How to reinforce EU Supply of CRM – deploying new value chains: voluntary standards, polices and regulatory framework

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Introduction

- Current use and **future CRM trends** in Europe
- Issues undermining CRM sector

- **How to reinforce CRM supply in Europe**
  - Primary sources (incl. by-products and mining waste)
  - Secondary sources
  - Substitution

- Good practises
- Outlook

EU - major global consumer of CRMs (1)

- EU consumes 25% of world´s CRM demand,
- EU´s share in world production (2015) between 0% and 17%;

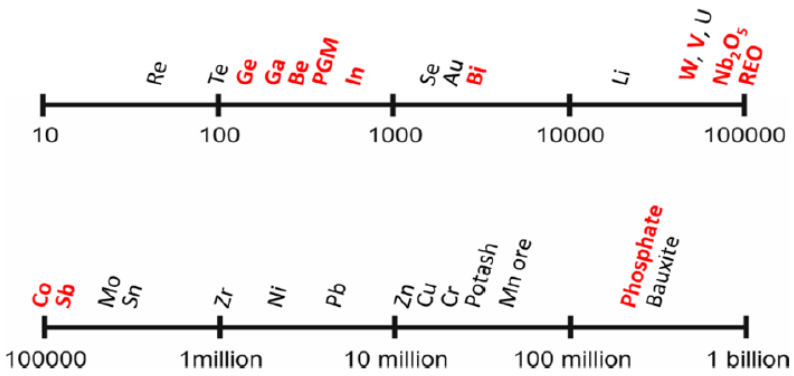


Figure 1: Indicative global annual production (metric tonnes, log scale) of selected metals and ores in 2015 (data from BGS, 2017 and USGS Mineral Commodity Summaries). Those metals and ores in red are currently classified as critical the EU (EC, 2017a).

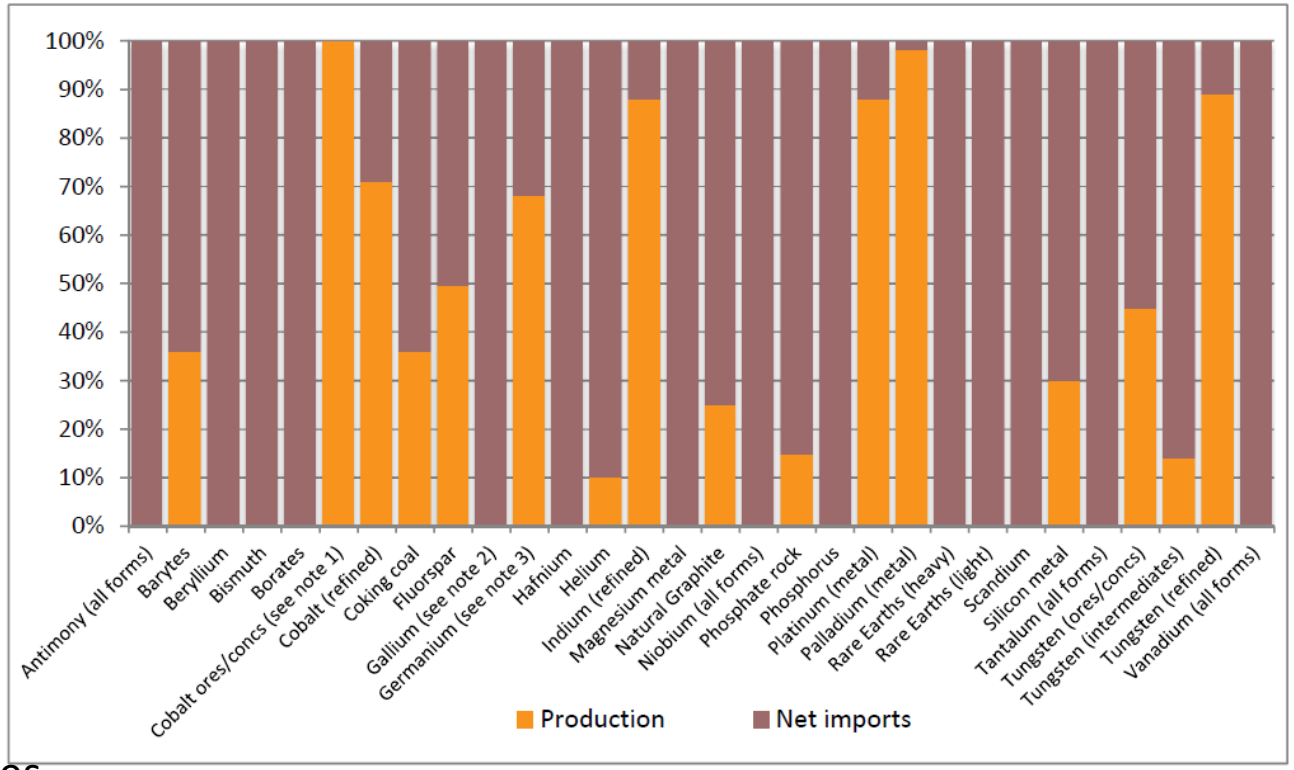


Figure 3: Proportion of apparent consumption that is met by production or net imports in 2015

Source/figures: SCRREEN/Deliverables

EU - major global consumer of CRMs - Future trends (2)

- **energy sector**,
  - requirements related to deployment of PV panels (mainly silicon, indium and gallium> less critical by 2035 due to material efficiency.
  - On contrary: development of wind power (involving REE) and domestic energy storage are expected to drive up mainly cobalt and natural graphite.
- **transport sector**,
  - need to decarbonise mobility and reduce air >hybrid and electric vehicles. Deployment of EVs is expected to drive most of CRM requirements (mainly REE, cobalt and natural graphite) by 2035.
  - Search for more performant materials to replace existing ones (ceramics for jet engines, Al-based alloys for car bodies): Nb, Ta, Mg
- **telecoms and electronics**,
  - global expansion of digital networks / services > increasing REE, Ta, Pd for electronic devices & appliances, Ge for optic fibres.

Currently the REE are not mined in Europe, but there are a number of areas with REE potential. According to the EURare project (EURare, 2018) these include alkaline igneous rocks such as those found in the Gardar Province of southwest Greenland (Kvanefjeld and Kringlerne exploration projects) and within the Fennoscandian Shield (including the carbonatites of Fen in Norway and Sokli in Finland, and the Norra Kärr syenite in Sweden). They also include secondary placer deposits such as those in Greece and Serbia.

Figure 13: Mine production and active project for REO (RE oxides) mining (end 2017)

Issues undermining CRM sector (1)

- **Low volume CRM markets** > instable / volatile
  - Prices formation > non-transparent
  - CRMs are used by few technology applications, demand may be suddenly modified by new product.
  - innovative product technologies may reduce (e.g. LED) or enhance (e.g. electric vehicles) need for CRMs suddenly.
  - Many CRMs: by-products > price volatility greater than base metals
- **Secondary CRMs (scrap)** > price volatility/instability - key concern
  - cheap primary CRMs, >secondary CRMs cannot compete
  - few initiatives exist in Europe focused on re-designing products /substitute parts containing CRMs
  - No level playing field for WEEE recycling sector: “parallel flows” (illegal flows) , operators that target profitable commodities but use low quality standards

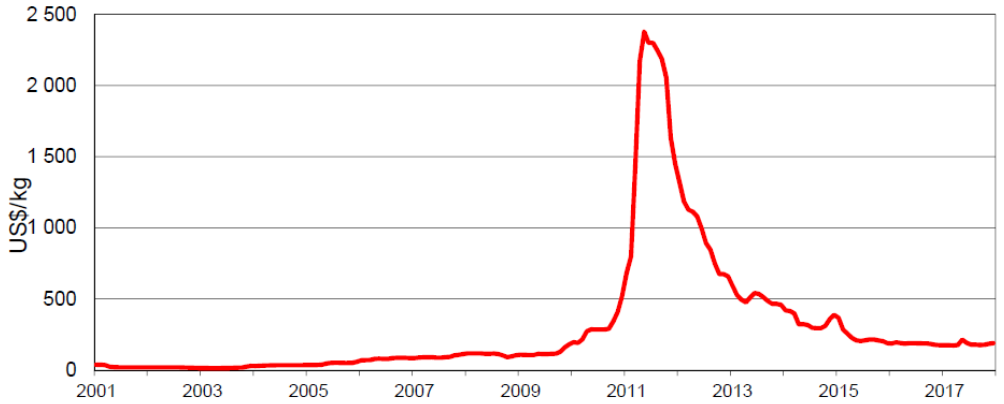


Figure 8: Development of dysprosium (>99% fob China) prices since 2000. (S&P Global (2018)

Quick changes to demand / supply (e.g. export restrictions) may cause price volatilities which affects SMEs

Issues undermining CRM sector (2)

- **EU has considerable CRM industry along value chain. > illustrated in Annual (EU-28) enterprise statistics by size class for special aggregates of activities (NACE Rev. 2) + SCRREEN mapping (D7.2):**
  - **Upstream market:** Exploration: 5, extraction: 17, recycling: 5, smelting, refining: 4
  - **Downstream market:** manufacturing: 5, final products, trading : 24
- **Availability of risk capital** > important but often lacking, e.g. **no alliance exists to fund important domestic mine developments including its value chain**
  - **Enhancing EU supply via development of domestic CRM-containing deposits does not mitigate supply risks since materials still need to be processed elsewhere, e.g. for intermediate products. >Developing CRM supply in Europe may not be enough if next 2-3 tiers of supply chain still are dominated by China or another non-EU country.**
  - Treibacher Industrie AG (Austria)Using separated Rare Earth compounds for value adding.
    - Identifies situation, where value chain moving to China / South East Asia.
    - Market for separated products (e.g. Nd-Metal) becoming smaller in Europe.
- **Funding of exploration**
  - campaigns mainly reflect short-term price volatilities.
  - Cp: Gold exploration costs accounts for around 50% of total costs.
  - But hardly any funds are made available for CRM-exploration althc
  - they may attract higher prices in future
- **Investment security / vs regulatory framework**

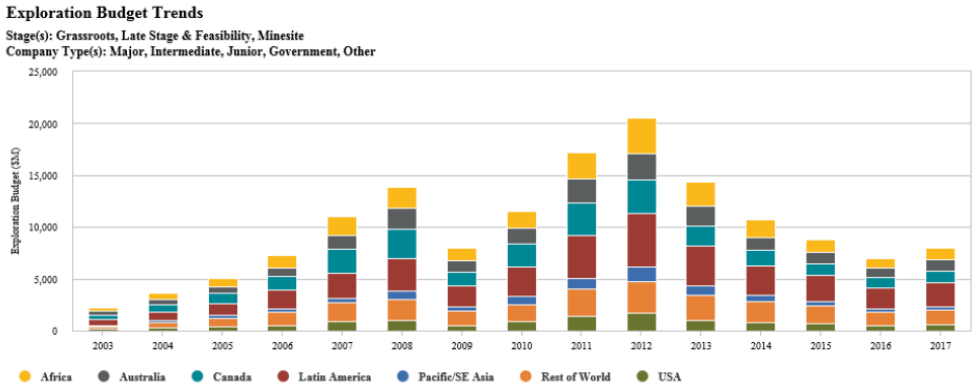


Figure 7: Development of global exploration budgets by regions since 2003 (S&P Global (2018)

Issues undermining CRM sector - investment security Norra Kärr heavy REE deposit/ (Swe

- **Investment 2009 – 2018 / still no mining**
  - REE deposit explored by (Canadian) Leading Edge Materials Corp, exploration licence granted in 2009
  - Economic Assessment study (2012) > mining 1.5 Mt / year (mineral resource base of 59 Mt) with 80% total recovery of 3 "critical" REOs (Y, Dy and Tb) > correspond to current demand.

- **Granting of mining lease in 2013, prefeasilibilty study** in March 2015 and exploration licence extension application in August 2015.
- However site is **close to a Natura 2000 site and a lake that is used as fresh water source for local population**. After appeals and counter-appeals to Swedish courts, the project's exploration licence has been extended but mining lease was changed from 'granted' status to 'application'.
- Swedish Mining Inspectorate requested **additional** information to **supplement environmental impact** assessment; operator has provided (Leading Edge Materials, 2018).
- company continues to evaluate processing methodologies and potential by-products from the deposit.
- **Courts' decision on Norra Kärr >effects on other projects in Sweden**, including Storuman fluorspar project, which is undergoing a re-assessment of its mining permit. Company has had to provide additional information relating to possible impact on another Natura 2000 site and reindeer herding (Tertiary Minerals, 2018).

- Tasman has invested **€15 million** on development of Norra Karr.
- The Company delivered an independent fully engineered Pre-Feasibility Study (PFS) in Jan 2015.
- Costs and revenue are accurately defined based on model of all mining and processing in Europe.
- 74% of revenue is from the high growth REE-magnet metals.
- Many areas remain to add value.

Mid 2015 (Current) Requirements	€7.5 million
Mid 2016 Requirements	€32.0 million
Late 2017 Capital Cost for Construction	€330 million
On Operation, Based on PFS	
Post-tax IRR	20%

Tasman's investment has greatly reduced th project risk.

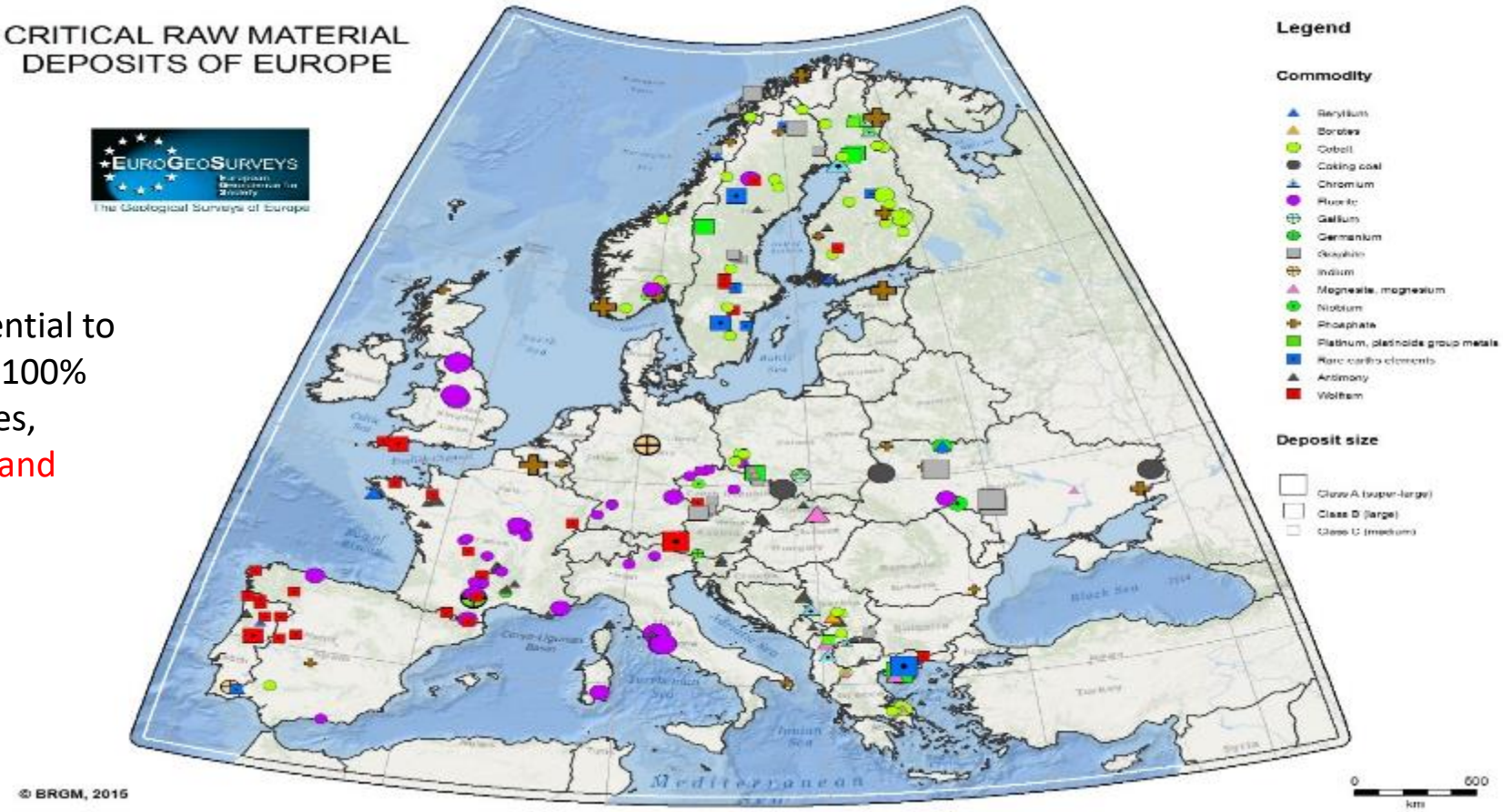
Europe's mega-industries are placed at risk by insecure REE supply, and are too important to be left to Venture Capital markets. To ensure Norra Karr's success, long term supportive financing is essential.

M.Saxon/CEO/Tasman Metals Ltd

- **Tasman has been unable to secure financing because:**
  - *Mining finance is at a multi-decade low*
  - *REE's have opaque markets unattractive to most resource investors*
  - *Understanding of the possibility for European mining is generally poor*
  - *European industrial companies push risk onto their supply chains*
  - *There is no functioning resource alliance in Europe (unlike Japan, Korea)*
  - *European explorers are unable to receive R&D incentives of Canadian/Australian /US competitors. Investors are concerned about higher share dilution*

CRMs supply from European deposits (1)

EU holds considerable geological potential to produce CRMs, also those nowadays 100% imported (antimony, beryllium, borates, magnesium metal, graphite, niobium and REE).



EuroGeoSurveys (2016) "New Map of Critical Raw Materials in Europe", http://egsnews.eurogeosurveys.org/?p=668.

CRM-potential in EU28+N

Country	Current mine production	Known unexploited resources (tonnage data exists)	Assumed unexploited resources only (no tonnage data)
Austria	Mg, W	Sb, In, Mg, Graphite, P, W	Baryte, Bi, Co, Fluorspar, Ga, Ge, Nb-Ta, Sc, Si, REE
Belgium		Baryte, P	REE
Bulgaria		Sb, Baryte, In, Mg, Nb-Ta, PGM	Bi, Fluorspar, Si, W, V
Croatia			Baryte, P
Cyprus			Co, PGM
Czech Republic		W, REE	Sb, Fluorspar, In, Nb-Ta
Denmark/Greenland		Sb, Co, Fluorspar, Ga, Graphite, Nb, Ta, Hf, REE, PGM, V	Be, Ge, P, W
Estonia		P	V, REE
Finland	Co, Mg, P, PGM	Sb, Be, Co, Nb-Ta, P, Sc, W, V, PGM, REE, Hf	Baryte, Bi, Mg, Graphite, Si,
France		Sb, Baryte, Be, Fluorspar, Ge, Mg, Nb-Ta, P, W, REE, Hf	Bi, Co, Graphite
Germany	Baryte, Fluorspar, In(?)	Baryte, Fluorspar, In, Si	Sb, Be, Bi, Co, P, W, PGM, REE
Greece	Co(?), Mg, PGM(?)	Sb, Co, In, Graphite, P, Sc, W, PGM, REE	Bi, Mg, Si
Greenland		Fluorspar, Ga, Graphite, Nb-Ta, W, V, PGM, REE	Sb, Be, Co, Ge, P
Hungary			Sb, Fluorspar, In, Sc, REE
Ireland		In, Mg, P	Baryte, Fluorspar, W, PGM, REE
Italy		Sb, Baryte, Fluorspar, P	Mg, Graphite, Si, W, REE
Latvia			
Lithuania			
Luxembourg			Sb
Malta			P
Netherlands	Mg		Mg
Norway	Graphite	Be, Co, Nb-Ta, P, Sc, Si, V, PGM, REE, Hf	Bi, Fluorspar, Graphite
Poland	Co(?), He, PGM(?)	Baryte, Co, Fluorspar, Ga, Ge, Mg, Si, V	He, Mg, P, PGM, REE
Portugal	In(?), W	Sb, Be, In, Nb-Ta, W, REE	Si, PGM
Romania		P	Sb, Baryte, Bi, B, Co, Graphite, REE
Slovakia	Mg	Sb, Mg	Co, REE, Nb, Ta
Slovenia			Sb
Spain	Fluorspar, Mg, W, PGM(?)	Baryte, Co, Fluorspar, Mg, Nb-Ta, P, W	Sb, PGM, REE
Sweden		Sb, Co, Fluorspar, Graphite, Nb-Ta, P, Si, W, V, REE, Hf	Be, Bi, Sc, W, PGM
United Kingdom	Baryte, Fluorspar, W	Baryte, Fluorspar, P, W, Hf	PGM, REE

Source: SCRREEN Deliverable D3.1_L.2017_CRM primary resource potential in EU, Norway and Greenland. Question marks indicate cases where a commodity may be recovered in current mining, but no data exist to confirm this.

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CRMs supply from European deposits (2)

- **location + extent of resources within Europe poorly understood for most CRM**.
  - Due to limited availability of high quality geoscience data focused on CRM.
  - Consequently, no sufficient CRM-focused exploration in EU (first stage in value chain). Without exploration >no resources / reserves /production of minerals that European industry depends upon.
  - Additional geoscience research required to provide a better understanding of regional geology, ore deposit genesis, mineralogy and deposit models.

- **Unlikely** primary resources of CRM will become exhausted in near future, but **access can be constrained by conflicting** land uses or social acceptability issues (SLO).
  - **Access to mineral resources** in the ground is an issue that relates to all minerals, not just CRM, but issues are significant.
    - Environmental or heritage designations, such as Natura 2000 sites, can cause real problems for companies wishing to access mineral resources.
      - Similarly, other conflicting land uses such as buildings, infrastructure, tourism or cultural uses can impose restrictions on mining activities.
    - Involvement of citizens in their surroundings (SLO) - important part of democracy. (MIREU project)
    - **Importance of Land Use Planning** (MinLand project)

Type	Land area and number in EU countries	Level of restriction for mining and quarrying
International designations		
Natura 2000 – established by two EU Directives for wild birds and natural habitats	>18% of EU's land area plus 8% of marine territory, located in all EU28 countries, >27,300 sites in total.	Significant, all Member States are required to prevent deterioration of them. All development requires an impact assessment and should only be permitted if it is shown that it will not adversely affect the site or there is an overriding reason and appropriate compensatory measures can be implemented.
World Heritage Sites – established by the UNESCO World Heritage Convention	no data on land area, located in all EU28 countries, 403 sites in total.	Significant, they generally have to be avoided. Historic mining sites can also be given this designation.
Ramsar sites – established by International Convention to protect wetlands	>3% of EU's land area, located in all EU28 countries, 865 sites in total.	Significant, although the boundaries of these sites can be moved if there are important national interests to do so but compensatory sites have to be provided instead.
National designations		
National Parks (or similar, e.g. National Forest Park in Cyprus) – usually established by national legislation	>3% of EU's land area, located in all EU28 countries, 278 sites in total.	Variable but can be significant in some countries depending on the specific laws and regulations that create them. In some countries mineral extraction does take place but only after the most rigorous examination and where there are few alternatives.
Ancient Monuments	Unknown number but likely in most EU28 countries.	Variable but can be significant in some countries. In the UK, for example, ancient monuments are 'scheduled' under Act of Parliament and incompatible land uses in or near them are restricted.

Sources: Brown, 2009; EC, 2018; UNESCO, 2018; Ramsar Secretariat, 2018; general internet search

Table 7: Exampls of key international and national environmental and heritage designations that could have an effect on mining operations.

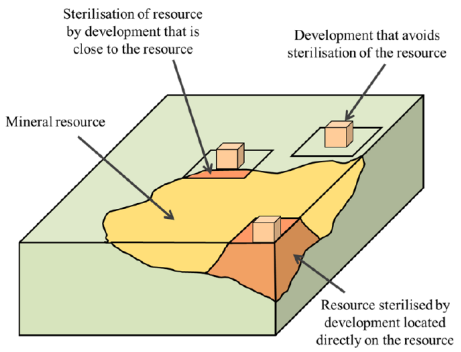


Figure 10: Simplified block diagram to illustrate how mineral resources can be sterilised by development that is nearby as well as directly on top of them (adapted from Wrighton et al, 2011; BGS © NERC).

CRMs supply from European deposits (3)

Exploration/extraction possible in NATURA2000:

- Exploration / extraction possible with environmental or heritage designations. >Exploration drilling at **Sakatti project in Finland** (copper, nickel and PGM) within Natura 2000 site.
  - Carried out in winter to minimise impact; utilises closed drilling system that collects drilling waste (Anglo American, 2013).
- **Extraction of fluorspar from Peak District National Park in UK**
  - 'planning permission' for extension to existing Milldam mine granted in 2015
  - subject to 45 conditions
    - +traffic numbers and routes, dust control, output levels, working scheme, heights of stockpiles, hours of working, noise controls and water monitoring (PDNPA, 2015).

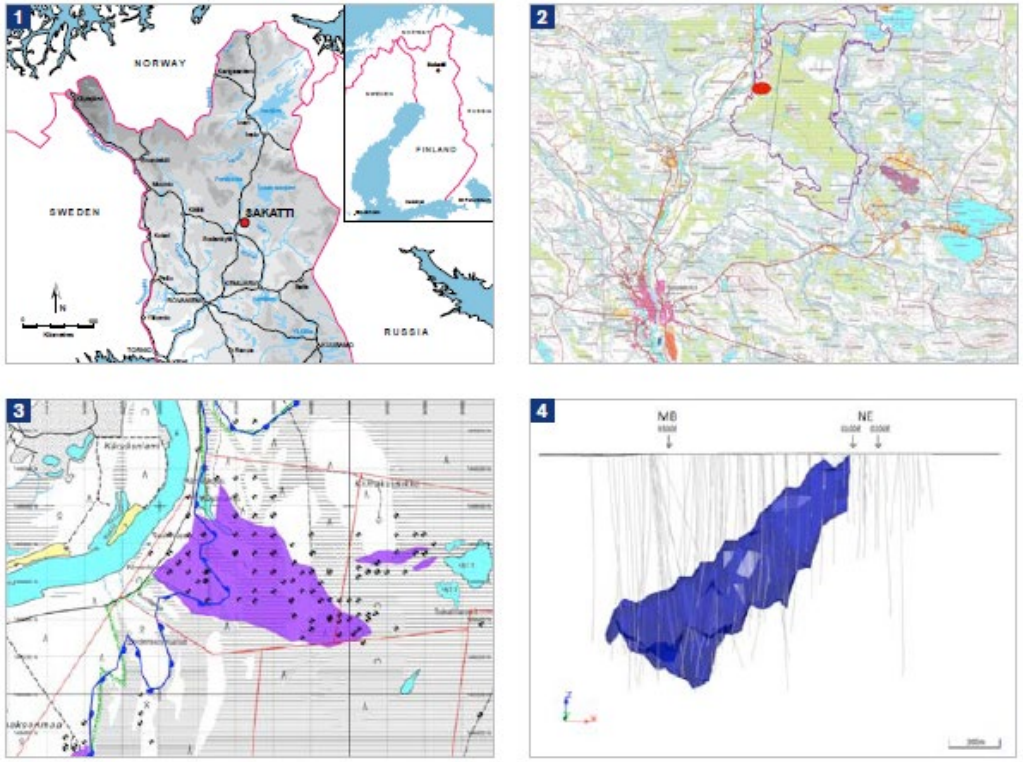


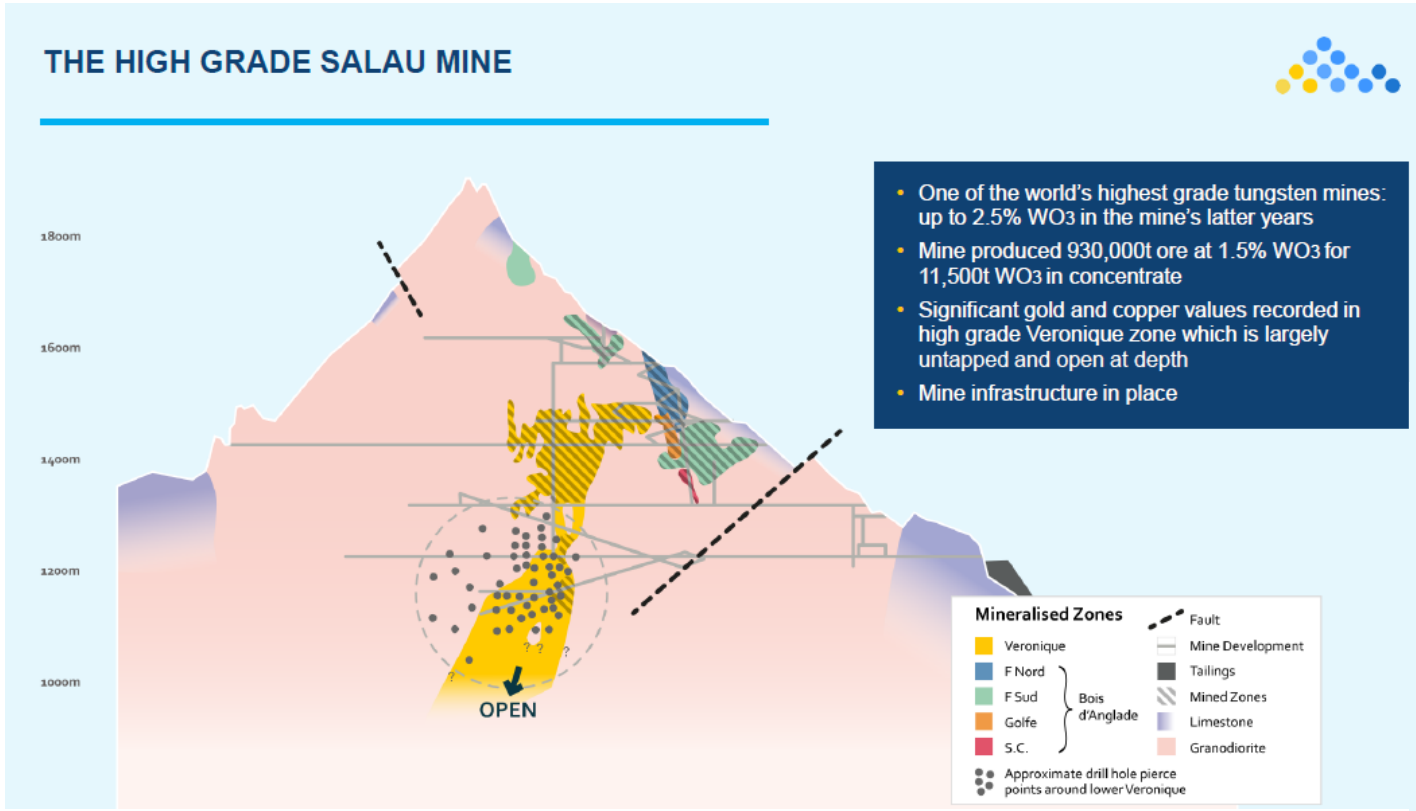
Figure 1: The location of the Sakatti copper-nickel-platinum group elements deposit in northern Finland.

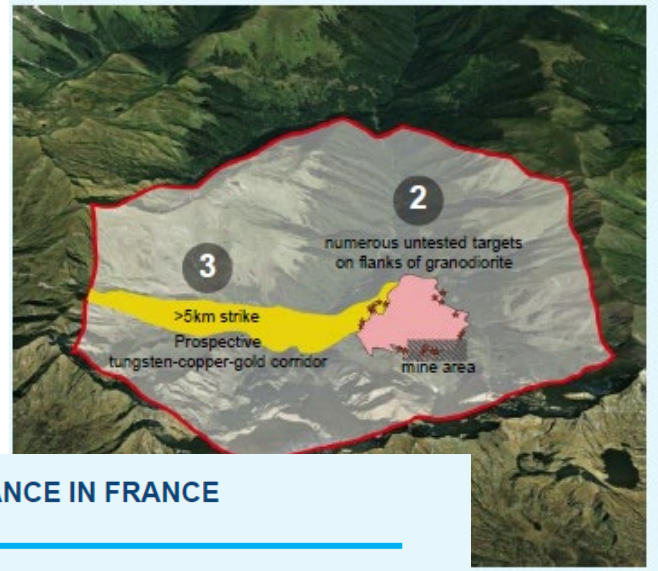
Figure 2: The location of the Sakatti marked by red circle. Location of Viiankiaapa Natura 2000 site marked by purple outline..

Figure 3: Sakatti mineralisation projected onto surface. Natura 2000 boundary marked by blue outline.

Figure 4: 3D view (looking north) showing an interpreted 0.20% Cu cut-off envelope with the current drilling information and relevant section lines labelled.

Couflens tungsten-copper project / southern France – reactivate former mine





MINING RENAISSANCE IN FRANCE

- First world jurisdiction
- Strong government support for mining sector reactivation
- Well defined mining laws
- Excellent infrastructure
- Skilled local workforce
- Excellent geological prospectivity
- Limited application of modern exploration technologies

Apollo Minerals (Australian) focus on exploration programs i.e. drilling and feasibility work at its Couflens Project in southern France (+progressing Aurenere Project in Spain). Reactivation of historical Salau mine which was one of world's highest grade tungsten Salau mine has potential to deliver tungsten to French / European industries.

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Support by Ministry of Industry / vs SLO issues

CRMs supply from European deposits /by-products (4)

- Support of projects targeting carrier metals contribute to domestic production of CRMs as long as miners have incentives to process those materials.
  - (e.g. PGMs associated to copper-nickel ores)
  - support / risk capital; identifying /market value chain (policy support)
- processing technologies for by-products (e.g. Innovative improvements in hydrometallurgical technology)

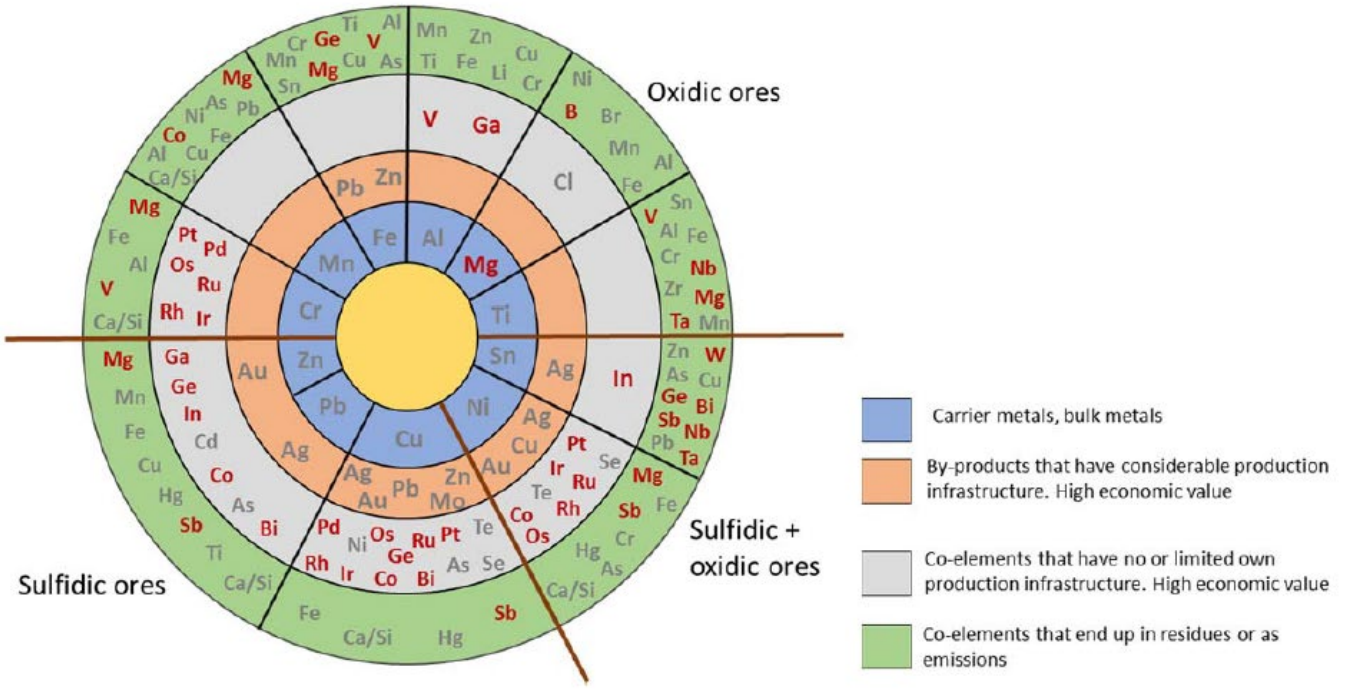
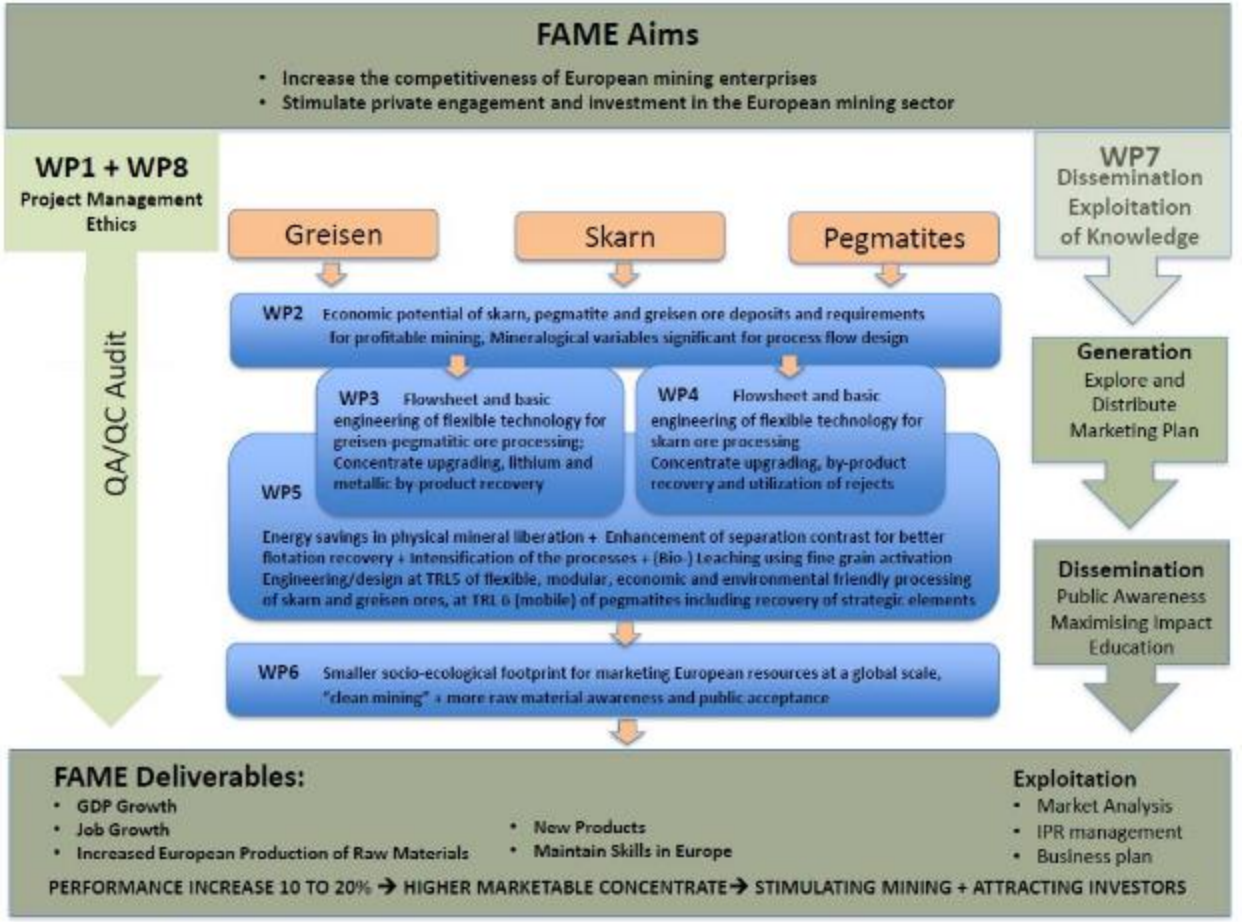


Figure 11: The metal wheel identifying links between main carrier metals and by- or co-product metals, with CRM highlighted (adapted from Verhoef et al, 2004).

Many CRMs (cobalt, gallium, germanium, indium, rare earth elements) extracted as by-products of minor economic importance.

CRMs supply from European deposits / innovative extraction and processing technologies (5)

- **FAME** (H2020) > increasing efficiency of extraction / processing technologies for CRMs crucial to economic development of EU.
  - new ore processing methods handling small deposits in rural and environmentally sensitive regions.
  - examines processing options of product recovery.
    - +valuable by-products.
  - Some of Partners hold exploration/mining licences to significant target ore reference deposits in GER, CZ, France, Finland and Portugal. >INPUT (e.g. Saxony region)



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FAME: Flexible And Mobile Economic processing technologies

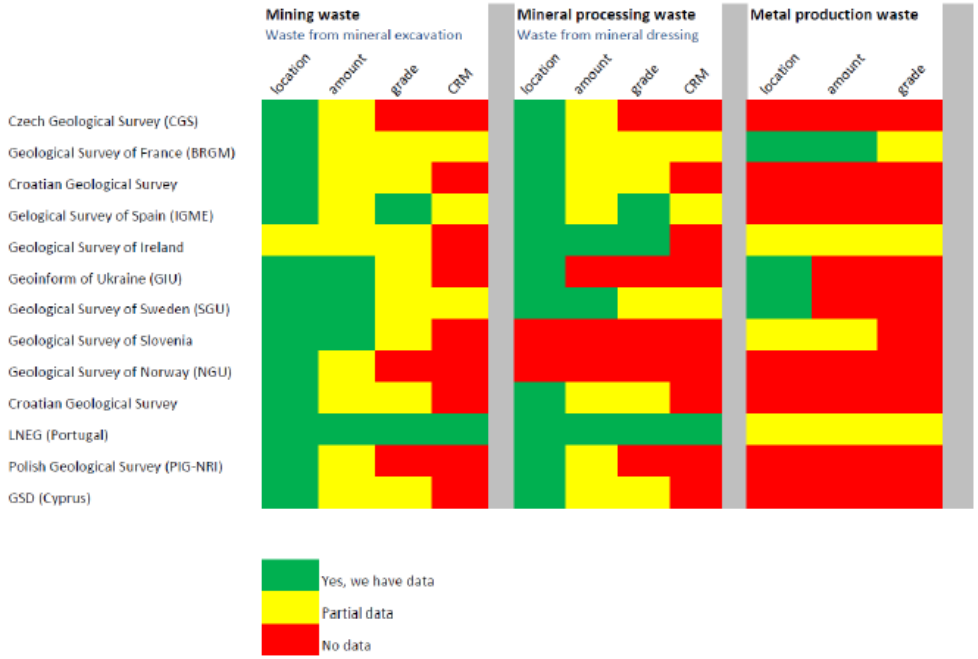
http://www.fame-project.info/research/

Supply from Mining Waste in Europe (1)

mineral-based wastes > challenging exploitation target

issues: no EU legislation that requires recycling of mining waste, no mayor industry, sparse EUROSTAT statistics on mining waste

Table 13. Current state of resource and compositional data on CRM in mining, mineral processing and production wastes among some EU member states.



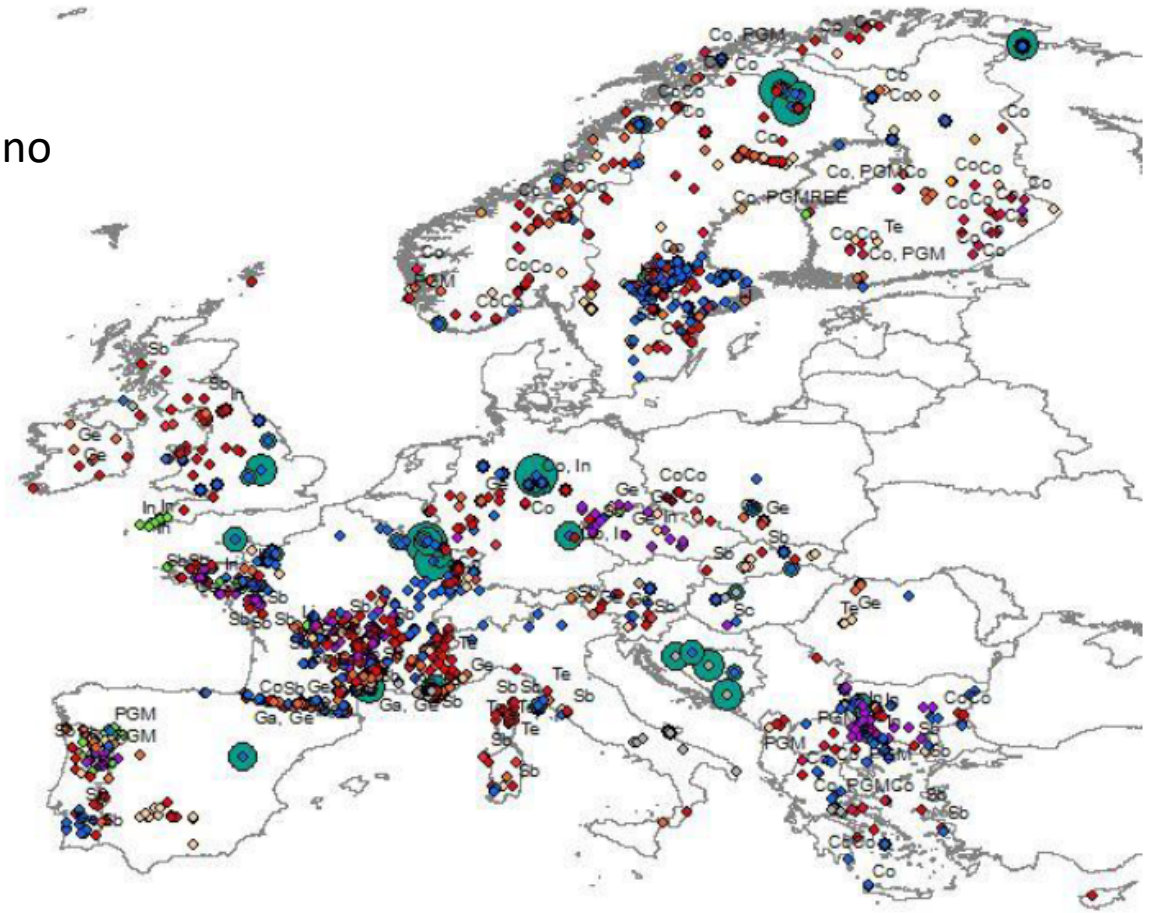
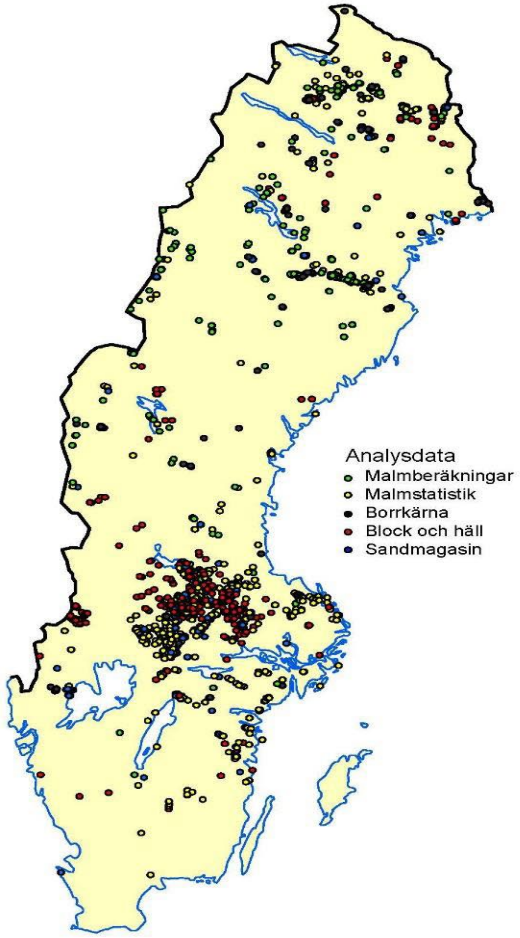


Figure 8. Map of Europe showing closed and operating mines. The green circles represent the calculated amount of waste rock where the largest circles represent more than 500 Mt of waste rock. Diamonds represents smaller mines and the colors represents type of ore; blue for iron and iron-alloy metals, yellow for precious metals, red for base metals, grey for bauxite, violet for energy metals (U) and green for special metals (data from ProMine (http://promine.gtk.fi/)and FODD (http://en.gtk.fi/informationservices/databases/fodd/)).

Source/figures: SCRREEN deliverables

GOOD PRACTICE EXAMPLE ON MINERAL-BASED WASTE IN SWEDEN

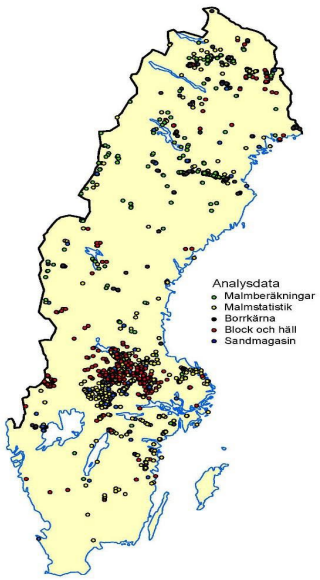
- Growing demand of CRM, **both from primary + secondary sources** (mineral-based wastes) addressed in Swedish Mineral Strategy
  - geological investigation of both raw materials undertaken in all mining districts of Sweden, eg Bergslagen region.
- Reasons for **integrating knowledge about primary and secondary resources** is to **encourage mining industry to develop routines and technologies for extraction of both primary and secondary resources**.



Locations of sites sampled in Sweden in order to create a chemical database for mineral resources including mineral-based waste (source: Hallberg and Reiginiussen 2018).

GOOD PRACTICE EXAMPLE ON MINERAL-BASED WASTE IN SWEDEN

- National legislation /policy do not require collection of data. However, data collected by Swedish Environmental Protection Agency (enforces Regulation (2013:319) on Extractive Waste)
  - GS of Sweden (=task government) > mapping + characterizing mining wastes, with special focus on recovery potential of CRM and related CRM prospectivity
    - With respect to operating mines, data is made available to site level to public: Location, Type of facility, Waste characterisation and Waste source (http://utslappisiffror.naturvardsverket.se/en/Search/).
    - Assessment of CRM content in selected mineral-based wastes.
      - **First step** > data base of existing mineral-based wastes (GS of Sweden, Swedish Environmental Protection Agency and Regional County Boards. **Next steps** > sampling of recorded wastes.
- Preliminary conclusion >CRM found both within old known mining districts, along with extensively exposed brownfields, but also beyond and outside them. From the information collected and evaluated it is obvious that there is a significant potential for CRM secondary resources in Sweden.



CRM supply via recycling (1)

Information collected by UNEP shows that **EOL-RR of many CRMs are low**, being lower than 1% for beryllium, borates, gallium, germanium, indium and REE, and 1 - 10% for antimony and tungsten.
Only CRMs > 50% EOL-RR >chromium, cobalt, niobium and PGMs .
Low EOL-RR >due to low efficiencies in collection / processing, technical limitations in recycling processes,
+ primary material is abundant and low-cost (thereby keeping down price of scrap).

Issues: **organization of CRM collection**; characterisation of their properties as secondary CRMs not standardized

CRM	EOL-RR (%)
Antimony	> 10-25
Berillyum	< 1
Borates	< 1
Chromium	> 50
Cobalt	> 50
Coking coal	nf
Fluorspar	nf
Gallium	< 1
Germanium	< 1
Indium	< 1
Magnesite	na
Magnesium (metal)	> 25 - 50
Natural graphite	na
Niobium	> 50
Phosphate rock	na
PGMs[136]	> 50
HREE	< 1
LREE	< 1
Silicon metal	na
Tungsten	> 10-25

Source: Global average and EU-based recycling rates for CRMs D7.1. end-of-life recycling rate (EOL-RR) - defined as percentage of a metal that is actually recycled

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CRM supply via recycling (2)

- Although increasing attention on CRM recycling from political and legislative sides, current recycling grades are far away from ‘’efficient’’ to fulfil vision of a “circular economy”.
  - valid for most of CRMs as shown in UNEP report on Recycling Rates of Metals (2011).

➢ EU end of life legislation does not focus on small flows of CRMs / collection + recovery rates for CRMs like cobalt.
  - ➢ Directive on End-of-life Vehicles (2000/53/EC), WEEE Directive (2012/19/EU), Batteries Directive (2006/66/EC), Eco-Design Directive.

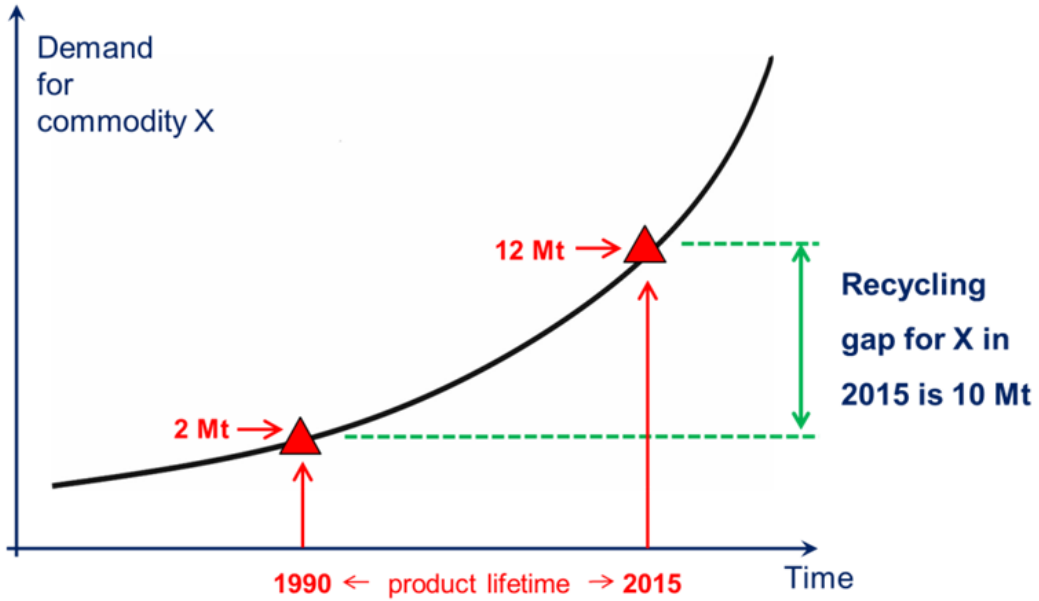
➢ Insufficient information on CRMs which could be recycled + lack of data on CRM use.
  - each year >10 million tonnes of waste electrical and electronic equipment (WEEE), containing large CRMs, generated in EU, but only 2% was collected / recycled (in 2014), meaning CRMs ‘crucial to many electrical products’ are lost.

CRM supply via recycling (3)

- Circular Economy Package (Action Plan > CRMs as priority waste stream), in 2014 a proposal (COM/2014/0397 final) in relation to CRMs :
  - for amending Waste Framework Directive (WFD), 2000/53/EC on end-of-life vehicles, 2006/66/EC on batteries / accumulators / waste batteries and accumulators, 2012/19/EU on WEEE.
  - in order to ensure supply of CRMs, MSs should "*take measures to achieve best possible management of waste containing significant amounts of CRMs".*
  - It was proposed that "*Member States should include in their waste management plans nationally appropriate measures regarding collection and recovery of waste containing significant amounts of critical raw materials*".

CRM supply via recycling (4)

CRM **recycling** still at technical cradle stage . Recycling CRM from secondary sources cannot supply entire quantity that is needed for growing market due to lifetime of products in 'use' stage and resulting 'recycling gap'



When demand for a commodity increases over time recycling alone cannot meet demand.
Here we consider a product that uses a commodity X and that has a lifetime of 25 years.
If demand for commodity X increases in that time from 2 million tonnes per annum to 12 million tonnes per annum, there is a 'recycling gap' of 10 million tonnes.
This gap can be filled by production from primary sources.

Source/figure SCRREEN/Deliverables

SCRREEN

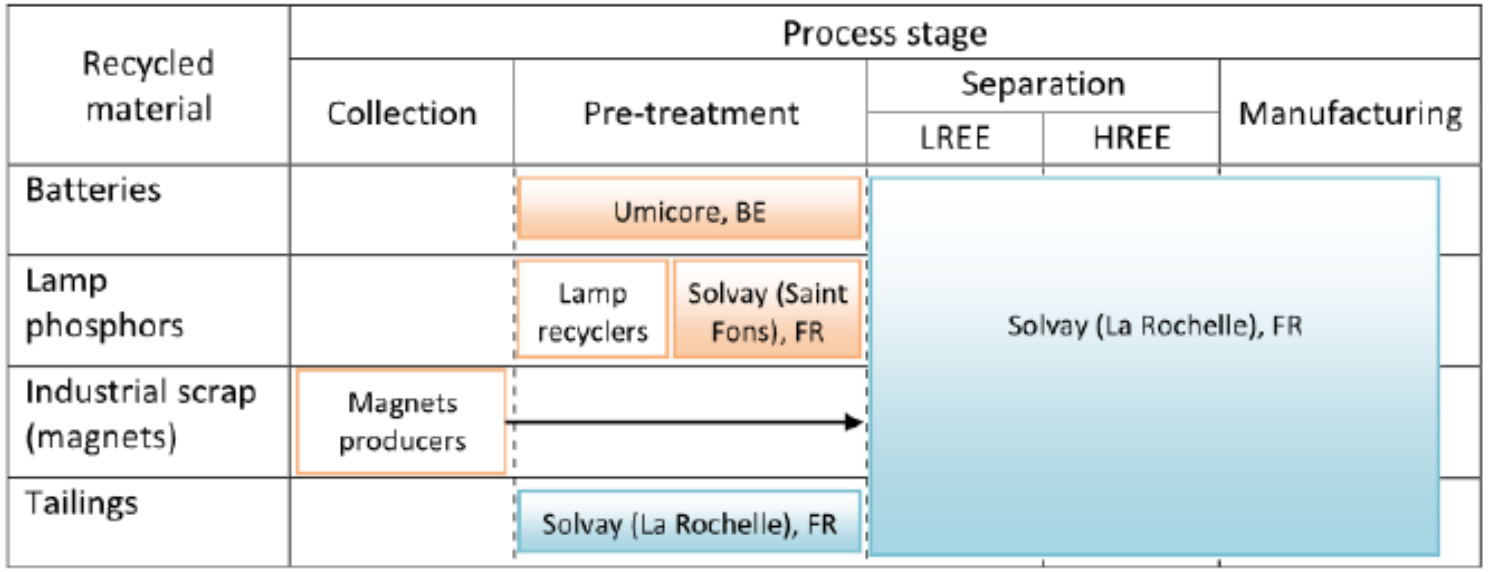
REE-recycling value chain/good example

France: to diversify its supply sources, Solvay developed process for recovering rare earths contained in end-of-life equipment such as low-energy light bulbs, batteries or magnets.

This **recycling channel opens new growth opportunities** for Solvay's "Rare Earths" activity.

http://annualreports.solvay.com/2016/en/risks/other-risks/regulatory-political-and-legal-risk.html

Standards – level playing field: defining technical and environmental treatment standards is important for the recycling industry, because standards help create a level playing field and promote innovation. Control and enforcement is crucial, especially with respect to recycling plants outside Europe. Figure 14 illustrated the REE secondary supply chain for the company SOLVAY.



REE secondary supply chan for Solvay

ECODOM (Italy consortium WEEE handlers) – good practice

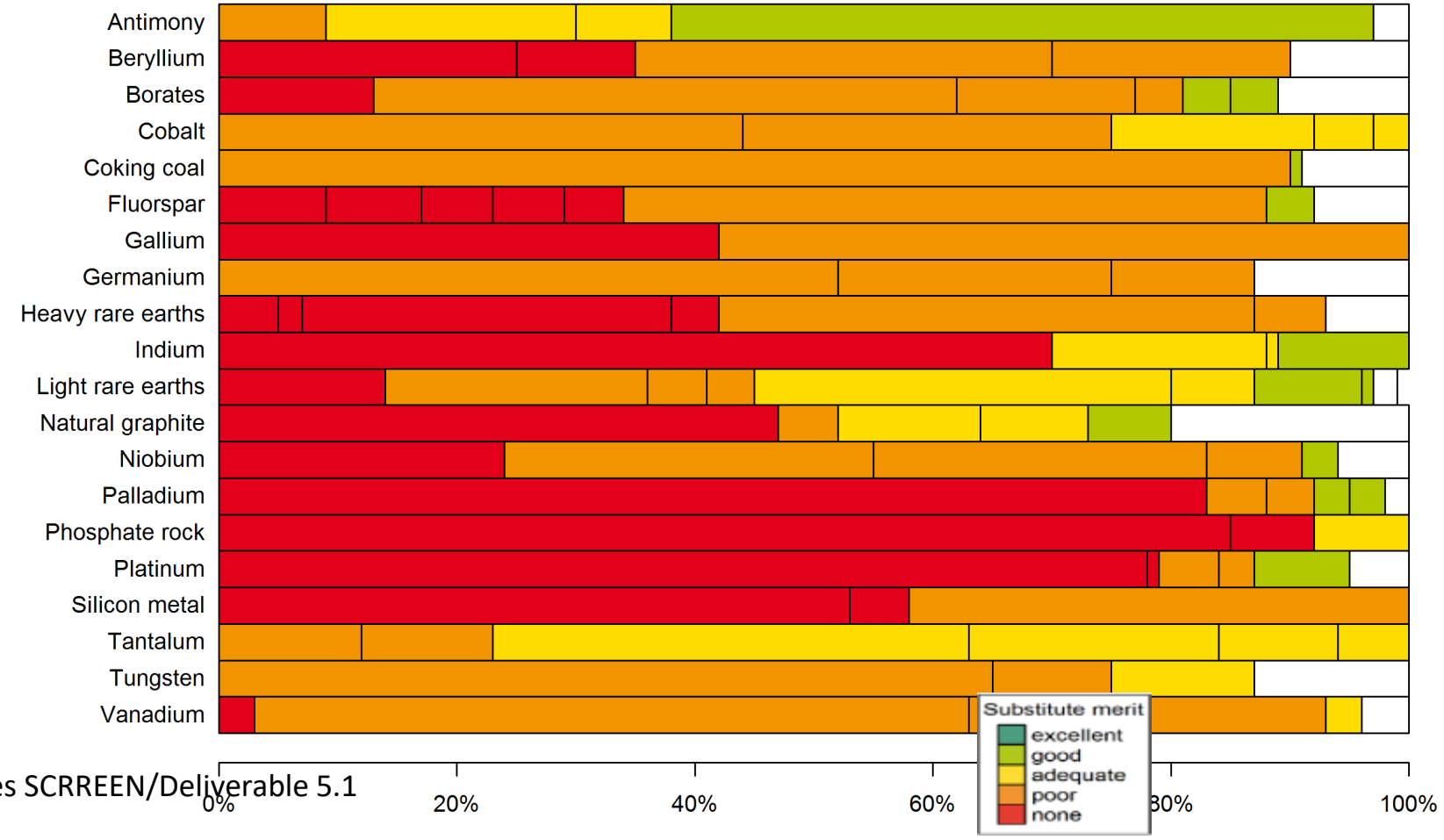
- largest Italian Household Appliance Recovery and Recycling Consortium.
  - Founded in 2004 and operational since 2008, private, not-for-profit Consortium that collects WEEE (Waste Electrical and Electronic Equipment) from facilities
- ECODOM agreed (voluntary) with partners to
  - apply price compensation mechanism to resolve low / instable scrap prices
    - cheap primary minerals > secondary materials cannot compete

- ECODOM (contracts with treatment providers) introduced **mechanism linked to market value of secondary raw materials**:
  - value rises, consortium pays suppliers lower amount;
  - value reduces, c. pays higher amount.
    - To **ensure suppliers maintain high quality standard**, even in unfavourable market situations.
    - sum paid by Ecodom + revenues from secondary materials sales

CRM – substitution

Assessing substitution of material >difficult to quantify >**information is limited**, potential substitutes with low Technical and Manufacturing Readiness Levels ;
confidentiality issues for industry developments.

CRMs often not easily substitutable;



Source/figure: summary of CRM substitution profiles SCRREEN/Deliverable 5.1

CRM Substitution priority in mining policies GER/FR/NL/UK

Mineral/Mining Policies

Austrian mineral strategy (2012)

Bulgarian National Strategy for Development of Mining Industry 2030 (2015)

Czech new Raw Materials Policy (2017)

Denmark, Greenland and the Faroe Islands – The Kingdom of Denmark, Strategy for the Arctic 2011 - 2020

Estonian Mining Strategy (2017)

Finland – Finnish Minerals Strategy (2010) and Arctic Region Strategy (2013)

France – Strategic metals plan (2010)

Germany – Raw materials strategy (2010) and Raw materials of strategic economic importance for high-tech made (2012)

Greece – The National Policy for the Strategic Planning and Exploitation of Mineral Resources (2012)

Hungary - Action Plan on Mineral Resources Management and Utilization (2015)

Lithuania – State Strategy of Use of Underground Resources (under preparation)

Netherlands – Raw Material document ("Grondstoffennotitie") (2011)

Poland – Mining Policy (2018), under discussion

Portugal – National Strategy for Mineral Resources (2012)

Romania – Strategy of Mining Industry 2012-2035

Slovakia – Raw Materials Policy (2004), new version under discussion

Slovenia – National Mineral Resource Management Programme (2009) and National Mining Strategy (2011)

Sweden – National mineral strategy (2013)

United Kingdom – Resource Security Action Plan (2012)

Country	Current mine production	Known unexploited resources (tonnage data exists)	Assumed unexploited resources only (no tonnage data)
Austria	Mg, W	Sb, In, Mg, Graphite, P, W	Baryte, Bi, Co, Fluorspar, Ga, Ge, Nb-Ta, Sc, Si, REE
Belgium		Baryte, P	REE
Bulgaria		Sb, Baryte, In, Mg, Nb-Ta, PGM	Bi, Fluorspar, Si, W, V
Croatia			Baryte, P
Cyprus			Co, PGM
Czech Republic		W, REE	Sb, Fluorspar, In, Nb-Ta
Denmark/Greenland		Sb, Co, Fluorspar, Ga, Graphite, Nb, Ta, Hf, REE, PGM, V	Be, Ge, P, W
Estonia		P	V, REE
Finland	Co, Mg, P, PGM	Sb, Be, Co, Nb-Ta, P, Sc, W, V, PGM, REE, Hf	Baryte, Bi, Mg, Graphite, Si,
France		Sb, Baryte, Be, Fluorspar, Ge, Mg, Nb-Ta, P, W, REE, Hf	Bi, Co, Graphite
Germany	Baryte, Fluorspar, In(?)	Baryte, Fluorspar, In, Si	Sb, Be, Bi, Co, P, W, PGM, REE
Greece	Co(?), Mg, PGM(?)	Sb, Co, In, Graphite, P, Sc, W, PGM, REE	Bi, Mg, Si
Greenland		Fluorspar, Ga, Graphite, Nb-Ta, W, V, PGM, REE	Sb, Be, Co, Ge, P
Hungary			Sb, Fluorspar, In, Sc, REE
Ireland		In, Mg, P	Baryte, Fluorspar, W, PGM, REE
Italy		Sb, Baryte, Fluorspar, P	Mg, Graphite, Si, W, REE
Latvia			
Lithuania			
Luxembourg			Sb
Malta			P
Netherlands	Mg		Mg
Norway	Graphite	Be, Co, Nb-Ta, P, Sc, Si, V, PGM, REE, Hf	Bi, Fluorspar, Graphite
Poland	Co(?), He, PGM(?)	Baryte, Co, Fluorspar, Ga, Ge, Mg, Si, V	He, Mg, P, PGM, REE
Portugal	In(?), W	Sb, Be, In, Nb-Ta, W, REE	Si, PGM
Romania		P	Sb, Baryte, Bi, B, Co, Graphite, REE
Slovakia	Mg	Sb, Mg	Co, REE, Nb, Ta
Slovenia			Sb
Spain	Fluorspar, Mg, W, PGM(?)	Baryte, Co, Fluorspar, Mg, Nb-Ta, P, W	Sb, PGM, REE
Sweden		Sb, Co, Fluorspar, Graphite, Nb-Ta, P, Si, W, V, REE, Hf	Be, Bi, Sc, W, PGM
United Kingdom	Baryte, Fluorspar, W	Baryte, Fluorspar, P, W, Hf	PGM, REE

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Mineral/Mining Policies – national/regional

- Strong influence of RMI 2008 > 19 countries > mining policies
  - Austria, CZ, Denmark, Finland, France, GER, Greece, Hungary, NL, Romania, Sweden and UK specifically included CRMs. But level of focus differs :
    - Sweden: strong focus; CZ New Mineral Policy 2017
      - UK Resource Security Action Plan > CRMs core focus,
      - Germany or Finland CRMs mentioned, but not in focus.
      - Spain dedicated policies on promoting domestic extraction (or recycling) at regional level (eg Andalusian MP/Portugal).
- No concrete CRM policies > less input in regulatory mining framework
  - no concrete CRM exploration provisions (e.g. giving priority), which could support a company or facilitate CRM protecting (based on LUP).
    - nearly no concrete CRM (land use) planning policies identified.
  - No mining law allocates CRM as special group i.e. is allocating special rules for exploration/extraction/processing

SWEDEN Mineral strategy – good practice example

- Growing demand of **CRM, both from primary and secondary sources** (e.g. mineral-based wastes) > addressed in Swedish Mineral Strategy,
  - launched with specific tasks commissioned by government to expert authorities, like the Geological Survey of Sweden.
- **Detailed assessment of primary mineral deposits** where advanced knowledge on mineralogical composition is available.
  - Special attention paid to CRM (e.g. cobalt, graphite) needed for manufacturing of Li-ion batteries required by electric vehicle industry.
  - Geological Survey of Sweden > **10 MSEK by government for investigating + mapping CRM within Sweden**.
- **Supporting new CRM value chain > REE, Graphite**, etc.

SWEDEN Mineral strategy – supporting new CRM value chain

REE, lithium and graphite potential in Sweden

The Swedish geology is rich, it contains many different types of metals and minerals. The potential for extraction of graphite and REE is promising. The Woxna graphite mine has previously been active, and there are deposits of high-grade graphite in the north of Sweden.

The potential for lithium is more uncertain. However, there are a couple of known deposits, one of them is Bergby on the east coast in central Sweden, and in Finland, there are promising findings as well

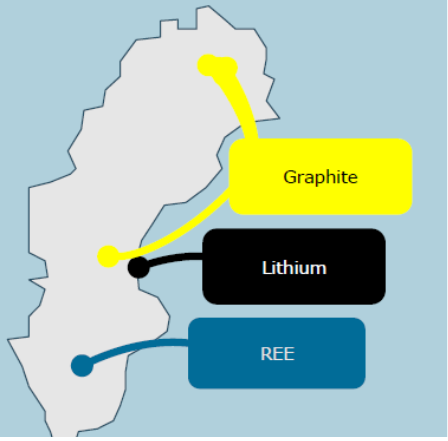


Table 3 Risk characteristics of potential, future value chains

Risks		'Battery industry'	'REE industry'
Technological risk	*Insecurity about the future technology and speed of development, complementary and substitute technologies, products and inputs*	**High** - Large research in different battery technologies and materials for cathodes and anodes - Uncertainty with respect to future scientific breakthrough in fuel cells, solar panels etc.	**Medium-High** - Expertise and know-how in China and a limited number of non-Chinese companies - Ore specific chemistry
Market risk	*Uncertainty about suppliers and customers in future value chains, lack of flexibility, economies of scale and possibly co-location advantages, incumbent(s) response to market entry*	**Medium** - Rapid development in market - Uncertainty as to flexibility and new business model partnerships in value chain	**High** - China strong incumbent - In-transparent markets
itutional	*Design of legal rules, speedy application procedures, schemes and standards to support or counteract industry*	**Medium** - Risk of lengthy permitting processes for new mines - Tough environmental requirements may hinder or delay battery factory	**High** - Chinese dominance - Risk of lengthy permitting processes for new mines - Tough environmental requirements

Table 4 Risk reducing policies

Risks	Examples of public risk reducing policies
Technological risk	*Government funded and supported R&D to strengthen companies incentive to conduct own R&D&I*
Market risk	*Government funded network activities to reduce coordination failure, provide for new (risk sharing) partnerships, diplomacy and trade agreements*
Institutional risk	*Adoption of national, industry strategies. Review of legislation, harmonization and standardization. Removal of administrative hurdles.*

Source/figures: SCRREEN/Deliverables

Austrian Minerals Strategy – good practice example

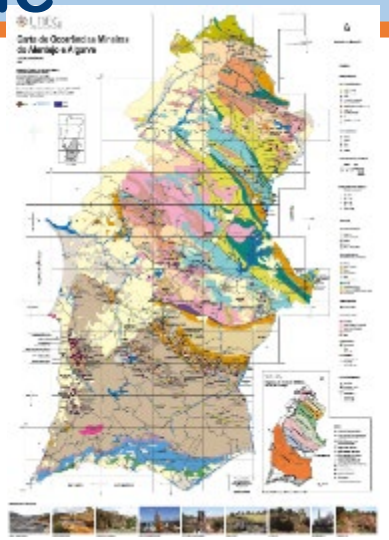
https://www.bmnt.gv.at/english/Energy---Mining/Mining/The-Austrian-Minerals-Strategy.html To transpose national minerals policy into reality. To ensure and to improve the supply of the Austrian economy with minerals.

- Pillar 1: Securing minerals supply from domestic resources (implementation of Austrian Mineral Resources Plan)
  - >245 occurrences of metallic ores and industrial minerals qualified to be safeguarded
  - CRM (2018): **known unexploited resources (tonnage data exists)**, Sb, In, Mg, Graphite, P, W; known unexploited resources (no tonnage data exists): Baryte, Bi, Co, Fluorspar, Ga, Ge, Nb-Ta, Sc, Si, REE,
- Pillar 2: Securing minerals supply from Non-EU countries (raw materials partnerships)
  - Besides efforts of EC, Austria is exploring bilateral agreements with countries important for Austrian economy.
  - Currently negotiations with Mongolia are taking place.
- Pillar 3: Promoting resources efficiency (substitution, recycling, etc.)
  - Federal Ministry of Agriculture, Forestry, Environment and Water management developed in a stakeholder process the "**Austrian Action Plan on Resource Efficiency**, 2012. > Much interest in developing policy on CRMs recycling. Challenging due to their low concentration in products/wastes.
- Austrian Raw Material Alliance (>value chain)
  - founded in 2012 by Federal Ministry of Science, Research and Economy, - acting as a discussion platform of stakeholders interested in improvements of raw material supply. > reduction of import dependency and increasing the supply security of raw material important for the Austrian economy.
  - An initial focus has been placed on identifying strategies to increase recovery of CRMs (critical for the Austrian economy) out of waste. >Recommendations for action to improve the framework conditions of R & D and regulatory framework to be implemented.
  - Implementation of resource-related issues in a research program called "Production of the Future" is already fixed.

Alentejo mining strategy – good practice example (region in Portugal)

- **Alentejo and Algarve mineral occurrences map** Atlanterra project, EU Interreg Atlantic Area, Matos and Filipe Eds, LNEG 2013

http://www.lneg.pt/download/7904

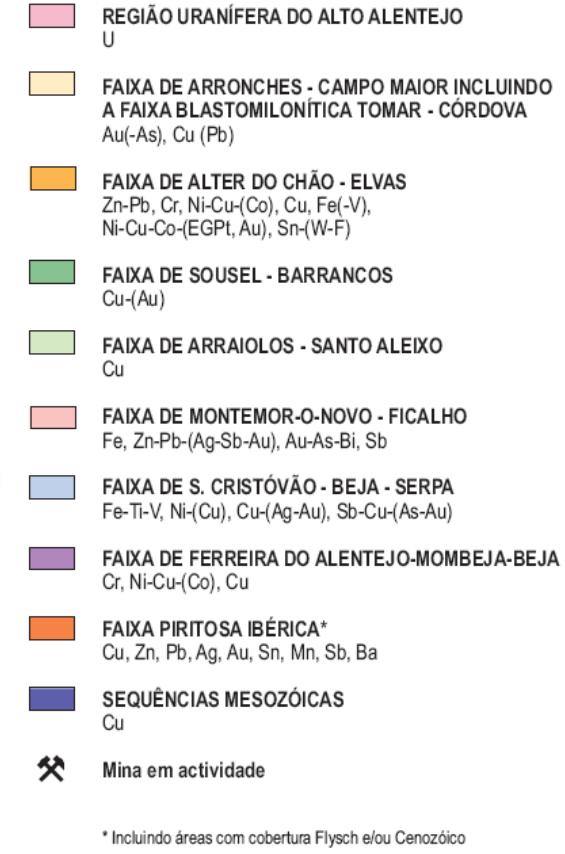


Alentejo mining regions

Iberian Pyrite Belt, an European Mine Region

Active mining:

- **Neves Corvo (Somincor/Lundin Mining)**
- **Aljustrel (Almina)**



Adaptado de: V. Oliveira 1986, Torres et al. 2006, Mateus et al. 2013, T. Oliveira et al. 2013

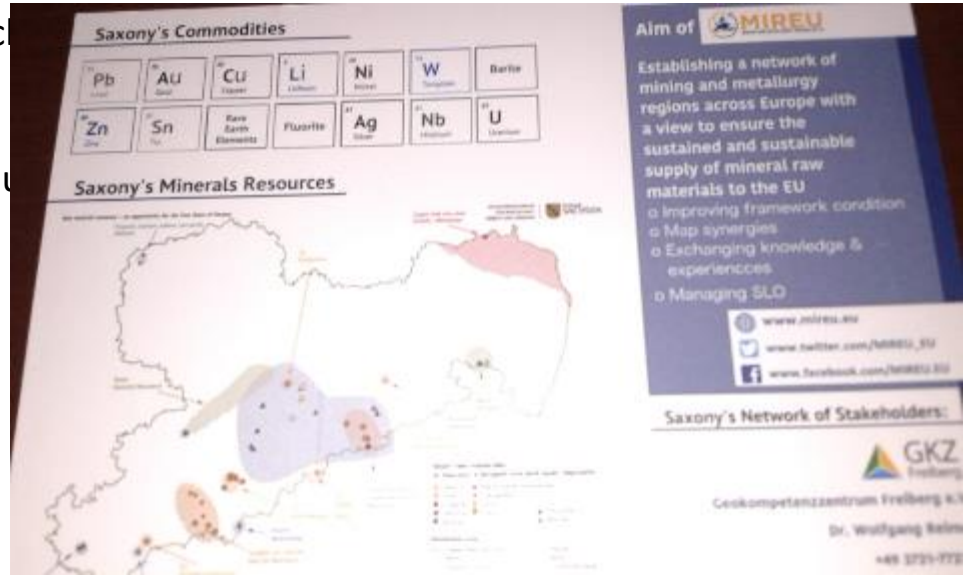
Alentejo mining strategy - Lessons learned

- Most important important lessons learned
  - **Mineral resources not fully identified and localized**
  - **Mining activity >complexity >previously evaluation - economic, social, cultural and environmental**
  - **Environmental liabilities due to past mining activities and how to deal with them and turn them into positive assets is essential to have the trust of populations**
  - **Old/new mines and its degree of impact on regional/local economy or connection to local companies**
  - **Mining projects must consider, since beginning, impact of closure and alternativ activities**
  - **Holistic view of the whole Value Chain and relevance of circular Economy**
  - **people that benefit directly from mining activity have positive view**
  - **Mines located near urban spaces always under extra pressure**

Saxony (GER) Raw Material strategy – good practice example

•Saxon RM strategy (2012)/2017 **Integration of mining into broader regional development approach**

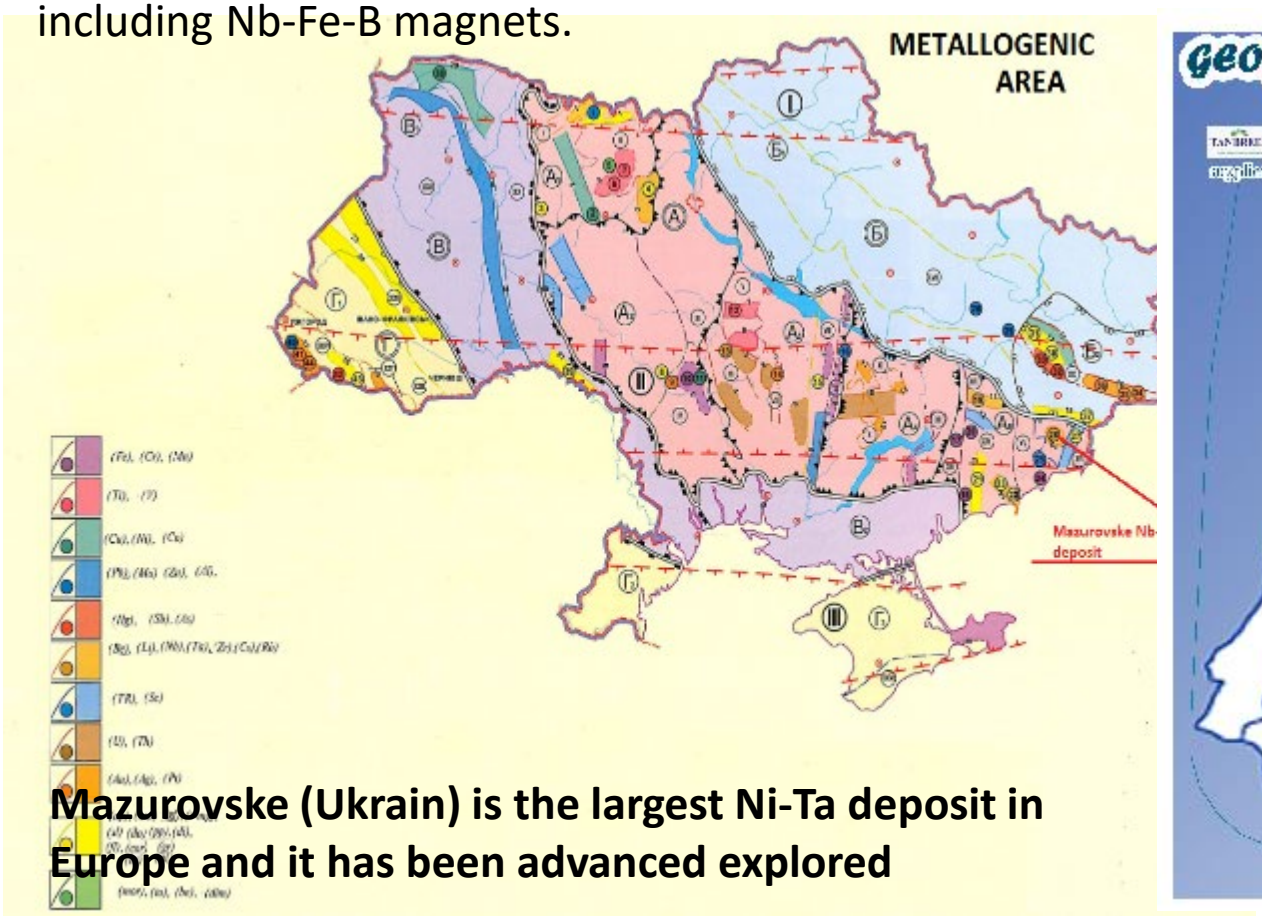
- **Closing value chain in valorisation of Tin, Lithium and Fluorspar deposits with existing and future downstream industry**
- **Relationships between mining, broader industry, community & regulator**
  - •Broader industry:
    - (Expecting) High acceptance: metallurgy, advance production tec
  - •Community:
    - Expects more larger companies to settle in Region;
    - engagement of mining with any other job-creating / sustain manu
  - •Regulator:
    - Government – Securing value chain (Saxon RM strategy)



- SLO / MIREU project

Identification of Nb-Ta value chain / Europe

A modern automobile industry uses more than 80 parts of Nb and Ta (windscreen wipers, washers, etc.), including Nb-Fe-B magnets.



Mazurovske (Ukrain) is the largest Ni-Ta deposit in Europe and it has been advanced explored

SGE, 2018

Nb-Ta mineralization is represented by pyrochlore. It contains: Nb2O5 - 57-67,5%; Ta2O5 - 1,5-6,6%; TiO2 - 0,7-9,0%; UO2 - up to 1.4%; ThO2 - 0,58%; TR2O3 - 4,6-21,4% (dominated by the elements cerium group); ZrO2 - 0,2-4,0% on average.

Outlook (1)

- Taking into account that CRM recycling is still at technical cradle stage, vast majority of CRM efforts need to taken to promote their primary production in order to satisfy current demand at the same time developing recycling efficiency and substitutions.
- Encourage:
  - The need for new exploration activities and opening of new mines in the EU28 is necessary for decreasing the import dependency.
  - Extraction of CRMs from mineral-based waste will play a main role in CRM supply in the nearest future.
- **Secure:**
  - **Risk capital for exploration/extraction/processing – EU-companies**

- Establishment of efficient CRM value chains will make a policy challenge for job creation, and transformation towards low-emission transport and production and from renewable energy sources.

Europe's mega-industries are placed at risk by insecure REE supply, and are too important to be left to Venture Capital markets. To ensure Norra Karr's success, long term supportive financing is essential.

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Outlook (2)

- **National minerals policy framework** = **Mining policy (domestic pot.) + circular economy policy + value chain**
  - based on CRM industry/economy analyses (+alliance with industry

- A transition to circular economy requires:
  - Better knowledge of waste flows and collaboration throughout the value chain;
  - Eco-design facilitating dismantling, collection and separation;
  - New processes for improving recovery and recycling;
  - Standardisation and certification of procedures for waste management and treatment facilities;
  - Development of policies on Member State level and of incentives facilitating adoptions of standards for recycling and recovery

Outlook (3)

- For **CRMs that are found in EU or can be recovered, an industrial chain needs to be developed**.
- **Filling gaps / improving the CRM value chain in Europe > increase interactions between national mineral policy actors in Europe**
  - E.g. Nb/Ta value chain (Ukraine/…/)
- Facilitate company investment security,
  - Streamline permitting and access to minerals, SLO
- Data issue.. RECOMMENDATIONS FOR IMPROVING CRM DATA AVAILABILITY
  - Ideally, national geological surveys are actors who collect / update raw materials-related data.
  - Building national databases through web server / downloadable, Updating databases continuously

Thank you for your attention

All of the reports produced in the project will be available for download on the SCRREEN website.

Project coordinator: Stephane Bourg, CEA
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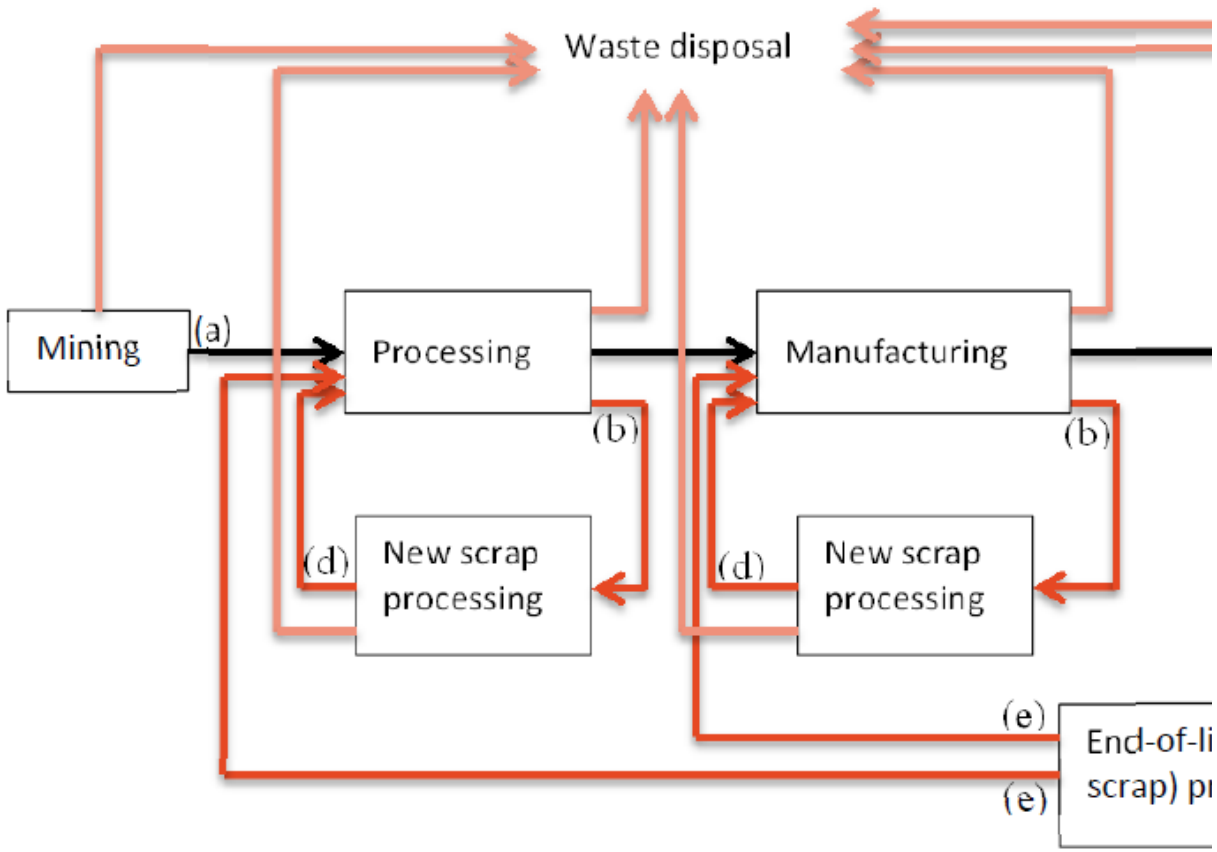

(a) Primary supply
(b) Reycling rate for new scrap
(c) End-of-life recycling rate
(b) + (c) Recycling rate including old and new scrap
(f) Recycled content

(d) Recycling input rate for new scrap
(e) End-of-life recycling input rate
(d) + (e) Recycling input rate including old an new scrap

Figure 9: Simplified material lifecycle illustrating the difference between 'old scrap' and 'new scrap', the location of primary supply and the various points at which recycling can be measured.

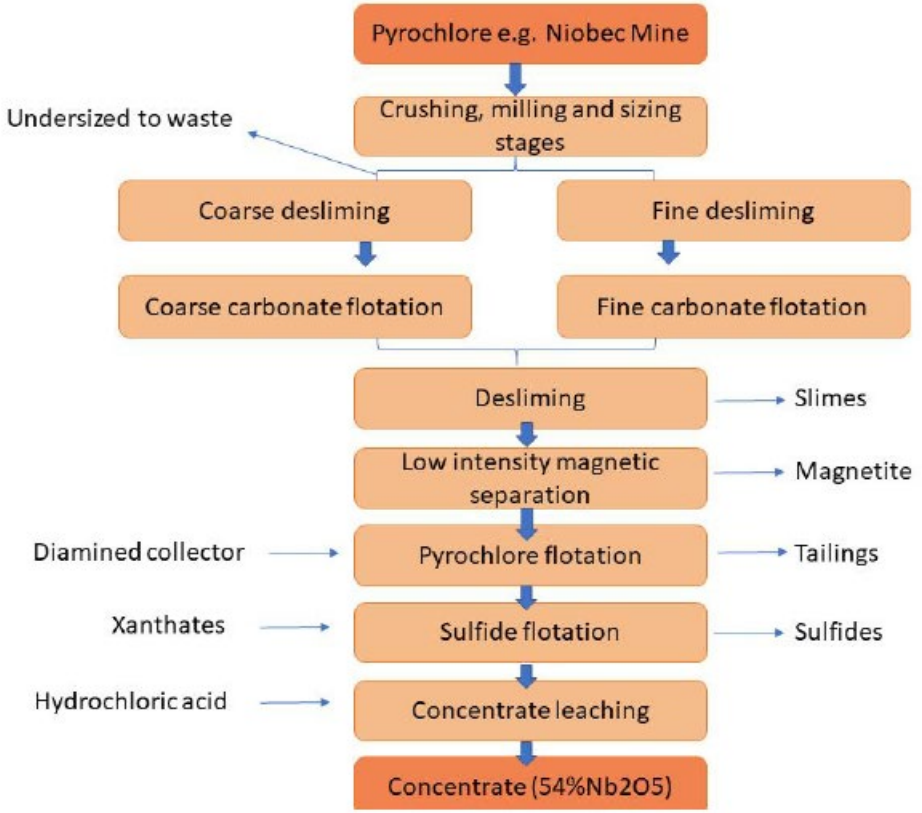

Figure 11 Nb production flowsheet of Niobec Mine [9]

Nb supply comes mainly for primary sources, with the mineral pyrochlore accounting for more than 95% of the total primary production. Columbo-tantalite minerals are also potential source of Nb. Concerning secondary sources, Nb is also extracted as a by-product from tin slags and recycling [1]. The main producers of Nb are CBMM in Brazil and Niobec mine in Canada. CBMM sells its products to steel companies (for example Arcelor Mittal in Germany) and major specialty alloy producers such as H.C. Starck (Germany), Treibacher AG (Austria), or Silmet (Estonia), which in turn sell their products to the automotive, manufacturing and construction industries [1].