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Potential Mapping of Chromite Deposits of South-West Sahneh Ophiolites in Kermanshah Province

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Abstract

The ophiolite complex of Sahneh is considered as a part of the sequences in Zagros suture zone. The studied ophiolite complex dating back to the late Cretaceous (Maastrichtian), formed in the two north and south ore body has been occurred in the southwest of Sahneh. In this complex, there is no complete ophiolitic sequence and generally, the existing lithologies of the region in the order of frequency consist of serpentinized ultramafic (harzburgitic peridotite, serpentine, dunite). The apical minerals analyzed in the polished sections in the order of frequency are magnetite, chromite and pyrite with less frequency, respectively. Chromium lenses are located in severely serpentinized harzburgites. Primary textures in chromite include cataclastic and lattice texture. The presence of cataclastic texture indicates active tectonics in the region, which causes corrosion in the chromites. The geochemical investigations of 7 rock samples by ICP-OES method and statistical approaches are indicated that the iron and chromite of the studied area have a remarkable and positive correlation with the presence of chromite in the mineralogical studies. The average of the main elements and mineralization factors in the region are Cr 493 ppm and Mg (ppm 03/0) and AL (2133 ppm) and FE (4490 ppm) and Ni (3255 ppm). Cadmium is an element that remains in acidic environment and is washed out in alkaline conditions from the environment. The presence of this element in the samples is due to change in the properties of the mineralization solutions of the region from acidic to alkaline conditions. Also, the presence of an element such as scandium with the high melting point implies the magnetism of magmatism of the region.

Keywords: Ophiolite, Sahneh, Chromite, Harzburgite, Geochemistry

Introduction

In general, Omani-Mediterranean ophiolitic belt has the features of ophiolites associated with subduction or super subduction zones (ssz) (Alabaster et al., 1982; Babaie et al., 2006; Bagci et al., 2008; Floyd et al., 1998; Godard et al., 2003, 2006; Hebert and Laurent, 1990; Lytwyn and Casey, 1993; Parlak et al., 1996, 2000; Robertson, 2002; Sengor, 1990; Dilek et al., 1999). Upper Cretaceous ophiolites of Zagros are the parts of this ophiolitic belt, which are divided into two groups of outer Zagros and inner Zagros (Stocklin, 1977). The inner ophiolites belt includes ophiolites around the central Iranian microcontinental crust while the outer ophiolites including Kermanshah, Neyriz and Haji Abad-Esfandaqeh ophiolites with a northwest-southeast trend are considered as a part of the 3000-kilometer ophiolitic belt that are stretched from Cyprus to Oman. Kermanshah ophiolites is a part of this ophiolite belt with 200 km long and 30-60 km wide located in the west of Iran. Also, it is a part of the Neo-Tethys oceanic crust that has been lifted on the passive Arabic border. Generally, Kermanshah ophiolites include scattered outcrops in the cities of Sahneh (Haghighi, 1995; Moradpur, 2005) and Harsin (Allahyari et al., 2012, Mousavi et al. 2013, Torkian et al., 2013), Alashtar and Noorabad (Kiani, 2011), Kermanshah (Ghazi and hassanipak, 1999; Allahyari et al., 2010) and Kamyaran (Ahmadi, 2001). According to Allahyari et al. (2012), the pillow lavas of Harsin belong to the E-MORB environment and WPB basalts, so that it is confirmed by the researches of Mousavi et al. (2013). However, Torkian et al. (2013) argue that the diabase dykes of the Harsin-Sahneh region have been formed in a tectonic setting of back-arc basin. Ghazi and Hassanipak (1999) considered that the magmatic sequences in the ophiolite complex of Kermanshah is similar to tholeiitic series of arcs islands and Oceanic Island Basalt (OIB). Ophiolites are a set of mafic and ultramafic rocks which consist of the minerals such as Cr, Co, Ni, Ti, V, Cu, Mn that are formed along with this set (Karimpour and Saadat, 2002). In the ophiolites of Iran, ultramafic rocks are the main rocks of this complex, which the harzburgites are the main part, which are associated with the chromite mineralization. The geochemical studies aiming the exploration of the chromite deposits in these complexes have been less considered in our country.

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The ophiolite complex of Iran is the remaining derivations of intracontinental setting formed by rifting and has been placed due to obduction and the emplacement of the continents and microcontinents across Paleo geosuture. Kermanshah Ophiolites are a part of the Zagros ophiolites, which is part of the Neo-Tethys oceanic crust, located in the Mesozoic between the Arabian plate and the central Iran (Khosrow Tehrani, 2004) and due to the continent-continent collision, the Arabian plate has been occurred across the Zagros with the central Iranian plate. Apart from crust geodynamics, the presence of chromite, porphyry copper sulfide, platinum-group minerals, rare earth elements and etc. are the features that gives economic value to ophiolitic complexes of Iran. Zagros belt ophiolites are occurred across the south-west main thrust of the Zagros in two broad and separated parts of the ophiolitic-radiolarite complex, which each part is arched and has a convexity towards the southwest: one is Kermanshah (Broud, 1989), and the other is Neyriz in Fars (Ricou, 1971).

The ophiolite strip of Kermanshah has been located as a full ophiolite among the folded zone of high Zagros in the west of Iran. This ophiolitic complex includes mantle sequences composed of peridotite, serpentinite and gabbro pegmatites (which have been injected as a lens within the peridotite) (Allahyari et al., 2010), While the crustal sequences in this ophiolitic complex include localized gabbros, isotropic gabbros, plate-dykes complex, basaltic lavas and sedimentary rocks (including radiolarite and upper Cretaceous pelagic limes). The ophiolite complex of Sahneh is also considered as a part of the sequence in the suture zone of Zagros. The geology of the area includes the altered igneous zone of Sanandaj-Sirjan and the sedimentary zone of the Zagros in the east and the west of Iran, respectively. In this sequence, which ophiolites of the southwest of Sahneh was taken into account, gabbros are firstly placed that are covered by lava and no trace of mixtures was seen. This complex includes alkaline rocks, serpentinized peridotites (harzburgitics) and pyroxenite.

Overall, the ophiolite sequence of Kermanshah can be divided into five sections as follows (Moradpur, 2005):

1. In this sequence, mantle peridotites including depleted or contaminated harzburgites which have been injected by gabbro lava flows with the lenses of gabbro pegmatites. In some cases, the harzburgites have stratigraphically been covered by Miocene lime (equivalent to Qom formation).
2. Isotropic cavernosum gabbro, which are locally layered.
3. A sequence of plate-dykes with asymmetric cooled borders.
4. A thick sequence of flows and pillow lavas. Although the corrosion and fractured faults have eliminated the relationships between the lithology units of the region however, in many minerals, a normal contact is observed between the plate-dykes and the pillow lavas complexes (Kiani, 2011). Volcanoes rocks of Kermanshah ophiolites include lava streams and pillow lavas with the mixture of basaltic to andesite basalts (Shafaii Moghadam & Stern, 2011).
5. Individual diabase dykes (up to large masses of dyke) are stretched largely but they are scattered.

The city of Sahneh is located in the Zagros mountain range relating the third Paleozoic fossils, which its sediments are related to the third period of the Triassic (Mesozoic). These sediments are mostly calcareous (calcium carbonate) and dolomite (double carbonate of calcium and magnesium), which are occurred along with the magmatic masses and igneous rocks. In this complex, three zones can be identified: the first zone is located in the southwest region of Sahneh, which has been formed by extremely alkaline rocks and peridotite and pyroxenolite, which are seen as not so high masses in the southwest of Sahneh. The ultramafic rocks of the Sahneh region are Harzburgite, Dunite and some Lherzolite. Based on the degree of alteration, the alteration veins are divided into three groups and their accurate investigation is classified into 5 generations of serpentine veins (v1-v5) (Farhangian, 2016). The second zone, which is stretched to the south, is severely tectonized and its outcrop is associated with ultra-basic rocks corresponding limestone and radiolarites, which have been connected as a result of structural pressures. The third zone of the complex is located in the Harsin region, whose ophiolitic rocks of a serpentinite mass, are probably associated with a remarkable amount of asbestos, which the feasibility of its exploitation and extraction can be analyzed by further studies. The Sahneh-Harsin ophiolites associated with Kermanshah radiolarites and Behistun lime has constituted over thrust of and is covered discontinuously by Oligo-Miocene limes. This is due to the progressive coverage of Triassic which confirms thrust occurrence in End-Cretaceous.

Chromium ore, i.e. chromite, is generally concentrated in ultrabasic rocks (harzburgite, peridotite, dunite, gabbro, norite and pyroxenite), and in fact, its mixture depends on the surrounding rocks. The mineralogy of chromite deposits has primarily composed of olivine, orthopyroxenes and clinopyroxenes. In some cases, there are amphiboles and alkaline feldspars as well.

Chromite is mainly concentrated in extremely alkaline rocks, and its mixture depends on the combination of the surrounding rocks. The higher the olivine content in the rock, the higher the amount of Cr2O3 could be found in the chromite composition. Chromite ore occurred in ophiolite complexes in the transitional zone of harzburgite are found in cumulative rocks and the lenses that are usually discontinuous to tectonized harzburgite. However, these chromite lenses in extremely altered ophiolite complexes, may be in conformity with the harzburgite-containing rocks.

In this research, the harzburgites have been studied geochemically and mineralogically as a part of the cropped out ophiolite complex of Sahneh-Harsin.

Method

In this study, an accurate investigation of tectonic plates which is so important in the detailed exploration was carried out with considering geologic maps of the region and location of hypothetical faults of the region on aerial photographs was determined. It has been attempted that the orientation of the sample was identified by the serpentinized outcrops which have the minimum weathering. In order to determine the petrological properties of various rock units and chromite, several polished thin sections were prepared and studied by polarizing microscope and reflected light. In addition to determine the name of the rocks, existing rock microstructures were analyzed. For the purpose of specifying the amount of main and sub-elements, these samples were powdered and then evaluated by chemical decomposition of ICP-OES method.

Mineralography

In this study, 7 polished section samples were prepared to perform the Mineralography analyses in Zarazma laboratory. Iron minerals and the percentage of their frequency were determined by polarizing microscope of reflected light. Finally, considering the studies on the polished samples of the region, it can be precisely represented that iron minerals of the region are magnetite with more frequency, chromite and pyrite.

Northern mass

Mineralography of sample (1), iron minerals: Chromite and pyrite

The frequency of chromite was very limited and, it was observed in a part of the cross section of several particles with dimensions of 20-300 μm (Figure 1). Handful of pyrite has been placed with dimension of up to 30 μm in the fractures and the cracks (Figure 2).

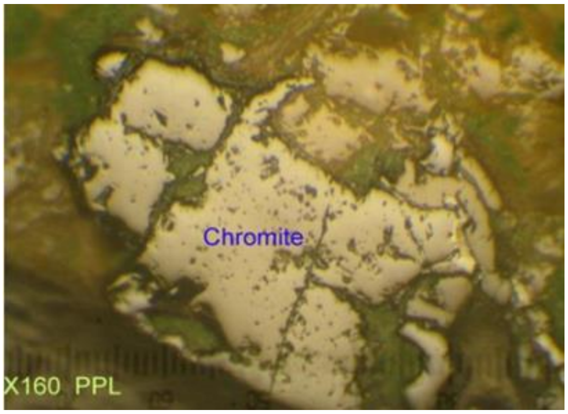

Fig. 1. Chromite with a dimension of 20-300 μm

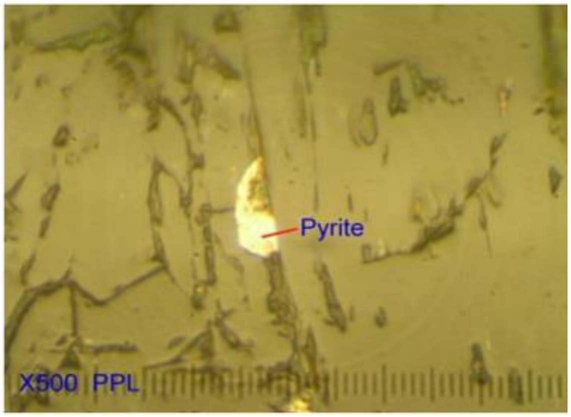

Fig. 2. Pyrite with a dimension of up to 30 μm

Mineralography of sample (2), iron minerals: Chromite and Magnetite

Frequency of chromite is approximately 4%. Scattering occurrence of chromite particles in cross section can be observed. Dimension of chromite crystals is between 10 to 400 μm and have cataclastic texture (Figure 3). This texture is constituted occasionally in the chromite particles which has been fractured under tectonic stresses. It could be stated that this texture has been constituted under the effects of created faults of the region. The frequency of magnetite is about 3 %. Magnetite was observed in dispersed particles or thin veinlets in canals and the spaces among gangue particles (Figure 4). Also it was introduced in chromite particles. The particle is in 2 to 200 μm.

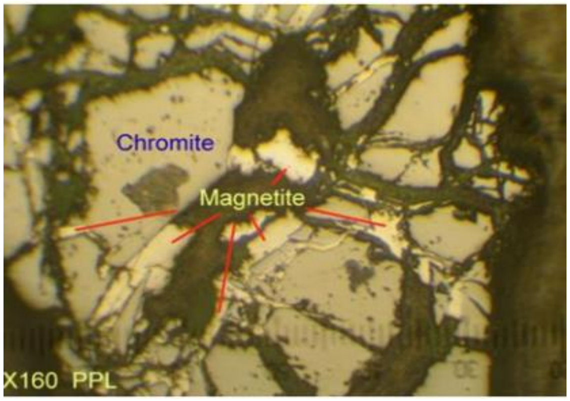

Fig. 3. Magnetite dispersed in chromite particles in 10-400 μm

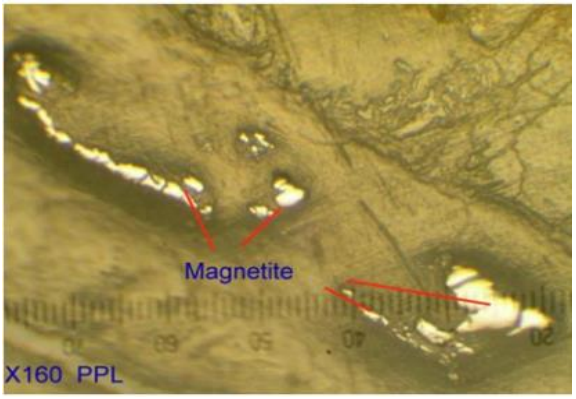

Fig. 4. Magnetite as dispersed particles of chromite or thin veinlets in canals and the spaces among gangue articles in 2-200 μm

Mineralography of sample (3), iron minerals: Magnetite and Pyrite

Frequency of magnetite is about 2%. Crystals of semi-automorph to automorph of magnetite class Epi were found in the canals between the gangue particles and thin veinlets (Figure 5). Handful of Pyrite with a dimension of up to 40μm were randomly observed and a number of them are replaced by iron hydroxides.

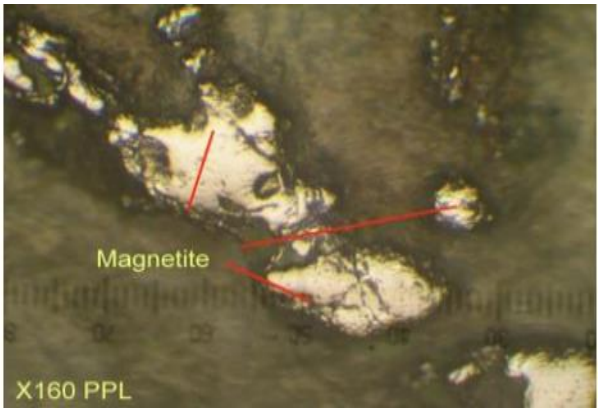

Fig. 5. Crystals of semi-automorph and automorph of Magnetite class Epi Southern mass

Mineralography of sample (1), Iron minerals: Magnetite

Magnetite with a very limited frequency and the maximum particle size of 100µm was found in the canals among the gangue particles (probably Olivine) (see Figure 6, 7).

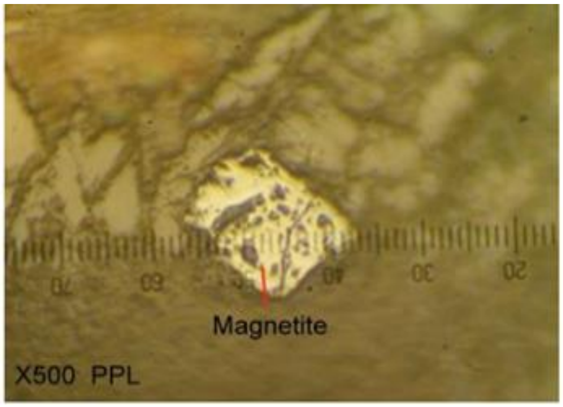

Fig. 6. Magnetite particles with few frequency with the maximum size 100 µm

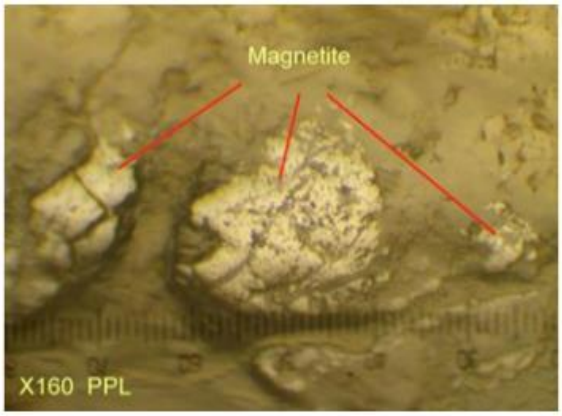

Fig. 7. Magnetite in the canals of gangues with the maximum size of 100 µm

Mineralography of sample (2), Iron minerals: Magnetite, Pyrite

The frequency of magnetite has been very few (less than 1%) and it was found in semi-automorph particles in the space and the canals of olivine (Figure 8). Sometimes, these magnetites of these canals are placed consecutively and create microscopic veinlets. The size of magnetite particles is 2 to 80 µm. Iron sulfide minerals (probably pyrite) by the size of less than 50 µm have been placed only in a handful inside of the gangue fractures. Some are replaced due to alteration of iron hydroxide (Figure 9).

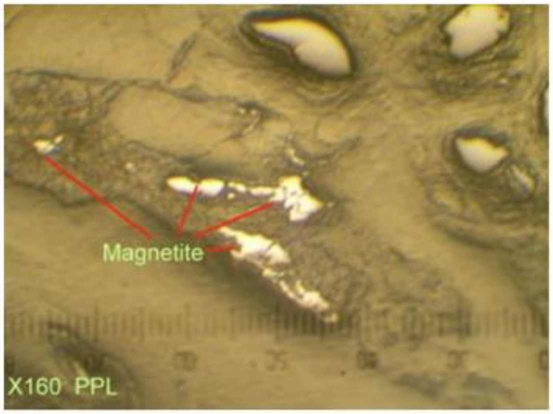

Fig. 8. Magnetite in semi-automorph particles in the space and gangue canals by the size 2-80 µm

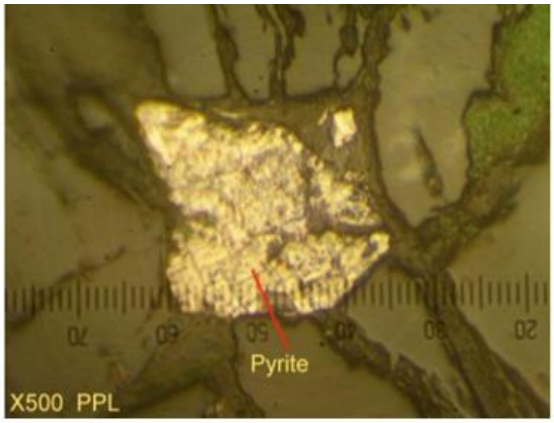

Fig. 9. Pyrite replaced due to alteration of iron hydroxide by the maximum size of 50 μm

Mineralography of sample (3), Iron minerals: Chromite

Chromite is found dispersedly in several masses containing the particles of 50 to 80 μm with Cataclastic texture. The frequency of Chromite is approximately 2-3% (Figure 10).

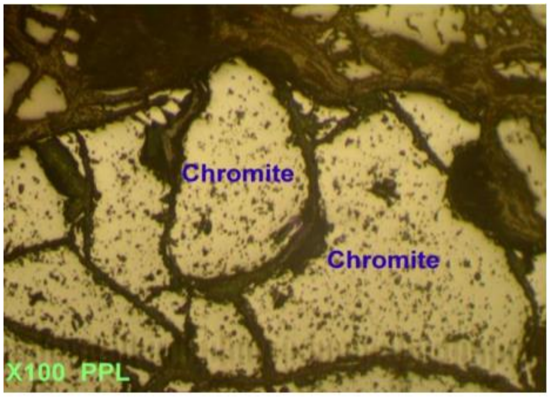

Fig. 10. Chromite with cataclastic texture in thin section with the size 50 to 80 μm

Mineralography of sample (4), Iron minerals: Magnetite, Pyrite, Chromite

The frequency of magnetite is about 1%. The particle size of this mineral is between 20 to 160 μm and as individual or united particles was observed in the intervals and the canals among the gangue particles (Figure 11). Chromite was found with the frequency of around 2% as half-shaped crystals and united crystals by the size of 20 to 250 μm (Figure 12). Pyrite has been placed among the canals of olivines in a very few frequency in the maximum size of 60 μm.

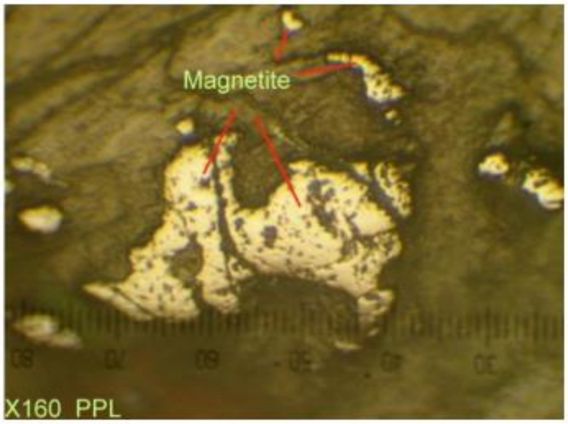

Fig. 11. Magnetite in the canals with the size 20-160 μm

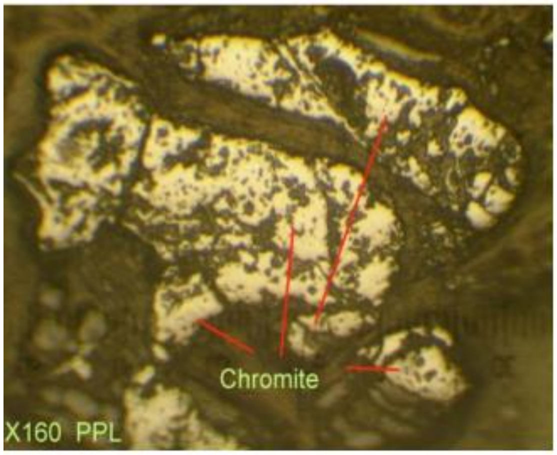

Fig. 12. Chromite as half-shaped crystals with the size of 20 to 250 μm

Regarding mineralographic studies of 7 polished samples by use of polarizing microscope of reflected light, three frequent iron minerals are magnetite with the minimum and maximum size of 2 and 500 μm, chromite with the minimum and maximum size of 10 and 500 μm and pyrite the maximum size of 50 μm which is slightly similar to podiform chromite deposits. Pyrite in most zones is replaced due to existing alteration of the region using iron hydroxide. Cataclastic texture in chromites indicates active tectonics of the region. The presence of this texture in the samples confirms the hypothetical faults on the geological map of the region.

Geochemistry of Ophiolitic rocks of the region

In this research, 7 samples were delivered to Zarazma laboratory to perform ICP-OES chemical analysis and the results were analyzed using SPSS software.

Exploration geochemistry

In order to be consistent with the studies of exploration geochemistry of 9 samples, 3 rock samples from the north mass and 4 rock samples from the south mass were taken which had the minimum alteration and weathering along the trenches created on the two masses and they were analyzed by ICP-OES (Figure 13) (Table 1).

Fig. 13. The google earth image of the region and the selected points (coordinates of Sahneh are 3420°-3445° N latitude, and 4710°-4750° E longitude)

Table 1: The results of chemical analysis of ICP-OES samples

Element	Ag	Al	AS	Ca	Cd	Ce	Co	Cr	Cu	Fe	La	Li	Mg
Unit	ppm	Ppm	ppm	ppm	ppm	ppm	ppm	Ppm	Ppm	Ppm	ppm	Ppm	ppm
DL	0.1	100	0.5	100	0.1	1	1	1	1	100	1	1	100
method	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01
co	-	-	-	-	-	-	-	-	-	-	-	-	-
J2	0.16	2739	2	10970	0.2	1	85	530	10	44640	1<	1	2%>
J3	0.19	1451	2.3	4231	0.2	1	90	334	3	46206	1<	1	2%>
J5	0.26	4502	2.1	5809	0.24	1	94	1162	36	47568	1<	1	2%>
S3	0.18	2309	2.1	3799	0.23	1	87	551	1	43827	1<	1	2%>
S4	0.14	845	2	1270	0.22	1	88	215	17	43881	1<	1	2%>
S5	0.15	1217	1.9	3405	0.17	1	88	284	13	43581	1<	1	2%>
S7	0.17	1734	2.1	4476	0.19	1	93	379	4	44880	1<	1	2%>

(Table 1 Continued)

Element	Mn	Mo	Ni	p	pb	S	Sb	Sc	Th	V	Y	Yb	Zn
Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	Ppm	Ppm	ppm	ppm	Ppm	ppm
DL	5	0.5	1	5	1	50	0.5	0.5	0.5	1	0.5	0.2	1
method	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01	ME-01
co	-	-	-	-	-	-	-	-	-	-	-	-	-
J2	650	0.53	1723	23	56	105	1.98	5.5	2	16	0.5<	0.3	43
J3	652	0.55	1852	31	61	69	1.21	4.9	1.3	11	0.5<	0.3	49
J5	756	0.5<	1842	21	224	56	2.12	9.2	1.7	28	0.5<	0.3	81
S3	643	0.79	1784	18	33	77	1.34	4.8	1.3	12	0.5<	0.2	76
S4	635	0.5<	1789	10<	18	136	1.31	3.9	0.9	8	0.5<	0.2	49
S5	626	0.7	1840	14	17	84	1.05	4.3	1.3	9	0.5<	0.2	62
S7	704	0.5<	1958	35	45	79	1.03	5.1	1.6	11	0.5<	0.3	56

Correlation coefficient and geochemical relationship between the elements

The distribution and dispersion of various elements in the rock units of an ore deposit and also, the study of the relationship and dependency of these elements with each other are considered as the most important factors in geochemical studies for determining effective processes involved in ore formation (Barnes 1997). Understanding the mutual relationship between elements can considerably aim at recognizing the environmental conditions, accurately interpreting of geochemical environments, better understanding mineralization of the region, and even in providing final regions. In order to determine the relationship between the elements in the ore-bearing rocks, the Pearson method was used in the southwest harzburgites of Sahneh. The results are presented in Table 2.

Table 2: The results of correlation coefficient of the elements by Pearson method

		AG	AL	AS	CA	CD	CO	CR	CU	FE	LA	LI	MG	MN	MO	NI
AG	Pearson Correlation	1														
AL	Pearson Correlation	.861	1													
AS	Pearson Correlation	.480	.158	1												
CA	Pearson Correlation	.192	.549	-.022	1											
CD	Pearson Correlation	.599	.593	.385	-.040	1										

CO	Pearson Correlation	.674	.375	.236	-.249	.202	1									
CR	Pearson Correlation	.915	.982	.187	.387	.651	.474	1								
CU	Pearson Correlation	.598	.624	-.163	.053	.444	.438	.697	1							
FE	Pearson Correlation	.897	.704	.598	.258	.431	.702	.738	.552	1						
LA	Pearson Correlation	.250	.357	.436	.542	.252	.036	.250	-.430	.250	1					
LI	Pearson Correlation	.903	.854	.149	.140	.596	.639	.923	.878	.793	-.061	1				
MG	Pearson Correlation	-.526	-.686	-.107	-.730	-.160	-.425	-.593	-.275	-.637	-.616	-.468	1			
MN	Pearson Correlation	.049	.383	-.766	.128	.214	.077	.374	.437	-.200	-.088	.328	-.233	1		
MO	Pearson Correlation	-.191	-.159	-.097	-.209	-.081	-.447	-.144	-.416	-.530	-.051	-.309	.606	.014	1	
NI	Pearson Correlation	-.205	.224	-.199	.895	-.137	-.572	.050	-.076	-.087	.372	-.167	-.477	.128	-.202	1
P	Pearson Correlation	.272	.136	.458	.331	-.212	.464	.072	-.365	.458	.706	-.035	-.645	-.354	-.341	.076
PB	Pearson Correlation	.950	.899	.297	.289	.580	.643	.941	.784	.896	.126	.971	-.613	.199	-.382	-.053
S	Pearson Correlation	-.764	-.559	-.448	-.138	-.096	-.587	-.591	-.106	-.630	-.326	-.511	.351	.163	-.196	.303
SB	Pearson Correlation	.595	.852	.090	.677	.589	.012	.798	.651	.556	.235	.690	-.605	.316	-.324	.545
SC	Pearson Correlation	.935	.948	.213	.384	.548	.603	.970	.753	.848	.194	.955	-.675	.295	-.332	.031
TH	Pearson Correlation	.383	.679	-.063	.928	-.041	.074	.544	.148	.400	.573	.319	-.868	.266	-.244	.698
V	Pearson Correlation	.897	.976	.186	.478	.582	.470	.980	.747	.798	.223	.929	-.676	.324	-.298	.157
Y	Pearson Correlation	.148	.299	-.015	.529	-.169	-.372	.244	.330	.179	-.268	.219	-.040	-.162	.095	.497
YB	Pearson Correlation	.515	.498	.420	.627	.018	.466	.421	.129	.754	.584	.354	-.896	-.209	-.659	.363
ZN	Pearson Correlation	.676	.597	.039	-.214	.528	.442	.695	.422	.299	-.022	.660	.011	.406	.428	-.506

The results of the studies indicate that:

1. Silver has a significant correlation with aluminum, chromium, iron, lithium, lead, sulfur, scandium and vanadium. The correlation between chromium and iron with the presence of chromite, and also, the correlation between iron and sulfur with the presence of pyrite, is consistent with mineralogical studies. Therefore, it is clear that the correlation between these elements is due to their presence in sulfide and oxide minerals of ore-bearing rocks of the region.
2. Aluminum has a significant correlation with chromium, lithium, lead, antimony, scandium and vanadium. The presence of elements such as scandium with high melting point implies the magnetism of magmatism in this region.
3. Arsenic significantly correlates with nickel and manganese. Positive correlation between nickel and manganese can be due to the replacement of these elements in iron-bearing sulfide minerals (e.g. pyrite).
4. Calcium has a significant correlation with nickel, thorium, antimony, scandium and vanadium. The presence of calcium in this component indicates the alkalinity of the precipitator unit of these elements.
5. Chromium significantly correlates with lithium, lead, antimony, scandium and vanadium.
6. Copper has a significant correlation between lead and lithium.
7. Iron has a significant correlation with lithium, lead, scandium, vanadium and yttrium.
8. Phosphor has a significant correlation with yttrium.
9. Lithium has a significant correlation with lead, scandium and vanadium.
10. Magnesium has a significant correlation with thorium and yttrium.
11. Lead has a significant correlation with scandium and vanadium and chromium.

12. Scandium has a significant correlation with vanadium.
13. Thorium has a significant correlation with zinc.

Determination of geochemical relations of elements using multivariate statistical methods

In order to determine the different phases of mineralization, multivariate analysis was utilized. Thus, the analysis of the main components was carried out to understand the relationships between the different elements in the samples, which the results are presented in Tables 3. According to this analysis, the various elements have been divided into six main components, which are placed in rows 1 to 6 of the table (the components, that are more than 6 have negligible amount).

Table 3: Analysis of the main components in the southwest region of Sahneh

Component	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.648	46.591	46.591	11.648	46.591	46.591	10.619	42.477	42.477
2	4.553	18.212	64.803	4.553	18.212	64.803	4.177	16.710	59.186
3	3.625	14.500	79.303	3.625	14.500	79.303	4.026	16.105	75.292
4	1.995	7.981	87.284	1.995	7.981	87.284	2.432	9.728	85.019
5	1.792	7.170	94.454	1.792	7.170	94.454	2.264	9.057	94.076
6	1.387	5.546	100.000	1.387	5.546	100.000	1.481	5.924	100.000

The elements related to these components have been mentioned in Table 4. The achieved results are listed as follows:

The first component contains the effective elements of silver, aluminum, cadmium, cobalt, chromium, copper, iron, lead, antimony, scandium, vanadium, zinc and lithium, which considering the main mineral elements in this component, it could be represented that the mineralogical occurrence of the region is related to this component. Cadmium is an element that remains in acidic conditions and is washed in alkaline environment. The presence of this element in the samples indicates the change in the properties of the mineralogical solutions from acidic to alkaline. The second component is the elements of phosphorus, thorium, ytterbium, lanthanum and magnesium, have the most effect. The third component includes the effective elements of calcium, lithium, antimony, thorium and yttrium which have an inverse effect of copper on this component. The presence of calcium in this component indicates the alkalinity of the precipitation environment of these elements. Less variables could be defined in the three subsequent components so that the elements of cadmium and arsenic have direct effect and the elements of manganese, molybdenum and zinc have inverse effect.

Therefore, geochemical studies of 7 rock samples by ICP-OES method and statistical methods depicts that there is a positive and significant correlation between iron and harzburgite-bearing mass of chromium located in the southwest of Sahneh which is consistent with the presence of chromite in mineralogical studies. The average of main and mineral elements in the region are Cr (493ppm), Mg (0.03ppm), AL (2133ppm), FE (4490ppm) and Ni (3255ppm). Due to the low amount of chromium in the samples, it could be noted that chromium ore do not have an economic efficiency in the region, and also cadmium is an element that remains in acidic conditions and is washed in alkaline environment. The presence of this element in the samples represents the change in the properties of the mineralogical solutions from acidic to alkaline, and also the presence of an element such as scandium with a high melting point implies the magnetism of magmatism of the region.

Table 4: Elements of the 6 main components

	Component					
	1	2	3	4	5	6
AG	.942	.223	-.088	.219	-.067	.050
AL	.898	.235	.306	-.112	-.096	.155
AS	.213	.265	-.115	.899	-.017	.252
CA	.209	.422	.876	-.073	.065	-.046
CD	.587	-.101	-.086	.085	-.035	.793
CO	.605	.351	-.629	-.002	.273	-.204
CR	.956	.147	.152	-.087	-.104	.154
CU	.814	-.414	.018	-.228	.334	-.055
FE	.811	.287	-.029	.405	.302	-.054
MN	.276	-.055	.040	-.944	-.052	.163
MO	-.222	-.193	-.024	-.018	-.955	-.005

NI	-.131	.183	.943	-.141	.184	.074
P	.020	.922	-.070	.282	.164	-.196
PB	.980	.112	.038	.066	.147	.024
S	-.606	-.464	.173	-.282	.440	.337
SB	.706	-.031	.618	-.058	.165	.297
SC	.973	.183	.109	-.036	.082	.014
TH	.386	.593	.654	-.206	.034	-.167
V	.952	.143	.246	-.051	.056	.082
YB	.387	.701	.265	.254	.448	-.152
ZN	.694	-.053	-.351	-.190	-.588	.101
LA	.022	.853	.247	.141	-.135	.416
LI	.988	-.062	-.059	-.061	.108	.017
MG	-.487	-.694	-.343	.150	-.375	-3.386E-5
Y	.275	-.386	.730	.240	-.107	-.417

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