FRAME
FORECASTING AND ASSESSING EUROPE'S STRATEGIC RAW MATERIALS NEEDS

Newsletter
OCTOBER 2021

www.frame.lneg.pt

Issue 9, October 2021

October 31st, 2021: a bitter sweet moment for project FRAME

After 40 months of intense research, numerous meetings, mineral intelligence innovation, scientific dissemination, stress and laughs, and mixed with a pandemic in between, FRAME is at an end. This is the final newsletter of project FRAME but we cannot leave without highlighting several issues, products and innovative milestones achieved.

FRAME is a fantastic, and proud team of dedicated geoscientists that pored over existing datasets, added to these, reviewed, and reinterpreted the data and produced a superb new set of products, which are milestones for the minerals industry and policy makers alike. As John Donne said, "No man is an island entire of itself; every man is a piece of the continent, a part of the main…" which could not be truer since all the achievements in FRAME were only possible through intense collaborative work amongst and within all WP teams.

As part of the four projects in the GeoERA Raw Materials theme, FRAME maintained close links to all the other projects (Eurolithos, MINDeSEA and Mintell4EU), worked with these and published; in some cases, joined, results under the supervision of Theme Coordinator, Dr. Antje Wittenberg of BGR. FRAME owes a debt of gratitude to Antje but also to the other project leads in the GeoERA RM theme, namely, Lisbeth Flindt Jørgensen (GEUS), Tom Heldal (NGU) and Javier González (IGME).

As FRAME project lead, I witnessed and wish to acknowledge the intense collaborative effort by all in bringing this project to the finishing line. My great thank you; both in FRAME and outside FRAME, to ALL who participated, to ALL who made this possible; thank you to the support structures placed in the monitoring team and overall GeoERA coordination; thank you Joop Hasselman and Yvonne Schavemaker.

Thank you to my WP leads, Maria João Ferreira, Teresa Calabaça, Nikos Arvanitidis, Martyia Sadeghi, Eric Gloaguen, Guillaume Bertrand, Sophie Decrée, Håvard Gautneb, Tuomo Törmänen, Helge Reginiussen, Henrike Sievers, Lídia Quental and Aurete Pereira who went above and beyond to achieve the results in FRAME.

Research in minerals is far from complete and it continues!

Daniel de Oliveira (FRAME Project Lead)

Outstanding results

Communication, Dissemination and Exploitation (CDE) activities

Introduction

FRAME prides itself on achieving a high number and level of communication and dissemination activities. Amongst the many scientific events that FRAME attended, both European and International, there were also many dissemination activities related with social media, internal meetings and workshops (see graph). FRAME prides itself on having the first operational website of all the GeoERA projects (https://www.frame.lneg.pt) and had a CDE plan

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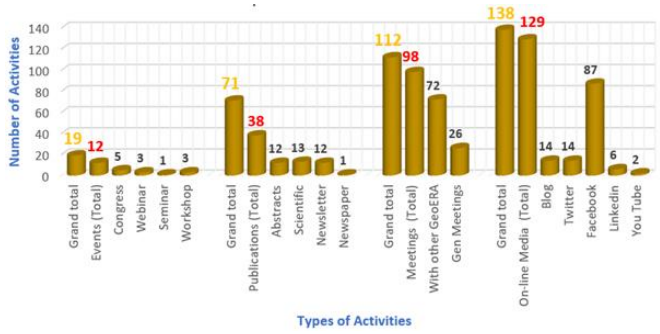
in place at M2 that focused on three aspects: Information, Involvement, and engagement and selected phases of stakeholder engagement through a list-of-contacts data set. A strong visual and graphical identity was established at the outset of the project with a unique logo, a colour palette, fonts, project brochure/flyer and leaflet, social media pages and media kit with a personalised USB stick containing info on FRAME.



First operational website, strong visual and graphical identity, media kit

Mapping the CRM

FRAME was designed to research the critical and strategic raw materials in Europe, better understand the ore genetic links between major deposit types and hosted critical mineral and metal associations, be able to identify governing conditions and processes involved in the formation of the CRM-potential deposits and develop conceptual models for their formation and carry out prospectivity assessments for a continental scale approach.

The favourability maps generated in FRAME which were derived from homogenised datasets, enable the ID of permissive and prospective areas, at the continental scale (see map), that reflect the geological data and knowledge applied.

FRAME on The European Researchers' Night

The Geological Survey of Slovenia, one of the partners of the European Researchers' Night, organized an Interactive Scientific Concert dedicated to the popularization of geosciences. The concert consisted of short scientific talks on geology and the environment, and a musical program performed by Geobanda - a band consisting of geologists. The concert took place on 20th September 2021 at the Ljubljana Castle and was broadcast via a YouTube stream.

Dr. Klemen Teran was invited to represent the FRAME project and in his short presentation he not only discussed the various applications of lithium, but also emphasized the importance of mining and described the most promising areas for lithium exploration in Europe. A final question to the audience concerned social license to operate: We all use lithium products, but would you support lithium mining in your backyard?

In the future, the highest mineral potential will be highlighted taking also into account data and knowledge updates related to mineral systems at the regional scale, economic geology approaches, till and lithogeochemical data, and airborne geophysical measurements. Then the prospectivity mapping at district and local scale will identify target areas of advanced exploration potential.

Ultimately, potential assessment of those areas will consider knowledge and data updates addressing deposit scale exploration efforts including alteration, mineralogy, ground geophysics and detail geochemical sampling.

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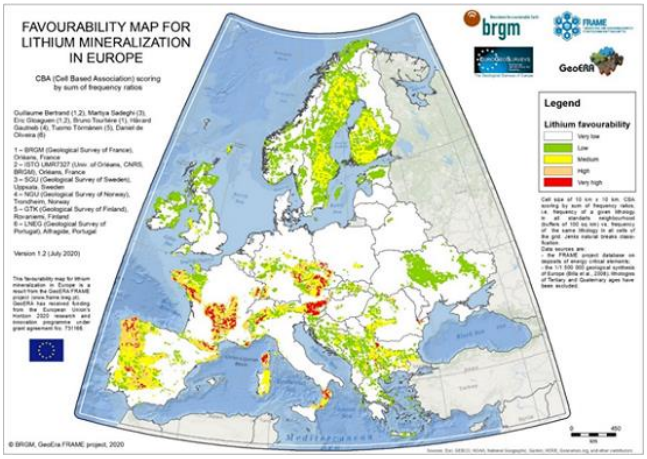
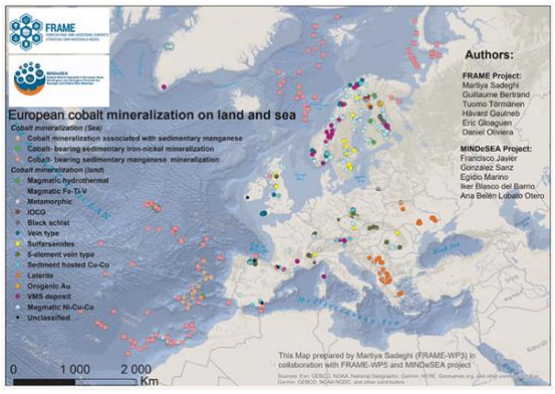


This methodology represents different development stages, scales and progress of economic geology surveys which could be a tool to improve effectiveness and efficiency of future investments in exploration. Improved understanding and support for a balance management of competitive land-use interests is an additional benefit.

Predictability mapping using both Cell Based Association and Fuzzy Weight of Evidence

This work confirms that the potential for mineral resources in Europe is very significant and is a strong asset to sovereignty of the European community. Beyond this, it highlights that this potential is not confined to onshore areas but also encompasses marine areas (see map). Enhancing the knowledge of this onshore and offshore mineral potential of Europe is a strategic goal that should strongly mobilize the scientific community in the coming years.



CRM in phosphate deposits

Phosphate deposits could significantly contribute to a secure sustainable access to a large proportion of Europe's requirement for CRM. Despite the obvious interest, the various types of phosphate deposits (See map) have not been re-examined in a few decades.

In FRAME, data sets were produced which, include (i) new mineralogical/geochemical data about almost one hundred phosphate occurrences/deposits, igneous-related and sedimentary and origin, and (ii) new data issued from several metallogenic studies carried out on the main phosphate deposit types encountered in Europe. These data confirm the potential for REE of phosphate deposits related to carbonatites and IOA-IOCG deposits.

Phosphate maps illustrate the diversity of phosphate deposits or highlight the potential regarding phosphate mineralization in Europe

In the sedimentary phosphorites, FRAME found that the Lower Palaeozoic sedimentary phosphorites (and probably the Jurassic ones; to be confirmed) are the most promising targets regarding their REE content. This opens up new areas of interest for CRM could be regions hosting phosphorites of this age, e.g., Estonia's Cambrian-Ordovician phosphorites.

FRAME innovated in the acquisition of new mineralogical and geochemical data on selected phosphate deposits and occurrences; carried out a synthetic study about the chemistry of apatite and igneous phosphate deposits in Europe, and developed a procedure to prepare and analyze phosphate deposits to provide internally consistent geochemical data at a European level.

Lower Palaeozoic sedimentary phosphorites are the most promising targets regarding their REE content

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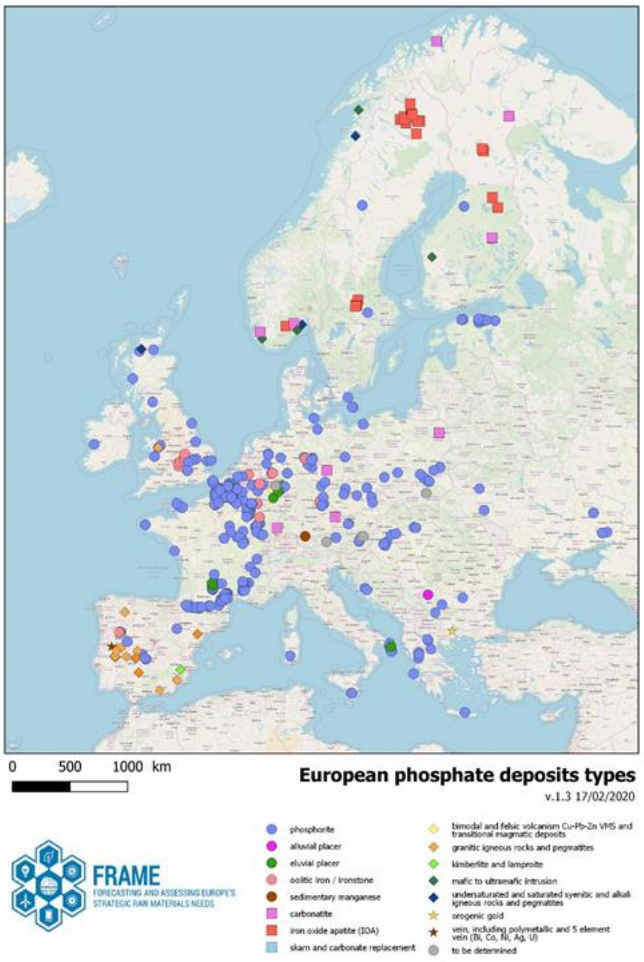
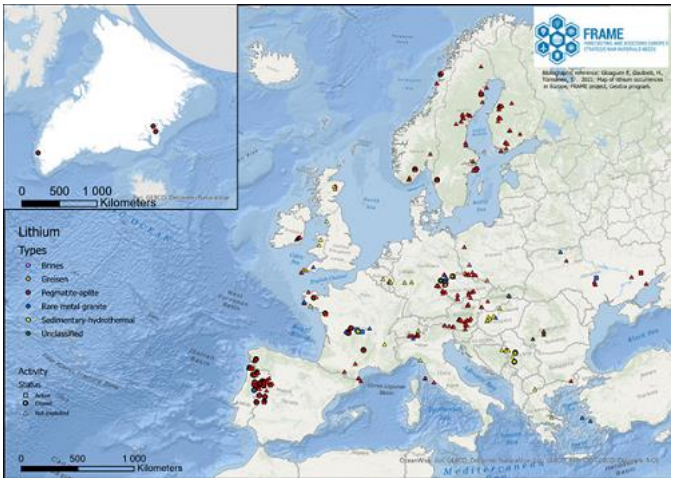


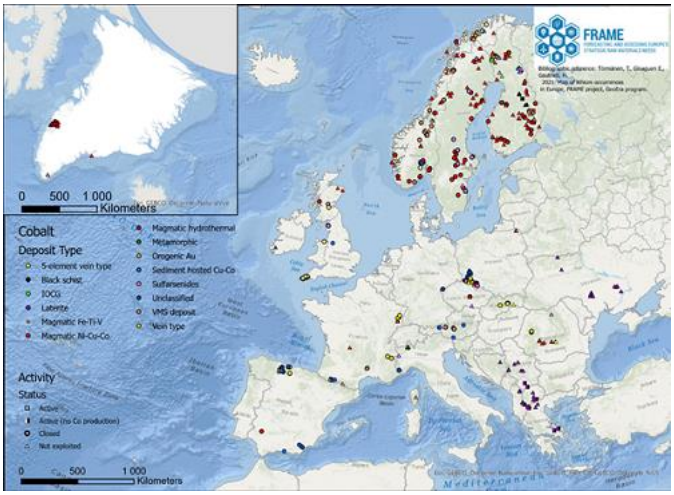
Energy Critical elements (cobalt, lithium, graphite)

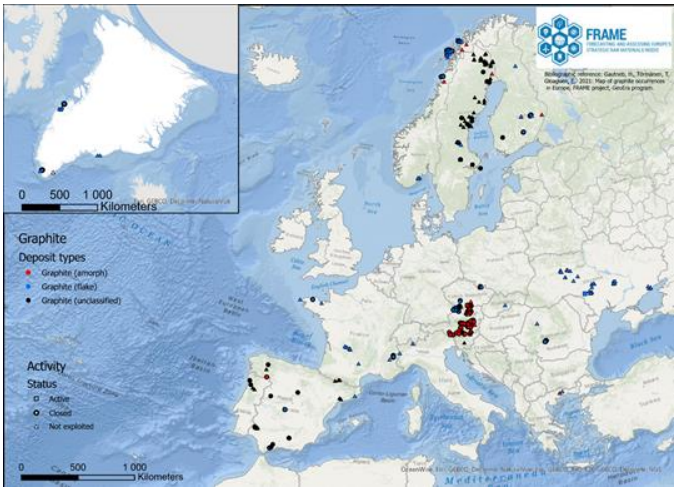
The transition to e-mobility and the development of other modern technological solutions have increased the need for Li-ion batteries which, can only be manufactured, using current battery technology, utilising cobalt and graphite.

High purity lithium can be produced from two distinct deposit types that are identified and defined as conventional lithium deposits: salars and hard-rock deposits containing Li-rich minerals, such as spodumene, zinnwaldite, lepidolite, petalite and jadarite. Identified deposits were mapped in FRAME.



Scandinavia and Finland have a potential for future cobalt production





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GeoERA RAW MATERIALS

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Occurrences, geology and potential for Lithium Cobalt and Graphite is compiled in an aggregated form

European potential is represented by spodumene and/or lepidolite pegmatites, rare-metal granites, greisens and jadarite from Portugal, Finland, Sweden, Ireland, Austria, Spain, France, Czechia, Germany, Serbia and Ukraine.

The highest potential of graphite occurs in Scandinavia

FRAME separated the European graphite deposits are of the so-called flake and amorphous types. Both types have different world economic market places.

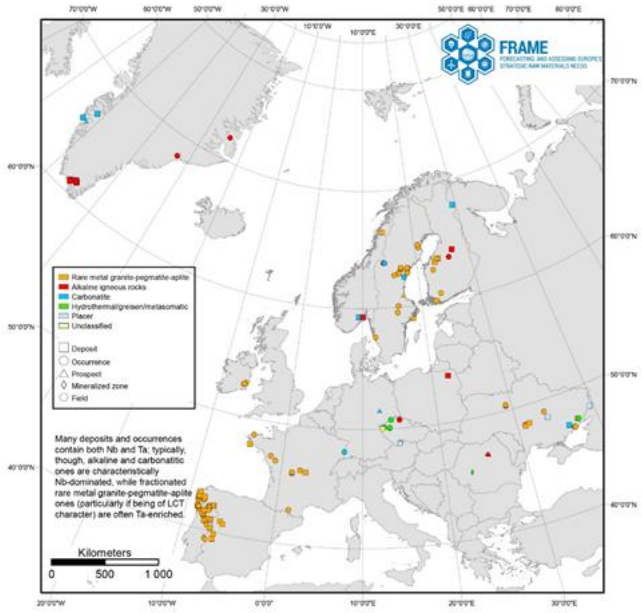
Conflict free Nb-Ta for Europe

The complex nature of conflict mineral issues requires a narrow focus not only on the supply chain and policies based singularly on legal regulations to control the mineral trade but these can be blunt instruments that may generate unintended effects which can seriously affect small-scale producers and artisanal miners in a number of African countries.

Ahead of the conflict minerals regulation (published 1/01/2020) FRAME was concerned with the collection and collation of geological and mineralogical/ metallogenetic data on Nb-Ta in Europe to enhance their exploration interest and potential, as well as highlight the possibility of producing these critical metals ethically and indigenous to the EU.

Most known Nb-Ta mineralisations and the best exploration potential in Europe are related to rare element granites, granitic pegmatites and aplites, together with alkaline igneous rocks and carbonatites.

With respect to Ta it was found that specific suites of peraluminous granites and their associated granitic pegmatite-aplite systems belonging to the LCT (lithium-caesium-tantalum) family in orogenic belts with metamorphic terranes featuring late to post-orogenic granitic rocks, such as the Variscan provinces of south, west, central, and east Europe, and the Svecokarelian orogen of the Fennoscandian Shield host the greatest amount of known occurrences.



Nb-Ta mineralisation and the best exploration potential in Europe reside in rare element granites, granitic pegmatites and aplites, and alkaline igneous rocks and carbonatites

recycling of mining waste and slags is a viable complementary source of Nb-Ta

Revisiting the historic mine sites

During Europe's long lasting mining history, countless deposits have been mined and some of those deposits are still in production today. FRAME took a closer look at those

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GeoERA RAW MATERIALS

historic mine sites to assess whether some of them have a potential to feed into Europe's demand for raw materials in the future.

FRAME developed criteria for the identification of case studies and identified potential case studies. As a first step, mining sites and regions were identified using existing databases and projects, the surveys' expertise and literature studies. Specific attention to given to mining sites, which for geological reasons provide high potential to host CRM but have not been mined for those in the past.

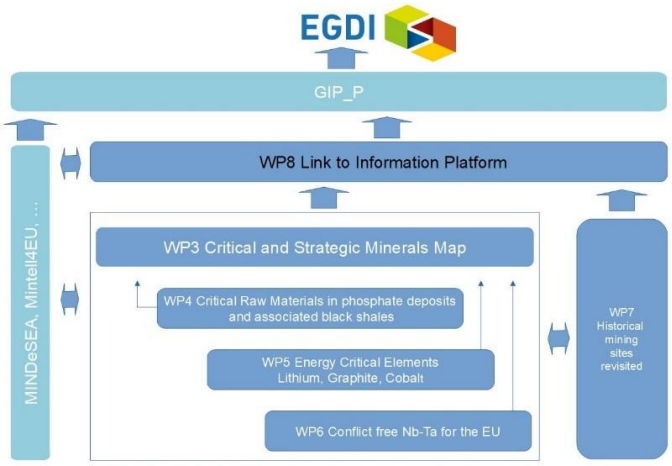
Detailed information on the CRM potential of 160 sites was collected - the majority of these site (mines and mine waste) were formerly mined for base metals and lead-zinc and copper mines account for about 50% of the sites.

This study was hampered by the COVID19-crisis with postponed field rips, reduced sampling campaings and severe delays in analytical data.

Twelve case studies were carried out: 1-The Kutná Hora ore district, Czech Republic, 2-The Kirki Mines, Greece, 3-The Avoca Mine, Ireland, 4-The Trepca mine tailings, Kosovo, 5-The Røros mines, Norway, 6-The Krobica and Gierczyn Sn deposits, Poland, 7-The Radzimowice Au-Cu-As deposit, Poland, 8-The Szklary Ni saprolitic deposit, Poland, 9-The Litija deposit, Slovenia, 10-The Riddarhyttan mining field, Bergslagen, Sweden, 11-Country Review: Historic Mine Sites in Romania with regard to their Potential of Critical Raw Materials, Romania and 12-Historic mines in the Romanian Banat - With special focus on Ocna de Fier deposit, Romania.

The Information platform

The cross-thematic integration of information is vital and links the data generated in FRAME to all other potential users and policy makers. The FRAME was used to update the national databases and was uploaded into data platforms, i.e., European Geological Data infrastructure (EGDI). The link to the information platform made sure that; 1- identified and discussed the requirements in close dialogue with the WP's and the Information platform (GIP-P) team; 2- Ensured that the principles and guidelines provided by the GIP-P are followed and implemented, and; 3- ensured that the information generated is provided to the improvement of the EGDI extension.



FRAME organized, prepared, and delivered to EGDI two categories of datasets (n=162): Structured (n=26) and Unstructured (n=136). Additionally, it delivered metadata respective identifier and number of linked documents (n=134) documents to EGDI.

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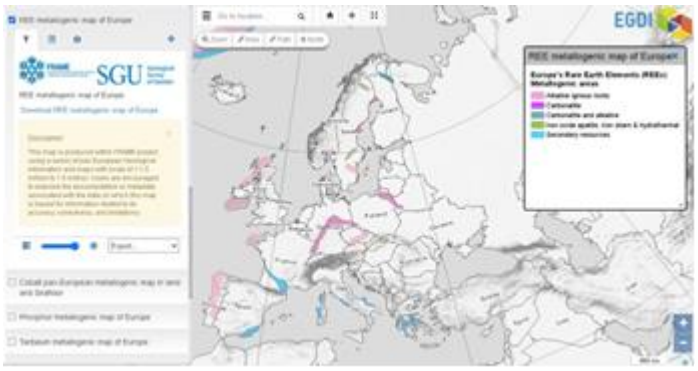
The maps uploaded are distributed by four main groups of products on critical raw materials in Europe: 1- Metallogenic maps (n=7); 2- Mineral occurrences/ deposits spatial distribution on land and the marine environment (n=11); 3- Potential/prospectivity maps (n=7), and; 4- Historical mine sites in Europe (n=1).

FRAME was instrumental in integrating the project results through EGDI Portal (metadata, structured and unstructured data (EU-MKDB architecture) and improving the present harvesting system and its quality assurance

The overall system is complex and relies on previous raw materials projects with continuous improvement, and encompasses: 1- Harmonised National Database, 2- Central Harvesting Database and, 3- Central Diffusion Database.



IT challenges were surpassed with respect to data collection, gathering and treatment among the different countries to provide pan-European information on CRM on land, including harmonization with MINDeSEA project for data on sea. Specifications were adopted concerning the database model, codelists, data formats and related metadata to obtain standardized and harmonized products throughout all the GeoERA RM projects, according to the INSPIRE directive requirements.

Networking between FRAME, MINDeSEA, Mintell4EU and GIP-P projects in order to facilitate on-going support was paramount in achieving the results of updating the EGDI data set

Epilogue

FRAME delivered what it promised at the beginning of the project. The unexpected pandemic situation was a giant hurdle to overcome during on-going research, which FRAME did so successfully. FRAME can be summarized as follows:

- FRAME represented a cohesive taskforce of scientists working together for common Pan-European goals and mitigating the dependency of mineral resources from non-European sources;
- FRAME created innovation in mineral prospectivity science with favourability mapping implementation;
- FRAME recognised the importance and the recognition and establishment of metallogenic provinces for the strategic CRM;
- FRAME produced comprehensive mineral deposits maps of the occurrences of P, Li, Co, C, Nb and Ta in Europe;
- FRAME made a significant review of Nb-Ta mineral deposits in Europe;
- FRAME increased by 60% the available data on battery critical elements (Li, Co, C) in Europe by interacting with MREG members;
- FRAME undertook and accomplished comprehensive phosphate mineralization indices in Europe;
- FRAME added unpublished geochemistry data of phosphate deposits;
- FRAME made a review of the CRM (REE) deposits in Europe;
- FRAME had a revitalized look at selected old mine sites;
- FRAME augmented and updated pan-European data sets, namely EGDI;

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- FRAME made a significant attempt to further unlock the mineral potential for a renewed raw materials sector in Europe as a driver for domestic raw material value chains;
- FRAME worked together successfully with other Raw Materials projects, within the GeoERA Raw Materials topic, and produced composite maps in conjunction with them, one example being the land-sea EU cobalt mineralization.

Research Continues!

Thank you for supporting FRAME

FRAME - Forecasting and Assessing Europe's Strategic Raw Materials Needs

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