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Rare Earths – Brazil x China

Contrary to what may be suggested by the name, rare earths (RE) are neither earth nor rare. They were discovered by Gadolin only in 1794.[1] Their name came from the difficulty in separating the elements[2] between atomic numbers 57 and 71 (La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb e Lu), besides Sc (21) and Y (39).

The most abundant element, Ce, is as abundant as Zn and the least abundant one, Tm, as abundant as Ag. The average percentage of the RE occurrence in the Earth crust is about 0.01% and more than 250 mineral types containing them are cataloged, the great majority of them in low concentrations.

From those, the most commercially exploited ones are only three: monazite (phosphate), bastnasite (fluorocarbonate) and xenotime (phosphate). The first two are responsible for about 90% of the production and contain mainly light RE (La and Ce), the third one contains Y and the heavy RE.

The fact that they are inner transition elements, which actually form only trivalent íons with $5s^2$, $5p^6$ outermost electron shells and with little ionic radii difference, makes them to be always mixed up and so, difficult to separate.

In Brazil, their exploitation started in 1885 with the extraction of monazite from the Prado shores, in the Northeastern state of Bahia. Until 1896, they were freely used as ship ballast. In the following decades, the monazite ton was worth less than US$10. Their destination was Europe (Austria and Germany), where Th and Ce nitrates were used to produce incandescent gas mantles. But the extraction, purification and separation of high purity compounds are processes that require specialized technology and can cause serious environmental damage.

In the 50's, Brazil, through ORQUIMA,[3] a private company, dominated the whole process and managed to obtain quite pure oxides (99.9 - 99.99%), having even exported Eu_2O_3 for the production of metallic bars to control by neutron absorption the reactor of the world's first nuclear submarine, the Nautilus.

In 1962, as an intern at ORQUIMA, along with Pawel Krumholz, we produced ten grams of Lu_2O_3 (> 99.9%), the largest amount of such compound ever produced in the world!

The company, which came to process up to 2 thousand tons of monazite a year (extracted from Espírito Santo and Rio de Janeiro shores) was nationalized in the early 60's and obsoleted until it was restricted to only extracting the monazite and producing a low purity RE and CeO_2 concentrate, being the production practically disabled by the Nuclear Industries of Brazil (INB) in 2002. All technological and human resources investment was virtually lost and when the RE started to have greater added value in the 70's and 80's, especially with phosphors and magnets, Brazil had no market competitiveness anymore.

China, holding the largest world reserves (more than 60% of a total of 150 million tons), has invested in all stages of the processes, from the extraction to the production of high elemental purity compounds (> 99.99%).

Monazitic sand (monazite, zircon, ilmenite and rutile) can be concentrated into monazite by gravitational and electromagnetic processes, used in Brazil since the beginning of last century. In the largest deposits of China (Bayanebo, Inner Mongolia), an intimate mixture of monazite and bastnasite together with other minerals (Fe, Nb, etc.) occurs.

Since the 50's, the Chinese have been investing in extraction processes that involve chemical agents (such as hydroxamic acid derivatives) in careful flotation systems interspersed with electromagnetic procedures.[4]

In 1990, the world production was approximately 25 thousand tons and China accounted for less than half. However, the low cost of the RE produced by China since the 90's and a greater environmental control made producers from countries like the United States, Australia and Canada close down all their activities at the end of last century and the beginning of the current one.

At first, at low cost and with no environmental concern, China has come to dominate the market

for these twenty years and currently sells over 97% of the RE compounds (mainly oxides and metals),[5] but the growing domestic demand (over 70% of its production) caused by the mastering of the technologies that enabled the manufacturing of final products (wind turbines, phosphors, batteries, etc.) and the environmental constraints have made China raise the average price of RE more than ten times in the last two years. And not only raised the price, but also established exportation quotas for oxides and metals.

The main RE importers, Japan and the United States, together with other countries, including Brazil, have initially tried more favorable trade agreements while, in the meantime, they started internal management to resume their RE production.

The world consumption of RE was, in 2010, approximately 125 thousand tons and is growing 5 to 10% a year. It is estimated that it would take at least two years for the countries that have already started the process of resuming production (USA – 19 thousand tons in Mountain Pass; Australia – 22 thousand tons in Mount Weld) to somewhat mitigate the situation.

In Brazil, scientists at the 4th National Meeting on Rare Earths, held in Aracaju (Northeast of Brazil), in April 2010, submitted a letter to the Minister of Science and Technology warning about the necessity of resuming the production of rare earths. In response, the Work Group on Strategic Minerals, related to the Ministry of Mines and Energy (MME) and the Ministry of Science and Technology (MCT) was created (614/2010 joint Decree, issued on June 30, 2010). After several meetings with representatives of governmental agencies and universities, in November 2010, that group produced a draft on the situation, suggesting to both Ministers measures to be taken.

After all, why has the demand for rare earths grown so much in recent decades? What are they useful for nowadays?

Much of their use in Brazil is concentrated on the formulation of Ce- and -La-based catalysts for oil processing. The FCCSA, a catalyst factory in Rio de Janeiro, which imports 900 tons of La_2O_3 from China every year, is concerned about the increasing supply difficulty. But the rare earths are also used in the super magnet technology: Nd, Tb and Dy, for lighting and displays: Eu, Tb and Y. The RE are also the raw materials for wind turbines, hybrid vehicles (the Toyota Prius uses about 10 kg of RE), optical fibers, etc.

The total recognized Brazilian reserves reach only about 50 thousand tons, but if one considers the lower-level deposits (approximately 10%), such as the Catalão one, in Goiás (central Brazil), which requires new techniques for extraction, the estimated value soars to nearly five million tons! So, the question to be asked is: will Brazil accept the challenge of exploiting the RE ores in an environmentally sustainable way and of developing the required technologies to get to high added-value commercial products or will it go on importing such commodities and products from China, USA, Japan and other countries?

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