Mapping of refractory metals primary resources in Europe

Guillaume Bertrand[1], Michel Bonnemaison[2], Quentin Monge[2], Laura S. Lauri[3], Thomas Poitrenaud[2], Jason Yang[3]

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Overview

Objective: "A comprehensive mapping of the primary resources of refractory metals, including resource types, reserves, and geological mineralogy and chemistry".

Team:

- BRGM - G. Bertrand
- E-Mines - M. Bonnemaison, Q. Monge and T. Poitrenaud
- GTK - L.S. Lauri and J. Yang

Output(s): official deliverable of the project (map of the primary resources in the EU)

Timing:

- Work completed in the early stage of the project (January to April 2016), in order to feed other actions of the project.

Two aspects in this work:

- Collecting global information on mine production in the whole World (for comparison purpose essentially)
- Mapping the known primary resources of refractory metals in Europe;

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World mine production of refractory metals

Context:

The main objective was to map the primary resources in the EU.

But, in order to replace European resources in a more global perspective, we have collected information on world mine production of refractory metals.

Source of data:

For global data, we sought a source of data that was, as much as possible

- exhaustive,
- homogeneous,
- reliable.

The source of information we have chosen was the Mineral Commodity Summaries published yearly by the U.S. Geological Survey*. In addition, we have obtained complementary data from the British Geological Survey.

For each of the five commodities, we highlighted the contribution of the European Union to the world production. We also tried to highlight the evolution during the past few years (2013-2014 to 2016).

* Available at http://minerals.usgs.gov/minerals/pubs/mcs/

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World mine production of refractory metals

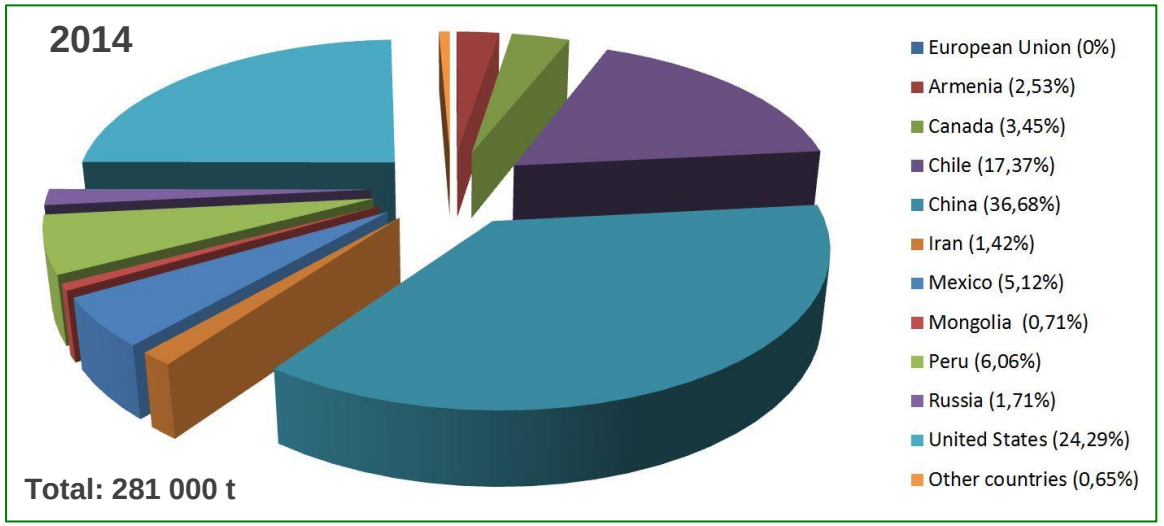
Molybdenum:

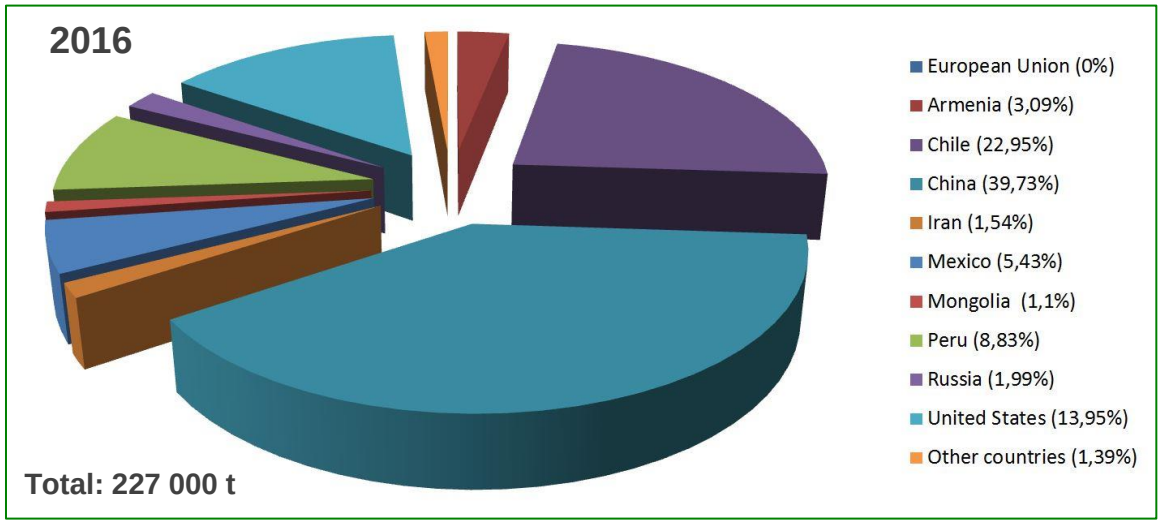
The world mine production of molybdenum, in 2016 (↘ compared to 2014), was essentially concentrated in 3 countries:

- China (39,7% of the total world production, ↗);
- the United States (13,9%, ↘);
- Chile (22,9%, ↗).

Other countries played a significant role, such as Peru (8,8%, ↗) and Mexico (5.4%, ↔).

The contribution of the European Union was null





Geographic distribution of the 2014 and 2016 molybdenum mine production (in percent of the total world production), and contribution from the European Union (source: USGS).

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World mine production of refractory metals

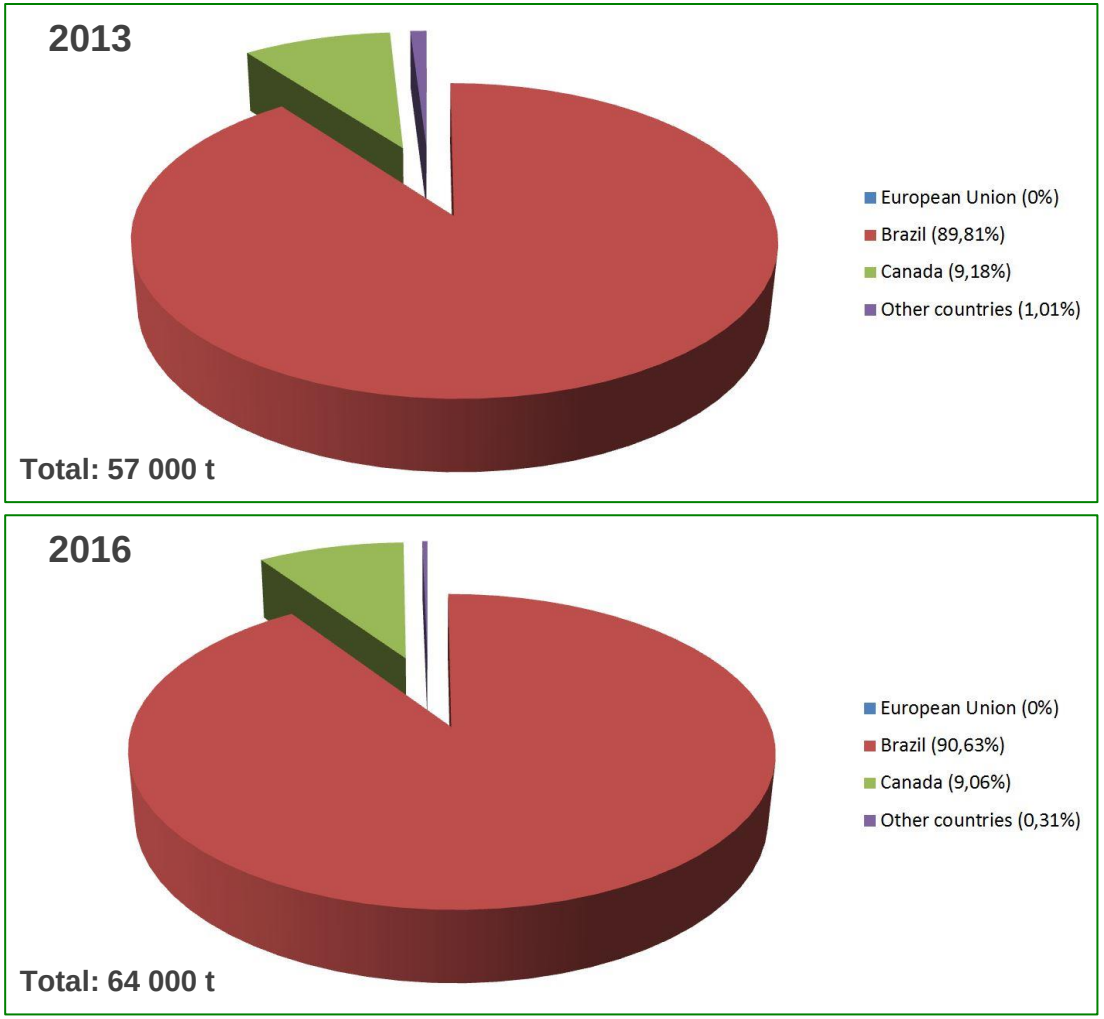
Niobium:

The production of niobium concentrate in 2016 (↗ compared to 2013) was essentially concentrated in Brazil (90,6% of the total world production, ↔).

Canada played a significant role with 9.1% of the world production (↔).

The combined contribution of all other producing countries was negligible and amounts to approx. 0,3% (↘).

The contribution of the European Union to the world production of niobium concentrate was null.



Geographic distribution of the 2013 and 2016 production of niobium concentrates (in percent of the total world production), and contribution from the European Union (source: USGS).

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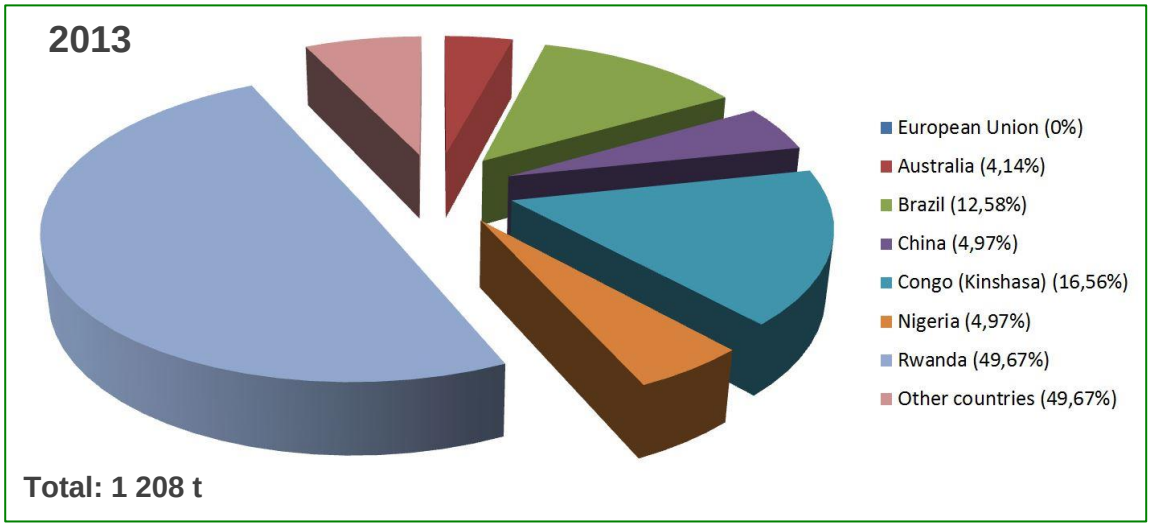
World mine production of refractory metals

Tantalum:

The world production of tantalum concentrate in 2016 (↘ compared to 2013) is dominated by Rwanda (39%, ↘) and Congo (33,3%, ↗).

Other countries, such as Brazil (10,9%, ↘) and China (5,7%, ↗), played a significant role.

Similarly to niobium concentrate, the contribution of the European Union to the world production of tantalum concentrate was null.



Geographic distribution of the 2013 production of tantalum concentrates (in percent of the total world production), and contribution from the European Union (source: USGS).

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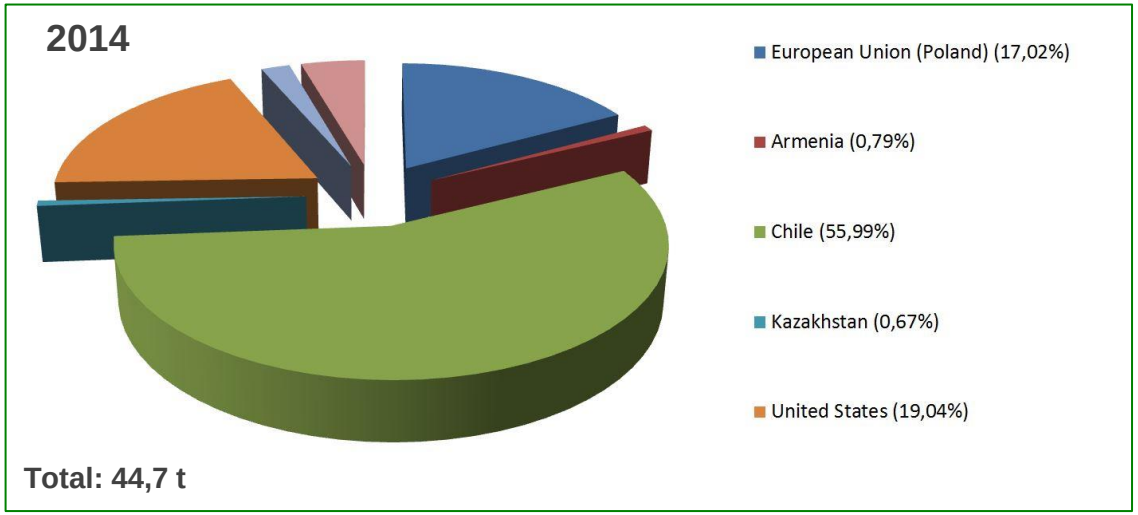
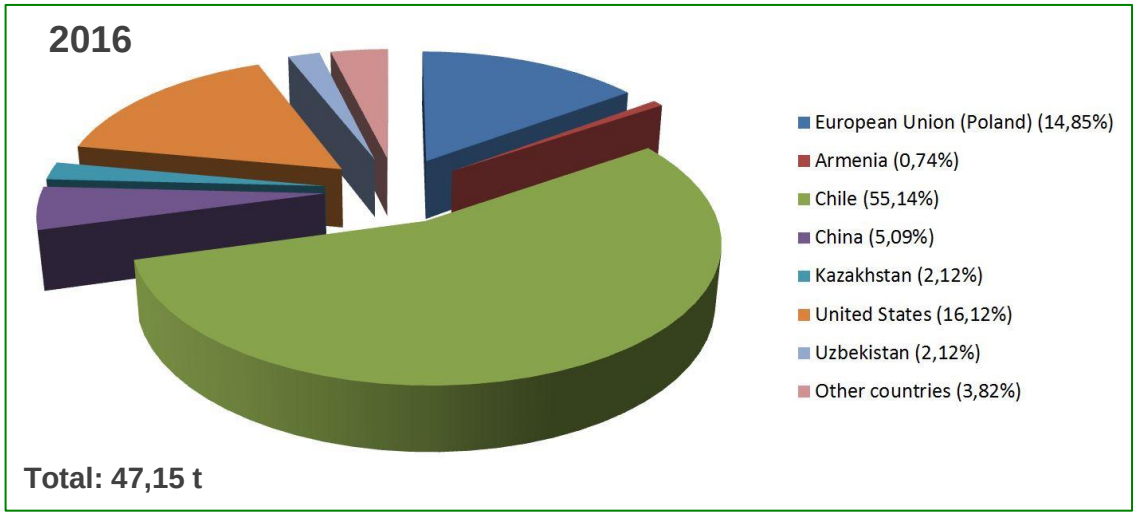
World mine production of refractory metals

Rhenium:

The world production of rhenium in 2016 (↗ compared to 2014) was highly concentrated in Chile (55,1%, ↔). The two other important producers were the United States (16,1%, ↘) and Poland (14,9%, ↘).

Owing to the Polish production, a significant amount of rhenium was produced within the European Union. Still, this contribution has decreased compared to 2014 (17% in 2014 to 14,9% in 2016).





Geographic distribution of the 2014 rhenium production (in percent of the total world production), and contribution from the European Union (source: USGS).

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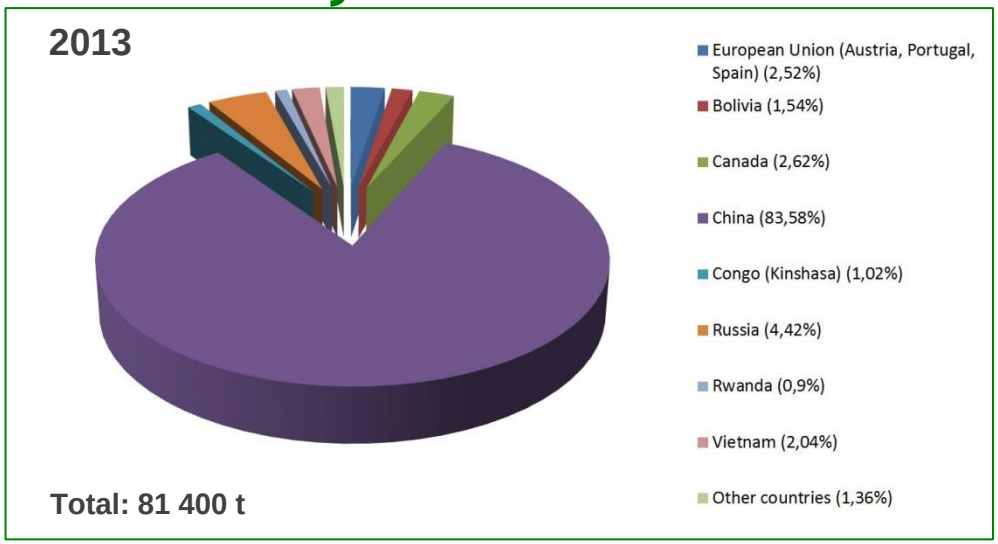
World mine production of refractory metals

Tungsten:

The world production of tungsten concentrate in 2016 (↗ compared to 2013) was distributed over many countries, although 82,2% of it was concentrated in China (↔).

Another emerging producer was Vietnam (6,9%, strongly ↗), while the contribution of other countries is limited and seldom exceed a few percent (e.g. 3% for Russia, ↘).

The contribution of the European Union was low but still significant, with 3,4% of the world total, by combining the production of Austria, Portugal, Spain and the UK. It has been increasing, compared to 2013, thanks to the contribution of UK.



Geographic distribution of the 2013 production of tungsten concentrate (in percent of the total world production), and contribution from the European Union (source: USGS).

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Mapping the primary resources in Europe

(preliminary) conclusion

These numbers set up the scene: except for Re, the contribution of the EU in the world mine production of refractory metals is very low (W) to null (Mo, Nb, Ta).

The arising questions then are:

- Is there a geological potential in Europe for these metals ?
- If yes, where ?

These questions have been underlying the primary resources mapping

This work included:

- Identifying relevant databases and extracting relevant information;
- Merging extracted information in homegeneous dataset(s); cleaning and controling the data;
- Editing the map layout, including additional data layers (e.g. geology);
- Displaying dataset(s) on the map (i.e. defining symbology, order of display, etc …);
- Editing the explanatory note to the map;
- Publishing the map and its explanatory note.

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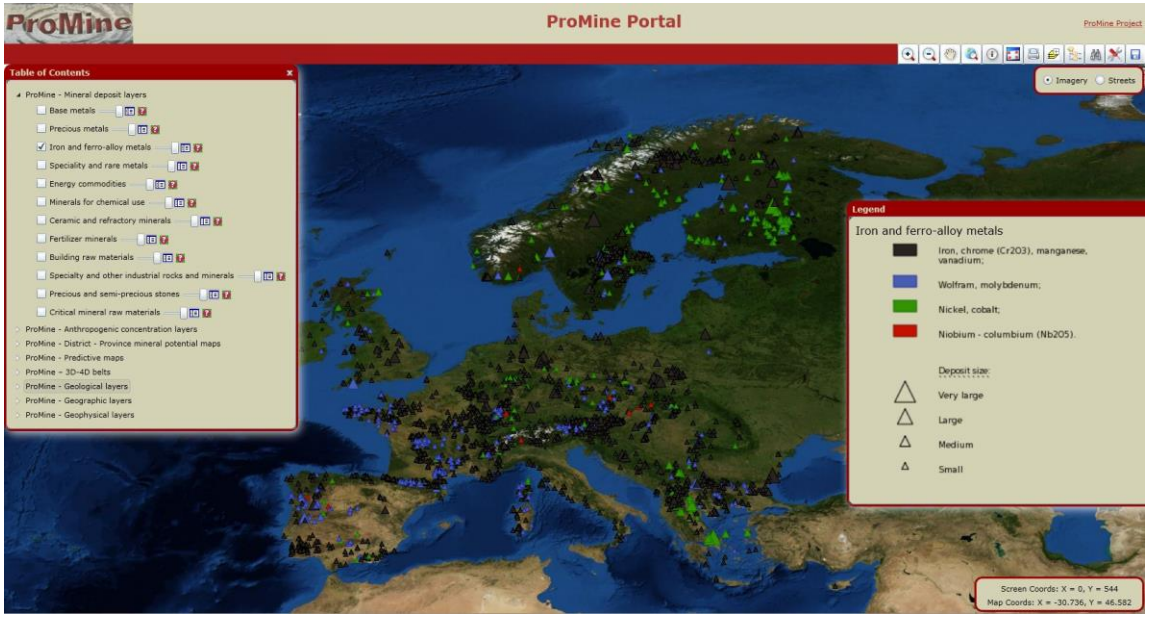
Mapping the primary resources in Europe

Sources of data:

1) The ProMine Mineral Deposit (MD) database (http://ptrarc.gtk.fi/ProMine/default.aspx)



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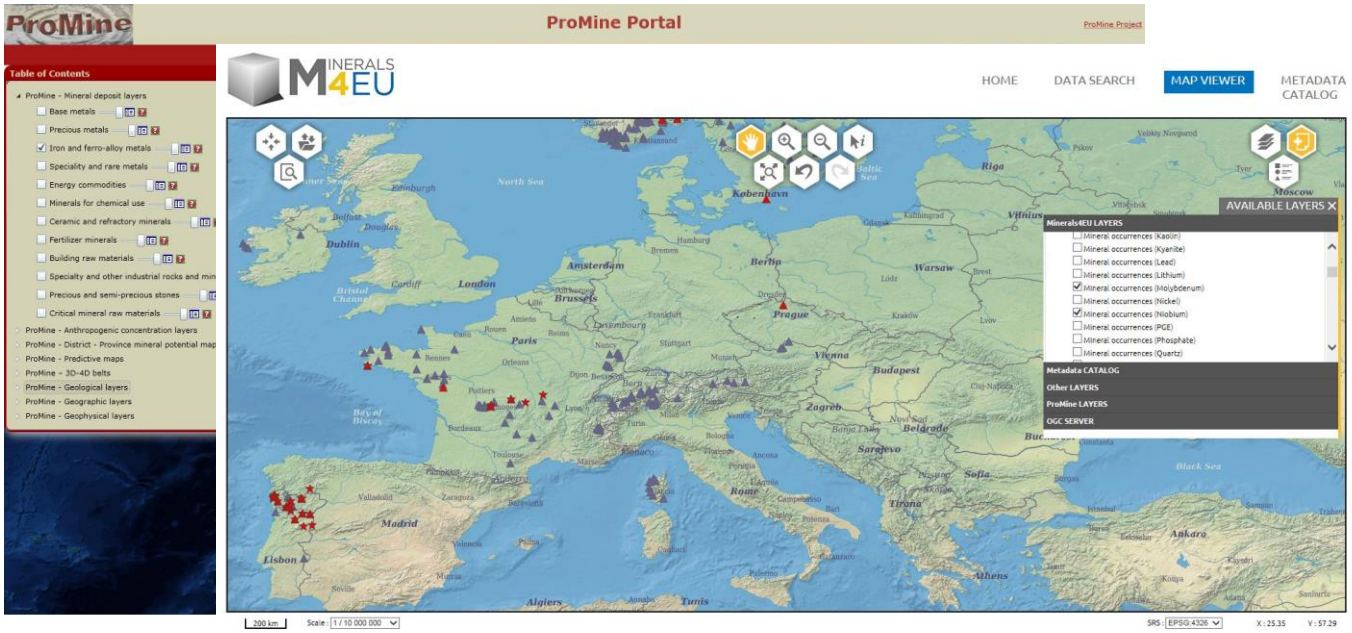

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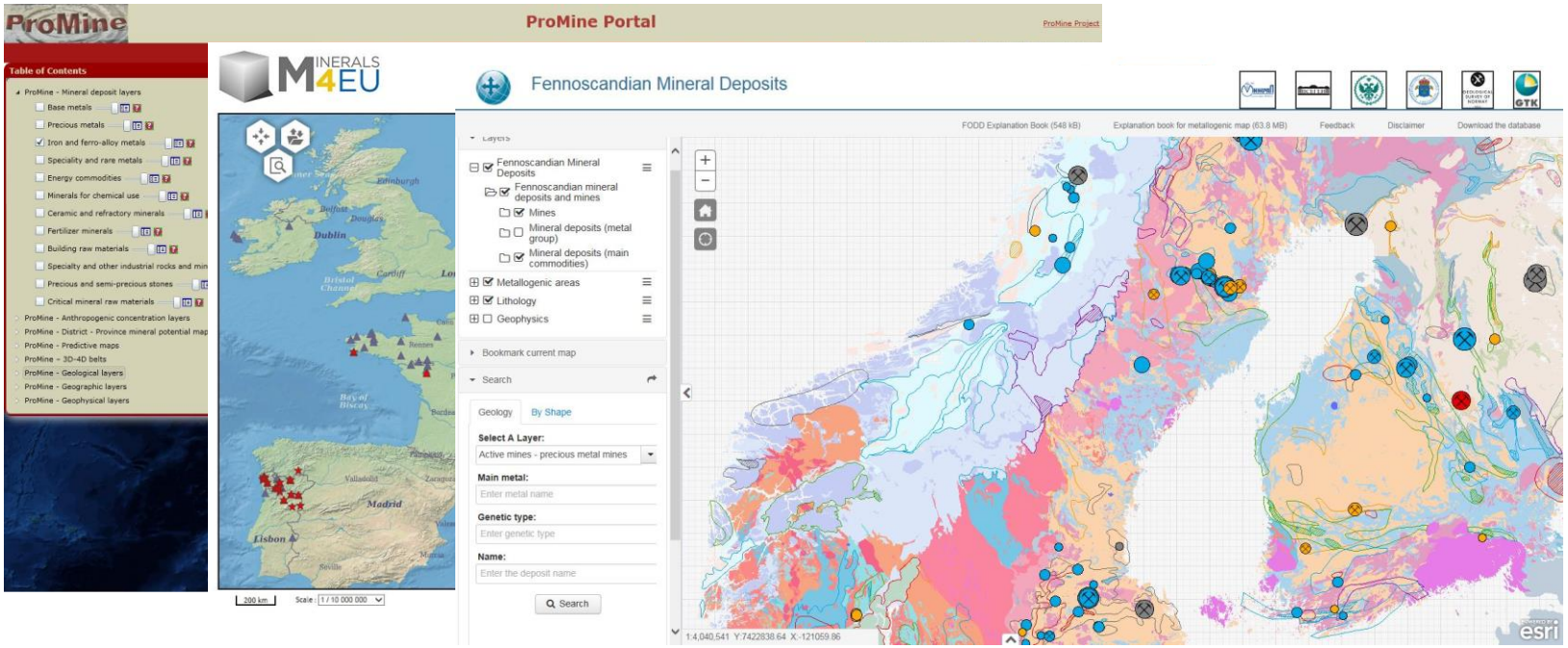

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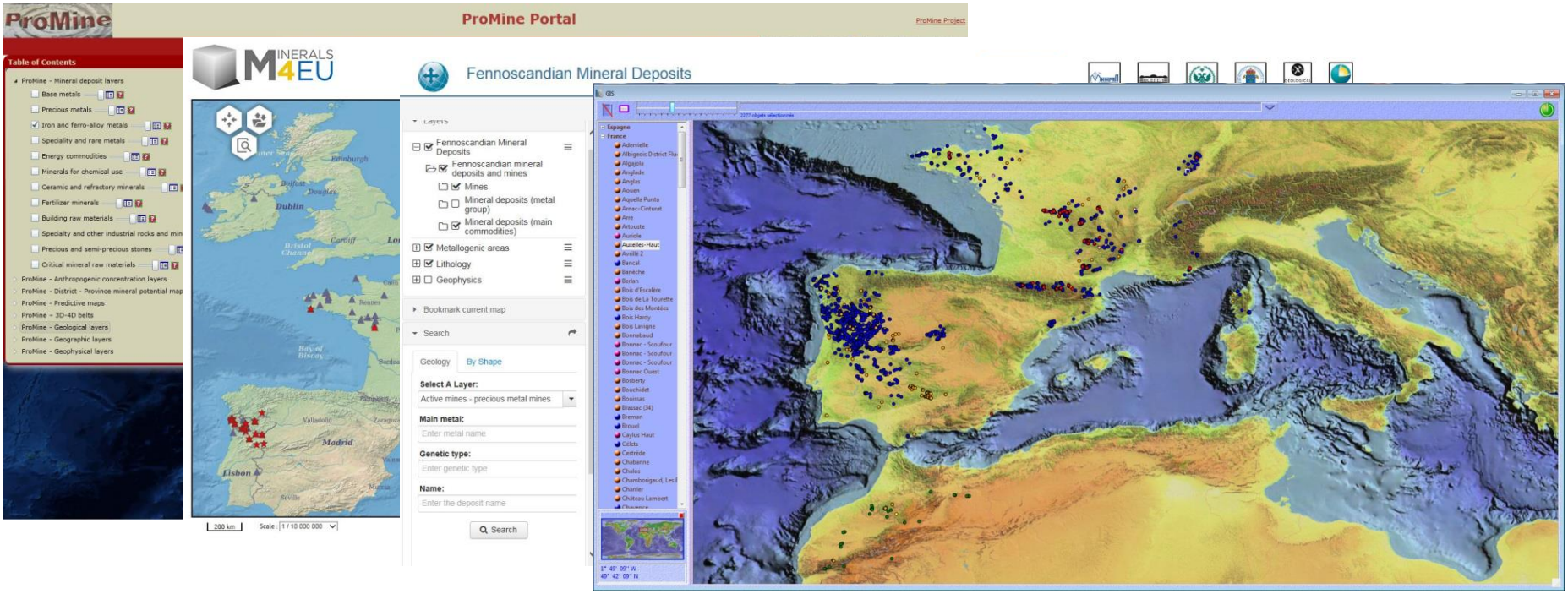
3) The Fennoscandian Ore Deposit Database, FODD (http://gtkdata.gtk.fi/fmd/)
4) The GKR expert system (commercial software developed by e-Mines, no public access)



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Mapping the primary resources in Europe

Two main types of databases:

1) **ProMine**, **Minerals4EU** and **FODD** are relational databases with structured data models.

They are constrained by their data models (b.t.w. relatively similar) but are well suited to easily extract structured information through appropriate queries (e.g. deposits containing a targeted commodity).

2) **GKR** is an expert system based on a wiki-type encyclopaedia architecture with ontology-based links.

It not as structured as the other databases but well suited to deduce information from relations between records (e.g. deposit of specific type and/or containing specific mineralogy, then possibly containing a targeted commodity).

These two types of databases have very different “philosophies” and can not satisfyingly be combined.

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Mapping the primary resources in Europe

Based on these differences, two datasets were produced:

1) A dataset of European deposits with reported amounts of refractory metals (resources and/or reserves and/or past production).

- based on data from the **ProMine** database, completed by additional information from **Minerals4EU**, **FODD** and (as much as possible) **GKR**.
- Query criteria = presence of Mo or Nb or Ta or Re or W as either main or secondary commodity.
- Resulting dataset has a limited number of highly detailed deposits (90).
- Contains information on*: name, country, lat and long, contained commodities, past production, resources et reserves (incl. type, year, grade and classification code), status, deposit type, morphology, mineralogy, source of data, age

* note that fields are not systematically documented, depending on available data

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Based on these differences, two datasets were produced:

2) A dataset of European deposits and occurrences containing refractory metals, but in unknown amount.

- based on the **GKR** that was completed (as much as possible) by additional information from the **ProMine**, **Minerals4EU** and **FODD** databases.
- required an important work to "de-convolute" information from the other "data-model based databases".
- Resulting dataset has a large number of less detailed deposits (1120) and occurrences (3889).
- Contains information on*: name , country, lat and long, nature, status, type of operation, contained commodities, mineralogy, morphology, deposit type and model, size

* note that fields are not systematically documented, depending on available data

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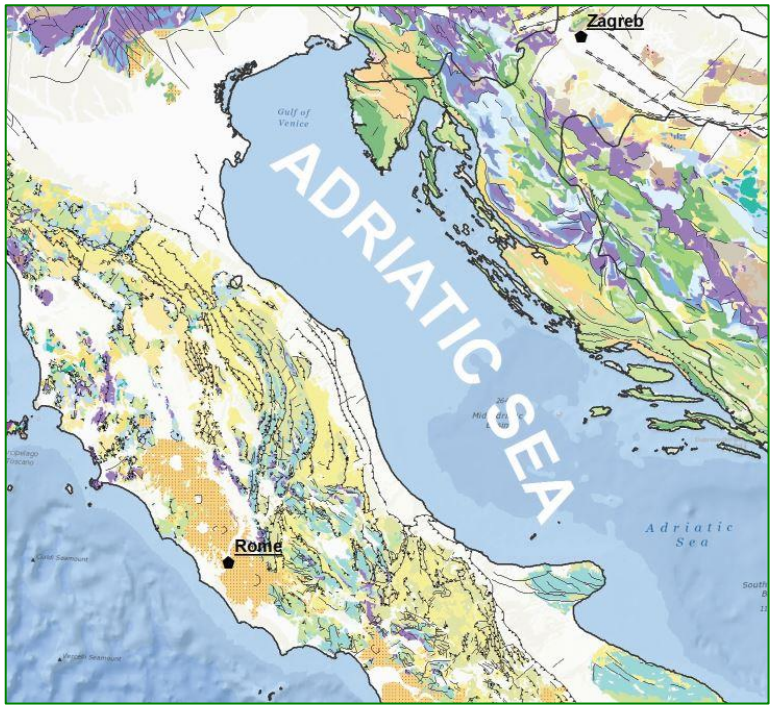
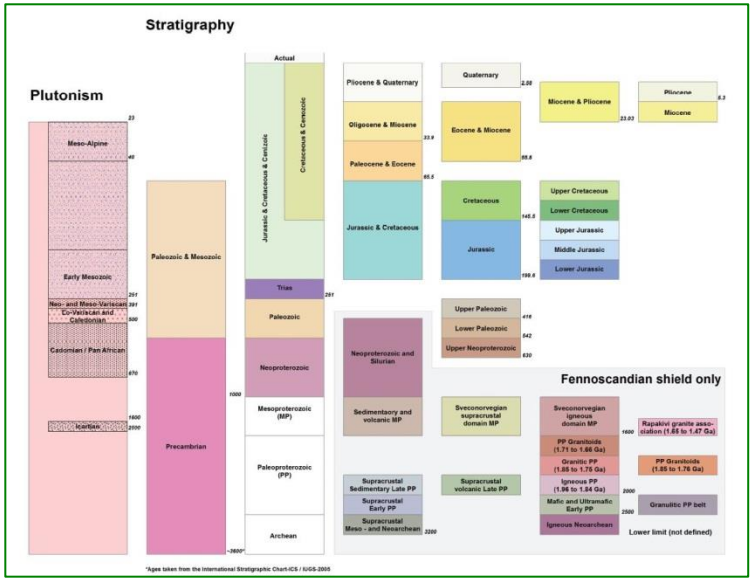
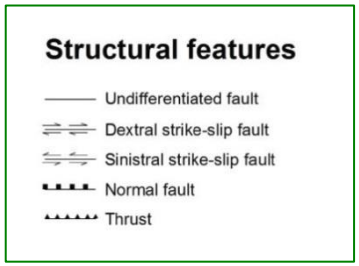
A map layout was prepared with backgroung morphological and geological layers:

- For offshore areas, the 1/1 000 000 ESRI's Ocean Basemap, that includes the General Bathymetric Chart of the Oceans (GEBCO);
- For inland Europe, the 1/1 500 000 Geological Synthesis of Europe (Billa et al., 2008), that includes harmonized lithology, stratigraphy and tectonic structures.







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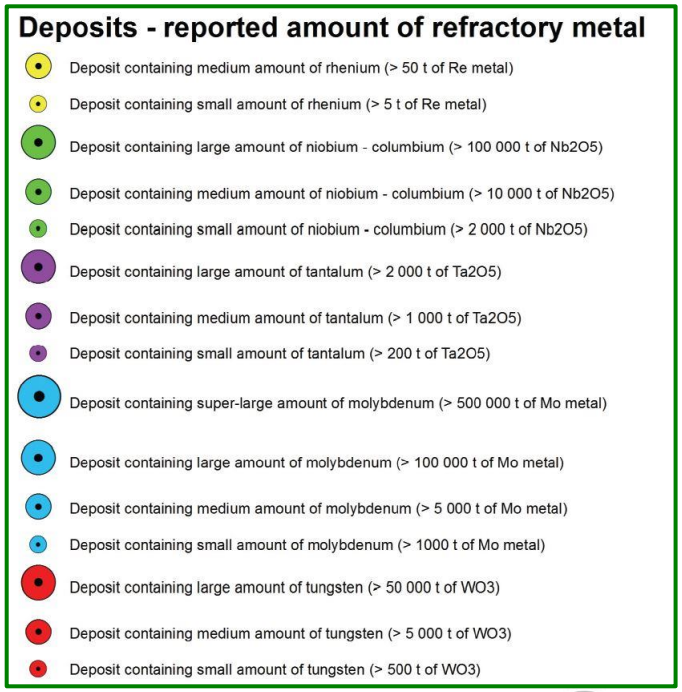
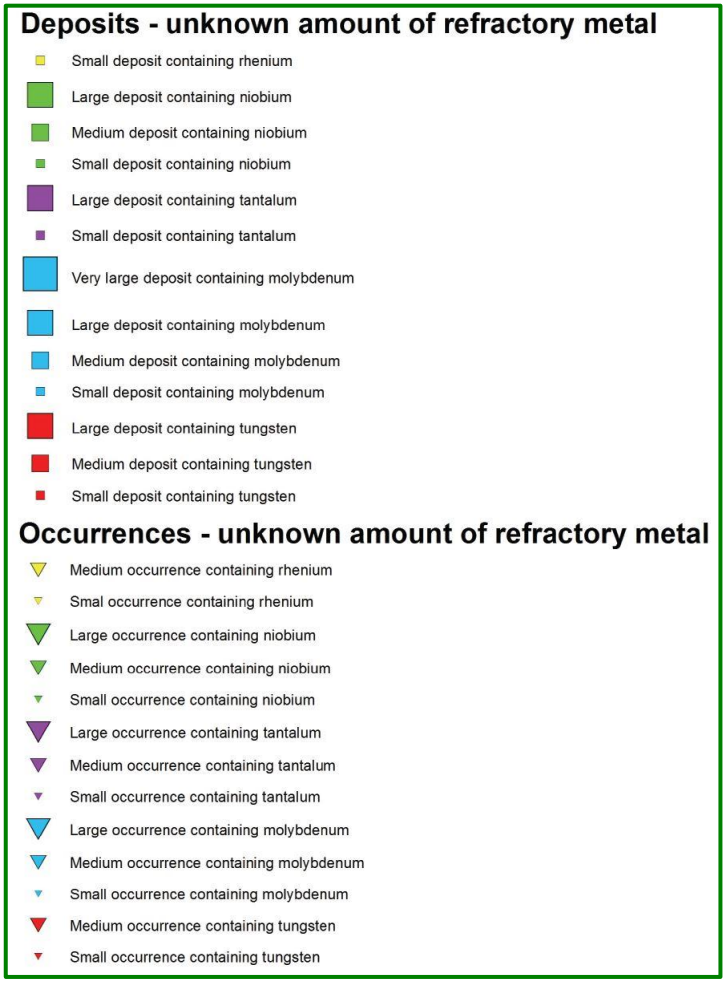
Mapping the primary resources in Europe

Datasets were included in the map with proper symbology:

- Based on 1) commodity and 2) size
- Size was based on the ProMine commodity code list classes.
- Categories with fewest records were displayed last (i.e. on top) in order to minimize the number of hidden symbols.





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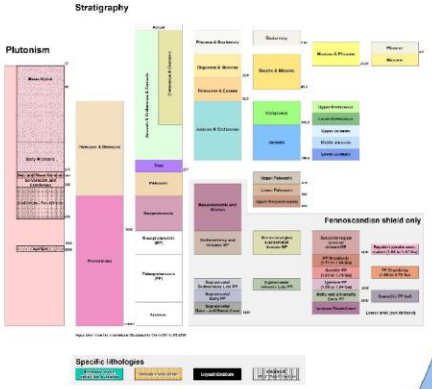
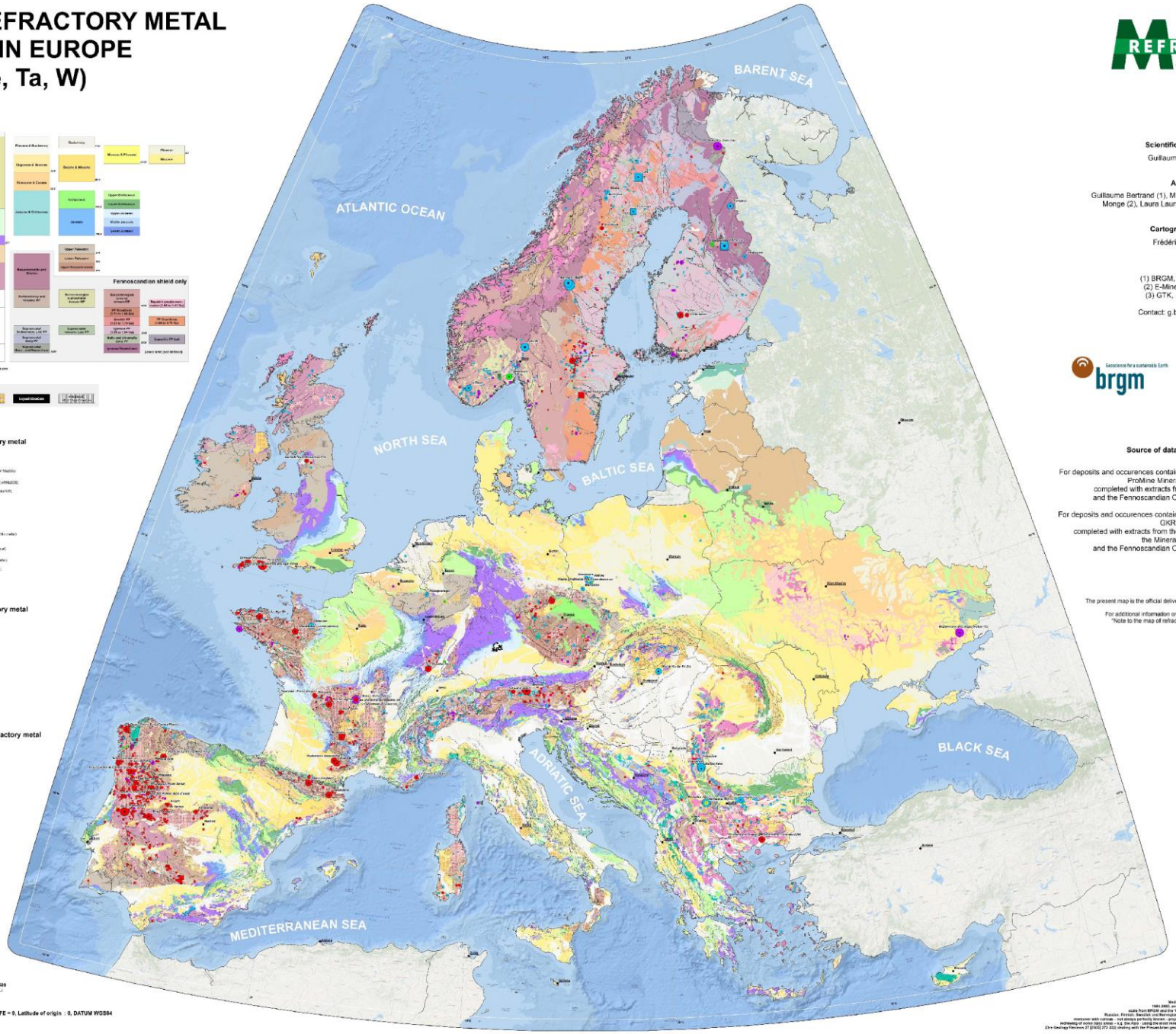
MAP OF REFRACTORY METAL DEPOSITS IN EUROPE (Mo, Nb, Re, Ta, W)





Deposits - reported amount of refractory metal

Deposits - unknown amount of refractory metal

Occurrences - unknown amount of refractory metal

Structural features

Undifferentiated fault
Normal fault
Thrust

0 500 km

Polyconic Projection, Central Meridian : 10°E, FE = 0, Latitude of origin : 0, DATUM WGS84

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Scientific coordination
Guillaume Bertrand (1)

Authors
Guillaume Bertrand (1), Michel Bonnemaison (2), Quentin Monge (2), Laura Lauri (3), Thomas Poitrenaud (2)

Cartographic layout
Frédérik Maldan (1)

(1) BRGM, Orléans, France
(2) E-Mines, Dun, France
(3) GTK, Espoo, Finland

Contact: g.bertrand@brgm.fr

Source of data (mineral deposits)

For deposits and occurences containing reported amount of refractory metal :
ProMine Mineral Deposit database,
completed with extracts from the Minerals4EU database
and the Fennoscandian Ore Deposits database (FODD).

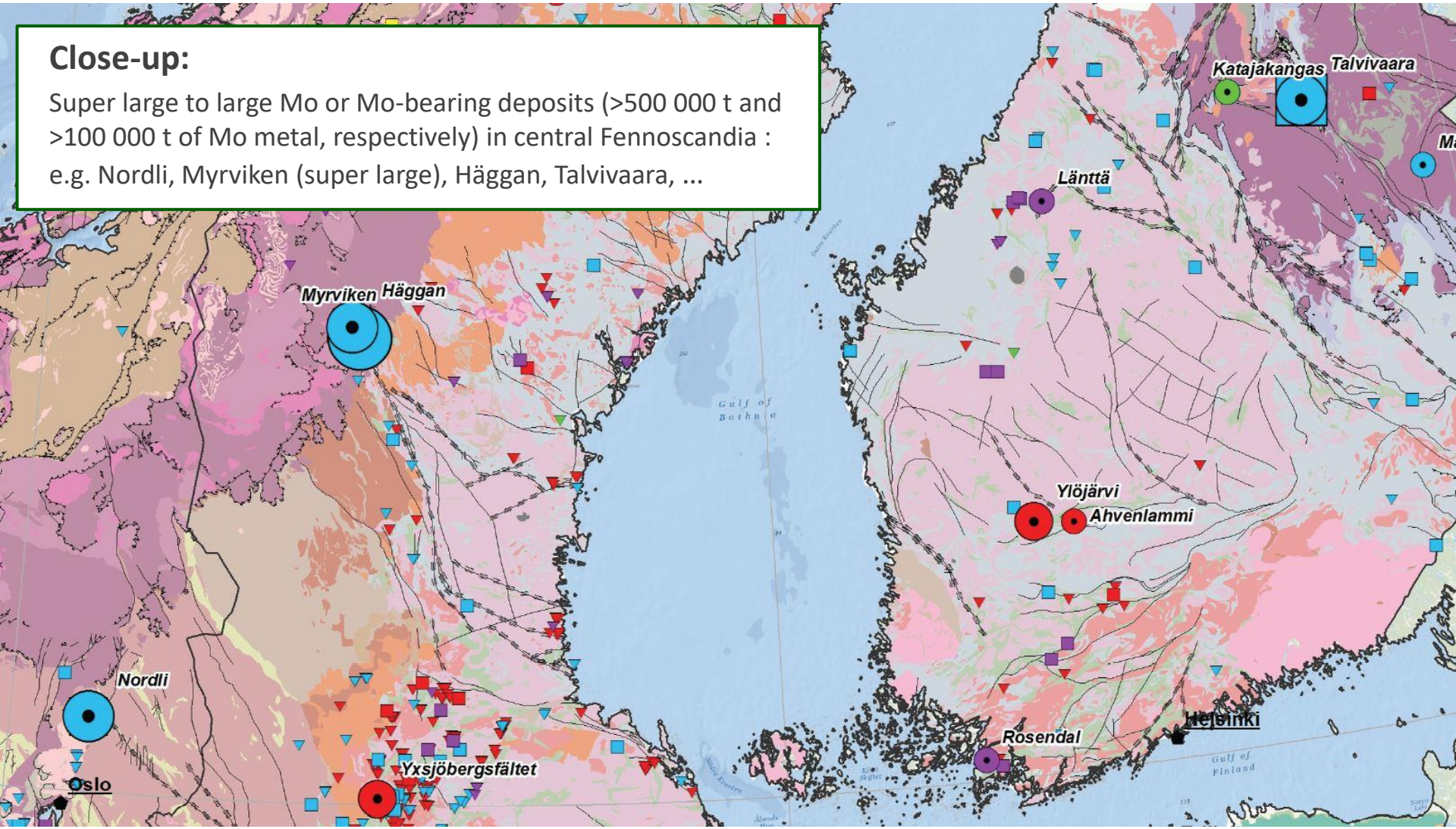
For deposits and occurences containing unknown amount of refractory metal :
GKR database,
completed with extracts from the ProMine Mineral Deposit database,
the Minerals4EU database
and the Fennoscandian Ore Deposits database (FODD).

The present map is the official deliverable D2.1 of the MSP-REFRAM project.

For additional information on this map, see the accompanying "Note to the map of refractory metal deposits in Europe".

April 2016

Mapping the primary resources in Europe



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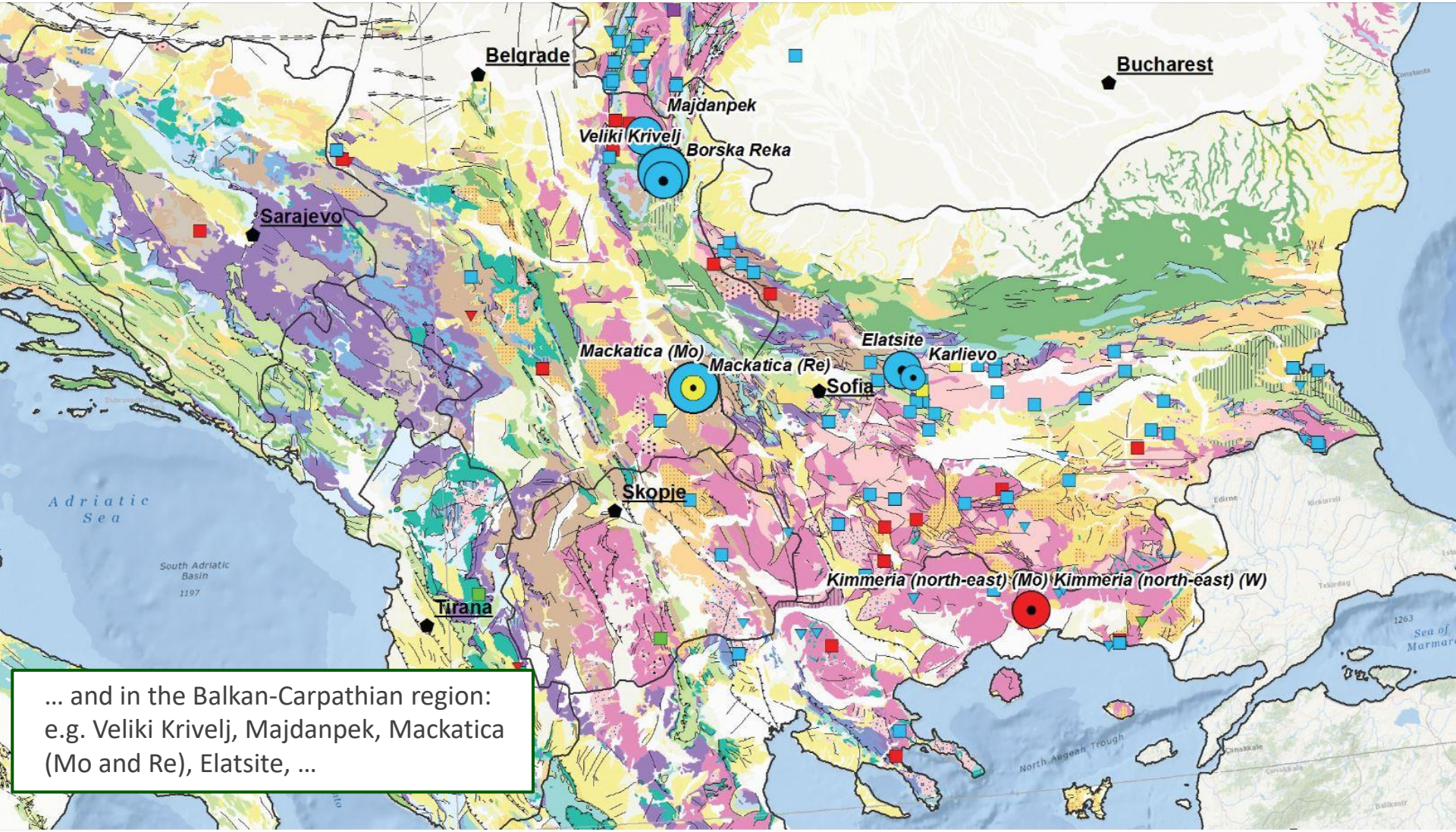

… and in the Balkan-Carpathian region: e.g. Veliki Krivelj, Majdanpek, Mackatica (Mo and Re), Elatsite, …

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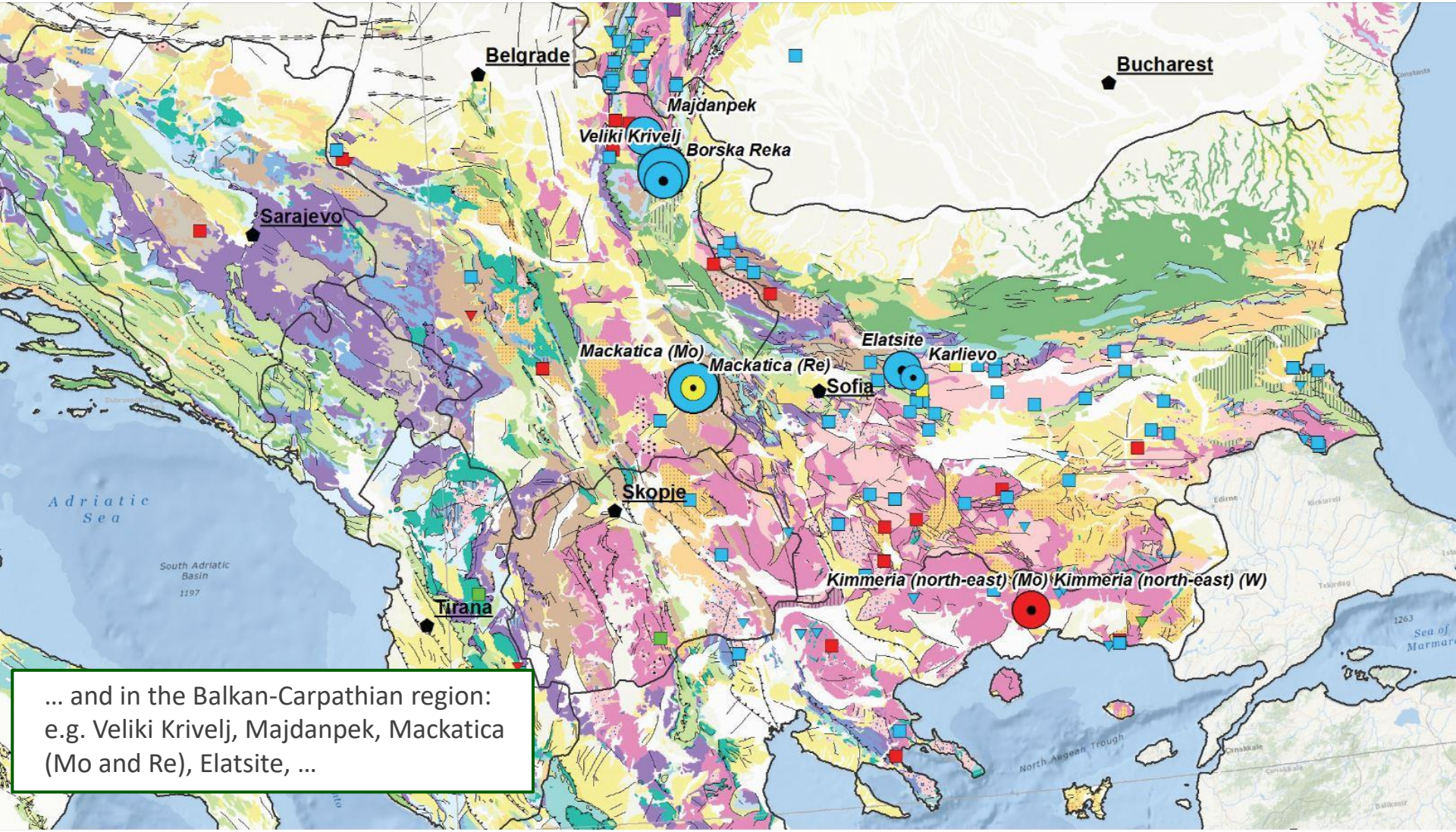
Mapping the primary resources in Europe



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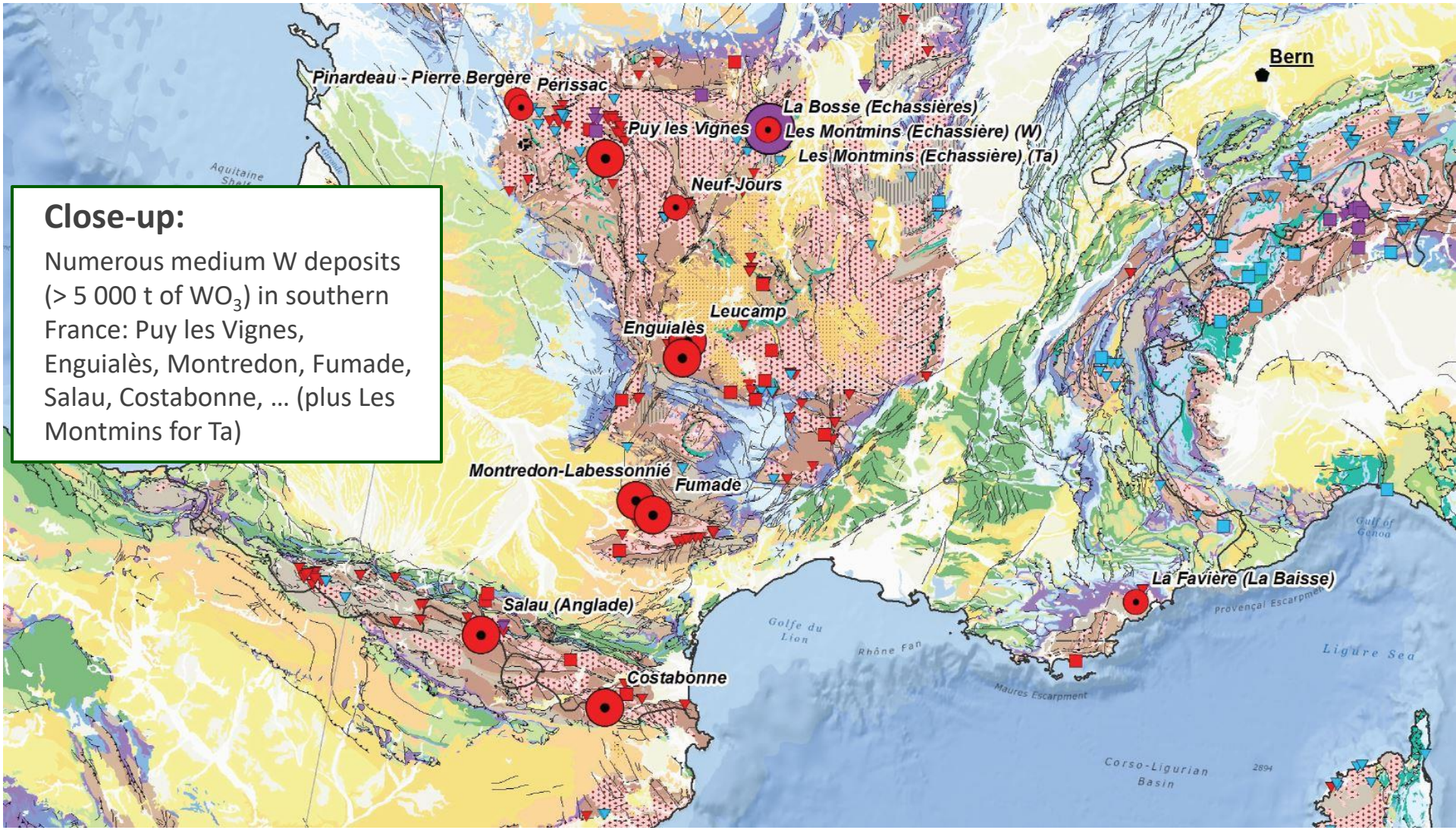

Close-up:

Numerous medium W deposits (> 5 000 t of WO_3) in southern France: Puy les Vignes, Enguialès, Montredon, Fumade, Salau, Costabonne, … (plus Les Montmins for Ta)

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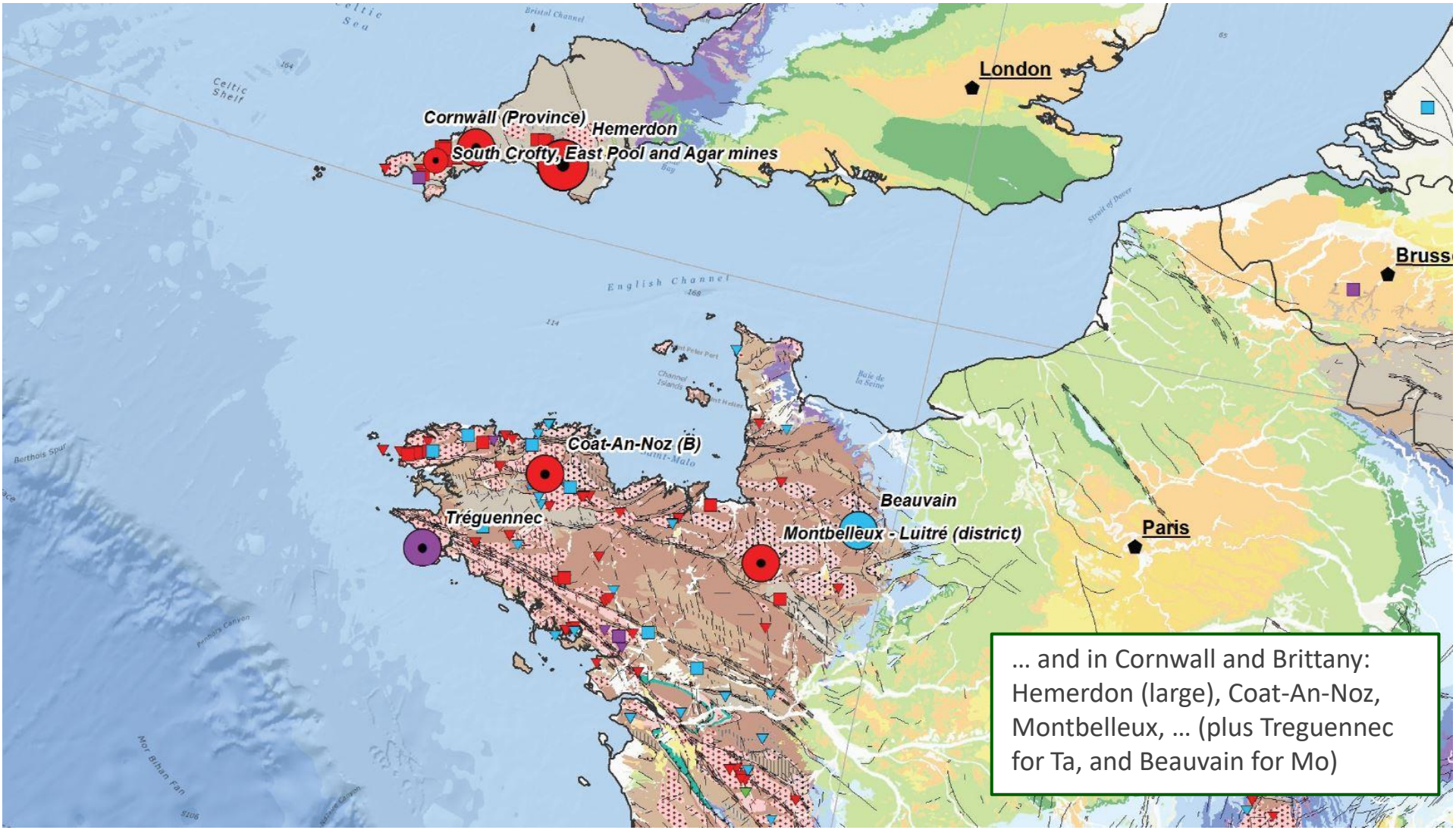
Mapping the primary resources in Europe



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Conclusion

This work confirms that a significant geological potential for refractory metals exists in Europe:

- Rhenium (already partly extracted) in Poland;
- Tungsten in paleozoic basements in Iberia, Pyrénées, French Central Massif, Brittany, Cornwall, Austrian Alps, Bohemian massif, and also in Fennoscandia;
- Molybdenum in the Fennoscandian shield and the Balkan-Carpathian domain, with numerous occurrences in the Bohemian massif;
- Tantalum and niobium, more scatered, but present, still, in the Hercynian domain and in the southern Fennoscandian shield.

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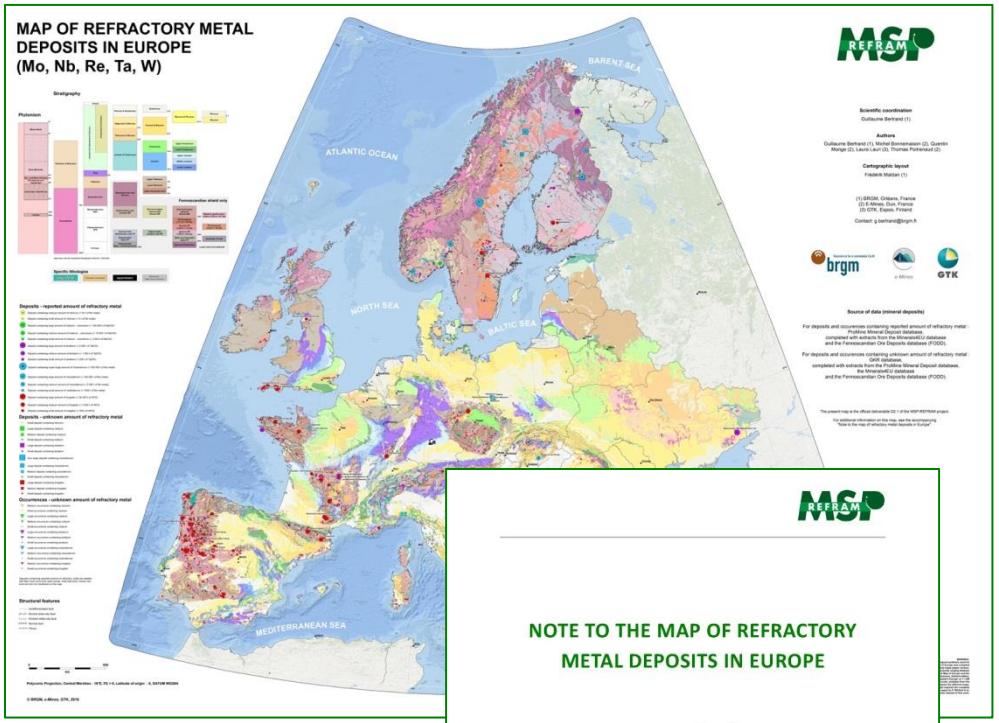
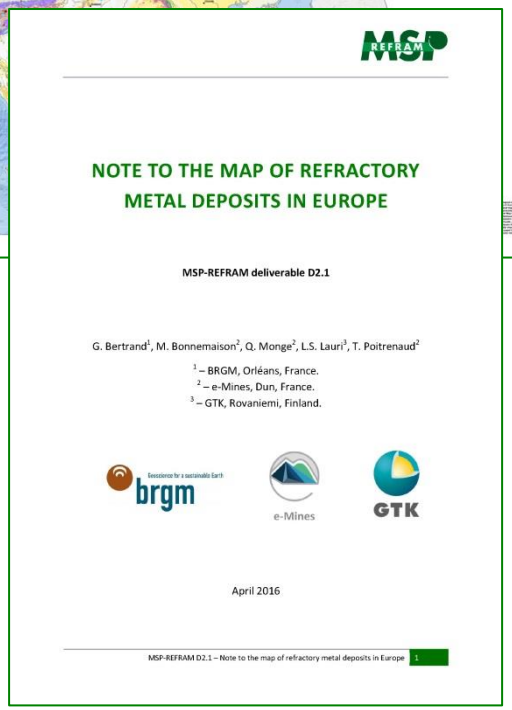
Conclusion

Results from this work are available for further studies …

- The map and its explanatory note are available as .pdf file on the web : http://prometia.eu/wp-content/uploads/2016/08/MSP-REFRAM-D2.1-Mapping-the-primary-resources-in-the-EU.pdf
- The map shows a limited portion of available information; full datasets are available on demand.
- The map is on display … feel free to have a look and comment during the coffee break !




NOTE TO THE MAP OF REFRACTORY METAL DEPOSITS IN EUROPE

MSP-REFRAM deliverable D2.1

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Thanks for your attention !

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