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"Raw Materials for Future Energy Supply"

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Introduction

"Raw Materials for Future Energy Supply" was published by Springer in 2016 and translated from German in 2019. It is part of the published series 'Energy systems of the Future' by a collaboration of German scientific academies: acatech-National Academy of Science and Engineering, Munich, Germany; Leopoldina National Academy of Sciences, Halle (Salle), Germany and the Union of the German Academies of Sciences and Humanities, Mainz, Germany. The book delves into the future supply of raw materials as a consequence of society, addressing primary and secondary resources and resource substitution. Discussions involve not only the technical details but also socioeconomic and ethical points of view. The energy sector is still a long way from being climate neutral, with many countries (especially Germany which is the focus of this book) pushing ahead with the development of new energy technologies. Emerging technologies create an increased demand for raw materials which in turn puts pressure on natural resources. This book targets anyone interested in the future raw material supply and how this interlinks with the development of renewable energies.

Fundamentals

Chapter 1 defines the changes that need to be made to minimise the environmental pollution and pollutants that originate from human activity. The authors determined that the emissions of carbon dioxide need to be reduced as quickly as possible, by moving away from the traditional methods of combustion of crude oil, natural gas and coal. As new technologies emerge for generating and storing energy, the demand for raw materials will also alter (increasing the use of metals, while decreasing our reliance on fossil fuels).

The fundamentals of natural resources are defined in Chapter 2 with the different classifications of natural resources available. It describes the differences between renewable and non-renewable materials, providing insights into materials that are not necessarily renewable but can still be recycled, such as metals. Many of the technology metals have only been used industrially during the last few decades. This is shown in **Figure 1** where the number of chemical elements used by a steam engine, compared to modern solar technologies is significantly different.

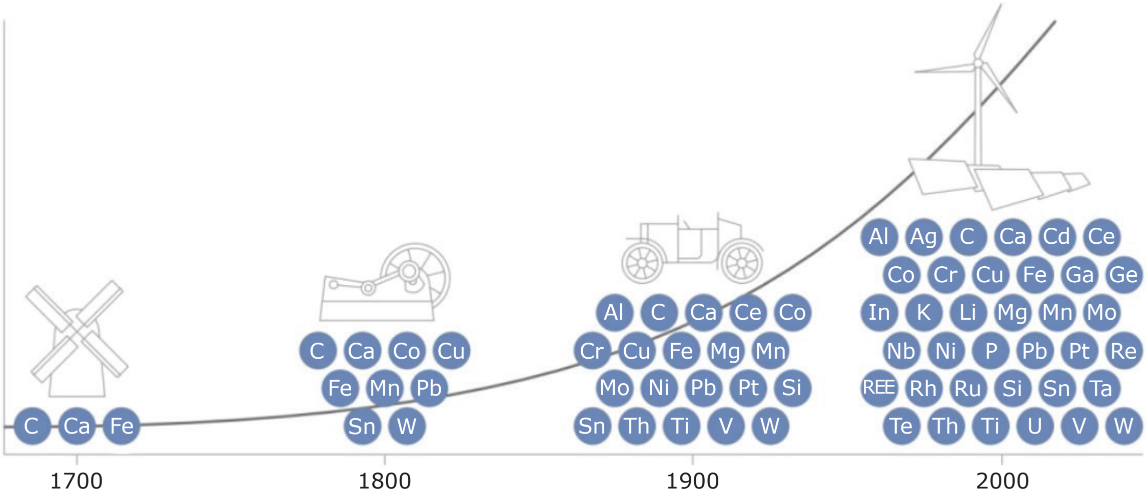

Fig. 1. The technology-related application of various elements with time (1). Copyright University of Augsburg, Germany. Reproduced with permission

The exploitation of minerals is categorised into reserves (mineral deposits that could be exploited economically with current available technology), resources (known deposits that cannot currently be exploited economically) and geopotential (occurrences and deposits that have not yet been identified). The link between these categories and consumption is discussed, looking at critical raw materials and those of strategic economic importance. Currently it has been determined that there is a sufficient supply of raw materials to meet the current demands, but market conditions can result either in short term shortages or increases in the price of the metal or mineral. When there is a shortage of a raw material, both the supply and demand side generally react. On the supply side more efficient recycling routes are often determined, while on the demand side there is a more economical use of the relevant natural resource.

Key to understanding which raw materials could be utilised in future energy systems is understanding the availability of these materials and extrapolating the information over the years to come. Political situations can also affect the supply of a material affecting whether it is classed as critical. Examples of this have been shown in Chapter 2, comparing reports compiled by different countries on the supply risk of manganese. The European Union (EU) classes the supply risk as low, due to the mine being controlled by a French company, whilst the USA classes the supply of Mn as high risk.

The information in these two chapters provides a good insight into the classification of raw materials, the terminology used when discussing the raw material market and understanding of the supply chain. It gives a flavour for how shifts in availability, cost and political situations can affect the supply chain. Though much of the information could be classed as common sense when thinking about topics individually, the detail compiled in this chapter helps tie it all together into one large picture.

Supply of Raw Materials and Effects of the Global Economy

The availability of raw materials is influenced not only by supply but also demand. Both are dependent on developments in mining and processing industries, global economy, environmental impact and political situations. Chapter 3 is the longest section in this book, delving into the analysis of the supply of raw materials. This chapter covers a range of topics from exploration and exploitation, price setting and understanding the demand for the materials, but for me some of the key points were:

- The social and environmental impact on the availability of raw materials
- Utilisation of renewable energies during the mining and processing of ores
- The available supply of secondary resources
- Technological advances, improving the supply of both primary and secondary resources.

For consumers, the application of raw materials is no longer well defined as the use of components in products is often complex. For example, the general public will recognise industrial products such as televisions, smartphones or electric vehicles, but will not always understand the raw materials that have been used during production.

One of the sub-chapters discusses how mineral exploitation in countries that are industrially advanced is a seemingly normal service industry that does not relate to technological progress. Whereas the indigenous populations of countries where the mining occurs can suffer serious consequences such as forced acquisition of their land and resettling. There can also be an impact on the landscape depending on whether the mine is based underground or a surface opening pit. The underground mine generally requires relatively small areas on the surface operating with minimal impact on the local environment. An open pit can cause vast changes to the landscape, villages may need relocating and the required surface areas may not be available for other uses for decades. To minimise both the social and environmental impact high standards need to be implemented, with industry taking responsibility for where the raw materials are sourced. Accountability should continue down the chain to the end user (customer). This chapter provides a really good insight into how these social and environmental factors can impact the supply chain for raw materials.

Another aspect considered in Chapter 3 is the processing of the mined ores, as both (fresh) water and energy are needed to process the materials. However, the availability of water is considered in some countries to be one of the limiting factors for the future supply of some natural materials. Some areas containing arid or semi-arid regions are using salt water but converting it into fresh water consumes large amounts of energy during the process. As salt water is found in numerous locations, the question surrounding the sufficient supply of water for mining and processing activities can be turned into a question regarding the supply of sustainable and sufficient energy. Research completed by the consortium has determined the energy needed during the mining and processing of the ores (along with social and political issues) is the most critical factor affecting the supply of raw materials. Therefore, with respect to the raw material requirements for 'green technologies' a sustainable approach to the water and energy supply for mineral exploitation is a central challenge for the future and could potentially mean a transition to renewable energy technologies.

It is important to note that so far, we have only discussed primary resources of raw materials, sourced by the mining of mineral resources from the geosphere, the portion that includes the Earth's interior, rocks and minerals, landforms and the processes that shape the Earth's surface. This chapter opens up the topic of recycling from the technosphere (all of the technological objects manufactured by humans) to supplement supplies. The technosphere still needs much development to reach its potential, it is unlikely to meet the full demands as they are always increasing. Germany has set up the German Mineral Resources Agency (DERA) to monitor critical raw materials and regularly report on the availability of natural resources that are critical to the German industry. The UK is also monitoring critical raw materials with the UK Government asking for reports from the Foresight Future of Manufacturing Project (reports available online). Industries need to secure their supply of raw materials, react to warning signals when necessary and outline alternative strategies which could involve substitution of raw materials (direct substitution) or technologies (technological substitution). The German government plays an active role in concluding trade agreements, subsidising research and financial guarantees.

It becomes clear through reading Chapter 3 that the supply of raw materials is vital but has many complicated issues that need to be considered. Though we often deliberate the here and now, we also need to consider the future and how the supply will change in terms of new technologies developed and availability (resources and geopotential). Increases in the efficiency of exploration, production and processing all lead to an enhanced availability of natural resources. Areas that have been identified in this book that need further technical advances are penetration depths, precision and surface coverage of exploitation.

It was concluded that the geosphere and technosphere have sufficient potential to meet an increasing demand for resources until 2050. This is conditional on functioning markets, efficient and sustainable infrastructures as well as research and development.

Current Status of Natural Resources – An Overview

Germany is an important mining country and is the largest global producer of lignite (brown coal) and the fifth main producer of potash in the world. Chapter 4 looks at the supply of raw materials within Germany. It produces enough sand, gravel, kaolin and gypsum for its home market, but it is reliant on imports of mined metallic mineral resources. These are primarily chromite sourced from South Africa and Turkey, iron ores from Brazil, Canada and Sweden, germanium from China, Russia and the USA along with copper ores from Peru, Chile, Argentina and Brazil.

Chapter 4 also covers the use and demand for fossil fuels within Germany and how the needs will change as renewable energy becomes more prevalent. Energy storage is a key infrastructure that needs to be developed in parallel with renewable energy due to the fluctuating supply (for example solar and wind). Until then fossil fuels will continue to play a key role in Germany's energy supply. Biomass is another source that is utilised within Germany though it is currently only required for non-energy uses. The waste produced from the biomass has the potential to be used for energy generation. Bioenergy has the lowest energy efficiency compared to other renewable sources, contributing less to the reduction of greenhouse gases compared to wind and solar energy. The higher energy density and storability though are advantageous for its use either in transport or generating electricity during periods of calm winds or low solar radiation. The information in this chapter is focused around what Germany's needs are and though resources in the UK may differ, it gives a good insight into how the availability of different resources could affect the development of renewable energy sources in developed countries.

The Raw Material Requirements for Energy Systems

In a previous chapter the criticality of raw materials was discussed in respect to its supply, derived from the ratio of demand and supply of the raw material. By designating a raw material critical, precautionary measures can be implemented to ensure a reliable supply, avoiding irregularities and price peaks. Chapter 5 looks at the criticality ratio of raw materials in greater detail. Many metals (platinum group metals, indium, niobium, tungsten, gallium, Ge and tellurium) are classified as critical in their supply. The information from criticality studies can be used by governments, businesses and society to implement measures to ensure the supply of these raw materials. Current indications predict that lithium and Cu have no significant problems in their supply for the 'energy systems of the future'.

Summary and Opinions

The book description puts the target audience as "everyone interested in the future raw material supply", but the overall text contains a lot of technical information that can be difficult to follow and retain due to the structure of the sentences. This is due to the translation of the text from German to English, creating long and complicated sentences, taking longer to absorb the information in a section. The summaries at the end of some of the sub-chapters are fantastic for reviewing the information and highlighting the key facts. These provide a good outline for each chapter and are a good point to start before actually going into the details of the chapter.

This book highlights what a vast array of information is needed to piece together the information regarding the supply, demand and use of raw materials for the future. The consortium that came together to produce the research for this book have combined their knowledge to understand how the markets could change, what could affect them and the predictions that can be made.

Reference

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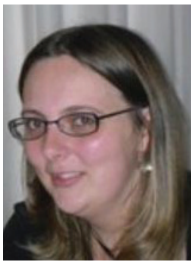

Jenny Mash received her PhD from the University of Surrey, UK, in the field of electrical energy storage, focusing on creating electrodes for use in supercapacitors. Since joining Johnson Matthey in 2012 she has gained experience working on a range of technologies in this field concentrating on polymer gel electrolytes, ink formulation, scale-up of electrodes and electrochemical analysis of electrodes for batteries and Li-ion capacitors. Currently Jenny works as a Senior Research Scientist in the Recycling and Separations Technology group, developing process models for battery recycling.

