## Optimizing quality of information in RAw MAterial data collection across Europe

### D3.1: Compatibility of improved datasets with the INSPIRE Directive and existing data models, and identification of necessary evolutions

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¹ PU=public, PP= Restricted to other programme participants (including the Commission Services), RE= Restricted to a group specified by the consortium (including the Commission Services), CO= Confidential, only for members of the consortium (including the Commission Services)
Publishable abstract

The implementation of the INSPIRE Directive and, for the field of raw materials, of the INSPIRE Mineral Resources (MR) data model - through several FP7 and H2020 projects - has shown that this task was complex, that the results were sometimes disappointing (for various reasons such as data quality, data completeness or gaps in the spatial coverage...) and that the data models, although complex (too complex?), had weaknesses or omissions and needed to be improved.

This study reviews the different implementations of the INSPIRE MR data model via two main projects, the EU-FP7 Minerals4EU and the H2020 ProSUM projects. ProSUM was essentially centered on the urban mine (WEEE, ELV and BATT) and this necessitated the development of a new data model (the ProSUM Unified data model), but at the same time ProSUM was also in charge of improving the management of mining waste data. Originally, mining wastes were not included in the INSPIRE core data model but in the INSPIRE MR extension data model. The implementation made in the M4EU data model needed to be refined, which was done in the frame of ProSUM.

One part of ProSUM has thus been dedicated to the improvement of the M4EU data model. During the development of the M4EU model (incl. improvements brought by ProSUM), great care has been taken to maintain compatibility with the ERML model on which the INSPIRE MR model is originally based. The (mandatory) modifications made on the Mining Waste part of the M4EU model were also the opportunity to make corrections and to improve other parts of the model in order to submit a single package of modifications to the CGI/ERML Group for approval. The modifications include (i) new feature types: Activity (new) which now covers MiningActivity (already existing) and ProcessingActivity (new), and ProcessingPlant (new), (ii) new data types such as ProductCommodityMeasure and a specialization of OreMeasure named TotalProduction, ProcessingPlantName, WasteDimension and MiningWasteMeasure, (iii) the reworking of existing code lists such as ProcessingPlantStatus, ProcessingActivityType and WasteType (to be submitted for approval), and (iv) the finalization of new code lists for mining wastes such as amountEstimationMethodUsed, and compositionEstimationMethodUsed (also to be submitted for final approval). In addition several cardinalities were corrected and some properties modified (e.g., removal of ‘range’ from Quantity) in certain cases. All these modifications – submitted and approved by the CGI, with the exception of those mentioned above - can be seen at the following address: https://www.seegrid.csiro.au/subversion/xmml/GGIC/trunk/doc/ERML_3_Doc/index.htm.

The introduction of the new dataType ‘TotalProduction’ will also cause the modification of the DataType ‘Endowment’ (Endowment being the sum of TotalProduction + Reserves + Resources [not including Reserves]).

Regarding two hot topics, the integration and use of the UNFC classification, and the partial automation of the e-Minerals Yearbook, solutions are proposed. For the UNFC classification, the creation in the INSPIRE MR data model of a specialization of OreMeasure (like in ERML) is the best solution. The associated code list is ready, and this will allow – when possible - establishing a correspondance between CRIRSCO and UNFC codes. For the e-Minerals
Yearbook, the data flow from the harvesting of aggregated data at national level to the checking/harmonization/blending with external data by BGS, and to the diffusion by the Minerals4EU portal has been set up. Two methods of encoding this type of information have been identified (ERML/ERML-Lite and O&M) and evaluated. The group of experts gathered in Ljubljana (Nov. 2018) proposed to use the ERML mode of encoding this type of information. ERML is well known from providers and it is therefore expected to be easier to use. Two methods of encoding this type of information have been identified (ERML/ERML-Lite and O&M) and evaluated. The group of experts gathered in Ljubljana (Nov. 2018) proposed to use the ERML mode of encoding this type of information over O&M. ERML is well known from providers and it is therefore expected to be easier to use. A separate / specific schema based on ERML, and taking into account the needed additions (e.g., related to exploration), will be developed and used for designing a dedicated harvesting database for data aggregated at the national level. In practice, this database can be stored in the same database management system side by side with the existing M4EU Harvesting DB, as several schemas and tables can be stored in the same database.

From the preliminary recommendations (see ORAMA Deliverable D1.1, Bide et al., 2018a) for optimized datasets made by Work Package 1 ‘Data for primary raw materials’, four main topics have been identified: data quality (proven, reliable), uncertainties, calculated commodity content and commodities (names and classification). The three first topics are already handled by the INSPIRE MR/ERML data model. The fourth one deals with the harmonization of the Commodity code lists, notably between INSPIRE/ERML on one side and the e-Minerals Yearbook (e-MYB) on the other side. As these ‘lexicons’ are used for several applications, modifying one or the other would be problematic, and the best solution is to make a mapping between these two classifications, trying to limit the inevitable loss of precision generated by this type of exercise. The BGS mapping realized in the frame of the Minerals4EU project has thus been reevaluated. Compared to ERML, only two concepts were missing in the INSPIRE MR and e-MYB code lists, that can be easily added, and thus confirming that this mapping is still completely valid.

Some other ongoing projects such as the GeoERA FRAME project express the need for greater detail in certain substances such as graphite, the different varieties of which have different physical properties corresponding to different uses. This is a classic problem for industrial rocks and minerals whose classification is largely based on their uses, and this should apply here also for graphite. This will inevitably lead to an update of the Commodity code list within ERML and INSPIRE MR, which must also be reflected in the mapping with the e-MYB.

From the second set of recommendations made by WP1 (see ORAMA Deliverable D1.2, Bide et al., 2018b), three main topics have been identified: (i) to use the UNFC classification, (ii) to complete EarthResourceDimension for raw materials, and (iii) to take into account raw materials physical properties (e.g., grain size, clarity).

The use of the UNFC classification is already allowed by the ERML v2.0 data model based on a specialization of OreMeasure (see above). Regarding the second point, the INSPIRE MR / ERML data models are more focused on metal substances than on industrial rocks and minerals. Some key parameters such as volume (m$^3$), bulk density… are missing for their description. The idea here would be to complete EarthResourceDimension for raw materials, similarly to WasteDimension. Regarding the third point on physical properties related to raw materials (industrial rocks) such as grain size, clarity and many others, this is probably manageable through GeoSciML 3.0 Package ‘PhysicalProperties’, available at: http://geosciml.org/doc/geosciml/3.0/documentation/html/. A new code list will be needed for managing these properties which should be accompanied by a QuantityRange (incl. units).
Regarding the ProSUM Unified data model and secondary raw materials from the urban mine (WEEE, ELV and spent batteries), no specific modification of the structure of the data model is needed at this stage. Modifications will essentially bear on vocabularies (code lists) in order to integrate more detailed and updated classifications (see ORAMA Deliverable D2.2, Huisman et al., 2018).

The need of a ‘Raw Data’ database is however emphasized. A large amount of data on the composition of EEE, batteries and vehicles were collected and harmonized within the ProSUM project, but no database was established for the storage of raw data, such as material compositions obtained by chemical analysis or from manufacturer data sheets. Of course, members of the ProSUM consortium responsible for composition data and data models are good candidates to drive the development of such a data repository on the composition of anthropogenic objects and materials (to be developed in a new project).

Finally, both data models are robust. The INSPIRE MR data model has been improved. Most of additions/corrections/improvements have been submitted to- and accepted by the IUGS/CGI ERML Group. They will have to be ‘pushed’ into the INSPIRE validation process, and a co-authored section with DG JRC is dedicated to how to proceed, whether it is the data model (extension or core) or the code lists that are concerned. The ProSUM Unified data model will have to be submitted to the CGI in order to get the opportunity to become a recognized standard. As this data model is intended to quantify flows and stocks of metals (including CRM), an option could be to make it an extension of EarthResourceML (ERML). This action will be started if possible in the course of 2019, depending on the CGI Agenda.
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Purpose

Taking into account the INSPIRE MR and ProSUM data models, and classification systems from the economic accounting domain, the objectives of the ORAMA-WP3 task T3.1 ‘Compatibility of improved datasets with the INSPIRE Directive and existing data models, and identification of necessary evolutions’ were:

(i) to produce a baseline assessment of the current situation with a summary of the status of the INSPIRE Directive implementation and,

(ii) to outline a vision of a high-level INSPIRE model for primary and for secondary raw materials, (whatever their origin, including the urban mine, and taking into account their environmental and also potentially economic impact), in a way that different datasets together can be easily linked in a Material System Analysis (MFA).

These objectives can then come into three actions whose results are examined in this deliverable:

- Re-evaluate the implementation done by Minerals4EU (M4EU data model) of the INSPIRE MR data model and make the necessary recommendations in order that all improvements are integrated (feedback effect) in the INSPIRE MR and the IUGS/CGI/ERML\(^2\) data models.

- Promote in the same way the ProSUM Unified Data Model for the urban mine and make it the reference to use.

- Regarding the architecture and the content of WP1 and WP2 improved datasets, to evaluate the necessity (i) to further develop existing data models and/or (ii) to develop new data models for handling possible new data types related to mineral occurrences and deposits and technical data, and set up datasets harmonization rules. A particular attention will be paid to aggregated datasets at national level, for both primary and secondary resources.

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\(^2\) [http://www.cgi-iugs.org/tech_collaboration/geoscience_terminology_working_group.html](http://www.cgi-iugs.org/tech_collaboration/geoscience_terminology_working_group.html)
Glossary of key-terms used in Work Package 3

API: an **Application Programming Interface** is a set of functions and procedures allowing the creation of applications that access the features or data of an operating system, application, or other service.

**BATT**: Spent batteries (secondary resources).

**Catalogue services** support the ability to publish and search collections of descriptive information (metadata) for data, services, and related information objects. Metadata in catalogues represent resource characteristics that can be queried and presented for evaluation and further processing by both humans and software. Catalogue services on the Web (CSW or CS-W) are required to support the discovery and binding to registered information resources within an information community. (OGC definition: [http://www.opengeospatial.org/standards/cat](http://www.opengeospatial.org/standards/cat)).

**CORS**: **Cross-origin resource sharing** is a mechanism that allows restricted resources on a web page to be requested from another domain outside the domain from which the first resource was served. A web page may freely embed cross-origin images, stylesheets, scripts, iframes, and videos. Certain "cross-domain" requests, notably Ajax requests, are forbidden by default by the same-origin security policy. CORS defines a way in which a browser and server can interact to determine whether or not it is safe to allow the cross-origin request. It allows for more freedom and functionality than purely same-origin requests, but is more secure than simply allowing all cross-origin requests.

**Data model**: A **data model** organizes data elements and standardizes how the data elements relate to one another. The ‘EURare – Minerals4EU’ data model, as well as the **INSPIRE MR data model**, is an entity-relationship model (ERM). This is an abstract conceptual data model (or semantic data model) used in software engineering to represent **structured data**. This model is transformed into a **relational model**, which in turn generates a relational database. These conceptual entity/relationship models are developed using **UML Class Diagram notation**. Thus, data models describe the structure, manipulation and integrity aspects of the data stored in data management systems such as relational databases. They typically do not describe unstructured data, such as word processing documents, e-mail messages, pictures, digital audio, and video.

**Diffusion database**: The role of the (Central) Diffusion Database (DB) is to provide the portal with data. These data are sent to the portal using Web services (WFS, JSON). In order to speed the process, the structure of the Diffusion DB is optimized for diffusion. This means that its structure does not follow exactly the data model which has been 'flattened' or simplified without altering the data. For this project, the (Central) Diffusion DB is hosted by BRGM in France. At the origin – before the addition of specific tables used for optimization – the Diffusion DB is an exact copy of the Harvesting DB made by using SQL scripts.

**Distributed architecture** means that the data served by the platform is regularly uploaded from data providers (national data provider or EU provider…) through a 'harvesting' system using web services. Data is sent to a central database (DB) (composed of two distinct DBs, one being dedicated to harvesting, the other one to diffusion) which only acts as caching mechanisms.
The central database is used to minimize the drawbacks of a purely distributed architecture: a user of the system may search for occurrences of commodities throughout Europe; in case all information is available on distributed servers, such a query will have to be executed at every data provider, resulting in a high risk of low performance. Therefore the data is stored centralized to act as an optimized search index. It also reduces the risk of having inaccurate results if local services are down or temporarily unreachable.

**ELV**: End-of-Life Vehicles (secondary resources).

**ERML** or EarthResourceML data model: This is the 'international – world-wide' fully compliant version of the INSPIRE MR data model (http://www.earthresourceml.org/). This data model is managed by the IUGS/CGI/ERMLWG and used in Europe, North America and Australia.

**ETL**: Extract, Transform and Load process in database management that performs data extraction from homogeneous or heterogeneous data sources; data transformation for storing in the proper format or structure for the purpose of querying and analysis; and data loading into the final target.

**EU-MKDP**: the European Union Minerals Knowledge Data Platform developed in the frame of the EU-FP7 Minerals4EU project. The IKMS (the EURare’s Integrated Knowledge Management System) and the EU-MKDP are based on the same architecture and share numerous components.

**EU-UMKDP**: the European Union Urban Mine Knowledge Data Platform developed in the frame of the H2020 ProSUM project, and which deals with WEEE, ELV and BATT, and also with mining wastes (MW). This platform communicates with the EU-MKDP through web services (mostly WFS & WMS).

**EU-RMICP**: The European Union Raw Materials Information Capacity Platform developed in the of the H2020 MICA project. This Platform lays the foundation of a modern expert system for the raw materials domain with notably an ontology-based Dynamic Decision Graph and a database of methods and tools used in mineral intelligence, in geology, mining… In practice, the system must be capable of bringing relevant ‘answers’ of the type ‘how to proceed for…’ on almost any question relative to mineral resources, on the whole supply chain, since the prospecting until the recycling, considering the environmental, political and social dimensions.

**GeoSciML**: The GeoSciML data model is an XML–based (conversion of a UML package) data transfer standard for the exchange of digital geoscientific information. It accommodates the representation and description of features typically found on geological maps, as well as being extensible to other geoscience data such as drilling, sampling, and analytical data (see: http://www.geosciml.org/).

**GML**: The Geography Markup Language (GML) is an XML grammar for expressing geographical features. GML serves as a modelling language for geographic systems as well as an open interchange format for geographic transactions on the Internet (see: http://www.opengeospatial.org/standards/gml).
Harvesting system: The Minerals4EU (Central) Harvesting System including the database periodically refreshes the information available about mineral resources by requesting data from the data providers using INSPIRE compliant Web services (WFS). This DB is structured in such a way that a large part exactly reflects the INSPIRE Mineral Resources (MR) data model, but it also includes the ProSUM mining waste modifications. During the harvesting phase the data that is received is checked whether codelists conform to the INSPIRE registry code list values and other data have the correct format (e.g., dates, numbers...). The Minerals4EU Harvesting DB is hosted by the Geological Survey of Slovenia (GeoZS) and connected to the Diffusion DB using SQL scripts. This Harvesting DB delivers data related to primary mineral resources and mining wastes. The ProSUM Harvesting DB has been built using the ProSUM Unified data model, and is dedicated to the urban mine (WEEE, ELV & BATT). It is hosted by the Geological Survey of Denmark and Greenland (GEUS) and data is currently extracted from Excel sheets that have a standardized format (portrayals) provided by the different ProSUM work packages.

IKMS: The Integrated Knowledge Management System for REE developed in the frame of the EURare EU-FP7 project. This system is based on the same architecture as the EU-MKDP (see above) with which it shares numerous components.

INSPIRE: The INSPIRE directive lays down a general framework for a Spatial Data Infrastructure (SDI) for the purposes of European Community environmental policies or activities which may have an impact on the environment. The INSPIRE Directive entered into force on 15 May 2007. INSPIRE is based on the infrastructures for spatial information established and operated by the Member States of the European Union. The directive addresses 34 spatial data themes needed for environmental applications, among which Mineral Resources and Geology. To ensure that the spatial data infrastructures of the Member States are compatible and usable in a community and transboundary context, the INSPIRE Directive requires that additional legislation or common Implementing Rules (IR) are adopted for a number of specific areas (metadata, interoperability of spatial data sets and services, network services, data and service sharing and monitoring and reporting). These are published either as Commission Regulations or as Decisions. See: [http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007L0002&from=EN](http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007L0002&from=EN)

INSPIRE MR data model: This is the European approved data model for mineral resources (MR), including both primary and secondary (i.e., Mining wastes) resources. However, mining wastes do not belong to the core part of this data model, being only an extension. One objective of the ProSUM project is to improve and extend the mining wastes part of the INSPIRE MR data model. ([http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_MR_v3.0.pdf](http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_MR_v3.0.pdf)). The mineral resources data model used in ProSUM is the M4EU data model (Minerals4EU project) directly derived (with GeoSciML extensions for geology) from the INSPIRE MR data model.

JSON (JavaScript Object Notation) is a data-interchange format. Although not a strict subset, JSON closely resembles a subset of JavaScript syntax. Though many programming languages support JSON, JSON is especially useful for JavaScript-based apps, including websites and browser extensions.
Modal: In user interface design for computer applications, a modal window is a graphical control element subordinate to an application's main window. It creates a mode that disables the main window but keeps it visible with the modal window as a child window in front of it. Users must interact with the modal window before they can return to the parent application. This avoids interrupting the workflow on the main window. Modal windows are sometimes called heavy windows or modal dialogs because they often display a dialog box.

SQL (script): SQL or Structured Query Language is a special-purpose programming language designed for managing data held in a relational database management system (RDBMS), or for stream processing in a relational data stream management system (RDSMS).

Structured data refers to any data that resides in a fixed field within a record or file. This includes data contained in relational databases and spreadsheets. Structured data first depends on creating a data model, i.e., a model of the types of business data that will be recorded and how they will be stored, processed and accessed. This includes defining what fields of data will be stored and how that data will be stored: data type (numeric, currency, alphabetic, name, date, address) and any restrictions on the data input (number of characters; restricted to certain terms...). Structured data has the advantage of being easily entered, stored, queried and analyzed.

ToolStack refers to a set of tools/softwares needed to perform a complex task such that no additional tools/softwares are needed to support this task.

UML, the Unified Modeling Language is a standardized general-purpose modeling language in the field of software engineering. It is a graphical language for visualizing, specifying, constructing, and documenting the artifacts of a software-intensive system.

Unstructured Data (or unstructured information) refers to information that either does not have a pre-defined data model or is not organized in a pre-defined manner. Unstructured information is typically text-heavy, but may contain data such as dates, numbers, and facts as well. This results in irregularities and ambiguities that make it difficult to understand using traditional programs as compared to data stored in fielded form in databases or annotated (semantically tagged) in documents.

Web service: is defined by the World Wide Web Consortium (W3C - https://www.w3.org/) as 'a software system designed to support interoperable machine-to-machine interaction over a network'. Several types of web services are used by the EU-CRMKDKP such as Web Feature Services (WFS) allowing the transfer of data, and Web Map Services (WMS) allowing the visualization of maps.

WEEE: Waste Electrical and Electronic Equipment (secondary resources).
1 Primary and secondary Mineral Resources data model evolution

1.1 The INSPIRE Directive in the framework of the EU legislation related to Mineral Resources

In the INSPIRE Directive, the Mineral Resources theme is defined as “Mineral resources including metal ores, industrial minerals, etc., where relevant including depth/height information on the extent of the resource”.

To specify in 2010 the scope of Data Specifications on Mineral Resources for INSPIRE (see INSPIRE Data Specifications on Mineral Resources – Technical Guidelines, 2013), reference material has been analysed, and particularly:

- two legal texts providing requirements for the data specification:
  - The EU Raw Materials Initiative;
  - The Management of waste from extractive industries;
- the standard data model EarthResourceML (http://www.earthresourceml.org/) for Mineral Resources;
- the work done on raw materials in the frame of EU-FP7 and EU-CIP-PSP projects such as ProMine and EuroGeosource, respectively accessible at:
  - http://gtkdata.gtk.fi/promine/default.html

The EU Raw Materials Initiative (2008)

In this document, the Commission notices that there has been no integrated policy response at EU level up to now to ensure that it has sufficient access to raw materials at fair and undistorted prices. It is proposed that the EU should agree on an integrated raw materials strategy. Such a strategy should be based on the following 3 pillars:

- ensure access to raw materials from international markets under the same conditions as other industrial competitors;
- set the right framework conditions within the EU in order to foster sustainable supply of raw materials from European sources;
- boost overall resource efficiency and promote recycling to reduce the EU’s consumption of primary raw materials and decrease the relative import dependence.

Two points are of particular interest for INSPIRE:

- The sustainable supply of raw materials based in the EU requires that the knowledge base of mineral deposits within the EU will be improved. In addition, the long term access to these deposits should be taken into account in land use planning.
- The Commission recommends better networking between the national geological surveys to facilitate the exchange of information and improve the interoperability of data and their dissemination, with particular attention to the needs of SMEs.

Two other points are also mentioned:

- Any land use policy for minerals must utilise a robust digital geological knowledge base ensuring fair and equal consideration of all potential uses of land including the eventual extraction of raw materials.

- To improve the knowledge base of mineral deposits in the EU, the need for harmonised EU level data sets stands out.

**The Management of waste from extractive industries (Directive 2006/21/EC)**

One of the properties the waste characterisation shall include, where appropriate and in accordance with the category of the waste facility, is the description of expected physical and chemical characteristics of the waste to be deposited in the short and the long term, with particular reference to its stability under surface atmospheric/meteorological conditions, taking account of the type of mineral or minerals to be extracted and the nature of any overburden and/or gangue minerals that will be displaced in the course of the extractive operations.

A communication of the European Commission (COM(2011) 25 final) entitled 'TACKLING THE CHALLENGES IN COMMODITY MARKETS AND ON RAW MATERIALS' presents an overview of what has been achieved in each of these areas and of the steps which are planned to take the work forward. This document sets out targeted measures to secure and improve access to raw materials for the EU, and it also confirms that the needs expressed above are more than never of actuality.

### 1.2 The INSPIRE data model for Mineral Resources

According to the definition of the INSPIRE Directive (2007/2/EC), the Mineral Resources data theme (see above) 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 was 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. Important attributes such as the nature, genesis, location, extent, mining and distribution of resources reflect the two main identified categories of potential use. These are (Cassard et al., 2014):

- Management of resources and their exploration and exploitation activities: provision of information on inventoried mineral resources as well as on the quantitative assessment of undiscovered mineral resources and the modelling of mineral deposits.
- Environmental impact assessments: mapping and measuring environmental geological parameters for assessing geological material to be used for construction and rehabilitation at the mine site.
The Mineral resources data model (Figure 1) is organized around two major categories of information: (i) the description and location of mines and mining activities (Figure 2) and (ii) the description and location of “Earth Resources” including their classification, estimates of amount, as well as a description of the main market commodities (Figure 3). Energy resources such as coal, oil and gas are excluded from this theme, as they are found in theme "Energy Resources".

Figure 1 - UML class diagram: Overview of the MineralResources application schema (Extract from INSPIRE MR specs, fig. 2).
Figure 2 - INSPIRE UML class diagram: Mining activity core data (Extract from INSPIRE MR specs, fig. 5).
1.3 EarthResourceML as base for the INSPIRE MR data models

1.3.1 The role of EarthResourceML / GeoSciML in the EU-MKDP development

EarthResourceML as well as GeoSciML, are the community developed exchange formats for providing detailed information on Earth resources including waste as a secondary resource. They both have served as the basis for the INSPIRE Geology / Mineral Resource core data models. For the purpose of the European Union Minerals Knowledge Data Platform (the EU-MKDP developed in the frame of the EU-FP7 project Minerals4EU), both community standard data models are used to extend the scope and detail of the INSPIRE core data models to address additional requirements mainly from the EU Raw Materials Initiative and the Mining Waste Directive or other EU activities. The proposed extended data model is presented in a simplified UML version in Figure 4.
1.3.2 Mineral Resource data model extension

In order to provide an extensive description of rock (Earth material) and mineral materials, the MineralResourcesExtension application schema was developed using the EarthMaterial class from GeoSciML (community extensive geological data model, http://www.cgi-iugs.org/tech_collaboration/geosciml.html). Figure 5Error! Source du renvoi introuvable. illustrates the use of EarthMaterial in the application schema. The integrated extension EarthResourceML makes use of the existing GeoSciML data standard for describing geological materials associated with mineral deposits. With this concept, original observations (e.g., chemical parameter upon which the interpretation was made) can be delivered using the GeoSciML and the ISO 19156 Observations & Measurements standard. It is also underpinned by established OGC and ISO standards, including Web Feature Service (WFS – ISO 19142), Geography Markup Language (GML – ISO 19136), and SWE Common (see https://www.opengeospatial.org/standards/swes and https://www.opengeospatial.org/standards/swecommon).
1.3.3 Mining waste data model extension

The requirement for this extension comes from the Mining Waste directive as well as from the Raw Material Initiative where the need for 1) the location of old mining waste sites, 2) the assessment of the waste material for the mineral/energy resource potential, and 3) the environmental risk assessment of the waste, is clearly stated. These requirements were analyzed and the model extension was proposed to provide the harmonized structure for the necessary information that also covers the type of a mined product, its name, size and grade (Figure 6).
1.4 The controlled vocabularies for the EU-MKDP

To facilitate semantic interoperability, the use of controlled vocabularies is embedded in the EU-MKDP data model. The resulting set of code lists and their values is based on the INSPIRE Core Data Model for Mineral Resources. For the additional vocabulary – not covered by INSPIRE - several interoperability activities and project results have been evaluated. This included mainly:

- EarthResourceML v.2.0;
- IUGS/CGI\(^3\) Geoscience Terminology Working Group (GTWG) recommendations;
- results of the EU-CIP-PSP EuroGeoSource project;
- results of the EU-FP7 ProMine project;
- the Commission Decision (2000/532/EC) related to hazardous waste;
- alignments with the EU-FP7 EURare project.

Taking into account the global aspect of mineral resources (business, protection, scarcity, etc.) the most important activity is the IUGS-\(\text{CGI}\) work on the EarthResourceML v.2.0 exchange data model. The latest development of the mineral resource terminology has also included the requirements from the past and ongoing EU projects (e.g., EURare). Currently the EarthResourceML v.2.0 model defines 24 code lists (see: [http://www.earthresourceml.org/](http://www.earthresourceml.org/)).

\(^3\) International Union of Geological Sciences (IUGS), Commission for the Management and Application of Geoscience Information (CGI).

[http://www.cgi-iugs.org/tech_collaboration/geoscience_terminology_working_group.html](http://www.cgi-iugs.org/tech_collaboration/geoscience_terminology_working_group.html)
For the EU-MKDP, the EarthResourceML v.2.0 code lists were used to extend, and partially update the core set of 14 INSPIRE code lists.

In addition, the final overview of the EU-MKDP code lists (Table 1) covers also the mining waste terminology which is based on the Commission decision (2000/532/EC) on hazardous waste.

<table>
<thead>
<tr>
<th>EU-MKDP controlled vocabularies</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>ClassificationMethodUsedValue</td>
<td>INSPIRE/EarthResourceML</td>
</tr>
<tr>
<td>CommodityCodeValue</td>
<td>INSPIRE/EarthResourceML</td>
</tr>
<tr>
<td>EndusePotentialValue</td>
<td>INSPIRE/EarthResourceML</td>
</tr>
<tr>
<td>ExplorationActivityTypeValue</td>
<td>INSPIRE/EarthResourceML</td>
</tr>
<tr>
<td>ExplorationResultValue</td>
<td>INSPIRE/EarthResourceML</td>
</tr>
<tr>
<td>ImportanceValue</td>
<td>INSPIRE/EarthResourceML</td>
</tr>
<tr>
<td>MineStatusValue</td>
<td>INSPIRE/EarthResourceML</td>
</tr>
<tr>
<td>MineralDepositGroupValue</td>
<td>INSPIRE/EarthResourceML</td>
</tr>
<tr>
<td>MineralDepositTypeValue</td>
<td>INSPIRE/EarthResourceML</td>
</tr>
<tr>
<td>MineralOccurrenceTypeValue</td>
<td>INSPIRE/EarthResourceML</td>
</tr>
<tr>
<td>MiningActivityTypeValue</td>
<td>INSPIRE/EarthResourceML</td>
</tr>
<tr>
<td>ProcessingActivityTypeValue</td>
<td>INSPIRE/EarthResourceML</td>
</tr>
<tr>
<td>ReserveCategoryValue</td>
<td>INSPIRE/EarthResourceML</td>
</tr>
<tr>
<td>ResourceCategoryValue</td>
<td>INSPIRE/EarthResourceML</td>
</tr>
<tr>
<td>EarthResourceMaterialRoleValue</td>
<td>EarthResourceML</td>
</tr>
<tr>
<td>EnvironmentalImpactValue</td>
<td>EarthResourceML</td>
</tr>
<tr>
<td>MiningWasteTypeValue</td>
<td>Commission Decision (2000/532/EC)</td>
</tr>
<tr>
<td>ProductValue</td>
<td>EarthResourceML/Census (<a href="http://www.census.gov/prod/ec02/02numlist/212.pdf">http://www.census.gov/prod/ec02/02numlist/212.pdf</a>)</td>
</tr>
<tr>
<td>RawMaterialRoleValue</td>
<td>EarthResourceML</td>
</tr>
<tr>
<td>WasteStorageTypeValue</td>
<td>EarthResourceML</td>
</tr>
<tr>
<td>AlterationTypeTerm</td>
<td>GeoSciML</td>
</tr>
<tr>
<td>MineralNameTerm</td>
<td>IMA (<a href="http://www.ima-mineralogy.org/">http://www.ima-mineralogy.org/</a>)</td>
</tr>
<tr>
<td>LithologyValue</td>
<td>INSPIRE/GeoSciML</td>
</tr>
<tr>
<td>GeochronologicEraValue</td>
<td>INSPIRE/GeoSciML</td>
</tr>
<tr>
<td>EventProcessValue</td>
<td>INSPIRE/GeoSciML</td>
</tr>
<tr>
<td>PhysicalPropertyTerm</td>
<td>GeoSciML</td>
</tr>
<tr>
<td>Composition category</td>
<td>GeoSciML</td>
</tr>
<tr>
<td>Genetic category</td>
<td>GeoSciML</td>
</tr>
<tr>
<td>MappingFrameValue</td>
<td>INSPIRE</td>
</tr>
</tbody>
</table>

Table 1 – Final overview of the EU-MKDP controlled vocabularies and their sources (Extract from Minerals4EU D5.2, table1).

At the end of the Minerals4EU project, the consortium has prepared an official change request to the INSPIRE Maintenance and Implementation Group (MIG), based on the gained implementation experience of all project partners (more than 24 European Member States), to
update the currently legally binding INSPIRE mineral resources related code lists. Proposed changes and additions were included in the INSPIRE code list register marked as submitted. Such statute of the code lists and value remained until the endorsement by the MIG. Then the status changed either to superseded, retired or valid. The list of formal statuses is according the ISO 19135 norm and is presented in Table 2.

<table>
<thead>
<tr>
<th>Label</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invalid</td>
<td>A decision has been made that a previously valid register item contains a substantial error and is invalid, and will normally have been replaced by a corrected item.</td>
</tr>
<tr>
<td>Retired</td>
<td>A decision has been made that the item is no longer recommended for use. It has not been superseded by another item.</td>
</tr>
<tr>
<td>Submitted</td>
<td>The item has been entered into the register, but the control body has not accepted the proposal to add it.</td>
</tr>
<tr>
<td>Superseded</td>
<td>The item has been superseded by another item and is no longer recommended for use.</td>
</tr>
<tr>
<td>Valid</td>
<td>The item has been accepted, is recommended for use, and has not been superseded or retired.</td>
</tr>
</tbody>
</table>

Table 2 - Status of the items in the INSPIRE code list register (Extract from Minerals4EU D5.2, table 2).

The code lists are available in the INSPIRE Registry (http://inspire.ec.europa.eu/registry/) created and maintained by the EC for all the topics covered by INSPIRE. A complete synthesis of the status of the different code lists, and the detailed comparison of the code list values of INSPIRE Mineral Resources and CGI vocabulary is presented in Schubert et al. (2014). See also Appendix 1.

1.5 The ProSUM input in the evolution of the MR data model

1.5.1 Rationale

The needs expressed in the ProSUM project made it necessary to create new Feature and datatype classes as they were incompatible with v 0.7.0.2 (May 2015) of the M4EU DB model. The ProSUM mining waste extension extends this M4EU DB model v0.7.0.2 without changing the former table names. However new attributes, constraints and new codes in code lists together with new tables are introduced in the ProSUM mining waste extension which currently has version v1.1.2.

The Minerals4EU data model (noted ‘M4EU’), which extends the INSPIRE model, is based on EarthResourceML version 2.0 (ERML) and allows associating mining waste information with specific minerals deposits. However, it only allows storing information about the amount, grade and density of one waste material. It does not include data on the presence, types and amounts of critical raw materials (CRM commodities) which is necessary in the ProSUM project (Cassard et al., 2017a).
The MiningWaste feature is therefore linked to a new MiningWasteMeasure concept which is quite similar to OreMeasure (used for primary resources) but adapted to the specifics of mining waste. For example a **WasteDimension** type has been created to handle density, volume and area of the MiningWasteMeasure, and the **miningWasteClassificationMethodUsed**, the **proposedExtractionMethod**, the **amountEstimationMethodUsed**, and the **compositionEstimationMethodUsed** attributes have been added. This new WasteMeasure is linked to the CommodityMeasure concept used for Earth Resources, similar to OreMeasure. In addition to this, a correction has been made to the link between CommodityMeasure and Commodity (cardinality was 1 to many, but is reduced to 1).

In the ERML V2.0 data model, a MiningWaste feature was linked to a MiningActivity feature. In the modified version\(^4\) MiningWaste is linked to the Activity Feature (Figure 7). Both MiningActivity and ProcessingTransformationActivity (see below) are derived from Activity. MiningActivity itself can be associated to 0 or 1 MineralOccurrence, whereas there can be several MiningActivities associated with a MineralOccurrence and each MiningActivity can generate one or many MiningWastes. A MiningWaste is linked to a MiningActivity but can be independent of a MineralOccurrence if no information about a MineralOccurrence is known. The location of a MiningWaste is represented by the geometry property of the MiningFeatureOccurrence that is linked to the MiningWaste. It is not dependent on other features.

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\(^4\) All these modifications/improvements proposed in the frame of ProSUM have been submitted to the CGI and will be integrated in the upcoming ERML v.3 version. The v.3 pre-version is accessible at: https://www.seegrid.csiro.au/subversion/xmml/GGIC/trunk/doc/ERML_3_Doc/index.htm
In addition to these changes a new concept `ProcessingTransformationPlant` has been introduced in the model (Figure 8). It represents the plant that processes the mined material coming from one or more mines, and/or the smelter that transforms mine products which can be as simple as a (very) rich ore or a concentrate. This concept allows a more detailed description of how mined material was processed and how this relates to wastes (tailings). This description includes downstream activities like smelting and captures specific wastes such as slags and fly ashes. It also makes it easier to extend the data model to primary transformation industries in general, notably those related to industrial rocks. A `ProcessingTransformationPlant` has one or many `ProcessingTransformationActivities`. The `ProcessingTransformationActivity` is an extension of the Activity Feature (as described before) and represents a period in which mined material was processed in a specific way. The `ProcessingTransformationActivity` consumes either MinedMaterial that is extracted from the mine or Products of a mining activity (e.g., a concentrate). This new concept is explained in Figure 9.
Figure 9 - The ProcessingTransformationActivity Feature (Extract from ProSUM T5.3.1, part of D5.7, fig. 12).

Figure 10 summarizes the modifications brought to the M4EU data model. These modifications are described in detail in section 1.5.2 below.
1.5.2 Detailed description of the changes brought to the M4EU data model

Figure 11 shows the original M4EU database model version 0.7.0.2, while Figure 12 shows the tables that were added to the model. The ProSUMMiningWaste table and related tables allow a more detailed description of the amount of waste. In addition, the type and grade of commodities can be defined (see Figure 13). Multiple activity types can be associated to the ProSUMMiningWaste table, where only one activity type was available in v7.0.2 version (Figure 14). To describe the processing of products and mining waste, two new main tables were introduced: ProcessingTransformationPlant and ProcessingTransformationActivity, these were not present in v7.0.2 (Figure 15).
Figure 11 - The M4EU and EURare DB model version 0.7.0.2. A PDF version can be found [here](#) (Extract from ProSUM D5.5, fig. 8).
Figure 12 - Overview of tables added to the M4EU DB model in the context of ProSUM. A PDF version can be found here (Extract from ProSUM D5.5, fig. 9).
Figure 13 - ProSUM mining waste relation to the M4EU DB model. A PDF version can be found here (Extract from ProSUM D5.5, fig. 10).
Figure 14 - ProSUM mining activity relation to the M4EU DB model. A PDF version can be found [here](Extract from ProSUM D5.5, fig. 11).
1.5.3 Code lists

The following code lists (Table 3) were updated or created in the context of ProSUM. Code list values are given in Appendix 2. Heijboer et al., (2017) give in the annex 4 of ProSUM Deliverable D5.5 an overview of all the existing code lists and their values that are associated with the extended M4EU database.

<table>
<thead>
<tr>
<th>Code list name</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 AmountEstimationMethodType</td>
<td>ProSUM</td>
</tr>
<tr>
<td>2 CompositionEstimationMethodType</td>
<td>ProSUM</td>
</tr>
<tr>
<td>3 ProcessingActivityTypeType</td>
<td>ProSUM merged with M4EU</td>
</tr>
<tr>
<td>4 ProcessingTransformationPlantStatusType</td>
<td>ProSUM</td>
</tr>
<tr>
<td>5 WasteTypeType</td>
<td>ProSUM merged with M4EU</td>
</tr>
</tbody>
</table>

Table 3 - List of code lists and sources for the ProSUM mining waste extension (Extract from ProSUM D5.5, table 14). Note that code lists ProcessingActivityType and MiningWasteType (N° 3 & 5) are currently (27/02/2019) being reworked.
1.5.4 Other improvements

Although not strictly linked to ProSUM, but taking advantage of this run of modifications to be pushed in the CGI validation process, several ‘minor’ corrections and improvements have been proposed for the INSPIRE/M4EU data model, that have already been implemented in the pre-version 3 of ERML. They are shown in red in Figure 16. See also:


![Figure 16 - Improvement of the INSPIRE MR / ERML data model.](image)

Essentially, it is about adding a new dataType ‘ProductCommodityMeasure’ for managing grades, a new specialization of ‘OreMeasure’ for ‘TotalProduction’ and to correct some cardinalities and remove ‘range’ from Quantity in some cases. TotalProduction will also be added\(^5\) to the dataType ‘Endowment’ (with reserves and resources), endowment being the global ‘metallogenic budget’ of a mineral/ore deposit: following the INSPIRE definition, it includes cumulated past production(s) + reserves + resources (not including reserves).

Regarding the reference to the classification of the UNFC (UNFClassification dataType and associated code list), this point is dealt with in section 4.2.

\(^5\) Currently being done (April-May, 2019).
2 The MR data model current implementation and the possibility to harvest aggregated datasets

2.1 Spatial coverage, data quality and completeness

2.1.1 Gaps in the data spatial coverage

Gaps in the data spatial coverage are a major issue as they prevent to develop other fundamental applications like pan-European statistical studies which would be so useful for aid-decision making.

Data coverage problems are all the more interesting that they can discredit some projects (e.g., Minerals4EU), sometimes considered by certain ‘observers’ as having partially failed, whereas they have in reality totally reached their technical goals, the result being obliterated notably (but not only) by partners not serving their data for various reasons which are reviewed below.

Table 4 gives the result of the monthly harvesting performed in the frame of the EU-MKDP (Minerals4EU Knowledge Data Platform) in December 2018.
Table 4 - EU-MKDP: harvesting results for December 2018, established by Andrej Vihtelič from GeoZS.

The examination of this table\(^6\) shows that (i) only 23 countries are serving their data and (ii) the number or density of data served is highly variable and not directly related to the mineral potential of the country.

Availability of data is not the same for all countries: some have better data collection systems than others; some have better data for metallic minerals than industrial minerals; some have better data for certain mineral/ore deposit types (especially those that are most common in the metallogenic province and the country), etc.

For some countries, data provision may be split between multiple data providers rather than one single organization. Some data providers do not have the data as it belongs, for example, to sub-national level administrations (e.g., Länder in Germany), or they are not allowed to disseminate information related to single metallic deposits, such as Slovenia which serves only data related to industrial rocks (aggregate, sand, gravels) single deposits. In this particular case, information related to metallic deposits is only served after aggregation at national level.

Not all the EuroGeoSurveys members, although invited to join the Minerals4EU consortium, have taken part in the project. This can be due to different reasons, such as a lack of staff to implement the project, a lack of financial resources, Survey or government decision to give priority to other topics, or administrative constraints. In the specific cases of Latvia and Bulgaria, they had both left the membership of EuroGeoSurveys in 2010 and 2013 respectively due to severe financial and human resources constraints and disruption of the functions of Geological Survey by the respective government. The law re-establishing the functions of Geological Survey in Bulgaria was still pending approval at the national Parliament in 2015. Latvia, re-joined EuroGeoSurveys in March 2015, therefore when Minerals4EU was already close to a conclusion. Nevertheless, although it was not possible to include Latvia, Estonia, Lithuania and Luxemburg as effective project partners, they responded positively to the request to provide data on their national resources/reserves, and the information they provided has been included in the European e-Minerals Yearbook (L. Demichelli [former EGS General Secretary], pers. comm., 2015).

The situation is slowly going in the right direction. Italy was involved in Minerals4EU, but did not have a mineral resources database. Construction of this database is now finalized, and deposit data have been made available in the form of portrayals. The next step is to make this dataset harvestable. Ukraine made many efforts to join the Consortium, and is currently serving its data (see Figure 17 below). Finally, there are indications that BGR will be allowed to gather data for Germany.

Additional obstacles for sharing mineral resources data can be related to the business model of a geological survey. For instance, in the UK, BGS is selling data related to individual metallic deposits. Because of this, UK provides essentially data related to industrial rocks in the form of large polygons.

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\(^6\) The columns represent the different countries serving their data and the rows represent the different ‘fields’ of the database. One can easily see that a lot of cells are empty and that there are huge differences between countries, that can be related to a lack of data, and/or also to the implementation of the WFS.
Condensed view extracted from the Minerals4EU Map viewer (http://minerals4eu.brgm-rec.fr/minerals4EU). Note that some countries having a low data density may appear as empty.

Figure 17 - Insight about the spatial coverage of the Minerals4EU dataset for mineral occurrences.

These obstacles (technical, budget, political, business model) cause gaps in the spatial coverage and preclude performing pan-European syntheses and even when there is a spatial coverage it does not mean that the data is detailed, accurate or useful, notably when this coverage is provided essentially via lithology polygons. As underlined in section 5.1, there is here, at least for some countries where data exists, a problem of respect, adaptation and application of the European legislation regarding data diffusion.

2.1.2 Data quality

Data quality covers several aspects from completeness, accuracy, attached references and metadata… In practice, it is specially the economical part (production, reserves and resources) of mineral resources data that needs to have a good quality:
- The available spatial data are often not linked to production, reserves or resource data, with the consequence that collecting data by individual deposit rarely results in complete data at national level.
- Often, there is no information on the quality of the data (attached references or metadata describing the data, how it was produced, from where it comes…).
- In many countries, there is no obligation to follow internationally recognized systems of reporting (e.g., JORC, PERC, NI43-101) for quantitative data on resources and reserves. Indeed, no single definitions of the terms ‘resources’ and ‘reserves’ are used consistently across the countries of Europe.
- For some commodities being considered as “sensitive”, the information may be missing as a whole, e.g., uranium.

**IMPLEMENTING THE MINERALS4EU AND PROSUM KNOWLEDGE DATA PLATFORMS: THE DIFFERENT STEPS**

![Diagram of the implementation process]

*Figure 18 - Implementation of Minerals4EU and ProSUM Knowledge Data Platforms: the different stages from the UML data model to the setup of a Web feature service (WFS).*

The above intrinsic quality defaults may be further amplified by a more or less rigorous implementation of the data model, when doing the mapping and building the WFS (Figure 18).

A statistical review of the content of the EU-MKDP Central Diffusion Database allows getting an insight on which data is most often missing: an internal survey (Agnès Tellez-Arenas [BRGM], pers. comm., 2017) shows for example that on 102,845 mineral occurrences records, only 13,390 have an OreMeasure, 7,596 have Resources and 4,981 Reserves. Only 15,812 have
a CommodityMeasure and, on this number there are only 1,052 for which Amount is not empty, 2,019 for which CutOffGrade is not empty and 614 for which Grade is not empty (Figure 19). Regarding now the 25,986 Mines, only 8,848 are linked with a MiningActivity, and Product (e.g., a concentrate) is only present 199 times, but Grade is never provided (Figure 20).

This short description shows that there is still a huge effort to do in order to deliver datasets that can really be used for Knowledge ‘production’. It is obviously difficult to distinguish what is
directly attributable to a poor implementation of the data model, and if it is perfectly understandable that all this information is not available for all mineralized 'objects' (e.g., showings, small occurrences, new projects...), it appears at least that there is an information deficit for larger objects. This is perhaps amplified by the fact that most attributes are 'voidable' in the data model, which means that in cases where no information is available, the attribute can be left nil\(^7\). This does not encourage data providers to search, exhume, validate and publish existing data not yet used ...

Note that in respect to secondary mineral resources (SRMs), the problems of data quality originate from the same fundamental reasons as for the PRMs, but are further complicated by:

- Subdivision into several waste categories: mining waste, WEEE, ELV and BATT, to name only those targeted by H2020 ProSUM and ORAMA projects.
- SRMs field often lacks the equivalent of national Geological Surveys holding the responsibility for national data gathering and management.
- This thematic domain was not covered by the INSPIRE Directive, hence the lack of an existing data model, and the need to develop harmonizing procedures from the scratch. ORAMA will build on the ProSUM Unified data model which is the first attempt organizing and managing datasets related to WEEE, ELV and BATT composition and products, stocks and flows, with a particular attention to CRM (see above).

### 2.2 Harvesting aggregated datasets at national level

#### 2.2.1 Rationale

The European Commission needs reliable statistics of commodity reserves and resources at a country level to create reliable mineral resource policies and forecasts. The Minerals4EU database can store and currently has commodity reserve and resource data of individual/single mineral/ore deposits of some of the European countries together with information about the spatial representation of mineral potential and applications for mineral/ore deposit geology and metallogeny. However, to accurately aggregate or sum up every deposit that contains a certain commodity in a certain country the following conditions should be met:

1. All EU countries should provide mineral/ore deposit data to the Minerals4EU database.

\(^7\) Note that data for all attributes in the INSPIRE data specification should be provided and a nil value used only where the date are unavailable. ‘Voidable’ does not mean ‘optional’ in INSPIRE. Where no value is provided for a voidable attribute then a nilReason must be provided. One of the nilReasons defined in the INSPIRE VoidReasonValue codelist should be used:

- **unpopulated** - The characteristic is not part of the dataset maintained by the data provider. However, the characteristic may exist in the real world.
- **unknown** - The correct value for the specific spatial object is not known to, and not computable by, the data provider. However, a correct value may exist.
- **withheld** - The characteristic may exist, but it is confidential and not divulged by the data provider.
2. Mineral resources data of small to large deposits should contain accurate and up-to-date reserve and resource data.

3. Values for reserves and resources should be compiled according to a harmonized reporting system (e.g., JORC, PERC, NI43-101…).

The current dataset in the Minerals4EU database does not meet these 3 conditions for various reasons.

Alternatively, the European Commission can use national level mineral resource statistics that have been compiled and processed by national experts based on official, exhaustive and controlled data. The aggregate data is however generally still not compiled according to a harmonized European reporting system, so condition 3 above is still not met. Both deposit specific and aggregated data should be reported using a harmonized reporting system (e.g., JORC, PERC, NI43-101…) so that it becomes easier for policy makers to compare mineral reserves data from different countries.

When the e-Minerals Yearbook was developed in the frame of Minerals4EU, BGS stood for compiling the data, which subsequently was made available on a Web platform developed by BRGM. Due to budgetary, time and organizational reasons, the option to set up a system similar to Minerals4EU where each country should provide their own national statistical data to a centralized database was not further explored. Since then the e-Minerals Yearbook has not been updated. For it to be useful now and in the future, it needs to be updated each year with data from every EU country. It is estimated that maintenance and update costs are several hundred thousand euros or more.

To mitigate these maintenance and update problems it is proposed in ORAMA to create a system that partially automates creating and updating the e-Minerals Yearbook (e-MYB) with aggregated data, which will be tested in the frame of ORAMA (WP3, T3.2). It is the intention to put this system into production for some Member States within the frame of the new GeoERA Mintell4EU project and if successful, it will be progressively extended to all the Member States.

Once this dataset is available it allows direct comparison with aggregated Minerals4EU data which would then show where gaps or large differences exist between reported national level reserve and resource data for a country and calculated aggregated values based on single deposits data.

2.2.2 e-Minerals Yearbook information and proposed encodings:

The previous e-Minerals Yearbook contained the following types of information (Table 5, column 1):
<table>
<thead>
<tr>
<th><strong>Reserve / Resource</strong></th>
<th>Minerals4EU: MineralProducing Country model</th>
<th>Observations and Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>o Country</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Group commodity</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Commodity</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Sub-commodity</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Classification System (JORC, NI43-101, UNFC…)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Classification sub-categories</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Quantity + uom</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Note/Comment</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td><strong>Production</strong></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>o Country</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Group commodity</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Commodity</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Sub-commodity</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Quantity + uom</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Note/Comment</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td><strong>Import / Export</strong></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>o Country</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>o Group commodity</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>o Commodity</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>o Sub-commodity</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>o Quantity + uom</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>o Note/Comment</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td><strong>Exploration</strong></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>o Country</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Group commodity</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Commodity</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Sub-commodity</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>o Number of active licences</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>o Number of licences issued</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>o Number of companies exploring</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>o The area covered by exploration licences</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>o The amount of expenditure incurred</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>o Note/Comment</td>
<td>-</td>
<td>X</td>
</tr>
</tbody>
</table>
Two methods of encoding this type of information have been identified: where each particular type of information gets its own named xml element or attribute (ERML method) or where each type of information is encoded in an observation record, as the value of a parameter, result or observation related element (Observations and Measurements, O&M).

2.2.3 ERML / ERML-Lite and INSPIRE models

Currently the (ERML) and ERML-Lite and the INSPIRE Mineral Resources models have different classes for encoding information about single mineral resources. These models would then need to be extended to encode country level information. In Minerals4EU the MineralProducingCountry feature class was adapted from the EuroGeoSource project and fitted into the Minerals4EU model (Figure 21).
Figure 21 - Conceptual UML Class model showing the MineralProducingCountry feature class with classes that are related to it. Yellow classes were introduced in the Minerals4EU extension model, classes in red are taken from INSPIRE extension schema and classes in beige are taken from the INSPIRE Mineral Resources core model. It can be seen that the INSPIRE Mineral Resources schema can easily be adapted to include country-wide aggregated mineral resource data.
This feature contains the following information:

- MineralProducingCountry
  - Year
  - Country
  - Commodity
    - Name
    - Rank
    - importance
  - Reserve
    - Classification system
    - category
    - Amount + uom
    - Commodity grade
  - Resource
    - Classification system
    - category
    - Amount + uom
    - Commodity grade
  - Endowment
    - Classification system
    - category
    - Amount + uom
    - Commodity grade
  - UNFC
    - Classification system
    - category
    - Amount + uom
    - Commodity grade
  - MiningActivity
    - Ore production
    - Type
    - Processingtype
      - Product
        - Amount
        - Type

It contains many of the types of information that are available for a single MineralOccurrence feature (Commodity, Reserve, Resource, etc.) but does not have the information that only relates to a specific mineral occurrence (e.g., the geological information). Figure 22 and Figure 23 provide an example of this feature encoded in xml markup.
Figure 22: MineralProducingCountry exchange format as created in Minerals4EU.

The resourceExtraction element that is not opened in Figure 22 contains the elements shown in Figure 23.
This example is available in the following link and contains about the same data as in the O&M model below. One could use the MineralProducingCountry feature as a basis to build an improved model, which could be standardized within the framework of ERML and/or create a possible simplification of it within the context of ERML-Lite. The link between MineralProducingCountry and MiningActivity may need to be removed and a direct link to Product should be made as there will be little interest in knowing the amount of ore produced or the processes involved in creating the product. In addition a datatype related to exploration should be introduced.
2.2.4 The O&M approach

Instead of extending ERML or ERML-Lite, an alternative solution could be using O&M\(^8\) (ISO 19156, Observations and Measurements).

O&M is part of the INSPIRE Foundation Schemas (Figure 24). It is a generic and powerful data model recommended for use wherever appropriate. It is extensively used in themes where data collection is a critical issue (Environmental Facilities, Soil, Oceanographic Geographical Features, Sea Regions, Atmospheric Conditions and Meteorological Geographical Features, Geology/Geophysics). O&M provides a generic approach to describe any kind of observation including instrumental measurements, data processing and computer simulations. It is an excellent way of linking observations and domain features (exploration details).

![Figure 24 - Observation and Measurements Data Model.](image)

To harmonize the application of the ISO19156 standard in INSPIRE, the BaseModels/Observation section has been added to the Generic Conceptual Model. It contains the specialisation of OM_Process, and a data model for ObservableProperty.

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\(^8\) See e.g.:  
[http://www.opengeospatial.org/standards/om](http://www.opengeospatial.org/standards/om),  
2.2.4.1 The e-Minerals Yearbook use case

A Yearbook record can be considered as the final result of a complex observation that has the following main properties:

- **featureOfInterest**: MineralProducingCountry
- **procedure**: OM_Process describing mining data aggregation
- **parameter**: search terms as process parameters
- **observedProperty**: a collection of observable properties (statistical properties)
- **result**: Yearbook statistical data record

**feature of interest (FOI)**: It is the target of the observation. The observation gives estimates for the observed properties of the FOI. In the Yearbook use case it is a mineral producing country.

**procedure**: It is an action or a joint series of actions that produces statistical data. For example, a manual or federated database search followed by statistical processing. An instance of OM_Process contains all that is known about the procedure: a reference to some documentation about the actions, responsible parties, a list of process parameters, etc.

Yearbook properties proposed in the previous section have different roles in the observation. Taking roles into account they may be separated into two groups:

**parameter**: These are qualifiers that may be used in queries as input or filter parameters.

- country
- year
- commodity
- classificationSystem
- classificationSubCategory

Parameter names must be dictionary items from the [http://inspire.ec.europa.eu/codelist/ProcessParameterNameValue](http://inspire.ec.europa.eu/codelist/ProcessParameterNameValue) code list.

**observed property**: These values are characterized as statistical types in the previous section. They may be calculated from query results by aggregating individual data items, or added manually.

- production
- reserve
- resource
- exploration/numberOfActiveLicences
- exploration/numberOfLicencesIssued
- exploration/numberOfCompaniesExploring
- exploration/areaCoveredByExplorationLicences
- exploration/amountOfExpenditureIncurred
- trade/import
- trade/export

An instance of CompositeObservableProperty may contain the above properties together with their uom. Names must be dictionary items from the http://inspire.ec.europa.eu/codelist/PhenomenonTypeValue code list.

Both code lists are empty and subject to future extensions. Extending the two dictionaries with the above properties is the only action needed to be able to use the existing schemas for creating an INSPIRE compliant e-Minerals Yearbooks.

► result: Data record containing the statistical data values to be published.

2.2.4.2 The benefits of using O&M

The benefits of using O&M are:

- Data model is available out of the box.
- No need to extend ERML-Lite.
- Flexible setup, only dictionaries must be used/extended.
- Properties can be defined in standard OM_Process and CompositeObservableProperty records. If new properties are required later, only these records must be changed, no modification of the data model is required.
- Data could be available by standard services (WFS, SOS).

2.2.4.3 The drawbacks of using O&M

The drawbacks of using O&M are:

- O&M must be implemented, but this should be done for EGDI in GeoERA anyway.
- O&M element names such as ObservationProperty, FeatureOfInterest are more abstract and not always directly clear to every developer or user. However clear examples such as below can help to communicate the intent of the model and most users.

2.2.4.4 Example of using O&M

The following illustrative example contains a e-Minerals YearBook record from 2014 (Table 6).
Table 6 - Example Observation record with aggregated statistical data.

The procedure referenced as orama:PRC_MiningDataAggregation describes the process and the required parameters. The same OM_Process record can be referenced by many Observations carried out the same way (Table 7).

Table 7 - OM_Process record describing the Aggregation procedure.
Observed properties are explained in a CompositObservableProperty record (Table 8). The same record can be referenced by a large number of Observations containing the same statistical parameters.

<table>
<thead>
<tr>
<th>label</th>
<th>AggregatedMineralStatistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>11</td>
</tr>
<tr>
<td>basePhenomenon</td>
<td></td>
</tr>
<tr>
<td>component</td>
<td></td>
</tr>
<tr>
<td>component</td>
<td></td>
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<td>component</td>
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<tr>
<td>component</td>
<td></td>
</tr>
<tr>
<td>component</td>
<td></td>
</tr>
</tbody>
</table>

Table 8 - CompositObservableProperty record describing statistical parameters.

Downloading a Yearbook of 2014 can be an SOS query action requesting the results of Observations with processParameter country=UK and year=2014.

XML examples are given in Appendix 3.

2.2.5 Chosen solution

Finally, it appeared to the group of experts attending the Ljubljana Work Package 3 meeting (November 7th, 2018), that it was probably more appropriate to use an ERML-type model (in particular because the data model is already known and used by data providers). A separate / specific ERML-based schema, as well as the necessary additions (see Table 5 above), will be developed and used to design a dedicated DB that will handle aggregated data collected for the e-MYB.

2.3 Data flow of aggregated mineral reserve, resource, exploration and trade data

Figure 25 gives a schematic overview of the flow of data and which procedures will take place before the data will become visible on the new e-Minerals Yearbook portal.
2.3.1 Reserve, resource and exploration data providers

For the harvesting of reserve and resource data, some partners will provide a dataset that is as up-to-date as is currently possible within the given project constraints using a test setup of the data provider system. Each provider should execute the necessary scripts for generating a database management system and working WFS setup before storing their data in this database. These scripts allow quick implementation of a standardized database model (DM) based on a standardized conceptual standard (UML). Once these are implemented and each country’s data is stored by the data providers, this can be harvested by a central harvesting database (which implements the same database model).

The chosen exchange format (and database model) will only contain production, resources, reserves and exploration data. Trade (i.e., import and export) data will currently not be a part of the standardization as it is purchased by BGS (see Figure 25 above), but as it has to be delivered to the Minerals4EU Diffusion Platform, it will need to be incorporated in the M4EU/ORAMA database model (if this one is reused by BGS to deliver data to BRGM as suggested). For production and trade, the new M4EU/ORAMA e-Minerals Yearbook data model should be able to include the BGS website data content in a simple way.

Figure 25 - The e-Minerals Yearbook feeding data flow.
2.3.2 The harvesting database

A harvesting procedure similar to the Minerals4EU one set up by GeoZS can work with national providers such as Geological Surveys (possibly not all). If other institutions are in charge of gathering this aggregated data at national level then, instead of WFS, Excel portrayals can be used. Their integration into the Harvesting DB (the same DB as for ‘true’ harvested data) would be made under the supervision of GeoZS.

Note regarding production data: ‘If those same Geological Surveys wish to also provide production data the same way [i.e., in addition to and in the same way than resources/reserves/exploration are collected], BGS agreed that it would be sensible to give them that option. The production data part of this will be a ‘trial’ to start with and BGS will continue to collect production data using their usual methods in addition to this’.

2.3.3 Delivery of harvested data to BGS

It is agreed that the best way to proceed is to deliver a dump of the harvesting database to BGS. Such a dump would then contain data related to resources, reserves, exploration and production (if production data is available – see the note above). The dump will be a SQL dump (the content of a SQL dump is a large collection of SQL commands in ASCII). Running the script will recreate the database in the same state as it was when the dump was created (see https://www.monetdb.org/Documentation/UserGuide/DumpRestore).

2.3.4 Storage, control and harmonisation of data by BGS

From the dump, data will follow two different ways:

- Production data will be extracted from the dump and incorporated into the BGS World Mineral Statistics DB and then extracted to feed the BGS website DB.
- Exploration, resource and reserve data would be stored in a BGS’ copy of the GeoZS’ Harvesting database.

 Production data will go through BGS’ usual quality control and standardisation procedures.

 For resources/reserves/exploration it depends on what data are collected. BGS will not be ‘standardising’ (nor ‘harmonising’) resources and reserves data because that needs to be done

---

9 In many countries the resources/reserves/exploration data are not sitting already in a database that can have a ‘web service’ built for it. Excel portrayals, (i.e., Excel templates based on the M4EU/ORAMA e-Minerals Yearbook data model) will have to be fed manually and sent to GeoZS. A more sophisticated procedure can also be envisaged that would require a person to log on to the GeoZS website (with a username and password) and enter their country’s data manually into a Web-based portrayal.
by the Geological Survey that provides them. This is because the harmonising process needs additional information that BGS will not have access to. BGS will however do some quality control work and ensure it is presented in an appropriate way.

### 2.3.5 Transfer of validated/harmonized data to the Diffusion DB at BRGM

- For production & trade data: BGS already delivers production and trade data via its website (and will continue to do so). This step is about how BGS makes that data available to BRGM for the M4EU e-Minerals Yearbook. BRGM have indicated that BGS’ existing ‘web service’ is not suitable. This web services, available at [http://www.bgs.ac.uk/mineralsuk/statistics/wms.cfc?method=searchWMS](http://www.bgs.ac.uk/mineralsuk/statistics/wms.cfc?method=searchWMS), proposes to visualize the data directly on the website or to download them in Excel format (xlsx). This Web service can be used to retrieve in Excel format the data for the production, import and export for a maximum of 10 years from 1970 to 2016 (depending on the commodities). The major problem with this service is the Excel output format which needs to be converted to database format (the use of JSON for example would have made the operation easier) before being used to feed the M4EU e-Minerals Yearbook database, and more problematic, the fact that this service is not designed to retrieve all the data in this way.

In order to bypass this series of problems, the best solution would be to use a Web service based on the M4EU/ORAMA e-Minerals Yearbook data model instead of the BGS website Mineral Statistics service.

- For resources/reserves/exploration data: development of a Web service based on the M4EU/ORAMA e-Minerals Yearbook data model.

### 2.4 Brief summary

A new M4EU/ORAMA e-Minerals Yearbook data model will be created which will include country-wide aggregated mineral resource, reserve, production and trade data. It will be able to incorporate the data available through the BGS website download tools for production and trade (import and export data). The data model will be jointly developed by the ORAMA project partners GEUS, BGS, BRGM, and GeoZS. It will be used (i) to harvest National Providers databases through a Web service, (ii) to build Excel portrayals for countries/institutions not having a working Provider databases and Web service setup (iii) to build the Harvesting database. BGS will receive a dump of this DB and will (i) create of a copy of the GeoZS’ Harvesting DB to store exploration, reserves and resources data, and (ii) extract production data from this DB, which will then be validated and incorporated in the BGS

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10 This was a deliberate policy, but BGS can very probably set up a procedure to bypass this limitation, at least for the ORAMA project.

11 Trade data is not harvested as it is directly provided by BGS. A Trade feature must however be part of the M4EU/ORAMA e-Minerals Yearbook data model, as this DM is planned to be used for delivering validated data including trade to the Diffusion Platform. To have a Trade feature can also be considered as a plus, as this makes the DM more complete.
World Mineral Statistics DB together with production and trade data from other sources. This validated dataset will be provided by BGS to BRGM for the update of the previous version of the interactive e-MYB (Minerals4EU Diffusion Platform, 2015 - http://minerals4eu.brgm-rec.fr/m4eu-yearbook/theme_selection.html) via a Web service based on the M4EU/ORAMA e-Minerals Yearbook data model.
3 WP1 improved datasets implications in terms of MR data model evolution

3.1 Recommendations from WP1 – D1.1

Note: This section is mainly based on recommendations made in D1.1 pages 48, 54-55, and 71.

From the first set of recommendations made by WP1 (D1.1, Bide et al., 2018a), the consequences in terms of INSPIRE data model evolution, i.e., the modifications/improvements to implement in order to manage the optimized datasets, four main topics can be identified, related to:

- Data quality (proven, reliable);
- Uncertainties;
- Calculated commodity content;
- Commodities (names, classification).

The three first topics are already managed by the INSPIRE MR data model, as:

1. it is possible to put a reference in front of each figure, indicating the source, the author and the date…
2. instead of a single value, a range of values can be used for certain figures. However, for certain dataType properties this possibility to enter a range of values has been removed because it leads to an impossibility for a graphic representation or for further statistical calculation: which figure or value to preferably retain? This is for example the case of OreMeasure/ore, CommodityMeasure/commodityAmount, Commodity/cutOffGrade and Commodity Measure/grade, for which single values are needed, the provider having to estimate the best (averaged) value.
3. this is the tonnage of a substance (metal, oxide…) and not of the ore, plus the grade of the ore which are given (e.g., 30 t Au @ 10 g/t, means that 30 tons of gold have been extracted from an ore at 10 g/t Au, the ore quantity being in this case 3 million of tons).

The fourth point is probably the most critical. For example, when comparing the e-Minerals Yearbook and the INSPIRE MR code list for commodities, it appears that both (i) do not put the same meaning behind the word ‘commodity’, the INSPIRE approach being more restrictive, and (ii) often do not use the same names.

There is thus an important work of mapping between the two ‘classifications’. A first attempt done in the frame of the Minerals4EU project will be re-evaluated (see below section 3.3).

3.2 Recommendations from WP1 – D1.2
From the second set of recommendations made by WP1 (D1.2, Bide et al., 2018b), the consequences in terms of INSPIRE data model evolution, i.e., the modifications/improvements to implement in order to manage the optimized datasets, three main topics can be identified:

- To use the UNFC classification;
- To complete EarthResourceDimension for raw materials;
- To take into account raw materials physical properties (e.g., grain size, clarity).

The use of the UNFC classification is already allowed by the ERML v2.0 data model (see section 4 below), based on a specialization of OreMeasure as for Resource, Reserve and Endowment (see Figure 28) and a dedicated code list. An improvement can probably be brought with an automated translation of CRIRSCO codes into UNFC 3-digit codes (the reverse being not possible as CRIRSCO codes are less detailed for exploration projects…).

The INSPIRE MR / ERML data models are more focused on metal substances than on industrial rocks and minerals. Some key parameters such as volume (m$^3$), bulk density… are missing for their description. The idea here would be to complete EarthResourceDimension for raw materials, similarly to WasteDimension (Figure 26).

![Figure 26 - EarthResourceDimension and WasteDimension properties.](image)

Recommendations from WP1 regarding physical properties related to raw materials (industrial rocks) such as grain size, clarity and many others are probably manageable through GeoSciML 3.0, Package ‘PhysicalProperties’, DataType ‘PhysicalDescription’, CodeList ‘PhysicalPropertyTerm’ (currently empty). Documentation related to the PhysicalProperties package is available at: [http://geosciml.org/doc/geosciml/3.0/documentation/html/](http://geosciml.org/doc/geosciml/3.0/documentation/html/). A new code list is thus needed for managing these properties. All these properties should also be accompanied by a QuantityRange.

### 3.3 The ERML/INSPIRE Commodity code list and the mapping to the BGS ‘e-MYB’ code list

It has been seen above in section 3.1 that the content of the ERML/INSPIRE and e-MYB code lists was sensibly different because the objectives were not the same. The ERML/INSPIRE MR code list has been developed to describe commodities from primary and secondary resources, while the e-MYB code list was describing more or less elaborated mining products (from...
primary ores to shipping normalized products). In these conditions a merging of these two code lists would lead to a duplication and/or an overlapping of certain terms and concepts, and a mapping, even if it will lead to some loss of precision, seems to be the best solution.

The mapping done by BGS when developing the Minerals4EU Yearbook has been reevaluated by GEUS and BRGM, comparing the e-MYB code list to the INSPIRE MR version and to the most recent ERML version of the Commodity code list (see Appendix 4). The result shows without any ambiguity, that this mapping is still valid and can be re-used. The only point to correct is that both the INSPIRE MR and the e-MYB do not have ‘heavy rare earth oxides’ (HREO) and ‘light rare earth oxides’ (LREO) which should be added for a full compliance with ERML/INSPIRE.

3.4 Commodity code list: additional requests by ongoing projects

This is for example the case of the GeoERA FRAME project. For the FRAME WP5 project there is a need to extend the present INSPIRE MR Commodity list to include some subdivisions of the commodity ‘Graphite’ as follows:

- Graphite (flake)
- Graphite (amorphous)
- Graphite (unspecified)
- Graphite (vein)

These different forms of graphite do not have the same origin and do not have the same use (see https://investingnews.com/daily/resource-investing/battery-metals-investing/graphite-investing/types-of-graphite-amorphous-flake-and-vein/)... The question here is more or less the same as for industrial rocks and minerals for which the classification is based on their physical properties and therefore their use... This is exactly as for the different types of clays in the codes and descriptions used in the INSPIRE Mineral Resources Specification (2013), and this makes this request (and other forthcoming/future requests of the same type) legitimate:

- Cly Clays, unknown use (substance) Clay
- ClyC Common clays for brick, tile (substance) Clay
- ClyCim Clays for cement works (substance) Clay

3.5 Pushing all the data model modifications incl. code lists into the INSPIRE ‘validation process’

Note: this section is based on exchanges with Robert Tomas from the DG JRC.
3.5.1 Regarding the update of the INSPIRE MR data model (excluding code list values changes)

The question here is: **is it an extension or a change in the core model?**

- If it is "only" an extension of the data model, then the procedure should be the following:
  
  a) Document and publish the extension and all relevant information on the INSPIRE Thematic Cluster forum to see if it is possible to get some user’s feedback.
  
  b) If the proposal is mature enough and already in use by communities, it is possible to apply for the official INSPIRE Good practice - that is a new endorsed (Maintenance and Implementation Group - MIG) way of promoting the use of INSPIRE. Here is the link to the page where one can find all the necessary details: [https://inspire.ec.europa.eu/portfolio/good-practice-library](https://inspire.ec.europa.eu/portfolio/good-practice-library). It also includes the first endorsed INSPIRE good practice - GeoDCAT-AP is an extension to the “DCAT application profile for European data portals” (DCAT-AP) for the representation of geographic metadata.

- If it requires a change of the core model: is it a change of the Technical Guidelines (Data specs) or does it change also the EU legislation (IR for Interoperability)? In both cases it should be published first on the INSPIRE Thematic Clusters platform for user's feedback highlighting precisely the changes proposed.
  
  a) If it is "only" a Technical Guidelines change a concrete proposal has to be submitted to JRC, for evaluation.
  
  b) Regarding the possible change of the legal text – JRC is currently finalizing the Change proposal collected from the MS representatives - the final deadline is 31-1-2019 (in any case, too early for ORAMA…). Note that in the proposal there is a systemic change of updating INSPIRE SEMANTICS - Code lists and their values - (definitions, descriptions, extensions...).

**Note:** The Change proposal should go via official submitting organisation (e.g., in France, the Ministry of Environment) and will be assessed by the Registry Control body. If agreed, it will then be implemented.

3.5.2 Regarding the changes to the code lists

There is an official process in place that should be followed:

4 The UNFC classification: how to include it in an efficient way in the MR data model?

4.1 Bridging between UNFC and other Classification systems

Comparing to the traditional qualification systems UNFC implements a different approach (UNFC, 2013, 2015). The result of qualification is a 3-digit code classifying Mineral Occurrences based on three fundamental criteria: economic and social viability (E), field project status and feasibility (F), and geological knowledge (G). The graphical representation of the UNFC system and the most common classes are shown on Figure 27.

![Figure 27 - UNFC-2009 categories and examples of classes (UNFC, 2010).](image)

A Class defined by a '3 dimensional vector' may or may not correspond to traditional categories. In the UNFC space there are classes that do not fit to any other system, e.g., Exploration project (334) cannot be considered as a Mineral Occurrence. However, any qualified Resource or Reserve can be described with a 3-digit UNFC code. The transformations from traditional systems to UNFC are defined in the Bridging Documents.

Table 9 presents matching classes as described in the UNFC-2009 specification.
Table 9 – Matching CRIRSCO Codes and UNFC Classes.

<table>
<thead>
<tr>
<th>CRIRSCOCode</th>
<th>UNFCCode</th>
<th>UNFC Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>provedReserve</td>
<td>111</td>
<td>commercialProject</td>
</tr>
<tr>
<td>probableReserve</td>
<td>112</td>
<td>commercialProject</td>
</tr>
<tr>
<td>measuredResource</td>
<td>221</td>
<td>potentialCommercialProject</td>
</tr>
<tr>
<td>indicatedResource</td>
<td>222</td>
<td>potentialCommercialProject</td>
</tr>
<tr>
<td>inferredResource</td>
<td>223</td>
<td>potentialCommercialProject</td>
</tr>
</tbody>
</table>

4.2 Creation of a specialization of OreMeasure

The simplest and more efficient way to proceed in order to take into account the UNFC Classification within INSPIRE, is to create – like in ERML v2.0 – a specialization of OreMeasure as for Resource, Reserve and Endowment, as shown in Figure 28.

The related code list has been developed and approved by the CGI Geoscience Terminology Working Group (GTWG) (Table 10). It can be consulted at:

- [https://docs.google.com/spreadsheets/d/1CnsNAFVvJG2CpsU4wlOiyMikMdE9IPFgWAI96dPNkM/edit#gid=4](https://docs.google.com/spreadsheets/d/1CnsNAFVvJG2CpsU4wlOiyMikMdE9IPFgWAI96dPNkM/edit#gid=4) (restricted access).
<table>
<thead>
<tr>
<th>Hkey</th>
<th>Term</th>
<th>Synonym</th>
<th>Parent_URI</th>
<th>Definition</th>
<th>CGI_URI</th>
<th>SourceNote</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>commercial projects</td>
<td>mineral reserves</td>
<td>top</td>
<td>Commercial Projects have been confirmed to be technically, economically and socially feasible.</td>
<td>commercial-projects</td>
<td><a href="http://www.unece.org/fileadmin/DAM/energy/se/pdfs/UNFC/UNFC2009_ECE_EnergySeries39.pdf">www.unece.org/fileadmin/DAM/energy/se/pdfs/UNFC/UNFC2009_ECE_EnergySeries39.pdf</a> - page 6; synonym from CRIRSCO</td>
</tr>
<tr>
<td>01.1.</td>
<td>on production</td>
<td>proved and probable (111+112)</td>
<td>commer-</td>
<td>On Production is used where the project is actually producing/extracting and selling one or more commodities to market as at the Effective Date of the evaluation.</td>
<td>on-production</td>
<td><a href="http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf">http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf</a> - page 19; synonym from CRIRSCO</td>
</tr>
<tr>
<td>01.2.</td>
<td>approved for development</td>
<td>proved and probable (111+112)</td>
<td>commer-</td>
<td>Approved for Development requires that all approvals/contracts are in place, and capital funds have been committed. Construction and installation of project facilities should be underway or due to start imminently.</td>
<td>approved-for-development</td>
<td><a href="http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf">http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf</a> - page 19; synonym from CRIRSCO</td>
</tr>
<tr>
<td>01.3.</td>
<td>justified for development</td>
<td>proved and probable (111+112)</td>
<td>commer-</td>
<td>Justified for Development requires that the project has been demonstrated to be technically feasible and commercially viable, and there must be a reasonable expectation that all necessary approvals/contracts for the project to proceed to development will be forthcoming.</td>
<td>justified-for-development</td>
<td><a href="http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf">http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf</a> - page 19; synonym from CRIRSCO</td>
</tr>
<tr>
<td>02.</td>
<td>potentially commercial projects</td>
<td>mineral resource</td>
<td>top</td>
<td>Potentially Commercial Projects are expected to be developed in the foreseeable future, in that the quantities are assessed to have reasonable prospects for eventual economic extraction, but technical and/or commercial feasibility has not yet been confirmed.</td>
<td>potentially-commercial-projects</td>
<td><a href="http://www.unece.org/fileadmin/DAM/energy/se/pdfs/UNFC/UNFC2009_ECE_EnergySeries39.pdf">www.unece.org/fileadmin/DAM/energy/se/pdfs/UNFC/UNFC2009_ECE_EnergySeries39.pdf</a> - page 6; synonym from CRIRSCO</td>
</tr>
<tr>
<td>02.01.</td>
<td>development pending</td>
<td>measured (221), indicated (222), inferred (223)</td>
<td>potential-</td>
<td>Development Pending is limited to those projects that are actively subject to projectspecific technical activities, such as acquisition of additional data (e.g. appraisal drilling) or the completion of project feasibility studies and associated economic analyses designed to confirm project commerciality and/or to determine the optimum development scenario or mine plan.</td>
<td>development-pending</td>
<td><a href="http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf">http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf</a> - page 19; synonym from CRIRSCO</td>
</tr>
<tr>
<td>02.02.</td>
<td>development on hold</td>
<td>indicated (222) and inferred (223)</td>
<td>potential-</td>
<td>Development On Hold is used where a project is considered to have at least a reasonable chance of achieving commerciality (i.e. there are reasonable development-on-hold</td>
<td>development-on-hold</td>
<td><a href="http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf">http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf</a> - page 19; synonym from CRIRSCO</td>
</tr>
</tbody>
</table>
prospects for eventual economic extraction), but where there are currently major non-technical contingencies (e.g. environmental or social issues) that need to be resolved before the project can move towards development.

<table>
<thead>
<tr>
<th>03.</th>
<th>non-commercial projects</th>
<th>top</th>
<th>Non-Commercial Projects include those that are at an early stage of evaluation in addition to those that are considered unlikely to become commercially feasible developments within the foreseeable future.</th>
<th><a href="http://www.unece.org/fileadmin/DAM/energy/se/pdfs/UNFC/UNFC2009_ECE_EnergySeries39.pdf">www.unece.org/fileadmin/DAM/energy/se/pdfs/UNFC/UNFC2009_ECE_EnergySeries39.pdf</a> - page 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>03.01.</td>
<td>development unclarified</td>
<td>non-commercial projects</td>
<td>Development Unclarified is appropriate for projects that are still in the early stages of technical and commercial evaluation (e.g. a recent new discovery), and/or where significant further data acquisition will be required, in order to make a meaningful assessment of the potential for a commercial development, i.e. there is currently insufficient basis for concluding that there are reasonable prospects for eventual economic extraction.</td>
<td><a href="http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf">http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf</a> - page 19</td>
</tr>
<tr>
<td>03.02.</td>
<td>development not viable</td>
<td>non-commercial projects</td>
<td>Development not Viable is used where a technically feasible project can be identified, but it has been assessed as being of insufficient potential to warrant any further data acquisition activities or any direct efforts to remove commercial contingencies.</td>
<td><a href="http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf">http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf</a> - page 19</td>
</tr>
<tr>
<td>04.</td>
<td>additional quantities in place</td>
<td>top</td>
<td>Quantities should only be classified as Additional Quantities in Place where no technically feasible projects have been identified that could lead to the extraction of any of these quantities.</td>
<td><a href="http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf">http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf</a> - page 19</td>
</tr>
<tr>
<td>05.</td>
<td>exploration projects</td>
<td>exploraton results (334)</td>
<td>Project identified that has not advanced enough to categorize further.</td>
<td><a href="http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf">http://www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc4_apr2013/SpecificationsUNFC2009.pdf</a> - page 19; synonym from CRIRSCO</td>
</tr>
</tbody>
</table>

Table 10 - CGI/ERML code list for UNFC values. Equivalences with CRIRSCO codes are given in the ‘Synonym’ column.

Note: The UNFC Classification, and the equivalence with the CRIRSCO codes, being an important topic, it is suggested here to move the UNFC dataType from Mineral Resource extension to mr:core in INSPIRE.
5 The ProSUM Urban mine data model

5.1 Introduction

Figure 29 summarizes the main parameters the urban mine data model must take into account from product characterization to stocks and flows management and to waste characterization, knowing that the parameters are given by country and that they are all continuously evolving with time… (Cassard et al., 2017a).

From this conceptual approach, a new data model has been developed in ProSUM that unifies the data aspects of the three urban product waste types, Waste Electrical and Electronic Equipment (WEEE), End-of-Life Vehicles (ELV) and spent batteries (BATT) that this project deals with (Figure 30) (Heijboer et al., 2017).
This new Unified data model allows describing products of the three wastes groups in detail with their special features (like the residence time which is needed to know the proportion of this product that will become waste for a certain date), and also with their composition in smaller components, materials or elements. These components can then be detailed with their own composition, in the same way the materials used can also be described with the component that are used to make them.

The entire life of the products can be described with the different flows and stocks the products will follow. The two concepts of ProcessWithStock and Flows are interlinked and can be used in combination or in a separate way as it is requested by the different actors of the domain who can represent the life of the products by moving stocks or flows between these stocks.

A PostgreSQL database implementation of this model has been developed and datasets provided by ProSUM work packages (WP) 2, 3 and 4 have been uploaded and inserted in the database tables. The vocabulary that has been created in WP2 to WP4 is stored in 13 code lists with 9 currently containing values (Table 11).
Table 11 - Code list and sources for WEEE, ELV and BATT.

These code lists values harmonize the data for WEEE, ELV and BATT that are available in Europe. A functionality has been created so that these data can be uploaded to the database system. This functionality can be extended or modified according to future needs for retrieving urban mine data such as specified in ProSUM Deliverable 5.3 (van Straalen et al., 2015)

5.2 The ProSUM data flow

Figure 31 - Representation of the data flow in the ProSUM Project schema. Note that most of the scattered data which are collected and collated, are homogenized using Excel spreadsheets, so-called ‘Project Excel databases’ (Extract from ProSUM D5.7, fig. 3).
Urban mine data flows through the ProSUM urban mine system architecture from source to the end user are described in Figure 31. To be able to have a clear idea of the detailed concepts that this project focusses on and their interrelations, a conceptual model has been created (see Section 5.3). From this conceptual model a physical data model has been created specific for the PostgreSQL data management system (see Section 5.4). This model has been implemented in a PostgreSQL database instance representing the Intermediate DB. An ETL procedure from the Excel portrayals to the database has been created. First the data is uploaded and extracted using a Java RESTful Web service, which can be re-used or updated in the future (see Section 5.5). Subsequently, the data is transformed and loaded into the correct tables in the database using a specifically created PostgreSQL function. The code list vocabulary used in these databases is described in (see Section 5.6). This physical model is also used in the Harvesting DB and Diffusion DB as shown in Figure 31. The flow of data is then as follows:

1. Data can be extracted from a provider database with its own format or from ProSUM data portrayals that have been created in this project. The current focus is mainly on project derived data.
2. It is then transformed and loaded into a Postgres database which has the same schema as described in Section 5.4.
3. This database can then be used together with deegree3 to create a Web feature service (WFS) that can be harvested in a second database. A Web feature service essentially represents the data in the database in an XML format.
4. Alternatively, a database dump file with SQL insert statements can be transferred to the Diffusion DB directly.

5.3 The Unified conceptual model

The conceptual data model (Figure 30) that has been created, describes: attributes e.g. productCategory in the Product class; dataTypes (ProductCategoryCodeValue in the case of productCategory); how specific attributes are grouped together in classes e.g. Product; and associations between classes e.g. arrow between Product and Material classes. Values below the arrowhead indicate how many instances of a class can be associated to another class. Non-standard dataTypes created for this project are listed as isolated boxes e.g. UncertainQuantity.

Other dataTypes not listed are defined in other ISO standards (19108:2008 and the swe common data model encoding standard). Classes with a “code list” annotation describe the vocabulary of the model.

In the model products including product components are uniquely characterized by the productKey, productionStart, productionEnd and country attributes and can also have information about the weight/volume/amounts of an instance of the Product class. However, in some datasets no information is available for productionStart, productionEnd or country i.e. they may be unknown or constant over time. The model also shows that a Product can have multiple Materials or Elements associated to it. In addition a Product can refer to a sub-product or a component. If this is the case, a ComponentMeasure associates this component to a parent product together with information about the component amount or mass fraction in the parent product if available. A Material can also have multiple elements associated to it.
5.4 The database implementation

The ProSUM urban mine data are stored in a PostgreSQL database with tables and Foreign Key relationships that are shown in Figure 32, Figure 33 and Figure 34. These figures together form the whole data model as it is implemented. In Figure 32, ProcessWithStock refers to the class of the same name as in Figure 30. Code list classes are implemented in the same way as in the Minerals4EU project: as tables which substitute ‘Type’ for ‘CodeValue’ in the conceptual model; and with 4 columns, a primary key column with a characterstring of maximum 50 characters, a name, a description and a url which can have unlimited characters. The associations shown in Figure 30 can be implemented approximately 1:1 in the table structure. The voidable stereotype that is often present in associations introduces a complexity for associations similar to the Minerals4EU physical data model, because in the context of INSPIRE a particular field cannot be left blank and a reason for missing data must also be given. This complexity is added to the model by introducing columns with a ‘voidreason’ postfix that should contain values from the voidreasontype code list: ‘unknown’, ‘withheld’.

Tables such as ProcessWithStock have many more columns than their UML counterparts. This is because the attributes stockQuantity and wasteQuantity are of type UncertainQuantity, which is a complex dataType, containing several attributes. Each of the UML attributes associated to stockQuantity is mapped to a columnname with a “stock” prefix. This makes it easier for a database user to determine what the meaning of a column is and what the conceptual basis is.
Figure 32: Database model showing only the stock and flows tables and their relationships to the product table. A more detailed image can be found [here](Extract from ProSUM D5.5, fig. 4).
Figure 33: Part of the unified database model showing only the product, component, material and element tables and their relationships and column names. A more detailed image can be found here (Extract from ProSUM D5.5, fig. 5).
A particular value in product, material, element or processWithStock tables can have multiple metadata sources. Link tables are therefore provided to a centralized metadata table having all the metadata sources for the data that was inserted (Figure 34).

5.5 Mapping CRM parameters to the Unified data model

Data from the CRM parameter templates that have been created for inserting into the database are first uploaded to the database, with only minor adjustments when necessary, and stored in the crmharvestingtemplate table. A more detailed image of the part of the database model related to harvesting can be found here. A custom Java upload service has been created for this, which can run on a Java EE application server. Once this is completed for a file, the database
function “insert_from_harvest_template” in the ProSUM urban mine database deals with transforming the CRM parameter data to the Unified data model. This function uses views with a prefix “crmharvestingtemplate_vw”. These database views give a database user the ability to check the different stages of how the data are transformed before they are inserted into the database tables. Other database views with the same name as the database tables, ending with “_vw”, are used by the deegree framework to create a valid Web feature service.

Table 12 shows further details on which tables are affected by the CRM parameter subscript of a particular record in a dataset. In some cases the mapping is relatively straightforward such as where CRM parameter subscript = “p”, in other cases it can be more complex, e.g. e-m or p-f, where new rows depend on existing rows if any. For some CRM parameter values (f-f) values should be calculatable from data derived from other CRM parameter subscripts.

<table>
<thead>
<tr>
<th>CRM parameter subscript</th>
<th>Description</th>
<th>Action in database</th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>Mass, length, area, volume or other extensive property of a product</td>
<td>Insert a row in product table.</td>
</tr>
<tr>
<td>c</td>
<td>Mass, length, area, volume or other extensive property of a component</td>
<td>Insert a row in product table.</td>
</tr>
<tr>
<td>m-c</td>
<td>Mass, mass fraction or volume of a material in a component</td>
<td>Insert a row in material table and link to a specific product in product table.</td>
</tr>
<tr>
<td>m-p</td>
<td>Mass, mass fraction or volume of a material in a product</td>
<td>Insert a row in material table and link to a specific product in product table.</td>
</tr>
<tr>
<td>m-f</td>
<td>Mass fraction of a material in a flow or stock</td>
<td>Calculatable if m-p/m-c, p-f are known.</td>
</tr>
<tr>
<td>c-c</td>
<td>Mass, mass fraction, number, length, volume, area or other extensive property of a component in another component</td>
<td>Same as in c-p, but link to a parent component.</td>
</tr>
<tr>
<td>c-p</td>
<td>Mass, mass fraction, number, length, volume, area or other extensive property of a component in a product</td>
<td>Link a parent product to a component by inserting a row in componentmeasure.</td>
</tr>
<tr>
<td>c-f</td>
<td>Mass fraction of a component in a flow or stock</td>
<td>Insert a row in processwithstock and/or flow and link to a row in product table by means of productmeasure and productdistribution table.</td>
</tr>
<tr>
<td>p-p</td>
<td>Mass, mass fraction, number, length, volume, area or other extensive property of a product in another product</td>
<td>Same as c-p, but link a product to a parent product.</td>
</tr>
<tr>
<td>p-f</td>
<td>Mass fraction of a product i a flow or stock</td>
<td>Same as c-f.</td>
</tr>
<tr>
<td>f-f</td>
<td>Mass fraction of a flow or stock in a flow or stock</td>
<td>Calculatable from associations between different stocks and flows.</td>
</tr>
<tr>
<td>e-m</td>
<td>Mass or mass fraction of an element in a material</td>
<td>Create a new row in element table and link to a row in material table if present.</td>
</tr>
<tr>
<td>e-c</td>
<td>Mass or mass fraction of an element in a component</td>
<td>Create a new row in element table and link to a row in product table if present representing a component.</td>
</tr>
<tr>
<td>e-p</td>
<td>Mass or mass fraction of an element in a product</td>
<td>Create a new row in element table and link to a row in product table if present representing a product.</td>
</tr>
</tbody>
</table>
Table 12: List of types of CRM parameter data and how data is stored in the unified database (Extract from ProSUM D5.5, table 2).

5.6 Code list values

Multiple code list classes are defined in Figure 30. In this section, the values that can be used for a particular record in the product, material, element, processwithstock or flow tables are listed. Note that the url addresses used in the tables follow the INSPIRE standard, but are project specific and do not link to existing internet resources.

These code lists are described in detail in the ProSUM Deliverable D5.5 by Heijboer et al. (2017). For convenience they are copied in Appendix 5 of this deliverable.
6 WP2 improved datasets implications in terms of urban mine data model evolution

Work Package 2 made a deep review of data and datasets of the EU, and has established a series of recommendations (Huisman et al., 2018) in terms of management and exploitation of these data. Of the generic aspects that are not part of WP3 direct actions (prior to data model support), some are recurrent, regardless of the type of product, and often bear on harmonization in a broad sense: in the interpretation of definitions, for classifications, methods, documentation… Also, the lack of Member States national mass balance of key materials and products in batteries, waste batteries and W/EEE in order to have knowledge of the recovery rates is several times mentionned.

The need of a ‘Raw Data’ database is also emphasized. A large amount of data on the composition of EEE, batteries and vehicles were collected and harmonized within the ProSUM project. However, as the primary goal was to create the Urban Mining Platform, which contains highly aggregated data, no database was established for the storage of raw data, such as material compositions obtained by chemical analysis or from manufacturer data sheets. Members of the ProSUM Consortium responsible for composition data and data models are good candidates to drive the development of a data repository on the composition of anthropogenic objects and materials.

Finally, and logically, the update and improvement of the vocabularies developed in ProSUM is part of the recommendations:

- For batteries (BATT), the code lists need to be further developed and improved to cover all stocks and flows. For example, the ProSUM code list does not cover yet the flows of re-used and re-manufactured batteries.

- For ELV, the ProSUM component and material code list should be further refined and statistical data reconciliation for consolidating composition data be enabled within the UMKDP. The H2020 project PolyCE, should refine and further develop the polymer code lists from ProSUM.

- For WEEE, the ProSUM component and material code list should be further refined and statistical data reconciliation for consolidating composition data be enabled within the UMKDP.

- For Mining wastes (MW), to review the mining waste database model, code lists, and harvesting methods to facilitate future improvements to the common harmonised database. Note that this work on the data model (incl. code lists - see sections 1.3.3, 1.4 and 1.5 above) is now completed, and that the latest code lists have been finalized and submitted to the CGI for review (March 2019) – see also: https://www.seegrid.csiro.au/subversion/xmml/GGIC/trunk/doc/ERML_3_Doc/index.htm.
Deliverable D2.2 also provides a synthesis of recommendation by product type, which is reviewed below.

6.1 Spent batteries (BATT)

Due to the level of details of the data available in Eurostat, the lack of harmonisation and due to significant data gaps, the existing official statistics on batteries do not enable to quantify the amounts of materials available in the urban mine or expected to get available from the urban mine. The data structure developed in the frame of ProSUM remains the most suitable for representing stocks and flows associated with batteries. This structure includes a two-dimensional classification of batteries distinguishing the electrochemical battery systems and the applications with different levels of details. The code lists can be completed in case of the market introduction of new applications and new electrochemical systems.

The main conclusion is to keep the proposed classification without changes and focus on further fill the main data gaps. Therefore, making no changes to the ProSUM Unified Data Model for batteries is recommended for WP3.

6.2 End-of-life vehicules (ELV)

In the proposed case study on electric vehicles and batteries (in deliverable D2.3 to come), there will be a particular focus on the structure and level of detail in the classification of vehicles. It is foreseen that the case study will lead to a concrete recommendation to revise the vehicle keys used in ProSUM, so that they are suitable for estimating SRM content in electric and hybrid cars (e.g., by replacing the current engine size classes with power classes instead).

6.3 WEEE

The demonstration of the feasibility of recommendations provided in D2.2 will be basis of Deliverable 2.3 which will serve as proof of concept for construction of protocols and market survey to potentially improve the data collection of SRM, by execution of a case studies.

No substantial change of the WEEE part in the UMP is foreseen, the focus being on developing guidelines and best practice material on harmonizing the existing classification and improving scavenging data c-f and p-f. Perhaps for the 2016-2018 update some new link to PRC/CN codes may happen, but this is not certain.

6.4 PV panels

The prioritized recommendations and the discussion of their feasibility provided in D2.2 will be basis for the PV Panel case study of D2.3. This case study will serve as proof of concept for
dynamized data on composition and weight-to-power ratio as well as further investigate the possibility e.g. to get more detailed information on POM (level of PV Panel technology type). The obtained results will prospectively support the work of WP3 (classification/characterization, dynamized data). Furthermore, it will provide more elaborated recommendations concerning official and industry statistics.

In summary, in the case of PV panels, however, it is foreseen the development of a more detailed classification (with the improvement of related code list(s)).

6.5 Mixed metal scraps

No specific recommendation.

6.6 Mining wastes (MW)

Because MW deposits have a spatial dimension, the M4EU/ProSUM-based INSPIRE compliant framework for MW data collection and reporting is reasonable in the long-term future. Due to the lack of MW information in most of the existing datasets, no suggestion of improvements of the existing MW data model structure have been foreseen for WP3. As described in the section 6.5.3 of deliverable D2.2, the communication with existing providers, identification of errors in harmonised national databases and improvement of harvesting methods has already been established within H2020 ORAMA project and is ongoing. Therefore WP3 should continue improving operational flow of ProSUM data collection and reporting, especially:

- Identify technical errors in the harvesting system and harmonised national databases;
- Describe and summarise the technical errors in harmonised national databases for future data providers (in order to avoid making the same errors, when establishing new national databases);
- Elaborate the future ProSUM application/web portal for MW information sharing and explain better its future use with regard to the end users. To this date the information from seven data providers has been successfully harvested, but is still not reported in the on-line application as it was aimed in ProSUM. The issues of why is that so should be clearly explained, addressed and resolved as soon as possible in order to share the information with the end users (stakeholders). When this will be accomplished the current status of MW dataset availability and related issues will be more easily communicated with the interested stakeholders as well as existing and future data providers.

**Note:** Regarding the last point, the non-publication of the harvested datasets is not in relation with any technical problem, but with a problem of cost of a secured server for the diffusion of data. It is thus in relation with the general problem of the cost of mobilisation and maintenance of IT architectures after the end of a project.
6.7 Making the ProSUM Unified data model a standard for the urban mine

The ProSUM Unified data model for the urban mine is robust, and the review done as part of Deliverable D2.2 seems to indicate that it has no major flaws. Of course, it may have to evolve to stick to technological developments. The idea is currently to try to make it a standard (it has no competitor currently 'on the market'). For this, the first step would be to have it validated by the CGI (Commission for the Management and Application of Geoscience Information - http://www.cgi-iugs.org/) whose role is to foster the interoperability and exchange of geoscience information, by active community leadership, collaboration, education, and the development and promotion of geoscience information standards and best practice. As this data model is intended to quantify flows and stocks of metals (including CRM), an option could be to make it an extension of EarthResourceML (ERML), a data transfer standard for mineral resources and mining information (see: https://www.seegrid.csiro.au/subversion/xmml/GGIC/trunk/doc/ERML_3_Doc/index.htm).

This action will be engaged if possible in the course of 2019, depending also on the CGI agenda.
7 About the environmental and social dimensions

The ProSUM Unified data model and the INSPIRE MR / ERML data model have not been modified to better reflect the social and environmental dimensions (see Work Package 3, task T3.4). The exploitation of the dataset inventory realized in Work Package 1 showed that less than 25% (11/47) of them are INSPIRE compliant.

In addition to the sometimes limited interest of certain datasets, it appears above all that automated harvesting of data via Web services (including Web Feature Services [WFS], possibly coupled to an ETL process), or better via APIs is most of the time impossible. The data is served and is downloadable in a variety of formats e.g., XLS(X), CSV, HTML, AXIS PC, SPSS, TSV, PDF ..., which require manual processing. The development of an ETL process is most of the time not justified, because first it is very expensive and second it applies to data updated annually or even more rarely.

Moreover, the introduction of these two dimensions into the existing models would have complicated them to the extreme, probably unnecessarily, since these data are almost exclusively served by supra-national organizations.

Instead, two actions were undertaken which are currently ongoing:

- to select some datasets related to the social and environmental aspects of mineral extraction for incorporation into the e-Minerals Yearbook. In addition to the fact that they must make sense in the context of the e-MYB, these data must be served in a sustainable way by the provider and be easily recoverable (avoiding if possible the implementation of a WFS - ETL process) and integrable.
- to continue to develop the MICA Expert System (Cassard et al., 2017b, 2019; Ziébelin et al., 2018) by acting on the perimeter of the Main Ontology and its granularity for these two approaches, and by concomitantly developing linkedSheets (pre-established forms describing an external – and perennial - resource), thus reinforcing the links with DG JRC's RMIS v2.0.

It should be noted, however, that the environmental dimension is not totally absent from the INSPIRE MR / ERML data model. Indeed, in the 'Mining Wastes' part of the model, a code list gives the terms indicating the environmental impacts of mining wastes (Schubert et al., 2014). See also Figure 35 and Table 13 below.
Figure 35 - Mining wastes and their environmental impact (code list EnvironmentalImpactValue on the right side). EarthResourceML version 3.0.

<table>
<thead>
<tr>
<th>CGI Code values</th>
<th>CGI Code values (continued)</th>
</tr>
</thead>
<tbody>
<tr>
<td>acid mine drainage</td>
<td>mineral fiber emission</td>
</tr>
<tr>
<td>aqueous liquid emission</td>
<td>neutral mine drainage</td>
</tr>
<tr>
<td>basic mine drainage</td>
<td>noise</td>
</tr>
<tr>
<td>collapse</td>
<td>non-aqueous liquid emission</td>
</tr>
<tr>
<td>dam failure</td>
<td>odour</td>
</tr>
<tr>
<td>dust</td>
<td>particulate emission</td>
</tr>
<tr>
<td>emission</td>
<td>physical impact</td>
</tr>
<tr>
<td>erosion</td>
<td>radiation</td>
</tr>
<tr>
<td>gaseous emission</td>
<td>radioactive emission</td>
</tr>
<tr>
<td>habitat modification</td>
<td>runoff water</td>
</tr>
<tr>
<td>health impact</td>
<td>sedimentation</td>
</tr>
<tr>
<td>heat</td>
<td>subsidence</td>
</tr>
<tr>
<td>instability</td>
<td>subsurface aqueous liquid discharge</td>
</tr>
<tr>
<td>landslide</td>
<td>surface aqueous liquid discharge</td>
</tr>
<tr>
<td>CGI Code values</td>
<td>CGI Code values (continued)</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>liquid emission</td>
<td>vibration</td>
</tr>
<tr>
<td>mine drainage</td>
<td>visual disturbance</td>
</tr>
</tbody>
</table>

Table 13 - EnvironmentalImpactValue code list.
8 Synthesis of actions for improving the INSPIRE MR / ERML data model and the ProSUM Unified data model for the urban mine

Both data models are robust, perform their roles effectively and are not more complex than needed. Their level of detail is relatively high (hence a certain complexity) but in return, it allows the correct processing of data and information.

Future changes will therefore not focus on the structure of the models but more on the vocabulary part (i.e., the code lists) in order to follow the improvements of the classifications and in particular the integration of more detail in order to better characterize stocks and flows.

The INSPIRE MR / ERML data model has been improved since the publication of the original version in 2013. Additions/corrections/improvements made in the frame of the Minerals4EU and ProSUM projects have been submitted to and accepted by the IUGS/CGI ERML Group (the process is still ongoing for some code lists). They will have to be ‘pushed’ into the INSPIRE validation process following the submission procedures described in collaboration with the DG JRC. Modifications can be seen at: https://www.seegrid.csiro.au/subversion/xmml/GGIC/trunk/doc/ERML_3_Doc/index.htm.

The INSPIRE MR / ERML data model is more focused on metal substances than on industrial rocks and minerals, and some key parameters such as volume (m³), bulk density… are missing for their description. The solution could be to complete EarthResourceDimension for raw materials, similarly to what has been done for WasteDimension. Physical properties, essential to characterize industrial rocks, define their use(s) and classify them, are obviously important but missing. This is probably manageable through GeoSciML 3.0 Package ‘PhysicalProperties’, available at: http://geosciml.org/doc/geosciml/3.0/documentation/html/, and a new code list will be needed.

The ProSUM Unified data model, for its part, will have to be submitted to the CGI in order to get the opportunity to become a recognized standard. As this data model is intended to quantify flows and stocks of metals (including CRM), an option could be to make it an extension of EarthResourceML (ERML). This action will be engaged if possible in the course of 2019, depending on the CGI Agenda.

The partial automation of the e-Minerals Yearbook (e-MYB) initially developed in the Minerals4EU project will necessitate the harvesting of resources and reserves (if any) and production data aggregated at the national level. Several options (ERML, ERML-Lite and O&M) have been evaluated in terms of data model for the building of the Web services and harvesting database. It appeared finally that the best option (saving time, ease of implementation) was to build on ERML by extending the Minerals4EU MineralProducingCountry feature class that was adapted from the EuroGeoSource project and fitted into the M4EU model. The extension will notably bear on the following properties: (i) Exploration (number of active licences, number of licences issued, number of companies exploring, the area covered by exploration licences, the amount of expenditure incurred), (ii)
Trade (data not harvested, only provided by BGS for diffusion - import data and export data), and (iii) Mineral-based waste flows issued by Eurostat.

Regarding ‘Commodities’ the mapping between the INSPIRE MR/CGI CommodityCodeValues and the BGS list of commodities used for the e-MYB has been reevaluated. Despite some inevitable loss of precision – the two code lists being alternatively more detailed for some commodities/products – this mapping is still valid and can be easily updated for the few missing terms or concepts (HREO & LREO notably). However the needs expressed by some ongoing projects regarding the lack of details for commodities such as graphite (and perhaps some others), will inevitably lead to an update (or more) of the Commodity code list within ERML and INSPIRE MR, which must imperatively be reflected in the mapping with the e-MYB.
References


http://data.geus.dk/svn/m4eu/00%20Cookbook%20m4eu/trunk/Deliverable/Minerals4EU/The%20EU-MKDP%20specifications%20of%20the%20system%20%20Deliverable%20D5.2/ (Last accessed on March 13th, 2019).


http://www.prosumproject.eu/sites/default/files/Deliverable%205.7%20Note%20accompanying%20the%20EU-UMKDP.PDF (Last accessed on February 28th, 2019).

(Last accessed on March 8th, 2019.)

EarthResourceML (ERML) version 2.0, EarthResourceML-Lite version 2.0.1:
http://www.earthresourceml.org/
(Last accessed on February 28th, 2019).

EarthResourceML (ERML) version 3.0:
(Last accessed on February 28th, 2019).

EURare project site: http://www.eurare.eu/
(Last accessed on February 28th, 2019).

EURare Integrated Knowledge Management System (IKMS: http://eurare.brgm-rec.fr/
(Last accessed on February 28th, 2019).

EuroGeoSource project site: http://www.eurogeosource.eu/
(Last accessed on February 28th, 2019).

EuroGeoSource portal: http://www.eurogeosource.eu/eurogeosource-portal
(Last accessed on February 28th, 2019).

(Last accessed on March 13th, 2019).

(Last accessed on February 28th, 2019).

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52008DC0699
(Last accessed on March 13th, 2019).

GeoSciML: http://www.geosciml.net/
(Last accessed on February 28th, 2019).

(Last accessed on February 28th, 2019).

https://www.dora.lib4ri.ch/empa/islandora/object/empa:13807
(Last accessed on March 8th, 2019)

(Last accessed on February 28th, 2019).

Minerals4EU project site: http://www.minerals4eu.eu/
(Last accessed on February 28th, 2019).

Minerals4EU Knowledge Data Platform: http://minerals4eu.brgm-rec.fr/
(Last accessed on February 28th, 2019).

ProMine project site: http://promine.gtk.fi/
(Last accessed on February 28th, 2019).

ProMine portal (use of Microsoft IE and Silverlight mandatory): 
http://gtkdata.gtk.fi/Promine/default.html
(Last accessed on February 28th, 2019).

ProSUM project site: http://www.prosumproject.eu/
(Last accessed on February 28th, 2019).

(Sites last accessed on February 28th, 2019).
(Last accessed on February 28th, 2019).

(Last accessed on March 21st, 2019).

(Last accessed on February 28th, 2019).

(Last accessed on February 28th, 2019).

http://www.prosumproject.eu/sites/default/files/ProSUM%20D5.3%20Review%20and%20Harmonisation%20of%20Data_0.pdf  
(Last accessed on February 28th, 2019).

DOI: https://doi.org/10.1007/978-3-319-90053-7_15  
https://link.springer.com/chapter/10.1007%2F978-3-319-90053-7_15#citeas  
(Last accessed on March 14th, 2019).
# Appendix 1

Complete list of code lists for Minerals4EU after Schubert et al. (2014)

<table>
<thead>
<tr>
<th>Code list name</th>
<th>URI</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>ClassificationMethodUsedValue</td>
<td><a href="http://inspire.ec.europa.eu/codelist/ClassificationMethodUsedValue">http://inspire.ec.europa.eu/codelist/ClassificationMethodUsedValue</a></td>
<td>INSPIRE legally binding</td>
</tr>
<tr>
<td>ExplorationActivityTypeValue</td>
<td><a href="http://inspire.ec.europa.eu/codelist/ExplorationActivityTypeValue">http://inspire.ec.europa.eu/codelist/ExplorationActivityTypeValue</a></td>
<td>INSPIRE legally binding</td>
</tr>
<tr>
<td>ImportanceValue</td>
<td><a href="http://inspire.ec.europa.eu/codelist/ImportanceValue">http://inspire.ec.europa.eu/codelist/ImportanceValue</a></td>
<td>INSPIRE legally binding</td>
</tr>
<tr>
<td>MineStatusValue</td>
<td><a href="http://inspire.ec.europa.eu/codelist/MineStatusValue">http://inspire.ec.europa.eu/codelist/MineStatusValue</a></td>
<td>INSPIRE legally binding</td>
</tr>
<tr>
<td>MineralDepositGroupValue</td>
<td><a href="http://inspire.ec.europa.eu/codelist/MineralDepositGroupValue">http://inspire.ec.europa.eu/codelist/MineralDepositGroupValue</a></td>
<td>Recommended values in TG</td>
</tr>
<tr>
<td>MineralDepositTypeValue</td>
<td><a href="http://inspire.ec.europa.eu/codelist/MineralDepositTypeValue">http://inspire.ec.europa.eu/codelist/MineralDepositTypeValue</a></td>
<td>INSPIRE legally binding</td>
</tr>
<tr>
<td>MineralOccurrenceTypeValue</td>
<td><a href="http://inspire.ec.europa.eu/codelist/MineralOccurrenceTypeValue">http://inspire.ec.europa.eu/codelist/MineralOccurrenceTypeValue</a></td>
<td>INSPIRE legally binding</td>
</tr>
<tr>
<td>MiningActivityTypeValue</td>
<td><a href="http://inspire.ec.europa.eu/codelist/MiningActivityTypeValue">http://inspire.ec.europa.eu/codelist/MiningActivityTypeValue</a></td>
<td>INSPIRE legally binding + recommendations</td>
</tr>
<tr>
<td>ProcessingActivityTypeValue</td>
<td><a href="http://inspire.ec.europa.eu/codelist/ProcessingActivityTypeValue">http://inspire.ec.europa.eu/codelist/ProcessingActivityTypeValue</a></td>
<td>INSPIRE legally binding</td>
</tr>
<tr>
<td>ReserveCategoryValue</td>
<td><a href="http://inspire.ec.europa.eu/codelist/ReserveCategoryValue">http://inspire.ec.europa.eu/codelist/ReserveCategoryValue</a></td>
<td>INSPIRE legally binding</td>
</tr>
<tr>
<td>LithologyValue</td>
<td><a href="http://inspire.ec.europa.eu/codelist/LithologyValue">http://inspire.ec.europa.eu/codelist/LithologyValue</a></td>
<td>INSPIRE legally binding + recommendations (TG Geology)</td>
</tr>
<tr>
<td>Earth-resource-material-role</td>
<td><a href="http://resource.geosciml.org/classifier/cgi/earth-resource-material-role">http://resource.geosciml.org/classifier/cgi/earth-resource-material-role</a></td>
<td>CGI</td>
</tr>
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<td>EnvironmentalImpactValue</td>
<td><a href="http://resource.geosciml.org/classifier/cgi/environmental-impact">http://resource.geosciml.org/classifier/cgi/environmental-impact</a></td>
<td>CGI</td>
</tr>
<tr>
<td>Code list name</td>
<td>URI</td>
<td>Scope</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>MiningWasteTypeValue</td>
<td><a href="http://www.census.gov/manufacturing/numerical_list">http://www.census.gov/manufacturing/numerical_list</a> - list 212, Mining (Except Oil and Gas)</td>
<td>this document</td>
</tr>
<tr>
<td>ProductValue</td>
<td><a href="http://resource.geosciml.org/classifier/cgi/raw-material-role">http://resource.geosciml.org/classifier/cgi/raw-material-role</a></td>
<td>Census list</td>
</tr>
<tr>
<td>RawMaterialRoleValue</td>
<td><a href="http://resource.geosciml.org/classifier/cgi/waste-storage">http://resource.geosciml.org/classifier/cgi/waste-storage</a></td>
<td>CGI</td>
</tr>
<tr>
<td>WasteStorageTypeValue</td>
<td><a href="http://resource.geosciml.org/classifier/cgi/waste-storage">http://resource.geosciml.org/classifier/cgi/waste-storage</a></td>
<td>CGI</td>
</tr>
<tr>
<td>Earth Resource FormValue</td>
<td><a href="http://resource.geosciml.org/classifier/cgi/earth-resource-form">http://resource.geosciml.org/classifier/cgi/earth-resource-form</a></td>
<td>CGI</td>
</tr>
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Appendix 2

Code lists values of the code lists updated or created for the ProSUM mining waste extension
(Extract from ProSUM D5.5)

**AmountEstimationMethodType**

Renamed: AmountEstimationMethod
Updated: creation of a hierarchy and addition of definitions
URIs are now resolvable: [https://data.geoscience.earth/ncl/_AmountEstimationMethod](https://data.geoscience.earth/ncl/_AmountEstimationMethod)
Submitted to CGI for approval (March 5th, 2019)

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<td>productionStatistics</td>
<td>Amount of mining waste calculated from statistics on produced amount of waste rock, produced amount of tailings, ore input to concentrator minus quantity of produced concentrate or similar. For highest accuracy information on amount of recycled waste (backfill, reprocessed, as aggregates, etc.) is known.</td>
<td><a href="http://www.minerals4eu.eu/codeList/amountEstimationMethodType/productionStatistics">http://www.minerals4eu.eu/codeList/amountEstimationMethodType/productionStatistics</a></td>
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<td>oreProductionStatistics</td>
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<td>fieldMeasurement</td>
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**ProcessingActivityTypeType**

Renamed: ProcessingActivityType  
Updated: creation of a hierarchy and addition of definitions  
URIs are now resolvable: [https://data.geoscience.earth/ncl/ProcessingActivityType](https://data.geoscience.earth/ncl/ProcessingActivityType)  
Submitted to CGI for approval (March 5th, 2019)
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**ProcessingTransformationPlantStatusType**

Renamed: ProcessingPlantStatus  
URIs are now resolvable: [https://data.geoscience.earth/ncl/_ProcessingPlantStatus](https://data.geoscience.earth/ncl/_ProcessingPlantStatus)  
Submitted to CGI for approval (March 5th, 2019)
<table>
<thead>
<tr>
<th>Code</th>
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<th>URL</th>
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</thead>
<tbody>
<tr>
<td>abandoned</td>
<td>A plant is abandoned.</td>
<td><a href="http://www.minerals4eu.eu/codelist/PlantStatusValue/abandoned">http://www.minerals4eu.eu/codelist/PlantStatusValue/abandoned</a></td>
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<tr>
<td>careAndMaintenance</td>
<td>A plant is under care and maintenance.</td>
<td><a href="http://www.minerals4eu.eu/codelist/PlantStatusValue/careAndMaintenance">http://www.minerals4eu.eu/codelist/PlantStatusValue/careAndMaintenance</a></td>
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<tr>
<td>retention</td>
<td>A plant can be kept unexploited until the price of contained commodity(ies) makes it economical.</td>
<td><a href="http://www.minerals4eu.eu/codelist/PlantStatusValue/retention">http://www.minerals4eu.eu/codelist/PlantStatusValue/retention</a></td>
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<tr>
<td>historic</td>
<td>An 'old' plant which has been exploited before 1900.</td>
<td><a href="http://www.minerals4eu.eu/codelist/PlantStatusValue/historic">http://www.minerals4eu.eu/codelist/PlantStatusValue/historic</a></td>
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<tr>
<td>pendingApproval</td>
<td>A plant waiting for the exploitation authorization, generally given by a State Mining Engineering Department.</td>
<td><a href="http://www.minerals4eu.eu/codelist/PlantStatusValue/pendingApproval">http://www.minerals4eu.eu/codelist/PlantStatusValue/pendingApproval</a></td>
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<tr>
<td>feasibility</td>
<td>Technical economic study aimed at assessing the possibility to launching a plant venture.</td>
<td><a href="http://www.minerals4eu.eu/codelist/PlantStatusValue/feasibility">http://www.minerals4eu.eu/codelist/PlantStatusValue/feasibility</a></td>
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**WasteTypeType**

Renamed: WasteType

Updated: creation of a hierarchy and addition of definitions

URIs are now resolvable: [https://data.geoscience.earth/ncl/_WasteType](https://data.geoscience.earth/ncl/_WasteType)

Submitted to CGI for approval (March 5th, 2019)

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</tr>
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<tr>
<td>explorationMiningQuarryingPhysicalChemicalTreatmentOfMinerals</td>
<td>wastes resulting from exploration, mining, quarrying, and physical and chemical treatment of minerals</td>
<td><a href="http://www.minerals4eu.eu/codeList/WasteTypeType/explorationMiningQuarryingPhysicalChemicalTreatmentOfMinerals">http://www.minerals4eu.eu/codeList/WasteTypeType/explorationMiningQuarryingPhysicalChemicalTreatmentOfMinerals</a></td>
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<td>wastes from mineral excavation</td>
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<td>mineralDressing</td>
<td>Wastes resulting from mineral processing - wastes from mineral dressing</td>
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<td>mineralDressingMetalliferous</td>
<td>Wastes resulting from the treatment of run of mine material which aims to physically separate its constituents in order to produce a marketable product - Wastes from the dressing of metalliferous minerals</td>
<td><a href="http://www.minerals4eu.eu/codeList/WasteTypeType/mineralDressingMetalliferous">http://www.minerals4eu.eu/codeList/WasteTypeType/mineralDressingMetalliferous</a></td>
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<td>Tailings - Smelter waste - (Smelting) Slag - Secondary refining residues - Roasting residues (pyrometallurgy) - Dephosphorization slag (Fe ores) Thomas' process slag - Matte (intermediate product)</td>
<td><a href="http://www.minerals4eu.eu/codeList/WasteTypeType/physicalChemicalProcessMetalliferousMineralsTailings">http://www.minerals4eu.eu/codeList/WasteTypeType/physicalChemicalProcessMetalliferousMineralsTailings</a></td>
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<td>otherSludgeMudsChemicalLiquidProducts</td>
<td>other sludges/muds/chemical liquid products than specified 01 03 01 - Electrolytic sludge - Brine, liquor (e.g. Bayer liquor, H3PO4) - U leach tailings (sludge) - Lagooned ash</td>
<td><a href="http://www.minerals4eu.eu/codeList/WasteTypeType/otherSludgeMudsChemicalLiquidProducts">http://www.minerals4eu.eu/codeList/WasteTypeType/otherSludgeMudsChemicalLiquidProducts</a></td>
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<td>wastes not otherwise specified</td>
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<td>castingOfNonFerrousPiecesCrackIndicatingAgentHazardousSubstances</td>
<td>waste crack-indicating agent containing hazardous substances</td>
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<td>waste glass-based fibrous materials</td>
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<tr>
<td>manufactureGlassAndGlassProductsParticulatesDust</td>
<td>particulates and dust</td>
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<td>waste preparation mixture before thermal processing, containing hazardous substances</td>
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<td>waste preparation mixture before thermal processing, other than those mentioned in 10 11 09</td>
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<td>waste glass in small particles and glass powder containing heavy metals (for example from cathode ray tubes)</td>
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<td><a href="http://www.minerals4eu.eu/codeList/WasteTypeType/manufactureCementLimeAndPlasterGasTreatmentSludgesFilterCakes">http://www.minerals4eu.eu/codeList/WasteTypeType/manufactureCementLimeAndPlasterGasTreatmentSludgesFilterCakes</a></td>
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Appendix 3

Examples of XML encoding for aggregated data
### Appendix 4

Mapping between the ERML / INSPIRE / e-MYB Commodity code lists

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<th>ERML PrefLabel@en</th>
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Appendix 5

ProSUM code lists values

(Extract from ProSUM D5.5)

ProductCategoryCodeValue

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Table 1: Values derived from the product types stored in product key

This code list represents the overall group in which a particular product falls. Each product key code in the following section is a member of a product category.

ProductKeyCodeValue

This code list consists of Battery key, Battery sub-key, Component group, Component code values, EEE key, EEE sub-key and EEE sub-sub-key values and Vehicle key values (see the sheets in Annex_D of Deliverable 5.3 “BatteryType”, “BatteryTypeType”, “ComponentGroupType”, “ComponentList”, “UNU KEY”, “UNU SUBKEY”, “Link UNU keys to devices” and “Vehicles”). A BATT key or sub-key code list value is prefixed with “BATT”, a component group or component with “COMP”, An EEE key, sub-key or sub-sub-key code list value with “EEE”, and a Vehicle with “VEHICLE”. The following list contains a few of these code list values as an example. The full set of code list values can be found in Annex 1 of ProSUM D5.5. EEE product key values refer to UNU keys, BATT code list values refer to BATT Keys. EEE codes are hierarchical where, for example, the key 0001 groups all keys which start with 0001 e.g. 000101 or 00010101. The key 000101 refers to a more specific item then 0001. Vehicle key values refer to a matrix defined by the properties listed in the description.

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<td><a href="http://www.prosumproject.eu/codelist/productCodeValue/BATT-battLiCFx">http://www.prosumproject.eu/codelist/productCodeValue/BATT-battLiCFx</a></td>
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MaterialKeyCodeValue

The values described in Table Error! Source du renvoi introuvable.3 are the same as described in the sheets of Annex D of Deliverable 5.3 “Material Group Type”, “Material Type” and “Material” (ProSUM D5.3 Review and Harmonisation of Data).

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Table 3: Example of material type code values.

ElementKeyCodeValue

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<tr>
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Table 2: Sub set of the Product code list values used in the project.
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</table>

Table 4: List of elements

Values in Table 4 are associated to a given record in the element table (Figure 34).

CountryCodeValue

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### Table 5: Country codes that may be used in the frame of urban mine data.

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### ProcessTypeCodeValue

The following processing types are defined in the Use and Stock and End-of-Life part of the system as described in the code lists that were used in the datasets that were uploaded.

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<tr>
<td>incineration</td>
<td>the use of combustible waste as a means to generate energy through direct incineration with or without other waste but with recovery of the heat. DIRECTIVE 2000/53/EC</td>
<td><a href="http://www.prosumproject.eu/codelist/processTypeValue/incineration">http://www.prosumproject.eu/codelist/processTypeValue/incineration</a></td>
</tr>
<tr>
<td>materialRecycling</td>
<td>material-recycling -e.g.- smelters</td>
<td><a href="http://www.prosumproject.eu/codelist/processTypeValue/materialRecycling">http://www.prosumproject.eu/codelist/processTypeValue/materialRecycling</a></td>
</tr>
<tr>
<td>recyclingInput</td>
<td>Recycling input</td>
<td><a href="http://www.prosumproject.eu/codelist/processTypeValue/recyclingInput">http://www.prosumproject.eu/codelist/processTypeValue/recyclingInput</a></td>
</tr>
<tr>
<td>recyclingOutput</td>
<td>Recycling output</td>
<td><a href="http://www.prosumproject.eu/codelist/processTypeValue/recyclingOutput">http://www.prosumproject.eu/codelist/processTypeValue/recyclingOutput</a></td>
</tr>
<tr>
<td>reuse</td>
<td>any operation by which components of end-of life vehicles are used for the same purpose for which they were</td>
<td><a href="http://www.prosumproject.eu/codelist/processTypeValue/reuse">http://www.prosumproject.eu/codelist/processTypeValue/reuse</a></td>
</tr>
</tbody>
</table>
conceived DIRECTIVE 2000/53/EC

<table>
<thead>
<tr>
<th>processType</th>
<th>definition</th>
<th>url</th>
</tr>
</thead>
<tbody>
<tr>
<td>shredding</td>
<td>any process used for tearing into pieces or fragmenting end-of-life vehicles, including for the purpose of obtaining directly reusable metal scrap. DIRECTIVE 2000/53/EC</td>
<td><a href="http://www.prosumproject.eu/codelist/processTypeValue/shredding">http://www.prosumproject.eu/codelist/processTypeValue/shredding</a></td>
</tr>
<tr>
<td>use</td>
<td>use</td>
<td><a href="http://www.prosumproject.eu/codelist/processTypeValue/use">http://www.prosumproject.eu/codelist/processTypeValue/use</a></td>
</tr>
<tr>
<td>wasteGeneration</td>
<td>products generated as waste</td>
<td><a href="http://www.prosumproject.eu/codelist/processTypeValue/wasteGeneration">http://www.prosumproject.eu/codelist/processTypeValue/wasteGeneration</a></td>
</tr>
</tbody>
</table>

Table 6: List of Processes types

**EconomicSectorCodeValue**
Currently empty, this code value may be defined in the future

**EvaluationMethodCodeValue**
Currently empty, this code value may be defined in the future

**FlowTypeCodeValue**
The following codes are taken from Annex 7 of the ProSUM D5.3 Review and Harmonisation of Data deliverable.

<table>
<thead>
<tr>
<th>code</th>
<th>name</th>
<th>url</th>
</tr>
</thead>
<tbody>
<tr>
<td>reported</td>
<td>Reported</td>
<td><a href="http://www.prosumproject.eu/codelist/flowTypeValue/reported">http://www.prosumproject.eu/codelist/flowTypeValue/reported</a></td>
</tr>
<tr>
<td>wasteBin</td>
<td>Waste Bin</td>
<td><a href="http://www.prosumproject.eu/codelist/flowTypeValue/wasteBin">http://www.prosumproject.eu/codelist/flowTypeValue/wasteBin</a></td>
</tr>
<tr>
<td>exportForReuse</td>
<td>Export for Reuse</td>
<td><a href="http://www.prosumproject.eu/codelist/flowTypeValue/exportForReuse">http://www.prosumproject.eu/codelist/flowTypeValue/exportForReuse</a></td>
</tr>
<tr>
<td>otherRecycling</td>
<td>Other Recycling</td>
<td><a href="http://www.prosumproject.eu/codelist/flowTypeValue/otherRecycling">http://www.prosumproject.eu/codelist/flowTypeValue/otherRecycling</a></td>
</tr>
<tr>
<td>scavengedParts</td>
<td>Scavenged parts</td>
<td><a href="http://www.prosumproject.eu/codelist/flowTypeValue/scavengedParts">http://www.prosumproject.eu/codelist/flowTypeValue/scavengedParts</a></td>
</tr>
<tr>
<td>importedNewVehiclesPOM</td>
<td>New vehicles POM, imported</td>
<td><a href="http://www.prosumproject.eu/codelist/flowTypeValue/importedNewVehiclesPOM">http://www.prosumproject.eu/codelist/flowTypeValue/importedNewVehiclesPOM</a></td>
</tr>
<tr>
<td>domesticNewComponentPOM</td>
<td>New components POM, domestic</td>
<td><a href="http://www.prosumproject.eu/codelist/flowTypeValue/domesticNewComponentPOM">http://www.prosumproject.eu/codelist/flowTypeValue/domesticNewComponentPOM</a></td>
</tr>
<tr>
<td>importedNewComponentPOM</td>
<td>New components POM, imported</td>
<td><a href="http://www.prosumproject.eu/codelist/flowType/importedNewComponentPOM">http://www.prosumproject.eu/codelist/flowType/importedNewComponentPOM</a></td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------------------------</td>
<td>-----------------------------------------------------------------------</td>
</tr>
<tr>
<td>importedSecondHandVehicles</td>
<td>Imported Second hand vehicles</td>
<td><a href="http://www.prosumproject.eu/codelist/flowType/importedSecondHandVehicles">http://www.prosumproject.eu/codelist/flowType/importedSecondHandVehicles</a></td>
</tr>
<tr>
<td>importedSecondHandComponents</td>
<td>Imported Second hand components</td>
<td><a href="http://www.prosumproject.eu/codelist/flowType/importedSecondHandComponents">http://www.prosumproject.eu/codelist/flowType/importedSecondHandComponents</a></td>
</tr>
<tr>
<td>domesticReportedELVForRecovery</td>
<td>Reported ELV for recovery, domestic</td>
<td><a href="http://www.prosumproject.eu/codelist/flowType/domesticReportedELVForRecovery">http://www.prosumproject.eu/codelist/flowType/domesticReportedELVForRecovery</a></td>
</tr>
<tr>
<td>domesticUnReportedELVForRecovery</td>
<td>Unreported ELV for recovery, domestic</td>
<td><a href="http://www.prosumproject.eu/codelist/flowType/domesticUnReportedELVForRecovery">http://www.prosumproject.eu/codelist/flowType/domesticUnReportedELVForRecovery</a></td>
</tr>
<tr>
<td>domesticUnReportedELVIllegalDumping</td>
<td>Unreported ELV illegal dumping, domestic</td>
<td><a href="http://www.prosumproject.eu/codelist/flowType/domesticUnReportedELVIllegalDumping">http://www.prosumproject.eu/codelist/flowType/domesticUnReportedELVIllegalDumping</a></td>
</tr>
<tr>
<td>exportedReportedELVForRecovery</td>
<td>Reported ELV for recovery, exported</td>
<td><a href="http://www.prosumproject.eu/codelist/flowType/exportedReportedELVForRecovery">http://www.prosumproject.eu/codelist/flowType/exportedReportedELVForRecovery</a></td>
</tr>
<tr>
<td>exportedUnreportedELVForRecovery</td>
<td>Unreported ELV for recovery, exported</td>
<td><a href="http://www.prosumproject.eu/codelist/flowType/exportedUnreportedELVForRecovery">http://www.prosumproject.eu/codelist/flowType/exportedUnreportedELVForRecovery</a></td>
</tr>
<tr>
<td>exportedReportedSecondHandVehicles</td>
<td>Reported second hand vehicles, exported</td>
<td><a href="http://www.prosumproject.eu/codelist/flowType/exportedReportedSecondHandVehicles">http://www.prosumproject.eu/codelist/flowType/exportedReportedSecondHandVehicles</a></td>
</tr>
<tr>
<td>exportedReportedSecondHandComponents</td>
<td>Reported second hand components, exported</td>
<td><a href="http://www.prosumproject.eu/codelist/flowType/exportedReportedSecondHandComponents">http://www.prosumproject.eu/codelist/flowType/exportedReportedSecondHandComponents</a></td>
</tr>
</tbody>
</table>

Table 7: Flow types

<table>
<thead>
<tr>
<th>code</th>
<th>name</th>
<th>description</th>
<th>url</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutomotiveBattery</td>
<td>Automotive Battery</td>
<td>Dismantled-automotive-battery</td>
<td><a href="http://www.prosumproject.eu/codelist/wasteType/AutomotiveBattery">http://www.prosumproject.eu/codelist/wasteType/AutomotiveBattery</a></td>
</tr>
<tr>
<td>ferrousScrap</td>
<td>ferrousScrap</td>
<td>ferrous-scrap-from-shredding</td>
<td><a href="http://www.prosumproject.eu/codelist/wasteType/ferrousScrap">http://www.prosumproject.eu/codelist/wasteType/ferrousScrap</a></td>
</tr>
<tr>
<td>glass</td>
<td>glass</td>
<td>Mixed-glass-from-dismantling</td>
<td><a href="http://www.prosumproject.eu/codelist/wasteType/glass">http://www.prosumproject.eu/codelist/wasteType/glass</a></td>
</tr>
<tr>
<td>metals</td>
<td>metals</td>
<td>Mixed-metals-from-dismantling</td>
<td><a href="http://www.prosumproject.eu/codelist/wasteType/metals">http://www.prosumproject.eu/codelist/wasteType/metals</a></td>
</tr>
<tr>
<td>nonFerrousScrap</td>
<td>nonFerrousScrap</td>
<td>non-ferrous-scrap-from-shredding</td>
<td><a href="http://www.prosumproject.eu/codelist/wasteType/nonFerrousScrap">http://www.prosumproject.eu/codelist/wasteType/nonFerrousScrap</a></td>
</tr>
<tr>
<td>OilFilter</td>
<td>OilFilter</td>
<td>Dismantled-Oil-filter</td>
<td><a href="http://www.prosumproject.eu/codelist/wasteType/OilFilter">http://www.prosumproject.eu/codelist/wasteType/OilFilter</a></td>
</tr>
<tr>
<td>other</td>
<td>other</td>
<td>mixed-residues-from-shredding</td>
<td><a href="http://www.prosumproject.eu/codelist/wasteType/other">http://www.prosumproject.eu/codelist/wasteType/other</a></td>
</tr>
<tr>
<td>polymers</td>
<td>polymers</td>
<td>Mixed-polymers-from-dismantling</td>
<td><a href="http://www.prosumproject.eu/codelist/wasteType/polymers">http://www.prosumproject.eu/codelist/wasteType/polymers</a></td>
</tr>
<tr>
<td>rest</td>
<td>rest</td>
<td>Aggregation-of-rest-fractions-from-dismantling</td>
<td><a href="http://www.prosumproject.eu/codelist/wasteType/rest">http://www.prosumproject.eu/codelist/wasteType/rest</a></td>
</tr>
<tr>
<td>shredderLightFraction</td>
<td>shredderLightFraction</td>
<td>light-residual-fraction-from-shredding</td>
<td><a href="http://www.prosumproject.eu/codelist/wasteType/shredderLightFraction">http://www.prosumproject.eu/codelist/wasteType/shredderLightFraction</a></td>
</tr>
</tbody>
</table>
WasteCategoryCodeValue
Currently empty, this code value may be defined in the future.

UncertaintyTypeCodeValue

<table>
<thead>
<tr>
<th>code</th>
<th>description</th>
<th>url</th>
</tr>
</thead>
<tbody>
<tr>
<td>conf90</td>
<td>90% confidence interval</td>
<td><a href="http://www.prosumproject.eu/codelist/uomUncertaintyValue/conf90">http://www.prosumproject.eu/codelist/uomUncertaintyValue/conf90</a></td>
</tr>
<tr>
<td>conf95</td>
<td>95% confidence interval</td>
<td><a href="http://www.prosumproject.eu/codelist/uomUncertaintyValue/conf95">http://www.prosumproject.eu/codelist/uomUncertaintyValue/conf95</a></td>
</tr>
<tr>
<td>conf99</td>
<td>99% confidence interval</td>
<td><a href="http://www.prosumproject.eu/codelist/uomUncertaintyValue/conf99">http://www.prosumproject.eu/codelist/uomUncertaintyValue/conf99</a></td>
</tr>
<tr>
<td>sd</td>
<td>standard deviation of sample</td>
<td><a href="http://www.prosumproject.eu/codelist/uomUncertaintyValue/standardDeviationOfSample">http://www.prosumproject.eu/codelist/uomUncertaintyValue/standardDeviationOfSample</a></td>
</tr>
<tr>
<td>sem</td>
<td>standard error of the mean of the sample</td>
<td><a href="http://www.prosumproject.eu/codelist/uomUncertaintyValue/standarderrorofthemeanofthesample">http://www.prosumproject.eu/codelist/uomUncertaintyValue/standarderrorofthemeanofthesample</a></td>
</tr>
<tr>
<td>unknown</td>
<td>unknown</td>
<td><a href="http://www.prosumproject.eu/codelist/uomUncertaintyValue/unknown">http://www.prosumproject.eu/codelist/uomUncertaintyValue/unknown</a></td>
</tr>
</tbody>
</table>

Table 9: Types of uncertainty defined in the project

UnitOfMeasureCodeValue

<table>
<thead>
<tr>
<th>code</th>
<th>name</th>
<th>description</th>
<th>url</th>
</tr>
</thead>
<tbody>
<tr>
<td>g</td>
<td>g</td>
<td>grams</td>
<td><a href="http://www.prosumproject.eu/codelist/uomCodeValue/g">http://www.prosumproject.eu/codelist/uomCodeValue/g</a></td>
</tr>
<tr>
<td>gramPerUnit</td>
<td>gramPerUnit</td>
<td>grams per unit</td>
<td><a href="http://www.prosumproject.eu/codelist/uomCodeValue/gramPerUnit">http://www.prosumproject.eu/codelist/uomCodeValue/gramPerUnit</a></td>
</tr>
<tr>
<td>kg</td>
<td>kg</td>
<td>kilograms</td>
<td><a href="http://www.prosumproject.eu/codelist/uomCodeValue/kg">http://www.prosumproject.eu/codelist/uomCodeValue/kg</a></td>
</tr>
<tr>
<td>kgPerKg</td>
<td>kgPerKg</td>
<td>kgPerKg</td>
<td><a href="http://www.prosumproject.eu/codelist/uomCodeValue/kgPerKg">http://www.prosumproject.eu/codelist/uomCodeValue/kgPerKg</a></td>
</tr>
<tr>
<td>kgPerUnit</td>
<td>kgPerUnit</td>
<td>kilograms per unit</td>
<td><a href="http://www.prosumproject.eu/codelist/uomCodeValue/kgPerUnit">http://www.prosumproject.eu/codelist/uomCodeValue/kgPerUnit</a></td>
</tr>
<tr>
<td>m</td>
<td>m</td>
<td>meters</td>
<td><a href="http://www.prosumproject.eu/codelist/uomCodeValue/m">http://www.prosumproject.eu/codelist/uomCodeValue/m</a></td>
</tr>
<tr>
<td>m2</td>
<td>m2</td>
<td>square meters</td>
<td><a href="http://www.prosumproject.eu/codelist/uomCodeValue/m2">http://www.prosumproject.eu/codelist/uomCodeValue/m2</a></td>
</tr>
<tr>
<td>m3</td>
<td>m3</td>
<td>cubic meters</td>
<td><a href="http://www.prosumproject.eu/codelist/uomCodeValue/m3">http://www.prosumproject.eu/codelist/uomCodeValue/m3</a></td>
</tr>
<tr>
<td>massPercentage</td>
<td>massPercentage</td>
<td>mass percentage</td>
<td><a href="http://www.prosumproject.eu/codelist/uomCodeValue/massPercentage">http://www.prosumproject.eu/codelist/uomCodeValue/massPercentage</a></td>
</tr>
<tr>
<td>mgPerKg</td>
<td>mgPerKg</td>
<td>milligrams per kilogram</td>
<td>(equal to ppm mass)</td>
</tr>
<tr>
<td>numberPerUnit</td>
<td>numberPerUnit</td>
<td>number per unit</td>
<td></td>
</tr>
</tbody>
</table>

Table 8: Materials present in down stream waste flow

Tyres | Tyres | Dismantled-Tyres | http://www.prosumproject.eu/codelist/wasteType/Tyres

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### Table 10: Units of measure

| tons | tons | tons | http://www.prosumproject.eu/codelist/uomCodeValue/tons |

### PreferredQuantityTypeCodeValue

<table>
<thead>
<tr>
<th>code</th>
<th>name</th>
<th>url</th>
</tr>
</thead>
<tbody>
<tr>
<td>actualData</td>
<td>actual data</td>
<td><a href="http://www.prosumproject.eu/codelist/preferredQuantityTypeCodeValue/actualData">http://www.prosumproject.eu/codelist/preferredQuantityTypeCodeValue/actualData</a></td>
</tr>
<tr>
<td>coherentEstimatesAndExtrapolations</td>
<td>coherent estimates and extrapolations</td>
<td><a href="http://www.prosumproject.eu/codelist/preferredQuantityTypeCodeValue/coherentEstimatesAndExtrapolations">http://www.prosumproject.eu/codelist/preferredQuantityTypeCodeValue/coherentEstimatesAndExtrapolations</a></td>
</tr>
<tr>
<td>expertAssumptionsInsufficientlySubstantiated</td>
<td>expert assumptions insufficiently substantiated</td>
<td><a href="http://www.prosumproject.eu/codelist/preferredQuantityTypeCodeValue/expertAssumptionsInsufficientlySubstantiated">http://www.prosumproject.eu/codelist/preferredQuantityTypeCodeValue/expertAssumptionsInsufficientlySubstantiated</a></td>
</tr>
<tr>
<td>unknown</td>
<td>unknown</td>
<td><a href="http://www.prosumproject.eu/codelist/preferredQuantityTypeCodeValue/unknown">http://www.prosumproject.eu/codelist/preferredQuantityTypeCodeValue/unknown</a></td>
</tr>
</tbody>
</table>

### Table 11: Preferred quantity types