Critical minerals for the EU economy: foresight to 2030

1. Introduction

As outlined in the paper titled "Critical minerals for the EU economy: foresight to2030", massive growth in the global demand for mineral resources is expected to occur as the human population progresses towards the 9 billion mark, to be reached about 2050 and as populations in developing countries aspire to enjoy infrastructure, services and goods currently enjoyed by wealthier Nations. In addition, at the "Far Horizon" considered, the fossil fuel shortage following the "peak oil" and climate constraints will make the mineral issue even more pertinent, as all alternative energy issues will require more and new metals consumption.

The quantity of minerals to be produced between now and 2050 is expected to greatly exceed the quantities extracted between the onset of humanity and now. This is an unprecedented challenge in many respects. Research and innovation is needed to explore and properly develop all the new deposits that will be needed to meet future demand, while geological infrastructures are old and fragmented in many countries and knowledge on deep-seated geology remains extremely limited. This is notably due to the low – nearly non-existent - public investment during the last 20 years during which time these substances remained relatively abundant and cheap. Furthermore, the mineral issue was considered at national level, when the subject is obviously global due to the inequity of mineral resources distribution on the planet. Hence, the development of an international capacity is needed, in order to bridge the gaps in knowledge, and to address the numerous issues related to the complex linkages between sustainable development and mineral resources supply to the global economy. Otherwise, the world will be exposed to conflicts that will be triggered by competition at any cost for mineral resources vital to economic-development of empowered countries. This is hence an issue for the EU level; until recently it was considered it at national level only. The need for an EU "view of the world" based on science and diplomacy is clear.

Key issues about future resources availability

Future sustainable production and consumption will require R&D, innovation and public incentives along the number of different, but complementary, lines including:

- Recycling;
- Re-use of old components that can be further used in new goods;
- Eco-design, for instance to facilitate later recycling of rare metals included in consumer goods such as laptops or mobile telephones;

- Reduction of use of raw materials thanks to innovative carbon-lean technologies allowing to use less materials while benefiting from the same services;
- Substitutions of rare metals by more common ones.

However, whatever the progress made towards a more circular economy, based on the cradle to cradle concept where waste becomes a resource, new tools allowing the development of the production of primary resources will remain of major importance.

A holistic approach to sustainable natural resources management at international level is absolutely needed, and this is even more specifically the case for mineral resources. This is the "raison d'être" of the International Panel on the Sustainable Management of Natural Resources, " Resource Panel" in short, recently established under the United Nations Environmental Programme (UNEP)[1]. But a specific approach to the subject from an EU point of view is equally needed, notably with neighbouring partners (notably ACP, Ukraine, Russia…).

2. Criticality

Over recent years most Western economies appeared very vulnerable to disruptions of the very diversified mineral resources supplies they require, while China developed a very strategic role raising its position of leading global minerals and metals producer of nine commodities in 1992 to leading global producer of 27 minerals and metals in 2008, with a share of global production of 50% and more for 12 of this substances (table 1)

Substance	China's share in the world production 2008
Rare Earth	99%
Antimony	91%
Germanium	82%
Tungsten	76%
Gallium	75%
Graphite	71%
Bismuth	62%
Mercury	58%
Fluorite	54%
Baryte	53%
Coal (coking)	52%
Indium	50%

Table 1 – China's 2008 share of the world mineral production (data source: World Mining Data 2010

The supply risk combined with rapid demand growth observed for almost every rare metal (2008 global production below 60,000 t) raises considerable concerns in Western and notably European economies as these appear indispensable to the development of innovative technologies all advanced economies count on to address issues such as the reduction of emissions of greenhouse gases, the production of renewable energy or new environmental issues.

[1] Metals related issues are an important component of the Resource Panel activities, with two already published reports: "Assessing the Environmental Impacts of Consumption and Production: Priority Products and Materials" and "Metal Stocks in Society - Scientific Synthesis". See Website : http://www.unep.fr/scp/rpanel/

Assessments of criticalities, attempting to define criticality factors and to elaborate a list of minerals crucial to their economies have been produced both in the US[2] and the EU[3]. The methodology used to define the critical minerals matrix presented in these reports is similar. According to Eggert et al. (2007) "*To be critical, a mineral must be both essential in use (represented on the vertical axis of the matrix) and subject to supply restriction (the horizontal axis of the matrix)* ». The methodology used in the EU report is based on three main aggregated indicators, detailed in p. 23 and 24 of the report, i.e. « *the economic importance of the considered raw material, its supply risk (for instance restrictive measures from resource-rich countries) and an environmental country risk assessing the potential for environmental measures that may restrain access to deposits or the supply of raw materials* ». These three aggregated indicators are calculated for each of the 41 assessed mineral raw materials.

None of these criticality assessments claim to be exact science. The lack of data on the trade of various communities and on real consumptions at country level, the opaqueness of rare metals markets and the choices are important obstacles. Choices had also to be made while aggregating data and such choices may be considered as partly subjective.

Key drivers affecting criticality

The long-term availability of a steady supply of the wide range of minerals and metals required by the EU economy is a major issue, and it requires much foresight to identify possible actions to be undertaken in order to reduce risks. It should be kept in mind that the minerals industry responds only very slowly to policy action, as 10 to 20 years are required to explore develop and process new metal deposits.

The EU report identified an important growth of the demand for many metals including some very rare ones that will be needed to meet the demand coming from innovative, low carbon and environmentally friendly emerging technologies such as energy-saving lighting, electric cars, fuel cells, photovoltaic's or windmills (table 2)

Base metals are also concerned as industry forecasts,[4] foresee a spectacular growth in the overall demand for copper (+ 250% between 2000 and 2030), aluminium (above +300%) and iron (nearly +400%). These are also major challenges for Europe, as conflicts may emerge for the access to these resources and as their production may cause severe environmental and social impacts.

---

[2] Eggert R. G. et al. - 2007 - Minerals, critical minerals and the US economy - National Research Council of the National Academies (Washington D.C, USA) - available for download from http://www.nma.org/pdf/101606_nrc_study.pdf

[3] Ad-hoc working group on defining critical raw materials - 2010 - Critical raw materials for the EU - European Commission , DG Enterprise (Brussels, Belgium) - as available for download from http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/report-b_en.pdf

[4] F.i. see the presentation given in March 2010 by RioTinto to North American fixed income investors Available here: http://www.riotinto.com/media/18435_presentations_19149.asp

Table 2 - 2030 demand forecast for mineral raw materials needed by emerging innovative technologies [from Ad-hoc working group on defining critical raw materials (2010)]

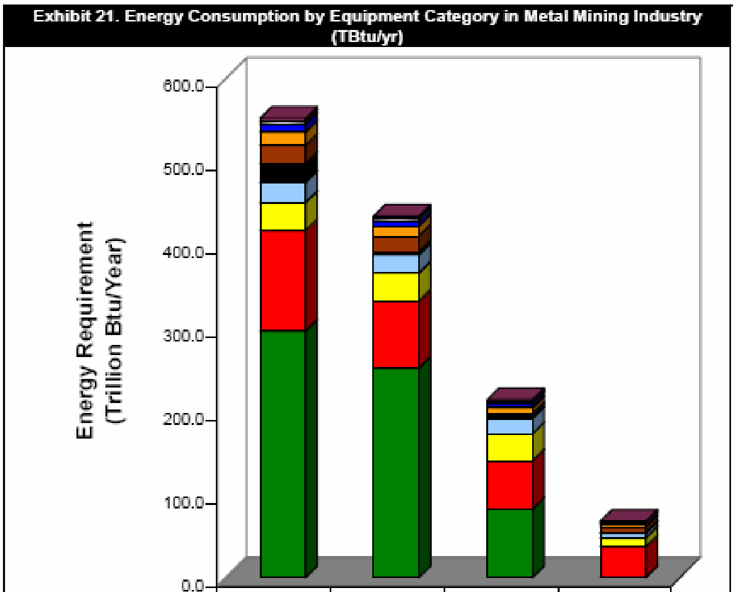
Raw material	Production 2006 (t)	Demand from emerging technologies 2006 (t)	Demand from emerging technologies 2030 (t)	Indicator[1] 2006	Indicator[1] 2030
Gallium	152	28	603	0,18	3,97
Indium	581	234	1.911	0,40	3,29
Germanium	100	28	220	0,28	2,20
Neodymium (rare earth)	16.800	4.000	27.900	0,23	1,66
Platinum (PGM)	255	very small	345	0	1,35
Tantalum	1.384	551	1.410	0,40	1,02
Silver	19.051	5.342	15.823	0,28	0,83
Cobalt	62.279	12.820	26.860	0,21	0,43
Palladium (PGM)	267	23	77	0,09	0,29
Titanium	7.211.000 [2]	15.397	58.148	0,08	0,29
Copper	15.093.000	1.410.000	3.696.070	0,09	0,24

The drivers are multiple, including growth of the world population, the aspiration of people from developing countries to enjoy a lifestyle approaching that of the wealthier part of this planet, technology shifts towards a greener carbon-lean economy.

3. Mineral processing, energy and environment issues

The minerals industry is highly intensive in its use of other natural resources, especially land use, energy and water. It is also an important emitter of greenhouse gases, of other gaseous and liquid emissions as well as of solid waste. The large tonnages extracted and processed to produce minerals such as aluminium, cement, copper, iron, lead and zinc are of major importance in this respect. Rapidly growing global demand for primary mineral resources, decreasing grades, deeper mines make it necessary to engage R&D efforts needed to significantly reduce the energy and water requirements necessary to produce one unit of marketable mineral products as well as the related emissions.

Reports by the US Department of Energy on the US mining industry provide a detailed breakdown of energy use and potential savings (fig.1).



	Current	Best Practice	Practical Minimum	Theoretical Minimum
Dewatering	3.1	2.8	2.6	0.7
Drilling	3.7	3.0	2.1	1.3
Crushing	9.6	6.0	5.0	1.5
Blasting	16.0	12.3	6.6	3.7
Digging	22.1	18.6	2.9	6.0
Separations	22.2	3.6	3.2	0.9
Ventilation	24.3	22.1	18.8	5.7
Ancillary Operations	33.8	33.8	32.5	10.6
Diesel Equipment	120.9	80.6	57.6	36.3
Grinding	296.3	251.9	82.7	0.9

Figure 1 - Energy consumption by equipment category in the US metal mining industry – 1 TBtu = 0,2931 TWh or 1055 TJ - Source: US Department of Energy (http://www1.eere.energy.gov/industry/mining/pdfs/mining_bandwidth.pdf)

Innovation, particularly in so-far energy intensive crushing and treatment processes, could lead to nearly 75% energy savings. The development of innovative process control technologies, of process modelling, the introduction of new, multiple sensors, of image recognition for froth control, of neural analysis networks or of real-time optimisation lead to significant achievements in energy and water savings as well as improved ore recovery[5].

Biohydrometallurgy is a major innovation that, in the 90's began to revolutionise the processing and metallurgy of sulphide rich ores. In copper production for instance, it allows us to reduce sulphur and/or arsenic emissions related to conventional technologies such as pyrometallurgy while containing the recovery of copper from low-grade ores otherwise not economically exploitable by other technologies[6]. In the

[5] In Chile, the world's largest primary copper producing country, technology improvements allowed to save 28% of the water consumed in conventional mineral processing and 49% in hydro-metallurgical processing. See BRANTES R. A. – 2008 - Best practices and efficient use of water in the mining industry - Chilean Copper Commission (COCHILCO, Santiago de Chile, Chile) - Available for download from: http://www.cochilco.cl/english/productos/doc/best_practices_and_the_efficient_use_of_water.pdf

[6] About 10% of the current Chilean copper production is produced by means of biohydrometallurgical processes. See : MIRANDA C. L. – 2009 – Biolixiviacion ; desarollo actual y sus expectativas - Chilean Copper Commission (COCHILCO, Santiago de Chile, Chile) – Available for download from: http://www.cochilco.cl/productos/pdf/2010/estudio_biolixiviacion.pdf

EU, biohydrometallurgy entails the exploitation of low-grade complex nickel, cobalt, copper and zinc ore of the Talvivaraa mine (Finland).

Research and technological development is essential to further enhance the effectiveness of mineral processing.

4. Recycling, re-use, substitutions and new applications

All the forecasts for future mineral resources demand foresee an unprecedented growth in the coming years, further boosted in the coming 20 years by the peak in oil supply and necessary substitution of fossil fuels. For many minerals the present average annual growth rate in consumption of 3 to 5% may be further increased. In order to alleviate the pressure on the production of primary resources (mining extraction), the eco-efficient use of mineral resources will develop. Secondary resources from scrap and waste, widely occurring in the "urban mine", industrial ecology and all forms of saving will need to be used in a much more intensive way than nowadays.

While recycling of certain metals such as copper, iron or lead is better developed recently in western economies, this is not the case for many of the rare metals, such as beryllium, gallium, germanium, lithium, tantalum or rare earth metals used in many high-tech applications. These rare metals are essential to the development of carbon-clean innovative technologies that which many European countries seek to develop as a key to their future competitiveness.

The development of a more sustainable use of the rare metals is of paramount importance to the future development of many industrial sectors vital to the European economy such as aerospace, renewable energies (photovoltaics and windmills), nuclear energy, electric and hybrid cars, high-speed trains, energy-saving lighting, health or defence.

Key issues about recycling, re-use, substitutions and new applications

Many of the rare metals are contained in very small quantities, sometimes only a fraction of a gram, in the appliances that need them to exist. They are however present in relatively standard industrial products. The challenges to overcome in recycling them are manifold:

- Those elements may be a component of an alloy, such as beryllium in copper beryllium alloys found in keyboard springs and in many connectors;
- They may be concealed in small components, and thus hard to access for recycling, such as tantalum in micro capacitors;
- The technologies to recover them economically and in an environmentally friendly manner are generally missing at present, as the large-scale use of those rare metals is a relatively new;
- The steep growth of consumption over the last decade, and their introduction in rather standardized widespread industrial products offer potential opportunities;

- Generalizing the eco-conception of future products will facilitate the recycling or the reuse of these metals;

A combination of innovations, breakthrough, R&D and public incentives will be needed to secure the long-term availability of these critical natural resources. These include:

- Better design of end-user products, in order to facilitate their dismantling and the reuse of components that would still be functional.
- Search for substitutes, to replace the use of a rare resource by more common ones. Where possible, renewable resources should substitute the use of non-renewable resources.
- The development of new, resource-lean, technologies that would provide the same functionalities but with the use of much less resources. e.g., the development of nanotechnologies is offering such possibilities for a wide range of applications.

Moreover, the knowledge of rare metal flows through economies, of traded quantities and life-cycle analysis is almost non-existent at appropriate scale, as there are very limited statistics on their production and trade.

5. Governance issues: political, legal, social, from local to national, from national to global

Minerals are non-renewable natural resources needed as essential inputs to develop physical, social and economic capital. Mineral extraction and refining needs to be done without damaging nature, the life supporting system, and in a way to maximise the profitability to investors and simultaneously the benefits to society. There is no sustainable mining industry without a social licence to operate.

Public and private governance are essential to the development of the mining industry operating in conformity with sustainable development ethics. Public and cooperate policy statements; well established legal frameworks; transparent leasing procedures; related development strategies; geoscientific data needed not only to access to resources but also to manage them preventing environmental impacts; indicators; data on production, trade, direct and indirect employment related issues, on payments made to/ received by governments are all part of the needed governance framework.

Policies, strategies, data and information are not only needed at national level, but also at a global level as the minerals distribution and industry are global while most minerals are globally traded. They are also needed at regional and local levels, as communities are directly affected by the mining activities, the industry being in a position of catalyst for local/regional development but also risking creating serious negative environmental and social impacts.

The issue of governance in the minerals industry is not new. Since 2002, the Mining, Minerals and Sustainable Development project (MMSD)[7] made an extensive review - bringing together several thousand stakeholders from all over the world - of the complex linkages, and related governance issues, between the mining industry and sustainable development issues. From 2000 to 2004, the World Bank conducted an extensive appraisal of its support to the extractive industries (oil, gas and mineral resources)[8]. Since 2003, the Extractive Industries Transparency Initiative[9] has promoted transparency in financial transactions between the minerals industry and the governments of the countries where extractive activities take place.

The UNEP Resource Panel[10] has worked since 2007 on providing independent scientific assessment of the environmental impacts due to the use of resources, including minerals and metals, over the full life cycle, and advice to governments and organisations on ways to reduce these impacts. In 2008, the Africa Union and the United Nations Economic Commission for Africa jointly developed an analysis of the status of the African Strategy and designed a comprehensive strategy for its long-term development, the Africa Mining Vision[11]. Finally, in 2008, the European Commission launched its Raw Materials Initiative[12], publishing two reports one on critical minerals for the EU economy and the second on improving framework conditions for extracting minerals for the EU.

All these undertakings identified the importance of governance issues. However, this political interest for mineral resources related issues remained rather low up to the last 3 to 4 years and limited R&D was supported in relation with this issue.

---

[7] Website: http://www.iied.org/sustainable-markets/key-issues/business-and-sustainable-development/mining-minerals-and-sustainable-development this

[8] Website: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTOGMC/0,,contentMDK:20605112~menuPK:592071~pagePK:148956~piPK:216618~theSitePK:336930,00.html

[9] Website : http://eiti.org/

[10] Website: http://www.unep.fr/scp/rpanel/

[11] Downloadable from here : http://www.eac.int/environment/index.php?option=com_docman&task=doc_download&gid=111&Itemid=143

[12] Website : http://ec.europa.eu/enterprise/policies/raw-materials/index_en.htm