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Geology, petrography and geochemistry of Khansorkh copper index (southwest Aligudarz, Lorestan, Iran)

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ABSTRACT

The Kansorkh copper index is located in 35Km of southwest of Aligudarz, Lorestan, Iran, and is regarded as a small portion of Sanandaj – Sirjan Zone (SSZ). The studied region is affected by important orogenic phases of Cimmerian and final cretaceous and several intrusive masses like Aligudarz are injected in it. These masses have penetrated into shales and Jurassic sandstone. The igneous rocks are mainly ranging from granodiorite to andesite volcanic. The petrology studies show that volcanic rocks of the region are porphyry andesite. In terms of mineralization : chalcopyrite, chalcosite, burnit, malachite, azurite, magnetite and limonite minerals are the most important minerals that occurring as veinlets. In terms of alteration, sericitiazation, chloritization, and epidotization are dominated alterations of the region. With regard to development of alteration zones in volcanic rocks and vein mineralization in these rocks it seems that these rocks are the main host rock of mineralization in the region and mineralize factor must be related to probably granodiritic intrusive. Based on geotectonic data these rocks are related to arcs after collision volcanic. The under studied region's rocks are normalized based on primitive mantle and ORG values. All cases almost show chemical-charactiritics and similar neicheru mantle metasomatism ore continental crust impregnation.

Key words: Khansorkh-copper-peterology-Alteration-mineralization-Geochemistry

Introduction

The area under studied is located in 35Km south-west Aligodarz (north-east of Lorestan province). The area is limited to geographical latitude of 33 17' 22" N and longitude of 49 36' 51" E in a mountain are with semi mountain geomorphological view. In the context of the structural subdivisions of Iran (Zarasvandi *et al*., 2005), this area is a portion of Sanandaj-Sirjan Zone. Seduction of the Tethyan oceanic lithosphere under the southwestern border Central Iran, caused volcanic activity between the Jurassic and Quaternary within and adjacent to the Sanandaj-Sirjan Zone in the Northwest-Southeast of Iran (Fig. 1) (Ricou *et al*.,1977; Berberian and King, 1981; Berberian, 1983; Mohajjel *et al*., 2003). The tectonic history of the Tethyan region has been studied by many authors (e.g. [8,9,10,11, …]m Takin, 1972; Stocklin, 1974, 1977; Farhoudi, 1978; Berberian, 1981, a, b; Berberian and King, 1981; Berberian and Berberian, 1981; Jankovic, 1984; Sengor, 1984, 1990, 1991; Alavi, 1994; Sengor *et al*., 1988; Ahmadi Khalaji *et al*., 2007) lithological point of view, porphyritic andesite is the mainly rocks and host rocks. In this limitation there are alteration zones such as sericitication, epidotization and chloritization zone. Copper mineralization as vein or alteration halos as primary and secondary oxides and sulfides minerals have been visible. The main aim of this paper is considering petrography, alteration, and mineralization in vein and inner alteration halos and drawing holes in Khansorkh ore index.

General geology:

The studied area is located in the Sanandaj-Sirjan Zone (Stocklin, 1968). This zone is extending from north-west to south-east and is divided into three subzones (Soheili *et al*., 1992). Sanandaj-Sirjan Zone is one of the most active zones and lead to the orogenic phases, many metamorphic and magmatic activities (Darvishzadeh, 1991). The studied area is located in Sub-Mesozoic zone and is mainly consisted of shales, Jurassic sandstones and replacement of numerous magmatic bodies such as Aligodarz. Khansorkh ore index is located in an agglomerate unit. This unit included lavas and pyroclastics to volcanic andesite along with granodiorite. Thickness of this complex varies from100-150 meters in south of Dareh -takht village to about 20 meters in north of Khansorkh village, and can be seen more thickness in around ore index. Upper contact of this unit is composed of thin layers to medium of limestone fossils to a little sandstone. Lower contact of this unit is gradually with microsparite calcareous bearing fossils. In some places of this area can be seen sub-marine lavas. (Mohammadbeigi, 1997)

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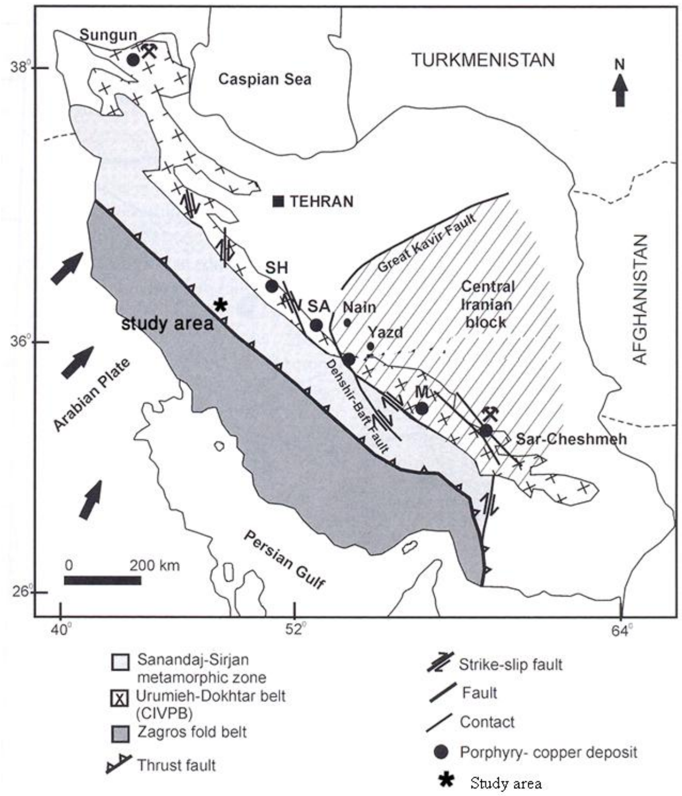

Fig. 1: Geological map of Iran (modified after: Zarasvandi *et al*, 2005) showing major lithotectonic units.

Structural setting:

The Limestone rock of the area under the study is a portion of Sanandaj-Sirjan Zone []. From the structural point of view, Sanandaj-Sirjan Zone is part of Central Iran Zone. Based on occurrences of later early Cimmerian can be seen many different part with variety trend which the one of it is Uromieh-Hamedan trough. This sedimentary trough is formed with north west to south east around of Aligodarz to the north of Dourod or south east of Boroujerd. Around of Hamedan to south east of Uromieh lake (late Triassic) is formed. It is difficult to say about structural area by two reasons. First little extent of area and the second extent of outcrop of rocks mainly belong to Jurassic. Then it can't show occurrences before and after itself. with total evidences, based on studies of are and around of area, we can draw tectonically situation of the area under study. This was influenced of late Cimmerian and late cretaceous orogenic phases and has been occurred Aligodarz pluton (Mohammadbeigi, 1997).

There are three groups of faults: A-great faults with north-west to south east trend which mainly over trusted and caused by squamous structural. This type of faults have cut the other structures such as reverse faults ,thrusts, axial folds, that is double faults in total pressure system in time of formed thrusts and folds B-accessory faults. These groups of faults that exactly cut the others such as reverse faults and folds. C-normal faults or grabbens with a general trend vertical on other trends are formed by extension forces that are caused of intrusive magma such as Khansorkh intrusive body.

Petrography studies:

Petrography studied, show that area is included of pyroclastic ,volcanic and probably intrusive rocks (granodiorite) with accessory types. The most alteration in area is sericitization, chlortization and epidotization. The ore minerals in the area are chalcopyrite, chalcosite, bornite, malachite, azurite -magnetite and limonite minerals. Malachite and chalcopyrite founded in volcanic rocks (Shahrokhi, 2002). Pyroclastic rocks included of plagioclases, chlorite and andesite with porphirc texture.

There is a lot of vein quartz in these rocks (Fig. 2-A). Volcanic rocks are included of andesite, porphirytic andesite, with plagioclase, hornblende, serecite, chlorite and epidote minerals (Fig. 2-B). Intrusive rocks are included of porphyritic granodiorite bearing quartz, plagioclase and biotite (chlorite) with granular texture and can be seen malachite, iron oxide quartz veins. We can see serecitic alteration in these rocks (Fig. 2-C).

Sometimes, mafic mineral altered to chlorite and epidote in andesite rocks so observed high chloritization in these rocks (Fig. 2-D). In some highly chloritised and epidotised samples crystals of plagioclase with polysynthetic cleavage and altered amphibole, vein of Iron oxide with granular texture can be seen (Fig.2-E). In many sections vein of Iron have been seen that, the vein of gotite, limonite along with malachite occurring in the porphyritic andesite. This phenomenon show oxidation zone in Khansorkh ore index (Fig. 2-F).

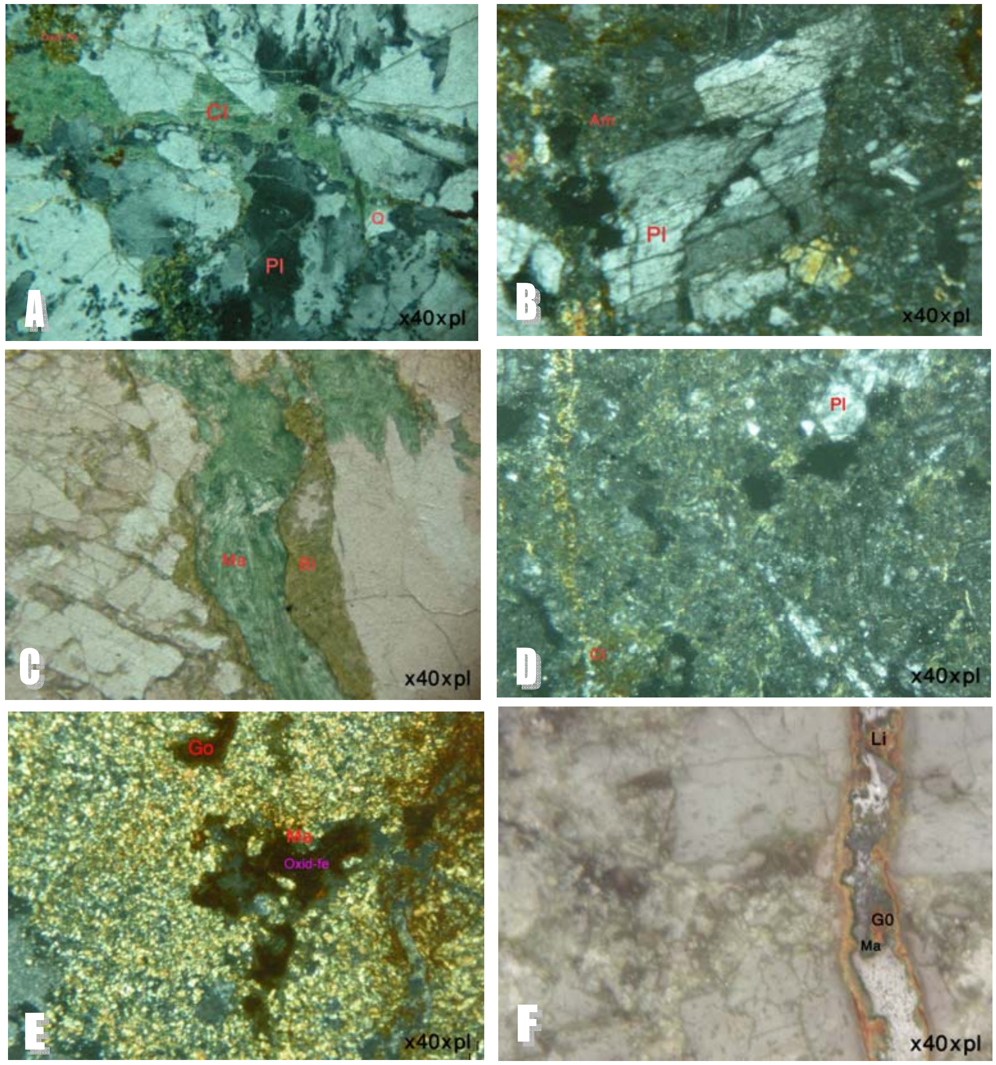

Fig. 2: Microphotographs of representative samples: (A): porphyry andesite is including minerals such as plagioclases, chlorite and quartz; it introduces as and focuses of iron oxide. (B): The andesite is including minerals such as, plagioclase, hornblende, serecite and chlorite (C): The porphyry granodiorite is including minerals such as, plagioclase, biotite and vein of malachite, iron oxide. (D): crystals of plagioclase with mafic minerals are effected chloritization alteration. (E): Plagioclase crystals of polysynthetic clearage with and altered amphibole, vein of Iron with granular texture can be seen in chloritization and epidotization area. (F): The vein of Irons (gotite and limonite) with vein of malachite is introducer oxidation zone in Khansorkh ore index. Bi=biotite; Pl=plagioclase; Q=quartz; Am=amphibole; Ma=malachite; Go=gotite; Li=limonite

Geochemistry:

Major elements:

In order to nominate output masses of under studied region base on virtual mineralogy, NEWPET, MINPET, IGPET software were used.

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Classification of the region's volcanic rocks base on main oxides and rare elements (Table 1). In order to classify volcanic igneous rocks, diagram 3 was used. Le Maitre *et al*, (1989) used alkali collection Na2O+K2O against silica to classify out put rocks. Based on this diagram, there are 5 trachy andesites and 1 basaltic trachy andesites (Fig. 3) and fall in the low K tholeiite field in the K_2O vs. SiO_2 diagram of Rickwood (1989; Fig.4).

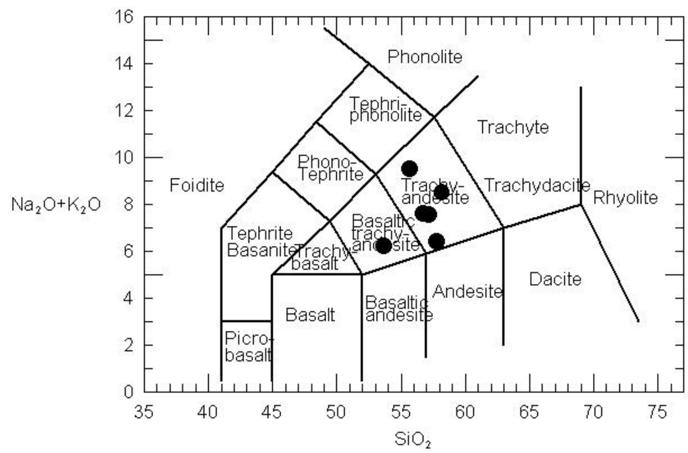

Fig. 3: SiO_2 vs. total alkalis ($Na_2O + K_2O$) after Le Maitre *et al*. (1989).

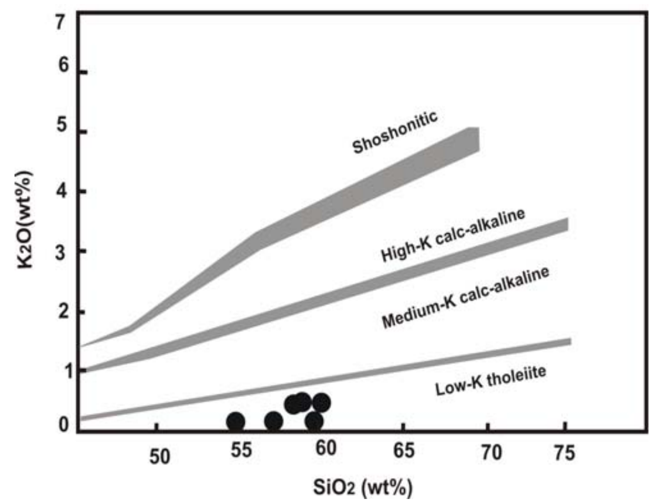

Fig. 4: SiO_2 vs. total K_2O after Rickwood (1989).

In classification of volcanic rocks by Winchester and Floyd (1997) [2] which is based on the ratio of SiO2 to Zr/Tio2*0.0001, 4 tracki andesites and 2 andesite existed (Fig. 5).

Winchester and Floyd (1997)[3], also classified volcanic rocks base on the ratio of Zr/Tio2*0.0001 to Nb/Zr (Fig. 6). On this base, 4 trachy andesite and 2 andesite were existed. Hence, volcanic rocks of region are trachy andesite and andesite port fire.

The changes of main and secondary elements against SiO2 show positive and negative Correlation (Fig. 7, 8) which reflecting the main role of crystallization processes during evolution of volcanic condition. The amount of Fe2O3, Al2O3, TiO2, MgO, CaO, P2O5, Sr, CO, Th, Cr increased by increasing of SiO2 in andesite rocks. While Ba and Nb show essential decrease by increasing of SiO2.The increase of litophile elements concentration such as K2O, Nb, Rb and decrease of the compatible elements concentration such as Ni, MgO, and Cr,with the increase of SiO2,considering the exit of olivine, cleanopiroxene and hornblende exude in early stages of magma crystallization. Probably decrease of TiO2, P2O5 and Sr related to segregation of apatite, titanomagnetite and plagioclase, respectively.

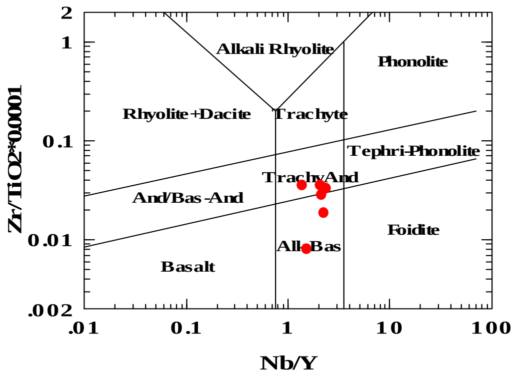

Fig. 6: Position of volcanic out rocks of the zone in diagram Nb/Y Zr/Tio2*0.0001 (Wincheste and Floyd 1997)

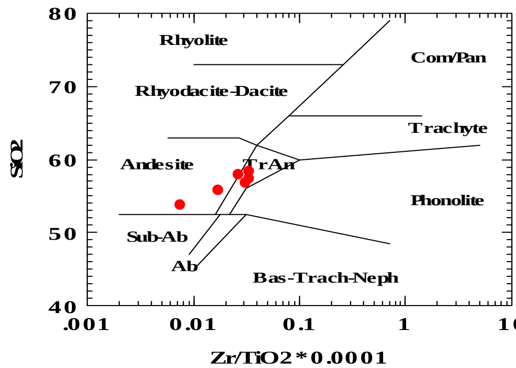

Fig. 5: Position of volcanic out rocks of the zone in diagram SiO2 Zr/Tio2*0.0001 (Wincheste and Floyd 1997)

Table 1: shows the chemical analyses of major and minor elements for khansorkh trachyandesite Complex (major elements is presented as % but minor elements as ppm)

Sample	Andesite					
	KA1	KA2	KA3	KA4	KA5	KA6
Sio2%	58.18	57.08	53.66	55.66	57.17	56.71
AL2O3	15.74	13.79	14.44	19.29	17.55	16.31
Fe2O3	6.06	6.63	6.73	5.41	8.41	6.52
CaO	2.17	3.27	3.58	1.18	1.49	2.15
Na2O	8.17	6.37	6.22	9.46	7.22	7.31
K2O	0.33	0.02	0.01	0.02	0.34	0.3
MgO	3.37	1.24	1.79	1.64	2.54	1.71
MnO	0.682	0.829	0.934	0.602	0.759	0.746
TiO2	0.682	0.829	0.934	0.602	0.702	0.802
P2O5	0.136	0.136	0.103	0.149	0.148	0.147
CuO	1.59	5.97	7.78	2.99	1.17	2.11
So3	0.493	0.09	0.04	0.025	0.028	0.026
L.O.I	2.92	4.18	4.33	3.11	2.65	2.91
Th(ppm)	1	1	1	1	1	1
U	1	1	1	1	1	1
As	3	4	18	8	7	8
Cl	145	16	13	14	17	18
Ba	68	81	24	40	69	51
Sr	153	481	522	129	219	160
Zn	6	4	5	3	9	7
Pb	12	26	17	3	2	4
Ni	35	26	31	25	21`	18
Cr	17	8	4	8	5	4
V	56	49	190	124	92	46
Ce	60	23	24	40	91	94
Co	1	3	26	19	10	4
La	30	6	12	24	43	37
W	35.2	41	28.9	24.4	33.1	38.2
MO	1	1	1	1	1	1
Nb	77	110	43	63	69	140
Zr	236	229	73	108	263	259
Y	54	50	27	27	32	57
Rb	264	223	55	60	92	217

Geodynamic setting:

These rocks include different compounds of shoshonites with volcanic calc alkaline rocks to lositites ultrapotassic (Peccerillo, 1976 & Taylor, 1976) that tend to be as separated ground masses in tectonic positions Inside plate while the related kinds to subduction tectonic position tend to be as final members of a contiguous spectrum of igneous rocks which include a range from tholeiite to shoshonite and potassium enriched calc alkaline rocks during arc evolution. One characteristic of calc alkaline rocks is their formation inside of subduction and also arc islands which related subduction. In continental area, these rocks are almost felsic and have different kinds, while when appear in the arc islands, have not variation of first group rocks and are so limited and form more than basalt and andesite. The diagrams which are represented by Pearce *et al*. (1984), Muller & Groves (1997) are used for determination of geo-structure position of region rocks. The special diagrams of potassic rocks which are represented by Muller & Groves (1997) and are base on (Y-Zr) and (TiO2-

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Al2O3) are used for determination of tectonic area of potassic rocks. Base on these diagrams, all cases located in the related area to volcanic arcs (Figures. 9, 10).

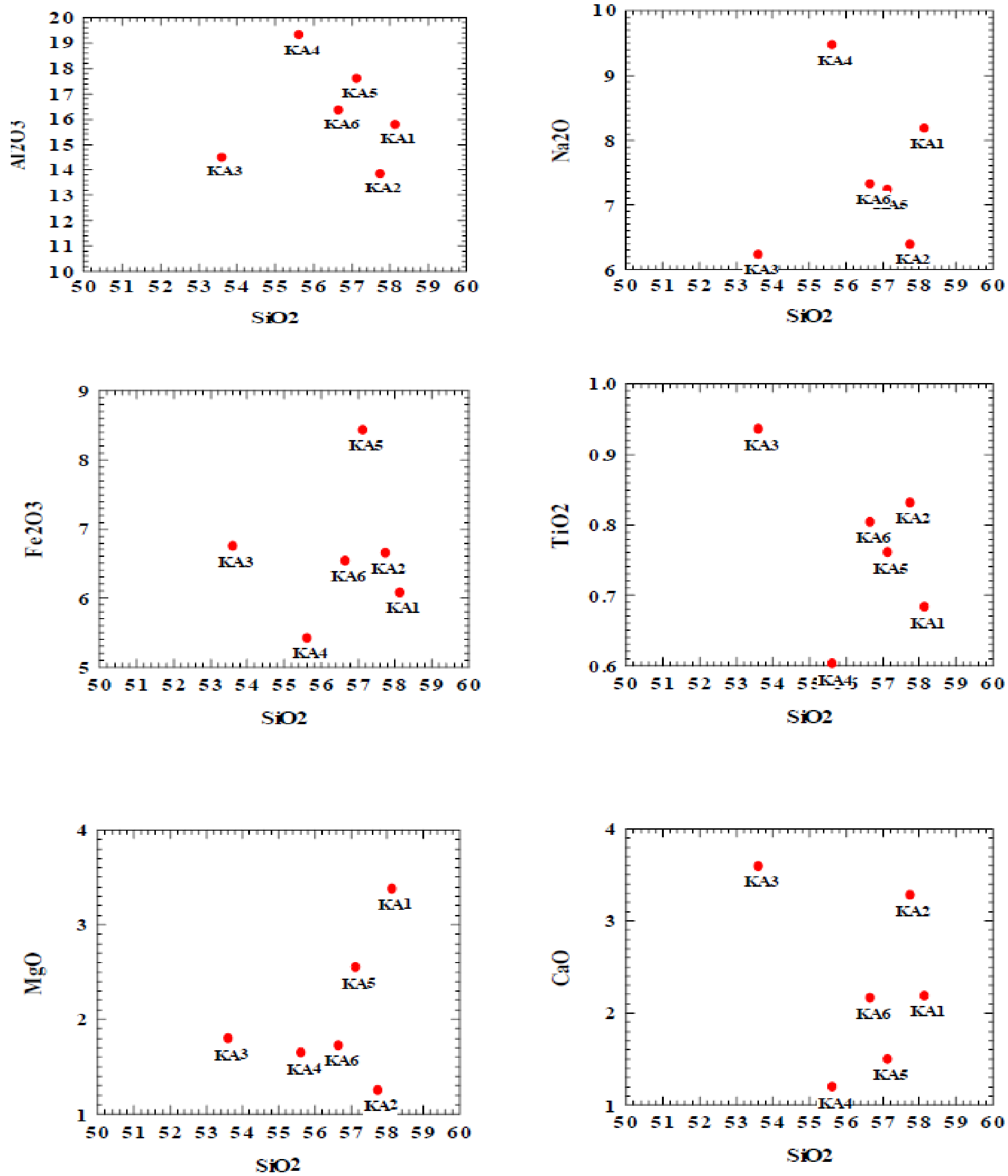

Fig. 6: Harker diagrams for major of the Khansorkh volcanic Complex

In order to have more precise determination of tectonic position of rocks and separation of continent arcs from arcs after collision, three variables diagram (Zr×3-Nb×50-Ce/P2O) which is represented by Muller & Groves (1997) was used. Based on this diagram, region's cases in tectonic position are located after collision (Fig. 11).

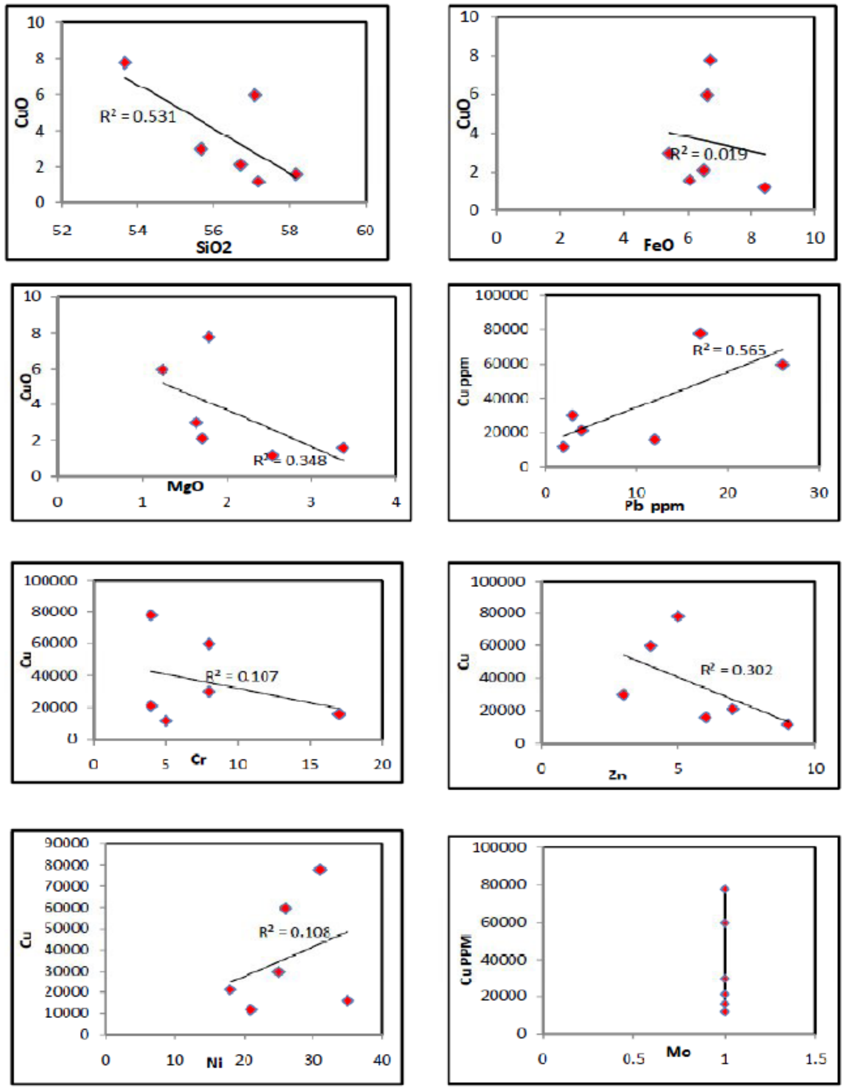

Fig. 7: Harker type diagrams showing correlation between various elements and oxide copper

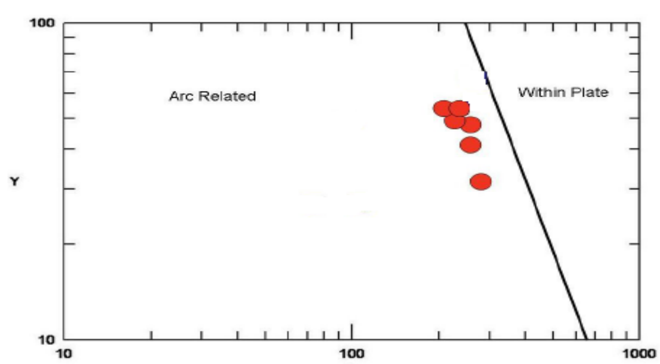

Fig. 8: Zr/y diagram after (Muller & Groves,1997) showing that this rock located on the Arc related area

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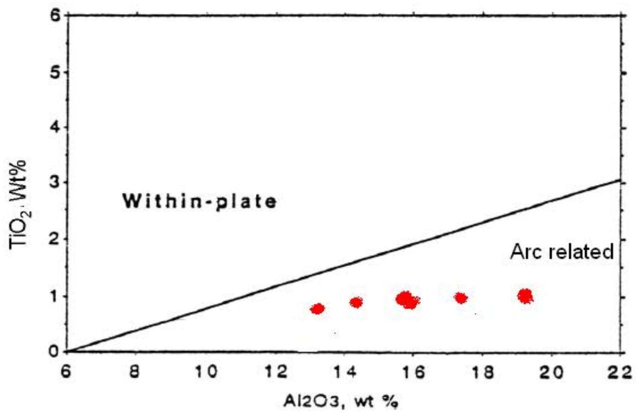

Fig.10: Position of the examples of the zone in diagram Al2O3- TiO2 (Muller & Groves, 1997)

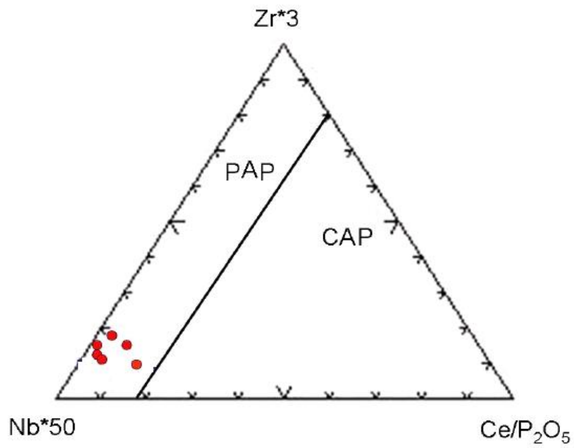

Fig. 11: Position of the examples of the zone in triangular diagram Zr×3-Nb×50-Ce/P2O5 (Muller &Groves, 1997)

The variation of different groups of magma rocks can be driven of various chemical changes that control main and secondary magma elements compounds, from formation of magma to its consolidation stage. These effective processes in magma formation as segregation, digestion, stain and magma integration have important role in evolution of magmas and determination of mineralogy and chemical compound of rocks resulted of that. Studying about changes, variations and following the occurred events in magma and resulted rocks take place by geochemical methods (Rollinson, 1993). 6 samples which were analyzed by XRF method were used for geochemical explanations.

Using analyzes data of 6 samples, the under studied region's rocks have following geochemical characteristics:

1- The range of SiO2 is rather high in these rocks and is between 53.66 to 58.38.
2- The amount of K2O+Na2O is between 6.23 to 8.5.
3- The amount of Fe/Mg is between 1.79 to 5.34.
4- The amount of Nb, Zr and Y is high.
5- The amount of CaO is between 1.18 to 3.58.
6- The amount of MgO is rather low and is between 1.24 to 3.37.

The spider diagrams are used in order to evaluate the amount of variation and productive magma changes in proportion to primary magma, also to determine origin and their genetic relation. For this purpose having a comprehensive model that by it could evaluate frequency of elements is beneficial, that it called normalization. Spider diagrams are plotted by main and rare elements and their normalization in proportion to the amount of these elements in primary crust or conderite and or ORG. As a result these diagrams frequently show more numbers of positive and negative anomalies which reflecting behavior of different rare elements groups. For example behaviors of elements with high mobility as (Eu, Rb, Ba, K, Cs, LILE) differ from elements with low mobility (Ta, Nb, Ti, Zr, Hf, HFSE). By chemistry the origin rock and HFSE are a function of fluid phase. While the concentration of LILE, concentration of crystallization-melting processes are controlled that are occurred during rock formation. Because of high mobility, LILE elements could be controlled by fluids, but these elements concentration in continent crust, their concentration in magma may be appearing as crust stains. In order to geochemical expression of rare magma rocks forming rocks in the tectonic area, spider diagrams are very significant (Rolinson, 1993). Potassic igneous rocks are usually replete with elements LILE, LREE volatile materials and halogens especially F, Cl (Muller & Grover, 1992) have some characteristics of shoshonite magma depletion Clear rocks elements (Ta, Nb, Ti) TNT and enrichment elements Rb, K by stones (Edwards *et al*, 1986). In other hand, depletion of LILE elements from magmatism index is related to infra buoyancy zone (Arjemand, 2008). Also potassic igneous rocks which related to arc show rather high content of elements K, Rb, Cs, Ba, and negative certain abnormalities of elements Ti, Nb, Ta, Pb (Sun & Mc Donough, 1989). The under studied region's rocks are normalized base on primary crust and ORG (Pearce *et al*., 1984). All of the samples almost have similar process which shows their similar magma (Fig. 12). Ba, Rb, in the represented diagrams, show enrichment in the region's rocks, enrichment of above elements could be related to crust metasomatism or continent crust stains. Since ionic radius of barium is equal to K ionic radius, so it can be accepted in place of potassium in the structure of alkali feldspar, biotite, and plagioclase. This is the reason of positive anomaly of barium. On the other hand the chemical behavior of rubidium element has so similarity to potassium and it can be a replace for potassium in mines structure lattices as biotite and alkali feldspar. Generally, frequency of these elements shows continent crust interference in evolution of magma reproducing region's rocks. According to Hezarkhani, *et al*. (1998), this negative anomaly of Nb shows rare elements model of continent arc igneous masses and magmas index of calc alkaline. Negative anomaly of Nb is the index of continent rocks and may show its contribution in magma processes (Rolinson, 1993). In rocks of the zone effect of subduction on resources shows some primary crust negative anomaly of Nd. In subduction environments, the elements like K, Ba, and Ca may become movable. Negative anomaly and weak Ce in the diagram normalized to primary crust is probably result of this element during subduction. Considering mentioned characteristics, in normalized spider diagram in proportion to primary crust, base on Sun & Mc Donough (1989) the igneous rocks of Khansorkh mine are from potassic igneous rocks kind and related to subduction regime.

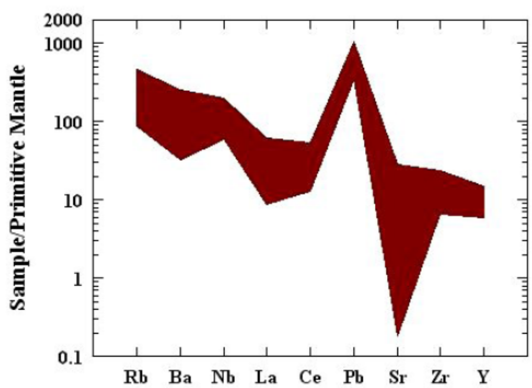

Fig. 12: Spider diagram normalized to primary crust (Sun& Mc Donough, 1989).

Conclusion:

The rocks of Khansorkh ore deposit ranges from intrusive (mainly granodiorite) to volcanic rocks (mainly andesite). The main trend of structural units in this area is north west- south east; this strike is parallel to the main faults in the area. Accessory faults are as ovrerthrust may be as type of double faults. The most alteration is seresitization, epidotization and chloritization. The most common primary ore minerals in this deposit are chalcopyrite, calcosite, bornite, malachite, and azurite acompanied with oxides like magnetite and limonite. The above studies and diagrams showing all of the samples are located in the area related to arcs after collision volcanic. The under studied region's rocks are normalized base on primary crust and ORG. igneous rocks in the area under studied, either intrusive and extrusive have signal magma sources. Negative anomaly of Nb indicates that these rocks are related to continental arcs of calc alkaline magma.

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