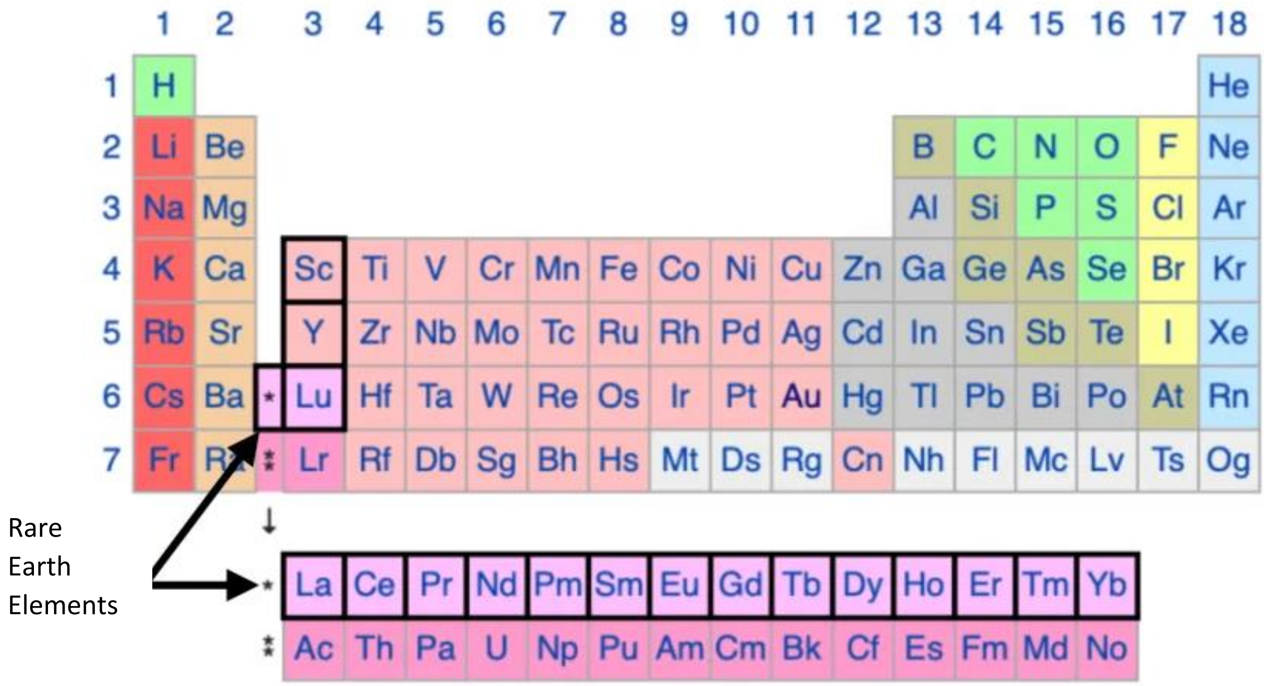
RARE-EARTH ELEMENTS

Rare earth elements, not that rare

Rare earths are a group of chemical elements belonging to the lanthanide group to which it is common to add two more, yttrium and scandium.



From a chemical standpoint, the lanthanides are characterised by atomic numbers between 57 and 71 (from Lanthanum to Lutetium). Due to their proximity in the periodic table, these 17 elements share exceptional physical and chemical properties which make them indispensable for the development of current technologies, particularly those of the energy transition (wind turbines, photovoltaic panels).

While these chemical elements correspond to the strict denomination of 'rare earths', we have decided to add certain metals whose geological abundance is limited and whose supply is described as critical by the European Commission. Thus, vanadium, germanium, gallium and tungsten can legitimately be considered as rare metals.

Contrary to what their name suggests, 'rare earths' are relatively abundant. Geologists estimate their content at 0.08% in the earth's crust. By comparison, gold and silver, which are not considered rare metals, have a crustal abundance of 0.004 ppm and 0.075 ppm respectively, while lanthanum is at 39 ppm and vanadium at 120 ppm.

The adjective 'rare' actually reflects the economic stakes that these chemical elements represent in the face of the low volumes that are available on the market.

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https://eduscol.education.fr/sti/articles/terres-rares-energies-renouvelables-et-stockage-denergie

https://rmis.jrc.ec.europa.eu/

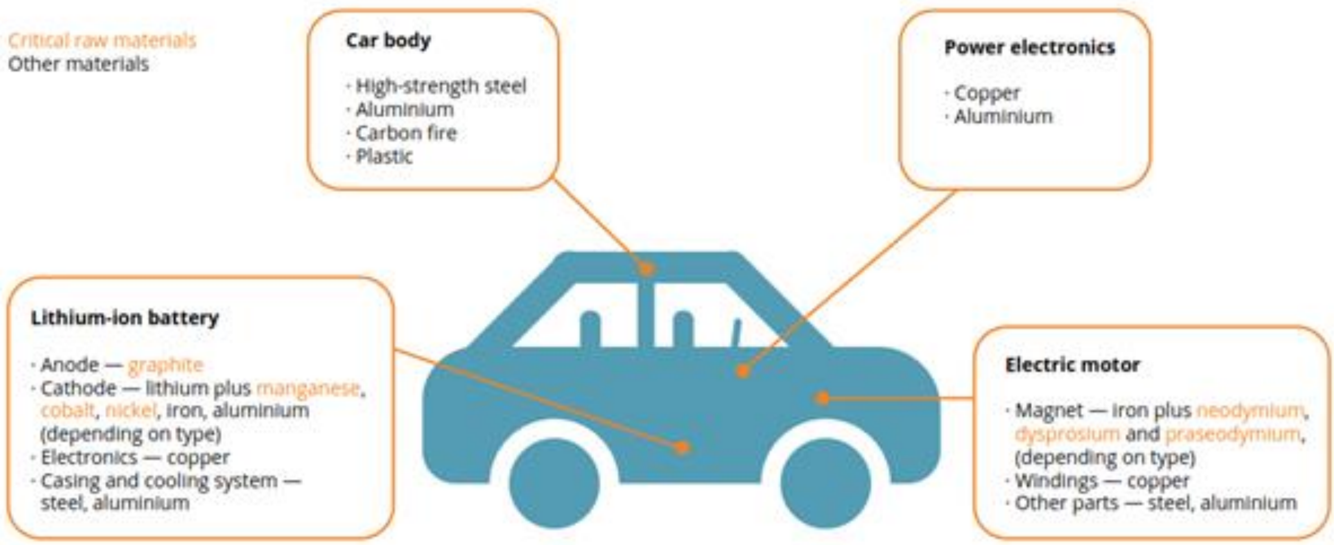
Geological deposits and industrial processes

But let's go back to their geological origin. Like most metals used by humans for thousands of years, rare earths occur naturally in the form of ores with exotic names, such as Bastnaesite, Monazite, or Loparite. It was the Swedish chemist Carl Axel Arrhenius who, in 1787, discovered the first ore containing a rare earth near Ytterby, Sweden, whose name recalls its origin: Yttrium. However, it was not until the 1950s that efficient extraction processes were developed, making it possible to use these materials with exceptional properties on an industrial scale two decades later.

Today, China is the world's leading producer of rare earths: approximately 140,000 tonnes were produced in 2020, which represents 58% of world production. The rest of the production is divided between 4 countries: the United States (15%), Myanmar (12%), Australia (7%) and Madagascar (3%)

The strategic and geopolitical stakes linked to rare earths and rare metals can be understood in the light of their use in all advanced technological fields and particularly in green technology and digital technology.

No electric or hybrid car battery could exist without the 12 to 15 kg of rare earths (cerium, lanthanum, praseodymium) it contains. The LED, LCD and plasma screens that fill our homes all depend on these materials with their exceptional optical properties (Europium; Terbium). Wind turbine generators only produce electricity thanks to the magnetic qualities of Neodymium. An almost endless list of uses for these chemical elements.



Human ingenuity had exploited 7 metals from its origins until the Renaissance, and 20 or so by the 1970s. Almost all of the 86 metals in the periodic table are now found in human creations

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G. Pitron, La guerre des Métaux rares, ed.Les Liens Qui Libèrent – oct 2019 ISBN 979-10-209-0717-2).

« Electric vehicles from life cycle and circular economy perspectives -EEA Report No 13/2018 -ISSN 1977-8449

The environmental impact of rare earth elements

We have just looked at the geological and physico-chemical characteristics of these elements, which are now essential for a successful energy transition. In a global approach, it is necessary to consider the ecological aspects of the extraction and uses of these rare elements.

Obtaining rare earths for industrial use follows a 4-step process: Mining, cracking, separation of rare earth oxides and finally reduction of the oxides to usable rare earths.

Each of the 4 stages generates a significant environmental impact, notably due to the systematic use of solvents at each stage of the industrial process.

Rare earths are mainly mined in China where regulations are often less strict than in Europe. The 2010 tragedy in Fujian province illustrates the devastating consequences of copper and gallium mining: massive pollution of the Ting River, destruction of aquatic life, pollution of surface water and agricultural land, and an explosion in cancer rates.

Without going into detail about the other stages of the industrial process that can produce numerous polluting wastes, we will refer to a report carried out in the framework of the EuRARE project of the European Commission in 2014 that reports on the conditions of exploitation of the largest rare earths mining site in the world: Bayan Obo, in Inner Mongolia in China ;

This appalling report emphasises the radioactive nature of certain compounds naturally associated with the rare earths mined, such as thorium 232, which is responsible for the irradiation of 3,000 of the 7,000 workers. In addition, the dust generated by the mining activity, which is also radioactive, contaminates the local population and agricultural land.

Given the extent of the pollution caused by the extraction and refining of rare earths, it is urgent to introduce binding environmental standards.

Another way forward is the recycling of rare earths at the end of the life of products containing these materials. This is obviously an absolute necessity. However, a recent paper entitled "Recycling of the Rare Earth Elements" published in March 2018 by S Jowitt, T. Werner, ZWeng, G Mudd states that only about 1% of rare earths are recycled at the end of their life, with the rest joining the huge mountain of industrial waste.... Of course, this currently low rate may increase in the years to come, but it is unlikely to meet the predicted increase in demand for these same materials.

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https://www.researchgate.net/publication/276042623_Social_and_Environmental_Impact_of_the_Rare_Earth_Industries

https://www.theguardian.com/environment/2011/apr/14/toxic-mine-spill-chinese-pollution

http://www.eurare.org/docs/internalGuidanceReport.pdf

https://doi.org/10.1016/j.cogsc.2018.02.008