British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL


# Critical raw materials: what, why and how?

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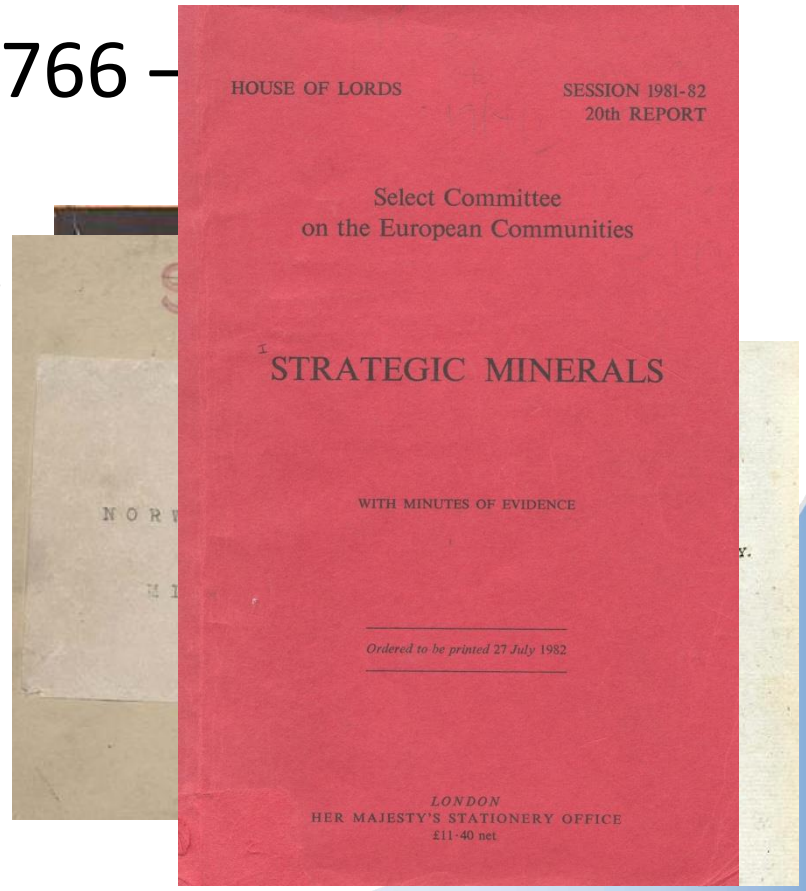
British Geological Survey

*GIFT WORKSHOP – 2015: MINERAL RESOURCES*
*Vienna, Austria, 12-15 April 2015*

# Security of supply of mineral resources

- Recurring theme in history is the availability of mineral resources
  - Rev. Thomas Malthus (1766 –
  - World War II – W mining in SW England, material stockpiles in the US
  - Cold War – ferroalloys, U availability



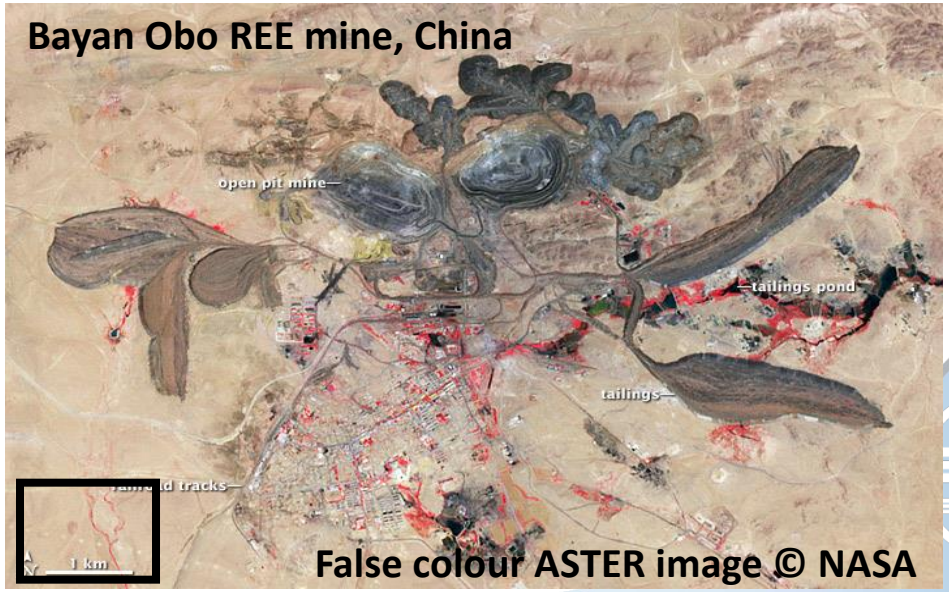
# Security of supply of mineral resources


- Late 20th / early 21st Century UK and EU public attitudes overwhelmingly hostile to domestic mineral extraction
- Poor past record
- Socio-economic change and a rise in environmental ‘consciousness’ has resulted in a challenging domestic minerals sector
- Reinforced by post-Cold War ‘market will provide’ paradigm which conceals the true impact of conspicuous consumption

# Globalisation: market efficiency or out of sight, out of mind?

- The EU now has a strong negative mineral trade balance
- In post-Cold War global free-market, both primary and manufactured goods flowed from producers with lower marginal costs


- Mineral industry benefitted from economies of scale
- As well as enjoying the economic benefits, to what extent have we moved our environmental impacts and obligations out of Europe?



# Mineral Resources: ‘supercycle’ and the new world order 2000-2010

- Booming World economy and double digit growth rates in the BRIC countries drive a sustained minerals ‘supercycle’

- Concentration of global production in a few countries, e.g. rare earth elements in China

- As a result, old concerns about mineral resource security start to re-emerge in the West

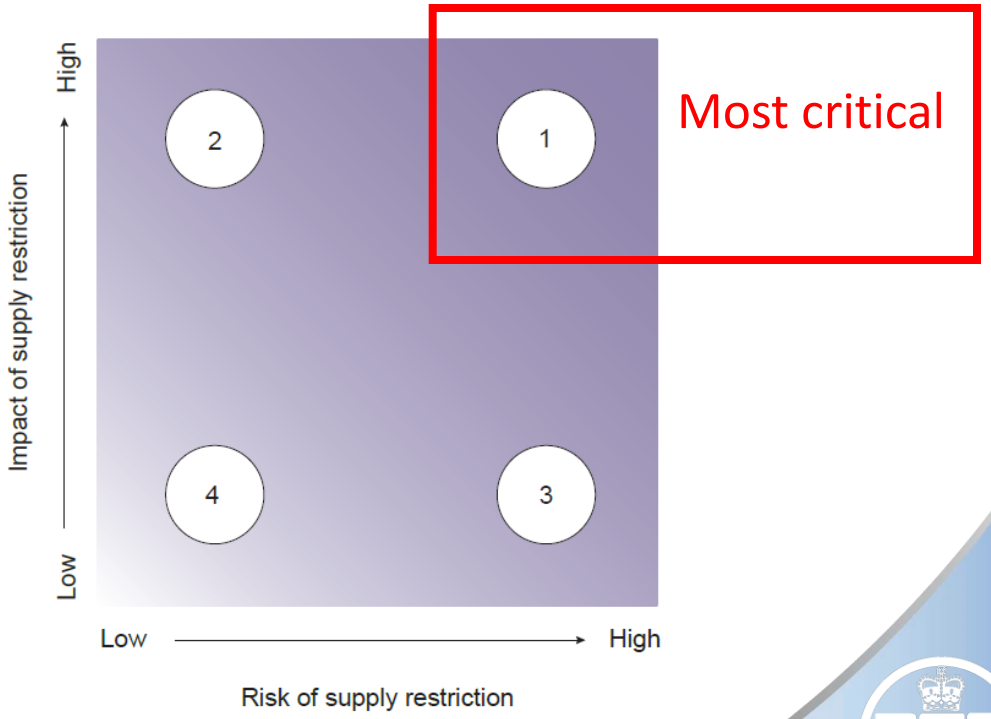
# Mineral criticality – what should we be worried about?

- EU is heavily import dependent on most metals including those used in high-tech. and green technologies
- This has led to the classification of some minerals as “at risk” to supply disruption
- Criticality shortlists are important for informing policy and prioritising research on security of supply issues


# The concept of criticality

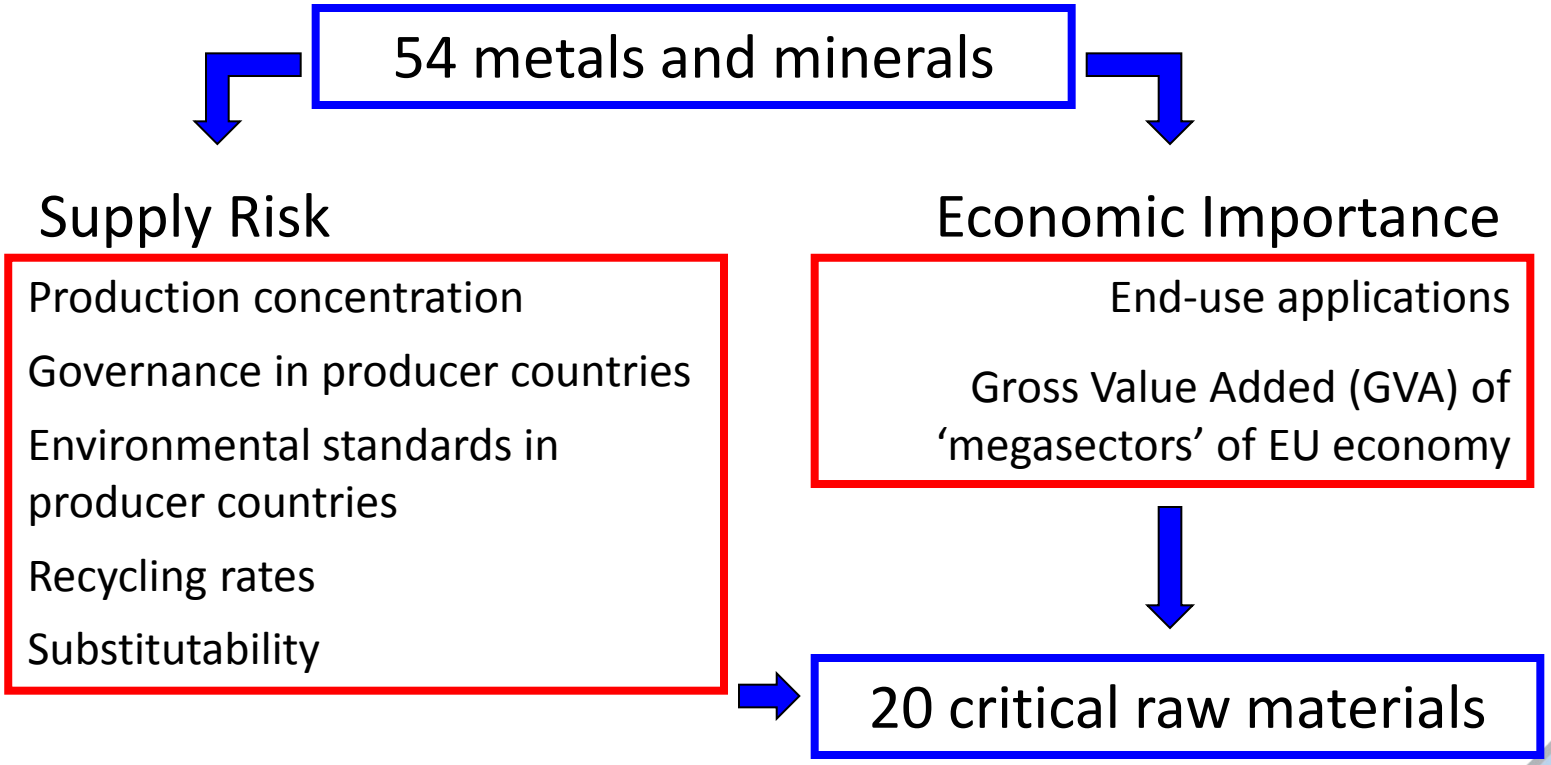
- Criticality is a matter of degree not state (Gunn, 2014)
- A mineral is neither critical or non-critical, moreover it has a criticality level based on the following criteria:

  - Supply risk
  - Economic importance
  - (Environmental impact (Graedel *et al*., 2015))



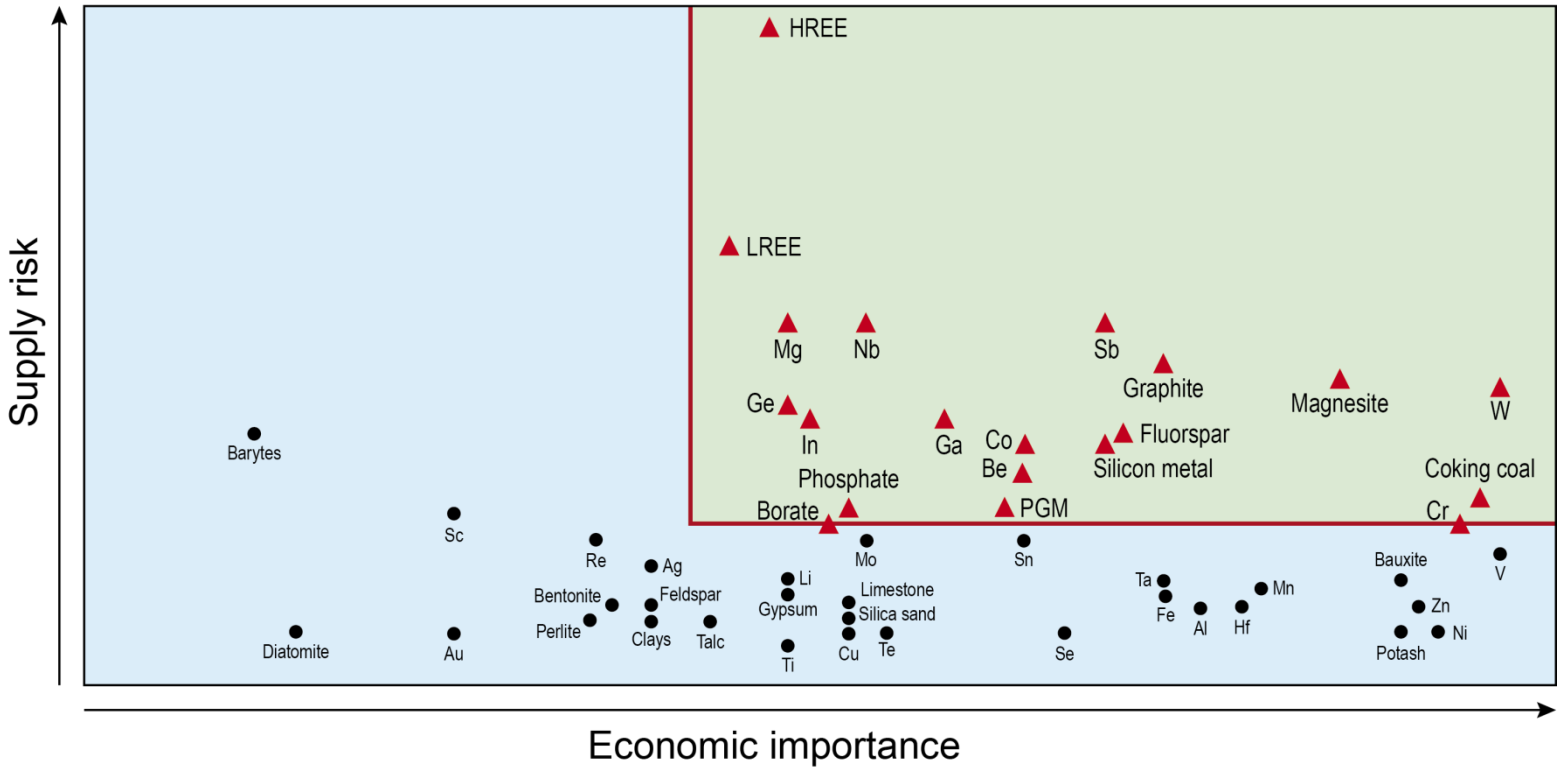
# EU criticality assessment - 2014

- Assessed mineral raw materials based on importance to the EU economy and the likelihood of supply disruption




http://ec.europa.eu/enterprise/policies/raw-materials/critical/index_en.htm

# Critical raw materials for the EU (2014)



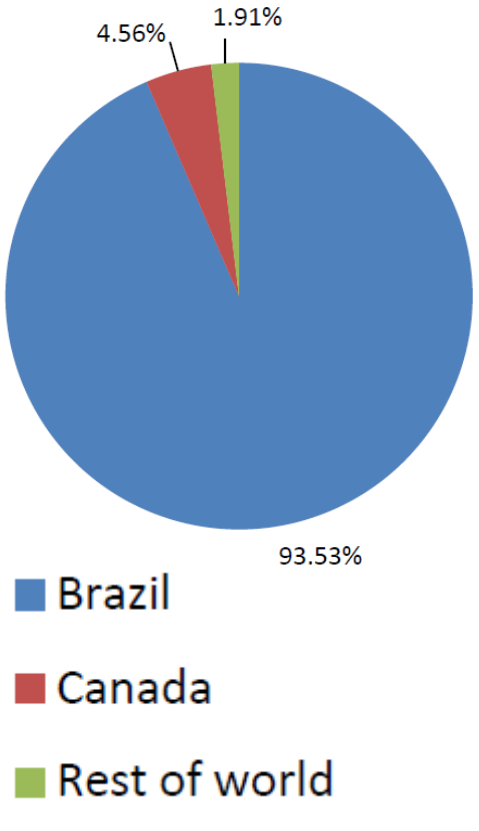

The EU critical 20

| 7 Industrial Minerals | 13 Metals | |
|---|---|---|
| Graphite | HREE | Cobalt |
| Fluorspar | LREE | Beryllium |
| Borate | Magnesium | PGM |
| Phosphate rock | Niobium | Antimony |
| Silicon metal | Germanium | Tungsten |
| Magnesite | Indium | Chromium |
| Coking coal | Gallium | |

# Supply risk: Concentration of production

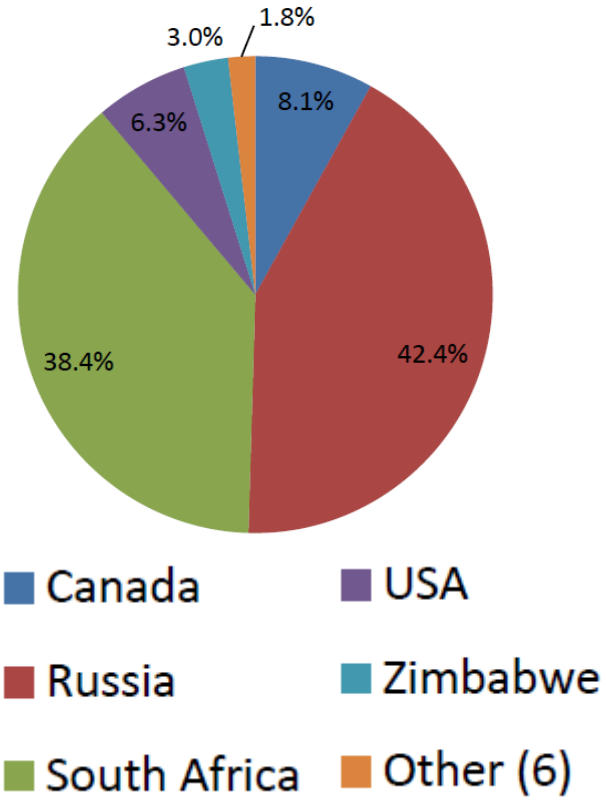
Global production total 2013: 267,000 t

## Ta-Nb concentrate



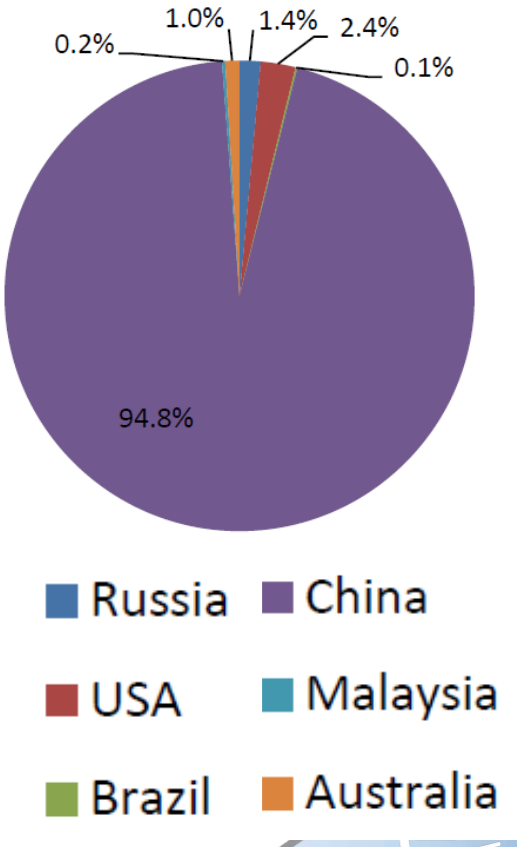

Global production total 2013: 198,142 kg metal content

## Palladium




Global production total 2013: 100,172 t

## REE as oxides






Data from British Geological Survey 2015, World Mineral Statistics database

# Supply risk: geopolitics

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## Australia supports public-private dialogue on mining

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Key representatives of government, civil society organisations, mining communities, and industry, have met in Accra to dialogue on issues concerning mining.

A statement issued by the Australian High Commission in Accra, and copied to the Ghana News Agency said, two key mining topics: How to improve the governance of the Artisanal and Small-scale Mining (ASM) Sector; and how to improve Public-Private Partnerships to ben communities, were discussed.

REUTERS

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## China's rare earths quotas go, possible new moves stoke supply doubts

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## Mining and geopolitical risk: A global breakdown

17 March, 2015 Cole Latimer 1 comments

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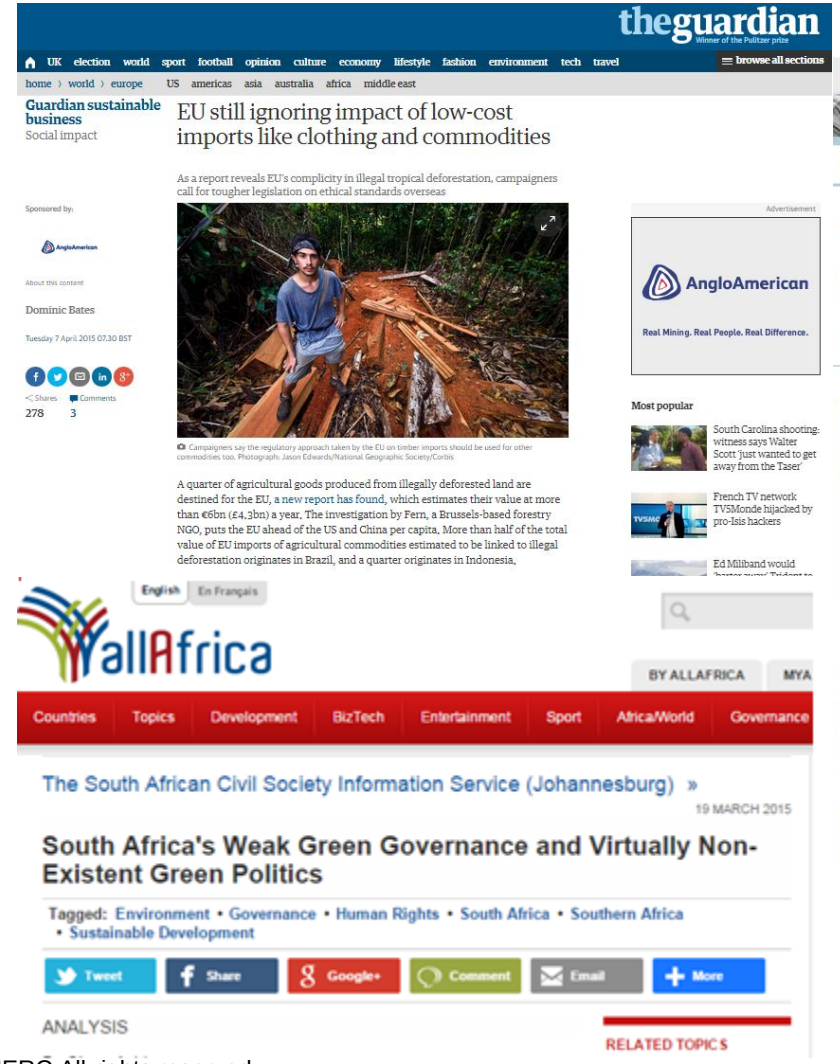
Australia has always had an insular view of the mining industry.

It is often forgotten that many of the mining companies that operate here have a large suite of overseas operations, or are simply headquartered here but operate solely overseas.

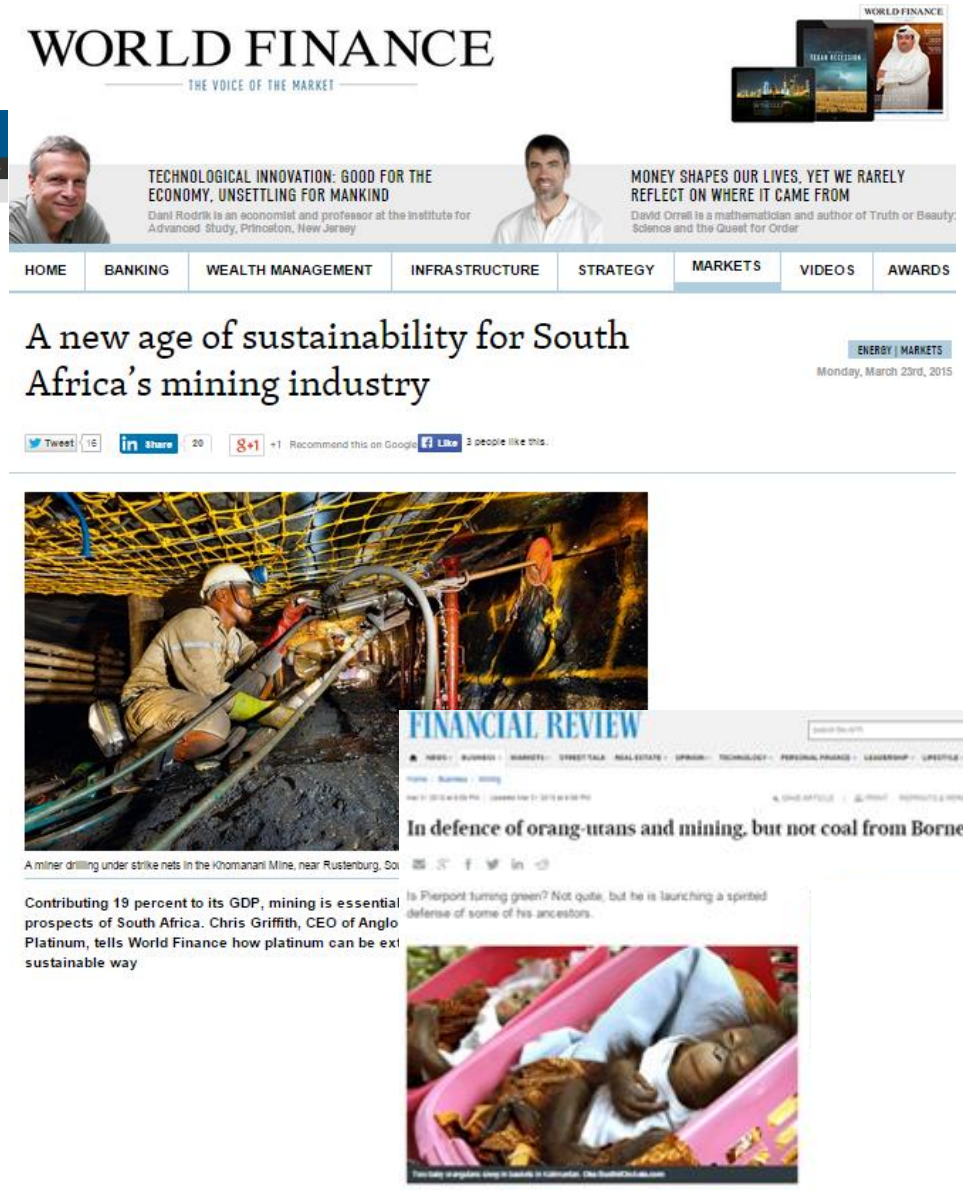
BGS 1835

# Supply risk: environmental standards in producer countries









# Supply risk: recycling – a complementary source of supply

MAJOR benefits of recycling:

- Mitigation of environmental impact of mining
- Extends the lifetime of primary resources
- Reduces geopolitical dependency
- Reduces the overall environmental burden e.g. emissions from discarded products, landfill, land use
- Reduces supply risk
- Supports ethical sourcing of raw materials
- Improving the 'balance-problem' between supply and demand
- Employment potential



Hagelüken, 2014; In: Gunn, 2014

# Supply risk: recycling in practice

However...

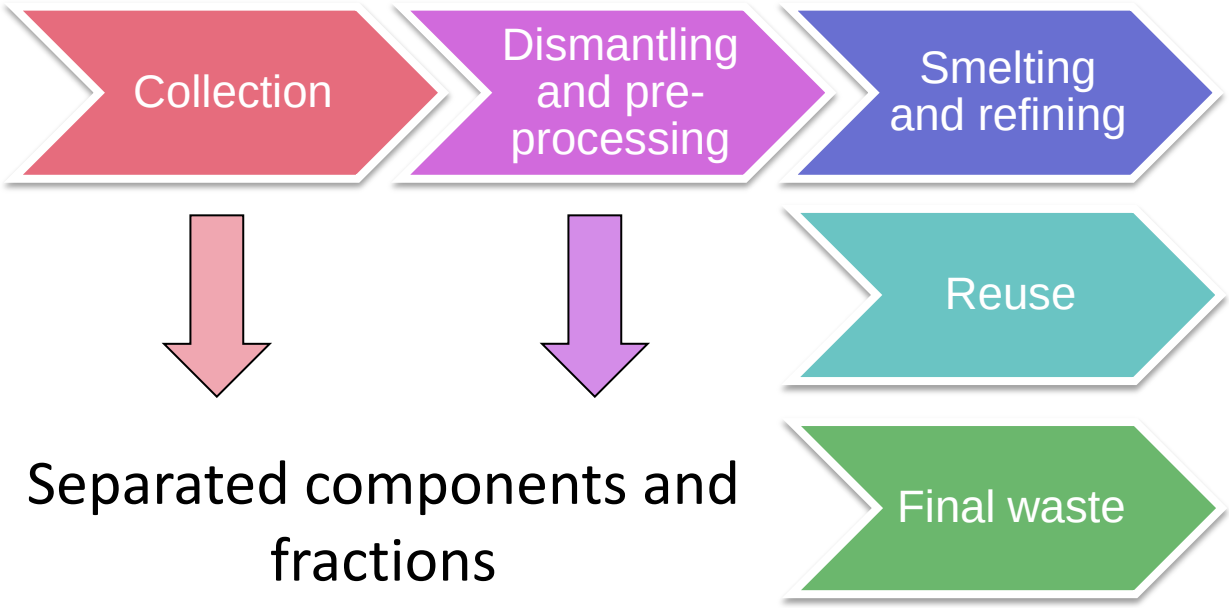
How many of you have an old mobile at home??

Unusual metal combinations

Efficiency at each stage

30 % x 60 % x 95 % = 17 %

End-of-life products

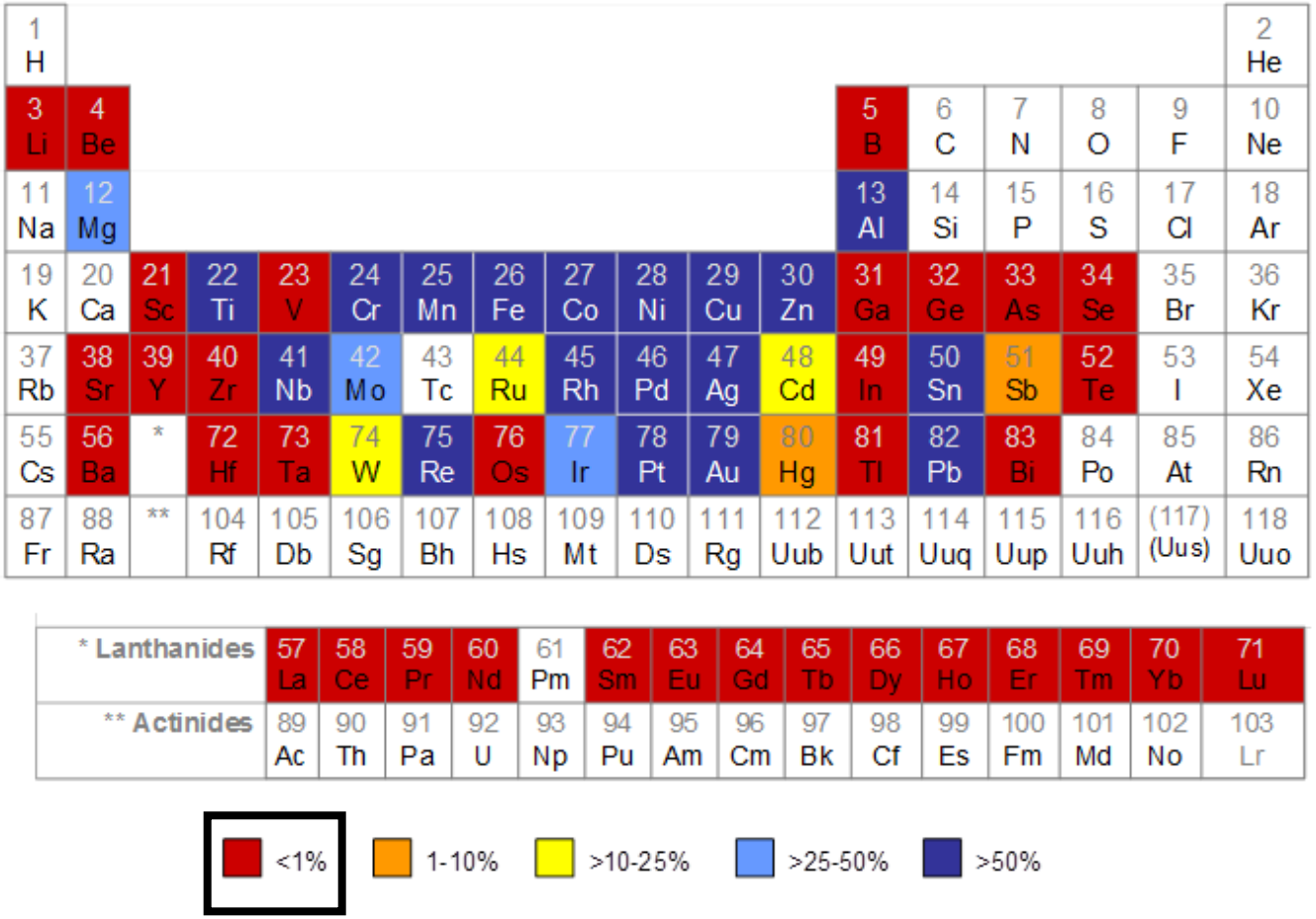





Adapted from Hagelüken, 2014; In: Gunn, 2014

# Supply risk: end-of-life recycling rates

## The reality...




UNEP, 2011

# Supply risk: substitutability

‘Necessity is the mother of invention’

| Substitution status | Critical Metals |
| --- | --- |
| Few known substitutes in some applications | REE, Re |
| Unique properties that make substitution difficult | Be, Ta, Nb, W |
| Alternatives available but result in poorer performance | Co, Sb, Ga, Li, Mg, PGMs |
| Alternatives have been developed | Ge |
| Alternatives available but developing technology has kept the critical material in use | In |

# Geological considerations

- Physical availability of mineral deposits is not the issue but...need to continue to find more deposits

Technology for exploration, mining, processing, etc. all need to be developed. Deposits are frequently concentrated in one country and supply needs to be diversified

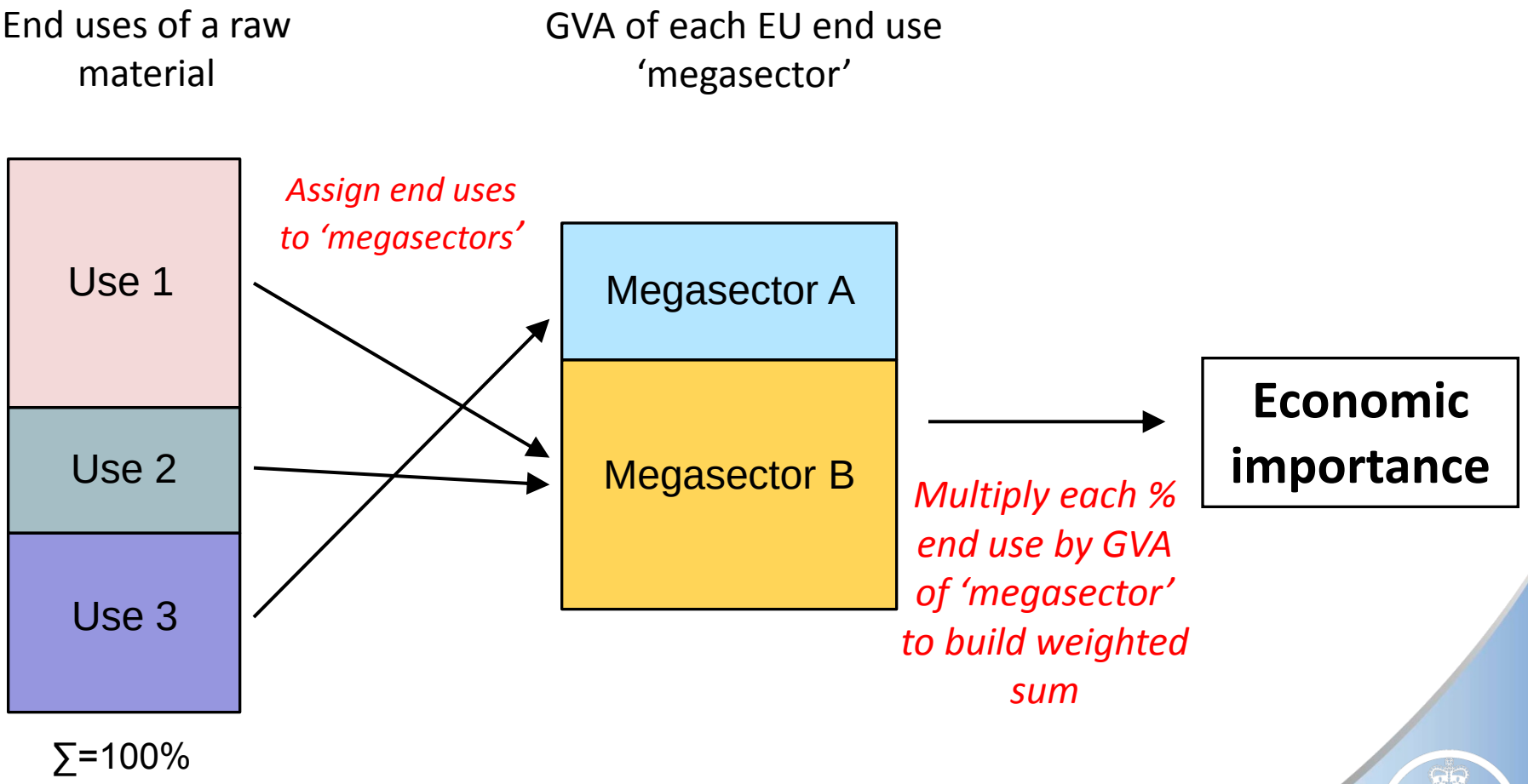
- Difficult to predict the future demands – criticality assessment tends to be a "snapshot" of the current situation

**British Geological Survey**

Risk list 2012—Current supply risk index for chemical elements or element groups which are of economic value

| Element or element group | Symbol | Relative supply risk index | Leading producer | Top reserve holder |
|---|---|---|---|---|
| rare earth elements | REE | 9.5 | China | China |
| tungsten | W | 9.5 | China | China |
| antimony | Sb | 9.0 | China | China |
| bismuth | Bi | 9.0 | China | China |
| molybdenum | Mo | 8.6 | China | China |
| strontium | Sr | 8.6 | China | China |
| mercury | Hg | 8.6 | China | Mexico |
| barium | Ba | 8.1 | China | China |
| carbon (graphite) | C | 8.1 | China | China |
| beryllium | Be | 8.1 | USA | Unknown |
| germanium | Ge | 8.1 | China | Unknown |
| niobium | Nb | 7.6 | Brazil | Brazil |
| platinum group elements | PGE | 7.6 | South Africa | South Africa |
| colbalt | Co | 7.6 | DRC | DRC |
| thorium | Th | 7.6 | India | USA |
| indium | In | 7.6 | China | Unknown |
| gallium | Ga | 7.6 | China | Unknown |
| arsenic | As | 7.6 | China | Unknown |
| magnesium | Mg | 7.1 | China | Russia |

# Measurement of economic importance of a raw material to the EU



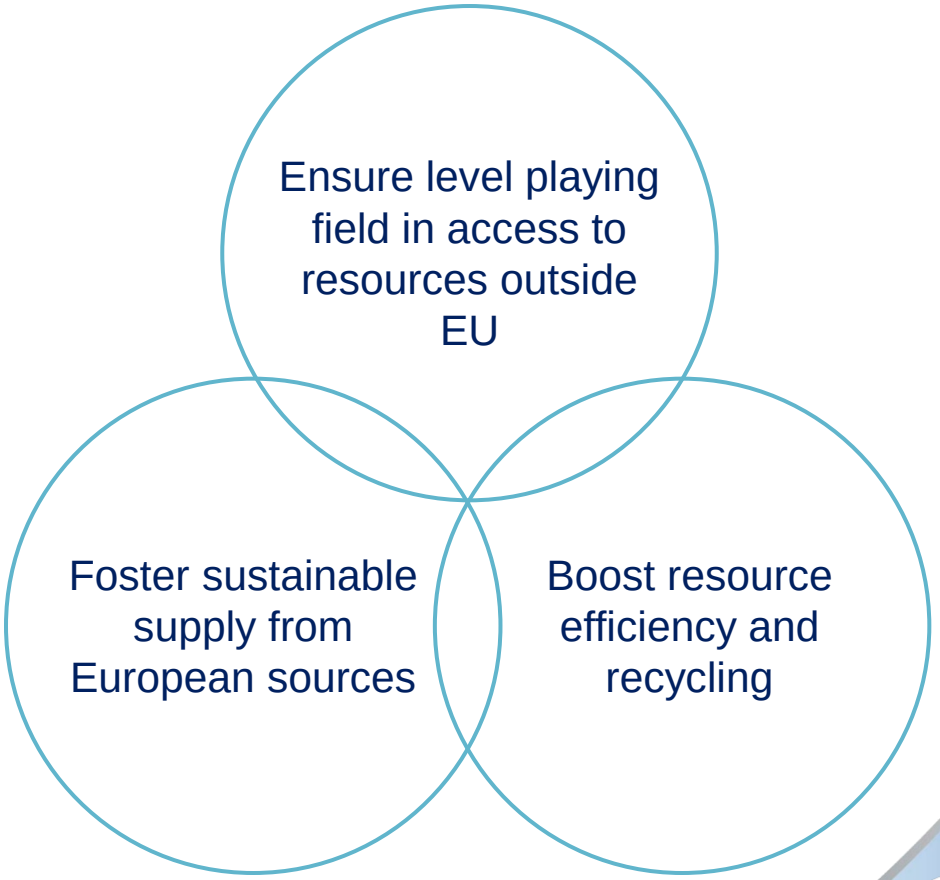
# So, what is the EU doing to address security of supply?

Raw Materials Initiative (2008-2011)

European Innovation Partnership (2014-2020)

# EU Raw Materials Initiative (RMI) 2008 – 2011 – securing sustainable supplies

- Increasing raw material demand, especially for new/green technologies, and increasing risk of supply disruption
- Launched in 2008, consolidated in 2011
- Non-energy, non-agricultural raw materials
- Integrated strategy built around 3 pillars, linking EU internal and external policies

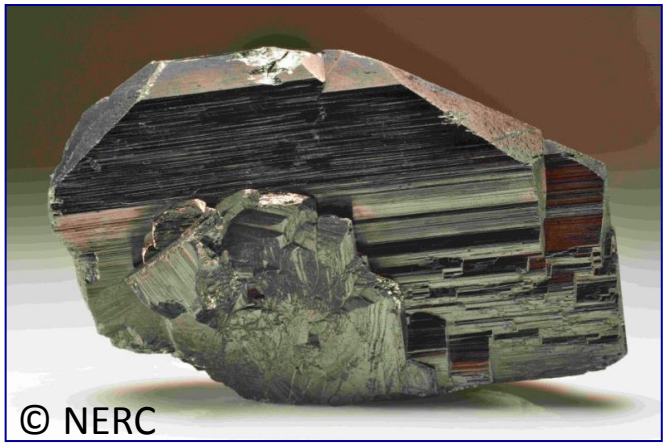


# European Innovation Partnership on Raw Materials, 2014 - 2020

- Major new policy initiative (EIP) building on the RMI
- Overall aim to ensure the sustainable supply of raw materials to the EU economy, while increasing benefits for society as a whole
- Specific objectives:
  - reducing import dependency
  - improving supply conditions in EU
  - diversifying raw materials sourcing
  - improving resource efficiency (including recycling)
  - finding alternative raw materials
- https://ec.europa.eu/eip/raw-materials/en

# Value of criticality assessments to the EU

- Raise awareness and understanding among stakeholders, providing an ‘early warning’ of potential supply problems
- Help to prioritise requirements and actions
- Industry views ‘critical’ designation as implying scarcity and promoting substitution
- ‘Non-critical’ raw materials remain important to the EU economy



Wolframite, a major ore mineral of tungsten

# Security of supply – working together in Europe

- Expert networks
  - CRM InnoNet (substitution)
  - ERECON (rare earths)
  - ERAMIN (coordination of research in raw materials supply)
- EU programmes – numerous projects, part or fully funded by EC

Niobium metal, Araxá, Brazil

# European Rare Earths Competency Network (ERECON) – towards EU supply security

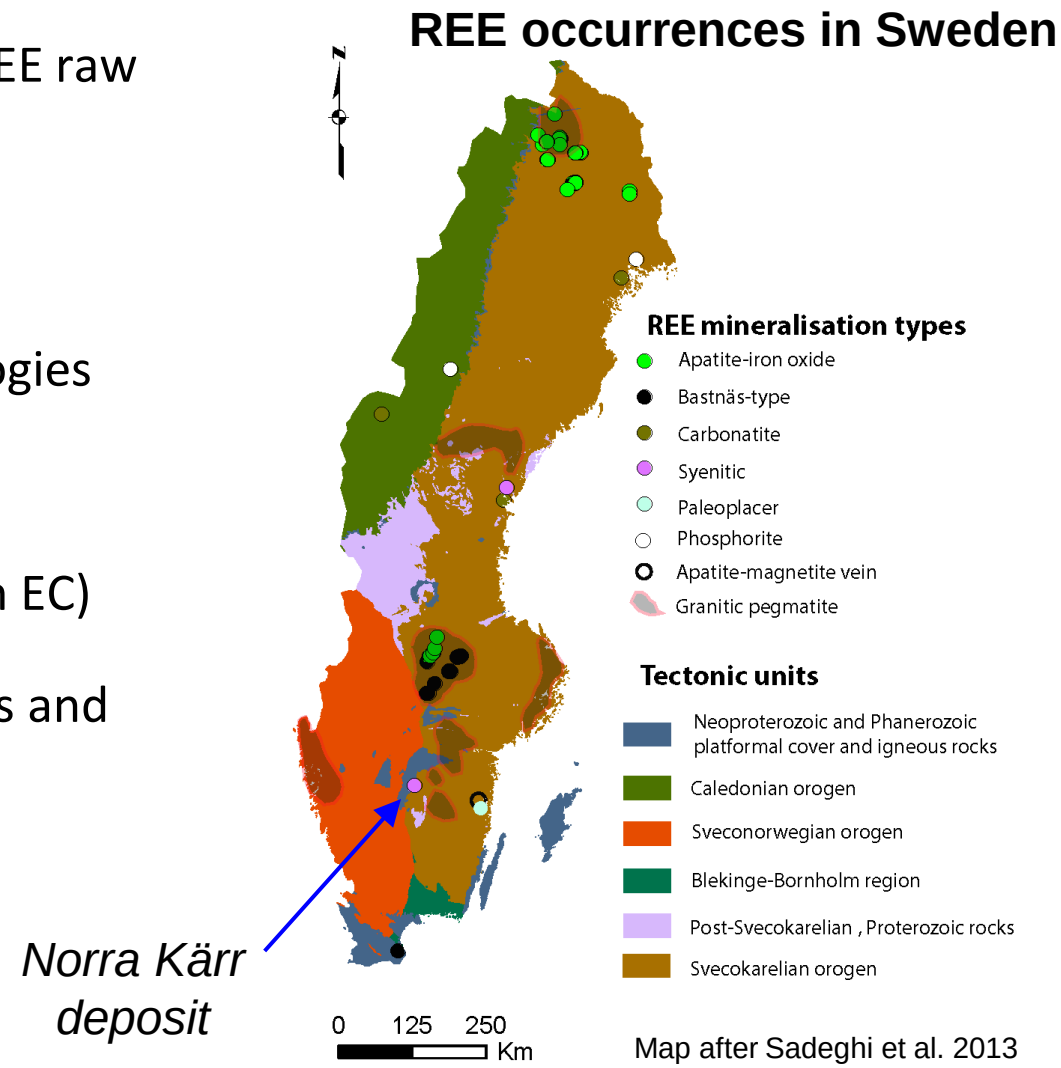
- Three Working Groups (established 2013)
  - Opportunities and road blocks for primary REE supply from EU
  - REE resource efficiency and recycling in EU
  - REE current and future industrial demand and supply challenges
- Reports to deliver clear-cut policy recommendations across the REE value chain
- http://ec.europa.eu/enterprise/policies/raw-materials/erecon/index_en.htm


Eudialyte, a potential REE ore mineral

# EURARE - development of a sustainable exploitation scheme for Europe's Rare Earth ore deposits

eu Rare 57-71 sustainable exploitation

- Aims to safeguard EU supply of REE raw materials
- Will characterise European REE resources and develop new ore beneficiation/extraction technologies
- 5-year project from Jan. 2013
- Budget 14 million euro (65% from EC)
- 23 partners, including researchers and industry
- http://www.eurare.eu/home.html




Map after Sadeghi et al. 2013

# Blue Mining – deep-sea mining

- Aims to develop technical capabilities to discover, assess and extract mineral deposits at up to 6000 m water depth

- 4 years, 2014 – 2018
- 19 partners, 6 countries
- 15 million euro (10 million from EC)

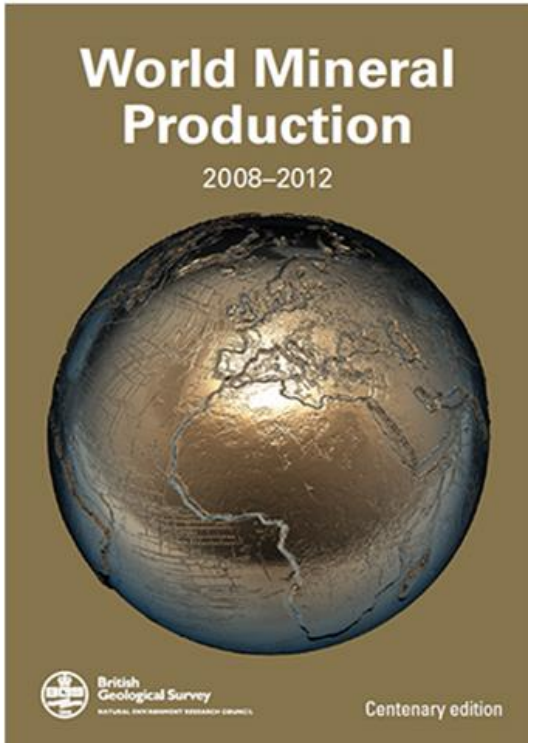
- http://www.bluemining.eu/

# Minerals4EU

Co-funded by the European Union

SEVENTH FRAMEWORK PROGRAMME

- Better information and analysis of EU's mineral resources and industry
- Aims to develop a permanent EU Mineral Intelligence Network
- Onshore and offshore resources, primary and secondary
- 31 partners, including 25 national geological surveys
- 2 million euro, 2 year project, started Sept 2013
- Deliverables
  - Minerals data and products
  - European Mineral Yearbook
  - Analysis and foresight studies
- http://www.minerals4eu.eu/



# Security of Supply of Minerals 2012–2017 (UK)

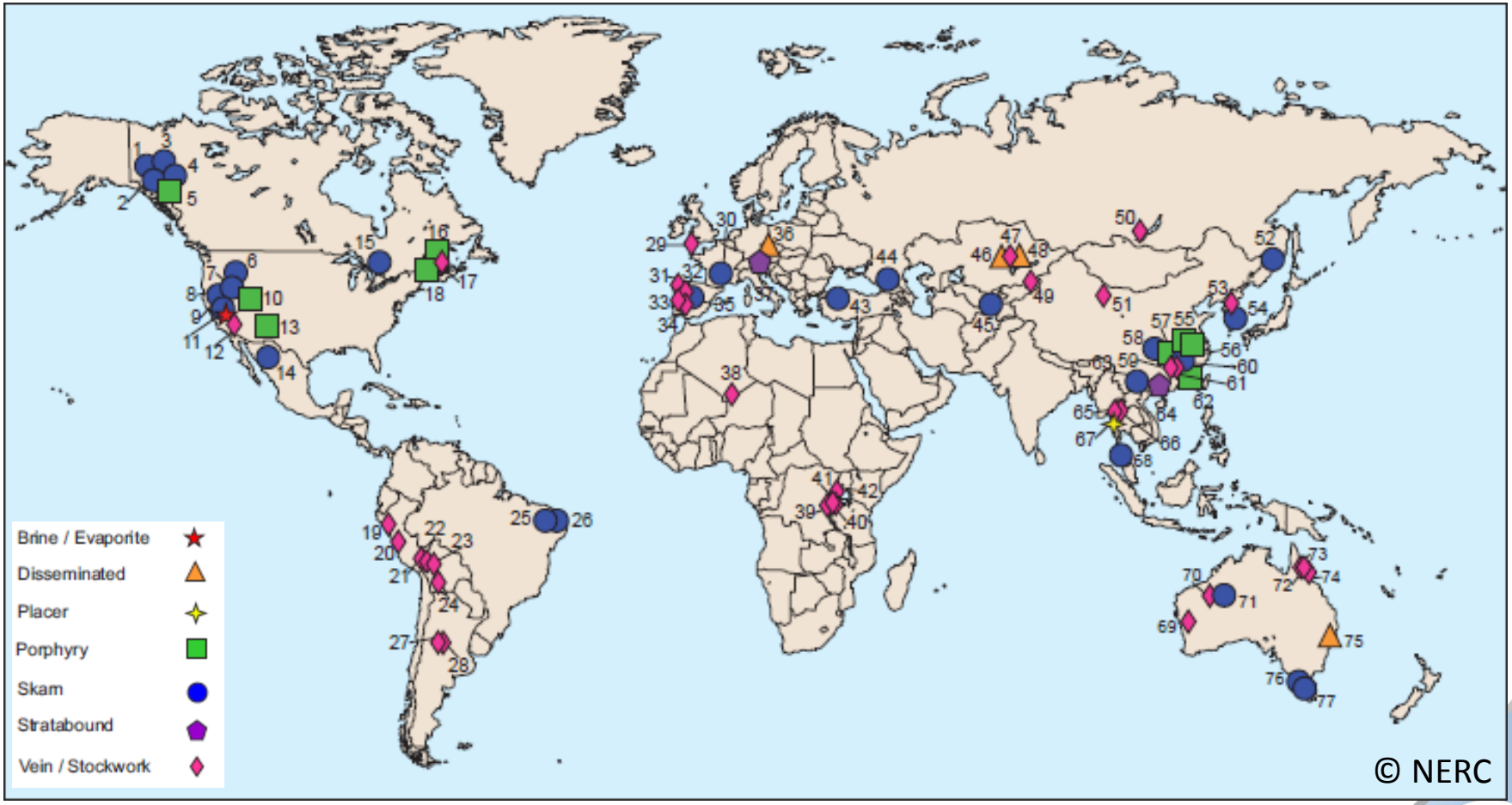
- Understand environmental-technology element cycling and concentration in natural systems
- Understand how to predict and mitigate the environmental effects of extraction and recovery of environmental-technology elements
- £15 million – REE, Co, Te, Se and deep sea mineral resources


- http://www.nerc.ac.uk/research/funded/programmes/minerals/#xcollapse3

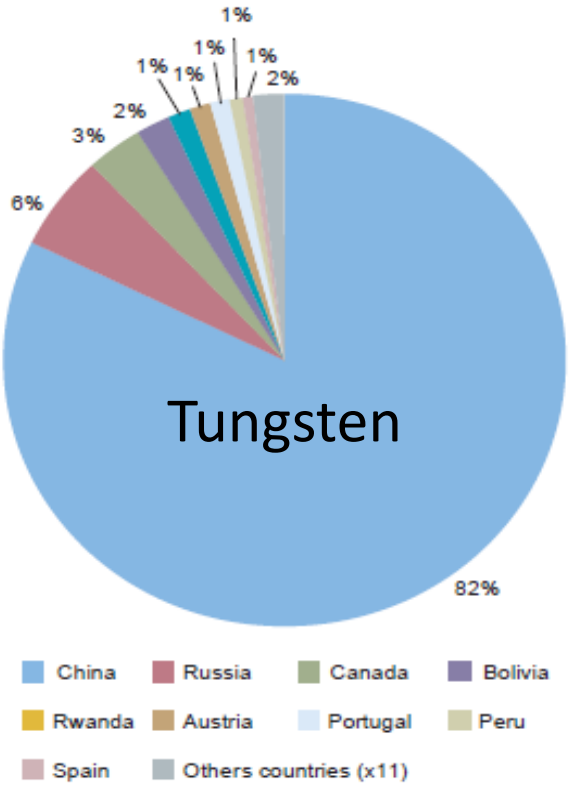
# Critical metal case study: Tungsten

- Tungsten is hard and very dense metal.
- It is resistant to corrosion, highest melting point of all non-alloyed metals, lowest coefficient of expansion and the highest tensile strength
- Production of “hard metals” ~50% e.g. tungsten carbide, steel alloys <~40%, mill products – sheets, wire, etc (used in light bulbs, etc), specialist applications in electronics and pigments
- Deposits are globally well distributed
- ~83% of production (2013) from China

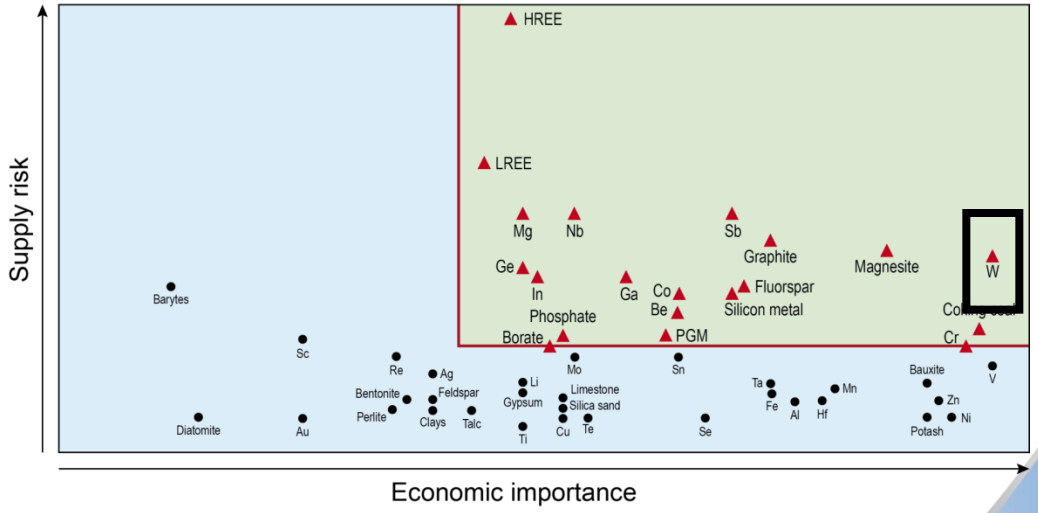
# Tungsten: global distribution



# Tungsten global production 2013




- Mine production of tungsten 2013: 77,200t (BGS, 2015)
- Production dominated by China




- Need to diversify the supply and reduce reliance on Chinese supplies

# Hemerdon tungsten-tin deposit, Devon, South West England

- Major, new secure UK supply of tungsten
- Sheeted vein greisen deposit located in the Hemerdon Ball granite
- 5th largest W deposit globally; reserve of 35.7Mt at 0.18% $WO_3$ and 0.03% Sn equalling 3 % of global W supply
- Mine and processing facilities under construction
- Due to start production in 2015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# Conclusions: security of mineral supply and critical raw materials in the EU

- Profile of mineral raw materials at all-time-high levels
- EU has defined those critical raw materials essential to the European economy
- Pan-EU criticality assessments provide early warning of potential supply disruption
- Useful tools for decision making by government and industry, and for prioritising research directions
- Research funding available from EC (and some MS governments) has grown rapidly
- Mining and recycling are both important to secure supply
- Begun to dispel the myth that physical depletion of resources is a threat:
  - Need to continue finding new deposits
  - While reducing the environmental footprint of extraction


# Thank you!!

# Economic Importance

End-use applications and Gross Value Added (GVA) of ‘megasectors’ of EU economy

- The end uses of critical materials are assigned to ‘megasectors’ of the European economy such as construction, electronics etc.
- The monetary value (GVA) of these ‘megasectors’ to the EU are calculated using Eurostat data
- The (weighted) value of each critical material to each ‘megasector’ is calculated to give a relative economic importance for the critical raw material of choice
- These values are plotted with supply risk to identify the ‘most critical’ raw materials to the European economy