FRAME

FORECASTING AND ASSESSING EUROPE'S STRATEGIC RAW MATERIALS NEEDS

DELIVERABLE 1.1

Description of Work

WP1 Coordination

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731166

GeoERA RAW MATERIALS

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Deliverable D1.1

Description of Work

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Disclaimer

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Purpose

This document presents the description of work for the FRAME project. It serves as a guideline for the basic activities to be developed and undertaken during the project lifetime. The description of work presented is also to be taken as merely a guideline. The on-going work will benefit from new data and new interpretations that may lead to activities not initially recognized by the involved partners.

The document is intended for both internal and external readers. Its dissemination level is Public. This document is under the responsibility of Work Package 1 (WP1). Amendments, comments and suggestions should be sent to the WP1 work package leader: Daniel de Oliveira.
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Executive Summary

The present document is a deliverable of the Forecasting and Assessing Europe's Strategic Raw Materials needs (FRAME) project, which is funded by the European Union's Horizon 2020 Programme under Grant Agreement 731166.

The document presents the guidelines for the envisaged activities to be developed and undertaken during the lifetime of the project. The on-going work will benefit from new data and new interpretations that may lead to activities not initially recognized in the proposed plan of work by the involved partners.

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Deliverable report

Introduction

The project "Forecasting and Assessing Europe's Strategic Raw Materials Needs" (FRAME) will build on previously and currently developed pan-European and national databases, and expand the strategic and CRM knowledge trough a compilation of mineral potential and metallogenic areas of critical raw materials resources in Europe, focused on related metal associations on land and the marine environment. Secondary resources, in terms of historical mining wastes and potential by-products will also be considered. The mineral resources targeted will have to extend beyond the current EU CRM list and include also minerals and metals (e.g. lithium, copper, and manganese) that are strategic for the European downstream industry in the mid- and long-term perspective. This project will collect and act as a source of mineral information data that will support the continuous work going on in the DG-Grow, Raw Materials Supply Group and the Ad Hoc Working Group on Criticality of the EU commission.

The FRAME consortium is composed of Geological Surveys from 19 European Countries.

FRAME project is led by the *National Laboratory of Energy and Geology (LNEG)* and supported by 18 additional leading organizations (Federal Institute for Geosciences and Natural Resources, Bureau de Recherches Géologiques et Minières, Czech Geological Survey, Geological Survey of Estonia, Geological Survey Sweden, Geological Survey Ireland, Geological Survey of Finland, Geological Survey of Croatia, Greek Institute of Geology and Mineral Exploration, Instituto Geológico y Minero de España, Mining and Geological Survey of Hungary, Geological Survey of Norway, Polish Geological Institute, Royal Belgian Institute of Natural Sciences, State Informational Geological Fund of Ukraine, Institutul Geologic al României, Geološki Zavod Slovenije, Istituto Superiore per la Protezione e la Ricerca Ambientale).

The Project will:

- Identify and define the strategic minerals and metals that will make part of the metallogenetic map and related interpretations, focused on the current list of CRM, but considering also the strategic importance of some of those which were among the original candidates, such as phosphate rock, lithium, graphite, cobalt, niobium, tantalum, and others such as selenium, silver, copper, manganese, lead and iron ore.

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All minerals and metals collected and selected to be part of the metallogenetic map will simply go under the term CRM.

- Produce a metallogenetic map and increase the knowledge on the CRM endowments and resource potential in Europe and EU seas, based on,
    - Mineralisations and deposits on land and the marine environment in which CRM make the main commodities, e.g. REE minerals related to carbonatite, nepheline syenites, pegmatites or paleoplacers, tungsten deposits related to granites, lithium feasible pegmatites, graphite hosted by schists.
    - Mineralisations and deposits on land and the marine environment in which CRM make associated commodities, e.g. REE in bauxite deposits and manganese nodules; cobalt in nickel deposits and ferromanganese crusts; vanadium in iron-titanium deposits;, indium and tellurium in VMS and epithermal gold deposits
    - Secondary resources, in terms of historical and modern mineral-based mining wastes (waste rocks, processing tailings, metallurgical residues) and by-products, e.g. REE in apatite concentrates related to iron extraction and red mud derived from alumina refining; indium in the waste streams of lead-zinc sulphide mining.
- Better understanding of the ore genetic links between major deposit types and hosted critical mineral and metal associations. Understanding also the mineralizing processes in different environments, including current deep sea, and using this understanding to predict and develop new mineral deposits or deposit types. This research also involves the characterization of ores, rocks, primary and secondary deposits etc. for significant elements and minerals, whose importance has increased and/or which represent cases where the occurrence is poorly understood or constrained. This objective and target will be interlinked and interactive with the tasks undertaken and the achievements resulted from GeoERA RM3 Metallogeny that will address the main deposit types and commodities.
- Be able to identify conditions and processes involved in the formation of the STR and CRM-potential deposits and develop conceptual models for their formation.
- Predictive targeting based on GIS exploration tools, of high potential mineral provinces and mining districts.
- Provide potential CRM resource estimates based on the UNECE classification system in close cooperation with RM 1/WP 5 on UNCF system.

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- Display and distribute the map and description on the Information platform.
- Highlight mineral resources criticality to high-tech economy and downstream sectors.

This project will collect and act as a source of mineral information data that will support the continuous work going on in the DG-Grow, Raw Materials Supply Group and the Ad Hoc Working Group on Criticality of the EU commission.

Description of Work

Objectives of WP1

Forecasting and Assessing Europe's Strategic Raw Materials Needs (FRAME) specifically builds upon the following work packages:

WP 1 (Coordination/Lead) - is the coordination and management work package lasting for the duration of the project. The first milestone occurs in Month 1 with a project inception meeting in order to commence work. WP 1 will deliver required management reports and ensure timely alignment of deliverables and milestones. WP 1 will be linked to clustering of researchers and results through the scheduling and organization of one kick-off meeting, two networking Workshops, five Consortium Meetings, three National (Regional / Local) Workshops and a final project meeting.

WP 2 (Communications, Dissemination and Exploitation) - will vehicle and disseminate information on the project, its progress and results to the wider community operating in the field of mineral policies and land management in the EU and beyond. WP 2 will focus in developing and implementing a comprehensive communication strategy plan that will define the project multiple stakeholders, messages and tools, as well as will implement a wide range of communications activities to fulfil its goals in accordance with the coordinator. WP 2 will receive inputs from all Work Packages for communicating their research in an understandable way to both scientific and non-scientific audiences with the help from the coordinator, who will make sure this communication works.
WP 3 (Critical and Strategic Minerals Map) will produce a map of the current 27 Critical Raw Materials and also of the strategic raw materials for Europe, namely the ECE's and conflict minerals. WP 3 will be the backbone of the project with links to the other WP's with whereas the leader will provide the links.

WP 4 (Critical Raw Materials associated with phosphate deposits and associated black shales) - WP 4 is dedicated to the evaluation of economic potential of igneous and

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sedimentary phosphate deposits (and their host black shales) in Europe, especially regarding critical and strategic raw materials (CRM). WP 4 will feed in to WP 3 and subsequently also supply data to WP 2 and coordinator will provide conditions for the communication promoting meetings and work sessions between WPs.

WP 5 (Energy Critical Elements) - The main objectives of this WP are to concentrate on strategic minerals and elements, namely lithium, graphite and cobalt, which are all considered vital to current energy storage equipment and drivers of today's technological societal mainstay. WP 5 interconnects and will feed in to WP 2 and WP 3. Another objective that the coordinator needs to help by promoting communication and workshops between the three raw materials specialists and the other WP specialists.

WP 6 (Conflict Minerals) - Although the term "conflict minerals" is normally applied to a group of several metals as well as minerals, including the columbite-tantalite group of minerals, also known as "coltan" (from which tantalum is derived), and additionally cassiterite (tin); gold; wolframite (tungsten); or their derivatives, this WP will focus solely on tantalum and niobium, the so called indispensable twins because of their affinity to occur in similar and very specific geological settings and their important applications in electronic superconducting technology, general high-technology applications, and alloy industries. WP 6 interconnects and will feed in to WP 2 and WP 3.

WP 7 (Historical mine sites revisited) - Based on the concept that today's mine dump is potentially tomorrow's mine, this WP will create a database of potential locations where some or all of the strategic and critical raw materials may be found in European mine sites. Where possible this potential will be measured and evaluated. This WP will strongly link with WP 2, 3, 4, 5, 6 and 8. The interlinking nature of the work packages can be seen in Fig. 3. This link will also be promoted by WP 1 with a workshop and work sessions between WP 3, 4, 5 and 6.

WP 8 (Link to Information Platform) - The cross-thematic integration of information is an important aspect to be addressed in GeoERA and therefore the objective of this WP is to provide and disseminate spatial information on the respective resources and underpinning geological data identified in the technical work packages of the project. It has a link to all WP's of the project and will provide data in a format that will allow it to be uploaded to data platforms in a future date. The WP 8 role will be of most important to make sure that data produced will be effectively introduced in the Information Platform.

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Actions of WP1

The purpose of work package 1 is to lead, manage, coordinate and monitor the progress of the project, and ensure that the project meets the objectives stated for the work described in the Grant Agreement and that WP leaders and partners respect the timeline and deliverables.

Task 1.1 - Manage the WP leaders and monitor the project progress against deliverables, milestones, tasks and use of resources. This work package is in charge of the leadership, coordination and project management tasks, including organizing the consortium meetings, steering the Management Committee, coordinating the reporting, and consulting with the advisory board. All participants are required to adhere to the project management procedures (D1.1).

- Keep track of progress and costs against budgeted expenditure.
- Report on progress and expenditure; process claims and validate that the project expenditure is in accordance with the eligibility criteria and the grant agreement.
- Provide procedures on ethical requirements (D1.2), including (a) an informed consent procedure for workshops, conferences, events with external participants, surveys and interviews, (b) a procedure to protect submitted personal data (POPD).
- The reporting part will run for the entire duration of the project and will consist of:
  - A compilation of management reports (D1.4, D1.6) incl. expenditure against profile.
  - Collated participant statements on expenditure and associated administrative documents, audit certificates, and the submission of consolidated reports to the European Commission.
  - Preparation of reports and required documentation and submitting these to the Commission (D1.4, D1.6, D1.7).

Task 1.2 - Organise Management meetings: Several meetings and workshops are foreseen to ensure timely and to the point work with in the project and towards related GeoERA projects. This includes kick-off meeting, workshops, regular consortium meetings where ever appropriate by using online tools, and a final meeting.

Task 1.3 - Management of the Consortium:

- Adopt the terms of reference (governance) in collaboration with the Management Committee (D1.3).

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Objectives of WP2

The objective of WP 2 is to widely disseminate the project results during the duration of the project as well as to maximize its impacts after the end of the project. WP 2 will focus in developing and implementing a comprehensive communication strategy plan that will define the project multiple stakeholders and the most suitable channels to reach them. WP 2 will support the technical and management project Work Packages in communicating their research in an understandable way for scientific and no-scientific audiences. In particular, WP 2 will:

- Disseminate information on the project, its progress and results to the wider community operating in the field of Forecasting and assessing Europe's Strategic Raw Materials needs in the EU and beyond, including national, local, regional public authorities, other interested third parties and the general public;
- Ensure that the project benefits are clearly and systematically promoted, and foster a two-way dialogue with stakeholders;
- Raise awareness and visibility on the importance of improving Europe's framework conditions for Forecasting and assessing Europe's Strategic Raw Materials needs (FRAME);

Foster the connection with existing EU and Member States initiatives and projects relevant to the Project outcomes.

Actions of WP2

Task 2.1 Communication Strategy & Plan: WP 2 will produce a Communication strategy, presenting the communication strategic objectives, and a detailed Communication Plan aimed at achieving them (Fig. 2). The communication strategy will define dissemination goals, segment the audience and establish dissemination channels. The Communication Plan will define resources to be allocated, media to be used, messages and sources. This will take into account the complexity of actors within the RM4 project. The focus will be on the major audiences: policy makers dealing with Raw Materials resources challenges; national, regional and local administrators and public institutions responsible for Raw Materials management; civil society, industry and the general public. Specific attention will be given to assessing the suitability and effectiveness of the communication activities that will be put in place to re-adapt actions whether necessary. In particular, the strategic communication objectives will be measurable, therefore several indicators will be identified (i.e. visitors of the project website, number of news issued, social media engagements, feedback provided by stakeholders) and will give insight on future actions. This task will include also the development of a coherent visual identity in support to the communication main messages. The visual identity will include graphics (logos, colour code, etc.) and templates for presentations, reports, deliverables.

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The Communication plan will identify dissemination opportunities that may arise (e.g. workshops, articles, interviews) and for which tailored tools may be developed. Dedicated informational and promotional materials will be produced to reach target audiences, in collaboration with the other WPs. The materials will be aligned in messaging and layout as defined in the Communication plan and will be meant for both online and offline distribution, in order to maximize impacts. A communication guideline will be distributed among WP leaders to ensure a common strategy of communication and circulation between the other WP and WP 2 and in close cooperation with the GeoERA secretariat. As main online channel, a website will be set up and will ensure a two-way communication between the project consortium and a broad range of stakeholders.

Task 2.2 Dissemination of project results: Following the main objectives of WP 2, this WP will disseminate the project results to target stakeholders by implementing tailored communication activities that will follow the project progress and deliverables. Dissemination on digital channels will be a priority, propelled by the website and social media (e.g. Facebook, YouTube). These channels will seek synergies with partners to maximise the dissemination of information. A Hub&Spoke model will be used to integrate different web platforms in one hub, which will be the project website, so that content will be easily shared, messaging will be better managed and dialogues will be stimulated along social media, thus making dissemination more efficient.

Specific attention will be given to the promotion of the project results produced by other Working Packages to better illustrate the concrete challenges of Forecasting and assessing Europe's Strategic Raw Materials needs providing technical solutions helping the market to enhance the exploration phase. The project outcomes will be presented in an understandable way for non-scientific audiences, in order to facilitate their adoption as a tool for policy makers and interested parties.

A range of communication materials will be produced (i.e. brochures, leaflets, newsletters, videos, infographics, etc.) with the support of the other WPs. Furthermore, this task will seek the collaboration of national and international media (specialised and general magazines and newspapers) that will ensure broader visibility to the project.

Task 2.3 Exploitation of results: The exploitation activities will ultimately make the Forecasting and assessing Europe's Strategic Raw Materials needs project more visible and accessible. The Contribution to self-sufficiency of strategic/critical raw materials within Europe, final outcome of FRAME, will be extensively promoted to its recipients (practitioners, investors, industry). These activities will improve the base for further investments, as results will be more predictable, and will give insight on future strategic/critical raw materials actions. During the project period one workshop will be

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organised with the purpose of facilitating the appraisal of the project outcomes, namely on Forecasting and assessing Europe's Strategic Raw Materials needs. To boost dissemination to specific target audiences, the existing network already available within the FRAME Consortium will be used, and tailored messages will be conveyed using social media channels. FRAME Partners are already involved in several EU H2020 projects focused on raw materials topics. FRAME will use this dissemination channel to spread the results and discussions widely within and over Europe. Some project partners are also regular participants of various working groups, panels and EU initiatives, and these interactions will provide an additional opportunity to improve the outcomes of each work package, and supply widest reaching opportunities for dialogue with policy makers and public agencies. The Plan for the dissemination and exploitation of the FRAME's results are shown in Fig. 1.

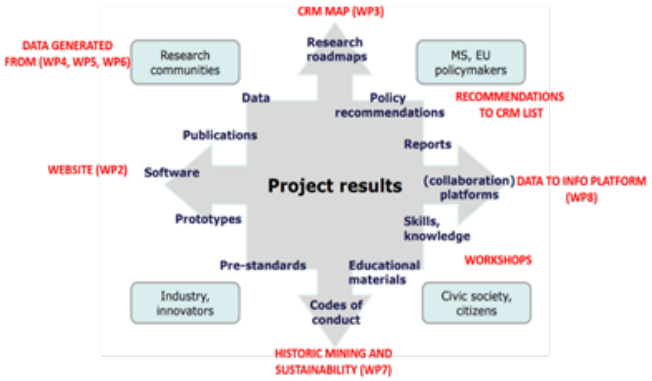

Figure 1 – Adaptation of the Dissemination plan model of H2020

Objectives of WP3

To develop metallogenic research and models at regional and deposit scales as well as prospectivity maps, with special attention to strategic critical minerals for which the EU is highly dependent, in support of more efficient exploration and mining the following specific objectives need to be addressed:

- Identify and define the strategic minerals and metals that will make part of the metallogenetic map and related interpretations, focused on the current list of CRM, but considering also the strategic importance of some of those which were among the original candidates, such as lithium, tellurium, selenium, silver, iron ore and others. All minerals and metals collected and selected to be part of the metallogenetic map will simply go under the term CRM.

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- Produce metallogenetic map and increase the knowledge on the CRM endowments and resource potential in Europe and EU seas.
- Better understanding of the ore genetic links between major deposit types and hosted critical mineral and metal associations. Understanding also the mineralizing processes in different environments, including Europe's deep sea areas, and using this understanding to find and develop new mineral deposits or deposit types.
- Be able to identify conditions and processes involved in the formation of the CRM-potential deposits and develop conceptual models for their formation.
- Predictive targeting based on GIS exploration tools, of high potential mineral provinces and mining districts.
- Provide potential CRM resources estimates based on the UNECE classification system
  European scale prospectivity maps were produced 5 years ago by the ProMine project, using a relatively basic approach (Weight of Evidence, for most of them). They deserve to be improved using a more appropriate methodology for a continental scale approach and considering the latest (2017) CRM list. The main objective of the present task is to produce a renewed and updated set of continental scale mineral prospectivity maps, covering all EU member states and neighbouring countries (Ukraine, Balkans, Norway, Switzerland, etc.), (according to the 2017 CRM list from the European Commission, and based on the availability of data, i.e. known mineral deposits of targeted commodities). These prospectivity assessments will benefit from the latest developments in "data driven" mineral prospectivity methods that allow mapping at continental scale (i.e., CBA, or "Cell Based Association" method developed by BRGM).
- Display and distribute the map and description on the Information platform.
- Highlight mineral resources criticality to high-tech economy and downstream sectors.

Actions of WP3

Produce metallogenetic map and increase the knowledge on the CRM endowments and resource potential in Europe and EU seas, based on collecting information of:

- Mineralisations and deposits on land and the marine environment (linkages to all relevant WPs of RM3A) in which CRM make the main commodities, e.g. REE minerals related to carbonatite, nepheline syenites, pegmatites or paleoplacers, tungsten deposits related to granites, lithium feasible pegmatites, graphite hosted by schists.

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- Mineralisations and deposits on land and the marine environment in which CRM make associated commodities, e.g. REE in bauxite deposits and manganese nodules; cobalt in nickel deposits and ferromanganese crusts; vanadium in iron-titanium deposits;, indium and tellurium in VMS and epithermal gold deposits.
- Secondary resources, in terms of historical and modern mineral-based mining wastes (waste rocks, processing tailings, metallurgical residues) and by-products, e.g. REE in apatite concentrates related to iron extraction and red mud derived from alumina refining; indium in the waste streams of lead-zinc sulphide mining.

Prospectivity assessments for a continental scale approach for a selection of STR and CRM materials (according to the 2017 CRM list from the European Commission, and based on the availability of data, i.e. known mineral deposits of targeted commodities). These prospectivity assessments will benefit from the latest developments in "data driven" mineral prospectivity methods that allow mapping at continental scale (i.e., CBA, or "Cell Based Association" method developed by BRGM).

Objectives of WP4

Work package 4 (WP 4), "Critical Raw Materials in phosphate deposits, and associated black shales" is dedicated to the assessment of economic potential of igneous and sedimentary phosphate deposits (and their host black shales) in Europe, especially regarding Critical Raw Materials (CRM). These deposits could significantly contribute to a secure sustainable access to a large proportion of Europe's requirement for these CRM. This project proposal is therefore consistent with the SRT "RM4 – Forecasting and Assessing Europe's Strategic Raw Materials Needs". More precisely, this WP aims to provide an overview about phosphate mineralization (and associated economically interesting black shales). It will comprise detailed mineralogical and geochemical characterization of key phosphate deposits, sedimentary and igneous in origin. These metallogenic, mineralogical and geochemical studies will help to decipher the processes leading to CRM enrichment in these deposits. Since part of the phosphorites in Europe are hosted within metalliferous black shales, the latter will be considered as well, with the view of a combined and rational exploitation of these resources. Another aim is the development of a procedure to prepare and analyze samples from phosphate deposits. This would be helpful to provide internally consistent geochemical data at a European level for this type of mineralization. Finally, the data from the project will contribute to databases, such as those from Minerals4EU, the European Union Raw Materials Knowledge Base (EURMKB), SRT RM1, and the GeoERA Information Platform.

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Despite the obvious interest, most phosphate deposits, and their host-rocks, have not been studied for some time (a few decades), especially with respect to their potential for CRM. The identification of the economic potential of phosphate deposits, whether they are of sedimentary or igneous origin, could significantly contribute to secure access to many elements listed as critical by the EC. The aim of this project is to provide an overview of phosphate mineralization (and economically interesting black shales) in Europe, with special emphasis on their CRM content. The project aims to identify new areas of interest for CRM.

More precisely, the objectives are:

- Mineralogical and geochemical data will be acquired on selected phosphate deposits and occurrences. WP partners have access to data and samples of phosphate deposits/occurrences (as well as host-rocks) within their respective countries. This will facilitate (1) the development of databases on these deposits, and (2) access to samples for mineralogical and geochemical studies.

Investigate more carefully a selection of key phosphate deposits, which will be representative of the different types of phosphate mineralization encountered in Europe. The goal will be (i) to provide an up-to-date scientific overview about the genesis of phosphate deposits in Europe, (ii) to determine more clearly the potential for and speciation of CRM in phosphate deposits (and host metalliferous black shales), and (iii) to investigate the processes leading to their enrichment.

- Establish a procedure for sample preparation and analysis of phosphate samples with the objective of providing internally consistent geochemical data on a European level.
- An enhanced database will be developed, compiling data collected during this project and information from the literature and older databases. These data will be integrated into existing databases, such as Minerals4EU, the European Union Raw Materials Knowledge Base (EURMKB), SRT RM1, and the GeoERA Information Platform. They will also be available in map format.

Actions of WP4

Task 4.1 Prepare an overview of the phosphate deposits and occurrences in Europe by compiling an integrated database – from the literature and older databases: The data that will contribute to the development of the database are:

- the different commodities/CRM associated with phosphate deposits (P, F, REE, and others);
- the size of the deposits according to their known tonnages (and at least the possibility to discriminate occurrences from deposits, when the tonnage of deposits is not known);

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- the type and origin of the phosphorus-phosphate mineralization and deposits (sedimentary, volcano-sedimentary, igneous, hydrothermal, Fe-apatite deposits, unspecified);
- the age of the deposits/occurrences and the host rock; (v) the commodities/CRM (Be, Sb, Co, PGM, V and Cr) associated with black shales, when applicable and available.
- The information (and maybe structure) of the Minerals4EU database will be used to develop the new database. The partners of this WP will provide information from within their own countries. Data from other European countries will be collected by WP 4 partners from readily available literature and data sources.

Task 4.2 Acquisition of new mineralogical and geochemical data on representative samples from phosphate deposits/occurrences (and their host-rocks), in order to determine their potential to host CRM, and the speciation of the latter. The deposits/occurrences should be as numerous as possible and distributed widely. To achieve that goal, each partner will select and study samples from its own country. For countries not in this WP, samples may be selected for those countries from partner organisations within the WP with large sample collections, such as GSB. These samples will be studied by WP partners.

From a geochemical point of view, the economic potential of phosphate mineralization will be assessed by whole-rock analyses comprising major elements, trace elements, and PGE (in case of black shales). An analytical protocol will be developed in order to obtain harmonized data is presented. The project aims to establish a procedure to prepare and analyse phosphate samples with the goal to provide internally consistent geochemical data at the European level for this type of mineralization. Most of these analyses will be carried out using instrastructure available within the partners. Further REE, F and PGM analyses will be obtained using ICPMS, in Geological Surveys such as CGS or BRGM. Wherever the samples are analysed, particular attention will be paid to the consistency of the analyses. Well-tested phosphate standards will be prepared/obtained and made available for all laboratories to ensure analytical homogeneity and comparability. In order to carry out mineralogical investigations several analytical techniques will be used, depending on the needs: X-ray diffraction (XRD), optical microscopy (including cathodoluminescence), scanning electron microscopy (SEM) coupled with energy dispersive spectrometer (EDS), Raman spectroscopy, and possibly electron microprobe. These facilities are commonly found in the Geological Surveys involved in this WP (GSB, CGS). If not available GSB will provide access to XRD, SEM and Raman spectroscopy.

Task 4.3 Detailed metallogenic studies of key phosphate deposits. These case studies will examine both sedimentary and igneous-related phosphate deposits, medium to large in size, with a view to future exploitation. The selection of deposits will be as representative

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as possible. This metallogenic approach could also be applied to black shales (hosting phosphorites), if the latter appear promising regarding their CRM content. For the study of these deposits, a careful petrographic study will be carried out. Apart from the analytical techniques evoked for objective 2, cathodoluminescence (CL) microscopy could be used to detect the presence and the level of REE-enrichment in apatite. The chemistry of minerals hosting CRM (such as apatite in phosphate deposits, or sulphides in metalliferous black shales) will be further investigated using electron microprobe and LA-ICP-MS analyses. The changes of apatite chemistry - and from an economic point of view, its REE and F enrichment - will provide crucial information about sedimentary processes/diagenesis in the case of phosphorites, and the involvement of different types of fluids (late-magmatic/metasomatic/hydro-thermal/supergene) in an igneous context. Further, oxygen, carbon and strontium isotopic compositions could be measured to provide additional information about the origin of the phosphate deposits. Oxygen and Sr isotopes are commonly used to emphasize (late-) magmatic/hydrothermal/supergene mineralizing processes in igneous environments. Carbon, oxygen and strontium isotopic compositions are also well suited for sedimentary deposits, to compare diagenetic apatite and seawater signatures. Other isotopic analyses (Pb, Nd, S) could be considered for the study of metalliferous black shales. Moreover, if possible, an up-to-date 'order of magnitude' estimate of the resources will be provided. Any publicly available information on phosphate (and any CRM content) reserves will also be collated and compiled. The combination of these new data sets will lead to (i) a better understanding of the CRM distribution and enrichment within these deposits, and constrain the processes which have led to these enrichments, and (ii) identify and highlight the potential of these deposits regarding the CRM.

Task 4.4 Data migration to specific databases. Finally, all the data acquired and developed within the project will be made available and integrated into the following databases: Minerals4EU, the European Union Raw Materials Knowledge Base (EURMKB), SRT RM1, and the GeoERA Information Platform in both web-viewer and atlas formats.

Objectives of WP5

Natural graphite, lithium and cobalt are essential components in modern and mobile energy storage technology, most notably in rechargeable lithium-ion batteries. The current work package will investigate, generate and compile data on the occurrence and production of these "energy critical elements" in order to provide a better and more accurate basis for exploration and exploitation, as well as land use management, and to provide high quality mineral intelligence data to the European data portals. Natural graphite and cobalt are both critical raw materials in the 2017 EU criticality assessment, while lithium is located above the supply risk threshold.

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The main application of **natural graphite** today is for refractories in the manufacture of steel and other metals. However, it is believed that the consumption for batteries will grow significantly over the coming years with increased electrification in the transport sector. Today natural graphite is produced in Norway, Austria and Ukraine, with Norway as the largest European supplier to the EU. In addition to Norway, The Czech Republic, Slovakia, Sweden and Finland are known to have potential for natural graphite. A pan-European compilation of resources, resource potentials, and geological data for natural graphite is essential in order to understand and assess the European potential for energy critical elements, and is a major objective in the work package.

The main application of **Lithium** today is for rechargeable batteries (Roskill 2016). Despite numerous European lithium ore deposits, used for ceramic industry needs, all batteries are made of non-European lithium. In Europe, lithium resources occur in several forms, including hard rock hosted and geothermal brines. Portugal, Spain, Austria, Finland, France, Czech Republic, Germany and Ireland among others, have high potential for Li-rich pegmatites and granites. Unknown/unconventional Li deposit types have not be considered, and a review of European Li ore deposit types & models is needed to improve mining exploration ore targeting. Knowledge on these resources (Minerals4EU, ProMine) are heterogeneous and considerably reduces the possibility for an exhaustive assessment of European reserves. The goal is first to complete existing databases and to extend them by the use of data augmentation. A second objective is to estimate the lithium reserves, of all types in Europe.

In the global perspective, **cobalt** is produced as byproduct of nickel production; the only significant exception to this rule is the deposits in the southernmost Democratic Republic of Congo (DRC) where cobalt is predominantly associated with copper mineralizations. Globally, economical cobalt deposits can be classified to three major types: 1) lateritic Ni-Co ores, 2) certain cobalt-enriched sedimentary rock-hosted copper deposits (only in DRC), and 3) mafic-ultramafic rock associated sulphidic Ni-Cu-PGE ores. Finland is currently the only EU country producing cobalt from its mines. In the entire Europe, also Russia has mine production of cobalt, from the Pechenga nickel mines. All countries producing nickel do have potential to also produce cobalt, as these two metals overwhelmingly occur in same ore minerals. However for the entire Europe, the mine production data available indicate no cobalt production in countries producing nickel: including Albania, Greece, Kosovo, Macedonia, Norway, Poland, and Spain. That these countries do not recover cobalt from their mined nickel ores suggests challenges in ore processing/recovery and/or insignificant cobalt concentrations in the ore, causing processing to be uneconomical. Globally significant cobalt refining has been done in Finland for decades. During years 1997–2003, Finland was even the largest cobalt refiner in the world. After that, China took over the leading position, but Finland is still the second

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biggest refiner globally. Annual refined cobalt production in Finland has ranged between 8 000 – 12 500 tpa.

Actions of WP5

Task 5.1. GRAPHITE: Provide an overview of geological provinces with known resources or potential for natural graphite in Europe. This includes a compilation of past and present graphite production and potential future prospects. Generate an overview of available exploration data, including drill cores, geophysics and other relevant data.

- Characterize the geological setting of graphite mineralisations in different countries through detailed case studies of representative deposits or prospects. The characterization should include (1) Host and country rock association, petrography and mineralogy; (2) Radiometric age; (3) Tectonics and structures; (4) Metamorphism and tectono-metamorphic history.
- Where available, case studies should include data from (1) XRD, Raman spectroscopy, stable isotope analyses; (2) Image analysis and in situ grain size distribution; (3) Beneficiation results.

Task 5.2. LITHIUM: Upgrade data on European lithium hard-rock deposits within the Minerals4EU database; Format all outcomes for integration in the Information Platform according to INSPIRE standards and the EU Raw Materials Knowledge Base (EU-RMKB).

- Develop and validate a simple method for data augmentation of the existing pan-European database (Minerals4EU).
- Provide an overview of known lithium ore deposit types, associated characteristics and spatial distribution in EU, and estimate the potential for new sedimentary/hydrothermal Li deposits types.
- Evaluation of lithium ore deposit as a source of other CRM – W, Nb, Ta, REE … as a complex ores.
- Overview of suitable beneficiation methods.

Task 5.3. COBALT: Provide an overview of known deposit types where cobalt occurs in significant concentrations in Europe. This includes a compilation of past and present production and potential for new discoveries.

- Provide an overview of geological provinces with known resources or potential for cobalt in Europe. Generate an overview of available exploration data.
- Characterize the geological setting of cobalt mineralization styles in different countries.

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Characterize mode of cobalt occurrence in different mineralization style for better understanding of the processing requirements.

Objectives of WP6

The chemically related elements niobium (Nb) and tantalum (Ta) are two of the most particular critical metals (critical raw materials; CRM), of which Ta, and associated Nb are extensively sourced as so-called conflict mineral from the central African region today. As such, their mine production is associated with abhorrent and often slave-like conditions for mine workers, which include children, as well as being a fundamental source of income for local warlords. While legislation is now in part being enforced to "guarantee" conflict-free Nb and Ta in industrial products, this is very far from being without major caveats. An alternative, or complimentary action to this, is to find potential sources of these rare metals within the EU and associated countries.

The main objectives of this WP are therefore to do a survey of the pan-European distribution of the conflict metals Nb-Ta and also enhance their exploration interest and potential in order to produce them ethically and indigenous to the Community. The deposits will be classified based on genetic type and subdivided as to timing of formation and regional distribution. As far as possible, the detailed ore mineralogy of Nb-Ta will be collated and described for the assessed deposits/mineralisations, to maximise the usefulness with regards to processing and associated evaluation parameters of their economic potential. Potential by-products, not least of other critical or strategic metals and minerals will be taken into account. This survey and its outcomes will also form the basis for developing recommendations for future exploration for these metals in Europe. Another important objective is to discuss and make draft recommendations for future projects to improve conditions for Nb-Ta and other CRM production in central Africa.

Actions of WP6

Task 6.1. Collection and integration of geological and mineralogical/metallogenic data on Nb-Ta. Nb-Ta mineralisations are typically associated with granites and specifically granitic pegmatites, such as generally known from e.g. the Palaeoproterozoic bedrock of the Fennoscandian Shield and several younger granites and granitic pegmatite fields in Europe. Niobium is also present in pyrochlore-group minerals in carbonatitic as well as syenitic rocks, which have a much more restricted distribution. Geological and mineralogical/metallogenic data from pan-European sources will be integrated in order to create a new dataset on the distribution and systematics of Nb-Ta mineralisation in Europe. Conventional as well as unconventional primary source types (e.g. granites,

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granitic pegmatites, greisens, syenitic to phonolitic rocks, carbonatites) will be considered. Regions with increased potential will be specifically assessed (e.g. Fennoscandia, Iberian Peninsula, SW England, Ireland, Massif Central/France and East central Europe). This will entail accessing and synthesising information that is available to the public and academia, as well as, when available, additional datasets, including e.g. exploration reports.

Task 6.2 Collect new data on selected deposits. Based on data compilation in Task 6.1, a selection of deposits from key areas will be sampled and analysed, both as to total chemistry as well as specific mineral chemistry of Nb-Ta and associated CRM, and their textures and grain sizes. An initial case study focusing on Swedish deposits will be undertaken, but this can potentially be expanded to include the entire Fennoscandian shield, and other regions in Europe.

Task 6.3. Develop recommendations for future exploration in Europe for Nb and Ta. Utilising findings of the task 6.1 and 6.2 as a baseline study for assessing the potential for Nb-Ta in Europe, the identified prospective regions and their character of mineralisation will also be used to develop recommendations for future exploration.

Task 6.4. Discussion of the potential for relieving European import dependence of Nb-Ta. While legislation, both within the EU and USA, is now being enforced to "guarantee" conflict-free Nb and Ta in industrial products, this is very far from being a simple solution, both with regards to the handling and transparency within any chosen process of classification of metal origins, and to the blunt avoidance of produce from central African sources which do not have a conflict situation. Any discussion of conflict minerals must address the conditions of Nb-Ta production in central Africa with the aim to suggest improvement and functional solutions to these prevalent issues. A discussion will be brought forward on the potential of intra-European production of Nb-Ta to decrease the now total dependence on imports. This will highlight selected mineralisations or regions with the best potential based on the knowledge base that has been created in task 6.1, 6.2 and 6.3.

Objectives of WP7

The project aims at improving European regional geological and metallogenic knowledge regarding future potential of existing mine sites and will contribute to improving pan-European geological information on CRM by providing an overview and case studies on critical raw materials contained in known European deposits while focus will be given to former highly and longtime active mining regions.

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The project will feed site-specific data of ore deposits with CRM potential into the pan-European knowledge base on raw materials and thus broaden the understanding of the raw material potential in Europe (including secondary raw materials from mine wastes).

The project will generate data and additional information which will be harvested into the GeoERA Information Platform and contributes also to the improvement of transparent information flow and general knowledge improvement.

Information provided by the project can contribute to special planning topics and ensure an integration of raw material potential into future land use and policy planning and thus to the optimal use and sustainable management of the subsurface.

Knowledge generated in the project can be used as an additional source of information by European, national and regional policy makers, industry and other stakeholders.

Actions of WP7

Europe is largely dependent on raw materials imports and thus relies on global markets and supply from international sources. Nevertheless, Europe has a long mining history and umpteen deposits have been mined even for hundreds of years. Some of those deposits are still in production today. The project will identify traditional mining regions or sites, which have the potential to feed in to Europe's demand of raw materials in the future. It will include not only the main commodities of the deposits examined, but also focus on by-products such as high-tech metals and CRM (both further summarized as CRM herein). These metals might be produced as primary raw materials from the mining and beneficiation process or be contained in mine waste/tailings.

Task 7.1 Develop criteria for the identification of case studies and identification of potential case studies: As a first step mining sites and regions will be identified using existing data bases and projects, the surveys' expertise and literature studies. Criteria to identify those deposits will be developed within the project by all partners. Specific attention will be given to mining sites, which for geological reasons provide high potential to host CRM but not mined for those so far. D1 will be a report on the selection criteria and process. *Partners* LNEG, BRGM, CGS, SGU, GSI, IGMEgr, NGU, PGI/NRI, RBINS, GeoInform, IGR, GeoZS and ISPRA*, Months 1-7.*

Task 7.2 Case studies on RM potential from historic mine sites or regions: The project partners will study some of the deposits identified in detail to further assess the potential for CRM further. These case studies might involve site visits conducted by the partners to gather additional information and to collect samples, which will be analyzed in the partner surveys to evaluate the potential for CRM. Also, previous work of the partner

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surveys on specific deposits will be taken into account and existing data will be incorporated. The case studies will serve as examples for Europe's remaining CRM potential and can contribute to the revitalization of underused former mining regions. Hence, case studies will focus on known but unexploited deposits as well as on existing mines and mine wastes. The latter provide also the potential to reduce existing negative environmental impact of raw material production. These studies will be accomplished by fieldwork (sample collection) and laboratory work (analysis at the partners' laboratory facilities) including preliminary work on processing (by IGME -Greece) where appropriate. *Partners* LNEG, BRGM, CGS, SGU, GSI, IGMEgr, NGU, PGI/NRI, RBINS, GeoInform, IGR, GeoZS and ISPRA*, Months 3-24.*

Task 7.3 Study European RM potential (especially CRM) from known deposits: The case studies will be supplemented by investigations on additional mine sites, deposits and mining regions at a broader level by employing data, results and expertise from previous projects in Geological Surveys. The aim is to get an as comprehensive overview over the European raw material potential from known deposits as possible to assess the amount of CRM in the regions and sites examined. *Partners* LNEG, BRGM, CGS, SGU, GSI, IGMEgr, NGU, PGI/NRI, RBINS, GeoInform, IGR, GeoZS and ISPRA*, Months 3-24.*

Task 7.4 Compilation of results in Final Report: Main findings and results will be compiled in a final report, which will draw conclusions on the European CRM potential and, wherever applicable, highlight specific site related topics that might be obstacles for the exploitation of those raw materials (legal conditions; cross-border aspects; extraction techniques related to the special geological conditions; environmental aspects etc.). Hence, the project will a) provide an overview over the European CRM potential, b) draw conclusions on the possible future exploitation of European ore deposits. *Partners* LNEG, BRGM, CGS, SGU, GSI, IGMEgr, NGU, PGI/NRI, RBINS, GeoInform, IGR, GeoZS and ISPRA*, Months 24-30.*

Task 7.5 Data migration into the Mineral Inventory database (RM1): Relevant site-specific information, especially on the case studies, will be fed into the Mineral Inventory database created in RM1 by the project partners. Close cooperation with RM1 and a coherent template shall ensure that all requirements for the Information Platform are met. *Partners* LNEG, BRGM, CGS, SGU, GSI, IGMEgr, NGU, PGI/NRI, RBINS, GeoInform, IGR, GeoZS and ISPRA*, Months 28-36.*

Relation to existing EU projects and programs: The proposed project will make use of existing database from projects and in particular Minerals4EU to identify regions/specific sites, where deposits already are or have been mined. The EU-list on CRM will be taken into account while special attention are given on the remaining potential of CRM.

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Scientific impact: The project will increase knowledge on Europe's raw material potential taking into account Europe's need for CRM. It will broaden the understanding of the raw material potential in Europe (including secondary raw materials from mine wastes) throughout its feed of site-specific data into the pan-European knowledge base on raw materials. It will contribute to the geological understanding of the ore deposits examined and touch on aspects concerning raw material extraction.

The knowledge generated on the Europe's remaining CRM potential is are delivered to feed into policy decisions, spatial planning aspects and be a support to the industry. Thus the results can become a valuable input for special planning with regard to raw materials.

Objectives of WP8

The main objective is to identify and discuss requirements in close dialogue with the Information platform (IP) team. Furthermore, this work-package is to ensure that the principles and guidelines provided by the GIP-project is followed and implemented. Facilitate that the information generated is provided to the improvement of the European Union Raw Materials Knowledge Base (EURMKB), as crucial input to the minerals yearbook and inventory information system (RM1), and ensure the information uploaded to the EGDI repository and extensions.

Actions of WP8

The tasks in this WP described below, will ensure that the requirements of this project are fully understood and considered in the IP-project. A dedicated collaboration structure coordinated though this WP toward the IP-project WP 1, will be established at an early phase (M1). In addition, the following tasks will be carried out:

Task 8.1: Requirements (M6-9) - Internal IT requirements to be able to deliver final data package to Information Platform. Task undertaken by lead partner in collaboration with internal IT experts.

Task 8.2: Prototyping (M14-18) - Testing of internal means in terms of data storage, treatment and delivery. Task undertaken by lead partner in collaboration with central GeoERA Information Platform.

Task 8.3: Testing and implementation (M24-36) - testing and implementation/delivery of external links and delivery to central data platforms. In collaboration with all lead partners of WPs and central GeoERA Information Platform.

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Note: WP8 depends on the internal workings of FRAME but is also dependent on the other projects, namely, GIP-P and Mintel4EU. These projects will governs the data structure and mode of delivery as these were not yet fully defined at the start of the project. FRAME will align with the directives of these projects and adapt accordingly. Hence, WP8 objectives and actions may adapt in the early part of the project.

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