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Correlation of Rare Earth Element (REEs) content in Turkey and World, and contribution of Rare Earth Elements to nano technology

Berna Yavuz Pehlivanlı[a]*, Selva Büyükakkaş[b]

[a]Yozgat Bozok University, Department of Geological Engineering, 66100, Ataturk Yolu, Yozgat, Turkiye
[b]Ömer Halisdemir Üniversitesi, Department of Physic, Faculty of Arts and Science Niğde, Türkiye

Rare earth elements come from the word unconventional rather than exactly rare, and there is a misnomer. The concentrations of the more abundant REEs in the earth's crust are similar to those of ordinary industrial metals such as chromium, nickel, copper, zinc, molybdenum, tin, tungsten or lead. In fact, some REEs are almost 200 times more abundant than gold. However, REEs are more difficult to obtain from ore deposits as concentrates, unlike ordinary base and precious metals. As a result, REEs obtained in the world are obtained from very few sources. Differences in individual REE abundances within the Earth's upper continental crust are represented by the superposition of both nuclear and geological effects. The Rare Earth Elements (REE) deposits and mineralization of Turkey can be divided into four types based on their geological setting and origin. These are deposits associated with carbonatite alkaline magmatic rocks, Triassic shales - the bauxites formed, the placer type and phosphorites. Although these rocks are home to the world's largest resources, it is an important issue that needs to be studied carefully for the country's economy, as there has not been enough work done in Turkey yet. In recent years, rare earth elements (REE) have become an essential part of advanced industries. Rare earth elements are used both in industries such as nuclear, metallurgy, chemical, catalytic, electrical, magnetic and optics, and in many futuristic industries such as lasers, fluorescent lamps, atomic batteries, motor turbines and super-magnets. However, its widespread use in these industries causes problems to enough obtain REE in geologic resources. Scientists are using nanotechnology to develop nano-cellulose that can effectively recover REE using a new and sustainable method.

Keywords: *Rare Earth Element (REEs), geological setting, nanotechnology, nano-cellulose, industries.*

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**Correspondingauthor:* berna.yavuz@yobu.com.tr (B.Yavuz Pehlivanlı)

1. Introduction

Rare earth elements, which are indispensable raw materials of technologies in recent years, have a very critical importance, from magnets used in generator systems in wind turbines to electric vehicles, mobile phones, lasers or LCD televisions. Although rare earths have very useful and unique properties, one of the main reasons why they are critical is that they are difficult to obtain and increasingly costly. In particular, rare earth elements such as Neodymium, praseodymium, and dysprosium can provide for magnetic systems storage of significantly smaller or significantly higher magnetic
energies compared to conventional magnetic materials. The world's strongest magnets are made of neodymium. A little too strong for your refrigerator, these magnets are integrated into computer disk drives, power windows, and wind turbines. Contrary to popular belief, REEs are actually quite abundant in the earth's crust, but they are widely distributed throughout the world. REE is very important as it has been seen as critical metals in recent

years due to China's dominance in the supply chain (1). China supplies more than 58% of the world's REE (Table 1). The USA and other countries attach importance to the search for alternative REE resources (2-3) and concentrate on studies on recycling products from used materials. (4).
It is estimated that 0.2 to 2 percent of Turkey's reserves are rare earth oxides, which could possibly mean up to 14 million tons of compounds (5).
In terms of geological resources, primary REE sources are controlled by high-temperature geological processes such as carbonatites, alkali rocks, veins and skarn deposits, and low-temperature processes such as placers, laterites, bauxites, and ion-adsorption clay formation (6).

Table 1. REE producing countries and their total reserves (7).

Country	Mine Production 2020	Mine Production 2021	Reserves (Tonnes)	% of Total Reserves
China	140,000	168,000	44,000,000	35.20%
Vietnam	700	400	22,000,000	17.60%
Brazil	600	500	21,000,000	16.80%
Russia	2,700	2,700	21,000,000	16.80%
India	2,900	2,900	6,900,000	5.52%
Australia	21,000	22,000	4,000,000	3.20%
United States	39,000	43,000	1,800,000	1.44%
Greenland	-	-	1,500,000	1.20%
Tanzania	-	-	890,000	0.71%
Canada	-	-	830,000	0.66%
South Africa	-	-	790,000	0.63%
Other Countries	100	300	280,000	0.22%
Burma	31,000	26,000	N/A	N/A
Madagascar	2,800	3,200	N/A	N/A
Thailand	3,600	8,000	N/A	N/A
Burundi	500	100	N/A	N/A
World Total	**244,900**	**277,100**	**124,990,000**	**100%**

2.Experimental

REE geochemistry is an important method for determining geochemical processes (8). REE analyzes are made by NAA and MS methods and generally, the results are normalized according to reference values such as Chondrite (CN), C1 Chondrite, NASC (North American Shale Component), shale (ŞN), PAAS (Post Archaean Australian shales). The normalized values of REEs are drawn by selecting characteristic zig-zag patterns (patterns) due to their increased stability all around, and weak variations within these REE patterns (patterns) are acceptable. The characteristic zig-zag patterns are drawn due to the increased stability of the REEs all around the normalized values, and weak variations within these REE patterns are acceptable (Fig. 1).

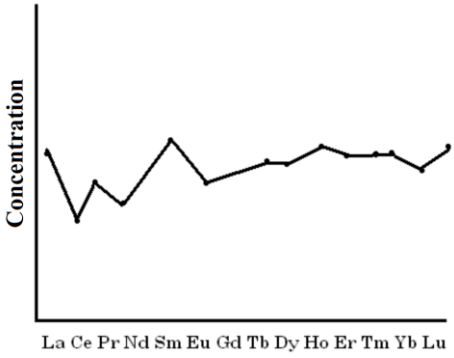

Fig. 1. Characteristic zig-zag patterns of REEs.

The abundance peaks in the normalized values of REE patterns reflect the geochemical history of the samples. REE patterns such as large ion lithophile elements (LILE) are also widely used in the search for ore formation sources (9). REE geochemistry is an important method for determining geochemical processes (8). This depth varies closely with alkalinity, oxygen, opal and calcium carbonate contents (10-11).

3. Results and Discussion

So far, approximately 200 different Rare Earth (RE) minerals have been identified, and the crystal structures of about half of them have been determined. All the structures detected in the chemical structures of RE minerals were reviewed. Here, RE minerals are grouped according to their chemical formulas in Table 2 as salts, carbonates, oxides, phosphates, and silicates. In Table 2, the most important RE minerals, bastnasite, monazite and kisenotyme, are highlighted with simple chemical formulas [12].
There is a slight difference in the radii of the LREE and HREE groups. This difference is affected by crystal structures and/or coordination numbers for RE. With the developments in technology, the design of nanostructured materials containing RE elements has been used a lot recently. In particular, nanoparticles (NPs) range from 1 to 100 nm in size at which most biomolecular interactions occur [13]. Therefore, the incorporation of RE into NPs is used in many different biomedical applications. For example, it can be used for drug delivery and other treatments such as bioimaging, and biosensing [14].
The above strategy-based synthesis of RE-based NPs falls into two groups. These are reactions carried out at atmospheric pressure and hydrothermal or solvothermal methods [15].

Table 2. Classification of rare earth minerals [12].

MINERAL CLASS	MINERAL SAMPLES AND CHEMICAL FORMULAS
SALTS	Flocerite -(F), CeF3
CORBONATES	
FLUORITES	Bastnasit, (Ce,La)(CO3)F
WITHOUT FLOTIT	Ankilite, (Ce,Sr,Ca)(CO3)(OH,H2O)
BORATES	Braistkit, (Ca,Na2)7CeB22O43 7H2O
OXIDES AND HYDRATES	
AO2-TYPE	Serianite, (Ce4+,Th4+)O2
ABO3-TYPE	Perovskite group, (Ca,Ce,Na,Sr)(Ti,Nb,Ta)O3
ABO4-TYPE	Fergusonite--Formanite, Y(Nb,Ta)O4–Y(Ta,Nb)O4
AB2 (O,OH)6 -TYPE	Euxenite group, (Y,Ca,Ce,U,Th)(Nb,Ta,Ti)2O6
A2B2O6 (O,OH,F)-TYPE	The pyroclar group, (Na,REE,K,U)2(Nb,Ta,Ti)2 (O,OH,F)
OTHERS	Hibonite, (Ca,Ce)(Al,Ti,Mg)12O19
PHOSPHATES, ARSENATES AND VANADATES	Apatite, (Ca,REE,Sr,Na,K)3Ca2 (PO4)3(F,OH) Monazite, (Ce,La)PO4 Kisenotime, YPO4
SILICATES	
ISOLATED GROUP	Serite,(Ce,La,Ca)9(Fe3+,Mg)(SiO4)6[SiO3(OH)](OH)3 Garnet,(Ca,Fe,Mg,Mn,Y)3(Al,Cr,Fe,Mn,Ti,V,Zr)2(Si,Al)3O12 Siphene, CaTiSiO4
DIORTHO GROUP	Allanite, Ca(Ce,Y,Ca)Al(Al,Fe)(Fe,Al)(SiO4)3(OH)
CHAIN GROUP	Stillivellit, CeBSiO5
RING GROUP	Eudialite, (Na,Ca,Ce)6 (Zr,Fe)2Si7 (O,OH,Cl)22
LAYER GROUP	Gadolinite, (Y,Ce)2Fe2+Be2Si2O10
FRAME GROUP	Kainosit, Ca2 (Y,NTE)2(Si4O12)CO3·H2O
OTHERS	Limorit, Y2(SiO4)(CO3)

4. Conclusion

High-tech and environmental applications of REEs have diversified and developed surprisingly over the last 50 years. Most of these applications are in a special position because their REEs are less known, the proportional uncertainty of REE is much higher than expected, and they have technological significance. However, it is much more difficult to obtain REE ore deposits as concentrated (concentrated) despite being more abundant than many similar industrial metals today. The Rare Earth Elements (REE) deposits and mineralization of Turkey can be divided into four types based on their geological setting and origin. These are deposits associated with carbonatite alkaline magmatic rocks, Triassic shales - the bauxites formed, the placer type and phosphorites. Although these rocks are home to the world's largest resources, it is an important issue that needs to be studied carefully for the country's economy, as there has not been enough work done in Turkey yet. In recent years, rare earth elements (REE) have become an essential part of advanced industries.

As a result, the vast majority of REEs in the world are derived from only a few beds. It is the largest self-sufficient bed in the world in the USA. However, this has become dependent on imports from China due to technological developments in the last twenty years. Rare earth-based nanostructures are widely used materials in recent years. One of the most important of these is the strategies of rare earth-based nanoparticles and different bioimaging and biosensing applications. In addition, all usage areas of rare earth elements are summarized in Figure 2 (14-16).

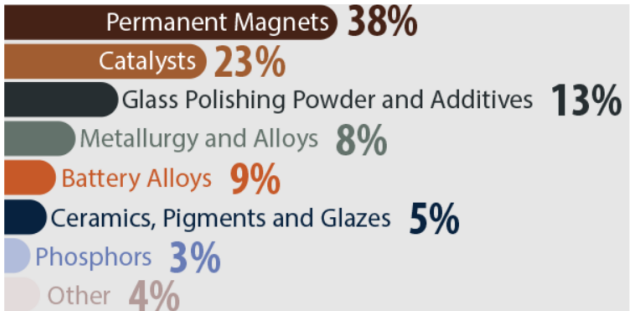

Figure 2. REE's main usage areas (16).

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