Optimising quality of information in RAw MAterial data collection across Europe

Deliverable 1.1: Initial analysis for the improvement of statistical data collection methods in Europe

Title of the project: Optimising quality of information in RAw MAterial data collection across Europe - ORAMA
Grant Agreement number: 776517
Start date: 01.12.2017
Duration: 24 months
Document title: Initial analysis for the improvement of statistical data collection methods in Europe
Work Package: Work package 1
Author(s): Tom Bide, Zoltan Horváth, Teresa Brown, Naomi Idoine, Ágnes Laukó, Katalin Sári, László Sőrés, Evi Petavratzi.
Date of delivery:
Dissemination level: PU
Reviewed by:
Status of the document: Final
Document location: Tiimeri: Documents / Deliverables
Project web site: http://www.orama-h2020.eu
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 is 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 area. Together this has built a comprehensive understanding of how minerals data is 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 of state ownership of minerals.

The review of previous projects showed the breadth of work that had gone into this area of 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 in gathering data on 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, for example as set out by the INSPIRE directive and that this needs to be adapted to accommodate statistical data for mineral resources which are aggregated at national scale.
# TABLE OF CONTENTS

1 Introduction and background ................................................................. 10

1.1 Setting the scene: what do we mean by minerals data and why is it important? ................................................................. 10

1.2 Legal requirements for data collection .................................................. 11

1.3 Who collects minerals data in Europe? ................................................... 11

1.3.1 National Geological Surveys .............................................................. 12

1.3.2 National Statistics Agencies ............................................................... 12

1.3.3 Mining Authorities ........................................................................... 12

1.3.4 Other organisations ......................................................................... 12

2 Task 1.1 Analysis of data collection methods ............................................ 13

2.1 Survey of primary raw materials data collection methods ....................... 13

2.1.1 Purpose of survey ............................................................................. 13

2.1.2 Survey methodology ........................................................................ 14

2.1.3 Survey results and analysis .............................................................. 15

2.1.3.1 Statistical data for production/extraction ........................................ 15

2.1.3.2 Statistical data for resources and/or reserves ................................. 18

2.1.3.3 Statistical data regarding imports or exports of minerals ................ 21

2.1.3.4 Statistical data on mineral exploration activities .............................. 22

2.2 Summary of data collection methods identified ....................................... 22

2.3 Data collection issues and good practices that may help to address them .. 25

2.3.1 Production data ................................................................................ 25

2.3.1.1 Missing or incomplete data for by-products ................................... 25

2.3.1.2 Conflicting sources ...................................................................... 26

2.3.1.3 Data may not exist ...................................................................... 26

2.3.2 Trade data ........................................................................................ 27

2.3.2.1 Triangular trade ......................................................................... 27

2.3.2.2 Accuracy of trade data .................................................................. 27

2.3.3 Resources and reserves .................................................................... 27

2.3.3.1 Confusion over terminology ......................................................... 27

2.3.3.2 Confidentiality ............................................................................. 28

2.3.3.3 Data not collected by governments ................................................. 28

2.3.3.4 Different terminology for commodities used .................................. 28

2.3.3.5 No data exists for the ‘uneconomic’ or ‘undiscovered’ proportion ... 29

2.3.4 Exploration data ................................................................................ 29
3 Task 1.2 Review of previous projects and recommendations for the improvement of statistical datasets

3.1 Aim and scope of Task 1.2

3.2 A historical perspective or resource and reserve data

3.3 Harmonisation of resources and reserves data

3.4 EU level data sources and availability

3.4.1 INSPIRE

3.4.1.1 Relevant recommendations for harmonisation

3.4.1.2 INSPIRE compliant data service

3.4.2 EUROSTAT

3.4.2.1 PRODCOM

3.4.3 ProMine

3.4.4 EURMKB and the EGDI

3.4.5 Raw Material Information System (RMIS)

3.5 Inventory of some selected projects having recommendations on harmonisation issues

3.5.1 Minventory: EU raw materials statistics on resources and reserves

3.5.2 Minerals4EU

3.5.3 Intraw

3.5.4 MICA: Mineral Intelligence Capacity Analysis

3.5.5 EGS MREG

3.5.6 UNECE EGRC

3.6 National projects
3.6.1 Hungarian project ................................................................. 60
  3.6.1.1 Hungarian case study .................................................. 61
3.6.2 Central and Eastern European projects ............................... 62
3.6.3 Scandinavian Project: Nordic Project (NGU) ...................... 63
3.7 Other relevant EU projects .................................................. 63
  3.7.1 SNAP-SEE ................................................................. 64
  3.7.2 MINATURA2020 .......................................................... 64
  3.7.3 BioMOre ................................................................. 65
  3.7.4 CERA ................................................................. 66
  3.7.5 MinFuture ............................................................. 66
4 Discussion and conclusions .................................................... 68
  4.1 Good practice examples .................................................... 68
    4.1.1 Data collection ....................................................... 68
    4.1.2 Mineral resource and reserve inventories ...................... 69
    4.1.3 Nationally managed databases ................................... 70
    4.1.4 EU harmonised data ................................................ 70
  4.2 Challenges and preliminary recommendations ...................... 71
  4.3 General Conclusions ...................................................... 71
  4.4 Conclusions from the survey of data collection methods .......... 72
  4.5 Conclusions regarding reserve and resource data ................ 73
  4.6 Conclusions regarding future provision of data ................... 73
References ................................................................................. 74
Appendix 1: comparison of BGS mineral production data with Eurostat production data for Belgium, Germany and Greece ........................................................................ 76
# Abbreviations and acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMRI</td>
<td>Annual Minerals Raised Inquiry</td>
</tr>
<tr>
<td>BGS</td>
<td>British Geological Survey</td>
</tr>
<tr>
<td>CRIRSCO</td>
<td>Committee for Mineral Reserves International Reporting Standards</td>
</tr>
<tr>
<td>EGDI</td>
<td>European Geological Data Infrastructure</td>
</tr>
<tr>
<td>EGS</td>
<td>EuroGeoSurveys</td>
</tr>
<tr>
<td>MREG</td>
<td>Mineral Resources Expert Group</td>
</tr>
<tr>
<td>E-PRTR</td>
<td>European Pollutant Release and Transfer Register</td>
</tr>
<tr>
<td>ERA-NET</td>
<td>European Research Area Net</td>
</tr>
<tr>
<td>ETP-SRM</td>
<td>European Technology Platform on Sustainable Mineral Resources</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>EURMBK</td>
<td>European Union Raw Materials Knowledge Base</td>
</tr>
<tr>
<td>EU-RMICP</td>
<td>European Union Raw Materials Intelligence Capacity Platform</td>
</tr>
<tr>
<td>EUROSTAT</td>
<td>Statistical Office of the European Union</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographical Information System</td>
</tr>
<tr>
<td>INSPIRE</td>
<td>Infrastructure for Spatial Information in the European Community</td>
</tr>
<tr>
<td>INTRAW</td>
<td>International cooperation on Raw materials</td>
</tr>
<tr>
<td>IUGS</td>
<td>International Union of Geological Sciences</td>
</tr>
<tr>
<td>JORC</td>
<td>Joint Ore Reserves Committee</td>
</tr>
<tr>
<td>MICA</td>
<td>Mineral Intelligence Capacity Analysis</td>
</tr>
<tr>
<td>MBFSZ</td>
<td>Mining and Geological Survey of Hungary</td>
</tr>
<tr>
<td>NACE</td>
<td>Nomenclature of Economic Activities</td>
</tr>
<tr>
<td>PERC</td>
<td>Pan-European Reserves and Resources Reporting Committee</td>
</tr>
<tr>
<td>PRODCOM</td>
<td>&quot;PRODuction COMmunautaire&quot; (Community Production)</td>
</tr>
<tr>
<td>REE</td>
<td>Rare Earth Elements</td>
</tr>
<tr>
<td>RMI</td>
<td>Responsible Minerals Initiative</td>
</tr>
<tr>
<td>RMIS</td>
<td>Raw Materials Information System</td>
</tr>
<tr>
<td>SPE-PRMS</td>
<td>Society of Petroleum Engineers - Petroleum Resource Management System</td>
</tr>
<tr>
<td>UNCOMTRADE</td>
<td>United Nations Comtrade Database</td>
</tr>
<tr>
<td>UNECE</td>
<td>United Nations Economic Commission for Europe</td>
</tr>
<tr>
<td>UNECE EGRC</td>
<td>United Nations Economic Commission for Europe - Expert Group on Resource Classification</td>
</tr>
<tr>
<td>UNFC</td>
<td>United Nations Framework Classification for Resources</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

This report is the combination of tasks 1.1 and 1.2 of the ORAMA Project. It is the first of two deliverables combining these tasks, this first deliverable is an initial analysis of data collection methods with Europe and a review of recommendations of previous projects. Whereas the second, deliverable 1.2 of the ORAMA Project, will include 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). 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 initial 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 might minerals data in Europe be better collected, presented and harmonised in the future. This report, Deliverable 1.1, is an initial analysis of data collection methods with Europe and a review of recommendations of previous projects. As such, it will be provided to all project partners for review and comment. Any feedback received on this report will be incorporated into Deliverable 1.2 together with a more detailed discussion of the future recommendations for minerals data harmonisation and improvement to statistical datasets.

The initial review of data collection methods was conducted via the use of a survey to primary data providers. The survey had 83 responses, although not all responders answered all questions. Some of the main conclusions of the survey are that: a) the majority of all minerals data collection is carried out as a result of a requirement in law to collect data; b) the three main data collection methods are a full census of the minerals industry, a representative sample and data provided under mineral licensing requirements; and c) that data sharing between national bodies and the European commission is common, with the European PRODCOM dataset often being reused.

Previous projects and expert forums in this subject area (e.g. Minventory, 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 for describing mineral resources. 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, such as the CRIRSCO template or the United Nations Framework Classification (UNFC). 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.
1 Introduction and background

This report for Deliverable 1.1 presents the preliminary results from Tasks 1.1 and 1.2 in Work Package 1 of the ORAMA project. A subsequent deliverable (D.1.2) will include the final results of the analysis and a set of recommendations for future actions. Work package 1 is specifically focused 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 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 will lead 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 and gas).

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 intrastate 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 Comtrade database.

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 organisation 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 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 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 on 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 maybe 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 re-sale 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.

• 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 are 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 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 produced 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 Task 1.1 Analysis of data collection methods

The main objective of task 1.1 is 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 the 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 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 data 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 expert advisors to the ORAMA project. 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 so 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 counties 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 83 responses (see Figure 1), however, it should be noted that these do not represent 83 separate organisations, in many cases different contacts from the same organisations answered different aspects of the survey depending on their area of expertise.
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. 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? 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)’. This distinction is important because ‘sold production’ implies that there could be material had has been extracted but not sold and remains on stock. For strategic level 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.

Over 80% of the survey participants’ organisations collect data predominately from companies extracting/processing and recycling mineral resources. 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%).

In terms of why an organisation collected this information, 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.

The methods organisations use to collect their production data are shown in Figure 2. 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’.
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) collect data as ‘quantity by mass e.g. tonnes’ (86%). A smaller proportion collect data by ‘quantity by volume e.g. cubic meters’ (44%) and by ‘value e.g. Euros’ (39%).

With regards to metals, 58% (21/36) participants stated that their organisations collect data for gross weight of ore extracted, whilst only 33% (12/36) collect metal content of the ore extracted. A smaller proportion (28%) collect data for gross weight of concentrate and 22% collect metal content of concentrate. Fewer respondents appeared to collect the grade of metal in ore or concentrate produced (19% and 17% respectively) or end use (17%).

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. 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, whereas 14% said they collect it monthly and 8% collect data weekly. 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, 67% (24/36) said that they aggregate the figures due to confidentiality issues, while 28% said that they aggregate the commodities and 22% carry out some other form of aggregation to simplify the report. 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.
- Data on production and reserves/ resources for particular deposit are not public, only summarised data for different types of mineral resources on a national level are publicly accessible.
- 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.

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.

### 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. 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 is shown in Figure 3. The highest proportion of 53% said that they used a National resource code. Only 12% said that they used PERC, the standard for European reporting which is aligned to the CRIRSCO template. More respondents seemed to be favouring other standards aligned to the CRIRSCO template such as JORC and NI 43-101/CIM. A selection of the free text comments relating to ‘other’ were as follows:
- Russian code system adapted to national system.
- Survey estimates
- The national system means the Russian type one
- We just use the original code used by the company and do not convert it

![What system(s) of reporting do you use?](image)

*Figure 3: Systems of reporting used by organisations that responded to the survey.*

Of the 17 respondents that answered this question, 11 (or 65%) said that national legislation specified the use of a particular system/code. For these respondents a further question was asked: for what purpose was this specified? The highest proportion of these survey participants said for the purpose of national inventory (70%), while 30% said it was for stock exchange 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 4). 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.
When collecting the resource and reserves data of a commodity, 86% said that their organisation makes no estimate for any missing portion. 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 this appears to be online in most cases. However, of these approximately half said that there were some confidentiality constraints. Also 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 where ‘slightly aware’ of the system. 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.

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 PERC reporting standard (one of several aligned with the CRIRSCO template), seven survey participants said they had ‘no experience’. No respondents felt they were an ‘expert’ in the system, although three were ‘competent
persons’ (as described by the PERC code). Two respondents indicated they had ‘some experience’ while a further three described their experience as ‘minimal’.

### 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 trade of minerals. Out of the 34 responses, a very high proportion said the national statistical office, followed by customs. This seems counter-intuitive and will be examined more closely for Deliverable 1.2. A total of 22 of the survey participants said that their organisation collected, compiled and published trade data and most subsequent (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%). 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 where not aware how the raw data were collected.

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 were usually available.

When asked whether an organisation makes an adjustment or estimate for any missing portion from the collected trade data, 56% (10/18) said that they do not and 28% (5/18) replied that they did not know. Three respondents provided quite detailed explanations of how such an adjustment or estimate is made and this may need to be followed up for inclusion in Deliverable 1.2.

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. Most of the organisations did not collect trade data relating to the intermediate stage of metal production, however of those that did most collected data for metal content (45% 9/20). Of those, three respondents also reported data for gross weight.

For industrial minerals, 70% of the survey respondents collected trade data at the raw primary production stage and 25% also collect data for primary production beneficiated (e.g. washed, processed, etc.). 20% of organisations do not collect trade data for industrial minerals.

For construction minerals, 75% (15/20) of survey participants said that they collected trade data categorised into rock types, while 45% (9/20) 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.

Regarding trade data, 80% (16/20) do not pass these data onto other organisations. 60% (12/20) collect the data annually. 85% (17/20) collect data in Mass e.g. tonnes. 60% collect data by value e.g. Euros (12/20).
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. 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.

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 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%).

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

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. 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. Final exploration reports are available in the Data Repository of the MBFSZ according to the Mining Act
- Yes - 7 years
- Reports and data from exploration work have to be sent to the directorate of mining at 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.

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 5). 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 5: 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 6).

![Figure 6: Proportions for each data collection method by mineral groups and data types](image)

Perhaps unsurprisingly, a high proportion of production data comes direct 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, with the result 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.

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 product, which is of most importance to their business. Hence the data often simply do not exist and where they do exist the figures will often be confidential and not publicly 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 an effort is required to collate this information from industry and third party data providers. As emphasised by the results of the survey the majority of all primary mineral data collected is done so with 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 7). 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 7: Illustration of the 'triangular trade' issue](image)

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 compliers 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 is being 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 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, 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 EarthResoucesML (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 contain significant quantities of cobalt. This is not recorded as a cobalt resource.

In addition, there are many deposits that for economic reasons are 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 counties 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 a 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 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.
A first step in 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 Task 1.2 Review of previous projects and recommendations for the improvement of statistical datasets

3.1 Aim and scope of Task 1.2

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 or 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 the recent decades, as the mining sector turned global, it became necessary to harmonise these systems or to develop new, comprehensive classifications.

In 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 8.

![Figure 8: Bridging UNFC and CRIRSCO (Bankes, 2013)](image)

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

Figure 9 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 a specific mineral commodities (resources or reserves, cut off, 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 (existence of Environmental Impact Assessment, social license, etc.) and for the feasibility (state of a project). These are 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 a 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. 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 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 on EU-level (European Federation of Geologists) and on 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 positive changes in the professional authorities (e.g. surveys, agencies, bureaus) additional investments (financial, human and time) but it has also benefits for governments (e.g. high quality data management systems for minerals, supporting expertise for further decisions on mining).

3.4 EU level data sources and availability

3.4.1 INSPIRE

The INSPIRE Directive was published in the official Journal on the 25th April 2007 and entered into force on the 15th May 2007. 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). 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 by representatives of the Member States and chaired by a representative of the Commission (Comitology procedure).

3.4.1.1 Relevant recommendations for harmonisation

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. 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 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.

The collection of 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 the 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 Earth Resource ML data model.

It is 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),
- **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 INSPIRE compliant 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 10). 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

Rendering is optimised, but bubbles can also be moved manually using the mouse. Zooming in or out will so 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 database 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.

MINGUIDE 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.

It may be a good idea to establish a mutual collaboration to take advantage of the synergies between both projects.

3.4.3 ProMine

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 strategic metals (e.g. cobalt, niobium, vanadium, antimony, platinum group elements and REE) and minerals that are currently not extracted in Europe.
- To develop five new, high value, mineral-based (nano) products.
- To enlarge the number of profitable potential 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. All results 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 mine sites. These may also have connections to assessments of mineral resources. For such models the use of a common language for the targeted minerals is essential.
Figure 11: Map of critical raw material deposits in Europe

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.

3.4.4 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 now 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. It provides access to Pan-European and national geological datasets and services from the Geological Survey Organisations of Europe. Through EGDI data from 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 data sets.

The operation and maintenance of EGDI is 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 go on for three years.

EGDI also provides the gateway from the Geological Survey Organisations and their geological data and digital services to the European Plate Observing System (EPOS).

![Diagram of EGDI and its connections](image)

Figure 12: Overview connection between the data systems developed in EU projects and the planned ERA-NET and Permanent Body.

(Daniel Cassard’s presentation, MIN4EU conference, 25.08.2015, Brussels)

### 3.4.5 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 can be found here: http://rmis.jrc.ec.europa.eu/.

![Image of RMIS portal](http://rmis.jrc.ec.europa.eu/)

**Figure 13:** The RMIS portal

### 3.5 Inventory of some selected projects having recommendations on harmonisation issues

In this chapter the following projects and forums/expert groups and related results and recommendations will be presented. The organisations responsible for delivery are presented in brackets:

- Minventory (BGS)
- MINERALS4EU (BGS-GTK)
- MICA (BGS – MBFSZ-GEUS)
- EGS MREG (MBFSZ)
- UNECE EGRC (MBFSZ- NGU)
- MINATURA2020 (MBFSZ)
SNAP SEE (MBFSZ)
National projects (MBFSZ, NGU, CE)

3.5.1 Minventory: EU raw materials statistics on resources and reserves

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 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 bulk 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 a critical component 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 to 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 1. Barriers to data harmonisation identified by Minventory (Parker et al., 2015)

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

3.5.1.1 Recommendations

The barriers identified are the targets for action in the Minventory roadmap (Figure 14), which outlines that many of these can be completed by the target date of 2020. At the time of publication 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 for 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.
The Minventory project has 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 has produced a pathway for the establishment of harmonised reporting of resources and reserves statistics at the EU level. This is outlined in Figure 15. 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 and mineral codes to reflect EU minerals priorities in the necessary detail.

3.5.1.2 Links between Minventory and ORAMA

The Minventory project is highly relevant to the ORAMA project and the detailed recommendations made will 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 can be brought forward for discussion with stakeholders of the ORAMA project.
Figure 15: A potential road map outlined by the Minventory project for data harmonisation (Parker et al., 2015)

### 3.5.2 Minerals4EU

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 a 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 16.

![Image](http://minerals4eu.brgm-rec.fr/m4eu-yearbook/theme_selection.html)

**Figure 16**: An example from the yearbook, showing some of the information available

### 3.5.2.1 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](http://minerals4eu.brgm-rec.fr/m4eu-yearbook/theme_selection.html)

Production data for primary minerals were collected by the BGS in accordance to 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 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.

### 3.5.2.2 Recommendations for improved data collection and harmonisation for primary raw materials data:

#### 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 commodity ‘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 six metrics 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 as, 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:


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

3.5.3 Intraw

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. 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.

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

3.5.3.1 Recommendations from the Intraw project for harmonisation:

INTRAW maps and develops new cooperation opportunities related to raw materials in 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; data reporting systems; exploration, extraction, processing and recycling practices; management and substitution of Critical Raw Materials.
The Repository is a database of the documents collected in the course of the INTRAW 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 analysis of industry it is stated that the minerals industry competitiveness depends on availability of public reliable geological data. The validation of data and information collected by raw materials 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 search information: (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

3.5.4 MICA: Mineral Intelligence Capacity Analysis

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 materials 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 17).
- 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 17: The raw materials Data-Information-Knowledge-Intelligence model developed to describe how data are transformed into knowledge. It is clear that there is a 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.]

### 3.5.4.1 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 are shown in Figure 18. 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.
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](https://eu-rmicp.org) (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.

The online metadata inventory which has been compiled for MICA comprises 410 records, see [http://metadata.mica-project.eu/mmd](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.
3.5.4.2 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. Some key recommendations made 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. As such, they can bridge knowledge gaps: primary/secondary production (urban mine).

3. RMI should include the future to enable policy and decision making for the somewhat longer term. Large knowledge gaps exist and persist in the areas of waste, recycling, circularity, urban mining. It is important to fill those gaps.

4. The MICA platform (EU-RMICP): An advanced, standalone online tool with a flexible ontology structure (consisting of various stakeholder-defined domains, concepts and subconcepts) to obtain data and information on mineral (raw) materials through structured and guided queries, based on raw material knowledge.

3.5.4.3 Data gaps

Several data gaps were identified from the MICA project. These are summarised in Table 2.

*Table 2. Data gaps identified by the MICA project (Petavratzi and Brown, 2017)*

<table>
<thead>
<tr>
<th>Data gap</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste and recycling data</td>
<td>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.</td>
</tr>
<tr>
<td>World Emission Registration data</td>
<td>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.</td>
</tr>
<tr>
<td>Urban stock data (built up or accumulation)</td>
<td>These are not currently available, but are essential for assessing the urban environment and for quantifying resources that may become available in the future.</td>
</tr>
<tr>
<td>Composition of goods (e.g. metal content of ores, materials, components, products, waste)</td>
<td>Essential data used by several methods but are currently only partially available from various dispersed sources.</td>
</tr>
<tr>
<td>Data on dissipative losses</td>
<td>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.</td>
</tr>
<tr>
<td>Data on the lifetime of goods</td>
<td>Data are only partially available from various dispersed sources. They are very important when quantifying the resource potential from secondary resources.</td>
</tr>
<tr>
<td>Data on the production of secondary raw materials</td>
<td>A comprehensive dataset that addresses several commodities is missing. Partially available for selected commodities alongside the mineral statistics.</td>
</tr>
<tr>
<td>Monitoring concentrations in soils</td>
<td>Partial data may be available for some countries, but often are deemed of insufficient detail or/and are not updated frequently.</td>
</tr>
<tr>
<td>Social factors and policy related data</td>
<td>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.</td>
</tr>
<tr>
<td>Mining waste data</td>
<td>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.</td>
</tr>
</tbody>
</table>

### 3.5.4.4 Methods gaps

The project also identified gaps in methods available as outlined below (Petavratzi and Brown, 2017):

- 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 are often missing.
- Building Information Modelling: This method has not been included in the MICA project, but could be relevant especially in assessments of the urban environment and stocks.

### 3.5.4.5 Data uncertainty

Key conclusions made in MICA regarding data uncertainty include (Petavratzi and Brown, 2017):
• 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.

3.5.4.6 **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 different context is that they are often not fit-for purpose. In order therefore 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 are to monitor the physical economy. Raw materials however are part 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.
3.5.5 EGS MREG

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

The EGS Mineral Resources Expert Group (MREG) 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 mission is to provide the best available mineral expertise and information based on the knowledge of member Geological Surveys, for policy, communication, public awareness and education purposes at European level, focusing mainly on strengthening the position of the European minerals industry towards resource sustainability and competitive growth.

EGS 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 EGS 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 and deals with data harmonisation (Minerals4EU, MINVENTORY, etc.). EGS MREG is committed to contribute to the development of the common language including statistical and spatial data for raw materials.

One of Task Team is dealing with classification / 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 UNECE EGRC. The development of the co-operation between the UNECE EGRC and EGS is in progress.

3.5.5.1 Some recommendations

- Development of national projects led by National Geological Surveys or these Surveys should be involved in national/regional level projects according to the presence of the knowledgebase and expertise on mineral resources.
- Sharing knowledge on data harmonisation (methodology, cases, good practices)
- Active participation in the activity of relevant working groups and forums (e.g. UNECE EGRC)
- Legislation for raw material data management should be developed. The legislative background is heterogeneous for using national and international reporting standards or classification framework (Figure 20). Governments are 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 because it links local, industry-specific standards with international classifications and allows for comparability.

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

Both systems, i.e. the CRIRSCO template and the UNFC, would be useful to develop on national/regional levels in Geological Surveys because these professional governmental bodies contribute to the mineral policies including mineral resource management and data services for minerals. The involvement of Competent Persons in national geological surveys, authorities and ministries that are responsible for mineral resources management is necessary because of the knowledge and skills required for the harmonisation. Many national/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 due to the EU-level data that has been collected by previous projects (Minerals4EU etc.) that may include not only national codes but harmonised datasets by international standards or by UNFC. Responsible authorities may benefit from the input of a Competent Person / 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 national level and may serve preliminary or informal analysis for national datasets harmonised by international standards, while the expertise with
report on assessments of the Competent Persons 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. This increasing involvement of internationally recognised experts into the national / 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.

Competent Persons 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 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.

NGS 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/regional inventories for mineral resources. Nations or regions that have no specific inventory for mineral resources should initiate the establishment of an appropriate inventory which may be supported by/require modifications in legislations (e.g. legally binding data service by companies). This may be an important interest and benefits for governments to know 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 of involvement of relevant experts. However this will take not years but decades as well depending on acceptance of recommendations and the time of the procedure of the implementation.

Particularly the UNFC category “E” may require co-operations 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; 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.

Four countries in Europe (Hungary, Italy, Portugal and Slovakia) had national projects for the harmonisation including aspects for classification and reporting as well. In Poland there is an annual publication for resources in their inventory with interpretation for harmonisation between national and international systems. 17 Members of the MREG think that this type of project would be useful on 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.

3.5.6 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.

3.5.6.1 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.

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.

The connection between the ORAMA project is that both projects seek the optimisation of data service for raw materials including primary and secondary as well, however the UNECE EGRC serves framework and forum on 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 / regional levels on a voluntary base but taking into consideration the foreseeable benefits (e.g. resource efficiency).

3.6 National projects

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

3.6.1 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, Australian Geothermal Reporting Code). The Survey have organised several consultations with professional organisations and companies to discuss the recently used Hungarian and internationally applied definitions and methods then to make an agreement about the common ground and application. A set of case studies covering all mineral types (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 PRMS that is aligned with the UNFC was integrated into the Hungarian Mining Law in 2017 based on stakeholder consultation between the representatives of oil and gas companies in the Hungarian Mining Association (MBSZ), the Mining and Geological Survey of Hungary (MBFSZ has been operating since 1st of July 2017 after the integration of the Geological and Geophysical Institute of Hungary, MFGI, into the Hungarian Office for Mining and Geology, MBFH, and the experts of the Hungarian Geological Society.

The Mining Law (Act No. XLVIII. 1993 on Mining) and the Governmental Decree No. 203/1998. (XII.19.) on the implementation of the 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. 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 nor international ones but the available reporting form on the changes on volumes of oil and resources contains terminology that is compliant with the SPE PRMS (Society of Petroleum Engineers Petroleum Resource Management System). 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.
### 3.6.1.1 Hungarian case study

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 m$^3$ non-metallic mineral resources according to the national inventory of 1 January 2015; mainly building stones and organic sediments (see Figure 21).

![Non-metallic mineral resources in Zala County](image)

**Figure 21: 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 have been used:

- the status of the mine/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, however, it is not registered in Hungarian non-metallic mineral resources inventory so it has been estimated.

Complexity is one of the most important factor between Russian type national and international systems. Complexity is designed to support the mineral resource management blocks that are part of the productive part of the deposit and considers the homogeneity of the deposit that needs to be taken into consideration in each km$^2$. 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/km$^2$ can be considered as a deposit of low complexity (relatively homogeneous), while over 100 blocks/km$^2$ a deposit can be considered as a complex one (heterogeneous).

Conversion algorithm used in our case study (Figure 22) is based on the FGU-GKZ & CRIRSCO (2010) conversion guideline and consists of 3 steps:

1. Category C1 was divided into two parts based on complexity group.
2. Categories A+B and less complex C1 were converted into Measured Resources while more complex C1 and C2 into Indicated Resources.
3. The status of the mine was examined: in case of an active mine/quarry all modifying factors had been considered so the resources can be converted into reserves.
UNFC classes can be determined based on UNFC–CRIRSCO bridging document (UNECE 2013). Figure 23 compares the mineral resources according to the original, CRIRSCO and UNFC classification systems. Classes A+B representing high level geological knowledge (max. 20 % uncertainty). C1 has 35 % uncertainty and C2 has 60 % uncertainty in the calculation of the volume of the resource. D categories (basically there are 3: D1, D2 and D3) are not indicated on 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 UNFC classes; 223 and 334 respectively.

![Classification of non-metallic mineral resources in Zala County](image)

**Figure 23: Original, CRIRSCO and UNFC classification of non-metallic mineral resources in Zala County**

### 3.6.2 Central and Eastern European projects

There are many examples in Central and Eastern Europe for the applicability of the harmonisation between the national classification/reporting system with the related inventory as well and international systems (CRIRSCO type reporting and UNFC classification...
framework for mineral resources. The concept and examples can be found in the Czech Republic, in Slovenia and in Poland here:

In the Mineral Resources (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.


For Slovenia the mapping between the Russian System and UNFC can be seen here:


Mineral reserve and resource classification in the Czech Republic and its evolutional comparison with international classifications is correctly described in an annual report:


### 3.6.3 Scandinavian Project: Nordic Project (NGU)

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 preparers to produce 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.

### 3.7 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.
3.7.1 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 (Herzegovinian Canton), Bulgaria, Croatia, Greece, Hungary, Italy (Autonomous Province of Trento and Emilia Romagna Region), Montenegro, Romania, Serbia, Slovakia and 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/regional, primary and secondary aggregates planning in SEE countries.

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/regional trade and strategies.

A map was presented and the importance of harmonised datasets was highlighted with case studies by Horváth et al. 2014. Without any specific recommendations the importance of the joint language was highlighted with a map for SEE region have also different classification and reporting systems but there are some similarities according to the Russian influence in the mineral resource data management.

3.7.2 MINATURA2020

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/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, in the Guidance and in 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 managements (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 covers 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 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/members of the Raw Material Community and by responsible authorities. The MINATURA2020 project is dealing with recommendations for a sustainable resource management system where in relation with mineral safeguarding and designation of MDoPI areas a potential joint language is considered. Many deliverables of the MINATURA2020 project highlight the importance of aligning the national classification and
reporting systems with international reporting codes. These recommendations fit to 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.

Based on the results of the multi-sectoral analysis during the development of the guidance and the joint vision for the implementation of the MDoPi concept on national/regional and EU-level as well following statements and recommendations were highlighted:

- Mineral resource inventories or comprehensive raw material inventory for primary and secondary resources including harmonised datasets is crucial for designation MDoPi areas and the facilitation of the development of sustainable resource management system.
- Mineral management requires well developed, regularly updated, modern and standardised data-sets on minerals.
- A comprehensive inventory supports the MDoPi definition, helping decision makers with the evaluation of quantity and quality of minerals on a specific territory. A mineral resource inventory ideally is aligned international reporting standards, such as UNFC-2009 or the CRIRSCO family.

If a national inventory using national classification and reporting system serves an appropriate base for supporting national raw material supply, in this case the harmonisation with international systems seems not be necessary. Taking into account the EU and the global level markets and EU-level intention to mitigate the raw material supply risk and import dependency with utilisation of European mineral resources (increasing economy, sustainability goals are met with the needs of EU-societies demands and consumption) with enhanced recycling (circular-economy) the joint language is needed primary and secondary resources that are used by the relevant stakeholders/members of the Raw Material Community and by responsible Authorities.

The MINATURA2020 project is dealing with the recommendation for a sustainable resource management system where in relation with the mineral safeguarding and designations of MDoPi areas a potential joint language is considered. 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).

Among others Portuguese, Polish, Slovakian cases are presented.

### 3.7.3 BioMOre

(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 surface, less noise and chemical impact etc.) (BioMOre, 2018).

The project duration was between 2015-2018 and in deliverable 5.3 the need of 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 mentioned recommendations it can be concluded that using harmonised classification framework on project levels and of course in national mineral resource management (inventory) for this type of mining activity would be important because all (resource-reserve; environmental, social and economic issues) can be handled and develop a project from initial level (e.g. Exploration Results according to the CRIRSCO concept and 334 based on UNRMS (former UNFC) to Proved Reserve by CRIRSCO and 111 by the UNRMS).

3.7.4 CERA
(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 UNRMS (former 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.

3.7.5 MinFuture

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 proposed 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 the 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 international level;
- 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 the related uncertainties that may support the idea of the involvement of the risk assessment into the classification and reporting of mineral resources. The knowledge and the development of a project are not static systems, these are rather a dynamic ones. Both the UNFC and the reporting codes including most commonly feasibility studies in the background require the knowledge and the maintenance of the risk may be appropriate to handle information on mineral resources even regarding the geological knowledge and potential, even concerning the project feasibility and social-economic viability (with environmental topics as well).
4 Discussion and conclusions

4.1 Good practice examples

4.1.1 Data collection

The European countries with the best 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, left over from the former USSR. Other European countries with strong systems for data collection include 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 collection of minerals data.

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 service local markets and support the national economy.

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’ or by the Austrian Government in its publication ‘World Mining data’. Considerable amounts of data can also be found in the electronic European Minerals Yearbook produced by the Minerals4EU project. 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 a wide variety of often disparate sources. For these types of publication harmonisation is achieved by 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.

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 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 currently replacement to the AMRI survey takes such a sample type approach and gathers data for 10% of the industry. This is then used to estimate the remaining 90%. 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.

### 4.1.2 Mineral resource and reserve inventories

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 national aggregated data). One example of where this type of bottom up, deposit focused approach has been very successful is the Fennoscandian mineral deposit database (http://en.gtk.fi/informationservices/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 minerals occurrences, 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 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 and it was assumed 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 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.
4.1.3 Nationally managed databases

Exploration for, and development of, mineral deposits generates 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). There are no examples of such advanced systems for the primary minerals considered by this study in in Europe, although clearly this would be much harder to achieve if a range of mineral resources with associated different industries needed to be considered. 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).

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 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 EarthResouceML, and this is being used for geological surveys for information sharing and data storage but with little involvement from the minerals industry.

4.1.4 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 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 are aware of and a process of reviewing the commodities 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 sensitives 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% NACE codes were too aggregated to get figures for the specific commodity in question.

4.2 Challenges and preliminary 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 across Europe
- Heterogeneous data infrastructure, provision and accessibility across Europe

A clear theme of common elements can be seen across good practice examples that facilitates 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.

4.3 General Conclusions

Taking into account that the collection and preparation of all types of statistical data related to mineral resources is intended to inform society, stakeholders and policy makers about the current situation of resources, the available information should be easily accessible and understandable as well as reliable and of a proven quality. So a great effort should be made in simplifying the aggregation / disaggregation of mineral commodities. Also, critically, for mineral resources and reserves, a common coding system must be used. This will greatly
facilitate the collection 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 section, where many of the issues that have been identified have been overcome it is important that these examples of good practice are taken note of so that lessons can be learnt for greater harmonisation of European minerals data.

Another issue that needs to be solved is the heterogeneity in legislation and regulation across Europe. It is important to understand how differences in legislation impact the quality and accessibility of minerals information and, if possible, Member States could be encouraged to consider adapting data gathering and planning systems to solve some of these issues. Concerning the benefits of the improvement of data management and provision of resource and reserve data the following points can be mentioned: increased resource efficiency, support of the resource management system, consideration of sustainable aspects, better planning systems including mineral and land use planning, better support for decision making, increase in investments, etc.

The barriers identified are the targets for action in the Minventory roadmap which has been the most comprehensive study on issues regarding European minerals data to date. This outlines that many of these were planned to be completed by the target date of 2020, however, in reality some issues are likely to take longer to resolve. 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. It should be emphasised that suggested actions are all voluntary to tackle the issues.

4.4 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. Firstly 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 this 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, data supplied under mineral licensing requirements, a census of all industrial activities and a representative sample of minerals operation comprised the vast majority of survey types. It does not necessarily matter how the data is collected (although some data collections methods will be more accurate than others) as long as there is a clear robust mechanism to do so.

The survey also showed ambiguity over intermediated products produced by the minerals industry, this highlights a large gap in data 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.

Finally 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 assessable (even if they may have significant data gaps, see Appendix 1), which may be more attractive to data users than more fragmented raw data which
they may be able to obtain from separate government departments from within their own country.

4.5 Conclusions regarding reserve and resource data

For many European countries that have mineral resource management and the related classification systems in place that are based on the experience of the Russian type / traditional classification system that is widely used in the former Soviet Union and the Eastern Bloc (e.g. Hungary), long term datasets with sufficient information for mineral resources are appropriate for the harmonisation. 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 / inhomogeneity of mineral deposits needs to be indicated clearly and the role of a competent expert (e.g. Competent Person) is important. 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.

4.6 Conclusions regarding future provision of data

Concerning the INSPIRE compliant data service EU Members need to continue the practice for developing the national level data service with sufficient and appropriate datasets and the user interface needs also to be developed in order to ensure access to information on minerals for stakeholders, especially for the mineral resource community.

The database should be developed in the European Geological Data Infrastructure.
References


FGU GKZ (RUSSIAN FEDERAL GOVERNMENT AGENCY STATE COMMISSION ON MINERAL RESERVES), AND CRIRSCO (COMMITTEE FOR MINERAL RESERVES INTERNATIONAL REPORTING STANDARDS). 2010. Guidelines on Alignment of Russian minerals reporting standards and the CRIRSCO Template. (Moscow)


HORVÁTH, Z, SÁRI, K, AND KOVÁCS, Z. 2014b. Classification of selected Hungarian mineral resources according to UNFC-2009, CRIRSCO Template, PRMS and the Importance of a common language for
mineral resources in SEE countries. Presentation to UNECE EGRC. Geneva. 


MCI, W, DOWLING, D B, AND LEACH, W W. 1913. The Coal Resources of the World. An inquiry made upon the initiative of the Executive Committee of the XII International Geological Congress, Canada. (Toronto, Canada)

MINPOL. 2017. Legal framework for mineral extraction and permitting procedures for exploration and exploitation in the EU final report.


PAŃSTWOWY INSTYTUT GEOLOGICZNY. 2016. BILANS ZASOBÓW ZŁÓZ KOPALIN W POLSCE wg stanu na 31 XII 2015 r. (Warsaw)


PERC (PAN-EUROPEAN RESERVES AND RESOURCES REPORTING COMMITTEE). 2013. Pan-European Standard for Reporting of Exploration Results, Mineral Resources and Reserves ("The PERC Reporting Standard"). (Bruxelles)


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

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>Commodity</th>
<th>UNITS</th>
<th>BGS</th>
<th>EUROSTAT</th>
<th>BGS</th>
<th>EUROSTAT</th>
<th>BGS</th>
<th>EUROSTAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>Cement Clinker</td>
<td>tonnes (metric)</td>
<td>911 116</td>
<td>911 116</td>
<td>900000*</td>
<td>not available</td>
<td>900000*</td>
<td>not available</td>
</tr>
<tr>
<td>Belgium</td>
<td>Cobalt (Metal &amp; refined)</td>
<td>tonnes (metric)</td>
<td>5415 (a)</td>
<td>2012 (c)</td>
<td>5850 (a)</td>
<td>2567 (c)</td>
<td>6306 (a)</td>
<td>2199 (c)</td>
</tr>
<tr>
<td>Belgium</td>
<td>Copper (refined)</td>
<td>tonnes (metric)</td>
<td>389 400</td>
<td>374 651</td>
<td>387 300</td>
<td>not available</td>
<td>378 600</td>
<td>not available</td>
</tr>
<tr>
<td>Belgium</td>
<td>Finished Cement</td>
<td>tonnes (metric)</td>
<td>6 119 000</td>
<td>6 599 715</td>
<td>6 364 000</td>
<td>3319851 (c)</td>
<td>6 275 000</td>
<td>3678877 (c)</td>
</tr>
<tr>
<td>Belgium</td>
<td>Indium (refined)</td>
<td>tonnes (metric)</td>
<td>30*</td>
<td>no specific code</td>
<td>30*</td>
<td>no specific code</td>
<td>30*</td>
<td>no specific code</td>
</tr>
<tr>
<td>Belgium</td>
<td>Kaolin</td>
<td>tonnes (metric)</td>
<td>300000*</td>
<td>not available</td>
<td>300000*</td>
<td>not available</td>
<td>300000*</td>
<td>not available</td>
</tr>
<tr>
<td>Belgium</td>
<td>Lead (Refined)</td>
<td>tonnes (metric)</td>
<td>129 429</td>
<td>135 305</td>
<td>133 252</td>
<td>132 917</td>
<td>130 000</td>
<td>1100012 (c)</td>
</tr>
<tr>
<td>Belgium</td>
<td>Pig Iron</td>
<td>tonnes (metric)</td>
<td>4 343 000</td>
<td>not available</td>
<td>4 335 000</td>
<td>not available</td>
<td>4 248 000</td>
<td>not available</td>
</tr>
<tr>
<td>Belgium</td>
<td>Primary aggregates (Crushed rock)</td>
<td>tonnes (metric)</td>
<td>46 000 000</td>
<td>28507393 (c)</td>
<td>45 000 000</td>
<td>30080593 (c)</td>
<td>45 000 000</td>
<td>30341938 (c)</td>
</tr>
<tr>
<td>Belgium</td>
<td>Primary aggregates (Sand And gravel)</td>
<td>tonnes (metric)</td>
<td>21 000 000</td>
<td>4136690 (c)</td>
<td>19 000 000</td>
<td>3752820 (c)</td>
<td>19 000 000</td>
<td>3950717 (c)</td>
</tr>
<tr>
<td>Belgium</td>
<td>Selenium, refined</td>
<td>tonnes (metric)</td>
<td>200*</td>
<td>no specific code</td>
<td>200*</td>
<td>no specific code</td>
<td>200*</td>
<td>no specific code</td>
</tr>
<tr>
<td>Belgium</td>
<td>Steel Ingots and Castings (Crude steel)</td>
<td>tonnes (metric)</td>
<td>7 127 000</td>
<td>not available</td>
<td>7 331 000</td>
<td>not available</td>
<td>7 257 000</td>
<td>not available</td>
</tr>
<tr>
<td>Belgium</td>
<td>Sulphur and Pyrites (Recovered, smelter gases &amp; hydrocarbons)</td>
<td>tonnes (sulphur content)</td>
<td>396900 (a)(b)</td>
<td>0</td>
<td>4000000 (a)(b)*</td>
<td>0</td>
<td>4000000 (a)(b)*</td>
<td>0</td>
</tr>
<tr>
<td>Belgium</td>
<td>Tin (Smelter)</td>
<td>tonnes (metric)</td>
<td>10 346</td>
<td>no specific code</td>
<td>9 718</td>
<td>no specific code</td>
<td>8 788</td>
<td>no specific code</td>
</tr>
<tr>
<td>Belgium</td>
<td>White Arsenic</td>
<td>tonnes (metric)</td>
<td>1000*</td>
<td>no specific code</td>
<td>1000*</td>
<td>no specific code</td>
<td>1000*</td>
<td>no specific code</td>
</tr>
<tr>
<td>Belgium</td>
<td>Zinc (Slab)</td>
<td>tonnes (metric)</td>
<td>252000 (b)</td>
<td>not available</td>
<td>262000 (b)</td>
<td>331 974</td>
<td>260000 (b)</td>
<td>340 449</td>
</tr>
</tbody>
</table>

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.
<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>Commodity</th>
<th>UNITS</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>BGS</td>
<td>EUROSTAT</td>
<td>BGS</td>
</tr>
<tr>
<td>Germany</td>
<td>Alumina (Al2O3)</td>
<td>tonnes</td>
<td>1000000 *</td>
<td>not available</td>
<td>1000000 *</td>
</tr>
<tr>
<td>Germany</td>
<td>Barytes (Barytes)</td>
<td>tonnes (metric)</td>
<td>45 446</td>
<td>no specific code</td>
<td>87 585</td>
</tr>
<tr>
<td>Germany</td>
<td>Bentonite &amp; Fuller's Earth (Bentonite)</td>
<td>tonnes (metric)</td>
<td>358 844</td>
<td>not available</td>
<td>394 657</td>
</tr>
<tr>
<td>Germany</td>
<td>Bromide</td>
<td>kilograms (metric)</td>
<td>1500000 *</td>
<td>no specific code</td>
<td>1500000 *</td>
</tr>
<tr>
<td>Germany</td>
<td>Cadmium</td>
<td>tonnes (metric)</td>
<td>400 *</td>
<td>not available</td>
<td>400 *</td>
</tr>
<tr>
<td>Germany</td>
<td>Cement Clinker</td>
<td>tonnes (metric)</td>
<td>23 127 000</td>
<td>6 185 436</td>
<td>23 871 000</td>
</tr>
<tr>
<td>Germany</td>
<td>Coal (Anthracite &amp; bituminous)</td>
<td>tonnes (metric)</td>
<td>8 260 000</td>
<td>Not inc. on Prodcom</td>
<td>8 340 000</td>
</tr>
<tr>
<td>Germany</td>
<td>Coal (Brown coal)</td>
<td>tonnes (metric)</td>
<td>182 995 337</td>
<td>Not inc. on Prodcom</td>
<td>178 154 846</td>
</tr>
<tr>
<td>Germany</td>
<td>Copper (refined)</td>
<td>tonnes (metric)</td>
<td>677 600</td>
<td>not available</td>
<td>674 000</td>
</tr>
<tr>
<td>Germany</td>
<td>Copper (Smelter)</td>
<td>tonnes (metric)</td>
<td>289 900</td>
<td>0 (h)</td>
<td>349 700</td>
</tr>
<tr>
<td>Germany</td>
<td>Diatomite</td>
<td>tonnes (metric)</td>
<td>51 435</td>
<td>no specific code</td>
<td>54 277</td>
</tr>
<tr>
<td>Germany</td>
<td>Feldspar</td>
<td>tonnes (metric)</td>
<td>350000 *</td>
<td>no specific code</td>
<td>320 000</td>
</tr>
<tr>
<td>Germany</td>
<td>Ferro-Alloys (Ferro-chrome)</td>
<td>tonnes (metric)</td>
<td>17500 *</td>
<td>no specific code</td>
<td>17000 *</td>
</tr>
<tr>
<td>Germany</td>
<td>Ferro-Alloys (Other ferro-alloys)</td>
<td>tonnes (metric)</td>
<td>8200 *</td>
<td>no specific code</td>
<td>8200 *</td>
</tr>
<tr>
<td>Germany</td>
<td>Ferro-Alloys (Silicon metal)</td>
<td>tonnes (metric)</td>
<td>30 283</td>
<td>not available</td>
<td>28 500</td>
</tr>
<tr>
<td>Germany</td>
<td>Finished Cement</td>
<td>tonnes (metric)</td>
<td>31 108 000</td>
<td>30 927 011</td>
<td>32 099 000</td>
</tr>
<tr>
<td>Germany</td>
<td>Fluor spar</td>
<td>tonnes (metric)</td>
<td>48 744</td>
<td>no specific code</td>
<td>58 100</td>
</tr>
<tr>
<td>Germany</td>
<td>Gallium (primary)</td>
<td>tonnes (metric)</td>
<td>38</td>
<td>no specific code</td>
<td>16</td>
</tr>
<tr>
<td>Germany</td>
<td>Graphite</td>
<td>tonnes (metric)</td>
<td>269</td>
<td>no specific code</td>
<td>517</td>
</tr>
<tr>
<td>Germany</td>
<td>Gypsum</td>
<td>tonnes (metric)</td>
<td>1778000 (a)</td>
<td>1 778 164</td>
<td>4090000 (a)</td>
</tr>
<tr>
<td>Germany</td>
<td>Indium (refined)</td>
<td>tonnes (metric)</td>
<td>10 *</td>
<td>no specific code</td>
<td>10 *</td>
</tr>
<tr>
<td>Germany</td>
<td>Iron Ore</td>
<td>tonnes (metric)</td>
<td>413404 (d)</td>
<td>0</td>
<td>461082 (d)</td>
</tr>
<tr>
<td>Germany</td>
<td>Kaolin</td>
<td>tonnes (metric)</td>
<td>11 00000 (e)</td>
<td>3 536 031</td>
<td>11 00000 (e)</td>
</tr>
<tr>
<td>Germany</td>
<td>Lead (Refined)</td>
<td>tonnes (metric)</td>
<td>400 000</td>
<td>352358 (h)</td>
<td>380 000</td>
</tr>
<tr>
<td>Germany</td>
<td>Natural Gas</td>
<td>million cubic (metric)</td>
<td>10 678</td>
<td>Not inc. on Prodcom</td>
<td>10 060</td>
</tr>
<tr>
<td>Germany</td>
<td>Petroleum (Crude)</td>
<td>tonnes (metric)</td>
<td>2 638 379</td>
<td>Not inc. on Prodcom</td>
<td>2 429 789</td>
</tr>
<tr>
<td>Germany</td>
<td>Pig Iron</td>
<td>tonnes (metric)</td>
<td>26 678 000</td>
<td>not available</td>
<td>27 943 000</td>
</tr>
<tr>
<td>Germany</td>
<td>Potash (Potassic salts)</td>
<td>tonnes (K20)</td>
<td>3 075 201</td>
<td>0</td>
<td>3 178 103</td>
</tr>
<tr>
<td>Germany</td>
<td>Primary aggregates (Crushed rock)</td>
<td>tonnes (metric)</td>
<td>207 000 000</td>
<td>148 307 403</td>
<td>211 000 000</td>
</tr>
<tr>
<td>Germany</td>
<td>Primary aggregates (Sand And gravel)</td>
<td>tonnes (metric)</td>
<td>228 000 000</td>
<td>147 638 376</td>
<td>238 000 000</td>
</tr>
<tr>
<td>Germany</td>
<td>Primary Aluminium</td>
<td>tonnes (metric)</td>
<td>492 368</td>
<td>not available</td>
<td>530 683</td>
</tr>
<tr>
<td>Germany</td>
<td>Salt (Brine salt)</td>
<td>tonnes (metric)</td>
<td>2 164 456</td>
<td>not available</td>
<td>2 133 359</td>
</tr>
<tr>
<td>Germany</td>
<td>Salt (Rock salt)</td>
<td>tonnes (metric)</td>
<td>8 510 652</td>
<td>not available</td>
<td>4 928 656</td>
</tr>
<tr>
<td>Germany</td>
<td>Salt (Salt in brine)</td>
<td>tonnes (metric)</td>
<td>7 878 895</td>
<td>not available</td>
<td>4 075 004</td>
</tr>
<tr>
<td>Germany</td>
<td>Selenium, refined</td>
<td>tonnes (metric)</td>
<td>700 (f)</td>
<td>922</td>
<td>700 (f)</td>
</tr>
<tr>
<td>Germany</td>
<td>Steel Ingots and Castings (Crude steel)</td>
<td>tonnes (metric)</td>
<td>42 645 000</td>
<td>10 815 789</td>
<td>42 943 000</td>
</tr>
<tr>
<td>Germany</td>
<td>Sulphur and Pyrites (Recovered, hydrocarbons)</td>
<td>tonnes (metric)</td>
<td>754 540 (b)</td>
<td>0</td>
<td>708 146 (b)</td>
</tr>
<tr>
<td>Germany</td>
<td>Sulphur and Pyrites (Recovered, other)</td>
<td>tonnes (metric)</td>
<td>464 776 (c)</td>
<td>no specific code</td>
<td>437 677 (c)</td>
</tr>
<tr>
<td>Germany</td>
<td>Uranium</td>
<td>tonnes (metal)</td>
<td>27</td>
<td>Not inc. on Prodcom</td>
<td>33</td>
</tr>
<tr>
<td>Germany</td>
<td>Zinc (Slab)</td>
<td>tonnes (metric)</td>
<td>162 000</td>
<td>not specific code</td>
<td>168 000</td>
</tr>
</tbody>
</table>
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)
<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>Commodity</th>
<th>UNITS</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greece</td>
<td>Alumina</td>
<td>tonnes (Al2O3 content)</td>
<td>811 600</td>
<td>Not available</td>
<td>813 500</td>
</tr>
<tr>
<td>Greece</td>
<td>Bauxite, Alumina &amp; Aluminium (Bauxite)</td>
<td>tonnes (metric)</td>
<td>1 844 000</td>
<td>1 844 519</td>
<td>1 876 000</td>
</tr>
<tr>
<td>Greece</td>
<td>Bentonite &amp; Fuller's Earth (Bentonite)</td>
<td>tonnes (metric)</td>
<td>1 000 000</td>
<td>Not available</td>
<td>1 011 485</td>
</tr>
<tr>
<td>Greece</td>
<td>Bentonite and Fuller's Earth (Attapulgite)</td>
<td>tonnes (metric)</td>
<td>32 400</td>
<td>Not inc. on Prodcom</td>
<td>45 000</td>
</tr>
<tr>
<td>Greece</td>
<td>Cement Clinker</td>
<td>tonnes (metric)</td>
<td>6 754 154</td>
<td>Not available</td>
<td>7 025 675</td>
</tr>
<tr>
<td>Greece</td>
<td>Coal (Lignite)</td>
<td>tonnes (metric)</td>
<td>55 500 000</td>
<td>Not inc. on Prodcom</td>
<td>50 411 000</td>
</tr>
<tr>
<td>Greece</td>
<td>Feldspar</td>
<td>tonnes (metric)</td>
<td>0</td>
<td>No specific code</td>
<td>0</td>
</tr>
<tr>
<td>Greece</td>
<td>Ferro-Alloys (Ferro-nickel)</td>
<td>tonnes (metric)</td>
<td>86 850</td>
<td>Not available</td>
<td>94 952</td>
</tr>
<tr>
<td>Greece</td>
<td>Finished Cement</td>
<td>tonnes (metric)</td>
<td>5 553 411</td>
<td>5 571 247</td>
<td>5 563 414</td>
</tr>
<tr>
<td>Greece</td>
<td>Gold</td>
<td>kilograms</td>
<td>823</td>
<td>no specific code</td>
<td>552</td>
</tr>
<tr>
<td>Greece</td>
<td>Gypsum</td>
<td>tonnes (metric)</td>
<td>760000 (a)</td>
<td>361 806</td>
<td>664000 (a)</td>
</tr>
<tr>
<td>Greece</td>
<td>Kaolin</td>
<td>tonnes (metric)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Greece</td>
<td>Lead (mined)</td>
<td>tonnes (metal content)</td>
<td>18 010</td>
<td>Not available</td>
<td>16 700</td>
</tr>
<tr>
<td>Greece</td>
<td>Lead (Refined)</td>
<td>tonnes (metric)</td>
<td>6000 *</td>
<td>Not available</td>
<td>12000 *</td>
</tr>
<tr>
<td>Greece</td>
<td>Magnesite &amp; Magnesia (Magnesite)</td>
<td>tonnes (metric)</td>
<td>314 770</td>
<td>no specific code</td>
<td>391 140</td>
</tr>
<tr>
<td>Greece</td>
<td>Natural Gas</td>
<td>million cubic metres</td>
<td>5</td>
<td>Not inc. on Prodcom</td>
<td>5</td>
</tr>
<tr>
<td>Greece</td>
<td>Nickel (Mined)</td>
<td>tonnes (metal content)</td>
<td>19 800</td>
<td>0</td>
<td>20 600</td>
</tr>
<tr>
<td>Greece</td>
<td>Nickel (Smelter/Refinery)</td>
<td>tonnes (metric)</td>
<td>17 500</td>
<td>0</td>
<td>18 481</td>
</tr>
<tr>
<td>Greece</td>
<td>Perlite</td>
<td>tonnes (metric)</td>
<td>890 000</td>
<td>no specific code</td>
<td>985 000</td>
</tr>
<tr>
<td>Greece</td>
<td>Petroleum (Crude)</td>
<td>tonnes (metric)</td>
<td>378 000</td>
<td>Not inc. on Prodcom</td>
<td>378 000</td>
</tr>
<tr>
<td>Greece</td>
<td>Primary aggregates (Sand and gravel and crushed rock)</td>
<td>tonnes (metric)</td>
<td>30000000 *</td>
<td>14 906 586</td>
<td>38000000 *</td>
</tr>
<tr>
<td>Greece</td>
<td>Primary Aluminium</td>
<td>tonnes (metric)</td>
<td>169 480</td>
<td>Not available</td>
<td>173 260</td>
</tr>
<tr>
<td>Greece</td>
<td>Salt</td>
<td>tonnes (metric)</td>
<td>189 500</td>
<td>Not available</td>
<td>146 402</td>
</tr>
<tr>
<td>Greece</td>
<td>Silver</td>
<td>kilograms (metal content)</td>
<td>39 759</td>
<td>no specific code</td>
<td>35 780</td>
</tr>
<tr>
<td>Greece</td>
<td>Steel Ingots and Castings (Crude steel)</td>
<td>tonnes (metric)</td>
<td>1 030 000</td>
<td>Not available</td>
<td>1 022 000</td>
</tr>
<tr>
<td>Greece</td>
<td>Sulphur and Pyrites (Recovered, hydrocarbons)</td>
<td>tonnes (sulphur content)</td>
<td>2280000 (b)</td>
<td>Not available</td>
<td>227140 (b)</td>
</tr>
<tr>
<td>Greece</td>
<td>Zinc</td>
<td>tonnes (metal content)</td>
<td>22 549</td>
<td>no specific code</td>
<td>23 085</td>
</tr>
</tbody>
</table>

**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.