

INTRODUCTION TO RARE EARTH ELEMENTS

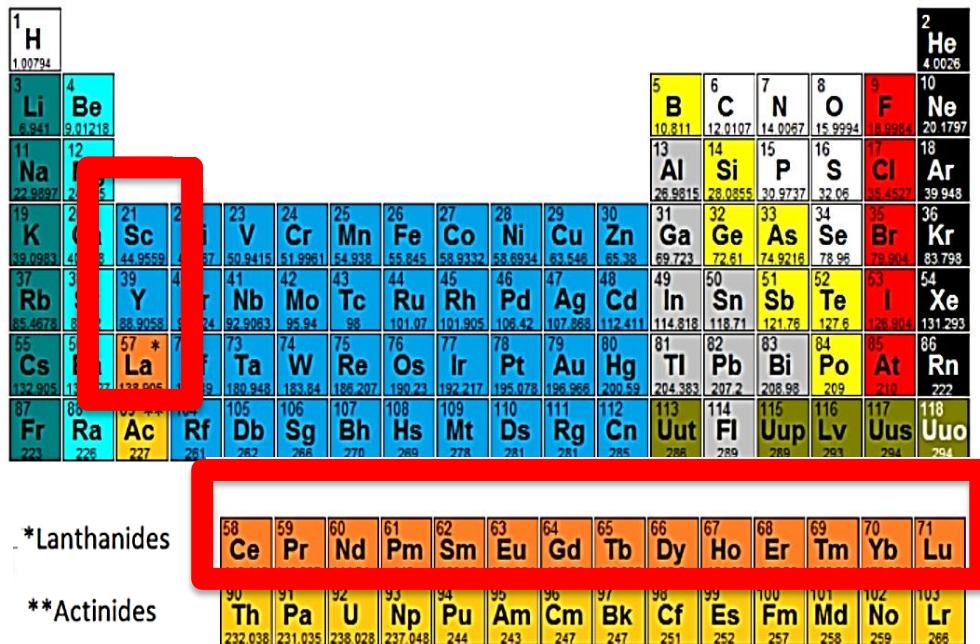
Definition:

Rare Earth Elements (REEs) are highly sought-after chemically similar elements which are essential components of a wide range of products, ranging from smart phones to wind turbines and cancer-treating drugs because of some unusual magnetic and optical properties stemming from their electron structure.

What are rare earths?

Often referred to as "rare earth metals", they include the lanthanides (atomic numbers 57 to 71 at the bottom of the Mendeleev periodic table of elements) and the lighter elements scandium and yttrium (Figure 1).

FIGURE 1



What are the differences between heavy and light rare earth elements?

The lanthanides are commonly divided into the light rare earth elements (LREE) – lanthanum through the europium (58 to 63) and the heavy rare earth elements (HREE) – gadolinium through the lutetium (64 to 74), in accordance with their atomic number (Figure 1). The light REE are relatively abundant and more strongly concentrated in the continental crust than the heavy REE. As a result, light REE have much lower value than the heavy REE where supply is already limited and where serious concerns prevail about their availability from current sources at reasonable prices in the future.

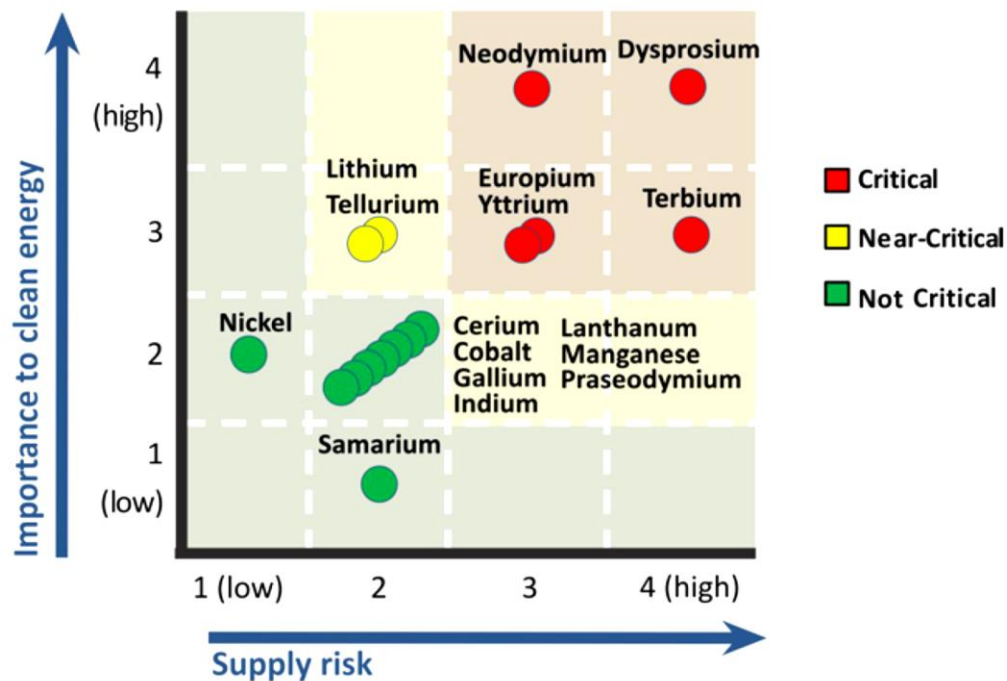
What are critical metals?

"Many new and emerging clean energy technologies, such as the components of wind turbines and electric vehicles, depend on materials with unique properties. The availability of a number of these materials is at risk due to their location, vulnerability to supply disruptions and lack of suitable substitutes."

- Steven Chu, U.S. Secretary of Energy and Nobel Laureate (2010)

Governments around the world (ex: USA, EU, UK, Japan) examine the risks that their industries will be disrupted by shortfalls in the availability of vital raw materials that are key inputs to their production. Figure 2 presents the results of the U.S. Department of Energy's assessment of the risk of a supply shortfall certain metals on clean energy technologies.

FIGURE 2
Medium Term (5-17 years)



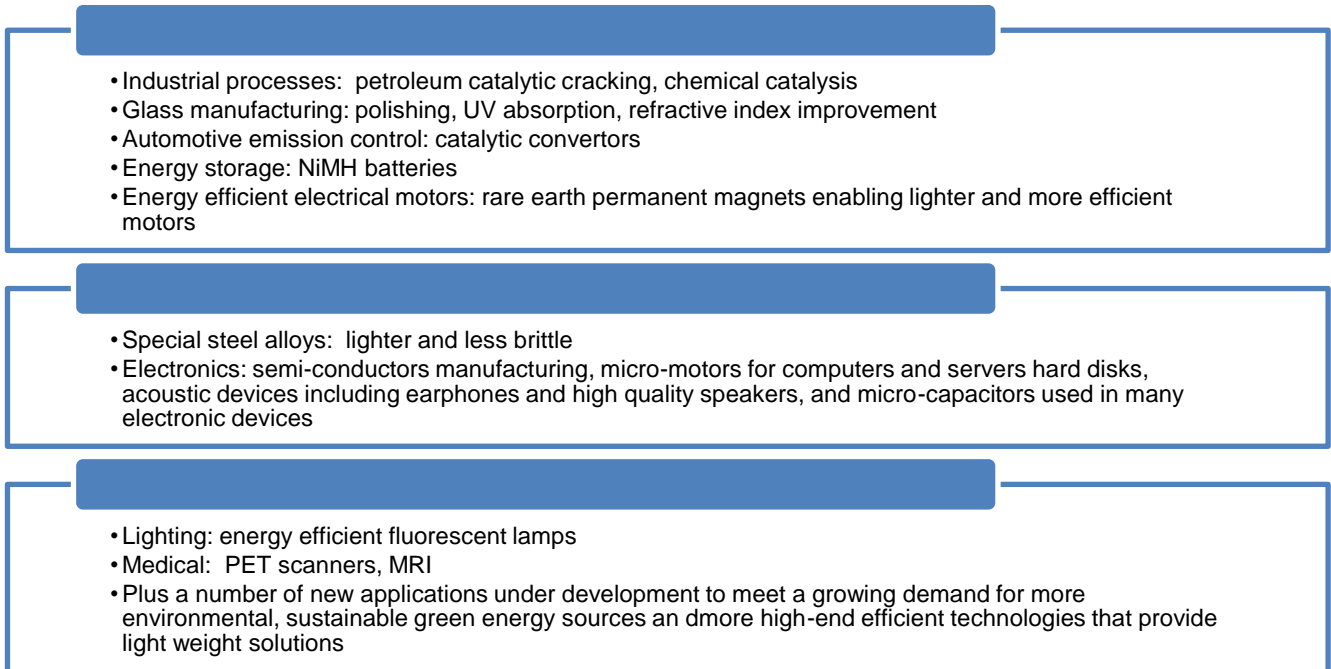
The global demand for REE:

What are rare earth used for:

Rare earth in the form of so-called mischmetal was used long time ago for lantern mantles and flint stones for lighters. Cerium and lanthanum were introduced as catalyst about 50 years ago. The magnetic properties of the rare earths in various alloys were discovered only 30 years ago. They were then utilized in so-called super magnets which are now widely used in very efficient and light weight electric motors for electric cars and as generators in wind turbines.

Because of their specific optical, magnetic and catalytic properties, rare earths are used in a variety of applications as illustrated in Figure 3.

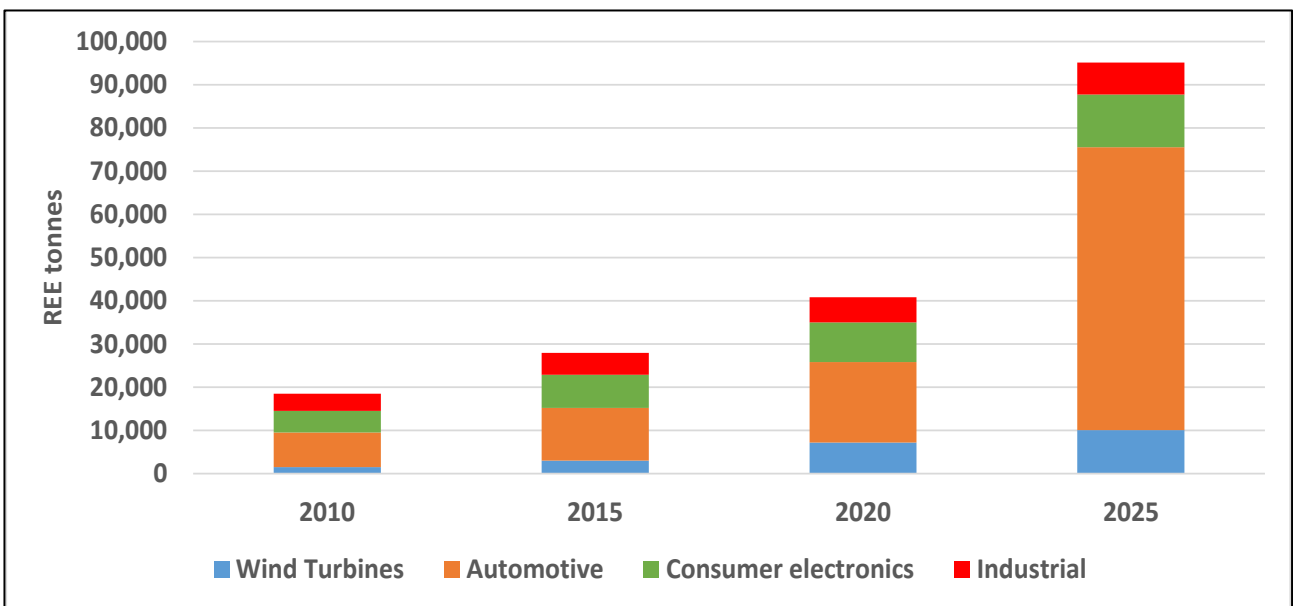
FIGURE 3
Rare earths affect many areas of our everyday life



What is the expected for REO demand:

Natural Resources Canada estimates that global demand for rare earth oxides (REO) in 2016 was 124,000 tonnes and that it will increase to 150,000 tonnes in 2020. Demand is particularly strong for high power permanent magnets which is expected to triple over the next 10 years and continue to grow afterwards (Figure 4). The demand for the light rare earth will continue to grow at a lighter pace.

FIGURE 4
Rare earths in permanent magnets by application



- Who are the consumers of REO:** China's domestic consumption has grown rapidly, leading it to become the largest user of the REE in the world. It is estimated that China will soon become a net importer of heavy REE for which it is not relatively well endowed. Japan has a dynamic and technologically advanced rare earth industry that uses rare earth products in various applications. In Europe, there is one manufacturer of rare earth metals for magnets destined mainly for the automotive industry and for power generation. In North America, the rare earth industry has disappeared over the past 20 years as it migrated to China.
- The production of REE:** Today, China produces about 95% of all rare earth worldwide supply. One company in Malaysia, Lynas, produces rare earth oxides with ore from Australia.
- Significant mineral resources have been identified in Australia, Canada, Brazil, South Africa, Greenland and other places around the world. These resources differ widely in concentration of rare earth, in distribution of heavy and light rare earth elements and in mineralogy. The mineralogy determines the effort and cost to extract the rare earth elements from the gangue and the environmental impact of the processing. The composition and the ratio of heavy and light REE determine the value of the production.
- How are rare earth extracted in China today?** The most significant source of rare earth in China is the ionic clays in the southern regions. The unregulated and mostly illegal extraction of REE is known to cause significant environmental pollution and is contaminating the water for millions of people.
- And what about the Quest mining approach?** The deposit at Quest's Strange Lake complex shows an exceptionally high content of valuable heavy rare earth in a granite rock matrix. Contrary to ionic clays, granite is inert and does not react with the acid used to extract the REE. Other deposits have a higher content of the low value light rare earth and the gangue also reacts with acid or caustic during processing resulting in excessively large quantities of process waste, which is not the case for Quest's eco-friendly Selective Thermal Sulphation process.