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Ontological Encoding of GeoSciML and INSPIRE geological standard vocabularies and schemas: application to geological mapping

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Encoding of geologic knowledge in formal languages is an ambitious task, aiming at the interoperability and organic representation of geological data, and semantic characterization of geologic maps.
Initiatives such as GeoScience Markup Language (last version is GeoSciML 4, 2015[1]) and INSPIRE "Data Specification on Geology" (an operative simplification of GeoSciML, last version is 3.0 rc3, 2013[2]), as well as the recent terminological shepherding of the Geoscience Terminology Working Group (GTWG[3]) have been promoting information exchange of the geologic knowledge. There have also been limited attempts to encode the knowledge in a machine-readable format, especially in the lithology domain (see e.g. the CGI_Lithology ontology[4]), but a comprehensive ontological model that connect the several knowledge sources is still lacking.

This presentation concerns the "OntoGeonous" initiative, which aims at encoding the geologic knowledge, as expressed through the standard vocabularies, schemas and data models mentioned above, through a number of interlinked computational ontologies, based on the languages of the Semantic Web and the paradigm of Linked Open Data. The initiative proceeds in parallel with a concrete case study, concerning the setting up of a synthetic digital geological map of the Piemonte region (NW Italy), named "GEOPiemonteMap" (developed by the CNR Institute of Geosciences and Earth Resources, CNR IGG, Torino), where the description and classification of GeologicUnits has been supported by the modeling and implementation of the ontologies.

We have devised a tripartite ontological model called OntoGeonous that consists of:
1) an ontology of the geologic features (in particular, GeologicUnit, GeomorphologicFeature, and GeologicStructure[5], modeled from the definitions and UML schemata of CGI vocabularies[6], GeoScienceML and INSPIRE, and aligned with the Planetary realm of NASA SWEET ontology[7]), 2) an ontology of the Earth materials (as defined by the SimpleLithology CGI vocabulary and aligned as a subclass of the Substance class in NASA SWEET ontology), and 3) an ontology of the MappedFeatures (as defined in the Representation sub-taxonomy of the NASA SWEET ontology).
The latter correspond to the concrete elements of the map, with their geometry (polygons, lines) and geographical coordinates. The ontology model has been developed by taking into account applications primarily concerning the needs of geological mapping; nevertheless, the model is general enough to be applied to other contexts. In particular, we show how the automatic reasoning capabilities of the ontology system can be employed in tasks of unit definition and input filling of the map database and for supporting geologists in thematic re-classification of the map instances (e.g. for coloring tasks).

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[1] http://www.geosciml.org

[2] http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_GE_v3.0rc3.pdf

[3] http://www.cgi-iugs.org/tech_collaboration/geoscience_terminology_working_group.html

[4] https://www.seegrid.csiro.au/subversion/CGI_CDTGVocabulary/trunk/OwlWork/CGI_Lithology.owl

[5] We are currently neglecting the encoding of the geologic events, left as a future work.

[6] http://resource.geosciml.org/vocabulary/cgi/201211/

[7] Web site: https://sweet.jpl.nasa.gov, Di Giuseppe et al., 2013, SWEET ontology coverage for earth system sciences, http://www.ics.uci.edu/~ndigiuse/Nicholas_DiGiuseppe/Research_files/digiuseppe14.pdf; S. Barahmand et al. 2009, A Survey on SWEET Ontologies and their Applications, http://www-scf.usc.edu/~taheriya/reports/csci586-report.pdf