CEHTES – BULLETIN NO.1

RARE EARTH ELEMENTS – REE

WHAT THEY ARE?

A group of 17 chemical elements in the Periodic Table that share similar physical & chemical properties

TIMELINE

1915: in 1915, Brazil was the world's largest supplier of monazite, a mineral containing REE [USP]

After 1915: : From 1915 onwards, Brazil alternated this position with India for 45 years

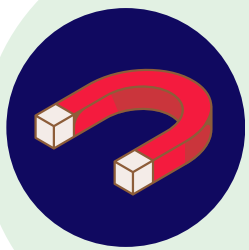
1960s: in the 1960s, when it began to be commercially produced, until the 1980s, the main source of REE was the Mountain Pass carbonatite deposit in California, USA (mine still operating)

1970s-2020s: China begins REE production in the late 1970s and quickly becomes the absolute world leader, with almost 90% of current refining capacity

WHY THEY MATTER?

- They are valued for their use in green and strategic technologies, including wind turbines, electric motors, smartphones, and alloys
- They stand out for their unique properties, especially **magnetic**, **optical**, and **catalytic**, which cannot be easily replaced by other materials

MOST USED



- The most important REE for the energy transition (Nd, Pr, Dy and Tb), used in the manufacture of permanent magnets (PERM), represented about **29%** in volume and **78%** in value in 2023 (90% in 2034) [REE]
- First developed in 1984, **PERMs** are **18x** stronger than ferrite magnets by volume and **12x** stronger by mass

MINERALOGY

- REE deposits can be **igneous** (carbonatites or hydrothermal), **sedimentary**, **secondary** (ionic clays), or other types [ITM]
- The minerals bastnasite, xenotime, and monazite, which account for 95% of REE production, can exceed **10%** of REE in raw form
- Ionic clays have lower mass contents (**0.05%** to **0.3%**) but enable more sustainable extraction processes [ITM]

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APPLICATIONS

- Transportation: electric vehicles, airplanes, bullet trains
- Power generation: wind turbines, PV panels
- Industries: chemical, electronics, aerospace, medical-hospital

FEATURES

- They exhibit **magnetic susceptibility**
- Although they do not have significantly radioactive natural isotopes, their minerals may be associated w/ radioactive elements, such as **uranium** & **thorium**
- Rare earth oxides (REO) are considered **commodities** because they are chemically stable, nonflammable, easy to store and transport
- 1 g of REO ≈ 0.85 g of metallic REE
- A 2 MW wind turbine uses about **350 kg** of REO; an electric car, 1–2 kg; and a smartphone, 1 g

CLASSIFICATION

- **LIGHT** (LREE): most abundant: Cerium (Ce), Lanthanum (La), Neodymium (Nd), Praseodymium (Pr), Samarium (Sm). **Uses**: magnets, catalysts, optical glasses, polishing materials
- **HEAVY** (HREE): Scarce and valuable: Terbium (Tb), Dysprosium (Dy), Holmium (Ho), Erbium (Er), Thulium (Tm), Ytterbium (Yb), Lutetium (Lu), Yttrium (Y): **Uses**: high-T magnets, lasers, electronics, alloys

PERM – VALUE CHAIN

- **STAGES:** mining, mineral processing (concentration), chemical separation, refining, and magnet manufacturing
- Although it is the most complex stage, mainly because it involves solvent extraction, the **chemical separation** of individual elements is what adds the most value to the production chain – around **20x** more than the previous stage

RESERVES / PRODUCTION

RESERVES (ROE) [USGS]:

- China: 44 Mt (largest reserve – 48% of total)
- Brazil: 21 Mt (second largest – 23% of total)

GOIÁS [BRM1, ITM]:

- Top 4 in Brazil (with MG, AM, BA)
- '**Pela Ema**' Project by Mineração Serra Verde (Minaçu): the only operating ionic clay mine in the country, with a capacity of **5 kt/year** of ROE concentrate (Phase I) (10 kt by 2030 – Phase II)
- Explorations in Nova Roma, Iporá, and others

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ADDITIONAL INFORMATION

- According to a report by Solange Srour, Director of Macroeconomics at UBS GWM and columnist for CNN Money, REE minerals have the potential to add up to **BRL 243 billion** to Brazil's GDP over the next 25 years – **BRL 47 billion** in the worst-case scenario [CNN]
- Rare earth mineralization in northern Goiás is associated with the **Serra Dourada** granite, an elongated rock formation covering 450 km² across parts of the municipalities of Trombas, Minaçu, and Palmeirópolis, which gave rise to the ionic clays [G1]
- The Peruvian mining company Aclara Resources, part of the Hochschild Mining group, plans to start implementing the '**Carina Project**' in the first quarter of 2026. Located in Nova Roma, Goiás, the project aims to produce a heavy rare earth concentrate. The company has set up a pilot plant in Aparecida de Goiânia to process ionic clay extracted from the Carina deposit, with the goal of producing a high-purity rare earth concentrate. In later stages, the objective is to produce metal alloys with REE and, through partnerships, manufacture permanent magnet [BRM2]
- Recently, a proposal from Mineração Serra Verde was selected by BNDES and Finep in the first phase of the initiative called **Transformação de Minerais Estratégicos** (Strategic Minerals Transformation), which aims to promote increased production/R&D of strategic minerals, such as rare earths [G1]

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