Plagioclase (35 - 45 percent mod.), K-feldspar (9 - 20 percent mod.), Quartz (21 - 40 percent mod.), Biotite (more than ten percent mod.) (Figure 2).

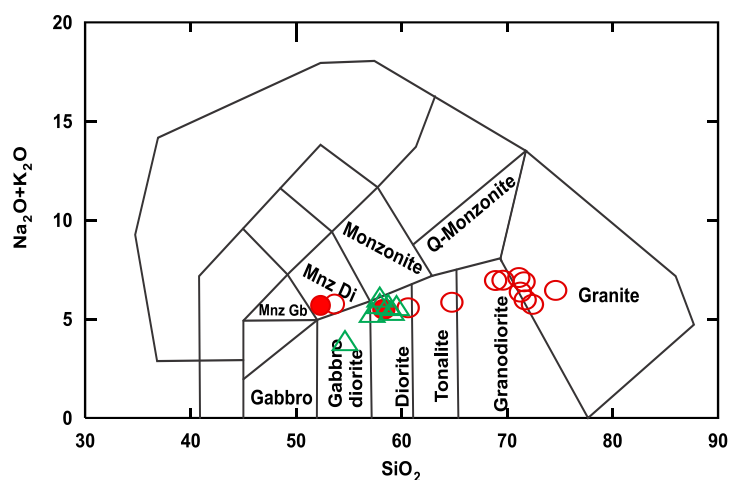
### 3. Materials and Methods

Approximately 100 examples of the granitoid stones gathered from various facies. To correctly characterize their chemical structures, 20 fresh specimens were taken for principal, track, and rare-earth-elements (REE) investigation. Principal and track factor wealth were discovered by inductively coupled plasma atomic emission and inductively coupled plasma-mass spectrometries at the Karaj Standard labs in Iran. The scientific methods are explained in [10].

#### *Geochemical properties*

The  $SiO_2$  amount of cases changes between 53 by 76 wt percent (Table 1). Large share of cases make approximate linear to curvilinear biases of reducing  $MnO$ ,  $TiO_2$ ,  $Al_2O_3$ ,  $Fe_2O_3^*$ ,  $MgO$ ,  $P_2O_5$ , and  $CaO$ , and developing  $Na_2O$  and  $K_2O$  via growing  $SiO_2$  (Figure 3). The models of these in the  $Al_2O_3$ ,  $P_2O_5$ ,  $CaO$ ,  $MgO$ ,  $FeO$ ,  $TiO_2$  versus  $SiO_2$  figures show decreasing trend versus increased  $SiO_2$  plot. These models recommend that fractionation and crystallization of plagioclase, hornblende, a Ti-bearing state, and apatite should have performed functions in the stones.

Harker pictures of the principal factors show amazing biases recommending



**Figure 2.** Total Alkali versus  $SiO_2$  for major factors of the Chahar-Gonbad Granitoid complex.

**Table 1.** Amount of cases changes between 53 by 76 wt percent.

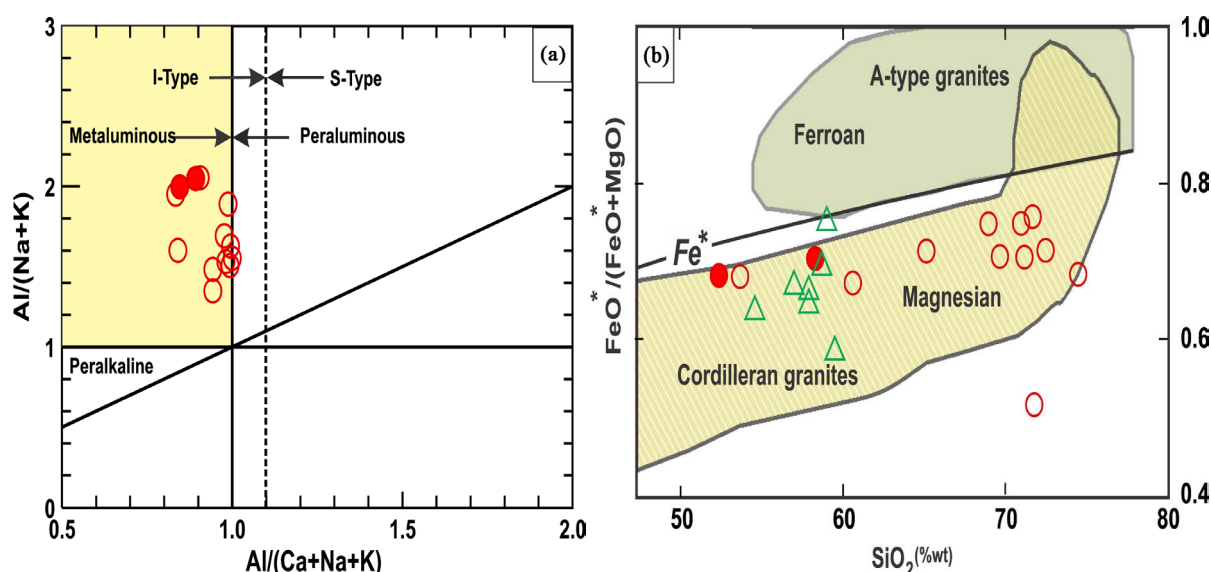
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## Continued

SAMPLE	DESCRIPTION	ME-MS81	V	Cr	ME-MS81	Ni	Ga	Rb	ME-MS81	Sr	Y	Zr	Nb	ME-MS81	Cs	Ba	ME-MS81	La	ME-MS81	Ce	Pr	ME-MS81	Nd
		ppm		ppm		ppm	ppm	ppm		ppm	ppm	ppm	ppm		ppm	ppm		ppm		ppm	ppm	ppm	
A.H-F5	Granite	37	100	14	15.5	4.9	403	15.9	157	5.6	3	0.61	101.5	11	27.4	3.38	12.9						
A.H-A9	Granite	49	90	15	15.7	101.5	226	19.3	172	4.6	2	2.3	464	21	41.9	4.78	17.9						
A.H-C12	Granite	24	120	16	13.9	3.3	251	10.3	135	4	1	0.24	84.5	8.2	22.4	2.79	10.7						
A.H-A13	Dyke	229	60	24	18.9	36.3	324	23	108	2.9	1	1.55	153	10.7	24.1	3.19	14.4						
A.H-C8	Dyke	171	50	15	18.8	66.8	346	14	70	2.4	2	4.61	136	7.3	16.4	2.09	9.5						
A.H-D1	Dyke	150	40	7	18.4	77.8	306	17.8	80	3.9	2	1.92	181.5	8.7	21.2	2.77	12.7						
A.H-C4	Dyke	139	120	28	16.5	50.4	353	13.4	102	3.9	1	0.65	287	12.4	24.3	2.76	10.4						
A.H-F3	Granite	41	80	<5	15.3	97.5	209	10.1	120	4.6	1	1.94	374	13.7	24.7	2.66	9.7						
A.H-H7	Granite	50	100	11	16.4	88.3	244	15.6	173	4.9	1	1.27	529	17.3	34.5	3.86	14.7						
A.H-F8	Granite	90	100	24	18.5	68.8	263	11.7	126	3.4	1	1.53	301	10.7	20.5	2.21	9.8						
A.H-A2	Granite	229	40	32	19.1	68.2	403	20.9	108	4.1	1	4.46	248	11.9	25.9	3.27	15.3						
A.H-C9	Dyke	166	40	29	20.5	84.6	354	13.9	62	2.9	2	5.61	192.5	7.4	16.2	2.02	10.3						
A.H-A14	Dyke	178	60	6	18.7	48.8	333	18.1	125	7.1	1	1.09	566	12.6	26.9	3.33	15.4						
A.H-D4	Dyke	183	90	14	19.2	62	334	12.7	55	3	2	1.22	221	7.5	16.2	1.98	9.6						
A.H-F4	Granite	44	120	14	14.9	83.3	200	10	104	3.9	1	1.21	374	13.2	24.4	2.61	9.6						
A.H-C15	Enclave	180	50	18	19	68.4	249	20.7	71	4.1	1	1.66	228	11.2	24.3	3.18	14.6						
A.H-A11	Granite	48	110	18	16.1	78.8	233	20.1	159	4.7	2	1.11	421	10.8	22.3	2.63	12.3						
A.H-C11	Granite	164	80	18	18.1	66.2	247	20.1	145	4.6	2	4.36	294	12.3	25.2	3.15	13.5						
A.H-F7	Granite	35	130	17	16.9	5.8	341	15	173	5	4	0.47	111	9	21.5	2.87	12.6						
A.H-C14	Enclave	240	20	12	21.6	99.4	244	22.2	43	4.3	2	3.03	235	11	26.4	3.41	16.5						

SAMPLE	ME-MS81	ME-MS81	Eu	Eu	Sm	ppm	ME-MS81	ME-MS81	Gd	Tb	Dy	Ho	Er	ME-MS81	Tm	Yb	Lu	Hf	ME-MS81	ME-MS81	W	Th	U
DESCRIPTION	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	
A.H-F5	Granite	2.75	0.68	0.68	2.21	0.39	2.48	0.52	0.52	1.63	0.27	1.85	0.31	4.4	0.5	0.5	1	11.3	1.37				
A.H-A9	Granite	3.77	0.8	0.8	3.24	0.49	3.2	0.71	2.06	0.34	2.34	0.36	4.5	0.4	0.4	1	9.06	1.22					
A.H-C12	Granite	2.03	0.54	0.54	1.83	0.25	1.65	0.33	1.13	0.17	1.23	0.2	3.5	0.3	0.3	<1	13.45	1.28					
A.H-A13	Dyke	3.81	0.96	0.96	3.69	0.6	3.96	0.84	2.34	0.39	2.35	0.37	3	0.2	0.2	1	4.24	1					
A.H-C8	Dyke	2.44	0.84	0.84	2.39	0.42	2.54	0.55	1.62	0.23	1.67	0.24	2.1	0.2	0.2	3	3.3	0.61					
A.H-D1	Dyke	3.1	0.82	0.82	3.36	0.52	3.23	0.69	2.04	0.34	2.1	0.31	2.3	0.2	0.2	1	4.3	0.7					
A.H-C4	Dyke	2.3	0.73	0.73	2.38	0.41	2.27	0.5	1.45	0.21	1.59	0.22	2.8	0.2	0.2	2	6	1.15					
A.H-F3	Granite	1.73	0.54	0.54	1.77	0.28	1.65	0.35	1.16	0.17	1.26	0.23	3.3	0.4	0.4	1	10.8	1.54					
A.H-H7	Granite	3.09	0.7	0.7	2.82	0.45	2.63	0.59	1.8	0.27	1.93	0.32	4.6	0.3	0.3	1	10	1.48					
A.H-F8	Granite	2.16	0.78	0.78	2.2	0.31	2.08	0.45	1.26	0.22	1.48	0.22	3.7	0.3	0.3	1	6.27	0.88					
A.H-A2	Granite	4.04	1.1	1.1	3.99	0.63	3.99	0.85	2.35	0.37	2.35	0.33	3.3	0.2	0.2	1	4.32	1.05					
A.H-C9	Dyke	2.35	0.96	0.96	2.84	0.37	2.86	0.56	1.59	0.25	1.6	0.23	2.2	0.2	0.2	2	3.67	0.61					
A.H-A14	Dyke	3.45	0.99	0.99	3.61	0.57	3.71	0.71	2.12	0.33	2.08	0.32	3.5	0.3	0.3	1	5.64	1.26					
A.H-D4	Dyke	2.3	0.8	0.8	2.65	0.42	2.69	0.51	1.56	0.24	1.5	0.21	1.8	0.2	0.2	1	4.3	0.79					
A.H-F4	Granite	2.04	0.59	0.59	1.97	0.28	1.68	0.38	1.02	0.17	1.13	0.21	3.2	0.3	0.3	1	8.01	0.97					
A.H-C15	Enclave	3.62	0.98	0.98	3.89	0.57	3.82	0.86	2.26	0.32	2.56	0.36	2.6	0.3	0.3	1	5.29	0.74					
A.H-A11	Granite	3.08	0.77	0.77	3.48	0.57	3.43	0.75	2.4	0.34	2.26	0.34	4.7	0.3	0.3	1	9.06	1.99					
A.H-C11	Granite	4.22	0.82	0.82	3.57	0.6	3.7	0.77	2.3	0.31	2.46	0.35	4.2	0.3	0.3	1	5.92	0.88					
A.H-F7	Granite	2.19	0.81	0.81	3	0.41	2.58	0.56	1.77	0.26	1.73	0.29	5	0.3	0.3	1	8.23	1.78					
A.H-C14	Enclave	3.95	1.02	1.02	4.03	0.67	4.22	0.94	2.73	0.38	2.52	0.44	1.8	0.3	0.3	1	4.94	1.17					





**Figure 3.** (a) Molar  $A/CNK [Al_2O_3 / (K_2O + Na_2O + CaO)]$  vs.  $A/NK [Al_2O_3 / (K_2O + Na_2O)]$  diagram, (b) Granitoid type identification by  $FeO^* / (MgO + FeO^*)$  Vs.  $SiO_2$ .

obviously that the monzogranites and granodiorites might be related to fractional crystallization procedures (Figure 4).

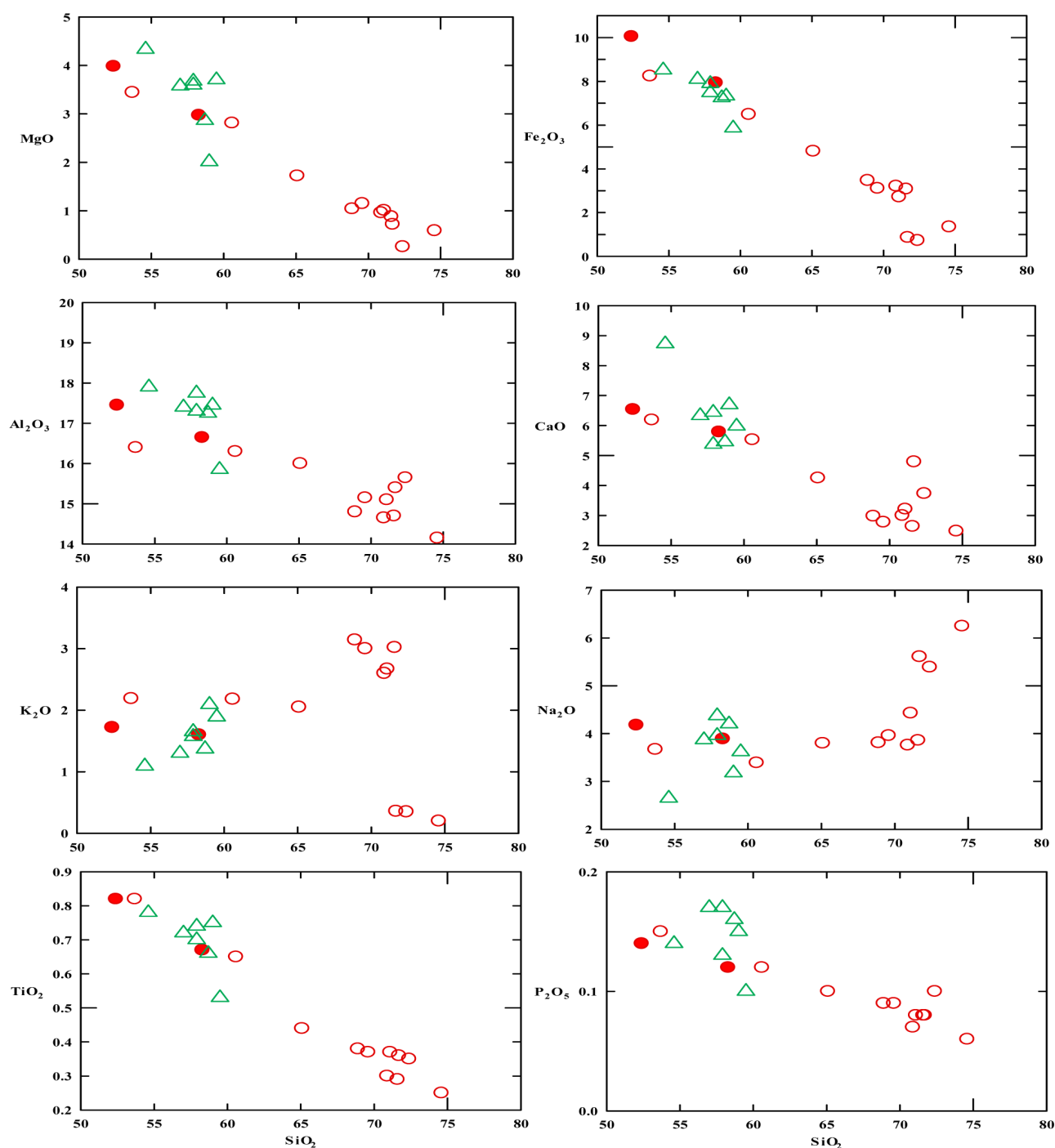
In the microscopic  $Al_2O_3 / (K_2O + Na_2O + CaO)$  vs.  $Al_2O_3 / (K_2O + Na_2O)$  [A/CNK versus A/NK] figure [11] the quartz-diorites structure, granodiorites, monzogranites scheme to the meta luminous area. The rate of The molecular A/CNK of these rocks are in the range of [1 - 1.1] of A/CNK (Figure 3(a)), so the stones were of I-kind in the presence of [12], so, these rocks fall in magnesian type of granitoids and related to cordillerian types of gnitic rocks (Figure 3(b)) [13].

All samples shown low-K affiliation based on the  $K_2O$  versus  $SiO_2$  figure of [14] (Figure 5(a)) and are sub-alkaline relation and relate to the calc-alkaline set from the [15] distribution system (Figure 5(b)).

#### ***Tectonic context of emplacement and magma generation***

The Chahar-Gonbad Granitic Complex is normally made of a Medium-K calc-alkaline set (Figure 5(a)) in that quartz-diorite, monzogranite, and granodiorite were the predominant stone models. Area associations, geochemistry, and petrography these stones present community to interventions standard of the dynamic continental boundaries. Various investigations recommend that trace parts could be utilized to distinguish among the various tectonic contexts of granitoid magmas [11] [12] [13]. The Chahar-Gonbad granitoid in the geotectonic distribution of [14] [15] are incorporated as volcanic arc stones (Figures 6(a)-(d)). Moreover, as explained beforehand, granitoid of the Chahar-Gonbad field improved in LILE like Rb and Cs, concerning the HFSE, particularly Nb and Ti (Figure 7). Magmas via these geochemical characteristics are frequently ascribed to the subduction-associated conditions [16]. High Th/Yb rates related via special rates for Th/Yb are compatible via continental arc magmas (Figure 7).



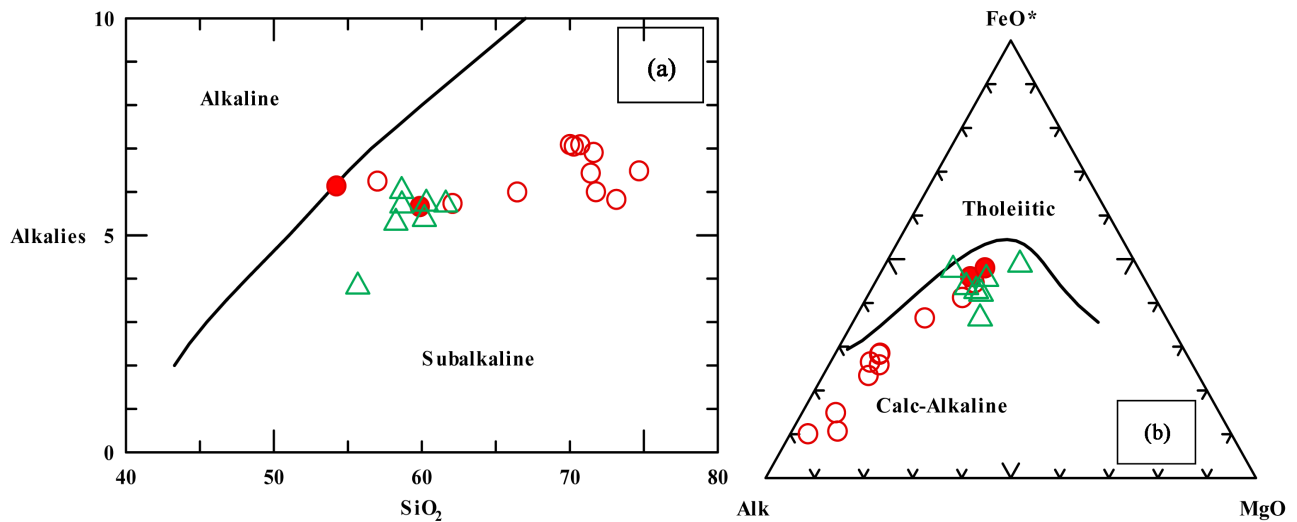


**Figure 4.** Harker figures for major factors of the Chahar-Gonbad Granitoid complex.

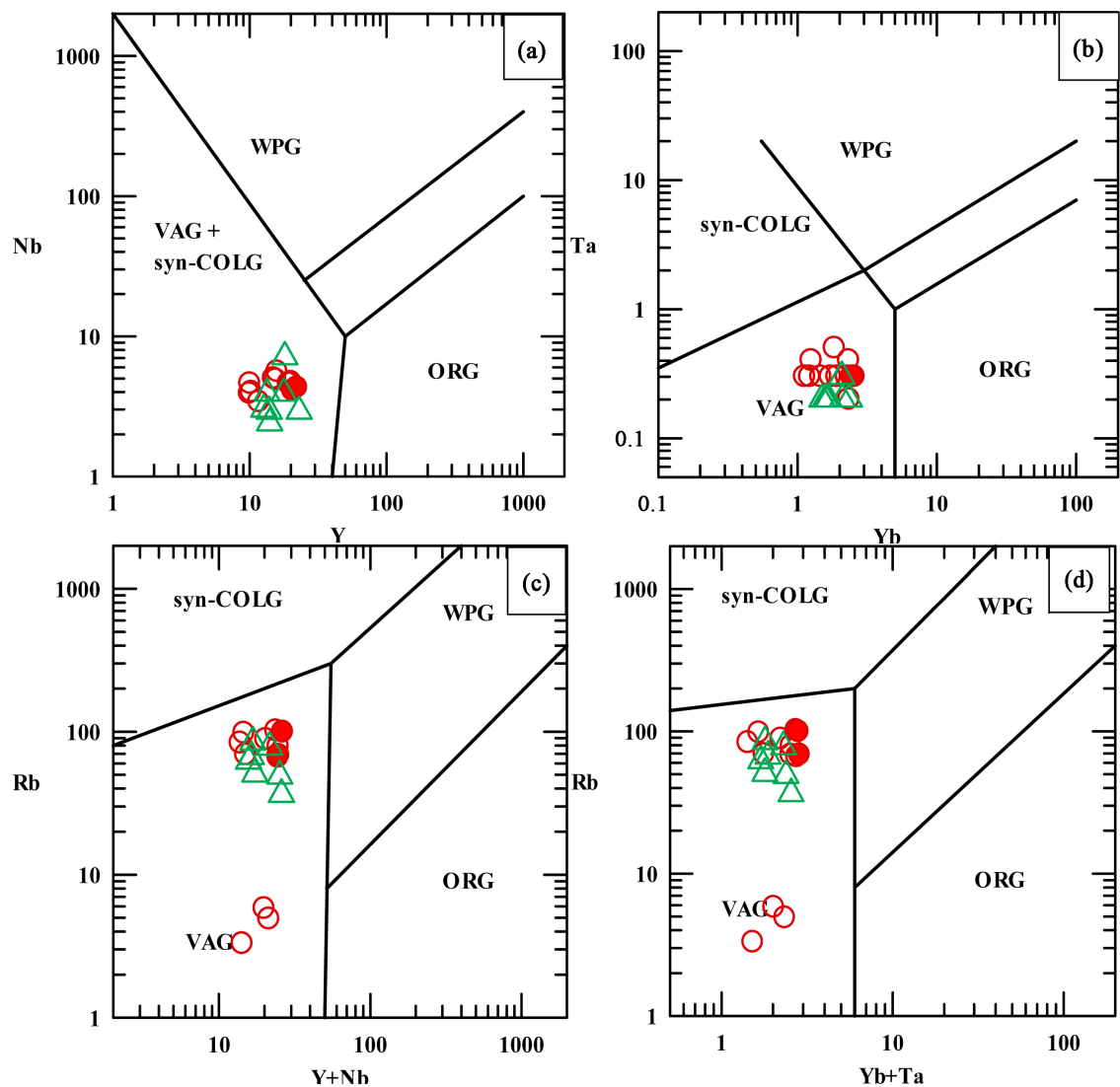
## 4. Conclusions

The Chahar-Gonbad complex can be described as follows according to the evidence:

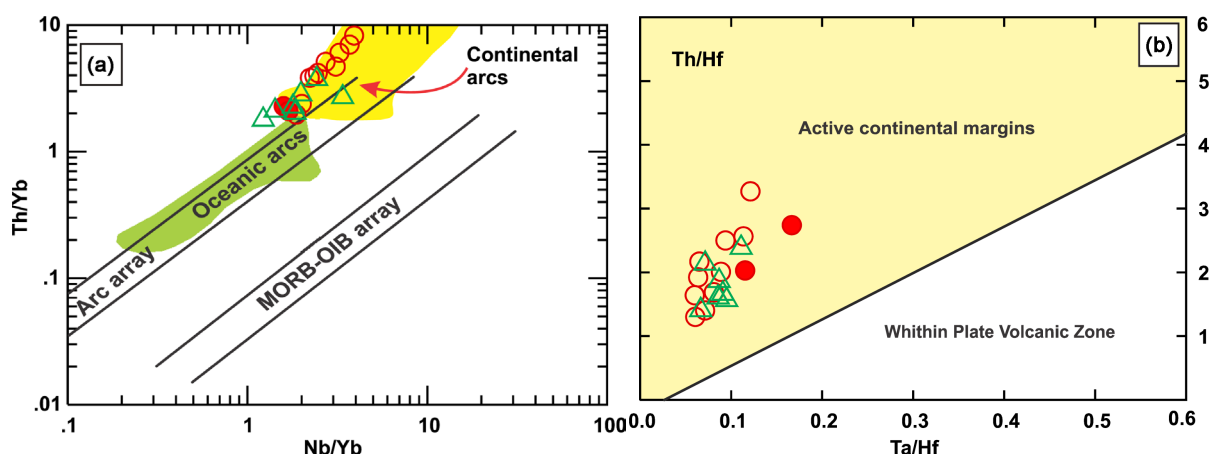
- A majority of the plutonic rocks are granites and granodiorites.
- Hydrothermal alterations have affected the intrusions.
- The study of the variation of the major elements shows that the samples of the three studied intrusions all formed in a similar setting.



**Figure 5.** (a) K<sub>2</sub>O Versus. SiO<sub>2</sub> plots via area; (b) AFM plot via are delineated after.



**Figure 6.** (a)-(d). Rb vs. (Yb + Ta), Rb versus (Nb + Y), Rb versus (Ta + Yb), Ta versus V and Ta versus Yb plots of Pearce (1984).



**Figure 7.** (a) Th/Yb ratios vs. Nb/Yb are compatible via continental arc magmas. (b) Ta/Hf ratios vs. Th/Hf Pearce (2008).

- The granitic magmas show typical calc-alkaline trends.
- The intrusions are post orogenic granitoids and shown within plate granite features.

So, the Chahar-Gonbad Granitoid Complex is composed of some factors containing monzogranite, quartz diorite, and granodiorite. The geochemical properties, mineralogy, and petrography of these stones are relative to the standard I-kind stones. The Complex refers to metal luminous, a medium-K calc-sub alkaline range, and presents geochemical features standard of volcanic arc stones compared to an actual continental border. The geochemical records for the Chahar-Gonbad granitoid are a descent from a screen origin, and it can be recommended that the granitoid started by partial melting of mantle protoliths having various structures in a deforming operating border. The obtained results are compatible via the common pattern of [17] that considered that the Sirjan-Sanandaj calc-alkaline magmatic arc made over a high angle subducting oceanic plate in the Neotethyan subduction region.

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