Refining Hyponymy in a Terminological Knowledge Base

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Abstract

Hyponymy or *type_of* relation is the backbone of all hierarchical semantic configurations. Although recent work has focused on other relations such as meronymy and causality, hyponymy maintains its special status since it implies property inheritance. As reflected in EcoLexicon, a multilingual terminological knowledge base on the environment, conceptual relations are a key factor in the design of an internally and externally coherent concept system. Terminological knowledge bases can strengthen their coherence and dynamicity when the set of conceptual relations is wider than the typical generic-specific and part-whole relations, which entails refining both the hyponymy and meronymy relations. This paper analyzes how hyponymy is built in the EcoLexicon knowledge base and discusses the problems that can ensue when the *type_of* relation is too simplistically defined or systematically represented. As a solution, this paper proposes the following: (i) the correction of property inheritance; (ii) the specification of different subtypes of hyponymy; (iii) the creation of 'umbrella concepts'. This paper focuses on the first two solutions and proposes a set of parameters that can be used to decompose hyponymy.

Keywords: terminological knowledge bases, conceptual modelling, generic-specific relations

1. Introduction

In recent years, research in specialized language has begun to acknowledge the need for an interdisciplinary approach and for a set of theoretical premises that will make conceptual modelling more objective (León-Araúz et al., 2012). In fact, the study of terminology and specialized communication is currently experiencing a 'cognitive shift' (Faber, 2009), which is granting greater importance to conceptual organization as reflected in neurological processes (Faber et al., 2014). Terms are specialized knowledge units used to designate the objects, events and processes characteristic of a specialized domain. In the same way as language mirrors the mind, terminological structure can be regarded as a reflection of conceptual structure.

However, the specification of conceptual structure must be grounded on a set of theoretical assumptions regarding categorization, more specifically, whether and to what extent sensory information is part of semantic representation and processing (Meteyard et al., 2012). In this sense, Patterson et al. (2007), propose a supramodal format for semantic representations, which is modality-invariant though derived from mappings across sensory and motor input. In Terminology, the correlate of this supramodal representation is a category schema or template as posited by various authors (Faber et al., 2014; Roche et al., 2009; Leonardi, 2010). This top-level schema constrains perceptual input though, at the same time, it is also derived from sensorimotor mappings. This type of schema facilitates the retrieval of all the information stored, and is the frame for any semantic network.

Not surprisingly, the configuration of specialized concepts in networks with both hierarchical and non-hierarchical or associative relations has proven to be one of the most important aspects of terminology work (León-Araúz et al., 2012). Nevertheless, this task is far from simple because, in certain cases, the semantics of the relations are too vague, as can be observed in many thesauri, conceptual maps, and semantic networks (Jouis, 2006). That is the reason why a wide range of methods for structuring knowledge have been considered in Terminology. These include extending non-hierarchical relations, specifying the properties of the relations, and integrating innovative theories from linguistics and artificial intelligence. In order to guarantee high-quality terminological work, it is thus necessary to establish a methodology based on logical properties that will facilitate the accurate organization of conceptual relations.

2. Terminological Knowledge Bases and Conceptual Relations

Regarded by Meyer et al. (1992) as a hybrid between term banks and knowledge bases, terminological knowledge bases (TKBs) represent the specialized knowledge of a certain field through related concepts and the terms that designate them in one or various languages. A TKB is thus a product that reflects both linguistic and cognitive processes. Optimally, TKBs should reflect how conceptual networks are established and structured in our minds. They must also be designed to meet the needs of a specific group of users, whether they are experts or lay public.

According to León-Araúz et al. (2013), TKBs should account for the representation of natural and contextual knowledge dynamism. Various issues must thus be considered when designing and creating a TKB. On the one hand, the organization of the knowledge field should accurately represent the concepts and the semantic relations linking them. On the other hand, access to information and its retrieval should facilitate knowledge acquisition.

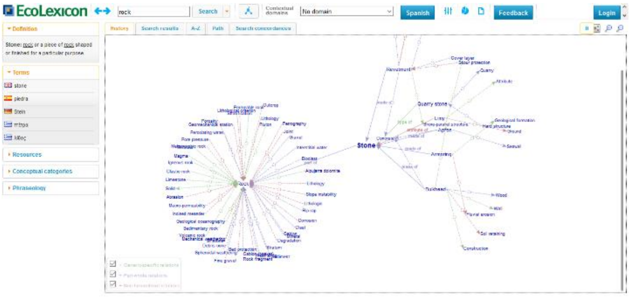

Figure 1: Visual interface of EcoLexicon

One difficulty in concept representation stems from the fact that the characteristics of a concept may vary depending on the perspective taken. Such conceptual multidimensionality can affect a wide range of properties from shape to function (Kageura, 1997). The representation of multidimensionality is thus a major challenge in TKB design since extracting a few concepts and establishing simple relations between them results in monodimensional systems, which are unrealistic and only permit *in vitro* knowledge acquisition (Dubuc & Lauriston, 1997; Cabré, 1999).

Nevertheless, the representation of multidimensionality must also follow rules. In this sense, conceptual (semantic) relations cannot be created on demand, but should systematically be derived from a set inventory (León-Araúz et al., 2012).

EcoLexicon[1] is one example of a multidimensional TKB. It is a multilingual knowledge resource on the environment whose content can be accessed through a user-friendly visual interface with different modules for conceptual, linguistic and graphical information (Faber et al., 2014; Reimerink et al., 2010) (see Figure 1). EcoLexicon targets different user groups interested in expanding their knowledge of the environment for text comprehension and generation, such as environmental experts, technical writers, and translators. This resource is available in English and Spanish, though five more languages (German, Modern Greek, Russian, French and Dutch) are being progressively implemented. It currently contains a total of 3,599 concepts and 20,070 terms.

In EcoLexicon, conceptual relations are classified in three main groups: generic-specific relations, part-whole relations and non-hierarchical relations (see Figure 2). As can be observed, hierarchical relations have been divided into two groups to distinguish between hyponymic relations and meronymic relations. The set of generic-specific relations only comprises *type_of*. In contrast, the set of part-whole relations contains *part_of*, *made_of*, *delimited_by*, *located_at*, *takes_place_in*, and *phase_of*. In the last place, the set of non-hierarchical relations includes *affects*, *causes*, *attribute_of*, *opposite_of*, *studies*, *measures*, *represents*, *result_of*, *effected_by*, and *has_function*. The set of all conceptual relations in EcoLexicon comes to a total of 17. In some cases, these relations are domain-specific (e.g. *measures*), which means that the set of conceptual relations of a TKB may vary from one field of knowledge to another.

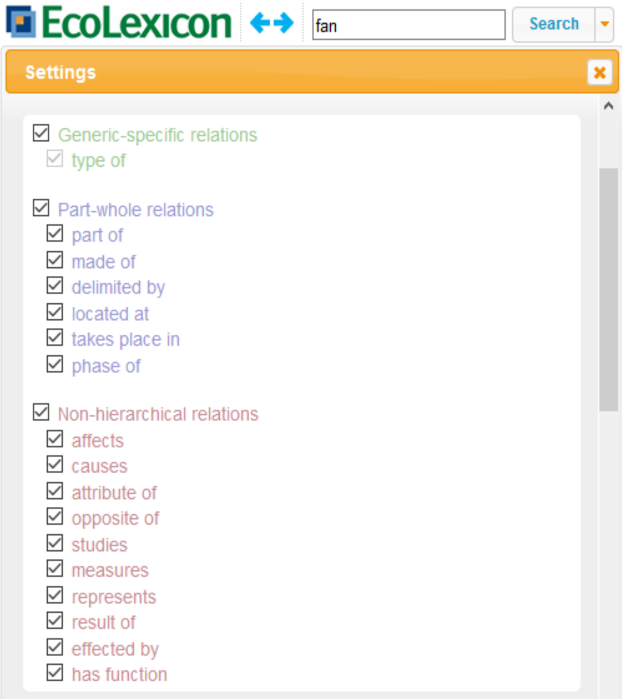

Figure 2: Semantic relations in EcoLexicon

3. Refining Hyponymy in EcoLexicon

TKBs can acquire greater coherence and dynamicity when the range of conceptual relations is wider than the traditional generic-specific and part-whole relations (León-Araúz et al., 2012), which entails taking into consideration non-hierarchic relations and, in addition, expanding the original sense of both hyponymy and meronymy. In EcoLexicon, the meronymic relation *part_of* has already been divided into subtypes, as shown in Figure 2. For example, even though CONDENSATION is *part_of* the HYDROLOGIC CYCLE, it is more accurate to say that CONDENSATION is a *phase_of* the HYDROLOGIC CYCLE. This distinction was made in EcoLexicon because of the following factors: (i) domain-specific needs, (ii) ontological reasoning, and (iii) transitivity-related consistency (León-Araúz & Faber, 2010).

Nevertheless, the *type_of* relation still has not been subdivided. This is the source of a wide range of problems in EcoLexicon, such as different cohyponyms at the same level (see Figure 3), which produces noise as well as information overload and redundancy. Still another problem lies in transitivity and property inheritance. For example: LIMESTONE is currently represented as a hyponym to both ROCK and SEDIMENTARY ROCK. A possible solution would be to refine the *type_of* relation.

[1] http://ecolexicon.ugr.es/

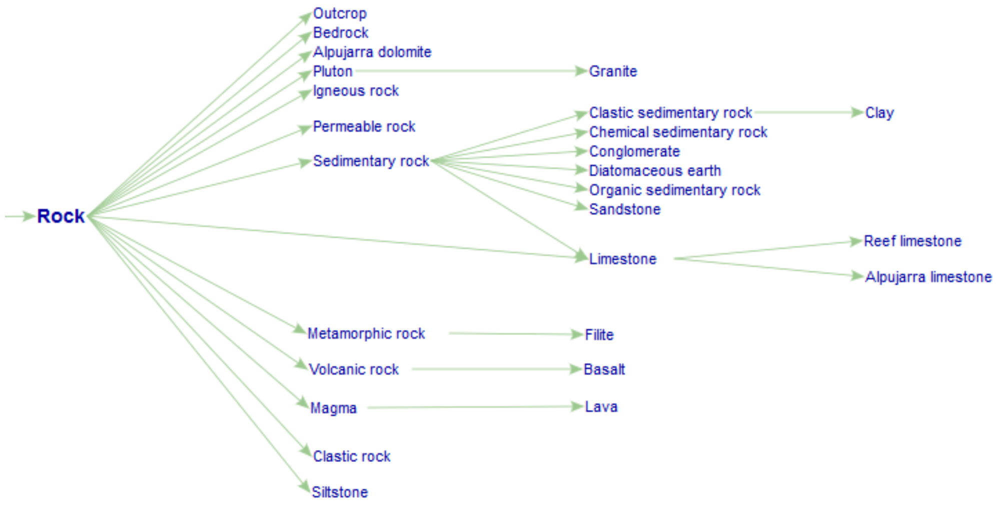

Figure 3: Presence of different dimensions of cohyponyms at the same level, and transitivity problems

Murphy (2003, 2006) states that hyponymy is a relation of inclusion whose converse is hyperonymy. Due to its inference-invoking nature, its importance in definitions, and its relevance to selectional restrictions in grammar, hyponymy is central in many models of the lexicon. Similarly to meronymy, hyponymy can be divided into subtypes (Murphy, 2003), but those subtypes should provide a valid taxonomy of generic-specific relations. According to Murphy (*ibid*: 219-220), the most commonly established distinction is among taxonomic hyponymy ('is-a-kind-of' relation) and functional hyponymy ('is-used-as-a-kind' relation). In some way, this dichotomy is related to what Cruse (2002) calls 'facets'.

On the other hand, another important phenomenon in the specification of hyponymic relations is the existence of 'microsenses' (Cruse, 2002), which are only activated in a certain context. In EcoLexicon, microsenses can already be made explicit by entering different concepts as hyperonyms of the same hyponym. It is even possible to filter the query by restricting the represented contextual domain (see Figure 4). More precisely, conceptual propositions (concept-relation-concept) in EcoLexicon are triggered or constrained based on their salience in different discipline-based subdomains.

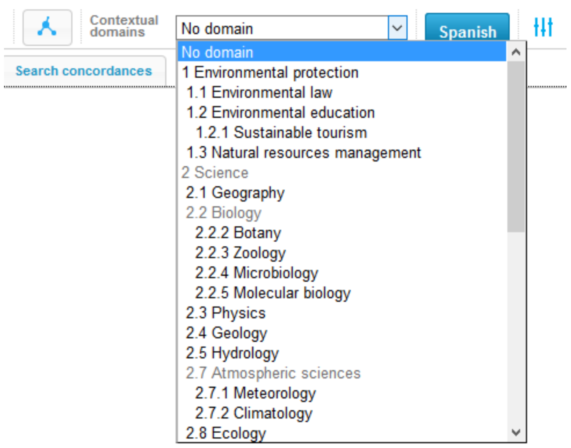

Figure 4: Contextual domains in EcoLexicon

This shows that the same concept may have different context-dependent hyperonyms, reflecting only a selection of its 'microsenses'. This phenomenon can be observed in Figures 5 and 6, which illustrate the different conceptual networks of SAND in the Soil Sciences domain (see Figure 5) and in the Geology domain (see Figure 6).

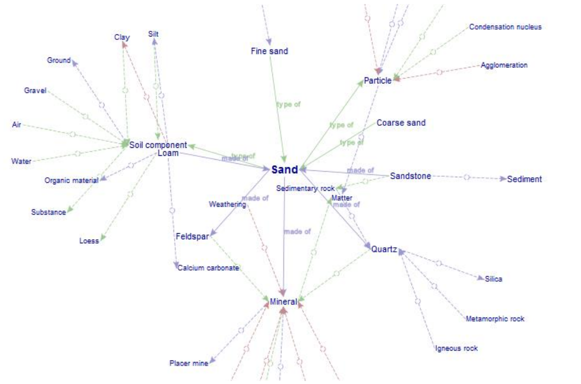

Figure 5: SAND network in Soil Sciences

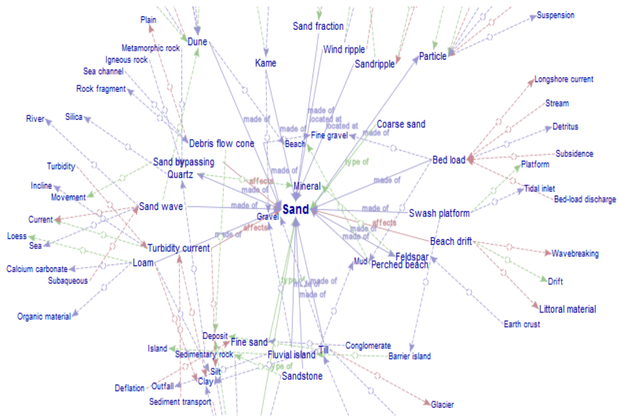

Figure 6: SAND network in Geology

Furthermore, Gheorghita & Pierrel (2012) state that the meaning of an input in a TKB can be disambiguated just by adding a domain to the definition. In the case of EcoLexicon, domains are not applied to definitions, but to conceptual relations. However, according to its database, only 2624 (50%) of all relations have been classified using a domain, and this invalidates the possibility of being completely accurate using this method.

Moreover, there is still the need to further refine the *type_of* relation. Possible solutions include: (i) the correction of property inheritance; (ii) the specification of different subtypes of hyponymy; and (iii) the creation of 'umbrella concepts'. This paper focuses on the first two, since the correction of property inheritance is the first step towards dividing the *type_of* relation into subtypes.

3.1 Correcting Property Inheritance

As previously mentioned, hyponymy is a unidirectional relation where child concepts inherit the properties of their parent concepts, though they also have differentiating properties that make their meaning more specific. In a TKB, property inheritance between hyperonyms and hyponyms can be represented through genus–differentia definitions, based on the explicitation of the *genus* (hyperonym or superordinate) and one or many *differentiae* (characteristics that vary between cohyponyms) (Temmerman, 2000).

Despite the fact that most of the concepts in EcoLexicon are defined in this way, transitivity problems still arise (see Figure 3). This paper proposes a solution, as exemplified in the analysis of two types of concept: an entity (ROCK) and a process (EROSION).

3.1.1. Property Inheritance in the Conceptual Network of an Entity: ROCK

The original *type_of* network of ROCK was initially not accurately defined (see Figure 3). For example, LIMESTONE appeared as a direct hyponym of both ROCK and SEDIMENTARY ROCK, and there were two similar entities that designated 'clastic rock' at two different levels (CLASTIC ROCK and CLASTIC SEDIMENTARY ROCK). In order to solve such problems and related issues, the conceptual network of ROCK was enhanced with the addition of new concepts (e.g. SOLID ROCK, MOLTEN ROCK or DOLOMITE) and the property inheritance relations were restructured.

Table 1 shows an example of property inheritance in the original conceptual network. BASALT is defined as a 'rock of igneous origin', but its hyperonym (VOLCANIC ROCK) is also defined as an 'igneous rock'. Furthermore, the hyperonym of VOLCANIC ROCK is assumed to be ROCK, regardless of the fact that the only types of rock mentioned in its definition are 'igneous, sedimentary and metamorphic'.

ROCK: consolidated or unconsolidated aggregate or mass of minerals or organic materials. The three types of rock are igneous, sedimentary, and metamorphic.
VOLCANIC ROCK: extrusive igneous rock solidified near or on the surface of the Earth, resulting from volcanic activity.
BASALT: very hard rock of igneous origin, consisting of augite and triclinic feldspar, with grains of magnetic or titanic iron, and also bottle-green particles of olivine. It is formed by decompression melting of the Earth's mantle.

Table 1: ROCK – BASALT in the former conceptual network (original definitions)

Table 2 shows how property inheritance has been improved in the enhanced conceptual network. In this case, it is respected in all senses: BASALT is a *type_of* VOLCANIC ROCK, which is a *type_of* IGNEOUS ROCK, which is a *type_of* SOLID ROCK, which is a *type_of* ROCK. In other words, BASALT in the end reflects the inheritance of the characteristics possessed by all of its hyperonyms.

ROCK: consolidated or unconsolidated aggregate or mass of minerals or organic materials.
SOLID ROCK: rock in solid state, formed by the compression of sediments or the solidification of molten material.
IGNEOUS ROCK: solid rock formed by solidification of molten magma either beneath or at the Earth's surface.
VOLCANIC ROCK: extrusive igneous rock solidified near or on the surface of the Earth, resulting from volcanic activity.
BASALT: very hard volcanic rock, consisting of augite and triclinic feldspar, with grains of magnetic or titanic iron, and also bottle-green particles of olivine. It is formed by decompression melting of the Earth's mantle.

Table 2: ROCK – BASALT in the new conceptual network (enhanced definitions)

Finally, as a result of modifications in the remaining conceptual relations, improved terminological definitions, and the addition of new concepts to fill semantic gaps, the conceptual network of ROCK was enhanced (see Table 3).

<table>
<thead>
<tr><th>LEVEL 0</th><th>LEVEL 1</th><th>LEVEL 2</th><th>LEVEL 3</th><th>LEVEL 4</th><th>LEVEL 5</th></tr>
</thead>
<tbody>
<tr><td>ROCK < type_of -</td><td>solid rock < type_of -------</td><td>sedimentary rock < type_of ----</td><td>limestone < type_of -------------</td><td>reef limestone |
Alpujarra limestone |</td><td></td></tr>
<tr><td></td><td></td><td></td><td>clastic rock < type_of -----------</td><td>clay |</td><td></td></tr>
<tr><td></td><td></td><td></td><td>chemical sedimentary rock < type_of</td><td>dolomite < type_of -</td><td>Alpujarra dolomite |</td></tr>
<tr><td></td><td></td><td></td><td>organic sedimentary rock |
conglomerate |
diatomaceous earth |
sandstone |
siltstone |</td><td></td><td></td></tr>
<tr><td></td><td></td><td>igneous rock < type_of ---------</td><td>plutonic rock < type_of ---------</td><td>granite |</td><td></td></tr>
<tr><td></td><td></td><td></td><td>volcanic rock < type_of ---------</td><td>basalt |</td><td></td></tr>
<tr><td></td><td></td><td>metamorphic rock < type_of ---</td><td>filite |</td><td></td><td></td></tr>
<tr><td></td><td></td><td>permeable rock |
bedrock |
outcrop |</td><td></td><td></td><td></td></tr>
<tr><td></td><td>molten rock < type_of ----</td><td>magma < type_of ----------------</td><td>lava |</td><td></td><td></td></tr>
</tbody>
</table>

Table 3: Enhanced conceptual network of ROCK (generic-specific relations)

3.1.2. Property Inheritance in the Conceptual Network of a Process: EROSION

Property inheritance is also manifested in 'process' type of concepts. In this case, the original conceptual network of EROSION was also analyzed to examine if the inheritance of characteristics between parent and child concepts was accurate. As a result, certain concepts had to be relocated, and the definitions of some hyponyms needed to be enhanced to correct property inheritance.

To portray how property inheritance has been corrected in the definitions of concepts, another comparison has been made to show the differences in the *type_of* relation established from EROSION to CHANNEL SCOUR. As can be observed in the original conceptual network (see Table 4), CHANNEL SCOUR, located at the third level with respect to EROSION, is defined as 'erosion' when it should inherit the traits of its direct hyperonym, SCOUR.

EROSION: process by which materials of the Earth's crust are worn away, loosened, or dissolved while being transported from their place of origin by different agents, such as wind, water, bacteria, etc.
FLUVIAL EROSION: <u>erosion</u> of bedrock on the sides and bottom of the river; the erosion of channel banks; and the breaking down of rock fragments into smaller fragments by the flow of water in the channel.
SCOUR: localized <u>erosive action of water</u> in streams, excavating and carrying away material from the bed and banks.
CHANNEL SCOUR: <u>erosion</u> of a stream bed.

Table 4: EROSION – CHANNEL SCOUR in the former conceptual network (original definitions)

In contrast, in the enhanced conceptual network (see Table 5), property inheritance is well expressed, since each hyponym adopts the characteristics of its hyperonym: CHANNEL SCOUR is a *type_of* SCOUR, which is a *type_of* FLUVIAL EROSION, which is a *type_of* WATER EROSION, which is a *type_of* EROSION. Therefore, CHANNEL SCOUR (at the fourth level of hyponymy), is now defined as a type of SCOUR rather than as a type of EROSION.

EROSION: process by which materials of the Earth's crust are worn away, loosened, or dissolved while being transported from their place of origin by different agents, such as wind, water, bacteria, etc.
WATER EROSION: <u>erosion</u> of rocks and sediment by water, involving detachment, transport and deposition.
FLUVIAL EROSION: <u>water erosion</u> of bedrock on the sides and bottom of the river; the erosion of channel banks; and the breaking down of rock fragments into smaller fragments by the flow of water in the channel.
SCOUR: localized <u>fluvial erosion</u> in streams, excavating and carrying away material from the bed and banks.
CHANNEL SCOUR: <u>scour</u> of a stream bed.

Table 5: EROSION – CHANNEL SCOUR in the new conceptual network (enhanced definitions)

Nevertheless, the previously mentioned modifications were not the only changes made to refine the conceptual network, as new concepts (e.g. WATER EROSION, RILL EROSION or STREAMBANK EROSION) were also added. In the end, an enhanced version was obtained (see Table 6). The correction of property inheritance not only enhances content, but also indicates how hyponymy can be decomposed into subtypes as discussed in the following section.

<table>
<tr><th>LEVEL 0</th><th>LEVEL 1</th><th>LEVEL 2</th><th>LEVEL 3</th><th>LEVEL 4</th></tr>
<tr><td>EROSION < type_of -</td><td>water erosion < type_of -</td><td>fluvial erosion < type_of</td><td>scour < type_of ------</td><td>channel scour |
outflanking |</td></tr>
<tr><td></td><td></td><td></td><td>sheet erosion |
rill erosion |
gully erosion |
streambank erosion |</td><td></td></tr>
<tr><td></td><td></td><td>sea erosion |</td><td></td><td></td></tr>
<tr><td></td><td>wind erosion < type_of --</td><td>deflation |</td><td></td><td></td></tr>
<tr><td></td><td>abrasion < type_of -------</td><td>glacier abrasion |</td><td></td><td></td></tr>
<tr><td></td><td>anthropic erosion |
glacier erosion |
internal erosion |
potential erosion |
differential erosion |
attrition |
denudation |</td><td></td><td></td><td></td></tr>
</table>

Table 6: Enhanced conceptual network of EROSION (generic-specific relations)

3.2. Specifying Subtypes of Hyponymy

According to Murphy (2003, 2006), hyponymy can be divided into subtypes, such as taxonomic hyponymy and functional hyponymy. In this case, the conceptual networks in EcoLexicon show a more fine-grained set of subtypes, which are initially based on whether the concept is an entity (ROCK) or a process (EROSION).

3.2.1. Subtypes of Hyponymy in the Conceptual Network of an Entity: ROCK

Based on the improved conceptual network of ROCK (see Table 3) and the enhanced concept definitions, up to five different subtypes of hyponymy related to entities can be established:

- **Formation-based hyponymy:** a *type_of* relation dependent on the formation process or the origin of the hyponyms.
- **Composition-based hyponymy:** a *type_of* relation dependent on the components or the constituents of the hyponyms.
- **Location-based hyponymy:** a *type_of* relation dependent on the physical situation or location of the hyponyms.
- **State-based hyponymy:** a *type_of* relation dependent on the state of matter of the hyponyms.
- **Attribute-based hyponymy:** a *type_of* relation dependent on the traits or features of the hyponyms.

Table 7 offers examples of these subtypes in the conceptual network of ROCK. For instance, IGNEOUS ROCK is considered to be a *formation-based_type_of* SOLID ROCK because it is 'formed by solidification of molten magma'; REEF LIMESTONE is presented as a *composition-based_type_of* LIMESTONE since it is 'composed of the remains of sedentary organisms'; and VOLCANIC ROCK is represented as a *location-based_type_of* IGNEOUS ROCK because it is 'solidified near or on the surface of the Earth'.

Formation-based hyponymy: (X *formation-based_type_of* Y)
• SEDIMENTARY ROCK < SOLID ROCK • IGNEOUS ROCK < SOLID ROCK • CLASTIC ROCK < SEDIMENTARY ROCK
Composition-based hyponymy: (X *composition-based_type_of* Y)
• DOLOMITE < CHEMICAL SEDIMENTARY ROCK • ORGANIC SEDIMENTARY ROCK < SEDIMENTARY ROCK • REEF LIMESTONE < LIMESTONE
Location-based hyponymy: (X *location-based_type_of* Y)
• BEDROCK < SOLID ROCK • VOLCANIC ROCK < IGNEOUS ROCK • ALPUJARRA LIMESTONE < LIMESTONE
State-based hyponymy: (X *state-based_type_of* Y)
• SOLID ROCK < ROCK • MOLTEN ROCK < ROCK
Attribute-based hyponymy: (X *attribute-based_type_of* Y)
• PERMEABLE ROCK < SOLID ROCK

Table 7: Examples of the subtypes of hyponymy found in the conceptual network of ROCK

Nevertheless, not all hyponymic relations can be classified using a subtype. There are certain child concepts whose differentiating features make it impossible to determine one subtype of hyponymy. For example, GRANITE is a *type_of* PLUTONIC ROCK based on its attributes ('coarse-grained, light-colored, hard'), its composition ('consisting chiefly of quartz, orthoclase or microline, and mica') and its function ('used as a building material'). Such cases will remain classified as general taxonomic hyponymy, or as a non-specific *type_of* relation.

Nonetheless, this list of subtypes is not a closed inventory of hyponymic relations, but only those which have been distinguished so far in the conceptual network of ROCK and similar entities. In fact, in regards to WATER, two more subtypes of hyponymy have been noticed:

- **Function-based hyponymy:** a *type_of* relation dependent on the function or the purpose of the hyponyms.
  e.g. DRINKING WATER *function-based_type_of* WATER
- **Shape-based hyponymy:** a *type_of* relation dependent on the shape or the physical aspect of the hyponyms.
  e.g. AMORPHOUS FROST *shape-based_type_of* FROST

A minimum number of coincidences will eventually be established to confirm the validity (and usefulness) of a subtype of hyponymy.

3.2.2. Subtypes of Hyponymy in the Conceptual Network of a Process: EROSION

In reference to EROSION (see Table 6), up to four subtypes of hyponymy, typical of processes, were established:

- **Agent-based hyponymy:** a *type_of* relation dependent on the agent or the promoter that causes the hyponyms.
- **Patient-based hyponymy:** a *type_of* relation dependent on the entity or location affected by the hyponyms.
- **Result-based hyponymy:** a *type_of* relation dependent on the results and effects of the hyponyms.
- **Attribute-based hyponymy:** a *type_of* relation dependent on the traits or features of the hyponyms.

Table 8 contains some examples of these subtypes of hyponymy found in the conceptual network of EROSION. For example, ANTHROPIC EROSION is considered to be an *agent-based_type_of* EROSION because it is 'caused by human activities'; GLACIER ABRASION is regarded as a *patient-based_type_of* ABRASION since it is the abrasion 'of a glacier bed'; and RILL EROSION is a *result-based_type_of* FLUVIAL EROSION because it 'forms small channels'.

As shown in Table 8, the subtypes of process hyponymy are different from those of an entity (except for attribute-based hyponymy, which is common to both). A process is generally a nominalization of a verb, and thus it often involves an agent, a patient, and a result. This differs from formation, composition, and state, which are typical of entities. Moreover, in the case of processes, patient-based hyponymy sometimes overrides location-based hyponymy, as the patient can be a physical location (e.g. CHANNEL SCOUR affects a stream bed, and therefore takes place in a stream bed).

Furthermore, the general taxonomic hyponymy (*type_of*) is also present in processes. In fact, various examples of it can be found in the conceptual network of EROSION. For instance, DENUDATION is a *type_of* EROSION based on its agents ('caused by the action of water, ice, wind and waves'), its patient ('the Earth's surface') and its result ('redistribution of Earth surface material').

Agent-based hyponymy (X *agent-based_type_of* Y)
• SEA EROSION < EROSION • ANTHROPIC EROSION < EROSION • FLUVIAL EROSION < WATER EROSION
Patient-based hyponymy (X *patient-based_type_of* Y)
• STREAMBANK EROSION < FLUVIAL EROSION • GLACIER ABRASION < ABRASION • CHANNEL SCOUR < SCOUR
Result-based hyponymy (X *result-based_type_of* Y)
• SHEET EROSION < FLUVIAL EROSION • RILL EROSION < FLUVIAL EROSION • GULLY EROSION < FLUVIAL EROSION
Attribute-based hyponymy: (X *attribute-based_type_of* Y)
• POTENTIAL EROSION < EROSION • DIFFERENTIAL EROSION < EROSION

Table 8: Examples of the subtypes of hyponymy found in the conceptual network of EROSION

In the same way as for entities, this set of subtypes of hyponymy is not a closed set since further research is needed to determine the extension and scope of subtypes of hyponymy applied to processes.

4. Conclusion

In this paper we have analyzed how to refine hyponymy in EcoLexicon, a multilingual terminological knowledge base on the environment. We have revised the theoretical background behind the fundamental characteristics of TKBs, their representation of multidimensionality and their reflection of conceptual relations. We have also studied how hyponymy is built in EcoLexicon and how different facets and microsenses can be expressed. The correction of property inheritance is a preliminary though essential phase in the refinement of the *type_of* relation.

This preliminary study has shown how to refine generic-specific relations and establish subtypes of hyponymy through the analysis of the concepts in a network and their definitions. In this way, several subtypes of hyponymy have been distinguished for entities (e.g. formation-based hyponymy), for processes (e.g. agent-based hyponymy) and for both types (e.g. attribute-based hyponymy).

We have also demonstrated how this type of refined hyponymy can be implemented in EcoLexicon, thus increasing its informativity for users. Another important issue is the formal modelling of relations in ontologies. Although restrictions on length oblige us to reduce the scope of our discussion, future work will focus on this topic in greater depth.

Moreover, the different subtypes of hyponymy and the new conceptual hierarchy must be corrected and validated by domain experts. Further research is also required to verify the existence of these subtypes of hyponymy in other fields of knowledge, to establish systematic parameters for the creation of new subtypes, and to explore how semantic relations are expressed in nominal clauses and compound nouns (Downing, 1977; Nastase & Szpakowicz, 2003).

This research opens the door to enhancing conceptual networks in TKBs and making them more informative.

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6. Bibliographical References

Cabré, M. T. (1999). *La Terminología: Representación y Comunicación*. Barcelona: Institut Universitari de Lingüística Aplicada, Universitat Pompeu Fabra.

Cruse, D. A. (2002). Hyponymy and its Varieties. In Rebecca Green, Carol A. Bean, and Sung Hyon Myaeng, editors, *The Semantics of Relationships: An Interdisciplinary Perspective*, 3–22. Dordrecht, Boston, London: Kluwer Academic Publishers.

Downing, P. (1977). On the Creation and Use of English Compound Nouns. *Language*, 53 (4): 810–842. Linguistic Society of America.

Dubuc, R. and Lauriston, A. (1997). Terms and Contexts. In Sue Ellen Wright and Gerhard Budin, editors, *Handbook of Terminology Management*, 1: 80–88. Amsterdam, Philadelphia: John Benjamins.

Faber, P. (2009). The Cognitive Shift in Terminology and Specialized Translation. *MonTI (Monografías de Traducción e Interpretación)*, 1: 107–134. Valencia: Universitat de València.

Faber, P., León-Araúz, P., Reimerink, A. (2014). Representing Environmental Knowledge in EcoLexicon. In Elena Bárcena, Timothy Read, and Jorge Arús, editors, *Languages for Specific Purposes in the Digital Era*, 19: 267–301. Berlin, Heidelberg: Springer.

Gheorghita, I., and Pierrel, J. (2012). Towards a Methodology for Automatic Identification of Hypernyms in the Definitions of Large-Scale Dictionary. In Nicoletta Calzolari (Conference Chair) et al., editors, *Proceedings of the Eighth International Conference on Language Resources and Evaluation (LREC2012)*, 2614–2618. Istanbul, Turkey: ELRA.

Jouis, C. (2006). Hierarchical Relationships "is-a": Distinguishing Belonging, Inclusion and Part/of Relationships. In Nicoletta Calzolari (Conference Chair) et al., editors, *Proceedings of the Fifth International Conference on Language Resources and Evaluation (LREC2006)*, 571–574. Genoa, Italy: ELRA.

Kageura, K. (1997). Multifaceted/Multidimensional Concept Systems. In Sue Ellen Wright and Gerhard Budin, editors, *Handbook of Terminology Management*, 1: 119–132. Amsterdam, Philadelphia: John Benjamins.

León-Araúz, P., and Faber, P. (2010). Natural and Contextual Constraints for Domain-Specific Relations. In Verginica Barbu Mititelu, Viktor Pekar, and Eduard Barbu, editors, *Proceedings of the Workshop Semantic Relations, Theory and Applications*, 12–17. Valletta, Malta.

León-Araúz, P., Faber, P., and Montero Martínez, S. (2012). Specialized Language Semantics. In Pamela Faber, editor, *A Cognitive Linguistics View of Terminology and Specialized Language*, 95–175. Berlin, Boston: De Gruyter Mouton.

León-Araúz, P., Reimerink, A., and García Aragón, A. (2013). Dynamism and Context in Specialized Knowledge. *Terminology*, 19 (1): 31–61. Amsterdam, Philadelphia: John Benjamins.

Leonardi, P. M. (2010). Digital Materiality? How Artifacts Without Matter, Matter. *First Monday,* 15 (6). Available from: http://firstmonday.org/article/view/3036/2567

Meteyard, L., Cuadrado, S. R., Bahrami, B., & Vigliocco, G. (2012). Coming of Age: A Review of Embodiment and the Neuroscience of Semantics. *Cortex*, 48: 788–804. doi: 10.1016/j.cortex.2010.11.002

Meyer, I., Bowker, L. and Eck, K. (1992). COGNITERM: An Experiment in Building a Knowledge-Based Term Bank. In Hannu Tommola, Krista Varantola, Tarja Salmi-Tolonen, and Jürgen Schopp, editors, *Proceedings of the Fifth EURALEX International Congress (EURALEX '92)*, 159–172. Tampere, Finland: Tampereen Yliopisto.

Murphy, M. L. (2003). *Semantic Relations and the Lexicon: Antonymy, Synonymy and Other Paradigms*. Cambridge: Cambridge University Press.

Murphy, M. L. (2006) Hyponymy and Hyperonymy. In Keith Brown, editor, *Encyclopedia of Language and Linguistics*, 1: 446–448. New York: Elsevier.

Nastase, V., and Szpakowicz, S. (2003). Exploring Noun-Modifier Semantic Relations. In *Fifth International Workshop on Computational Semantics (IWCS-5)*. Tilburg, The Netherlands, pp. 285–301.

Patterson, K., Nestor, P. J., and Rogers, T. T. (2007). Where Do You Know What You Know? The Representation of Semantic Knowledge in the Human Brain. *Nature Reviews Neuroscience*, 8: 976–988.

Reimerink, A., León-Araúz, P., Magaña Redondo, P. J. (2010). EcoLexicon: An Environmental TKB. In Nicoletta Calzolari (Conference Chair) et al., *Proceedings of the Seventh International Conference on Language Resources and Evaluation (LREC2010)*, 2322–2329. Valletta, Malta.

Roche, C., Calberg-Challot, M., Damas, L., Rouard P. (2009). Ontoterminology: A New Paradigm for Terminology. In Jan L. G. Dietz, editor, *Proceedings of the International Conference on Knowledge Engineering and Ontology Development (KEOD 2009)*, 2626–2630. Madeira, Portugal.

Temmerman, R. (2000). *Towards New Ways of Terminology Description: The Sociocognitive Approach*. Amsterdam, Philadelphia: John Benjamins.