Critical Raw Materials Alliance - A Single Voice For the Critical Raw Materials Sector

What you need to know about critical raw materials

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Contents

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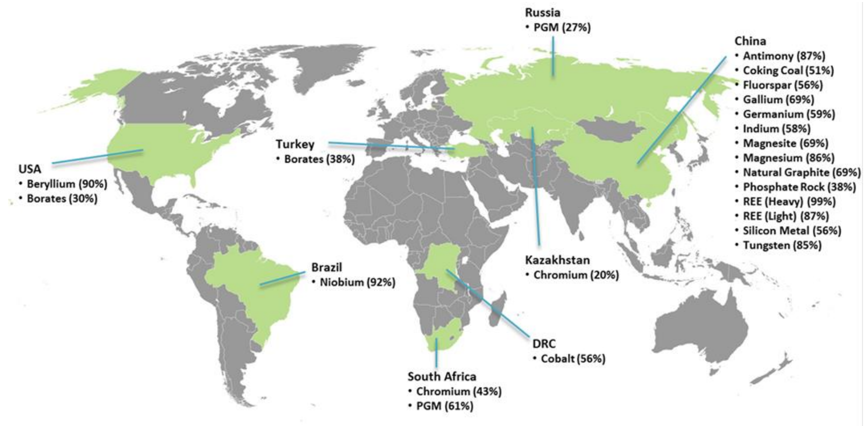
1. The Critical Raw Materials Alliance

The CRM Alliance has been created by industry to advocate the importance of those critical raw materials (CRMs) in Europe and to promote our common interests. The Alliance represents the interests of primary producers, traders and associations.

The CRM Alliance supports the creation of a strong critical raw materials policy which will benefit the economic and national security interests of the EU and its leadership in innovation, manufacturing and technology-dependent services which is inextricably linked to reliable access to, and the use of, critical raw materials. This document provides the public with our general position and individual facts about CRMs.

Given the high socio-economic importance of those critical materials and using alternative substances while maintaining the same level of performance is often not a viable option. CRM and other policies should thus not be directed in any way towards substitution of those CRMs. Instead, CRM policies should rather look for enhanced raw material supply, allocate more funds to R&D since critical materials are highly important for resource efficiency, strive to have other EU policies such as REACH give special consideration for critical materials; andfinally, trade policies that reflect both free and fair trade.



Source: European Commission website – DG GROW – Critical Raw Materials

The CRM Alliance is currently an observer in important European Commission – DG GROW stakeholder groups such as the Raw Materials Supply Group which is comprised of industry representatives, environmental NGOs, trade unions, Member States and the Commission. The CRM Alliance also holds the observer status in the Ad-Hoc Working Group on Defining CRMs which is an expert group tasked to identify the list of critical raw materials. This means that when a particular substance is being discussed by this Working Group, our members representing that substance are allowed to take part in the meeting and provide its members with the most up-to-date information on their substance.

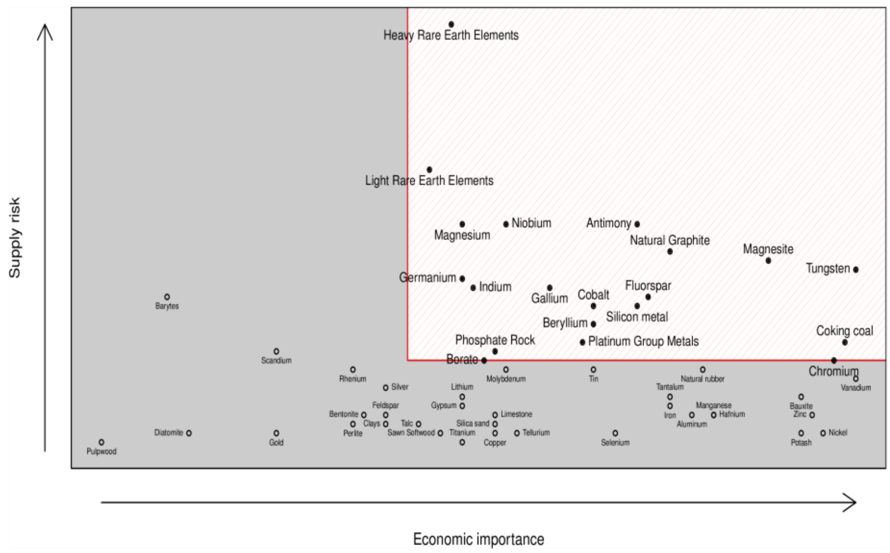
The CRM Alliance is supported by a Secretariat located at the core of European decision-making in Brussels. It is operated by Ridens Public Affairs, a business consultancy practice that assists organizations in dealing with regulatory and advocacy issues related to the raw materials sector, provides membership services, raises visibility of the associations and brings additional value to its members.

2. Background CRM List

In 2010, the European Commission identified 14 raw materials critical because they are "economically and strategically important and are subject to a higher risk of supply interruption in the next 10 years". This list should help incentivize EU production of CRMs, facilitate the launching of new mining and recycling opportunities and support negotiating trade agreements.

In 2014, the European Commission analysed 54 substances - including non-energy, non-agricultural materials - and identified 6 more materials as critical, seperated heavy from light rare earth metals and decided to remove tantalum from the list. These 20 materials are antimony, beryllium, chromium, coking coal, fluorspar, gallium, germanium, magnesium, niobium, platinum group metals, heavy rare earth metals, light rare earth metals, silicon metal and tungsten.

Since the list is being reviewed every three years, the European Commission is currently refining the methodology used to identify these materials. By early next year – 2015 - the current list of 20 materials will be reviewed and updated which is expected to be finished by late spring 2017. Given the current global state of play in the metals field, the CRM Alliance is expecting the CRM list to also grow with the next review.



Source: European Commission website – DG GROW – Critical Raw Materials

Members

The CRM Alliance currently consists of 19 members representing 15 Critical Raw Materials and more than 350 companies globally: Beryllium Science & Technology Association; Etimine (borates); The Cobalt Development Institute; World Coal Association (coking coal); Eurofluor (fluorspar); Tertiary Minerals (Fluorspar); German Engineering Federation (gallium arsenide); EcoPhos (graphite rock); Indium Corporation; International Magnesium Association; Minor Metals Trade Association; Imerys Graphite and Carbon (natural graphite); Beta Technology (niobium); International Precious Metals Institute (PGMs); Great Western Minerals Group (REEs); Tasman Metals (REEs); EuroAlliages (silicon metal); and Commerce Resources Corporation (REEs and former CRM tantalum).

3. General Position Statement

5 Key Recommendations for a Critical Raw Materials Policy

- CRM policies should look for enhanced raw material supply and use and not substitution of the CRMs
- Industrial Sector Policies should incorporate and highlight the economic and strategic importance of Critical Raw Materials (CRMs) and their value to future innovation
- Waste legislation should not include disincentives for usage of CRMs
- Legislation affecting CRMs should require a special socio- economic analysis of potentially harmful impacts to the supply of CRMs on upstream European producers as well as to downstream European supply chains
- Trade policy should incorporate principles of both free and fair trade for CRMs

3.a General

Critical Raw Materials play an essential role in the European economy.

In 2010, the European Commission identified 14 raw materials as being critical because they are "economically and strategically important and are subject to a higher risk of supply interruption in the next 10 years" according to the European Commission. In May 2014 the European Commission published a new critical raw materials list containing a total of 20 materials. EU industry would like to take this as a clear sign from the EU that critical raw materials should be promoted in Europe. This would be in line with the EU Industrial Policy.

The listing of these materials underlines their essential role for the European economy. The word "critical" can be perceived as negative while the criticality of CRMs is positive. In context, CRMs are immediately important to Europe's economy and essential to drive future innovations in maintaining Europe's technological leadership in a highly competitive world economy.

Many different suppliers as well as traders and industries, rely on the unique properties of CRMs to manufacture lifesaving and reliable products. To ensure the continued supply of these critical materials, a specific critical raw materials policy is needed which underlines the importance and dependence of the European economy on them. Such a policy should include and promote the exploration and extraction of CRMs in Europe.

In summary, a strong critical raw materials policy will benefit the economic and national security interests of the EU and its leadership in innovation, manufacturing and technology-dependent services which is inextricably linked to reliable access to, and the use of, critical raw materials.

3.b Applications & Innovation

Critical raw materials are transforming renewable and traditional energy, acoustical, computational, medical, transportation, microelectronics, telecommunications, aerial imaging, aerospace, and other high-technology products and systems. These materials hold the key to future applications that will move ideas from the research laboratory to products in commerce.

The ability to engineer critical raw materials in unique ways that can separate innovators from competitors should be a high priority among EU countries wishing to remain technology leaders. Technology is necessary to enhance the value of intellectual products, delivery of services, and transformation of essential functions of both government and civilian providers.

☞ **Industrial Sector Policies should incorporate and highlight the economic and strategic importance of CRMs and their value to future innovation**

Regulation and Critical Raw Materials

Discussions on EU regulation should lead to the establishment of policies that preserve the availability and broad applicability of critical raw materials in their respective research development and regulatory systems. Minimizing the adverse regulatory burdens that impede advancement or the continued availability of critical raw materials must be a high priority. This applies also to the inclusion of CRMs in proposed EU regulation concerning Conflict Minerals.

☞ **Legislation affecting CRMs should require a socio-economic analysis of any potentially harmful impacts to the supply and use of CRMs on upstream European producers as well as to downstream European supply chains as a first step in the regulatory process**

Substitution is not a viable option for CRMs due to their unique properties and economic significance, in particular, in high-tech applications requiring high standard performance and specification (often critical for safety).

Enhanced recycling of CRMs in the EU is helpful to reduce import dependency however, in many cases the high technical recyclability of CRMs is jeopardized by insufficient collection and inappropriate pre-treatment of CRM bearing material. In other cases, recycling alone offers very little impact on the value chain as the extraction of CRMs from recycling of alloys may not be commercially viable or attractive due to the low percentage of CRM in the scrap or waste streams.

☞ **CRM and other policies should not be directed in any way towards substitution of CRMs**

☞ **Waste legislation should not include disincentives for usage of CRMs**

Much legislation is general in nature and does not take into account the specific aspects of CRMs, notably the fact that the EU has characterised them as critical and non-substitutable in many applications. Additionally, the development of legislation has the potential to adversely impact the use and therefore supply of CRMs. Legislators should be required to conduct a socio-economic analysis during the legislative process to identify and address these potentially harmful impacts on the supply and use of CRMs.

3.c Trade

The EU should support general principles of both free and fair trade. This would include tariff and non-tariff barriers. In its assessments, the EU must ensure free and fair trade through the elimination of unnecessary or over burdensome regulation along with the recognition of the particular economic imbalances and the absence of a level playing field that exist in the markets of some CRMs.

- ☞ **Trade policy should incorporate principles of both free and fair trade for CRMs**

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4. Next steps

The CRM Alliance is in anticipation of the next review of the CRM list to be expected in spring 2017. We will be actively involved in the process leading up to the updated CRM list and will provide the respective Ad-Hoc Working Group on Raw Materials with the most up-to-date information about the critical materials represented by the CRM Alliance.

Furthermore, we will continue to advocate different avenues to secure the supply of those critical materials to the European Union. We support an EU Industrial Policy which takes into consideration the 5 key recommendations as laid down in our general position statement.

5. Appendix

The CRM Alliance has prepared one page fact sheets about all critical materials represented by the CRM Alliance to provide a clear overview on:

1. What the materials are and where they are used;
2. Where they are explored;
3. Where they are produced;
4. How much they cost; and
5. What specific issues for those materials are.

For consistency purposes, the CRM Alliance has used price figures as provided in the Critical Raw Materials Profiles report related to the CRM report 2014 of the European Commission – DG GROW.

BERYLLIUM

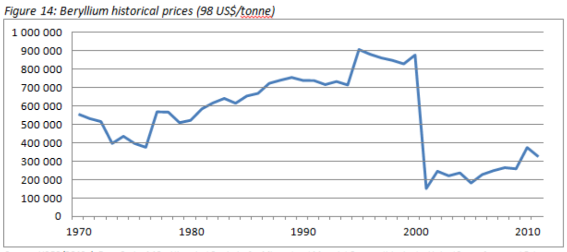
What Is Beryllium And Where Do I Use It?

- Beryllium is a naturally occurring critical material and the fourth element in the periodic table. It is used in a variety of highly-innovative industry sectors such as the automotive, aerospace, consumer electronics electrical engineering and medical equipment sectors.
- Beryllium is very light and rigid with a density thirty percent lower than Aluminium and 3 times the stiffness of titanium.
- The alloy of copper with less than 2% Beryllium is as strong as steel, a very good conductor of electricity and heat, non-magnetic and non-sparkling. It resists deformation over time at elevated temperatures and thus is used to make extremely reliable conductive springs, such as connector terminals.
- Beryllium metal is highly transparent to X-rays making it essential for X-Ray and CT Scan medical systems.

Where is Beryllium Explored?

- The majority of world beryllium ore production (65%) takes place in the US.
- The remaining output comes from China, Brazil and several nations in Africa, such as Nigeria, Madagascar and Mozambique.

Figure 14: Beryllium historical prices (98 US$/tonne)



Source: USGS (2012-), Data Series 140 - Historical Statistics for Mineral and Material Commodities in the United States [accessed February 2013]. Figures are indexed to 1998 values.

Where is Beryllium Produced?

- Most of the production is in the US.
- The balance comes from Kazakhstan and China.

How Much Does It Cost?

- Beryllium annual consumption is expected to grow to 425 MT / year by 2020 and to >450 MT/year by 2030, driven by such applications as the construction of the ITER fusion reactor.
- The price of beryllium is dependent on the form.
  - As a fully machined aerospace component of pure beryllium: €300 – 1,500/kg
  - As a cast aluminium 39% beryllium alloy aerospace component: €200 – €500/kg
  - As a copper 2% beryllium alloy in bulk form: €20 – 50 /kg
  - As a copper 2% beryllium alloy in strip form: €20 – 50 /kg
  - As a copper 0.3% beryllium alloy in strip form: €12 – 20 /kg

Specific Issues for Beryllium

- The first Critical Raw Materials report by the European Commission in 2010 identified Beryllium as a CRM, and this status was renewed in the 2014 revision of the CRM report.
- The **economic importance** of Beryllium was established due to its very unique combination of properties that make it **non-substitutable** in many demanding high-tech applications which would suffer a loss in performance if it were to be substituted.
- In terms of **supply risk**, there are no commercially viable sources of Beryllium in the EU. One US mine with over 100+ years of reserves is producing the ore used for over 65% of global demand.
- **Overly restrictive EU regulations** such as REACH and workplace legislation do not embrace recent scientific data and proven industrial safety practices. This could alter the customer environment for the manufacture of critical components containing beryllium that will create economic disincentives to the ongoing supply of beryllium and its use in the EU.

BORATES

What are Borates And Where Do I Use Them?

- Boron, the semi metallic element with atomic number 5, does not occur in nature as free element. It rather occurs in the form of a natural mineral associated with other elements such as Na, Ca, and Mg.
- Among over 200 naturally occurring boron minerals, the most commercially important borates (known as the salts of industry) are: Tincal, Colemanite and Ulexite.
- About 80% of borates placed on the EU market are used in intermediate uses such as in the manufacture of glass & frits and/or for the synthesis of new substances, in mixtures below the specific concentration limits, and in biocidal applications.
- The remaining one-fifth is used in agriculture (13-14%), in articles (4-5%) and in other uses (2-3%) such as coatings, industrial fluids and/or metallurgical applications.
- In addition, boron is an essential micronutrient for normal, productive plant growth and is one of seven essential micronutrients for plants according to the EU Fertiliser Regulation (2003/2003/EC).
- Furthermore, for safety reasons, the use of borates is essential in nuclear power plants.

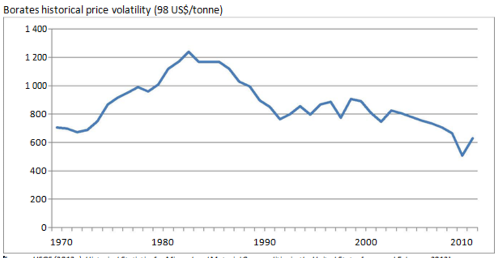
Where are Borates Produced?

- Turkey has almost three-fourths (about 73%) of the world's total boron reserves.
- Having Etimine S.A as the only representative of Turkish borates produced in Turkey and placed on the EU market, Eti Maden IGM is the global leader of the boron sector.
- Exporting 97% of its boron products to over 100 countries (i.e. about 400 different destinations), the exclusive Turkish State Enterprise Eti Maden is the biggest borate producer in the world and also has the largest share of the world boron market.

How Much Does It Cost?

- Borates prices decreased between 2008-2009 due to the global economic crisis. After 2010 market conditions stabilised again.

Borates historical price volatility (98 US$/tonne)



Source: USGS (2012-), Historical Statistics for Mineral and Material Commodities in the United States [accessed February 2013]. Figures are indexed to 1998 values.

Specific Issues for Borates

- The **harmonised classification of Borates** under the EU's Classification, Labelling and Packaging Regulation (CLP) in 2009 was the step towards the EU's stifling of Borates supply.
- The subsequent **listing of borates as substances of very high concern** on the candidate list of the EU's REACH Regulation and the prioritisation attempts of Borate substances for Authorisation under REACH are creating further obstacles.
- Despite having scientific evidence from Chinese studies, which were further supported by Turkish studies conducted more recently, Eti Maden was **not given the opportunity** to put this peer-reviewed new scientific knowledge through the official European procedure directly due to the fact that in order to submit an Annex XV dossier, you must be part of a Member State.
- Ultimately, **authorisation aims for substitution of all SVHCs**. Applying the generic exemptions, about 20% of the volumes of borates remain in the scope of authorisation and when considering the uses for which there will never be a substitute (i.e. nuclear and/ or agricultural applications), this figure drops below 2-3%.
- All in all it is underlined that these matters are essentially **political**. Policy makers need to be aware that critical raw materials such as borates are essential for the EU industry and they need political support.

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COBALT

What Is Cobalt And Where Do I Use It?

- Cobalt is a relatively abundant metal element which is almost always found in combination with other naturally occurring minerals.
- It is naturally occurring and exists in the environment in soil/dust/rocks and in vegetation. It is an essential dietary element for the growth of animals and micro-organisms.

Metallurgical applications include:

- Cobalt's exceptional high temperature strength and corrosion-resistance make it an essential alloying element for jet engine and electrical power generation turbines (improving combustibility and reducing fuel consumption), specialty high strength steel for medical/scientific instrumentation and hard facing alloys in abrasive applications (e.g. bulldozer scoops).
- Other uses are orthopaedic hip and knee implants, jewellery for fine detailed casting, as a binding agent for hard metal (tungsten and diamond) cutting and drilling tools or in permanent magnets for ABS breaking systems in automobiles.

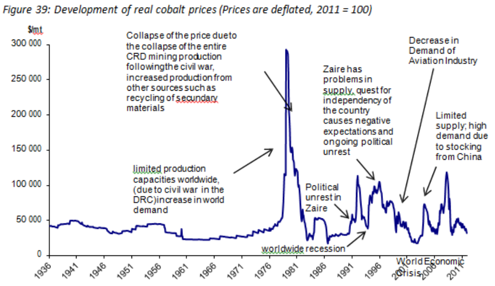
Chemical applications include:

- rechargeable batteries (for electric/hybrid cars and in portable electronic devices
- catalysts to reduce energy consumption and increase productivity of industrial processes, and for the production of low sulphur fuels and synthetic fibres
- as an essential nutrient in animal feed and in biotechnology processes for diagnostics and pharmaceuticals
- Other uses are pigments (the well-known 'Cobalt blue'), semi-conductors and other electronic components, alternative energy producing technologies such as solar panels, fuel cells and wind turbines

Where is Cobalt Produced?

- Cobalt's estimated worldwide production is ~100,000 metric tonnes with cobalt reserves in the Central Africa (50%), Australasia (24%), Americas (10%), Russia (3%), and the ROW (13%).
- The main source of refined cobalt is as a by-product of nickel (~50 %) and copper (~44%) which are in abundant supply, while a minority (~6%) is from primary cobalt mines.

Figure 39: Development of real cobalt prices (Prices are deflated, 2011 = 100)



Source: DERA, HWWI (2013) Ursachen von Preispeaks, -einbrüchen und –trends bei mineralischen Rohstoffen (Causes of price peaks, collapses and trends of mineral raw materials), Hamburg Institute of International Economics (HWWI) in contract for Deutsche Rohstoffagentur (DERA). April 2013., translated into English by Fraunhofer ISI

How Much Does It Cost?

- Pure cobalt metal costs approximately US$30 per kg and is quoted daily on the London Metal Exchange as well as through trade publications.

Specific Issues for Cobalt

- Cobalt is a 'technology enabler' used mostly in the workplace and is **indispensable** to enhance the many metallurgical and chemical applications.
- Cobalt **cannot be substituted** in most of its key applications, due to its unique properties and it adds to the quality of our everyday lives by contributing to the reduction of greenhouse gas emission, and to alternative and high-tech technologies.
- The **potential socio-economic impact** and regulatory efficiency of policies or regulatory measures on critical raw materials must be well understood before they are proposed.

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COKING COAL

What is Coking Coal And Where Do I Use It?

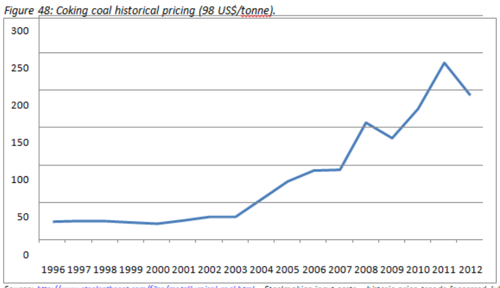
- Coal is a fossil fuel and is the altered remains of prehistoric vegetation that originally accumulated in swamps and peat bogs.
- The quality of each coal deposit is determined by: varying types of vegetation from which the coal originated; depths of burial; temperatures and pressures at those depths; and length of time the coal has been forming in the deposit.
- One of the highest grades of coal is metallurgical coal or coking coal. It forms one of the key inputs required for the production of steel and cement.
- 70% of the steel produced today uses coal. In 2010, world crude steel production was 1.4 billion tonnes, requiring 721 million tonnes of coking coal.
- Steel is one of the most efficient modern construction materials. It offers the highest strength-to-weight ratio of any commonly-used material and is exceptionally durable. It is an essential material used in the construction sector, used to build high-rise buildings, bridges and tunnels as well as in the transport sector, to build railroads, trains, aeroplanes, ships and car bodies.

Where is Coking Coal Produced?

- Coal is abundant, affordable and geographically well-distributed. Major developed and developing economies are able to utilise large indigenous coal reserves, while coal is also available from a wide variety of sources in a well-supplied worldwide market.
- In 2013, the top four largest coking coal producers were: China (527 Mt), Australia (158 Mt), USA (78 Mt) and Russia (73 Mt).
- In the same year, China (77 Mt), Japan (54 Mt), India (38 Mt) and South Korea (31 Mt) were the largest consumers driven by rapid urbanization and industrialization.
- According to the International Energy Agency, world coking production grew from 783478 thousand tonnes in 2009 to 1003458 thousand tonnes in 2013.

How much does it cost?

Figure 48: Coking coal historical pricing (98 US$/tonne).



Source: http://www.steelonthenet.com/files/metallurgical-coal.html, Steelmaking input costs – historic price trends [accessed July 2013]. Figures are indexed to 1998 values.

- Coking coal is not a homogenous product. It varies in quality with hard coking coal representing the highest grade which attracts a premium price. Semi-soft or high-volatile coking coal is of a lower quality and as such sold at a discount.
- In addition freight, insurance and whether the price refers to contracted coal or spot price are important factors in considering the price of coal.
- Currently the coal market is over-supplied and low coal prices dominate. Over production and declining demand has resulted in the price of EU coking coal imports from Australia drop from 243.76 USD (2009) to 213.42 USD (2010).

Specific Issues for Coking Coal

- Australia and China are the overwhelming suppliers of coking coal. As noted in the 'Critical Raw Materials for the EU' report this **concentration of supply creates risk**, for instance in 2011 Australian coking coal supply was disrupted by flooding.
- Similarly coking coal has a **high economic importance** due to its use in the steel sector with few options for substitution available.
- Coking coal faces political, technical and financial challenges as the world attempts to transition to a lower carbon economy. To reconcile the role of coking coal **EU and member states must increase investment** and develop policy consistent with encouraging support for carbon capture and storage technology.

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FLUORSPAR

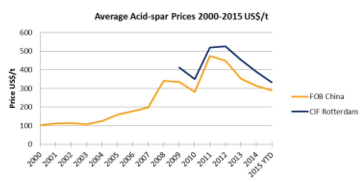
What is Fluorspar and Where Do I Use It?

- Fluorspar is the commercial name for the naturally occurring mineral fluorite, composed of calcium and fluorine (CaF2).
- Fluorspar is the predominant commercial source for the chemical element fluorine.
- Fluorine is a non-metallic element and the lightest of the halogens and therefore largely irreplaceable in its use.
- There are two principal commercial grades of fluorspar: Metallurgical grade (60-96% CaF2); and acid grade (+97% CaF2).
- **Metallurgical grade fluorspar** accounts for approximately 40-45% of total fluorspar production with the principal applications being:
  - Steel production – used as a flux to lower the melting temperature and increase the chemical reactivity to help the absorption and removal of sulphur, phosphorus, carbon and other impurities in the slag;
  - Cement – used as a flux to speed up the calcination process and enables the kiln to operate at lower temperatures.
- **Acid grade fluorspar** accounts for approximately 55-60% of total fluorspar production with the principal applications being:
  - Aluminium production – used to produce aluminium fluoride (ALF3) which acts as a flux to lower the bath temperature in the manufacture of aluminium;
  - Manufacture of hydrofluoric acid (HF) – the primary source of all fluorochemicals (the single largest consumer of fluorspar), a wide range of applications include: Fluorocarbons e.g. refrigerant gases, propellants, etc; Metallurgical industry (extraction, manufacture and processing); Petrochemical catalysts; Electrical and electronic appliances; Lithium batteries; and Pharmaceuticals, polymers and agrochemicals.

Where is Fluorspar Produced and Consumed?

- World production of fluorspar: 6.0Mt – 6.5Mt per year
  - Major producing regions: China (>50% of the world's production); Mexico; Mongolia/CIS; and South Africa;
  - Major consuming regions (highest to lowest): China; Europe; North America; and Russia/CIS.

How Much Does It Cost?



- Acid grade fluorspar has historically commanded the highest price however the price gap between this and metallurgical grade fluorspar has reduced recently.
- Current acid grade mid-market price (source: Industrial Minerals Magazine) is US$270/t FOB China and US$310/t CIF Rotterdam.
- Current metallurgical grade mid-market price (source Industrial Minerals Magazine) is US$250/t FOB China and US$300/t CIF Rotterdam (min 85% CaF2).
- Acid-spar prices have declined since late 2012 but the long-term trend has been upwards with prices increasing >3 fold since 2000.

Specific Issues for Fluorspar

- China produces >50% of the world's fluorspar. **No large scale commercial alternative**
- **Chinese exports have declined substantially since 2000** – internal demand and production/export restrictions.
- **China may become a net importer in the future.**
- **North America and Europe are the largest acid-spar consumers outside China**, all net importers – potential risk to long term security of supply.

Source: Tertiary, Industrial Minerals Magazine, US Geological Survey, Roskill, UN Comtrade, CRU, Eurofluor

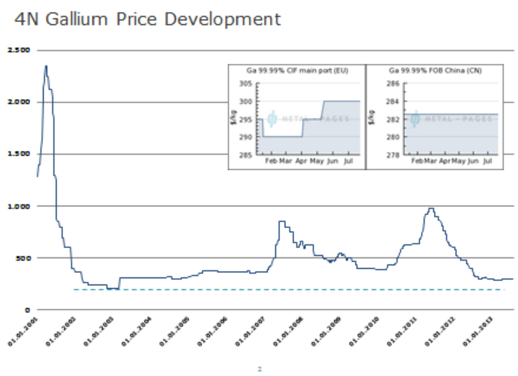
GALLIUM & GALLIUM ARSENIDE

What Is Gallium & Gallium Arsenide And Where Do I Use It?

- Elemental gallium does not occur in free form in nature, but as the gallium compounds that are in trace amounts in zinc ores and in bauxite. Gallium is mainly used for the manufacturing of Gallium arsenide which is the primary chemical compound of gallium in electronics.
- Gallium arsenide owns a high socio-economic importance being widely used for radio frequency chipsets in mobile and satellite communication, for laser diodes in fiber based communication systems, for LEDs in displays, automotive and lighting applications, for sensors in avionic, space and defence systems.
- GaAs is often used as a substrate material for the epitaxial growth of other III-V semiconductors including: Indium gallium arsenide, Aluminium gallium arsenide and others.
- Gallium is a soft, silvery metal, and elemental gallium is a brittle solid at low temperatures. Gallium arsenide is a III-V direct bandgap semiconductor (different from silicon).

Where is Gallium and Gallium arsenide Produced?

- The production of gallium metal is often connected with the processing of bauxite to aluminium. The majority (ca. 80%) is located in China. The only production site in Germany is owned by companies located in USA and Canada.
- Gallium arsenide in the required high-pure quality is produced by only a few companies in the world (one in Europe, others in Japan, China).



How Much Does It Cost?

- The prices for gallium metal are changing. In the past gallium was used speculatively on the stock exchange.

Specific Issues for Gallium Arsenide

- A particular concern for gallium criticality is its main use in growing and emerging markets in its compound form **Gallium arsenide** that forms the core substrate for semiconductors.
- Gallium arsenide is manufactured from the raw materials arsenic (As) and gallium (Ga). The semiconductor is **used in encapsulated articles in very small quantities** in the EU.
- The **economic importance** of Gallium arsenide was established due to its very unique combination of properties that makes it **non-substitutable** (e.g. by silicon) in many demanding high-tech applications
- The **consumer has no direct contact** with Gallium arsenide hence there is absolutely no risk in using GaAs based products and technologies. Associated risks at the **workplace are adequately controlled** by already existing workplace safety regulations.
- The **harmonised classification** of Gallium arsenide under the EU's **CLP regulation** opens the opportunity for even **more stringent regulations under REACH**.
- Before any further regulatory action is taken, an **obligatory risk assessment option analysis** and check of proportionality by **active involvement of industry expertise** shall be performed.

INDIUM

What is Indium And Where Do I Use It?

- Indium is very abundant in host metals such as zinc, lead, tin, and copper. Host metals, in contrast to minor metals, are base metals spread across the globe.
- Concentrated in Asia, flat panel displays represent about 55% of the world demand for indium. All other numerous applications, consuming the remaining 45% of primary indium are spread worldwide and range from mechanical to high end electronics.
- The current world demand of primary indium is estimated at 500 MT, while the proven amount of primary indium in host metals is close to 2,000 MT per year.

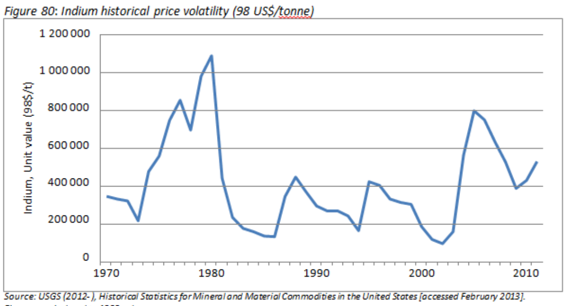
Where is Indium Produced?

- The mining and refining of primary (virgin) indium has grown in the last three years by about 20%.
- The extraction and production of primary indium takes place during the production of host metals in refineries in France, South Korea, Japan, Canada, South America, and China.
- Over the past 3 years China has produced about 1,000 MT per year of primary indium and has stockpiled more than 3,000 MT, all without adversely affecting global prices or supply, including in Europe.
- The EU is essentially indium self-sufficient. In 2013, more primary indium was produced in Europe than consumed. The cost to use indium is low, and the lack of any foreseeable shortage means it is readily available for future applications.
- The annual demand growth for primary indium worldwide is stable and in some markets approaches zero.
- Industrial re-processing of ITO scrap is a proven way of returning a significant amount of indium to the global market. The technology to do so is very efficient and the process cycle time very fast.

How Much Does It Cost?

- Of the $2–$3 cost in putting ITO (indium tin oxide) on a 42-inch screen, the indium portion contributes less than 1% to the retail price.
- Indium is a proven and essential component of a cost-effective, mature technology which does not hinder achieving gains through implementing further cost cutting measures.

Figure 80: Indium historical price volatility (98 US$/tonne)



Source: USGS (2012-), Historical Statistics for Mineral and Material Commodities in the United States [accessed February 2013]. Figures are indexed to 1998 values.

Specific Issues for Indium

- Although more and more coated screens from end-of-life products are being collected, still more needs to be done to **economically recover the indium** from these materials.
- To maintain this level of self-sufficiency, and to expand on the low cost and proven technological benefits of indium use, EU policy makers should focus on increasing market access by **reducing tariff barriers** on indium bearing substances, **encouraging greater indigenous production**, and **investing in improving economically viable recovery technologies** from the growing amount of EOL products.

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CRM Alliance Critical Raw Materials

International Magnesium Association

MAGNESIUM

What Is Magnesium And Where Do I Use It?

- Magnesium is the sixth most abundant metal comprising 2.5% of the earth's surface.
- On a volume basis, magnesium is the lightest structural metal: one quarter the weight of steel, two thirds the weight of aluminium, and same light weighting potential as carbon fibres. Magnesium can be cast, rolled, extruded, machined, and forged as any other metal.
- Magnesium is used in a variety of industry sectors, such as transport (automotive, aircraft, train), consumer electronics (laptop, mobile phone, tablet), steel industry, Titanium and Zirconium production, pharmaceutical and agricultural chemical production and medical implants. Magnesium, as alloying element, is essential for the aluminium industry.
- Magnesium may also be a preference in all light-weighting vehicle concepts, hydrogen storage and advanced battery technology.

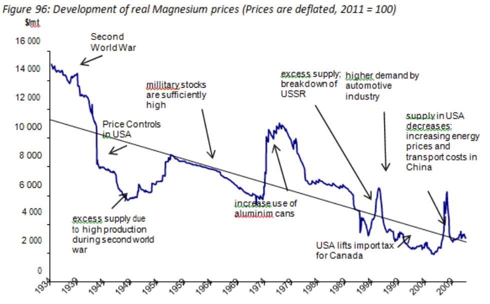
Where is Magnesium Produced?

- The worldwide primary magnesium production in 2014 was around 870 Kt, and 85% of global demand was delivered from China.
- Since 1990, cheaper and less CAPEX intensive processes have experienced a rapid growth with the introduction of Pidgeon process technology in China.
- The remaining electrolytic based primary production outside China is mainly supported by anti-dumping duties.

How Much Does It Cost?

- Compared to most other mineral based raw materials, Mg pure and alloys show a stable price after the political motivated sharp price peak in 2008, caused by regulative closing of Mg plants to improve air quality during the Olympic Games in Beijing.

Figure 96: Development of real Magnesium prices (Prices are deflated, 2011 = 100)



Source: DERA, HWWI (2013) Ursachen von Preispeaks, -einbrüchen und –trends bei mineralischen Rohstoffen (Causes of price peaks, collapses and trends of mineral raw materials), Hamburg Institute of International Economics (HWWI) in contract for Deutsche Rohstoffagentur (DERA). April 2013., trend line and translation to English by Fraunhofer ISI

Specific Issues for Magnesium

- Magnesium's criticality is not based on geographical lack of raw material in Europe, rather on **trade issues**, since China's production and export policy made primary production in Europe redundant.
- The last smelter in Europe closed in 2001, since European based smelters were unable to compete with low cost Chinese production, and as a result European primary demand depends mainly on **China imports**.
- Europe has maintained a solid Mg recycling industry of significant size, providing stable **employment across Europe**.
- Magnesium alloys are for both weight saving and application performance an ideal contribution for **reducing carbon dioxide emissions** in a vehicles operating life, but also a material of choice for all new vehicle concepts, such as electrical, hydrogen and smart city automobiles.
- The main drawback for a wider use e.g. in the Automotive industry, is the **lack of a solid supply base** in combination with competitive Mg production outside China.
- Magnesium is one of the **main alloying elements** for Aluminium alloys providing e.g. unique properties to aluminium cans, aerospace and transport applications and substitution is technically not feasible.

NATURAL GRAPHITE

What Is Graphite And Where Do I Use It?

- Graphite is one of the purest and most crystalline forms of carbon and can be either mined of synthetically made.
- Natural graphite powders are mined and occur in 3 different forms: vein, amorphous (actually microcrystalline) and flake.
- Synthetic graphite powders are made from carbon precursors (like natural carbons or petcoke) through a high temperature electrochemical process.
- Both synthetic and natural graphite powders compete on final applications like batteries, carbon brushes, brake pads, lubricants, foils, refractories and recarburizers for steel.

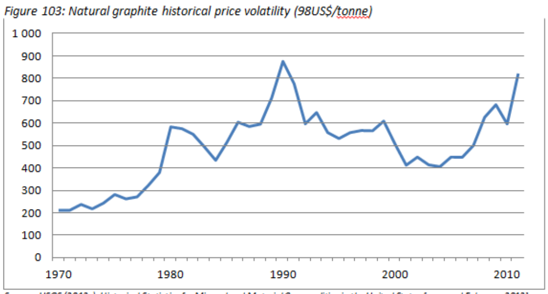
Where is Graphite Produced?

- Natural graphite powders are mainly produced in China, which holds a 70% share of total world production, followed by Latin America with 20%. Europe production of natural graphite powders is less than 1%.
- On the other side, Europe holds a very strong share in the synthetic graphite production: about 35% of the total world production.

How Much Does It Cost?

- Selling prices of graphite vary a lot depending on the purity level, the particle size and additional products properties.
- Nowadays, graphite price ranges from 500 euro/ton till 15'000 euro/ton.

Figure 103: Natural graphite historical price volatility (98US$/tonne)



Source: USGS (2012-), Historical Statistics for Mineral and Material Commodities in the United States [accessed February 2013]. Figures are indexed to 1998 values.

Specific Issues for Graphite

- Graphite is an essential ingredient in the production of the Lithium-ion batteries that will power the electrical and hybrid vehicles of tomorrow. Therefore the **demand of graphite is forecasted in strong increase over the next 5-10 years**.
- Today the EU has a leading position in the synthetic graphite powders production, development and marketing. To maintain and further strengthen this position, EU policy makers should **focus on increasing and facilitating the market access of synthetic graphite**, **encouraging additional indigenous production** of synthetic graphite and **supporting the related R&D efforts.**

NIOBIUM

What is Niobium and Where Do I Use It?

- Niobium (Nb), formerly known as Columbium (Cb), is a soft, silvery transition metal. It has chemical properties very similar to Tantalum (Ta) making it difficult to distinguish the two and it was only confirmed as a separate element by Charles Hatchett in 1801.
- It is most commonly found as pyrochlore - $(Na,Ca)_2Nb_2O_6(OH,F)$ and most of the niobium mined is sold as ferroniobium, an alloy of niobium and iron.
- Over 90% of Nb is used in steels. Its principal use is as a grain refiner, where very small additions (200-1,000 g/t), significantly increases both steel strength and toughness simultaneously. These high strength steels are mostly used in structures, pipelines and automotive applications.
- Nb has a high melting point and low density relative to other refractory metals, which make it an important alloying addition in "superalloys" for use in high temperature applications, particularly where weight is an important factor such as aircraft engines and rocket motors.
- Its superconducting properties also make it an important element in the production of components for superconducting magnets, used in products such as MRI scanners and in particle accelerators including the Large Hadron Collider at CERN.

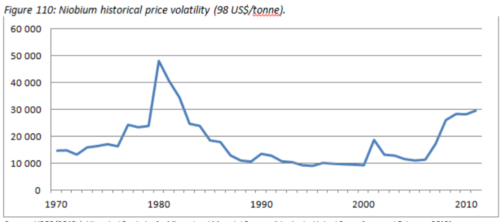
Where is Niobium Produced?

- Niobium is the 35th most abundant element in the earth's crust at a concentration of about 8 ppm. The two largest production sites for niobium are in Brazil with the third largest mine in Canada.
- The bulk of the niobium extracted is concentrated by flotation and then converted to ferro-niobium (FeNb) by aluminothermic reduction followed by electron beam refining.

How Much Does It Cost?

- Transaction prices are usually confidential between buyers and suppliers, as niobium is not an exchange-traded commodity.
- Historically the prices of niobium and ferroniobium have been held constant. In 2007, the average price increased, in line with other rare metals due to increasing demand from the emerging economies.

Figure 110: Niobium historical price volatility (98 US$/tonne).



Source: USGS (2012-), Historical Statistics for Mineral and Material Commodities in the United States [accessed February 2013]. Figures are indexed to 1998 values.

Specific issues for Niobium

- In excess of 90% of the world's niobium is produced from two mines in Brazil, despite a wide dispersion of deposits globally. This **concentration of supply** was identified as a risk by the European Commission in compiling the list of Critical Raw Materials for the EU.
- Its physical and chemical properties give it applications in several important areas, such as high strength steels. Ironically, using **Nb reduces the need to use larger additions of other elements** which are either more expensive or also classified as critical.
- The use of high strength niobium-bearing steels also brings **environmental benefits**, primarily associated with light weighting, which is often overlooked by policy makers. This results in a reduced consumption of steel, welding consumables and transportation costs (reducing CO_2 emissions).

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PHOSPHATE ROCK

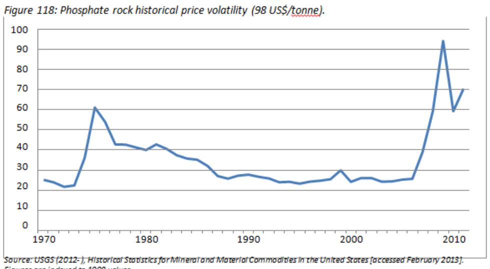
What Is Phosphate Rock And Where Do I Use It?

- Phosphate rock is formed in oceans in the form of calcium phosphate, called phosphorite. The phosphorus is an essential element for life and cannot be replaced.
- Phosphate rock is used for its phosphorus content, to produce fertilizer, feed, food and pharmaceutical product.

Where is Phosphate Rock Produced?

- Main phosphate rock producers are located in North-Africa, Middle East, USA and China.
- Europe does not have any phosphate mine and is completely dependent on foreign producers.

Figure 118: Phosphate rock historical price volatility (98 US$/tonne).

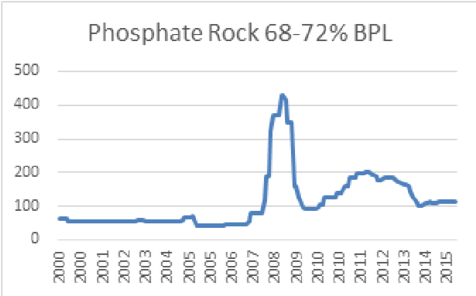


Source: USGS (2012-), Historical Statistics for Mineral and Material Commodities in the United States [accessed February 2013]. Figures are indexed to 1998 values.

How Much Does It Cost?

- Historically, the rock phosphate price was very low and stable. Since the financial crisis and the depleting of the reserves of high grade phosphate, the price continues to rise and is today twice as expensive as before 2008.

Specific Issues for Phosphate Rock



- All the producers of phosphate in the world need high grade phosphate rock to produce fertilizer, feed and food phosphate. The main issue is that today, the **reserves of high grade rock are depleting** and are held by four or five big suppliers outside Europe. Low supply combined with high demand means a price increase.
- The **full dependency of Europe for its phosphate**, the depleting of the reserve calls for new technology able to use alternative sources of phosphates (ashes from sewage sludge incineration "Urban mines", low grade rock phosphate).
- Ecophos has the technology to use the low grade phosphate, but also to close the loop by using the ashes coming from the sewage sludge incinerators.
- We **need new European legislation concerning the incineration of the sewage sludge**. The sewage sludge should be mono-incinerated and not co-incinerated with the household waste in order to close the loop.

PLATINUM GROUP METALS

What Are Platinum Group Metals (PGMs) And Where Do I Use Them?

- PGM's refer to the 'platinum group metals'
- There are six (6) PGM's: palladium/platinum/rhodium/iridium/osmium/ruthenium
- Catalysts: petroleum refining, petrochemical processing, air pollution control (mobile for gasoline & diesel vehicles & stationary abatement)
- Electronics: computer hard drives, fuel cells, thermocouples, multilayer ceramic capacitors, plasma display screens, touch-pads on all hand-held devices (I-pads, I-phones and similar products)
- Glass: for flat-screen tv's, fiberglass, sputtering targets for reflective coatings on windows
- Automobile manufacturing; air bags, anti-lock brakes, spark plugs, oxygen sensors
- Jet engines; turbine blades
- Dental alloys
- Sulfuric acid manufacturing
- Medical: cancer fighting drugs, stents for blocked arteries, pacemakers, implanted defibrillators.

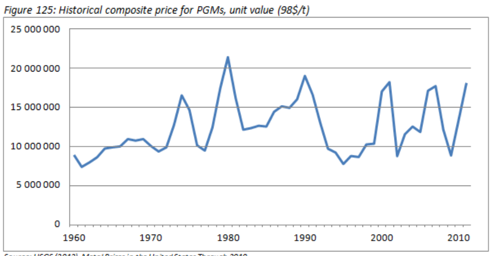
Where Are PGMs Produced?

- Approximately 70% of the world's supply comes from South Africa
- Approximately 20% comes from Russia
- The balance comes from a handful of mines in North America & from recycling

How Much Do They Cost?

- Like all other commodities, their prices fluctuate as a direct result of supply & demand. The average prices for 2014 were:
- Platinum: USD $1385 per troy oz
- Palladium: USD $803 per troy oz
- Rhodium: USD $1128 per troy oz
- Iridium: USD $620 per troy oz
- Osmium: USD $ 400 per troy oz
- Ruthenium: USD $69 per troy oz

Figure 125: Historical composite price for PGMs, unit value (98$/t)



Source: USGS (2012), Metal Prices in the United States Through 2010

Specific Issues for PGMs

- PGM's are **highly critical** & **key components** in the above sectors, plus many more. There are **no effective substitutes** that provide the same cost-effective performance as the PGM's.
- A **supply disruption will dramatically & negatively impact all**, affecting people around the world and disrupting our entire modern way of life.

SILICON METAL

What Is Silicon And Where Do I Use It?

- Silicon, in its pure form, is a grey metallically lustrous metalloid element. Metallurgical grade silicon is known as silicon metal because of its lustrous appearance.
- Silicon is used mainly in the manufacture of silanes, silicones and silica, as a “hardener” or alloying element to produce aluminium alloys, and in the manufacture of micro-processors and solar cells.
- Silicon is also used as a secondary smelting additive in the manufacture of photonic devices and in the manufacture of industrial refractories.
- Silicon metal is commonly produced by smelting submerged electric arc furnaces, which is an energy-intensive process. Further processing of the material into different product grades makes it applicable in many industry processes.
- The industry is investing in R&D for the development of high value silicon bound to the photovoltaic market.

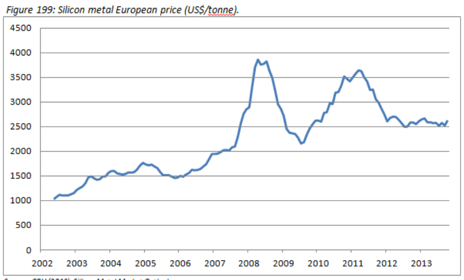
Where is Silicon Produced?

- China has a dominant position in Silicon metal production (56% of world market shares in 2011 and constantly growing). This production is not only well above the domestic consumption but also well above the total world demand for Silicon metal.
- Brazil is another producer outside of Europe, as well as the US.
- Within Europe, the producing countries are Norway, France, Spain and Germany.
- Overall, the EU is a net importer of Silicon metal.

How Much Does It Cost?

- The price of Silicon is dependent on the quality provided.
- The price of a tonne of Si 99% min. is 2,250-2,400 €.

Figure 199: Silicon metal European price (US$/tonne).



Source: CRU (2013), Silicon Metal Market Outlook

Specific Issues for Silicon

- Silicon metal is absolutely **necessary to the production of aluminium** and chemical products since it provides them with essential properties. A wide range of modern technologies depend on this material.
- Silicon metal **cannot be substituted** and there is no recycling of (pure) Silicon.
- The **global demand for Silicon metal is growing**.
- The European Commission identified Silicon as a Critical Raw Material in 2014.
- The **economic importance** of Silicon has been demonstrated – in the aluminium and chemical sectors, but also as essential material in the electronics and solar industries. The absence of substitutes for the wide range of end-uses only increases the critical character of this material.
- In terms of **supply risk**, China’s production of Silicon leads to an evident overcapacity. The world consumption of Silicon today is ca. 2 Mio T and the installed capacities in China are ca. 5 Mio T. The supply risk will increase in the future: the market balance expected for 2020 clearly shows large excess capacity. The surplus is expected to mainly originate in China.
- Today there is **no level playing** field between the EU and its main competing regions in terms of policy in the energy, climate and environment field. European Silicon metal producers are faced with **fierce and often unfair competition from third countries**. The still existing Europe-based commodity production must be preserved if the EU wants to avoid exposing its main economic sectors to a total dependence vis-à-vis external raw materials supply.

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TANTALUM

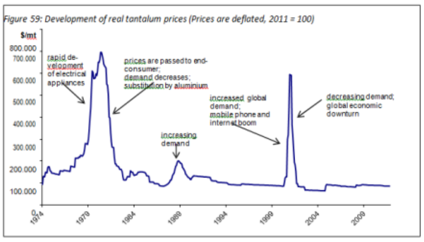
What Is Tantalum And Where Do I Use It?

- Tantalum is a refractory metal that is corrosion-resistant, very hard, and an exceptional conductor of heat and electricity.
- Consumer electronics or electronic devices consume about 75% of tantalum produced. This includes items like capacitors in mobile phones or thin films of tantalum in touch screens and printers.
- Other important uses of tantalum are nickel superalloys for turbine engines, carbides for tool bits, explosively-formed projectiles for missiles, and tantalum-coated orthopedic implants.

Where is Tantalum Produced?

- Until 2008, the largest tantalum producers were industrial-scale mines in Australia (Wodgina), Canada (Tanco), Brazil (Mibra and Pitinga), Ethiopia (Kenticha), Mozambique (Marropino), Russia (Lovozero), and Yichun (China).
- With the exception of mines in Brazil, Russia, and China, all of the mines listed above closed by 2013 due to a combination of rising operating costs, high radiation levels, and / or financial distress.
- Large numbers of artisanal miners from Central African and, to a lesser extent, South America stepped-in to fill this gap. African tantalum now accounts for more than 50% of global output.
- Downstream companies and smelters also have increased tantalum recycling and alternative material use.

Figure 59: Development of real tantalum prices (Prices are deflated, 2011 = 100)



Source: DERA, HWWI (2013) Ursachen von Preispeaks, -einbrüchen und –trends bei mineralischen Rohstoffen (Causes of price peaks, collapses and trends of mineral raw materials), Hamburg Institute of International Economics (HWWI) in contract for Deutsche Rohstoffagentur (DERA). April 2013, translated to English by Fraunhofer ISI

How Much Does It Cost?

- Tantalum prices increased significantly in response to the promulgation of draft rules on ***conflict minerals*** in the United States in December 2010.
- Industrial-scale mines have ***closed*** as tantalum prices have increased.

Specific Issues for Tantalum

- Tantalum was **removed from the Critical Raw Materials** List in 2014 due to factually wrong information.
- The tantalum market **needs more diversified global sources of supply**.
- Under U.S. law, tantalum is a "**conflict mineral**" because its extraction and trade in the Democratic Republic of Congo (and countries that border it) is helping to finance armed conflict, including sexual- and gender-based violence.
- Some companies have begun supporting artisanal miners in the Democratic Republic of Congo, and **industry groups are standing-up "bag-and-tag" or "conflict-free" auditing regimes.**
- According to the United Nations Group of Experts (Jan. 2015), tantalum smuggling into countries bordering the Democratic Republic of Congo continues, due to the higher price of tantalum in those countries and the **availability of "tags" and "conflict-free" documentation for purchase.**
- Of the minerals seized by customs officials in North Kivu (Democratic Republic of Congo) from February to August 2014, ***91% was tantalum***.

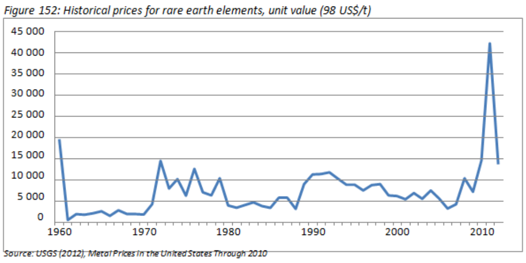
HEAVY AND LIGHT RARE EARTHS METALS

What Are REE's And Where Do I Use Them?

- The term rare earth elements (REEs) describes 17 different elements which have a unique set of properties that makes them very difficult to substitute. They lie at the bottom of the periodic table of elements.
- The definition of a LREE and HREE is based on the electron configuration of each rare-earth element. LREE have in common increasing unpaired electrons while HREE have paired electrons (a clockwise and counter-clockwise spinning electron). LREE include the atomic number 57 through 64 (La, Ce, Pr, Nd, Pm, Sm, Eu, Gd). HREE include the atomic number 65 through 71 plus number 39 (Tb, Dy, Ho, Er, Tm, Yb, Lu, Y). Scandium (Sc number 21) forms a group in itself as its properties cannot be classified as either a LREE or HREE.
- These differences in electronic configuration are critical to the individual properties the REE exhibit and how they interact with other elements and compounds.
- REEs permit an extraordinary wide range of enabling technologies and as such are widely distributed through most consumer and industrial products in the automotive, aerospace, consumer electronics and electrical engineering fields.
- The most important sector by value is that of REE-bearing permanent magnets, which are used extensively in applications such as motors, couplings and sensors. REE magnets are critical to the efficient operation of large wind turbines and hybrid cars.
- They are also widely consumed in lighting products, as catalysts and in the production of glass.

Where are REE's Produced?

Figure 152: Historical prices for rare earth elements, unit value (98 US$/t)



Source: USGS (2012), Metal Prices in the United States Through 2010

- While each REE is slightly different, on average more than 90% of REE's are currently produced in China.
- Chinese practices for production of rare earths are poorly regulated, such that production of REE's has a significant impact on the environment compared to their relatively small market value.
- Some critical REE's like dysprosium (Dy) are only mined in China, which places the supply chain for high power magnets at risk.

How Much Does It Cost?

- REEs range in price from US$4/kg for the most abundant light REE's cerium (Ce) and lanthanum (La), to more than US$400 per tonne for the scarcer dysprosium (Dy) and terbium (Tb).
- Price of the materials varies with purity, and whether the product is sold as an oxide or as a metal.
- Historically, the Chinese Government applied export taxes and tariffs to control REE supply. Currently the Chinese Government is pursuing policies to bring the industry under full State control. Many of the REE suppliers are Chinese State Owned Enterprises and the remaining private companies are being required to join into state controlled "Groupings" in order to continue operating.

Specific Issues for REEs

- **Both Light and Heavy REEs have been identified as Critical Raw Materials** by the European Commission in both 2010 and 2014.
- This is a result of both the **industrial importance** of the metals, and the **Chinese supply monopoly**. The Chinese supply monopoly has led to volatile price and availability, and caused Western consumers to move away from the best industrial solutions.
- While **REEs are not rare in nature**, it is **uncommon to find them concentrated into mineable deposits**. Furthermore, it is expensive to process and extract the REEs to commercial standards.
- The **long term lack of investment in a Western supply chain** lead to the Chinese market dominance.
- This dominance can be overcome, with **investment in new non-Chinese supply options**.
- European based OEMs are significant consumers of REEs and have publically stated their desire for non-Chinese alternatives, for which they would be willing to pay premiums for
    - reduced dependence on a single source
    - improved security of supply
    - lower risk of price volatility
    - environmentally acceptable supply chain
- Currently there are well-established companies in the REE supply chain operational within Europe. These include the Solvay separation plant in la Rochelle, France and the Less Common Metals rare earth alloy plant in Ellesmere Port, UK. Both companies have excellent reputations internationally. However they address only specific aspects of the overall supply chain and cannot in isolation remove the EU's dependency on China for REEs.
- The **EU can be self-sufficient for REEs with modest investment** in mining and greater investment in recycling. By broadening the supply alternatives, it is believed the price volatility will end, and REEs can be engineered in Europe with confidence.

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