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OGC Geoscience Markup Language 4.0

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Abstract

This specification describes a conceptual model, logical model, and GML/XML encoding rules for the exchange of geological map data. In addition, this specification provides GML/XML encoding examples for guidance.

Keywords

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

ogcdoc, 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 Finland (GTK), Finland
6. Geological Survey of Italy (ISPRA), Italy
7. Geological Survey of Sweden (SGU), Sweden
8. Geoscience Australia (GA), Australia
9. Institute of Geological and Nuclear Sciences (GNS), New Zealand
10. Natural Resources Canada (NRCan), Canada
11. U.S. Geological Survey (USGS), United States of America

Submitters

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

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| 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 borehole and geologic specimen. The model 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 having affiliation with GeoSciML).

# Conformance

This standard defines a logical model and an XML encoding following ISO 19136 (2007) specification for GML applications.

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 ISO 19136:2007.

[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 ―http://www.opengis.net/gml/3.2‖ as specified in ISO 19136:2007.

[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]

# Conceptual Model

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 Commisssion.
* 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 packages

Each application package is the subject of a 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 adopted for 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 display a map layer and perform simple “identify” operations. The classes are model 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 portrayal data model provides several “pointers”, in the form of HTTP URI, to form a sort of “switchboard” where application operating on portrayal model can extract complex representations of the features when required (Figure 2).



Figure 2 Linkage between portrayal and other GeoSciML packages

## GeoSciML Basic and Extension

GeoSciML describes geological features in a mapping perspective, articulated around the concept of a MapFeature – the cartographic element shown on a map, and the GeologicalFeature it represents. All concepts that can be represented on a map are subtypes of GeologicalFeatures. 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\_SamplingFeatures (O&M) subtypes.



Figure 3 Core feature model for GeoSciML

GeologicFeature can share relationships through Relation 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)

* Does not require the creation of a new feature type
* Extra properties can be defined by a community and use by another one

GeoSciML Basic contains 9 stub abstract classes that are implemented 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 an explicit requirement clause. Specific encoding idiosyncrasies shall be addressed in the requirement clause pertaining to this encoding.

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 and borrows some of artefacts of GML and several design decisions were guided by limitations of UML (eg. single inheritance) and XSD (package dependencies artefacts). 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 3.2 where all properties were made mandatory, forcing the data provider to document why the property was missing using “nillables”. This design attracted a lot of criticism (not necessary for GeoSciML but other communities presented with the same pattern) from application developers and data providers that consider the filling the instance with nil properties as “unnecessary verbose” and a waste of bandwidth. This issue is a real concern for mobile applications where payload has an impact on user experience.

It has been argued that nillable properties are just a verbose absent value, but nillable properties actually carry useful or even required information – through nilReason attribute in XML- in certain use cases, such a legally bounded data exchange scenarios.

### 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 experiences (eg, kyanite for high pressure and low temperature). There is an obvious difference between reporting conformed absence of kyanite and the presence of kyanite if not known.

## GeoSciML Core Abstract Requirements Class

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

|  |  |
| --- | --- |
| **Requirements Class** | |
| **/req/gsml4-core** | |
| Target type | Logical model |
| Dependency | **http://www.example.org/req/blah** |
| Dependency | **urn:iso:ts:iso:19139:clause:6** |
| **Requirement** | **/req/gsml4-core/uml-entity-name**  *When the target implementation allows it, the exact name of the classifier shall be used.* |
| **Requirement** | **/req/gsml4-core/uml-cardinality**  *Target implementation SHALL constrain cardinality of properties and association in a way that is consistent with UML* |
| **Requirement** | **/req/gsml4-core/quantities-uom**  *Quantities and measurements SHALL have explicit units of measure specified using the URI for an individual from a class governed as an external ontology.* |
| **Recommendation** | **/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* |
| **Requirement** | **/req/gsml4-core/identifier**  *HTTP URI used as identifiers SHALL be resolvable following Linked Open Data principles.* |

### Naming of entities

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

If a target implementation is capable of encoding all the names used in UML, it shall do so. Some target implementation 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 | Target implementation shall constrain cardinality of properties and association in a way that is consistent with UML |

Cardinality shall be consistent with UML model. Ideally it should be the same, but a target implementation could decide to further constrain the cardinality. For instance, an optional (0..1) can be modelled as mandatory (1..1), but on the other hand, the same optional cannot be converted as a multiple/mandatory (1..M) because many occurrences would contravene the maximum occurrence of 1.

### Quantities

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

|  |  |
| --- | --- |
| /req/gsml4-core/quantities-uom | Quantities and measurements SHALL have explicit units of measure specified using the URI for an individual from a class governed as an external 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. |

## GeoSciML Portrayal Requirements Class

The GeoSciML-Portrayal schema standardises the interaction (request/response formats) with layer-based map services or GIS applications. It is best thought of as a view of GeoSciML data that denormalises the data and concatenates complex property values into single, human-readable, labels and returns single, representative, values from controlled vocabularies for properties multi-valued properties that can be used when generating thematic maps, or portrayals, of the data.



Figure 6 : Package dependency for GeoSciML Portrayal

It is separate to, but harmonized with, GeoSciML and conforms to the level 0 of the Simple Features Profile for GML (OGC 10-099r2). Labels, are 'free-text' fields that are , in robust services, well-structured summaries of complex GeoSciML data, while the representative thematic properties will be URIs of concepts in a controlled vocabulary (for example CGI Simple Lithology). There will also be links, via identifier URIs, providing hooks to full GeoSciML representations of the geologic feature in question.

|  |  |
| --- | --- |
| **Abstract Requirements Class** | |
| **/req/gsml4-portrayal** | |
| Target type | Logical model |
| Dependency | **/req/gsml4-core** |
| Dependency | **Linked Open Data** |
| **Requirement** | **/req/gsml4-portrayal/geomtype**  *A data instance SHALL use a single geometry type (Point, Line, Polygon, etc.)* |
| **Requirement** | **/req/gsml4-portrayal/multiple**  *Multiple values SHALL be reported as a comma delimited list.* |
| **Requirement** | **/req/gsml4-portrayal/uri**  *Properties of type URI SHALL provide a resolvable HTTP URI referring to a resources resolvable using Linked Open Data principles* |
| **Requirement** | **/req/gsml4-portrayal/user-defined-cardinality**  *User defined properties SHALL have limit maximum occurrence to one (1)* |
| **Requirement** | **user-defined-geom**  *User defined SHALL NOT be of type Geometry, or of its subtype.* |
|  | Will add the other requirement clauses once they are agreed on |

### Geometry type

A data instance (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.) |

### Multiple values

A property that lists a collection shall delimit the values using commas

|  |  |
| --- | --- |
| /req/gsml4-portrayal/multiple | Multiple values SHALL be encoded as a comma delimited list. |

### URI

A property that lists a collection shall delimit the values using commas

|  |  |
| --- | --- |
| /req/gsml4-portrayal/uri | Properties of type URI SHALL provide a resolvable HTTP URI referring to a resources resolvable using Linked Open Data principles |

****

Figure 7 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 property cardinality

Each class is “open ended” to allow data provider specific properties. Since the expected target type is GML simple feature, new properties should follow the same restriction. User defined properties must have maximum occurrence set to 1. Therefore, only 0..1 or 1..1 are allowed.

|  |  |
| --- | --- |
| /req/gsml4-portrayal/user-defined-cardinality | User defined properties SHALL have limit maximum occurrence to one (1) |

### Multiple geometries

GML Simple Feature prohibits multiple geometries to prevent portrayal confusion. Therefore, user defined properties cannot be of type Geometry.

|  |  |
| --- | --- |
| /req/gsml4-portrayal/user-defined-geom | User defined SHALL NOT be of type Geometry, or of its subtype. |

### GeologicUnitView

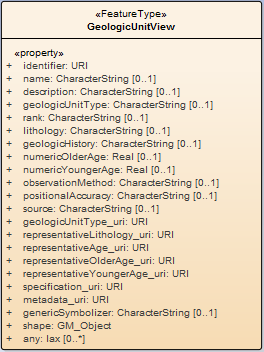


Figure 8 GeologicUnitView class

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

Table 2 : GeologicUnitView properties

|  |  |  |
| --- | --- | --- |
| Property | Type | Description |
| Identifier | URI | Globally unique identifer. Should have the same value as the corresponding GeoSciML MappedFeature. |
| Name | CharacterString | Display name for the the GeologicalUnit. |
| description | CharacterString | Text description of the GeologicUnit, typically taken from an entry on a geological map legend. |
| geologicUnitType | CharacterString | Type of GeologicUnit (as defined in GeoSciML). |
| rank | CharacterString | Rank of GeologicUnit (as defined by ISC. eg; group, formation, member). |
| lithology | CharacterString | Text (possibly formatted with formal syntax) description of the GeologicUnit's lithology. |
| geologicHistory | CharacterString | Text (possibly formatted with formal syntax) description of the age of the GeologicUnit (where age is a sequence of events and may include process and environment information). |
| numericOlderAge | Real | Older age in numerical representation in Ma. |
| numericYoungerAge | Real | Younger age in numerical representation 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 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. |
| geologicUnitType\_uri | URI | URI referring to a controlled concept from a vocabulary defining the GeologicUnit 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. |
| representativeLithology\_uri | URI | URI referring to a controlled concept specifying the characteristic or represntative 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 | URI | 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 | URI | 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 |  | 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 | URI | URI referring 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 | URI | 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/geologicunitview-identifier | GeologicUnitView identifier SHALL correspond to and instance of MappedFeature |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geologicunitview-geologicunit-type | GeologicUnitType\_uri value SHALL refer to a controlled concept from a vocabulary defining the GeologicUnit types or a controlled concept explaining why the value is nil. |

|  |  |
| --- | --- |
| /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. |

|  |  |
| --- | --- |
| /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. |

|  |  |
| --- | --- |
| /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. |

|  |  |
| --- | --- |
| /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. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geologicunitview-specification | Specification\_uri value SHALL 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. |

### BoreholeView

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.

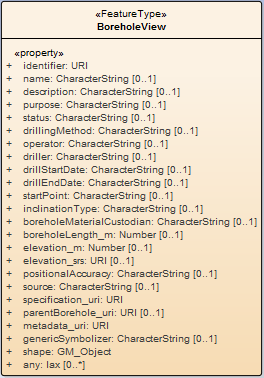


Figure 9 : BoreholeView class

Table 3 BoreholeView properties

|  |  |  |
| --- | --- | --- |
| Name | Type | Notes |
| identifier | URI | Globally unique identifer. Use XML anyURI datatype |
| 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 as a gml:timePosition - eg, 2012-03-17) |
| drillEndDate | CharacterString | The date of the end of drilling (formatted as a gml:timePosition - 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 | URI | 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. |
| specification\_uri | URI | URI referring 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. |
| parentBorehole\_uri | URI | URI referring to the unique ID of a parent borehole (eg, parent well of a sidetrack wellbore) |
| metadata\_uri | URI | 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 SHALL resolve to a representation of a GeoSciML Borehole |

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

|  |  |
| --- | --- |
| /req/gsml4-portrayal/boreholeview-specification\_uri | Specification\_uri SHALL resolve to a representation of a GeoSciML GeologicUnit or a controlled concept describing why the value if nil. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/boreholeview-parentBorehole\_uri | If present, parentBorehole\_uri SHALL resolver to a representation of a GeoSciML borehole. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/boreholeview-metadata\_uri | If present, metadata\_uri SHALL resolver to a metadata record. |

### ContactView

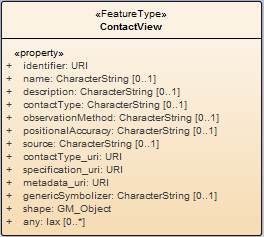


Figure 10: ContactView class

Simplified view of a GeoSciML Contact. 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 | URI | 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 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 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 | URI | 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 | URI | 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 | URI | 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 SHALL correspond to an instance of MappedFeature |

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

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

|  |  |
| --- | --- |
| /req/gsml4-portrayal/contactview-metadata-uri | Metadata\_uri SHALL resolver to a representation of a metadata record |

### GeologicSpecimenView

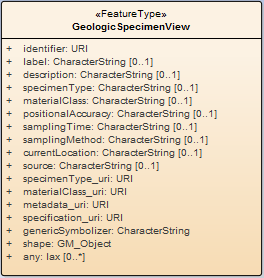


Figure 11: GeologicSpecimenView class

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 | URI | Globally unique identifier (eg, an IGSN sample number). Use XML anyURI datatype |
| 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 as a gml:timePosition - eg, 2012-03-28) |
| 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 | URI | URI link for a specimen type identifier from a controlled vocabulary. |
| materialClass\_uri | URI | URI link for a class of material drawn from a controlled vocabulary. |
| metadata\_uri | URI | URI link to a metadata document. |
| specification\_uri | URI | URI referring the Observation&Measurements (ISO19156) SF\_Specimen 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. |
| 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 a representation 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 |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geologicspecimenview-metadata-uri | metadata-uri SHALL resolve to a representation of a metadata record |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geologicspecimenview-specification-uri | specification-uri SHALL resolve to a representation of (ISO-19156) SF\_Specimen or a vocabulary term describing why the value is nil |

### GeomorphologicUnitView

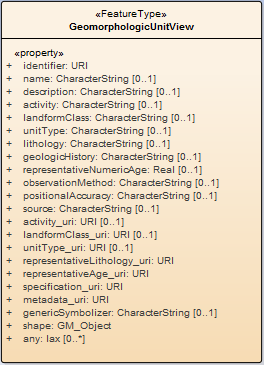


Figure 12 : GeomorphologicUnitView

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 | URI | 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 | URI | URI identifier of activity term drawn from a controlled vocabulary. |
| landformClass\_uri | URI | URI identifier of landform term drawn from a controlled vocabulary. |
| unitType\_uri | URI | 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 | URI | 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 | URI | 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 | URI | 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 | URI | 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 SHALL 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 | Landform\_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. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/geomorphologicunitview-metadata-uri | metadata\_uri SHALL resolve to a representation of a metadata record |

### ShearDisplacementStructureView

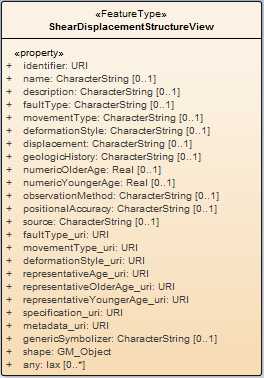


Figure 13: ShearDisplacementStructureView

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 | URI | 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 | URI | 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 | URI | 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 | URI | 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 | URI | 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 | URI | 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 | URI | 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 | URI | 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 | URI | 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. |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/sheardisplacemenstructureview-metadata-uri | metadata\_uri SHALL resolve to a representation metadata document |

### SiteObservationView

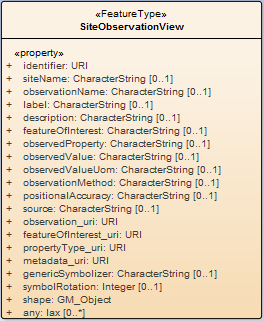


Figure 14: SiteObservationView class

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. 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 | URI | 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. |
| observation\_uri | URI | URI link to a full O&M observation description. |
| featureOfInterest\_uri | URI | URI link to a document describing the feature of interest (eg, a GeoSciML geologic unit or structure). |
| propertyType\_uri | URI | URI to a term from a controlled vocabulary of observed property types. |
| metadata\_uri | URI | 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 SHALL correspond to a representation of (?) |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/siteobservationview-observation\_uri | Observation\_uri SHALL resolve to a representation of (ISO19156) OM\_Observation |

|  |  |
| --- | --- |
| /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) |

|  |  |
| --- | --- |
| /req/gsml4-portrayal/siteobservationview-metadata-uri | metadata\_uri SHALL resolve to a representation of a metadata record |

## GeoSciML Basic Requirements Class

Basic package provides a collection of classes representing fundamental geological features (units, structures, and events), earth materials, and the relations between them. It limits the number of descriptive properties to match INSPIRE geological theme (INSPIRE Data Specification D2.8.II.4).

|  |  |
| --- | --- |
| **Requirements Class** | |
| **/req/gsml4-basic** | |
| Target type | Logical model |
| Dependency | **/req/gsml4-core** |
| Dependency |  |

### GeoSciML Data Types

A package of classes to describe the planar or linear orientation of a geologic feature. Allows 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 FES query of upper and lower values.



Figure 15 : Specialised GeoSciML data types

#### GSML\_GeometricDescriptionValue

Special data types for description of the planar or linear orientation 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 querying 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; if is quadrant. |
| dip | QuantityRange | Dip is the angle that the structural surface (eg bedding, fault plane) makes with the horizontal measured perpindicular to the strike of the structure and in the vertical plane as a numeric or term |
| polarity | PlanarPolarityCode | Indicates whether the planar orientation is associated with a directed feature that is overturned, upright, vertical etc. |

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

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

|  |  |
| --- | --- |
| /req/gsml4-basic/plane-az-degree | Azimuth SHALL be express in clockwise degree from geographic north |

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-degree | Dip SHALL be expressed in degree downward from the horizontal. |

#### 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 orientated (a vector) 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.  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. |

An instance of Linear Orientation shall have either the trend or the plunge value.

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

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

For non-directed linear measurements, plunge are generally always express downward (upward plunge are just downward plunge in the opposite direction). But when the lineation is directed, upward plunge shall be expressed using a negative number.

|  |  |
| --- | --- |
| /req/gsml4-basic/linear-plunge-degree | Plunge SHALL be expressed in degree downward from the horizontal. |

#### GSML\_Vector

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

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

#### 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 16 : 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 |

### Geology basic



Figure 17 : Geologic Feature and MappedFeature

#### 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*.

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 dirty approach to observation metadata when data are reported using a feature view (as opposed to observation view). For a borehole, the GeologicFeature observation method specifies how the geologic properties were determined (eg, visual observation, or standard AzGS logging procedure (described in detail somewhere else)).  This property corresponds (loosely) to ISO19115 Lineage. |
| 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 |  | |
| 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 18 : 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 | Material 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 19 : 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 20: Geologic Event

#### GeologicEvent

|  |  |  |
| --- | --- | --- |
| 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 21: 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 22: 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 23: 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 24: 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 25 : 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 26 : 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 27: 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 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 | Type of collection |
| 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 Geological Time Scale |
| 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 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.

### Geologic Relations

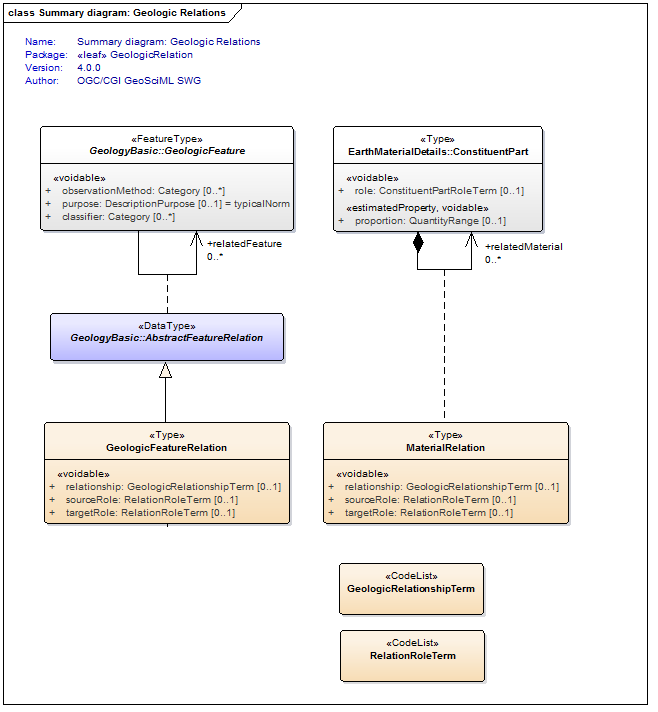


Figure 28: GeologicFeatureRelation is a concrete subtype of AbstractFeatureRelation stub class

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 29: 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 30: 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 31: 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 32: 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 33: 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).

|  |  |  |
| --- | --- | --- |
| 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. |

#### 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) |

#### 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 34: 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 35: 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 36: 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 37: 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 38: 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 39: 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 40: 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 41: 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 42: 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 |

#### DisplacementEvent

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



Figure 43: DisplacementEvent

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

#### DisplacementValue

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



Figure 44: 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 45: 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 46: 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 47: 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 48: 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 49: 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 GeologicTime 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.

## GeoSciML Borehole 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).

## GeoSciML Laboratory 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.)

# GML Encoding Requirements classes

The normative artefacts for XML encoding are the W3C XSD documents and W3C schematron SCH documents that provide instance validation. Those documents provide explicitly 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. This specification does not exclude other XML encodings.

For brievity of XML example, namespace declaration might be omitted. Throughout this document, the following prefixes will be used

XML snippets will use the following prefixes:

|  |  |
| --- | --- |
| Prefix | Namespace |
| 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

|  |  |
| --- | --- |
| **Abstract Requirements Class** | |
| **/req/gsml4xsd** | |
| Target type | XML instance |
| Dependency | **/req/gsml4-core** |
| Dependency | **Linked Open Data** |
| **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 against XSD schema |

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

### CodeList

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

|  |  |
| --- | --- |
| /req/gsml4xsd/byref | /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 |

Code List are encoded as gml:ReferenceType which is a sequence of gml:OwnershipAttributeGroup and gml:AssociationAttributeGroup, providing a series of xml attributes from XLink. 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 href contains a HTTP URI must resolve to resource (most probably a SKOS document)

## GeoSciML Portrayal XML Requirements Class

## GeoSciML Basic XML Requirements Class

## GeoSciML Extension XML Requirements Class

## GeoSciML Geologic Time XML Requirements Class

## GeoSciML Borehole XML Requirements Class

## GeoSciML Laboratory XML Analysis Requirements Class

# 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)

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 |
|  |  |  |  |  |
|  |  |  |  |  |

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)