**Open Geospatial Consortium**

Submission Date: <yyyy-dd-mm>

Approval Date:   <yyyy-dd-mm>

Publication Date:   <yyyy-dd-mm>

External identifier of this OGC® document: <<http://www.opengis.net/doc/geosciml/>4.0>

Internal reference number of this OGC® document:    15-nnnrx

Version: 1.0.0

Category: OGC® Abstract specification

Editor:   GeoSciML Modelling Team

OGC Geoscience Markup Language 4.0

**Copyright notice**

Copyright © 2015 Open Geospatial Consortium  
To obtain additional rights of use, visit <http://www.opengeospatial.org/legal/>.

**Warning**

This document is not an OGC Standard. This document is distributed for review and comment. This document is subject to change without notice and may not be referred to as an OGC Standard.

Document type:    OGC® Standard

Document subtype:    if applicable

Document stage:    Draft

Document language:  English

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

**Notes about this draft (this section is for GeoSciML SWG commenting this document and will be removed from the document when published)**

Modular specification requires the document to be formatted in a specific way where a lot of sections are crossed referenced. Each requirement classes must have a table (see 6.1) of all the requirements, and all requirements must be tested in the conformance section, which refers to requirement using their unique URI. Keeping all those artefacts in synch while the document is being edited is tedious and error prone. Any change in the requirement section must be reflected in the conformance class and the requirements table must be updated.

In order to improve the process, we propose that the document is built in steps

1. Build the documentation and identify requirements and recommendations in the text (requirement URI and descriptive text in a box within the text as described in 6.2). The requirement table at the beginning of the section only contains dependencies at this point.
2. Once the requirements are agreed on and accepted, build the conformance classes, hopefully without having to revisit requirements (although, it will happen)
3. Once requirements and conformances are final, build the tables.

Step 3 will be done at the very end since it’s just a document structure task.

Therefore, you won’t see conformance classes in this document before we are done with step 1.

License Agreement

Permission is hereby granted by the Open Geospatial Consortium, ("Licensor"), free of charge and subject to the terms set forth below, to any person obtaining a copy of this Intellectual Property and any associated documentation, to deal in the Intellectual Property without restriction (except as set forth below), including without limitation the rights to implement, use, copy, modify, merge, publish, distribute, and/or sublicense copies of the Intellectual Property, and to permit persons to whom the Intellectual Property is furnished to do so, provided that all copyright notices on the intellectual property are retained intact and that each person to whom the Intellectual Property is furnished agrees to the terms of this Agreement.

If you modify the Intellectual Property, all copies of the modified Intellectual Property must include, in addition to the above copyright notice, a notice that the Intellectual Property includes modifications that have not been approved or adopted by LICENSOR.

THIS LICENSE IS A COPYRIGHT LICENSE ONLY, AND DOES NOT CONVEY ANY RIGHTS UNDER ANY PATENTS THAT MAY BE IN FORCE ANYWHERE IN THE WORLD.

THE INTELLECTUAL PROPERTY IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NONINFRINGEMENT OF THIRD PARTY RIGHTS. THE COPYRIGHT HOLDER OR HOLDERS INCLUDED IN THIS NOTICE DO NOT WARRANT THAT THE FUNCTIONS CONTAINED IN THE INTELLECTUAL PROPERTY WILL MEET YOUR REQUIREMENTS OR THAT THE OPERATION OF THE INTELLECTUAL PROPERTY WILL BE UNINTERRUPTED OR ERROR FREE. ANY USE OF THE INTELLECTUAL PROPERTY SHALL BE MADE ENTIRELY AT THE USER’S OWN RISK. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR ANY CONTRIBUTOR OF INTELLECTUAL PROPERTY RIGHTS TO THE INTELLECTUAL PROPERTY BE LIABLE FOR ANY CLAIM, OR ANY DIRECT, SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES, OR ANY DAMAGES WHATSOEVER RESULTING FROM ANY ALLEGED INFRINGEMENT OR ANY LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR UNDER ANY OTHER LEGAL THEORY, ARISING OUT OF OR IN CONNECTION WITH THE IMPLEMENTATION, USE, COMMERCIALIZATION OR PERFORMANCE OF THIS INTELLECTUAL PROPERTY.

This license is effective until terminated. You may terminate it at any time by destroying the Intellectual Property together with all copies in any form. The license will also terminate if you fail to comply with any term or condition of this Agreement. Except as provided in the following sentence, no such termination of this license shall require the termination of any third party end-user sublicense to the Intellectual Property which is in force as of the date of notice of such termination. In addition, should the Intellectual Property, or the operation of the Intellectual Property, infringe, or in LICENSOR’s sole opinion be likely to infringe, any patent, copyright, trademark or other right of a third party, you agree that LICENSOR, in its sole discretion, may terminate this license without any compensation or liability to you, your licensees or any other party. You agree upon termination of any kind to destroy or cause to be destroyed the Intellectual Property together with all copies in any form, whether held by you or by any third party.

Except as contained in this notice, the name of LICENSOR or of any other holder of a copyright in all or part of the Intellectual Property shall not be used in advertising or otherwise to promote the sale, use or other dealings in this Intellectual Property without prior written authorization of LICENSOR or such copyright holder. LICENSOR is and shall at all times be the sole entity that may authorize you or any third party to use certification marks, trademarks or other special designations to indicate compliance with any LICENSOR standards or specifications. This Agreement is governed by the laws of the Commonwealth of Massachusetts. The application to this Agreement of the United Nations Convention on Contracts for the International Sale of Goods is hereby expressly excluded. In the event any provision of this Agreement shall be deemed unenforceable, void or invalid, such provision shall be modified so as to make it valid and enforceable, and as so modified the entire Agreement shall remain in full force and effect. No decision, action or inaction by LICENSOR shall be construed to be a waiver of any rights or remedies available to it.

Contents

[1. Scope 11](#_Toc439664555)

[2. Conformance 11](#_Toc439664556)

[3. References 12](#_Toc439664557)

[4. Terms and Definitions 13](#_Toc439664558)

[4.1 coverage 13](#_Toc439664559)

[4.2 domain feature 13](#_Toc439664560)

[4.3 element <XML> 14](#_Toc439664561)

[4.4 feature 14](#_Toc439664562)

[4.5 GML application schema 14](#_Toc439664563)

[4.6 GML document 14](#_Toc439664564)

[4.7 GML schema 14](#_Toc439664565)

[4.8 measurement 14](#_Toc439664566)

[4.9 observation 14](#_Toc439664567)

[4.10 observation procedure 15](#_Toc439664568)

[4.11 observation result 15](#_Toc439664569)

[4.12 property <General Feature Model> 15](#_Toc439664570)

[4.13 sampled feature 15](#_Toc439664571)

[4.14 sampling feature 15](#_Toc439664572)

[4.15 schema <XML Schema> 15](#_Toc439664573)

[5. Logical Model 16](#_Toc439664574)

[5.1 Portrayal 17](#_Toc439664575)

[5.2 GeoSciML Basic and Extension 18](#_Toc439664576)

[6. Conventions 22](#_Toc439664577)

[6.1 Requirement classe 22](#_Toc439664578)

[6.2 Requirement 23](#_Toc439664579)

[6.3 Conformance class 23](#_Toc439664580)

[6.4 Identifiers 24](#_Toc439664581)

[7. Clauses not Containing Normative Material 24](#_Toc439664582)

[7.1 Clauses not containing normative material sub-clause 1 24](#_Toc439664583)

[7.1.1 Clauses not containing normative material sub-clause 2 25](#_Toc439664584)

[8. Logical Model 25](#_Toc439664585)

[8.1.1 Property cardinality 25](#_Toc439664586)

[8.1.2 Observed absence 26](#_Toc439664587)

[8.2 GeoSciML Core Abstract Requirements Class 26](#_Toc439664588)

[8.2.1 Naming of entities 26](#_Toc439664589)

[8.2.2 Cardinality 26](#_Toc439664590)

[8.2.3 Abstract classes 27](#_Toc439664591)

[8.2.4 Quantities 27](#_Toc439664592)

[8.2.5 Code lists 27](#_Toc439664593)

[8.2.6 Code lists URI 27](#_Toc439664594)

[8.2.7 Identifier 27](#_Toc439664595)

[8.3 GeoSciML Portrayal Abstract Requirements Class 28](#_Toc439664596)

[8.3.1 Geometry type 29](#_Toc439664597)

[8.3.2 String properties 29](#_Toc439664598)

[8.3.3 URI 29](#_Toc439664599)

[8.3.4 User defined properties 30](#_Toc439664600)

[8.3.5 GeologicUnitView 30](#_Toc439664601)

[8.3.6 BoreholeView 34](#_Toc439664602)

[8.3.7 ContactView 37](#_Toc439664603)

[8.3.8 GeologicSpecimenView 39](#_Toc439664604)

[8.3.9 GeomorphologicUnitView 41](#_Toc439664605)

[8.3.10 ShearDisplacementStructureView 43](#_Toc439664606)

[8.3.11 SiteObservationView 48](#_Toc439664607)

[8.4 GeoSciML Basic Abstract Requirements Class 50](#_Toc439664608)

[8.4.1 GeoSciML Data Types 52](#_Toc439664609)

[8.4.2 Geology basic 58](#_Toc439664610)

[8.4.3 Geologic Event 66](#_Toc439664611)

[8.4.4 Geologic Structure 68](#_Toc439664612)

[8.4.5 Geomorphology 74](#_Toc439664613)

[8.4.6 Collection 75](#_Toc439664614)

[8.4.7 GeoSciML basic vocabularies 79](#_Toc439664615)

[8.5 GeoSciML Extension Abstract Requirements Class 81](#_Toc439664616)

[8.5.1 Geologic Relations 82](#_Toc439664617)

[8.5.2 Earth material details 87](#_Toc439664618)

[8.5.3 GeologicAgeDetails 101](#_Toc439664619)

[8.5.4 Geologic Structure Details 103](#_Toc439664620)

[8.5.5 Geologic Unit Details 114](#_Toc439664621)

[8.5.6 GeoSciML extension vocabularies 116](#_Toc439664622)

[8.6 GeoSciML GeologicTime Abstract Requirements Class 118](#_Toc439664623)

[8.6.1 Global Boundary Stratotype Sections and Points 120](#_Toc439664624)

[8.6.2 Temporal Reference System 124](#_Toc439664625)

[8.6.3 Time scale 126](#_Toc439664626)

[8.6.4 Geologic time vocabularies 131](#_Toc439664627)

[8.7 GeoSciML Borehole Abstract Requirements Class 131](#_Toc439664628)

[8.7.1 Borehole 133](#_Toc439664629)

[8.8 GeoSciML Laboratory Abstract Analysis Requirements Class 143](#_Toc439664630)

[8.8.1 Laboratory Analysis 145](#_Toc439664631)

[8.8.2 Geochronology 151](#_Toc439664632)

[8.8.3 Geologic Specimen 154](#_Toc439664633)

[8.8.4 GeoSciML Laboratory analysis and specimen vocabularies 159](#_Toc439664634)

[8.8.5 Outcrop encoding pattern (Informative) 160](#_Toc439664635)

[9. GML Encoding Requirements classes 160](#_Toc439664636)

[9.1 Prefixes used in examples 161](#_Toc439664637)

[9.2 GeoSciML Core XML Requirements Class 162](#_Toc439664638)

[9.2.1 XML document validation 162](#_Toc439664639)

[Reference 163](#_Toc439664640)

[9.2.2 CodeList 164](#_Toc439664641)

[9.2.3 Identifiers 165](#_Toc439664642)

[9.2.4 Nillables or Voidables 165](#_Toc439664643)

[9.2.5 Date encoding 165](#_Toc439664644)

[9.2.6 Units of Measure 166](#_Toc439664645)

[9.3 GeoSciML Portrayal XML Requirements Class 166](#_Toc439664646)

[9.4 GeoSciML Portrayal GML 3.2 profile 167](#_Toc439664647)

[9.5 GeoSciML Portrayal GML 3.1 profile 168](#_Toc439664648)

[9.6 GeoSciML Basic XML Requirements Class 169](#_Toc439664649)

[9.7 GeoSciML Extension XML Requirements Class 170](#_Toc439664650)

[9.8 GeoSciML Geologic Time XML Requirements Class 170](#_Toc439664651)

[9.9 GeoSciML Borehole XML Requirements Class 171](#_Toc439664652)

[9.10 GeoSciML Laboratory XML Analysis Requirements Class 172](#_Toc439664653)

[9.10.1 GeologicSpecimen located along a borehole 172](#_Toc439664654)

[10. GeoSciML relative position profile 174](#_Toc439664655)

[11. GeoSciML CGI-IUGS Profile 175](#_Toc439664656)

[12. Media Types for any data encoding(s) 175](#_Toc439664657)

[A.1 Conformance class: AAAA (repeat as necessary) 176](#_Toc439664658)

Abstract

GeoSciML (Geoscience Markup Language or Geoscience ModeL) is a model of geological features commonly depicted on geological maps, cross sections, geological reports and databases. The model was developed by the CGI (Commission for the Management and Application of Geoscience Information) and version 4 is the first version officially submitted as an OGC standard. This specification describes a logical model and GML/XML encoding rules for the exchange of geological map data, geological time scales, borehole data and laboratory analysis. It provides a portrayal model, used for simple map based application, a basic model, aligned on INSPIRE, for basic data exchange and and extended model to address more complex scenarios.

The specification also provides patterns, profiles, most notably of Observations and Measurements (ISO19156), and best practices to deal with common geoscience use cases.

Keywords

The following are keywords to be used by search engines and document catalogues.

Ogc doc, OGC document, geology, geoscience, stratigraphy, borehole, geochemistry, geophysics, rock, fault, contact, fold, fossil, UML, GML.

Preface

The primary goal of this specification is to capture the semantics, schema, and encoding syntax of key elements present on geological maps and databases, in order to enable information systems to interoperate with such data.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The Open Geospatial Consortium shall not be held responsible for identifying any or all such patent rights.

*Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.*

Submitting organizations

The following organizations submitted this Document to the Open Geospatial Consortium (OGC):

1. Arizona Geological Survey, Arizona, United States of America
2. British Geological Survey (BGS), UK
3. Bureau de Recherches Géologiques et Minières (BRGM), France
4. Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia
5. Geological Survey of Victoria, Australia
6. Geological Survey of Finland (GTK), Finland
7. Geological Survey of Italy (ISPRA), Italy
8. Geological Survey of Sweden (SGU), Sweden
9. Geoscience Australia (GA), Australia
10. Institute of Geological and Nuclear Sciences (GNS), New Zealand
11. Natural Resources Canada (NRCan), Canada
12. U.S. Geological Survey (USGS), United States of America

Submitters

All questions regarding this submission should be directed to the editor or the submitters:

|  |  |
| --- | --- |
| Name | Affiliation |
| Oliver Raymond | Geoscience Australia |
| Steve Richard | Arizona Geological Survey |
| Eric Boisvert | Geological Survey of Canada (Natural Resources Canada) |

# Scope

GeoSciML (Geoscience Markup Language) covers the domain of geology (earth material, geological units, geochronology, , geological structures, geomorphology and composition) and sampling features common to the practice of geoscience, such as boreholes and geologic specimens. The specification also proposes a simplified version of GeoSciML suitable for map portrayal. This specification does not address (or very partially addresses) more specialised geoscience domains such as hydrogeology, seismology, geophysics or economic geology. Some of these domains are covered by other specifications (e.g. GWML for hydrogeology and EarthResourceML for economic geology – both developed in concert with GeoSciML).

# Conformance

This standard defines a logical model and an XML encoding conform to OGC GML 3.3 encoding rules, itself, an iteration over ISO 19136 (2007).

Requirements for two standardization target types are considered:

* Abstract logical model
* Data instance

Conformance with this standard shall be checked using all the relevant tests specified in Annex A (normative) of this document. The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance are specified in the OGC Compliance Testing Policies and Procedures and the OGC Compliance Testing web site[[1]](#footnote-1).

In order to conform to this OGC™interface standard, a software implementation shall choose to implement:

1. Any one of the conformance levels specified in Annex B (normative).
2. Any one of the Distributed Computing Platform profiles specified in Annexes TBD through TBD (normative).

All requirements-classes and conformance-classes described in this document are owned by the standard(s) identified.

# References

The following normative documents are referenced in the text or provide significant context for the development of GeoSciML 4.0. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document applies.

* OGC 06-121r9, OGC® Web Services Common Standard
* ISO 19103:2005 – Conceptual Schema Language
* ISO 8601- Data elements and interchange formats – Information interchange – Representation of dates and times
* OGC Abstract Specification Topic 20 – Observations and Measurements (also ISO 19156:2011)
* OGC Abstract Specification Topic 2 – Spatial Referencing by Coordinates (also ISO 19111:2007)
* OGC Abstract Specification Topic 6 – Schema for Coverage geometry and functions (also ISO 19123:2005)
* OGC Abstract Specification Topic 11 – Geographic information — Metadata (also ISO 19115:2003)
* OGC 07-036 Geography Markup Language (also ISO 19136:2007)
* OGC Observations and Measurements v2.0 OGC Document 10-004r1 http://www.opengis.net/doc/AS/Topic20 (also published as ISO/DIS 19156:2010,
* Geographic information — Observations and Measurements)
* OGC Observations and Measurements - XML Implementation v2.0 OGC Document 10-025r1 http://www.opengis.net/doc/IS/OMXML/2.0
* OGC SWE Common Data Model Encoding Standard v2.0 OGC Document 08-094r1 http://www.opengis.net/doc/IS/SWECommon/2.0
* Schematron: ISO/IEC 19757-3, Information technology — Document Schema Definition Languages (DSDL) — Part 3: Rule-based validation — Schematron <http://standards.iso.org/ittf/PubliclyAvailableStandards/c040833_ISO_IEC_19757-3_2006(E).zip>
* The Specification Model — A Standard for Modular specifications OGC Document 08-131r3.
* Unified Code for Units of Measure (UCUM) – Version 1.8, July 2009
* Unified Modeling Language (UML). Version 2.3. May 2010.
* Extensible Markup Language (XML) – Version 1.0 (Fourth Edition), August 2006
* XML Schema – Version 1.0 (Second Edition), October 2004

# Terms and Definitions

This document uses the terms defined in Sub-clause 5.3 of [OGC 06-121r8], which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this standard.

For the purposes of this document, the following additional terms and definitions apply.

## coverage

Feature that acts as a function to return values from its range for any direct position within its spatial, temporal or spatiotemporal domain.

[ISO 19123:2005, definition 4.17]

## domain feature

Feature of a type defined within a particular application domain.

NOTE: This may be contrasted with observations and sampling features, which are features of types defined for cross-domain purposes.

[ISO 19156, definition 4.4]

## element <XML>

Basic information item of an XML document containing child elements, attributes and character data.

NOTE: From the XML Information Set ― each XML document contains one or more elements, the boundaries of which are either delimited by start-tags and end-tags, or, for empty elements, by an empty-element tag. Each element has a type, identified by name, sometimes called its ‘generic identifier’ (GI), and may have a set of attribute specifications. Each attribute specification has a name and a value.

[ISO 19136:2007]

## feature

Abstraction of a real-world phenomenon.

[ISO 19101:2002, definition 4.11]

## GML application schema

Application schema written in XML Schema in accordance with the rules specified in OGC GML 3.3

[ISO 19136:2007]

## GML document

XML document with a root element that is one of the elements AbstractFeature, Dictionary or TopoComplex, specified in the GML schema or any element of a substitution group of any of these elements.

[ISO 19136:2007]

## GML schema

Schema components in the XML namespace ―‖ as specified in OGC GML 3.3

[ISO 19136:2007]

## measurement

Set of operations having the objective of determining the value of a quantity.

[ISO/TS 19101-2:2008, definition 4.20]

## observation

Act of observing a property.

NOTE: The goal of an observation may be to measure or otherwise determine the value of a property.

[ISO 19156:2011 definition 4.10]

## observation procedure

Method, algorithm or instrument, or system which may be used in making an observation.

[ISO19156, definition 4.11]

## observation result

Estimate of the value of a property determined through a known procedure.

[ISO 19156:2011]

## property <General Feature Model>

Facet or attribute of an object referenced by a name.

EXAMPLE: Abby's car has the colour red, where "colour red" is a property of the car instance.

## sampled feature

The real-world domain feature of interest, such as a groundwater body, aquifer, river, lake, or sea, which is observed.

[ISO 19156:2011]

## sampling feature

Feature, such as a station, transect, section or specimen, which is involved in making observations of a domain feature.

NOTE: A sampling feature is purely an artefact of the observational strategy, and has no significance independent of the observational campaign.

[ISO 19156:2011, definition 4.16]

## schema <XML Schema>

XML document containing a collection of schema component definitions and declarations within the same target namespace.

Example Schema components of W3C XML Schema are types, elements, attributes, groups, etc.

NOTE: The W3C XML Schema provides an XML interchange format for schema information. A single schema document provides descriptions of components associated with a single XML namespace, but several documents may describe components in the same schema, i.e. the same target namespace.

[ISO 19136:2007]

# Logical Model

GeoSciML 4.0 Logical model is an interpretation and repackaging of version 3.2 of the conceptual model published by IUSG (<http://www.geosciml.org/>). The conceptual model is organised into 13 thematic packages while the logical model proposes a packaging aligned on data delivery use cases.

GeoSciML is organised into 6 application packages (Figure 1).

* GeoSciML Portrayal : a simplified version for layer based application
* GeoSciML Basic : a set of core features, aligned to INSPIRE Geoscience model
* GeoSciML Extension : an extension providing detailed description of basic features. Adds additional properties and associations.
* GeoSciML Geologic Age : a model for the representation of geologic time using procedures adopted by the International Stratigraphic Commission.
* GeoSciML Borehole : a model of boreholes and their properties as sampling features.
* GeoSciML Laboratory analysis: a model of laboratory analytical data, specimens and isotopic age observation results.



Figure 1: GeoSciML 4.0 packages

Each application package is the subject of at least one requirements class (to conform to modular specification) per target implementation (this specification has two targets; logical model and XML). More target implementations might be published as separate documents.

## Portrayal

GeoSciML portrayal is a denormalised view of key geological and sampling features, designed as a simple entry level model to publish datasets, particularly adapted to geographic visualization with key reporting properties. The use case target for portrayal is a simple layer-based application, such as web map application or GIS where the key functionality is to display a map layer and perform simple identify operations. The classes are modelled to be easily implementable in any GIS or web mapping applications. One class maps to one table composed of optional, single occurrence, properties – consistent with the structure of RDBMS tables The XML implementation (clause 9.5) is conformant with GML Simple Feature (OGC 10-100r3).

Several fields are external references, in the form of HTTP URI, to form a “switchboard” where application operating on instances of the portrayal model could access complex representations of the features when required (Figure 2).

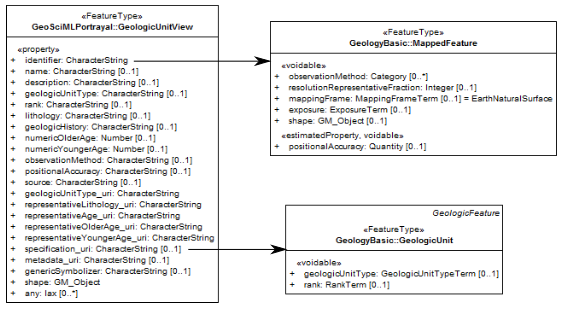


Figure 2 Linkage between portrayal and other GeoSciML packages. An instance of GeologicUnitView matches an instance of MappedFeature.

## GeoSciML Basic and Extension

GeoSciML describes geological features from the mapping perspective, articulated around the concept of a MapFeature – the cartographic element shown on a map, and the GeologicalFeature it represents. All geologic concepts that can be represented on a map are subtypes of GeologicalFeature. GeologicFeature is an abstract class materialised into four concrete classes (Figure 1) ; GeologicEvent, GeologicStructure, GeologicUnit and GeomorphologicFeatures. Other main features from GeoSciML are not geologic features themselves, but features related to the activity of sampling and observing geology (such as Borehole or GeologicSpecimen) and are therefore modelled as SF\_SamplingFeature (O&M) subtypes.



Figure 3 Core feature model for GeoSciML

GeologicFeature can share relationships through relation (AbstractRelation) class, subtyped into different kind of relationships, providing different properties and constrains.

In order to provide a simple entry level model for data providers, but also to align to INSPIRE, only a minimal set of properties are supported by **basic** package. When more properties are required, the data provider can bring in the **extension** package. To split properties between basic and extension, a modelling pattern has been adopted to overcome the limitations of classical object oriented subtyping imposed by UML and XSD.

To add custom properties to an existing class (what extension package actually does), the technique normally used is to create a class as a subtype to carry the new properties.



Figure 4: Adding properties by extension

But this only works when properties need to be added to a leaf class. Properties added to a class higher up won’t propagate to existing subtypes. GeoSciML uses an extension pattern by property blocks. Blocks of properties are organized in their own type and associated to the class



Figure 5 : Extension pattern using a property block (Description class)

This pattern has two main advantages:

* Does not require the creation of a new feature type to add properties to core features.
* Extra properties can be defined by a community and use by another one (for example, properties added by geophysic application could be reused by groundwater applications)

GeoSciML Basic contains 9 stub abstract classes concretised in GeoSciML extension (Table 1).

Table 1 GeoSciML basic stub classes

|  |  |
| --- | --- |
| **Class** | **Description** |
| **AbstractFeatureRelation** | Association class placeholder to implement relation between geologic features |
| **EarthMaterialAbstractDescription** | Detailed earth material description placeholder for GeologicUnit and EarthMaterial |
| **GeologicUnitAbstractDescription** | Detailed geologic unit description placeholder for GeologicUnit |
| **GeologicEventAbstractDescription** | Detailed geologic event description placeholder for GeologicEvent |
| **ContactAbstractDescription** | Detailed contact description placeholder for Contact |
| **FoliationAbstractDescription** | Detailed foliation description placeholder for Foliation |
| **FoldAbstractDescription** | Detailed fold description placeholder for Fold |
| **ShearDisplacementStructureAbstractDescription** | Detailed shear displacement description placeholder for ShearDisplacementStructure |
| **GeomorphologicUnitAbstractDescription** | Detailed geomorphologic unit description placeholder for GeomorphologicUnit |

Since those classes are abstract in GeoSciML Basic, data providers need to implement GeoSciML Extension, or any third party extension to get concrete classes.

# Conventions

## Requirement classe

Each normative statement (requirement or recommendation) in this specification is a member of a requirements class. Each requirements class is described in a discrete clause or sub-clause, and summarized using the following template:

|  |  |
| --- | --- |
| **Requirements class** | **/req/{classM}** |
| **Target type** | [artefact or technology type] |
| **Dependency** | [identifier for another requirements class] |
| **Requirement** | /req/{classM}/{reqN} |
| **Recommendation** | /req/{classM}/{recO} |
| **Requirement** | /req/{classM}/{reqP} |
| **Requirement /Recommendation** | [repeat as necessary] |

All requirements in a class must be satisfied. Hence, the requirements class is the unit of re-use and dependency, and the value of a dependency requirement is another requirements class. All requirements in a dependency must also be satisfied by a conforming implementation. A requirements class may consist only of dependencies and introduce no new requirements.

## Requirement

All requirements are normative, and each requirement is presented using the following template:

|  |  |
| --- | --- |
| **/req/[classM]/[reqN]** | [Normative statement] |

where /req/[classM]/[reqN] identifies the requirement or recommendation. The use of this layout convention allows the normative provisions of this specification to be easily located by implementers.

## Conformance class

Conformance to this specification is possible at a number of levels, specified by conformance classes (Annex A). Each conformance class is summarized using the following template:

|  |  |
| --- | --- |
| **Conformance class** | **/conf/{classM}** |
| **Dependency** | [identifier for another conformance class] |
| **Requirements** | /req/{classA} |
| **Tests** | [reference to clause(s) containing tests] |

All tests in a class must be passed. Each conformance class tests conformance to a set of requirements packaged in a requirements class.

W3C Schema (XSD) and ISO Schematron (SCH) files are considered as part of this specification, although available online only, due to concerns about document size. Many requirements are expressed in a single XSD or SCH file although tests are listed individually in the conformance annex (one test for XSD and one test for SCH).

Schematron files explicitly specify which requirements are being tested in the title of the schematron pattern.

<pattern id="origin\_elevation">

<title>Test requirement: /req/geosciml-borehole/origin\_elevation</title>

<rule context="gsmlb:Borehole">

<assert test="count(gsml:gwWellReferenceElevation/gwml2w:Elevation[gwml2w:elevationType/@xlink:href='http://www.opengis.net/req/gwml2-well/origin\_elevation']) = 1">A GW\_Well needs at least one origin Elevation</assert>

</rule>

</pattern>

## Identifiers

The normative provisions in this specification are denoted by a URI constructed using this pattern:

http://www.opengis.net/spec/{standard}/{m.n}

All requirements and conformance tests that appear in this document are denoted by partial URIs which are relative to this base. The identifier supports cross-referencing of class membership, dependencies, and links from each conformance test to the requirements tested. In this specification identifiers are expressed as partial URIs or paths, which can be appended to a base URI that identifies the specification as a whole in order to construct a complete URI for identification in an external context.

The URI for each requirements class has the form

http://www.opengis.net/spec/geosciml/4.0**/req/[classM]**.

The URI for each requirement or recommendation has the form

http://www.opengis.net/spec/geosciml/4.0**/req/[classM]/[reqN]**.

The URI for each conformance class has the form

http://www.opengis.net/spec/geosciml/4.0**/conf/[classM]**.

The URI for each conformance test has the form

http://www.opengis.net/spec/geosciml/4.0**/conf/[classM]/[testN]**.

# Clauses not Containing Normative Material

Paragraph

## Clauses not containing normative material sub-clause 1

Paragraph

### Clauses not containing normative material sub-clause 2

# Logical Model

This section describes requirements that must be met by all target implementations that claim conformance to this specification. The logical model, expressed using UML, provides naming, structure and cardinality for any physical implementation or instance encoding. The UML model is a normative artefact as it is the official representation of GeoSciML. Rules that can unambiguously inferred from the UML model won’t be documented as explicit requirements . Specific encoding idiosyncrasies shall be addressed in the requirement clause pertaining to this encoding.

Add explanation on how community must extend this specification (for example, to impose their own vocabularies)

The UML model provides name, structure and cardinality for the data element composing various potential physical implementations of GeoSciML. There are formal mappings between UML and GML (ISO-19136), UML and RDF (ISO-19150) and best practices exists for mapping UML to RDBMS. Although it is assumed that UML is technologically neutral, in reality, UML models always end up addressing some of the physical model details. The current UML model has been designed as a GML application according to ISO 19109 and borrows some of artefacts of GML. Several design decisions were guided by limitations of UML (eg. single inheritance) and XSD (package dependencies artefacts) and some constrains of GML delivery over WFS (for instance, some XSD encoding are not queryable easily with FES). But the UML model is detailed enough to constrain the main elements of any encoding; the name of the entities and the cardinality of the properties, the associations between entities and to some extent property types. On the other hand, some UML features do not have equivalences in certain encoding (for instance JSON does not have a native support for namespaces or even schema).

This section defines the minimal UML mapping requirements that shall be met by any target claiming compliance to this specification.

### Property cardinality

All properties that could be made optional are optional in GeoSciML 4.0. This is a complete reversal of version 3.2 where all properties were made mandatory, forcing the data provider to document why the property was missing using nillable properties. This design attracted a lot of criticism (not only for GeoSciML but from other communities presented with the same pattern) from application developers and data providers that consider filling the instance with nil properties is “unnecessarely verbose” and a waste of bandwidth. It has been argued that nillable properties are just a verbose absent value. This issue is a real concern for mobile applications where payload has an impact on user experience.

Nillable properties actually carry useful or even required in certain use cases, such as legally bounded data exchange scenarios. Some communities using GeoSciML might still want to force usage of nilled properties and the SWG recognised that different communities might want to enforce different sets of properties. To meet this requirements and to offer flexibility to various communities wanting to use (or extend) GeoSciML, properties are optional, but can still be nilled. A data provider is offered two options when a value is missing:

* Omit the property
* Emit a nilled property with relevant missing value justifications.

What option is useful for a community is left to that community that can enforce the rules using Schematron. Therefore what we foresee is a) GeoSciML ontology, defined by this specification providing naming and structure and b) a series of community defined rule to enforce presence of certain properties relevant to their use cases. For XML, this translates into a set of common XSD and SCH to anyone claiming conformance to GeoSciML and community specific SCH to enforce specific use cases, such as INSPIRE.

### Observed absence

There are situation in geology where the absence of something is actually important information (as opposed to “unknown” presence). Certain biostratigraphic units are defined by the absence of marker species.

*Biostratigraphic classification is also an early step in working out the stratigraphy of a region. Biostratigraphic units are based on the fossil content of the rocks.The selection and establishment of biostratigraphic units are not determined by the lithologic composition of the strata, except that the presence or* ***absence*** *of fossils and the kind of fossils present, may be related to the type and lithofacies of the rocks in which they are found.*

*International Stratigraphic Guide <*[*http://www.stratigraphy.org/upload/bak/rel.htm*](http://www.stratigraphy.org/upload/bak/rel.htm)*>*

Another example lies in description of metamorphic facies where absence or presence of certain index minerals informs the temperature and pressure conditions the rock experienced (eg, kyanite for high pressure and low temperature). There is adifference between reporting confirmed absence of kyanite and the presence of kyanite is not known.

## GeoSciML Core Abstract Requirements Class

This section presents requirements that all targets must conform to in to order to claim compliance with GeoSciML 4.0.

### Naming of entities

|  |  |
| --- | --- |
| /req/gsml4-core/uml-entity-name | When the target implementation allows it, the exact name of the entity SHALL be used. |

If a target implementation is capable of encoding all the names used in UML, it shall do so. Some target implementations might prevent it; for example, DBF column names are restricted to 10 characters or some RDBMS limits the use of camel case names. But if the target allows it, the exact names shall be used.

### Cardinality

|  |  |
| --- | --- |
| /req/gsml4-core/uml-cardinality | If the Target implementation allows it, it SHALL implement the same cardinality of properties and associations as defined in the UML |

### Cardinality shall be the same as defined in UML model. Since essentially all properties are optional, this clause addressed the upper bound : “1” or “many” in almost all cases. Therefore, if the UML limits a property to “1”, the target implementation can’t be “many”.Abstract classes

|  |  |
| --- | --- |
| /req/gsml4-core/uml-abstract | Abstract classes SHALL not be materialised |

Not all physical implementation support the concept of abstract class or even inheritance and polymorphism. XSD does support that concept and all its implications, but JSON does not. This requirement specifies that the physical model shall not allow materialisation of an instace of a class marked as abstract.

|  |  |
| --- | --- |
| /req/gsml4-core/uml-polymorphism | Target implementation SHALL implements type substitutions inferred from the UML model |

The type hierarchy of the UML model implies type substitutions as property values. For instance, a property value of type GeologicEvent can be substituted by a value of type DisplacementEvent because DisplacementEvent is a sub type of GeologicEvent (Figure 6). A lot of property type are abstract type and only a concrete subtype can be materialised (as per /req/gsml4-core/uml-abstract). A target implementation shall consider type substitutions using mechanisms available for this implementation.

Figure 6 : DisplacementEvent as subtype of GeologicEvent

### Quantities

The Quantities and Measurements units of measure shall be taken from a standard vocabulary governed by an appropriate community, for example UCUM.

|  |  |
| --- | --- |
| /req/gsml4-core/quantities-uom | Quantities and measurements SHALL have explicit units of measure from a governed ontology |

### Code lists

All properties that require formal vocabularies are modelled in UML as classes having the stereotype <<CodeList>>. The list of valid terms should be taken from a standard vocabulary governed by an appropriate community.

|  |  |
| --- | --- |
| /req/gsml4-core/codelist | Classes of stereotype <<CodeList>> SHOULD be specified using the URI for an individual from a class governed as an external ontology |

### Code lists URI

The URI used to identify vocabulary terms SHALL be resolvable using Linked Open Data Principles, where a URI identifier can resolve to multiple representations (or formats) for the term using HTTP content, MIME-type and language negotiation mechanisms.

|  |  |
| --- | --- |
| /req/gsml4-core/codelistURI | URI used for vocabulary terms SHALL be resolvable using Linked Open Data principles. |

### Identifier

Features that use an HTTP URI as their identifier SHALL be resolvable following Linked Open Data principles.

|  |  |
| --- | --- |
| /req/gsml4-core/identifier | HTTP URI used as identifiers SHALL be resolvable following Linked Open Data principles. |

The URI shall point to one or more representations of the feature it identifies. It is expected that one of the representations should be a XML(GML) representation.

## GeoSciML Portrayal Abstract Requirements Class

GeoSciML-Portrayal is a simplication of GeoSciML for map based applications. It was developed to provide a simple schema to deliver geologic map unit, contact, borehole, samples, geomorphologic unit and shear displacement structure (fault and ductile shear zone) descriptions in web map services. The intention is to support interoperable map services, for which interoperability is based on a shared data schema and the use of standard vocabulary terms for basic type classification of contacts and faults, age of geologic units and faults, and lithology of geologic units.

Use of standard vocabulary enables map display using a shared legend (symbolization scheme) to achieve visual harmonization of maps provided by different services. In addition the GeoSciML-Portrayal data structure includes text fields with information for human users browsing a geologic map, a link to a full GeoSciML feature element if available, and a symbol identifier field to enable a user-defined symbolization scheme in each map service.

By linking the simple feature WMS with a GeoSciML WFS, clients can acquire geologic feature descriptions that can be used in web-mapping applications to construct custom legends. Linking to full GeoSciML features allows the portrayal schema to be used in a map browsing and query interface to identify and select features for further processing that can be acquired as highly structured, information-rich GML features.

Figure 7 : Package dependency for GeoSciML Portrayal

GeoSciML-Portrayal conforms to the level 0 of the Simple Features Profile for GML (OGC 10-100r3 - van den Brink et al., 2011; OGC 06-049). The simple features profile supports only a limited subset of possible GML geometry types that may be used to describe feature geographic location and shape. For the purposes of GeoSciML simple features, these include gml:Point, gml:LineString, gml:Curve, gml:Polygon, gml:Surface, gml:MultiPoint, gml:MultiCurve, gml:MultiSurface and multi-geometry types consisting of collections of these base types.

GeoSciML-Portrayal features are analogous to GeoSciML mapped features, with additional text attributes for human consumption, a flatted-relation view of the age, and assignment to a single lithology. The portrayal schema consists of ‘free-text’ fields and identifier fields. In robust services the free-text fields will contain well-structured summaries of data in a format suitable for reading by the intended users. Identifier fields should contain identifiers for concepts in a controlled vocabulary (for example CGI Simple Lithology) that specify representative thematic properties. Inclusion of these standardized identifiers enables interoperability across services. Ideally these should be URIs that can be dereferenced to obtain machine-processable or human-readable representations of the identified concepts.

In addition, each feature includes an (optional) identifier for a specification, which is a resource containing a description of that particular feature. In many cases, the descriptions will be the same for all polygons assigned to the same map unit or classified as the same kind of contact or structure. If more complete information is available, different descriptions may be associated with subsets of features of the same type that are portrayed with the same symbol. In the most extreme case, each feature might have a unique description that captures the full spatial variability of a geologic unit or structure. Following the standard patterns of web architecture, the specification\_uri should be dereferenceable to obtain one or more representations of that description. For maximum interoperability, one of these representations should be a GeoSciML encoded description of the feature, but other encodings might also be available, for example HTML web pages, other XML schema, or JSON. For those familiar with full GeoSciML, the specification\_uri property is equivalent to the specification association from MappedFeature to GeologicFeature.

|  |  |
| --- | --- |
| **Abstract Requirements Class** | |
| **/req/gsml4-portrayal** | |
| Target type | Logical model |
| Dependency | **/req/gsml4-core** |
| Dependency | **GML Simple Feature SF-0 OGC 10-100r3** |
| Dependency | **ISO 8601 (Date and Time format)** |
| Dependency | **Linked Open Data** |

### Geometry type

A dataset (for example, a GML document or a GeoJSON instance) shall use a single geometry type. Most GIS and software rendering a dataset containing geometry don’t expect mixed geometries.

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geomtype | A data instance SHALL use a single geometry type (Point, Line, Polygon, etc.) |

### String properties

String properties should provide information easily readable by human. The intent of string field is to display, not to query. The string properties can be translated according to the language of the user as needed while URI should not.

|  |  |
| --- | --- |
| /req/gsml4-portrayal/string | Properties of type “CharacterString” SHOULD contain human readable text. |

#### Formal Syntax

Some string properties can be constructed using formal syntax, such as comma delimited list or any other text based structure (JSON for example). The use of such syntax should be formalised in a profile of this specification.

### Date and Time formatting

|  |  |
| --- | --- |
| /req/gsml4-portrayal/datetime | Calendar date and time SHALL be formatted according to ISO 8601 |

All dates and times, excluding geological ages, shall be formatted using ISO 8601 format (YYYY-MM-DD). When a time must be specified, time zone shall be provided.

Examples:

* 2016-01-05 (simple date)
* 2016-01-05T08:40:15-05 (time expressed for time zone GMT -5)
* 2016-01-05T13:40:15Z (same as above, but expressed in UTC a.k.a Zulu)

### URI

Properties which names end with “\_uri” shall contain a single absolute URI conformant to RFC 3986.

|  |  |
| --- | --- |
| /req/gsml4-portrayal/uri | Properties which name end with “\_uri” shall contain a string conformant to URI format as specified in RFC 3986 |

Properties containing a URI should resolve following Linked Open Data principles.

|  |  |
| --- | --- |
| /req/gsml4-portrayal/resolvable-uri | Properties containing a valid URI SHOULD provide a resolvable URI referring to a resources resolvable using Linked Open Data principles |

Although many vocabulary terms are defined as URI, not all URI are actually supported by a formal Linked Open Data infrastructure. URI are just convenient mechanism to ensure governance. Some community might create a profile of this requirements class and add more constrains, such as mandatory resolution of the URI to one or more resources and impose mandatory mime-types (GeoSciML/XML or GeoSciML/GeoJSON).



Figure 8 GeoSciML portrayal classes

Figure 3 shows the 7 portrayal classes supported by GeoSciML 4.0. Each class is equivalent to a layer in a GIS or a Web Map Service.

### User defined properties

|  |  |
| --- | --- |
| /req/gsml4-portrayal/user-defined | Features delivered with user defined properties SHALL be conformant to GML Simple Feature Level 0 |

New properties added by the data provider shall keep the feature conformant to GML Simple Feature Level 0. For example, no duplicate property names, nor extra geometry properties.

### GeologicUnitView

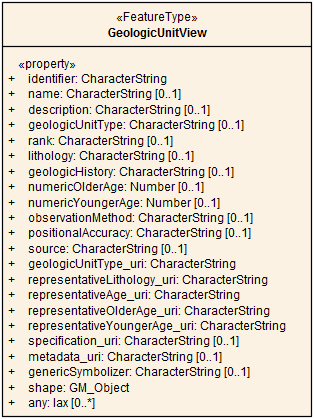


Figure 9: GeologicUnitView class

GeologicUnitView is a simplified view of a GeoSciML GeologicUnit. In GeoSciML terms this will be an instance of a MappedFeature with key property values from the associated GeologicUnit feature summarised as labels (unconstrained character strings) or arbitrarily selected classifiers to be used for thematic mapping purposes. The latter are the properties suffixed with '\_uri' and will contain URIs referring to controlled concepts in published vocabularies

#### identifier

Globally unique identifier:CharacterString shall uniquely identifies a tuple within the dataset

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geologicunitview-identifier-unique | Identifier SHALL be globally unique to a dataset |

It should have the same value as the corresponding GeoSciML MappedFeature identifier, if available.

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geologicunitview-identifier | Where possible, GeologicUnitView identifier SHOULD correspond to and instance of MappedFeature |

#### name

name:CharacterString is a Display name for the the GeologicalUnit.

#### description

Text description:CharacterString of the GeologicUnit, typically taken from an entry on a geological map legend.

#### geologicUnitType

Label (CharacterString) of the type of GeologicUnit (as defined in GeoSciML). The formal URI identifier is provided in field geologicUnitType\_uri

#### rank

Label rank:CharacterString of GeologicUnit (as defined by ISC. eg; group, formation, member).

#### Lithology

Human readable description as CharacterString of the GeologicUnit’s lithology, possibly formatted with formal syntax (see 8.3.2.1). The descrition can be language dependent. The representativeLithology\_uri should be use for a language neutral controlled term.

**geologicHistory**

Human readable description in CharacterString, possibly formatted with formal syntax (see 8.3.2.1), of the age of the GeologicUnit (where age is a sequence of events and may include process and environment information). For definition of ages using controlled terms, representativeAge\_uri, representativeOlderAge\_uri, representativeYoungerAge\_uri shall be used.

#### numericOlderAge

Older age is a numerical representation (Real) of the unit’s older age in million years (Ma).

#### numericYoungerAge

Younger age is a numerical representation (Real) of the unit’s younger age in million years (Ma).

#### observationMethod

The property observationMethod:CharacterString is a metadata snippet indicating how the spatial extent of the feature was determined. ObservationMethod is a convenience property that provides a simple approach to observation metadata when data are reported using a feature view (as opposed to observation view).

#### positionalAccuracy

The property positionalAccuracy:CharacterString is a quantitative values defining the radius of an uncertainty buffer around a mappedFeature (eg: a positionAccuracy of 100 m for a line feature defines a buffer polygon of total width 200 m centred on the line).

#### source

The property source:CharacterString is a human readable text describing feature-specific details and citations to source materials, and if available provides URLs to reference material and publications describing the geologic feature. This could be a short text synopsis of key inforamtion that would also be in the metadata record referenced by metadata\_uri.

#### geologicUnitType\_uri

The property geologicUnitType\_uri:CharacterString shall contain a URI referring to a controlled concept from a vocabulary defining the GeologicUnit types. It is a mandatory property - if no value is provided then a URI referring to a controlled concept explaining why the value is nil must be provided.

#### representativeLithology\_uri

The property representativeLithology\_uri:CharacterString shall contain a URI referring to a controlled concept specifying the characteristic or representative lithology of the unit. This may be a concept that defines the super-type of all lithology values present within a GeologicUnit or a concept defining the lithology of the dominant CompositionPart (as defined in GeoSciML) of the unit.

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geologicunitview-representativeLithology | RepresentativeLithology\_uri value SHALL refer to a controlled concept specifying the characteristic or representative lithology of the unit. This may be a concept that defines the super-type of all lithology values present within a GeologicUnit or a concept defining the lithology of the dominant CompositionPart (as defined in GeoSciML) of the unit. |

#### representativeAge\_uri

The property representativeAge\_uri:CharacterString shall contain a URI referring to a controlled concept specifying the most representative stratigraphic age interval for the GeologicUnit. This will be defined entirely at the discretion of the data provider and may be a single event selected from the geologic feature's geological history or a value summarising the all or part of the feature's history.

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geologicunitview-representativeAge | RepresentativeAge\_uri value SHALL refer to a controlled concept specifying the most representative stratigraphic age interval for the GeologicUnit. This will be defined entirely at the discretion of the data provider and may be a single event selected from the geologic feature's geological history or a value summarising the all or part of the feature's history. |

#### representativeOlderAge\_uri

The property representativeOlderAge\_uri:CharacterString shall contain a URI referring to a controlled concept specifying the most representative lower value in a range of stratigraphic age intervals for the GeologicUnit. This will be defined entirely at the discretion of the data provider and may may be a single event selected from the geologic feature's geological history or a value summarising the all or part of the feature's history.

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geologicunitview-representativeOlderAge | RepresentativeAge\_uri value SHALL refer to a controlled concept specifying the most representative lower value in a range of stratigraphic age intervals for the GeologicUnit. This will be defined entirely at the discretion of the data provider and may be a single event selected from the geologic feature's geological history or a value summarising the all or part of the feature's history. |

#### representativeYoungerAge\_uri

The property representativeYounderAge\_uri:CharacterString shall contain a URI referring to a controlled concept specifying the most representative upper value in a range of stratigraphic age intervals for the GeologicUnit. This will be defined entirely at the discretion of the data provider and may be a single event selected from the geologic feature's geological history or a value summarising the all or part of the feature's history.

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geologicunitview-representativeYoungerAge | RepresentativeAge\_uri value SHALL refer to a controlled concept specifying the most representative upper value in a range of stratigraphic age intervals for the GeologicUnit. This will be defined entirely at the discretion of the data provider and may be a single event selected from the geologic feature's geological history or a value summarising the all or part of the feature's history. |

#### specification\_uri

The property specification\_uri:CharacterString shall contain a URI referring the GeoSciML GeologicUnit feature that describes the instance in detail. It is a mandatory property - if no value is provided then a URI referring to a controlled concept explaining why the value is nil must be provided.

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geologicunitview-specification | Specification\_uri value SHOULD refer the GeoSciML GeologicUnit feature that describes the instance in detail. Mandatory property - if not value is provided then a URI referring to a controlled concept explaining why the value is nil must be provided. |

#### metadata\_uri

#### The property metadata\_uri:CharacterString shall contain a URI referring to a metadata record describing the provenance of data.genericSymbolizer

The property genericSymbolizer:CharacterString contains a identifier for a symbol from standard (locally or community defined) symbolization scheme for portrayal.

#### shape

The property shape:GM\_Object contains a geometry defining the extent of the feature of interest.

#### Any

A data provider can add an arbitrary number of extra properties, as long as the instance is conformant to GML Simple Feature Level 0.

### BoreholeView

BoreholeView is a simplified view of a GeoSciML Borehole. In GeoSciML terms, this will be an instance of a Borehole feature with key property values summarised as labels (unconstrained character strings) or arbitrarily selected classifiers to be used for thematic mapping purposes. The latter are the properties suffixed with '\_uri' and will contain URIs referring to controlled concepts in published vocabularies.

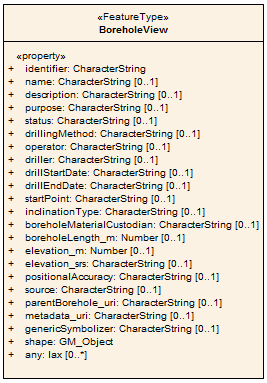


Figure 10: BoreholeView class

Table 3 BoreholeView properties

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Notes** |
| identifier | CharacterString | Globally unique identifier. |
| name | CharacterString | Display name for the borehole. |
| description | CharacterString | Text description of the borehole. |
| purpose | CharacterString | The purpose for which the borehole was drilled. (eg, mineral exploration, hydrocarbon exploration, hydrocarbon production, groundwater monitoring, geothermal) |
| status | CharacterString | The present status of the borehole (eg, abandoned, completed, proposed, suspended) |
| drillingMethod | CharacterString | Indicates the drilling method, or methods, used for this borehole (eg, RAB, auger, diamond core drilling, air core drilling, piston) |
| operator | CharacterString | Organisation or agency responsible for commissioning of the borehole (as opposed to the agency which drilled the borehole). |
| driller | CharacterString | The organisation responsible for drilling the borehole (as opposed to commissioning the borehole). |
| drillStartDate | CharacterString | The date of the start of drilling formatted according to ISO 8601 (eg 2012-03-17) |
| drillEndDate | CharacterString | The date of the end of drilling formatted according to ISO 8601 (eg 2012-03-28) |
| startPoint | CharacterString | Indicates the position relative to the ground surface where the borehole commenced (eg, open pit floor or wall, underground, natural land surface, sea floor) |
| inclinationType | CharacterString | Indicates the type of inclination of the borehole (eg, vertical, inclined up, inclined down, horizontal) |
| boreholeMaterialCustodian | CharacterString | Organisation that is the custodian of the material recovered from the borehole |
| boreholeLength\_m | Number | The length of a borehole, in metres, as determined by the data provider. Length may have different sources, eg, driller's measurement, logger's measurement, survey measurement) |
| elevation\_m | Number | Compromise approach to supply elevation data, in metres, for the borehole (ie, wellbore) start point. This is to allow for legacy data without elevation data, and for software that cannot process a 3D GM\_Point. The SRS will be a one dimensional vertical SRS (ie, EPSG code in the range 5600-5799). |
| elevation\_srs | CharacterString | URI of a spatial reference system of the elevation value. (eg, mean sea level) Mandatory if elevation\_m is populated. |
| positionalAccuracy | CharacterString | An estimate of the accuracy of the location of the borehole collar location. |
| source | CharacterString | Text describing details and citations to source materials for the borehole and, if available, providing URLs to reference material and publications describing the borehole. This could be a short text synopsis of key information that would also be in the metadata record referenced by metadata\_uri. |
| parentBorehole\_uri | CharacterString | URI referring to the unique ID of a parent borehole (eg, parent well of a sidetrack wellbore) |
| metadata\_uri | CharacterString | URI referring to a metadata record describing the provenance of data. |
| genericSymbolizer | CharacterString | Identifier for a symbol from standard (locally or community defined) symbolization scheme for portrayal. |
| shape | GM\_Object | Geometry defining the extent of the borehole start point. |
| any |  | A placeholder allowing any user-defined attributes to be delivered in addition to those specified above. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/boreholeview-identifier | Identifier SHOULD resolve to a representation of a GeoSciML Borehole |

If available, the identifier should provide a deferencable URI pointing to one or more representation of the borehole.

|  |  |
| --- | --- |
| /req/gsml4-portrayal/boreholeview-elevationSrs | Elevation\_srs SHOULD resolve to a valid EPSG vertical datum |

Vertical datum are in the range [5600,5800[.

|  |  |
| --- | --- |
|  |  |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/boreholeview-parentBorehole-uri | If present, parentBorehole\_uri SHOULD resolve to a representation of a GeoSciMLl borehole. |

If the borehole does not have any parent, this field shall be empty

|  |  |
| --- | --- |
|  |  |

### ContactView

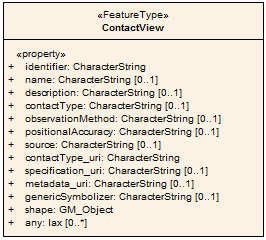


Figure 11 ContactView class

ContactView is a simplified view of a GeoSciML Contact feature. In GeoSciML terms this will be an instance of a MappedFeature with key property values from the associated Contact feature summarised as labels (unconstrained character strings) or arbitrarily selected classifiers to be used for thematic mapping purposes. The latter are the properties suffixed with '\_uri' and will contain URIs referring to controlled concepts in published vocabularies.

Table 4 : ContactView properties

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Notes** |
| identifier | CharacterString | Globally unique identifier. Should have the same value as the corresponding GeoSciML MappedFeature. |
| name | CharacterString | Display name for the Contact. |
| description | CharacterString | Text description of the Contact, typically taken from an entry on a geological map legend. |
| contactType | CharacterString | Type of Contact (as defined in GeoSciML). |
| observationMethod | CharacterString | Metadata snippet indicating how the spatial extent of the feature was determined. ObservationMethod is a convenience property that provides a quick and simple approach to observation metadata when data are reported using a feature view (as opposed to observation view). |
| positionalAccuracy | CharacterString | Quantitative values define the radius of an uncertainty buffer around a mappedFeature (eg: a positionalAccuracy of 100 m for a line feature defines a buffer polygon of total width 200 m centred on the line). |
| source | CharacterString | Text describing feature-specific details and citations to source materials, and if available providing URLs to reference material and publications describing the geologic feature. This could be a short text synopsis of key information that would also be in the metadata record referenced by metadata\_uri. |
| contactType\_uri | CharacterString | URI referring to a controlled concept from a vocabulary defining the Contact types. Mandatory property - if not value is provided then a URI referring to a controlled concept explaining why the value is nil must be provided. |
| specification\_uri | CharacterString | URI referring the GeoSciML Contact feature that describes the instance in detail. Mandatory property - if not value is provided then a URI referring to a controlled concept explaining why the value is nil must be provided. |
| metadata\_uri | CharacterString | URI referring to a metadata record describing the provenance of data. |
| genericSymbolizer | CharacterString | Identifier for a symbol from standard (locally or community defined) symbolization scheme for portrayal. |
| shape | GM\_Object | Geometry defining the extent of the feature of interest. |
| any |  | A placeholder allowing any user-defined attributes to be delivered in addition to those specified above. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/contactview-identifier | Identifier SHOULD correspond to an instance of MappedFeature |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/contactview-contacttype | contactType\_uri SHALL refer to a vocabulary term describing a contact type or… |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/contactview-specification-uri | Specification\_uri SHALL resolve to a representation of GeoSciML Contact. |

|  |  |
| --- | --- |
|  |  |

### GeologicSpecimenView

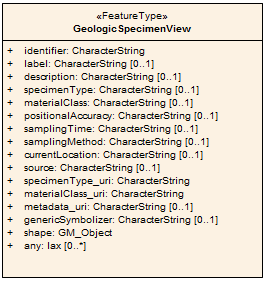


Figure 12 GeologicSpecimenView class

A simplified view of a point-located specimen from GeoSciML GeologicSpecimen (an extension of Observations & Measurements - ISO19156) with key property values summarised as labels (unconstrained character strings) or arbitrarily selected classifiers to be used for thematic mapping purposes. The latter are the properties suffixed with '\_uri' and will contain URIs referring to controlled concepts in published vocabularies.

Table 5 : GeologicSpecimentView properties

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Notes** |
| identifier | CharacterString | Globally unique identifier (eg, an IGSN sample number) that shall correspond to an instance of GeologicSpecimen |
| label | CharacterString | Short label for map display. (eg, a sample number) |
| description | CharacterString | Detailed description of the specimen. |
| specimenType | CharacterString | Description of the specimen type. Preferably a term from a controlled vocabulary (eg, hand specimen, thin section, drill core). |
| materialClass | CharacterString | Classification of the material that comprises the specimen. Preferably a term from a controlled vocabulary (eg, rock, sediment, etc) |
| positionalAccuracy | CharacterString | Description of the positional accuracy of the sampling location. (eg, 50 metres) |
| samplingTime | CharacterString | Date (+/- time) when the specimen was collected formatted according to ISO 8601 |
| samplingMethod | CharacterString | The method used to collect the specimen (eg, diamond drilling, field mapping survey) |
| currentLocation | CharacterString | The current location of the specimen (eg, a warehouse or other repository location) |
| source | CharacterString | Citation of the source of the data (eg, a publication, map, etc) |
| specimenType\_uri | CharacterString | URI link for a specimen type identifier from a controlled vocabulary. |
| materialClass\_uri | CharacterString | URI link for a class of material drawn from a controlled vocabulary. |
| metadata\_uri | CharacterString | URI link to a metadata document. |
| genericSymbolizer | CharacterString | Identifier for a symbol from standard (locally or community defined) symbolization scheme for portrayal. |
| shape | GM\_Object | Map geometry of the specimen (generally a point) |
| any |  | Place holder for user-defined properties. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geologicspecimenview-identifier | Identifier SHALL correspond to an instance of GeoSciML GeologicSpecimen |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geologicspecimenview-specimentype-uri | Specimentype-uri SHALL resolve to a vocabulary term describing a geologic specimen type |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geologicspecimenview-materialclass-uri | materialClass\_uri SHALL resolve to a vocabulary term describing a material class |

|  |  |
| --- | --- |
|  |  |

|  |  |
| --- | --- |
|  |  |

### GeomorphologicUnitView

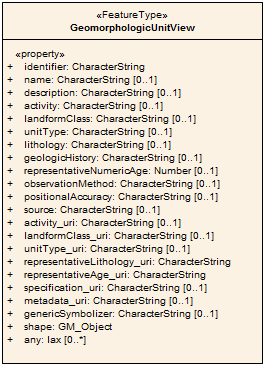


Figure 13 GeomorphologicUnitView

GeomorphologicUnitView is a simplified view of a GeoSciML GeomorphologicUnit. In GeoSciML terms this will be in instance of a MappedFeature with key property values from the associated GeomorphologicUnit feature summarised as labels (unconstrained character strings) or arbitrarily selected classifiers to be used for thematic mapping purposes. The latter are the properties suffixed with '\_uri' and will contain URIs referring to controlled concepts in published vocabularies.

Table 6 : GeomorphologicUnitView properties

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Notes** |
| identifier | CharacterString | Globally unique identifier. Should have the same value as the corresponding GeoSciML MappedFeature. |
| name | CharacterString | Display name for the GeomorphologicUnit. |
| description | CharacterString | Text description of the GeomorphologicUnit, typically taken from an entry on a map legend. |
| activity | CharacterString | Term to specify if the feature is changing and how fast.  e.g. active, dormant, stable.... |
| landformClass | CharacterString | Term to specify a broad classification of landform, preferably from a controlled vocabulary. (eg, anthropogenic, natural) |
| unitType | CharacterString | Type of GeomorphologicUnit. Preferably from a controlled vocabular (eg, hill, crater, moraine, plain) |
| lithology | CharacterString | Text (possibly formatted with formal syntax) description of the GeomorphologicUnit's lithological composition. |
| geologicHistory | CharacterString | Text (possibly formatted with formal syntax) description of the age of the GeomorphologicUnit (where age is a sequence of events and may include process and environment information). |
| representativeNumericAge | Real | Numerical representation of the representative age in Ma. |
| observationMethod | CharacterString | Metadata snippet indicating how the spatial extent of the feature was determined. ObservationMethod is a convenience property that provides a quick approach to observation metadata when data are reported using a feature view (as opposed to observation view). |
| positionalAccuracy | CharacterString | Quantitative values define the radius of an uncertainty buffer around a mappedFeature (eg: a positionAccuracy of 100 m for a line feature defines a buffer polygon of total width 200 m centred on the line). |
| source | CharacterString | Text describing feature-specific details and citations to source materials, and if available providing URLs to reference material and publications describing the geologic feature. This could be a short text synopsis of key information that would also be in the metadata record referenced by metadata\_uri. |
| activity\_uri | CharacterString | URI identifier of activity term drawn from a controlled vocabulary. |
| landformClass\_uri | CharacterString | URI identifier of landform term drawn from a controlled vocabulary. |
| unitType\_uri | CharacterString | URI referring to a controlled concept from a vocabulary defining the GeomorphologicUnit types. Mandatory property - if no value is provided then a URI referring to a controlled concept explaining why the value is nil must be provided. |
| representativeLithology\_uri | CharacterString | URI referring to a controlled concept specifying the characteristic or representative lithology of the unit. This may be a concept that defines the super-type of all lithology values present within a GeomorphologicUnit or a concept defining the lithology of the dominant CompositionPart (as defined in GeoSciML) of the unit. |
| representativeAge\_uri | CharacterString | URI referring to a controlled concept specifying the most representative stratigraphic age interval for the GeomorphologicUnit. This will be defined entirely at the discretion of the data provider. Typically geomorphic units are not assigned age ranges. |
| specification\_uri | CharacterString | URI referring the GeoSciML GeomorphologicUnit feature that describes the instance in detail. Mandatory property - if not value is provided then a URI referring to a controlled concept explaining why the value is nil must be provided. |
| metadata\_uri | CharacterString | URI referring to a metadata record describing the provenance of data. |
| genericSymbolizer | CharacterString | Identifier for a symbol from standard (locally or community defined) symbolization scheme for portrayal. |
| shape | GM\_Object | Geometry defining the extent of the feature of interest. |
| any |  | A placeholder allowing any user-defined attributes to be delivered in addition to those specified above. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geomorphologicunitview-identifier | Identifier SHOULD correspond to a representation of GeoSciML MappedFeature |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geomorphologicunitview-activity-uri | Activity\_uri SHALL resolve to a representation of a vocabulary term describing an activity |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geomorphologicunitview-landformClass-uri | Landform\_uri SHALL resolve to a representation of a vocabulary term describing a landform class |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geomorphologicunitview-unitType-uri | unitType\_uri SHALL resolve to a representation of a vocabulary term describing a GeomorphologicUnit or a vocabulary term describing why the value is nil. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geomorphologicunitview-representativeLithology-uri | representativeLithology\_uri SHALL resolve to a representation of a vocabulary term describing a lithology |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geomorphologicunitview-representativeAge-uri | If present, representativeAge\_uri SHALL resolve to a representation of a vocabulary term describing a GeoSciML GeologicAge |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geomorphologicunitview-specification-uri | specification\_uri SHALL resolve to a representation of a GeoSciML GeomorphologicUnit or a vocabulary term describing why the value is nil. |

|  |  |
| --- | --- |
|  |  |

### ShearDisplacementStructureView

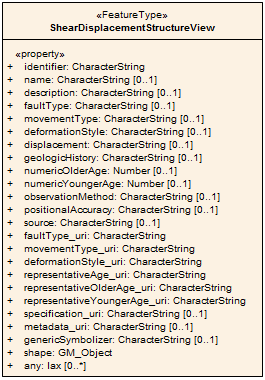


Figure 14 ShearDisplacementStructureView

ShearDisplacementStructureView is a simplified view of a GeoSciML ShearDisplacementStructure. In GeoSciML terms this will be an instance of a MappedFeature with key property values from the associated ShearDisplacementStructure feature summarised as labels (unconstrained character strings) or arbitrarily selected classifiers to be used for thematic mapping purposes. The latter are the properties suffixed with '\_uri' and will contain URIs referring to controlled concepts in published vocabularies.

Table 7: ShearDisplacementStructureView properties

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Notes** |
| identifier | CharacterString | Globally unique identifer. Should have the same value as the corresponding GeoSciML MappedFeature. |
| name | CharacterString | Display name for the the ShearDisplacementStructure. |
| description | CharacterString | Text description of the ShearDisplacementStructure, typically taken from an entry on a geological map legend. |
| faultType | CharacterString | Type of ShearDisplacementStructure (as defined in GeoSciML). |
| movementType | CharacterString | Summarises the type of movement (eg dip-slip, strike-slip) on the ShearDisplacementStructure. |
| deformationStyle | CharacterString | Describes the style of deformation (eg brittle, ductile etc) for the ShearDisplacementStructure. |
| displacement | CharacterString | Summarises the displacement across the ShearDisplacementStructure. |
| geologicHistory | CharacterString | Text (possibly formatted with formal syntax) description of the age of the ShearDisplacementStructure (where age is a sequence of events and may include process and environment information). |
| numericOlderAge | Real | Older age of the fault/shear structure, represented Ma. |
| numericYoungerAge | Real | Younger age of the fault/shear structure, represented Ma. |
| observationMethod | CharacterString | Metadata snippet indicating how the spatial extent of the feature was determined. ObservationMethod is a convenience property that provides a quick and dirty approach to observation metadata when data are reported using a feature view (as opposed to observation view). |
| positionalAccuracy | CharacterString | Quantitative values define the radius of an uncertainty buffer around a mappedFeature (eg: a positionAccuracy of 100 m for a line feature defines a buffer polygon of total width 200 m centred on the line). |
| source | CharacterString | Text describing feature-specific details and citations to source materials, and if available providing URLs to reference material and publications describing the geologic feature. This could be a short text synopsis of key inforamtion that would also be in the metadata record referenced by metadata\_uri. |
| faultType\_uri | CharacterString | URI referring to a controlled concept from a vocabulary defining the fault (ShearDisplacementStructure) type. Mandatory propery - if not value is provided then a URI referring to a conctrolled concept explaining why the value is nil must be provided. |
| movementType\_uri | CharacterString | URI referring to a controlled concept from a vocabulary defining the ShearDisplacementStructure movement type. Mandatory propery - if not value is provided then a URI referring to a conctrolled concept explaining why the value is nil must be provided. |
| deformationStyle\_uri | CharacterString | URI referring to a controlled concept from a vocabulary defining the ShearDisplacementStructure deformation style. Mandatory propery - if not value is provided then a URI referring to a conctrolled concept explaining why the value is nil must be provided. |
| representativeAge\_uri | CharacterString | URI referring to a controlled concept specifying the most representative stratigraphic age interval for the GeologicUnit. This will be defined entirely at the discretion of the data provider and may be a single event selected from the geologic feature's geological history or a value summarising the all or part of the feature's history. |
| representativeOlderAge\_uri | CharacterString | URI referring to a controlled concept specifying the most representative lower value in a range of stratigraphic age intervals for the GeologicUnit. This will be defined entirely at the discretion of the data provider and may be a single event selected from the geologic feature's geological history or a value summarising the all or part of the feature's history. |
| representativeYoungerAge\_uri | CharacterString | URI referring to a controlled concept specifying the most representative upper value in a range of stratigraphic age intervals for the GeologicUnit. This will be defined entirely at the discretion of the data provider and may be a single event selected from the geologic feature's geological history or a value summarising the all or part of the feature's history. |
| specification\_uri | CharacterString | URI referring the the GeoSciML ShearDisplacementStructure feature that describes the instance in detail. Mandatory propery - if not value is provided then a URI referring to a conctrolled concept explaining why the value is nil must be provided. |
| metadata\_uri | CharacterString | URI referring to a metadata record describing the provenance of data. |
| genericSymbolizer | CharacterString | Identifier for a symbol from standard (locally or community defined) symbolization scheme for portrayal. |
| shape | GM\_Object | Geometry defining the extent of the feature of interest. |
| any |  | A placeholder allowing any user-defined attributes to be delivered in addition to those specified above. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/sheardisplacemenstructureview-identifier | Identifier SHALL correspond to a representation of GeoSciML MappedFeature |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/sheardisplacemenstructureview-faultType-uri | faultType\_uri SHALL resolved to a representation of a vocabulary term that fault (ShearDisplacementStructure) type or a vocabulary term describing why the value is nil. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/sheardisplacemenstructureview-movementType-uri | movementType\_uri SHALL resolved to a representation of a vocabulary term that fault (ShearDisplacementStructure) movement type or a vocabulary term describing why the value is nil. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/sheardisplacemenstructureview-deformationStyle-uri | movementType\_uri SHALL resolved to a representation of a vocabulary term that fault (ShearDisplacementStructure) deformation tyle or a vocabulary term describing why the value is nil. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/sheardisplacemenstructureview-representativeAge-uri | If present, representativeAge\_uri SHALL resolved to a representation of GeoSciML GeologicAge |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/sheardisplacemenstructureview-representativeOlderAge-uri | If present, representativeOlderAge\_uri SHALL resolved to a representation of GeoSciML GeologicAge |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/sheardisplacemenstructureview-representativeYoungerAge-uri | If present, representativeYoungerAge\_uri SHALL resolved to a representation of GeoSciML GeologicAge |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/sheardisplacemenstructureview-specification-uri | Specification\_uri SHALL resolve to a representation of GeoSciML ShearDisplacementStructure or a vocabulary term describing why the value is nil. |

|  |  |
| --- | --- |
|  |  |

### SiteObservationView

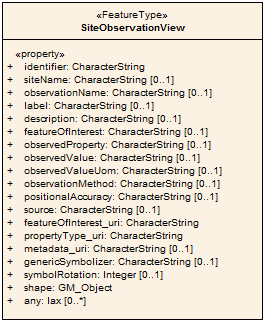


Figure 15 SiteObservationView class

SiteObservationView is a simplified view of a point-located geological observation, like a structural measurement. This is a simplified instance of a sampling point from Observations & Measurements (ISO19156) with an associated geological observation. Each tuple should represent a single observation. Key property values are summarised as labels (unconstrained character strings) or arbitrarily selected classifiers to be used for thematic mapping purposes. The latter are the properties suffixed with '\_uri' and will contain URIs referring to controlled concepts in published vocabularies.

Table 8: SiteObservationView properties

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Notes** |
| identifier | CharacterString | Unique identifier for this site observation record. |
| siteName | CharacterString | The name of the sampling feature at this location (e.g. a station number, a borehole) |
| observationName | CharacterString | Text string to identify the observation. |
| label | CharacterString | Short text string to associate with a symbol in a visualization/portrayal |
| description | CharacterString | Text string providing descriptive information about the observation. |
| featureOfInterest | CharacterString | The geologic feature that the observation is intended to characterize, e.g. foliation (observed property= orientation), a geologic unit (observed property = age,magnetic susceptibility, density, uranium content). |
| observedProperty | CharacterString | The property reported in this record. (eg. orientation, age, density, gold content). Preferably a term from a controlled vocabulary. |
| observedValue | CharacterString | Although this field is implemented as a character string to conform with simple feature requirements, it can be encoded as a swe:Record. This value may be numeric (eg; 235 degrees, 50 ppm) or textual (eg; red). |
| observedValueUom | CharacterString | The unit of measure for a numerical value of an observation or measurement, preferable from a controlled vocabulary. |
| observationMethod | CharacterString | Preferably a term from a controlled vocabulary to categorize the observation method. Further details on procedure can be put in the source field. |
| positionalAccuracy | CharacterString | Estimate of the position uncertainty for the site location. For numerical measurements, include a unit of measure in the description. (eg, 50 metres, poor, good). |
| source | CharacterString | Text description of measurement procedure, processing, and provenance of data. |
| featureOfInterest\_uri | CharacterString | URI link to a document describing the feature of interest (eg, a GeoSciML geologic unit or structure). |
| propertyType\_uri | CharacterString | URI to a term from a controlled vocabulary of observed property types. |
| metadata\_uri | CharacterString | URI link to metadata document. |
| genericSymbolizer | CharacterString | Identifier for a symbol to portray this observation. Conventions for symbol identifiers can be adopted within information exchange communities. In any given exchange document, the symbols should all be from the same portrayal scheme, which can be specified in the portrayal section of an associated ISO metadata record. |
| symbolRotation | Integer | Integer value between 0 and 360 to specify rotation of symbol at this location, e.g. rotation of a geologic strike and dip symbol to reflect the strike azimuth. |
| shape | GM\_Object | Map geometry of the observation site. |
| any |  | Additional user-defined properties. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/siteobservationview-identifier | Identifier SHOULD correspond to a representation of OM\_Observation |

Ideally, the identifier should be resolvable URI pointing to a representation of an Observation (ISO-19156).

|  |  |
| --- | --- |
|  |  |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/siteobservationview-featureOfInterest-uri | featureOfInterest\_uri SHALL resolve to a representation of a (ISO19109) Feature |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/siteobservationview-propertyType-uri | propertyType\_uri SHALL resolve to a representation of vocabulary term describing a property (ISO 19156 observedProperty) |

A property type shall identify a “*phenomenon associated with the feature-of-interest.*” (OGC 10-004r3, clause 7.2.2.8). The Observation and Measurement specification (op. cit.) explains that a property type “*may be, but need not be, modelled as a property (in the sense of the General Feature Model) in a formal application schema that defines the type of the feature-of-interest*” or “*Property-type definitions may be organized into a hierarchy or ontology and managed in a register and catalogued to support discovery functions.”*

|  |  |
| --- | --- |
|  |  |

## GeoSciML Basic Abstract Requirements Class

Basic package provides a collection of classes representing fundamental geological and geomorphological features (units, structures, and events), earth materials, geologic time, and the relations between them. It also provides an extension of Observation and Measurement (ISO-19156) covering Boreholes, GeologicSpecimen and AnalyticalProcess for both geochemistry and geochronology. It limits the number of descriptive properties to match important common use cases, including INSPIRE geological theme (INSPIRE Data Specification D2.8.II.4).



Figure 16 GeoSciML Basic dependencies

|  |  |
| --- | --- |
| **Requirements Class** | |
| **/req/gsml4-basic** | |
| Target type | Logical model |
| Dependency | **/req/gsml4-core** |
| Dependency | **Spatial Schema ISO19107** |
| Dependency | **Conceptual schema language ISO19103** |
| Dependency | **ISO19136** |

### Geology basic

Geologic Basic is a package of classes representing fundamental geological map features and the relations between them. GeoSciML describes a geologic dataset as a series of GeologicFeature occurrences, spatially described as MappedFeature. A map is a collection of MappedFeature. The term “map”, generally understood as a map sheet (a given area on the surface of the earth) is only one possible collection of MappedFeature. Other examples are cross-sections, block diagram, or event a borehole log (a linear map). MappedFeature can represent any features; GeologicFeatures are a subset of features it can represent. A MappedFeature identifies what it represents using its “specification” association.

Figure 17 shows the fundamental relationships between a MappedFeature and the GeologicFeature.



Figure 17 Geologic Feature and MappedFeature

GeologicFeature are further subtyped into GeologicUnit, GeologicStructure, GeomorphologicFeature and GeologicEvent.

#### GeologicFeature

The abstract GeologicFeature class represents a conceptual feature that is hypothesized to exist coherently in the world. It corresponds with a "legend item" from a traditional geologic map and its instance acts as the "description package". The description package is classified according to its purpose as an Instance; *TypicalNorm*, *DefiningNorm or Instance*. GeologicFeature can be used outside the context of a map (it can lack a MappedFeature), for example when describing typical norms (describing expected property from a feature) or defining norms (describing properties required from a feature to be classifying in a group, such as given geologic unit). GeologicFeature appearing on a map is considered as an “instance”.



Figure 18 Geologic Feature context diagram

Table 9 : GeologicFeature properties

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Notes** |
| observationMethod | Category | Feature ObservationMethod specifies the approach to acquiring the collection of attribute values that constitute an individual feature instance (e.g. point count, brunton compass on site, air photo interpretation, field observation, hand specimen, laboratory, aerial photography, creative imagination). ObservationMethod is a convenience property that provides a quick and simple approach to observation metadata when data are reported using a feature view (as opposed to observation view). |
| purpose | DescriptionPurpose | Specification of the intended purpose/level of abstraction for a given feature or object instance. Scoped name because intention is asserted by author of the data instance. Values are: instance, typicalNorm, definingNorm. |
| classifier | Category | A standard description or definition of the feature type (eg; the definition of a particular Geologic Unit in a stratigraphic lexicon) |
| occurrence | MappedFeature | A description association that links a notional geologic feature with any number of mapped features. A geologic feature, such as a geologic unit may be linked to mapped features from a number of different maps. |
| geologicHistory | GeologicEvent | Relates one or more GeologicEvents to a GeologicFeature to describe their age or geologic history |
| relatedFeature | GeologicFeature | General structure used to define relationships between any feature or object within GeoSciML. Relationships are always binary and directional. There is always a single source and a single target. The relationship is always defined from the perspective of the Source and is generally an active verb. In Basic, relatedFeature is a stub association (see clause 5.2) |

|  |  |
| --- | --- |
| /req/gsml4-basic/geologicfeature-purpose | Purpose SHALL be a values from Table 9 |

GeoSciML uses the generic relatedFeature/GeologicRelation to associate GeologicFeature with other GeologicFeatures. However, this functionality is only available from the Extension package because it adds extra complexity that is not required for Basic. But Basic does need to support age descriptions that implies using GeologicEvent and by consequence would require bringing GeologicRelation into Basic.

To avoid extra complexity, Basic provides an explicit geologicHistory property to associate GeologicFeature with an GeologicEvent without using a GeologicRelation. The consequence for someone using Extension is that he/she is now offered two ways to link a GeologicFeature and GeologicEvent: through geologicHistory and through a generic GeologicRelation.

To prevent confusion and promote consistency, association between GeologicFeature and GeologicEvent, for the purpose of describing geologic history, and therefore geologic age, shall use geologicHistory property.

|  |  |
| --- | --- |
| /req/gsml4-basic/geologicfeature-history | Association between GeologicFeature and GeologicEvent SHALL not use GeologicRelation |

Table 10: GeologicFeature purposes

|  |  |
| --- | --- |
| **Purpose** | **Description** |
| **TypicalNorm** | A description that specifies properties to be expected of some occurrence associated with the geologic entity. This description may include many properties that are not part of the DefiningNorm. For example, the fact that granite is typically light-colored is not a defining property, but is certainly a useful typical property. These kinds of descriptions would be used to address queries like '*This area is within a polygon classified as Podunk Formation; what sort of lithology am I most likely to encounter when I start digging?*' The Podunk Formation may be defined by the presence of a certain ammonite... TypicalNorm description would be constructed as a summary over many Instance descriptions. |
| **DefiningNorm** | A description that specifies properties sufficient to identify a new occurrence as belonging to the class represented by the description. Basically these are the 'sufficient conditions' for class membership. Used when presented with a query '*I have an outcrop with these properties; which geologic unit should I assign to the outcrop?*' DefiningNorm has to do with the intension of a ControlledConcept. |
| **Instance** | A description that is specific to a particular observed occurrence. This is 'raw data', and its classification may start out as very general. There are kinds of narrowly defined ControlledConcepts that might not allow 'instances' that are different from the DefiningNorm. It might be worth considering a different relationship between MappedFeature and an Instance geologic entity, with the geologic entity role being 'description'. |

#### MappedFeature

A MappedFeature is part of a geological interpretation. It provides a link between a notional feature (description package) and one spatial representation of it, or part of it (Exposures, Surface Traces and Intercepts, etc). The Mapped Features are the elements that compose a map, a cross-section, a borehole log or any other representation. The mappingFrame identifies the domain being mapped by the geometries. For typical geological maps, the mapping frame is the surface of the earth (the 2.5D interface between the surface of the bedrock and whatever sits on it), but it could be different domains, such as the arbitrary place that forms a mine level or a cross-section, the 3D volume enclosing an ore body or the line that approximate the path of a borehole.

The occurrence association identifies what notional feature is being mapped. This specification does not constrain what kind of feature can be represented, but for typical geological maps (or other representation), the MappedFeature occurrences will be GeologicalFeatures.

* the specific bounded occurrence, such as an outcrop or map polygon
* the association with a Geologic Feature (legend item) provides specification of all the other descriptors
* the association with a Sampling Feature provides the context and dimensionality

A Mapped Feature is always associated with some sampling feature - e.g. a mapping surface, a section, a Borehole (see Borehole) etc. As noted on the diagram, if the associated sampling feature is a Borehole, then the shape associated with the MappedFeature will usually be either a point or an interval. This reconciles the 2-D ("map", section) and 1-D (borehole, traverse) viewpoints in a common abstraction.

Table 11: MappedFeature properties

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Description** | |
| **observationMethod** | Category | MappedFeature ObservationMethod is a metadata snippet indicating how the spatial extent of the mapped feature was determined, and the basis for association of the geometry with some GeologicFeature specification to define a MappedFeature. For a borehole, the MappedInterval observation method indicates how the boundaries of the interval were defined (eg, linear measurement from borehole collar). ObservationMethod is a convenience property that provides a quick and dirty approach to observation metadata when data are reported using a feature view (as opposed to observation view). This property corresponds (loosely) to ISO19115 Lineage.  (eg: digitised, Global Positioning System, published map, fieldObservation, downhole survey, aerial photography, field survey) | |
| **positionalAccuracy** | Quantity | Quantitative values define the radius of an uncertainty buffer around a mappedFeature (eg: a positionAccuracy of 100 m for a line feature defines a buffer polygon of total width 200 m centred on the line). Corresponds to ISO19115 DQ\_PositionalAccuracy. | |
| **resolutionRepresentativeFraction** | Integer | An integer representing the denominator of the representative scale of the spatial feature.  (ie, 10,000 = the spatial feature is represented at 1:10,000 scale) | |
| **mappingFrame** | MappingFrameTerm | Terms indicating the surface on which the MappedFeature is projected. | |
| **exposure** | ExposureTerm | | Description of the nature of the expression of the mapped feature at the earth's surface (eg, exposed, concealed) |
| **shape** | GM\_Object | map geometry | |
| **specification** | GFI\_Feature | The feature being mapped. In a geological map, MappedFeature are used to represent GeologicFeature, but other features from other domains could be represented. | |

#### GeologicUnit

Operationally, a GeologicUnit is a container used to associate geologic properties with some mapped occurrence (through GeologicFeature.occurrence -> MappedFeature link), or with a geologic unit with a vocabulary (through the GeologicUnit.classifier ).

Conceptually, it may represent a body of material in the Earth whose complete and precise extent is inferred to exist (North American Data Model GeologicUnit, Stratigraphic unit in sense of NACSN or International Stratigraphic Code), or a classifier used to characterize parts of the Earth (e.g. lithologic map unit like 'granitic rock' or 'alluvial deposit', surficial units like 'till' or 'old alluvium').

Spatial properties are only available through association with a MappedFeature. It includes both formal units (i.e. formally adopted and named in the official lexicon) and informal units (i.e. named but not promoted to the lexicon) and unnamed units (i.e. recognisable and described and delineable in the field but not otherwise formalised).



Figure 19 : GeologicUnit and related classes

Table 12 : GeologicUnit properties

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | | **Description** |
| **geologicUnitType** | | GeologicUnitTypeTerm | A term from a controlled vocabulary defining the type of geologic unit. Logical constraints of definition of unit and valid property cardinalities should be contained in the definition. Use of the CGI Geologic Unit Type vocabulary (eg: something like http://geosciml.org/classifierScheme/CGI/GeologicUnitType/200811) is preferred. |
| **rank** | | RankTerm | Term that classifies the geologic unit in a generalization hierarchy from most local/smallest volume to most regional. Scoped name because classification is asserted, not based on observational data.  Examples: group, subgroup, formation, member, bed, intrusion, complex, batholith |
| **hirearchyLink** | | GeologicUnitHierarchy | Represents containment of a part GeologicUnit within another GeologicUnit. indicates a subsiduary unit with its role and proportion with respect to the container unit |
| **Composition** | | CompositionPart | Describes the composition (detailed, instance specific, lithologic description) of the GeologicUnit |
| **gbMaterialDescription** | | EarthMaterialAbstractDescription | Detailed material description. This is a stub property in GeoSciML Basic |
| **gbUnitDescription** | | GeologicUnitAbstractDescription | Detailed unit description. This is a stub property in GeoSciML Basic |

#### GeologicUnitHierarchy

GeologicUnitHierarchy associates a GeologicUnit with another GeologicUnit that is a proper part of that unit. Parts may be formal or notional. Formal parts refer to a specific body of rock, as in formal stratigraphic members. Notional parts refer to assemblages of particular EarthMaterials with particular internal structure, which may be repeated in various places within a unit (e.g. 'turbidite sequence', 'point bar assemblage', 'leucosome veins')

Table 13 : GeologicUnitHierarchy properties

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **role** | GeologicUnitHierarchyRoleTerm | Nature of the parts, e.g. facies, stratigraphic, interbeds, geographic, eastern facies, |
| **proportion** | QuantityRange | Quantity that specifies the fraction of the geologic unit formed by the part. |
| **targetUnit** | GeologicUnit | Indicates the parent unit that contains the GeologicUnitPart. |

#### CompositionPart

CompositionPart represents composition of a geologic unit in terms of earth material constituents (CompoundMaterial)

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **role** | CompositionPartRoleTerm | Defines the relationship of the CompoundMaterial constituent in the geologic unit, e.g. vein, interbedded constituent, layers, dominant constituent. Scoped name because role is asserted by the geologist building the description. |
| **proportion** | QuantityRange | Quantity that specifies the fraction of the geologic unit composed of the compound material. |
| **Material** | CompoundMaterial | EarthMaterial composing the part. |

#### EarthMaterial

The Earth Material class holds a description of a naturally occurring substance in the Earth. Earth Material represents material composition or substance, and is thus independent of quantity or location. Ideally, Earth Materials are defined strictly based on physical properties, but because of standard geological usage, genetic interpretations may enter into the description as well.



Figure 20 : EarthMaterial and related classes

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **color** | Category | Terms to specify color of the earth material. Color schemes such as the Munsell rock and soil color schemes could be used. |
| **purpose** | DescriptionPurpose | Specification of the intended purpose/level of abstraction for the given EarthMaterial. Scoped name because intention is asserted by author of the data instance.  Values: Instance, TypicalNorm, IdentifyingNorm. |
| **gbEarthMaterialDescription** | EarthMaterialAbstractDescription | Detailed material description. This is a stub property in GeoSciML Basic |

#### CompoundMaterial

An EarthMaterial composed of particles composed of EarthMaterials, possibly including other CompoundMaterials. This class is provided primarily as an extensibility point for related domain models that wish to import and build on GeoSciML, and wish to define material types that are compound but are not rock or rock-like material. For most users of GeoSciML "RockMaterial" should be used.

#### RockMaterial

Rock material is a specialized CompoundMaterial that includes consolidated and unconsolidated materials as well as mixtures of consolidated and unconsolidated materials.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **lithology** | LithologyTerm | lithology class from a controlled vocabulary |

### Geologic Event

A geologic event is an identifiable event during which one or more geological processes act to modify geological entities. A GeologicEvent has a specified geologic age and may have specified environments and processes. An example might be a cratonic uplift event during which erosion, sedimentation, and volcanism all take place. Traditionally, geologists have described the age of a feature without explicitly specifying the event or processes the age related to (age of a pluton without explicitly specifying the age is the age of crystallization). The GeologicEvent class allows to explicitly document the process and environment without imposing it.

Geological history is an ordered aggregation of Geological Event objects, each of which may have an associated geological Age, geological environment, and one or more geological process

The age attributes are age representation of a particular geological event or feature expressed in terms of years (numericAge) before present (absolute age), referred to the geological time scale (youngerNamedAge and olderNamedAge), or by comparison with other geological events or features (relative age). An event age can represent an instant in time, an interval of time, or any combination of multiple instants or intervals. Specifications of age in years before present are based on determination of time durations based on interpretation of isotopic analyses of EarthMaterial (some other methods are used for geologically young materials). Ages referred to geological time scales are essentially based on correlation of a geological unit with a standard chronostratigraphic unit that serves as a reference. Relative ages are based on relationships between geological units such as superposition, intruded by, cross-cuts, or "contains inclusions of".



Figure 21: Geologic Event

#### GeologicEvent

An identifiable event during which one or more geological processes act to modify geological entities. A GeologicEvent may have a specified geologic age (numeric age or GeochologicEraTerm) and may have specified environments and processes. An example might be a cratonic uplift event during which erosion, sedimentation, and volcanism all take place.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **eventProcess** | EventProcessTerm | The eventProcess specifies the process or processes that occurred during the event. Examples include deposition, extrusion, intrusion, cooling. |
| **numericAge** | NumericAgeRange | Age in absolute year before present |
| **olderNamedAge** | GeochronologicEraTerm | Older boundary of age of event expressed using a geochronologic era defined according to a geologic time scale per GeologicTime schema |
| **youngerNamedAge** | GeochronologicEraTerm | Younger boundary of age of event expressed using a geochronologic era defined according to a geologic time scale per GeologicTime schema |
| **eventEnvironment** | Category | The physical setting within which a GeologicEvent takes place. GeologicEnvironment is construed broadly to include physical settings on the Earth surface specified by climate, tectonics, physiography or geography, and settings in the Earth’s interior specified by pressure, temperature, chemical environment, or tectonics. |
| **geEventDescription** | GeologicEventAbstractDescription | Detailed event description. This is a stub property in GeoSciML Basic |

A single event cannot be shared between DisplacementEvent, AlterationDescription of MetamorphicDescription.

|  |  |
| --- | --- |
| /req/gsml4-basic/geologicevent-single | An individual event SHALL only apply to one of {DisplacementEvent, AlterationDescription, MetamorphicDescription} |

A geologic event must at least have one age representation, either numerical or named.

|  |  |
| --- | --- |
| /req/gsml4-basic/geologicevent-non-null | Either (olderNamedAge + youngerNamedAge) or NumericAgeDate SHALL not be null. |

#### NumericAgeRange

Numeric age Range class represents absolute age assignment using numeric measurement results.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **reportingDate** | Quantity | Single time coordinate value to report as representative for this NumericAge assignment |
| **olderBoundDate** | Quantity | The older bounding time coordinate in an age range |
| **youngerBoundDate** | Quantity | The younger bounding time coordinate in an age range |

### Geologic Structure

GeologicStructures are a configuration of matter in the Earth based on describable inhomogeneity, pattern, or fracture in an Earth Material. The scale of geological structures ranges from microscopic (micron-scale) to megascopic (km-scale). Examples of such inhomogeneities include fractures, mineral grain boundaries, and boundaries between parts of the rock with different particle geometry (texture) or composition.

Geologic structure is grounded in relationships between parts of a rock or rock body. As used here, it includes sedimentary structures. The identity of a Geologic Structure is independent of the material that is the substrate for the structure. There are almost always strong dependencies between the nature of the Earth Material substrate and the kinds of Geological Structure that may be present.

A disaggregated heap of particles does not have structure, and can only be described in terms of the mineralogy and geometrical character of the constituent particles. Geologic Structures are more likely to be found in, and are more persistent in, consolidated materials than in unconsolidated materials. Properties like "clast-supported", "matrix-supported", and "graded bed" that do not involve orientation are considered kinds of Geologic Structure because they depend on the configuration of parts of a rock body.



Figure 22: Summary diagram of Geologic structures

#### GeologicStructure

A configuration of matter in the Earth based on describable inhomogeneity, pattern, or fracture in an EarthMaterial. The identity of a GeologicStructure is independent of the material that is the substrate for the structure. The general GeologicRelation is used to associate penetrative GeologicStructures with GeologicUnits.

#### Contact

Very general concept representing any kind of surface separating two geologic units including primary boundaries such as depositional contacts, all kinds of unconformities, intrusive contacts, and gradational contacts, as well as faults that separate geologic units.

Bedding measured as discrete surfaces in the case that those are the feature of interest (e.g. individual cross set surfaces for paleocurrent analysis) should be represented here.



Figure 23: Contact

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **contactType** | ContactTypeTerm | Classifies the contact (eg intrusive, unconformity, bedding surface, lithologic boundary, phase boundary) |
| **stContactDescription** | ContactAbstractDescription | Detailed contact description. This is a stub property in GeoSciML Basic |

#### Fold

A fold is formed by one or more systematically curved layers, surfaces, or lines in a rock body. Fold denotes a structure formed by the deformation of a GeologicStructure to form a structure that may be described by the translation of an abstract line (the fold axis) parallel to itself along some curvilinear path (the fold profile). Folds have a hinge zone (zone of maximum curvature along the surface) and limbs (parts of the deformed surface not in the hinge zone). Folds are described by an axial surface, hinge line, profile geometry, the solid angle between the limbs, and the relationships between adjacent folded surfaces if the folded structure is a Layering fabric (similar, parallel).



Figure 24: Fold

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **profileType** | FoldProfileTypeTerm | Terminology specifying concave/convex geometry of fold relative to earth surface, and relationship to younging direction in folded strata if known. (eg; antiform, synform, neutral, anticline, syncline, monocline, ptygmatic) |
| **stFoldDescription** | FoldAbstractDescription | Detailed fold description. This is a stub property in GeoSciML Basic |

#### Foliation

A foliation is a planar arrangement of textural or structural features in any type of rock. It includes any of a wide variety of penetrative planar geological structures that may be present in a rock. Examples include schistosity, mylonitic foliation, penetrative bedding structure (lamination), and cleavage. Following the proposed definition of gneiss by the NADM Science Language Technical Team, penetrative planar foliation defined by layers > 5 mm thick is considered Layering.

Bedding as a fabric representing the average orientation of paleodepositional surface should be encoded through the foliationType; might apply to bedding that is layering or a foliation without layering (e.g. clast alignment in amalgamated beds).



Figure 25: Foliation

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **foliationType** | FoliationTypeTerm | Specifies the type of foliation.  Examples include crenulation cleavage, slaty cleavage, schistosity |
| **stFoliationDescription** | FoliationAbstractDescription | Detailed foliation description. This is a stub property in GeoSciML Basic |

#### ShearDisplacementStructure

A shear displacement structure includes all brittle to ductile style structures along which displacement has occurred, from a simple, single 'planar' brittle or ductile surface to a fault system comprised of 10's of strands of both brittle and ductile nature. This structure may have some significant thickness (a deformation zone) and have an associated body of deformed rock that may be considered a deformation unit (geologicUnitType = ‘DeformationUnit’)



Figure 26 : ShearDisplacementStructure

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **faultType** | FaultTypeTerm | Refers to a vocabulary of terms describing the type of shear displacement structure (eg; thrust fault, normal fault, wrench fault). |
| **stStructureDescription** | ShearDisplacementStructure AbstractDescription | Detailed shear displacement description. This is a stub property in GeoSciML Basic |

### Geomorphology

The Geomorphology package describes features that comprise the shape and nature of the Earth's land surface (ie, landforms). These landforms may be created by natural Earth processes (eg, river channel, beach, moraine, mountain) or through human (anthropogenic) activity (eg, dredged channel, reclaimed land, mine waste dumps).



Figure 27 : Geomorphologic feature

#### GeomorphologicFeature

A geomorphologic feature is a feature describing the shape and nature of the Earth's land surface (ie, a landform). These landforms may be created by natural Earth processes (eg, river channel, beach, moraine, mountain) or through human (anthropogenic) activity (eg, dredged channel, reclaimed land, mine waste dumps).

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **unitDescription** | GeologicUnit | Geologic description of the morphologic feature (eg, related stratigraphic units and earth materials |
| **gmFeatureDescription** | GeomorphologicUnitAbstractDescription | Detailed geomorphologic description. This is a stub property in GeoSciML Basic |

#### NaturalGeomorphologicFeature

A geomorphologic feature (ie, landform) that has been created by natural Earth processes. For example, river channel, beach ridge, caldera, canyon, moraine, mud flat.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **naturalGeomorphologicFeatureType** | NaturalGeomorphologicFeatureTypeTerm | A byReference link to a dictionary of terms describing the type of geomorphologic feature |
| **activity** | Category | Describes the current activity status of the geomorphologic feature (eg, currently active, dormant, inactive, reactivated, etc) |

#### AnthropogenicGeomorphologicFeature

A geomorphologic feature (ie, landform) which has been created by human activity. For example, dredged channel, midden, open pit, reclaimed land.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **anthropogenicGeomorphologic FeatureType** | AnthropogenicGeomorphologic FeatureTypeTerm | A reference link to a dictionary of terms describing the type of geomorphologic feature |

### Collection

Collection contains facade classes that facilitate the structuring of WFS response documents and other application uses.



Figure 28: GSML collection diagram

GSML (Figure 17) constrains the collection members to instances of EarthMaterial, GeologicFeature, GM\_Object, MappedFeature, AbstractFeatureRelation and SF\_SamplingFeature. It is important to note that the <<Union>> stereotype can be encoded in two distinct ways

1. by materializing the GSMLItem (as prescribed by ISO 19136 for example)  
     
   GSML.member.GSMLItem.earthMaterial.EarthMaterial
2. using GSMLItem as a validation constrain (as prescribed by iso19136 2007 INSPIRE Extensions)   
     
   GSML.member.EarthMaterial

This requirements class does not impose any encoding style for Union stereotype, although XML encoding requirements class chose the second option.

### GeoSciML Data Types

GeoSciML Data is a package of classes to describe the planar or linear orientation of a geologic feature. They allow specifying direction by a numerical direction vector (eg; dip/dip direction), or a description (eg; compass point (NE), or other text - "toward fold hinge", "below").An additional GSML\_QuantityRange class extends sweCommon:QuantityRange to allow upper and lower values in a numerical range to be delivered as two separate attributes.

This is to facilitate query operations on upper and lower values by providing explicit names for these values (which are encoded as anonymous members of an array in SWE common).



Figure 29 : Specialised GeoSciML data types

#### GSML\_GeometricDescriptionValue

GSML\_GeometricDescriptionValue is a special abstract data types for descriptions of planar or linear orientations of a geologic feature. They allow specifying direction by DirectionVector (eg Dip/Dip Direction), compass point (NE), description ("toward fold hinge", "below')

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **determinationMethod** | DeterminationMethodTerm | Describes the way the orientation value was determined (eg measured, inferred from dip slope, etc) |
| **descriptiveOrientation** | CharacterString | Textual specification of orientation, possibly referencing some local geography |

#### GSML\_PlanarOrientation

A planar orientation is composed of two values; the azimuth (a compass point) and a dip (the angle from the horizontal). Polarity of the plane indicates whether the planar orientation is associated with a directed feature that is overturned, upright, vertical etc. There are several conventions to encode a planar orientation and this specification does not impose one but provide a convention property to report it. It must be noted that allowance of different convention makes manipulation of the data more difficult.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **convention** | ConventionCode | The convention used for the measurement |
| **azimuth** | QuantityRange | The azimuth (compass point, bearing etc) value of the orientation. Convention reports how azimuth is interpreted |
| **dip** | QuantityRange | Dip is the angle that the structural surface (eg bedding, fault plane) makes with the horizontal measured perpendicular to the strike of the structure and in the vertical plane as a numeric value or term |
| **polarity** | PlanarPolarityCode | Indicates whether the planar orientation is associated with a directed feature that is overturned, upright, vertical etc. |

|  |  |
| --- | --- |
| /req/gsml4-basic/plane-pol-dip-az-not-null | At least one of polarity, azimuth or dip SHALL not be nil |

The Planar orientation shall have at least a value for polarity, azimuth or dip, otherwise there is no useful information to report.

|  |  |
| --- | --- |
| /req/gsml4-basic/plane-pol-dip-az-range | Azimuth SHALL be values in range [0,360[ |

Azimuth shall be a value >= 0 and < 360.

|  |  |
| --- | --- |
| /req/gsml4-basic/plane-dip-degree | Dips SHALL be expressed in degree downward from the horizontal. |

Dips are always downward. Depending of the convention, “upward” dips are just equivalent of downward for the azimuth flipped 180 degrees.

|  |  |
| --- | --- |
| /req/gsml4-basic/plane-dip-range | Dips SHALL be values in range [0,90] |

Dip values shall be between 0 (horizontal) and 90 (vertical downward).

#### GSML\_LinearOrientation

Linear orientation is composed of a trend (the compass orientation of the line) and a plunge (the angle from the horizontal). This vector can be oriented (pointing in a specific direction) or not.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **directed** | LinearDirectedCode | To indicate if orientation represents linear feature that is directed, e.g. clast imbrication, mylonitic lineation with sense of shear, slickenlines with displacement direction, rather than undirected (like a fold hinge line or intersection lineations).  A code list to indicate which is the directed end of the linear orientation |
| **plunge** | QuantityRange | Magnitude of the plunge. |
| **trend** | QuantityRange | The azimuth (compass bearing) value of the linear orientation. |

|  |  |
| --- | --- |
| /req/gsml4-basic/linear-dip-plunge-not-null | At least one of plunge or trend SHALL not be nil. |

An instance of Linear Orientation shall at least have a trend or a plunge value.

|  |  |
| --- | --- |
| /req/gsml4-basic/linear-az-degree | Trend SHALL be expressed in clockwise degree from geographic north |

The bearing shall be expressed as clockwise angle in degree from the geographic north (90° is pointing east)

|  |  |
| --- | --- |
| /req/gsml4-basic/linear-az-range | Trend SHALL be a value between [0,360[ |

Azimuths shall be normalised to a value >=0 and < 360.

|  |  |
| --- | --- |
| /req/gsml4-basic/linear-plunge-range | Plunge SHALL be a value in range [0 and 90] |

Plunges shall be a value between 0 and 90 (pointing up or down, depending of the directed property)

#### GSML\_Vector

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **magnitude** | QuantityRange | The magnitude of the vector |

A Vector is a data type for linear orientation with a magnitude. If magnitude is unknown, a GSML\_LinearOrientation shall be used

#### GSML\_QuantityRange

GSML\_QuantityRange range is a specialization of SWE Common (OGC 08-094r1, Clause 7.2.13) QuantityRange where lower and upper values are made explicit, instead of using an array of values (RealPair, see Clause 7.2.1) where the lowest value is the first element and the highest the second. This convenience class has been created as an alternative encoding for implementation that do no support encoding of arrays (eg. DBF) or reference to elements in string encoded arrays[[2]](#footnote-2) (eg. Filter Encoding Specification 2.0 – OGC 09-029r2)



Figure 30 : QuantityRange making lower and upper values explicit

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **lowerValue** | Real | Lower bound of the range. Replaces the value that would be (and still be) encoded as value[0]. |
| **upperValue** | Real | Upper bound of the range. Replaces the value that would be (and still be) encoded as value[1]. |

For client application that can process swe common QuantityRange, it is **recommended** to provide the values in both values (RealPair) and lowerValue/upperValue

|  |  |
| --- | --- |
| /req/gsml4-basic/quantity-range-repeat | Value[0] should provide the same value as lowerValue and value[1] the same as upperValue. |

Although the name of the properties infers quite obviously that lowerValue <= upperValue, it is stated here formally as a requirement.

|  |  |
| --- | --- |
| /req/gsml4-basic/quantity\_range\_order | lowerValue SHALL be less of equals to upperValue |

### GeoSciML basic vocabularies

Geology is a descriptive science and uses vocabularies extensively. Table 14 lists the vocabularies used in Basic. Each of those vocabularies should be implemented using externally managed vocabularies as specified in clause 8.2.4

Table 14: Vocabularies used in GeoSciML Basic

|  |  |
| --- | --- |
| **Vocabulary** | **Description** |
| **CompositionPartRoleTerm** | This class is a blank placeholder for a vocabulary of terms to describe the role that a compositional part plays in a geologic unit. |
| **DescriptionPurpose** | Codes used for the specification of the intended purpose/level of abstraction for a given feature or object instance, ie the reason for the existence of the GeologicFeature.  Values: instance, typicalNorm, definingNorm. |
| **ExposureTerm** | This class is a blank placeholder for a vocabulary of terms describing the nature of the expression of the mapped feature at the earth's surface (eg, exposed, concealed) |
| **GeologicUnitHierarchyRoleTerm** | Role of the unit in the hierarchy |
| **GeologicUnitTypeTerm** | This class is an indicative placeholder only for a vocabulary of terms describing the type of geologic unit.  Users are encouraged to use the vocabulary of unit types provided by the CGI vocabularies working group.  Example values: GeologicUnit, AllostratigraphicUnit,  AlterationUnit, ArtificialGround, BiostratigraphicUnit, ChronostratigraphicUnit ,DeformationUnit,ExcavationUnit, GeophysicalUnit, LithodemicUnit, LithogeneticUnit, LithologicUnit, LithostratigraphicUnit, LithotectonicUnit, MagnetostratigraphicUnit, MassMovementUnit, Pedoderm, PedostratigraphicUnit, PolarityChronostratigraphicUnit |
| **GeologicUnitPartRoleTerm** | This class is a blank placeholder for a vocabulary of terms describing the nature of the parts of a geologic unit, e.g. facies, stratigraphic, interbeds, geographic, eastern facies, |
| **LithologyTerm** | Refers to a vocabulary of terms describing the lithology of the compound earth material (eg, granite, sandstone, schist) |
| **MappingFrameTerm** | A mapping surface, a section, a Borehole |
| **RankTerm** | This class is a blank placeholder for a vocabulary of terms describing the rank of a geologic unit (eg, Group, Formation, Member, etc) |
| **CollectionTypeTerm** | Types of collections of geological and geophysical objects. |
| **EventProcessTerm** | Refers to a vocabulary of terms specifying the process or processes that occurred during an event. Examples include deposition, extrusion, intrusion, cooling. |
| **GeochronologicEraTerm** | Term from a Geochronological vocabulary |
| **ContactTypeTerm** | Refers to a vocabulary of terms describing types of geological contacts |
| **FaultTypeTerm** | A vocabulary of terms describing the type of shear displacement structure (eg; thrust fault, normal fault, wrench fault) |
| **FoldProfileTypeTerm** | Refers to a vocabulary of terms specifying concave/convex geometry of fold relative to earth surface, and relationship to younging direction in folded strata if known. antiform, synform, neutral, anticline, syncline, monocline, ptygmatic |
| **FoliationTypeTerm** | Refers to a vocabular of terms defining the type of foliation (eg, crenulation cleavage, gneissic layering, slaty cleavage, schistosity, etc) |
| **AnthropogenicGeomorphologic FeatureTypeTerm** | Refers to a vocabulary of terms describing the type of anthropogenic geomorphologic feature |
| **NaturalGeomorphologic FeatureTypeTerm** | Refers to a vocabulary of terms describing the type of natural geomorphologic feature |
| **ConventionCode** | Suggested values: "dip dip direction", "strike dip right hand rule" (The strike and dip of planar data is listed according to the ‘right-hand rule’ or, as one looks along the strike direction, the surface dips to the right.)  This list is an indicative list only of terms used to describe the convention used for the orientation measurement.  Users are encouraged to use a vocabulary of terms managed by the CGI vocabularies working group outside of this model. |
| **DeterminationMethodTerm** | This class is an empty placeholder for a vocabulary of terms describing the method used to determine the measured orientation. Users are encouraged to use a vocabulary of terms managed by the CGI vocabularies working group outside of this model. |
| **LinearDirectedCode** | eg,  "directed" (indicates that the orientation is directed)  "directed down" (indicates that the linear orientation is directed below the horizon)  "directed up" (indicates that the linear orientation is directed above the horizon)  This list is an indicative example list only of terms used to describe the values to use for terms related to directedness of linear orientations.  Users are encouraged to use a vocabulary of terms managed by the CGI vocabularies working group outside of this model. |
| **PlanarPolarityCode** | eg: "upright", "overturned", "vertical"  This list is an indicative list only of terms used to describe the values to use for expressing overturned or upright facing of planar orientation measurements. Users are encouraged to use a vocabulary of terms managed by the CGI vocabularies working group outside of this model. |

## GeoSciML Extension Abstract Requirements Class

The extension package provides classes to further the descriptions of basic classes by adding more properties and supplemental relation between basic classes. It extends AbstractDescription stubs declared in basic package. It also introduces new GeologicStructure features.



Figure 31: GeoSciML extension dependencies

|  |  |
| --- | --- |
| **Requirements Class** | |
| **/req/gsml4-extension** | |
| Target type | Logical model |
| Dependency | **/req/gsml4-basic** |
| Dependency | **/req/gsml4-geologictime** |
| Dependency | **Observation and Measurement ISO19156** |
| Dependency | **Sampling Feature ISO19156** |
| Dependency | **SWE Common data model** |

### Geologic Relations

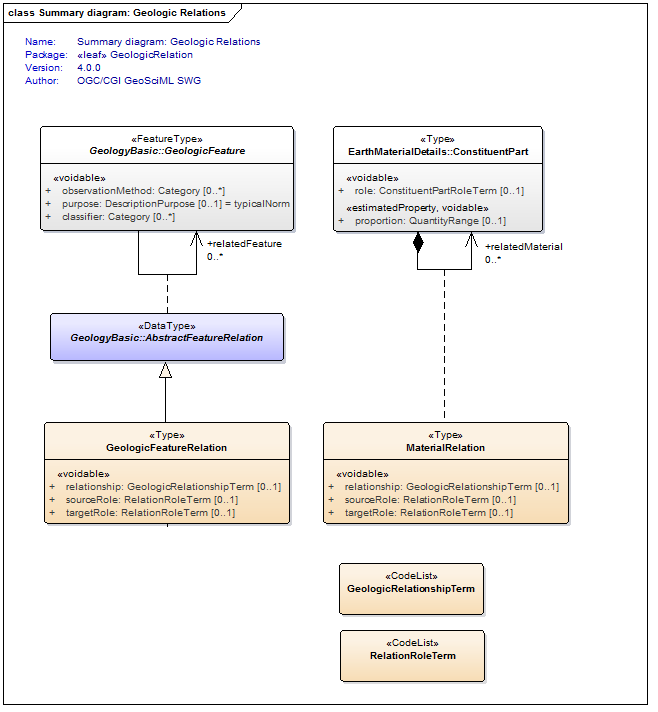


Figure 32: GeologicFeatureRelation is a concrete subtype of AbstractFeatureRelation stub class

GeoSciML uses the generic relatedFeature/GeologicRelation to associate GeologicFeature with other GeologicFeatures. However, this functionality is only available from the Extension package because it adds extra complexity that is not required for Basic. But Basic does need to support age descriptions that implies using GeologicEvent and by consequence would require bringing GeologicRelation into Basic.

To avoid extra complexity, Basic provides an explicit geologicHistory property to associate GeologicFeature with an GeologicEvent without using a GeologicRelation. The consequence for someone using Extension is that he/she is now offered two ways to link a GeologicFeature and GeologicEvent: through geologicHistory and through a generic GeologicRelation.

To prevent confusion and promote consistency, association between GeologicFeature and GeologicEvent, for the purpose of describing geologic history, and therefore geologic age, shall use geologicHistory property.

|  |  |
| --- | --- |
| /req/gsml4-extension/geologicfeature-history | Association between GeologicFeature and GeologicEvent SHALL not use GeologicRelation |

#### GeologicFeatureRelation

The GeologicRelation class is an abstract class that defines the general structure used to define relationships between any feature type within GeoSciML. Relationships are always binary and directional. There is always a single source and a single target. The relationship is always defined from the perspective of the Source and is generally an active verb. Example: a Source may point to an intrusive igneous rock unit. In this case, the Target would point to the appropriate host rock body and the relationship attribute would be 'intrudes'. Other appropriate relationship attributes might include: overlies, offsets, crosscuts, folds, etc.

Many other types of relationships can also be accommodated via GeologicRelation, for example, topological relations between spatial objects could be described where they are scientifically significant.



Figure 33: Generic geologic feature relation

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **relationship** | GeologicRelationshipTerm | A term from a controlled vocabulary to describe the geologic relationship (eg; stratigraphic relation, structural relation, intrusive relation) |
| **sourceRole** | RelationRoleTerm | The role played by the source geologic feature or object (eg, overlying unit, underlying unit) |
| **targetRole** | RelationRoleTerm | The role played by the target geologic feature or object. (eg, overlying unit, underlying unit) |

#### MaterialRelation

The MaterialRelation class describes the relationships between constituent parts in an Earth Material (eg: A mineral overgrowth on a phenocryst within a granite).

Example: Consider an overgrowth of albite on plagioclase in a granite. The Source would originate with the albite constituentPart description. In this case, the Target would point to the plagioclase constituentPart description and the relationship attribute would be 'overgrowth' and the sourceRole is 'overgrows'. Other appropriate role attributes might include: crosscuts, replaces, etc. for crosscutting and replacement relationships. Inverse relationships must be explicitly recorded as well or else they are invisible.



Figure 34: Material relations

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **relationship** | GeologicRelationshipTerm | A term from a controlled vocabulary to describe the geologic relationship (eg; sedimentary relation, igneous relation) |
| **sourceRole** | RelationRoleTerm | The role played by the source earth material part (eg, matrix, clast, overgrowth) |
| **targetRole** | RelationRoleTerm | The role played by the target earth material part (eg, matrix, clast, overgrowth). |

### Earth material details

Extended descriptions of earth materials that comprise geologic features.



Figure 35: Overview of earth material description

#### Alteration description

AlterationDescription decribes aspects of a geologic unit or earth material that are the result of bulk chemical, mineralogical or physical changes related to change in the physical or chemical environment. Includes weathering, supergene alteration, hydrothermal alteration and metasomatic effects not considered metamorphic. A soil profile description would have to be constructed as a GeologicUnit with unit parts representing the various horizons in the profile. Thickness of a weathering profile can be delivered as unitThickness of an AlterationUnit.



|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **alterationType** | AlterationTypeTerm | Term from a controlled vocabulary of alteration types (eg; potassic, argillic, advanced argillic) |
| **alterationProduct** | EarthMaterial | AlterationProduct is the material result of alteration processes, e.g. alteration minerals, saprolite, ferricrete, clay, calcrete, skarn, etc. Materials observed in a soil profile could be identified using this property. |
| **alterationDistribution** | Category | AlterationDistribution describes the spatial distribution or geometry of alteration zones. eg: patchy, spotted, banded, viens, vein breccia, pervasive, disseminated, etc |
| **alterationDegree** | Category | Term from a controlled vocabulary to indicate the strength of observed alteration. |
| **alterationEvent** | GeologicEvent | Alteration age |

#### Chemical Composition

A class to deliver the chemical composition of a geological unit or earth material, as a list of element or oxide concentrations.



Figure 36: Chemical composition

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **chemicalAnalysis** | DataRecord | This element delivers a swe:DataRecord of analyte concentrations (ie, swe:Quantity elements) which describe the chemical composition of an earth material or geologic unit |

#### Compound material description

Extended description of a compound earth material (ie, rocks and unconsolidated solid earth materials).



Figure 37: Compound material description

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **compositionCategory** | Category | Term to specify the gross compositional character of a compound material. Composition as used here is loosely construed to include both chemical composition and petrograpic composition, thus multiple values may be applied to a single rock, e.g. metaluminous and alkalic, undersaturated and basic, etc. Terms would typically include broad chemical classifications such as silicate, carbonate, ferromagnesian, oxide.  However, this attribute may have different terminology for different kinds of rocks - for example sandstone petrographic classification terms (e.g. feldspathic) might be placed here. |
| **geneticCategory** | Category | A term that represents a summary geologic history of the material. (ie, a genetic process classifier term). Examples include igneous, sedimentary, metamorphic, shock metamorphic, volcanic, pyroclastic. |
| **particleGeometry** | ParticleGeometry Description | Detailed particle geometry description |
| **constituent** | ConstituentPart | Specifies the ConstituentPart that makes up part of the CompoundMaterial |

#### ParticleGeometryDescription

ParticleGeometryDescription describes particles in a CompoundMaterial independent of their relationship to each other or orientation. It is distinguished from Fabric in that the ParticleGeometryDescription remains constant if the material is disaggregated into its constituent particles, whereas Fabric is lost if the material is disaggregated. Properties include the particle size (grainsize), particle sorting (size distribution, eg: well sorted, poorly sorted, bimodal sorting), particle shape (surface rounding or crystal face development, eg: well rounded, euhedral, anhedral), and particle aspectRatio (eg: elongated, platy, bladed, compact, acicular).



Figure 38: ParticleGeometry

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **particleType** | ParticleTypeTerm | Terms to specify the nature of individual particles of each constituent in an Earth Material aggregation, based mostly on their genesis.  If applied on ParticleDescription for CompoundMaterial, then would characterize all particles in aggregate. Use this property on CompoundMaterial to distinguish rocks composed of crystals (crystalline rocks) from rocks composed of granular particles (clasts, fragments). Examples include oolith, crystals, pore space. Constituent type is determined based on the nature of the particles, and ideally is independent of the relationship between particles in a compound material aggregation.  See discussion of particleType vs ConstituentPart.role in the scope notes for ConstituentPart. |
| **aspectRatio** | Category | AspectRatio describes the geometry of particles based on the ratios of lengths of long, intermediate and short axes of grains. Equates to sphericity in sedimentary rocks (ie: the degree to which the shape of a particle approximates a sphere).  A quantitative specification based on the ratio of lengths of long, intermediate and short axes of grain shape (Sneed and Folk, 1958; Zingg, 1935). (eg: prolate, slightly flattened, very bladed, equant, acicular, tabular) |
| **shape** | Category | The Shape attribute describes, a) the development of crystal faces bounding particles in crystalline compond materials, and b) surface rounding of grains in sedimentary rocks. Roundness is a measure of the sharpness of the edges between surfaces bounding a particle (see Jackson, 1997; Wadell, 1932). Terms should be appropriate for the kind of compound material (eg: for crystalline rocks- euhedral, ideoblastic, subhedral, anhedral, xenoblastic; for sedimentary rocks - angular, rounded) |
| **size** | QuantityRange | The Size attribute specifies particle grainsize.  Values may be reported using absolute measurements (eg: range, mean, median, mode, maximum) or as descriptive terms from a schema appropriate to the type of Compound Material (eg: the Udden-Wentworth sheme for clastic sedimentary rocks - silt, sand, gravel; volcaniclastic rocks - ash, lapilli, bomb; crystalline rocks - fine, medium, coarse, cryptocrystalline) |
| **sorting** | Category | The Sorting attribute holds text terms to specify size distribution of particles in a CompoundMaterial. Terminology for sorting in sedimentary rocks is based on the quantitative Graphic Standard Deviation (IGSD) scheme proposed by Folk (1968, 1974).  Example terms for this attribute may include sedimentary terms such as well sorted and poorly sorted, or igneous terms such as porphyritic, equigranuilar, seriate. |
| **sourceOrganism** | Organism | Organism that are the source of the particles (sponge spicules, bivalvia shells, etc.) |

#### ConstituentPart

The Constituent Part class describes how Earth Materials may be made up of other Earth Materials, including the proportion of the constituent part in the whole (eg: 20%, minor, dominant); the role that the constituent plays in the whole (eg: matrix, groundmass, framework, phenocryst, xenolith, vein). The particleType property that specifies type of particle (eg: grain, clast, crystal, fossil, oolite) has been moved to the ParticleGeometryDescription data type, associated with both ConstituentPart and CompoundMaterial

The distinction between "role" and "particleType" is subtle. An operational test is that constituentType may be determined independent of relationship between particles in the aggregation, whereas role requires consideration of the relationship to other particles. A particle may be identified as clast, independent of its material composition, and independent of its relationship to other grains in a rock. The term 'floating clast' is a role, because it is dependent on the relationship 'not in contact with other clasts'. Consider Dunham's textural classification of carbonate rocks (wackestone, packstone, grainstone...) in the description of carbonate rocks. The description is predicated on identification of two kinds of intraclasts (grains) and matrix (carbonate mud), and then uses this distinction to establish relationships--mud supported vs. grain supported -- that define roles for the two types of constituents (framework, matrix...).

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **role** | ConstituentPartRoleTerm | The role a ConstituentPart plays in a CompoundMaterial aggregation. The same EarthMaterial may occur as different ConstituentParts playing different roles within the same CompoundMaterial.  For example, feldspar may be present as groundmass (a ConstituentPart::role) and as phenocrysts (an ConstituentPart::role) within a single igneous rock. |
| **proportion** | QuantityRange | The fraction of the whole that is formed by a ConstituentPart in a part/whole relationship.  Used for the ConstituentPart portion in a CompoundMaterial.  Quantity that specifies the fraction of the Earth Material formed by the part (eg: 20%, minor, dominant) |
| **constituentMaterial** | EarthMaterial | Specifies the EarthMaterial that is forming the ConstituentPart |

#### Fabric Description

The FabricDescription class describes all types of fabrics associated with a CompoundMaterial (ie, tectonic, metamorphic, sedimentary, igneous fabrics or textures). It denotes a pattern, defined by one or more CompoundMaterial constituents, that is present throughout a rock body when considered at some scale. FabricDescription is defined based on the average configuration of many constituents. Penetrative fabric denotes that these constituents are distributed throughout the rock volume at the scale of observation [Passchier and Trouw, 1998], and are repeated at distances that are small relative to the scale of the whole, such that they can be considered to pervade the whole uniformly (Turner and Weiss [1963] p. 21-24; Hobbs and others [1976], p. 73; Jackson [1997]; Passchier and Trouw [1998]).

FabricDescription is distinguished from Particle Geometry based on the criteria that Particle Geometry is preserved if a CompoundMaterial is disaggregated, while FabricDescription is not defined if the material is disaggregated.



Figure 39: Fabric description

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **fabricType** | FabricTypeTerm | Attribute to denote the type of fabric in the CompoundMaterial (eg, rapikivi texture, autobrecciation, spaced cleavage, porphyroblastic, cross-bedding).  The fabricType describes a pattern, defined by one or more CompoundMaterial constituents, that is present throughout a rock body when considered at some scale. FabricDescription is defined based on the average configuration of many constituents. Penetrative fabric denotes that these constituents are distributed throughout the rock volume at the scale of observation [Passchier and Trouw, 1998], and are repeated at distances that are small relative to the scale of the whole, such that they can be considered to pervade the whole uniformly. |

#### Inorganic fluid

An inorganic, non-crystalline EarthMaterial (solid, liquid, or gas) that tends to flow or conform to the shape of its container. Includes glass. By convention liquid mercury is considered a mineral (examples: water, brine, glass). This class is an empty placeholder for extension at a later date, or by other domain models.



Figure 40: Inorganic fluid

#### Metamorphic description

MetamorphicDescription describes the character of metamorphism applied to a CompoundMaterial or GeologicUnit using one or more properties including estimated intensity (grade; eg high grade, low grade), characteristic metamorphic mineral assemblages (facies; eg, greenschist, amphibolite), peak P-T estimates, and protolith material if known.



Figure 41: Metamorphic Description

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **metamorphicFacies** | Category | A description of characteristic mineral assemblages indicative of certain metamorphic P-T conditions. Examples include Barrovian metasedimentary zones (eg: biotite facies, kyanite facies) or assemblages developed in rocks of more mafic composition (eg: greenschist facies, amphibolite facies). |
| **metamorphicGrade** | Category | A term to indicate the intensity or rank of metamorphism applied to an EarthMaterial (eg: high metamorphic grade, low metamorphic grade)  Indicates in a general way the P-T environment in which the metamorphism took place. Determination of metamorphic grade is based on mineral assemblages (ie, facies) present in a rock that are interpreted to have crystallized in equilibrium during a particular metamorphic event. |
| **peakPressureValue** | Quantity | A numerical value to indicate the estimated pressure at peak metamorphic conditions. |
| **peakTemperatureValue** | Quantity | A numerical value to indicate the estimated temperature at peak metamorphic conditions. |
| **protolithLithology** | EarthMaterial | An interpretation of the EarthMaterial that constituted the pre-metamorphic lithology for this metamorphosed CompoundMaterial. |
| **metamorphicEvent** | GeologicEvent | To denote the age, environment and process associated with a particular metamorphic assemblage in a GeologicUnit |

#### OrganicMaterial

An EarthMaterial that belongs to the class of chemical compounds having a reduced carbon basis (as distinct from carbonates), and derived from living organisms. Includes high-carbon EarthMaterials such as bitumen, peat, and coal. This class is an empty placeholder for extension at a later date, or by other domain models



#### Organism

Broad class to represent any living or once living thing. This is the connection to taxonomy/biology for fossils.



Figure 42: Organism

#### Physical Description

A class to describe the numeric physical properties of a geologic unit, earth material, or geologic structure. (eg; density, porosity, magnetic susceptibility, remanent magnetism). These properties are modelled here as scalar numeric values (swe:Quantity).

Vector and tensor physical properties are considered to be more applicable to located observations and should be delivered as SamplingFeature/Observations with associated geologic unit or geologic structure features.



Figure 43: Physical Description

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **propertyName** | PhysicalPropertyTerm | A term from a controlled vocabulary of physical properties of rock materials (eg; density, porosity, magnetic susceptibility, remnant magnetism, permeability, seismic velocity) |
| **propertyMeasure** | Quantity | A scalar measurement of the physical property of a rock material, unit or structure |

#### Rock material description

Extended descriptive attributes of a rock material.



Figure 44: Rock material description

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **consolidationDegree** | Category | A property that specifies the degree to which an aggregation of EarthMaterial particles is a distinct solid material. Consolidation and induration are related concepts specified by this property. They define a continuum from unconsolidated material to very hard rock. Induration is the degree to which a consolidated material is made hard, operationally determined by how difficult it is to break a piece of the material. Consolidated materials may have varying degrees of induration (NADMSC, 2004) |

### GeologicAgeDetails

GeologicEventDescription provides extended description of geologic events through links to GeochronologicEras in the GeologicTimescale schema. GeoSciML basic provides terms whereas extension provides a full ontology to describe geochronology (see 8.6).



Figure 45: GeologicEventDescription

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **olderGeochronologicEra** | GeochronologicEra | Link to description of the GeochronologicEra that corresponds to the older estimated age of a geologic feature. |
| **youngerGeochronologicEra** | GeochronologicEra | Link to description of the GeochronologicEra that corresponds to the younger estimated age of a geologic feature. |

### Geologic Structure Details

The GeologicStructureDetails package provides for extended descriptions of geologic structures.



Figure 46: Summary diagram of GeologicStructureDetailes

#### ContactDescription

Contact description provides extended descriptive properties of a geologic contact. If the contact type is ChronostratigraphicBoundary, it can be associated contact with a geochronologic (ie, time zone) boundary that may correlate with it.



Figure 47: ContactDescription

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **contactCharacter** | Category | The character of the boundary, as opposed to its type. e.g. abrupt, gradational |
| **orientation** | GSML\_PlanarOrientation | The orientation of the contact surface |
| **correlatesWith** | GeochronologicBoundary | This associates a physical geologic contact with a geochronologic (ie, time zone) boundary that may correlate with it. |

|  |  |
| --- | --- |
| /req/gsml4-extension/contact-chronoboundary | correlatesWith association to a GeochronologicBondary SHALL be allowed only when contactType = ChronostratigraphicBoundary |

Add that a contact can only have 2 and only 2 GeologicFeatureRelation with GeologicUnit when the type is a contactType (erosionalContact, etc..)

#### DisplacementEvent

A displacement event is a description of the age, environment and process of a shear displacement event.



Figure 48: DisplacementEvent

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **incrementalDisplacement** | DisplacementValue | Description of the parameters of the displacement |

#### Layering

Planar foliation defined by a tabular succession of layers > 5 mm thick. This definition is based on the proposed definition of gneiss by the NADM Science Language Technical Team, so that the GeologicStructure characteristic of gneiss is layering. The committee discussed the possibility that layering should be considered a kind of foliation, but the majority opinion was that it is a different kind of structure. Kept so that instance documents have a "Layering" tag



Figure 49: Layering

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **layeringComposition** | RockMaterial | Describes the rock material that may define compositional layering |

#### DisplacementValue

A displacement value expresses the displacement on a fault with respect to a planar approximation of its shape



Figure 50: Displacement value subtypes

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **hangingWallDirection** | GSML\_LinearOrientation | Normally the compass quadrant indicating the hanging wall side of the fault-system for faults that are steep enough to define a hanging-wall on the map trace |
| **movementSense** | MovementSenseTerm | The movement sense of displacement along a geologic structure (eg, dextral, sinistral) |
| **movementType** | MovementTypeTerm | Defines the type of movement  (eg dip-slip, strike-slip) |
| **displacementEvent** | DisplacementEvent | A description of the age, environment and process of a shear displacement event |

#### SeparationValue

The amount of separation displacement across a structure.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **separation** | GSML\_Vector | Reported apparent offset of planar feature, report as vector. |

#### NetSlipValue

The total amount of slip displacement along a structure.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **netSlip** | GSML\_Vector | The value of the net slip, expressed as vector. |
| **slipComponent** | SlipComponents | Associates the individual slip components with the net slip values. |

#### SlipComponents

Representation of slip as vector resolved into components resolved into reference frame in which horizontal axes are parallel and perpendicular to the strike of the fault. At least one of heave, horizontalSlip, or throw must not be null.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **heave** | GSML\_Vector | Component of slip in the horizontal, and perpendicular to the strike of the fault |
| **horizontalSlip** | GSML\_Vector | Slip component that is horizontal and parallel to strike of the fault |
| **throw** | GSML\_Vector | Vertical component of slip. |

#### FoldDescription

Extended descriptive properties of a fold structure.



Figure 51: FoldDescription

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **amplitude** | QuantityRange | Length from line segment connecting inflection points on adjacent fold limbs to the intervening fold hinge |
| **axialSurfaceOrientation** | GSML\_PlanarOrientation | This is used to characterize the geometry of a fold. The axial surface of a particular fold may be located based on observations of the folded geologic structure, but in general it has no direct physical manifestions. As a geologic surface, it has geometric properties, including orientation, which may be specified by observations at one or more locations, or generalized using terminology (upright, inclined, reclined, recumbent, overturned). Dip and Dip Direction are one approach to specifying the value. |
| **geneticModel** | Category | Specification of genetic model for fold, e.g. flexural slip, parallel |
| **hingeLineCurvature** | Category | Variation in orientation of fold hinge along trend of fold, distinguish sheath from cylindrical folds. Specify with terminology eg sheath, dome, basin, cylindrical. |
| **hingeLineOrientation** | GSML\_LinearOrientation | Specification of hinge line orientation for fold. CGI\_LinearOrientation allows for a term value specification or a numeric specification of either or both the trend and plunge of hinge line. kHinge plunge term examples: sub-vertical, steeply plunging, ... sub-horizontal, reclined and vertical for special cases in which hinge plunge is close to axial surface dip. 0..\* cardinality allows for both a numeric specification a term specification. |
| **hingeShape** | Category | Rounded vs. angular hinge zones; has to do with the proportion of the wavelength that is considered part of hinge |
| **interLimbAngle** | Category | Specify using a tightness term (gentle (120-180), open (70-120), close (30-70), tight (10-30), isoclinal (0-10)) |
| **limbShape** | Category | Straight vs curved limbs, eg kink, chevron, sinusoidal, box |
| **span** | QuantityRange | Llinear distance between inflection points in a single fold |
| **symmetry** | Category | Concordance or discordance of bisecting surface and axial surface, or ratio of length of limbs. Folded surface may have asymmetry defined by limb length ratio if inflection points are defined. Defintion based on bisecting surface/axial surface angle depends on having multiple surfaces defined such that the axial surface may be identified. (symmetric, assymetric) |
| **System** | FoldSystem | Aggregates Folds to create a FoldSystem |

#### FoldSystem

A collection of congruent folds (axis and axial surface are parallel) produced by the same tectonic event. Sometimes referred to as a "Fold Train".



Figure 52: FoldSystem

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **periodic** | Boolean | True if fold hinges in train are regularly spaced. |
| **wavelength** | QuantityRange | Quantitative specification of length between adjacent antiforms (or synforms) in a fold train. |
| **foldSystemMember** | Fold | Fold member of the system |

#### FoliationDescription

Extended descriptive properties of a foliation structure.



Figure 53: FoliationDescription

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **definingElement** | Category | Kinds of describable inhomogeneity in a rock body that may define a GeologicStructure.   Examples include Discontinuity, Shaped Surface, Oriented Particle, Material Boundary, and Layer. |
| **continuity** | Category | Terms to distinguish continuous vs. disjunct cleavages |
| **intensity** | Category | How well the foliation is developed. Terms such as weak, moderate, strong. |
| **mineralElement** | Mineral | The mineral that defines the foliation |
| **orientation** | GSML\_PlanarOrientation | Estimate of the planar orientation of the foliation structure. |
| **spacing** | QuantityRange | Linear dimension representing the thickness of foliation domains. Also use for thickness of layers of a given composition |

#### ShearDisplacementStructureDescription

Extended descriptive properties of a shear displacement structure (ie, fault or shear).



Figure 54: ShearDisplacementStructureDescription

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **deformationStyle** | DeformationStyleTerm | A mandatory element referring to a vocabulary of terms to describe the style of deformation, ie brittle (fault, breccia), ductile (shear), brittle-ductile, unknown. |
| **planeOrientation** | GSML\_PlanarOrientation | Allows capturing the orientation of the plane of the structure |
| **stPhysicalProperty** | PhysicalDescription | Arbitrary physical descriptions not covered specifically by this specification. |

### Geologic Unit Details

The GeologicUnitDetails package provides for extended description of geologic unit features.



Figure 55: GeologicUnitDetails

#### GeologicUnitDescription

Extended description of the characteristics of a geologic unit.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **bodyMorphology** | Category | The geometry or form of a GeologicUnit.  Examples include: dike (dyke), cone, fan, sheet, etc. Morphology is independent of the substance (EarthMaterial) that composes the GeologicUnit or process that formed it. |
| **unitComposition** | Category | Composition-based classification that requires integrating the character of the unit over large area, not applicable at the rock-material/specimen level. Examples: alkalic, subaluminous, peraluminous, I-Type, carbonate, phosphate. |
| **outcropCharacter** | Category | Describes the nature of outcrops formed by a geologic unit. Examples: bouldery, cliff-forming, ledge-forming, slope-forming, poorly exposed |
| **unitThickness** | QuantityRange | Typical thickness of the geologic unit. Always reported as a range. If have a single value, the upper and lower limit of range are the same. |
| **bedding** | BeddingDescription | Description of the bedding |

#### BeddingDescription

Extended description of the bedding characteristics of a geologic unit.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **beddingPattern** | Category | Term(s) specifying patterns of bedding thickness or relationships between bedding packages. (eg; thinning upward, thickening upward) |
| **beddingStyle** | Category | Term(s) specifying the style of bedding in a stratified geologic unit (e.g. lenticular, irregular, planar, vague, massive) |
| **beddingThickness** | Category | Term(s) or numeric values characterizing the thickness of bedding in the unit. |

### GeoSciML extension vocabularies

Vocabularies uses in GeoSciML are listed in Table 15

Table 15 : GeoSciML vocabularies

|  |  |
| --- | --- |
| **Vocabulary** | **Description** |
| **GeologicRelationshipTerm** | Refers to a vocabulary of terms describing a relationships between geologic features or objects |
| **RelationRoleTerm** | Refers to a vocabulary of terms describing roles played by geologic features or objects in a geologic relationship |
| **AlterationTypeTerm** | Refers to a vocabulary of terms describing the dominant alteration mineralogy or alteration type, in common usage. Examples include: argillic, phyllic, potassic, propylitic, calc-silicate, skarn, deuteric, greisen, serpenitisation, weathering, etc. |
| **ConstituentPartRoleTerm** | Refers to a vocabulary of terms describing the role played by a constituent part of a compound material (eg, matrix, phenocryst) |
| **FabricTypeTerm** | Refers to a vocabulary of terms describing the type of fabric present |
| **MineralNameTerm** | Refers to a vocabulary of mineral names |
| **ParticleTypeTerm** | Refers to a vocabulary of terms describing the type of particle in the compound earth material (eg, bioclast, phenocryst, pyroclast) |
| **PhysicalPropertyTerm** | Refers to a vocabulary of physical property types (eg, density, porosity, magnetic susceptibility, magnetic remanence, conductivity, etc) |
| **DeformationStyleTerm** | A controlled vocabulary of terms describing the style of deformation (eg, brittle, ductile). |
| **LineationTypeTerm** | Refers to a vocabulary of terms describing the type of lineation. Examples include: flow lines, scratches, striae, slickenlines, linear arrangements of elongate components in sediments, elongate minerals, crinkles, and lines of intersection between penetrative planar structures. |
| **MovementSenseTerm** | Refers to a vocabulary of terms describing the sense of movement on a shear displacement structure |
| **MovementTypeTerm** | Refers to a vocabulary of terms describing the type of movement (eg, dip-slip, strike-slip) |
| **NonDirectionalStructureTypeTerm** | Refers to a vocabulary of terms describing types of non-directional structures (eg, miarolitic cavity, flame structure, load cast, shatter cone, trace fossil, fossil mold, etc) |

## GeoSciML GeologicTime Abstract Requirements Class

The Geologic Time package contains elements used to describe the classification of geologic time: time periods, time boundaries, and the relationships between them as defined by the International Commission on Stratigraphy.



Figure 56: GeologicTime dependencies

|  |  |
| --- | --- |
| **Requirements Class** | |
| **/req/gsml4-geologictime** | |
| Target type | Logical model |
| Dependency | **Observation and Measurement** |
| Dependency | **SWE Common 2.0** |
| Dependency | **ISO 19108 Temporal Schema** |



Figure 57: Geologic Time summary diagram

### Global Boundary Stratotype Sections and Points

The GSSP model describes "Global Boundary Stratotype Sections and Points" as defined by the International Stratigraphy Commission.



Figure 58: Global Boundary Stratotype Sections and Points

#### StratigraphicPoint

A point in the stratigraphic record used to define a geochronologic boundary or point in geologic time



Figure 59: Stratigraphic points

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **primaryGuidingCriterion** | CharacterString | A description of the primary criterion used to establish this stratigraphic point |
| **additionalCorrelationProperty** | CharacterString | Any additional criteria used to establish this stratigraphic point |
| **status** | CharacterString | A description of the status of stratigraphic point (eg, formally accepted, etc) |

#### GlobalStratotypePoint

A type of stratigraphic point used to define a globally agreed point in geologic time

#### StratigraphicSection

A sampled section of the stratigraphic record used to define a period in geologic time



Figure 60: Stratigraphic sections

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **geologicSetting** | CharacterString | A description of the geologic setting of the stratigraphic section |
| **geologicDescription** | CharacterString | A description of the geology of the stratigraphic section (eg, lithology, paleontology, paleogeography, etc) |
| **accessibility** | CharacterString | A description of the ability to access the stratigraphic section |
| **conservation** | CharacterString | A description of measures to conserve the stratigraphic section |

### Temporal Reference System

This package is an extension of ISO19108 Temporal Schema and describes geologic eras and the relationships between them.



Figure 61: Temporal Reference System

#### TimeOrdinalReferenceSystem

A time reference system comprised of an ordered set of time periods (time ordinal eras).

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **referencePoint** | TimeOrdinalEraBoundary | Two reference points defining the extent of the system |
| **component** | TimeOrdinalEra | TimeOrdinalEra composing the TimeOrdinalReferenceSystem |

#### TimeOrdinalEra

The association of an era with a stratotype is optional. In the GSSP approach recommended by ICS for the Global Geologic Timescale, Unit Stratotypes are not used. Rather, the association of an Era with geologic units and sections is indirect, via the association of an era with Boundaries, which are in turn tied to Stratotype Points, which occur within host Stratotype Sections.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **member** | TimeOrdinalEra | Subdivisions of TimeOrdinalEra |
| **group** | TimeOrdinalEra | Parent era |
| **start** | TimeOrdinalEraBoundary | Boundary starting the era |
| **end** | TimeOrdinalEraBoundary | Boundary ending the era |

#### TimeOrdinalEraBoundary

A point in Earth's history which bounds a TimeOrdinalEra.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **position** | TM\_Instant | A point in time corresponding to the era boundary |
| **positionalUncertainty** | Quantity | A measure of the uncertainty in the estimate of the point in time of the era boundary |
| **previousEra** | TimeOrdinalEra | Preceding era |
| **nextEra** | TimeOrdinalEra | Succeeding era |
| **observationalBasis** | OM\_Observation | Observation supporting the existence of the boundary (geochronology, paleontology, etc.) |

### Time scale

The Timescale package describes geologic time periods (geochronologic eras) and the boundaries between them.



Figure 62: Time scale

#### GeologicTimeScale

The classic "Geologic Timescale" comprising an ordered, hierarchical set of named "eras" is an example of an Ordinal Temporal Reference System. It may be calibrated with reference to a numeric Temporal Coordinate System, but is in principle defined independently.

#### GeochronologicEra

The association of an era with a stratotype is optional. In the GSSP approach recommended by ICS for the Global Geologic Timescale, Unit Stratotypes are not used.

Rather, the association of an Era with geologic units and sections is indirect, via the association of an era with Boundaries, which are in turn tied to Stratotype Points, which occur within host Stratotype Sections.



Figure 63 : GeochronologicEra

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **rank** | GeochronologicEraRank | A term from a controlled vocabulary describing the rank of the time period (eg, eon, era, period, stage) |
| **stratotype** | StratigraphicSection | Type section that names the physical location or outcrop of a particular reference exposure of a stratigraphic sequence or stratigraphic boundary. A unit stratotype is the agreed reference point for a particular stratigraphic unit and a boundary stratotype the reference for a particular boundary between strata (Wikipedia) |

#### GeochronologicBoundary

A boundary between two geochronologic time periods



Figure 64: GeochronologyBoundary

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **stratotype** | StratigraphicPoint | Several StratigraphicPoints may be associated with a boundary, but only one may have GSSP ratified status. The others are proposed equivalent. |

#### NumericEraBoundary

Used for pre-Ediacaran and Pleistocene / Holocene boundaries in the standard timescale (where boundaries are not defined by a material reference but a numerical value).



#### StandardGlobalNumericalAge

A standard numeric age point (a numeric analogue to a 'golden spike') applicable to the formal subdivision of the Precambrian, and perhaps the Pleistocene/Holocene boundary (Walshe, Gradstein and Ogg, 2004)

### Geologic time vocabularies

Geologic time package had only one vocabulary (Table 16).

Table 16: Geologic time vocabulary

|  |  |
| --- | --- |
| **Vocabulary** | **Description** |
| **GeochronologicEraRank** | This list is an indicative list only of terms used to describe the rank of time periods defined by the International Commission on Stratigraphy. Users are encouraged to use vocabulary of terms owned by the ICS or CGI vocabularies working group and managed outside of this model.  For example:   * eon * era * period * epoch * age |

## GeoSciML Borehole Abstract Requirements Class

The GeoSciML Borehole package contains model elements for representing Boreholes. This is primarily through re-use of standard components from the Observations and Measurements package (ISO 19156).



Figure 65: Borehole dependency diagram

|  |  |
| --- | --- |
| **Requirements Class** | |
| **/req/gsml4-extension** | |
| Target type | Logical model |
| Dependency | **/req/gsml4-core** |
| Dependency | **Observation and Measurement** |
| Dependency | **Conceptual Schema Language ISO19105** |
| Dependency | **Spatial Schema** |
| Dependency | **Metadata ISO19115** |
| Dependency | **SWE Common 2.0** |
| Dependency | **Temporal Schema ISO19108** |



Figure 66: Borehole summary diagram

### Borehole

This requirements class describes Borehole and BoreholeInterval and related data types. This package is interested in Borehole as a mean to sample geologic units underground and thus provide a linear map of the geology.



Figure 67: Borehole

#### Borehole

A borehole is the generalized term for any narrow shaft drilled in the ground, either vertically, horizontally, or inclined.

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **indexData** | StratigraphicPoint | Several StratigraphicPoints may be associated with a boundary, but only one may have GSSP ratified status. The others are proposed equivalent. |
| **downholeDrilling Details** | DrillingDetails | Specifies the drilling method and borehole diameter for intervals down the borehole |
| **logElement** | BoreholeInterval | Links to 1-D MappedFeature instances that are logged (interpreted) intervals within a borehole. This requirement is common in geoscience boreholes |
| **referenceLocation** | OriginPosition | A Borehole OriginPosition is a feature corresponding to the start point of a borehole log. This may, but not necessarily, correspond to the borehole collar location (eg, kelly bush). |

#### DrillingDetails

A class to capture description of drilling methods and hole diameter down the hole.



Figure 68: Drilling details

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | | **Description** |
| **drillingMethod** | BoreholeDrillingMethodCode | | Indicates the drilling method used. Appropriate terms would include rotary air blast; auger; diamond core; air core; etc |
| **boreholeDiameter** | Quantity | | The diameter of the drilled hole. |
| **intervalBegin** | Quantity | | The measured distance of the start of the interval along the path of the borehole. The measured value must be less than or equal to the IntervalEnd value. The "IntervalBegin" and "IntervalEnd" elements are added in version 3.2 as a measure to overcome problems with the delivery and queryability of 1D GML shapes via the "shape" property. |
| **intervalEnd** | Quantity | | The measured distance of the end of the interval along the path of the borehole. The measured value must be greater than or equal to the IntervalBegin value. The "IntervalBegin" and "IntervalEnd" elements are added in version 3.2 as a measure to overcome problems with the delivery and queryability of 1D GML shapes via the "shape" property. |
| **Interval** | GM\_Object | A shape that is a 1-D interval (eg, a "from" and "to", or "top" and "base" measurement) and uses the SRS of the containing borehole | |

Encoding of the drilled interval using GM\_LineString shall consist of two 1D points only (the start and end point of the interval, measured as distance from the borehole collar), with a 1-D CRS corresponding to the borehole curve shape

|  |  |
| --- | --- |
| /req/gsml4-borehole/drill-interval-1D | Interval SHALL be encoded with GM\_LineString with 2 1D points |

|  |  |
| --- | --- |
| /req/gsml4-borehole/ drill-interval-1D-CRS | Coordinate Reference System of interval geometries SHALL use an appropriate 1D CRS |

#### BoreholeInterval

A special kind of Mapped Feature whose shape is 1-D interval and uses the SRS of the containing borehole



Figure 69: Borehole interval

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **observationMethod** | Category | The method used to observe the properties of the borehole |
| **specification** | GFI\_Feature | The domain feature that is sampled by the interval (eg, a GeologicUnit). Equaivalent to O&M "sampledFeature". |
| **mappedIntervalBegin** | Quantity | The measured distance of the start of the mapped interval along the path of the borehole. The measured value must be less than or equal to the mappedIntervalEnd value. The "mappedIntervalBegin" and "mappedIntervalEnd" elements are included here as a measure to overcome problems with the delivery and queryability of 1D GML shapes via the "shape" property. |
| **mappedIntervalEnd** | Quantity | The measured distance of the start of the mapped interval along the path of the borehole. The measured value must be less than or equal to the mappedIntervalEnd value. The "mappedIntervalBegin" and "mappedIntervalEnd" elements are included here as a measure to overcome problems with the delivery and queryability of 1D GML shapes via the "shape" property. |
| **collectionIdentifier** | ScopedName | A property to group BoreholeIntervals in order to implement multiple logs on a single borehole. GenericName should identify a particular log observation event. |
| **parentBorehole** | Borehole | Borehole in context for the interval |
| **shape** | GM\_Object | Geometry of the interval |

Encoding of a intervals within the borehole using GM\_LineString should consist of two 1D points only (the start and end point of the interval, measured as distance from the borehole collar), with a 1-D CRS corresponding to the borehole curve shape

|  |  |
| --- | --- |
| /req/gsml4-borehole/interval-1D | Interval SHALL be encoded with GM\_LineString with 2 1D points |

|  |  |
| --- | --- |
| /req/gsml4-borehole/interval-1D-SRS | Coordinate Reference System of interval geometries SHALL use an appropriate 1D CRS |

#### BoreholeDetails

Borehole-specific index or header information. This data does not relate to downhole intervals.



Figure 70: Borehole details

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **operator** | CI\_Responsibility | Organisation responsible for commissioning the borehole (as opposed to drilling the borehole) |
| **driller** | CI\_Responsibility | The organisation responsible for drilling the borehole (as opposed to commissioning the borehole) |
| **dateOfDrilling** | TM\_Period | The time period during which drilling of the borehole occurred. |
| **startPoint** | BoreholeStartPointCode | Indicates the position relative to ground surface where the borehole commenced. Appropriate terms would include Drilled from Ground Surface; Drilled Underground; Drilled from Quarry Floor etc |
| **inclinationType** | BoreholeInclinationCode | Indicates the inclination of the borehole. Appropriate terms would include vertical; inclined up; inclined down, horizontal |
| **boreholeMaterial Custodian** | CI\_Responsibility | Organisation that is custodian of the core recovered from the borehole |
| **purpose** | BoreholePurposeCode | The purpose for which the borehole was drilled. eg, site investigation, mineral exploration, hydrocarbon exploration, water resources |
| **dataCustodian** | CI\_Responsibility | The custodian (person or organisation) that is the custodian of data pertaining to this borehole. |
| **boreholeLength** | Quantity | The "length" of a borehole will be determined by the data provider (ie, "length" can have different sources, like drillers measurement, loggers measurement, survey measurement, etc) |

#### OriginPosition

A Borehole OriginPosition is a feature corresponding to the start point of a borehole log. This may, but not necessarily, correspond to the borehole collar location (eg, kelly bush).



Figure 71: Origin position

If a text description of the location is available, it should be placed in the description inherited from Feature. If no GM\_Point is available, an OGC nil value should be used.

|  |  |
| --- | --- |
| /req/gsml4-borehole/borehole-position-null | If no GM\_Point is available, an OGC nil value SHALL be used |

In situations where the origin position changes over the life of the borehole (eg, due to subsidence or destruction of the original collar), the origin position should be updated to the new location.

Implementers delivering 3-D origin locations should provide an elevation to improve interoperability.

|  |  |
| --- | --- |
| /req/gsml4-borehole/borehole-3d | Implementers delivering 3-D origin locations SHOULD provide an elevation to improve interoperability. |

#### GeoSciML Borehole vocabularies

Vocabularies used in Borehole package are listed in Table 17

Table 17: Borehole vocabularies

|  |  |
| --- | --- |
| **Vocabulary** | **Description** |
| **BoreholeDrillingMethodCode** | This class is an indicative placeholder only for a vocabulary of terms describing the borehole drilling method. Users are encouraged to use a vocabulary of terms managed by the CGI vocabularies working group. (eg; auger, hand auger, air core, cable tool, diamond core, rotary air blast, etc) |
| **BoreholeInclinationCode** | This class is an indicative placeholder only for a vocabulary of terms describing the general orientation of a borehole. Users are encouraged to use a vocabulary of terms managed by the CGI vocabularies working group.  For example:   * vertical * horizontal * inclined up * inclined down |
| **BoreholePurposeCode** | Place holder for a vocabulary containing terms describing the purpose for which the borehole was drilled. eg, mineral exploration, water pumping, site evaluation, stratigraphic research, etc |
| **BoreholeStartPointCode** | This class is an indicative placeholder only for a vocabulary of terms describing the location of the start of a borehole. Users are encouraged to use a vocabulary of terms managed by the CGI vocabularies working group.  Examples may include:   * natural ground surface - drilling started from a natural topographic surface * open pit floor or wall - drilling started from the wall of an open pit or quarry * underground - drilling started from an underground location, such as a driveway, chamber or open-stope * from pre-existing hole - new drill hole spudded off the wall of an existing hole |

## GeoSciML Laboratory Abstract Analysis Requirements Class

The LaboratoryAnlaysis-Specimen application schema extends the ISO19156 schema for Observations, Measurements and Sampling. It specifically describes processes and results related to the analysis of (geological) samples using instruments, most commonly in a laboratory environment. (Design of this package is based upon, and extends, the MOLES v3 data model.) . It also constrains certain elements of ISO19156 to align them on the specifics of geoscience lab analysis



Figure 72: LaboratoryAnalysis and Specimen dependencies

|  |  |
| --- | --- |
| **Requirements Class** | |
| **/req/gsml4-extension** | |
| Target type | Logical model |
| Dependency | **/req/gsml4-basic** |
| Dependency | **ISO10156 Observation and Measurement** |
| Dependency | **ISO19115 Metadata** |

The "sampledFeature" association links the SF\_SamplingFeature to the feature which the sampling feature was designed to sample. The target of this association shall not be a sampling feature. It is usually a real-world feature from an application domain.

|  |  |
| --- | --- |
| /req/gsml4-lab-analysis/sampledFeature | SF\_SamplingFeature::sampledFeature SHALL not be an instance of SF\_SamplingFeature |

OM\_Observation/resultQuality/ DQ\_QuantitativeAttributeAccuracy attribute shall be used to represent analytical errors and detection limits for each analytical measurement.

|  |  |
| --- | --- |
| /req/gsml4-lab-analysis/accuracy | Analytical error and detection limits SHALL be encoded using OM\_Observation/resultQuality/ DQ\_QuantitativeAttributeAccuracy |

At least "nameOfMeasure" and "result" shall be used when delivering om:resultQuality/gmd:DQ\_QuantitativeAttributeAccuracy.

|  |  |
| --- | --- |
| /req/gsml4-lab-analysis/accuracy-measure | For analytical error and detection limits, both DQ\_QuantitativeAttributeAccuracy::nameOfMeasure and DQ\_QuantitativeAttributeAccuracy::result SHALL be non-null |

The characterString in "nameOfMeasure" should be a term from a controlled vocabulary

|  |  |
| --- | --- |
| /req/gsml4-lab-analysis/accuracy-vocabulary | The characterString in "nameOfMeasure" SHOULD be a term from a controlled vocabulary |

Analytical methods are very varied and a single model can’t capture all the intricacies of each method used in geoscience. Communities that need to report specific parameter that are not covered by this specification shall us NamedParameter.

|  |  |
| --- | --- |
| /req/gsml4-lab-analysis/specific-parameters | Method specific parameters SHALL be reported using OM\_Observation::NamedParameter |

### Laboratory Analysis

The LaboratoryAnalysis leaf package describes processes, instruments and result quality associated with quantitative analysis of samples.



Figure 73: Laboratory analysis summary diagram

#### AnalyticalInstrument

Type of instrument used to perform an analytical observation



Figure 74: Analytical instrument

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **type** | InstrumentTypeTerm | The category of instrument used in an analytical session (eg; XRF, ICPMS, SHRIMP, etc) |
| **model** | CharacterString | An optional text string to identify the model of instrument used. (eg instrument type = XRD, model = Siemens Diffraktometer D500) |
| **serialNumber** | CharacterString | An optional text string for the serial number of the machine used in an analytical session. |
| **commissionDate** | TM\_Instant | The date of the commissioning of an instrument (optional) |
| **location** | CI\_Responsibility | The location and owner of an instrument |
| **usedIn** | AnalyticalSession | Identifies one or more analytical sessions which used this instrument |

#### AnalyticalSession

This class describes the time and operator of a particular laboratory analytical session. AnalyticalSession also has associated links to the type of instrument and analytical method used, processing steps applied to data collected during a session, and instrument parameters unique to that session.



Figure 75: Analytical session

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **time** | TM\_Period | The time period during which the analysis was performed |
| **operator** | CI\_Responsibility | The name of the operator or organisation responsible for the analytical session |
| **parameter** | NamedValue | This association is analogous to the "parameter" attribute of OM\_Observation, but in this case describes environmental or instrument setting parameters that apply to an entire analytical session (eg, voltage, current, temperature, vacuum). The "name" attribute of NamedValue is implemented in OMXML as a byReference URI to a controlled list. |
| **instrument** | AnalyticalInstrument | Identifies the instrument used in the analytical session |
| **referenceAnalysis** | ReferenceSpecimen | Describes any reference specimens (ie, standards, blanks) used in the analytical session. |

#### AnalyticalProcess

An analytical process is a concrete implementation of OM\_Process. It links to an analytical session (data acquisition) or a computational process which produce analytical results.



Figure 76: Analytical process

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **method** | AnalyticalMethod | Identifies the type of analytical method used to make an observation. |
| **acquisition** | AnalyticalSession | Describes the analytical session (eg, laboratory session) in which an observation was made and data acquired. |
| **Computation** | LI\_ProcessStep | Computational process associated with the Process. |

#### AnalyticalMethod

Name, and published citation, of the analytical method used in an analytical session



Figure 77 : Analytical method

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **methodName** | AnalyticalMethodTerm | Reference to a controlled vocabulary of names of analytical method used in a session (eg; XRF mass spectrometry, ICPMS, SHRIMP geochronology) |
| **citation** | CI\_Citation | A published description of a particular analytical method (eg; a standard operating procedure document). This attribute is nillable if such a document does not exist. |

#### Image

Use for image of sampling features, for example, photographs of ion microprobe grain mounts.



Figure 78: Image

When the image is available online, the description field should provide a link to it.

|  |  |
| --- | --- |
| /req/gsml4-lab-analysis/image-url | When a URL to the image is available, the URL SHALL be encoded in it GML description property. |

The process for an image should be a camera

|  |  |
| --- | --- |
| /req/gsml4-lab-analysis/image-process | The image SHOULD make reference to a camera for its SF\_Process |

### Geochronology

This model allows the delivery of geochronological interpretations by describing:

1. a Specimen (eg; rock sample)
2. a related collection of sampling features within that specimen (eg; ion probe burn spots),
3. and a GeochronologicInterpretation related to that sampling collection.

Each member of the sampling collection has related OM\_Observation/result(s)



Figure 79: Summary diagram of geochronology

#### GeochronologicInterpretation

An interpretation made by a geologist of the age of a specimen made by statistical analysis of a single collection of observations. A specimen may have multiple geochronological interpretations made on it, each related to a different observation collection.



Figure 80: Geochronologic interpretation

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **interpretedAge** | GeologicEvent | Use GeoSciML GeologicEvent to describe event age, process and environment. e.g, Event age = 350 Ma +/- 3 Ma. Event process = intrusion, extrusion, metamorphism. Event environment = plutonic, marine. |
| **isotopicEvent** | IsotopicEventType | Describes any isotopic events that are relevant to the interpretation. eg; closure, isotopic mixing, Pb loss, etc |
| **isotopicSystem** | IsotopicSystemName | Describes the isotopic system used to calculate geochronological age. StatisticalAgeTypes vocabulary would contain values like:  Ar-Ar, K-Ar, Nd-Sm, Pb-Pb, Rb-Sr, Re-Os, U-Pb, etc |
| **statisticalMethod** | StatisticalMethodTerm | The statistical method used to interpret the results |
| **interpretedBy** | CI\_Responsibility | Party responsible for this interpretation |
| **citation** | CI\_Citation | Use ISO metadata citation element to describe author and other reference information. Can be used to describe reference for new or legacy data |
| **preferredInterpretation** | Boolean | Indicates whether this interpretation is the preferred interpretation (ie; the analytical data may be reinterpreted) |
| **sourceCollection** | SF\_SamplingFeature Collection | Each geochronological interpretation has a mandatory association to a collection of sampling features (eg; a collection of burn spots or craters from a SHRIMP analytical session). Legacy published data for which the SamplingFeatureCollection is unknown may be delivered with SamplingFeatureCollection = 'unknown'. |

### Geologic Specimen

The GeologicSpecimen package extends the ISO19156 O&M schema, and describes processes relevant to the sampling, preparation and analysis of geologic specimens.



Figure 81: Geologic speciment summary diagram

#### ReferenceSpecimen

A reference specimen is a specimen with known or accepted values of some property. The citation property describes the location of a published description of these values. Reference specimens include analytical blanks.

Analytical results from a reference specimen analysed during an AnalyticalSession are delivered in the same way as the results of other specimens analysed in that session.



Figure 82: Reference specimen

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **referenceDescription** | CI\_Citation | Citation of published analytical results for this standard reference specimen |
| **usedIn** | AnalyticalSession | Identifies any analytical sessions in which the reference specimens were used |

#### GeologicSpecimenPreparation

An extension of ISO Specimen:PreparationStep to allow details of preparation steps to be delivered (eg, filtration and mesh size, chemical additives, crushing methods, drying parameters, etc)



Figure 83 : Geologic specimen preparation

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **preparationMethod** | GeologicSpecimenPreparationTerm | A term from a controlled vocabulary to describe the method employed for the preparation of a geologic specimen for further analysis. |
| **parameter** | NamedValue | One or more parameters used in this preparation step. eg, mesh size in a sieving process, type of chemical additives, parameters in a mineral separation process |

#### GeologicSamplingMethod

Implementation of SF\_Process to describe the method used to obtain a geologic specimen

Examples:

* diamond drilling
* percussion drilling
* piston core drilling
* vibro core drilling
* channel sampling
* sea floor dredging
* geological hammer



Figure 84 : Geologic sampling method

GeologicSamplingMethod can only be used in a context of a SF\_Specimen::samplingMethod

|  |  |
| --- | --- |
| /req/gsml4-lab-analysis/specimen-sampling-method | In a GeoSciML instance, GeologicMethod SHALL only be used as a value for SF\_Speciment::samplingMethod. |

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| **method** | GeologicSamplingMethodTerm | Name of the process used to obtain or create a geologic specimen. eg: diamond drilling, percussion drilling, piston core drilling, vibro core drilling, channel sampling, sea floor dredging, crushing, mineral separation, melting, geological hammer. |
| **parameter** | NamedValue | One or more specific parameters used in the sampling process. |

### GeoSciML Laboratory analysis and specimen vocabularies

|  |  |
| --- | --- |
| **Vocabulary** | **Description** |
| **AnalyticalMethodTerm** | Refers to a vocabulary of terms describing the analytical method used in an analytical session (eg; XRF mass spectrometry, ICPMS, SHRIMP geochronology) |
| **InstrumentTypeTerm** | Refers to a vocabulary of Instrument types (eg; XRF, ICPMS, SHRIMP, etc) |
| **IsotopicEventType** | Refers to a vocabulary of terms to describe any isotopic processes relevant to the geochronologic interpretation. eg:closure, isotopic mixing, Pb loss, etc |
| **IsotopicSystemName** | Refers to a vocabulary of isotopic systems such as Ar-Ar, K-Ar, Nd-Sm, U-Pb, Pb-Pb, Re-Os, etc |
| **StatisticalMethodTerm** | Refers to a vocabulary describing statistical methods used in interpret geochronologic data |
| **GeologicSamplingMethodTerm** | Refers to a vocabulary of terms describing the samplingProcess used to obtain or create the Specimen. eg: diamond drilling, percussion drilling, piston core drilling, vibro core drilling, channel sampling, sea floor dredging, crushing mineral separation ,melting ,geological hammer |
| **GeologicSpecimenPreparationTerm** | Refers to a vocabulary of terms to describe sample preparation applied to geologic specimens, typically in preparation for analytical processes like geochemistry or microscopy. eg: crush, mineral separation, thin section, cut, polish, mount, acid digestion |

### Outcrop encoding pattern (Informative)

It is suggested to use SamplingFeatureCollection for representing geological field data collected at an outcrop, (ie; an outcrop is modelled as a collection of sampling points). At each point at an outcrop, observations may be made on a single geologic feature (sampledFeature), such as a geologic unit description, a fault description, a contact description, or structural measurements on a foliation. If more than one geologic feature is observed at an outcrop, it is delivered as a separate sampling point.



Figure 85: Outcrop encoding pattern using ISO19156

SamplingFeatureCollection might also be used to represent dredge hauls, measured sections, and other sorts of sampling features with multiple kinds of associated observations.

|  |  |
| --- | --- |
| /req/gsml4-lab-analysis/outcrop-pattern | Observations at outcrop SHOULD be encoded using the pattern described at clause 8.8.5 |

# GML Encoding Requirements classes

XSD were derived from the UML model following GML 3.3 encoding (OGC 10-129r1) that extends and superceeds some of ISO 19136-2007, specifically regarding clauses 11 (CodeType encoding) and 12.3 (Association encoding)

The normative artefacts for XML encoding are the W3C XSD documents and W3C schematron SCH documents provided online with this specification. Those documents explicitly provide the requirements that must be met by any XML instance claiming compliance to this specification. Any requirements that cannot be expressed in XSD or SCH are described in the relevant XML encoding section.

## Prefixes used in examples

For brevity in XML examples, namespace declaration might be omitted. Throughout this document, the following namespaces mapping will be assumed.

|  |  |
| --- | --- |
| **Prefix** | **Namespace URI** |
| **cit** | <http://standards.iso.org/iso/19115/-3/cit/1.0> |
| **cv** | <http://www.opengis.net/cv/0.2/gml32> |
| **gco** | <http://www.isotc211.org/2005/gco> |
| **gmd** | <http://www.isotc211.org/2005/gmd> |
| **gml** | <http://www.opengis.net/gml/3.2> |
| **gmlexr** | <http://www.opengis.net/gml/3.3/exr> |
| **gsmlb** | <http://xmlns.geosciml.org/GeoSciML-Basic/4.0> |
| **gsmlbh** | <http://xmlns.geosciml.org/Borehole/4.0> |
| **gsmle** | <http://xmlns.geosciml.org/GeoSciML-Extension/4.0> |
| **gsmlgt** | <http://xmlns.geosciml.org/GeologicTime/4.0> |
| **gsmlla** | <http://xmlns.geosciml.org/LaboratoryAnalysis-Specimen/4.0> |
| **gsmlp** | <http://xmlns.geosciml.org/geosciml-portrayal/4.0> |
| **mrl** | <http://standards.iso.org/iso/19115/-3/mrl/1.0> |
| **om** | <http://www.opengis.net/om/2.0> |
| **sam** | <http://www.opengis.net/sampling/2.0> |
| **sams** | <http://www.opengis.net/samplingSpatial/2.0> |
| **spec** | <http://www.opengis.net/samplingSpecimen/2.0> |
| **swe** | <http://www.opengis.net/swe/2.0> |
| **wfs** | <http://www.opengis.net/wfs/2.0> |
| **xlink** | <http://www.w3.org/1999/xlink> |

## GeoSciML Core XML Requirements Class

|  |  |
| --- | --- |
| **Requirements Class** | |
| **/req/gsml4xsd** | |
| Target type | XML instance |
| Dependency | **/req/gsml4-core** |
| Dependency | **Linked Open Data** |
| Dependency | **http://www.w3.org/TR/xlink11/** |
| **Requirement** | **/req/gsml4xsd/xsd**  *Instance document SHALL validate with against XSD of the package* |
| **Requirement** | **/req/gsml4xsd/sch**  *Instance document SHALL validate against schematron rules of the package* |
| **Requirement** | **/req/gsml4xsd/codelist**  *Vocabulary term shall be encoded with HTTP Uri in xlink:href and a human readable description in xlink:title* |
| **Requirement** | **/req/gsml4xsd/byref**  *By Reference property SHALL be encoded with HTTP URI in xlink:href, and resolve to a representation of that resource using Linked Open Data principles* |

### XML document validation

An XML instance shall validate to both the XSD and schematron rules provided by this specification for each of the XML requirements classes.

|  |  |
| --- | --- |
| /req/gsml4xsd/xsd | XML instance SHALL validate against XSD schema |

|  |  |
| --- | --- |
| /req/gsml4xsd/sch | XML instance SHALL validate against schematron rules |

Some core rules are implemented in .sch that apply to all instances. Since this is a abstract requirement class, there are no instance of “core” to be tested. But all concrete targets will import this schematron file.

|  |  |
| --- | --- |
| /req/gsml4xsd/code-sch | All XML instance SHALL validate with gsml4-core.sch |



ReferenceXML document forbids the serialization of duplicate xs:ID (gml:id is of type xsd:ID) and since gml:id is a local identifier for a <<Type>>, an entity cannot be repeated. Property must therefore use a reference to the already serialized entity.

<gsmlb:GSML>

<gsmlb:mappedItem>

<gsmlb:MappedFeature gml:id="m1">

<gsmlb:specification>

<gsmlb:GeologicUnit gml:id="G1">

...

</gsmlb:GeologicUnit>

</gsmlb:specification>

</gsmlb:MappedFeature>

</gsmlb:mappedItem>

<gsmlb:mappedItem>

<gsmlb:MappedFeature gml:id="m2">

**<gsmlb:specification xlink:href="#G1" xlink:title="G1"/>**

</gsmlb:MappedFeature>

</gsmlb:mappedItem>

<gsmlb:mappedItem>

<gsmlb:MappedFeature gml:id="m3">

**<gsmlb:specification xlink:href="http://host.org/resources/geologicUnit/G1" xlink:title="G1"/>**

</gsmlb:MappedFeature>

</gsmlb:mappedItem>

</gsmlb:GSML>

This example shows 3 encoding of a gsmlb:specification property containing (or referring) to a gsmlb:GeologicUnit. The first is inline, the second uses a local reference while the last uses a LOD reference.

<gsmlb:GSML>

<gsmlb:mappedItem>

<gsmlb:MappedFeature gml:id="m4">

**<gsmlb:specification xlink:href="http://host.org/files/geologicUnit.xml#G1" xlink:title="G1"/>**

</gsmlb:MappedFeature>

</gsmlb:mappedItem>

<gsmlb:mappedItem>

<gsmlb:MappedFeature gml:id="m4">

**<gsmlb:specification xlink:href="http://host.org/wfs?** **REQUEST=GetFeature&VERSION=2.0.0&SERVICE=WFS&STOREDQUERY\_ID=urn:ogc:def:query:OGC-WFS::GetFeatureById&ID=G1" xlink:title="G1"/>**

</gsmlb:MappedFeature>

</gsmlb:mappedItem>

</gsmlb:GSML>

The next examples shows yet another W3C encoding of a link by referencing to a fragment inside a XML document and using a WFS 2.0 request. While they are valid encodings, the links are not identifier (although the information is hidden in the link).

LOD HTTP URIs have the dual roles of being both an identifier **and** a location. For this reason, this specification demands that external references use LOD.

|  |  |
| --- | --- |
| /req/gsml4xsd/byref | /req/gsml4xsd/byref  By Reference property referencing to an external resource SHALL be encoded with HTTP URI in xlink:href, and resolve to a representation of that resource using Linked Open Data principles |

### CodeList

Code List are encoded as gml:ReferenceType which is a sequence of gml:OwnershipAttributeGroup and gml:AssociationAttributeGroup, providing a series of xml attributes from W3C XLINK (<http://www.w3.org/TR/xlink11/>) . A vocabulary reference have xlink:href and xlink:title as mandatory attributes.

<gsmlb:lithology xlink:href="http://resource.geosciml.org/classifier/cgi/simplelithology/mudstone" xlink:title="mudstone"/>

The xlink:href contains an absolute HTTP URI that must resolve to a resource (often a SKOS document). The resource can have multiple representations and it’s not guaranteed that an XML parsable document can be obtained from the vocabulary service.

|  |  |
| --- | --- |
| /req/gsml4xsd/codelist | Vocabulary term shall be encoded with HTTP Uri in xlink:href and provide a human readable description in xlink:title |

### Identifiers

Feature identifiers shall be encoded as gml:identifier which value is a Linked Open Data resource identifier

|  |  |
| --- | --- |
| /req/gsml4xsd/identifier-uri | Feature identifiers (unique name) provided in gml:identifier SHALL be URI of resource using Linked Open Data principles. |

<gml:identifier codeSpace="http://data.geoscience.gov.xx/">[http://data.geoscience.gov.xx/feature/asc/geologicunit/stratno/25947</gml:identifier](http://data.geoscience.gov.xx/feature/asc/geologicunit/stratno/25947%3c/gml:identifier)>

### Nillables or Voidables

A nillable property (identified as “voidable” in the UML model) is a property than can document the reason it does not provide any values. There are two ways to identify a nil value

### Date encoding

The date-time formats will conform to ISO standards. Although this is already a GML 3.2 encoding rule (clause 14.2.2.7), this format shall also be used in any string that does not attempt to validate the date time structure.

|  |  |
| --- | --- |
| /req/gsml4xsd/iso8601-time | All date-time elements SHALL be encoded using ISO8601 extended time format |

Note that this precludes the use of time-coordinate systems such as UNIX time. This is specified in order to be maximally consistent with WML2 requirements. The time zone will be included in the time element.

|  |  |
| --- | --- |
| /req/gsml4xsd/time-zone | The value of each time element SHALL include a time zone definition using a signed 4 digit character or a ‘Z’ to represent Zulu or Greenwich Mean Time (GMT). This is defined by the following regular expression:  (Z|[+-]HH:MM) |

Greenwich Mean Time (GMT or Zulu)

<om:phenomenonTime>

<gml:TimeInstant gml:id="ti.1">

<gml:timePosition>1981-09-12T00:00:00Z</gml:timePosition>

</gml:TimeInstant>

</om:phenomenonTime>

Time Zone (example is Newfoundland time zone -3:30)

<om:phenomenonTime>

<gml:TimeInstant gml:id="ti.2">

<gml:timePosition>1981-09-12T00:00:00-03:30</gml:timePosition>

</gml:TimeInstant>

</om:phenomenonTime>

### Units of Measure

SWE Quantity shall have a unit of measure (uom)

|  |  |
| --- | --- |
| /req/gsml4xsd/unit-of-measure | SWE Common Quantities SHALL have a defined unit of measure |

## GeoSciML Portrayal XML Requirements Class

The abstract portrayal encoding set general encoding rules for XML targets, regardless or version of GML from the 3.x series.

|  |  |
| --- | --- |
| **Abstract Requirements Class** | |
| **/req/gsml4xsd** | |
| Target type | XML instance |
| Dependency | **/req/gsml4-portrayal** |
| Dependency | **/req/gsml4xsd** |
| Dependency | **Linked Open Data** |
| Dependency | **GML Simple Feature OGC 10-100r3 SF-1** |
| **Requirement** | **/req/gsml4xsd-portrayal/**  *Instance document SHALL validate with against XSD of the package* |

Because of the limited availability of WFS 2.0 compliant servers and clients, GeoSciML Portrayal targets WFS 1.1.0 and GML 3.1.1.

Portrayal schemas are meant to deliver simple content, consistent with simple scenarios described in GML Simple Feature Level 1 (OGC 10-100r3), user defined properties must respect the same constrains as defined in SF-1 specification

|  |  |
| --- | --- |
| /req/gsml4xsd-portrayal/SF-1 | XML instance document shall SHALL be compliant to GML Simple Feature Level 1 |

SF-1 allows the definition of complex content (Clause 9.3.2 of OGC 10-100r3). To be consistent with the most common scenario encountered in GIS which is a direct mapping between a database table to XML, this specification restrict user defined content to simple type

|  |  |
| --- | --- |
| /req/gsml4xsd-portrayal/SF-1-simpletype | User defined elements SHALL be XSD simpleType |

User defined properties are defined as

<any processContents="lax" minOccurs="0" maxOccurs="unbounded">

<annotation>

<documentation>A placeholder allowing any user-defined attributes to be delivered in addition to those specified above.</documentation>

</annotation>

</any>

Process content is set to “lax”, which means that the validator will attempt to validate user defined property is a schema is available. To help client applications and developer to validate instance containing use defined property, a XSD file should be provided.

|  |  |
| --- | --- |
| /req/gsml4xsd-portrayal/user-xsd | An XSD schemas SHOULD be provided by data provider to validate user defined properties. |

## GeoSciML Portrayal GML 3.2 profile

Target specifically GML 3.2

|  |  |
| --- | --- |
| **Abstract Requirements Class** | |
| **/req/gsml4xsd-portrayal-32** | |
| Target type | XML instance |
| Dependency | **/req/gsml4-portrayal** |
| **Requirement** | **/req/gsml4xsd-portrayal/**  *Instance document SHALL validate with against XSD of the package* |

All the elements from the portrayal package must be schema valid according to the XSD document provided at http://schemas.opengis.net/gsml/4.0/geosciml-portrayal.xsd

|  |  |
| --- | --- |
| /req/gsml4xsd-portrayal-32/xsd | XML instance document shall validate with schema located at http://schemas.opengis.net/gsml/4.0/geosciml-portraya.xsd |

All the elements from portrayal package must pass the schematron rule defined in the schematron file located at <http://schemas.opengis.net/gsml/4.0/geosciml-portrayal.sch>

|  |  |
| --- | --- |
| /req/gsml4xsd-portrayal-32/scg | XML instance document shall pass schematron defined in schematron file located at http://schemas.opengis.net/gsml/4.0/geosciml-portrayal.sch |

## GeoSciML Portrayal GML 3.1 profile

Targets specifically GML 31 to accommodate WFS 1.1.0 services

|  |  |
| --- | --- |
| **Abstract Requirements Class** | |
| **/req/gsml4xsd-portrayal-31** | |
| Target type | XML instance |
| Dependency | **/req/gsml4-portrayal** |
| **Requirement** | **/req/gsml4xsd-portrayal/**  *Instance document SHALL validate with against XSD of the package* |

All the elements from the portrayal package must be schema valid according to the XSD document provided at http://schemas.opengis.net/gsml/4.0/geosciml-portrayal-wfs1.xsd

|  |  |
| --- | --- |
| /req/gsml4xsd-portrayal-31/xsd | XML instance document shall validate with schema located at http://schemas.opengis.net/gsml/4.0/geosciml-portrayal\_wfs1.xsd |

All the elements from portrayal package must pass the schematron rule defined in the schematron file located at <http://schemas.opengis.net/gsml/4.0/geosciml-portrayal.sch>

|  |  |
| --- | --- |
| /req/gsml4xsd-portrayal-31/scg | XML instance document shall pass schematron defined in schematron file located at http://schemas.opengis.net/gsml/4.0/geosciml-portrayal\_wfs1.sch |

## GeoSciML Basic XML Requirements Class

|  |  |
| --- | --- |
| **Requirements Class** | |
| **/req/gsml4xsd-basic** | |
| Target type | XML instance |
| Dependency | **/req/gsml4-basic** |
| Dependency | **/req/gsml4xsd** |
| Dependency | **Linked Open Data** |
| **Requirement** | **/req/gsml4xsd-basic/**  *Instance document SHALL validate with against XSD of the package* |

All the elements from the basic package must be schema valid according to the XSD document provided at http://schemas.opengis.net/gsml/4.0/geoSciMLBasic.xsd

|  |  |
| --- | --- |
| /req/gsml4xsd-basic/xsd | XML instance document shall validate with schema located at http://schemas.opengis.net/gsml/4.0/geoSciMLBasic.xsd |

All the elements from basic package must pass the schematron rule defined in the schematron file located at <http://schemas.opengis.net/gsml/4.0/geoSciMLBasic.sch>

|  |  |
| --- | --- |
| /req/gsml4xsd-basic/sch | XML instance document shall pass schematron defined in schematron file located at http://schemas.opengis.net/gsml/4.0/geoSciMLBasic.sch |

Some properties links to stub property blocks (see 5.2) which value are empty abstract classes, therefore no value can be provided in basic package. XML encoding still allows the presence of an empty tag

<gsmlb:GeologicUnit>

<gsmlb:gbMaterialDescription/>

</gsmlb:GeologicUnit>

It is recommended in basic package to not serialise those properties at all

|  |  |
| --- | --- |
| /req/gsml4xsd-basic/abstractDescription | Properties that link to abstract description classes should not be serialized. |

## GeoSciML Extension XML Requirements Class

|  |  |
| --- | --- |
| **Requirements Class** | |
| **/req/gsml4-extension** | |
| Target type | XML instance |
| Dependency | **/req/gsml4-extension** |
| Dependency | **/req/gsml4xsd-basic** |
| Dependency | **Linked Open Data** |
| **Requirement** | **/req/gsml4xsd-portrayal/**  *Instance document SHALL validate with against XSD of the package* |

All the elements from the extension package must be schema valid according to the XSD document provided at http://schemas.opengis.net/gsml/4.0/geoSciMLExtension.xsd

|  |  |
| --- | --- |
| /req/gsml4xsd-extension/xsd | XML instance document shall validate with schema located at http://schemas.opengis.net/gsml/4.0/extension.xsd |

All the elements from extension package must pass the schematron rule defined in the schematron file located at http://schemas.opengis.net/gsml/4.0/geoSciMLExtension.sch

|  |  |
| --- | --- |
| /req/gsml4xsd-extension/sch | XML instance document shall pass schematron defined in schematron file located at http://schemas.opengis.net/gsml/4.0/geoSciMLExtension.sch |

## GeoSciML Geologic Time XML Requirements Class

|  |  |
| --- | --- |
| **Requirements Class** | |
| **/req/gsml4xsd-geologictime** | |
| Target type | XML instance |
| Dependency | **/req/gsml4-geologictime** |
| Dependency | **/req/gsml4xsd** |
| Dependency | **Linked Open Data** |
| **Requirement** | **/req/gsml4xsd-geologictime/**  *Instance document SHALL validate with against XSD of the package* |

All the elements from the geologic time package must be schema valid according to the XSD document provided at http://schemas.opengis.net/gsml/4.0/geologicTime.xsd

|  |  |
| --- | --- |
| /req/gsml4xsd-geologictime/xsd | XML instance document shall validate with schema located at http://schemas.opengis.net/gsml/4.0/geologictime.xsd |

All the elements from basic must pass the schematron rule defined in the schematron file located at <http://schemas.opengis.net/gsml/4.0/geologictime.sch>

|  |  |
| --- | --- |
| /req/gsml4xsd-geologictime/sch | XML instance document shall pass schematron defined in schematron file located at http://schemas.opengis.net/gsml/4.0/geologictime.sch |

## GeoSciML Borehole XML Requirements Class

|  |  |
| --- | --- |
| **Requirements Class** | |
| **/req/gsml4xsd-borehole** | |
| Target type | XML instance |
| Dependency | **/req/gsml4-borehole** |
| Dependency | **/req/gsml4xsd-basic** |
| **Requirement** | **/req/gsml4xsd-borehole/**  *Instance document SHALL validate with against XSD of the package* |

All the elements from the borehole package must be schema valid according to the XSD document provided at http://schemas.opengis.net/gsml/4.0/borehole.xsd

|  |  |
| --- | --- |
| /req/gsml4xsd-borehole/xsd | XML instance document shall validate with schema located at http://schemas.opengis.net/gsml/4.0/borehole.xsd |

All the elements from basic must pass the schematron rule defined in the schematron file located at http://schemas.opengis.net/gsml/4.0/borehole.sch

|  |  |
| --- | --- |
| /req/gsml4xsd-borehole/sch | XML instance document shall pass schematron defined in schematron file located at http://schemas.opengis.net/gsml/4.0/borehole.sch |

## GeoSciML Laboratory XML Analysis Requirements Class

|  |  |
| --- | --- |
| **Requirements Class** | |
| **/req/gsml4xsd-lab** | |
| Target type | XML instance |
| Dependency | **/req/gsml4-lab** |
| Dependency | **/req/gsml4xsd-basic** |
| **Requirement** | **/req/gsml4xsd-lab/**  *Instance document SHALL validate with against XSD of the package* |

All the elements from the laboratory analysis and speciment package must be schema valid according to the XSD document provided at http://schemas.opengis.net/gsml/4.0/laboratoryAnalysis-Specimen.xsd

|  |  |
| --- | --- |
| /req/gsml4xsd-lab/xsd | XML instance document shall validate with schema located at http://schemas.opengis.net/gsml/4.0/laboratoryAnalysis-Specimen.xsd |

All the elements from basic must pass the schematron rule defined in the schematron file located at http://schemas.opengis.net/gsml/4.0/laboratoryAnalysis-Specimen.sch

|  |  |
| --- | --- |
| /req/gsml4xsd-lab/sch | XML instance document shall pass schematron defined in schematron file located at http://schemas.opengis.net/gsml/4.0/laboratoryAnalysis-Specimen.sch |

### GeologicSpecimen located along a borehole

GeologicSpecimen located along a borehole must report their location along its path measured relative to the beginning of the borehole. The GeologicSpecimen shall refer to the Borehole using relatedSamplingFeature property and report the relative position using sf:NamedValue inherited from SF\_SamplingFeature.

To unambiguously identify which related SF\_SamplingFeature refers to the borehole along which the GeologicSpecimen is located and identify which NamedValue parameters carry the relative position, this specification imposes a role name for the SamplingFeatureComplex and parameter names for the specimen sf:NamedValue

|  |  |
| --- | --- |
| /req/gsml4-lab-analysis/geologic-specimen-borehole | The xlink:href of the role of the SamplingFeatureComplex use to identify the sampled borehole SHALL use the value “http://www.opengis.net/def/role/GSML/4.0/sampledBorehole” |

|  |  |
| --- | --- |
| /req/gsml4-lab-analysis/geologic-specimen-pos-param | The xlink:href attribute in the XML element sf:name of the sf:parameter/sf:NamedValue element that carries the location SHALL have values from Table 18 |

Table 18: NamedValue parameter names for GeologicSpecimen location along a borehole

|  |  |
| --- | --- |
| **NamedValue name** | **Description** |
| [**http://www.opengis.net/def/param-name/GSML/4.0/starts**](http://www.opengis.net/def/param-name/GSML/4.0/starts) | Reports the position **closest** from the beginning of the borehole along its path. |
| [**http://www.opengis.net/def/param-name/GSML/4.0/ends**](http://www.opengis.net/def/param-name/GSML/4.0/ends) | Reports the position **furthest** from the beginning of the borehole along its path |

The position of the GeologicSpecimen shall be a swe:Quantity

|  |  |
| --- | --- |
| /req/gsml4-lab-analysis/geologic-specimen-pos-value | The XML element sf:value in the sf:parameter/sf:NamedValue element SHALL contain a subelement of type swe:Quantity |

Example of encoding for a GeologicSample located between 3.5 and 3.76 meters from the start of the borehole.

<gsmlla:GeologicSpecimen gml:id="s1">

...

<!-- identifying the sampled borehole --->

<sf:relatedSamplingFeature>

<sf:SamplingFeatureComplex>

<sf:role xlink:href="http://www.opengis.net/def/role/GSML/4.0/sampledBorehole" xlink:title="sampled borehole"/>

<sf:relatedSamplingFeature xlink:href="#borehole-1"/>

</sf:SamplingFeatureComplex>

<sf:relatedSamplingFeature>

...

<!-- reporting the position -->

<sf:parameter>

<sf:NamedValue>

<sf:name xlink:href="http://www.opengis.net/def/param-name/GSML/4.0/starts"/>

<sf:value>

<swe:Quantity>

<swe:uom code="m" xlink:href="http://www.opengis.net/def/uom/OGC/1.0/metre" xlink:title="metre"/>

<swe:value>3.5</swe:value>

</swe:Quantity>

</sf:value>

</sf:NamedValue>

</sf:parameter>

<sf:parameter>

<sf:NamedValue>

<sf:name xlink:href="http://www.opengis.net/def/param-name/GSML/4.0/ends"/>

<sf:value>

<swe:Quantity>

<swe:uom code="m" xlink:href="http://www.opengis.net/def/uom/OGC/1.0/metre" xlink:title="metre"/>

<swe:value>3.76</swe:value>

</swe:Quantity>

</sf:value>

</sf:NamedValue>

</sf:parameter>

...

</gsmla:GeologicSpecimen>

# GeoSciML relative position profile

This profile describes how to encode a relative position of a SF\_SamplingFeature or OM\_Observation. This profile is designed to support the common use case of sampling (or observing in situ) along a borehole path where the sample location is expressed as a distance from some origin point (normally, the collar of the borehole).

This profile provides encoding rules to

* Link a sampling feature to a reference sampling feature that provide the reference geometry (a GM\_Curve)
* A encoding pattern for *in situ* observation using a virtual SF\_SamplingFeature
* An linear spatial encoding

There are two relative position encoding options. Using GML 3.3 Linear referencing or using “GeoSciML” encoding.

# GeoSciML CGI-IUGS Profile

This profile is the “international” version of GeoSciML, which essentially imposes a set of controlled vocabularies. The profile simply states that vocabularies must come from <http://resource.geosciml.org/>

This version of the profile uses the 2012 version of the vocabulary

# Media Types for any data encoding(s)

A section describing the MIME-types to be used is mandatory for any standard involving data encodings. If no suitable MIME type exists in http://www.iana.org/assignments/media-types/index.html then this section may be used to define a new MIME type for registration with IANA.

Annex A: Conformance Class Abstract Test Suite (Normative)

Conformance class: AAAA (repeat as necessary)

To consider for date time validation in portrayal (date are characterstring) :

^([\+-]?\d{4}(?!\d{2}\b))((-?)((0[1-9]|1[0-2])(\3([12]\d|0[1-9]|3[01]))?|W([0-4]\d|5[0-2])(-?[1-7])?|(00[1-9]|0[1-9]\d|[12]\d{2}|3([0-5]\d|6[1-6])))([T\s]((([01]\d|2[0-3])((:?)[0-5]\d)?|24\:?00)([\.,]\d+(?!:))?)?(\17[0-5]\d([\.,]\d+)?)?([zZ]|([\+-])([01]\d|2[0-3]):?([0-5]\d)?)?)?)?$

- See more at: <http://www.pelagodesign.com/blog/2009/05/20/iso-8601-date-validation-that-doesnt-suck/#sthash.4gfIv4KR.dpuf>

Annex <insert Annex number>: Revision history

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Date | Release | Author | Paragraph modified | Description |
| 2015-10-02 | 1.0.0 | Eric Boisvert | All | Moved text into standard OGC template |
| 2015-10- | 1.0.1 | Eric Boisvert | Portrayal and basic | Group review of some clauses at Ispra meeting. |
| 2016-01-05 | 1.1.0 | Eric Boisvert | All | Global review of text for first draft |
|  |  |  |  |  |

Annex <insert annex number>: Bibliography

<A Bibliography, if present, shall appear as the last annex. >

1. [www.opengeospatial.org/cite](http://www.opengeospatial.org/cite) [↑](#footnote-ref-1)
2. SWE RealPairs are encoded as space delimited lists (**<swe:value>10 300</swe:value>**) in XML , which requires parsing the string to extract each token. To build a WFS/FES query that tests the first element, it requires parsing of the string either using string-before(swe:value,’ ’) or tokenize(swe:value,’ ’). This is either cumbersome at best, or not even supported server at worst. 09-026r2 Clause 7.4.4 describes the minimal XPath supports and string parsing is not present. [↑](#footnote-ref-2)