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ECONOMIC GEOLOGY, PETROLOGY AND ENVIRONMENTAL GEOLOGY OF COPPER ORE DEPOSITS OF CHAGHO IN SOUTH WEST KARAJ

GEOLOGIA ECONÔMICA, PETROLOGIA E GEOLOGIA AMBIENTAL DOS DEPÓSITOS MINERAIS DE COBRE DE CHAGHO NO SUDOESTE DE KARAJ

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ABSTRACT

The mineral zone under study is 32 square kilometers located in Chagho village, Akhtarabad village, Malard county, Shahriar city, Tehran province. This area is part of the Urumieh-Dokhtar Volcanic Belt. The age of the studied rocks is related to the Eocene and younger than the Eocene. The downward trend of some oxides of major elements such as MgO, CaO and AL2O3 and the increasing trend of K2O and Na2O over SiO2 from the basaltic rocks to the intermediate-acidic rocks in rocks of the studied area are consistent with the magmatic subduction process. Based on standardized radar charts relative to chondrite of the rocks under study, enrichment of elements (LILE) such as Cs, Rb, Ba and light rare earth elements (LREE) relative to HFS elements (Ti, Nb) and heavy rare earth elements (HREE) (Y, Yb, Lu) is shown. In all of the rocks mentioned above, the element u is enriched relative to the primary mantle. The positive anomaly of this element may indicate contamination of their constituent melts with the upper crust. In all studied rocks, HFS elements such as Ti, Nb show depletion and concave pattern. The depletion of the aforementioned elements to the primary mantle may be attributed to the contamination of the melts with lower and upper crustal or possibly

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the dependence of the melts constituting these rocks on the geodynamic environments of subduction of Neo-Tethyan. According to the study of fluids involved in the region, the temperature of homogenization with the temperature of formation of copper veins is between 120 and 306 ° C, and the salinity percentage varies from 6.45 to 15.96 wt% of sodium chloride. Accordingly, this ore deposit is classified as mesothermal and is a type of hydrothermal allogenic deposits, the presence of sub-faults and seams and gaps in the host rock as a low-pressure environment has provided a suitable site for vein-type mineralization.

KEYWORDS: ECONOMIC GEOLOGY, PETROLOGY, ENVIRONMENTAL GEOLOGY, COPPER ORE DEPOSIT

RESUMO

A zona mineral em estudo é de 32 quilômetros quadrados, localizada na vila de Chagho, vila de Akhtarabad, condado de Malard, cidade de Shahriar, província de Teerã. Esta área faz parte do Cinturão Vulcânico Urumieh-Dokhtar. A idade das rochas estudadas está relacionada ao Eoceno e é mais recente que o Eoceno. A tendência de queda de alguns óxidos de elementos principais como MgO, CaO e AL2O3 e a tendência de aumento de K2O e Na2O sobre SiO2 das rochas basálticas para as rochas intermediárias ácidas nas rochas da área estudada são consistentes com o processo de subducção magmática. Com base em gráficos de radar padronizados relativos ao condrito das rochas em estudo, enriquecimento de elementos (LILE), como Cs, Rb, Ba e elementos de terras raras leves (LREE) em relação a elementos HFS (Ti, Nb) e elementos de terras raras pesadas (HREE) (Y, Yb, Lu) é mostrado. Em todas as rochas mencionadas acima, o elemento u é enriquecido em relação ao manto primário. A anomalia positiva deste elemento pode indicar contaminação de seus fundidos constituintes com a crosta superior. Em todas as rochas estudadas, elementos HFS como Ti, Nb apresentam depleção e padrão côncavo. O esgotamento dos referidos elementos para o manto primário pode ser atribuído à contaminação dos derretimentos com crosta inferior e superior ou possivelmente à dependência dos derretimentos que constituem essas rochas dos ambientes geodinâmicos de subducção de Neo-Tethyan. De acordo com o estudo dos fluidos envolvidos na região, a temperatura de homogeneização com a temperatura de formação dos veios de cobre está entre 120 e 306 ° C, e o percentual de salinidade varia de 6,45 a 15,96% em peso de cloreto de sódio. Consequentemente, este depósito de minério é classificado como mesotérmico e é um tipo de depósito alogênico hidrotérmico, a presença de subfalhas e fendas e lacunas na rocha hospedeira como um ambiente de baixa pressão proporcionou um local adequado para mineralização do tipo veios.

PALAVRAS-CHAVE: GEOLOGIA ECONÔMICA, PETROLOGIA, GEOLOGIA AMBIENTAL, DEPÓSITO DE MINÉRIO DE COBRE

INTRODUCTION

The Earth's crust is an important source of all minerals human need. And it is natural that an understanding of the principles and rules governing the formation of mineral reserves is essential for optimal exploitation of these infinite deposits. Geologists and mine experts have a heavy duty for human use of the mineral resources of the Earth's crust.

Therefore, it is essential for mankind to know the earth and its blessings. Geology is the guiding light of the people of a country towards many of the riches of their country and that is why it is so important. It is the knowledge of how to form, identify the type, origin and find reserves and exploit them in appropriate ways (Ahmadi and Sheykhi, 2019). And all minerals experts consider exploration as the keystone of mineral activities and through accurate exploration one can well understand the quantity and quality of minerals under investigation and make the right decision whether the reserves are economical to continue mining and related investments. The present study is part of the thousands of work that can be done in the field of economic geology. In this study, mineral traces, exploration and exploitation of copper in the Chagho region are investigated (Baratian *et. al.*, 2018, Yazdi *et. al.* 2017, 2019).

PROBLEM STATEMENT

Chagho Copper Mine is located 70 kilometers west of Tehran and 36 kilometers southwest of Karaj (Figure 1). This area is about 32 square kilometers, with geographical coordinates ranging from 50° 38' to 50° 42' east longitude and 35° 36' to 35° 39' north latitude. This area ranges from north to Mahdasht (Mardabad) to Eshtehard Road. In other words, this mineral potential is 23 km southwest of Mahdasht (Mardabad) and 35 km southeast of Eshtehard.

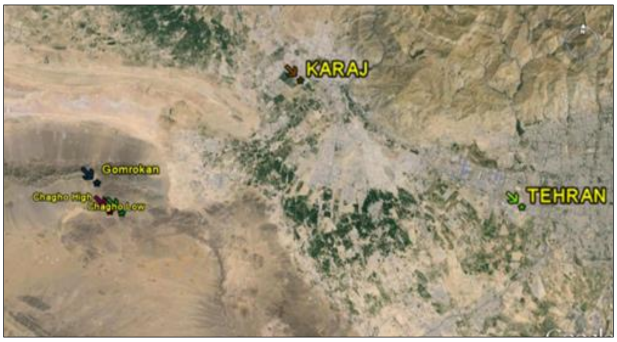

Figure 1. Satellite image of Tehran, Karaj and Chagho.
Fonte: Google Earth© (2021)

Investigating the area in terms of economy, mineral controller indices based on field data and observations and perceptions, and investigating structural factors tectonically, physicochemical factors, investigating fluid inclusion, investigating mechanisms of transport and deposition of minerals such as the origin of copper and gold and other precious elements, as well as investigating the area in terms of economic potential for copper production, determining the origin of minerals for exploration of similar minerals, identifying lithological factors or lithological and structural studies, Determining magmatic origin, collecting and determining the samples of polished sections, double polished sections and thin sections, geochemical sampling of units, collection and preparation and analysis of rock data, presenting geochemical diagrams of rock units, data processing of aerial photos and satellite photos in terms of type of rocks and other complications in the area, as well as in terms of environmental and medical geology, studying the type and elements of water, soil and constituent plants in the area (Nazemi *et. al.* 2019, Zadmehr 2019, Baratian *et. al.* 2020). Therefore, investigations on structural controlling factors, identification of elements and mineralization are not possible without field operations and their confirmation with laboratory data.

The average rainfall in the area is 115 mm / year. The hottest month in this region is July with an average temperature of 33 ° C and the coldest month of the year is January, with an average temperature of -12 ° C. The climate of the region is affected by the northwest, west and southwest systems in cold seasons. Vegetation in this area includes *Pennyroyal, Alhagi maurorum, Astragalus aziziana, Rhamnus, Alfalfa, Descurainia sophia, Acanthophyllum, Tragopogon dubius, Althaea hirsuta, Glycyrrhiza glabra, Rhaponticum repens, Artemisia, Iris reticulata, Papaveraceae, Thymus trantventteri, Sonchus arvensis, Celtis sp., Tamarix and Cirsium vulgare*.

The area under investigation follows the trend of Jaroo Mountains with a height of 2013 m and Kordha Mountains (Kordlardaghi) with a height of 1792 m and the northern highlands of the region. The area is generally a nearly flat area, most of which is covered by plain or lowland areas. The highest elevation in Mount Jaroo is 2013 meters above sea level, and the lowest elevation is near the SHoor River at approximately 1013 meters above sea level. The area under study, however, has relatively mild topography, which is rougher to the north and to Jatoo Mountains of 2013 meters and to Kordha (Lardaghi) or Kordan Mountains of 1792 meters.

The purpose of this dissertation is to identify key factors and indicators in economic geology, petrology and environmental geology.

Investigating the area in terms of economy, mineral controller indices based on field data and observations and perceptions, and investigating structural factors tectonically, physicochemical factors, investigating fluid inclusion, investigating mechanisms of transport and deposition of minerals such as the origin of copper and gold and other precious elements, as well as investigating the area in terms of economic potential for copper production, determining the origin of minerals for exploration of similar minerals, identifying lithological factors or lithological and structural studies, Determining magmatic origin, collecting and determining the samples of polished sections, double polished sections and thin sections, geochemical sampling of units, collection and preparation and analysis of rock data, presenting geochemical diagrams of rock units, data processing of aerial photos and satellite photos in terms of type of rocks and other complications in the area, as well as in terms of environmental and medical geology, studying the type and elements of water, soil and constituent plants in the area (Novruzov *et. al.* 2019).

Therefore, investigations on structural controlling factors, identification of elements and mineralization are not possible without field operations and their confirmation with laboratory data. Initial data gathering, including office and library studies as well as satellite photos of the area, including Google Earth satellite images, spot satellite image with a scale of 1: 25000 from the National Cartographic Center in 2005, IRS satellite image with a scale of 1: 50000 in 2005, from the National Cartographic Center and LANSAT-ETM satellite image in 2001 from Iranian Space Agency

Also providing aerial photo with a scale of 1: 30000 (in 1988) and aerial photo with a scale of 1: 40000 (in 1999) from the National Cartographic Center, aerial photo with a scale of 1: 55000 (in 1955), of Chagho area from Geographic organization of the armed forces. Data collection and analysis are related to analyses of rocks and minerals and biomaterials.

Due to the high economic importance of the elements, especially copper in some parts of Iran, it is necessary to discover more unknown areas of copper in the country than ever before. In this regard, the study of copper ore deposits and minerals in the area is important both scientifically and economically (Abdoli Sereshgi *et. al.*, 2019). Examination of previously dug bores, wells and trenches, to determine the length, thickness and depth and length of the mineral that previously dug bores, wells and trenches available at the site were used for the studies.

Samples were collected from different parts such as wells, bores and trenches, especially minerals associated with mineralization and mineral veins, with 65 samples taken along with photography and field operations. Samples were taken from different lithologies and sent to the laboratory for various tests such as preparation of thin sections and etc.

Study of existing alterations such as:

A) Determination and severity of the types of existing alterations and separation of their zoning from each other.

B) Detailed mineralogical examination of the alterations with justified explanations for the presence of index minerals in each zone.

Mineralization in the mineral potential of Chagho is as follows: first the quartzite and hematite parts of veins have been formed, followed by sulfide mineralization inside or with the silica. Therefore, fluid inclusion in quartzes of the vein silica can indicate formation conditions and physicochemical properties of it. Therefore, double polished samples of the quartzes have been prepared and their fluid inclusions have been studied.

Preparation and collection of samples of each plant, soil and water from the northern and southern parts of the Chagho area are for analysis of their elements and analysis of each data in order to obtain environmental results in terms of contamination rate of each plant, water and soil or biological resources. Measuring and determining each of the parameters of temperature and humidity for the soil and climate of the region and their effects on the animal and plant environment. Investigating the extent of the destruction of natural landscapes by mining, which destroys vegetation and the natural face of the earth, and furthermore, the holes and spaces caused by mining make the environment ugly and unpleasant.

Since the Chagho area has a mining background and there are numerous and varied mineral indexes around the area. And in terms of specific lithological features as well as existence of alteration zones and valuable mineral resources such as copper and gold, which increases the importance of studying this area.

In 1959, the National Iranian Oil Company (NIOC) published a report, titled North Area of Saveh, prepared by Soder. This report contains a stratigraphic, tectonic, lithological, paleontological study and a map at 1: 250,000 scale and a seven-page map at 1: 100,000 scale and an index map at 1: 500,000 scale are attached to this report. Geochemical exploration studies of sheet 1: 100,000 of Karaj in Tehran Province Industries and Mines Organization conducted by Tehran Padir Consulting Engineers in 2006. The area under study in the investigations made due to mineralized and heavy mineral samples along with geochemical anomalies, a suitable region for exploration of copper and paragenesis elements has been introduced. In 2014, Shojaei Baghini presented a research on the petrology and geochemistry of volcanic rocks in the Jaroo area with an emphasis on copper and iron mineralization by the Research Institute for Earth Sciences and Geological Survey & Mineral Explorations of Iran. Report of mineral exploration phases in the Chagho area were carried out by Rahpooyan Engineers Company in 2015.

FINDINGS

In this area, magmatic rocks include plutonic (including granite, quartz syenite, quartz monzonite) and volcanic (including rhyolite, quartz, trachyandesite, trachyandesite,

andesite, trachyandesite alkali basalt basalt, trachybasalt, basalt and olivine basalt). Chagho copper ore deposit is located in southwest of Karaj in Tehran province. The deposit is near the village of Chagho and consists of two mineral sites, one in the northeast and the other in the south. The geological units of the area are: andesite, trachyandesite, trachy basalt of Eocene age.

Mineral paragenesis in the northeast part of the Chagho ore deposit consists of pyrite, chalcopyrite, boronite, malachite, azorite and in the southern part consists of chalcopyrite, malachite and azorite. The vein type mineralization in this area originates from ore-bearing fluids that are the result of post-magmatic activity of a sub-volcanic mass. The intrusive mass in this deposit is quartz-porphyry, and has intruded into the Eocene volcanic rocks and created mineralization. According to the lithostratigraphic position, the replacement and intrusion of the sub-volcanic mass may be related to the Pyrenees orogenic phase, which occurred between the Late Eocene to the Early Oligocene. The homogenization temperature range of the copper veins varies between 123 and 319 ° C, the percentage of fluid salinity ranges from 15.7 to 17.2 wt% of sodium chloride equivalent percentage.

Depth of ore bearing solution with respect to static surface is between 40 and 1100 m and pressure applied to fluid is 10.6 to 291 bar, respectively. Accordingly, the ore deposit is classified as mesothermal. Generally, the mineralization in this region is of mesothermal type, which in higher horizons is associated with oxide and supergene mineral productions due to surface events.

Mardabad-Buin Zahra volcanic-intrusive belt in 60 km southwest of Karaj hosts numerous signs and abandoned mines of base and precious metals. Jaroo polymetallic ore deposits of the Middle Eocene – Oligocene age occurred in the eastern part of the belt in the classical volcano and subvolcanic shear host rock with acidic to basaltic composition and calc-alkaline to alkaline nature. The mine is located at 35° 41' north latitude and 50° 33' 25' east longitude. The access route is via Karaj-Eshtehard Road and 50 kilometers west of Karaj Jaroo Village. This area is a small part of the Urmia-Dokhtar area in terms of the sedimentary-structural divisions of the country and is metallurgically located in the western part of the Copper-Gold bearing zone of Saveh-Kashan, Nain, in which the intrusions of the granite and diorite masses have resulted in the formation of ore zones. The mine is located at an altitude of about 1,450 meters on the northern slope of Mount Jaroo. The main structure of the mountain is an anticline with an east-west axis.

Its rocks are mostly tuff, lava and early Tertiary sediments. The intrusions of porphyritic andesite dacitic masses have altered the tuffs and lavas, as well as intrusions of various diabase dykes have altered them, brown dacitic rocks along the east-west and south slope have several mineralization zones, one of which is large enough to have economic value. Mineralization with free (natural copper), sulfide (intrusive and extrusive), carbonate and oxy-hydroxy natures with vein-veinlet, shear, diffusion, succession, and open space filling texture and structure along with gangue minerals of quartz, calcite, barite and chlorite have been formed in the region. Siliceous, chloritic, propylitic, and sericitic alterations are common alterations in the region (Daya, 2019). The ore geochemical studies based on Spearman-Pearson rank matrix and factor experience indicate a significant relationship between element pairs of lead-zinc 0.8, lead-copper 7.0, gold-silver 0.6 and gold-copper 0.5 and two elemental groups including: lead, zinc, molybdenum and copper (factor 1) and copper, gold and silver (factor 2).

According to economic geological studies, and lithological and mineralogical evidence, texture and structure, and geochemical studies, Jaroo ore deposits are in the range of vein epithermal ore deposits of base (copper and lead-zinc) and precious (silver) metals with a high silver content of 200 ppm. Mineralization in this area is mainly of vein type and is done by filling in the spaces and is directly related to faults in the area. The main mineralization trend along the east-west is less than 1200 m in length and less than 200 m in width that the thickness of mineralization of vein thickness is 1 to 2 m. Mineralogically, the malachite and zorite minerals are found in the surface and the minerals of chalcopyrite, chalcocite, boronite, covolite in the deeper parts of the exploration area.

Analyzing the elements of rock index samples in north Chagho zone and southern Chagho zone by ICP-MS method:

To investigate and identify the minor elements by Inductively Coupled Plasma Mass Spectrometry (ICP-MS), 9 samples were selected (Table 1) from index samples of rocks in north Chagho zone and 6 from southern Chagho zone. These tests (ICP-MS) were carried out by the Zarazma Mineral Studies Company.

Number of sample	Name zone
R1-114	North Chagho zone
R1-117	
R1-119	
R1-125	
R1-127	
R3-301	
R3-302	
R5-100	
R5-103	
R2-205	Southern Chagho zone
R2-207	
R2-208	
R2-213	
R2-215	
R2-217	

Table 1. Rock Index Samples (ICP-MS Analysis).
Source: Authors (2021)

Conclusion of the comparison of the concentration of drinking water elements in two villages of north Chagho and south Chagho:

- In terms of concentration, elements such as silica (Si), magnesium (Mg), sodium (Na), phosphorus (P), sulfur (S), uranium (u) are higher in drinking water of the north Chagho village than in drinking water of the southern Chagho village. Chart (1-1) and Chart (1-2)
- In terms of concentration elements such as copper (Cu), silver (Ag), calcium (Ca), strontium (Sr), molybdenum (Mo), arsenic (As), barium (Ba), potassium (K), silver (Ag), Lead (Pb), zinc (Zn) and thallium (Th) are higher in drinking water of the

southern Chagho village than in drinking water of the north Chagho village. Chart (1-1) and Chart (1-2)

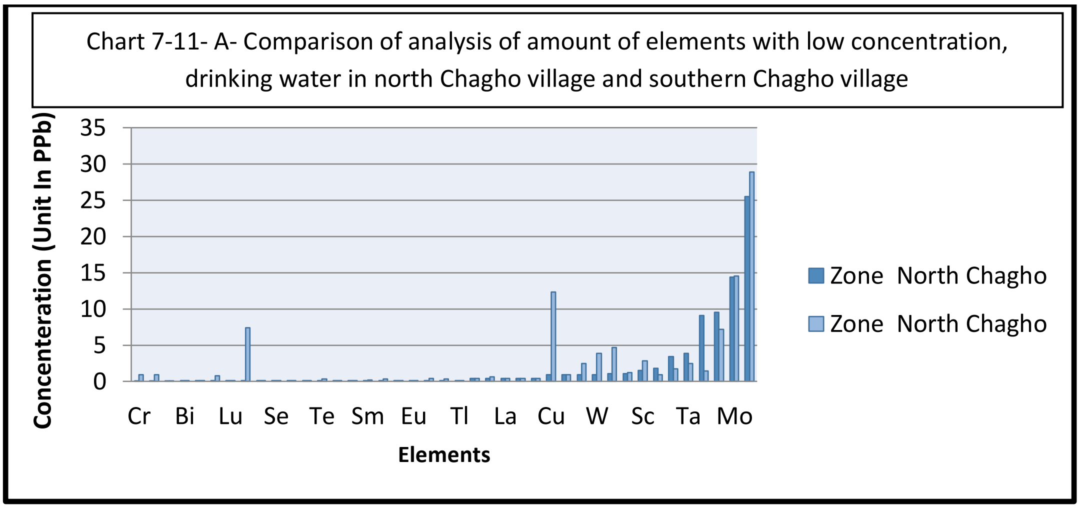

Chart 1
Source: Authors (2021)

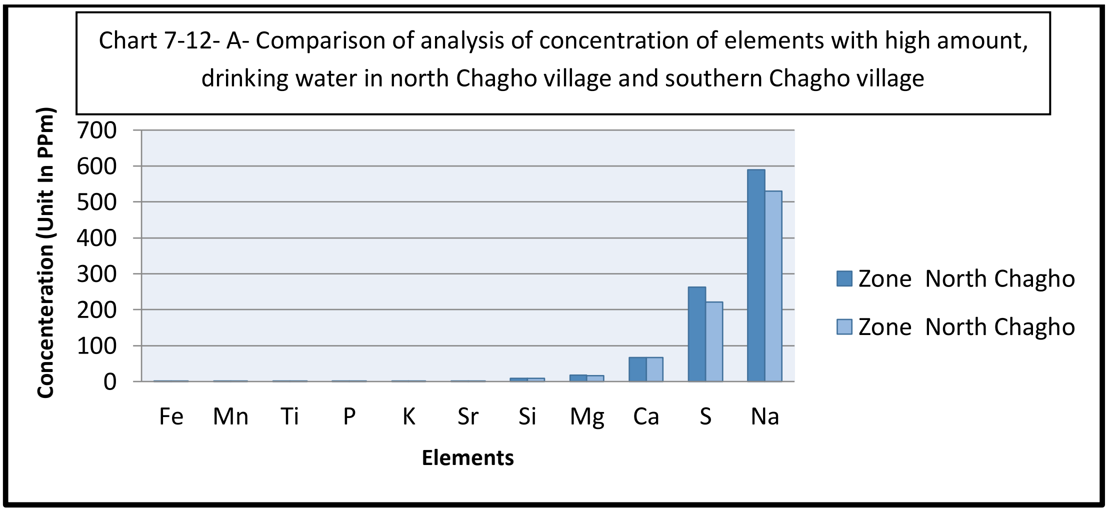

Chart 2
Source: Authors (2021)

Conclusion of the comparison of concentration of soil elements in two villages of north Chagho and south Chagho:

- Concentrations of elements such as copper (Cu), iron (Fe), calcium (Ca), potassium (K), Ti (titanium), P (phosphor), Pb (lead), bismuth (Bi), antimony (Sb), arsenic (As), sulfur (S), and nickel (Ni) were higher in the north Chagho zone than in the south Chagho zone. Concentrations of elements such as silver (Ag), aluminium (Al), magnesium (Mg), sodium (Na), manganese (Mn), cadmium (Cd), thorium (Th), zinc (Zn), uranium (u) and molybdenum (Mo) were higher in the southern Chagho zone than in the north Chagho zone.

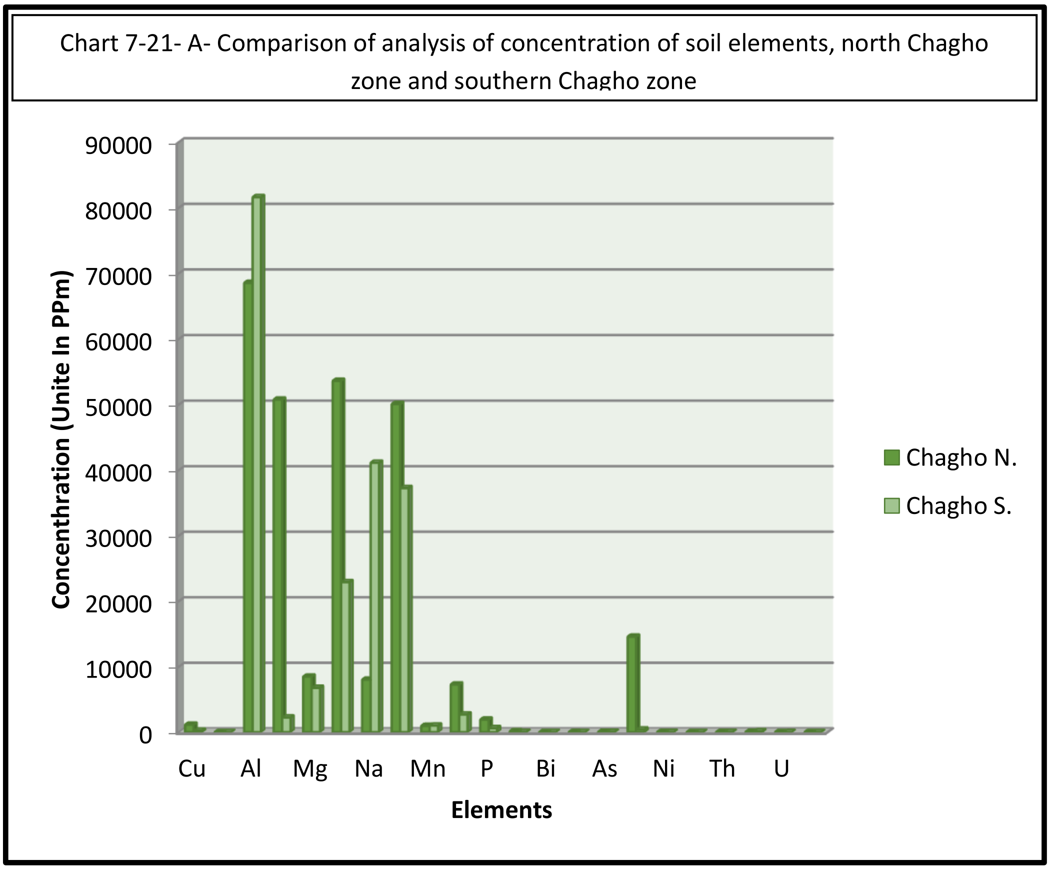

Chart 3
Source: Authors (2021)

Conclusion of the comparison of concentration of soil elements (rare earth elements) in north Chagho and southern Chagho zones:

- The concentration of REEs such as cerium (Ce), Neodymium (Nd), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), erbium (Er) in soil of the north Chagho zone is higher

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than in the southern Chagho region. (Chart 1-4) The concentration of REEs such as La lanthanum (La), praseodymium (Pr), dysprosium (Dy), thiolium (Tm), ytterbium (Yb) and luthium (Lu) in the southern Chagho zone is higher than in the north Chagho zone. (Chart 1-5) Also, the concentration of REEs such as yttrium (y), promethium (pm), holmium (Ho) is zero ppm in the north Chagho and southern Chagho zones. This indicates the absence of these elements in the soil of the two zones of north Chagho and southern Chagho. (Chart 1-6).

Chart 7-29- B- Comparison of analysis of amount of elements with high concentration, soil (rare earth elements) in north Chagho zone and southern Chagho zone

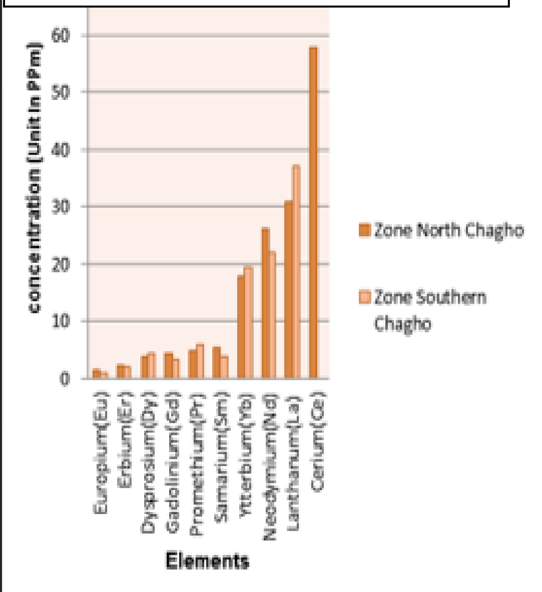

Chart 5

Chart 7-28- A- Comparison of analysis of amount of elements with low concentration, soil (rare earth elements) in north Chagho zone and southern Chagho zone

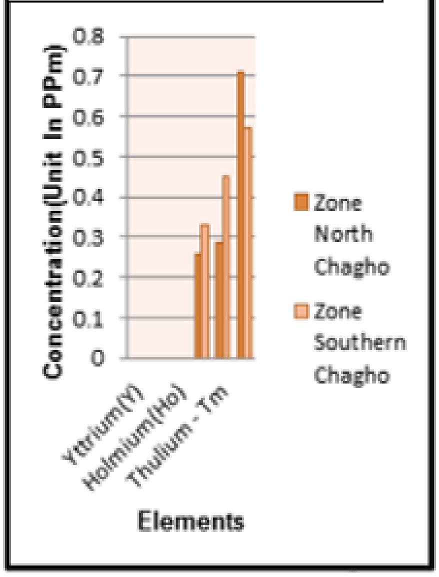

Chart 4

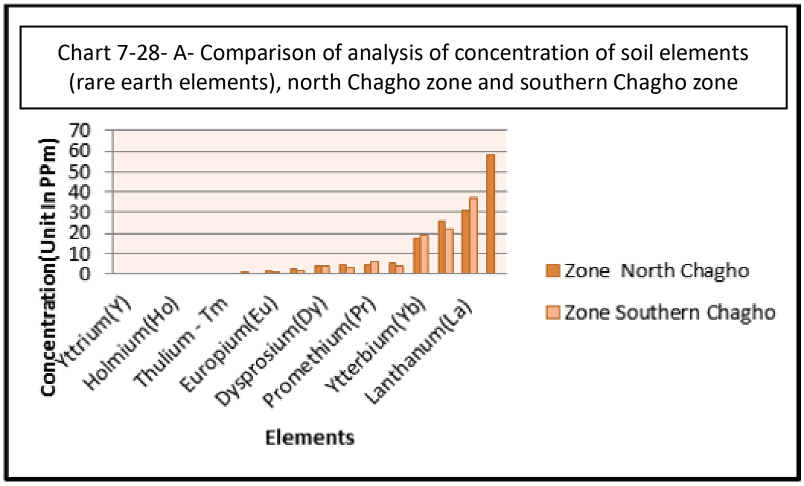

Chart 6
Source: Authors (2021)

Conclusion of the comparison of concentration of plant elements in two zones of north Chagho and southern Chagho:

- Concentrations of elements such as copper (Cu), potassium (K), lead (Pb), cadmium (Cd) and cerium (Ce) were higher in plants of the north Chagho zone than those of the southern Chagho zone. Chart (1-7) Concentrations of elements such as silver (Ag), aluminium (Al), iron (Fe), magnesium (Mg), calcium (Ca), sodium (Na), manganese (Mn), strontium (Sr), rubidium (Rb), bismuth (Bi), antimony (Sb), arsenic (As), sulfur (S), nickel (Ni), thallium (Th), uranium (u) and molybdenum (Mo) were higher in plants of the southern Chagho zone than those of the north Chagho zone. Chart (1-8) Concentrations of elements such as zirconium (Zr), tungsten (W) in plants of the two north Chagho and southern Chagho zones are equal. Chart (1-9)

Chart 7-40- A- Comparison of analysis of concentration of elements in plants (P1), (P2), north Chagho zone and southern Chagho zone

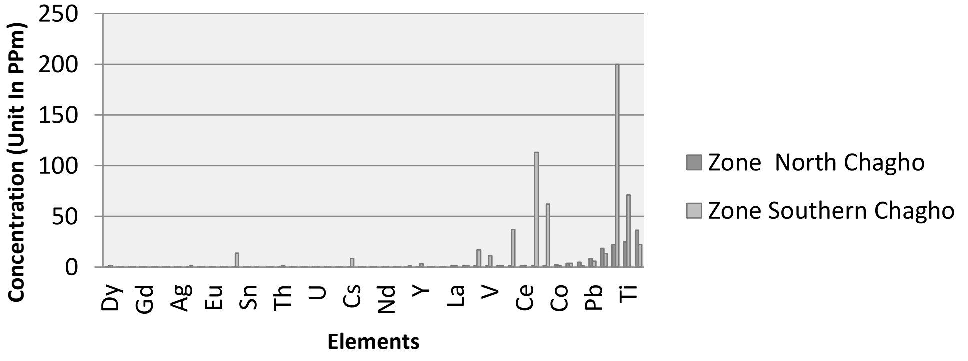

Chart 7
Source: Authors (2021)

Chart 7-41- B- Comparison of analysis of amount of elements with high concentration in plants (P1), (P2), north Chagho zone and southern Chagho zone

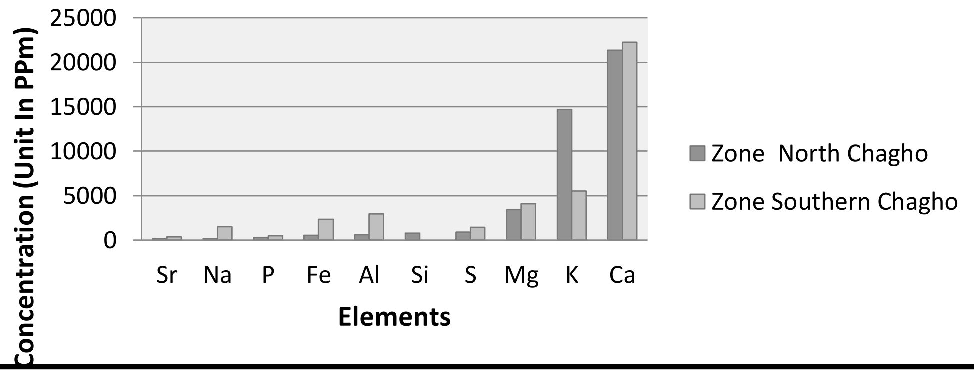

Chart 8
Source: Authors (2021)

Chart 7-42- C- Comparison of analysis of concentration of elements in plants (P1), (P2), north Chagho zone and southern Chagho zone

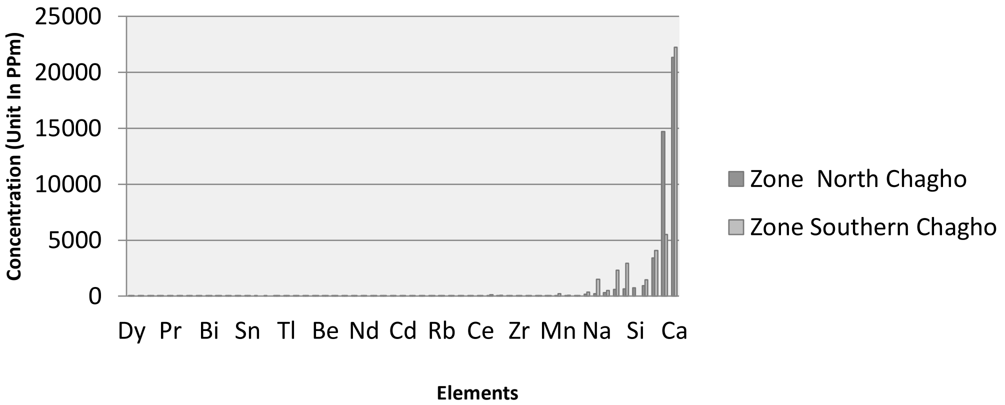

Chart 9
Source: Authors (2021)

CONCLUSION

1. The Chagho study area is part of the Urmia-Dokhtar Volcanic Belt, where the major copper mineralization in Iran is formed in this zone.
2. Minerals have been associated with tectonics in the area, and mineralization has taken place in the area of minor faults.
3. The ages of rocks in the Chagho area are Eocene and younger than Eocene. According to petrographic studies, the rock samples of the Chagho region were of the type of plutonic rocks and volcanic rocks.

The types of plutonic rocks in this region have granular texture and mineralogically they have minerals of plagioclase, quartz, orthose, chlorite, pyroxene, iron carbonate hydroxides and opaque minerals.

The types of volcanic rocks in this area have porphyritic textures and mineralogically they have minerals of plagioclase, quartz, amphibole, pyroxene, sericite, serpentine, olivine, phlogopite, albite, iron oxides and opaque minerals.

In terms of petrology, the studied volcanic rocks have lithic composition including: rhyolite, quartz trachyandesite, trachyandesite, andesite, trachyandesite basalt, alkali basalt, basalt and olivine basalt.

The studied plutonic rocks also have lithic composition including:

Granite, quartz syenite, and quartz monzonite which are consistent with their petrographic studies.

4. Mineralization is mainly in the form of filling space, accompanied by siliceous veins, and silicification is one of the most prominent alternations and markers of copper mineralization on the surface of the earth and the studied plutonic rocks are of meta-aluminum type.
5. The mineralization in the northern part of the Chagho region is sulfide and its main minerals are chalcopyrite CuFeS2 and chalcocite Cu2S and the mineralization in the southern part of the Chagho area is oxide and its minerals are malachite Cu2Co3(OH)2 and azurite Cu3(Co)3(OH)2.

And according to geochemical diagrams, the nature of the rocks studied is high potassium calc-alkaline and calc-alkaline.

6. Considering the formation temperature of the ore deposit which is between 170 and 220 ° C according to fluid inclusion studies and considering that the host rock of mineralization is andesitic tuffs and other evidences, this ore deposit is epithermal.

And the trend of major elements and some rare elements towards SiO2 indicates that the magmatic subtraction process has been involved in the formation of the studied rocks.

7. According to geochemical studies, the correlation between copper and chlorine and sulfur is positive and significant, indicating two phases of mineralization, one being the low temperature of the sulfide phase and the other having a relatively high and semi-deep temperature, which was in the form of a chloride complex. And the decreasing trend of heavy rare earth elements relative to light rare earth elements on the non-normalized radar pattern with chondrite indicates that the magma forming the rocks of the study area is resulted from a subducted oceanic crustal magmatic origin.
8. According to Morata et al, 2005, and based on the normalized radar pattern relative to chondrites of the study area, enrichment of light rare earth elements relative to heavy rare earth elements can indicate the presence of garnet and pyroxen in the rocks in the magma forming the Chagho zone, and these minerals have been able to retain heavy rare earth elements and have resulted in the depletion of the investigated rock sample.

SUGGESTIONS

According to the studies conducted in this research and previous studies, it has been investigated and concluded, and has elucidated some of the economic, geological, petrological and environmental geological issues of this area. Also, considering the facilities and time and financial constraints of this dissertation, the following are suggested for the better and more detailed study of the area and future studies and for the continuation of the follow-up work, exploitation especially the exploration operations.

1. Completion of economic geological surveys seems to be necessary for identifying promising and suspected mineralization points in terms of important minor elements such as titanium Ti, uranium U, thorium th, tungsten w, silver Ag, gold Au, beryllium Be, etc.
2. Preparation of geological maps of trace elements and rare earth elements (REE) and complete map of zones in the region with regard to economic value of these elements and investigation of these elements with regard to possible centralization in host rocks of the region can be useful and effective in determining the geochemical nature of primary source rock.
3. According to the evidence and studies, a porphyry copper deposit is likely to be present in the Chagho region, which is related to the northeast and southwest igneous mass of the region. Studying the depth and specifications of this ore deposit require exploratory studies, especially through aerial geophysics.
4. Detailed and complete isotopic studies of elements to investigate primary hydrothermal systems, especially on sulfur (S) and oxygen (O2), in order to obtain more accurate results on the origin of ore-forming fluids.

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