This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 776487

Ref. Ares(2017)5879386 - 30/11/2017

PROSPECTIVE AREAS FOR CRITICAL RAW MATERIALS

IN THE EU

SRK Exploration Services Ltd.

INFACT

INNOVATIVE NON-INVASIVE & FULLY ACCEPTABLE EXPLORATION TECHNOLOGIES

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1. Objectives

Prioritise areas of the EU for INFACT activities

1. Identify zones within the EU that are prospective for the Strategic Minerals in question;

2. Prioritise these areas with respect to geology and mineralisation potential;

3. These areas will contribute to the selection of locations for stakeholder engagement activities within the INFACT project;

4. The prioritisation will be refined when further information becomes available regarding barriers to exploration, investment risk and so on.

Strategic Materials – the focus of this study

The EU has identified and ranked **Strategic Minerals** based on their:

- Economic Importance;
- Supply Risk.

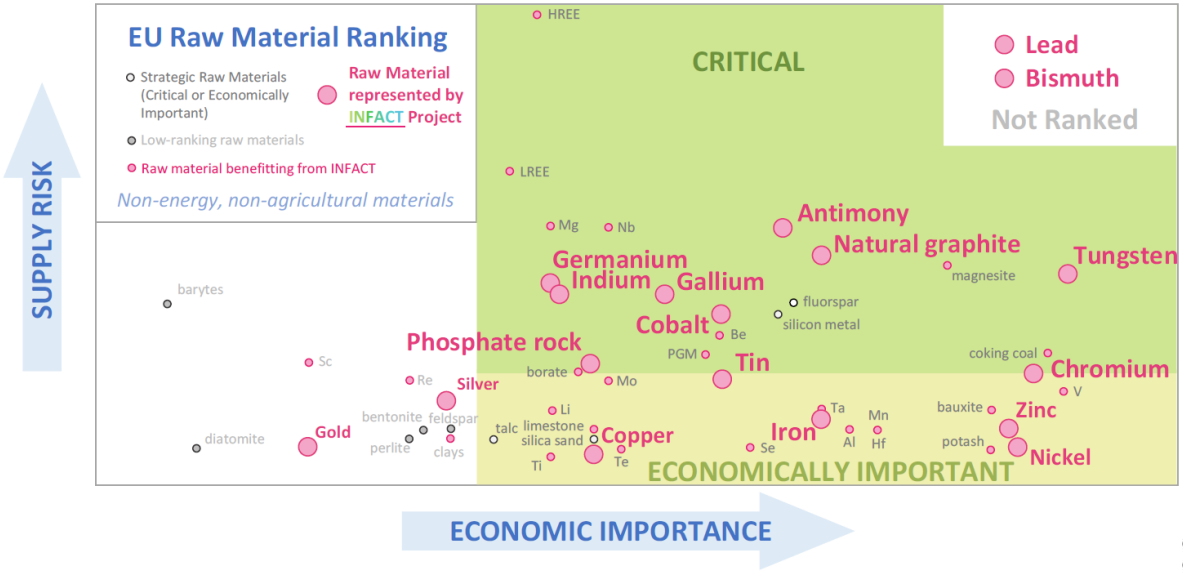
Strategic Minerals include:

- Critical Raw Materials (CRM): economically important (sometimes non-substitutable) minerals with significant supply risk;
- Economically Important Minerals (EIM)

The INFACT project and this prospectivity review includes all of the Strategic Minerals.

2. Strategic Minerals

INFACT Strategic Minerals	Represented at INFACT test site	INFACT Strategic Minerals	Represented at INFACT test site
Tungsten	✔	Nickel	✔
Natural graphite		Zinc	✔
Antimony	✔	Iron	
Gallium	✔	Copper	✔
Indium	✔	Silver	
Germanium	✔	Gold	
Cobalt		Platinum Group	✔
Chromium		Lead	
Tin	✔	Bismuth	
Phosphate rock			



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How do we prioritise?

Mineral deposits form as a result of **geological processes** that lead to the formation of particular types of mineralisation. **Geological age** is also an important factor: some types of mineralisation are more commonly associated to certain geological periods.

So, to predict and prioritise areas of high potential for Strategic Minerals on the scale of the EU, it is important to consider the following factors:

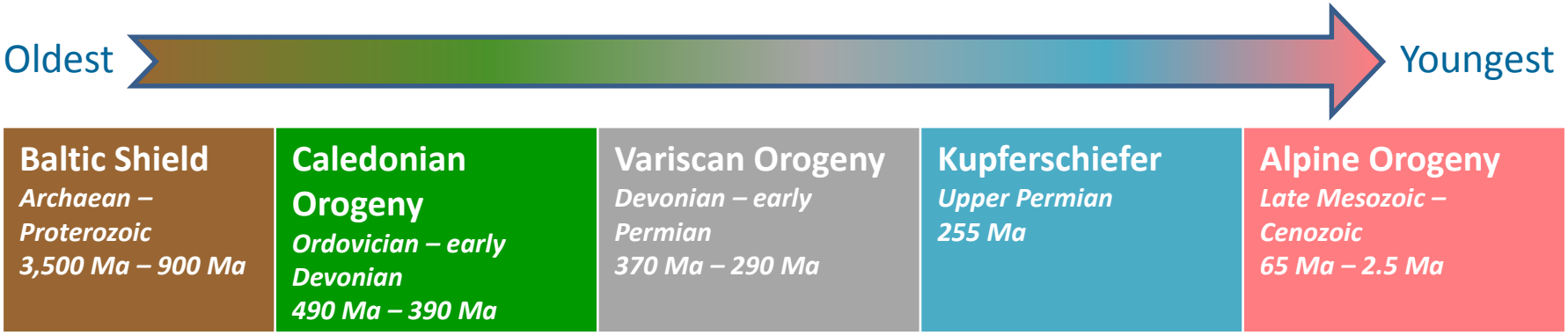
1. The current distribution of features relating to geological events (or "orogenies") that are likely to have influenced the formation of mineral deposits
2. The age of geological units on a provincial scale – certain minerals are more likely to be found in rocks of a particular age
3. The distribution of known mineral occurrences plus historical and current mining activity

3. Rationale and Methods

European Mineral Systems Overview

The EU has been subjected to several geological events that influence the distribution of minerals, or contains zones of geological ages that are known for mineralisation. They give a broad starting point for exploration prioritisation.

What are these and what are they best known to contain?



3. Rationale and Methods

European Mineral Systems Overview

Feature/Event	What is it?	Which Strategic Minerals is it known for?	Which European countries does it influence?
Baltic Shield *Archaean – Proterozoic* *3,500 Ma – 900 Ma*	The EU's oldest rocks. Metamorphosed and deformed gneisses and greenstones	Nickel Gold Silver Copper Lead-Zinc Iron PGEs Graphite Cobalt Chromium Phosphate	Finland Sweden *Norway*
Caledonian Orogeny *Ordovician – early Devonian* *490 Ma – 390 Ma*	Rocks and features formed during mountain building when the Laurentia, Baltica and Avalonia continents and terranes collided	Gold Silver Copper Lead-Zinc Iron Chromite	UK *Norway Greenland*
Variscan Orogeny *Devonian – early Permian* *370 Ma – 290 Ma*	Rocks and features formed during mountain building when the Euramerica and Gondwana continents collided	Tin-tungsten Copper Gold Antimony Lead-Zinc Minor metals (Ga, Ge, In)	UK Ireland France Spain Portugal Germany Austria Czech Republic Poland Belgium Luxembourg
Kupferschiefer *Upper Permian* *255 Ma*	Thin bed of marine sediments found over a large area of north-central Europe	Copper Lead-Zinc Silver Nickel	Germany Poland Denmark Netherlands UK
Alpine Orogeny *Late Mesozoic – Cenozoic* *65 Ma – 2.5 Ma*	Rocks and features formed during mountain building when the African and Indian continents collided with Eurasia	Copper Gold Silver Antimony Tungsten Nickel Chromite Lead-Zinc Phosphate? Minor metals (Ga, Ge, In)	Spain France *Switzerland Liechtenstein* Italy Slovenia Austria Slovakia Hungary Romania Bulgaria Greece Croatia *Serbia Bosnia-Herzegovina Montenegro Albania Macedonia*

3. Rationale and Methods

European Mineral Systems Overview

	Baltic Shield	Caledonian	Variscan	Kupferschiefer	Alpine
Tungsten			✔		✔
Graphite	✔				
Antimony			✔		✔
Gallium			✔		✔
Indium			✔		✔
Germanium			✔		✔
Cobalt	✔				
Chromium	✔	✔			✔
Tin			✔		
Phosphate	✔				✔
Nickel	✔			✔	✔
Zinc	✔	✔	✔	✔	✔
Iron	✔	✔			
Copper	✔	✔	✔	✔	
Silver	✔	✔		✔	✔
Gold	✔	✔	✔		✔
PGEs	✔				
Lead	✔	✔	✔	✔	✔
Bismuth					

3. Rationale and Methods

Examples of EU mines, by metallogenic belt

Baltic Shield

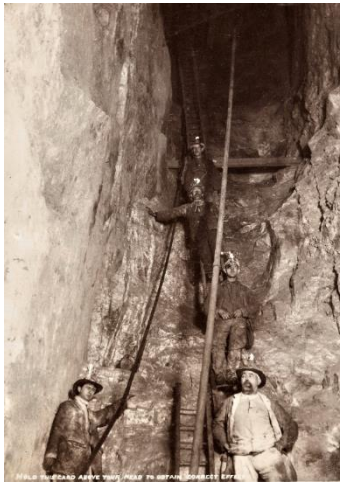
Aitik Cu-Au-Ag mine, Sweden. Boliden AB.
Photo: Lars deWall

Caledonian

Cononish gold mine, Scotland (in development). Scotgold Resources Ltd.
Photo: Murdo Macleod/for the Guardian

Variscan

Corta Atalya Cu-Zn-Pb mine, Iberian Pyrite Belt, Spain. *Photo: J. L. Carrizo*

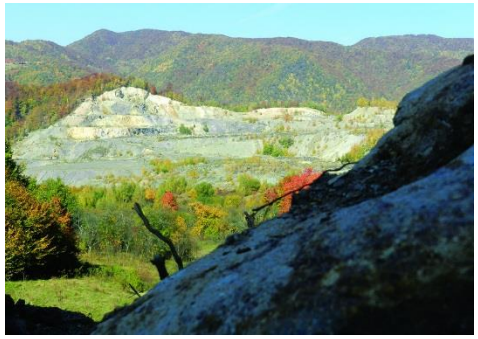


South Crofty tin mine, UK, c. 1910. *© H. D. Wootton, Albany Road, Redruth*

Kupfersheifer

Waste dumps of the Zirkelschacht copper mine, Germany. *Photo: G. Borg*

Alpine



Old open pit at the Certej Au-Ag project, Romania. *Photo: Eldorado Gold Corp.*

4. Data Sources

Information used for prospectivity analysis

The EU is fortunate to have a long history of geological research and an abundance of publicly-available data that can be used for this purpose. Some of this data has been sourced from previous EU-funded programmes.

The following has been used in this assessment:

1. Geological mapping data
2. Published research on the distribution of orogenic and metallogenic belts
3. Strategic Mineral occurrences and mining activity from databases[1]

This information has been brought together so that it can be viewed spatially to identify key areas of interest for critical raw materials.

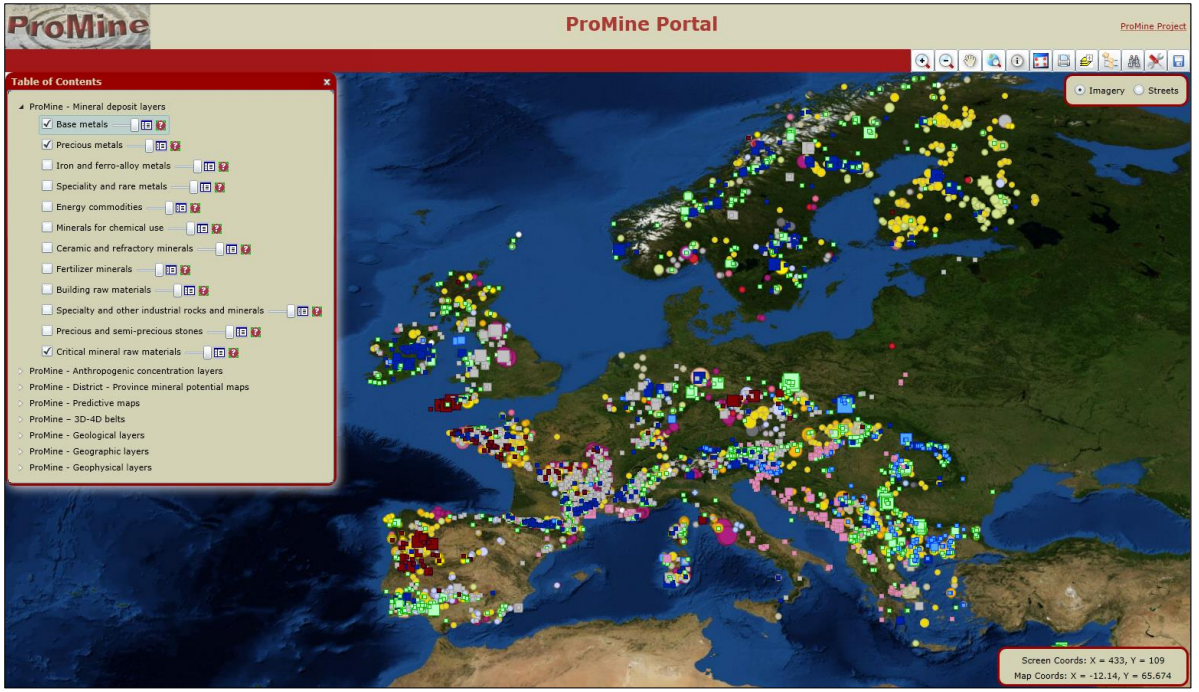
[1] ***Particular use made of the database developed by the part-EU funded ProMine project***

4. Data Sources

Information used for prospectivity analysis

ProMine database contains records of mineral occurrences and mining activity for:

- 13,493 locations in European countries
- 11,993 locations in EU countries
- 6,774 locations of primary Strategic Mineral occurrences or mining in EU countries



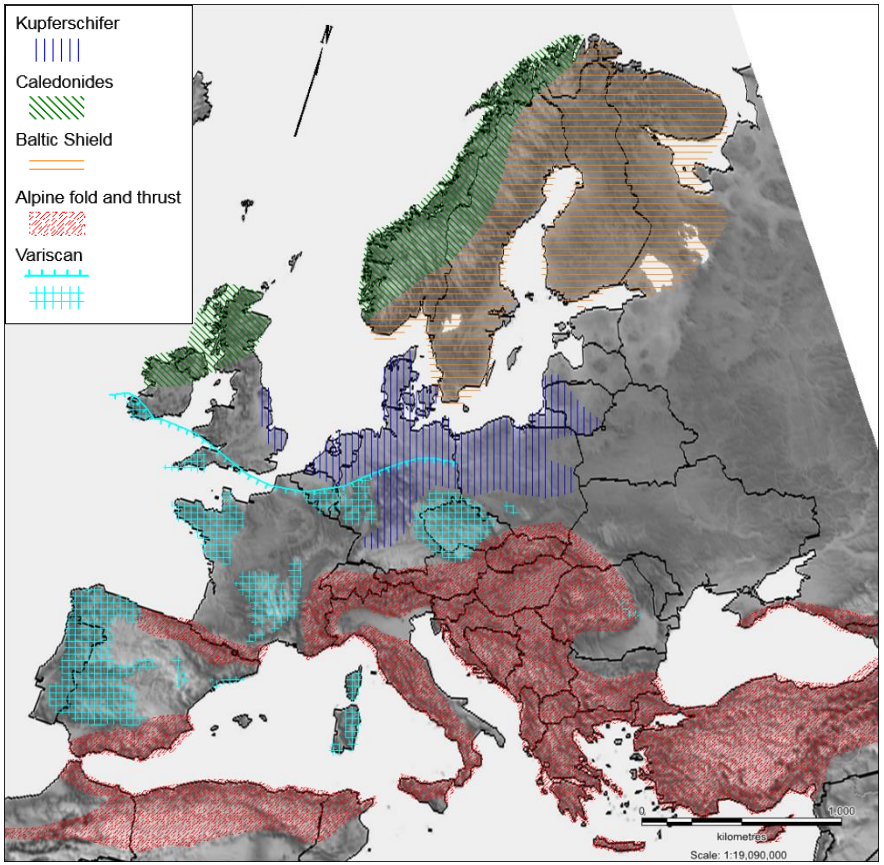
SEVENTH FRAMEWORK PROGRAMME

NMP - Nanosciences, Nanotechnologies, Materials and New Production Technologies

Part-financed by the European Union

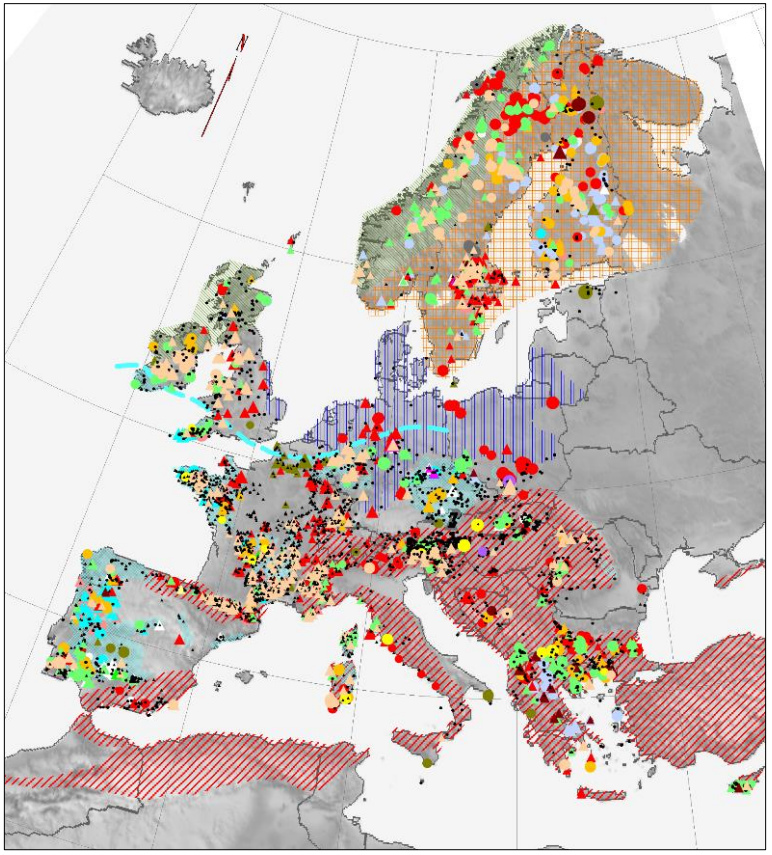
5. Summary of Outcomes

Metallogenic Belts



Key controls on mineralisation in the EU

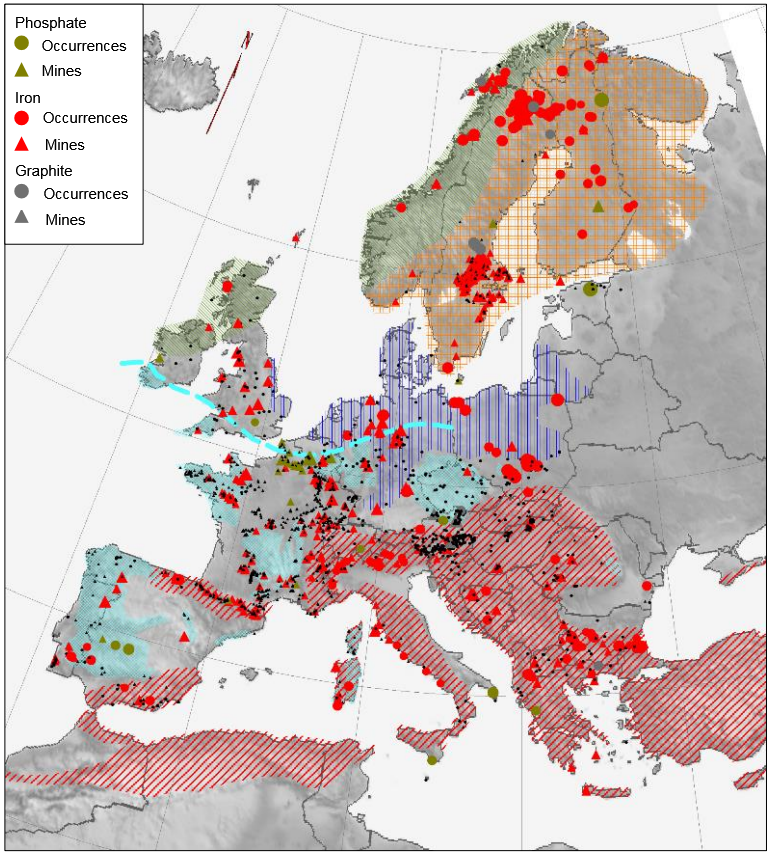
All Strategic Mineral occurrences



Mineralisation in the EU is widespread and diverse

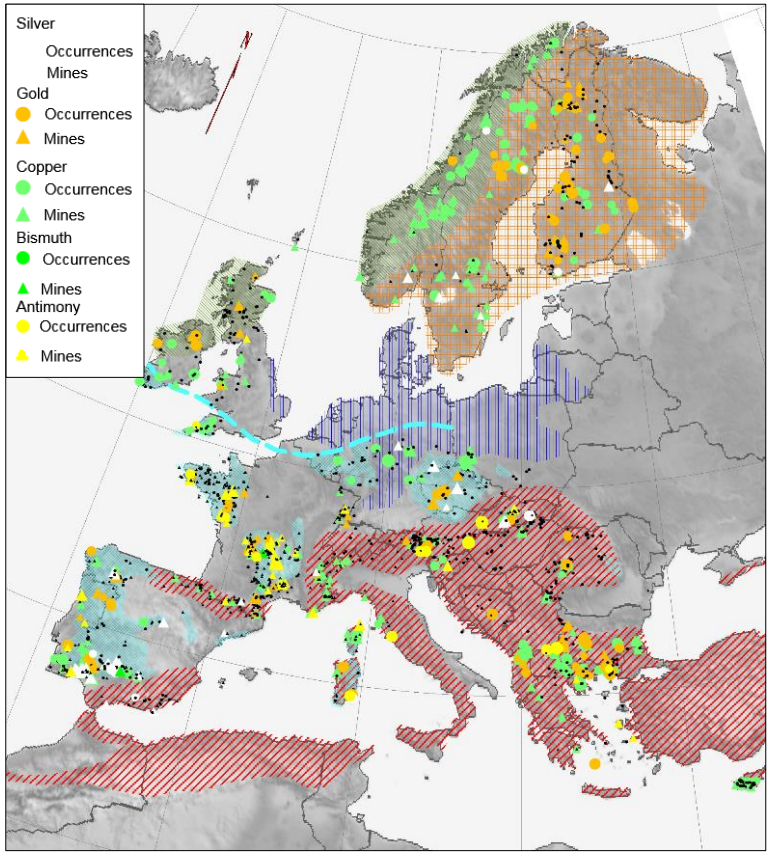
5. Summary of Outcomes

Iron, Graphite, Phosphate



Key areas: Fennoscandia

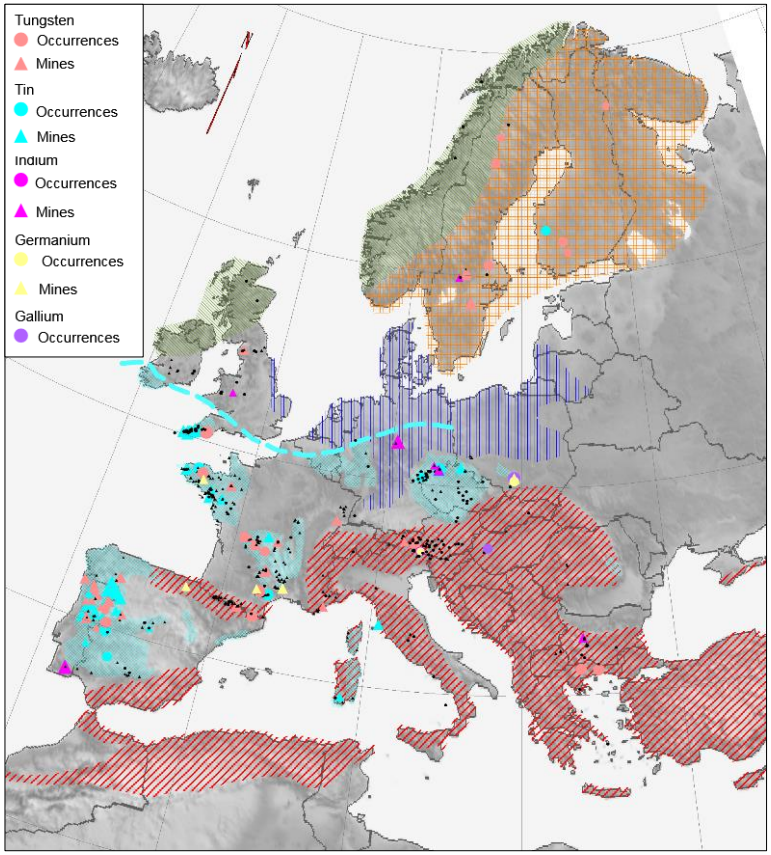
Copper, Gold, Silver, Antimony, Bismuth



Key areas: Fennoscandia, Spain, Southeast Europe

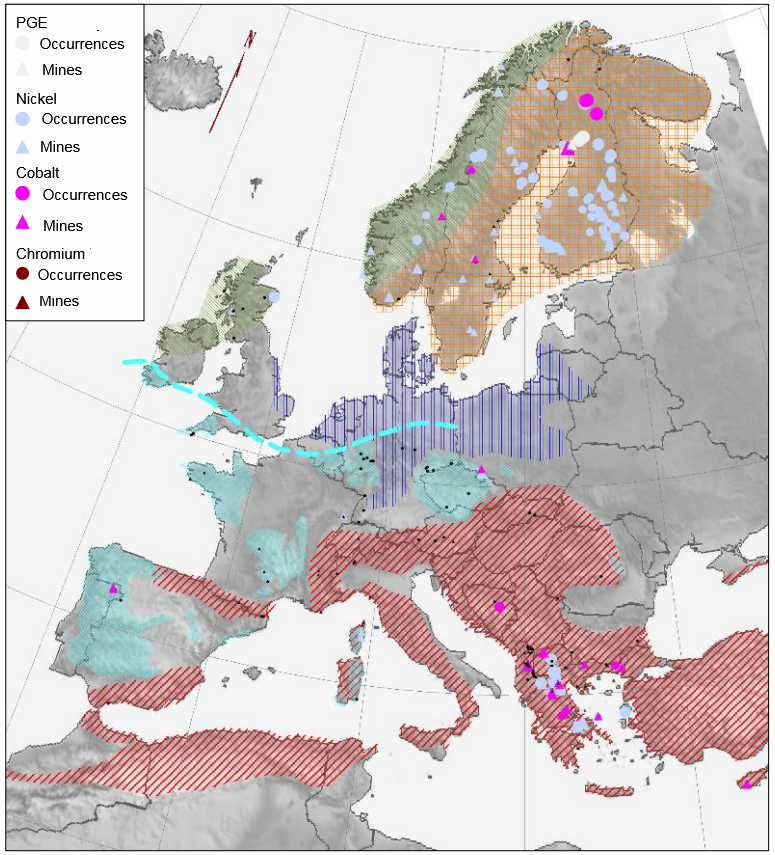
5. Summary of Outcomes

Tin, Tungsten, Indium, Gallium, Germanium



Key areas: UK, Portugal, Spain, France, Czech Republic, Austria

Nickel, Chromium, Cobalt, Platinum Group



Key areas: Fennoscandia, Southeast Europe

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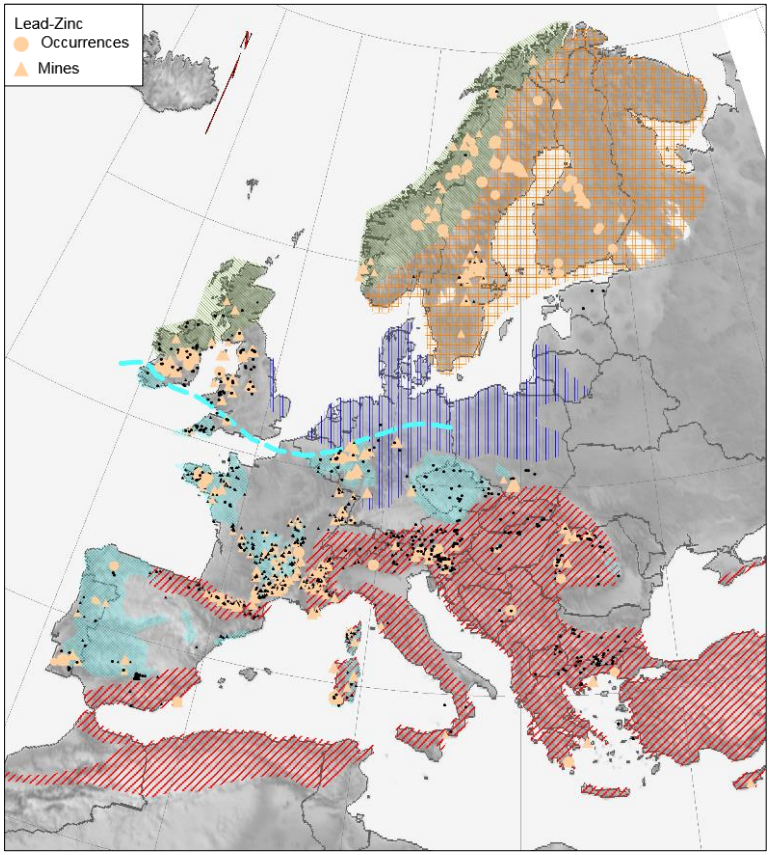
srk exploration

5. Summary of Outcomes

Lead, Zinc



Key areas: Ireland, Fennoscandia, Central Europe

5. Summary of Outcomes

Mineral diversity ←

	Finland	Sweden	France	UK	Czech	Spain	Portugal	Germany	Austria	Romania	Poland	Greece	Hungary	Italy	Slovakia	Cyprus	Bulgaria	Ireland	Belgium	Slovenia
Gold	✔	✔	✔	✔	✔	✔	✔		✔	✔		✔	✔		✔					
Silver	✔	✔			✔	✔	✔	✔		✔			✔		✔					
Copper	✔	✔		✔		✔	✔	✔		✔	✔	✔	✔	✔	✔	✔				
Antimony			✔						✔				✔		✔					✔
Bismuth			✔	✔		✔														
Tungsten			✔	✔		✔	✔	✔	✔											
Tin			✔	✔	✔	✔	✔	✔												
Indium			✔	✔	✔	✔	✔	✔									✔			
Gallium			✔		✔				✔											
Germanium			✔		✔			✔	✔	✔	✔			✔			✔	✔		
Nickel	✔	✔										✔								
Chromium	✔	✔										✔				✔				
Cobalt	✔	✔										✔								
PGEs	✔	✔																		
Zinc	✔	✔	✔	✔		✔	✔	✔		✔	✔			✔		✔		✔	✔	
Lead	✔	✔	✔	✔		✔	✔	✔		✔	✔			✔		✔		✔	✔	
Graphite	✔	✔			✔				✔											
Phosphate	✔	✔	✔														✔		✔	
Iron	✔	✔									✔			✔						

6. Conclusions

The EU is well-placed for mineral discovery

1. The EU has a substantial mineral endowment and a long mining history

2. Compared to many other places in the world, the region has an extremely comprehensive record of mineral occurrences, the geology is well-understood and many leading research centres for economic geology are found in the EU

3. There are still major deposits to be found in Europe

4. The decline of exploration in the EU is not due to a lack of geological potential, technical challenges or investment risk – the perception of mining, historical mining legacies and complex regulation may have more influence

5. Exploration must play its part in addressing the perception of mining in the EU– a key objective of INFACT!

6. Conclusions

Geology crosses borders

1. The foundation for forming minable ores in Europe started billions of years ago

2. Deposit model classification may not be completely understood yet

3. Mineral occurrences and prospective regions do not follow political boundaries, but mining histories may do

4. Geological classification and mapping is often not synchronised across political borders, which can result in an obstacle to exploration

5. Classification of a Mineral Resource/Reserve (i.e. whether or not a deposit is economically feasible as a mine), may be critically affected across political borders due to differences in legislation, royalties, landowner rights, social acceptance etc.

The EU has an opportunity to address these issues and offer a common mining code in a similar way to other EU regulations adopted by member states.

7. Further Work

Refining the priority areas

Further **geological refinements** to prioritisation areas should make use of:

- Recent and current exploration data, not yet in databases – this requires monitoring and regular updating
- Monitoring changes to Critical Raw Material and Strategic Mineral rankings and reprioritising accordingly
- Whether regions should be prioritised based on their mineral diversity or the potential for large deposits of limited types, or both
- Whether a lack of exploration data or recent exploration activity in geologically prospective areas increases the chances of significant undiscovered deposits
- Reprioritising according to new advances in the understanding of mineral systems

7. Further Work

Refining the priority areas

As well as technical exploration factors, target prioritisation should also consider:

1. **Deposit size: what is best for the EU?**
   - Small and high grade (smaller footprint, less impact, shorter development time, shorter mine life, less economic benefit)
   - Large and low grade (large footprint, larger impact, long development time, longer mine life, more economic benefit)

2. **Social acceptance and existing landuse**
   - This will vary across the EU, often due each country's track record of mining and environmental protection

3. **Environmental regulation**
   - Fairly standard across the EU, but Natura 2000 sites are significant obstacles

4. **Local mining regulation and legislation**
   - Environmental, safety and social laws are quite standard across the EU, but most countries still have their own and often very different exploration and mining laws