FRAME

FORECASTING AND ASSESSING EUROPE'S STRATEGIC RAW MATERIALS NEEDS

Newsletter
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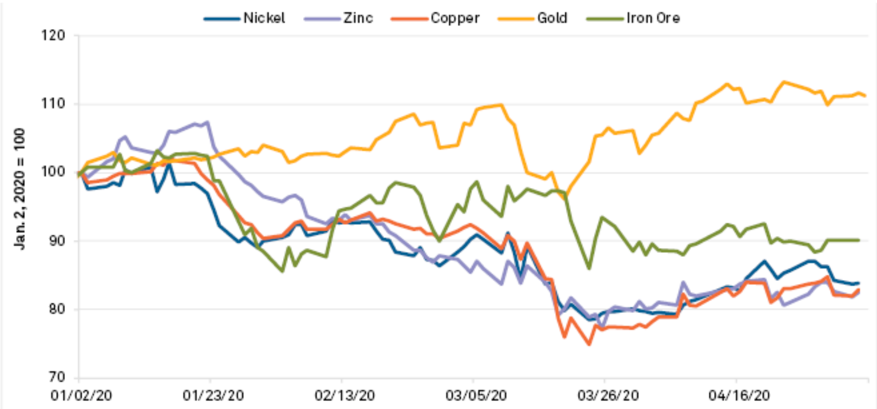
Innovative Science in jumbled times

A few days from the publication of this newsletter, the total number of confirmed Covid19 cases was 9394558 worldwide (source: Google News) with almost half of those numbers being recovered cases and with approximately half a million deaths. Yet these alarming numbers are a small sample of the true reality as the numbers only include people who were tested and confirmed positive.

This unprecedented pandemic caused a major change in the lives of the populations from every corner of the world and the snowball effect affected livelihoods and economies alike. Essentially, from early March to late April, major stock markets felt the effects of the slow down (Nikkei: -14.7%, Dow Jones: -18.5%, FTSE 100: -24.5% - source: Bloomberg, 27 April, GMT), the price per barrel of WTI (oil) plummeted to negative values and across the primary mineral raw materials the effects were just as disastrous.

The prices of the benchmark metals, apart from gold (+5%), palladium (+19%) and rhodium (+77%), all fell between 5% (Li) and 26% (Pt) – Fe ore: -10%, copper: -22%, lead: -10%, zinc: -19%, nickel: -20%, silver: - 22%, cobalt: -8%; source: S&P Global Market Intelligence; S&P Global Platts; Benchmark Minerals; LME; Johnson Matthey).

The downhill effect of Covid19 has affected research and FRAME could not be any different from other projects. Field and laboratory work associated with the responsible sourcing of Nb/Ta and the phosphates and associated black shales is still on hold but hoping to restart in early July, conditions permitting.



Data as of May 5, 2020.
Sources: S&P Global Market Intelligence; S&P Global Platts; LME; CME Group

Despite the inevitable delays of some of FRAME's work, internally we have made a commitment to hand in all deliverables on time, albeit that they might be in a draft form.

In confinement, FRAME has not stood still and waited for the pandemic to pass. FRAME has been actively engaged with the other GeoERA Raw Materials projects (MINDeSEA, EUROLITHOS and MINTELL4EU) to optimise collaborations and end products. The connections to digital platforms and methodologies for doing this were optimised and strengthened during this trimester.

Contact and information exchange has been maintained with EU institutions demonstrating the capability of innovation and generation of products and results to aid decision and policy makers at this crucial time when we are nearing the end of H2020.

On the forefront of the predictability/favourability issues, FRAME has been continuously updating and refining data and models to be able to create robust maps on the CRM.

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GeoERA RAW MATERIALS

FRAME has also been continuously disseminating results and promoting GEoERA Raw Materials in events such as EGU2020 – Sharing Geoscience online (May 4-8) and will be present in at least two events coming up later this year: GeoUtrecht2020 and The Mineral Exploration Symposium but more details on that in the next newsletter.

FRAME has managed to beat Covid19 and that is a testament of the commitment of the many dedicated scientists and the strong consortium that is together forging new ground for mineral resource innovation.

Thank you all and keep up the good work!

Daniel de Oliveira, FRAME Project Coordinator

Integrated exploration solutions focused on featuring potential targets for new mineral deposits in Europe: apart from FRAME project

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The prime aim of work package (WP)3 in the FRAME project is to produce a map of strategic and critical raw materials (SCRM) for Europe, including the so-called energy and conflict minerals. In cooperation with other FRAME WPs, there was a consensus on the methodology used for the identification and selection process of the SCRM to be included in the metallogenic map (Arvanitidis, et al., 2019), linked mainly to information collected from existing databases, such as the ones of ProMine, Mineral4EU (M4EU) and European Geological Data Infrastructure (EGDI).

1. Prospectivity mapping at continental scale

One main objective of WP3 is the predictive targeting based on GIS exploration tools and prospectivity assessments at the continental scale. Preliminarily, two types of prospectivity maps have been produced based on the different approaches of “knowledge” and “data”-driven methods, respectively. The first method is the latest among the developments in “data driven” mineral prospectivity that allows mapping at the continental scale, such as the “Cell Based Association-CBA” method developed by BRGM (Tourlière et al., 2015). CBA is an alternative to GIS supported prospectivity methods. It has been developed to better manage uncertainties related to cartographic data which are highly significant at continental scale.

So far, CBA has been applied for the battery minerals (i.e., Li, Co and natural graphite). CBA prospectivity maps for Ta, Nb and phosphates are under construction. The results of these maps will be presented in sessions

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dedicated to mineral exploration and prospectivity in international conferences. Another method is hybrid fuzzy weight of evidence (WofE) model (Porwal et al., 2006) for mineral potential mapping. This method has so far been applied for preliminary data on mineralisations of Li, Co, Graphite, Niobium (Nb), Tantalum (Ta) (Fig. 1) and phosphor. The result of preliminary prospectivity mapping on Nb and Ta has been presented at the EGU2020 conference (Sadeghi et al., 2020). Compilation of Nb and Ta occurrences/deposits from Europe has started within FRAME's WP6. The data have been used for the spatial analysis and prospectivity mapping related to geology and geotectonic settings at European scale. The results of prospectivity mapping highlight several areas of exploration potential, mostly in Scandinavian, Spain, France, Portugal and Greenland.

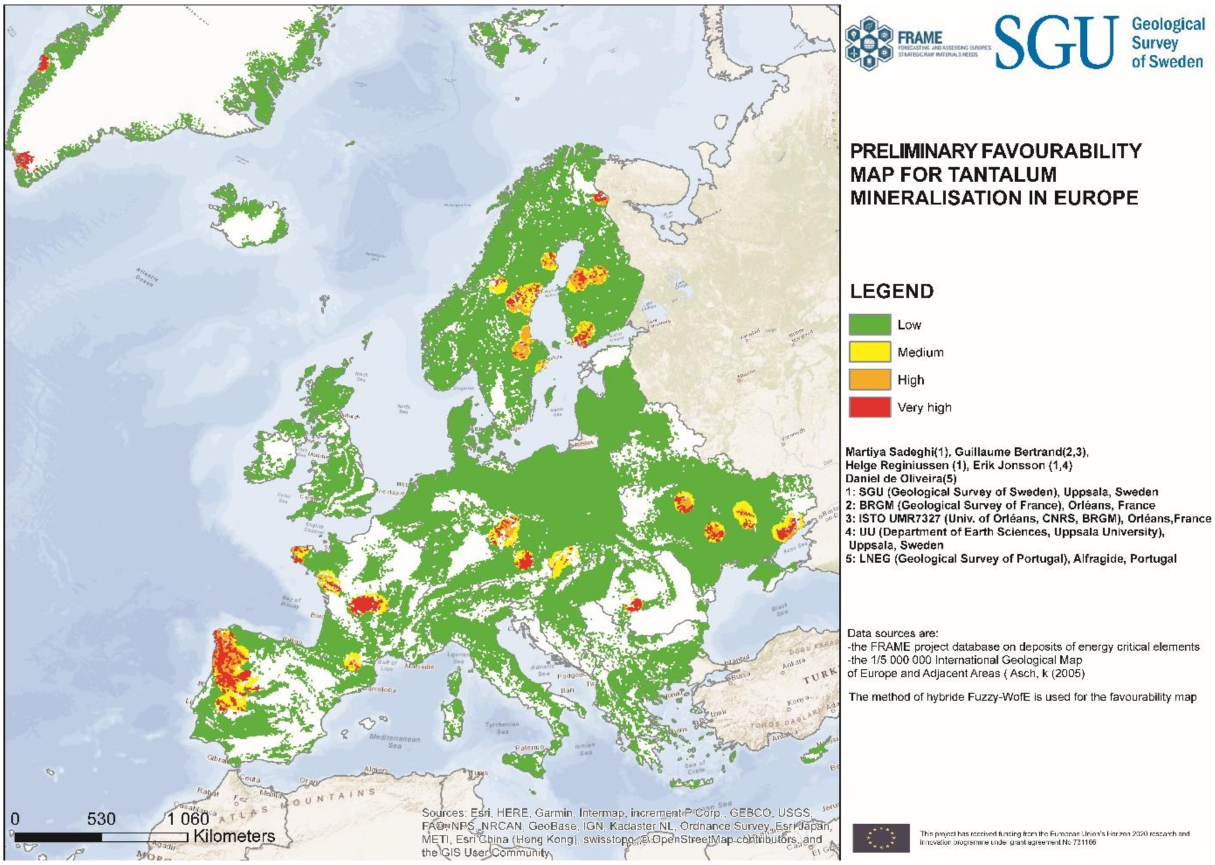

Figure 1. An example of favourability maps using hybrid fuzzy weights of evidence (Tantalum mineralization in Europe) produced in the FRAME project.

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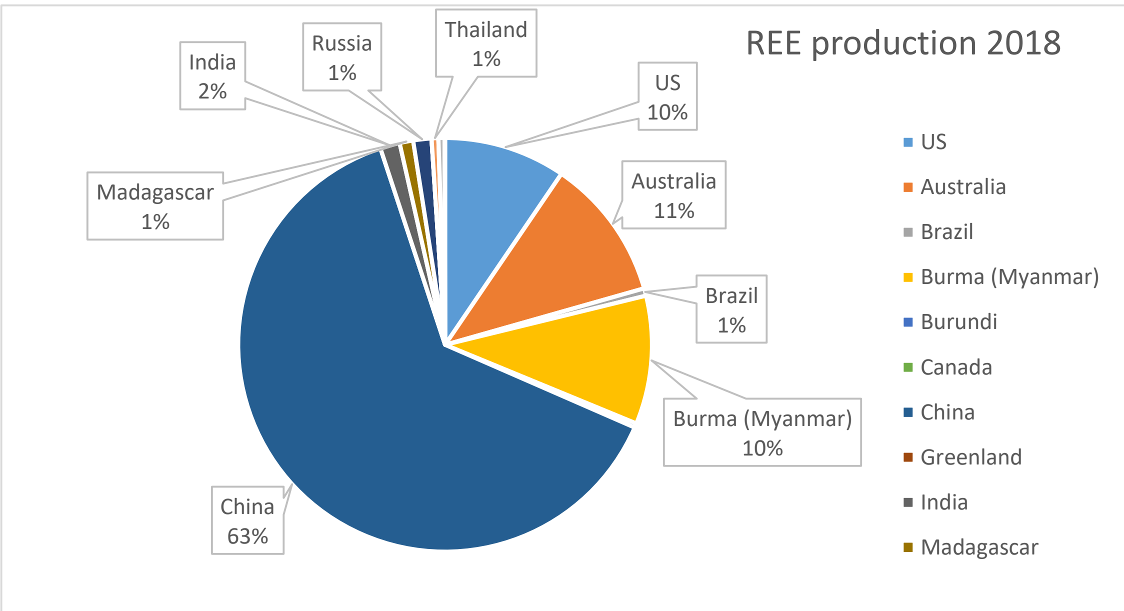
2. Metallogenetic areas of selected CRM at continental scale

European geology and bedrock contain some areas favorable for the occurrence of mineralization and facilitating genetic studies of ore deposits, putting emphasis on their metallogenetic relationships in space and time which are fundamental for determining new mineral exploration targets. Here we present a revised version of the distribution of rare earth elements and metallogenetic areas and a paper (Goodenough et al., 2016) dedicated to geology and metallogenesis of rare earth elements in Europe based on EURARE project (http://eurare.eu/).

2.1 Rare Earth elements

The demand for rare earth elements (REE) has grown enormously in recent times as they are essential for many new technologies. World mine production based on mineral commodity summaries 2020 (UGSS, 2020) is 190 000 and 210 000 tons in 2018 and 2019, respectively. The total reserves are reported to about 120 000 000 tons. World resources of REE are relatively abundant in the Earth's crust, but mineable concentrations are less common than for most other ores. (Fig. 2)

Based on Figure 2, China owns 38 percent of the world's reserves; Vietnam, Brazil, Russia, and India have substantial deposits. Europe, including Greenland, has a high potential of voluminous deposits but most of them are not sufficiently advanced that reserves can be reported. Still, presently over 63 % of the REE used globally are produced in China.



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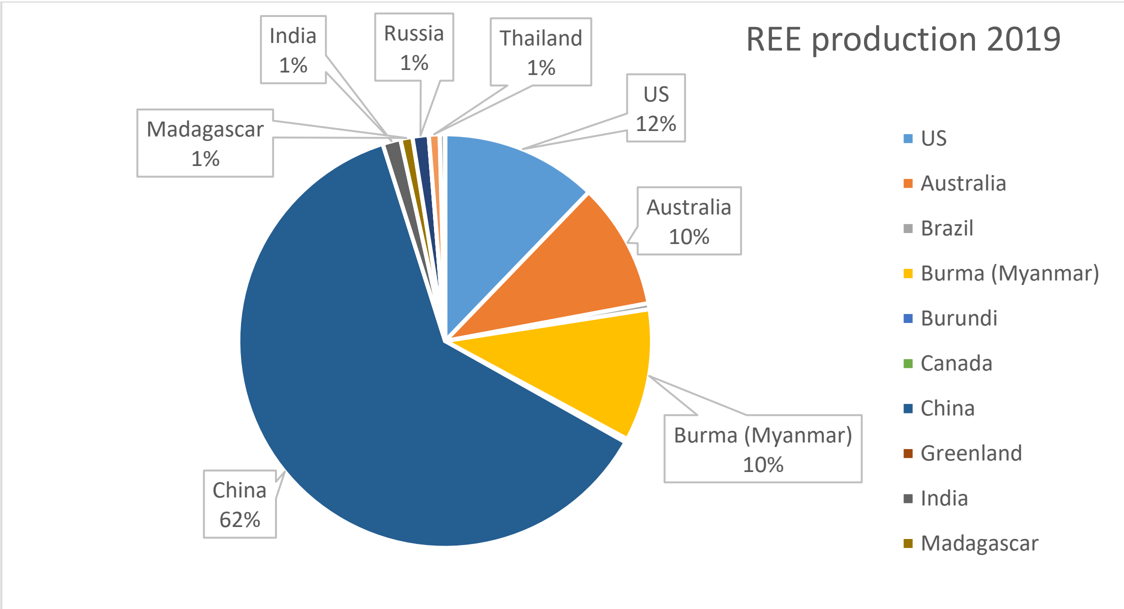

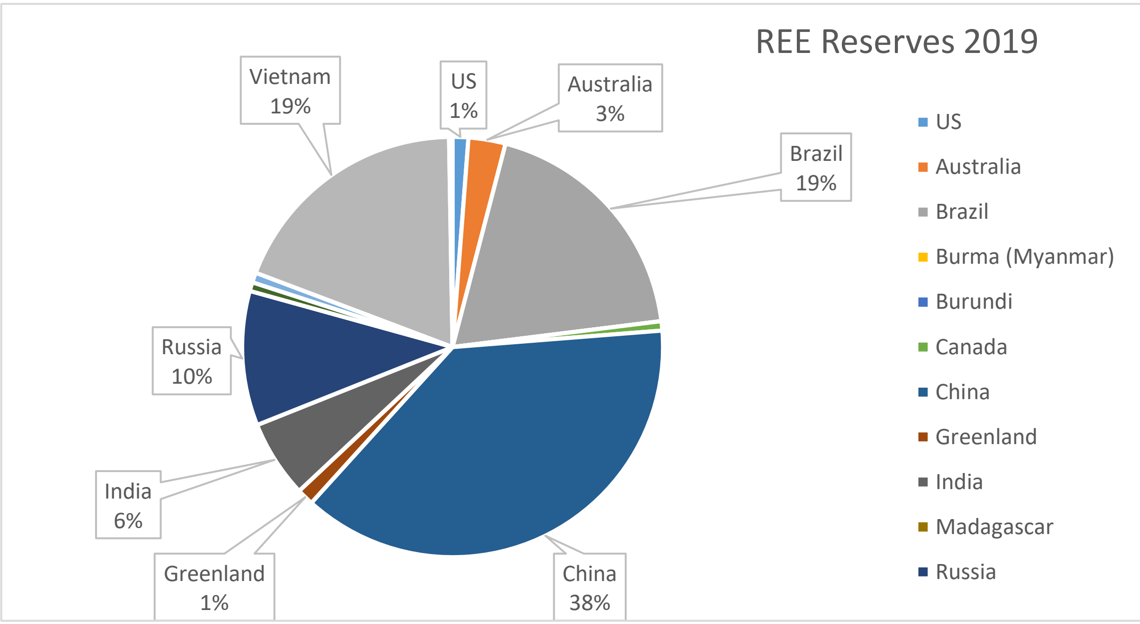

Figure 2. Rare earth element world production by country for the year 2018, 2019 and Reserves. Data Source USGS (2020).

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There are many different types of REE mineral deposits/occurrences in Europe; these have been found in a variety of geological environments and are of a wide range of ages. However, REE occurrences can be fundamentally divided into primary and secondary types. Most of the primary types are related to igneous processes in continental rift/extensional settings. The secondary types are formed when enrichments develop through sedimentary processes such as erosion and accumulation of heavy minerals, weathering and soil development.

2.1.1. REE mineralisation types in Europe

There are many different types of REE mineral deposits in Europe, including both Light Rare Earth Elements (LREE) and Heavy Rare Earth Elements (HREE) (Goodenough et al., 2016). Sweden hosts a large number of known REE occurrences and numerous REE-bearing minerals were originally discovered in Swedish mines and deposits, including Bastnäs and Ytterby in the Bergslagen province (Fig. 3) (e.g. Jonsson 2014; Sadeghi, 2019; Sadeghi et al., 2020). Greenland is endowed with several large REE mineral deposits, in various geological settings. The largest deposits are hosted by peralkaline intrusions related to the Gardar Province in South Greenland, encompassing the deposits at Kvanefjeld, Kringlerne, and Motzfeldt Sø. REE mineral deposits are also associated with carbonatites at the margins of the North Atlantic Craton in west Greenland. (Sørensen et al. 2011). Finland hosts a few sub-economic to economic REE deposits mostly associated with intrusions of alkaline rocks (e.g. Sokli carbonatite and Iivaara ijolite complexes). (Sarapää et al. 2013), located in the central part of Fennoscandian shield. Norway hosts a variety of REE mineral occurrences, including primary and secondary deposits, typically associated with alkaline igneous and carbonatite magmatic systems (e.g. Fen, Kodal, and others) (Andersen 1986, Ihlen et al. 2014). In southern and central Europe, the extensional and rift systems are less deeply eroded, and potential REE deposits are likely to be buried. Carbonatites in Mesozoic to Cenozoic rifts of Central Europe may well be prospective for REE, whilst secondary deposits associated with alkaline magmatism are of interest in the Mediterranean countries. (Fig. 3). A prospectivity map realized by Bertrand et al. (2017) for REE, using the DBQ (DataBase Querying) method shows favourable prospective areas in Europe (Fig. 4). As alkaline/peralkaline intrusions is by far the most enriched metallogenic family, this prospectivity map closely mimics their spatial distribution in Europe, highlighting potentially favorable areas, such as the Svidnya-Seslavtsi region in Bulgaria, for instance. In addition, it shows favorable areas related to other metallogenic families, such as IOCG deposits in the northern Svecofennian belt (northern Sweden), placers in French Britany and Normandy, pegmatites in southern Austria or the Iberian massif (northern Portugal), or numerous bauxite occurrences in the Delfi region (Greece).

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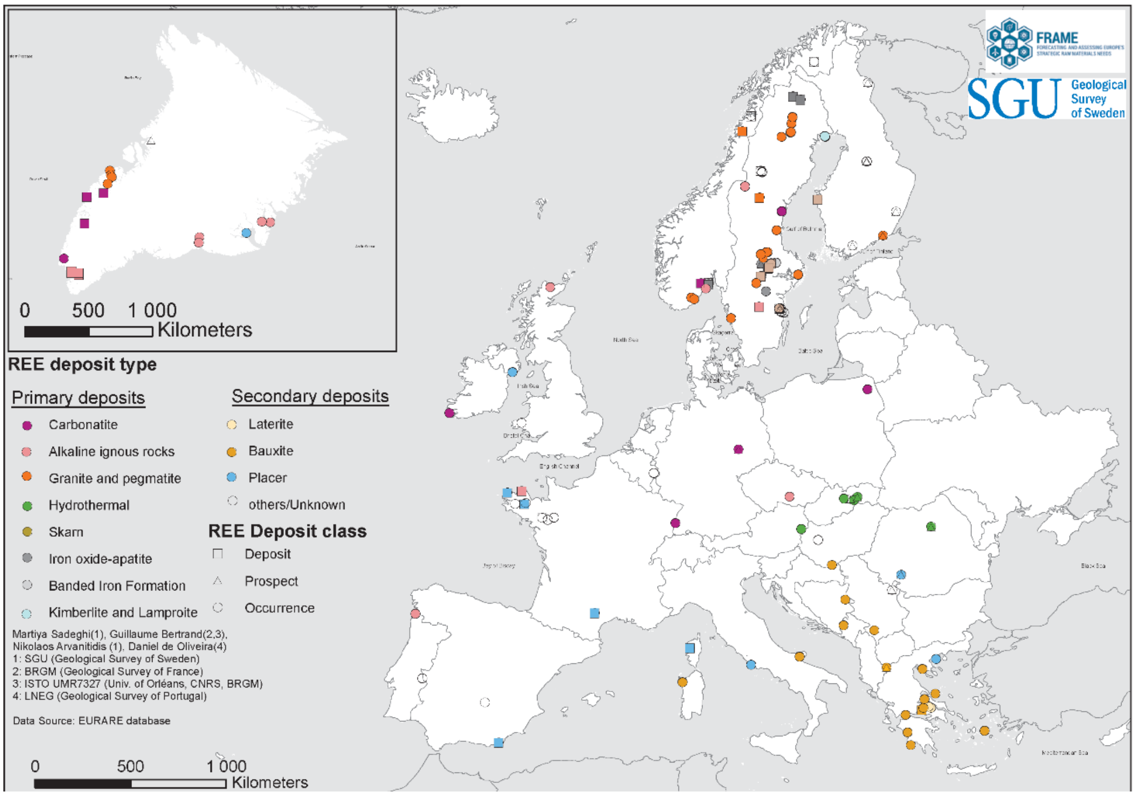

Figure 3: Map showing the main REE mineral occurrences and deposit types in Europe (revised). Data source: EURARE.

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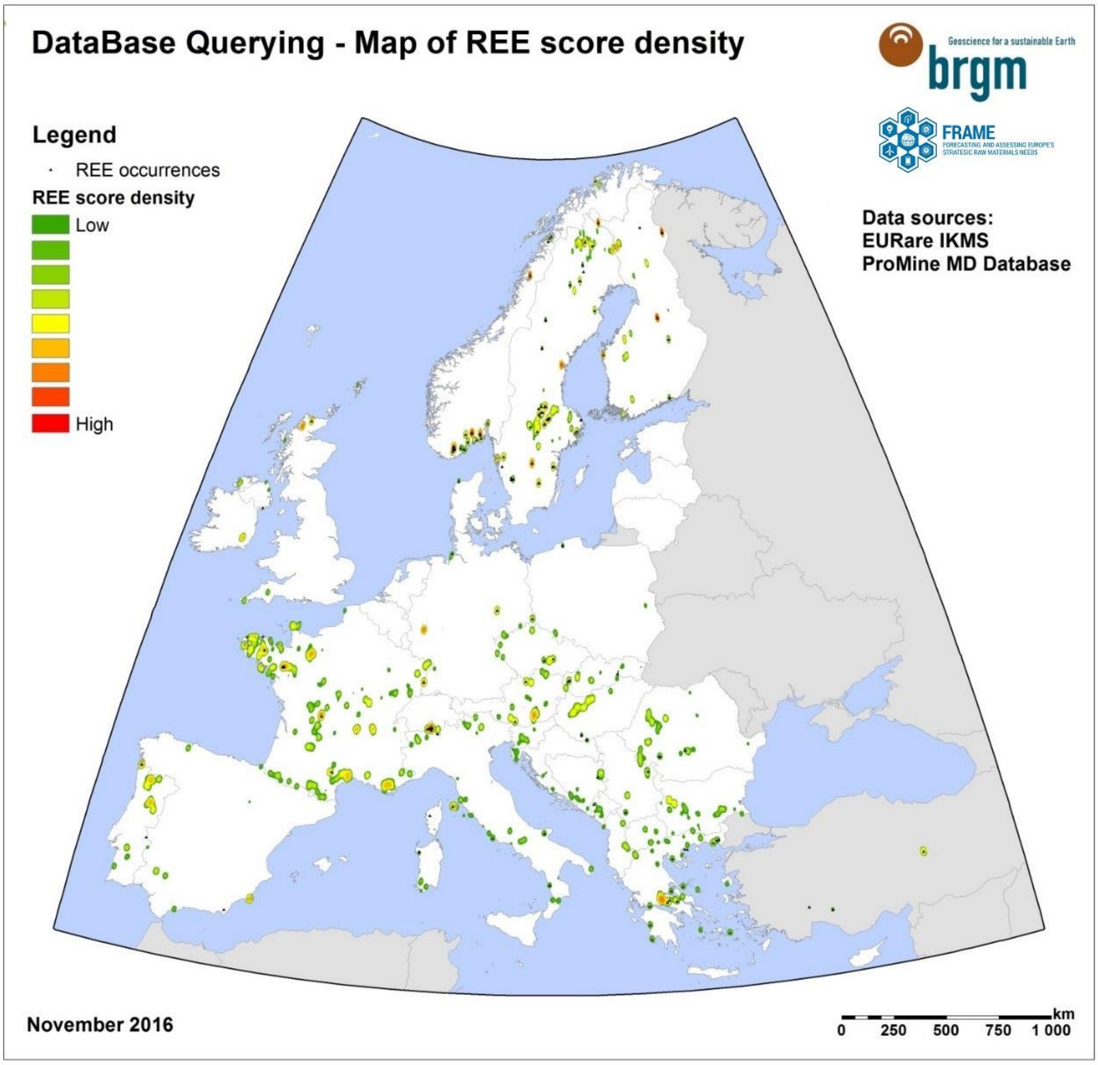

Figure 4: Prospectivity map of kernel density of ponderated REE scores in Europe, calculated with the DataBase Querying method (Bertrand et al., 2017).

2.1.2 REE metallogenetic provinces

A simplified metallogenetic map of REE (Fig. 5) has been prepared based on these previous works. This map shows overall distribution and potential of REE mineral exploration targets based on the different genetic types classification. The carbonatite and alkaline igneous rocks are presented separately, because of the significant potential of tonnage and grade they commonly host. The secondary REE mineral resources are presented as a separate target areas related to bauxite, laterite and placer deposits.

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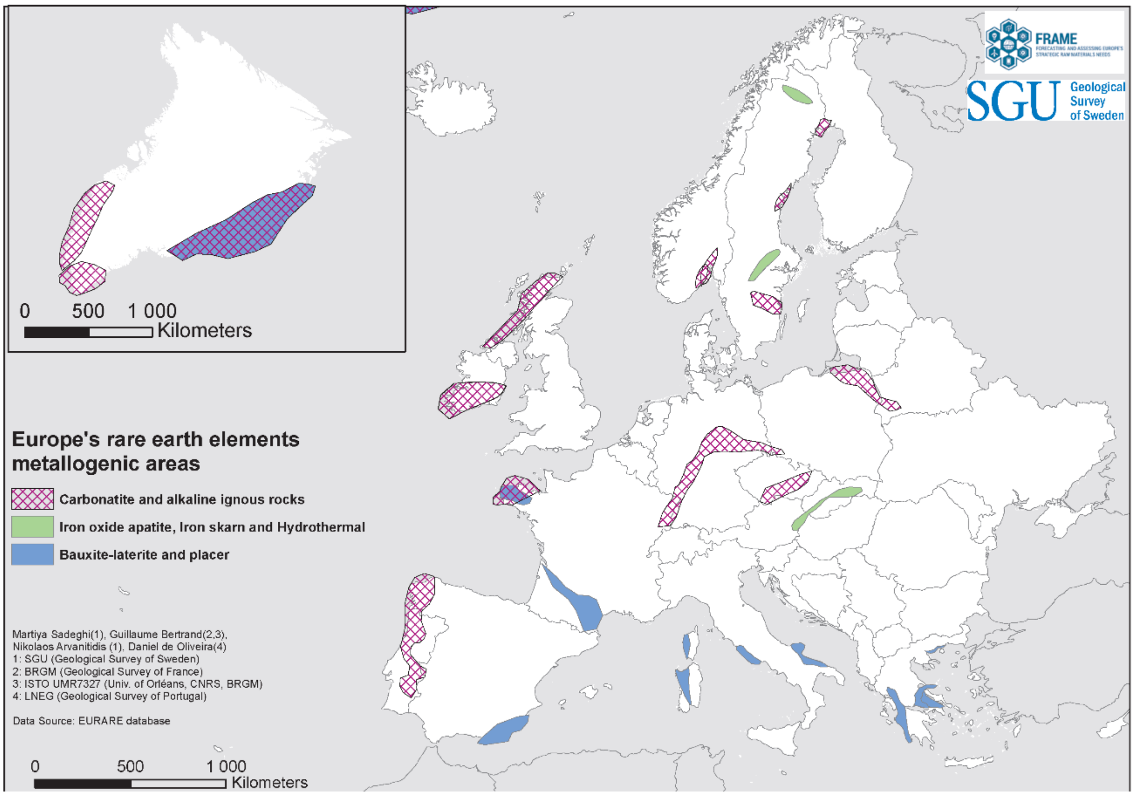

Figure 5: Map showing major REE metallogenetic areas and related exploration potential in Europe (Revised version).

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…And then there were 20

FRAME is very pleased to welcome the Geological Survey of Austria (GBA) into the FRAME consortium. FRAME now has a round number of 20 official partners!

Geologische Bundesanstalt

Over the first 2/3 of the project GBA has been a contributing partner with data in WP5 and will now make significant contributions to WP3 as well.

We welcome GBA in the persons of [Julia Weilbold]() and [Dr. Holger Paulick]() into the folds of the FRAME scientists.

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Tungsten is a prominent example of a critical mineral raw material, for which supply is strongly dependent on mining in China. However, one notable exception, representing primary EU-domestic tungsten supply, is the Felbertal scheelite deposit in Austria (picture). Following the discovery of the Felbertal deposit (1967) substantial greenfield exploration during the 1980s defined a large number of scheelite occurrences in Austria. Different geological settings are known, including vein-stockwork scheelite mineralization, strata-bound scheelite mineralization in meta-carbonate and calc-silicate rocks, orogenic Au-W veins, scheelite-bearing metamorphic veins etc.

A collaborative project of the Geological Survey of Austria and Montanuniversität Leoben aims to re-evaluate their origin in the context of the current geological-tectonic concept for the Eastern Alps and provide LA-ICP-MS compositional data for petrogenetic fingerprinting. A holistic metallogenetic model will provide guidance to define areas of high prospectivity for W mineralization in the Easter Alps. These results will be discussed and integrated within the scope of work package 3 of FRAME. Amongst other aspects, the Austrian expertise in W is an added value to FRAME.

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