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EU-Raw Materials Intelligence Capacity Platform (EU-RMCP) – Technical system specification

Daniel Cassard, François Tertre, (BRGM, France)

Danielle Ziebelin, Philippe Genoud, Marie-Jeanne Natete, (LIG, Grenoble University, France)

Jakob Molander, (GEUS, Danmark)

Nicole Ostlaender, Robert Tomas, Emanuela Epure
(DG JRC)

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MICA Mineral Intelligence
Capacity Analysis

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Contact information Name: Robert Tomas
Address: Via Fermi, 21027 Ispra (VA), Italy
Email: robert.tomas@ec.europa.eu
Tel.: +390332785426

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Authors

Daniel Cassard, François Tertre, (BRGM, France) ;

Danielle Ziebelin, Philippe Genoud, Marie-Jeanne Natete, (LIG, Grenoble University, France) ;

Jakob Molander, (GEUS, Danmark) ;

Nicole Ostlaender, Robert Tomas, Emanuela Epure (EC - DG JRC)

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TABLE OF CONTENTS

TABLE OF CONTENTS	5
LIST OF TABLES AND ILLUSTRATIONS	6
PURPOSE	8
EXECUTIVE SUMMARY	9
DELIVERABLE REPORT	13
1. Introduction.....	13
2. The MICA Main Ontology and the associated knowledge	14
2.1 The MICA Main Ontology and the generic, transverse ontologies.....	14
2.2 The knowledge containers: the different types of sheets.....	14
3. Relationships with GeoNetwork.....	16
4. The MICASheetEditor development.....	18
4.1 New MICASheet	18
4.2 New flowSheet.....	19
4.3 New linkedSheet.....	19
4.4 New FAQ	19
4.5 Searching.....	19
4.6 Updating	20
5. The MICA Triple Store.....	30
6. The innermost mechanics of the system (ontology management, MICA data model, URIs, querying the Triple Store ..).....	33
6.1 Ontology management.....	33
6.2 MICA URIs.....	36
6.3 MICA Data Model.....	39
6.4 Querying the MICA Triple Store.....	43
7. The ranking of results by relevance	46
7.1 Inferencing and the Search Task.....	48
7.2 Ranking Task.....	51
8. The DDG and its side applications: the interface with end users.....	58
9. The connection with other Knowledge Data Platforms (KDPs), including the RMIS 2.0	65
10. Conclusion.....	66
11. References	68

Appendix 1. The MICA Main Ontology concepts (version 24/07/2017).....	70
Appendix 2. The MICA Main multidimensional Ontology (DomainScheme), the transverse ontologies and the links between concepts and with other schemes (version 07/11/2017)	76
Appendix 3. Overview of the doc/fact/linked/flowSheets prepared by in the frame of the project (September 2017)	116
Appendix 4. SPARQL Queries for the DDG	121
Appendix 5. SPARQL Queries for the MICASheetEditor	139
Appendix 6. Inference rules for the MICA Triple Store	180

LIST OF TABLES AND ILLUSTRATIONS

Table 1 Ranking results for multiple concepts search.....	57
Figure 1 WP6 objective, and the Dynamic Decision Graph.....	8
Figure 2. The MICA Expert System. General architecture of the EU-Raw Materials Intelligence Capacity Platform.....	10
Figure 3 The DDG interface showing the Main Ontology and the 7 domains covered, representing about 300 concepts and sub-concepts.....	11
Figure 4 Left: Structure of a factSheet, showing the different rubrics and the Indexation section. Right: factSheets and docSheets indexation over (or annotation with) the main ontology.....	12
Figure 5 Interactions between the EU-RMICP components.....	16
Figure 6 New MICASheet.....	21
Figure 7 New author.....	22
Figure 8 New flowSheet.....	23
Figure 9 New linkedSheet.....	24
Figure 10 New Question.....	25
Figure 11 Search existing sheets.....	26
Figure 12 Update a MICASheet.....	27
Figure 13 Update a flowSheet.....	28
Figure 14 Update a linkedSheet.....	29

Figure 15 MICA databases (Triple Store and relational) server.....	30
Figure 16 VocBench web-interface for collaborative edition of MICA ontologies.	33
Figure 17 Management tools for the MICA Ontology.....	34
Figure 18 Transformation of MICA main (Domain) ontology and transversal ontologies structured with concepts schemes into a “pure” tree of concepts.....	35
Figure 19 HTML page for rapid navigation between related concepts.....	36
Figure 20 Redirection of URIs using the w3id service.....	37
Figure 21 Content negotiation for MICA resources.....	39
Figure 22 HTML page corresponding to the MICASheet resource about Mine closure.....	40
Figure 23 UML diagram class of MICA data model.....	42
Figure 24 Sample MICASheets annotated with D1 (PRIMARY MINERAL RESOURCES) concepts.....	47
Figure 25 RDF graph of annotated MICA resources.....	48
Figure 26 SKOS broaderTransitive inferences.....	49
Figure 27 Saturation of the concepts graph with the skos:broaderTransitive inferences.....	50
Figure 28 Resources associated to C1_1 (Resource Assessment) concept.....	51
Figure 29 Semantic distance between concepts.....	52
Figure 30 Ranking of resources for search based on C1_1 (Resource Assessment) concept.....	53
Figure 31 Ranking example with multiple concepts search.....	56
Figure 32 MICA end-user application: DDG and side applications.....	58
Figure 33 MICA Graph Application.....	59
Figure 34 MICA Wizard Application. Presentation of a simplified workflow.....	62
Figure 35 MICA Direct Search Application.....	63
Figure 36 MICA FAQs Application.....	64

PURPOSE

If specialists have – at least for some facets or sub-domains – the necessary knowledge on how to efficiently use all the data which is available to perform various studies, most of the stakeholders do not have the combined set of essential skills allowing such an efficient use of this data for solving problems they may meet. Actually:

- (i) they neither have a clear and global vision of all the methods and tools that can be used,
- (ii) nor know how to implement these methods and tools, their limits of use (requisite characteristics of the initial dataset, scale, accuracy ...),
- (iii) how to choose the best available technique (BAT) to obtain the expected result(s) and/or, if necessary,
- (iv) how to combine or link several of these techniques.

The objective of the MICA project is to fill this gap in the chain of use of data and to allow the end user to select in a seamless way the best available set of technologies for answering his/her question(s)/problem(s).

To reach this objective work package 6 (WP6) has created a database of methodologies and tools descriptions with an ontology-based interface (a Dynamic Decision Graph or DDG) to visualize the database content and the relationships between the different techniques, and to search for the most appropriate method(s) and tool(s) (Figure 1). The descriptions are called ‘factSheets’ and ‘flowSheets’; factSheets describe single methods/tools, and flowSheets describe how to link several methods (and the data) for answering complex queries.

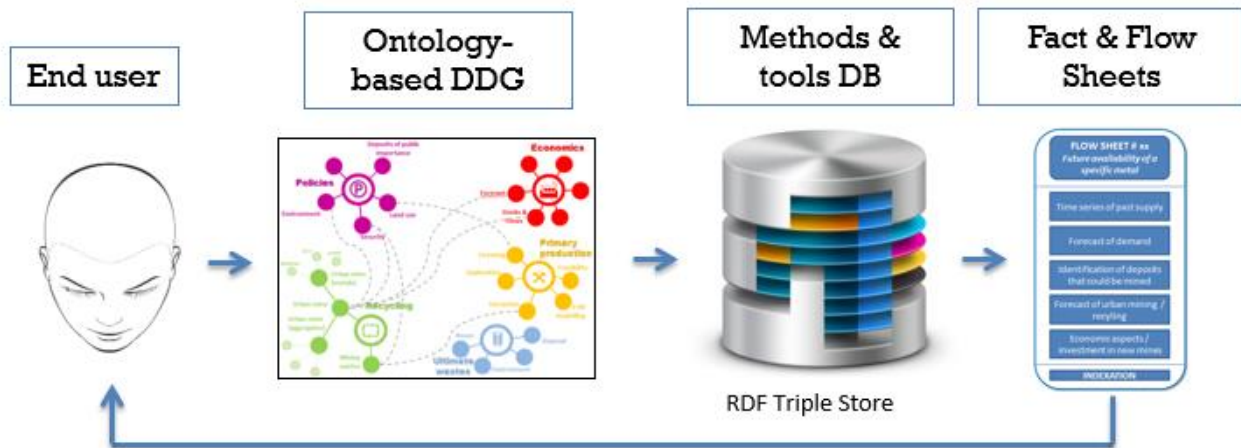


Figure 1 WP6 objective, and the Dynamic Decision Graph.

The MICA DDG and its side applications can be accessed at: <http://micaontology.brgm-rec.fr/MICAOntology/> (note that this URL is provisional and may change in the future).

EXECUTIVE SUMMARY

THE MICA EXPERT SYSTEM: AN OVERVIEW

The MICA Expert System is currently being developed in the frame of the H2020 MICA project; more precisely within its work package 6 entitled 'The European Raw Materials Intelligence Capacity Platform (EU-RMICP)' whose partners are BRGM, GeoZS, GEUS, GTK, JRC, LIG (Laboratoire d'Informatique de Grenoble) and NERC (BGS).

The description of the project can be found on the project website (www.mica-project.eu/). To briefly summarize: MICA (Mineral Intelligence Capacity Analysis – 2015-2017) has among its objectives to develop a platform of knowledge, the EU-Raw Materials Intelligence Capacity Platform (or EU-RMICP), integrating metadata on data sources related to primary and secondary mineral resources and bringing the end users with an expertise on the methods and tools used in mineral intelligence. In practice, the system should be capable of bringing relevant 'answers' of the type 'how to proceed for ...' on almost any question related to mineral resources, on the whole supply chain, from prospecting to recycling, taking into account the environmental, political and social dimensions.

To meet this challenge, the EU-RMICP is based on an ontology of the domain of mineral resources (coupled with more generic cross-functional ontologies, relative to commodities, time and space), which represents the domain of the questions of the users (experts and non-experts). The user navigates in the ontology by using a Dynamic Graph of Decision (DDG), which allows him/her to discover the solutions which he/she is looking for without having to formulate any question. The system is coupled with a 'RDF Triple Store' (a database storing the ontologies), factSheets, docSheets and flowSheets (i.e., specific formatted forms) related to methods and documentation, scenarios and metadata (Figure 2).

This particularly innovative system can be widened (perimeter or scope and granularity) and represents now a prototype of a modern expert system.

In practice, this system will be connected with the existing Knowledge Data Platforms (KDPs), e.g. the IKMS (EURare), the EU-MKDP (Minerals4EU), the EU-UMKDP (ProSUM), the EU-CRMKDP (SCRREEN), the European Geological Data Infrastructure (EGDI) developed by EuroGeoSurveys (EGS) and the RMIS 2.0 (Raw Materials Information System) which is currently being developed by the European Commission DG JRC in Ispra, allowing all these KDPs to enable their users from benefitting of the Expert System (see Figure 2).

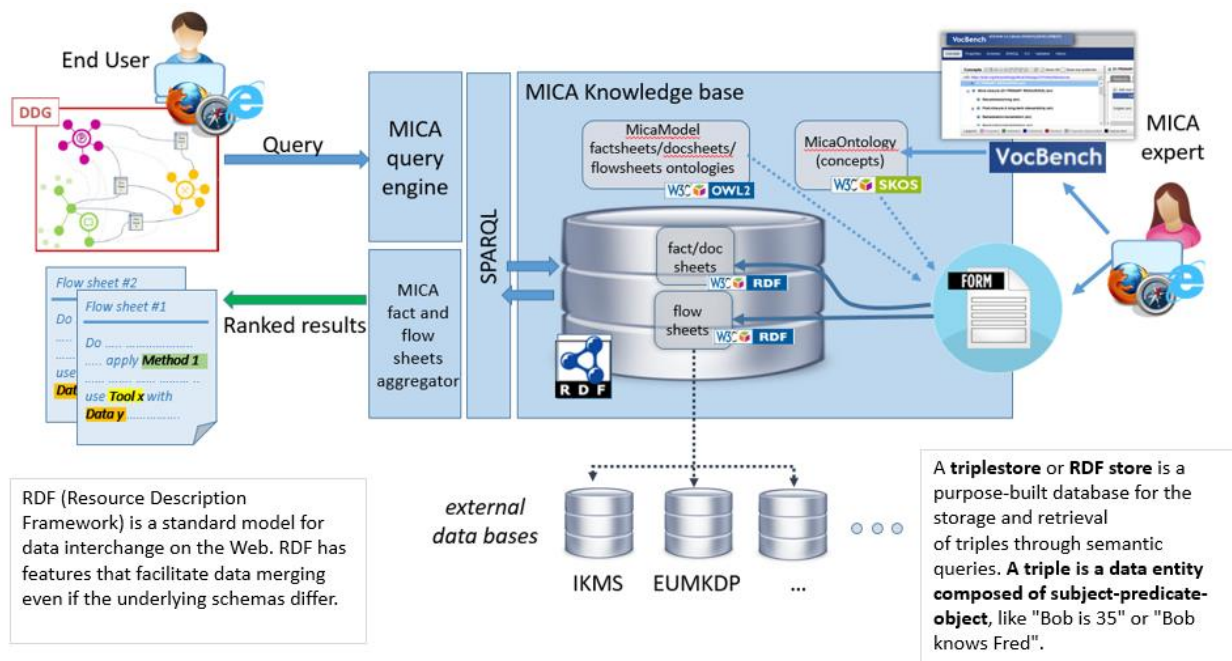


Figure 2. The MICA Expert System. General architecture of the EU-Raw Materials Intelligence Capacity Platform.

The MICA Main Ontology actually covers 7 thematic domains: 'Primary' and 'Secondary Mineral Resources', 'Industrial Processing and Transformation', 'Raw Materials economics' (including CRMs), 'Raw materials Policy & Legal Framework', 'Sustainability of Raw Materials' and 'International Reporting' (Figure 3). The DDG offers in a single place, a unique access to most of the data available, including a contextual access to resources like the European legislation, and an access to several key studies like the Minventory study¹ (Parker et al., 2015), or the Material System Analysis² (BIO by Deloitte, 2015), etc.

The first functionality of the DDG and its side applications is an 'intelligent' search engine in which data, information and knowledge are strongly and cleverly connected, which allows for it to be a powerful decision-aid tool. Thus, the DGG is not a 'pure' search engine that simply generates a pre-formulated answer as we experience with many other search engines.

Figure 3 shows the DDG interface with the Main Ontology and the 7 domains covered, representing about 300 concepts and sub-concepts. Transversal ontologies, i.e., 'Value_Supply Chain', 'Temporal', 'Spatial' and 'Commodities' are used as filters allowing to speed up the process of retrieval of doc/fact/flowSheets and linkedSheets. Results are presented on the right side and are ranked by pertinence.

¹ http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8273&lang=en

² <https://ec.europa.eu/jrc/en/scientific-tool/msa>

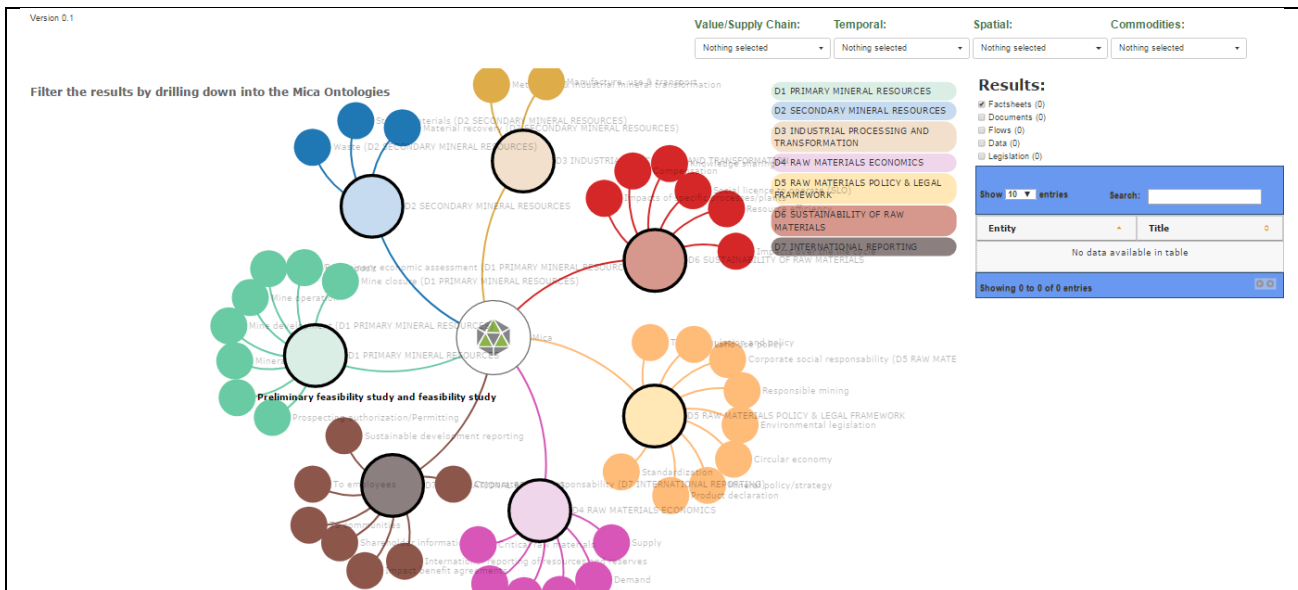


Figure 3 The DDG interface showing the Main Ontology and the 7 domains covered, representing about 300 concepts and sub-concepts.

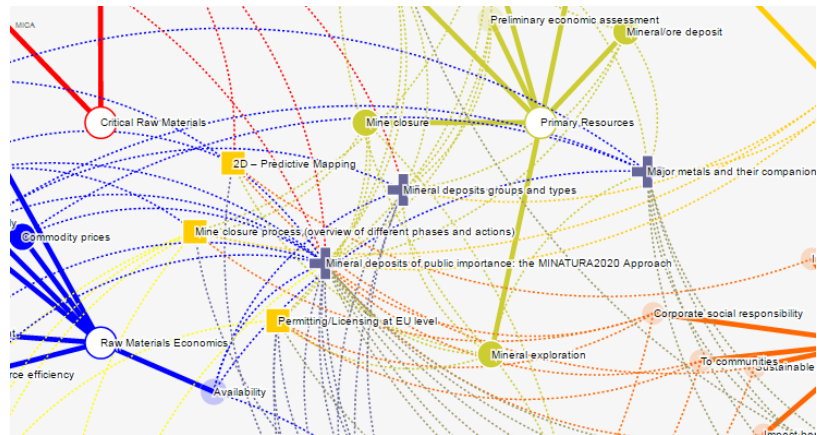
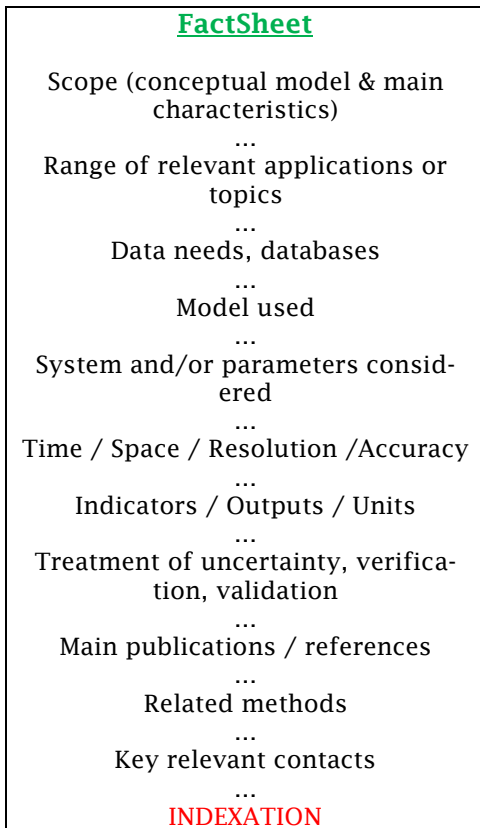
FACTSHEETS, DOCSHEETS AND FLOWSHEETS

FactSheets are used to describe in detail a method or a tool, giving all the necessary information to the end user on how to implement this method for resolving a problem. DocSheets can be seen as a complementary source of information, explaining some concepts that are not methods or tools, i.e., substitution, criticality etc., an end user may appreciate to find during the navigation on the DDG. FlowSheets can be seen as ‘cooking recipes’ allowing to answer complex queries an end user may have. The flowSheets necessitate to link several factSheets and related data in a certain order.

FactSheets and flowSheets indicate what type of data is necessary for running the method(s) and their source(s). An exhaustive inventory of data/data sources has been realized in WP3, which provides the system with detailed metadata related to these data sources. Each metadata is internally indexed (i) to the fact/doc/flowSheet using this source and (ii) to the domain(s)/concept(s)/sub-concept(s) to which it may be useful.

A factSheet template was created in order to ensure that method and tool descriptions and documentation are homogeneous. Figure 4 lists the different rubrics to be filled up.

FactSheets, docSheets and flowSheets are essential pieces of the RMICP: they bring the answer(s) to the end user question(s) and help the user to know how to proceed to solve the original problem and take a decision.



In order to be retrieved and selected during the navigation over the ontology within the DDG, factSheets (blue crosses) and docSheets (orange squares) are annotated and indexed over the main ontology (and transversal ontologies too). The lines materialize the links between factSheets and docSheets with various concepts and sub-concepts.

Figure 4 Left: Structure of a factSheet, showing the different rubrics and the Indexation section. Right: factSheets and docSheets indexation over (or annotation with) the main ontology.

DELIVERABLE REPORT

1. Introduction

This note summarizes the IT developments made for the creation of the EU-Raw Materials Information Capacity Platform (EU-RMICP), including its Dynamic Decision Graph (DDG) and the MICASheetEditor. This note is only a part of the deliverable and accompanies the release of the application/software that is the core of deliverable 6.2.

The following topics will be reviewed in order to provide end users with an overview of the EU-RMICP, of the principles of development and of the mechanics behind³:

- The MICA Main Ontology and the generic, transverse ontologies;
- The different knowledge containers;
- The extension of the MICA Knowledge Base with external data/information sources;
- The connection with the GeoNetwork metadata catalogue of data sources;
- The MICASheetEditor development;
- The MICA Triple Store;
- The innermost mechanics of the system (ontology management, MICA data model, URIs, querying the Triple Store ...);
- The ranking of the results by relevance;
- The DDG and its side applications;
- The connection with other Knowledge Data Platforms (KDPs), including the RMIS 2.0.

³ This note builds on a former document: Note accompanying the release of the first stabilized version of the MICA Dynamic Decision Graph (DDG). Deliverable D6.0 (Cassard et al., 2016).

2. The MICA Main Ontology and the associated knowledge

2.1 The MICA Main Ontology and the generic, transverse ontologies

The Main Multidimensional Ontology is an essential piece of the MICA Expert System that notably supports the set of applications related to the Dynamic Decision Graph (DDG). The Main Ontology represents the Domain of questions an end user may have about mineral resources/raw materials. It was designed in 2016, essentially on the base of experts' ideas and visions, during a dedicated WP2 session organized during the kick-off meeting in Copenhagen.

An important work of revision has been undertaken in order to finalise this ontology, taking into account the results of D2.2 of the MICA project, which documents in an exhaustive way the identification and mapping of stakeholders' needs and requirements related to raw material intelligence.

This work resulted in the partial reorganization of the ontology, and the suppression/addition/ modification of some of the associated concepts and sub-concepts. The critical raw material part of the ontology has been integrated in the D5 Domain 'Raw Materials Policy and Legal Framework', thus reducing the number of domains from 8 to 7. The Main Ontology is now composed of around 300 concepts and sub-concepts (see Appendix 1).

In parallel, the relations between domains/concepts/sub-concepts have been deeply reworked, in order to reinforce concept hierarchies and inferences that can be exploited by queries. Put in other words, this is to improve the capacity of the system to retrieve, not only the information directly linked to a topic or a question, but also all related information (see Appendix 2).

Transversal ontologies (see Appendix 2), i.e., 'Value_Supply Chain', 'Temporal', 'Spatial' and 'Commodities' are used as filters allowing to speed up the process of retrieval of doc/fact/flowSheets and linkedSheets (see Figure 3).

2.2 The knowledge containers: the different types of sheets

FactSheets are used to describe in detail a method or a tool, giving all the necessary information to the end user on how to implement this method for resolving a problem. DocSheets are a complementary source of information, explaining concepts, i.e., substitution, criticality etc., which an end user may appreciate to find during the navigation on the DDG. FlowSheets can be seen as 'cooking recipes' allowing to answer complex queries an end user may have. Flowsheets necessitate to link several factSheets and related data in a certain order.

MICA also aims to integrate information coming from external knowledge bases and sources, without duplicating the work already done by others (provided the information is of high quality and the data source is 'perennial'). Prominent examples are EUR-Lex, under the responsibility of the EC Publications Office, and the DOI system, under the responsibility of the International DOI Foundation, both of which provide Unique Resource Identifiers (using

CELEX & DOI numbers) and knowledge bases that can be queried using them. However, also other information sources providing access to data or lists of relevant reports without DOIs are relevant. In order to facilitate integration of all these sources, the concept of a 'linkedSheet' was developed and is currently being implemented in the RDF Triple Store for storage and in the MICASheetEditor for the generation of these sheets. Note that linkedSheets are also used to link data sources to other types of sheets.

FactSheets and flowSheets indicate what type of data is necessary for running the method(s) and what their source(s) are. An exhaustive inventory of data/data sources has been realized in WP3, which provides the system with detailed metadata related to these data sources (see below). Each metadata is internally indexed (i) to the fact/doc/flowSheet using this source and (ii) to the domain(s)/concept(s)/sub-concept(s) to which it may be useful (see Appendix 2).

A factSheet template (also used for docSheets) was created in order to ensure that method and tool descriptions and documentation are homogeneous. Figure 4 gives an overview of the different rubrics to be filled. In addition to the indexation over the ontologies (annotation with concepts and sub-concepts), it is important to note that the link(s) with other doc/factSheets has/have to be carefully entered in order to allow the system suggesting both precise/pertinent and 'contextual' answers.

The revision the Main Ontology (taking into account the results of D2.2 of the MICA project, see above), has also resulted in the update of the doc/fact/link/flowSheet Production document which lists in detail which sheets (theme and format) have to be produced to answer end-user's questions. Over 160 doc/fact/linkedSheets and around 40 flowSheets have been prepared by the MICA partners to feed the system (see Appendix 3).

3. Relationships with GeoNetwork

Information related to data sources or ‘metadata on data’ are managed by BGS under GeoNetwork, in the frame of WP3. This is an important piece of information, as an answer to an end-user question does not only indicate how to proceed and which method/tool to apply but also which data or datasets can be used and their characteristics. It is thus essential that the two systems, GeoNetwork and the DDG Triple Store, communicate perfectly, the first one delivering metadata on datasets including the site(s) where they can be accessed, the second one delivering the doc/fact/link/flowSheets explaining how to proceed – and related topics – in order to get an answer.

These relationships have been formalized and are summarized in Figure 5.

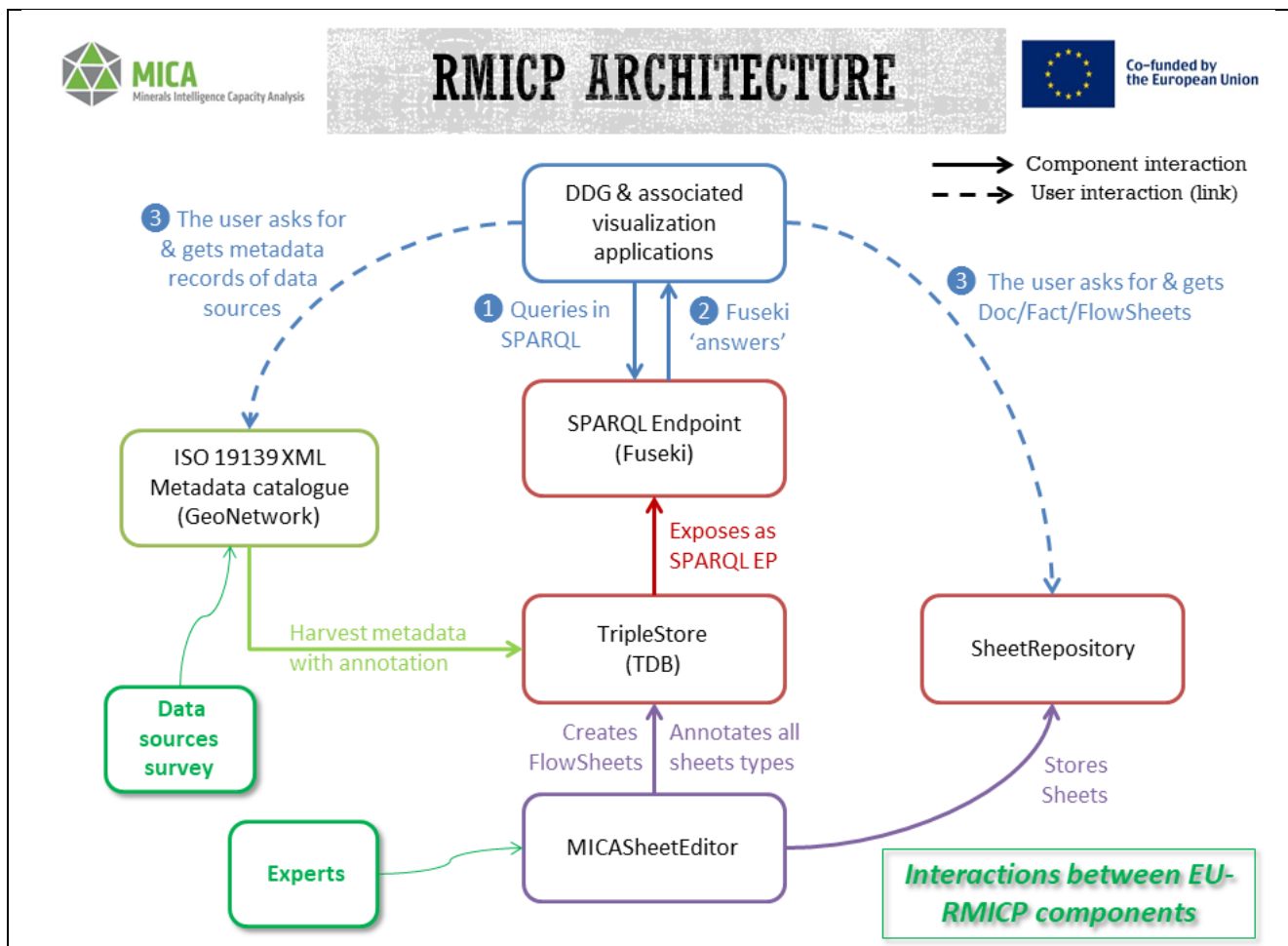


Figure 5 Interactions between the EU-RMICP components.

From a technical point of view, a third party software developed by BRGM is in charge of harvesting the content of GeoNetwork to insert in the DDG Triple Store. The operation of harvesting is made with GetRecords query to the GeoNetwork CS/W interface. This query returns all whole content of GeoNetwork that is then processed to extract the relevant part (title, abstract, annotation with the ontology). The content extracted from the metadata is

transposed to SPARQL query (i) to be inserted in the Triple Store if the content was not already harvested in a previous step or (ii) to be updated if the content was present in the Triple Store and modified in GeoNetwork.

The DDG queries the Triple Store using the query SPARQL Endpoint (<http://geusjuptest.geus.dk/fuseki/MICA/sparql> (for test), <http://data.geus.dk/fuseki/MICA/sparql> (for production)) and the queries described in Appendix 4 (SPARQL Queries for DDG). All the queries are made on the fly, so all the new sheets/FAQs added in the MICASheetEditor are immediately available in the DDG applications.

This third party software can be launched manually by an operator in charge of the maintenance of the EU-RMICP or can be integrated as a recurrent task (e.g., using a cron, which is a time-based job scheduler).

4. The MICASheetEditor development

The MICASheetEditor is a web portal enabling you to upload and annotate sheets and questions into the MICA Triple Store. Once inside the Triple Store, they are made accessible for the MICA end-user portal DDG.

The MICASheetEditor handles the following sheet types:

- MICASheets (= Fact-/DocSheets);
- FlowSheets;
- LinkedSheets;
- FAQs.

When inserting sheets and questions into the Triple Store, the data need to be annotated with relations, concepts and other metadata. These relations and metadata are required by the Triple Store in order to make the data easily queryable and in accordance with the MICA model (see Figure 23). The MICASheetEditor does not ensure the consistency of the relations and metadata registered within the sheets and registered within the Triple Store.

The MICASheetEditor is accessible in two separate environments: TEST and PROD.

- For test and evaluation purposes (subject to instability and immediate changes): <http://geusjuptest.geus.dk/MICASheetEditor/>
- For real, production content: <http://data.geus.dk/MICASheetEditor/>

To access the MICASheetEditor, an account is needed. This can be created directly through the MICASheetEditor. It is your e-mail address, which uniquely identifies you – hence you cannot have multiple accounts with the same e-mail address.

4.1 New MICASheet

The formula to input a MICASheet, can be seen in Figure 6. All fields are mandatory except “Link with existing sheet” and “Answers FAQs”. The full word document and cropped (of the indexation-annotation section) pdf file of the MICASheet have to be submitted with this form. The title and summary both have character limits of 150 and 1,000 characters respectively.

All authors need to have an account on the MICASheetEditor. This ensures that they can access the system and see and modify all elements associated with their name. If an author does not have an account yet, it is created using the “Add” button – the modal box is shown in Figure 7. In addition to the name, you have to supply an e-mail address and password. Please coordinate with the author in order to get the correct information and inform the author that the account has been created.

If links with existing sheets or questions are relevant, you can select one or more of these. If not, simply leave them empty.

Finally, you have to select all the concepts from the MICASheet. Even though the MICASheet word document contains these data, you have to select them in order to make this information queryable. Once the sheet is submitted, it is immediately made accessible for the MICA end-user portal DDG.

4.2 New flowSheet

The formula to input a flowSheet, can be seen in Figure 8. All fields are mandatory. The title and summary both have character limits of 150 and 1,000 characters respectively.

In order to attach a knowledge element to the flowSheet, you have to select the sheet, write a note and click the add button. Once you click the add button, the element is attached to the list shown below. Only elements shown in this list will be attached as knowledge elements. The order of the element within this list will be preserved in the Triple Store.

You also have to select and add at least one question, which this flowSheet answers. Hence, you have to create the question(s) before the flowSheet, if they do not exist already.

Finally, you have to select all the concepts the flowSheet covers. This could be more or less than the concept of all the knowledge elements. Once the sheet is submitted, it is immediately made accessible for the MICA end-user portal DDG.

4.3 New linkedSheet

The formula to input a linkedSheet, can be seen in Figure 9. All fields are mandatory except “Link with existing sheet” and “Answers FAQs”. The title and summary both have character limits of 150 and 1,000 characters respectively.

The linkedSheet can reference one of the following elements:

- An EU legislation using the CELEX number;
- A publication using the DOI;
- A predefined online data query using the direct URL;
- Other sources using the direct URL.

Finally, you have to select all the concepts this linkedSheet covers. Once the sheet is submitted, it is immediately made accessible for the MICA end-user portal DDG.

4.4 New FAQ

The formula to input a question, can be seen in Figure 10. All fields are mandatory except “Link with existing sheet”. The questions have a 250 character limit.

Finally, you have to select all the concepts this question covers.

4.5 Searching

To search and manage the existing sheets within the Triple Store, the MICASheetEditor has a search utility. This utility allows querying using different filters and is shown in Figure 11. The search utility gives access to the stored MICASheet full word document and cropped pdf file. For linkedSheet, it allows you to go directly to the referenced source.

4.6 Updating

The MICASheetEditor enables updating (or re-annotation) of the elements stored within the Triple Store. The forms for updating MICASheet, flowSheet and linkedSheet are identical to forms for creating new elements and are shown in Figure 12, Figure 13 and Figure 14. All rules are the same as for creation, but it is not possible to change the type of an existing sheet.

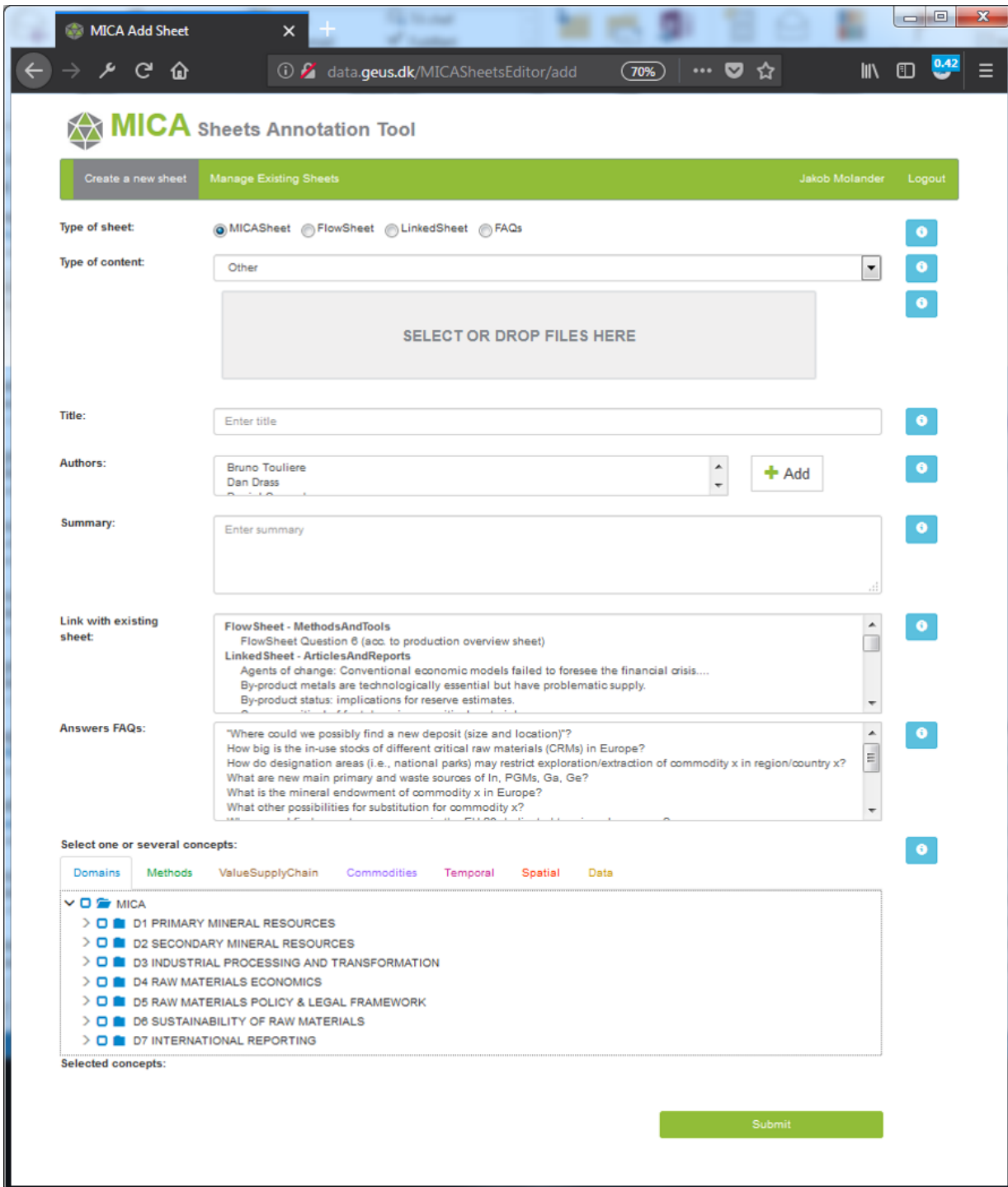


Figure 6 New MICASheet.

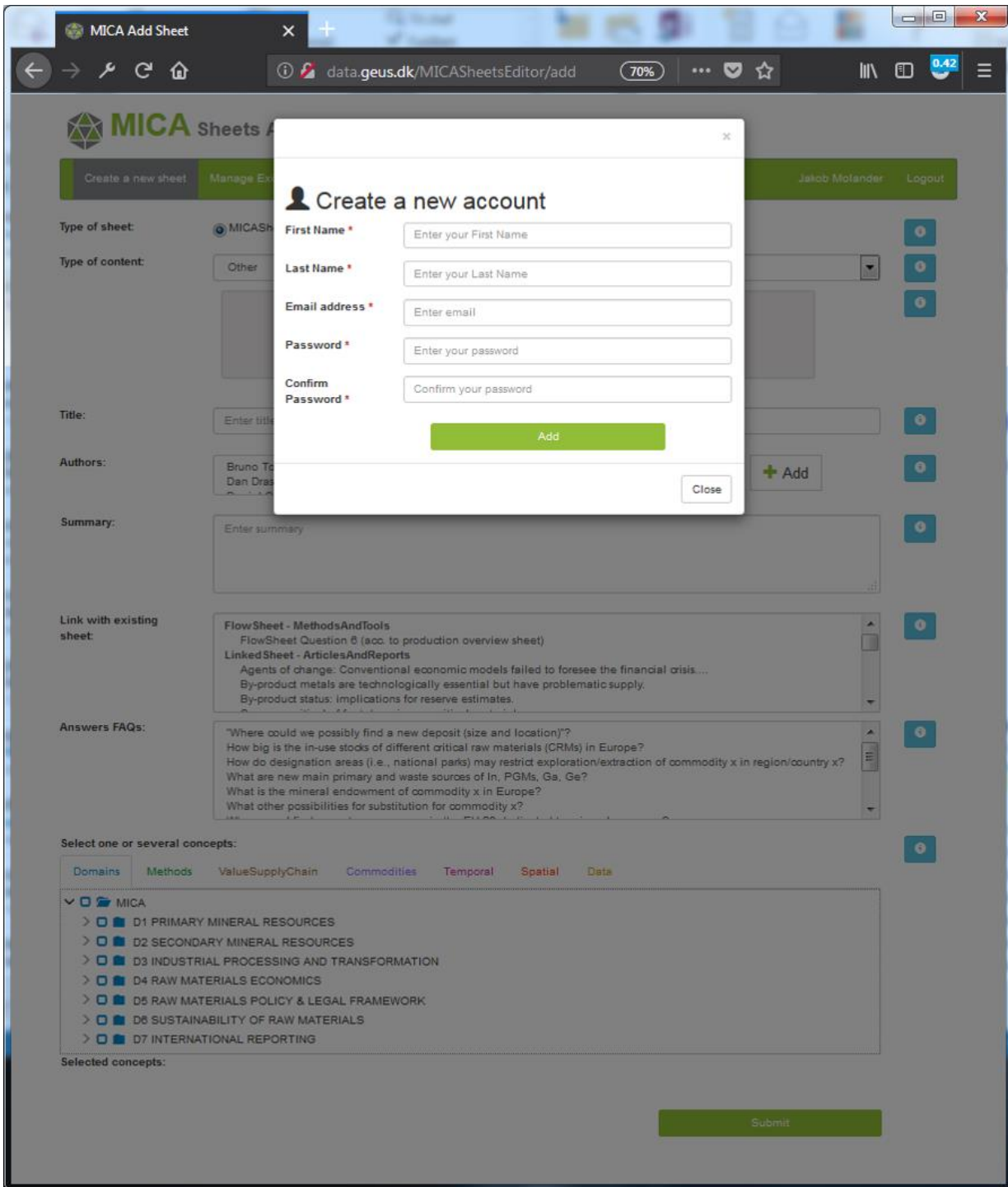


Figure 7 New author.

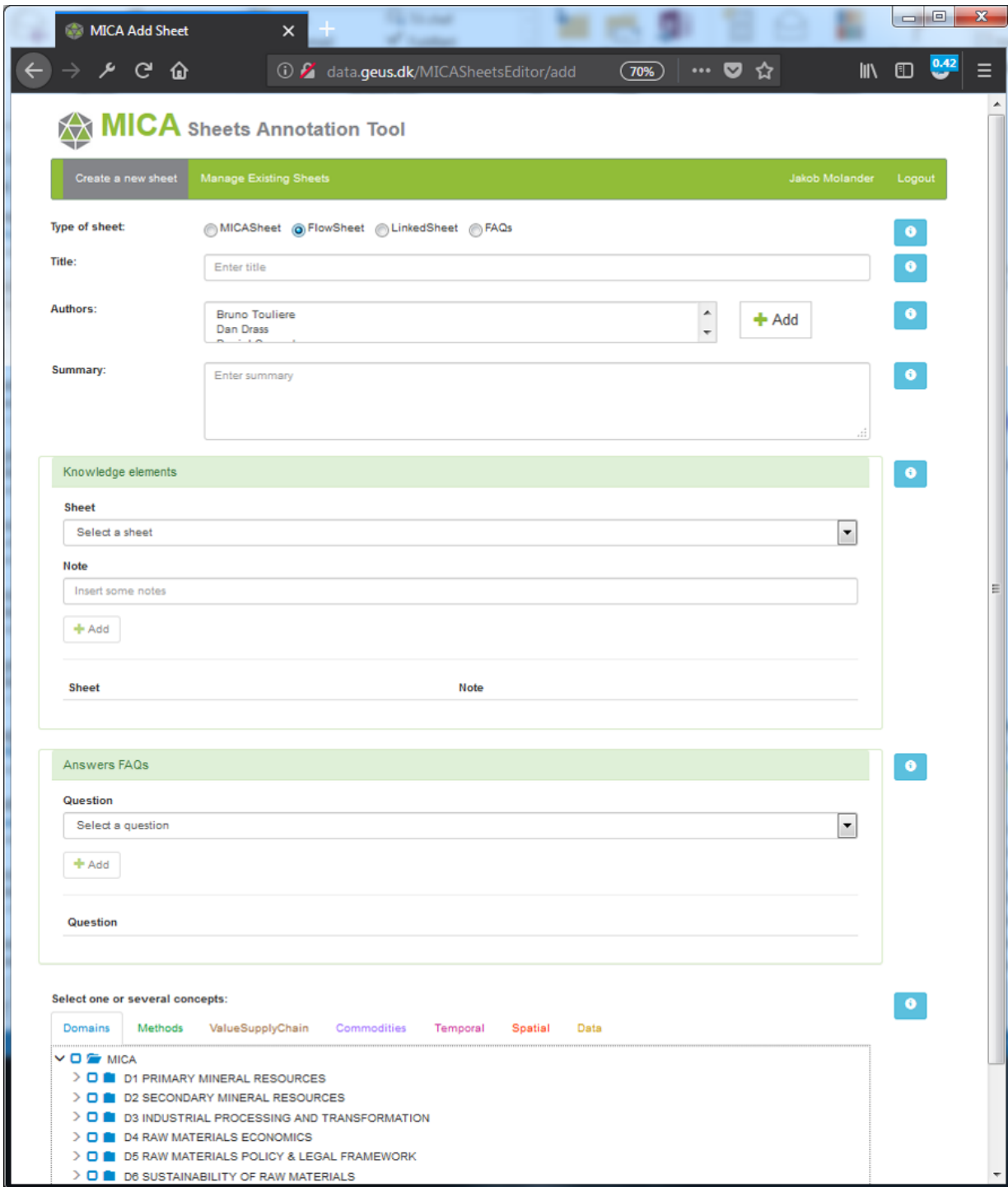


Figure 8 New flowSheet.

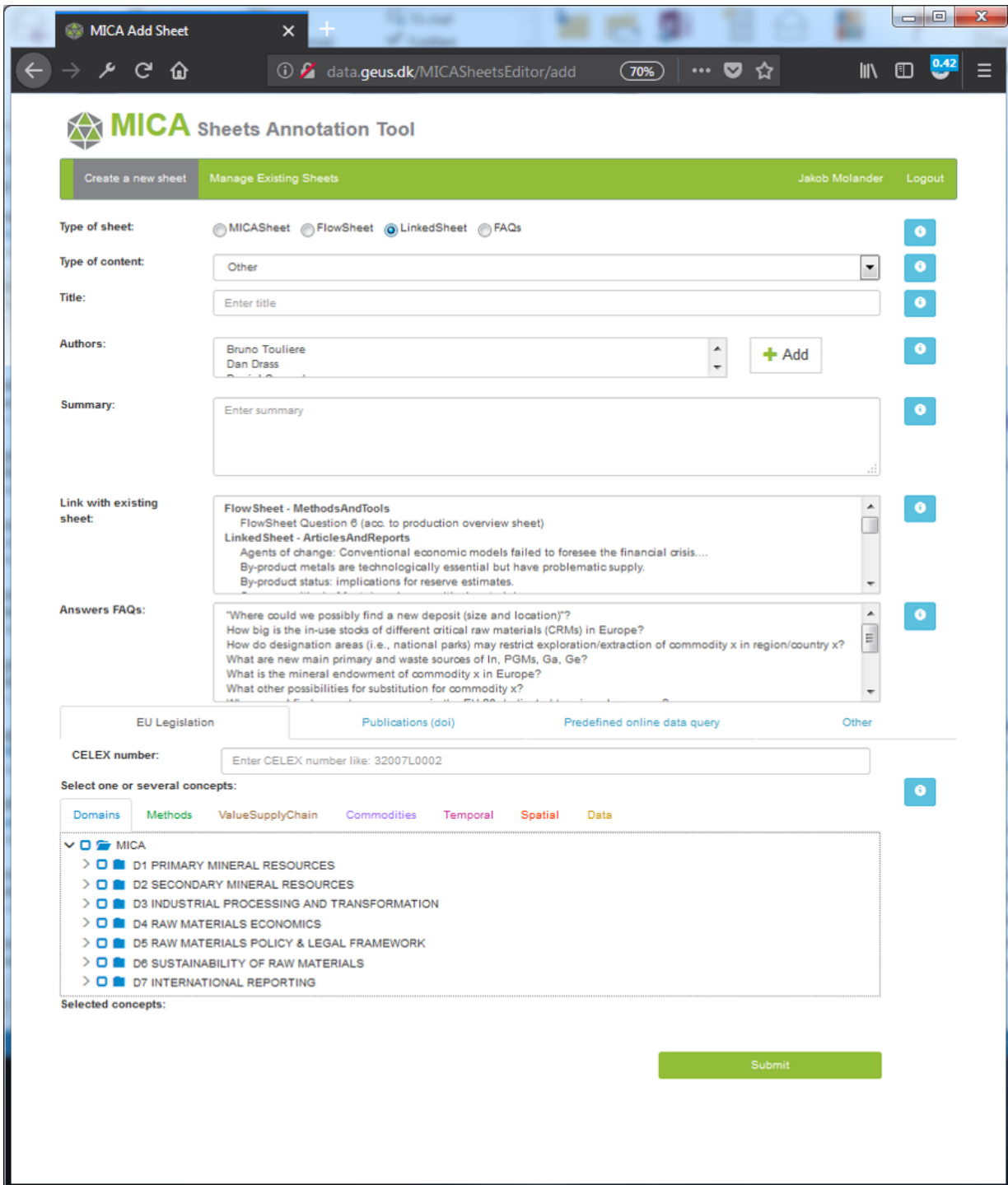


Figure 9 New linkedSheet.

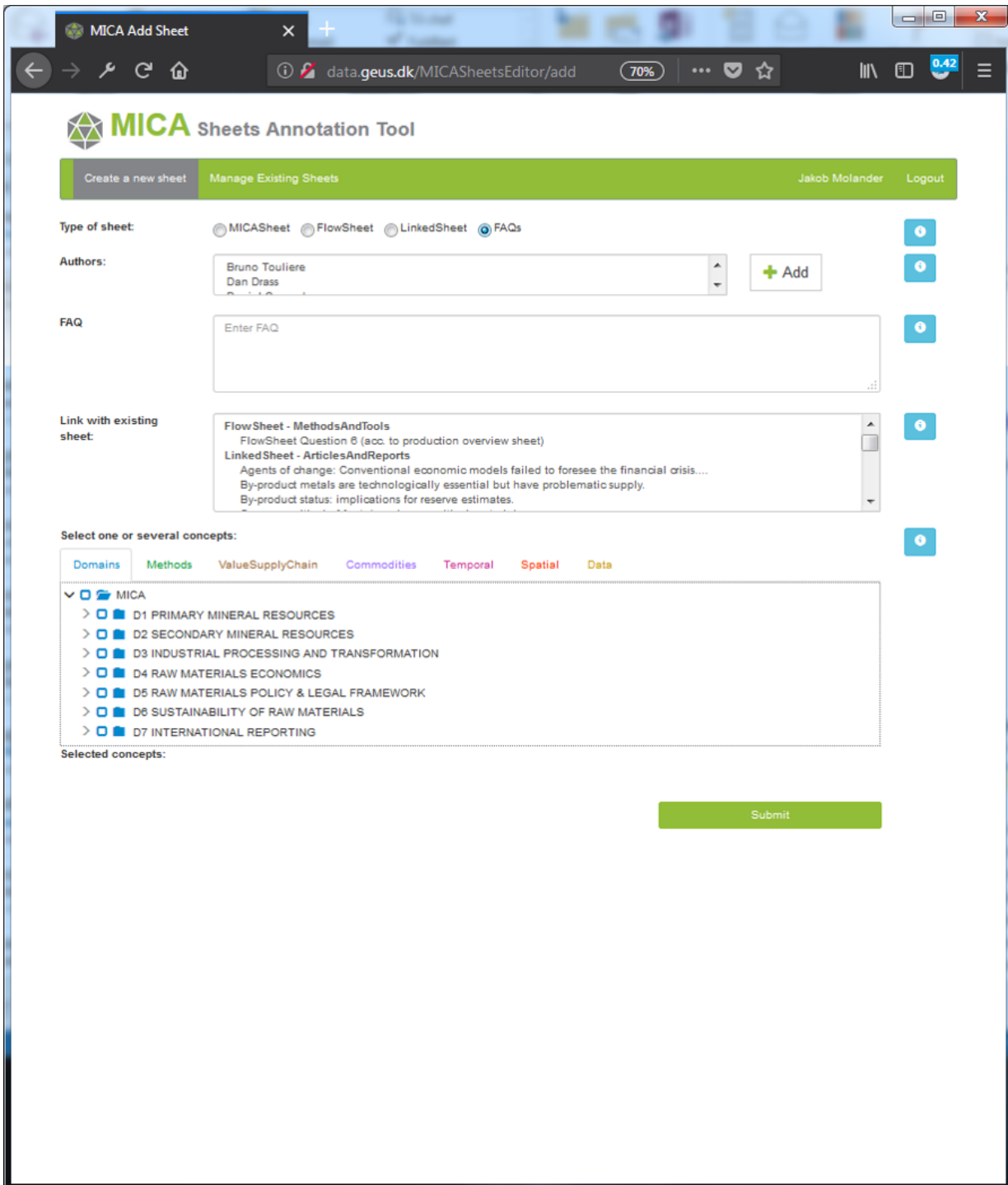


Figure 10 New Question.

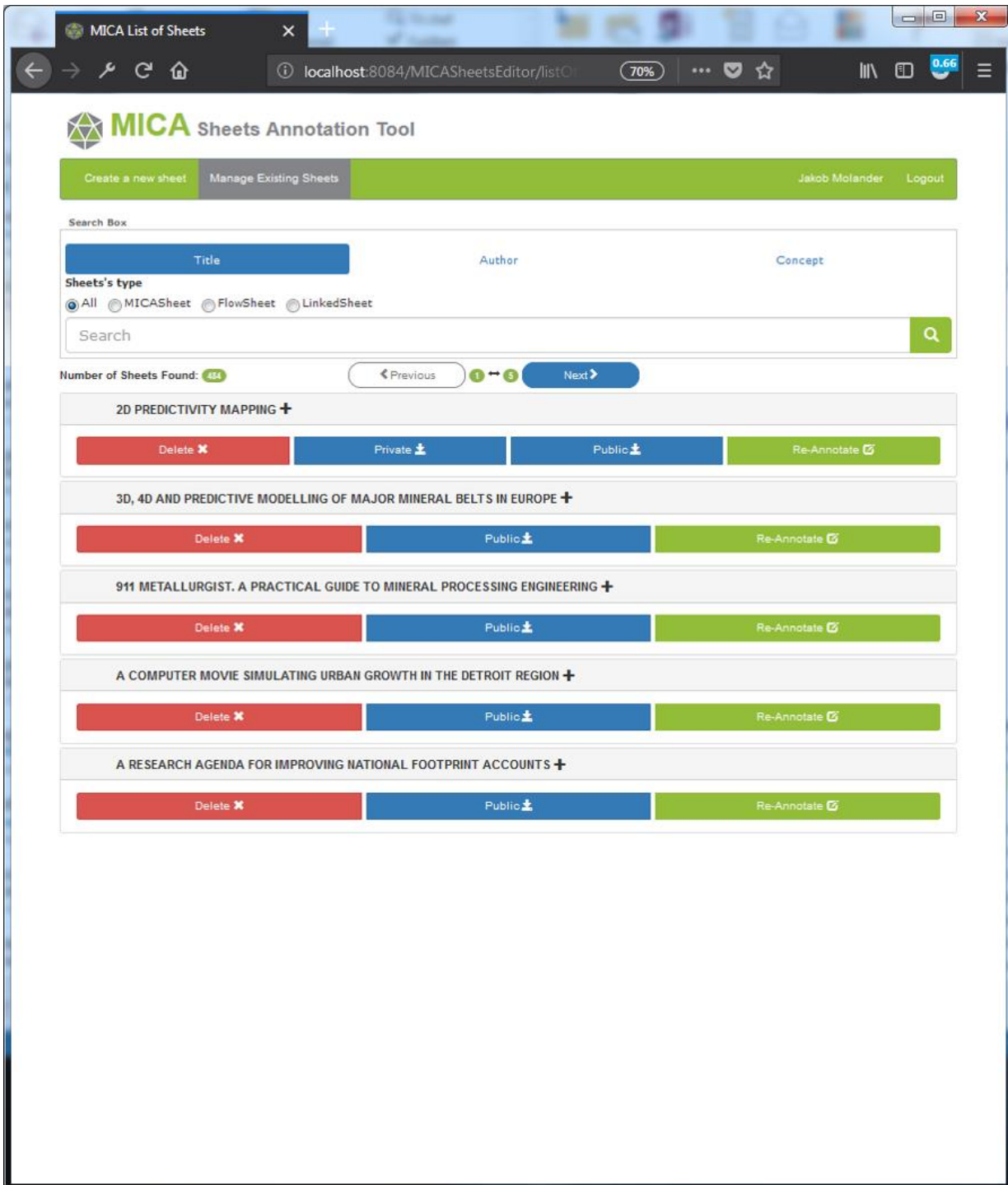


Figure 11 Search existing sheets.

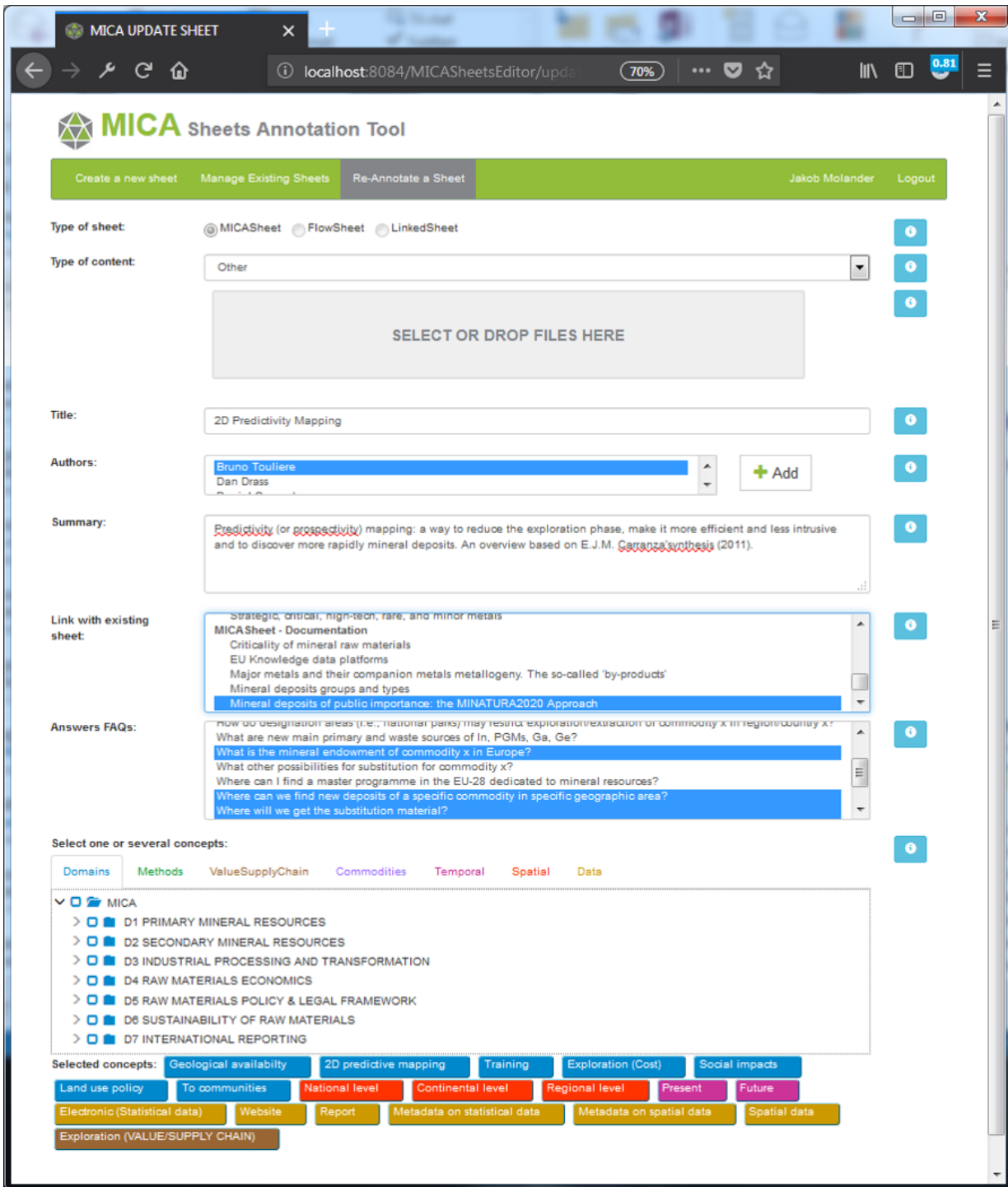


Figure 12 Update a MICASheet.

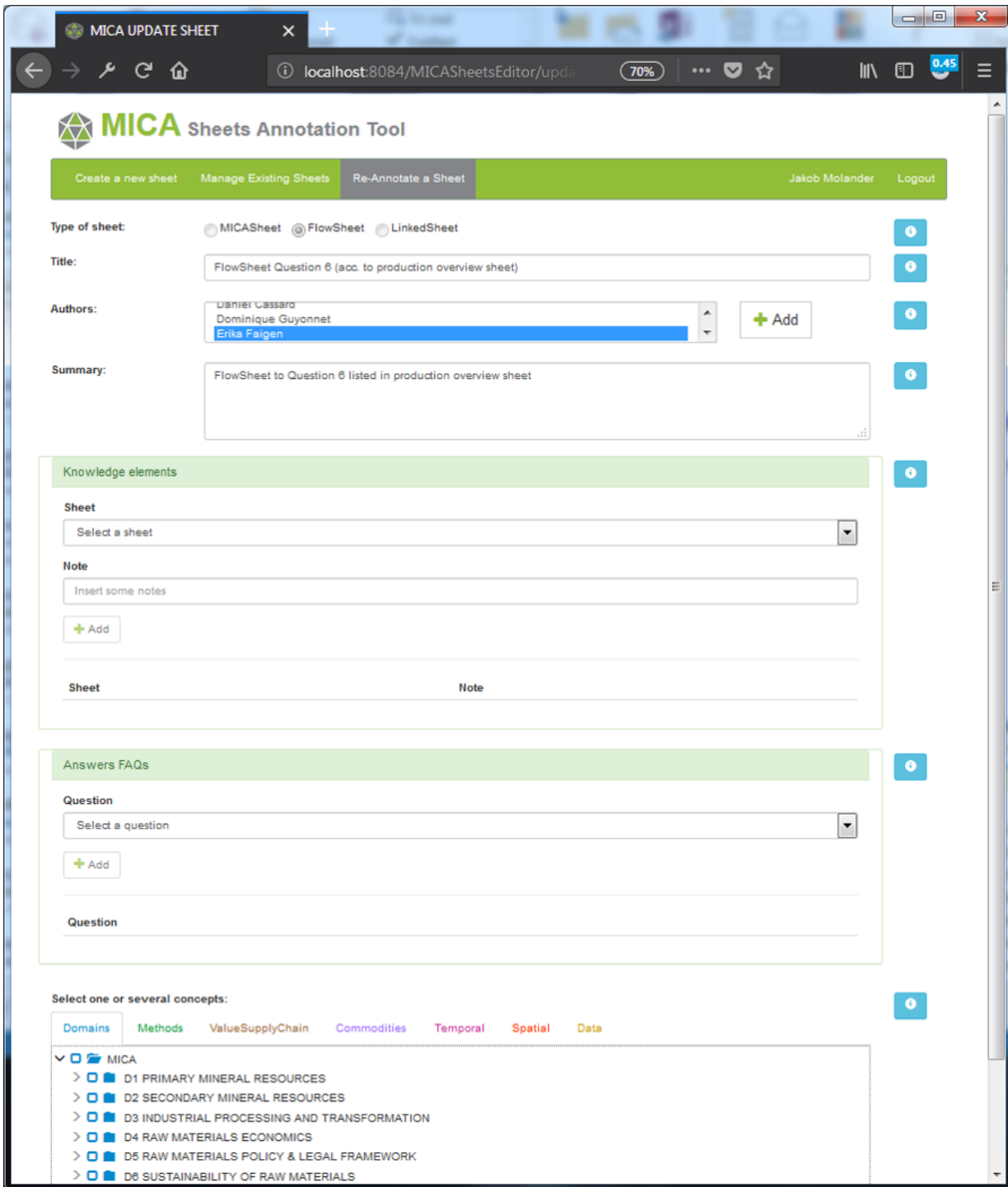


Figure 13 Update a flowSheet.

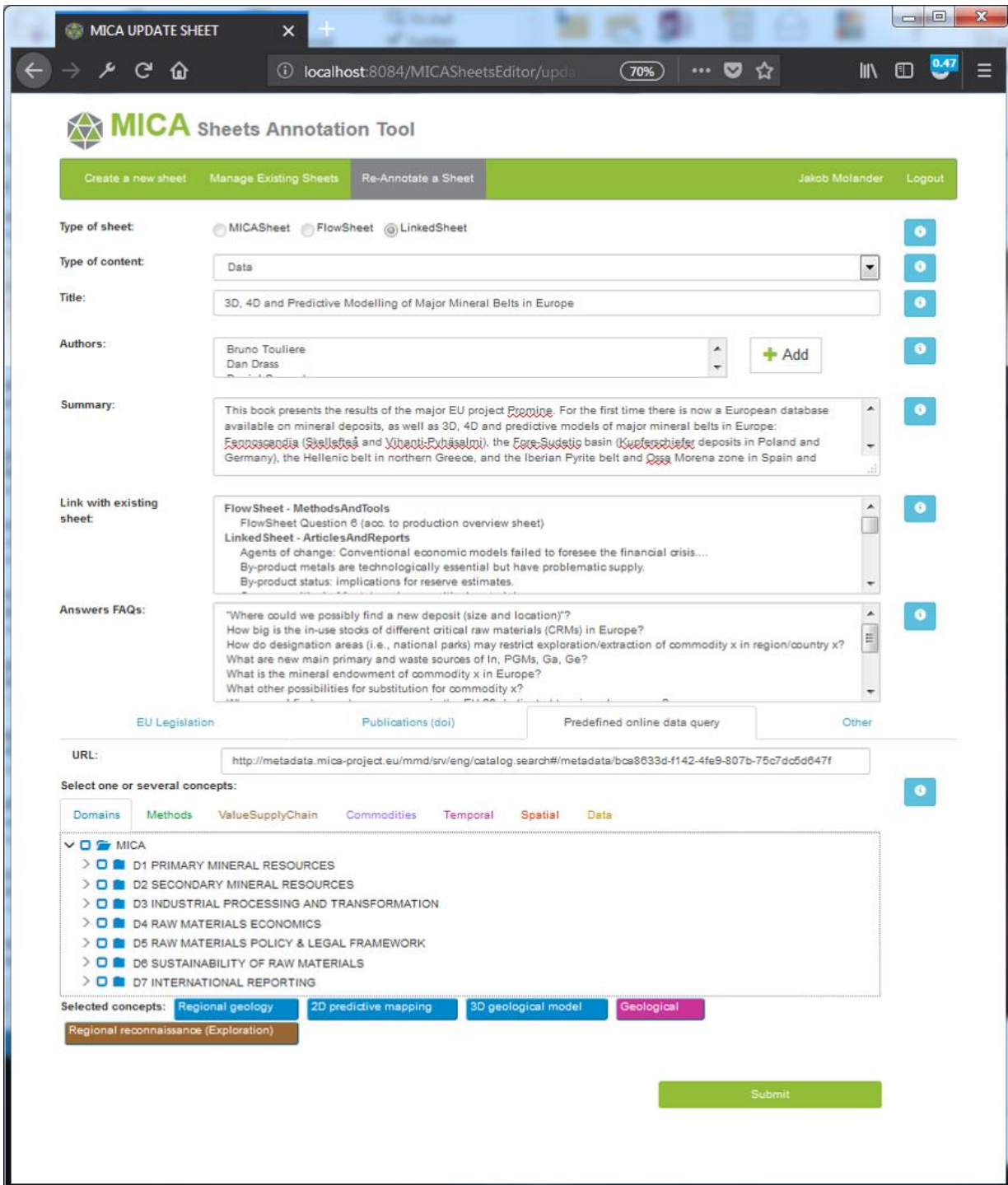


Figure 14 Update a linkedSheet.

5. The MICA Triple Store

The MICA platform “database” is hosted on a dedicated server at GEUS and stores all the information about sheets provided by the MICA experts through the MICASheetEditor. This “database” actually consists of two components (see Figure 15):

- A relational database (a PostgreSQL database) that stores the raw sheet documents in pdf and .docx format.
- An RDF Triple Store (Jena Triple Database (TDB)) with persistent RDF data that annotates the sheets using the MICA Ontology concepts. This data, indexed with MICA Ontology concepts, is structured according to the MICA data model described as an OWL ontology. It is used to make semantic queries to retrieve the sheets through the DDG interface.

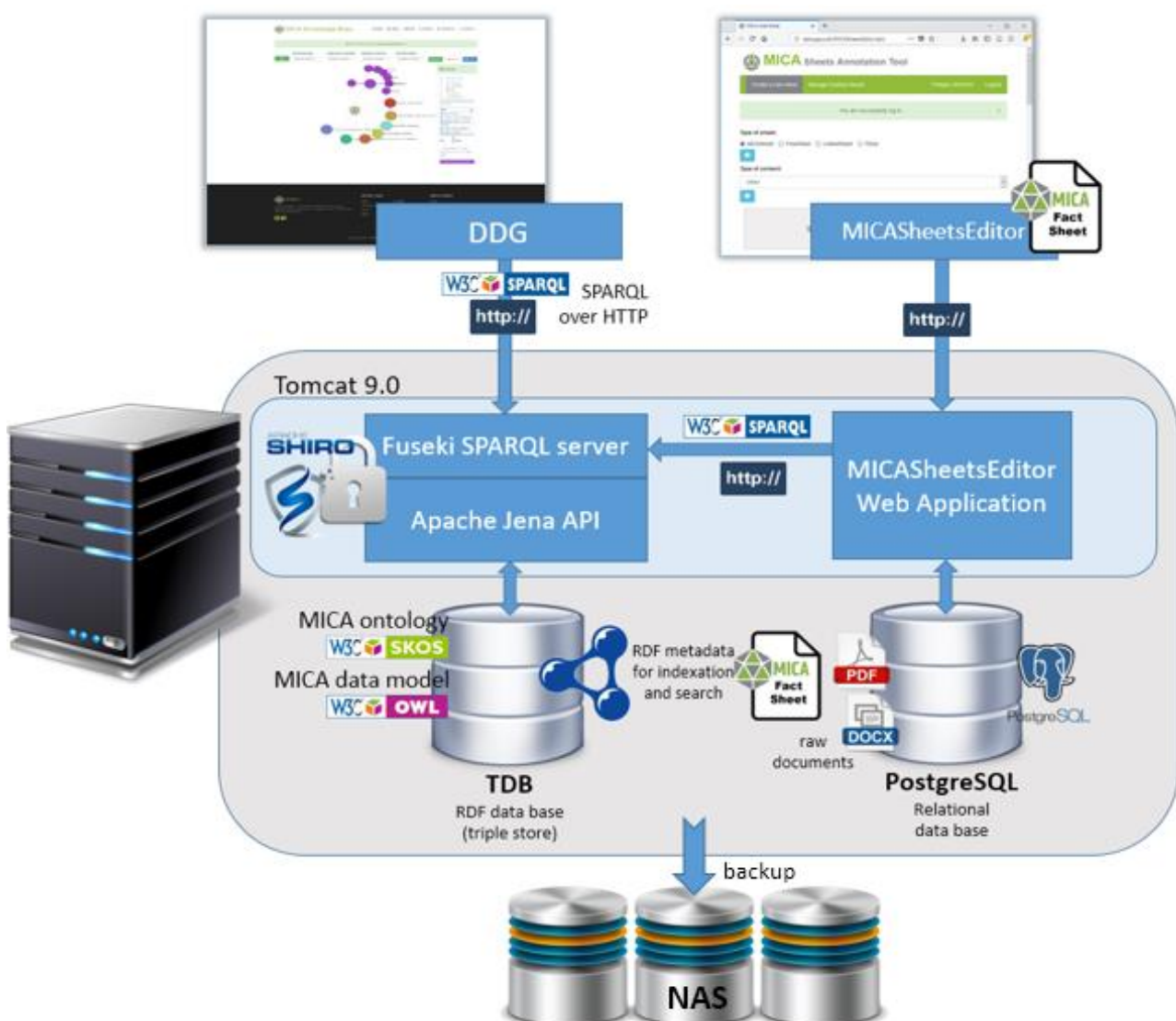


Figure 15 MICA databases (Triple Store and relational) server.

A Triple Store or RDF store is a purpose-built graph database specialized in the storage and retrieval of semantic facts expressed as triples (subject, predicate, object) with RDF (Re-

source Description Framework, a model for data publishing and interchange on the Web standardized by W3C). TDB is the native and high performance triple store component of Apache Jena (<https://jena.apache.org>), a free and open source Java framework for building Semantic Web and Linked Data applications developed by the Apache Software Foundation (ASF). TDB supports the full range of Jena APIs and can be used as a high performance RDF store on a single machine.

Although it can be accessed by command line scripts or Java programs (via Jena APIs), as part of the MICA platform it is fully managed by a Fuseki server.

Fuseki, a SPARQL server, is another open source component of the Apache Jena Framework. It is run as a Java web application (WAR file) deployed in an Apache Tomcat 9 open-source Java Servlet container. Fuseki provides security using Apache Shiro (<https://shiro.apache.org/>). It is tightly integrated with TDB to provide a robust, transactional persistent storage layer. Fuseki exposes the RDF data (triples) stored in TDB as a SPARQL end-point accessible through HTTP; it provides the SPARQL 1.1 protocols for queries and updates as well as the SPARQL Graph Store protocol.

The choice of using Fuseki and TDB to manage the MICA semantic data has two advantages:

- Based on an open-source solution supported by Apache Software Foundation, it offers a high performance and secure solution well-suited to the needs of the MICA project. Integrated to the Jena framework, it comes with a full set of tools and APIs that facilitate the development of semantic web and linked data applications.
- The DDG and MICASheetEditor access the Triple Store only through SPARQL queries through HTTP. Therefore, they are not closely coupled to the storage solution⁴. Replacing TDB and Fuseki by another triple store and another SPARQL end-point does not impact the DDG and MICASheets application code.

GEUS has setup two servers for MICA; one test server (<http://geusjuptest.geus.dk/>) and one production server (<http://data.geus.dk/>). For security, only the query SPARQL calls can pass through the GEUS firewall. The MICA dataset is exposed to everybody through the SPARQL 1.1 Query end-point at URL: <http://geusjuptest.geus.dk/fuseki/MICA/sparql> (test), <http://data.geus.dk/fuseki/MICA/sparql> (production). For updating or deleting data in the triple store, SPARQL 1.1 update requests are performed through a different end-point (<http://geusjuptest.geus.dk/fuseki/MICA/sparql> (test), <http://data.geus.dk/fuseki/MICA/update> (production)) not accessible from the Internet and protected by Apache Shiro.

The Java web applications Fuseki (SPARQL end-point), MICASheetEditor as well as TDB (Triple Store) and PostgreSQL run on a server dedicated to the MICA project (they are the only application hosted by this server).

⁴ In the case of the MICA platform, MICASheetEditor back-end runs in the same servlet container (Tomcat 9) as Fuseki server, but it is not mandatory. Since it accesses TDB through SPARQL protocol (HTTP), it can run on a different server as long it has access to the SPARQL end-point.

Using the NAS (Network Attached Storage) infrastructure of GEUS, an incremental backup is made on a daily basis and saved for 180 days. Each year, one full backup is saved for 5 years.

6. The innermost mechanics of the system (ontology management, MICA data model, URIs, querying the Triple Store ...)

6.1 Ontology management

To facilitate the construction of the MICA Ontology (main and transversal ontologies) a VocBench editor has been chosen (Figure 16). VocBench is a Web-based, multilingual, collaborative ontology editor developed by the ART Research Group at the University of Rome Tor Vergata. VocBench manages OWL ontologies, SKOS-XL thesauri and generic RDF datasets. VocBench is used by the different partners to collaboratively edit the MICA Ontology. Various accounts have been created for the different partners with different roles: editors – who can create/update/delete concepts, publishers – who can additionally approve or reject the modifications proposed by the editors.

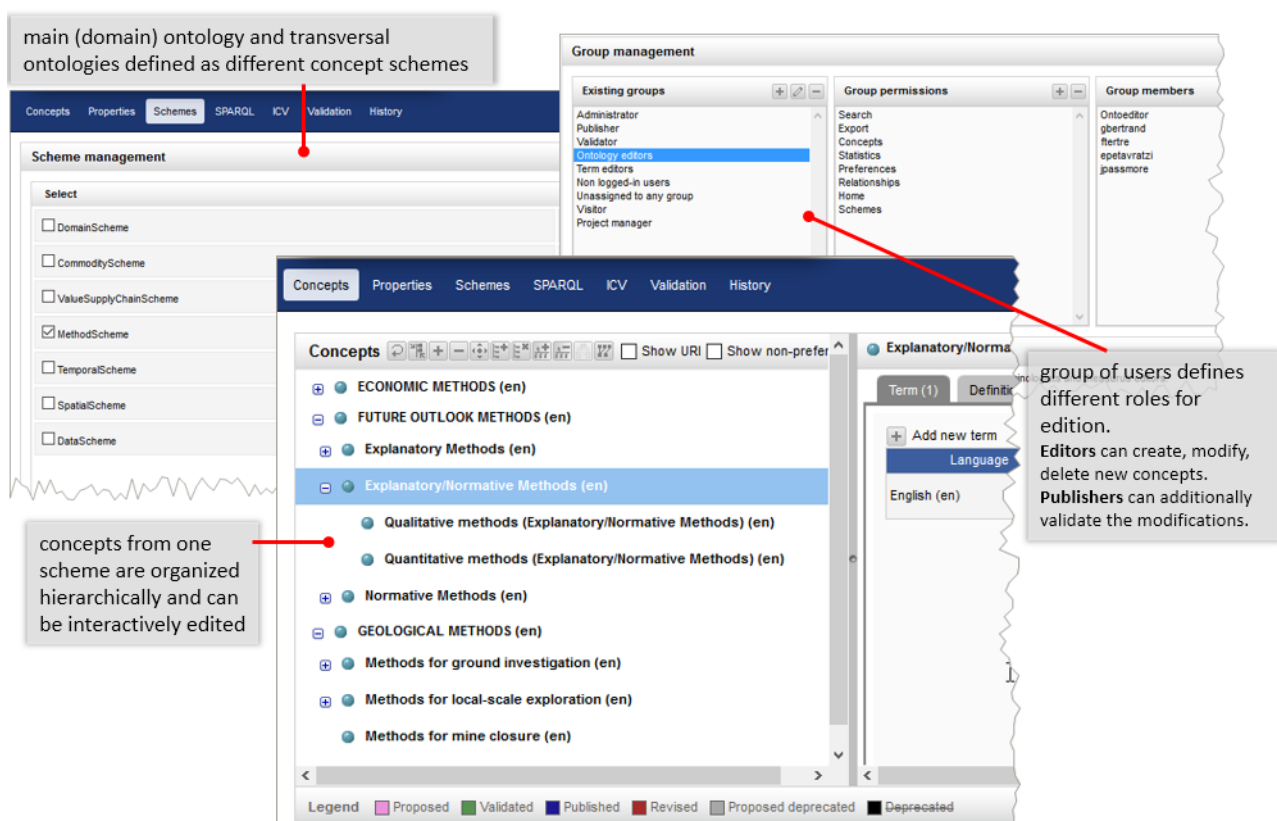


Figure 16 VocBench web-interface for collaborative edition of MICA ontologies.

The MICA Ontology created with VocBench uses the SKOS-XL vocabulary to represent MICA concepts and the relationships between them. It can be exported as an RDF file in various RDF serialization formats (RDF/XML, Turtle, NTriples).

The exported ontology is not directly usable by the various tools developed in the MICA platform. In particular, it contains extra RDF statements (triples) used internally by VocBench for the collaborative edition of concepts. Furthermore, SKOS-XL by reifying labels adds an extra level of complexity that is not necessary in the MICA platform. Therefore, to integrate

the MICA ontology into the different tools of the MICA platform (Triple Store, DGG, MICA GeoNetwork catalog for data sources) various transformation programs have been developed. These Java programs (based on the open source Apache Jena Framework) are conceived as command line tools that can be chained (using pipe commands, the output of one program can be used as the input of another program). Figure 17 presents these different tools and the workflows in which they are involved.

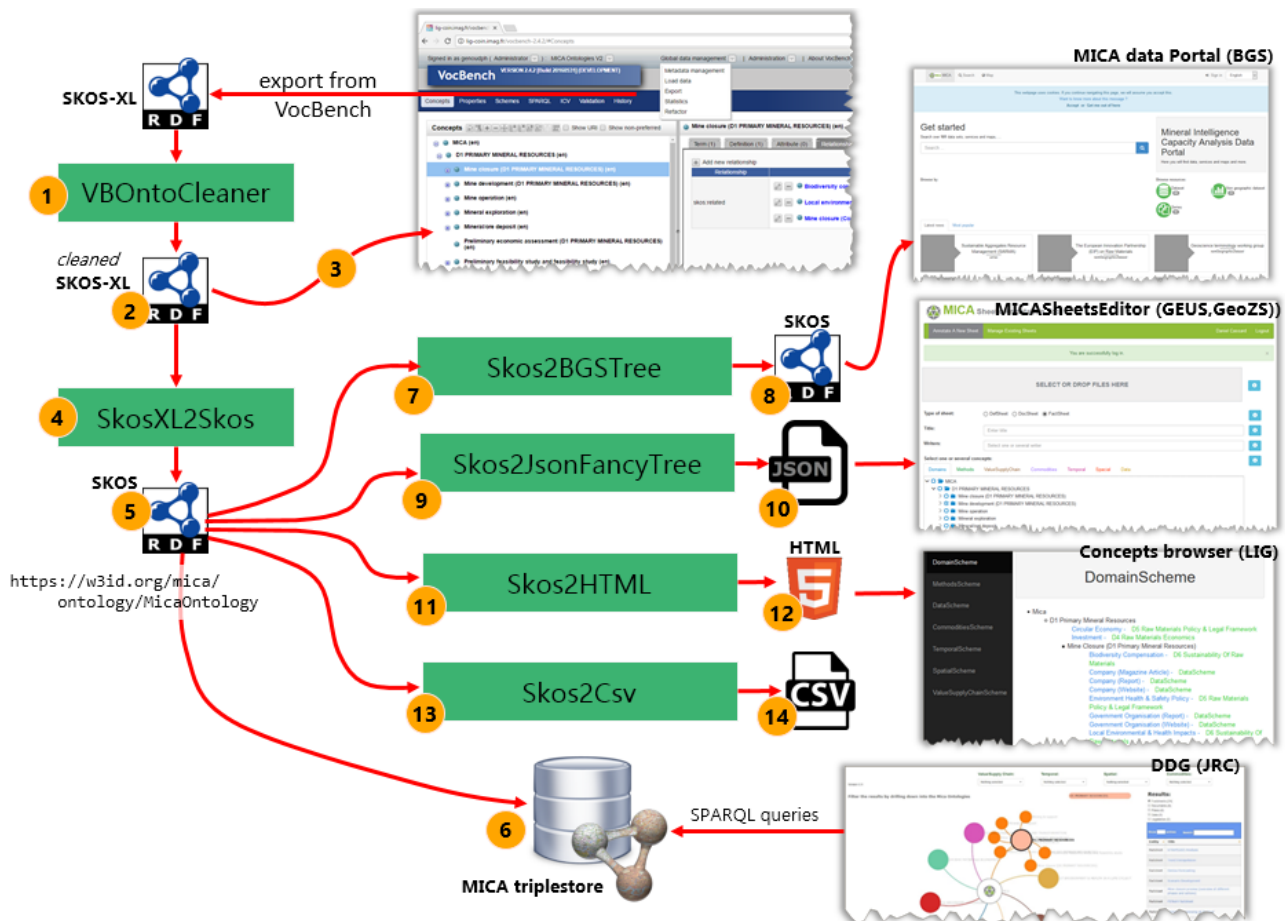


Figure 17 Management tools for the MICA Ontology.

The VBOnoCleaner (1) program takes as input the SKOS-XL file generated from an export form of VocBench. It removes all extra statements internally used by VocBench and definitively deletes the concepts whose suppression has been approved by MICA expert publishers. It produces a new SKOS-XL file (2) that can be re-imported into VocBench (3) as a new MICA ontology version for a future collaborative edition or used as input of the chain of treatments that need to be performed in order for it to be used by the MICA platform tools.

The SkosXL2Skos (4) program transforms the SKOS-XL file into a regular SKOS file (5) (it transforms reified labels of SKOS-XL into simple string literals). This SKOS file corresponds to the MICA Ontology published with URI <https://w3id.org/mica/ontology/MicaOntology>. This Ontology is the one used by the MICA platform to annotate the MICA resources in the MICA database (6) and by the DGG to retrieve these resources.

In the MICA SKOS Ontology, the concepts are organized using `skos:ConceptSchemes`. Each concept scheme regroups the concepts either of the main ontology or of one of the transversal ontologies (data, methods, temporal, spatial...). In each concept scheme, concepts are organized in hierarchies, with top-level concepts directly attached to the scheme. This structure is not practical for the GeoNetwork catalog for MICA data sources that needs a “pure” tree hierarchy of concepts. The `Skos2BGSTree` program (7) transforms the MICA Ontology SKOS file into such a tree of concepts (Figure 18). It adds two “artificial” levels of concepts: a top-level concept and sub-concepts that correspond to the concepts schemes. The output is a RDF/XML SKOS file (8) that can be used by the GeoNetwork catalog.

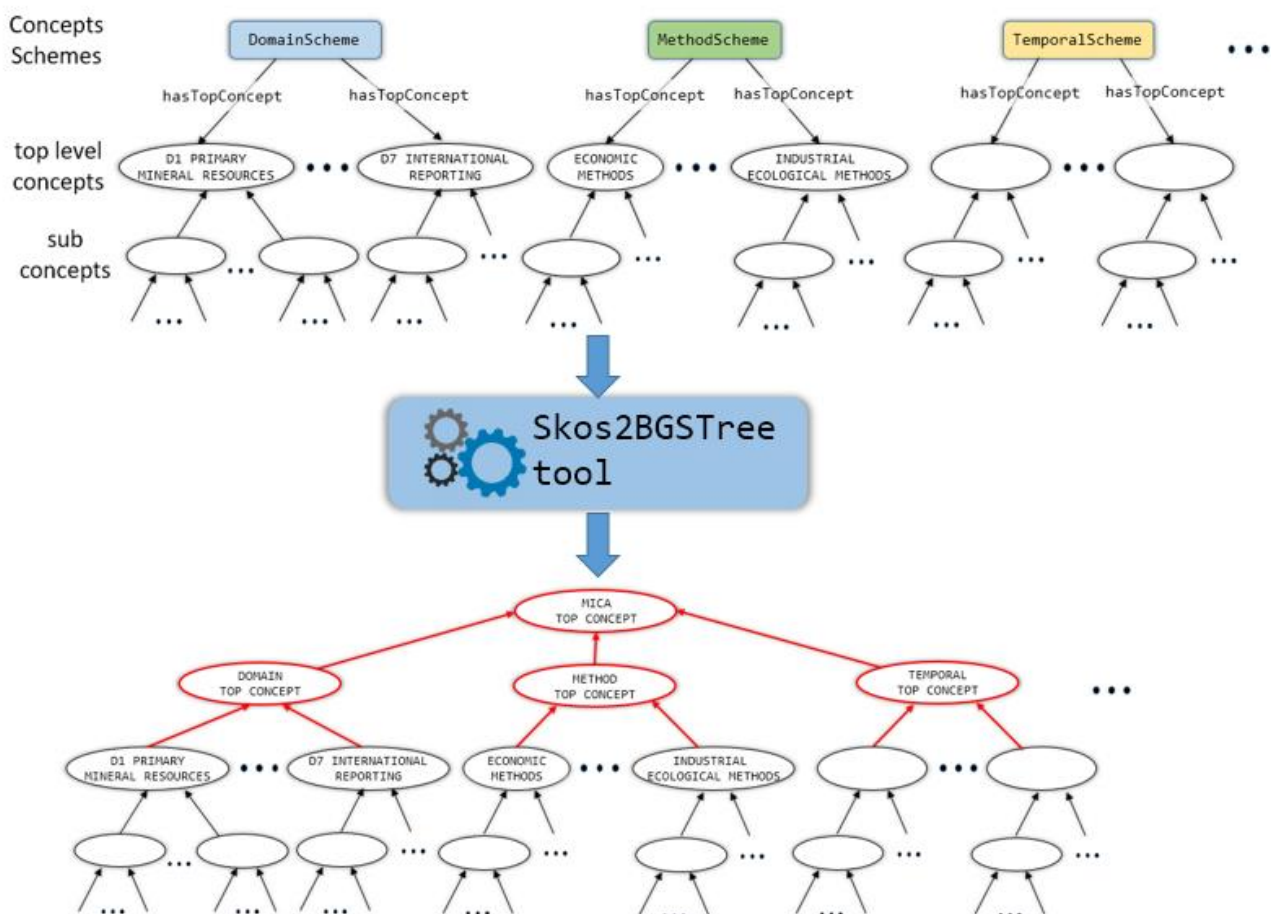


Figure 18 Transformation of MICA main (Domain) ontology and transversal ontologies structured with concepts schemes into a “pure” tree of concepts.

In the same way, the `Skos2JsonFancyTree` program (9) transforms the MICA Ontology SKOS file into a JSON file (10) that can be directly used by the `FancyTree` JavaScript component that displays the concept hierarchy in the `MICASheetEditor`.

`VocBench` is well suited for editing the MICA Ontology, but it is less convenient for browsing all the trees of concepts and, for a given concept, to visualize immediately the related con-

cepts. In order to facilitate this navigation for MICA experts elaborating the ontologies, two programs have been developed:

- Skos2HTML (11) that takes the MICA Ontology SKOS/RDF file as input and produces an HTML page (12), see Figure 19 (<http://lig-coin.imag.fr/mica/concepts.html>).
- Skos2CSV (13) that takes the MICA Ontology SKOS/RDF file as input and produces a CSV file (14).

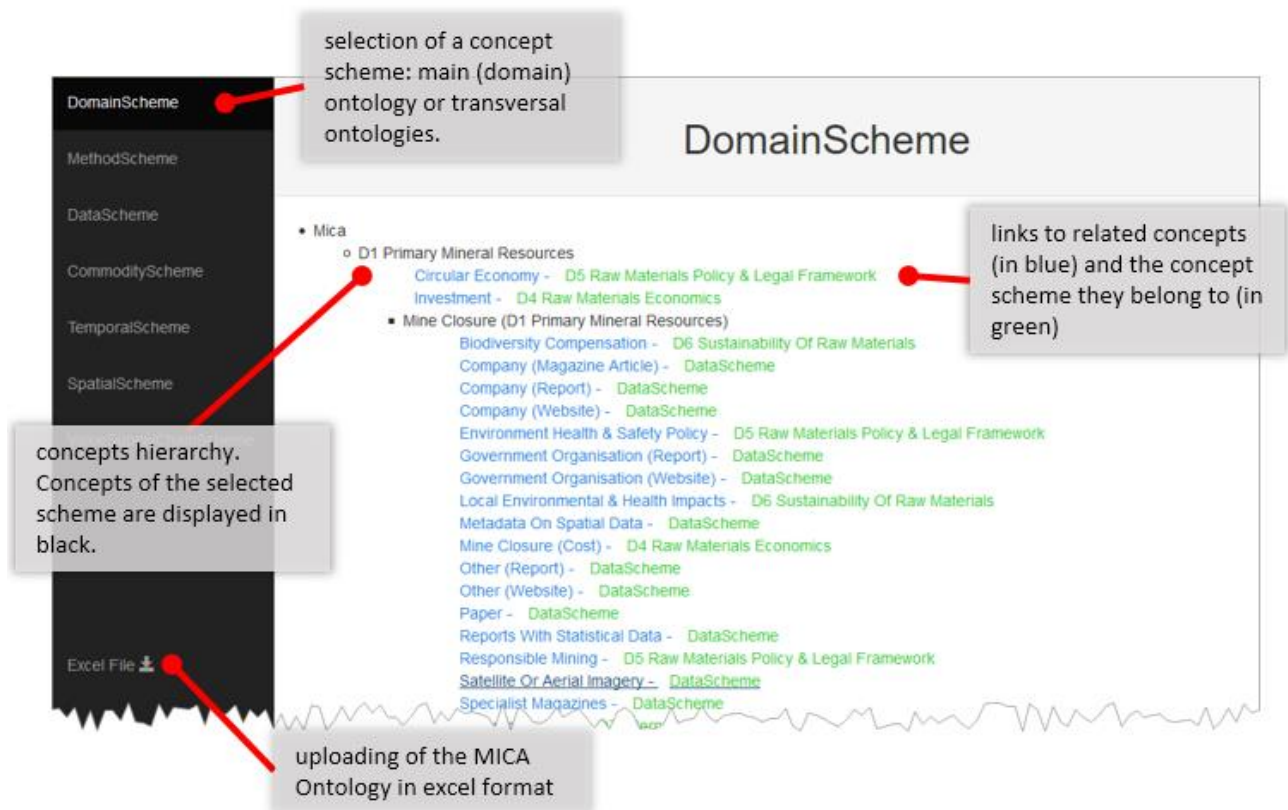


Figure 19 HTML page for rapid navigation between related concepts.

6.2 MICA URIs

6.2.1 Persistent URIs

According to the Web of Data principles, all resources in the MICA platform are identified using HTTP URIs (Uniform Resource Identifiers) as persistent URIs. These resources are vocabulary elements (defined in ontologies) or documents (factSheet, flowSheet, data sources, etc.) managed by the platform. Through the resource URIs (for example a MICASheet) it is possible to access various representations of it: a PDF document, a docx document, and an RDF representation, etc. For this reason it is important to choose URIs for MICA resources in

a domain whose HTTP server can be configured to either serve the vocabulary elements directly, or host a resolver or redirection service.

We chose to use <https://w3id.org>, to define a MICA domain, and to obtain persistent URIs. Proceeding this way, all the URIs concerning MICA resources start with the same prefix: <https://w3id.org/mica/>.

This w3id.org service (Figure 20) is run by the W3C Permanent Identifier Community Group, and provides a secure, permanent URL re-direction service for Web applications. This service uses Apache rewriting rules expressed in .htaccess files.

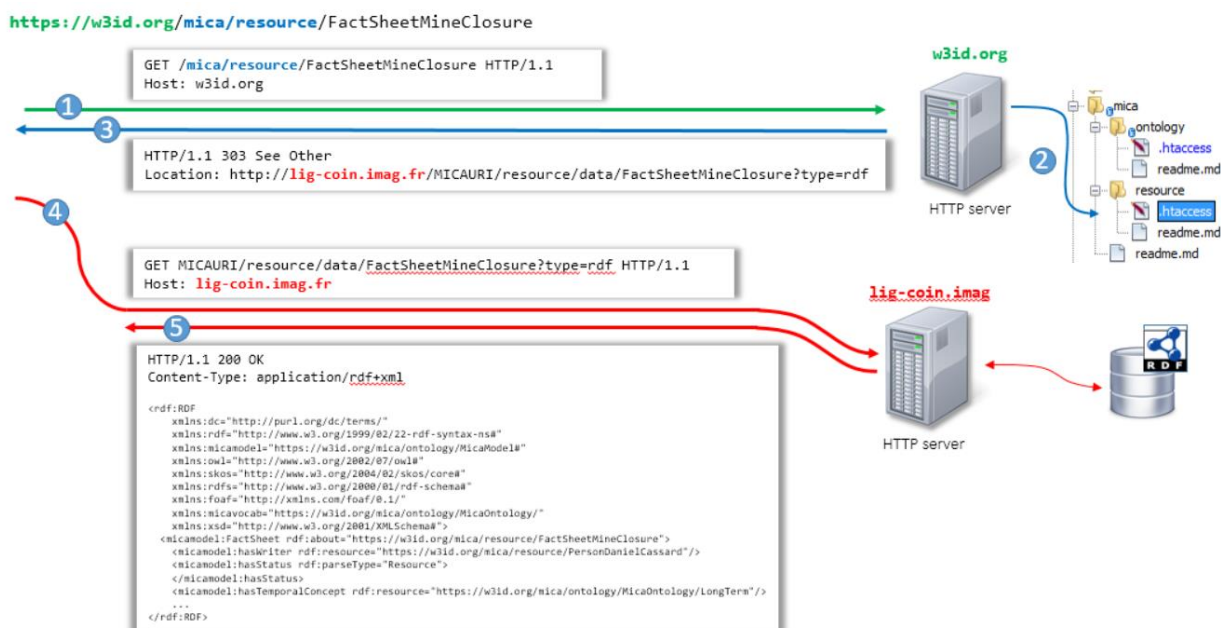


Figure 20 Redirection of URIs using the w3id service.

6.2.2 MICA namespaces

As we saw above, HTTP URIs (Uniform Resource Identifiers) are used to uniquely identify the entities used in the MICA project, and we use persistent URIs based on the w3id.org service. So all MICA URIs are defined in namespaces starting with the same string: <https://w3id.org/mica/>.

Three namespaces are defined:

- <https://w3id.org/mica/ontology/MicaModel#>: the prefix used for all the classes and properties described in the OWL ontology defining the data model for the resources managed by the MICA platform.
- <https://w3id.org/mica/ontology/MicaOntology/>: the prefix used for all the SKOS concepts for the MICA domain and transversal ontologies.
- <https://w3id.org/mica/resource/>: the prefix for all the resources managed by the MICA platform and for which an RDF representation conforming to the MICA data model is stored in the MICA database (Triple Store).

For the MICA Model ontology the local name part of the URIs is the class or property name, for example:

- <https://w3id.org/mica/ontology/MicaModel#Sheet> for the Sheet class,
- <https://w3id.org/mica/ontology/MicaModel#hasDomainConcept> for the hasDomain-Concept property.

For concepts defined in the MICA Ontology, URIs are of the form
<https://w3id.org/mica/ontology/MicaOntology/xxxxx>

where xxxxx is a random UUID (Universally Unique Identifier). For example, <https://w3id.org/mica/ontology/MicaOntology/fe14c339024c48a893fb7ec2a322071c> is the URI of the Carbon Footprint concept.

The same rule applies for resources created by the MICA Sheet Editor and stored in the MICA Triple Store: the local name part of the URI is a UUID. An example of such a URI:
<https://w3id.org/mica/resource/71b5acd42e5447d491460e9dd6dbd30>

6.2.3 Dereferencing MICA URIs

The Linked Data Third principle states that "When someone looks up a URI, provide useful information, using the standards"⁵, in other words, URIs should be dereferenceable, meaning that HTTP clients can look up the URI using the HTTP protocol and retrieve a description of the resource that is identified by the URI. Given a resource URI, any client should be able to retrieve a representation of the resource in a form that meets his/her needs, such as HTML or PDF for humans and RDF for machines.

The HTTP mechanism called content negotiation addresses this issue (Figure 21). The basic idea of content negotiation is that HTTP clients send HTTP headers with each request to indicate what kind of documents they prefer. Servers can inspect these headers and select an appropriate response. For example, if the headers indicate that the client prefers HTML, then the server will respond by sending an HTML document. If the client prefers RDF, then the server will send the client an RDF document (which may be in various serialization formats).

⁵ www.w3.org/DesignIssues/LinkedData.html, *Linked Data - Design issues* - Tim Berners-Lee - Date: 2006-07-27, last change: \$Date: 2009/06/18

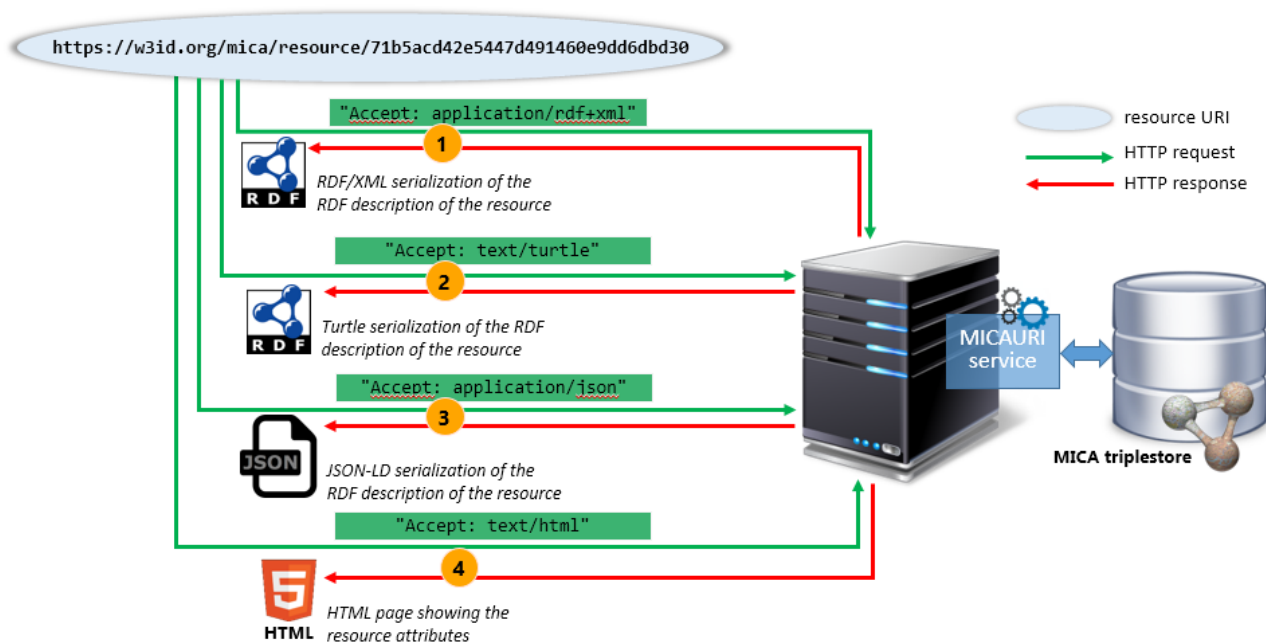


Figure 21 Content negotiation for MICA resources.

We adopted this approach for all MICA URI's. For example, given a MICA resource URI identifying a resource stored in the MICA Triple Store, it is possible to obtain its RDF description in a given RDF serialization format (RDF/XML, Turtle or JSON-LD) or as a HTML page (see Figure 22). The representation format is defined in the `Accept:` header of the HTTP request used to dereference the resource URI.

When PDF files for MICA sheets are stored in the MICA database, the MICA-URI service implements this content negotiation and allows direct retrieval of these documents using the resource URI (for example for visualization in the DDG interface).

6.3 MICA Data Model

The MICA Model ontology defines a data model for the MICA project. This data model is implemented as an OWL ontology that defines the vocabulary used for describing the MICA resources stored in the database (triple store) and annotated with the concepts defined by the MICA Ontology.

Figure 23 presents a UML class diagram view of the classes and properties defined in this data model.

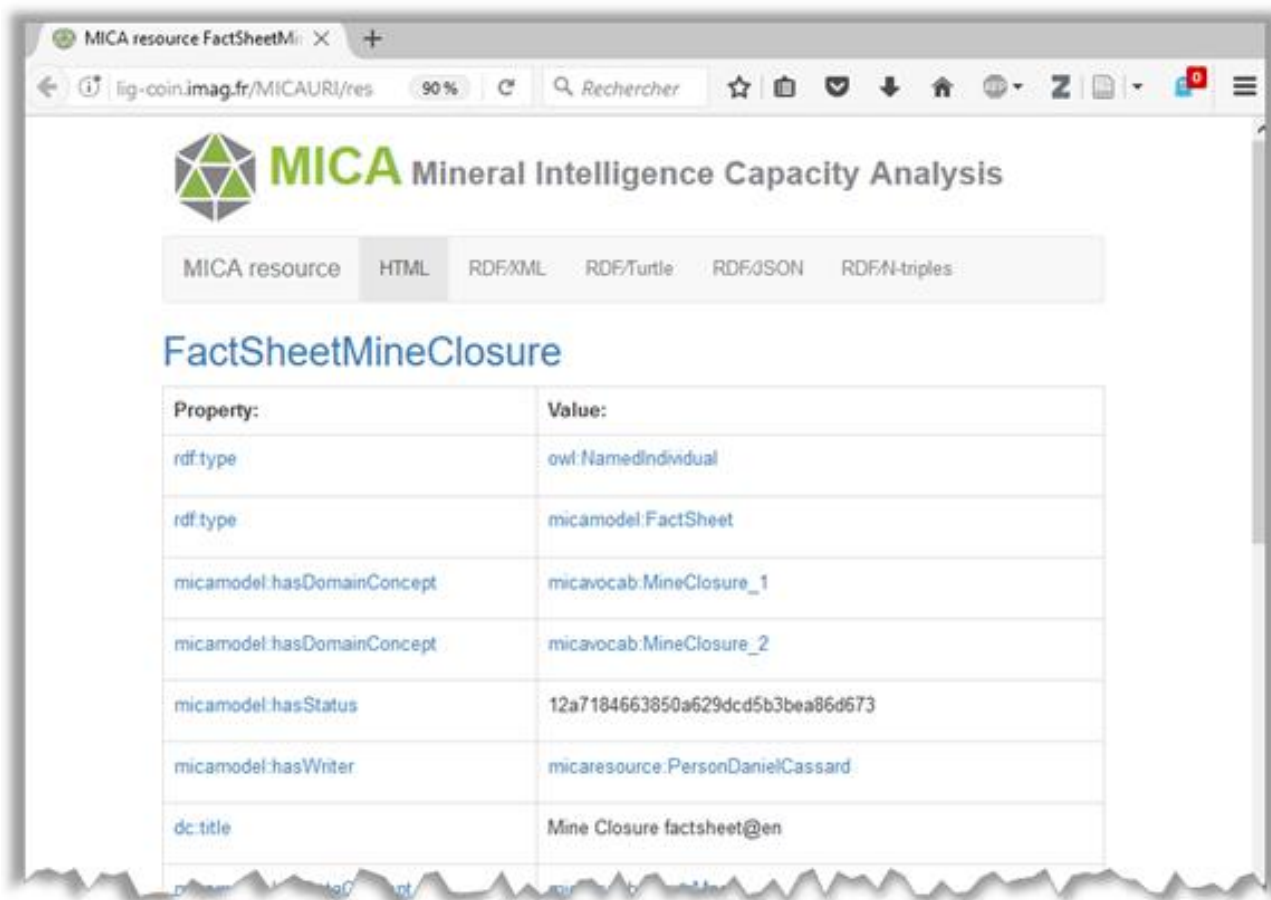


Figure 22 HTML page corresponding to the MICASheet resource about Mine closure.

The main classes of this model are described below.

MICAResource: A MICA Resource is any resource defined in MICA database (triple store) which is annotated with MICA concepts (defined in the MICA Ontology). Resources can be sheets, questions, link to external resources etc. A resource can be linked to other resources using the relatedTo property.

MICAQuestion: A MICA Question is any sentence which asks about the MICA project and that can be answered by some MICA Knowledge Elements.

MICAKnowledgeElement: A MICA Knowledge Element is a piece of knowledge concerning Mineral Intelligence that has been identified by MICA experts and has been annotated with MICA concepts defined in the MICA Ontology. The expert has also to give it a title and a small summary.

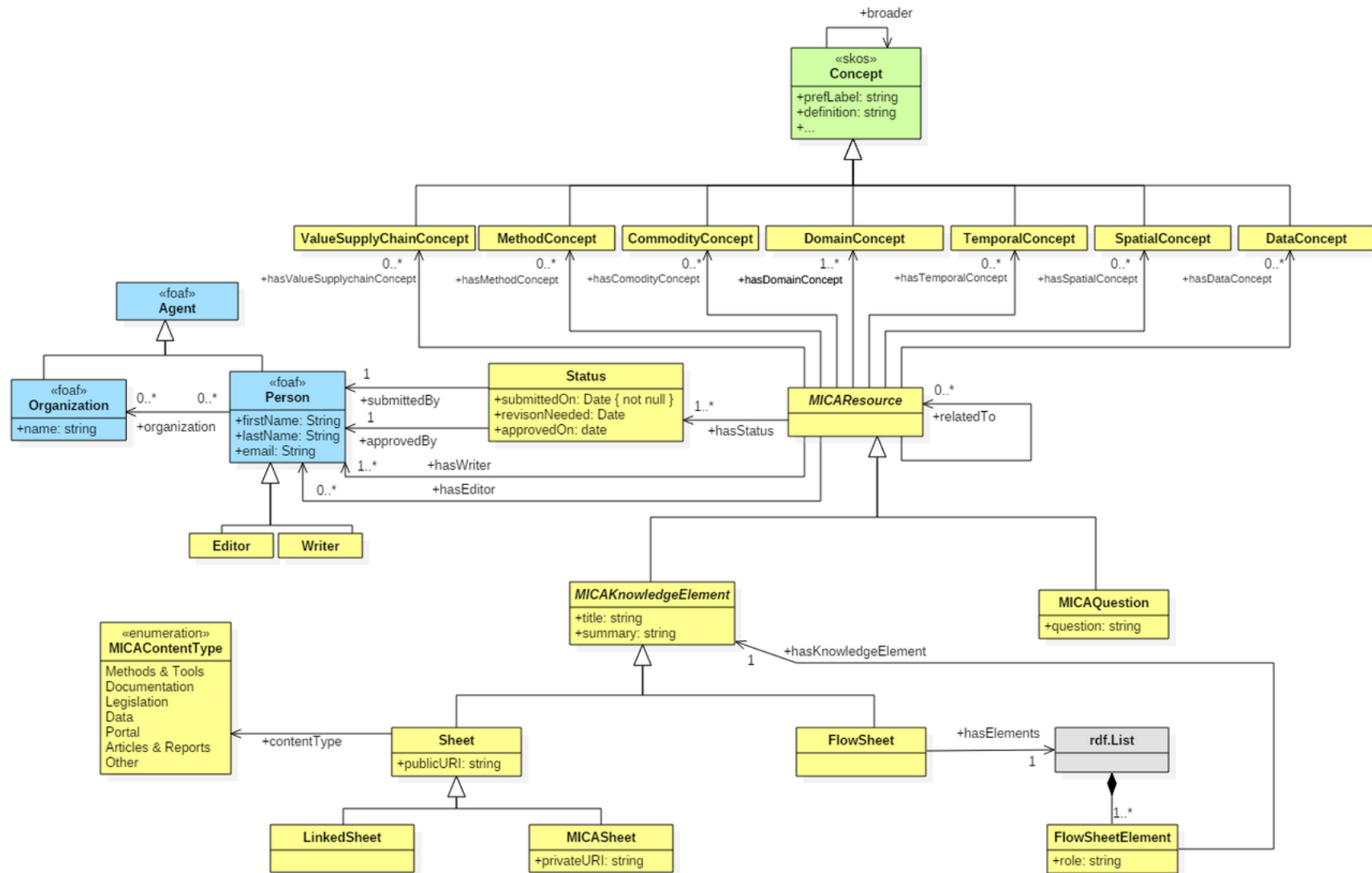


Figure 23 UML diagram class of MICA data model.

MICASheet: A Sheet is an elementary piece of knowledge (MICAKnowledgeElement). This knowledge is accessible through a URI (publicURI). This URI can identify either a resource already available on the Web (for example legislation from EUR-Lex) or a new resource that MICA experts have produced. The public URI allows to access a representation of the resource.

MICAContentType: defines the various content types a sheet can have (Methods&Tools, Documentation ...).

LinkedSheet: For a linkedSheet, the knowledge comes from a resource external to the MICA platform and is accessible on the Web (through its publicURI).

FlowSheet: A flowSheet is an ordered list of MICA Knowledge Elements that can be either a sheet or a flowSheet. Typically, a flowSheet can be seen as a "recipe" for answering a MICA Question. It is the ordered assembly of MICA Knowledge Elements involved and for each of them there is an explanation that defines its role in this assembly.

FlowSheetElement: A flowSheet Element associates a MICA Knowledge Element with a role in a flowSheet. To put it in another way, a flowSheet is composed of a list of flowSheet Elements.

A full description of this ontology (classes and properties) is available online and can be accessed through the ontology URI: <https://w3id.org/mica/ontology/MicaModel>.

6.4 Querying the MICA Triple Store

All the resources defined in MICA are described in RDF using the vocabulary defined by the MICA Model ontology and are annotated with the concepts defined by the MICA Ontology. These descriptions are stored in the MICA Triple Store. All the applications that manage these resources (DDG, MICASheetEditor) access this description through SPARQL queries.

6.4.1 Searching for MICA resources

A set of SPARQL queries has been defined in order to provide useful information in the DDG interface. Queries can be sorted according to the type of resource to which they relate. In the following paragraphs we list by category, the queries made (for more details, the SPARQL implementation of these queries, see Appendix 4):

Concept centric queries

- Get top level domain concepts (top level concepts in MICA main ontology)
- Select all concepts which have a given concept as parent
- Get direct sub-concepts of a given concept
- Get direct parent concept of a given concept
- Get all concepts of a given concept scheme
- Get statistics by concept
- Get all sheets of a given type directly related to a given concept

Get all sheets of a given type related to a given concept
Get all flowSheets related to a given concept
Get all questions related to a given concept
Get all concepts of a given concept scheme related to a given concept
Get metadata (label definition, description, links...) for a given concept
Get all concepts containing a text in their label or definition or other available metadata

Sheet centric queries

Sheets can be any type of MICAContentType, MethodsAndTools, Documentation and Legislation...

Get all sheets of a given type of content
Get all sheets related to a given sheet
Get all questions related to a given sheet
Get all the flowSheets related to a given sheet
Get all concepts related to a given sheet
Get metadata (label definition, description, links...) for a given sheet
Get statistics by sheet
Get all sheets of a given type containing a text in their title or summary or other available metadata

FlowSheet centric queries

Get all flowSheets
Get all MICAKnowledgeElements belonging to a flowSheet
Get all sheets related to a given flowSheet
Get all questions related to a given flowSheet
Get all the flowSheets related to a given sheet
Get all concepts related to a given sheet
Get metadata (label definition, description, links...) for a given flowSheet
Get statistics by flowSheet
Get all sheets of a given type containing a text in their title or summary or other available metadata

Questions

Get all questions
Get all sheets related to a given question
Get all questions related to a given question
Get statistics by question
Get all metadata (question, links...) about a given question
Get all questions containing a given text in their description

A full documentation of the queries is available in Appendix 4.

6.4.2 Annotating MICA resources

The MICASheetEditor annotates resources (MICASheets, linkedSheets, flowSheets) using MICA concepts and stores these annotations in the MICA Triple Store. To create these annotations, the MICASheetEditor uses SPARQL 1.1 Update⁶ queries that permit CRUD (Create, Read, Update and Delete) operations on the graph data base. Queries can be sorted according to the type of resource to which they relate:

- MICASheets Queries concern MICASheets
- LinkedSheets Queries concern linkedSheets
- MICAQuestions Queries concern MICAQuestions
- FlowSheets Queries concern flowSheets
- RelatedResources Queries concern relations between MICAResources (skos:relatedTo relationship).

A full documentation of the queries is available in Appendix 5.

⁶ www.w3.org/TR/2013/REC-sparql11-update-20130321/ SPARQL 1.1 Update - W3C Recommendation 21 March 2013

7. The ranking of results by relevance

In order to make the system more powerful and more convenient for the end user, it has been decided in WP6 that the results will be presented by pertinence or relevance. In other words, the answers of the system will take into account all the information related to the navigation on the ontology-based DDG. This will allow the MICA resources presented to the end user to be ranked.

The system has been designed in such a way that the end user can graphically formulate the question he/she has in mind. The navigation on the ontology-based DDG allows him/her to select the concepts and sub-concepts that are the closest to what he/she is looking for. This is possible because the Main Ontology has been designed by the MICA Experts to cover most of the topics related to the Raw Materials domain from prospecting to recycling, taking into account the environmental, technical, political and social dimensions. To each of the concepts and sub-concepts one or several 'Sheets' describing methods and tools are attached, giving recipes on 'how to proceed to get such or such a result', providing the end user with the best documents related to the question he/she has in mind.

These different resources (MICASheets for documentation, methods and tools, articles and reports, flowSheets for complex scenarios, linkedSheets for 'external high-quality' resources, etc.) are attached to one or several concepts from the MICA Ontology. They can also be linked together: for example, a MICASheet can be linked, to one or several sheets that detail some aspects (i.e., some piece of EU legislation, some types of data, etc.). In other words, a resource is not an isolated element: when navigating on the DDG and choosing one or several concepts, the end user will not only get directly related sheets but also some other sheets – less closely related – but which make sense:

- Resources that are annotated with more specific concepts than the ones selected by the user in the DDG.
- Related resources.

To illustrate this, let us consider the following example. Suppose we have in the MICA Triple Store five sheets annotated with D1 PRIMARY MINERAL RESOURCES concepts as shown in Figure 24.

We also have:

- R1 with concept C1_1, Resource assessment (sub-concept of C1 Mineral Exploration)
- R2 with concept C1_1_1, Approximate resource calculation (sub-concept of C1_1)
- R3 with concept C1_1_3, Geological Interpretation (sub-concept of C1_1)
- R4 with concepts C1_1_2, Drilling Assessment, and C1_1_3, Geological Interpretation, (both sub-concepts of C1_1)
- R5 with concept C1_2, Subsurface Exploration, (sub-concept of C1).

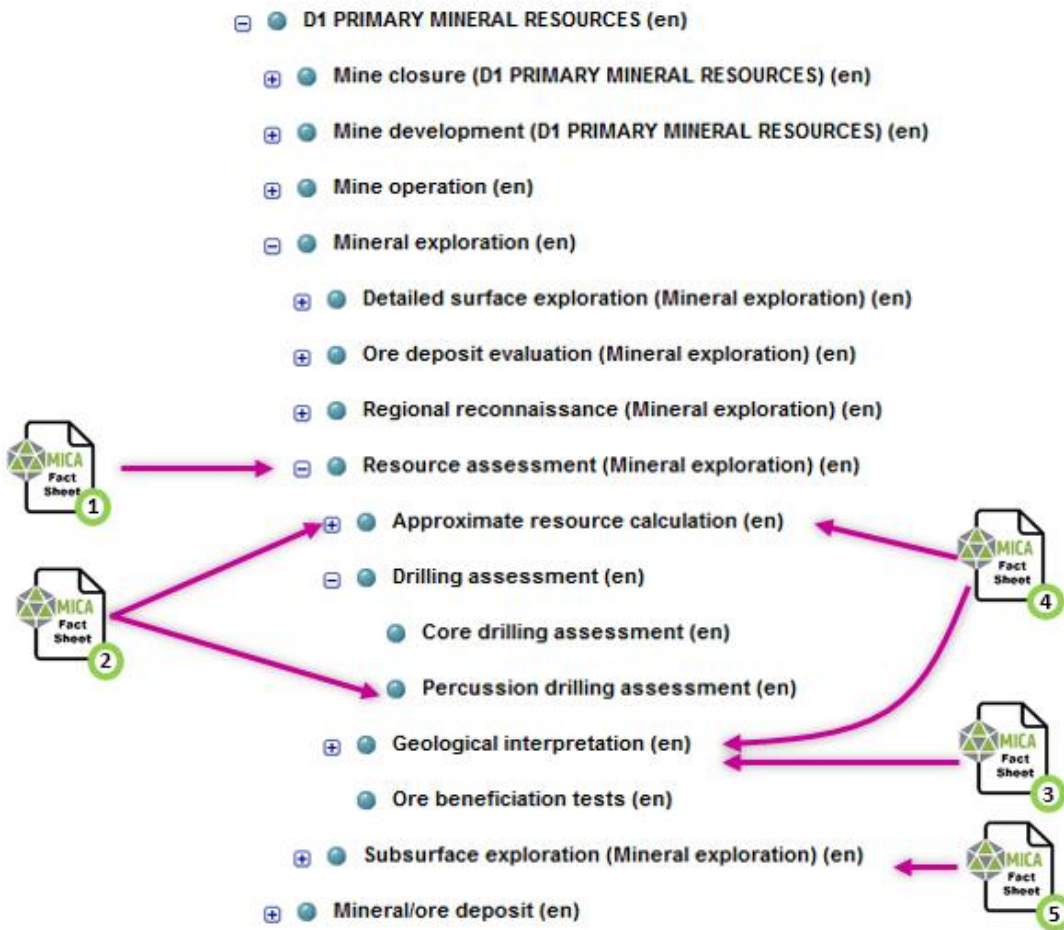


Figure 24 Sample MICA Sheets annotated with D1 (PRIMARY MINERAL RESOURCES) concepts.

Figure 25 shows the RDF graph representing the concepts hierarchy and the annotated MICA Resources.

If we suppose the user selects the C1_1 concept (Resource Assessments) in the DDG and asks for all resources that are relevant for this concept, we can expect the system will retrieve all the resources that are directly related to C1_1 (here R1), but also the ones that are related to more specific concepts (R2, R3 and R4). To achieve that, it is necessary to:

1. Search all the resources that are annotated with C1_1 concept (Resource Assessment) or any sub-concept of C1_1.
2. Rank (order) these resources according to some relevance criteria.

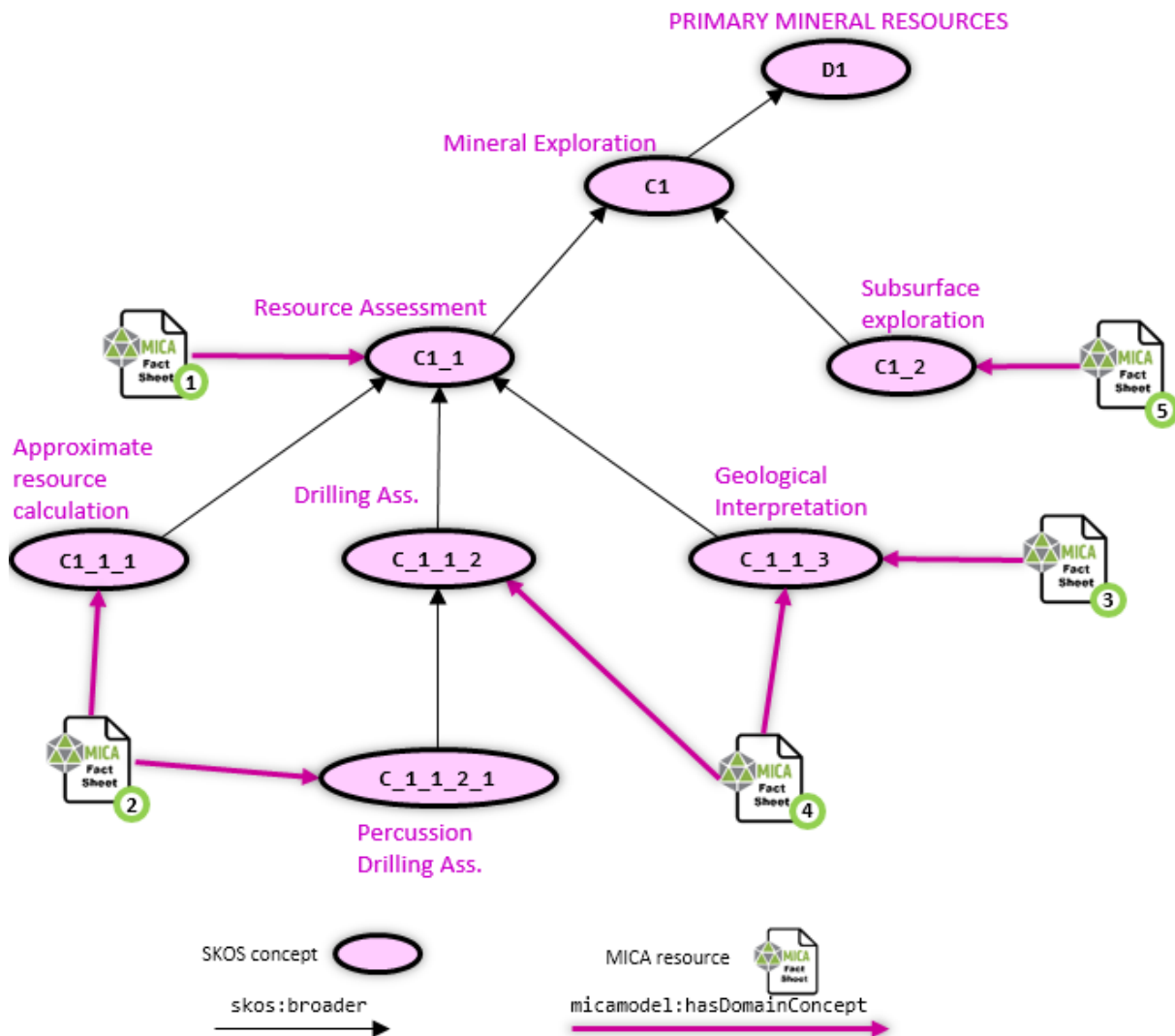


Figure 25 RDF graph of annotated MICA resources.

7.1 Inferencing and the Search Task

The search task is performed through SPARQL queries that are constructed dynamically with the concepts selected by the user with the DGG user interface. To facilitate and optimize the SPARQL queries for search, inferences are first performed on the RDF Graph stored in the MICA Triple Store. Inferencing means creating new facts (new assertions and new relations) in the Triple Store based on the well-defined semantic of RDFS, OWL and SKOS knowledge representation languages on which the MICA Model Ontology and the MICA Ontology are based.

For example, the MICA Ontology defines hierarchies of concepts using the `skos:broader` relation to assert immediate (i.e., direct) hierarchical links between two SKOS concepts. But the `skos:broader` property is defined as a sub-property of the `skos:broaderTransitive` property (1) and `skos:broaderTransitive` is defined as transitive property (2).

- (1) Implies that if A is a sub-concept of B (A skos:broader B) and B a sub-concept of C then A skos:broaderTransitive C can be inferred.
- (2) Implies that if A skos:broaderTransitive B and B skos:broaderTransitive C then A skos:broaderTransitive C can be inferred.

Figure 26 shows the effect of such inferences on the hierarchy of MICA concepts *D1 PRIMARY MINERAL RESOURCES*, *Mineral Exploration* and *Subsurface exploration*.

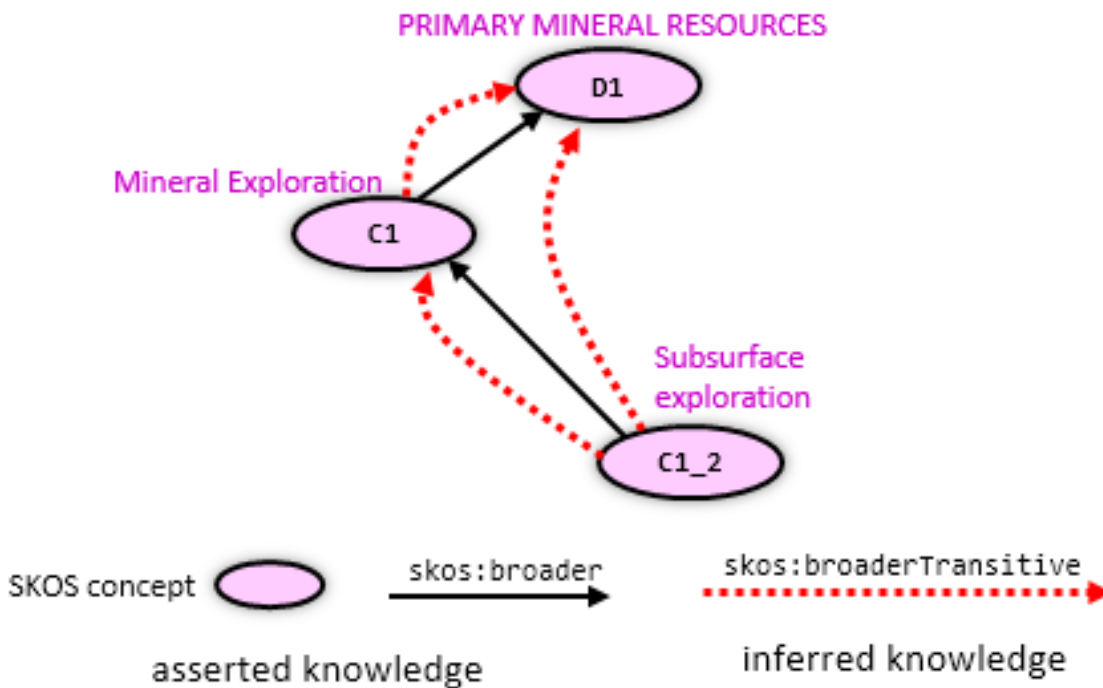


Figure 26 SKOS broaderTransitive inferences.

The strategy adopted to create these new facts consists in deducing all possible assertions; we call this action “saturation”. The Triple Store is therefore saturated by these deductions.

Figure 27 shows the saturation of the graph of *D1 PRIMARY MINERAL RESOURCES* concepts used in the previous example to annotate MICA resources.

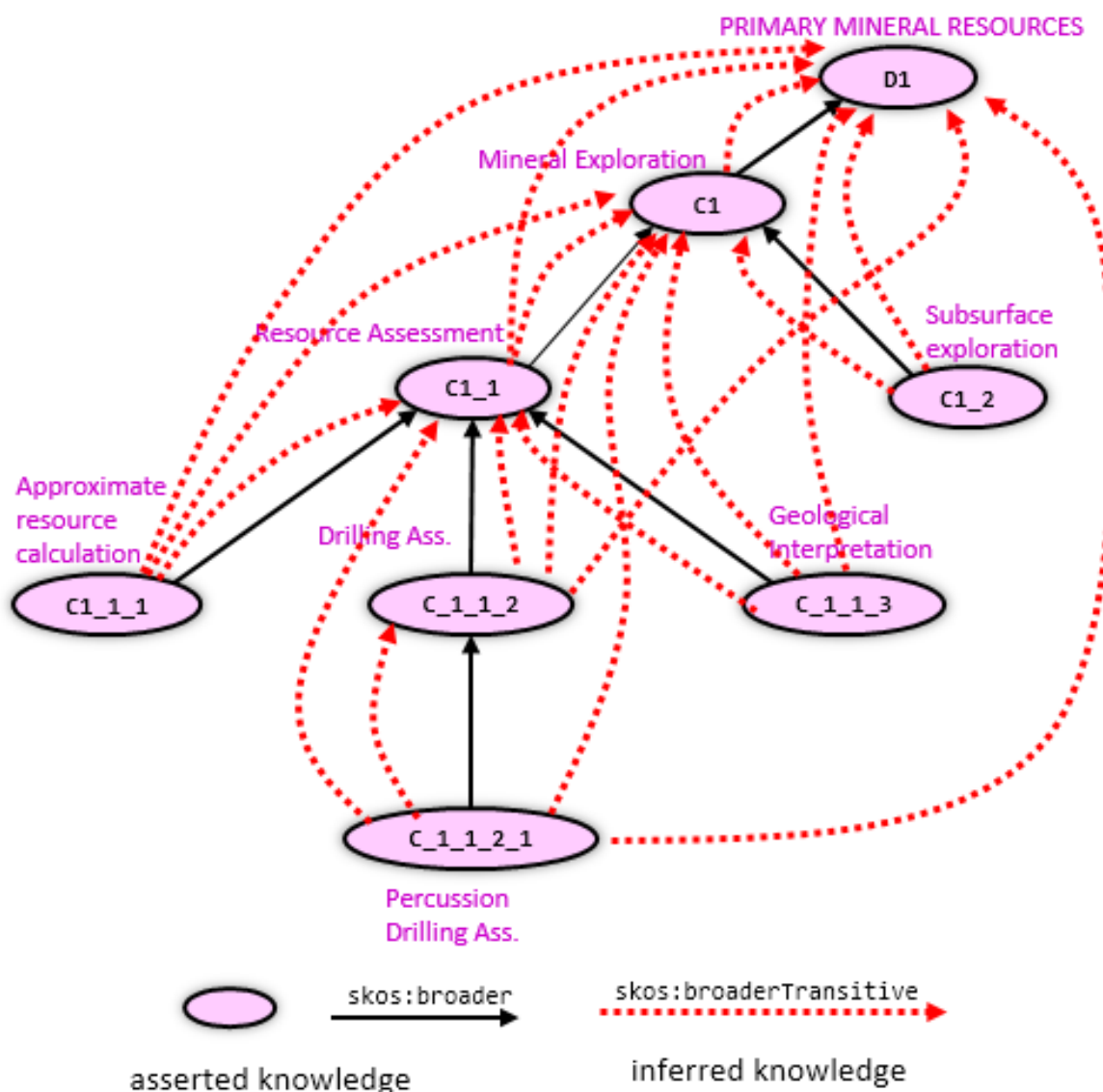


Figure 27 Saturation of the concepts graph with the `skos:broaderTransitive` inferences.

All inferences necessary to perform the MICA search queries are expressed through 18 inference rules detailed in Appendix 6. To complete the RDF graph saturation with these inferences, the Fuseki server that supports the Triple Store has been configured to perform automatically the inferences every time new triples are inserted in the graph by the MICASheetEditor using SPARQL queries.

Once the inferences have been performed, a very simple and generic SPARQL query can be used to find all the MICA resources associated to a given concept. For example, to find all the resources of type sheet (i.e., `linkedSheet` or `MICASheet`), the SPARQL query is:

```
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX model: <https://w3id.org/mica/ontology/MicaModel#>
```

```

PREFIX micaresource: <https://w3id.org/mica/resource/>

SELECT ?sheetURI
WHERE {
  ?sheetURI a model:Sheet;
            model:hasMicaConcept ?conceptURI.
  ?conceptURI skos:broaderTransitive micavocab:C1_1 ;
}
order by ?sheetURI

```

This query will retrieve resources R1, R2, R3 and R4 as shown in Figure 28.

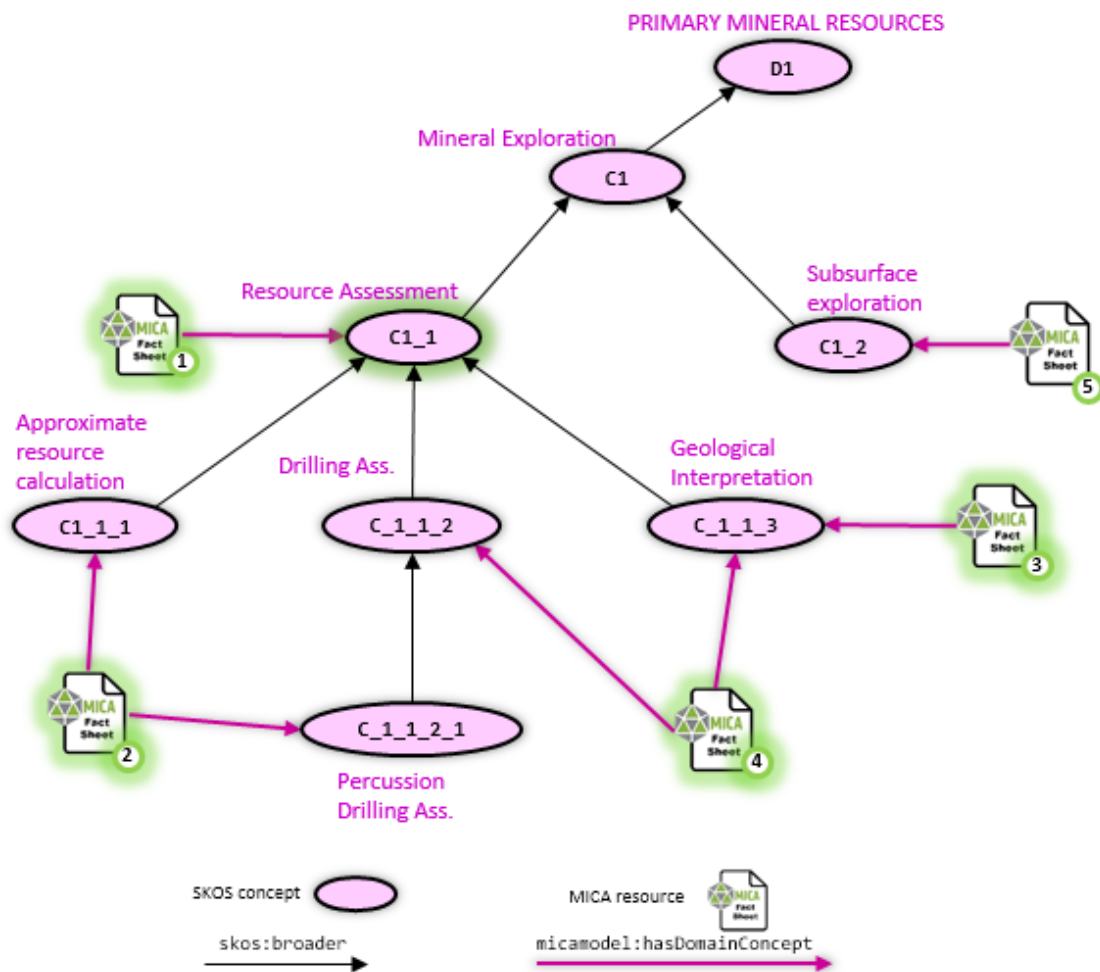


Figure 28 Resources associated to C1_1 (Resource Assessment) concept.

7.2 Ranking Task

Once the results of the queries are obtained by applying the inference and then computing the query, the results must be ordered according to their relevance. The relevance is based on a combination of the semantic distance between concepts annotating a resource and the concepts used to express the search and the number of concepts annotating the resource.

The semantic distance between two hierarchically related concepts is the number of skos:broader edges that separate the concepts. For example the semantic distance between concepts C_1_1_2_1 (Percussion Drilling Assessment) and C_1_1 (Resource Assessment) is 3 as shown in Figure 29.

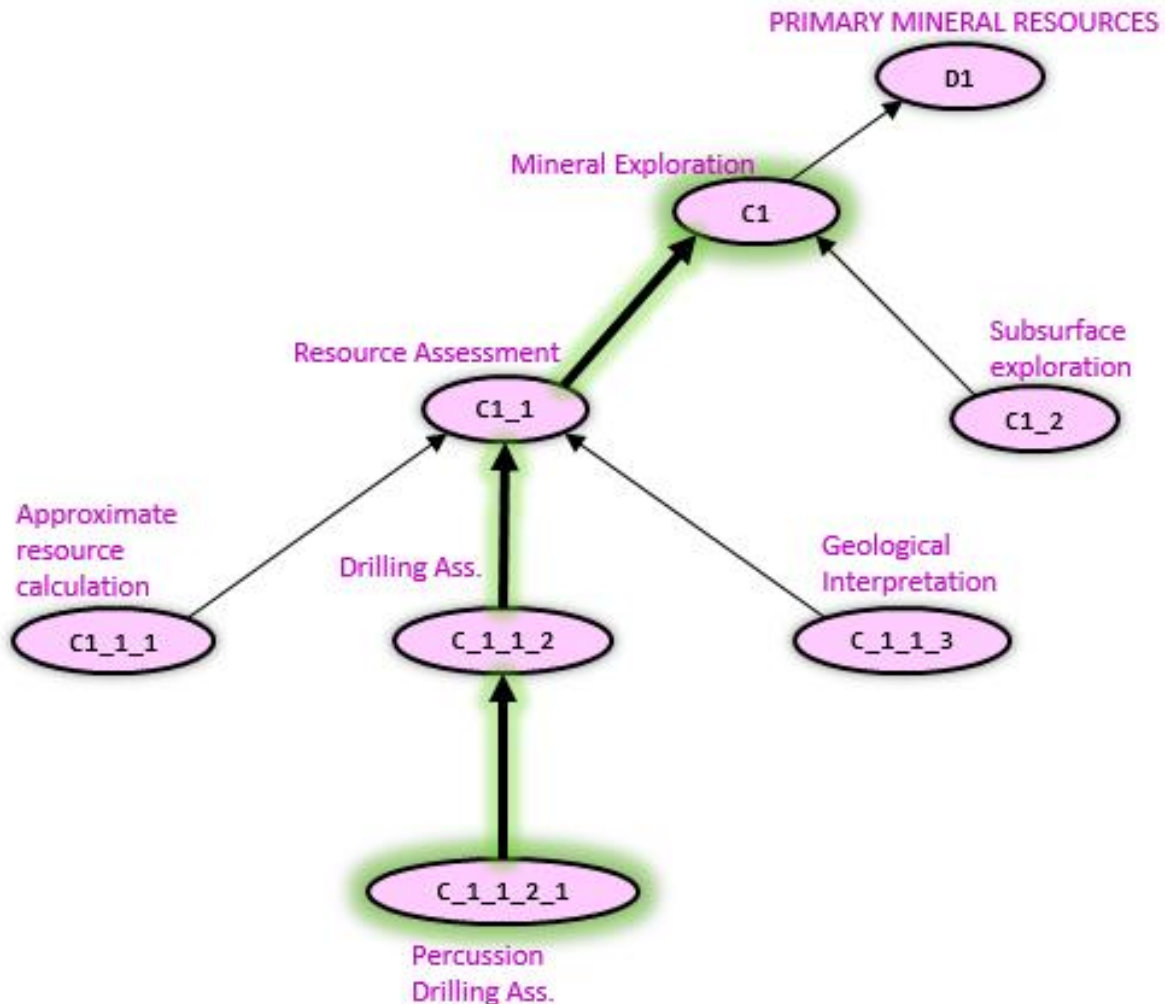


Figure 29 Semantic distance between concepts.

To rank the resources, priority is given to the ones which are annotated with concepts that are closer to the concepts used to define the search. Thus, the ranking algorithm for a single search (search based on only one concept) consists, for each retrieved resource, of calculating:

- 1) minDist, the minimum distance between concepts annotating the resource and the search concept. Formally, for a resource annotated with concepts c_i , $i \in [1..n]$, $\text{minDist} = \min(\text{semanticDistance}(c_i, c)$ where c is the searched concept.
- 2) maxDist, the maximum distance between concepts annotating the resource and the search concept. Formally, for a resource annotated with concepts c_i , $i \in [1..n]$, $\text{maxDist} = \max(\text{semanticDistance}(c_i, c)$ where c is the searched concept.
- 3) nbConcepts the number of concepts that annotate the resource.

The first ranking criteria is minDist. Resources are ordered with an ascending minDist value (resource with the smallest minDist is the first and so on...).

In the case of equality, the second criteria is based on maxDist in an ascending order (resource with the smaller maxDist will be the first and so on...).

Finally, in the case of equality on minDist and maxDist criteria, the nbConcepts criteria in a descending order is used (resource with the biggest nbConcepts criteria is the first and so on...).

Figure 30 below illustrates the application of this ranking algorithm on the resources presented in the previous examples.

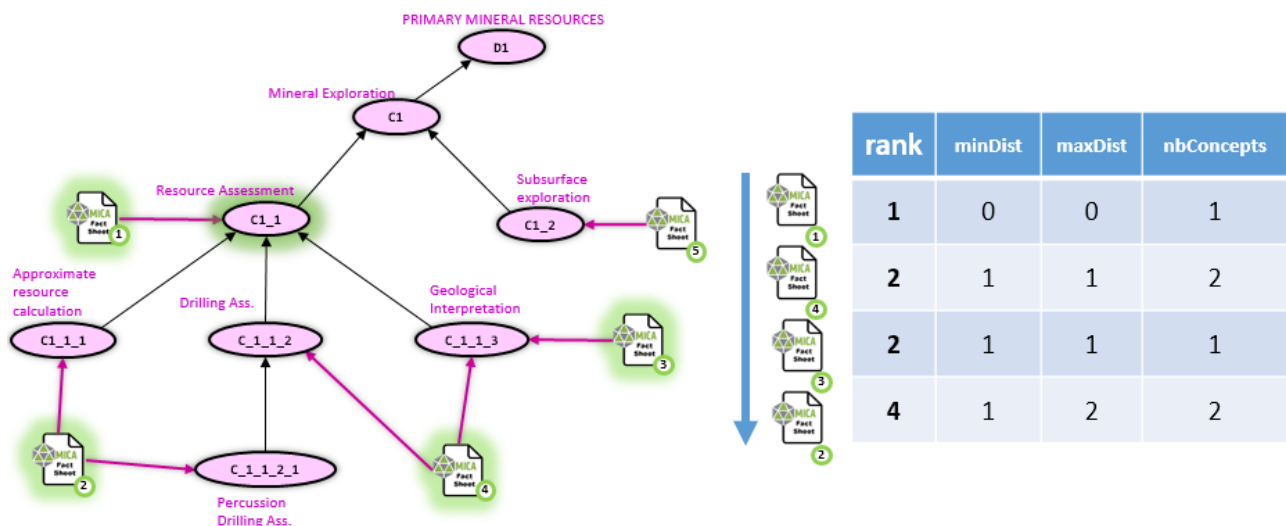


Figure 30 Ranking of resources for search based on C1_1 (Resource Assessment) concept.

This ranking algorithm can be performed directly with a single SPARQL query that extends the search query:

```

PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX model: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX micaresource: <https://w3id.org/mica/resource/>

SELECT ?sheetURI
      (group_concat( ?conceptURI; separator ";" )AS ?conceptURIs)
      (min(?nbParentURI-?nbParentRefURI) as ?minDist)
      (max(?nbParentURI-?nbParentRefURI) as ?maxDist)
      (COUNT(distinct ?conceptURI) as ?nbConcepts)
WHERE {
  SELECT ?sheetURI ?conceptURI
        (COUNT(distinct ?parentURI) as ?nbParentURI)
        (COUNT( distinct ?parentRefURI) as ?nbParentRefURI)
  WHERE {

```

```

        ?sheetURI a model:Sheet;
                model:hasMicaConcept ?conceptURI.
        ?conceptURI skos:broaderTransitive micavocab:C1_1 ;
                skos:broaderTransitive ?parentURI.
        micavocab:C1_1 skos:broaderTransitive ?parentRefURI.
    }
    GROUP BY ?sheetURI ?conceptURI
}

GROUP BY ?sheetURI
ORDER BY ?minDist ?maxDist DESC(?nbConcepts) ?sheetURI

```

This technical choice to perform searches and ranking through inferences rules and SPARQL queries is justified by the flexibility the declarativity of rules and queries provides. Ease of modification and extension offered by queries and rules can be opposed to the creation of a more complex search and inference algorithm that would be more difficult to modify.

The ranking algorithm for a one-concept-based search can be easily extended to a multiple concepts search. The basic idea is to perform a single search on each concept selected by the user, and then to cumulate and order the minDist, maxDist and nbConcepts criteria.

The algorithm for ranking query results with a several-concept search is the following:

$CS_i = \{C_i, i \in [1..n]$ the set of concepts the user selected for her search}
 $RS = \{\}$ the set of Resources matching the query

For every concept C_i in CS_i

$RS_i = \{R_j, j \in [1..k]$ the set of resources that are annotated with at least C_i
or any sub-concept of $C_i\}$

For each R_j in RS_i calculate

Add R_j to RS

 minDist_{j,i} the minimal semantic distance to C_i for R_j

 maxDist_{j,i} the maximal semantic distance to C_i for R_j

 nbConcepts_{j,i} the number of concepts C annotating R_j , such as C subclass of C_i
endFor

endFor

For each R_j in RS calculate

 nb_j = 0 // the number of search concepts matched by R_j

 sumMinDist_j = \sum minDist_{j,i} the sum of the minimal semantic distances for R_j

 sumMaxDist_j = \sum maxDist_{j,i} the sum of the maximal semantic distances for R_j

 sumNbConcepts_j = \sum nbConcepts_{j,i} the total number of concepts annotating R_j
endFor

sort RS first by nb_j in descending order

 second by sumMinDist_j in ascending order

 third by sumMaxDist_j in ascending order

 fourth by sumNbConcepts_j in descending order

To illustrate this algorithm, consider the following example (see Figure 31):

micaresource:R1 annotated by micavocab:C1, micavocab:C2, micavocab:C3 & micavocab:C4

micaresource:R2 annotated by micavocab:C1, micavocab:C2 & micavocab:C3

micaresource:R3 annotated by micavocab:C1

micaresource:R4 annotated by micavocab:C1_1 & micavocab:C2

micaresource:R5 annotated by micavocab:C2_2 & micavocab:C3_1

micaresource:R6 annotated by micavocab:C4_2

micaresource:R7 annotated by micavocab:C1_2 & micavocab:C2_1_1

micaresource:R8 annotated by micavocab:C1_1_1

micaresource:R9 annotated by micavocab:C2_2_1 & micavocab:C3_1_1 & micavocab:C4_1

micaresource:R10 annotated by micavocab:C3_2_1 & micavocab:C4_2_1

micaresource:R11 annotated by micavocab:C5

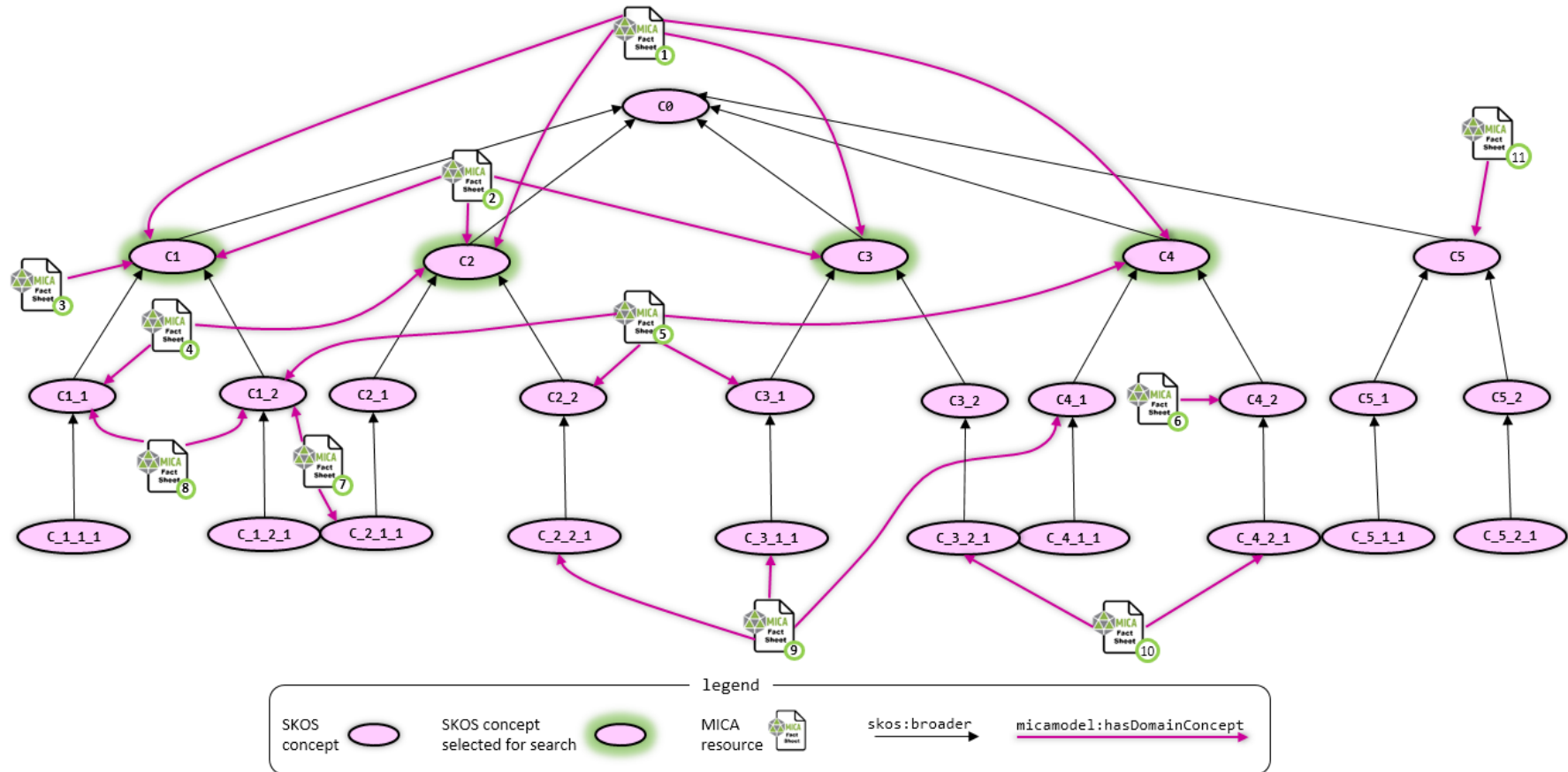



Figure 31 Ranking example with multiple concepts search.

If the user selects concepts C1, C2, C3, C4 for search, the ranking result can be seen in Table 1.

Table 1 Ranking results for multiple concepts search.



resource	rank	nb _j	sumMinDist _j	sumMaxDist _j	sumNbConcepts _j
R1	1	4	0	0	4
R5	2	4	3	3	4
R2	3	3	0	0	3
R9	4	3	5	5	3
R4	5	2	1	1	2
R7	6	2	3	3	2
R10	7	2	4	4	2
R3	8	1	0	0	1
R8	9	1	1	1	2
R6	10	1	1	1	1

8. The DDG and its side applications: the interface with end users

The updated version of the MICA end-user application (DDG and side applications) – see Figure 32 – is being finalised taking into account the final version of the MICASheetEditor – the tool for storing and annotating all types of sheets, i.e. the MICA Expert content.

As agreed, the DDG offers several ways of utilizing the MICA knowledge base (RTD – Triple Store). The DDG was developed further following closely developments of the structure, model, and content of the MICA RDF.

MICA Knowledge Base

HOME GRAPH WIZARD SEARCH FAVORITES CONTACT

MICA Knowledge Base

Mineral Intelligence Capacity Analysis

project will provide stakeholders with the best possible Raw Materials Information, in a seamless and flexible way using the European Union Raw Materials Intelligence Capacity Platform (EU-RMICP).

Revolution in Mineral Intelligence Capacity Analysis

- Graph**
allows the end user to navigate & visualize the database content and to search for the most appropriate method(s) and tool(s) to use for resolving his problem.
- Search**
looks into the labels and definitions of available Concepts / FactSheets / DocSheets / Legislation / Data / Question / FlowSheets / ...
- Wizard**
guides you through the available concepts. In this way we help you to build a query based on those concepts, that best fit your question.
- FAQ**
these questions have been collected by the Work Package 2 on Stakeholder consultation. Here we map these questions to Flow Sheets, which can be best described as cooking recipes on how to answer them.

MICA KNOWLEDGE BASE
project will provide stakeholders with the best possible Raw Materials Information, in a seamless and flexible way using the European Union Raw Materials Intelligence Capacity Platform (EU-RMICP).

HELPFUL LINKS
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Ontology Graph
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Wizard

CONCEPTS
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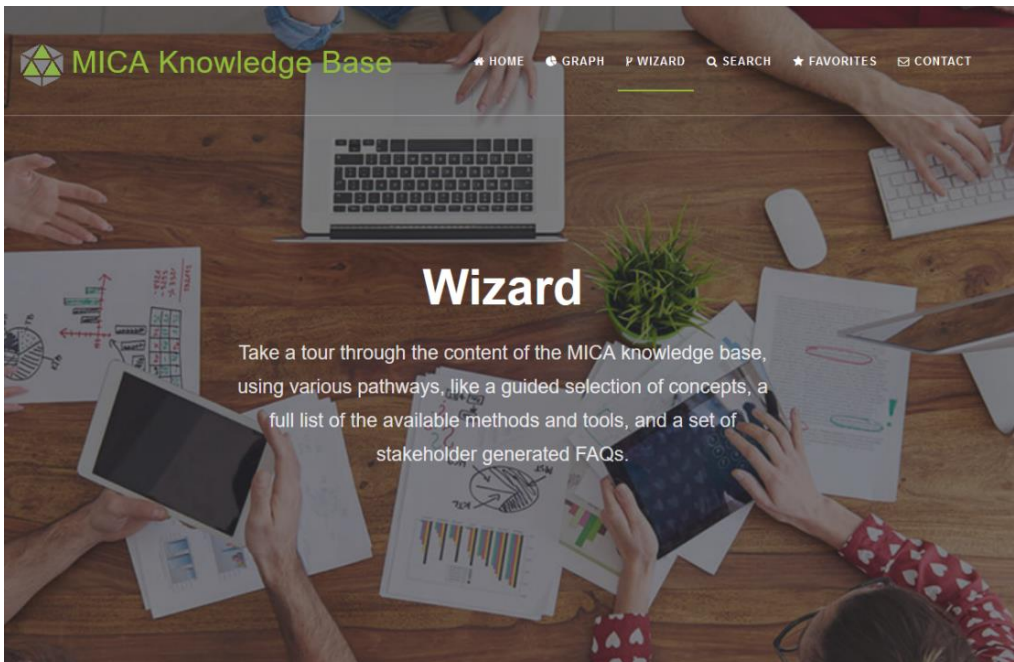
Figure 32 MICA end-user application: DDG and side applications.

The current set of user applications (4 ways) of accessing the content of the MICA knowledge base are (see <http://micaontology.brgm-rec.fr/MICAontology/>):

- Graph – allows the end-users to navigate and visualize the MICA database content and to search for most appropriate method(s) & tool(s), legislation, portals, articles & reports and FAQs, etc., to use to resolve his/hers problem (Figure 33). For user-searches the MICA Ontology and MICA transverse-ontology concepts are fully utilised.

Figure 33 MICA Graph Application.

- Wizard – also guides users through the MICA Ontology (RM related concepts) to help to find the most related concept, methods, tools as well as FAQs to the user problem, and eventually to see associated other “Sheets” and other type of information that might be relevant to the user problem. A simplified workflow (set of steps) that users can follow is to be found in Figure 34 (composed of a sequence of screenshots).



Concepts Workflow

guides you through the available concepts. In this way we help you to build a query based on those concepts, that best fit your question.

START



Methods & Tools

provides a list of all methods and tools, which can then be narrowed down and filtered using MICA concepts, commodities etc.

START



FAQ/FlowSheets

these questions have been collected by the Work Package 2 on Stakeholder consultation. Here we map these questions to Flow Sheets, which can be best described as cooking recipes on how to answer them.

START

guides you through the available concepts. In this way we help you to build a query based on those concepts, that best fit your question.

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Workflow - Step 1

Workflow - Step 2



MICA Available concepts

- D1 PRIMARY MINERAL RESOURCES** [Details](#) [Favorite](#)
 - Methods&Tools 16 Documentation 0 Legislation 0 Data 0 Portal 0 Articles&Reports 0 Others 0 FAQ 0
- D2 SECONDARY MINERAL RESOURCES** [Details](#) [Favorite](#)
 - Methods&Tools 15 Documentation 0 Legislation 0 Data 0 Portal 0 Articles&Reports 0 Others 0 FAQ 0
- D3 INDUSTRIAL PROCESSING AND TRANSFORMATION** [Details](#) [Favorite](#)
 - Methods&Tools 10 Documentation 0 Legislation 0 Data 0 Portal 0 Articles&Reports 0 Others 0 FAQ 0
- D4 RAW MATERIALS ECONOMICS** [Details](#) [Favorite](#)
 - Methods&Tools 15 Documentation 0 Legislation 0 Data 0 Portal 0 Articles&Reports 0 Others 0 FAQ 0
- D5 RAW MATERIALS POLICY & LEGAL FRAMEWORK** [Details](#) [Favorite](#)
 - Methods&Tools 15 Documentation 0 Legislation 0 Data 0 Portal 0 Articles&Reports 0 Others 0 FAQ 0
- D6 SUSTAINABILITY OF RAW MATERIALS** [Details](#) [Favorite](#)
 - Methods&Tools 16 Documentation 0 Legislation 0 Data 0 Portal 0 Articles&Reports 0 Others 0 FAQ 0
- D7 INTERNATIONAL REPORTING** [Details](#) [Favorite](#)
 - Methods&Tools 14 Documentation 0 Legislation 0 Data 0 Portal 1 Articles&Reports 0 Others 0 FAQ 0



D1 PRIMARY MINERAL RESOURCES Available sub-concepts

- Mineral/ore deposit** [Details](#) [Favorite](#)
 - Methods&Tools 0 Documentation 3 Legislation 0 Data 0 Portal 1 Articles & Reports 0 Others 0 FAQ 0
- Prospecting authorization/Permitting** [Details](#) [Favorite](#)
 - Methods&Tools 0 Documentation 0 Legislation 0 Data 0 Portal 0 Articles & Reports 0 Others 0 FAQ 0
- Mine development (D1 PRIMARY MINERAL RESOURCES)** [Details](#) [Favorite](#)
 - Methods&Tools 1 Documentation 3 Legislation 0 Data 0 Portal 0 Articles & Reports 0 Others 0 FAQ 0
- Mineral exploration** [Details](#) [Favorite](#)
 - Methods&Tools 2 Documentation 2 Legislation 0 Data 0 Portal 0 Articles & Reports 0 Others 0 FAQ 0
- Preliminary feasibility study and feasibility study** [Details](#) [Favorite](#)
 - Methods&Tools 0 Documentation 2 Legislation 0 Data 0 Portal 0 Articles & Reports 0 Others 0 FAQ 0
- Mine closure (D1 PRIMARY MINERAL RESOURCES)** [Details](#) [Favorite](#)
 - Methods&Tools 3 Documentation 1 Legislation 0 Data 0 Portal 0 Articles & Reports 0 Others 0 FAQ 0
- Preliminary economic assessment (D1 PRIMARY MINERAL RESOURCES)** [Details](#) [Favorite](#)
 - Methods&Tools 0 Documentation 2 Legislation 0 Data 0 Portal 0 Articles & Reports 0 Others 0 FAQ 0
- Mine operation** [Details](#) [Favorite](#)
 - Methods&Tools 0 Documentation 0 Legislation 0 Data 0 Portal 0 Articles & Reports 0 Others 0 FAQ 0

Please, select one or more concepts that satisfy your needs.

Summary

Selected concepts:

- D1 PRIMARY MINERAL RESOURCES
- D2 SECONDARY MINERAL RESOURCES

Selected sub-concepts:

- Mineral/ore deposit
- Preliminary feasibility study and feasibility study

[Next](#)

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- D2 SECONDARY MINERAL RESOURCES

WORKFLOW

guides you through the available concepts. In this way we help you to build a query based on those concepts, that best fit your question.

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D2 SECONDARY MINERAL RESOURCES Available sub-concepts

- Material recovery (D2 SECONDARY MINERAL RESOURCES)** [Details](#) [Favorite](#)
 - Methods&Tools 1 Documentation 1 Legislation 0 Data 0 Portal 0 Articles & Reports 0 Others 0 FAQ 0
- Waste (D2 SECONDARY MINERAL RESOURCES)** [Details](#) [Favorite](#)
 - Methods&Tools 1 Documentation 0 Legislation 0 Data 0 Portal 0 Articles & Reports 0 Others 0 FAQ 0
- Stocks/Materials (D2 SECONDARY MINERAL RESOURCES)** [Details](#) [Favorite](#)
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WORKFLOW

guides you through the available concepts. In this way we help you to build a query based on those concepts, that best fit your question.

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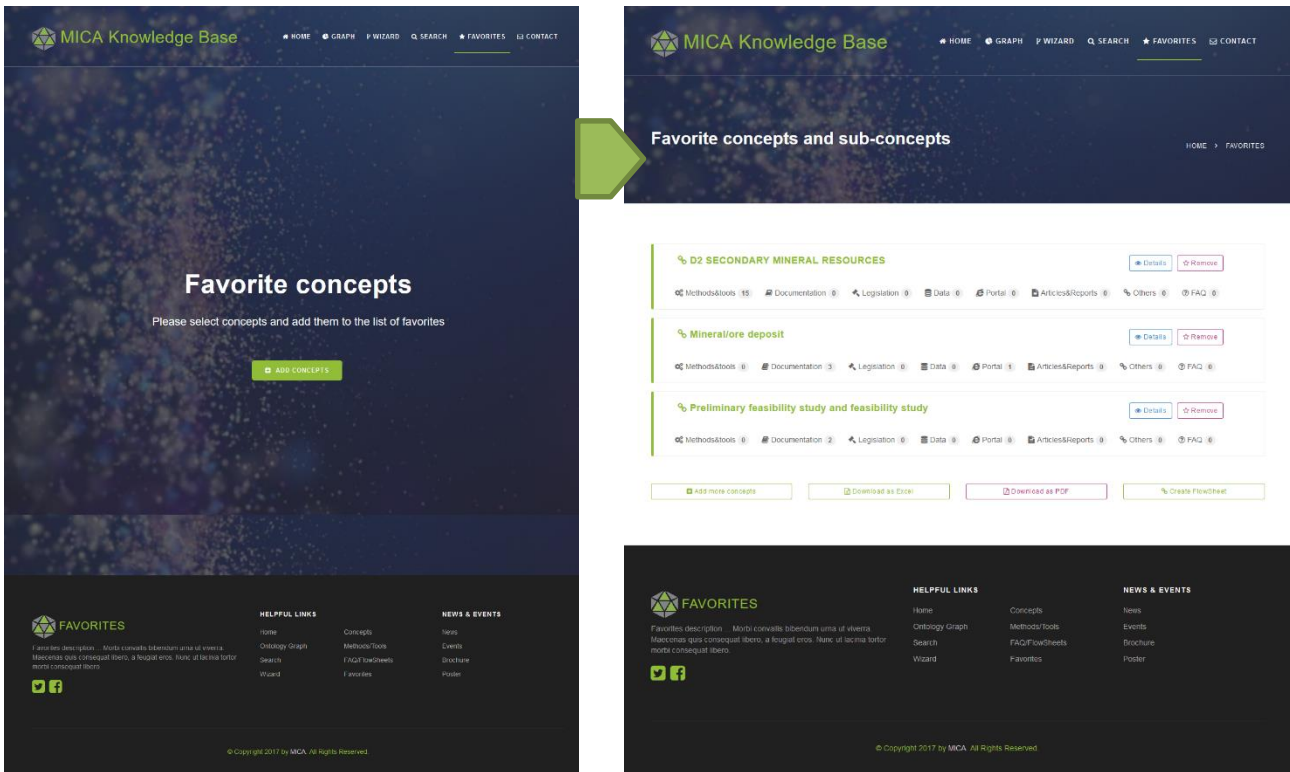


Figure 34 MICA Wizard Application. Presentation of a simplified workflow.

- Direct Search – allows users to enter a text string reflecting their problem to get a structured result from the entire MICA Knowledge Base utilising the titles and descriptions of all data/system artefacts (concepts, sheets, FAQs...) (Figure 35);

Search

HOME > SEARCH

The search engine looks into the labels and definitions of available Concepts / Sheets / FlowSheets/ Questions ...

D1 PRIMARY MINERAL RESOURCES

Filter by

- Concepts
- Methods&Tools
- Documentation
- Legislation
- Data
- Portal
- Articles&Reports
- Others

Reset Apply

Results: 4

- 
Mine development (D1 PRIMARY MINERAL RESOURCES)

[Details](#) [Favorite](#)

- 
D1 PRIMARY MINERAL RESOURCES

[Details](#) [Favorite](#)

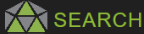
- 
Mine closure (D1 PRIMARY MINERAL RESOURCES)

[Details](#) [Favorite](#)


- 
Preliminary economic assessment (D1 PRIMARY MINERAL RESOURCES)

[Details](#) [Favorite](#)

1



looks into the labels and definitions of available Concepts / FactSheets / DocSheets / Legislation / Data / Question / FlowSheets/ ...



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Figure 35 MICA Direct Search Application.

- **Frequently Asked Questions (FAQs)** – based on the collection of the possible user questions to the future MICA knowledge base, this application shows the list of questions, the most complex associated with a flowSheet that represents the expert extraction of the type of information (e.g., sheet(s)) relevant for addressing the respective question. (Figure 36).

Frequently Asked Questions / FlowSheets

HOME > WIZARD > FAQ/FLOWSHEETS

The functionalities are under construction.

Filter by:

Value/Supply Chain:
Nothing selected

Temporal Scheme:
Nothing selected

Spatial Scheme:
Nothing selected

Commodities Scheme:
Nothing selected

Concepts:
Nothing selected

Reset Apply

- Where could we possibly find a new deposit (size and location)? +
Morphological Analysis FlowSheet FlowSheet
- Documentation 16 Legislation 11 Data 1 Portal 4 Articles & Reports 2 Others 0
Description: Morbi convallis bibendum uma ut viverra. Maecenas quis consequat libero, a feugiat eros. Nunc ut lacinia tortor morbi consequat libero. Description: Morbi convallis bibendum uma ut viverra.
- How can we collect information for product/building passports? +
- Relevant regulatory frameworks at national levels? +
- How big is the in-use stocks of different CRMs in Europe? +
- How much is expected to be reused or recycled? +
- When do policies and value chains need to be developed? +
- What is the future availability of a specific metal? +
- What are new main primary and waste sources of In, PGMs, Ga, Ge? +
- How is a recovery level of waste equipment other than recycling? +
- What is the recycling level of large and small household appliances? +

FAQ / FLOWSHEET

these questions have been collected by the Work Package 2 on Stakeholder consultation. Here we map these questions to Flow Sheets, which can be best described as cooking recipes on how to answer them.

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Figure 36 MICA FAQs Application.

9. The connection with other Knowledge Data Platforms (KDPs), including the RMIS 2.0

In practice, this system will be connected with the existing Knowledge Data Platforms (e.g., the IKMS (EURare – Cassard et al., 2014a, 2017), the EU-MKDP (Minerals4EU – Cassard et al., 2014b), the EU-UMKDP (ProSUM – Huisman et al., 2016), the EU-CRMKDP (SCRREEN), and also with the EGDI (Cassard and Tertre, 2017). This will (i) allow them to make their users benefitting of the MICA Expert System, and (ii) acting as privileged data sources for the MICA Expert System (see Figure 2).

The MICA DDG with its side applications (allowing different types of search) is a stand-alone application. The connection between the MICA DDG and the RMIS 2.0 (Manfredi et al., 2017) will be established through the creation of new linkedSheets toward the RMIS resources, or via new factSheets or flowSheets that will be added to the MICA system by the RMIS JRC Team, annotated using the MICASheetEditor and becoming retrievable through the MICA DDG. A complementary way to proceed is that the RMIS JRC Team increases the perimeter and the granularity of the Main Ontology towards his own activities/topics and produces the adapted sheets.

Note that in this context, JRC (as a MICA full-partner) can have a full-access (i) to the MICASheetEditor which allows managing the different types of sheets (docSheets, factSheets, flowSheets (creation, update, deletion), to annotate them over the ontologies, to link them between themselves and/or with data sources; and (ii) to the ontology editor (VocBench – see Figure 2 – currently under replacement because of its lack of stability) which allows editing the ontologies, modifying both perimeter and granularity and characterizing the relationships between the different concepts.

10. Conclusion

Before synthesizing the work done in developing the EU-RMICP, it seems useful to put this work into context and summarize the overall objectives of the project:

- What is the issue being addressed? Since around ten years, a huge effort has been made in Europe to provide end users in a seamless way with public data related to raw materials. However, most of the stakeholders have neither the comprehensive set of skills for using these data made available on recently developed spatial geo-portals and associated Knowledge bases nor the know-how to implement specific methods and tools which would allow answering their questions/problems. The ambition of MICA and its ontology-based DDG is to help them, on how to proceed to get a pertinent answer (nearly) whatever the question or the query is,
- Why is it important for society? This is important because such a project allows end users to better understand on the background of which data, methods and processes, decisions are made which will later on influence their life. This project thus offers the possibility to get an insight on the mechanics supporting a decision-making process.
- What are the overall objectives? One of the overarching objectives of this approach is to make people aware of the role of raw materials in their life, all along the value chain, delivering a balanced vision of the constraints and of the benefits.

The work performed from the beginning of the project and the progress beyond the state of the art and the expected potential impact can be summarized as follows:

The WP6 Team, in collaboration with other work packages, has developed from scratch the ontology covering the whole raw materials domain, from primary and secondary resources, transformation, economy, environment, policies and international reporting. In parallel, transversal ontologies such as 'commodities', 'space', 'time' and 'value-supply chain' have been developed in order to refine end-user queries. This ontology is at the heart of the system. It is accessible through the VocBench collaborative tool. The architecture of the system has been set up with a RDF Triple Store, several doc/fact/flowSheets have been generated using the template developed with other WPs, and a proto-editor allowing the annotation of these sheets with the ontology concepts has been developed. Finally, a first prototype of the ontology-based DDG, along with its main specifications, has been released for testing at the end of 2016.

The system has then been refined and improved in 2017, notably with:

- The refining of the Main Ontology and some other transversal ontologies (notably the Methods transversal ontology).
- The development (on the basis of the prototype) of a sophisticated MICASheetEditor, allowing not only to annotate the doc- and factSheets with the ontologies concepts and sub-concepts and to upload the sheets in the Triple Store, but also to generate on the fly all the linkedSheets (i.e., the links toward external resources and notably data sources) and the flowSheets scenarios.
- The development of the final version of the DDG interface and its side applications.

- The development of the ranking module allowing sorting the results (i.e., the different sheets) by relevance, in relation with the end-users navigation over the DDG.

The approach developed inside MICA is totally new, and makes this project in essence a re-search/innovation project. In practice, this project is laying the foundations of a Raw Materials Expert System. The interest is that the results can be used and upgraded by new projects for different potential applications. The perimeter of the ontology and its depth/granularity can be easily extended and the mechanics behind can be used for expertise/decision-making in other domains/sub-domains linked to raw materials. The system can thus be seen as a powerful, one-stop-shop or one-stop information gateway and can play the role – even if it is not its first application – of an ‘intelligent’ search engine in the Raw Materials domain, and also act as a powerful decision-aid tool.

11. References

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Appendix 1. The MICA Main Ontology concepts (version 24/07/2017)

- <https://w3id.org/mica/ontology/MicaOntology/DomainScheme>
 - MICA
 - D1 PRIMARY MINERAL RESOURCES
 - Mine closure (D1 PRIMARY MINERAL RESOURCES)
 - Decommissioning
 - Post-closure & long-term stewardship
 - Monitoring programs
 - Treatment of mine discharge water
 - Remediation/reclamation
 - Restoration/rehabilitation
 - Shut-down
 - Mine development (D1 PRIMARY MINERAL RESOURCES)
 - Design and construction
 - Type of mineral processing
 - Beneficiation/concentration
 - Ore milling
 - Pre- or primary concentration
 - Type of mining operation (Design & construction)
 - Finance
 - Operation planning
 - Mine operation
 - Consumables
 - Lease renewals
 - Machinery
 - Mining environment (e.g., challenging to materials)
 - Yearly reserves assessment
 - Mineral/ore deposit
 - Main/accompanying metals
 - Mineral deposit groups and types
 - Resources and reserves
 - Mineral exploration
 - Detailed surface exploration (Mineral exploration)
 - Detailed geochemistry
 - Detailed geology
 - Detailed geophysics
 - Detailed heavy mineral sampling
 - Ore deposit evaluation (Mineral exploration)
 - Core drilling systematic
 - Geostatistical estimates
 - Mine workings reconnaissance/adit mapping
 - Trial tests
 - Regional reconnaissance (Mineral exploration)
 - 2D predictive mapping
 - Mineral resources potential assessment/estimating undiscovered resources
 - Preliminary studies
 - Regional geochemistry
 - Regional geology
 - Regional heavy mineral sampling

- Remote sensing (including regional geophysics)
 - Resource assessment (Mineral exploration)
 - Approximate resource calculation
 - 3D 'block' model (Approximate resource calculation)
 - Drilling assessment
 - Core drilling assessment
 - Percussion drilling assessment
 - Geological interpretation
 - 3D geological model
 - Ore beneficiation tests
 - Subsurface exploration (Mineral exploration)
 - Drilling
 - Auger drilling
 - Core drilling
 - Percussion drilling
 - Excavation
 - Trenches
 - Trial pits and sampling
- Preliminary economic assessment (D1 PRIMARY MINERAL RESOURCES)
- Preliminary feasibility study and feasibility study
 - Economic (Preliminary feasibility study and feasibility study)
 - Social feasibility
 - Technical (Preliminary feasibility study and feasibility study)
 - Geostatistics
 - Grade-tonnage relationships on blocks
 - 3D 'block' model (Grade-tonnage relationships on blocks)
 - Pilot plant
- Prospecting authorization/Permitting
 - Exploitation permit
 - Exploration permit
 - Prospecting authorization
- **D2 SECONDARY MINERAL RESOURCES**
 - Material recovery (D2 SECONDARY MINERAL RESOURCES)
 - Collection
 - Product lifespan
 - Recycling (Material recovery)
 - EOL recycling rates
 - Recovery rates
 - Recycling content
 - Refurbishment (Recycling)
 - Remanufacture
 - Reuse
 - Stocks/Materials (D2 SECONDARY MINERAL RESOURCES)
 - Metal stocks in industry
 - Metal stocks in use
 - Stocks/Metals in buildings (Metal stocks in use)
 - Stocks/Metals in household appliances (Metal stocks in use)
 - Stocks/Metals in infrastructures (Metal stocks in use)

- Stocks/Metals in transport (Metal stocks in use)
 - Non-metal stocks in industry
 - Non-metal stocks in use
 - Stocks/Non-metals in buildings (Non-metal stocks in use)
 - Stocks/Non-metals in household appliances (Non-metal stocks in use)
 - Stocks/Non-metals in infrastructures (Non-metal stocks in use)
 - Stocks/Non-metals in transport (Non-metal stocks in use)
- Waste (D2 SECONDARY MINERAL RESOURCES)
 - End-of-life waste
 - Batteries and accumulator wastes
 - Construction and demolition waste
 - Discarded equipment
 - Discarded vehicles
 - Glass waste (End-of-life waste)
 - Incineration waste
 - Bottom ash
 - Fly ash
 - Other mineral waste
 - WEEE
 - Manufacturing/Industrial Waste
 - Combustion waste
 - Dredging spoils
 - Glass waste (Manufacturing/Industrial Waste)
 - Mineral waste from waste treatment and stabilised waste
 - Smelter/refining scrap and residues/slags
 - Metallic waste - ferrous (Smelter/refining scrap and residues)
 - Metallic waste - mixed (Smelter/refining scrap and residues)
 - Metallic waste - non-ferrous (Smelter/refining scrap and residues)
 - Mining wastes
 - Drilling muds and other drilling wastes
 - Rocks & dumps
 - Mineral metalliferous excavation
 - Mineral non-metalliferous excavation
 - Tailings
 - Processing of metalliferous minerals
 - Processing of non-metalliferous minerals
 - Waste deposited in landfills
 - Hazardous
 - Inert
 - Non-hazardous
- D3 INDUSTRIAL PROCESSING AND TRANSFORMATION
 - Manufacture, use & transport
 - Material design & manufacturing
 - Product manufacturing & use
 - Transport

- Metallurgy & industrial mineral transformation
 - Biometallurgy/bioleaching
 - Electrometallurgy
 - Hydrometallurgy
 - Industrial rocks transformation
 - Mineralurgy of secondary resources
 - Pyrometallurgy
- D4 RAW MATERIALS ECONOMICS
 - Commodity prices
 - LME prices
 - LME stocks
 - Non-LME prices
 - Secondary raw material prices
 - Costs
 - Exploration (Cost)
 - Mine closure (Cost)
 - Mine development (Cost)
 - Production
 - Recycling (Cost)
 - Critical raw materials
 - Importance for industry
 - Commodity end uses
 - Substitution (Importance for industry)
 - Value added
 - Supply risk
 - Geological availability
 - Geopolitical risk
 - Import dependence
 - Production concentration
 - Recycling rate
 - Substitution (Supply risk)
 - Demand
 - Consumption (Demand)
 - EU industry sectors (Demand)
 - NACE classification (Demand/EU industry sectors)
 - Investment
 - Investors
 - Risks
 - Supply
 - EU industry sectors (Supply)
 - NACE classification (Supply/EU industry sectors)
 - Production (Supply)
 - Primary raw materials (Supply/Production)
 - Secondary raw materials (Supply/Production)
 - Supply chain information
 - Trade (Supply)
 - CN codes (Supply/Trade)
 - Primary raw materials (Supply/Trade)
 - Secondary raw materials (Supply/Trade)
- D5 RAW MATERIALS POLICY & LEGAL FRAMEWORK
 - Circular economy

- Resource efficiency policies
 - Recycling policy & legislation
 - Waste policies
 - Corporate social responsibility (D5 RAW MATERIALS POLICY & LEGAL FRAMEWORK)
 - Environmental legislation
 - Environment health & safety policy
 - European Parliamentary resolutions
 - Local/communal by-laws
 - National environmental legislation
 - National emission legislation
 - National soil legislation
 - National water legislation
 - National environmental policies
 - Regional/provincial environmental laws
 - UN conventions
 - Aarhus Convention
 - Basle Convention
 - HELCOM
 - MARPOL
 - OSPARCOM
 - Land use policy
 - Deposits of public importance
 - Designation areas (e.g., conservation [nature, culture, etc.])
 - Permitting/Licensing (Land use policy)
 - Mineral policy/strategy
 - Conflict mineral use
 - Product declaration
 - Responsible mining
 - Standardization
 - Trade regulation and policy
- **D6 SUSTAINABILITY OF RAW MATERIALS**
 - Compensation
 - Biodiversity compensation
 - Carbon trading
 - Impacts of specific processes/plants
 - Local environmental & health impacts
 - Air and water pollution
 - Ecosystems, biodiversity
 - Human health
 - Occupational health
 - Soil contamination
 - Regional/global environmental & health impacts
 - Climate change
 - Ocean pollution
 - Transboundary air pollution
 - Social impacts
 - Child labour
 - Gender issues
 - Local population
 - Responsible sourcing

- Workers
- Impacts over the life cycle
 - Environmental footprints of materials, products & services
 - Carbon footprint
 - Ecological footprint
 - Land footprint
 - Material footprint
 - Water footprint
 - Environmental impacts of materials, products & services
 - Aggregate indicators
 - Impact categories
 - Emissions of GHG & pollutants (Impacts of materials, products & services)
 - Energy use (Impacts of materials, products & services)
 - Extraction of resources (Impacts of materials, products & services)
 - Final waste production (Impacts of materials, products & services)
 - Land use (Impacts of materials, products & services)
- Knowledge sharing
 - Knowledge platforms
 - Training
 - Initial training
 - Life-long training
- Resource efficiency
 - Eco-design
 - Frugal design
 - Indicators
- Social licence to operate (SLO)
- **D7 INTERNATIONAL REPORTING**
 - Corporate social responsibility (D7 INTERNATIONAL REPORTING)
 - Impact benefit agreements
 - International reporting of resources and reserves
 - Classification system
 - CRIRSCO 'framework'
 - National reporting code
 - Other classification systems
 - UNFC
 - Shareholder information
 - Sustainable development reporting
 - To communities
 - To employees

Appendix 2. The MICA Main multidimensional Ontology (DomainScheme), the transverse ontologies and the links between concepts and with other schemes (version 07/11/2017)

DomainScheme (Main Ontology)

- Mica
 - **D1 Primary Mineral Resources**
 - Circular Economy - D5 Raw Materials Policy & Legal Framework
 - Investment - D4 Raw Materials Economics
 - Mine Closure (D1 Primary Mineral Resources)
 - Biodiversity Compensation - D6 Sustainability Of Raw Materials
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Environment Health & Safety Policy - D5 Raw Materials Policy & Legal Framework
 - Government Organisation (Report) - DataScheme
 - Government Organisation (Website) - DataScheme
 - Local Environmental & Health Impacts - D6 Sustainability Of Raw Materials
 - Metadata On Spatial Data - DataScheme
 - Mine Closure (Cost) - D4 Raw Materials Economics
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Reports With Statistical Data - DataScheme
 - Responsible Mining - D5 Raw Materials Policy & Legal Framework
 - Satellite Or Aerial Imagery - DataScheme
 - Specialist Magazines - DataScheme
 - To Communities - D7 International Reporting
 - To Employees - D7 International Reporting
 - Decommissioning
 - Post-Closure & Long-Term Stewardship
 - Monitoring Programs
 - Treatment Of Mine Discharge Water
 - Remediation/Reclamation
 - Restoration/Rehabilitation
 - Biodiversity Compensation - D6 Sustainability Of Raw Materials
 - Shut-Down
 - Mine Development (D1 Primary Mineral Resources)
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Consumption (Demand) - D4 Raw Materials Economics
 - Electronic (Spatial Data) - DataScheme
 - Environment Health & Safety Policy - D5 Raw Materials Policy & Legal Framework
 - Impacts Of Specific Processes/Plants - D6 Sustainability Of Raw Materials
 - Land Use Policy - D5 Raw Materials Policy & Legal Framework
 - Metadata On Spatial Data - DataScheme
 - Mine Development (Cost) - D4 Raw Materials Economics
 - Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
 - Other (Report) - DataScheme

- Other (Website) - DataScheme
- Paper - DataScheme
- Permitting/Licensing (Land Use Policy) - D5 Raw Materials Policy & Legal Framework
- Production - D4 Raw Materials Economics
- Production (Supply) - D4 Raw Materials Economics
- Reports With Statistical Data - DataScheme
- Responsible Mining - D5 Raw Materials Policy & Legal Framework
- Satellite Or Aerial Imagery - DataScheme
- Specialist Magazines - DataScheme
- Trade Association (Report) - DataScheme
- Trade Association (Website) - DataScheme
 - Design And Construction
 - Extraction Of Resources (Impacts Of Materials, Products & Services) - D6 Sustainability Of Raw Materials
 - Type Of Mineral Processing
 - Biometallurgy/Bioleaching - D3 Industrial Processing And Transformation
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Industrial Rocks Transformation - D3 Industrial Processing And Transformation
 - Pyrometallurgy - D3 Industrial Processing And Transformation
 - Beneficiation/Concentration
 - Ore Milling
 - Pre- Or Primary Concentration
 - Type Of Mining Operation (Design & Construction)
 - Finance
 - Operation Planning
 - Extraction Of Resources (Impacts Of Materials, Products & Services) - D6 Sustainability Of Raw Materials
- Mine Operation
 - Impacts Of Specific Processes/Plants - D6 Sustainability Of Raw Materials
 - Mining Wastes - D2 Secondary Mineral Resources
 - Production - D4 Raw Materials Economics
 - Consumables
 - Lease Renewals
 - Machinery
 - Mining Environment (E.G., Challenging To Materials)
 - Yearly Reserves Assessment
- Mineral Exploration
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Electronic (Spatial Data) - DataScheme
 - Electronic (Statistical Data) - DataScheme
 - Environment Health & Safety Policy - D5 Raw Materials Policy & Legal Framework
 - Exploration (Cost) - D4 Raw Materials Economics
 - Geopolitical Risk - D4 Raw Materials Economics
 - Government Organisation (Report) - DataScheme
 - Government Organisation (Website) - DataScheme
 - Import Dependence - D4 Raw Materials Economics
 - Infographics And Other Media - DataScheme

- Land Use Policy - D5 Raw Materials Policy & Legal Framework
- Metadata On Spatial Data - DataScheme
- Metadata On Statistical Data - DataScheme
- Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
- Other (Report) - DataScheme
- Other (Website) - DataScheme
- Paper - DataScheme
- Reports With Statistical Data - DataScheme
- Responsible Mining - D5 Raw Materials Policy & Legal Framework
- Satellite Or Aerial Imagery - DataScheme
- Specialist Magazines - DataScheme
 - Detailed Surface Exploration (Mineral Exploration)
 - Permitting/Licensing (Land Use Policy) - D5 Raw Materials Policy & Legal Framework
 - Detailed Geochemistry
 - Detailed Geology
 - Detailed Geophysics
 - Detailed Heavy Mineral Sampling
 - Ore Deposit Evaluation (Mineral Exploration)
 - Deposits Of Public Importance - D5 Raw Materials Policy & Legal Framework
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Core Drilling Systematic
 - Geostatistical Estimates
 - Mine Workings Reconnaissance/Adit Mapping
 - Trial Tests
 - Regional Reconnaissance (Mineral Exploration)
 - Permitting/Licensing (Land Use Policy) - D5 Raw Materials Policy & Legal Framework
 - 2d Predictive Mapping
 - Mineral Resources Potential Assessment/Estimating Undiscovered Resources
 - Preliminary Studies
 - Regional Geochemistry
 - Regional Geology
 - Regional Heavy Mineral Sampling
 - Remote Sensing (Including Regional Geophysics)
 - Resource Assessment (Mineral Exploration)
 - Permitting/Licensing (Land Use Policy) - D5 Raw Materials Policy & Legal Framework
 - Approximate Resource Calculation
 - 3d 'Block' Model (Approximate Resource Calculation)
 - Drilling Assessment
 - Core Drilling Assessment
 - Percussion Drilling Assessment
 - Geological Interpretation
 - 3d Geological Model
 - Ore Beneficiation Tests
 - Subsurface Exploration (Mineral Exploration)
 - Permitting/Licensing (Land Use Policy) - D5 Raw Materials Policy & Legal Framework
 - Drilling
 - Auger Drilling

- Core Drilling
 - Percussion Drilling
 - Excavation
 - Trenches
 - Trial Pits And Sampling
- Mineral/Ore Deposit
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Consumption (Demand) - D4 Raw Materials Economics
 - Electronic (Spatial Data) - DataScheme
 - Electronic (Statistical Data) - DataScheme
 - Geological Availability - D4 Raw Materials Economics
 - Geopolitical Risk - D4 Raw Materials Economics
 - Government Organisation (Report) - DataScheme
 - Government Organisation (Website) - DataScheme
 - Import Dependence - D4 Raw Materials Economics
 - Industrial Rocks Transformation - D3 Industrial Processing And Transformation
 - Infographics And Other Media - DataScheme
 - Land Use Policy - D5 Raw Materials Policy & Legal Framework
 - Lobbying Group (Report) - DataScheme
 - Lobbying Group (Website) - DataScheme
 - Metadata On Spatial Data - DataScheme
 - Metadata On Statistical Data - DataScheme
 - Other (Magazine Article) - DataScheme
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Paper Format Statistical Data - DataScheme
 - Paper Maps - DataScheme
 - Production (Supply) - D4 Raw Materials Economics
 - Reports With Statistical Data - DataScheme
 - Satellite Or Aerial Imagery - DataScheme
 - Specialist Magazines - DataScheme
 - Trade Association (Report) - DataScheme
 - Trade Association (Website) - DataScheme
 - Main/Accompanying Metals
 - Biometallurgy/Bioleaching - D3 Industrial Processing And Transformation
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Pyrometallurgy - D3 Industrial Processing And Transformation
 - Mineral Deposit Groups And Types
 - Resources And Reserves
 - Commodity Prices - D4 Raw Materials Economics
 - Deposits Of Public Importance - D5 Raw Materials Policy & Legal Framework
 - International Reporting Of Resources And Reserves - D7 International Reporting
- Preliminary Economic Assessment (D1 Primary Mineral Resources)
 - Mine Closure (Cost) - D4 Raw Materials Economics
 - Mine Development (Cost) - D4 Raw Materials Economics
 - Production - D4 Raw Materials Economics
- Preliminary Feasibility Study And Feasibility Study

- Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Compensation - D6 Sustainability Of Raw Materials
 - Impacts Of Specific Processes/Plants - D6 Sustainability Of Raw Materials
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Reports With Statistical Data - DataScheme
 - Specialist Magazines - DataScheme
 - Economic (Preliminary Feasibility Study And Feasibility Study) International Reporting Of Resources And Reserves - D7 International Reporting
 - Social Feasibility
 - Corporate Social Responsibility (D5 Raw Materials Policy & Legal Framework) - D5 Raw Materials Policy & Legal Framework
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Responsible Mining - D5 Raw Materials Policy & Legal Framework
 - Technical (Preliminary Feasibility Study And Feasibility Study)
 - Geostatistics
 - Grade-Tonnage Relationships On Blocks
 - 3d 'Block' Model (Grade-Tonnage Relationships On Blocks)
 - Pilot Plant
 - Prospecting Authorization/Permitting
 - Permitting/Licensing (Land Use Policy) - D5 Raw Materials Policy & Legal Framework
 - Social Licence To Operate (Slo) - D6 Sustainability Of Raw Materials
 - Exploitation Permit
 - Exploration Permit
 - Prospecting Authorization
- **D2 Secondary Mineral Resources**
 - Circular Economy - D5 Raw Materials Policy & Legal Framework
 - Secondary Raw Material Prices - D4 Raw Materials Economics
 - Material Recovery (D2 Secondary Mineral Resources)
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Consumption (Demand) - D4 Raw Materials Economics
 - Electronic (Spatial Data) - DataScheme
 - Electronic (Statistical Data) - DataScheme
 - Government Organisation (Report) - DataScheme
 - Government Organisation (Website) - DataScheme
 - Infographics And Other Media - DataScheme
 - Investment - D4 Raw Materials Economics
 - Material Flow Analysis - MethodScheme
 - Metadata On Spatial Data - DataScheme
 - Metadata On Statistical Data - DataScheme
 - Other (Magazine Article) - DataScheme
 - Paper - DataScheme
 - Production (Supply) - D4 Raw Materials Economics

- Recycling (Cost) - [D4 Raw Materials Economics](#)
- Recycling Rate - [D4 Raw Materials Economics](#)
- Reports With Statistical Data - [DataScheme](#)
- Resource Efficiency - [D6 Sustainability Of Raw Materials](#)
- Specialist Magazines - [DataScheme](#)
- Trade (Supply) - [D4 Raw Materials Economics](#)
 - Collection
 - Product Lifespan
 - Recycling (Material Recovery)
 - [Recycling \(Cost\) - D4 Raw Materials Economics](#)
 - Eol Recycling Rates
 - Recovery Rates
 - Recycling Content
 - Refurbishment (Recycling)
 - Remanufacture
 - Reuse
- Stocks/Materials (D2 Secondary Mineral Resources)
 - [Consumption \(Demand\) - D4 Raw Materials Economics](#)
 - [Production \(Supply\) - D4 Raw Materials Economics](#)
 - [Resource Efficiency - D6 Sustainability Of Raw Materials](#)
 - [Supply - D4 Raw Materials Economics](#)
 - [Trade \(Supply\) - D4 Raw Materials Economics](#)
 - Metal Stocks In Industry
 - Metal Stocks In Use
 - [Critical Raw Materials - D4 Raw Materials Economics](#)
 - [D4 Raw Materials Economics - D4 Raw Materials Economics](#)
 - [Infographics And Other Media - DataScheme](#)
 - [Input Output Analysis - MethodScheme](#)
 - [Material Flow Analysis - MethodScheme](#)
 - [Metadata On Spatial Data - DataScheme](#)
 - [Paper - DataScheme](#)
 - [Reports With Statistical Data - DataScheme](#)
 - [Satellite Or Aerial Imagery - DataScheme](#)
 - [Substance Flow Analysis - MethodScheme](#)
 - [Trade Association \(Report\) - DataScheme](#)
 - [Trade Association \(Website\) - DataScheme](#)
 - Stocks/Metals In Buildings (Metal Stocks In Use)
 - Stocks/Metals In Household Appliances (Metal Stocks In Use)
 - Stocks/Metals In Infrastructures (Metal Stocks In Use)
 - Stocks/Metals In Transport (Metal Stocks In Use)
 - Non-Metal Stocks In Industry
 - Non-Metal Stocks In Use
 - [Demand - D4 Raw Materials Economics](#)
 - [Infographics And Other Media - DataScheme](#)
 - [Input Output Analysis - MethodScheme](#)
 - [Material Flow Analysis - MethodScheme](#)
 - [Metadata On Spatial Data - DataScheme](#)
 - [Paper - DataScheme](#)
 - [Reports With Statistical Data - DataScheme](#)
 - [Satellite Or Aerial Imagery - DataScheme](#)
 - [Substance Flow Analysis - MethodScheme](#)
 - [Supply - D4 Raw Materials Economics](#)
 - [Trade Association \(Report\) - DataScheme](#)
 - [Trade Association \(Website\) - DataScheme](#)

- Stocks/Non-Metals In Buildings (Non-Metal Stocks In Use)
 - Stocks/Non-Metals In Household Appliances (Non-Metal Stocks In Use)
 - Stocks/Non-Metals In Infrastructures (Non-Metal Stocks In Use)
 - Stocks/Non-Metals In Transport (Non-Metal Stocks In Use)
- Waste (D2 Secondary Mineral Resources)
 - End-Of-Life Waste
 - Company (Magazine Article) - [DataScheme](#)
 - Company (Report) - [DataScheme](#)
 - Company (Website) - [DataScheme](#)
 - Critical Raw Materials - [D4 Raw Materials Economics](#)
 - Electronic (Statistical Data) - [DataScheme](#)
 - Government Organisation (Report) - [DataScheme](#)
 - Government Organisation (Website) - [DataScheme](#)
 - Infographics And Other Media - [DataScheme](#)
 - Material Flow Analysis - [MethodScheme](#)
 - Metadata On Spatial Data - [DataScheme](#)
 - Metadata On Statistical Data - [DataScheme](#)
 - Paper - [DataScheme](#)
 - Paper Format Statistical Data - [DataScheme](#)
 - Reports With Statistical Data - [DataScheme](#)
 - Satellite Or Aerial Imagery - [DataScheme](#)
 - Specialist Magazines - [DataScheme](#)
 - Substance Flow Analysis - [MethodScheme](#)
 - To Communities - [D7 International Reporting](#)
 - To Employees - [D7 International Reporting](#)
 - Trade Association (Report) - [DataScheme](#)
 - Trade Association (Website) - [DataScheme](#)
 - Batteries And Accumulator Wastes
 - [Other Metadata - DataScheme](#)
 - Construction And Demolition Waste
 - [Other Metadata - DataScheme](#)
 - Discarded Equipment
 - [Other Metadata - DataScheme](#)
 - Discarded Vehicles
 - [Other Metadata - DataScheme](#)
 - Glass Waste (End-Of-Life Waste)
 - [Other Metadata - DataScheme](#)
 - Incineration Waste
 - Bottom Ash
 - Fly Ash
 - Other Mineral Waste
 - Weee
 - [Other Metadata - DataScheme](#)
 - Manufacturing/Industrial Waste
 - Company (Magazine Article) - [DataScheme](#)
 - Company (Report) - [DataScheme](#)
 - Company (Website) - [DataScheme](#)
 - Electronic (Spatial Data) - [DataScheme](#)
 - Electronic (Statistical Data) - [DataScheme](#)
 - Environmental Risk Assessment - [MethodScheme](#)
 - Estimates Of Waste And Emissions - [MethodScheme](#)
 - Government Organisation (Report) - [DataScheme](#)
 - Government Organisation (Website) - [DataScheme](#)

- Infographics And Other Media - [DataScheme](#)
- Inputs And Outputs Of Industrial Processes - [MethodScheme](#)
- Material Flow Analysis - [MethodScheme](#)
- Metadata On Spatial Data - [DataScheme](#)
- Metadata On Statistical Data - [DataScheme](#)
- Metallurgy & Industrial Mineral Transformation - [D3 Industrial Processing And Transformation](#)
- Paper - [DataScheme](#)
- Paper Format Statistical Data - [DataScheme](#)
- Reports With Statistical Data - [DataScheme](#)
- Satellite Or Aerial Imagery - [DataScheme](#)
- Specialist Magazines - [DataScheme](#)
- Substance Flow Analysis - [MethodScheme](#)
- To Communities - [D7 International Reporting](#)
- To Employees - [D7 International Reporting](#)
- Trade Association (Report) - [DataScheme](#)
- Trade Association (Website) - [DataScheme](#)
- Combustion Waste
 - Dredging Spoils
 - Glass Waste (Manufacturing/Industrial Waste)
 - Mineral Waste From Waste Treatment And Stabilised Waste
 - Smelter/Refining Scrap And Residues/Slags
 - Metallic Waste - Ferrous (Smelter/Refining Scrap And Residues)
 - Metallic Waste - Mixed (Smelter/Refining Scrap And Residues)
 - Metallic Waste - Non-Ferrous (Smelter/Refining Scrap And Residues)
- Mining Wastes
 - [Company \(Magazine Article\) - DataScheme](#)
 - [Company \(Report\) - DataScheme](#)
 - [Company \(Website\) - DataScheme](#)
 - [Electronic \(Spatial Data\) - DataScheme](#)
 - [Electronic \(Statistical Data\) - DataScheme](#)
 - [Environmental Risk Assessment - MethodScheme](#)
 - [Estimates Of Waste And Emissions - MethodScheme](#)
 - [Government Organisation \(Report\) - DataScheme](#)
 - [Government Organisation \(Website\) - DataScheme](#)
 - [Infographics And Other Media - DataScheme](#)
 - [Inputs And Outputs Of Industrial Processes - MethodScheme](#)
 - [Lobbying Group \(Website\) - DataScheme](#)
 - [Material Flow Analysis - MethodScheme](#)
 - [Metadata On Spatial Data - DataScheme](#)
 - [Metadata On Statistical Data - DataScheme](#)
 - [Mine Closure \(Cost\) - D4 Raw Materials Economics](#)
 - [Mine Operation - D1 Primary Mineral Resources](#)
 - [Mineralurgy Of Secondary Resources - D3 Industrial Processing And Transformation](#)
 - [Other \(Magazine Article\) - DataScheme](#)
 - [Other \(Report\) - DataScheme](#)
 - [Other \(Website\) - DataScheme](#)
 - [Paper - DataScheme](#)
 - [Paper Format Statistical Data - DataScheme](#)
 - [Recycling \(Cost\) - D4 Raw Materials Economics](#)

- Reports With Statistical Data - DataScheme
 - Satellite Or Aerial Imagery - DataScheme
 - Specialist Magazines - DataScheme
 - Substance Flow Analysis - MethodScheme
 - To Communities - D7 International Reporting
 - To Employees - D7 International Reporting
 - Trade Association (Report) - DataScheme
 - Trade Association (Website) - DataScheme
 - Drilling Muds And Other Drilling Wastes
 - Rocks & Dumps
 - Mineral Metalliferous Excavation
 - Mineral Non-Metalliferous Excavation
 - Tailings
 - Processing Of Metalliferous Minerals
 - Processing Of Non-Metalliferous Minerals
 - Waste Deposited In Landfills
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Electronic (Spatial Data) - DataScheme
 - Electronic (Statistical Data) - DataScheme
 - Environmental Risk Assessment - MethodScheme
 - Estimates Of Waste And Emissions - MethodScheme
 - Government Organisation (Report) - DataScheme
 - Government Organisation (Website) - DataScheme
 - Infographics And Other Media - DataScheme
 - Material Flow Analysis - MethodScheme
 - Metadata On Spatial Data - DataScheme
 - Metadata On Statistical Data - DataScheme
 - Paper - DataScheme
 - Paper Format Statistical Data - DataScheme
 - Reports With Statistical Data - DataScheme
 - Satellite Or Aerial Imagery - DataScheme
 - Specialist Magazines - DataScheme
 - Substance Flow Analysis - MethodScheme
 - To Communities - D7 International Reporting
 - To Employees - D7 International Reporting
 - Hazardous
 - Inert
 - Non-Hazardous
- **D3 Industrial Processing And Transformation**
 - Circular Economy - D5 Raw Materials Policy & Legal Framework
 - D4 Raw Materials Economics - D4 Raw Materials Economics
 - Investment - D4 Raw Materials Economics
 - To Communities - D7 International Reporting
 - To Employees - D7 International Reporting
 - Manufacture, Use & Transport
 - Material Design & Manufacturing
 - Product Manufacturing & Use
 - Transport
 - Metallurgy & Industrial Mineral Transformation
 - Impacts Of Specific Processes/Plants - D6 Sustainability Of Raw Materials
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Production - D4 Raw Materials Economics

Recycling (Cost) - D4 Raw Materials Economics

- **Biometallurgy/Bioleaching**
 - Main/Accompanying Metals - D1 Primary Mineral Resources
 - Type Of Mineral Processing - D1 Primary Mineral Resources
- **Electrometallurgy**
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Ee-loa - MethodScheme
 - Electronic (Spatial Data) - DataScheme
 - Infographics And Other Media - DataScheme
 - Input Output Analysis - MethodScheme
 - Main/Accompanying Metals - D1 Primary Mineral Resources
 - Metadata On Spatial Data - DataScheme
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Paper Maps - DataScheme
 - Reports With Statistical Data - DataScheme
 - Satellite Or Aerial Imagery - DataScheme
 - Specialist Magazines - DataScheme
 - Substance Flow Analysis - MethodScheme
 - Trade Association (Report) - DataScheme
 - Trade Association (Website) - DataScheme
 - Type Of Mineral Processing - D1 Primary Mineral Resources
- **Hydrometallurgy**
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Ee-loa - MethodScheme
 - Electronic (Spatial Data) - DataScheme
 - Infographics And Other Media - DataScheme
 - Input Output Analysis - MethodScheme
 - Main/Accompanying Metals - D1 Primary Mineral Resources
 - Material Flow Analysis - MethodScheme
 - Metadata On Spatial Data - DataScheme
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Paper Maps - DataScheme
 - Reports With Statistical Data - DataScheme
 - Satellite Or Aerial Imagery - DataScheme
 - Specialist Magazines - DataScheme
 - Substance Flow Analysis - MethodScheme
 - Trade Association (Report) - DataScheme
 - Trade Association (Website) - DataScheme
 - Type Of Mineral Processing - D1 Primary Mineral Resources
- **Industrial Rocks Transformation**
 - Input Output Analysis - MethodScheme
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Type Of Mineral Processing - D1 Primary Mineral Resources
- **Mineralurgy Of Secondary Resources**
 - Input Output Analysis - MethodScheme
 - Material Flow Analysis - MethodScheme

- Mining Wastes - D2 Secondary Mineral Resources
 - Pyrometallurgy
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Ee-loa - MethodScheme
 - Electronic (Spatial Data) - DataScheme
 - Infographics And Other Media - DataScheme
 - Input Output Analysis - MethodScheme
 - Main/Accompanying Metals - D1 Primary Mineral Resources
 - Metadata On Spatial Data - DataScheme
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Paper Maps - DataScheme
 - Reports With Statistical Data - DataScheme
 - Satellite Or Aerial Imagery - DataScheme
 - Specialist Magazines - DataScheme
 - Substance Flow Analysis - MethodScheme
 - Trade Association (Report) - DataScheme
 - Trade Association (Website) - DataScheme
 - Type Of Mineral Processing - D1 Primary Mineral Resources
 - D4 Raw Materials Economics**
 - Circular Economy - D5 Raw Materials Policy & Legal Framework
 - D3 Industrial Processing And Transformation - D3 Industrial Processing And Transformation
 - D6 Sustainability Of Raw Materials - D6 Sustainability Of Raw Materials
 - Metal Stocks In Use - D2 Secondary Mineral Resources
 - Commodity Prices
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Electronic (Statistical Data) - DataScheme
 - Government Organisation (Report) - DataScheme
 - Government Organisation (Website) - DataScheme
 - Infographics And Other Media - DataScheme
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Metadata On Statistical Data - DataScheme
 - Other (Magazine Article) - DataScheme
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Paper Format Statistical Data - DataScheme
 - Reports With Statistical Data - DataScheme
 - Resources And Reserves - D1 Primary Mineral Resources
 - Specialist Magazines - DataScheme
 - Trade Association (Report) - DataScheme
 - Trade Association (Website) - DataScheme
 - Lme Prices
 - Lme Stocks
 - Non-Lme Prices
 - Secondary Raw Material Prices
 - D2 Secondary Mineral Resources - D2 Secondary Mineral Resources
 - Costs

Electronic (Statistical Data) - DataScheme
 Government Organisation (Report) - DataScheme
 Government Organisation (Website) - DataScheme
 Infographics And Other Media - DataScheme
 Metadata On Statistical Data - DataScheme
 Other (Report) - DataScheme
 Other (Website) - DataScheme
 Reports With Statistical Data - DataScheme
 Specialist Magazines - DataScheme

- Exploration (Cost)
 - Mineral Exploration - D1 Primary Mineral Resources
- Mine Closure (Cost)
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Preliminary Economic Assessment (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
- Mine Development (Cost)
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Preliminary Economic Assessment (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
- Production
 - Metallurgy & Industrial Mineral Transformation - D3 Industrial Processing And Transformation
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mine Operation - D1 Primary Mineral Resources
 - Preliminary Economic Assessment (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Production (Supply) - D4 Raw Materials Economics
- Recycling (Cost)
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Metallurgy & Industrial Mineral Transformation - D3 Industrial Processing And Transformation
 - Mining Wastes - D2 Secondary Mineral Resources
 - Recycling (Material Recovery) - D2 Secondary Mineral Resources
- Critical Raw Materials
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Metal Stocks In Use - D2 Secondary Mineral Resources
 - Importance For Industry
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Demand - D4 Raw Materials Economics
 - Government Organisation (Report) - DataScheme
 - Government Organisation (Website) - DataScheme
 - Other (Magazine Article) - DataScheme
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Reports With Statistical Data - DataScheme
 - Specialist Magazines - DataScheme

- Trade Association (Report) - DataScheme
- Trade Association (Website) - DataScheme
 - Commodity End Uses
 - Substitution (Importance For Industry)
 - Value Added
- Supply Risk
 - Government Organisation (Report) - DataScheme
 - Government Organisation (Website) - DataScheme
 - Lobbying Group (Report) - DataScheme
 - Lobbying Group (Website) - DataScheme
 - Other (Magazine Article) - DataScheme
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Reports With Statistical Data - DataScheme
 - Specialist Magazines - DataScheme
 - Substance Flow Analysis - MethodScheme
 - Supply - D4 Raw Materials Economics
 - Trade Association (Report) - DataScheme
 - Trade Association (Website) - DataScheme
 - Geological Availability
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Geopolitical Risk
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Import Dependence
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Production Concentration
 - Recycling Rate
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Substitution (Supply Risk)
- Demand
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Electronic (Statistical Data) - DataScheme
 - Government Organisation (Report) - DataScheme
 - Government Organisation (Website) - DataScheme
 - Importance For Industry - D4 Raw Materials Economics
 - Infographics And Other Media - DataScheme
 - Input Output Analysis - MethodScheme
 - Metadata On Statistical Data - DataScheme
 - Non-Metal Stocks In Use - D2 Secondary Mineral Resources
 - Other (Magazine Article) - DataScheme
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Paper Format Statistical Data - DataScheme
 - Reports With Statistical Data - DataScheme
 - Specialist Magazines - DataScheme
 - Trade Association (Report) - DataScheme
 - Trade Association (Website) - DataScheme
 - Consumption (Demand)

- Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Stocks/Materials (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
- Eu Industry Sectors (Demand)
 - Nace Classification (Demand/Eu Industry Sectors)
- Investment
 - D1 Primary Mineral Resources - D1 Primary Mineral Resources
 - D3 Industrial Processing And Transformation - D3 Industrial Processing And Transformation
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Investors
 - Shareholder Information - D7 International Reporting
 - Risks
- Supply
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Electronic (Spatial Data) - DataScheme
 - Electronic (Statistical Data) - DataScheme
 - Government Organisation (Report) - DataScheme
 - Government Organisation (Website) - DataScheme
 - Infographics And Other Media - DataScheme
 - Input Output Analysis - MethodScheme
 - Metadata On Spatial Data - DataScheme
 - Metadata On Statistical Data - DataScheme
 - Non-Metal Stocks In Use - D2 Secondary Mineral Resources
 - Other (Magazine Article) - DataScheme
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Paper Format Statistical Data - DataScheme
 - Reports With Statistical Data - DataScheme
 - Specialist Magazines - DataScheme
 - Stocks/Materials (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Supply Risk - D4 Raw Materials Economics
 - Trade Association (Report) - DataScheme
 - Trade Association (Website) - DataScheme
 - Eu Industry Sectors (Supply)
 - Nace Classification (Supply/Eu Industry Sectors)
 - Production (Supply)
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Production - D4 Raw Materials Economics
 - Stocks/Materials (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Primary Raw Materials (Supply/Production)

- Secondary Raw Materials (Supply/Production)
 - Supply Chain Information
 - Trade (Supply)
 - [Material Recovery \(D2 Secondary Mineral Resources\) - D2 Secondary Mineral Resources](#)
 - [Stocks/Materials \(D2 Secondary Mineral Resources\) - D2 Secondary Mineral Resources](#)
 - [Trade Regulation And Policy - D5 Raw Materials Policy & Legal Framework](#)
 - Cn Codes (Supply/Trade)
 - Primary Raw Materials (Supply/Trade)
 - Secondary Raw Materials (Supply/Trade)
- **D5 Raw Materials Policy & Legal Framework**
 - Circular Economy
 - [D1 Primary Mineral Resources - D1 Primary Mineral Resources](#)
 - [D2 Secondary Mineral Resources - D2 Secondary Mineral Resources](#)
 - [D3 Industrial Processing And Transformation - D3 Industrial Processing And Transformation](#)
 - [D4 Raw Materials Economics - D4 Raw Materials Economics](#)
 - [D6 Sustainability Of Raw Materials - D6 Sustainability Of Raw Materials](#)
 - [D7 International Reporting - D7 International Reporting](#)
 - Resource Efficiency Policies
 - [Resource Efficiency - D6 Sustainability Of Raw Materials](#)
 - Recycling Policy & Legislation
 - Waste Policies
 - Corporate Social Responsibility (D5 Raw Materials Policy & Legal Framework)
 - [Corporate Social Responsibility \(D7 International Reporting\) - D7 International Reporting](#)
 - [Social Feasibility - D1 Primary Mineral Resources](#)
 - Environmental Legislation
 - [D6 Sustainability Of Raw Materials - D6 Sustainability Of Raw Materials](#)
 - [Government Organisation \(Report\) - DataScheme](#)
 - [Government Organisation \(Website\) - DataScheme](#)
 - [Other \(Report\) - DataScheme](#)
 - [Other \(Website\) - DataScheme](#)
 - [Paper - DataScheme](#)
 - [Reports With Statistical Data - DataScheme](#)
 - Environment Health & Safety Policy
 - [Mine Closure \(D1 Primary Mineral Resources\) - D1 Primary Mineral Resources](#)
 - [Mine Development \(D1 Primary Mineral Resources\) - D1 Primary Mineral Resources](#)
 - [Mineral Exploration - D1 Primary Mineral Resources](#)
 - European Parliamentary Resolutions
 - Local/Communal By-Laws
 - National Environmental Legislation
 - National Emission Legislation
 - National Soil Legislation
 - National Water Legislation
 - National Environmental Policies
 - Regional/Provincial Environmental Laws
 - Un Conventions
 - Aarhus Convention
 - Basle Convention

- Helcom
 - Marpol
 - Osparcom
- Land Use Policy
 - D7 International Reporting - D7 International Reporting
 - Electronic (Spatial Data) - DataScheme
 - Government Organisation (Report) - DataScheme
 - Government Organisation (Website) - DataScheme
 - Land Use (Impacts Of Materials, Products & Services) - D6 Sustainability Of Raw Materials
 - Metadata On Spatial Data - DataScheme
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Paper Maps - DataScheme
 - Reports With Statistical Data - DataScheme
 - Satellite Or Aerial Imagery - DataScheme
 - Specialist Magazines - DataScheme
 - Deposits Of Public Importance
 - Ore Deposit Evaluation (Mineral Exploration) - D1 Primary Mineral Resources
 - Resources And Reserves - D1 Primary Mineral Resources
 - Designation Areas (E.G., Conservation [Nature, Culture, Etc.]
 - Permitting/Licensing (Land Use Policy)
 - Biodiversity Compensation - D6 Sustainability Of Raw Materials
 - Detailed Surface Exploration (Mineral Exploration) - D1 Primary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Prospecting Authorization/Permitting - D1 Primary Mineral Resources
 - Regional Reconnaissance (Mineral Exploration) - D1 Primary Mineral Resources
 - Resource Assessment (Mineral Exploration) - D1 Primary Mineral Resources
 - Subsurface Exploration (Mineral Exploration) - D1 Primary Mineral Resources
- Mineral Policy/Strategy
 - Electronic (Spatial Data) - DataScheme
 - Government Organisation (Report) - DataScheme
 - Government Organisation (Website) - DataScheme
 - Metadata On Spatial Data - DataScheme
 - Methods To Assess Environmental Impacts - MethodScheme
 - Methods To Assess Material Flows - MethodScheme
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Paper Maps - DataScheme

- Reports With Statistical Data - DataScheme
 - Satellite Or Aerial Imagery - DataScheme
 - Specialist Magazines - DataScheme
 - Trade Association (Report) - DataScheme
 - Trade Association (Website) - DataScheme
 - Conflict Mineral Use
 - Responsible Sourcing - D6 Sustainability Of Raw Materials
 - Product Declaration
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Electronic (Statistical Data) - DataScheme
 - Infographics And Other Media - DataScheme
 - Material Flow Analysis - MethodScheme
 - Metadata On Statistical Data - DataScheme
 - Paper Format Statistical Data - DataScheme
 - Responsible Mining
 - D7 International Reporting - D7 International Reporting
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Social Feasibility - D1 Primary Mineral Resources
 - Social Licence To Operate (Slo) - D6 Sustainability Of Raw Materials
 - Standardization
 - Classification System - D7 International Reporting
 - Trade Regulation And Policy
 - Trade (Supply) - D4 Raw Materials Economics
- **D6 Sustainability Of Raw Materials**
 - Circular Economy - D5 Raw Materials Policy & Legal Framework
 - D4 Raw Materials Economics - D4 Raw Materials Economics
 - Environmental Legislation - D5 Raw Materials Policy & Legal Framework
 - Compensation
 - Ee-loa - MethodScheme
 - Environmental Footprinting - MethodScheme
 - Life Cycle Assessment - MethodScheme
 - Preliminary Feasibility Study And Feasibility Study - D1 Primary Mineral Resources
 - Biodiversity Compensation
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Permitting/Licensing (Land Use Policy) - D5 Raw Materials Policy & Legal Framework
 - Restoration/Rehabilitation - D1 Primary Mineral Resources
 - Carbon Trading
 - Carbon Footprint - D6 Sustainability Of Raw Materials
 - Impacts Of Specific Processes/Plants
 - Metallurgy & Industrial Mineral Transformation - D3 Industrial Processing And Transformation
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mine Operation - D1 Primary Mineral Resources
 - Preliminary Feasibility Study And Feasibility Study - D1 Primary Mineral Resources
 - Local Environmental & Health Impacts

- Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
- Resource Efficiency Policies - D5 Raw Materials Policy & Legal Framework
- Stocks/Materials (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Eco-Design
 - Frugal Design
 - Indicators
- Social Licence To Operate (Slo)
 - Prospecting Authorization/Permitting - D1 Primary Mineral Resources
 - Responsible Mining - D5 Raw Materials Policy & Legal Framework
- **D7 International Reporting**
 - Circular Economy - D5 Raw Materials Policy & Legal Framework
 - Land Use Policy - D5 Raw Materials Policy & Legal Framework
 - Responsible Mining - D5 Raw Materials Policy & Legal Framework
 - Corporate Social Responsibility (D7 International Reporting)
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Corporate Social Responsibility (D5 Raw Materials Policy & Legal Framework) - D5 Raw Materials Policy & Legal Framework
 - Ee-loa - MethodScheme
 - Electronic (Statistical Data) - DataScheme
 - Environmental Footprinting - MethodScheme
 - Infographics And Other Media - DataScheme
 - Life Cycle Assessment - MethodScheme
 - Metadata On Statistical Data - DataScheme
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Reports With Statistical Data - DataScheme
 - Social Feasibility - D1 Primary Mineral Resources
 - Social Impacts - D6 Sustainability Of Raw Materials
 - Specialist Magazines - DataScheme
 - Trade Association (Report) - DataScheme
 - Trade Association (Website) - DataScheme
 - Impact Benefit Agreements
 - Environmental Assessment - MethodScheme
 - Environmental Footprinting - MethodScheme
 - Life Cycle Assessment - MethodScheme
 - International Reporting Of Resources And Reserves
 - Commodity Prices - D4 Raw Materials Economics
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Economic (Preliminary Feasibility Study And Feasibility Study) - D1 Primary Mineral Resources
 - Electronic (Spatial Data) - DataScheme
 - Metadata On Spatial Data - DataScheme
 - Metadata On Statistical Data - DataScheme
 - Ore Deposit Evaluation (Mineral Exploration) - D1 Primary Mineral Resources
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme

Preliminary Feasibility Study And Feasibility Study - D1 Primary Mineral Resources

Reports With Statistical Data - DataScheme

Resources And Reserves - D1 Primary Mineral Resources

Satellite Or Aerial Imagery - DataScheme

Specialist Magazines - DataScheme

Trade Association (Report) - DataScheme

Trade Association (Website) - DataScheme

- Classification System
 - Standardization - D5 Raw Materials Policy & Legal Framework
 - CrirSCO 'Framework'
 - National Reporting Code
 - Other Classification Systems
 - Unfc
- Shareholder Information
 - Investors - D4 Raw Materials Economics
- Sustainable Development Reporting
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - Ee-loa - MethodScheme
 - Electronic (Statistical Data) - DataScheme
 - Environmental Assessment - MethodScheme
 - Environmental Footprinting - MethodScheme
 - Infographics And Other Media - DataScheme
 - Life Cycle Assessment - MethodScheme
 - Metadata On Spatial Data - DataScheme
 - Metadata On Statistical Data - DataScheme
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Paper - DataScheme
 - Reports With Statistical Data - DataScheme
 - Satellite Or Aerial Imagery - DataScheme
 - Specialist Magazines - DataScheme
- To Communities
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - D3 Industrial Processing And Transformation - D3 Industrial Processing And Transformation
 - Ee-loa - MethodScheme
 - Electronic (Statistical Data) - DataScheme
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Environmental Footprinting - MethodScheme
 - Government Organisation (Report) - DataScheme
 - Government Organisation (Website) - DataScheme
 - Life Cycle Assessment - MethodScheme
 - Local Environmental & Health Impacts - D6 Sustainability Of Raw Materials
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Metadata On Statistical Data - DataScheme
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Other (Magazine Article) - DataScheme
 - Other (Report) - DataScheme

- Other (Website) - DataScheme
- Paper - DataScheme
- Risk Assessment Methods - MethodScheme
- Specialist Magazines - DataScheme
- Waste Deposited In Landfills - D2 Secondary Mineral Resources
- To Employees
 - Company (Magazine Article) - DataScheme
 - Company (Report) - DataScheme
 - Company (Website) - DataScheme
 - D3 Industrial Processing And Transformation - D3 Industrial Processing And Transformation
 - Electronic (Spatial Data) - DataScheme
 - Electronic (Statistical Data) - DataScheme
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Government Organisation (Report) - DataScheme
 - Government Organisation (Website) - DataScheme
 - Infographics And Other Media - DataScheme
 - Local Environmental & Health Impacts - D6 Sustainability Of Raw Materials
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Metadata On Spatial Data - DataScheme
 - Metadata On Statistical Data - DataScheme
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Other (Magazine Article) - DataScheme
 - Other (Report) - DataScheme
 - Other (Website) - DataScheme
 - Risk Assessment Methods - MethodScheme
 - Specialist Magazines - DataScheme
 - Trade Association (Report) - DataScheme
 - Trade Association (Website) - DataScheme
 - Waste Deposited In Landfills - D2 Secondary Mineral Resources

MethodScheme

- **Future Outlook Methods**
 - Explanatory Methods
 - Qualitative Methods (Explanatory Methods)
 - Quantitative Methods (Explanatory Methods)
 - Explanatory/Normative Methods
 - Qualitative Methods (Explanatory/Normative Methods)
 - Quantitative Methods (Explanatory/Normative Methods)
 - Normative Methods
 - Qualitative Methods (Normative Methods)
 - Quantitative Methods (Normative Methods)
- **Economic Methods**
 - Methods To Assess And/Or Predict Monetary And/Or Physical Flows
 - Computable General Equilibrium Modelling
 - Input Output Analysis
 - Methods To Assess Economic Risk
 - Cost Benefit Analysis
 - Criticality Assessment
 - Econometrics
 - Life Cycle Costing
- **Geological Methods**

- Methods For Ground Investigation
 - Methods For Deep Investigation
 - Methods For Sub-Surface
- Methods For Local-Scale Exploration
 - Geochemical Methods (Methods For Local-Scale Exploration)
 - Geological Mapping (Methods For Local-Scale Exploration)
 - Geophysical Methods
- Methods For Mine Closure
- Methods For Ore Treatment
- Methods For Regional Exploration
 - Geochemical Methods (Methods For Regional Exploration)
 - Geological Mapping (Methods For Regional Exploration)
 - Predictive Methods
 - Remote Sensing Methods (Incl. Geophysics)
- Methods For Resource Assessment
 - Methods For Primary Resources
 - 3d Modelling
 - Economic Assessment
 - Environmental Assessment
 - Feasibility Studies
 - Geostatistical Methods
 - Methods For Reporting
 - Methods For Secondary Resources
 - Compositional Analysis Of Stocks
 - Wastes Characterization
- **Industrial Ecology Methods**
 - Methods To Assess Environmental Impacts
[Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework](#)
 - Methods Covering The Supply Chain (Methods To Assess Environmental Impacts)
 - Ee-loa
[Compensation - D6 Sustainability Of Raw Materials](#)
[Corporate Social Responsibility \(D7 International Reporting\) - D7 International Reporting](#)
[Electrometallurgy - D3 Industrial Processing And Transformation](#)
[Hydrometallurgy - D3 Industrial Processing And Transformation](#)
[Pyrometallurgy - D3 Industrial Processing And Transformation](#)
[Sustainable Development Reporting - D7 International Reporting](#)
[To Communities - D7 International Reporting](#)
 - Geographical Coverage
 - Other (Ee-loa)
 - Sectoral Coverage / Level Of Detail
 - Trade-Linked Or Not
 - With Gem Core Or Not
 - Environmental Footprinting
[Compensation - D6 Sustainability Of Raw Materials](#)
[Corporate Social Responsibility \(D7 International Reporting\) - D7 International Reporting](#)
[Impact Benefit Agreements - D7 International Reporting](#)
[Sustainable Development Reporting - D7 International Reporting](#)
[To Communities - D7 International Reporting](#)
 - Covering A Wide Array Of Impacts
 - Oef
 - Pef

- Covering Selected Impacts
 - Carbon Footprint
 - Ecological Footprint
 - Water Footprint
 - Life Cycle Assessment
 - Compensation - D6 Sustainability Of Raw Materials
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Impact Benefit Agreements - D7 International Reporting
 - Sustainable Development Reporting - D7 International Reporting
 - To Communities - D7 International Reporting
 - Life Cycle Impact Assessment
 - Endpoint Methods
 - Other (Endpoint Methods)
 - Midpoint Methods
 - Cml2001
 - Other (Midpoint Methods)
 - Other Methods
 - Recipe
 - Life Cycle Inventory
 - Ecoinvent
 - Other (Life Cycle Inventory)
 - Methods Not Covering The Supply Chain (Methods To Assess Environmental Impacts)
 - Environmental Assessment
 - Impact Benefit Agreements - D7 International Reporting
 - Sustainable Development Reporting - D7 International Reporting
 - Risk Assessment Methods
 - To Communities - D7 International Reporting
 - To Employees - D7 International Reporting
 - Disasters / Incidental Impacts
 - Related To Explosions
 - Related To Other Accidents
 - Related To Toxic Emissions
 - Environmental Risk Assessment
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Waste Deposited In Landfills - D2 Secondary Mineral Resources
 - Exposure Models
 - Related To Ecosystem Health
 - Related To Human Health
 - Fate Models
 - Technology Assessment
- Methods To Assess Material Flows
 - Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
 - Methods Covering The Supply Chain (Methods To Assess Material Flows)
 - Input Output Analysis
 - Demand - D4 Raw Materials Economics
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Industrial Rocks Transformation - D3 Industrial Processing And Transformation
 - Metal Stocks In Use - D2 Secondary Mineral Resources

- Mineralurgy Of Secondary Resources - D3 Industrial Processing And Transformation
- Non-Metal Stocks In Use - D2 Secondary Mineral Resources
- Pyrometallurgy - D3 Industrial Processing And Transformation
- Supply - D4 Raw Materials Economics
 - Environmentally Extended Input Output Analysis
 - Physical Input Output Tables
- Material Flow Analysis
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Metal Stocks In Use - D2 Secondary Mineral Resources
 - Mineralurgy Of Secondary Resources - D3 Industrial Processing And Transformation
 - Mining Wastes - D2 Secondary Mineral Resources
 - Non-Metal Stocks In Use - D2 Secondary Mineral Resources
 - Product Declaration - D5 Raw Materials Policy & Legal Framework
 - Waste Deposited In Landfills - D2 Secondary Mineral Resources
 - Material Flow Accounting According To Eurostat Methodology
 - Reconciliation In Mfa
 - Substance Flow Analysis
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Metal Stocks In Use - D2 Secondary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Non-Metal Stocks In Use - D2 Secondary Mineral Resources
 - Pyrometallurgy - D3 Industrial Processing And Transformation
 - Supply Risk - D4 Raw Materials Economics
 - Waste Deposited In Landfills - D2 Secondary Mineral Resources
 - Dynamic Modelling Of Substance Flows
 - Static Modelling Of Substance Flows
 - Substance Flow Accounting
- Methods Not Covering The Supply Chain (Methods To Assess Material Flows)
 - Material Balances
 - Estimates Of Waste And Emissions
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Waste Deposited In Landfills - D2 Secondary Mineral Resources
 - Inputs And Outputs Of Industrial Processes
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Stock Assessments
- Methods To Assess Uncertainty In Mineral Intelligence Analysis

DataScheme

- Metadata

- Metadata On Spatial Data
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Land Use Policy - D5 Raw Materials Policy & Legal Framework
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Metal Stocks In Use - D2 Secondary Mineral Resources
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Non-Metal Stocks In Use - D2 Secondary Mineral Resources
 - Pyrometallurgy - D3 Industrial Processing And Transformation
 - Supply - D4 Raw Materials Economics
 - Sustainable Development Reporting - D7 International Reporting
 - To Employees - D7 International Reporting
 - Waste Deposited In Landfills - D2 Secondary Mineral Resources
- Metadata On Statistical Data
 - Commodity Prices - D4 Raw Materials Economics
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Costs - D4 Raw Materials Economics
 - Demand - D4 Raw Materials Economics
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Product Declaration - D5 Raw Materials Policy & Legal Framework
 - Supply - D4 Raw Materials Economics
 - Sustainable Development Reporting - D7 International Reporting
 - To Communities - D7 International Reporting
 - To Employees - D7 International Reporting
 - Waste Deposited In Landfills - D2 Secondary Mineral Resources
- Other Metadata
 - Batteries And Accumulator Wastes - D2 Secondary Mineral Resources
 - Construction And Demolition Waste - D2 Secondary Mineral Resources
 - Discarded Equipment - D2 Secondary Mineral Resources
 - Discarded Vehicles - D2 Secondary Mineral Resources
 - Glass Waste (End-Of-Life Waste) - D2 Secondary Mineral Resources
 - Weee - D2 Secondary Mineral Resources
- **Spatial Data**
 - Electronic (Spatial Data)
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - International Reporting Of Resources And Reserves - D7 International Reporting

- Land Use Policy - D5 Raw Materials Policy & Legal Framework
- Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
- Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
- Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
- Mineral Exploration - D1 Primary Mineral Resources
- Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
- Mineral/Ore Deposit - D1 Primary Mineral Resources
- Mining Wastes - D2 Secondary Mineral Resources
- Pyrometallurgy - D3 Industrial Processing And Transformation
- Supply - D4 Raw Materials Economics
- To Employees - D7 International Reporting
- Waste Deposited In Landfills - D2 Secondary Mineral Resources
- Paper Maps
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Land Use Policy - D5 Raw Materials Policy & Legal Framework
 - Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Pyrometallurgy - D3 Industrial Processing And Transformation
- Satellite Or Aerial Imagery
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Land Use Policy - D5 Raw Materials Policy & Legal Framework
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Metal Stocks In Use - D2 Secondary Mineral Resources
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Non-Metal Stocks In Use - D2 Secondary Mineral Resources
 - Pyrometallurgy - D3 Industrial Processing And Transformation
 - Sustainable Development Reporting - D7 International Reporting
 - Waste Deposited In Landfills - D2 Secondary Mineral Resources
- **General Descriptive Information**
 - Magazine Article
 - Company (Magazine Article)
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Importance For Industry - D4 Raw Materials Economics
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources

- Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
- Mineral Exploration - D1 Primary Mineral Resources
- Mineral/Ore Deposit - D1 Primary Mineral Resources
- Mining Wastes - D2 Secondary Mineral Resources
- Preliminary Feasibility Study And Feasibility Study - D1 Primary Mineral Resources
- Pyrometallurgy - D3 Industrial Processing And Transformation
- Sustainable Development Reporting - D7 International Reporting
- To Communities - D7 International Reporting
- To Employees - D7 International Reporting
- Waste Deposited In Landfills - D2 Secondary Mineral Resources
- Other (Magazine Article)
 - Commodity Prices - D4 Raw Materials Economics
 - Demand - D4 Raw Materials Economics
 - Importance For Industry - D4 Raw Materials Economics
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Supply - D4 Raw Materials Economics
 - Supply Risk - D4 Raw Materials Economics
 - To Communities - D7 International Reporting
 - To Employees - D7 International Reporting
- Specialist Magazines
 - Commodity Prices - D4 Raw Materials Economics
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Costs - D4 Raw Materials Economics
 - Demand - D4 Raw Materials Economics
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Importance For Industry - D4 Raw Materials Economics
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Land Use Policy - D5 Raw Materials Policy & Legal Framework
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Preliminary Feasibility Study And Feasibility Study - D1 Primary Mineral Resources
 - Pyrometallurgy - D3 Industrial Processing And Transformation
 - Supply - D4 Raw Materials Economics
 - Supply Risk - D4 Raw Materials Economics
 - Sustainable Development Reporting - D7 International Reporting
 - To Communities - D7 International Reporting

- To Employees - D7 International Reporting
 - Waste Deposited In Landfills - D2 Secondary Mineral Resources
- Paper
 - Commodity Prices - D4 Raw Materials Economics
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Demand - D4 Raw Materials Economics
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Environmental Legislation - D5 Raw Materials Policy & Legal Framework
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Importance For Industry - D4 Raw Materials Economics
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Land Use Policy - D5 Raw Materials Policy & Legal Framework
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Metal Stocks In Use - D2 Secondary Mineral Resources
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Non-Metal Stocks In Use - D2 Secondary Mineral Resources
 - Preliminary Feasibility Study And Feasibility Study - D1 Primary Mineral Resources
 - Pyrometallurgy - D3 Industrial Processing And Transformation
 - Supply - D4 Raw Materials Economics
 - Supply Risk - D4 Raw Materials Economics
 - Sustainable Development Reporting - D7 International Reporting
 - To Communities - D7 International Reporting
 - Waste Deposited In Landfills - D2 Secondary Mineral Resources
- Report
 - Company (Report)
 - Commodity Prices - D4 Raw Materials Economics
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Demand - D4 Raw Materials Economics
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Importance For Industry - D4 Raw Materials Economics
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources

- Preliminary Feasibility Study And Feasibility Study - D1 Primary Mineral Resources
- Product Declaration - D5 Raw Materials Policy & Legal Framework
- Pyrometallurgy - D3 Industrial Processing And Transformation
- Supply - D4 Raw Materials Economics
- Sustainable Development Reporting - D7 International Reporting
- To Communities - D7 International Reporting
- To Employees - D7 International Reporting
- Waste Deposited In Landfills - D2 Secondary Mineral Resources
- Government Organisation (Report)
 - Commodity Prices - D4 Raw Materials Economics
 - Costs - D4 Raw Materials Economics
 - Demand - D4 Raw Materials Economics
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Environmental Legislation - D5 Raw Materials Policy & Legal Framework
 - Importance For Industry - D4 Raw Materials Economics
 - Land Use Policy - D5 Raw Materials Policy & Legal Framework
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Supply - D4 Raw Materials Economics
 - Supply Risk - D4 Raw Materials Economics
 - To Communities - D7 International Reporting
 - To Employees - D7 International Reporting
 - Waste Deposited In Landfills - D2 Secondary Mineral Resources
- Lobbying Group (Report)
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Supply Risk - D4 Raw Materials Economics
- Other (Report)
 - Commodity Prices - D4 Raw Materials Economics
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Costs - D4 Raw Materials Economics
 - Demand - D4 Raw Materials Economics
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - Environmental Legislation - D5 Raw Materials Policy & Legal Framework
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Importance For Industry - D4 Raw Materials Economics
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Land Use Policy - D5 Raw Materials Policy & Legal Framework
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources

- Preliminary Feasibility Study And Feasibility Study - D1 Primary Mineral Resources
- Pyrometallurgy - D3 Industrial Processing And Transformation
- Supply - D4 Raw Materials Economics
- Supply Risk - D4 Raw Materials Economics
- Sustainable Development Reporting - D7 International Reporting
- To Communities - D7 International Reporting
- To Employees - D7 International Reporting
- Trade Association (Report)
 - Commodity Prices - D4 Raw Materials Economics
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Demand - D4 Raw Materials Economics
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Importance For Industry - D4 Raw Materials Economics
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Metal Stocks In Use - D2 Secondary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Non-Metal Stocks In Use - D2 Secondary Mineral Resources
 - Pyrometallurgy - D3 Industrial Processing And Transformation
 - Supply - D4 Raw Materials Economics
 - Supply Risk - D4 Raw Materials Economics
 - To Employees - D7 International Reporting
- Website
 - Company (Website)
 - Commodity Prices - D4 Raw Materials Economics
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Demand - D4 Raw Materials Economics
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Importance For Industry - D4 Raw Materials Economics
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Preliminary Feasibility Study And Feasibility Study - D1 Primary Mineral Resources

- Product Declaration - D5 Raw Materials Policy & Legal Framework
- Pyrometallurgy - D3 Industrial Processing And Transformation
- Supply - D4 Raw Materials Economics
- Sustainable Development Reporting - D7 International Reporting
- To Communities - D7 International Reporting
- To Employees - D7 International Reporting
- Waste Deposited In Landfills - D2 Secondary Mineral Resources
- Government Organisation (Website)
 - Commodity Prices - D4 Raw Materials Economics
 - Costs - D4 Raw Materials Economics
 - Demand - D4 Raw Materials Economics
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Environmental Legislation - D5 Raw Materials Policy & Legal Framework
 - Importance For Industry - D4 Raw Materials Economics
 - Land Use Policy - D5 Raw Materials Policy & Legal Framework
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Supply - D4 Raw Materials Economics
 - Supply Risk - D4 Raw Materials Economics
 - To Communities - D7 International Reporting
 - To Employees - D7 International Reporting
 - Waste Deposited In Landfills - D2 Secondary Mineral Resources
- Lobbying Group (Website)
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Supply Risk - D4 Raw Materials Economics
- Other (Website)
 - Commodity Prices - D4 Raw Materials Economics
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Costs - D4 Raw Materials Economics
 - Demand - D4 Raw Materials Economics
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - Environmental Legislation - D5 Raw Materials Policy & Legal Framework
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Importance For Industry - D4 Raw Materials Economics
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Land Use Policy - D5 Raw Materials Policy & Legal Framework
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Preliminary Feasibility Study And Feasibility Study - D1 Primary Mineral Resources

- Pyrometallurgy - D3 Industrial Processing And Transformation
 - Supply - D4 Raw Materials Economics
 - Supply Risk - D4 Raw Materials Economics
 - Sustainable Development Reporting - D7 International Reporting
 - To Communities - D7 International Reporting
 - To Employees - D7 International Reporting
 - Trade Association (Website)
 - Commodity Prices - D4 Raw Materials Economics
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Demand - D4 Raw Materials Economics
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Importance For Industry - D4 Raw Materials Economics
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Metal Stocks In Use - D2 Secondary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Non-Metal Stocks In Use - D2 Secondary Mineral Resources
 - Pyrometallurgy - D3 Industrial Processing And Transformation
 - Supply - D4 Raw Materials Economics
 - Supply Risk - D4 Raw Materials Economics
 - To Employees - D7 International Reporting
- **Statistical Data**
 - Electronic (Statistical Data)
 - Commodity Prices - D4 Raw Materials Economics
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Costs - D4 Raw Materials Economics
 - Demand - D4 Raw Materials Economics
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Product Declaration - D5 Raw Materials Policy & Legal Framework
 - Supply - D4 Raw Materials Economics
 - Sustainable Development Reporting - D7 International Reporting
 - To Communities - D7 International Reporting
 - To Employees - D7 International Reporting
 - Waste Deposited In Landfills - D2 Secondary Mineral Resources
 - Infographics And Other Media
 - Commodity Prices - D4 Raw Materials Economics
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Costs - D4 Raw Materials Economics

- Demand - D4 Raw Materials Economics
- Electrometallurgy - D3 Industrial Processing And Transformation
- End-Of-Life Waste - D2 Secondary Mineral Resources
- Hydrometallurgy - D3 Industrial Processing And Transformation
- Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
- Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
- Metal Stocks In Use - D2 Secondary Mineral Resources
- Mineral Exploration - D1 Primary Mineral Resources
- Mineral/Ore Deposit - D1 Primary Mineral Resources
- Mining Wastes - D2 Secondary Mineral Resources
- Non-Metal Stocks In Use - D2 Secondary Mineral Resources
- Product Declaration - D5 Raw Materials Policy & Legal Framework
- Pyrometallurgy - D3 Industrial Processing And Transformation
- Supply - D4 Raw Materials Economics
- Sustainable Development Reporting - D7 International Reporting
- To Employees - D7 International Reporting
- Waste Deposited In Landfills - D2 Secondary Mineral Resources
- Paper Format Statistical Data
 - Commodity Prices - D4 Raw Materials Economics
 - Demand - D4 Raw Materials Economics
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Product Declaration - D5 Raw Materials Policy & Legal Framework
 - Supply - D4 Raw Materials Economics
 - Waste Deposited In Landfills - D2 Secondary Mineral Resources
- Reports With Statistical Data
 - Commodity Prices - D4 Raw Materials Economics
 - Corporate Social Responsibility (D7 International Reporting) - D7 International Reporting
 - Costs - D4 Raw Materials Economics
 - Demand - D4 Raw Materials Economics
 - Electrometallurgy - D3 Industrial Processing And Transformation
 - End-Of-Life Waste - D2 Secondary Mineral Resources
 - Environmental Legislation - D5 Raw Materials Policy & Legal Framework
 - Hydrometallurgy - D3 Industrial Processing And Transformation
 - Importance For Industry - D4 Raw Materials Economics
 - International Reporting Of Resources And Reserves - D7 International Reporting
 - Land Use Policy - D5 Raw Materials Policy & Legal Framework
 - Manufacturing/Industrial Waste - D2 Secondary Mineral Resources
 - Material Recovery (D2 Secondary Mineral Resources) - D2 Secondary Mineral Resources
 - Metal Stocks In Use - D2 Secondary Mineral Resources
 - Mine Closure (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mine Development (D1 Primary Mineral Resources) - D1 Primary Mineral Resources
 - Mineral Exploration - D1 Primary Mineral Resources
 - Mineral Policy/Strategy - D5 Raw Materials Policy & Legal Framework
 - Mineral/Ore Deposit - D1 Primary Mineral Resources
 - Mining Wastes - D2 Secondary Mineral Resources
 - Non-Metal Stocks In Use - D2 Secondary Mineral Resources
 - Preliminary Feasibility Study And Feasibility Study - D1 Primary Mineral Resources
 - Pyrometallurgy - D3 Industrial Processing And Transformation

Supply - D4 Raw Materials Economics
 Supply Risk - D4 Raw Materials Economics
 Sustainable Development Reporting - D7 International Reporting
 Waste Deposited In Landfills - D2 Secondary Mineral Resources

CommodityScheme

- Produced Commodity^{inspire}
 - Chemical Compound Product^{inspire}
 - Chemical Oxide Product^{inspire}
 - Alumina^{inspire}
 - Chrome^{inspire}
 - Iron Oxide^{inspire}
 - Ochre^{inspire}
 - Lithium Oxide^{inspire}
 - Magnesia^{inspire}
 - Niobiumpentoxide^{inspire}
 - Phosphorouspentoxide^{inspire}
 - Rare Earth Oxide^{inspire}
 - Tantalumpentoxide^{inspire}
 - Uranium Oxide^{inspire}
 - Vanadium Pentoxide^{inspire}
 - Yttrium Oxide^{inspire}
 - Zirconia^{inspire}
 - Lime^{inspire}
 - Nitrate^{inspire}
 - Potash^{inspire}
 - Soda Ash^{inspire}
 - Metal^{inspire}
 - Aluminium^{inspire}
 - Barium^{inspire}
 - Base Metal^{inspire}
 - Cobalt^{inspire}
 - Copper^{inspire}
 - Lead^{inspire}
 - Nickel^{inspire}
 - Zinc^{inspire}
 - Beryllium^{inspire}
 - Bismuth^{inspire}
 - Cadmium^{inspire}
 - Cesium^{inspire}
 - Chromite^{inspire}
 - Ferrous Metal^{inspire}
 - Chromium^{inspire}
 - Iron^{inspire}
 - Manganese^{inspire}
 - Titanium^{inspire}
 - Vanadium^{inspire}
 - Gallium^{inspire}
 - Hafnium^{inspire}
 - Indium^{inspire}
 - Lithium^{inspire}
 - Magnesium^{inspire}
 - Mercury^{inspire}

- Molybdenum^{inspire}
- Niobium^{inspire}
- Potassium^{inspire}
- Precious Metal^{inspire}
 - Gold^{inspire}
 - Platinum Group Metal^{inspire}
 - Iridium^{inspire}
 - Osmium^{inspire}
 - Palladium^{inspire}
 - Platinum^{inspire}
 - Rhodium^{inspire}
 - Ruthenium^{inspire}
 - Silver^{inspire}
- Radium^{inspire}
- Rare Earth Element^{inspire}
 - Hree^{inspire}
 - Dysprosium^{inspire}
 - Erbium^{inspire}
 - Holmium^{inspire}
 - Lutetium^{inspire}
 - Terbium^{inspire}
 - Thulium^{inspire}
 - Ytterbium^{inspire}
 - Yttrium^{inspire}
 - Lree^{inspire}
 - Cerium^{inspire}
 - Europium^{inspire}
 - Gadolinium^{inspire}
 - Lanthanum^{inspire}
 - Neodymium^{inspire}
 - Praseodymium^{inspire}
 - Promethium^{inspire}
 - Samarium^{inspire}
 - Scandium^{inspire}
- Rhenium^{inspire}
- Rubidium^{inspire}
- Strontium^{inspire}
- Tantalum^{inspire}
- Thallium^{inspire}
- Thorium^{inspire}
- Tin^{inspire}
- Tungsten^{inspire}
- Uranium^{inspire}
- Zirconium^{inspire}
- Metalloid^{inspire}
 - Antimony^{inspire}
 - Arsenic^{inspire}
 - Boron^{inspire}
 - Germanium^{inspire}
 - Silicon^{inspire}
 - Tellurium^{inspire}
- Non Metal^{inspire}
 - Bromine^{inspire}
 - Fluorine^{inspire}

- Iodine^{inspire}
 - Phosphorous^{inspire}
 - Selenium^{inspire}
 - Sulphur^{inspire}
- Direct Use Commodity^{inspire}
 - Gemstone^{inspire}
 - Amber^{inspire}
 - Apatite-Gemstone^{inspire}
 - Beryl^{inspire}
 - Aquamarine^{inspire}
 - Emerald^{inspire}
 - Heliodor^{inspire}
 - Morganite^{inspire}
 - Cassiterite-Gemstone^{inspire}
 - Chrysoberyl^{inspire}
 - Cordierite^{inspire}
 - Corundum-Gemstone^{inspire}
 - Ruby^{inspire}
 - Sapphire^{inspire}
 - Diamond-Gemstone^{inspire}
 - Diopside-Enstatite^{inspire}
 - Dioptase^{inspire}
 - Dumortierite^{inspire}
 - Euclase^{inspire}
 - Feldspar-Gemstone^{inspire}
 - Amazonite^{inspire}
 - Moonstone^{inspire}
 - Spectrolite^{inspire}
 - Garnet-Gemstone^{inspire}
 - Tsavorite^{inspire}
 - Hematite-Gemstone^{inspire}
 - Jade^{inspire}
 - Kornerupine^{inspire}
 - Kyanite-Gemstone^{inspire}
 - Lazulite^{inspire}
 - Malachite^{inspire}
 - Obsidian^{inspire}
 - Olivine-Gemstone^{inspire}
 - Phenakite^{inspire}
 - Prehnite^{inspire}
 - Quartz-Gemstone^{inspire}
 - Amethyst^{inspire}
 - Citrine^{inspire}
 - Rose Quartz^{inspire}
 - Smokey Quartz^{inspire}
 - Rhodonite^{inspire}
 - Sapphirine^{inspire}
 - Scapolite^{inspire}
 - Silica-Gemstone^{inspire}
 - Chalcedony^{inspire}
 - Agate^{inspire}
 - Mossagate^{inspire}
 - Onyx^{inspire}
 - Carnelian^{inspire}

- Chrysoprase^{inspire}
 - Opal^{inspire}
 - Sihalite^{inspire}
 - Sodalite^{inspire}
 - Spinel-Gemstone^{inspire}
 - Spodumene^{inspire}
 - Tanzanite^{inspire}
 - Topaz^{inspire}
 - Tourmaline^{inspire}
 - Turquoise^{inspire}
 - Variscite^{inspire}
 - Vesuvianite^{inspire}
 - Xenotime-Gemstone^{inspire}
 - Zircon-Gemstone^{inspire}
- Industrial Material^{inspire}
 - Aggregate^{inspire}
 - Natural Secondary Aggregate^{inspire}
 - Primary Aggregate^{inspire}
 - Crushed Rock^{inspire}
 - Riprap^{inspire}
 - Sand And Gravel^{inspire}
 - Recycled Aggregate^{inspire}
 - Dimension Stone^{inspire}
 - Basalt^{inspire}
 - Granite^{inspire}
 - Greenstone^{inspire}
 - Limestone^{inspire}
 - Marble^{inspire}
 - Miscellaneous Dimension Stones^{inspire}
 - Sandstone^{inspire}
 - Slate^{inspire}
 - Direct Shipping Ore^{inspire}
 - Bauxite^{inspire}
 - Iron Ore^{inspire}
 - Hematite Ore^{inspire}
 - Magnetite Ore^{inspire}
 - Manganese Ore^{inspire}
 - Industrial rock^{inspire}
 - Diatomite^{inspire}
 - Laterite^{inspire}
 - Nephelinesyenite^{inspire}
 - Perlite^{inspire}
 - Phosphaterock^{inspire}
 - Pozzolan^{inspire}
 - Pumice^{inspire}
 - Shell Grit^{inspire}
 - Spongolite^{inspire}
 - Organic material^{inspire}
 - Carbonaceous material^{inspire}
 - Coal^{inspire}
 - Anthracite^{inspire}
 - Black Coal^{inspire}
 - Brown Coal^{inspire}
 - Peat^{inspire}

- Gaseous Hydrocarbons^{inspire}
 - Coal Bed Methane^{inspire}
 - Gas Hydrate^{inspire}
 - Reservoir Gas^{inspire}
 - Liquid hydrocarbons^{inspire}
 - Asphalt^{inspire}
 - Oil^{inspire}
 - Oil Shale^{inspire}
 - Tar Sand^{inspire}
 - Sand^{inspire}
 - Foundry Sand^{inspire}
 - Frac Sand^{inspire}
- Industrial mineral^{inspire}
 - Aluminosilicate^{inspire}
 - Andalusite^{inspire}
 - Kyanite^{inspire}
 - Pyrophyllite^{inspire}
 - Sillimanite^{inspire}
 - Alunite^{inspire}
 - Apatite^{inspire}
 - Asbestos^{inspire}
 - Asbestos-Amphibole^{inspire}
 - Anthophyllite^{inspire}
 - Crocidolite^{inspire}
 - Asbestos-Serpentine^{inspire}
 - Chrysotile^{inspire}
 - Baryte^{inspire}
 - Borate^{inspire}
 - Calcite^{inspire}
 - Chlorite^{inspire}
 - Clay^{inspire}
 - Brick Clay^{inspire}
 - Fullers Earth^{inspire}
 - Bentonite^{inspire}
 - Palygorskite^{inspire}
 - Halloysite^{inspire}
 - Kaolin^{inspire}
 - Sepiolite^{inspire}
 - White-Firing Clay^{inspire}
 - Corundum^{inspire}
 - Cryolite^{inspire}
 - Diamond^{inspire}
 - Epsomite^{inspire}
 - Evaporite^{inspire}
 - Anhydrite^{inspire}
 - Carnallite^{inspire}
 - Gypsum^{inspire}
 - Salt^{inspire}
 - Sylvite^{inspire}
 - Feldspar^{inspire}
 - Fluorite^{inspire}
 - Garnet^{inspire}
 - Glauconite^{inspire}
 - Graphite^{inspire}

- Hematite^{inspire}
- Ilmenite^{inspire}
- Jarosite^{inspire}
- Leucoxene^{inspire}
- Magnesite^{inspire}
- Magnetite^{inspire}
- Mica^{inspire}
- Molybdenite^{inspire}
- Monazite^{inspire}
- Olivine^{inspire}
- Pyrite^{inspire}
- Quartz^{inspire}
- Rutile^{inspire}
- Saponite^{inspire}
- Sericite^{inspire}
- Serpentine^{inspire}
- Silica^{inspire}
 - Chert^{inspire}
- Spinel^{inspire}
- Staurolite^{inspire}
- Strontianite^{inspire}
- Talc^{inspire}
- Thenardite^{inspire}
- Tremolite-Actinolite^{inspire}
- Vermiculite^{inspire}
- Wollastonite^{inspire}
- Zeolite^{inspire}
- Zircon^{inspire}

TemporalScheme

- Historic
- Future
 - Long Term ($5 < T < 30$ Years)
 - Near Future ($T < 5$ Years)
 - Very Long Term ($T > 30$ Years)
- Recent Past
- Present
- Geological

SpatialScheme

- Scale
 - Continental Level
 - Asia
 - Europe
 - Eu 15
 - Eu 28
 - Non-Eu 15
 - Non-Eu 28
 - North America
 - Oceania
 - South America

- Global Level
- Local Level
 - Lau 1
 - Lau 2
- National Level
 - Eu Member State
 - Non-Eu Member State
- Regional Level
 - Nuts 1
 - Nuts 2
 - Nuts 3
- Site Level
- Continental Vs. Marine
 - Off-Shore
 - On-Shore

ValueSupplyChainScheme

- Value/Supply Chain
 - Down-Cycling/Disposal
 - Mine Closure Operations
 - Exploration (Value/Supply Chain)
 - Detailed Surface Exploration (Exploration)
 - Ore Deposit Evaluation (Exploration)
 - Regional Reconnaissance (Exploration)
 - Resource Assessment (Exploration)
 - Subsurface Exploration (Exploration)
 - Fabrication
 - Manufacturing
 - Metallurgy
 - Mine Development (Value/Supply Chain)
 - Type Of Mining Operation (Mine Development)
 - Type Of Processing
 - Mining
 - Packaging
 - Pre-Feasibility & Feasibility
 - Economic (Pre-Feasibility & Feasibility)
 - Social
 - Technical (Pre-Feasibility & Feasibility)
 - Preliminary Economic Assessment (Value/Supply Chain)
 - Recycling And Material Recovery
 - Reuse, Repair, Refurbish & Remanufacture
 - Transport (Value/Supply Chain)
 - Use
 - Wastes Management

Deliverable D6.2

Appendix 3. Overview of the doc/fact/linked/flowSheets prepared by in the frame of the project (September 2017)

1 – FactSheets (F), docSheets (D) and linkedSheets (L)

Note: the list presented here was lastly updated on 25/08/2017. Titles were provisional and may have changed in the final version uploaded in the system. Ranking following the alphabetic order.

Title	F/D/L	Title	F/D/L
2D geological mapping (geological vs. mining)	F	Link to I2Mine	L
2D predictive mapping	F	Link to Ifixit.com	L
3D modelling: Geological	F	Link to IMP@CT	L
3D modelling: Mining (blocs models)	F	Link to JRC's RMIS (LCA)	L
Back-casting method	F	Link to JRC's Scoreboard	L
Bottom up quantitative forecasting	F	Link to list of blacklisted companies (Oxfam?)	L
Causal Layered Analysis (CLA)	F	Link to MARPOL	L
Circular economy	D	Link to MINATURA2020	L
Citizens' panel or Focus Groups	F	Link to MinFuture project	L
Cob-web Theorem	F	Link to MinPol report on permitting	L
Commodity prices forecasting	D	Link to Nüss & Eckelman (2014) on 'LCA of metals: a scientific synthesis'	L
Compensation concept	D	Link to OSPARCOM	L
Computable Equilibrium Modelling	F	Link to ProMine paper (Cassard et al., 2015)	L
Conflict minerals	D	Link to report on critical metals (Moss et al., 2013)	L
Cost Benefit Analysis	F	Link to SNL	L
Costs (mine closure, etc.)	D	Link to UN World Heritage Convention	L
Criticality	D	Link to UNEP report on recycling rate of elements	L
Criticality assessment	F	Link UNU Paper (URI; Balde, Huisman, etc.)	L
Cross Impact Analysis (CIA)	F	List of eco-organisms	D

Dangerous wastes (e.g., radioactive, REE wastes, see EURare)	L	Local/communal by-laws (Environmental legislation)	L
Delphi surveys method	F	Major metals and their companion metals metallogeny	D
Deposits of public importance: the MINATURA2020 approach	D	Material Flow Accounting MFA	F
DERA report (URI)	L	Material/Substance Flow Analysis	F
Different types detailed geophysical surveys	F	Metals price elasticities	D
Different types of drilling in mining	F	Mind mapping method	F
Different types of mining operations	F	Mine closure process (overview of # phases and actions)	F
Different types of processing	F	Mine project life cycle	D
DPSIR framework	F	Mineral deposit types and groups	D
Eco- and frugal design requirements	D	Mining wastes characterization (parameters to be considered)	F
Econometrics	F	Minventory study	L
Education/Formation/Graduate	D	Morphological analysis method	F
EIA (Environmental Impact Assessment)	F	Multi-agents method (Agent-Based Modelling)	F
Energy transition	D	NACE and other comparable classification system : an overview	L
Environmental impacts of exploration and mining activities + biodiversity	D	National environmental legislations (emission, soil & water)	L
Environmentally extended Input Output Analysis	F	Other reports (e.g., Yale, etc.)	L
Estimating undiscovered resources (e.g., USGS methods)	F	Overall cost of bringing a commodity to a user (is it feasible?)	D
Exploration phases (overview: different phases & methods)	F	Panorama of the European MR Industry	D
Exploration phases: time, costs & surfaces	D	Permitting/Licensing at EU level	D
Fast lane procedure to certified recyclers?	L	Preliminary economic assessment	F
Feasibility study	F	Preliminary economic assessment (PEA)	D
Footprinting	F	Preliminary feasibility study (PFS) and feasibility study	F
Foresight studies	F	Processing, including mining wastes	F
Genius forecasting method	F	Product life extension (recycling, refurbishment, reuse, remanufacture,...)	D
Geochemical analysis	F	Prospectivity: which commodities will do best in the coming years? (+ pricing)	F
Geological mapping	F	Public perception of extractive industry, acceptability	D
Geostatistical estimates	F	Raw Materials Foresight Case Study: Mineral Futures Collaboration Cluster (Australia)	F
Global supply chain and stakeholders (incl. biggest producers and consumers)	D	Reconciliation in material flow analysis (Data reconciliation method)	F
Ground investigation	F	Regional heavy mineral sampling	F

IdeaNetwork	F	Regional/provincial environmental laws (Environmental legislation)	L
Input output analysis	F	Relevance tree method	F
Investors	D	Remote sensing/regional geophysics	F
Knowledge platforms/information systems	D	Resource efficiency (incl. indicators)	D
Kymerberly, EITI processes– link to kimberlyprocess.com?	L	Resource estimation of primary minerals	F
Land use and protected areas	F	Responsible mining	D
Legal aspects of mine waste ownership	D	Responsible sourcing	D
Life Cycle Assessment	F	Risk Assessment	F
Life cycle costing	F	Scenario development method	F
Link to Aarhus convention	L	SEA (Strategic Environmental Assessment)	L
Link to Basel Convention	L	Serious gaming method	F
Link to be identified to quality standard for secondary resources	L	SLO & CSR (Social license to operate, corporate social responsibility)	D
Link to Brookings Institution (demographic and population prospective studies)	L	Standard classification codes or Minerals reporting standards - CRIRSCO, UNFC...	D
Link to circular economy (Wikipedia en)	L	STEEP(LED) analysis	F
Link to construction/heavy minerals mining sites?	L	Strategic stocks (at country level, LME...)	L
Link to CRM_InnoNet	L	Strategic, critical, high-tech, rare and minor metals	D
Link to Eco-Invent	L	Substitution: the CRM-InnoNet vision	D
Link to EIT-RM QR-code	L	Supply risk, an overview	D
Link to EUR-Lex - Birds Directive	L	SWOT analyses	F
Link to EUR-Lex - Chemicals Directive	L	System Dynamics Modelling	F
Link to EUR-Lex - Drinking Water Directive	L	Tax incentives for circular economy	D
Link to EUR-Lex - Groundwater Directive	L	The Future Wheel method	F
Link to EUR-Lex - Habitats Directive	L	The Raw Materials Initiative — Meeting our critical needs for growth and jobs in the EU	L
Link to EUR-Lex - Mine waste Directive	L	Top down quantitative forecasting	F
Link to EUR-Lex - Seveso Directive	L	Trade incentives (tariffs, restrictions...)	D
Link to EUR-Lex - Waste Directive	L	Trade regulation and policy	D
Link to EUR-Lex - Water Framework Directive	L	Trend Extrapolation	F
Link to EUROMINE	L	Uncertainties	F
Link to EUROSTAT	L	What is INSPIRE?	L

Link to FAME	L	WildCards foresight	F
Link to HELCOM	L		

2 – Frequently asked questions (FAQs) and related flowSheets

Note: FAQs are ranked following the alphabetic order.

Titre
Are there and how accurate are the codes of WEEE in the EU?
How big is the city level urban mine?
How big is the in-use stocks of different CRMs in Europe?
How can we collect information for product/building passports?
How do designation areas (i.e national parks) may restrict exploration/extraction of commodity x in region/country x?
How do I know that my supply chain/product is conflict free?
How does the production of major metals affect the production of companion metals?
How is a recovery level of waste equipment other than recycling?
How much is being invested in exploration for commodity/metal x?
How much is expected to be reused or recycled?
How much of commodity x will Europe be producing in year x?
How much waste is generated by mining commodity x at location y?
How will the future supply and demand of future raw materials develop?
Relevant regulatory frameworks at national levels?
Should the EU invest in appropriate infrastructure and know-how?
Should the EU invest/investigate in getting more mines in Europe?
What are new main primary and waste sources of In, PGMs, Ga, Ge?
What are price elasticities of metals?
What are the environmental impacts of using a specific resource/ raw material in general?
What are the impacts of energy transition on resource/demand/supply?
What is the contribution of secondary raw materials to the EU economy?

What is the future availability of a specific metal?

What is the mineral endowment of commodity x in Europe?

What is the potential of the circular economy for specific resources?

What is the recycling and recovery level of IT and technology equipment?

What is the recycling level of large and small household appliances?

What is the resource potential at EU/regional/national level in commodity x?

What other possibilities for substitution for commodity x?

What trends in metal prices can we expect in the short, medium and long term?

When do policies and value chains need to be developed?

Where can I find a master programme in the EU-28 dedicated to mineral resources?

Where can I find secondary materials of sufficient quality in urban stocks?

Where can we find new deposits of a specific commodity in specific geographic area?

Where could we possibly find a new deposit (size and location)?

Where will we get the substitution material?

Which firms are mostly interacting/ negotiating in the supply/value chain?

Which minerals will become critical in 30 years and where can we find them?

Which raw materials are critical for the EU and why?

Which type of Raw Material based industry will be developed in the near future and how do we supply them?

Who are the major investors in mineral resources in Europe?

Grey-shaded cells = FAQs from the Copenhagen Kick-off Meeting

White cells = FAQs from D2.2

Appendix 4. SPARQL Queries for the DDG

This appendix presents various SPARQL queries that can be performed on the MICA Triple Store in order to provide useful information in the DDG interface. Queries are sorted according to the type of resource to which they relate.

Concepts centric queries

Get top level domain concepts (top level concepts in MICA main ontology). These concepts are the concepts that have micavocab:MICA as parent concept.

Select all concepts which have micavocab:MICA as parent and for these concepts give the URI and label:

```
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>

SELECT ?conceptURI ?label
WHERE {
    ?conceptURI a skos:Concept;
                skos:prefLabel ?label;
                skos:broader micavocab:MICA.
}
order by ?label
```

Get direct subconcepts of a given concept.

In fact, the previous query can be generalized to find all the direct sub-concepts of any given concept. For example:

Select all concepts which have micavocab:0491ee9f6cf74dcda7ab92db86284c05 as parent and for these concepts give the URI and label:

```
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>

SELECT ?conceptURI ?label
WHERE {
    ?conceptURI a skos:Concept;
                skos:prefLabel ?label;
                skos:broader micavocab:0491ee9f6cf74dcda7ab92db86284c05.
}
order by ?label
```

The previous query uses the skos:broader relation to retrieve the sub-concepts. It is also possible to use the inverse relation skos:narrower.

```
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
```

```

PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>

SELECT ?conceptURI ?label
WHERE {
  ?conceptURI a skos:Concept;
              skos:prefLabel ?label.
  micavocab:0491ee9f6cf74dcda7ab92db86284c05 skos:narrower ?conceptURI.
}
order by ?label

```

Get direct parent concept of a given concept:

e.g., parent of concept micavocab:0491ee9f6cf74dcda7ab92db86284c05:

```

PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>

SELECT ?conceptURI ?label
WHERE {
  ?conceptURI a skos:Concept;
              skos:prefLabel ?label .
  micavocab:0491ee9f6cf74dcda7ab92db86284c05 skos:broader ?conceptURI.
}
order by ?label

```

The same query using skos:narrower instead of skos:broader.

```

PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>

SELECT ?conceptURI ?label
WHERE {
  ?conceptURI a skos:Concept;
              skos:narrower micavocab:0491ee9f6cf74dcda7ab92db86284c05;
              skos:prefLabel ?label .
}
order by ?label

```

Get all concepts of a given Concept scheme:

e.g., select all concepts of micavocab:DomainScheme:

```

PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>

SELECT ?conceptURI ?label
WHERE {
  ?conceptURI a skos:Concept;
              skos:prefLabel ?label;
              skos:inScheme micavocab:DomainScheme.
}
order by ?label

```

To get all the concepts of a concept scheme other than domain scheme just replace micavocab:DomainScheme URI by the corresponding MICA scheme URI:

micavocab:CommodityScheme for commodity concepts
micavocab:DataScheme for data concepts
micavocab:MethodScheme for method concepts
micavocab:SpatialScheme for spatial concepts
micavocab:TemporalScheme for temporal concepts
micavocab:ValueSupplyChainScheme for value supply chain concepts

Get statistics by concept:

To get all statistics about a given concept (all types of sheets directly or undirectly related to a given conceptURI. micavocab:0491ee9f6cf74dcda7ab92db86284c05:

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>

SELECT (count (DISTINCT ?methodURI) as ?methodsNb)
       (count (DISTINCT ?documentationURI) as ?documentationNb)
       (count (DISTINCT ?legislationURI) as ?legislationNb)
       (count (DISTINCT ?dataURI) as ?dataNb)
       (count (DISTINCT ?portalURI) as ?portalNb)
       (count (DISTINCT ?articleURI) as ?articleNb)
       (count (DISTINCT ?otherURI) as ?otherNb)
       (count (DISTINCT ?flowsheetURI) as ?flowsheetNb)
       (count (DISTINCT ?questionURI) as ?questionNb)

WHERE {
  {
    ?methodURI micamodel:hasContentType micamodel:MethodsAndTools;
    ?hasMicaConcept ?d.
    ?d skos:broaderTransitive micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
  }
  union {
    ?documentationURI micamodel:hasContentType micamodel:Documentation;
    ?hasMicaConcept ?d.
    ?d skos:broaderTransitive micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
  }
  union {
    ?legislationURI micamodel:hasContentType micamodel:Legislation;
    ?hasMicaConcept ?d.
    ?d skos:broaderTransitive micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
  }
  union {
    ?dataURI micamodel:hasContentType micamodel:Data;
    ?hasMicaConcept ?d.
    ?d skos:broaderTransitive micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
  }
  union {
    ?portalURI micamodel:hasContentType micamodel:Portal;
    ?hasMicaConcept ?d.
    ?d skos:broaderTransitive micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
  }
  union {
    ?articleURI micamodel:hasContentType micamodel:ArticlesAndReports;
    ?hasMicaConcept ?d.
    ?d skos:broaderTransitive micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
  }
}

```

```

}
union {
  ?otherURI micamodel:hasContentType micamodel:Other;
  ?hasMicaConcept ?d.
  ?d skos:broaderTransitive micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
}
union {
  ?flowSheetURI a micamodel:FlowSheet;
  ?hasMicaConcept ?d.
  ?d skos:broaderTransitive micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
}
union {
  ?questionURI a micamodel:MICAQuestion;
  ?hasMicaConcept ?d.
  ?d skos:broaderTransitive micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
}
}
}

```

Get all sheets of a given type directly related to a given concept:

Select all Methods and Tools sheets (URI and title) directly related to domain concept micavocab:0491ee9f6cf74dcda7ab92db86284c05:

```

PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT ?sheetURI ?title
WHERE {
  ?sheetURI a micamodel:Sheet;
  micamodel:hasContentType micamodel:MethodsAndTools;
  dcterms:title ?title;
  ?hasMicaConcept micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
}
order by ?title

```

For other types of content (Documentation, Legislation, Data, Portal, Articles & Reports, Other) just replace micamodel:MethodsAndTools in the previous query by the corresponding data type defined in MicaModel ontology:

Documentation: micamodel:Documentation
Legislation: micamodel:Legislation
Data: micamodel:Data
Portal: micamodel:Portal
Articles & Reports: micamodel:ArticlesAndReports
Other: micamodel:Other

Get all sheets of a given type related to a given concept (directly or undirectly i.e. through subconcepts):

e.g., find all Methods and Tools sheets (URI, title) related (directly or undirectly through subconcepts) to the concept micavocab:0491ee9f6cf74dcda7ab92db86284c05:

```

PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT distinct ?sheetURI ?title
WHERE {
  ?sheetURI a micamodel:Sheet;
            micamodel:hasContentType micamodel:MethodsAndTools;
            dcterms:title ?title;
            ?hasMicaConcept ?d.
  ?d skos:broaderTransitive micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
}
order by ?title

```

To search for an other type of content (e.g. Documentation) just replace micamodel:MethodsAndTools by the appropriate corresponding type defined in types of content .

Get all flowsheets related to a given concept:

Select all flowSheets (URI and title) directly related to a given concept micavocab:0491ee9f6cf74dcda7ab92db86284c05:

```

PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT ?flowSheetURI ?title
WHERE {
  ?flowSheetURI a micamodel:FlowSheet;
                dcterms:title ?title;
                ?hasMicaConcept micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
}
order by ?title

```

Select all flowSheets (URI and title) directly or undirectly (i.e. through subconcepts) related to a given concept micavocab:0491ee9f6cf74dcda7ab92db86284c05:

```

PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT distinct ?flowSheetURI ?title
WHERE {
  ?flowSheetURI a micamodel:FlowSheet;
                dcterms:title ?title;
                ?hasMicaConcept ?d.
  ?d skos:broaderTransitive micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
}
order by ?title

```

Get all questions related to a given concept:

e.g., get all questions (URI, description) directly related to the a given concept micavocab:0491ee9f6cf74dcda7ab92db86284c05:

```
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

SELECT ?questionURI ?question
WHERE {
    ?questionURI a micamodel:MICAQuestion;
                micamodel:question ?question;
                ?hasMicaConcept micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
}
order by ?question
```

e.g., get all questions (URI, description) directly or undirectly (i.e., through subconcepts) related to the a given concept micavocab:0491ee9f6cf74dcda7ab92db86284c05:

```
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

SELECT distinct ?questionURI ?question
WHERE {
    ?questionURI a micamodel:MICAQuestion;
                micamodel:question ?question;
                ?hasMicaConcept ?d.
    ?d skos:broaderTransitive micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
}
order by ?question
```

Get all concepts of a given concept scheme related to a given concept.

Main ontology (domain) concepts and transversal ontologies concepts are defined in different concept schemes:

e.g., get all domain concepts (URI, label) related to the concept micavocab:0491ee9f6cf74dcda7ab92db86284c05

```
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>

SELECT ?conceptURI ?label
WHERE {
    ?conceptURI a skos:Concept;
                skos:prefLabel ?label;
                skos:inScheme micavocab:DomainScheme;
                skos:related micavocab:0491ee9f6cf74dcda7ab92db86284c05 .
}
order by ?label
```

To get all the concepts of a concept scheme other than domain scheme just replace micavocab:DomainScheme URI by the corresponding MICA scheme URI:

micavocab:CommodityScheme for commodity concepts

micavocab:DataScheme for data concepts
micavocab:MethodScheme for methods concepts
micavocab:SpatialScheme for spatial concepts
micavocab:TemporalScheme for temporal concepts
micavocab:ValueSupplyChainScheme for value supply chain concepts

e.g., get all commodity concepts (URI, label) related to the domain concept micavocab:0491ee9f6cf74dcda7ab92db86284c05:

```
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>

SELECT ?conceptURI ?label
WHERE {
  ?conceptURI a skos:Concept;
              skos:prefLabel ?label;
              skos:inScheme micavocab:CommodityScheme;
              skos:related micavocab:0491ee9f6cf74dcda7ab92db86284c05.
}
order by ?label
```

Get metadata (label definition, description, links ...) for a given concept:

e.g., find URI, label and if they exist the definition and alternative labels of the domain concept micavocab:0491ee9f6cf74dcda7ab92db86284c05:

```
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>

SELECT ?label ?definition ?altLabel ?scheme ?uriSame
(group_concat(distinct ?broaderURI; separator = ";") AS ?broaderURIs)
(group_concat(distinct ?narrowerURI; separator = ";") AS ?narrowerURIs)
(group_concat(distinct ?relatedURI; separator = ";") AS ?relatedURIs)

WHERE {
  micavocab:0491ee9f6cf74dcda7ab92db86284c05 skos:prefLabel ?label.
  optional { micavocab:0491ee9f6cf74dcda7ab92db86284c05 skos:definition ?definition.}
  optional { micavocab:0491ee9f6cf74dcda7ab92db86284c05 skos:altLabel ?altLabel.}
  optional { micavocab:0491ee9f6cf74dcda7ab92db86284c05 skos:inScheme ?scheme.}
  optional { micavocab:0491ee9f6cf74dcda7ab92db86284c05 owl:sameAs ?uriSame.}
  optional { micavocab:0491ee9f6cf74dcda7ab92db86284c05 skos:broader ?broaderURI.}
  optional { micavocab:0491ee9f6cf74dcda7ab92db86284c05 skos:narrower ?narrowerURI.}
  optional { micavocab:0491ee9f6cf74dcda7ab92db86284c05 skos:related ?relatedURI.}
}
group by ?label ?definition ?altLabel ?scheme ?uriSame
```

Get all concepts containing a text in their label or definition or other available metadata:

e.g., find URI, label and if they exist the definition and alternative labels of all the concepts containing the text "drilling":

```
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
```

```

SELECT    ?conceptURI ?label ?definition ?altLabel
WHERE {
  ?conceptURI a skos:Concept;
              skos:prefLabel ?label.
  FILTER regex( ?label ,"drilling","i")
  optional{
    ?conceptURI skos:definition ?definition.
    FILTER regex( ?definition ,"drilling","i")
  }
  optional{
    ?conceptURI skos:altLabel ?altLabel.
    FILTER regex( ?altLabel ,"drilling","i")
  }
}
order by ?label

```

Sheets centric queries

Sheets can be of any type of MICAContentType MethodsAndTools, Documentation, Legislation... See MicaModel ontology.

Get all sheets of a given type of content:

e.g., get all Methods and Tools (URI and title):

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT ?sheetURI ?title
WHERE {
  ?sheetURI a micamodel:Sheet;
            micamodel:hasContentType micamodel:MethodsAndTools;
            dcterms:title ?title.
}
order by ?title

```

For other type of content just replace micamodel:MethodsAndTools by the appropriate MicaModel ontology type. see types of content.

Get all sheets related to a given sheet:

e.g., find all Methods and Tools related to the sheet micaresource:3928d0113e70425a8d26212e7db52247:

```

PREFIX micaresource: <https://w3id.org/mica/resource/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT ?sheetURI ?title
WHERE {
  ?sheetURI a micamodel:Sheet;
            dcterms:title ?title;
            micamodel:hasContentType micamodel:MethodsAndTools;

```



```
        micamodel:relatedTo micaresource:3928d0113e70425a8d26212e7db52247.
    }
    order by ?title
```

For other type of sheets just replace micamodel:MethodsAndTools by the appropriate MicaModel ontology data type. see types of content.

Get all questions related to a given sheet:

e.g., get all the questions (URI and question) related to the sheet micaresource:3928d0113e70425a8d26212e7db52247:

```
PREFIX micaresource: <https://w3id.org/mica/resource/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

SELECT ?questionURI ?question
WHERE {
    ?questionURI a micamodel:MICAQuestion;
                micamodel:question ?question;
                micamodel:relatedTo micaresource:3928d0113e70425a8d26212e7db52247.
}
order by ?question
```

Get all the flowsheets related to a given sheet:

e.g., get all the flowsheets (URI and title) related to the sheet micaresource:3928d0113e70425a8d26212e7db52247:

```
PREFIX micaresource: <https://w3id.org/mica/resource/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT ?flowsheetURI ?title
WHERE {
    ?flowsheetURI a micamodel:FlowSheet;
                 dcterms:title ?title;
                 micamodel:relatedTo micaresource:3928d0113e70425a8d26212e7db52247.
}

```

Get all concepts related to a given sheet:

e.g., get all concepts (URI and label) related to the sheet micaresource:3928d0113e70425a8d26212e7db52247:

```
PREFIX micaresource: <https://w3id.org/mica/resource/>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

SELECT ?conceptURI ?label ?hasMicaConcept
WHERE {
    micaresource:3928d0113e70425a8d26212e7db52247 ?hasMicaConcept ?conceptURI .
    ?conceptURI a skos:Concept;
                skos:prefLabel ?label.
}
```

```
}
```

Get metadata (label definition, description, links ...) for a given sheet:

e.g., find URI, label and if they exist the definition and alternative labels of a given sheet
micaresource:3928d0113e70425a8d26212e7db52247:

```
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

SELECT ?title ?summary ?publicURI
(group_concat(distinct ?micaResourceURI; separator = ";") AS ?micaResourceURIs)
(group_concat(distinct ?conceptURI; separator = ";") AS ?conceptURIs)

WHERE {
  micaresource:3928d0113e70425a8d26212e7db52247 dcterms:title ?title;
  micamodel:summary ?summary;
  micamodel:publicURI ?publicURI;
  optional { micaresource:3928d0113e70425a8d26212e7db52247 micamodel:relatedTo ?micaResourceU-
RI.}
  optional { micaresource:3928d0113e70425a8d26212e7db52247 ?hasMicaConcept ?conceptURI.}
}
group by ?title ?summary ?publicURI
```

Get statistics by sheet:

To get all statistics about a given sheet. For a given sheetURI. micaresour-
ce:3928d0113e70425a8d26212e7db52247:

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX micaresource: <https://w3id.org/mica/resource/>

SELECT (count (DISTINCT ?methodURI) as ?methodsNb)
(count (DISTINCT ?documentationURI) as ?documentationNb)
(count (DISTINCT ?legislationURI) as ?legislationNb)
(count (DISTINCT ?dataURI) as ?dataNb)
(count (DISTINCT ?portalURI) as ?portalNb)
(count (DISTINCT ?articleURI) as ?articleNb)
(count (DISTINCT ?otherURI) as ?otherNb)
(count (DISTINCT ?flowsheetURI) as ?flowsheetNb)
(count (DISTINCT ?questionURI) as ?questionNb)

WHERE {
  {
    ?methodURI micamodel:relatedTo micaresource:3928d0113e70425a8d26212e7db52247;
    micamodel:hasContentType micamodel:MethodsAndTools.
  }
  union {
    ?documentationURI micamodel:relatedTo micaresource:3928d0113e70425a8d26212e7db52247;
    micamodel:hasContentType micamodel:Documentation.
  }
  union {
    ?legislationURI micamodel:relatedTo micaresource:3928d0113e70425a8d26212e7db52247;
```

```

        micamodel:hasContentType micamodel:Legislation.
    }
    union {
        ?dataURI micamodel:relatedTo micaresource:3928d0113e70425a8d26212e7db52247;
        micamodel:hasContentType micamodel:Data.
    }
    union {
        ?portalURI micamodel:relatedTo micaresource:3928d0113e70425a8d26212e7db52247;
        micamodel:hasContentType micamodel:Portal.
    }
    union {
        ?articleURI micamodel:relatedTo micaresource:3928d0113e70425a8d26212e7db52247;
        micamodel:hasContentType micamodel:ArticlesAndReports.
    }
    union {
        ?otherURI micamodel:relatedTo micaresource:3928d0113e70425a8d26212e7db52247;
        micamodel:hasContentType micamodel:Other.
    }
    union {
        ?flowSheetURI micamodel:relatedTo micaresource:3928d0113e70425a8d26212e7db52247;
        a micamodel:FlowSheet.
    }
    union {
        ?questionURI micamodel:relatedTo micaresource:3928d0113e70425a8d26212e7db52247;
        a micamodel:MICAQuestion.
    }
}

```

Get all sheets of a given type containing a text in their title or summary or other available metadata:

e.g., find all Methods and Tools (URI, title and summary) containing the text "de"

prefix micamodel: <<https://w3id.org/mica/ontology/MicaModel#>>

prefix dcterms: <<http://purl.org/dc/terms/>>

```

SELECT ?sheetURI ?title ?summary
WHERE {
    ?sheetURI a micamodel:Sheet;
    dcterms:title ?title;
    micamodel:hasContentType micamodel:MethodsAndTools;
    FILTER regex( ?title ,"de","i")
    micamodel:summary ?summary.
    FILTER regex( ?summary ,"de","i")
}

```

For other type of sheets just replace micamodel:MethodsAndTools by the appropriate MicaModel ontology data type. See types of content.

FlowSheets centric queries

FlowSheets is an ordered list of Sheets MicaModel FlowSheet.

Get all FlowSheets, e.g., get all flowSheets(URI and title):

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT ?flowsheetURI ?title
WHERE {
  ?flowsheetURI a micamodel:FlowSheet;
                dcterms:title ?title.
}

```

Get all MICAKnowledgeElements belonging in FlowSheet:

```

prefix micaresource: <https://w3id.org/mica/resource/>
prefix micamodel: <https://w3id.org/mica/ontology/MicaModel#>
prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

SELECT ?micaKnowledgeElementURI ?role
WHERE {
  micaresource:b86f2a6a40414626889222fbff4d9305 micamodel:hasElements/rdf:rest*/rdf:first ?element.
  ?element micamodel:role ?role;
  micamodel:hasKnowledgeElement ?micaKnowledgeElementURI.
}

```

Get all sheets related to a given FlowSheet:

e.g., find all Methods and Tools related to the sheet micaresource:b86f2a6a40414626889222fbff4d9305:

```

PREFIX micaresource: <https://w3id.org/mica/resource/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT ?sheetURI ?title
WHERE {
  ?sheetURI a micamodel:Sheet;
            dcterms:title ?title;
            micamodel:hasContentType micamodel:MethodsAndTools;
            micamodel:relatedTo micaresource:b86f2a6a40414626889222fbff4d9305.
}

```

For other type of sheets just replace micamodel:MethodsAndTools by the appropriate MicaModel ontology data type. see types of content.

Get all questions related to a given FlowSheet:

e.g., get all the questions (URI and question) related to the FlowSheet micaresource:b86f2a6a40414626889222fbff4d9305:

```

PREFIX micaresource: <https://w3id.org/mica/resource/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

SELECT ?questionURI ?question
WHERE {

```

```

?questionURI a micamodel:MICAQuestion;
    micamodel:question ?question;
    micamodel:relatedTo micaresource:b86f2a6a40414626889222fbff4d9305.
}

```

Get all the flowSheets related to a given sheet, e.g., get all the flowSheets (URI and title) related to the FlowSheet micaresource:b86f2a6a40414626889222fbff4d9305:

```

PREFIX micaresource: <https://w3id.org/mica/resource/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT ?flowsheetURI ?title
WHERE {
    ?flowsheetURI a micamodel:FlowSheet;
        dcterms:title ?title;
        micamodel:relatedTo micaresource:b86f2a6a40414626889222fbff4d9305.
}

```

Get all concepts related to a given sheet:

e.g., get all concepts (URI and label) related to the FlowSheet micaresource:b86f2a6a40414626889222fbff4d9305:

```

PREFIX micaresource: <https://w3id.org/mica/resource/>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

SELECT ?conceptURI ?label ?hasMicaConcept
WHERE {
    micaresource:b86f2a6a40414626889222fbff4d9305 ?hasMicaConcept ?conceptURI .
    ?conceptURI a skos:Concept;
        skos:prefLabel ?label.
}

```

Get metadata (label definition, description, links...) for a given FlowSheet:

e.g., find URI, label and if they exist the definition and alternative labels of a given sheet micaresource:b86f2a6a40414626889222fbff4d9305:

```

PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

SELECT ?title ?summary
(group_concat(distinct ?micaResourceURI; separator = ";") AS ?micaResourceURIs)
(group_concat(distinct ?conceptURI; separator = ";") AS ?conceptURIs)

WHERE {
    micaresource:b86f2a6a40414626889222fbff4d9305 dcterms:title ?title;
        micamodel:summary ?summary;
}

```

```

optional { micaresource:b86f2a6a40414626889222fbff4d9305 micamodel:relatedTo ?mi-
caResourceURI.}
optional { micaresource:b86f2a6a40414626889222fbff4d9305 ?hasMicaConcept ?conceptURI.}
}
group by ?title ?summary

```

Get statistics by FlowSheet:

To get all statistics about a given sheet, for a given sheetURI. mi-
caresource:b86f2a6a40414626889222fbff4d9305:

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX micaresource: <https://w3id.org/mica/resource/>

SELECT (count (DISTINCT ?methodURI) as ?methodsNb)
      (count (DISTINCT ?documentationURI) as ?documentationNb)
      (count (DISTINCT ?legislationURI) as ?legislationNb)
      (count (DISTINCT ?dataURI) as ?dataNb)
      (count (DISTINCT ?portalURI) as ?portalNb)
      (count (DISTINCT ?articleURI) as ?articleNb)
      (count (DISTINCT ?otherURI) as ?otherNb)
      (count (DISTINCT ?flowsheetURI) as ?flowsheetNb)
      (count (DISTINCT ?questionURI) as ?questionNb)

WHERE {
  {
    ?methodURI micamodel:relatedTo micaresource:b86f2a6a40414626889222fbff4d9305;
    micamodel:hasContentType micamodel:MethodsAndTools.
  }
  union {
    ?documentationURI micamodel:relatedTo micaresource:b86f2a6a40414626889222fbff4d9305;
    micamodel:hasContentType micamodel:Documentation.
  }
  union {
    ?legislationURI micamodel:relatedTo micaresource:b86f2a6a40414626889222fbff4d9305;
    micamodel:hasContentType micamodel:Legislation.
  }
  union {
    ?dataURI micamodel:relatedTo micaresource:b86f2a6a40414626889222fbff4d9305;
    micamodel:hasContentType micamodel:Data.
  }
  union {
    ?portalURI micamodel:relatedTo micaresource:b86f2a6a40414626889222fbff4d9305;
    micamodel:hasContentType micamodel:Portal.
  }
  union {
    ?articleURI micamodel:relatedTo micaresource:b86f2a6a40414626889222fbff4d9305;
    micamodel:hasContentType micamodel:ArticlesAndReports.
  }
  union {
    ?otherURI micamodel:relatedTo micaresource:b86f2a6a40414626889222fbff4d9305;
    micamodel:hasContentType micamodel:Other.
  }
  union {
    ?flowSheetURI micamodel:relatedTo micaresource:b86f2a6a40414626889222fbff4d9305;
    a micamodel:FlowSheet.
  }
  union {

```

```
?questionURI micamodel:relatedTo micaresource:b86f2a6a40414626889222fbff4d9305;
      a micamodel:MICAQuestion.
}
}
```

Get all sheets of a given type containing a text in their title or summary or other available metadata:

e.g., find all Methods and Tools (URI, title and summary) containing the text "de"

prefix micamodel: <https://w3id.org/mica/ontology/MicaModel#>

prefix dcterms: <http://purl.org/dc/terms/>

```
SELECT ?sheetURI ?title ?summary
WHERE {
  ?sheetURI a micamodel:FlowSheet;
    dcterms:title ?title;
    FILTER regex( ?title ,"de","i")
    micamodel:summary ?summary.
    FILTER regex( ?summary ,"de","i")
}
```

Questions centric queries

Get all questions (URI and description):

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

SELECT ?questionURI ?question
WHERE {
  ?questionURI a micamodel:MICAQuestion;
    micamodel:question ?question.
}
```

Get all sheets related to a given question:

e.g., get all Methods and Tools (URI and title) related to the question micaresource:1bfc399dfc314a8b81f50cfd119cc9e:

```
PREFIX micaresource: <https://w3id.org/mica/resource/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT ?sheetURI ?title
WHERE {
  ?sheetURI a micamodel:Sheet;
    dcterms:title ?title;
    micamodel:hasContentType micamodel:MethodsAndTools;
    micamodel:relatedTo micaresource:1bfc399dfc314a8b81f50cfd119cc9e.
}
```

For other type of sheets just replace micamodel:MethodsAndTools by the appropriate MicaModel ontology data type. see types of content.

Get all questions related to a given question:

```
PREFIX micaresource: <https://w3id.org/mica/resource/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

SELECT ?questionURI ?question
WHERE {
  ?questionURI a micamodel:MICAQuestion;
              micamodel:question ?question;
              micamodel:relatedTo micaresource:1bfc399dfc314a8b81f50cfd119cc9e.
}
```

Get all flowsheet related to a given question:

```
PREFIX micaresource: <https://w3id.org/mica/resource/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT ?flowsheetURI ?title
WHERE {
  ?flowsheetURI a micamodel:FlowSheet;
               dcterms:title ?title;
               micamodel:relatedTo micaresource:1bfc399dfc314a8b81f50cfd119cc9e.
}
```

Get statistics by question:

To get all statistics about a given question. For a given questionURI. micaresource:1bfc399dfc314a8b81f50cfd119cc9e

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX micaresource: <https://w3id.org/mica/resource/>

SELECT (count (DISTINCT ?methodURI) as ?methodsNb)
       (count (DISTINCT ?documentationURI) as ?documentationNb)
       (count (DISTINCT ?legislationURI) as ?legislationNb)
       (count (DISTINCT ?dataURI) as ?dataNb)
       (count (DISTINCT ?portalURI) as ?portalNb)
       (count (DISTINCT ?articleURI) as ?articleNb)
       (count (DISTINCT ?otherURI) as ?otherNb)
       (count (DISTINCT ?flowsheetURI) as ?flowsheetNb)
       (count (DISTINCT ?questionURI) as ?questionNb)
WHERE {
  {
    ?methodURI micamodel:relatedTo micaresource:1bfc399dfc314a8b81f50cfd119cc9e;
              micamodel:hasContentType micamodel:MethodsAndTools.
  }
  union {
    ?documentationURI micamodel:relatedTo micaresource:1bfc399dfc314a8b81f50cfd119cc9e;
                    micamodel:hasContentType micamodel:Documentation.
  }
}
```



```

union {
  ?legislationURI micamodel:relatedTo micaresource:1bfc399dfc314a8b81f50cfd119cc9e;
    micamodel:hasContentType micamodel:Legislation.
}
union {
  ?dataURI micamodel:relatedTo micaresource:1bfc399dfc314a8b81f50cfd119cc9e;
    micamodel:hasContentType micamodel:Data.
}
union {
  ?portalURI micamodel:relatedTo micaresource:1bfc399dfc314a8b81f50cfd119cc9e;
    micamodel:hasContentType micamodel:Portal.
}
union {
  ?articleURI micamodel:relatedTo micaresource:1bfc399dfc314a8b81f50cfd119cc9e;
    micamodel:hasContentType micamodel:ArticlesAndReports.
}
union {
  ?otherURI micamodel:relatedTo micaresource:1bfc399dfc314a8b81f50cfd119cc9e;
    micamodel:hasContentType micamodel:Other.
}
union {
  ?flowSheetURI micamodel:relatedTo micaresource:1bfc399dfc314a8b81f50cfd119cc9e;
    a micamodel:FlowSheet.
}
union {
  ?questionURI micamodel:relatedTo micaresource:1bfc399dfc314a8b81f50cfd119cc9e;
    a micamodel:MICAQuestion.
}
}

```

Get all metadata (question, links ...) about a given question:

e.g., find metadata of a given question micaresource:1bfc399dfc314a8b81f50cfd119cc9e:

```

PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX micavocab: <https://w3id.org/mica/ontology/MicaOntology/>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

SELECT ?question
(group_concat(distinct ?micaResourceURI; separator = ";") AS ?micaResourceURIs)
(group_concat(distinct ?conceptURI; separator = ";") AS ?conceptURIs)

WHERE {
  micaresource:1bfc399dfc314a8b81f50cfd119cc9e micamodel:question ?question;
  optional { micaresource:1bfc399dfc314a8b81f50cfd119cc9e micamodel:relatedTo ?micaResourceU-
RI.}
  optional { micaresource:1bfc399dfc314a8b81f50cfd119cc9e ?hasMicaConcept ?conceptURI.}
}
group by ?question

Get all questions containing a given text in their description

e.g. get all questions containing the text "mining waste"

prefix micamodel: <https://w3id.org/mica/ontology/MicaModel#>
prefix dcterms: <http://purl.org/dc/terms/>

SELECT ?questionURI ?description

```

```
WHERE {  
  ?questionURI a micamodel:MICAQuestion;  
  micamodel:question ?question.  
  FILTER regex( ?question , "mining waste", "i")  
}
```

Appendix 5. SPARQL Queries for the MICASheetEditor

This appendix presents various SPARQL queries that can be performed on the MICA Triple Store in order to manage MICA resources. The purpose of this documentation is to provide elements that can facilitate the writing of the requests necessary to MICASheetEditor tool. All the queries presented are sorted according to the type of MICA resource to which they relate

For better readability of the examples we use "explicit" strings for the local name of resource URIs. For example:

- Cassard for a foaf:Person, (full URI is <https://w3id.org/mica/resource/Cassard>),
- MS1 for a micamodel:MICASheet (full URI is <https://w3id.org/mica/resource/MS1>),
- FS1 for a micamodel:FlowSheet (full URI is <https://w3id.org/mica/resource/FS1>),
- etc.

The effective value of this local name can be different, according to the policy adopted for URI generation in the MICASheet Editor (for example using an UUID).

CAUTION: With Fuseki, SPARQL updates queries must be performed on the update SPARQL endpoint that has a different URL than the query endpoint. For example for the test-MicaModel dataset on the LIG fuseki server:

- URL of the SPARQL endpoint for UPDATE queries is <http://lig-coin.imag.fr/fuseki/testMicaModel/update>
- URL of the SPARQL endpoint for SLECT and ASK queries is <http://lig-coin.imag.fr/fuseki/testMicaModel/query>

MICASheets Queries

These queries concern resources of type `micamodel:MICASheet`.

Creating a new MICASheet

This example shows a SPARQL query to create a new MICASheet whose URI is `https://w3id.org/mica/resource/MS1` and with the following data:

- **title:** MICA Sheet #1
- **summary:** MICA Sheet #1 summary
- **publicURI:** `http://.../MICASheet1.pdf` a URI where the public version (pdf) of the MICASheet can be retrieved. The form of the URI needs to be defined by GEUS (which manages the database).

- **privateURI:** `http://.../MICASheet1.docx` a URI where the private (internal) version (docx) of the MICASheet can be retrieved. The form of the URI needs to be defined by GEUS (which manages the database).
- **contentType:** in this example `micamodel:ArticlesAndReports` (*reminder: this value should be one of the values for the enumerated class `micamodel:ContentType`. It can be `micamodel:MethodsAndTools`, `micamodel:Documentation`, `micamodel:Legislation`, `micamodel:Data`, `micamodel:Portal`, `micamodel:ArticlesAndReports` or `micamodel:Other`*).
- **two writers:**
 - Daniel Cassard described by a RDF resource whose URI is `https://w3id.org/mica/resource/Cassard`
 - François Tertre described by a RDF resource whose URI is `https://w3id.org/mica/resource/Tertre`
- **This MicaSheet is annotated by 3 concepts from the MicaOntology:**
 - **two Domain concepts:**
 - `https://w3id.org/mica/ontology/MicaOntology/32831dae9fc247f390f1362bee1dcd76` : biodiversity compensation (D6 sustainability of raw materials)
 - `https://w3id.org/mica/ontology/MicaOntology/e2badc7277b344abb4b45d794c20a313` : environment health & safety policy (D5 raw materials policy & legal framework)
 - **one Method concept:**
 - `https://w3id.org/mica/ontology/MicaOntology/12bebe7935734e829fa772a0c4162900` : risk assessment methods - MethodsScheme
- **This MicaSheet is related to three other MICAResources (the local names of these three resources are S1, S2 and S3).**

To create such a MICASheet, the SPARQL Update query is the following:

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

INSERT DATA {
<https://w3id.org/mica/resource/MS1>
  a micamodel:MICASheet;
  dcterms:title "MICA Sheet #1";
  micamodel:summary "MICA Sheet #1 summary";
  micamodel:publicURI "MICASheet1.pdf";
  micamodel:privateURI "MICASheet1.docx";
  micamodel:hasContentType micamodel:ArticlesAndReports;
  micamodel:hasWriter
    <https://w3id.org/mica/resource/Cassard>,
    <https://w3id.org/mica/resource/Tertre>;
  micamodel:hasDomainConcept
    <https://w3id.org/mica/ontology/MicaOntology/32831dae9fc247f390f1362bee1dcd76>,
    <https://w3id.org/mica/ontology/MicaOntology/e2badc7277b344abb4b45d794c20a313>;
  micamodel:hasMethodConcept
    <https://w3id.org/mica/ontology/MicaOntology/12bebe7935734e829fa772a0c4162900>;
  micamodel:relatedTo
```

```

    <https://w3id.org/mica/resource/S1>,
    <https://w3id.org/mica/resource/S2>,
    <https://w3id.org/mica/resource/S3>;
}

```

Updating an existing MICASheet

To update an existing MICASheet, proceed in two steps:

1. remove from the triplestore all triples having that sheet as subject.
2. reinsert all the triples describing the MicaSheet using the same type of query as the one of the previous example ([Creating a new MICASheet](#)).
 - For data that have not changed, triples are the same as before deletion.
 - For data that have been modified, values for the triples are the new values.
 - For data that have been added, new triples are inserted.
 - For data that have been removed, the corresponding triples are no longer present in the query.

For example for updating the `MS1` MICASheet created in the previous example by changing its summary (replace "MICA Sheet #1 summary" by "MICA Sheet #1 new summary" and add a new related MICAResource (`S4`), the queries will be:

1.

```

DELETE {
  <https://w3id.org/mica/resource/MS1> ?p ?o.
}
WHERE {
  <https://w3id.org/mica/resource/MS1> ?p ?o.
}

```

2.

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

INSERT DATA {
  <https://w3id.org/mica/resource/MS1>
    a micamodel:MICASheet;
    dcterms:title "MICA Sheet #1";
    micamodel:summary "MICA Sheet #1 new summary";
    micamodel:publicURI "MICASheet1.pdf";
    micamodel:privateURI "MICASheet1.docx";
    micamodel:hasContentType micamodel:ArticlesAndReports;
    micamodel:hasWriter
      <https://w3id.org/mica/resource/Cassard>,
      <https://w3id.org/mica/resource/Tertre>;
    micamodel:hasDomainConcept

  <https://w3id.org/mica/ontology/MicaOntology/32831dae9fc247f390f1362bee1dcd76>,

  <https://w3id.org/mica/ontology/MicaOntology/e2badc7277b344abb4b45d794c20a313>;
    micamodel:hasMethodConcept

```

```

<https://w3id.org/mica/ontology/MicaOntology/12bebe7935734e829fa772a0c4162900>;
    micamodel:relatedTo
        <https://w3id.org/mica/resource/S1>,
        <https://w3id.org/mica/resource/S2>,
        <https://w3id.org/mica/resource/S3>,
        <https://w3id.org/mica/resource/S4>;
}

```

Deleting an existing MICASheet

When a MICASheet is deleted all the triples with this MICASheet URI as subject or as object must be removed from the MICA Triple Store. In addition to that, if the MICASheet is used in one or several flowSheets, it must be removed from the elements lists of these FlowSheets. All the triples defining the FlowSheetElements referencing the deleted MICASheet must be removed and the triples defining the elements listed of the FlowSheets must be updated.

For example to delete `MS1` MICASheet, the query is:

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

DELETE
{
  <https://w3id.org/mica/resource/MS1> ?p ?o.
  ?otherResource micamodel:relatedTo <https://w3id.org/mica/resource/MS1>.
  ?element micamodel:hasKnowledgeElement <https://w3id.org/mica/resource/MS1>;
  micamodel:role ?role.
  ?node rdf:first ?element;
  rdf:rest ?rest.
  ?previousNode ?property ?node.
}
INSERT { ?previousNode ?property ?rest. }
WHERE {
  <https://w3id.org/mica/resource/MS1> ?p ?o;
  OPTIONAL {
    ?otherResource micamodel:relatedTo <https://w3id.org/mica/resource/MS1>.
  }
  OPTIONAL {
    ?element micamodel:hasKnowledgeElement <https://w3id.org/mica/resource/MS1>;
    micamodel:role ?role.
    ?node rdf:first ?element;
    rdf:rest ?rest.
    ?previousNode ?property ?node.
  }
}

```

Retrieving a MICASheet

The following queries retrieve information associated to a given MICASheet. Two options are available depending on the type of information retrieved from the resources associated with the sheet:

- retrieve the URIs of those associated resources,
- retrieve the labels of those associated resources.

To display information in the UI, the second option may be more appropriate than the first . This avoids making new queries using the related resources URIs to obtain displayable information.

Of course, according to the needs of the application, a combination of these two solutions can be performed.

Retrieving MICASheet data and related resources URIs

The following query retrieves all the information directly associated to a given sheet identified by its URI. In other words it retrieves all the values of the triples *<sheetURI predicate object>* where:

- *sheetURI* is the URI identifying the sheet,
- *predicate* is any property of this given *sheetURI*,
- *object* is the value of the property,
 - If this value is a literal, it is retrieved as a String,
 - If this value is another resource (e.g., a Person, another Sheet, a Concept ...), the *object* value is this resource URI.

In order to facilitate its exploitation, the ResultSet contains only one line and when there are multiple values for a given predicate, they are concatenated into a String and separated by a comma. For example if the sheet has one *title* and multiple *Domain* concepts annotations the following query:

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT ?title
      (group_concat(distinct ?domain; separator = ",") AS ?domains)
WHERE {
  <https://w3id.org/mica/resource/45bc4f322c794ca6adb521a3c64d45e> dcterms:title ?title;
                                                                    micamodel:hasDomainConcept
?domain.
}
GROUP BY ?title
gives the ResultSet

```

title	domains
"Circular Economy def-	"https://w3id.org/mica/ontology/MicaOntology/a0ecbc56233b4245b57aa997fe1ea1a1, https://w3id.org/mica/ontology/MicaOntology/20c7030f1bfd41508c57ebec0962caf2"

sheet"@en

The ?domains variable is a String concatenating all the domains Concepts URIs the Sheet is related to, separated by a ','.

If we did not use a group_concat aggregation function we would obtain a multiple lines ResultSet as in the following query.

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

PREFIX dcterms: <http://purl.org/dc/terms/>

```
SELECT ?title ?domain
WHERE {
  <https://w3id.org/mica/resource/45bc4f322c794ca6adb521a3c64d45e> dcterms:title ?title;
  micamodel:hasDomainConcept ?domain.
}
the ResultSet
```

title	domain
"Circular Economy defsheet"@en	https://w3id.org/mica/ontology/MicaOntology/a0ecbc56233b4245b57aa997fe1ea1a1
"Circular Economy defsheet"@en	https://w3id.org/mica/ontology/MicaOntology/20c7030f1bfd41508c57ebee0962caf2

For example, the complete query to get all the information associated to MS1 MICASheet is as follows

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

PREFIX dcterms: <http://purl.org/dc/terms/>

```
SELECT DISTINCT ?title ?summary ?contentType ?publicURI ?privateURI
(group_concat(DISTINCT ?author; separator = ",") AS ?authors)
(group_concat(DISTINCT ?relatedURI; separator = ",") AS ?relatedURIs)
(group_concat(DISTINCT ?domain; separator = ",") AS ?domains)
(group_concat(DISTINCT ?method; separator = ",") AS ?methods)
(group_concat(DISTINCT ?spatial; separator = ",") AS ?spatials)
(group_concat(DISTINCT ?temporal; separator = ",") AS ?temporals)
(group_concat(DISTINCT ?commodity; separator = ",") AS ?commodities)
(group_concat(DISTINCT ?data; separator = ",") AS ?datas)
(group_concat(DISTINCT ?valueSupplyChain; separator = ",") AS ?valueSupplyChains)

WHERE {
  <https://w3id.org/mica/resource/MS1>
    a micamodel:MICASheet;
    dcterms:title ?title;
    micamodel:summary ?summary;
    micamodel:publicURI ?publicURI;
    micamodel:hasContentType ?contentType;
    micamodel:privateURI ?privateURI;
    micamodel:hasWriter ?author.
    OPTIONAL{<https://w3id.org/mica/resource/MS1> micamodel:relatedTo ?relatedURI. }
    OPTIONAL{<https://w3id.org/mica/resource/MS1> micamodel:hasDomainConcept ?domain. }
    OPTIONAL{<https://w3id.org/mica/resource/MS1> micamodel:hasMethodConcept ?method. }
    OPTIONAL{<https://w3id.org/mica/resource/MS1> micamodel:hasSpatialConcept ?spatial. }
    OPTIONAL{<https://w3id.org/mica/resource/MS1> micamodel:hasTemporalConcept ?temporal.
}
  OPTIONAL{<https://w3id.org/mica/resource/MS1> micamodel:hasCommodityConcept ?commodity. }
  OPTIONAL{<https://w3id.org/mica/resource/MS1> micamodel:hasDataConcept ?data. }
  OPTIONAL{<https://w3id.org/mica/resource/MS1> micamodel:hasValueSupplyChainConcept
?valueSupplyChain. }
}
group by ?title ?summary ?contentType ?publicURI ?privateURI
```


Requested variables are:

- `?title` the MICASheet title.
- `?summary` the MICASheet summary.
- `?contentType` the content type (one of the value for the enumerated class `micamodel:ContentType : MethodsAndTools, Documentation, Legislation, Data...`).
- `?publicURI` the MICASheet's public URI.
- `?privateURI` the MICASheet's private URI.
- `?authors` a String containing the list of authors as URIs of the MICASheet. Each author is represented by its URI, and URIs are separated by commas.
- `?relatedURIs` a String containing the list of resources as URIs that the MICASheet is relatedTo. Each resource is represented by its URI, and URIs are separated by commas. The string is empty if there is no related resource.
- `?domains` a String containing the list of Domain concepts as URIs that the MICASheet is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Domain concept.
- `?methods` a String containing the list of Method concepts as URIs that the MICASheet is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no method concept.
- `?spatials` a String containing the list of Spatial concepts as URIs that the MICASheet is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Spatial concept.
- `?temporals` a String containing the list of Temporal concepts as URIs that the MICASheet is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Temporal concept.
- `?commodities` a String containing the list of Commodity concepts as URIs that the MICASheet is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Commodity concept.
- `?datas` a String containing the list of Data concepts as URIs that the MICASheet is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Data concept.
- `?valueSupplyChains` a String containing the list of ValueSupplyChain concepts as URIs that the MICASheet is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no ValueSupplyChain concept.

Retrieving MICASheet data and related resources labels

The following query retrieves all the information directly associated to a given sheet identified by its URI. In other words it retrieves all the values of the triples *<sheetURI predicate object>* where:

- *sheetURI* is the URI identifying the sheet,
- *predicate* is any property the *sheetURI* is subject of,
- *object* is the value of the property,
 - If this value is a literal, it is retrieved as a String,
 - If this value is another resource (e.g., a Person, another Sheet, a Concept...), *object* value is this resource label.

If we consider the example above, retrieving a Sheet title and the domain concepts the sheet is annotated with, the ResultSet will be of the following form:

title	domains
"Circular Economy defsheets"@en	"Circular economy,D7 International Reporting"

instead of

title	domains
"Circular Economy def-sheets"@en	"https://w3id.org/mica/ontology/MicaOntology/a0ecbc56233b4245b57aa997fe1ea1a1, https://w3id.org/mica/ontology/MicaOntology/20c7030f1bfd41508c57ebee0962caf2"

The complete query to get all the information associated to MS1 Sheet, in a human readable form, is as follows:

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT DISTINCT ?title ?summary ?contentType ?publicURI ?privateURI
      (group_concat(DISTINCT ?name; separator = ",") AS ?authors)
      (group_concat(DISTINCT ?relatedURIlabel; separator = ",") AS ?relatedURIs)
      (group_concat(DISTINCT ?domainLabel; separator = ",") AS ?domains)
      (group_concat(DISTINCT ?methodLabel; separator = ",") AS ?methods)
      (group_concat(DISTINCT ?spatialLabel; separator = ",") AS ?spatials)
      (group_concat(DISTINCT ?temporalLabel; separator = ",") AS ?temporals)
      (group_concat(DISTINCT ?commodityLabel; separator = ",") AS ?commodities)
      (group_concat(DISTINCT ?dataLabel; separator = ",") AS ?datas)
      (group_concat(DISTINCT ?valueSupplyChainLabel; separator = ",") AS ?valueSupply-
Chains)
```

```

WHERE {
<https://w3id.org/mica/resource/MS1>
  a micamodel:MICASheet;
  dcterms:title ?title;
  micamodel:summary ?summary;
  micamodel:publicURI ?publicURI;
  micamodel:hasContentType ?contentType;
  micamodel:privateURI ?privateURI;
  micamodel:hasWriter ?author.
  ?author foaf:givenName ?firstName;
  foaf:familyName ?lastName.
  bind(concat(?lastName," ",?firstName) as ?name)

  OPTIONAL{
    <https://w3id.org/mica/resource/MS1> micamodel:relatedTo ?relatedURI.
    OPTIONAL{?relatedURI dcterms:title ?relatedURILabel.}
    OPTIONAL{?relatedURI micamodel:question ?relatedURILabel.}
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/MS1> micamodel:hasDomainConcept ?domain.
    ?domain skos:prefLabel ?domainLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/MS1> micamodel:hasMethodConcept ?method.
    ?method skos:prefLabel ?methodLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/MS1> micamodel:hasSpatialConcept ?spatial.
    ?spatial skos:prefLabel ?spatialLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/MS1> micamodel:hasTemporalConcept ?temporal.
    ?temporal skos:prefLabel ?temporalLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/MS1> micamodel:hasCommodityConcept ?commodity.
    ?commodity skos:prefLabel ?commodityLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/MS1> micamodel:hasDataConcept ?data.
    ?data skos:prefLabel ?dataLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/MS1> micamodel:hasValueSupplyChainConcept ?value-
SupplyChain.
    ?valueSupplyChain skos:prefLabel ?valueSupplyChainLabel.
  }
}
group by ?title ?summary ?contentType ?publicURI ?privateURI

```

Requested variables are:

- ?title **the MICASheet title.**
- ?summary **the MICASheet summary.**
- ?contentType **the content type (one of the value for the enumerated class micamodel:ContentType : micamodel:MethodsAndTools, micamodel:Documentation, micamodel:Legislation, Data...).**

- `?publicURI` the MICASheet's public URI.
- `?privateURI` the MICASheet's private URI.
- `?authors` a String containing the list of authors as labels of the MICASheet. Each author is represented by its name as `(?lastName," ",?firstName)` , and names are separated by commas.
- `?relatedURIs` a String containing the list of resources as labels that the MICASheet is relatedTo. Each resource is represented by its Label as title for `micamodel:MICAKnowledgeElement` or question for `micamodel:MICAQuestion`, and labels are separated by commas. The string is empty if there is no related resource.
- `?domains` a String containing the list of Domain concepts as labels that the MICASheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Domain concept.
- `?methods` a String containing the list of Method concepts as labels that the MICASheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no method concept.
- `?spatials` a String containing the list of Spatial concepts as labels that the MICASheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Spatial concept.
- `?temporals` a String containing the list of Temporal concepts as labels that the MICASheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Temporal concept.
- `?commodities` a String containing the list of Commodity concepts as labels that the MICASheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Commodity concept.
- `?datas` a String containing the list of Data concepts as labels that the MICASheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Data concept.
- `?valueSupplyChains` a String containing the list of ValueSupplyChain concepts as labels that the MICASheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no ValueSupplyChain concept.

Get All MICASheets

The following query selects all MICASheets by filtering by a given title text. Each metadata is represented by its label:

- filter text is ""
- offset is 0
- limit is 25

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT DISTINCT ?uri ?title ?summary ?contentType ?publicURI ?privateURI
(group_concat(DISTINCT ?name; separator = ",") AS ?authors)
(group_concat(DISTINCT ?relatedURIlabel; separator = ",") AS ?relatedURIs)
(group_concat(DISTINCT ?domainLabel; separator = ",") AS ?domains)
(group_concat(DISTINCT ?methodLabel; separator = ",") AS ?methods)
(group_concat(DISTINCT ?spatialLabel; separator = ",") AS ?spatials)
(group_concat(DISTINCT ?temporalLabel; separator = ",") AS ?temporals)
(group_concat(DISTINCT ?commodityLabel; separator = ",") AS ?commodities)
(group_concat(DISTINCT ?dataLabel; separator = ",") AS ?datas)
(group_concat(DISTINCT ?valueSupplyChainLabel; separator = ",") AS ?valueSupplyChains)

WHERE {
  ?uri a micamodel:MICASheet;
  dcterms:title ?title;
  micamodel:summary ?summary;
  micamodel:publicURI ?publicURI;
  micamodel:hasContentType ?contentType;
  micamodel:privateURI ?privateURI;
  micamodel:hasWriter ?author.
  ?author foaf:givenName ?firstName;
  foaf:familyName ?lastName.
  bind(concat(?lastName," ",?firstName) as ?name)
  OPTIONAL{
    ?uri micamodel:relatedTo ?relatedURI.
    OPTIONAL{?relatedURI dcterms:title ?relatedURIlabel.}
    OPTIONAL{?relatedURI micamodel:question ?relatedURIlabel.}
  }
  OPTIONAL{
    ?uri micamodel:hasDomainConcept ?domain.
    ?domain skos:prefLabel ?domainLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasMethodConcept ?method.
    ?method skos:prefLabel ?methodLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasSpatialConcept ?spatial.
    ?spatial skos:prefLabel ?spatialLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasTemporalConcept ?temporal.
    ?temporal skos:prefLabel ?temporalLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasCommodityConcept ?commodity.
    ?commodity skos:prefLabel ?commodityLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasDataConcept ?data.
    ?data skos:prefLabel ?dataLabel.
  }
}

```

```

    }
    OPTIONAL{
        ?uri micamodel:hasValueSupplyChainConcept ?valueSupplyChain.
        ?valueSupplyChain skos:prefLabel ?valueSupplyChainLabel.
    }
FILTER regex(str(?title), "", "i") }
GROUP BY ?uri ?title ?summary ?contentType ?publicURI ?privateURI
ORDER BY ?title
OFFSET 0
LIMIT 25

```

Requested variables are:

- `?uri` the MICASheet URI.
- the other variables are the same as [Retrieving MICASheet data and related resources labels](#).

Count MICASheets

The following query counts all MICASheets by filtering with a given title text:

- filter text is ""

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT (COUNT ( DISTINCT ?uri) AS ?nbresources)

WHERE {
    ?uri a micamodel:MICASheet;
        dcterms:title ?title.
    FILTER regex(str(?title), "", "i")
}

```

Requested variables are:

- `?uri` the MICASheet URI.
- `?title` the MICASheet title.
- `?nbresources` the number of selected MICASheets.

LinkedSheets Queries

These queries concern resources of type `micamodel:LinkedSheet`.

Creating a new LinkedSheet

Creating a new LinkedSheet whose URI is <https://w3id.org/mica/resource/LS1> and with the following data:

- **title:** Linked Sheet #1
- **summary:** Linked Sheet #1 summary
- **publicURI:** www.LinkedList.fr
- **contentType:** here micamodel:MethodsAndTools
- **two writers:**
 - **Daniel Cassard described by a RDF resource whose URI is** <https://w3id.org/mica/resource/Cassard>
 - **François Tertre described by a RDF resource whose URI is** <https://w3id.org/mica/resource/Tertre>
- **This LinkedSheet is annotated by 3 concepts from the MicaOntology:**
 - **two Domain concepts:**
 - <https://w3id.org/mica/ontology/MicaOntology/32831dae9fc247f390f1362bee1dcd76> : **biodiversity compensation (D6 sustainability of raw materials)**
 - <https://w3id.org/mica/ontology/MicaOntology/e2badc7277b344abb4b45d794c20a313> : **environment health & safety policy (D5 raw materials policy & legal framework)**
 - **one Method concept:**
 - <https://w3id.org/mica/ontology/MicaOntology/12bebe7935734e829fa772a0c4162900> : **risk assessment methods - MethodsScheme**
- **This LinkedSheet is related to three other MICAResources (the local names of three resources are S1, S2 and S3).**

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
```

```
PREFIX dcterms: <http://purl.org/dc/terms/>
```

```
INSERT DATA {
```

```
<https://w3id.org/mica/resource/LS1>
```

```
  a micamodel:LinkedSheet;
```

```
  dcterms:title "Linked Sheet #1";
```

```
  micamodel:summary "Linked Sheet #1 summary";
```

```
  micamodel:publicURI "www.LinkedList.fr";
```

```
  micamodel:hasContentType micamodel:MethodsAndTools;
```

```
  micamodel:hasMethodConcept
```

```
<https://w3id.org/mica/ontology/MicaOntology/12bebe7935734e829fa772a0c4162900>;
```

```
  micamodel:hasDomainConcept
```

```
<https://w3id.org/mica/ontology/MicaOntology/32831dae9fc247f390f1362bee1dcd76>;
```

```
<https://w3id.org/mica/ontology/MicaOntology/e2badc7277b344abb4b45d794c20a313>;
```

```
  micamodel:hasWriter
```

```
    <https://w3id.org/mica/resource/Cassard>;
```

```
    <https://w3id.org/mica/resource/Tertre>;
```

```
  micamodel:relatedTo
```

```
    <https://w3id.org/mica/resource/S1>;
```

```

    <https://w3id.org/mica/resource/S2>,
    <https://w3id.org/mica/resource/S3>;
}

```

Updating an existing LinkedSheet

To update an existing LinkedSheet, we proceed in two steps:

1. we remove from the triplestore all triples having that sheet as subject.
2. we reinsert all the triples describing the LinkedSheet using the same query as the one for ([Creating a new LinkedSheet](#)).
 - For data that have not changed, triples are the same as before deletion.
 - For data that have been modified, values for the triples are the new values.
 - For data that have been added, new triples are inserted.
 - For data that have been removed, the corresponding triples are no longer present in the query.

For example to update LS1) LinkedSheet created in the previous example by changing its title (replace "Linked Sheet #1" by "Linked Sheet New Title#1", removing one author (François Tertre) and by adding a new related MICAResource (S4), the queries will be:

```

DELETE {
  <https://w3id.org/mica/resource/LS1> ?p ?o.
}
WHERE {
  <https://w3id.org/mica/resource/LS1> ?p ?o.
}
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>
INSERT DATA {
<https://w3id.org/mica/resource/LS1>
  a micamodel:LinkedSheet;
  dcterms:title "Linked Sheet New Title #1";
  micamodel:summary "Linked Sheet #1 summary";
  micamodel:publicURI "www.Linkeds.fr";
  micamodel:hasContentType micamodel:MethodsAndTools;
  micamodel:hasMethodConcept

<https://w3id.org/mica/ontology/MicaOntology/12bebe7935734e829fa772a0c4162900>;
  micamodel:hasDomainConcept

<https://w3id.org/mica/ontology/MicaOntology/32831dae9fc247f390f1362bee1dcd76>,

<https://w3id.org/mica/ontology/MicaOntology/e2badc7277b344abb4b45d794c20a313>;
  micamodel:hasWriter
    <https://w3id.org/mica/resource/Cassard>;
  micamodel:relatedTo
    <https://w3id.org/mica/resource/S1>,
    <https://w3id.org/mica/resource/S2>,
    <https://w3id.org/mica/resource/S3>,
    <https://w3id.org/mica/resource/S4>;
}

```


Deleting an existing LinkedSheet

The following query removes a given LinkedSheet from the MICA Triple Store. Given the sheet URI, all the triples with this URI as subject or as object are removed. If the LinkedSheet belongs to one or several flowsheets, we remove from the elements lists of these FlowSheets the corresponding FlowSheetElements and delete all the triples defining the FlowSheetElement (role and knowledge element).

For example to delete LS1 LinkedSheet, the query is:

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

DELETE
{
  <https://w3id.org/mica/resource/LS1> ?p ?o.
  ?otherResource micamodel:relatedTo <https://w3id.org/mica/resource/LS1>.
  ?element micamodel:hasKnowledgeElement <https://w3id.org/mica/resource/LS1>;
  micamodel:role ?role.
  ?node rdf:first ?element;
  rdf:rest ?rest.
  ?previousNode ?property ?node.
}
INSERT { ?previousNode ?property ?rest. }
WHERE {
  <https://w3id.org/mica/resource/LS1> ?p ?o;
  OPTIONAL {
    ?otherResource micamodel:relatedTo <https://w3id.org/mica/resource/LS1>.
  }
  OPTIONAL {
    ?element micamodel:hasKnowledgeElement <https://w3id.org/mica/resource/LS1>;
    micamodel:role ?role.
    ?node rdf:first ?element;
    rdf:rest ?rest.
    ?previousNode ?property ?node.
  }
}
```

Retrieving a LinkedSheet

As for MICASheets, two options are available for retrieving queries depending on the type of information retrieved from the resources associated with the LinkedSheet:

- retrieve the URIs of those associated resources,
- retrieve the labels of those associated resources.

Retrieving LinkedSheet data and related resources URIs

For example, the complete query to get all the information associated to LS1 LinkedSheet is as follows;

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>
SELECT DISTINCT ?title ?summary ?contentType ?publicURI
(group_concat(DISTINCT ?author; separator = ",") AS ?authors)
(group_concat(DISTINCT ?relatedURI; separator = ",") AS ?relatedURIs)
(group_concat(DISTINCT ?domain; separator = ",") AS ?domains)
(group_concat(DISTINCT ?method; separator = ",") AS ?methods)
(group_concat(DISTINCT ?spatial; separator = ",") AS ?spatials)
(group_concat(DISTINCT ?temporal; separator = ",") AS ?temporals)
(group_concat(DISTINCT ?commodity; separator = ",") AS ?commodities)
(group_concat(DISTINCT ?data; separator = ",") AS ?datas)
(group_concat(DISTINCT ?valueSupplyChain; separator = ",") AS ?valueSupplyChains)

WHERE {
  <https://w3id.org/mica/resource/LS1>
    a micamodel:LinkedSheet;
    dcterms:title ?title;
    micamodel:summary ?summary;
    micamodel:publicURI ?publicURI;
    micamodel:hasContentType ?contentType;
    micamodel:hasWriter ?author.
    OPTIONAL{<https://w3id.org/mica/resource/LS1> micamodel:relatedTo ?relatedURI. }
    OPTIONAL{<https://w3id.org/mica/resource/LS1> micamodel:hasDomainConcept ?domain. }
    OPTIONAL{<https://w3id.org/mica/resource/LS1> micamodel:hasMethodConcept ?method. }
    OPTIONAL{<https://w3id.org/mica/resource/LS1> micamodel:hasSpatialConcept ?spatial. }
    OPTIONAL{<https://w3id.org/mica/resource/LS1> micamodel:hasTemporalConcept ?temporal.
}
    OPTIONAL{<https://w3id.org/mica/resource/LS1> micamodel:hasCommodityConcept ?commodi-
ty. }
    OPTIONAL{<https://w3id.org/mica/resource/LS1> micamodel:hasDataConcept ?data. }
    OPTIONAL{<https://w3id.org/mica/resource/LS1> micamodel:hasValueSupplyChainConcept
?valueSupplyChain. }
}
group by ?title ?summary ?contentType ?publicURI
```

Requested variables are:

- `?title` **the LinkedSheet title.**
- `?summary` **the LinkedSheet summary.**
- `?contentType` **the content type (one of the value for the enumerated class `micamodel:ContentType:MethodsAndTools, Documentation, Legislation, Data...`).**
- `?publicURI` **the LinkedSheet's public URI.**
- `?authors` **a String containing the list of authors as URIs of the LinkedSheet. Each author is represented by its URI, and URIs are separated by commas.**
- `?relatedURIs` **a String containing the list of resources as URIs that the LinkedSheet is relatedTo. Each resource is represented by its URI, and URIs are separated by commas. The string is empty if there is no related resource.**

- `?domains` a String containing the list of Domain concepts as URIs that the `LinkedSheet` is annotated with.
Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Domain concept.
- `?methods` a String containing the list of Method concepts as URIs that the `LinkedSheet` is annotated with.
Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no method concept.
- `?spatials` a String containing the list of Spatial concepts as URIs that the `LinkedSheet` is annotated with.
Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Spatial concept.
- `?temporals` a String containing the list of Temporal concepts as URIs that the `LinkedSheet` is annotated with.
Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Temporal concept.
- `?commodities` a String containing the list of Commodity concepts as URIs that the `LinkedSheet` is annotated with.
Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Commodity concept.
- `?datas` a String containing the list of Data concepts as URIs that the `LinkedSheet` is annotated with.
Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Data concept.
- `?valueSupplyChains` a String containing the list of ValueSupplyChain concepts as URIs that the `LinkedSheet` is annotated with.
Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no ValueSupplyChain concept.

Retrieving `LinkedSheet` data and related resources labels

The complete query to get all the information associated to `LS1` Sheet, in a human readable form, is as follows:

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT DISTINCT ?title ?summary ?contentType ?publicURI
(group_concat(DISTINCT ?name; separator = ",") AS ?authors)
(group_concat(DISTINCT ?relatedURIlabel; separator = ",") AS ?relatedURIs)
(group_concat(DISTINCT ?domainLabel; separator = ",") AS ?domains)
(group_concat(DISTINCT ?methodLabel; separator = ",") AS ?methods)
(group_concat(DISTINCT ?spatialLabel; separator = ",") AS ?spatials)
(group_concat(DISTINCT ?temporalLabel; separator = ",") AS ?temporals)
(group_concat(DISTINCT ?commodityLabel; separator = ",") AS ?commodities)
(group_concat(DISTINCT ?dataLabel; separator = ",") AS ?datas)
(group_concat(DISTINCT ?valueSupplyChainLabel; separator = ",") AS ?valueSupplyChains)
```

```

WHERE {
<https://w3id.org/mica/resource/LS1>
  a micamodel:LinkedSheet;
  dcterms:title ?title;
  micamodel:summary ?summary;
  micamodel:publicURI ?publicURI;
  micamodel:hasContentType ?contentType;
  micamodel:hasWriter ?author.
  ?author foaf:givenName ?firstName;
          foaf:familyName ?lastName.
  bind(concat(?lastName," ",?firstName) as ?name)

  OPTIONAL{
    <https://w3id.org/mica/resource/LS1> micamodel:relatedTo ?relatedURI.
    OPTIONAL{?relatedURI dcterms:title ?relatedURILabel.}
    OPTIONAL{?relatedURI micamodel:question ?relatedURILabel.}
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/LS1> micamodel:hasDomainConcept ?domain.
    ?domain skos:prefLabel ?domainLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/LS1> micamodel:hasMethodConcept ?method.
    ?method skos:prefLabel ?methodLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/LS1> micamodel:hasSpatialConcept ?spatial.
    ?spatial skos:prefLabel ?spatialLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/LS1> micamodel:hasTemporalConcept ?temporal.
    ?temporal skos:prefLabel ?temporalLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/LS1> micamodel:hasCommodityConcept ?commodity.
    ?commodity skos:prefLabel ?commodityLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/LS1> micamodel:hasDataConcept ?data.
    ?data skos:prefLabel ?dataLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/LS1> micamodel:hasValueSupplyChainConcept ?value-
SupplyChain.
    ?valueSupplyChain skos:prefLabel ?valueSupplyChainLabel.
  }
}
group by ?title ?summary ?contentType ?publicURI

```

Requested variables are :

- ?title **the LinkedSheet title.**
- ?summary **the LinkedSheet summary.**
- ?contentType **the content type (one of the value for the enumerated class micamodel:ContentType : micamodel:MethodsAndTools, micamodel:Documentation, micamodel:Legislation, Data...).**

- `?publicURI` the LinkedSheet's public URI.
- `?authors` a String containing the list of authors as labels of the LinkedSheet. Each author is represented by its name as `(?lastName, " ", ?firstName)` , and names are separated by commas.
- `?relatedURIs` a String containing the list of resources as labels that the LinkedSheet is relatedTo. Each resource is represented by its Label as title for `micamodel:MICAKnowledgeElement` or question for `micamodel:MICAQuestion`, and labels are separated by commas. The string is empty if there is no related resource.
- `?domains` a String containing the list of Domain concepts as labels that the LinkedSheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Domain concept.
- `?methods` a String containing the list of Method concepts as labels that the LinkedSheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no method concept.
- `?spatials` a String containing the list of Spatial concepts as labels that the LinkedSheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Spatial concept.
- `?temporals` a String containing the list of Temporal concepts as labels that the LinkedSheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Temporal concept.
- `?commodities` a String containing the list of Commodity concepts as labels that the LinkedSheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Commodity concept.
- `?datas` a String containing the list of Data concepts as labels that the LinkedSheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Data concept.
- `?valueSupplyChains` a String containing the list of ValueSupplyChain concepts as labels that the LinkedSheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no ValueSupplyChain concept.

Get All LinkedSheets

The following query selects all LinkedSheets by filtering with a given title text. Each metadata is represented by its label:

- filter text is ""
- offset is 0
- limit is 25

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
```

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
```

```
SELECT DISTINCT ?uri ?title ?summary ?contentType ?publicURI
(group_concat(DISTINCT ?name; separator = ",") AS ?authors)
(group_concat(DISTINCT ?relatedURIlabel; separator = ",") AS ?relatedURIs)
(group_concat(DISTINCT ?domainLabel; separator = ",") AS ?domains)
(group_concat(DISTINCT ?methodLabel; separator = ",") AS ?methods)
(group_concat(DISTINCT ?spatialLabel; separator = ",") AS ?spatials)
(group_concat(DISTINCT ?temporalLabel; separator = ",") AS ?temporals)
(group_concat(DISTINCT ?commodityLabel; separator = ",") AS ?commodities)
(group_concat(DISTINCT ?dataLabel; separator = ",") AS ?datas)
(group_concat(DISTINCT ?valueSupplyChainLabel; separator = ",") AS ?valueSupplyChains)
```

```
WHERE {
  ?uri a micamodel:LinkedSheet;
  dcterms:title ?title;
  micamodel:summary ?summary;
  micamodel:publicURI ?publicURI;
  micamodel:hasContentType ?contentType;
  micamodel:hasWriter ?author.

  ?author foaf:givenName ?firstName;
          foaf:familyName ?lastName.
  bind(concat(?lastName," ",?firstName) as ?name)

  OPTIONAL{
    ?uri micamodel:relatedTo ?relatedURI.
    OPTIONAL{?relatedURI dcterms:title ?relatedURIlabel.}
    OPTIONAL{?relatedURI micamodel:question ?relatedURIlabel.}
  }
  OPTIONAL{
    ?uri micamodel:hasDomainConcept ?domain.
    ?domain skos:prefLabel ?domainLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasMethodConcept ?method.
    ?method skos:prefLabel ?methodLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasSpatialConcept ?spatial.
    ?spatial skos:prefLabel ?spatialLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasTemporalConcept ?temporal.
    ?temporal skos:prefLabel ?temporalLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasCommodityConcept ?commodity.
    ?commodity skos:prefLabel ?commodityLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasDataConcept ?data.
```

```

        ?data skos:prefLabel ?dataLabel.
    }
    OPTIONAL{
        ?uri micamodel:hasValueSupplyChainConcept ?valueSupplyChain.
        ?valueSupplyChain skos:prefLabel ?valueSupplyChainLabel.
    }
FILTER regex(str(?title), "", "i") }
GROUP BY ?uri ?title ?summary ?contentType ?publicURI
ORDER BY ?title
OFFSET 0
LIMIT 25

```

Requested variables are:

- `?uri` the LinkedSheet URI.
- the other variables are the same as [Retrieving LinkedSheet data and related resources labels](#).

Count LinkedSheets

The following query counts all LinkedSheets by filtering with a given title text:

- filter text is ""

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT (COUNT ( DISTINCT ?uri) AS ?nbresources)
WHERE {
    ?uri a micamodel:LinkedSheet;
        dcterms:title ?title.
    FILTER regex(str(?title), "", "i")
}

```

Requested variables are:

- `?uri` the LinkedSheet URI.
- `?title` the LinkedSheet title.
- `?nbresources` the number of selected LinkedSheets.

MICAQuestions Queries

These queries concern resources of type `micamodel:MICAQuestion`.

Creating a new MICAQuestion

Creating a new MICAQuestion whose URI is <https://w3id.org/mica/resource/MQ1> and with the following data:

- **question:** MICA Question #1
- **two writers:**
 - Daniel Cassard described by a RDF resource whose URI is <https://w3id.org/mica/resource/Cassard>
 - François Tertre described by a RDF resource whose URI is <https://w3id.org/mica/resource/Tertre>
- This MICAQuestion is annotated by 3 concepts from the MicaOntology:
 - two Domain concepts:
 - <https://w3id.org/mica/ontology/MicaOntology/32831dae9fc247f390f1362bee1dcd76> : biodiversity compensation (D6 sustainability of raw materials)
 - <https://w3id.org/mica/ontology/MicaOntology/e2badc7277b344abb4b45d794c20a313> : environment health & safety policy (D5 raw materials policy & legal framework)
 - one Method concept:
 - <https://w3id.org/mica/ontology/MicaOntology/12bebe7935734e829fa772a0c4162900> : risk assessment methods - MethodsScheme
- This MICAQuestion is related to three other MICAResources (the local names of three resources are S1, S2 and S3).

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
INSERT DATA {
  <https://w3id.org/mica/resource/MQ1>
    a micamodel:MICAQuestion;
    micamodel:question "MICA Question #1";
    micamodel:hasMethodConcept

  <https://w3id.org/mica/ontology/MicaOntology/12bebe7935734e829fa772a0c4162900>;
    micamodel:hasDomainConcept

  <https://w3id.org/mica/ontology/MicaOntology/32831dae9fc247f390f1362bee1dcd76>,

  <https://w3id.org/mica/ontology/MicaOntology/e2badc7277b344abb4b45d794c20a313>;
    micamodel:hasWriter
      <https://w3id.org/mica/resource/Cassard>,
      <https://w3id.org/mica/resource/Tertre>;
    micamodel:relatedTo
      <https://w3id.org/mica/resource/S1>,
      <https://w3id.org/mica/resource/S2>,
      <https://w3id.org/mica/resource/S3>;
}
```


Updating an existing MICAQuestion

To update an existing MICAQuestion, we proceed in two steps:

1. we remove from the triplestore all triples having that question as subject.
2. we reinsert all the triples describing the MICAQuestion using the same query as the one for ([Creating a new MICAQuestion](#)).
 - For data that have not changed, triples are the same as before deletion.
 - For data that have been modified, values for the triples are the new values.
 - For data that have been added, new triples are inserted.
 - For data that have been removed, the corresponding triples are no longer present in the query.

For example to update `MQ1`) MICAQuestion created in the previous example by replacing the question text (replace "MICA Question #1" by "MICA New Question #1", removing one author (François Tertre) and by adding a new related MICAResource (`S4`), the queries will be:

```
DELETE {
  <https://w3id.org/mica/resource/MQ1> ?p ?o.
}
WHERE {
  <https://w3id.org/mica/resource/MQ1> ?p ?o.
}
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
INSERT DATA {
  <https://w3id.org/mica/resource/MQ1>
    a micamodel:MICAQuestion;
    micamodel:question "MICA New Question #1";
    micamodel:hasMethodConcept

<https://w3id.org/mica/ontology/MicaOntology/12bebe7935734e829fa772a0c4162900>;
  micamodel:hasDomainConcept

<https://w3id.org/mica/ontology/MicaOntology/32831dae9fc247f390f1362bee1dcd76>,

<https://w3id.org/mica/ontology/MicaOntology/e2badc7277b344abb4b45d794c20a313>;
  micamodel:hasWriter
    <https://w3id.org/mica/resource/Cassard>;
  micamodel:relatedTo
    <https://w3id.org/mica/resource/S1>,
    <https://w3id.org/mica/resource/S2>,
    <https://w3id.org/mica/resource/S3>,
    <https://w3id.org/mica/resource/S4>;
}
```

Deleting an existing MICAQuestion

The following query removes a given MICAQuestion from the MICA Triple Store. Given the question URI, all the triples with this URI as subject or as object are removed. For example to delete `MQ1` MICAQuestion, the query is:

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

DELETE
{
  <https://w3id.org/mica/resource/MQ1> ?p ?o.
  ?otherResource micamodel:relatedTo <https://w3id.org/mica/resource/MQ1>.
}
WHERE {
  <https://w3id.org/mica/resource/MQ1> ?p ?o;
  OPTIONAL {
    ?otherResource micamodel:relatedTo <https://w3id.org/mica/resource/MQ1>.
  }
}
```

Retrieving a MICAQuestion

As for MICASheets, two options are available for retrieving queries depending on the type of information retrieved from the resources associated with the MICAQuestion:

- retrieve the URIs of those associated resources,
- retrieve the labels of those associated resources.

Retrieving MICAQuestion data and related resources URIs

For example, the complete query to get all the information associated to `MQ1` MICAQuestion is as follows:

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

SELECT DISTINCT ?question
(group_concat(DISTINCT ?author; separator = ",") AS ?authors)
(group_concat(DISTINCT ?relatedURI; separator = ",") AS ?relatedURIs)
(group_concat(DISTINCT ?domain; separator = ",") AS ?domains)
(group_concat(DISTINCT ?method; separator = ",") AS ?methods)
(group_concat(DISTINCT ?spatial; separator = ",") AS ?spatials)
(group_concat(DISTINCT ?temporal; separator = ",") AS ?temporals)
(group_concat(DISTINCT ?commodity; separator = ",") AS ?commodities)
(group_concat(DISTINCT ?data; separator = ",") AS ?datas)
(group_concat(DISTINCT ?valueSupplyChain; separator = ",") AS ?valueSupplyChains)

WHERE {
  <https://w3id.org/mica/resource/MQ1>
    a micamodel:MICAQuestion;
    micamodel:question ?question;
    micamodel:hasWriter ?author.
  OPTIONAL{<https://w3id.org/mica/resource/MQ1> micamodel:relatedTo ?relatedURI. }
  OPTIONAL{<https://w3id.org/mica/resource/MQ1> micamodel:hasDomainConcept ?domain. }
```

```

OPTIONAL{<https://w3id.org/mica/resource/MQ1> micamodel:hasMethodConcept ?method. }
OPTIONAL{<https://w3id.org/mica/resource/MQ1> micamodel:hasSpatialConcept ?spatial. }
OPTIONAL{<https://w3id.org/mica/resource/MQ1> micamodel:hasTemporalConcept ?temporal. }
OPTIONAL{<https://w3id.org/mica/resource/MQ1> micamodel:hasCommodityConcept ?commodity. }
OPTIONAL{<https://w3id.org/mica/resource/MQ1> micamodel:hasDataConcept ?data. }
OPTIONAL{<https://w3id.org/mica/resource/MQ1> micamodel:hasValueSupplyChainConcept ?valueSupplyChain. }
}
group by ?question

```

Requested variables are:

- `?question` the question string.
- `?authors` a String containing the list of authors as URIs of the MICAQuestion. Each author is represented by its URI, and URIs are separated by commas.
- `?relatedURIs` a String containing the list of resources as URIs that the MICAQuestion is relatedTo. Each resource is represented by its URI, and URIs are separated by commas. The string is empty if there is no related resource.
- `?domains` a String containing the list of Domain concepts as URIs that the MICAQuestion is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Domain concept.
- `?methods` a String containing the list of Method concepts as URIs that the MICAQuestion is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no method concept.
- `?spatials` a String containing the list of Spatial concepts as URIs that the MICAQuestion is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Spatial concept.
- `?temporals` a String containing the list of Temporal concepts as URIs that the MICAQuestion is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Temporal concept.
- `?commodities` a String containing the list of Commodity concepts as URIs that the MICAQuestion is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Commodity concept.
- `?datas` a String containing the list of Data concepts as URIs that the MICAQuestion is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Data concept.
- `?valueSupplyChains` a String containing the list of ValueSupplyChain concepts as URIs that the MICAQuestion is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no ValueSupplyChain concept.

Retrieving MICAQuestion data and related resources labels

The complete query to get all the information associated to MQ1 MICAQuestion, in a human readable form, is as follows:

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT DISTINCT ?question
(group_concat(DISTINCT ?name; separator = ",") AS ?authors)
(group_concat(DISTINCT ?relatedURIlabel; separator = ",") AS ?relatedURIs)
(group_concat(DISTINCT ?domainLabel; separator = ",") AS ?domains)
(group_concat(DISTINCT ?methodLabel; separator = ",") AS ?methods)
(group_concat(DISTINCT ?spatialLabel; separator = ",") AS ?spatials)
(group_concat(DISTINCT ?temporalLabel; separator = ",") AS ?temporals)
(group_concat(DISTINCT ?commodityLabel; separator = ",") AS ?commodities)
(group_concat(DISTINCT ?dataLabel; separator = ",") AS ?datas)
(group_concat(DISTINCT ?valueSupplyChainLabel; separator = ",") AS ?valueSupplyChains)

WHERE {
  <https://w3id.org/mica/resource/MQ1>
    a micamodel:MICAQuestion;
    micamodel:question ?question;
    micamodel:hasWriter ?author.
    ?author foaf:givenName ?firstName;
            foaf:familyName ?lastName.
    bind(concat(?lastName," ",?firstName) as ?name)

  OPTIONAL{
    <https://w3id.org/mica/resource/MQ1> micamodel:relatedTo ?relatedURI.
    OPTIONAL{?relatedURI dcterms:title ?relatedURIlabel.}
    OPTIONAL{?relatedURI micamodel:question ?relatedURIlabel.}
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/MQ1> micamodel:hasDomainConcept ?domain.
    ?domain skos:prefLabel ?domainLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/MQ1> micamodel:hasMethodConcept ?method.
    ?method skos:prefLabel ?methodLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/MQ1> micamodel:hasSpatialConcept ?spatial.
    ?spatial skos:prefLabel ?spatialLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/MQ1> micamodel:hasTemporalConcept ?temporal.
    ?temporal skos:prefLabel ?temporalLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/MQ1> micamodel:hasCommodityConcept ?commodity.
    ?commodity skos:prefLabel ?commodityLabel.
  }
  OPTIONAL{
    <https://w3id.org/mica/resource/MQ1> micamodel:hasDataConcept ?data.
    ?data skos:prefLabel ?dataLabel.
  }
}
```

```

OPTIONAL{
  <https://w3id.org/mica/resource/MQ1> micamodel:hasValueSupplyChainConcept ?value-
SupplyChain.
  ?valueSupplyChain skos:prefLabel ?valueSupplyChainLabel.
}
group by ?question

```

Requested variables are:

- `?question` the question string.
- `?authors` a String containing the list of authors as labels of the MICAQuestion. Each author is represented by its name as `(?lastName, " ",?firstName)` , and names are separated by commas.
- `?relatedURIs` a String containing the list of resources as labels that the MICAQuestion is relatedTo. Each resource is represented by its Label as title for `micamodel:MICAKnowledgeElement` or question for `micamodel:MICAQuestion`, and labels are separated by commas. The string is empty if there is no related resource.
- `?domains` a String containing the list of Domain concepts as labels that the MICAQuestion is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Domain concept.
- `?methods` a String containing the list of Method concepts as labels that the MICAQuestion is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no method concept.
- `?spatials` a String containing the list of Spatial concepts as labels that the MICAQuestion is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Spatial concept.
- `?temporals` a String containing the list of Temporal concepts as labels that the MICAQuestion is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Temporal concept.
- `?commodities` a String containing the list of Commodity concepts as labels that the MICAQuestion is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Commodity concept.
- `?datas` a String containing the list of Data concepts as labels that the MICAQuestion is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Data concept.
- `?valueSupplyChains` a String containing the list of ValueSupplyChain concepts as labels that the MICAQuestion is annotated with.

Each concept is represented by its prefLabel, and prefLabels are separated by commas. The string is empty if there is no ValueSupplyChain concept.

Get All MICAQuestions

The following query selects all MICAQuestions by filtering with a given title text. Each metadata is represented by its label:

- filter text is ""
- offset is 0
- limit is 25

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT DISTINCT ?uri ?question

(group_concat(DISTINCT ?name; separator = ",") AS ?authors)
(group_concat(DISTINCT ?relatedURILabel; separator = ",") AS ?relatedURIs)
(group_concat(DISTINCT ?domainLabel; separator = ",") AS ?domains)
(group_concat(DISTINCT ?methodLabel; separator = ",") AS ?methods)
(group_concat(DISTINCT ?spatialLabel; separator = ",") AS ?spatials)
(group_concat(DISTINCT ?temporalLabel; separator = ",") AS ?temporals)
(group_concat(DISTINCT ?commodityLabel; separator = ",") AS ?commodities)
(group_concat(DISTINCT ?dataLabel; separator = ",") AS ?datas)
(group_concat(DISTINCT ?valueSupplyChainLabel; separator = ",") AS ?valueSupplyChains)

WHERE {
  ?uri a micamodel:MICAQuestion;
  micamodel:question ?question;
  micamodel:hasWriter ?author;
  ?author foaf:givenName ?firstName;
  foaf:familyName ?lastName.
  bind(concat(?lastName," ",?firstName) as ?name)
  OPTIONAL{
    ?uri micamodel:relatedTo ?relatedURI.
    OPTIONAL{?relatedURI dcterms:title ?relatedURILabel.}
    OPTIONAL{?relatedURI micamodel:question ?relatedURILabel.}
  }
  OPTIONAL{
    ?uri micamodel:hasDomainConcept ?domain.
    ?domain skos:prefLabel ?domainLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasMethodConcept ?method.
    ?method skos:prefLabel ?methodLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasSpatialConcept ?spatial.
    ?spatial skos:prefLabel ?spatialLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasTemporalConcept ?temporal.
    ?temporal skos:prefLabel ?temporalLabel.
  }
}
```

```

    }
    OPTIONAL{
      ?uri micamodel:hasCommodityConcept ?commodity.
      ?commodity skos:prefLabel ?commodityLabel.
    }
    OPTIONAL{
      ?uri micamodel:hasDataConcept ?data.
      ?data skos:prefLabel ?dataLabel.
    }
    OPTIONAL{
      ?uri micamodel:hasValueSupplyChainConcept ?valueSupplyChain.
      ?valueSupplyChain skos:prefLabel ?valueSupplyChainLabel.
    }
  }
}

```

```

FILTER regex(str(?question), "", "i") }
GROUP BY ?uri ?question
ORDER BY ?question
OFFSET 0
LIMIT 25

```

Requested variables are:

- `?uri` the MICAQuestion URI
- the other variables are the same as [Retrieving MICAQuestion data and related resources labels](#)

Count MICAQuestions

The following query counts all MICAQuestions by filtering with a given title text:

- filter text is ""

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>

SELECT (COUNT ( DISTINCT ?uri) AS ?nbresources)

WHERE {
  ?uri a micamodel:MICAQuestion;
      micamodel:question ?question.
  FILTER regex(str(?question), "", "i")
}

```

Requested variables are:

- `?uri` the MICAQuestion URI.
- `?question` the question text.
- `?nbresources` the number of selected MICAQuestion.

FlowSheets Queries

These queries concern resources of type `micamodel:FlowSheet`.

Creating a new FlowSheet

Creating a new FlowSheet whose URI is `https://w3id.org/mica/resource/FS1` and with the following data:

- **title:** Flow Sheet #1
- **summary:** Flow Sheet #1 summary
- **two writers:**
 - **Daniel Cassard described by a RDF resource whose URI is** `https://w3id.org/mica/resource/Cassard`
 - **François Tertre described by a RDF resource whose URI is** `https://w3id.org/mica/resource/Tertre`
- **This FlowSheet is annotated by 3 concepts from the MicaOntology:**
 - **two Domain concepts:**
 - `https://w3id.org/mica/ontology/MicaOntology/32831dae9fc247f390f1362bee1dcd76` : **biodiversity compensation (D6 sustainability of raw materials)**
 - `https://w3id.org/mica/ontology/MicaOntology/e2badc7277b344abb4b45d794c20a313` : **environment health & safety policy (D5 raw materials policy & legal framework)**
 - **one Method concept:**
 - `https://w3id.org/mica/ontology/MicaOntology/12bebe7935734e829fa772a0c4162900` : **risk assessment methods - MethodsScheme**
- **This FlowSheet is related to three other MICAResources (the local names of three resources are S1, S2 and S3).**
- **This FlowSheet is composed of an ordered list of three FlowSheetElements:**
 1. **another FlowSheet resource FS2 with role "role1".**
 2. **a LinkedSheet resource LS1 with role "role2".**
 3. **a MICASheet resource MS1 with role "role3".**

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>
INSERT DATA {
  <https://w3id.org/mica/resource/FS1>
    a micamodel:FlowSheet;
    dcterms:title "Flow Sheet #1";
    micamodel:summary "Flow Sheet #1 summary";
    micamodel:hasMethodConcept
      <https://w3id.org/mica/ontology/MicaOntology/12bebe7935734e829fa772a0c4162900>;
    micamodel:hasDomainConcept
      <https://w3id.org/mica/ontology/MicaOntology/32831dae9fc247f390f1362bee1dcd76>,
      <https://w3id.org/mica/ontology/MicaOntology/e2badc7277b344abb4b45d794c20a313>;
```



```

micamodel:hasWriter
  <https://w3id.org/mica/resource/Cassard>,
  <https://w3id.org/mica/resource/Tertre>;
micamodel:relatedTo
  <https://w3id.org/mica/resource/S1>,
  <https://w3id.org/mica/resource/S2>,
  <https://w3id.org/mica/resource/S3>;
micamodel:hasElements (
  [ micamodel:hasKnowledgeElement <https://w3id.org/mica/resource/FS2>; micamod-
el:role "role1" ]
  [ micamodel:hasKnowledgeElement <https://w3id.org/mica/resource/LS1>; micamod-
el:role "role2" ]
  [ micamodel:hasKnowledgeElement <https://w3id.org/mica/resource/MS1>; micamod-
el:role "role3" ]
  ) .
}

```

Updating an existing FlowSheet

To update an existing flowSheet, we proceed in two steps:

1. we remove from the triplestore all triples having that FlowSheet URI as subject. We remove also all the triples defining the list of FlowSheetElements.
2. we reinsert all the triples describing the FlowSheet using the same query as the one for ([Creating a new FlowSheet](#)).
 - For data that have not changed, triples are the same as before deletion.
 - For data that have been modified, values for the triples are the new values.
 - For data that have been added, new triples are inserted.
 - For data that have been removed, the corresponding triples are no longer present in the query.

For example to update FS1) FlowSheet created in the previous example by changing its summary

(replace "Flow Sheet #1 summary" by "Flow Sheet #1 new summary", adding one author (Daniel), removing one domain concept (e2badc7277b344abb4b45d794c20a313) and adding a new KnowledgeElement (ELT4 with role "role4") at the end of the list of KnowledgeElements.

The queries will be:

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
DELETE
{
  <https://w3id.org/mica/resource/FS1> ?p ?o.
  ?z rdf:first ?head ; rdf:rest ?tail .
  ?head micamodel:role ?role;
    micamodel:hasKnowledgeElement ?ke.
}
WHERE {
  <https://w3id.org/mica/resource/FS1> ?p ?o;
    micamodel:hasElements ?list .
}

```

```

    ?list rdf:rest* ?z .
    ?z rdf:first ?head ;
        rdf:rest ?tail .
    ?head micamodel:role ?role;
        micamodel:hasKnowledgeElement ?ke.
}
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>
INSERT DATA {
<https://w3id.org/mica/resource/FS1>
    a micamodel:FlowSheet;
    dcterms:title "Flow Sheet #1";
    micamodel:summary "Flow Sheet #1 new summary";
    micamodel:hasMethodConcept

<https://w3id.org/mica/ontology/MicaOntology/12bebe7935734e829fa772a0c4162900>;
    micamodel:hasDomainConcept

<https://w3id.org/mica/ontology/MicaOntology/32831dae9fc247f390f1362bee1dcd76>;
    micamodel:hasWriter
        <https://w3id.org/mica/resource/Cassard>,
        <https://w3id.org/mica/resource/Tertre>,
        <https://w3id.org/mica/resource/Daniel>;
    micamodel:relatedTo
        <https://w3id.org/mica/resource/S1>,
        <https://w3id.org/mica/resource/S2>,
        <https://w3id.org/mica/resource/S3>;
    micamodel:hasElements (
micamodel:role "role1" ] [ micamodel:hasKnowledgeElement <https://w3id.org/mica/resource/FS2>;
micamodel:role "role2" ] [ micamodel:hasKnowledgeElement <https://w3id.org/mica/resource/LS1>;
micamodel:role "role3" ] [ micamodel:hasKnowledgeElement <https://w3id.org/mica/resource/MS1>;
micamodel:role "role4" ] [ micamodel:hasKnowledgeElement <https://w3id.org/mica/resource/ELT4>;
    ) .}

```

Deleting an existing FlowSheet

The following query removes a given FlowSheet from the MICA Triple Store. Given the sheet URI, all the triples with this URI as subject or as object are removed. All the triples defining the ordered list of FlowSheetElements of this FlowSheet are also removed from the Triple Store. If the deleted FlowSheet belongs to one or several other flowsheets:

- the corresponding FlowSheetElement is removed from the elements lists of these FlowSheets,
- all the triples defining the FlowSheetElement (role and knowledge element) are deleted.

For example to delete `FS1` FlowSheet, the query is:

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

```

```

DELETE
{
  <https://w3id.org/mica/resource/FS1> ?p ?o.
  ?z rdf:first ?head ; rdf:rest ?tail .
  ?head micamodel:role ?role;
      micamodel:hasKnowledgeElement ?ke.
  ?otherResource micamodel:relatedTo <https://w3id.org/mica/resource/FS1>.
  ?element micamodel:hasKnowledgeElement <https://w3id.org/mica/resource/FS1>;
      micamodel:role ?role1.
  ?node rdf:first ?element;
      rdf:rest ?rest.
  ?previousNode ?property ?node.
}
INSERT
{
  ?previousNode ?property ?rest.
}
WHERE {
  <https://w3id.org/mica/resource/FS1> ?p ?o;
  micamodel:hasElements ?list .
  ?list rdf:rest* ?z .
  ?z rdf:first ?head ;
      rdf:rest ?tail .
  ?head micamodel:role ?role;
      micamodel:hasKnowledgeElement ?ke.
  OPTIONAL {
    ?otherResource micamodel:relatedTo <https://w3id.org/mica/resource/FS1>.
  }
  OPTIONAL
  {
    ?element micamodel:hasKnowledgeElement <https://w3id.org/mica/resource/FS1>;
      micamodel:role ?role1.
    ?node rdf:first ?element;
      rdf:rest ?rest.
    ?previousNode ?property ?node.
  }
}

```

Retrieving a FlowSheet data

As for MICASheets, two options are available for retrieving queries depending on the type of information retrieved from the resources associated with the FlowSheet:

- retrieve the URIs of those associated resources,
- retrieve the labels of those associated resources.

Retrieving FlowSheet data and related resources URIs

For example, the complete query to get all the information associated to FS1 FlowSheet is as follows:

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

```

```

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT DISTINCT ?title ?summary
(group_concat(DISTINCT ?sheet; separator = ",") AS ?sheets)
(group_concat(DISTINCT ?author; separator = ",") AS ?authors)
(group_concat(DISTINCT ?relatedURI; separator = ",") AS ?relatedURIs)
(group_concat(DISTINCT ?domain; separator = ",") AS ?domains)
(group_concat(DISTINCT ?method; separator = ",") AS ?methods)
(group_concat(DISTINCT ?spatial; separator = ",") AS ?spatials)
(group_concat(DISTINCT ?temporal; separator = ",") AS ?temporals)
(group_concat(DISTINCT ?commodity; separator = ",") AS ?commodities)
(group_concat(DISTINCT ?data; separator = ",") AS ?datas)
(group_concat(DISTINCT ?valueSupplyChain; separator = ",") AS ?valueSupplyChains)

WHERE {
  <https://w3id.org/mica/resource/FS1>
    a micamodel:FlowSheet;
    dcterms:title ?title;
    micamodel:summary ?summary;
    micamodel:hasWriter ?author;
    micamodel:hasElements/rdf:rest*/rdf:first ?element.
  ?element micamodel:role ?role;
    micamodel:hasKnowledgeElement ?micaKnowledgeElementURI.
  bind(concat( str(?micaKnowledgeElementURI),";",?role) as ?sheet)
  OPTIONAL { <https://w3id.org/mica/resource/FS1> micamodel:relatedTo ?relatedURI. }
  OPTIONAL { <https://w3id.org/mica/resource/FS1> micamodel:hasDomainConcept ?domain. }
  OPTIONAL { <https://w3id.org/mica/resource/FS1> micamodel:hasMethodConcept ?method. }
  OPTIONAL { <https://w3id.org/mica/resource/FS1> micamodel:hasSpatialConcept ?spatial. }
  OPTIONAL { <https://w3id.org/mica/resource/FS1> micamodel:hasTemporalConcept ?temporal. }
  OPTIONAL { <https://w3id.org/mica/resource/FS1> micamodel:hasCommodityConcept ?commodity. }
}
  OPTIONAL { <https://w3id.org/mica/resource/FS1> micamodel:hasDataConcept ?data. }
  OPTIONAL { <https://w3id.org/mica/resource/FS1> micamodel:hasValueSupplyChainConcept
?valueSupplyChain. }
}
group by ?title ?summary

```

Requested variables are:

- `?title` the FlowSheet title.
- `?summary` the FlowSheet summary.
- `?sheets` a String containing the ordered list of KnowledgeElement as URIs. Each KnowledgeElement is represented by its elementURI and role separated by ";". KnowledgeElements are separated by commas.
- `?authors` a String containing the list of authors as URIs of the FlowSheet. Each author is represented by its URI, and URIs are separated by commas.
- `?relatedURIs` a String containing the list of resources as URIs that the FlowSheet is relatedTo. Each resource is represented by its URI, and URIs are separated by commas. The string is empty if there is no related resource.
- `?domains` a String containing the list of Domain concepts as URIs that the FlowSheet is annotated with. Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Domain concept.

- `?methods` a String containing the list of Method concepts as URIs that the FlowSheet is annotated with.
Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no method concept.
- `?spatials` a String containing the list of Spatial concepts as URIs that the FlowSheet is annotated with.
Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Spatial concept.
- `?temporals` a String containing the list of Temporal concepts as URIs that the FlowSheet is annotated with.
Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Temporal concept.
- `?commodities` a String containing the list of Commodity concepts as URIs that the FlowSheet is annotated with.
Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Commodity concept.
- `?datas` a String containing the list of Data concepts as URIs that the FlowSheet is annotated with.
Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no Data concept.
- `?valueSupplyChains` a String containing the list of ValueSupplyChain concepts as URIs that the FlowSheet is annotated with.
Each concept is represented by its URI, and URIs are separated by commas. The string is empty if there is no ValueSupplyChain concept.

Retrieving FlowSheet data and related resources labels

The complete query to get all the information associated to `FS1` FlowSheet, in a human readable form, is as follows:

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT DISTINCT ?title ?summary
  (group_concat(DISTINCT ?sheet; separator = ",") AS ?sheets)
  (group_concat(DISTINCT ?name; separator = ",") AS ?authors)
  (group_concat(DISTINCT ?relatedURIlabel; separator = ",") AS ?relatedURIs)
  (group_concat(DISTINCT ?domainLabel; separator = ",") AS ?domains)
  (group_concat(DISTINCT ?methodLabel; separator = ",") AS ?methods)
  (group_concat(DISTINCT ?spatialLabel; separator = ",") AS ?spatials)
  (group_concat(DISTINCT ?temporalLabel; separator = ",") AS ?temporals)
  (group_concat(DISTINCT ?commodityLabel; separator = ",") AS ?commodities)
  (group_concat(DISTINCT ?dataLabel; separator = ",") AS ?datas)
  (group_concat(DISTINCT ?valueSupplyChainLabel; separator = ",") AS ?valueSupplyChains)

WHERE {
  <https://w3id.org/mica/resource/FS1>
```

```

a micamodel:FlowSheet;
dcterms:title ?title;
micamodel:summary ?summary;
micamodel:hasWriter ?author;
micamodel:hasElements/rdf:rest*/rdf:first ?element.
?element micamodel:role ?role;
micamodel:hasKnowledgeElement ?micaKnowledgeElementURI.
OPTIONAL{?micaKnowledgeElementURI dcterms:title ?micaKnowledgeElementURILabel.}
OPTIONAL{?micaKnowledgeElementURI micamodel:question ?micaKnowledgeElementURILabel.}
bind(concat(?micaKnowledgeElementURILabel,";",?role) as ?sheet)

?author foaf:givenName ?firstName;
foaf:familyName ?lastName.
bind(concat(?lastName," ",?firstName) as ?name)

OPTIONAL{
  <https://w3id.org/mica/resource/FS1> micamodel:relatedTo ?relatedURI.
  OPTIONAL{?relatedURI dcterms:title ?relatedURILabel.}
  OPTIONAL{?relatedURI micamodel:question ?relatedURILabel.}
}
OPTIONAL{
  <https://w3id.org/mica/resource/FS1> micamodel:hasDomainConcept ?domain.
  ?domain skos:prefLabel ?domainLabel.
}
OPTIONAL{
  <https://w3id.org/mica/resource/FS1> micamodel:hasMethodConcept ?method.
  ?method skos:prefLabel ?methodLabel.
}
OPTIONAL{
  <https://w3id.org/mica/resource/FS1> micamodel:hasSpatialConcept ?spatial.
  ?spatial skos:prefLabel ?spatialLabel.
}
OPTIONAL{
  <https://w3id.org/mica/resource/FS1> micamodel:hasTemporalConcept ?temporal.
  ?temporal skos:prefLabel ?temporalLabel.
}
OPTIONAL{
  <https://w3id.org/mica/resource/FS1> micamodel:hasCommodityConcept ?commodity.
  ?commodity skos:prefLabel ?commodityLabel.
}
OPTIONAL{
  <https://w3id.org/mica/resource/FS1> micamodel:hasDataConcept ?data.
  ?data skos:prefLabel ?dataLabel.
}
OPTIONAL{
  <https://w3id.org/mica/resource/FS1> micamodel:hasValueSupplyChainConcept ?value-
SupplyChain.
  ?valueSupplyChain skos:prefLabel ?valueSupplyChainLabel.
}
}
group by ?title ?summary

```

Requested variables are:

- ?title **the FlowSheet title.**
- ?summary **the FlowSheet summary.**

- `?sheets` a String containing the ordered list of KnowledgeElement as labels. Each KnowledgeElement is represented by its element's label and role separated by ";". KnowledgeElements are separated by commas.
- `?authors` a String containing the list of authors as labels of the FlowSheet. Each author is represented by its name as `(?lastName, " ", ?firstName)`, and names are separated by commas.
- `?relatedURIs` a String containing the list of resources as labels that the FlowSheet is relatedTo. Each resource is represented by its Label as title for `micamodel:MICAKnowledgeElement` or question for `micamodel:MICAQuestion`, and labels are separated by commas. The string is empty if there is no related resource.
- `?domains` a String containing the list of Domain concepts as labels that the FlowSheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Domain concept.
- `?methods` a String containing the list of Method concepts as labels that the FlowSheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no method concept.
- `?spatials` a String containing the list of Spatial concepts as labels that the FlowSheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Spatial concept.
- `?temporals` a String containing the list of Temporal concepts as labels that the FlowSheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Temporal concept.
- `?commodities` a String containing the list of Commodity concepts as labels that the FlowSheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Commodity concept.
- `?datas` a String containing the list of Data concepts as labels that the FlowSheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no Data concept.
- `?valueSupplyChains` a String containing the list of ValueSupplyChain concepts as labels that the FlowSheet is annotated with. Each concept is represented by its `prefLabel`, and `prefLabels` are separated by commas. The string is empty if there is no ValueSupplyChain concept.

[Get All flowSheets](#)

The following query selects all flowSheets by filtering by a given title text. Each metadata is represented by its label:

- filter text is ""
- offset is 0
- limit is 25

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT DISTINCT ?uri ?title ?summary
(group_concat(DISTINCT ?sheet; separator = ",") AS ?sheets)
(group_concat(DISTINCT ?name; separator = ",") AS ?authors)
(group_concat(DISTINCT ?relatedURIlabel; separator = ",") AS ?relatedURIs)
(group_concat(DISTINCT ?domainLabel; separator = ",") AS ?domains)
(group_concat(DISTINCT ?methodLabel; separator = ",") AS ?methods)
(group_concat(DISTINCT ?spatialLabel; separator = ",") AS ?spatials)
(group_concat(DISTINCT ?temporalLabel; separator = ",") AS ?temporals)
(group_concat(DISTINCT ?commodityLabel; separator = ",") AS ?commodities)
(group_concat(DISTINCT ?dataLabel; separator = ",") AS ?datas)
(group_concat(DISTINCT ?valueSupplyChainLabel; separator = ",") AS ?valueSupplyChains)

WHERE {
  ?uri a micamodel:FlowSheet;
      dcterms:title ?title;
      micamodel:summary ?summary;
      micamodel:hasWriter ?author;
      micamodel:hasElements/rdf:rest*/rdf:first ?element.
  ?element micamodel:role ?role;
      micamodel:hasKnowledgeElement ?micaKnowledgeElementURI.
  OPTIONAL{?micaKnowledgeElementURI dcterms:title ?micaKnowledgeElementURIlabel.}
  OPTIONAL{?micaKnowledgeElementURI micamodel:question ?micaKnowledgeElementURIlabel.}
  bind(concat(?micaKnowledgeElementURIlabel,";",?role) as ?sheet)
  ?author foaf:givenName ?firstName;
      foaf:familyName ?lastName.
  bind(concat(?lastName," ",?firstName) as ?name)
  OPTIONAL{
    ?uri micamodel:relatedTo ?relatedURI.
    OPTIONAL{?relatedURI dcterms:title ?relatedURIlabel.}
    OPTIONAL{?relatedURI micamodel:question ?relatedURIlabel.}
  }
  OPTIONAL{
    ?uri micamodel:hasDomainConcept ?domain.
    ?domain skos:prefLabel ?domainLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasMethodConcept ?method.
    ?method skos:prefLabel ?methodLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasSpatialConcept ?spatial.
    ?spatial skos:prefLabel ?spatialLabel.
  }
  OPTIONAL{
    ?uri micamodel:hasTemporalConcept ?temporal.
    ?temporal skos:prefLabel ?temporalLabel.
  }
}

```



```

OPTIONAL{
    ?uri micamodel:hasCommodityConcept ?commodity.
    ?commodity skos:prefLabel ?commodityLabel.
}
OPTIONAL{
    ?uri micamodel:hasDataConcept ?data.
    ?data skos:prefLabel ?dataLabel.
}
OPTIONAL{
    ?uri micamodel:hasValueSupplyChainConcept ?valueSupplyChain.
    ?valueSupplyChain skos:prefLabel ?valueSupplyChainLabel.
}

FILTER regex(str(?title), "", "i") }
GROUP BY ?uri ?title ?summary
ORDER BY ?title
OFFSET 0
LIMIT 25

```

Requested variables are:

- `?uri` the flowSheet URI.
- the other variables are the same as [Retrieving FlowSheet data and related resources labels](#).

Count FlowSheets

The following query counts all FlowSheets by filtering with a given title text:

- filter text is ""

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT (COUNT ( DISTINCT ?uri) AS ?nbresources)

WHERE {
    ?uri a micamodel:FlowSheet;
        dcterms:title ?title.
    FILTER regex(str(?title), "", "i")
}

```

Requested variables are:

- `?uri` the flowSheet URI.
- `?title` the flowSheet title.
- `?nbresources` the number of selected FlowSheets.

RelatedResources Queries

Create a relatedTo relation between two Resources

The following query creates a relatedTo relation between two Resources:

- FS1 a FlowSheet
- MQ1 a MICAQuestion

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
INSERT DATA {
  <https://w3id.org/mica/resource/FS1> micamodel:relatedTo <https://w3id.org/mica/resource/MQ1> .
}
```

Remove a relatedTo relation between two Resources

The following query removes a relatedTo relation between two MICAResources:

- FS1 a FlowSheet

```
MQ1 a MICAQuestion
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
DELETE {
  <https://w3id.org/mica/resource/FS1> micamodel:relatedTo <https://w3id.org/mica/resource/MQ1> .
  <https://w3id.org/mica/resource/MQ1> micamodel:relatedTo <https://w3id.org/mica/resource/FS1> .
}
WHERE {
  <https://w3id.org/mica/resource/FS1> micamodel:relatedTo <https://w3id.org/mica/resource/MQ1> .
}
```

List of relatedTo

The following query get a list of relation relatedTo by filtering by a given text for label:

- filter text is ""
- offset is 0
- limit is 25

```
PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>
```

```

SELECT ?uri ?relatedURI ?uriLabel ?relatedURILabel
WHERE {
  ?uri micamodel:relatedTo ?relatedURI.
  OPTIONAL{?uri dcterms:title ?uriLabel.}
  OPTIONAL{?uri micamodel:question ?uriLabel.}
  FILTER regex(str(?uriLabel), "", "i")

  OPTIONAL{?relatedURI dcterms:title ?relatedURILabel.}
  OPTIONAL{?relatedURI micamodel:question ?relatedURILabel.}
}
OFFSET 0
LIMIT 25

```

Requested variables are:

- `?uri` **the Resource URI.**
- `?relatedURI` **the related Resource URI.**
- `?uriLabel` **the label of uri.**
- `?relatedURILabel` **the related Resource label.**

Count the relatedTo

The following query counts all relatedTo relation by filtering with a given text:

- **filter text is ""**

```

PREFIX micamodel: <https://w3id.org/mica/ontology/MicaModel#>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT (COUNT (DISTINCT ?uri) AS ?nbRelatedTos)
WHERE {
  ?uri micamodel:relatedTo ?relatedURI.
  OPTIONAL{?uri dcterms:title ?uriLabel.}
  OPTIONAL{?uri micamodel:question ?uriLabel.}
  FILTER regex(str(?uriLabel), "", "i")
}

```

Requested variables are:

- `?uri` **the MICAResource URI.**

Appendix 6. Inference rules for the MICA Triple Store

This appendix presents the inferences rules defined for the Fuseki server that manages the MICA Triple Store. The inference rules are defined according to the MICA model and SKOS semantics.

For example, in SKOS `skos:broader` and `skos:narrower` are inverse properties. This statement means that:

```
<A> skos:narrower <B> . entails <B> skos:broader <A> .
```

In Fuseki server, this rule is specified in the following manner:

```
@prefix skos: <http://www.w3.org/2004/02/skos/core#> .  
  
# R1: create the narrower property  
[broaderNarrowerRule: (?A skos:broader ?B) -> (?B skos:narrower ?A) ]
```

For MICA, 18 inferences rules must be defined in a file named `MICA.rules` stored in the configuration folder of Fuseki server.

```
@prefix skos: <http://www.w3.org/2004/02/skos/core#> .  
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .  
@prefix micamodel: <https://w3id.org/mica/ontology/MicaModel#> .  
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .  
@prefix micavocab: <https://w3id.org/mica/ontology/MicaOntology/> .  
  
# R1: create the narrower property  
[broaderNarrowerRule: (?A skos:broader ?B) -> (?B skos:narrower ?A) ]  
  
# R2: create the directly broaderTransitive property  
[broaderRule: (?A skos:broader ?B) -> (?A skos:broaderTransitive ?B) ]  
  
# R3: create the hierarchical broaderTransitive property  
[broaderTransitiveRule: (?A skos:broaderTransitive ?B),(?B skos:broaderTransitive ?C)  
-> (?A skos:broaderTransitive ?C) ]  
  
# R4: create the directly narrowerTransitive property  
[narrowerRule: (?A skos:narrower ?B) -> (?A skos:narrowerTransitive ?B) ]  
  
# R5: create the hierarchical narrowerTransitive property  
[narrowerTransitiveRule: (?A skos:narrowerTransitive ?B),(?B skos:narrowerTransitive ?C)  
-> (?A skos:narrowerTransitive ?C) ]  
  
# R6: create the reflexive broaderTransitive and narrowerTransitive  
[conceptReflexiveRule: (?A rdf:type skos:Concept)  
-> (?A skos:broaderTransitive ?A), (?A skos:narrowerTransitive ?A) ]  
  
# R7: create the symmetric property for related concept  
[relatedRule: (?A skos:related ?B) -> (?B skos:related ?A) ]  
  
# R8: create Heritage on data  
[ dataHeritageRule: (?A rdf:type ?B ),(?B rdfs:subClassOf ?C ) -> (?A rdf:type ?C )]
```

```

# R9: create heritage on class
[ subClassRule: (?A rdfs:subClassOf ?B ),(?B rdfs:subClassOf ?C )-> (?A rdfs:subClassOf ?C )]

# R10: create Heritage on property
[ propertyHeritageRule: (?P rdfs:subPropertyOf ?Q ),(?A ?P ?B )-> (?A ?Q ?B ) ]

# R11: create the symetric property for relatedTo MICAResource
[ relatedToRule: (?A micamodel:relatedTo ?B) -> (?B micamodel:relatedTo ?A)]

# R12: create the DomainConcept
[ DomainConceptRule: (?A rdf:type skos:Concept ),(?A skos:inScheme micavocab:DomainScheme )
-> (?A rdf:type micamodel:DomainConcept)]

# R13: create the MethodConcept
[ MethodConceptRule: (?A rdf:type skos:Concept ),(?A skos:inScheme micavocab:MethodScheme )
-> (?A rdf:type micamodel:MethodConcept)]

# R14: create the DataConcept
[ DataConceptRule: (?A rdf:type skos:Concept ),(?A skos:inScheme micavocab:DataScheme )
-> (?A rdf:type micamodel:DataConcept)]

# R15: create the TemporalConcept
[ TemporalConceptRule: (?A rdf:type skos:Concept ),(?A skos:inScheme micavocab:TemporalScheme )
-> (?A rdf:type micamodel:TemporalConcept)]

# R16: create the SpatialConcept
[ SpatialConceptRule: (?A rdf:type skos:Concept ),(?A skos:inScheme micavocab:SpatialScheme )
-> (?A rdf:type micamodel:SpatialConcept)]

# R17:create the CommodityConcept
[ CommodityConceptRule: (?A rdf:type skos:Concept ),
(?A skos:inScheme micavocab:CommodityScheme ) -> (?A rdf:type micamodel:CommodityConcept)]

# R18: create the ValueSupplyChainConcept
[ ValueSupplyChainConceptRule: (?A rdf:type skos:Concept ),
(?A skos:inScheme micavocab:ValueSupplyChainScheme )
-> (?A rdf:type micamodel:ValueSupplyChainConcept)]

```

Then the Fuseki dataset that stores the MICA RDF graph must be configured to uses these inferences rules. To do that the, supposing the MICA RDF graph is stored in a dataset name micaDataset, the micaDataset.ttl file in the configuration folder of fuseki server must be look like:

```

@prefix : <http://base/#> .
@prefix tdb: <http://jena.hp1.hp.com/2008/tdb#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix ja: <http://jena.hp1.hp.com/2005/11/Assembler#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix fuseki: <http://jena.apache.org/fuseki#> .

:service_tdb_all a fuseki:Service ;
  rdfs:label "TDB testMicaOntology" ;
  fuseki:dataset :tdb_dataset_readwrite ;
  fuseki:name "testMicaOntology" ;
  fuseki:serviceQuery "query" , "sparql" ;
  fuseki:serviceReadGraphStore "get" ;
  fuseki:serviceReadWriteGraphStore
    "data" ;
  fuseki:serviceUpdate "update" ;
  fuseki:serviceUpload "upload" .

```

```
:tdb_dataset_readwrite rdf:type ja:RDFDataset ;
    ja:defaultGraph :modelInf .

:modelInf a ja:InfModel ;
    ja:reasoner [
        ja:reasonerURL <http://jena.hp1.hp.com/2003/GenericRuleReasoner> ;
        ja:rulesFrom <file:./MICA.rules> ;
    ] ;
    ja:baseModel :dataGraph .

:dataGraph a    tdb:GraphTDB ;
    tdb:location "/srv/fuseki/databases/testMicaOntology" ;
```

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