INSPIRE
Infrastructure for Spatial Information in Europe

# D2.8.II.4 Data Specification on Geology – Draft Guidelines

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# Foreword
# How to read the document?

This document describes the “INSPIRE data specification on <Theme Name> - Guidelines” as developed by the Thematic Working Group *Geology* using both natural and a conceptual schema language. The data specification is based on a common template used for all data specifications and has been harmonised with the other Annex I data specifications by a joint editing team.

This document provides guidelines for the implementation of the provisions laid down in the draft Implementing Rule for spatial data sets and services of the INSPIRE Directive.

This document includes two executive summaries that provide a quick overview of the INSPIRE data specification process in general, and the content of the data specification on *Administrative units* in particular. We highly recommend that managers, decision makers, and all those new to the INSPIRE process and/or information modelling should read these executive summaries first.

The UML diagrams (in Chapter 5) offer a rapid way to see the main elements of the specifications and their relationships. The definition of the spatial object types, attributes, and relationships are included in the Feature Catalogue (also in Chapter 5). People having thematic expertise but not familiar with UML can fully understand the content of the data model focusing on the Feature Catalogue. Users might also find the Feature Catalogue especially useful to check if it contains the data necessary for the applications that they run. The technical details are expected to be of prime interest to those organisations that are/will be responsible for implementing INSPIRE within the field of *Administrative units.*

The technical provisions and the underlying concepts are often illustrated by examples. Smaller examples are within the text of the specification, while longer explanatory examples are attached in the annexes.

In order to distinguish the INSPIRE spatial data themes from the spatial object types, the INSPIRE spatial data themes are written in *italics.*

# Interoperability of Spatial Data Sets and Services – General Executive Summary

The challenges regarding the lack of availability, quality, organisation, accessibility, and sharing of spatial information are common to a large number of policies and activities and are experienced across the various levels of public authority in Europe. In order to solve these problems it is necessary to take measures of coordination between the users and providers of spatial information. The Directive 2007/2/EC of the European Parliament and of the Council adopted on 14 March 2007 aims at establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) for environmental policies, or policies and activities that have an impact on the environment.

INSPIRE will be based on the infrastructures for spatial information that are created and maintained by the Member States. To support the establishment of a European infrastructure, Implementing Rules addressing the following components of the infrastructure are being specified: metadata, interoperability of spatial data themes (as described in Annexes I, II, III of the Directive) and spatial data services, network services and technologies, data and service sharing, and monitoring and reporting procedures.

INSPIRE does not require collection of new data. However, after the period specified in the Directive[1] Member States have to make their data available according to the Implementing Rules.

Interoperability in INSPIRE means the possibility to combine spatial data and services from different sources across the European Community in a consistent way without involving specific efforts of humans or machines. It is important to note that "interoperability" is understood as providing access to spatial data sets through network services, typically via Internet. Interoperability may be achieved by either changing (harmonising) and storing existing data sets or transforming them via services for publication in the INSPIRE infrastructure. It is expected that users will spend less time and efforts on understanding and integrating data when they build their applications based on data delivered within INSPIRE.

In order to benefit from the endeavours of international standardisation bodies and organisations established under international law their standards and technical means have been referenced, whenever possible.

To facilitate the implementation of INSPIRE, it is important that all stakeholders have the opportunity to participate its specification and development. For this reason, the Commission has put in place a consensus building process involving data users, and providers together with representatives of industry, research and government. These stakeholders, organised through Spatial Data Interest Communities (SDIC) and Legally Mandated Organisations (LMO)[2], have provided reference materials, participated in the user requirement and technical[3] surveys, proposed experts for the Data Specification Drafting Team[4] and Thematic Working Groups[5], expressed their views on the drafts of

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[1] For Annex I data: within two years of the adoption of the corresponding Implementing Rules for newly collected and extensively restructured data and within 5 years for other data in electronic format still in use

[2] Number of SDICs and LMOs on 21/11/2008 was 276 and 162 respectively

[3] Surveys on unique identifiers and usage of the elements of the spatial and temporal schema,

[4] The Data Specification Drafting Team has been composed of experts from Austria, Belgium, Czech Republic, France, Germany, Greece, Italy, Netherlands, Norway, Poland, Switzerland, UK, and the European Environmental Agency

[5] The Thematic Working Groups of Annex I themes have been composed of experts from Belgium, Czech Republic, Denmark, France, Finland, Germany, Hungary, Italy Netherland, Norway, Poland, Portugal, Slovenia, Spain, Sweden, Switzerland, UK, the European Commission, and the European Environmental Agency

the technical documents of the data specification development framework[6] and are invited to comment the draft Implementing Rule on Interoperability of Spatial Data Sets and Services.

The development framework elaborated by the Data Specification Drafting Team aims at keeping the data specifications of the different themes coherent. It summarises the methodology to be used for the data specifications and provides a coherent set of requirements and recommendations to achieve interoperability. The pillars of the framework are four technical documents:

- The Definition of Annex Themes and Scope[7] describes in greater detail the spatial data themes defined in the Directive, and thus provides a sound starting point for the thematic aspects of the data specification development.

- The Generic Conceptual Model[8] defines the elements necessary for interoperability and data harmonisation including cross-theme issues. It specifies requirements and recommendations with regard to data specification elements of common use, like the spatial and temporal schema, unique identifier management, object referencing, a generic network model, some common code lists, etc. Those requirements of the Generic Conceptual Model that are directly implementable will be included in the Implementing Rule on Interoperability of Spatial Data Sets and Services.

- The Methodology for the Development of Data Specifications[9] defines a repeatable methodology. It describes how to arrive from user requirements to a data specification through a number of steps including use-case development, initial specification development and analysis of analogies and gaps for further specification refinement.

- The "Guidelines for the Encoding of Spatial Data"[10] defines how geographic information can be encoded to enable transfer processes between the systems of the data providers in the Member States. Even though it does not specify a mandatory encoding rule it sets GML (ISO 19136) as the default encoding for INSPIRE.

Based on the data specification development framework, the Thematic Working Groups have created the INSPIRE data specification for each Annex I theme. The data specifications follow the structure of "ISO 19131 Geographic information - Data product specifications" standard. They include the technical documentation of the application schema, the spatial object types with their properties, and other specifics of the spatial data themes using natural language as well as a formal conceptual schema language[11].

A consolidated model repository, feature concept dictionary, and glossary are being maintained to support the consistent specification development and potential further reuse of specification elements. The consolidated model consists of the harmonised models of the relevant standards from the ISO 19100 series, the INSPIRE Generic Conceptual Model, and the application schemas[12] developed for each spatial data theme. The multilingual INSPIRE Feature Concept Dictionary contains the definition and description of the INSPIRE themes together with the definition of the spatial object types present in the specification. The INSPIRE Glossary defines all the terms (beyond the spatial object types) necessary for understanding the INSPIRE documentation including the terminology of other components (metadata, network services, data sharing, and monitoring).

By listing a number of requirements and making the necessary recommendations, the data specifications enable full system interoperability across the Member States, within the scope of the

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[6] Four documents describing common principles for data specifications across all spatial data themes. See further details in the text.

[7] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.3_Definition_of_Annex_Themes_and_scope_v3.0.pdf*

[8] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.5_v3.1.pdf*

[9] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.6_v3.0.pdf*

[10] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.7_v3.0.pdf*

[11] UML – Unified Modelling Language

[12] Conceptual models related to specific areas (e.g. INSPIRE themes)

application areas targeted by the Directive. They are published as technical guidelines and provide the basis for the content of the Implementing Rule on Interoperability of Spatial Data Sets and Services for data themes included in Annex I of the Directive. The Implementing Rule will be extracted from the data specifications keeping in mind short and medium term feasibility as well as cost-benefit considerations. The Implementing Rule will be legally binding for the Member States.

In addition to providing a basis for the interoperability of spatial data in INSPIRE, the data specification development framework and the thematic data specifications can be reused in other environments at local, regional, national and global level contributing to improvements in the coherence and interoperability of data in spatial data infrastructures.

# Geology – Executive Summary

In the INSPIRE context Geology could be seen as a "reference data theme" as it provides information for several themes of annex III: Mineral resources, Natural Risk Zones, Soil, Energy resources, and it has a specific relationship with one of the main important natural resource, the water, through groundwater bodies and aquifers.

To specify the scope of Geology for INSPIRE, the terms contained in the definition have been clearly explained in the description section. Reference material have been analysed, and particularly:

- the standard data model GeoSciML for Geology, managed by the CGI (Commission for Geoscience Information) of the IUGS (International Union for Geological Sciences),
- a candidate for a standard data model in the groundwater domain: GroundWaterML, linked with GeoSciML to describe the geologic part of aquifers and groundwater,
- the work currently done in the European project OneGeology-Europe, which is delivering a European geological map at 1:1M scale by gathering on-line each national geological map served by a national Web Map Service, and delivering data according to a GeoSciML profile by a national Web Feature Service. This project provides also elements on data quality and metadata that are important for Geology.
- And two legal texts providing requirements for the data specification concerning groundwater and aquifers:
    - The Water Framework Directive (WFD),
    - The Groundwater Directive (GWD).

**The Water Framework Directive (WFD)**

Maintaining a sustainable balance between natural systems and human activities is one objective of the Water Framework Directive (WFD) 2000/60/EC. The WFD implements a comprehensive water policy framework for the European Union. It establishes a series of environmental objectives for groundwater, surface water and associated ecosystems. Maintaining a balance between recharge, abstraction and the needs of the environment is one of the requirements. The aim is to achieve sustainable long-term management of water resources.

**The Groundwater Directive (GWD)**

Groundwater Directive (GWD) 2006/118/EC sets criteria for assessing groundwater chemical status. The main objective of GWD is to protect groundwater against pollution and deterioration. It gives specifications for the identification of degradation trends in chemical quality that require Member States to take action to prevent or limit inputs of pollutants into groundwater. In order to protect the environment as a whole, and human health in particular, detrimental concentrations of harmful pollutants in groundwater must be avoided, prevented or reduced.

The INSPIRE data model has completed GeoSciML with objects and properties related to geomorphology, and geophysics not existing in the standard version of GeoSciML.

All this analysis has been completed by the description of the most relevant examples of use of geology in various domains:

- Detecting geo-hazards
- Ensuring the safe disposal of wastes, nuclear wastes, Carbon Capture and Storage
- Ensuring the safe construction of buildings
- Providing information for environmental planning
- Providing information for natural resources exploration
- Vulnerability underground to contamination
- Aid in depicting indicators for climatic change
- Providing construction material and minerals

and for groundwater and aquifers:

- Water supply (water abstraction)

- Groundwater resources (water availability)
- Providing base flow for rivers, wetlands
- Protecting ecosystems dependent on groundwater
- Groundwater quality and quantity assessment
- Transboundary groundwater management

From these examples, several use cases are detailed:

- Providing geological data to detect geo-hazards,
- Providing geological data to ensure safe disposal of waste, relevant for the disposal of many different kinds of waste in various geological environments,
- Providing geological data to detect ground instability in a flat area for land and urban planning,
- Looking for deep fractured zones in the basement for geothermal exploration,
- Checking background radiation level changes,
- Providing data to undertake water balance to ensure compliance with the WFD,
- Groundwater reporting for WFD,
- Providing hydrogeological data to define significant pressure,
- Providing data to assess corrosivity to underground assets,
- Providing data to plan tunneling operations safely and effectively.

This overview shows the wide range of use with various sets of geological properties of rocks according to the use: the assessment of natural hazards does not request the same information about rock properties than the mineral exploration or the groundwater protection.
In geology, some disciplines are also used to define the properties of geologic units:

- Geophysics:

  From the explanation of terms used in the definition of the geology theme, and from the analysis of the use cases a clear demand for geophysical objects can be seen. Geological knowledge about underground structures is largely based on geophysical results. The quest for traditional and geothermal energy resources is impossible without geophysics. It is widely used in environmental assessment, engineering applications and many other fields. The efficient use and reuse of geophysical information requires information on the existence, location and availability of geophysical data systems.

- Geomorphology:

  Geomorphology is a part of geology which provides basic knowledge about the present shape of the sub aerial and submerged parts of the Earth surface, about its dynamics (genesis and involved processes) and about the physical, mechanical and chemical properties and the behaviors of their constitutive materials. The past and the future of landforms, often displayed on a topographic map, are strongly related to the type of rock, and the understanding of geomorphological mechanisms is a key element for assessing geohazards.

According to this wide range of uses, the TWG decided to provide two application schemas: one related to the common object types and common properties requested by all examples of use (basic geological properties of rocks and structures, and aquifers, considered as geological units with specific properties), and another one to address more properties, but optional, able to provide more attributes describing the rocks and their relationships, and aquifers and groundwater bodies, specially to meet requirements from the Groundwater Directive.

**Difficulties to provide this data specification version 1:**
The TWG tried to address two main difficulties with a first result which could be improved:

- Considering the wide range of uses of geology where many rock properties are important, it was difficult to find the compromise between a simple data model, with a few properties but useful only for a few use cases, and a more detailed model dealing with properties often available only at a local scale but useful to solve more geological problems.
- To describe some properties like the type of rock or their age, we use code lists with several hundred of values which represent the natural variety of rocks. The difficulty is then to define an acceptable set of terms (the highest levels in the hierarchy) but with some loss in the useful description. A mechanism managing the two levels (European level – harmonised but less detailed, and local level – less harmonised but with enough details) should be found.

# Table of contents

# 1 Scope

This document specifies a harmonised data specification for the spatial data theme *Geology* as defined in Annex II of the INSPIRE Directive.

This data specification provides the basis for the drafting of Implementing Rules according to Article 7 (1) of the INSPIRE Directive [Directive 2007/2/EC]. The entire data specification will be published as implementation guidelines accompanying these Implementing Rules.

**This is something else in the scope.**

# 2 Overview

## 2.1 Name and acronyms

INSPIRE data specification for the theme Geology

## 2.2 Informal description

**Definition:**

Geology characterised according to composition and structure. Includes bedrock, aquifers and geomorphology [Directive 2007/2/EC]

**Description:**

From the definition, we detail each word. **Geology** is the study of the past and present aspects of the Earth, including its history and life on Earth.
The **composition** of an earth material describes what it consists of (its components), both the weight percentage of elements or molecules (chemical composition), and the species and number of particles, e.g. minerals (mineralogic composition), clasts and fossils.
The **structure** of an earth material describes the physical arrangements of its components. A geologic structure is a configuration of matter in the Earth based on describable inhomogeneity, pattern, or fracture in an earth material.
The composition and structure of earth materials

- is reflected by their physical properties (e.g. density, porosity, and mechanical, magnetic, electrical, seismic and hydraulic properties)
- influences geological processes (genesis, fracturing, alteration)
- controls the properties of aquifers
- controls the morphology of the landscape
- controls their use as a natural resources
- determines their behaviour during natural and industrial processes

The **bedrock** is a general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material. A British syn. of the adjectival form is solid, as in solid geology.

**Aquifer** is a porous rock structure within which water travels and is stored. Aquifers may be shallow, a few meters in depth, or very deep being several hundred meters in depth.

**Groundwater** is all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil. This zone is commonly referred to as an aquifer which is a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow a significant flow of groundwater or the abstraction of significant quantities of groundwater.

**Water body** is a discrete and significant element of surface water such as a river, lake or reservoir, or a distinct volume of groundwater within an aquifer.

Generally the groundwater body is not exactly correlated with main (deeper) groundwater aquifers because it was based on the surface water basins. So it means that not always aquifer = groundwater body (GWB) (the methodology differs in different member states).
**Geomorphology** provides basic knowledge about the present shape of the sub aerial and submerged parts of the Earth surface, about its dynamics (genesis and involved processes) and about the physical, mechanical and chemical properties and the behaviors of their constitutive materials.

In the INSPIRE context Geology could be seen as a “reference data theme” as it provides information for several themes of annex III: Mineral resources, Natural Risk Zones, Soil, Energy resources, and it has a specific relationship with one of the main important natural resource, the water, through groundwater bodies and aquifers.

To identify the most relevant object types and their properties, the TWG has analysed reference material and user requirements, and has provided a list of “Examples of use” of geology:

- Detecting geo-hazards (geology + geomorphology)
- Ensuring the safe disposal of wastes, nuclear wastes, Carbon Capture and Storage
- Ensuring the safe construction of buildings
- Providing information for environmental planning
- Providing information for natural resources exploration
- Vulnerability underground to contamination
- Aid in depicting indicators for climatic change
- Providing construction material and minerals
- …

and for groundwater and aquifers:

- Water supply (water abstraction)
- Groundwater resources (water availability)
- Providing base flow for rivers, wetlands
- Protecting ecosystems dependent on groundwater
- Groundwater quality and quantity assessment
- Transboundary groundwater management

*(All these examples are described in detail in the TWG document “Examples of use” in circa)*

This overview shows the wide range of use with various sets of rock properties according to the use: a geologist in charge of mineral prospection, or mining waste protection, does not request the same information about rocks than an engineer dealing with natural hazards more interested on underground stability.
So the TWG decided to provide two application schemas: one related to the common object types and common properties requested by all examples of use (the basic geological knowledge about rocks under our feet), and another one to address more properties but optional.

This specification identifies two application schemas of Geology:

- Simple: able to provide the basic geological knowledge on an area, with a limited number of attributes,
- Full: able to provide the basic geological knowledge but also more attributes describing rock composition and structure.

## 2.3 Normative References

[Directive 2007/2/EC] Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)

[ISO 19107] EN ISO 19107:2005, Geographic Information – Spatial Schema

[ISO 19108] EN ISO 19108:2005, Geographic Information – Temporal Schema

[ISO 19108-c] ISO 19108:2002/Cor 1:2006, Geographic Information – Temporal Schema, Technical Corrigendum 1

[ISO 19111] EN ISO 19111:2007 Geographic information - Spatial referencing by coordinates (ISO 19111:2007)

[ISO 19113] EN ISO 19113:2005, Geographic Information – Quality principles

[ISO 19115] EN ISO 19115:2005, Geographic information – Metadata (ISO 19115:2003)

[ISO 19118] EN ISO 19118:2006, Geographic information – Encoding (ISO 19118:2005)

[ISO 19123] EN ISO 19123:2007, Geographic Information – Schema for coverage geometry and functions

[ISO 19135] EN ISO 19135:2007 Geographic information – Procedures for item registration (ISO 19135:2005)

[ISO 19138] ISO/TS 19138:2006, Geographic Information – Data quality measures

[ISO 19139] ISO/TS 19139:2007, Geographic information – Metadata – XML schema implementation

[OGC 06-103r3] Implementation Specification for Geographic Information - Simple feature access – Part 1: Common Architecture v1.2.0

NOTE This is an updated version of "EN ISO 19125-1:2006, Geographic information – Simple feature access – Part 1: Common architecture". A revision of the EN ISO standard has been proposed.

[Regulation 1205/2008/EC] Regulation 1205/2008/EC implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata

Web sites describing the data model standard:

- **GeoSciML:** http://*www.geosciml.org*
- **GWML:** http://ngwd-bdnes.cits.rncan.gc.ca/service/api_ngwds/en/gwml.html

DIRECTIVE 2000/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2000 establishing a framework for Community action in the field of water policy

DIRECTIVE 2006/118/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 December 2006 on the protection of groundwater against pollution and deterioration

## 2.4 Terms and definitions

Terms and definitions necessary for understanding this document are defined in the INSPIRE Glossary[13].

In addition the following terms and definitions are used:

***Geologic feature and sub-types (***adapted from the GeoSciML cookbook - ):

A GeologicFeature can be either a Geologic Unit, a Geologic Structure, a Geomorphologic Unit or a Hydrogeologic Unit, linked to a Mapped Feature describing the geometry.

A MappedFeature can be considered an occurrence, such as a polygon on a geologic map, of a real world GeologicFeature the full extent of which is unknown. It is independent of geometry, so the same GeologicFeature can have different MappedFeature instances representing mapped polygons at different scales or a modelled volume, for example. Each MappedFeature, however, can represent only one GeologicFeature.

A Geologic Unit is a notional unit, complete and precise extent of which is inferred to exist. Spatial properties are only available through association with a MappedFeature. GeologicUnits can be formal units (i.e. formally adopted and named in the official lexicon), 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).

A Geologic Structure, for the INSPIRE context, considers only faults.

A Hydrogeologic Unit is a subset of Geologic Unit and means any soil of rock unit or zone which by virtue of its porosity or permeability, or lack thereof, has a distinct influence on the storage or movement of groundwater.
An Aquifer is formation, group of formations, or part of a formation that contains sufficient saturated, pemeable material to yield significant quantities of water to wells and springs. An aquifer is an underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, silt, or clay) from which groundwater can be usefully extracted using a water well.

The age of GeologicFeatures is described in terms of GeologicEvents. This can either be as a single GeologicEvent giving a preferredAge for the GeologicFeature, or as a series of one or more GeologicEvents describing the geologicHistory of the GeologicFeature.

## 2.5 Symbols and abbreviations

No abbreviations are included in this version of the specification

## 2.6 Notation of requirements and recommendations

To make it easier to identify the mandatory requirements and the recommendations for spatial data sets in the text, they are highlighted and numbered.

[13] The INSPIRE Glossary is available from http://inspire-registry.jrc.ec.europa.eu/registers/GLOSSARY

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| **IR Requirement X** | Requirements that are reflected in the Implementing Rule on interoperability of spatial data sets and services are shown using this style. |

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| **DS Requirement X** | Requirements that are not reflected in the Implementing Rule on interoperability of spatial data sets and services are shown using this style. |

**Recommendation 1** Recommendations are shown using this style.

## 2.7 Conformance

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| **DS Requirement 1** | Any dataset claiming conformance with this INSPIRE data specification shall pass the requirements described in the abstract test suite presented in Annex A. |

# 3 Specification scopes

This data specification has only one scope, the general scope.

# 4 Identification information

**Table 1 – Information identifying the INSPIRE data specification *Geology***

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| Title | INSPIRE data specification *Geology* |
| Abstract | Geological information provides basic knowledge about the physical properties and composition of the rocks and sediments in the underground, and their structure. It also provides knowledge about aquifers, i.e. subsurface units of rocks or sediments of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater. Knowledge about landforms are also provided. |
| Topic categories | geoscientificInformation |
| Geographic description | This INSPIRE data specification covers spatial data sets which relate to an area where a Member State has and/or exercises jurisdictional rights. |
| Purpose | The purpose of this document is to specify a harmonised data specification for the spatial data theme *Geology* as defined in Annex III of the INSPIRE Directive.<br><br>Information about geology, including aquifers and geomorphology, is provided with the purpose to support several themes in Annex III: Mineral resources, Natural Risk Zones, Soil, Energy resources, and it has a specific relationship with one of the main important natural resources, the water, through groundwater bodies and aquifers |
| Spatial representation type | vector<br>grid |

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|---|---|
| Spatial resolution | National level 1:250 000 to 1 000 000<br>Regional level 1:250 000 to 1:25 000<br>Local level >1:25 000 too detailed?<br>(see D2.6, page 76) |
| Supplemental information | These are the key Feature Types of the theme Geology:<br>A GeologicFeature can be either a GeologicUnit (e.g. a granite body), a GeologicStructure (e.g. a fault) or a GeomorphologicUnit (e.g. an erosional channel), linked to a MappedFeature describing the geometry. A GroundwaterBody is a kind of WaterBody, which is contained within an Aquifer (a kind of GeologicUnit, e.g. a porous sandstone). The GroundwaterBody has a WaterQualityDescription. Boreholes are also linked to MappedFeatures |

# 5 Data content and structure

**IR Requirement 1** Spatial data sets related to the theme **Geology** shall be provided using the spatial object types and data types specified in the application schema(s) in this section.

**IR Requirement 2** Each spatial object shall comply with all constraints specified for its spatial object type or data types used in values of its properties, respectively.

**Recommendation 1** The reason for a void value should be provided where possible using a listed value from the VoidValueReason code list to indicate the reason for the missing value.

NOTE The application schema specifies requirements on the properties of each spatial object including its multiplicity, domain of valid values, constraints, etc. All properties have to be reported, if the relevant information is part of the data set. Most properties may be reported as “void”, if the data set does not include relevant information. See the Generic Conceptual Model [INSPIRE DS-D2.5] for more details.

## 5.1 Basic notions

This section explains some of the basic notions used in the INSPIRE application schemas. These explanations are based on the GCM [DS-D2.5].

### 5.1.1 Placeholder and candidate types

INSPIRE data specifications may refer to types that thematically belong and might be fully specified in future (i.e. Annex II or III) spatial data themes. Two kinds of such types are distinguished:

- A *placeholder type* is a type that act as a placeholder for a type (typically a spatial object type) that will be specified as part of a future spatial data theme, but is already used as a value type of an attribute or association role in this data specification.

  Placeholder types receive the stereotype «placeholder» and are placed in the application schema package of the future spatial data theme where they thematically belong. A definition for the placeholder type is specified based on the requirements of the Annex I theme. This

definition shall be taken into account when the type is specified in the future spatial data theme, and the attributes or association roles in this data specification that have the placeholder as a value type shall be updated if necessary.

- A *candidate type* is a type (typically a spatial object type) for which already a preliminary specification is given. Candidate types does not receive a specific stereotype and is placed in the application schema package of the future spatial data theme where they thematically belong. A definition for the type and its attributes and association roles are specified based on the requirements of the Annex I theme.

  This specification shall be taken into account in the specification work of the Annex II or III theme. If the type cannot be incorporated in the Annex II or III data specification according to its preliminary specification, it shall be moved into the application schema of the Annex I theme where it has first been specified. In this case, the attributes or association roles in this data specification that have the type as a value type shall be updated if necessary.

Placeholders and candidate types are listed in a separate subsection of the Feature Catalogue.

### 5.1.2 Voidable characteristics

If a characteristic of a spatial object is not present in the spatial data set, but may be present or applicable in the real world, the property shall receive this stereotype.

If and only if a property receives this stereotype, the value of *void* may be used as a value of the property. A *void* value shall imply that no corresponding value is contained in the spatial data set maintained by the data provider or no corresponding value can be derived from existing values at reasonable costs, even though the characteristic may be present or applicable in the real world.

It is possible to qualify a value of void in the data with a reason using the VoidValueReason type. The VoidValueReason type is a code list, which includes the following pre-defined values:

- *Unpopulated*: The characteristic is not part of the dataset maintained by the data provider. However, the characteristic may exist in the real world. For example when the “elevation of the water body above the sea level” has not been included in a dataset containing lake spatial objects, then the reason for a void value of this property would be ‘Unpopulated’. The characteristic receives this value for all objects in the spatial data set.
- *Unknown*: The correct value for the specific spatial object is not known to, and not computable by the data provider. However, a correct value may exist. For example when the “elevation of the water body above the sea level” *of a certain lake* has not been measured, then the reason for a void value of this property would be ‘Unknown’. This value is applied on an object-by-object basis in a spatial data set.

NOTE It is expected that additional reasons will be identified in the future, in particular to support reasons / special values in coverage ranges.

The «voidable» stereotype does not give any information on whether or not a characteristic exists in the real world. This is expressed using the multiplicity:

- If a characteristic may or may not exist in the real world, its minimum cardinality shall be defined as 0. For example, an if an Address may or may not have a house number, the multiplicity of the corresponding property shall be 0..1.
- If at least one value for a certain characteristic exists in the real world, the minimum cardinality shall be defined as 1. For example, if an Administrative Unit always has at least one name, the multiplicity of the corresponding property shall be 1..*.

In both cases, the «voidable» stereotype can be applied. A value (the real value or void) only needs to be made available for properties that have a minimum cardinality of 1.

### 5.1.3 Code lists and Enumerations

**Style**

All code lists and enumerations use the following modelling style:

- No initial value, but only the attribute name part, is used.
- The attribute name conforms to the rules for attributes names, i.e. is a lowerCamelCase name. Exceptions are words that consist of all uppercase letters (acronyms).

**Governance**

Two types of code lists can be distinguished:

- code lists that shall be managed centrally in the INSPIRE code list register and only values from that register may be used, and
- code lists that may be extended by data providers.

In the UML model, all code lists that are centrally managed have the tagged value "codeList" with the preliminary value "urn:x-inspire:def:codeList:INSPIRE:<name of the class>".

### 5.1.4 Stereotypes

In the application schemas in this sections several stereotypes are used that have been defined as part of a UML profile for use in INSPIRE [INSPIRE DS-D2.5]. These are explained in Table 2 below.

**Table 2 – Stereotypes (adapted from [INSPIRE DS-D2.5])**

| Stereotype | Model element | Description |
|---|---|---|
| applicationSchema | Package | An INSPIRE application schema according to ISO 19109 and the Generic Conceptual Model. |
| featureType | Class | A spatial object type. |
| type | Class | A conceptual, abstract type that is not a spatial object type. |
| dataType | Class | A structured data type without identity. |
| union | Class | A structured data type without identity where exactly one of the properties of the type is present in any instance. |
| enumeration | Class | A fixed list of valid identifiers of named literal values. Attributes of an enumerated type may only take values from this list. |
| codeList | Class | A flexible enumeration that uses string values for expressing a list of potential values. |
| placeholder | Class | A placeholder class (see definition in section 5.1.1). |
| voidable | Attribute, association role | A voidable attribute or association role (see definition in section 5.1.2). |
| lifeCycleInfo | Attribute, association role | If in an application schema a property is considered to be part of the life-cycle information of a spatial object type, the property shall receive this stereotype. |
| version | Association role | If in an application schema an association role ends at a spatial object type, this stereotype denotes that the value of the property is meant to be a specific version of the spatial object, not the spatial object in general. |

## 5.2 Application schema GE

### 5.2.1 Description

#### 5.2.1.1. Narrative description and UML Overview

The core of the data specification for Geology, Geology Main, is based closely on GeoSciML (*http://www.geosciml.org/*). GeoSciML has been developed by an international geological working group under the auspices of the Commission for Geoscience Information (CGI) of the International Union of Geological Sciences (IUGS). The scope of GeoSciML is primarily the information shown on geological maps, along with boreholes, and for the INSPIRE data specification a sub-set of GeoSciML has been used. Geomorphology is not covered by GeoSciML and this has been added to Geology Main.

The hydrogeology part of the data specification is based closely on GroundwaterML (*http://ngwd-bdnes.cits.rncan.gc.ca/service/api_ngwds/en/gwml.html*) developed by the Geological Survey of Canada. GrondwaterML is a derived implementation of GeoSciML. Again, a subset of GroundwaterML has been used for the INSPIRE data specification, and in addition features concerned with the recharge and discharge of aquifers have been added.

The third principal component of the INSPIRE Geology specification covers geophysics. This is not based on any external domain specific standard, but draws on ISO19156 on Observations & Measurements. Figure 1 shows the relationships between the main components of the Geology specification and external packages.

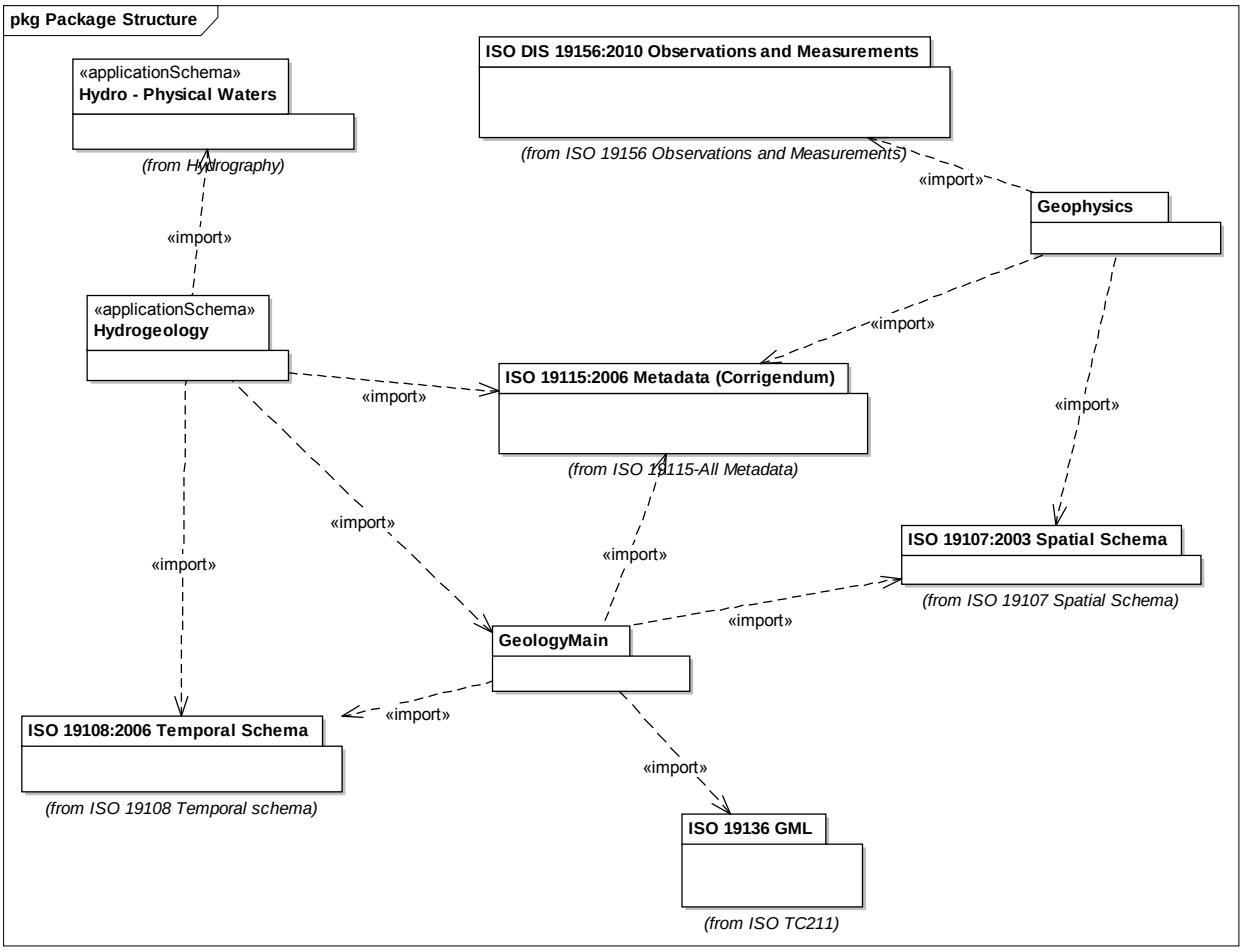



**Figure 1 – UML package diagram: Overview of the GE application schema**

A characteristic of geologic data is that many properties have a large number of permissible values. These are generally held in vocabularies and referenced by applications. It is considered that putting these large codelists in the model is not appropriate so they have been listed in Appendix C.

For each of the three main components of the data specification a simple subset has been identified which it is considered should be the minimum requirement for the INSPIRE process.

The Geology Main package includes six distinct application schema: Geology Core; GeologicAge; CGI_Value; EarthMaterial; Borehole; and PhysicalProperties. From these the simple minimum mandatory subset is shown in Figure 2.

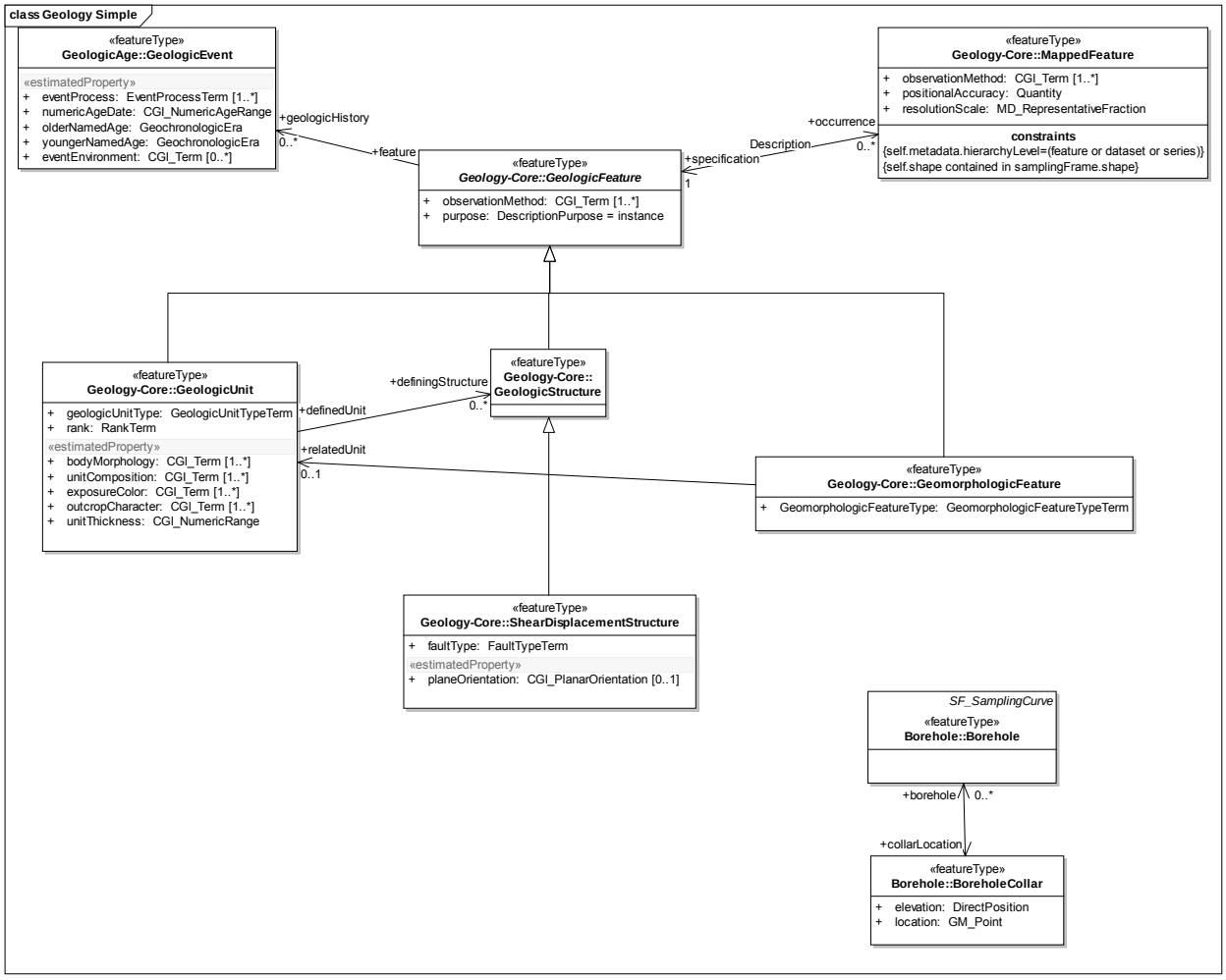



**Figure 2 - UML class diagram : Geology Main mandatory core**

GeologicFeature is an abstract class including GeologicUnits (bodies of rock of some type), GeologicStructures, and GeomorphologicFeatures. In the INSPIRE specification the only type of GeologicStructure being considered are ShearDispacementStructures, which include faults. GeomorphologicFeatures are landforms, but they can have an association to an underlying GeologicUnit. A deformed GeologicUnit may have an association to a defining GeologicStructure.

GeologicFeatures can be considered as description classes which have an association to MappedFeatures which provide the spatial representation for the GeologicFeature. A MappedFeature obtains its geometry from GM_Object. A GeologicFeature can be associated with several MappedFeatures, for example for maps at different scales or 3D models. GeologicFeatures also have an association to GeologicEvent which provides both the age of the GeologicFeature, the event process, and the environment in which the event took place. All ages are considered the age of some event.

The final component of the mandatory core is Borehole with an association to BoreholeCollar to provide the location of the start point of the borehole.

The full specification for GeologicUnit, in the Geology Core schema, is shown in Figure 3. As can be seen, in addition to that included in the mandatory core (Figure 2) GeologicUnit has two further associated description packages: CompositionPart and PhysicalDescription. CompositionPart allows for the description of the lithological composition of the GeologicUnit using the EarthMaterial application schema. PhysicalDescription is a generic means of describing any of the physical properties of the GeologicUnit using the PhysicalProperties application schema.

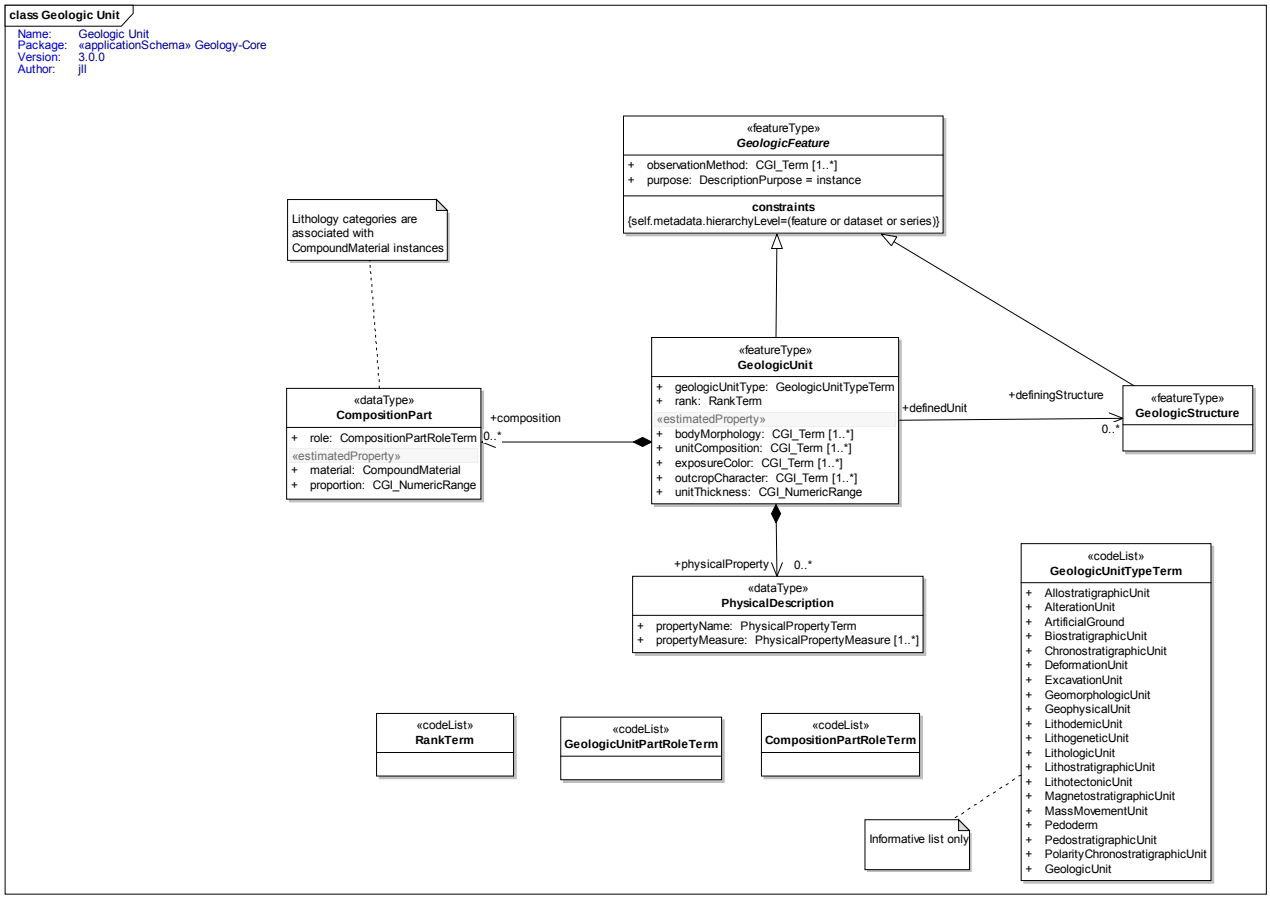



**Figure 3 - UML class diagram: GeologicUnit**

The full specification of GeologicStructure, also in the Geology Core schema, is shown in Figure 4. This shows that in addition to that included in the mandatory core GeologicStructures have associations to PhysicalDescription, to enable the description of any of the physical properties of the GeologicStructure using the PhysicalProperties application schema, and an association to DisplacementValue to record the total displacement that has taken place on the structure. Figure 4 also shows that ShearDisplacementStructure has two sub-types, Fault and DuctileShearStructure.

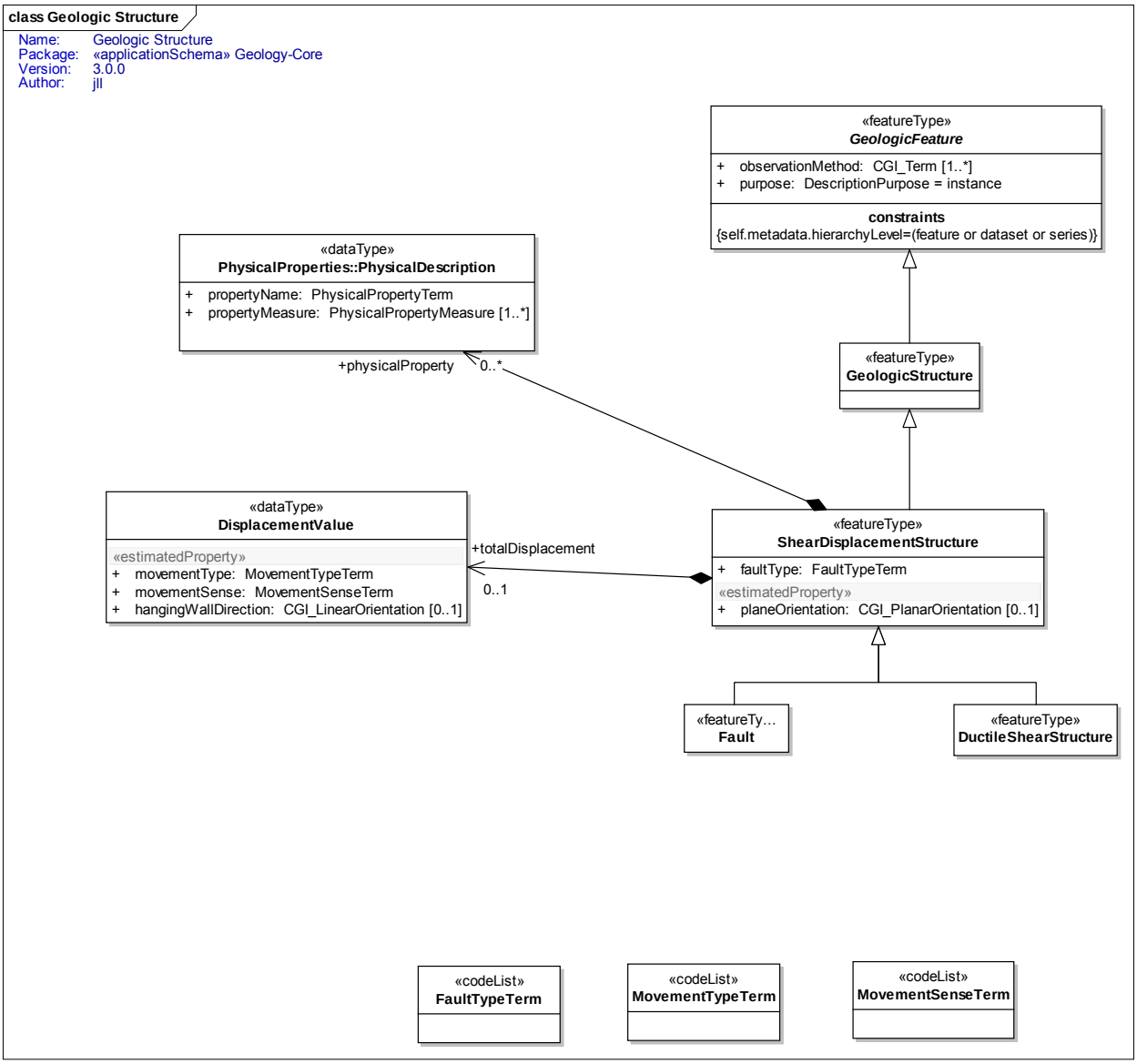



**Figure 4- UML class diagram: GeologicStructure**

The final part of the Geology Core schema is the metadata links from several features to MD_Metadata, shown on Figure 5. These have been adopted from GeoSciML and included in version 1 of the data specification, but it is recognised that metadata may be handled differently in INSPIRE.

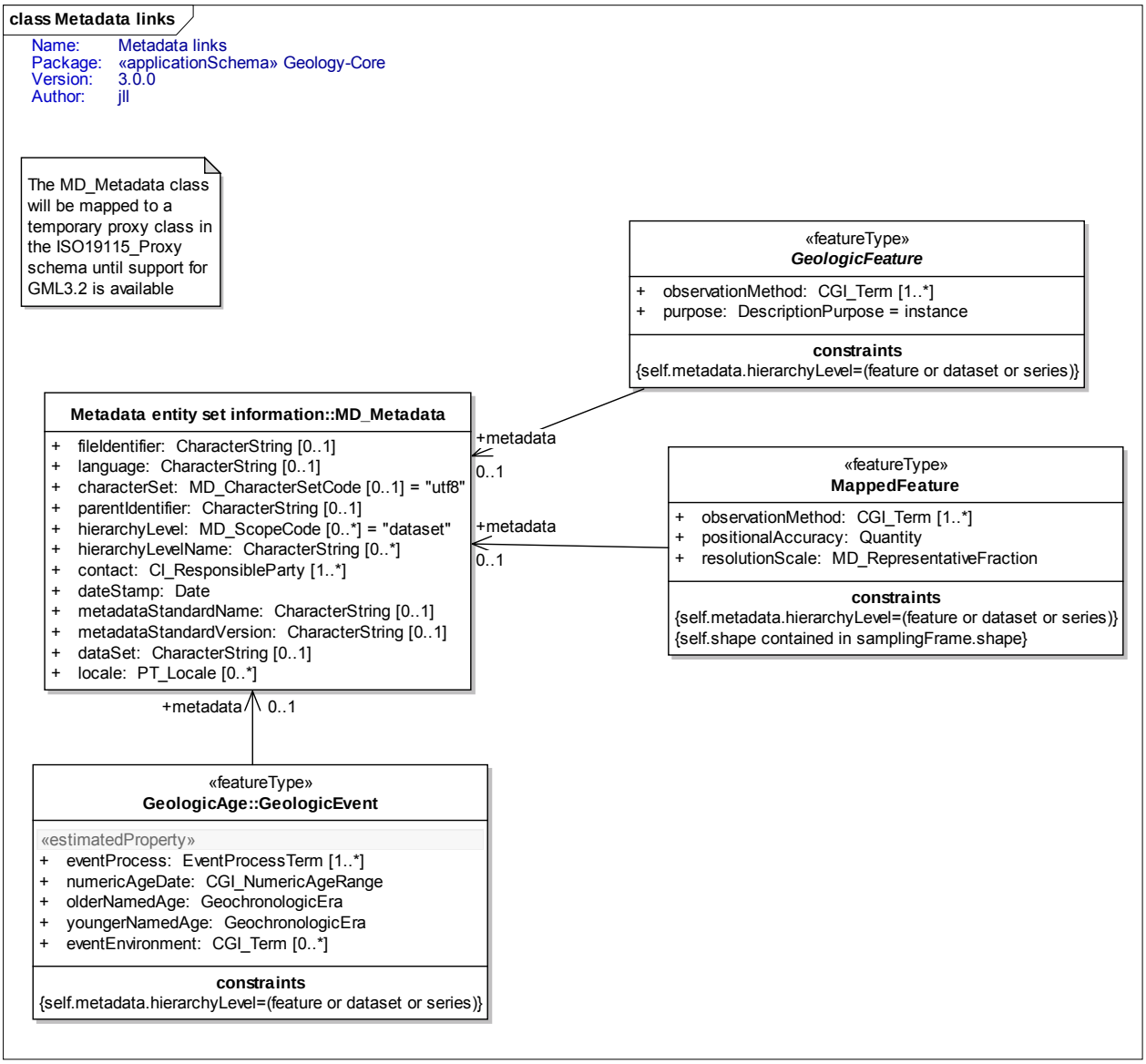



**Figure 5 - UML class diagram: Metadata links**

In geology ages are recorded both numerically and in terms of geochronological eras, and GeologicEvent allows for both methods to be used. Figure 6 shows the GeochronologicalEra type used in GeologicEvent. Ages are commonly recorded as a range of time and the data type CGI_NumericAgeRange allows for both a single reporting age and older and younger bounding ages, all with an accuracy measure.

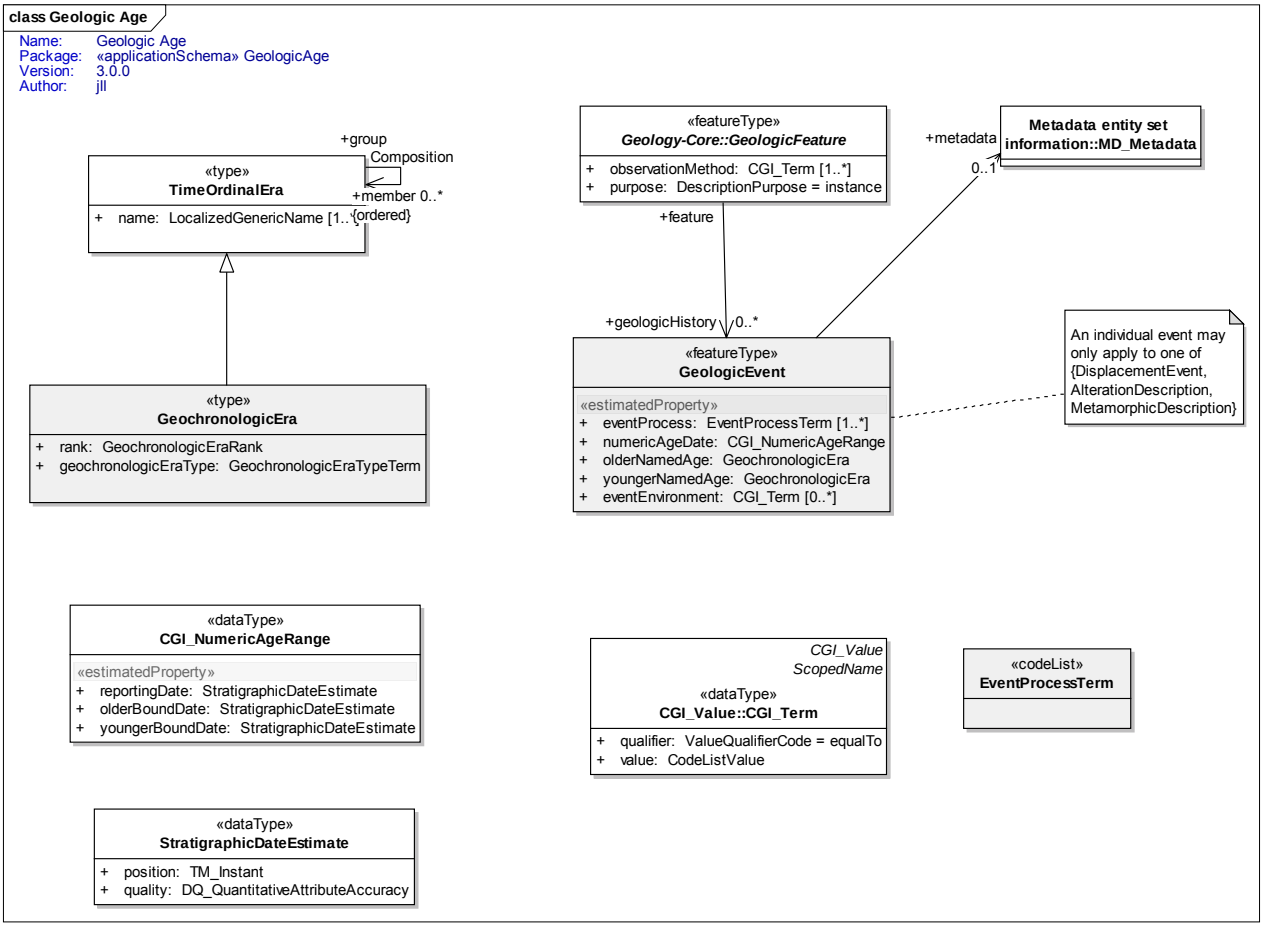



**Figure 6 - UML class diagram: GeologicEvent**

The CGI_Value application schema includes specific geological data types used in other parts of the specification. Figure 7 shows generic values and Figure 8 shows geometric values.

A characteristic of many geological term properties is that they require a qualification of some type. Similarly numeric values are commonly an estimate requiring a statistical measure or variability measure attached to them. In addition both term and numeric property values commonly are recorded as a range (distinct from numeric variability). The abstract CGI_Value data type and its sub-types shown in Figure 7 implement these requirements.

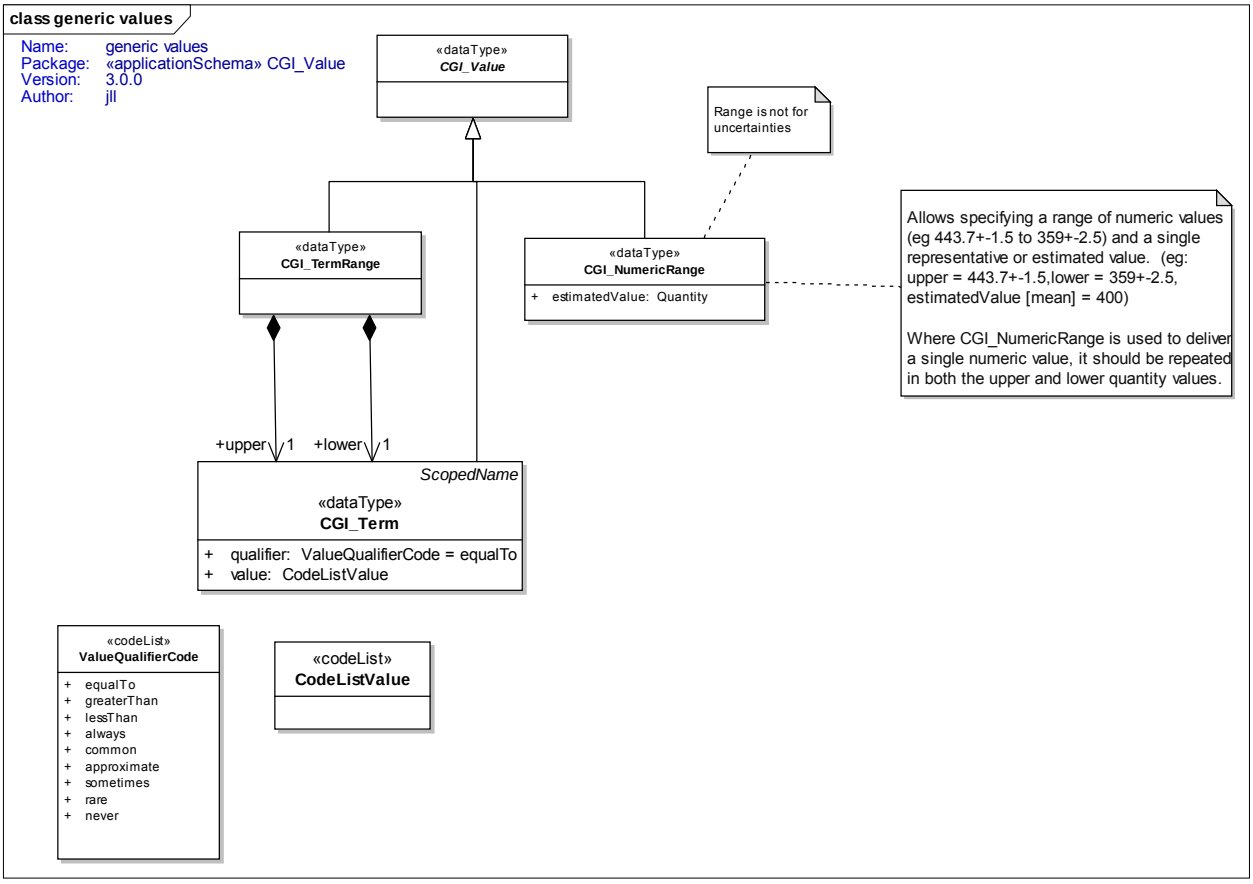



**Figure 7 - UML class diagram: Generic values**

The geometric data types shown in Figure 8 implement the specific geological measures for planar and linear orientation of geological structures.

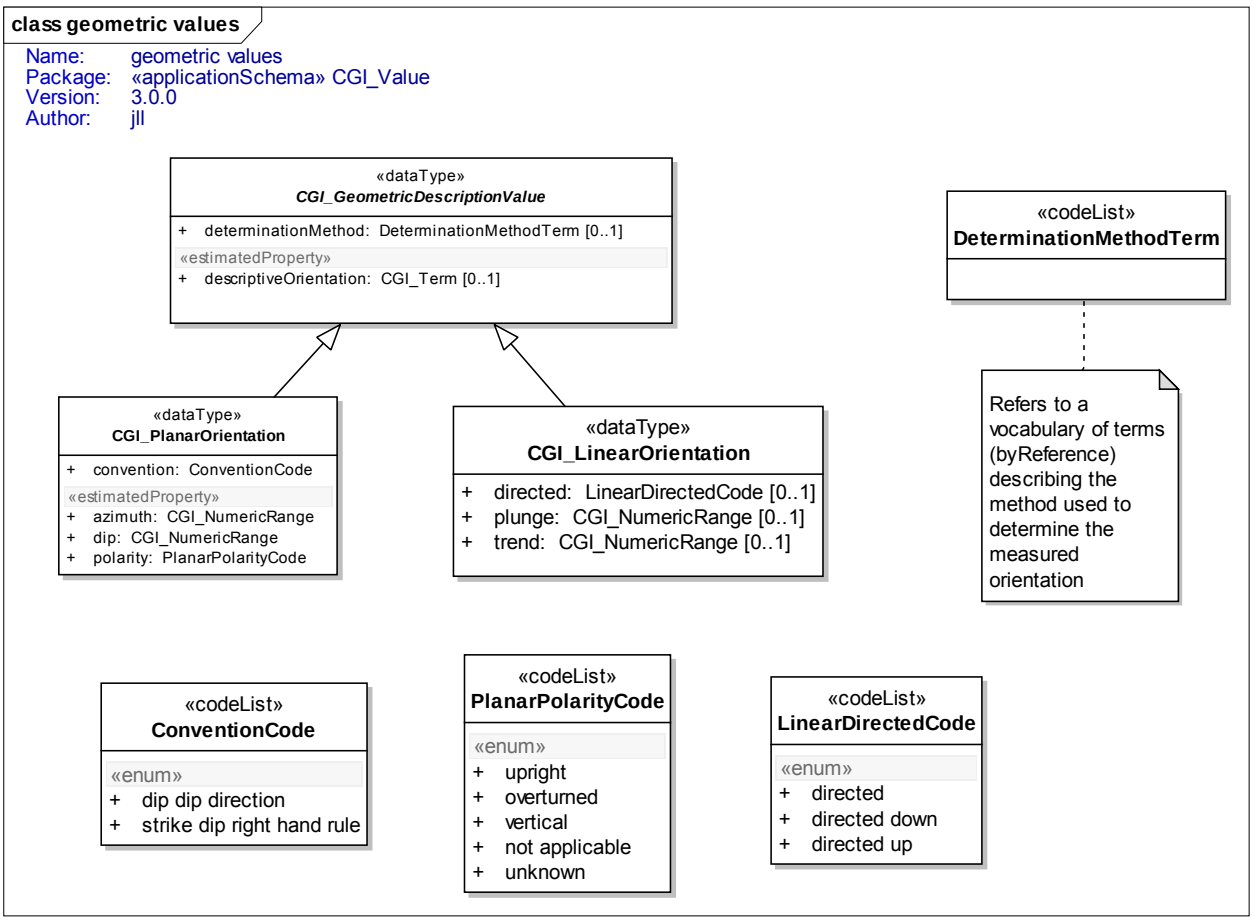



**Figure 8 - UML class diagram: Geometric values**

The lithological description of GeologicUnits, through CompositionPart, is an important aspect of the geology data specification. Lithological descriptions are provided using the EarthMaterial type shown in Figure 9. EarthMaterials can be minerals or CompoundMaterials, such as rocks (RockMaterial). CompoundMaterials in turn can be built from one or more ConstituentPart EarthMaterials, allowing for a detailed and complete description of a rock lithology to be recorded. Alternatively the lithology property of RockMaterial can be used to reference a list of terms, usually held in a vocabulary, for a simpler means of defining an EarthMaterial.

Other properties can be recorded through associations to datatype description packages: ParticleGeometryDescription; AlterationDescription; and PhysicalDescription. PhysicalDescription is a generic means of describing any of the physical properties of the RockMaterial using the PhysicalProperties application schema.

The four empty codelists in Figure 9 would generally reference a vocabulary of terms.

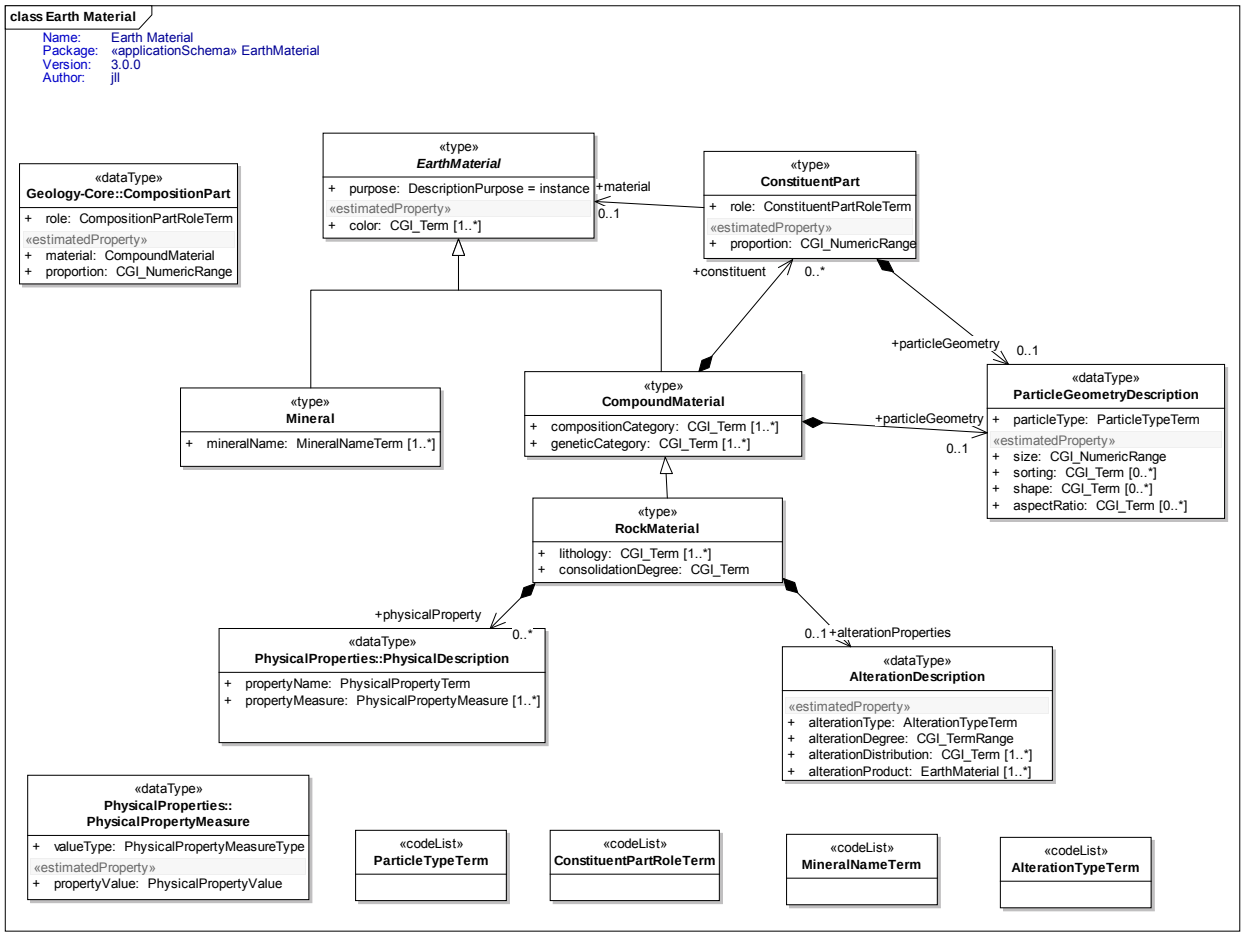



**Figure 9 - UML class diagram: EarthMaterial**

The full application schema for Boreholes is shown in Figure 10. This shows that in addition to the classes included in the mandatory core there is an association from Borehole to BoreholeDetails, a datatype providing borehole specific metadata. There is also an association to MappedInterval, a type of MappedFeature. MappedInterval is used to record information about an interval of a borehole log in the same way as an area on a geological map, and allows boreholes to be regarded as linear geological maps. Boreholes are modelled as types of SamplingCurve.

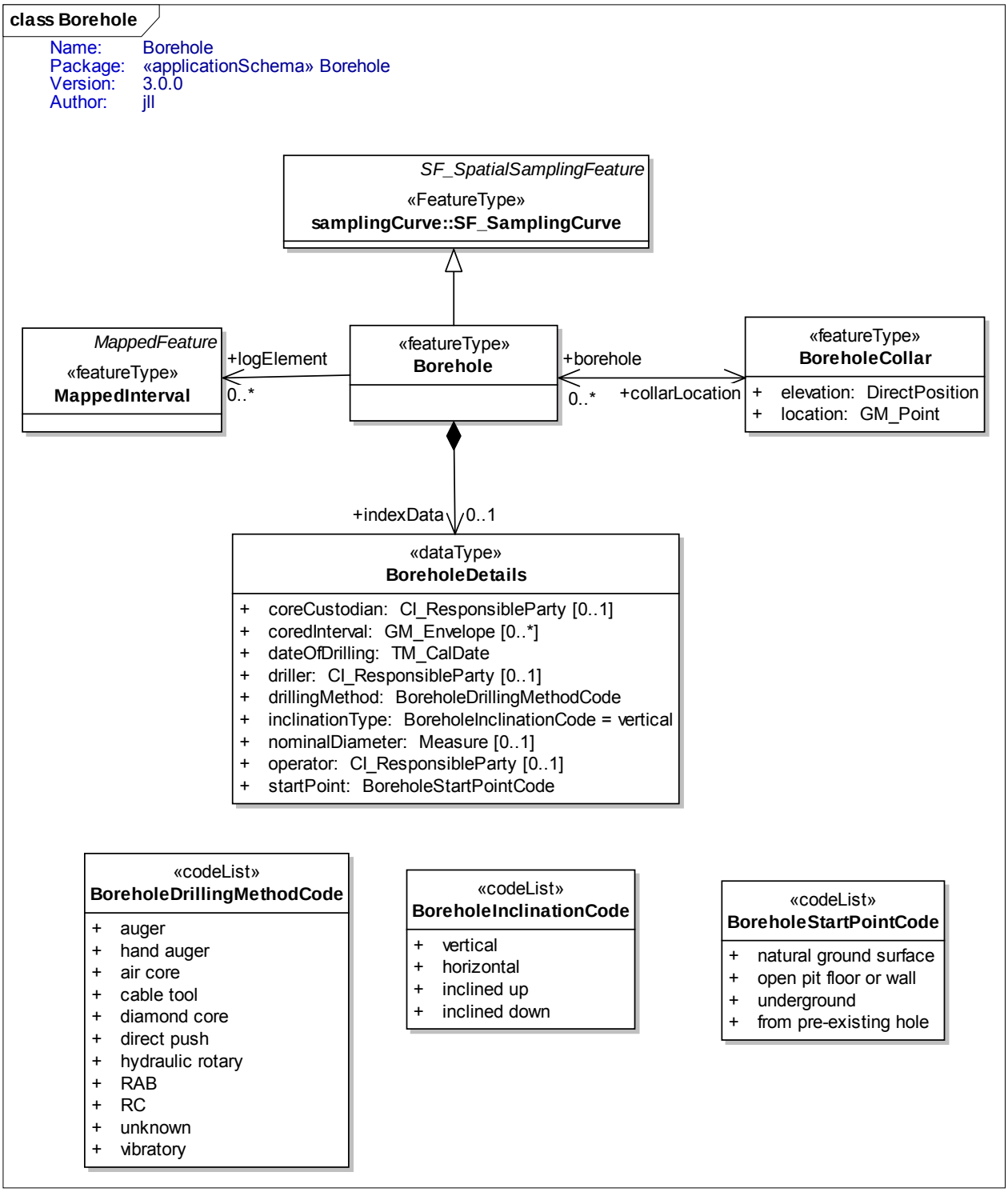



**Figure 10 - UML class diagram: Borehole**

The PhysicalDescription datatype is used as a means of recording the physical properties of GeologicUnits, RockMaterial and ShearDisplacementStructures (Figure 11). It has two properties, propertyName and propertyMeasure, allowing the value of any physical property, as given in propertyName, to be recorded. In this version of the specification the PhysicalPropertyTerm codelist has not been populated.

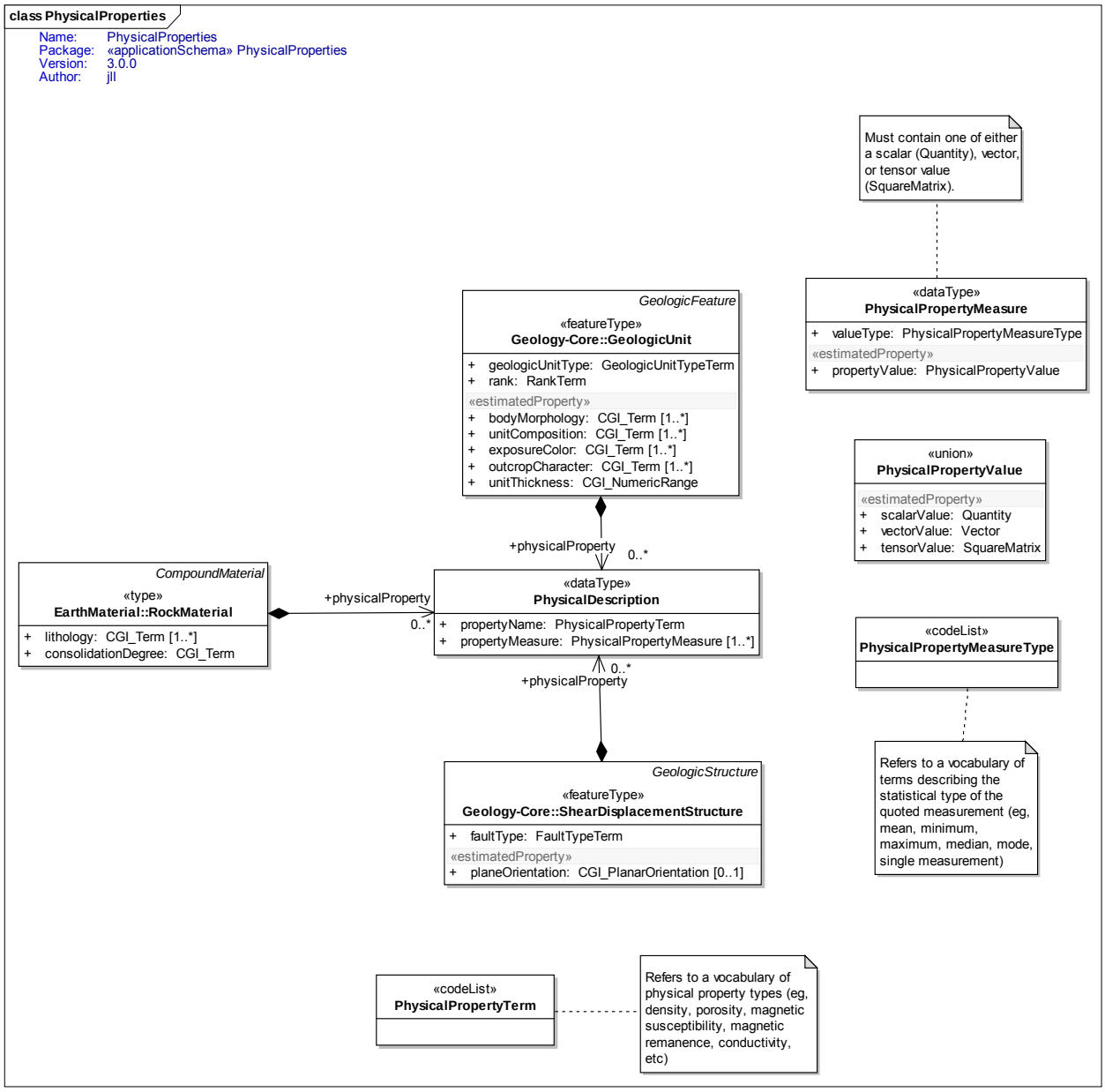



**Figure 11 - UML class diagram: PhysicalDescription**

Figure 12 shows the minimum mandatory requirement for hydrogeology for the INSPIRE process. There are two principal components that are modelled, the rock containing water (Aquifer) and the contained water (GroundwaterBody). Aquifers are modelled as a type of HydroStratigraphicUnit which is in turn a type of GeologicUnit. Aquifers in turn can be either confined or unconfined.

There is an association between HydrogeologicalUnit and GroundwaterBody, and GroundwaterBody is modelled as a type of WaterBody. There is also an association from WaterBody to HydrogeologicMappedFeature which is a type of MappedFeature and enables the mapping of a WaterBody.

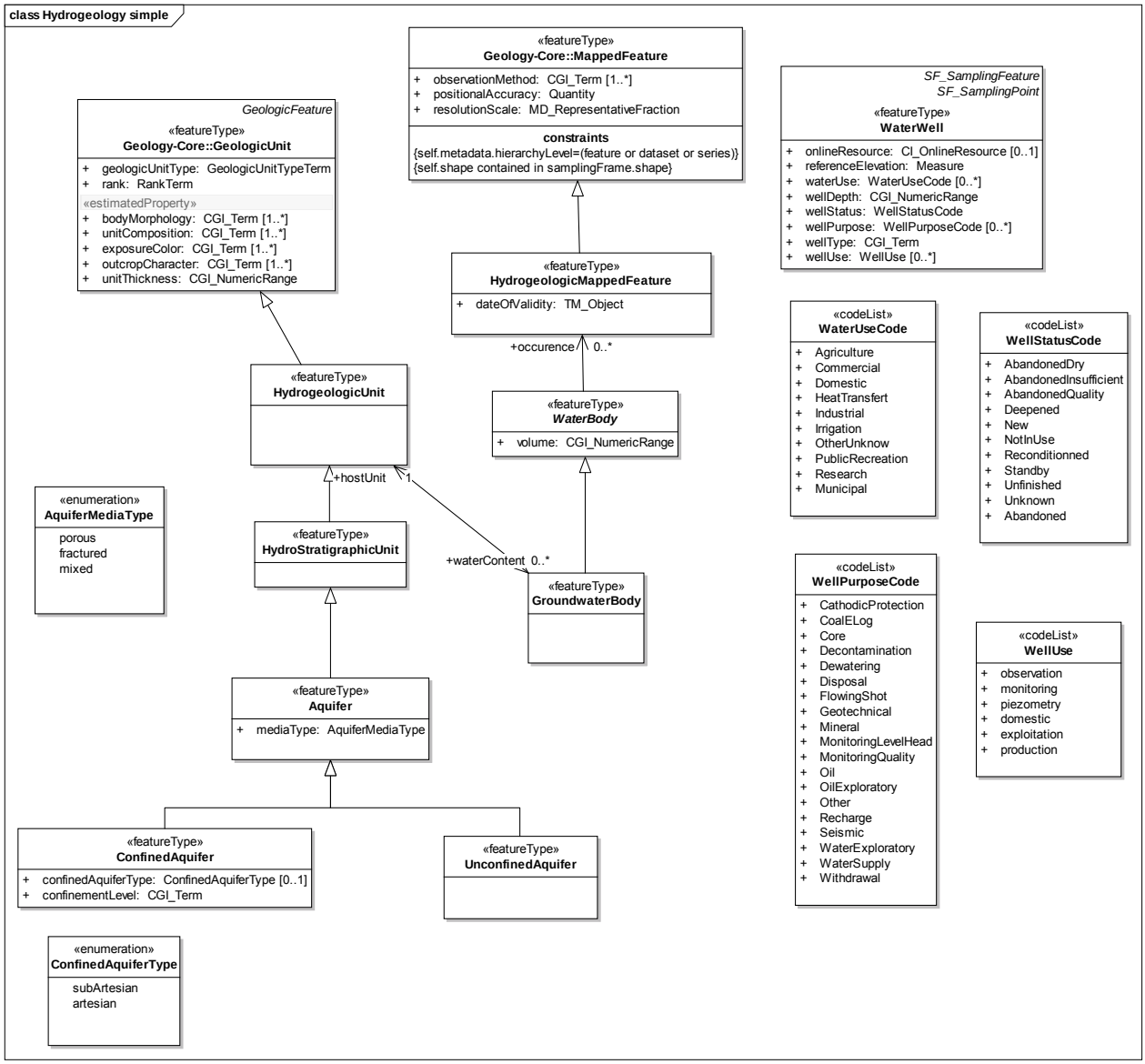



**Figure 12 - UML class diagram: Hydrogeology mandatory core**

The full data specification includes Aquiclude, in addition to Aquifer, as a type of HydrostratigraphicUnit. In addition the full specification includes the VanishingPoint and SpringOrSeep features modelled as types of HydroPointOfInterest in the Hydrography specification. These features are considered types of the more general RechargeSite and DischargeSite (Figure 13) which have associations to the Aquifer being recharged or discharged. It might be better if it were these more general features which were modelled as HydroPointOfInterest. Figure 13 also shows AbstractionWell as another type of DischargeSite, with an association to the WaterWell from which abstraction takes place.

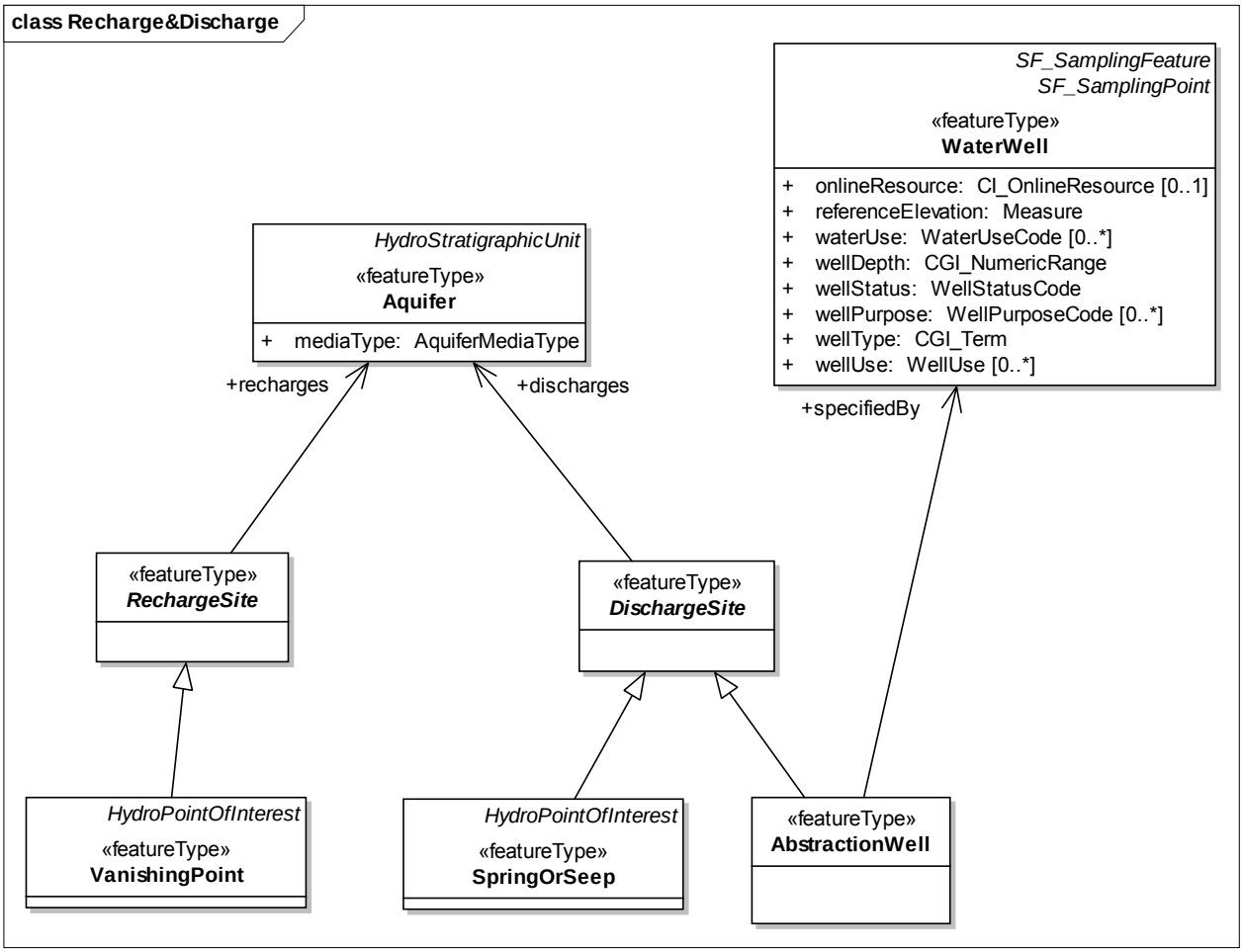



**Figure 13 - UML class diagram: Recharge & Discharge**

In the full specification a range of datatypes are modelled to provide additional properties of the WaterBody and HydrogeologicalUnit. These description packages are modelled as types of WaterPropertyDescription as shown in Figure 14.

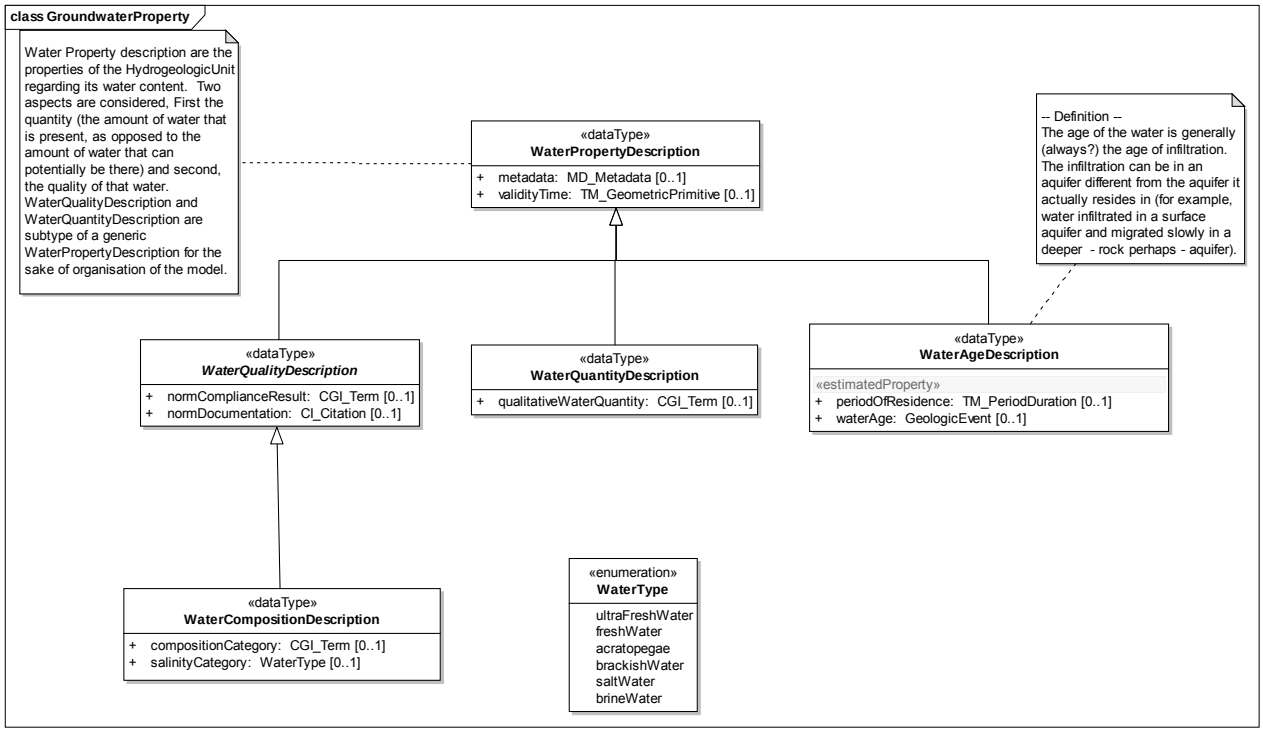



**Figure 14 - UML class diagram: Groundwater properties**

The associations between the various description package datatypes and WaterBody and HydrogeologicUnit are shown in Figure 15.

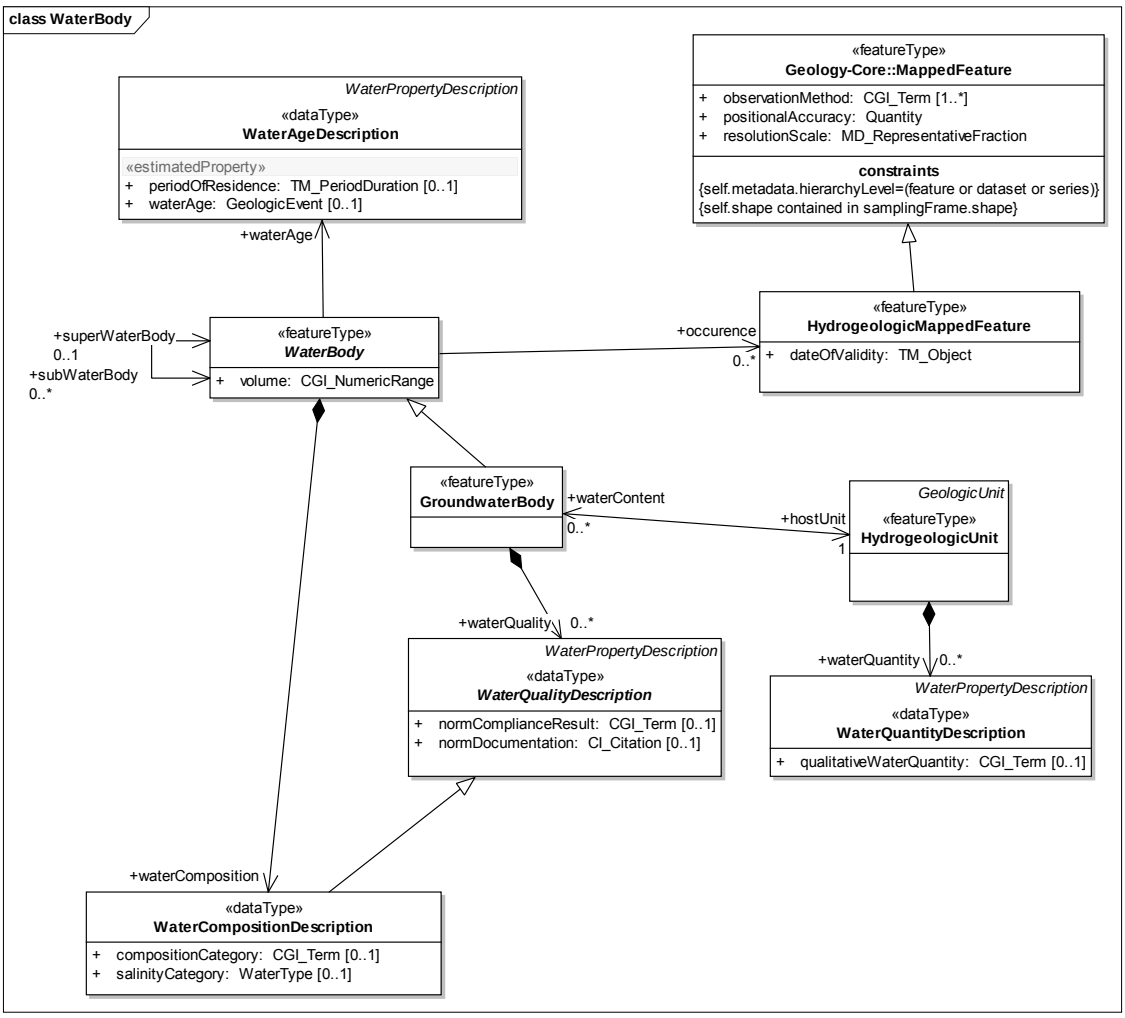



**Figure 15 - UML class diagram: Groundwater property associations**

The final component of the full hydrogeological part of the data specification is WaterWells (Figure 16). These are modelled as types of SamplingPoint with an association to BoreholeDetails to provide borehole specific metadata.

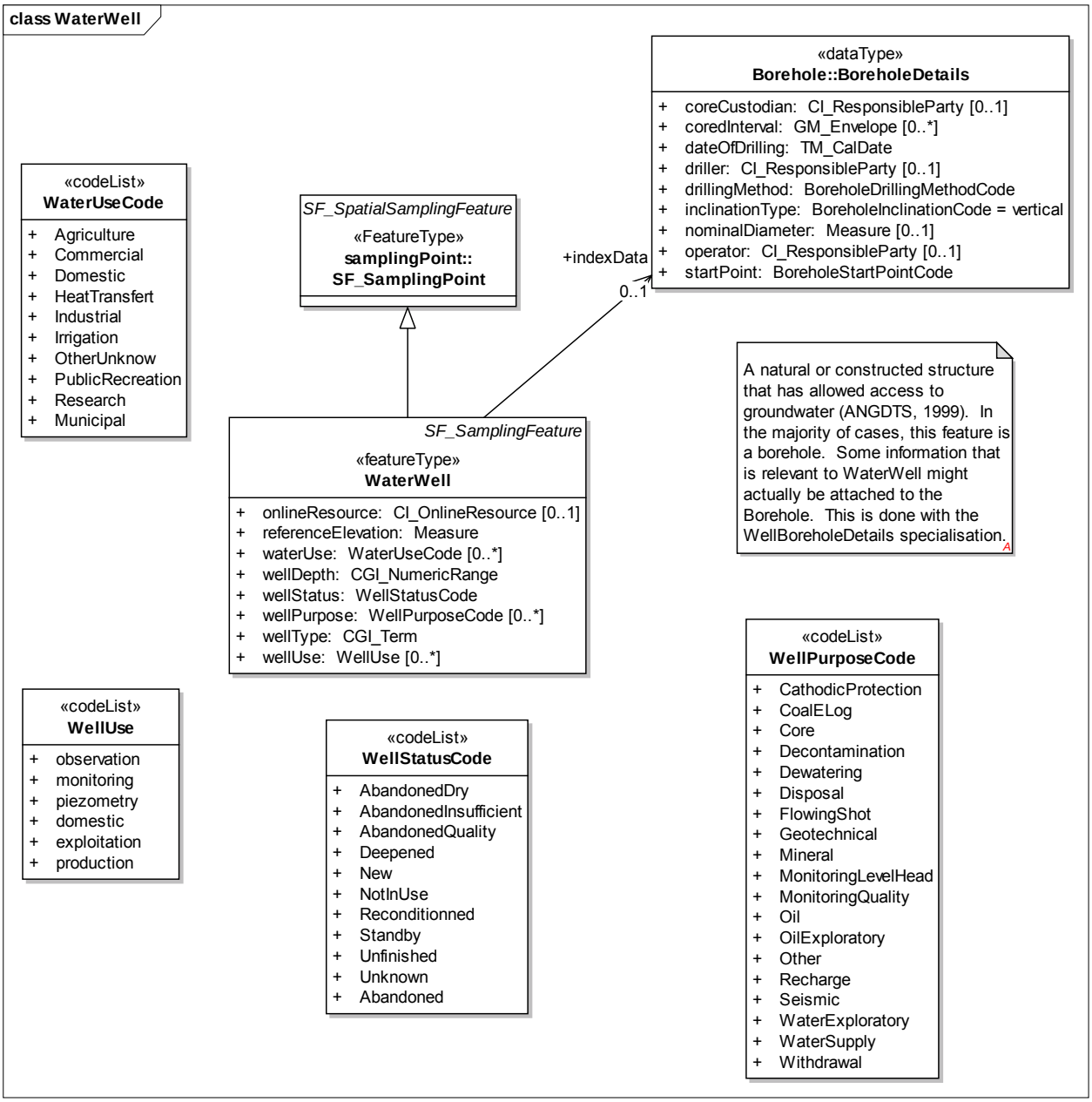



**Figure 16 - UML class diagram: Water well**

The final component of the specification concerns geophysics and all geophysical elements included in this version of the specification are considered part of the mandatory requirement for the INSPIRE process. There are two parts of the geophysical specification, one concerned with geophysical measurements (Figure 17) and one with geophysical models (Figure 18). In both cases the specification is concerned with providing geometry and metadata, rather than the actual measurements and models. Future versions of the specification might include, non-mandatory, classes for the actual measurements and models.

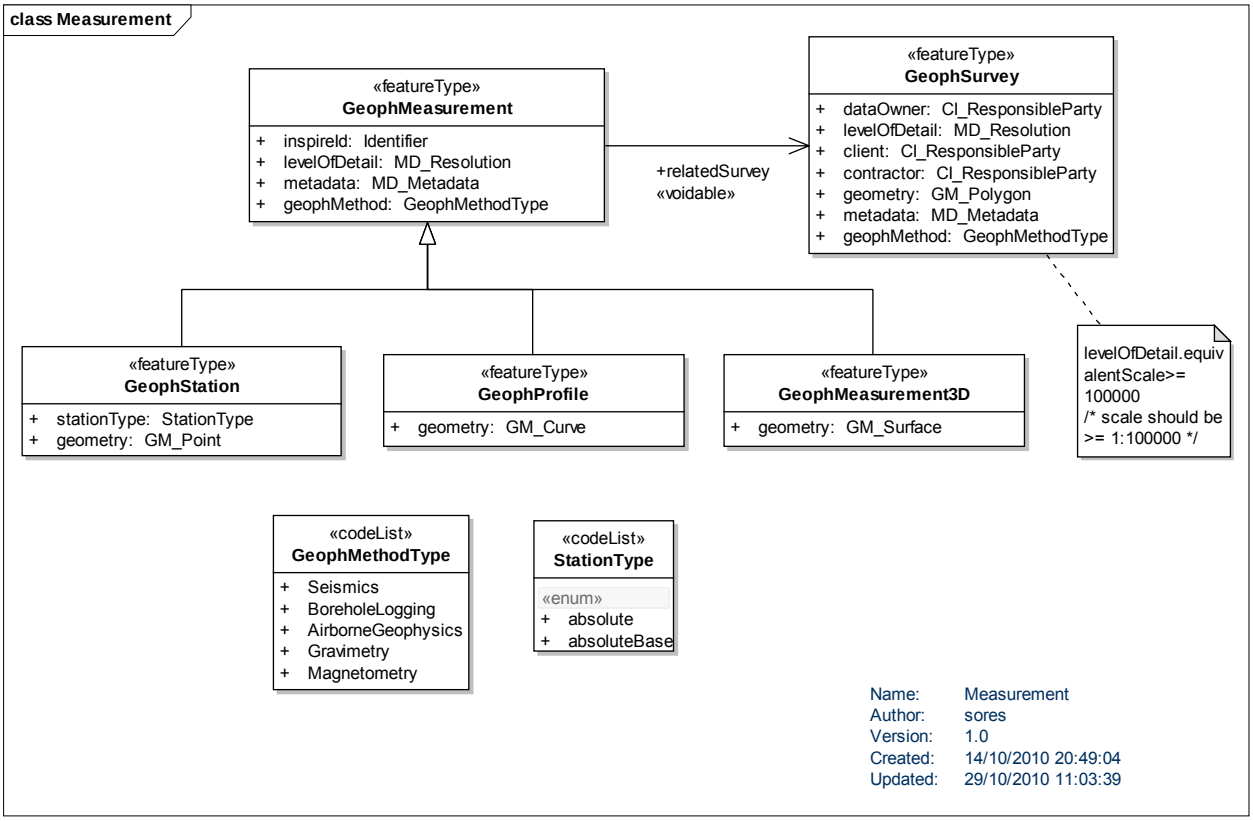



**Figure 17 - UML class diagram: Geophysical measurements**

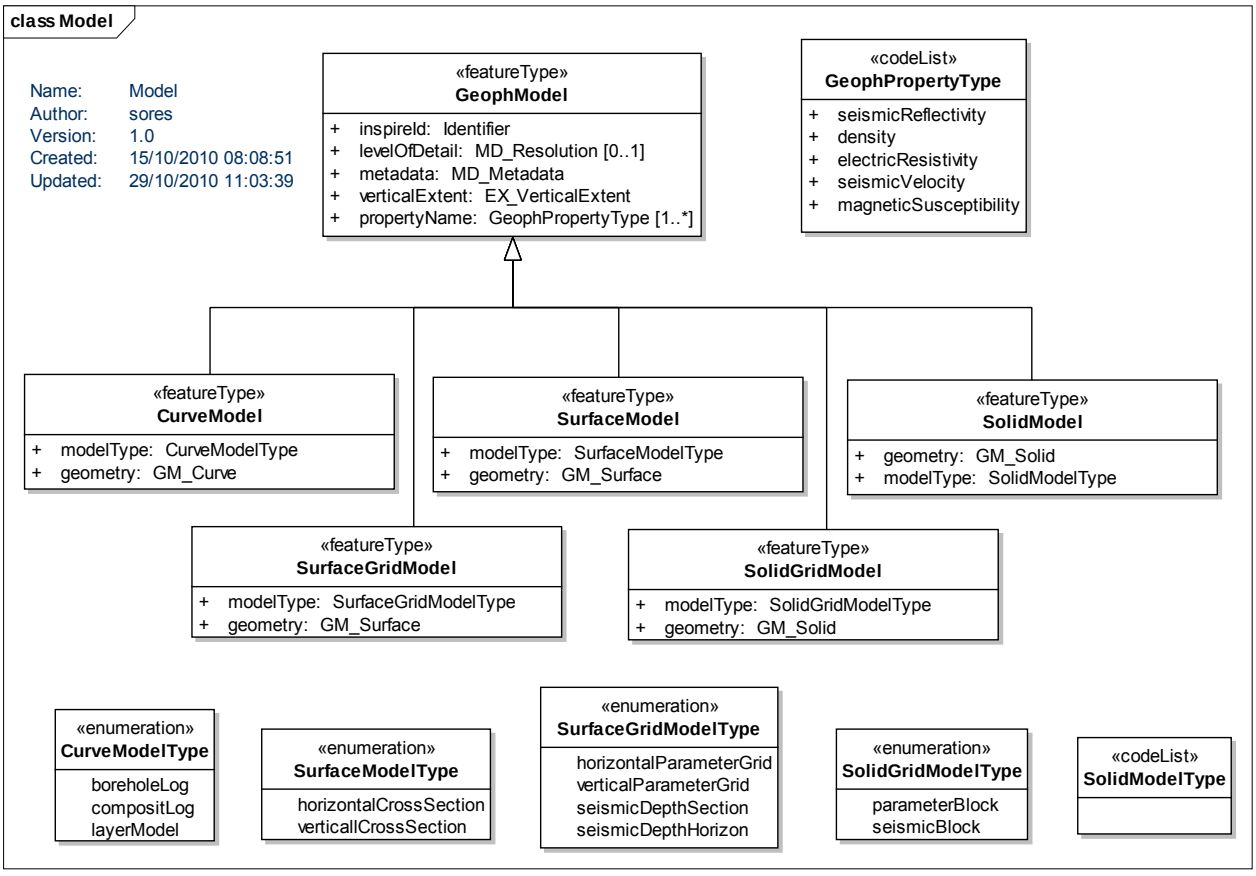



**Figure 18 - UML class diagram: Geophysical models**

#### 5.2.1.2. Consistency between spatial data sets

The observation location is specified by its coordinates.

### 5.2.2 Feature catalogue - Geology-Core

**Table 3 - Feature catalogue metadata**

| | |
|---|---|
| Feature catalogue name | INSPIRE feature catalogue Geology-Core |
| Scope | Geology-Core |
| Version number | 0.1 |
| Version date | 2010-10-27 |
| Definition source | INSPIRE data specification Geology-Core |

**Table 4 - Types defined in the feature catalogue**

| Type | Package | Stereotypes | Section |
|---|---|---|---|
| CompositionPart | Geology-Core | «dataType» | 5.2.2.2.1 |
| CompositionPartRoleTerm | Geology-Core | «codeList» | 5.2.2.3.1 |
| DisplacementValue | Geology-Core | «dataType» | 5.2.2.2.2 |
| DuctileShearStructure | Geology-Core | «featureType» | 5.2.2.1.1 |
| Fault | Geology-Core | «featureType» | 5.2.2.1.2 |
| FaultTypeTerm | Geology-Core | «codeList» | 5.2.2.3.2 |
| GeologicFeature | Geology-Core | «featureType» | 5.2.2.1.3 |
| GeologicStructure | Geology-Core | «featureType» | 5.2.2.1.4 |
| GeologicUnit | Geology-Core | «featureType» | 5.2.2.1.5 |
| GeologicUnitPart | Geology-Core | «dataType» | 5.2.2.2.3 |
| GeologicUnitPartRoleTerm | Geology-Core | «codeList» | 5.2.2.3.3 |
| GeologicUnitTypeTerm | Geology-Core | «codeList» | 5.2.2.3.4 |
| GeomorphologicFeature | Geology-Core | «featureType» | 5.2.2.1.6 |
| GeomorphologicFeatureTypeTerm | Geology-Core | «codeList» | 5.2.2.3.5 |
| MappedFeature | Geology-Core | «featureType» | 5.2.2.1.7 |
| MovementSenseTerm | Geology-Core | «codeList» | 5.2.2.3.6 |
| MovementTypeTerm | Geology-Core | «codeList» | 5.2.2.3.7 |
| RankTerm | Geology-Core | «codeList» | 5.2.2.3.8 |
| ShearDisplacementStructure | Geology-Core | «featureType» | 5.2.2.1.8 |

#### 5.2.2.1. Spatial object types

*5.2.2.1.1. DuctileShearStructure*

| **DuctileShearStructure** | |
|---|---|
| Subtype of: | ShearDisplacementStructure |
| Definition: | Parallel-sided zone of localised shearing displacement; may contain sigmoidal mineral-filled veins, locally well-developed cleavage or foliation, wholesale grain size reduction or mylonitisation, or a combination of these features a discrete tabular zone (very thin compared to its along-strike and down dip dimensions) of plastic deformation across which there has been shear displacement. DuctileShearStructure is a map-scale feature. |
| Status: | Proposed |
| Stereotypes: | «featureType» |

*5.2.2.1.2. Fault*

| **Fault** | |
|---|---|
| Subtype of: | ShearDisplacementStructure |
| Definition: | A discrete surface, or zone of discrete surfaces, with some thickness, separating two rock masses across which one mass has slid past the other and characterized by brittle deformation. Fault is a map-scale feature. When observed in outcrop, some faults are just big breccia/gouge zones with no discrete surfaces, sometimes they are breccia/gouge zones bounded by discrete fault surfaces, sometimes a discrete surface in relatively unbroken rock (at the scale of description). |
| Status: | Proposed |
| Stereotypes: | «featureType» |

*5.2.2.1.3. GeologicFeature*

| **GeologicFeature (abstract)** | |
|---|---|
| Definition: | The abstract GeologicFeature class represents a conceptual feature that is hypothesized to exist coherently in the world. * this corresponds with a "legend item" from a traditional geologic map * while the bounding coordinates of a Geologic Feature may be described, its shape is not. The implemented Geologic Feature instance acts as the "description package" * the description package is classified according to its purpose as an Instance, TypicalNorm, or DefiningNorm. |
| Status: | Proposed |
| Stereotypes: | «featureType» |
| **Attribute: observationMethod** | |
| Value type: | CGI_Term |
| Definition: | 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. |
| Multiplicity: | 1..* |
| **Attribute: purpose** | |
| Value type: | DescriptionPurpose |
| Definition: | 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. |
| Multiplicity: | 1 |
| **Association role: geologicHistory** | |
| Value type: | GeologicEvent |
| Definition: | A sequence of GeologicEvents with role geologicHistory allow describing the Genesis of the GeologicFeature. In future versions of GeoSciML this sequence should be ordered. |
| Multiplicity: | 0..* |
| **Association role: metadata** | |
| Value type: | MD_Metadata |
| Multiplicity: | 0..1 |

| **GeologicFeature (abstract)** | |
|---|---|
| **Association role: occurrence** | |
| Value type: | MappedFeature |
| Multiplicity: | 0..* |
| **Constraint: self.metadata.hierarchyLevel=(feature or dataset or series)** | |
| Natural language: | |

*5.2.2.1.4. GeologicStructure*

| **GeologicStructure** | |
|---|---|
| Subtype of: | GeologicFeature |
| Definition: | 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. GeologicStructures 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 GeologicStructure because they depend on the configuration of parts of a rock body. Includes: sedimentary structures. In GeoSciML 2.0 Fabric is treated as a class that describes an EarthMaterial (FabricDescription). The general GeologicRelation is used to associate penetrative GeologicStructures with GeologicUnits. |
| Status: | Proposed |
| Stereotypes: | «featureType» |

*5.2.2.1.5. GeologicUnit*

| **GeologicUnit** | |
|---|---|
| Subtype of: | GeologicFeature |
| Definition: | Operationally, the GeologicUnit element is a container used to associate geologic properties with some mapped occurrence (through GeologicFeature.occurrence -> MappedFeature link), or with a geologic unit ControlledConcept in a vocabulary (through the GeologicUnit.classifier ->ControlledConcept link). Conceptually, may represent a body of material in the Earth whose complete and precise extent is inferred to exist (NADM GeologicUnit, Stratigraphic unit in sense of NACSN or Intnl 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. 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). Will be made Abstract when a complete (enough) set of specialized subtypes is defined. |
| Status: | Proposed |
| Stereotypes: | «featureType» |
| **Attribute: bodyMorphology** | |
| Value type: | CGI_Term |
| Definition: | 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. |
| Multiplicity: | 1..* |
| Stereotypes: | «estimatedProperty» |
| **Attribute: exposureColor** | |

**GeologicUnit**

Value type: CGI_Term
Definition: Typical color at the outcrop of a geologic unit.
Multiplicity: 1..*
Stereotypes: «estimatedProperty»

**Attribute: geologicUnitType**

Value type: GeologicUnitTypeTerm
Definition: ScopedName pointing to a vocabulary defining the type of 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 urn:cgi:classifierScheme:CGI:GeologicUnitType:200811 is preferred. That includes members similar to those in the GeologicUnitType class in this package, but arranged as an ontology.
Multiplicity: 1

**Attribute: outcropCharacter**

Value type: CGI_Term
Definition: Describes the nature of outcrops formed by a geologic unit. Examples: bouldery, cliff-forming, ledge-forming, slope-forming, poorly exposed
Multiplicity: 1..*
Stereotypes: «estimatedProperty»

**Attribute: rank**

Value type: RankTerm
Definition: 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
Multiplicity: 1

**Attribute: unitComposition**

Value type: CGI_Term
Definition: 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.
Multiplicity: 1..*
Stereotypes: «estimatedProperty»

**Attribute: unitThickness**

Value type: CGI_NumericRange
Definition: 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.
Multiplicity: 1
Stereotypes: «estimatedProperty»

**Association role: alterationCharacter**

Value type: AlterationDescription
Multiplicity: 0..*

**Association role: composition**

Value type: CompositionPart
Multiplicity: 0..*
Stereotypes: «estimatedProperty»

**Association role: definingStructure**

| **GeologicUnit** | |
|---|---|
| Value type: | GeologicStructure |
| Multiplicity: | 0..* |
| **Association role: part** | |
| Value type: | GeologicUnitPart |
| Multiplicity: | 0..* |
| **Association role: physicalProperty** | |
| Value type: | PhysicalDescription |
| Multiplicity: | 0..* |

*5.2.2.1.6. GeomorphologicFeature*

| **GeomorphologicFeature** | |
|---|---|
| Subtype of: | GeologicFeature |
| Definition: | A geomorphological feature is a linear or areal landform. It may be associated with an underlying GeologicUnit |
| Status: | Proposed |
| Stereotypes: | «featureType» |
| **Attribute: GeomorphologicFeatureType** | |
| Value type: | GeomorphologicFeatureTypeTerm |
| Definition: | The type of geomorphological feature |
| Multiplicity: | 1 |
| **Association role: relatedUnit** | |
| Value type: | GeologicUnit |
| Multiplicity: | 0..1 |

*5.2.2.1.7. MappedFeature*

| **MappedFeature** | |
|---|---|
| Definition: | 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 specific bounded occurrence, such as an outcrop or map polygon * the Mapped Feature carries a geometry or shape - 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 BoreHolesAndObservation) 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. |
| Status: | Proposed |
| Stereotypes: | «featureType» |
| **Attribute: observationMethod** | |
| Value type: | CGI_Term |

| **MappedFeature** | |
|---|---|
| Definition: | 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) |
| Multiplicity: | 1..* |
| **Attribute: positionalAccuracy** | |
| Value type: | Quantity |
| Definition: | 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. |
| Multiplicity: | 1 |
| **Attribute: resolutionScale** | |
| Value type: | MD_RepresentativeFraction |
| Definition: | NOTE: this attribute type will be mapped to a temporary proxy for MD_RepresentativeFraction until support for GML3.2 is achieved. Reciprocal of equivalent scale of resolution for delineation of a feature's geometry. This is in contrast to positionAccuracy which is a measure of how well a feature is located relative to other features in the geographic reference system. |
| Multiplicity: | 1 |
| **Association role: metadata** | |
| Value type: | MD_Metadata |
| Multiplicity: | 0..1 |
| **Association role: samplingFrame** | |
| Value type: | SF_SpatialSamplingFeature |
| Multiplicity: | |
| **Association role: shape** | |
| Value type: | GM_Object |
| Multiplicity: | |
| **Association role: specification** | |
| Value type: | GeologicFeature |
| Multiplicity: | 1 |
| **Constraint: self.metadata.hierarchyLevel=(feature or dataset or series)** | |
| Natural language: | |
| **Constraint: self.shape contained in samplingFrame.shape** | |
| Natural language: | |

*5.2.2.1.8. ShearDisplacementStructure*

| **ShearDisplacementStructure** |
|---|

| **ShearDisplacementStructure** | |
|---|---|
| Subtype of: | GeologicStructure |
| Definition: | A generalized shear displacement structure without any commitment to the internal nature of the structure (anything from a simple, single 'planar' brittle or ductile surface to a fault system with 10's of strands of both brittle and ductile nature). This surface may have some significant thickness (a deformation zone) and have an associated body of deformed rock that may be considered a DeformationUnit |
| Status: | Proposed |
| Stereotypes: | «featureType» |
| **Attribute: faultType** | |
| Value type: | FaultTypeTerm |
| Definition: | Direction of movement of the plates for sub-vertical faults (typically 'sinistral', 'dextral', 'left-lateral', 'dip-slip', 'unknown') |
| Multiplicity: | 1 |
| **Attribute: planeOrientation** | |
| Value type: | CGI_PlanarOrientation |
| Definition: | allows capturing the orientation of the plane of the structure |
| Multiplicity: | 0..1 |
| Stereotypes: | «estimatedProperty» |
| **Association role: physicalProperty** | |
| Value type: | PhysicalDescription |
| Multiplicity: | 0..* |
| **Association role: totalDisplacement** | |
| Value type: | DisplacementValue |
| Multiplicity: | 0..1 |

### 5.2.2.2. Data types

#### *5.2.2.2.1. CompositionPart*

| **CompositionPart** | |
|---|---|
| Definition: | Element to represent composition of a geologic unit in terms of earth material constituents. Lithology categories are associated with the compound material instances. |
| Status: | Proposed |
| Stereotypes: | «dataType» |
| **Attribute: material** | |
| Value type: | CompoundMaterial |
| Definition: | 0..1 because this is where the "description" of the material is (optionally) held |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |
| **Attribute: proportion** | |
| Value type: | CGI_NumericRange |
| Definition: | Quantity that specifies the fraction of the geologic unit composed of the compound material. |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |
| **Attribute: role** | |
| Value type: | CompositionPartRoleTerm |

| **CompositionPart** | |
|---|---|
| Definition: | Defines the relationship of the earth material 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. |
| Multiplicity: | 1 |

*5.2.2.2.2. DisplacementValue*

| **DisplacementValue** | |
|---|---|
| Definition: | Trying to express the displacement on a fault with respect to a planar approximation of its shape |
| Status: | Proposed |
| Stereotypes: | «dataType» |
| **Attribute: hangingWallDirection** | |
| Value type: | CGI_LinearOrientation |
| Definition: | Normally the compass quadrant indicating the hangingwall side of the fault-system for faults that are steep enough to define a hanging-wall on the map trace |
| Multiplicity: | 0..1 |
| Stereotypes: | «estimatedProperty» |
| **Attribute: movementSense** | |
| Value type: | MovementSenseTerm |
| Definition: | eg, dextral, sinistral |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |
| **Attribute: movementType** | |
| Value type: | MovementTypeTerm |
| Definition: | Defines the type of movement (eg dip-slip, strike-slip) |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |
| **Association role: displacementEvent** | |
| Value type: | GeologicEvent |
| Multiplicity: | 0..1 |

*5.2.2.2.3. GeologicUnitPart*

| **GeologicUnitPart** | |
|---|---|
| Definition: | GeologicUnitPart 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') |
| Status: | Proposed |
| Stereotypes: | «dataType» |
| **Attribute: proportion** | |
| Value type: | CGI_NumericRange |
| Definition: | Quantity that specifies the fraction of the geologic unit formed by the part. |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |
| **Attribute: role** | |

| **GeologicUnitPart** | |
|---|---|
| Value type: | GeologicUnitPartRoleTerm |
| Definition: | Nature of the parts, e.g. facies, stratigraphic, interbeds, geographic, eastern facies, |
| Multiplicity: | 1 |
| **Association role: containedUnit** | |
| Value type: | GeologicUnit |
| Multiplicity: | 1 |

### 5.2.2.3. Code lists

*5.2.2.3.1. CompositionPartRoleTerm*

| **CompositionPartRoleTerm** | |
|---|---|
| Definition: | Refers to a vocabulary of terms to describe the role that a compositional part plays in a geologic unit. |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

*5.2.2.3.2. FaultTypeTerm*

| **FaultTypeTerm** | |
|---|---|
| Definition: | Refers to a vocabulary of terms describing the type of shear displacement structure (eg; thrust fault, normal fault) |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

*5.2.2.3.3. GeologicUnitPartRoleTerm*

| **GeologicUnitPartRoleTerm** | |
|---|---|
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

*5.2.2.3.4. GeologicUnitTypeTerm*

| **GeologicUnitTypeTerm** | |
|---|---|
| Definition: | The types of Geologic Unit |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |
| **Value: AllostratigraphicUnit** | |
| **Value: AlterationUnit** | |
| **Value: ArtificialGround** | |
| **Value: BiostratigraphicUnit** | |
| **Value: ChronostratigraphicUnit** | |
| **Value: DeformationUnit** | |
| **Value: ExcavationUnit** | |

| **GeologicUnitTypeTerm** |
|---|
| **Value: GeologicUnit** |
| **Value: GeomorphologicUnit** |
| **Value: GeophysicalUnit** |
| **Value: LithodemicUnit** |
| **Value: LithogeneticUnit** |
| **Value: LithologicUnit** |
| **Value: LithostratigraphicUnit** |
| **Value: LithotectonicUnit** |
| **Value: MagnetostratigraphicUnit** |
| **Value: MassMovementUnit** |
| **Value: Pedoderm** |
| **Value: PedostratigraphicUnit** |
| **Value: PolarityChronostratigraphicUnit** |

*5.2.2.3.5. GeomorphologicFeatureTypeTerm*

| **GeomorphologicFeatureTypeTerm** | |
|---|---|
| Definition: | The types of geomorphological feature |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

*5.2.2.3.6. MovementSenseTerm*

| **MovementSenseTerm** | |
|---|---|
| Definition: | Refers to a vocabulary of terms describing the sense of movement on a shear displacement structure |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

*5.2.2.3.7. MovementTypeTerm*

| **MovementTypeTerm** | |
|---|---|
| Definition: | Refers to a vocabulary of terms describing the type of movement (eg, dip-slip, strike-slip) |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

*5.2.2.3.8. RankTerm*

| **RankTerm** | |
|---|---|
| Definition: | Refers to a vocabulary of terms describing the rank of a geologic unit (eg, Group, Formation, Member, etc) |

| **RankTerm** | |
|---|---|
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

#### 5.2.2.4. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

##### *5.2.2.4.1. AlterationDescription*

| **AlterationDescription** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::EarthMaterial [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | 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. |

##### *5.2.2.4.2. CGI_LinearOrientation*

| **CGI_LinearOrientation** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::CGI_Value [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | Description of the measured orientation of a line. |

##### *5.2.2.4.3. CGI_NumericRange*

| **CGI_NumericRange** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::CGI_Value [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | Allows specifying a range of numeric values (eg 443.7+-1.5 to 359+-2.5) and a single representative or estimated value. (eg: upper = 443.7+-1.5,lower = 359+-2.5, estimatedValue [mean] = 400) 1. Best practice for use with GeoSciML would be for Quantity:value, uom, and quality to be mandatory. 2. The UoMIdentifier type has been implemented in the SWE schema as gml:UnitDefinition (ie, not exactly as implied by the Quantity UML class) 3. Use Quantity "definition" attribute to indicate statistical type of esimatedValue/Quantity (eg; mean, median, mode). Possible example: <swe:Quantity definition="urn:cgi:classifier:CGI:Statistical_qualifier::mean"> 4. Where CGI_NumericRange is used to deliver a single numeric value, it should be repeated in both the upper and lower quantity values. |

##### *5.2.2.4.4. CGI_PlanarOrientation*

| **CGI_PlanarOrientation** |
|---|

| **CGI_PlanarOrientation** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::CGI_Value [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | Description of the geometry of a plane. |

*5.2.2.4.5. CGI_Term*

| **CGI_Term** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::CGI_Value [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | A value with a qualifier code. Many geological properties are recorded with some form of qualification. |

*5.2.2.4.6. CompoundMaterial*

| **CompoundMaterial** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::EarthMaterial [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | 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. |

*5.2.2.4.7. DescriptionPurpose*

| **DescriptionPurpose** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::CGI_Value [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | 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. |

*5.2.2.4.8. GM_Object*

| **GM_Object (abstract)** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107 Spatial Schema::ISO 19107:2003 Spatial Schema:: Geometry::Geometry root [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.2.4.9. GeologicEvent*

| **GeologicEvent** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::GeologicAge [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

| **GeologicEvent** | |
|---|---|
| Definition: | An identifiable event during which one or more geological processes act to modify geological entities. A GeologicEvent must have a specified GeologicAge and may have specified environments and processes. An example might be a cratonic uplift event during which erosion, sedimentation, and volcanism all take place. 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 objects. Genesis typically pertains to some geological phenomenon (Geological Structure, Earth Material, Geological Unit, Fossil, etc.) In GeoSciML 2.0 this ordering cannot be specified. A GeologicEvent must have a specified eventAge (numericAgeDate, olderNamedAge, or youngerNamedAge), at least one eventProcess, and may have specified eventEnvironments. 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. The GeologicEvent package allows for explicitly linking the three, without mandating it. The eventAge attribute is the age of a particular geological event or feature expressed in terms of years before present (absolute age), referred to the geological time scale, or by comparison with other geological events or features (relative age). An eventAge 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". |

*5.2.2.4.10. MD_Metadata*

| **MD_Metadata** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2006 Metadata (Corrigendum)::Metadata entity set information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.2.4.11. MD_RepresentativeFraction*

| **MD_RepresentativeFraction** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2006 Metadata (Corrigendum)::Identification information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.2.4.12. PhysicalDescription*

| **PhysicalDescription** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::PhysicalProperties [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | A class to describe the numeric physical properties of a geologic unit, earth material, or geologic structure. (eg; density, porosity, magnetic susceptibility, remanent magnetism) |

*5.2.2.4.13. Quantity*

| **Quantity** |
|---|

| **Quantity** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19136 GML::valueObjects [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.2.4.14. SF_SpatialSamplingFeature*

| **SF_SpatialSamplingFeature (abstract)** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19156 Observations and Measurements::ISO DIS 19156:2010 Observations and Measurements::Sampling Manifold::spatialSamplingFeature [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

## 5.2.3 Feature catalogue - GeologicAge

**Table 3 - Feature catalogue metadata**

| | |
|---|---|
| Feature catalogue name | INSPIRE feature catalogue GeologicAge |
| Scope | GeologicAge |
| Version number | 0.1 |
| Version date | 2010-10-27 |
| Definition source | INSPIRE data specification GeologicAge |

**Table 4 - Types defined in the feature catalogue**

| Type | Package | Stereotypes | Section |
|---|---|---|---|
| CGI_NumericAgeRange | GeologicAge | «dataType» | 5.2.2.2.1 |
| EventProcessTerm | GeologicAge | «codeList» | 5.2.2.4.1 |
| GeochronologicEraRank | GeologicAge | «enumeration» | 5.2.2.3.1 |
| GeochronologicEraTypeTerm | GeologicAge | «codeList» | 5.2.2.4.2 |
| GeologicEvent | GeologicAge | «featureType» | 5.2.2.1.1 |
| StratigraphicDateEstimate | GeologicAge | «dataType» | 5.2.2.2.2 |

### 5.2.3.1. Spatial object types

*5.2.3.1.1. GeologicEvent*

| **GeologicEvent** |
|---|

**GeologicEvent**

| | |
|---|---|
| Definition: | An identifiable event during which one or more geological processes act to modify geological entities. A GeologicEvent must have a specified GeologicAge and may have specified environments and processes. An example might be a cratonic uplift event during which erosion, sedimentation, and volcanism all take place. 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 objects. Genesis typically pertains to some geological phenomenon (Geological Structure, Earth Material, Geological Unit, Fossil, etc.) In GeoSciML 2.0 this ordering cannot be specified. A GeologicEvent must have a specified eventAge (numericAgeDate, olderNamedAge, or youngerNamedAge), at least one eventProcess, and may have specified eventEnvironments. 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. The GeologicEvent package allows for explicitly linking the three, without mandating it. The eventAge attribute is the age of a particular geological event or feature expressed in terms of years before present (absolute age), referred to the geological time scale, or by comparison with other geological events or features (relative age). An eventAge 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". |
| Status: | Proposed |
| Stereotypes: | «featureType» |

**Attribute: eventEnvironment**

| | |
|---|---|
| Value type: | CGI_Term |
| Definition: | 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. |
| Multiplicity: | 0..* |
| Stereotypes: | «estimatedProperty» |

**Attribute: eventProcess**

| | |
|---|---|
| Value type: | EventProcessTerm |
| Definition: | The eventProcess specifies the process or processes that occurred during the event. Examples include deposition, extrusion, intrusion, cooling. |
| Multiplicity: | 1..* |
| Stereotypes: | «estimatedProperty» |

**Attribute: numericAgeDate**

| | |
|---|---|
| Value type: | CGI_NumericAgeRange |

| **GeologicEvent** | |
|---|---|
| Definition: | The numericAgeDate attribute is the age of a particular geological event or feature expressed in terms of years before present (1950), using CGI_NumericAgeRange. This datatype allows a younger and older age boundary to express an interval, and a reporting age, which is a single numeric age to report for applications that can not use a numeric range. Age in years before present is an estimated time durations based on interpretation of isotopic analyses of EarthMaterial (some other methods are used for geologically young materials). Numeric age range uses StratigraphicDateEstimate to allow incorporation of various uncertainty measures using ISO19115 DataQuality elements, and binding with observation features to report details of date determination measurement. |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |
| **Attribute: olderNamedAge** | |
| Value type: | GeochronologicEra |
| Definition: | Older boundary of age of event expressed using a geochronologic era defined according to a geologic time scale per GeologicTime schema |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |
| **Attribute: youngerNamedAge** | |
| Value type: | GeochronologicEra |
| Definition: | Younger boundary of age of event expressed using a geochronologic era defined according to a geologic time scale per GeologicTime schema |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |
| **Association role: incrementalDisplacement** | |
| Value type: | DisplacementValue |
| Multiplicity: | 0..* |
| **Association role: metadata** | |
| Value type: | MD_Metadata |
| Multiplicity: | 0..1 |
| **Constraint: self.metadata.hierarchyLevel=(feature or dataset or series)** | |
| Natural language: | |

### 5.2.3.2. Data types

#### *5.2.3.2.1. CGI_NumericAgeRange*

| **CGI_NumericAgeRange** | |
|---|---|
| Definition: | Class to represent general age assignment using numeric measurement results. All attributes have cardinality 1; report with nilReason="missing" if a value is absent. |
| Status: | Proposed |
| Stereotypes: | «dataType» |
| **Attribute: olderBoundDate** | |
| Value type: | StratigraphicDateEstimate |
| Definition: | The older bounding time coordinate in an age range |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |

| **CGI_NumericAgeRange** |
|---|
| **Attribute: reportingDate**<br>Value type: StratigraphicDateEstimate<br>Definition: Single time coordinate value to report as representative for this NumericAge assignment<br>Multiplicity: 1<br>Stereotypes: «estimatedProperty» |
| **Attribute: youngerBoundDate**<br>Value type: StratigraphicDateEstimate<br>Definition: The younger bounding time coordinate in an age range<br>Multiplicity: 1<br>Stereotypes: «estimatedProperty» |

*5.2.3.2.2. StratigraphicDateEstimate*

| **StratigraphicDateEstimate** |
|---|
| Definition: an estimate of a point in geologic time and a link to its observational basis<br>Status: Proposed<br>Stereotypes: «dataType» |
| **Attribute: position**<br>Value type: TM_Instant<br>Multiplicity: 1 |
| **Attribute: quality**<br>Value type: DQ_QuantitativeAttributeAccuracy<br>Multiplicity: 1 |
| **Association role: observationalBasis**<br>Value type: OM_Observation<br>Multiplicity: 0..* |

### 5.2.3.3. Enumerations

*5.2.3.3.1. GeochronologicEraRank*

| **GeochronologicEraRank** |
|---|
| Definition: A hierarchical list of the rank of time periods defined by the international Stratigraphy Commission.<br>Status: Proposed<br>Stereotypes: «enumeration» |
| **Value: Age** |
| **Value: Chron** |
| **Value: Eon** |
| **Value: Epoch** |
| **Value: Era** |
| **Value: Period** |
| **Value: Sub-Age** |

| **GeochronologicEraRank** |
|---|
| **Value: Sub-Eon** |
| **Value: Sub-Epoch** |
| **Value: Sub-Era** |
| **Value: Sub-Period** |

#### 5.2.3.4. Code lists

##### *5.2.3.4.1. EventProcessTerm*

| **EventProcessTerm** | |
|---|---|
| Definition: | Refers to a vocabulary of terms specifying the process or processes that occurred during an event. Examples include deposition, extrusion, intrusion, cooling. |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

##### *5.2.3.4.2. GeochronologicEraTypeTerm*

| **GeochronologicEraTypeTerm** | |
|---|---|
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

#### 5.2.3.5. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

##### *5.2.3.5.1. CGI_Term*

| **CGI_Term** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::CGI_Value [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | A value with a qualifier code. Many geological properties are recorded with some form of qualification. |

##### *5.2.3.5.2. DQ_QuantitativeAttributeAccuracy*

| **DQ_QuantitativeAttributeAccuracy** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2006 Metadata (Corrigendum)::Data quality information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

##### *5.2.3.5.3. DisplacementValue*

| **DisplacementValue** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::Geology-Core [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | Trying to express the displacement on a fault with respect to a planar approximation of its shape |

*5.2.3.5.4. GeologicUnit*

| **GeologicUnit** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::Geology-Core [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | Operationally, the GeologicUnit element is a container used to associate geologic properties with some mapped occurrence (through GeologicFeature.occurrence -> MappedFeature link), or with a geologic unit ControlledConcept in a vocabulary (through the GeologicUnit.classifier ->ControlledConcept link). Conceptually, may represent a body of material in the Earth whose complete and precise extent is inferred to exist (NADM GeologicUnit, Stratigraphic unit in sense of NACSN or Intnl 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. 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). Will be made Abstract when a complete (enough) set of specialized subtypes is defined. |

*5.2.3.5.5. MD_Metadata*

| **MD_Metadata** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2006 Metadata (Corrigendum)::Metadata entity set information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.3.5.6. OM_Observation*

| **OM_Observation** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19156 Observations and Measurements::ISO DIS 19156:2010 Observations and Measurements::Observation Core [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.3.5.7. TM_Instant*

| **TM_Instant** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19108 Temporal schema::ISO 19108:2006 Temporal Schema::Temporal Objects [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

### 5.2.4 Feature catalogue - CGI_Value

**Table 3 - Feature catalogue metadata**

| | |
|---|---|
| Feature catalogue name | INSPIRE feature catalogue CGI_Value |
| Scope | CGI_Value |
| Version number | 0.1 |
| Version date | 2010-10-27 |
| Definition source | INSPIRE data specification CGI_Value |

**Table 4 - Types defined in the feature catalogue**

| Type | Package | Stereotypes | Section |
|---|---|---|---|
| CGI_GeometricDescriptionValue | CGI_Value | «dataType» | 5.2.2.1.1 |
| CGI_LinearOrientation | CGI_Value | «dataType» | 5.2.2.1.2 |
| CGI_NumericRange | CGI_Value | «dataType» | 5.2.2.1.3 |
| CGI_PlanarOrientation | CGI_Value | «dataType» | 5.2.2.1.4 |
| CGI_Term | CGI_Value | «dataType» | 5.2.2.1.5 |
| CGI_TermRange | CGI_Value | «dataType» | 5.2.2.1.6 |
| CGI_Value | CGI_Value | «dataType» | 5.2.2.1.7 |
| CGI_Vector | CGI_Value | «dataType» | 5.2.2.1.8 |
| CodeListValue | CGI_Value | «codeList» | 5.2.2.2.1 |
| ConventionCode | CGI_Value | «codeList» | 5.2.2.2.2 |
| DescriptionPurpose | CGI_Value | «codeList» | 5.2.2.2.3 |
| DeterminationMethodTerm | CGI_Value | «codeList» | 5.2.2.2.4 |
| LinearDirectedCode | CGI_Value | «codeList» | 5.2.2.2.5 |
| PlanarPolarityCode | CGI_Value | «codeList» | 5.2.2.2.6 |
| ValueQualifierCode | CGI_Value | «codeList» | 5.2.2.2.7 |

### 5.2.4.1. Spatial object types

### 5.2.4.2. Data types

*5.2.4.2.1. CGI_GeometricDescriptionValue*

**CGI_GeometricDescriptionValue (abstract)**

Definition: Description of the planar or linear orientation of a geologic feature. Allows specifying direction by DirectionVector (eg Dip/Dip Direction), compass point (NE), description ("toward fold hinge", "below')
Status: Proposed
Stereotypes: «dataType»

**Attribute: descriptiveOrientation**

Value type: CGI_Term
Definition: terminologic specification of orientation, referencing to some local geography
Multiplicity: 0..1
Stereotypes: «estimatedProperty»

**Attribute: determinationMethod**

Value type: DeterminationMethodTerm
Definition: Describes the way the orientation value was determined (eg measured, inferred from dip slope, etc)
Multiplicity: 0..1

*5.2.4.2.2. CGI_LinearOrientation*

**CGI_LinearOrientation**

Subtype of: CGI_GeometricDescriptionValue
Definition: Description of the measured orientation of a line.
Status: Proposed
Stereotypes: «dataType»

**Attribute: directed**

Value type: LinearDirectedCode

| **CGI_LinearOrientation** | |
|---|---|
| Definition: | 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 |
| Multiplicity: | 0..1 |
| **Attribute: plunge** | |
| Value type: | CGI_NumericRange |
| Definition: | Magnitudeof the plunge. May be a term (eg steeply) or numeric (eg 75 degrees) or range. |
| Multiplicity: | 0..1 |
| **Attribute: trend** | |
| Value type: | CGI_NumericRange |
| Definition: | The azimuth (compass point, bearing etc) value of the linear orientation. |
| Multiplicity: | 0..1 |

*5.2.4.2.3. CGI_NumericRange*

| **CGI_NumericRange** | |
|---|---|
| Subtype of: | CGI_Value |
| Definition: | Allows specifying a range of numeric values (eg 443.7+-1.5 to 359+-2.5) and a single representative or estimated value. (eg: upper = 443.7+-1.5,lower = 359+-2.5, estimatedValue [mean] = 400) 1. Best practice for use with GeoSciML would be for Quantity:value, uom, and quality to be mandatory. 2. The UoMIdentifier type has been implemented in the SWE schema as gml:UnitDefinition (ie, not exactly as implied by the Quantity UML class) 3. Use Quantity "definition" attribute to indicate statistical type of esimatedValue/Quantity (eg; mean, median, mode). Possible example: <swe:Quantity definition="urn:cgi:classifier:CGI:Statistical_qualifier::mean"> 4. Where CGI_NumericRange is used to deliver a single numeric value, it should be repeated in both the upper and lower quantity values. |
| Status: | Proposed |
| Stereotypes: | «dataType» |
| **Attribute: estimatedValue** | |
| Value type: | Quantity |
| Definition: | A single measured value chosen on some basis (eg; mean, mode, median, best guess) that is representative for the measurement. Best practice to consider the value, uom, and quality attributes of swe:Quantity to be mandatory. |
| Multiplicity: | 1 |

*5.2.4.2.4. CGI_PlanarOrientation*

| **CGI_PlanarOrientation** | |
|---|---|
| Subtype of: | CGI_GeometricDescriptionValue |
| Definition: | Description of the geometry of a plane. |
| Status: | Proposed |
| Stereotypes: | «dataType» |
| **Attribute: azimuth** | |
| Value type: | CGI_NumericRange |
| Definition: | The azimuth (compass point, bearing etc) value of the orientation. Convention reports how azimuth is interpreted; if is quadrant. Allowance of different convention makes querying more difficult. |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |

**CGI_PlanarOrientation**

**Attribute: convention**

Value type: ConventionCode
Definition: The convention used for the measurement
Multiplicity: 1

**Attribute: dip**

Value type: CGI_NumericRange
Definition: 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
Multiplicity: 1
Stereotypes: «estimatedProperty»

**Attribute: polarity**

Value type: PlanarPolarityCode
Definition: Indicates whether the planar orientation is associated with a directed feature that is overturned, upright, vertical etc.
Multiplicity: 1
Stereotypes: «estimatedProperty»

*5.2.4.2.5. CGI_Term*

**CGI_Term**

Subtype of: ScopedName, CGI_Value
Definition: A value with a qualifier code. Many geological properties are recorded with some form of qualification.
Status: Proposed
Stereotypes: «dataType»

**Attribute: qualifier**

Value type: ValueQualifierCode
Definition: A qualifying term (eg; sometimes, common, always) used with term values.
Multiplicity: 1

**Attribute: value**

Value type: CodeListValue
Definition: A byReference attribute, referring to a vocabulary of terms suitable to describe a GeoSciML element.
Multiplicity: 1

*5.2.4.2.6. CGI_TermRange*

**CGI_TermRange**

Subtype of: CGI_Value
Definition: Allows specifying a range of terms (eg Silurian - Devonian) by specifying an upper (Devonian) and lower (Silurian) CGI_TermValue
Status: Proposed
Stereotypes: «dataType»

**Association role: lower**

Value type: CGI_Term
Multiplicity: 1

**Association role: upper**

Value type: CGI_Term

| **CGI_TermRange** | |
|---|---|
| Multiplicity: | 1 |

*5.2.4.2.7. CGI_Value*

| **CGI_Value (abstract)** | |
|---|---|
| Definition: | The Value structures are for when you need 1. a qualifier, 2. to be able to use either single values or ranges, or 3. to express uncertainty on numeric values 4. use numbers or words as alternatives for a single value or in a mixed range e.g. "usually X", "greater than Y" where X and Y are either a Measure (number with a scale) or Term (word from a vocabulary) or a range constructed from measures and terms |
| Status: | Proposed |
| Stereotypes: | «dataType» |

*5.2.4.2.8. CGI_Vector*

| **CGI_Vector** | |
|---|---|
| Definition: | data type for linear orientation with magnitude. Cardinality on magnitude is 1, if magnitude is unknown use CGI_LinearOrientation |
| Status: | Proposed |
| Stereotypes: | «dataType» |
| **Attribute: magnitude** | |
| Value type: | CGI_NumericRange |
| Definition: | The numerical length of a linear vector |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |

### 5.2.4.3. Code lists

*5.2.4.3.1. CodeListValue*

| **CodeListValue** | |
|---|---|
| Definition: | Refers to a vocabulary of terms applicable to the GeoSciML element that is being described by CGI_Term |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

*5.2.4.3.2. ConventionCode*

| **ConventionCode** | |
|---|---|
| Definition: | Code list to specify the convention used for the orientation measurement |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |
| **Value: dip dip direction** | |
| **Value: strike dip right hand rule** | |

*5.2.4.3.3. DescriptionPurpose*

| **DescriptionPurpose** | |
|---|---|
| Definition: | 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. |
| Status: | Proposed |
| Stereotypes: | «codeList» |

| **DescriptionPurpose** |
|---|
| Governance: May be extended by Member States. |
| **Value: definingNorm** |
| **Value: instance** |
| **Value: typicalNorm** |

*5.2.4.3.4. DeterminationMethodTerm*

| **DeterminationMethodTerm** |
|---|
| Definition: Refers to a vocabulary of terms describing the method used to determine the measured orientation<br>Status: Proposed<br>Stereotypes: «codeList»<br>Governance: May be extended by Member States. |

*5.2.4.3.5. LinearDirectedCode*

| **LinearDirectedCode** |
|---|
| Definition: Code list to capture terms related to directedness of linear orientations<br>Status: Proposed<br>Stereotypes: «codeList»<br>Governance: May be extended by Member States. |
| **Value: directed** |
| **Value: directed down** |
| **Value: directed up** |

*5.2.4.3.6. PlanarPolarityCode*

| **PlanarPolarityCode** |
|---|
| Definition: values to use for expressing overturned property on planar orientation measurements.<br>Status: Proposed<br>Stereotypes: «codeList»<br>Governance: May be extended by Member States. |
| **Value: not applicable** |
| **Value: overturned** |
| **Value: unknown** |
| **Value: upright** |
| **Value: vertical** |

*5.2.4.3.7. ValueQualifierCode*

| **ValueQualifierCode** |
|---|
| Definition: A vocabulary of terms used to qualify text values<br>Status: Proposed<br>Stereotypes: «codeList»<br>Governance: May be extended by Member States. |

| ValueQualifierCode |
|---|
| **Value: always** |
| **Value: approximate** |
| **Value: common** |
| **Value: equalTo** |
| **Value: greaterThan** |
| **Value: lessThan** |
| **Value: never** |
| **Value: rare** |
| **Value: sometimes** |

#### 5.2.4.4. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

*5.2.4.4.1. Quantity*

| Quantity | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19136 GML::valueObjects [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.4.4.2. ScopedName*

| ScopedName | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103 Conceptual Schema Language::ISO 19103:2005 Schema Language::Basic Types::Implementation::Names [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

### 5.2.5 Feature catalogue - EarthMaterial

**Table 3 - Feature catalogue metadata**

| | |
|---|---|
| Feature catalogue name | INSPIRE feature catalogue EarthMaterial |
| Scope | EarthMaterial |
| Version number | 0.1 |
| Version date | 2010-10-27 |
| Definition source | INSPIRE data specification EarthMaterial |

**Table 4 - Types defined in the feature catalogue**

| Type | Package | Stereotypes | Section |
|---|---|---|---|
| AlterationDescription | EarthMaterial | «dataType» | 5.2.2.1.1 |
| AlterationTypeTerm | EarthMaterial | «codeList» | 5.2.2.2.1 |
| ConstituentPartRoleTerm | EarthMaterial | «codeList» | 5.2.2.2.2 |

| Type | Package | Stereotypes | Section |
|---|---|---|---|
| MineralNameTerm | EarthMaterial | «codeList» | 5.2.2.2.3 |
| ParticleGeometryDescription | EarthMaterial | «dataType» | 5.2.2.1.2 |
| ParticleTypeTerm | EarthMaterial | «codeList» | 5.2.2.2.4 |

### 5.2.5.1. Spatial object types

### 5.2.5.2. Data types

#### *5.2.5.2.1. AlterationDescription*

| **AlterationDescription** | |
|---|---|
| Definition: | 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. |
| Status: | Proposed |
| Stereotypes: | «dataType» |
| **Attribute: alterationDegree** | |
| Value type: | CGI_TermRange |
| Definition: | AlterationDegree is a term to specify degree of modification from original material. eg: weak, moderate, strong, intense |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |
| **Attribute: alterationDistribution** | |
| Value type: | CGI_Term |
| Definition: | AlterationDistribution describes the spatial distribution or geometry of alteration zones. eg: patchy, spotted, banded, viens, vein breccia, pervasive, disseminated, etc |
| Multiplicity: | 1..* |
| Stereotypes: | «estimatedProperty» |
| **Attribute: alterationProduct** | |
| Value type: | EarthMaterial |
| Definition: | 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. |
| Multiplicity: | 1..* |
| Stereotypes: | «estimatedProperty» |
| **Attribute: alterationType** | |
| Value type: | AlterationTypeTerm |
| Definition: | AlterationType is a general description of the dominant alteration mineralogy or alteration type, in common usage. Examples include: argillic, phyllic, potassic, propylitic, calc-silicate, skarn, deuteric, greisen, serpenitisation, weathering, etc. |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |
| **Association role: alterationEvent** | |
| Value type: | GeologicEvent |
| Multiplicity: | 0..1 |

*5.2.5.2.2. ParticleGeometryDescription*

**ParticleGeometryDescription**

Definition: 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).

Status: Proposed

Stereotypes: «dataType»

**Attribute: aspectRatio**

Value type: CGI_Term

Definition: 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)

Multiplicity: 0..*

Stereotypes: «estimatedProperty»

**Attribute: particleType**

Value type: ParticleTypeTerm

Definition: 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.

Multiplicity: 1

**Attribute: shape**

Value type: CGI_Term

Definition: 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)

Multiplicity: 0..*

Stereotypes: «estimatedProperty»

**Attribute: size**

Value type: CGI_NumericRange

| **ParticleGeometryDescription** | |
|---|---|
| Definition: | 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) |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |

**Attribute: sorting**

| | |
|---|---|
| Value type: | CGI_Term |
| Definition: | 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. |
| Multiplicity: | 0..* |
| Stereotypes: | «estimatedProperty» |

### 5.2.5.3. Code lists

#### *5.2.5.3.1. AlterationTypeTerm*

| **AlterationTypeTerm** | |
|---|---|
| Definition: | Refers to a vocabulary of terms describing the dominant alteration mineralogy or alteration type, in common usage. Examples include: argillic, phyllic, potassic, propylitic, calc-silicate, skarn, deuteric, greisen, serpenitisation, weathering, etc. |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

#### *5.2.5.3.2. ConstituentPartRoleTerm*

| **ConstituentPartRoleTerm** | |
|---|---|
| Definition: | Refers to a vocabulary of terms describing the role played by a constituent part of a compound material (eg, matrix, phenocryst) |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

#### *5.2.5.3.3. MineralNameTerm*

| **MineralNameTerm** | |
|---|---|
| Definition: | Refers to a vocabulary of mineral names |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

#### *5.2.5.3.4. ParticleTypeTerm*

| **ParticleTypeTerm** | |
|---|---|
| Definition: | Refers to a vocabulary of terms describing the type of particle in the compound earth material (eg, bioclast, phenocryst, pyroclast) |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

#### 5.2.5.4. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

##### *5.2.5.4.1. CGI_NumericRange*

| **CGI_NumericRange** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::CGI_Value [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | Allows specifying a range of numeric values (eg 443.7+-1.5 to 359+-2.5) and a single representative or estimated value. (eg: upper = 443.7+-1.5,lower = 359+-2.5, estimatedValue [mean] = 400) 1. Best practice for use with GeoSciML would be for Quantity:value, uom, and quality to be mandatory. 2. The UoMIdentifier type has been implemented in the SWE schema as gml:UnitDefinition (ie, not exactly as implied by the Quantity UML class) 3. Use Quantity "definition" attribute to indicate statistical type of esimatedValue/Quantity (eg; mean, median, mode). Possible example: <swe:Quantity definition="urn:cgi:classifier:CGI:Statistical_qualifier::mean"> 4. Where CGI_NumericRange is used to deliver a single numeric value, it should be repeated in both the upper and lower quantity values. |

##### *5.2.5.4.2. CGI_Term*

| **CGI_Term** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::CGI_Value [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | A value with a qualifier code. Many geological properties are recorded with some form of qualification. |

##### *5.2.5.4.3. CGI_TermRange*

| **CGI_TermRange** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::CGI_Value [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | Allows specifying a range of terms (eg Silurian - Devonian) by specifying an upper (Devonian) and lower (Silurian) CGI_TermValue |

##### *5.2.5.4.4. DescriptionPurpose*

| **DescriptionPurpose** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::CGI_Value [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | 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. |

##### *5.2.5.4.5. GeologicEvent*

| **GeologicEvent** |
|---|

| **GeologicEvent** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::GeologicAge [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | An identifiable event during which one or more geological processes act to modify geological entities. A GeologicEvent must have a specified GeologicAge and may have specified environments and processes. An example might be a cratonic uplift event during which erosion, sedimentation, and volcanism all take place. 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 objects. Genesis typically pertains to some geological phenomenon (Geological Structure, Earth Material, Geological Unit, Fossil, etc.) In GeoSciML 2.0 this ordering cannot be specified. A GeologicEvent must have a specified eventAge (numericAgeDate, olderNamedAge, or youngerNamedAge), at least one eventProcess, and may have specified eventEnvironments. 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. The GeologicEvent package allows for explicitly linking the three, without mandating it. The eventAge attribute is the age of a particular geological event or feature expressed in terms of years before present (absolute age), referred to the geological time scale, or by comparison with other geological events or features (relative age). An eventAge 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". |

*5.2.5.4.6. MD_Metadata*

| **MD_Metadata** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2006 Metadata (Corrigendum)::Metadata entity set information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.5.4.7. PhysicalDescription*

| **PhysicalDescription** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::PhysicalProperties [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | A class to describe the numeric physical properties of a geologic unit, earth material, or geologic structure. (eg; density, porosity, magnetic susceptibility, remanent magnetism) |

## 5.2.6 Feature catalogue - Borehole

**Table 3 - Feature catalogue metadata**

| | |
|---|---|
| Feature catalogue name | INSPIRE feature catalogue Borehole |
| Scope | Borehole |

| | |
|---|---|
| Version number | 0.1 |
| Version date | 2010-10-27 |
| Definition source | INSPIRE data specification Borehole |

**Table 4 - Types defined in the feature catalogue**

| Type | Package | Stereotypes | Section |
|---|---|---|---|
| Borehole | Borehole | «featureType» | 5.2.2.1.1 |
| BoreholeCollar | Borehole | «featureType» | 5.2.2.1.2 |
| BoreholeDetails | Borehole | «dataType» | 5.2.2.2.1 |
| BoreholeDrillingMethodCode | Borehole | «codeList» | 5.2.2.3.1 |
| BoreholeInclinationCode | Borehole | «codeList» | 5.2.2.3.2 |
| BoreholeStartPointCode | Borehole | «codeList» | 5.2.2.3.3 |
| MappedInterval | Borehole | «featureType» | 5.2.2.1.3 |

### 5.2.6.1. Spatial object types

*5.2.6.1.1. Borehole*

**Borehole**

Subtype of: SF_SamplingCurve
Definition: A borehole is the generalized term for any narrow shaft drilled in the ground, either vertically or horizontally.
Status: Proposed
Stereotypes: «featureType»

**Association role: collarLocation**

Value type: BoreholeCollar
Multiplicity:

**Association role: indexData**

Value type: BoreholeDetails
Multiplicity: 0..1

**Association role: logElement**

Value type: MappedInterval
Multiplicity: 0..*

**Constraint: mappedInterval.samplingFrame=self**

Natural language:

*5.2.6.1.2. BoreholeCollar*

**BoreholeCollar**

Definition: A Borehole Collar is a feature corresponding to the start point of a borehole. These are often plotted on a map. If a text descripiton of the location is available, which should be placed in the gml:description for that feature. If no GM_Point is available, URN:CGI:unknown should be used Implementers delivering 3-D collar locations should provide and elevation to improve interoperability.
Status: Proposed
Stereotypes: «featureType»

**Attribute: elevation**

Value type: DirectPosition

| **BoreholeCollar** | |
|---|---|
| Definition: | Compromise approach to supply elevation explictly for location; this is to allow for software that cannot process 3-D GM_Point. Use null if elevation is unknown. Direct position shall have a dimension of 1, and CRS will be a "vertical" CRS (e.g. EPSG CRSs in the range 5600-5799). |
| Multiplicity: | 1 |
| **Attribute: location** | |
| Value type: | GM_Point |
| Definition: | The location of the BoreholeCollar |
| Multiplicity: | 1 |
| **Association role: borehole** | |
| Value type: | Borehole |
| Multiplicity: | 0..* |

*5.2.6.1.3. MappedInterval*

| **MappedInterval** | |
|---|---|
| Subtype of: | MappedFeature |
| Definition: | A special kind of Mapped Feature whose shape is 1-D (a curve) |
| Status: | Proposed |
| Stereotypes: | «featureType» |

### 5.2.6.2. Data types

*5.2.6.2.1. BoreholeDetails*

| **BoreholeDetails** | |
|---|---|
| Definition: | Borehole specific index (or metadata) information |
| Status: | Proposed |
| Stereotypes: | «dataType» |
| **Attribute: coreCustodian** | |
| Value type: | CI_ResponsibleParty |
| Definition: | NOTE: This property will be mapped to a temporary proxy ISO19115 schema until GML3.2 support is available. Organisation that is custodian of the core recovered from the borehole |
| Multiplicity: | 0..1 |
| **Attribute: coredInterval** | |
| Value type: | GM_Envelope |
| Definition: | Interval(s) within the borehole from which core was recovered Use GM_Envelope with 1-D CRS corresponding to borehole curve shape |
| Multiplicity: | 0..* |
| **Attribute: dateOfDrilling** | |
| Value type: | TM_CalDate |
| Definition: | The date on which drilling of the borehole commenced |
| Multiplicity: | 1 |
| **Attribute: driller** | |
| Value type: | CI_ResponsibleParty |
| Definition: | NOTE: this attribute will be mapped to a temporary proxy ISO19115 schema until GML3.2 support is available. The organisation responsible for drilling the borehole (as opposed to commissioning the borehole) |
| Multiplicity: | 0..1 |

**BoreholeDetails**

**Attribute: drillingMethod**

Value type: BoreholeDrillingMethodCode
Definition: Indicates the drilling method used. Appropriate terms would include Rotary; Shell & Auger; Downhole Air Hammer; Hand Auger etc
Multiplicity: 1

**Attribute: inclinationType**

Value type: BoreholeInclinationCode
Definition: Indicates the inclination of the borehole. Appropriate terms would include vertical; inclined up; inclined down, horizontal
Multiplicity: 1

**Attribute: nominalDiameter**

Value type: Measure
Definition: The starting diameter
Multiplicity: 0..1

**Attribute: operator**

Value type: CI_ResponsibleParty
Definition: NOTE: This property will be mapped to a temporary proxy ISO19115 schema until GML3.2 support is available. Organisation responsible for commissioning the borehole (as opposed to drilling the borehole)
Multiplicity: 0..1

**Attribute: startPoint**

Value type: BoreholeStartPointCode
Definition: Indicates the position relative to ground surface where the borehole commenced. Appropriate terms would include Drilled from Ground Surface; Drilled Underground; Drilled from Quarry Floor etc
Multiplicity: 1

### 5.2.6.3. Code lists

#### *5.2.6.3.1. BoreholeDrillingMethodCode*

**BoreholeDrillingMethodCode**

Definition: Borehole drilling method
Status: Proposed
Stereotypes: «codeList»
Governance: May be extended by Member States.

**Value: RAB**

**Value: RC**

**Value: air core**

**Value: auger**

**Value: cable tool**

**Value: diamond core**

**Value: direct push**

| **BoreholeDrillingMethodCode** |
|---|
| **Value: hand auger** |
| **Value: hydraulic rotary** |
| **Value: unknown** |
| **Value: vibratory** |

*5.2.6.3.2. BoreholeInclinationCode*

| **BoreholeInclinationCode** | |
|---|---|
| Definition: | General orientation of a borehole |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |
| **Value: horizontal** | |
| **Value: inclined down** | |
| **Value: inclined up** | |
| **Value: vertical** | |

*5.2.6.3.3. BoreholeStartPointCode*

| **BoreholeStartPointCode** | |
|---|---|
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |
| **Value: from pre-existing hole** | |
| **Value: natural ground surface** | |
| **Value: open pit floor or wall** | |
| **Value: underground** | |

### 5.2.6.4. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

*5.2.6.4.1. CI_ResponsibleParty*

| **CI_ResponsibleParty** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2003 Metadata::Citation and responsible party information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.6.4.2. DirectPosition*

| **DirectPosition** |
|---|

| **DirectPosition** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107 Spatial Schema::ISO 19107:2003 Spatial Schema:: Geometry::Coordinate geometry [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.6.4.3. GM_Envelope*

| **GM_Envelope** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107 Spatial Schema::ISO 19107:2003 Spatial Schema:: Geometry::Coordinate geometry [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.6.4.4. GM_Point*

| **GM_Point** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107 Spatial Schema::ISO 19107:2003 Spatial Schema:: Geometry::Geometric primitive [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.6.4.5. MappedFeature*

| **MappedFeature** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::Geology-Core [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | 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 specific bounded occurrence, such as an outcrop or map polygon * the Mapped Feature carries a geometry or shape - 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 BoreHolesAndObservation) 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. |

*5.2.6.4.6. Measure*

| **Measure** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103 Conceptual Schema Language::ISO 19103:2005 Schema Language::Basic Types::Derived::Units of Measure [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.6.4.7. SF_SamplingCurve*

| **SF_SamplingCurve** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19156 Observations and Measurements::ISO DIS 19156:2010 Observations and Measurements::Sampling Manifold::samplingCurve [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.6.4.8. TM_CalDate*

| **TM_CalDate** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19108 Temporal schema::ISO 19108:2006 Temporal Schema::Temporal Reference System [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

## 5.2.7 Feature catalogue - PhysicalProperties

**Table 3 - Feature catalogue metadata**

| | |
|---|---|
| Feature catalogue name | INSPIRE feature catalogue PhysicalProperties |
| Scope | PhysicalProperties |
| Version number | 0.1 |
| Version date | 2010-10-27 |
| Definition source | INSPIRE data specification PhysicalProperties |

**Table 4 - Types defined in the feature catalogue**

| Type | Package | Stereotypes | Section |
|---|---|---|---|
| PhysicalDescription | PhysicalProperties | «dataType» | 5.2.2.1.1 |
| PhysicalPropertyMeasure | PhysicalProperties | «dataType» | 5.2.2.1.2 |
| PhysicalPropertyMeasureType | PhysicalProperties | «codeList» | 5.2.2.2.1 |
| PhysicalPropertyTerm | PhysicalProperties | «codeList» | 5.2.2.2.2 |

### 5.2.7.1. Spatial object types

### 5.2.7.2. Data types

*5.2.7.2.1. PhysicalDescription*

| **PhysicalDescription** | |
|---|---|
| Definition: | A class to describe the numeric physical properties of a geologic unit, earth material, or geologic structure. (eg; density, porosity, magnetic susceptibility, remanent magnetism) |
| Status: | Proposed |
| Stereotypes: | «dataType» |

**Attribute: propertyMeasure**

| | |
|---|---|
| Value type: | PhysicalPropertyMeasure |
| Definition: | A scalar or vector measurement of the physical property of a rock material |
| Multiplicity: | 1..* |

**Attribute: propertyName**

| | |
|---|---|
| Value type: | PhysicalPropertyTerm |
| Definition: | A term from a controlled vocabulary of physical properties of rock materials (eg; density, porosity, magnetic susceptibility, remanent magnetism, permeability, seismic velocity) |
| Multiplicity: | 1 |

*5.2.7.2.2. PhysicalPropertyMeasure*

| **PhysicalPropertyMeasure** | |
|---|---|
| Definition: | Describes the value of the phyical property measure (must contain one of either a scalar (Quantity), vector, or tensor value (SquareMatrix)) and a term to explicitly describe the statistical type of measurement (eg; maximum, minimum, mean, median) |

| **PhysicalPropertyMeasure** | |
|---|---|
| Status: | Proposed |
| Stereotypes: | «dataType» |
| **Attribute: propertyValue** | |
| Value type: | PhysicalPropertyValue |
| Definition: | Element must contain one of either a scalar (swe:Quantity), vector (swe:Vector), or tensor (swe:SquareMatrix) value |
| Multiplicity: | 1 |
| Stereotypes: | «estimatedProperty» |
| **Attribute: valueType** | |
| Value type: | PhysicalPropertyMeasureType |
| Definition: | A term from a controlled vocabulary to denote if the value represents a statistical measure (eg; maximum, minimum, mean, mode, median, etc) derived from of a number of individual measurements, or if the value represents a single measurement. |
| Multiplicity: | 1 |

### 5.2.7.3. Code lists

*5.2.7.3.1. PhysicalPropertyMeasureType*

| **PhysicalPropertyMeasureType** | |
|---|---|
| Definition: | Refers to a vocabulary of terms describing the statistical type of the quoted measurement (eg, mean, minimum, maximum, median, mode, single measurement) |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

*5.2.7.3.2. PhysicalPropertyTerm*

| **PhysicalPropertyTerm** | |
|---|---|
| Definition: | Refers to a vocabulary of physical property types (eg, density, porosity, magnetic susceptibility, magnetic remanence, conductivity, etc) |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |

### 5.2.7.4. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

*5.2.7.4.1. Quantity*

| **Quantity** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19136 GML::valueObjects [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.7.4.2. Vector*

| **Vector** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103 Conceptual Schema Language::ISO 19103:2005 Schema Language::Basic Types::Primitive::Numerics [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

## 5.2.8 Feature catalogue - Hydrogeology

**Table 3 - Feature catalogue metadata**

| | |
|---|---|
| Feature catalogue name | INSPIRE feature catalogue Hydrogeology |
| Scope | Hydrogeology |
| Version number | 0.1 |
| Version date | 2010-10-27 |
| Definition source | INSPIRE data specification Hydrogeology |

**Table 4 - Types defined in the feature catalogue**

| Type | Package | Stereotypes | Section |
|---|---|---|---|
| AbstractionWell | Hydrogeology | «featureType» | 5.2.2.1.1 |
| Aquiclude | Hydrogeology | «featureType» | 5.2.2.1.2 |
| Aquifer | Hydrogeology | «featureType» | 5.2.2.1.3 |
| AquiferMediaType | Hydrogeology | «enumeration» | 5.2.2.3.1 |
| ConfinedAquifer | Hydrogeology | «featureType» | 5.2.2.1.4 |
| ConfinedAquiferType | Hydrogeology | «enumeration» | 5.2.2.3.2 |
| DischargeSite | Hydrogeology | «featureType» | 5.2.2.1.5 |
| GroundwaterBody | Hydrogeology | «featureType» | 5.2.2.1.6 |
| HydroStratigraphicUnit | Hydrogeology | «featureType» | 5.2.2.1.7 |
| HydrogeologicMappedFeature | Hydrogeology | «featureType» | 5.2.2.1.8 |
| HydrogeologicUnit | Hydrogeology | «featureType» | 5.2.2.1.9 |
| RechargeSite | Hydrogeology | «featureType» | 5.2.2.1.10 |
| SpringOrSeep | Hydrogeology | «featureType» | 5.2.2.1.11 |
| UnconfinedAquifer | Hydrogeology | «featureType» | 5.2.2.1.12 |
| VanishingPoint | Hydrogeology | «featureType» | 5.2.2.1.13 |
| WaterAgeDescription | Hydrogeology | «dataType» | 5.2.2.2.1 |
| WaterBody | Hydrogeology | «featureType» | 5.2.2.1.14 |
| WaterCompositionDescription | Hydrogeology | «dataType» | 5.2.2.2.2 |
| WaterPropertyDescription | Hydrogeology | «dataType» | 5.2.2.2.3 |
| WaterQualityDescription | Hydrogeology | «dataType» | 5.2.2.2.4 |
| WaterQuantityDescription | Hydrogeology | «dataType» | 5.2.2.2.5 |
| WaterType | Hydrogeology | «enumeration» | 5.2.2.3.3 |
| WaterUseCode | Hydrogeology | «codeList» | 5.2.2.4.1 |
| WaterWell | Hydrogeology | «featureType» | 5.2.2.1.15 |
| WellPurposeCode | Hydrogeology | «codeList» | 5.2.2.4.2 |
| WellStatusCode | Hydrogeology | «codeList» | 5.2.2.4.3 |
| WellUse | Hydrogeology | «codeList» | 5.2.2.4.4 |

### 5.2.8.1. Spatial object types

*5.2.8.1.1. AbstractionWell*

| **AbstractionWell** | |
|---|---|
| Subtype of: | DischargeSite |
| Definition: | A WaterWell used for the of abstraction of water from a groundwater body |
| Status: | Proposed |
| Stereotypes: | «featureType» |

**AbstractionWell**

**Association role: specifiedBy**

Value type: WaterWell
Multiplicity:

*5.2.8.1.2. Aquiclude*

**Aquiclude**

Subtype of: HydroStratigraphicUnit
Definition: Impermeable beds of geologic material that hinder or prevent groundwater movement. http://www.groundwater.org/gi/gwglossary.html A formation which, although porous and capable of absorbing water slowly, will not transmit water fast enough to furnish an appreciable supply for a well or spring. Aquicludes are characterized by very low values of "leakage" (the ratio of vertical *Hydraulic Conductivity* to thickness), so that they transmit only minor inter-aquifer flow and also have very low rates of yield from compressible storage. Therefore, they constitute boundaries of aquifer flow systems. http://water.nv.gov/WaterPlanning/dict-1/PDFs/wwords-a.pdf
Status: Proposed
Stereotypes: «featureType»

*5.2.8.1.3. Aquifer*

**Aquifer**

Subtype of: HydroStratigraphicUnit
Definition: A formation, group of formations, or part of a formation that contains sufficient saturated, permeable material to yield significant quantities of water to wells and springs. (USGS) An underground geological formation able to store and yield water. http://www.groundwater.org/gi/gwglossary.html An aquifer is an underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, silt, or clay) from which groundwater can be usefully extracted using a water well. http://en.wikipedia.org/wiki/Aquifer
Status: Proposed
Stereotypes: «featureType»

**Attribute: mediaType**

Value type: AquiferMediaType
Definition: Property used to specify the medium of an aquifer.
Multiplicity: 1

*5.2.8.1.4. ConfinedAquifer*

**ConfinedAquifer**

Subtype of: Aquifer

**ConfinedAquifer**

| | |
|---|---|
| Definition: | Aquifer confined under an impermeable layer. Confined aquifers have the water table above their upper boundary (an aquitard or aquiclude), and are typically found below unconfined aquifers. The term "perched" refers to ground water accumulating above a low-permeability unit or strata, such as a clay layer. This term is generally used to refer to a small local area of ground water that occurs at an elevation higher than a regionally-extensive aquifer. The difference between perched and unconfined aquifers is their size (perched is smaller). http://en.wikipedia.org/wiki/Confined_aquifer#Confined_versus_unconfined (1) An aquifer containing water between two relatively impermeable boundaries. The water level in a well tapping a confined aquifer stands above the top of the confined aquifer and can be higher or lower than the water table that may be present in the material above it. In some cases the water level can rise above the ground surface, yielding a flowing well. (2) An aquifer or water-bearing subsurface stratum which is bounded above and below by formations of impermeable or relatively impermeable material; a water-bearing formation whose upper boundary is a layer which does not transmit water readily. (3) An aquifer in which ground water is under pressure significantly greater than atmospheric and its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the aquifer itself. http://water.nv.gov/WaterPlanning/dict-1/PDFs/wwords-c.pdf |
| Status: | Proposed |
| Stereotypes: | «featureType» |

**Attribute: confinedAquiferType**

| | |
|---|---|
| Value type: | ConfinedAquiferType |
| Definition: | This property refers to the type of confined aquifer. |
| Multiplicity: | 0..1 |

**Attribute: confinementLevel**

| | |
|---|---|
| Value type: | CGI_Term |
| Definition: | Level of confinement. |
| Multiplicity: | 1 |

*5.2.8.1.5. DischargeSite*

**DischargeSite (abstract)**

| | |
|---|---|
| Definition: | A site at which a GroundwaterBody is discharged |
| Description: | At present only SpringOrSeep and AbstractionSite are modelled but other types of discharge site could be added |
| Status: | Proposed |
| Stereotypes: | «featureType» |

**Association role: discharges**

| | |
|---|---|
| Value type: | Aquifer |
| Multiplicity: | |

*5.2.8.1.6. GroundwaterBody*

**GroundwaterBody**

| | |
|---|---|
| Subtype of: | WaterBody |
| Definition: | A distinct volume of groundwater within an aquifer or aquifers (Vogt, 2002). The equivalent in the European Water Framework Directive (2000/60/CE, 2000) is "Body of groundwater" defined exactly in the same way. |
| Status: | Proposed |
| Stereotypes: | «featureType» |

**Association role: hostUnit**

| **GroundwaterBody** | |
|---|---|
| Value type: | HydrogeologicUnit |
| Multiplicity: | 1 |
| **Association role: waterQuality** | |
| Value type: | WaterQualityDescription |
| Multiplicity: | 0..* |

*5.2.8.1.7. HydroStratigraphicUnit*

| **HydroStratigraphicUnit** | |
|---|---|
| Subtype of: | HydrogeologicUnit |
| Definition: | Formation, or part of a formation, or a group of formation in which there are similar hydrologic characteristics that allow for grouping into aquifers and associated confininf layers (Domenico & Schwartz, 1997) Hydrostratigraphic units were originally defined by Maxey (1964) as bodies of rock with considerable lateral extent that act as a reasonably distinct hydrologic system. It is clear from Maxey's definition that hydrostratigraphic units were to be hydraulically continuous, mappable, and scale-independent entities. Mappability, in this case, means the subsurface geology can be subdivided according to permeability (Seaber, 1988). Thus, a single hydrostratigraphic unit may include a formation, part of a formation, or a group of formations. -Maxey, G. B., 1964, Hydrostratigraphic units: Journal of Hydrology, v. 2, p. 124-129. |
| Status: | Proposed |
| Stereotypes: | «featureType» |

*5.2.8.1.8. HydrogeologicMappedFeature*

| **HydrogeologicMappedFeature** | |
|---|---|
| Subtype of: | MappedFeature |
| Definition: | Mapped feature more oriented on spatial temporal (although geometries could handle this). A physical hydrogeologic feature represented on a map. |
| Status: | Proposed |
| Stereotypes: | «featureType» |
| **Attribute: dateOfValidity** | |
| Value type: | TM_Object |
| Definition: | MappedFeature in hydrogeology are quite variable over time. This property defines over what time period this geometry actually make sense. |
| Multiplicity: | 1 |

*5.2.8.1.9. HydrogeologicUnit*

| **HydrogeologicUnit** | |
|---|---|
| Subtype of: | GeologicUnit |
| Definition: | Means any soil of rock unit or zone which by virtue of its porosity or permeability, or lack thereof, has a distinct influence on the storage or movement of groundwater. (EPA) Any soil or rock unit or zone that because of its hydraulic properties has a distinct influence on the storage or movement of ground water. http://water.nv.gov/WaterPlanning/dict-1/PDFs/wwords-h.pdf |
| Status: | Proposed |
| Stereotypes: | «featureType» |
| **Association role: waterContent** | |
| Value type: | GroundwaterBody |
| Multiplicity: | 0..* |
| **Association role: waterQuantity** | |
| Value type: | WaterQuantityDescription |

| **HydrogeologicUnit** | |
|---|---|
| Multiplicity: | 0..* |

*5.2.8.1.10. RechargeSite*

| **RechargeSite (abstract)** | |
|---|---|
| Definition: | A site at which a GroundwaterBody is recharged |
| Description: | At present only VanishingPoint is modelled but other types of recharge site could be added |
| Status: | Proposed |
| Stereotypes: | «featureType» |
| **Association role: recharges** | |
| Value type: | Aquifer |
| Multiplicity: | |

*5.2.8.1.11. SpringOrSeep*

| **SpringOrSeep** | |
|---|---|
| Subtype of: | HydroPointOfInterest, DischargeSite |
| Definition: | A natural outflow of water from below the ground surface. |
| Description: | NOTE 1 Corresponds to a 'source' node in a network view.<br><br>NOTE 2 Regarded as a placeholder in Annex II theme 'Geology' due to the connection with groundwater. |
| Status: | Proposed |
| Stereotypes: | «featureType» |

*5.2.8.1.12. UnconfinedAquifer*

| **UnconfinedAquifer** | |
|---|---|
| Subtype of: | Aquifer |
| Definition: | An aquifer containing water that is not under pressure; the water level in a well is the same as the water table outside the well. An unconfined aquifer made up of loose material, such as sand or gravel, that has not undergone lithification (settling). In an unconfined aquifer the upper boundary is the top of the *Zone of Saturation* (water table). http://water.nv.gov/WaterPlanning/dict-1/PDFs/wwords-u.pdf |
| Status: | Proposed |
| Stereotypes: | «featureType» |

*5.2.8.1.13. VanishingPoint*

| **VanishingPoint** | |
|---|---|
| Subtype of: | HydroPointOfInterest, RechargeSite |
| Definition: | Location where a watercourse disappears into the terrain or vanishes due to anthropization. |
| Description: | NOTE 1 Corresponds to an 'outlet' node in a network view.<br><br>NOTE 2 Regarded as a placeholder in Annex II theme 'Geology' due to the connection with groundwater. |
| Status: | Proposed |
| Stereotypes: | «featureType» |

*5.2.8.1.14. WaterBody*

| **WaterBody (abstract)** |
|---|

| **WaterBody (abstract)** | |
|---|---|
| Definition: | A mass or a volume of water, constrained geographically and/or structurally. An ocean is a water body, as a the water within an aquifer. This class is a distinction between water as a material and water as a feature The concept of water body is also present in Vogt (2002) [Vogt, J., 2002. Guidance Document on Implementing the GIS Elements of the Water Framework Directive] as an European directive. In the latter case, the european concept is more administrative than scientific. The spatio-temporal representation of this body (it's geometry at time T is representated by a MappedFeature) |
| Status: | Proposed |
| Stereotypes: | «featureType» |
| **Attribute: volume** | |
| Value type: | CGI_NumericRange |
| Definition: | Volume of water present in a water body. |
| Multiplicity: | 1 |
| **Association role: occurence** | |
| Value type: | HydrogeologicMappedFeature |
| Multiplicity: | 0..* |
| **Association role: subWaterBody** | |
| Value type: | WaterBody |
| Multiplicity: | 0..* |
| **Association role: superWaterBody** | |
| Value type: | WaterBody |
| Multiplicity: | 0..1 |
| **Association role: waterAge** | |
| Value type: | WaterAgeDescription |
| Multiplicity: | |
| **Association role: waterComposition** | |
| Value type: | WaterCompositionDescription |
| Multiplicity: | |

*5.2.8.1.15. WaterWell*

| **WaterWell** | |
|---|---|
| Subtype of: | SF_SamplingFeature, SF_SamplingPoint |
| Definition: | An excavation where the intended use is for location, acquisition, development, or artificial recharge of ground water. http://water.nv.gov/WaterPlanning/dict-1/PDFs/wwords-w.pdf A water well is an excavation or structure created in the ground ? by digging, driving, boring or drilling to access water in underground aquifers. http://en.wikipedia.org/wiki/Water_well |
| Status: | Proposed |
| Stereotypes: | «featureType» |
| **Attribute: onlineResource** | |
| Value type: | CI_OnlineResource |
| Definition: | Reference to an external online representation (URI, web page, URN) |
| Multiplicity: | 0..1 |
| **Attribute: referenceElevation** | |
| Value type: | Measure |
| Definition: | Elevation from which other elevation are calculated (such as Water Level) |

| **WaterWell** | |
|---|---|
| Multiplicity: | 1 |
| **Attribute: waterUse** | |
| Value type: | WaterUseCode |
| Definition: | The use of water may be classified by specific types according to distinctive uses. http://water.nv.gov/WaterPlanning/dict-1/PDFs/wwords-w.pdf Can be agriculture, commercial, domestic, heat transfer, industrial, irrigation, municipal, other, unknown, public recreation, research. Groundwater Data Management Guidelines, Environment Canada, Dec. 1991 |
| Multiplicity: | 0..* |
| **Attribute: wellDepth** | |
| Value type: | CGI_NumericRange |
| Definition: | Depth of the well |
| Multiplicity: | 1 |
| **Attribute: wellPurpose** | |
| Value type: | WellPurposeCode |
| Definition: | Purpose of the well. Can be cathodic protection, coalELog, core, decontamination, Dewatering, Disposal, FlowingShot, Geotechnical, Mineral, MonitoringlevelHead, MonitoringQuality, Oil, OilExploratory, Recharge, Seismic, WaterExploratory, WaterSupply, Other. Groundwater Data Management Guidelines, Environment Canada, Dec. 1991 |
| Multiplicity: | 0..* |
| **Attribute: wellStatus** | |
| Value type: | WellStatusCode |
| Definition: | Status of the well, Can be new, unfinished, reconditioned, deepened, not in use, standby, unknown, abandoned dry, abandoned insufficient, abandoned quality. Groundwater Data Management Guidelines, Environment Canada, Dec. 1991 |
| Multiplicity: | 1 |
| **Attribute: wellType** | |
| Value type: | CGI_Term |
| Definition: | Type of wells, related to the way they are build, eg: Dug Well, Drilled Well.. |
| Multiplicity: | 1 |
| **Attribute: wellUse** | |
| Value type: | WellUse |
| Definition: | Well use represents what the well is used for (monitoring, production) while water use is what the water is destined for (agriculture, domestic, industry), For example a Monitoring well on a farm. |
| Multiplicity: | 0..* |
| **Association role: indexData** | |
| Value type: | BoreholeDetails |
| Multiplicity: | 0..1 |
| **Association role: logElement** | |
| Value type: | MappedInterval |
| Multiplicity: | 0..* |

### 5.2.8.2. Data types

#### *5.2.8.2.1. WaterAgeDescription*

| **WaterAgeDescription** |
|---|

**WaterAgeDescription**

Subtype of: WaterPropertyDescription
Definition: The age of the water is generally (always?) the age of infiltration. The infiltration can be in an aquifer different from the aquifer it actually resides in (for example, water infiltrated in a surface aquifer and migrated slowly in a deeper - rock perhaps - aquifer).
Status: Proposed
Stereotypes: «dataType»

**Attribute: periodOfResidence**

Value type: TM_PeriodDuration
Definition: The time period in which a unit of water resides in an aquifer.
Multiplicity: 0..1
Stereotypes: «estimatedProperty»

**Attribute: waterAge**

Value type: GeologicEvent
Definition: The age of the water, expressed as a geologicEvent. Refer to http://www.geosciml.org/documentation/geosciml/2.0_rc3/GeoSciML/GeologicAge/GeologicEvent.html for a complete description of a geologicEvent.
Multiplicity: 0..1
Stereotypes: «estimatedProperty»

*5.2.8.2.2. WaterCompositionDescription*

**WaterCompositionDescription**

Subtype of: WaterQualityDescription
Definition: An abstract class used to describe the composition of water.
Status: Proposed
Stereotypes: «dataType»

**Attribute: compositionCategory**

Value type: CGI_Term
Definition: Describe what kind of concentration is represented, such as "Natural quality", "suitability for irrigation", etc..
Multiplicity: 0..1

**Attribute: salinityCategory**

Value type: WaterType
Definition: This property refers to the type of salinity that is present in the water.
Multiplicity: 0..1

*5.2.8.2.3. WaterPropertyDescription*

**WaterPropertyDescription**

Definition: Water Property description are the properties of the HydrogeologicUnit regarding its water content. Two aspects are considered, First the quantity (the amount of water that is present, as opposed to the amount of water that can potentially be there) and second, the quality of that water.
Status: Proposed
Stereotypes: «dataType»

**Attribute: metadata**

Value type: MD_Metadata
Definition: Metadata used to describe the water properties.
Multiplicity: 0..1

**Attribute: validityTime**

| **WaterPropertyDescription** | |
|---|---|
| Value type: | TM_GeometricPrimitive |
| Definition: | Time instant or period at which this value has any validity. NOTE: the time at which this observation was made is carried by O&M |
| Multiplicity: | 0..1 |

*5.2.8.2.4. WaterQualityDescription*

| **WaterQualityDescription (abstract)** | |
|---|---|
| Subtype of: | WaterPropertyDescription |
| Definition: | A list of common properties related to water quality assessment. Head of a substitution list that include Qualitative and Quantitative water quality properties |
| Status: | Proposed |
| Stereotypes: | «dataType» |
| **Attribute: normComplianceResult** | |
| Value type: | CGI_Term |
| Definition: | Evaluation of the compliance of this result compared to the norm (eg, below the norm, above the norm, meeting, exceeding..) |
| Multiplicity: | 0..1 |
| **Attribute: normDocumentation** | |
| Value type: | CI_Citation |
| Definition: | Identification of a norm (if any) that is should be considered to interpret the result. |
| Multiplicity: | 0..1 |

*5.2.8.2.5. WaterQuantityDescription*

| **WaterQuantityDescription** | |
|---|---|
| Subtype of: | WaterPropertyDescription |
| Definition: | A class used to describe the the quantity of water that is present in an aquifer. |
| Status: | Proposed |
| Stereotypes: | «dataType» |
| **Attribute: qualitativeWaterQuantity** | |
| Value type: | CGI_Term |
| Definition: | Qualitative description of the water quantity (such as 'wet' or 'dry'). Often the only information recorded in some water well records |
| Multiplicity: | 0..1 |

### 5.2.8.3. Enumerations

*5.2.8.3.1. AquiferMediaType*

| **AquiferMediaType** | |
|---|---|
| Definition: | Aquifers are generally classified as porous or fractured (or mixed in a cased of fractured porous media) |
| Status: | Proposed |
| Stereotypes: | «enumeration» |
| **Value: fractured** | |
| **Value: mixed** | |
| **Value: porous** | |

*5.2.8.3.2. ConfinedAquiferType*

| **ConfinedAquiferType** |
|---|

| **ConfinedAquiferType** | |
|---|---|
| Definition: | Exist where the groundwater is bounded between layers of impermeable substances like clay or dense rock. When tapped by a well, water in confined aquifers is forced up, sometimes above the soil surface. This is how a flowing artesian well is formed. http://www.groundwater.org/gi/gwglossary.html#C |
| Status: | Proposed |
| Stereotypes: | «enumeration» |
| **Value: artesian** | |
| **Value: subArtesian** | |

*5.2.8.3.3. WaterType*

| **WaterType** | |
|---|---|
| Definition: | This enumeration class refers to the concept of salinity and its classes in water. Salinity is the saltiness or dissolved salt content of a body of water. http://en.wikipedia.org/wiki/Salinity Generally, the concentration of mineral salts dissolved in water. Salinity may be expressed in terms of a concentration or as electrical conductivity. When describing salinity influenced by seawater, salinity often refers to the concentration of chlorides in the water. See also total dissolved solids. http://www.groundwater.water.ca.gov/groundwater_basics/gwb_glossary/index.cfm#ss |
| Status: | Proposed |
| Stereotypes: | «enumeration» |
| **Value: acratopegae** | |
| **Value: brackishWater** | |
| **Value: brineWater** | |
| **Value: freshWater** | |
| **Value: saltWater** | |
| **Value: ultraFreshWater** | |

### 5.2.8.4. Code lists

*5.2.8.4.1. WaterUseCode*

| **WaterUseCode** | |
|---|---|
| Definition: | The use of water may be classified by specific types according to distinctive uses. http://water.nv.gov/WaterPlanning/dict-1/PDFs/wwords-w.pdf |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |
| **Value: Agriculture** | |
| **Value: Commercial** | |
| **Value: Domestic** | |
| **Value: HeatTransfert** | |
| **Value: Industrial** | |

| **WaterUseCode** |
|---|
| **Value: Irrigation** |
| **Value: Municipal** |
| **Value: OtherUnknow** |
| **Value: PublicRecreation** |
| **Value: Research** |

*5.2.8.4.2. WellPurposeCode*

| **WellPurposeCode** |
|---|
| Definition: Code associated to define the purpose of the well.<br>Status: Proposed<br>Stereotypes: «codeList»<br>Governance: May be extended by Member States. |
| **Value: CathodicProtection** |
| **Value: CoalELog** |
| **Value: Core** |
| **Value: Decontamination** |
| **Value: Dewatering** |
| **Value: Disposal** |
| **Value: FlowingShot** |
| **Value: Geotechnical** |
| **Value: Mineral** |
| **Value: MonitoringLevelHead** |
| **Value: MonitoringQuality** |
| **Value: Oil** |
| **Value: OilExploratory** |
| **Value: Other** |
| **Value: Recharge** |
| **Value: Seismic** |
| **Value: WaterExploratory** |
| **Value: WaterSupply** |
| **Value: Withdrawal** |

*5.2.8.4.3. WellStatusCode*

| **WellStatusCode** | |
|---|---|
| Definition: | Status of the well. |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |
| **Value: Abandoned** | |
| **Value: AbandonedDry** | |
| **Value: AbandonedInsufficient** | |
| **Value: AbandonedQuality** | |
| **Value: Deepened** | |
| **Value: New** | |
| **Value: NotInUse** | |
| **Value: Reconditionned** | |
| **Value: Standby** | |
| **Value: Unfinished** | |
| **Value: Unknown** | |

*5.2.8.4.4. WellUse*

| **WellUse** | |
|---|---|
| Definition: | A list of terms for well use |
| Status: | Proposed |
| Stereotypes: | «codeList» |
| Governance: | May be extended by Member States. |
| **Value: domestic** | |
| **Value: exploitation** | |
| **Value: monitoring** | |
| **Value: observation** | |
| **Value: piezometry** | |
| **Value: production** | |

### 5.2.8.5. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

*5.2.8.5.1. BoreholeDetails*

| **BoreholeDetails** |
|---|

| **BoreholeDetails** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::Borehole [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | Borehole specific index (or metadata) information |

*5.2.8.5.2. CGI_NumericRange*

| **CGI_NumericRange** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::CGI_Value [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | Allows specifying a range of numeric values (eg 443.7+-1.5 to 359+-2.5) and a single representative or estimated value. (eg: upper = 443.7+-1.5,lower = 359+-2.5, estimatedValue [mean] = 400) 1. Best practice for use with GeoSciML would be for Quantity:value, uom, and quality to be mandatory. 2. The UoMIdentifier type has been implemented in the SWE schema as gml:UnitDefinition (ie, not exactly as implied by the Quantity UML class) 3. Use Quantity "definition" attribute to indicate statistical type of esimatedValue/Quantity (eg; mean, median, mode). Possible example: <swe:Quantity definition="urn:cgi:classifier:CGI:Statistical_qualifier::mean"> 4. Where CGI_NumericRange is used to deliver a single numeric value, it should be repeated in both the upper and lower quantity values. |

*5.2.8.5.3. CGI_Term*

| **CGI_Term** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::CGI_Value [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | A value with a qualifier code. Many geological properties are recorded with some form of qualification. |

*5.2.8.5.4. CI_Citation*

| **CI_Citation** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2003 Metadata::Citation and responsible party information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.8.5.5. CI_OnlineResource*

| **CI_OnlineResource** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2003 Metadata::Citation and responsible party information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.8.5.6. GeologicEvent*

| **GeologicEvent** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::GeologicAge [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

| **GeologicEvent** | |
|---|---|
| Definition: | An identifiable event during which one or more geological processes act to modify geological entities. A GeologicEvent must have a specified GeologicAge and may have specified environments and processes. An example might be a cratonic uplift event during which erosion, sedimentation, and volcanism all take place. 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 objects. Genesis typically pertains to some geological phenomenon (Geological Structure, Earth Material, Geological Unit, Fossil, etc.) In GeoSciML 2.0 this ordering cannot be specified. A GeologicEvent must have a specified eventAge (numericAgeDate, olderNamedAge, or youngerNamedAge), at least one eventProcess, and may have specified eventEnvironments. 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. The GeologicEvent package allows for explicitly linking the three, without mandating it. The eventAge attribute is the age of a particular geological event or feature expressed in terms of years before present (absolute age), referred to the geological time scale, or by comparison with other geological events or features (relative age). An eventAge 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". |

*5.2.8.5.7. GeologicUnit*

| **GeologicUnit** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::Geology-Core [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | Operationally, the GeologicUnit element is a container used to associate geologic properties with some mapped occurrence (through GeologicFeature.occurrence -> MappedFeature link), or with a geologic unit ControlledConcept in a vocabulary (through the GeologicUnit.classifier ->ControlledConcept link). Conceptually, may represent a body of material in the Earth whose complete and precise extent is inferred to exist (NADM GeologicUnit, Stratigraphic unit in sense of NACSN or Intnl 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. 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). Will be made Abstract when a complete (enough) set of specialized subtypes is defined. |

*5.2.8.5.8. HydroPointOfInterest*

| **HydroPointOfInterest (abstract)** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex I::Hydrography::Hydro - Physical Waters [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | A natural place where water appears, disappears or changes its flow. |

| **HydroPointOfInterest (abstract)** | |
|---|---|
| Description: | EXAMPLE Fluvial points (waterfall, cascade, rapids, breaker), spring/water hole (spring, source, geyser, thermal spring, natural fountain, well, also fumarole, artesian), sinkhole (sinkhole, drainage loss).<br><br>NOTE A hydro point of interest may create a flow constriction in the network. |

*5.2.8.5.9. MD_Metadata*

| **MD_Metadata** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2006 Metadata (Corrigendum)::Metadata entity set information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.8.5.10. MappedFeature*

| **MappedFeature** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::Geology-Core [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | 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 specific bounded occurrence, such as an outcrop or map polygon * the Mapped Feature carries a geometry or shape - 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 BoreHolesAndObservation) 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. |

*5.2.8.5.11. MappedInterval*

| **MappedInterval** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::Borehole [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | A special kind of Mapped Feature whose shape is 1-D (a curve) |

*5.2.8.5.12. Measure*

| **Measure** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103 Conceptual Schema Language::ISO 19103:2005 Schema Language::Basic Types::Derived::Units of Measure [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.8.5.13. SF_SamplingFeature*

| **SF_SamplingFeature (abstract)** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19156 Observations and Measurements::ISO DIS 19156:2010 Observations and Measurements::Sampling Core [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.8.5.14. SF_SamplingPoint*

| **SF_SamplingPoint** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19156 Observations and Measurements::ISO DIS 19156:2010 Observations and Measurements::Sampling Manifold::samplingPoint [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.8.5.15. TM_GeometricPrimitive*

| **TM_GeometricPrimitive** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19108 Temporal schema::ISO 19108:2006 Temporal Schema::Temporal Objects [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.8.5.16. TM_Object*

| **TM_Object** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19108 Temporal schema::ISO 19108:2006 Temporal Schema::Temporal Objects [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.8.5.17. TM_PeriodDuration*

| **TM_PeriodDuration** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19108 Temporal schema::ISO 19108:2006 Temporal Schema::Temporal Objects [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

## 5.2.9 Feature catalogue - Geophysics

**Table 3 - Feature catalogue metadata**

| | |
|---|---|
| Feature catalogue name | INSPIRE feature catalogue Geophysics simple |
| Scope | Geophysics simple |
| Version number | 0.1 |
| Version date | 2010-10-27 |
| Definition source | INSPIRE data specification Geophysics simple |

**Table 4 - Types defined in the feature catalogue**

| Type | Package | Stereotypes | Section |
|---|---|---|---|
| CurveModel | Geophysics simple | «featureType» | 5.2.2.1.1 |
| CurveModelType | Geophysics simple | «enumeration» | 5.2.2.2.1 |
| GeophMeasurement | Geophysics simple | «featureType» | 5.2.2.1.2 |
| GeophMeasurement3D | Geophysics simple | «featureType» | 5.2.2.1.3 |
| GeophMethodType | Geophysics simple | «codeList» | 5.2.2.3.1 |
| GeophModel | Geophysics simple | «featureType» | 5.2.2.1.4 |
| GeophProfile | Geophysics simple | «featureType» | 5.2.2.1.5 |
| GeophPropertyType | Geophysics simple | «codeList» | 5.2.2.3.2 |
| GeophStation | Geophysics simple | «featureType» | 5.2.2.1.6 |
| GeophSurvey | Geophysics simple | «featureType» | 5.2.2.1.7 |
| SolidGridModel | Geophysics simple | «featureType» | 5.2.2.1.8 |

| Type | Package | Stereotypes | Section |
|---|---|---|---|
| SolidGridModelType | Geophysics simple | «enumeration» | 5.2.2.2.2 |
| SolidModel | Geophysics simple | «featureType» | 5.2.2.1.9 |
| SolidModelType | Geophysics simple | «codeList» | 5.2.2.3.3 |
| StationType | Geophysics simple | «codeList» | 5.2.2.3.4 |
| SurfaceGridModel | Geophysics simple | «featureType» | 5.2.2.1.10 |
| SurfaceGridModelType | Geophysics simple | «enumeration» | 5.2.2.2.3 |
| SurfaceModel | Geophysics simple | «featureType» | 5.2.2.1.11 |
| SurfaceModelType | Geophysics simple | «enumeration» | 5.2.2.2.4 |

### 5.2.9.1. Spatial object types

*5.2.9.1.1. CurveModel*

**CurveModel**

Subtype of: GeophModel
Definition: Curve coverage of geophysical properties
Description: Distribution of geophysical properties along a curve. Examples: layer model from 1D inversion, interpreted borehole log, composit log.

NOTE 1. In the core model only the bounding geometry is defined. Source data access may be provided as explained in the metadata distribution options.
Status: Proposed
Stereotypes: «featureType»

**Attribute: geometry**

Value type: GM_Curve
Multiplicity: 1

**Attribute: modelType**

Value type: CurveModelType
Multiplicity: 1

*5.2.9.1.2. GeophMeasurement*

**GeophMeasurement**

Definition: Generic feature to for geophysical measurements.
Description: Geophysical measurements collect data on the boundary of the observed spatial domain.
Status: Proposed
Stereotypes: «featureType»

**Attribute: geophMethod**

Value type: GeophMethodType
Multiplicity: 1

**Attribute: inspireId**

Value type: Identifier
Definition: External object identifier of the measurement.
Description: NOTE An external object identifier is a unique object identifier published by the responsible body, which may be used by external applications to reference the spatial object. The identifier is an identifier of the spatial object, not an identifier of the real-world phenomenon.
Multiplicity: 1

**Attribute: levelOfDetail**

Value type: MD_Resolution

| **GeophMeasurement** | |
|---|---|
| Definition: | Resolution, expressed as the inverse of an indicative scale or a ground distance. |
| Description: | NOTE The object is captured at a scale of this level of detail; rules apply for portrayal and visualisation. |
| Multiplicity: | 1 |
| **Attribute: metadata** | |
| Value type: | MD_Metadata |
| Multiplicity: | 1 |
| **Association role: relatedSurvey** | |
| Value type: | GeophSurvey |
| Multiplicity: | |

*5.2.9.1.3. GeophMeasurement3D*

| **GeophMeasurement3D** | |
|---|---|
| Subtype of: | GeophMeasurement |
| Definition: | Geophysical measurement spatially referenced to a surface |
| Description: | Used to collect data on a surface. Examples: 3D seismic measurement, 3D DC tomography.<br><br>NOTE 1. Measured data access may be provided as explained in the metadata distribution options.<br>NOTE 2. Processing results of 3D measurements are usually solid coverages |
| Status: | Proposed |
| Stereotypes: | «featureType» |
| **Attribute: geometry** | |
| Value type: | GM_Surface |
| Multiplicity: | 1 |

*5.2.9.1.4. GeophModel*

| **GeophModel** | |
|---|---|
| Definition: | Generic feature type for geophysical models |
| Description: | Coverage of physical properties. Usually it is the result of geophysical processing. It provides distribution of physical properties within the observed spatial domain. |
| Status: | Proposed |
| Stereotypes: | «featureType» |
| **Attribute: inspireId** | |
| Value type: | Identifier |
| Definition: | External object identifier of the model . |
| Description: | NOTE An external object identifier is a unique object identifier published by the responsible body, which may be used by external applications to reference the spatial object. The identifier is an identifier of the spatial object, not an identifier of the real-world phenomenon. |
| Multiplicity: | 1 |
| **Attribute: levelOfDetail** | |
| Value type: | MD_Resolution |
| Definition: | Resolution, expressed as the inverse of an indicative scale or a ground distance. |
| Description: | NOTE The object is captured at a scale of this level of detail; rules apply for portrayal and visualisation. |
| Multiplicity: | 0..1 |

| **GeophModel** |
|---|
| **Attribute: metadata**<br>Value type: MD_Metadata<br>Multiplicity: 1 |
| **Attribute: propertyName**<br>Value type: GeophPropertyType<br>Multiplicity: 1..* |
| **Attribute: verticalExtent**<br>Value type: EX_VerticalExtent<br>Multiplicity: 1 |

*5.2.9.1.5. GeophProfile*

| **GeophProfile** |
|---|
| Subtype of: GeophMeasurement<br>Definition: Geophysical measurement spatially referenced to a curve<br>Description: Used to collect data along a curve. Examples: 2D seismic measurement, borehole logging, airborne geophysical flight line<br><br>NOTE 1. Measured data access may be provided as explained in the metadata distribution options.<br>NOTE 2. Processing results of geophProfiles are often surface coverages<br>Status: Proposed<br>Stereotypes: «featureType» |
| **Attribute: geometry**<br>Value type: GM_Curve<br>Multiplicity: 1 |

*5.2.9.1.6. GeophStation*

| **GeophStation** |
|---|
| Subtype of: GeophMeasurement<br>Definition: Geophysical measurement spatially referenced to a single point location<br>Description: Used to collect data at a single location. The source-sensor setup may be alongated or two dimensional, but the collected data is referenced to a single point.<br><br>NOTE 1. Measured data access may be provided as explained in the metadata distribution options.<br>NOTE 2. Processing results of geophStations are often curve coverages<br>Status: Proposed<br>Stereotypes: «featureType» |
| **Attribute: geometry**<br>Value type: GM_Point<br>Multiplicity: 1 |
| **Attribute: stationType**<br>Value type: StationType<br>Multiplicity: 1 |

*5.2.9.1.7. GeophSurvey*

| **GeophSurvey** |
|---|
| Definition: Generic feature for geophysical surveys. |

| **GeophSurvey** | |
|---|---|
| Description: | The main purpose is to provide discovery data. Apart from geometry it provides responsible parties that are important or has no corresponding role in the ISO metadata profile. |
| Status: | Proposed |
| Stereotypes: | «featureType» |
| **Attribute: client** | |
| Value type: | CI_ResponsibleParty |
| Multiplicity: | 1 |
| **Attribute: contractor** | |
| Value type: | CI_ResponsibleParty |
| Multiplicity: | 1 |
| **Attribute: dataOwner** | |
| Value type: | CI_ResponsibleParty |
| Definition: | Owner of geophysical data created during the campaign. |
| Multiplicity: | 1 |
| **Attribute: geometry** | |
| Value type: | GM_Polygon |
| Multiplicity: | 1 |
| **Attribute: geophMethod** | |
| Value type: | GeophMethodType |
| Multiplicity: | 1 |
| **Attribute: levelOfDetail** | |
| Value type: | MD_Resolution |
| Definition: | Resolution, expressed as the inverse of an indicative scale or a ground distance. |
| Description: | NOTE The object is captured at a scale of this level of detail; rules apply for portrayal and visualisation. |
| Multiplicity: | 1 |
| **Attribute: metadata** | |
| Value type: | MD_Metadata |
| Multiplicity: | 1 |
| **Constraint: levelOfDetail.equivalentScale>=100000** | |
| Natural language: | scale should be >= 1:100000 |
| OCL: | |

*5.2.9.1.8. SolidGridModel*

| **SolidGridModel** | |
|---|---|
| Subtype of: | GeophModel |
| Definition: | Solid grid coverage of geophysical properties |
| Description: | 3D grid of different geophysical properties. Examples are seismic block, or 3D resistivity grid from DC tomography.<br><br>NOTE 1. In the core model only the bounding geometry is defined. Source data access may be provided as explained in the metadata distribution options. |
| Status: | Proposed |
| Stereotypes: | «featureType» |

**SolidGridModel**

**Attribute: geometry**

Value type: GM_Solid
Multiplicity: 1

**Attribute: modelType**

Value type: SolidGridModelType
Multiplicity: 1

*5.2.9.1.9. SolidModel*

**SolidModel**

Subtype of: GeophModel
Definition: Solid coverage of geophysical properties
Description: Collection of solids that represent rock bodies delineated by different geophysical properties.

NOTE 1. In the core model only the bounding geometry is defined. Source data access may be provided as explained in the metadata distribution options.
Status: Proposed
Stereotypes: «featureType»

**Attribute: geometry**

Value type: GM_Solid
Multiplicity: 1

**Attribute: modelType**

Value type: SolidModelType
Multiplicity: 1

*5.2.9.1.10. SurfaceGridModel*

**SurfaceGridModel**

Subtype of: GeophModel
Definition: Surface grid coverage of geophysical properties
Description: Horizontal or vertical cross section with grids of different geophysical properties. Examples: seismic depth section, resistiviy section from 2D inversion.

NOTE 1. In the core model only the bounding geometry is defined. Source data access may be provided as explained in metadata distribution options.
Status: Proposed
Stereotypes: «featureType»

**Attribute: geometry**

Value type: GM_Surface
Multiplicity: 1

**Attribute: modelType**

Value type: SurfaceGridModelType
Multiplicity: 1

*5.2.9.1.11. SurfaceModel*

**SurfaceModel**

Subtype of: GeophModel
Definition: Surface coverage of geophysical properties

| **SurfaceModel** | |
|---|---|
| Description: | Horizontal or vertical cross section with polygons that represent rock bodies delineated by different geophysical properties. Examples: density section from 2D gravity modelling, geoelectric profile edited from a series of layer models.<br><br>NOTE 1. In the core model only the bounding geometry is defined. Source data access may be provided as explained in the metadata distribution options. |
| Status: | Proposed |
| Stereotypes: | «featureType» |
| **Attribute: geometry** | |
| Value type: | GM_Surface |
| Multiplicity: | 1 |
| **Attribute: modelType** | |
| Value type: | SurfaceModelType |
| Multiplicity: | 1 |

### 5.2.9.2. Enumerations

*5.2.9.2.1. CurveModelType*

| **CurveModelType** | |
|---|---|
| Status: | Proposed |
| Stereotypes: | «enumeration» |
| **Value: boreholeLog** | |
| **Value: compositLog** | |
| **Value: layerModel** | |

*5.2.9.2.2. SolidGridModelType*

| **SolidGridModelType** | |
|---|---|
| Status: | Proposed |
| Stereotypes: | «enumeration» |
| **Value: parameterBlock** | |
| **Value: seismicBlock** | |

*5.2.9.2.3. SurfaceGridModelType*

| **SurfaceGridModelType** | |
|---|---|
| Status: | Proposed |
| Stereotypes: | «enumeration» |
| **Value: horizontalParameterGrid** | |
| **Value: seismicDepthHorizon** | |
| **Value: seismicDepthSection** | |
| **Value: verticalParameterGrid** | |

*5.2.9.2.4. SurfaceModelType*

| **SurfaceModelType** | |
|---|---|
| Status: | Proposed |

| **SurfaceModelType** |
|---|
| Stereotypes: «enumeration» |
| **Value: horizontalCrossSection** |
| **Value: verticallCrossSection** |

### 5.2.9.3. Code lists

*5.2.9.3.1. GeophMethodType*

| **GeophMethodType** |
|---|
| Status: Proposed<br>Stereotypes: «codeList»<br>Governance: May be extended by Member States. |
| **Value: AirborneGeophysics** |
| **Value: BoreholeLogging** |
| **Value: Gravimetry** |
| **Value: Magnetometry** |
| **Value: Seismics** |

*5.2.9.3.2. GeophPropertyType*

| **GeophPropertyType** |
|---|
| Status: Proposed<br>Stereotypes: «codeList»<br>Governance: May be extended by Member States. |
| **Value: density** |
| **Value: electricResistivity** |
| **Value: magneticSusceptibility** |
| **Value: seismicReflectivity** |
| **Value: seismicVelocity** |

*5.2.9.3.3. SolidModelType*

| **SolidModelType** |
|---|
| Status: Proposed<br>Stereotypes: «codeList»<br>Governance: May be extended by Member States. |

*5.2.9.3.4. StationType*

| **StationType** |
|---|
| Status: Proposed<br>Stereotypes: «codeList»<br>Governance: May be extended by Member States. |
| **Value: absolute** |
| **Value: absoluteBase** |

#### 5.2.9.4. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

*5.2.9.4.1. CI_ResponsibleParty*

| **CI_ResponsibleParty** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2006 Metadata (Corrigendum)::Citation and responsible party information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.9.4.2. EX_VerticalExtent*

| **EX_VerticalExtent** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2006 Metadata (Corrigendum)::Extent information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.9.4.3. GM_Curve*

| **GM_Curve** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107 Spatial Schema::ISO 19107:2003 Spatial Schema:: Geometry::Geometric primitive [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.9.4.4. GM_Point*

| **GM_Point** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107 Spatial Schema::ISO 19107:2003 Spatial Schema:: Geometry::Geometric primitive [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.9.4.5. GM_Polygon*

| **GM_Polygon** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107 Spatial Schema::ISO 19107:2003 Spatial Schema:: Geometry::Coordinate geometry [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.9.4.6. GM_Solid*

| **GM_Solid** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107 Spatial Schema::ISO 19107:2003 Spatial Schema:: Geometry::Geometric primitive [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.9.4.7. GM_Surface*

| **GM_Surface** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107 Spatial Schema::ISO 19107:2003 Spatial Schema:: Geometry::Geometric primitive [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.9.4.8. Identifier*

| **Identifier** |
|---|

| **Identifier** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Generic Conceptual Model::Base Types [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |
| Definition: | External unique object identifier published by the responsible body, which may be used by external applications to reference the spatial object. |
| Description: | NOTE1 External object identifiers are distinct from thematic object identifiers.<br><br>NOTE 2 The voidable version identifier attribute is not part of the unique identifier of a spatial object and may be used to distinguish two versions of the same spatial object.<br><br>NOTE 3 The unique identifier will not change during the life-time of a spatial object. |

*5.2.9.4.9. MD_Metadata*

| **MD_Metadata** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2006 Metadata (Corrigendum)::Metadata entity set information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

*5.2.9.4.10. MD_Resolution*

| **MD_Resolution** | |
|---|---|
| Package: | INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2006 Metadata (Corrigendum)::Identification information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM] |

# 6 Reference systems

## 6.1 Coordinate reference systems

### 6.1.1 Datum

| **IR Requirement 3** | For the coordinate reference systems used for making available the INSPIRE spatial data sets, the datum shall be the datum of the European Terrestrial Reference System 1989 (ETRS89) in areas within its geographical scope, and the datum of the International Terrestrial Reference System (ITRS) or other geodetic coordinate reference systems compliant with ITRS in areas that are outside the geographical scope of ETRS89. Compliant with the ITRS means that the system definition is based on the definition of the ITRS and there is a well established and described relationship between both systems, according to EN ISO 19111. |
|---|---|

### 6.1.2 Coordinate reference systems

**IR Requirement 4** INSPIRE spatial data sets shall be made available using one of the three-dimensional, two-dimensional or compound coordinate reference systems specified in the list below.

Other coordinate reference systems than those listed below may only be used for regions outside of continental Europe. The geodetic codes and parameters for these coordinate reference systems shall be documented, and an identifier shall be created, according to EN ISO 19111 and ISO 19127.

1. Three-dimensional Coordinate Reference Systems
   - Three-dimensional Cartesian coordinates
   - Three-dimensional geodetic coordinates (latitude, longitude and ellipsoidal height), using the parameters of the GRS80 ellipsoid

2. Two-dimensional Coordinate Reference Systems
   - Two-dimensional geodetic coordinates, using the parameters of the GRS80 ellipsoid
   - Plane coordinates using the Lambert Azimuthal Equal Area projection and the parameters of the GRS80 ellipsoid
   - Plane coordinates using the Lambert Conformal Conic projection and the parameters of the GRS80 ellipsoid
   - Plane coordinates using the Transverse Mercator projection and the parameters of the GRS80 ellipsoid

3. Compound Coordinate Reference Systems
   - For the horizontal component of the compound coordinate reference system, one of the two-dimensional coordinate reference systems specified above shall be used
   - For the vertical component on land, the European Vertical Reference System (EVRS) shall be used to express gravity-related heights within its geographical scope
   - Other vertical reference systems related to the Earth gravity field shall be used to express gravity-related heights in areas that are outside the geographical scope of EVRS. The geodetic codes and parameters for these vertical reference systems shall be documented and an identifier shall be created, according to EN ISO 19111 and ISO 19127
   - For the vertical component measuring the depth of the sea floor, where there is an appreciable tidal range, the Lowest Astronomical Tide shall be used as reference surface. In marine areas without an appreciable tidal range, in open oceans and effectively in waters that are deeper than 200 m, the depth of the sea floor shall be referenced to the Mean Sea Level
   - For the vertical component measuring depths above the sea floor in the free ocean, barometric pressure shall be used
   - For the vertical component in the free atmosphere, barometric pressure, converted to height using ISO 2533:1975 International Standard Atmosphere shall be used

### 6.1.3 Display

**IR Requirement 5** For the display of the INSPIRE spatial data sets with the View Service specified in D003152/02 Draft Commission Regulation implementing Directive 2007/2/EC of the European Parliament and of the Council as regards Network Services, at least the two dimensional geodetic coordinate system shall be made available.

### 6.1.4 Identifiers for coordinate reference systems

**IR Requirement 6** For referring to the non-compound coordinate reference systems listed in this Section, the identifiers listed below shall be used.

For referring to a compound coordinate reference system, an identifier composed of the identifier of the horizontal component, followed by a slash (/), followed by the identifier of the vertical component, shall be used.

- ETRS89-XYZ for Cartesian coordinates in ETRS89
- ETRS89-GRS80h for three-dimensional geodetic coordinates in ETRS89 on the GRS80 ellipsoid
- ETRS89-GRS80 for two-dimensional geodetic coordinates in ETRS89 on the GRS80
- EVRS for height in EVRS
- LAT for depth of the sea floor, where there is an appreciable tidal range
- MSL for depth of the sea floor, in marine areas without an appreciable tidal range, in open oceans and effectively in waters that are deeper than 200m
- ISA for pressure coordinate in the free atmosphere
- PFO for Pressure coordinate in the free ocean
- ETRS89-LAEA for ETRS89 coordinates projected into plane coordinates by the Lambert Azimuthal Equal Area projection
- ETRS89-LCC for ETRS89 coordinates projected into plane coordinates by the Lambert Conformal Conic projection
- ETRS89-TMzn for ETRS89 coordinates projected into plane coordinates by the Transverse Mercator projection

## 6.2 Temporal reference system

**IR Requirement 7** The Gregorian Calendar shall be used for as a reference system for date values, and the Universal Time Coordinated (UTC) or the local time including the time zone as an offset from UTC shall be used as a reference system for time values.

## 6.3 Theme-specific requirements and recommendations on reference systems

There are no theme-specific requirements or recommendations on reference systems.

# 7 Data quality

This chapter includes a description of data quality elements and sub-elements as well as the associated basic data quality measures to be used to describe data related to the spatial data theme *Geology (see* ***Error! Reference source not found.***). The data quality elements are described in section 7.1.

NOTEAdditional guidance documents on procedures and methods that can be used to implement the basic data quality measures introduced in this section will be provided at a later stage.

In addition, recommendations on minimum data quality are included for specific elements. These recommendations are included in section 7.2.

## 7.1 Data quality elements

Data quality information can be described at level of spatial object (feature), spatial object type (feature type), dataset or dataset series. Data quality information at spatial object level is modelled directly in the application schema (Chapter 5).

Chapter 8 describes the corresponding metadata elements to report about this data quality information.

**Recommendation 2** Aggregated data quality information should ideally be collected at the level of spatial object types and included in the dataset (series) metadata

| Section | Data quality element and sub-elements<br>Data quality sub-element | Scope(s) |
|---|---|---|
| 7.1.1 | Completeness – Commission | spatial object type |
| 7.1.2 | Completeness – Omission | spatial object type |
| 7.1.3 | Logical Consistency – Topological consistency | spatial object type<br>(delete as appropriate) |
| 7.1.4 | Positional accuracy – Absolute or external accuracy | spatial object type<br>(delete as appropriate) |

### 7.1.1 Completeness – Commission

Commission should be documented using the rate of excess items.

| Name | Rate of excess items |
|---|---|
| Alternative name | – |
| Data quality element | Completeness |
| Data quality sub-element | Commission |
| Data quality basic measure | Error rate |
| Definition | Number of excess items in the dataset in relation to the number of items that should have been present. |
| Description | – |
| Parameter | – |
| Data quality value type | Real, percentage, ratio (example: 0,0189 ; 98,11% ; 11:582) |
| Data quality value structure | – |
| Source reference | – |
| Example | – |
| Measure identifier | 3 (ISO 19138) |

### 7.1.2 Completeness – Omission

Omission should be documented using the rate of missing items.

| Name | Rate of missing items |
|---|---|
| Alternative name | – |
| Data quality element | Completeness |
| Data quality sub-element | Omission |
| Data quality basic measure | Error rate |
| Definition | Number of missing items in the dataset in relation to the number |

| | |
|---|---|
| | of items that should have been present. |
| Description | – |
| Parameter | – |
| Data quality value type | Real, percentage, ratio (example: 0,0189 ; 98,11% ; 11:582) |
| Data quality value structure | – |
| Source reference | – |
| Example | – |
| Measure identifier | 7 (ISO 19138) |

### 7.1.3 Logical Consistency – Topological consistency

Topological consistency should be documented using <Name of the measure>.

*Specify the data quality measure (from ISO 19138, clause D2.4) using the template below.*

| **Name** | **<Name of the measure, from ISO 19138>** |
|---|---|
| Alternative name | *Other recognised name for the same data quality measure. It can either be a different commonly used name or an abbreviation or a short name. More than one alias may be provided.* |
| Data quality element | Logical consistency |
| Data quality sub-element | Topological consistency |
| Data quality basic measure | Error rate |
| Definition | *Statement of the fundamental concept of the data quality measure. If the data quality measure is derived from a data quality basic measure, the definition is based on the data quality basic measure definition and specialized for this data quality measure. The data quality measures are designed to test the topological consistency of geometric representations of features.* |
| Description | *Description of the data quality measure including method of calculation with all formulae and/or illustrations needed to establish the result of applying the measure. If the data quality measure uses the concept of errors, it shall be stated how an item shall be classified as incorrect.* |
| Parameter | *Auxiliary variable used by the data quality measure including name, definition and description. More than one parameter may be provided.* |
| Data quality value type | *Value type for reporting a data quality result. A data quality value type shall be provided for a data quality result. Examples include Boolean, Real, Integer, Ratio (numerator of type integer : denominator of type integer), Percentage, Measure(s) (value(s) + unit(s))* |
| Data quality value structure | *Structure for reporting a complex data quality result. A data quality result may consist of multiple values. In this case the data quality result shall be structured using one of the following data quality value structures: Bag, Set, Sequence, Table, Matrix, Coverage* |
| Source reference | *Citation of the source of the data quality measure. When a data quality measure for which additional information is provided in an external source is added to the list of standardized data quality measures, a reference to that source may be provided here.* |
| Example | *Example of applying the data quality measure or the result obtained for the data quality measure. More than one example may be provided.* |
| Measure identifier | *Integer number, uniquely identifying a data quality measure. Use the identifier number from ISO 19138, Annex D.* |

### 7.1.4 Positional accuracy – Absolute or external accuracy

Absolute or external accuracy should be documented using <Name of the measure>.

*Specify the data quality measure (from ISO 19138, clause D3.1) using the template below.*

| **Name** | **<Name of the measure, from ISO 19138>** |
|---|---|
| Alternative name | *Other recognised name for the same data quality measure. It can either be a different commonly used name or an abbreviation or a short name. More than one alias may be provided.* |
| Data quality element | Positional accuracy |
| Data quality sub-element | Absolute or external accuracy |
| Data quality basic measure | 1) Counting-related data quality basic measures:<br>Error indicator \| Correctness indicator \| Error count \| Correct items count \| Error rate \| Correct items rate *(delete as appropriate)*<br>*2)* Uncertainty-related data quality basic measures:<br>One-dimensional random variable, Z \| Two-dimensional random variable X and Y \| Three-dimensional random variable X, Y, Z<br>*(delete as appropriate: between 1) and 2) and between options under 1) and 2)*<br><br>*See also ISO 19138, section 7.2.5 and Annex C* |
| Definition | *Statement of the fundamental concept of the data quality measure. If the data quality measure is derived from a data quality basic measure, the definition is based on the data quality basic measure definition and specialized for this data quality measure.* |
| Description | *Description of the data quality measure including method of calculation with all formulae and/or illustrations needed to establish the result of applying the measure. If the data quality measure uses the concept of errors, it shall be stated how an item shall be classified as incorrect.* |
| Parameter | *Auxiliary variable used by the data quality measure including name, definition and description. More than one parameter may be provided.* |
| Data quality value type | *Value type for reporting a data quality result. A data quality value type shall be provided for a data quality result. Examples include Boolean, Real, Integer, Ratio (numerator of type integer : denominator of type integer), Percentage, Measure(s) (value(s) + unit(s))* |
| Data quality value structure | *Structure for reporting a complex data quality result. A data quality result may consist of multiple values. In this case the data quality result shall be structured using one of the following data quality value structures: Bag, Set, Sequence, Table, Matrix, Coverage* |
| Source reference | *Citation of the source of the data quality measure. When a data quality measure for which additional information is provided in an external source is added to the list of standardized data quality measures, a reference to that source may be provided here.* |
| Example | *Example of applying the data quality measure or the result obtained for the data quality measure. More than one example may be provided.* |

| Measure identifier | *Integer number, uniquely identifying a data quality measure. Use the identifier number from ISO 19138, Annex D.* |
|---|---|

## 7.2 Minimum data quality recommendations

No recommendations on minimum data quality are defined in this data specification.

# 8 Dataset-level metadata

Metadata can be reported for each individual spatial object (spatial object-level metadata) or once for a complete dataset or dataset series (dataset-level metadata). Spatial object-level metadata is fully described in the application schema (section **5**). If data quality elements are used at spatial object level, the documentation shall refer to the appropriate definition in section 7. This section only specifies dataset-level metadata elements.

For some dataset-level metadata elements, in particular on data quality and maintenance, a more specific scope can be specified. This allows the definition of metadata at sub-dataset level, e.g. separately for each spatial object type. When using ISO 19115/19139 to encode the metadata, the following rules should be followed:

- The scope element (of type DQ_Scope) of the DQ_DataQuality subtype should be used to encode the scope.
- Only the following values should be used for the level element of DQ_Scope: Series, Dataset, featureType.
- If the level is featureType the levelDescription/MDScopeDescription/features element (of type Set< GF_FeatureType>) shall be used to list the feature type names.

NOTE The value featureType is used to denote spatial object type.

Mandatory or conditional metadata elements are specified in Section 8.1. Optional metadata elements are specified in Section 8.2. The tables describing the metadata elements contain the following information:

- The first column provides a reference to a more detailed description.
- The second column specifies the name of the metadata element.
- The third column specifies the multiplicity.
- The fourth column specifies the condition, under which the given element becomes mandatory (only for Table 4 and Table 5).

## 8.1 Common metadata elements

| **IR Requirement 8** | The metadata describing a spatial data set or a spatial data set series related to the theme **Geology** shall comprise the metadata elements required by Regulation 1205/2008/EC (implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata) for spatial datasets and spatial dataset series (Table 4) as well as the metadata elements specified in Table 5. |
|---|---|

**Table 3 – Metadata for spatial datasets and spatial dataset series specified in Regulation 1205/2008/EC (implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata)**

| **Metadata Regulation Section** | **Metadata element** | **Multiplicity** | **Condition** |
|---|---|---|---|
| 1.1 | Resource title | 1 | |
| 1.2 | Resource abstract | 1 | |
| 1.3 | Resource type | 1 | |
| 1.4 | Resource locator | 0..* | Mandatory if a URL is available to obtain more information on the resource, and/or access related services. |
| 1.5 | Unique resource identifier | 1..* | |
| 1.7 | Resource language | 0..* | Mandatory if the resource includes textual information. |
| 2.1 | Topic category | 1..* | |
| 3 | Keyword | 1..* | |
| 4.1 | Geographic bounding box | 1..* | |
| 5 | Temporal reference | 1..* | |
| 6.1 | Lineage | 1 | |
| 6.2 | Spatial resolution | 0..* | Mandatory for data sets and data set series if an equivalent scale or a resolution distance can be specified. |
| 7 | Conformity | 1..* | |
| 8.1 | Conditions for access and use | 1..* | |
| 8.2 | Limitations on public access | 1..* | |
| 9 | Responsible organisation | 1..* | |
| 10.1 | Metadata point of contact | 1..* | |
| 10.2 | Metadata date | 1 | |
| 10.3 | Metadata language | 1 | |

**Table 4 – Mandatory and conditional common metadata elements**

| **INSPIRE Data Specification** Geology **Section** | **Metadata element** | **Multiplicity** | **Condition** |
|---|---|---|---|
| 8.1.1 | Coordinate Reference System | 1 | |

| | | | |
|---|---|---|---|
| 8.1.2 | Temporal Reference System | 0..* | Mandatory, if the spatial data set or one of its feature types contains temporal information that does not refer to the Gregorian Calendar or the Coordinated Universal Time. |
| 8.1.3 | Encoding | 1..* | |
| 8.1.4 | Character Encoding | 0..* | Mandatory, if an encoding is used that is not based on UTF-8. |

### 8.1.1 Coordinate Reference System

| **Metadata element name** | **Coordinate Reference System** |
|---|---|
| Definition | Description of the coordinate reference system used in the dataset. |
| ISO 19115 number and name | 13. referenceSystemInfo |
| ISO/TS 19139 path | referenceSystemInfo |
| INSPIRE obligation / condition | mandatory |
| INSPIRE multiplicity | 1 |
| Data type(and ISO 19115 no.) | 189. MD_CRS |
| Domain | Either the referenceSystemIdentifier (RS_Identifier) or the projection (RS_Identifier), ellipsoid (RS_Identifier) and datum (RS_Identifier) properties shall be provided. |
| Implementing instructions | <instructions on how the metadata can be obtained> |
| Example | referenceSystemIdentifier:<br>code: ETRS_89<br>codeSpace: INSPIRE RS registry |
| Example XML encoding | |
| Comments | |

### 8.1.2 Temporal Reference System

| **Metadata element name** | **Temporal Reference System** |
|---|---|
| Definition | Description of the temporal reference systems used in the dataset. |
| ISO 19115 number and name | 13. referenceSystemInfo |
| ISO/TS 19139 path | referenceSystemInfo |
| INSPIRE obligation / condition | Mandatory, if the spatial data set or one of its feature types contains temporal information that does not refer to the Gregorian Calendar or the Coordinated Universal Time. |
| INSPIRE multiplicity | 0..* |
| Data type(and ISO 19115 no.) | 186. MD_ReferenceSystem |
| Domain | No specific type is defined in ISO 19115 for temporal reference systems. Thus, the generic MD_ReferenceSystem element and its reference SystemIdentifier (RS_Identifier) property shall be provided. |
| Implementing instructions | <instructions on how the metadata can be obtained> |
| Example | referenceSystemIdentifier:<br>code: GregorianCalendar<br>codeSpace: INSPIRE RS registry |
| Example XML encoding | |
| Comments | |

### 8.1.3 Encoding

| **Metadata element name** | **Encoding** |
|---|---|
| Definition | Description of the computer language construct that specifies the representation of data objects in a record, file, message, storage device or transmission channel |
| ISO 19115 number and name | 271. distributionFormat |
| ISO/TS 19139 path | distributionInfo/MD_Distribution/distributionFormat |
| INSPIRE obligation / condition | mandatory |
| INSPIRE multiplicity | 1 |
| Data type (and ISO 19115 no.) | 284. MD_Format |
| Domain | See B.2.10.4. The following property values shall be used for default and alternative encodings specified in section **Error! Reference source not found.**:<br><br>Default Encoding<br>– name: **Geology** GML application schema<br>– version: version <version of this specification>; GML, version 3.2.1<br>– specification: D2.8.**II**.**4** Data Specification on **Geology** – Draft Guidelines<br><br>Alternative Encoding<br>– name: <Encoding name><br>– version: version <version of the encoding><br>– specification: <specification> |
| Implementing instructions | <instructions on how the metadata can be obtained> |
| Example | name: **Geology** GML application schema<br>version: version 3.0, GML, version 3.2.1<br>specification: D2.8.**II**.**4** Data Specification on **Geology** – Draft Guidelines |
| Example XML encoding | |
| Comments | <comments> |

### 8.1.4 Character Encoding

| **Metadata element name** | **Data Quality – Logical Consistency – Topological Consistency** |
|---|---|
| Definition | The character encoding used in the data set. |
| ISO 19115 number and name | |
| ISO/TS 19139 path | |
| INSPIRE obligation / condition | Mandatory, if an encoding is used that is not based on UTF-8. |
| INSPIRE multiplicity | 0..* |
| Data type (and ISO 19115 no.) | |
| Domain | |
| Implementing instructions | |
| Example | - |
| Example XML encoding | - |
| Comments | |

## 8.2 Theme-specific metadata elements

| | |
|---|---|
| **IR Requirement 9** | The metadata describing a spatial data set or a spatial data set series related to the theme *Geology shall* also comprise the theme-specific metadata elements specified in Table 6. |
| **IR Requirement 10** | |
| **IR Requirement 11** | The metadata describing a spatial data set or a spatial data set series related to the theme **Geology** should comprise the theme-specific metadata elements specified in Table 7. |

| | |
|---|---|
| **Recommendation 3** | |
| **Recommendation 4** | It is important to provide the user with information about positional accuracy. This is partly a *function of the quality of the topographic data used during the* mapping and the mapping process. The attribute positionalAccuracy of the feature type MappedFeature is suitable for this **purpose. No additional theme specific metadata elements are required.** |

**Table 5 – Mandatory and conditional theme-specific metadata elements for the theme *Geology***

| **INSPIRE Data Specification *Geology* Section** | **Metadata element** | **Multiplicity** | **Condition** |
|---|---|---|---|

**Table 6 – Optional theme-specific metadata elements for the theme** Geology

| INSPIRE Data Specification Geology **Section** | Metadata element | Multiplicity |
|---|---|---|

### 8.2.1 Data Quality – Logical Consistency – Topological Consistency

| **Metadata element name** | **Data Quality – Logical Consistency – Topological Consistency** |
|---|---|
| Definition | Correctness of the explicitly encoded topological characteristics of the dataset as described by the scope |
| ISO 19115 number and name | 18. dataQualityInfo |
| ISO/TS 19139 path | dataQualityInfo |
| INSPIRE obligation / condition | Mandatory, if the data set includes types from the Generic Network Model and does not assure centreline topology (connectivity of centrelines) for the network. |
| INSPIRE multiplicity | 0..* |
| Data type (and ISO 19115 no.) | 115. DQ_TopologicalConsistency |
| Domain | Lines 100-107 from ISO 19115 |
| Implementing instructions | This metadata should be filled, at least, with these elements:<br>- valueUnit: UnitOfMeasure<br>- value: Record |
| Example | |
| Example XML encoding | |

| | |
|---|---|
| Comments | See clauses **Error! Reference source not found.Error! Reference source not found.** and **Error! Reference source not found.** in **Error! Reference source not found.** in Chapter 7 related to missing connections due to undershoots and overshoots for detailed information.<br>This metadata element is mandatory if connectivity is not assured for transport network centrelines in the dataset. In this case the *Connectivity tolerance* parameter – as described in **Error! Reference source not found.** and **Error! Reference source not found.** – must be provided in order to ensure automatic and unambiguous creation of centreline topology in post-process. |

### 8.2.2 Maintenance Information

| **Metadata element name** | **Maintenance information** |
|---|---|
| Definition | Information about the scope and frequency of updating |
| ISO 19115 number and name | 30. resourceMaintenance |
| ISO/TS 19139 path | identificationInfo/MD_Identification/resourceMaintenance |
| INSPIRE obligation / condition | optional |
| INSPIRE multiplicity | 0..1 |
| Data type(and ISO 19115 no.) | 142. MD_MaintenanceInformation |
| Domain | This is a complex type (lines 143-148 from ISO 19115).<br>At least the following elements should be used (the multiplicity according to ISO 19115 is shown in parentheses):<br>– maintenanceAndUpdateFrequency [1]: frequency with which changes and additions are made to the resource after the initial resource is completed / domain value: MD_MaintenanceFrequencyCode:<br>– updateScope [0..*]: scope of data to which maintenance is applied / domain value: MD_ScopeCode<br>– maintenanceNote [0..*]: information regarding specific requirements for maintaining the resource / domain value: free text |
| Implementing instructions | |
| Example | |
| Example XML encoding | |
| Comments | |

**Error! Not a valid filename.**

### 8.2.3 Data Quality – Completeness – Omission

| **Metadata element name** | **Data Quality – Completeness – Omission** |
|---|---|
| Definition | Data absent from the dataset, as described by the scope |
| ISO 19115 number and name | 18. dataQualityInfo |
| ISO/TS 19139 path | dataQualityInfo |
| INSPIRE obligation / condition | optional |
| INSPIRE multiplicity | 0..* |
| Data type (and ISO 19115 no.) | 110. DQ_CompletenessOmission |
| Domain | Lines 100-107 from ISO 19115 |
| Implementing instructions | |
| Example | |
| Example XML encoding | |

| Comments | See clause **7.1.2** in Chapter 7 for detailed information. |
|---|---|

## 8.3 Guidelines on using metadata elements defined in Regulation 1205/2008/EC

### 8.3.1 Conformity

The *Conformity* metadata element defined in Regulation 1205/2008/EC allows to report the conformance with the Implementing Rule for interoperability of spatial data sets and services or another specification. The degree of conformity of the dataset can be *Conformant* (if the dataset is fully conformant with the cited specification), *Not Conformant* (if the dataset does not conform to the cited specification) or *Not evaluated* (if the conformance has not been evaluated).

**Recommendation 5** The Conformity metadata element should be used to report conceptual consistency with this INSPIRE data specification. The value of Conformant should be used for the Degree element only if the dataset passes all the requirements described in the abstract test suite presented in Annex A. The Specification element should be given as follows:
- title: “INSPIRE Data Specification on <Theme Name> – Draft Guidelines”
- date:
  - dateType: publication
  - date: 2010-11-03

### 8.3.2 Lineage

Following the ISO 19113 Quality principles, if a data provider has a procedure for quality validation of their spatial data sets then the data quality elements listed in the Chapter 8 should be used. If not, the *Lineage* metadata element (defined in Regulation 1205/2008/EC) should be used to describe the overall quality of a spatial data set.

According to Regulation 1205/2008/EC, lineage “is a statement on process history and/or overall quality of the spatial data set. Where appropriate it may include a statement whether the data set has been validated or quality assured, whether it is the official version (if multiple versions exist), and whether it has legal validity. The value domain of this metadata element is free text”.

**Recommendation 6** Apart from describing the process history, if feasible within a free text, the overall quality of the dataset (series) should be included in the *Lineage* metadata element. This statement should contain any quality information required for interoperability and/or valuable for use and evaluation of the data set (series).

### 8.3.3 Temporal reference

According to Regulation 1205/2008/EC, at least one of the following temporal reference metadata elements shall be provided: temporal extent, date of publication, date of last revision, date of creation.

**Recommendation 7** If feasible, the date of the last revision of a spatial data set should be reported using the *Date of last revision* metadata element.

# 9 Delivery

## 9.1 Delivery medium

**DS Requirement 2** Data conformant to this INSPIRE data specification shall be made available through an INSPIRE network service.

**DS Requirement 3** All information that is required by a calling application to be able to retrieve the data through the used network service shall be made available in accordance with the requirements defined in the Implementing Rules on Network Services.

EXAMPLE 1 Through the Get Spatial Objects function, a download service can either download a pre-defined data set or pre-defined part of a data set (non-direct access download service), or give direct access to the spatial objects contained in the data set, and download selections of spatial objects based upon a query (direct access download service). To execute such a request, some of the following information might be required:

- the list of spatial object types and/or predefined data sets that are offered by the download service (to be provided through the Get Download Service Metadata operation),
- and the query capabilities section advertising the types of predicates that may be used to form a query expression (to be provided through the Get Download Service Metadata operation, where applicable),
- a description of spatial object types offered by a download service instance (to be proviced through the Describe Spatial Object Types operation).

EXAMPLE 2 Through the Transform function, a transformation service carries out data content transformations from native data forms to the INSPIRE-compliant form and vice versa. If this operation is directly called by an application to transform source data (e.g. obtained through a download service) that is not yet conformant with this data specification, the following parameters are required:
Input data (mandatory). The data set to be transformed.

- Source model (mandatory, if cannot be determined from the input data). The model in which the input data is provided.
- Target model (mandatory). The model in which the results are expected.
- Model mapping (mandatory, unless a default exists). Detailed description of how the transformation is to be carried out.

**DS Requirement 4** Data conformant to the application schema(s) defined in section 5.2 shall be encoded using the encoding(s) specified in this section.

**Recommendation 8** It is recommended that also the encodings specified in this section be provided for the relevant application schemas.

## 9.2 Encodings

### 9.2.1 Default Encoding(s)

#### 9.2.1.1. Default encoding for application schema <application schema name>

Encoding information is not provided in this version of the standard

# 10 Data Capture

There is no specific guidance required with respect to data capture.

# 11 Portrayal

This clause defines the rules for layers and styles to be used for portrayal of the spatial object types defined for this theme.

In section 11.1, the *types* of layers are defined that are to be used for the portrayal of the spatial object types defined in this specification. A view service may offer several layers of the same type, one for each dataset that it offers on a specific topic.

Section 11.2 specifies the default styles to be used for each of these layer types, while section **Error! Reference source not found.** specifies other well-defined styles.

Where XML fragments are used in these sections, the following namespace prefixes apply:

- sld="http://www.opengis.net/sld" (WMS/SLD 1.1)
- se="http://www.opengis.net/se" (SE 1.1)
- ogc="http://www.opengis.net/ogc" (FE 1.1)

| | |
|---|---|
| **IR Requirement 12** | If an INSPIRE view services supports the portrayal of data related to the theme *Geology*, it shall provide layers of the types specified in this section. |

| | |
|---|---|
| **DS Requirement 5** | If an INSPIRE view network service supports the portrayal of spatial data sets corresponding to the spatial data theme *Geology*, it shall support the default styles specified in the tables in this section.<br><br>If no user-defined style is specified in a portrayal request for a specific layer to an INSPIRE view service, the default style specified in this section for that layer shall be used. |

| | |
|---|---|
| **DS Requirement 6** | If an INSPIRE view service supports the portrayal of spatial data sets corresponding to the spatial data themes *Geology*, apart from the default styles specified in Section 11.2, it shall also support the well-defined styles specified in this section. |

## 11.1 Layer types for the spatial data theme *Geology*

The Geology theme is represented with a number of layers. The organization has not yet been decided but a first proposal is:

For Geology:

- Geologic Units
- Geologic Structures
- Geomorphologic Units
- Hydrogelogic Units

| **Layer Type** | **Layer Title** | **Spatial object type(s)** | **Keywords** |
|---|---|---|---|
| Geology.GeologicUnit | Lithology / Geologic Age (1) | GeologicUnit | rock, lithology, petrology, rock age, geochronology |
| Geology.GeologicStructure | Geologic Structure | GeologicStructure | geologic contact, geologic structure |
| Geology.GeomorphologicUnit | Geomorphological Type | GeomorphologicUnit | geomorphology, landform |
| Geology.HydrogeologicUnit | Aquifer Type | HydrogeologicUnit | hydrogeology, aquifer |
| Geology.GroundwaterBody | GWB Status | GroundwaterBody | hydrogeology |

(1) A Geologic Unit could be protrayed according to several properties. The main ones are lithology and age. It is not yet decided how this will be managed for INSPIRE.

Completed by geophysics:

| **Layer Type** | **Layer Title** | **Spatial object type(s)** | **Keywords** |
|---|---|---|---|
| Geophysics. GeophStation | Geophysical Station | GeophStation | geophysics, gravimetry, magnetometry |
| Geophysics. GeophProfile | Geophysical Profile | GeophProfile | geophysics, airborne geophysics, seismics, borehole logging |
| Geophysics. GeophMeasurement3D | 3D Geophysical Measurement | GeophMeasurement3D | geophysics, seismics |
| Geophysics. GeophCurveModel | Curve Model | CurveModel | geophysics, borehole logging, layer model |
| Geophysics. GeophSurfaceModel | Surface Model | SurfaceModel | geophysics, vertical section, horizontal section, vertical grid, horizontal grid, seismic depth section, seismic depth horizon |
| Geophysics. Geoph.SolidModel | Solid Model | SolidModel | geophysics, solid grid model, seismic block |

| | | | |
|---|---|---|---|
| Geophysics. GeophSurvey | Geophysical Survey | GeophSurvey | geophysics, gravimetry, magnetometry, seismics, borehole logging, airborne geophysics |

## 11.2 Default styles for the spatial data theme *Geology*

The default style for Geology is not yet available, but some proposals exist in the OneGeology-Europe project for surface and bedrock geology. Geologic units are portrayed according to their lithology (a proposal from the project is available adopted by 20 Geological Surveys in Europe), or to their age (a standard exists from ICS - International Chart of Stratigraphy, completed by the project).
The project has also proposals for Geologic structures.

## 11.3 Layers organisation

None.

# Bibliography

[DS-D2.3] INSPIRE DS-D2.3, Definition of Annex Themes and Scope, v3.0, *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.3_Definition_of_Annex_Themes_and_scope_v3.0.pdf*

[DS-D2.5] INSPIRE DS-D2.5, Generic Conceptual Model, v3.1, *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.5_v3.1.pdf*

[DS-D2.6] INSPIRE DS-D2.6, Methodology for the development of data specifications, v3.0, *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.6_v3.0.pdf*

[DS-D2.7] INSPIRE DS-D2.7, Guidelines for the encoding of spatial data, v3.0, *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.7_v3.0.pdf*

[ISO 19101] EN ISO 19101:2005 Geographic information – Reference model (ISO 19101:2002)

[ISO 19103] ISO/TS 19103:2005, Geographic information – Conceptual schema language

[ISO 19107] EN ISO 19107:2005, Geographic information – Spatial schema (ISO 19107:2003)

[ISO 19108] EN ISO 19108:2005 Geographic information - Temporal schema (ISO 19108:2002)

[ISO 19111] EN ISO 19111:2007 Geographic information - Spatial referencing by coordinates (ISO 19111:2007)

[ISO 19115] EN ISO 19115:2005, Geographic information – Metadata (ISO 19115:2003)

[ISO 19118] EN ISO 19118:2006, Geographic information – Encoding (ISO 19118:2005)

[ISO 19135] EN ISO 19135:2007 Geographic information – Procedures for item registration (ISO 19135:2005)

[ISO 19139] ISO/TS 19139:2007, Geographic information – Metadata – XML schema implementation

[OGC 06-103r3] Implementation Specification for Geographic Information - Simple feature access – Part 1: Common Architecture v1.2.0

# Annex A
(normative)

# Abstract Test Suite

Any dataset conforming to this INSPIRE data specification shall meet all requirements specified in this document.

NOTEA common abstract test suite including detailed instructions on how to test each requirement will be added at a later stage.

# Annex B
(informative)
# Use Cases for Geology and Aquifers

## B.1 Introduction
This document is a collection of use cases for Geology and Mineral Resources defined from the analysis of Examples of use.

## B.2 Use cases for Geology
Geological information is mainly collected or produced to be used by other thematic domains (geo-hazard assessment, ensuring safe disposal of wastes, providing construction material, …) as described in the document "Examples of use".

### *B.2.1 UC01: Providing geological data to detect geo-hazards*
This use case is related to example of use:
- GE-02: Detecting geo-hazards.

#### B.2.1.1 Overview and involved actors
This use case is a part of a more general use case which provides risk maps in a process that involves many other data than geological data (like meteorological data, elements at risk, …) in the disaster management cycle.
The goal of this use case is therefore to deliver geological data to the engineer responsible for establishing risk maps.

Actors:
- Geological surveys to provide geological information (Geological Surveys represent the Member States)
- Engineers responsible for establishing risk maps using the geological information in combination with other data.

#### B.2.1.2 Narrative description
The hazard is often defined as the probability of occurrence of a potentially damaging phenomenon within a given area and a given period of time. To define this probability the engineer has to access data describing the physical, chemical, mechanical properties of rocks.

#### B.2.1.3 Detailed description

| **Use case description** | |
|---|---|
| Name | Providing geological data to detect geo-hazards |
| Priority | High |
| Description | The user selects the relevant geographic area and search for geological data: geological map, borehole data, and geotechnical data. |
| Pre-condition | Geological data are available in line with INSPIRE specifications. A specific vocabulary related to the user requirements is available with a "mapping" between geological terms and user's terms (done by the data provider?). |
| Flow of events – Basic path | |
| Step 1 | The user selects on a geo-portal the area of interest and search in a metadata catalogue for geological maps with lithological and |

| | |
|---|---|
| | structural information. |
| Step 2 | The user displays the geological map and accesses detailed information about the geologic units (lithology) and structures (existing faults) |
| Step 3 | The user searches in a metadata catalogue for borehole data with information about geologic unit thickness and depth, water level, physical and chemical properties |
| Step 4 | The user accesses the borehole data to get the values of the properties. |
| Step 5 | The user searches in a metadata catalogue for geotechnical data related to the area (existing measurements), or geotechnical properties related to the lithology in general. |
| Step 6 | The user accesses the geotechnical data to get the values of the properties. |
| | |
| Flow of events – Alternative path | |
| | |
| | |
| | |
| Post-conditions | |
| Post-condition | The user has a set of geological data related to the selected area. |
| Data source: *INSPIRE-conformant Geology data set provided by Member Sate* | |
| Description | Geological data from national sources. |
| Data provider | Each Member State |
| Geographic scope | All EU Member States, with appropriate cross border cooperation where necessary |
| Thematic scope | Geology |
| Scale, resolution | Scale relevant to the application (tbd) |
| Delivery | INSPIRE Geology GML Application schema |
| Documentation | INSPIRE Geology Data Specification |

### B.2.1.4 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:

Geological units with:
- their related polygons
- lithology

Geologic structures (faults) with:
- their related lines
- attribute: active or non-active

Borehole data with:
- geologic unit thickness and depth
- water level
- any other properties (physical and chemical) measured

Geotechnical data with:
- data related to the geologic units (from measurements: porosity, …)
- or values related to the rock types in general

### B.2.1.5 Relationship with other INSPIRE Themes

This use case has some relationships with the following INSPIRE data themes:

- Soils: the geotechnical properties are those of the rocks but also of the soil on a “continuous column”.
- Natural Risk Zones: Geology is a provider of information about underground to engineers who has to define the risk zones.

## B.2.2 UC02: Providing geological data to ensure safe disposal of waste

This use case is related to example of use:

- GE-03: Ensuring the safe disposal of wastes, Nuclear Waste, Carbon Capture and Storage.

### B.2.2.1 Overview and involved actors

This use case is a part of a more general use case which provides geological data in a process that involves many other data than geological data (like population distribution, land use …) in the waste disposal management cycle. It is relevant for the disposal of many different kinds of waste in various geological environments. The goal of the use case is to deliver geological data to the authorities and companies responsible for safe disposal of waste.

Actors:

- Geological surveys to provide geological data (Geological Surveys represent the Member States)
- Authorities and companies responsible for safe disposal of waste using the geological data in combination with other data.

### B.2.2.2 Narrative description

“Safe disposal” usually means that the waste is placed in the bedrock or in unconsolidated superficial deposits at some depth (< 2 500 meters) below the surface. Depending on the nature of the waste the actual site of disposal is either in a natural space (e.g. pore space) or in man-made space (e.g. excavation or bore hole). Examples of waste are burned nuclear fuel and carbon dioxide. Geological data is needed to build a 3D-model that is used and refined during all stages of the waste disposal process: site selection, planning, characterization, construction, and follow-up program.

### B.2.2.3 Detailed description

| **Use case description** | |
|---|---|
| Name | Providing geological data to ensure safe disposal of waste |
| Priority | High |
| Description | The user selects the relevant geographic area and searches for geological data from the surface and underground: geological map, borehole data, groundwater data, geophysical and geochemical data. |
| Pre-condition | Geological data are available in line with INSPIRE specifications. |
| Flow of events – Basic path | |
| Step 1 | The user selects on a geo-portal the area of interest and searches in a metadata catalogue for geological maps with lithological and structural information. |
| Step 2 | The user displays the geological map and accesses detailed information about the geologic units (lithology etc) and structures (existing faults) |
| Step 3 | The user searches in a metadata catalogue for mineral resource data with information about location of known mineral deposits |
| Step 4 | The user displays the mineral resource data and accesses detailed information about the deposits |

| | |
|---|---|
| Step 5 | The user searches in a metadata catalogue for geophysical data with information about seismicity and survey data |
| Step 6 | The user displays the geophysical data and accesses detailed information about the geophysical expression of the rocks |
| Step 7 | The user searches in a metadata catalogue for borehole data with information about geologic unit thickness and depth, water level, physical and chemical properties, fracture properties |
| Step 8 | The user accesses the borehole data to get the values of the properties. |
| Step 9 | The user searches in a metadata catalogue for groundwater data with information about groundwater flow and groundwater chemistry |
| Step 10 | The user accesses the groundwater data to get the values of the properties. |
| | |
| Flow of events – Alternative path | |
| | |
| | |
| | |
| Post-conditions | |
| Post-condition | The user has a set of geological data for 3D-modelling of the selected area. |
| Data source: *INSPIRE-conformant Geology data set provided by Member Sate* | |
| Description | Geological data from national sources. |
| Data provider | Each Member State |
| Geographic scope | All EU Member States, with appropriate cross border cooperation where necessary |
| Thematic scope | Geology |
| Scale, resolution | National to local |
| Delivery | INSPIRE Geology GML Application schema |
| Documentation | INSPIRE Geology Data Specification |

### B.2.2.4 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:

Geological units with:
- their related spatial objects
- lithology, mineralogical composition, chemical composition, age, contact relationships, alteration

Geologic structures (faults) with:
- their related spatial objects
- attribute: active or non-active

Mineral resource data
- location of mineral deposits

Geophysical data
- seismicity
- survey data (magnetic, electromagnetic, gravity, elevation)

Borehole data with:
- location of bore holes
- geologic unit thickness and depth
- water level
- mineralogical and chemical composition of rocks

- porosity, permeability, temperature, fracture pressure, capillary pressure
- fracture frequency, fracture fillings

Groundwater data
- location of wells
- groundwater flow
- groundwater chemistry

### B.2.2.5 Relationship with other INSPIRE Themes

This use case some relationships with the following INSPIRE data themes.

- Environmental monitoring facilities: Aquifer monitoring stations, seismicity networks
- Protected sites: Groundwater protection
- Elevation: Digital elevation models

## B.2.3 UC03: Providing geological data to detect ground instability in a flat area

This use case is related to example of use:
- GE-02: Detecting geo-hazards.

### B.2.3.1 Overview and involved actors

This use case is a very particular case which provides risk maps in a process that involves many other data than geological data (like use of the subsurface data, elements at risk…) in the land and urban management cycle.

The goal of this use case is to deliver geological data to the responsible for land and urban planning. These data should then be merged with other related data, in order to construct a basic framework which allows classifying areas according to its hazard and risk levels. From this, further specific works, at the scale of the project, should be developed.

Actors:
- Geological surveys to provide geological information, including hazard assessment, if available (Geological Surveys represent the Member States)
- Mining Authorities to provide information on active and abandoned underground activities
- Geological Surveys and/or Water Authorities to provide information on groundwater
- Responsible for establishing risk maps using the geological information in combination with other data.
- Land and urban planners

### B.2.3.2 Narrative description

Land and urban planning need to know the ground stability for safe infrastructure development.

In flat areas, ground instabilities are mainly related to:

- The existence of soluble lithologies in the subsurface (i.e. evaporites: gypsum or salt; carbonates…)
- The existence of sand and gravel deposits, loess, peat, shrinking and swelling clays, and other unconsolidated materials, including artificial landfills.
- The variations in the water table (natural and induced by artificial activities)
- The existence of a (melting) permafrost
- The presence of mining, gas production, subsurface infrastructures and other anthropic underground structures, both active and abandoned
- The seismic activity

Some surface features, as are dolines, some kind of depressions, or other landforms, can be indications of ground instability.

The three first groups of data (lithologies, unconsolidated deposits and hydrogeological data) and the surface features indicating ground instability (geomorphological elements) are geological data and the rest are related data.

(The hazard is often defined as the probability of occurrence of a potentially damaging phenomenon within a given area and a given period of time. To define this probability the engineer (?) has to access data describing the physical, chemical, mechanical properties of rocks).

### B.2.3.3 Detailed description

| **Use case description** | |
|---|---|
| Name | Providing geological data to detect ground stability in a flat area |
| Priority | High |
| Description | The user views the geographic work area and search for geological data (geological map, borehole data, geotechnical data) and other related data (presence of mining, gas production, subsurface infrastructures and other anthropic underground activities, both active and abandoned; presence of permafrost; seismological zoning) |
| Pre-condition | Geological and the other related data are available in line with INSPIRE specifications. A specific vocabulary related to the user requirements is available with a “mapping” between geological terms and user’s terms (done by the data provider). |
| Flow of events – Basic path | |
| Step 1 | The user selects on a geo-portal the area of interest and search in a metadata catalogue for geological maps with lithological, structural and geomorphological information. |
| Step 2 | The user displays the geological map and accesses detailed information about the geologic units (rock type, including unconsolidated natural materials and anthropogenic deposits or landfills), the landforms (indices of collapse structures), hydrogeological (watertable) and tectonic structures (existing faults) |
| Step 3 | The user searches in a metadata catalogue for borehole data with information about geologic unit thickness and depth (including artificial landfills), water level, physical and chemical properties |
| Step 4 | The user accesses the borehole data to get the values of the properties. |
| Step 5 | The user searches in a metadata catalogue for geotechnical data related to the area (existing measurements), or geotechnical properties related to the materials in general. |
| Step 6 | The user accesses the geotechnical data to get the values of the properties. |
| Step 7 | The user downloads all the selected information to his computer and makes a specific map of the work area |
| | |
| Flow of events – Alternative path | |
| | |
| | |
| | |
| Post-conditions | |
| Post-condition 1 | The user has a set of geological data related to the selected area (a specific geological map). |
| Post-condition 2 | The same user (or a different user involved in the land and urban |

| | |
|---|---|
| | management) merges the geological information with the other related data and constructs a map which will be the basis for further specific, on site works, at the scale of the project. |
| Data source: *INSPIRE-conformant Geology and other related data set provided by Member Sate* | |
| Description | Geological and other related data from national sources. |
| Data provider | Each Member State |
| Geographic scope | All EU Member States, with appropriate cross border cooperation where necessary |
| Thematic scope | Geology |
| Scale, resolution | Scale relevant to the application (tbd) |
| Delivery | INSPIRE Geology GML Application schema |
| Documentation | INSPIRE Geology Data Specification |

### B.2.3.4 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:

Geological units, including artificial unconsolidated deposits, with:
- their related polygons
- lithology

Geologic structures (contacts (primary = original, and secondary = mechanical: faults) with:
- their related lines
- their related indications of dip and dip direction
- landforms (collapse structures, dolines)
- attribute: active or non-active

Borehole data with:
- geologic unit thickness and depth
- water level
- any other properties (physical and chemical) measured

Geotechnical data with:
- data related to the geological units (from measurements: porosity, …)
- or values related to the rock types in general

### B.2.3.5 Relationship with other INSPIRE Themes

This use case has some relationships with the following INSPIRE data themes:
- Soils: the geotechnical properties are those of the rocks but also of the soil on a “continuous column”.
- Natural Risk Zones: Geology is a provider of information about underground to engineers who have to define the risk zones.
- Energy
- Several aspects from Annex I

## B.2.4 UC04: Looking for deep fractured zones in the basement (Geothermal exploration)

This use case is related to example of use:

- GE-12: Use of geophysics.

### B.2.4.1 Overview and involved actors

This use case is part of a more general use case of providing access to public geophysical information for users interested in mineral or geothermal exploration.
The goal of this use case is to demonstrate the interoperability between geological, borehole and geophysical data services.

Actors:

- Geological surveys to provide geological information
- Geophysicists responsible for establishing
- Geothermal exploration company (user)

### B.2.4.2 Narrative description

.
In order to find an optimum location for a geothermal drilling the user is looking for data resources related to deep fractured zones in a specific geological unit. Borehole locations are identified in a GIS search and then a specific borehole is selected. From the list of geological units crossed by the borehole the one related to the carboniferous basement is selected and the related observations are examined. From the observation results a geophysical resistivity cross section is selected. If it is freely available the user can download the online resource, otherwise the distributor is contacted and the data is purchased.

### B.2.4.3 Detailed description

| **Use case description** | |
|---|---|
| Name | Looking for deep fractured zones in the basement |
| Priority | High |
| Description | |
| Pre-condition | Geological data are available in line with INSPIRE specifications. |
| Flow of events – Basic path | |
| Step 1 | The user selects „**borehole**” from the **catalogue of available features** on the geoportal. |
| Step 2 | Starts a BBOX search for boreholes in the target area |
| Step 3 | Locates a borehole and opens it |
| Step 4 | Identifies a **geologicUnit** from the list of **features of interest** and opens it. (basement) |
| Step 5 | Selects a **physical property** (conductivity) of the geologicalUnit and opens the list of related **observations** |
| Step 6 | The results of the selected observation is a **geophysical model** (2D MT conductivity profile showing the resistivity variations of the basement) |
| Step 7 | The user opens the coverage in a 3D viewer |
| | |
| Flow of events – Alternative path | |
| Step 7 | The user checks the **distribution metadata** of the model and finds the link to the data provider |
| Step 8 | Data provider is contacted and the results are purchased |
| | |
| Post-conditions | |
| Post-condition | |
| Data source: *INSPIRE-conformant Geology data set provided by Member Sate* | |

| | |
|---|---|
| Description | Geological data from national sources. |
| Data provider | Each Member State |
| Geographic scope | All EU Member States, with appropriate cross border cooperation where necessary |
| Thematic scope | Geology |
| Scale, resolution | Scale relevant to the application (tbd) |
| Delivery | INSPIRE Geology GML Application schema |
| Documentation | INSPIRE Geology Data Specification |

### B.2.4.4 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:

Borehole data with:
- geologic unit thickness and depth
- water level
- any other properties (physical and chemical) measured

Geological units crossed by the borehole with:
- their physical properties (conductivity) and related observations

Geophysical objects:
- geophysical method type, location, distribution metadata
- geophysical cross section, online resource, distribution metadata

### B.2.4.5 Relationship with other INSPIRE Themes

This use case has some relationships with the following INSPIRE data themes:
- Mineral resources – for exploration
- Energy resources – for the Geothermal potential

## B.2.5 UC05: Checking background radiation level changes

This use case is related to example of use:
- GE-12: Use of geophysics.

### B.2.5.1 Overview and involved actors

This use case is part of a more general use case of providing access to public geophysical information for users interested in the physical state of environment and the impact of industrial contaminations. The goal of this use case is to demonstrate the importance of access to geophysical monitoring data in order to locate large areas affected by possible radioactive contamination.

Actors:
- Environment agency (user)
- Geophysicists responsible for establishing

### B.2.5.2 Narrative description

After a nuclear power plant accident an environment agency analyses the impact of the possible radioactive contamination and collects information on the changes of background radiation intensity. The INSPIRE geoportal is used to locate airborne geophysical surveys that acquired total gamma radiation data over large areas before and after the accident. The results are compared and the areas showing significant changes are outlined for further inversitation.

### B.2.5.3 Detailed description

| **Use case description** | |
|---|---|
| Name | Checking background radiation level changes |
| Priority | High |
| Description | |
| Pre-condition | Geological data are available in line with INSPIRE specifications. |
| Flow of events – Basic path | |
| Step 1 | The user starts a BBOX search for airborne **geophysical surveys** carried out before the accident in the target area |
| Step 2 | The user locates a survey and checks the measured **physical parameters** |
| Step 3 | If the list of physical parameters include total gamma radiation the user checks the **distribution metadata** of the model and finds the link to the data provider |
| Step 4 | The user starts a BBOX search for airborne **geophysical surveys** carried out after the accident in the target area |
| Step 5 | The user locates a survey and checks the measured **physical parameters** |
| Step 6 | If the list of physical parameters include total gamma radiation the user checks the **distribution metadata** of the model and finds the link to the data provider |
| Step 7 | Data provider is contacted and the results are purchased |
| Step 8 | Radiation maps are compared and anomalous areas are selected for further investigation |
| Post-conditions | |
| Post-condition | |
| Data source: *INSPIRE-conformant Geology data set provided by Member Sate* | |
| Description | Geological data from national sources. |
| Data provider | Each Member State |
| Geographic scope | All EU Member States, with appropriate cross border cooperation where necessary |
| Thematic scope | Geology |
| Scale, resolution | Scale relevant to the application (tbd) |
| Delivery | INSPIRE Geology GML Application schema |
| Documentation | INSPIRE Geology Data Specification |

### B.2.5.4 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:

Geophysical Survey:
- geometry, geophysical method type (airborne geophysics), list of measured physical parameters (total gamma radiation)
- distribution metadata

### B.2.5.5 Geophysical features

From the use cases there is a request for three main types of geophysical features. These are:

- **Geophysical measurement**
- **Geophysical model**
- **Geophysical survey**

**Geophysical measurement**

Geophysical measurements are used to collect information on the boundary of the observed features. According to the geometry of their sampling characteristics three subtypes has to be defined: stations, profiles and 3D measurements.

- Station (sampling point). Examples: magnetic station, gravity station, vertical electric sounding, seismology monitoring station, magnetotelluric station, etc.
- Profile (sampling curve). Examples: seismic profile, flight line, borehole log, multielectrode DC profile, etc.
- 3D measurment (sampling surface). Examples: 3D seismics, 3D multielectrode measurements (DC tomography), etc.

Measurement data itself is subject of analysis done by experts, and therefore it is not in the scope of INSPIRE. Important attributes of geophysical measurements are location, geometry, geophysical method type, and metadata, especially distribution information.

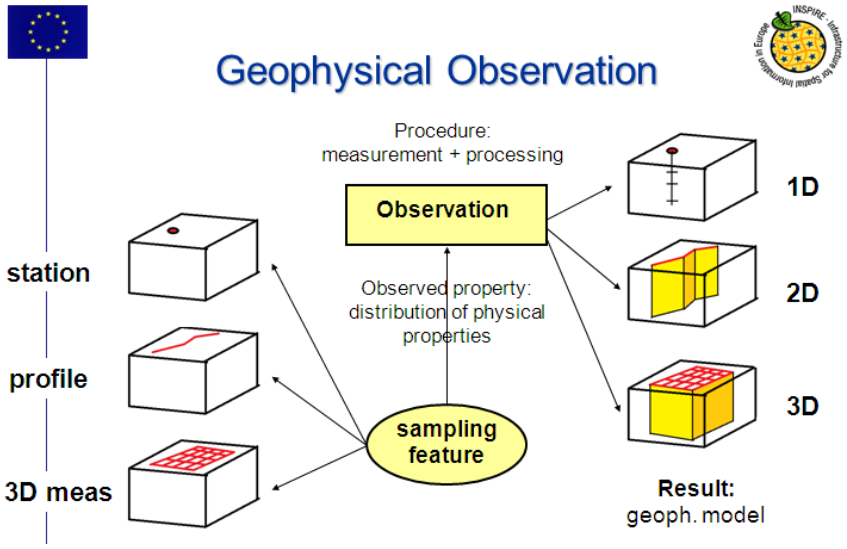



*figure 1. Geophysical features and the O&M model*

**Geophysical model**

Geophysical models are results of processing data collected by geophysical measurements. Models represent spatial distribution of physical parameters within the observed feature, and can be described as standard coverages. According to their spatial characteristics the following subtypes has to be defined:

Discrete models:

- Curve model (discrete curve coverage). Example: geoelectric layer model
- Surface model (discrete surface coverage). Example: horizontal and vertical cross sections, (cross section of geoelectric layers)
- Solid model (discrete solid coverage). Example: a conductive 3D body in a resistive host

Discrete grid models:

- Surface grid model (2D grid coverage) Example: cross sections, depth horizons, (seismic depth section, resistivity cross section)
- Solid grid model (3D grid coverage) Example: seismic 3D block, DC tomography

Geophysical processing is an observation through sampling, where the sampled feature is the measured data, the result is the distribution of the observed property. We can also say that the sampled feature is the earth, because the result contains earth properties at the sampling locations (figure 1.).

**Geophysical survey**

Geophysical exploration surveys may include large number of measurements over large areas. The individual measurements may not be important for the user, but the existence, type, and availability of their results are essential. Surveys are defined as polygon features with the most important attributes of the related survey, like geophysical method types, measured physical properties metadata, especially distribution information.

### B.2.5.6 Relationship with other INSPIRE Themes

This use case has some relationships with the following INSPIRE data themes:

- Human health – for identifying areas with different level of hazard caused by increased background radiation intensity
- Natural risk zones – to register hazardous areas with increased background radiation intensity

## B.2.6 UC06: Providing data to undertake water balance to ensure compliance with the WFD

This use case is related to example of use:

- AQ-01: Water supply (water abstraction).

### B.2.6.1 Overview and involved actors

The goal of this use case is therefore to deliver hydrogeological data to professionals responsible for establishing whether groundwater bodies are over or under abstracted according to the WFD. Examples of the professionals include regulators such as the Environment Agency of England and Wales.

Actors:

- Geological surveys to provide geological information (Geological Surveys represent the Member States)
- Other hydrometric organizations to provide relevant hydrological data, e.g. rainfall
- Professionals responsible for ensuring compliance with the WFD, e.g. regulator in each member state.
- Professionals responsible for establishing water supply system, for local government to support water management decision process as well as individual investors.
- Water modelers.

### B.2.6.2 Narrative description

The WFD requires that a groundwater body has “good status” in that it is not over abstracted. In order to ensure that a groundwater body is not over abstracted, then a water balance needs to be undertaken. The various inputs and outputs to the system need to be quantified and the balance calculated. Importantly the proportion of abstraction compared to recharge to the aquifer has to be determined. The water balance is created for an Assessment Point (AP) for each sub-catchment.

### B.2.6.3 Detailed description

| **Use case description** | |
|---|---|
| Name | Providing data to undertake water balance to ensure compliance with the WFD |
| Priority | High |
| Description | The user selects the relevant geographic area and searches for hydrogeological and hydrological data: abstraction, baseflow, springflow, rainfall, potential evaporation. |
| Pre-condition | Hydrogeological and hydrometric data are available in line with |

| | |
|---|---|
| | INSPIRE specifications. A specific vocabulary related to the user requirements is available with a “mapping” between hydrogeological terms and user’s terms. |
| Flow of events – Basic path | |
| Step 1 | The user selects on a geo-portal the area of interest and searches in a metadata catalogue for hydrogeological maps and other relevant hydrological data. |
| Step 2 | The user displays the hydrogeological map and accesses detailed information about the groundwater resources location (useful groundwater aquifers) and hydrogeological parameters (potential discharge of the well, drawdown) |
| Step 3 | The user searches in a metadata catalogue for relevant hydrological data. |
| Step 4 | The user accesses the hydrological data to get the values of the properties and combines them with the hydrogeological data to perform a water balance for the required AP. |
| Step 5 | The user uploads the water balance back into a portal to provide information at the AP. |
| | |
| Flow of events – Alternative path | |
| | |
| | |
| | |
| Post-conditions | |
| Post-condition | The user has a set of hydrogeological and hydrometric data related to the selected area as well as a water balance for the relevant AP. |
| Data source: *INSPIRE-conformant Geology data set provided by Member Sate* | |
| Description | Hydrogeological and hydrological data from national sources. |
| Data provider | Each Member State |
| Geographic scope | All EU Member States, with appropriate cross border cooperation where necessary |
| Thematic scope | Geology |
| Scale, resolution | Scale relevant to the application (tbd) |
| Delivery | INSPIRE Geology GML Application schema |
| Documentation | INSPIRE Geology Data Specification |

### B.2.6.4 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:

Hydrogeological units with:
- their related polygons
- potential discharge
- water table depth
- aquifer type
- rock lithology

Well data in relation to borehole with:
- geologic unit thickness and depth
- water level
- any other properties (physical and chemical) measured

Generally to create water balance two main information are needed:
- Recharge (rainfall, river infiltration, river vanish point)
- Discharge – groundwater abstraction (water well, effluent stream, spring or seep)

Vanishing point, spring and seep are objects of interest in Hydrography DS (Annex I)

### B.2.6.5 Relationship with other INSPIRE Themes

This use case has some relationships with the following INSPIRE data themes:
- Hydrology: HydroPointOfInterest
- Geology: the geologic property of an aquifer

Groundwater Unit is an object in GWML in relation to Geologic Unit in GeoSciML. Although to describe aquifer the more precise information is expected. The GWML object structure may be use as pointed at figure bellow (pink). Those object allow to define type aquifer water table (confined, unconfined).

## B.2.7 UC07: Groundwater reporting for WFD

This use case is related to example of use:
- AQ-05: Groundwater quality and quantity assessment.

### B.2.7.1 Overview and involved actors

The implementation of the WFD requires the handling of spatial data both for the preparation of the River Basin Management Plans and for the reporting to the Commission.
Article 15 of the Water Framework Directive (WFD) requires Member States to provide information to the European Commission concerning the river basin management plans (RBMP). The RBMP covers, among others a general description of the characteristics of the river basin district (RBD) required under Article 5 and Annex II WFD including the mapping of the location and boundaries of groundwater bodies (GWB) (Annex VII, WFD).
Recommendation for the form and scope of spatial information deliver under the WFD and the Groundwater Directive (GWD) were presented in “Updated Guidance on Implementing the Geographical Information System (GIS) Elements of the EU Water policy”.
Member States are obliged to deliver necessary data to fulfill Water Information System of Europe (WISE) managed by European Environmental Agency (EEA).

Actors:
- Geological surveys to provide geological information (Geological Surveys represent the Member States)
- Member States Environmental Agencies or other bodies responsible for reporting
- European Environmental Agencies (EEA)

### B.2.7.2 Narrative description

GWBs according to Article 2.12 WFD are defined as “a distinct volume of groundwater within an aquifer or aquifers”. Thus GWBs are three-dimensional. For the time being it is not possible to represent WBs three-dimensionally in geographic information systems as there are, in most cases, not enough data available to develop three-dimensional models of GWBs. Thus the representation of the feature will be as two-dimensional polygons.

The spatial data concerning GWB is a basis for general maps produce:
- Map 1: Quantitative status – Identification of bodies that are at “good quantitative status” and those that are at “poor quantitative status”;
- Map 2: Achievement/exceedance of standard for nitrates (value in Annex 1 of GWD or set according to paragraph 3 of Annex 1 GWD, and according to status assessment procedure in Article 4 of GWD);
- Map 3: Achievement/exceedance of standard for pesticides (combined total and individual value in Annex 1 of GWD or set according to paragraph 3 of Annex 1 GWD, and according to status assessment procedure in Article 4 of GWD);
- Map 4: Achievement/exceedance of threshold values set by Member States for other pollutants (considering in this category the list of substances as contained in Part B of Annex II of GWD and more generally any other pollutants contributing to the characterisation of groundwater bodies as being 'at risk', and according to status assessment procedure in Article 4 of GWD);

- Map 5: Trends - Identification of: (a) groundwater bodies with environmentally significant and sustained upward trends in pollutant concentrations, and (b) groundwater bodies in which trends have been reversed;

GIS data submitted by Member States will be also used to produce a **WISE Reference GIS dataset of groundwater bodies** by the EEA or its contracted partners.
GWBs provided by Member States will be merged into one dataset taking into account the description of the submitted GWBs (layered, depth range, aquifer type etc.) to produce a consistent dataset.

### B.2.7.3 Detailed description

| **Use case description** | |
|---|---|
| Name | Providing groundwater data to WISE reporting |
| Priority | High |
| Description | The Member States are obliged to deliver Groundwater Bodies and Groundwater monitoring information to European Environment Agency (EEA) for Water Management Plans |
| Pre-condition | Hydrogeological data are available in line with INSPIRE specifications. The Reporting schema provide a framework for water related reporting(Water Framework Directive). Format of reporting sheets is defined in Water Information System for Europe (WISE) hosted by EEA |
| Flow of events – Basic path | |
| Step 1 | The user selects on a geo-portal the area of interest and search in a metadata catalogue for groundwater maps with groundwater bodies. |
| Step 2 | The user displays the groundwater map and accesses detailed information about the groundwater bodies (status) and monitoring stations (quality and quantity) |
| Step 3 | The user searches in a metadata catalogue for groundwater monitoring station data with information about aquifer unit thickness and depth, water level, physical and chemical properties |
| Step 4 | The user accesses the monitoring station data to get the values of the properties. |
| | |
| Flow of events – Alternative path | |
| | The user (EEA) selects on a geo-portal the area of interest and search in a metadata catalogue for groundwater maps with groundwater bodies and monitoring stations |
| | The user (EEA) displays the groundwater map and accesses detailed information about the groundwater bodies (status) and monitoring stations (quality and quantity) |
| | |
| Post-conditions | |
| Post-condition | The user has a set of groundwater data related to the selected area. |
| Data source: *INSPIRE-conformant Geology data set provided by Member Sate* | |
| Description | Groundwater data from national sources. |
| Data provider | Each Member State |
| Geographic scope | All EU Member States, with appropriate cross border cooperation where necessary |
| Thematic scope | Geology |
| Scale, resolution | Scale relevant to the application (tbd) |
| Delivery | INSPIRE Geology GML Application schema |
| Documentation | INSPIRE Geology Data Specification |

### B.2.7.4 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:

The following data were requested as a minimum to be provided for each GWB (under Reporting sheet GWB1):

- Unique code;
- Name (if available);
- X co-ordinate (Longitude) of the centroid of the GWB;
- Y co-ordinate (Latitude) of the centroid of the GWB; and
- Size (surface area ($m_2$), unique identifier for the horizon where separate overlying bodies exist and, if possible, volume of aquifer ($m_3$).

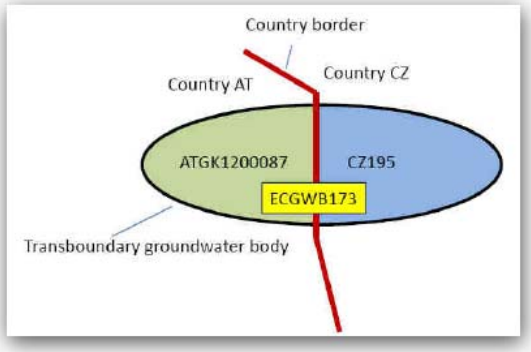
This was translated into the reporting schemas as follows:

| Field | Data Type | Size | Obligation | Description |
|---|---|---|---|---|
| EU_CD | Text | 42 | mandatory | Unique code for GWB at European level |
| MS_CD | Text | 40 | mandatory | Unique code for the GWB within the MS |
| LAT | Text | 9 | mandatory | Latitude of the centre of the GWB in ETRS89 projection |
| LON | Text | 9 | mandatory | Longitude of the centre of the GWB in ETRS89 projection |
| AREA | Double | | mandatory | GWB1: Total surface area of the water body in sq km |
| NAME | Text | 100 | optional | Locally used name for GWB |
| TRANSBOUNDARY | Text | 1 | optional | Does the groundwater body crass a country border |
| CAPACITY | Double | | optional | Capacity of GWB in m3 |
| HORIZON | Double | | optional | Groundwater horizon when separate overlaying GWB exist |
| LAYERED | Text | 1 | optional | Indicator for groundwater bodies with deeper relevant layers 0 = no deeper layers 1 = deeper aquifer layers |
| OUT_OF_RBD | Text | 1 | optional | Indicator if any part of GWB falls outside RBD |

In addition to the IDs assigned by Member States (MS_CD), unique IDs will be generated at EC level (EU_CD) to uniquely identify groundwater bodies in the WISE Reference GIS dataset. This is necessary to identify and visualise **transboundary GWBs**. With the IDs assigned by Member States only the Member State part of transboundary GWBs can be identified.

The structure of the WISE code will be defined by the data provider of the reference dataset according to the specifications given in the WISE GIS guidance document, second edition. The data provider will be the EEA or its contracted partner.

The following diagram illustrates a fictive example of MS GWB-IDs and European (WISE) GWBIDs for a transboundary groundwater body.




*There is a transboundary GWB between AT and CZ. Both Member States delineate the national parts of the transboundary GWBs and assign IDs (EUGroundwaterBodyCode=ATGK1200087, CZ195). The boundaries of the GWB are harmonised at the country border and the GWBs are marked as transboundary. At EU level it will be identified which Member State parts of transboundary GWBs belong together and unique IDs for the total GWB will be assigned (ECGWB173).*

To develop a more consistent picture of groundwater bodies it will be necessary to get information on aquifer types and the 3-dimensional characteristics of GWBs, as they might overlay each other.

GIS data to be reported for each groundwater body are specified in Guidance Document: Guidance for reporting under the Water Framework Directive (see Chapter 13). This data will allow the description and visualisation of GWBs and groups of GWBs. Furthermore the parameter horizon should also be characterised according to the groundwater body layer (e.g. alluvial deposit layer, “main” layer, deep horizon (cenoman), thermal or mineral water).

The definition of the parameter “**horizon**”, which will be used in the sense of the numerical position of groundwater body layer (e.g. 1 for the first horizon from the surface, 2 for the second horizon from the surface, 3 for the third horizon from the surface, 4 for fourth and deeper horizons from the surface).

The following attributes should be reported for each GWB

- Water body code
- Water body name
- Shape/GML file
  - Groundwaters: boundaries of all groundwater bodies or groups of groundwater bodies identified.
- For groundwater bodies or groups of groundwater bodies, if available:
  - Layered (Y/N)
  - Average depth to groundwater body (m)
  - Average thickness of groundwater body (m)
  - Assignment to a depth range where the main part of the GWB is situated in (depth ranges: 0-20m, 20-50 m, 50-200 m, >200m)
  - Directly dependent aquatic ecosysteRBD (Y/N)
  - Directly dependent terrestrial ecosysteRBD (Y/N)
  - Geological formation – aquifer type (according to a predefined typology)
  - Type of vertical orientation of GWB (indicated by category and visualised by symbols)
  - Volume of aquifer (m3) (if possible)
- Relevant point source discharges to groundwater
  - ID of significant point sources where data already available
  - Latitude and longitude of each relevant point source (if possible)
  - Type of point source (see GWPI3)
- Relevant diffuse source pollution to groundwater bodies
  - WB Affected? (Y/N)
  - Type of source (see GWPI4)
- Relevant abstractions from groundwater
  - WB Affected? (Y/N)
  - Latitude and longitude of each abstraction (if possible)
  - Type of abstraction (see GWPI5)
- Relevant artificial recharge of groundwater
  - WB Affected? (Y/N)
  - Type of Regulation/Alteration (see GWPI6)
- Significant saltwater or other intrusion

  - o WB Affected? (Y/N)
- Other pressures
  - o WB Affected? (Y/N)
  - o Type of Pressure (to be specified see GWPI8)
- Impacts
  - o Type of impact identified (see GWPI9)
- Protected areas
  - o Water body within or overlapping with a protected area (Y/N)
  - o Type of protected area (provide a shape file only where information is NOT reported under any other Directive. Where information has been provided under other Directives provide the unique identifier (code) of the appropriate protected area)

For WISE reporting it is expected that except the GroundWater bodies the Groundwater monitoring station location will be required for reporting.

### B.2.7.5 Relationship with other INSPIRE Themes

This use case has some relationships with the following INSPIRE data themes:

- Hydrography (HY): GWB is a subset of Water Body class which is the main element in WFD directive reporting as well as base information for Water Management Plans analyzes (water balance)..
- Area management/restriction/regulation zones and reporting units (AM): there is a important relation between GWB and water related reporting units
- Environmental Monitoring Facilities (EF): location and characteristics of Groundwater monitoring facilities will be provided by EF specification, but the link to GW monitoring measurement method and properties is needed in Geology DS

## B.2.8 UC08: Providing hydrogeological data to define significant pressure

This use case is related to example of use:

- AQ-04: Protecting ecosystems dependent on groundwater

### B.2.8.1 Overview and involved actors

The goal of this use case is therefore to deliver hydrogeological data to professionals responsible for biological diversity

Actors:

- Geological surveys to provide geological information (Geological Surveys represent the Member States)
- Professionals responsible for biological diversity.
- Soil experts

### B.2.8.2 Narrative description

Groundwater dependent ecosystems (GDE) are a diverse and important component of biological diversity. The term GDE takes into account ecosystems that use groundwater as part of survival, and can potentially include wetlands, vegetation, mound springs, river base flows, cave ecosystems, playa lakes and saline discharges, springs, mangroves, river pools, billabongs and hanging swamps. The groundwater dependence of ecosystems will range from complete reliance to those that partially rely on groundwater, such as during droughts. The degree and nature of dependency will influence the extent to which ecosystems are affected by changes to the groundwater system, both in quality and quantity. The EU Water Framework Directive (WFD) requires those terrestrial ecosystems dependent on groundwater be identified and the anthropogenic pressures acting on the ecosystems analysed.

### B.2.8.3 Detailed description

| **Use case description** | |
|---|---|
| Name | Managing the positive role aquifers play in supporting ecosystems |
| Priority | High |
| Description | The user selects the relevant geographic area and search for hydrogeological data: hydrogeological map (groundwater table level) and well data (geological profile) to estimate the risks associated with groundwater abstraction pressures on the condition of groundwater dependent ecological features. |
| Pre-condition | Hydrogeological data are available in line with INSPIRE specifications. A specific vocabulary related to the user requirements is available with a “mapping” between hydrogeological terms and user’s terms (done by the data provider?). |
| Flow of events – Basic path | |
| Step 1 | The user selects on a geo-portal the area of interest and search in a metadata catalogue for hydrogeological maps with groundwater bodies information. |
| Step 2 | The user displays the hydrogeological map and accesses detailed information about the groundwater bodies location, useful groundwater aquifers and hydrogeological parameters (potential discharge of the well, regional discharge pressures, drawdown) |
| Step 3 | The user searches in a metadata catalogue for well data with information about geologic unit thickness and depth, water level changes, groundwater quality (physical and chemical properties) |
| Step 4 | The user accesses the well data to get the values of the properties. |
| | |
| Flow of events – Alternative path | |
| | |
| | |
| | |
| Post-conditions | |
| Post-condition | The user has a set of hydrogeological data related to the selected area and is able to analyse data to provide information for decision makers. |
| Data source: *INSPIRE-conformant Geology data set provided by Member Sate* | |
| Description | Hydrogeological data from national sources. |
| Data provider | Each Member State |
| Geographic scope | All EU Member States, with appropriate cross border cooperation where necessary |
| Thematic scope | Geology |
| Scale, resolution | Scale relevant to the application (tbd) |
| Delivery | INSPIRE Geology GML Application schema |
| Documentation | INSPIRE Geology Data Specification |

### B.2.8.4 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:

Hydrogeological units with:

- their related polygons
- potential discharge
- water table depth
- rock lithology

The dependency of ecosystems on groundwater is based on some basic groundwater attributes :

- flow or flux - the rate and volume of supply of groundwater;
- level - for unconfined aquifers, the depth below surface of the water table;
- pressure - for confined aquifers, the potentiometric head of the aquifer and its expression in groundwater discharge areas;
- quality - the chemical quality of groundwater expressed in terms of pH, salinity and/or other potential constituents, including nutrients and contaminants.

### B.2.8.5 Relationship with other INSPIRE Themes

This use case has some relationships with the following INSPIRE data themes:

- Bio-geographical Regions, Habitats and Biotopes, Species Distribution (BR, HB, SD): existence of some ecosystems in strong plant and animal communities relations with groundwater system.
- Geology (GE): the geologic property of an aquifer
- Soil (SO): changing soil moisture level can cause drought
- Sea region (SR): saline or other intrusion changing ecosystem condition
- Land Use (LU)

## B.2.9 UC09: Providing data to assess Corrosivity to Underground Assets

This use case is related to example of use:
- AQ-07: Groundwater as a hazard

### B.2.9.1 Overview and involved actors

The goal of this use case is therefore to deliver hydrogeological and geochemical data to professionals responsible for operating underground assets such as water pipes and building foundations to establish whether corrosion will occur and degrade the asset sufficient to cause a leakage, etc.
Actors:

- Geological surveys to provide geological information (Geological Surveys represent the Member States)
- Other organizations to provide relevant geochemical data, e.g. concentration of sulphates/sulphides.
- Professionals responsible for assessing risk of corrosivity to underground assets, i.e. pipeline operators, etc.

### B.2.9.2 Narrative description

Underground assets, such as iron pipes, concrete foundations are at risk from corrosion due to chemical attack from solutes found in groundwater and leached from the rock they are in contact with. To provide an understanding of areas where the potential for corrosion is greatest, then the relevant data need to be brought together and an assessment undertaken of the potential for corrosion. By combining hydrogeologcial and geochemical data then the likelihood of corrosion occurring to the underground asset can be quantified and maps produced to inform operators of these assets to be informed.

### B.2.9.3 Detailed description

| **Use case description** | |
|---|---|
| Name | Providing data to assess Corrosivity to Underground Assets |
| Priority | Medium |
| Description | The user selects the relevant geographic area and searches for hydrogeological and geochemical data: depth to water table, geochemical information - sulphate/sulphides, pH, moisture content, organic carbon and resistivity. |

| | |
|---|---|
| Pre-condition | Hydrogeological and geochemical data are available in line with INSPIRE specifications. A specific vocabulary related to the user requirements is available with a “mapping” between hydrogeological terms and user’s terms. |
| Flow of events – Basic path | |
| Step 1 | The user selects on a geo-portal the area of interest and searches in a metadata catalogue for geological maps and other relevant hydrogeological and geochemical data. |
| Step 2 | The user displays the hydrogeological map and accesses detailed information about the groundwater system (depth to water table and moisture content), rock properties (resistivity) and geochemistry (pH, Organic Carbon and sulphate/sulphide concentration) |
| Step 3 | The user accesses the relevant data to get the values of the properties and combines them to produce potential corrosion maps for each type of asset. |
| Step 4 | The user uploads the gridded data back into a portal to provide information for the operator of the asset. |
| | |
| | |
| Flow of events – Alternative path | |
| | |
| | |
| | |
| Post-conditions | |
| Post-condition | The user has a set of hydrogeological and geochemical data related to the selected area as well as a map of potential corrosivity.. |
| Data source: *INSPIRE-conformant Geology data set provided by Member Sate* | |
| Description | Hydrogeological and geochemical data from national sources. |
| Data provider | Each Member State |
| Geographic scope | All EU Member States, with appropriate cross border cooperation where necessary |
| Thematic scope | Geology |
| Scale, resolution | Scale relevant to the application (tbd) |
| Delivery | INSPIRE Geology GML Application schema |
| Documentation | INSPIRE Geology Data Specification |

### B.2.9.4 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:

Hydrogeological units with:
- their related polygons
- water table depth
- rock lithology

Unsaturated zone data:
- moisture content

Geochemical data:
- pH
- Sulphate/sulphide concentration

Geophysical data:
- Resistivity of the rocks

### B.2.9.5 Relationship with other INSPIRE Themes

This use case has some relationships with the following INSPIRE data themes:

- Soils: moisture content:
- Geology: the geologic property of an aquifer

To understand corrosivity, it is important to quantify groundwater flow and solute transport, therefore data for groundwater quantity and quality need to be available.

The majority of groundwater measurements are undertaken at a well, therefore the WaterWell feature type needs to be included.

## B.2.10 UC10: Providing data to plan tunneling operations safely and effectively

This use case is related to example of use:

- AQ-07: Groundwater as a hazard

### B.2.10.1 Overview and involved actors

The goal of this use case is therefore to deliver hydrogeological data to professionals responsible for tunneling operations.

Actors:

- Geological surveys to provide geological information (Geological Surveys represent the Member States)
- Other organizations to provide relevant hydrogoelogical data, e.g. groundwater level.
- Professionals responsible for planning and undertaking tunneling operations.

### B.2.10.2 Narrative description

Tunneling is an activity that required suitable knowledge of the geological and hydrogeological conditions to be undertaken safely and cost effectively. Knowledge of the ground conditions that are likely to be encountered is very important to ensure that the correct tunnel boring techniques are used and that the operations are conducted in a safe a way as possible. Understanding of the saturation of the deposits being tunnelled through is equally important to ensure the safe undertaking of underground working. Therefore, building a 3D understanding of the geology combined with the variation of groundwater heads is important in planning any tunneling operation.

### B.2.10.3 Detailed description

| **Use case description** | |
|---|---|
| Name | Providing data to plan tunneling operations safely and effectively |
| Priority | Medium |
| Description | The user selects the relevant geographic area and searches for geological and hydrogeological data. The geological data will be used to construct a 3D model |
| Pre-condition | Geological and hydrogeological data are available in line with INSPIRE specifications. A specific vocabulary related to the user requirements is available with a “mapping” between hydrogeological terms and user’s terms. |
| Flow of events – Basic path | |
| Step 1 | The user selects on a geo-portal the area of interest and searches in a metadata catalogue for geological maps and other relevant hydrogeological data. |
| Step 2 | The user accesses a DTM, borehole data and other relevant data to produce a 3D geological model. |
| Step 3 | The user displays the hydrogeological map and accesses detailed information about the groundwater system (water table and moisture content). |
| Step 4 | The user accesses the relevant data to get the values of the properties and combines them with the 3D geolgocial model to produce the required understanding of rock properties and moisture content to plan the tunneling activities. |
| Step 5 | The user uploads the 3D geological model with groundwater data back into a portal to provide information for the tunneling organisation. |
| | |
| | |
| Flow of events – Alternative path | |

| | |
|---|---|
| | |
| | |
| | |
| Post-conditions | |
| Post-condition | The user has a 3D geological model and a set of hydrogeological data related to the selected area. The can be combined to produce a 4D understanding of groundwater flow. |
| Data source: *INSPIRE-conformant Geology data set provided by Member Sate* | |
| Description | Hydrogeological and geochemical data from national sources. |
| Data provider | Each Member State |
| Geographic scope | All EU Member States, with appropriate cross border cooperation where necessary |
| Thematic scope | Geology |
| Scale, resolution | Scale relevant to the application (tbd) |
| Delivery | INSPIRE Geology GML Application schema |
| Documentation | INSPIRE Geology Data Specification |

### B.2.10.4 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:

Topographic data:
- DTM

Geological data:
- Borehole logs
- 2D maps
- Previously created cross sections

Hydrogeological units with:
- their related polygons
- water table depth
- rock lithology

Unsaturated zone data:
- moisture content

### B.2.10.5 Relationship with other INSPIRE Themes

This use case has some relationships with the following INSPIRE data themes:
- Soils: moisture content:
- Elevation: DTM
- Geology: the geologic property of an aquifer

To understand water movement around any underground structure, it is important to quantify groundwater flow, therefore data for groundwater quantity need to be available.

The majority of groundwater measurements are undertaken at a well, therefore the WaterWell feature type needs to be included.

# Annex C
(informative)
# Proposed Codelists/Vocabularies

## *C.1 Introduction*

In geology many properties are controlled by vocabularies with a large number of values. In addition it is common for different organisations to use different vocabularies, and mapping from these internal vocabularies to common ones can involve significant scientific effort and probable loss of semantic resolution. Fotr these reasons for the time being codelists for many properties have not been incorporated into the specification. This Annex list possible codelists for some properties in the specification.

### C.1.1 Proposed codelists

Observation method:

- Borehole cuttings observation
- Borehole geophysical log measurements
- Data from single published description
- Digital conversion from published source
- Drill core observation, estimated values
- Outcrop observation, estimated values
- Remotely sensed data
- Synthesis from multiple sources

Composition part role:

- Bed lithosome
- Blocks
- Concretion
- Cyclic bedding package
- Enclave
- Facies
- Geologic unit matrix
- Inclusion
- Irregular lithosome
- Layer lithosome
- Lenticular lithosome
- Lithosome
- Marker bed
- Only part
- Part of
- Pendants
- Rafts
- Roof pendant
- Screen
- Stratigraphic part
- Tectonic block
- Unspecified part role
- Vein or dike lithosome
- Xenolith

Composition part lithology:

The code list is too long to be included in this document. The lithologies can be found on https://www.seegrid.csiro.au/subversion/CGI_CDTGVocabulary/tags/SKOSVocabularies/SimpleLithology201001.rdf

Fault type:
- Detachment fault
- Dextral strike slip fault
- Extraction fault
- Fault
- High angle reverse
- High-angle fault
- High-angle normal fault
- Horizontal fault
- Left normal fault
- Left reverse fault
- Low angle fault
- Low-angle normal fault
- Mixed extraction fault
- Normal fault
- Oblique slip fault
- Pure extraction fault
- Reverse fault
- Right normal fault
- Right reverse fault
- Scissor fault
- Sinistral strike slip fault
- Strike slip fault
- Thrust fault
- Wrench fault

Geodynamic environment:
- Structural
- Volcanic
- Gravitational
- Fluvial
- Glacial, periglacial and nival
- Aeolian
- Lacustrine
- Litoral
- Chemical weathering
- Miscellaneous
- Artificial (Anthropic)

Landform type:
- Structural surfaces
- Area with intense bedrock jointing
- Caldera edge
- Dome
- Neck
- Fissure with fumarole
- Mud volcano
- Lava flow direction
- Lava emersion from a lava tunnel
- Hornito
- Bombs
- Debris talus
- Rock fall
- Slide scar
- Hill creep
- Solifluction
- Linear incision
- Badlands
- Floodplain

- Terrace escarpment
- Glacial cirque
- Overexcavation basin
- Abrasion surface
- Drumlin
- Erratic block
- Cryoplanation surface
- Head avalanche escarpment
- Avalanche flow direction
- Gelifluction area
- Stone pavement
- Permafrost boundary
- Melting permafrost
- Direction of the dominant wind
- Deflaction basin
- Dune field
- Reg/Stone pavement
- Endoreic area
- Longshore drift
- Abrasion platform
- Tidal flat
- Tidal channel
- Doline/Sinkhole
- Polje boundary
- Blind valley
- Boundary intense karstification area
- Karren/Lapiaz
- Corrosion surface
- Natural bridge
- Granite blockfield
- Isolated granite block
- Area with chemical weathering
- Subsidence area
- Erosion surface
- Artificial escarpment
- Quarry
- Restored quarry
- Landfill/mine spoil (Made ground)
- Heavily artificial disturbed surface
- Artificial depression
- Reclaimed land (from a lake or the sea)

Named age:

The code list is too long to be included in this document. The ages can be found on https://www.seegrid.csiro.au/subversion/CGI_CDTGVocabulary/tags/SKOSVocabularies/ICS_TimeScale2008.rdf

In OneGeology Europe this was complemented with a list of informal Precambrian epochs to account for the large Precambrian areas in northern Europe. see “Explanatory Notes for the vocabulary to describe spatial geological data in Europe at a 1:1 million scale” (document available in circa, folder Data Specifications of Geology theme – GE: . *http://circa.europa.eu/Members/irc/jrc/imaco2000/library?l=/drafting_folders/data_specifications/thematic_working/geology_resourcesge-mr/data_specifications/explanatory_notespdf/_EN_1.0_&a=i*

Geologic event name (for Europe, provided by the OneGeology-Europe project):

- Alpine (Late Alpine, Middle Alpine, Early Alpine)
- Variscan (Late Variscan, Middle Variscan, Early Variscan)
- Caledonian
- Cadomian
- Sveconorwegian

- Hallandian
- Gothian
- Svecokarelian
- Archean

Event environment:
- Abandoned river channel setting
- Above carbonate compensation depth setting
- Abyssal setting
- Active continental margin setting
- Active spreading center setting
- Aeolian process setting
- Algal flat setting
- Alluvial fan
- Alluvial plain
- Anoxic setting
- Arid or Semi Arid environment setting
- Back arc setting
- Backreef setting
- Barrier beach setting
- Barrier island coastline setting
- Barrier lagoon setting
- Basin bog
- Basin plain setting
- Bathyal setting
- Beach setting
- Below carbonate compensation depth setting
- Biological reef setting
- Blanket bog
- Bog setting
- Braided river channel setting
- Carbonate dominated shoreline setting
- Cave
- Coastal dune field setting
- Coastal plain setting
- Collisional setting
- Contact metamorphic origin
- Continental borderland setting
- Continental crust
- Continental rift setting
- Continental shelf setting
- Crust
- Cutoff meander setting
- Deep sea trench
- Delta distributary channel setting
- Delta distributary mouth setting
- Delta front
- Delta plain
- Deltaic system setting
- Dunefield setting
- Earth interior setting
- Earth surface setting
- Englacial setting
- Epicontinental marine setting
- Estuarine delta setting
- Estuarine lagoon setting
- Estuary setting
- Extended terrane setting
- Extra-terrestrial origin
- Fast spreading center setting

- Floodplain setting
- Forearc setting
- Foreland setting
- Forereef setting
- Gibber plain setting
- Glacial outwash plain setting
- Glacier lateral setting
- Glacier related setting
- Glacier terminus setting
- Hadal setting
- High pressure low temperature Earth interior setting
- Hillslope setting
- Hinterland tectonic setting
- Hot spot setting
- Humid temperate climatic setting
- Humid tropical climatic setting
- Hypabyssal setting
- Inactive spreading center
- Inner neritic setting
- Interdistributary bay setting
- Intertidal setting
- Intraplate tectonic setting
- Lacustrine delta setting
- Lacustrine setting
- Lagoonal setting
- Low energy shoreline setting
- Low pressure high temperature setting
- Lower bathyal setting
- Lower continental crust
- Lower delta plain setting
- Lower mantle
- Lower oceanic crustal setting
- Mantle
- Marginal marine sabkha setting
- Marine carbonate platform setting
- Marine setting
- Meandering river channel setting
- Medium-rate spreading center setting
- Mid ocean ridge setting
- Middle bathyal setting
- Middle continental crust setting
- Middle neritic setting
- Mud flat setting
- Neritic setting
- Ocean highland setting
- Oceanic crust
- Oceanic plateau setting
- Outer neritic setting
- Passive continental margin setting
- Pediment setting
- Piedmont slope system setting
- Plate margin setting
- Plate spreading center setting
- Playa setting
- Polar climatic setting
- Prodelta setting
- Proglacial setting
- Reef flat setting
- Regional metamorphic origin
- River channel setting

- River plain system setting
- Rocky coast setting
- Sand plain setting
- Seamount setting
- Shoreline settings
- Slope-rise setting
- Slow spreading center setting
- Strandplain setting
- Subaerial setting
- Subaqueous setting
- Subduction zone setting
- Subglacial setting
- Submarine fan setting
- Supraglacial setting
- Supratidal setting
- Swamp or marsh setting
- Tectonically defined setting
- Terrestrial setting
- Tidal channel setting
- Tidal flat setting
- Tidal marsh setting
- Tidal setting
- Transform plate boundary setting
- Transitional crust
- Ultra high pressure crustal setting
- Upper bathyal setting
- Upper continental crustal setting
- Upper delta plain setting
- Upper mantle
- Upper oceanic crustal setting
- Volcanic arc setting
- Wetland setting

Event process:

- accretion
- alteration
- biological precipitation
- biological weathering
- bolide impact
- chemical precipitation
- chemical weathering
- cometary impact
- contact metamorphism
- continental breakup
- continental collision
- debris flow deposition
- deep water oxygen depletion
- deformation
- deformation twinning
- deposition
- deposition from moving fluid
- diagenetic process
- diffusion creep
- dislocation metamorphism
- dissolution
- dissolution creep
- ductile flow
- effusive eruption
- erosion
- eruption

- excavation
- extinction
- faulting
- folding
- fracturing
- frost shattering
- geologic process
- geomagnetic process
- grading
- haloclasty
- hawaiian eruption
- human activity
- hydration
- hydrolysis
- ice erosion
- intrusion
- magmatic crystallisation
- magmatic process
- magnetic field reversal
- mass wasting
- mass wasting deposition
- material transport and deposition
- mechanical deposition
- melting
- metamorphic process
- meteorite impact
- microfracturing
- obduction
- organic accumulation
- orogenic process
- oxidation
- partial melting
- physical weathering
- plinian eruption
- polar wander
- pressure release weathering
- pyroclastic eruption
- rifting
- sea level change
- sea level fall
- sea level rise
- sedimentary process
- shearing
- speciation
- spreading
- strombolian eruption
- subduction
- tectonic process
- thermal shock weathering
- transform faulting
- turbidity current deposition
- vulcanian eruption
- water erosion
- weathering
- wind erosion
-