

Optimising quality of information in RAW MAterial data collection across Europe

Deliverable 1.2: Final analysis and recommendations for the improvement of statistical data collection methods in Europe for primary raw materials

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Publishable abstract

This report brings together the outputs of Task 1.1 and 1.2 of Work Package 1 of the ORAMA project. Task 1.1 aims to produce an inventory of how minerals data are collected within Europe, via a survey of data providers, and Task 1.2 aims to review previous work from past projects, working groups and professional organisations in this subject area. Together this has built a comprehensive understanding of how minerals data are collected in Europe, what data gaps exist, what the issues are with regard to creating harmonised European datasets for minerals information and what good practice examples exist that lessons can be learnt from.

The results of the survey show that countries that have a clear legal and regulatory procedure for collecting data often have the most robust systems in place. These countries often also have a strong motivation for collecting such data, such as receiving a significant income from mineral royalties as a result of state ownership of minerals, although resource management or land use planning also provide motivation for the collection of data. The results of the survey also showed there is a large variety in the way data is collected within Europe. This variety is not necessarily an issue with regard to harmonisation as long as data providers ensure that they adhere to common data standards and classification systems, such as INSPIRE or UNFC when providing data for aggregation at a European level.

The review of previous projects showed the breadth of work that had gone into the improvement of statistical datasets over the last few years. Especially from projects such as Minventory and Minerals4EU, which provide a clear roadmap for harmonising European minerals datasets, or the work of the EGS MREG (EuroGeoSurveys Mineral Resources Expert Group) towards the harmonisation of resource and reserve codes within Europe. A common theme of many of these recommendations is the need for common standards to be adhered to and that in some instances these specifications may need to be adapted to accommodate statistical data for mineral resources which are aggregated at a national scale.

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Abbreviations and acronyms

AMRI	Annual Minerals Raised Inquiry
BGS	British Geological Survey
CN	Combined Nomenclature, a system for trade codes
ComExt	The EC's database for statistics on international trade in goods
CRIRSCO	Committee for Mineral Reserves International Reporting Standards
Diskos-NDR	National Data Repository of the Norwegian Petroleum Directorate
EGDI	European Geological Data Infrastructure
EGS	EuroGeoSurveys
E-PRTR	European Pollutant Release and Transfer Register
ERA-NET	European Research Area Net
ETP-SMR	European Technology Platform on Sustainable Mineral Resources
EU	European Union
EURMKB	European Union Raw Materials Knowledge Base
EU-RMICP	European Union Raw Materials Intelligence Capacity Platform
EUROSTAT	Statistical Office of the European Union
GeoZS	Geological Survey of Slovenia
GIS	Geographical Information System
GTK	Geological Survey of Finland
HS	Harmonised System, a system for trade codes
INSPIRE	Infrastructure for Spatial Information in the European Community
INTRAW	International Cooperation on Raw materials
IUGS	International Union of Geological Sciences
JORC	Joint Ore Reserves Committee
MICA	Mineral Intelligence Capacity Analysis (H2020 project)
MBFSZ	Mining and Geological Survey of Hungary
MREG	Mineral Resources Expert Group (from EuroGeoSurveys)
NACE	Nomenclature of Economic Activities
NGU	Geological Survey of Norway
PERC	Pan-European Reserves and Resources Reporting Committee
PRODCOM	"PRODUCTION COMMUNAUTAIRE" (Community Production)
REE	Rare Earth Elements
RMI	Responsible Minerals Initiative

RMIS	Raw Materials Information System (from EC DG JRC)
RMKG	Raw Materials Knowledge Gateway, the entry point to the RMIS
SPE-PRMS	Society of Petroleum Engineers - Petroleum Resource Management System
TUKES	Finnish Safety and Chemicals Agency
UNCOMTRADE	United Nations Commodity trade Database
UNECE	United Nations Economic Commission for Europe
UNECE EGRC	United Nations Economic Commission for Europe - Expert Group on Resource Classification
UNFC	United Nations Framework Classification for Resources
UNRMS	United Nations Resource Management System (the successor of the UNFC from the second half of 2018).

EXECUTIVE SUMMARY

This report is the combination of tasks 1.1 and 1.2 of the ORAMA Project. It is the second of two deliverables combining these tasks. The first deliverable was an initial analysis of data collection methods with Europe and a review of recommendations of previous projects. Whereas this (second), deliverable 1.2 of the ORAMA Project, includes a more detailed discussion of the future recommendations for minerals data harmonisation and improvement to statistical datasets that can be taken from previous projects and analysis of current practices.

This deliverable is a joint output of the British Geological Survey (BGS) and the Mining and Geological Survey of Hungary (MBFSZ), with additional input from other project partners. BGS have completed the analysis of statistical data collation methods (section 2) and MBFSZ have undertaken the review of previous projects (section 3).

This report comprises a review and analysis of data collection methods, data harmonisation issues and solutions and good practice examples for minerals data within Europe. This has been achieved by a survey of minerals data providers and a review of recommendations made by previous projects that have worked in this area. The results of the survey and review of past projects have been used to summarise how minerals data in Europe could be better collected, presented and harmonised in the future.

The review of data collection methods was conducted via the use of a survey to primary data providers. The survey had 70 responses containing useful information (83 response in total), although not all responders answered all questions. Some of the main conclusions of the survey are that:

- the majority of all minerals data collection is carried out as a result of legal requirements in Member States to collect data;
- the three main data collection methods are a full census of the minerals industry, a representative sample extrapolated to represent the whole of the mineral industry and data provided under mineral licensing requirements;
- the survey also showed both ambiguity over the products of the minerals industry (e.g. metal content vs gross weight of ore) and significant data gaps for many downstream products for both production and trade data;
- that data sharing between national bodies and the European Commission is common, with the European PRODCOM dataset often being reused; and
- Exploration data is the least reported and least understood data type considered by the survey (which covered production, trade, resources and exploration). The metrics used to measure mineral exploration throughout Europe vary greatly.

Previous projects and expert forums in this subject area (e.g. Mininventory, Minerals4EU, Intraw) have made a number of recommendations that include ones aimed at improving the quality and availability of statistical datasets. The existing recommendations are examined in this report to identify which ones are relevant to the specific topics addressed by the ORAMA project; which ones have already been implemented and the effect they have had (using case studies where possible); and which would lead to the development of good practice if they were implemented. Of specific interest are relevant recommendations that consider how to integrate different approaches and to facilitate data harmonisation for primary mineral resources for different stakeholders of the raw material community.

A theme of many of the projects described in this report is that the INSPIRE compliant environment is an appropriate basic framework to develop the interoperability and describing mineral resources with the opportunity of exchanging related datasets. Mineral resources naturally have a spatial dimension and as such INSPIRE can be used to embed statistical datasets for mineral resources but only if the data are collected and stored alongside the spatial element and in many cases, this does not currently occur. The comparability of Europe's mineral resources, using an INSPIRE compliant environment, requires that the statistical data, that is embedded with the spatial data, is aligned with a single internationally recognised system of reporting for harmonised reporting on a national or European scale. It would seem that the United Nations Framework Classification (UNFC) is the most versatile and useful method for defining mineral resources in a consistent way. Although an individual country's mineral resource data may be collected according to national classification systems or reporting standards, and in some cases these are mandated by national laws or for commercial investors through stock exchanges, for the purposes of strategic planning at trans-national scale these data need to be translated into a single reporting system for Europe. This can be achieved with the UNFC classification framework by using bridging procedures associated with these other commonly used codes and classifications. For countries that do not have a history of resource management and do not have minerals inventories or experience of using standard codes and classifications, it will be more challenging to develop data suitable for harmonisation and at European level. This will require help with training and expert input to the relevant government bodies, which is what it is hoped that ORAMA can begin to provide. These types of resource are important if data providers, such as national geological surveys, are to become authorised bodies for the provision of resource data adhering to the UNFC system.

It must also be recognised that regardless of harmonisation significant gaps still exist with regard to European resource data. This must be taken into account when comparing data across national boundaries as the absence of data does not mean there are no resources. Equally the presence of data may not represent the totality resources, uneconomic or poorly defined resources are often not considered, although the UNFC does have the flexibility to include these figures. These undiscovered resources can only be delineated by detailed geological assessments.

The examples of good practice reviewed here show three clear themes that are common for the provision of quality harmonised primary raw materials data: data collection by an organisation with a clear responsibility and a legal basis to do so; a robust legal system to ensure data is provided in the correct format and at correct resolution; and a clear set of standards for data to ensure interoperability between different countries and bodies responsible for data collection. These suggest that for future harmonisation of European raw materials data, either an INSPIRE type approach could be taken, where standards and procedures for data harmonisation is legislated for, which may be a long-term goal and unlikely for the foreseeable future, or projects, such as ORAMA, could provide training materials on harmonisation (via aspects like the use of UNFC for resources data) and persuade geological surveys and other data collection agencies of the importance of obtaining high quality data on raw materials on a European level.

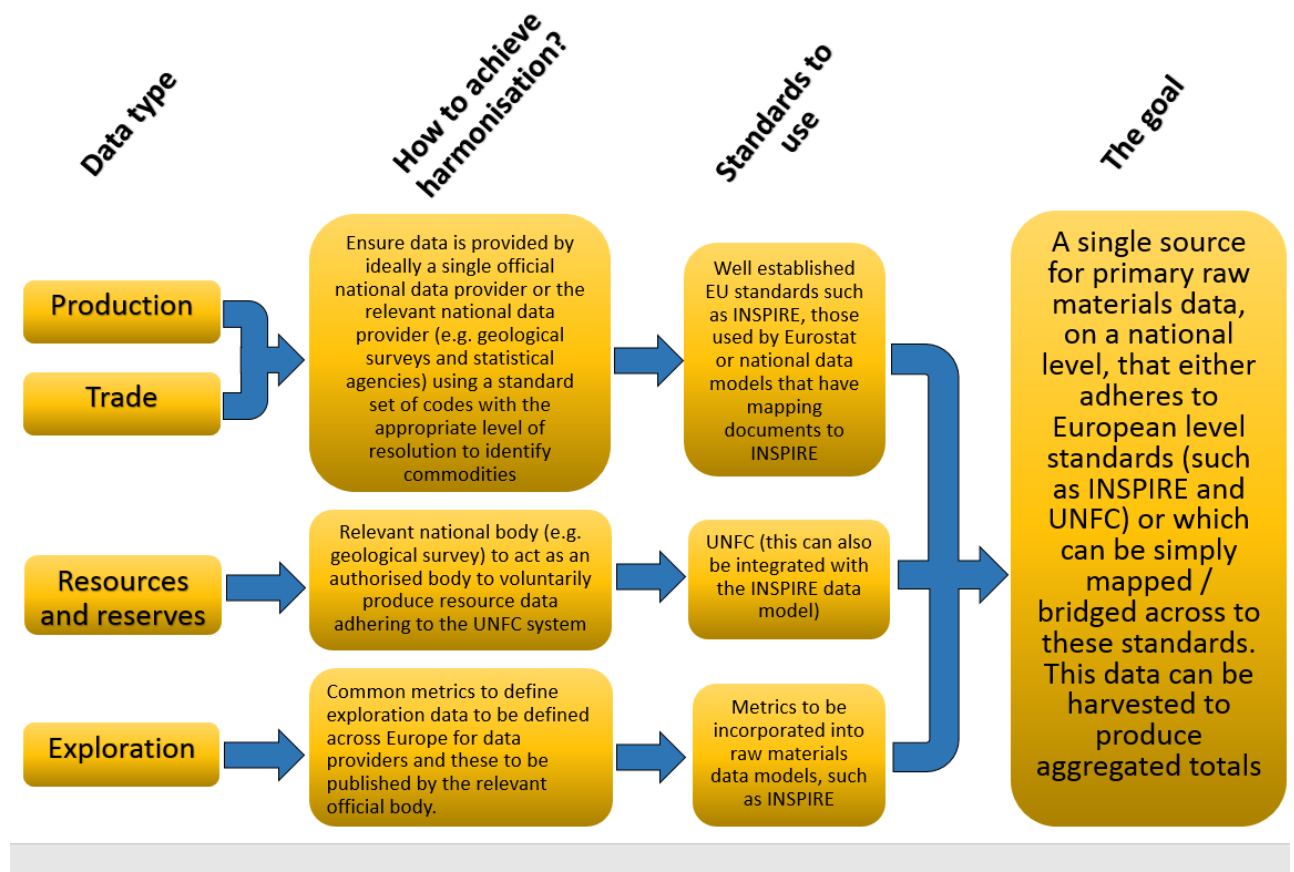
This report gives many examples of good practice that can be learnt from by data providers, helping them to move forward with the provision of harmonised European raw materials data. Many countries have strong resource management systems in place that rely on the collection of all types of raw materials data. This is especially so for countries that use derivations of the Russian resource code, for example, Hungary, Slovenia and Poland. This enables these countries to provide a single point of contact for official national raw materials data. Other good examples of resource management systems are also present in Europe. In the UK the land

planning system is used for some aspects of resource management, data for aggregates are produced by a compulsory survey to mineral producers, this is used to plan future demand and assess the current economic situation. As well as these ‘top-down’ resource management systems excellent examples of data collection and provision can also be seen via a bottom-up approach, where data to a consistent standard is collected from the minerals industry and stored in a central database. In Finland TUKES (Finnish Safety and Chemicals Agency) act as a single point of entry for all mining and exploration data. Outside the raw materials considered here, working with oil and gas, the Norwegian Petroleum Directorate is also an excellent example of this approach.

When considering data for resources and reserves a comprehensive database of mineral deposits is required. Excellent examples for this can be seen for the Fennoscandian Ore Deposits Database which has greatly aided European projects that have worked towards data harmonisation, such as ProMine.

Exploration data is the least well reported data type for primary raw materials, Ireland has clear systems of legally obliging minerals companies to report a wide range of metrics on exploration, which are collated by an official government body and then published in an accessible format.

A flow diagram outlining the recommendations and how they can be achieved for the various different types of data discussed in this report is outlined below:



1 Introduction and background

This report presents the results from Tasks 1.1 and 1.2 in Work Package 1 of the ORAMA project and includes a set of recommendations for future actions for primary raw materials data harmonisation. A previous deliverable (Deliverable 1.1) contained preliminary results of this analysis. Work package 1 is specifically focussed on the methods used to collect statistical data for primary minerals and consequently, it does not consider spatial datasets nor data relating to secondary raw materials.

The purpose of these two tasks is firstly to build an inventory of data collection methods used within Europe according to a broad classification and identify current barriers to harmonisation and ways these can be overcome (Task 1.1). Secondly, to examine previous recommendations from earlier projects to identify which ones are relevant to data collection methods, which have been implemented and the effect they have had, as well as facilitating the demonstration of the applicability of data harmonisation for primary minerals statistics for different stakeholders of the raw material community (Task 1.2). Both tasks have led to the identification of good practice examples and training needs.

After some initial background material in Section 1, Section 2 focuses on Task 1.1 while Section 3 considers Task 1.2. Some final comments in Section 4 aim to bring the work of both tasks together into a single set of conclusions.

1.1 Setting the scene: what do we mean by minerals data and why is it important?

The data being discussed in this report is statistical data on primary minerals production, imports, exports, resources, reserves and exploration. This deliverable is not considering spatial data, although spatial attributes could possibly be ascribed to many of the types of data discussed. By primary minerals this report is exclusively meaning minerals and ignoring biotic materials; we are also not including energy minerals (coal, oil, gas and uranium).

These data are important because all industries (and human activities) depend upon supplies of raw materials and consequently knowing how much is produced enables governments and industries to plan for continuous uninterrupted supplies. In an increasingly connected world supplies are no longer produced locally to where they are used so an understanding of how minerals are traded and shipped around the world is a part of ensuring supplies are maintained. Attention has been drawn in recent years to how much there might be 'in the ground' so interest has increased in the scale of resources and reserves (although that has led to a great deal of misunderstanding and misuse of statistical data). Interest has also increased with regards to exploration activities and how much more is being discovered because this feeds into resources.

However, with more than 30 individual sovereign countries on the continent of Europe, all with extensive histories and different cultures, the evolution of data provision has inevitably varied widely in both time and space. Each nation is entitled to develop its own system for managing its resources to suit its own use and may have built up its own systems and processes for doing so. This works fine when a country is operating in isolation, but with the world becoming increasingly interconnected, and with an increase in the number of commodities necessary for our high-tech world, being able to compare country to country across the continent becomes more important so that nations can work together to ensure supplies for all countries of Europe are maintained.

1.2 Legal requirements for data collection

Each individual country will have its own internal legal requirements for collecting and publishing data relating to minerals. This project is not considering whether these laws are appropriate, but rather is examining data at a more strategic EU level.

Within the EU there is a legal requirement to provide data on primary mineral production (for the PRODCOM database) and trade (for the ComExt database). However, although these data can be regarded as harmonised, this does not necessarily mean the data will be available at a suitable resolution for public reporting of national level aggregated data. Often individual commodities cannot be split from larger aggregated groups and large amounts of data are confidential and cannot be publically released.

There is a legal requirement for all EU countries to submit trade data, both within the EU and with external partners, for all trade including primary minerals, to the Intrastat system (Regulation (EC) No 638/2004 and Regulation (EC) N 471/2009). For countries outside the EU, there is no international legal basis for trade data to be publically reported but almost all countries report customs returns which allows these data to be collected by the United Nations (UN) which is assessed via the UN Commodity trade database (UN Comtrade).

There are no legal requirements within the EU for the collection of data regarding mineral resources and reserves and data regarding mineral exploration. As a result, each country will have different quantities of data depending on the legal and regulatory regime that exists within that nation for the mining sector. Some may have a detailed inventory of primary minerals and others may have no data whatsoever. This must be taken into account when comparing data across national boundaries. In many countries, the data simply do not exist or are in ad-hoc or informal formats. **The absence of data does not mean there are no resources.** Equally the presence of data may not represent the totality of the continent's endowment for a commodity, i.e. there may be additional minerals which have not been identified or sufficiently quantified to be considered 'resources'. These undiscovered resources can only be delineated by detailed geological assessments, it is rare for such studies to have been undertaken and included into national resource inventories.

1.3 Who collects minerals data in Europe?

Data regarding primary minerals cover a wide spectrum of potential data and as a result, there are a number of different organisations that collect and publish these data. Exactly who publishes what within a county will often depend on the regulatory and legal framework that determines who has responsibility for certain aspects of primary minerals extraction, for example licencing, taxation, environmental monitoring, etc. There are three main types of organisations who collect and publish these data: geological surveys, national statistical offices and mining authorities. Ultimately the source of all data will be from the minerals industry, i.e. the mining companies, who will supply them on a legal or voluntary basis, depending on the data type, for aggregation at a regional or national level. This flow of data between companies, regional and national governments and European organisations, however, is not linear. Many organisations collect data from other organisations, so a national statistics office may aggregate data from other government organisations as well as companies. These data may then be reported elsewhere for other purposes and possibly aggregated further. Therefore it is important that the source of data and the methodology used to collect them is understood first before use and before recommendations for harmonisation can be made.

1.3.1 National Geological Surveys

Traditionally national geological surveys have had an important role with regard to mineral exploration and many have a regulatory role within the minerals sector. National geological surveys, therefore, are often, but not always, the primary data collectors and providers for production statistics and data regarding exploration.

1.3.2 National Statistics Agencies

Almost all countries will have some form of national statistical agency that will be responsible for collecting and reporting important national statistical indicators and in many instances they have legal powers to collect statistical data. However, these bodies are not specialist scientific organisations and data regarding primary minerals will only be a minor part of the data they collect. As a result, these organisations often report data as received without the technical ability for detailed quality assurance or harmonisation between methods of reporting used by different companies or regions.

National statistical agencies are also normally responsible for the publication of trade data, which is usually reported via a national statistics portal. However, these data are often aggregated by sector, are sometimes indexed, or reported as values, making their presentation at a suitable resolution difficult and hindering the harmonisation of data across countries.

1.3.3 Mining Authorities

Many countries have specific mining authorities, which can be part of the national level government or delegated to regional or local authorities. These have a legal role in overseeing the mining sector and often also have a role in collecting data. In many cases the data they collect and hold may be confidential.

1.3.4 Other organisations

As well as the primary data providers in individual European countries there are several organisations who provide collations of data on a national level, or on a global or European level, that can be freely accessed. There are many other organisations who compile information for resale but they are not considered here because the data are not publically available for free. These data have undergone some degree of harmonisation and quality assurance, however, their provision relies on the third party organisations continuing to fund the provision of these datasets.

Organisations that provide free collations of global or European primary mineral data are:

- British Geological Survey: The BGS produces global annual production data for a range of metals and industrial minerals at a national level. It also publishes production data for construction aggregates and cement for European countries and has published European trade data in the recent past.
<https://www.bgs.ac.uk/mineralsUK/statistics/worldStatistics.html>;
<http://www.bgs.ac.uk/mineralsuk/statistics/europeanStatistics.html>
- United States Geological Survey: the USGS produces global annual production data for a range of metals, industrial minerals and some construction minerals.
<https://minerals.usgs.gov/minerals/>

- The Austrian Federal Ministry of Sustainability and Tourism produce a publication entitled World Mining Data: this publication is produced annually and contains global production data on a national level for a range of metals and industrial minerals. <http://www.world-mining-data.info/>
- Eurostat: Eurostat is a directorate of the European Commission and is responsible for providing statistical information to the commission and to harmonise statistical data across Europe. Eurostat publishes a very wide range of statistical information including production (PRODCOM), imports and exports (ComExt) for a wide range of commodities. Reporting of production data is based on NACE codes and trade data are available in both combined nomenclature (CN) and harmonised system (HS) classification systems. <http://ec.europa.eu/eurostat/data/database>
- UN Comtrade: this is the platform for the United Nations international trade statistics database. This contains information on an annual basis for over 170 countries for import and export of goods, reported using the harmonised system (HS) codes. <https://comtrade.un.org/>
- Minerals4EU: the Minerals for EU project produced a yearbook for a wide range of European primary mineral statistics, including production, trade, exploration and resources and reserves. Production and trade data were sourced from the BGS; other data were collected by specific surveys. The yearbook published data up to 2013 and the GeoERA project, Mintell4EU, plans to update this between 2018/19 and 2020/21. http://minerals4eu.brgm-rec.fr/m4eu-yearbook/theme_selection.html

2 Analysis of data collection methods

The main objective of task 1.1 was to build an inventory of data collection methods used within the countries of Europe, building on work carried out previously under the Minventory and Minerals4EU projects. This task has examined which types of organisations provide statistical data and has described in a broad sense where and how data are collected. As this is a challenging task due to a large number of organisations involved, a broad classification of data collection methods has been developed rather than an exhaustive list of data sources. This process enables the identification of good practice which will feed through to Task 1.5 for the development of technical guidance documents and training materials. This task has been aided by the use of an online questionnaire and by utilising the participants' contacts with data providers throughout Europe.

2.1 Survey of primary raw materials data collection methods

2.1.1 Purpose of survey

For primary minerals, the first stage of understanding where and how data are collected was obtained by surveying the organisations that collect data. This work builds on that of the Minventory and Minerals4EU projects, which both included some form of a survey of data providers, but this questionnaire attempted to clarify issues raised by those projects as well as gather new information for minerals data collection methods. The purpose of the survey was to gather metadata on which types of organisations provide statistical data and describe where and how data are collected. The aim is to both identify issues which will feed into recommendations for harmonisation and to identify examples of good practice.

2.1.2 Survey methodology

Due to the wide brief of the survey, looking at all issues with primary minerals data across Europe there was a need to carefully frame questions and constrain the scope and length of the survey to ensure as high as possible response rate, whilst still capturing the required information. To achieve this, the survey was designed with input from all project partners and advice from the ORAMA advisory board. The survey was split into four sections, each focusing in on one thematic aspect of primary minerals data. These were: production; exports and imports (trade); resources and reserves; and exploration. It was recognised that for many survey respondents one or more sections may not be relevant to this structure allowed the non-relevant sections to be easily skipped.

In a broad simplistic sense, the flow of data is: from extractive companies to a regional or national level government organisation, to further national government organisations (as needed) and/or to other collecting organisations (e.g. production data to BGS, trade data to Eurostat, etc.). However, in reality, the network of data flows is often quite complicated. The survey was designed to be completed by the initial government organisation that collected the primary data from the companies, rather than by the companies themselves or the end users of the data. It was considered that capturing information about data collection methods at this point in the data flow would most easily identify examples of good practice that could be used to improve processes elsewhere.

To this end requests to complete the survey and share with us some of their knowledge and experience in how their organisation collects data for primary minerals were sent to geological surveys, national statistical agencies, mining authorities and other relevant government agencies for the 30 European countries that the ORAMA project is concerned with. Contacts were obtained through BGS's own contact lists of organisations that dealt with these data, consultation with project partners and EuroGeoSurveys' list of geological surveys. In total 149 requests were directly sent out and more were forwarded on through third parties. The questionnaire was also featured on the ORAMA website. The survey ran from the 14th March 2018 to the 23rd May 2018. In total the survey received 70 responses, however, it should be noted that these do not represent 70 separate organisations, in many cases different contacts from the same organisations answered different aspects of the survey depending on their area of expertise. The survey received a good geographical spread of responses across Europe with at least one response from the majority of countries that were contacted. The geographical spread of survey responses can be seen in Figure 1 whilst Figure 2 provides a breakdown of the types of organisation that responded.

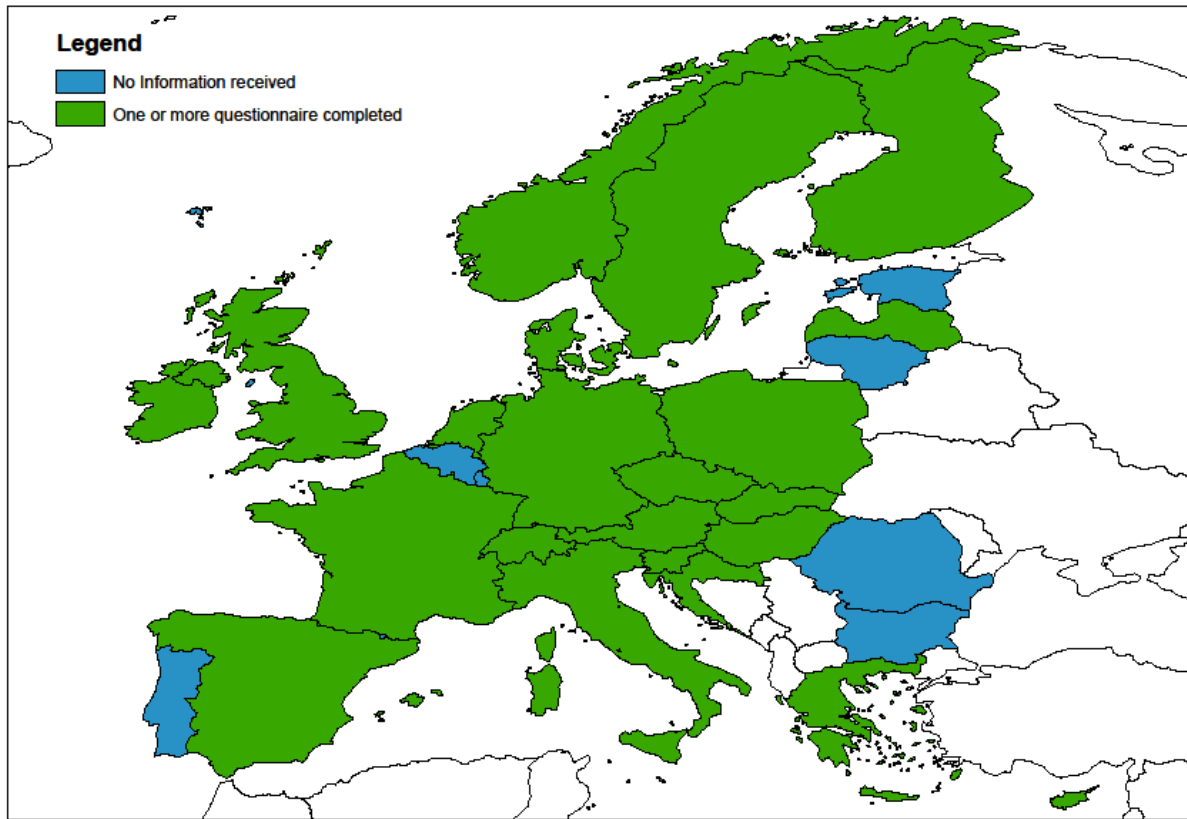


Figure 1 Geographical spread of responses

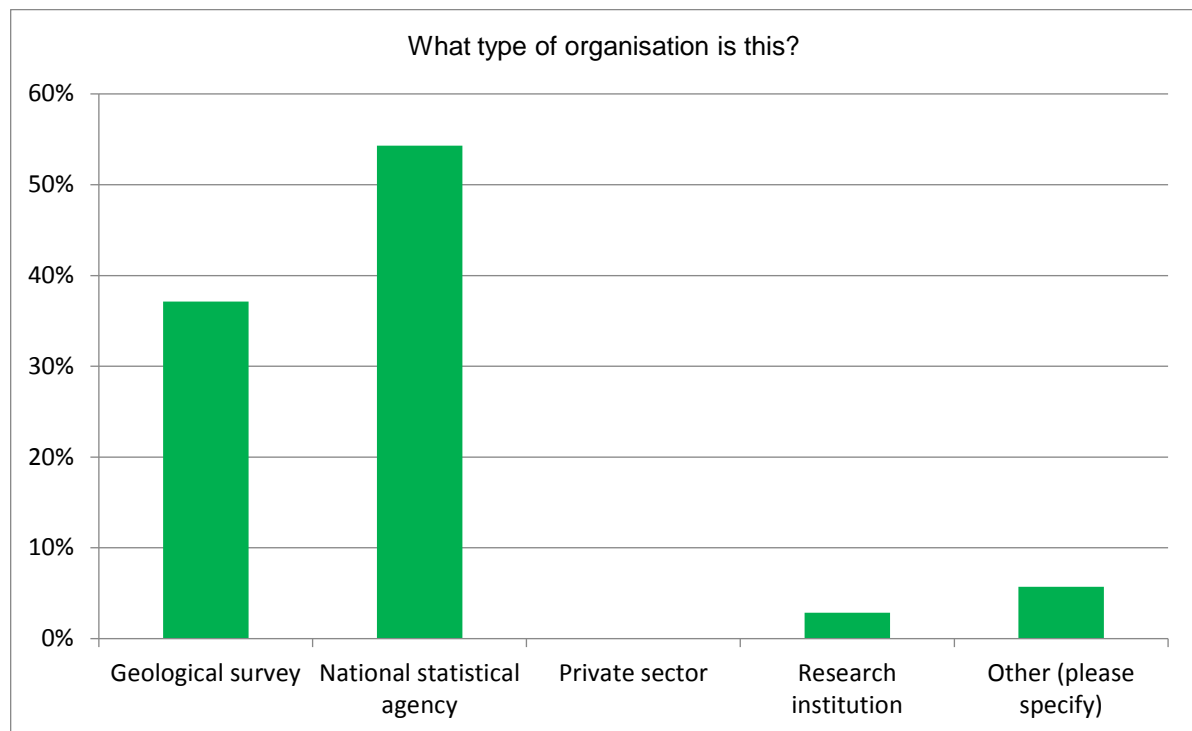


Figure 2: Response to a question relating to the type of organisation survey participants come from.

2.1.3 Survey results and analysis

The survey asked participants if they would share with us some of their knowledge and experience in how their organisations collect data for primary minerals. It was explained to them that the results of this questionnaire would help to form recommendations on how raw materials data collection could be improved.

The survey participants were asked to complete questions covering the following areas:

- Statistical data for production and extraction.
- Statistical data for resources and reserves.
- Statistical data regarding imports and exports of minerals.
- Statistical data on mineral exploration activities.

Each area asked questions broadly relating to the following:

- What data does their organisation collect?
- How does their organisation collect the data?
- What system(s) does their organisation use for reporting data?
- How are estimates calculated for missing elements of data?
- At what frequency does their organisation collect the data?
- Are there confidentiality constraints that their organisation has to comply with?

The responses to each of these areas are summarised below.

2.1.3.1 *Statistical data for production/extraction*

In total 58 survey participants said that their organisation published data for production/extraction. A further 36 of the survey participants continued to answer the questions relating to this theme, of these 36 respondents 20 were representing statistical agencies, 13 were geological surveys and the remaining three were mining authorities. Many of the questions enabled respondents to select more than one answer from the list provided (hence the percentages that follow do not always sum to 100%) and free text boxes were also available.

The survey asked participants at what stage in the life cycle of minerals do they publish statistical data for? The results of this can be seen in Figure 3. Of the 36 respondents, 83% said 'Mine production (i.e. material extracted from mine/quarry)' and 47% said 'Sold production (i.e. material sold from extractive operations)' although only four respondents solely publish sold production (all statistical agencies), the majority publish both. This distinction is important because 'sold production' implies that there could be material that has been extracted but not sold and remains on stock. For a strategic level of analysis, it can be assumed that stockpiled material will be accounted for in future years and this distinction can be ignored. However, detailed material flow analyses or mass balance calculations need to take these stocks into account. Further analysis shows that in general geological surveys are focused on the mineral extraction stage, with 100% of geological surveys who responded collecting this type of data. Whereas statistical agencies are more likely to report data on other life cycle stages, although 70% of those that responded to this section of the survey do collect mine production data. The number of respondents dropped significantly at later stages of the value chain, only 11 respondents stated they reported data for smelter/refinery production and very few report data for stocks or secondary production.

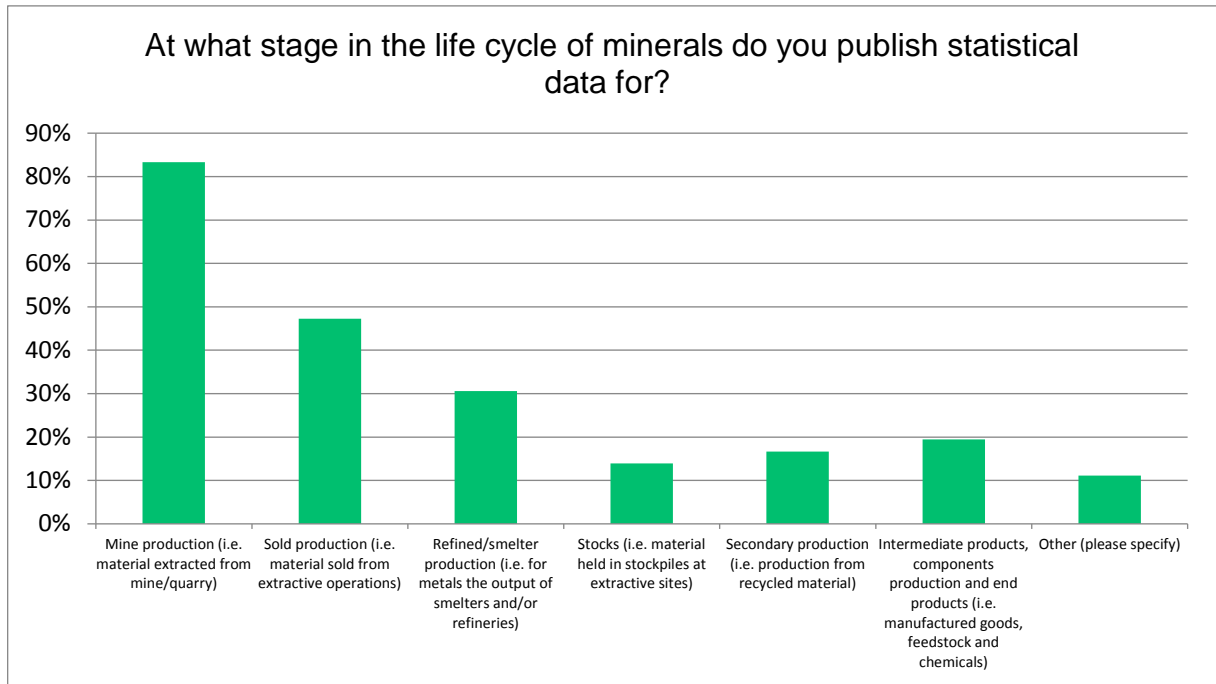


Figure 3, Lifecycle stages for production data

Over 80% of the survey participants' organisations collect data predominately from companies extracting/processing and recycling mineral resources as shown in Figure 4. Data is also obtained from national governments (25%), regional governments (19%), national statistical offices (17%), local government or regulators (6% each) or other sources (11%), which illustrates the non-linear nature of the data flow. 67% of respondents use a single source only and 56% of these single sources is company data. It is positive that the majority of sources are companies as this will ultimately be the source of all mineral production data and the more data that comes from primary sources the less scope there is for misunderstandings regarding the data.

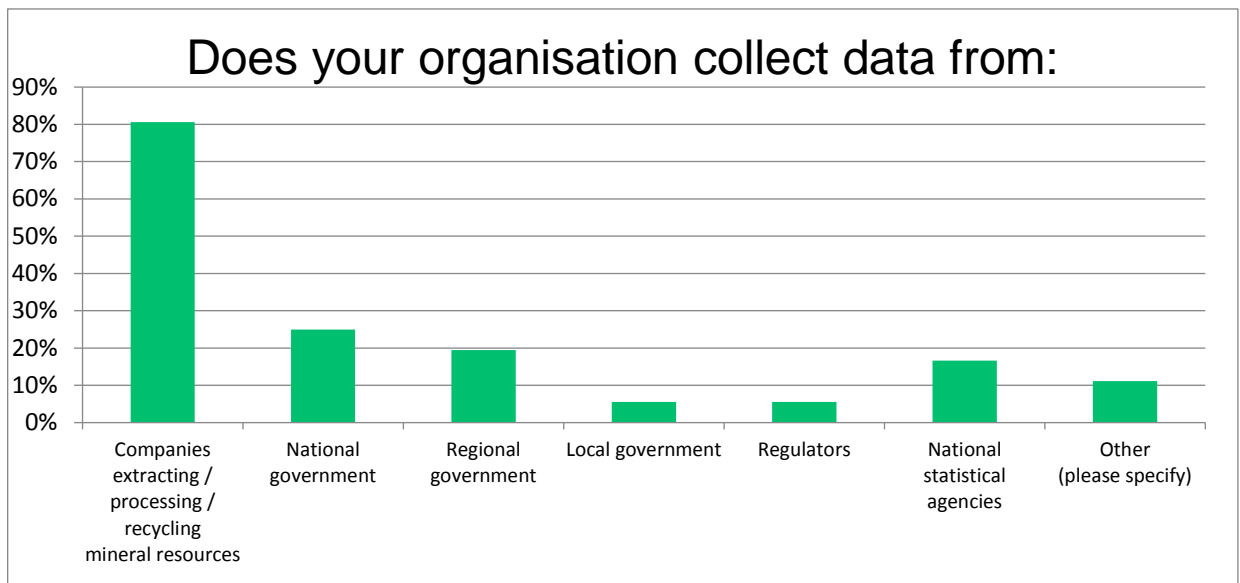


Figure 4, Data sources for production data

In terms of why an organisation collected this information, as shown in Figure 5, 47% said that they collect data for statutory/legal obligations and 33% said national reporting/land use planning requirements. Other options included mineral licencing (17%), environmental monitoring (11%), taxation or mineral royalties (8% each). None of the organisations collected the data for commercial purposes. The option ‘other reasons’ was selected by 31% of respondents and the comments in the accompanying free text box seem to suggest this is partially relating to a legal requirement to provide data to the EC for the PRODCOM database. To summarise, statistical agencies are more likely to collect data for other statutory/legal obligations, national reporting/land use purposes or taxation. Whereas geological surveys collect data for a greater variety of reasons but still with statutory and legal obligations in the majority. This highlights the different roles that the different types of organisation have, but also shows the wide range of reasons there can be for collecting the data. It emphasises that data are rarely collected if there is no specific reason for it. However, that reason could be that organisations are required to collect them due to legislation, even if there is not a full understanding of the subsequent uses they might be put to.

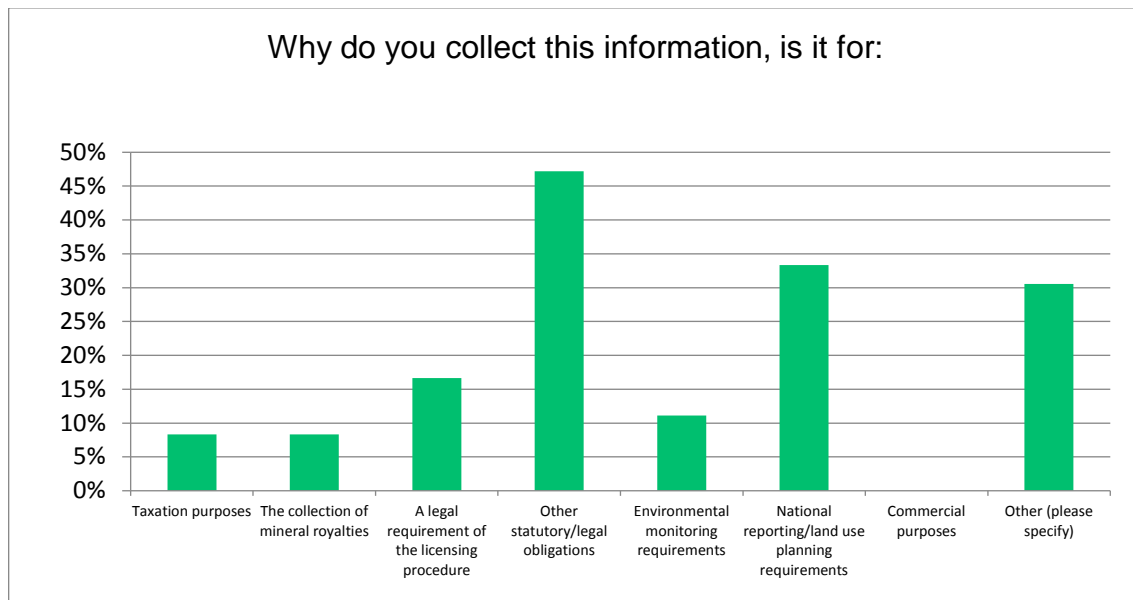


Figure 5, Why is production data collected?

The methods organisations use to collect their production data are shown in Figure 6. The highest proportion of all methods used in all commodity groups is ‘A request to ALL producing companies AND there is a legal requirement for them to respond’. Followed by ‘A request to SOME producing companies (not all) AND there is a legal requirement for them to respond’. These results suggest data is more likely to be collected if there is a legal basis for doing so and voluntary provision of data is rare. These results also show that it is more common for a full ‘census type’ survey to be carried out but partial ‘sample type’ surveys are also regularly done. The latter means some extrapolation is required in order to publish comprehensive results for the entire mineral industry.

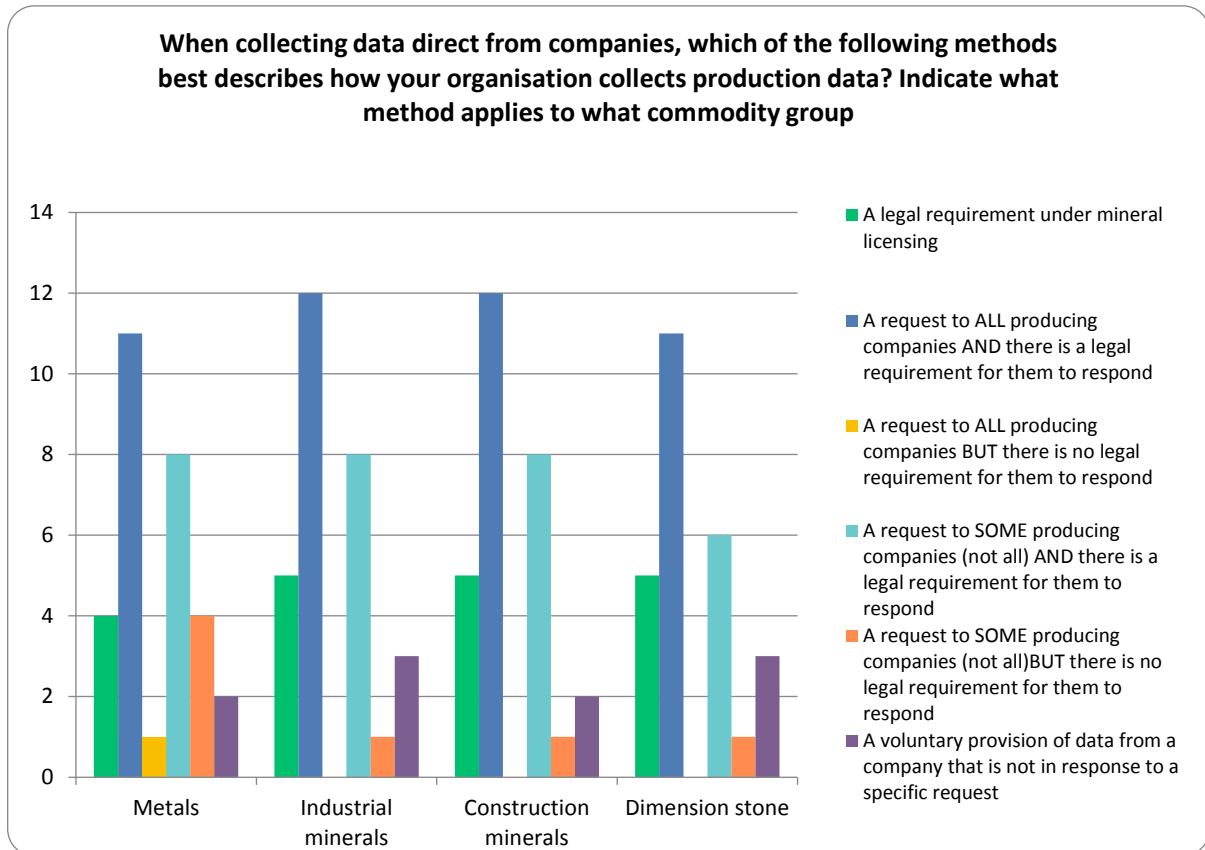


Figure 6: Methods by which organisations collect production data.

Of the 36 survey participants, 29 said that their organisations do not make estimates for any production of minerals that are missing from the data when collected. This is very important because it will lead to potentially significant under-reporting of Europe’s mineral production.

Most organisations (31 out of 36, equivalent to 86%) collect data as ‘quantity by mass e.g. tonnes’. A smaller proportion collect data by ‘quantity by volume e.g. cubic meters’ (44%) and by ‘value e.g. Euros’ (39%). No organisations collected data for value only, if value data was collected it was alongside data for volume and/or mass. Geological surveys are the least likely to collect value data (only one survey who responded did) as opposed to statistical agencies where 12 reported they collect value and mass while six just collected data for mass.

With regards to metals, 58% (21/36) participants stated that their organisations collect data for a gross weight of ore extracted, whilst only 33% (12/36) collect metal content of the ore extracted. A smaller proportion (28%) collect data for a gross weight of concentrate and 22% collect metal content of concentrate. Fewer respondents appeared to collect the grade of metal in an ore or concentrate produced (19% and 17% respectively) or end use (17%). The majority of respondents report more than one type of production data for metals. The fact that fewer respondents collect data for metal content or grade, demonstrates that it is necessary for some assumptions to be made when publishing data for contained metal, which is usually the way figures for most metals are presented. This adds a degree of uncertainty to the final numbers.

For industrial minerals, 78% of participants stated that their organisation collects raw primary production data (28/36), while 33% (12/36) collected beneficiated primary production data (although all of these also report raw primary production). Only ten respondents noted that they collect industrial minerals data by end use and five said that their organisation did not collect data for industrial minerals at all.

With regards to construction minerals, 53% (19/36) of respondents collect data that is categorised into rock types, whereas 42% (15/36) collects data separated only into ‘sand and gravel’ and ‘crushed rock aggregates’. Fewer respondents noted that they collect data by end use (28%), or separate onshore from marine sources (11%). Six stated that their organisation does not collect data for construction minerals.

With regards to the frequency of data collection, 81% said that their organisations collect the data annually (59% of these were geological surveys or mining authorities, with the remainder being statistical agencies), whereas 14% said they collect it monthly and 8% collect data weekly, all of these were statistical agencies. No one collected data quarterly or on an ad-hoc basis. Of the 36 respondents, 86% said that they made the data available publically and from the comments made most of these seem to appear available online. However, 86% of responders indicated they aggregate figures in some way before publication. 48% (15/36) said that they aggregate the figures due to confidentiality issues, while 23% said that they aggregate the commodities. Other actions prior to publication include conversion from volume to mass (17%) or conversion from monetary value to quantity (3%). Only four survey participants said that their organisation did nothing with the figures before publishing.

Nine survey participants said that there were no constraints on confidentiality. However the rest did have constraints, some of the free text comments regarding confidentiality of data are:

- Confidentiality.
- No-data publically available.
- Standard confidentiality constraints to suppress data if a dominant company could be identified.
- Protected by copyright.
- Only aggregated data are made publically available.
- Yes, some of the data are confidential based on the Statistical Law.
- Data are collected according to the PRODCOM classification. In compliance with the Law on State Statistics, data on the kinds of products and industries are not published if there are less than 4 enterprises operating or if one of the enterprises holds a dominant position.
- Confidential data are protected.

Although confidentiality is clearly an issue for production data in many cases it will involve aggregating from a mine scale to a national scale, which is not so much of an issue for EU level reporting.

The survey asked participants if they used PRODCOM and what they thought about the level of detail provided by PRODCOM. Of the 36 survey respondents, 19 use PRODCOM codes or consider PRODCOM when compiling their statistics. Of these, 74% thought the level of detail in the range of codes under PRODCOM was sufficient or more than required. Almost all respondents who used PRODCOM were statistical agencies whereas 87% of responders who did not were geological surveys or mining authorities. It could be that geological surveys and mining authorities do not use PRODCOM because of a lack of detail or they may not undertake tasks for which this data is required.

2.1.3.2 ***Statistical data for resources and/or reserves***

For this part of the survey, 21 participants indicated that their organisations published resources /reserves statistical data, although subsequent questions were sometimes answered by fewer

respondents than this. Responders were split roughly 50-50 between statistical agencies and geological surveys. Again respondents were allowed to select more than one option for several of the questions and therefore the percentage figures do not sum to 100% for those questions.

The systems of reporting that organisations surveyed were currently using are shown in Figure 7. Of the 15 responders that provided information, 80% only used one code, of these the majority (60%) are using a national reporting code. Only 13% said that they used PERC, the standard for European reporting which is aligned to the CRIRSCO template. More respondents appear to be favouring other standards aligned with the CRIRSCO template, such as JORC and NI 43-101/CIM, but most of these respondents have selected multiple options. The actual number of respondents selecting one or more of these is 40%. The free text comments relating to ‘other’ indicate that in some cases the Russian code has been adapted to form the ‘national system’ while in other instances the respondent just uses the original code provided by the company and does not convert it.

Some broad conclusions can be drawn from this: if a country uses either a national code or the Russian code they are unlikely to use any other code; if a country is using CRIRSCO compliant codes they are likely to use a mixture of these, and no respondents stated they are currently using UNFC.

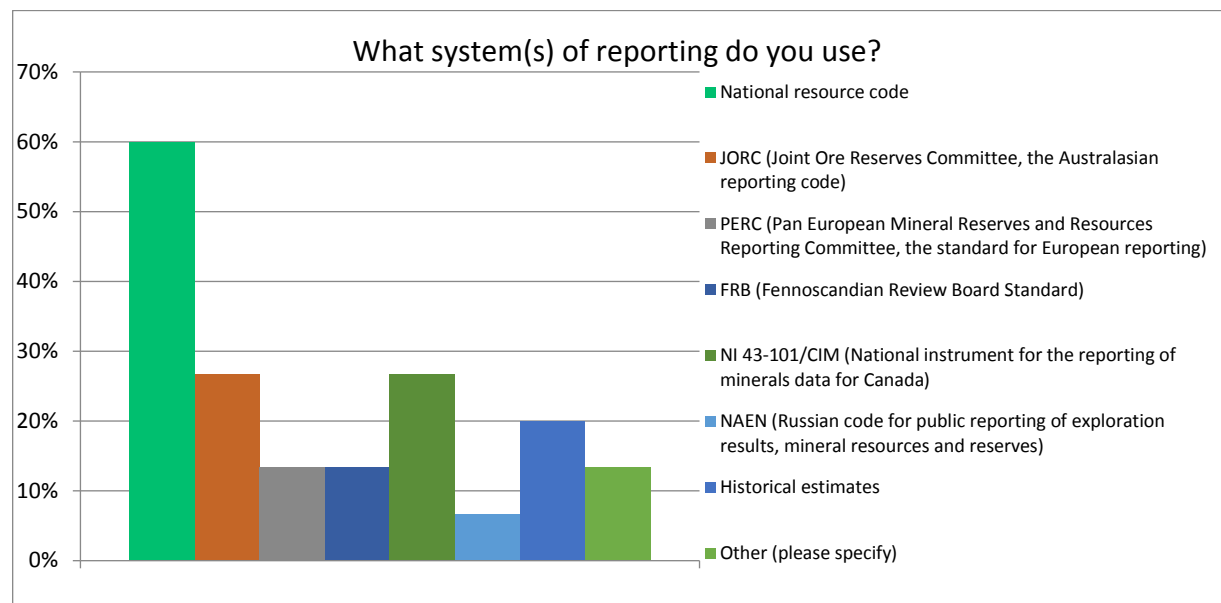


Figure 7: Systems of reporting used by organisations that responded to the survey (note, systems that were not used are not shown).

The survey asked whether national legislation specified the use of a particular code and of the 17 respondents that answered this question, 11 (or 65%) said that national legislation did specify the use of a particular system/code. All of these respondents only used one code and for 8 of these respondents, the specified system/code was a national one. The survey then asked: for what purpose was this specified? The highest proportion of respondents said it was for the purpose of national inventory (70%), while 30% said it was for stock exchange reporting.

These results suggest that a country is more likely to use a single system/code if their legislation requires it. Where there is no legislation requiring a specific system/code then multiple systems/codes are likely to be used. If legislation is put in place that requires a single system to be used across Europe, to ensure harmonisation via a common code like UNFC, this will have

to be in addition to what is already used not instead of existing systems/codes because individual countries have other specified purposes that require particular styles of reporting.

To gain a better understanding about how resources and reserves data are collected, the survey asked participants to identify the method that best described how their organisation collected resources and reserves data and this was subdivided by commodity group (Figure 8). For all four commodity groups ‘A request to ALL producing companies AND there is a legal requirement for them to respond’ was a high percentage. ‘A legal requirement under mineral licensing; also scored highly for all the commodity groups except for metals.

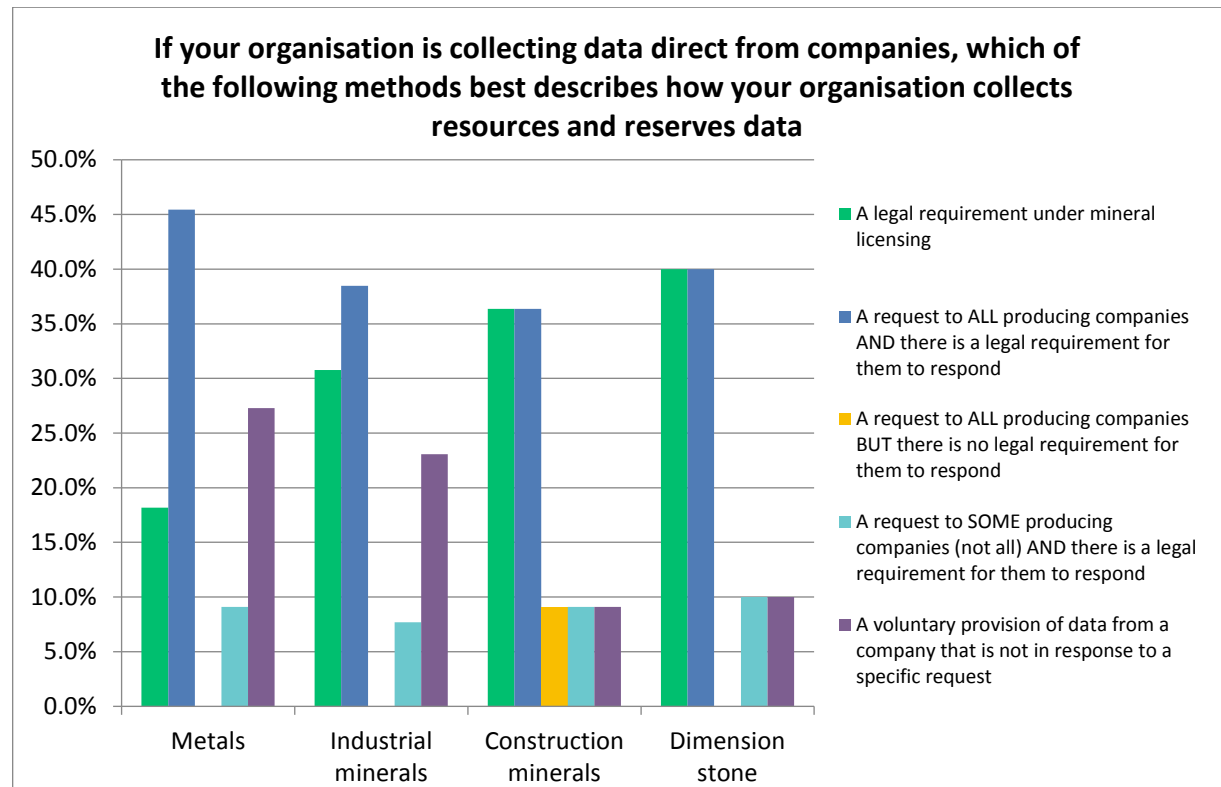


Figure 8: Methods used to describe how different organisations collect resources and reserves data.

When collecting the resource and reserves data of a commodity, 86% said that their organisation makes no estimate for any missing portion meaning many figures will be an under representation. In terms of frequency, 67% said that their data is collected annually, although a few respondents also collected data quarterly, monthly, weekly and on an ad-hoc basis.

Of the 15 respondents that answered this question, 73% said that their organisation makes the data public in some form and from the additional comments in most cases this appears to be online. However, of these approximately half said that there were some confidentiality constraints. In addition, from 15 respondents, 53% (8 survey participants) said that the data was aggregated due to confidentiality issues. Four survey participants (27%) said that aggregation is carried out to simplify reporting and two (13%) that aggregation of commodities is carried out. At 93% nearly all organisations do not pass these data on to other organisations.

When asked about the United Nations Framework Classification (UNFC), only four survey participants said that they were not at all aware of the UNFC system. Eight said that they were very aware of the system and three had ‘some awareness’ or were ‘slightly aware’ of the system. Generally, geological surveys had more awareness of UNFC compared to statistical agencies.

When asked about their level of experience with the UNFC, three respondents described themselves as an ‘expert’, four had ‘some experience’ and three described their experience as ‘minimal’. Five respondents said they had no experience with it at all. Again levels of experience were higher amongst geological surveys when compared to statistical agencies.

The same questions were asked about the CRIRSCO reporting standards template, five respondents said that they were very aware of it. Three respondents said they had ‘some awareness’ and another three were ‘slightly aware’, while four indicated they were ‘not at all’ aware of this standards template. When asked about the level of experience using the CRIRSCO reporting standards template (which includes JORC, PERC, etc.), seven survey participants said they had ‘no experience’. No respondents felt they were an ‘expert’ in the system, although two were ‘competent persons’ (as described by the CRIRSCO template). Two respondents indicated they had ‘some experience’ while a further four described their experience as ‘minimal’.

Like UNFC, geological surveys had more awareness and understanding compared to statistical agencies, however, the experience is much lower than awareness and both are lower compared to UNFC. More detail on these responses is shown in Table 1.

	UNFC	UNFC	CRIRSCO	CRIRSCO
	awareness	experience	awareness	experience
Competent person	n/a	n/a	n/a	2
Expert/very aware	8	3	5	0
Some	2	4	3	2
Minimal	1	3	3	4
None	4	5	4	7

Table 1, Respondents awareness and experience of different reporting methods

This highlights the fact that ‘awareness’ is not the same as ‘experience’. To ensure organisations gain the skills to use different reporting methods to enable harmonisation it is important that work is undertaken using methods such as UNFC in order to gain ‘experience’, this experience can only be improved if work is done in a practical sense.

This result, stating medium to high experience and awareness of UNFC seems to be at odds with previous answers where no respondent stated that UNFC was used, this may represent that the use of UNFC is still at very early stages with data providers.

2.1.3.3 **Statistical data regarding imports or exports of minerals**

The first question in this section asked which organisation in the survey participant’s country collected the raw data regarding the trade of minerals. Out of the 34 responses, a very high proportion said the national statistical agency (59%), followed by customs (22%). This seems counter intuitive as in most countries customs are responsible for traded goods. However, this could be perhaps because data are published by the statistical agency rather than the customs office. A total of 22 of the survey participants said that their organisation collected, compiled and published trade data and most (but not all) of the subsequent questions were answered by that number of respondents or similar.

When asked how the data were collected, answers indicated that the raw data are collected both by customs declarations (64%) and the Intrastat survey (59%) as shown in Figure 9. This is to

be expected because the former collects data for extra-EU trade while the latter collects data for intra-EU trade. The free text for this question indicates that the remaining participants obtain their data indirectly from another body or were not aware of how the raw data were collected.

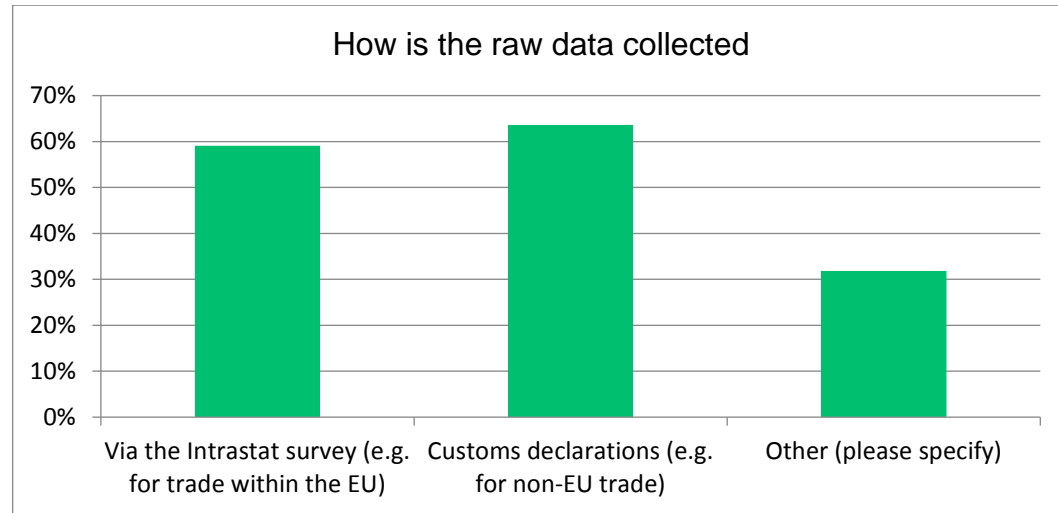


Figure 9, Collection of raw data for trade statistics

Of the 22 respondents, 64% said that the data were publically available and the free text sources list appears to indicate that this is mainly in an online format.

Only 36% (8/22) said that their organisations use the trade data published by Eurostat. Of those, five found it easy to use but only four considered that the data they needed was usually available. Of the 8 answers, 6 were from statistical agencies and the remainder from geological surveys.

When asked whether an organisation makes an adjustment or estimates for any missing portion from the collected trade data, 56% (10/18) said that they do not (6 of which were geological surveys) and 28% (5/18) replied that they did not know (all of which were statistical agencies). Three respondents provided quite detailed explanations of how such an adjustment or estimate is made. It may not be an issue that estimates are not made by geological surveys as it is unlikely they will be collecting raw data, however, no estimates from statistical agencies could represent an issue and could mean trade data is commonly underreported.

Of those that collect trade data for metals which are imported/exported at the mine extraction stage, 55% report data at gross weight of ore, 40% report data for metal content and 15% report gross weight of concentrate. The percentage indicating they report metal content is interesting because none of the publically available trade databases includes figures for metal content of traded ores or concentrates. Most of the organisations did not collect trade data relating to the intermediate stage of metal production, however, of those that did, all collected data for metal content and three respondents also reported data for gross weight. Only one respondent reported data was collected 'by end use'.

For industrial minerals, of the 16 survey participants that responded to this sub-question, 88% collected trade data at the raw primary production stage, 31% collected trade data for beneficiated primary products (e.g. washed, processed, etc.) and 19% of respondents collected trade data by end use. Of the respondents collecting trade data for raw primary production, most

(9/14) are only collecting this type of data whereas most of the respondents collecting trade data for beneficiated products (4/5) are also collecting trade data for raw products.

For construction minerals, 18 survey participants indicated they collect trade data for construction minerals. Of these, 83% (15/18) said that they collected trade data categorised into rock types, while 50% (9/18) said they separated the data only into sand and gravel and crushed rock aggregates. This would seem to suggest there has been some misunderstanding of the question here as these two options were intended to be exclusive of each other. However, it is interesting to note that most respondents indicated they collect trade data for construction minerals by individual rock type because most publically available trade databases do not differentiate crushed rock aggregates by rock type (nor indeed do the existing trade codes allow gravel to be separated from crushed rock).

Regarding trade data, most respondents indicated that they do not pass these data onto other organisations and this likely reflects that trade data is often considered as ‘final’ once published. In terms of frequency, 60% of respondents (12/20) collect the data annually (this is a mixture of statistical agencies geological Surveys and mining authorities). Of the 40% of organisations that collect data more frequently, all are statistical agencies. With regards to units, 85% (17/20) collect data in Mass e.g. tonnes and 60% collect data by value e.g. Euros (12/20). Further analysis of types of organisations who report this data show that statistical agencies are more likely to collect value (although most also collect mass) whereas as geological surveys are more likely to collect mass. Most respondents indicated that the data are publically available but 11 respondents (55%) indicated that they use some level of aggregation of data due to confidentiality.

2.1.3.4 ***Statistical data on mineral exploration activities***

Only 8 survey participants answered the questions relating to exploration activities. This is likely to be reflected in the scarcity of available data across Europe and the low response rate shows the lack of data in this area. The Minerals4EU project collected exploration data for a larger number of countries than this. However, the results of this section of the survey are still of interest. Of the eight organisations that answered, four were geological surveys, two were statistical agencies, and two were mining authorities.

The most common metric used for recording exploration data is the number of exploration licenses issued in a year (75%), followed by the number of active exploration licenses in a year (63%), area covered by active exploration licenses (63%) and the number of companies exploring (50%). The metrics, which is less likely to be collected, are the number of boreholes drilled (38%), company expenditure (38%), government/public sector expenditure (38%) and the number of metres drilling in boreholes (25%). Further analysis shows that most organisations who collect exploration data collect more than one type (of the eight responders two statistical agencies and once geological survey only collect one metric). Mining authorities appear to collect the most diverse range of metrics. The range of metrics collected by geological surveys varied the most (between one and six) and statistical agencies are likely to collect the least types of metrics.

Where exploration data is collected, for all commodity groups (i.e. metals, industrial minerals, construction minerals and dimension stone) it appears to be because there is a legal obligation for companies to provide data. This is either under mineral licensing procedures or in response to a request that encompasses all the relevant companies. Details are given in Figure 10.

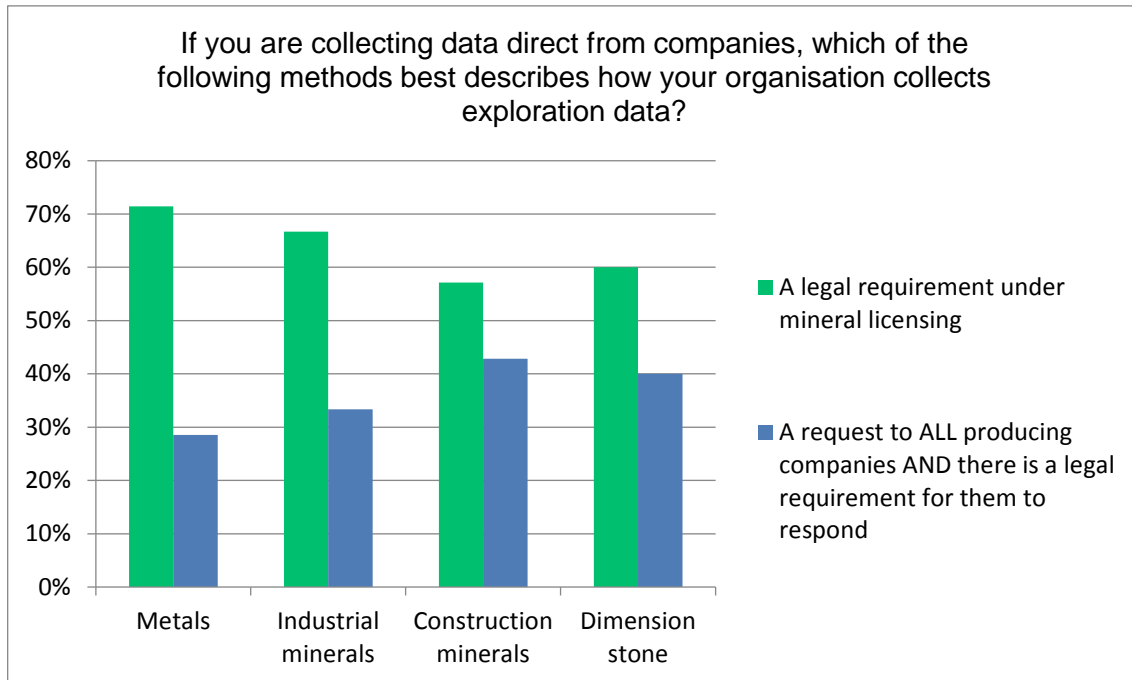


Figure 10, Collection methods for exploration data

Six of eight respondents did not pass data on to other organisations for further national compilations/aggregation.

No organisations collect exploration data quarterly but three of the eight respondents collect these data on an ad-hoc basis, two collect data monthly or annually and one collects data weekly. Broadly this shows that: the collection of data more frequently than on an annual basis is rare, if the collection is monthly it will not be for all mineral groups, ad hoc collection is more common for geological surveys. For five of eight respondents data is made publically available in some form online, but only three respondents indicated no constraints on published data.

The survey asked whether there is a period of time, once an exploration license is surrendered, after which there is open access to exploration results. Only four participants responded and the free text comments were:

- 6 months
- The so called "3 years rule" is valid for this topic as well.
- Yes - 7 years
- Reports and data from exploration work have to be sent at the latest 6 months after the exploration license is surrendered. The results will then be published unless the licensee has other valid exploration permits in the area.

Of the eight survey participants, seven (88%) indicated that the data are aggregated due to confidentiality before they are published. Four respondents also indicated other types of aggregation to simplify the reporting of the data. Perhaps unsurprisingly this highlights that confidentiality is a significant issue for mineral exploration data.

2.2 Summary of data collection methods identified

The most common methods used for data collection appears to vary across different themes and commodity groups, as does the legal basis for collection.

For production data the majority of respondents (between 62% and 74% depending on the commodity group) state that they collect data because they have a legal requirement to do so. For resources and reserves data, this decreases to between 53% and 67% of respondents having a legal obligation to collect these data. However, for exploration data, it rises to between 63% and 88% of respondents with a legal requirement to collect data (Figure 11). The percentages for exploration data, however, are significantly affected by the much lower number of respondents that answered questions in this section, but it also appears that exploration data are rarely collected if there is no legal requirement to do so.

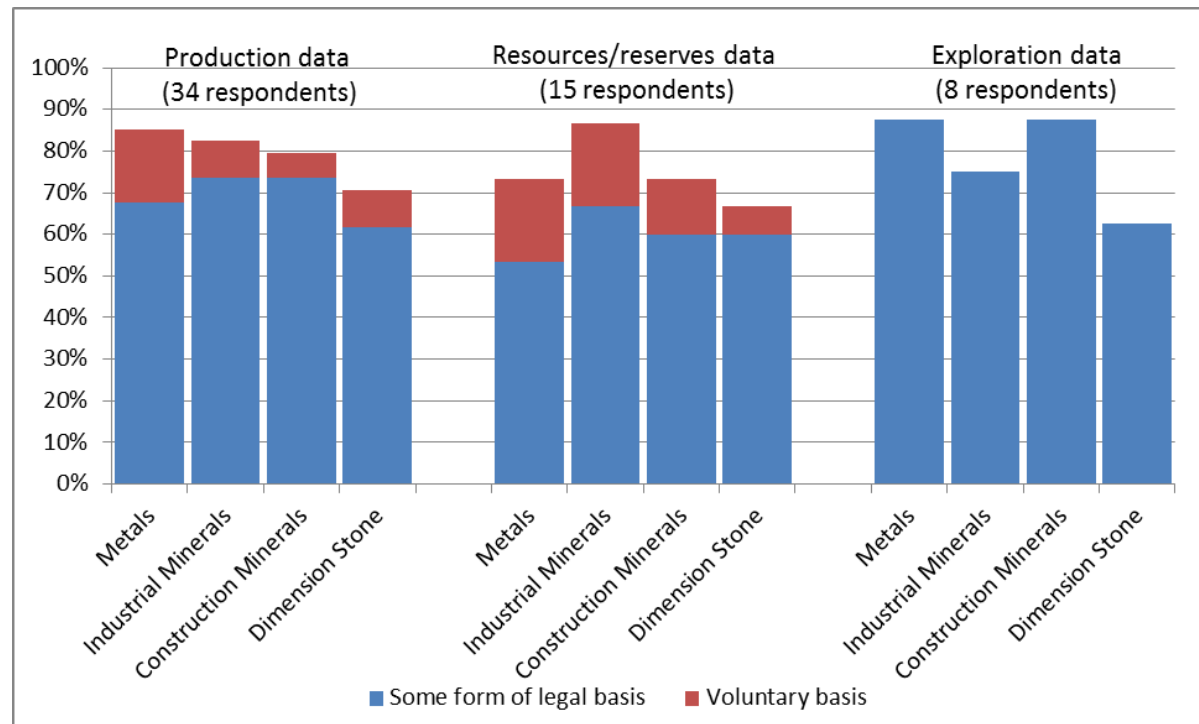


Figure 11: Proportion of respondents that indicated there was a legal basis for data collection compared with data collection carried out on a voluntary basis

These results highlight that although there are some good examples of voluntary and non-legally required provision of data the vast majority of reported figures are due to a legal requirement, either under mineral licensing or some other legal provision. This shows that although not necessarily essential, a legal basis for the collection of minerals information appears desirable. This result is to be expected because a legal requirement is both a strong motivator for the organisation collecting data but also means that companies are more likely to provide them when requested.

The survey questions made a distinction between four broad method categories:

- A requirement under mineral licensing;
- A ‘census’ type survey (requesting data from all producing companies);
- A ‘sample’ type survey (requesting data from some but not all producing companies);
- and
- A voluntary provision of data (not in response to a specific request).

For production data, between 12% and 15% of respondents indicated that data collection was carried out as part of the mineral licensing process (depending on the commodity group, compared to between 32% and 35% for a full ‘census’ type survey and 21% to 35% for a partial ‘sample’ type survey. The voluntary provision of data was selected by between 3% and 6% of respondents. The comparison with resources/reserves data is interesting because the figures for mineral licensing rises to 27% for all mineral groups apart from metals and the voluntary provision of data increases to 20% for both metals and industrial minerals. The partial ‘sample’ type survey falls to 7% for all mineral groups, which indicates this type of survey is less useful for resources/reserves data. For exploration data, the mineral licencing method increases significantly to between 38% and 63% with the remainder of the data collection taking place using full ‘census’ type surveys (Figure 12).

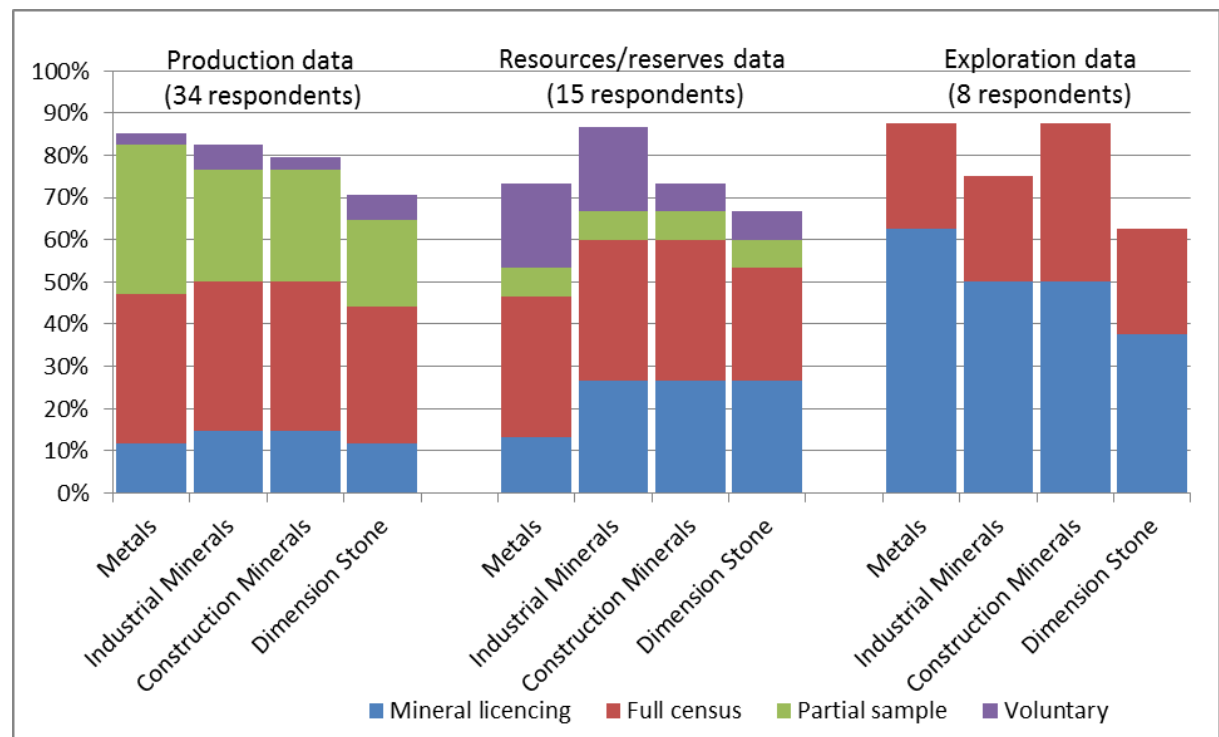


Figure 12: Proportions for each data collection method by mineral groups and data types

Perhaps unsurprisingly, a high proportion of production data comes directly from the companies extracting and processing the minerals rather than from regulators, local or national government or other governmental organisations. However, these bodies do make up a significant proportion of data sources reported during the survey indicating that data does flow between governmental organisations.

Most organisations collect mine production data with refined production and intermediate products making up a much smaller proportion of published data. There is some ambiguity as to where on the minerals value chain some of these products sit and this, combined with a focus on primary products by many data collectors, will mean that data are often incomplete or absent for these products.

Around half the organisations used PRODCOM data for compiling their statistics. This is interesting as PRODCOM data is provided to the EC from member states own data collations. This may highlight the value of already easily accessible and harmonised datasets, such as

PRODCOM, due to the fact that organisations use this for information rather than try to find the source material from within their own country.

Across all types of primary minerals data that were considered by the survey, a high percentage of organisations do not make any estimate for missing portions/elements from the data they are collecting. As it is unlikely that any survey will achieve 100% coverage, this may indicate an under-representation of figures in some areas, and possibly a lack of expertise from data collectors of the minerals sector to enable estimates to be made.

Aggregation of data, primarily due to confidentiality, was also commonly reported across all areas.

A very broad summary of the results from the survey that have the greatest implications for data harmonisation across Europe are as follows:

- Geological surveys are more likely to collect data on primary stages for production and trade whereas statistical agencies are more likely to have data on later stages of production and trade.
- There is much less data available for downstream products, both for production and trade data, i.e. intermediate or refinery stages.
- Most data are from companies (which is good, ultimately all data will be from companies if another source is quoted it will be second hand from other government agencies).
- Although there are a variety of reasons for collecting data statutory and legal obligations are by far the most common.
- Data are normally collected by mass, or value and mass together, just value are rare. This is positive because on a national/European level mass is needed for longer-term strategic planning.
- For metals, there is a mix of forms in the reported data. The majority report gross weight of ore but organisations also collect data by gross weight of concentrate and metal content. This can be an issue for harmonisation and will require expert input to ensure data points are all the same form when aggregating.
- Most data is collected annually.
- There is normally some level of aggregation before publishing. Confidentiality is frequently cited as a reason and this increases from production data to trade data to exploration data.
- No respondents use UNFC currently.
- Countries are likely to exclusively use a national code, exclusively use the Russian code, or use a mixture of CRISCO template codes and standards.
- For many countries, there is legislation in place specifying that a particular code must be used. This shows that if a single system for harmonisation is to be used it will need to be in addition to, rather than instead of, currently used codes and standards
- Geological surveys have a higher awareness of resource codes and standards than statistical agencies. Awareness of UNFC seems to be higher than awareness of CRIRSCO compliant codes and standards. This is at odds with the statistics showing more frequent use of CRIRSCO codes and standards.
- Awareness of both UNFC and the CRIRSCO template is higher than 'experience' levels.

2.3 Data collection issues and good practices that may help to address them

There are a number of issues with primary minerals data and these matters do need to be highlighted so the limitations of the data can be understood by end users. However, it can be very difficult to overcome all of the problems because in many cases the required data simply do not exist. This section will attempt to identify the extent to which good practice in data collection methods can help to address some of these issues.

Many concerns regarding data for production, trade, exploration and resources and reserves for primary minerals were highlighted by the Minerals4EU project during the production of the minerals yearbook (Brown and Petavratzi, 2015). The recommendations from that project can be reviewed in section 3.5.2 but some of the most important issues, as well as some others not mentioned by Minerals4EU are detailed below.

2.3.1 Production data

2.3.1.1 *Missing or incomplete data for by-products*

Many primary minerals are produced as a by-product of a main commodity, for example, lead contained in gold ore or cobalt contained in nickel ore. Many raw materials that are currently labelled as ‘critical’ are currently only produced as by-products, such as gallium or indium. Detailed case studies regarding the issues around by-products for gallium and indium are detailed in the deliverable 3.3 of the Horizon 2020-funded SCRREEN project (Brown and Gunn, 2018). Production data for these by-product materials can be very difficult to obtain because often it is not recorded by the producing companies as they are focused on the primary products, which is of most importance to their business. Hence the data often simply does not exist and where they do exist the figures will often be confidential and not publically reported. Because the by-product is not the principal product of the mining and beneficiation process, and because of its relative economic insignificance when compared to the primary product, the producer might report only the main commodity but this does not mean the by-product is absent.

Furthermore, the by-product material may be separated by a different company, perhaps in a different country, due to the complex processing route and technology required. It can be difficult to track where the material has been shipped from/to for processing because it is often ‘hidden’ in trade data by a description that does not mention the potential by-product. If the material is subsequently produced in minor amounts by specialist producers the reporting of data may be restricted due to confidentiality. By-products are also produced from waste products of primary processing or as complex chemical compounds that require further processing. This makes the chain of reporting very complex and the content of waste streams are often not reported.

Evidence would suggest that introducing a requirement to record the metal content of all by- and co-product elements would significantly improve the availability of data. This would, however, place an increased burden on producing companies. Additional transparency on what is contained, even if not quantified, and where waste streams are sent for further processing would be beneficial.

2.3.1.2 **Conflicting sources**

Sometimes when reviewing a country's national production statistics, data for a particular commodity can be found from multiple sources but are of different values. This can be due to a wide variety of factors such as: preliminary versus final figures; figures with differing amounts of estimation; different degrees of rounding; later revisions or corrections; the inclusion or not of small producers or confusion over commodity definitions. This type of issue is inevitable when large statistical collations are being considered and require expert input to resolve.

Where a complete annual figure is not yet available it is good practice for a degree of estimation to be made rather than publishing a part figure. However, the level of estimation and the date at which the figure was compiled would greatly increase transparency and enable the 'best' figure to be identified and published. Any figure containing a degree of estimation should be rounded to reflect the estimation and always revised when finalised statistics become available.

It is also good practice to indicate with footnotes the degree of rounding, later revisions and corrections and any omission of small producers. A standard glossary should be developed, either at national or international level, to define exactly what is meant by commodity names and related terms.

2.3.1.3 **Data may not exist**

In some instances, data may not be collected at all by any government organisation. This may be due to a shortage of funding to conduct a survey, due to the structure of mineral licencing or because these data are not seen as important. Data from state-owned or private companies are more difficult to obtain than data from publically-owned companies because these companies do not have to report to shareholders or stock exchanges. Data for construction or industrial minerals can be more difficult to collect than for metals because mineral licencing tends to be less restrictive or because small companies, for example with fewer than a certain number of employees, may have reporting exemptions (MinPol, 2017).

Many countries do not routinely collect production data for primary minerals and it cannot be assumed that these data exist in a readily available database that can be collated at a European level. In these cases, expert knowledge and a significant amount of time and effort are required to collate this information from industry and third party data providers or to derive suitable methods to arrive at a realistic estimate. As emphasised by the results of the survey the majority of all primary mineral data collected is done where there is a legal basis either as part of the permitting/licensing procedure or outside this process as part of a survey where respondents are legally obliged to provide a return. This suggests that in most cases there needs to be a legal requirement for the industry to report to ensure provision of data.

2.3.2 **Trade data**

2.3.2.1 **Triangular trade**

This is the situation whereby country A exports a commodity to country B but B immediately re-exports the commodity to country C (this is illustrated in Figure 13). Country A could record the trade as going to B or C; country C could record the trade as originating in A or B, and country B may not record it at all. This is one of the primary reasons why imports and exports rarely match.

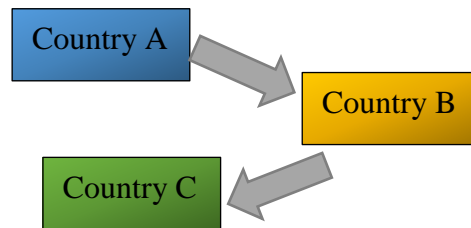


Figure 13: Illustration of the 'triangular trade' issue

This is a longstanding issue with all trade data and is one that cannot be solved by optimisation of data collection methods, therefore, although important to understand when dealing with these data, is outside the scope of this study. Guidelines and training materials do exist to try to deal with this issue but due to the complexity of trade data it is still known to occur.

2.3.2.2 **Accuracy of trade data**

All reporting based on systems of codes relies on the person completing the return accurately and in a timely fashion. This requires an understanding of the code classification system and the written descriptions associated with the codes. In general trade statistics are compiled from individual customs declarations and should, therefore, have a high level of accuracy, however, due to the complexity with different specifications of similar commodities and individuals who compile trade data are not normally experts in materials or geology it is not uncommon for figures to be miscoded or incorrectly aggregated.

Much like triangular trade, it is unlikely that this issue can be solved by optimisation of data collection methods. To overcome this issue both data providers and compilers need to have a good understanding of trade code systems. Although much training material on their use does exist this may not be seen by data providers. Data compilers dealing with large amounts of data on a range of complex industrial products may not see the miscoding issues.

2.3.3 Resources and reserves

2.3.3.1 **Confusion over terminology**

There is no single definition for the terms 'resource' and 'reserve' and consequently these terms are defined differently by the various internationally recognised systems of reporting and are used to mean dissimilar things by different countries. This causes confusion over what is meant by 'resource' and 'reserve' and prevents the aggregation of figures at European level. One step to overcome this is to use a single internationally recognised system of reporting with a clear definition of what is meant by 'resource' and 'reserve'. This issue will be examined under Task 1.3 of ORAMA and will be discussed in detail in deliverable 1.4 and 1.5 which will focus on harmonisation of resources and reserves data.

2.3.3.2 **Confidentiality**

Due to commercial interests, much data for primary minerals remains confidential at individual deposit or mine scale. That is not to say these data cannot be collected, because much of this data is gathered by local, regional or national government organisations, but they cannot be

published in the public domain. The issue of confidentiality is not something that is easy to overcome, however, one possible solution is the increased use of regional or national level aggregation within countries to produce national totals that, if enough producers contribute to a figure, may no longer be confidential. At an international scale, aggregation could be possible across small groups of countries, however, no body currently exists that has the legal permissions to collate such aggregated statistics. In some cases (for example the cement industry) due to antitrust regulations, any sharing of short term confidential industry data is prohibited but aggregated data can be released after an acceptable time lag.

2.3.3.3 ***Data not collected by governments***

The Minerals4EU study identified that of the 33 returns the project received from individual countries 12 countries (36%) indicated there is no requirement to collect data on resources and reserves and a further 7 (21%) indicated there are some issues with central collation that may affect its comprehensiveness (Brown and Petavratzi, 2015). Therefore it must be clearly stated that regardless of issues regarding standardisation in many countries these data simply do not exist at a national level currently. To overcome this it must be made clear which organisation within a country (geological survey, statistics office, the ministry of mining, etc.) has responsibility for this data and this organisation needs to be given both the responsibility and resources required to collect them. As shown by the results of the survey, a legal basis to collect data is also greatly beneficial. Although it must be emphasised that for a national government to provide the legal basis for data collection it needs to be convinced of the benefit of the data. The vast majority of countries where a legal basis for data provision is present there is either a high degree of state mineral ownership or high income to the state from mineral derived royalties and taxation.

2.3.3.4 ***Different terminology for commodities used***

The Minerals4EU project noted considerable issues regarding the lack of standardisation of commodity terminology with regard resource and reserve reporting (Brown and Petavratzi, 2015). In some cases, the differences in commodity names are due to variations in spelling, for example, ‘barytes’ and ‘barite’, but in other cases, the names suggest that different materials are included and consequently the figures cannot be directly compared. The situation does appear to be more complicated for industrial or construction minerals than for metals and this is probably because industrial and construction minerals are often defined partially by their end use rather than entirely by their composition. For example, the same deposit of limestone could be used for construction aggregates and for a range of industrial uses as ‘calcium carbonate’ – some countries may separate the resource in this case while others do not.

To overcome this issue standard dictionaries or glossaries must be developed and used when reporting figures. There are several internationally recognised examples, such as that set out by the INSPIRE directive or EarthResourceML (a XML-based data transfer standard for the exchange of digital information for mineral occurrences, mines and mining activity) (IUGS, 2018). These, however, do need regular updating and input from end users to ensure sufficient resolution exists. This is especially in the case of many industrial minerals where end use is key, for example, it may be difficult to split limestone used for construction from limestone used for chemical purposes.

2.3.3.5 ***No data exists for the ‘uneconomic’ or ‘undiscovered’ proportion***

Much of the data for mineral resources are reported direct from industry. Reporting standards used by industry (CRIRISCO template) do not allow for the reporting of anything that is deemed to be ‘uneconomic’ based on current market conditions. This is an issue because there may be quantities of material that may be economic in the future with changes to processing technology, metals prices, global supply and demand from new technologies, etc. This is information that governments require when considering long term industrial strategies.

This type of situation often occurs with by-product materials, for example, large quantities of cobalt associated with nickel laterite deposits are currently worked in Greece but due to metal prices and processing technology, this material is not recovered and not considered a resource, so no data exists for it. The same can be said for lead in association with gold deposits in Northern Ireland, large quantities of lead ore exist in association with the gold but it is not economic to extract in its own right, so no data exists for the quantities in place. Similarly, slag from copper processing in Poland contains significant quantities of cobalt. This is not recorded as a cobalt resource.

In addition, there are many deposits that for economic reasons currently are of no interest to the minerals industry and are therefore not reported. Generally, national geological surveys take the responsibility to collect data and define these types of deposit, and for many countries, a good level of data exists for ‘uneconomic resources’, for example, probabilistic modelling of undiscovered mineral resources in Finland (Rasilainen, 2012). However, for many countries, for example, the UK, the geological survey has no statutory role in collecting these data and consequently, they may not exist. Regardless of the role of the geological survey, understanding of these deposits requires continued investment in exploration and research.

These data gaps can be eliminated through exploration and research, however filling these data gaps will take significant time and investment and in the interim, it must be recognised that data from some countries will be deficient in information when compared to others. Other steps that can be taken to address this issue include the adoption of a standard system for the reporting of mineral resources that includes a mechanism for the reporting of uneconomic proportion of resources, such as the UNFC system. This classification system allows for the reporting of ‘uneconomic’ and ‘undiscovered’ resources, including early stage exploration, giving a more complete picture of mineral stocks. However, it should be recognised that regardless of the effort spent on geological investigations geological knowledge will never be 100%, therefore, there will always be unknown resources.

2.3.4 **Exploration data**

Of all the different themes for primary minerals data, exploration is the theme with the smallest quantity of available data and those that are reported are the least harmonised. Much less work has been undertaken with regard to exploration data than for production, trade or resources and reserves data and little attempt has been made to harmonise across national boundaries. Currently, the metrics used to measure exploration are poorly defined.

The first step in the harmonisation of data would be to define and reach a consensus on what metrics are essential for recording mineral exploration. Currently, different metrics are used in different jurisdictions. Also, much like other minerals data, often the countries with the most comprehensive datasets are the ones with an organisation with a clear role in collecting the data and a strong regulatory regime with a legal requirement for industry to provide data. This needs to be encouraged.

3 Review of previous projects and recommendations for the improvement of statistical datasets

3.1 Aim and scope of review

The aim of this chapter is to collect and summarise relevant recommendations that have been made previously with regard to how to integrate different approaches and to facilitate the demonstration of the applicability of the data harmonisation for primary mineral statistics for different stakeholders of the raw material community. These include data related to production, trade, resources, reserves and exploration. It was regarded as critical that earlier reports were reviewed as many previous projects have considered some of the issues associated with harmonisation of minerals data and have already made recommendations on how these may be dealt with.

3.2 A historical perspective on resource and reserve data

The first mineral resource classification system was a three category system (proved, probable and prospective ore) invented by the British Institution of Mining and Metallurgy (IMM) in 1902 and published by Hoover in 1909 (Hoover, 1909). At the 12th International Geological Congress “A” (actual), “B” (probable) and “C” (possible) categories of geological knowledge were presented (McInnes et al., 1913). This method was adopted by the Soviet Union in 1927 and after the 2nd World War, its use in national mineral inventories spread within the Eastern bloc (Fodor, 1998). Although the principles of classification were the same, the details of the application were regulated differently in each country (Bárdossy and Fodor, 1989).

During the 20th century, many different systems were developed worldwide for resource classification, reflecting the different needs of countries. In recent decades, as the mining sector turned global, it became necessary to harmonise these systems or to develop new, comprehensive classifications.

In the case of solid minerals one of the most commonly used classification standards are the CRIRSCO-aligned standards. All standards and codes aligned with the CRIRSCO Template (CRIRSCO 2013) use the same set of standard definitions and the same classification. The aim of CRIRSCO Template is to set out minimum standards and guidelines for national standards and codes used for the public reporting of exploration results, mineral resources and mineral reserves. CRIRSCO-aligned standards such as JORC (2012) and PERC (2013) define mineral resource and reserve categories and detail the requirements of a Competent Person responsible for mineral resource or reserve estimation.

The CRIRSCO system classifies mineral deposits primarily based on geological knowledge; it distinguishes exploration results, three categories of mineral resources and two categories of mineral reserves. According to CRIRSCO, a mineral resource is “a concentration or occurrence of solid material of economic interest in or on the Earth’s crust in such form, grade or quality and quantity that there are reasonable prospects for eventual economic extraction.” Mineral resources can be converted to mineral reserves by the use of so-called modifying factors including mining, processing, metallurgical, infrastructure, economic, marketing, legal, environmental, social and governmental factors.

UNFC-2009 (UNECE (United Nations Economic Commission for Europe), 2013) covers all types of minerals including solid minerals, hydrocarbons, renewables, injection projects and secondary resources. The principal objective of UNFC-2009 is to enhance international communication by providing a generic classification framework for the reporting of fossil

energy and mineral reserves and resources, even though such estimates may have been generated using different classification or reporting systems. UNFC-2009 has been developed to meet the needs of applications pertaining to international energy and mineral studies, government resource management functions, corporate business processes and financial reporting standards.

UNFC-2009 is a generic principle-based system in which mineral quantities are classified on the basis of the three fundamental criteria of economic and social viability (E), field project status and feasibility (F), and geological knowledge (G), using a numerical coding system. Combinations of these criteria create a three-dimensional system. The categories and sub-categories are the building blocks of the system, and are combined in the form of “classes”. A class is uniquely defined by selecting from each of the three criteria a particular combination of a category or a sub-category.

The connection between UNFC and CRIRSCO reporting standards is ensured by so-called Bridging Documents. The relation of UNFC and CRIRSCO classification is illustrated in Figure 14.

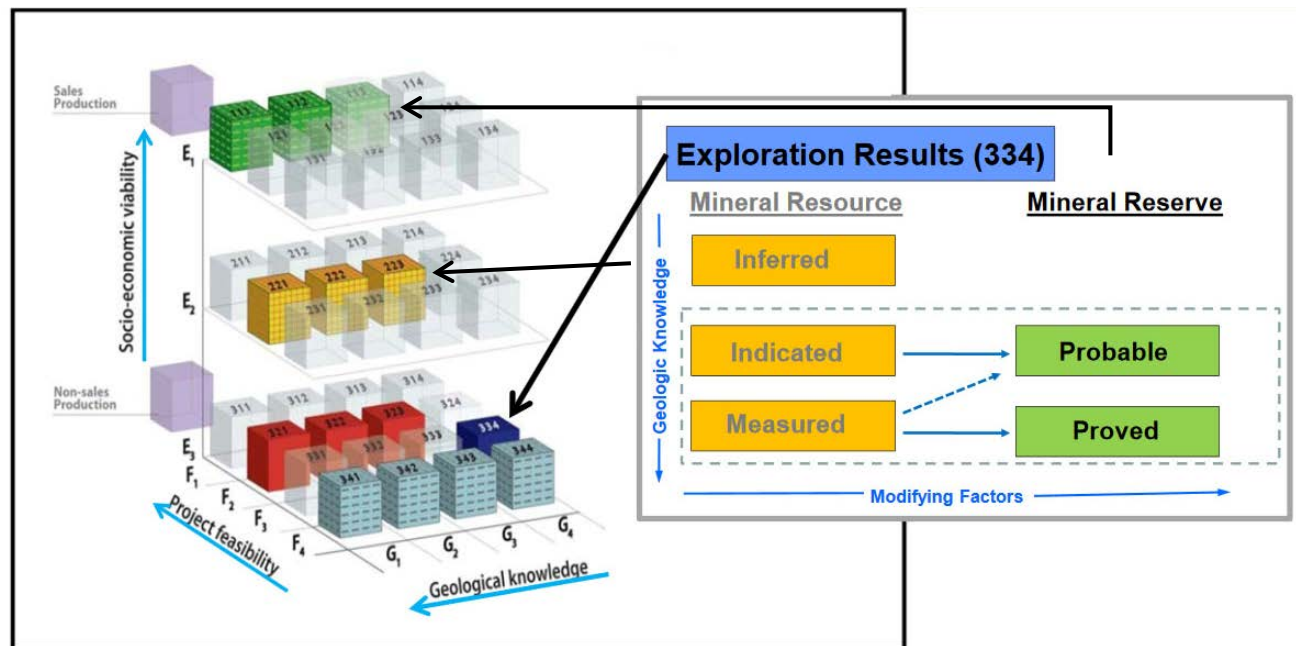


Figure 14. Bridging UNFC and CRIRSCO (Banks, 2013)

3.3 Harmonisation of resources and reserves data

Within the European Union, the INSPIRE Directive (2007/2/EC) is an important tool for harmonisation. The Directive aims to establish a uniform infrastructure for spatial information in the European Community that is necessary for Community environmental policies. The Directive does not require the collection of new spatial data but it builds upon infrastructures for spatial information established and operated by the Member States. Spatial data themes regulated by INSPIRE Directive include information on mineral resources.

In order to move towards harmonisation between available and forthcoming or new statistical datasets for mineral resources, some main elements of this topic and the connection between them should be discussed and clarified.

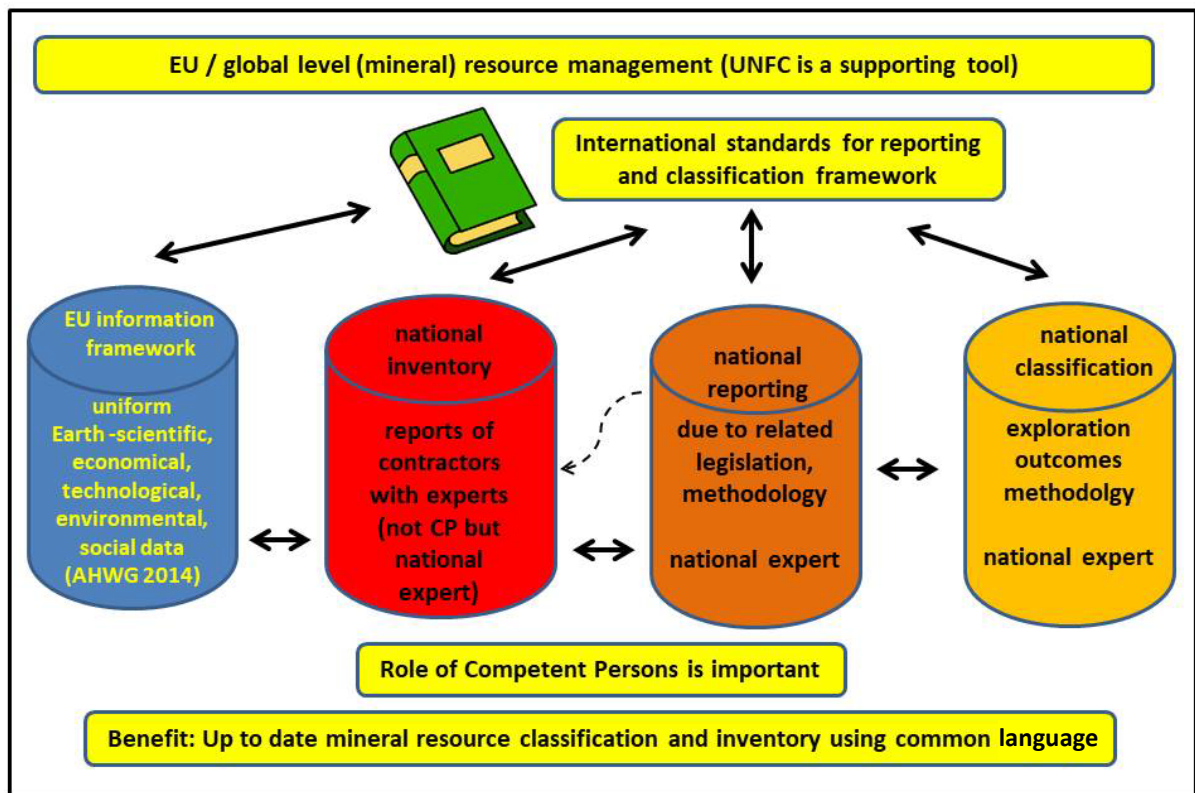


Figure 15. General connections between systems that use data for minerals. Arrows represent effects on each other, the dashed line shows data flow (after Horváth et al. (2014b)).

Figure 15 represents the connection between a national classification system, the national reporting system, the national registration and the role of international reporting standards or the UNFC classification framework that can facilitate the interoperability between different systems. The EU information framework requires INSPIRE-compliant data infrastructure but the content and meaning of specific mineral commodities (resources or reserves, cutoff, quality, etc.) may influence the quality of the information.

National classification systems are based mainly on the knowledge level of the mineral resources but many inventories contain information for a specific area (e.g. exploration area, mining plot) and information on the economic and social aspects, for example existence of Environmental Impact Assessment, social license to operate (SLO) and for the feasibility (state of a project) but not all countries have inventories and the content may be different (for social licences it can be indirect: in case of an operating quarry an accepted social license can be assumed). Statistical and additional data can be used in the harmonisation between national and international systems. Classification is used for both scientific and industrial purposes. Reporting is mainly required by responsible authorities and it is done mainly by companies. In some cases, according to the missions of research institutions or geological surveys that deal with this data, reporting can be directly integrated into the national inventory that is based on principles of classification. However, due to the legislative framework classification and reporting may be separated (national classification may be developed in the academic sector, while reporting may be controlled and developed by the responsible authority). Reporting may be prescribed by authority. Ideally reporting that supports the mineral resource management will be based on classification principles that are agreed between stakeholders (researchers, companies, decision makers).

The aim is to find the interoperability between different national and international systems based on bridging documents and by the contribution of relevant experts. The role of Competent Persons in the procedure of data harmonisation and ensuring interoperability between different systems has been increasing due to their relevant knowledge and expertise in the use of international reporting standards for the evaluation of projects dealing with mineral resources, reserves and with the related exploration and exploitation activities. It is very well accepted at EU-level (e.g. the European Federation of Geologists) and at a global level (UNECE EGRC) that these experts should be involved in the national/regional mineral resource management including the development and harmonisation of the relevant inventories. This may require some minor changes in the professional authorities (e.g. surveys, agencies, bureaus), for example additional investments (financial, human and time) but it has also benefits for governments in the form of high quality data management systems for minerals, supporting expertise for further decisions on mining. Positive benefits may be: additional important data that allows the development of an up to date inventory for resources and supports sustainable resource management. It may require minor legislative changes for example more guidelines or prescriptions for reporting exploration and exploitation results that may also increase the knowledge on resources, like inhomogeneity of a deposit. Institutional background and expertise also needs to be developed.

3.4 EU-level data sources, harmonisation tools and their availability

3.4.1 INSPIRE

The [INSPIRE Directive](#), Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), entered into force on the 15th May 2007.. Concerning the implementing rules, the aim is to ensure that the spatial data infrastructures of the Member States were compatible and usable in a Community and transboundary context. The INSPIRE Directive required that common Implementing Rules (IR) were adopted in a number of specific areas. These Implementing Rules were adopted as Commission Decisions or Regulations and are binding in their entirety. The Commission was assisted in the process of adopting such rules by a regulatory committee composed of representatives of the Member States and chaired by a representative of the Commission (Comitology procedure).

Within the European Union, the INSPIRE Directive is an important tool for harmonisation. The Directive aims to establish a uniform infrastructure for spatial information in the European Community. The Directive does not require the collection of new spatial data but it builds upon infrastructures for spatial information established and operated by the Member States. Spatial data themes regulated by INSPIRE Directive include information on mineral resources.

The mineral resources data theme is defined as “Mineral resources including metal ores, industrial minerals, etc., where relevant including depth/height information on the extent of the resource”. This data scope definition is specified in the "INSPIRE Data Specification on Mineral Resources – Technical Guidelines" as data that refers to the description of natural concentrations of very diverse mineral resources of potential or proven economic interest.

The Mineral resources data model is organised around two major categories of information:

- Description and location of mines and mining activities

- Description and location of “earth resources” including their classification, estimates of the amount, as well as a description of the main market commodities.

The challenges regarding the lack of availability, quality, organisation, accessibility, and sharing of spatial information are common to a large number of policies and activities and are experienced across the various levels of public authority in Europe.

In a similar way, the fact that it is not currently possible to produce reliable statistics related to reserves and resources at EU level is a major concern for the Commission

3.4.1.1 ***Relevant recommendations for harmonisation***

Despite the fact that the INSPIRE compliant data service is being processed at an EU-level the quality of the data service still requires development (not all countries provide the same datasets for raw materials and not with the same frequency). Different approaches for the consideration of the confidentiality may also contribute to the heterogeneity of the INSPIRE compliant data service that needs to be improved.

The collection of INSPIRE compliant mineral resource information, developed under the Minerals4EU project, shows several issues regarding: spatial data coverage; links between spatial and statistical data; and quality of data. Data coverage problems are a major issue as they prevent the development of other applications like statistical studies.

The reason for this can be that the availability of data is not the same for all countries or some data providers are not allowed to disseminate information related to single deposits. There are also some countries where data exists, but there are problems in respect of harmonising and serving data according to the required specifications or just lack of staff or financial resources to implement the EarthResourceML data model.

It was also shown that having spatial coverage does not mean that detailed and accurate data are available. Data quality covers several aspects from completeness, accuracy, attached references and metadata. The available spatial data are often not linked to statistical data, with the consequence that collecting data by individual deposit rarely results in complete data at national level. In many countries, there is no obligation to follow internationally recognised systems of reporting (e.g., JORC, PERC, NI43-101) for statistical data on resources and reserves. Also, the definitions of the terms (e.g. resources or reserves) can vary across the countries of Europe.

The lack of data, the initial quality of data and the data model implementation are the main challenges of implementation and these can be strongly improved in order to deliver datasets which can really be used for applications.

The system developed by the Minerals4EU projects contains the following elements:

- **Harmonised National Database (HNDB)** – a database that is established by a data provider, which includes harmonised information aligned with M4EU data model,
- **Central Harvesting Database (CHDB)** - receives data through Web Feature Services from the HNDB, checks the quality of data and their format and provides harvested data to the CDDB (hosted by GeoZS),
- **Central Diffusion Database (CDDB)** – receives data through Web Feature Services from the harvesting database and provide the EU-MKDP portal with data (hosted by BRGM), - <http://minerals4eu.brgm-rec.fr/>),

- **EU-MKDP portal** - an INSPIRE-compliant European Union Minerals Knowledge Data Platform, which stores and shares publicly available data on primary and secondary resources related to mining.

3.4.1.2 The INSPIRE data service

A simplified ontological description for Mineral Resources and Mining Waste topics is being prepared by the Mining and Geological Survey of Hungary (Figure 16). The aim is to facilitate the overview of the related terms, terminologies (dictionaries) and demonstrating the connection between different entities. The referenced graph contains the main classes and connections in the INSPIRE, Minerals4EU and ProSUM data models with links to different code-lists. Other attributes are ignored in order to be simple and easily understandable. The ontology can be accessed via the following link:

[http://www.visualdataweb.de/webvowl/#opts=\[cd=70;\]#iri=http://geonetwork.mfgi.hu/ontology/mr.owl](http://www.visualdataweb.de/webvowl/#opts=[cd=70;]#iri=http://geonetwork.mfgi.hu/ontology/mr.owl)

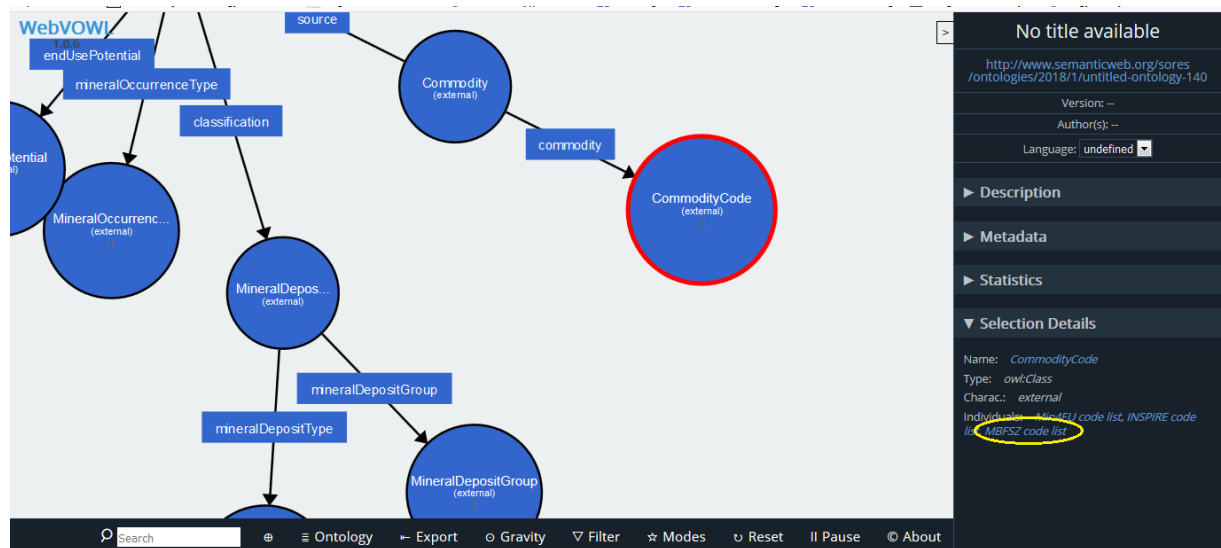


Figure 16. : Simplified Ontology is shown in open source web viewer.

Rendering is optimised, but bubbles can also be moved manually using the mouse. Zooming in or out will show more/less detail as required. Clicking on an item brings up the item description in the right-hand menu. Where it is appropriate the links after "individuals" points to the relevant dictionaries; e.g. Clicking on the EndUsePotential bubble the INSPIRE code list of end-use potential values can be accessed.

3.4.2 EUROSTAT

Eurostat is the statistical office of the European Union situated in Luxembourg. Its mission is to provide high quality statistics for Europe. Eurostat offers a whole range of important and interesting data that governments, businesses, the education sector, journalists and the public can use for their work and daily life. Eurostat databases include data on minerals such as production, international trade, export and import, etc.

3.4.2.1 **PRODCOM**

Prodcom is part of the Eurostat database and provides statistics on the production of 3900 different types of manufactured goods including products of the mining and quarrying sector. Prodcom uses the product codes specified on the Prodcom List where products are identified by an 8-digit code.

The MIN-GUIDE WP 6 Raw Materials Knowledge and Information Base is currently supporting DG Grow C.2 “Resources efficiency and raw materials” in the working group on PRODCOM statistics. This Working Group is responsible for thoroughly preparing all dossiers in the area of PRODCOM Statistics, prior to the decisions to be taken in the Business Statistics Directors Group. WP6 is thus sharing good practices with the DG Growth with the final objective of providing all interested parties with understandable information, which eventually will help to improve the social perception of mining and its actors.

Within deliverable 6.2 of MIN-GUIDE there are many recommendations on how raw materials knowledge can be improved, that are relevant to ORAMA. Like the need for more research projects and permanent databases addressing minerals and mining data and knowledge (including statistics) orientated to society at all levels, from primary schools to policy and decision making stakeholders. The needs of a longer term strategy such as the development of a European Mining Agency should also be considered. However, the concept of the data need, developed by ORAMA, has important synergy with the MIN-GUIDE.

3.4.3 **EURMKB and the EGDI**

The Geological Surveys of Europe under their umbrella organisation EuroGeoSurveys (EGS) have been cooperating in addressing the challenges facing Europe with respect to raw materials. EGS has participated in a number of projects which aim to address the European Union Raw Materials Knowledge Base (EURMKB). The main projects in which EGS has been involved include Minerals4EU (Minerals Intelligence Network for Europe), ProSUM (Prospecting Secondary raw materials in the Urban mine and Mining wastes) and MICA (Mineral Intelligence Capacity Analysis).

The European Union Raw Materials Knowledge Base (EURMKB) is a part of the European Innovation Partnership’s Strategic Implementation Plan. Its aim is to be a one-stop-shop for all information on raw materials in the EU.

The information on primary and secondary sources of raw materials, together with expertise, will form the three main blocks of the EURMKB:

Data and information will be collected from different sources, such as EUROSTAT, the Joint Research Centre, agencies (such as geological surveys) in EU countries, other national and international organisations, European projects and programmes and industry.

EGDI is EuroGeoSurveys’ European Geological Data Infrastructure (<http://www.europe-geology.eu/>). It provides access to Pan-European and national geological datasets and services from the Geological Survey Organisations of Europe. Through EGDI data, a number of European data harmonisation projects are accessible. EGDI was launched in June 2016 in a Version 1 and has since then been extended to include more datasets.

The operation and maintenance of EGDI are funded by a number of EuroGeoSurveys members.

EGDI will form the basis for an Information Platform which will be developed under the GeoERA programme which started on the 1st of July 2018 and goes on for three years.

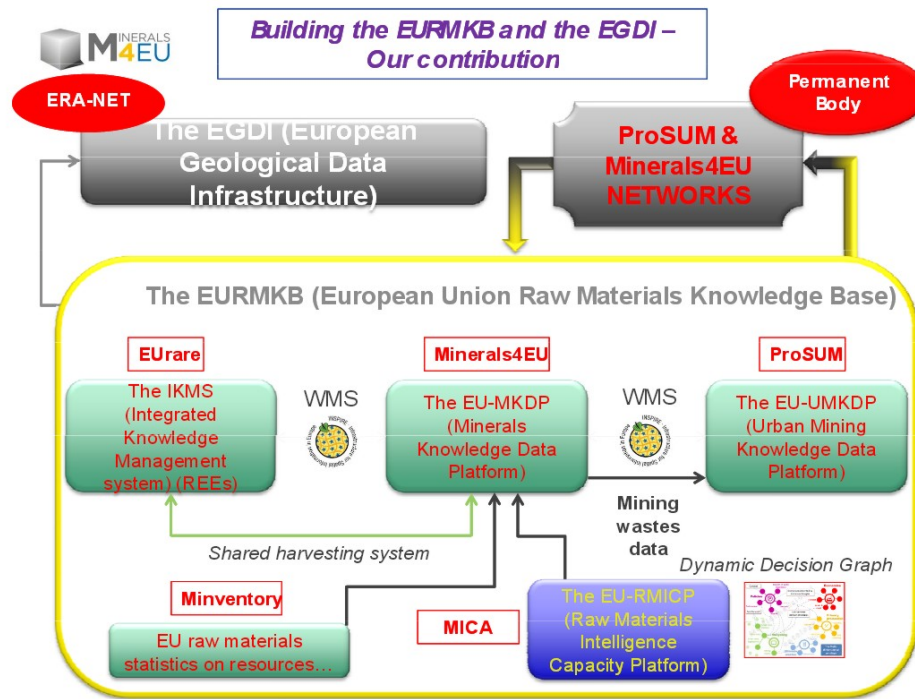


Figure 17. Overview connection between the data systems developed in EU projects and the planned ERA-NET (a mechanism under H2020 to support partnerships) and Permanent Body. (Daniel Cassard's presentation, MIN4EU conference, 25.08.2015, Brussels)

3.4.4 Raw Material Information System (RMIS)

The RMIS is the Commission's reference web-based knowledge platform on non-fuel, non-agricultural raw materials from primary and secondary sources. It provides an overview of the European raw materials context, the policy mandate that underlies the development of the RMIS, its goal and scope.

RMIS 2.0 will support European Union (EU) policy with tailor-made applications like the Raw Material Scoreboard and CRM assessments, as well as help coordinate other EU-level data and information on raw materials. The EU policy support will rely on knowledge from the EURMKB. This knowledge will be made available in the RMIS from different sources. The coordination role will be jointly developed with Member States, industry representatives, and other stakeholders via the so-called Raw Materials Knowledge Gateway (RMKG), which will be the key RMIS' entry point to the EURMKB. The RMKG will also facilitate further coordination activities with a focus on compilation, presentation and application of EU-level data. The aim is that outputs from relevant projects on minerals will become available through RMIS. The RMIS Knowledge Platform (Fig. 13) can be found here: <http://rmis.jrc.ec.europa.eu/>.



Figure 18. The RMIS portal, through which one can get into the RMIS KP.

3.5 Inventory of some selected projects having recommendations on harmonisation issues

In this chapter, the following projects and forums/expert groups, which are the most relevant work either ongoing or recently completed, carried out on a European level for the ORAMA project, and related results and recommendations will be presented. The organisations responsible for delivery are presented in brackets:

- ProMine (GTK)
- Minventory (BGS)
- MINERALS4EU (BGS, GTK)
- INTRAW (EGS)
- MICA (BGS, MBFSZ, GEUS)

3.5.1 ProMine (2009-2013)

Main objectives of [ProMine project](#) were:

- To develop the first pan-European GIS-based database containing the known and predicted metalliferous and non-metalliferous resources, which together define the strategic reserves (including secondary resources) of the EU.
- To calculate the volumes of potentially critical metals (e.g. cobalt, niobium, vanadium, antimony, platinum group elements and REE) and minerals that are currently not extracted in Europe (Figure 17).

- To develop five new, high value, mineral-based (nano) products.
- To enlarge the number of profitable potential exploration and mining targets in Europe.
- To establish a new, cross-platform information group between the European Technology Platform on Sustainable Mineral Resources (ETP-SMR) and other platforms.

The ProMine deliverables do not give specific recommendations for data optimisation from a classification/reporting point of view. However, one of the main messages of this project was that the infrastructure and database which were set up needs to be maintained and developed. Some results of the ProMine have been compiled in the 3D modelling program, goCad to construct 3D and 4D models of the mine site geology that may contribute to identify and characterise mineral resources. These predictive models form the base for future exploration around the mining regions (metallogenic belts) modelled in detail within the ProMine. These also help in assessing the mineral resources of the belts modelled. For such models the use of a common language for the targeted minerals is essential.

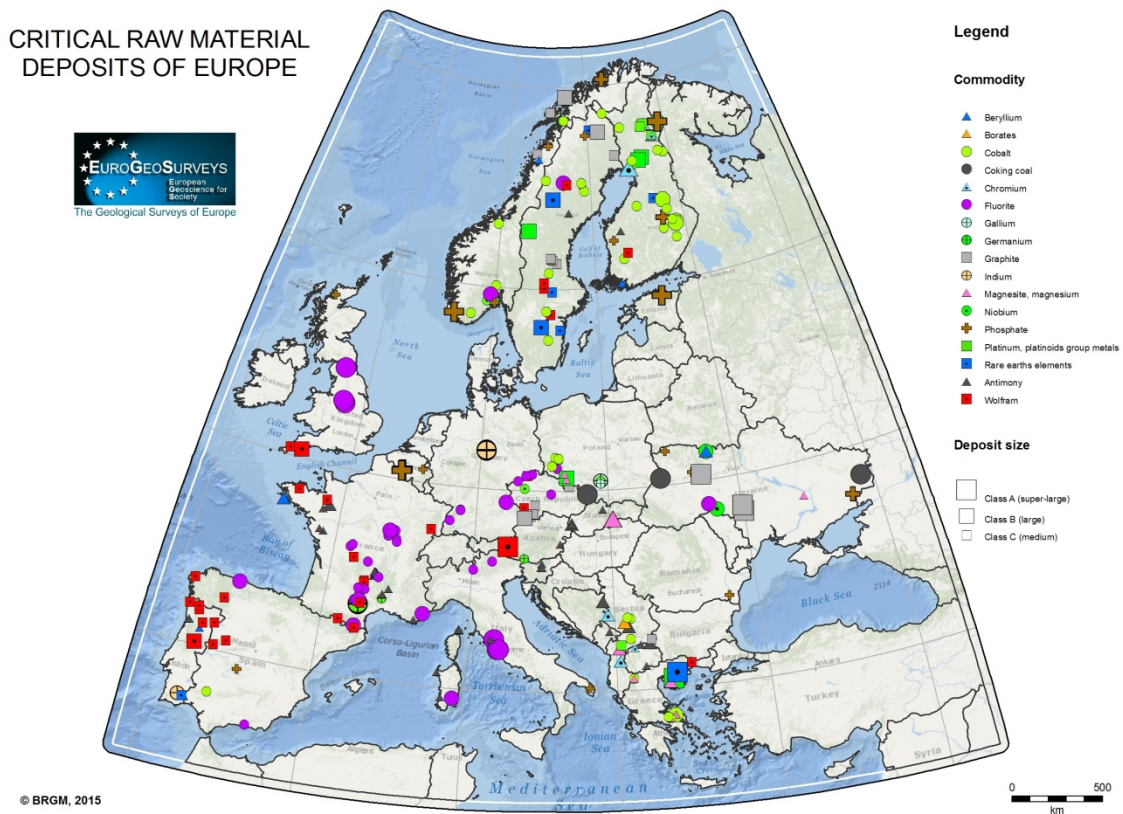


Figure 19: Map of critical raw material deposits in Europe (Bertrand, 2018). Source: <http://egsnews.eurogeosurveys.org/?p=668>

An Excel file can be downloaded from the ProMine Portal containing the details of all the deposits that the ProMine project collected data for: http://geodata.gtk.fi/Promine/deposits_AllComoditiesBis.xls. The various maps contained in the ProMine portal (ProMine maps of mineral potential, predictive maps, Geology at 1:1.5M scale, Geophysics) can also be integrated in a map viewer, using the following WMS/WFS URL: <http://mapsrefrec.brgm.fr/wxs/promine/wp1ogc>.

3.5.2 Minventory: EU raw materials statistics on resources and reserves (2013-2015)

The aim of the [MINVENTORY project](#) was to create a harmonised pan-European metadata inventory on resource and reserve information related to primary and secondary raw materials (including mining wastes, landfill stocks & flows and in-use materials).

The Minventory project delivered the following:

- A study that documents the prevalence, metadata and standards employed by the EU Member States and neighbouring countries of Europe in quantifying resource and reserve information related to primary and secondary raw materials, including an assessment of the level of application of a system of reporting resource and reserve data;
- A roadmap outlining the barriers and possible voluntary actions that might be taken to harmonise and publish the resource and reserve data at an EU level;
- An action plan on harmonisation of resources and reserves statistics and their incorporation in future European Minerals Yearbook;
- A Commission [portal](#) that summarises metadata available on primary raw material resources and reserves (by mineral, country and land/marine domain), on secondary raw materials (mining wastes, landfill inventories and waste flows), and where such data might be found.

A key part of Minventory was centred on questionnaires sent to State public authority data owners, providers or publishers and other stakeholders in the domains of geological knowledge, mining waste, and of landfill and waste flows. Account was taken of existing data harmonisation practices and systems of reporting used across Europe; relevant legislation, such as the Mining Waste Directive, the Waste Framework Directive and related Directives on waste treatment (i.e. Landfill Directive) and on specific waste streams (various End-of-Life Directives), and the INSPIRE Directive on the reporting of spatial data; of related activities such as EuroGeoSource, ProMine, Minerals4EU, GIS Central Europe, OneGeology Europe and European Geological Data Infrastructure; and policies in other domains, such as the standards for public reporting of resources and reserves data endorsed by the European Securities and Markets Authority. The results of the above were used to describe the current situation of EU-28 and 13 neighbouring countries.

Barriers to harmonisation were examined under broad themes identified in the second pillar of the Raw Materials Initiative:

- Policy, legislation and regulation
- Data quality and comparability
- Data infrastructure, provision and accessibility

Minventory has determined the availability and accessibility of statistical data on resources and reserves for 42 key minerals held in Member States and 13 neighbouring countries. Data categories include resources, reserves and 'other' non-statistical data. 17 of 21 respondent countries do not consider minerals data to be confidential at the aggregated national level. In addition 25 of 29 respondents make some or all data available to the public.

In general, data on metalliferous minerals is deemed more sensitive than that for industrial and aggregate minerals. This reflects that there are typically rules within State mining laws that restrict dissemination or at least set a moratorium on disclosure. In other cases, private

companies will limit disclosure based on self-interest. Confidentiality, aggregation and redaction protocols (as already operate within Eurostat) will, therefore, be critical components of EU-level harmonisation.

A review of systems of reporting shows that the process of collecting data on mineral resources and reserves is far more structured for countries in Eastern Europe (7 of these are aligned or in the process of aligning to a widely accepted code or standard). Here, requirements to provide data to the relevant authority commonly form part of the legislation on mining. Likewise, it is also a requirement to provide data in a format that complies with a national Reporting Code. National Reporting Codes often align with the international CRIRSCO Template. Whilst only the UK does not have a national mining policy, all other States have such a law or policy, and two thirds of these mandate data disclosure.

Considering the full responses to the questionnaires, issues and gaps in practice which would hamper harmonisation were identified as summarised in the table below. The severity of each of these issues has been rated on a scale of 1 (least) to 5 (most) according to the judgement of the project team and feedback from participants in the Stakeholder Meetings and the steering group.

Table 2. Barriers to data harmonisation identified by Minventory (Parker et al., 2015)

Topic	Issues/Gaps	Severity
I. Policy, legislation and regulation	1. National mining law or minerals policy	4
	2. Legal requirement to provide resources/reserves data	5
	3. Terminology of primary RM and dedicated legislation	5
II. Data quality and comparability	1. Mandated use of a system of reporting	5
	2. Alignment of national systems of reporting with a widely accepted standard or code	3
	3. Process of harmonising data	4
	4. Data reliability	4
	5. Application of the INSPIRE Directive	3
III. Data infrastructure, provision and accessibility	1. Number of organisation(s) in charge of collecting and centralising data	4
	2. Data ownership and confidentiality	4
	3. Public access to open data	3
	4. Multilingual format of data	2

3.5.2.1 **Recommendations**

The barriers identified are the targets for action in the Minventory roadmap (Figure 20). At the time of publication (2015), it was foreseen that many of these could have been completed by the target date of 2020. However, it now appears that many of these dates were too optimistic. Some of the more tractable issues relate to: converging use of terminology, establishing data confidentiality and redaction rules at EU level, and asking Member States to nominate single contact points for data handling. More problematic are the issues associated with making data available for publishing, adopting a common system of reporting, and dealing with historic data in diverse systems of reporting. A detailed analysis of each action proposed, together with different options for action and recommendations are included in the Minventory final report (Parker et al., 2015). It should be emphasised that suggested actions are all voluntary to tackle the issues.

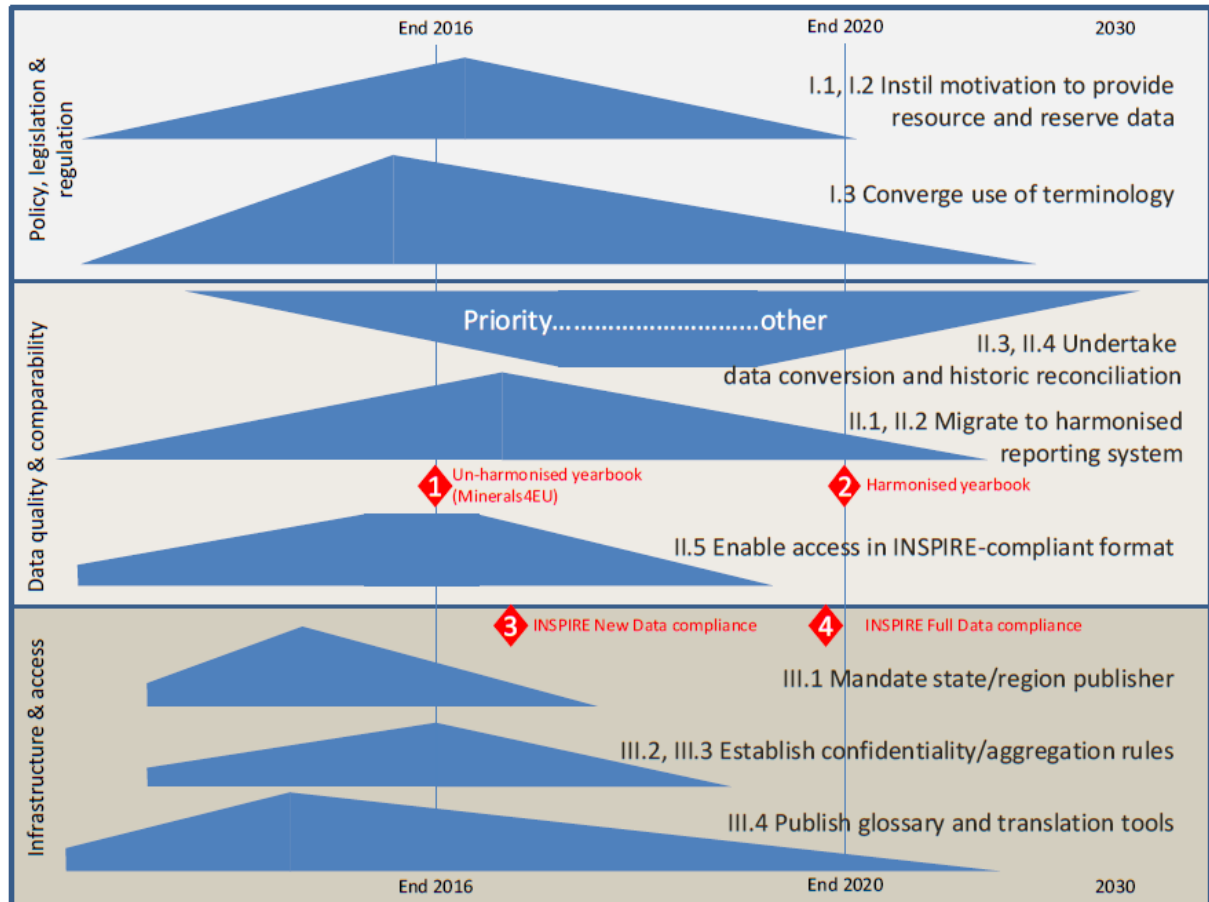


Figure 20. Key actions in the Primary Raw Materials Roadmap (Parker et al., 2015)

The Minventory project also produced a possible harmonisation process which could be used to map how reserve and resource information may be compiled at an EU level. Consideration was given to both the stages of data processing for EU-level publication and detail of how the process might be implemented on a national level where various different standards are used.

Minventory produced a pathway for the establishment of harmonised reporting of resources and reserves statistics at the EU level. This is outlined in Figure 21. Minventory concluded that a reporting standard or code aligned to the CRIRSCO-template or the UNFC system could be adopted for reporting resources and reserves at the European level. The Final Report presents advantages and disadvantages of each, but further discussion amongst Member States is needed to come to a firm conclusion. It is not implied that Member States must adopt such a code nationally, but that it should be used for transmission of information to the EU level and by the EU in its subsequent publication or communication of statistical data related to resources and reserves. In any case, any CRIRSCO-based reporting system can be mapped to UNFC by prevailing bridging documents.

EU-level data quality assurance processes should be put in place, to ensure comparability of application of harmonisation rules and to perform redaction prior to publication. These tasks could be performed by one or more bodies, if necessary, to merge minerals competence with proven confidential data management capabilities. For example, Eurostat is a model for data redaction; a public institution (Geological Survey for example) or private data company could manage the harmonisation task.

The INSPIRE Directive goes some way to providing a framework for public authority data reporting in this domain, but would require a recommendation on systems of reporting employed and possibly further work to define pragmatic minimum metadata sets for production, trade and mineral exploration data and mineral resource codes, standards and classification schemes to reflect EU minerals priorities in the necessary detail.

3.5.2.2 ***Links between Minventory and ORAMA***

The Minventory project is highly relevant to the ORAMA project and the detailed recommendations made will be carefully reviewed by the ORAMA project team. Several suggestions about options for actions and implementation are provided with regards to the harmonisation of resources and reserves data at EU level. These will be brought forward for discussion with stakeholders of the ORAMA project.

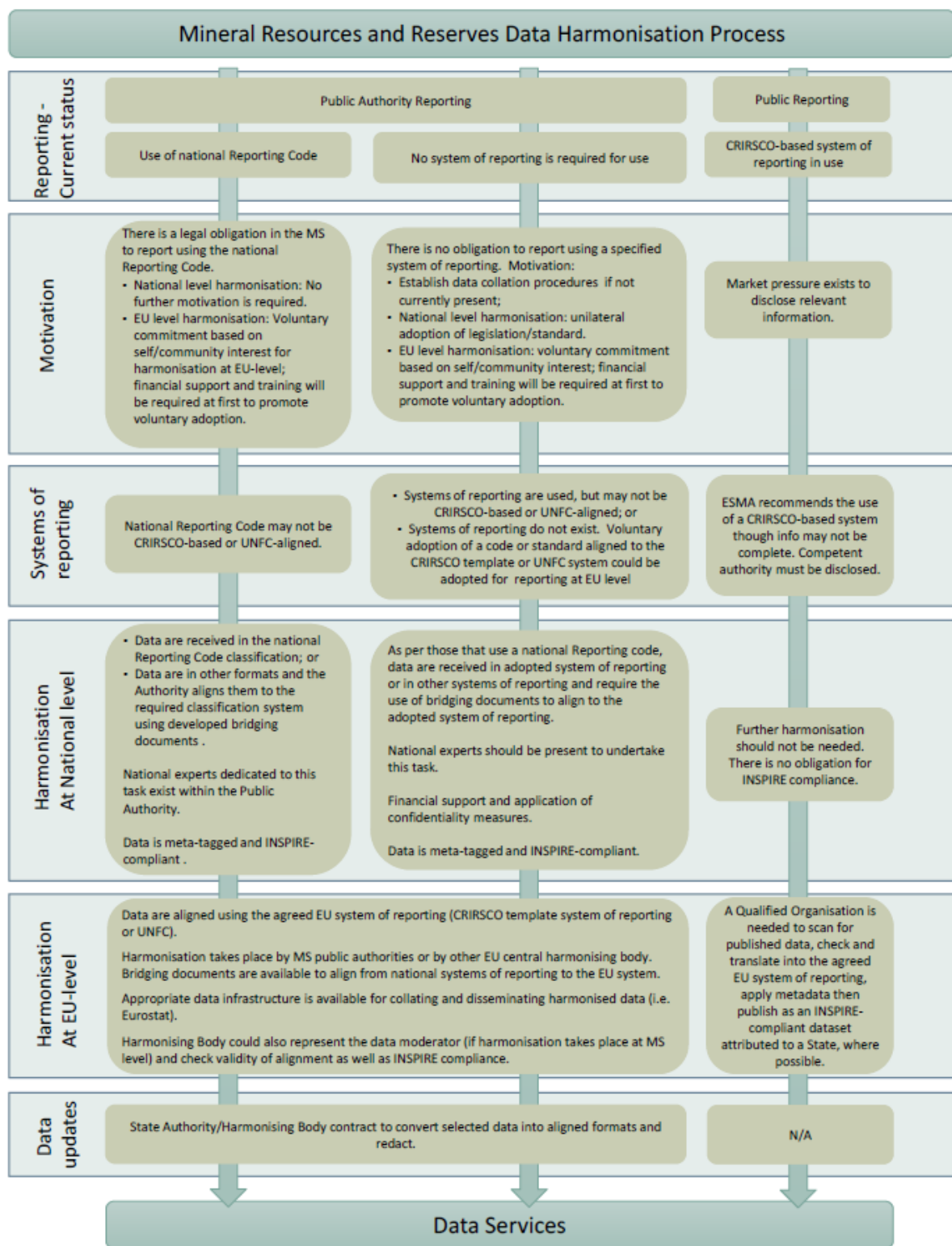


Figure 21. A potential roadmap outlined by the Minventory project for data harmonisation (Parker et al., 2015). This could form the basis of how harmonisation could be implemented by ORAMA.

3.5.3 Minerals4EU (2013-2015)

The Minerals Intelligence Network for Europe ([Minerals4EU](#)) project was designed to meet the recommendations of the Raw Materials Initiative and the project was successful in developing a web portal containing a wide variety of statistical and spatial information regarding raw materials, a European Minerals Yearbook and foresight studies. The project also established an EU mineral intelligence network.

The Minerals4EU project was built around an INSPIRE compatible infrastructure that enables European geological surveys and other partners to share mineral information and knowledge, and stakeholders to find, view and acquire georesource and related data. The resulting knowledge base provides support to policy-makers, industry and society at European and international levels.

The basis of the data that underpinned the yearbook produced by the Minerals4EU project was set of questionnaire, sent to geological surveys and other relevant stakeholders, which collected information on primary mineral production, resources, reserves and exploration. Data on minerals trade and secondary raw materials were also compiled via separate data gathering exercises. The latter are presented alongside primary minerals data for the first time. An example page from the yearbook is shown in Figure 22.

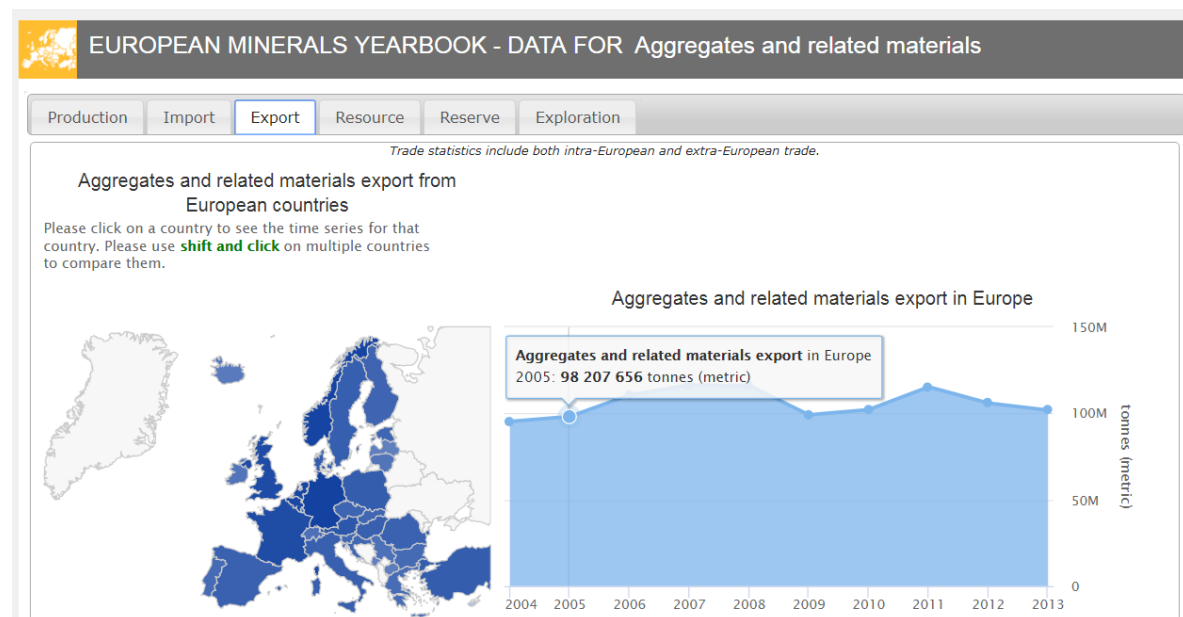


Figure 22. An example from the yearbook, showing some of the available information

3.5.3.1 Results of the data gathering exercise for primary raw materials

All data collected by the project can be viewed at http://minerals4eu.brgm-rec.fr/m4eu-yearbook/theme_selection.html

Production data for primary minerals were collected by the BGS in accordance with the procedures they have used for more than 100 years. This included questionnaires to geological surveys, statistical offices and government departments. Data gaps were filled by consulting data published on websites; by contacting additional data providers such as trade associations

and individual companies (in some cases); and by estimates based on available trade data or qualitative information.

Trade (import and export) data were obtained in bulk from an agency that specialises in collating these figures and then subjected to quality review procedures which included a comparison to the United Nations commodity trade database, Eurostat and/or national statistics as required. In general, estimates were not made to fill data gaps because trade data is much more variable than statistics for production and it is often not clear whether the trade flow has ceased or the figure is unavailable for another reason. The resolution of the classification systems used for trade flows can limit the availability of data for certain commodities.

Data for resources, reserves and exploration of primary minerals were collected for the first time during the project using a specially designed questionnaire, which also collected relevant metadata. Inevitably the data returned were not comprehensive; no attempts were made to fill data gaps, although attempts were made to identify the causes behind these data gaps.

The most significant issue for resources and reserves data is the absence of a single system of reporting that is common across all the European countries, which means it is not possible to compare resource or reserve figures between countries nor is it possible to compile overall totals for the European continent. In addition to data, the questionnaire also collected details of the reporting system(s) used by each country which is a valuable source of information for future steps. There were no attempts to standardise the returned data for the first edition of the European Minerals Yearbook but recommendations were included for how this might be achieved in the future.

Data for exploration were collected against six different metrics, again using a specially designed questionnaire that also collected metadata. As expected, the returned statistics were not fully complete for any one of those metrics but it was a useful exercise to gain insight into the types of data collected by each country relating to mineral exploration.

Despite the incomplete and quite variable nature of the returned data, the statistics presented in the Yearbook for resources, reserves and exploration represent an important first step towards the ultimate goal of a comprehensive and consistent dataset covering all the countries of Europe. Due to the complexities involved in harmonising and checking all the data received this has been done manually, ORAMA and the GeoERA funded Mintel4EU project are now developing ways in which this process can become more automated.

3.5.3.2 ***Recommendations for improved data collection and harmonisation for primary raw materials data***

The Minerals4EU project made many recommendations for better provision and harmonisation which are relevant to ORAMA, many of the following recommendations also echo the findings of the survey detailed in section 2.1.3.

Production

- To minimise the number of BGS estimates that are required to complete the dataset, work should continue, where necessary, to establish contact with new data providers within the countries concerned.
- Where there is already a data provider supplying the majority of the required statistics, discussions should take place to see if they can also supply data for any additional commodities needed.

- Where multiple sources supply different figures for the same commodity and the reason for the differences is unclear, discussions should take place with the data providers to attempt to understand the reasons and thus ensure the most accurate statistics are used.

Trade (imports and exports)

- Investigate the mechanism(s) for making suggestions for improving the data resolution in trade code systems used by the United Nations, Eurostat and other organisations

Resources and reserves

Definition of terms

- A common definition of the terms ‘resources’ and ‘reserves’ is needed so that all countries are understanding the same thing when those terms are used. This may be addressed in conjunction with the next bullet point because internationally recognised systems of reporting all have a clear distinction between these terms.

System of reporting

- Agreement needs to be reached between the countries for a common system of reporting to be adopted specifically for use in the Yearbook. Perhaps this should be PERC (the Pan-European Reserves and Resources Reporting Committee) standard which is aligned with the CRIRSCO template. Individual countries, or the companies operating in those countries, may choose to continue with a national reporting code, or a different internationally recognised system of reporting, for their own internal purposes if they wish but would be requested to supply their data for the Yearbook in accordance with the adopted system of reporting.
- Once a common system of reporting has been adopted for the Yearbook, each country will need to examine how their resource and reserve statistics can be ‘mapped’ to that common system and a bridging document should be written if one does not already exist.
- A person (or persons) with an appropriate level of competency would be required to carry out such ‘mapping’ and additional training of staff within key countries may be required to develop and undertake this exercise. Support from other European organisations may be necessary to conduct or assist with this training.

Commodity names

- The grouping hierarchy used for the first edition of Yearbook should be considered a temporary measure and a greater standardisation of commodity names should occur.
- A number of commodities ‘code lists’ or ‘classification codes’ are in existence for different purposes (including for spatial data under the INSPIRE directive and the Harmonised system codes for mineral trade) but it is not clear which of these is the most satisfactory. There needs to be a detailed discussion between experts in the countries producing those commodities, together possibly with data users, to establish an agreed list of commodities to be included in the Yearbook in future. This list may need to include an agreed description or definition for certain commodity names.

Collection, collation and presentation of data

- The benefits of central collation of data should be demonstrated and publicised to all countries, both those that currently undertake it and those that do not.
- There can be no compulsion for a sovereign state to change its national laws, therefore other ideas for encouraging central collation should be explored.
- The goal should be established of presenting as much data as possible in accordance with internationally recognised standards. Over time this will lead to greater consistency between countries and eventually lead to a standardised dataset.
- The inclusion of calculated commodity content, in addition to tonnage and grade, should be considered, where possible, because this would help to facilitate the inclusion of summary figures for Europe as a whole.

Confidentiality

- This has not been as big an issue as was originally expected. However, the reasons behind the specific instances where it occurs are not fully understood and should be explored and discussed further.

Exploration

- It is recommended that all metrics used by Minerals4EU (expenditure, number of exploration licences, number of licenses issued total area under licence and total number of companies exploring) continue to be requested in future updates of the European Minerals Yearbook, for the foreseeable future. In time it may be possible to remove some of them, particularly if the data for expenditure becomes more comprehensive. But in the meantime, having a range of metrics is useful too, firstly, demonstrate that exploration is ongoing for particular minerals and, secondly, to give some indication of the scale of the exploration.

Recommendations were also made with regards to the provision of data for secondary raw materials but these are not included here as they are outside the scope of WP1 within the ORAMA project.

All deliverables for minerals4EU can be found here:

<http://www.minerals4eu.eu/index.php/downloads/deliverables>

Of relevance to recommendations made for harmonisation of data are deliverables 4.3 and 4.5.

3.5.4 INTRAW (2015-2018)

As part of the European Commission's Horizon 2020 Programme for Research & Innovation, the 36-month [project INTRAW](#) has been launched in February 2015 to foster international cooperation on raw materials (INTRAW, 2018). The INTRAW project has been set up to map and develop new cooperation opportunities related to raw materials between the EU and other technologically advanced countries, such as Australia, Canada, Japan, South Africa and the United States, addressing:

- Research and innovation.
- Raw materials policies and strategies.
- Joint educational and skills programmes.
- Licensing and permitting procedures, royalties and tax policies.

- Data reporting systems.
- Exploration, extraction, processing and recycling practices.
- Management and substitution of critical raw materials.

Three reports were presented in 2017 that focus on raw materials [research and innovation](#), [education and outreach](#) or [industry and trade](#), in five reference countries. The operational reports and their summaries are available through the project [website \(https://intraw.eu/publications/\)](https://intraw.eu/publications/).

The INTRAW project refers to the Australian concept and relevant data management (Analysis on Industry and Trade Operational report, 2016) that can be considered as a good example. In Australia there is publicly available data standards (<http://www.ga.gov.au/data-pubs/datastandards>) and a declared [Public Data Policy Statement](#) that provides a clear mandate for Australian Government entities to: optimise the use and reuse of public data, release non-sensitive data as open by default, and collaborate with the private and research sectors to extend the value of public data for the benefit of the Australian public. The JORC (Joint Ore Reserves Committee) is a globally recognized reporting standard that needs to be considered in the process of developing interoperability between national and international systems that have uniform terminology and methodology for classifying mineral raw materials.

In a Workshop in Brussels (La Palma Research Centre, 2017) the need of comprehensive mineral resource inventory harmonised by international reporting standards and UNFC classification framework was highlighted.

3.5.4.1 ***Recommendations from the INTRAW project for harmonisation***

INTRAW created a database of the documents collected in the course of the project. These documents cover the whole scope of the project. Some are held in digital form (most as PDF files) within the database itself and available for download. Others are available online in digital form elsewhere and links are provided to these. Yet others are not available online but may exist as digital files or on paper within the INTRAW Observatory or in institutions or companies elsewhere.

In a report on the analysis of industry, it is stated that the minerals industry competitiveness depends on the availability of public reliable geological data. The validation of data and information collected by raw material experts from each reference country is important. In some cases, the statistical data on resources and reserves are unclear, likely because of unclear concepts in some compilations. Therefore, the figures on the percentage of the world reserves and on the life expectancy of mining until depletion must be considered with caution (Bonito et al., 2016).

There is a specific repository in the INTRAW project where raw materials related databases can be visited and searched: (<http://www.intraw-repository.eu/searchother.asp>). The elements of this list are the following:

- CRM_InnoNet – Substitution of critical raw materials
- EGDI – European Geological Data Infrastructure
- EIT-KIC Raw Materials– turning the challenge of raw materials dependence into a strategic strength for Europe
- EO-MINERS – Earth Observation to improve best practice in mining

- EuroGeoSource – aggregated geographical information on geo-energy and mineral resources
- i2Mine – the Intelligent Deep Mine of the Future
- MINVENTORY – directory of statistical data holders on stocks and flows of primary and secondary raw materials
- EURare – development of a European Rare Earth Element (REE) industry for uninterrupted supply of REE raw materials and products
- ProMine – stimulate the extractive industry to deliver new products to manufacturing industry
- RMIS - Raw Materials Information System
- IRP - International Resource Panel Working Group on Global Metal Flows

The linkages to these projects and the related information and data systems indicate that INTRAW has accepted the basics for the establishment of a coherent information system for raw materials established by previous work and has opened the dialogue for the development of a sustainable resource management system, including the optimisation of raw materials data collection and data management.

3.5.5 MICA: Mineral Intelligence Capacity Analysis (2016-2018)

The [MICA project](#) had the aim of identifying, collecting and disseminating data, information and knowledge in the field of raw materials that correspond to the needs of different stakeholder groups. The project delivered the following:

- A detailed stakeholder analysis and mapping of their raw material intelligence requirements.
- A metadata inventory with multiple sources of data and information on raw materials.
- An assessment of data uncertainty, which explored whether uncertainty is of concern to data users, how is it managed and what its implications are.
- An inventory of methods and tools that can be used in conjunction with data to respond to stakeholder needs.
- A knowledge management framework which can be used to track the transformation of data into knowledge (Figure 23).
- A methodological framework that assists stakeholders who do not have the expert knowledge to identify a route to answer questions of interest related to raw materials.
- An analysis of options to integrate raw materials intelligence within the European mineral policy framework.
- The development of the MICA knowledge platform (EU-Raw materials Intelligence Capacity platform (EU-RMICP)), an intelligent search engine, which integrates data, methods, tools and knowledge and attempts to provide users with tailored results that respond to topics or questions of interest.

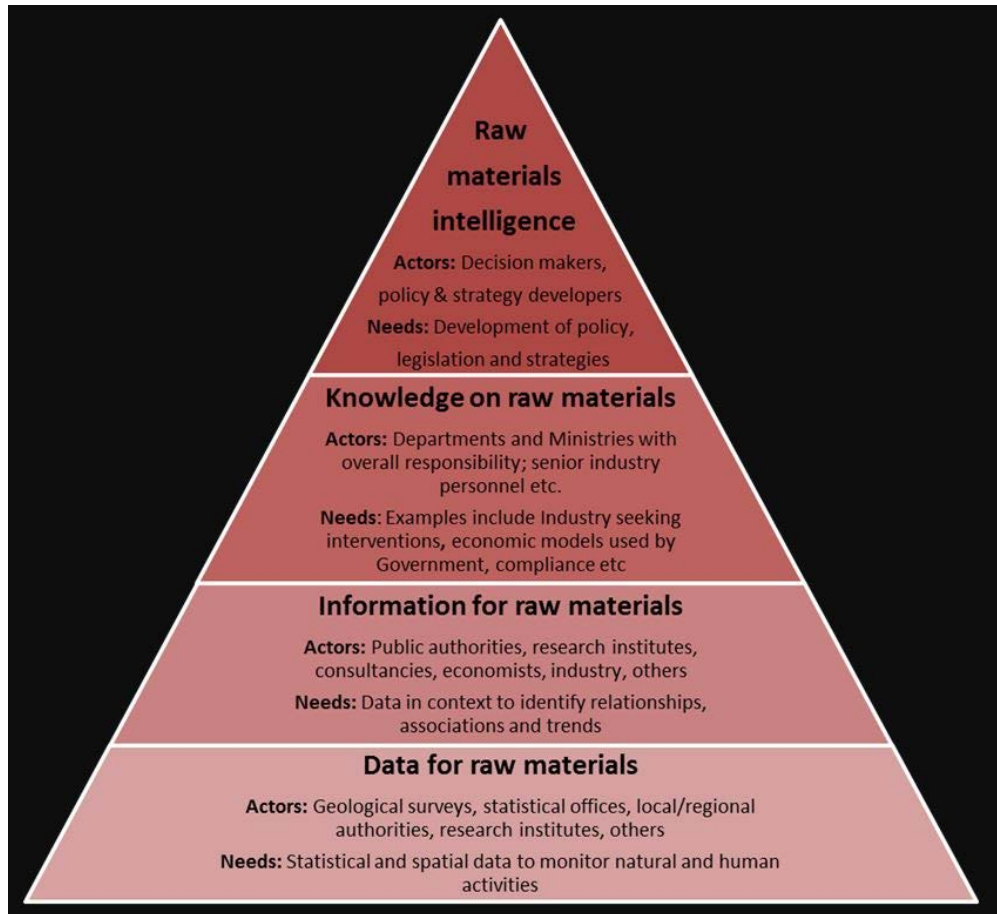


Figure 23. The raw materials Data-Information-Knowledge-Intelligence model developed to describe how data are transformed into knowledge. There is a clear hierarchical connection between data and information, information and knowledge and so on. The framework was used in MICA to map knowledge chains and to report the actors involved and their needs.

3.5.5.1 Results

The Mica project has undertaken significant work in identification, appraisal and mapping of stakeholder requirements for raw materials information which has led to the development of the MICA ontology. The broad range of topics (domains), identified during the stakeholder analysis is shown in Figure 24. Multiple sub-topics (concepts) are included within these Domains which are structured in a hierarchical way to create the MICA ontology. Datasets and methods are identified for the outlined Domains and Concepts of the MICA ontology and factsheets are developed to describe them to users.



Figure 24. MICA has explored 7 major topics (Domains). Each one of this Domains includes a series of related sub-topics (Concepts)

The MICA project has developed a series of “factSheets” and “flowSheets”. FactSheets are domain-specific descriptions of data sources, methods, tools and models, whereas flowSheets can be considered “recipes” that describe the pathway to an answer. FlowSheets are developed for questions of interest posed by stakeholders and they provide the data, methods and knowledge, as well as how they should be combined and in what sequence to obtain answers to specific question. These factSheets and flowSheets have been integrated into the [European Union Raw Materials Intelligence Capacity Platform](#) (EU-RMICP), which is intended to be a stand-alone product that can be incorporated into a European Union Raw Materials Knowledge Base (EURMKB) within a future permanent structure of an EU Raw Materials Intelligence service.

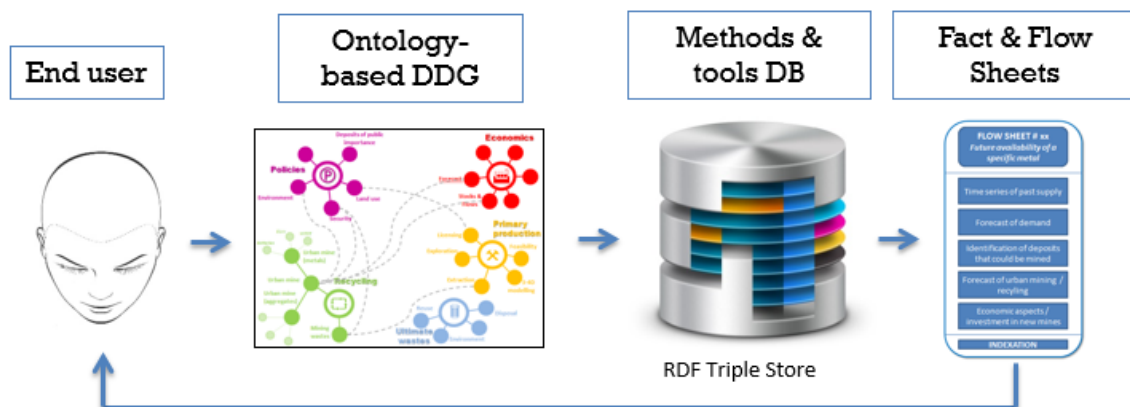


Figure 25. The flow of knowledge through the MICA system to the end users

The online metadata inventory which has been compiled for MICA comprises 410 records, see <http://metadata.mica-project.eu/mmd>. The impact thereof is broad as data is made more easily accessible, and above all, is structured to facilitate rapid, systematic searches for mineral (raw) material topics.

3.5.5.2 **Data gaps**

Several data gaps were identified by the MICA project. These are summarised in Table 3.

Table 3. Data gaps identified by the MICA project (Petavratzi and Brown, 2017)

Data gap	Description
Waste and recycling data	Data currently available are considered poor and incomplete. They cannot be incorporated into methods without making additional assumptions, which affect subsequent analyses and models developed.
World Emission Registration data	These are not available for every country. In order to calculate normalisation factors that find use in LCA models, emission registration data from some countries are used and extrapolated to a World-wide level. This is an important gap and can introduce significant uncertainties in LCA models.
Urban stock data (built up or accumulation)	These are not currently available but are essential for assessing the urban environment and for quantifying resources that may become available in the future.
Composition of goods (e.g. metal content of ores, materials, components, products, waste)	Essential data used by several methods but are currently only partially available from various dispersed sources.
Data on dissipative losses	The European Pollutant Release and Transfer Register (E-PRTR) reports emissions from installations. A start has been made to also include dissipative emissions e.g. from livestock and fertilizer use etc.). Dissipative losses are required by several methods. Essential in quantifying environmental impacts and undertaking mass balance exercises.
Data on the lifetime of goods	Data are only partially available from various dispersed sources. They are very important when quantifying the resource potential from secondary resources.
Data on the production of secondary raw materials	A comprehensive dataset that addresses several commodities is missing. Partially available for selected commodities alongside the mineral statistics.
Monitoring concentrations in soils	Partial data may be available for some countries, but often are deemed of insufficient detail or/and are not updated frequently.
Social factors and policy related data	These are often available from reports rather than databases. They may be partially present in national statistics for some countries. Overall comprehensive and standardised datasets are missing.
Mining waste data	Some may be available through national statistics or public authorities, but there is no comprehensive dataset that holds such data at EU/ World level. Again an important dataset used for assessing society's metabolism and environmental impacts.

3.5.5.3 **Recommendations**

The MICA project is primarily concerned with communicating knowledge on raw materials so that mineral intelligence, namely decision making is informed using the best available information data and methods. The project did not focus on data standardisation and harmonisation.

The MICA project made some key conclusions regarding data uncertainty (Petavratzi and Brown, 2017) along with recommendations on how this uncertainty can be overcome, these include:

- Overall two key types of uncertainty are associated with data on raw materials: conceptual uncertainty regarding the meaning of data, and data uncertainty caused by random errors.
- The comprehensiveness and quality of metadata is particularly important. Information and explanatory notes on detection limits, missing data, the data sources used to produce a dataset, sampling variability, location position, the type of survey undertaken and procedures followed, and many more, are important and should accompany any dataset.
- Communication between data users and data providers to understand the data generation and data supply chain is crucial in optimising data collection and minimising uncertainty.
- Employed measures of managing uncertainty need to be effectively communicated to data users, including confidence levels and intervals, verbal labels that are clearly explained and the use of a system context approach to make data available to users.
- Establishing peer review processes to address uncertainty is also a method that can be constructive and lead to good results.

Some key recommendations from MICA by the final project deliverable are described below (Faigen et al., 2018):

1. Raw materials intelligence (RMI) should transcend the realm of the mining, metals and minerals sectors. Stakeholder questions focus not just on resource availability but also on environmental, social and economic aspects. Many of the questions refer to:
 - the whole supply chain;
 - need for information throughout the supply chain;
 - this knowledge is important to support raw material policies.
2. A variety of data and methods is required to provide mineral intelligence. Stakeholder questions are complex and require data and methods in addition to geological data and methods. Industrial Ecology methods and data can be a powerful addition as they speak to the geological methods (assessing flows and stocks of (raw) materials) and extend to metal flows and stocks in society.
3. The knowledge gaps need to be filled in and the related methodology is also needed to be developed for both primary (e.g. mineral raw materials) and secondary resources (different types of wastes, mining heaps and tailing and other mine by-product).

The project also identified gaps in methods available as outlined below (Petavratzi and Brown, 2017) which need to be addressed by future projects:

- Mapping urban stocks: there is no specific method for developing such models, but the research community has been exploring this subject (Hamilton, 2017). The use of 4D-GIS data at urban scale is one of the approaches followed to map urban stocks. Good data at urban scale are required to apply this approach, which is often missing.
- Building Information Modelling: This method (HM Government, 2012) has not been included in the MICA project, but could be relevant especially in assessments of the urban environment and stocks.

3.5.5.4 *Links between MICA and ORAMA*

The MICA project is possibly of less relevance to ORAMA than some other EU projects that specifically dealt with issues around improving data provision and harmonisation for raw materials information. However, the following key points, which are derivatives of the various MICA deliverables are of relevance to ORAMA and should be taken into consideration.

- Data are developed to serve a specific role, but they are often used in different ways to answer a variety of questions outside their original scope. The problem in using data in a different context is that they are often not fit for the new purpose. Therefore, in order for harmonisation and standardisation to be effective, the role of data and their potential multiple angles and uses need to be thoroughly understood.
- The main purpose of data on raw materials is to monitor the physical economy. Raw materials, however, are parts of complex supply chains and undertake several transformations across their lifetime. It is important that harmonisation actions take into consideration the system that raw materials belong to and that they are implemented within this system context following a whole life cycle approach.
- Data uncertainty should be addressed and communicated adequately. Issues surrounding data uncertainty should be central to any harmonisation action.
- The MICA metadata inventory can prove a useful resource for identifying data providers. The inventory involves a wealth of records related to a broad range of topics, including primary mineral resources, secondary mineral resources, sustainability of raw materials and international reporting that are all relevant to ORAMA. FactSheets on the above topics are also made available through the EU-RMICP.

3.6 Permanent Bodies

3.6.1 UNECE EGRC

The Expert Group on Resource Classification (formerly known as the Ad Hoc Group of Experts on Harmonisation of Fossil Energy and Mineral Resources Terminology) is responsible for the promotion and further development of the United Nations Framework Classification for Resources (UNFC). The basis of the activity of the UNECE EGRC is written in the [ECOSOC Decision 2004/233](#)

3.6.1.1 **United Nations Framework Classification for Resources**

At its 42nd plenary meeting, on 16 July 2004, the Economic and Social Council, recalling its decision 1997/226 of 18 July 1997, welcomed the endorsement by the Economic Commission for Europe of the United Nations Framework Classification for Fossil Energy and Mineral Resources and decides to invite the Member States of the United Nations, international organisations and regional commissions to consider taking appropriate measures for ensuring worldwide application of the Framework Classification. The Council notes that this new classification for fossil energy and mineral resources, which now includes energy commodities (for example, natural gas, oil and uranium), is an extension of the earlier framework developed for solid fuels and mineral commodities, on which the Council took similar action in 1997 upon endorsement and recommendation by the Economic Commission for Europe (Source: <https://www.un.org/en/ecosoc/docs/2004/decision%202004-233.pdf>)

In line with ECOSOC Decision 2004/233, in order facilitate worldwide application of the United Nations Framework Classification for Fossil Energy and Mineral Resources, the Expert Group on Resource Classification developed a simplified, generic and revised version of the Classification. The United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009) was approved by the Committee on Sustainable Energy of the United Nations Economic Commission for Europe at its Eighteenth Session in November 2009 (decision ECE/ENERGY/80 para 21(g)). The specifications for the application of UNFC-2009 were approved by the Committee at its Twenty-second Session in November 2013. "UNFC-2009 incorporating Specifications for its Application" is now available as a UNECE publication, ECE Energy Series No. 42 (Source: <https://www.unece.org/energy/se/egrc.html>).

The connection between the UNECE EGRC and the ORAMA project is that both seek the optimisation of data service for raw materials including primary and secondary as well. However, the UNECE EGRC provides a framework and forum for discussion of the harmonisation concept for resource management for all types of energy and non-energy mineral commodities on global level, while the ORAMA project works on EU-level with a focus on real data service for non-energy mineral commodities and the necessary harmonisation steps for statistical and spatial data. Both approaches aim to facilitate the development of a sustainable resource management system that may be adopted on national and regional levels on a voluntary basis but taking into consideration the foreseeable benefits (e.g. resource efficiency).

3.6.2 **EGS MREG**

EuroGeoSurveys operates the Mineral Resource Expert Group (MREG) including experts on mineral resources delegated by each National Geological Survey.

This group is actively involved in contributing to policy- and strategy-making processes aiming to identify, characterise and safeguard a sustainable resource potential, notably on critical raw materials, through research, development and innovation.

The MREG aims to become the leading partner within a European Raw Materials Knowledge Base and Information Network or another form of cooperation that will be providing innovative tools and expertise to support sustainable minerals supply for Europe. Mineral information provided by the MREG is based on globally comparable standards of excellence for research and development, and these standards are maintained to become permanent. The MREG Vision

is carried out collaboratively with other organisations that have mineral intelligence capacities and expertise and with consumers of that information and other potential stakeholders.

Concerning the need of the harmonised database for mineral resources in an INSPIRE compliant service/infrastructure environment, the activity is continuous. Some EU-funded projects dealt with and continue to deal with data harmonisation (Minerals4EU, MINVENTORY, etc.). The MREG is committed to contributing to the development of the common language including statistical and spatial data for raw materials.

One of Task Teams of the MREG is dealing with classification and harmonisation issues based on international reporting standards (e.g. CRIRSCO: PERC and JORC) and United Nations classification framework on mineral resources (UNFC) led by the United Nations Economic Commission for Europe (UNECE) Expert Group on Resource Classification (EGRC). The development of co-operation between the UNECE EGRC and EGS is in progress.

3.6.2.1 ***Some recommendations***

- Development of national projects for data harmonisation is important and, due to their relevant knowledge base and expertise on raw materials, National Geological Surveys should be involved into the development of the concept of data harmonisation and data optimisation on regional and national and EU-level as well.
- Sharing knowledge on data harmonisation (methodology, cases, good practices) should continue between the National Geological Surveys and other relevant stakeholders.
- National Geological Surveys should continue with active participation in the activity of relevant working groups and forums (e.g. UNECE EGRC)
- Legislation for raw material data management should be considered as a tool for harmonisation. The legislative background is heterogeneous for using national and international reporting standards or classification framework (Figure 26). Governments should be encouraged to consider UNFC for the classification of national mineral resource inventories and for resource assessment. UNFC facilitates long-sighted resource governance by integrating environmental and social considerations. Furthermore, it is suitable for consistent national and international reporting

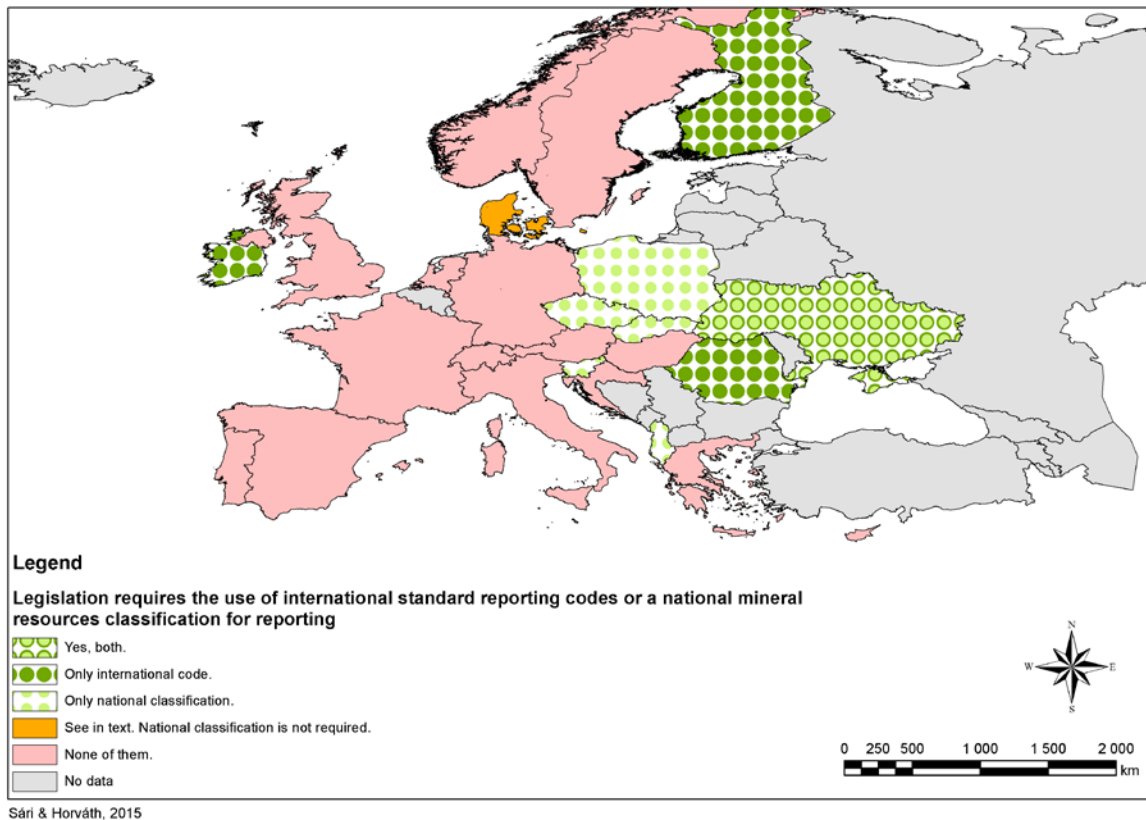


Figure 26. The use of international reporting standards and mineral classification systems in Europe. Source: https://www.unece.org/fileadmin/DAM/energy/se/pp/unfc_egrc/egrc6_apr2015/1_May/10_Horvath.MinRes.EuroGeoSurveys.pdf

The need for harmonisation between national mineral resources classification and inventories and international standards and classification frameworks has been uniformly agreed on by all National Geological Surveys. UNFC is more encompassing and more suitable to be used by governments as it covers solid and fluid type resources, uranium, and renewable energy and also integrates sustainability indicators. It facilitates long-sighted resource governance by integrating environmental and social considerations.

Before the ORAMA project, in 2015 the statement of the MREG was that both systems, i.e., the CRIRSCO template and the UNFC, would be useful to develop on national and regional levels in National Geological Surveys because these professional governmental bodies contribute to the mineral policies including mineral resource management and data services on minerals.

The MREG considered the relationship between national geological surveys and UNFC in detail and reached the following conclusions:

The involvement of a person with an appropriate level of competency in National Geological Surveys, authorities and ministries that are responsible for mineral resources management is necessary because of the knowledge and skills required for harmonisation. Many national and regional legislations require that the reporting of the volume of mineral resources or changes in the volume must be by national-level competent persons as experts. Expert input is essential because the EU-level data that has been collected by previous projects (Minerals4EU etc.) may

include not only national codes but also industrial reporting standards or UNFC and these are not directly comparable. Responsible authorities may benefit from the input of a Competent Person or Qualified Person for the national, regional, or EU-level data service and data management. National-level experts may be responsible for data on minerals on a national level and may serve preliminary or informal analysis for national datasets harmonised by international standards, while the expertise with a report on assessments of the Competent Persons (as formally defined by the CRIRSCO template) may have a greater weight. The EuroGeologist title or the detailed descriptions of internationally recognised experts by CRIRSCO template standards may be an appropriate level for this, but other definitions of competency could be considered.

This increasing involvement of internationally recognised experts into the national and EU-level data management and service may require and accelerate the education of geologists on national and regional levels. Involvement into the data service that may be aligned with international reporting standards and with the UNFC (harmonisation) is still very low and should be increased to support the formulation and implementation of mineral policies and develop sustainable mineral resources management. For this, different aspects and interests of stakeholders (state, investors, experts, NGO's) have to be taken into consideration for strategic mineral resources planning.

A person with an appropriate level of competency may be required for mediation between stakeholders and to assure the reliability of data as well as transparency, materiality and impartiality. The development of Bridging Documents between national classification systems to CRIRSCO reporting codes (e.g. PERC and JORC) and/or UNFC-2009 should be developed on a national level by NGSs, where they do not already exist. The concept of the PERC system (CRIRSCO-aligned Pan-European standard) partially overlaps with UNFC by the relevant bridging between them (interoperability between terms and methodologies with relevant studies: e.g. scoping, pre-feasibility, feasibility) that provides an opportunity for EGS to build co-operation and collaboration between the stakeholder organisations.

National Geological Surveys should develop the concept of harmonisation and support collaboration projects. The streamlining of the national classification and inventories may be performed based on the experience of other countries having relevant types of mineral resources. Digitalisation, using appropriate terms and forms, mapping between national and international systems, sharing experiences, acceptance of recommendations from EU, national and regional guidance and from EU-projects may strongly contribute to the development of modern national and regional inventories for mineral resources. Nations or regions that have no specific inventory for mineral resources should be encouraged to initiate the establishment of an appropriate inventory which may be supported by and require modifications in legislations (e.g. legally binding data service by companies). This may be an important interest for governments and brings benefits to them by providing knowledge of the volume of relevant mineral resources and to support long term resource management including secondary resources as well (mitigation of the consumption of primary resources).

Terminology for harmonisation of “resources” and “reserves” should be adopted from international standards. The bridging for harmonised classification, inventories and the UNFC system can be done by Bridging Documents provided by the UNECE-EGRC.

National characteristics may necessitate individual approaches to encourage the use of the standards on national levels. Governments are encouraged to consider UNFC for the classification of national mineral resource inventories and for resource assessment by experts of companies or, in specific cases, experts of Geological Surveys. In an ideal case when most

of the national systems are clearly aligned with international standards and reporting is viable in the UNFC data, harmonisations may be much easier with obvious steps and algorithms. This does not exclude individual assessment of a specific deposit and the need for involvement of relevant experts. However, this will take not years but decades, as well depending on the acceptance of recommendations and the time of the procedure of the implementation.

Particularly, the UNFC category “E” may require co-operation with other organisations (regional authorities, ministries and agencies) in the progress of the harmonisation. Harmonisation is partially a kind of translation between terminologies in national classification and reporting and internationally accepted standards. The harmonisation takes into account the necessary model and forms as well (INSPIRE; the connection between spatial and statistical datasets). This process can also significantly contribute to the common objectives of mineral policies developed at national and EU-levels.

Many National Geological Surveys and National Research Institutions had and have projects dealing with the potential interoperability between national and international systems for mineral resources classification and reporting. Based on the EGS MREG Survey four countries in Europe (Hungary, Italy, Portugal and Slovakia) had national projects for the harmonisation including aspects for classification and reporting as well. However available publications confirm that this types of activity are more widespread. In Poland, there is an annual publication for resources in their inventory with interpretation for harmonisation between national and international systems (Szamała et al., 2017). A detailed analysis the need of a Polish Code, including, guidance considering CRIRSCO type reporting templates, including JORC, was underlined by Sobczyk and Saługa (2013). The Polish classification system can be compared with other methods of reporting resources through UNFC. However, it is not straightforward to harmonise it with the JORC Code, other CRIRSCO template codes or with PRMS (Petroleum Resource Management System) (for hydrocarbons) due to different terminology used and classification purposes (Nieć and Sobczyk, 2015). In the Czech Republic the comparison between national and international systems for classification and reporting has also been mapped and published (Stary et al., 2016). In Hungary general mapping and specifications for linking between the national (Russian-type system), the UNFC, CRIRSCO and PRMS (for hydrocarbons) with case studies for solid and fluid type mineral commodities have been published (Horváth et al 2016, see Section 3.7.1.1 regarding the Hungarian case study).

In the EGS MREG 17 Members consider this type of project to be useful on a national level and it may contribute to the appropriate EU-level data service. Many countries may be willing to link to or adopt an agreed international mineral resources classification system.

In addition in Romania, there is a specification for the application of the United Nations Recommendations on the International Classification of Reserves / Resources for Solid Fuels and Mineral Products in the frame of a guidance that was elaborated according to the Mining Law no. 61/1998 (National Mineral Resources Agency, 1998).

3.7 National projects

This section gives an overview on some relevant national and regional levels projects that aim to map the harmonisation opportunities between national and regional classification, reporting systems and the structure and elements of a national and regional inventory. These studies identify the necessary regional/national level steps toward establishing harmonisation that may also contribute to the successful implementation of the establishment of EU-level data.

3.7.1 Hungarian project

In order to achieve the joint modernisation of the national mineral resources inventory, the predecessors of the Mining and Geological Survey of Hungary (MBFSZ) started a research project in 2013. During the last 5 years, the project members have analysed the mineral resources classification systems applied in practice and the reporting standards and codes based on these classifications (UNFC-2009, CRIRSCO-aligned standards, SPE-PRMS (Society of Petroleum Engineers Petroleum Resource Management System), Australian Geothermal Reporting Code). The Survey has organised several consultations with professional organisations and companies to discuss the recently used Hungarian and internationally applied definitions and methods in order to make an agreement about the common ground and application. A set of case studies covering all mineral deposit types (metallic ores, coal, non-metallic minerals, hydrocarbon, geothermal energy, carbon capture and storage) have been carried out to test the conversion algorithms.

The principles and elements of the SPE-PRMS that is aligned with the UNFC were integrated into the Hungarian Mining Law in 2017. It was based on stakeholder consultation between the representatives of oil and gas companies and the MBSZ (Mining and Geological Survey of Hungary) and the experts of the Hungarian Geological Society. (MBSZ was integrated into MBFSZ in 2017.)

The Mining Law (Act No. XLVIII. 1993 on Mining) and the Governmental Decree No. 203/1998. (XII.19.) on the implementation of Act No. XLVIII. 1993 on mining control the whole sequence of mining activities, from the exploration phase to the closure of mines with the relevant obligatory data service. The statute (Governmental Decree No. 161/2017. VI. 28.) on the Mining and Geological Survey of Hungary (MBFSZ) describes the related tasks that support the Hungarian mineral policy. These legislative documents do not prescribe either the obligatory use of national classification or reporting systems or international ones but the available reporting form on the changes on volumes of oil and gas contains terminology that is compliant with the SPE- PRMS. By reporting changes in resources and based on the bridging between SPE-PRMS and UNFC companies contribute to the development of the compatibility of the National Inventory for Mineral Resources and Geothermal Energy with the UNFC system.

3.7.1.1 *Hungarian case studies*

In the frame of the above mentioned project, several case studies have been carried out. Hereby the classification of non-metallic resources in Zala County is presented. In Zala County there are approximately 600 million m³ non-metallic mineral resources according to the national inventory of 1 January 2015; mainly building stones and organic sediments (see Figure 27).

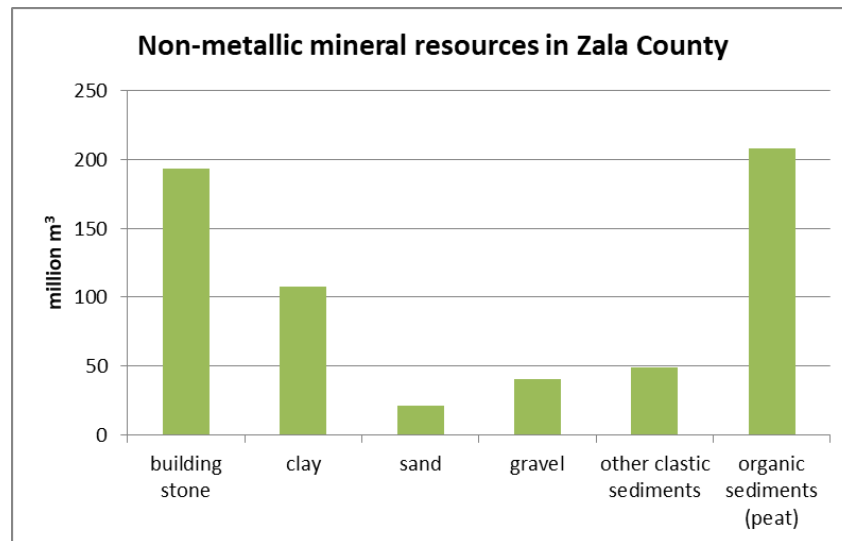


Figure 27. Non-metallic mineral resources in Zala County, Hungary

Mineral resources are registered in the Hungarian national mineral resource inventory based on the reports of mining operators according to the “Russian” classification system. For resource conversion the following information has been used:

- the status of the mine or quarry (active, pending, abandoned, unoccupied explored area);
- resource category (A, B, C1 or C2; in case of non-metallic resources categories A and B are merged into A+B);
- in situ mineral resource;
- a 'complexity group' is also necessary to be defined, as is explained below. However, it is not registered in Hungarian non-metallic mineral resources inventory so it has been estimated.

Complexity is one of the most important differences between the Russian-type national and international systems. Complexity is designed to support the mineral resource management blocks that make up the productive part of the deposit and considers the homogeneity of the deposit that needs to be taken into consideration for a specific volume. These blocks may be separated tectonically or may differ by their quality. Resources can be calculated for these blocks and separation may also be interpreted by the need of different mining operation. Deposits may be classified into 3, 4 or 5 classes depending on national/regional practices. Generally below 50 blocks/km² can be considered as a deposit of low complexity (relatively homogeneous), whereas over 100 blocks/km² a deposit can be considered as a complex one (heterogeneous).

Conversion algorithm used in our case study (Figure 28) is based on the FGU-GKZ & CRIRSCO (2010) conversion guideline and consists of 3 steps:

1. Category C1 is divided into two parts based on complexity group.
2. Categories A+B and less complex C1 are converted into Measured Resources whereas the more complex C1 and C2 go into Indicated Resources.
3. The status of the mine is examined: in case of an active mine or quarry, all modifying factors had been considered so the resources can be converted into reserves.

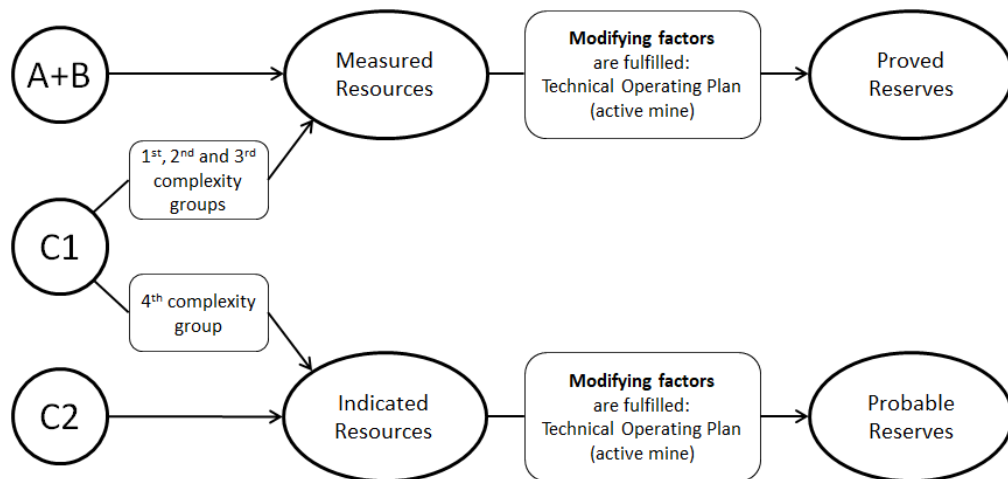


Figure 28. Conversion algorithm between the national (Russian type) and international systems including the CRIRSCO type reporting codes and the UN classification framework.

UNFC classes can be determined based on UNFC–CRIRSCO bridging document (UNECE 2013). Table 4 shows the mapping of CRIRSCO Template to UNFC-2009 Classes and Categories. Figure 29 compares the mineral resources according to the original, CRIRSCO and UNFC classification systems. Classes A+B represent a high level of geological knowledge (max. 20 % uncertainty). C1 has 35 % uncertainty and C2 has 60 % uncertainty in the calculation of the volume of the resource. The D categories (basically there are 3: D1, D2 and D3) are not indicated in the Figure below because these weakly known resources are the topics of potential assessments. However, less known resources can also be interpreted as Inferred Resources or Exploration Results that may be harmonised with the UNFC classes 223 and 334, respectively.

CRIRSCO template		UNFC-2009 “minimum Categories”			UNFC-2009 Class
Mineral Reserve	Proved	E1	F1	G1	Commercial Projects
	Probable			G2	
Mineral Resource	Measured	E2	F2	G1	Potentially Commercial Projects
	Indicated			G2	
	Inferred			G3	
Exploration Results					Exploration Projects

Table 4, Original, CRIRSCO and UNFC classification of non-metallic mineral resources in Zala County

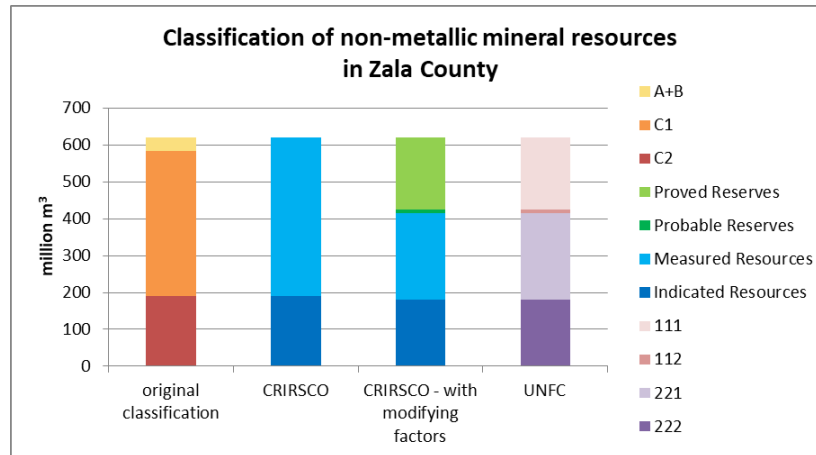


Figure 29. Original, CRIRSCO and UNFC classification of non-metallic mineral resources in Zala County

3.7.2 Central and Eastern European projects

There are many examples in Central and Eastern Europe for the applicability of the harmonisation between the national classification or reporting system, with the related inventory as well, and international systems (CRIRSCO-type reporting and UNFC classification framework for mineral resources).

In the summary of one of the most recent publications from Central Europe, concluded that (Horváth, 2018):

- Lessons learnt from an overview of relevant national/regional levels projects, that aim to map the harmonisation opportunities between national/regional classification, reporting systems may contribute to the successful implementation of the optimised data harmonisation and data service on EU-level. This also identifies the structure and elements of a national/regional inventory that is necessary for regional/national level steps towards establishing harmonisation. .
- The Hungarian project has demonstrated that mapping and bridging between national Russian type systems and international reporting codes and UNFC are possible. Although this requires acceptance of some recommendations such as; development of a team for relevant types of mineral commodities needs to achieve collection and translation of relevant reporting codes and UNFC on national language and understanding the similarities and differences between national and international systems (bridging).
- Development of case studies is essential and dissemination of results (communication, publication) can contribute to a smooth procedure of harmonisation. Stakeholder consultation between relevant parties (e.g. geological survey, mining authority, mining association, geological society) is important for agreement on changes in the reporting system. Preparation of guidance may help to other region or countries to develop their own national concept for the data harmonisation with international systems.
- In the future preparation of training materials and training may improve the harmonised data service. This may initiate the improvement of infrastructure and reporting systems (e.g. reporting forms) including inventories and the improvement of relevant legislation.

- It can also be stated that a careful assessment of available datasets on mineral resources is needed with respect to the information-base derived from mining enterprises (specific standards were applied).
- On national level national experts can perform tasks for harmonisation (informal datasets), however, the involvement of Competent Persons / Euro-Geologists may have additional benefits.
- In the V4 Region (the Czech Republic Hungary, Poland and Slovakia), it is important to confirm that data collection and maintenance in the frame of mineral resource management is in progress. All the four countries have a national system that has been developing. The Czech Republic and Poland provide printed and online available description of the opportunities for harmonisation between national and international systems.
- Besides positive results on the harmonisation the most significant difference – in terminology only - is that „reserves” in the Czech classification system include „potentially economic reserves”. In Poland to obtain full compatibility between the national system and UNFC, the data on Polish resources should be released separately. It is suggested that the terminology used by the EC („reserves” and „resources”) is comparable to two definitions used in the Polish classification system, i.e. anticipated economic resources („balance resources”) are comparable to „resources” whereas economic resources in place („industrial resources”) are comparable to „reserves”.
- In Slovakia reserves of „exclusive mineral deposits” are classified into three categories according to the stage of the survey, quality, technological characteristics and mining conditions. These are further subdivided into a number of additional „reserve” categories. The term resource is not used in Slovakia classification system. Accordingly, Slovakia reserve classification system differs significantly from that used in the Czech Republic and is not aligned with an internationally recognised standard code. It is used for „reserve” reporting on all reserved minerals in the country.
- Besides differences (not all the four countries resources and reserves are used and not the same harmonisation concept exists), theoretically the systematic national data collection for mineral deposits by geological knowledge point of view and taking into account environmental, social viability with the identification of the feasibility of a certain project on mineral exploration on exploitation serves opportunity to develop the interoperability between national and international systems.
- UNFC can handle environmental and social characteristics of a certain project dealing with mineral resource exploration or exploitation that is why this system can be a tool to support the sustainable management of natural resources which directly contribute to the implementation of the 2030 Agenda for Sustainable Development.

The concept and examples for the Czech Republic, Slovenia, and Poland are listed below:

In the Mineral Resources of Poland report (Szamale et al., 2017) details of the national system and the interpretation of the comparison and conversion of mineral resources from Polish mineral classification system into UNFC classification is presented in the publication ‘Mineral resources of Poland’, Polish Geological Institute (2017)

For Slovenia, the mapping between the Russian System and UNFC can be seen in Rokavec (2011)

Mineral reserve and resource classification in the Czech Republic and its evolutionary comparison with international classifications is correctly described in an annual report (Ministry of the Environment of the Czech Republic, 2016)

3.7.3 Nordic Project

A team from the Geological Surveys of Finland (GTK), Norway (NGU) and Sweden (SGU), the Swedish Association of Mines, Minerals and Metal Producers (SveMin) and Petronavit a.s., have worked on the application of the United Nations Framework Classification (UNFC) for mineral resources in Finland, Norway and Sweden. The group have presented the “Draft guidance for the application of the UNFC for mineral resources in Finland, Norway and Sweden” (<https://www.unece.org/index.php?id=45992>).

The purpose of the document is to provide guidance on the application of UNFC incorporating Specifications for its Application (as set out in ECE Energy Series No. 42), to mineral resources in Finland, Norway and Sweden.

The draft document is intended to assist in producing UNFC inventories and support the users by clarifying how UNFC can be used to facilitate policy and strategy formulation, Government resources management, industry business processes and capital allocation, the four principal areas of application of the UNFC. By using the full UNFC inventory in conjunction with the underlying project information, the classification provides a system that can be used for data collection, standardisation, aggregation and cross-comparison, thus facilitating the management of extractive activities across multiple temporal and spatial scales.

Part of the motivation has been to explore how the application of UNFC will provide better harmonization of mineral resource data across projects from uncertain, reconnaissance stage, and under-explored prospects to well characterized and well assessed resources and reserves.

Conventional reporting standards are mostly employed in developing or on-going mining projects, and required only for listed companies. These standards are not used, nor intended to be used, comprehensively, and are therefore not suitable tools for comparing and aggregating resource, and potential resource, inventories.

3.7.4 Norwegian project

In Norway, NGU, has modernized and reclassified the national mineral deposits databases according to INSPIRE. In this work NGU has introduced an INSPIRE compliant nomenclature for mineral occurrence types using the terms: occurrence, prospect, deposit. Mineral deposits have been reassessed and reclassified from a qualitative scale of significance to a more quantitative economic value/public importance assessment scale based on criteria, such as in situ value, volume, location, quality, national supply etc. As a result the deposits are now classified according to public significance and are classified as; international, national, regional, local importance, not important or not assessed. The Norwegian Directorate of Mining can then react if deposits of international, national or regional importance are affected by competing land use, such as infrastructure, nature conservation or other types of land use.

NGU delivers much of this data as a map service, this is continually being updated and new maps of mineral resources created. These maps will include both deposits previously registered in the database as points, as well as newly defined areas for prospects, deposits and provinces.

3.7.5 Finland, GTK's status of UNFC implementation

GTK has conducted persistent mineral exploration and bedrock mapping in Finland leading to an excellent understanding as to the location and size of many of the country's mineral deposits. GTK's current mineral potential mapping approach is more reconnaissance to prospecting stage exploration to attract further investments in ore potential areas. In this context UNFC provides a neutral framework for reporting governmental resources and a mechanism for reporting early stage exploration results and disseminate geological information for industry and society.

Mining Decree (28.6.2012/391) states that when reporting exploration results under an Exploration permit in a study area an internationally recognized standard has to be followed. However, the mining law does not specify which code to use. International exploration and mining companies operating in Finland follow the CRIRSCO Template and prepare the Public Reports under the company specific reporting codes. The most common reporting standards being used in Finland are the Australasian Code (JORC Code) and Canadian National Instrument 43-101 (see Figure 29). There is not a national standard reporting code for Finland.

GTK has decided in 2014 that UNFC will be implemented and few case studies have been made (e.g. Kiviniemi Sc, Mäkärä Au, Virtasalmi Cu). In these case studies deposits have been classified according to UNFC for demonstration purposes but formal reports have not yet been made. GTK participates in Mintell4EU project and one target of the project is to make a UNFC report of one of these case studies.

Before the UNFC classification of all mineral resources and reserves of Finland can be made, there needs to be a common understanding of the criteria of classification. Criteria can't change by deposit, commodity or time and they have to be comparable with other countries. Work on the criteria of classification is ongoing, draft guidance has been prepared by the Nordic Project (see chapter 3.7.3) and work continues in Mintell4EU project. Based on the criteria, GTK needs to create consistent practice how to classify new and historical mineral resources. CRIRSCO template could give basics for this work but final classification will be UNFC.

Due to a large amount of non-compliant resource estimates (see Figure 29) the harmonisation of the whole dataset to UNFC will be challenging. These non-compliant resource estimates can be based on sparse geological data with a low level of confidence or systematically explored targets with high data density. Non-compliant resource estimates cannot be mapped to UNFC before a deposits' data is inspected and classified by persons with expertise. At the current state, non-compliant resource estimates will be problematic in data providing sense. A temporary solution could be that all of these deposits will be classified as "Additional quantities in place" (344) until further knowledge.

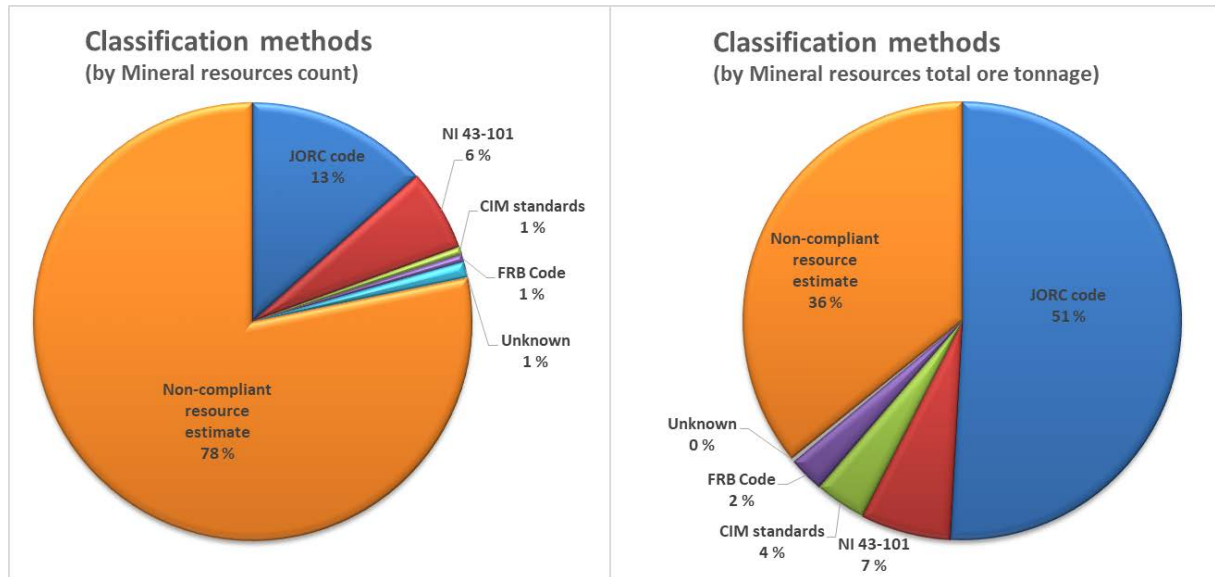


Figure 30. Mineral resources of Finland classified by the number of the resource estimates (349) and by the total ore tonnage (7009 Mt). Exploration and mining companies use mainly JORC and NI43-101 codes, but since there is no national code, all GTK's and old Outokumpu's resource estimates are non-compliant.

3.7.6 Slovenian project to transform statistical data from the national mineral classification to UNFC

Slovenia has an active minerals industry, in 2017 there were around 210 mineral deposits with concessions and around 170 mining right holders. There are no currently working operations for metallic minerals and production is focused on construction and industrial minerals (as well as coal oil and gas).

In Slovenia, there is a national "Commission for determining mineral reserves and resources". All mineral deposits are in State ownership. Concessioners are obligated to report annually to the ministry responsible for mining (Ministry for Infrastructure). Annual reporting forms include the following data:

- Volume of extracted mineral commodities (t/m³)
- Degraded area (ha)
- Reserves/resources in situ (m³).

Mineral commodities data are collected by:

- The Geological Survey, on behalf of the ministry responsible for mining, (National MR Database and Mining Registry Book) and
- "Commission for determining mineral reserves and resources" on a national level.

The Slovenian national classification is derived from the Russian mineral classification, reserves and resources are divided into 3 classes: 1- economic, 2-potentially economic and 3-non-economic. These classes are categorised in the following categories: A, B, C1 (named "reserves") and C2 (named "resources").

The Geological Survey of Slovenia (GeoZS) was involved in the Minerals4EU project, during which statistics on mineral resources and reserves were collected from official sources across 40 European countries, reported at the European level, and are made publicly available through the European Minerals Yearbook. In order to report the data into the EU-MKDP, Slovenian mineral data were transformed from the national classification into the UNECE- 2009 classification (Figure 31). Because the resource/reserve data for single deposits are not public, the data reported to Minerals4EU were summarised for the level of the type of mineral resource/reserves (e.g. crushed stone - limestone) on a national level.

fundamental characterization	economic efficiency	categories (national classification)	UNFC E _{axis}	UNFC F _{axis}	UNFC G _{axis}
economic	proved reserves	A, B, C ₁ , C ₂	1	1	1, 2, 3
potentially economic		A, B, C ₁ , C ₂	2	2	1, 2, 3
non-economic	measured resources	A, B, C ₁ , C ₂	3	2	1, 2, 3

Figure 31, Overview of simplified transformation of the Slovenian national classification into UNFC

However, only those UNFC-2009 categories (marked yellow in Figure 3) have been adopted for reporting, as these can be transformed from the existing national mineral classification. For the rest of the categories, the balancing of mineral data will have to be generated separately.

	Extracted	Sales Production			
		Non-Sales Production ^a			
	Class	Categories			
		E	F	G ^b	
Total Commodity Initially in Place	Future recovery by commercial development projects or mining operations	Commercial Projects ^c	1	1	1, 2, 3
	Potential future recovery by contingent development projects or mining operations	Potentially Commercial Projects ^d	2 ^e	2	1, 2, 3
		Non-Commercial Projects ^f	3	2	1, 2, 3
	Additional quantities in place associated with known deposits ^g		3	4	1, 2, 3
	Potential future recovery by successful exploration activities	Exploration Projects	3	3	4
	Additional quantities in place associated with potential deposits ^g		3	4	4

Figure 32, Categories from UNFC used for transformation

Therefore the model for the transformation of statistical data from the national mineral classification to UNFC in Slovenia was developed. As such it is suitable for annual reporting of mineral statistics into EU data platforms.

It should be noted that the Slovenian transformation model cannot be used for other ESEE (East and South East Europe) countries (using national classifications based on Russian system) because each country has its own version of the classification system.

3.8 Other relevant EU projects

In this subchapter, some relevant projects are discussed with regards to the need and recommendations to use harmonised joint language for different types of primary mineral resources even if they are on-shore or off-shore and require specific technologies. Projects overview is based on the list that was gathered in the frame of WP5 of the ORAMA project.

3.8.1 SNAP-SEE

The Sustainable Aggregates Planning in South East Europe ([SNAP-SEE](#)) project was implemented under the 4th call in the South East Europe (SEE) Program. It lasted from October 2012 to November 2014 and gathered 27 partners from 13 SEE countries, namely Albania, Austria, Bosnia and Herzegovina (Herzegovian Canton), Bulgaria, Croatia, Greece, Hungary, Italy (Autonomous Province of Trento and Emilia Romagna Region), Montenegro, Romania, Serbia, Slovakia, Slovenia, and Turkey. The SNAP-SEE project focused on developing and disseminating tools for aggregates management and planning in the SEE. Its primary objective was to develop a Toolbox for Aggregates Planning to support national and regional, primary and secondary aggregates planning in SEE countries. The minerals planning policy is part of the national mineral policy framework (European Commission and DG Enterprise and Industry, 2010; Tiess, 2011). Aggregates planning policy can be defined as the protection of aggregates deposits through land use planning (i.e. securing raw materials) (Tiess and Chalkiopolou, 2011).

Even if this project has not dealt with data harmonisation, an important element of the mineral (here aggregates) planning policy is the common, joint language for mineral resources that may influence transnational and regional trade and strategies.

In minerals or concerning specifically aggregates planning mainly if we are talking about EU-regional or EU-level approach the use of the joint language these type of raw materials is a fundamental need. This was presented on the UNECE EGRC Meeting in Geneva in the frame of the SNAP SEE project. A map was presented and the importance of harmonised datasets was highlighted with case studies by Horváth et al. (2014a). Without any specific recommendations, the importance of the joint language was highlighted with a map for SEE region where different classification and reporting systems exist but there are some similarities (geological knowledge in codes) according to the Russian influence that may be a base for the joint development of a common language for minerals and may improve the mineral resource management system.

3.8.2 MINATURA2020 (2015-2018)

The overall objective of [MINATURA2020](#) is to develop a concept and methodology for the definition and subsequent protection of “mineral deposits of public importance” (MDoPI) in order to ensure their “best use” in the future, in order to be included in a harmonised European

regulatory, guidance, and policy framework. Providing a policy-planning framework that comprises the sustainability principle for mining, like for other land uses, is the key driving force behind MINATURA2020.

In both the Guidance and the Joint Vision regarding the integration of the MDoPI concept into national, regional, and EU-level legislation, the following recommendations are highlighted:

- All types of management (land-use, mineral, waste, water, etc.) and the related policies need basic information from inventories.
- Mineral management in a sustainable manner requires a well-developed, regularly updated, modern, standardised, and INSPIRE-compliant datasets on the quantity and quality of mineral occurrences.
- A comprehensive inventory should cover all, primary and secondary resources, active mines and potential areas. It supports the MDoPI delineation, helping decision makers in the evaluation of quantity and quality of minerals beneath a given territory.
- A mineral resource inventory could follow international reporting standards, such as UNFC-2009 (UNECE, 2013) or the CRIRSCO family (CRIRSCO, 2013; JORC, 2012; PERC, 2013, etc.).
- If a national inventory using national classification and reporting system serves an appropriate base for the national raw material supply, the harmonisation with international systems does not seem to be necessary. However, taking into account EU-level and global markets and EU-level intention to mitigate the raw material supply risk and import dependency with the utilisation of European mineral resources and with enhanced recycling, the joint language is essential to be used by relevant stakeholders, the members of the Raw Material Community, and by responsible authorities.

Many deliverables of the MINATURA2020 projects highlight the importance of the alignment of national classification and reporting systems with international reporting codes (e.g. CRIRSCO family: JORC and PERC) and by the UNECE Resource Classification Framework (UNFC). These recommendations are fit to the activity of the UNECE EGRC (Geneva) that has been developing an appropriate joint language for primary and secondary resources (including anthropogenic ones) and other organisations are also committed in this activity (e.g. PERC, EFG).

These recommendations fit the activity of the UNECE EGRC and the objectives of the ORAMA developing an appropriate joint language for primary and secondary resources and other organisations (e.g. PERC, EFG) are also committed to this activity.

3.8.3 BIOMore (2015-2018)

<https://www.biomore.info/home/>

The general statement of this H2020 project is the following:

“The increasing shortage in technology metals in the EU requires innovative and yet environmentally sustainable mining technologies. BIOMore intends to be a cost-efficient and ecological answer to this problem. Its main objective is to develop new technological concepts for the in-situ recovering of metals from deep deposits using controlled stimulation of pre-existing fractures in combination with in-situ bioleaching. Within the scope of this project, methods and procedures of the process will be designed, tested and evaluated in laboratories

and in a small test facility in an operating underground mine in Poland. BIOMore is an ambitious approach including quite a lot of environmental benefits (no waste heaps, no dust exposure, minimum infrastructure on the surface, less noise and chemical impact etc.)” (BioMOre, 2018).

The project duration was between 2015-2018 and in deliverable 5.3 the need for public reporting is clearly emphasised in order to achieve new mining concepts for the extraction of metals from deep ore deposits using biotechnology:

“Rigorous monitoring and public reporting programs should be used to demonstrate both progress towards, and achievement of, agreed environmental outcomes, such that it will be possible to take corrective or enforcement action if the environmental outcomes may not be, or are not being, achieved. Monitoring data should be publicly available.”

Based on the above recommendations, it can be concluded that using harmonised classification framework on project levels and in national mineral resource management (inventory) for this type of mining activity would be important. All (resource-reserve; environmental, social and economic issues) can be handled and develop a project from an initial level (e.g. Exploration Results according to the CRIRSCO concept and 334 based on UNFC to Proved Reserve by CRIRSCO and 111 by the UNFC).

3.8.4 CERA (2016-)

(<http://www.cera-standard.org/home/>)

This project states that in contrast to other sectors such as the forestry, food or textile sector, in which a comprehensive certification scheme for production and transport is already established, an all-encompassing standard for the certification of mineral resources does not yet exist.

The ultimate objective of this project is to establish a label for mineral resources which will confirm that the product meets certain ethical, environmental, and sustainability criteria. Over the long term, it is intended that this will be a globally recognised label. In order for this to be established, it is necessary to develop an all-encompassing global standard which incorporates all of the other standards which currently exist for raw materials.

The UNFC can be a tool to support the achievement of these objectives because the three-axis logical system handles social and environmental considerations and indirectly sustainability criteria.

Deliverable for primary raw materials will be available in 2018. Some outputs of this project should be taken into consideration when the relevant deliverables of the ORAMA project are finalised.

3.8.5 MinFuture (2016-2018)

(<https://minfuture.eu/compilation-uncertainty-approaches-and-recommendations-reporting-data-uncertainty>)

Global demand for minerals is growing rapidly, driven by rapid population growth, urbanisation and an increasingly diverse range of technical applications. Global material supply chains linking the extraction, transport and processing stages of raw materials have become increasingly complex and today involve multiple players and product components. Knowledge that enhances transparency on existing approaches and information gaps concerning global

material flows is needed to understand these global supply chains. Developing this capability is critical for maintaining competitiveness in the European economy. Against this backdrop, the MinFuture project aims to identify, integrate, and develop expertise for global material flow analysis and scenario modelling.

Specific activities include:

- the analysis of barriers and gateways for delivering more transparent and interoperable materials information;
- the assessment of existing model approaches for global material flow analysis, including demand-supply forecasting methods;
- the delivery of a ‘common methodology’ which integrates mineral data, information and knowledge across national boundaries and between governmental and non-governmental organisations;
- the development of recommendations for a roadmap to implement the ‘common methodology’ at the international level; and
- the creation of a web portal to provide a central access point for material flow information, including links to existing data sources, models, tools and analysis.

MinFuture brings together 16 international partners from across universities, public organisations and companies, to deliver new insight, strategic intelligence and a clear roadmap for enabling effective access to global material information.

A transdisciplinary Advisory Board supports early-on and continuous integration of relevant expertise and perspectives into project activities for strategic guidance. It furthermore enables to increase the salience and topicality of project findings in relation to ongoing processes, as the AB members will function as enabling agents to take MinFuture results further to their organisations and networks.

This project confirms the importance of the Material Flow Analysis (MFA) and that raw material projects (and the data relating to them) are dynamic systems not static ones. For data harmonisation these systems need to be carefully understood so data points can be placed in the correct spatial and temporal location.

3.8.6 RESEERVE - Mineral potential of the ESEE region (2016-)

The RESEERVE project is a RIS (Regional Innovation Scheme) project within EIT (Education, Innovation Technology) Raw Materials programme. This 3 year project, which started in June 2018, aims to bring together 14 partners aiming towards a creation of a West Balkan Mineral Register for primary and secondary mineral resources. The register will be created by mapping the resources, focused on metals and industrial minerals with regard to primary raw materials (PRM) and mine and metallurgic waste sites with regard to secondary raw materials (SRM), in the following West Balkan countries: Croatia, Bosnia and Herzegovina, Serbia, Montenegro, FYRO Macedonia and Albania. All aforementioned countries are located in the Eastern and South-Eastern European (ESEE) region, which is identified as one of the priority outreach regions by the Strategic Innovation Agenda of the EIT and as such of particular strategic interest for the European sector. Furthermore, the project has committed to:

- establish an ESEE mineral community to determine available and further needed information on PRM and SRM in West Balkan;

- increase capacity of West Balkan countries for mineral management on a national level; and
- ensure sufficient flow of information on mineral resources for European industry to expand their business and investments into the West Balkan region.

The RESEERVE project will be a “pioneering” project in the region, representing the first step in the implementation of the EIT RawMaterials KIC’s plan to establish fruitful collaboration amongst countries where there are no KIC partners yet. The RESEERVE project will initiate the integrating process of the involved SEE partners into the INSPIRE-compliant “Pan-European Minerals Intelligence Network. This will be done by disseminating the knowledge and know-how of the previous and ongoing EU projects (EuroGeoSource, Minerals4EU, ProSUM, MICA and ORAMA), which have been aiming towards a creation of a common EU Knowledge Data Platform for mineral resources.

This project is very relevant to ORAMA as it aims to bridge the gap of accessibility of raw materials data and systematically organized PRM and SRM information from ESEE countries in the EU and will deal with their availability and harmonisation. Synergies of the project are foreseen that will bring mutual benefits for both projects. RESEERVE has been carrying out activities related with the identification of relevant data providers and examination of data quantity, quality and format for PRM and SRM. In addition, RESEERVE tasks include synthesis and creation of common datasets as well as harmonisation of datasets according to existing EU guidelines. Therefore the RESEERVE intermediate results will be interesting for ORAMA and vice versa; ORAMA intermediate and final results will be useful for RESEERVE. In particular with regard to (1) recommendations for the improvement of PRM and SRM datasets and (2) good practice guidelines and training materials for the collection of PRM and SRM data.

4 Good practice examples

There are a significant number of examples of good practice undertaken within the countries of Europe and these are presented in this section. It is important to be clear that the authors of this report, and the ORAMA project more generally, are not saying this is how these processes must be done. However, these are some ideas that other countries may wish to draw from when seeking to improve their processes and move towards harmonisation across the continent.

4.1 Data collection

Data collection and provision is variable between the different countries of Europe. Some have very comprehensive procedures and strict regulations on what is required, while others tend to rely more on the industries themselves and on voluntary schemes. The European countries with the most comprehensive data provision tend to be those of central and eastern Europe that have a strong history of central record collation and state ownership of mineral resources. However, there are other examples of European countries with strong systems for data collection, including Ireland where the Department of Communications, Climate Action and Environment has a direct involvement with mineral licensing, and Finland where TUKES, the Finnish Safety and Chemicals Agency have a statutory role in the collection of minerals data. In 2019 TUKES will introduce a new web-based data transfer system where all mining and exploration companies are obligated to report annually mine production data, exploration costs and exploration data. Both Sweden and Norway also have extensive databases for mineral production managed by the countries respective geological surveys.

In the Czech Republic, the majority of minerals are owned by the state and are categorised as ‘reserved minerals’. In Poland, the majority of minerals are owned by the state and exploration and mining licenses are issued by a central body, the Ministry of Environment. These types of systems create the requirement for collecting resource or reserve data on a statutory basis and are commonly linked to the collection of mining royalties or taxes. For example, in Poland there is a statutory requirement for all ‘concession holders’ to send resources data to a central body (the equivalent of the national geological survey); for deposits that are being worked this is an annual requirement and for non-exploited deposits it is mandatory to send these data on a regular basis.

Poland also has, as part of its regulations for mineral extraction and exploration, a requirement for central records to be kept on any new discoveries of mineral deposits (Państwowy Instytut Geologiczny, 2016). This allows the national reporting standard of Poland to be followed and total reserve and resource estimates for the country to be calculated. In turn, these data can feed into important planning and policy decisions that reflect which mineral deposits need to be developed in order to better serve local markets and support the national economy.

Similarly, in Slovenia, all the mineral commodities are owned by the State (by national Constitutional). The Ministry of Infrastructure (The Energy Directorate) is responsible for minerals and mining and performs tasks related to mining legislation and legal procedures within the mining sector. Within the National Geological Survey (GeoZS) the Public Mining Service (PMS/MSS) is established, in accordance with the Mining Act in force (ZRud-1; Official Gazette of the RS, No. 14/14 and 61/17 – BA). As a result, the following activities are undertaken with regard data provision:

- The compilation and maintenance of a Mining Register and Cadastre on a national level (database and web application),

- Records and statistics of wide variety of data on production, reserves and resources of mineral resources (MR) in the country (annual and 5-year Statement of mineral reserves and resources in the Republic of Slovenia),
- Participation in the process of land-use planning and designation of mining areas and other MR deposits in spatial documents, defining the areas with mining rights for the exploration and commercial exploitation,
- Cooperation with the Ministry responsible for mining in various administrative procedures (compliance, notification forms, etc.),
- Communication with the wider expert and public audience (MR web application, the annual publication “Bulletin of MR” in Slovenian and English language = Slovenian “Mineral Yearbook”),
- Professional storage/archiving of closed mines documentation,
- Supervision of field research works, sampling and sample storage,
- Archiving of closed mines documentation.

As well as data collected nationally, good examples for data provision within Europe can be seen by data collected by third-party organisations. For example, for mineral production, by the British Geological Survey in its publication ‘World Mineral Production’ (<https://www.bgs.ac.uk/mineralsUK/statistics/worldStatistics.html>) or by the Austrian Government in its publication ‘World Mining data’ (<http://www.world-mining-data.info/>). Considerable amounts of data can also be found in the electronic European Minerals Yearbook produced by the Minerals4EU project (http://minerals4eu.brgm-rec.fr/m4eu-yearbook/theme_selection.html). On a European level, the data produced by Eurostat in the form of the Prodcom production database is a good example of a single point source of data, compiled from submissions from individual Member States. These studies are excellent sources of aggregated, easily accessible statistical data. However, they rely on funding from third-party organisations and also require considerable resources in data collection and quality assurance from often a wide variety of sources. For these types of publication, harmonisation is achieved by a review of the data by expert staff when compiling the figures. Much less effort would be required if some level of harmonisation was already in place in the data sources.

If data is to be collected on a national level it is important that clear, robust procedures should be in place to do so. A good example of a successful industry survey for the production of mineral products can be seen in the Annual Minerals Raised Inquiry (AMRI) in the UK. Although the AMRI survey was stopped in 2015 due to funding cuts, prior to this it acted as a compulsory survey for minerals producers (producers were legally required to respond) that collected and presented data for separate mineral commodities and end uses, on a regional bases for England, Scotland and Wales. Due to respondents being legally obliged to complete a return, response rates were above 90%. This is in contrast to other sample type surveys which may only sample a fraction of the industry and then rely on estimates to bring the total to 100 %. The AMRI survey also had some restrictions on reporting to ensure commercial confidentiality is preserved. The survey had the support of the industry who accepted that the outputs of the survey were worthwhile and justified the time and cost involved in completing a return.

4.1.1 Mineral resource and reserve data

One approach to build a comprehensive harmonised inventory of mineral resources is to build a database defined on a deposit by deposit basis (as opposed to starting with nationally aggregated data). One example of where this type of bottom-up, deposit focused approach has been very successful is the Fennoscandian Ore Deposit Database (<http://en.gtk.fi/information-services/databases/fodd/index.html>). This is a database, with an associated web-based mapping application that details metal deposits and potential future metal discoveries in the Fennoscandian Shield. The database was compiled in a joint project between the geological surveys of Finland, Norway, Sweden and Russia based on known mineral occurrences, a compilation of mineral exploration records, mine locations, and mineral prospectivity analysis. This comprehensive database is only made possible due to the strong role of the geological surveys involved in mineral exploration, a wealth of available historical data on mineral deposits (all countries involved have robust resource management system and have a regularly updated database of mineral deposits and their properties) and a significant investment in combining several extensive datasets. This database covers metallic and industrial minerals, however, no data are available for construction minerals.

The ProMine project (see section 3.4.3) was a first attempt to produce a dataset where harmonised data on resources and reserves could be calculated on a European level (<http://promine.gtk.fi/>) using a bottom-up deposit based approach. The ProMine model was to develop a comprehensive database of mineral deposits, at the deposit level for all European countries. This dataset had the potential to store a range of information for each deposit including the quantities of resources and reserves contained within (along with other factors such as mineralogy, structure etc...). It was assumed at the start of the project that that all member states would already have these datasets prepared that could be assimilated into the ProMine project.

However, whilst ProMine produced some good results on the spatial locations of deposits in many countries, it is currently not possible to compile statistical information in this way because these data are simply not available at this resolution in many countries. The vast majority of records of deposits identified through ProMine (and subsequently through Minerals4EU) do not have resources or reserve figures attached to them. Often these figures at individual deposit scale are confidential. In other cases, deposits have not yet been quantified sufficiently to enable figures to be reported.

The other approach to construct an inventory of mineral resources is ‘top-down’ whereby experts within each country are asked to supply, calculate or estimate mineral inventories for each country on an aggregated national scale. This is done in many central and eastern European countries that use a national resource code based on the Russian standard. This requires some level of national resource management and collection of data for resources and this type of data exists in Slovenia, Hungary, Poland, the Czech Republic to name a few. These databases, however, are to national standards and not comparable to each other.

On a larger European scale, this approach was taken by the Minerals4EU project, for the electronic European Minerals Yearbook, where this data was compiled via a one-off survey of European countries. Although this project succeeded in producing national totals for countries where good data provision exist, significant gaps were present for countries who did not respond, or who did not have access to the data. Also, European aggregated totals were not able to be produced due to the numerous, incomparable reporting codes, standards and classification schemes used in different countries. This issue could be overcome by the adoption

of a single standard or classification scheme, such as the UNFC, albeit with appropriate levels of guidance, training and support.

4.1.2 Nationally managed databases

Exploration for, and development of, mineral deposits generate vast quantities of data which are of high value on both an industry and national level. However, as shown by differences in standards used and quantities of data reported for both exploration and resources and reserves data, these are often not well captured by national governments. To ensure that this information, which may have great national value, is stored for prosperity a robust system needs to be in place to ensure that the collectors of data (generally the minerals industry but also geological surveys) deposit this data in a central data store. Examples, where this has been successfully achieved, can be found from industrial sectors outside the area of primary non-energy minerals considered here, from which the minerals industry may be able to learn.

The petroleum sector is an example of where many countries have a clear system in place for capturing industry derived exploration, resource and production data. One of the most developed systems is in Norway, where the petroleum act dictates that exploration data must be passed to the Norwegian Petroleum Directorate after a specified time period to specified standards and formats and from where it will be made accessible for other stakeholders to use. This is stored in a National Data Repository (Diskos NDR) which has been specifically designed as a tool to enable rapid and efficient access to data, to further promote investment and better management of Norway's petroleum resources (Norwegian Petroleum Directorate, 2018a). In such systems, it is imperative that common standards and data formats are adhered to. These databases rapidly lose value if an ad-hoc collection of reports, data of different formats and miscellaneous files are submitted. The Norwegian Petroleum Directorate overcomes this by clearly outlining the standards and formats that are required in a document (Norwegian Petroleum Directorate, 2018b). There are no examples of such advanced systems for the primary minerals considered by this study in Europe, although clearly, this would be much harder to achieve if a range of mineral resources with associated industries needed to be considered (compared to the oil and gas industry). However, GTK and TUKES are developing such a system in Finland

In Finland TUKES in collaboration with GTK has developed a new data transfer system (TUKES-GTK Geodata flow) which will be launched in 2019. Mine production data, exploration costs and exploration data will be collected into the central database maintained by TUKES. GTK has prepared the requirement specification for the system; all reported data will be consistent and structured in an identical way, this allows for some level of automation with regard quality control of the data. After an exploration permit expires, GTK will load exploration data from the TUKES database and deliver it to the stakeholders in a map and download service. Mine production data will also be loaded directly from the TUKES central database to GTK. Production information will be part of GTK's mineral deposit database. This database is built according to global data models and vocabularies (EarthResourceML and GeoSciML) and it contains production, resource and reserve data from all deposits. Another industry that has successfully tackled this issue is the UK geotechnical sector. Here it was recognised that a lack of data sharing and interoperability between data formats between different parts of the industry and government was causing delays and incurring costs for engineering projects. To overcome this, a trade body, the Association of Geotechnical and Geoenvironmental Specialists (AGS) developed the AGS data format which provides a standard way to transfer data such as laboratory testing, monitoring and ground investigations

between contributing parties (Association of Geotechnical and Geoenvironmental Specialists, 2018). This standard allows the industry to easily share between themselves and also easily lodge legacy data with national repositories, and as the data is to a recognised and maintained standard little management or quality assurance is needed to oversee the database (Bland et al., 2014). A similar system is being developed for mineral resources, called EarthResourceML, and this is being used for geological surveys for information sharing and data storage but with little involvement from the minerals industry.

4.1.3 EU harmonised data

The Eurostat data portal is a clear example of harmonised, accessible data on an EU scale. With regards to primary minerals data, the Eurostat trade database provides a comprehensive single point of entry source for European minerals trade information. These data are collected according to a system of commodity codes (known as Combined Nomenclature) which is compatible with the Harmonised System (HS), an internationally recognised system for defining traded commodities. Also as described in section 1.2, there is a legal basis for these data to be provided by member states to Eurostat.

Eurostat also administer a production database (PRODCOM), this is another good example of harmonised data at European level. However, these data are compiled by a classification system for commodity codes (NACE). For many mineral commodities, especially minor metals and industrial minerals, these codes are often aggregated at such a level that that specific primary minerals of interest cannot be individually separated. Examples of where aggregation of codes leads to data on specific commodities being not available can be seen in Appendix 1. This issue of aggregation is one Eurostat is aware of and a process of reviewing the commodity codes is underway which aims to ensure that primary minerals on the Critical Raw Materials list can be separated.

Another major issue is with confidentiality of data, due to low numbers of producers in many countries and industrial sensitivities, much data on PRODCOM is labelled as confidential which can limit the usefulness of this database for many commodity types. An analysis of data collected by of the BGS's World Mineral Production publication against that published by PRODCOM for three countries for 2015 highlights some of the issues (see Appendix 1). Of all commodities known to be produced by individual countries, between 30-40 % of figures were labelled as confidential by Eurostat and 25-30 % of the NACE codes were too aggregated to get figures for the specific commodity in question.

4.1.4 Exploration data

4.1.4.1 *Case study from Ireland*

There are many examples of good practice of systems for collection of exploration data within Europe. One particular example noted by this study was data for mineral exploration produced by Ireland due to a large amount of publically available data for a wide range of metrics.

Mineral exploration in Ireland is regulated and licensed by the Exploration and Mining Division (EMD) of the Department of Communications, Climate Action and Environment (DCCA). For the purposes of licensing, Ireland is divided up into over 1,700 Prospecting Licenses or PLs. A PL grants the holder the right to explore for specified minerals over the PL area.

Competition Areas are PLs which have either been surrendered, terminated or that have been offered and subsequently declined in the previous three months. A list of these PLs is published quarterly in February, May, August and November of every year in a competition booklet. Applicants are ranked using a fixed list of criteria and the PL is awarded to the highest ranked applicant.

Exploration activity and expenditure data

Each of the quarterly competition booklets describes the application procedure and list the available competitive ground. Most of these booklets are very brief and are typically 3-8 pages long. The May edition, however, is much longer and contains data about the previous calendar year with respect to production and exploration activity. Within the exploration activity section, there is a complete breakdown of annual exploration expenditure for the previous year, broken down by commodity and expenditure type, as well as various other things such as industry news, etc. Table 5 is an example of the headline data which is published in this competition booklet. This data is collected every January by EMD and is made available publicly on an aggregated, anonymised basis in May (Department of Communications Climate Action and Environment, 2018b).

These competition booklets and the contained data are available on the EMD website for every year going back to 2011 and are archived in hard copy as far back as 1994 when the current PL regulatory framework was introduced.

<u>Exploration Highlights</u>	
Number of Current Prospecting Licences (PLs):	566
Number of Corporate Entities holding Prospecting Licences:	45
Percentage of Ireland Land Area under Licence:	27%
Total Exploration Expenditure in 2017:	€19.545 Million
Exploration Expenditure on PLs in 2017:	€17.30 Million
Exploration Expenditure on State Mining Facilities in 2017:	€2.24 Million
2017 Drilling on PLs (non-mine related):	Approx. 60,000 metres.

Table 5 Exploration highlight table for 2017 taken from the May 2018 EMD competition and industry news booklet. Irish office overheads account for the difference between total exploration expenditure and exploration expenditure on PLs.

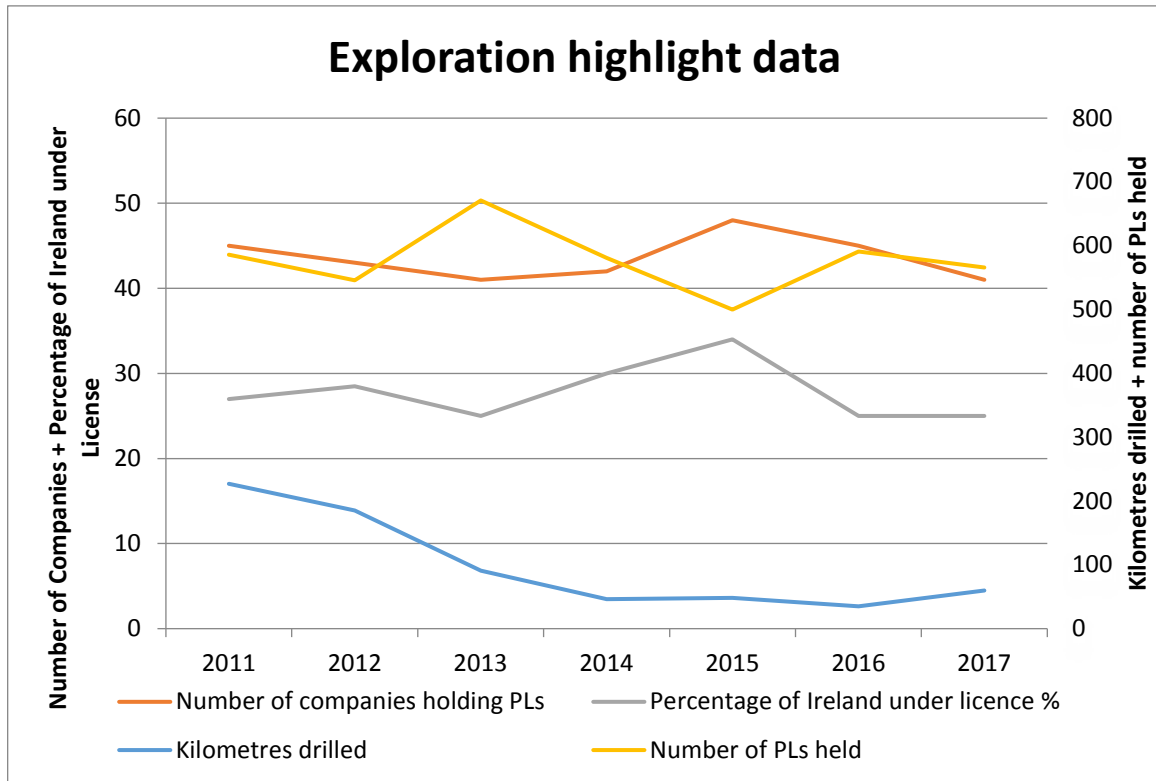


Figure 33, History of exploration highlights data. Note the two Y axes.

Figure 31 shows is a graphical summary of the important exploration data going back to 2011, excluding expenditure data. There is a slight change in the way commodities were recorded from 2012 onwards; before 2012 there were only two categories: Base metals and Gold/Other. Expenditure data and the pre-2012 data represented in Figures 34-35 is apportioned based on a rough average ratio from the other years.

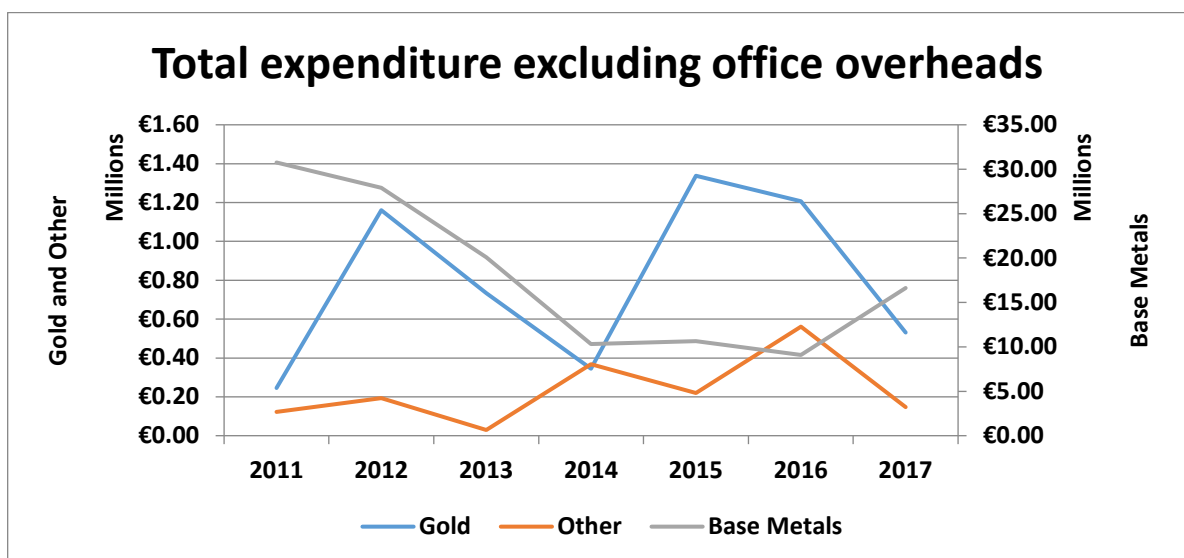


Figure 34, Total exploration expenditure in Ireland excluding Irish office overheads broken down by commodity. The Y-axes scaling shows the disparity between base metal expenditure (driven by zinc/lead) (Department of Communications Climate Action and Environment, 2018a)

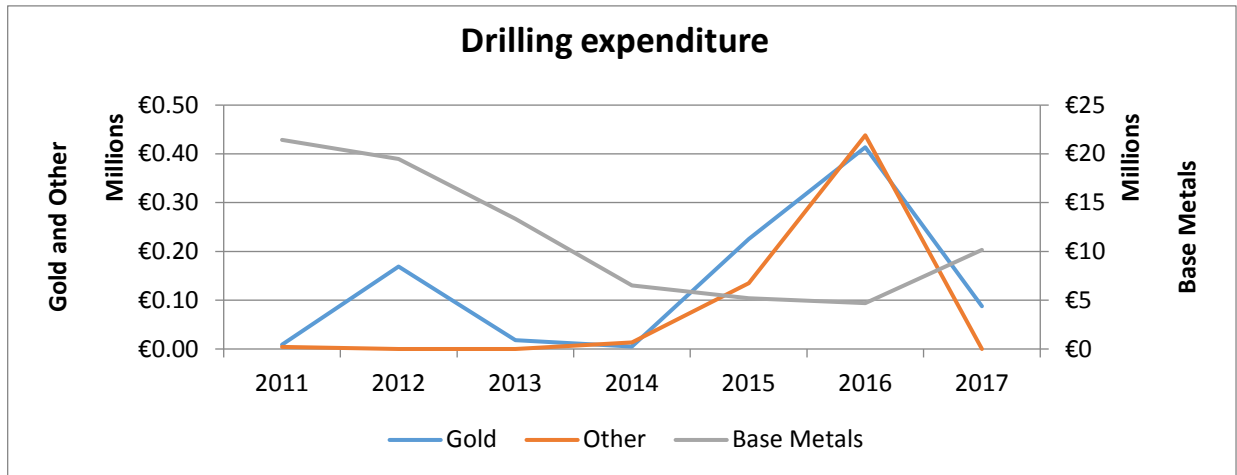


Figure 35, A history of expenditure on drilling by commodity. Drilling includes all bedrock drilling, cored and open hole, deep and shallow. It does not include overburden drilling as part of a soil geochemical survey. (Department of Communications Climate Action and Environment, 2018a)

Uses and benefits of the data

EMD collects this data primarily to ensure compliance with minimum expenditure requirements and exploration programme commitments. EMD also uses exploration metrics as a general indicator for exploration as a whole in Ireland and provides this information to the Central Statistics Office. It is also made available to inform policy and fee scheduling for the department and the responsible minister.

4.1.4.2 Comparison to Finland

Finland is currently ranked number one on the influential Fraser institute report on mineral investment attractiveness. This metric is determined using two criteria: geological prospectivity and its policy perception index (PPI). The latter is a way of quantifying a country's mining regulatory regime and how favourable their government is towards mining investment. Ireland has ranked number one in this PPI since its inception (Fraser Institute, 2017).

Turvallisuus- ja kemikaalivirasto or Tukes is the public body in Finland given a broad range of responsibilities including mining and mineral exploration. Every March it publishes a brief review of exploration expenditure in the previous calendar year. This review typically takes the form of a short, 300-400 word summary on the previous year's activities including data highlights. These updates are only available on the Finnish website. In addition, there are English language PowerPoint presentations presenting this and additional data in tabular and graphical form as seen in Table 6. There are plans to upload these presentations to the new Tukes website.

	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008
Exploration (million €)	61.4 +50%	41	34.5	39.1	52.8	86.8	81.0	60.8	50.5	60.1
No. of prospectors	46	41	42	41	38	45	52	49	42	45
No. of reservation notifications	96	68	50	61	64	197	176	133	123	96
No. of exploration applications	185	98	70	120	125	250				
Area of claims/exploration (km ²)	1610	1700	1930	1850	1400	1310	1080	890	960	1100
Area of exploration applications (km ²)	3420	2160	1980	3900	5450	8210	4620	2700		
Drilling (kilometres)	273 +53%/t	178	130	142	179	366	369	363	271	340
Grassroot	40	20	23	26	32	36				
Greenfield	53	57	51	46	51	103				
Brownfield	180	101	56	70	95	227				

Table 6, Expenditure summary from Tukes on the mineral exploration and mining industry. Key trends are easily spotted and the data is comparable to Ireland's exploration highlights data shown in Table 5.

4.1.4.3 Discussions and recommendations for exploration data

- Ireland and Finland both collect excellent data and both rank highly in the policy perception index (PPI) of the Fraser institute. This isn't a coincidence and is a model that could be replicated throughout Europe. Europe cannot do much about its score in terms of prospective geology but actions could be taken to improve its PPI score.
- None of the European countries studied provided easily accessible, downloadable data on the mining authority website or the geological survey. Ireland's data is somewhat hidden within a competition booklet and without knowing where to look, it would be difficult for a member of the public or investor to find the information. Finland makes it very difficult to obtain data by seemingly only hosting it on the Finnish language version of the website. It can only be found by opening Tukes in the Finnish language version and trawling through it using a translation tool. A member of the public would have great difficulty finding it without knowing where to look. Making data downloadable in a convenient format and available on the front page of a mining authority website would be ideal.
- The accessibility and metrics displayed varied across all organisations that collect this data considerably (as is also shown by the results of the survey of data providers). Ireland has the most complete data sets with the most variables. Tukes made it clear that they do collect more data, however, this is not in the public domain. It would be useful to get an idea of the exact data Tukes collects rather than just what it publishes.

4.2 Challenges and recommendations

All examples discussed above show a clear set of issues regarding barriers to harmonisation:

- Heterogeneous policy, legislation and regulation across Europe
- Heterogeneous data quality and comparability (in terms of both what data is collected and the standards used to collect data) across Europe
- Heterogeneous data infrastructure, provision and accessibility across Europe

These three issues are all intrinsically linked, as shown by the survey conducted by data providers. In the vast majority of cases the type of data, quality of data and standards used to collect data are controlled by national legislation (although good examples exist of good voluntary provision of data, these are rare). This is a serious issue for the harmonisation of raw materials information across Europe as member states are unlikely to be willing to change from systems that have suited their needs and for which may have a legal basis. They are also unlikely to welcome additional burdens of having to use new ways to classify data, such as UNFC alongside what they already use. However, the benefits of harmonisation are clear and these should be explained fully in order to encourage progress towards this end.

A clear theme of common elements can be seen across good practice examples that facilitate the harmonisation of primary minerals data:

- An organisation with a clear responsibility for data collection, ideally with a legal basis to do so.
- A robust legal system to ensure data is provided by the industry.
- A clear set of standards for data to ensure interoperability between different countries and bodies responsible for data collection.

These examples of good practice suggest there are two pathways forward for the harmonisation across Europe for raw materials data. Either new legislation is created at a European level that requires data to be collected, from specific points in the value chain of raw materials production, and in accordance with specific standards and classification schemes, such as UNFC in the case of resource data. This approach has worked very well in the case of spatial data using the example of the INSPIRE directive, however, this is likely unrealistic to expect for the foreseeable future. The more realistic alternative is for a voluntary process through projects, such as ORAMA, to persuade geological surveys and other data collection agencies the merits of a unified approach across Europe and the importance of obtaining high quality harmonised data on raw materials on a European level. It is hoped that training materials, outreach and training events and advances in how these data are collected and displayed which will be produced by the ORAMA project can go some way to achieve this goal whichever route is chosen.

5 Conclusions

This section attempts to pull together all the proceeding sections and define some key messages and final conclusions from Tasks 1.1 and 1.2. This report has covered a range of topics and consequently, this section first discusses some general conclusions before focussing on some specific topics.

5.1 Conclusions from the survey of data collection methods

The results of the survey conducted as part of this study showed several important points which can be used to highlight how good minerals data can be successfully collected.

- The majority of all surveys undertaken by government bodies on the minerals industry were done because there was a legal requirement to do so. Whilst there were examples of excellent surveys undertaken voluntarily, the survey suggests the best way to ensure data is collected is for there to be a provision in law.
- The methods used to collect data varied depending on the type of data being collected (production, resources, exploration etc.). However, a census of all industrial activities, data supplied under mineral licensing requirements and a representative sample of minerals operation comprised the vast majority of survey types. Clearly, some data collection methods will be more accurate than others and the accuracy depends on the percentage return rate (i.e. a census achieving a 90% return rate is likely to be more accurate than a sample survey where only 10% of companies were asked to provide data). However, a clear and robust mechanism is more important overall than the precise method selected for data collection.
- Regular collection of minerals data (ideally at least annually) also is likely to achieve better results than collection on an ad-hoc basis, because it leads to familiarity and improvements in understanding of requirements.
- The survey showed some ambiguity over the form of the materials produced by the minerals industry (such as metal content vs gross weight of ore) and also that there are significant data gaps for many downstream products for both production and trade data. This highlights significant issues for many industrial minerals and many metallic mineral commodities that require several steps of processing. Extra effort is required to both educate data collectors in the complex value chains of these commodities and to ensure these data are captured where they are needed.
- Geological surveys are more likely to collect data for primary stages in the value chain and also to report data by mass, whereas statistical agencies are more likely to report on downstream stages and are more likely to report data by value as well as mass. This highlights the different roles and expertise of different organisations that need to be considered when trying to implement data harmonisation procedures.
- Ultimately data relating to production will always come from the extraction companies (it cannot come from anywhere else). Data relating to resources and reserves may also come from the companies but could also come from geological surveys' own work (in some cases). Data for imports and exports are generally collected by customs organisations or national statistical offices. Data for exploration will come from companies too but usually collected by a mining authority or geological survey (if they have been given appropriate authority).

- Although the majority of data is subject to some level of aggregation at local level this may not be an issue for data on a European level provided they are aggregated in a similar way. Also, confidentiality issues increases from production to resources to exploration data. Again it is hoped that confidentiality issues may be overcome due to appropriate types of aggregation at a European scale.
- Exploration data is the least reported and understood data type considered by the survey (out of production, trade, resources and exploration). The metrics available vary greatly. If a harmonised approach is to be taken a first step would be to decide upon the most useful metrics. If current availability is used as an indicator of what may be most useful, these metrics could be: number of licences issued, number of active licences, the areas these licences cover and the number of companies involved in exploration. If, however, other metrics are required then more effort needs to be made to encourage their collection.
- The survey showed that the European PRODCOM dataset is heavily used by data providers. This may seem unusual in some respects as these data are collected by national governments and supplied to the EC. However, this may highlight that datasets that are to some extent harmonised and easily accessible (even if they may have significant data gaps, see Appendix 1) may be more attractive to data users than more fragmented raw data which they may be able to obtain from other sources. Nevertheless, disaggregation of certain commodity codes is desirable to enable individual minerals to be isolated when required by data users.

Confidentiality can be a serious issue where there are only a small number of producers within a country. Standard protocols are needed to deal with this, including aggregation at national level. Further aggregation amongst groups of countries could be examined as an option, as could the publication of data with an appropriate time delay.

The collection of statistical data for by-product commodities is often more difficult than for main products. This of particular concern for the ‘critical’ raw materials because often these occur or are produced as by- or co-products. Greater transparency would clearly be very helpful and options requiring this should be examined.

5.2 Conclusions regarding reserve and resource data

Within Europe, some countries have a legal basis for collecting data relating to resources and reserves, while other countries do not. Some countries have good quality data (albeit not always for all commodities), while data quality in other countries is highly variable. Even where data are provided, the figures are not always complete, i.e. additional known deposits do not have quantities associated with them and are therefore not included. In some instances, deposits may be too small to be considered economic in the current market but these may become economic in future. Other deposits may be at too early a stage to have been sufficiently evaluated for a resource quantity to have been developed.

It is also important to remember that quoted figures for ‘resources’ or ‘reserves’, or even ‘endowment’ or ‘inventory’, do not represent ‘all there is’ in the Earth because even in Europe undiscovered deposits remain..

International codes aligned with the CRIRSCO template do not have classes available that allow inclusion of sub-economic deposits, early stage exploration, historical data or probabilistic estimates of resources. The classification systems that are aligned with the CRIRSCO template

are only concerned with resources that are economic to work now or in the very near future. The UNFC system is, however, more flexible and includes classes that can be utilised for all these types of deposit and thus allows a longer-term view of mineral supply. Data provided in accordance with UNFC can be much closer to ‘all there is’, or at least as close as it is possible to be bearing in mind the uncertainties associated with certain types of estimate and the fact that some deposits are completely unquantified. It is therefore recommended that the UNFC should be adopted for longer-term studies at the more strategic scale. However, there are consequences arising from this recommendation, such as the need to provide guidance and training for people who are responsible for transforming the figures between classification systems.

No organisation who responded to the survey indicated that UNFC has been adopted as a national system of reporting so far. This is not surprising when consideration is given to the reasons for which such a system is adopted, i.e. a national inventory or for stock exchange reporting. However, this is a situation which could be changing as shown by the numerous case studies presented in this report, which highlight that some countries are beginning to use UNFC, and also the high awareness of UNFC amongst data providers reported by the survey. The survey showed that for countries that only use one code, that code was more likely to be a national code or the Russian system and that this was likely to be set in legislation. Although some national codes or the Russian system can be bridged to other codes and classifications, this can also be a barrier because if another system, such as UNFC, is to be used for harmonisation purposes this will need to be in addition to what is currently collected, not instead of. Countries will need to be encouraged to voluntarily bridge their resource data to UNFC for harmonisation purposes. This is a difficult task but is more realistic for the foreseeable future than calling for legislation at a European Commission level requiring member states to produce harmonised data.

For many European countries that have mineral resource management procedures and the related classification systems in place that are based on, or developed from, the Russian system (e.g. Hungary Czech Republic, Poland, etc.), long term datasets are available with sufficient information for mineral resources and these are appropriate for the harmonisation process. This can be achieved with international reporting standards and the UNFC classification framework by using bridging procedures associated with these codes and classifications. However, the heterogeneity of mineral deposits needs to be indicated clearly and the role of a competent expert (e.g. Competent Person) is important. It is also critical that further bridging documents are developed for those countries that have not already undertaken this exercise.

For countries that do not have a history of resource management and do not have minerals inventories or experience of using standard codes and classifications, it may be more challenging to develop data suitable for harmonisation at European level. However, bridging documents also exist between other codes/systems aligned with the CRIRSCO template (e.g. JORC, PERC, NI 43-101, etc.) and work is underway in several countries to explore how other resource figures could be aligned with UNFC.

The use of UNFC will require help with training and expert input to the relevant government bodies, which is what an EU project, such as ORAMA, can provide along with resources to aid in the bringing from other national and international codes and standards to UNFC. The survey conducted by task 1.1 highlighted that ‘awareness’ and ‘experience’ are two different things and the respondents indicated they were aware of both UNFC and the CRIRSCO template but in both cases, their experience was lower. The ORAMA project will develop training materials to help with this that includes practical worked examples. It must also be recognised that

although one of the strengths of UNFC is its ability to incorporate uneconomic resources and deposits that have not been fully evaluated for many countries this data does not exist. As a result, care needs to be taken when considering data gaps when comparing across countries, even when using a consistent standard.

5.3 Conclusions regarding exploration data

There are some good examples of data collection for exploration data, as shown in the case studies in Section 4. However, most other countries do not have the same processes in place and exploration activity levels vary widely. Each country can decide for itself whether it wishes to encourage more or less exploration and will develop its own policies to achieve that end. But, in general, more exploration will usually lead to the discovery of more deposits.

Not all of Europe has been explored to the same degree. Exploration in the past has not always considered the commodities that are now important for modern technology and past exploration may not have used the more modern techniques now available. Exploration is an important part of the extractive industry but it requires investment and support.

A system of exploration licencing is more likely to generate data on the amount of activity that is taking place. Where there is no licensing system for exploration then it is hard to gather the accurate data that is required to assist the level of activity. This is often related to mineral ownership and/or land ownership. However, even where minerals are owned by local landowners (and not the state), if exploration requires some kind of permit then data can be collected.

5.4 Conclusions regarding future provision of data

The good practice examples regarding the provision of data showed the importance of an accessible source of raw materials data that can be regarded as 'official' data for that particular country. Ideally, this will be in the form of a single publication or web portal but could also be specific to the data type produced by a particular organisation (i.e. a national statistical agency may be an expert in trade data and publish this whereas a mining authority may publish data for exploration). Data that can be regarded as official and has undertaken appropriate quality assurance by the relevant experts is also essential for reporting on resources using the UNFC system where an authorised body, which has the knowledge and experience required, can ensure harmonised data regarding resources is published.

With regards to an INSPIRE-compliant data service, European countries need to continue to develop the national-level data provision with sufficient and appropriate datasets. Also, the user interface needs to be developed to continue to improve the access to information on minerals for stakeholders, especially for the mineral resource community and the political decision makers.

It is necessary to be familiar with classification and reporting methodology and data content for primary resources but the concept and terminology are also important to develop for different types of secondary resources (e.g. municipal, electronic and other wastes, mining heaps and tailing and other sources like power plant fly ash). Ultimately the concept for the classification of raw materials should combine primary and secondary sources and the content of datasets should be sensitive enough to include data relating to the sustainability goals and energy consumption of the utilization of raw materials. UNFC can be an appropriate tool to support

sustainable resource management, with appropriate data collection and data management by competent authorities.

The database, developed through several EU projects, should be maintained (architecture + data) within the frame of the Minerals4EU Permanent Body. It will serve data to the EGDI which will build (new) services on top. This database and the services/applications already running, and the different diffusion portals are elements of the EURMKB which is exploited by the JRC's Raw Material Information System (RMIS).

5.5 Final comments and key messages

The continent of Europe contains more than 40 independent, sovereign countries that are heterogeneous due to their long and varied evolution. However, there are times when groups of countries need to work together towards common goals because more can be achieved in this way. The Raw Material Initiative was established in part to assist with collaboration between countries in order to improve the security of supply of materials to all European countries.

An important step towards improving the security of supply of materials is to know what is available within Europe, what materials are produced within its borders and what is imported or exported. Exploration is ultimately a means to improve the available knowledge of what materials are available within Europe. Data for resources and reserves are a quantification of past exploration, but it is important to remember they do not represent “all there is” within the continent. Additional exploration is still likely to find more deposits worth evaluating and this evaluation may lead to additional resources.

Taking into account that the collection and preparation of all types of statistical data related to mineral resources are intended to inform society, stakeholders and policymakers about the current situation of resources, the available information should be easily accessible and understandable as well as reliable and of a proven quality. Harmonisation of statistical data is a key part of knowing what is available within Europe. Without it, data becomes patchy, incomparable and hard to interpret.

Also, critically, for mineral resources and reserves, a common classification system should be used when reporting at a European level. This will greatly facilitate the harmonisation of data and the use of them by the end-users. There are many good examples from individual projects, individual countries and from other industrial sectors, detailed in the previous sections, where many of the issues that have been identified have been overcome (albeit on a national rather than a European level, where issues are compounded by the wide variety of laws, regulatory regimes and standards involved when considering aggregating data across different countries). It is important that these examples of good practice are taken note of so that lessons can be learnt for a greater harmonisation of European minerals data.

Because the countries of Europe are all different, each one has evolved its own priorities and therefore its own unique legal system, structures and processes. There is nothing wrong with this, but when users wish to look at a more strategic, continental scale it becomes a barrier that inhibits the development of sensible policies to help all countries. Identifying actions to benefit European industry, jobs and growth across all countries can also be more difficult.

It is important to understand how these differences in legislation impact the quality and accessibility of minerals information and, if possible, countries could be encouraged to consider adopting data gathering and planning systems to address some of the issues created as a result

of these differences. The benefits of improving data management and, specifically, the provision of resource and reserve data, are:

- increased resource efficiency;
- support for/development of a resource management system;
- improvement in sustainable aspects;
- better planning systems including mineral and land use planning;
- better support for decision making;
- increase in investments; etc.

The targets for action identified by the Minventory roadmap are still relevant, although in reality, some issues are likely to take longer to resolve than that project anticipated. Some of the more tractable issues relate to:

- converging use of terminology;
- establishing data confidentiality and redaction rules at EU level, and
- asking countries to each nominate single contact points for data handling.

More problematic, but still relevant, are the issues associated with:

- making data available for publishing;
- adopting a common system of reporting, and
- dealing with historic data in diverse systems of reporting.

It should be emphasised that suggested actions are all voluntary to tackle the issues.

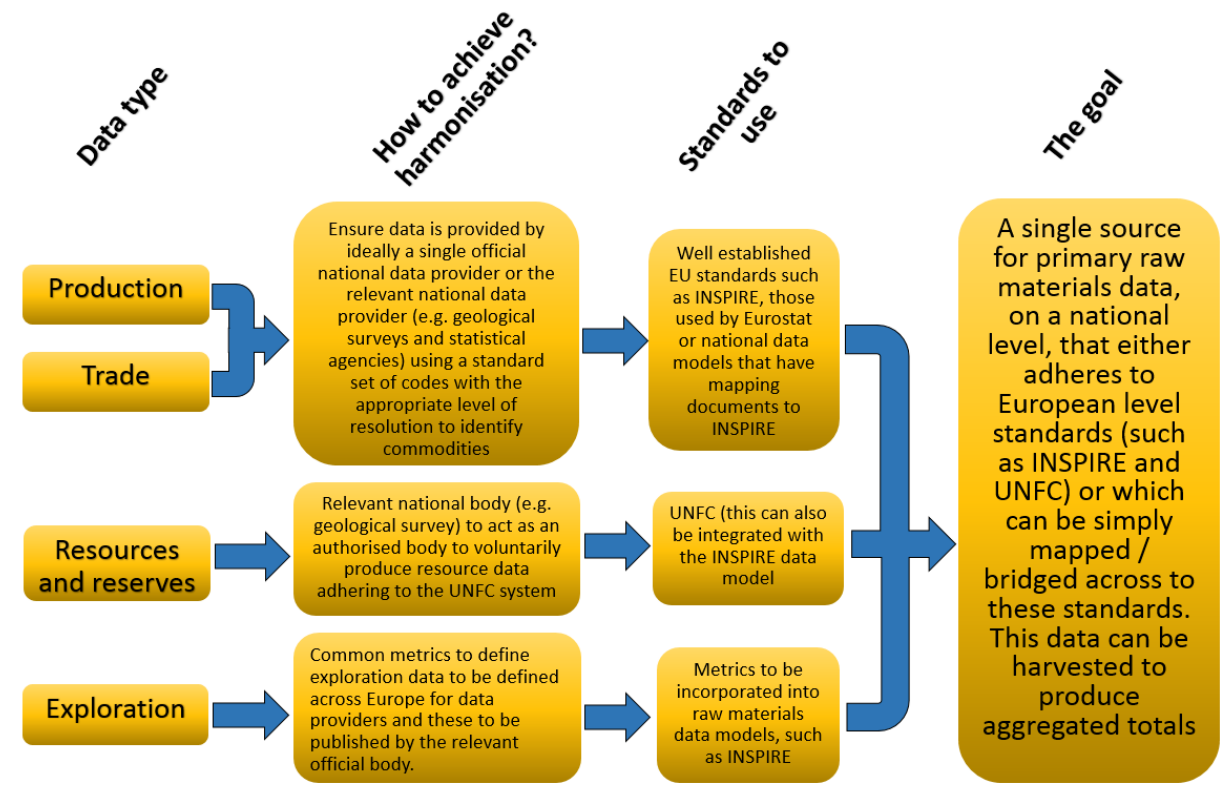


Figure 36, Summary of recommendations

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Appendix 1: comparison of BGS mineral production data with Eurostat production data for Belgium, Germany and Greece

COUNTRY	Commodity	UNITS	2013		2014		2015	
			BGS	EUROSTAT	BGS	EUROSTAT	BGS	EUROSTAT
Belgium	Cement Clinker	tonnes (metric)	911 116	911 116	900000*	not available	900000*	not available
Belgium	Cobalt (Metal & refined)	tonnes (metric)	5415 (a)	2012 (c)	5850 (a)	2567 (c)	6306 (a)	2199 (c)
Belgium	Copper (refined)	tonnes (metric)	389 400	374 651	387 300	not available	378 600	not available
Belgium	Finished Cement	tonnes (metric)	6 119 000	6 599 715	6 364 000	3311851 (c)	6 275 000	3678877 (c)
Belgium	Indium (refined)	tonnes (metric)	30*	no specific code	30*	no specific code	30*	no specific code
Belgium	Kaolin	tonnes (metric)	300000*	not available	300000*	not available	300000*	not available
Belgium	Lead (Refined)	tonnes (metric)	129 429	135 305	133 252	132 917	130 000	110012 (c)
Belgium	Pig Iron	tonnes (metric)	4 343 000	not available	4 335 000	not available	4 248 000	not available
Belgium	Primary aggregates (Crushed rock)	tonnes (metric)	46 000 000	28507393 (c)	45 000 000	30080593 (c)	45 000 000	30341938 (c)
Belgium	Primary aggregates (Sand And gravel)	tonnes (metric)	21 000 000	4136690 (c)	19 000 000	3752820 (c)	19 000 000	3950717 (c)
Belgium	Selenium, refined	tonnes (metric)	200*	no specific code	200*	no specific code	200*	no specific code
Belgium	Steel Ingots and Castings (Crude steel)	tonnes (metric)	7 127 000	not available	7 331 000	not available	7 257 000	not available
Belgium	Sulphur and Pyrites (Recovered, smelter gases & hydrocarbons)	tonnes (sulphur content)	396900 (a)(b)	0	400000 (a)(b)*	0	400000 (a)(b)*	0
Belgium	Tin (Smelter)	tonnes (metric)	10 346	no specific code	9 718	no specific code	8 788	no specific code
Belgium	White Arsenic	tonnes (metric)	1000*	no specific code	1000*	no specific code	1000*	no specific code
Belgium	Zinc (Slab)	tonnes (metric)	252000 (b)	not available	262000 (b)	331 974	260000 (b)	340 449


EUROSTAT figure that BGS have used

Notes

- (a) From metal sulphide processing
- (b) Some refined cobalt production in China is recorded in Belgium
- (c) missing one or more codes
- * BGS estimate

BGS data for Belgium comes from a mixture of trade associations, company data and other organisations dealing with mineral statistics.

COUNTRY	Commodity	UNITS	2013		2014		2015	
			BGS	EUROSTAT	BGS	EUROSTAT	BGS	EUROSTAT
Germany	Alumina	tonnes (Al ₂ O ₃)	1000000 *	not available	1000000 *	not available	1000000 *	not available
Germany	Barytes (Barytes)	tonnes (metric)	45 446	no specific code	87 585	no specific code	45 311	no specific code
Germany	Bentonite & Fuller's Earth (Bentonite)	tonnes (metric)	358 844	not available	394 657	not available	395000 *	not available
Germany	Bromine	kilograms	1500000 *	no specific code	1500000 *	no specific code	1500000 *	no specific code
Germany	Cadmium	tonnes (metric)	400 *	not available	400 *	not available	400 *	not available
Germany	Cement Clinker	tonnes (metric)	23 127 000	6 185 436	23 871 000	6 732 901	23 355 000	13 373 817
Germany	Coal (Anthracite & bituminous)	tonnes (metric)	8 260 000	Not inc. on Prodcom	8 340 000	Not inc. on Prodcom	6 650 000	Not inc. on Prodcom
Germany	Coal (Brown coal)	tonnes (metric)	182 995 337	Not inc. on Prodcom	178 154 848	Not inc. on Prodcom	178 065 353	Not inc. on Prodcom
Germany	Copper (refined)	tonnes (metric)	677 600	not available	674 000	not available	678 100	not available
Germany	Copper (Smelter)	tonnes (metric)	289 900	0 (h)	349 700	0 (h)	338 300	0 (h)
Germany	Diatomite	tonnes (metric)	51 435	no specific code	54 277	no specific code	52 784	no specific code
Germany	Feldspar	tonnes (metric)	350000 *	no specific code	320 000	no specific code	317 352	no specific code
Germany	Ferro-Alloys (Ferro-chrome)	tonnes (metric)	17500 *	no specific code	17000 *	no specific code	17000 *	no specific code
Germany	Ferro-Alloys (Other ferro-alloys)	tonnes (metric)	8200 *	no specific code	8200 *	no specific code	8200 *	no specific code
Germany	Ferro-Alloys (Silicon metal)	tonnes (metric)	30 283	not available	28 500	86 625	29 953	91 504
Germany	Finished Cement	tonnes (metric)	31 308 000	30 927 011	32 099 000	31 716 792	31 160 000	31 160 344
Germany	Fluorspar	tonnes (metric)	48 744	no specific code	58 100	no specific code	49 801	no specific code
Germany	Gallium (primary)	tonnes (metric)	38	no specific code	16	no specific code	11	no specific code
Germany	Graphite	tonnes (metric)	269	no specific code	517	no specific code	398	no specific code
Germany	Gypsum	tonnes (metric)	1778000 (a)	1 778 164	4090000 (a)	1 801 518	4200000 (a)	1 847 822
Germany	Indium (refined)	tonnes (metric)	10 *	no specific code	10 *	no specific code	10 *	no specific code
Germany	Iron Ore	tonnes (metric)	413404 (d)(g)	0	461082 (d)(g)	0	467690 (d)(g)	0
Germany	Kaolin	tonnes (metric)	1100000 (e)*	3 536 031	1100000 (e)	435353 (h)	1100000 (e)	467317 (h)
Germany	Lead (Refined)	tonnes (metric)	400 000	352358 (h)	380 000	339724 (h)	378 000	337944 (h)
Germany	Natural Gas	million cubic	10 678	Not inc. on Prodcom	10 060	Not inc. on Prodcom	9 323	Not inc. on Prodcom
Germany	Petroleum (Crude)	tonnes (metric)	2 638 379	Not inc. on Prodcom	2 429 789	Not inc. on Prodcom	2 412 063	Not inc. on Prodcom
Germany	Pig Iron	tonnes (metric)	26 678 000	not available	27 943 000	not available	27 844 000	not available
Germany	Potash (Potassic salts)	tonnes (K ₂ O)	3 075 201	0	3 178 103	0	3 109 903	0
Germany	Primary aggregates (Crushed rock)	tonnes (metric)	207 000 000	148 307 403	211 000 000	147 938 985	210 000 000	142 283 253
Germany	Primary aggregates (Sand And gravel)	tonnes (metric)	228 000 000	147 638 376	238 000 000	151 920 868	239 000 000	146 097 908
Germany	Primary Aluminium	tonnes (metric)	492 368	not available	530 683	not available	541 379	455 217
Germany	Salt (Brine salt)	tonnes (metric)	2 164 456	not available	2 133 359	not available	2 286 769	not available
Germany	Salt (Rock salt)	tonnes (metric)	8 510 652	not available	4 928 656	not available	6 027 873	not available
Germany	Salt (Salt in brine)	tonnes (metric)	7 878 895	not available	4 075 004	not available	8 132 675	not available
Germany	Selenium, refined	tonnes (metric)	700 (f)*	922	700 (f)*	872 (h)	790 (f)*	720 (h)
Germany	Steel Ingots and Castings (Crude steel)	tonnes (metric)	42 645 000	10 815 789	42 943 000	11 024 534	42 674 000	11 192 874
Germany	Sulphur and Pyrites (Recovered, hydrocarbons)	tonnes (sulphur)	754540 (b)	0	708146 (b)	0	627797 (b)	0
Germany	Sulphur and Pyrites (Recovered, other)	tonnes (sulphur)	464776 (c)	no specific code	437677 (c)	no specific code	383894 (c)	no specific code
Germany	Uranium	tonnes (metal)	27	Not inc. on Prodcom	33	Not inc. on Prodcom	0	Not inc. on Prodcom
Germany	Zinc (Slab)	tonnes (metric)	162 000	no specific code	168 000	no specific code	173 000	no specific code

 EUROSTAT figure that BGS have used

BGS Footnotes

- (a) Including anhydrite
- (b) From petroleum refining and/or natural gas
- (c) Other
- (d) Including manganiferous iron ore
- (e) Washed and dried
- (f) Includes selenium produced from imported material
- (g) Used as aggregate in the construction industry
- (h) missing one or more codes
- * BGS estimate

The majority of BGS data for Germany comes from BGR (the German Geological Survey)



COUNTRY	Commodity	UNITS	2013		2014		2015	
			BGS	EUROSTAT	BGS	EUROSTAT	BGS	EUROSTAT
Greece	Alumina	tonnes (Al ₂ O ₃ content)	811 600	Not available	813 500	Not available	806 500	Not available
Greece	Bauxite, Alumina & Aluminium (Bauxite)	tonnes (metric)	1 844 000	1 844 519	1 876 000	2 000 329	1 831 000	2 140 852
Greece	Bentonite & Fuller's Earth (Bentonite)	tonnes (metric)	1 000 000	Not available	1 011 485	Not available	1 150 000	Not available
Greece	Bentonite and Fuller's Earth (Attapulgit)	tonnes (metric)	32 400	Not inc. on Prodc	45 000	Not inc. on Prodc	108 000	Not inc. on Prodc
Greece	Cement Clinker	tonnes (metric)	6 754 154	Not available	7 025 675	Not available	6000000 *	Not available
Greece	Coal (Lignite)	tonnes (metric)	55 500 000	Not inc. on Prodc	50 411 000	Not inc. on Prodc	46 308 000	Not inc. on Prodc
Greece	Feldspar	tonnes (metric)	0	No specific code	0	No specific code	0	No specific code
Greece	Ferro-Alloys (Ferro-nickel)	tonnes (metric)	86 850	Not available	94 952	Not available	89 129	Not available
Greece	Finished Cement	tonnes (metric)	5 553 411	5 571 247	5 563 414	5 142 177	5 291 113	5 405 817
Greece	Gold	kilograms	823	no specific code	552	no specific code	510	no specific code
Greece	Gypsum	tonnes (metric)	760000 (a)	361 806	664000 (a)	363 822	649280 (a)	Not available
Greece	Kaolin	tonnes (metric)	0	0	0	0	0	0
Greece	Lead (mined)	tonnes (metal content)	18 010	Not available	16 700	Not available	14 500	Not available
Greece	Lead (Refined)	tonnes (metric)	6000 *	Not available	12000 *	Not available	14000 *	Not available
Greece	Magnesite & Magnesite (Magnesite)	tonnes (metric)	314 770	no specific code	391 140	no specific code	383 312	no specific code
Greece	Natural Gas	million cubic metres	5	Not inc. on Prodc	5	Not inc. on Prodc	5 *	Not inc. on Prodc
Greece	Nickel (Mined)	tonnes (metal content)	19 800	0	20 600	0	20 800	0
Greece	Nickel (Smelter/Refinery)	tonnes (metric)	17 500	0	18 481	0	17 113	0
Greece	Perlite	tonnes (metric)	890 000	no specific code	985 000	no specific code	890 610	no specific code
Greece	Petroleum (Crude)	tonnes (metric)	378 000	Not inc. on Prodc	378 000	Not inc. on Prodc	378 000	Not inc. on Prodc
Greece	Primary aggregates (Sand and gravel and crushed rock)	tonnes (metric)	30000000 *	14 906 580	38000000 *	19 012 744	21 632 000	14 418 746
Greece	Primary Aluminium	tonnes (metric)	169 480	Not available	173 260	Not available	179 993	Not available
Greece	Salt	tonnes (metric)	189 500	Not available	146 402	Not available	145000 *	Not available
Greece	Silver	kilograms (metal content)	39 759	no specific code	35 785	no specific code	25 200	no specific code
Greece	Steel Ingots and Castings (Crude steel)	tonnes (metric)	1 030 000	Not available	1 022 000	Not available	910 000	Not available
Greece	Sulphur and Pyrites (Recovered, hydrocarbons)	tonnes (sulphur content)	228000 (b)	Not available	227140 (b)	Not available	161050 (b)	Not available
Greece	Zinc	tonnes (metal content)	22 549	no specific code	23 085	no specific code	13 174	no specific code

EUROSTAT figure that BGS have used

BGS Footnotes

- (a) Including anhydrite
- (b) From petroleum refining and/or natural gas
- * BGS estimate

The majority of BGS data for Greece comes from the Greek Mining Enterprise Association website