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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. Geoscience Australia (GA), Australia
8. Institute of Geological and Nuclear Sciences (GNS), New Zealand
9. Natural Resources Canada (NRCan), Canada
10. 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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# 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 (GWML for hydrogeology and EarthResourceML for economic geology – both having filiation with GeoSciML - for instance).

# 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 phenomena.

[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]

# 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.

## 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.

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.* |

### 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 1 GeoSciML portrayal classes

Figure 1 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. |

## 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. The subset of features matches INSPIRE geological theme

## 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.

## 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.

## 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* |

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

## GeoSciML Portrayal XML Requirements Class

## GeoSciML Basic XML Requirements Class

## GeoSciML Extension 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

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| Date | Release | Author | Paragraph modified | Description |
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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)