GeoSciML Cookbook 1

How To Map Data to GeoSciML

Draft

Version 1

Contents

1 INTRODUCTION

1.1 The purpose of this cookbook

The OneGeology project aims for a complete coverage of the world with a target 1:1 000 000 Geological Map. Every country will display its own map series within the national or wider boundaries that it chooses. Further integration or international harmonisation of the content is not included in the project. The maps are displayed as Web Services, so the source keeper keeps full control of the national map, while it is still possible by calling all the webservices to compose a full covering of the world.

This document is one of a series of “cookbooks” written to assist organisations contributing to OneGeology. **Level 1** participants in OneGeology will be serving a WMS, and the means to do this are described on OneGeology Cookbook 1. As a WMS serves only an image of the map, and not the underlying features, there is no requirement in this case to map data to the GeoSciML logical model. **Level 2** participants in OneGeology will be serving GeoSciML in a WFS and to achieve this will have to map their data to the GeoSciML logical model as outlined in this cookbook. This cookbook will also be of use, more widely, to anyone wishing to make use of the GeoSciML data exchange standard, whether as part of OneGeology or not.

This particular cookbook describes the GeoSciML logical model and provides information on its scope and the background to its development in sections 2 and 3. As the GeoSciML logical data model is complex, and designed to handle a wide range of different types of geoscience data, there are many instances where it is possible to encode information, using the model, in more than one way. This means that use of the GeoSciML data exchange format, of itself, is insufficient to lead to the interoperability which was the main objective behind the development of GeoSciML. For this reason guidelines on how to map particular types of data to GeoSciML have been developed, and these are described in section 4 through the use of exemplar GeoSciML instance documents.

1.2 Who should be using this cookbook?

The cookbook is designed to assist users map their data to the GeoSciML logical data model. In most cases users with digital geoscience data will have their own formalised model of some type, although this will not always be the case. Where a formalised user data model exists then the process of mapping data to GeoSciML will largely involve mapping features/entities in the user model to their equivalents in the GeoSciML logical data model. Where no such user model exists then mapping must be carried out direct from the data, and the worked examples in section 4 should assist with this for the most common types of geoscience data.

To carry out the mapping, from either a model or direct from data, requires staff with geoscientific knowledge, familiarity with the user’s own data and data model, and an understanding of the UML formalisation used in documenting GeoSciML. These staff are likely to be geoscientists, possibly those who were involved in developing the organisation’s own data model, and it is these people who are seen as the main users of this cookbook.

1.3 Related documentation

Materials and documentation on GeoSciML have been produced by the CGI Interoperability Working Group (IWG) and are available "as is" for download from http://www.cgi-

iugs.org/tech_collaboration/data_model/downloads.html. It is the aim of the Working Group to ensure that the most current materials and information relating to GeoSciML are available from this site. The supporting documents most relevant to this cookbook are listed in section 1.3.1.

Although use of GeoSciML is open to the geoscience community, in order to ensure the integrity on the GeoSciML standard across the community the IWG requests that the following points be applied to any work involving GeoSciML:

- full compliance with existing GeoSciML conformance criteria
- the IWG and its GeoSciML products are not misrepresented or misused
- the IWG retains full copyright to all IWG and GeoSciML names and products, including logos, text, images and technical materials
- the GeoSciML name and associated namespaces, as well as the IWG name and associated task group names, are reserved strictly for IWG activities and products
- the GeoSciML products developed by the IWG may be freely copied and used within third-party information systems, with acknowledgements as per (8) below
- the GeoSciML products developed by the IWG are not to be modified by third-parties, except as part of the revision process within the IWG
- extensions to GeoSciML by third-parties remain distinct from GeoSciML, exist in non-GeoSciML namespaces, and are not to be represented as IWG or GeoSciML products
- acknowledgement of GeoSciML and the IWG is made in all communications and products related to work involving GeoSciML or the IWG, with appropriate citation
- the IWG gives no warranty, expressed or implied, as to the quality or accuracy of the information supplied, or to the information's suitability for any use. The IWG accepts no liability whatever in respoect of loss, damage, injury or other occurrence however caused

1.3.1 GeoSciML documentation and materials

Full documentation of the GeoSciML model is available at http://www.cgi-iugs.org/GeoSciML/index.html). This documentation has been generated automatically from the GeoSciML UML diagrams and draws on the scope notes in those diagrams. It describes the model in more detail that is done is section 3 of this cookbook and should be seen as the definitive reference. This full documentation, however, does not include any best practice guidance.

Tagged versions of the model, schema, and examples are available from https://www.seegrid.csiro.au/subversion/GeoSciML/tags.

An Enterprise Architect version of the UML for the CGI packages (GeoSciML_V2_Unversioned.eap) (https://www.seegrid.csiro.au/twiki/pub/CGIModel/GeoSciMLModel/GeoSciML_V2_Unversioned.eap).

Full information about the GeoSciML model and schema can be found at https://www.seegrid.csiro.au/twiki/bin/view/CGIModel/GeoSciMLModel

2 BACKGROUND AND SCOPE

2.1 Background to the model development

It is becoming increasingly important to be able to query and exchange digital geoscientific information between data providers and users. Technological opportunities arising from the development of geospatial information standards are making such interoperability a viable

proposition. In order to investigate these opportunities a meeting of international geoscience data providers, mainly geological surveys, was held in Edinburgh in 2003. Following from this meeting the Interoperability Working Group (IWG) under the auspices of the IUGS Commission for the Management and Application of Geoscience Information (CGI) was set up.

The IWG was tasked with developing a conceptual geoscience data model, mapping this to a common interchange format, and demonstrating the use of this interchange format through the development of a testbed. Active participants in the working group are drawn from BGS (United Kingdom), BRGM (France), CSIRO (Australia), GA (Australia), GSC (Canada), GSV (Australia), APAT (Italy), GSJ (Japan), SGU (Sweden) and USGS (USA). The ultimate objective of the working group is to enable seamless web integration of select information hosted at different agencies in varied formats.

More specific objectives are to:

- develop a conceptual model of geoscientific information drawing on existing data models
- implement an agreed subset of this model in an agreed schema language
- implement an XML/GML encoding of the model subset
- develop a testbed to illustrate the potential of the data model for interchange
- identify areas that require standardised classifications in order to enable interchange

The working group has set up six task groups to address specific aspects of the work:-

UseCases and Requirements task group is developing technical goals for GeoSciML by describing new use-cases and requirements;

GeoSciML Design task group is working on the design of GeoSciML;

Service Architecture task group is developing and documenting the formal architecture required to deliver GeoSciML services

Implementation Test Bed task group is working on interoperability testbeds using GeoSciML;

Outreach and Technical Assistance task group provides advice and assistance to direct collaborators, assisting them to deploy conformant GeoSciML Services;

Geoscience Concept Definitions task group is responsible for designing vocabulary services that satisfy the requirements of GeoSciML.

GeoSciML development work is mainly carried out on a Twiki site (https://www.seegrid.csiro.au/twiki/bin/view/CGIModel/WebHome) where detailed information about all aspects of the work can be found. We welcome participation in these discussions from all those interested in the development of geoscience interchange standards. A password is required for such participation and you can apply for one by mailing John Laxton (jll@bgs.ac.uk) giving your accreditiation and outlining your interest and involvement in geoscience interoperability.

Occasional face to face meetings are also held. These are by invitation to those who have been active in the relevant Twiki discussions and are designed to provide a concentrated period of development and decision making.

2.2 Purpose of the model

In order for there to be interchange of information there has to be agreement on the nature and structure of the information to be interchanged. The simplest way of achieving this would be if all geoscience data providers shared a common database structure. However, because data providers already have their own database implementations, and the information gathered and held by different providers is not exactly the same, this option is not possible. The solution is to agree a common conceptual data model, to which data held in existing databases can be mapped. Such a data model needs to identify the objects being described (eg 'faults'), their properties (eg 'displacement') and the relations between objects (eg 'faults are a type of Geologic Structure'). Such a model can be described graphically using Universal Modeling Language (UML), an ISO standard.

Having agreed a conceptual data model it needs to be mapped on to an interchange format. The GeoSciML application is a standards-based data format that provides a framework for application-neutral encoding of geoscience thematic data and related spatial data. GeoSciML is based on Geography Markup Language (GML – ISO DIS 19136) for representation of features and geometry, and the Open Geospatial Consortium (OGC) Observations and Measurements standard for observational data. Geoscience-specific aspects of the schema are based on a conceptual model for geoscience concepts and include geologic unit, geologic structure, earth material, and borehole information. Development of controlled vocabulary resources for specifying content to realize semantic data interoperability is underway.

Intended uses are for data portals publishing data for customers in GeoSciML, for interchanging data between organizations that use different database implementations and software/systems environments, and in particular for use in geoscience web services. Thus, GeoSciML allows applications to utilize globally distributed geoscience data and information.

GeoSciML is *not* a database structure. GeoSciML defines a format for data interchange. Agencies can provide a GeoSciML *interface* onto their existing data base systems, with no restructuring of internal databases required (Figure 1).

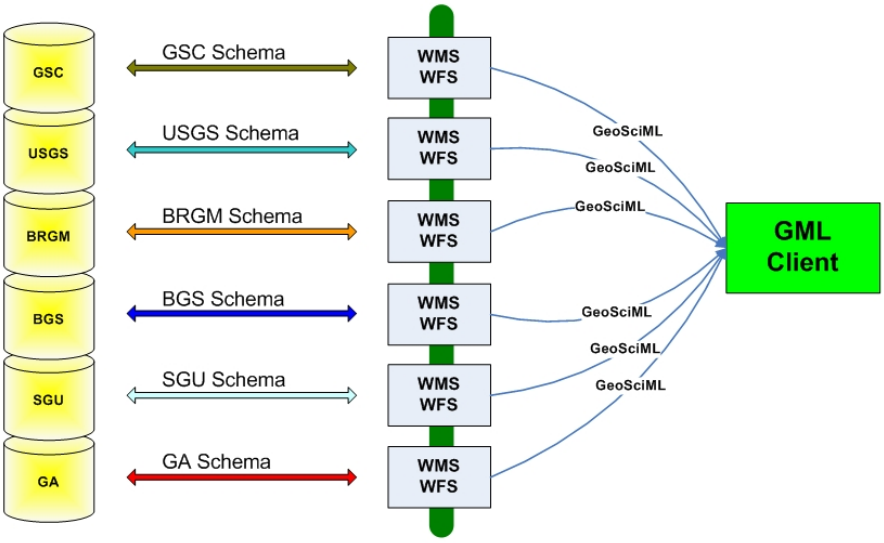

Figure 1: Architecture of a GeoSciML web service

2.3 Scope of the model

Developing a conceptual data model for geoscience is a major piece of work and in the current phase of development the scope has been restricted to those geoscience objects which form the main components of a geological map, as well as boreholes and field observations.

The GeoSciML model will never provide definitions of everything in geoscience because other groups may governance of particular areas of geoscience. The IWG aims to coordinate with the work of these other groups.

GWML (http://ngwd-bdnes.cits.rncan.gc.ca/gwml) is an example of a derived implementation of GeoSciML. It is also the first official collaboration between GeoSciML and an external exchange model group.

MineralOccurrences is an example of an inherited implementation of GeoSciML. It is being developed by the Australian Government Geologists Information Committee (GGIC) as a model to deliver mineral occurrences information as a WMS/WFS. Australian State, territory and federal organizations presently govern the model.

GeoSciML has not got a clearly defined ultimate limit to its scope. It has been developed primarily by Geological Survey Organisations (GSOs) to assist them in the interchange and delivery of their data, although it has always been envisaged that it would be adopted by other geoscience data providers. GeoSciML has been developed in the first instance to handle the interpretative information shown on geological maps, as this is GSOs most widely used data set, but there is a recognised need also to have the facility to interchange the data underlying the map. The extent to which this need will be met by extending GeoSciML, as opposed to using standards developed elsewhere, will depend on what external standards are developed. GeoSciML will always aim to adopt external standards where possible and GeoSciML will only be extended where no such standards exist or are being developed by other governance bodies.

3 OVERVIEW OF THE MODEL

3.1 Methodology and documentation

3.1.1 UML model

GeoSciML is formally defined by a UML model, also known as an "Application Schema" (following the terminology of ISO 19109). In addition, the domain for certain feature-properties will be provided, typically serialized as GML Dictionaries. Designators for key components that are required for deployment in a distributed environment follow the CGIIdentifierScheme (https://www.seegrid.csiro.au/twiki/bin/view/CGIModel/CGIIdentifierScheme).

The reference version of the Application Schema is provided as XMI documents. (XMI is an XML serialization of UML).

The UML profile used follows the ISO 19103 profile, and in particular using the rules from ISO 19136:2007 (GML 3.2.1) Annex E as summarized in https://www.seegrid.csiro.au/twiki/bin/view/AppSchemas/UmlGml#ISO_TC_211_Profile_of_UML

Implementation views of GeoSciML are provided as a GML-conformant XML Schema and as a set of HTML documents organized in a frame-set. The implementation views are generated using an automated process, starting with the XMI.

3.1.2 XML Schema

The schema is automatically generated from the UML model following the rules described in ISO 19136:2007 (GML 3.2.1) Annex E with the following variations:

- GeoSciML v2 is currently bound to GML v3.1.1
- the rule for encoding <<Union>> classes follows https://www.seegrid.csiro.au/twiki/bin/view/AppSchemas/UmL2GMLAS#4_Class_association_pattern_targ
- additional stereotypes are used as described in https://www.seegrid.csiro.au/twiki/bin/view/AppSchemas/UmlGml#ISO_TC_211_Profile_of_UML

3.1.3 Documentation

Detailed documentation of the model may be viewed at http://www.cgi-iugs.org/GeoSciML/index.html or downloaded as a zip from https://www.seegrid.csiro.au/subversion/GeoSciML/trunk/Documents/GeoSciML_V2_html_doc.zip

3.1.4 Working with the UML model

GeoSciML is available as a set of XMI documents (https://www.seegrid.csiro.au/subversion/GeoSciML/trunk/model).

The GeoSciML design team uses the Enterprise Architect (EA) UML tool to maintain the model. A free EA viewer (EAViewer.exe, intended for distribution with such models) can be obtained from http://www.sparxsystems.com/products/ea_downloads.html.

The development trunk version of the model is no longer provided as a .EAP cache. Instructions for how to load the XMI into EA are provided at https://www.seegrid.csiro.au/twiki/bin/view/CGIModel/ConfiguringEnterpriseArchitectForGeoSciML . Periodic snapshots of the model as both XMI exports and .EAP caches will be available in https://www.seegrid.csiro.au/subversion/GeoSciML/tags

When loaded in EA, the model is found under [Model]->[GeoScience Resources]->[CGIWorld]->[GeoSciML].

3.1.5 Working with the XML Schema

The XML Schema representation of GeoSciML can be used to validate GeoSciML instance documents. The GeoSciML specific schemas are available at https://www.seegrid.csiro.au/subversion/GeoSciML/trunk/schema/GeoSciML/. These import schemas from other namespaces which can be found at a number of locations.

During development successful validation can be dependent on using particular versions of these other schemas. You may need to configure your validation environment specially to do this - see

https://www.seegrid.csiro.au/twiki/bin/view/CGIModel/ConfiguringXmlValidatorsForGeoSciML for notes on this.

3.2 Model Packages

There are twelve distinct packages in the GeoSciML data model, and in this section the UML of each will be shown along and the key points of each identified. The relationships between the packages will also be identified.

3.2.1 Geologic Feature

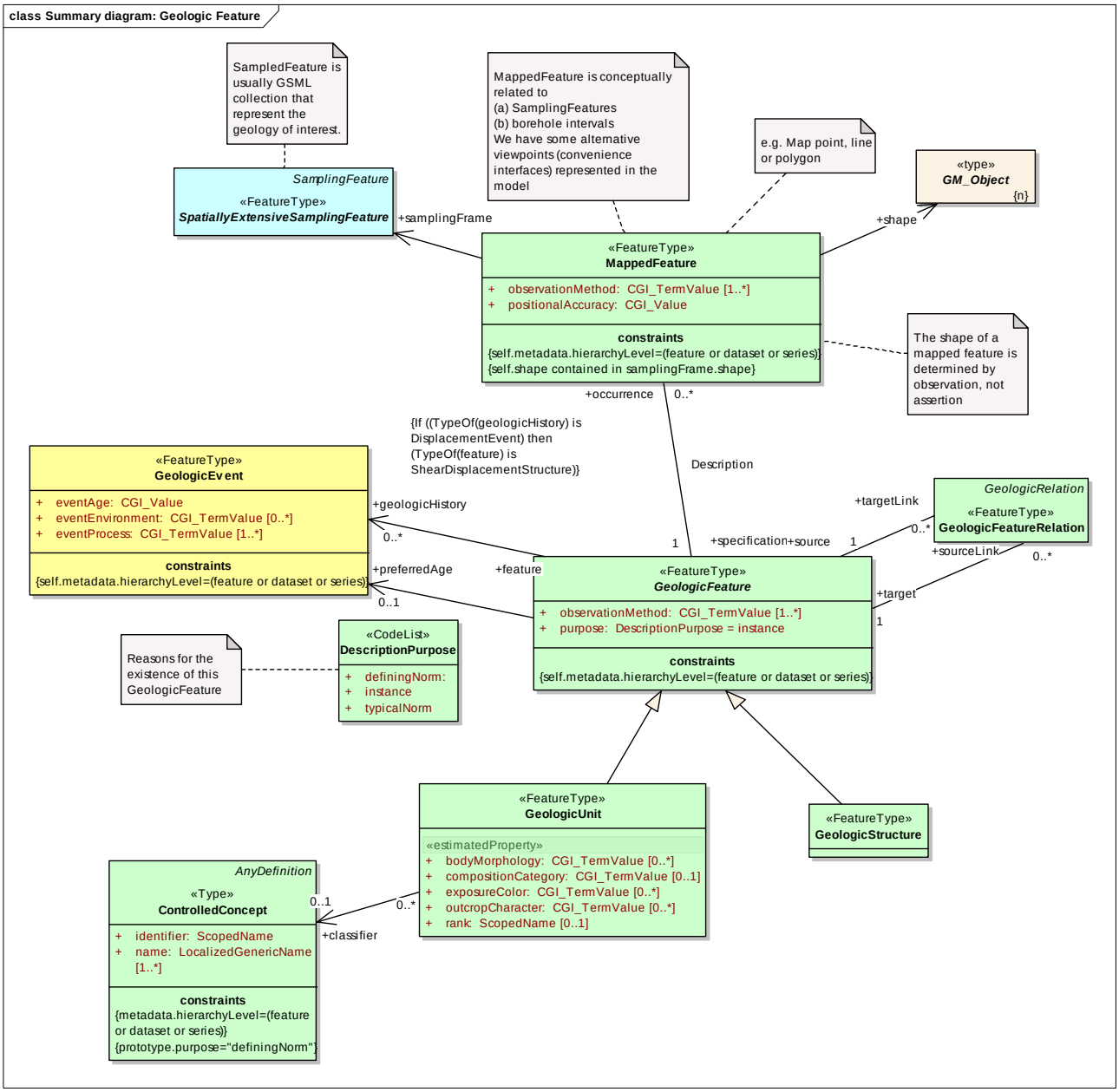

Figure 2: Summary UML diagram for the Geologic Feature package

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

A mandatory property of GeologicFeature is ‘purpose’ which states whether the GeologicFeature is an instance or normative description. On published geologic maps, for example, it is generally the case that normative GeologicUnits are shown, for which a standard description is given in a StratigraphicLexicon. Survey scale, or field, maps on the other hand may describe unclassified instances of GeologicUnits.

The observationalMethod properties of both MappedFeature and GeologicFeature enable the distinct methodologies for observing each of these to be recorded. For example a MappedFeature might be observed through field observation (mapping) while the normative GeologicFeature it is an occurrence of may have been observed (defined) through summarising published descriptions.

Each MappedFeature is associated with a SamplingFrame that indicates the spatial reference frame within which the MappedFeatures have been observed, such as a surface of mapping or a borehole.

A GeologicFeature can be either a GeologicUnit or GeologicStructure (described in distinct packages below).

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

The relationship between GeologicFeatures can be described using GeologicFeatureRelation (see package description below). Relationships are described from a source to a target - for example a source GeologicFeature might be an intrusive igneous rock body which could point to a target indicating the host rock body. In this case the ‘relationship’ attribute would be 'intrudes'. Other appropriate relationship attributes might include: overlies, offsets, crosscuts, folds, etc.

3.2.2 Geologic Unit

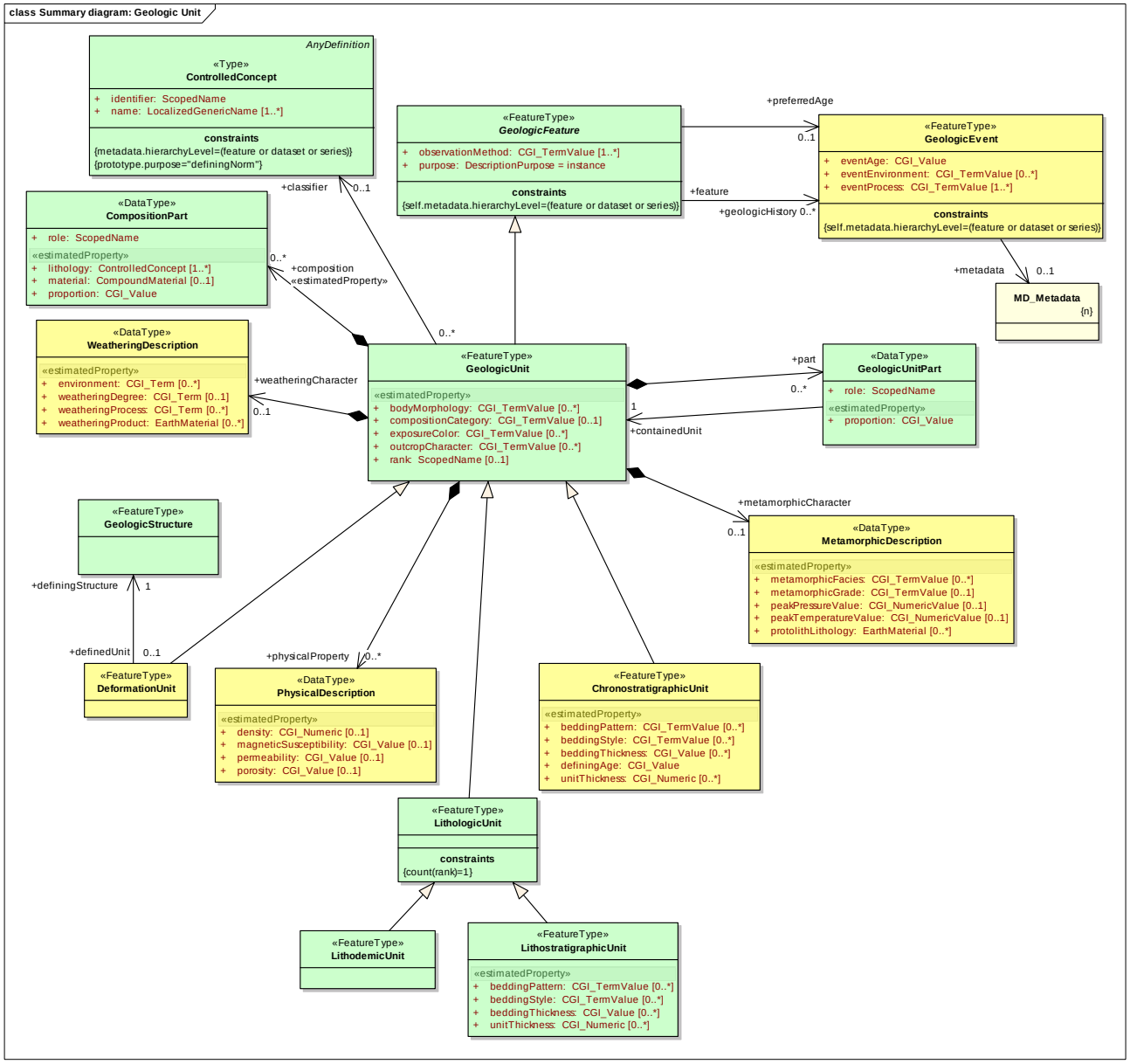

Figure 3: Summary UML diagram for the Geologic Unit package

A notional unit, whose complete and precise extent is inferred to exist. 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).

Geologic units have specialisations for lithostratigraphic units, lithodemic units, chronostratigraphic units and deformation units. More will be added in the future as required.

A GeologicUnit can be classified with a ControlledConcept (see package description below). The ControlledConcept can be a normative description of a GeologicUnit, defined in a Stratigraphic Lexicon for example

The model allows for composite geologic units, made up of other geologic units, to be described. This can be used for formal stratigraphic hierarchies as well as informal relationships.

The composition of a GeologicUnit is described using CompositionPart. A GeologicUnit can have a single CompositionPart describing the entire unit, in which case the 'proportion' property would be 100%, or it can be made up of several CompositionParts with the relationship of each to the whole GeologicUnit described by the 'role' property (e.g. vein, interbedded constituent, layers, dominant constituent). The lithology is described using a lithology term (eg conglomerate) drawn from an Earth Material vocabulary, but can in addition have a specific Earth Material description using the 'material' property to provide more detailed information about the lithology of the particular GeologicUnit.

The MetamorphicDescription and PhysicalDescription data types allow the recording of certain specific properties of GeologicUnits. It is appreciated that the properties included, particularly in the case of the PhysicalDescription, are a subset of those which may be required. Additional properties may be added in future versions of the model in light of user requirements.

3.2.3 Earth Material

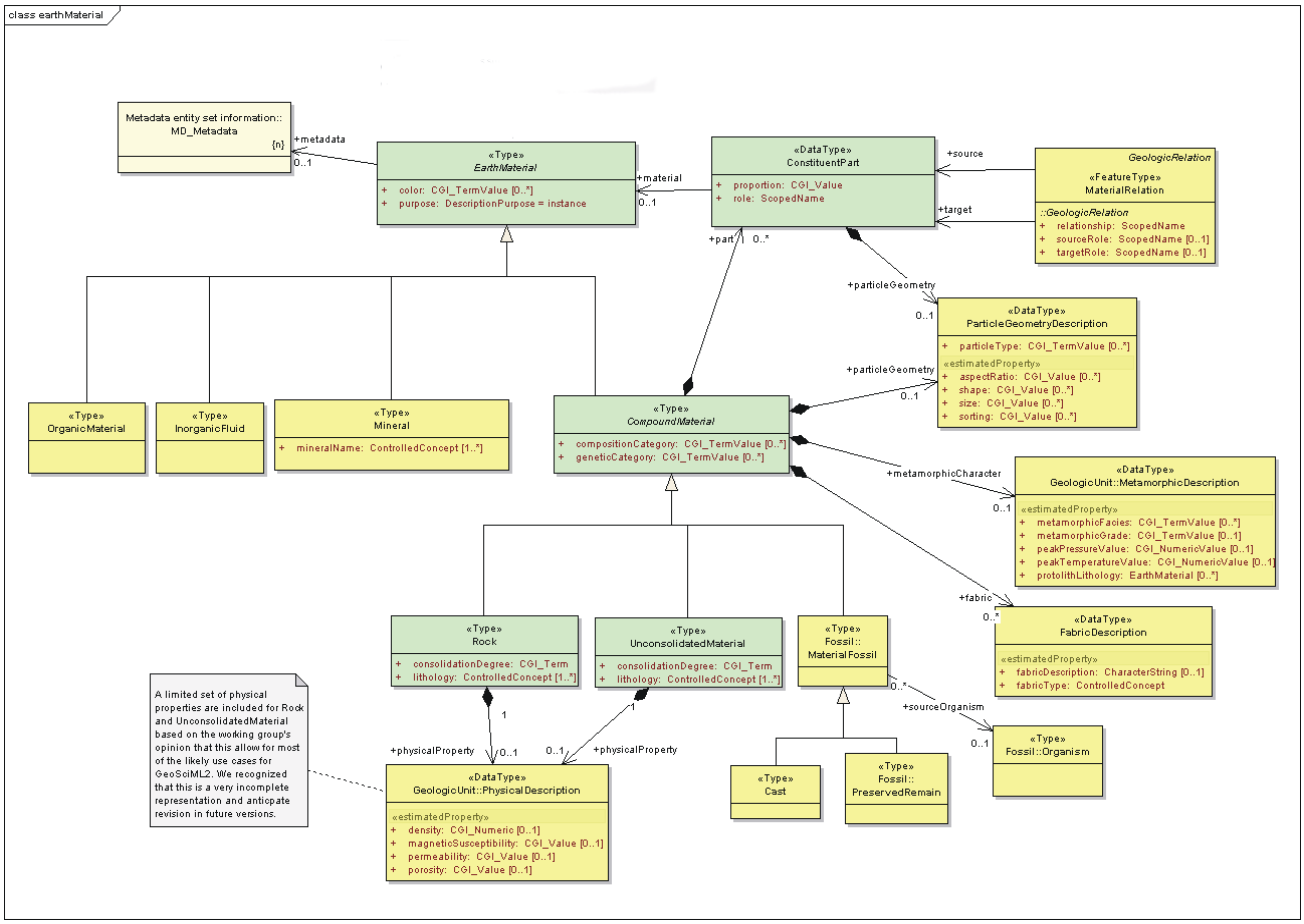

Figure 4: Summary UML diagram for the Earth Material package

The EarthMaterial package allows for the description of naturally occurring substances in the earth. These substances can be either discrete components, such as a specific type of mineral, or CompoundMaterials built up from either the discrete components or other CompoundMaterials. Rocks are a type of CompoundMaterial.

A CompoundMaterial can be described in terms of its ConstituentParts, each of which has a role and a proportion property to allow, for example, for the description and relative abundance of the framework and matrix in a rock such as oolitic limestone. The description of the ConstituentParts can be enhanced using the ParticleGeometryDescription which provides additional properties relating to particle geometry such as size and shape. The relationship between the ConstituentParts (as opposed to the role of the ConstituentPart in the CompoundMaterial) can be described using the MaterialRelation class. This is a subtype of the abstract GeologicRelation class which describes the relationships between constituent parts in an Earth Material, for example mineral overgrowth on a phenocryst within a granite.

The MetamorphicDescription, PhysicalDescription and FabricDescription data types allow the recording of certain specific properties of CompoundMaterials. It is appreciated that the properties included, particularly in the case of the PhysicalDescription, are a subset of those which may be required. Additional properties may be added in future versions of the model in light of user requirements. FabricDescription is distinguished from ParticleGeometry on the criterion that ParticleGeometry is preserved if a CompoundMaterial is disaggregated, while FabricDescription is not defined if the material is disaggregated.

A MaterialFossil is a particular type of CompoundMaterial describing the preserved remains or replaced remains (casts) of plants and animals. MaterialFossils may form a constituent part of another CompoundMaterial (such as a limestone rock). Note that trace fossils and molds are GeologicStructures and may be related to MaterialFossils through their associated organisms (see full description in Fossil package below). Individual fossil instances (ie, fossil specimens) are treated in this model as specimens composed of CompoundMaterial/MaterialFossil.

3.2.4 Geologic Structure

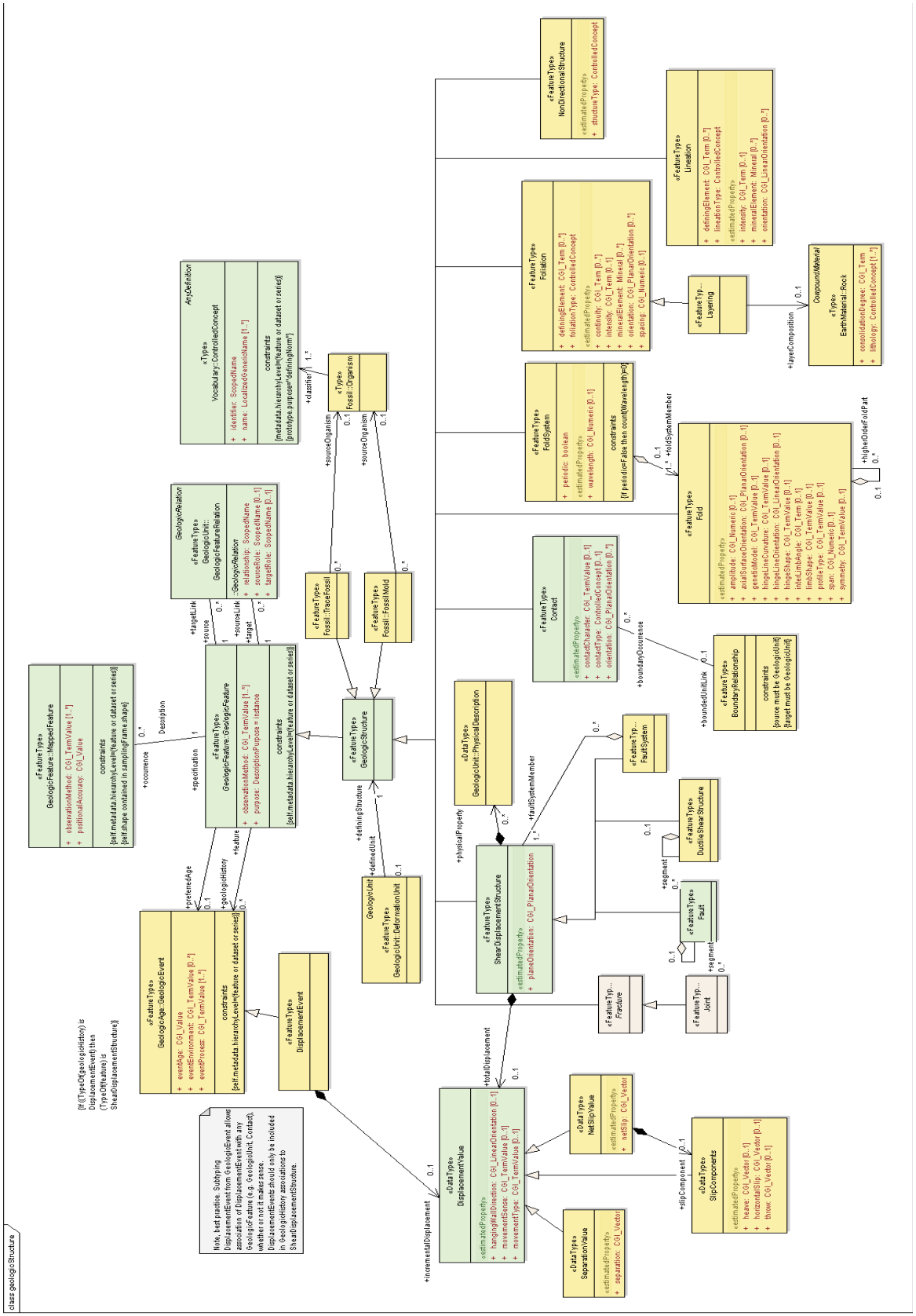

Figure 5: Summary UML diagram for the Geologic Structure package

The Geologic Structure package models most types of geologic structure. Primary sedimentary and igneous structures, as well as tectonic structures, are included. TraceFossils and FossilMolds are included as types of GeologicStructure, although the only specific information recorded about these is their sourceOrganism (see description of Fossil package below). Many of the structural properties concern orientation measurements and specific orientation data types are used for recording these (described in the CGI_Value package below).

ShearDisplacementStructures include both Faults and FaultSystems, with the latter described in terms of their component Faults. The DisplacementValue can be described both as a single totalDisplacement for the structure, and as a series of incrementalDisplacements each associated with a particular DisplacementEvent. The DisplacementValue is recorded in terms of its SeparationValue and NetSlipValue and, optionally, as SlipComponent vectors. Physical properties, such as porosity and permeability, can be recorded for ShearDisplacementStructures.

Both Folds and FoldSystems are modelled, the latter described in terms of their component Folds.

Foliation is modelled and includes Layering, along with the layerComposition of each individual layer in terms of a Rock type.

Contacts are included as a type of Structure and the BoundaryRelationship between the GeologicUnits either side of the Contact can be described along with their descriptive properties.

3.2.5 Fossil

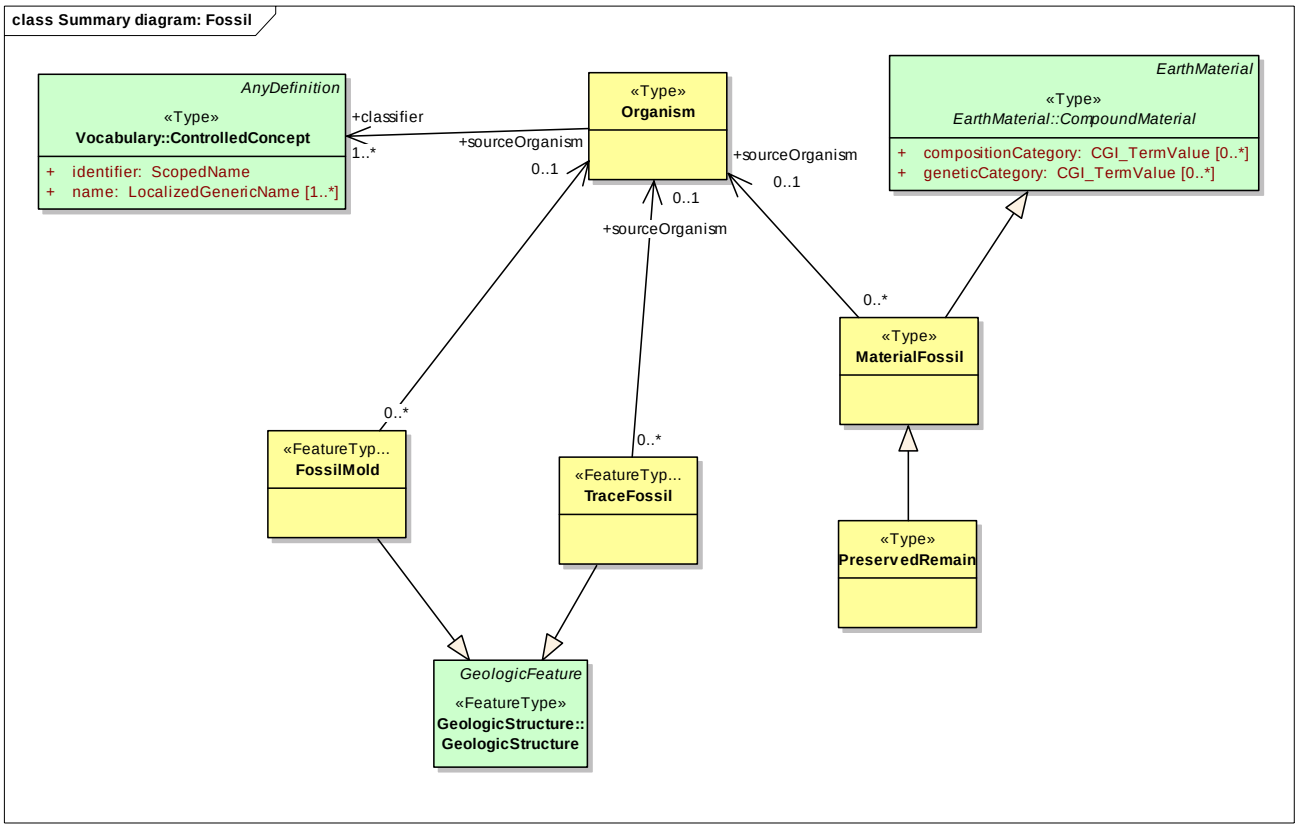

Figure 6: Summary UML diagram for the Fossil package

The GeoSciML Fossil package is not attempting to model taxonomy. 'Organism' is a broad class to represent any living or once living thing and can be classified using a vocabulary of ControlledConcepts (see Vocabulary package description below). This vocabulary could be a full taxonomy for fossils.

Fossils have a limited role in the GeoSciML model. They are either modelled as types of GeologicStructure (see GeologicStructure package description above) or as types of CompoundMaterial (see EarhMaterial package description above).

3.2.6 Geologic Age

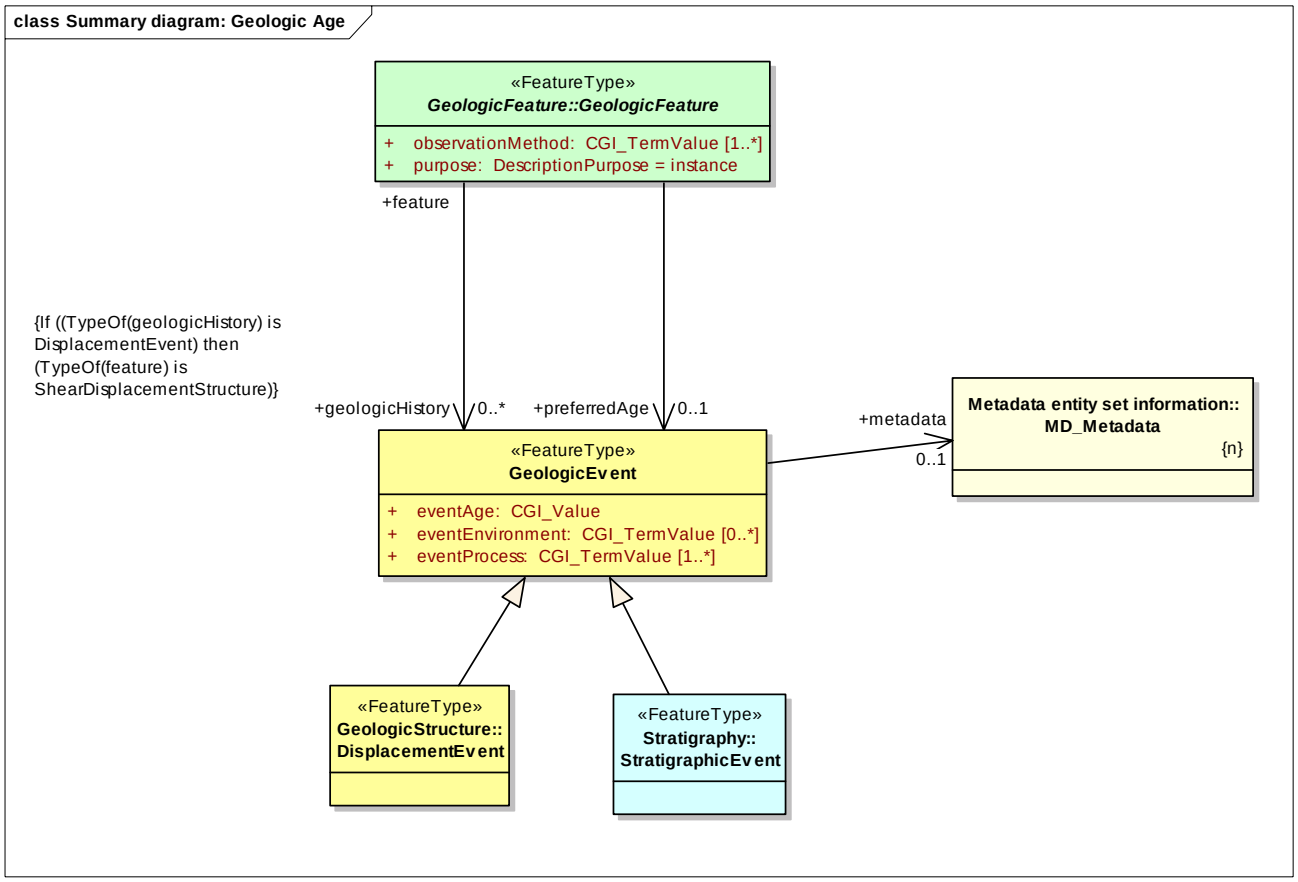

Figure 7: Summary UML diagram for the Geologic Age package

GeologicAge is defined in terms of GeologicEvents which, in addition to age, may have information about the event environment (the physical setting within which a GeologicEvent takes place) and the event process (a function that acts on one geologic entity to produce another geologic entity at a later time) recorded.

GeologicEvents record the age and history of GeologicFeatures (see GeologicFeature package description above). DisplacementEvents are the particular type of GeologicEvents associated with ShearDisplacementStructures (see GeologicStructure package description above). StratigraphicEvents record the particular events used to define Chronostratigraphic and Geochronological boundaries.

3.2.7 Boreholes and Observations

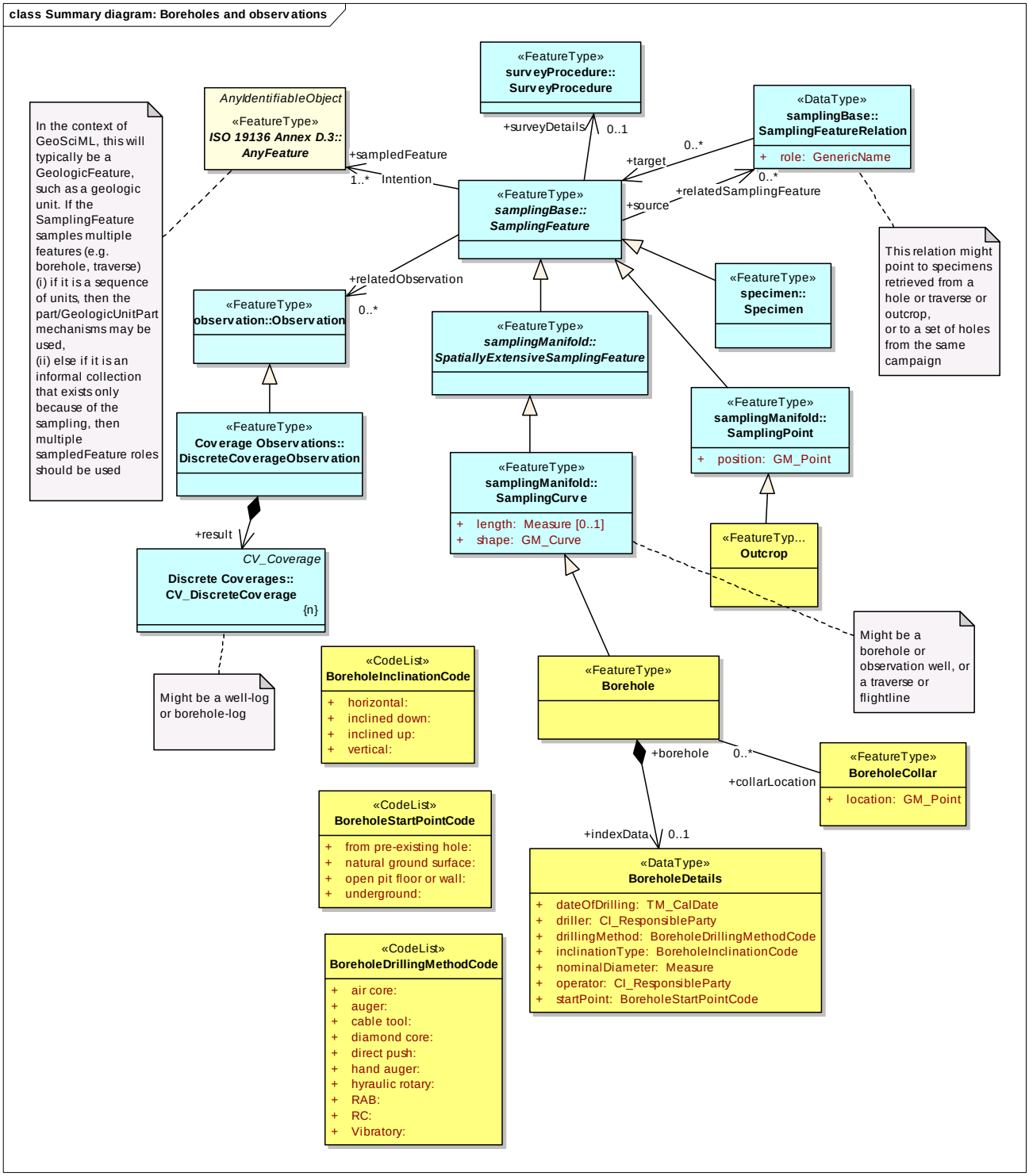

Figure 8: Summary UML diagram for the Boreholes & Observations package

Boreholes can be described in two ways in the GeoSciML model – either as a special type of SamplingCurve feature or as a collection of MappedFeatures (see Section 3.2.1). The GeoSciML Boreholes and Observations package re-uses standard components from the OGC Observations and Measurements package.

A borehole is a feature whose median axis is a curve. Related observations and measurements are made on points or intervals, at depths measured from the collar along the borehole curve. Observations may concern, for example, lithology, stratigraphy (category results), porosity, geophysical logs data, and ore-grades (numerical results). In the case of holes with non-constant diameter, the variation of the diameter may also be described as a log.

The shape of the boreholes (median axis of the borehole) is a 3D curve, which in the simplest cases may be vertical and straight, but is commonly deviated, and often not straight. The axis-shape may be described by means of another log known as the “survey” (3-D direction as a function of depth) which may be converted (“de-surveyed”) to obtain the shape in an x-y-z reference frame.

A borehole is associated with one or more domain features which it samples: for instance, the geological unit (a geological feature from GeoSciML) intersected by the borehole. A borehole may also be associated with related sampling features. This allows a set of boreholes to be grouped as a campaign, or specimens to be associated with boreholes, boreholes with mines, etc.

While boreholes may carry various kinds of observation, in a geological mapping context, lithology logs are a key information type. There are two ways to describe these:

1. A borehole is a special sampling curve feature, and the lithology log is reported as the result of a related observation – i.e. **borehole-centric**, in which the association points from the sampling frame to the observed units. This point of view is natural when comparing multiple logs of different properties.
2. The lithology log is a collection of mapped features (i.e. occurrences of geologic units) whose sampling frame is a sampling curve describing the borehole – i.e. **classification-centric**, in which the association points from the observed lithology to its sampling frame. This point of view is natural when comparing a borehole log with other representations of the same property, perhaps sampled in a different frame (e.g. map or section).

When to use which approach?

1. The first approach (borehole feature) is important during observation/data-collection and for re-examination through the lens of an observational campaign.
2. The second approach (collection of mapped features) is important after interpretation, and is used later on during compilation.

With the second approach, it is highly convoluted to also include measurements of continuously varying properties, such as ore-grades, porosity, etc. Hence, the first approach is recommended when it is required to compare geologic features (e.g. units) and ore-grade within a hole. However, the second approach is more convenient to compare a geological interpretation from a borehole with a 2-D or 3-D model described as a set of mapped features (i.e. a geologic map).

3.2.8 Geologic Relation

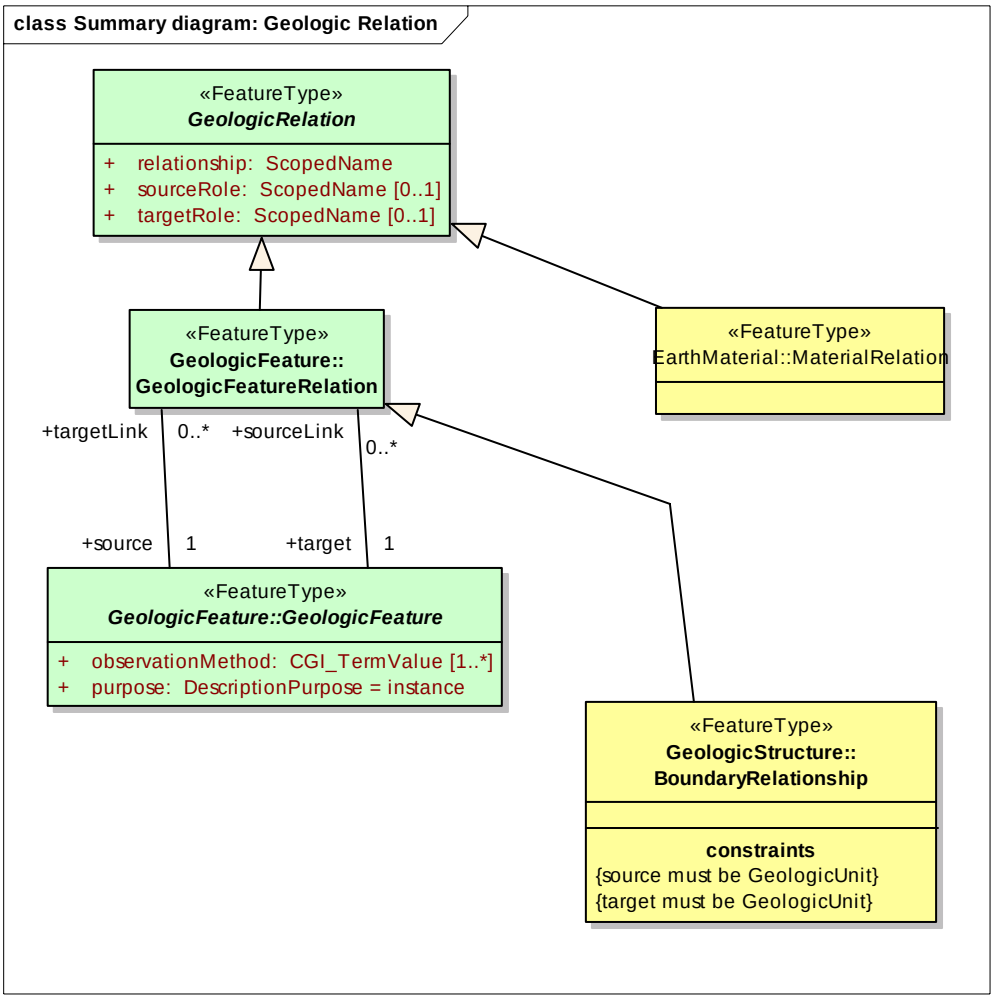

Figure 9: Summary UML diagram for the Geologic Relation package

GeologicRelations are typed, directed associations between geologic objects. They can represent any of a wide variety of relationships that can exist between two or more Features or other entities. GeologicRelations are likely to be of most use where specialisations have been developed.

The GeologicFeatureRelation class is a subtype that is used to define relationships between geologic features, ie. structure-structure, unit-unit, and structure-unit relationships. For example, 'Source' might point to an intrusive igneous rock body and 'Target' would then point to the appropriate host rock body, and the relationship attribute would be 'intrudes'. Other appropriate relationship attributes might include: overlies, offsets, crosscuts, folds, etc. Both the 'Source' and 'Target' have a role in the relationship. Where an igneous unit intrudes a sedimentary unit, the geological relationship is "intrudes", the intruded sedimentary unit has the role "host", and the igneous unit has the role "intrusion".

A special type of GeologicFeatureRelation is the BoundaryRelationship which defines the two GeologicUnits that bound a Contact (see section 3.2.4).

At present the only other specialisation of GeologicRelation is MaterialRelation which describes the relationship between two ConstituentParts of a CompoundMaterial (see section 3.2.3).

3.2.9 CGI Values

The CGI_Value package defines two different data types of particular relevance to geoscience: generic values and geometric values.

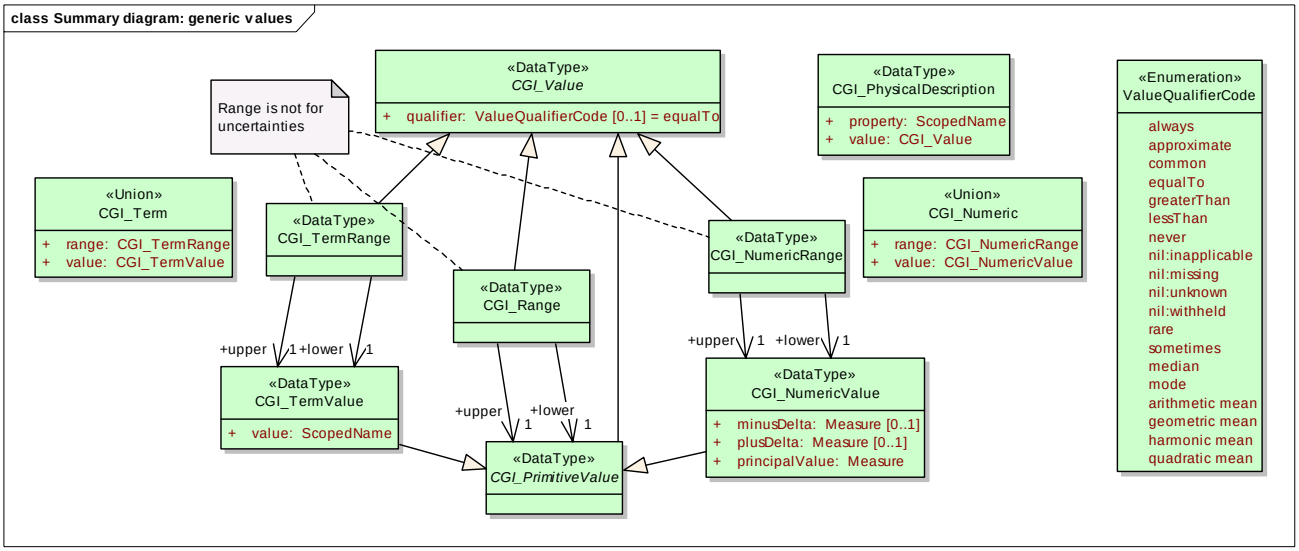

Figure 10: Summary UML diagram for the Generic Values package

The generic values model (Figure 10) provides a way of encoding "literal" values, both textual and numeric, which have uncertainty and may be a range. These structures are designed to be able to capture value descriptions as conventionally recorded by geologists. They are required if the value you wish to record has a qualifier, such as ‘rare’ or ‘approximate’; where it can be either a single value or a range; where you wish to record the uncertainty of a numeric value; or where a value or range can contain either text or numeric values or a combination of both.

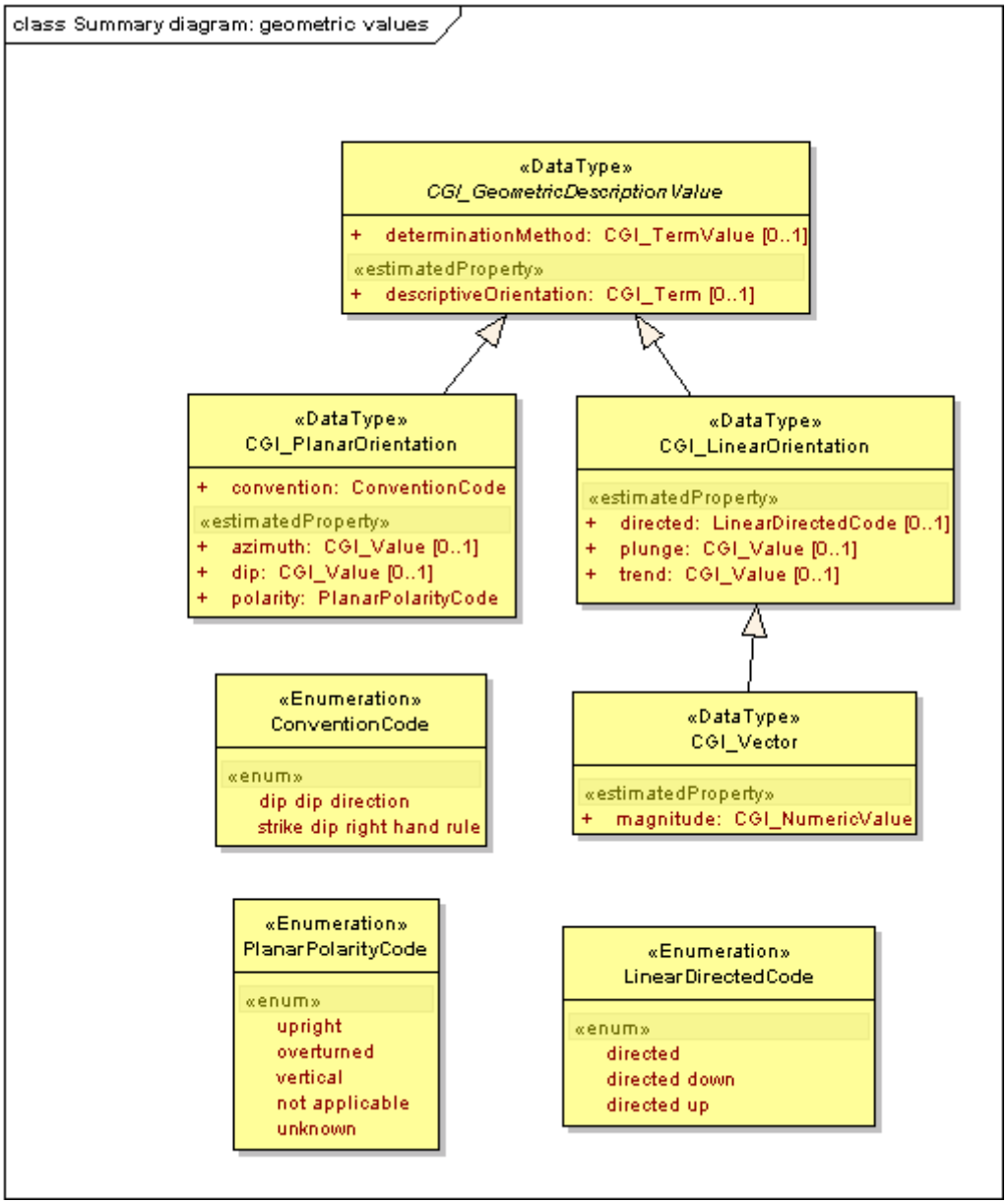

Figure 11: Summary UML diagram for the Geometric Values package

The geometric values model (Figure 11) enables the description of the planar or linear orientation of a geologic feature. Geometric values are particularly used in the GeologicStructure package (see section 3.2.4). For PlanarOrientation values differing measurement conventions (eg right hand rule) can be used and recorded, as can the polarity (upright or overturned) of the feature being measured. LinearOrientations may have an orientation in 3D space, described by trend and plunge, along with a direction and magnitude.

3.2.10 Vocabulary

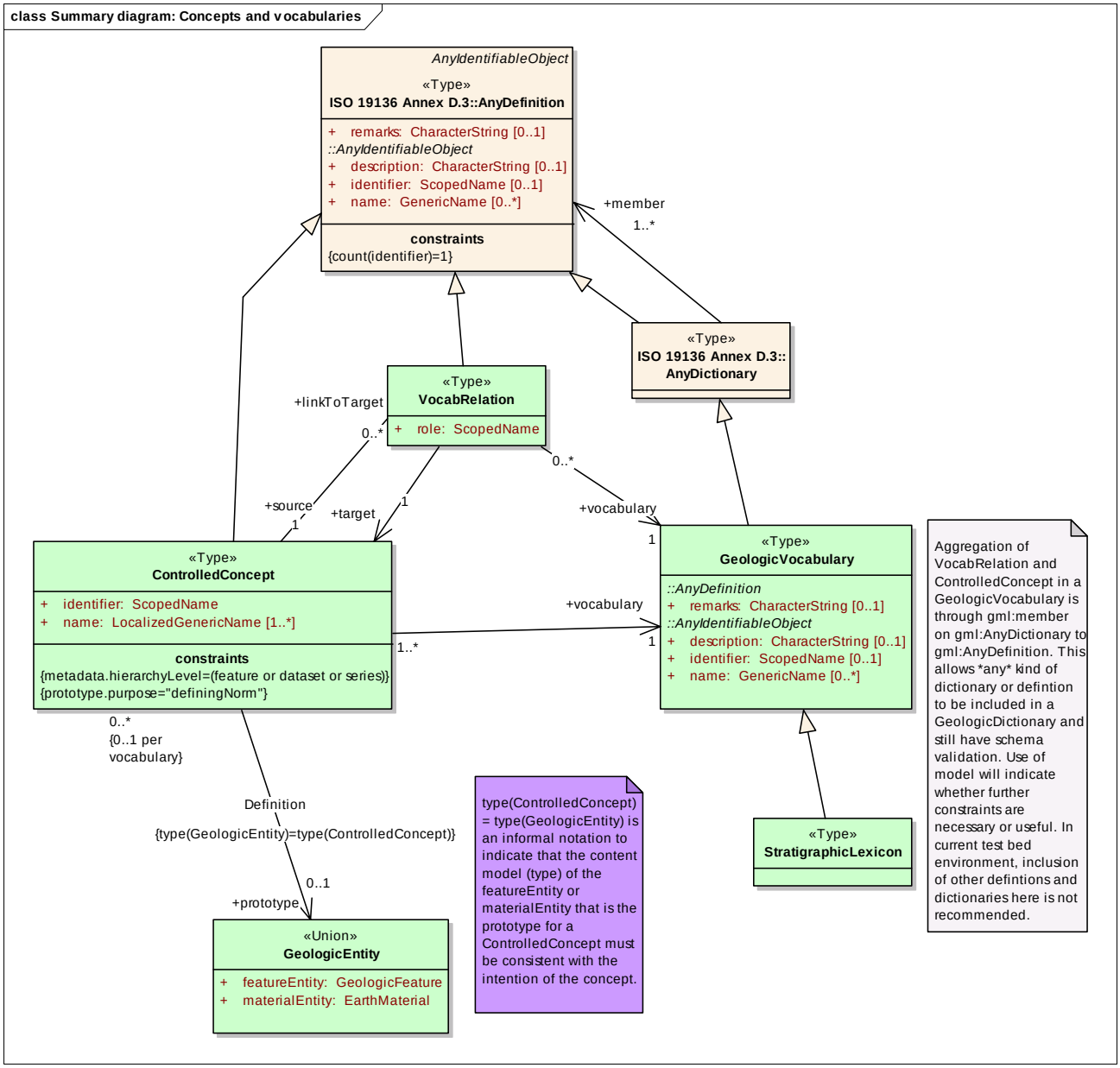

Figure 12: Summary UML diagram for the Vocabulary package

The specification of a GeologicVocabulary is derived as a sub-type from the ISO19136 AnyDictionary definition. A StratigraphicLexicon is defined as a particular sub-type of GeologicVocabulary. A GeologicVocabulary contains members which may be either ControlledConcepts or VocabRelations.

At its simplest a ControlledConcept will have an identifier, name and description. A ControlledConcept can have several names, for example in different languages. More commonly a ControlledConcept will be defined using a GeologicEntity prototype. For example, most geological maps do not have descriptive information about each individual polygon, rather they have a key, usually related to a stratigraphic lexicon, which provides a standard (prototype) definition and description. At present GeologicEntity can be either a GeologicFeature or an EarthMaterial, but potentially more types could be added in the future. The GeologicFeature and EarthMaterial

prototype definitions follow the same pattern for these feature types as described in sections 3.2.1 and 3.2.3 above, but the ‘purpose’ property is set to ‘definingNorm’ to distinguish prototype descriptions from instance descriptions.

VocabRelations enable the relationship between ControlledConcepts to be described and can be used to implement thesaurus type relationships like 'broader than', 'narrower than', 'related term', and 'synonym'. The ‘role’ property specifies the nature of the relationship between the source ControlledConcept and the target ControlledConcept, read as 'source' - 'role' - 'target' (eg metasediment broader than metalimestone).

The Vocabulary package is likely to be replaced at some point by more suitable ontology models, but these are not yet available.

3.2.11 Metadata

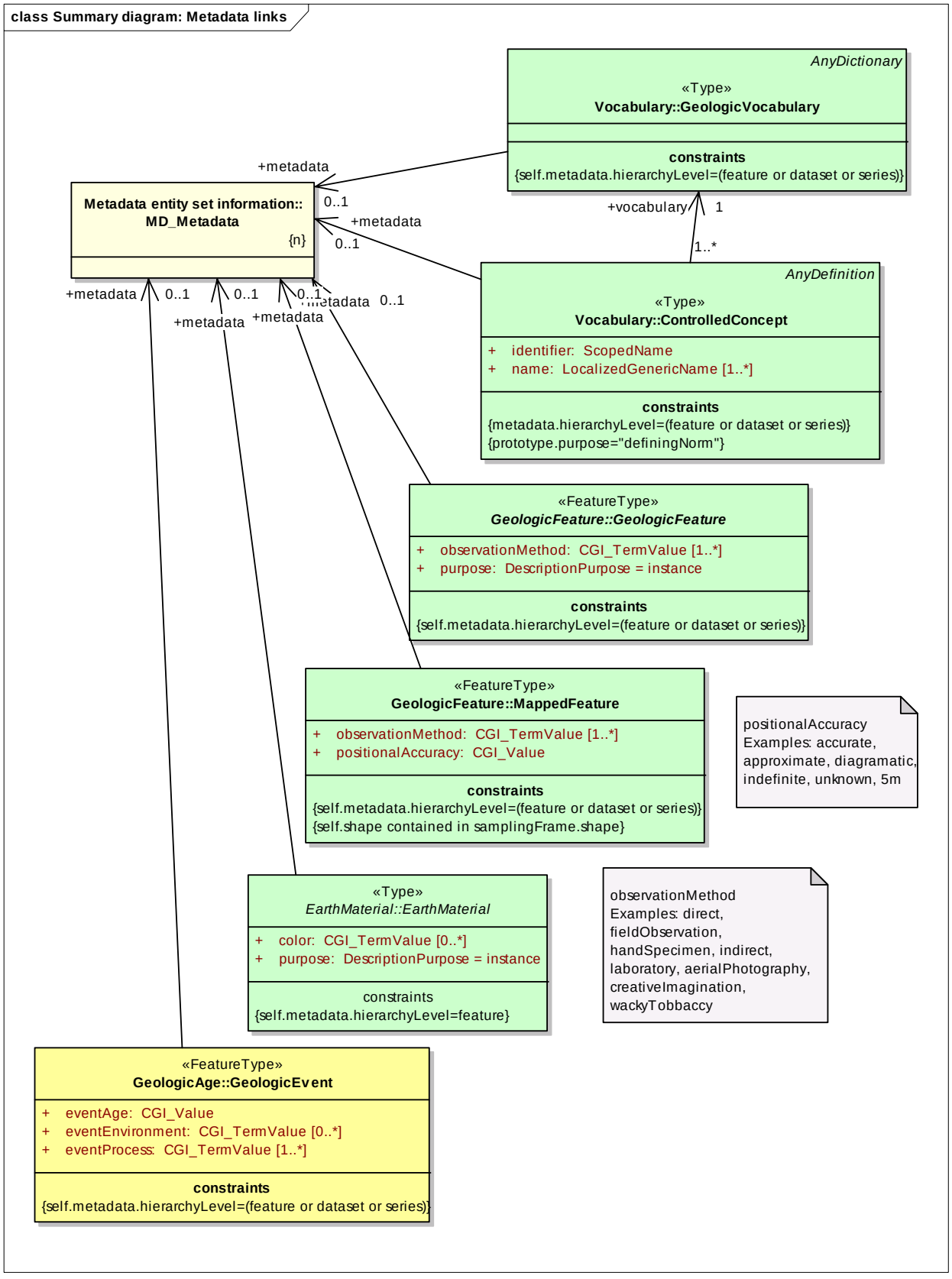

Figure 13: Summary UML diagram for the Metadata package

The GeoSciML Metadata package shows the metadata links from various GeoSciML classes. For metadata support, GeoSciML refers to the (externally maintained) ISO 19115 metadata package (MD_Metadata). The metadata can apply to an individual feature, for example a particular map polygon; a dataset, for example a map sheet; or a series, for example all 1:50k scale bedrock geology maps. Pending GeoSciML migrating to GML v3.2, the XML Schema contains a stub schema representing the actual metadata elements. As well as metadata referring to individual GeoSciML classes, metadata can be provided describing the package of information being delivered in response to a particular WFS call (see section 3.2.12).

3.2.12 Collection

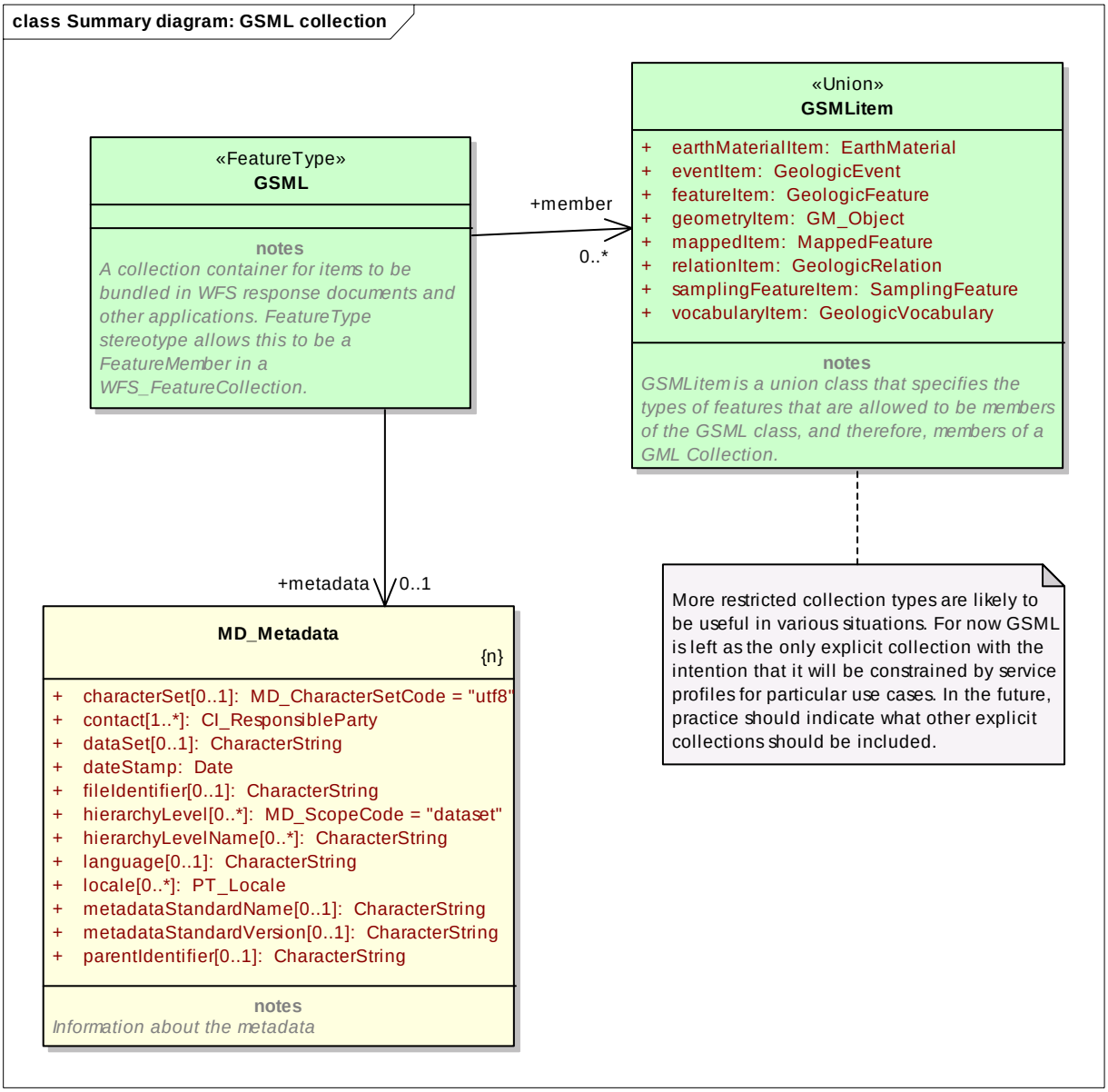

Figure 14: Summary UML diagram for the Collection package

The GSML feature is a container for the information to be sent in response to a WFS request. The GSML container can hold, as members, any of the types of feature in the GSMLitem union class which includes all of the GeoSciML classes. In the future, sub-types of the GSML container may be required to define the scope of information returned in response to particular types of WFS request.

Metadata can be provided about the collection. This is distinct from the metadata describing items within the collection, which is documented in section 3.2.11.

4 GUIDELINES FOR MAPPING DATA TO GEOSCIML

In this version of the guide the mapping from data to the GeoSciML model will be illustrated using the exemplar instance documents produced for GeoSciML Testbed 3, presented at the IGC2008 in August 2008. Each instance document has been designed to address one of the Use Cases developed for TestBed 3, and for each of these a profile diagram shows that part of the model that is being addressed by the Use Case. These can be compared with the diagrams in section 3 which show the complete model. Key points from the mapping are given as notes within the exemplar documents.

The profile and exemplar instance documents for Use Cases 3A and 3D are not included as these are identical to those for Use Cases 2A and 2D respectively. Use Case 3B, although designed as a Use Case for querying, is included as the serialized document returned is an example of encoding Geologic Units.

4.1 Use Case 2A – Mapped Features

This use case is defined as: ‘WFS delivery of all mapped features specified with geologicUnit (or any subtypes) features with properties’. Which properties to include and how deep to traverse circular relationships (like GeologicUnitPart) is not defined.

4.1.1 Profile diagram for Use Case 2A

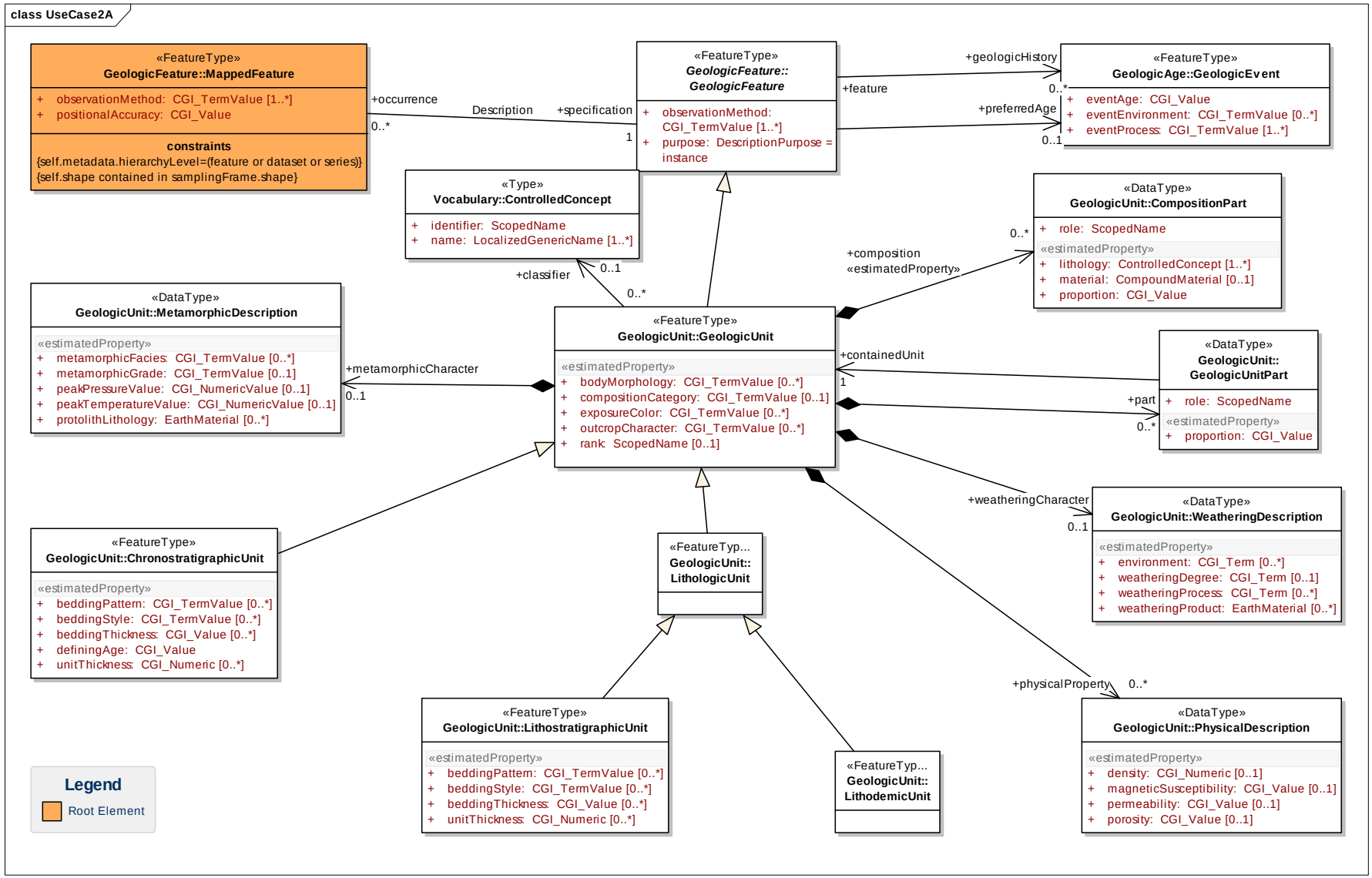

Figure 15: Profile diagram for Use Case 2A

4.1.2 Exemplar GeoSciML for Use Case 2A

```
<?xml version="1.0" encoding="UTF-8"?>
<!-- TB3 Profile Note: The exemplar instances for UC2A and UC3A are identical.  -->
<wfs:FeatureCollection xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/wfs http://schemas.opengis.net/wfs/1.1.0/wfs.xsd urn:cgi:xmlns:CGI:GeoSciML:2.0
http://www.geosciml.org/schemas/geosciml/2.0_rc2/geosciml.xsd" xmlns:gml="http://www.opengis.net/gml" xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:wfs="http://www.opengis.net/wfs"
xmlns:gsml="urn:cgi:xmlns:CGI:GeoSciML:2.0">
   <gml:featureMember>
      <MappedFeature xmlns="urn:cgi:xmlns:CGI:GeoSciML:2.0" gml:id="mf.1">
         <!-- TB3 Profile Note: gml:id can be used to retrieve a particular feature by id from the WFS so each WFS should ensure it
         assigns unique values for each feature it can return. -->
         <!-- TB3 Profile Note: There is no real gml:name appropriate for mapped polygons advise not populating this. -->
          <!-- The gml:description is not worth using unless there is some specific descriptive information available for the particular MappedFeature;
            so don't use this to put a generic description like 'geological polygon' or similar. -->
         <!-- TB3 Profile Note: All organizations examples to date have very generic values for observation method meaning basically
         "geological mapping procedures" which suggests that no-one actually explicitly stores this information at the moment. Thus it
         would be possible to use a CDTG defined term registered in the urn:cgi:classifierScheme:CGI:ObservationMethod:2008 codeSpace.
         As this information will not be the basis of any queries, however, we will not constrain whether people use the cgi codeSpace or their
         own. Need to clarify whether all codeSpaces should be recorded in CGIClassifierSchemeRegister .-->
         <observationMethod>
            <CGI_TermValue>
               <value codeSpace="urn:cgi:classifierScheme:BGS:ObservationMethod">fieldObservation</value>
            </CGI_TermValue>
         </observationMethod>
         <observationMethod>
            <CGI_TermValue>
               <value codeSpace="urn:cgi:classifierScheme:BGS:ObservationMethod">Boreholes</value>
            </CGI_TermValue>
         </observationMethod>
         <!-- TB3 Profile Note: You may use numerical values or your own term values for positionalAccuracy using your own codeSpace.
         For nil values it is preferable to use the OGC URNs although, if you have your own dictionary and this complicates
         the mapping implementation we won't insist. -->
         <positionalAccuracy>
            <CGI_TermValue>
               <value codeSpace="urn:ietf:rfc:2141">urn:ogc:def:nil:OGC:unknown</value>
            </CGI_TermValue>
         </positionalAccuracy>
         <!-- TB3 Profile Note: See https://www.seegrid.csiro.au/twiki/bin/view/CGIModel/CGIFeatureRegister to check if there is a suitable already
            registered suitable feature for your surface of mapping (e.g. urn:cgi:feature:CGI:EarthNaturalSurface). If not you may need to create an
         organisation specific one. -->
         <samplingFrame xlink:href="urn:cgi:feature:BGS:EarthBedrockSurface"/>
         <specification>
            <!-- TB3 Profile Note: Organizations are free to return GeologicUnit or  a subtype like LithodemicUnit etc.
            However, do not return DeformationUnits (which require links to GeologicStructures and are getting too complex for this UseCase. -->
            <GeologicUnit>
               <!-- TB3 Profile Note: Suggest everyone includes a name and description here. -->
               <gml:description>
                  Lithology:
```

A pebbly and cobbly, well-rounded, clast-supported conglomerate of lava, psammite, quartzite and feldspar-porphyry in a matrix of poorly-sorted, fine- to medium-grained lithic sandstone, commonly with lenses of trough cross-bedded pebbly sandstone.

Definition of Lower Boundary:

The base of the formation is placed at the top of a thick succession of andesitic lavas of the Montrose Volcanic Formation where this is conformably and somewhat diachronously overlain by a massive clast-supported conglomerate, above which it passes laterally into, and interfingers with, sandstone of the Tannadice Sandstone Member of the Scone Sandstone Formation.

Definition of Upper Boundary:

A clast-supported conglomerate conformably, somewhat diachronously and locally interfingered with the base of a red, massive or laminated, poorly-sorted siltstone of the Cromlix Mudstone Formation.

Thickness:

Up to 880 m thick in the type area, passing laterally into sandstone of Tannadice Sandstone Member towards the south-west.

Geographical Limits:

North-eastern Midland Valley, between Drumlithie and the River South Esk.

```
</gml:description>
<!-- TB3 Profile Note: A name with a codeSpace of urn:ietf:rfc:2141 should be a URN which uniquely identifies the feature.
 For Testbed participants this will
generally follow the pattern urn:cgi:feature:{your_registered_organization}:{your_unique_feature_id}.
(This is a temporary convention prior to upgrading to GML 3.2 and gml:identifier property.) -->
<gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:feature:BGS:StratigraphicLexicon:DECO</gml:name>
<gml:name codeSpace="urn:cgi:classifierScheme:BGS:StratigraphicLexicon">DECO</gml:name>
<!-- TB3 Profile Note: All organizations examples to date have very generic values for observation method meaning basically
   "published description" which suggests that no-one actually explicitly stores this information at the moment. Thus it
   would be possible to use a CDTG defined term registered in the
   urn:cgi:classifierScheme:CGI:ObservationMethod:2008 codeSpace.
   As this information will not be the basis of any queries, however, we will not constrain whether people use the cgi codeSpace or their
   own. Need to clarify whether all codeSpaces should be recorded in CGIClassifierSchemeRegister .-->
<observationMethod>
   <CGI_TermValue>
      <value codeSpace="urn:cgi:classifierScheme:BGS:ObservationMethod">Summary of published description</value>
   </CGI_TermValue>
</observationMethod>
<!-- TB3 Profile Note: typicalNorm, definingNorm and instance are acceptable. -->
<purpose>instance</purpose>
<!-- TB3 Profile Note: occurrence is optional. -->
<!-- TB3 Profile Note: It is OK to have any CGI_Term for the preferredAge as we are not querying on this. -->
<preferredAge>
   <GeologicEvent>
      <eventAge>
         <CGI_TermRange>
            <lower>
               <CGI_TermValue>
                  <value codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Lochkovian</value>
               </CGI_TermValue>
            </lower>
            <upper>
               <CGI_TermValue>
                  <value codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Pragian</value>
               </CGI_TermValue>
            </upper>
         </CGI_TermRange>
      </eventAge>
      <eventProcess>
         <CGI_TermValue>
            <value codeSpace="urn:cgi:classifierScheme:BGS:GeologicProcess">DEPOSITION</value>
         </CGI_TermValue>
```

```
                </eventProcess>
              </GeologicEvent>
            </preferredAge>
            <!-- TB3 Profile Note: It is OK to put a geologicHistory property if you have that information.
              Note that it is acceptable to have a geologicHistory with only one event.-->
            <!-- TB3 Profile Note: Can include compositionCategory property if you have the data but can omit if you don't. -->
            <!-- TB3 Profile Note: Can include or omit rank depending on whether you have data. -->
            <!-- TB3 Profile Note: It is optional whether to return part property. Refer to TB3_UC3B_GSV_GeologicUnit_All.xml for example. -->
            <!-- TB3 Profile Note: All other properties of GeologicUnit and subtypes are optional and can be included if you have the data.. -->
            <composition>
              <CompositionPart>
                <role codeSpace="urn:cgi:classifierScheme:BGS:RoleVocab">dominantConstituent</role>
                <!-- TB3 Profile Note: BGS has included ControlledConcept inline, others have used xlink:href with a URN value. Will these URNs
                be registered with the registry? No consensus on email discussion yet? -->
                <lithology>
                  <!-- TB3 Profile Note: Should use the CGI Simple Lithology terms at
                  .http://tellus.brgm.fr/exist/brgm_geosciml/concept.xql?request=GetResource&resourcetype=vocabulary&resourcepath=CGI_SimpleLithology_2008.xml -->
                  <!-- TB3 Profile Note: Could also include extra lithology properties using your own dictionaries if you wish. -->
                  <!-- TB3 Profile Note: Example has same gml:id as in register vocabulary for convenience but this cannot be a requirement. -->
                  <ControlledConcept gml:id="CGILith_042">
                    <gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:CGI:SimpleLithology:2008:conglomerate</gml:name>
                    <identifier codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:CGI:SimpleLithology:2008:conglomerate</identifier>
                    <name xml:lang="en" codeSpace="urn:cgi:classifierScheme:CGI:SimpleLithology:2008">conglomerate</name>
                    <vocabulary xlink:href="urn:cgi:classifierScheme:CGI:SimpleLithology:2008"/>
                  </ControlledConcept>
                </lithology>
                <!-- TB3 Profile Note: For use cases 2A and 3A the material property is not required. -->
                <!-- TB3 Profile Note: For proportion use either a numerical percentage or a value from the  dictionary at
                  http://tellus.brgm.fr/exist/brgm_geosciml/concept.xql?request=GetResource&resourcetype=vocabulary&resourcepath=CGI_CompositionPartProportion.xml
                  -->
                <proportion>
                  <CGI_NumericValue>
                    <principalValue uom="urn:ogc:def:uom:UCUM:%25">100</principalValue>
                  </CGI_NumericValue>
                </proportion>
              </CompositionPart>
            </composition>
          </GeologicUnit>
        </specification>
        <!-- To do: put some example polygon data in the shape property. -->
        <shape/>
      </MappedFeature>
    </gml:featureMember>
</wfs:FeatureCollection>
```

4.2 Use Case 2B – Mapped Features with links to Earth Material

The Use Case is defined as: ‘the same as Use Case 2A but the profile includes composition links to EarthMaterial and all related EarthMaterial properties.’ Which properties to include and how deep to traverse circular relationships is not defined. The exemplar instance document also illustrates the encoding of shape (geometry) information.

4.2.1 Profile diagram for Use Case 2B

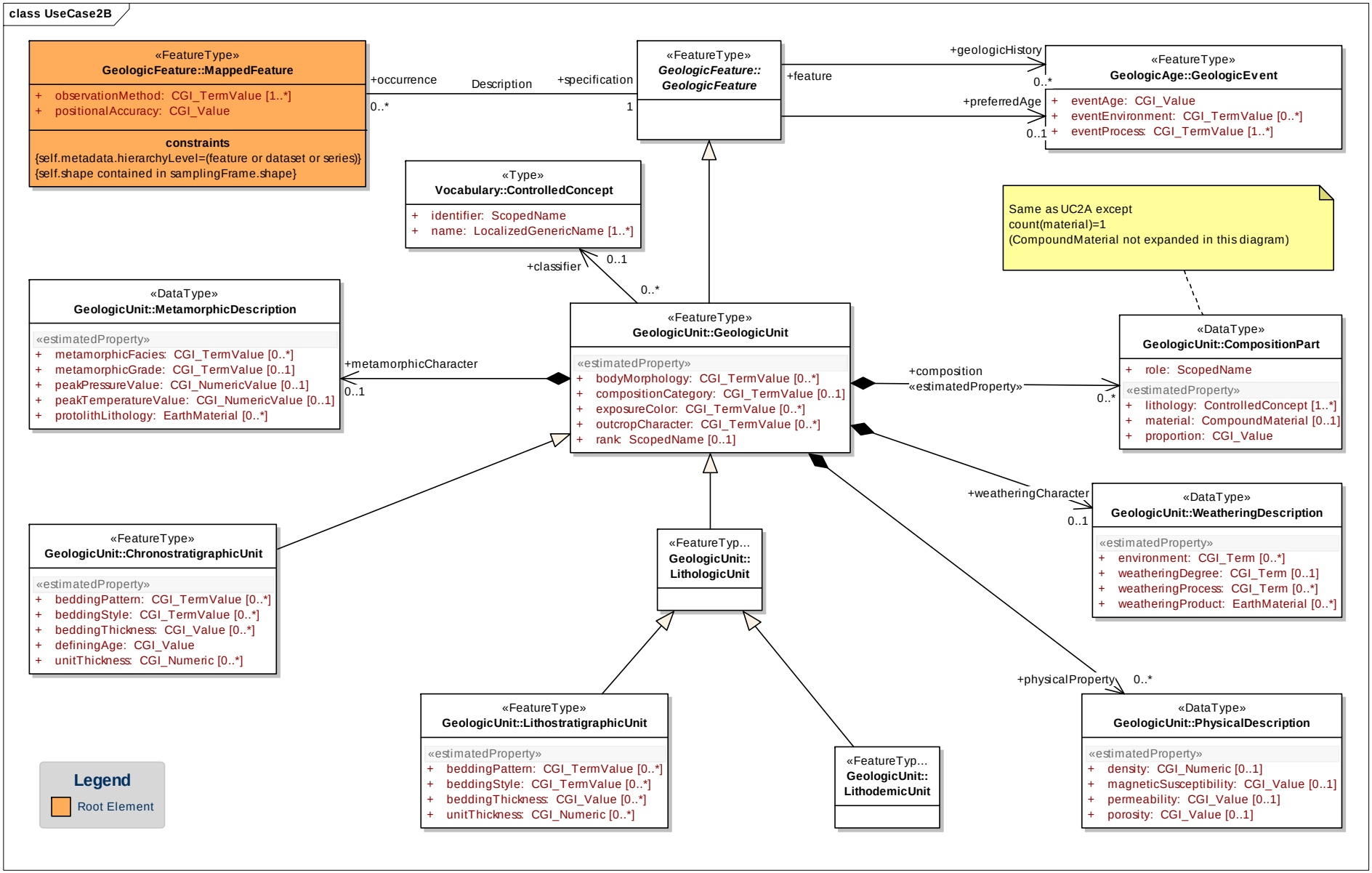

Figure 16: Profile diagram for Use Case 2B

4.2.2 Exemplar GeoSciML for Use Case 2B

```
<?xml version="1.0" encoding="UTF-8"?>
<wfs:FeatureCollection
        xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
        xsi:schemaLocation="http://www.opengis.net/wfs http://schemas.opengis.net/wfs/1.1.0/wfs.xsd urn:cgi:xmlns:CGI:GeoSciML:2.0 http://www.geosciml.org/schemas/geosciml/2.0_rc2/geosciml.xsd"
        xmlns:gml="http://www.opengis.net/gml"
        xmlns:wfs="http://www.opengis.net/wfs"
        xmlns:gsml="urn:cgi:xmlns:CGI:GeoSciML:2.0"
        xmlns:sa="http://www.opengis.net/sampling/1.0"
        xmlns:om="http://www.opengis.net/om/1.0" xmlns:cgu="urn:cgi:xmlns:CGI:Utilities:1.0"
        xmlns:xlink="http://www.w3.org/1999/xlink"
        xmlns:mo="urn:cgi:xmlns:GGIC:MineralOccurrence:1.0"
        gml:id="GA_1M_GeologicUnits_Collection_000001">
        <gml:boundedBy>
                <gml:Envelope srsName="urn:ogc:def:crs:EPSG:4326">
                        <gml:lowerCorner>142.17 -18.56</gml:lowerCorner>
                        <gml:upperCorner>142.173 -20.56</gml:upperCorner>
                </gml:Envelope>
        </gml:boundedBy>
        <gml:featureMember>
                <gsml:MappedFeature gml:id="MappedFeature_5555">  <!-- Concatenate "MappedFeature_" and gsml_geology_1m.objectid -->
                        <!-- TB3 Profile Note: gml:id can be used to retrieve a particular feature by id from the WFS so each WFS should ensure it
                                assigns unique values for each feature it can return. -->
                        <!-- TB3 Profile Note: There is no real gml:name appropriate for mapped polygons advise not populating this. -->
                        <!-- The gml:description is not worth using unless there is some specific descriptive information available for the particular MappedFeature;
                                so don't use this to put a generic description like 'geological polygon' or similar. -->
                        <!-- TB3 Profile Note: All organizations examples to date have very generic values for observation method meaning basically
                                "geological mapping procedures" which suggests that no-one actually explicitly stores this information at the moment. Thus it
                                would be possible to use a CDTG defined term registered in the      urn:cgi:classifierScheme:CGI:ObservationMethod:2008 codeSpace.
                                As this information will not be the basis of any queries, however, we will not constrain whether people use the cgi codeSpace or their
                                own. Need to clarify whether all codeSpaces should be recorded in CGIClassifierSchemeRegister .-->
                        <gsml:observationMethod>
                                <gsml:CGI_TermValue>
                                        <gsml:value codeSpace="urn:cgi:classifierScheme:GA:1MillionGeology_ObservationMethods">Geological Survey of Queensland, 1:100,000 scale geological
maps, July 2004. Simplified, edge matched and modified for representation at 1:1 million scale.</gsml:value>
                                </gsml:CGI_TermValue>
                        </gsml:observationMethod>
                        <!-- TB3 Profile Note: You may use numerical values or your own term values for positionalAccuracy using your own codeSpace.
                                For nil values it is preferable to use the OGC URNs although, if you have your own dictionary and this complicates
                                the mapping implementation we won't insist. -->
                        <gsml:positionalAccuracy>
                                <gsml:CGI_NumericValue>
                                        <gsml:principalValue uom="urn:ogc:def:uom:UCUM:m">500</gsml:principalValue>
                                </gsml:CGI_NumericValue>
                        </gsml:positionalAccuracy>
                        <!-- TB3 Profile Note: See https://www.seegrid.csiro.au/twiki/bin/view/CGIModel/CGIFeatureRegister to check if there is a suitable already
                                registered suitable feature for your surface of mapping (e.g. urn:cgi:feature:CGI:EarthNaturalSurface). If not you may need to create an
                                organisation specific one. -->
```

```
<gsml:samplingFrame xlink:href="urn:cgi:feature:CGI:EarthNaturalSurface"/>
<gsml:specification>
    <!-- TB3 Profile Note: Organizations are free to return GeologicUnit or  a subtype like LithodemicUnit etc.
        However, do not return DeformationUnits (which require links to GeologicStructures and are getting too complex for this UseCase. -->
    <gsml:GeologicUnit gml:id="GA_GeologicUnit_Stratno_38485">
        <!-- TB3 Profile Note: Suggest everyone includes a name and description here. -->
        <gml:description>Channel and flood plain alluvium; gravel, sand, silt, clay</gml:description>  <!-- gsml_geol_stratnames.description  -->
        <!-- TB3 Profile Note: A name with a codeSpace of urn:ietf:rfc:2141 should be a URN which uniquely identifies the feature.
            For Testbed participants this will
            generally follow the pattern urn:cgi:feature:{your_registered_organization}:{your_unique_feature_id}.
            (This is a temporary convention prior to upgrading to GML 3.2 and gml:identifier property.) -->
        <gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:feature:GA:StratigraphicLexicon:Stratno:38485</gml:name>
        <gml:name codeSpace="urn:cgi:classifierScheme:GA:StratigraphicLexicon:Stratname">alluvium 38485</gml:name>
        <gml:name codeSpace="urn:cgi:classifierScheme:GA:StratigraphicLexicon:Map_symbol">Qa</gml:name>
        <!-- TB3 Profile Note: All organizations examples to date have very generic values for observation method meaning basically
            "published description" which suggests that no-one actually explicitly stores this information at the moment. Thus it
            would be possible to use a CDTG defined term registered in the
            urn:cgi:classifierScheme:CGI:ObservationMethod:2008 codeSpace.
            As this information will not be the basis of any queries, however, we will not constrain whether people use the cgi codeSpace or their
            own. Need to clarify whether all codeSpaces should be recorded in CGIClassifierSchemeRegister .-->
        <gsml:observationMethod>
            <gsml:CGI_TermValue>
                <gsml:value codeSpace="urn:cgi:classifierScheme:GA:ObservationMethods">published description</gsml:value>    <!-- Constant value
for this dataset-->
            </gsml:CGI_TermValue>
        </gsml:observationMethod>
        <!-- TB3 Profile Note: typicalNorm, definingNorm and instance are acceptable. -->
        <gsml:purpose>typicalNorm</gsml:purpose>
        <!-- TB3 Profile Note: occurrence is optional. -->
        <!-- TB3 Profile Note: It is OK to have any CGI_Term for the preferredAge as we are not querying on this. -->
        <gsml:preferredAge>
            <gsml:GeologicEvent>
                <gsml:eventAge>
                    <gsml:CGI_TermValue>
                        <gsml:value
codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Quaternary</gsml:value>
                    </gsml:CGI_TermValue>
                </gsml:eventAge>
                <gsml:eventEnvironment>
                    <gsml:CGI_TermValue>
                        <gsml:value codeSpace="urn:cgi:classifierScheme:GA:Process">fluvial</gsml:value>
                    </gsml:CGI_TermValue>
                </gsml:eventEnvironment>
                <gsml:eventProcess>
                    <gsml:CGI_TermValue>
                        <gsml:value codeSpace="urn:cgi:classifierScheme:GA:Process">deposition</gsml:value>
                    </gsml:CGI_TermValue>
                </gsml:eventProcess>
            </gsml:GeologicEvent>
        </gsml:preferredAge>
        <!-- TB3 Profile Note: It is OK to put a geologicHistory property if you have that information.
            Note that it is acceptable to have a geologicHistory with only one event.-->
        <gsml:geologicHistory>
```

```
                        <gsml:GeologicEvent>
                            <gsml:eventAge>
                                <gsml:CGI_TermRange>
                                    <gsml:lower>
                                        <gsml:CGI_TermValue>
                                            <gsml:value
codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Quaternary</gsml:value>
                                        </gsml:CGI_TermValue>
                                    </gsml:lower>
                                    <gsml:upper>
                                        <gsml:CGI_TermValue>
                                            <gsml:value
codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Quaternary</gsml:value>
                                        </gsml:CGI_TermValue>
                                    </gsml:upper>
                                </gsml:CGI_TermRange>
                            </gsml:eventAge>
                            <gsml:eventEnvironment>
                                <gsml:CGI_TermValue>
                                    <gsml:value codeSpace="urn:cgi:classifierScheme:GA:Process">fluvial</gsml:value>
                                </gsml:CGI_TermValue>
                            </gsml:eventEnvironment>
                            <gsml:eventProcess>
                                <gsml:CGI_TermValue>
                                    <gsml:value codeSpace="urn:cgi:classifierScheme:GA:Process">deposition</gsml:value>
                                </gsml:CGI_TermValue>
                            </gsml:eventProcess>
                        </gsml:GeologicEvent>
                    </gsml:geologicHistory>
                    <!-- TB3 Profile Note: Can include compositionCategory property if you have the data but can omit if you don't. -->
                    <gsml:compositionCategory>
                        <gsml:CGI_TermValue>
                            <gsml:value codeSpace="urn:cgi:classifierScheme:GA:CompositionCategory">silicate</gsml:value>
                        </gsml:CGI_TermValue>
                    </gsml:compositionCategory>
                    <!-- TB3 Profile Note: Can include or omit rank depending on whether you have data. -->
                    <gsml:rank codeSpace="urn:cgi:classifierScheme:GA:Rank">formation</gsml:rank>
                    <!-- TB3 Profile Note: It is optional whether to return part property. Refer to TB3_UC3B_GSV_GeologicUnit_All.xml for example. -->
                    <!-- TB3 Profile Note: All other properties of GeologicUnit and subtypes are optional and can be included if you have the data.. -->
                    <gsml:classifier xlink:href="urn:cgi:classifier:GA:StratigraphicLexicon:Stratno:38485"/>
                    <gsml:composition>
                        <gsml:CompositionPart>
                            <gsml:role codeSpace="urn:cgi:classifierScheme:GA:Role">part of</gsml:role>
                            <!-- TB3 Profile Note: BGS has included ControlledConcept inline, others have used xlink:href with a URN value. Will these URNs
                                be registered with the registry? No consensus on email discussion yet? -->
                            <gsml:lithology>
                                <!-- TB3 Profile Note: Should use the CGI Simple Lithology terms at
http://tellus.brgm.fr/exist/brgm_geosciml/concept.xql?request=GetResource&resourcetype=vocabulary&resourcepath=CGI_SimpleLithology_2008.xml -->
                                <!-- TB3 Profile Note: Could also include extra lithology properties using your own dictionaries if you wish. -->
                                <!-- TB3 Profile Note: Example has same gml:id as in register vocabulary for convenience but this cannot be a requirement. -->
                                <gsml:ControlledConcept gml:id="CGILith_036">
                                    <gml:name
codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:CGI:SimpleLithology:2008:clastic_sediment</gml:name>
```

```
                                                                        <gsml:identifier
codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:CGI:SimpleLithology:2008:clastic_sediment</gsml:identifier>
                                                                        <gsml:name xml:lang="en" codeSpace="urn:cgi:classifierScheme:CGI:SimpleLithology:2008">clastic
sediment</gsml:name>
                                                                        <gsml:vocabulary xlink:href="urn:cgi:classifierScheme:CGI:SimpleLithology:2008"/>
                                                                </gsml:ControlledConcept>
                                                        </gsml:lithology>
                                                        <gsml:material>
                                                                <gsml:UnconsolidatedMaterial>
                                                                        <gsml:purpose>instance</gsml:purpose>
                                                                        <gsml:compositionCategory>
                                                                                <gsml:CGI_TermValue>
                                                                                        <gsml:value
codeSpace="urn:cgi:classifierScheme:GA:CompositionCategory">unknown</gsml:value>
                                                                                </gsml:CGI_TermValue>
                                                                        </gsml:compositionCategory>
                                                                        <gsml:geneticCategory>
                                                                                <gsml:CGI_TermValue>
                                                                                        <gsml:value
codeSpace="urn:cgi:classifierScheme:GA:GeneticCategory">sedimentary</gsml:value>    <!-- gsml_lithology_vocab.geneticCategory for the lithology  -->
                                                                                </gsml:CGI_TermValue>
                                                                        </gsml:geneticCategory>
                                                                        <!-- TB3 Profile Note: In the case of UnconsolidatedMaterial it would be useful to
                                                                        illustrate the use of the gsml:part association if the data can be provided. -->
                                                                        <gsml:consolidationDegree>
                                                                                <gsml:CGI_TermValue>
                                                                                        <gsml:value
codeSpace="urn:cgi:classifierScheme:GA:ConsolidationDegree">unknown</gsml:value>  <!-- constant -->
                                                                                </gsml:CGI_TermValue>
                                                                        </gsml:consolidationDegree>
                                                                        <gsml:lithology xlink:href="#CGILith_036"/>  <!-- Use gml:id of gsml:CompositionPart/lithology   -->
                                                                </gsml:UnconsolidatedMaterial>
                                                        </gsml:material>
                                                        <!-- TB3 Profile Note: For proportion use either a numerical percentage or a value from the  dictionary at
http://tellus.brgm.fr/exist/brgm_geosciml/concept.xql?request=GetResource&resourcetype=vocabulary&resourcepath=CGI_CompositionPartProportion.xml
                                                        -->
                                                        <gsml:proportion>
                                                                <gsml:CGI_TermValue>
                                                                        <gsml:value codeSpace="urn:ietf:rfc:2141">urn:ogc:def:nil:OGC:unknown</gsml:value>
                                                                </gsml:CGI_TermValue>
                                                        </gsml:proportion>
                                                </gsml:CompositionPart>
                                        </gsml:composition>
                                </gsml:GeologicUnit>
                        </gsml:specification>
                        <gsml:shape>
                                <gml:Polygon srsName="urn:ogc:def:crs:EPSG:4326">
                                        <gml:outerBoundaryIs>
                                                <gml:LinearRing>
                                                        <gml:posList> 143.019928248895 -18.4179733837457 143.019752415561 -18.4162544948568 143.274354099028 -17.807396261653
                                                143.274213366215 -17.8075344771032 </gml:posList>
                                                </gml:LinearRing>
                                        </gml:innerBoundaryIs>
```

<gml:innerBoundaryIs>
<gml:LinearRing>
<gml:posList> 143.228436177555 -17.9495477320497 143.227511816447 -17.9480527099533 143.227319970513 -17.947963857735 141.467803212896 -17.296648488443 141.473443311439 -17.296403262635 141.477366867342 -17.2961580558352 </gml:posList>
</gml:LinearRing>
</gml:innerBoundaryIs>
</gml:Polygon>
</gsml:shape>
</gsml:MappedFeature>
</gml:featureMember>
<gml:featureMember>
<gsml:MappedFeature gml:id="MappedFeature_999999">
<gml:description>Geological unit polygon</gml:description>
<gml:name>1M_geology_polygon_999999</gml:name>
<gsml:observationMethod>
<gsml:CGI_TermValue>
<gsml:value codeSpace="urn:cgi:classifierScheme:GA:1MillionGeology_ObservationMethods">Smout, J., Grimes, K.G., Poutch, H.F., Swoboda, R.A., Russell, E.A., 1980, Carpentaria and Karumba Basins 1:1,000,000, Geological Survey of Queensland & Bureau of Mineral Resources.</gsml:value>
</gsml:CGI_TermValue>
</gsml:observationMethod>
<gsml:positionalAccuracy>
<gsml:CGI_NumericValue>
<gsml:principalValue uom="urn:ogc:def:uom:UCUM:m">1500</gsml:principalValue>
</gsml:CGI_NumericValue>
</gsml:positionalAccuracy>
<gsml:samplingFrame xlink:href="urn:cgi:feature:CGI:EarthNaturalSurface"/>
<gsml:specification> <!-- This unit is an example of a unit with multiple gsml:composition elements -->
<gsml:GeologicUnit gml:id="GA_GeologicUnit_Stratno_134">
<gml:description>Medium to coarse-grained hornblende diorite, metagabbro; very minor acid veins</gml:description>
<gml:name codeSpace="urn:cgi:classifierScheme:GA:StratigraphicLexicon:Stratname">Adelong Norite</gml:name>
<gml:name codeSpace="urn:cgi:classifierScheme:GA:StratigraphicLexicon:Map_symbol">Sgad</gml:name>
<gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:feature:GA:StratigraphicLexicon:Stratno:134</gml:name>
<gsml:observationMethod>
<gsml:CGI_TermValue>
<gsml:value codeSpace="urn:cgi:classifierScheme:GA:ObservationMethods">published description</gsml:value>
</gsml:CGI_TermValue>
</gsml:observationMethod>
<gsml:purpose>typicalNorm</gsml:purpose>
<gsml:preferredAge>
<gsml:GeologicEvent>
<gsml:eventAge>
<gsml:CGI_TermValue>
<gsml:value codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Silurian</gsml:value>
</gsml:CGI_TermValue>
</gsml:eventAge>
<gsml:eventProcess>
<gsml:CGI_TermValue>
<gsml:value codeSpace="urn:cgi:classifierScheme:GA:Process">intrusion</gsml:value>
</gsml:CGI_TermValue>
</gsml:eventProcess>
</gsml:GeologicEvent>
</gsml:preferredAge>

```
                                        <gsml:geologicHistory>
                                                <gsml:GeologicEvent>
                                                        <gsml:eventAge>
                                                                <gsml:CGI_TermRange>
                                                                        <gsml:lower>
                                                                                <gsml:CGI_TermValue>
                                                                                        <gsml:value
codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Silurian</gsml:value>
                                                                                </gsml:CGI_TermValue>
                                                                        </gsml:lower>
                                                                        <gsml:upper>
                                                                                <gsml:CGI_TermValue>
                                                                                        <gsml:value
codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Silurian</gsml:value>
                                                                                </gsml:CGI_TermValue>
                                                                        </gsml:upper>
                                                                </gsml:CGI_TermRange>
                                                        </gsml:eventAge>
                                                        <gsml:eventProcess>
                                                                <gsml:CGI_TermValue>
                                                                        <gsml:value codeSpace="urn:cgi:classifierScheme:GA:Process">intrusion</gsml:value>
                                                                </gsml:CGI_TermValue>
                                                        </gsml:eventProcess>
                                                </gsml:GeologicEvent>
                                        </gsml:geologicHistory>
                                        <gsml:compositionCategory>
                                                <gsml:CGI_TermValue>
                                                        <gsml:value codeSpace="urn:cgi:classifierScheme:GA:CompositionCategory">basic</gsml:value>
                                                </gsml:CGI_TermValue>
                                        </gsml:compositionCategory>
                                        <gsml:rank codeSpace="urn:cgi:classifierScheme:GA:Rank">formation</gsml:rank>
                                        <gsml:classifier xlink:href="urn:cgi:classifier:GA:StratigraphicLexicon:Stratno:134"/>
                                        <gsml:composition> <!-- If there are multiple values in gsml_geol_strat_liths, then create multiple gsml:composition elements -->
                                                <gsml:CompositionPart>
                                                        <gsml:role codeSpace="urn:cgi:classifierScheme:GA:Role">part of</gsml:role>
                                                        <gsml:lithology>
                                                                <gsml:ControlledConcept gml:id="CGILith_070">
                                                                        <gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:CGI:SimpleLithology:2008:gabbro</gml:name>
                                                                        <gsml:identifier
codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:CGI:SimpleLithology:2008:gabbro</gsml:identifier>
                                                                        <gsml:name codeSpace="urn:cgi:classifierScheme:CGI:SimpleLithology:2008"
xml:lang="en">gabbro</gsml:name>
                                                                        <gsml:vocabulary xlink:href="urn:cgi:classifierScheme:CGI:SimpleLithology:2008"/>
                                                                </gsml:ControlledConcept>
                                                        </gsml:lithology>
                                                        <gsml:material>
                                                                <gsml:Rock>
                                                                        <gsml:purpose>instance</gsml:purpose>
                                                                        <gsml:compositionCategory>
                                                                                <gsml:CGI_TermValue>
                                                                                        <gsml:value
codeSpace="urn:cgi:classifierScheme:GA:CompositionCategory">basic</gsml:value>
                                                                                </gsml:CGI_TermValue>
```

```
                                                                    </gsml:compositionCategory>
                                                                    <gsml:geneticCategory>
                                                                        <gsml:CGI_TermValue>
                                                                            <gsml:value
codeSpace="urn:cgi:classifierScheme:GA:GeneticCategory">plutonic</gsml:value>
                                                                        </gsml:CGI_TermValue>
                                                                    </gsml:geneticCategory>
                                                                    <gsml:consolidationDegree>
                                                                        <gsml:CGI_TermValue>
                                                                            <gsml:value
codeSpace="urn:cgi:classifierScheme:GA:ConsolidationDegree">unknown</gsml:value>
                                                                        </gsml:CGI_TermValue>
                                                                    </gsml:consolidationDegree>
                                                                    <gsml:lithology xlink:href="#CGILith_070"/>
                                                                </gsml:Rock>
                                                            </gsml:material>
                                                            <gsml:proportion>
                                                                <gsml:CGI_TermValue>
                                                                    <gsml:value codeSpace="urn:cgi:classifierScheme:GA:Proportion">unknown</gsml:value>
                                                                </gsml:CGI_TermValue>
                                                            </gsml:proportion>
                                                        </gsml:CompositionPart>
                                                    </gsml:composition>
                                                    <gsml:composition>
                                                        <gsml:CompositionPart>
                                                            <gsml:role codeSpace="urn:cgi:classifierScheme:GA:Role">part of</gsml:role>
                                                            <gsml:lithology>
                                                                <gsml:ControlledConcept gml:id="CGILith_048">
                                                                    <gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:CGI:SimpleLithology:2008:dioritic rock</gml:name>
                                                                    <gsml:identifier
codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:CGI:SimpleLithology:2008:dioritic_rock</gsml:identifier>
                                                                    <gsml:name codeSpace="urn:cgi:classifierScheme:CGI:SimpleLithology:2008" xml:lang="en">dioritic
rock</gsml:name>
                                                                    <gsml:vocabulary xlink:href="urn:cgi:classifierScheme:CGI:SimpleLithology:2008"/>
                                                                </gsml:ControlledConcept>
                                                            </gsml:lithology>
                                                            <gsml:material>
                                                                <gsml:Rock>
                                                                    <gsml:purpose>instance</gsml:purpose>
                                                                    <gsml:compositionCategory>
                                                                        <gsml:CGI_TermValue>
                                                                            <gsml:value
codeSpace="urn:cgi:classifierScheme:GA:CompositionCategory">basic</gsml:value>
                                                                        </gsml:CGI_TermValue>
                                                                    </gsml:compositionCategory>
                                                                    <gsml:geneticCategory>
                                                                        <gsml:CGI_TermValue>
                                                                            <gsml:value
codeSpace="urn:cgi:classifierScheme:GA:GeneticCategory">plutonic</gsml:value>
                                                                        </gsml:CGI_TermValue>
                                                                    </gsml:geneticCategory>
                                                                    <gsml:consolidationDegree>
                                                                        <gsml:CGI_TermValue>
```

<gsml:value codeSpace="urn:cgi:classifierScheme:GA:ConsolidationDegree">unknown</gsml:value>
</gsml:CGI_TermValue>
</gsml:consolidationDegree>
<gsml:lithology xlink:href="#CGILith_048"/>
</gsml:Rock>
</gsml:material>
<gsml:proportion>
<gsml:CGI_TermValue>
<gsml:value codeSpace="urn:cgi:classifierScheme:GA:Proportion">unknown</gsml:value>
</gsml:CGI_TermValue>
</gsml:proportion>
</gsml:CompositionPart>
</gsml:composition>
</gsml:GeologicUnit>
</gsml:specification>
<gsml:shape>
<gml:Polygon srsName="urn:ogc:def:crs:EPSG:4326">
<gml:outerBoundaryIs>
<gml:LinearRing>
<gml:posList> 142.1 -19.2583990608557 142.172068544096 -19.2546485090388 142.155416913158 -19.2516959832536
142.141116191144 -19.2449615283995 142.136385949755 -19.2457329336206 142.136395566884 -19.2479970732439 142.140372291732 -19.2517521359808 142.153849380413 -19.2577358051352
142.168928361458 -19.2599404653786 142.172899243883 -19.2621870745973 142.176062814743 -19.262174894991 142.1 -19.2583990608557 </gml:posList>
</gml:LinearRing>
</gml:outerBoundaryIs>
</gml:Polygon>
</gsml:shape>
</gsml:MappedFeature>
</gml:featureMember>
<gml:featureMember>
<gsml:MappedFeature gml:id="MappedFeature_11462">
<gml:description>Geological unit polygon</gml:description>
<gml:name>1M_geology_polygon_11462</gml:name>
<gsml:observationMethod>
<gsml:CGI_TermValue>
<gsml:value codeSpace="urn:cgi:classifierScheme:GA:1MillionGeology_ObservationMethods">Smout, J., Grimes, K.G., Poutch, H.F., Swoboda, R.A., Russell,
E.A., 1980, Carpentaria and Karumba Basins 1:1,000,000, Geological Survey of Queensland & Bureau of Mineral Resources.</gsml:value>
</gsml:CGI_TermValue>
</gsml:observationMethod>
<gsml:positionalAccuracy>
<gsml:CGI_NumericValue>
<gsml:principalValue uom="urn:ogc:def:uom:UCUM:m">1500</gsml:principalValue>
</gsml:CGI_NumericValue>
</gsml:positionalAccuracy>
<gsml:samplingFrame xlink:href="urn:cgi:feature:CGI:EarthNaturalSurface"/>
<gsml:specification>
<gsml:GeologicUnit gml:id="GA_GeologicUnit_Stratno_38484">
<gml:description>Quaternary sediments, undivided</gml:description>
<gml:name codeSpace="urn:cgi:classifierScheme:GA:StratigraphicLexicon:Stratname">sediments 38484</gml:name>
<gml:name codeSpace="urn:cgi:classifierScheme:GA:StratigraphicLexicon:Map_symbol">Qs</gml:name>
<gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:feature:GA:StratigraphicLexicon:Stratno:38484</gml:name>
<gsml:observationMethod>
<gsml:CGI_TermValue>

```
                                                <gsml:value codeSpace="urn:cgi:classifierScheme:GA:ObservationMethods">published description</gsml:value>
                                        </gsml:CGI_TermValue>
                                </gsml:observationMethod>
                                <gsml:purpose>typicalNorm</gsml:purpose>
                                <gsml:preferredAge>
                                        <gsml:GeologicEvent>
                                                <gsml:eventAge>
                                                        <gsml:CGI_TermValue>
                                                                <gsml:value
codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Quaternary</gsml:value>
                                                        </gsml:CGI_TermValue>
                                                </gsml:eventAge>
                                                <gsml:eventProcess>
                                                        <gsml:CGI_TermValue>
                                                                <gsml:value codeSpace="urn:cgi:classifierScheme:GA:Process">deposition</gsml:value>
                                                        </gsml:CGI_TermValue>
                                                </gsml:eventProcess>
                                        </gsml:GeologicEvent>
                                </gsml:preferredAge>
                                <gsml:geologicHistory>
                                        <gsml:GeologicEvent>
                                                <gsml:eventAge>
                                                        <gsml:CGI_TermRange>
                                                                <gsml:lower>
                                                                        <gsml:CGI_TermValue>
                                                                                <gsml:value
codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Quaternary</gsml:value>
                                                                        </gsml:CGI_TermValue>
                                                                </gsml:lower>
                                                                <gsml:upper>
                                                                        <gsml:CGI_TermValue>
                                                                                <gsml:value
codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Quaternary</gsml:value>
                                                                        </gsml:CGI_TermValue>
                                                                </gsml:upper>
                                                        </gsml:CGI_TermRange>
                                                </gsml:eventAge>
                                                <gsml:eventProcess>
                                                        <gsml:CGI_TermValue>
                                                                <gsml:value codeSpace="urn:cgi:classifierScheme:GA:Process">deposition</gsml:value>
                                                        </gsml:CGI_TermValue>
                                                </gsml:eventProcess>
                                        </gsml:GeologicEvent>
                                </gsml:geologicHistory>
                                <gsml:compositionCategory>
                                        <gsml:CGI_TermValue>
                                                <gsml:value codeSpace="urn:cgi:classifierScheme:GA:CompositionCategory">unknown</gsml:value>
                                        </gsml:CGI_TermValue>
                                </gsml:compositionCategory>
                                <gsml:rank codeSpace="urn:cgi:classifierScheme:GA:Rank">formation</gsml:rank>
                                <gsml:classifier xlink:href="urn:cgi:classifier:GA:StratigraphicLexicon:Stratno:38484">
<!--                                    <gsml:ControlledConcept gml:id="GA_stratno_38484">
                                                <gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:GA:StratigraphicLexicon:Stratno:38484</gml:name>
```

```
                                        <gsml:identifier codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:GA:StratigraphicLexicon:Stratno:38484</gsml:identifier>
                                        <gsml:name xml:lang="en" codeSpace="urn:cgi:classifierScheme:GA:StratigraphicLexicon:Stratname">sediments 38484</gsml:name>
                                        <gsml:name xml:lang="en" codeSpace="urn:cgi:classifierScheme:GA:StratigraphicLexicon:Map_symbol">Qs</gsml:name>
                                        <gsml:vocabulary xlink:href="urn:cgi:classifierScheme:GA:StratigraphicLexicon"/>
                                </gsml:ControlledConcept>-->
                        </gsml:classifier>
                        <gsml:composition>
                                <gsml:CompositionPart>
                                        <gsml:role codeSpace="urn:cgi:classifierScheme:GA:Role">part of</gsml:role>
                                        <gsml:lithology xlink:href="#CGILith_036"/>  <!-- xlink ref to "clastic sediment".  First ref is in line (see above) -->
                                        <gsml:material>
                                                <gsml:UnconsolidatedMaterial>
                                                        <gsml:purpose>instance</gsml:purpose>
                                                        <gsml:compositionCategory>
                                                                <gsml:CGI_TermValue>
                                                                        <gsml:value
codeSpace="urn:cgi:classifierScheme:GA:CompositionCategory">unknown</gsml:value>
                                                                </gsml:CGI_TermValue>
                                                        </gsml:compositionCategory>
                                                        <gsml:geneticCategory>
                                                                <gsml:CGI_TermValue>
                                                                        <gsml:value
codeSpace="urn:cgi:classifierScheme:GA:GeneticCategory">sedimentary</gsml:value>
                                                                </gsml:CGI_TermValue>
                                                        </gsml:geneticCategory>
                                                        <gsml:consolidationDegree>
                                                                <gsml:CGI_TermValue>
                                                                        <gsml:value
codeSpace="urn:cgi:classifierScheme:GA:ConsolidationDegree">unknown</gsml:value>
                                                                </gsml:CGI_TermValue>
                                                        </gsml:consolidationDegree>
                                                        <gsml:lithology xlink:href="#CGILith_036"/>
                                                </gsml:UnconsolidatedMaterial>
                                        </gsml:material>
                                        <gsml:proportion>
                                                <gsml:CGI_TermValue>
                                                        <gsml:value codeSpace="urn:cgi:classifierScheme:GA:Proportion">unknown</gsml:value>
                                                </gsml:CGI_TermValue>
                                        </gsml:proportion>
                                </gsml:CompositionPart>
                        </gsml:composition>
                </gsml:GeologicUnit>
        </gsml:specification>
        <gsml:shape>
                <gml:Polygon srsName="urn:ogc:def:crs:EPSG:4326">
                        <gml:outerBoundaryIs>
                                <gml:LinearRing>
                                        <gml:posList> 142.177639798951 -19.2583990608557 142.172068544096 -19.2546485090388 142.155416913158 -19.2516959832536
142.141116191144 -19.2449615283995 142.136385949755 -19.2457329336206 142.136395566884 -19.2479970732439 142.140372291732 -19.2517521359808 142.153849380413 -19.2577358051352
142.168928361458 -19.2599404653786 142.172899243883 -19.2621870745973 142.176062814743 -19.262174894991 142.177639798951 -19.2583990608557 </gml:posList>
                                </gml:LinearRing>
                        </gml:outerBoundaryIs>
                </gml:Polygon>
```

```
                        </gsml:shape>
                    </gsml:MappedFeature>
                </gml:featureMember>
                <gml:featureMember>
                    <gsml:MappedFeature gml:id="MappedFeature_11341">
                        <gml:description>Geological unit polygon</gml:description>
                        <gml:name>1M_geology_polygon_11341</gml:name>
                        <gsml:observationMethod>
                            <gsml:CGI_TermValue>
                                <gsml:value codeSpace="urn:cgi:classifierScheme:GA:1MillionGeology_ObservationMethods">Smout, J., Grimes, K.G., Poutch, H.F., Swoboda, R.A., Russell,
E.A., 1980, Carpentaria and Karumba Basins 1:1,000,000, Geological Survey of Queensland &amp;amp; Bureau of Mineral Resources.</gsml:value>
                            </gsml:CGI_TermValue>
                        </gsml:observationMethod>
                        <gsml:positionalAccuracy>
                            <gsml:CGI_NumericValue>
                                <gsml:principalValue uom="urn:ogc:def:uom:UCUM:m">1500</gsml:principalValue>
                            </gsml:CGI_NumericValue>
                        </gsml:positionalAccuracy>
                        <gsml:samplingFrame xlink:href="urn:cgi:feature:CGI:EarthNaturalSurface"/>
                        <gsml:specification xlink:href="#GA_GeologicUnit_Stratno_38484"/>  <!-- xlink ref to unit described above -->
                        <gsml:shape>
                            <gml:Polygon srsName="urn:ogc:def:crs:EPSG:4326">
                                <gml:outerBoundaryIs>
                                    <gml:LinearRing>
                                        <gml:posList> 142.213110178538 -19.2205518057331 142.205966387869 -19.2160542100034 142.179787766919 -19.2093689425853
142.164716518787 -19.2026408667063 142.161532761034 -19.2034070041275 142.163939693161 -19.2071678093696 142.176648483254 -19.2146613609424 142.20837070366 -19.2243406910478
142.210761360764 -19.2243311133382 142.213110178538 -19.2205518057331 </gml:posList>
                                    </gml:LinearRing>
                                </gml:outerBoundaryIs>
                            </gml:Polygon>
                        </gsml:shape>
                    </gsml:MappedFeature>
                </gml:featureMember>
                <gml:featureMember>
                    <gsml:MappedFeature gml:id="MappedFeature_6512">
                        <gml:description>Geological unit polygon</gml:description>
                        <gml:name>1M_geology_polygon_6512</gml:name>
                        <gsml:observationMethod>
                            <gsml:CGI_TermValue>
                                <gsml:value codeSpace="urn:cgi:classifierScheme:GA:1MillionGeology_ObservationMethods">Smout, J., Grimes, K.G., Poutch, H.F., Swoboda, R.A., Russell,
E.A., 1980, Carpentaria and Karumba Basins 1:1,000,000, Geological Survey of Queensland &amp;amp; Bureau of Mineral Resources.</gsml:value>
                            </gsml:CGI_TermValue>
                        </gsml:observationMethod>
                        <gsml:positionalAccuracy>
                            <gsml:CGI_NumericValue>
                                <gsml:principalValue uom="urn:ogc:def:uom:UCUM:m">1500</gsml:principalValue>
                            </gsml:CGI_NumericValue>
                        </gsml:positionalAccuracy>
                        <gsml:samplingFrame xlink:href="urn:cgi:feature:CGI:EarthNaturalSurface"/>
                        <gsml:specification>
                            <gsml:GeologicUnit gml:id="GA_GeologicUnit_Stratno_4090">
                                <gml:description>Clayey quartzose sand and sandy mud; minor gravel</gml:description>
                                <gml:name codeSpace="urn:cgi:classifierScheme:GA:StratigraphicLexicon:Stratname">Claraville beds</gml:name>
```

```
                                        <gml:name codeSpace="urn:cgi:classifierScheme:GA:StratigraphicLexicon:Map_symbol">Czcla</gml:name>
                                        <gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:feature:GA:StratigraphicLexicon:Stratno:4090</gml:name>
                                        <gsml:observationMethod>
                                                <gsml:CGI_TermValue>
                                                        <gsml:value codeSpace="urn:cgi:classifierScheme:GA:ObservationMethods">published description</gsml:value>
                                                </gsml:CGI_TermValue>
                                        </gsml:observationMethod>
                                        <gsml:purpose>typicalNorm</gsml:purpose>
                                        <gsml:preferredAge>
                                                <gsml:GeologicEvent>
                                                        <gsml:eventAge>
                                                                <gsml:CGI_TermValue>
                                                                        <gsml:value
codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Cenozoic</gsml:value>
                                                                </gsml:CGI_TermValue>
                                                        </gsml:eventAge>
                                                        <gsml:eventProcess>
                                                                <gsml:CGI_TermValue>
                                                                        <gsml:value codeSpace="urn:cgi:classifierScheme:GA:Process">deposition</gsml:value>
                                                                </gsml:CGI_TermValue>
                                                        </gsml:eventProcess>
                                                </gsml:GeologicEvent>
                                        </gsml:preferredAge>
                                        <gsml:geologicHistory>
                                                <gsml:GeologicEvent>
                                                        <gsml:eventAge>
                                                                <gsml:CGI_TermRange>
                                                                        <gsml:lower>
                                                                                <gsml:CGI_TermValue>
                                                                                        <gsml:value
codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Pleistocene</gsml:value>
                                                                                </gsml:CGI_TermValue>
                                                                        </gsml:lower>
                                                                        <gsml:upper>
                                                                                <gsml:CGI_TermValue>
                                                                                        <gsml:value
codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Pliocene</gsml:value>
                                                                                </gsml:CGI_TermValue>
                                                                        </gsml:upper>
                                                                </gsml:CGI_TermRange>
                                                        </gsml:eventAge>
                                                        <gsml:eventProcess>
                                                                <gsml:CGI_TermValue>
                                                                        <gsml:value codeSpace="urn:cgi:classifierScheme:GA:Process">deposition</gsml:value>
                                                                </gsml:CGI_TermValue>
                                                        </gsml:eventProcess>
                                                </gsml:GeologicEvent>
                                        </gsml:geologicHistory>
                                        <gsml:compositionCategory>
                                                <gsml:CGI_TermValue>
                                                        <gsml:value codeSpace="urn:cgi:classifierScheme:GA:CompositionCategory">silicate</gsml:value>
                                                </gsml:CGI_TermValue>
                                        </gsml:compositionCategory>
```

```
                                        <gsml:rank codeSpace="urn:cgi:classifierScheme:GA:Rank">formation</gsml:rank>
                                        <gsml:classifier xlink:href="urn:cgi:classifier:GA:StratigraphicLexicon:Stratno:4090">
<!--                                        <gsml:ControlledConcept gml:id="GA_stratno_4090">
                                                <gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:GA:StratigraphicLexicon:Stratno:4090</gml:name>
                                                <gsml:identifier codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:GA:StratigraphicLexicon:Stratno:4090</gsml:identifier>
                                                <gsml:name xml:lang="en" codeSpace="urn:cgi:classifierScheme:GA:StratigraphicLexicon:Stratname">Claraville beds</gsml:name>
                                                <gsml:name xml:lang="en" codeSpace="urn:cgi:classifierScheme:GA:StratigraphicLexicon:Map_symbol">Czcla</gsml:name>
                                                <gsml:vocabulary xlink:href="urn:cgi:classifierScheme:GA:StratigraphicLexicon"/>
                                        </gsml:ControlledConcept>-->
                                        </gsml:classifier>
                                        <gsml:composition>
                                                <gsml:CompositionPart>
                                                        <gsml:role codeSpace="urn:cgi:classifierScheme:GA:Role">part of</gsml:role>
                                                        <gsml:lithology>
                                                                <gsml:ControlledConcept gml:id="CGILith_129">
                                                                        <gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:CGI:Simple Lithology:2008:sandstone</gml:name>
                                                                        <gsml:identifier codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:CGI:Simple
Lithology:2008:sandstone</gsml:identifier>
                                                                        <gsml:name xml:lang="en"
codeSpace="urn:cgi:classifierScheme:CGI:SimpleLithology:2008">sandstone</gsml:name>
                                                                        <gsml:vocabulary xlink:href="urn:cgi:classifierScheme:CGI:SimpleLithology:2008"/>
                                                                </gsml:ControlledConcept>
                                                        </gsml:lithology>
                                                        <gsml:material>
                                                                <gsml:Rock>
                                                                        <gsml:purpose>instance</gsml:purpose>
                                                                        <gsml:compositionCategory>
                                                                                <gsml:CGI_TermValue>
                                                                                        <gsml:value
codeSpace="urn:cgi:classifierScheme:GA:CompositionCategory">silicate</gsml:value>
                                                                                </gsml:CGI_TermValue>
                                                                        </gsml:compositionCategory>
                                                                        <gsml:geneticCategory>
                                                                                <gsml:CGI_TermValue>
                                                                                        <gsml:value
codeSpace="urn:cgi:classifierScheme:GA:GeneticCategory">sedimentary</gsml:value>
                                                                                </gsml:CGI_TermValue>
                                                                        </gsml:geneticCategory>
                                                                        <gsml:lithology xlink:href="CGILith_129"/>
                                                                </gsml:Rock>
                                                        </gsml:material>
                                                        <gsml:proportion>
                                                                <gsml:CGI_TermValue>
                                                                        <gsml:value codeSpace="urn:cgi:classifierScheme:GA:Proportion">unknown</gsml:value>
                                                                </gsml:CGI_TermValue>
                                                        </gsml:proportion>
                                                </gsml:CompositionPart>
                                        </gsml:composition>
                                </gsml:GeologicUnit>
                        </gsml:specification>
                        <gsml:shape>
                                <gml:Polygon srsName="urn:ogc:def:crs:EPSG:4326">
                                        <gml:outerBoundaryIs>
```

<gml:LinearRing>
<gml:posList> 143.028301582228 -19.2830208837457 143.026444360006 -19.2812589393012 143.02576130445 -19.2802419948568 141.126545338775 -17.694596969197 141.12812821978 -17.6931019325912 141.135987900066 -17.6946043270231 141.144634050737 -17.7036815572296 141.14384039071 -17.708216382361 </gml:posList>
</gml:LinearRing>
</gml:innerBoundaryIs>
</gml:Polygon>
</gsml:shape>
</gsml:MappedFeature>
</gml:featureMember>
</wfs:FeatureCollection>

4.3 Use Case 2C - Mapped Features specified with Geologic Structure

The Use Case is defined as: ‘WFS delivery of all mapped features specified with GeologicStructure (or any subtypes) features with properties. Include all properties associated with GeologicStructure’. It is considered that different types of Geologic Structure would normally be delivered in discrete GeoSciML documents, and example documents are given here for Contacts, Ductile Shear Structures and Faults.

4.3.1 Profile diagram for Use Case 2C

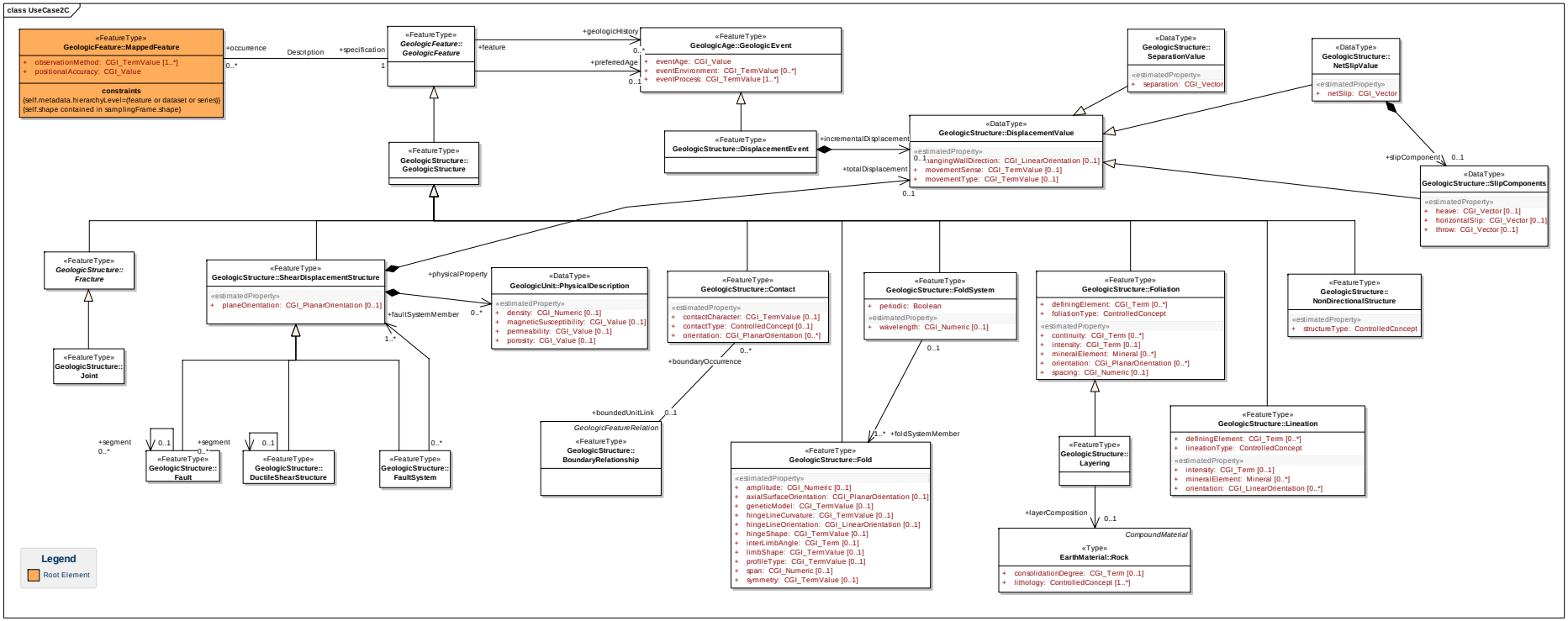

Figure 17: Profile diagram for Use Case 2C

4.3.2 Exemplar GeoSciML for Use Case 2C (Contacts)

```
<?xml version="1.0" encoding="UTF-8"?>
<wfs:FeatureCollection xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   xsi:schemaLocation="http://www.opengis.net/wfs http://schemas.opengis.net/wfs/1.1.0/wfs.xsd urn:cgi:xmlns:CGI:GeoSciML:2.0 http://www.geosciml.org/schemas/geosciml/2.0_rc2/geosciml.xsd"
   xmlns:gml="http://www.opengis.net/gml"
   xmlns:wfs="http://www.opengis.net/wfs"
   xmlns:gsml="urn:cgi:xmlns:CGI:GeoSciML:2.0"
   xmlns:sa="http://www.opengis.net/sampling/1.0"
   xmlns:om="http://www.opengis.net/om/1.0"
   xmlns:cgu="urn:cgi:xmlns:CGI:Utilities:1.0"
   xmlns:xlink="http://www.w3.org/1999/xlink"
   gml:id="GA_1M_ShearDisplacementStructures_Collection_000001">

   <gml:boundedBy>
      <gml:Envelope srsName="urn:ogc:def:crs:EPSG:4326">
```

```
        <gml:lowerCorner>142.17 -18.56</gml:lowerCorner>
        <gml:upperCorner>142.173 -20.56</gml:upperCorner>
      </gml:Envelope>
    </gml:boundedBy>

    <!-- ================================================================================================
      ####   This instance document describes MappedFeature lines of two ShearDisplacementStructures from the Eastern Australia 1:1million scale data.  ####
      ================================================================================================ -->
    <!--   <gml:description>Faults - Surface Geology of Eastern Australia - 1:1 million scale</gml:description>-->
    <!-- TB3 Profile Note: The GML 3.1 spec says for gml:location NOTE The flexible content model of the location property has proved to be difficult to implement in practice, so the
      element gml:location is deprecated in this version of GML. So suggest not having it. -->
    <gml:location xlink:href="urn:cgi:classsifier:GA:EasternAustralia"/>  <!-- constant, no spaces in URN -->
    <gml:featureMember>
      <gsml:MappedFeature gml:id="GA_Mapped_Contact_24680">    <!-- Concatenate "GA_Mapped_Contact_" and gsml_contacts.UFI  -->
        <gml:description>Mapped location of geological unit contact</gml:description>    <!-- Constant for this dataset -->
        <gsml:observationMethod>  <!-- gsml_contacts.src_data -->
          <gsml:CGI_TermValue>
            <gsml:value codeSpace="urn:cgi:classifierScheme:GA:1MillionGeology_ObservationMethods">Geological Survey of New South Wales, Statewide geodatabase, 1:250,000 scale or better, 2003.
Simplified, edge matched and modified for representation at 1:1 million scale</gsml:value>
          </gsml:CGI_TermValue>
        </gsml:observationMethod>
        <gsml:positionalAccuracy>
          <gsml:CGI_NumericValue>
            <gsml:principalValue uom="urn:ogc:def:uom:UCUM:m">500</gsml:principalValue>  <!-- UOM is constant; gsml_contacts.loc_acc  -->
          </gsml:CGI_NumericValue>
        </gsml:positionalAccuracy>
        <gsml:samplingFrame xlink:href="urn:cgi:feature:CGI:EarthNaturalSurface"/>
        <gsml:specification>
          <!--          <gsml:specification xlink:href="http://features.ga.gov.au?1000100"/>  But can't use an xlink to a generic specification because each contact has specific related boundedUnits?  -->
          <gsml:Contact gml:id="GA_Contact_24680">    <!-- Concatenate "GA_Contact_" & gsml_contacts.uid. One contact per mapped feature -->
            <!-- TB3 Profile Note: Same comments as above for name, description, observationMethod and purpose. -->
            <gml:description>Geological boundary</gml:description>        <!-- gsml_contacts.descript -->
            <gsml:observationMethod>
              <gsml:CGI_TermValue>
                <gsml:value codeSpace="urn:cgi:classifierScheme:GA:ObservationMethods">published map</gsml:value>        <!-- Constant value -->
              </gsml:CGI_TermValue>
            </gsml:observationMethod>
            <gsml:purpose>instance</gsml:purpose>
            <gsml:contactType>
              <gsml:ControlledConcept gml:id="GA_FeatureCode_1000199">    <!-- Concatenate "GA_FeatureCode gsml_contacts.feat_code.  First contactType/ControlledConcept in line, then by xlink:href.  See
the last FeatureMember in this doc. -->
                <!-- TB3 Profile Note: Do not include gml:description if it does not actually add extra information about the item. -->
                <gml:description>Geological boundary</gml:description>  <!-- gsml_contacts.descript -->
                <gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:feature:GA:FeatureCode:Feat_code:1000199</gml:name>        <!-- Concatenate "urn:cgi:feature:GA:FeatureCode:Feat_code:" and
gsml_contacts.feat_code -->
                <gsml:identifier codeSpace="urn:ietf:rfc:2141">urn:cgi:feature:GA:FeatureCode:Feat_code:1000199</gsml:identifier>          <!-- Concatenate "urn:cgi:feature:GA:FeatureCode:Feat_code:" and
gsml_contacts.feat_code -->
                <gsml:name xml:lang="en" codeSpace="urn:cgi:classifierScheme:GA:FeatureCode:Description">Geological boundary</gsml:name>    <!-- Concatenate
"urn:cgi:classifierScheme:GA:FeatureCode:Description:" and gsml_contacts.descript -->
                <gsml:vocabulary xlink:href="urn:cgi:classifierScheme:GA:FeatureCode"/>
              </gsml:ControlledConcept>
            </gsml:contactType>
            <!--            <gsml:boundedUnitLink>  *** Could do an implementation of this element at a later date.  ****
```

```
                <gsml:BoundaryRelationship>
                <gml:description>Conformable stratigraphic boundary</gml:description>
                <gsml:relationship codeSpace="urn:cgi:classifierScheme:GA:Relations">Stratigraphic boundary - conformity</gsml:relationship>
                <gsml:sourceRole codeSpace="urn:cgi:classifierScheme:GA:Role">overlying unit</gsml:sourceRole>    **** Need to get this from searching the stratigraphic lexicon ?
                <gsml:targetRole codeSpace="urn:cgi:classifierScheme:GA:Role">underlying unit</gsml:targetRole>    **** Need to get this from searching the stratigraphic lexicon  ?
                <gsml:target xlink:href="GA_Stratigraphic_Lexicon.xml#GA_Stratno_33373"/>      **** xlink to Kombolgie Formation in stratigraphic lexicon doc.  Alternative to describing the LithologicUnit like
above example.
                <gsml:source xlink:href="GA_Stratigraphic_Lexicon.xml#GA_Stratno_24881"/>       **** xlink to Cottee Formation in stratigraphic lexicon doc
                </gsml:BoundaryRelationship>
                </gsml:boundedUnitLink>       -->
            </gsml:Contact>
        </gsml:specification>
        <gsml:shape>   <!-- gsml_contacts.geom -->
            <gml:LineString srsName="urn:ogc:def:crs:EPSG:4326">
                <gml:posList>
                    -36.59701912 141.94618067
                    -36.60132373 141.94828905 -36.60617081 141.94951633
                    -36.59688031 141.94651695 -36.59700336 141.94622325
                </gml:posList>
            </gml:LineString>
        </gsml:shape>
    </gsml:MappedFeature>
</gml:featureMember>
<gml:featureMember>
    <gsml:MappedFeature gml:id="GA_Mapped_Contact_24610">
        <gml:description>Mapped location of geological unit contact</gml:description>
        <gsml:observationMethod>
            <gsml:CGI_TermValue>
                <gsml:value codeSpace="urn:cgi:classifierScheme:GA:1MillionGeology_ObservationMethods">Geological Survey of New South Wales, Statewide geodatabase, 1:250,000 scale or better, 2003.
Simplified, edge matched and modified for representation at 1:1 million scale</gsml:value>
            </gsml:CGI_TermValue>
        </gsml:observationMethod>
        <gsml:positionalAccuracy>
            <gsml:CGI_NumericValue>
                <gsml:principalValue uom="urn:ogc:def:uom:UCUM:m">500</gsml:principalValue>
            </gsml:CGI_NumericValue>
        </gsml:positionalAccuracy>
        <gsml:samplingFrame xlink:href="urn:cgi:feature:CGI:EarthNaturalSurface"/>   <!-- constant -->
        <gsml:specification>
            <!-- TB3 Profile Note: Same comments apply as for gsml:Contact above. -->
            <gsml:Contact gml:id="GA_Contact_123456">
                <gml:description>Fault</gml:description>
                <gsml:observationMethod>
                    <gsml:CGI_TermValue>
                        <gsml:value codeSpace="urn:cgi:classifierScheme:GA:ObservationMethods">published map</gsml:value>     <!-- Constant value -->
                    </gsml:CGI_TermValue>
                </gsml:observationMethod>
                <gsml:purpose>instance</gsml:purpose>
                <gsml:contactType>
                    <gsml:ControlledConcept gml:id="GA_FeatureCode_1100100">
                        <gml:description>Geological boundary</gml:description>
                        <gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:feature:GA:FeatureCode:Feat_code:1000100</gml:name>
                        <gsml:identifier codeSpace="urn:ietf:rfc:2141">urn:cgi:feature:GA:FeatureCode:Feat_code:1000100</gsml:identifier>
```

```
                    <gsml:name xml:lang="en" codeSpace="urn:cgi:classifierScheme:GA:FeatureCode:Description">Fault</gsml:name>
                    <gsml:vocabulary xlink:href="urn:cgi:classifierScheme:GA:FeatureCode"/>
                  </gsml:ControlledConcept>
                </gsml:contactType>

              </gsml:Contact>
            </gsml:specification>
            <gsml:shape>
              <gml:LineString srsName="urn:ogc:def:crs:EPSG:4326">
                <gml:posList>
                  -26.59701912 152.94618067
                  -26.60132373 152.94828905 -26.60617081 152.94951633
                  -26.59688031 152.94651695 -26.59700336 152.94622325
                </gml:posList>
              </gml:LineString>
            </gsml:shape>
          </gsml:MappedFeature>
        </gml:featureMember>
        <gml:featureMember>
          <gsml:MappedFeature gml:id="GA_Mapped_Contact_24650">
            <gml:description>Mapped location of geological unit contact</gml:description>
            <gsml:observationMethod>
              <gsml:CGI_TermValue>
                <gsml:value codeSpace="urn:cgi:classifierScheme:GA:1MillionGeology_ObservationMethods">Geological Survey of New South Wales, Statewide geodatabase, 1:250,000 scale or better, 2003.
Simplified, edge matched and modified for representation at 1:1 million scale</gsml:value>
              </gsml:CGI_TermValue>
            </gsml:observationMethod>
            <gsml:positionalAccuracy>
              <gsml:CGI_NumericValue>
                <gsml:principalValue uom="urn:ogc:def:uom:UCUM:m">500</gsml:principalValue>
              </gsml:CGI_NumericValue>
            </gsml:positionalAccuracy>
            <gsml:samplingFrame xlink:href="urn:cgi:feature:CGI:EarthNaturalSurface"/>
            <gsml:specification>
              <!-- TB3 Profile Note: Same comments apply as for gsml:Contact above. -->
              <gsml:Contact gml:id="GA_Contact_9876542">
                <gml:description>Fault</gml:description>
                <gsml:observationMethod>
                  <gsml:CGI_TermValue>
                    <gsml:value codeSpace="urn:cgi:classifierScheme:GA:ObservationMethods">published map</gsml:value>
                  </gsml:CGI_TermValue>
                </gsml:observationMethod>
                <gsml:purpose>instance</gsml:purpose>
                <gsml:contactType xlink:href="#GA_FeatureCode_1000199"/>   <!-- Example of reference to previous contactType/ControlledConcept.  Ref = gsml_contacts.feat_code -->
              </gsml:Contact>
            </gsml:specification>
            <gsml:shape>
              <gml:LineString srsName="urn:ogc:def:crs:EPSG:4326">
                <gml:posList>
                  -26.595 152.957
                  -26.605 152.505 -26.6051 152.94533
                  -26.55 152.955 -26.556 152.94525
                </gml:posList>
```

```
            </gml:LineString>
          </gsml:shape>
        </gsml:MappedFeature>
    </gml:featureMember>
</wfs:FeatureCollection>
```

4.3.3 Exemplar GeoSciML for Use Case 2C (Ductile Shear Structures)

```
<?xml version="1.0" encoding="UTF-8"?>
<wfs:FeatureCollection xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.opengis.net/wfs http://schemas.opengis.net/wfs/1.1.0/wfs.xsd urn:cgi:xmlns:CGI:GeoSciML:2.0 http://www.geosciml.org/schemas/geosciml/2.0_rc2/geosciml.xsd"
    xmlns:gml="http://www.opengis.net/gml"
    xmlns:wfs="http://www.opengis.net/wfs"
    xmlns:gsml="urn:cgi:xmlns:CGI:GeoSciML:2.0"
    xmlns:sa="http://www.opengis.net/sampling/1.0"
    xmlns:om="http://www.opengis.net/om/1.0"
    xmlns:cgu="urn:cgi:xmlns:CGI:Utilities:1.0"
    xmlns:xlink="http://www.w3.org/1999/xlink"
    gml:id="GA_1M_ShearDisplacementStructures_Collection_000001">

    <gml:boundedBy>
      <gml:Envelope srsName="urn:ogc:def:crs:EPSG:4326">
        <gml:lowerCorner>142.17 -18.56</gml:lowerCorner>
        <gml:upperCorner>142.173 -20.56</gml:upperCorner>
      </gml:Envelope>
    </gml:boundedBy>

    <!-- ============================================================================================
      ####   This instance document describes MappedFeature lines of two ShearDisplacementStructures from the Eastern Australia 1:1million scale data.  ####
      ============================================================================================  -->
    <!--    <gml:description>Faults - Surface Geology of Eastern Australia - 1:1 million scale</gml:description>-->
    <!-- TB3 Profile Note: The GML 3.1 spec says for gml:location NOTE The flexible content model of the location property has proved to be difficult to implement in practice, so the
      element gml:location is deprecated in this version of GML. So suggest not having it. -->
    <gml:location xlink:href="urn:cgi:classsifier:GA:EasternAustralia"/>   <!-- constant, no spaces in URN -->
    <gml:featureMember>
      <gsml:MappedFeature gml:id="GA_Mapped_Structure_123457">     <!-- Concatenate "GA_Mapped_Structure_" and gsml_faults.UFI  -->
        <gml:description>Mapped location of structure</gml:description>    <!-- constant -->
        <gml:name>GA_Structure_123457"</gml:name>     <!-- Concatenate "GA_Structure_" and gsml_faults.UFI -->
        <gsml:observationMethod>                                <!-- gsml_faults.SRC_DATA -->
          <gsml:CGI_TermValue>
            <gsml:value codeSpace="urn:cgi:classifierScheme:GA:1MillionGeology_ObservationMethods">Blake, D.H., 1987, Mt Isa Inlier and Environs 1:500,000, Bureau of Mineral Resources</gsml:value>
          </gsml:CGI_TermValue>
        </gsml:observationMethod>
        <gsml:positionalAccuracy>
          <gsml:CGI_NumericValue>
            <gsml:principalValue uom="urn:ogc:def:uom:UCUM:m">1000</gsml:principalValue>      <!-- gsml_faults.LOC_ACC   UOM = constant urn value -->
          </gsml:CGI_NumericValue>
        </gsml:positionalAccuracy>
        <gsml:samplingFrame xlink:href="urn:cgi:feature:CGI:EarthNaturalSurface"/>   <!-- Constant xlink value for this dataset  -->
        <gsml:specification>
```

```
            <!-- TB3 Profile Note: Same comments apply as for gsml:Fault above. -->
            <gsml:DuctileShearStructure gml:id="GA_Shear_123457">                    <!--NOTE:  Feature = gsml:Fault where gsml_faults.descript = 'Fault%'.  Feature = gsml:DuctileShearStructure where
gsml_faults.descript = 'Shear%'.
              gml:id = concatenate either "GA_Fault_" or "GA_Shear_" with gsml_faults.ufi.   One MappedFeature per structure for this dataset.-->
              <gml:description>Shear</gml:description>       <!--  gsml_faults.descript-->
              <gml:name>MT ISA SHEAR ZONE</gml:name>          <!--    gsml_faults.name   (May be NULL) -->
              <gsml:observationMethod>
                <gsml:CGI_TermValue>
                  <gsml:value codeSpace="urn:cgi:classifierScheme:GA:ObservationMethods">published map</gsml:value>     <!-- Constant for this dataset -->
                </gsml:CGI_TermValue>
              </gsml:observationMethod>
              <gsml:purpose>instance</gsml:purpose>              <!-- Constant for this dataset -->
              <gsml:planeOrientation>          <!-- ##  THIS SHOULD NOT BE MANDATORY!! ## -->
                <gsml:CGI_PlanarOrientation>
                  <gsml:convention>dip dip direction</gsml:convention>     <!-- constant -->
                  <gsml:polarity>not applicable</gsml:polarity>     <!-- constant -->
                </gsml:CGI_PlanarOrientation>
              </gsml:planeOrientation>
            </gsml:DuctileShearStructure>
          </gsml:specification>
          <gsml:shape>
            <gml:LineString srsName="urn:ogc:def:crs:EPSG:4326">
              <gml:posList> 145.501319825907 -38.2958677646128 145.502161775186 -38.2953282079323 145.503003724465 -38.2947886512518 145.503845673744 -38.2942490945713 145.504687623023 -
38.2937095378908 145.505529572302 -38.2931699812103 145.506371521581 -38.2926304245298 145.50721347086 -38.2920908678493 145.508055420139 -38.2915513111688 145.508412165401 -
38.2913226937285 145.509264270359 -38.2907993227888 145.510116375317 -38.290275951849 145.510968480275 -38.2897525809093 145.511820585233 -38.2892292099695 145.512672690191 -
38.2887058390298 145.513524795149 -38.28818246809 145.514376900107 -38.2876590971503 145.514935929831 -38.2873157357962 </gml:posList>
            </gml:LineString>
          </gsml:shape>
        </gsml:MappedFeature>
      </gml:featureMember>
    </wfs:FeatureCollection>
```

4.3.4 Exemplar GeoSciML for Use Case 2C (Faults)

```
<?xml version="1.0" encoding="UTF-8"?>
<wfs:FeatureCollection xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   xsi:schemaLocation="http://www.opengis.net/wfs http://schemas.opengis.net/wfs/1.1.0/wfs.xsd urn:cgi:xmlns:CGI:GeoSciML:2.0 http://www.geosciml.org/schemas/geosciml/2.0_rc2/geosciml.xsd"
   xmlns:gml="http://www.opengis.net/gml"
   xmlns:wfs="http://www.opengis.net/wfs"
   xmlns:gsml="urn:cgi:xmlns:CGI:GeoSciML:2.0"
   xmlns:sa="http://www.opengis.net/sampling/1.0"
   xmlns:om="http://www.opengis.net/om/1.0"
   xmlns:cgu="urn:cgi:xmlns:CGI:Utilities:1.0"
   xmlns:xlink="http://www.w3.org/1999/xlink"
   gml:id="GA_1M_ShearDisplacementStructures_Collection_000001">

   <gml:boundedBy>
      <gml:Envelope srsName="urn:ogc:def:crs:EPSG:4326">
         <gml:lowerCorner>142.17 -18.56</gml:lowerCorner>
         <gml:upperCorner>142.173 -20.56</gml:upperCorner>
```

```
    </gml:Envelope>
  </gml:boundedBy>

  <!--  ================================================================================================
     ####   This instance document describes MappedFeature lines of two ShearDisplacementStructures from the Eastern Australia 1:1million scale data.  ####
     ================================================================================================  -->
  <!--    <gml:description>Faults - Surface Geology of Eastern Australia - 1:1 million scale</gml:description>-->
  <!-- TB3 Profile Note: The GML 3.1 spec says for gml:location NOTE The flexible content model of the location property has proved to be difficult to implement in practice, so the
     element gml:location is deprecated in this version of GML. So suggest not having it. -->
  <gml:location xlink:href="urn:cgi:classsifier:GA:EasternAustralia"/>   <!-- constant, no spaces in URN -->
  <gml:featureMember>
     <!-- TB3 Profile Note: gml:id can be used to retrieve a particular feature by id.
        There is no real gml:name appropriate for mapped polygons advise not populating this.
        The gml:description is not worth using unless there is some specific descriptive information available for the particular MappedFeature;
        so don't use this to put a generic description like 'geological polygon' or similar. -->
     <!-- TB3 Profile Note: All organizations examples to date have very generic values for observation method meaning basically
        "geological mapping procedures" which suggests that no-one actually explicitly stores this information at the moment. Thus it
        would be possible to use a CDTG defined term registered in the urn:cgi:classifierScheme:CGI:ObservationMethod:2008 codeSpace.
        As this information will not be the basis of any queries, however, we will not constrain whether people use the cgi codeSpace or their
        own. Need to clarify whether all codeSpaces should be recorded in CGIClassifierSchemeRegister .-->
     <gsml:MappedFeature gml:id="GA_Mapped_Structure_12345">    <!-- Concatenate "GA_Mapped_Structure_" and gsml_faults.UFI  -->
        <gml:description>Mapped location of structure</gml:description>  <!-- constant -->
        <gml:name>GA_Structure_12345"</gml:name>     <!-- Concatenate "GA_Structure_" and gsml_faults.UFI -->
        <gsml:observationMethod>                              <!-- gsml_faults.SRC_DATA -->
           <gsml:CGI_TermValue>
              <gsml:value codeSpace="urn:cgi:classifierScheme:GA:1MillionGeology_ObservationMethods">Geological Survey of New South Wales, Statewide geodatabase, 1:250,000 scale or better, 2003.
Simplified, edge matched and modified for representation at 1:1 million scale</gsml:value>
           </gsml:CGI_TermValue>
        </gsml:observationMethod>
        <!-- TB3 Profile Note: Check that there is no CGI URN scheme for positional accuracy that we should use.
           Some people have put numerical values in here; that is also fine.-->
        <gsml:positionalAccuracy>
           <gsml:CGI_NumericValue>
              <gsml:principalValue uom="urn:ogc:def:uom:UCUM:m">500</gsml:principalValue>         <!-- gsml_faults.LOC_ACC   UOM = constant urn value -->
           </gsml:CGI_NumericValue>
        </gsml:positionalAccuracy>
        <!-- TB3 Profile Note: For most geological maps the sampling frame can be identified by one of the two global features
           urn:cgi:feature:CGI:EarthBedrockSurface or urn:cgi:feature:CGI:EarthNaturalSurface which are in the CGI Register at
           https://www.seegrid.csiro.au/twiki/bin/view/CGIModel/CGIFeatureRegister. Email the Testbed mailing list if you think you
           might want to use a different value here. -->
        <gsml:samplingFrame xlink:href="urn:cgi:feature:CGI:EarthNaturalSurface"/>   <!-- Constant xlink value for this dataset  -->
        <gsml:specification>
           <gsml:Fault gml:id="GA_Fault_12345">                <!--NOTE:  Feature = gsml:Fault where gsml_faults.descript = 'Fault%'.  Feature = gsml:DuctileShearStructure where gsml_faults.descript = 'Shear%'.
              gml:id = concatenate either "GA_Fault_" or "GA_Shear_" with gsml_faults.ufi.   One MappedFeature per structure for this dataset.-->
              <!-- TB3 Profile Note: Suggest only include gml:name and gml:description if there is specific information about this structure.
                 A description of "Fault" is not worth including. -->
              <!-- TB3 Profile Note: Is including a URN name with codeSpace urn:ietf:rfc:2141. Is this necessary / desirable?
                 -->
                 <gml:description>Fault</gml:description>       <!--  gsml_faults.descript-->
              <gml:name>LAKE GEORGE FAULT</gml:name>                <!--    gsml_faults.name   (May be NULL) -->
              <!-- TB3 Profile Note: All organizations examples to date have very generic values for observation method meaning basically
                 "published description" which suggests that no-one actually explicitly stores this information at the moment. Thus it
                 would be possible to use a CDTG defined term registered in the
```

```
            urn:cgi:classifierScheme:CGI:ObservationMethod:2008 codeSpace.
            As this information will not be the basis of any queries, however, we will not constrain whether people use the cgi codeSpace or their
            own. Need to clarify whether all codeSpaces should be recorded in CGIClassifierSchemeRegister .-->
          <gsml:observationMethod>
            <gsml:CGI_TermValue>
              <gsml:value codeSpace="urn:cgi:classifierScheme:GA:ObservationMethods">published map</gsml:value>  <!-- constant -->
            </gsml:CGI_TermValue>
          </gsml:observationMethod>
          <gsml:purpose>instance</gsml:purpose>    <!-- constant -->
          <gsml:planeOrientation>       <!--    ##  THIS SHOULD NOT BE MANDATORY!! ## -->
            <gsml:CGI_PlanarOrientation>
              <gsml:convention>dip dip direction</gsml:convention>   <!-- constant -->
              <!-- TB3 Profile Note: For Cookbook purposes will put real example value for polarity. -->
              <gsml:polarity>not applicable</gsml:polarity>   <!-- constant -->
            </gsml:CGI_PlanarOrientation>
          </gsml:planeOrientation>
        </gsml:Fault>
      </gsml:specification>
      <gsml:shape>
        <gml:LineString srsName="urn:ogc:def:crs:EPSG:4326">
          <gml:posList> 145.399810295539 -38.4030971333489 145.400792683478 -38.4032839860626 145.401775071417 -38.4034708387762 145.402757459357 -38.4036576914898 145.403739847296 -
38.4038445442034 145.404722235236 -38.4040313969171 145.405704623175 -38.4042182496307 145.406687011114 -38.4044051023443 145.407669399054 -38.4045919550579 145.408651786993 -
38.4047788077716 145.409634174932 -38.4049656604852 145.410616562872 -38.4051525131988 145.411598950811 -38.4053393659124 145.41258133875 -38.4055262186261 145.41356372669 -
38.4057130713397 145.414546114629 -38.4058999240533 145.415528502569 -38.4060867767669 145.416510890508 -38.4062736294806 145.417493278447 -38.4064604821942 145.418475666387 -
38.4066473349078 145.41938124242 -38.4068195777994 145.420375138625 -38.4069298970368 145.42136903483 -38.4070402162743 145.422362931035 -38.4071505355118 145.423356827239 -
38.4072608547492 145.424350723444 -38.4073711739867 145.425344619649 -38.4074814932242 145.426338515854 -38.4075918124616
            145.427332412058 -38.4077021316991 145.428326308263 -38.4078124509366 145.429320204468 -38.407922770174 145.430314100673 -38.4080330894115 145.431307996877 -38.408143408649
145.432301893082 -38.4082537278865 145.433295789287 -38.4083640471239 145.434108599582 -38.408454266416 145.435106755948 -38.4085149612926 145.436104912315 -38.4085756561693
145.437103068681 -38.408636351046 145.438101225048 -38.4086970459226 145.439099381414 -38.4087577407993 145.440097537781 -38.408818435676 145.441095694147 -38.4088791305526
145.442093850514 -38.4089398254293 145.44309200688 -38.409000520306 145.444090163247 -38.4090612151826 145.445088319613 -38.4091219100593 145.44608647598 -38.409182604936
145.447084632346 -38.4092432998126 145.448082788713 -38.4093039946893 145.449080945079 -38.409364689566 145.450079101446 -38.4094253844426 145.451077257812 -38.4094860793193
145.451148047036 -38.4094903837984 145.45214804665 -38.4094912623472 145.453148046264 -38.4094921408959 145.454148045878
            -38.4094930194447 145.455148045492 -38.4094938979935 145.456148045106 -38.4094947765423 145.45714804472 -38.4094956550911 145.458148044334 -38.4094965336399 145.459148043948
-38.4094974121887 145.460148043562 -38.4094982907375 145.461148043176 -38.4094991692863 145.462148042791 -38.4095000478351 145.463148042405 -38.4095009263838 145.464148042019 -
38.4095018049326 145.465148041633 -38.4095026834814 145.466148041247 -38.4095035620302 145.467148040861 -38.409504440579 145.468148040475 -38.4095053191278 145.469148040089 -
38.4095061976766 145.469936721227 -38.4095068905717 </gml:posList>
        </gml:LineString>
      </gsml:shape>
    </gsml:MappedFeature>
  </gml:featureMember>
</wfs:FeatureCollection>
```


4.4 Use Case 2D – Sampling Features (including boreholes)

The Use Case is defined as: ‘WFS delivery of Sampling Features (including boreholes) within a bounding box with properties. Includes 0..* observations for each sampling feature.’ At present only an exemplar document for boreholes has been produced.

4.4.1 Profile diagram for Use Case 2D (Boreholes)

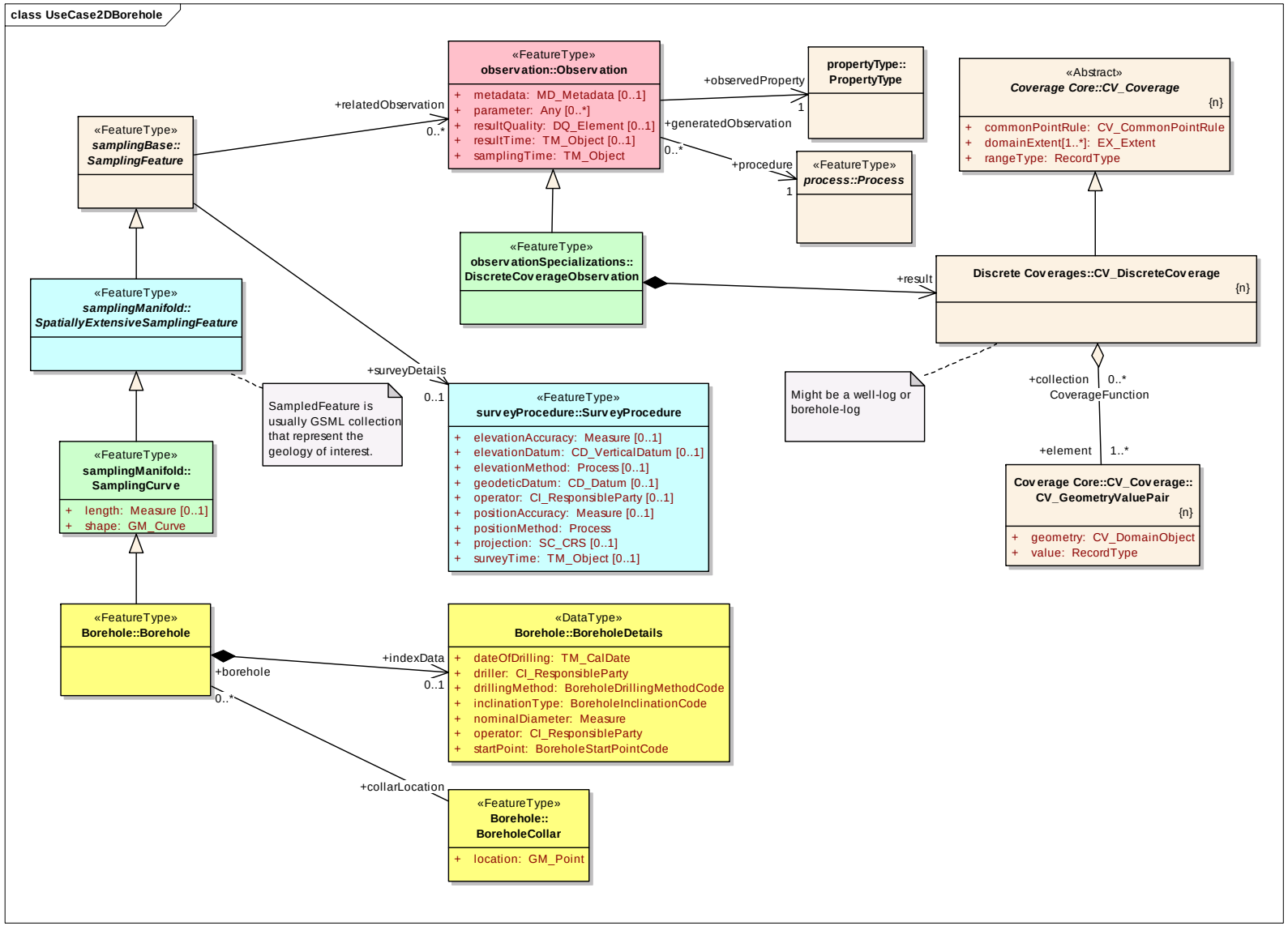

Figure 18: Profile diagram for Use Case 2D (Boreholes)

4.4.2 Exemplar GeoSciML for Use Case 2D (Boreholes)

```
<?xml version="1.0" encoding="utf-8"?>
<!-- TB3 Profile Note: UC2D and UC3D Exemplar instances are identical.  -->
<!-- BRGM profile for WFS delivering boreholes with lithology and age encoded as gml:ReferenceType values -->
<!-- General BRGM rules for encoding boreholes: (the same ones as TB3_UC3_BRGM_Boreholes_ReferenceToGeologicalUnits.xml)
                - BRGM boreholes are all vertical
                - Lithology values are encoded as gml:Reference values
                - Lithology references refer to the BRGM dictionary of lithology
                - Note that when the lithology is unknown, there is no xlink:href in the cv:value tag
                - There is no observation on points.
                - All the intervals are sorted by increasing values of depth
                - We assume that the borehole length, all the depth values and all the elevation values are expressed with the same unit
                - As there is more than one observation for the boreholes, we define a gml:id for the geometry of each interval in order to reuse it in the other observations. We don't want to duplicate the geometry of the intervals because it's the same one for all the observations
                - As the starting point is also defined in the collarLocation tag, we refer to it in the 3D line string definition of the borehole in order not to duplicate it
                - Coordinates are defined according to the epsg:7412 projection system, i.e elevation in meters for Z and French Lambert II projection system for X and Y. In this projection system, X, Y and Z are expressed in meters.
                - Rules to encode the gml:id
                        bh. for borehole
                        string got from the borehole name. Each character of the borehole name is transformed into 2 characters. Like that, we have no problems with the characters that are forbidden in gml:id values.
                        .1,2,... for the interval numbers
                        .Shape for the shape of the borehole
                        and so on -->
<!-- General rules for encoding boreholes:
                - Property names are always by reference using the agreed URNs that GeoSciML group has settled on
                        Property name for lithology is urn:cgi:propertyType:CGI:GeoSciML:2.0:CompositionPart:lithology
                        Property name for age is urn:cgi:propertyType:CGI:GeoSciML:2.0:GeologicEvent:eventAge
                - In all boreholes, observations of lithology and age must be in the same order
                - Although the sa:length element is optional, we must use it and give it a value in order to query it (filter boreholes with length greater than)
                - Although the gsml:collarLocation element is optional, we must use it and give it values in order to query it (BBOX filter to get boreholes inside a 2D bounding box)
                - For vertical boreholes, we only need the starting point and the end point to define the 3D line string of the borehole -->
<!-- Special rules for encoding BRGM boreholes with age encoded as gml:ReferenceType values
                - Age references refer to the ICS dictionary
                - Lithology and age are observed on the same intervals -->
<wfs:FeatureCollection
xmlns:wfs="http://www.opengis.net/wfs"
xmlns:om="http://www.opengis.net/om/1.0"
xmlns:sa="http://www.opengis.net/sampling/1.0"
xmlns:gml="http://www.opengis.net/gml"
xmlns:cv="http://www.opengis.net/cv/0.2.1"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:gsml="urn:cgi:xmlns:CGI:GeoSciML:2.0"
xsi:schemaLocation="http://www.opengis.net/wfs http://schemas.opengis.net/wfs/1.1.0/wfs.xsd
http://www.opengis.net/cv/0.2.1 http://bp.schemas.opengis.net/06-188r1/cv/0.2.1/cv.xsd
http://www.opengis.net/om/1.0 http://schemas.opengis.net/om/1.0.0/om.xsd
http://www.opengis.net/sampling/1.0 http://schemas.opengis.net/sampling/1.0.0/sampling.xsd
```

```
urn:cgi:xmlns:CGI:GeoSciML:2.0 http://www.geosciml.org/schemas/geosciml/2.0_rc2/geosciml.xsd">
        <!-- The 3D envelope of all the boreholes expressed in the same projection system as all the boreholes -->
        <gml:boundedBy>
                <gml:Envelope srsName="urn:ogc:def:crs:EPSG:6.15:7412">
                        <gml:lowerCorner>631154.1 2622191.9 -112</gml:lowerCorner>
                        <gml:upperCorner>631154.1 2622191.9 18</gml:upperCorner>
                </gml:Envelope>
        </gml:boundedBy>
        <!-- One borehole -->
  <gml:featureMember>
                <gsml:Borehole gml:id="bh.303031333558303031382F53">
                        <!-- The BRGM name of the borehole -->
                        <!-- TB3 Profile Note: The gml:description is not worth using unless there is some specific descriptive information available for the particular Borehole;
                                so don't use this to put a generic description like 'borehole' or similar. Don't use for other names either
                        these should use gml:name with other codeSpace's or no codeSpace .-->
                        <gml:description>00135X0018/S borehole</gml:description>
                        <gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:feature:BRGM:Borehole:00135X0018/S</gml:name>
                        <!-- The 3D envelope of the borehole expressed in the same projection system as the borehole one -->
                        <!-- TB3 Profile Note: bounding box is not mandatory but should be provided if possible as this can be helpful for clients. -->
                        <gml:boundedBy>
                                <gml:Envelope srsName="#bh.303432383858303032312F53.BoreholeShape">
                                        <gml:lowerCorner>631154.1 2622191.9 -112</gml:lowerCorner>
                                        <gml:upperCorner>631154.1 2622191.9 18</gml:upperCorner>
                                </gml:Envelope>
                        </gml:boundedBy>
                        <!-- TB3 Profile Note: sampledFeature is a mandatory property in O&M; some previous instances have left this
                        element empty which validates but isn't really the purpose of the model. For boreholes returning properties of GeologicUnits
                        implementors should attempt to list the GeologicUnit features which are sampled here if possible.-->
                        <sa:sampledFeature xlink:href="urn:cgi:feature:BRGM:GeologicUnit:50K:F12"/>
                        <sa:sampledFeature xlink:href="urn:cgi:feature:BRGM:GeologicUnit:50K:F21"/>
                        <sa:sampledFeature xlink:href="urn:cgi:feature:BRGM:GeologicUnit:50K:F23"/>
                        <sa:sampledFeature xlink:href="urn:cgi:feature:BRGM:GeologicUnit:50K:F24"/>
                        <!-- Lithology encoded as gml:Reference -->
                        <sa:relatedObservation>
                                <om:Observation gml:id="bh.303031333558303031382F53.lithology.1">
                                        <gml:description>Lithology</gml:description>
                                        <!-- TB3 Profile Note: For mandatory properties the element should not just be left empty to get past
                                        XML Schema validation but should have the xlink:href property set to an OGC nil reason from page
                                        OgcURNScheme if no value can be given.-->
                                        <om:samplingTime  xlink:href="urn:ogc:def:nil:OGC:unknown"/>
                                        <om:procedure xlink:href="urn:cgi:classifier:CGI:ObservationMethod:Direct_observation"/>
                                        <om:observedProperty xlink:href="urn:cgi:propertyType:CGI:GeoSciML:2.0:CompositionPart:lithology"/>
                                        <!-- TB3 Profile Note: See https://www.seegrid.csiro.au/twiki/bin/view/AppSchemas/ObservationsAndSampling#Unknown_features
                                        for notes on suitable values for featureOfInterest particularly when there isn't a specific known feature. -->
                                        <om:featureOfInterest xlink:role="urn:cgi:featureType:CGI:GeoSciML:2.0:GeologicUnit" xlink:href="urn:ogc:def:nil:OGC:unknown" />
                                        <om:result>
                                                <cv:CV_DiscreteCoverage>
                                                        <cv:domainExtent xlink:href="#bh.303031333558303031382F53.Shape"/>
                                                        <!-- TB3 Profile Note: What's the difference between the rangeType here and the parent Observation observedProperty ?
                                                        There should really be at least an xlink:href value put here rather than an empty element. -->
                                                        <cv:rangeType/>
                                                        <cv:element>
                                                                <cv:CV_GeometryValuePair>
```

```
                                        <cv:geometry>
                                                <cv:CV_DomainObject>
                                                        <cv:spatialElement>
                                                                <gml:LineString srsName="#bh.3030313335583030313 82F53.Shape"
srsDimension="1" gml:id="bh.3030313335583030313 82F53.1">
                                                                        <gml:pos>0</gml:pos>
                                                                        <gml:pos>34</gml:pos>
                                                                </gml:LineString>
                                                        </cv:spatialElement>
                                                </cv:CV_DomainObject>
                                        </cv:geometry>
                                        <cv:value xsi:type="gml:ReferenceType" xlink:href="urn:cgi:classifier:CGI:SimpleLithology:2008:sandstone"/>
                                </cv:CV_GeometryValuePair>
                        </cv:element>
                        <cv:element>
                                <cv:CV_GeometryValuePair>
                                        <cv:geometry>
                                                <cv:CV_DomainObject>
                                                        <cv:spatialElement>
                                                                <gml:LineString srsName="#bh.3030313335583030313 82F53.Shape"
srsDimension="1" gml:id="bh.3030313335583030313 82F53.2">
                                                                        <gml:pos>34</gml:pos>
                                                                        <gml:pos>100</gml:pos>
                                                                </gml:LineString>
                                                        </cv:spatialElement>
                                                </cv:CV_DomainObject>
                                        </cv:geometry>
                                        <cv:value xsi:type="gml:ReferenceType" xlink:href="urn:cgi:classifier:BRGM:Lithology:2008:S234"/>
                                </cv:CV_GeometryValuePair>
                        </cv:element>
                        <cv:element>
                                <cv:CV_GeometryValuePair>
                                        <cv:geometry>
                                                <cv:CV_DomainObject>
                                                        <cv:spatialElement>
                                                                <gml:LineString srsName="#bh.3030313335583030313 82F53.Shape"
srsDimension="1" gml:id="bh.3030313335583030313 82F53.3">
                                                                        <gml:pos>100</gml:pos>
                                                                        <gml:pos>108</gml:pos>
                                                                </gml:LineString>
                                                        </cv:spatialElement>
                                                </cv:CV_DomainObject>
                                        </cv:geometry>
                                        <cv:value xsi:type="gml:ReferenceType"/>
                                </cv:CV_GeometryValuePair>
                        </cv:element>
                        <cv:element>
                                <cv:CV_GeometryValuePair>
                                        <cv:geometry>
                                                <cv:CV_DomainObject>
                                                        <cv:spatialElement>
                                                                <gml:LineString srsName="#bh.3030313335583030313 82F53.Shape"
srsDimension="1" gml:id="bh.3030313335583030313 82F53.4">
```

```
                                                                                <gml:pos>108</gml:pos>
                                                                                <gml:pos>130</gml:pos>
                                                                            </gml:LineString>
                                                                        </cv:spatialElement>
                                                                    </cv:CV_DomainObject>
                                                                </cv:geometry>
                                                                <cv:value xsi:type="gml:ReferenceType" xlink:href="urn:cgi:classifier:BRGM:Lithology:2008:S234"/>
                                                            </cv:CV_GeometryValuePair>
                                                        </cv:element>
                                                    </cv:CV_DiscreteCoverage>
                                                </om:result>
                                            </om:Observation>
                                        </sa:relatedObservation>
                                        <!-- Age encoded as gml:Reference -->
                                        <sa:relatedObservation>
                                            <!-- TB3 Profile Note: Age and other properties are optional to return if you wish; lithology is the only Observation that must be
                                            included. -->
                                            <om:Observation gml:id="bh.3030313335583030313 82F53.eventAge.1">
                                                <gml:description>Event age</gml:description>
                                                <om:samplingTime/>
                                                <om:procedure xlink:href="urn:cgi:classifier:CGI:ObservationMethod:Direct_observation"/>
                                                <om:observedProperty xlink:href="urn:cgi:propertyType:CGI:GeoSciML:2.0:GeologicEvent:eventAge"/>
                                                <om:featureOfInterest xlink:role="urn:cgi:featureType:CGI:GeoSciML:2.0:GeologicUnit" xlink:href="urn:ogc:def:nil:OGC:unknown"/>
                                                <om:result>
                                                    <cv:CV_DiscreteCoverage>
                                                        <cv:domainExtent xlink:href="#bh.3030313335583030313 82F53.Shape"/>
                                                        <cv:rangeType/>
                                                        <cv:element>
                                                            <cv:CV_GeometryValuePair>
                                                                <cv:geometry>
                                                                    <cv:CV_DomainObject>
                                                                        <cv:spatialElement xlink:href="#bh.3030313335583030313 82F53.1"/>
                                                                    </cv:CV_DomainObject>
                                                                </cv:geometry>
                                                                <cv:value xsi:type="gml:ReferenceType" xlink:href="urn:cgi:classifier:ICS:StratChart:2008:Quaternary"/>
                                                            </cv:CV_GeometryValuePair>
                                                        </cv:element>
                                                        <cv:element>
                                                            <cv:CV_GeometryValuePair>
                                                                <cv:geometry>
                                                                    <cv:CV_DomainObject>
                                                                        <cv:spatialElement xlink:href="#bh.3030313335583030313 82F53.2"/>
                                                                    </cv:CV_DomainObject>
                                                                </cv:geometry>
                                                                <cv:value xsi:type="gml:ReferenceType" xlink:href="urn:cgi:classifier:ICS:StratChart:2008:Rupelian"/>
                                                            </cv:CV_GeometryValuePair>
                                                        </cv:element>
                                                        <cv:element>
                                                            <cv:CV_GeometryValuePair>
                                                                <cv:geometry>
                                                                    <cv:CV_DomainObject>
                                                                        <cv:spatialElement xlink:href="#bh.3030313335583030313 82F53.3"/>
                                                                    </cv:CV_DomainObject>
```

```
                                                                </cv:geometry>
                                                                <cv:value xsi:type="gml:ReferenceType" xlink:href="urn:cgi:classifier:ICS:StratChart:2008:Priabonian"/>
                                                        </cv:CV_GeometryValuePair>
                                                </cv:element>
                                                <cv:element>
                                                        <cv:CV_GeometryValuePair>
                                                                <cv:geometry>
                                                                        <cv:CV_DomainObject>
                                                                                <cv:spatialElement xlink:href="#bh.3030313335583030313 82F53.4"/>
                                                                        </cv:CV_DomainObject>
                                                                </cv:geometry>
                                                                <cv:value xsi:type="gml:ReferenceType" xlink:href="urn:cgi:classifier:ICS:StratChart:2008:Paleocene"/>
                                                        </cv:CV_GeometryValuePair>
                                                </cv:element>
                                        </cv:CV_DiscreteCoverage>
                                </om:result>
                        </om:Observation>
                </sa:relatedObservation>
                <!-- As the borehole is a 3D line, we need a 3D CRS -->
                <!-- EPSG:6.15:7412 means that Z coordinate values are expressed in meters -->
                <!-- TB3 Profile note: surveyDetails are optional include only if you have the data. -->
                <sa:surveyDetails>
                        <sa:SurveyProcedure gml:id="bh.3030313335583030313 82F53.sp">
                                <!-- TB3 Profile Note: Use urn:ogc:def:uom:UCUM:* for units specification.
                                        See https://www.seegrid.csiro.au/twiki/bin/view/CGIModel/OgcURNScheme -->
                                <sa:elevationAccuracy uom="urn:ogc:def:uom:UCUM:m">0.1</sa:elevationAccuracy>
                                <sa:positionMethod xlink:href="urn:ogc:def:nil:OGC:missing"/>
                                <sa:positionAccuracy uom="urn:ogc:def:uom:UCUM:m">10</sa:positionAccuracy>
                        </sa:SurveyProcedure>
                </sa:surveyDetails>
                <sa:shape>
                        <gml:LineString gml:id="bh.3030313335583030313 82F53.Shape" srsName="urn:ogc:def:crs:EPSG:6.15:7412" srsDimension="3">
                                <!-- As the X and Y coordinates have the same values in all the points of the 3D line, it means that the borehole is vertical -->
                                <gml:pointProperty xlink:href="#bh.3030313335583030313 82F53.CollarLocation"/>
                                <gml:pos>631154.1 2622191.9 -112</gml:pos>
                        </gml:LineString>
                </sa:shape>
                <sa:length uom="urn:ogc:def:uom:UCUM:m">130</sa:length>
                <gsml:collarLocation>
                        <gsml:BoreholeCollar>
                                <gsml:location>
                                        <gml:Point gml:id="bh.3030313335583030313 82F53.CollarLocation" srsName="#bh.3030313335583030313 82F53.Shape">
                                                <gml:pos>631154.1 2622191.9 18</gml:pos>
                                        </gml:Point>
                                </gsml:location>
                        </gsml:BoreholeCollar>
                </gsml:collarLocation>
                <!-- TB3 Profile Note: we would like to include indexData if available but at the moment the model restricts drillingMethod to a fixed
                list of codes which don't include unknown or other and so may be impossible to fill except with wrong data to produce a valid instance
                Therefore awaiting a proposed change to model not to restrict this list before providing this data in any instances. -->
        </gsml:Borehole>
</gml:featureMember>
</wfs:FeatureCollection>
```

4.5 Use Case 3B – Geologic Units

The Use Case is defined as: ‘serialize Geologic Unit, filter based on preferredAge. Age terms used for query will come from a GeoSciML stratigraphic time scale register constructed using GeologicTime package, based on International Stratigraphic Chart (ISC). Unique identifiers for ControlledConcepts in this time scale vocabulary will be the names of the geochronologic units as presented on the chart (http://www.stratigraphy.org/cheu.pdf).

4.5.1 Profile diagram for Use Case 3B

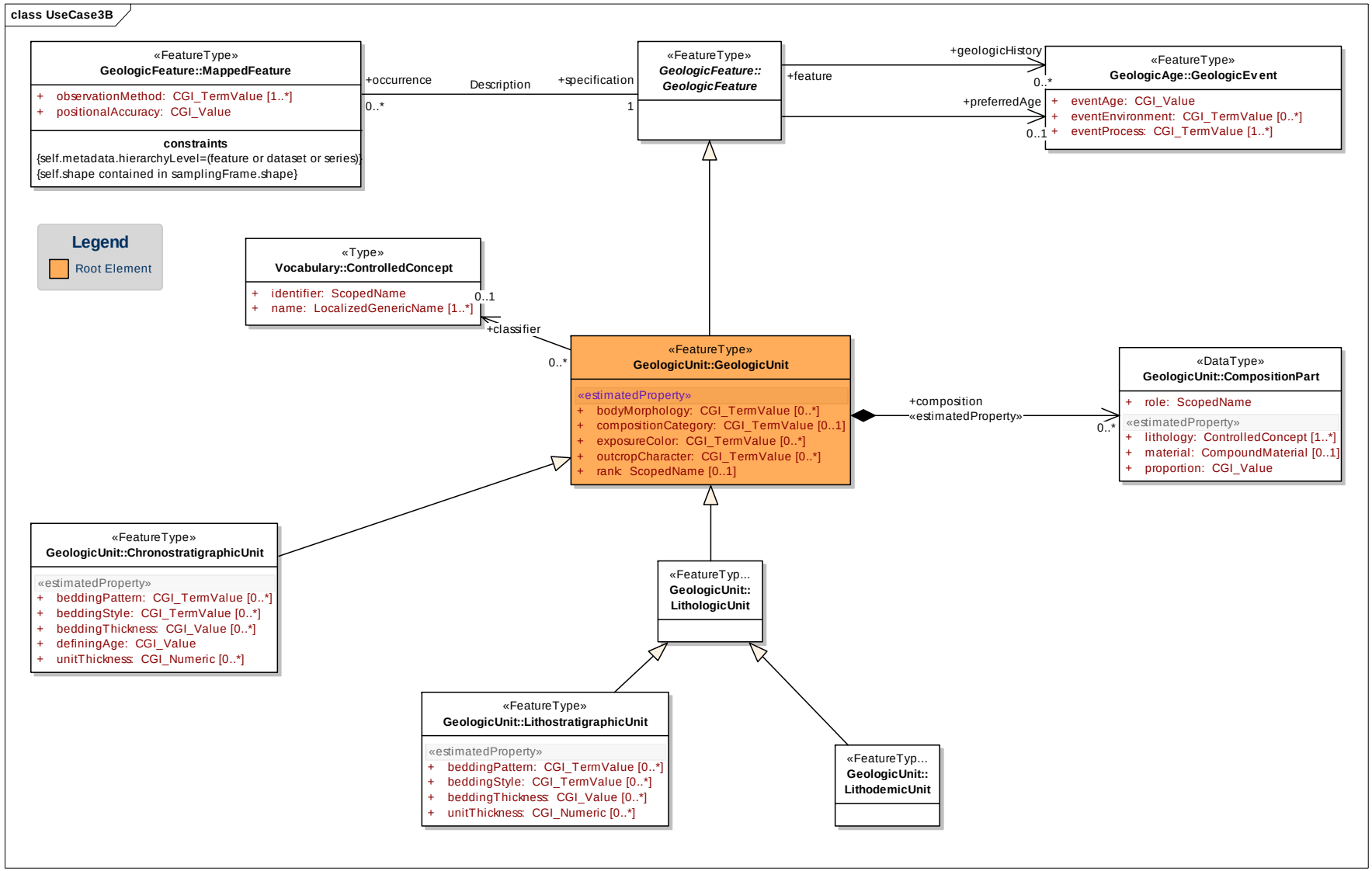

Figure 19: Profile diagram for Use Case 3B

4.5.2 Exemplar GeoSciML for Use Case 3B

```
<?xml version="1.0" encoding="UTF-8"?>
<wfs:FeatureCollection xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/wfs http://schemas.opengis.net/wfs/1.1.0/wfs.xsd urn:cgi:xmlns:CGI:GeoSciML:2.0
http://www.geosciml.org/schemas/geosciml/2.0_rc2/geosciml.xsd" xmlns:gml="http://www.opengis.net/gml" xmlns:wfs="http://www.opengis.net/wfs" xmlns:gsml="urn:cgi:xmlns:CGI:GeoSciML:2.0"
xmlns:cgu="urn:cgi:xmlns:CGI:Utilities:1.0" xmlns:xlink="http://www.w3.org/1999/xlink" gml:id="GA_1M_GeologicUnits_Collection_000001">
        <gml:featureMember>
                <!-- TB3 Profile Note: Organizations are free to return GeologicUnit or  a subtype like LithodemicUnit etc.
                        However, do not return DeformationUnits (which require links to GeologicStructures and are getting too complex for this UseCase. -->
                <gsml:GeologicUnit gml:id="GA_GeologicUnit_Stratno_38485">
                        <!-- TB3 Profile Note: Suggest everyone includes a name and description here. -->
                        <!-- TB3 Profile Note: A name with a codeSpace of urn:ietf:rfc:2141 should be a URN which uniquely identifies the feature.
                                        For Testbed participants this will
                                        generally follow the pattern urn:cgi:feature:{your_registered_organization}:{your_unique_feature_id}.
                                        (This is a temporary convention prior to upgrading to GML 3.2 and gml:identifier property.) -->
                        <gml:description>Channel and flood plain alluvium; gravel, sand, silt, clay</gml:description>
                        <gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:feature:GA:StratigraphicLexicon:Stratno:38485</gml:name>
                        <gml:name codeSpace="urn:cgi:classifierScheme:GA:StratigraphicLexicon:Stratname">alluvium 38485</gml:name>
                        <gml:name codeSpace="urn:cgi:classifierScheme:GA:StratigraphicLexicon:Map_symbol">Qa</gml:name>
                        <!-- TB3 Profile Note: All organizations examples to date have very generic values for observation method meaning basically
                                        "published description" which suggests that no-one actually explicitly stores this information at the moment. Thus it
                                        would be possible to use a CDTG defined term registered in the
                                        urn:cgi:classifierScheme:CGI:ObservationMethod:2008 codeSpace.
                                        As this information will not be the basis of any queries, however, we will not constrain whether people use the cgi codeSpace or their
                                        own. Need to clarify whether all codeSpaces should be recorded in CGIClassifierSchemeRegister .-->
                        <gsml:observationMethod>
                                <gsml:CGI_TermValue>
                                        <gsml:value codeSpace="urn:cgi:classifierScheme:GA:ObservationMethods">published description</gsml:value>
                                        <!-- Constant  -->
                                </gsml:CGI_TermValue>
                        </gsml:observationMethod>
                        <!-- TB3 Profile Note: typicalNorm, definingNorm and instance are acceptable. -->
                        <gsml:purpose>typicalNorm</gsml:purpose>
                        <!-- Constant  -->
                        <!-- TB3 Profile Note: occurrence is optional. -->
                        <!-- TB3 Profile Note: For Use Cases 3B must have a single value for the preferredAge as we are querying on this. -->
                        <gsml:preferredAge>
                                <gsml:GeologicEvent>
                                        <gsml:eventAge>
                                                <gsml:CGI_TermValue>
                                                        <gsml:value codeSpace="urn:cgi:classifierScheme:ICS:StratChart:2008">urn:cgi:classifier:ICS:StratChart:2008:Quaternary</gsml:value>
                                                </gsml:CGI_TermValue>
                                        </gsml:eventAge>
                                        <gsml:eventEnvironment>
                                                <gsml:CGI_TermValue>
                                                        <gsml:value codeSpace="urn:cgi:classifierScheme:GA:Process">fluvial</gsml:value>
                                                </gsml:CGI_TermValue>
                                        </gsml:eventEnvironment>
                                        <gsml:eventProcess>
                                                <gsml:CGI_TermValue>
```

```
                                                <gsml:value codeSpace="urn:cgi:classifierScheme:GA:Process">deposition</gsml:value>
                                        </gsml:CGI_TermValue>
                                </gsml:eventProcess>
                        </gsml:GeologicEvent>
                </gsml:preferredAge>
                <!-- TB3 Profile Note: It is OK to put a geologicHistory property if you have that information.
                        Note that it is acceptable to have a geologicHistory with only one event.-->
                <!-- TB3 Profile Note: Can include compositionCategory property if you have the data but can omit if you don't. -->
                <gsml:compositionCategory>
                        <gsml:CGI_TermValue>
                                <gsml:value codeSpace="urn:cgi:classifierScheme:GA:CompositionCategory">silicate</gsml:value>
                        </gsml:CGI_TermValue>
                </gsml:compositionCategory>
                <!-- TB3 Profile Note: Can include or omit rank depending on whether you have data. -->
                <gsml:rank codeSpace="urn:cgi:classifierScheme:GA:Rank">formation</gsml:rank>
                <!-- TB3 Profile Note: It is optional whether to return part property. Refer to TB3_UC3B_GSV_GeologicUnit_All.xml for example. -->
                <!-- TB3 Profile Note: All other properties of GeologicUnit and subtypes are optional and can be included if you have the data.. -->
                <gsml:classifier xlink:href="urn:cgi:classifier:GA:StratigraphicLexicon:Stratno:38485"/>
                <gsml:composition>
                        <gsml:CompositionPart>
                                <gsml:role codeSpace="urn:cgi:classifierScheme:GA:Role">part of</gsml:role>
                                <!-- TB3 Profile Note: BGS has included ControlledConcept inline, others have used xlink:href with a URN value. Will these URNs
                                        be registered with the registry? No consensus on email discussion yet? -->
                                <gsml:lithology>
                                        <!-- TB3 Profile Note: Should use the CGI Simple Lithology terms at

        .http://tellus.brgm.fr/exist/brgm_geosciml/concept.xql?request=GetResource&resourcetype=vocabulary&resourcepath=CGI_SimpleLithology_2008.xml -->
                                        <!-- TB3 Profile Note: Could also include extra lithology properties using your own dictionaries if you wish. -->
                                        <!-- TB3 Profile Note: Example has same gml:id as in register vocabulary for convenience but this cannot be a requirement. -->
                                        <gsml:ControlledConcept gml:id="CGILith_036">
                                                <gml:name codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:CGI:SimpleLithology:2008:clastic_sediment</gml:name>
                                                <gsml:identifier codeSpace="urn:ietf:rfc:2141">urn:cgi:classifier:CGI:SimpleLithology:2008:clastic_sediment</gsml:identifier>
                                                <gsml:name xml:lang="en" codeSpace="urn:cgi:classifierScheme:CGI:SimpleLithology:2008">clastic sediment</gsml:name>
                                                <gsml:vocabulary xlink:href="urn:cgi:classifierScheme:CGI:SimpleLithology:2008"/>
                                        </gsml:ControlledConcept>
                                </gsml:lithology>
                                <!-- TB3 Profile Note: For proportion use either a numerical percentage or a value from the  dictionary at
                                http://tellus.brgm.fr/exist/brgm_geosciml/concept.xql?request=GetResource&resourcetype=vocabulary&resourcepath=CGI_CompositionPartProportion.xml
                                -->
                                <gsml:proportion>
                                        <gsml:CGI_TermValue>
                                                <gsml:value
codeSpace="urn:cgi:classifierScheme:CGI:CompositionPartProportion:2008">urn:cgi:classifier:CGI:CompositionPartProportion:2008:dominant</gsml:value>
                                        </gsml:CGI_TermValue>
                                </gsml:proportion>
                        </gsml:CompositionPart>
                </gsml:composition>
        </gsml:GeologicUnit>
    </gml:featureMember>
</wfs:FeatureCollection>
```