Rare elements from coal

A **rare-earth element** (**REE**) or **rare-earth metal** (**REM**), as defined by IUPAC, is one of a set of seventeen chemical elements in the periodic table, specifically the fifteen lanthanides, as well as scandium and yttrium. Scandium and yttrium are considered rare-earth elements because they tend to occur in the same ore deposits as the lanthanides and exhibit similar chemical properties. The 17 rare-earth elements are cerium (Ce), dysprosium (Dy), erbium (Er), europium (Eu), gadolinium (Gd), holmium (Ho), lanthanum (La), lutetium (Lu), neodymium (Nd), praseodymium (Pr), promethium (Pm), samarium (Sm), scandium (Sc), terbium (Tb), thulium (Tm), ytterbium (Yb), and yttrium (Y). Despite their name, rare-earth elements are – with the exception of the radioactive promethium – relatively plentiful in Earth's crust, with cerium being the 25th most abundant element at 68 parts per million, more abundant than copper. They are not especially rare, but they tend to occur together in nature and are difficult to separate from one another. However, because of their geochemical properties, rare-earth elements are typically dispersed and not often found concentrated as rare-earth minerals in economically exploitable ore deposits.

While comprising just 17 elements of the periodic table, the group known as rare earth elements (REEs) provides significant value to our national security, energy independence, environmental future, and economic growth. Currently greater than 90 percent of the world's REE production capacity is controlled by China (DiLallo, 2014[1]).

The World Trade Organization's recent report regarding China's actions related to the price and supply of certain REEs (World Trade Organization, 2014[2]) and the creation of the U.S. DOE's Critical Materials Institute funded in part by DOE's Office of Energy Efficiency and Renewable Energy provide evidence of the need for a new REE supply chain. As the pursuit of current and developing technologies in military, energy, and medical fields continues to expand, so does the need for a reliable and affordable domestic supply of REEs (Blunt, 2014[3]). By 2022, however, China's market share of REE production is anticipated to fall from 95% to 46% with around 25 new REE production projects under development, including 2 in the U.S. (Visiongain, 2012[4]).

A recent analysis of the economic importance of the REE industry in the U.S (American Chemistry Council, 2014[5]) indicated that:

- Intermediate products (magnets, catalysts, metallurgical additives, polishing powders, glass additives, ceramics, and batteries) delivered $39.2 billion in revenue.
- Intermediate products created 101,800 jobs generating $6.1 billion in payroll.
- End-market products/technologies (health care, hybrid electric vehicles, lighting, communication systems, audio equipment, defense technologies, optics, oil refining, and wind power) delivered $259.6 billion in revenue.

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1 DiLallo, M. (2014, January 12). *Investing commentary*. Retrieved September 9, 2014, from: http://www.fool.com/investing/general/2014/01/12/america-is-finally-waking-up-to-thefact-that-chin.aspx

2 World Trade Organization. (2014, August 7). *WTO>Trade Topics>Dispute Settlement> thedisputes> ds431*. Retrieved September 9, 2014, from World Trade Organization: http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds431_e.htm

3 Blunt, M. R. (2014, February 6). National Rare Earth Refinery Cooperative Act of 2014. *Senate Bill 2006, 113th congress, 2D session*

4 Visiongain. (2012). *The Rare Earth Market 2012-2022.* Retrieved from https://www.visiongain.com/Report/843/The-Rare-Earths-Market-2012-2022

5 American Chemistry Council. (2014, April). The Economic Benefit of the North American Rare Earths Industry. *Rare Earth Technology Alliance*. Retrieved from http://www.rareearthtechalliance.com/Resources/The-Economic-Benefits-of-the-North-American-Rare-Earths-Industry.pdf

- End-market products/technologies created 433,500 jobs generating $27.3 billion in payroll.

The REE value chain comprises many recovery and processing steps to produce high purity rare earth oxides that are subsequently offered for sale in the global marketplace. Few sources of REEs are in commercial operation today although approximately 25 new REE production projects are currently at different stages of pre-production development, in the U.S.

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