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A Review of Mineralization of Rare Earth Elements in Iran

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Abstract: Due to the increasing progress of modern technology, the increasing use of rare earth elements, the strategic nature of these elements, and the national need for these elements, the study and exploration of these elements are of great importance. Therefore, to achieve this goal, rare earth elements in different deposits in Iran were studied. Iran's highest concentration of rare earth elements is in phosphate and iron-apatite deposits and coal ash, respectively. It can also be noted that these elements are concentrated in bauxite and copper deposits along with alterations, laterites, and placers, requiring more detailed studies. According to these studies, the distribution of these elements in different deposits was determined. Also, the high dependence of these elements on different deposits such as phosphates was determined. Therefore, due to the growing need of the country for these elements, as well as self-sufficiency in this sector and even the export of these elements, emphasis is placed on further studies in the sectors that are considered promising and become waste dams. We are going to use it to explore new resources.

Keywords: REE, Mining Engineering, Geochemical Exploration, LREE, HREE

1. INTRODUCTION

Rare earth metals include scandium (Sc), yttrium (Y) and elements of the lanthanide group and are divided into two categories: light (La, Ce, Pr, Nd, Pm, Sm, Eu, Sc) and heavy (Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y) are divided. Some elements are not rare in abundance, but they cannot be concentrated due to dispersion in different minerals. Rare earth elements are also in this category. For this reason, it is more challenging to search, explore and extract rare earth elements than other elements. Rare earth elements, light earth rare elements and rare earth elements are abbreviated REE, LREE and HREE. [1]

In today's world, advanced technologies desperately need strategic elements such as rare earth elements, Which can be traced in essential industries such as the production of permanent magnets, metal alloys, coolants and catalysts.

It also has many applications in various chemical, metallurgical, military, aerospace, nuclear, optics and electronics industries, oil extraction and refining, automobile, nanotechnology, etc. Application of these elements in the manufacture of superalloys, oxygen sensors, fluorescent lamps, optical fibres, laser synthesis, computer memory and mobile phones, crude oil refining, permanent magnets, industrial engines for modern cameras and camcorders, medicine, Dentistry and ... more visible. [2]

In general, rare earth elements in terms of origin and origin in two types of primary mineralisation with intrusive igneous masses and veins, dykes, pegmatites and secondary mineralisation, including dunes and detrital placers and lateritic residues and Beach sand is found. Also, most of the world's rare earth elements are concentrated in carbonates, which are associated with the last stage of the magmatic series. The three main minerals include these elements, monazite, xenotime and anti-archaeite. [3, 4]

Significant reserves and sources of rare earth elements in the world include the Pass Mountains in southern California, the Bayan Obo Reserve in central Mongolia, and Kairona, Sweden. [5]

For the first time in Iran, researchers of the Amir Kabir University of Technology have extracted rare earth elements and produced metal ewes from the tailings of iron processing plants. Also, extensive and semi-extensive studies with geochemical methods and geochemistry and geology on areas such as magnetite-apatite deposits of Choghart, Chadormelo and Esfordi and phosphorous iron deposits in Central Iran and alterations and laterite and placer and in coal Coal ash, bauxite deposits, etc. have been done, which are discussed in this article. [6-10]

2. DISCUSSION

According to studies and studies on rare earth elements in Iran, these elements have been proven in various deposits or have exploratory hope. This paper discusses their location in different deposits and their importance in iron, phosphate, copper and alloy deposits, laterite and placer, along with coal, coal ash, and bauxite.[11]

2.1 Rare earth elements with iron deposits (magnetite - apatite)

Please Iron ores in the world have always been of great importance for political and economic reasons, so detailed studies on these ores and, in particular, the amount and distribution of rare earth elements in them have been done. Extreme Consumption of Minerals, especially Metals Rare earth elements, are generally not formed independently and are found with base metal deposits, especially iron. The most crucial type of iron deposits containing these elements is apatite iron deposits, which also have alternating amounts of phosphorus, in other words, rare earth elements with phosphorus. They are concentrated in apatite minerals. In the Bafgh region, due to the presence of apatite iron deposits, there are rich sources of rare earth elements. [12-15]

According to the studies of Moradkhani et al. (2015), the following results were obtained on the Narigan exploration area, located in the southern part of the mining area of rare Esfordi soil elements and black spot (which has been identified as rich in these elements). In the Narigan region, the presence of semi-deep granitoid intrusion mass called Narigan granite as the source of mineralisation and joint system and fault system and many joints around the mass has created suitable conditions for forming metal veins. From this point of view and studies of the origin of rocks in these areas that are consistent with each other, there is a possibility of rare earth elements in the Narigan iron mine and the surrounding area. [16]

In another study in the Bafgh region, on the Choghart mine, which is located 13 km northeast of Bafgh and 120 km from Yazd, geologically, the complex that forms the rock inside the Choghart mine has two completely different facades. : Geologists have dubbed these quartz- and feldspar-rich rocks quartzite, porphyry quartz, granofir, plagiofir, keratofir and albitofir quartz, and rocks with a high percentage of actinolite of thermolite and feldspar (albite) and alter parts Amphibolitized, which is referred to as amphibolite, amphibole pyroxenite, hornblende and metasomatic with different compounds, we achieved the following results. Choghart iron deposit is considered one of the most crucial mineral potentials of iron and rare earth elements in Iran. In order to identify the rare elements of Choghart ore and determine their amount, samples from different parts of ore, mineral tailings and tailings of processing plants were prepared and studied using ICP, XRD light microscope and electron microscope. The results show that apatite and monazite are other valuable minerals after magnetite and hematite. Zones with high phosphorus are also due to the increase in these minerals. Analysis of different samples shows that the amount of rare elements is strongly related to the amount of phosphorus, and these two have a high correlation of $r = 0.987$. The amount of rare elements present in the development plan processing tailings is higher than the ore and mine tailings samples. About 97% of the rare elements in the samples are rare earth elements. These elements include cerium (Ce), lanthanum (La) and neodymium (Nd), which even amount to 1205,540,467 ppm, respectively. Only the amount of yttrium (Y) is significant in the group of rare earth elements. Most of the rare earth elements are independent minerals of monazite or inclusions or inclusions within apatite. Many rare earth elements have also been substituted for calcium $Ca2 +$ in the apatite mineral network. [17]

In another survey on the north-northeast side of the Choghart iron mine to investigate the petrography of rare earth elements, sampling was systematically performed. To determine the principal and rare earth elements, thin and polished sections were prepared and studied microscopically after preparing the samples. The results showed that the primary ore in the northeastern part of the Choghart deposit contains a large amount of massive magnetite. The sub-minerals include apatite, pyrite, alkaline amphiboles, especially actinolite and thermolite, calcite, talc, quartz, monazite and bastnasite. Air ores are found in orthopaedics and yellow matter, with apatite being the main constituent of these elements in the region. [18]

In another study by Shekarian et al. On the Choghart deposit, due to the complex geological structure and the effect of grade distribution in this deposit, more detailed studies on grade zoning and creation of grade distribution models following geological structures by the method The separation of mineralisation zones from a geological and geochemical point of view and the relationship between the obtained models and rock units were investigated by fractal geostatistical method better to understand the distribution of rare elements by these models. The soil in the deposit is to be provided for further studies. For this purpose, they use fractal modelling by the carat-number method to separate different mineralisation zones and justify the distribution of carat based on lithological models and geochemical communities. Fractal geometry and lithology confirmed the relationship between the zones separated by the grade-number method and the lithological model. Metasomatic and albitofer type and a sub-community b The name of phosphorus iron type, which is a subset of phosphate type, exists in the region in which special attention can be paid to rare earth elements. [15, 19-21]

In another study by Moghiseh et al. (2014) in the tailings dam of the Choghart iron plant, in order to pre-concentrate the rare earth elements, the reagent sample was removed, and XRF analysis was performed on the sample with cerium, lanthanum, neodymium with 120, 98 and 350 ppm of light rare elements and yttrium, gadolinium and erbium with 630, 110 and 23 ppm of heavy rare elements showed the highest values, respectively. According to the results of minerals identified in XRD and the properties of rare earth minerals, a series of processing operations were performed on it, which have the grade of cerium, lanthanum, neodymium, and yttrium, gadolinium and erbium, respectively, equal to 4.335, 4.278, 1010. 8.8, 1907, 322/8, 4.66 ppm and the recovery of these elements were 60, 61, 62, 65, 63 and 62%, respectively. $Fe2O3$ grade was 10% in this section. [22]

Shirzaei et al. (2014) studied the northern anomaly located 11 km northwest of the Choghart iron mine, divided into three massifs: eastern, central and western due to tectonics. The central massif of this deposit was studied in terms of reserves of valuable elements. First, this information was analysed by collecting the information from the central massif. Then by preparing the information resulting from the excavations and drawing the geological profiles of the three-dimensional model of the central massif of this deposit and the number of rare earth elements stored In this massif, it was evaluated using the software. Finally, the amount of rare earth elements stored in the central massif of the anomalous northern deposit has been compared with several deposits in different continents. [21, 23-25]

Hazarkhani et al. (2014) investigated the geochemistry of rare earth elements in apatites and magnetites of Choghart iron deposits after sampling from the study area and chemical analysis of samples by ICP-MA EMPA and XRF methods, case samples Geochemical analysis was performed. Spider diagrams normalised to chondrite were drawn for all host rock types (albitofer), mineral, metasomatic and phosphate. The results showed that in all types, the enrichment of light rare earth elements is higher than heavy rare earth elements and spider diagrams with Eu negative anomaly, one of the main characteristics of alkaline ultrabasic magma. The results also showed that the distribution of REE in apatites and magnetites of Choghart iron ores is similar to that of Kirona type iron ores in other parts of the world, and the concentration of these elements in Choghart depends on the type of concentrating mineral which is fluorite apatite. [26]

In another study by Lak et al. (2013), the Balestan iron ore deposit, located 55 km southeast of Urmia city, West Azerbaijan province, was studied, and the following results were obtained for rare earth elements. The mean values of LREEs and HREEs in iron ores are 13.30 and 22.4 ppm, respectively, which are a sign of poor enrichment of these elements and require further investigation in other zones, as well as the presence of negative Ce anomalies. Iron ores indicate high fluoride content in ores and complexes (Ce (+4) with fluoride ligands. [25, 27-30]

In a study conducted by Mirzaei et al. (2016) on the Hassan Salar iron deposit, which is located 29 km south of Saqez, the behaviour of rare earth elements in the alterations of the region has been studied. The addition or reduction of a particular mineral has caused a change in the pattern of behaviour of rare earth elements. During potash alteration, rare earth elements were almost immobile, but the Eu element was sharply reduced. Filic alteration, except for the Eu element, increased compared to unaltered rock, while in propylitic alteration, which is more extensive than potassic, rare earth elements decreased sharply. [31, 32]

2.2 Rare soil elements along with phosphate deposits

Esfordi mining area, located 30 km northeast of Bafgh, is one of the country's essential sources of phosphate ore containing rare earth elements. This deposit contains three rare earth elements: cerium, lanthanum, and neodymium. According to the analysis of the control sample with OES-ICP, the amount of each of these elements is 5510, 2220, and 1980 ppm, respectively, which indicates the richness of these elements in this region. Be. Also, the amount of phosphorus in the control sample is 31.25%, which shows the high correlation of these elements with phosphate mineralisation. [33, 34]

In another study by Cheshmeh Sari et al. (2012), the Lar phosphate deposit in the southeast of Dehdasht, Kohkiluyeh and Boyer-Ahmad provinces was investigated. The host rocks of this deposit are limestones, shales and marls of the Pabdeh Formation to the Eocene-Oligocene age. Mineralogical studies show that these deposits contain calcite, quartz, francolite, dolomite, glauconite, illite and pyrite, which are accompanied by secondary minerals such as fluorine apatite, kaolinite, crandallite, hematite and goethite. Examination of the distribution process of elements in a selected profile reveals that elements such as P, REE and U are washed from the upper parts of the profile and enriched in the lower parts. The distribution pattern of normalised REEs to the Australian Archean (PAAS) shale composition shows poor subtraction of LREEs from HREEs and negative and weak Ce and Gd anomalies during phosphating. These features indicate La / Ce ratios well that changes in the chemistry of aerating solutions such as pH and weathering intensity are the two main factors that affect the mineralogy and distribution and stabilisation of REEs U and P in Lar phosphate deposits. Have put. Correlation coefficients between elements suggest that minerals such as apatite, granite, iron oxides, zircon and clay minerals are possible hosts for REEs and U. [35] [36-39]

2.3 Rare earth elements along with copper deposits

Songun copper mine, located 130 km northeast of Tabriz, northwest of Iran, was studied by Hassanzadeh et al. (2011) to investigate the scattering pattern of rare earth elements. The formation of this deposit is attributed to the hydrothermal activity associated with quartz monzonite stock monzonite and several granodiorite dykes that have penetrated the Cretaceous and Eocene sedimentary and volcanic rocks in the Oligocene to Miocene. In terms of lithography, Cretaceous volcanic rocks have a combination of carbonate and Chile. According to field observations and microscopic studies (presence of pyrite, chalcopyrite, colitis, calcite, quartz, clay minerals, plagioclase and chlorite). The main alterations observed in the massifs from the outside massif were potassic, phyllic, argillic and propylitic, which are indicators of porphyry copper deposits of the continental margin type. Geochemical studies show that rare earth elements in all three alteration zones have undergone both stabilisation and leaching processes. The distribution pattern of normalised REEs to chondrite implies the differentiation of LREEs from HREEs and the occurrence of Eu-negative anomalies during alteration. The results obtained from geochemical studies suggest that the effects of the tetrad, stabilisation in Neomorphic mineralised phases, the chemical composition of the primary rock, and change in water-to-rock ratio have been factors that play a valuable role in the distribution, mobility and enrichment of rare earth elements in The alteration system of the region has been played, so in order to explore these elements in this deposit, the factors mentioned above should be considered. [36, 37, 40-42]

Since metallic and non-metallic mines in South Khorasan province are suitable for discovering strategic elements such as rare earth elements, uranium, etc., Shirazi et al. South Khorasan Province; paid. These studies, despite small investments, can provide a platform for mining to flourish. In a case study on a copper deposit of coppersmiths located in this area, despite the potential of copper metal, it can be investigated to discover the ideal storage of yttrium. Yttrium may be enough to extract yttrium after extraction and further investigation. It is recommended that analyses be performed on mine tailings as well. [43]

2.4 Rare earth elements (hopeful) along with alterations

In a geochemical study of rare earth elements in the Shelah Baran region, two kilometres northeast of Ahar city and in the southeastern part of Qara Dagh batholith, East Azerbaijan province, by Mohammadi et al. (2014), The following results can be inferred about rare earth elements Appeared. Field observations and petrographic studies show that Eocene volcanic igneous rocks in this area with a combination of dacite tuff and trachyandesite along with Oligocene intrusive igneous rocks with a combination of diorite, quartz monzonite, and granodiorite are altered by hydrothermal fluids and in parts of It is associated with metal mineralisation, especially copper. Alteration zones in the rocks mentioned include phyllite, proplitic, intermediate argillic, advanced argillic, siliceous and biotite zones. The results of calculations of mass changes of elements using the Isocone method reveal that the development of the advanced argillic alteration zone associated with Eocene dacite tuffs with depletion of elements such as Mn, P, V, Cr, Co, As, Sr, Hf, Zr, Th, K, Si, LREE, C, Ba, Rb, Se, Zn, S, and enrichment of elements such as Mg, Cr, Na, Al, Ti, Cu, Fe, Pb, HREE, Y, Ga, Nd, Sn is included. The results of mineralogy and geochemistry of mass changes show that factors such as pH of alterating solutions, oxidation potential, differences in the stability of primary minerals, scanning by metal oxides and hydroxides, adsorption, and entry of metal elements by hypogenic solutions. The system, differences in the degree of alteration of the primary rock and changes in the ratio of water to rock have played an essential role in the degree of mobility, distribution and stabilisation of major, partial and rare earth elements in the advanced argillic alteration zone of the floodplain area. In particular, Y and HREE and considering the factors mentioned above, we can hope for exploration in this area and conduct further studies on this area. [44-48]

A geochemical study was performed on rare earth elements in the Mahour Chahkaleh area, 44 km northeast of Nazanz city, Isfahan province. Field observations and mineralogical studies indicate that the intrusion of the Oligocene granodiorite stock into the Eocene andesitic and Thracian andesitic rocks in this area has been associated with the development of a significant alteration system and metal mineralisation. Alteration zones in andesitic and trachyandesitic rocks include three potassic, two phyllic, three propylitic and four argillic. The distribution patterns of normalised REEs to the chondrite reveal that the differentiation of LREEs from HREEs has been associated with Eu-negative anomalies during the formation of phyllic, propylitic, and potassic alteration zones. The argillic and potassium alteration zones contain the largest and lowest quantities of REEs, respectively, according to the chemical analysis findings. Investigation of element enrichment factors indicates leaching and stabilisation of REEs during the development of alteration zones. Studies reveal that the high activity of sulfate coagulants combined with the low pH nature of alteration solutions is the main reason for the depletion of REEs in the potash zone, and the adsorption coupled with the low activity of sulfate coagulants is the leading cause of REE enrichment in the argillic zone. The results obtained from geochemical studies suggest that the distribution of REEs in the alteration zones in Mahour Chahkaleh is a function of changes in the physical and chemical conditions of the alteration environment, differences in the intensity of adsorption and scavenging by metal oxides, and the presence in phases. Mineralisation has been resistant. Therefore, further studies on the argylic zone are recommended due to enrichment. [49-52]

Zonooz kaolin deposit is located 15 km northeast of Marand, East Azarbaijan province, which was investigated by Alipour et al. (2010). In field studies (based on physical features such as colour, five distinct types of kaolin, including (1) white, (2) lemon, (3) grey, (4 brown and (5) yellow, were identified in this deposit. Field evidence And petrographic studies show that this deposit is genetically related to trachy andesitic rocks. According to the mineralogical findings of this deposit, including quartz, kaolinite, montmorillonite, calcite, pyrophyllite, chlorite, muscovite-illite, dolomite hematite and anatase, The study of element enrichment factors shows the performance of alteration processes on the rocks and, Yb, Tm, Cu, Hf, Zr, Ba, Rb, V andesitic trachea during the development of Xenoz kaolin deposit by washing elements such as Ga, Y, Ni, Cr, Co, Th, Sr, Cs and leaching-stabilisation of elements such as, Ta and, Nb, U were accompanied by enrichment of elements such as Lu. , Ho, Dy, Tb indicate that the physicochemical conditions of the alteration medium, the relative stability of the primary minerals, and the stabilisation in the mineral phases have played a role in this deposit. Manganese oxides, zircon, anatase, hematite, muscovite-illite, chlorite, cyanite, and in this deposit are essential morphs in geochemical distribution. Secondary phosphates (monazite, rhabdofan, xenotime) host REE in this deposit and can be substantial. [53-55]

Taghizadeh et al. (2010) explored the Baavaran Kaolin Reserve, 35 km northeast of the Middle East, East Azerbaijan Province. Field evidence and laboratory studies indicate that this reserve was developed from the alteration and weathering of oligomycin dacite rocks. Mineralogically, this reserve includes kaolinite, quartz, illite, cristobalite, muscovite, orthoclase and goethite. The results of calculations of mass changes of elements with the assumption of Al as immobilised index elements show that the performance of alteration processes on dacite rocks during the development of Baavaran kaolin deposit by leaching of elements such as Rb, enrichment of elements such as Sr, Th, Nb, Hf, Y, Ta, Ga, Pr, Nd, Sm, Eu, Gd, Yb, and Lu, and wash and stabilise elements such as Ba, Cs, U, Zr, V, Co, Cr, Ni, Cu, La, Ce, Tb, Dy, Ho, Er, and Tm were associated. The results indicate that factors such as pH changes of alteration solutions, adsorption, scanning and concentration by metal oxides, presence in resistant mineral phases, homogeneity of mother rock, the overlap of supergene processes on hypogenic processes and stabilisation in neomorphic mineral phases have played a valuable role in the distribution of rare earth elements in this reserve. Further geochemical considerations indicate that zircon, Ti-containing phases, serpentine, and secondary phosphates (monazite, rhabdofan, and xenotime) are the hosts of rare earth elements in this reserve that require further investigation. [50, 56-59]

2.5 Rare earth elements with laterite and placer

For The following results were obtained from the geochemical study of rare earth elements in the laterite Zan deposit, 25 km southeast of Damavand, Tehran province. This deposit is developed as a stratigraphy in the Chilean and sandstone basins of the Shemshak (Jurassic) Formation. Mineralogical findings indicate that the minerals of this deposit include diaspora, hematite, goethite, anatase, kaolinite, boehmite, siderite, rutile, quartz, titanomagnetite, zircon, and pyrite. The lateritization process in Zan has been accompanied by the enrichment of elements such as V, Y, Co, Cr, Ni, Nb, Zr, Fe, Ti, Al and REEs and the washing and stabilisation of elements such as Ba, Sr, Mn, U and Ca. Combining the results obtained from mineralogical and geochemical studies suggest that changes in pH of aeration solutions, oxidation potential, adsorption, presence of organic matter, preferential adsorption by metal oxides, presence in resistant mineral phases and stabilisation in neomorphic phases play a valuable role in the distribution of major, minor, and rare earth elements in the laterite deposit. The correlation coefficients between the elements suggest that zircon, rutile, gorsexite and xenotime are the host minerals of REEs in the ores of this deposit. If the grade of these elements in these minerals is high, we can hope for exploration of these elements in this area. [60]

In another case study on Marvast Marvaz place in Yazd in the east and west, Morshedi et al. (2017) performed the following results. Data and samples were analysed from 53 wells in the eastern area; this anomaly in the south of Yazd city was used to model and find the potential of rare earth elements. In the Marvast region, the source rock is black shale monazite, which is found alternately with limestone and limestone sandstones and conglomerates in the form of scattered nodules in the shales. Examination of the distribution pattern of standardised rare earth elements to chondrite values indicates high compliance with the standard pattern of monazite. To investigate the geochemical distribution and concentration in the region, an interpolation map of the distribution of these elements was drawn. The most concentrations were related to light, intermediate and heavy elements, respectively. It was also proved by the intensity coefficient, including the ratio of the concentration of rare earth elements to light to heavy. In the next step, data clustering was performed at two levels of elements and samples, indicating four groups of elements based on light and weight (atomic and chemical structure) and four spatial zones based on promising areas, labelled as the fourth cluster. , Corresponds to the area of anomaly. Finally, the multivariate statistical method of principal component analysis was used to model the anomaly. [61]

2.6 Rare earth elements with coal and coal ash

In recent years, the reduction of familiar sources of rare earth elements in the world, such as carbonatites, has led to the beginning of exploration activities to provide primary sources of these elements in other fields. Recovery of rare earth elements from coal reserves as a by-product in many countries can help reduce the current raw material crisis. It can also be used to convert polluted coal into clean energy sources. Studies have shown that the concentration of these elements in coal ash is several times that of coal. Rare earth elements in coal ash are divided into three groups: heavy, medium and light. Among these, medium and heavy groups are more critical because their available resources are more limited. These elements accumulate in coal under four types of genetics and are 1- alluvial type, 2- tuff type, 3- infiltration type, and 4- hydrothermal type. The resulting hydrothermal reserves are more desirable in terms of grade and storage. By examining Iran's coal resources and comparing it with other countries in the world, Iran is richer in sources of rare earth elements in coal than China, the United States, etc. Paying attention to this issue can have a bright future in recovering these elements from coal ash in our country. [62]

According to the above points, extracting these elements from coal ash, which contains a significant amount of REE, should be considered. According to the study, the dissolution of elements in ash in an acidic environment depends on the content and formation of the ash. However, the amount of dissolved elements increases with increasing temperature and dissolution time. After the dissolution of REE elements in sulfuric acid, these elements' separation methods are the same as those used for processing common REE ores. [63]

The following results were obtained in a study on rare earth elements in coal conducted by Shahraz et al. (2014). In addition, the mineralogy was examined using the SEM technique. According to the data, the accumulation of some trace elements in Iran's coal reserves is much more than that of China, the United States, and the majority of the world's coal and its Clark quantity. In the commission area, the average accumulation of rare elements and the perspective index were 378.21 g / kg and 0.48 g, respectively. Also, the value of 16.35 ratio of light to heavy rare elements indicates enrichment in the group of light rare elements. The origin of the accumulation of these elements in the coalfield is of clastogen type and depends on the fall and leaching of pyroclastic materials, rich in rare light soil elements. Therefore, these precious metals can be recovered at different stages of coal deposit development (overburden, coal mining, coal combustion and after the completion of coal storage in these mines). [64]

In another case study by Memar et al. (2016), the following results were obtained by examining the coal zones of Iran. After sampling from different coal zones (raw coal and concentrate and waste from coal processing in coal washing factories), the sample was analysed by mass spectrometer (ICP-MASS) method of fifty-seven elements and the abundance of some rare elements. Rare and earthy were treated. Then, by interpreting the data obtained from the analysis of samples, rare and rare elements and determining their concentration and enrichment in the country's coal and the economics of their extraction were examined. By reviewing and analysing the results of the analysis, the Khomrud mine has the highest number of anomalies, with anomalies in 13 elements. Also, Mazino Tabas thermal coal with anomalies in 9 elements and Central Alborz region (underwater) with anomalies in 8 elements are in the following ranks regarding the number of anomalies in rare earth elements. [65]

2.7 Reserves with bauxite deposits

Jajarm bauxite deposit (northeast of Iran) is the largest diaspora bauxite deposit in Iran, which is located as a stratiform deposit between Elika and Shemshak formations. The bottom-up of this deposit is composed of four parts of lower kaolinite, shale bauxite, hard bauxite and upper kaolinite. Rare soil elements have been studied using correlation coefficients between these elements and other elements. In the normalised chondritic diagrams of rare earth elements in the challenging bauxite section, the elements (Ce) and (Eu), especially the element Ce), show different behaviour compared to other elements and show positive and somewhat negative anomalies, respectively. Show. This is a result of the existence of these elements with different capacities compared to other rare earth elements in the hard bauxite section so that Ce with a capacity of +4 and Eu with a capacity of +2 have entered the mineral structure. The La / Y ratio in the hard bauxite section also indicates the acidic conditions prevailing in this section of the deposit, due to which the rare earth elements may have been partially washed away and settled in the lower sections. [66]

Mineralogical and geochemical studies in the Jajarm bauxite deposit indicate that rare earth elements that have shown a positive correlation with phosphorus and iron in the lower kaolinite section have been absorbed by hematite and clay minerals. Nb, V, Cr, rare earth metals and phosphorus. From top to bottom, bauxite horizons have an irregular vertical distribution. Also, a comparison of the content of Jajarm bauxite with Chinese bauxite deposits shows that the amount of rare earth elements in Jajarm bauxite is higher. [67]

3. CONCLUSION & RECOMMENDATIONS

Considering that in different stages of exploration and extraction of a mine, comprehensive information from mineralogy and elemental analysis is continuously collected from different zones, attention and use of this information can be of great help in exploring rare earth elements in that area and surrounding areas. . In many mines, despite the high percentage of these elements due to lack of study and lack of sufficient information about them, these elements are directed to tailings dams.

Attention to rare earth elements and iron-apatite deposits is considered and recommended for more comprehensive studies in various iron mines in Iran. Also, since these elements are associated with phosphates, phosphate can be an excellent exploration guide in determining the exact location of these elements.

In bauxite deposits, these elements are absorbed by clay minerals and iron oxides, and their extraction is more manageable, so the presence of these elements in bauxite deposits is essential.

Since these elements have not received much attention in recent decades and are now essential sources, tailings dams in various mines, especially coal mines, can be rich sources of REE, so to study the percentage and amount of storage of these elements in these mines are recommended as additional studies in this section can be of great help in exploring these resources.

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