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# The Role of Terminological Knowledge Bases in Specialized Translation: The Use of Umbrella Concepts

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## 1. Introduction

A complex knowledge acquisition process, which is a necessary prelude to specialized translation or technical writing, requires optimal terminological resources and an accurate representation of specialized knowledge. Terms are the linguistic units that designate our conceptualization of objects, processes, states and attributes in a specialized domain. Therefore, they play a key role in understanding, representing, transmitting, and acquiring specialized knowledge. However, most translation-oriented terminological resources fail to reflect the complexity and dynamicity of conceptualization (Faber & San Martín, 2010: 118), since the vast majority of specialized dictionaries, thesauri, and glossaries are term-based rather than concept-based.

Without a doubt, translators need to be proficient in the use of specialized language in order to translate specialized texts. Moreover, they also need to know how to access different terminological resources and how to acquire a certain amount of their conceptual content. Although it does not necessarily signify that they have as much knowledge in a particular field as a domain expert, they must reach a minimum threshold so as to guarantee high-quality work. For this reason, translators can acquire specialized knowledge in a cost-effective way if they have access to useful knowledge resources and if they have good documentation and search skills.

For example, according to López Rodríguez et al. (2013: 50), ontology-based terminological databases can solve different problems related to translation, information retrieval, and knowledge management. This is possible because they link terms that designate the same concept in different languages, showing both conceptual and linguistic information whilst at the same time fomenting data interoperability.

Accordingly, lexicographic and terminographic tools should endeavor to reflect the dynamic way in which we conceptualize the world around us. Tercedor *et al.* (2012:

181) state that from the perspective of professional translation, these resources should simultaneously respond to user needs towards the source text (i.e. information access and knowledge retrieval and acquisition) and the target text (i.e. knowledge transmission and text production). That is the reason why terminological knowledge bases (TKBs), which are focused on dynamic and multidimensional knowledge representation, are highly valuable tools in specialized translation.

Furthermore, structuring specialized concepts in networks with both hierarchical and non-hierarchical or associative relations is one of the key elements in modern terminological resources. Nonetheless, this process can give rise to an overly simplistic resource if, in the design stage, methods for structuring knowledge (e.g. establishing subtypes of conceptual relations, extending non-hierarchical relations, and specifying the properties of the relations) are not addressed.

In fact, it has been shown that an exceedingly broad definition of hyponymy is the source of a wide range of problems in a TKB, which include information overload, noise, redundancy and transitivity-based inconsistencies (Gil-Berrozpe & Faber, 2016: 9). For this reason, hyponymy, which is the backbone of all hierarchical semantic configurations in a terminological resource, should be refined according to different criteria: (i) corrected property inheritance in concept definitions; (ii) a more refined set of subtypes of hyponymy; and/or (iii) the creation of umbrella concepts. This paper focuses on the third solution, which involves introducing artificial concepts at intermediate levels to further specify the *type_of* relation.

## 2. Terminological knowledge bases and knowledge acquisition enhancement

According to Dury (2005: 34), there are two categories of specialized translators: (i) scientists or domain experts who became translators for professional reasons and have a good knowledge of the concepts and their organization, but often lack competence and expertise in translation; (ii) specialized translators, who were trained as linguists and have experience in translation, but who often lack information and knowledge of specialized concepts and their organization. Both types of translator need knowledge resources that provide linguistic, conceptual, and contextual information, and which are specifically adapted to their needs.

In this sense, TKBs are terminological resources that store and represent the specialized knowledge in a certain domain, as reflected in the concepts and the terms that designate them in one or several languages. In addition, from a cognitive perspective, Meyer et al. (1992: 159) state that the conceptual categories in TKBs should be structured in a similar way to how they are related in the brain. Therefore, they are products that encompass both linguistic and cognitive phenomena.

A conceptually-structured TKB, in which terms are linked to concepts based on non-language-specific criteria, is a useful resource for specialized translators. In this way, not only is there coherent cross-referencing, but also linguistic data can be added and manipulated without altering the quality and consistency of the conceptual design (Giacomini 2014: 83). Moreover, their representation of metalinguistic and encyclopedic data contributes to the enhancement of knowledge acquisition for specialized translation purposes, as TKBs enable translators to search for corpus concordances and parallel texts. Not surprisingly, this is an extremely valuable feature for translators since it allows them to avoid extra-lexicographic searches and queries, which can be time-consuming tasks.

Furthermore, according to Giacomini (2015: 10), any type of e-lexicographic resource (including TKBs) should respond to three requirements:

— Conceptual structure availability and properties, with a multi-level depth of conceptual structures and multi-vocal relations.
— Ease of access to conceptual data, with direct access via the conceptual structure and the microstructure, and with specified relations.
— Consistency of concept-term correspondences, in the search by concept or by term.

Therefore, these criteria reveal the importance of having a conceptual structure in the form of an ontology. Moreover, any ontology-based terminological database geared to the fulfillment of these requirements should reflect phenomena such as multidimensionality (Kageura, 1997; Bowker, 1997) and natural and contextual knowledge dynamism (León Araúz *et al.,* 2013), which are basic to specialized knowledge representation and acquisition.

On the one hand, multidimensionality can be implemented in a TKB. Methods for doing this include the addition or the deletion of certain concepts or relations in specific nodes or in the system as a whole, the modification of certain characteristics or relations in specific nodes or in the system as a whole, and the implementation of new ways to represent knowledge (linguistic, conceptual, visual, interactive, etc.). On the other hand, contextual dynamism can be achieved by showing how concepts — and therefore, terms — modify their features and use depending on the context in which they are found or used, and depending on the level of user expertise or knowledge.

In fact, regarding specialized translators, the representation of contextual information in a TKB enhances the knowledge acquisition process because it allows them to comprehend how terms are used in real texts and helps them to select the best term for each discourse segment, depending on contextual domains and use situation (León Araúz et al., 2010: 140). In line with this, Tercedor et al. (2012: 186) also remark on the intimate link between dynamicity and multidimensionality. Since it is now possible to represent concepts from different perspectives or dimensions, lexicographic and terminographic practice should thus envisage the elaboration of more dynamic representations.

Furthermore, apart from features such as multidimensionality or accessibility, another salient characteristic of TKBs is multimodality. It has been shown that linking multimedia information (e.g. images) to the linguistic, conceptual, and contextual information of a TKB helps to satisfy user needs with regard to the reception, production, and translation of specialized texts (Prieto Velasco, 2009: 227). In this way, TKBs can be represented as visual thesauri, merging multimodal information and highlighting the multidimensional character of knowledge representations.

These are all basic characteristics of a TKB, which optimize knowledge retrieval in specialized translation. Therefore, when properly designed, TKBs can provide information about term meaning (core meaning, peripheral meaning, metaphorical extensions), term collocations and morphological elements (combinatory potential, derivational potential), and term use and activation in certain texts and contexts (register, genre, dialect, position in associative networks) (Tercedor et al., 2012: 182).

## 3. EcoLexicon: an environmental TKB

EcoLexicon[1] (Faber et al., 2005; Faber et al., 2014; Buendía Castro & Faber, 2015), based on the theoretical premises of Frame-Based Terminology (Faber, 2009; Faber, 2012), is a multidimensional and dynamic TKB on environmental science. It specifically targets user knowledge acquisition through different types of multimodal and contextualized information, in order to respond to both cognitive and communicative needs. More specifically, its public is any user group interested in broadening its knowledge of the environment for text comprehension and/or generation (environmental experts, technical writers, translators, etc.). This resource is currently available in English and Spanish, though five more languages (German, Modern Greek, Russian, French and Dutch) are being gradually implemented. To date, its database consists of a total of 3,601 concepts and 20,212 terms.

EcoLexicon can be explored through an accessible visual interface with different modules for conceptual, linguistic, and graphical information (see Figure 1). Regarding the interest of a specialized translator, this TKB allows users to perform a concept search query. Once a concept has been selected, it is represented in the center of an interactive map. Also displayed are the multilingual terms for that concept, as well as different conceptual relations between all the concepts belonging to the same contextual domain.

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

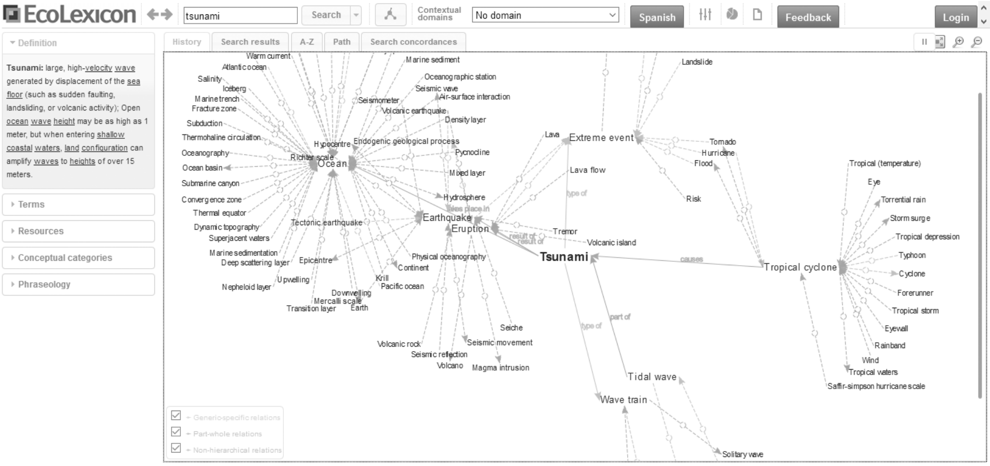


Figure 1. *Visual interface of EcoLexicon (conceptual network of tsunami)*

In EcoLexicon, conceptual relations are classified in three main groups: generic-specific relations, part-whole relations, and non-hierarchical relations. Hierarchical relations are thus 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 has the following subtypes: *part_of*, *made_of*, *delimited_by*, *located_at*, *takes_place_in*, and *phase_of*. Finally, the set of non-hierarchical relations includes *affects*, *causes*, *attribute_of*, *opposite_of*, *studies*, *measures*, *represents*, *result_of*, *effected_by*, and *has_function*.

With regard to the microstructure of the TKB, when a concept is selected, five sections are displayed on the left side of the interface:

— Definition: this section provides a terminological definition based on the explicitation of the *genus* (hyperonym or superordinate) and one or many *differentiae* (characteristics that vary in each cohyponym), alongside hyperlinks redirecting users to other concepts also contained in the database (see Figure 2). In the case of TSUNAMI, "WAVE" IS THE *GENUS*, AND THERE ARE ASSORTED *DIFFERENTIAE* ('LARGE' [*ATTRIBUTE_OF*], 'HIGH-VELOCITY' [*ATTRIBUTE_OF*], 'GENERATED BY DISPLACEMENT OF THE SEA FLOOR' [*RESULT_OF*], ETC.).

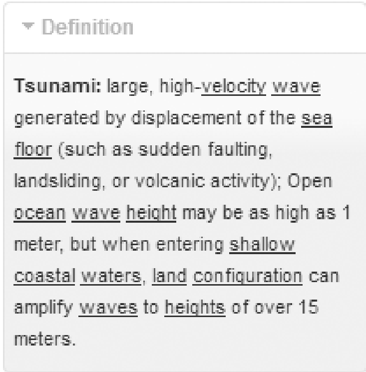


Figure 2. *Definition section for tsunami.*

— **Terms:** it displays the lexical denominations for a concept in the different languages available in EcoLexicon, information regarding the term type and the part of speech, and the option to display a list of corpus concordances (see Figure 3). For example, for tsunami, it shows term variations in English ('tsunami' and 'tidal wave'), in Spanish ('*maremoto*' and '*tsunami*'), in German ('*Tsunami*', '*Flutwelle*' and '*Tsunami-Welle*'), in Russian ('цунами'), and in Modern Greek ('θαλάσσιο σεισμικό κύμα' and 'τσουνάμι').

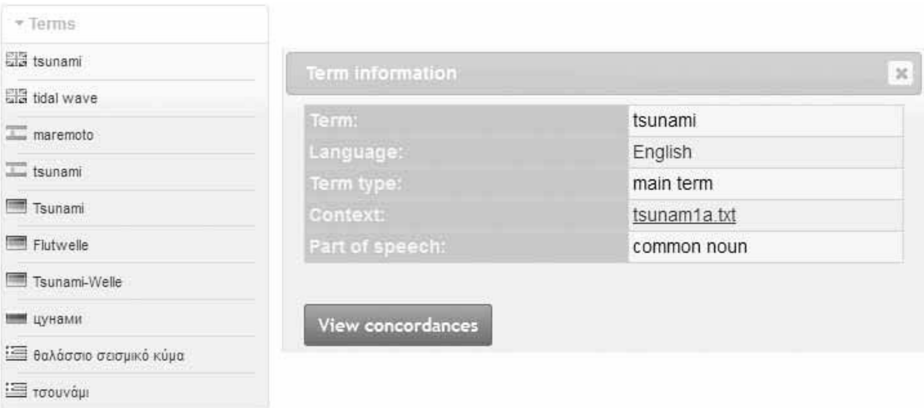


Figure 3. *Term section for tsunami*

— **Resources**: this section offers a list of multimodal resources (images, videos, hyperlinks to external websites) for the chosen concept (see Figure 4). In this case, tsunami presents a wide variety of resources, including clarifying pictures or diagrams, academic websites with thorough explanations on the topic, and even satellite images of tsunamis.


Figure 4. *Resource section for tsunami*

— **Conceptual categories:** this module provides a list of different conceptual categories, and classifies the concept as a member of one of the categories (see Figure 5). For example, tsunami is classified at the same time as a 'physical agent' (A.1.5.), as 'movement' (B.1.1.), and as 'part of water mass' (C.1.1.2.1.).

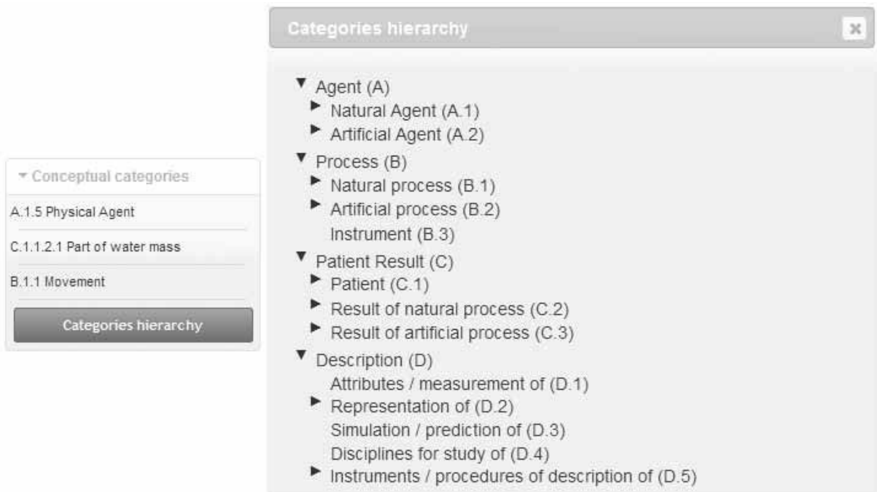


Figure 5. *Conceptual category section for tsunami*

— **Phraseology**: this section displays the phraseological module, showing the nuclear meaning, the meaning dimension, the phraseological pattern and the verbs related to a certain concept (see Figure 6). Tsunami, for example, has a negative semantic prosody, since it is described as a "NATURAL DISASTER that causes a PATIENT to change for the worse". Moreover, it is related to the verb 'destroy', which further increases the negative connotation of the concept.


Figure 6. *Phraseology section for tsunami*

These are the five features that can be found within the microstructure of EcoLexicon, which highlight its linguistic, conceptual and multimodal nature. Furthermore, for the benefit of specialized translators, EcoLexicon also provides access to contextual information by means of corpus concordances. In this way, with the function 'Search concordances', users can obtain a list of contexts in which a term appears in the texts in the EcoLexicon corpus (see Figure 7).

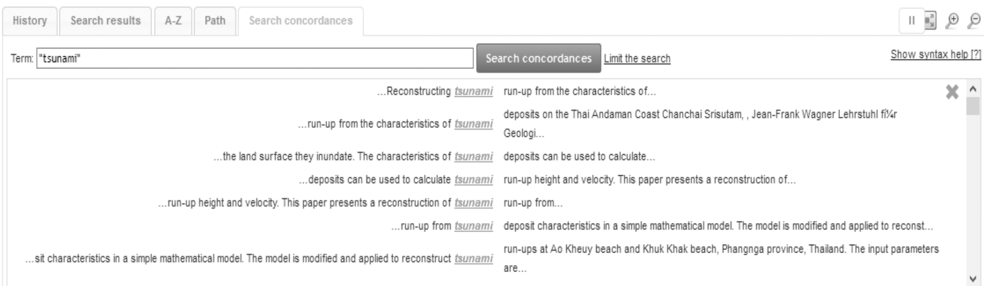


Figure 7. *'Search concordances' function for tsunami*

Thanks to all of these features, EcoLexicon is a resource that enhances knowledge acquisition. It also facilitates specialized translation because of its many-faceted knowledge representation: (i) through conceptual relations that codify conceptual propositions (concept-relation-concept) according to hierarchical and non-hierarchical criteria; (ii) through terminological definitions that reflect the salience of those conceptual relations, drawing from a central *genus*; and (iii) through multimodal resources that complement the conceptual and the linguistic information.

Furthermore, studies by García Aragón et al. (2014) and Giacomini (2014), corroborate and validate the effectiveness of this terminological resource. Nevertheless, EcoLexicon can still be improved. Not surprisingly, the vast amount of information contained in this TKB is a double-edged sword, which occasionally causes the following problems: (i) information overload; (ii) excessive noise and redundancy; (iii) transitivity problems in conceptual relations and hierarchies; (iv) lack of property inheritance in terminological definitions; and (v) the presence of different types of cohyponyms at the same hierarchical level. One solution would be to refine hyponymy (*type_of* relations) in EcoLexicon.

## 4. Hyponymy in EcoLexicon: representation and subtypes

The most basic definition of hyponymy is a relation of inclusion whose converse is hyperonymy (Murphy, 2006: 446). According to Murphy (2003: 217), hyponymy is central to many models of the lexicon for three reasons: (i) its inference-invoking nature; (ii) its importance in definition; and (iii), its relevance to selectional restrictions in grammar. Therefore, hyponymy plays a key role in ontology-based terminological resources, such as EcoLexicon, since it is the basis of all concept hierarchies.

As in meronymy, hyponymy can also be refined to provide an enhanced representation of generic-specific relations. This can be achieved by specifying subtypes of hyponymy (Murphy, 2003) or by establishing 'facets' and/or 'microsenses' (Cruse, 2002: 4-5). Regarding subtypes of hyponymy, the most commonly accepted distinction is between taxonomic hyponymy ('is-a-kind-of' relation) and functional hyponymy ('is-used-as-a-kind' relation). For example, cow is in a taxonomic relation to animal (a cow is an animal), but in a functional relation to livestock (a cow functions as livestock). Moreover, whilst taxonomic relations are always analytic, functional relations are vaguer since they are not logically necessary relations (not every cow is livestock) (Murphy 2003: 219-220).

Related to different types of hyponymy, Cruse (2002: 4) proposes 'facets'. For instance, he distinguishes two dimensions in the hyponyms of book, and divides them into two sets: 'physical object' (such as hardback or paperback) and 'abstract text' (such as novel or biography). In these cases, the cohyponyms of the same hyperonym display within-set incompatibility, but between-set compatibility (a certain book can be simultaneously a novel and a hardback, but a hardback cannot be a paperback at the same time).

On the other hand, another important phenomenon in the specification of hyponymic relations is the existence of 'microsenses' (Cruse, 2002: 5). A 'microsense' is a specific meaning of a concept (e.g. regarding its properties, attributes or functions) which is only activated in a certain context, and which makes it differ from the meaning of the same concept in a different context. For example, although knife generally has a single sense, it can be classified in different domains under a variety of hyperonyms (weapon, tool, surgical instrument, etc.).

These 'microsenses' are currently represented in EcoLexicon by means of conceptual propositions in contextual discipline-based domains in which they are activated. For example, based on the information in EcoLexicon, chlorine has two 'microsenses', one in the domain of 'Water Treatment and Supply' and the other in 'Chemical Engineering'. This occurs because, apart from being a *type_of* halogen, chlorine can also be regarded as a *type_of* water disinfectant (see Figure 8). In contrast, in all other domains, chlorine is only classified as a *type_of* halogen (see Figure 9).

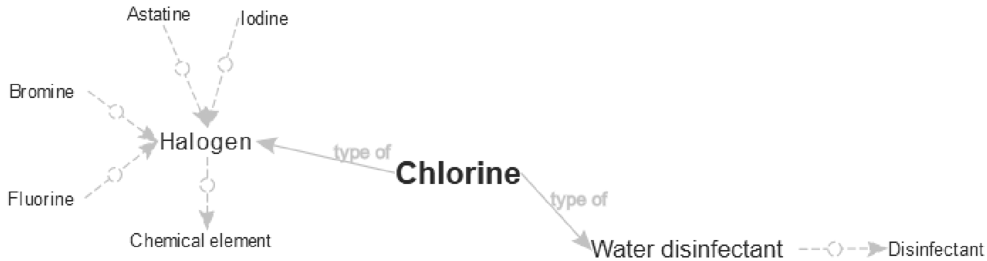


Figure 8. *Chlorine's generic-specific relations in 'Water Treatment and Supply' and 'Chemical Engineering'*

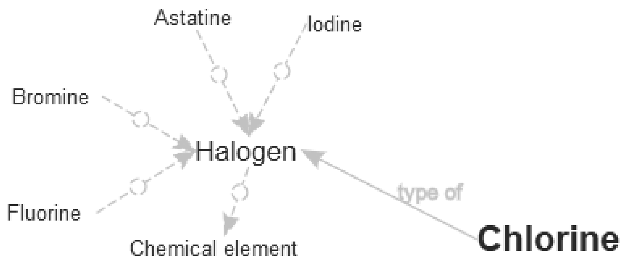


Figure 9. *Chlorine's generic-specific relations in the remaining contextual domains*

However, with regard to hyponymy refinement, classifying concepts using contextual domains only makes it possible to filter the query and show context-dependent hyperonyms and hyponyms. In other words, the original sense of hyponymy remains the same and still needs to be decomposed in a certain way so as to guarantee a more accurate representation of generic-specific relations. For this reason, Gil-Berrozpe & Faber (2016), using EcoLexicon as a reference, performed a case study on how to correct property inheritance in concept definitions and subsequently establish subtypes of hyponymy.

On the one hand, property inheritance correction was regarded as the first step towards dividing the *type_of* relation into subtypes because, before obtaining the final result, it was necessary to guarantee coherence and correction in concept definitions. In this way, it was possible to show how hyponyms inherited the features or traits of their respective hyperonyms.

On the other hand, the establishment of fine-grained hyponymy subtypes was based on the enhanced conceptual networks of two concepts: an entity (rock) and a process (erosion). Thus, different subtypes of hyponymy were established depending on the type of concept. Nevertheless, since not all hyponymic relations can be classified using only one subtype, given the wide variety of differentiating features of certain child concepts, a general taxonomic hyponymy or non-specific *type_of* relation was also considered during the case study.

Figure 10 shows the improved conceptual network of rock, which distinguishes up to five different entity-related subtypes of hyponymy:

— **Formation-based hyponymy:** dependent on the formation process or the origin of the hyponyms.
  - sedimentary rock *formation-based_type_of* solid rock
  - clastic rock *formation-based_type_of* sedimentary rock

— **Composition-based hyponymy:** dependent on the components or the constituents of the hyponyms.
  - organic sedimentary rock *composition-based_type_of* sedimentary rock
  - reef limestone *composition-based_type_of* limestone

— **Location-based hyponymy:** dependent on the physical situation or location of the hyponyms.
  - volcanic rock *location-based_type_of* igneous rock
  - Alpujarra limestone *location-based_type_of* limestone

— **State-based hyponymy:** dependent on the state of matter of the hyponyms.
  - solid rock *state-based_type_of* rock
  - molten rock *state-based_type_of* rock

— **Attribute-based hyponymy:** dependent on the traits or features of the hyponyms.
  - permeable rock *attribute-based_type_of* rock

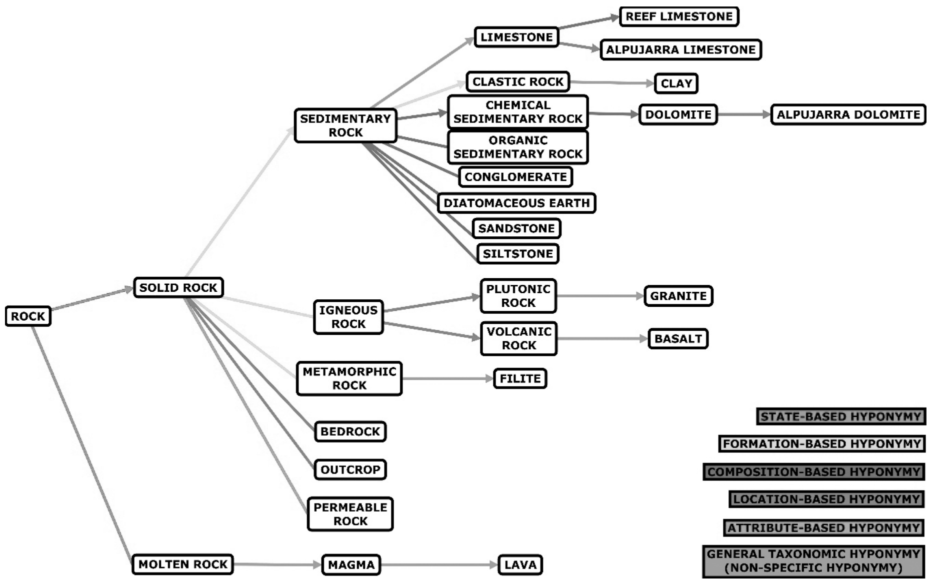


Figure 10. *Entity-related subtypes of hyponymy in the conceptual network of rock*

Figure 11 shows the enhanced conceptual network of erosion, which establishes up to four different process-related subtypes:

— **Agent-based hyponymy:** dependent on the agent or the promoter that causes the hyponyms.
  - anthropic erosion *agent-based_type_of* erosion
  - fluvial erosion *agent-based_type_of* water erosion

— **Patient-based hyponymy:** dependent on the entity or location affected by the hyponyms.
  - streambank erosion *patient-based_type_of* fluvial erosion
  - glacier abrasion *patient-based_type_of* abrasion

— **Result-based hyponymy:** dependent on the results and effects of the hyponyms.
  - rill erosion *result-based_type_of* fluvial erosion
  - gully erosion *result-based_type_of* fluvial erosion

— **Attribute-based hyponymy:** dependent on the traits or features of the hyponyms.
  - potential erosion *attribute-based_type_of* erosion
  - differential erosion *attribute-based_type_of* erosion

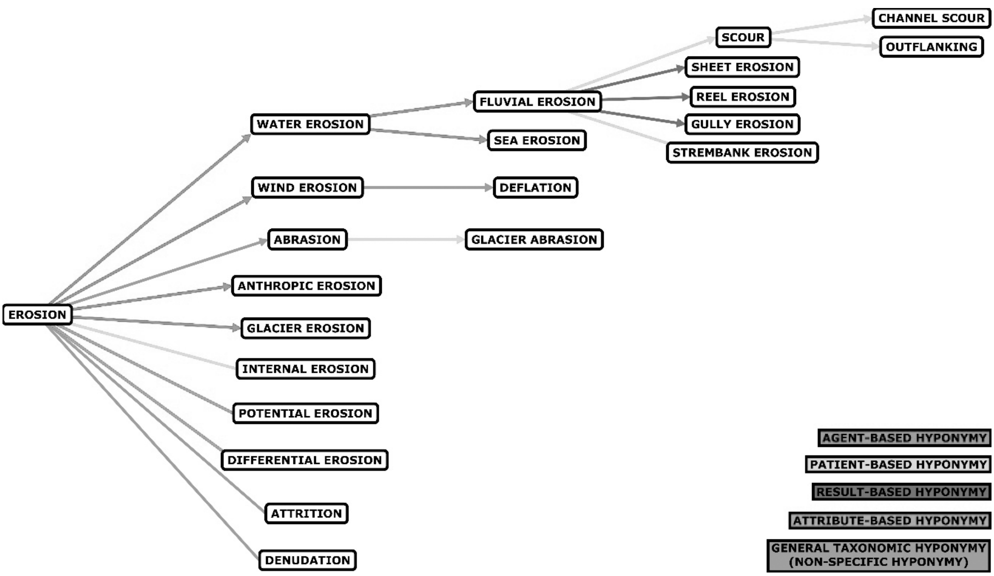


Figure 11. *Process-related subtypes of hyponymy in the conceptual network of erosion*

As can be observed, process-related subtypes of hyponymy are different from those of an entity (except for attribute-based hyponymy). A process is commonly a nominalization of a verb, and therefore it usually involves an agent, a patient, and a result. In contrast, entities are related to features such as formation, composition, and state. Furthermore, in the case of processes, patient-based hyponymy sometimes overlaps with location-based hyponymy, as the patient can be a physical location (e.g. glacier abrasion affects a glacier, so it takes place in a glacier as well).

However, the previous list of subtypes cannot be regarded as a closed inventory of hyponymic relations, but only those that have been detected in the conceptual networks of rock and process. For instance, in the conceptual network of water, two more subtypes of hyponymy can be established:

— **Function-based hyponymy:** dependent on the function or the purpose of the hyponyms.
  • drinking water *function-based_type_of* water
— **Shape-based hyponymy:** dependent on the shape or the physical aspect of the hyponyms.
  • amorphous frost *shape-based_type_of* erosion

In line with this, a minimum number of coincidences has yet to be established to confirm the validity and usefulness of a hyponymy subtype.

Therefore, generic-specific relations can be refined to establish subtypes of hyponymy through the analysis of the concepts in a network and their definitions. This helps to solve problems related to redundancy and transitivity-based inconsistencies. It also enhances specialized knowledge representation and acquisition since users can easily determine the specific subsense by means of which two or more concepts are linked with a generic-specific relation. However, other issues, such as information overload and noise with regards to the visual representation of knowledge must still be resolved. For this reason, it is still necessary to explore the creation and use of umbrella concepts as a means to further refine hyponymy and the concept hierarchy in EcoLexicon.

## 5. Umbrella concepts as a means to refine hyponymy

Umbrella concepts, as previously mentioned, are artificial concepts which can be introduced at intermediate levels of a hierarchy to further specify the sense of the expressed hyponymic relation. Therefore, their main objective is to narrow the link that connects parent concepts to child concepts by implementing an intermediate abstract concept, often characterized by an essential adjective (e.g. MEASURING INSTRUMENT).

Most of the umbrella concepts assessed during this case study were noun compounds or noun phrases. In fact, this kind of syntactic construction carries a semantic component that makes it possible to classify noun compounds similarly to hyponymy subtypes (i.e. according to composition, formation, agent, etc.). Levi (1978: 50) states that the semantic meaning of complex nominals (noun compounds consisting of a head noun preceded by a modifier, which is either another noun or a nominal adjective) can be extracted from their components. In fact, they imply semantic relationships, since they are all derived from the deletion or the nominalization of the predicate in the underlying sentence. For this reason, Levi (*ibid*: 76-77) highlights nine types of semantic predicates extracted by its deletion (cause, have, make, use, be, in, for, from, about) and four types of semantic predicates extracted by its nominalization (act, product, agent, patient).

Furthermore, various authors have also examined the assignment of semantic relations to noun-modifier pairs. For example, Rosario & Hearst (2001) follow Levi's premises and criteria to assign semantic relations to noun compounds in a domain-specific corpus. This resulted in a multi-class classification that greatly diminished raw information content. Moreover, Nastase & Szpaczowski (2003) also explored noun-modifier semantic relations based on semantic and morphological information about words themselves. In their study, they obtained a set of thirty semantic relations, which were subsequently used to represent identifying data (Nastase et al., 2006). More specifically, those thirty fine-grained semantic relations were classified in five classes: causal (e.g. cause, effect, purpose), participant (e.g. agent, object, beneficiary), spatial (e.g. direction, location, location at), temporal (e.g. frequency, time at, time through), and quality (e.g. manner, material, measure). Downing (1977: 828) also proposed an inventory of the most common underlying semantic relations in noun compounds, made up of a total of twelve relations: whole-part, half-half, part-whole, composition, comparison, time, place, source, product, user, purpose, and occupation.

Thus, the identification and assignment of semantic relations to noun compounds could be a useful method to define and create umbrella concepts in EcoLexicon. For instance, depending on the semantic predicate underlying a noun compound, we could speak of *function-based umbrella concepts*, *formation-based umbrella concepts,* and *agent-based umbrella concepts*, similarly to how hyponymy was decomposed into the previously described subtypes. In fact, in EcoLexicon we can find many examples of concept hierarchies that could be enhanced or have already been enhanced by using umbrella concepts. To be precise, this case study focused on assessing the inclusion of umbrella concepts in the hierarchies of instrument, process, chemical element, and representation.

To begin with, the original concept hierarchy of instrument (see Table 1) presented a vast amount of information overload because of the large number of subordinates (68 hyponyms) that were linked to the same superordinate. For this reason, and because of the semantics of the concept instrument, a set of five *function-based umbrella concepts* (e.g. filtering instrument, measuring instrument, recording instrument) was introduced to provide a more accurate classification of the hyponyms (see Table 2).

| | |
|---|---|
| INSTRUMENT **(68 hyponyms)** | ACCELEROMETER │ AIR SAMPLER │ ALBEDOGRAPH │ ALBEDOMETER │ ALTI-ELECTROGRAPH │ ALTIMETER │ ANEMOCLINOMETER │ ANEMOGRAPH │ ANEMOMETER │ ANEROID CAPSULE │ ATMORADIOGRAPH │ AUTOMATIC SAMPLER │ BAR SCREEN │ BAROMETER │ BATHYMETER │ CLINOMETER │ CLOUD CHAMBER │ COMPASS │ CREST GAGE │ CTD │ CURRENT METER │ DEGREASER │ DEPTH │ FINDER │ DREDGE │ ECHO SOUNDER │ EKMAN WATER BOOTLE │ ELECTROSONDE │ EMANOMETER │ EVAPORIMETER │ EVAPOTRANSPIROMETER │ FLOWMETER │ HYGROMETER │ IMPEDOMETER │ INCLINED GAUGE │ INFILTROMETER │ MARIGRAPH │ METEOROGRAPH │ PERMEAMETER │ PHOTOMETER │ PIEZOMETER │ PLUVIOGRAPH │ PLUVIOMETER │ PSYCHROMETER │ RADAR │ SALINOMETER │ SAND FILTER │ SECCHI DISK │ SEDIMENT SAMPLER │ SEDIMENT TRAP │ SEISMOGRAPH │ SEISMOMETER │ SEXTANT │ SNOW GAUGE │ SOLAR CELL │ SOLAR PANEL │ SOUNDING BALLOON │ SOUNDING LEAD │ STADIMETER │ STAFF GAUGE │ TENSIOMETER │ THERMOMETER │ THICKENER │ TIDE STAFF │ VENTILATED THERMOMETER │ WATER SAMPLER │ WATER-LEVEL RECORDER │ WATER-TREATMENT PLANT |

Table 1. *Original concept hierarchy of instrument (without umbrella concepts)*

| | | |
|---|---|---|
| INSTRUMENT **(5 hyponyms)** | FILTERING INSTRUMENT | BAR SCREEN │ DEGREASER │ SAND FILTER │ SIEVE |
| | MEASURING INSTRUMENT | ALBEDOGRAPH │ ALTI-ELECTROGRAPH │ ANEMOGRAPH │ ATMORADIOGRAPH │ COMPASS │ MARIGRAPH │ METEOROGRAPH │ PLUVIOGRAPH │ RADAR │ SEISMOGRAPH │ WATER-LEVEL RECORDER |
| | RECORDING INSTRUMENT | ACCELEROMETER │ ALBEDOMETER │ ALTIMETER │ ANEMOCLINOMETER │ ANEMOMETER │ ANEROID CAPSULE │ BAROMETER │ BATHYMETER │ CLINOMETER │ CREST GAGE │ CTD │ CURRENT METER │ DEPTH FINDER │ ECHO SOUNDER │ ELECTROSONDE │ EMANOMETER │ EVAPORIMETER │ EVAPOTRANSPIROMETER │ FLOWMETER │ HYGROMETER │ IMPEDOMETER │ INCLINED GAUGE │ INFILTROMETER │ PERMEAMETER │ PHOTOMETER │ PIEZOMETER │ PLUVIOMETER │ PSYCHROMETER │ SALINOMETER │ SECCHI DISK │ SEDIMENT TRAP │ SEISMOMETER │ SEXTANT │ SNOW GAUGE │ SOUNDING BALLOON │ SOUNDING LEAD │ STADIMETER │ STAFF GAUGE │ TENSIOMETER │ THERMOMETER │ TIDE STAFF │ VENTILATED THERMOMETER |
| | SAMPLING INSTRUMENT | AIR SAMPLER │ AUTOMATIC SAMPLER │ DREDGE │ EKMAN WATER BOTTLE │ SEDIMENT SAMPLER │ WATER SAMPLER |
| | TRANSFORMING INSTRUMENT | CLOUD CHAMBER │ SOLAR CELL │ SOLAR PANEL │ THICKENER │ WATER-TREATMENT PLANT |

Table 2. *Enhanced concept hierarchy of instrument (with umbrella concepts)*

The second example of how umbrella concepts can be implemented to refine the step from a hyperonym to a hyponym is shown in the concept hierarchy of process. In its original version (see Table 3), the number of hyponyms proposed for the same hyperonym (111 in total) was disproportionate in comparison to what is usually found in EcoLexicon. However, in the enhanced version of the concept hierarchy (see Table 4), the visual representation of these relations is much clearer thanks to the inclusion of two *agent-based umbrella concepts* (artificial process and natural process).

| | |
|---|---|
| **PROCESS (111 hyponyms)** | ABSORPTION \| ACCLIMATIZATION \| ACCRETION \| ADIABATIC PROCESS \| AERATION \| AFFLUX \| AGGLOMERATION \| ALIMENTATION \| ANOMALOUS PROPAGATION \| ANTICYCLOGENESIS \| ANTICYCLOLYSIS \| ATMOSPHERIC ABSORPTION \| ATMOSPHERIC EMISSION \| ATMOSPHERIC PROCESS \| ATTENUATION \| BERGERON PROCESS \| BIOACCUMULATION \| BIOTIC PROCESS \| BLEEDING \| BREAKING DROPS \| CATCHMENT \| CHANGE \| CHEMICAL REACTION \| CHEMOTAXIS \| CLIMATE CHANGE \| CLOUD ELECTRIFICATION \| CLOUD SEEDING \| COAGULATION \| COALESCENCE \| COASTAL PROCESS \| COLLISION \| COMPOSTING \| CONDENSATION \| CONDUCTION \| CONSOLIDATION \| CONTAMINATION \| COOLING (OFF) \| CORROSION \| CYCLOGENESIS \| DECANTATION \| DECOMPOSITION \| DECREASE \| DEPOSITION \| DESALINATION \| DISCHARGE \| DISEASE \| DRAIN \| DRAW-OFF \| EFFLORESCENCE \| ELIMINATION OF SOLID WASTE \| ELUTRIATION \| EMISSION \| ENDOGENIC GEOLOGICAL PROCESS \| EROSION \| ERROR CORRECTION \| EUSTATIC SEA LEVEL CHANGE \| EUTROPHICATION \| EVAPORATION \| EXOGENOUS GEOLOGICAL PROCESS \| FERTIGATION \| FERTILIZATION \| FILTRATION \| FREEZING \| GEOREFERENCING \| GULLYING \| HYDRODYNAMIC PROCESS \| HYDROLOGICAL PROCESS \| INLET STABILISATION \| IONIZATION \| ISOSTASY \| LEACHING (SOIL) \| LEACHING (WASTEWATER) \| LOWERING OF THE WATER TABLE \| MANAGEMENT \| MELTING \| NOURISH \| NUCLEAR REACTION \| OSMOSIS \| OVERFLOW \| OZONE DEPLETION \| PARTICLE DISPERSION \| PERCOLATION \| PONDING \| PUMPING \| RADIATION PROCESS \| RECYCLING \| RETARD BEACH EROSION \| RETARD LITTORAL DRIFT \| REVEGETATION \| RISE OF THE WATER TABLE \| SALINIZATION \| SAMPLING \| SELECTIVE SORTING \| SHOALING \| SOLIDIFICATION \| SOLUTION \| SOUND \| STOCHASTIC PROCESS \| SUBLIMATION \| SUSTAINED DEVELOPMENT \| TECHNOLOGY \| TEST DRILLING \| THAW \| TREATMENT \| WATER EVACUATION \| WATER LEVEL \| REGULATION \| WATER PONDING \| WATERLOGGING \| WAVE GENERATION \| WAVE PROPAGATION |

Table 3. *Original concept hierarchy of process (without umbrella concepts)*

| | | |
|---|---|---|
| **PROCESS (2 hyponyms)** | ARTIFICIAL PROCESS | AERATION \| AFFLUX \| ALIMENTATION* \| ATMOSPHERIC EMISSION* \| ATTENUATION* \| CATCHMENT \| CHANGE* \| CHEMICAL REACTION* \| CLIMATE CHANGE* \| CLOUD SEEDING \| COMPOSTING \| CONTAMINATION* \| CORROSION* \| DECANTATION \| DECREASE* \| DESALINATION \| DISCHARGE \| DRAIN \| DRAW-OFF \| ELIMINATION OF SOLID WASTE \| ELUTRIATION \| EROSION* \| ERROR CORRECTION \| EUTROPHICATION* \| FERTIGATION \| FERTILIZATION \| FILTRATION* \| GEOREFERENCING \| INLET STABILISATION* \| IONIZATION* \| LEACHING (WASTEWATER) \| MANAGEMENT \| NOURISH \| NUCLEAR REACTION \| OZONE DEPLETION \| PUMPING \| RECYCLING \| RETARD BEACH EROSION \| RETARD LITTORAL DRIFT \| REVEGETATION* \| SALINIZATION* \| SAMPLING \| SOUND \| SUSTAINED DEVELOPMENT \| TECHNOLOGY \| TEST DRILLING \| TREATMENT \| WATER EVACUATION \| WATER LEVEL REGULATION<br><br>**<u>New umbrella concepts:</u>**<br>ATMOSPHERIC PROCESS* \| RADIATION PROCESS* \| STOCHASTIC PROCESS |
| | NATURAL PROCESS | ABSORPTION \| ACCLIMATIZATION \| ACCRETION \| AGGLOMERATION \| ALIMENTATION* \| ANOMALOUS PROPAGATION \| ANTICYCLOGENESIS \| ANTICYCLOLYSIS \| ATMOSPHERIC ABSORPTION \| ATMOSPHERIC EMISSION* \| ATTENUATION* \| BERGERON PROCESS \| BIOACCUMULATION \| BLEEDING \| BREAKING DROPS \| CHANGE* \| CHEMICAL REACTION* \| CHEMOTAXIS \| CLIMATE CHANGE* \| CLOUD ELECTRIFICATION \| COAGULATION \| CONDENSATION \| CONDUCTION \| CONSOLIDATION \| CONTAMINATION* \| COOLING (OFF) \| CORROSION* \| CYCLOGENESIS \| DECOMPOSITION \| DECREASE* \| DEPOSITION \| DISEASE \| EFFLORESCENCE \| EMISSION \| EROSION* \| EUSTATIC SEA LEVEL CHANGE \| EUTROPHICATION* \| EVAPORATION \| FILTRATION* \| FREEZING \| GULLYING \| INLET STABILISATION* \| IONIZATION* \| ISOSTASY \| LEACHING (SOIL) \| LOWERING OF THE WATER TABLE \| MELTING \| NUCLEAR REACTION \| OSMOSIS \| OVERGLOW \| PARTICLE DISPERSION \| PERCOLATION \| PONDING \| PROGRADATION \| REVEGETATION* \| RISE OF THE WATER TABLE \| SALINIZATION* \| SELECTIVE SORTING \| SHOALING \| SOLIDIFICATION \| SOLUTION \| SUBLIMATION \| THAW \| WATER PONDING \| WATERLOGGING \| WAVE GENERATION \| WAVE PROPAGATION<br><br>**<u>New umbrella concepts:</u>**<br>ADIABATIC PROCESS \| ATMOSPHERIC PROCESS* \| BIOTIC PROCESS \| COASTAL PROCESS \| ENDOGENIC GEOLOGICAL PROCESS \| EXOGENOUS GEOLOGICAL PROCESS \| HYDRODYNAMIC PROCESS \| HYDROLOGICAL PROCESS \| RADIATION PROCESS* |
| The concepts marked with an asterisk (*) can be hyponyms of ARTIFICIAL PROCESS and NATURAL PROCESS at the same time.<br>The real distinction that will reveal if they actually refer to an artificial process or to a natural process will be made in further hyponymic levels. | | |

Table 4. *Enhanced concept hierarchy of process (with umbrella concepts)*

Furthermore, after umbrella concepts were included in the hierarchy of process, certain original concepts became new umbrella concepts (e.g. atmospheric process, endogenic geological process, hydrological process) which also improved the whole hierarchy of the conceptual network. This case study was limited to the inclusion of those umbrella concepts located at upper levels (i.e. artificial process and natural process). However, in future work the use and function of these new sets of umbrella concepts will be examined to consider their inclusion in the TKB.

The third example analyzed was chemical element. Without umbrella concepts, the concept hierarchy was extremely shallow since there was no intermediate level between the hyperonym and the hyponyms (42 in total) that could be used to classify them in more specific subgroups (see Table 5). However, in chemistry, chemical elements can be classified according to different criteria (period, group, block, etc.), so a set of ten *general umbrella concepts* (e.g. actinide, noble gas, transition metal) was implemented to refine the hyponymic classification of the concept hierarchy (see Table 6).

| | |
|---|---|
| CHEMICAL ELEMENT **(42 hyponyms)** | ALUMINUM \| ARGON \| ARSENIC \| ASTATINE \| BERYLLIUM \| BORON \| BROMINE \| CALCIUM \| CARBON \| CHLORINE \| CHROMIUM \| COBALT \| COPPER \| FLUORINE \| GALLIUM \| GERMANIUM \| HELIUM \| HYDROGEN \| IODINE \| IRON \| ISOTOPE \| LEAD \| LITHIUM \| MAGNESIUM \| MANGANESE \| NEON \| NICKEL \| NITROGEN \| OXYGEN \| PHOSPHORUS \| POTASSIUM \| RADON \| SCANDIUM \| SELENIUM \| SILICON \| SODIUM \| SULFUR \| TITANIUM \| TRACE ELEMENT \| URANIUM \| VANADIUM \| ZINC |

Table 5. *Original concept hierarchy of chemical element (without umbrella concepts)*

| | | |
|---|---|---|
| CHEMICAL ELEMENT **(13 hyponyms)** | ACTINIDE | URANIUM |
| | ALKALI METAL | LITHIUM \| POTASSIUM \| SODIUM |
| | ALKALINE EARTH METAL | BERYLLIUM \| CALCIUM \| MAGNESIUM |
| | BASIC METAL | ALUMINUM \| GALLIUM \| LEAD |
| | HALOGEN | ASTATINE \| BROMINE \| CHLORINE \| FLUORINE \| IODINE |
| | LANTHANIDE | - |
| | NOBLE GAS | ARGON \| HELIUM \| NEON \| RADON |
| | NONMETAL | CARBON \| NITROGEN \| OXYGEN \| PHOSPHORUS \| SELENIUM \| SULFUR |
| | SEMIMETAL | ARSENIC \| BORON \| GERMANIUM \| SILICON |
| | TRANSITION METAL | CHROMIUM \| COBALT \| COPPER \| IRON \| MANGANESE \| NICKEL \| SCANDIUM \| TITANIUM \| VANADIUM |
| | HYDROGEN \| ISOTOPE \| TRACE ELEMENT | |

Table 6. *Enhanced concept hierarchy of chemical element (with umbrella concepts)*

Nevertheless, as can be observed in Table 6, umbrella concepts are not always reflected in polylexical terms. In fact, in this case, umbrella concepts can be both monolexical (e.g. ACTINIDE, HALOGEN) and polylexical terms (e.g. NOBLE GAS, TRANSITION METAL). The fact that most of the umbrella concepts are noun compounds or noun phrases means that they can be created relatively easily through simple syntactic and semantic constructions. Nevertheless, in certain cases the umbrella concepts carry an essive component which can only be described with a completely different term. These are mostly *general umbrella concepts* with exactly the same use and function as those noun compounds derived from a process of semantic predicate deletion or nominalization.

Our last case study was of the concept hierarchy of representation, in which all of the umbrella concepts implemented were monolexical terms. Since the original concept hierarchy of representation (see Table 7) was characterized by a vast amount of hyponyms (204), it was necessary to include an intermediate classification to regroup the cohyponyms in more specific dimensions. Therefore, a set of 18 *general umbrella concepts* related to ways of representing information (e.g. *graph*, *image*, *model*) was implemented so as to filter the hierarchy and thus obtain a much clearer hyponymic classification (see Table 8).

| | |
|---|---|
| **Representation (204 hyponyms)** | adiabatic chart \| age of the sea waves \| ageostrophic model \| air density \| aircraft meteorological data relay \| analog model \| anemogram \| atmospheric model \| average monthly and yearly precipitation map \| axis of anticyclone \| axis of depression \| backwater curve \| balance between the pressure field and the horizontal field of motion \| balance equation \| baseline cartography \| bathymetric chart \| Beaufort scale \| behavior model \| berm line \| bifurcation ratio \| Bowen ratio \| capillary-tube model \| cartogram \| cartographic information \| Celsius temperature scale \| chemical system \| climate model \| coalescence efficiency \| coefficient \| contour \| co-range line \| co-tidal line \| Darcy's law \| data model \| derived model \| design storm \| diagnostic equation \| differential equation \| digital elevation model \| digital terrain model \| discharge curve \| distributed model \| divergence equation \| Douglas scale \| dynamic equation \| dynamics \| Earth's elliptic orbit \| echogram \| ecliptic plane \| ecosystem \| Ekman spiral \| electricity potential \| empirical flood formula \| energy equation \| environmental fluid dynamics code \| environmental map \| equation of state \| equator \| equilibrium line \| equinoctial low tide \| erosion model \| Fahrenheit temperature scale \| falling curve \| fall-stage-discharge relation \| farming and exploitation map \| foam line \| Fujita-pearson scale \| future and emerging technologies \| geographic coordinate system \| geologic map \| gradient \| groin system \| groundwater flow model \| height above sea level \| Hele-shaw model \| high latitudes \| high water line \| hydraulic radius model \| hydrograph \| hydrologic data \| hydrologic model \| hydrostatic equation \| impedance \| index \| integrated watershed management model \| irrigation system \| isobar \| isobath \| isochron \| isochrone map \| isohaline \| isohyet \| isohypse \| isopach \| isopach chart \| isotach \| isotherm \| jet-stream axis \| Kelvin temperature scale \| land modelling \| land use map \| level \| limit of backwash \| limit of uprush \| limnigraph \| Linke blue sky scale \| longitude \| low latitudes \| low water line \| Lucdeme project \| manning equation \| map of nutrient sources \| Margules equation \| marigram \| mathematical function \| mathematical model \| Mercalli scale \| meridian \| mesoscale \| metadata \| meteorogram \| microscale \| mixing ratio \| momentum equation \| Monin-obukhov equation \| nautical chart \| Newton's laws of motion \| non-linear equation \| numerical model \| one-line model \| operational model \| ordinary high water mark \| orthophoto \| outflow boundary \| photomap \| physical system \| pluviogram \| prediction \| pressure-volume-temperature relationship \| probable maximum precipitation \| profile map \| protocol \| radiant flux \| Rankine temperature scale \| raster \| rating curve \| Réaumur temperature scale \| recession curve \| reef system \| reference evapotranspiration \| refraction-diffraction model \| relative evaporation \| relative humidity \| relative permeability \| Richter scale \| ridge and runnel system \| road map \| rule \| Saffir-simpson hurricane scale \| sand fraction \| satellite image \| shoreline \| significant wave \| simulation \| slope map \| soil density \| soil map \| soil saturation \| spatial correlation \| spatial interpolation of the average yearly and monthly precipitation \| specific groundwater runoff \| specific humidity \| stage-discharge relation \| star chart \| state-of-sea scale \| step \| storage ratio \| strand line \| stratigraphic column \| stream line \| stream tube \| synoptic scale \| tap water system \| tendency equation \| thalweg \| tidal current chart \| tidal piezometric efficiency \| tide table \| topographic map \| tropic of cancer \| tropic of capricorn \| T-s diagram \| urban system \| Van genuchten model \| water density \| water line (land) \| water line (vessel) \| water quality model \| water retention curve \| wave climate \| wave equation \| wave frequency \| wave steepness \| waveform |

Table 7. *Original concept hierarchy of representation (without umbrella concepts)*

| | | |
|---|---|---|
| **Representation (18 hyponyms)** | axis | axis of anticyclone / axis of depression / jet-stream axis |
| | equation | balance equation / diagnostic equation / differential equation / divergence equation / dynamic equation / energy equation / equation of state / hydrostatic equation / manning equation / Margules equation / momentum equation / Monin-obukhov equation / non-linear equation / tendency equation / wave equation |
| | graph | anemogram / backwater curve / contour / discharge curve / echogram / falling curve / hydrograph / limnigraph / marigram / pluviogram / rating curve / recession curve / T-s diagram / water retention curve / waveform |
| | image | satellite image |
| | isogram | isobar / isobath / isochron / isohaline / isohyet / isohypse / isopach / isotach / isotherm |
| | latitude | high latitudes / low latitudes |
| | limit | berm line / co-range line / co-tidal line / equilibrium line / foam line / high water line / level / limit of backwash / limit of uprush / low water line / ordinary high water mark / outflow boundary / shoreline / step / strand line / stream line / thalweg / water line (land) / water line (vessel) |
| | longitude | - |
| | map | adiabatic chart / average monthly and yearly precipitation map / bathymetric chart / cartogram / environmental map / farming and exploitation map / geologic map / isochrone map / isopach chart / land use map / map of nutrient sources / nautical chart / orthophoto / photomap / profile map / road map / slope map / soil map / star chart / tidal current chart / topographic map |
| | meridian | - |
| | model | ageostrophic model / analog model / atmospheric model / behavior model / capillary-tube model / climate model / data model / derived model / design storm / digital elevation model / digital terrain model / distributed model / environmental fluid dynamics code / erosion model / groundwater flow model / Hele-shaw model / hydraulic radius model / hydrologic model / integrated watershed management model / land modelling / mathematical model / numerical model / one-line model / operational model / refraction-diffraction model / simulation / Van genuchten model / water quality model |
| | parallel | equator / tropic of cancer / tropic of capricorn |
| | path | Earth's elliptic orbit / ecliptic plane |
| | piece of data | baseline cartography / cartographic information / coefficient / Ekman spiral / equinoctial low tide / height above sea level / hydrologic data / index / metadata / meteorogram / prediction / probable maximum precipitation / raster / reference evapotranspiration / rule / sand fraction / significant wave / soil saturation / spatial interpolation of the average yearly and monthly precipitation / stratigraphic column / stream tube / tide table / wave climate / wave frequency |
| | programme | aircraft meteorological data relay / future and emerging technologies / Lucdeme project / protocol |

| | | |
|---|---|---|
| **Representation (18 hyponyms)** | ratio | age of the sea waves / air density / balance between the pressure field and the horizontal field of motion / bifurcation ratio / Bowen ratio / coalescence efficiency / Darcy's law / electricity potential/ empirical flood formula / fall-stage-discharge relation / gradient / impedance / mathematical function / mixing ratio / Newton's laws of motion / pressure-volume-temperature relationship / radiant flux / relative evaporation / relative humidity / relative permeability / soil density / spatial correlation / specific groundwater runoff / specific humidity / stage-discharge relation / storage ratio / tidal piezometric efficiency / water density / wave steepness |
| | scale | Beaufort scale / Celsius temperature scale / Douglas scale / Fahrenheit temperature scale / Fujita-pearson scale / Kelvin temperature scale / Linke blue sky scale / Mercalli scale / mesoscale / microscale / Rankine temperature scale / Réaumur temperature scale / Richter scale / Saffir-simpson hurricane scale / state-of-sea scale / synoptic scale |
| | system | chemical system / dynamics / ecosystem / geographic coordinate system / groin system / irrigation system / physical system / reef system / ridge and runnel system / tap water system / urban system |

Table 8. *Enhanced concept hierarchy of representation (with umbrella concepts)*

All these examples indicate the usefulness of umbrella concepts as a means of refining hyponymy in a TKB, complementarily to correcting property inheritance and to decomposing hyponymy into subtypes. However, further research is needed to determine the usefulness of umbrella concepts in EcoLexicon as a whole. Moreover, it will also be necessary to establish objective parameters (i.e. abstraction, information overload, noise, etc.) to decide which conceptual networks should be enhanced with umbrella concepts. Nonetheless, our results show that enriching hierarchies with umbrella concepts is a promising approach to the refinement of hyponymy.

## 6. Conclusion

This paper has discussed the importance of terminological resources in specialized translation, which implies a complex knowledge acquisition process. Not only do translators need to master the writing, understanding, and use of specialized discourse in order to carry out their work, they also need to have access to effective tools for knowledge acquisition. For this reason, we have examined the usefulness of TKBs based on their main features: accessibility, dynamism, multidimensionality, and multimodality. When TKBs accurately represent contextual information, they allow users to understand how terms are used in real situations. This makes them an excellent resource for translators.

In this line, we have assessed the usefulness of EcoLexicon, a multilingual TKB on environmental science that displays an accessible visual interface and provides access to conceptual, linguistic, and graphical information. EcoLexicon shows its content in the form of a visual thesaurus (linking concepts through semantic relations), five main features (definition, terms, resources, conceptual categories, and phraseology) and corpus concordances searches. More precisely, in previous research, we explored how hyponymic relations could be enhanced by correcting property inheritance in concept definitions and by establishing subtypes of hyponymy.

However, a third way to refine hyponymy is the creation and implementation of umbrella concepts. After explaining how noun compounds and noun phrases contain semantic meanings that allow them to be classified according to different nuances, this process was used to create and implement umbrella concepts in various concept hierarchies in EcoLexicon. Nevertheless, it was observed that umbrella concepts are not only represented with polylexical terms, but also with monolexical terms. Therefore, further research is necessary to determine when they are necessary and the extent to which they should be implemented in the TKB. Future work will also focus on the automatization of hyponymic patterns extraction directly from the corpus of the TKB, as a means to retrieve hyponymic pairs and possible umbrella concepts only with the use of corpus query language (CQL).

In conclusion, this paper demonstrates how translation-oriented TKBs can enhance specialized knowledge representation and retrieval. Moreover, this research also takes previous work on hyponymy refinement one step further by showing its validity in EcoLexicon and thus opening the door to its application in similar TKBs.

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