What is meant by the term "critical raw materials"?

Europe is almost entirely dependent on ore imports as primary raw materials for many raw materials that are particularly important for digitalisation and electromobility (EC, 2020). There is a lack of economically viable sources of its own.

The European Commission has been regularly publishing assessments of non-energy and non-agricultural resources under the concept of critical raw materials since 2011. In 2020, 30 currently critical raw materials were again identified. For them, the risk of a supply shortage and its consequences for the economy are greater for the EU than for other raw materials (EC, 2020).

Tab.1: Reasons for classification as a critical raw material (based on: European Commission 2020b; Furze & Harrison 2021)

Reasons for criticality	Example	Use
low occurrence in the earth's crust	platinum group elements	Automotive catalysts
difficulty / expensive in gaining	rare earth elements	any electronic device, renewable energy applications
dangerous gain	Lanthane	petroleum refining, hybrid cars
environmentally harmful during extraction	Bauxite (Al)	Construction of vehicles and aircraft
gain as a byproduct	Gallium	semiconductors used in microchips
supply shortage and conflict mining	Cobalt, Phosphate rock	
import dependency	Natural rubber	Li-Ion batteries, Fertilizer
difficult recycling	Scandium	H_2-fuel cells in electric vehicles

The list of critical raw materials will become a central and evidence-based element of policy-making in the EU. This means that it will be taken into account in the negotiation of trade agreements as well as in the elimination of trade distortions. Industrial policy investment needs will also be identified on its basis to guide research and innovation (e.g. EU funding programmes such as Horizon 2020) that bring to market discoveries and application novelties from the research areas of mining technology, substitution and recycling. In addition to promoting sustainable and responsible procurement, advances in the circular economy with high-quality recycling and use without harmful impacts are particularly important now and in the future (Friege, Kummer, Steinhäuser, Wuttke & Zeschmar-Lahl 2019, European Commission 2020c)).

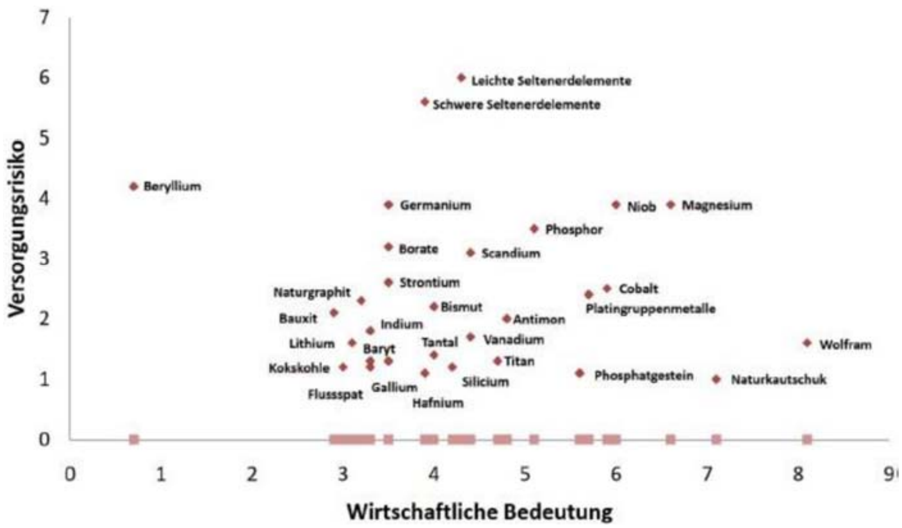


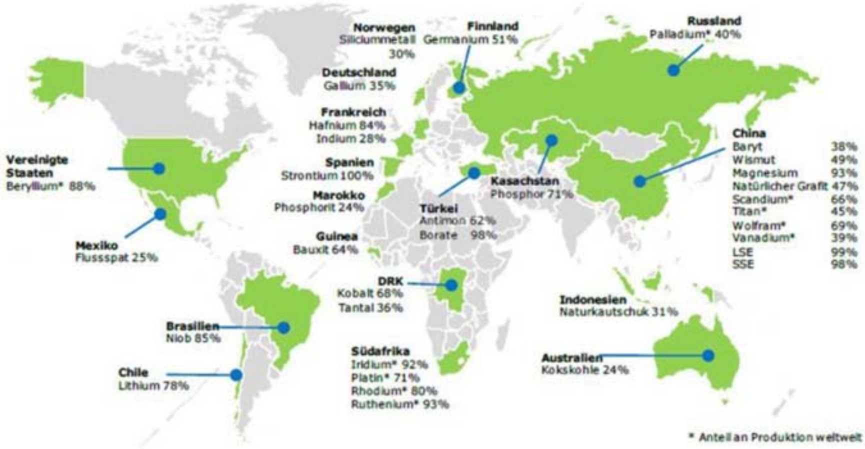
Fig. 1: Classification as critical raw materials according to EI and SR (based on: European Commission 2020a, p. 29)

For the deepening of the topic in school and study, the digital teaching-learning offer "Critical raw materials in chemistry lessons" by Jana-Christin Bütow (Master Thesis) in a double lesson on the background, conditions and criticality of raw materials. The prerequisite for this is the installation of the open source H5P https://h5p.org/.

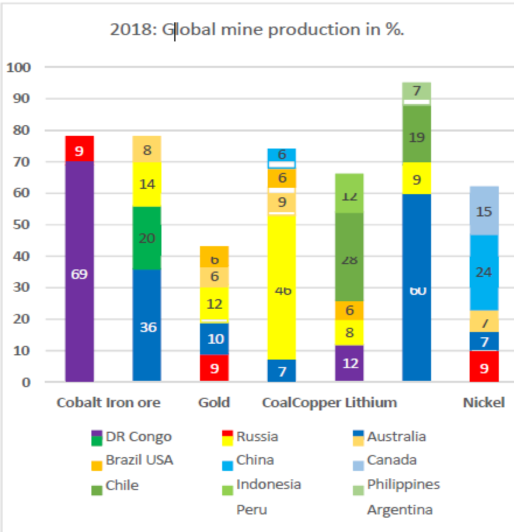
Where are the world's raw material reserves stored and what quantities are extracted?

The best-known example is the light and heavy rare earth elements, which are at the top of the EU's list of critical raw materials published every three years in terms of supply risk (EC 2020). Although some of these rare earth elements are not that rare on Earth in quantitative terms, they are only found in a few economically viable sources - primarily in China and Inner Mongolia. Another well-known example are the platinum group metals (palladium, platinum, rhodium, ruthenium, iridium), which are indeed very rare; for platinum, there are about only 0.0005 ppm in the upper crust (Zientek et al. 2017).

Figure 2: Main countries supplying critical raw materials to the EU Source: European Commission Criticality Assessment Report 2020



- China is often cited here as the most influential country for the global supply of many critical raw materials, e.g. rare earth elements, magnesium, tungsten, antimony, gallium and germanium.
- Other countries dominate supply in other areas, such as Brazil (niobium) or the USA (beryllium and helium). Platinum group metals are concentrated in Russia (palladium) and South Africa (iridium, platinum, rhodium and ruthenium).
- The largest share of global lithium reserves - cumulatively about three quarters - is located in Australia and Chile. The light metal lithium is extracted from solid rock in mines as well as from brine, especially in South American desert regions. Chile currently accounts for 44% of global production; the EU covers 78% of its lithium requirements from Chile.
- Cobalt occurs naturally in larger quantities in only a few countries. The largest share of the world's cobalt reserves - just under two-thirds - is found in the DR Congo. However, Russia and Cuba also produce a relatively large amount of cobalt, depending on the cobalt in line with the available reserves. In addition, there are potential reserves of strategic raw materials in the deep sea as a component of manganese nodules.



Tab.2: Aggregated data of the leading mining companies worldwide by market capitalization (based on: US Geological Survey 2022)

So there are not just 30, but actually well over 40 raw materials with critical supply status. In addition to the risks associated with supply, in many cases critical raw materials are not at all or only with difficulty substitutable in their areas of application and their recovery rates are insufficient. Also, since May 2017, there has been an EU regulation on the handling of minerals from conflict zones, which will come into force at the beginning of 2021. This is intended to create a system for due diligence in the supply chain. The possibilities for armed groups and security forces to trade in tin, tantalum, tungsten or gold or the corresponding ores are to be restricted.

Efficient circular economy to open up the secondary market

In order to avoid dependence on individual states for the availability of raw materials, alternatives to raw material extraction are necessary. One source of some of these critical raw materials that has been insufficiently tapped to date would be the consistent recycling of electronic waste - especially in times of increasing digitalisation of the economy, mobility or education.

In 2019, the share of secondary raw materials (scrap, used metal) in the production of copper in Germany was around 44 %, of aluminium just under 58 % and for crude steel 44.6 %. The recycling rate for gold is currently 25 %.

The recycling rate for electronic waste in Germany was around 40 % in 2018. This puts Germany only in the lower midfield in a comparison of EU countries. Croatia (83 %) and Bulgaria (69 %) do much better. The recycling of cobalt, nickel and lithium from batteries of electronic products such as smartphones or notebooks and especially from large battery cells - the batteries of electric cars - is the most important option. At present, however, these processes are not yet economically viable for lithium. In addition, material losses in metallurgy limit recycling in a natural way. For this reason, research is already being conducted into new types of batteries that use alternative raw materials such as sodium - so-called "**post-lithium batteries**".

The recycling of rare earths from e-waste is expensive due to the small quantity in which they are used. Yields are only below 1% (European Commission 2020b, p. 560; Umbach 2019). Approximately 77% of all raw materials on the list are recycled only 10% of the time (Furze & Harrison 2021, p. 4). These quantities add up to an estimated 1.2 billion tonnes of electronic waste ending up in landfills in 2018.

Circular economy - holistically integrated production and recycling processes for raw materials and materials.
Metallurgical total of processes for the primary or recovery of metals.
Reserves-Currently economically recoverable raw material deposits.
Resources-Potentially extractable raw material deposits in the future, currently not economically or technically extractable.
Key technology-Technology that accounts for a growing share of value creation within production.
Strategic raw material-Cobalt, lithium, tungsten and tantalum are regarded as necessary raw materials for the manufacture of innovative products and technologies by important industries in Germany, such as the automotive and electrical industries.

Sources and literature

• Statista dossier on tablets https://de.statista.com/statistik/studie/id/6247/dokument/tablets-statista-dossier/ retrieved 26.7.2021
• EU critical raw materials CELEX 52020DC0474 EN TXT - https://eur-lex.europa.eu/legal-content/DE/TXT/PDF/?uri=CELEX:52020DC0 retrieved 26.7.2021
• Hohmann, M. (2018) Statista study_id64582_raw-materials-for-key-technologies at www.statista.com retrieved 1.3.2022
• U.S. Geological Survey, 2022, Mineral commodity summaries 2022: U.S. Geological Survey, Reston, Virginia: 2022; 202 p., ISBN 978-1-4113-4434-1 https://doi.org/10.3133/mcs2022. retrieved 3/1/2022.
• EuroGeoSurvey (EGS) and the Mineral Resources Expert Group; Cassard, D. et al. (2015) A Note on the map of Critical Raw Material deposits of Europe. Version. 3, Brussel, https://www.eurogeosurveys.org/wp-content/uploads/2016/04/CRM-MAP-FINAL_HQ-F.pdf retrieved 1.3.2022
• Bütow, J.C. (2022) A digital learning environment on critical raw materials in chemistry education, Master thesis, University of Bremen.