FRAME
FORECASTING AND ASSESSING EUROPE'S STRATEGIC RAW MATERIALS NEEDS

DELIVERABLE D4.1

Overview of the phosphate deposits and occurrences in Europe under the form of a database and map(s)

WP 4 "Critical Raw Materials in phosphate deposits and associated black shales"

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

GeoERA RAW MATERIALS

Table of Contents

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1. Introduction

The objectives of this deliverable are to prepare an overview of the phosphate deposits and occurrences in Europe by compiling an integrated database, based on the literature and older data sources.

The data contributing to the development of the database are meant to give information about the potential in Critical Raw Materials (CRMs) of phosphate mineralization, and help to identify new areas of interest for CRMs, based on criteria as: (i) the different commodities/CRMs associated with phosphate deposits (REE, F, V, U and Y); (ii) the size of the deposits according to their known tonnages; (iii) the type and origin of the phosphorus-phosphate mineralization and deposits; (iv) the age of the deposits/occurrences and the host rock; (v) the commodities/CRMs (Be, Sb, Co, PGM, V and Cr) associated with black shales, when applicable and available.

2. Methodology

The database has been shaped to take into account the above mentioned information, in compliance with the Inspire requirements.

The partners of this WP have provided information from within their own countries. Data from other European countries have been collected by WP4 partners from readily available literature and data sources.

The data sources used to fill in this new database are ProMine, FODD (Fennoscandian Mineral Deposit Database), SIORMINP (Sistema de Informação de Ocorrências e Recursos Minerais Portugueses), and Mine records database (Ireland).

In addition, information extracted from about 56 references, among which very recent ones, are mentioned in the database. These papers usually allow compiling up-to-date mineralogical and geochemical data, which will be helpful in a further stage of this WP. This is particularly true regarding the geochemical data (whole rock and in situ analyses of apatite), which give clues about the enrichment in CRMs of apatite and phosphate deposits/occurrences.

3. Outcome

3.1. Database

The database compiled for this first deliverable present 429 phosphate deposits and occurrences throughout Europe. This is undoubtedly one of the most complete (if not the most complete) database about phosphate mineralization in this continent.

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The tables 1 to 4 presented here below illustrate the work done for phosphate deposits and occurrences in Belgium (the complete database is provided as Annex 1).

The database comprises 27 columns, giving information about:

- the coordinates, name, locality, and country of the deposit/occurrence (columns A to F, see Table 1). A column (D in the present stage of the database) will allow numbering the new samples studied in the frame of this WP
- the commodities (main commodity and all commodities) present in the deposit/occurrence, the mineral occurrence type, and its importance (columns G to J, Table 1)
- the host rock (and its age), the mineral deposit type, and the age of the mineralization (columns K to N, Table 2)
- the mine status, reserves, resources, reporting codes (JORC, NI 43-101, Russian), commodity (ore vs P2O5) and grade (columns O to U, Table 3)
- the petrography, mineralogy, and geochemistry of the mineralization, and references where the information can be found (when applicable, and if the data are not already extensively presented in the database) (columns V to AA).

Taken as a whole, this database shows fairly well the diversity and potential regarding phosphate mineralization in Europe. Additional information regarding other CRMS and commodities are given either in the "main commodity"/"all commodities" columns, or as chemical analyses (columns W and Y). The latter are quite scarce at the present stage of the project, but their number will tremendously increase in the next few months.

Table 1. Structure of the database - part 1. Data for Belgian phosphate deposits and occurrences

	A	B	C	D	E	F	G	H	I	J
1	Longitude	Latitude	Deposit Name	Identifiant	Locality	Country	Main Commodity	Mineral occurrence type	All commodities	Importance
2	3.94605	50.42445	Mons basin		Hainaut	Belgium	Phosphate	District	Phosphate	Large
3	3.73759	50.73678	Flobecq		Flobecq	Belgium	Phosphate	Occurrences	Phosphate	Occurrence
4	5.54338	50.67591	Rocourt		Rocourt	Belgium	Phosphate	Occurrence	Phosphate	Occurrence
5	5.48163	49.52591	Lamorteau		Lamorteau	Belgium	Phosphate	Occurrence	Phosphate	Occurrence
6	5.5007	49.53543	Harnoncourt		Harnoncourt	Belgium	Phosphate	Occurrence	Phosphate	Occurrence
7	5.83458	49.56298	Athus		Athus	Belgium	Phosphate	Occurrence	Phosphate	Occurrence
8	5.79842	49.57166	Aubange		Aubange	Belgium	Phosphate	Occurrence	Phosphate	Occurrence
9	5.90585	50.32609	Grand-Halleux		Grand-Halleux	Belgium	Phosphate	Occurrence	Phosphate	Occurrence
10	5.56667	50.63333	Liège- Meuse Valley		Liège- Meuse Valley	Belgium	Phosphate	District	Phosphate	Small
11	4.86667	51.20000	Demer (bassin de la)		Demer (bassin de la)	Belgium	Iron	Occurrence	Iron, Phosphate	Occurrence
12	5.03333	51.28330	Nethe (fleuve) Petite et Grande		Nethe (fleuve) Petite et Grande	Belgium	Iron	Occurrence	Iron, Phosphate	Occurrence
13	3.83333	50.48333	Baudour		Baudour	Belgium	Phosphate	Occurrence	Phosphate, Uranium	Occurrence
14	5.35000	50.66670	Momalle		Momalle	Belgium	Phosphate	Occurrence	Phosphate	Occurrence
15	3.95667	50.41667	Saint Symphorien		Saint Symphorien	Belgium	Phosphate	Occurrence	Phosphate, Uranium	Occurrence

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Tableau 2. Structure of the database - part 2. Data for Belgian phosphate deposits and occurences

	A	B	C	K	L	M	N
1	Longitude	Latitude	Deposit Name	Host-rock	Host-rock age	Mineral Deposit Group	Mineralization age
2	3.94605	50.42445	Mons basin	Chalk, Craie de Ciply and Tuffeau de Ciply	Upper Cretaceous and Palaeocene	phosphorite	Upper Cretaceous and Palaeocene
3	3.73759	50.73678	Flobecq	Clays and sands	Upper ypresian	phosphorite	Upper Ypresian
4	5.54338	50.67591	Rocourt	Clays and sands	Maastrichtian	phosphorite	Maastrichtian
5	5.48163	49.52591	Lamorteau	Ferruginous limestone	Lias	oolitic iron/ironstone	Lias
6	5.5007	49.53543	Harnoncourt	Ferruginous limestone	Lias	oolitic iron/ironstone	Lias
7	5.83458	49.56298	Athus	Ferruginous limestone	Lias	oolitic iron/ironstone	Lias
8	5.79842	49.57166	Aubange	Ferruginous limestone	Lias	oolitic iron/ironstone	Lias
9	5.90585	50.32609	Grand-Halleux	Dark shales and silty quartzites	Middle Cambrian	phosphorite	Middle Cambrian
10	5.56667	50.63333	Liège- Meuse Valley	Clays and sands	Maastrichtian	phosphorite	Maastrichtian
11	4.86667	51.20000	Demer (bassin de la)	Oolitic ferruginous limestone	Lias	oolitic iron/ironstone	Lias
12	5.03333	51.28330	Nethe (fleuve) Petite et Grande	Oolitic ferruginous limestone	Lias	oolitic iron/ironstone	Lias
13	3.83333	50.48333	Baudour	Chalk, Craie de Ciply and Tuffeau de Ciply	Upper Cretaceous and Palaeocene	phosphorite	Upper Cretaceous and Palaeocene
14	5.35000	50.66670	Momalle	Chalk, Craie de Ciply and Tuffeau de Ciply	Upper Cretaceous and Palaeocene	phosphorite	Upper Cretaceous and Palaeocene
15	3.95667	50.41667	Saint Symphorien	Chalk, Craie de Ciply and Tuffeau de Ciply	Upper Cretaceous and Palaeocene	phosphorite	Upper Cretaceous and Palaeocene

Table 3. Structure of the database - part 3. Data for phosphate deposits and occurrences in Belgium

	A	B	C	O	P	Q	R	S	T	U
1	Longitude	Latitude	Deposit Name	Mine status	Reserves	Resources	Code, commodity	Avg. Grade - Reserves	Avg. Grade - Resources	Grade unit
2	3.94605	50.42445	Mons basin	closed		600-900.000.000			8-10.5	%
3	3.73759	50.73678	Flobecq	not operating						
4	5.54338	50.67591	Rocourt	closed					21	%
5	5.48163	49.52591	Lamorteau	not operating						
6	5.5007	49.53543	Harnoncourt	not operating						
7	5.83458	49.56298	Athus	not operating						
8	5.79842	49.57166	Aubange	not operating						
9	5.90585	50.32609	Grand-Halleux	not operating						
10	5.56667	50.63333	Liège- Meuse Valley	closed		5.000.000				
11	4.86667	51.20000	Demer (bassin de la)	not operating						
12	5.03333	51.28330	Nethe (fleuve) Petite et Grande	not operating						
13	3.83333	50.48333	Baudour	not operating						
14	5.35000	50.66670	Momalle	not operating						
15	3.95667	50.41667	Saint Symphorien	not operating						

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Table 4. Structure of the database - part 4. Data for phosphate deposits and occurrences in Belgium

	A	B	C	V	W	X	Y	Z	AA
1	Longitude	Latitude	Deposit Name	Petrography	Mineralogy	Whole rock analyses	Isotope analyses	Microanalyses	References
2	3.94605	50.42445	Mons basin	Yes	Yes	Yes	O and Sr isotopes	Yes	Robaszynski, 1989; ; Jacquemin et al., 2019; Decrée et al., in prep
3	3.73759	50.73678	Flobecq						Notholt et al., 1979
4	5.54338	50.67591	Rocourt						Notholt et al., 1979
5	5.48163	49.52591	Lamorteau						Notholt et al., 1979
6	5.5007	49.53543	Harnoncourt						Notholt et al., 1979
7	5.83458	49.56298	Athus						Notholt et al., 1979
8	5.79842	49.57166	Aubange						Notholt et al., 1979
9	5.90585	50.32609	Grand-Halleux	Yes	Yes	Yes	O and Sr isotopes	Yes	Graulich, 1980; Decrée et al., in prep
10	5.56667	50.63333	Liège- Meuse Valley						ProMine database
11	4.86667	51.20000	Demer (bassin de la)						ProMine database
12	5.03333	51.28330	Nethe (fleuve) Petite et Grande						ProMine database
13	3.83333	50.48333	Baudour						ProMine database
14	5.35000	50.66670	Momalle						ProMine database
15	3.95667	50.41667	Saint Symphorien	Yes	Yes	Yes	O and Sr isotopes	Yes	Robaszynski, 1989; ; Jacquemin et al., 2019; Decrée et al., in prep

3.2. Maps

The maps drawn after the database constitute an added value to the database itself, since they allow visualizing at a glance the most striking features concerning phosphate mineralization in Europe.

In the frame of this deliverable, three maps (draft version) have been drawn. The first one (Figure 1) presents the location of phosphate deposits and occurrences in Europe. The size of the symbol used on the map directly relates to the size of the deposit (not yet UNFC compliant, but aiming to at the end of the project).

The second map (Figure 2) allows discriminating the different "Mineral Deposit Types" (according to *Inspire*). This map gives clues about the metallogenic provinces and the genetic type of the phosphate mineralization. The latter has typically an incidence on the potential in CRMs of the deposit.

The last map (Figure 3) shows the deposits/occurrences according to their age. This map allows considering the regions where important phosphogenetic event occurred. This is also of interest because the potential in CRMs of sedimentary phosphate deposits is highly dependent on their age and the environment/settings in which they formed (Emsbo et al., 2015).

Both maps 2 and 3 aim at indentifying new areas of interest for CRMs, and constrain the potential of the deposits. The new geochemical data to acquire in the course of this project will help to better constrain these zones.

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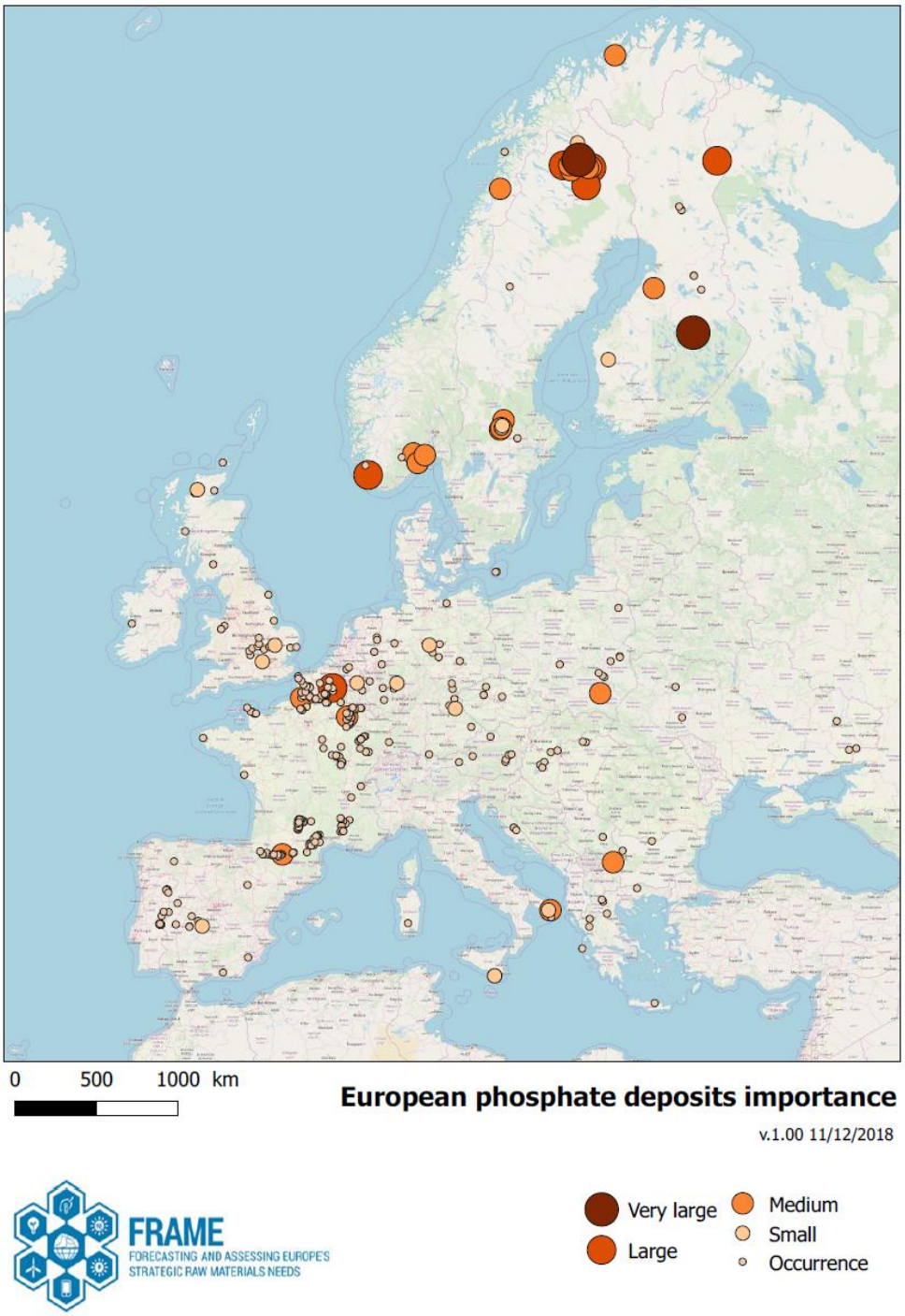

Figure 1. Phosphate deposits and occurrences in Europe. Deposit size: Small (>X) 2,000,000; Medium (>X): 20,000,000; Large (>X): 200,000,000; Very large (>X): 2,000,000,000 tonnes. Draft version of the final map to provide for deliverable D4.5

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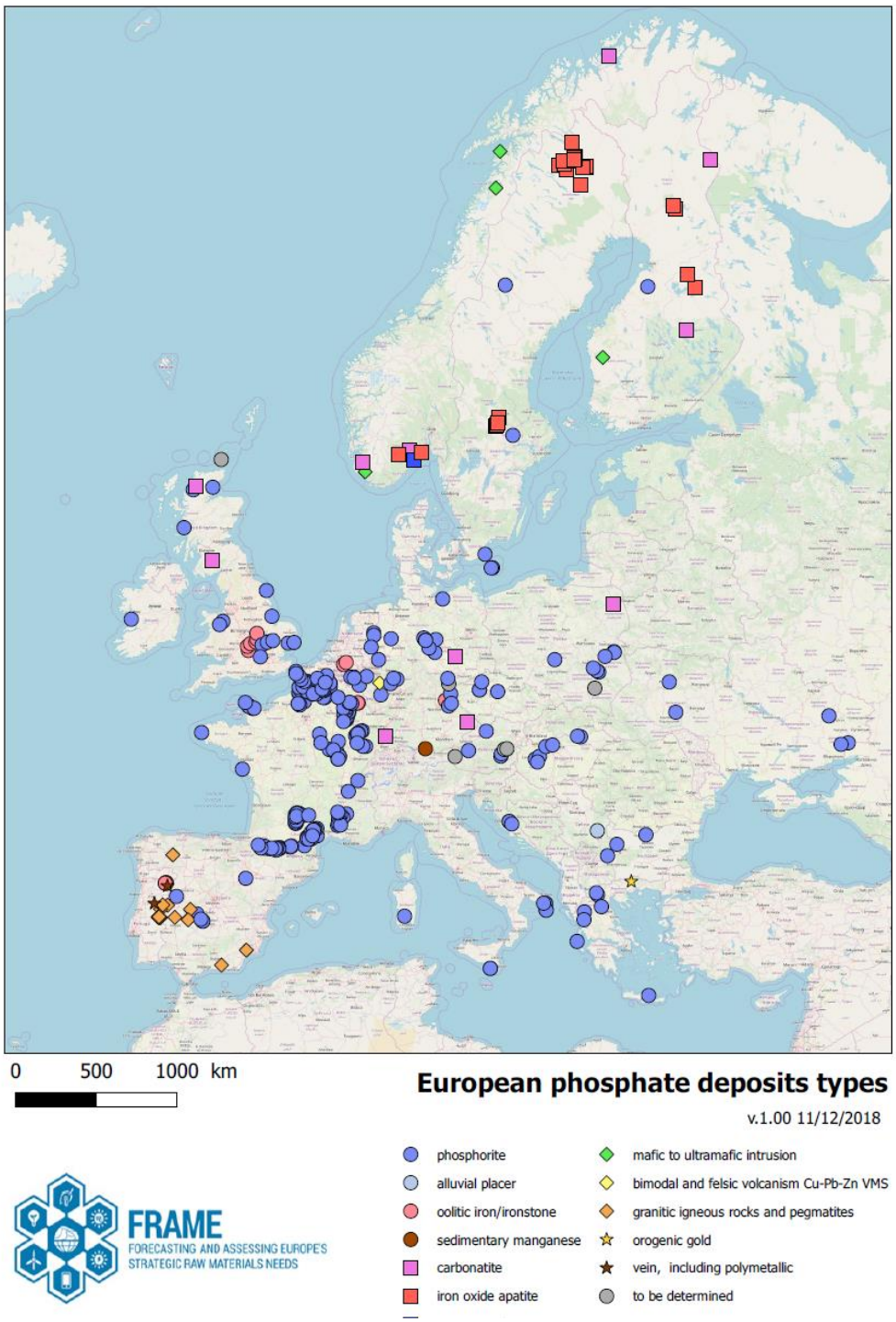

Figure 2. Mineral deposit type of phosphate mineralization and deposits in Europe. Draft version of the final map to provide for deliverable D4.5

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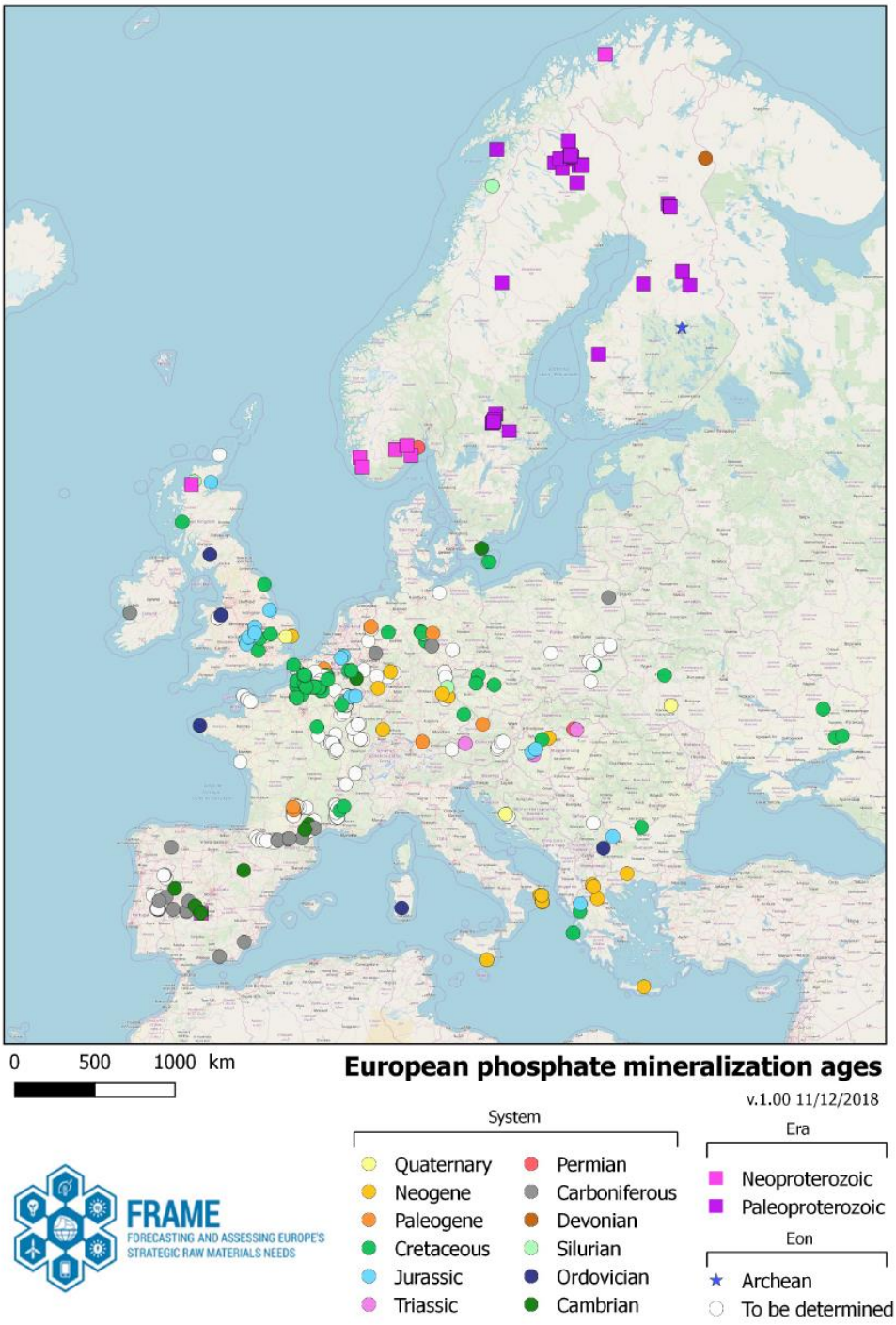

Figure 3. Map illustrating the phosphate deposits/occurrences according to their age (System/Period for Phanerozoic mineralization, Era for Proterozoic mineralization, and Eon for Archean mineralization). Draft version of the final map to provide for deliverable D4.5

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4. Prospects

In the future, an enhanced database will be developed, compiling data collected for deliverable D4.2 “New mineralogical and geochemical data on samples from phosphate deposits/occurrences (+host black shales)” and deliverable D4.3 “Detailed metallogenic studies of key phosphate deposits”.
The combination of these new data sets will lead to a better understanding of the CRM distribution and enrichment within phosphate deposits, and help to identify and highlight the potential of these deposits regarding the CRMs.
In addition, the general structure of the database could evolve a bit to accommodate data/information that haven’t been taken into account so far and are yet needed. If so, this will be done as far as possible in compliance with the Inspire requirements.
Finally, 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.
Regarding the maps, even though only three of them are presented for this first deliverable, more will be produced/developed from the database to fit at the best the needs of the FRAME and other GeoERA projects

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