MINERALS INFORMATION FOR EUROPE – DEVELOPMENTS TOWARDS A MORE CONSISTENT FUTURE

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Abstract

Access to data and information relating to the current and potential supply of minerals in Europe is of fundamental importance to policy-makers at all levels of government and also to the European manufacturing and infrastructure sectors. However, the availability of data across the individual countries of Europe is variable and the quality of those data is inconsistent.

Whilst statistical data on the production and trade of minerals has been compiled by the British Geological Survey (BGS) for many years, no dataset existed for mineral resources, reserves or exploration activities at a European level. A two year project called 'Minerals Intelligence Network for Europe' (Minerals4EU) aimed to begin the process of addressing these data gaps by bringing together all the available statistical data relating to mineral production, trade, resources, reserves, exploration and, for the first time, mineral-based secondary materials into the most comprehensive European Minerals Yearbook ever attempted. This new Yearbook was delivered digitally via an innovative EU Knowledge Data Platform which also included the compilation of spatial data relating to the location of mineral deposits across many countries of Europe.

This paper includes basic facts about the Minerals4EU project, highlights some of the features of the Yearbook and provides examples of the available statistical data from 40 European countries. The project involved the collaboration of 31 organisations across 26 different nationalities and in itself provided valuable lessons in how disparate countries and cultures can work together towards a common aim. There is still much work to do in this area but at least the process has begun.

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INTRODUCTION

The European Union (EU) has acknowledged that raw materials are '*crucial to Europe's economy*' and essential for '*maintaining and improving the quality of life*' of its citizens (European Commission, 2017a). It has also stated that '*securing reliable and unhindered access to raw materials is important*', not least because it supports jobs throughout the continent (European Commission, 2017b). The EU established the Raw Material Initiative in 2008, which is an integrated strategy designed to assist with securing supply for raw materials. It consists of three pillars (Figure 1):

1) Access to raw materials on world markets at undistorted conditions – including actions relating to raw materials diplomacy, the promotion of international co-operation and the inclusion of raw materials in EU trade and regulatory policy and in EU development policy.
2) Foster sustainable supply of raw materials from European sources – including actions to facilitate improvements in land use planning, geological knowledge of European deposits and co-ordination between national geological surveys. It also considers the issues of skills shortages and public awareness.
3) Reduce the EU's consumption of primary raw materials – including actions to improve resource efficiency, increase the use of secondary raw materials and encourage the reuse or recycling of products and materials.

All three of these pillars require access to data and information relating to the current and potential supply of minerals in Europe. Collectively these are known as the 'knowledge base'. These data are useful at all levels of government (i.e. national, regional or local, as well as EU) for the development of appropriate policies related to the three pillars described by the strategy and which will benefit European industries and economies. Improved access to data can also be used to attract investment, including in mineral exploration which will help to secure future indigenous sources and to sustain the existing network of European mines and quarries.

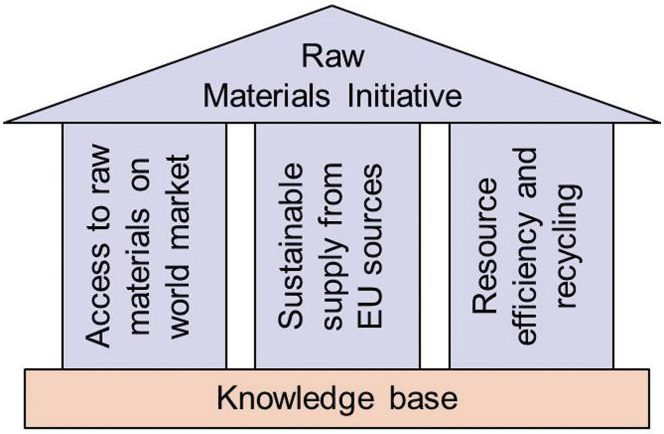


Figure 1. *Diagram showing the three pillars of the Raw Materials Initiative, which have their foundation on the EU Knowledge Base.*

The provision of data is also useful to European manufacturing and infrastructure sectors because they are reliant on sustainable and unhindered access to raw materials, the majority of which are minerals or mineral-based products. The data can be used to evaluate supply chains, reduce associated supply risks and inform decisions related to the procurement of raw materials or for commercial strategic planning. In addition, these data are frequently required by academia and scientific researchers in connection with a variety of topics from environmental studies to market analyses and these in turn inform a wide range of decision-makers.

The availability of data across Europe, however, is highly variable with each country developing its own systems and procedures to suit its own purposes. One of the consequences of this is often that data quality is inconsistent, which makes it very difficult to compare countries or to amalgamate figures into a continental scale total.

Whilst statistical data on the production and trade of minerals has been compiled for each country by the British Geological Survey (BGS) for many years, other types of data have not received the same attention. For example, prior to 2015 no dataset existed at a European level for mineral resources, reserves or exploration activities and for some countries it was unknown whether such data existed even at national level. Other countries were known to have data for certain commodities but not for all the minerals of interest and additional data gaps were believed to exist. As a consequence there was a clear need to examine the availability of data as a prerequisite to understanding how standardisation could be achieved.

The Minerals4eu Project

The 'Minerals Intelligence Network for Europe' (Minerals4EU) project, co-funded by the EU under its Framework 7 Programme, ran from September 2013 to August 2015. The project was co-ordinated by the Geological Survey of Finland (GTK) and it was conducted by a large consortium consisting of 31 partner organisations from 26 countries (Figure 2). The main aims of the project were to create a significant component of the 'knowledge base' required to underpin the Raw Materials Initiative, to facilitate access to information relating to raw materials and to promote collaboration amongst the geological surveys of Europe.

These project aims were achieved through the delivery of four key outcomes:

- European Minerals Yearbook – The European statistical yearbook brings together all the available statistical data relating to mineral production, trade, resources, reserves, exploration and, for the first time, mineral-based secondary materials (waste flows).
- Foresight Studies – A series of reports on different themes including the European raw material potential, societal challenges, legislative and governmental challenges, developments in raw material markets and secondary raw materials.
- EU Knowledge Data Platform – An online portal that includes a map viewer displaying mineral resources for many European countries on a deposit scale, together with the digital Yearbook with interactive graphs and charts, an expansive data search function and the foresight study reports.
- Minerals4EU Foundation and Network – The establishment of a non-profit making foundation, based in Brussels, and connected to a network of partners. Its initial purpose is to sustain the achievements of the Minerals4EU project into the future.

Further details relating to the project, including a full list of the partners, are available on its website: http://www.minerals4eu.eu/ and the EU Knowledge Data Platform is available at: http://minerals4eu.brgm-rec.fr/

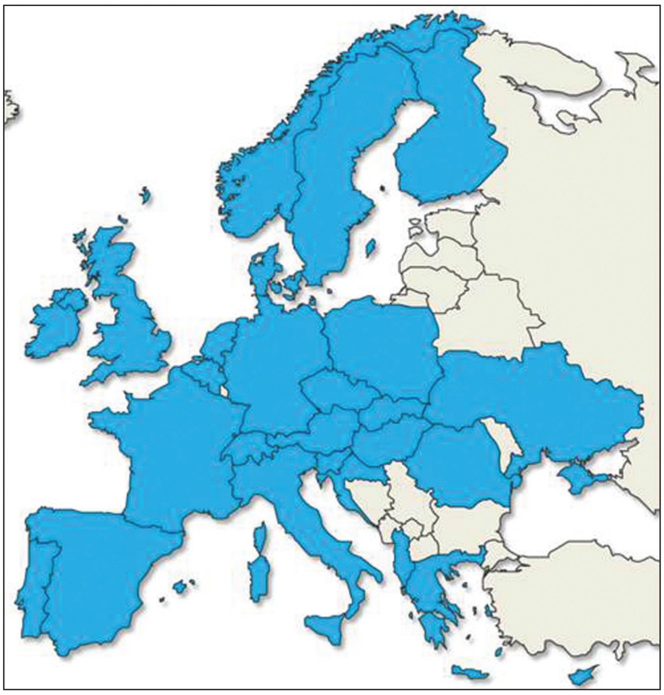


Figure 2. *Countries represented by partners within the Minerals4EU project consortium (Minerals4EU, 2015a).*

European Minerals Yearbook

This paper will focus on the Yearbook delivered by the Minerals4EU project because this is the component of the wider project that was led by BGS. This was the most comprehensive yearbook that has been attempted for minerals data. It includes six different types of statistical data for primary minerals, together with associated metadata, and two different elements for secondary raw materials, i.e. waste flow statistics and case studies of the potential of raw material supply from key waste streams. To our knowledge, this was the first time data and information for primary and secondary raw materials had been presented side by side on a comprehensive European scale. Each element had to be assessed and processed independently of each other in order to take account of the unique character and challenges associated with them.

Primary minerals

Production and trade data

The BGS has been collecting these datasets for many years prior to the Minerals4EU project and it made sense for BGS to continue with its normal processes, including its usual quality assurance steps and to provide these data for the Yearbook. In addition to saving time and resources, this approach enabled the Yearbook to include 10 years of production, import and export data rather than just a single year.

The Yearbook includes these data for 40 countries including all countries represented by project partners, all EU Member States and all EU candidate or potential candidate countries (Table 1). Production data is included for all of these countries and trade data for 35 of the 40. The remaining five countries were not part of the normal BGS trade data collection and consequently would have required additional work for which insufficient time was available. Data does exist for these countries and it is hoped that they can be added in future.

Country name	Production	Imports	Exports	Resources	Reserves	Exploration	Waste flow
Albania	Yes	No	No	Yes	No data	Yes	Limited
Austria	Yes	Yes	Yes	Yes	No data	No data	Yes
Belgium	Yes	Yes	Yes	No reply	No reply	No reply	Yes
Bosnia & Herzegovina	Yes	No	No	No reply	No reply	No reply	Yes
Bulgaria	Yes	Yes	Yes	No reply	No reply	No reply	Yes
Croatia	Yes	Yes	Yes	No data	Yes	Yes	Yes
Cyprus	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Czech Rep.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Denmark	Yes	Yes	Yes	Yes	Yes	No data	Yes
Estonia	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Finland	Yes	Yes	Yes	Yes	Yes	Yes	Yes
France	Yes	Yes	Yes	Yes	No data	No reply	Yes
Germany	Yes	Yes	Yes	No data	No data	No data	Yes
Greece	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Greenland	Yes	No	No	Yes	No data	Yes	Limited
Hungary	Yes	Yes	Yes	Yes	No data	Yes	Yes
Iceland	Yes	Yes	Yes	No reply	No reply	No reply	Yes
Ireland	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Italy	Yes	Yes	Yes	Yes	Yes	No reply	Yes
Kosovo	Yes	No	No	Yes	Yes	Yes	2012 only
Latvia	Yes	Yes	Yes	Yes	No data	No reply	Yes
Lithuania	Yes	Yes	Yes	Yes	No data	No reply	Yes
Luxembourg	Yes	Yes	Yes	No data	No data	No data	Yes
Macedonia (TFYR of)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Malta	Yes	Yes	Yes	No data	No data	No data	Yes
Montenegro	Yes	Yes	Yes	No reply	No reply	No reply	2012 only
Netherlands	Yes	Yes	Yes	Yes	No data	Yes	Yes
Norway	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Poland	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Portugal	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Romania	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Serbia	Yes	Yes	Yes	No reply	No reply	No reply	Yes
Slovakia	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Slovenia	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spain	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sweden	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Switzerland	Yes	Yes	Yes	Yes	Yes	Yes	Limited
Turkey	Yes	Yes	Yes	No reply	No reply	No reply	Yes
Ukraine	Yes	No	No	Yes	Yes	Yes	2012 only
United Kingdom	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 1. *Summary of data contained in the digital European Minerals Yearbook created by the Minerals4EU project*

Resources and reserves data

These were collected together for the first time on a European scale during the Minerals4EU project through the design and circulation of a questionnaire. It was anticipated that the data received would be quite variable, and so the questionnaire included the requirement to specify the reporting system used for each figure returned and also included some metadata fields to enable each country to provide further explanation.

There are a variety of internationally recognised systems for reporting resource and reserves data (sometimes referred to as 'standards' or 'codes') and these provide strict legal definitions for the terms 'resources' and 'reserves'. In addition, there is an even wider diversity of national level reporting codes which may, or may not, have been adapted from one of the international systems. These national level codes have often evolved over time to suit the individual purposes of the country concerned. Many of these systems are not comparable with each other and the resulting numbers cannot be summed to provide amalgamated figures on a continental scale because the different categories represent different types of resources or reserves.

At the start of the Minerals4EU project is was unclear just how significant an issue this was for European countries and consequently the decision was taken not to attempt to standardise or harmonise the resources and reserves data during the project. Instead it was agreed that the project would collect whatever data was available, irrespective of the reporting system used, so that the scale of the issue could be assessed.

Of the 40 countries contacted during the project, 33 returned the resources and reserves questionnaire (Table 1). However, not all of the returned questionnaires contained statistical data and some countries were only able to return data for one or other term.

Exploration data

As with resources and reserves, exploration data was collected together for the first time on a European scale during the Minerals4EU project, and again a questionnaire was designed and circulated to obtain these. At the start of the project it was not known which metrics each country recorded in relation to exploration and consequently the questionnaire had the option of reporting five different pieces of data and also a free text box for a general description of exploration activity. The data requested included exploration expenditure in the reference year (2013), the number of exploration licences active in the year, the number of exploration licences issued in the year, the area under exploration licences at the end of the year and the number of companies actively exploring within the country.

Of the 40 countries contacted during the project, 29 returned the exploration questionnaire (Table 1). Not all of the returned questionnaires contained statistical data, some questionnaires contained data only for some of the requested metrics and other countries were only able to provide partially complete data or only the total figures with no breakdown by commodity. In one case, Malta, no data were returned because no exploration activity was ongoing in the reference year.

Secondary raw materials

Waste flow

For the first time on a European scale, the Minerals4EU project attempted to present statistics for secondary raw materials alongside those for primary minerals. Because data for the production of minerals from secondary sources are not available, the decision was taken to present figures for mineral-based waste flows. These waste flow data include the types and quantities of mineral-based waste generated, the quantitative flows of these materials through different treatment methods, import and export data and the waste generated specifically by mining and quarrying activities. The number and capacity of waste treatment facilities was also captured.

Data for waste flows are not recorded at a level of detail that is comparable to primary minerals. Therefore the data were collected and are presented as categories of mineral-based waste with no details of the individual mineral content of these categories. After careful examination of the available category descriptions the following were selected for inclusion in the Yearbook:

- Metallic waste, ferrous (e.g. mill scales, discarded moulds, filings and turnings, ferrous metal, iron and steel)
- Metallic waste, non-ferrous (e.g. as above but for aluminium, copper, brass, bronze, zinc, tin, lead, etc.)
- Metallic waste, mixed ferrous and non-ferrous (e.g. metallic packaging, mixed metallic wastes)
- Glass waste (e.g. glass packaging waste)
- Discarded vehicles (e.g. end-of life vehicles)
- Discarded electrical and electronic equipment (e.g. discarded electrical and electronic equipment, discarded machines and equipment components)
- Batteries and accumulators wastes (e.g. alkaline batteries, lead batteries, nickel-cadmium batteries and accumulators)
- Mineral waste from construction and demolition (e.g. concrete, bricks, ceramic tiles, track ballast, road surfacing waste)
- Other mineral wastes (e.g. waste of naturally occurring minerals, artificial mineral waste, waste refractory materials, waste with asbestos)
- Combustion wastes (e.g. flue gas purification waste, slags and ashes)
- Dredging spoils
- Mineral wastes from waste treatment and stabilised wastes (e.g. waste treatment waste (i.e. ashes), solidified or stabilised waste, vitrified waste)

Data were collected through a desk-based review from a number of publically available databases including those published by Eurostat or national environmental and statistical agencies. Waste flow data from these agencies are available on a biennial basis and are therefore included in the Yearbook for 2010 and 2012. Complete datasets for both years were available for 34 of the 40 European countries and for a further 3 countries data were available for 2012 only (Table 1). For the remaining 3 countries only limited data, e.g. for fewer categories or waste flow stages, were available and are included.

Further details relating to the processes, method and the results described above for both primary and secondary minerals are available in the project deliverable report number 4.3 (Minerals4EU, 2015b).

Case studies on recovery from key waste streams

In addition to compiling data relating to the quantities of mineral-based waste generated and treated, eight case studies were conducted to examine the potential of key waste streams for use as a resource of specific mineral commodities. The case studies were conducted for iron/steel, aluminium, copper, platinum, palladium, indium, dysprosium and yttrium. These were selected to provide a broad coverage across ferrous, non-ferrous, precious and speciality metals because it was felt that variations in data availability could have an impact on this analysis and it was important to assess whether this kind of study could be conducted on other commodities.

For each material the first step was to identify the key application fields and specific product groups where the material is used. The in-use stock of the material contained within those product groups was calculated using available data for the material content and apparent consumption of the product. Next the product lifetime was examined in order to calculate the likely quantity of the product reaching the end of its life in a single year and consequently the quantity of the material contained within those end-of-life products. This represents the maximum quantity that could be produced from this waste stream if the metal recovery rate was 100%. The actual quantity of the material sourced from end-of-life products was also calculated and the two sets of results were compared and presented as the percentage of supply that could be, and is, covered by recycling of the key waste stream. The results are presented as a range of values, represented by a minimum and maximum, due to the uncertainties involved in calculating them (Table 2).

Unsurprisingly, there were significant gaps in the availability of data required for this analysis requiring the use of many assumptions. Despite this, however, the results clearly indicated that there is a considerable variation between the different commodities in the proportion of EU demand that could be met by supply from secondary sources. For example, the recycling of platinum from non-electrical passenger vehicles could supply 26–73% of the EU's demand for that metal, whereas the recycling of indium from LCD TVs, computer monitors and laptops combined is lower at 15–19%. There is also considerable variation between the results for 'potential' supply and 'actual' supply, which indicates that the collection of end-of-life products and the recovery rates of metals within those products remains a significant issue. Full details of the method, all the assumptions used and other relevant discussion are available in a separate project report (Minerals4EU, 2015c).

Digital delivery

The European Minerals Yearbook was delivered digitally via a new online Knowledge Data Platform, available at: http://minerals4eu.brgm-rec.fr/. From the front page of the Yearbook (Figure 3) the four options are, from left to right:

- Access to data for primary minerals and waste flows by country;
- Access to data for primary minerals by commodity;
- Access to data for waste flows by category; and
- Access to documents relating to the Yearbook including the deliverable reports, the case studies and the full report on the resource potential of secondary raw materials.

Inside the Yearbook, data for production and trade can be viewed in tabular form by country or graphical form by commodity (Figures 4 and 5 respectively). In both cases the user can interact with the data.

Product		Metal	Potential supply from key waste streams (% of demand)		Actual supply from key waste streams (% of demand)	
			min	max	min	max
TV Set	LCD	Indium	8.8	11.1	0.09	0.1
		Yttrium	0.006	73.9	0	0
	CRT	Yttrium	0.06	0.1	0	0
Monitor	LCD	Indium	1.7	2.3	0.02	0.02
		Yttrium	0.003	7.1	0	0
	CRT	Yttrium	0.02	0.03	0	0
Laptop	LCD	Dysprosium	20.6	23.5	0.1	0.2
		Indium	4.4	5.3	0.04	0.05
		Yttrium	0.007	3.7	0	0
Desktop PCs		Dysprosium	7.0	14.1	0.07	0.1
Non-electric passenger vehicles		Platinum	25.8	72.6	16.5	46.4
		Palladium	41.1	124.7	26.7	81.1
		Aluminium	22.4	40.6	13.5	24.4
		Copper	12.3	16.9	4.2	5.7
		Iron/steel	12.9	17.6	8.2	11.2
Wind turbines		Dysprosium	0.8	n/a	0	n/a
Smartphones		Yttrium	0.0001	0.0002	0	0

Table 2. *Minimum and maximum values for potential and actual supply from key waste streams calculated during the Minerals4EU project to the selected materials and products, expressed as the percentage of demand. LCD = Liquid Crystal Display; CRT = Cathode*

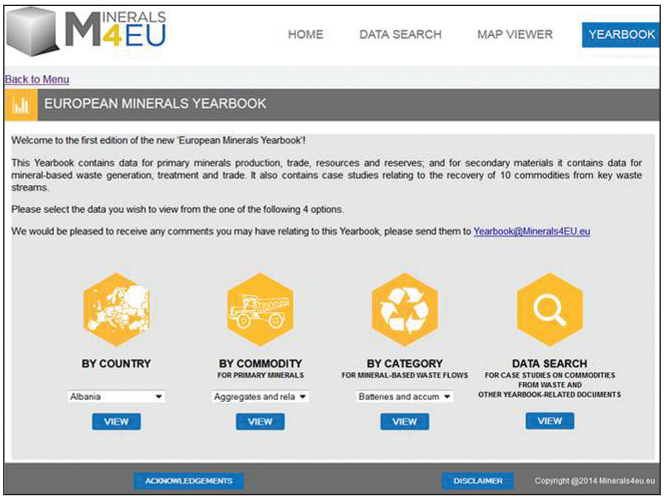
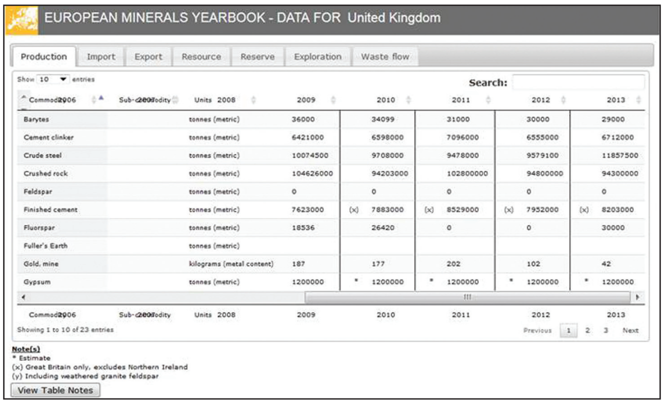


Figure 3. *Front page of the digital European Minerals Yearbook with four options for accessing the data and information (see text for details).*



Commodity	Sub-commodity	Units	2009	2010	2011	2012	2013
Barytes		tonnes (metric)	36000	34099	31000	30000	29000
Cement clinker		tonnes (metric)	6421000	6598000	7096000	6555000	6712000
Crude steel		tonnes (metric)	10074500	9708000	9478000	9579100	11857500
Crushed rock		tonnes (metric)	104626000	94203000	102800000	94800000	94300000
Feldspar		tonnes (metric)	0	0	0	0	0
Finished cement		tonnes (metric)	7623000	(x) 7883000	(x) 8529000	(x) 7952000	(x) 8203000
Fluorspar		tonnes (metric)	18536	26420	0	0	30000
Fuller's Earth		tonnes (metric)					
Gold, mine		kilograms (metal content)	187	177	202	102	42
Gypsum		tonnes (metric)	1200000	* 1200000	* 1200000	* 1200000	* 1200000

Figure 4. *Example data from the Yearbook, showing production data by country. Import and export data appear in the same layout.*

By country the user can:

- sort on any column;
- search for commodities;
- alter the number of visible rows;
- scroll left and right to see more years of data;
- select a different page; or
- click a button to view the table notes.

By commodity the user can:

- see a map with graduated colour to distinguish the size of production;
- view a trend graph for the European total;
- select one or more countries on the map, which will open second trend graph comparing countries; or
- hover the cursor over any of the graphics to view the actual figures.

Resources, reserves and exploration data in the Yearbook can be viewed by country in a similar tabular format to Figure 4. However, data by commodity is presented differently because data are only available for a single year and consequently it is not possible to draw trend graphs. Also, different categories needed to be added to the map to indicate the presence or absence of

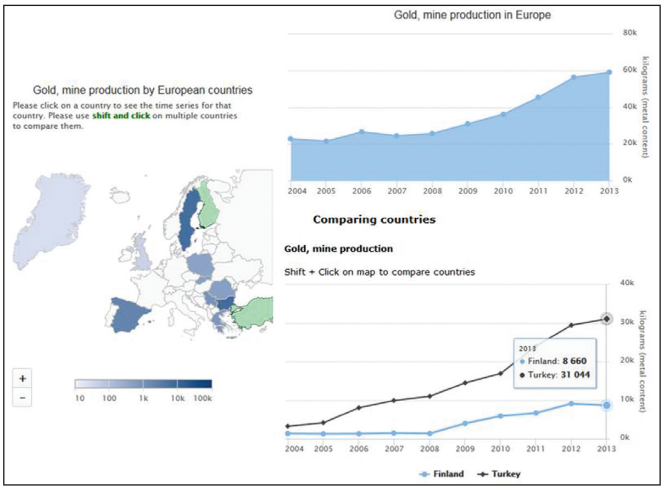


Figure 5. *Example data from the Yearbook, showing production data by commodity. Import and export data can be viewed the same layout.*

statistical data as well as whether resources or reserves are known to exist or whether exploration activity is known to be taking place. For each of these maps, if the user clicks on a country they will see the available data for that country and/or a button to access any available metadata (Figure 6).

Waste flow data is presented in the Yearbook in tabular form by country or by waste category, with the same interactive options as are available in other tables. In addition, simple Sankey diagrams are presented in the section by country to illustrate the flows from waste generation to the various waste treatment options (Figure 7).

A full user guide to the digital Yearbook is available to assist with navigating through the various pages in the deliverable 4.5 report (Minerals4EU, 2015d).

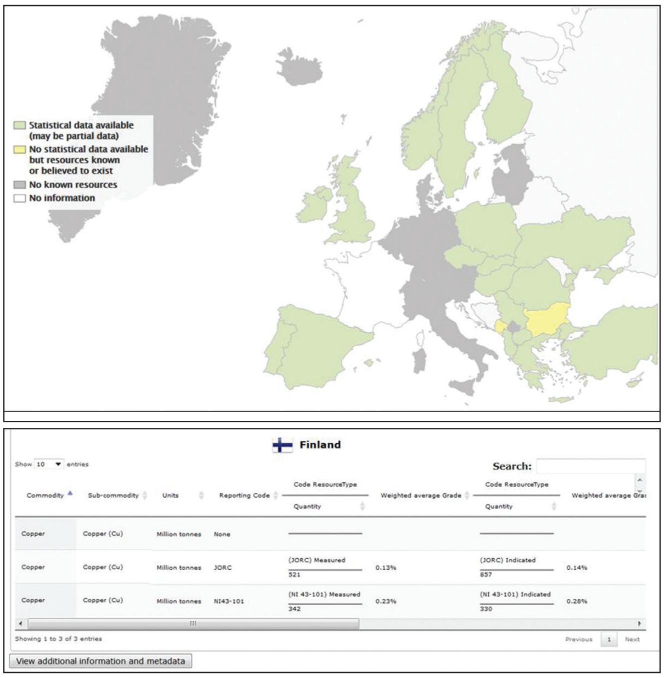
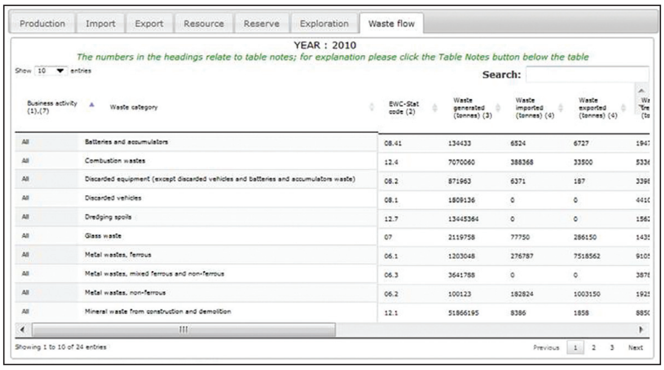


Figure 6. *Example of layout for resources, reserves and exploration data within the Yearbook and viewed by commodity. In this example countries with resources of copper are shown on the map and the user has selected Finland to view the statistical data below.*



Business activity (1),(7)	Waste category	EWC-Stat code (2)	Waste generated (tonnes) (3)	Waste imported (tonnes) (4)	Waste exported (tonnes) (4)
All	Batteries and accumulators	08.41	134433	6524	6727
All	Combustion wastes	12.4	7070060	388368	33500
All	Discarded equipment (except discarded vehicles and batteries and accumulators waste)	08.2	871963	6371	187
All	Discarded vehicles	08.1	1809136	0	0
All	Dredging spoils	12.7	13445364	0	0
All	Glass waste	07	2119758	77750	286150
All	Metal wastes, ferrous	06.1	1203048	276787	7518562
All	Metal wastes, mixed ferrous and non-ferrous	06.3	3641788	0	0
All	Metal wastes, non-ferrous	06.2	100123	182824	1003150
All	Mineral waste from construction and demolition	12.1	51866195	8386	1858

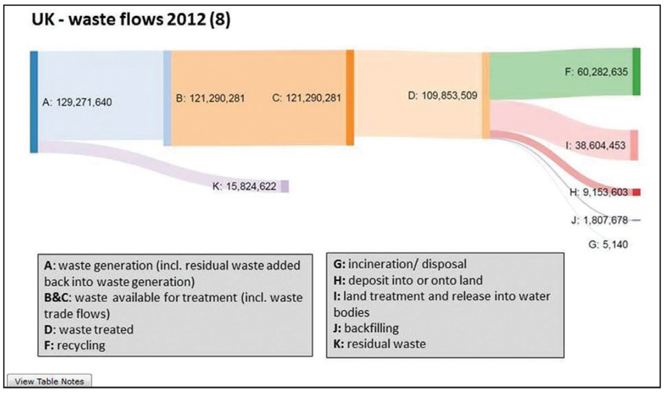


***Figure 7.** Example of waste flow data in the Yearbook viewed by country with the tabular format shown top and an example of the Sankey diagrams below.*

Key Challenges And Lessons Learnt

Compiling data and information from such wide ranging and disparate sources reveals quite a number of challenges, at various different scales. Although this list is not exhaustive, five key challenges are described here, of which the first three relate to specific data types, while the other two are more general and apply across the whole of the project.

Resources and reserves statistics

Across the countries of Europe there are no agreed or consistently used definitions for the terms 'resources' and 'reserves'. Some countries define all their data under one or other of these terms, other countries use them interchangeably while further countries use one of them for metalliferous minerals and the other for industrial minerals. The Minerals4EU project attempted to gauge just how serious an issue this is by collecting details relating to the system(s) used for reporting figures in addition to the numbers themselves.

Whilst there are several internationally recognised systems of reporting resources and reserves data, all of which contain strict legal definitions for both 'resources' and 'reserves', these systems are not used universally across Europe. Many countries use a National Reporting Code which is unique to their country, albeit some of these may be adapted from codes or standards used elsewhere. Other countries do not require the use of a standard of any sort and consequently the data returned were categorised according to whatever description had been applied to it by others. In several countries, including the UK, these data are not routinely collected centrally because there is no requirement to do so under national laws. Some countries could only return estimated data for many commodities for various reasons. While in other countries resources and reserves data are confidential and could not be reported at all.

In total 17 different systems of reporting resources and reserves were returned in the questionnaires, in addition to data that was estimated or where no code was used. The frequency of use of different reporting systems is shown in Figure 8. Many countries reported that more than one system was used and usually this was due to the diverse nationality of the companies operating in those countries.

National reporting codes were used by Albania, Croatia, Czech Republic, Estonia, Kosovo, Latvia, Poland, Slovakia and Slovenia. As shown in Figure 8, eight countries used the Australian Joint Ore Reserves Committee (JORC) code and nine used the Canadian National Instrument 43-101 (NI 43-101) but many of these were the same countries. Perhaps not surprisingly, Finland and Sweden used the Fennoscandian Review Board (FRB) standard (amongst other systems). The United States Geological Survey (USGS) system is based on the McKelvey diagram (USBM and USGS, 1980) and was used by Greece and Spain (amongst other options). The 'Russian classification' is also known as the National Association for Subsoil Examination (NAEN) code and was used by Hungary, Serbia and Ukraine. The 'ex-Yugoslavian' code is believed to have been adapted from the Russian NAEN code but this was not confirmed during the project; it was used by the former Yugoslavian Republic of Macedonia. Greece also returned data that was described as being in accordance with the Canadian Institute of Mining Metallurgy and Petroleum (CIM); this is believed to be the same as NI 43-101. The United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources (UNFC) is reported to be used by Romania and Slovenia (albeit the latter also used a national reporting code).

Furthermore six countries returned data that were estimated in some way; usually this was in addition to figures reported against one of the other options. A total of 14 countries had one or more commodities that were not reported according to any code or standard at all. Eight countries did not return the questionnaire and a consequently the position there is unknown.

This multiplicity of systems used for reporting figures for mineral resources and reserves has very significant consequences when there is a requirement to compare countries or when a total figure is needed for resources of any commodity in 'Europe' as a whole. It is not appropriate to add resources or reserves figures together when they are reported against different systems. For example, a category within one reporting system could be including material that another reporting system would specifically exclude. It would be 'like adding apples to oranges', they may be all fruit but they are not comparable.

Exploration metrics

At the start of the Minerals4EU project it was unclear whether or how the different countries across Europe recorded exploration activity. It was known that some countries had well developed processes for the issuance

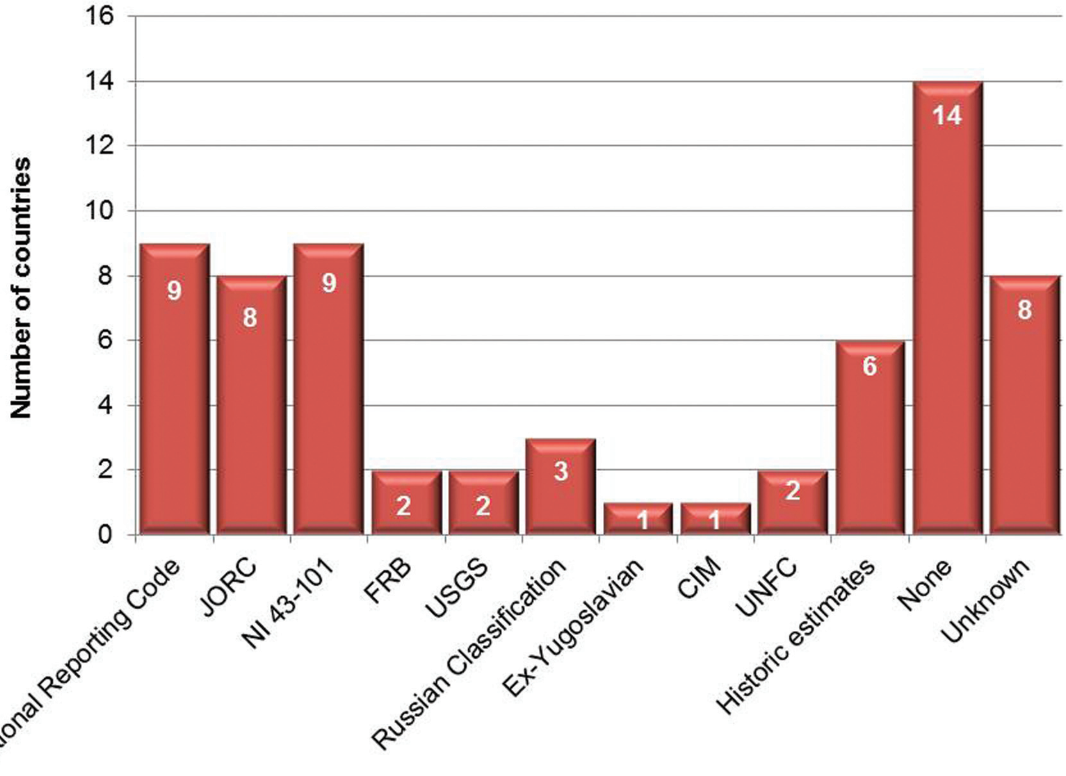


Figure 8. *Frequency of use of different reporting codes in data returned by questionnaire for the Minerals4EU project (see text for details of the abbreviations).*

of licences for exploration but also that many others did not. It quickly became clear that even where exploration licences are issued, the terms and conditions attached to them varied widely and consequently the requirement to report information centrally also differed considerably. Hence the decision was taken to include five different metrics on the questionnaire, together with a free text box for a general description of exploration activity, in order that as many countries as possible would be able to report something. The frequency of return for each metric is shown on Figure 9.

The most commonly returned metric was simply the number of companies involved in exploration within the country in 2013. This was followed by the number of exploration licences active in 2013, the number of new licences issued in 2013 and the area involved with exploration activity in 2013. The metric that was returned least often was the amount of expenditure that was spent on exploration.

Even where figures were returned, the quality of the data was quite variable. Some countries were only able to return data for certain commodities, which is one example of the 'yes but part only' category in Figure 9. Another example of this category would be that only partial data is collected for some reason, or that part of the data is considered confidential and therefore cannot be published. In other cases a figure that was the total for all commodities was provided but not a breakdown by individual mineral, shown in Figure 9 as 'Total only'.

Based on these returns, it is simply not possible to state accurately how much exploration is ongoing in Europe. However, only one country stated categorically that there was no exploration activity within its borders, which in itself is more informative than the position at the start of the project.

Waste flow data

Recycling of materials from waste is something that has generated a great deal of discussion in recent years and there is no doubt that for certain commodities it can be a significant source of raw materials. However, obtaining accurate and precise statistics on the quantities that may be available from secondary sources is very difficult. Within the Minerals4EU project it was decided to collect together the data that were available and in so doing to highlight the data that do not exist. Waste statistics are collected for the purpose of measuring waste management or treatment and thereby of controlling pollution. They are not collected with the view that the waste materials are a 'resource' and consequently there is no information on what the waste may contain (it simply categorises in into hazardous or non-hazardous). The waste flow data, for example, can inform the user how much metallic or non-ferrous waste was generated or treated in a particular country but not what proportion of that was copper.

Although the waste flow data is presented in the European Minerals Yearbook, because of the way it is collected it is not comparable with data for primary minerals.

Different nationalities do not speak the same language

This sounds obvious, but the challenge is more than just the fact that the EU has 24 official languages (Table 3) requiring the employment of 1,750 linguists (European

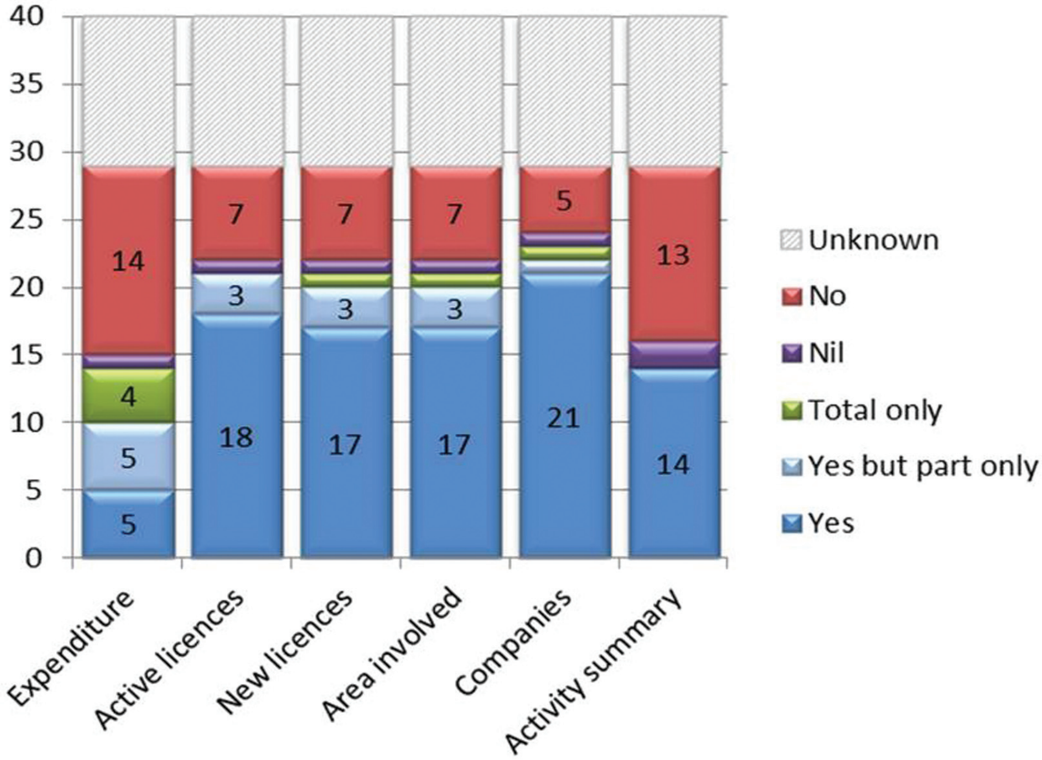


Figure 9. *Number of countries able to return data relating to each of the five exploration metrics and the exploration activity summary*

Bulgarian	Croatian	Czech	Danish
Dutch	English	Estonian	Finnish
French	German	Greek	Hungarian
Irish	Italian	Latvian	Lithuanian
Maltese	Polish	Portuguese	Romanian
Slovak	Slovenian	Spanish	Swedish

Table 3. *The 24 official languages of the European Union (European Commission, 2017c).*

Commission, 2017c). The Minerals4EU project included partners from 26 countries, not all of them were EU member states so primary languages spoken included some that are not listed in Table 3.

The working language for the Minerals4EU project was English but for the vast majority of individuals working for the 32 partners this was not their 'first' language and for some it was not even their 'second' language. Consequently there was significant scope for misunderstanding of terminology, particularly any technical terms. There was a constant need for vigilance because it was all too easy for disagreements to occur when the issue was really just the different use of a word or phrase.

European countries have evolved independently and inconsistently

Beyond the simple language difficulties, the project was corresponding with 40 independent sovereign countries, each of which has developed its own processes and methodologies for dealing with minerals. There is no reason to assume that any of these procedures should be consistent with those in any other country nor that they should result in congruent statistics. This is a very different position from a single large country, such as the USA or Russian Federation, which can impose a common standard across its component states or provinces should it wish to. Within Europe consistency can only be achieved with agreement, collaboration and co-ordination. This is more difficult to achieve and will take some time as a consequence.

Conclusions

Given the very real challenges identified by the Minerals4EU project, the question could be posed as to whether a project like this is worthwhile. But the collection and presentation of data such as those contained in the European Minerals Yearbook are important because they underpin many actions undertaken both within and outside of the framework of Raw Materials Initiative. Policy-makers across Europe, at many different levels, will continue to make policies that affect the minerals industries and it is clearly better that those policies are based on data even if those data are incomplete and inconsistent. The Minerals4EU project was a helpful exercise in bringing together people from a wide range of European countries and for highlighting the current situation in this area. There's a long way to go before the ideal outcome is reached but at least the process has started.

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