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Research Article

Geology, Petrology and Geochemical Dispersion of Elements in Noorabad Ophiolite (Northwest Lorestan),Iran

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Abstract

The Noorabad ophiolitic complex in western Iran is part of the high Zagros situated between the the Zagros folded belt and Sanandaj-Sirjan zones. This ophiolite is an important part of Kermanshah ophiolite .High Zagros has three separate sub-units, which consist of the Biston limestone ,the ophiolite complex , and the Bakhtaran radiolarite. The rocks of this ophiolitic complex consist of bottom to top, serpentinized peridotites, layered gabbros,isotropic gabbros,minor plagiogranit, sheeted dike complex, basalt, andesite and sedimentary rocks. The petrographic studies show that the primary minerals (olivine, plagioclase ,pyroxene and metallic minerals) of rocks of this ophiolitic complex altered to secondary minerals(serpentine,amphibol,chlorite,sericite and Fe-Oxide).

Also, mineralization in rocks consists of chalcopyrite, burnit, malachite ,azurite and iron minerals. Chemical analysis of some lithogeochemical samples from the some area shows noticeable assays for elements such as Mn,Ti and Cu.The majority of anomalous areas are intimately associated with alteration zones in the region.The results of chemical analysis rocks of this ophiolite show that this rocks have geochemical anomalies for Cr, Ni , Mn,Ti,Cu and Ag.

Key words: Noorabad ophiolitic complex, high Zagros, lithogeochemical, geochemical anomalies

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1. Introduction

Metal economic deposits of mafic and ultramafic rocks consist of Cr, Co, Ni, Ti, V, Cu and Mn . As regards the bulk of the ophiolites rocks are composed of mafic and ultramafic rocks. It is expected that theses elements can be found in these rocks. Around the world there are about 150 ophiolitic complexes that 10% of the these complexes are located in Iran (Fig. 1). Stocklin (1974) divided Iranian ophiolites into four groups: (i) ophiolites of the Zagros; (ii) ophiolites (coloured melanges) of northwestern Iran; (iii) ophiolites and coloured melanges that mark the boundaries of the Central and Eastern Iranian micro-continent (Takin, 1972); and (iv) ophiolites at the northern foot of the Alborz range that have chromite, copper and manganese ores. The Neyriz-Kermanshah Ophiolitic Belt in suture zone is a remnant of the Neo-Tethys ocean that was obducted along the Zagros margin. The Kermanshah ophiolitic complex in western Iran, which is about 200km long and 30-60 km wide is part of the High Zagros that situated between the the Zagros Folded Belt and Sanandaj-Sirjan Zone (Fig. 2). The Noorabad ophiolite is an important part of Kermanshah ophiolite (Fig. 2) that is by presented the results of petrological and geochemical explorations studies of this ophiolite. Area study is located in 47° 30 to 48° 45 E and 33° 45 to 34° 20 N.

2. Regional Geological Setting

The Noorabad ophiolite is part of the High Zagros situated between the Zagros Folded Belt and Sanandaj-Sirjan Zone (Fig. 2).The Zagros Fold belt consists of cretaceous limestone and pliocene conglomerates (Bakhtiari Formation) which were folded strongly. The internal Sanandaj–Sirjan zone (Stocklin ,1968), made mainly of Jurassic, interbedded phyllites and metavolcanics showing a moderate metamorphic imprint except close to large-scale Mesozoic calc–alkaline plutons (Agard et al., 2005).The high Zagros unit (or Crush Zone) has three separate sub-units, which consists of the Biston limestone (Upper Cretaceous-Lower Triassic), the Kermanshah ophiolite, and the Bakhtaran radiolarite (Aghanabati, 1978, 1990).This ophiolite is the uppermost part of the thrusted unit, and the thrusting is thought to have occurred during the Maastrichtian (Ghazi and Hassanipak ,1999).

The rocks of Noorabad ophiolite consist of peridotites, serpentinites and pegmatite gabbros as mantle sequence, whereas crustal sequences are composed of locally layered gabbros, isotropic gabbros, sheeted dike complex, basaltic to andesitic lavas and sedimentary rock (radiolarites and late cretaceous pelagic limestones) (Fig. 2).

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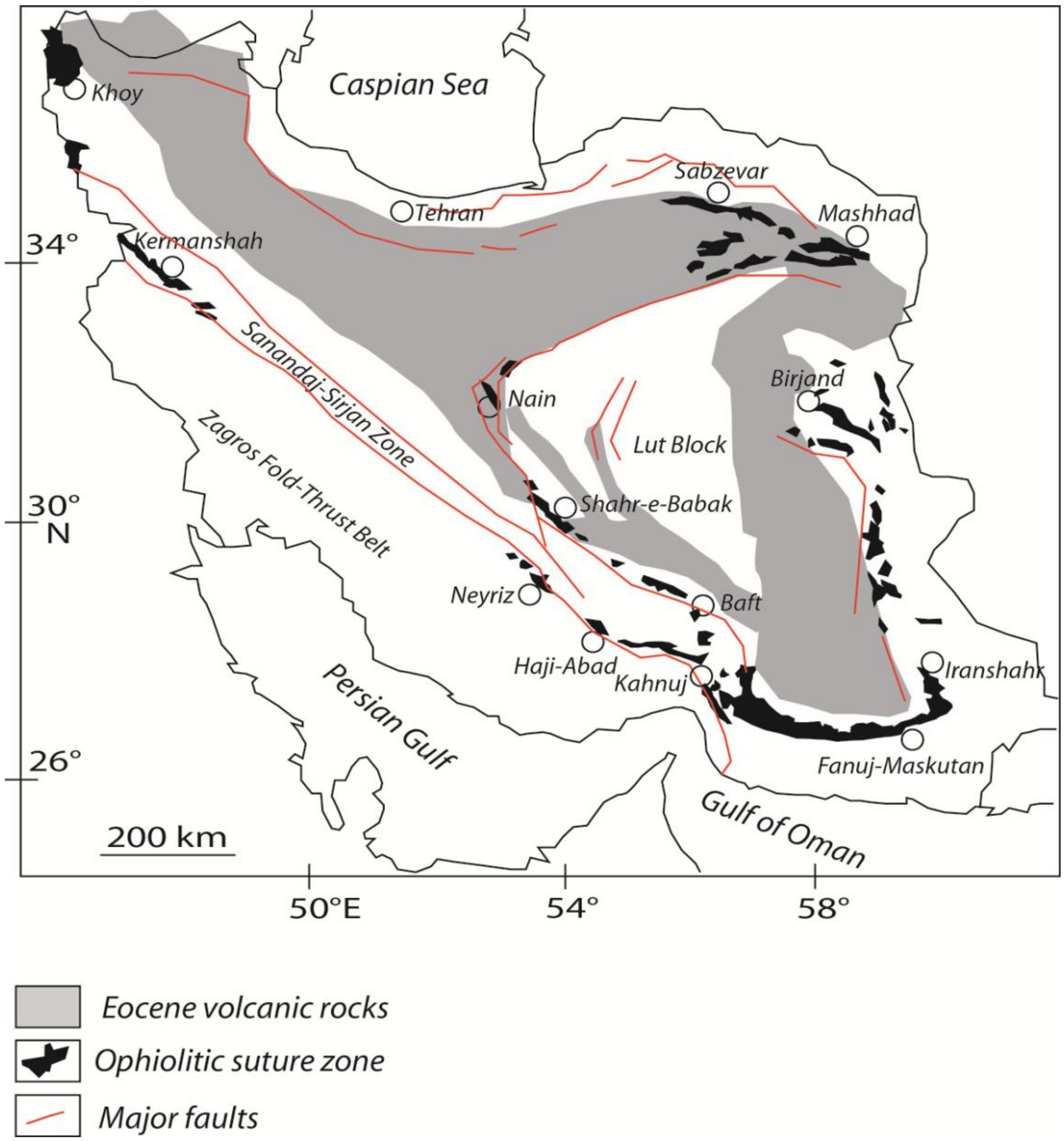

Fig.1. Map showing locations of major Iranian ophiolites.

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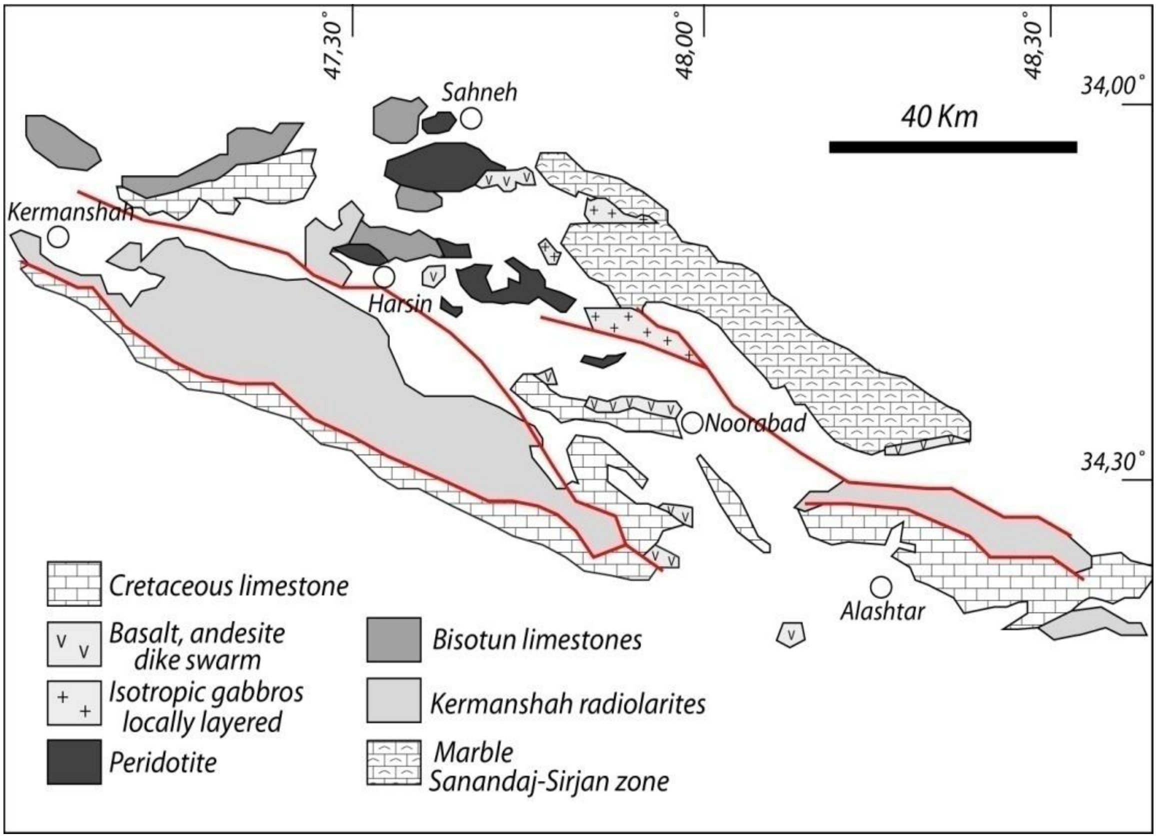

Fig.2. Geologic map of the Kermanshah ophiolitic complex.

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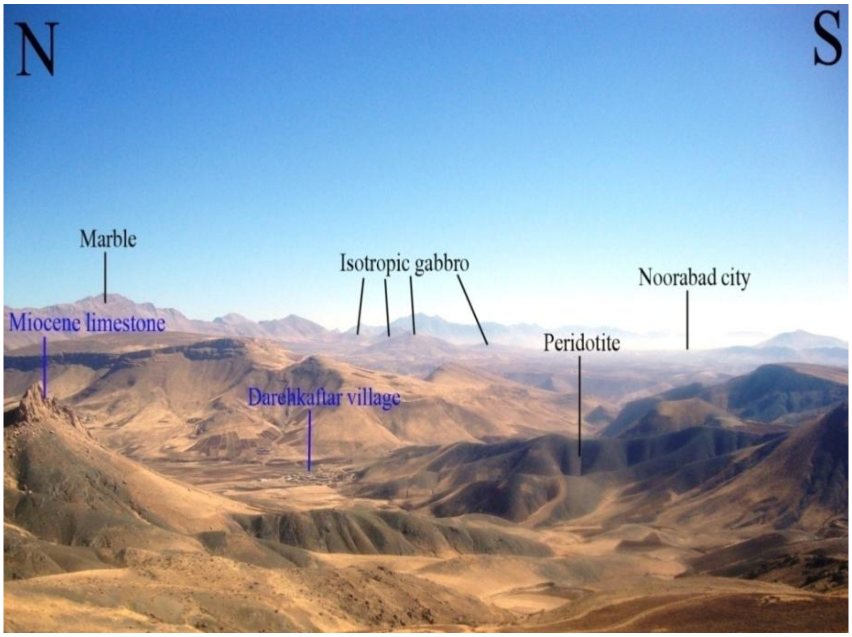

Fig.3. Field photo of the Noorabad ophiolite.

3. Methods

During the field survey of the study area, 90 rock samples of rocks of ophiolite sequence were removed and thin sections were prepared out of them. After petrographic study for the major and trace elements composition, 60 rock samples were determined by inductively coupled plasma-mass spectrometry (ICP-MS) in SGS laboratory in Canada and then frequency diagrams as raw of the area study has been drawn by Igpet software, and element distribution maps were drawn by the software Surfer 8.

4. Petrographic and Mineralogical Studies

Petrographic study in this part consists of ophiolitic sequence from bottom to top:

A. Peridotite

The peridotite unit rocks are the most altered part of Noorabad ophiolite including dunite, harzburgite and lherzolite. These rocks can be seen form many large and small mass of green to gray. The minerals of these rocks consists of olivine, clinopyroxene,

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orthopyroxene and chrome- spinel that have mesh and granular texture that altered to serpentine minerals and iron-oxid (Fig. 4A).

B. Gabbro

These rocks are located in 15 kilometers north-west of the Noorabad city and are large and small masses which cover space of 40 square kilometers. The rocks of this unit consist of troctolite, olivine gabbro and layered gabbros. The minerals of gabbros include olivine, plagioclase, clinopyroxene and opaque mineral that altered to serpentine, amphibole, sericite and iron oxides. Thees gabbros have granular, poikilitic and cumulative textures (Fig. 4B).

C. Plagiogranite

Plagiogranite unit of study area is located in northwest of the city Noorabad that is a small white mass having boundary fault with layered gabbros. The minerals in these rocks consist of plagioclase, amphibole and quartz that have granular textures and their plagioclase altered to sericite and epidotite (Fig 4C).

D. Diabase dikes

Diabase dikes have been extensive but scattered and have green to brown colors that have plagioclase, clinopyroxene and opaque mineral. In these rocks, secondary mineral include chlorite, zeolite, prehnite, iron oxides and sericitie that rocks fractures and spaces are filled with minerals. These rocks have doleritic, intergranular and poikilitic texture (Fig 4D).

E. Basaltic lava

The basaltic lava of this ophiolite are divided into two types :(1) pillow lava (2) spilitic basalts. The pillow lavas have microvesicles that are filled with chlorite; carbonate and opaque minerals that located in a groundmass of plagioclase and clinopyroxene microlites. The spilitic basalts have plagioclase, clinopyroxene and minor opaque minerals (titaniferous minerals) that have intersertal texture. The clinopyroxenes of these rocks are uralitized and plagioclases altered into sericite(Fig. 4E).

F. Andesite

The andesites of Noorabad ophiolite in hand specimen and thin section have phenocrysts of plagioclase in a groundmass of clinopyroxene and amphibole minerals. In these rocks, the primary minerals (plagioclase and pyroxene) of rocks altered to secondary minerals (chlorite, sericite,quartz, zeolite and Fe-Oxide).The microvesicles of these rocks are filled with secondary minerals consisting sericite, quartz, zeolite, chlorite and opaque minerals(Fig. 4F). The plagioclases are euhedral to subhedral that show evidences of fracture and breakage. These rocks have glomeroporphyritic and porphyritic texture. The opaque minerals in these rocks consist of chalcopyrite, bornite, malachite, azurite and Fe-oxide.

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G. Radiolarites

This radiolarite unit has the maximum volume of the rocks of the Noorabad ophiolitic compelex and has expanded from east of Noorabad to Kermanshah that has green to reddish brown colors. In some places in the rocks occurs Mn mineralization as veins and masses.

5. Geochemistry and dispersion

In order to identify where and determine the amount of elements of deposit of instrument of area study has been drawn frequency diagrams and geochemical dispersion maps for nickel, chromium, copper, arsenic, silver and cobalt elements. It should be noted that element frequency diagrams is plotted as raw.

Fig.4. (A) The chrome - spinel minerals (Cr-Spi) in the matrix of serpentinized orthopyroxene (Opx); (B) Olivine (Ol), plagioclase (Pl) and clinopyroxene (Cpx), which are altered to serpentine, sericitic (Ser) and iron oxides respectively; (C) Granular texture in plagiogranite which epidote plagioclase (Ep) located in the matrix of quartz (Qtz); (D) Intergranular texture of diabase that spaces between plagioclase are filled by clinopyroxene and opaque minerals ; (E) Intersertal texture in split basalts that spaces between plagioclase are filled by pyroxene, sericitic plagioclase, chlorite (Chl) were between the by pyroxene, and skeletal opaque minerals; (F) Space filling of andesitic rocks by sericite opaque minerals.

A. Nickel

The raw frequency histogram of the element nickel of area study maximum amount of nickel 2666 ppm is associated with peridotite rocks and has positive skewness (Fig. 5). Since the effect of nickeliferous mineral are unobserved in the sections studied, likely this element is replaced with the olivine structure. On based geochemical dispersion map, the maximum concentration of this element is located in northwest of area study and is consistent with limited area of the peridotite and gabbro rocks (Fig. 13).

B. Chromium

On based frequency histogram of the element is chromium maximum amount 2239 ppm associated with peridotite rocks (Fig. 6) that can be linked to the presence of chrome- spinel minerals in this rocks (F.5A). In geochemical dispersion map is observed that is similar to nickel geochemical dispersion map the concentration of this element located in northwest of area study and has been limited to the area of the peridotite rocks (Fig. 14).

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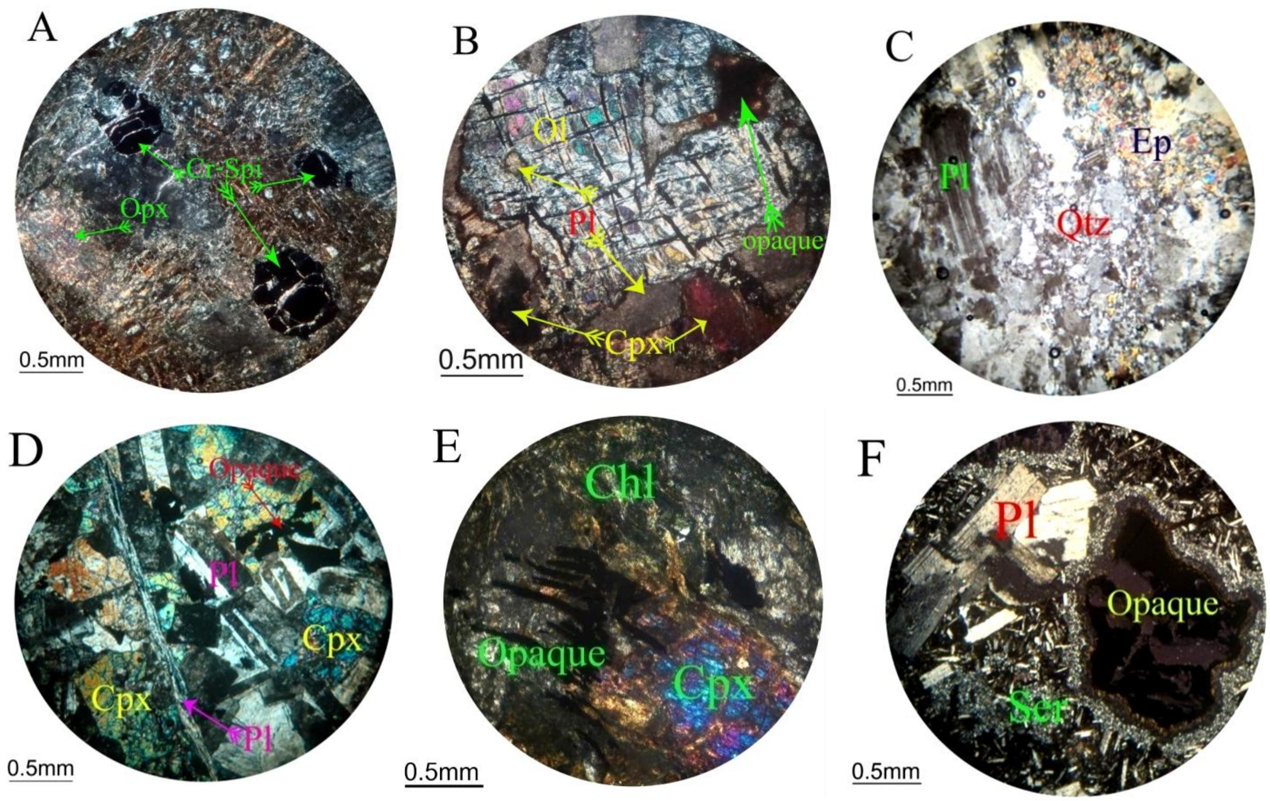

Figure 4. (A) The chrome - spinel minerals (Cr-Spi); (B) Olivine (Ol), plagioclase (Pl) and clinopyroxene (Cpx); (C) Granular texture in plagiogranite; (D) Intergranular texture of diabase; (E) Intersertal texture in split basalts; (F) Space filling of andesitic rocks

C. Titanium

Frequency histogram of the 60 samples shows a positive skewness for element titanium (Fig. 7). Maximum amount of this element with 2.48% related to diabasic-basaltic rocks (Fig. 8). According to geochemical dispersion map, the maximum amount of this element is located in south Noorabad (Fig. 15). Since observed in the thin section of the rocks studies skeletal opaque minerals that high levels of this element can be attributed to the presence of these minerals (Fig. 5D and E).

D. Manganese

Frequency histogram for manganese show that maximum amount of this element is 16.71% (Fig. 8) that attributed to radiolarite unit rocks of the east of study area (Fig. 16). In some places of this area in the rocks occurs manganese mineralization as veins and masses.

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E. Copper

The element copper has abundance 6900 ppm in study area (Fig. 9). That attributed to andesitic rocks of south of area study (Fig. 17). In this area observed copper mineralization as hypogenous (chalcopyrite and bornite) and supergene (malachite and azurite). In this area the copper mineral with secondary minerals filling cavities of andesitic rocks (Fig. 5F).

F. Cobalt

The maximum amount of element cobalt is 11 ppm in peridotite rocks (Fig. 10) and is related to ultramafic rocks of northwest of Noorabad area (Fig. 18). This dispersion pattern is similar to nickel and chromium patterns that is occurrence in ultramafic rocks.

G. Arsenic

In most samples, arsenic amount is less than 0.5 ppm but volcanic rocks have to 6.5 ppm (Fig. 11). The dispersion pattern of this element confirms that copper-bearing andesitic rocks have maximum amount of this element (Fig. 19).

H. Silver

Removed samples from andesitic rocks have 7ppm silver (Fig. 12) that dispersion map show this anomaly is in the south Noorbabd city (Fig. 20). The silver can be found in structure of chalcopyrite and bornite minerals (Rankama and Sahama, 1950).

6. Correlation coefficient

In order to understand the relationship between genetic and geochemical, spearman correlation coefficient were calculated to elements exploration (Table. 1). The spearman method is used when that the data distribution are abnormal(Rollinson,1993).In this table can be seen that the elements have tree correlation patterns.The first group are consists of the elements chromium, nickel and cobalt. The elements in the study area are compatible elements and have high positive correlation coefficient, so that the highest correlation is related to presence of nickel and cobalt elements (0.829).This correlation can be due to similar geochemical behavior of these elements, such that these elements can be in the early stages of magmatic differentiation replacement of each other in a structure of ferromagnesian minerals of ultramafic rocks (Mason and Moore, 1982).

The elements of second group are consists of copper, titanium, silver and arsenic elements. These elements together have positive correlation and than the elements of first group have negative correlation, such that lowest correlation is within nickel (first group) and titanium (second group) elements (-0.601).

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The dispersion maps confirm this incompatible pateerns of elements of second group, such that concentration of these elements Increases of the ultramafic rocks to the mafic and intermediate rocks of the southern study area. Low positive correlation of these elements can be related to their non-uniform geochemical behavior.

The third group is consists only manganese, which show intermediate behavior that has positive correlation with all elements except nickel. Also this element has almost better correlation with the elements of the second group.

7. Conclusions

The rocks of the Noorabad ophiolite in northwest lorestan province are part of Kermanshah ophiloite in western iran that are consist rocks of crustal and mantle sequences . In these rocks occurring different alteration processes such as serpentine, epidotite, siliceous, sericitic, zeolite, chlorite, carbonate, and iron oxides. Also mineralization in rocks consist: Chrome spinel , Iron - titanium,chalcopyrite, burnit, malachite ,azurite and iron minerals. The highest grade of elements are consist Ni 2666 ppm, Cr 2239 ppm, CO 111ppm, copper, 6900 ppm, arsenic 6.5 ppm, Ag 7ppm, Mn 16.71% and Ti 2.48 percent. In the ultramafic rocks of chromium, nickel and cobalt have highest concentrations so have similar geochemical characteristics. Ttitanium, copper, silver and arsenic elements have dispersion than together and similar geochemical characteristics, such that concentration of these elements increases of the ultramafic rocks to the mafic and intermediate rocks . The majority of anomalous areas are related to alteration zones in the region.

Table.1. Spearman correlation coefficients of the elements of area study .

	Ni	Cr	Ti	Mn	Cu	Co	Ag	As
Ni	1							
Cr	0.585	1						
Ti	-0.601	-0.459	1					
Mn	0.103	-0.129	0.239	1				
Cu	-0.223	-0.208	0.627	0.311	1			
Co	0.829	0.503	-0.441	0.311	-0.131	1		
Ag	-0.401	-0.312	0.771	0.259	0.478	-0.233	1	
As	-0.296	-0.032	0.311	0.265	0.356	-0.186	0.206	1

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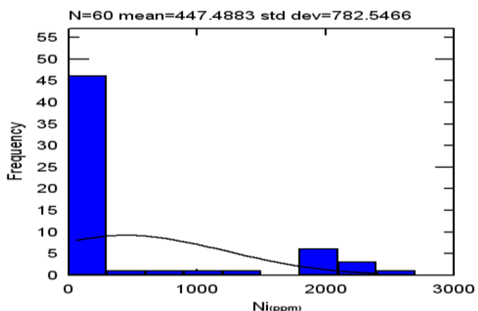

Fig .5. Frequency histogram of the element nickel .

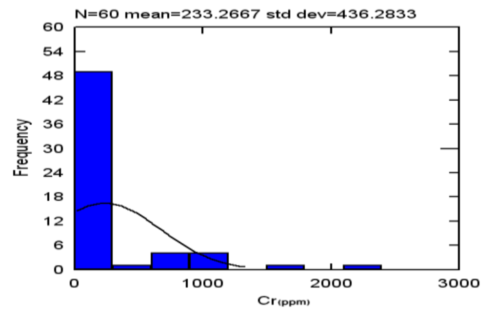

Fig. 6. Frequency histogram of the element chromium.

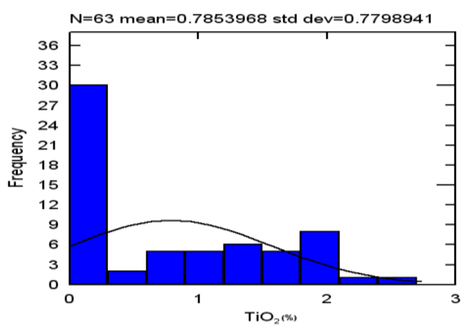

Fig.7. Frequency histogram of the element ttitanium.

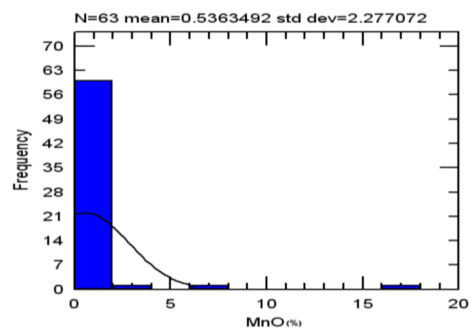

Fig.8. Frequency histogram of the element manganese.

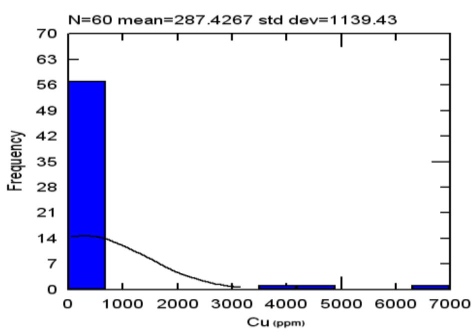

Fig. 9. Frequency histogram of the element copper **.**

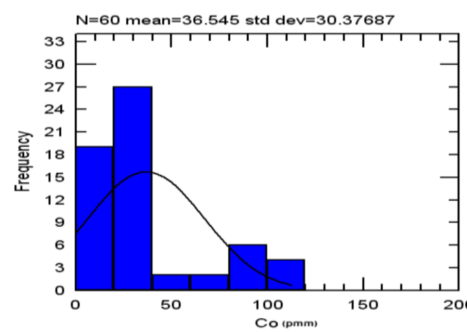

Fig.10. Frequency histogram of the element cobalt.

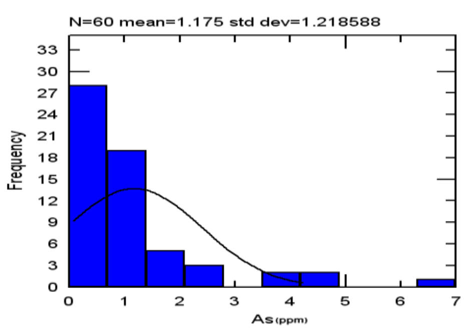

Fig.11. Frequency histogram of the element arsenic .

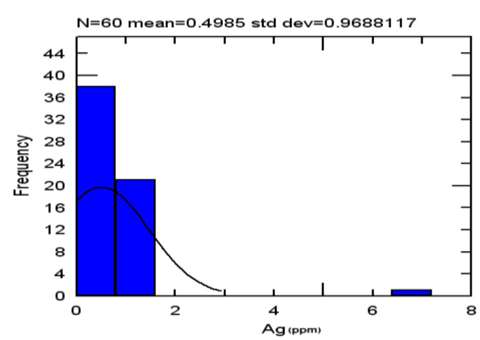

Fig.12. Frequency histogram of the element silver.

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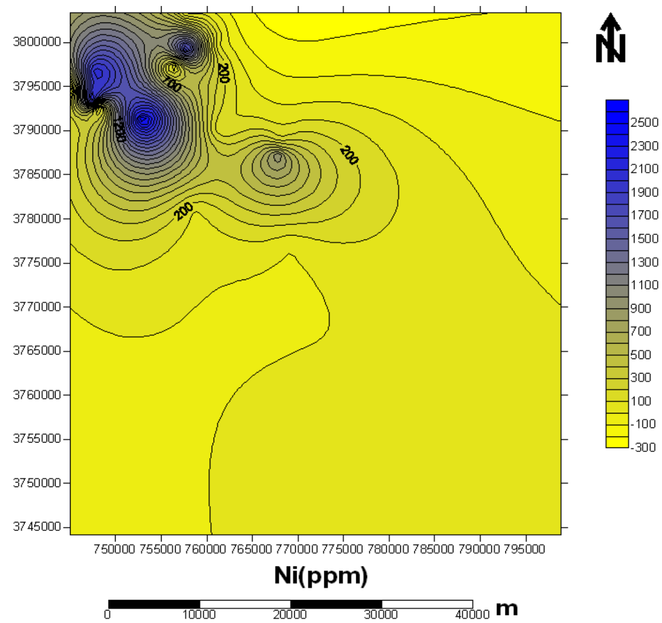

Fig.13. Geochemical dispersion map of the element nickel.

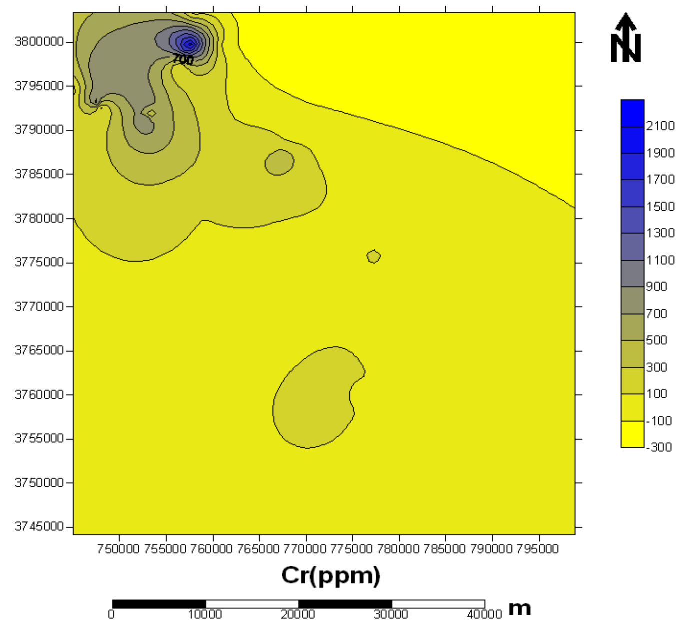

Fig.14. Geochemical dispersion map of the element chromium.

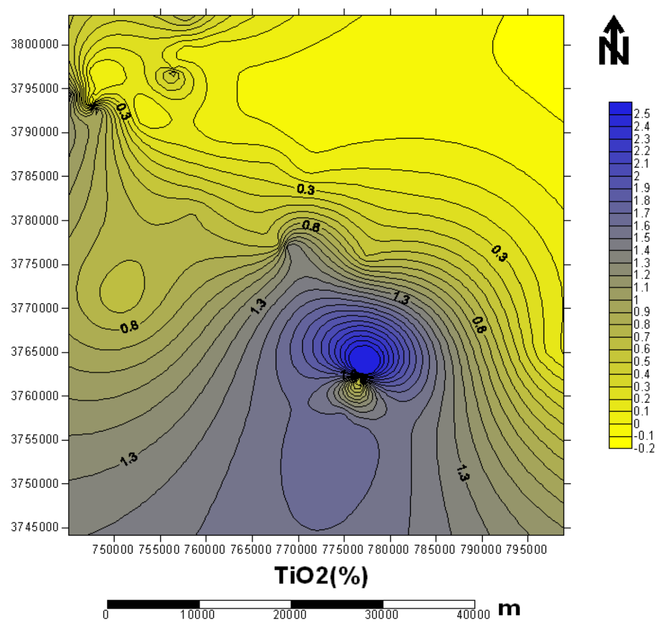

Fig.15. Geochemical dispersion map of the element titanium.

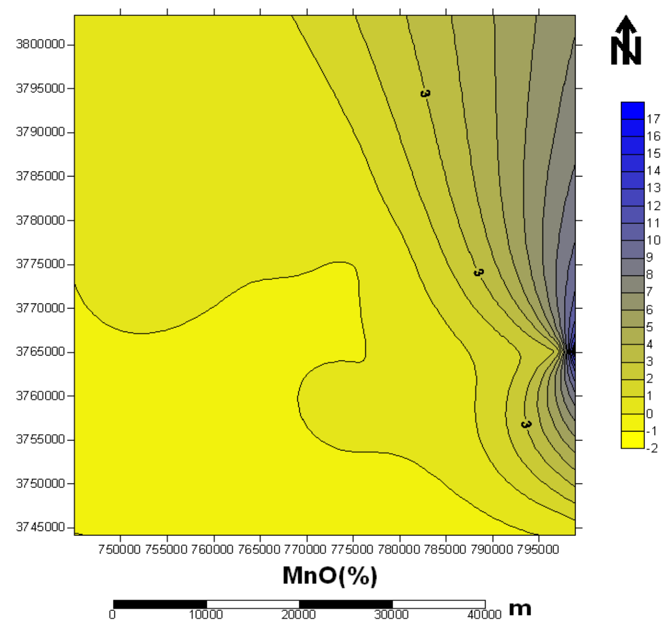

Fig.16. Geochemical dispersion map of the element manganese.

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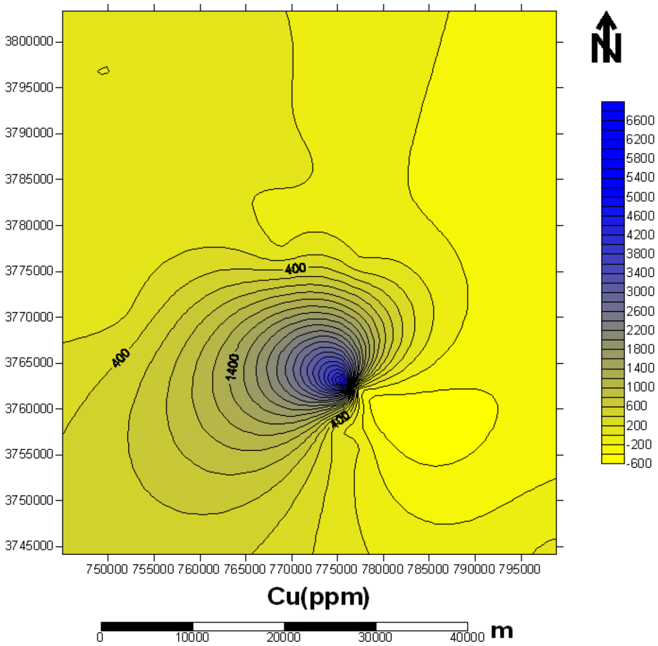

Fig.17. Geochemical dispersion map of the element copper.

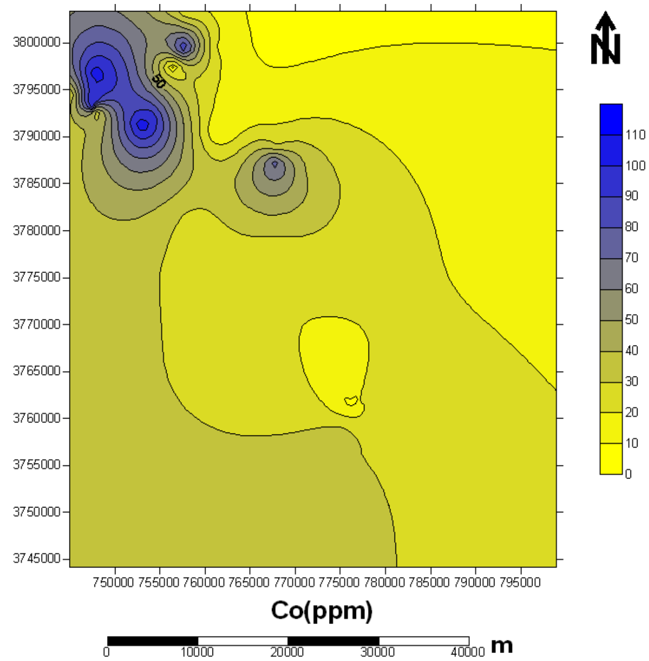

Fig.18. Geochemical dispersion map of the element cobalt .

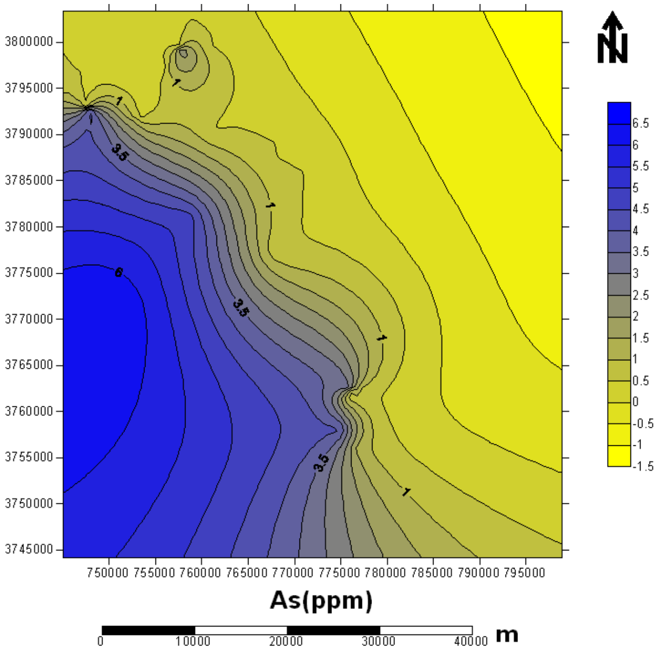

Fig.19. Geochemical dispersion map of the element arsenic.

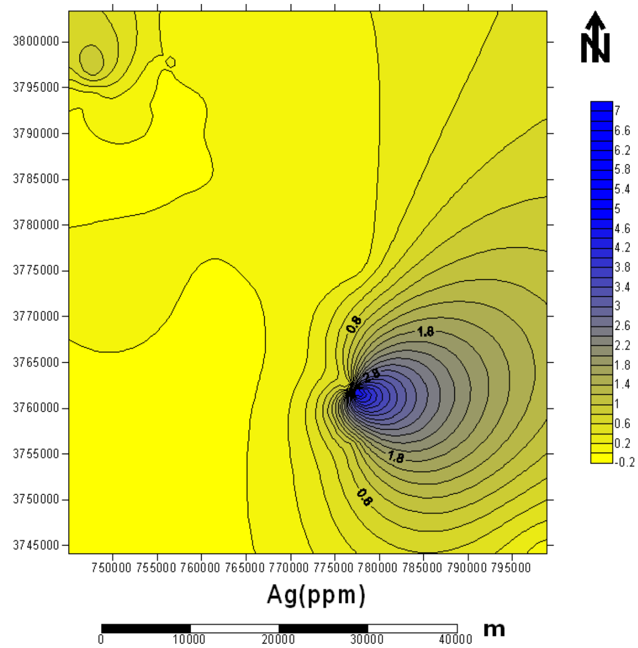

Fig.20. Geochemical dispersion map of the element silver.

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