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Research Article

Evaluation of Heavy and Precious Metal Potentials in Ophiolitic Rocks in Bozkır (Konya-Türkiye) Region by Resistivity and Geochemical Method

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Abstract

In this study, ore deposit investigations were realized using with the geological, geophysical and geochemical methods on the ophiolitic rocks exposed in Bozkır (Konya) region. Accordingly, samples were taken from the study area to represent the study area and lithology. From the samples taken, examinations were carried out on 17 rock and 6 placer (stream sediment) samples. These separated samples were sent to Canada for chemical analysis. Geophysical study, Resistivity (Electrical Resistivity) method was preferred in which the changes of the layers in the vertical direction were examined. In the field of electrical geophysical methods, investigations were made on the basis of resistivity levels / units. Afterwards, correlation and regression analysis of the 31 components analyzed were performed in order to interpret the geochemical events in the rocks in the study area. As a result of all the findings, interpretations were made and the study was completed. As a result of the data obtained, in the Bozkır region, altered by hydrothermal fluids and metal-rich gabbro, spilite and siliceous levels were determined.

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Ethics statement: We hereby declare that research/publication ethics and citing principles have been considered in all the stages of the study. We take full responsibility for the content of the paper in case of dispute.

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Bozkır Bölgesindeki Ofiyolitik Kayalarda Ağır ve Kıymetli Metal Potansiyellerinin Resistivity ve Jeokimyasal Yöntemle Değerlendirilmesi

Özet

Bu çalışmada, Bozkır (Konya) bölgesinde açığa çıkan ofiyolitik kayaçlar üzerindeki jeolojik, jeofizik ve jeokimyasal yöntemler kullanılarak maden yatağı araştırmaları yapılmıştır. Bu doğrultuda çalışma alanını ve litolojiyi temsil etmek için çalışma alanından numuneler alınmıştır. Alınan numunelerden, incelemeler 17 kaya ve 6 plaser (dere tortusu) örneği üzerinde gerçekleştirilmiştir. Ayrılan bu numuneler kimyasal analiz için Kanada'ya gönderilmiştir. Jeofizik çalışmada, düşey doğrultuda tabaka değişimlerinin incelendiği Resistivity (Elektriksel Özdirenç) yöntemi tercih edilmiştir. Elektriksel jeofizik yöntemler alanında özdirenç düzeyleri / birimleri bazında incelemeler yapılmıştır. Daha sonra, çalışma alanındaki kayaçlardaki jeokimyasal olayları yorumlamak için analiz edilen 31 bileşenin korelasyon ve regresyon analizi yapılmıştır. Tüm bulgular neticesinde yorumlar yapılmış ve çalışma tamamlanmıştır. Elde edilen veriler sonucunda Bozkır bölgesinde, hidrotermal sıvılarca altere edilmiş ve metal bakımından zengin gabro, spilit ve silisli düzeyler tespit edilmiştir.

Anahtar Kelimeler

Bozkır
Jeofizik
Kıymetli Metal
Resistivite

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INTRODUCTION

An important part of our country is covered with ophiolitic rocks which may be the source of precious platinum group metals (PGM), Au and heavy metals (Cr, Co, Ti, Ni, Fe). In this study, it is aimed to search for other heavy metal and mineral enrichments, especially PGM and Au, in ophiolitic rocks, listwanites and current placers derived from them in Bozkır (Konya) region. For this purpose, geological and geochemical studies were carried out in the region and in the light of the data obtained, it was tried to determine the physical and geometrical properties (thickness, extension) of the ore deposits (complex, massive, disseminated etc.) and the distances to the surface by the Resistivity (electrical resistivity) method. In addition, the economic potentials of precious and heavy metal enrichments in these regions were determined and it was investigated whether they have mining properties. The Bozkır region is located on the southwestern border of the city center of Konya (Figure 1).

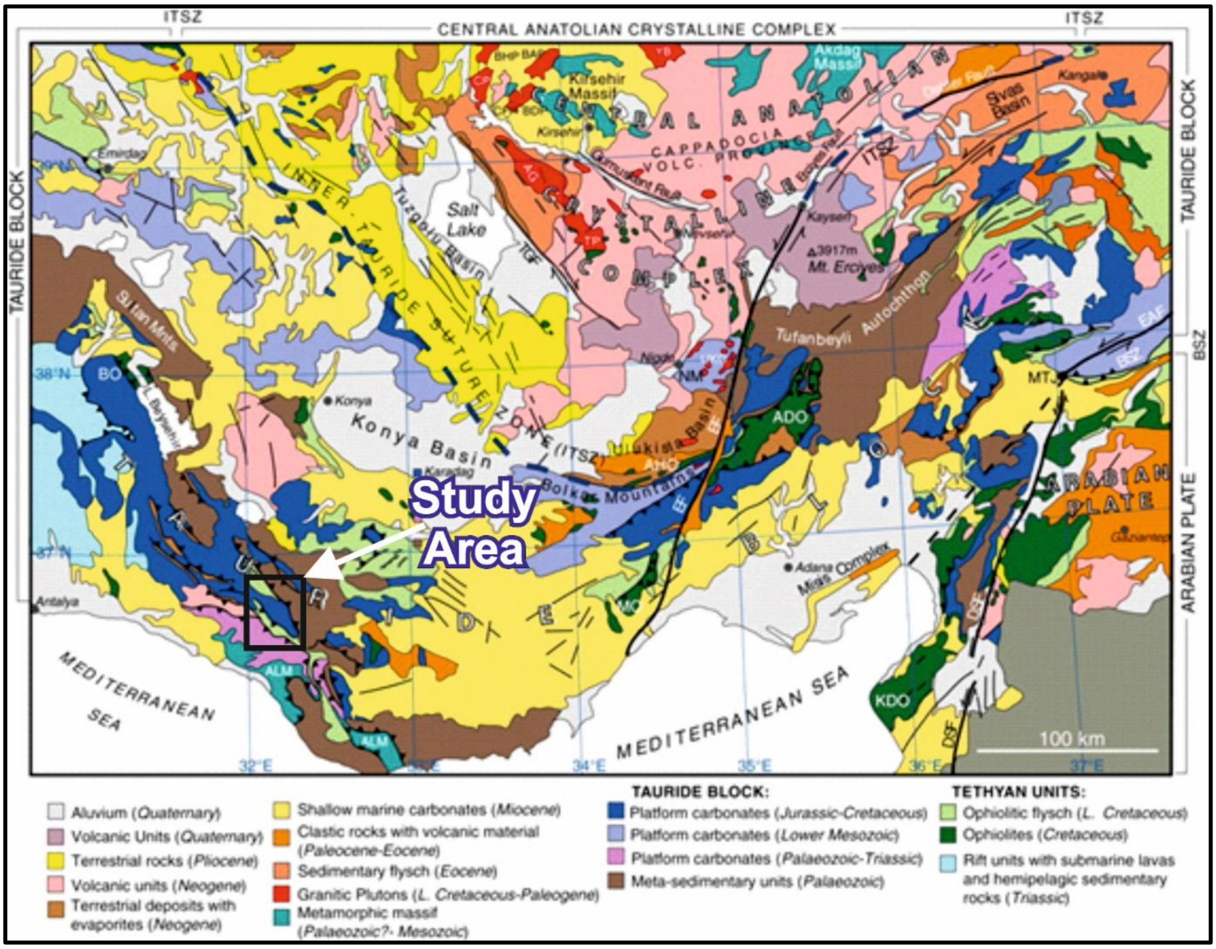

Figure 1. Study areas location maps [1]

The geological characteristics of the Taurus belt in terms of tectonics, stratigraphic and metamorphism and the fact that it is suitable for exploration in terms of mineral deposits have been subject to intensive research and various studies have been not carried out [2-16].

Geological Settings

Regional geological setting

The unit containing the chaotic structure of the ophiolitic rocks extending from the south of Beysehir Lake (Konya) to the south of Sugla Lake (Konya) and to the west of Bozkır-Hadim (Konya) is named as Dipsiz Lake ophiolite [17]. The ophiolitic rocks found in the Central Taurus were included in the [7] Beysehir-Fan nappe, while [5] was considered within the Bozkır Union. Unity, the outcrops of the Taurus Mountains in different parts of the study area was studied under different names such as West Lycia Nappes [18], East Lycian Nappes [19], Beysehir-Hoyran Nappe [7], Ophiolite Series [4], the Schist-Radiolarite Formation [3], Tashkent ophiolitic melange [13], Bozkır allochtonous [9], ophiolitic melange [20], Bozkır union-Bozkır ophiolitic melange [16]. In his study in [6] stated that, Bozkır association consists of pelagic and neritic limestone, radiolarite, basic underwater volcanite, tuff, diabase, ultrabasite, serpentinite etc. deposited in the Triassic-Cretaceous range. He stated that the rocks had a large "melange" appearance including blocks and slices of different sizes. There is still a controversy over the existence of the inner-Tauride ocean, which is considered a branch of the Neotethys Ocean. Some researchers have reported that the ophiolitic rocks in the form of tectonic slices over the carbonate rocks of the Taurus Platform have been carried tectonically from the Izmir-Ankara-Erzincan Suture Zone [21]. Yılmaz and Yılmaz [22], separating the North Anatolian Ophiolite Belt into two sub-zones and the Menderes and Kırsehir massifs from the south of Erzurum-Kars along the generation of ophiolite slices, can be included in the inner-Torid ophiolite belt [23]. According to some authors, all of the ophiolites in the Taurus belt were formed in the oceanic basin of the Taurus carbonate platform in the northern part of the Taurus carbonate platform and were formed in the oceanic basin defined as the ocean of Taurus, and gained their current position due to later nappe movements [5, 7, 17, 23, 24, 25, 26, 27, 28, 29, 30]. The ophiolitic rocks in Çayırbagı-Hatip (Konya) are on the Taurus mountain belt.

Local geological setting

In the Bozkır (Konya) region, the autochthonous Geyikdagı Union (Seydisehir Formation, Hacıalabaz formation, Çökelen diabase, Saytepe formation) and the Bolkardagı Union (Hocalar formation, Taskent formation, Sinatdagı formation) and the Bozkır Union, which tectonically overlaps this unit with different lithological ophiolitic melange and Boyalıtepe group which are composed of Mahmuttepe, Kuztepe, Sogucak and Erenlertepe limestones. In addition, there are Kızıltepe volcanic which are outcropped by cutting these unions and Gündügün formation which covers all these units with angular unconformity. There is no detailed study of the region in terms of mineral deposits. However, the volcanic and carbonate Pb and Zn occurrences developed in the vicinity of Alanözü-Habiller (Karaman) region in the vicinity of the Bozkır Union [31] and Göktepe (Ermenek-Karaman) in the vicinity of the Bozkır Union [32].

MATERIAL AND METHOD

Geochemistry

Ophiolitic rock samples which are important in terms of precious / heavy metals / minerals were taken for petrographic and geochemical studies and approximately 10-15 kg weighty creeks that can bring suitable material sediments. 17 rocks-6 placers (stream sediments) samples were analyzed for represent the study area and lithology.

Laboratory Works

In the study area, it is focused on ophiolitic rocks which are more important in terms of precious metal and heavy metal and the creeks that can bring material from this unit. In the study areas, firstly 1/25000 scale geology map of the region was made and the regions which covered with heavy metal and precious metal were determined. Rocks and terraces were determined on the map and after creeks and terraces were determined in terms of rich with heavy metal and precious metal and rocks and stream sediments samples were taken for petrographic and chemical analysis purposes. At the stage of field studies placer samples, placer formation and density of the existing creeks were determined and the sources were analyzed by determining the coordinates of the samples and using GPS, samples were taken weight of 10-20 kg from the appropriate points of the main creeks and branches close to the main creeks, where heavy metals and precious metals could be concentrated. Placer samples from the study area were subjected to water washing to separate from the organic material and concentrated. The pre-prepared flask was screened in a sieve set containing 0.106 mm, 0.425 mm and 0.5 mm spacing sieves. Samples prepared for chemical analysis and samples in the range of 0.106 mm and milled rock samples were made in ACME (ACME Analytical Laboratories Ltd. Vancouver) laboratory in Canada, chemical (whole rock) and precious metal (Au, Pt, Pd) analyzes were performed. In geophysical study, Resistivity (Electrical Resistivity) method was preferred in which the changes of the layers in the vertical direction were examined. This method has been applied in the field of Vertical Electrical Drilling (DES) and Schlumberger electrode array has been applied. This method is applied to the ground with the help of two electrodes on the earth and the other two electrodes to determine the voltage difference is applied. Visible resistivity values are obtained by multiplying the measured voltage difference by a coefficient depending on the position of the electrodes and dividing the value by the current value according to Ohm's law. The most important physical properties measured in electrical resistivity method are the electrical resistivity and electrical permeability of the rocks. While the resistivity in metallic ores is very low due to their conductivity, the resistivity of water-free intrusive rocks is very high since they are not conductive. By using these properties, ρ_a values were obtained by adding geometric factor effect to the resistivity values obtained in the field. Based on the measurements made in the field, the ρa apparent resistivity values were determined as a curve, and by evaluating this curve, the resistivity (ρ) thickness (h) and depth (d) values of the layer parameters for that measurement point were found. The obtained ρ_a values were plotted in the IP2WIN program as a function of distance and correlated with the geological data with the apparent resistivity (ρa) curves and the underground geological structure was tried to be defined. Wall-rock samples were crushed, quartered, pulverized to 125 mesh and homogenized. Geochemical analysis was carried out to determine the bulk geochemistry of the 45 ore samples in Breau Veritas Analytical Laboratories Ltd., Vancouver, Canada. Analyses were carried out by ICP-Emission Spectrometry for major oxides and ICP-Mass Spectrometry for trace elements, following the lithium metaborate/tetraborate fusion and dilute nitric digestion. In addition, a separate 0.5 g split is digested in Aqua Regia and analyzed for ICP Mass Spectrometry for trace and rare earth elements. Detection limits are 0.01% for SiO_2, Al_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, P_2O_5 and MnO; 0.04% for Fe_2O_3; 0.02% for Cr_2O_3; 0.01 ppm for Hg, Tm, Lu; 0.5 ppm for Sr and W; 0.1 ppm for Zr, Y, La, Ce, Bi, Ta, Nb, Hf, Ag, Cd, Sb, Mo, Ni; 0.05 ppm for Sm, Gd, Dy, Yb and 8 ppm for V. Au has 0.5 ppb detection limit. Detection limits for Pr and Eu were 0.02 ppm. The detection limits for Pb were 0.1%. The detection limit was 0.001% for Cu. Detection limits were 1 ppm for Ba, Zn, Sc and Sn; 0.3 ppm for Nd and 0.03 ppm for Er.

RESULT AND DISCUSSION

Whole-rock Geochemistry

Main oxide and Trace element Geochemistry of Bozkır Region

Geochemical and statistical interpretations of 17 rock samples of the Bozkır ophiolitic melange in the Bozkır region were made. Some of the main components analyzed in the oxide composition (SiO_2, Al_2O_3, Fe_2O_3, MgO, TiO_2, MnO and Cr_2O_3) were converted to elemental concentrations in order to make the interpretations parallel to the applied methods (Table 1).

Table 1. The main oxide, trace element and PGM analysis results of the rocks belonging to the Bozkır ophiolitic melange and statistical summaries of the results of the analysis (S.N.: Sample numbers, A.A.: Arithmetic average, Std.D.: Standard deviation)

S.N.		BK1	BK2	BK3	BK4	BK5	BK6	BK7	BK8	BK9	BK10	BK11	BK12	BK13	BK14	BK15	BK16	BK17	A.A.	Std.D.
SiO_2	%	46.61	45.94	47.46	47.06	46.22	70.29	68.91	46.07	46.85	63.13	66.31	74.30	66.31	46.30	46.75	48.29	50.48	54.55	10.67
Al_2O_3	%	14.46	14.21	12.78	14.79	13.25	12.58	12.83	14.51	13.84	16.43	13.59	12.64	13.46	15.07	15.78	16.20	15.86	14.25	1.28
Fe_2O_3	%	11.61	11.59	11.53	11.89	12.26	3.84	5.62	10.80	11.38	5.43	6.12	2.45	4.00	10.98	11.49	10.84	11.06	8.99	3.47
MgO	%	8.19	8.49	8.32	6.31	8.13	0.71	0.62	6.74	7.32	2.48	1.69	0.40	1.62	7.24	6.80	5.27	5.79	5.07	3.06
CaO	%	8.30	9.83	10.64	8.78	11.58	0.23	0.62	10.42	9.64	2.90	1.12	0.33	2.27	11.42	10.14	8.30	4.22	6.51	4.37
Na_2O	%	3.24	2.17	2.43	4.19	2.11	0.11	3.65	2.75	2.88	2.99	5.63	5.38	2.12	2.59	3.01	4.68	5.49	3.26	1.45
K_2O	%	1.41	1.06	1.61	0.17	1.22	9.50	3.97	0.76	1.73	3.86	0.61	2.12	5.02	0.88	1.11	0.09	0.35	2.09	2.37
TiO_2	%	1.06	1.15	1.22	0.48	1.09	0.32	0.50	1.07	1.02	0.54	0.45	0.36	0.39	1.14	1.13	0.43	0.44	0.75	0.35
P_2O_5	%	0.21	0.21	0.26	0.06	0.24	0.05	0.15	0.23	0.23	0.14	0.13	0.07	0.08	0.21	0.24	0.05	0.05	0.15	0.08
MnO	%	0.20	0.22	0.22	0.28	0.28	0.10	0.17	0.16	0.19	0.11	0.22	0.04	0.09	0.18	0.19	0.20	0.21	0.18	0.06
Cr_2O_3	%	0.02	0.03	0.03	0.02	0.03	0.00	0.00	0.03	0.03	0.03	0.01	0.12	0.01	0.03	0.03	0.02	0.02	0.03	0.03
LOI	%	4.4	4.9	3.3	5.8	3.3	2.0	2.8	6.2	4.6	I.S.	3.9	1.7	4.4	3.7	3.0	5.5	5.8	4.08	1.65
TOT/C	%	0.21	0.33	0.06	0.35	0.05	0.09	0.16	0.25	0.10	0.45	0.03	0.07	0.45	0.12	0.03	0.21	0.04	0.18	0.14
Au	ppm	0.009	0.012	0.013	0.003	0.003	0.003	0.003	0.002	0.002	I.S.	0.002	0.002	0.002	0.002	0.003	0.002	0.002	0.004	0.004
Pt	ppm	0.008	0.003	0.003	0.003	0.009	0.003	0.003	0.007	0.008	I.S.	0.003	0.003	0.003	0.003	0.006	0.003	0.003	0.004	0.002
Pd	ppm	0.008	0.007	0.005	0.006	0.012	0.002	0.002	0.007	0.011	I.S.	0.002	0.002	0.002	0.008	0.008	0.005	0.006	0.006	0.003
Co	ppm	39.7	41.3	38.9	37.8	43.6	5.3	8.6	39.8	40.1	10.0	8.9	3.9	5.2	39.3	41.5	34.8	36.4	27.95	16.14
Hf	ppm	2.5	2.5	2.6	0.8	2.0	5.6	4.9	2.4	2.3	4.4	5.2	5.7	6.2	2.2	2.6	0.7	0.7	3.14	1.82
Nb	ppm	7.9	8.6	11.6	3.5	7.3	8.9	7.5	7.4	6.5	12.4	5.6	13.9	16.8	7.6	8.6	2.4	2.0	8.15	3.89
Ta	ppm	0.4	0.5	0.7	0.2	0.5	0.5	0.4	0.5	0.4	0.9	0.3	1.0	1.1	0.4	0.6	0.1	0.1	0.51	0.29
V	ppm	290	317	322	336	327	14	28	292	317	69	51	22	33	310	313	326	305	216	137.84
W	ppm	0.5	0.5	0.5	0.5	0.5	1.2	2.2	0.5	0.5	1.6	0.8	1.4	1.3	0.5	0.5	0.5	0.7	0.84	0.52
Zr	ppm	81.1	85.3	90.1	26.6	71.8	176.1	144.0	84.5	77.6	174.1	168.6	212.1	258.1	82.7	95.5	31.7	29.6	111.15	66.57
Y	ppm	19.4	20.8	21.1	11.9	18.6	28.1	35.8	20.7	18.8	19.8	45.9	23.9	27.0	19.6	22.4	10.4	9.1	21.96	8.92
Mo	ppm	0.2	0.6	0.5	0.5	0.4	1.5	1.8	1.0	1.3	I.S.	0.4	0.7	0.4	0.8	1.2	0.8	0.8	0.81	0.48
Cu	ppm	96.3	57.7	115.7	97.7	104.6	55.0	61.1	213.7	117.6	I.S.	47.2	9.6	11.3	90.1	42.3	99.9	111.9	83.23	52.00
Pb	ppm	2.3	2.8	2.9	6.5	1.8	22.2	25.2	3.8	5.1	I.S.	8.6	22.6	13.8	3.6	4.0	6.1	4.6	8.49	7.95
Zn	ppm	72	69	66	75	62	109	130	61	62	I.S.	86	23	103	61	70	67	78	74.63	29.56
Ni	ppm	30.7	26.9	27.6	15.4	24.9	19.3	11.5	29.2	21.5	I.S.	1.7	5.4	3.7	23.2	32.4	13.4	17.5	19.02	10.54
As	ppm	2.7	4.5	1.7	8.4	2.2	20.5	30.8	5.9	3.8	I.S.	6.4	9.8	6.2	2.4	2.1	6.6	6.5	7.53	7.67
Hg	ppm	0.10	0.06	0.08	0.11	0.08	0.39	0.11	0.02	0.12	I.S.	0.02	0.03	0.04	0.02	0.02	0.01	0.02	0.08	0.09

Correlation and regression analysis of the 31 components analyzed were performed in order to interpret the geochemical events in the rocks in the study area. In order to determine the relationship between the components in the rocks, correlation analyzes were performed and these results were obtained: **SiO_2**; very strong negative with Fe_2O_3, CaO, MnO, Co and V and very strong positive with Hf, W, Pb. **Fe_2O_3** very strong negative with Hf, Zr, Pb and very strong positive with MgO, CaO, Co, V. **MgO** very strong positive with CaO, Co, V and very strong negative with Pb. **CaO**; very strong positive with Co and V and very strong negative with Pb. **TiO_2** has a very strong positive correlation with P_2O_5. **Pd**; Very strong positive with Co. **Co** very strong positive with V, very strong negative with Hf, Zr and Pb.; **Hf** very strong negative with V. Very strong positive with Zr. **Nb**; with Ta. **W**; with Pb and As. **Pb**; very strong positive with As. **V** with Zr and Pb show a very strong negative correlation. Simple regression analyzes were applied to the components which had a very strong correlation to reveal the significance of the correlation determined between the components. Fe_2O_3-SiO_2, Pd-Co, TiO_2-P_2O_5 which having very strong correlation coefficients in rocks, simple regression analyzes of components and regression distribution diagrams show that regression line alignment is important. However, in the regression distribution diagrams points show that the concentration of two different areas has the effect of decomposition. In the cluster analysis diagram which prepared according to the coefitic correlation coefficients of the elements 3 distinct groups were distinguished (Figure 2).

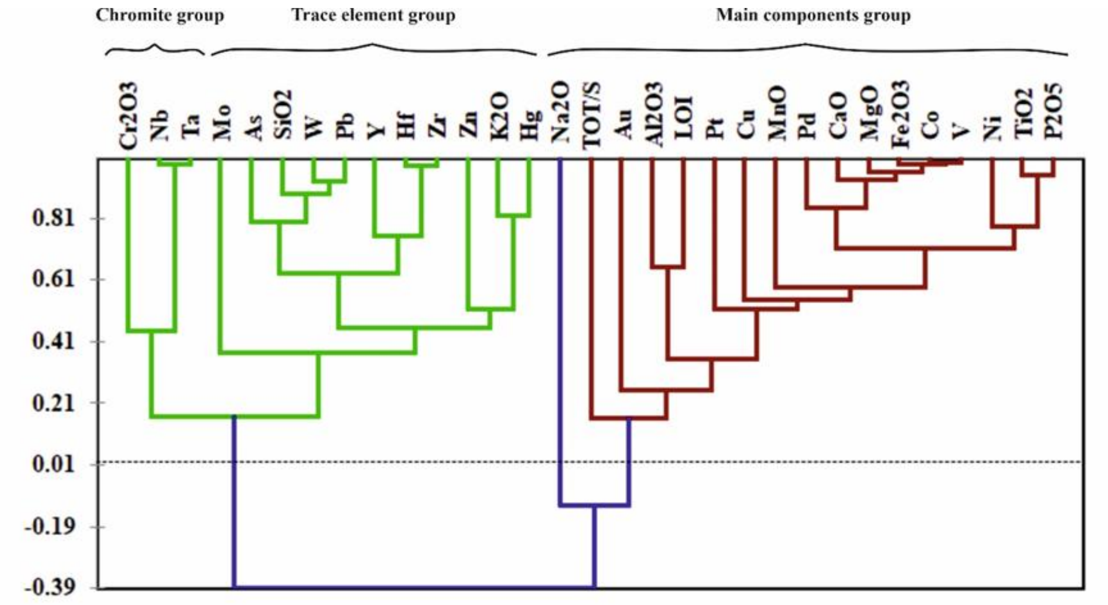

Figure 2. Proximity sequence (dendogram/hierarchical clustering) according to coefitic correlation coefficients of main oxides and trace elements analyzed in samples collected from rocks belonging to Bozkır ophiolitic mélange.

Correlation relations and cluster analysis generally show that the main oxides in basic ultrabasic rocks and trace elements come from different sources from the beginning. Besides, the addition of the group of traces by the Chromite Group together with the alteration of the ultrabasic rocks and silicification of the trace elements to the environment / enrichment shows.

Placer Geochemistry

Placers are the junction of heavy and clastic minerals by gravity and the process of change of chemical and physical properties [33]. Placers are very important in geological studies and samples compiled from stream sediment samples are used to find anomaly related to bedrock geochemistry [34]. The concept of environmental geochemistry is studied in a wide area from salts [35] to heavy metal accumulation [36-37] and placer geochemistry [38] is also important for environmental safety [39-40].

Main oxide and trace elements geochemistry of Bozkır Region

In the placer samples collected from the study area, main oxide and trace element analyzes were performed (Table 2).

Table 2. Main elemental analyzes of placers belonging to the Bozkır ophiolitic melange and statistical summaries (S.N.: Sample numbers, A.A.: Arithmetic average, Std.D.: Standard deviation)

S.N.		BP1	BP2	BP3	BP4	BP5	BP6	A.A.	Std. D.
SiO_2	%	45.58	45.73	64.65	44.86	48.36	47.87	49.51	7.54
Al_2O_3	%	18.72	11.78	13.62	13.31	13.71	15.01	14.36	2.37
Fe_2O_3	%	10.31	11.25	6.52	10.84	10.35	11.81	10.18	1.88
MgO	%	4.16	8.57	1.04	7.64	6.87	5.88	5.69	2.74
CaO	%	3.87	11.92	0.94	9.89	7.85	5.36	6.64	4.04
Na_2O	%	2.06	1.18	3.40	1.43	1.87	2.65	2.10	0.82
K_2O	%	1.05	0.92	3.63	1.05	1.17	0.80	1.44	1.08
TiO_2	%	0.41	0.99	0.66	0.95	0.97	0.51	0.75	0.26
P_2O_5	%	0.04	0.15	0.16	0.16	0.17	0.07	0.13	0.06
MnO	%	0.27	0.22	0.21	0.22	0.21	0.31	0.24	0.04
Cr_2O_3	%	0.01	0.05	0.01	0.04	0.04	0.03	0.03	0.02
LOI	%	13.20	7.00	5.00	9.30	8.20	9.50	8.70	2.76
TOT/C	%	0.14	0.11	0.12	0.54	0.46	0.41	0.30	0.19
Au	**ppm**	0.003	0.002	0.002	0.005	0.003	0.005	0.003	0.001
Pt	**ppm**	0.005	0.009	0.003	0.007	0.005	0.003	0.005	0.002
Pd	**ppm**	0.002	0.007	0.002	0.013	0.007	0.009	0.007	0.004
Co	**ppm**	33.30	43.00	11.70	46.10	44.70	43.50	37.05	13.22
Hf	**ppm**	1.00	2.20	4.70	2.40	2.80	1.60	2.45	1.27
Nb	**ppm**	3.50	5.70	7.70	8.00	9.20	4.70	6.47	2.18
Ta	**ppm**	0.30	0.30	0.50	0.40	0.50	0.30	0.38	0.10
V	**ppm**	225.00	330.00	59.00	299.00	313.00	307.00	255.50	102.90
W	**ppm**	0.50	0.50	2.90	0.50	0.50	0.70	0.93	0.97
Zr	**ppm**	32.20	68.80	160.90	86.80	107.20	69.90	87.63	43.57
Y	**ppm**	10.20	17.10	29.50	18.00	21.80	14.10	18.45	6.67
Mo	**ppm**	0.20	0.30	1.00	0.60	0.70	0.50	0.55	0.29
Cu	**ppm**	78.20	102.80	61.50	110.80	92.20	104.90	91.73	18.74
Pb	**ppm**	6.40	13.80	10.10	39.10	5.70	13.50	14.77	12.40
Zn	**ppm**	90.00	235.00	117.00	458.00	68.00	92.00	176.67	150.07
Ni	**ppm**	8.80	23.00	9.90	32.60	23.60	22.70	20.10	9.11
As	**ppm**	7.10	3.10	32.20	5.60	3.90	9.20	10.18	11.01
Hg	**ppm**	0.01	0.02	0.03	0.07	0.02	0.02	0.03	0.02

In order to interpret the geochemical events in the placers in the study area correlation and regression analyzes of 31 components were performed. In order to determine the correlations of the components in the placers correlation analyzes were performed and these results were obtained: **SiO_2**; very strong negative with Fe_2O_3, Co and V and very strong positive with Hf, W, Zr, As, K_2O. **Fe_2O_3**; very strong negative with K_2O, W, As and very strong positive with Cu, Co and V. **MgO**; very strong positive with CaO, Cr_2O_3, Co, V and Cu; very strong negative with Na_2O and As. **CaO** very strong positive with Cr_2O_3 and Pt; very strong negative with Na_2O. **TiO_2**; very strong positive with P_2O_3 and Cr_2O_3. **Pd**; very strong positive with Cu and Ni. **Co**; very strong positive V and Cu; very strong negative with W and As. **Hf**; very strong positive with W, Zr, Y and Mo. **Nb** very strong positive with Ta; **W** with As and **Pb** with Zn and Hg. **V**, very strong negative with W and Au.; very strong positive with Cu. Simple regression analyzes were applied to the components which had a very strong correlation to reveal the significance of the correlation determined between the components. Cr_2O_3-TiO_2, As-Co, Cu-Pd, Zn-Pb are very strong correlation coefficients in placers, simple regression analyzes of components and regression distribution diagrams are important for the regression line. In the cluster analysis diagram (dendrogram) was prepared according to the coefitic correlation coefficients of the elements analyzed, 7 distinct groups were distinguished (Figure 3).

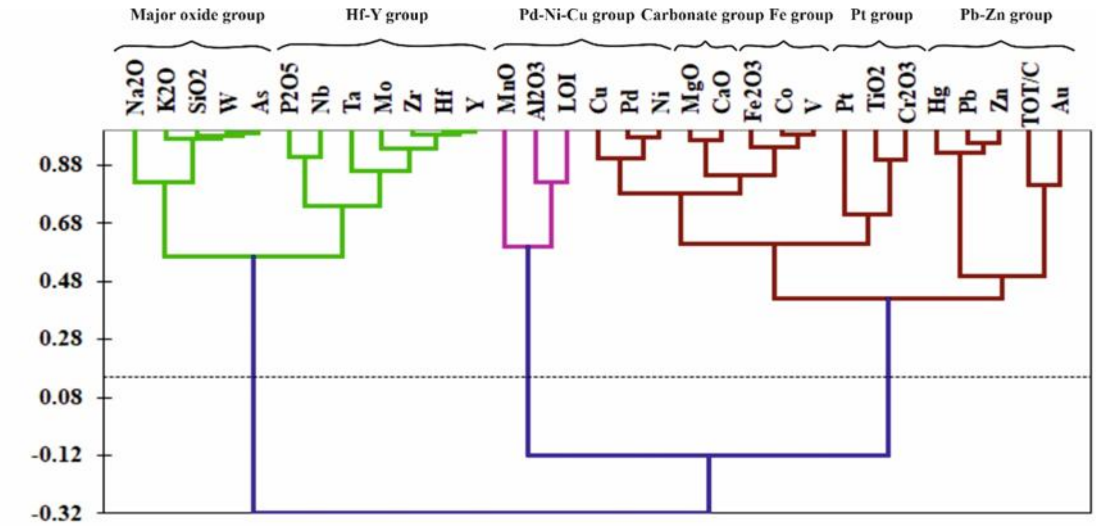

Figure 3. Proximity sequence (dendrogram) according to coefitic correlation coefficients of samples collected from the placers of the Bozkır ophiolitic melange

When the correlation relations and cluster analyzes are examined, it is seen that more than one source of abrasion and transport are different from different source rocks and levels (basic, ultrabasic and silicified levels).

Vertical Electrical Drilling (VED) Studies

In the geophysical study in the region of Bozkır (Konya), the Schlumberger electrode array was used (Figure 4; 5; 6).

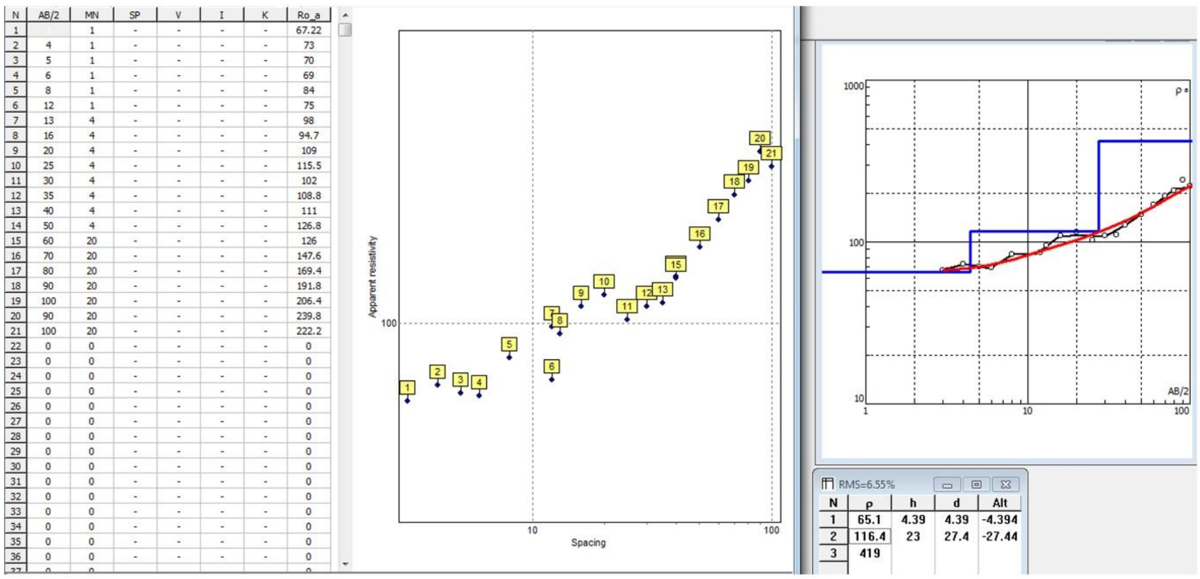

Figure 4. Resistivity measurement values and resistivity (ρ), layer thickness (h), depths values from surface to layer (d) in 1st Region

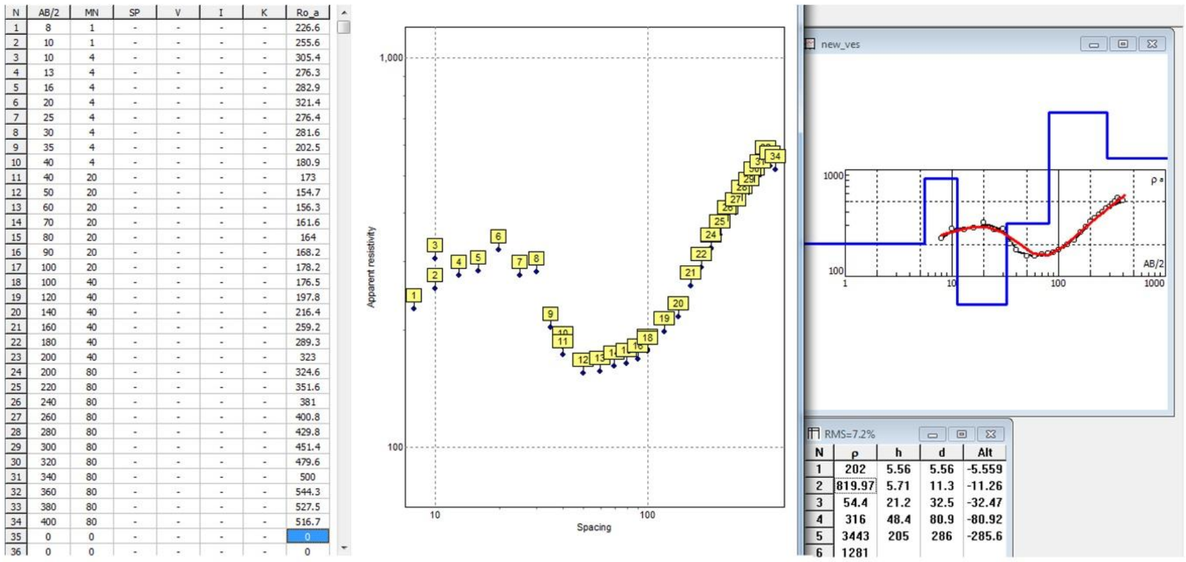

Figure 5. Resistivity measurement values and resistivity (ρ), layer thickness (h), depths values from surface to layer (d) in 2st Region

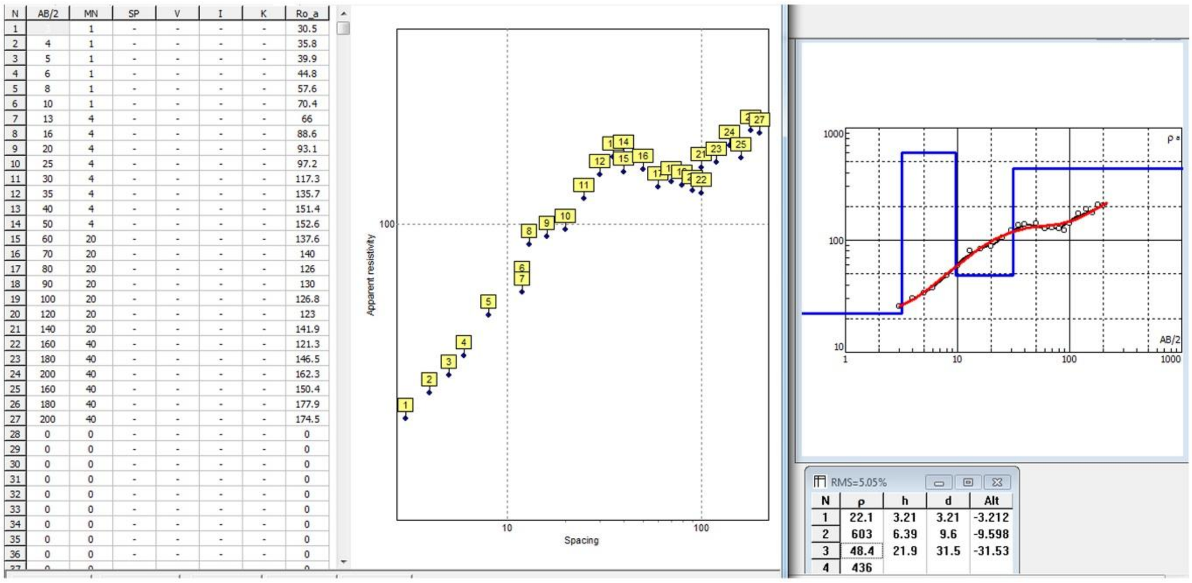

Figure 6. Resistivity measurement values and resistivity (ρ), layer thickness (h), depths values from surface to layer (d) in 3st Region

The distance between the current and voltage electrodes was increased systematically and Vertical Electric Drilling (VED) was applied in three different regions and the data were recorded with 95% accuracy (Table 3). The apparent resistivity values obtained from the measurements were multiplied by the geometric factor to obtain the resistivity values.

Table 3. Vertical Electric Drilling (VED) application in 1st Region, 2nd Region and 3rd Region

Measurement Zone	Expansion	Layer Thickness	Depts of Layer	Resistivity Value	Geological Unit
		4.39 m	4.39 m	65.1 Ω	Separated cover layer
1st Region	100 m	23.00 m	27.4 m	116.4 Ω	Siliceous altered gabbro
		-	-	419.0 Ω	Gabbro
		5.56 m	5.56 m	202.00 Ω	Separated/Altered Gabbro
		5.71 m	11.71 m	819.97 Ω	Gabbro
2nd Region	400 m	21.20 m	32.50 m	54.40 Ω	Metallic level
		48.40 m	80.90 m	316.00 Ω	Serpentinite
		205.00 m	286.00 m	3443.00 Ω	Dunite -Harzburgite

		-	-	1281.00 Ω	Dunite –Harzburgite-Gabbro (?)
		3.21 m	3.21 m	22.10 Ω	Separated cover layer
3rd Region	200 m	6.39 m	9.60 m	603.00 Ω	Spillites
		21.90 m	31.50 m	48.40 Ω	Metallic level
		-	-	436.00 Ω	Serpentinite

Because of showing different lithological characteristics of the ophiolitic rocks at short distances, geological and geochemical studies as well as geophysical (resistivity) studies were needed in the study area and geophysical studies were carried out for the first time in this study and supported by geological and geochemical data. As a result of the data obtained, it is also seen that the region is important for chromium, iron, copper and precious metals. General geology, geochemical (rock and placer chemical analysis) and resistivity studies performed in the Bozkır region and according to the rock and placer analyzes performed near the Bozkır-1 region BK6 rock sample which have high SiO_2 ratio includes those elements; Pb (22.2 ppm), Zn (109 ppm), As (20.50 ppm) and in the BK7 rock sample, Pb (25.2 ppm), Zn (130 ppm), As (30.8 ppm) and BP3 in placer sample includes those elements; Cu (61.5 ppm), Pb (10.1 ppm), Zn (117 ppm) and the presence of Kızıltepe volcanic which are close to the region with gabbro level which is deeper than 27.4 m and obtained from 4.39 m-27.4 m silage altered gabbro obtained in Vertical Electric Drilling (VED) application shows that a mineral of hydrothermal origin is possible in the region. In addition, high Au (14 ppm) value was determined in this region [16]. Therefore, it is important in terms of metal enrichment of the silicic zones determined by geophysical measurements. As a result of the field observations in the study area, two different types of silicification (silicified shell and listwanitization) were distinguished by alterations. The silicified crustal formation (Bozkır ophiolitic melange) is developed in a way that alters the original textures of all the rocks belonging to the ophiolitic melange, but is observed more intensely in the uppermost part of the melange. On the silicified cover rocks (cap-rocks), which are very common on the melange [41] carried out a study and they were defined as the cementing of the basaltic formations in active hydrothermal areas with silica and covering the rocks as a totally silicified shell, [42] describes silicification as the mostly represented by amorphous silica and chalcedony, bearing barite traces as well as rare ore minerals such as pyrite, sphalerite and chalcopyrite, whose formation temperature varies between 85-110 ° C.

Vertical Electric Drilling application in the Bozkır-2 region has a low resistivity-high conductivity (metallic property) level from 11.71 m to 11.71 m and a high conductivity at 11.71 - 32.50 m. According to the results BK2, BK3, BK5 rock samples Fe_2O_3 (11.61%), TiO2 (1.6%), Cr_2O_3 (0.02%), Au (0.009 ppm), Pt (0.008 ppm), Pd (0.008 ppm), Cu (96.3 ppm) and approximately the same properties as Fe_2O_3 (11.25%), TiO_2 (0.99%), Cr_2O_3 (0.05%), Au (0.002 ppm), Pt (0.009 ppm), According to the values obtained from this metallic level is thought to be a magnetite level with high iron content of Au-Pt-Pd-Ti-Cu due to the low chromite value. In DES application in Bozkır-3 region, there are decomposed/altered spilites up to 9.60 m and range of 9.60-31.50 m low resistivity-high conductivity (metallic properties) spilites with magnetite content. According to the results of rock and placer chemical analysis in this region,BK8 rock sample includes; Fe_2O_3 (10.80%), TiO_2 (1.07%), Cr_2O_3 (0.03%), Au (0.002 ppm), Pt (0.007 ppm), Pd (0.007 ppm) Cu (213.7 ppm) and showing approximately the same properties BK12, BK15, BK16, BK17 rock samples and BP1 include Fe_2O_3 (10.31%), TiO2 (0.41%), BP_2O_3 (0.01%), Au (0.003 ppm), Pd (0.002 ppm), Cu (78.2 ppm) According these results it is believed to be a magnetite level with Au-Pt-Pd-Ti-Cu content. In the study area, the second group silicified formations which contain ore minerals are the listvenites. They fill the cracks, slits and even small fractures of the rock which developed in narrower areas than the primary ones, especially in the serpentinite and spilites. However, it was not possible to obtain sufficient data about how deeply these formations were observed as small outcrops. In the examinations carried out on the scale and hand sample scale of said silicified formations, they are thought to be related to hydrothermal-derived solutions, rather than as superficial weathering products. Probably these formations were developed due to the volcanic activities after the ophiolitic units settled in the area. A similar study was carried out at the upper levels of ophiolitic rocks in the Hatip-Çayırbağı (Konya) region with a fractured, silicium-rich (listvenit) formation at the bottom with a metallic content and serpentinite at the bottom. Level (chromite) formation is stated to be found [43]. Additionally, the listvenites contain serpentinite, rock fragments, chromite residues, pyrite, chalcopyrite, barite, rutile and monazite minerals and Au, Sb, Cu, Ni, Co ore elements [44-52].

High resistivity bands were observed in the silicified level. These band levels are considered to be not fully silicified serpentinites. Siliceous minerals are generally much more conductive than other rocks due to their high surface conductivity. Therefore, as the depth increased in this region, an increase in resistivity values was observed.

The data are similar to the formations observed in the Ural / Alaska complex and called four different types (tetraauricuprite; Au – Ag mixture; Au – Ag – Pd – Cu mixture and Au – Pd – Cu mixture) [53-55]. Shcheka and Lehmann [55] interpreted these formations as the Au-Pd-Cu-Ag mixture into salty liquids as Pt-Fe mixture crystals through late magmatic hydrothermal processes. In addition, similar studies on this subject [56-57], PGM in the oxide and silicate inclusions Os- (Ir-Ru) mixture, mostly Ru-Os-Ir-Pt- Fe mixtures are expressed as being present. These formations can be evaluated within the scope of liquidation and depending on this mechanism, Os, Ir and Ru are precipitated together with pyrrhotite in MSS (Monosulfide Solid Solution); it can be said that Pt, Au and Ag crystallize together with chalcopyrite in ISS. In the cluster analysis using the chemical analysis results obtained from the rocks collected from the region, the addition of Au, Pt, group of Fe_2O_3 and Cu components in the same group formed their own minerals of Cu and Fe_2O_3, namely chalcopyrite and pyrrhotine. Show that they are into these minerals as alloy. Furthermore, factor analysis showed that Cu, Au, Ag and Pt had a positive charge at factor 2; indicating that ISS (Intermediate Solid Solution) phase had occurred and significant ratio Au and Pt enrichments were observed.

Since Au and PGM minerals are more intense than other metals, they cannot be moved very far from the main source and they cannot be altered very quickly. Patyk-Kara [58] attributed placer formation processes to endogenous (topographic structures, faults and tectonic structures) and exogenous (superficial decomposition) events. In many studies on this subject [59-62], placental formations develop in tropical, humid-temperate regions due to stream regime and high chemical decomposition, and are mainly due to barriers [63-64] or thresholds [65] are expressed that they can accumulate. The prevalence, the size and the density of the grains forming the placers in the source rock are important elements in placer formation. Placing and precipitation of placer minerals in the presence of topography and climatic factors is possible to reach economic dimensions. All these issues will affect the transport distances from the source rock. In chemical analysis and petrographic studies in placer in the study area, heavy and precious metals are generally concentrated around the source rock and the concentration of these metals decreases as they move away from ophiolitic rocks.

CONCLUSION

In the study area, serpentinization and shell-shaped silicified (listwanite) formations have been identified along with the widespread alteration and it is thought that the region is important for iron and chrome according to the results obtained from rocks. In the geological, geochemical and resistivity studies conducted in the region, a silicified zone of hydrothermal origin (14 ppm Au) and a level of magnetite which includes Au-Pt-Pd-Ti-Cu was determined. Therefore, a detailed study should be carried out in the Bozkır region in the vicinity of gabbro / diabase and split formations with hydrothermal origin (listwanite), using more detailed rock and placer sampling and geophysical methods together with resistivity, magnetic and gravimetric methods. In addition, all these works should be controlled by drilling and splitting and the determined anomalies should be confirmed.

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