INSPIRE
Infrastructure for Spatial Information in Europe

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

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Change Log

Version	Changed Sections	Changes made
2.9	All	Text has been updated to reflect comments
	4 Data content	Data model has been significantly changed to reflect comments. The GeologyCore has been simplified and separated from GeoSciML; the Hydrogeology has been modified and simplified; Geophysics has been modified to reflect comments
	10 Portrayal	Significant updates and extension
	Annex D	The data model extensions will be documented in Annex D but this section is not yet ready
	Annex E	The codelists have been updated in light of the comments

Foreword
How to read the document?

This document describes the *"INSPIRE data specification on Geology – Guidelines"* version 2.9.0 as developed by the Thematic Working Group (TWG) *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 using the experience from the development of the Annex I data specifications.

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 *Geology* 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 *Geology.*

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 and descriptions of selected use cases 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 utilised and referenced, whenever possible.

To facilitate the implementation of INSPIRE, it is important that all stakeholders have the opportunity to participate in 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] and participated in the public

[1] For all 34 Annex I,II and III data themes: 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] The current status of registered SDICs/LMOs is available via INSPIRE website: *http://inspire.jrc.ec.europa.eu/index.cfm/pageid/42*

[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 II and III themes have been composed of experts from Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Netherlands, Norway, Poland, Romania, Slovakia, Spain, Sweden, Switzerland, Turkey, UK, the European Commission, and the European Environmental Agency

stakeholder consultations on draft versions of the data specifications. These consultations covered expert reviews as well as feasibility and fitness-for-purpose testing of the data specifications[6].

This open and participatory approach was successfully used during the development of the data specification on Annex I data themes as well as during the preparation of the Implementing Rule on Interoperability of Spatial Data Sets and Services[7] for Annex I spatial data themes.,

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 five technical documents:

- The Definition of Annex Themes and Scope[8] 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[9] 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[10] 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"[11] 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.

- The "Guidelines for the use of Observations & Measurements and Sensor Web Enablement-related standards in INSPIRE Annex II and III data specification development" provides guidelines on how the "Observations and Measurements" standard (ISO 19156) is to be used within INSPIRE.

The structure of the data specifications is based on the "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[12].

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

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[6] For Annex II+III, the consultation phase lasted from 20 June to 21 October 2011.
[7] Commission Regulation (EU) No 1089/2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services, published in the Official Journal of the European Union on 8th of December 2010.
[8] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.3_Definition_of_Annex_Themes_and_scope_v3.0.pdf*
[9] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.5_v3.3.pdf*
[10] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.6_v3.0.pdf*
[11] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.7_v3.2.pdf*
[12] UML – Unified Modelling Language

19100 series, the INSPIRE Generic Conceptual Model, and the application schemas[13] 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 application areas targeted by the Directive. Once finalised (version 3.0), the data specifications are published as technical guidelines and provide the basis for the content of the Implementing Rule on Interoperability of Spatial Data Sets and Services[14]. The content of the Implementing Rule is extracted from the data specifications keeping in mind short- and medium-term feasibility as well as cost-benefit considerations. The requirements included in the Implementing Rule will be legally binding for the Member States according to the timeline specified in the INSPIRE Directive.

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.

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

[14] In the case of the Annex II+III data specifications, the extracted requirements will be used to formulate an amendment to the existing Implementing Rule.

Geology – Executive Summary

Include the executive summary of the spatial data theme Geology.

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 most important natural resources, the water, through groundwater bodies contained in aquifers. Geomorphology describes the Earth’s present-day surface, and the processes creating its geometry.

The use of geological data

Geological data are used in various domains related to the surface and underground knowledge of the geological environment: 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 of the 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.

How geoscientists could provide this useful information?

Geological information provides basic knowledge about the physical properties and composition of the geologic materials (rocks and sediments) outcropping at the land’s surface and forming the underground, and about their structure and their age. 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 is also provided.

The main product delivered by geologists for the users is a geological map which is the result of an **interpretation** of the observations and measurements made on rocks and sediments, on and under the surface. Because the rocks forming the subsurface are visible or accessible only on very small parts of the surface, the outcrops, the geologists have to interpret these observations and measurements to group rocks in geologic units, and to connect other information observed locally to identify the general geological structure. 3D geological models are also being developed both at a regional scale and at a very local scale.

At the outcrops (locations where rocks are visible), geologists make direct observations of the rocks and measurements of their structure, and take samples. The analyses of samples provides values for physical properties, as well as information on the chemical and mineralogical composition of the rocks, and data relative to their age.

Geophysical surveys provide values of physical properties of rocks (like density, porosity, magnetic susceptibility, …), regardless their organization as geologic units. Geophysical boundaries may or may not coincide with geological boundaries, depending on the changes of physical properties within and outside the geological units. Geophysics provides extra - quite often the only - information on the organization of the units in the subsurface. These results are processed by geophysicists to deliver the spatial distribution (1D, 2D or 3D) of the property. The spatial property distributions are then interpreted by geologists to build geological models of the subsurface for instance to detect hydrocarbon bearing structures or zones of mineral resources.

Boreholes are another important source of information for interpreting the subsurface geology. These can provide a stratigraphic and lithological log, analogous to a vertical geological map, and can also be used to gather samples and make measurements of various properties at depth.

Geochemistry surveys, geochemical measurements and analyses provide information about the chemical composition of samples. Satellite images, aerial photographs and other airborne surveys are

used to improve the outlines of geologic units, geologic structures, and geomorphologic features. Boreholes provide knowledge about the underground, and according to the reasons rationale by which a borehole is made, some or many rock properties are observed or measured.

All this information is interpreted to make the geological map, and in some cases 3D models. The landforms (geomorphologic features) are often indicated on general geological maps, and are detailed on specific, applied geomorphological maps.

Which geological data to provide through INSPIRE?

Several main categories of data could be identified:

- Geological and geophysical observations and measurements,
- Boreholes,
- The lithology (type of rock) and composition of rocks and samples, collected from them,
- Models of properties values (variations in space of a property value) made from observations and measurements,
- Geological interpretation based on observations and measurements, in the form of maps and models.

The users of Geology in INSPIRE are mainly geoscientists of other data themes (of Annex III) as Mineral Resources, Natural Risk Zones, Soil, Energy resources, and the identified use cases request to deliver various geological information. The TWG suggests to deliver this information with a **core data model** for the basic knowledge, and to use the **extension model** to meet requirements from the use cases with more properties.
Some domains of Geology are not addressed by this INSPIRE model as they are for geologists, but the GeoSciML data model, developed by the community of geologists, can be used for these domains.

The core data model contains the main Geologic Features (Geological Units, Geological Structures, and Geomorphologic Features). The geometry of these features is described in Mapped Features, the geometry of which is included in geological maps and profiles in the form of points, lines and polygons. The data model describes also some information about boreholes, geophysical measurements, and models; and features related to aquifers and groundwater.

The extension data model contains more properties of the same features described in the core model.

In this version of data specification we do not provide a data model to deliver raw data like geophysical raw data, geochemical data, geomechanical data, and borehole observations and measurements. The ISO standard Observations and Measurements could be used by data providers to deliver such data.
3D Geological models of properties values (variations in space of a property value in the form of grid coverages) are not taken into account.

Basic geological knowledge and applied maps

As mentioned above, Geology is used by other thematic domains which are interested only in some properties of the underground (to prevent landslides, to insure safe disposal of wastes, …). Geological surveys provide the knowledge they have about the Earth. A process must be run by Geological Surveys or thematic experts to transform this basic knowledge into specific maps (named applied maps) required by thematic users. As very often the needs of thematic users concern local area, the basic knowledge must be completed by new data related to specific properties (for example to know the porosity of the local rocks to contribute to the assessment of a landslide).

The INSPIRE Geology model provides elements to build applied maps but does not describe these applied features.

Aquifers and groundwater bodies

Hydrogeology describe the flow, condition of occurrence and behavior of water in underground environment. It is a science located between hydrology and geology, while both have a strong influence on the groundwater resources creation. Hydrological processes are responsible e. g. for

quantity of water supply by the recharge area to aquifers. On the other hand the physical properties and composition of the geologic materials (rocks and sediments) create the main environment for groundwater flow and storage, rocks and sediments also influent on groundwater quality in terms of their chemical composition.

The main idea of INSPIRE model for groundwater is to identify two basic elements: the rock system (including aquifers, dependent on the geological condition) and the groundwater system (including groundwater bodies), completed by hydrogeological objects (as water wells). See annex C for a detailed description of this domain.

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Other contributors to the INSPIRE data specifications are the Drafting Team Data Specifications, the JRC data specifications team and the INSPIRE stakeholders - Spatial Data Interested Communities (SDICs) or Legally Mandated Organisations (LMOs).

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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.

2 Overview

2.1 Name

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 (mineralogical 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

- are reflected by their physical properties (e.g. density, porosity, and mechanical, magnetic, electrical, seismic and hydraulic properties)
- influence geological processes (genesis, fracturing, alteration)
- control the properties of aquifers
- control the morphology of the landscape
- control their use as a natural resources
- determine their behavior 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 and its dynamics (genesis and involved processes).

The analysis of reference material and examples of use shortly described in the executive summary 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.

This specification identifies two kind of application schemas of Geology:

- The **core schema**: able to provide the basic geological knowledge on an area, with a limited number of attributes,
- The **extension schema**: able to provide the basic geological knowledge but also more attributes describing rock composition and structure to meet requirements from use cases.

The core data model contains:

- Geologic Features with Geologic Events, Geologic Units, Geologic Structures, and Geomorphologic Features. The geometry of these features is described in Mapped Features, the geometry of which is included in geological maps and profiles in the form of points, lines and polygons. Mapped Features and Boreholes can be bundled in Collections,
- The lithology of rock units,
- The processes of Geologic Events and their environments and ages
- The types of Shear Displacement Structures and Folds
- Borehole details, such as location and purpose,
- Geophysical measurements, and models.

The extension model contains:

- more properties about e.g. Geologic Features and Boreholes with use of GeoSciML,
- a seismic example as an example of the use of Observations & Measurements.

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

[ISO19157] ISO/DIS 19157, Geographic information – Data Quality

[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

[Regulation 2000/60/EC] 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

[Regulation 2006/118/EC] 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

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

2.4 Terms and definitions

General terms and definitions helpful for understanding the INSPIRE data specification documents are defined in the INSPIRE Glossary[15].

Specifically, for the theme Geology, the following terms are defined: (delete if no additional terms are defined)

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

(<running number>) <Term>
<definition>

NOTE <note> *(delete as appropriate)*

EXAMPLE <example> *(delete as appropriate)*

(1) GeologicFeature
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"

(2) MappedFeature
A MappedFeature is part of a geological interpretation. It provides a link between a notional feature (description package) and one spatial representation of it, or part of it. (Exposures, Surface Traces and Intercepts, etc) * the 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.

(3) Geologic Unit
Operationally, the GeologicUnit element is a container used to associate geologic properties with some mapped occurrence. 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).

(4) Geologic Structure
Geologic Structure, for the INSPIRE context, considers faults (as fault type terms) and folds (as foldProfileTypeterms).
A Fault is defined as 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.
Fold profile type terms contain terminology specifying concave/convex geometry of fold relative to earth surface, and relationship to younging direction in folded strata if known.

(5) Hydrogeologic Unit
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.

(6) Aquifer
An Aquifer is 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. 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.

2.5 Symbols and abbreviations

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.

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

TG 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 X	Recommendations are shown using this style.

2.7 Conformance

TG 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 does not distinguish different specification scopes, but just considers one general scope.

NOTE For more information on specification scopes, see [ISO 19131:2007], clause 8 and Annex D.

4 Identification information

NOTE Since the content of this chapter was redundant with the overview description (section 2) and executive summary, it has been decided that this chapter will be removed in v3.0.

5 Data content and structure

The data specification for ‘Geology’ covers three sub-domain areas: Geology, Geophysics and Hydrogeology. Geomorphology is included in the Geology sub-domain. The Geology domain data specification is based closely on GeoSciML (http://www.geosciml.org/) which has been incorporated into the INSPIRE foundation schema. 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).

Geology, Hydrogeology and Geophysics sub-domains have a core and an extension application schema. The core schema for the Geology sub-domain is designed to provide the basic information required to meet the use cases described in Annex B, whereas the extension schema allows the provision of more detailed information on Geologic Structures, Boreholes, Geological Age, and Physical Properties.

Geophysics has a long history of international industry standards. Methods extensively used in the hydrocarbon industry, like seismic and borehole logging have their strong standards that are used worldwide by global exploration companies. The Society of Exploration Geophysicists (SEG) takes the responsibility of developing and maintaining international geophysical standards. On the other hand, there are a large number of methods widely used in geological and environmental studies, mineral, geothermal, building material exploration that do not have real standards and suffer from the abundance of ad hoc formats and the difficulties of data exchange.

Geophysics has just started to move to the direction of ISO and OGC standards and it will take time before this process leads to a generic schema based standard such as GeoSciML in geology, or CSML in climate science. Due to the large number of techniques and application fields the world of geophysical data management is very heterogeneous, and creating a generic data model is extremely difficult.

The INSPIRE geophysics application schemas try to respond to the user requirements defined in the use cases and to minimize the load on data providers in creating and maintaining INSPIRE conformant data systems. The GeophysicsCore application schema is mainly restricted to location and basic metadata of the most important geophysical features. The GeophysicsExtension application schema provides a wider range of classes to help share geophysical results with the public.

This data specification defines the following application schemas:

- The GeologyCore application schema
- The GeophysicsCore application schema
- The HydrogeologicCore application schema

IR Requirement 1 Need to list also extensions here ??
IR Requirement 2
IR Requirement 3
Spatial data sets related to the theme Geology shall be made available using the spatial object types and data types specified in the following application schema(s): GeologyCore, GeophysicsCore, HydrogeologyCore

These spatial object types and data types shall comply with the definitions and constraints and include the attributes and association roles defined in this section.

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 [DS-D2.5] for more details.

In addition to the application schemas listed in 0, additional application schemas have been defined for the theme Geology. These additional application schemas typically address requirements from specific (groups of) use cases and/or may be used to provide additional information. They are included in this specification in order to improve interoperability also for these additional aspects.

Recommendation 2
Additional and/or use case-specific information related to the theme *Geology* should be made available using the spatial object types and data types specified in the following application schema(s): GeologyExtension, GeophysicsExtension, HydrogeologyExtension

These spatial object types and data types should comply with the definitions and constraints and include the attributes and association roles defined in this section.

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 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 [DS-D2.5]. These are explained in Table 1 below.

Table 1 – Stereotypes (adapted from [DS-D2.5])

Stereotype	Model element	Description
applicationSchema	Package	An INSPIRE application schema according to ISO 19109 and the Generic Conceptual Model.
leaf	Package	A package that is not an application schema and contains no packages.
featureType	Class	A spatial object type.
placeholder	Class	A class that acts as a placeholder for a class, typically a spatial object type, that will be specified in the future as part of another spatial data theme. The class should at least have a definition, but may otherwise have a preliminary or no specification (see section 5.1.2).
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 code list.
import	Dependency	The model elements of the supplier package are imported.
voidable	Attribute, association role	A voidable attribute or association role (see section 5.1.3).
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.

5.1.2 Placeholder and candidate types

Some of the INSPIRE Annex I data specifications (which were developed previously to the Annex II+III data specifications) refer to types that were considered to thematically belong and which were expected to be fully specified in Annex II or III spatial data themes. Two kinds of such types were distinguished:

- *Placeholder types* were created as placeholders for types (typically spatial object types) that were to be specified as part of a future spatial data theme, but which was already used as a value type of an attribute or association role in this data specification.

  Placeholder types received the stereotype «placeholder» and were placed in the application schema package of the future spatial data theme where they thematically belong. For each placeholder, a definition was specified based on the requirements of the Annex I theme. The Annex II+III TWGs were required to take into account these definitions in the specification work of the Annex II or III theme.

  If necessary, the attributes or association roles in the Annex I data specification(s) that have a placeholder as a value type shall be updated.

- *Candidate types* were types (typically spatial object types) for which already a preliminary specification was given in the Annex I data specification. Candidate types did not receive a specific stereotype and were placed in the application schema package of the future spatial data theme where they thematically belong. For each candidate type, a definition and attributes and association roles were specified based on the requirements of the Annex I theme. The Annex II+III TWGs were required to take into account these specifications in the specification work of the Annex II or III theme.

  If the type could not be incorporated in the Annex II or III data specification according to its preliminary specification, it should be moved into the application schema of the Annex I theme where it had first been specified. In this case, the attributes or association roles in the Annex I data specification(s) that have the type as a value type shall be updated if necessary.

NOTE Once the Annex II+III data specifications have been finalised by the TWGs (version 3.0), all placeholders and candidate types should have been removed. In some cases, this may require one or several of the Annex I data specifications (and the Implementing Rule on interoperability of spatial data sets and services) to be updated.

5.1.3 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, 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.

5.1.4 Enumerations

Enumerations are modelled as classes in the application schemas. Their values are modelled as attributes of the enumeration class using 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).

IR Requirement 4	Attributes of spatial object types or data types whose type is an enumeration shall only take values included in the enumeration.

5.1.5 Code lists

Code lists are modelled as classes in the application schemas. Their values, however, are managed outside of the application schema.

5.1.5.1. Obligation

For each attribute that has a code list as its value, a tagged value called "obligation" is specified to define the level of obligation to use values from the list. The tagged value can take the following values:

- *IR* means that only the values defined by the code list shall be used for the attribute. This obligation is also included in the Implementing Rule on interoperability of spatial data and services.
- *TG* means that only the values defined by the code list should be used for the attribute. This obligation is *not* included in the Implementing Rule on interoperability of spatial data and services.

IR Requirement 5	Attributes of spatial object types or data types whose type is a code list with an "obligation" value of "IR" shall only take values that are valid according to the code list's specification.

Recommendation 3	Attributes of spatial object types or data types whose type is a code list with an "obligation" value of "TG" should only take values that are valid according to the code list's specification.

5.1.5.2. Governance

The following two types of code lists are distinguished in INSPIRE:

- *Code lists that are governed by INSPIRE (INSPIRE-governed code lists).* These code lists will be managed centrally in the INSPIRE code list register, which is managed and governed by the INSPIRE expert group on maintenance and implementation. Change requests to these code lists (e.g. to add, deprecate or supersede values) are processed and decided upon using the maintenance workflows defined by the INSPIRE expert group.

  INSPIRE-governed code lists will be made available in the INSPIRE code list register at *http://inspire.ec.europa.eu/codeList/<CodeListName>*. They will be available in SKOS/RDF, XML and HTML. The maintenance will follow the procedures defined in ISO 19135. This means that the only allowed changes to a code list are the addition, deprecation or supersession of values, i.e. no value will ever be deleted, but only receive different statuses (valid, deprecated, superseded). Identifiers for values of INSPIRE-governed code lists are constructed using the pattern *http://inspire.ec.europa.eu/codeList/<CodeListName>*/<value>.

- *Code lists that are governed by an organisation outside of INSPIRE (externally governed code lists).* These code lists are managed by an organisation outside of INSPIRE, e.g. the World Meteorological Organization (WMO) or the World Health Organization (WHO). Change requests to these code lists follow the maintenance workflows defined by the maintaining organisations. Note that in some cases, no such workflows may be formally defined.

  The tables describing externally governed code lists in this section contain the following columns:
  - The *Governance* column describes the external organisation that is responsible for maintaining the code list.
  - If the code list is versioned, the *Version* column specifies which version of the code list shall be used in INSPIRE. The version can be specified using a version number or the publication date of a version. The specification can also refer to the “latest available version”.
  - The *Availability* column specifies from where the values of the externally governed code list are available, through a URL for code lists that are available online, or a citation for code lists that are only available offline.
  - In the *Formats* column the formats are listed, in which a code list is available. These can be machine-readable (e.g. SKOS/RDF, XML) or human-readable (e.g. HTML, PDF).
  - In some cases, for INSPIRE only a subset of an externally governed code list is relevant. The subset is specified using the *Subset* column.
  - For encoding values of externally governed code lists, rules have to be specified for generating URI identifiers and labels for code list values. These are specified in a separate table.

5.1.5.3. Vocabulary

For each code list, a tagged value called “vocabulary” is specified to define a URI identifying the values of the code list. For INSPIRE-governed code lists and externally governed code lists that do not have a persistent identifier, the URI is constructed following the pattern *http://inspire.ec.europa.eu/codeList/<UpperCamelCaseName>*.

If the value is missing or empty, this indicates an empty code list. If no sub-classes are defined for this empty code list, this means that any code list may be used that meets the given definition.

An empty code list may also be used as a super-class for a number of specific code lists whose values may be used to specify the attribute value. If the sub-classes specified in the model represent all valid extensions to the empty code list, the subtyping relationship is qualified with the standard UML constraint "{complete,disjoint}".

5.1.5.4. Extensibility

For each code list, a tagged value called “extensibility” is specified to define which additional values (other than those explicitly specified) are allowed as valid values of the code list. The tagged value can take the following values:

- *none* means that only the values explicitly specified shall / should[16] be used for the attribute.
- *narrower* means that only the values explicitly specified or values narrower than the specified values shall / should be used for the attribute.
- *any* means that, in addition to the values explicitly specified, any other value may be used.

NOTE The “extensibility” tagged value does *not* affect the possibility to update the code list values following the formal maintenance procedure. For example, even for code lists, for which the “extensibility” is set to *none*, it is still possible to add values following the maintenance procedure of the code list. As a result of this update, the code list may include additional valid values, and these additional may be used for attributes having the code list as a type.

5.1.6 Coverages

Coverage functions are used to describe characteristics of real-world phenomena that vary over space and/or time. Typical examples are temperature, elevation, precipitation, imagery. A coverage contains a set of such values, each associated with one of the elements in a spatial, temporal or spatio-temporal domain. Typical spatial domains are point sets (e.g. sensor locations), curve sets (e.g. contour lines), grids (e.g. orthoimages, elevation models), etc.

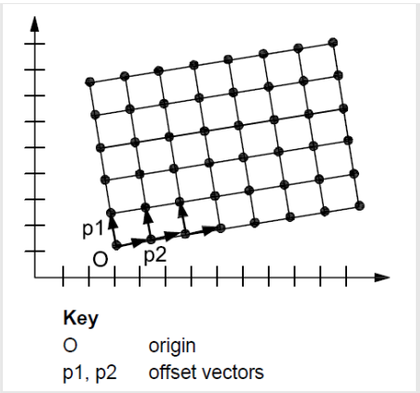
In INSPIRE application schemas, coverage functions are defined as properties of spatial object types where the type of the property value is a realisation of one of the types specified in ISO 19123.

To improve alignment with coverage standards on the implementation level (e.g. ISO 19136 and the OGC Web Coverage Service) and to improve the cross-theme harmonisation on the use of coverages in INSPIRE, an application schema for coverage types is included in the Generic Conceptual Model in 9.9.4. This application schema contains the following coverage types:

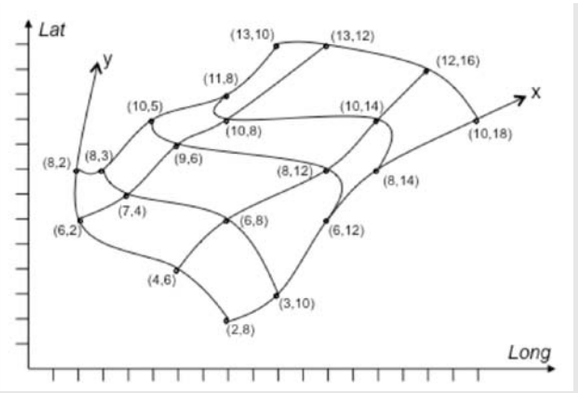
- *RectifiedGridCoverage*: coverage whose domain consists of a rectified grid – a grid for which there is an affine transformation between the grid coordinates and the coordinates of a coordinate reference system (see Figure 1, left).
- *ReferenceableGridCoverage*: coverage whose domain consists of a referenceable grid – a grid associated with a transformation that can be used to convert grid coordinate values to values of coordinates referenced to a coordinate reference system (see Figure 1, right).
- *MultiTimeInstantCoverage*: coverage providing a representation of the time instant/value pairs, i.e. time series (see Figure 2).

Where possible, only these coverage types (or a subtype thereof) are used in INSPIRE application schemas.

[16] It depends on the level of the “obligation” tagged value on the attribute, whether this is a requirement or recommendation.



(Source: ISO 19136:2007)



(Source: GML 3.3.0)

Figure 1 – Examples of a rectified grid (left) and a referenceable grid (right)

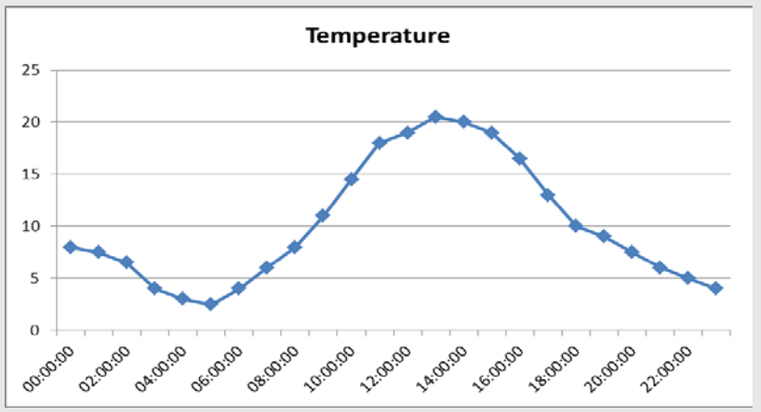


Figure 2 – Example of a MultiTimeSeriesCoverage (a time series)

5.2 Application schema GeologyCore

5.2.1 Description

5.2.1.1. Narrative description and UML overview

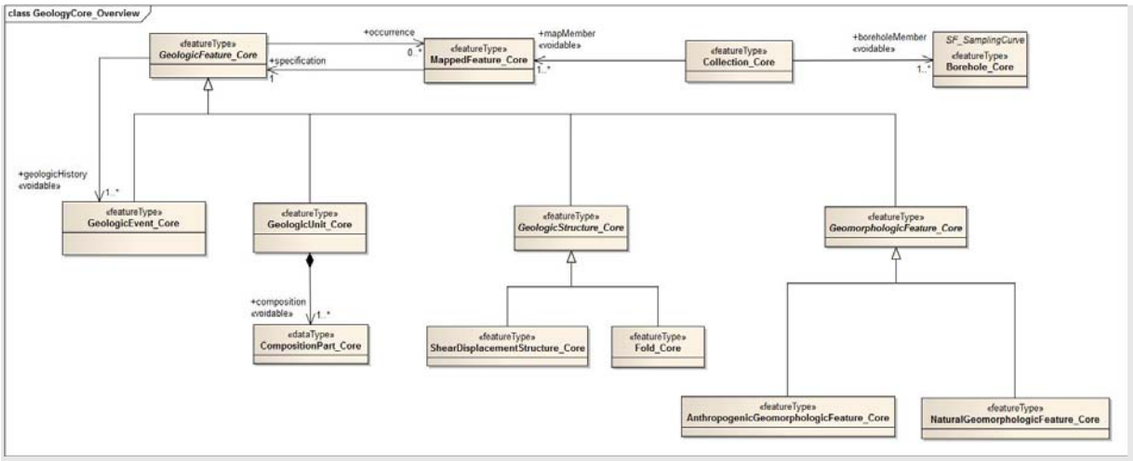


Figure 3 – UML class diagram: Overview of the GeologyCore application schema

This figure shows only the feature types and their relationships. It does not include data *types and code-lists. The properties are* not visible in Figure 1 but are shown in following figures, which describes the main part of the GeologyCore data model.

MappedFeature_Core and GeologicFeature_Core are central classes in the model. The abstract GeologicFeature_Core *class represents a conceptual geological feature that is hypothesized to exist coherently in the world, and includes as sub-types the main information classes in the model. The implemented Geologic Feature instance acts as* the *"description package". A MappedFeature provides a spatial representation of a GeologicFeature, and the occurrence association from GeologicFeature to MappedFeature allows for several spatial representations of the same Geologic Feature, for example in maps of different scales or* a 3D model as well as a 2D map. The *specification* association from *MappedFeature* to *GeologicFeature* allows only one Geologic Feature to be represented by any Mapped Feature.

There are four sub-types of *GeologicFeature_Core* in the data model: *GeologicEvent_Core, GeologicUnit_Core, GeologicStructure_Core and GeomorphologicFeature_Core.*

GeologicEvent_Core is defined as an identifiable event during which one or more geological processes act to modify geological entities. A Geologic Event must have a specified *GeologicAge* and may have specified environments and processes. *GeologicEvent* is considered a type of *GeologicFeature* because it has existence in space-time, for example a particular orogeny or a period of deposition of a river delta. In most circumstances, however, it will not be possible or necessary to provide any geometry for a *GeologicEvent*.

GeologicUnit_Core is a container used to associate geologic properties with some mapped occurrence (through the GeologicFeature.occurrence -> MappedFeature link). Conceptually, may represent a body of material in the Earth whose complete and precise extent is inferred to exist. Spatial properties are only available through association with a *MappedFeature_Core*. *GeologicUnit_Core* has only one mandatory property: geologic UnitType which indicates the type of Geologic Unit – one of the values from the *GeologicUnitTypeTerm* codelist should be used.

GeologicStructure_Core is *defined as* 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. In the data model, 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. GeologicStructure_Core has two types: ShearDisplacementStructure_Core and Fold_Core.

ShearDisplacementStructure_Core includes all brittle to ductile *style* structures along *which* displacement *has* occurred, from a simple, single 'planar' brittle or ductile surface to a fault system comprised of 10's of strands of both brittle and ductile nature.
Fold_*Core* is defined as ne or more systematically curved layers, surfaces, or lines in a rock body. Fold denotes a structure formed by the deformation of a GeologicStructure to form a structure that may be described by the translation of an abstract line (the fold axis) parallel to itself along some curvilinear path (the fold profile). Folds have a hinge zone (zone of maximum curvature along the surface) and limbs (parts of the deformed surface not in the hinge zone). Folds are described by an axial surface, hinge line , profile geometry, the solid angle between the limbs, and the relationships between adjacent folded surfaces if the folded structure is a Layering fabric (similar, parallel).

GeomorphologicFeature_Core includes point, *linear* or areal landforms or landscapes*. It* is a natural or an anthropogenic surface feature and may be erosional, depositional or both.
GeomorphologicFeature_Core has two subtypes: *NaturalGeomorphologicFeature_Core* and *AnthropogenicGeomorphologicFeature_Core*.

A *NaturalGeomorphologicFeature* is a geomorphologic feature produced by *the natural* dynamics.

An AnthropogenicGeomorphologicFeature is a man-made geomorphologic feature. An artificial feature on the earth's surface (including those in shallow water),having a characteristic shape and range in composition, composed of unconsolidated earthy, organic materials, artificial materials, or rock, that is the direct result of human manipulation or activities; can be either constructional (e.g., artificial levee) or destructional (quarry), or both

Borehole_Core *is* a generalized class for any narrow shaft drilled in the ground.

A *Collection_Core* is a container for items to be bundled in WFS response documents.

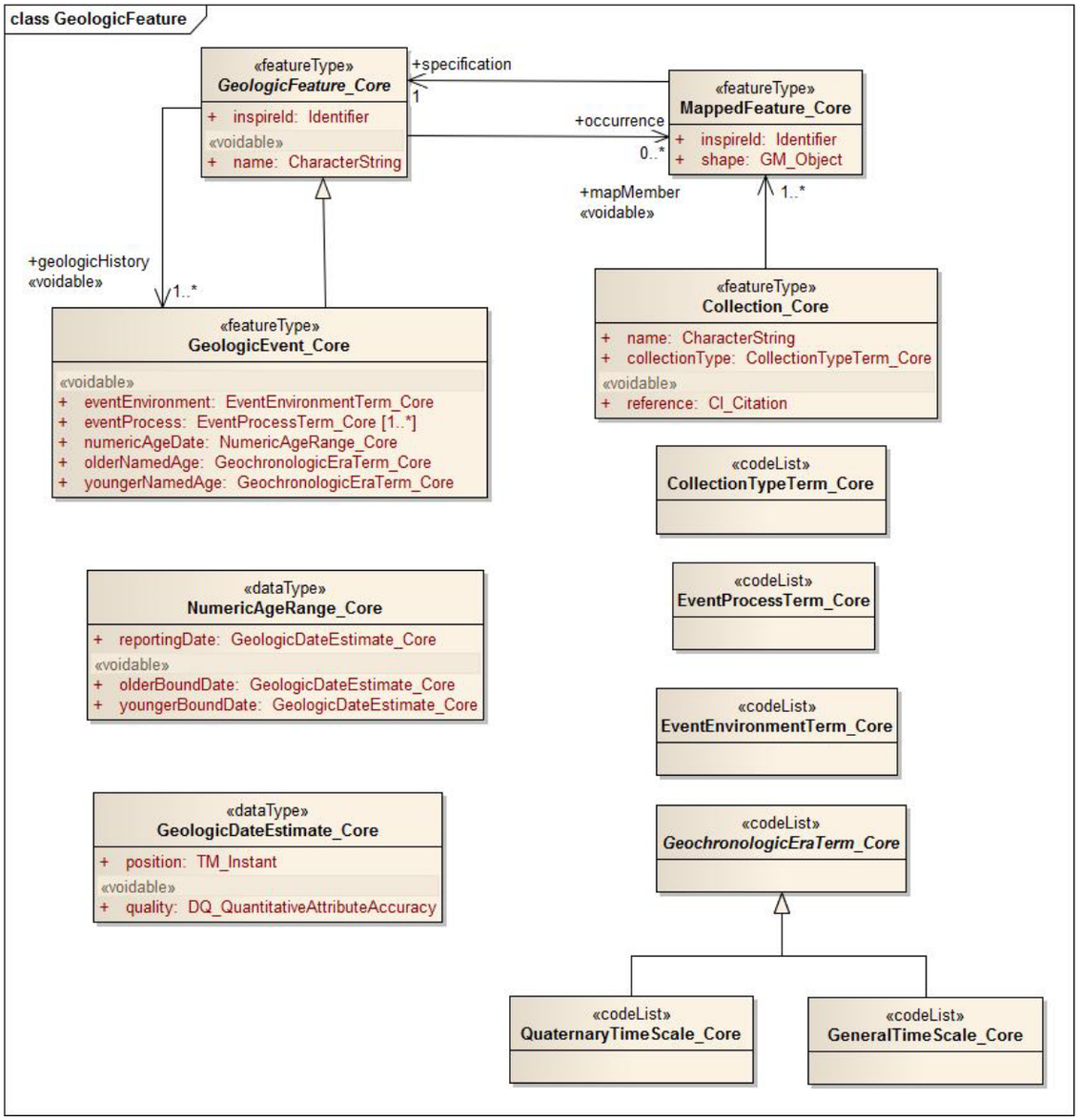


Figure 4 – UML class diagram: GeologicFeature, MappedFeature, GeologicEvent, Collection

Figure 4 shows the relationships of *GeologicFeature_Core* with *MappedFeature_Core*, *GeologicEvent_Core* and *Collection_Core*.

GeologicFeature_Core class represents a conceptual geological feature that is hypothesized to exist coherently in the world, and includes as sub-types the main information classes in the model. *GeologicFeature* has two properties: InspireId and a name.

A MappedFeature provides a spatial representation of a GeologicFeature, and *the* occurrence association from GeologicFeature_Core to MappedFeature_*Core* allows for several spatial representations of the same Geologic Feature, for example in maps of different scales or a 3D model as well as a 2D map. The *specification* association from *MappedFeature_Core* to *GeologicFeature_Core* allows only one Geologic Feature to be represented by any Mapped Feature. *MappedFeature_Core* has two properties: InspireId and shape

A *Geologic Event is* defined as an identifiable event during which one or more geological processes act to modify geological entities. Geological age is modelled as GeologicEvent – the age of some geological event occurring. GeologicEvents can be grouped into a geologicHistory for a GeologicFeature. Commonly GeologicFeatures will have a geologicHistory comprising only one GeologicEvent, which represents the formation of the GeologicFeature. A Geologic Event must have a specified age (which can be numeric, geochronologic or both) and may have specified environments and processes.

GeologicEvent_Core has five properties:

- *Event Environment* is the physical setting *within* which a *Geologic* Event *takes* place. event*Environment* 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.
- Event *Process* specifies the process or processes that occurred during the Geologic Event. Examples include erosion, deposition, extrusion, intrusion, heating and cooling.
- Numeric Age Date is the age of a particular geologic event or feature expressed in terms of years before present (1950), using NumericAgeRange. Numeric age range uses GeologicDateEstimate to allow incorporation of various uncertainty measures using ISO19115 DataQuality elements, and binding with observation features to report details of date determination
- *Older Named Age*: older boundary of age of event expressed using a GeochronologicEraTerm defined according to a geologic time scale
- *Younger Named Age*: younger boundary of age of event expressed using a GeochronologicEraTerm defined according to a geologic time scale.

The geologicHistory association from GeologicFeature to GeologicEvent describes a sequence of one or more Geologic Events which together describe the age or geologic history of the Geologic Feature.

A *Collection_Core* is a container for items to be bundled in WFS response documents and other applications. FeatureType stereotype allows this to be a FeatureMember in a WFS_FeatureCollection. A collection has a type, a name and a reference to describe it in detail.

The mapMember association from MappedFeature_Core to Collection_Core allows MappedFeature objects *to* be included as members in a GML Collection, through the use of the Collection class.

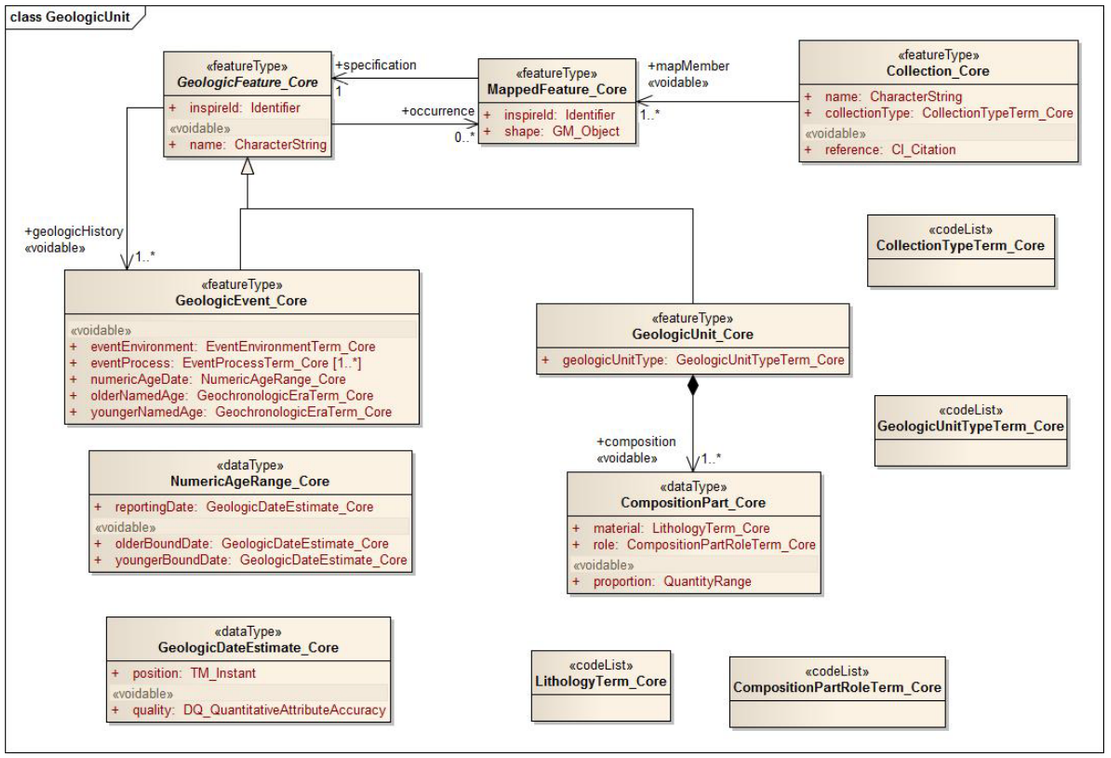


Figure 5 – *UML* class diagram: GeologicUnit

Figure 5 shows the relationships between GeologicUnit_Core, GeologicFeature_Core and CompositionPart_Core.

GeologicUnit_Core is a container used to associate geologic properties with some mapped occurrence (through the GeologicFeature.occurrence -> MappedFeature link). Conceptually, may represent a body of material in the Earth whose complete and precise extent is inferred to exist. Spatial properties are only available through association with a *MappedFeature_Core*. GeologicUnit_Core has only one mandatory property: Geologic Unit Type which indicates the type of Geologic Unit – one of the values from the *GeologicUnitTypeTerm* codelist should be used.

The *composition* association from *GeologicUnit_Core* to *CompositionPart_Core* allows the lithological description of the Geologic Unit. The composition of a Geologic Unit can be made up of several Composition Parts, for example where there lithologically distinct components interbedded. *CompositionPart* has three properties:

Role: a mandatory property *which* defines the relationship of the *Composition Part* in *the* Geologic Unit, e.g. vein, interbedded constituent, layers, dominant constituent
Material: a mandatory property which provides the lithological term - one of the values from the *LithologyTerm* codelist should be used.
Proportion: quantity that specifies the fraction of the Geologic Unit composed of the Composition Part

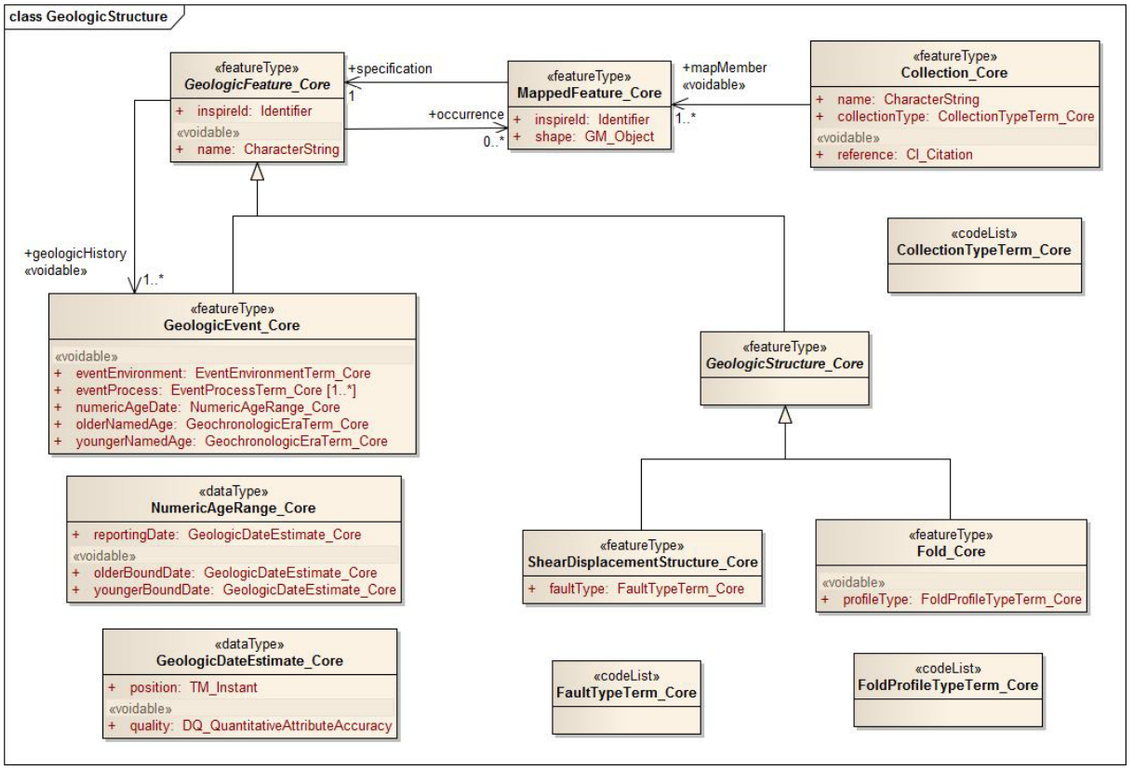


Figure 6 – UML class diagram: GeologicStructure

Figure 6 illustrates the relationships between *GeologicStructure_Core, ShearDisplacementStructure_Core and Fold_Core*.

Geologic Structure_Core is defined as 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. In the data model, 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.

The two types of *GeologicStructure_Core* in the data model are the *ShearDisplacementStructure_Core and the Fold_Core*.

A Shear Displacement Structure *includes* all brittle *to* ductile style structures along which displacement has occurred, from a simple, single 'planar' brittle (fault) or ductile surface to a fault system comprised of 10's of strands of both brittle *and* ductile nature. ShearDisplacementStructure_*Core* has only one mandatory property, FaultType, that refers to a vocabulary of terms describing the type of shear displacement structure (eg; thrust fault, normal fault, wrench fault)

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

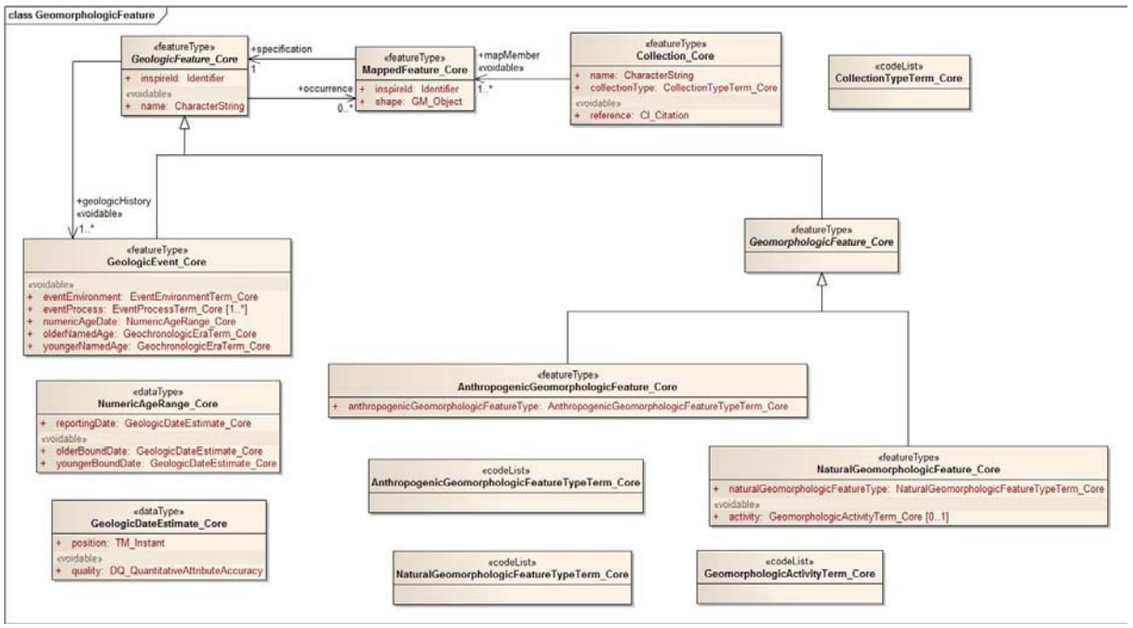


Figure 7 – UML class diagram: GeomorphologicFeature

Figure 7 shows the relationships betwen GeomorphologicFeature_Core and Its subtypes.

A GeomorphologicFeature is a point, linear or areal landform or landscape. It is a natural or an anthropogenic surface feature and may be erosional, depositional or both. *GeomorphologicFeature_Core* has two subtypes: *NaturalGeomorphologicFeature_Core* and *AnthropogenicGeomorphologicFeature_Core*

A *NaturalGeomorphologicFeature* is a geomorphologic feature produced by the natural dynamics.

An *AnthropogenicGeomorphologicFeature* is a man-made geomorphologic feature. An artificial feature on the earth's surface (including those in shallow water),having a characteristic shape and range in composition, composed of unconsolidated earthy, organic materials, artificial materials, or rock, that is the direct result of human manipulation or activities; can be either constructional (e.g., artificial levee) or destructional (quarry), or both.

NaturalGeomorphologicFeature_Core and AnthropogenicGeomorphologicFeature_Core have a mandatory property, GeomorphologicFeatureType, indicating the type of Natural or Anthropogenic Geomorphologic Feature.

NaturalGeomorphologicFeatureType has a voidable *property,* GeomorphologicActivity, indicating the level of activity *of its related geomorphologic process.*

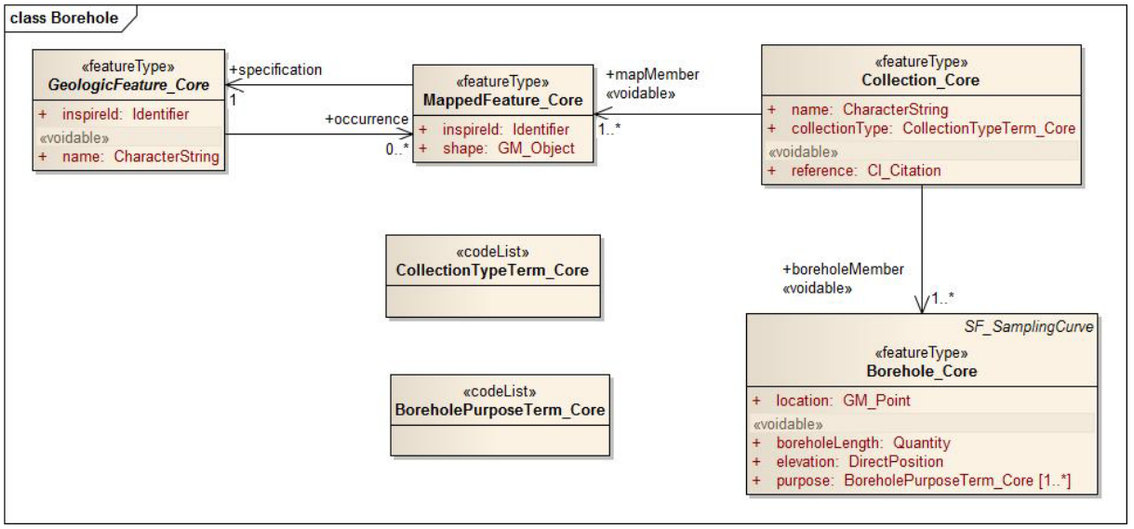


Figure 8 – UML class diagram: Borehole

Borehole is a generalized class for any narrow shaft drilled in the ground, either vertically or horizontally, and has four properties:

Location: a mandatory property providing the location of the Borehole Collar (point at a surface where drilling started)
Elevation: the elevation of the Borehole Collar. This is a compromise approach to supply elevation explicitly for software that cannot process 3-D GM_Point
BoreholeLength: the "length" of a borehole will be determined by the data provider (ie, "length" can have different sources, like drillers measurement, loggers measurement, survey)
Purpose for which the borehole was drilled. eg, site investigation, mineral exploration, hydrocarbon exploration, water resources

5.2.1.2. Consistency between spatial data *sets*

5.2.1.3. Identifier management

5.2.1.4. Modelling of object references (Optional)

5.2.1.5. Geometry representation (Optional)

The value domain of spatial properties used in this specification shall be restricted to the Simple Feature spatial schema as defined by EN ISO 19125-1.

NOTEThe specification restricts the spatial schema to 0-, 1-, 2-, and 2.5-dimensional geometries where all curve interpolations are linear.

NOTEThe topological relations of two spatial objects based on their specific geometry and topology properties can in principle be investigated by invoking the operations of the types defined in ISO 19107 (or the methods specified in EN ISO 19125-1)

5.2.1.6. Temporality representation (Optional)

*The application schema(**s**) **use(s) the derived** attributes "beginLifespanVersion" and "endLifespanVersion" to record the lifespan of a spatial* object*.*

The attribute "beginLifespanVersion" specifies the date and time at which this version of the spatial object was inserted or changed in the spatial data set. The attribute "endLifespanVersion" specifies the date and time at which this version of the spatial object was superseded or retired in the spatial data set.

NOTE 1 The attributes specify the beginning of the lifespan of *the version in the spatial data set itself, which is different from the temporal characteristics of the real-world phenomenon described* by *the spatial object. This lifespan information, if available, supports mainly two requirements: First, knowledge about the spatial* data set content at a specific time; second, knowledge about changes to a data set in a specific time frame. The lifespan information should be as detailed as in the data set (i.e., if the lifespan information in the data set includes seconds, the seconds should be represented in data published in INSPIRE) and include time zone information.

NOTE 2 Changes to the attribute "endLifespanVersion" does not trigger a change in the attribute "beginLifespanVersion".

If life-cycle information is not maintained as part of the spatial *data set, all spatial objects belonging to* this *data set should provide a void value with* a reason of "unpopulated".

5.2.2 Feature catalogue

Table 3 - Feature catalogue metadata

Feature catalogue name	INSPIRE feature catalogue GeologyCore
Scope	GeologyCore
Version number	2.9
Version date	2012-02-24
Definition source	INSPIRE data specification GeologyCore

Table 4 - Types defined in the feature catalogue

Type	Package	Stereotypes	Section
AnthropogenicGeomorphologicFeatureTypeTerm_Core	GeologyCore	«codeList»	5.2.2.3.1
AnthropogenicGeomorphologicFeature_Core	GeologyCore	«featureType»	5.2.2.1.1
BoreholePurposeTerm_Core	GeologyCore	«codeList»	5.2.2.3.2
Borehole_Core	GeologyCore	«featureType»	5.2.2.1.2
CollectionTypeTerm_Core	GeologyCore	«codeList»	5.2.2.3.3
Collection_Core	GeologyCore	«featureType»	5.2.2.1.3
CompositionPartRoleTerm_Core	GeologyCore	«codeList»	5.2.2.3.4
CompositionPart_Core	GeologyCore	«dataType»	5.2.2.2.1
EventEnvironmentTerm_Core	GeologyCore	«codeList»	5.2.2.3.5
EventProcessTerm_Core	GeologyCore	«codeList»	5.2.2.3.6
FaultTypeTerm_Core	GeologyCore	«codeList»	5.2.2.3.7
FoldProfileTypeTerm_Core	GeologyCore	«codeList»	5.2.2.3.8
Fold_Core	GeologyCore	«featureType»	5.2.2.1.4

Type	Package	Stereotypes	Section
GeneralTimeScale_Core	GeologyCore	«codeList»	5.2.2.3.9
GeochronologicEraTerm_Core	GeologyCore	«codeList»	5.2.2.3.10
GeologicDateEstimate_Core	GeologyCore	«dataType»	5.2.2.2.2
GeologicEvent_Core	GeologyCore	«featureType»	5.2.2.1.5
GeologicFeature_Core	GeologyCore	«featureType»	5.2.2.1.6
GeologicStructure_Core	GeologyCore	«featureType»	5.2.2.1.7
GeologicUnitTypeTerm_Core	GeologyCore	«codeList»	5.2.2.3.11
GeologicUnit_Core	GeologyCore	«featureType»	5.2.2.1.8
GeomorphologicActivityTerm_Core	GeologyCore	«codeList»	5.2.2.3.12
GeomorphologicFeature_Core	GeologyCore	«featureType»	5.2.2.1.9
LithologyTerm_Core	GeologyCore	«codeList»	5.2.2.3.13
MappedFeature_Core	GeologyCore	«featureType»	5.2.2.1.10
NaturalGeomorphologicFeatureTypeTerm_Core	GeologyCore	«codeList»	5.2.2.3.14
NaturalGeomorphologicFeature_Core	GeologyCore	«featureType»	5.2.2.1.11
NumericAgeRange_Core	GeologyCore	«dataType»	5.2.2.2.3
QuaternaryTimeScale_Core	GeologyCore	«codeList»	5.2.2.3.15
ShearDisplacementStructure_Core	GeologyCore	«featureType»	5.2.2.1.12

5.2.2.1. Spatial object types

5.2.2.1.1. AnthropogenicGeomorphologicFeature_Core

AnthropogenicGeomorphologicFeature_Core	
Name:	Anthropogenic Geomorphologic Feature_ Core
Subtype of:	GeomorphologicFeature_Core
Definition:	A geomorphologic feature (ie, landform) which has been created by human activity. For example, dredged channel, midden, open pit, reclaimed land.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

Attribute: anthropogenicGeomorphologicFeatureType

Value type:	AnthropogenicGeomorphologicFeatureTypeTerm_Core
Definition:	A byReference link to a dictionary of terms describing the type of geomorphologic feature
Multiplicity:	1
Obligation:	Technical Guidance (recommendation)

5.2.2.1.2. Borehole_Core

Borehole_Core	
Name:	Borehole_ Core
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»
Identifier:	null

Attribute: boreholeLength

Value type:	Quantity
Definition:	The "length" of a borehole will be determined by the data provider (ie, "length" can have different sources, like drillers measurement, loggers measurement, survey

Borehole_Core

Multiplicity: 1
Stereotypes: «voidable»

Attribute: elevation

Value type: DirectPosition
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
Stereotypes: «voidable»

Attribute: location

Value type: GM_Point
Definition: The location of the borehole collar
Multiplicity: 1

Attribute: purpose

Value type: BoreholePurposeTerm_Core
Definition: The purpose for which the borehole was drilled. eg, site investigation, mineral exploration, hydrocarbon exploration, water resources
Multiplicity: 1..*
Stereotypes: «voidable»
Obligation: Technical Guidance (recommendation)

5.2.2.1.3. Collection_Core

Collection_Core

Name: Collection_ Core
Definition: A collection container for items to be bundled in WFS response documents and other applications. FeatureType stereotype allows this to be a FeatureMember in a WFS_FeatureCollection.
Status: Proposed
Stereotypes: «featureType»
Identifier: null

Attribute: name

Value type: CharacterString
Definition: The name of the collection.
Multiplicity: 1

Attribute: collectionType

Value type: CollectionTypeTerm_Core
Definition: The type of collection eg geological map, geological model etc. Refers to a vocabulary of types
Multiplicity: 1
Obligation: Technical Guidance (recommendation)

Attribute: reference

Value type: CI_Citation
Definition: A reference for the collection, if available
Multiplicity: 1
Stereotypes: «voidable»

Association role: boreholeMember

Collection_Core	
Value type:	Borehole_Core
Definition:	Association that allows Borehole objects to be included as members in a GML Collection, through the use of the Collection class.
Multiplicity:	1..*
Stereotypes:	«voidable»
Association role: mapMember	
Value type:	MappedFeature_Core
Definition:	Association that allows MappedFeature objects to be included as members in a GML Collection, through the use of the Collection class.
Multiplicity:	1..*
Stereotypes:	«voidable»
Association role: geophysicsMember	
Value type:	GeophObject
Definition:	Association that allows GeophObject objects to be included as members in a GML Collection, through the use of the Collection class.
Multiplicity:	1..*
Stereotypes:	«voidable»

5.2.2.1.4. Fold_Core

Fold_Core	
Name:	Fold_ Core
Subtype of:	GeologicStructure_Core
Definition:	One or more systematically curved layers, surfaces, or lines in a rock body. Fold denotes a structure formed by the deformation of a GeologicStructure to form a structure that may be described by the translation of an abstract line (the fold axis) parallel to itself along some curvilinear path (the fold profile). Folds have a hinge zone (zone of maximum curvature along the surface) and limbs (parts of the deformed surface not in the hinge zone). Folds are described by an axial surface, hinge line , profile geometry, the solid angle between the limbs, and the relationships between adjacent folded surfaces if the folded structure is a Layering fabric (similar, parallel).
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null
Attribute: profileType	
Value type:	FoldProfileTypeTerm_Core
Definition:	Terminology specifying concave/convex geometry of fold relative to earth surface, and relationship to younging direction in folded strata if known. (eg; antiform, synform, neutral, anticline, syncline, monocline, ptygmatic)
Multiplicity:	1
Stereotypes:	«voidable»
Obligation:	Technical Guidance (recommendation)

5.2.2.1.5. GeologicEvent_Core

GeologicEvent_Core	
Name:	Geologic Event_ Core
Subtype of:	GeologicFeature_Core

GeologicEvent_Core

Definition:	An identifiable event during which one or more geological processes act to modify geological entities. A GeologicEvent must have a specified geologic age and may have specified environments and processes. An example might be a cratonic uplift event during which erosion, sedimentation, and volcanism all take place. The numeric or named age attributes of a particular geological event are 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 named age). A geologic event age can represent an instant in time or an interval of time.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

Attribute: eventEnvironment

Value type:	EventEnvironmentTerm_Core
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:	1
Stereotypes:	«voidable»
Obligation:	Technical Guidance (recommendation)

Attribute: eventProcess

Value type:	EventProcessTerm_Core
Definition:	The eventProcess specifies the process or processes that occurred during the event. Examples include deposition, extrusion, intrusion, cooling.
Multiplicity:	1..*
Stereotypes:	«voidable»
Obligation:	Technical Guidance (recommendation)

Attribute: numericAgeDate

Value type:	NumericAgeRange_Core
Definition:	The numericAgeDate attribute is the age of a particular geological event or feature expressed in terms of years before present (1950), using 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:	«voidable»

Attribute: olderNamedAge

Value type:	GeochronologicEraTerm_Core
Definition:	Older boundary of age of event expressed using a geochronologic era defined in a vocabulary of recognised units, such as those of the International Commission on Stratigraphy (ICS) Stratigraphic Chart.
Multiplicity:	1
Stereotypes:	«voidable»

GeologicEvent_Core	
Obligation:	Technical Guidance (recommendation)
Attribute: youngerNamedAge	
Value type:	GeochronologicEraTerm_Core
Definition:	Younger boundary of age of event expressed using a geochronologic era defined in a vocabulary of recognised units, such as those of the International Commission on Stratigraphy (ICS) Stratigraphic Chart.
Multiplicity:	1
Stereotypes:	«voidable»
Obligation:	Technical Guidance (recommendation)

5.2.2.1.6. GeologicFeature_Core

GeologicFeature_Core (abstract)	
Name:	Geologic Feature_ Core
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"
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null
Attribute: inspireId	
Value type:	Identifier
Definition:	A unique identifier for the GeologicFeature
Multiplicity:	1
Attribute: name	
Value type:	CharacterString
Definition:	The name of the GeologicFeature, for example of a lithostratigraphic unit, orogenic event, or major fault. Not all GeologicFeatures will have names, for example minor faults.
Multiplicity:	1
Stereotypes:	«voidable»
Association role: geologicHistory	
Value type:	GeologicEvent_Core
Definition:	Relates one or more GeologicEvents to a GeologicFeature to describe their age or geologic history.
Multiplicity:	1..*
Stereotypes:	«voidable»
Association role: occurrence	
Value type:	MappedFeature_Core
Definition:	Points to any number of mapped features which are occurrences of the geologic feature. Mapped features may all be from a single map or from several maps.
Multiplicity:	0..*

5.2.2.1.7. GeologicStructure_Core

GeologicStructure_Core (abstract)	
Name:	Geologic Structure_ Core
Subtype of:	GeologicFeature_Core

GeologicStructure_Core (abstract)	
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. 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.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

5.2.2.1.8. GeologicUnit_Core

GeologicUnit_Core	
Name:	Geologic Unit_ Core
Subtype of:	GeologicFeature_Core
Definition:	Operationally, the GeologicUnit element is a container used to associate geologic properties with some mapped occurrence.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).
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null
Attribute: geologicUnitType	
Value type:	GeologicUnitTypeTerm_Core
Definition:	A scoped name 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.
Multiplicity:	1
Obligation:	Technical Guidance (recommendation)
Association role: composition	
Value type:	CompositionPart_Core
Definition:	Describes the Composition of the GeologicUnit
Multiplicity:	1..*
Stereotypes:	«voidable»

5.2.2.1.9. GeomorphologicFeature_Core

GeomorphologicFeature_Core (abstract)	
Name:	Geomorphologic Feature_ Core
Subtype of:	GeologicFeature_Core
Definition:	A feature describing the shape and nature of the Earth's land surface (ie, a landform). These landforms may be created by natural Earth processes (eg, river channel, beach, moraine, mountain) or through human (anthropogenic) activity (eg, dredged channel, reclaimed land, mine waste dumps).
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

5.2.2.1.10. MappedFeature_Core

MappedFeature_Core	
Name:	Mapped Feature_ Core

MappedFeature_Core

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.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

Attribute: inspireId

Value type:	Identifier
Definition:	The unique identifier of the MappedFeature
Multiplicity:	1

Attribute: shape

Value type:	GM_Object
Definition:	The geometry of the MappedFeature
Multiplicity:	1

Association role: specification

Value type:	GeologicFeature_Core
Definition:	A description association that links a mapped feature to a notional geologic feature. A geologic feature, such as a geologic unit may be linked to mapped features from a number of different maps. A mapped feature, however is always associated with only a single description (geologic feature).
Multiplicity:	1

Association role: samplingFrame

Value type:	SF_SpatialSamplingFeature
Definition:	It is expected that this byReference association will resolve to a SF_SpatialSamplingFeature instance which may include a spatial (GML) representation of the sampling frame (eg, a map tile, a 3D surface), or may resolve to a concept from a controlled source
Multiplicity:	1

5.2.2.1.11. NaturalGeomorphologicFeature_Core

NaturalGeomorphologicFeature_Core

Name:	Natural Geomorphologic Feature_ Core
Subtype of:	GeomorphologicFeature_Core
Definition:	A geomorphologic feature (ie, landform) that has been created by natural Earth processes. For example, river channel, beach ridge, caldera, canyon, moraine, mud flat.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

Attribute: naturalGeomorphologicFeatureType

Value type:	NaturalGeomorphologicFeatureTypeTerm_Core
Definition:	A byReference link to a dictionary of terms describing the type of geomorphologic feature
Multiplicity:	1

NaturalGeomorphologicFeature_Core	
Obligation:	Technical Guidance (recommendation)
Attribute: activity	
Value type:	GeomorphologicActivityTerm_Core
Definition:	Indicates the level of activity of a geomorphologic feature
Multiplicity:	0..1
Stereotypes:	«voidable»
Obligation:	Technical Guidance (recommendation)

5.2.2.1.12. ShearDisplacementStructure_Core

ShearDisplacementStructure_Core	
Name:	Shear Displacement Structure_ Core
Subtype of:	GeologicStructure_Core
Definition:	A shear displacement structure includes all brittle to ductile style structures along which displacement has occurred, from a simple, single 'planar' brittle or ductile surface to a fault system comprised of 10's of strands of both brittle and ductile nature.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null
Attribute: faultType	
Value type:	FaultTypeTerm_Core
Definition:	Refers to a vocabulary of terms describing the type of shear displacement structure (eg; thrust fault, normal fault, wrench fault).
Multiplicity:	1
Obligation:	Technical Guidance (recommendation)

5.2.2.2. Data types

5.2.2.2.1. CompositionPart_Core

CompositionPart_Core	
Name:	Composition Part_ Core
Definition:	Element to represent composition of a geologic unit in terms of lithological constituents.
Status:	Proposed
Stereotypes:	«dataType»
Identifier:	null
Attribute: material	
Value type:	LithologyTerm_Core
Definition:	The material that comprises part or all of the geologic unit. Refers to a vocabulary of lithological terms.
Multiplicity:	1
Obligation:	Technical Guidance (recommendation)
Attribute: proportion	
Value type:	QuantityRange
Definition:	Quantity that specifies the fraction of the geologic unit composed of the material.
Multiplicity:	1
Stereotypes:	«voidable»
Obligation:	null
Attribute: role	

CompositionPart_Core	
Value type:	CompositionPartRoleTerm_Core
Definition:	Defines the relationship of the lithological constituent in the geologic unit, e.g. vein, interbedded constituent, layers, dominant constituent.
Multiplicity:	1
Obligation:	Technical Guidance (recommendation)

5.2.2.2.2. GeologicDateEstimate_Core

GeologicDateEstimate_Core	
Name:	Geologic Date Estimate_ Core
Definition:	An estimate of a point in geologic time and a link to its observational basis
Status:	Proposed
Stereotypes:	«dataType»
Identifier:	null
Attribute: position	
Value type:	TM_Instant
Definition:	A point in geologic time
Multiplicity:	1
Attribute: quality	
Value type:	DQ_QuantitativeAttributeAccuracy
Definition:	A measure of the accuracy of the estimate of the point in time
Multiplicity:	1
Stereotypes:	«voidable»

5.2.2.2.3. NumericAgeRange_Core

NumericAgeRange_Core	
Name:	Numeric Age Range_ Core
Definition:	A class to represent a numeric measurement of geologic age. All attributes have cardinality 1. Report with nilReason="missing" if a value is absent.
Status:	Proposed
Stereotypes:	«dataType»
Identifier:	null
Attribute: reportingDate	
Value type:	GeologicDateEstimate_Core
Definition:	Single time coordinate value to report as representative for this NumericAge assignment
Multiplicity:	1
Attribute: olderBoundDate	
Value type:	GeologicDateEstimate_Core
Definition:	The older bounding time coordinate in an age range
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: youngerBoundDate	
Value type:	GeologicDateEstimate_Core
Definition:	The younger bounding time coordinate in an age range
Multiplicity:	1
Stereotypes:	«voidable»

5.2.2.3. Code lists

5.2.2.3.1. AnthropogenicGeomorphologicFeatureTypeTerm_Core

AnthropogenicGeomorphologicFeatureTypeTerm_Core	
Name:	Anthropogenic Geomorphologic Feature Type Term_ Core
Definition:	Refers to a vocabulary of terms describing the type of anthropogenic geomorphologic feature
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.2.2.3.2. BoreholePurposeTerm_Core

BoreholePurposeTerm_Core	
Name:	Borehole Purpose Term_ Core
Definition:	Place holder for a vocabulary containing terms describing the purpose for which the borehole was drilled. eg, mineral exploration, water pumping, site evaluation, stratigraphic research, etc
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.2.2.3.3. CollectionTypeTerm_Core

CollectionTypeTerm_Core	
Name:	Collection Type Term_ Core
Definition:	A vocabulary of types of Collection eg geological map, geological model etc
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.2.2.3.4. CompositionPartRoleTerm_Core

CompositionPartRoleTerm_Core	
Name:	Composition Part Role Term_ Core
Definition:	This class is a blank placeholder for a vocabulary of terms to describe the role that a compositional part plays in a geologic unit.
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.2.2.3.5. EventEnvironmentTerm_Core

EventEnvironmentTerm_Core	
Name:	Event Environment Term_ Core
Definition:	A codelist of terms for the Geologic Environments within which Geologic Events take place.
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.2.2.3.6. EventProcessTerm_Core

EventProcessTerm_Core	
Name:	Event Process Term_ Core

EventProcessTerm_Core	
Definition:	Refers to a vocabulary of terms specifying the process or processes that occurred during an event. -- Example -- Examples include deposition, extrusion, intrusion, cooling.
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.2.2.3.7. FaultTypeTerm_Core

FaultTypeTerm_Core	
Name:	Fault Type Term_ Core
Definition:	A vocabulary of terms describing the type of shear displacement structure (eg; thrust fault, normal fault, wrench fault)
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.2.2.3.8. FoldProfileTypeTerm_Core

FoldProfileTypeTerm_Core	
Name:	Fold Profile Type Term_ Core
Definition:	Refers to a vocabulary of terms specifying concave/convex geometry of fold relative to earth surface, and relationship to younging direction in folded strata if known. -- Example -- antiform, synform, neutral, anticline, syncline, monocline, ptygmatic
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.2.2.3.9. GeneralTimeScale_Core

GeneralTimeScale_Core	
Name:	General Time Scale_ Core
Subtype of:	GeochronologicEraTerm_Core
Definition:	A vocabulary of recognised units , such as those of the International Commission on Stratigraphy (ICS) Stratigraphic Chart.
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.2.2.3.10. GeochronologicEraTerm_Core

GeochronologicEraTerm_Core (abstract)	
Name:	Geochronologic Era Term_ Core
Definition:	A vocabulary of recognised units, such as those of the International Commission on Stratigraphy (ICS) Stratigraphic Chart.
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.2.2.3.11. GeologicUnitTypeTerm_Core

GeologicUnitTypeTerm_Core

GeologicUnitTypeTerm_Core	
Name:	Geologic Unit Type Term_ Core
Definition:	This class is an indicative placeholder only for a vocabulary of terms describing the type of geologic unit. -- Example -- Example values: GeologicUnit AllostratigraphicUnit AlterationUnit ArtificialGround BiostratigraphicUnit ChronostratigraphicUnit DeformationUnit ExcavationUnit GeophysicalUnit LithodemicUnit LithogeneticUnit LithologicUnit LithostratigraphicUnit LithotectonicUnit MagnetostratigraphicUnit MassMovementUnit Pedoderm PedostratigraphicUnit PolarityChronostratigraphicUnit
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.2.2.3.12. GeomorphologicActivityTerm_Core

GeomorphologicActivityTerm_Core	
Name:	Geomorphologic Activity Term_ Core
Definition:	A codelist of terms indicating the level of activity of a geomorphologic feature
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.2.2.3.13. LithologyTerm_Core

LithologyTerm_Core	
Name:	Lithology Term_ Core
Definition:	Refers to a vocabulary of terms describing the lithology (eg, granite, sandstone, schist)
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.2.2.3.14. NaturalGeomorphologicFeatureTypeTerm_Core

NaturalGeomorphologicFeatureTypeTerm_Core	
Name:	Natural Geomorphologic Feature Type Term_ Core
Definition:	Refers to a vocabulary of terms describing the type of natural geomorphologic feature
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.2.2.3.15. QuaternaryTimeScale_Core

QuaternaryTimeScale_Core	
Name:	Quaternary Time Scale_ Core
Subtype of:	GeochronologicEraTerm_Core
Definition:	A vocabulary of recognised Quaternary units such as those of the "Global chronostratigraphical correlation table for the last 2.7 million years" by the Subcommission on Quaternary Stratigraphy .
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

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. CI_Citation

CI_Citation	
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]

5.2.2.4.2. CharacterString

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

5.2.2.4.3. DQ_QuantitativeAttributeAccuracy

DQ_QuantitativeAttributeAccuracy	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115-All Metadata::ISO 19115:2003 Metadata::Data quality information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.2.2.4.4. 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]

5.2.2.4.5. 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]

5.2.2.4.6. 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]

5.2.2.4.7. GeophObject

GeophObject	
Package:	INSPIRE Consolidated UML Model::Themes::Annex II::Geology::Geophysics::GeophysicsCore [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Generic class for geophysical objects

GeophObject	
Description:	Used to collect data at a single location. The source-sensor setup may be elongated or two dimensional, but the collected data is referenced to a single point. Example: Gravity station, Magnetic station NOTE 1. Processing results of geophStations are often curve coverages

5.2.2.4.8. 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. 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. NOTE 3 The unique identifier will not change during the life-time of a spatial object.

5.2.2.4.9. 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]

5.2.2.4.10. SF_SamplingCurve

SF_SamplingCurve	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19156 Observations and Measurements::ISO 19156:2011 Observations and Measurements::Sampling Features::samplingCurve [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.2.2.4.11. SF_SpatialSamplingFeature

SF_SpatialSamplingFeature (abstract)	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19156 Observations and Measurements::ISO 19156:2011 Observations and Measurements::Sampling Features::spatialSamplingFeature [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.2.2.4.12. 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]

***INSPIRE-governed code** lists*
Recommendation 4
Recommendation 5 *The INSPIRE-defined code lists included in this application schema include the values* specified in the tables in this section.

***Values of** code list <UMLCodeListName>*
Recommendation 6

Value	Name	Definition	Description	Parent value
disused	disused	The facility is not used.		
functional	functional	The facility is functional.		
projected	projected	The facility is being designed. Construction has not yet started.		
underConstruction	under construction	The facility is under construction and not yet functional. This applies only to the initial construction of the facility and not to maintenance work.		

5.2.3 Externally governed code lists

The externally governed code lists included in this application schema are specified in the tables in this section.

5.2.3.1. Governance, availability and constraints

Code **list**	Governance	Version	**Availability**	**Formats**	**Subset**
EUCountryCode	Publications Office of the European Union	Latest available version	http://publications.europa.eu/code/en/en-5000600.htm	HTML	

The values of selected external code lists are included in Annex X for information.

5.2.3.2. Rules for code list values

Code list	Identifiers	Identifier examples	Labels
EUCountryCode	Append the upper-case two-letter code in the "Code" column of Annex A6 to the URI prefix http://inspire.ec.europa.eu/co	http://inspire.ec.europa.eu/codeList/CountryCode/DE http://inspire.ec.europa.eu/codeList/CountryCode/UK	The name in the "Country/territory" column of Annex A6

	deList/Co untryCod e/	

Note: perhaps include a note in the data specifications as to the governance of extensible code lists (point to the governance document of the JRC)?

5.3 Application schema GeophysicsCore

5.3.1 Description

5.3.1.1. Narrative description and UML overview

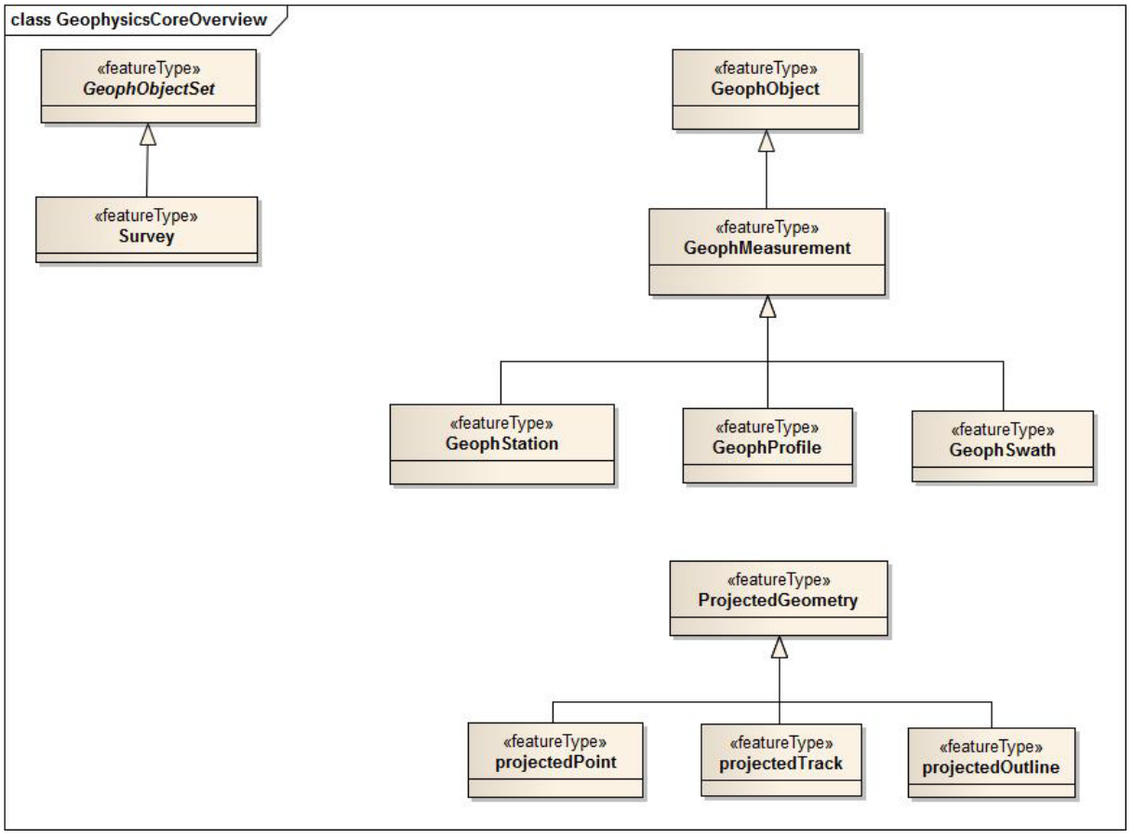


Figure 9 – UML class diagram: Overview of the Geophysics application schema

The core model is designed to fulfil the legal requirements of data provisioning by LMO-s. The simplicity of the core doesn't support all the functions that are required by the use cases. Such expectations are targeted in the extension model.

Fundamental classes are defined in the core model. These are related to well-known geophysical concepts as measurement, survey:

- *GeophMeasurement* is a generic feature type that models the field observation procedure with its location, spatial characteristics and related metadata. The related projectedGeometry is

necessary when measurement setup is 3 dimensional, to define a 2D geometry for displaying purposes

- *GeophSurvey* is used to document geophysical campaigns and projects

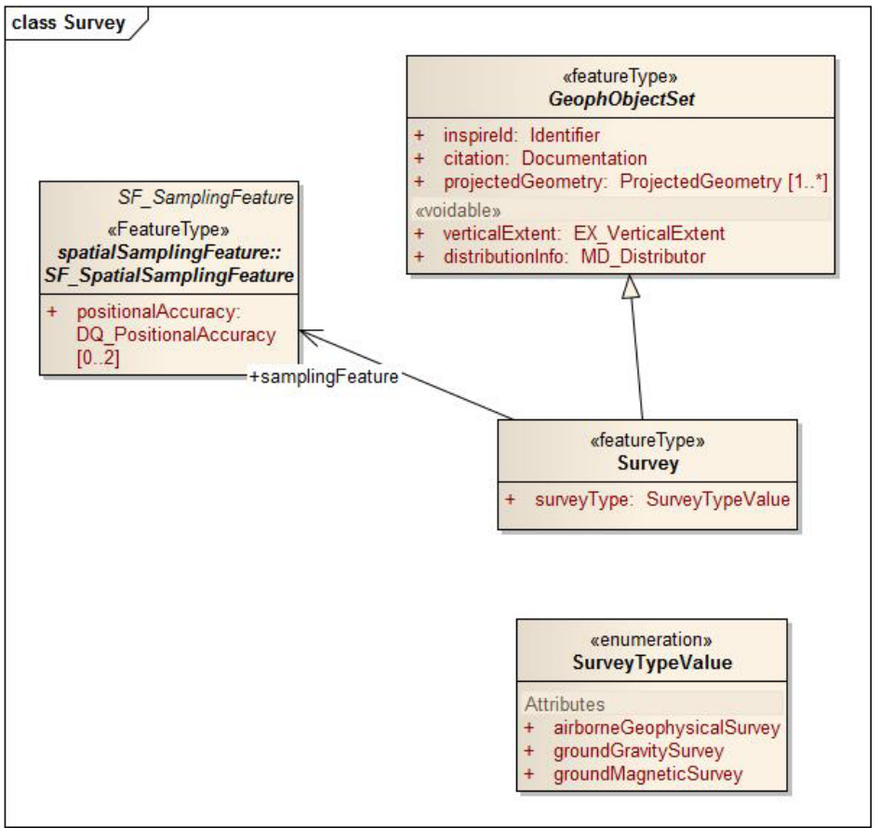


Figure 10 – UML class diagram: Geophysics - Survey

GeophObjectSet is an abstract feature type that models geophysical entity collections like campaigns, or projects. In the core model Survey is a collective class to be used for them. *GeophObjectSet* has the following attributes:

- inspireId: Object identifier with codespace and optional version number
- citation: ISO 19115 citation (CI_Citation), reference to offline and online documentation can be added to any *GeophObjectSet*.
- projectedGeometry: Projected geometry of the object set (survey), that is usually the bounding polygon of the working area.
- SamplingFeature: In some cases it is useful to link observation results to collections, rather than to individual geophysical objects. (e.g. a gravity map can be associated with a gravity survey and not with a single station) This association is used to describe the results that were created during the observation. To encode geophysical observations, procedures and results the ISO 19156 Observations and Measurements standard has to be used. The only mandatory attribute of SF_SpatialSamplingFeature is the shape. It means that in the core data model, as a minimum the sampling geometry shall always be provided. Recommendations for the use of O&M, and coding examples are provided in the guidelines.

Voidable attributes:

- verticalExtent: This parameter serves discovery purposes. It may refer both to the vertical extent of the setup of measurements within the survey, or the extent of the range where processed data is spatially referenced to (estimated depth of investigation).
- distributionInfo: Data providers may use external services to provide information on a survey. Links to the access points, description of ordering procedures can be added in distributionInfo that is an ISO MD_Distributor record.

Survey is subtype of *GeophObjectSet*. Geophysical activity is usually organized into campaigns and projects. *Survey* is used to document such activities by providing attributes for location, extent and responsible parties. In the core model *Survey* is restricted to airborneGeophysicalSurvey, groundGravitySurvey, and groundMagneticSurvey. In the extension model more types are available. Apart from the ones inherited from *GeophObjectSet Survey* has one additional attribute:

- surveyType: The geophysical method is specified by this attribute. Value shall be one of the items defined in surveyTypeValue.

Constraint: Geophysical surveys extending over more than 1 km^2 should always be reported.

Note: Exclusion of surveys smaller than 1 km^2 prevents data providers from the obligation of reporting large number of less significant surveys.

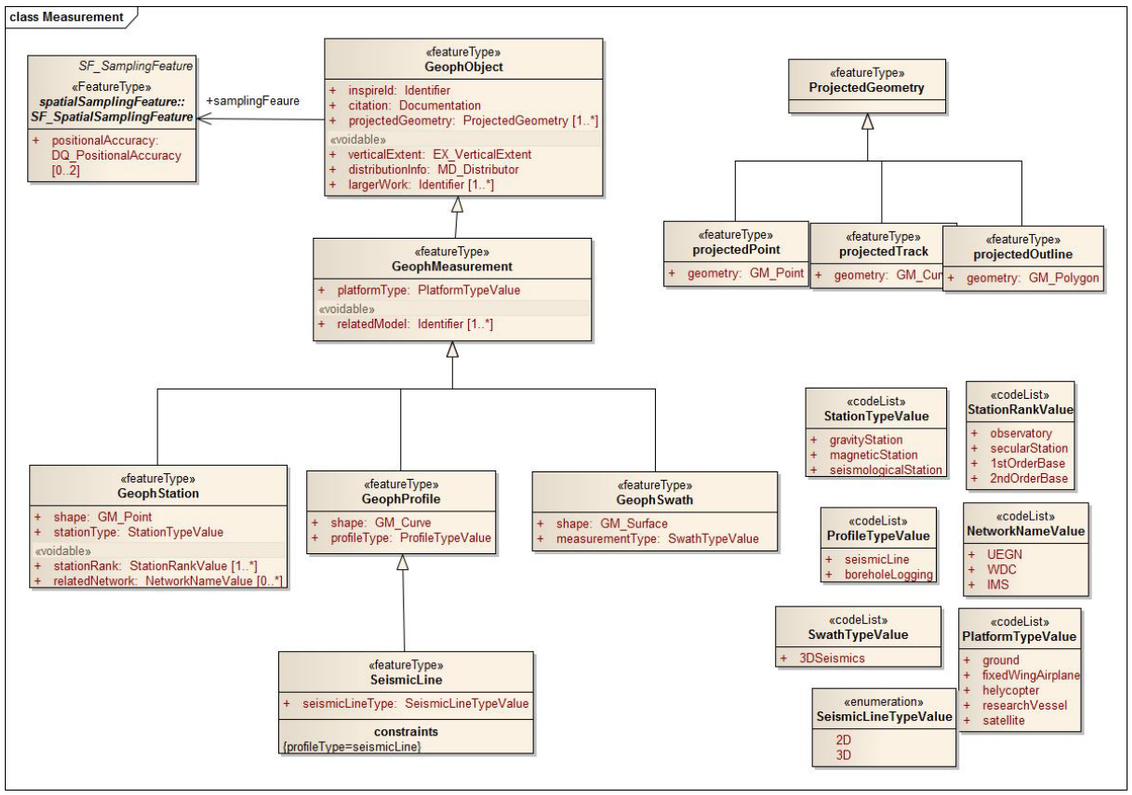


Figure 11 – UML class diagram: Geophysics - Measurement

GeophObject is an abstract feature type that models single geophysical entities. It has two subtypes: *GeophMeasurement* and *GeophModel.* The latest is only used in the extended geophysics application scema.

- inspireId: Object identifier with codespace.

- citation: ISO 19115 citation (CI_Citation), reference to offline and online documentation can be added to *GeophMeasurement.* In the citation record it is possible to add further identifiers used by different authorities for the same object. It is useful, when the user is looking for national identifiers.
- projectedGeometry: When measurement setup is 3 dimensional, it is necessary to define a 2D geometry for displaying purposes. It is usually the 2D projection of the spatial object on the ground surface. It has 3 types: point, track and outline. Examples: projected geometry of a borehole logging measurement is a point coincident with the borehole collar location. Projected geometry of a 3D multielectrode DC measurement is a polygon.
- SamplingFeature: Geophysical objects are always related to spatial sampling. This association is used to describe the procedures that were applied and the results that were created during the observation. To encode geophysical observations, procedures and results the ISO 19156 Observations and Measurements standard has to be used. The only mandatory attribute of SF_SpatialSamplingFeature is the shape. It means, that in the core data model, as a minimum the sampling geometry shall always be provided. Recommendations for the use of O&M, and coding examples are provided in the guidelines.

Voidable attributes:

- verticalExtent: This parameter serves discovery purposes. It may refer both to the vertical extent of the measurement setup (p.e. borehole logging) or the extent of the range where processed data is spatially referenced to (Vertical Electric Sounding).
- distributionInfo: Data providers may use external services to provide information on a geophysical measurement. Links to the access points, description of ordering procedures or external services can be added in distributionInfo, that is an ISO MD_Distributor record.
- largerWork: Measurements are usually made in campaigns. Measurements that were made in a common campaign may refer to the parent *GeophSurvey object* (core), a Campaign, or to a Project (extension)

GeophMeasurement is a generic feature type that models the field observation procedure with its loca tion, spatial characteristics and related metadata. It has all the attributes of *GeophObject* and two additional attributes:

- platformType: The platform from which the measurement was carried out can be defined here. Values to be used are in the codelist called platformTypeValue.

Voidable attribute:

- relatedModel: Results of the measurement can be referenced by these identifiers.

In the core model *GeophMeasurement* has three subtypes: *GeophStation, GeophProfile*, and *GeophSwath.*

GeophStations are measurements spatially referenced to a point. They are used to collect data at a single location. The source – sensor setup may be elongated or two dimensional, but the observed data is either zero dimensional or a function of non spatial parameter, for example time, frequency or electrode spacing. Processed results can be one dimensional (eg. a sounding curve) but it does not change the fact that the original sampling feature geometry is still a point. Type of *GeophStation* is restricted to gravityStation, magneticStation and seismologicalStation. *GeophStations* have all attributes of a *GeophMeasurement*, and additionally some more:

- shape: Point geometry, equivalent to the center or reference point of the measurement.
- stationType: The geophysical method is specified by this attribute. Value shall be one of the items defined in stationTypeValue.

Voidable attributes:

- stationRank: Significance of stations can be very different even for the same geophysical method. Rank shall be one of the following: 1stOrderBase, 2ndOrderBase, secularStation,

observatory. Base stations are used to tie local measurements to higher level networks. Secular stations are visited from time to time to detect long term temporal changes of physical parameters. Observatories are important facilities that collect data continuously, or on a regular base. Normal stations that are ordinary survey measurements are excluded from the core model.

- relatedNetwork: Base stations are often part of larger networks. It means that observation data is regularly sent to the archives of the related network in an official way. Value shall be one of the following: UEGN, WDC, IMS (to be extended if necessary)

Note: Exclusion of normal stations prevents data providers from the obligation of reporting millions of ordinary survey stations. These stations shall be reported in a collective manner by using the GeophSurvey class.

*GeophProfile*s are measurements spatially referenced to a curve. They are used to collect data along a curve or a series of points that can either be on the surface or in the 3D space. Observed data is curve coverage. Range data may contain non dimensional parameters, for example time, frequency. Processed results can be two dimensional (eg. a depth section) but it does not change the fact that the original sampling feature geometry is still a curve. Type of *GeophProfile* is restricted to seismicLine, and boreholeLogging. *GeophProfile*s have all attributes of a *GeophMeasurement*, and additionally some more:

- shape: Curve geometry, equivalent to the reference curve of the measurement.
- profileType: The geophysical method is specified by this attribute. Value shall be one of the items defined in profileTypeValue

Constraint: Profiles that are longer than 1000 m should always be reported (Opened for discussion)

Note: Exclusion of profiles shorter than 1000 m prevents data providers from the obligation of reporting thousands of small profiles from detailed local surveys. These profiles shall be reported in a collective manner by using the *GeophSurvey* class.

The importance of the seismic method explains the explicit definition of the *SeismicLine* feature type. SeismicLine is a specialized *GeophProfile*. It has one additional attribute: seismicLineType. Its value shall be any of 2D or 3D specified in the *SeismicLineTypeValue* codelist.

Constraint: profileType shall be sesmicLine

GeophSwath is a geophysical measurement spatially referenced to a surface. Range data may contain non dimensional parameters, for example time, frequency. Processed results are two or three dimensional. Type of *GeophSwath* is restricted to 3DSeismics. *GeophSwath* have all attributes of a *GeophMeasurement*, and additionally some more:

- shape: Equivalent to the reference surface of the measurement. In most cases – like 3DSeismics – it is a surface.
- measurementType: The geophysical method is specified by this attribute. Value shall be one of the items defined in *SwathTypeValue* (at the moment the only value is 3DSeismics)

Geophysical swaths greater than 1 km^2 shall always be reported.

Note: Exclusion of measurements smaller than 1 km^2 prevents data providers from the obligation of reporting large number of less significant surveys.

5.3.1.2. Consistency between spatial data sets

The observation location is specified by its coordinates

5.3.1.3. Identifier management

All geophysical feature types shall be identified by an inspireId of type Identifier. It is composed of a local identification code, a codespace that identifies the naming authority, and an optional version number. Features derived from *GeophMeasurement* usually don't get updated, and for this reason version number is not required.

5.3.1.4. Modelling of object references *(Optional)*

Using geophysical features object referencing is often required. (eg. largerWork, relatedMeasurement, relatedModel) For internal referencing in the geophysics application schema Identifier class of the General Concept Model is used. For external referencing the usage of MD_Identifier embedded in citation records is recommended.

5.3.1.5. Geometry representation *(Optional)*

IR Requirement 6	The value domain of spatial properties used in this specification shall be restricted to the Simple Feature spatial schema as defined by EN ISO 19125-1.

NOTE The specification restricts the spatial schema to 0-, 1-, 2-, and 2.5-dimensional geometries where all curve interpolations are linear.

NOTE The topological relations of two spatial objects based on their specific geometry and topology properties can in principle be investigated by invoking the operations of the types defined in ISO 19107 (or the methods specified in EN ISO 19125-1).

5.3.1.6. Temporality representation *(Optional)*

The application schema(s) use(s) the derived attributes "beginLifespanVersion" and "endLifespanVersion" to record the lifespan of a spatial object.

The attribute "beginLifespanVersion" specifies the date and time at which this version of the spatial object was inserted or changed in the spatial data set. The attribute "endLifespanVersion" specifies the date and time at which this version of the spatial object was superseded or retired in the spatial data set.

NOTE 1 The attributes specify the beginning of the lifespan of the version in the spatial data set itself, which is different from the temporal characteristics of the real-world phenomenon described by the spatial object. This lifespan information, if available, supports mainly two requirements: First, knowledge about the spatial data set content at a specific time; second, knowledge about changes to a data set in a specific time frame. The lifespan information should be as detailed as in the data set (i.e., if the lifespan information in the data set includes seconds, the seconds should be represented in data published in INSPIRE) and include time zone information.

NOTE 2 Changes to the attribute "endLifespanVersion" does not trigger a change in the attribute "beginLifespanVersion".

Recommendation 7	If life-cycle information is not maintained as part of the spatial data set, all spatial objects belonging to this data set should provide a void value with a reason of "unpopulated".

5.3.2 Feature catalogue

Table 3 - Feature catalogue metadata

Feature catalogue name	INSPIRE feature catalogue GeophysicsCore
Scope	GeophysicsCore
Version number	2.9
Version date	2012-02-24
Definition source	INSPIRE data specification GeophysicsCore

Table 4 - Types defined in the feature catalogue

Type	Package	Stereotypes	Section
GeophMeasurement	GeophysicsCore	«featureType»	5.3.2.1.1
GeophObject	GeophysicsCore	«featureType»	5.3.2.1.2
GeophObjectSet	GeophysicsCore	«featureType»	5.3.2.1.3
GeophProfile	GeophysicsCore	«featureType»	5.3.2.1.4
GeophStation	GeophysicsCore	«featureType»	5.3.2.1.5
GeophSwath	GeophysicsCore	«featureType»	5.3.2.1.6
NetworkNameValue	GeophysicsCore	«codeList»	5.3.2.3.1
PlatformTypeValue	GeophysicsCore	«codeList»	5.3.2.3.2
ProfileTypeValue	GeophysicsCore	«codeList»	5.3.2.3.3
ProjectedGeometry	GeophysicsCore	«featureType»	5.3.2.1.7
SeismicLine	GeophysicsCore	«featureType»	5.3.2.1.8
SeismicLineTypeValue	GeophysicsCore	«enumeration»	5.3.2.2.1
StationRankValue	GeophysicsCore	«codeList»	5.3.2.3.4
StationTypeValue	GeophysicsCore	«codeList»	5.3.2.3.5
Survey	GeophysicsCore	«featureType»	5.3.2.1.9
SurveyTypeValue	GeophysicsCore	«enumeration»	5.3.2.2.2
SwathTypeValue	GeophysicsCore	«codeList»	5.3.2.3.6
projectedOutline	GeophysicsCore	«featureType»	5.3.2.1.10
projectedPoint	GeophysicsCore	«featureType»	5.3.2.1.11
projectedTrack	GeophysicsCore	«featureType»	5.3.2.1.12

5.3.2.1. Spatial object types

5.3.2.1.1. GeophMeasurement

GeophMeasurement

Name:	Geoph Measurement
Subtype of:	GeophObject
Definition:	Generic feature for geophysical measurements.
Description:	Geophysical measurements collect data outside or on the boundary of the observed spatial domain.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

Attribute: relatedModel

Value type:	Identifier
Definition:	Identifier of the geophysical model that was created from the measurement
Multiplicity:	1..*
Stereotypes:	«voidable»

Attribute: platformType

GeophMeasurement	
Value type:	PlatformTypeValue
Definition:	platform from which the measurement was carried out
Multiplicity:	1
Obligation:	Technical Guidance (recommendation)

5.3.2.1.2. GeophObject

GeophObject	
Name:	Geoph Object
Definition:	Generic class for geophysical objects
Description:	Used to collect data at a single location. The source-sensor setup may be elongated or two dimensional, but the collected data is referenced to a single point. Example: Gravity station, Magnetic station NOTE 1. Processing results of geophStations are often curve coverages
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

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: citation	
Value type:	Documentation
Definition:	Citation of the model resource data
Description:	title, date of publication etc.
Multiplicity:	1

Attribute: projectedGeometry	
Value type:	ProjectedGeometry
Definition:	2D projection of the feature to the ground surface. This is going to be used by WMS to display the 3D feature
Multiplicity:	1..*

Attribute: verticalExtent	
Value type:	EX_VerticalExtent
Definition:	Vertical extent of the range of interest.
Description:	It may be an estimated value for the depth of investigation, or the extent of the sampling configuration (p.e.: borehole) or an estimated depth of penetration. (seismic or EM measurements)
Multiplicity:	1
Stereotypes:	«voidable»

Attribute: distributionInfo	
Value type:	MD_Distributor
Definition:	Distribution metadata
Description:	description of offline/online access and ordering procedure
Multiplicity:	1
Stereotypes:	«voidable»

GeophObject

Attribute: largerWork

Value type:	Identifier
Definition:	Identifier of a larger work dataset, tipically a campaign or project
Multiplicity:	1..*
Stereotypes:	«voidable»

Association role: samplingFeaure

Value type:	SF_SpatialSamplingFeature
Multiplicity:	

5.3.2.1.3. GeophObjectSet

GeophObjectSet (abstract)

Name:	Geoph Object Set
Definition:	Generic class for collections of geophysical objects
Description:	Set of geophysical objects that are grouped by some common properties. p.e: created in the same measuring campaign.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

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: citation

Value type:	Documentation
Definition:	Citation of geophysical object set documentation
Description:	online or offline documentation about the data set.
Multiplicity:	1

Attribute: verticalExtent

Value type:	EX_VerticalExtent
Definition:	Vertical extent of the range of interest.
Description:	It may be an estimated value for the depth of investigation, or the extent of the sampling configuration (p.e.: borehole) or an estimated depth of penetration. (seismic or EM measurements)
Multiplicity:	1
Stereotypes:	«voidable»

Attribute: distributionInfo

Value type:	MD_Distributor
Definition:	Distribution metadata
Description:	description of offline/online access and ordering procedure
Multiplicity:	1
Stereotypes:	«voidable»

Attribute: projectedGeometry

Value type:	ProjectedGeometry

GeophObjectSet (abstract)	
Definition:	2D projection of the feature to the ground surface. This is going to be used by WMS to display the 3D feature
Multiplicity:	1..*

5.3.2.1.4. GeophProfile

GeophProfile	
Name:	Geoph Profile
Subtype of:	GeophMeasurement
Definition:	Geophysical measurement spatially referenced to a curve
Description:	Used to collect data along a curve. Examples: 2D seismic line (field measurement), borehole logging, airborne geophysical flight line NOTE1. Processing results of geophProfiles are often surface coverages
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null
Attribute: shape	
Value type:	GM_Curve
Definition:	Shape of geophysical profile. It must be a curve.
Description:	The curve can be defined in either 2D or 3D coordinate system depending on the geometry of the profile. e.g the shape of a seismic line is 2D curve, the shape of a boreholeLogging measurement is 3D.curve.
Multiplicity:	1
Attribute: profileType	
Value type:	ProfileTypeValue
Definition:	Type of geophysical profile
Multiplicity:	1
Obligation:	Technical Guidance (recommendation)

5.3.2.1.5. GeophStation

GeophStation	
Name:	Geoph Station
Subtype of:	GeophMeasurement
Definition:	Geophysical measurement spatially referenced to a single point location
Description:	Used to collect data at a single location. The source-sensor setup may be elongated or two dimensional, but the collected data is referenced to a single point. Example: Gravity station, Magnetic station NOTE 1. Processing results of geophStations are often curve coverages
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null
Attribute: shape	
Value type:	GM_Point
Definition:	Shape of geophysical station. It must be a point.
Multiplicity:	1
Attribute: stationType	
Value type:	StationTypeValue
Definition:	Type of geophysical measurement
Description:	provides access to the extended codelist

GeophStation	
Multiplicity:	1
Obligation:	Technical Guidance (recommendation)
Attribute: stationRank	
Value type:	StationRankValue
Definition:	Geophysical stations may be part of a hyerarchical system. Rank relates to the importance of a station
Multiplicity:	1..*
Stereotypes:	«voidable»
Obligation:	Technical Guidance (recommendation)
Attribute: relatedNetwork	
Value type:	NetworkNameValue
Definition:	Name of a national or international observation network which the station belongs to, or which measured data is reported to.
Multiplicity:	0..*
Stereotypes:	«voidable»
Obligation:	Technical Guidance (recommendation)

5.3.2.1.6. GeophSwath

GeophSwath	
Name:	Geoph Swath
Subtype of:	GeophMeasurement
Definition:	Geophysical measurement spatially referenced to a surface
Description:	Used to collect data over a surface. Examples: seismic swath, radar bathimetry NOTE1. Processing results of geophProfiles can be both surface and solid coverages
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null
Attribute: shape	
Value type:	GM_Surface
Definition:	Shape of geophysical swath. It must be a surface
Description:	The surface can be defined in either 2D or 3D coordinate system depending on the geometry of the profile. NOTE: in the core model measurement type is restricted to 3D seismics where geometry is 2D polygon.
Multiplicity:	1
Attribute: measurementType	
Value type:	SwathTypeValue
Definition:	Type of geophysical swath
Multiplicity:	1
Obligation:	Technical Guidance (recommendation)

5.3.2.1.7. ProjectedGeometry

ProjectedGeometry	
Name:	Projected Geometry
Definition:	2D projection of the feature to the ground surface. This is going to be used by WMS to display the 3D feature
Status:	Proposed

ProjectedGeometry

Stereotypes:	«featureType»
Identifier:	null

5.3.2.1.8. SeismicLine

SeismicLine

Name:	Seismic Line
Subtype of:	GeophProfile
Definition:	2D or 3D seismic line
Description:	Seismic measurement alon a line
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

Attribute: seismicLineType

Value type:	SeismicLineTypeValue
Definition:	Type (dimensionality) of seismic line
Multiplicity:	1

Constraint: profileType=seismicLine

Natural language:	

5.3.2.1.9. Survey

Survey

Name:	Survey
Subtype of:	GeophObjectSet
Definition:	Geophysical activity for producing geophysical data
Description:	In the core model survey is used to document geophysical measurements that belong together and are too numerous to be handled one by one. p.e: gravity or airborne geophysical surveys that cover large areas and may contain millions of individual measurements.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

Attribute: surveyType

Value type:	SurveyTypeValue
Definition:	Type of geophysical survey
Multiplicity:	1

Association role: samplingFeature

Value type:	SF_SpatialSamplingFeature
Multiplicity:	

5.3.2.1.10. projectedOutline

projectedOutline

Name:	projected Outline
Subtype of:	ProjectedGeometry
Definition:	Representative bounding polygon of the related geophysical object or object set.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

Attribute: geometry

projectedOutline	
Value type:	GM_Polygon
Definition:	Polygon geometry to be displayed on a map
Multiplicity:	1

5.3.2.1.11. projectedPoint

projectedPoint	
Name:	projected Point
Subtype of:	ProjectedGeometry
Definition:	representative point of the related geophysical object
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null
Attribute: geometry	
Value type:	GM_Point
Definition:	Point geometry to be displayed on a map
Multiplicity:	1

5.3.2.1.12. projectedTrack

projectedTrack	
Name:	projected Track
Subtype of:	ProjectedGeometry
Definition:	Representative curve of the related geophysical object.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null
Attribute: geometry	
Value type:	GM_Curve
Definition:	Curve geometry to be displayed on a map.
Multiplicity:	1

5.3.2.2. Enumerations

5.3.2.2.1. SeismicLineTypeValue

SeismicLineTypeValue	
Name:	Seismic Line Type
Definition:	Type (dimensionality) of seismic line
Status:	Proposed
Stereotypes:	«enumeration»
Identifier:	null
Value: 2D	
Definition:	2 dimensional siesmic line
Value: 3D	
Definition:	3 dimensional siesmic line

5.3.2.2.2. SurveyTypeValue

SurveyTypeValue	
Name:	Survey Type
Definition:	Type of geophysical survey or dataset
Status:	Proposed
Stereotypes:	«enumeration»

SurveyTypeValue	
Identifier:	null
Value: airborneGeophysicalSurvey	
Definition:	airborne geophysical survey
Value: groundGravitySurvey	
Definition:	ground gravity survey
Value: groundMagneticSurvey	
Definition:	ground magnetic survey

5.3.2.3. Code lists

5.3.2.3.1. NetworkNameValue

NetworkNameValue	
Name:	Network Name
Definition:	Name of geophysical network
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.3.2.3.2. PlatformTypeValue

PlatformTypeValue	
Name:	Platform Type
Definition:	Platform on which data acquisition was carried out
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.3.2.3.3. ProfileTypeValue

ProfileTypeValue	
Name:	Profile Type
Definition:	Type of geophysical profile
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.3.2.3.4. StationRankValue

StationRankValue	
Name:	Station Rank
Definition:	Rank of geophysical station
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.3.2.3.5. StationTypeValue

StationTypeValue	
Name:	Station Type
Definition:	Type of geophysical station
Status:	Proposed

StationTypeValue	
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.3.2.3.6. SwathTypeValue

SwathTypeValue	
Name:	Swath Type
Definition:	Type of geophysical swath
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.3.2.4. 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.

5.3.2.4.1. Documentation

Documentation	
Package:	INSPIRE Consolidated UML Model::Generic Conceptual Model::Base Models::Observations::Processes [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.3.2.4.2. 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]

5.3.2.4.3. 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]

5.3.2.4.4. 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]

5.3.2.4.5. 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]

5.3.2.4.6. 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]

5.3.2.4.7. 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. 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. NOTE 3 The unique identifier will not change during the life-time of a spatial object.

5.3.2.4.8. MD_Distributor

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

5.3.2.4.9. SF_SpatialSamplingFeature

SF_SpatialSamplingFeature (abstract)	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19156 Observations and Measurements::ISO 19156:2011 Observations and Measurements::Sampling Features::spatialSamplingFeature [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.3.3 INSPIRE-governed code lists

The INSPIRE-defined code lists included in this application schema include the values specified in the tables in this section.

5.3.3.1. Values of code list StationTypeValue

Value	Name	Definition
gravityStation	gravity station	Gravity measurement station
magneticStation	magnetic station	Magnetic measurement station
seismologicalStation	seismological station	Seismologic measurement station

5.3.3.2. Values of code list ProfileTypeValue

Value	Name	Definition
seismicLine	seismic line	Seismic measurement along a line
boreholeLogging	borehole logging	Geophysical measurement in a borehole

5.3.3.3. Values of code list SwathTypeValue

Value	Name	Definition
3DSeismics	3D seismics	3D seismic measurement

5.3.3.4. Values of code list StationRankValue

Value	Name	Definition
observatory	observatory	Permanent monitoring facility with continuous observation scedule.
secularStation	secular station	Base station to observe long term time variations. Applied to magnetic stations.
1stOrderBase	1st. Order base	Base station of higher importance
2ndOrderBase	2nd. Order base	Base station of lower importance

Values of code list NetworkNameValue

Value	Name	Definition
UEGN	UEGN	Station is part of the Unified European Gravity Network
WDC	WDC	Station data is reported to World Data Center
IMS	IMS	IMS Seismological network

Values of code list PlatformTypeValue

Value	Name	Definition
ground	ground	Ground based measurement
fixedWingAircraft	fixed-wing aircraft	Measurement carried out from fixed-wing aircraft
helycopter	helycopter	Measurement carried out from helycopter
researchVessel	research vessel	Measurement carried out from a ship
satellite	satellite	Measurement carried out from a satellite

Values of code list SurveyTypeValue

Value	Name	Definition
2DSeismicSurvey	2D seismic survey	2D seismic survey
3DSeismicSurvey	3D seismic survey	3D seismic survey
airborneGeophysicalSurvey	airborne geophysical survey	Airborne geophysical survey
groundGravitySurvey	ground gravity survey	Ground gravity survey
groundMagneticSurvey	ground magnetic	Ground magnetic measurement survey

	survey	

Externally governed code lists

The externally governed code lists included *in this application schema are specified in the tables in this section.*

Governance, availability and constraints

Code list	Governance	Version	Availability	Formats	Subset
EUCountryCode	Publications Office of the European Union	Latest available version	http://publications.europa.eu/code/en/en-5000600.htm	HTML	

5.3.4 The values of selected external code lists are included in Annex E for information.

Rules for code list values

Code **list**	Identifiers	Identifier examples	**Labels**
GeophMeasurementTypeValue		http://geomind.elgi.hu/skos/GeophMeasurement/geophStation/timeDomainEMSounding.xml	skos:prefLabel
SurveyTypeValue		http://geomind.elgi.hu/skos/SurveyType/seismologicSurvey.xml	skos:prefLabel
CurveModelTypeValue		http://geomind.elgi.hu/skos/GeophModel/curve/seismicTimeSection.xml	skos:prefLabel
SurfaceGridModelTypeValue		http://geomind.elgi.hu/skos/GeophModel/surface/seismicDepthSection.xml	skos:prefLabel
SolidGridModelTypeValue		http://geomind.elgi.hu/skos/GeophModel/solid/seismicVolume.xml	skos:prefLabel
OtherGeophModelTypeValue		http://geomind.elgi.hu/skos/GeophModel/other/discSurface.xml	skos:prefLabel
GeophProperty		http://geomind.elgi.hu/skos/GeophProperty/seismics/seismicVelocity/Vp.xml	skos:prefLabel
ProcessParameter		http://geomind.elgi.hu/skos/ProcessParameter/2DseisProc/CDP_SPACING.xml	skos:prefLabel
GeophProcess		http://geomind.elgi.hu/skos/GeophProcess/2DseisProc/timeStacking.xml	skos:prefLabel

5.4 Application schema HydrogeologyCore

5.4.1 Description

5.4.1.1. Narrative description and UML overview

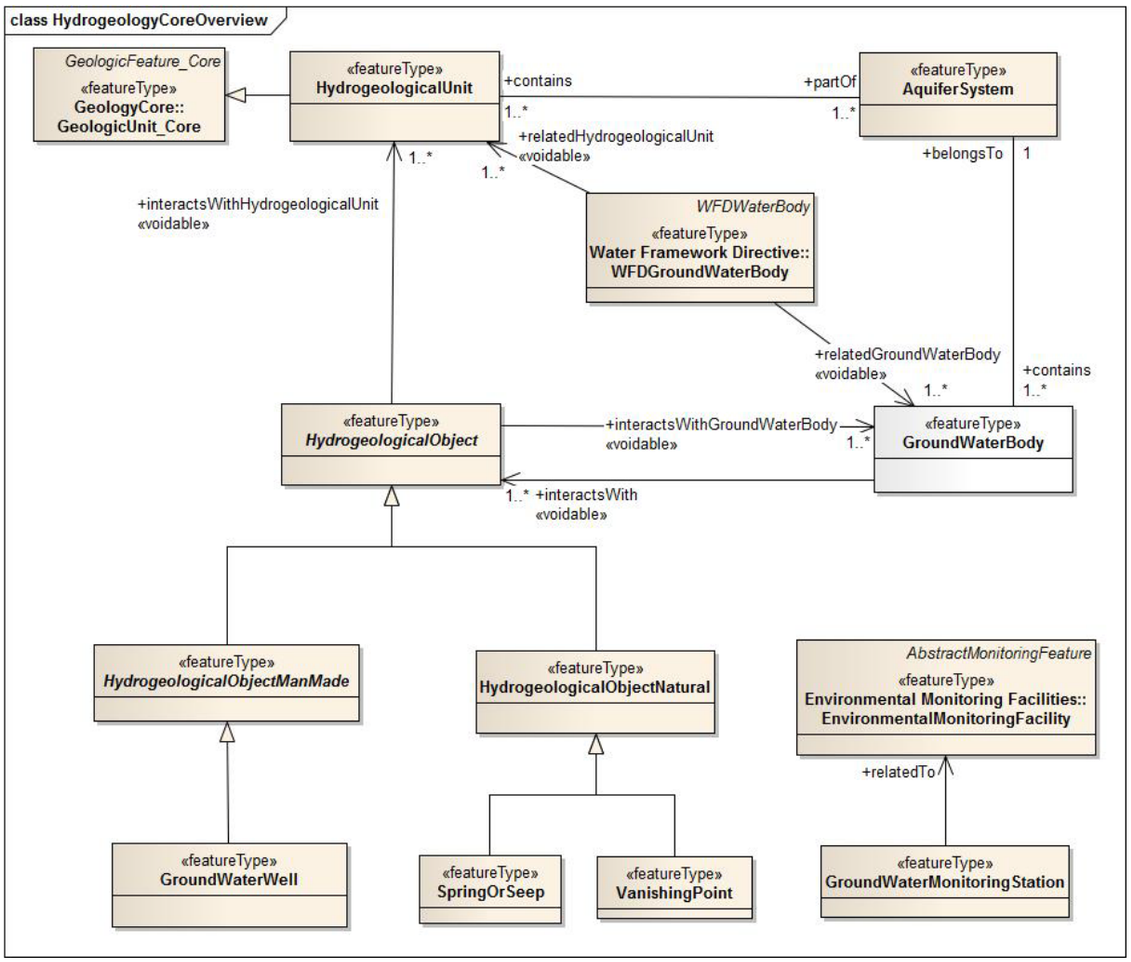


Figure 12 – UML class diagram: Overview of the HydrogeologicalCore application schema

The basic idea of the INSPIRE model for groundwater is to identify two basic elements: the **'rock' system** or aquifer system (invariable in time) with hydrogeological units, classified as aquifers, aquitards and aquicludes (dependent on the geological characteristics) and the **'groundwater' system** with groundwater bodies (variable in time).
Both components taken together create a hydrogeological system.
Hydrogeological objects (man-made and natural objects such as groundwater wells and springs) interact with these domains of the 'rock' system and the 'groundwater' system.
The principal aim of the core model is to capture the main classes of these objects and to provide the logical links between them. The Groundwater Flow system has distinct groundwater properties and a distinct pressure regime and is confined by permeability, groundwater surface or other barriers in the subsurface.
The **'groundwater' system** is created by groundwater flow in aquifers of the **'rock' system**, which have the right porosity and permeability to conduct groundwater.

The hydrogeology core model provides the classes of the 'rock' system and the 'groundwater' system and the links between them and also the interaction of these systems with man-made and natural objects.
Like the Geology core model the suggested Hydrogeology core model represents a more static approach aimed at providing hydrogeological maps on a regional or national scale (1 : 50.000 or smaller) .

Dynamic groundwater models and the dynamic flow of groundwater are out of scope of the core model, while these are mostly available only for the large scales (maybe up to 1:10.000) through more detailed groundwater modelling approaches.
Also out of scope are detailed measurements on the quality and chemical composition of groundwater and time series measurements of groundwater level within groundwater wells.

These are modelled in more detail in the WaterML 2.0 specification, as explained in the Annex for the hydrogeological extension schema.

The 'Rock' system

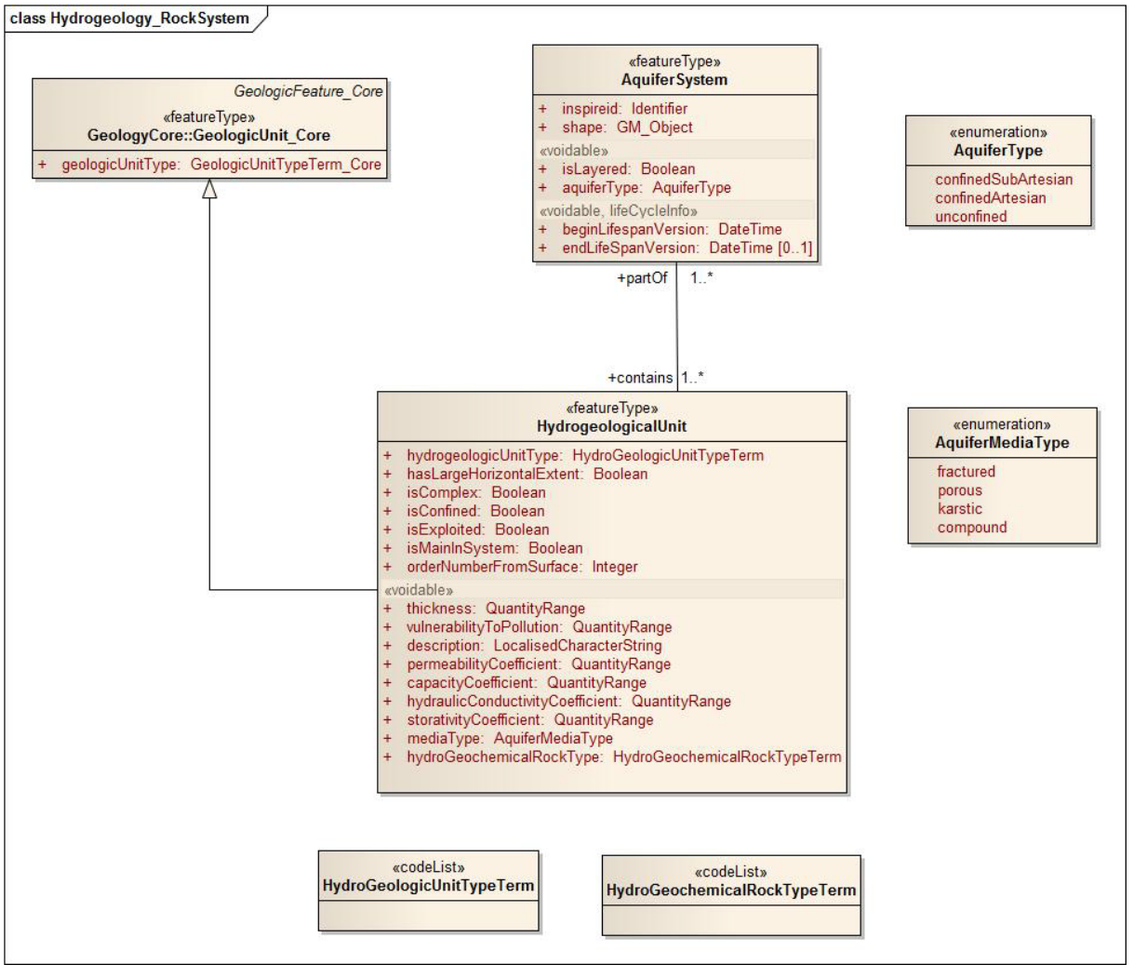


Figure 13 – UML class diagram: HydrogeologicalCore – the Rock system

The 'Rock' system has 2 classes: *HydrogeologicalUnit and AquiferSystem*
A *HydrogeologicalUnit* is any soil or rock unit which by virtue of its porosity or permeability, or lack thereof, has a distinct influence on the storage or movement of groundwater. *HydrogeologicalUnit* is a type of *GeologicUnit* and has a number of properties:

- hydrogeologicalUnitType; the type of hydrogeological unit
- isComplex: indicates if the unit contains a number of hydrogeological units
- hasLargeHorizontalExtent: indicates if aquifer is of regional or local extent
- isConfined: indicates if the aquifer water table is confined or not.
- isExploited: indicates if groundwater from the aquifer is exploited by wells or intakes
- isMainInSystem: indicates if aquifer is the main useful aquifer in the aquifer system

– orderNumber: consecutive layer number counted from the ground surface
– mediaType: the media type of a hydrogeological unit

voidable properties:
– thickness: the average perpendicular vertical distance between aquifer bottom and roof
– vulnerabilityToPollution: the potential degree of aquifer risk arising from the geological structure, hydrogeological conditions and the existence of real or potential source of contamination
– capacityCoefficient: volumetric capacity of an aquifer or aquitard to hold water
– permeabilityCoefficient: parameter expressing the permeability of the porous medium regardless of fluid properties
– hydraulicConductivityCoefficient: hydraulic conductivity is a measure of the ability to transmit water when submitted to a hydraulic gradient
– storativityCoefficient: the volume of water released from storage per unit decline in hydraulic head in the aquifer or aquitard, per unit area

There are three important types of *HydrogeologicalUnit*: *Aquifer*, *Aquitard and Aquiclude*. An *Aquifer* is a wet underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, silt, or clay) from which groundwater can be usefully extracted by a water well. An *Aquitard* is a saturated, but poorly permeable bed that impedes groundwater movement and does not yield water freely to wells, but which may transmit appreciable water to or from adjacent aquifers and, where sufficiently thick, may constitute an important groundwater storage unit. An *Aquiclude* is a HydrogeologicalUnit that due to its low permeability can act as a barrier to groundwater flow and as such often confines GroundWaterBodies.

An *AquiferSystem* is a collection of Aquifers and/or Aquitards which together constitute the environment of groundwater - "communicating vessels" that are filled or can be filled with groundwater i.e. a GroundWaterBody. *AquiferSystem* has three properties:
– isLayered: indicates if there is more than one layer
– mediaType: the media type of an aquifer system (to be moved to HydrogeologicalUnit?)
– aquiferType: the type of confined or unconfined aquifers in the aquifer system

An *AquiferSystem* must contain one or more *HydrogeologicalUnits.*

The 'Groundwater' system

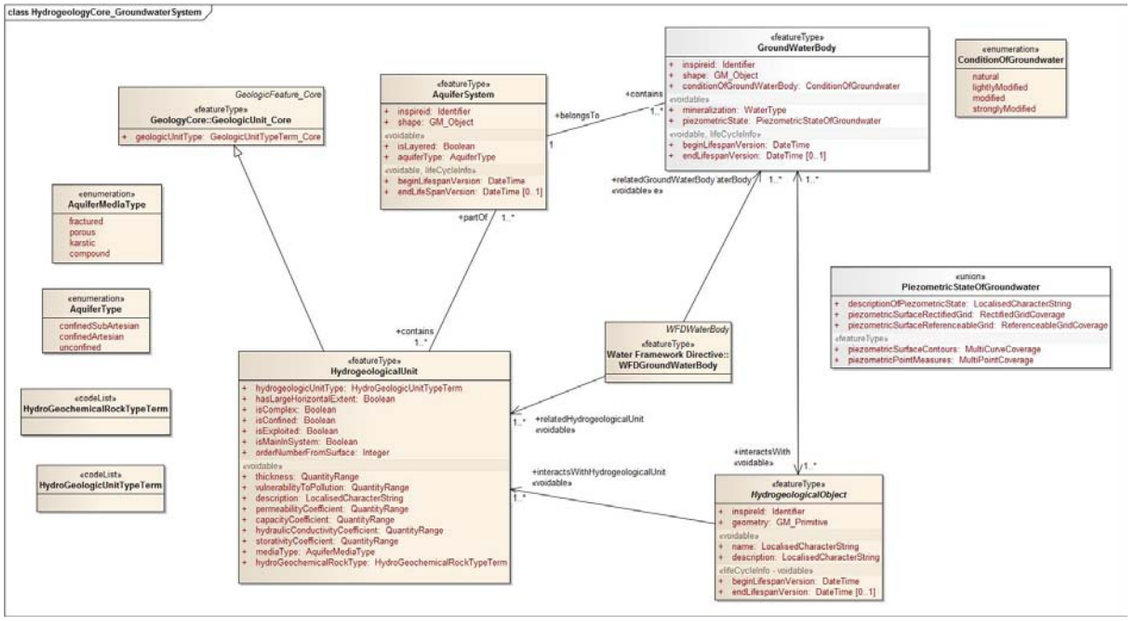


Figure 14 – UML class diagram: HydrogeologicalCore – the Groundwater system

A *GroundWaterBody* is a distinct volume of groundwater within an aquifer or system of aquifers, which is hydraulically isolated from nearby groundwater bodies. *GroundWaterBody* has three properties:

- conditionOfGroundwaterBody: records the approximate degree of change to groundwater as a result of human activity
- mineralization: is one of the main chemical characteristics of water. A value is a sum of all water chemical concentration components
- piezometricState: specifies the piezometric state of the GroundwaterBody water table

The *piezometricState* property of a *GroundWaterBody,* which specifies the piezometric state of the groundwater body water table, is modelled in a separate class *PiezometricStaeOfGroundwater.*

The surface of the water table can be delivered is the form of one of 4 coverage types:

- as a grid: piezometricSurfaceRectifiedGrid or piezometricSurfaceReferenceableGrid
- as a set of contours: piezometricSurfaceContours
- as a set of points: piezometricPointMeasures

Alternatively it can be described by free text through the *descriptionOfPiezoMetricState* property.

WFD_GroundWaterBody is a distinct volume of groundwater within a groundwater flow system, which is used as a reporting or management unit within the Water Framework Directive (WFD). This class is imported from the AM theme and is a special cases of a ManagementRegulationOrRestrictionZone.
It has seven properties, which are compliant with the WFD requirements and reporting to the Water Information System for Europe (WISE).

The relationship to the GroundWaterBody is modeled through an association (with multiplicity 0..n, i.e. every WFDGroundWaterBody may be based on mulitiple GroundWaterBodies). This is in analogy to the relatedHydroObject association (now moved from WFDWaterBody to WFDSurfaceWaterBody).

Hydrogeological objects

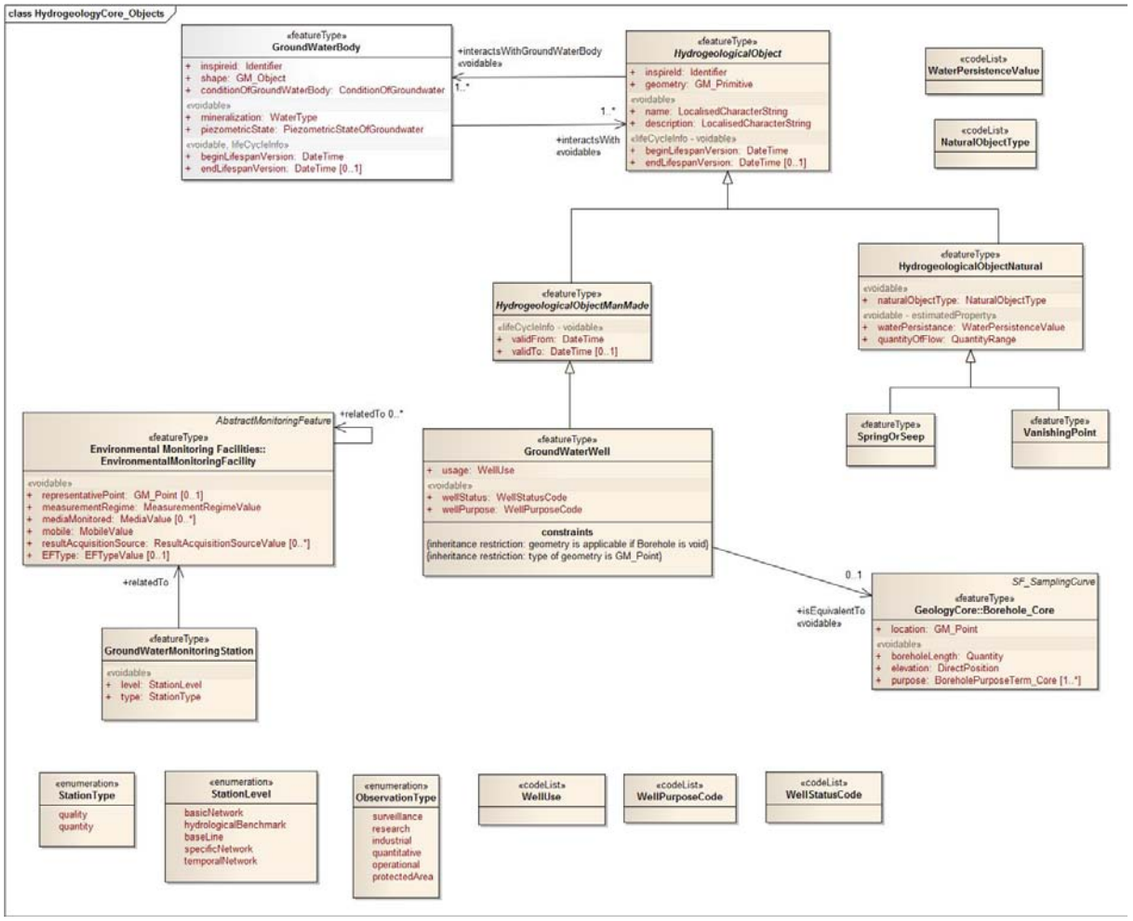


Figure 15 – UML class diagram: HydrogeologicalCore – the Hydrogeological Objects

HydrogeologicalObject is an abstract class for man-made or natural objects where interaction occurs with the hydrogeological system. *HydrogeologicalObject* has two subclasses *HydrogeologicalObjectManMade and HydrogeologicalObjectNatural*

HydrogeologicalObjectManMade is an abstract class for a manmade facility, where interaction occurs with the hydrogeological system.

A *GroundwaterWell* is the only type of *HydrogeologicalObjectManMade* currently defined in the application schema. It is a cased excavation or opening into the ground where the intended use is for location, acquisition, development, or artificial recharge of ground water. The *isEquivalentTo* association from *GroundwaterWell* to *Borehole* allows the *GroundwaterWell* to be associated with a particular Borehole. Where there is an associated *Borehole* the geometry should be taken from *Borehole* rather than from *HydrogeologicalObject*. Not all *GroundwaterWells* are Boreholes though.

GroundwaterWell has three properties:

- usage: a classification of the use of the well eg observation, monitoring etc
- wellStatus: the status of the well using classes from the *WaterUseCode* codelist
- wellPurpose: the purpose of the well using classes from the *WellPurposeCode* codelist

A *GroundWaterMonitoringStation* is a facility, where groundwater data are collected, generally at regular time intervals in order to provide information which may be used to determine the state of groundwater both in a quantitative and qualitative sense.
A *GroundWaterMonitoringStation* is made up of one or more GroundWaterObservationWells and is a type of *EnvironmentalMonitoringFacility (EF_Model_V2)*. *GroundWaterMonitoringStation* has two properties:
- level: the level of the monitoring station in the hierarchy of the monitoring system. Refers to the organisation of the monitoring network from national, regional and local levels
- type: the type of monitoring carried out at the monitoring station. Can be either quality (chemical status) or quantity (groundwater table level changes).

HydrogeologicalObjectNatural is the type of *HydrogeologicalObject* for natural objects where interaction (inflow or outflow) occurs with the hydrogeological system.
HydrogeologicalObjectNatural has three properties:
- naturalObjectType: the type of natural object
- waterPersistence: specifies the water occurrence frequency in the object
- quantityOfFlow: specifies the water flow value measures

The two placeholder features inherited from the Hydrography theme, *SpingOrSeep* and *VanishingPoint*, have been modelled as types of *HydrogeologicalObjectNatural*. Note however that this should not be considered a complete set of *HydrogeologicalObjectNatural* sub-types, there are many more which have not been modelled in this application schema.

5.4.1.2. Consistency between spatial data sets

5.4.1.3. Identifier management

5.4.1.4. Modelling of object references *(Optional)*

5.4.1.5. Geometry representation *(Optional)*

IR Requirement 7	The value domain of spatial properties used in this specification shall be restricted to the Simple Feature spatial schema as defined by EN ISO 19125-1.

NOTE The specification restricts the spatial schema to 0-, 1-, 2-, and 2.5-dimensional geometries where all curve interpolations are linear.

NOTE The topological relations of two spatial objects based on their specific geometry and topology properties can in principle be investigated by invoking the operations of the types defined in ISO 19107 (or the methods specified in EN ISO 19125-1).

5.4.1.6. Temporality representation *(Optional)*

The application schema(s) use(s) the derived attributes "beginLifespanVersion" and "endLifespanVersion" to record the lifespan of a spatial object.

The attribute "beginLifespanVersion" specifies the date and time at which this version of the spatial object was inserted or changed in the spatial data set. The attribute "endLifespanVersion" specifies

the date and time at which this version of the spatial object was superseded or retired in the spatial data set.

NOTE 1 The attributes specify the beginning of the lifespan of the version in the spatial data set itself, which is different from the temporal characteristics of the real-world phenomenon described by the spatial object. This lifespan information, if available, supports mainly two requirements: First, knowledge about the spatial data set content at a specific time; second, knowledge about changes to a data set in a specific time frame. The lifespan information should be as detailed as in the data set (i.e., if the lifespan information in the data set includes seconds, the seconds should be represented in data published in INSPIRE) and include time zone information.

NOTE 2 Changes to the attribute "endLifespanVersion" does not trigger a change in the attribute "beginLifespanVersion".

Recommendation 8 If life-cycle information is not maintained as part of the spatial data set, all spatial objects belonging to this data set should provide a void value with a reason of "unpopulated".

5.4.2 Feature catalogue

Table 3 - Feature catalogue metadata

Feature catalogue name	INSPIRE feature catalogue HydrogeologyCore
Scope	HydrogeologyCore
Version number	2.9
Version date	2012-02-24
Definition source	INSPIRE data specification HydrogeologyCore

Table 4 - Types defined in the feature catalogue

Type	Package	Stereotypes	Section
AquiferMediaType	HydrogeologyCore	«enumeration»	5.4.2.3.1
AquiferSystem	HydrogeologyCore	«featureType»	5.4.2.1.1
AquiferType	HydrogeologyCore	«enumeration»	5.4.2.3.2
ConditionOfGroundwater	HydrogeologyCore	«enumeration»	5.4.2.3.3
GroundWaterBody	HydrogeologyCore	«featureType»	5.4.2.1.2
GroundWaterMonitoringStation	HydrogeologyCore	«featureType»	5.4.2.1.3
GroundWaterWell	HydrogeologyCore	«featureType»	5.4.2.1.4
HydroGeochemicalRockTypeTerm	HydrogeologyCore	«codeList»	5.4.2.4.1
HydroGeologicUnitTypeTerm	HydrogeologyCore	«codeList»	5.4.2.4.2
HydrogeologicalObject	HydrogeologyCore	«featureType»	5.4.2.1.5
HydrogeologicalObjectManMade	HydrogeologyCore	«featureType»	5.4.2.1.6
HydrogeologicalObjectNatural	HydrogeologyCore	«featureType»	5.4.2.1.7
HydrogeologicalUnit	HydrogeologyCore	«featureType»	5.4.2.1.8
NaturalObjectType	HydrogeologyCore	«codeList»	5.4.2.4.3
ObservationType	HydrogeologyCore	«enumeration»	5.4.2.3.4
PiezometricStateOfGroundwater	HydrogeologyCore	«union»	5.4.2.2.1
SpringOrSeep	HydrogeologyCore	«featureType»	5.4.2.1.9
StationLevel	HydrogeologyCore	«enumeration»	5.4.2.3.5
StationType	HydrogeologyCore	«enumeration»	5.4.2.3.6
VanishingPoint	HydrogeologyCore	«featureType»	5.4.2.1.10

Type	Package	Stereotypes	Section
WaterPersistenceValue	HydrogeologyCore	«codeList»	5.4.2.4.4
WaterType	HydrogeologyCore	«enumeration»	5.4.2.3.7
WellPurposeCode	HydrogeologyCore	«codeList»	5.4.2.4.5
WellStatusCode	HydrogeologyCore	«codeList»	5.4.2.4.6
WellUse	HydrogeologyCore	«codeList»	5.4.2.4.7

5.4.2.1. Spatial object types

5.4.2.1.1. AquiferSystem

AquiferSystem

Name:	Aquifer System
Definition:	A collection of aquifers and aquitards, which together constitute the environment of groundwater - "communicating vessels", that are filled or can be filled with water. Attributes of Aquifer System and its components determine the feasibility of water collection, its movement, as well as the impact on its chemical state. -- Note -- The Aquifer System components and their attributes (including geometry) are relative stable over time except in special cases.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

Attribute: inspireid

Value type:	Identifier
Definition:	INSPIRE identifier
Multiplicity:	1

Attribute: shape

Value type:	GM_Object
Definition:	The geometry of the aquifer system.
Multiplicity:	1

Attribute: isLayered

Value type:	Boolean
Definition:	AquiferSystem which has more than one layer
Multiplicity:	1
Stereotypes:	«voidable»

Attribute: aquiferType

Value type:	AquiferType
Definition:	The type of confined or unconfined aquifer
Multiplicity:	1
Stereotypes:	«voidable»

Attribute: beginLifespanVersion

Value type:	DateTime
Definition:	Date and time at which this version of the spatial object was inserted or changed in the spatial data set.
Multiplicity:	1
Stereotypes:	«voidable,lifeCycleInfo»

Attribute: endLifeSpanVersion

Value type:	DateTime
Definition:	Date and time at which this version of the spatial object was superseded or retired in the spatial data set.

AquiferSystem	
Multiplicity:	0..1
Stereotypes:	«voidable,lifeCycleInfo»

5.4.2.1.2. GroundWaterBody

GroundWaterBody	
Name:	Ground Water Body
Definition:	A distinct volume of groundwater within an aquifer or system of aquifers, which is hydraulically isolated from nearby groundwater bodies. -- Note -- Groundwater bodies form the principal management units under the European Water Framework Directive (2000/60/CE, 2000) They should be hydraulically continuous entities, and must be defined on the basis of flow or abstraction, and are inextricably linked to surface water bodies.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null
Attribute: inspireid	
Value type:	Identifier
Definition:	INSPIRE identifier
Multiplicity:	1
Attribute: shape	
Value type:	GM_Object
Definition:	The geometry of the GroundWaterBody
Multiplicity:	1
Attribute: mineralization	
Value type:	WaterType
Definition:	One of the main chemical characteristics of water. A value is a sum of all water chemical concentration components.
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: conditionOfGroundWaterBody	
Value type:	ConditionOfGroundwater
Definition:	The approximate degree of change to groundwater as a result of human activity
Multiplicity:	1
Attribute: piezometricState	
Value type:	PiezometricStateOfGroundwater
Definition:	Specifies the piezometric state of the GroundwaterBody water table
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: beginLifespanVersion	
Value type:	DateTime
Definition:	Date and time at which this version of the spatial object was inserted or changed in the spatial data set.
Multiplicity:	1
Stereotypes:	«voidable,lifeCycleInfo»
Attribute: endLifespanVersion	
Value type:	DateTime

GroundWaterBody	
Definition:	Date and time at which this version of the spatial object was superseded or retired in the spatial data set.
Multiplicity:	0..1
Stereotypes:	«voidable,lifeCycleInfo»
Association role: interactsWith	
Value type:	HydrogeologicalObject
Definition:	The hydrogeological objects with which the groundwater body interacts
Multiplicity:	1..*
Stereotypes:	«voidable»

5.4.2.1.3. GroundWaterMonitoringStation

GroundWaterMonitoringStation	
Name:	Ground Water Monitoring Station
Definition:	A GroundWaterMonitoringStation is a facility, where groundwater data are collected, generally at regular time intervals in order to provide information which may be used to determine the state of groundwater both in quantitative and qualitative sense. -- Note -- Class GroundWaterMonitoringStation realizes class Station from ISO 19156 standard in hydrogeology domain.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null
Attribute: level	
Value type:	StationLevel
Definition:	Specifies the level of the monitoring station in the hierarchy of the monitoring system. Refers to the organisation of the monitoring network from national, regional and local levels.
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: type	
Value type:	StationType
Definition:	Specifies the type of monitoring carried out at the monitoring station. Can be either quality (chemical status) or quantity (groundwater table level changes)
Multiplicity:	1
Stereotypes:	«voidable»
Association role: relatedTo	
Value type:	EnvironmentalMonitoringFacility
Definition:	The Environmental Monitoring Station that the Groundwater Monitoring Station is related to.
Multiplicity:	

5.4.2.1.4. GroundWaterWell

GroundWaterWell	
Name:	Ground Water Well
Subtype of:	HydrogeologicalObjectManMade
Definition:	A cased excavation or opening into the ground where the intended use is for location, acquisition, development, or artificial recharge of ground water.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

GroundWaterWell

Attribute: usage

Value type:	WellUse
Definition:	A classification of the use of the well eg observation, monitoring etc
Multiplicity:	1
Obligation:	Technical Guidance (recommendation)

Attribute: wellStatus

Value type:	WellStatusCode
Definition:	Specifies the status of the well
Multiplicity:	1
Stereotypes:	«voidable»
Obligation:	Technical Guidance (recommendation)

Attribute: wellPurpose

Value type:	WellPurposeCode
Definition:	Specifies the purpose of the well eg water supply, recharge etc
Multiplicity:	1
Stereotypes:	«voidable»
Obligation:	Technical Guidance (recommendation)

Association role: isEquivalentTo

Value type:	Borehole_Core
Definition:	A Groundwater Well may be a borehole and this association describes that equivalence.
Multiplicity:	0..1
Stereotypes:	«voidable»

Constraint: inheritance restriction: geometry is applicable if Borehole is void

Natural language:

Constraint: inheritance restriction: type of geometry is GM_Point

Natural language:

5.4.2.1.5. HydrogeologicalObject

HydrogeologicalObject (abstract)

Name:	Hydrogeological Object
Definition:	A man-made or natural object where interaction occurs with the hydrogeological system
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

Attribute: inspireId

Value type:	Identifier
Definition:	INSPIRE identifier
Multiplicity:	1

Attribute: geometry

Value type:	GM_Primitive
Definition:	Spatial configuration of the object
Multiplicity:	1

HydrogeologicalObject (abstract)

Attribute: name

Value type: LocalisedCharacterString
Definition: Name by which this part of the system is known
Multiplicity: 1
Stereotypes: «voidable»

Attribute: description

Value type: LocalisedCharacterString
Definition: Text providing description of object
Multiplicity: 1
Stereotypes: «voidable»

Attribute: beginLifespanVersion

Value type: DateTime
Definition: The date the new object was created
Multiplicity: 1
Stereotypes: «lifeCycleInfo - voidable»

Attribute: endLifespanVersion

Value type: DateTime
Definition: The date that the next version of the object was created. If the endLifespanVersion is null, this indicates that the object is the current representation of the feature
Multiplicity: 0..1
Stereotypes: «lifeCycleInfo - voidable»

Association role: interactsWithHydrogeologicalUnit

Value type: HydrogeologicalUnit
Definition: The hydrogeological units that the HydrogeologicalObject interacts with.
Multiplicity: 1..*
Stereotypes: «voidable»

Association role: interactsWithGroundWaterBody

Value type: GroundWaterBody
Definition: The groundwater bodies with which the hydrogeological object interacts
Multiplicity: 1..*
Stereotypes: «voidable»

5.4.2.1.6. HydrogeologicalObjectManMade

HydrogeologicalObjectManMade (abstract)

Name: Hydrogeological Object Man Made
Subtype of: HydrogeologicalObject
Definition: A man-made facility, where interaction occurs with the hydrogeological system. -- Note -- Examples of man-made hydrogeological objects are: groundwater abstraction well, groundwater monitoring station or groundwater monitoring well.
Status: Proposed
Stereotypes: «featureType»
Identifier: null

Attribute: validFrom

Value type: DateTime
Definition: The date the object started being used
Multiplicity: 1

HydrogeologicalObjectManMade (abstract)

Stereotypes: «lifeCycleInfo - voidable»

Attribute: validTo

Value type: DateTime
Definition: The date the object ceased being used
Multiplicity: 0..1
Stereotypes: «lifeCycleInfo - voidable»

5.4.2.1.7. HydrogeologicalObjectNatural

HydrogeologicalObjectNatural

Name: Hydrogeological Object Natural
Subtype of: HydrogeologicalObject
Definition: A natural object, where interaction (inflow or outflow) occurs with the hydrogeological system. -- Note -- Examples of natural hydrogeological objects are: spring, seep or vanishing point.
Status: Proposed
Stereotypes: «featureType»
Identifier: null

Attribute: naturalObjectType

Value type: NaturalObjectType
Definition: The type of natural object
Multiplicity: 1
Stereotypes: «voidable»
Obligation: Technical Guidance (recommendation)

Attribute: waterPersistance

Value type: WaterPersistenceValue
Definition: Specifies the water occurrence frequency in the object
Multiplicity: 1
Stereotypes: «voidable - estimatedProperty»
Obligation: Technical Guidance (recommendation)

Attribute: quantityOfFlow

Value type: QuantityRange
Definition: Specifies the water flow value measures
Multiplicity: 1
Stereotypes: «voidable - estimatedProperty»
Obligation: null

5.4.2.1.8. HydrogeologicalUnit

HydrogeologicalUnit

Name: Hydrogeological Unit
Subtype of: GeologicUnit_Core
Definition: Any soil or rock unit which by virtue of its porosity or permeability, or lack thereof, has a distinct influence on the storage or movement of groundwater. -- Note -- Hydrogeological unit is almost always invariable in time. Examples of hydrogeological units are aquifer and aquitard. Groundwater flow system and groundwater body are not hydrogeological units.
Status: Proposed
Stereotypes: «featureType»
Identifier: null

Attribute: hydrogeologicUnitType

HydrogeologicalUnit

Value type: HydroGeologicUnitTypeTerm
Definition: The type of hydrogeologic unit, eq aquifer, aquitard etc
Multiplicity: 1
Obligation: Technical Guidance (recommendation)

Attribute: hasLargeHorizontalExtent

Value type: Boolean
Definition: Indicates if the hydrogeologic unit is of regional or local extent
Multiplicity: 1

Attribute: isComplex

Value type: Boolean
Definition: Contains a number of hydrogeological units
Multiplicity: 1

Attribute: isConfined

Value type: Boolean
Definition: Indicates if aquifer water table is confined or not.
Multiplicity: 1

Attribute: isExploited

Value type: Boolean
Definition: Indicates if groundwater from the hydrogeologic unit is exploited by wells or intakes
Multiplicity: 1

Attribute: isMainInSystem

Value type: Boolean
Definition: Indicates if the hydrogeologic unit is the main useful aquifer in the aquifer system
Multiplicity: 1

Attribute: orderNumberFromSurface

Value type: Integer
Definition: Consecutive layer number counted from the ground surface
Multiplicity: 1

Attribute: thickness

Value type: QuantityRange
Definition: The average perpendicular vertical distance between hydrogeologic unit bottom and roof
Multiplicity: 1
Stereotypes: «voidable»
Obligation: null

Attribute: vulnerabilityToPollution

Value type: QuantityRange
Definition: Term for the potential degree of aquifer risk arising from the geological structure, hydrogeological conditions and the existence of real or potential source of contamination
Multiplicity: 1
Stereotypes: «voidable»
Obligation: null

Attribute: description

HydrogeologicalUnit

Value type:	LocalisedCharacterString
Definition:	General hydrogeologic unit characteristics
Multiplicity:	1
Stereotypes:	«voidable»

Attribute: permeabilityCoefficient

Value type:	QuantityRange
Definition:	Parameter expressing the permeability of the porous medium regardless of fluid properties. The volume of an incompressible fluid that will flow in unit time through a unit cube of a porous substance across which a unit pressure difference is maintained.
Multiplicity:	1
Stereotypes:	«voidable»
Obligation:	null

Attribute: capacityCoefficient

Value type:	QuantityRange
Definition:	Volumetric capacity of a hydrogeologic unit to hold water.
Multiplicity:	1
Stereotypes:	«voidable»
Obligation:	null

Attribute: hydraulicConductivityCoefficient

Value type:	QuantityRange
Definition:	The hydraulic conductivity is a measure of the ability to transmit water when submitted to a hydraulic gradient. Hydraulic conductivity is defined by Darcy's law.
Multiplicity:	1
Stereotypes:	«voidable»
Obligation:	null

Attribute: storativityCoefficient

Value type:	QuantityRange
Definition:	Storativity is the volume of water released from storage per unit decline in hydraulic head in the aquifer or aquitard, per unit area. SOURCE: http://en.wikipedia.org/wiki/Specific_storage
Multiplicity:	1
Stereotypes:	«voidable»
Obligation:	null

Attribute: mediaType

Value type:	AquiferMediaType
Definition:	The media type of an aquifer system
Multiplicity:	1
Stereotypes:	«voidable»

Attribute: hydroGeochemicalRockType

Value type:	HydroGeochemicalRockTypeTerm
Definition:	The prevailing hydrogeochemical influence of groundwater in the unit.
Multiplicity:	1
Stereotypes:	«voidable»
Obligation:	Technical Guidance (recommendation)

5.4.2.1.9. SpringOrSeep

SpringOrSeep	
Name:	Spring Or Seep
Subtype of:	HydrogeologicalObjectNatural
Definition:	A natural outflow of water from below the ground surface.
Description:	NOTE 1 Corresponds to a 'source' node in a network view. NOTE 2 Regarded as a placeholder in Annex II theme 'Geology' due to the connection with groundwater.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

5.4.2.1.10. VanishingPoint

VanishingPoint	
Name:	Vanishing Point
Subtype of:	HydrogeologicalObjectNatural
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. NOTE 2 Regarded as a placeholder in Annex II theme 'Geology' due to the connection with groundwater.
Status:	Proposed
Stereotypes:	«featureType»
Identifier:	null

5.4.2.2. Data types

5.4.2.2.1. PiezometricStateOfGroundwater

PiezometricStateOfGroundwater	
Name:	Piezometric State Of Groundwater
Definition:	A data type describing the piezometric state of groundwater in a groundwater body or groundwater system in terms of a description, surface grid, surface contours or a set of point measures.
Status:	Proposed
Stereotypes:	«union»
Identifier:	null
Attribute: descriptionOfPiezometricState	
Value type:	LocalisedCharacterString
Definition:	Free text describing the piezometric state of the groundwater
Multiplicity:	1
Attribute: piezometricSurfaceRectifiedGrid	
Value type:	RectifiedGridCoverage
Definition:	Piezometric state value obtained from a rectified surface grid
Multiplicity:	1
Attribute: piezometricSurfaceReferenceableGrid	
Value type:	ReferenceableGridCoverage
Definition:	Piezometric state value obtained from a referenceable surface grid
Multiplicity:	1
Attribute: piezometricSurfaceContours	

PiezometricStateOfGroundwater	
Value type:	MultiCurveCoverage
Definition:	Piezometric state value obtained from surface contour map presented as a range
Multiplicity:	1
Stereotypes:	«featureType»
Obligation:	null

Attribute: piezometricPointMeasures

Value type:	MultiPointCoverage
Definition:	Piezometric state value obtained from direct measurements
Multiplicity:	1
Stereotypes:	«featureType»
Obligation:	null

5.4.2.3. Enumerations

5.4.2.3.1. AquiferMediaType

AquiferMediaType	
Name:	Aquifer Media Type
Definition:	An enumeration for describing the characteristics of the aquifer medium
Status:	Proposed
Stereotypes:	«enumeration»
Identifier:	null

Value: fractured

Definition:	Fractured aquifers are rocks in which the groundwater moves through cracks, joints or fractures in otherwise solid rock. Examples of fractured aquifers include granite and basalt. Porous media such as sandstone may become so highly cemented or recrystallized that all of the original space is filled. In this case, the rock is no longer a porous medium. However, if it contains cracks it can still act as a fractured aquifer.

Value: porous

Definition:	Porous media are those aquifers consisting of aggregates of individual particles such as sand or gravel. The groundwater occurs in and moves through the openings between the individual grains. Porous media where the grains are not connected to each other are considered unconsolidated. If the grains are cemented together, such aquifers are called consolidated. Sandstones are examples of consolidated porous media

Value: karstic

Definition:	Karstic aquifers are fractured aquifers where the cracks and fractures may be enlarged by solution, forming large channels or even caverns. Limestone terrain where solution has been very active is termed karst.

Value: compound

Definition:	A combination of a porous, karstic and/or fractured aquifer

5.4.2.3.2. AquiferType

AquiferType	
Name:	Aquifer Type
Definition:	An enumeration for describing the type of aquifer.
Status:	Proposed
Stereotypes:	«enumeration»
Identifier:	null

Value: confinedSubArtesian

AquiferType	
Definition:	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. The water level does not rise above the ground surface
Value: confinedArtesian	
Definition:	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. The water level rises above the ground surface, yielding a flowing well.
Value: unconfined	
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).

5.4.2.3.3. ConditionOfGroundwater

ConditionOfGroundwater	
Name:	Condition Of Groundwater
Definition:	Enumeration for indicating the approximate degree of changes, which have taken place on the natural state of groundwater. -- Note -- The groundwater in a GroundWaterFlowSystem is in a variable condition, dependent on external factors, among which diverse human activities.
Status:	Proposed
Stereotypes:	«enumeration»
Identifier:	null
Value: natural	
Definition:	Groundwater composition is dependent only on natural factors.
Value: lightlyModified	
Definition:	Groundwater composition is dependent mostly on natural factors, but with some human activity
Value: modified	
Definition:	Groundwater composition is modified by human activity.
Value: stronglyModified	
Definition:	Groundwater composition is modified by human activity and the values of a number of parameters exceed the drinking water standards.

5.4.2.3.4. ObservationType

ObservationType	
Name:	Observation Type
Definition:	A type of an observation made on the feature of interest.
Status:	Proposed
Stereotypes:	«enumeration»
Identifier:	null
Value: surveillance	

ObservationType	
Definition:	Monitoring programme to: - Validate risk assessments: supplement and validate the characterisation and risk assessment procedure with respect to risks of failing to achieve good groundwater chemical status; - Classify groundwater bodies: confirm the status of all groundwater bodies, or groups of bodies, determined as not being at risk on the basis of the risk assessments; and - Assess trends: provide information for use in the assessment of long-term trends in natural conditions and in pollutant concentrations resulting from human activity. Parameters indicative of all the biological, hydro-morphological and general as well as specific physico-chemical quality elements must be monitored
Value: research	
Definition:	Monitoring programme to research the GroundWaterBody (or any local groundwater conditions) to obtain quality or quantity measures.
Value: industrial	
Definition:	Local monitoring networks created to control groundwater status around industrial objects (factories, petrol stations and others)
Value: quantitative	
Definition:	Monitoring programme to supplement and validate the WFD Article 5 characterisation and risk assessment procedure with respect to risks of failing to achieve good groundwater quantitative status in all groundwater bodies, or groups of bodies. Its principal purpose is therefore to facilitate quantitative status assessment.
Value: operational	
Definition:	Monitoring programme to - establish the status of all groundwater bodies, or groups of bodies, determined as being ‘at risk’, - establish the presence of significant and sustained upward trends in the concentration of pollutants.
Value: protectedArea	
Definition:	Monitoring program established directly for Protected Areas (including Drinking Water Protected Area (DWPA))

5.4.2.3.5. StationLevel

StationLevel	
Name:	Station Level
Definition:	A type of level for a groundwater monitoring station.
Status:	Proposed
Stereotypes:	«enumeration»
Identifier:	null
Value: basicNetwork	
Definition:	National groundwater monitoring network or the network for filling out the Water Framework Directive tasks
Value: hydrologicalBenchmark	
Definition:	Provides a continuing series of consistent observations on hydrological and related climatological variables.
Value: baseLine	
Definition:	Provides baseline environmental conditions with which to compare changes in water quality
Value: specificNetwork	
Definition:	Monitoring network created for local assessment tasks or other purposes

StationLevel	
Value: temporalNetwork	
Definition:	Monitoring network created just for temporal purposes

5.4.2.3.6. StationType

StationType	
Name:	Station Type
Definition:	A type of groundwater monitoring station.
Status:	Proposed
Stereotypes:	«enumeration»
Identifier:	null
Value: quality	
Definition:	Monitoring stations where the quality (chemical parameters) measurements are collected
Value: quantity	
Definition:	Monitoring stations where the quantity measurements are collected

5.4.2.3.7. WaterType

WaterType	
Name:	Water Type
Definition:	An enumeration class, that refers to the concept of salinity and its classes in water. -- Note -- Salinity is the saltiness or dissolved salt content of a body of water. 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.
Status:	Proposed
Stereotypes:	«enumeration»
Identifier:	null
Value: ultraFreshWater	
Definition:	Very pure water with little or no mineral content.
Value: freshWater	
Definition:	Freshwater is a word that refers to bodies of water such as ponds, lakes, rivers and streams containing low concentrations of dissolved salts (less than 0.5 parts per thousand) and other total dissolved solids. In other words, the term excludes seawater and brackish water. Freshwater can also be the output of desalinated seawater.
Value: acratopegae	
Definition:	Groundwater with total mineralization lower than 1000 mg/dm3 and temperature lower than 20 C
Value: brackishWater	
Definition:	Brackish water (less commonly brack water) is water that has more salinity than fresh water, but not as much as seawater. It may result from mixing of seawater with fresh water, as in estuaries, or it may occur in brackish fossil aquifers. Technically, brackish water contains between 0.5 to 30 grams of salt per litre more often expressed as 0.5 to 30 parts per thousand (ppt). Thus, brackish covers a range of salinity regimes and is not considered a precisely defined condition.
Value: saltWater	

WaterType	
Definition:	Salt (Saline) water is a general term for water that contains a significant concentration of dissolved salts (NaCl). The concentration is usually expressed in parts per million (ppm) of salt. The salinity concentration level used by United States Geological Survey classifies saline water in three categories. Slightly saline water contains around 1,000 to 3,000 ppm. Moderately saline water contains roughly 3,000 to 10,000 ppm. Highly saline water has around 10,000 to 35,000 ppm of salt. Seawater has a salinity of roughly 35,000 ppm, equivalent to 35 g/L.
Value: brineWater	
Definition:	Brine (lat. saltus) is water saturated or nearly saturated with salt (NaCl).

5.4.2.4. Code lists

5.4.2.4.1. HydroGeochemicalRockTypeTerm

HydroGeochemicalRockTypeTerm	
Name:	Hydro Geochemical Rock Type Term
Definition:	A codelist of hydrogeochemical rock types
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.4.2.4.2. HydroGeologicUnitTypeTerm

HydroGeologicUnitTypeTerm	
Name:	Hydro Geologic Unit Type Term
Definition:	A vocabulary of the types of hydrogeologic unit eg aquifer, aquitard etc
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.4.2.4.3. NaturalObjectType

NaturalObjectType	
Name:	Natural Object Type
Definition:	A type of natural hydrogeological object.
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.4.2.4.4. WaterPersistenceValue

WaterPersistenceValue	
Name:	Water Persistence
Definition:	The type of hydrological persistence of water.
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.4.2.4.5. WellPurposeCode

WellPurposeCode	
Name:	Well Purpose Code
Definition:	Code for defining the purpose of a water well.

WellPurposeCode	
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.4.2.4.6. WellStatusCode

WellStatusCode	
Name:	Well Status Code
Definition:	A code list for defining the status of a well.
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.4.2.4.7. WellUse

WellUse	
Name:	Well Use
Definition:	A code list for the usage of a water well (production or pumping wells, monitoring wells, piezometers).
Status:	Proposed
Stereotypes:	«codeList»
Extensibility:	any
Identifier:	

5.4.2.5. 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.

5.4.2.5.1. Boolean

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

5.4.2.5.2. Borehole_Core

Borehole_Core	
Package:	INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::GeologyCore [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	A borehole is the generalized term for any narrow shaft drilled in the ground, either vertically or horizontally.

5.4.2.5.3. DateTime

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

5.4.2.5.4. EnvironmentalMonitoringFacility

EnvironmentalMonitoringFacility	
Package:	INSPIRE Consolidated UML Model::Themes::Annex III::Environmental Monitoring Facilities::Environmental Monitoring Facilities [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	An Environmental Monitoring Facility is a georeferenced object directly collecting and or processing data or hosting other Environmental Monitoring Facility objects collecting data about features whose properties (e.g. physical, chemical, biological or other aspects of environmental conditions) are repeatedly observed/measured using static or mobile, in-situ or remote methods. An Environmental Monitoring Facility encompasses notions of platform/site/station/sensor often found within various thematic domains.
Description:	NOTE 1: An Environmental Monitoring Facility is not a Facility in the following Inspire annex perspectives : - Buildings - Agricultural and aquacultural facilities - Production and industrial facilities - Utility and governmental services . NOTE 2: Laboratories are not Environmental Monitoring Facilities from INSPIRE perspective as the exact location of the laboratory does not add further information to the measurement. The methodology used in the laboratory should be provided with observational data. NOTE 3: From INSPIRE perspective, an Environmental Monitoring Facility requires the provision of Observations only in the case that these have been required under a given reporting obligation or a commonly agreed voluntarily based one.

5.4.2.5.5. 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]

5.4.2.5.6. GM_Primitive

GM_Primitive (abstract)	
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]

5.4.2.5.7. GeologicUnit_Core

GeologicUnit_Core	
Package:	INSPIRE Consolidated UML Model::Themes::Annex II::Geology::GeologyMain::GeologyCore [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.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).

5.4.2.5.8. 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. 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. NOTE 3 The unique identifier will not change during the life-time of a spatial object.

5.4.2.5.9. Integer

Integer	
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]

5.4.2.5.10. LocalisedCharacterString

LocalisedCharacterString	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19139 Metadata - XML Implementation::Cultural and linguistic adapdability [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.4.2.5.11. RectifiedGridCoverage

RectifiedGridCoverage	
Package:	INSPIRE Consolidated UML Model::Generic Conceptual Model::Base Models::Coverages (Domain and Range) [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	coverage whose domain consists of a rectified grid
Description:	A rectified grid is a grid for which there is an affine transformation between the grid coordinates and the coordinates of a coordinate reference system. NOTE This type can be used for both discrete and continuous coverages.

5.4.2.5.12. ReferenceableGridCoverage

ReferenceableGridCoverage	
Package:	INSPIRE Consolidated UML Model::Generic Conceptual Model::Base Models::Coverages (Domain and Range) [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	coverage whose domain consists of a referencable grid
Description:	A referencable grid is a grid associated with a transformation that can be used to convert grid coordinate values to values of coordinates referenced to a coordinate reference system. NOTE This type can be used for both discrete and continuous coverages.

5.4.3 INSPIRE-governed code lists

The INSPIRE-defined code lists included in this application schema include the values specified in the tables in this section.

5.4.3.1. Values of code list <UMLCodeListName>

Value	Name	Definition	Description	**Parent value**
disused	disused	The facility is not used.		
functional	functional	The facility is functional.		
projected	projected	The facility is being designed. Construction has not yet started.		
underConstruction	under construction	The facility is under construction and not yet functional. This applies only to the initial construction of the facility and not to maintenance work.		

5.4.4 Externally governed code lists

5.4.5

5.4.6 The externally governed code lists included in this application schema are specified in the tables in this section.

5.4.7

5.4.8 Governance, availability and constraints

Code list	Governance	Version	Availability	**Formats**	**Subset**
EUCountryCode	Publications Office of the European Union	Latest available version	http://publications.europa.eu/code/en/en-5000600.htm	HTML	

5.4.9 The values of selected external code lists are included in Annex X for information.

5.4.10 Rules for code list values

5.4.11

Code list	Identifiers	Identifier **examples**	Labels
EUCountryCode	Append the upper-case two-letter code in	http://inspire.ec.europa.eu/codeList/CountryCode/DE http://inspire.ec.europa.eu/codeList/CountryCode/UK	The name in the "Country/territory" column of Annex A6

	the "Code" column of Annex A6 to the URI prefix http://inspire.ec.europa.eu/codeList/CountryCode/	

5.4.12

5.4.13

5.4.14

6 Reference systems

6.1 Coordinate reference systems

6.1.1 Datum

IR Requirement 8	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 9	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 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 10	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 11	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 12	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 the data quality elements and sub-elements as well as the corresponding data quality measures that should be used to evaluate and document data quality for data sets related to the spatial data theme *Geology* (section 7.1).

It may also define requirements or recommendations about the targeted data quality results applicable for data sets related to the spatial data theme *Geology* (sections 7.2 and 7.3).

In particular, the data quality elements, sub-elements and measures specified in section 7.1 should be used for

- evaluating and documenting data quality properties and constraints of spatial objects, where such properties or constraints are defined as part of the application schema(s) (see section 5);
- evaluating and documenting data quality metadata elements of spatial data sets (see section 8); and/or
- specifying requirements or recommendations about the targeted data quality results applicable for data sets related to the spatial data theme *Geology* (see sections 7.2 and 7.3).

The descriptions of the elements and measures are based on Annex D of ISO/DIS 19157 Geographic information – Data quality.

7.1 Data quality elements

Table 1 lists all data quality elements and sub-elements that are being used in this specification. Data quality information can be evaluated at level of spatial object, spatial object type, dataset or dataset series. The level at which the evaluation is performed is given in the “Evaluation Scope” column.

The measures to be used for each of the listed data quality sub-elements are defined in the following sub-sections.

Table 2 – Data quality elements used in the spatial data theme *Geology*

Section	Data quality element	Data quality sub-element	Definition	Evaluation Scope
7.1.1	Completeness	Commission	excess data present in the dataset, as described by the scope	dataset series; dataset; spatial object type
7.1.2	Completeness	Omission	data absent from the dataset, as described by the scope	dataset series; dataset; spatial object type
7.1.3	Logical consistency	Conceptual consistency	adherence to rules of the conceptual schema	dataset series; dataset; spatial object type; spatial object
7.1.4	Logical consistency	Domain consistency	adherence of values to the value domains	dataset series; dataset; spatial object type; spatial object
7.1.5	Logical consistency	Format consistency	degree to which data is stored in accordance with the physical structure of the dataset, as described by the scope	dataset series; dataset; spatial object type; spatial object
7.1.6	Logical consistency	Topological consistency	correctness of the explicitly encoded topological characteristics of the dataset, as described by the scope	dataset series; dataset; spatial object type; spatial object
7.1.7	Positional accuracy	Absolute or external accuracy	closeness of reported coordinate values to values accepted as or being true	spatial object
7.1.8	Positional accuracy	Relative or internal accuracy	closeness of the relative positions of features in the scope to their respective relative positions accepted as or being true	dataset series; dataset; spatial object type; spatial object
7.1.9	Positional accuracy	Gridded data position accuracy	closeness of gridded data position values to values accepted as or being true	dataset series; dataset; spatial object type; spatial object
7.1.10	Thematic accuracy	Classification correctness	comparison of the classes assigned to features or their attributes to a universe of discourse	dataset series; dataset; spatial object type; spatial object
7.1.11	Thematic accuracy	Non-quantitative attribute correctness	correctness of non-quantitative attributes	dataset series; dataset; spatial object type; spatial object
7.1.12	Thematic accuracy	Quantitative attribute accuracy	accuracy of quantitative attributes	dataset series; dataset; spatial object type; spatial object
7.1.13	Temporal quality	Accuracy of a time measurement	correctness of the temporal references of an item (reporting of error in time measurement)	dataset series; dataset; spatial object type; spatial object
7.1.14	Temporal quality	Temporal consistency	correctness of ordered events or sequences, if reported	dataset series; dataset; spatial object type; spatial object

7.1.15	Temporal quality	Temporal validity	validity of data specified by the scope with respect to time	dataset series; dataset; spatial object type; spatial object
7.1.16	Usability	--	degree of adherence of a dataset to a specific set of requirements	dataset series; dataset; spatial object type; spatial object

Name	**<Name of the measure, from ISO/DIS 19157>**
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	*The name of the data quality element to which this data quality measure applies. See the appropriate column of Table 2.*
Data quality sub-element	*The name of the data quality sub-element to which this data quality measure applies. See the appropriate column of Table 2.*
Data quality basic measure	*Choose one of the listed measures and delete the others as appropriate.* *See also ISO/DIS 19157, Annex G.* 1) Counting-related data quality basic measures: Error indicator | Correctness indicator | Error count | Correct items count | Error rate | Correct items rate *2)* Uncertainty-related data quality basic measures: One-dimensional random variable, Z | Two-dimensional random variable X and Y | Three-dimensional random variable X, Y, Z
Definition	*Give definition from the standard or your own definition if this is a self-defined element.*
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.*
Evaluation scope	*Define the scope at which the data quality is evaluated. Use one or several of the following. This is the same scope as listed in Table 2.* spatial object: <Name(s) of spatial object type(s)> spatial object type: <Name(s) of spatial object type(s)> data set data set series
Reporting scope	*Define the scope(s) at which the data quality is to be reported in the metadata. Use one or several of the following:* spatial object type: <Name(s) of spatial object type(s)> data set data set series
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	*A data quality result may be a single value or consist of multiple*

	values. In the latter case the data quality result shall be structured using one of the data quality value structures listed below. Use one of the following options: Single value 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. ISO/DIS 19157 is included as the default citation. Delete or add as appropriate.* ISO/DIS 19157 Geographic information – Data quality
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/DIS 19157, Annex D.*

Recommendation 9 Where it is impossible to express the evaluation of a data quality element in a quantitative way, the evaluation of the element should be expressed with a textual statement as a data quality descriptive result.

7.1.1 Completeness – Commission

Recommendation 10 Commission should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

7.1.2 Completeness – Omission

Recommendation 11 Omission should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

7.1.3 Logical consistency – Conceptual consistency

Recommendation 12 Conceptual consistency should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

7.1.4 Logical consistency – Domain consistency

Recommendation 13 Domain consistency should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

7.1.5 Logical Consistency – Format consistency

Recommendation 14 Format consistency should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

7.1.6 Logical Consistency – Topological consistency

Recommendation 15 Topological consistency should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

7.1.7 Positional accuracy – Absolute or external accuracy

Recommendation 16 Absolute or external accuracy should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

Name	**Positional accuracy – Absolute or external accuracy**
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	Two-dimensional random variable X and Y
Definition	Value of the positional uncertainty of a borehole collar location.
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.*
Evaluation scope	spatial object type: Borehole
Reporting scope	*Define the scope(s) at which the data quality is to be reported in the metadata. Use one or several of the following:* spatial object type: Borehole
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	*A data quality result may be a single value or consist of multiple values. In the latter case the data quality result shall be structured using one of the data quality value structures listed below. Use one of the following options:* Single value
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. ISO/DIS 19157 is included as the default citation. Delete or add as appropriate.* ISO/DIS 19157 Geographic information – Data quality
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	19

7.1.8 Positional accuracy – Relative or internal accuracy

Recommendation 17 Relative or internal accuracy should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

7.1.9 Positional accuracy – Gridded data position accuracy

Recommendation 18 Gridded data position accuracy should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

7.1.10 Thematic accuracy – Classification correctness

Recommendation 19 Classification correctness should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

7.1.11 Thematic accuracy – Non-quantitative attribute correctness

Recommendation 20 Non-quantitative attribute correctness should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

7.1.12 Thematic accuracy – Quantitative attribute accuracy

Select the measure(s) for documenting this DQ sub-element from Annex D of ISO/DIS 19157. List the selected data quality measure(s) in the recommendation below.

Recommendation 21 Quantitative attribute accuracy should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

Insert a table for each selected data quality measure using the template included at the beginning of section 7.1 above.

7.1.13 Temporal quality – Accuracy of a time measurement

Select the measure(s) for documenting this DQ sub-element from Annex D of ISO/DIS 19157. List the selected data quality measure(s) in the recommendation below.

Recommendation 22 Accuracy of a time measurement should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

Insert a table for each selected data quality measure using the template included at the beginning of section 7.1 above.

7.1.14 Temporal quality – Temporal consistency

Select the measure(s) for documenting this DQ sub-element from Annex D of ISO/DIS 19157. List the selected data quality measure(s) in the recommendation below.

Recommendation 23 Temporal consistency should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

Insert a table for each selected data quality measure using the template included at the beginning of section 7.1 above.

7.1.15 Temporal quality – Temporal validity

Select the measure(s) for documenting this DQ sub-element from Annex D of ISO/DIS 19157. List the selected data quality measure(s) in the recommendation below.

Recommendation 24	Temporal validity should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

Insert a table for each selected data quality measure using the template included at the beginning of section 7.1 above.

7.1.16 Usability

Usability describes the adherence to a particular application/specification or user requirements. For example, with this element a data provider can show for a specific dataset, with quantitative elements, how it fits different identified usages. In the table describing the data quality measure the application / specification / user requirements shall be referred as external source.

Select the measure(s) for documenting this DQ sub-element from Annex D of ISO/DIS 19157. List the selected data quality measure(s) in the recommendation below.

Recommendation 25	Usability should be evaluated and documented using <Name of the measure(s), from ISO/DIS 19157> as specified in the tables below.

Insert a table for each selected data quality measure using the template included at the beginning of section 7.1 above.

7.2 Minimum data quality requirements

If no minimum data quality requirements are defined, include the following sentence and remove the IR requirement and the table. Otherwise delete the sentence.
No minimum data quality requirements are defined for the spatial data theme Geology.

IR Requirement 13	For the data quality elements listed in **Error! Reference source not found.**, all data sets related to the spatial data theme Geology shall meet the specified target results.

List all data quality elements, for which minimum data quality requirements are defined in the following table, and remove all other elements.

Table 3 – Minimum data quality requirements for spatial data theme Geology

Section	Data quality element and sub-element	Measure name(s) *e.g. Rate of excess items*	Target result(s) *e.g. Max. 5/1000.* *If appropriate indicate also the unit of measure of the DQ measure used.*	Condition *If the target result shall be met only under certain conditions, specify these conditions here.* *This column should also be used if different measures or target results are used for different spatial object types within a data set.*

7.3 Recommendation on data quality

No minimum data quality recommendations are defined.

Recommendation 26 For the data quality elements listed in **Error! Reference source not found.**, all data sets related to the spatial data theme *Geology* should meet the specified target results.

List all data quality elements, for which minimum data quality requirements are defined in the following table, and remove all other elements.

Table 4 – Recommended minimum data quality results for spatial data theme Geology

Section	Data quality element and sub-element	Measure name(s) *e.g. Rate of excess items*	Target result(s) *e.g. Max. 5/1000.* *If appropriate indicate also the unit of measure of the DQ measure used.*	Condition *If the target result shall be met only under certain conditions, specify these conditions here.* *This column should also be used if different measures or target results are used for different spatial object types within a data set.*
7.XX	Absolute or external accuracy			

8 Dataset-level metadata

This section specifies dataset-level metadata elements, which should be used for documenting metadata for a complete dataset or dataset series.

NOTE Metadata can also be reported for each individual spatial object (spatial object-level metadata). Spatial object-level metadata is fully described in the application schema(s) (section 5).

For some dataset-level metadata elements, in particular those for reporting 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 19115/19157/19139 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 reporting scope.

  NOTE The reporting scope can be different from the evaluation scope (see section 7).

- Only the following values should be used for the level element of DQ_Scope: Series, Dataset, featureType.

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

- If the level is featureType the levelDescription/MDScopeDescription/features element (of type Set< GF_FeatureType>) shall be used to list the feature type names.

Mandatory or conditional metadata elements are specified in Section 8.1. Optional metadata elements are specified in Section 8. 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 1 and Table 2).

8.1 Common metadata elements

IR Requirement 14	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 1) as well as the metadata elements specified in Table 2.

Table 5 – 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 6 – 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.

8.1.5	Data Quality – Logical Consistency – Topological Consistency	0..*	Mandatory, if the data set includes types from the Generic Network Model and does not assure centreline topology (connectivity of centrelines) for the network.

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.)	186. MD_ReferenceSystem
Domain	To identify the reference system, the referenceSystemIdentifier (RS_Identifier) shall be provided. NOTE More specific instructions, in particular on pre-defined values for filling the referenceSystemIdentifier attribute should be agreed among Member States during the implementation phase to support interoperability.
Implementing instructions	
Example	referenceSystemIdentifier: code: ETRS_89 codeSpace: INSPIRE RS registry
Example XML encoding	<gmd:referenceSystemInfo> <gmd:MD_ReferenceSystem> <gmd:referenceSystemIdentifier> <gmd:RS_Identifier> <gmd:code> <gco:CharacterString>ETRS89 </gco:CharacterString> </gmd:code> <gmd:codeSpace> <gco:CharacterString>INSPIRE RS registry</gco:CharacterString> </gmd:codeSpace> </gmd:RS_Identifier> </gmd:referenceSystemIdentifier> </gmd:MD_ReferenceSystem> </gmd:referenceSystemInfo>
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. NOTEMore specific instructions, in particular on pre-defined values for filling the referenceSystemIdentifier attribute should be agreed among Member States during the implementation phase to support interoperability.
Implementing instructions	
Example	referenceSystemIdentifier: code: GregorianCalendar codeSpace: INSPIRE RS registry
Example XML encoding	<gmd:referenceSystemInfo> <gmd:MD_ReferenceSystem> <gmd:referenceSystemIdentifier> <gmd:RS_Identifier> <gmd:code> <gco:CharacterString>GregorianCalendar</gco:CharacterString> > </gmd:code> <gmd:codeSpace> <gco:CharacterString>INSPIRE RS registry</gco:CharacterString> </gmd:codeSpace> </gmd:RS_Identifier> </gmd:referenceSystemIdentifier> </gmd:MD_ReferenceSystem> </gmd:referenceSystemInfo>
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 property values (name, version, specification) specified in section 9 shall be used to document the default and alternative encodings.
Implementing instructions	
Example	name: **Geology** GML application schema version: version **2.9.0**, GML, version 3.2.1 specification: D2.8.**II**.**4** Data Specification on **Geology** – Draft Guidelines

Example XML encoding	<gmd:MD_Format> <gmd:name> <gco:CharacterString> **Geology** GML application schema </gco:CharacterString> </gmd:name> <gmd:version> <gco:CharacterString>**2.9.0**, GML, version 3.2.1</gco:CharacterString> </gmd:version> <gmd:specification> <gco:CharacterString>D2.8.**II.4** Data Specification on **Geology** – Draft Guidelines</gco:CharacterString> </gmd:specification> </gmd:MD_Format>
Comments	

8.1.4 Character Encoding

Metadata element name	**Character Encoding**
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	<gmd:characterSet> <gmd:MD_CharacterSetCode codeListValue="8859part2" codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codelist/ML_gmxCodelists.xml#CharacterSetCode">8859-2</gmd:MD_CharacterSetCode> </gmd:characterSet>
Comments	

8.1.5 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
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..*

Comments	See clauses on topological consistency in section 7 for detailed information. This metadata element is mandatory if connectivity is not assured for network centrelines in the dataset. In this case the *Connectivity tolerance* parameter – as described in section 7 – must be provided in order to ensure automatic and unambiguous creation of centreline topology in post-process.

NOTE See section 8.2 for further instructions on how to implement metadata elements for reporting data quality.

8.2 Metadata elements for reporting data quality

Recommendation 27 For reporting the results of the data quality evaluation, the data quality elements, sub-elements and (for quantitative evaluation) measures defined in chapter 7 should be used.

The scope for reporting may be different from the scope for evaluating data quality (see section 7). If data quality is reported at the data set or spatial object type level, the results are usually derived or aggregated.

Recommendation 28 The metadata elements specified in the following tables should be used to report the results of the data quality evaluation. At least the information included in the row “Implementation instructions” should be provided.

The first table applies to reporting quantitative results (using the element DQ_QuantitativeResult), while the second table applies to reporting non-quantitative results (using the element DQ_DescriptiveResult).

NOTE These tables may need to be updated once the XML schemas for ISO 19157 have been finalised.

Metadata element name	**See chapter 7**
Definition	See chapter 7
ISO/DIS 19157 number and name	3. report
ISO/TS 19139 path	dataQualityInfo/*/report
INSPIRE obligation / condition	optional
INSPIRE multiplicity	0..*
Data type (and ISO/DIS 19157 no.)	Corresponding DQ_xxx subelement from ISO/DIS 19157, e.g. 12. DQ_CompletenessCommission
Domain	Lines 7-9 from ISO/DIS 19157 7. DQ_MeasureReference (C.2.1.3) 8. DQ_EvaluationMethod (C.2.1.4.) 9. DQ_Result (C2.1.5.)

Implementing instructions	39. nameOfMeasure NOTE This should be the name as defined in Chapter 7. 42. evaluationMethodType 43. evaluationMethodDescription NOTE If the reported data quality results are derived or aggregated (i.e. the scope levels for evaluation and reporting are different), the derivation or aggregation should also be specified using this property. 46. dateTime NOTE This should be data or range of dates on which the data quality measure was applied. 63. DQ_QuantitativeResult / 64. value NOTE The DQ_Result type should be DQ_QuantitativeResult and the value(s) represent(s) the application of the data quality measure (39.) using the specified evaluation method (42-43.)
Example	See Table E.12 — Reporting commission as metadata (ISO/DIS 19157)
Example XML encoding	

Metadata element name	**See chapter 7**
Definition	See chapter 7
ISO/DIS 19157 number and name	3. report
ISO/TS 19139 path	dataQualityInfo/*/report
INSPIRE obligation / condition	optional
INSPIRE multiplicity	0..*
Data type (and ISO/DIS 19157 no.)	Corresponding DQ_xxx subelement from ISO/DIS 19157, e.g. 12. DQ_CompletenessCommission
Domain	Line 9 from ISO/DIS 19157 9. DQ_Result (C2.1.5.)
Implementing instructions	67. DQ_DescripitveResult / 68. statement NOTE The DQ_Result type should be DQ_DescriptiveResult and in the statement (68.) the evaluation of the selected DQ sub-element should be expressed in a narrative way.
Example	See Table E.15 — Reporting descriptive result as metadata (ISO/DIS 19157)
Example XML encoding	

Open issue 1: For reporting compliance with minimum data quality requirements and recommendations specified in section 7, the INSPIRE conformity metadata element should be used. However, since this issue is part of the larger discussion on the Abstract Test Suite and the definition of conformance classes for the data specification, detailed instructions on how to provide metadata on compliance with minimum data quality requirements and recommendations will only be provided for v3.0.

8.3 Theme-specific metadata elements

No mandatory theme-specific metadata elements are defined for this theme.

IR Requirement 15 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 3.

Table 7 – Mandatory and conditional theme-specific metadata elements for the theme *Geology*

Section	Metadata element	Multiplicity	Condition
Error! Reference source not found.	**Error! Reference source not found.**	<multiplicity> *at least 1 unless conditional*	*To be filled if the minimum cardinality is 0*

No optional theme-specific metadata elements are defined for this theme.

Recommendation 29 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 4.

Table 8 – Optional theme-specific metadata elements for the theme *Geology*

Section	Metadata element	Multiplicity
8.3.2	Maintenance Information	0..1
Error! Reference source not found.	Positional accuracy – Absolute or external accuracy	0..1

8.3.1 Positional accuracy – Absolute or external accuracy

Metadata element name	**Data Quality – Positional accuracy – Absolute or external accuracy**
Definition	closeness of reported coordinate values to values accepted as or being true
ISO 19115 number and name	18. dataQualityInfo
ISO/TS 19139 path	dataQualityInfo
INSPIRE obligation / condition	optional
INSPIRE multiplicity	0..1
Data type (and ISO 19115 no.)	117. DQ_AbsoluteExternalPositionalAccuracy
Domain	See section 7.1.2 of Data Quality.
Implementing instructions (optional)	
Example (optional)	
Example XML encoding (optional)	
Comments (optional)	

8.3.2 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). At least the following elements should be used (the multiplicity according to ISO 19115 is shown in parentheses): – maintenanceAndUpdateFrequency [1]: frequency with which changes and additions are made to the resource after the initial resource is completed / domain value: MD_MaintenanceFrequencyCode: – updateScope [0..*]: scope of data to which maintenance is applied / domain value: MD_ScopeCode – maintenanceNote [0..*]: information regarding specific requirements for maintaining the resource / domain value: free text
Implementing instructions	
Example	
Example XML encoding	
Comments	

Include optional elements here.

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

8.4.1 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 30 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: 2012-02-24

Open issue 2: Conformance testing is still an open issue under discussion.

Instructions on conformance testing and a common abstract test suite (including detailed instructions on how to test specific requirements) will be added at a later stage.

This may also lead to an update of the recommendations on how to fill the conformity metadata element.

8.4.2 Lineage

Recommendation 31 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 Chapters 7 and 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".

The Metadata Technical Guidelines based on EN ISO 19115 and EN ISO 19119 specify that the statement sub-element of LI_Lineage (EN ISO 19115) should be used to implement the lineage metadata element.

Recommendation 32 To describe the transformation steps and related source data, it is recommended to use the following sub-elements of LI_Lineage:
- For the description of the transformation process of the local to the common INSPIRE data structures, the LI_ProcessStep sub-element should be used.
- For the description of the source data the LI_Source sub-element should be used.

NOTE 1 This recommendation is based on the conclusions of the INSPIRE Data Quality Working Group to avoid overloading of the overall lineage statement element with information on the transformation steps and related source data.

NOTE 2 In order to improve the interoperability, domain templates and instructions for filling these free text elements (descriptions) may be specified in an Annex of this data specification.

Open issue 3: The suggested use of the LI_Lineage sub-elements needs to be discussed as part of the maintenance of the INSPIRE metadata Technical Guidelines.

8.4.3 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. 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

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

TG 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.

9.2 Encodings

9.2.1 Default Encoding(s)

TG Requirement 4	Data conformant to the application schema(s) defined in section 5 shall be encoded using the encoding(s) specified in this section.

9.2.1.1. Default encoding for application schema GeologyCore

Name: GeologyCore GML Application Schema
Version: version <version of the GML Application Schema>, GML, version 3.2.1
Specification: D2.8.**II**.**4** Data Specification on **Geology** – Draft Guidelines
Character set: UTF-8

The GML Application Schema is distributed in a zip-file separately from the data specification document.

9.2.1.1.1. Specific mappings from UML classes to GML/XML Schema types and elements

In addition to the mappings between conceptual UML classes and the associated GML object element, XML Schema type and GML property type provided in Table D.2 of ISO 19136 (GML), the mappings included in have been used to generate the GML application schema.

Table 9. Mappings between conceptual UML classes and the associated GML object elements, XML Schema types and GML property types

UML class *(e.g. GM_Object)*	**GML object element** *(e.g. gml:AbstractGeometry)*	**GML type** *(e.g. gml:AbstractGeometryType)*	**GML property type** *(e.g. gml:GeometryPropertyType)*

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 styles that shall be supported by INSPIRE view services for each of these layer types.

In section **Error! Reference source not found.**, further styles can be specified that represent examples of styles typically used in a thematic domain. It is recommended that also these styles should be supported by INSPIRE view services, where applicable.

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)

Requirement 1	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.

TG 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 styles specified in section 11.2.

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 section 11.2 for that layer shall be used.

Recommendation 1 In addition to the styles defined in section 11.2, it is recommended that, where applicable, INSPIRE view services also support the styles defined in section **Error! Reference source not found.**.

11.1 Layers to be provided by INSPIRE view services

Layer Type	Layer Title	Spatial object type(s)
GE.GeologicUnitsLithology	Geologic Units	GeologicUnit
GE.GeologicStructuresType	Geologic Structures	GeologicStructure
GE.GeomorphologicFeatureType	Geomorphologic Features	GeomorphologicFeature
GE.Geophysics.gravityStation	gravity station	XGeophStation
GE.Geophysics.magneticStation	magnetic station	
GE.Geophysics.seismologicalStation	seismological station	
GE.Geophysics.geophysicalStation	geophysical station	
GE.Geophysics.boreholeLogging	borehole logging	XGeophProfile
GE.Geophysics.conePenetrationTest	cone penetration test	XGeophProfile
GE.Geophysics.boreholeLog	borehole log	CurveModel
GE.Geophysics.layerModel	layer model	
GE.Geophysics.seismicLine	seismic line	XGeophProfile
GE.Geophysics.flightLine	flight line	
GE.Geophysics.geophysicalProfile	geophysical profile	
GE.Geophysics.seismicTimeSection	seismic time section	CurveGridModel
GE.Geophysics.verticalParameterGrid	vertical parameter grid	XSurfaceGridModel
GE.Geophysics.seismicDepthSection	seismic depth section	
GE.Geophysics.verticallCrossSection	vertical cross section	SurfaceModel
GE.Geophysics.radarBathimetry	surface measurement	SurfaceMeasurement
GE.Geophysics.radarInterferometry	surface measurement	
GE.Geophysics.seismicSwath	seismic swath	
GE.Geophysics.3DSeismics	3D seismic measurement	X3DMeasuremt
GE.Geophysics.3DMultielectrodeDC	3D measurement	
GE.Geophysics.spotModel	spot model	SpotModel
GE.Geophysics.horizontalParameterGrid	horizontal parameter grid	SurfaceGridModel
GE.Geophysics.parameterBlock	parameter block	SolidGridModel
GE.Geophysics.seismicVolume	seismic volume	
GE.Geophysics.horizontalCrossSection	horizontal cross section	SurfaceModel
GE.Geophysics.2DSeismicSurvey	2D seismic survey	GeophSurvey
GE.Geophysics.3DSeismicSurvey	3D seismic survey	
GE.Geophysics.airborneGeophysicalSurvey	airborne geophysical survey	
GE.Geophysics.gravitySurvey	gravity survey	
GE.Geophysics.magneticSurvey	magnetic survey	
GE.Geophysics.geophysicalCampaign	geophysical campaign	Campaign
GE.Aquifers	Aquifers	Aquifer

11.1.1 Layers organisation

It is mandatory to describe at least one geological unit layer which is recommended to be the uppermost main geological unit layer with a thickness > 1 m. This layer should represent a national level, i.e data within the scale range of at least 1 : 250.000 or larger.
Optionally, additional over- or underlaying layers can also be defined. However, the recommendation is to define not more than 3 layers.

11.2 Styles to be supported by INSPIRE view services

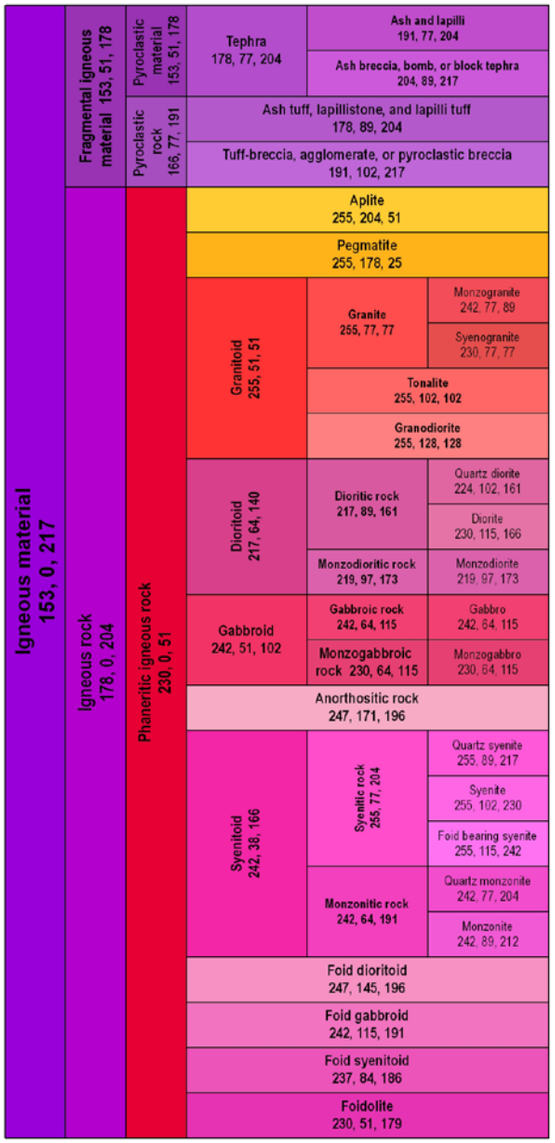
Open issue 4: The suggested styles are presented graphically. As there is no related standard but only some uses, the definition is still in discussion and required comments, suggestions from stakeholders. The template to provide detailed information about styles (Style Name, Default Style, Style Title, Style Abstract, Symbology, Minimum & maximum scales) will be used for the next version of this data specification.

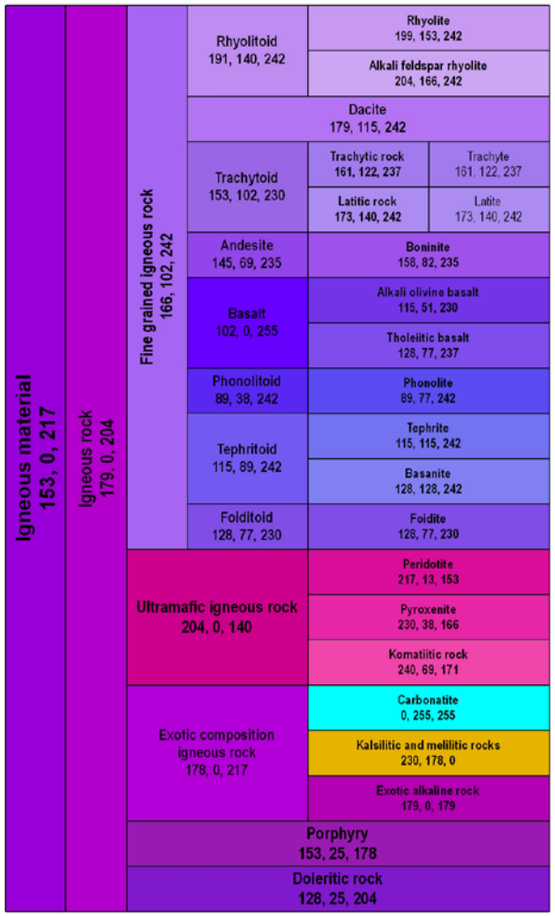
11.2.1 Styles for the layer Geologic Units

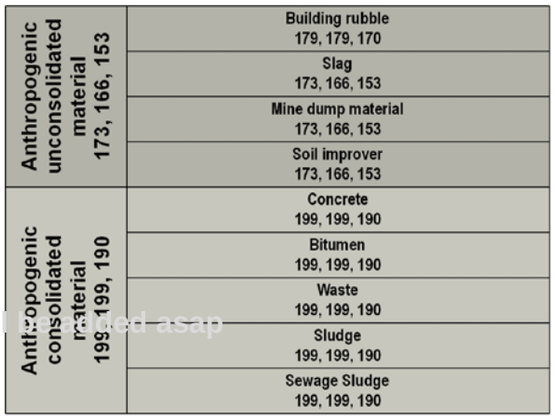
The way rock units are portrayed on maps is an important factor in facilitating the understanding of geological data and can be used to highlight, for example, the different lithologies or ages. For the user it is important to be able to recognise patterns and schemes, so that relevant information can be drawn from the spatial data base immediately.
A portrayal scheme for lithology, age and contacts and faults was developed for 1G-E with special attention paid to the particularities of the different European countries.
The polygons (MappedFeatures) of **Geologic Units** are portrayed by colours related to both the property LithologyTerm_Core and by colours related to the property olderNamedAge (based on the lower age). A proposal is to define the colours with the 3 numbers (Red, Green, Blue):

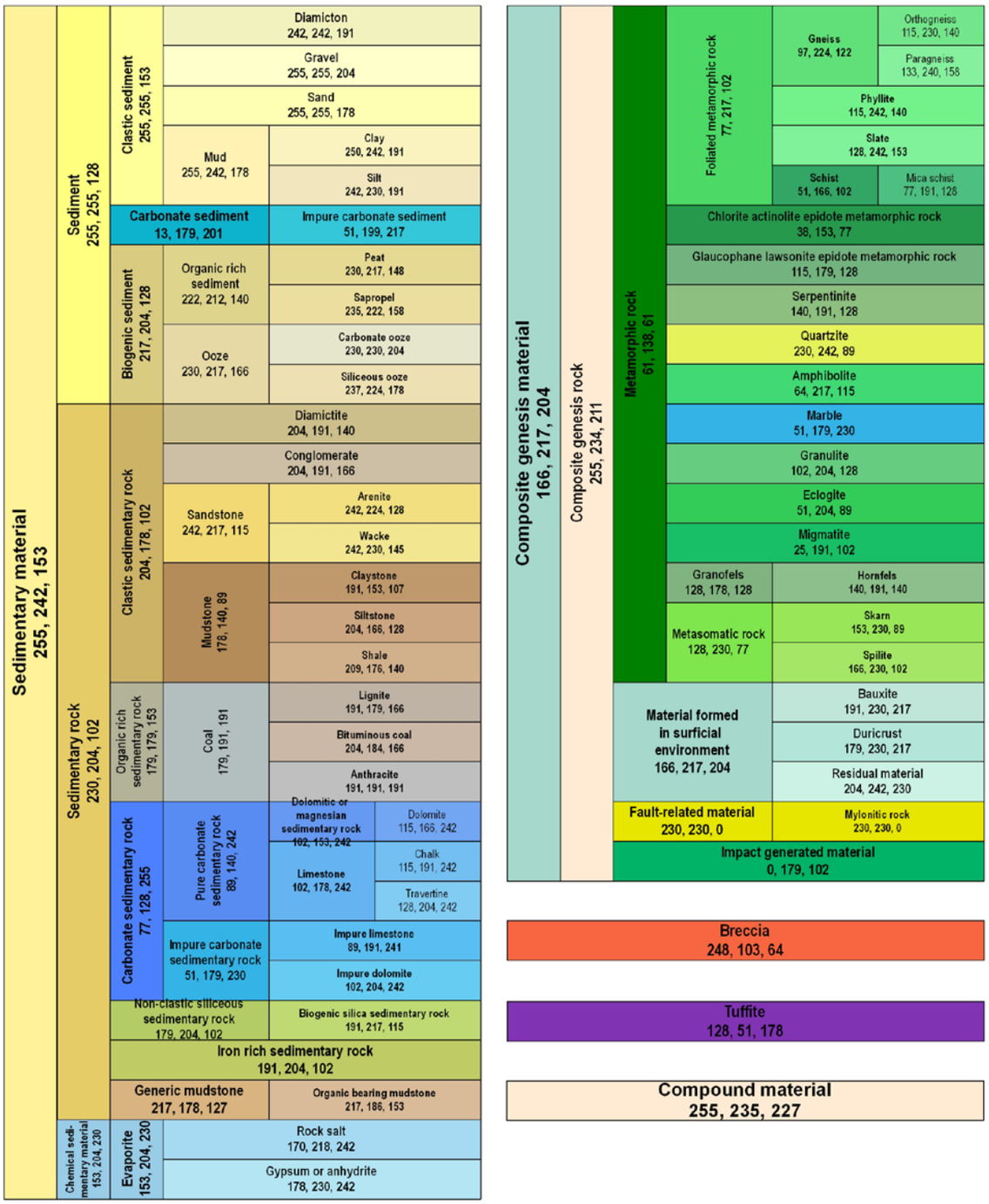
11.2.2 Styles for the lithology layer (LithologyTerm_Core)

[here all RGB codes for lithology will be included as two A 4 sheets]



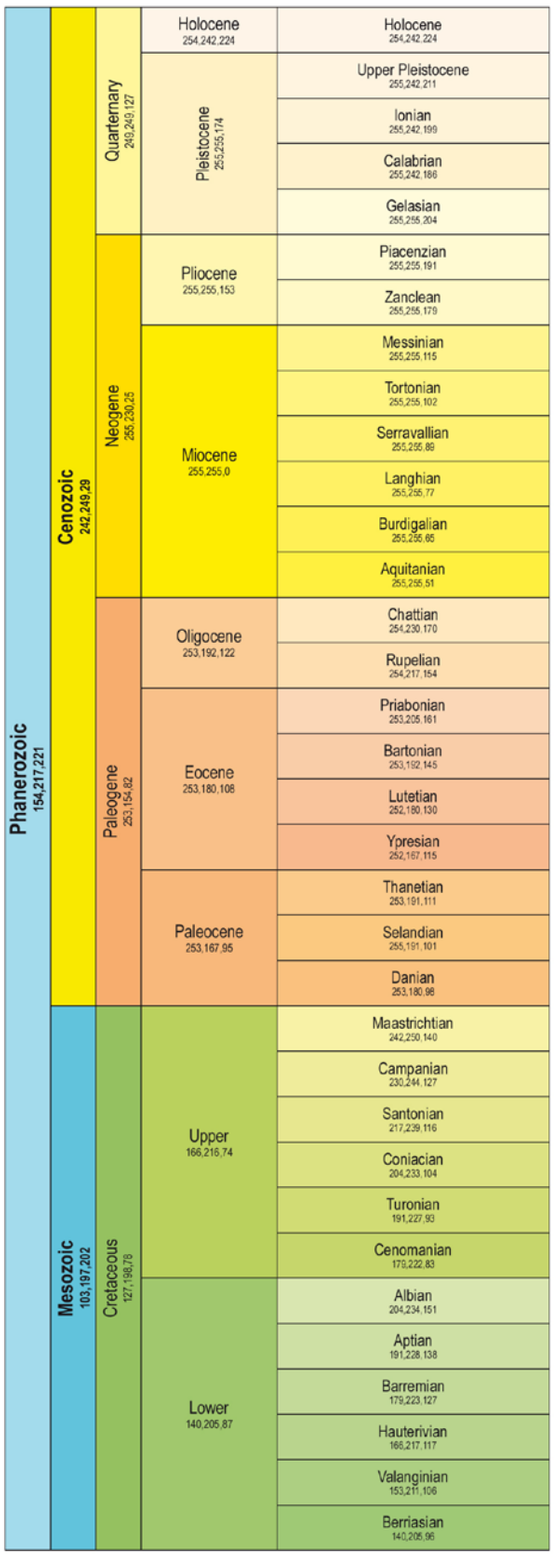


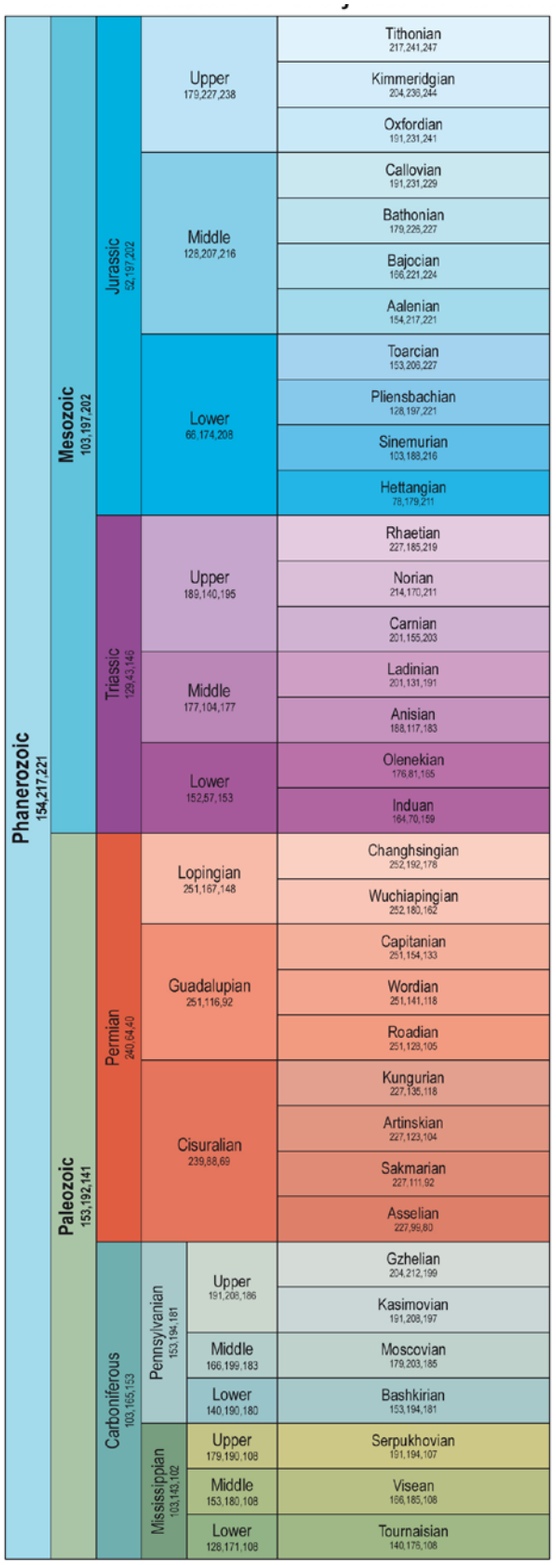


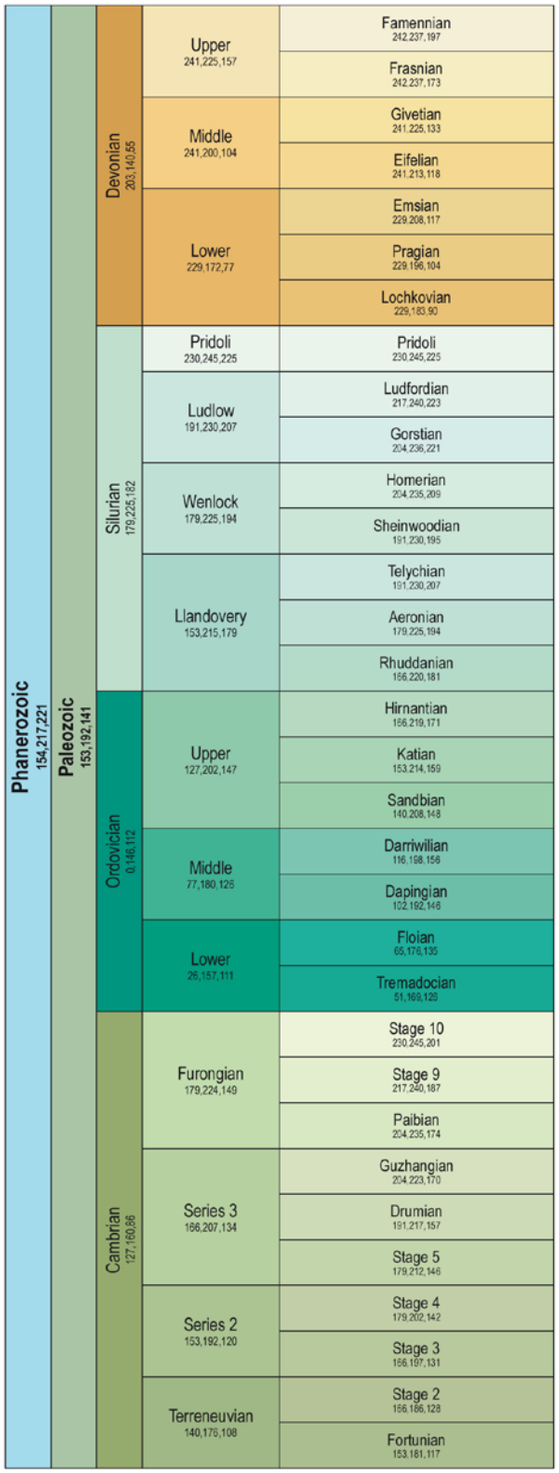


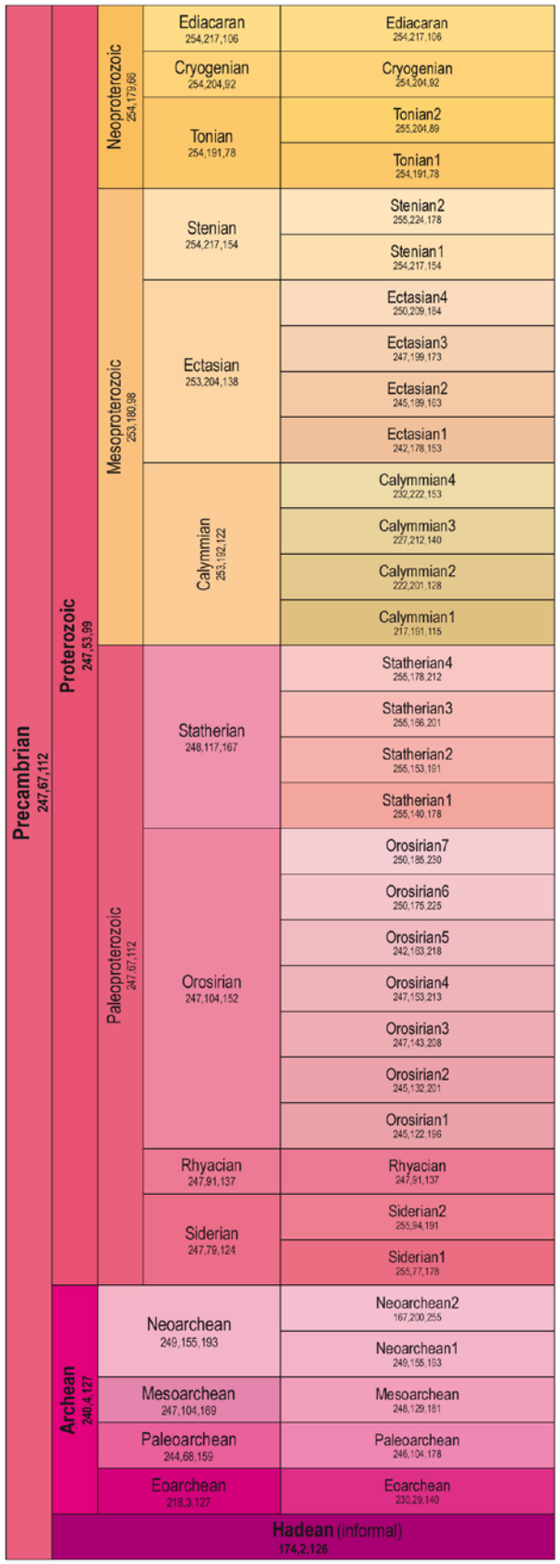
11.2.3 Styles for the age layer (olderNamedAge)

[here all RGB codes for age will be included as two A 4 sheets] Colours according to the Geological Time Scale 2008, International Commission of Stratigraphy,with the addition of 27 newly defined colours for the proposed new European Proterozoic Epochs


Phanerozoic 154,217,221
Cenozoic 242,249,29
Quaternary 249,249,127
Holocene 254,242,224
Holocene 254,242,224
Pleistocene 255,255,174
Upper Pleistocene 255,242,211
Ionian 255,242,199
Calabrian 255,242,186
Gelasian 255,255,204
Neogene 255,230,25
Pliocene 255,255,153
Piacenzian 255,255,191
Zanclean 255,255,179
Miocene 255,255,0
Messinian 255,255,115
Tortonian 255,255,102
Serravallian 255,255,89
Langhian 255,255,77
Burdigalian 255,255,65
Aquitanian 255,255,51
Paleogene 253,154,82
Oligocene 253,192,122
Chattian 254,230,170
Rupelian 254,217,154
Eocene 253,180,108
Priabonian 253,205,161
Bartonian 253,192,145
Lutetian 252,180,130
Ypresian 252,167,115
Paleocene 253,167,95
Thanetian 253,191,111
Selandian 255,191,101
Danian 253,180,98
Mesozoic 103,197,202
Cretaceous 127,198,78
Upper 166,216,74
Maastrichtian 242,250,140
Campanian 230,244,127
Santonian 217,239,116
Coniacian 204,233,104
Turonian 191,227,93
Cenomanian 179,222,83
Lower 140,205,87
Albian 204,234,151
Aptian 191,228,138
Barremian 179,223,127
Hauterivian 166,217,117
Valanginian 153,211,106
Berriasian 140,205,96

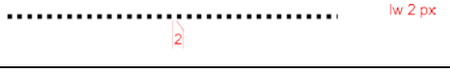
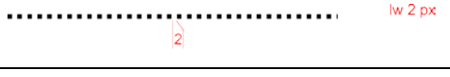
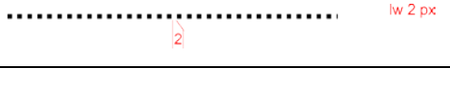
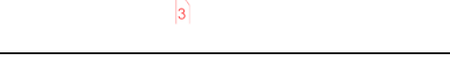

Phanerozoic 154,217,221
Mesozoic 103,197,202
Jurassic 52,197,202
Upper 179,227,238
Tithonian 217,241,247
Kimmeridgian 204,230,244
Oxfordian 191,231,241
Middle 128,207,216
Callovian 191,231,229
Bathonian 179,226,227
Bajocian 166,221,224
Aalenian 154,217,221
Lower 66,174,208
Toarcian 153,205,227
Pliensbachian 128,197,221
Sinemurian 103,188,216
Hettangian 78,179,211
Triassic 129,43,146
Upper 189,140,195
Rhaetian 227,185,219
Norian 214,170,211
Carnian 201,155,203
Middle 177,104,177
Ladinian 201,131,191
Anisian 188,117,183
Lower 152,57,153
Olenekian 176,81,165
Induan 164,70,159
Paleozoic 153,192,141
Permian 240,64,40
Lopingian 251,167,148
Changhsingian 252,192,178
Wuchiapingian 252,180,162
Guadalupian 251,116,92
Capitanian 251,154,133
Wordian 251,141,118
Roadian 251,129,105
Cisuralian 239,88,69
Kungurian 227,135,118
Artinskian 227,123,104
Sakmarian 227,111,92
Asselian 227,99,80
Carboniferous 103,165,153
Pennsylvanian 153,194,181
Upper 191,208,186
Gzhelian 204,212,199
Kasimovian 191,208,197
Middle 166,199,183
Moscovian 179,203,185
Lower 140,190,180
Bashkirian 153,194,181
Mississippian 103,143,102
Upper 179,190,108
Serpukhovian 191,194,107
Middle 153,180,108
Visean 166,185,108
Lower 128,171,108
Tournaisian 140,175,108

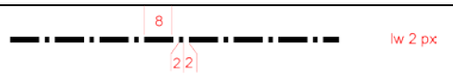

Phanerozoic
154,217,221
Paleozoic
153,192,141
Devonian
200,140,55
Upper
241,225,157
Famennian
242,237,197
Frasnian
242,237,173
Middle
241,200,104
Givetian
241,225,133
Eifelian
241,213,118
Lower
229,172,77
Emsian
229,208,117
Pragian
229,196,104
Lochkovian
229,183,90
Silurian
179,225,182
Pridoli
230,245,225
Pridoli
230,245,225
Ludlow
191,230,207
Ludfordian
217,240,223
Gorstian
204,236,221
Wenlock
179,225,194
Homerian
204,235,209
Sheinwoodian
191,230,195
Llandovery
153,215,179
Telychian
191,230,207
Aeronian
179,225,194
Rhuddanian
166,220,181
Ordovician
0,146,112
Upper
127,202,147
Hirnantian
166,219,171
Katian
153,214,159
Sandbian
140,208,148
Middle
77,180,126
Darriwilian
116,198,156
Dapingian
102,192,146
Lower
26,157,111
Floian
65,176,135
Tremadocian
51,169,128
Cambrian
127,160,86
Furongian
179,224,149
Stage 10
230,245,201
Stage 9
217,240,187
Paibian
204,235,174
Series 3
166,207,134
Guzhangian
204,223,170
Drumian
191,217,157
Stage 5
179,212,146
Series 2
153,192,120
Stage 4
179,202,142
Stage 3
166,197,131
Terreneuvian
140,176,108
Stage 2
166,186,128
Fortunian
153,161,117


Precambrian
247,67,112
Proterozoic
247,53,99
Neoproterozoic
254,179,66
Ediacaran
254,217,106
Ediacaran
254,217,106
Cryogenian
254,204,92
Cryogenian
254,204,92
Tonian
254,191,78
Tonian2
255,204,89
Tonian1
254,191,78
Mesoproterozoic
253,180,98
Stenian
254,217,154
Stenian2
255,224,178
Stenian1
254,217,154
Ectasian
253,204,138
Ectasian4
250,209,184
Ectasian3
247,199,173
Ectasian2
245,189,163
Ectasian1
242,178,153
Calymmian
253,192,122
Calymmian4
232,222,153
Calymmian3
227,212,140
Calymmian2
222,201,128
Calymmian1
217,191,115
Paleoproterozoic
247,67,112
Statherian
248,117,167
Statherian4
255,178,212
Statherian3
255,156,201
Statherian2
255,153,191
Statherian1
255,140,178
Orosirian
247,104,152
Orosirian7
250,185,230
Orosirian6
250,175,225
Orosirian5
242,183,218
Orosirian4
247,153,213
Orosirian3
247,143,208
Orosirian2
245,132,201
Orosirian1
245,122,196
Rhyacian
247,91,137
Rhyacian
247,91,137
Siderian
247,79,124
Siderian2
255,94,191
Siderian1
255,77,178
Archean
240,4,127
Neoarchean
249,155,193
Neoarchean2
167,200,255
Neoarchean1
249,155,193
Mesoarchean
247,104,169
Mesoarchean
248,129,181
Paleoarchean
244,68,159
Paleoarchean
246,104,178
Eoarchean
218,3,127
Eoarchean
230,29,140
Hadean (informal)
174,2,126

11.2.4 Styles for the layer Geologic Structures

The lines (MappedFeatures) of **Geologic Structures** are portrayed by type. A proposal from is: Fault types (only coloured in black):

CGI Term (prefLabel)	Draw annotation	Symbol [lw = line width in pixel]
fault		
strike slip fault		
dextral strike-slip fault		
sinistral strike-slip fault		
wrench fault		
reverse fault (no dip)	*Symbols in the upthrown block. (For cartographers: The line should be drawn so that the upthrown block is to the right in the drawing direction.)*	
thrust fault	*Symbols in the upthrown block. (For cartographers: The line should be drawn so that the upthrown block is to the right in the drawing direction.)*	
high angle reverse	*Symbols in the upthrown block. (For cartographers: The line should be drawn so that the upthrown block is to the right in the drawing direction.)*	
normal fault (no dip)		
low-angle normal fault	*Symbols in the downthrown block. (For cartographers: The line should be drawn so that the downthrown block is to the right in the drawing direction*	
detachment fault	*Symbols in the downthrown block. (For cartographers: The line should be drawn so that the downthrown block is to the right in the drawing direction*	
high-angle normal fault	*Symbols in the downthrown block. (For cartographers: The line should be drawn so that the downthrown block is to the right in the drawing direction*	
high-angle fault		
low-angle fault		
horizontal fault		
oblique slip fault		
left normal fault		

right normal fault		
left reverse fault		
right reverse fault		
scissor fault		
extraction fault		
mixed extraction fault		
pure extraction fault		

11.2.5 Styles for the layer Geomorphologic Features

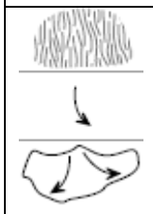
The fact that a widely accepted standard for Geomorphological mapping symbology is not yet available makes difficult to present here a generalized portrayal for representing the mapped Geomorphological objects. Some current uses include:

Color codes: Some rules consider color codes associated to the landform genesis or geomorphic environments (References 1 and 2). In other cases (Reference 3) the color code is not directly related to any specific geomorphic environment:

ORIGIN		GENESIS OR GEOMORPHIC ENVIRONMENT	COLOR	C,M,Y,K CODE	REFERENCE
NATURAL	ENDOGENOUS	Structural	**Black**	0,0,0,100	1
			Red	0 100 100 0	2
		Volcanic	**Pink**	18,83,0,0	1
			Black; Red	0,0,0,100; 100% red	3
	EXOGENE	Gravitational (Mass-movements; Landslide and mass-wasting features)	**Brown**	0,56,94,34	1
			Ochre	8 46 91 2	2
			Black; Magenta	0,0,0,100; 0,100,0,0	3
		Fluvial, Alluvial and surface runoff	**Green**	100,0,65,0	1
			Green	100 0 100 20	2
			Cyan	100,0,0,0	3
		Glacial, periglacial and nival	**Violet**	78,79,6,0	1
		Glacial	**Violet**	80 100 0 10	2
			Cyan; Grey	100,0,0,0	3
		Periglacial	**Mauve**	10 100 0 10	2
			Cyan	100,0,0,0	3
		(Snow) Avalanches	**Burgundy Red**	10 100 80 10	2
		Permanent snowfields	**Cyan**	100,0,0,0	3
		Eolian	**Yellow**	0,27,76,0	1
			Black	0,0,0,100	3
		Lacustrine and endoreic	**Light Blue**	76,0,6,0	1
		Lacustrine	**Dark Blue**	100 40 0 40	2
		Lacustrine and marine	**Cyan**	100,0,0,0	3
		Littoral	**Blue**	100,43,0,0	1
		Chemical weathering, Karstic and Collapse features	**Red**	0,91,87,0	1
			Turquoise	100 0 40 0	2
			Black	0,0,0,100	3
		Other natural landforms (i.e, natural impact features)	**Orange**	0,51,87,0	1
			Black	0,0,0,100	3
ANTHROPOGENIC		Anthropogenic	**Olive green**	0,0,100,43	1
			Grey	0 0 0 50	2
		Hazardous waste sites	**Red**	100% red	3
		Surface mining	**Black**	0,0,0,100	
		Areas of extensively disturbed ground; surface workings; subsurface workings projected to surface	**Black; Red**	0,0,0,100; 100% red	

Polygons, lines and points: Depending on the information resolution, the landforms are represented using polygons, lines or points. As an example:

SYMBOL	LANDFORM/FEATURE	GENESIS OR GEOMORPHIC ENVIRONMENT	REFERENCE
	Frontal moraine (Polygon)	Glacial	1
	Cordones, contornos o crestas morrénicas (Line)		1
	Cordon morainique (Line)		2
	Crest of moraine (Line)		3
	Solifluction lobes (Polygon)	Periglacial	3

	Area with solifluction (Polygon)	Gravitational	1
	Loupes de solifluction (Line)	Periglacial	2
	Volcanic cone with crater (Polygon)	Volcanic	1
	Rim of volcanic crater. Dot shows low point of crater		3
	Éboulement (Landslide) (Polygon and line)	Gravitational	2
	Area of slip surface of landslide, Direction of downslope movement of landslide and Landslide deposits—Arrows show direction of downslope movement (Polygon,and line)		3
	Landslide (Line)		1

REFERENCES

1. Mapa geomorfológico de España a escala 1:50.000: Guía para su elaboración / Instituto Geológico y Minero de España. Área de Cartografía Geológica; Martín-Serrano, Á., Salazar, Á., Nozal, F., Suárez, Á. Madrid: Instituto Geológico y Minero de España, 2004.

2. Université de Lausanne**.** Faculté des Géosciences et de l'Environnement**.** Institut de Géographie. *http://www.unil.ch/igul/page19238.html* (April 2011)

3. Federal Geographic Data Committee [prepared for the Federal Geographic Data Committee by the U.S. Geological Survey], 2006, FGDC Digital Cartographic Standard for Geologic Map Symbolization: Reston, Va., Federal Geographic Data Committee Document Number FGDC-STD-013-2006, 290 p., 2 plates.

11.2.6 Styles for the layer for the layer Borehole Purpose

The Point Symbols of Boreholes (Borehoel_Core) are portrayed according to the BoreholePurposeTerm_Core by type. Windings Font……..:

Term (BoreholePurposeTerm_Core**)**	**Portrayal**	**Portrayal Code**
Aquaculture	▣	170-w2
Contingency water supply	◘	165-w2
Dewatering	□ + ▲	163-w2 + 230-w2
Disposal	⊗	85-w2
Drinking water supply	□ + ◆	163-w2 + 174-w2
Enviromental monitoring	✪	155-w2
Exploration and exploitation of nonmetallic mineral deposits	✕	209-w2

Eploration and exploitation of raw material	★	171-w
Exploration of natural underground storage space	⬟	193-w2
Exploration on exploitation of energy resources	◆	191-w2
Flowing Shot	☒	163-w2
Geochemical survey, analyses	✧	178-w
Geological survey	✚	202-w2
Geophysical survey	✳	226-w2
Geotechnical Survey, construction site charcterization	⌑	179w
Geothermal energy, geothermal heat exchangers	✸	236-w2
Groundwater level monitoring	■ + ✧	162-w2 + 178-w
Hydrogeological survey	■	162-w2
Industrial water supply	□ + ✸	163-w2 + 236-w2
Irrigation	□ + ✦	163-w2 + 231-w2
Mineral	⟠	185-w2
Mitigation	⊙	156-w2
Monitoring quality	✪	181w
Oil	◈	179-w2
Oil exploratory	◈	178-w2
Pedological Survey	⬢	195-w2
Pollution monitoring (waste dumps etc.)	⊘	88-w2
Recharge	⊡	167-w2
Remediation	●	152-w2
Shallow methane production	⟐	176-w2
Shot hole	✳	224-w2
Sparging / thermal cleaning	⊙	56-w2
Water injection	▣	168-w2
	□	Fonts:
		w = Wingdings
		w2 = Windings2

11.2.7 Styles for the layers Geophysics

The large number of geophysical layer types comes from the complexity of the package. All main classes (measurement, model. survey) encompass subclasses with different geometrical characteristics. Using point, line an polygon symbolizers 9 layer types theoretically could be enough, but taking into account the classification based on codelist attributes the number is further increased. Due to their importance feature types that fall into the scope of the core model are represented by individual styles. model feature types are defined by extendable code lists with unforeseen elements, and for this reason they share common styling. The SLD schema allows changing the appearance based on feature attribute values. Changing the size of symbols based on a specific attribute can increase graphical information. For example, geophysical stations with different station rank may be represented by symbols of different size. (normal – 4 pixels, 1stOrderBase – 8 pixels, 2ndOrderBase – 10 pixels, Observatory – 12 pixels) A possible set of portrayal rules is given in the following tables.

Layer types of the GeophysicsCore model:

	point	**line**	**polygon**
geophysical measurement	gravity station magnetic station seismological station boreholeLogging	seismic line	3D seismic measurement
geophysical model		vertical parameter grid	horizontal parameter grid
geophysical survey			gravity survey magnetic survey 2D seismic survey 3D seismic survey airborne geophysical survey

Layer types of the GeophysicsExtension model:

	point	**line**	**polygon**
geophysical measurement	geophysical station cone penetration test	geophysical profile flight line	surface measurement 3D measurement seismic swath
geophysical model	borehole log layer model	seismic time section seismic depth section vertical cross section	spot model parameter block horizontal cross section seismic volume seismic horizon
geophysical survey			geophysical campaign

11.2.8 Styles for the layer Aquifers

[To be done]

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)

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

[ISO 19156] ISO FDIS 19156:2011, Geographic Information – Observation and Measurements

[ISO19157] ISO/DIS 19157, Geographic information – Data Quality

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

Delete any of these references or add further references as applicable.

Annex A
(normative)

Abstract Test Suite

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

Open issue 5: Conformance testing is still an open issue under discussion.

Instructions on conformance testing and a common abstract test suite (including detailed instructions on how to test specific requirements) will be added at a later stage.

Annex B
(informative)
Use cases

This annex describes the use cases related to Geology, Hydrogeology & Geophysics, that were used as a basis for the development of this data specification.

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

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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.

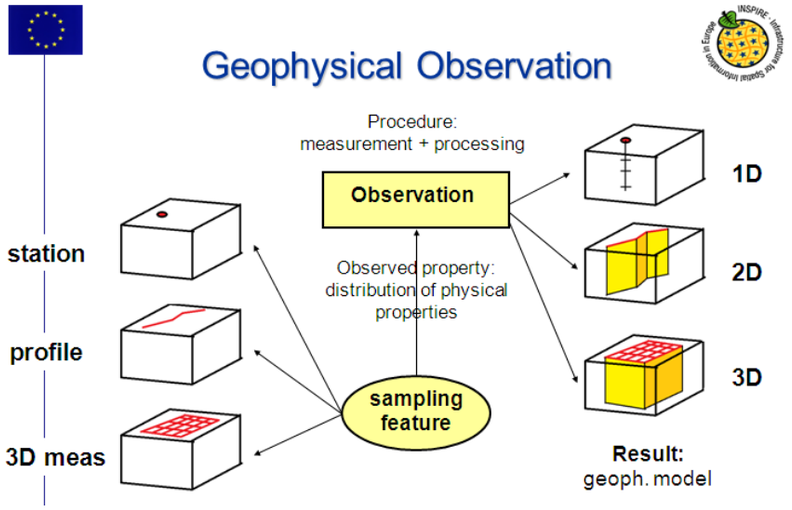


figure 1. Geophysical features and the O&M model

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).

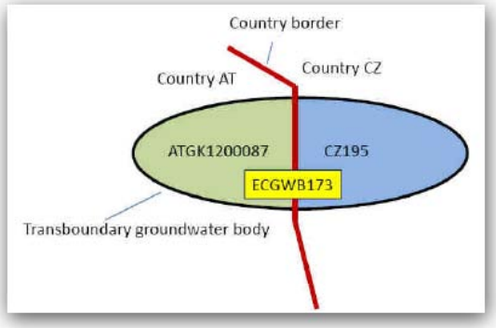
This was translated into the reporting schemas as follows:

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
  - WB Affected? (Y/N)
- Other pressures
  - WB Affected? (Y/N)
  - Type of Pressure (to be specified see GWPI8)
- Impacts
  - Type of impact identified (see GWPI9)
- Protected areas
  - Water body within or overlapping with a protected area (Y/N)
  - 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
- physical and mechanical properties of geological units
- rock mass classification

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)
Aquifers and Groundwater bodies

C.1 Aquifers and Groundwater bodies

C.1.1 Introduction

Water has always been the basis for human existence. World water use in the past century grew twice as fast as world population. Groundwater has been described as “our Hidden Asset” and although this is a truism groundwater makes up about twenty percent of the world's fresh water supply. As far as “clean”, drinking water resources are concerned it is much more. Groundwater is one of the most important components of water cycle in environment (Fig. 1).

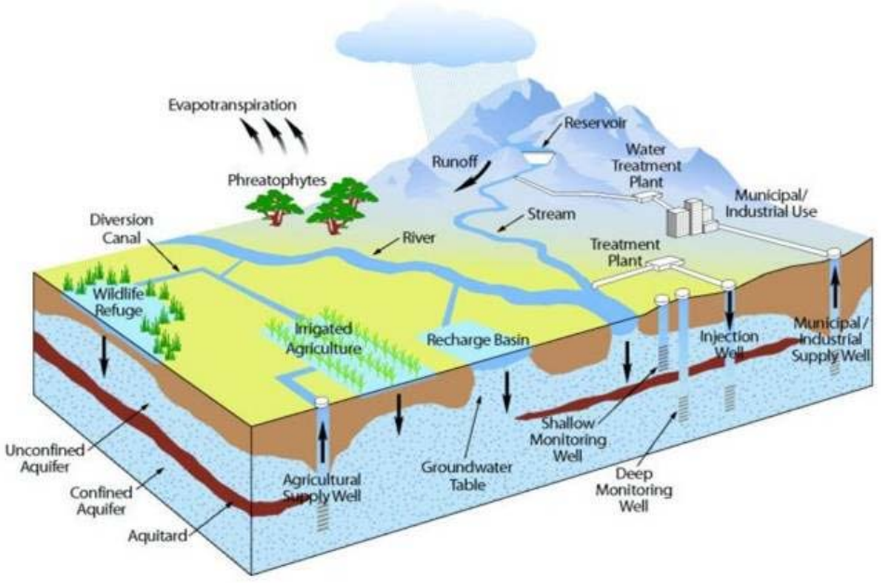


Fig. 1 Summary of groundwater processes.

The European Union has recognized the need for a consistent framework for legislation on water management. According to the Water Framework Directive (WFD) introduced in 2000 water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such.
Hydrogeology describes the flow, condition of occurrence and behaviour of water in the underground environment. It is a science located between hydrology and geology, whilst it is necessary to have an understanding of both disciplines. Hydrological processes are responsible for the quantity of water supply e.g. as a result of aquifer recharge. On the other hand, the physical properties and composition of the geologic materials (rocks and sediments) create the main environment for groundwater flow and storage and rocks and sediments also influence groundwater quality as a result of their chemical composition.
Groundwater can be both a resource and a problem depending on what activity is being undertaken. A positive benefit is abstraction for drinking water supply, whereas groundwater flooding causes significant problems to properties and transport infrastructure. Hydrogeology has a direct influence on the environment; groundwater abstraction not only provides water for human consumption but also can cause changes in water flow direction and in some cases may have a dramatic impact on surface

water bodies. Overexploitation in an area where groundwater dependent ecosystems are located may change the water table level or the chemical composition of water which may lead to irreversible changes in the ecosystems.
In terms of INSPIRE, the groundwater domain has many connections and dependencies on other human activities described in other themes (Area Management, Soil, Environmental Facilities, Energy Resources, Hydrography, Protected Sites, Utility and Governmental Services). Contamination introduced to groundwater systems takes years to decades to be cleaned out. Prediction is a problem but slow rates of flushing and low rates of degradation are significant issues.
This document intends to introduce groundwater issues to the members of the INSPIRE Geology and Mineral Resources TWG.

C.1.2 Background to groundwater processes

One suitable source of background information for groundwater issues is the UK's groundwater forum website – *www.groundwateruk.org*. The section "Groundwater in Depth", see *www.groundwateruk.org/Groundwater-in-depth.aspx*, has some excellent articles on some of the issues introduced below.

Hydrogeology is a large and complex subject involving the appreciation of many aspects of groundwater, including flow, solute and heat transport, and multi-phase flow. The discipline also includes the study of the unique ecology that inhabits the sub-surface water environment. However, for the purposes of this document, a short summary of the most important aspect of groundwater is required.

Traditionally sub-surface flow of water has been defined as occurring in aquifers, which consist of permeable rocks through which water can flow. These aquifers can be separated by aquitards which are less permeable, or are not as good at passing water through them. In the extreme low permeability case, aquicludes are defined as geological strata which impede the flow of water. However, in the last decade, this definition has been seen as too simplistic and the concept of a groundwater system has been developed. This concept allows the study of the sub-surface water environment in a holistic way which better reflects the hydrological cycle.

Typically the approach to understanding a groundwater system is to determine the inflows, outflows and the movement of water through the system (see Fig. 2). For example the WHO defines a groundwater system as "a discrete, closed three-dimensional system containing flow paths from the point at which recharging water enters an aquifer to the topographically lower point at which it leaves the aquifer (WHO 2006)". Inflows to and outflows from the system can be effected by both natural and anthropogenic factors.

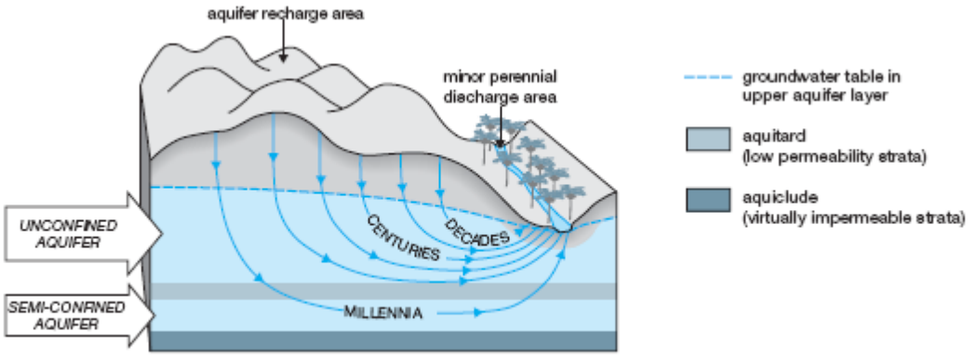


Fig. 2 Example groundwater system showing inflows and outflows and time of travel of water through the system. (GWMate briefing note no. 2: Characterization of Groundwater Systems).

Inflow: The majority of recharge occurs through the soil zone, especially in temperate countries, such as those in Europe. Recharge is defined as the amount of water leaving the soil zone that can eventually reach the groundwater table. Other ways water can be emplaced in the groundwater system include artificial recharge by injecting water into the aquifer via boreholes or surface ponds.

Outflow: There are a number of natural ways that water can leave a groundwater system. These include baseflow to rivers, springflow and outflow to the sea. The most obvious man made outflow to any groundwater system is pumped abstraction from a borehole.

The interaction between rivers and groundwater is complex; rivers can provide both inflow and outflow to the system (Fig. 3) and this can change with time depending on the relationship of the river stage and groundwater head locally. When the groundwater head is below the river stage then water can flow from the river to the aquifer beneath the river. When the flow in the river reduces and thus the stage, then the flow direction can be reversed and the groundwater system can provide an input to the river (Fig. 3). The contribution of groundwater to a river is normally termed “baseflow”.

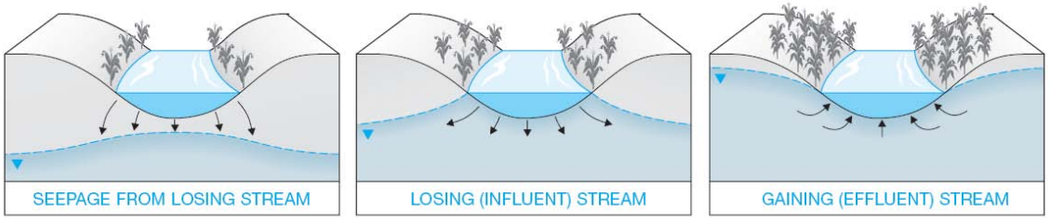


Fig. 3 Different types of river-aquifer interaction (GWMate briefing note no. 2: Characterization of Groundwater Systems).

There are a number of different ways that groundwater can move through the sub-surface (Fig. 4): flow through porous media, flow through fractured aquifers and karstic flow. Flow through porous media is characterised by water moving through the gaps between the rock particles, often in unconsolidated deposits. Where water movement exploits cracks or fissures in the rock to move then this is termed fracture flow. In the extreme case large connected conduit or even “cave” systems can be developed and water movement through this system is termed karstic flow.

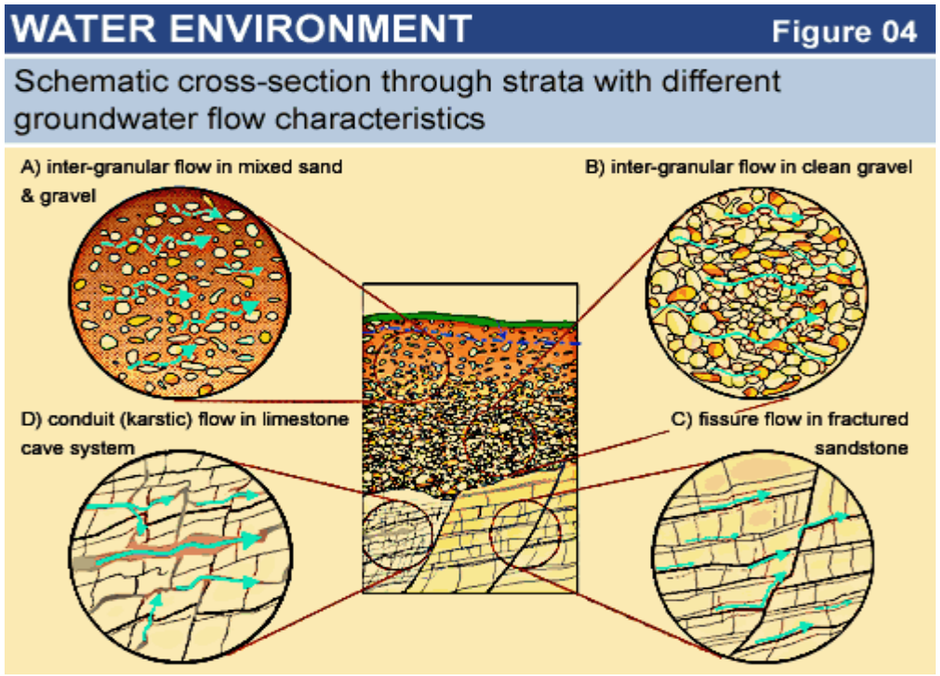


Fig. 4 Different types of flow regimes in groundwater systems (www.goodquarry.com).

Groundwater systems can be exploited for a number of uses: supply, including water for drinking, heat reservoir, repository for waste (solid and liquid), a store for excess water during the winter, to name but a few. Groundwater systems are used by humans in many ways and an understanding of the complex interaction between the natural system and the effects of human intervention needs to be developed, normally called conceptualisation.

Conceptualisation: collect data, develop an understanding of the groundwater system and formalise this understanding into a conceptual model, quantify processes including water balance and then create a model of the system. Attention needs to be given to the question that is under consideration.

C.1.3 Description of issues

Traditionally the study of groundwater has been categorised as examining either water quantity or quality; the former examining the amount of groundwater flow and the latter examining the solutes dissolved in groundwater. However, the occurrence and use groundwater is much wider than this. For example as part of climate change mitigation, groundwater systems have been recognised as heat stores for ground source heat pumps and saline aquifers for the disposal of supercritical CO_2.

Groundwater flow

Groundwater flow is important for supporting abstractions for water supply for domestic (i.e. people in their homes) as well as industrial purposes. It is also important to support river flows for ecological purposes, amenity value (people to enjoy their surroundings), etc. Groundwater dependent ecosystems, as the name suggests, are also supported by sub-surface flows. These include wetlands, which can be small areas fed by seeps to large nationally significant bodies.

Pollution

Aquifers are vulnerable to polluting activities. These include “catastrophic” events such as accidental spills, i.e. a road tanker crash, to diffuse pollution from agricultural activities. European countries have a long history of industrial activities and groundwater has been polluted from these processes. Understanding the vulnerability of groundwater systems to pollution from current activities and clean-up of aquifers from past activities is equally important. Polluted groundwater can contribute to pollution in rivers, lakes and the seas as well as causing hazards for activities such as mining, etc.

Natural attenuation
Reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods. The 'natural attenuation processes' that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favourable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants.

Saline aquifers

Saline aquifers occur in a range of settings. Aquifers in close proximity to estuaries and the sea are often saline. Deep aquifers with old or “connate” waters are also often highly saline. Basins of internal drainage, where evaporation is the only outflow are highly saline. Saline intrusion is a problem where abstraction occurs in aquifers close to saline water bodies. Careful management has to be undertaken to avoid despoiling the systems permanently. However, deep saline aquifers are being considered for disposal of supercritical CO_2. Finally highly saline aquifers that are the result of evaporative processes often contain economically important minerals and are exploited commercially.

Geotechnical considerations

The interaction of groundwater with the built environment is extremely important. As the water content or pore pressure of the ground changes so does its geotechnical properties. For example, rising groundwater in cities causes problems with deep foundations and tunnels. An understanding of water movement in the sub-surface is, therefore, important to ensure safe construction of buildings. Dewatering of aquifers for temporary works is also important to allow sub-water table working in construction works.

Groundwater monitoring
Groundwater, in view of its prevalence and quality is a very important source of supply for the population with drinking water. Because of its economic importance and the widespread risks to water quality caused by pollution discharged to the ground, it requires special protection. This protection is achieved, inter alia, by using amonitoring network for both qualitative and quantitative aspects of groundwater status.

Geohazards

As well as being a resource, groundwater can cause problems either by appearing at the surface or by entering sub-surface structures. Groundwater flooding is one such problem. Under extreme recharge events, the water table can rise to the surface and result in flooding. Groundwater flooding differs from surface water flooding in that it is often long-lasting, typically of the order of weeks to months and can affect areas not identified in traditional flood risk mapping. Unlike surface water floods, it is not possible to control this phenomenon easily by flood defences.

Other geohazards that are related to groundwater include:
- landslides
- swell-shrink clays
- subsidence

All of these geohazards need an assessment of water movement in the sub-surface to understand how they occur and what influence human activity and climate change will have on them.

Heat

Heat flows both into and out of aquifers are increasingly being recognised as a way of reducing reliance on fossil fuels. Groundwater systems and aquifers are being developed to be used as a temporary store for heat. Systems may be based on pumping groundwater into and out of an aquifer using boreholes, such as Ground Source Heat Pumps (GSHP), or heat exchange in trenches or boreholes for Ground Coupled Heat Pumps (GCHP). Groundwater can also be used to exploit hotter rocks close to the surface by pumping cold water down or abstracting hot water. These systems can be used to heat, cool and power systems in buildings. Where very elevated groundwater temperatures are found, electricity generation is possible.

Mineral resources

Exploitation of mineral resources requires the control of water where it isn't wanted and supply of water where it is in short supply. So-called "wet working" of mines requires removal of water where it enters the mine. However mining requires water to operate its processes so in some areas, where water is scare, then groundwater can be used for supply purposes. Groundwater can be rich in minerals and the economic extraction of minerals from groundwaters is possible for high value minerals such as Lithium. As well as this mineral waters can be thought of groundwater as an economic resource, with the dissolved solids giving the water its taste, e.g. bottled waters.

C.1.4 Approach to data models

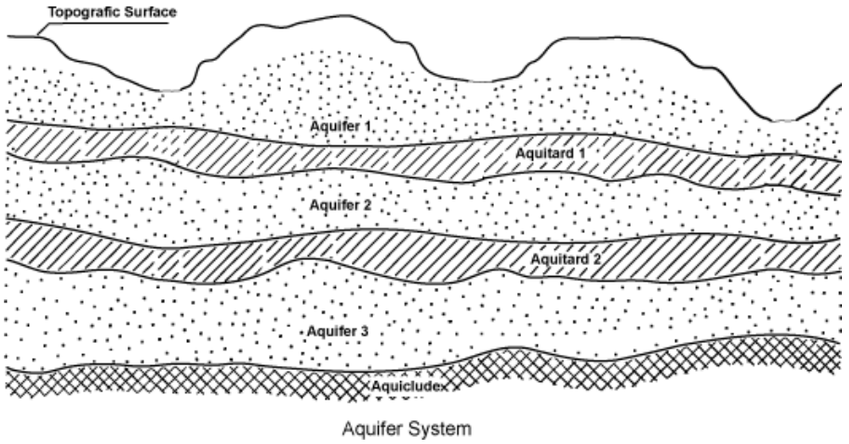


Fig. 5 Example of an aquifer system

The Aquifer System is dependent of rock properties such as permeability and porosity for water flow and storage. Generally the two main components are Aquifers (e.g. sand and gravel) where water flow is may easily occur and Aquitards, which are poorly permeable formations (e.g. clay) that do not yield water freely to a well or a spring. However, an aquitard may transmit appreciable water to or from adjacent aquifers.

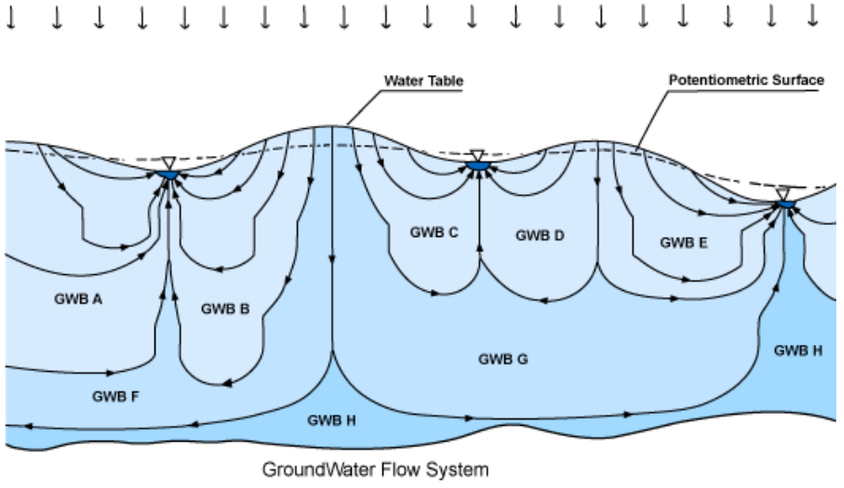
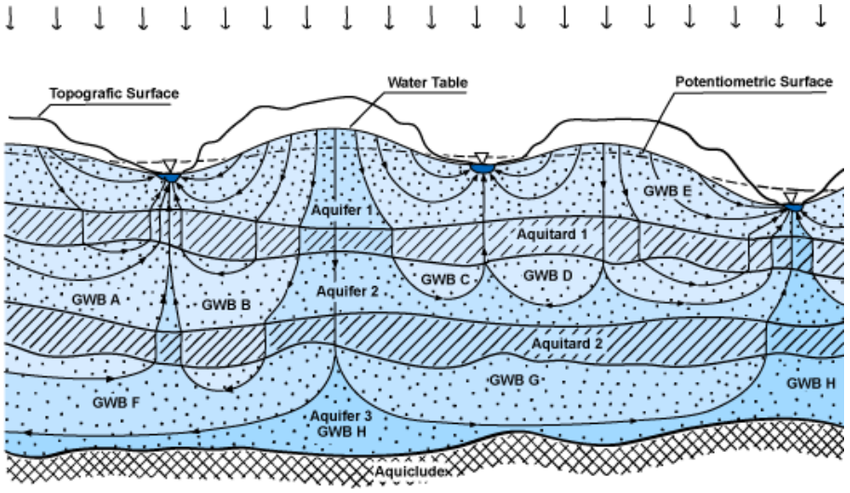


Fig. 6 Example of a groundwater flow system

The aquifer system provides a framework for the groundwater flow system and encompasses it. The nature of the groundwater flow system depends partly on the aquifer system but also on factors such as the geometry of the water table (or confined potentiometric surface) and the location of discharge points such as rivers, springs and wells. Groundwater bodies are discrete bodies of groundwater lying within a groundwater flow system'.

The basic idea of the INSPIRE model for groundwater is to identify two basic elements: the Aquifer System (dependent on the geological conditions) and the Groundwater Flow System. Both components taken together create the Hydrogeological System.



Hydrogeological System = Aquifer System + GroundWater Flow System

Fig. 7 Example of an hydrogeological system

The mutual relationships between those components create and build the condition for groundwater flow. The main assessment of model is base on the hydrodynamic processes (groundwater flow).

C.1.5 Relevant EU legislation

There is a significant amount of EU legislation that impacts on groundwater systems and their management. The following provides a list of the relevant EU legislation. The most important piece of legislation in terms of shaping how groundwater systems are conceptualised and managed is the water framework Directive. This legislation has encapsulated the changes in approach to the study of groundwater flow described above.

Bathing Water Directive 76/160/EEC
Birds Directive 79/409/EEC
Drinking Water Directive 98/83/EEC
Major Accidents (Seveso) Directive 96/82/EC
Environment Impact Assessment 85/337/EEC
Sewage Sludge Directive 86/278/EEC
Urban Wastewater Treatment Directive 91/271/EEC
Plant Protection Products Directive 91/414/EEC
Nitrates Directive 91/676/EEC
Habitats Directive 92/43/EEC
Integrated Pollution Prevention Control 96/61/EEC
Nitrates Directive
Urban Wastewater Treatment Directive
Plant Protection Products Directive - Directive 91/414/EEC, OJ L230 of 19.08.1991
Biocides Directive - Directive 98/8/EC, OJ L123 of 24.04.1998
Integrated Pollution Prevention and Control (IPPC) Directive - Directive 96/61/EEC, OJ L257 of 10.10.1996
Landfill Directive - Directive 99/31/EC, OJ L182 of 16.07.1999
Waste Framework Directive - Directive 2006/12/EC, OJ L102 of 11.04.2006
Construction Product Directive - Directive 89/106/EC, OJ L40 of 11.02.1989
Floods Directive 2007/60/EC
Water Framework Directive (2000/60/EC)
Groundwater Directive (2006/118/EC)
Groundwater Directive (80/ 68/EEC)

Annex D
(informative)
Data model extensions

D.1 Introduction

This section is not yet complete

D.2 Data model extension for Geology

D.2.1 Introduction

D.2.2 Examples

D.3 Data model extension for Geophysics

D.3.1 Introduction

D.3.2 Surveys

D.3.3 Measurements

D.3.4 Models

D.3.5 Results and procedures

D.4 Data model extension for Hydrogeology

D.5 Examples for Geophysics

Annex E
(informative)
Code-lists values

E.1 Code list values for geology

For reasons of interoperability, it is recommended that the INSPIRE thematic working groups re-use existing code lists. The Thematic Working Group has re-used vocabularies managed by CGI (the Commission for the Management and Application of Geoscience Information) wherever possible. The group will request that CGI also manage any new code lists created during the preparation of the data specification.

The code lists shown here contain corrections, additions and proposals for new terms that the Thematic Working Group has received and accepted after the consultation process of version 2.0 of the data specification. The Thematic Working Group cannot guarantee that all changes will ultimately be accepted by CGI.

Some of the code lists below have a hierarchical structure and in this case the column “parent” is shown. The terms are often also described with other properties like “source” and “notation” but there is no room for this in this presentation. Chapter 5 “Data content and structure” contains the reference to the code lists where the reader is able to find a full description.

Code list: AnthropogenicGeomorphologicFeatureTypeTerm_Core

Term	Definition
anthropogenic geomorphologic feature	A man-made geomorphologic feature.
landfill site	Waste disposal site used for the controlled deposit of the waste onto or into land.
levelled land	A land area, usually a field, that has been mechanically flattened or smoothed to facilitate management practices such as flood irrigation.
openpit mine	A relatively large depression resulting from the excavation of material and redistribution of overburden associated with surficial mining operations.
pit	A depression, ditch or pit excavated to furnish gravel, sand or other materials for roads or other construction purposes; a type of borrow pit.
quarry	Excavation areas, open to the sky, usually for the extraction of stone.
reclaimed land	a) A land area composed of earthy fill material that has been placed and shaped to approximate natural contours, commonly part of land-reclamation efforts after mining operations; b) A land area, commonly submerged in its native state, that has been protected by artificial structures (e.g. dikes) and drained for agricultural or other purposes (e.g. polder).
reservoir lake	An inland body of permanently standing water, usually fresh, occupying a depression on the Earth’s surface closed by a dam.

Term	Definition
spoil bank	A bank, mound, or other artificial accumulation of rock debris and earthy dump deposits removed from ditches, strip mines, or other excavations.
subsidence area (anthropogenic)	An area subject to a process of subsidence induced by anthropogenic activities, for example subsurface mining, tunneling, hydrocarbon or groundwater production.
anthropogenic feature	An artificial feature on the earth's surface (including those in shallow water),having a characteristic shape and range in composition, composed of unconsolidated earthy, organic materials, artificial materials, or rock, that is the direct result of human manipulation or activities; can be either constructional (e.g., artificial levee) or destructional (quarry).
artificial collapsed depression	A collapse basin, commonly a closed depression, which is the direct result of surficial subsidence associated with subsurface mining or tunneling.
artificial drainage	Human-made network (ditches, canals, etc.) built primarily to lower or control the local water table.
artificial levee	An artificial embankment constructed along the bank of a watercourse or an arm of the sea, to protect land from inundation or to confine streamflow to its channel.
dredged channel	A roughly linear, deep water area formed by a dredging operation for navigation purposes
dump	An area of smooth or uneven accumulations or piles of waste rock, earthy material, or general refuse that without major reclamation are incapable of supporting plants.
fill	Human-constructed deposits of natural earth materials (e.g., soil, gravel, rock) and/or waste materials (e.g., tailings or spoil from dredging) used to fill a depression, to extend shore land into a body of water, or in building dams.
impact crater (anthropogenic)	A generally circular or elliptical depression formed by hypervelocity impact of an experimental projectile or ordinance into earthy or rock material.

Code list: BoreholePurposeTerm_Core

Term	Definition	Parent
geological survey	General examination of an area's geological entities	
exploration and exploitation of raw material	Examination of the subsurface with regard to the availability of earth-borne raw materials in general and planning the extraction thereof. Exploration: the discovery and identification of mineral resources, in the assessment of their importance and in the evaluation of the economic benefit of the eventual exploitation of the potentially economic deposit. Exploitation: All works and activities done to extract mineral resources with a view to mining and marketing them	

Term	Definition	Parent
exploration and exploitation of energy resources	Examination of the subsurface with regard to the availability of fossil energy resources (e.g. oil, gas, coal, lignite) and planning the extraction thereof	
hydrocarbon production	Production of petroleum oil and/or gas	exploration and exploitation of energy resources
hydrocarbon exploration	Exploration in an unproved area to test for a new field, a new pay, a deeper reservoir, or a shallower reservoir.	exploration and exploitation of energy resources
hydrocarbon appraisal	Assessment of characteristics (such as flow rate) of a proven hydrocarbon accumulation.	exploration and exploitation of energy resources
geothermal energy, geothermal heat exchangers	Exploration pertaining to the utilization of geothermal energy resources and design of geothermal heat pumps. Geothermal energy is the form of energy stored below the surface of the solid earth as heat. Borehole heat exchangers are heat exchangers which are installed vertically or oblique in the underground.	exploration and exploitation of energy resources
heat storage	The ground is used as heat storage. E.g. water is injected and relatively cooler water is extracted in summer and relatively warmer water in winter.	geothermal energy, geothermal heat exchangers
mineral exploration and extraction	Well drilled for the purpose of locating and/or extracting mineral resources from the subsurface, usually through the injection and/or extraction of mineral bearing fluids.	exploration and exploitation of raw material
exploration and exploitation of nonmetallic mineral deposits	Prospecting with regard to the availability of nonmetallic mineral deposits such as building stones, limestone, gravel, sand, clay, kaolin, diatomite etc. (mainly for construction purposes, cement and ceramic or glass industry) and planning to be excavated	exploration and exploitation of raw material
disposal	A well, often a depleted oil or gas well, into which waste fluids can be injected for safe disposal. Disposal wells typically are subject to regulatory requirements to avoid the contamination of freshwater aquifers. http://www.glossary.oilfield.slb.com/Display.cfm?Term=disposal%20well	
exploration of natural underground storage space	Examination of the subsurface's ability to store various materials such as natural gas, captured carbon, etc.	
water supply	Water supply in general.	

Term	Definition	Parent
drinking water supply	Well construction for drinking water	water supply
industrial water supply	Well construction for industrial water supply	water supply
aquaculture	To supply water to aquaculture, for example fish farming	water supply
irrigation	Well construction for irrigation purposes	water supply
emergency water supply	Well construction for emergency water supply (e.g. extinguish a fire)	water supply
contingency water supply	Stand-by water supply in case of water deficiency.	water supply
geophysical survey	Examination of the subsurface's geophysical properties such as electric resistivity, seismicity, gravity, radiation, etc.	
shot hole	In connection with seismic surveys explosives are loaded into shot holes.	geophysical survey
flowing shot	A flowing shot hole is a drilled (seismic) hole that has entered an underground water source that has sufficient pressure to cause the hole to "overflow". http://www.etsurvey.com/water/h20main.htm	shot hole
hydrogeological survey, water management	Examination of groundwater flow (i.e. the hydraulic characteristics of an aquifer), the chemical properties of ground water, and transport of particles, solutes, and energy, as well as the management of the sustainable use of ground water resources	
geotechnical survey, construction site characterization	Examination of the subsurface's properties with respect to slope stability, construction of building foundations, tunnels, dams etc.; Geotechnical investigations performed to obtain information on the physical and mechanical properties of soil and rock around a site to design earthworks and foundations for proposed structures and for repair of distress to earthworks and structures caused by subsurface conditions. GEUS: Geotechnical drill holes made to investigate the ground before construction work. Geotechnical: A geotechnical well is defined as a hole drilled for the exclusive purpose of collecting geotechnical data, including soil samples, vapour samples, and water samples obtained through bailing, driven sampler or other similar methods. http://www.adwr.state.az.us/dwr/Content/Find_by_Category/Laws_and_Rules/files/SPS/Well%20Construction/Well%20Construction%20and%20LIcensing%20-%20WL7.pdf	
geochemical survey, analyses	Examination of chemical properties of the rock formation and /or the porosity fluids (samples to be analyzed)	
pedological survey	Survey and characterization of soils, e.g. for agricultural	

Term	Definition	Parent
	purposes, ground water protection, etc.	
environmental monitoring	Groundwater chemistry and groundwater level is monitored.	
pollution monitoring	The purpose is to monitor known pollution sites (waste dumps, etc.).	environmental monitoring
water quality monitoring	Most monitoring wells constructed today are used to assess the nature and distribution of pollutants and contaminants in groundwater; the nature and distribution of naturally occurring chemical constituents; subsurface hydrologic conditions, and hydraulic properties of strata as they relate to pollutant and contaminant movement.	environmental monitoring
groundwater level monitoring	Construction of a gauge for recording groundwater level changes	environmental monitoring
dewatering	Dewatering is the removal of water from solid material or soil by wet classification, centrifugation, filtration, or similar solid-liquid separation processes. Removing or draining water from a riverbed, construction site, caisson, or mine shaft, by pumping or evaporation. This is often done during the site development phase of a major construction project due to a high water table. Usually involves the use of "dewatering" pumps. Methods of dewatering include Wellpoint, Deep Well and Eductor systems. http://en.wikipedia.org/wiki/Dewatering	
mitigation	Lowering of the groundwater level to prevent the groundwater table to reach polluted sites.	dewatering
remediation	Remediation in general. The removal of pollution or contaminants from groundwater, soil and other rock	
sparging , thermal cleaning	A kind of remediation. In situ cleaning of soil using heat (steam).	remediation
recharge	a- Aquifer Recharge Wells (5R21) Used to recharge depleted aquifers and may inject fluids from a variety of sources such as lakes, streams, domestic wastewater treatment plants, other aquifers, etc. b- Saline Water Intrusion Barrier Wells (5B22) Used to inject water into fresh water aquifers to prevent intrusion of salt water into fresh water aquifers. Used in highly populated areas. c- Subsidence Control Wells (5S23) Used to inject fluids into a non-oil or gas-producing zone to reduce or eliminate subsidence associated with overdraft of fresh water and not used for the purpose of oil or natural gas production. a, b, c - http://www.epa.gov/Region2/water/compliance/wellclasstypetable_inventoryc_form.pdf	

Code list: CollectionTypeTerm_Core

Term	Definition	Parent
borehole collection		
geological map		
geological model		
geophysical object collection		

Code list: CompositionPartRoleTerm_Core

Term	Definition	Parent
bed lithosome	Lithosome in lithostratigraphic unit that occurs as individual beds interleaved with other constituents on the outcrop (m) scale or larger.	lithosome
blocks	Geologic unit constituent is present as masses with generally sharp boundaries and block-like geometry within a matrix of some other material emplaced by processes at the earth's surface--e.g. volcanic eruption or mass wasting. Implication is that blocks were derived from the same source geologic unit and emplaced in the described unit.	inclusion
concretion	Hard, compact mass or aggregate of mineral matter, normally subsperical but commonly oblate, disc-shaped or irregular. Formed from precipitation from solution about a nucleus or centre. Use as a geologic unit part should be restricted to concretions that are too large to consider as constituents in the rock material that composes the unit.	inclusion
cyclic bedding package	Lithosome characterized by an internal sequence of units, which is repeated in a stacked sequence; e.g. fining-upward sequence, thickening upward sequence, bouma sequence.	lithosome
enclave	General term for a polymineralic aggregate enclosed in a granitoid.	inclusion
facies	Represents a particular body of rock that is a lateral variant of a lithostratigraphic unit, or a variant of a lithodemic unit. Contrast with lithosome in being a particular, connected body of rock, as opposed to a kind of rock body that is repeated in many places in a unit.	part of
geologic unit matrix	Lithosome in a geologic unit that is generally interstitial to other constituents, e.g. in a mass wasting deposit, melange, tuff breccia.	lithosome
inclusion	Geologic unit constituent is present as masses with generally sharp boundaries enclosed within a matrix of some other	part of

Term	Definition	Parent
	material.	
irregular lithosome	lithosome in a mixed/heterogeneous lithodemic unit that occurs in irregular bodies within unit	lithosome
layer lithosome	lithosome in igneous or metamorphic geologic unit that occurs as layers alternating with other constituents.	lithosome
lenticular lithosome	lithosome occurs as discrete lense-shaped bodies, not connected with other bodies.	lithosome
lithosome	A kind of rock body that has multiple occurrences in a single geologic unit. A mass of rock of uniform character, characterized by geometry, composition, and internal structure. Generally denotes rock mass that is the product of a particular rock forming process or related sequence of processes in the containing unit. Example--bouma sequence, point bar sequence. A particular lithosome may be characterized by the presence of blocks, but blocks are not treated as kinds of lithosome because the internal character of the blocks is determined by a separate genetic sequence from the described unit. This vocabulary generalizes the concept defined in Neuendorf et al 2005 to include bodies of igneous or metamorphic rock as well as sedimentary rock. NADM SLTTs (2004) used the term 'lithotope' with similar meaning for sedimentary rocks.	part of
marker bed	Stratigraphic part that is a thin laterally continuous bed within another unit.	stratigraphic part
only part	entire described unit consists of a single part or constituent	
part of	The geologic unit part role is not known in any greater detail. Inclusion of Only_part as a separate concept implies that this concept is the equivalent of 'proper part' in mereology.	
pendants	A block of wall rock material in an igneous intrusion. Pendants become xenoliths as the dimension becomes smaller than about 10 m in their longest dimension. Although term pendant has connotation of being suspended or supported from above, this is rarely demonstrable in geologic situations, and the concept here does not require connection to the wall of the containing intrusion.	inclusion
rafts	Pendants of pre-intrusive country rock in intrusive igneous matrix that have large horizontal extent relative to their thickness	pendants
roof pendant	Pendant that is demonstrably derived from the upper boundary of an igneous body.	pendants

Term	Definition	Parent
screen	Pendant that is a vertical sheet like pendant in an intrusive igneous rock body.	pendants
stratigraphic part	A geologic unit part that occupies a particular stratigraphic position within a geologic unit. Part is a particular body of rock.	part of
tectonic block	The geologic unit part occurs as discrete masses with faulted boundaries, emplaced into the host unit by tectonic processes inside the earth, e.g. blocks in tectonic melange	inclusion
unspecified part role	Geologic unit part with unspecified role; use in normative descriptions when any role is allowed.	part of
vein or dike lithosome	Lithosome occurs as intrusive, sheet-like bodies within the unit as an essential part of the unit.	lithosome
xenolith	Inclusion of pre-intrusive country rock in intrusive igneous matrix, cm to about 10 meter diameter in longest dimension. Use term pendant for larger blocks.	inclusion

Code list: EventEnvironmentTerm_Core

Term	Definition	Parent
abandoned river channel setting	A drainage channel along which runoff no longer occurs, as on an alluvial fan	river plain system setting
above carbonate compensation depth setting	Marine environment in which carbonate sediment does not dissolve before reaching the sea floor and can accumulate.	marine setting
abyssal setting	The ocean environment at water depths between 3,500 and 6,000 metres	marine setting
active continental margin setting	Plate margin setting on continental crust.	plate margin setting
active spreading center setting	Divergent plate margin at which new oceanic crust is being formed	plate margin setting
aeolian process setting	Sedimentary setting in which wind is the dominant process producing, transporting, and depositing sediment. Typically has low-relief plain or piedmont slope physiography.	subaerial setting
agricultural and forestry land setting		
algal flat setting	Modern "algal flats are found on rock or mud in areas flooded only by the highest tides and are often subject to high evaporation rates. Algal flats survive only when an area is salty enough to eliminate snails and other herbivorous animals that eat algae, yet is not so salty that the algae cannot survive. The	low energy shoreline setting

Term	Definition	Parent
	most common species of algae found on algal flats are blue-green algae of the genera Scytonema and Schizothrix. These algae can tolerate the daily extremes in temperature and oxygen that typify conditions on the flats. Other plants sometimes found on algal flats include one-celled green algae, flagellates, diatoms, bacteria, and isolated scrubby red and black mangroves, as well as patches of saltwort. Animals include false cerith, cerion snails, fiddler crabs, and great land crabs. Flats with well developed algal mats are restricted for the most part to the Keys, with Sugarloaf and Crane Keys offering prime examples of algal flat habitat." (Audubon, 1991)	
alluvial fan setting	A low, outspread, relatively flat to gently sloping mass of loose rock material, shaped like an open fan or a segment of a cone, deposited by a stream (esp. in a semiarid region) at the place where it issues from a narrow mountain valley upon a plain or broad valley, or where a tributary stream is near or at its junction with the main stream, or wherever a constriction in a valley abruptly ceases or the gradient of the stream suddenly decreases; it is steepest near the mouth of the valley where its apex points upstream, and it slopes gently and convexly outward with gradually decreasing gradient	piedmont slope system setting
alluvial plain setting	A level or gently sloping tract or a slightly undulating land surface produced by extensive deposition of alluvium, usually adjacent to a river that periodically overflows its banks; it may be situated on a floodplain, a delta, or an alluvial fan.	piedmont slope system setting
anoxic setting	Setting depleted in oxygen, typically subaqueous.	earth surface setting
arid or semi arid environment setting	Setting characterized by mean annual precipitation of 10 inches (25 cm) or less. (Jackson, 1997, p. 172). Equivalent to SLTT 'Desert setting', but use 'Arid' to emphasize climatic nature of setting definition.	earth surface setting
back arc setting	Tectonic setting adjacent to a volcanic arc formed above a subduction zone. The back arc setting is on the opposite side of the volcanic arc from the trench at which oceanic crust is consumed in a subduction zone. Back arc setting includes terrane that is affected by plate margin and arc-related processes.	tectonically defined setting
backreef setting	The landward side of a reef. The term is often used adjectivally to refer to deposits within the restricted lagoon behind a barrier reef, such as the "back-reef facies" of lagoonal deposits. In some places, as on a platform-edge reef tract, "back reef" refers to the side of the reef away from the open sea, even though no land may be nearby	biological reef setting
barrier beach setting	A narrow, elongate sand or gravel ridge rising slightly above	barrier island

Term	Definition	Parent
	the high-tide level and extending generally parallel with the shore, but separated from it by a lagoon (Shepard, 1954, p.1904), estuary, or marsh; it is extended by longshore transport and is rarely more than several kilometers long.	coastline setting
barrier island coastline setting	setting meant to include all the various geographic elements typically associated with a barrier island coastline, including the barrier islands, and geomorphic/geographic elements that are linked by processes associated with the presence of the island (e.g. wash over fans, inlet channel, back barrier lagoon).	shoreline setting
barrier lagoon setting	A lagoon that is roughly parallel to the coast and is separated from the open ocean by a strip of land or by a barrier reef. Tidal influence is typically restricted and the lagoon is commonly hypersaline.	barrier island coastline setting
basin bog setting	An ombrotrophic or ombrogene peat/bog whose nutrient supply is exclusively from rain water (including snow and atmospheric fallout) therefore making nutrients extremely oligotrophic	bog setting
basin plain setting	Near flat areas of ocean floor, slope less than 1:1000; generally receive only distal turbidite and pelagic sediments.	marine setting
bathyal setting	The ocean environment at water depths between 200 and 3500 metres	marine setting
beach setting	The unconsolidated material at the shoreline that covers a gently sloping zone, typically with a concave profile, extending landward from the low-water line to the place where there is a definite change in material or physiographic form (such as a cliff), or to the line of permanent vegetation (usually the effective limit of the highest storm waves); at the shore of a body of water, formed and washed by waves or tides, usually covered by sand or gravel, and lacking a bare rocky surface.	shoreline setting
below carbonate compensation depth setting	Marine environment in which water is deep enough that carbonate sediment goes into solution before it can accumulate on the sea floor.	marine setting
biological reef setting	A ridgelike or moundlike structure, layered or massive, built by sedentary calcareous organisms, esp. corals, and consisting mostly of their remains; it is wave-resistant and stands topographically above the surrounding contemporaneously deposited sediment.	marine setting
blanket bog	A bog covering a large, fairly horizontal area and depending on high rainfall or high humidity, rather than local water sources, for its supply of moisture.	bog setting
bog setting	Waterlogged, spongy ground, consisting primarily of mosses, containing acidic, decaying vegetation that may develop into	terrestrial setting

Term	Definition	Parent
	peat.	
braided river channel setting	A stream that divides into or follows an interlacing or tangled network of several small branching and reuniting shallow channels separated from each other by ephemeral branch islands or channel bars, resembling in plan the strands of a complex braid. Such a stream is generally believed to indicate an inability to carry all of its load, such as an overloaded and aggrading stream flowing in a wide channel on a floodplain	river channel setting
carbonate dominated shoreline setting	A shoreline setting in which terrigenous input is minor compared to local carbonate sediment production. Constructional biogenic activity is an important element in geomorphic development.	shoreline setting
carbonate shelf setting	A type of carbonate platform that is attached to a continental landmass and a region of sedimentation that is analogous to shelf environments for terrigenous clastic deposition. A carbonate shelf may receive some supply of material from the adjacent landmass.	
cave setting	A natural underground open space; it generally has a connection to the surface, is large enough for a person to enter, and extends into darkness. The most common type of cave is formed in limestone by dissolution.	earth surface setting
coastal dune field setting	A dune field on low-lying land recently abandoned or built up by the sea; the dunes may ascend a cliff and travel inland.	dunefield setting
coastal plain setting	A low relief plain bordering a water body extending inland to the nearest elevated land, sloping very gently towards the water body. Distinguished from alluvial plain by presence of relict shoreline-related deposits or morphology.	shoreline setting
collisional setting	Tectonic setting in which two continental crustal plates impact and are sutured together after intervening oceanic crust is entirely consumed at a subduction zone separating the plates. Such collision typically involves major mountain forming events, exemplified by the modern Alpine and Himalayan mountain chains.	continental-crustal setting
contact metamorphic setting	Metamorphism of country rock at the contact of an igneous body.	earth interior setting
continental borderland setting	"An area of the continental margin between the shoreline and the continental slope that is topographically more complex than the continental shelf. It is characterized by ridges and basins, some of which are below the depth of the continental shelf. An example is the southern California continental borderland;...." (Jackson, 1997, p. 138)..	marine setting

Term	Definition	Parent
continental rift setting	Extended terrane in a zone of continental breakup, may include incipient oceanic crust. Examples include Red Sea, East Africa Rift, Salton Trough	extended terrane setting
continental shelf setting	"That part of the ocean floor that is between the shoreline and the continental slope (or, when there is no noticeable continental slope, a depth of 200 m). It is characterized by its gentle slope of 0.1 degree" (Jackson, 1997, p. 138). Continental shelves have a classic shoreline-shelf-slope profile termed 'clinoform'.	marine setting
continental-crustal setting	That type of the Earth's crust which underlies the continents and the continental shelves; it is equivalent to the sial and continental sima and ranges in thickness from about 25 km to more than 70 km under mountain ranges, averaging ~40 km. The density of the continental crust averages ~2.8 g/cm3 and is ~2.7 g/cm3 in the upper layer. The velocities of compressional seismic waves through it average ~6.5 km/s and are less than ~7.0 km/sec.	crustal setting
crustal setting	The outermost layer or shell of the Earth, defined according to various criteria, including seismic velocity, density and composition; that part of the Earth above the Mohorovicic discontinuity, made up of the sial and the sima.	earth interior setting
cutoff meander setting	The abandoned, bow- or horseshoe-shaped channel of a former meander, left when the stream formed a cutoff across a narrow meander neck. Note that these are typically lakes, thus also lacustrine.	river plain system setting
deep sea trench setting	Deep ocean basin with steep (average 10 degrees) slope toward land, more gentle slope (average 5 degrees) towards the sea, and abundant seismic activity on landward side of trench. Does not denote water depth, but may be very deep.	marine setting
delta distributary channel setting	A divergent stream flowing away from the main stream and not returning to it, as in a delta or on an alluvial plain	deltaic system setting
delta distributary mouth setting	The mouth of a delta distributary channel where fluvial discharge moves from confined to unconfined flow conditions	deltaic system setting
delta front setting	A narrow zone where deposition in deltas is most active, consisting of a continuous sheet of sand, and occurring within the effective depth of wave erosion (10 m or less). It is the zone separating the prodelta from the delta plain, and it may or may not be steep"	deltaic system setting
delta plain setting	The level or nearly level surface composing the landward part of a large or compound delta; strictly, an alluvial plain characterized by repeated channel bifurcation and divergence, multiple distributary channels, and interdistributary flood basins	deltaic system setting

Term	Definition	Parent
delta slope setting	Slope setting within the deltaic system	
deltaic system setting	Environments at the mouth of a river or stream that enters a standing body of water (ocean or lake). The delta forms a triangular or fan-shaped plain of considerable area. Subaerial parts of the delta are crossed by many distributaries of the main river, and commonly extend beyond the general trend of the coast. Subaqueous parts of the delta merge with the adjacent basin floor, and are progressively influenced by non-fluvial processes. Deltas result from the accumulation of sediment supplied by the river in such quantities that it is not removed by tides, waves, and currents.	earth surface setting
dunefield setting	Extensive deposits on sand in an area where the supply is abundant. As a characteristic, individual dunes somewhat resemble barchans but are highly irregular in shape and crowded; erg areas of the Sahara are an example.	aeolian process setting
dust accumulation setting	Setting in which finegrained particles accumulate, e.g. loess deposition.	aeolian process setting
dwelling area setting		
earth interior setting	Geologic environments within the solid Earth.	
earth surface setting	Geologic environments on the surface of the solid Earth. Hierarchy presented here is based on assumption that a particular setting may be specified by a combination of a climatic setting with one or more process or geomorphically defined settings.	
englacial setting	Contained, embedded, or carried within the body of a glacier or ice sheet; said of meltwater streams, till, drift, moraine	glacier related setting
epicontinental marine setting	Marine setting situated within the interior of the continent, rather than at the edge of a continent.	marine setting
estuarine delta setting	A delta that has filled, or is in the process of filling, an estuary	deltaic system setting
estuarine lagoon setting	A lagoon produced by the temporary sealing of a river estuary by a storm barrier. Such lagoons are usually seasonal and exist until the river breaches the barrier; they occur in regions of low or spasmodic rainfall	estuary setting
estuary setting	Environments at the seaward end or the widened funnel-shaped tidal mouth of a river valley where fresh water comes into contact with seawater and where tidal effects are evident (adapted from Glossary of Geology, Jackson, 1997, p. 217).	shoreline setting
extended terrane setting	Tectonic setting characterized by extension of the upper crust, manifested by formation of rift valleys or basin and range	tectonically defined setting

Term	Definition	Parent
	physiography, with arrays of low to high angle normal faults. Modern examples include the North Sea, East Africa, and the Basin and Range of the North American Cordillera. Typically applied in continental crustal settings.	
extra-terrestrial setting	Material originated outside of the Earth or its atmosphere.	
fan delta setting	A debris-flow or sheetflood-dominated alluvial fan build out into a lake or the sea.	
fast spreading center setting	Spreading center at which the opening rate is greater than 100 mm per year.	active spreading center setting
floodplain setting	The surface or strip of relatively smooth land adjacent to a river channel, constructed by the present river in its existing regimen and covered with water when the river overflows its banks. It is built of alluvium carried by the river during floods and deposited in the sluggish water beyond the influence of the swiftest current. A river has one floodplain and may have one or more terraces representing abandoned floodplains.	river plain system setting
forearc setting	Tectonic setting between a subduction-related trench and a volcanic arc	plate margin setting
foreland setting	The exterior area of an orogenic belt where deformation occurs without significant metamorphism. Generally the foreland is closer to the continental interior than other portions of the orogenic belt are.	continental-crustal setting
forereef setting	The seaward side of a reef; the slope covered with deposits of coarse reef talus	biological reef setting
foreshore	A foreshore is the region between mean high water and mean low water marks of the tides. Depending on the tidal range this may be a vertical distance of anything from a few tens of centimetres to many meters. The seaward extent of the foreshore is governed also by the slope and it may be anything from a few meter, if the shelf is steeply sloping and/or the tidal range is small, to over a kilometre in places where there is a high tidal range and a gently sloping shelf. The foreshore is part of the beach environment or littoral zone	
gibber plain setting	A desert plain strewn with wind-abraded pebbles, or gibbers; a gravelly desert.	arid or semi arid environment setting
glacial outwash plain setting	A broad, gently sloping sheet of outwash deposited by meltwater streams flowing in front of or beyond a glacier, and formed by coalescing outwahs fans; the surface of a broad body of outwash.	glacier related setting

Term	Definition	Parent
glacier lateral setting	Settings adjacent to edges of confined glacier.	glacier related setting
glacier related setting	Earth surface setting with geography defined by spatial relationship to glaciers (e.g. on top of a glacier, next to a glacier, in front of a glacier...). Processes related to moving ice dominate sediment transport and deposition and landform development. Includes subaqueous, shoreline, and terrestrial settings that are impacted by the presence of glaciers. Considered a geographically defined setting in that a glacier is a geographic feature.	earth surface setting
glacier terminus setting	Region of sediment deposition at the glacier terminus due to melting of glacier ice, melt-out, ablation and flow till setting.	proglacial setting
glaciofluvial setting	A setting influenced by glacial meltwater streams. This setting can be sub- en-, supra- and proglacial.	
glaciolacustrine setting	Ice margin lakes and other lakes related to glaciers. Where meltwater streams enter the lake, sands and gravels are deposited in deltas. At the lake floor, typivally rhythmites (varves) are deposited.Ice margin lakes and other lakes related to glaciers. Varve is a typical sediment in this environment.	
glaciomarine setting	A marine environment influenced by glaciers. Dropstone diamictons and dropstone muds are typical deposits in this environment.	
graben	An elongate trough or basin, bounded on both sides by high-angle normal faults that dip toward one another. It is a structual form that may or may not be geomorphologically expressed as a rift valley	
hadal setting	The deepest oceanic environment, i.e., over 6,000 m in depth. Always in deep sea trench.	marine setting
half-graben	A elongate , asymmetric trough or basin bounded on one side by a normal fault.	
high pressure low temperature earth interior setting	High pressure environment characterized by geothermal gradient significantly lower than standard continental geotherm; environment in which blueschist facies metamorphic rocks form. Typically associated with subduction zones.	earth interior setting
hillslope setting	Earth surface setting characterized by surface slope angles high enough that gravity alone becomes a significant factor in geomorphic development, as well as base-of-slope areas influenced by hillslope processes. Hillslope activities include creep, sliding, slumping, falling, and other downslope movements caused by slope collapse induced by gravitational	earth surface setting

Term	Definition	Parent
	influence on earth materials. May be subaerial or subaqueous.	
hinterland tectonic setting	Tectonic setting in the internal part of an orogenic belt, characterized by plastic deformation of rocks accompanied by significant metamorphism, typically involving crystalline basement rocks. Typically denotes the most structurally thickened part of an orogenic belt, between a magmatic arc or collision zone and a more 'external' foreland setting.	continental-crustal setting
hot spot setting	Setting in a zone of high heat flow from the mantle. Typically identified in intraplate settings, but hot spot may also interact with active plate margins (Iceland...). Includes surface manifestations like volcanic center, but includes crust and mantle manifestations as well.	tectonically defined setting
human environment setting		
humid temperate climatic setting	Setting with seasonal climate having hot to cold or humid to arid seasons.	earth surface setting
humid tropical climatic setting	Setting with hot, humid climate influenced by equatorial air masses, no winter season.	earth surface setting
hypabyssal setting	Igneous environment close to the Earth's surface, characterized by more rapid cooling than plutonic setting to produce generally fine-grained intrusive igneous rock that is commonly associated with co-magmatic volcanic rocks.	earth interior setting
inactive spreading center setting	Setting on oceanic crust formed at a spreading center that has been abandoned.	intraplate tectonic setting
inner neritic setting	The ocean environment at depths between low tide level and 30 metres	neritic setting
interdistributary bay setting	A pronounced indentation of the delta front between advancing stream distributaries, occupied by shallow water, and either open to the sea or partly enclosed by minor distributaries	deltaic system setting
intertidal setting	Pertaining to the benthic ocean environment or depth zone between high water and low water; also, pertaining to the organisms of that environment	subaqueous setting
intracratonic setting	A basin formed within the interior region of a continent, away from plate boundaries.	
intraplate tectonic setting	Tectonically stable setting far from any active plate margins.	tectonically defined setting
lacustrine delta setting	The low, nearly flat, alluvial tract of land at or near the mouth of a river, commonly forming a triangular or fan-shaped plain of considerable area, crossed by many distributaries of the main river, perhaps extending beyond the general trend of the lake	deltaic system setting

Term	Definition	Parent
	shore, resulting from the accumulation of sediment supplied by the river in such quantities that it is not removed by waves or currents. Most deltas are partly subaerial and partly below water.	
lacustrine setting	Setting associated with a lake. Always overlaps with terrestrial, may overlap with subaerial, subaqueous, or shoreline.	terrestrial setting
lagoonal setting	A shallow stretch of salt or brackish water, partly or completely separated from a sea or lake by an offshore reef, barrier island, sand or spit (Jackson, 1997). Water is shallow, tidal and wave-produced effects on sediments; strong light reaches sediment.	shoreline setting
land reclamation setting		
low energy shoreline setting	Settings characterized by very low surface slope and proximity to shoreline. Generally within peritidal setting, but characterized by low surface gradients and generally low-energy sedimentary processes.	shoreline setting
low pressure high temperature setting	Setting characterized by temperatures significantly higher that those associated with normal continental geothermal gradient.	earth interior setting
lower bathyal setting	The ocean environment at depths between 1000 and 3500 metres	bathyal setting
lower continental-crustal setting	Continental crustal setting characterized by upper amphibolite to granulite facies metamorphism, in situ melting, residual anhydrous metamorphic rocks, and ductile flow of rock bodies.	continental-crustal setting
lower delta plain setting	The part of a delta plain which is penetrated by saline water and is subject to tidal processes	delta plain setting
lower mantle setting	That part of the mantle that lies below a depth of about 660 km. With increasing depth, density increases from ~4.4 g/cm3 to ~5.6 g/cm3, and velocity of compressional seismic waves increases from ~10.7 km/s to ~13.7 km/s (Dziewonski and Anderson, 1981).	mantle setting
lower oceanic-crustal setting	Setting characterized by dominantly intrusive mafic rocks, with sheeted dike complexes in upper part and gabbroic to ultramafic intrusive or metamorphic rocks in lower part.	oceanic-crustal setting
mantle setting	The zone of the Earth below the crust and above the core, which is divided into the upper mantle and the lower mantle, with a transition zone separating them.	earth interior setting
marginal marine sabkha setting	Setting characterized by arid to semi-arid conditions on restricted coastal plains mostly above normal high tide level, with evaporite-saline mineral, tidal-flood, and eolian deposits. Boundaries with intertidal setting and non-tidal terrestrial	arid or semi arid environment setting

Term	Definition	Parent
	setting are gradational (Jackson, 1997, p. 561).	
marine carbonate platform setting	A shallow submerged plateau separated from continental landmasses, on which high biological carbonate production rates produce enough sediment to maintain the platform surface near sea level. Grades into atoll as area becomes smaller and ringing coral reefs become more prominent part of the setting.	marine setting
marine setting	Setting characterized by location under the surface of the sea.	subaqueous setting
meandering river channel setting	Produced by a mature stream swinging from side to side as it flows across its floodplain or shifts its course laterally toward the convex side of an original curve	river channel setting
medium-rate spreading center setting	Spreading center at which the opening rate is between 50 and 100 mm per year.	active spreading center setting
mid ocean ridge setting	Ocean highland associated with a divergent continental margin (spreading center). Setting is characterized by active volcanism, locally steep relief, hydrothermal activity, and pelagic sedimentation.	ocean highland setting
middle bathyal setting	The ocean environment at water depths between 600 and 1000 metres	bathyal setting
middle continental crust setting	Continental crustal setting characterized by greenschist to upper amphibolite facies metamorphism, plutonic igneous rocks, and ductile deformation.	continental-crustal setting
middle neritic setting	The ocean environment at depths between 30 and 100 metres	neritic setting
mining area setting		
mud flat setting	A relatively level area of fine grained material (e.g. silt) along a shore (as in a sheltered estuary or chenier-plain) or around an island, alternately covered and uncovered by the tide or covered by shallow water, and barren of vegetation. Includes most tidal flats, but lacks denotation of tidal influence..	low energy shoreline setting
neritic setting	The ocean environment at depths between low-tide level and 200 metres, or between low-tide level and approximately the edge of the continental shelf	marine setting
ocean highland setting	Broad category for subaqueous marine settings characterized by significant relief above adjacent sea floor.	marine setting
oceanic plateau setting	Region of elevated ocean crust that commonly rises to within 2-3 km of the surface above an abyssal sea floor that lies several km deeper. Climate and water depths are such that a marine carbonate platform does not develop.	ocean highland setting

Term	Definition	Parent
oceanic-crustal setting	That type of the Earth's crust which underlies the ocean basins. The oceanic crust is 5-10 km thick; it has a density of 2.9 g/cm3, and compressional seismic-wave velocities travelling through it at 4-7.2 km/sec. Setting in crust produced by submarine volcanism at a mid ocean ridge.	crustal setting
outer neritic setting	The ocean environment at depths between 100 meters and approximately the edge of the continental shelf or between 100 and 200 meters	neritic setting
passive continental margin setting	Boundary of continental crust into oceanic crust of an oceanic basin that is not a subduction zone or transform fault system. Generally is rifted margin formed when ocean basin was initially formed.	tectonically defined setting
pediment setting	A gently sloping erosional surface developed at the foot of a receding hill or mountain slope. The surface may be essentially bare, exposing earth material that extends beneath adjacent uplands; or it may be thinly mantled with alluvium and colluvium, ultimately in transit from upland front to basin or valley lowland. The term has been used in several geomorphic contexts: Pediments may be classed with respect to (a) landscape positions, for example, intermontane-basin piedmont or valley-border footslope surfaces (respectively, apron and terrace pediments (Cooke and Warren, 1973)); (b) type of material eroded bedrock or regolith; or (c) combinations of the above. Compare - Piedmont slope.	piedmont slope system setting
piedmont slope system setting	Location on gentle slope at the foot of a mountain; generally used in terms of intermontane-basin terrain. Main components include: (a) An erosional surface on bedrock adjacent to the receding mountain front (pediment, rock pediment); (b) A constructional surface comprising individual alluvial fans and interfan valleys, also near the mountain front; and (c) A distal complex of coalescent fans (bajada), and alluvial slopes without fan form. Piedmont slopes grade to basin-floor depressions with alluvial and temporary lake plains or to surfaces associated with through drainage.	subaerial setting
plate margin setting	Tectonic setting at the boundary between two tectonic plates.	tectonically defined setting
plate spreading center setting	Tectonic setting where new oceanic crust is being or has been formed at a divergent plate boundary. Includes active and inactive spreading centers.	tectonically defined setting
playa setting	The usually dry and nearly level plain that occupies the lowest parts of closed depressions, such as those occurring on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation-runoff events.	arid or semi arid environment setting

Term	Definition	Parent
polar climatic setting	Setting with climate dominated by temperatures below the freezing temperature of water. Includes polar deserts because precipitation is generally scant at high latitude. Climatically controlled by arctic air masses, cold dry environment with short summer.	earth surface setting
prodelta setting	The part of a delta that is below the effective depth of wave erosion, lying beyond the delta front, and sloping gently down to the floor of the basin into which the delta is advancing and where clastic river sediment ceases to be a significant part of the basin-floor deposits; it is entirely below the water level	deltaic system setting
proglacial setting	Immediately in front of or just beyond the outer limits of a glacier or ice sheet, generally at or near its lower end; said of lakes, streams, deposits, and other features produced by or derived from the glacier ice	glacier related setting
reef flat setting	A stony platform of reef rock, landward of the reef crest at or above the low tide level, occasionally with patches of living coral and associated organisms, and commonly strewn with coral fragments and coral sand. It may include shallow pools, irregular gullies, low islands of sand or rubble (often vegetated, esp. by palms), and scattered colonies of the more hardy species of coral.	biological reef setting
regional metamorphic setting	Metamorphism not obviously localized along contacts of igneous bodies; includes burial metamorphism and ocean ridge metamorphism	earth interior setting
river channel setting	The bed where a natural body of surface water flows or may flow; a natural passageway or depression of perceptible extent containing continuously or periodically flowing water, or forming a connecting link between two bodies of water; a watercourse	river plain system setting
river plain system setting	Geologic setting dominated by a river system; river plains may occur in any climatic setting. Includes active channels, abandoned channels, levees, oxbow lakes, flood plain. May be part of an alluvial plain that includes terraces composed of abandoned river plain deposits.	terrestrial setting
rocky coast setting	Shoreline with significant relief and abundant rock outcrop.	shoreline setting
sand plain setting	A sand-covered plain dominated by aeolian processes.	aeolian process setting
seamount setting	Setting that consists of a conical mountain on the ocean floor (guyot). Typically characterized by active volcanism, pelagic sedimentation. If the mountain is high enough to reach the photic zone, carbonate production may result in reef building to produce a carbonate platform or atoll setting.	intraplate tectonic setting

Term	Definition	Parent
shoreline setting	Geologic setting characterized by location adjacent to the ocean or a lake. A zone of indefinite width (may be many kilometers), bordering a body of water that extends from the water line inland to the first major change in landform features. Includes settings that may be subaerial, intermittently subaqueous, or shallow subaqueous, but are intrinsically associated with the interface between land areas and water bodies.	earth surface setting
slope-rise setting	The part of a subaqueous basin that is between a bordering shelf setting, which separate the basin from an adjacent landmass, and a very low-relief basin plain setting.	marine setting
slow spreading center setting	Spreading center at which the opening rate is less than 50 mm per year.	active spreading center setting
spring setting	Setting characterized by a place where groundwater flows naturally from a rock or the soil onto the land surface or into a water body.	river plain system setting
strandplain setting	A prograded shore built seaward by waves and currents, and continuous for some distance along the coast. It is characterized by subparallel beach ridges and swales, in places with associated dunes.	shoreline setting
subaerial setting	Setting at the interface between the solid earth and the atmosphere, includes some shallow subaqueous settings in river channels and playas. Characterized by conditions and processes, such as erosion, transport and accumulation, that exist or operate in the open air on or immediately adjacent to the land surface.	earth surface setting
subaqueous setting	Setting situated in or under permanent, standing water. Used for marine and lacustrine settings, but not for fluvial settings.	earth surface setting
subduction zone setting	Tectonic setting at which a tectonic plate, usually oceanic, is moving down into the mantle beneath another overriding plate.	plate margin setting
subglacial setting	Formed or accumulated in or by the bottom parts of a glacier or ice sheet; said of meltwater streams, till, moraine, etc.	glacier related setting
submarine fan setting	Large fan-shaped cones of sediment on the ocean floor, generally associated with submarine canyons that provide sediment supply to build the fan..	marine setting
supraglacial setting	"Carried upon, deposited from, or pertaining to the top surface of a glacier or ice sheet; said of meltwater streams, till, drift, etc. " (Jackson, 1997, p. 639). Dreimanis (1988, p. 39) recommendation that "supraglacial" supersede "superglacial" is followed.	glacier related setting

Term	Definition	Parent
supratidal setting	Pertaining to the shore area marginal to the littoral zone, just above high-tide level	shoreline setting
swamp or marsh setting	A water-saturated, periodically wet or continually flooded area with the surface not deeply submerged, essentially without the formation of peat. Marshes are characterized by sedges, cattails, rushes, or other aquatic and grasslike vegetation. Swamps are characterized by tree and brush vegetation.	wetland setting
tectonically defined setting	Setting defined by relationships to tectonic plates on or in the Earth.	
terrestrial setting	Setting characterized by absence of direct marine influence. Most of the subaerial settings are also terrestrial, but lacustrine settings, while terrestrial, are not subaerial, so the subaerial settings are not included as subcategories.	earth surface setting
tidal channel setting	A major channel followed by the tidal currents, extending from offshore into a tidal marsh or a tidal flat.	subaqueous setting
tidal flat setting	An extensive, nearly horizontal, barren tract of land that is alternately covered and uncovered by the tide, and consisting of unconsolidated sediment (mostly mud and sand). It may form the top surface of a deltaic deposit.	tidal setting
tidal marsh setting	A marsh bordering a coast (as in a shallow lagoon or sheltered bay), formed of mud and of the resistant mat of roots of salt-tolerant plants, and regularly inundated during high tides; a marshy tidal flat.	swamp or marsh setting
tidal setting	Setting subject to tidal processes	shoreline setting
transform plate boundary setting	Plate boundary at which the adjacent plates are moving laterally relative to each other.	plate margin setting
transitional-crustal setting	Crust formed in the transition zone between continental and oceanic crust, during the history of continental rifting that culminates in the formation of a new ocean.	crustal setting
ultra high pressure crustal setting	Setting characterized by pressures characteristic of upper mantle, but indicated by mineral assemblage in crustal composition rocks.	earth interior setting
upper bathyal setting	The ocean environment at water depths between 200 and 600 metres	bathyal setting
upper continental crustal setting	Continental crustal setting dominated by non metamorphosed to low greenschist facies metamorphic rocks, and brittle deformation.	continental-crustal setting
upper delta plain setting	The part of a delta plain essentially unaffected by basinal processes. They do not differ substantially from alluvial environments except that areas of swamp, marsh and lakes	delta plain setting

Term	Definition	Parent
	are usually more widespread and channels may bifurcate downstream	
upper mantle setting	That part of the mantle which lies above a depth of about 660 km and has a density of 3.4 g/cm3 to 4.0 g/cm3 with increasing depth. Similarly, P-wave velocity increases from about 8 to 11 km/sec with depth and S wave velocity increases from about 4.5 to 6 km/sec with depth. It is presumed to be peridotitic in composition. It includes the subcrustal lithosphere, the asthenosphere, and the transition zone.	mantle setting
upper oceanic crustal setting	Oceanic crustal setting dominated by extrusive rocks, abyssal oceanic sediment, with increasing mafic intrusive rock in lower part.	oceanic-crustal setting
volcanic arc setting	A generally curvillinear belt of volcanoes above a subduction zone.	plate margin setting
waste and material deposition area setting		
wet to sub-humid setting	A Wet to sub-humid climate is according Thornthwaite's climate classification system associated with rain forests (wet), forests (humid) and grassland (sub-humid).	
wetland setting	Setting characterized by gentle surface slope, and at least intermittent presence of standing water, which may be fresh, brackish, or saline. Wetland may be terrestrial setting or shoreline setting.	earth surface setting

Code list: EventProcessTerm_Core

Term	Definition	Parent
accretion	The addition of material to a continent. Typically involves convergent or transform motion.	tectonic process
alteration	General term for any change in the mineralogical or chemical composition of a rock. Typically related to interaction with hydrous fluids.	metamorphic process
biological precipitation	the deposition of minerals from solution by the agency of organisms	deposition
biological weathering	breakdown of rocks by biological agents, e.g. the penetrating and expanding force of roots, the presence of moss and lichen causing humic acids to be retained in contact with rock, and the work of animals (worms, moles, rabbits) in modifying surface soil	weathering
bolide impact	the impact of an extraterrestrial body on the surface of the	geologic process

Term	Definition	Parent
	earth	
casting	covering of the surface with a material liquid during processing and solidifying afterwards	material transport and deposition
chemical precipitation	The deposition of mineral matter by precipitation from solution or as a result of chemical reactions. May be sedimentary or hydrothermal.	deposition
chemical weathering	The process of weathering by which chemical reactions (hydrolysis, hydration, oxidation, carbonation, ion exchange, and solution) transform rocks and minerals into new chemical combinations that are stable under conditions prevailing at or near the Earth's surface; e.g. the alteration of orthoclase to kaolinite.	weathering
cometary impact	the impact of a comet on the surface of the earth	bolide impact
contact metamorphism	Metamorphism taking place in rocks at or near their contact with a genetically related body of igneous rock	metamorphic process
continental breakup	Fragmentation of a continental plate into two or more smaller plates; may involve rifting or strike slip faulting.	tectonic process
continental collision	The amalgamation of two continental plates or blocks along a convergent margin.	tectonic process
cryoturbation	A collective term to describe the stirring and churning of unconsolidated material resulting from frost action	mass wasting
debris flow deposition	Laminar high-concentration, generally cohesionless deposition process. Flow types included liquefied flow, fluidized flow, grain flow, traction carpet or modified grain flow.	mechanical deposition
deep ploughing	mixing of loose surface material by ploughing deeper than frequently done during annual soil cultivation	mixing
deep water oxygen depletion	Process of removal of oxygen from from the deep part of a body of water.	geologic process
deformation	Movement of rock bodies by displacement on fault or shear zones, or change in shape of a body of Earth material.	geologic process
deformation twinning	Deformation of a crystal by gliding to produce crystallographic twinning.	ductile flow
deluviation	process of non-linear, grain-size selective erosion	mass wasting
deposition	Accumulation of material; the constructive process of accumulation of sedimentary particles, chemical precipitation of mineral matter from solution, or the accumulation of organic material on the death of plants and animals.	sedimentary process

Term	Definition	Parent
deposition by or from moving ice	Deposition of sediment from ice by melting or pushing. The material has been transported in the ice after entrainment in the moving ice or after deposition from other moving fluids on the ice.	deposition from fluid
deposition from air	Deposition of sediment from air, in which the sediment has been transported after entrainment in the moving air.	deposition from fluid
deposition from fluid	Deposition of sediment from moving water or air, in which the sediment is transported by entrainment in the moving fluid. Constrast with debris flow or turbidity current deposition in which movement of fluid/sediment mixture is due to incorporation of sediment in fluid.	mechanical deposition
deposition from moving fluid	Deposition of sediment from moving water or air, in which the sediment is transported by entrainment in the moving fluid. Constrast with debris flow or turbidity current deposition in which movement of fluid/sediment mixture is due to incorporation of sediment in fluid.	mechanical deposition
deposition from water	Deposition of sediment from water, in which the sediment has been transported after entrainment in the moving water or after deposition from other moving fluids.	deposition from fluid
diagenetic process	Any chemical, physical, or biological process that affects a sedimentary EarthMaterial after initial deposition, and during or after lithification, exclusive of weathering and metamorphism. [adapt. Jackson, 1997] Example processes include compaction, cementation, authigenesis, replacement, leaching, hydration, and bacterial action. Includes processes that are normal in the surficial or outer part of the earth's crust [Jackson, 1997]. Changes in a deeply buried sedimentary rock may be continuous from diagenesis into recrystallization to form a metamorphic rock. Robertson [1999] defines the boundary between diagenesis and metamorphism in sedimentary rocks as follows: "the boundary between diagenesis and metamorphism is somewhat arbitrary and strongly dependent on the rock types involved. For example changes take place in organic materials at lower temperatures than in rocks dominated by silicate minerals. In mudrocks, a white mica (illite) crystallinity value of less than 0.42D.2U obtained by X-ray diffraction analysis, is used to define the onset of metamorphism (Kisch, 1991). In this scheme, the first appearance of glaucophane, lawsonite, paragonite, prehnite, pumpellyite or stilpnomelane is taken to indicate the lower limit of metamorphism (Frey and Kisch, 1987; Bucher and Frey, 1994; Frey and Robinson, 1998). Most workers agree that such mineral growth starts at 150 ± 50° C in silicate rocks. Many rock types may show no change in mineralogy under these conditions and hence the recognition of the onset of	geologic process

Term	Definition	Parent
	metamorphism will vary with bulk composition."	
diffusion creep	Grain-scale, ductile deformation accomplished by the motion of atoms through crystals, along grain boundaries, and through pore fluids.	ductile flow
digging	repeated mixing of loose surface material by digging with a spade or similar tool	mixing
dislocation metamorphism	Metamorphism concentrated along narrow belts of shearing or crushing without an appreciable rise in temperature	metamorphic process
dissolution	The process of dissolving into a homogenous solution, as when an acidic solution dissolves limestone. In karst, refers to the process of dissolving rock to produce landforms, in contrast to solution, the chemical product of dissolution.	chemical weathering
dissolution creep	Deformation by dissolution under the effects of differential stress and its transport to a new location by movement of fluid in the rock body.	ductile flow
ductile flow	deformation without apparent loss of continuity at the scale of observation.	deformation
dumping	heaping of mostly solid material, as in a land fill, mine dump, dredging operations	material transport and deposition
effusive eruption	Eruptions characterized by low volatile content of the erupting magma relative to ambient pressure	eruption
erosion	The process of disaggregation of rock and displacement of the resultant particles (sediment) usually by the agents of currents such as, wind, water, or ice by downward or down-slope movement in response to gravity or by living organisms (in the case of bioerosion).	sedimentary process
eruption	The ejection of volcanic materials (lava, pyroclasts, and volcanic gases) onto the Earth's surface, either from a central vent or from a fissure or group of fissures	magmatic process
excavation	removal of material, as in a mining operation	human activity
excavation	removal of material, as in a mining operation	human activity
extinction	Process of disappearance of a species or higher taxon, so that it no longer exists anywhere or in the subsequent fossil record.	geologic process
faulting	The process of fracturing, frictional slip, and displacement accumulation that produces a fault	deformation
folding	deformation in which planar surfaces become regularly curviplanar surfaces with definable limbs (zones of lower	deformation

Term	Definition	Parent
	curvature) and hinges (zones of higher curvature).	
fracturing	The formation of a surface of failure resulting from stress	deformation
frost shattering	Propagation of fractures due to expansion of freezing water in intergranular spaces and fractures in a rock body. Result is mechanical disintegration spliitting, or breakup of rock.	physical weathering
geologic process	process that effects the geologic record	
geomagnetic process	process that results in change in Earth's magnetic field	geologic process
grading	leveling of earth surface by rearrangement of prexisting material	human activity
haloclasty	propagation of fractures in rock due to crytallization of mineral salts (typically sodium chloride) from interstitial water, or volumetrick expansion of salts in capillaries, or hydration pressure of interstitial, trapped salts. Generally results in mechanical disintegration of the rock surface.	physical weathering
hawaiian eruption	Eruption in which great quantities of extremely fluid basaltic lava are poured out, mainly issuing in lava fountains from fissures on the flanks of a volcano. Explosive phenomena are rare, but much spatter and scoria are piled into cones and mounds along the vents. Characteristic of shield volcanoes	eruption
human activity	processes of human modification of the earth to produce geologic features	geologic process
hydration	The process of absorption of water into the crystal structure of a mineral, thereby changing its volume and fracturing and loosening grains	chemical weathering
hydrolysis	A decomposition reaction involving water. In geology, it commonly indicates reaction between silicate minerals and either pure water or aqueous solution. In such reactions, H	chemical weathering
ice erosion	Erosion by corrasion or plucking by moving ice.	erosion
in-situ organismic growth	accumulation of dead organic material originating from the plants, e.g. paet accumulation in bogs	deposition
intrusion	The process of emplacement of magma in pre-existing rock	magmatic process
magmatic crystallisation	The process by which matter becomes crystalline, from a gaseous, fluid, or dispersed state	magmatic process
magmatic process	A process involving melted rock (magma).	geologic process
magnetic field reversal	geomagnetic event	geomagnetic

Term	Definition	Parent
		process
mass wasting	the dislodgement and downslope transport of soil and rock material under the direct application of gravitational body stresses. In contrast to other erosion processes, the debris removed by mass wasting is not carried within, on, or under another medium. The mass properties of the material being transported depend on the interaction of the soil and rock particles and on the moisture content.	erosion
mass wasting deposition	A general term for the dislodgement and downslope transport of soil and rock material under the direct application of gravitational body stresses. In contrast to other erosion processes, the debris removed by mass wasting is not carried within, on, or under another medium. The mass properties of the material being transported depend on the interaction of the soil and rock particles and on the moisture content. Mass wasting includes slow displacements, such as creep and solifluction, and rapid movements such as rockfalls, rockslides, and cohesive debris flows (Jackson, 1997, p. 392). Includes both subaerial mass-wasting processes and subaqueous mass-wasting processes.	mechanical deposition
material transport and deposition	transport and heaping of material, as in a land fill, mine dump, dredging operations	human activity
mechanical deposition	process by which material that is being transported as particles by moving air, water, ice, or other fluid comes to rest and accumulates.	deposition
melting	change of state from a solid to a liquid	magmatic process
metamorphic process	Mineralogical, chemical, and structural adjustment of solid rocks to physical and chemical conditions that differ from the conditions under which the rocks in question originated, and are generally been imposed at depth, below the surface zones of weathering and cementation.	geologic process
meteorite impact	the impact of a meteorite on the surface of the earth	bolide impact
microfracturing	Development of fractures within a single grain or cutting several grains.	fracturing
mixing		human activity
obduction	The overthrusting of continental crust by oceanic crust or mantle rocks at a convergent plate boundary.	tectonic process
organic accumulation	sediment accumulation of biologically produced organic material, as in bog, coal swamps.	deposition

Term	Definition	Parent
orogenic process	mountain building process.	tectonic process
oxidation	Chemical reaction that involve stripping of electrons from cations. Typicall reactions include converting sulfide minerals to oxide minerals, or increasing the oxidation state of cations in existing oxide minerals. The most commonly observed is the oxidation of Fe	chemical weathering
partial melting	Process of melting involving only some of the mineral phases in a rock, to produce a mixture of melt and residual particles.	melting
physical weathering	The process of weathering by which frost action, salt-crystal growth, absorption of water, and other physical processes break down a rock to fragments, involving no chemical change	weathering
plinian eruption	An explosive eruption in which a steady, turbulent stream of fragmented magma and magmatic gas is released at a high velocity from a vent. Large volumes of tephra and tall eruption columns are characteristic	pyroclastic eruption
polar wander	process of migration of the axis of the earth's dipole field relative to the rotation axis of the Earth.	geomagnetic process
pressure release weathering	propagation of fractures near the surface of solid rock due to expansion related to release of confining pressure when deeply buried rock is unroofed. Fractures typically propagate along surfaces close to and subparallel to the surface of the outcrop.	physical weathering
pyroclastic eruption	Eruption produced by the generation and rapid expansion of a gas phase that disrupts magma, surrounding wall rock or sediment	eruption
reworking	near-range transport by water with predominantly changing the inner physical organisation of the sediment particles	mass wasting
rifting	Extension of the crust to form one or more long, narrow graben of regional extent.	continental breakup
sea level change	process of mean sea level changing relative to some datum	geologic process
sea level fall	process of mean sea level falling relative to some datum	sea level change
sea level rise	process of mean sea level rising relative to some datum	sea level change
sealing	covering of the surface with a non-liquid material not or little permeable for water after processing	material transport and deposition
sedimentary process	a phenomenon that changes the distribution or physical properties of sediment at or near the earth's surface	geologic process
shearing	A deformation in which contiguous parts of a body are displaced relatively to each other in a direction parallel to a	deformation

Term	Definition	Parent
	surface. The surface may be a discrete fault, or the deformation may be a penetrative strain and the shear surface is a geometric abstraction.	
speciation	process that results inappearance of new species	geologic process
spreading	A process whereby new oceanic crust is formed by upwelling of magma at the center of mid-ocean ridges and by a moving-away of the new material from the site of upwelling at rates of one to ten centimeters per year.	tectonic process
strombolian eruption	Eruption characterized by jetting of clots or "fountains" of fluid, basaltic lava from a central crater	eruption
subduction	The process of one lithospheric plate descending beneath another	tectonic process
tectonic process	Processes related to the interaction between or deformation of rigid plates forming the crust of the Earth.	geologic process
thermal shock weathering	propagation of fractures near the surface of solid rock due to expansion and contraction caused by temperature changes. Fractures typically propagate along surfaces close to and subparallel to the surface of the outcrop.	physical weathering
transform faulting	A strike-slip fault that links two other faults or two other plate boundaries (e.g. two segments of a mid-ocean ridge). Transform faults often exhibit characteristics that distinguish them from transcurrent faults: (1) For transform faults formed at the same time as the faults they link, slip on the transform fault has equal magnitude at all points along the transform; slip magnitude on the transform fault can exceed the length of the transform fault, and slip does not decrease to zero at the fault termini. (2) For transform faults linking two similar features, e.g. if two mid-ocean ridge segments linked by a transform have equal spreading rates, then the length of the transform does not change as slip accrues on it.	tectonic process
turbidity current deposition	Deposition from a turbulent, low concentration sediment-water mixture.	mechanical deposition
vulcanian eruption	Eruption characterized by the explosive ejection of fragments of new lava, commonly incandescent when they leave the vent but either solid or too viscous to assume any appreciable degree of rounding during their flight through the air. With these there are often breadcrust bombs or blocks, and generally large proportions of ash	pyroclastic eruption
water erosion	Erosion by clast impact or plucking by moving liquid water	erosion
weathering	The process or group of processes by which earth materials exposed to atmospheric agents at or near the Earth's surface	geologic process

Term	Definition	Parent
	are changed in color, texture, composition, firmness, or form, with little or no transport of the loosened or altered material. Processes typically include oxidation, hydration, and leaching of soluble constituents.	
wind erosion	Erosion by clast impact or plucking by moving air (wind)	erosion

Code list: FaultTypeTerm_Core

Term	Definition
detachment fault	A regional-scale, large displacement, low-angle normal fault.
dextral strike slip fault	Fault with right-lateral strike-parallel displacement component of slip vector more than 10 times the dip-parallel component of the slip vector at at least one location along the fault, and right-lateral displacement over more than half the mapped trace of the fault.
extraction fault	A fault whose two sides have approached each other substantially in the direction perpendicular to the fault.
fault	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.
high angle reverse	Reverse fault that dips at least 45 degrees over more than half of its recognized extent, for which slip or separation is not explicitly specified.
high-angle fault	Fault that dips at least 45 degrees over more than half of its recognized extent, for which slip or separation is not explicitly specified.
high-angle normal fault	Fault that dips at least 45 degrees over more than half of the recognized extent of the fault with the hanging wall displaced from a structurally higher position relative to footwall rocks.
horizontal fault	Fault that dips less than 10 degrees over more than half the recognized extent of the fault.
left normal fault	High angle fault with slip vector that has ratio of strike-parallel to dip-parallel displacement between 10 to 1 and 1 to 10 at at least one location along the mapped trace, with left-lateral strike-parallel component and normal dip-parallel component over at least half the mapped trace of the fault.
left reverse fault	High angle fault with slip vector that has ratio of strike-parallel to dip-parallel displacement between 10 to 1 and 1 to 10 at at least one location along the mapped trace, with left-lateral strike-parallel component and reverse dip-parallel component over at least half the mapped trace of the fault.
low angle fault	Fault that dips less than 45 degrees over more than half of the recognized extent of the fault.

Term	**Definition**
low-angle normal fault	Fault that dips less than 45 degrees over more than half of the recognized extent of the fault with the hanging wall displaced from a structurally higher position relative to footwall rocks.
mixed extraction fault	An extraction fault with some displacement within the fault plane.
normal fault	Fault with dip-parallel displacement component of slip vector more than 10 times the strike-parallel component of the slip vector over more than half recognized extent of the fault, and for which the fault dips consistently in the same direction, and for which the hanging wall has been displaced down relative to the footwall.
oblique slip fault	Fault with slip vector that has ratio of strike-parallel to dip-parallel displacement between 10 to 1 and 1 to 10 at at least one location along the mapped trace of the fault.
pure extraction fault	An extraction fault with no discernible displacement within the fault plane.
reverse fault	Fault with dip-parallel displacement component of slip vector more than 10 times the strike-parallel component of the slip vector at at least one location along the mapped trace of the fault, and the fault dips consistently in the same direction with the hanging wall displaced up relative to the footwall over at least half the mapped trace of the fault.
right normal fault	High angle fault with slip vector that has ratio of strike-parallel to dip-parallel displacement between 10 to 1 and 1 to 10 at at least one location along the mapped trace, with right-lateral strike-parallel component and normal dip-parallel component of slip over at least half the mapped trace of the fault
right reverse fault	High angle fault with slip vector that has ratio of strike-parallel to dip-parallel displacement between 10 to 1 and 1 to 10 at at least one location along the mapped trace, with a right-lateral strike-parallel component and reverse dip-parallel component of slip over at least half the mapped trace of the fault.
scissor fault	A fault on which there is increasing offset or separation along the strike from an initial point of no offset, with the opposite sense of offset in the opposite direction.
sinistral strike slip fault	Fault with left-lateral strike-parallel displacement component of slip vector more than 10 times the dip-parallel component of the slip vector at at least one location along the fault, and left-lateral displacement over more than half the mapped trace of the fault.
strike slip fault	Fault with strike-parallel displacement component of slip vector more than 10 times the dip-parallel component of the slip vector at at least one location along the mapped trace of the fault.
thrust fault	Fault that dips less than 45 degrees over more than half of the recognized extent of the fault, with a hanging wall displaced from a structurally deeper position relative to footwall rocks.
wrench fault	A strike slip fault in which the fault plane dips at least 45 degrees over more than half of the recognized extent of the fault.

Code list: FoldProfileTypeTerm_Core

Term	Definition
anticline	A fold, general convex upward, whose core contains the stratigraphically older rocks.
antiform	Any convex-upward, concave downward fold. The term is usually used when the folded layers do not possess a stratigraphic order, when the stratigraphic order of the folded layers is not known, or when the fold core also contains the stratigraphically younger rock.
monocline	A local steepening in an otherwise uniform gentle dip
neutral	A fold which closes laterally and is therefore neither antiformal nor synformal
ptygmatic	Folds with rounded hinges and fold amplitudes nearly equal to fold wavelength; they develop in isolated layers, usually in metamorphic rocks
syncline	A fold of which the core contains the stratigraphically younger rocks; it is generally concave upward.
synform	Any fold whose limbs close at the bottom. The term is usually used when the folded layers do not possess a stratigraphic order, when the stratigraphic order of the folded layers is not known, or when the fold core also contains the stratigraphically older rock.

Code list: GeneralTimeScale_Core

Term	Definition	Parent
Phanerozoic	Phanerozoic (older bound-542 +/-1, younger bound-0.0)	
Cenozoic	Cenozoic (older bound-65.5 +/-0.3, younger bound-0.0)	Phanerozoic
Quaternary	Quaternary (older bound-2588.0, younger bound-0.0)	Cenozoic
Holocene	Holocene (older bound-0.0117, younger bound-0.0)	Quaternary
Pleistocene	Pleistocene (older bound-2588.0, younger bound-0.0117)	Quaternary
Late/Upper Pleistocene	Late/Upper Pleistocene (older bound-0.126, younger bound-0.0117)	Pleistocene
Ionian	Ionian (older bound-0.781, younger bound-0.126)	Pleistocene
Calabrian	Calabrian (older bound-1806.0, younger bound-0.781)	Pleistocene
Gelasian	Gelasian (older bound-2588.0, younger bound-1806.0)	Pleistocene
Neogene	Neogene (older bound-23.03, younger bound-2588.0)	Cenozoic
Pliocene	Pliocene (older bound-5332.0, younger bound-2588.0)	Neogene
Piacenzian	Piacenzian (older bound-3.6, younger bound-2588.0)	Pliocene

Term	Definition	Parent
Zanclean	Zanclean (older bound-5332.0, younger bound-3.6)	Pliocene
Miocene	Miocene (older bound-23.03, younger bound-5332.0)	Neogene
Messinian	Messinian (older bound-7246.0, younger bound-5332.0)	Miocene
Tortonian	Tortonian (older bound-11608.0, younger bound-7246.0)	Miocene
Serravallian	Serravallian (older bound-13.82, younger bound-11608.0)	Miocene
Langhian	Langhian (older bound-15.97, younger bound-13.82)	Miocene
Burdigalian	Burdigalian (older bound-20.43, younger bound-15.97)	Miocene
Aquitanian	Aquitanian (older bound-23.03, younger bound-20.43)	Miocene
Paleogene	Paleogene (older bound-65.5 +/-0.3, younger bound-23.03)	Cenozoic
Oligocene	Oligocene (older bound-33.9 +/-0.1, younger bound-23.03)	Cenozoic
Chattian	Chattian (older bound-28.4 +/-0.1, younger bound-23.03)	Oligocene
Rupelian	Rupelian (older bound-33.9 +/-0.1, younger bound-28.4 +/-0.1)	Oligocene
Eocene	Eocene (older bound-55.8 +/-0.2, younger bound-33.9 +/-0.1)	Cenozoic
Priabonian	Priabonian (older bound-37.2 +/-0.1, younger bound-33.9 +/-0.1)	Eocene
Bartonian	Bartonian (older bound-40.4 +/-0.2, younger bound-37.2 +/-0.1)	Eocene
Lutetian	Lutetian (older bound-48.6 +/-0.2, younger bound-40.4 +/-0.2)	Eocene
Ypresian	Ypresian (older bound-55.8 +/-0.2, younger bound-48.6 +/-0.2)	Eocene
Paleocene	Paleocene (older bound-65.5 +/-0.3, younger bound-55.8 +/-0.2)	Paleogene
Thanetian	Thanetian (older bound-58.7 +/-0.2, younger bound-55.8 +/-0.2)	Paleocene
Selandian	Selandian (older bound-61.1, younger bound-58.7 +/-0.2)	Paleocene
Danian	Danian (older bound-65.5 +/-0.3, younger bound-61.1)	Paleocene
Mesozoic	Mesozoic (older bound-251 +/-0.4, younger bound-65.5 +/-0.3)	Phanerozoic
Cretaceous	Cretaceous (older bound-145.5 +/-4, younger bound-65.5 +/-0.3)	Mesozoic
Late/Upper Cretaceous	Late/Upper Cretaceous (older bound-99.6 +/-0.9, younger bound-65.5 +/-0.3)	Cretaceous

Term	**Definition**	**Parent**
Maastrichtian	Maastrichtian (older bound-70.6 +/-0.6, younger bound-65.5 +/-0.3)	Late/Upper Cretaceous
Campanian	Campanian (older bound-83.5 +/-0.7, younger bound-70.6 +/-0.6)	Late/Upper Cretaceous
Santonian	Santonian (older bound-85.8 +/-0.7, younger bound-83.5 +/-0.7)	Late/Upper Cretaceous
Coniacian	Coniacian (older bound-88.6, younger bound-85.8 +/-0.7)	Late/Upper Cretaceous
Turonian	Turonian (older bound-93.6 +/-0.8, younger bound-88.6)	Late/Upper Cretaceous
Cenomanian	Cenomanian (older bound-99.6 +/-0.9, younger bound-93.6 +/-0.8)	Late/Upper Cretaceous
Early/Lower Cretaceous	Early/Lower Cretaceous (older bound-145.5 +/-4, younger bound-99.6 +/-0.9)	Cretaceous
Albian	Albian (older bound-112 +/-1, younger bound-99.6 +/-0.9)	Early/Lower Cretaceous
Aptian	Aptian (older bound-125 +/-1, younger bound-112 +/-1)	Early/Lower Cretaceous
Barremian	Barremian (older bound-130 +/-1.5, younger bound-125 +/-1)	Early/Lower Cretaceous
Hauterivian	Hauterivian (older bound-133.9, younger bound-130 +/-1.5)	Early/Lower Cretaceous
Valanginian	Valanginian (older bound-140.2 +/-3, younger bound-133.9)	Early/Lower Cretaceous
Berriasian	Berriasian (older bound-145.5 +/-4, younger bound-140.2 +/-3)	Early/Lower Cretaceous
Jurassic	Jurassic (older bound-199.6 +/-0.6, younger bound-145.5 +/-4)	Mesozoic
Late/Upper Jurassic	Late/Upper Jurassic (older bound-161.2 +/-4, younger bound-145.5 +/-4)	Jurassic
Tithonian	Tithonian (older bound-150.8 +/-4, younger bound-145.5 +/-4)	Late/Upper Jurassic
Kimmeridgian	Kimmeridgian (older bound-155.6, younger bound-150.8 +/-4)	Late/Upper Jurassic
Oxfordian	Oxfordian (older bound-161.2 +/-4, younger bound-155.6)	Late/Upper Jurassic

Term	Definition	Parent
Middle Jurassic	Middle Jurassic (older bound-175.6 +/-2, younger bound-161.2 +/-4)	Jurassic
Callovian	Callovian (older bound-164.7 +/-4, younger bound-161.2 +/-4)	Middle Jurassic
Bathonian	Bathonian (older bound-167.7 +/-3.5, younger bound-164.7 +/-4)	Middle Jurassic
Bajocian	Bajocian (older bound-171.6 +/-3, younger bound-167.7 +/-3.5)	Middle Jurassic
Aalenian	Aalenian (older bound-175.6 +/-2, younger bound-171.6 +/-3)	Middle Jurassic
Early/Lower Jurassic	Early/Lower Jurassic (older bound-199.6 +/-0.6, younger bound-175.6 +/-2)	Jurassic
Toarcian	Toarcian (older bound-183 +/-1.5, younger bound-175.6 +/-2)	Early/Lower Jurassic
Pliensbachian	Pliensbachian (older bound-189.6 +/-1.5, younger bound-183 +/-1.5)	Early/Lower Jurassic
Sinemurian	Sinemurian (older bound-196.5 +/-1, younger bound-189.6 +/-1.5)	Early/Lower Jurassic
Hettangian	Hettangian (older bound-199.6 +/-0.6, younger bound-196.5 +/-1)	Early/Lower Jurassic
Triassic	Triassic (older bound-251 +/-0.4, younger bound-199.6 +/-0.6)	Mesozoic
Late/Upper Triassic	Late/Upper Triassic (older bound-228.7, younger bound-199.6 +/-0.6)	Triassic
Rhaetian	Rhaetian (older bound-203.6 +/-1.5, younger bound-199.6 +/-0.6)	Late/Upper Triassic
Norian	Norian (older bound-216.5 +/-2, younger bound-203.6 +/-1.5)	Late/Upper Triassic
Carnian	Carnian (older bound-228.7, younger bound-216.5 +/-2)	Late/Upper Triassic
Middle Triassic	Middle Triassic (older bound-245.9, younger bound-228.7)	Middle Triassic
Ladinian	Ladinian (older bound-237 +/-2, younger bound-228.7)	Middle Triassic
Anisian	Anisian (older bound-245.9, younger bound-237 +/-2)	Middle Triassic
Early/Lower Triassic	Early/Lower Triassic (older bound-251 +/-0.4, younger bound-245.9)	Triassic
Olenekian	Olenekian (older bound-249.5, younger bound-245.9)	Early/Lower Triassic

Term	Definition	Parent
Induan	Induan (older bound-251 +/-0.4, younger bound-249.5)	Early/Lower Triassic
Paleozoic	Paleozoic (older bound-542 +/-1, younger bound-251 +/-0.4)	Phanerozoic
Permian	Permian (older bound-299 +/-0.8, younger bound-251 +/-0.4)	Paleozoic
Lopingian	Lopingian (older bound-260.4 +/-0.7, younger bound-251 +/-0.4)	Permian
Changhsingian	Changhsingian (older bound-253.8 +/-0.7, younger bound-251 +/-0.4)	Lopingian
Wuchiapingian	Wuchiapingian (older bound-260.4 +/-0.7, younger bound-253.8 +/-0.7)	Lopingian
Guadalupian	Guadalupian (older bound-270.6 +/-0.7, younger bound-260.4 +/-0.7)	Permian
Capitanian	Capitanian (older bound-265.8 +/-0.7, younger bound-260.4 +/-0.7)	Guadalupian
Wordian	Wordian (older bound-268 +/-0.7, younger bound-265.8 +/-0.7)	Guadalupian
Roadian	Roadian (older bound-270.6 +/-0.7, younger bound-268 +/-0.7)	Guadalupian
Cisuralian	Cisuralian (older bound-299 +/-0.8, younger bound-270.6 +/-0.7)	Permian
Kungurian	Kungurian (older bound-275.6 +/-0.7, younger bound-270.6 +/-0.7)	Cisuralian
Artinskian	Artinskian (older bound-284.4 +/-0.7, younger bound-275.6 +/-0.7)	Cisuralian
Sakmarian	Sakmarian (older bound-294.6 +/-0.8, younger bound-284.4 +/-0.7)	Cisuralian
Asselian	Asselian (older bound-299 +/-0.8, younger bound-294.6 +/-0.8)	Cisuralian
Carboniferous	Carboniferous (older bound-359.2 +/-2.5, younger bound-299 +/-0.8)	Paleozoic
Pennsylvanian	Pennsylvanian (older bound-318.1 +/-1.3, younger bound-299 +/-0.8)	Carboniferous
Late/Upper Pennsylvanian	Late/Upper Pennsylvanian (older bound-307.2 +/-1, younger bound-299 +/-0.8)	Pennsylvanian
Gzhelian	Gzhelian (older bound-303.4 +/-0.9, younger bound-299 +/-0.8)	Late/Upper Pennsylvanian
Kasimovian	Kasimovian (older bound-307.2 +/-1, younger bound-303.4 +/-	Late/Upper

Term	Definition	Parent
	0.9)	Pennsylvanian
Moscovian	Moscovian (older bound-311.7 +/-1.1, younger bound-307.2 +/-1)	Pennsylvanian
Bashkirian	Bashkirian (older bound-318.1 +/-1.3, younger bound-311.7 +/-1.1)	Pennsylvanian
Mississippian	Mississippian (older bound-359.2 +/-2.5, younger bound-318.1 +/-1.3)	Carboniferous
Serpukhovian	Serpukhovian (older bound-328.3 +/-1.6, younger bound-318.1 +/-1.3)	Mississippian
Visean	Visean (older bound-345.3 +/-2.1, younger bound-328.3 +/-1.6)	Mississippian
Tournaisian	Tournaisian (older bound-359.2 +/-2.5, younger bound-345.3 +/-2.1)	Mississippian
Devonian	Devonian (older bound-416 +/-2.8, younger bound-359.2 +/-2.5)	Paleozoic
Late/Upper Devonian	Late/Upper Devonian (older bound-385.3 +/-2.6, younger bound-359.2 +/-2.5)	Devonian
Famennian	Famennian (older bound-374.5 +/-2.6, younger bound-359.2 +/-2.5)	Late/Upper Devonian
Frasnian	Frasnian (older bound-385.3 +/-2.6, younger bound-374.5 +/-2.6)	Late/Upper Devonian
Middle Devonian	Middle Devonian (older bound-397.5 +/-2.7, younger bound-385.3 +/-2.6)	Devonian
Givetian	Givetian (older bound-391.8 +/-2.7, younger bound-385.3 +/-2.6)	Middle Devonian
Eifelian	Eifelian (older bound-397.5 +/-2.7, younger bound-391.8 +/-2.7)	Middle Devonian
Early/Lower Devonian	Early/Lower Devonian (older bound-416 +/-2.8, younger bound-397.5 +/-2.7)	Devonian
Emsian	Emsian (older bound-407 +/-2.8, younger bound-397.5 +/-2.7)	Early/Lower Devonian
Pragian	Pragian (older bound-411.2 +/-2.8, younger bound-407 +/-2.8)	Early/Lower Devonian
Lochkovian	Lochkovian (older bound-416 +/-2.8, younger bound-411.2 +/-2.8)	Early/Lower Devonian
Silurian	Silurian (older bound-443.7 +/-1.5, younger bound-416 +/-2.8)	Paleozoic

Term	Definition	Parent
Pridoli	Pridoli (older bound-418.7 +/-2.7, younger bound-416 +/-2.8)	Silurian
Ludlow	Ludlow (older bound-422.9 +/-2.5, younger bound-418.7 +/-2.7)	Silurian
Ludfordian	Ludfordian (older bound-421.3 +/-2.6, younger bound-418.7 +/-2.7)	Ludlow
Gorstian	Gorstian (older bound-422.9 +/-2.5, younger bound-421.3 +/-2.6)	Ludlow
Wenlock	Wenlock (older bound-428.2 +/-2.3, younger bound-422.9 +/-2.5)	Silurian
Homerian	Homerian (older bound-426.2 +/-2.4, younger bound-422.9 +/-2.5)	Wenlock
Sheinwoodian	Sheinwoodian (older bound-428.2 +/-2.3, younger bound-426.2 +/-2.4)	Wenlock
Llandovery	Llandovery (older bound-443.7 +/-1.5, younger bound-428.2 +/-2.3)	Silurian
Telychian	Telychian (older bound-436 +/-1.9, younger bound-428.2 +/-2.3)	Llandovery
Aeronian	Aeronian (older bound-439 +/-1.8, younger bound-436 +/-1.9)	Llandovery
Rhuddanian	Rhuddanian (older bound-443.7 +/-1.5, younger bound-439 +/-1.8)	Llandovery
Ordovician	Ordovician (older bound-488.3 +/-1.7, younger bound-443.7 +/-1.5)	Paleozoic
Late/Upper Ordovician	Late/Upper Ordovician (older bound-460.9 +/-1.6, younger bound-443.7 +/-1.5)	Ordovician
Hirnantian	Hirnantian (older bound-445.6 +/-1.5, younger bound-443.7 +/-1.5)	Late/Upper Ordovician
Katian	Katian (older bound-455.8 +/-1.6, younger bound-445.6 +/-1.5)	Late/Upper Ordovician
Sandbian	Sandbian (older bound-460.9 +/-1.6, younger bound-455.8 +/-1.6)	Late/Upper Ordovician
Middle Ordovician	Middle Ordovician (older bound-471.8 +/-1.6, younger bound-460.9 +/-1.6)	Ordovician
Darriwilian	Darriwilian (older bound-468.1 +/-1.6, younger bound-460.9 +/-1.6)	Middle Ordovician
Dapingian	Dapingian (older bound-471.8 +/-1.6, younger bound-468.1 +/-	Middle

Term	Definition	Parent
	1.6)	Ordovician
Early/Lower Ordovician	Early/Lower Ordovician (older bound-488.3 +/-1.7, younger bound-471.8 +/-1.6)	Ordovician
Floian	Floian (older bound-478.6 +/-1.7, younger bound-471.8 +/-1.6)	Early/Lower Ordovician
Tremadocian	Tremadocian (older bound-488.3 +/-1.7, younger bound-478.6 +/-1.7)	Early/Lower Ordovician
Cambrian	Cambrian (older bound-542 +/-1, younger bound-488.3 +/-1.7)	Paleozoic
Furongian	Furongian (older bound-499.0, younger bound-488.3 +/-1.7)	Cambrian
Cambrian-Stage 10	Cambrian-Stage 10 (older bound-492.0, younger bound-488.3 +/-1.7)	Furongian
Cambrian-Stage 9	Cambrian-Stage 9 (older bound-496.0, younger bound-492.0)	Furongian
Paibian	Paibian (older bound-499.0, younger bound-496.0)	Furongian
Cambrian-Series 3	Cambrian-Series 3 (older bound-510.0, younger bound-499.0)	Cambrian
Guzhangian	Guzhangian (older bound-503.0, younger bound-499.0)	Cambrian-Series 3
Drumian	Drumian (older bound-506.5, younger bound-503.0)	Cambrian-Series 3
Cambrian-Series 3-Stage 5	Cambrian-Series 3-Stage 5 (older bound-510.0, younger bound-506.5)	Cambrian-Series 3
Cambrian-Series 2	Cambrian-Series 2 (older bound-521.0, younger bound-510.0)	Cambrian
Cambrian-Stage 4	Cambrian-Stage 4 (older bound-515.0, younger bound-510.0)	Cambrian-Series 2
Cambrian-Stage 3	Cambrian-Stage 3 (older bound-521.0, younger bound-515.0)	Cambrian-Series 2
Terreneuvian	Terreneuvian (older bound-542 +/-1, younger bound-521.0)	Cambrian
Cambrian-Stage 2	Cambrian-Stage 2 (older bound-528.0, younger bound-521.0)	Terreneuvian
Fortunian	Fortunian (older bound-542 +/-1, younger bound-528.0)	Terreneuvian
Precambrian	Precambrian (older bound-4600.0, younger bound-542.0)	
Proterozoic	Proterozoic (older bound-2500.0, younger bound-542.0)	Precambrian
Neoproterozoic	Neoproterozoic (older bound-1000.0, younger bound-542.0)	Proterozoic
Ediacaran	Ediacaran (older bound-635.0, younger bound-542.0)	Neoproterozoic

Term	Definition	Parent
Cryogenian	Cryogenian (older bound-850.0, younger bound-635.0)	Neoproterozoic
Tonian	Tonian (older bound-1000.0, younger bound-850.0)	Neoproterozoic
Tonian 2 *	Tonian 2 * (older bound-910.0, younger bound-850.0)	Tonian
Tonian 1 *	Tonian 1 * (older bound-1000.0, younger bound-910.0)	Tonian
Mesoproterozoic	Mesoproterozoic (older bound-1600.0, younger bound-1000.0)	Proterozoic
Stenian	Stenian (older bound-1200.0, younger bound-1000.0)	Mesoproterozoic
Stenian 2 *	Stenian 2 * (older bound-1130.0, younger bound-1000.0)	Stenian
Stenian 1 *	Stenian 1 * (older bound-1200.0, younger bound-1130.0)	Stenian
Ectasian	Ectasian (older bound-1400.0, younger bound-1200.0)	Mesoproterozoic
Ectasian 4 *	Ectasian 4 * (older bound-1250.0, younger bound-1200.0)	Ectasian
Ectasian 3 *	Ectasian 3 * (older bound-1270.0, younger bound-1250.0)	Ectasian
Ectasian 2 *	Ectasian 2 * (older bound-1360.0, younger bound-1270.0)	Ectasian
Ectasian 1 *	Ectasian 1 * (older bound-1400.0, younger bound-1360.0)	Ectasian
Calymmian	Calymmian (older bound-1600.0, younger bound-1400.0)	Mesoproterozoic
Calymmian 4 *	Calymmian 4 * (older bound-1440.0, younger bound-1400.0)	Calymmian
Calymmian 3 *	Calymmian 3 * (older bound-1470.0, younger bound-1440.0)	Calymmian
Calymmian 2 *	Calymmian 2 * (older bound-1520.0, younger bound-1470.0)	Calymmian
Calymmian 1 *	Calymmian 1 * (older bound-1600.0, younger bound-1520.0)	Calymmian
Paleoproterozoic	Paleoproterozoic (older bound-2500.0, younger bound-1600.0)	Proterozoic
Statherian	Statherian (older bound-1800.0, younger bound-1600.0)	Paleoproterozoic
Statherian 4 *	Statherian 4 * (older bound-1660.0, younger bound-1600.0)	Statherian
Statherian 3 *	Statherian 3 * (older bound-1740.0, younger bound-1660.0)	Statherian
Statherian 2 *	Statherian 2 * (older bound-1770.0, younger bound-1740.0)	Statherian
Statherian 1 *	Statherian 1 * (older bound-1800.0, younger bound-1770.0)	Statherian
Orosirian	Orosirian (older bound-2050.0, younger bound-1800.0)	Paleoproterozoic
Orosirian 7 *	Orosirian 7 * (older bound-1820.0, younger bound-1800.0)	Orosirian
Orosirian 6 *	Orosirian 6 * (older bound-1840.0, younger bound-1820.0)	Orosirian
Orosirian 5 *	Orosirian 5 * (older bound-1870.0, younger bound-1840.0)	Orosirian

Term	Definition	Parent
Orosirian 4 *	Orosirian 4 * (older bound-1880.0, younger bound-1870.0)	Orosirian
Orosirian 3 *	Orosirian 3 * (older bound-1920.0, younger bound-1880.0)	Orosirian
Orosirian 2 *	Orosirian 2 * (older bound-1960.0, younger bound-1920.0)	Orosirian
Orosirian 1 *	Orosirian 1 * (older bound-2050.0, younger bound-1960.0)	Orosirian
Rhyacian	Rhyacian (older bound-2300.0, younger bound-2050.0)	Paleoproterozoic
Siderian	Siderian (older bound-2500.0, younger bound-2300.0)	Paleoproterozoic
Siderian 2 *	Siderian 2 * (older bound-2400.0, younger bound-2300.0)	Siderian
Siderian 1 *	Siderian 1 * (older bound-2500.0, younger bound-2400.0)	Siderian
Archean	Archean (older bound-4000.0, younger bound-2500.0)	Precambrian
Neoarchean	Neoarchean (older bound-2800.0, younger bound-2500.0)	Archean
Neoarchean 2 *	Neoarchean 2 * (older bound-2650.0, younger bound-2500.0)	Neoarchean
Neoarchean 1 *	Neoarchean 1 * (older bound-2800.0, younger bound-2650.0)	Neoarchean
Mesoarchean	Mesoarchean (older bound-3200.0, younger bound-2800.0)	Archean
Paleoarchean	Paleoarchean (older bound-3600.0, younger bound-3200.0)	Archean
Eoarchean	Eoarchean (older bound-4000.0, younger bound-3600.0)	Archean
Hadean (informal)	Hadean (informal) (older bound-4600.0, younger bound-4000.0)	Precambrian

Code list: GeologicUnitTypeTerm_Core

Term	Definition	Parent
allostratigraphic unit	Geologic unit defined by bounding surfaces. Not necessarily stratified. Donovon (2004, IUGS abstract Florence) makes good case for use of a noncommittal term for the bounding surface. “While there may be no agreement that a given stratal boundary is a discontinuity, there is consensus that all the identified boundaries are stratal surfaces.” Includes: 1. Unconformity bounded units (Salvador 1994), defined by bounding stratigraphic discontinuities ('significant unconformities'; unconformity is defined as surface of erosion in Salvador 1994). 2. Sequence stratigraphic unit, an allostratigraphic unit that is used to interpret the depositional origin of sedimentary strata and assumes, though this is not always stated, an implicit connection to base level change. It does this by establishing how the sequence of strata accumulated in order in the sedimentary section over a	geologic unit

Term	Definition	Parent
	subdividing framework of surfaces.	
alteration unit	Geologic unit defined by alteration process.	geologic unit
artificial ground	Geologic unit defined by genesis involving direct human action to deposit or modify material.	lithogenetic unit
biostratigraphic unit	Geologic unit defined based on fossil content. Five kinds of biozones are recognized by the revised NACSN (Lenz et al., 2000, Note 64, a recommended complete replacement of Articles 48 through 54 of the North American Stratigraphic Code (NACSN, 1983) accepted for publication 2000.): range biozone, interval biozone, lineage biozone, assemblage biozone, and abundance biozone. These represent different approaches to defining and recognizing biozones.	geologic unit
chronostratigraphic unit	Geologic unit that includes all rocks formed during a specific interval of geologic time	geologic unit
deformation unit	Lithotectonic unit defined by deformation style or characteristic geologic structure observable in outcrop.	lithotectonic unit
excavation unit	Geologic unit defined by human-made genesis involving excavation. Not necessarily defined by landform (a hole...), as they could have been subsequently filled/landscaped etc. If the excavation is filled becomes an excavation with artificial ground wholly or partly superimposed on it. This sort of thing can become quite important in urban geology where an excavation can be filled and landscaped.	lithogenetic unit
geologic unit	Type of geologic unit is unknown, unspecified, irrelevant, or some type not included in the vocabulary. Type makes no implication for required properties or cardinalities. This is the root concept for the type hierarchy.	
geomorphologic unit	Geologic unit defined by surface landform, e.g. hummocky moraine	geologic unit
geophysical unit	Geologic unit defined by its geophysical characteristics. Denotes that the properties used to define the unit are measured by intrumental techniques, not directly observable by humans, e.g. density, magnetic susceptibility, magnetization, electrical conductivity.	geologic unit
lithodemic unit	Lithostratigraphic unit that lacks stratification	lithostratigraphic unit
lithogenetic unit	Geologic unit defined by genesis. The genesis is manifested by material properties, but the material is not the defining property. Example-- alluvial deposits, glacial deposits.	geologic unit
lithologic unit	Geologic unit defined by lithology independent of relationships	geologic unit

Term	Definition	Parent
	to other units. Denotes a \'kind\' of rock body characterized by lithology, e.g. basaltic rocks.	
lithostratigraphic unit	Geologic unit defined on the basis of observable and distinctive lithologic properties or combination of lithologic properties and stratigraphic relationships. Denotes a particular body of rock.	geologic unit
lithotectonic unit	Geologic unit defined defined on basis of structural or deformation features, mutual relations, origin or historical evolution. Contained material may be igneous, sedimentary, or metamorphic.	geologic unit
magnetostratigraphic unit	Geologic unit defined by magnetic characteristics.	geophysical unit
mass movement unit	Geologic unit produced by gravity driven, down-slope displacemnt of material, and characterized by the type of movement giving rise to the deposit, and by how the individual movement types present in the deposit are related in time and space.	lithogenetic unit
pedoderm	Geologic unit defined based on soil development and character. Pedoderm is not a surface classification unit because soil classification requires knowledge of the soil profile, which always extends some distance beneath the surface.	geologic unit
pedostratigraphic unit	Geologic unit that represents a single pedologic horizon in a sequence of strata (consolidated or non-consolidated). The presence of an overlying geologic unit is required, but locally the soil horizon may be at the Earth surface (in which case is may be coincident with a Pedoderm). See discussion at https://www.seegrid.csiro.au/twiki/bin/view/CGIModel/PedostratigraphicUnit	geologic unit
polarity chronostratigraphic unit	Geologic unit defined by primary magnetic-polarity record imposed whien the rock was deposited or crystallized during a specific interval of geolgoic time. Kind of chronostratigraphic unit and kind of geophysical unit.	geologic unit

Code list: GeomorphologicActivityTerm_Core

Term	Definition
inactive	A relict or fossil geomorphologic process
active	A geomorphologic process that is currently in a state of action, or that has been reactivated since a conventionally short period of time
dormant	A geomorphologic process that has not showed signs of activity since a conventionally short period of time, and that could be reactivated by their original

Term	Definition
	causes, or by triggered by induced causes (as anthropogenic activites).
reactivated	A reactivated geomorphologic process is an active geomorphologic process which has been dormant.
stabilised	A stabilised geomorphologic process is an inactive process which has been protected from its original causes by remedial measures (i.e. a stabilised landslide)

Code list: LithologyTerm_Core

Term	Definition	Parent
compound material	An Earth Material composed of an aggregation of particles of Earth Material, possibly including other Compound Materials. This is 'top' of lithology category hierarchy, and should be used to indicate 'any rock or unconsolidated material.	
igneous material	Earth material formed as a result of igneous processes, eg. intrusion and cooling of magma in the crust, volcanic eruption.	compound material
fragmental igneous material	igneous_material of unspecified consolidation state in which greater than 75 percent of the rock consists of fragments produced as a result of igneous rock-forming process.	igneous material
pyroclastic material	Fragmental igneous material that consists of more than 75 percent of particles formed by disruption as a direct result of volcanic action.	fragmental igneous material
tephra	Unconsolidated pyroclastic material in which greater than 75 percent of the fragments are deposited as a direct result of volcanic processes and the deposit has not been reworked by epiclastic processes. Includes ash, lapilli tephra, bomb tephra, block tephra and unconsolidated agglomerate.	pyroclastic material
ash and lapilli	Tephra in which less than 25 percent of fragments are greater than 64 mm in longest dimension.	tephra
ash breccia, bomb, or block tephra	Tephra in which more than 25 percent of particles are greater than 64 mm in largest dimension. Includes ash breccia, bomb tephra and block tephra of Gillespie and Styles (1999).	tephra
pyroclastic rock	Fragmental igneous rock that consists of greater than 75 percent fragments produced as a direct result of eruption or extrusion of magma from within the earth onto its surface. Includes autobreccia associated with lava flows and excludes deposits reworked by epiclastic processes.	pyroclastic material
ash tuff, lapillistone, and lapilli tuff	Pyroclastic rock in which less than 25 percent of rock by volume are more than 64 mm in longest diameter. Includes tuff, lapilli tuff, and lapillistone.	pyroclastic rock

Term	Definition	Parent
tuff-breccia, agglomerate, or pyroclastic breccia	Pyroclastic rock in which greater than 25 percent of particles are greater than 64 mm in largest dimension. Includes agglomerate, pyroclastic breccia of Gillespie and Styles (1999).	pyroclastic rock
igneous rock	rock formed as a result of igneous processes, for example intrusion and cooling of magma in the crust, or volcanic eruption.	igneous material
phaneritic igneous rock	Igneous rock in which the framework of the rock consists of individual crystals that can be discerned with the unaided eye. Bounding grain size is on the order of 32 to 100 microns. Igneous rocks with 'exotic' composition are excluded from this concept.	igneous rock
aplite	Light coloured crystalline rock, characterized by a fine grained allotriomorphic-granular (aplitic, saccharoidal or xenomorphic) texture; typically granitic composition, consisting of quartz, alkali feldspar and sodic plagioclase.	phaneritic igneous rock
pegmatite	Exceptionally coarse grained crystalline rock with interlocking crystals; most grains are 1cm or more diameter; composition is generally that of granite, but the term may refer to the coarse grained facies of any type of igneous rock;usually found as irregular dikes, lenses, or veins associated with plutons or batholiths.	phaneritic igneous rock
granitoid	Phaneritic crystalline igneous rock consisting of quartz, alkali feldspar and/or plagioclase. Includes rocks defined modally in QAPF fields 2, 3, 4 and 5 as alkali feldspar granite, granite, granodiorite or tonalite.	phaneritic igneous rock
granite	Phaneritic crystalline rock consisting of quartz, alkali feldspar and plagioclase (typically sodic) in variable amounts, usually with biotite and/or hornblende. Includes rocks defined modally in QAPF Field 3.	granitoid
monzogranite	Granite that has a plagiolcase to total feldspar ratio between 0.35 and 0.65. QAPF field 3b.	granite
syenogranite	Granite that has a plagiolcase to total feldspar ratio between 0.10 and 0.35. QAPF field 3a.	granite
tonalite	Granitoid consisting of quartz and intermediate plagioclase, usually with biotite and amphibole. Includes rocks defined modally in QAPF field 5; ratio of plagioclase to total feldspar is greater than 0.9.	granitoid
granodiorite	Phaneritic crystalline rock consisting essentially of quartz, sodic plagioclase and lesser amounts of alkali feldspar with minor hornblende and biotite. Includes rocks defined modally	granitoid

Term	Definition	Parent
	in QAPF field 4.	
dioritoid	Phaneritic crystalline igneous rock with M less than 90, consisting of intermediate plagioclase, commonly with hornblende and often with biotite or augite. Plagioclase to total feldspar ratio is greater that 0.65, and anorthite content of plagioclase is less than 50 percent. Less than 10 percent feldspathoid mineral and less than 20 percent quartz in the QAPF fraction. Includes rocks defined modally in QAPF fields 9 and 10 (and their subdivisions).	phaneritic igneous rock
dioritic rock	Phaneritic crystalline rock with M less than 90, consisting of intermediate plagioclase, commonly with hornblende and often with biotite or augite. A dioritoid with a plagioclase to total feldspar ratio (in the QAPF fraction) greater than 0.9. Includes rocks defined modally in QAPF fields 10, 10' and 10*.	dioritoid
quartz diorite	Dioritic rock that contains between 5 to 20 percent quartz in the QAPF fraction. QAPF field 10*.	dioritic rock
diorite	Phaneritic crystalline rock consisting of intermediate plagioclase, commonly with hornblende and often with biotite or augite; colour index M less than 90, sodic plagioclase (An0-An50), no feldspathoid, and between 0 and 5 percent quartz. Includes rocks defined modally in QAPF field 10 as diorite.	dioritic rock
monzodioritic rock	Phaneritic crystalline igneous rock consisting of sodic plagioclase (An0 to An50), alkali feldspar, hornblende and biotite, with or without pyroxene, and 0 to 10 percent feldspathoid or 0 to 20 percent quartz in the QAPF fraction. Plagioclase to total feldspar ratio in the QAPF fraction is between 0.65 and 0.9. Includes rocks defined modally in QAPF field 9, 9' and 9* as monzodiorite, foid-beaing monzodiorite, and quartz monzodiorite.	dioritoid
monzodiorite	Phaneritic crystalline igneous rock consisting of sodic plagioclase (An0 to An50), alkali feldspar, hornblende and biotite, with or without pyroxene, and 0 to 5 percent quartz. Includes rocks defined modally in QAPF field 9.	monzodioritic rock
gabbroid	Phaneritic crystalline igneous rock that contains less than 90 percent mafic minerals, and up to 20 percent quartz or up to 10 percent feldspathoid in the QAPF fraction. The ratio of plagioclase to total feldspar is greater than 0.65, and anorthite content of the plagioclase is greater than 50 percent. Includes rocks defined modally in QAPF fields 9 and 10 and their subdivisions.	phaneritic igneous rock
gabbroic rock	Gabbroid that has a plagioclase to total feldspar ratio greater than 0.9 in the QAPF fraction. Includes QAPF fields 10*, 10, and 10'. This category includes the various categories defined in LeMaitre et al. (2002) based on the mafic mineralogy, but	

Term	Definition	Parent
	apparently not subdivided based on the quartz/feldspathoid content.	
gabbro	Gabbroic rock that contains between 0 and 5 percent quartz and no feldspathoid mineral in the QAPF fraction. Includes rocks defined modally in QAPF Field 10 as gabbro.	gabbroic rock
monzogabbroic rock	Gabbroid with a plagioclase to total feldspar ratio between 0.65 and 0.9. QAPF field 9, 9' and 9*.	gabbroid
monzogabbro	Monzogabbroic rock that contains between 0 an 5 percent quartz and no feldspathoid mineral in the QAPF fraction. Includes rocks defined modally in QAPF field 9.	monzogabbroic rock
anorthositic rock	Leucocratic phaneritic crystalline igneous rock consisting essentially of plagioclase, often with small amounts of pyroxene. By definition, colour index M is less than 10, and plagiclase to total feldspar ratio is greater than 0.9. Less than 20 percent quartz and less than 10 percent feldspathoid in the QAPF fraction. QAPF field 10, 10*, and 10'.	phaneritic igneous rock
syenitoid	Phaneritic crystalline igneous rock with M less than 90, consisting mainly of alkali feldspar and plagioclase; minor quartz or nepheline may be present, along with pyroxene, amphibole or biotite. Ratio of plagioclase to total feldspar is less than 0.65, quartz forms less than 20 percent of QAPF fraction, and feldspathoid minerals form less than 10 percent of QAPF fraction. Includes rocks classified in QAPF fields 6, 7 and 8 and their subdivisions.	phaneritic igneous rock
syenitic rock	Syenitoid with a plagioclase to total feldspar ratio between 0.1 and 0.35. Includes rocks in QAPF fields 7, 7*, and 7'.	syenitoid
quartz syenite	Syenitic rock that contains between 5 and 20 percent quartz in the QAPF fraction. Defined modally in QAPF Field 7*.	syenitic rock
syenite	Syenitic rock that contains between 0 and 5 percent quartz and no feldspathoid mineral in the QAPF fraction. Defined modally in QAPF Field 7.	syenitic rock
foid bearing syenite	Syenitic rock that contains between 0 and 10 percent feldspathoid mineral and no quartz in the QAPF fraction. Defined modally in QAPF Field 7'.	syenitic rock
monzonitic rock	Syenitoid with a plagioclase to total feldspar ratio between 0.35 and 0.65. Includes rocks in QAPF fields 8, 8*, and 8'.	syenitoid
quartz monzonite	Monzonitic rock that contains 5-20 percent quartz iin the QAPF fraction. Includes rocks defined modally in QAPF Field 8*.	monzonitic rock
monzonite	Monzonitic rock that contains 0-5 percent quartz and no feldspathoid mineral in the QAPF fraction. Includes rocks	monzonitic rock

Term	Definition	Parent
	defined modally in QAPF Field 8.	
foid dioritoid	Phaneritic crystalline igneous rock in which M is less than 90, the plagioclase to total feldspar ratio is greater than 0.5, feldspathoid minerals form 10-60 percent of the QAPF fraction, plagioclase has anorthite content less than 50 percent. These rocks typically contain large amounts of mafic minerals. Includes rocks defined modally in QAPF fields 13 and 14.	phaneritic igneous rock
foid gabbroid	Phaneritic crystalline igneous rock in which M is less than 90, the plagioclase to total feldspar ratio is greater than 0.5, feldspathoids form 10-60 percent of the QAPF fraction, and plagioclase has anorthite content greater than 50 percent. These rocks typically contain large amounts of mafic minerals. Includes rocks defined modally in QAPF fields 13 and 14.	phaneritic igneous rock
foid syenitoid	Phaneritic crystalline igneous rock with M less than 90, contains between 10 and 60 percent feldspathoid mineral in the QAPF fraction, and has a plagioclase to total feldspar ratio less than 0.5. Includes QAPF fields 11 and 12.	phaneritic igneous rock
foidolite	Phaneritic crystalline rock containing more than 60 percent feldspathoid minerals in the QAPF fraction. Includes rocks defined modally in QAPF field 15.	phaneritic igneous rock
fine grained igneous rock	Igneous rock in which the framework of the rock consists of crystals that are too small to determine mineralogy with the unaided eye; framework may include up to 50 percent glass. A significant percentage of the rock by volume may be phenocrysts. Includes rocks that are generally called volcanic rocks.	igneous rock
rhyolitoid	fine_grained_igneous_rock consisting of quartz and alkali feldspar, with minor plagioclase and biotite, in a microcrystalline, cryptocrystalline or glassy groundmass. Flow texture is common. Includes rocks defined modally in QAPF fields 2 and 3 or chemically in TAS Field R as rhyolite. QAPF normative definition is based on modal mineralogy thus: less than 90 percent mafic minerals, between 20 and 60 percent quartz in the QAPF fraction, and ratio of plagioclse to total feldspar is less than 0.65.	fine grained igneous rock
rhyolite	rhyolitoid in which the ratio of plagioclase to total feldspar is between 0.1 and 0.65.	rhyolitoid
alkali feldspar rhyolite	Rhyolitoid in which the ratio of plagioclase to total feldspar is less than 0.1. QAPF field 2.	rhyolitoid
dacite	Fine grained or porphyritic crystalline rock that contains less than 90 percent mafic minerals, between 20 and 60 percent quartz in the QAPF fraction, and has a plagioclase to total feldspar ratio greater than 0.65. Includes rocks defined	fine grained igneous rock

Term	Definition	Parent
	modally in QAPF fields 4 and 5 or chemically in TAS Field O3. Typcially composed of quartz and sodic plagioclase with minor amounts of biotite and/or hornblende and/or pyroxene; fine-grained equivalent of granodiorite and tonalite.	
trachytoid	Fine grained igneous rock than contains less than 90 percent mafic minerals, less than 10 percent feldspathoid mineral and less than 20 percent quartz in the QAPF fraction and has a plagioclase to total feldspar ratio less than 0.65. Mafic minerals typically include amphibole or mica; typically porphyritic. Includes rocks defined modally in QAPF fields 6, 7 and 8 (with subdivisions) or chemically in TAS Field T as trachyte or latite.	fine grained igneous rock
trachytic rock	Trachytoid that has a plagioclase to total feldspar ratio between 0.1 and 0.35. QAPF fields 7, 7', and 7*.	trachytoid
trachyte	Trachytoid that has a plagioclase to total feldspar ratio between 0.1 and 0.35, between 0 and 5 percent quartz in the QAPF fraction, and no feldspathoid minerals. QAPF field 7.	trachytic rock
latitic rock	Trachytoid that has a plagioclase to total feldspar ratio between 0.35 and 0.65. QAPF fields 8, 8' and 8*.	trachytoid
latite	Latitic rock that contains between 0 and 5 percent quartz and no feldspathoid in the QAPF fraction. QAPF field 8.	latitic rock
andesite	Fine-grained igneous rock with less than 20 percent quartz and less than 10 percent feldspathoid minerals in the QAPF fraction, in which the ratio of plagioclase to total feldspar is greater 0.65. Includes rocks defined modally in QAPF fields 9 and 10 or chemically in TAS field O2 as andesite. Basalt and andesite, which share the same QAPF fields, are distinguished chemically based on silica content, with basalt defined to contain less than 52 weight percent silica. If chemical data are not available, the color index is used to distinguish the categories, with basalt defined to contain greater than 35 percent mafic minerals by volume or greater than 40 percent mafic minerals by weight. Typically consists of plagioclase (frequently zoned from labradorite to oligoclase), pyroxene, hornblende and/or biotite. Fine grained equivalent of dioritic rock.	fine grained igneous rock
boninite	andesitic rock that contains more than 8 percent MgO. Typically consists of phenocrysts of protoenstatite, orthopyroxene, clinopyroxene, and olivine in a glassy base full of crystallites, and exhibits textures characterisitc of rapid crystal growth.	andesite
basalt	Fine-grained or porphyritic igneous rock with less than 20 percent quartz, and less than 10 percent feldspathoid minerals, in which the ratio of plagioclase to total feldspar is greater	fine grained igneous rock

Term	Definition	Parent
	0.65. Typically composed of calcic plagioclase and clinopyroxene; phenocrysts typically include one or more of calcic plagioclase, clinopyroxene, orthopyroxene, and olivine. Includes rocks defined modally in QAPF fields 9 and 10 or chemically in TAS field B as basalt. Basalt and andesite are distinguished chemically based on silica content, with basalt defined to contain less than 52 weight percent silica. If chemical data are not available, the color index is used to distinguish the categories, with basalt defined to contain greater than 35 percent mafic minerals by volume or greater than 40 percent mafic minerals by weight.	
alkali olivine basalt	Alkali olivine basalt is silica-undersaturated, characterized by the absence of orthopyroxene, absence of quartz, presence of olivine, and typically contains some feldspathoid mineral, alkali feldspar or phlogopite in the groundmass. Feldspar phenocrysts typically are labradorite to andesine in composition. Augite is rich in titanium compared to augite in tholeiitic basalt. Alkali olivine basalt is relatively rich in sodium.	basalt
tholeiitic basalt	Tholeiitic basalt is defined here to contain 2 pyroxene phases and interstitial quartz or tridymite or cristobalite in the groundmass. Pyroxene (augite and orthopyroxene or pigeonite) and calcium-rich plagioclase are common phenocryst minerals. Olivine may also be a phenocryst, and when present, may have rims of pigeonite. Only in tholeiitic basalt is olivine in reaction relationship with melt. Interstitial siliceous residue may be present, and is often glassy. Tholeiitic basalt is relatively poor in sodium. This category includes most basalts of the ocean floor, most large oceanic islands, and continental flood basalts such as the Columbia River Plateau.	basalt
phonolitoid	Fine grained igneous rock than contains less than 90 percent mafic minerals, between 10 and 60 percent feldspathoid mineral in the QAPF fraction and has a plagioclase to total feldspar ratio less than 0.5. Includes rocks defined modally in QAPF fields 11 and 12, and TAS field Ph.	fine grained igneous rock
phonolite	Phonolitoid in which the plagioclase to total feldspar ratio is less than 0.1. Rock consists of alkali feldspar, feldspathoid minerals, and mafic minerals.	phonolitoid
tephritoid	Fine grained igneous rock than contains less than 90 percent mafic minerals, between 10 and 60 percent feldspathoid mineral in the QAPF fraction and has a plagioclase to total feldspar ratio greater than 0.5. Includes rocks classified in QAPF field 13 and 14 or chemically in TAS field U1 as basanite or tephrite.	fine grained igneous rock

Term	Definition	Parent
tephrite	Tephritoid that has a plagioclase to total feldspar ratio greater than 0.9, and contains less than 10 percent normative (CIPW) olivine.	tephritoid
basanite	Tephritoid that has a plagioclase to total feldspar ratio greater than 0.9, and contains more than 10 percent normative (CIPW) olivine.	tephritoid
foiditoid	Fine grained crystalline rock containing less than 90 percent mafic minerals and more than 60 percent feldspathoid minerals in the QAPF fraction. Includes rocks defined modally in QAPF field 15 or chemically in TAS field F.	fine grained igneous rock
foidite	Foiditoid that contains greater than 90 percent feldspathoid minerals in the QAPF fraction.	foiditoid
ultramafic igneous rock	Igneous rock that consists of greater than 90 percent mafic minerals.	igneous rock
peridotite	Ultramafic rock consisting of more than 40 percent (by volume) olivine with pyroxene and/or amphibole and little or no feldspar. Commonly altered to serpentinite. Includes rocks defined modally in the ultramafic rock classification as dunite, harzburgite, lherzolite, wehrlite, olivinite, pyroxene peridotite, pyroxene hornblende peridotite or hornblende peridotite.	
pyroxenite	Ultramafic phaneritic igneous rock composed almost entirely of one or more pyroxenes and occasionally biotite, hornblende and olivine. Includes rocks defined modally in the ultramafic rock classification as olivine pyroxenite, olivine-hornblende pyroxenite, pyroxenite, orthopyroxenite, clinopyroxenite and websterite.	
komatiitic rock	Ultramafic, magnesium-rich volcanic rock, typically with spinifex texture of intergrown skeletal and bladed olivine and pyroxene crystals set in abundant glass. Includes komatiite and meimechite.	
exotic composition igneous rock	Rock with 'exotic' mineralogical, textural or field setting characteristics; typically dark colored, with abundant phenocrysts. Criteria include: presence of greater than 10 percent melilite or leucite, or presence of kalsilite, or greater than 50 percent carbonate minerals. Includes Carbonatite, Melilitic rock, Kalsilitic rocks, Kimberlite, Lamproite, Leucitic rock and Lamprophyres.	igneous rock
carbonatite	Igneous rock composed of more than 50 percent modal carbonate minerals.	exotic composition igneous rock
kalsilitic and melilitic	Igneous rock containing greater than 10 percent melilite or kalsilite. Typically undersaturated, ultrapotassic (kalsilitic	exotic composition

Term	Definition	Parent
rocks	rocks) or calcium-rich (melilitic rocks) mafic or ultramafic rocks.	igneous rock
exotic alkaline rock	Kimberlite, lamproite, or lamprophyre. Generally are potassic, mafic or ultramafic rocks. Olivine (commonly serpentinized in kimberlite), and phlogopite are significant constituents.	exotic composition igneous rock
porphyry	Igneous rock that contains conspicuous phenocrysts in a finer grained groundmass; groundmass itself may be phaneritic or fine-grained.	igneous rock
doleritic rock	Dark colored gabbroic (basaltic) or dioritic (andesitic) rock intermediate in grain size between basalt and gabbro and composed of plagioclase, pyroxene and opaque minerals; often with ophitic texture. Typically occurs as hypabyssal intrusions. Includes dolerite, microdiorite, diabase and microgabbro.	igneous rock
sedimentary material	Material formed by accumulation of solid fragmental material deposited by air, water or ice, or material that accumulated by other natural agents such as chemical precipitation from solution or secretion by organisms. Includes both sediment and sedimentary rock. Includes epiclastic deposits. All stated composition criteria are based on the mineral/ compound material (GeoSciML term)/particulate fraction of the material, irrespective of porosity or the pore-fluid. No distinctions are made based on porosity or pore fluid composition (except organic rich sediment in which liquid hydrocarbon content may be considered)	compound material
sediment	Unconsolidated material consisting of an aggregation of particles transported or deposited by air, water or ice, or that accumulated by other natural agents, such as chemical precipitation, and that forms in layers on the Earth's surface. Includes epiclastic deposits.	sedimentary material
clastic sediment	Sediment in which at least 50 percent of the constituent particles were derived from erosion, weathering, or mass-wasting of pre-existing earth materials, and transported to the place of deposition by mechanical agents such as water, wind, ice and gravity.	sediment
diamicton	Unsorted or poorly sorted, clastic sediment with a wide range of particle sizes, including a muddy matrix. Biogenic materials that have such texture are excluded. Distinguished from conglomerate, sandstone, mudstone based on polymodality and lack of structures related to transport and deposition of sediment by moving air or water. Assignment to an other size class can be used in conjunction to indicate the dominant grain size.	clastic sediment
gravel	Clastic sediment containing greater than 30 percent gravel-size particles (greater than 2.0 mm diameter). Gravel in which	clastic sediment

Term	Definition	Parent
	more than half of the particles are of epiclastic origin.	
sand	Clastic sediment in which less than 30 percent of particles are gravel (greater than 2 mm in diameter) and the sand to mud ratio is at least 1. More than half of the particles are of epiclastic origin.	clastic sediment
mud	Clastic sediment consisting of less than 30 percent gravel-size (2 mm) particles and with a mud-size to sand-size particle ratio greater than 1. More than half of the particles are of epiclastic origin.	clastic sediment
clay	Mud that consists of greater than 50 percent particles with grain size less than 0.004 mm.	mud
silt	Mud that consists of greater than 50 percent silt-size grains.	mud
carbonate sediment	Sediment in which at least 50 percent of the primary and/or recrystallized constituents are composed of one (or more) of the carbonate minerals calcite, aragonite and dolomite, in particles of intrabasinal origin.	
impure carbonate sediment	Carbonate sediment in which between 50 and 90 percent of the constituents are composed of one (or more) of the carbonate minerals in particles of intrabasinal origin.	carbonate sediment
biogenic sediment	Sediment composed of greater than 50 percent material of biogenic origin. Because the biogenic material may be skeletal remains that are not organic, all biogenic sediment is not necessarily organic-rich.	sediment
organic rich sediment	Sediment with color, composition, texture and apparent density indicating greater than 50 percent organic content by weight on a moisture-free basis.	biogenic sediment
peat	Unconsolidated organic-rich sediment composed of at least 50 percent semi-carbonised plant remains; individual remains commonly seen with unaided eye; yellowish brown to brownish black; generally fibrous texture; can be plastic or friable. In its natural state it can be readily cut and has a very high moisture content, generally greater than 90 percent. Liptinite to Inertinite ratio is less than one (Economic Commission for Europe, Committee on Sustainable Energy- United Nations (ECE-UN), 1998, International Classification of in-Seam Coals: Energy 19, 41 pp.).	organic rich sediment
sapropel	Jelly like organic rich sediment composed of plant remains, usually algal. Liptinite to Inertinite ratio is greater than one (Economic Commission for Europe, Committee on Sustainable Energy- United Nations (ECE-UN), 1998, International Classification of in-Seam Coals: Energy 19, 41 pp.).	organic rich sediment

Term	Definition	Parent
ooze	Biogenic sediment consisting of less than 1 percent gravel-size (greater than or equal to 2 mm) particles, with a sand to mud ratio less than 1 to 9, and less than 50 percent carbonate minerals.	biogenic sediment
carbonate ooze	ooze that consists of more than 50 percent carbonate skeletal remains.	ooze
siliceous ooze	ooze that consists of more than 50 percent siliceous skeletal remains.	ooze
sedimentary rock	Rock formed by accumulation and cementation of solid fragmental material deposited by air, water or ice, or as a result of other natural agents, such as precipitation from solution, the accumulation of organic material, or from biogenic processes, including secretion by organisms. Includes epiclastic deposits.	sedimentary material
clastic sedimentary rock	Sedimentary rock in which at least 50 percent of the constituent particles were derived from erosion, weathering, or mass-wasting of pre-existing earth materials, and transported to the place of deposition by mechanical agents such as water, wind, ice and gravity.	sedimentary rock
diamictite	Unsorted or poorly sorted, clastic sedimentary rock with a wide range of particle sizes including a muddy matrix. Biogenic materials that have such texture are excluded. Distinguished from conglomerate, sandstone, mudstone based on polymodality and lack of structures related to transport and deposition of sediment by moving air or water. If more than 10 percent of the fine grained matrix is of indeterminant clastic or diagenetic origin and the fabric is matrix supported, may also be categorized as wacke.	clastic sedimentary rock
conglomerate	Clastic sedimentary rock composed of at least 30 percent rounded to subangular fragments larger than 2 mm in diameter; typically contains finer grained material in interstices between larger fragments. If more than 15 percent of the fine grained matrix is of indeterminant clastic or diagenetic origin and the fabric is matrix supported, may also be categorized as wackestone. If rock has unsorted or poorly sorted texture with a wide range of particle sizes, may also be categorized as diamictite.	clastic sedimentary rock
sandstone	Clastic sedimentary rock in which less than 30 percent of particles are greater than 2 mm in diameter (gravel) and the sand to mud ratio is at least 1.	clastic sedimentary rock
arenite	Clastic sandstone that contains less than 10 percent matrix. Matrix is mud-size silicate minerals (clay, feldspar, quartz, rock fragments, and alteration products) of detrital or	sandstone

Term	Definition	Parent
	diagenetic nature.	
wacke	Clastic sandstone with more than 10 percent matrix of indeterminate detrital or diagenetic nature. Matrix is mud size silicate minerals (clay, feldspar, quartz, rock fragments, and alteration products)	sandstone
mudstone	Clastic sedimentary rock consisting of less than 30 percent gravel-size (2 mm) particles and with a mud to sand ratio greater than 1.	clastic sedimentary rock
claystone	Mudstone that contains no detectable silt, inferred to consist virtually entirely of clay-size particles.	mudstone
siltstone	Mudstone that contains detectable silt.	mudstone
shale	Laminated mudstone that will part or break along thin, closely spaced layers parallel to stratification.	mudstone
organic rich sedimentary rock	Sedimentary rock with color, composition, texture and apparent density indicating greater than 50 percent organic content by weight on a moisture-free basis.	sedimentary rock
coal	A consolidated organic sedimentary material having less than 75% moisture. This category includes low, medium, and high rank coals according to International Classification of In-Seam Coal (United Nations, 1998), thus including lignite. Sapropelic coal is not distinguished in this category from humic coals. Formed from the compaction or induration of variously altered plant remains similar to those of peaty deposits.	organic rich sedimentary rock
lignite	Coal that has a gross calorific value less than 24 MJ/kg (determined in conformance with ISO 1928), and vitrinite mean random reflectance less than 0.6% (determined in conformance with ISO 7404-5). Gross calorific value is recalculated to a moist, ash free basis using bed moisture (determined according to ISO 1015 or ISO 5068). Includes all low-rank coals, including sub-bitiminous coal. A consolidated, dull, soft brown to black coal having many readily discernible plant fragments set in a finer grained organic matrix. Tends to crack and fall apart on drying. Operationally sub-bituminous and bitiminous coal are qualitatively distinguished based on brown streak for sub-bitiminous coal and black streak for bituminous coal.	coal
bituminous coal	Coal that has vitrinite mean random reflectance greater than 0.6% and less than 2.0% (determined in conformance with ISO 7404-5), or has a gross calorific value greater than 24 MJ/kg (determined in conformance with ISO 1928). Hard, black, organic rich sedimentary rock; contains less than 91 percent fixed carbon on a dry, mineral-matter-free basis, and greater than 13-14 percent volatiles (dry, ash free). Formed from the	coal

Term	Definition	Parent
	compaction or induration of variously altered plant remains similar to those of peaty deposits.	
anthracite	Coal that has vitrinite mean random reflectance greater than 2.0% (determined in conformance with ISO 7404-5). Less than 12-14 percent volatiles (dry, ash free), greater than 91 percent fixed carbon (dry, ash free basis). The highest rank coal; very hard, glossy, black, with semimetallic luster, semi conchoidal fracture.	coal
carbonate sedimentary rock	Sedimentary rock in which at least 50 percent of the primary and/or recrystallized constituents are composed of one (or more) of the carbonate minerals calcite, aragonite, magnesite or dolomite.	sedimentary rock
pure carbonate sedimentary rock	Sedimentary rock in which greater than 90 percent of the primary and/or recrystallized constituents are carbonate minerals.	
dolomitic or magnesian sedimentary rock	Carbonate sedimentary rock with a ratio of magnesium carbonate to calcite (plus aragonite) greater than 1 to 1. Includes dolostone, lime dolostone and magnesite-stone.	pure carbonate sedimentary rock
dolomite	Pure carbonate sedimentary rock with a ratio of magnesium carbonate to calcite (plus aragonite) greater than 1 to 1.	dolomitic or magnesian sedimentary rock
limestone	Pure carbonate sedimentary rock with a calcite (plus aragonite) to dolomite ratio greater than 1 to 1. Includes limestone and dolomitic limestone.	pure carbonate sedimentary rock
chalk	A generally soft, white, very fine-grained, extremely pure, porous limestone. It forms under marine conditions from the gradual accumulation of skeletal elements from minute planktonic green algae (cocoliths), associated with varying proportions of larger microscopic fragments of bivalves, foraminifera and ostracods. It is common to find flint and chert nodules embedded in chalk.	limestone
travertine	Biotically or abiotically precipitated calcium carbonate, from spring-fed, heated, or ambient-temperature water. May be white and spongy, various shades of orange, tan or gray, and ranges to dense, banded or laminated rock. Macrophytes, bryophytes, algae, cyanobacteria and other organisms often colonize the surface of travertine and may be preserved, to produce the porous varieties.	limestone
impure carbonate sedimentary rock	Sedimentary rock in which between 50 and 90 percent of the primary and/or recrystallized constituents are composed of carbonate minerals.	carbonate sedimentary rock

Term	Definition	Parent
impure limestone	Impure carbonate sedimentary rock with a calcite (plus aragonite) to dolomite ratio greater than 1 to 1.	impure carbonate sedimentary rock
impure dolomite	Impure carbonate sedimentary rock with a ratio of magnesium carbonate to calcite (plus aragonite) greater than 1 to 1.	impure carbonate sedimentary rock
non-clastic siliceous sedimentary rock	Sedimentary rock that consists of at least 50 percent silicate mineral material, deposited directly by chemical or biological processes at the depositional surface, or in particles formed by chemical or biological processes within the basin of deposition.	sedimentary rock
biogenic silica sedimentary rock	Sedimentary rock that consists of at least 50 percent silicate mineral material, deposited directly by biological processes at the depositional surface, or in particles formed by biological processes within the basin of deposition.	non-clastic siliceous sedimentary rock
iron rich sedimentary rock	Sedimentary rock that consists of at least 50 percent iron-bearing minerals (hematite, magnetite, limonite-group, siderite, iron-sulfides), as determined by hand-lens or petrographic analysis. Corresponds to a rock typically containing 15 percent iron by weight.	sedimentary rock
generic mudstone	Sedimentary rock consisting of less than 30 percent gravel-size (2 mm) particles and with a mud to sand ratio greater than 1. Clasts may be of any composition or origin.	
organic bearing mudstone	Mudstone that contains a significant amount of organic carbon, typically kerogen. Commonly finely laminated, brown or black in color.	
chemical sedimentary material	Sedimentary material that consists of at least 50 percent material produced by inorganic chemical processes within the basin of deposition. Includes inorganic siliceous, carbonate, evaporite, iron-rich, and phosphatic sediment classes.	sedimentary material
evaporite	Nonclastic sedimentary rock composed of at least 50 percent non-carbonate salts, including chloride, sulfate or borate minerals; formed through precipitation of mineral salts from a saline solution (non-carbonate salt rock).	chemical sedimentary material
rock salt	Evaporite composed of at least 50 percent halite.	evaporite
gypsum or anhydrite	Evaporite composed of at least 50 percent gypsum or anhydrite.	evaporite
composite genesis material	Material of unspecified consolidation state formed by geological modification of pre-existing materials outside the realm of igneous and sedimentary processes. Includes rocks formed by impact metamorphism, standard dynamothermal metamorphism, brittle deformation, weathering, metasomatism and hydrothermal alteration (diagenesis is a sedimentary	compound material

Term	Definition	Parent
	process in this context).	
composite genesis rock	Rock formed by geological modification of pre-existing rocks outside the realm of igneous and sedimentary processes. Includes rocks formed by impact metamorphism, standard dynamothermal metamorphism, brittle deformation, weathering, metasomatism and hydrothermal alteration (diagenesis is a sedimentary process in this context).	composite genesis material
metamorphic rock	Rock formed by solid-state mineralogical, chemical and/or structural changes to a pre-existing rock, in response to marked changes in temperature, pressure, shearing stress and chemical environment.	composite genesis rock
foliated metamorphic rock	Metamorphic rock in which 10 percent or more of the contained mineral grains are elements in a planar or linear fabric. Cataclastic or glassy character precludes classification with this concept.	metamorphic rock
gneiss	Foliated metamorphic rock with bands or lenticles rich in granular minerals alternating with bands or lenticles rich in minerals with a flaky or elongate prismatic habit. Mylonitic foliation or well developed, continuous schistosity (greater than 50 percent of the rock consists of grains participate in a planar or linear fabric) precludes classification with this concept.	foliated metamorphic rock
orthogneiss	A gneiss with mineralogy and texture indicating derivation from a phaneritic igneous rock protolith. Typically consists of abundant feldspar, with quartz, and variable hornblende, biotite, and muscovite, with a relatively homogeneous character.	gneiss
paragneiss	A gneiss with mineralogy and texture indicating derivation from a sedimentary rock protolith. Typically consists of abundant quartz, mica, or calcsilicate minerals; aluminosilicate minerals or garnet commonly present. Composition of rock tends to be more variable on a decimetric scale that in orthogneiss.	gneiss
phyllite	Rock with a well developed, continuous schistosity, an average grain size between 0.1 and 0.5 millimeters, and a silvery sheen on cleavage surfaces. Individual phyllosilicate grains are barely visible with the unaided eye.	foliated metamorphic rock
slate	Compact, fine grained rock with an average grain size less than 0.032 millimeter and a well developed schistosity (slaty cleavage), and hence can be split into slabs or thin plates.	foliated metamorphic rock
schist	Foliated phaneritic metamorphic rock with well developed, continuous schistosity, meaning that greater than 50 percent of the rock by volume is mineral grains with a thin tabular, lamellar, or acicular prismatic crystallographic habit that are	foliated metamorphic rock

Term	Definition	Parent
	oriented in a continuous planar or linear fabric.	
mica schist	A schist that consists of more than 50 percent mica minerals, typically muscovite or biotite. Special type included to distinguish this common variety of schist.	schist
chlorite actinolite epidote metamorphic rock	Metamorphic rock characterized by 50 percent or more of combined chlorite, actinolite and epidote. Category for rocks generally named greenschist or greenstone.	metamorphic rock
glaucophane lawsonite epidote metamorphic rock	A metamorphic rock of roughly basaltic composition, defined by the presence of glaucophane with lawsonite or epidote. Other minerals that may be present include jadeite, albite, chlorite, garnet, and muscovite (phengitic white mica). Typically fine-grained, dark colored. Category for rocks commonly referred to as blueschist.	metamorphic rock
serpentinite	Rock consisting of more than 75 percent serpentine-group minerals, eg. antigorite, chrysotile or lizardite; accessory chlorite, talc and magnetite may be present; derived from hydration of ferromagnesian silicate minerals such as olivine and pyroxene.	metamorphic rock
quartzite	Metamorphic rock consisting of greater than or equal to 75 percent quartz; typically granoblastic texture.	metamorphic rock
amphibolite	Metamorphic rock mainly consisting of green, brown or black amphibole and plagioclase (including albite), which combined form 75 percent or more of the rock, and both of which are present as major constituents. The amphibole constitutes 50 percent or more of the total mafic constituents and is present in an amount of 30 percent or more; other common minerals include quartz, clinopyroxene, garnet, epidote-group minerals, biotite, titanite and scapolite.	metamorphic rock
marble	Metamorphic rock consisting of greater than 75 percent fine- to coarse-grained recrystallized calcite and/or dolomite; usually with a granoblastic, saccharoidal texture.	metamorphic rock
granulite	Metamorphic rock of high metamorphic grade in which Fe-Mg silicate minerals are dominantly hydroxl-free; feldspar must be present, and muscovite is absent; rock contains less than 90 percent mafic minerals, less than 75 percent calcite and/or dolomite, less than 75 percent quartz, less than 50 percent iron-bearing minerals (hematite, magnetite, limonite-group, siderite, iron-sulfides), and less than 50 percent calc-silicate minerals.	metamorphic rock
eclogite	Metamorphic rock composed of 75 percent or more (by volume) omphacite and garnet, both of which are present as major constituents, the amount of neither of them being higher than 75 percent (by volume); the presence of plagioclase	metamorphic rock

Term	Definition	Parent
	precludes classification as an eclogite.	
migmatite	Silicate metamorphic rock that is pervasively heterogeneous on a decimeter to meter scale that typically consists of darker and lighter parts; the darker parts usually exhibit features of metamorphic rocks whereas the lighter parts are of igneous-looking appearance.	metamorphic rock
granofels	Metamorphic rock with granoblastic fabric and very little or no foliation (less than 10 percent of the mineral grains in the rock are elements in a planar or linear fabric). Grainsize not specified.	metamorphic rock
hornfels	Granofels formed by contact metamorphism, composed of a mosaic of equidimensional grains in a characteristically granoblastic or decussate matrix; porphyroblasts or relict phenocrysts may be present. Typically fine grained.	granofels
metasomatic rock	Rock that has fabric and composition indicating open-system mineralogical and chemical changes in response to interaction with a fluid phase, typically water rich.	composite genesis rock
skarn	Metasomatic rock consisting mainly of Ca-, Mg-, Fe-, or Mn-silicate minerals, which are free from or poor in water. Typically formed at the contact between a silicate rock or magma and a carbonate rock.	metasomatic rock
spilite	Altered basic to intermediate composition fine-grained igneous rock in which the feldspar is partially or completely composed of of albite, typically accompanied by chlorite, calcite, quartz, epidote, prehnite, and low-tempaerature hydrous crystallization products. Preservation of eruptive volcanic features is typical.	metasomatic rock
material formed in surficial environment	Material that is the product of weathering processes operating on pre-existing rocks or deposits, analogous to hydrothermal or metasomatic rocks, but formed at ambient Earth surface temperature and pressure.	composite genesis material
bauxite	Highly aluminous material containing abundant aluminium hydroxides (gibbsite, less commonly boehmite, diaspore) and aluminium-substituted iron oxides or hydroxides and generally minor or negligible kaolin minerals; may contain up to 20 percent quartz. Commonly has a pisolitic or nodular texture, and may be cemented.	material formed in surficial environment
duricrust	Rock forming a hard crust or layer at or near the Earth's surface at the time of formation, e.g. in the upper horizons of a soil, characterized by structures indicative of pedogenic origin.	material formed in surficial environment
residual material	Material of composite origin resulting from weathering processes at the Earth's surface, with genesis dominated by removal of chemical constituents by aqueous leaching. Miinor	material formed in surficial

Term	Definition	Parent
	clastic, chemical, or organic input may also contribute. Consolidation state is not inherent in definition, but typically material is unconsolidated or weakly consolidated.	environment
fault-related material	Material formed as a result brittle faulting, composed of greater than 10 percent matrix; matrix is fine-grained material caused by tectonic grainsize reduction. Includes cohesive (cataclasite series) and non-cohesive (breccia-gouge series) material.	composite genesis material
mylonitic rock	Metamorphic rock characterised by a foliation resulting from tectonic grain size reduction, in which more than 10 percent of the rock volume has undergone grain size reduction. Includes protomylonite, mylonite, ultramylonite, and blastomylonite.	fault-related material
impact generated material	Material that contains features indicative of shock metamorphism, such as microscopic planar deformation features within grains or shatter cones, interpreted to be the result of extraterrestrial bolide impact. Includes breccias and melt rocks.	composite genesis material
breccia	Coarse-grained material composed of angular broken rock fragments; the fragments typically have sharp edges and unworn corners. The fragments may be held together by a mineral cement or in a fine-grained matrix, and consolidated or nonconsolidated. Clasts may be of any composition or origin. In sedimentary environments, breccia is used for material that consists entirely of angular fragments, mostly derived from a single source rock body, as in a rock avalanche deposit, and matrix is interpreted to be the product of comminution of clasts during transport. Diamictite or diamicton is used when the material reflects mixing of rock from a variety of sources, some sub angular or subrounded clasts may be present, and matrix is pre-existing fine grained material that is not a direct product of the brecciation/deposition process.	compound material
tuffite	Rock consists of more than 50 percent particles of indeterminate pyroclastic or epiclastic origin and less than 75 percent particles of clearly pyroclastic origin. Commonly the rock is laminated or exhibits size grading. (based on LeMaitre et al. 2002; Murawski and Meyer 1998).	compound material
anthropogenic material	Material known to have artificial (human-related) origin	compound material
building rubble	Material of various size originating from broken down buildings or former road coatings	
slag	by-product of smelting ore and processing metals	
mine dump material	spoil, overburden and other material excavated in mining	

Term	Definition	Parent
soil improver	material added to soil to improve plant growth and health	
anthropogenic consolidated material	Consolidated material known to have artificial (human-related) origin.	anthropogenic material
concrete	hardening composite construction material composed primarily of coarse gravel, cement and water	
bitumen	a composite material composed primarily of bitumen and mineral aggregates, e.g. gravel	
waste	disposed, non-liquid by-products of any kind, e.g. domestic or industrial waste	
sludge	more or less liquid (when disposed) by-products of industrial processes	
sewage sludge	more or less liquid (when disposed) by-products of wastewater treatment	

Code list: NaturalGeomorphologicFeatureTypeTerm_Core

Term	Definition
geomorphologic feature	A point, linear or areal landform or landscape. It is a natural or anthropogenic surface feature and may be erosional, depositional or both.
erosion surface	A land surface shaped by the action of erosion, especially by running water.
hill	A generic term for an elevated area of the land surface, rising at least 30 metres to as much as 300 metres above surrounding lowlands, usually with a nominal summit area relative to bounding slopes, a well-defined, rounded outline and slopes that generally exceed 15 percent. A hill can occur as a single, isolated mass or in a group. A hill can be further specified based on the magnitude of local relief: low hill (30 – 90 m) or high hill (90 - 300 m). Informal distinctions between a hill and a mountain are often arbitrary and dependent on local convention.
interfluve	A geomorphologic component of hills consisting of the uppermost, comparatively level or gently sloped area of a hill; shoulders of backwearing hillslopes can narrow the upland (e.g., ridge) or merge (e.g., crest, saddle) resulting in a strongly convex shape.
crest	A geomorphologic component of hills consisting of the convex slopes (perpendicular to the contour) that form the narrow, roughly linear top area of a hill, ridge, or other upland where shoulders have converged to the extent that little or no summit remains; dominated by erosion, slope wash and mass movement processes and sediments (e.g., slope alluvium, creep). Commonly, soils on crests are more similar to those on side slopes than to soils on adjacent interfluves.
head slope	A geomorphologic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway, resulting in converging overland water flow (e.g. heet wash); head slopes are dominated by colluvium and slope

Term	Definition
	wash sediments (e.g., slope alluvium); contour lines form concave curves. Slope complexity (downslope shape) can range from simple to complex. Headslopes are comparatively moister portions of hillslopes and tend to accumulate sediments (e.g., cumulic profiles) where they are not directly contributing materials to channel flow.
side slope	A geomorphologic component of hills consisting of a laterally planar area of a hillside, resulting in predominantly parallel overland water flow (e.g., sheet wash); contour lines generally form straight lines. Side slopes are dominated by colluvium and slope wash sediments. Slope complexity (downslope shape) can range from simple to complex. ; the slope bounding a drainageway and lying between the drainageway and the adjacent interfluve. It is generally linear along the slope width.
nose slope	A geomorphologic component of hills consisting of the projecting end (laterally convex area) of a hillside, resulting in predominantly divergent overland water flow (e.g., sheet wash); contour lines generally form convex curves. Nose slopes are dominated by colluvium and slope wash sediments (e.g., slope alluvium). Slope complexity (downslope shape) can range from simple to complex. Nose slopes are comparatively drier portions of hillslopes and tend to have thinner colluvial sediments and profiles.
free face	A geomorphologic component of hills and mountains consisting of an outcrop of bare rock that sheds rock fragments and other sediments to, and commonly stands more steeply than the angle of repose of, the colluvial slope immediately below; most commonly found on shoulder and backslope positions, and can comprise part or all of a nose slope or side slope.
base slope	A geomorphologic component of hills consisting of the concave to linear slope (perpendicular to the contour) which, regardless of the lateral shape is an area that forms an apron or wedge at the bottom of a hillside dominated by colluvial and slope wash processes and sediments (e.g., colluvium and slope alluvium). Distal base slope sediments commonly grade to, or interfinger with, alluvial fills, or gradually thin to form pedisediment over residuum.
mountain	A generic term for an elevated area of the land surface, rising more than 300 metres above surrounding lowlands, usually with a nominal summit area relative to bounding slopes and generally with steep sides (greater than 25 percent slope) with or without considerable bare-rock exposed. A mountain can occur as a single, isolated mass or in a group forming a chain or range. Mountains are primarily formed by tectonic activity and/or volcanic action and secondarily by differential erosion.
natural geomorphologic feature	A geomorphologic feature produced by the natural dynamics
mountaintop	A geomorphologic component of mountains consisting of the uppermost, comparatively level or gently sloped area of mountains, characterized by relatively short, simple slopes composed of bare rock, residuum, or short-transport colluvial sediments. In humid environments, mountaintop soils can be quite thick and well developed.

Term	Definition
mountainslope	A part of a mountain between the summit and the foot.
mountainflank	A geomorphologic component of mountains characterized by very long, complex backslopes with comparatively high slope gradients and composed of highly-diverse colluvial sediment mantles, rock outcrops or structural benches. Complex near-surface hydrology, mass movement processes and related features may be present. The mountainflank can be subdivided by the general location along the mountainside.
mountainbase	A geomorphologic component of mountains consisting of the strongly to slightly concave colluvial apron or wedge at the bottom of mountain slopes. It is composed of longtransport colluvium and slope alluvium sediments.
tectonic and structural features	Geomorphologic landscapes and landforms related to regional or local bedrock structures, or crustal movement, and geomorphologic features related dominantly to water erosion but excluding perennial, channel flow (i.e. fluvial, glaciofluvial), or eolian erosion.
volcanic features	Geomorphologic landscapes and landforms related to the deep seated (igneous) processes by which magma and associated gases rise through the crust and are extruded onto the earth's surface and into the atmosphere.
hydrothermal features	Geomorphologic landscapes and landforms related to hydrotermal processes.
erosional features	Geomorphologic landscapes and landforms related dominantly to water erosion but excluding perennial channel flow (i.e. fluvial, glaciofluvial) or eolian erosion.
slope and gravitational features	Geomorphologic landscapes and landforms related to slope environments and geomorphologic features developed under the action of the gravitational force.
periglacial, nival and permafrost features	Geomorphologic landscapes and landforms related to snow, non-glacial, cold climate, or occurring in the vicinity of glaciers and ice sheets
drainage pattern	The configuration or arrangement, in map view, of stream courses in an area, including gullies or first-order channelized flow areas, higher order tributaries, and main streams. Drainage pattern is related to the local geologic materials and structure, the geomorphologic features, and the geomorphic history of an area. Also called drainage network.
glacial, glaciofluvial, glaciolacustrine and glaciomarine features	Geomorphologic landscapes and landforms related to to glacial, glaciofluvial, glaciolacustrine and glaciomarine environments.
eolian features	Geomorphologic landscapes and landforms related to wind-dominated environments.
marine, littoral and coastal wetlands features	Geomorphologic landscapes and landforms related to wave or tidal dynamics developed in marine, shallow marine, near-shore and littoral zone environments, and those related to vegetated and / or shallow wet areas
karstic and chemical weathering features	Geomorphologic features and landforms dominated by mineral dissolution, and commonly, subsurface drainage. Excludes thermokarst-related features.

Term	Definition
alluvial and fluvial features	Geomorphologic landscapes and landforms dominantly related to concentrated water flow (channel flow), excluding glaciofluvial and deltaic landscapes and landforms.
lacustrine features	Geomorphologic landscapes and landforms related to inland permanent water bodies (lakes).
meteorite impact crater features	Geomorphologic landscapes and landforms related to the impact of extraterrestrial material on the Earth's surface.
degradation feature	The wearing down or away, and the general lowering of the land surface by natural processes of weathering and erosion and may infer the process of transportation of sediment.
relict feature	Surface landforms, geomorphologic surfaces, and paleosols that have never been buried and yet are predominantly products of past environments.
erosion remnant feature	A topographic feature that remains or is left standing above the general land surface after erosion has reduced the surrounding area.
exhumed feature	Formerly buried landforms, geomorphologic surfaces, or paleosols that have been reexposed by erosion of the covering mantle.
buried feature	Landforms, geomorphologic surfaces, or paleosols covered by younger sediments.
pediment	A gently sloping erosional surface developed at the foot of a receding hill or mountain slope, commonly with a slightly concave-upward profile, that cross-cuts rock or sediment strata that extend beneath adjacent uplands.

Code list: QuaternaryTimeScale_Core

Term	Definition	Parent
Weichselian	Weichselian	
Eemian	Eemian	
Saalian	Saalian	
Holsteinian	Holsteinian	
Elsterian	Elsterian	
"Cromerian complex"	"Cromerian complex"	
Bavelian	Bavelian	
Middle Pleistocene	Middle Pleistocene	
Early Pleistocene	Early Pleistocene	