Revista Ensayos Militares
vol. 6 - nº 1 - 2020, pp. 81-98

ISSN 0719-6334 / versión impresa
ISSN 0719-6989 / versión en línea

Mineral Resources from a Strategic Perspective

Recursos minerales desde una perspectiva estratégica

Juan Pablo Mardones*
Ingeniero civil metalurgista

Abstract: There exists at present a high demand for critical materials in several areas of human activity, such as consumption of electric vehicles and electronic devices, cutting-edge applications, emerging technologies, military development, and the transition to clean & renewable energies under fears of a wide impact due to climate change. Such is the case of a few minerals (for instance lithium, cobalt, rare earths, platinum and others) whose supply is stressed by resource availability, production capacity, economic conditions and market restrictions, among others; so becoming strategic minerals since are deemed essential but not found or produced domestically in sufficient quantity/quality. This document examines the concepts of strategic minerals and resource scarcity within a strategic environment setting, and presents several indicators for assessment in the physical, economical and geopolitical dimensions.

Key words: Strategic minerals – Resource scarcity – Energy transition.

Resumen: Existe actualmente una gran demanda por materiales críticos en diversas áreas de la actividad humana, como son el consumo de vehículos eléctricos y dispositivos electrónicos, aplicaciones de vanguardia, tecnologías emergentes, desarrollo militar, y en la transición hoy hacia energías limpias y renovables en un contexto de incertidumbre y temor ante los impactos del cambio climático. Este es el caso de ciertos minerales (por ejemplo litio, cobalto, tierras raras, platino y otros) cuyo suministro se ve presionado por la disponibilidad de recursos minerales, capacidad de producción, condiciones económicas y restricciones de mercado, entre otras; transformándose, por tanto, en minerales estratégicos, porque son considerados esenciales pero no son producidos domésticamente en suficiente cantidad/calidad. Este documento aborda los conceptos de minerales estratégicos y escasez de recursos dentro de un ambiente estratégico, y presenta un número de indicadores para la apreciación de los mismos en las dimensiones física, económica y geopolítica.

Palabras claves: Minerales estratégicos – Escasez de recursos – Transición energética.

Fecha de recepción: 30 de julio de 2020
Fecha de aceptación y versión final: 4 de agosto de 2020

---

* Juan Pablo Mardones is a Metallurgist Engineer graduated from University of Concepción (Chile, 2007) and Université Laval (Canada, 2010) with professional experience in the public and private sectors of the mining and metallurgical industry. He holds a MSc degree in Engineering from Delft University of Technology (Netherlands, 2012) and a Master's degree in Military Sciences (Strategic Management) from the Chilean Army War College (Chile, 2019). E-mail: jumardones@udec.cl Telephone: +56 9 92252449

Introduction

In October 2017, Kazuo Ishiguro, the recipient of the Nobel Prize of Literature that year, stated when being notified of the honour that "*The world is in a very uncertain moment…at a very uncertain time*" (BBC, 2017).

Uncertainty is one of the inherent characteristics of any strategic environment, a milieu which the mineral resources sector is a fitting example of. Especially at a time when the centre of gravity of the international system is shifting and a new political and economic order is being sought.

Although the commodities business experiences cyclical phases, physical, economic, and geopolitical factors –external or internal, wide-ranging or focused, short-living or enduring, expected or not– all pose a number of variables that trigger changes in the mining activity, and all hold the quality of being dynamic at inconstant rates and interrelated at different degrees, or at least prone to be so.

The concept of strategic minerals has evolved in the last one hundred years hand in hand with human advance, by way of both progress and setbacks of society, from iron and coal in times of war and conflict, through the dependence on oil in all corners of the globe, to lithium and rare earths in innovative technological endeavours as the world undergoes an energy transition and faces climate change and environmental degradation.

This article approaches mineral resources from a strategic environment standpoint, resources that have been under stress in the recent past, that are being influenced today by market speculation and distortions on one hand and state policies on the other, and whose value chain is expected to remain pressured hereafter by global trends.

In perspective, the challenge of this era is to achieve economic growth and improve human development while succeeding in the global evolution to a cleaner and more sustainable energy with less mineral resources in a strategic environment.

As the astrophysicist Carl Sagan wrote in a book that won the Pulitzer Prize four decades ago, "*…mere critical thinking, without creative and intuitive insights, without the search for new patterns, is sterile and doomed*" (Sagan, 1977). Clausewitz would agree.

Strategic environment

A strategic environment consists of four distinct, interrelated parts (Guillot, 2003):

- National security
- Domestic
- Military
- International

Several features are common to these components: they include a number of factors and actors which are conceptualized in the political and military realms, and they are interrelated, complementary, and often contradictory.

Within the national sub-environment, for instance, national priorities, opportunities, potential threats and risks along with underlying assumptions must be considered; understanding it is the foundation for grasping the military background, particularly the balance between capabilities (means) and vulnerabilities, and also because military strategy follows directly from national security decisions and pronouncements. For its part, the international sub-environment is the most challenging and unfamiliar of the four: history, culture, geography, politics and foreign security have to be carefully well-thought out, especially the threats that may arise to the balance of power in the environment. All in all, the two greatest influences on strategic decisions come from the domestic and international sub-environments (Guillot, 2003).

Figure 1
The strategic environment

Source: Own elaboration.

The nature of the strategic environment is defined by two axes of action and four challenging, intrinsic characteristics. Irrespective of the situation, all decisions have **consequences**. Those made in a strategic scenario, still, are long-term planned because they involve high costs, which are measured not only in monetary terms but also in influence, and generate profound effects and implications due to their potential (latent or immediate) to create change and lead trends. Consequently, their repercussions (possible and probable; necessary and unwanted) must be critically analyzed and evaluated in advance.

Performance in a strategic environment requires conceptual analysis and must deal with: time horizon, which can extend from several years to even decades; power, since influence becomes more important than position (Jacobs, 2000); and focus, for it must be set in a two-way relationship between domestic and external sub-environments, particularly how the former can influence the latter.

Having framed its consequential and performance nature, four qualities are inherent to the strategic environment (Jacobs, 2000):

- **Volatility:** The world has changed in its structure since the Cold War and is no longer bipolar, the strategic landscape having become more volatile as conflict breaks forth in diverse fronts and for dissimilar reasons, not a few times unexpectedly. The dual challenge is to anticipate scenarios and take **action**, **consequently**.
- **Uncertainty:** This is the deceptive characteristic of the strategic environment. Intentions of competitors are not known; they run like a surreptitious **flow** behind official statements and activities, deliberately. Information becomes a key element: at different times, the actual meaning of truthful data will be called into question and put to the test. The challenge is to penetrate the fog of uncertainty that **floods** the environment.
- **Complexity:** This is the most challenging characteristic. Complexity is generated by the dynamic interdependence of the components of the environment, whose understanding constitutes the first footstep to solve complexity. The effects (or **consequences**, as described above) of a decision can be forecast if patterns can appropriately be identified; integrative thinking is essential for this purpose so that a frame of reference can be configured. Thus the challenge is to recognize the impact

on the strategic environment that now has to be viewed instead as a **STRATEGIC SYSTEM**.

- **Ambiguity:** The origin of ambiguity is the natural existence of different viewpoints, interpretations and perceptions about the same piece of data. This is to be expected, making the frame of reference mentioned in the previous point needful. Uncertainty and complexity should have already been overcome, at least to a large degree. Yet it is this broad outlook the base for seeking novel ideas, solving problems creatively and building effective consensus in order to eliminate ambiguity and organize chaos.

Strategic minerals

As stated by David Haglund from Queen's University, Canada, 'strategic minerals' is to a certain extent an **AMBIGUOUS** term. Regardless of the context of usage, being it for scholarly or policy-making purposes in both domestic and international domains, the concept itself is interpreted differently (Haglund, 1984).

Even though the first explicit use of this notion was observed in the U.S. during the 1920s interwar years, the conceptual origin may be found in the course of World War I in Europe, when the 'war of attrition' depended severely on a **continuous supply** of essential industrial materials in order to sustain the military capabilities, as was the case of iron ore and coal, steel, and soon after petroleum.

The label of those minerals would change in the coming decades and strongly influence the current notion to the following:

- **Strategic materials:** essential for defence; fully or mainly supplied from foreign sources; subject to strict conservation and control.
- **Critical materials:** essential for defence; lower degree of challenging supply than strategic materials.

Parameters like adequate quantity and appropriate quality along with stocking-time uncertainty are also taken into account for this labelling.

In general, strategic minerals can be identified as those looked-for to supply the military, industrial and essential civilian necessities in the long term but not found or produced domestically in sufficient quantity and/or quality to meet such needs. This concept is applied at present to a handful of commodities, such as lithium, cobalt, rare earths[1] and the platinum group[2] metals for instance, a matter that will be approached later.

One point of policy discussion (not studied here but declared as relevant) concerns that this categorization might induce the perception that availability and accessibility of minerals are vulnerable, implying that more powerful international actors could establish expensive strategies to guarantee that "continuous supply".

Another point of interest is that the tagging of being 'essential for defence' takes the concept towards the question of national security, which has transitioned from a 'physical' security of strategic minerals last century to a more 'economic' security in our time (Haglund, 1984). However, the fine balance between physical and economic is not to be taken for granted lightly since it depends on a healthy economy.

On the other hand, the aspect of vulnerability has to do with how vulnerable a country (or actor) is to supply disruption and not directly with import dependence. In fact, a state is vulnerable to supply disruption according to some conditions, which include:

- Concentration degree of extraction/production of the mineral in question
- Identity, prestige and international status of the supplying countries
- Existence of alternative supply prospects (domestic and foreign)
- Opportunities for substitution
- Opportunities for recycling and conservation
- Existence of stockpiles in the consuming country

Thus, import dependence is necessary but not sufficient *per se* for determining whether a mineral is strategic or not, as an analysis of the conditions listed above is required for each individual case, particularly in terms of supply variability and state policies that may place disruptive tendencies.

VULNERABILITY to supply disturbances (*v.g.* shortage of production, disruption in the value chain, state interference, weather interruption) is not associated with all minerals, though the situation of rare earths for instance shows that the strategic resources concept must also include the interaction with market developments, business conditions, policy statements and regulatory frameworks. Nonetheless, criticality has to be understood as a

---

[1] REE: Rare Earth Elements, a collection of seventeen chemical elements.

[2] A group of six precious metals: ruthenium, rhodium, palladium, osmium, iridium and platinum.

function of the importance of the subject mineral to both the military and industrial welfare of a state for a certain horizon of time.

The definition of what a strategic mineral is will depend ultimately on the extent that supply & demand as a system is vulnerable, and it will vary from country to country, even among industries.

Summing up, strategic minerals are those deemed essential to the national security while being traded internationally to a significant degree.

Minerals scarcity

In flat words, the definition of scarcity relates to a situation in which something is not easy to find and obtain (Cambridge, 2019). The concept arises in any analysis of natural mineral resources and is dominated by the following straightforward paradigm: there exists a finite albeit not necessarily precise known amount of minerals on Earth, which are continuously being diminished by the human actions of extractive mining and cumulative consumption. The rate of depletion is thereupon determined by those rates of mining and consumption. It is in this context that the fear of scarcity appears when the stock of economically extractable material –mineral reserves– start approaching the exhaustion point (which could have been forecast ahead of time, or not) and production starts fighting to meet demand.

This model is known as the static scarcity paradigm, whose central notion is the static range, a forecast of the time frame left before exhaustion of a given mineral (HCSS, 2019).

The predicament then turns to determining that static range, a problem in principle calculable but one that bleakly suffers from two sources of **UNCERTAINTY**:

- Determining the course (rate) of future consumption: influenced by economic development, population growth, standard of living, society conditions and welfare, etc.
- Estimating the volume of reserves left: dependent on geo-mining technology improvements.

The solution to this paradigm lies in two actions that came into view in the previous page:

- Less and more efficient consumption by means of the 3Rs of Reducing, Reusing and Recycling (EPA, 2019) metals and mineral compounds will result in increasing the static range parameter (opportunities for recycling; opportunities for conservation).
- Substitution of minerals close to exhaustion with others more abundant will result in refreshing and updating the static rage indicator (opportunities for substitution).

The benefit of both set of engagements in plain words will be buying time. However, the reality of mineral scarcity is more **COMPLEX**: reserve levels have remained more or less stable in the last decades in spite of ongoing and constantly expanding production on one hand and the ongoing and constant exploration of new deposits resulting in many cases in new discoveries and subsequent mine operations on the other. Following this logic, those reserve levels should exhibit a negative trend since –on the paper– mine production depletes its associated 'finite' mineral reserve.

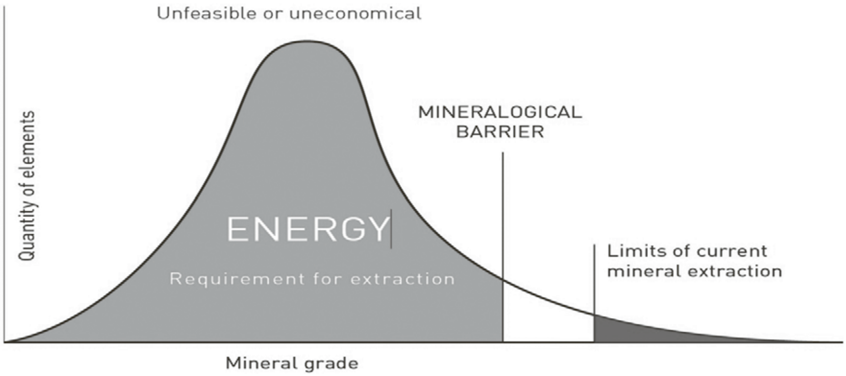
This behaviour is not explained by the static scarcity paradigm, mainly due to the second source of uncertainty referred to in the previous page, the estimation of the reserves: geological surveys conducted by national agencies and even exploration/mining companies produce data that does not report the 'absolute' amount of mineral resources available for extraction, needless to say on the planet, but only accounts those natural resources deemed profitable for extraction now or in the near future, a delineation dependent, in turn, on two conditions: profitable with existing production technology; profitable under current market environment.

These two conditions are dynamic: one positively dynamic in the long run as the human technological domain advances and adapts to challenges posed by new deposits and/or mineral characteristics, the other variably dynamic (in terms of variability) thanks to changing market forces, correspondingly.

The static scarcity paradigm described before has to be reinterpreted then as a dynamic-adaptive scarcity paradigm since the estimate of reserves left on the ground captures a dynamic equilibrium that continuously adapts in time to the two conditions aforementioned.

This reasoning confirms that scarcity of minerals is a complex phenomenon, one that does not suffice from simple flat definitions of scarcity, or shortages. In fact, elements and their occurring associated minerals are abundant on the Earth's crust. As an example, if annual world production increased so abruptly to the total sum in the last one hundred years, this outer layer of the globe would still contain enough aluminium for more than 50 billion years and gold for 5 million years. Yet, most of the about five thousand recognized minerals (Bressan, 2016) are too dispersed to be extracted at an industrial scale and mined mechanically: a threshold subsists between 'minerals too dispersed' and 'minerals concentrated and locatable for mining', the mineralogical barrier:

Figure 2
Overall distribution of elements on Earth and threshold between unfeasible/uneconomical and concentrated/locatable minerals



Source: HCSS, 2009.

Three basic conditions must be met in order to mine minerals practically and profitably:

- Mineral concentration (grade) must be sufficiently high
- Mineral volume (tonnage) must be sufficiently large
- Due accessibility to the deposit, horizontally (transport) and vertically (pit or underground)

Since the total amount of a metal element can so be considered as irrelevant for understanding mineral scarcity, then what matters is reserves, the array of accessible mineral bodies that can be mined in a technically and economically viable fashion under current conditions, from which follows that scarcity in the dynamic-adaptive paradigm is a matter of how scarce a mineral or metal is in the global market concert, or theater.

Adaptation to mineral scarcity, as in biology, is in some way a dynamic evolutionary process, within certain limits, and comes following this sequence:

1. Price of a scarce product rises, generally in a fast, swift way;
2. Consumers try to reduce consumption of those scarce –and now more expensive– products, meaning a falling demand;
3. The manufacturing industry substitutes those products with more abundant, less expensive goods, in order to keep selling;
4. Recycling then comes in;
5. Alternative materials are being developed almost simultaneously to 3, but it takes time;
6. The mining industry seizes the opportunity and start mining deposits formerly uneconomical;
7. Investments on exploration for finding new mineral deposits come in too;
8. Over time, 4, 5, 6, 7 will result in an increasing production, at different rates for each case, but positive as a whole;
9. The market system adapts and scarcity decreases.

Nevertheless, as brought up and implied above, adaptation to scarcity needs a relevant amount of time, like any adaptive process. Setting up new mining projects takes typically five to ten years, not including the stages of geological exploration. Substituting can also require long period phases due to research & development. Commodity prices respond to cycles, but may increase permanently in amplitude and affect structurally the dependence of society's wellbeing on scarce resources, access to materials, economic growth and technological breakthrough.

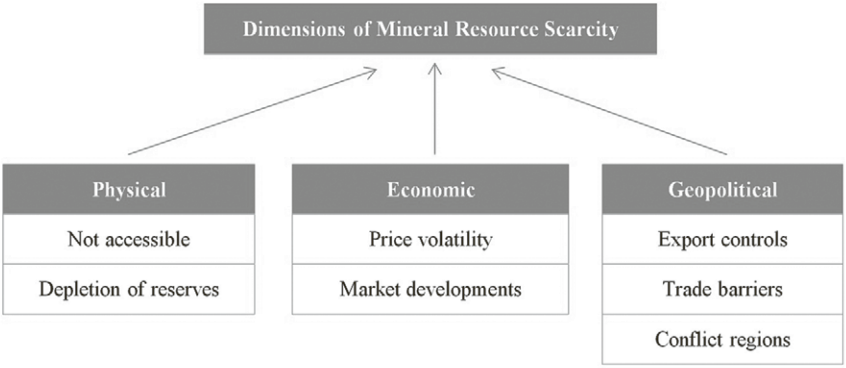
Taking into consideration what has been discussed up to here, the scarcity of mineral resources can be divided into three dimensions, which the enumerated key indicators per each dimension are suggested for in order to assess strategic minerals:

- **Physical:** There is a lack of the resource because either there is no access to its geographic location or mineral deposits have been depleted.
  1. *Amount of resources/reserves for current and future consumption*
  2. *Raw production of minerals for metal refining and further output*
  3. *Status of demand forecast*

- **Economic:** There are market fluctuations with high degrees of variation that may tend to increasing prices of mineral commodities.
  1. *Price level regarding average tendencies and historical weighing*
  2. *Degree of variation of observed market fluctuations*
  3. *Pressure exercised by challenges (to be discussed ahead) on demand*

- **Geopolitical:** State regulations may impose restriction on exports to foreign markets on grounds of policy or national security. Regions in conflict may also experience or create disruptions to production or supply due to political instability.
  1. *Export control on quantity and timeliness on delivering products (supply security)*
  2. *State-induced commercial restrictions translated into trade barriers (trade security)*
  3. *Instability and/or conflict in the productive region or along the transit zone of products (production security)*

Figure 3
Dimensions of mineral resource scarcity.



Source: Own elaboration.

Energy transition

The Paris Agreement on Climate Change adopted on December 12th, 2015 (United Nations, 2015a), along with the seventeen United Nations Sustainable Development Goals (SDG) set that same year (United Nations, 2015b), defined ambitious long-term goals for the 196 signatory countries[3] in order to limit the world temperature rise to 2 °C above pre-industrial levels, aiming at restraining the increase to 1.5 °C, so that risks and impacts on climate change can be reduced. Thereupon, transition from a high-carbon, greenhouse-gas-emissions economy towards renewable energy based on low-carbon technologies is forthwith essential for the successful implementation of the accord.

This international commitment will imply a major effect on the energy, mining and supply sectors (generation/transmission/transport) for both developed and developing countries, since a direct consequence will be an increase of world-wide demand for raw minerals and refined metal products, particularly strategic resources. For instance, one of the main conclusions of the Raw Materials Conference held two years later in 2017 in The Hague, Netherlands, established that "realizing energy transition requires large amounts of raw materials and a significant upscaling of mining activities" (HCSS, 2017).

Around 85 % of the world's electricity is produced from fossil fuels –carbon, petroleum, coal, natural gas– and power generation accounts for about 40 % of global carbon dioxide (CO_2) emissions (Kleijn *et al.*, 2011). Low-carbon technologies will play then a key role in this energy evolution, four of which have been regarded as priority areas for meeting renewable energy targets: wind, solar photovoltaic, electricity grid and bioenergy (biofuel). The following table lists some of the metals required for them:

---

[3] The U.S. is to withdraw in November 2020 under the Trump Administration.

Table 1
Metals required for renewable energy targets' priority areas, plus EVs

Technology	Metals requirement
Wind	REE, Manganese, Molybdenum, Nickel, Chromium, Copper
Solar photovoltaic	Tellurium, Indium, Tin, Silver, Cadmium, Copper, Lead, Silicon
Electricity grid	Copper, Lead
Bioenergy	Ruthenium, Cobalt
EVs	Batteries: Lithium, Cobalt; Permanent magnets: REE

Source: European Commission, 2018.

For example, wind power global capacity is expected to expand by 63 % in 2023 to 839 gigawatts (GW): a single wind turbine for offshore or on-shore use that generates 3 megawatts (MW) requires the following materials, among others (World Bank, 2017):

- 335 tons of steel (which is mainly based on iron)
- 3.6 tons of copper
- 3 tons of aluminium
- 2 tons of rare earth elements

Another example concerns the automotive sector: worldwide sales of electric vehicles (EVs) are expected to increase steadily from eleven million units in 2025 to thirty million units by 2030 (Soulopoulos, 2018), figures that could represent a 55 % share by 2040 if the tendency is extended to all commercial transportation –*v.g.* human, animal, goods transport– (BBVA Research, 2018). This forecast sets stress on the supply of three basic components of lithium-ion batteries used in EVs:

- Nickel
- Lithium
- Cobalt

These two examples service in visualizing that energy transition will put and is putting pressure on the availability and accessibility of raw materials and, as a self-evident result, will lead and is leading to an increase in the demand for such minerals. Three cases can be used to briefly illustrate this:

- **Lithium:** The share of demand for lithium to be used in the EVs production industry has moved from 20 % in 2014 to almost 50 % in 2018, and it could reach 90 % by 2030 (Morsy, 2018), implying an increase in the annual demand of lithium from 53 thousand metric tonnes in 2018 to almost 300 thousand by 2030 (Soulopoulos, 2018). The evidence shows that the market for EVs is growing, but the rapid increase raises concerns in terms of securing reliable supply chains and stable sourcing of lithium which experiences rigidities in the value chain.

- **Cobalt:** The stake of refined cobalt in EVs manufacturing moved from a mere single percentage unit in 2014 to 8 % in 2018 (just a four years span), and it could reach almost half the total cobalt market by the end of the next decade. In terms of demand, it is expected to consolidate firmly from the 123 thousand metric tonnes in 2018 to more than 350 thousand by 2030 (Soulopoulos, 2018). However, three sources of supply disruption can be identified:

i) A high degree of concentration in one single geographical source, the Democratic Republic of Congo, whose production accounts in the range of 55-60 % of all cobalt directed to further metallurgical refining;
ii) A significant amount of cobalt is not mined on its own but is recovered as a by-product during the metallurgical processing (extraction and refining) of other base metals, such as copper and nickel. Indeed, around 58 % of the world cobalt production comes from copper ores (Cobalt Institute, 2019a and 2019b) and 30 % from the mining of nickel. Hence, the supply of this commodity is in part limited to the economic behaviour of the host metal;
iii) Instability of the main producing country, DR Congo (Jäger and Zogg, 2019; Karacan, 2020): issues of internal violence, resource mismanagement, underdevelopment and land disputes, armed groups frequently crossing borders, among others.

- **Rare Earths:** Although relatively important deposits can be found presently in Australia and the U.S., China holds today the largest known mineral resources of REE in the world. Global reserves currently are estimated to be on the order of 116 million metric tonnes, and almost 40 % of them are situated in China (USGS, 2019c). Mine production in 2019 accounted for 213,000 metric tonnes, albeit undocumented production from China is not included in these numbers. Irrespective of that, China represents more than 60% of the world's production, patently dominating the market. From 2006 on, China has implemented exporting quotas of REE with the argument of resource conservation and environmental preservation while being criticized back of protectionism in disguise. Several countries, such as Japan, the U.S. and the European Union, have stated that that kind of restrictions is in violation of World Trade Organization's trade regulations (WTO, 2015). China even imposed an embargo on Japan in 2010 over a territorial dispute (Overland, 2019), a clear example of supply constraints within the geopolitical dimension, in which the risk of disruption increases as government interference emerges.

To sum up, several challenges can be identified within the frame of energy transition and minerals (HCSS, 2017), among which the following are highlighted:

- **Future demand:** Demand for minerals and metals is increasing as a result of energy transition; also, renewable technologies such as photovoltaics and wind power have a lower energy density (in fact, one order of magnitude less effective) than high-carbon technologies, resulting in larger volume requirements of minerals (Weißbach, 2013).

- **Future supply:** Minerals and materials are subject to limited supply or a high level of risk (HCSS, 2017; Vidal *et al.*, 2013); other factors include bottlenecks in production, transport costs, economic feasibility of mining (high energy requirements for extraction and processing) and metallurgy (refining efficiency).

- **Geographical distribution:** Mineral deposits are located in an uneven fashion; large suppliers of critical minerals are based in developing countries or nations in transition, such as Chile (lithium), China (REE), Democratic Republic of Congo (cobalt), as well as Brazil, Russia, South Africa (USGS, 2020a, 2020b, 2020c).

- **Energy and Mining:** Mining and metallurgical production of critical minerals needs to be scaled up significantly if the demand rise is to be met, but that production requires more and more energy; in 2013 already 10% of world energy consumption was used for extraction and processing of mineral resources (Vidal *et al.*, 2013).

Conclusions

Current global trends, such as demographic growth, shift in economic power, technology development and climate change, among others, are putting tremendous pressure in terms of demand and prices on several mineral resources.

A number of those, such as lithium, rare earths, cobalt, the platinum group, are identified as strategic minerals since are looked-for to supply the military, industrial and essential civilian necessities in the long term but not found or produced domestically in sufficient quantity and/or quality.

Nowadays, the supply of strategic minerals is experiencing stress to keep up with that demand, as the fear of mineral resource scarcity, a complex phenomenon of a dynamic equilibrium continuously adapting, is ever present due to concerns in the economic, physical and geopolitical dimensions.

It is the imbalance between growing demand and limited supply what constitutes the main challenge to mineral security, which is expected to remain in tension for decades to come.

The mineral resources sector has therefore to be understood as a strategic system.

Bibliography

BBVA Research. (2018, July 26). "Lithium and Cobalt. Same purpose, different paths". U.S. Economic Watch, BBVA Research, pp. 1-8.

Bressan, D. (2016, December 04). "What are the most common minerals on Earth?" Forbes, Science section, pp. 1-3.

Cobalt Institute. (2019a). "About Cobalt". Guildford, UK: Cobalt Institute Press.

Cobalt Institute. (2019b). "Manganese nodules and cobalt-rich crusts". Guildford, UK: Cobalt Institute Press.

"English Dictionary" (2019). Cambridge, UK: Cambridge University Press.

EPA Environmental Protection Agency of the U.S. (2019). "Reduce, Reuse, Recycle". Available at: https://www.epa.gov/recycle

European Commission. (2018). "Raw materials scoreboard". Brussels, Belgium: EC Press.

Guillot, M. (2003). "Strategic Leadership. Defining the Challenge". Air & Space Power Journal, Winter 2003 Edition, pp. 67-75.

HCSS The Hague Centre for Strategic Studies. (2009). "Scarcity of minerals". The Hague, Netherlands: HCSS Press.

HCSS The Hague Centre for Strategic Studies. (2017). "Policy paper: Energy transition and demand for raw materials". The Hague, Netherlands: HCSS Press.

Haglund, D. (1984). "Strategic minerals. A conceptual analysis". Resources Policy, 10, 146.

Jacobs, T. (2000). "Strategic leadership: The competitive edge". Fort Lesley J. McNair, Washington DC, U.S.: Industrial College of the Armed Forces.

Jäger, L. and Zogg, B. (2019). "More continuity than change in the Congo". Center for Security Studies (CSS), ETH Zürich, 239, pp. 1-4.

Karacan, T. (2020). "Reframing Islamic State. Trends and themes in contemporary messaging". Danish Institute for International Studies (DIIS), 2020:06, pp. 19-21.

"Kazuo Ishiguro: Nobel Literature Prize is a magnificent honour". (05 October 2017). BBC News, Arts section, p. 1.

Kleijn, R. *et al.* (2011). "Metal requirements of low-carbon power generation". Energy, 36, 5640.

Morsy, S. (2018, May 21). "Long-term electric vehicle outlook". Bloomberg New Energy Finance, p. 1.

Overland, I. (2019). "The geopolitics of renewable energy: debunking four emerging myths". Energy Research & Social Science, 49, 36.

Sagan, C. (1977). "The dragons of eden". New York, U.S.: Random House.

Soulopoulos, N. (2018, March 22). "When will EVs be cheaper than conventional vehicles?". Bloomberg New Energy Finance, p. 1.

UN United Nations. (2015a). "Accord de Paris". Available at: https://treaties.un.org/doc/Publication/MTDSG/Volume%20II/Chapter%20XXVII/XXVII-7-d.fr.pdf

UN United Nations. (2015b). "17 objectifs pour transformer notre monde". Available at: https://www.un.org/sustainabledevelopment/fr

USGS U.S. Geological Survey. (2020a). "Lithium. Mineral Commodity Summaries (January 2020)". Virginia, U.S.: USGS Press.

USGS U.S. Geological Survey. (2020b). "Cobalt. Mineral Commodity Summaries (January 2020)". Virginia, U.S.: USGS Press.

USGS U.S. Geological Survey. (2020c). "Rare Earths. Mineral Commodity Summaries (January 2020)". Virginia, U.S.: USGS Press.

Vidal, O. *et al.* (2013). "Metals for a low-carbon society". Nature Geoscience, 6, 894.

Weißbach, D. *et al.* (2013). "Energy intensities, EROIs (energy returned on invested), and energy payback times of electricity generating power plants". Energy, 52, 210.

World Bank. (2017). "The growing role of minerals and metals for a low carbon future". Washington DC, U.S: World Bank Press.

WTO World Trade Organization. (2015). "Dispute Settlement. DS431: China - Measures related to the exportation of Rare Earths, Tungsten and Molybdenum". Available at: https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds431_e.htm