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Deliverable D5.6

Dedicated search in KDPs from RMIS: note accompanying the release of the 'OpenSearch' API

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1 GENERAL INTRODUCTION

The aim of Mintell4EU work package 5 entitled 'Improvement of KDPs' applications and interaction with the RMIS and the GeoERA Information Platform' is to set up the rules of communication/interaction between the existing Knowledge Data Platforms (KDPs) and their applications, developed within EU-FP7 and H2020 projects, and the Raw Materials Information System (RMIS) version 2.0 launched in November 2017 by the European Commission DG JRC. The ambition of the RMIS 2.0 is to become 'the one-stop information gateway and knowledge service centre for non-energy, non-food primary (e.g., extracted through mining) and secondary (e.g., recycled, recovered from mining waste) raw materials and materials/commodities.'

Together, the different KDPs constitute the European Union Raw Materials Knowledge Base (**EURMKB** – see the EIP-SIP) that will be 'exploited' by the RMIS. The RMIS is thus both a **high-level application producing knowledge** through exploitation of the EURMKB in parallel with the exploitation of external sources and a **high-level interface toward end users**.

Mintell4EU Work Package 5 (i) defines how structured data and information and non-structured information and knowledge can be delivered to, and be exploited by the RMIS 2.0 via its thematic interface(s), using either web services such as WMS and WFS (possibly coupled with ETL process), or more sophisticated and dedicated Application Programming Interfaces (APIs) and (ii) design the prototypes of such applications, having in mind key-functions of the RMIS such as providing information for the Raw Materials Scoreboard (European Commission, 2016b).

The developments presented here are based on the recommendations made in the Mintell4EU Deliverable D5.1 (Cassard and Tertre, 2019a) which carried out a comparative analysis of KDPs resources versus RMIS 2.0 needs. This note accompanies the release of the 'OpenSearch' API, which aims to enable the JRC's RMIS 2.0 to perform targeted searches in already established data corpora (e.g. unstructured data and metadata related to CRM, REE, the urban mine [WEEE, ELV, BATT]…), in addition to classical searches conducted on the Web.

The 'OpenSearch API' was developed as an operational prototype in order to concretise the interoperability between the Mintell4EU data sets served by the EU-MKDP and the RMIS 2.0. Following the Mintell4EU project timeline, this development anticipated the technical compatibility between these two data infrastructures. Meantime, the RMIS team released a technical recommendation note "Channelling knowledge from H2020 projects into the Raw Materials Information System (RMIS) (https://rmis.jrc.ec.europa.eu/uploads/Technical_guidelines_for_knowledge_transfers_into_RMIS.pdf). It turns out that the use of APIs such as the one prototyped by Task 5.6 cannot be enabled for the time being. Instead, the Mintell4EU and RMIS teams started a dialogue about alternative solutions to facilitate the visibility/dissemination of up-to-date mineral resource data and information through the RMIS web portal. This will be through embedding an EGDI web-GIS viewer in the RMIS.

2 EXECUTIVE REPORT SUMMARY

Most of the KDPs recently developed (e.g., the IKMS for REE (EURare), the EU-MKDP for all deposit types (Minerals4EU), the EU-UMKDP for the urban mine (ProSUM), the EU-CRMKDP for CRMs (SCRREEN) are providing data and information and generally store and manage thematic unstructured knowledge. Some of them have sophisticated applications to exploit their contained data e.g., the e-Minerals Yearbook included in the Minerals4EU geospatial portal and the e-Stat ProSUM module, which now looks like a standalone application and has been renamed 'the Urban Mine Platform'. Different in its spirit and design, the EU-RMICP (Raw Materials Intelligence Capacity Platform) developed in the frame of the H2020 MICA project (and connected to the other above mentioned platforms) is an ontology-based Expert System that can act as a decision-aid tool on all questions related to mineral resources.

All these 'services' and 'applications' are of interest to the RMIS, knowing that (i) the RMIS cannot maintain this data and the harvesting systems or compilation processes that are behind them and (ii) the platforms need to be autonomous in order to ensure their survival.

The Mintell4EU WP5 task T5.1 entitled 'Comparative analysis of KDP's resources versus RMIS 2.0 needs' examined how KDPs can/should deliver their resources to the RMIS, looking at the **Data** level (all platforms), the **Application** level with the e-Minerals Yearbook and the ProSUM e-Stat module and the **Knowledge** level (all platforms).

The assessments made in this study showed that there were several ways to deliver data, information and knowledge from existing platforms to the RMIS (e.g., WFS and ETL process, API and pre-computed views). Deliverable D5.1 (Cassard and Tertre, 2019a) assessed the possible solutions and compared them in terms of ease of implementation, maintenance and sustainability and therefore cost.

One key point regarding the RMIS, is to bring relevant answers to questions - and particularly to complex ones - in a limited time. Searching on the Web may also allow discovering very pertinent answers but the quality of the source has each time to be evaluated, and it may take quite a long time to discover answers fitting with the end user expectations in terms of quality, detail, complexity, formulation and wording… Searching **in already established data corpora, prepared by 'H2020 Experts'**, i.e. in the Knowledge Bases of different Platforms (namely Minerals4EU, ProSUM, EURare, SCRREEN…), allows accelerating the process with the certainty of discovering quality documents and therefore relevant answers.

Deliverable D5.6 presents in detail the 'OpenSearch' API, which is fully operational.

The 'OpenSearch API' was developed as an operational prototype in order to concretize the interoperability between the Mintell4EU data sets served by the EU-MKDP and the RMIS 2.0. Following the Mintell4EU project timeline, this development anticipated the technical compatibility between these two data infrastructures. Meantime, the RMIS team released a technical recommendation note "Channelling knowledge from H2020 projects into the Raw Materials Information System (RMIS) (https://rmis.jrc.ec.europa.eu/uploads/Technical_guidelines_for_knowledge_transfers_into_RMIS.pdf). It turns out that the use of APIs such as the one prototyped by Task 5.6 cannot be enabled for the time being. Instead, the Mintell4EU and RMIS teams started a dialogue about

alternative solutions to facilitate the visibility/dissemination of up-to-date mineral resource data and information through the RMIS web portal. This will be through embedding an EGDI web-GIS viewer in the RMIS.

3 GLOSSARY OF KEY-TERMS USED IN WORK PACKAGE 5

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).

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.

EGDI: European Geological Data Infrastructure (http://www.europe-geology.eu/). EGDI is developed by members of EuroGeoSurveys (the organization of geological surveys in Europe) and organizes and gives access to results from a number of current and previous projects on mineral resources, geo-energy, groundwater, geochemistry, geophysics, geohazards, etc. EGDI will be extended to support data and other results from all GeoERA projects.

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 sytem 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

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). 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).

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7 SUMMARY: THE RMIS, THE EURMKB, THE MAIN KNOWLEDGE DATA PLATFORMS – HOW IS ALL THIS CONNECTED?

7.1 THE RMIS 2.0 GENERAL ARCHITECTURE AND ITS LINKS WITH THE EURMKB

The wording used in the publication entitled 'Raw Materials Information System (RMIS): Towards v2.0 – An interim progress report & roadmap (Manfredi et al., 2017) for describing the relationships between the RMIS and the EURMKB (European Union Raw Materials knowledge Base – European Commission, 2013) is sometimes confusing for an external reader.

In some places, it is clearly said that the 'RMIS provides an entry point to the EURMKB', and that the EURMKB itself 'aims at providing EU level data and information on raw materials from different sources in a harmonized and standardized way'. However in some other places, the RMIS is 'located' in the center of the EURMKB, or it 'acts as a core to the EU Knowledge Base, facilitating the availability of data and information in a coordinated manner.'

This wording, which is very likely used to stress/emphasize the importance of the RMIS role, contributes to generate confusion particularly when attempts are made to understand and graphically represent the EURMKB-RMIS relationships.

If the intention is that the RMIS 2.0 becomes 'a one-stop information gateway', i.e., an entrance or an access to information sources and knowledge, then it would be better represented as an interface making the link between the end users and the data and knowledge repository represented by the EURMKB (Figure 1).

Figure 1 shows the ways RMIS can use data, knowledge and applications stored in the EURMKB, from both national and European levels, and exploit external sources. Some key points related to the general architecture of the whole 'RMIS and EURMKB' system are worthy of note:

- The EURMKB is seen here as a composite of layers, including (i) databases for structured data (D) and unstructured data (K for knowledge), (ii) applications or services (e.g., map viewer, search and download capabilities, dedicated statistical modules like the e-Minerals Yearbook…) and (iii) web interfaces, such as spatial portals. This description complies with the vision of the EURMKB expressed in the Strategic Implementation Plan (SIP) for the European Innovation Partnership (EIP) on Raw Materials (European Commission, 2013, pages 41 and following). The EURMKB is thus not a simple data/knowledge warehouse. The Integrated Knowledge Management System for REE (IKMS - EU-FP7 EURare) (Cassard et al., 2014a, 2017a), the EU-Minerals Knowledge Data Platform (EU-MKDP - EU-FP7 Minerals4EU) (Cassard et al., 2014b), the EU-Urban Mining Knowledge Data Platform (EU-UMKDP – H2020 ProSUM) (Huisman et al., 2016), the EU-Critical Raw Materials Knowledge Data Platform (EU-CRMKDP – H2020 SCRREEN) (Cassard et al., 2019), etc., are built in the same way and are some of the most striking bricks of the EURMKB.

- The RMIS 2.0 is seen as an overarching structure with key roles and tasks, being at the same time:
  (i) **a high-level application producing new knowledge** through the exploitation of the EURMKB's content in parallel with the exploitation of external sources, and
  (ii) **a high-level interface toward end users**, putting at disposal both the EURMKB's content and the new knowledge created.

- This organization schema is in accordance with the '**Cooperation concept**' developed in the Roadmap (Manfredi et al., op. cit.). It is based on an intelligent exploitation and preservation of what has already been done in EU-FP7 and H2020 projects and the intention to build on them in order to provide the end users with enhanced syntheses. This is an application of the well-known **principle of subsidiarity:** the *Oxford English Dictionary* defines subsidiarity as, "the principle that a central authority should have a subsidiary function, performing only those tasks which cannot be performed at a more local level."[1]

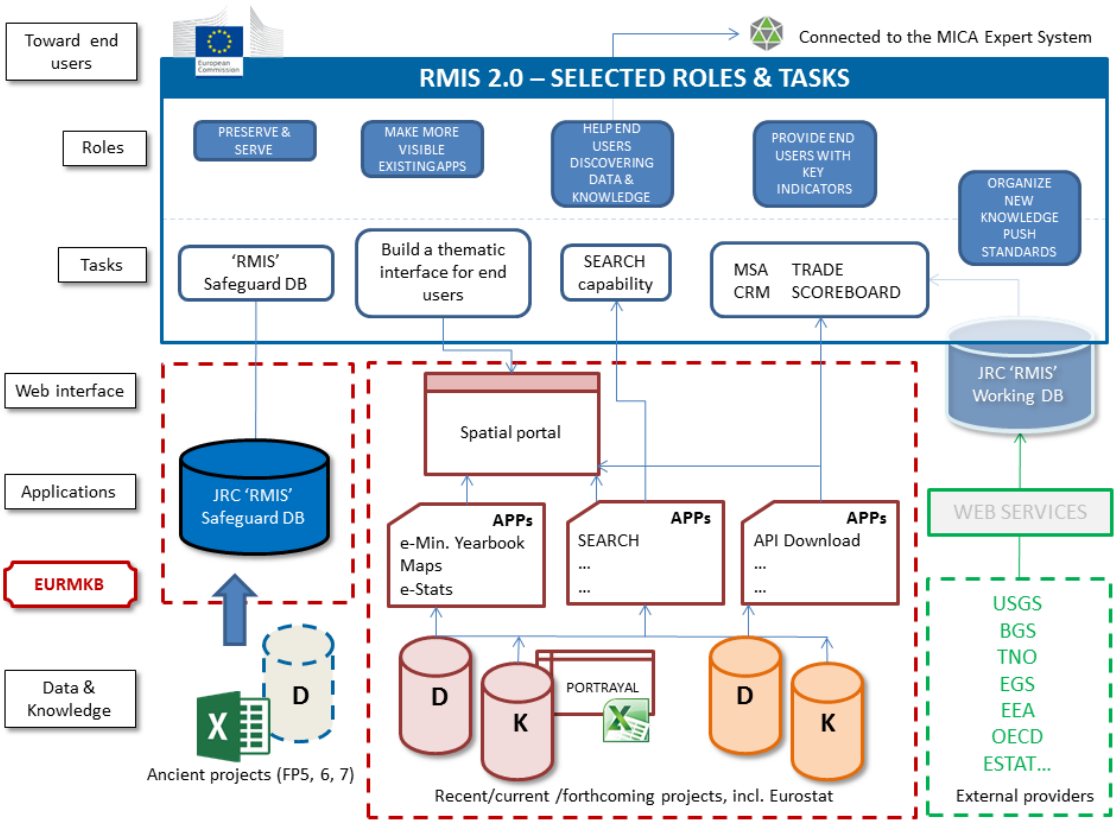

Figure 1. The RMIS 2.0 with some of its most striking roles and tasks.

[1] See: https://en.wikipedia.org/wiki/Subsidiarity

7.2 THE EUROPEAN UNION KNOWLEDGE DATA PLATFORMS CHARACTERISTICS

Several European Knowledge Data Platforms (EU-KDPs) have been developed these last years in the frame of the EU-FP7 and H2020 programs. Two EU-FP7 projects contributed to set the foundations of the EURMKB:

- The **ProMine** project which:
  - collected and collated a great amount of data related to both primary and secondary mineral resources over the whole Europe (Cassard et al., 2015);
  - contributed to define the INSPIRE Mineral Resources data model (European Commission, 2007 ; INSPIRE Thematic Working Group Mineral Resources, 2013) and to improve the EarthResourceML data model (ERML).
- The **EuroGeoSource** project which:
  - collected and collated numerous energy and mineral resources data over several European countries;
  - implemented an INSPIRE compliant distributed architecture.

All the developments done in EURare and Minerals4EU, and then in ProSUM and SCRREEN, reuse and develop the skills acquired within these two projects. These platforms represent the first bricks of both the EURMKB and of the future European Geological Data Infrastructure (EGDI). The technical choices were made to assure effective and sustainable systems designed for facilitating data updates and maintenance, and for offering a full and seamless access to information related to the complete mineral resources value chain.

The technical solutions implemented include:

- The management of both **structured data** from national databases and **semi- and non-structured information**: syntheses and statistics (graph charts and time-series), related to primary and secondary resources, from exploration, production, reserves and resources evaluations to waste characterization… in various formats (text files, PDF files, images…) (Figure 2).
- A **system fully INSPIRE compliant** based on INSPIRE v.3 and EarthResourceML (ERML) v.2 (and now v.3.0[2]) data models, which internally communicates through- and delivers Web services.
- A sustainable system always kept up to date with the adoption and development of **a distributed architecture**.
- A professional architecture with a Central Harvesting Database synchronized with a Central Diffusion Database. The first one controls data quality and the second one is optimized for diffusion. Synchronization is made using SQL scripts (Figure 3).
- Both Harvesting and Diffusion Systems are self-contained systems that can easily be moved to other installations/platforms if needed.

[2] See: https://www.seegrid.csiro.au/subversion/xmml/GGIC/trunk/doc/ERML_3_Doc/index.htm

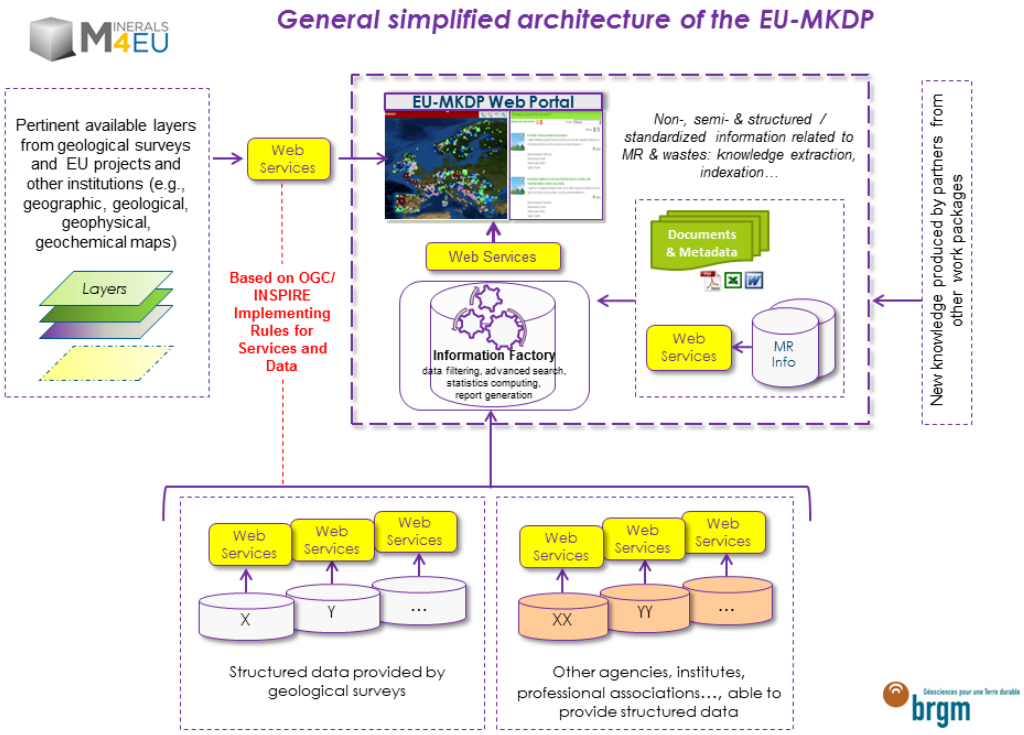

Figure 2. General simplified architecture of the EU-MKDP (Minerals4EU EU-FP7 project).

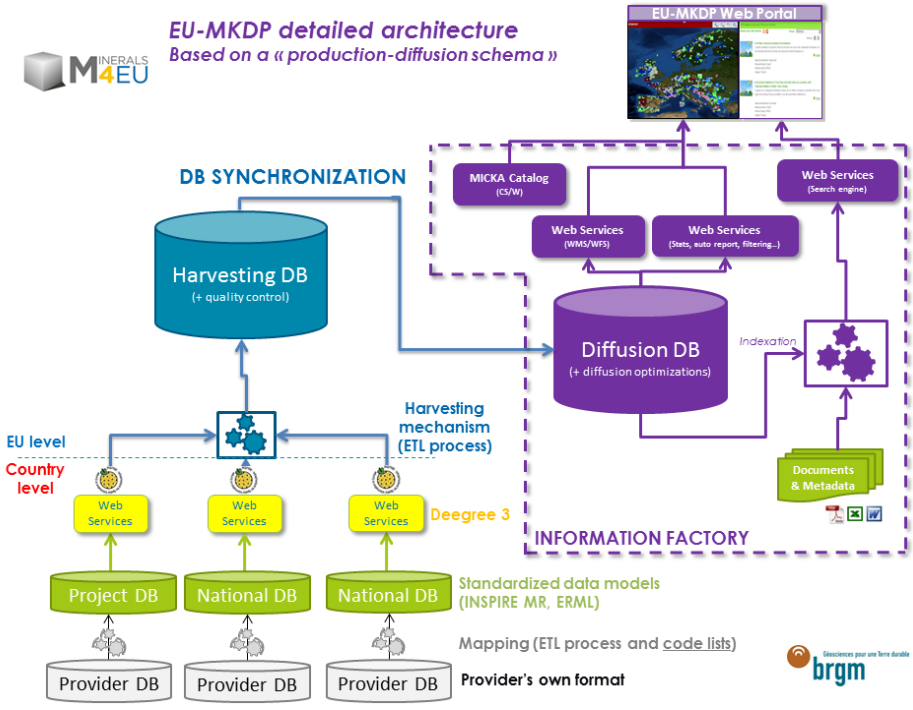

Figure 3. EU-MKDP detailed architecture, based on a 'production-diffusion' schema (Minerals4EU EU-FP7 project).

The technical characteristics of the ProSUM Urban Mining Knowledge Data Platform (EU-UMKDP) slightly differ from this general schema as for WEEE, ELV and BATT, there are no national providers. Data are coming partly from the Eurostat database, but most of them are compiled by professional organizations and universities (Figure 4). This has considerable consequences in terms of maintenance of such a platform.

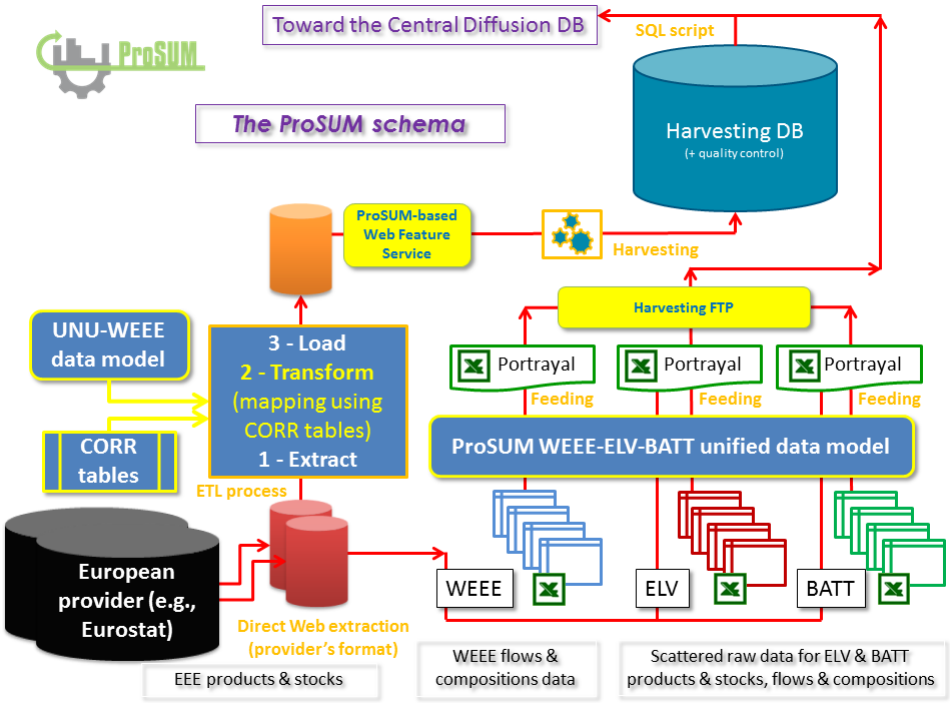

Figure 4. The ProSUM EU-UMKDP architecture. Extract from Cassard and Tertre (2017).

All the platforms are equipped with a geospatial portal making the interface with the end user and allowing him to access to:

- A spatial viewer.
- A powerful Search Capability which allows to search simultaneously in the Central Diffusion PostgreSQL Database (i.e., structured data), the documents corpus and its metadata (i.e., non-structured data), the CSW Metadata Catalog for structured data (called here 'MICKA') and some external databases (if any).
- A set of dedicated applications like the e-Minerals Yearbook[3] (EU-MKDP, Minerals4EU) or those developed in the EU-UMKDP (ProSUM) which exploit the content of the PostgreSQL database and produce on the fly always updated diagrams[4].
- A Download Capability currently implemented in the IKMS (EURare) and the EU-CRMKDP (SCRREEN) and which will be extended to other platforms.

[3] See: http://minerals4eu.brgm-rec.fr/m4eu-yearbook/theme_selection.html

[4] See: http://www.urbanmineplatform.eu/homepage

These characteristics show that the EURMKB is far more than a simple data/knowledge warehouse. The EURMKB is a composite of layers, including:

(i) databases for structured and unstructured data,
(ii) applications or services and,
(iii) Web interfaces, such as spatial portals.

This description complies with the vision of the EURMKB expressed in the Strategic Implementation Plan (SIP) for the European Innovation Partnership (EIP) on Raw Materials (Part II, Final version – 18/09/2013 – pp. 41-44).

7.3 A UNIFIED VISION OF EU KNOWLEDGE DATA PLATFORMS

In practice, several Knowledge Data Platforms, because they are built on the same data model, share the same database infrastructure. There is one single Harvesting DB and on single Diffusion DB for the IKMS (REE data), the MKDP (all types of mineral resources), the CRMKDP (CRM data) (

Figure 5).

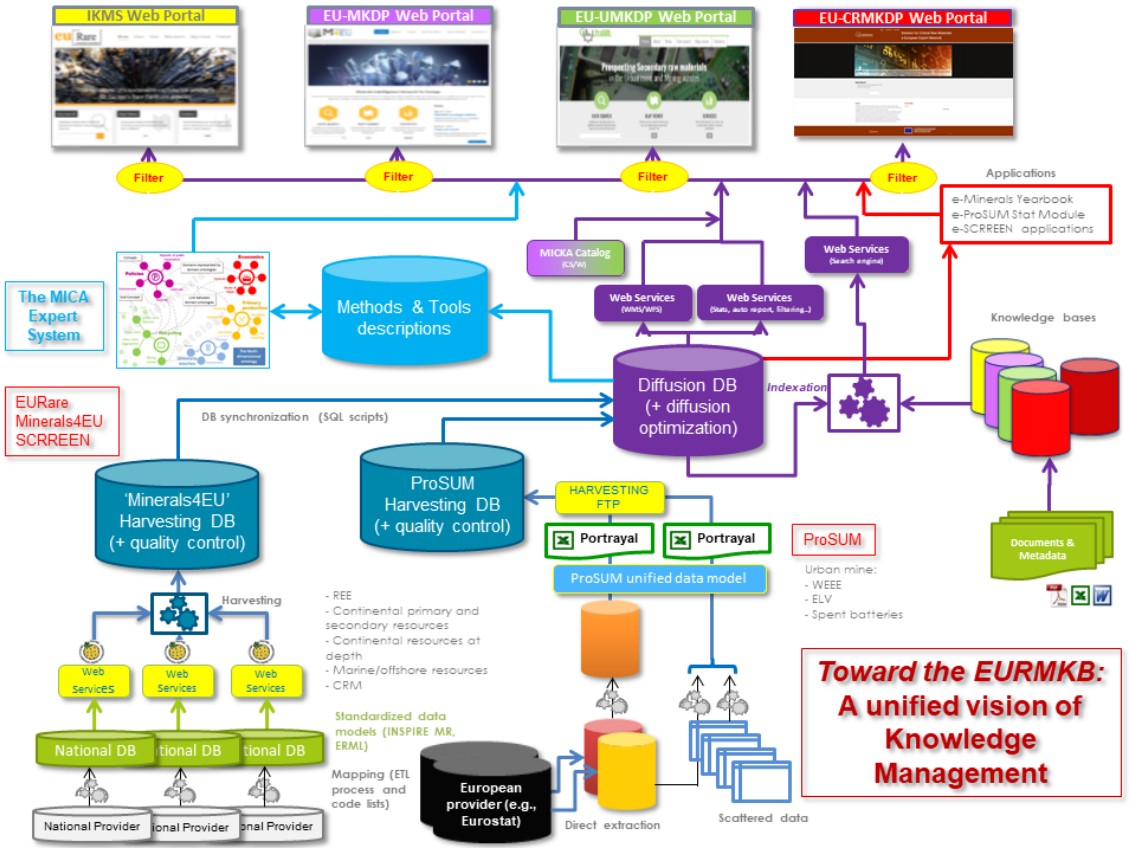

Figure 5. A unified vision of Knowledge Management in the Raw Materials domain, and the first steps for building the EURMKB (Cassard and Tertre, 2017).

Data sent from the Central Diffusion DB to the different geospatial portals are filtered on one or several criteria (e.g., commodity, nameSpace…) depending on the portal thematics.

Two platforms do not share the same architecture as the others: the ProSUM EU-UMKDP and the MICA EU-RMICP. The EU-UMKDP is dealing with the urban mine and secondary resources from WEEE, ELV and BATT (see Glossary), and the features to modelize and the ways to get the data were so different from primary resources that this necessitated the development of a dedicated data model, 'the ProSUM Unified data model', the use of portrayals and the development of a specific harvesting DB. The EU-RMICP (Cassard et al., 2017b; Ziébelin et al., 2018), can be considered as an Expert System allowing a end user to find an answer of the type 'how to proceed' when he has a question/query (simple or complex) related to raw materials in general or mineral resources. The system is based on a Dynamic Decision Graph (DDG) allowing the navigation over a Raw Materials Ontology coupled with a database of Methods and Tools (in practice, a TripleStore or RDF store) elaborated by experts. This system is also connected to other information platforms, including recently the RMIS 2.0 (through the SCRREEN project) (see also Figure 1 – upper part).

This review does not pretend to be exhaustive. It is mostly based on European projects led in a broad sense by EuroGeoSurveys partners, i.e., the Mineral Resources/Mining departments of European Geological Surveys that were/are also strongly involved in the implementation of (i) the INSPIRE directive (European Commission, 2007 ; INSPIRE Thematic Working Group Mineral Resources, 2013) and (ii) the FAIR guidelines (European Commission, 2016a). There is thus presently a homogeneous set of data that can be provided to JRC for the development of the RMIS.

8 ABOUT APIS AND THEIR INTEREST FOR THE RMIS

Automated data recovery can be performed through OGC Web services (Web Map Services [WMS] and Web Feature Services [WFS]) **which can be seen as very simple APIs** (Application Programming Interfaces). These services describe themselves and provide requests to retrieve maps (in the case of WMS), or access to raw data (in the case of WFS). One also could speak of 'Standardized API' for OGC services vs. 'Custom API' for more elaborate and dynamic Web APIs[5]. Said in other words, all Web services are APIs but all APIs are not Web services.

API's are a more sophisticated approach as they allow a full parametrization of the data access process. Only a few sites among those likely to feed the RMIS propose such a component, e.g., UN Comtrade Database, USGS, WITS and the World Bank. Figure 6 briefly summarizes the relationships between a client and an external server which delivers the data in the expected format via an API.

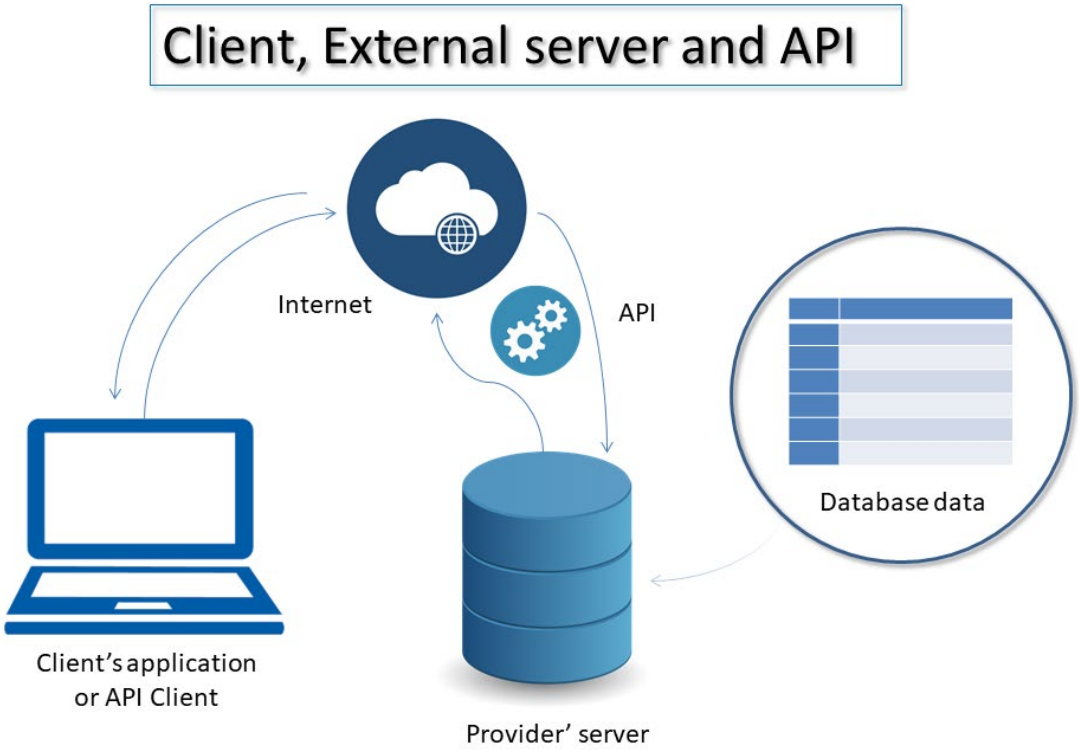

Figure 6. Overview of the relationships between a client and an external server via an API.

[5] See for example: https://blogs.mulesoft.com/dev/api-dev/apis-versus-web-services/ or http://www.differencebetween.net/technology/internet/difference-between-api-and-web-service/

An API 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. Said differently, an API is a code that allows two software programs to communicate with each other.

An API is the tool that makes a website's data digestible for a computer. Through it, a computer can view and edit data, just like a person can by loading pages and submitting forms.

APIs are made up of two related elements. The first is a specification that describes how information is exchanged between programs, done in the form of a request for processing and a return of the necessary data. The second is a software interface written to that specification and published in some way for use.

When systems link up through an API, it is said they are integrated: on one side the server that serves the API, and the other side the client that consumes the API and can manipulate it (Figure 7). The software that wants to access the features and capabilities of the API is said to call it, and the software that creates the API is said to publish it.

In the case of the RMIS and the access to the Minerals4EU dataset (i.e., structured data related to all types of mineral/ore deposits), the development of a ERML-Lite-based API can be considered, this initiating a very first step toward an e-Scoreboard. Because a new, fully operational, version of ERML-Lite[6] (Vuollo et al., 2018) has just been released, and because ERML-Lite is incredibly easier 'to manipulate' than the full version of ERML, this makes possible to even envisage such a development in the frame of Mintell4EU (e.g., in Work Package 5, Task T5.4).

In the same way, and in synergy with the H2020 SCRREEN project (work package 9 'Knowledge management'), the development of a ProSUM-based API related to the urban mine (WEEE, ELV & BATT), and dealing with data on products and stocks and flows and composition has been realized in the frame of Mintell4EU Work Package 5 Task T5.5, (Deliverable D5.5 - Cassard and Tertre, 2019b), thus providing the RMIS 2.0 with essential data for material flow and system analysis.

[6] ERML-Lite v.2.0.1 is a fully-compliant but eased/lightened version of ERML. The splitting of the full ERML schema into several dedicated 'views' makes ERML-Lite easier to use, favouring new developments. See: http://earthresourceml.org/

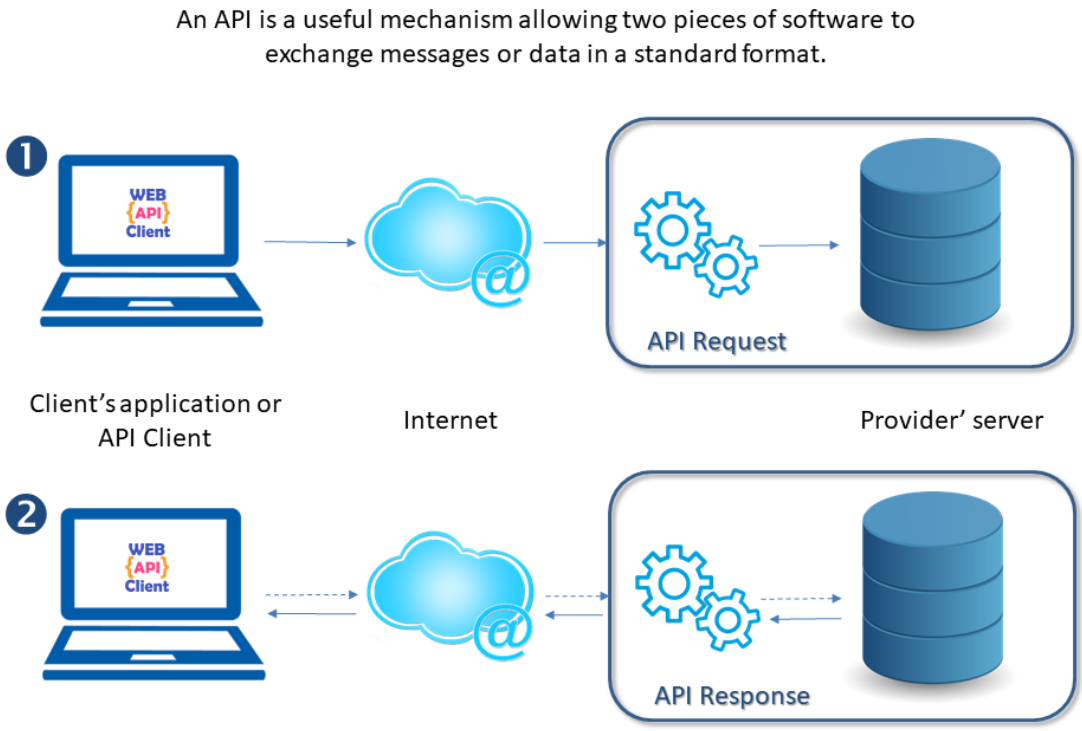

Figure 7. API: the provider' server side and the client's application.

9 A POWERFUL SEARCH CAPABILITY FOR THE RMIS CONNECTED TO KDP'S EXISTING ONES

All the Knowledge Data Platforms developed by the EGS Core Team (BRGM, CGS, GeoZS, GEUS) are endowed with a powerful Search Capability.

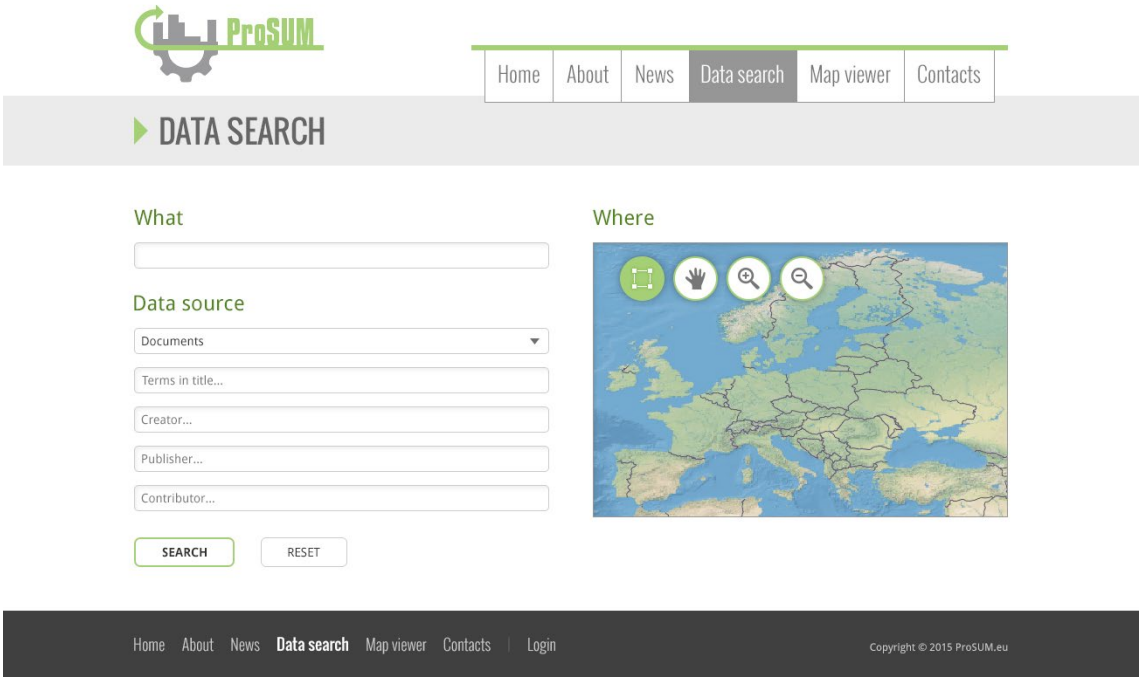

Figure 8. The Search interface of the EU-UMKDP (H2020 ProSUM project).

This Search facility is based on a search engine indexing (via Apache Solr - http://lucene.apache.org/solr/) the Central Diffusion Database (i.e., structured data), the documents corpora and its metadata (i.e., non-structured data), the CSW Metadata Catalog for structured data (called here 'MICKA') and some external databases (if any). A user interface allows end users to retrieve data from the whole Knowledge Data Platform using either a simple input like a Google-like search, i.e., a simple sentence (What?)[7] or using some specialized interfaces[8]. Almost all the indexed concepts have geographic and temporal extents (coming from the INSPIRE MR/ERML [and other possible] data model(s) for the Diffusion Database, or coming from the Dublin Core metadata for the documents). These extents allow the user (i) to perform geographic searches using the spatial interface (Where?) and (ii) to retrieve the most accurate response(s) for his search (Figure 8).

[7] Searching in the whole KDP.

[8] Searching for specific concepts using their main attributes, e.g., selecting a data source and searching in the 'Creator' field and/or in the 'Title' field of the document, or for Mining Wastes, searching according to the name of the related mine, or to the commodity…

It is quite conceivable that the RMIS 2.0 could connect to these different Search capabilities as suggested in Figure 1. In addition to its own search facilities, this would allow this information system performing more targeted searches (e.g., on CRM, on secondary resources like WEEE, BATT or ELV…) and benefiting from already constituted corpora of information and knowledge.

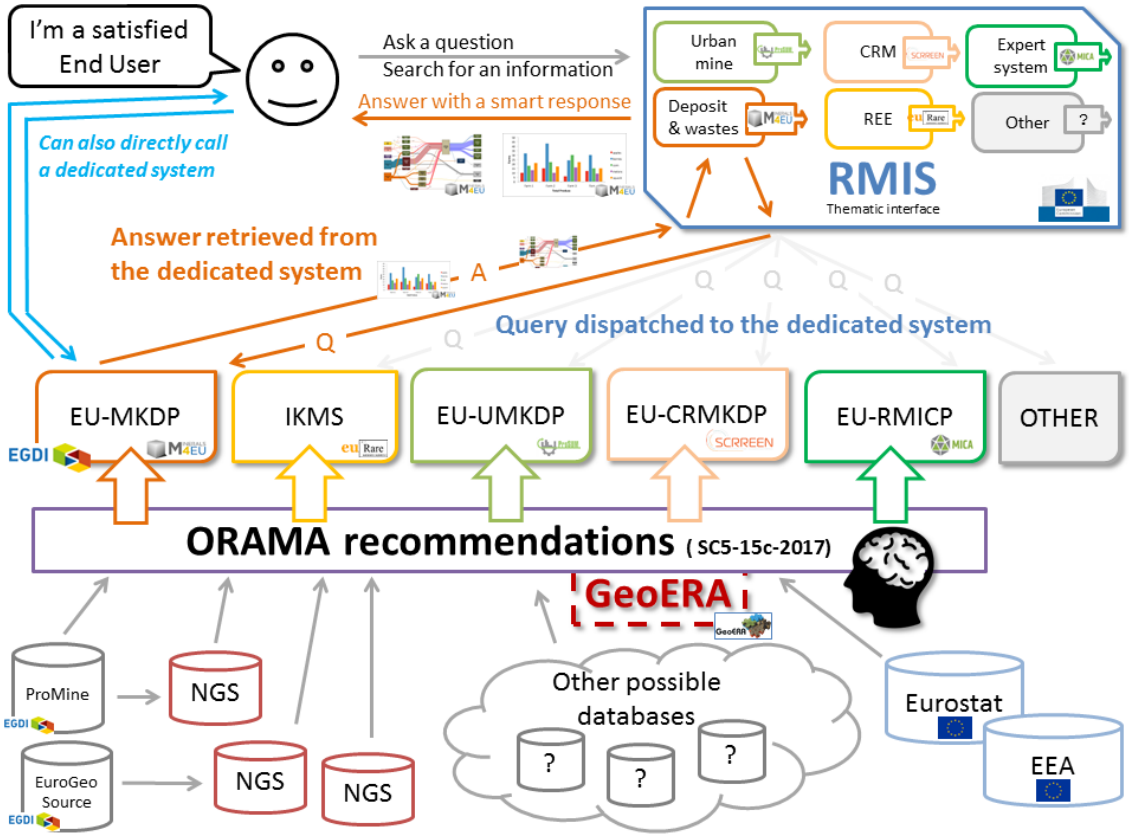

Figure 9. Relationships between the RMIS 2.0 and external services and applications, and the role played by the ORAMA project and the GeoERA program in the improvement of datasets. The MICA Expert System is represented by the brain. Extract from Cassard and Tertre (2017), modified.

As in the 'Application' interface (see Figure 1), a dedicated 'Search' Capability interface should be developed in the RMIS, allowing at the same time the end user to perform generic (on the Web) and/or more targeted searches. The idea developed here is that the end user is capable to perform the search directly through the RMIS 2.0 interface, the results being displayed to him within this same interface, and this solution relies on the search capabilities of the existing KDPs that are part of the EURMKB. The end user obviously should also have the possibility to search directly in the original platform (Figure 9).

➔ Technically, this supposes that existing KDPs propose a search interface (API) that can be requested from the RMIS (with CORS limitation, see glossary). These search

interfaces need to be standardized and the use of **OpenSearch**[9] might be considered (at this stage, none of the Minerals4EU, EURare or ProSUM KDPs propose such kind of search interface). Then the RMIS would have to implement the client-side of OpenSearch to be able to request these KDPs.

OpenSearch is a collection of technologies that allow publishing of search results in a format suitable for syndication and aggregation. It is a way for websites and search engines to publish search results in a standard and accessible format (see https://en.wikipedia.org/wiki/OpenSearch for a brief description and http://www.opensearch.org/Home for more details).

Figure 10 summarizes how OpenSearch works:

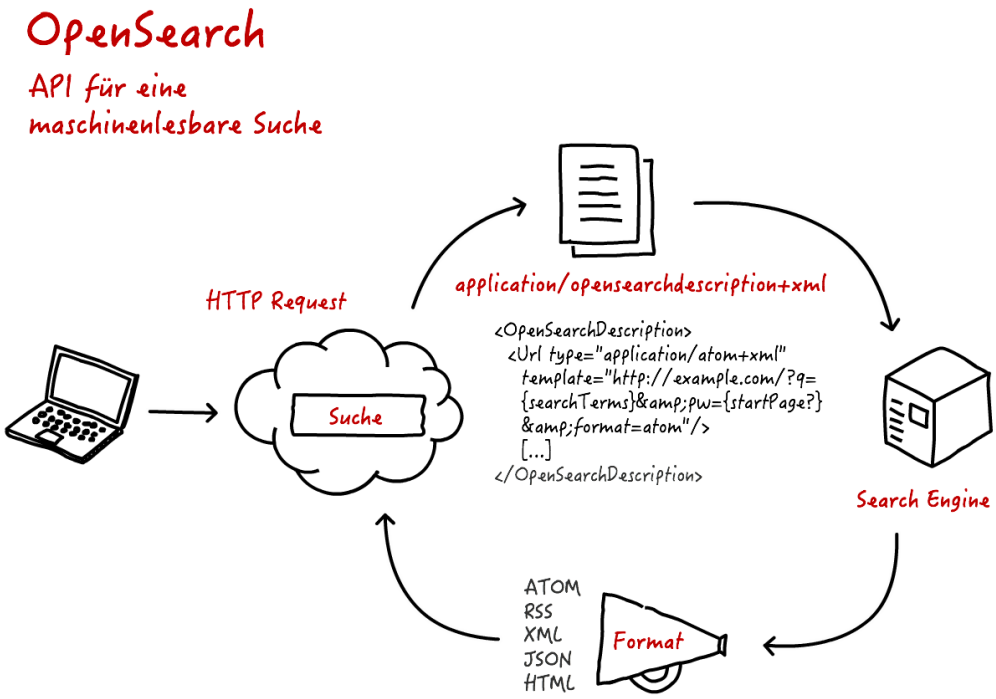

Figure 10. OpenSearch API is a collection of simple formats for the sharing of search results (see https://github.com/dewitt/opensearch).

➔ Mintell4EU will benefit from the synergy with the H2020 SCRREEN project. An attempt to make the RMIS benefiting from the SCRREEN CRM Knowledge Base content is currently underway in Work Package 9 'Knowledge Management' (Cassard et al., 2019). Once the various problems related to this implementation will be resolved, it is here, in this project, that the implementation of the OpenSearch API will be extended to allow the connection of the RMIS 2.0 to other Knowledge Bases such as those of the IKMS, of the EU-MKDP and of the EU-UMKDP, for respectively REEs, all mineral/ore deposit types and the urban mine non-structured data.

[9] http://www.opensearch.org/Home

10 PRESENTATION OF THE OPENSEARCH API

Note about the SCRREEN – MINTELL4EU OPENSEARCH API

The *DataSearch* developed in the scope of the SCRREEN project (http://scrreen.eu/) (see Cassard et al., 2019) in synergy with MINTELL4EU – WP5, exposes an API based on the OpenSearch protocol (http://www.opensearch.org)[10].

BASE URL OF THE API

The SCRREEN OpenSearch base URL is: http://scrreen.brgm-rec.fr/opensearch/apachesolr_search/

CORS

Right now, the API accepts all the origins (i.e. *Access-Control-Allow-Origin: **), so all external websites can reuse the data. In the future, if an abuse is noticed, a whitelist might be settled up.

OPENSEARCH API EXPLANATION

DATA SOURCES RETURNED

All the available data and documents present in the SCRREEN Knowledge Platform are exposed via this API.

SEARCH URI COMPOSITION

The URI is composed as described in the description document:

http://scrreen.brgm-rec.fr/search/apachesolr_search/{searchTerms}

One has to replace {searchTerms} by his own request. The request is based on the SOLR query language (http://archive.apache.org/dist/lucene/solr/ref-guide/apache-solr-ref-guide-5.5.pdf - section *The Standard Query Parser*)

The query result is paginated. To access directly a page one has to add the page parameter in the query string:

http://scrreen.brgm-rec.fr/search/apachesolr_search/{searchTerms}?page=[n]

[10] OpenSearch logo taken from: https://colhub.copernicus.eu/userguide/APIsOverview

RESULT FORMAT

The result is formatted following the RSS 2.0 normalization (https://validator.w3.org/feed/docs/rss2.html).

OPENSEARCH EXTENSIONS

Some extensions are available as specified in the OpenSearch protocol:

- *opensearch:totalResults*: specify the total results of the search
- *opensearch:startIndex*: specify the index of the first item in the current page
- *opensearch:itemsPerPage*: specify the number of items returns in a page
- *opensearch:Query*: specify the query received

RSS EXTENSIONS

Some link elements (atom:link) are present to facilitate the navigation between the results:

- *rel="prev"*: specify the url to access to the previous result page. It is not present on the first page.
- *rel="next"*: specify the url to access to the next result page. It is not present on the last page.

ITEMS CONTENT

Each item in the flow is composed of the following elements:

- *title*: The title of the item, for mine occurrences and mineral occurrences, it is the name of the mine.
- *link*: The link to the detail page of the item.
- *description*: The description of the item. For documents, it is the subject list. For mineral occurrences, it is the commodity list.
- *guid*: it's the RSS unique identifier of the item.

QUERY SAMPLES

- http://scrreen.brgm-rec.fr/opensearch/apachesolr_search/nickel

This request will return all the data where the word 'nickel' is present in any field (title, description, subject …)

- http://scrreen.brgm-rec.fr/opensearch/apachesolr_search/bundle_name:mineralOccurence

This request will return all the mineral occurrences presents in the knowledge portal.

- http://scrreen.brgm-rec.fr/opensearch/apachesolr_search/sm_field_country_code:AT

This request will return all the Austrian's data.

- http://scrreen.brgm-rec.fr/opensearch/apachesolr_search/sm_field_country_code:AT%20and%20sm_field_commodity_term:tungsten

This request will return all the Austrian's data with nickel present as a commodity.

RESPONSE SAMPLE

```
<?xml version="1.0" encoding="utf-8" ?>
<rss version="2.0" xmlns:atom="http://www.w3.org/2005/Atom"
xmlns:opensearch="http://a9.com/-/spec/opensearch/1.1/"
xmlns:relevance="http://a9.com/-/opensearch/extensions/relevance/1.0/">
   <channel>
      <title>scrreen.brgm-rec.fr Site search: sm_field_country_code:AT and
sm_field_commodity_term:tungsten</title>
      <link>http://scrreen.brgm-rec.fr</link>
      <description>Site search results for &amp;quot;sm_field_country_code:AT and
sm_field_commodity_term:tungsten&amp;quot; at scrreen.brgm-rec.fr</description>
      <language>en</language>
      <opensearch:totalResults>57</opensearch:totalResults>
      <opensearch:startIndex>1</opensearch:startIndex>
      <opensearch:itemsPerPage>10</opensearch:itemsPerPage>
      <atom:link rel="self" href="http://scrreen.brgm-
rec.fr/opensearch/apachesolr_search/sm_field_country_code%253AAT%2Band%2Bs
m_field_commodity_term%253Atungsten" type="application/rss+xml" />
      <atom:link rel="search" href="http://scrreen.brgm-
rec.fr/opensearch/apachesolr_search" type="application/opensearchdescription+xml"
/>
      <atom:link rel="alternate" href="http://scrreen.brgm-
rec.fr/search/apachesolr_search" type="text/html" />
      <opensearch:Query role="request" searchTerms="sm_field_country_code:AT and
sm_field_commodity_term:tungsten" />
      <atom:link rel="next" href="http://scrreen.brgm-
rec.fr/opensearch/apachesolr_search/sm_field_country_code%253AAT%2Band%2Bs
m_field_commodity_term%253Atungsten?page=2" type="application/rss+xml" />
      <item>
         <title>Altenbergtal</title>
         <link>http://scrreen.brgm-rec.fr/fiche/mineral_occurence/4349</link>
         <description>tungsten</description>
         <guid isPermaLink="false">http://scrreen.brgm-
rec.fr/fiche/mineral_occurence/4349</guid>
      </item>
   </channel>
</rss>
```

11 OPENSEARCH API IMPLEMENTATION IN OTHER KNOWLEDGE DATA PLATFORMS

The OpenSearch API has also been implementated in other existing KDPs, allowing thus the RMIS to perform targeted searches in specific data corpora such as primary resources / all mineral deposit types, and mining wastes (Minerals4EU), REE (EURare), the urban mine, i.e., WEEE, ELV and BATT (ProSUM), in addition to CRMs (SCRREEN, see above).

The different URLs for the OpenSearch API are:

- http://prosum.brgm-rec.fr/opensearch/apachesolr_search/
- http://minerals4eu.brgm-rec.fr/opensearch/apachesolr_search/mine
- http://eurare.brgm-rec.fr/opensearch/apachesolr_search/mine

Note 1: The ProSUM portal will be transferred from a development server to a production server. The date of this transfer is currently (April 2019) not known. The new URL will be http://www.prosumportal.eu, which will therefore replace in the URL given above the part http://prosum.brgm-rec.fr.

Note 2: The Minerals4EU portal will also be tranferred from a development server to a production server. The date of this transfer is currently (April 2019) not known. The new URL will be http://minerals4eu.brgm.fr, which will therefore replace in the URL given above the part http://minerals4eu.brgm-rec.fr.

Note 3: The implementation of the 'SCRREEN – MINTELL4EU' OpenSearch API is currently under way in the H2020 MIREU project (https://mireu.eu/).

12 CONCLUSION

Table 1 from Deliverable D5.1, was an attempt to summarize the recommendations made regarding the transfer of part(s) of data and information, aggregated data and knowledge stored in KDPs to the RMIS 2.0.

DIKW	Detailed type	Type of transfer	RMIS' target	Synergy with
D, I	Structured data. Primary resources (Mineral4EU, EURare, SCRREEN)	▶ WFS + ETL (not recommended) ▶ API based on ERML-Lite (recommended).	ScoreBoard	-
D, I	Structured data. Secondary resources – Mining wastes (Minerals4EU, ProSUM)	▶ WFS + ETL (not recommended) ▶ API based on ERML-Lite (recommended).	ScoreBoard	-
D, I	Structured data. Secondary resources - Urban mine (ProSUM)	▶ API 'ProSUM e-Stat' ▶ Pre-computed views	Scoreboard, MSA	SCRREEN
D, I	Structured data. Aggregated data (e-Minerals Yearbook)	▶ API 'e-MY' ▶ Pre-computed views	ScoreBoard, MSA, CRM, Trade	ORAMA
K	Knowledge from Knowledge Bases (all platforms)	▶ API 'OpenSearch'	RMIS Search Capability	SCRREEN
W	Methods & Tools. Ontology-based MICA Expert System	▶ Connection via newly developed sheets	RMIS Search Capability Decision-aid system	SCRREEN

*DIKW refers to Data, Information, Knowledge, and Wisdom (or intelligence).

Table 1. Mintell4EU Deliverable D5.1: Summary of recommendations (from Cassard and Tertre, 2019a).

Deliverable D5.6 is thus one of the first steps (with D5.5 [Cassard and Tertre, 2019b] and the creation of the 'UrbanMinePlatform' or 'ProSUM' API) of a series of developments whose role is to improve the communication and the exchanges between the existing KDPs and the RMIS. Note that since the writing of Deliverable D5.1, the synergy with the SCRREEN project has become fully operational (see Cassard et al., 2019), leading to the joint development of the SCRREEN-MINTELL4EU OpenSearch API.

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