GeoSciML 3.2 Encoding Cookbook for OneGeology 5 star WFS services

1. Introduction

GeoSciML is a standards-based data format that provides a framework for application-neutral encoding of geosciences information. This cookbook refers to GeoSciML v3.2. GeoSciML has a wide scope allowing the encoding of most information depicted on geological maps, as well as information about boreholes and laboratory analyses. This cookbook, however, concentrates on just that part of GeoSciML necessary for delivering geological age and lithology information through OneGeology-Global services. Geological age and lithology are used as the basis for querying and portrayal in OneGeology-Global, and so this is essential information that must be provided as part of a OneGeology-Global service. Other mandatory GeoSciML fields will also be described. A OneGeology-Global service can, of course, deliver much more information using other parts of GeoSciML, but this won't be described in this cookbook.

GeoSciML is based on Geography Markup Language v3.2 (GML) (ISO 19136:2007) for representation of features and geometry. To facilitate semantic interoperability vocabularies have been developed by the CGI for many GeoSciML properties and these are available from the GeoSciML resources website (http://resource.geosciml.org/). The use of these vocabularies is mandatory for OneGeology-Global and will be described in the relevant section of the model below. The CGI vocabularies are encoded in SKOS RDF and use http URIs as concept identifiers.

The cookbook is designed to assist users map their data to the GeoSciML 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.

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.

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.geosciml.org/. The supporting materials most relevant to this cookbook include:

- Full documentation of the GeoSciML model. This is generated automatically from the GeoSciML UML diagrams and draws on the scope notes in those diagrams. This full documentation, however, does not include any best practice guidance
- An Enterprise Architect version of the UML for the CGI packages
- GeoSciML examples

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

1. full compliance with existing GeoSciML conformance criteria
2. the IWG and its GeoSciML products are not misrepresented or misused
3. the IWG retains full copyright to all IWG and GeoSciML names and products, including logos, text, images and technical materials
4. 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
5. the GeoSciML products developed by the IWG may be freely copied and used within third-party information systems, with acknowledgements as per (8) below
6. 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
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8. acknowledgement of GeoSciML and the IWG is made in all communications and products related to work involving GeoSciML or the IWG, with appropriate citation
9. 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 respect of loss, damage, injury or other occurrence however caused

2. *GeoSciML model and OneGeology-Global encoding*

There are fifteen packages in GeoSciML, five of which are required for OneGeology-Global services: GeoSciML-Core; GeologicUnit; GeologicAge; GeologicTimescale;

and EarthMaterial. This section will describe those parts of these packages which are the minimum requirement for OneGeology-Global necessary to support the queries implemented in the OneGeology-Global portal (section 3). In order to show the context of the GeoSciML used in OneGeology-Global the complete UML diagram for the relevant packages are shown. The objects required by OneGeology-Global are enclosed by red rectangles, as are the required attributes of those objects.

In GeoSciML most attributes have a cardinality of one or more, but are voidable. This is because these attributes must have a value, although it may not be available to the data provider. For example GeologicUnit has an attribute of unitThickness to describe the range in thickness of the unit. All units must have a range of thickness, but it may not be known. Where no value is provided for a voidable attribute then a nilReason must be provided. One of the nilReasons defined in ISO 19136:2007 section 8.2.3.1 should be used:

- **inapplicable** - there is no value
- **missing** - the correct value is not readily available to the sender of this data. Furthermore, a correct value may not exist
- **template** - the value will be available later
- **unknown** - the correct value is not known to, and not computable by, the sender of this data. However, a correct value probably exists
- **withheld** - the value is not divulged

An example of encoding nil values for GeologicUnit attributes is given in Figure 1.

```
<gsmlgu:bodyMorphology nilReason="unknown" xsi:nil="true" />
<gsmlgu:unitComposition nilReason="unknown" xsi:nil="true" />
 <gsmlgu:exposureColor nilReason="missing" xsi:nil="true" />
 <gsmlgu:outcropCharacter nilReason="missing" xsi:nil="true" />
```

Figure 1: Example of encoding of nil values

As GeoSciML is a GML schema all objects must have a value for the mandatory gml:id attribute. This provides an identifier for the XML element representing the object, and must be unique within the XML document. XML elements representing a particular object, for example a specific GeologicUnit, need only be described once in the document. Subsequent occurrences can reference the element using the gml:id. The gml:id attribute should not be used for the global identifier of the object, it is simply an identifier for an XML document element.

Vocabulary concepts should be encoded by reference. This enables information about the concept, such as a full description, to be accessed from the relevant vocabulary service. The general pattern is that the href attribute provides the URI of the concept and the title attribute provides a human readable label for it.

2.1 GeoSciML-Core – Mapped Feature and Geologic Feature

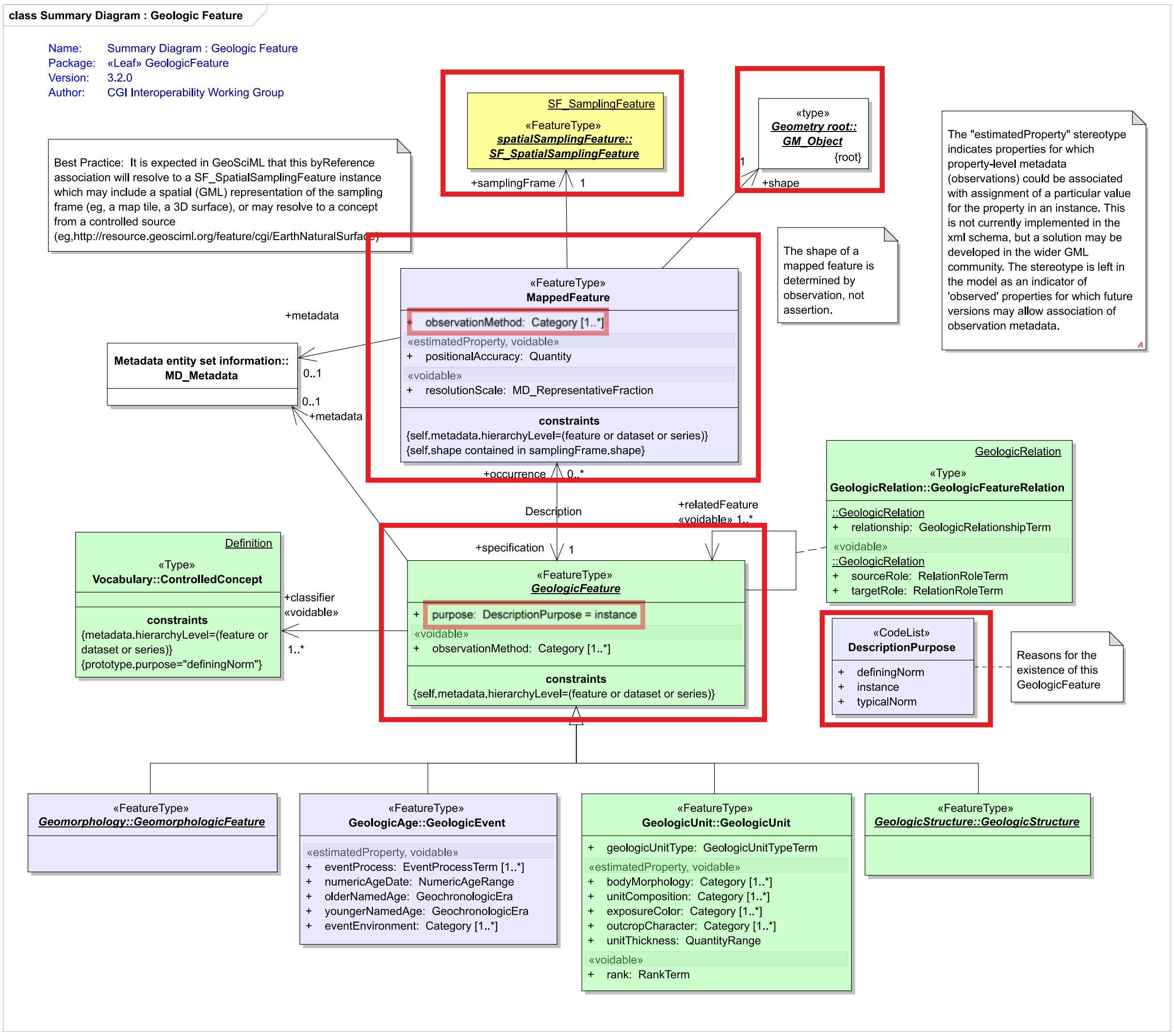

Figure 2: Summary UML for the GeologicFeature package

The MappedFeature and GeologicFeature objects are at the core of GeoSciML (Figure 2). 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 be specified by only one GeologicFeature. A OneGeology-Global service provides a collection of MappedFeatures. The complete encoding of a single MappedFeature, including its GeologicUnit specification, is provided in Annex 1.

2.1.1 Mapped Feature - observation method

The observationalMethod is the only attribute of MappedFeature required by OneGeology-Global and enables the distinct methodologies for observing it to be recorded. For example a MappedFeature might be observed through field observation (mapping). The vocabulary describing observationMethod is MappedFeatureObservationMethod (http://resource.geosciml.org/vocabulary/cgi/201211/MappedFeatureObservationMethod201211.rdf).

The observationMethod attribute is of type 'Category' which provides the resolvable URI for the vocabulary containing the observationMethod concepts in the codeSpace attribute, a definition of observationMethod in the definition property, the URI identifier for the observationMethod concept describing the MappedFeature in the value attribute, and a human readable version of the concept in the label attribute. The definition property can be populated with the URI of the vocabulary as this resolves to a page including the definition.

There is also a 'Category extension' which uses the same Category type and attributes to provide 'qualification' information on the data value being provided. For example where an observation method of 'Compilation' is provided the qualification information might be 'always' or 'sometimes'. These qualification values are given in the ValueQualifier vocabulary (http://resource.geosciml.org/vocabulary/cgi/201211/ValueQualifier201211.rdf).

```xml
<gsml:observationMethod>
 <swe:Category
  definition="http://resource.geosciml.org/classifierscheme/cgi/201211/mappedfeatureobservationmethod">
  <swe:extension>
   <swe:Category
    definition="http://resource.geosciml.org/classifierscheme/cgi/201211/valuequalifier">
    <swe:identifier>http://resource.geosciml.org/classifier/cgi/valuequalifier/always</swe:identifier>
    <swe:label>always</swe:label>
    <swe:codeSpace
     xlink:href="http://resource.geosciml.org/classifierscheme/cgi/201211/valuequalifier"
    />
   </swe:Category>
  </swe:extension>
  <swe:identifier>http://resource.geosciml.org/classifier/cgi/mappedfeatureobservationmethod/compilation</swe:identifier>
  <swe:label>Compilation</swe:label>
  <swe:codeSpace
   xlink:href="http://resource.geosciml.org/classifierscheme/cgi/201211/mappedfeatureobservationmethod"
  />
 </swe:Category>
</gsml:observationMethod>
```

Figure 3: Example of the encoding of observation method

2.1.2 Mapped Feature - sampling frame

Each MappedFeature has a samplingFrame association to SF_SpatialSamplingFeature that indicates the spatial reference frame within which the MappedFeatures have been observed, such as a surface of mapping or a borehole. This should ideally reference a concept from a controlled source, and the CGI is in the process of developing a vocabulary for this.

```xml
<gsml:samplingFrame xlink:href="http://inspire.ec.europa.eu/codelist/MappingFrameValue/topOfBedrock"
```

Figure 4: Example of the encoding of sampling frame

2.1.3 Mapped Feature - geometry (shape)

The geometry of each MappedFeature is provided by the shape association to GM_Object. The geological map elements delivered in OneGeology-Global should be encoded as Polygons with exterior, and where there are included polygons, interior, LinearRings.

```
<gsml:shape>
   <gml:Polygon srsName="urn:ogc:def:crs:EPSG::4326" gml:id="LOCAL_ID_0">
      <gml:exterior>
         <gml:LinearRing>
            <gml:posList srsDimension="2" count="8">55.0760921318516 -3.31719604609088 55.0833753209835 -3.31853455922777 55.0825574334633 -3.31921378657955 55.0801997429522 -3.31978309699423 55.0768616358466 -3.3194575613054 55.0741365291192 -3.31966903508197 55.0756843873373 -3.31747948721346 55.0760921318516 -3.31719604609088</gml:posList>
         </gml:LinearRing>
      </gml:exterior>
   </gml:Polygon>
</gsml:shape>
```

Figure 5: Example of the encoding of MappedFeature geometry (shape)

2.1.4 Geologic Feature - purpose

GeologicFeature is the abstract parent class for GeologicUnit and GeologicEvent, which will be described in subsequent sections. It has only one mandatory attribute, purpose, describing the intention of the GeologicFeature. This must take one of the three values from the DescriptionPurpose codelist (Figure 2): an instance where the GeologicFeature description is of an individual occurrence; a defining norm which provides the normative description of a type of GeologicFeature (eg a particular lithostratigraphic unit); and a typical norm which includes descriptive information in addition to that which defines the GeologicFeature and which is commonly derived from multiple instance descriptions. Most GeologicFeatures on a published geological map will be typical norms.

2.2 Geologic Unit and Earth Material

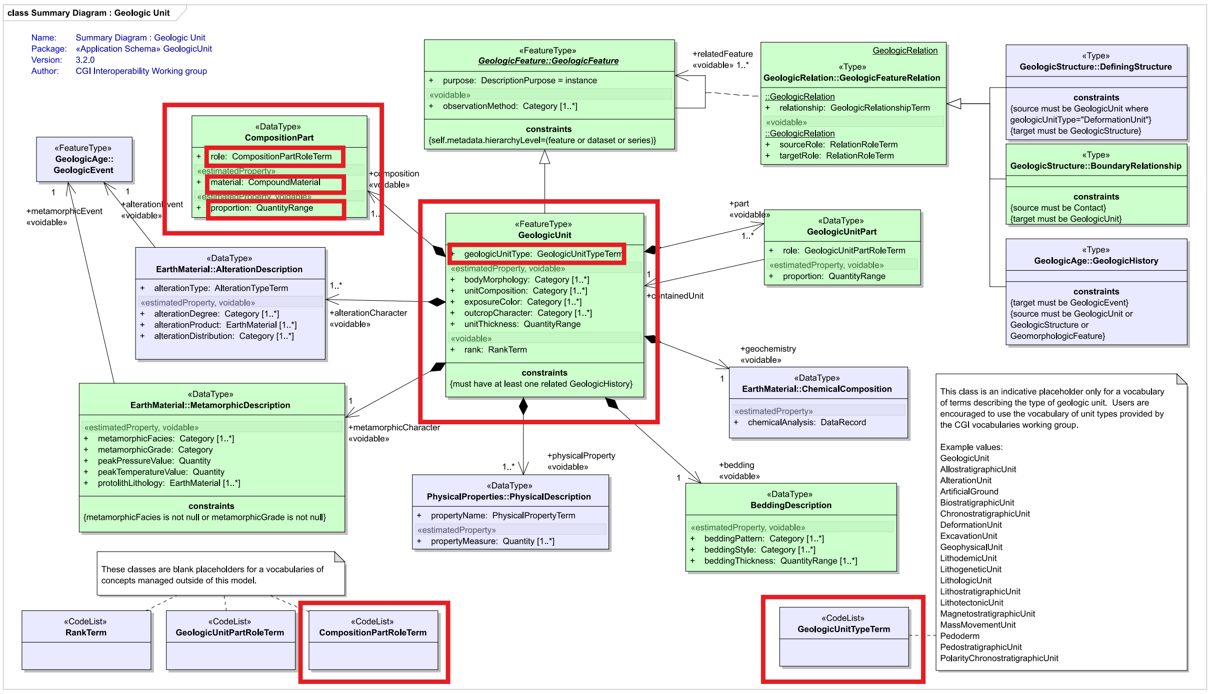

Figure 6: Summary UML for the GeologicUnit package

GeologicUnit is a specialisation of GeologicFeature (Figure 6) and is the only type of GeologicFeature used to specify MappedFeatures in OneGeology-Global.

2.2.1 Geologic Unit – geologic unit type

The only GeologicUnit attribute that is mandatory for OneGeology-Global is geologicUnitType. This indicates the type of the geologic unit, for example a lithostratigraphic unit or a lithologic unit. Values must be drawn from the GeologicUnitType vocabulary (http://resource.geosciml.org/vocabulary/cgi/201211/GeologicUnitType201211.rdf).

2.2.2 Geologic Unit – composition

The composition association from GeologicUnit to CompositionPart provides the means for describing the lithology of the GeologicUnit. In OneGeology-Global a GeologicUnit must have at least one CompositionPart, but can have several where the GeologicUnit is composed of several different lithologies. For each CompositionPart values for three attributes must be provided: role, material and proportion.

2.2.3 Composition Part - role

Role defines the relationship of the compositionPart in the GeologicUnit as a whole, e.g. vein, interbedded constituent, layers, dominant constituent. Values should be drawn from the GeologicUnitPartRole vocabulary (http://resource.geosciml.org/vocabulary/cgi/201211/GeologicUnitPartRole201211.rdf).

2.2.4 Composition Part - proportion

The proportion attribute defines the proportion of the GeologicUnit as a whole that the CompositionPart comprises. It is of type GSML_QuantityRange and should be encoded as two percentage numbers giving the upper and lower limits of the range within which the CompositionPart proportion is considered to lie which are included both as a space separated tuple to be compatible with SWE and as separate lower and upper values to enable querying in a WFS (Figure 7).

```
<gsmlgu:proportion>
  <GSML_QuantityRange xmlns="http://xmlns.geosciml.org/Utilities/3.2">
    <swe:uom code="%" xlink:href="http://unitsofmeasure/ucum.html#para-29" xlink:title="percent"/>
    <swe:value>5.0 50.0</swe:value>
    <lowerValue>5.0</lowerValue>
    <upperValue>50.0</upperValue>
  </GSML_QuantityRange>
</gsmlgu:proportion>
```

Figure 7: Example of the encoding of proportion

2.2.5 Composition Part - material

The material attribute is of type CompoundMaterial (Figure 8) and provides the lithology of the CompositionPart. CompoundMaterial is a specialisation of EarthMaterial and the parent class of RockMaterial. The only two attributes that are mandatory for OneGeology-Global are EarthMaterial.purpose and RockMaterial.lithology (see Annex 1).

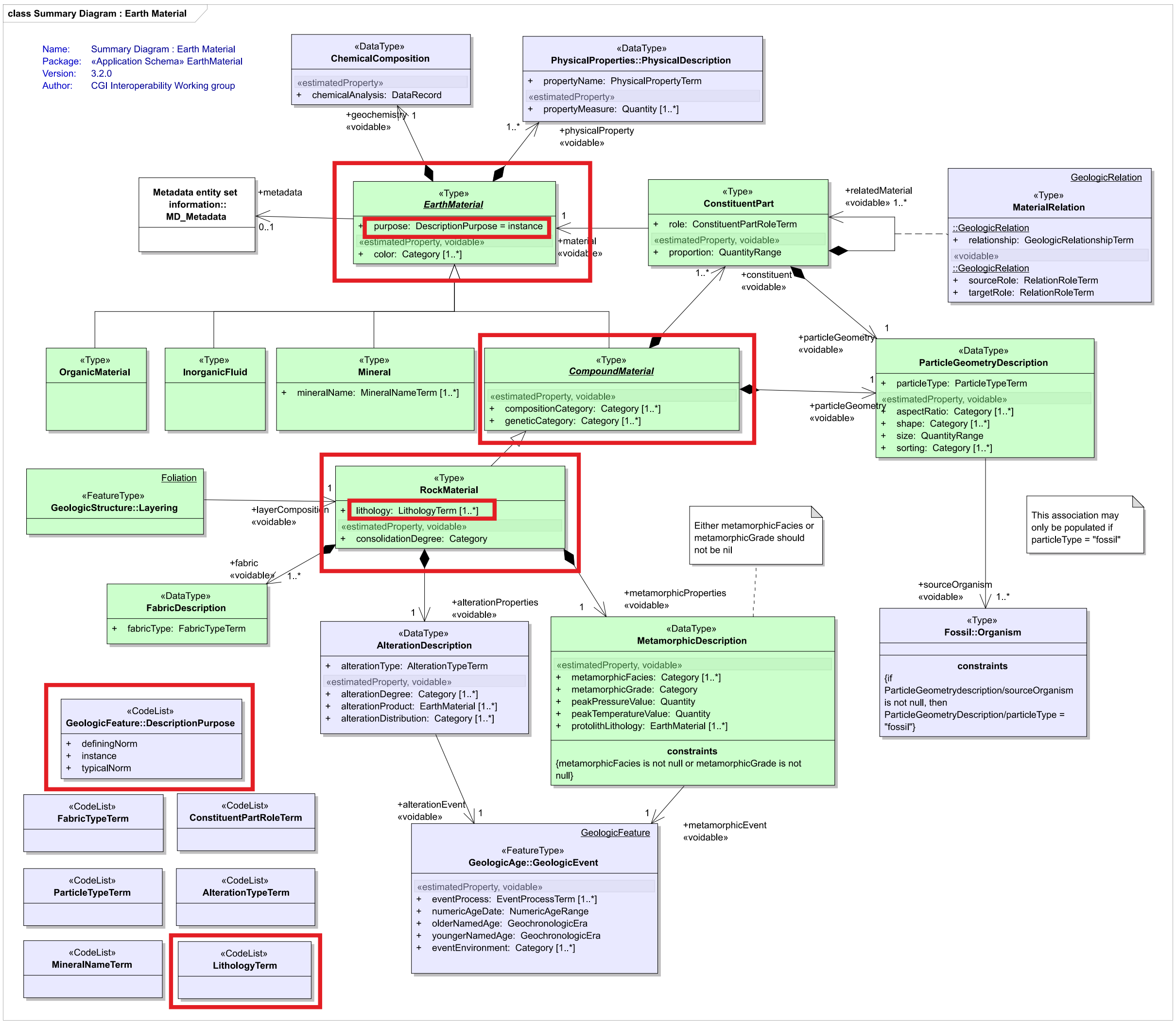

Figure 8: Summary UML for the EarthMaterial package

2.2.6 Earth Material - purpose

The purpose attribute of EarthMaterial has identical semantics to the purpose attribute of GeologicFeature described in section 2.1.4, and like it would commonly have a value of ‘typicalNorm’ for information from geological maps.

2.2.7 Rock Material - lithology

The lithology attribute provides the lithology of the CompositionPart of the GeologicUnit. GeoSciML allows multiple lithologies for each CompositionPart, but in OneGeology-Global each CompositionPart should be restricted to a single lithology, although, as indicated in section 2.2.2, a GeologicUnit can have multiple CompositionParts. Values for lithology should be drawn from the SimpleLithology vocabulary (http://resource.geosciml.org/vocabulary/cgi/201211/SimpleLithology201211.rdf).

2.3 Geologic Age and Geologic Timescale

Geologic age is provided using the relatedFeature association from GeologicFeature to itself (Figure 9). This association is described by GeologicHistory, a specialisation of GeologicFeatureRelation, which constrains relatedFeature to associate a GeologicFeature to a GeologicEvent. GeologicHistory allows the recording of a succession of geologic events that affected the GeologicUnit , along with the period over which they occurred. In OneGeology-Global however only a single GeologicEvent defining the formation of the GeologicUnit should be provided (see section 3.1.3).

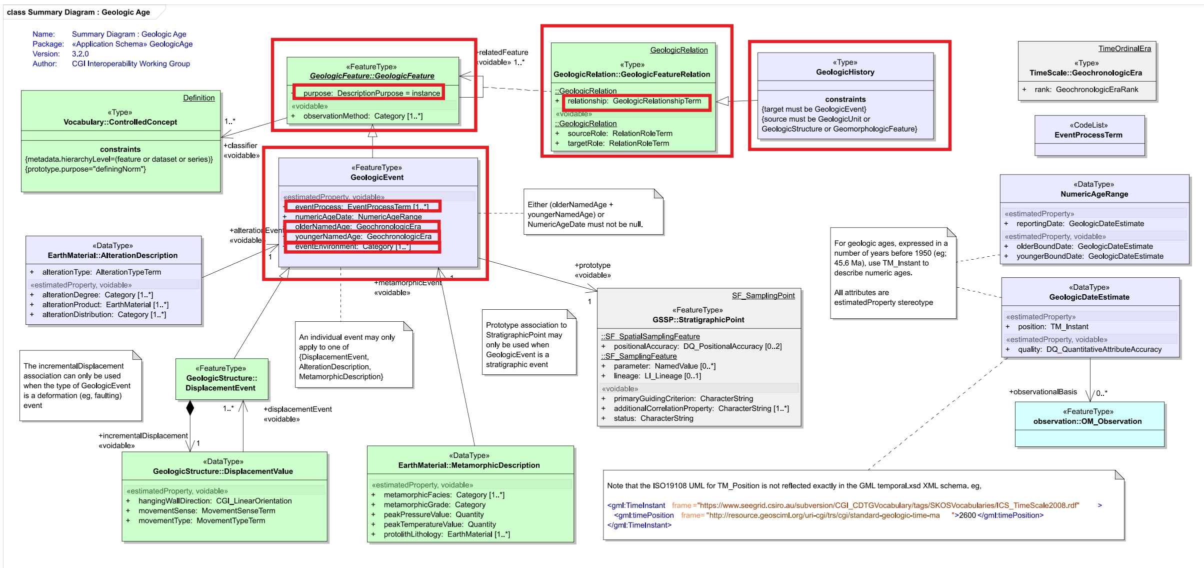

Figure 9: Summary UML of the Geologic Age package

2.3.1 Geologic Feature Relation – relationship

The only mandatory attribute of GeologicFeatureRelation is ‘relationship’ which describes the nature of the relationship. In OneGeology-Global the GeologicEvent that is being provided is that which was responsible for the creation of the GeologicUnit, so the relationship attribute will have a value something like ‘Formation of the unit’. These values should be drawn from a vocabulary, such as that at present under development by the CGI.

2.3.2 Geologic Event – purpose

GeologicEvent is a type of GeologicFeature from which it inherits the mandatory purpose attribute. The semantics are as described in section 2.1.4, and would commonly have a value of ‘typicalNorm’ for information from geological maps.

2.3.3 Geologic Event – younger named age and older named age

GeoSciML enables ages to be provided as numeric ages and/or as a named age expressed using a geochronologic era defined according to a geologic time scale. In OneGeology-Global it is only necessary to provide a named age. Geochronologic era names should be drawn from the CGI 2011 Timescale vocabulary (http://resource.geosciml.org/static/vocabulary/timescale/isc-2012.rdf), which is based on the International Commission for Stratigraphy (ICS) international stratigraphic chart supplemented with a more detailed chronology for parts of the Precambrian. Both the olderNamedAge and the youngerNamedAge attributes should be populated, giving the age of the start and end of the GeologicEvent respectively. It may be that the GeologicEvent age is fully enclosed by a single geochronologic era, in which case the olderNamedAge and the youngerNamedAge attributes should both be populated with the same value.

3. *OneGeology-Global querying*

The OneGeology-Global portal at present implements three queries which will be briefly explained here: spatial, lithology and age. These queries can be combined so as to select, for example, all those MappedFeatures of a particular age and lithology within a specified area. The purpose of the queries is to enable the delivery of just a sub-set of the data provided by the service, to more closely meet the requirements of the user.

3.1.1 Spatial querying

Spatial querying is possible using a defined rectangle. In the query (Figure 10) the BBOX operator is used to filter for all those MappedFeatures where the geometry given by the shape attribute (section 2.1.3) lies within a rectangle defined by upper and lower corner points.

```xml
<wfs:GetFeature xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.opengis.net/wfs/2.0 http://schemas.opengis.net/wfs/2.0/wfs.xsd
http://www.opengis.net/gml/3.2 http://schemas.opengis.net/gml/3.2.1/gml.xsd"
  xmlns:gsml="http://xmlns.geosciml.org/GeoSciML-Core/3.2"
  xmlns:fes="http://www.opengis.net/fes/2.0"
  xmlns:wfs="http://www.opengis.net/wfs/2.0"
  xmlns:gml="http://www.opengis.net/gml/3.2" service="WFS" version="2.0.0"
  outputFormat="application/gml+xml; version=3.2" count="10">
  <wfs:Query typeNames="gsml:MappedFeature">
    <fes:Filter>
      <fes:BBOX>
        <fes:ValueReference>gsml:shape</fes:ValueReference>
        <gml:Envelope srsName="urn:ogc:def:crs:EPSG::4326">
          <gml:lowerCorner>50.61 -1.29</gml:lowerCorner>
          <gml:upperCorner>50.67 -1.19</gml:upperCorner>
        </gml:Envelope>
      </fes:BBOX>
    </fes:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

Figure 10: Example of a spatial query using a rectangle

3.1.2 Lithology querying

The first lithology query (Figure 11) filters on the lithology attribute (section 2.2.7), looking for an exact match with the specified value. Note that the portal client by default adds any child concepts for lithologies you select to the query so in this example, where limestone was selected, the sub-types of limestone (chalk and travertine) are also included in the query. As explained in section 2.2.2 a GeologicUnit can have multiple CompositionParts describing the different lithological components of the GeologicUnit. This lithology query takes no account of the proportion attribute and will retrieve GeologicUnits where any CompositionPart is of the specified lithology, not just those where the specified lithology is predominant.

```
<wfs:GetFeature xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xsi:schemaLocation=
 "http://www.opengis.net/wfs/2.0 http://schemas.opengis.net/wfs/2.0/wfs.xsd
 http://www.opengis.net/gml/3.2 http://schemas.opengis.net/gml/3.2.1/gml.xsd"
 xmlns:gsml="http://xmlns.geosciml.org/GeoSciML-Core/3.2"
 xmlns:gsmlgu="http://xmlns.geosciml.org/GeologicUnit/3.2"
 xmlns:gsmlga="http://xmlns.geosciml.org/GeologicAge/3.2"
 xmlns:fes="http://www.opengis.net/fes/2.0"
 xmlns:wfs="http://www.opengis.net/wfs/2.0"
 xmlns:gml="http://www.opengis.net/gml/3.2"
 xmlns:xlink="http://www.w3.org/1999/xlink"
 count="10"
 service="WFS"
 version="2.0.0"
 outputFormat="application/gml+xml; version=3.2">
 <wfs:Query typeNames="gsml:MappedFeature">
  <fes:Filter>
   <fes:Or>
    <fes:PropertyIsEqualTo>
     <fes:ValueReference>
gsml:specification/gsmlgu:GeologicUnit/gsmlgu:composition/gsmlgu:CompositionPart/gsmlgu:material/gsmlem:RockMater
ial/gsmlem:lithology/@xlink:href
     </fes:ValueReference>
     <fes:Literal>
      http://resource.geosciml.org/classifier/cgi/lithology/limestone
     </fes:Literal>
    </fes:PropertyIsEqualTo>
    <fes:PropertyIsEqualTo>

<fes:ValueReference>gsml:specification/gsmlgu:GeologicUnit/gsmlgu:composition/gsmlgu:CompositionPart/gsmlgu:materi
al/gsmlem:RockMaterial/gsmlem:lithology/@xlink:href
     </fes:ValueReference>
     <fes:Literal>
      http://resource.geosciml.org/classifier/cgi/lithology/chalk
     </fes:Literal>
    </fes:PropertyIsEqualTo>
    <fes:PropertyIsEqualTo>
     <fes:ValueReference>

gsml:specification/gsmlgu:GeologicUnit/gsmlgu:composition/gsmlgu:CompositionPart/gsmlgu:material/gsmlem:RockMater
ial/gsmlem:lithology/@xlink:href
     </fes:ValueReference>
     <fes:Literal>
      http://resource.geosciml.org/classifier/cgi/lithology/travertine
     </fes:Literal>
    </fes:PropertyIsEqualTo>
   </fes:Or>
  </fes:Filter>
```

```
  </wfs:Query>
</wfs:GetFeature>
```

Figure 11: Example of a lithology query

In addition there is a query on a single lithology only which will take into account the proportion attribute and allow you to restrict the returned features to those where the requested lithology has a proportion range with lower bound at least as large as some user specified value (Figure 12). This allows you not to retrieve features where the specified lithology is only present in minor amounts.

```
<wfs:GetFeature xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xsi:schemaLocation=
 "http://www.opengis.net/wfs/2.0 http://schemas.opengis.net/wfs/2.0/wfs.xsd
 http://www.opengis.net/gml/3.2 http://schemas.opengis.net/gml/3.2.1/gml.xsd"
 xmlns:gsml="http://xmlns.geosciml.org/GeoSciML-Core/3.2"
 xmlns:gsmlgu="http://xmlns.geosciml.org/GeologicUnit/3.2"
 xmlns:gsmlga="http://xmlns.geosciml.org/GeologicAge/3.2"
 xmlns:gsmlu="http://xmlns.geosciml.org/Utilities/3.2"
 xmlns:gsmlem="http://xmlns.geosciml.org/EarthMaterial/3.2"
 xmlns:fes="http://www.opengis.net/fes/2.0"
 xmlns:wfs="http://www.opengis.net/wfs/2.0"
 xmlns:gml="http://www.opengis.net/gml/3.2"
 xmlns:xlink="http://www.w3.org/1999/xlink"
 count="200"
 service="WFS"
 version="2.0.0"
 outputFormat="application/gml+xml; version=3.2">
 <wfs:Query typeNames="gsml:MappedFeature">
  <fes:Filter>
   <fes:PropertyIsGreaterThanOrEqualTo>
    <fes:ValueReference>

gsml:specification/gsmlgu:GeologicUnit/gsmlgu:composition/gsmlgu:CompositionPart[gsmlgu:material/gsmlem:RockMater
ial/gsmlem:lithology/@xlink:href
      =
'http://resource.geosciml.org/classifier/cgi/lithology/sandstone']/gsmlgu:proportion/gsmlu:GSML_QuantityRange/gsmlu:low
erValue
    </fes:ValueReference>
    <fes:Literal>10.0</fes:Literal>
   </fes:PropertyIsGreaterThanOrEqualTo>
  </fes:Filter>
 </wfs:Query>
</wfs:GetFeature>
```

Figure 12 Example of a lithology query conditional on proportion

3.1.3 Age querying

The age query (Figure 13) filters on the youngerNamedAge attribute (section 2.3.3), looking for an exact match with the specified value. This means that only GeologicUnits the upper boundary of which lies with the specified geochronologic unit will be retrieved, not those which encompass the geochronologic unit or have their lower boundary within it. Note that the portal client by default adds any child named ages to the query so, in the example given in figure 13 where the Pliocene epoch was selected, the Piacenzian and Zanclean stages are also included in the query, so a GeologicUnit with its upper boundary in either of these geochronologic units would be retrieved. The query does not look at any properties of GeologicEvent to determine if the event is that which formed the GeologicUnit and it would therefore retrieve any GeologicEvent matching the age criteria. Only the GeologicEvent responsible for the formation of the GeologicUnit should therefore be provided in the OneGeology-Global service.

```
<wfs:GetFeature xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xsi:schemaLocation=
 "http://www.opengis.net/wfs/2.0 http://schemas.opengis.net/wfs/2.0/wfs.xsd
 http://www.opengis.net/gml/3.2 http://schemas.opengis.net/gml/3.2.1/gml.xsd"
 xmlns:gsml="http://xmlns.geosciml.org/GeoSciML-Core/3.2"
 xmlns:gsmlgu="http://xmlns.geosciml.org/GeologicUnit/3.2"
 xmlns:gsmlga="http://xmlns.geosciml.org/GeologicAge/3.2"
 xmlns:fes="http://www.opengis.net/fes/2.0"
 xmlns:wfs="http://www.opengis.net/wfs/2.0"
 xmlns:gml="http://www.opengis.net/gml/3.2"
 xmlns:xlink="http://www.w3.org/1999/xlink"
 count="10"
 service="WFS"
 version="2.0.0"
 outputFormat="application/gml+xml; version=3.2">
 <wfs:Query typeNames="gsml:MappedFeature">
  <fes:Filter>
   <fes:Or>
    <fes:PropertyIsEqualTo>
     <fes:ValueReference>

gsml:specification/gsmlgu:GeologicUnit/gsml:relatedFeature/gsmlga:GeologicHistory/gsml:relatedFeature/gsmlga:Geologic
Event/gsmlga:youngerNamedAge/@xlink:href
     </fes:ValueReference>
     <fes:Literal>
      http://resource.geosciml.org/classifier/ics/ischart/Pliocene
     </fes:Literal>
    </fes:PropertyIsEqualTo>
    <fes:PropertyIsEqualTo>
     <fes:ValueReference>

gsml:specification/gsmlgu:GeologicUnit/gsml:relatedFeature/gsmlga:GeologicHistory/gsml:relatedFeature/gsmlga:Geologic
Event/gsmlga:youngerNamedAge/@xlink:href
     </fes:ValueReference>
     <fes:Literal>
      http://resource.geosciml.org/classifier/ics/ischart/Piacenzian
     </fes:Literal>
    </fes:PropertyIsEqualTo>
    <fes:PropertyIsEqualTo>
     <fes:ValueReference>

gsml:specification/gsmlgu:GeologicUnit/gsml:relatedFeature/gsmlga:GeologicHistory/gsml:relatedFeature/gsmlga:Geologic
Event/gsmlga:youngerNamedAge/@xlink:href
     </fes:ValueReference>
     <fes:Literal>
      http://resource.geosciml.org/classifier/ics/ischart/Zanclean
     </fes:Literal>
    </fes:PropertyIsEqualTo>
```

```
      </fes:Or>
    </fes:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

Figure 13: Example of an age query

Annex 1: Example encoding of a MappedFeature

Note that this example includes the encoding of attributes which are not mandatory for GeooSciML, such as eventProcess in GeologicEvent. Extending the basic information required for OneGeology-Global in this way makes the service more useful. Where appropriate such extensions should use the CGI vocabulariers provided at http://resource.geosciml.org/.


```xml
<?xml version="1.0" encoding="UTF-8"?>
<!--Created by GO Publisher WFS 2.1.2 Build 28125 from 2012-03-22 11:26-->
<!--Snowflake Software Ltd. (http://www.snowflakesoftware.com)-->
<wfs:FeatureCollection xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xmlns:xs="http://www.w3.org/2001/XMLSchema"
 xmlns:gsml="http://xmlns.geosciml.org/GeoSciML-Core/3.2"
 xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:xlink="http://www.w3.org/1999/xlink"
 xmlns:gmd="http://www.isotc211.org/2005/gmd" xmlns:gco="http://www.isotc211.org/2005/gco"
 xmlns:gss="http://www.isotc211.org/2005/gss" xmlns:gts="http://www.isotc211.org/2005/gts"
 xmlns:gsr="http://www.isotc211.org/2005/gsr" xmlns:swe="http://www.opengis.net/swe/2.0"
 xmlns:sam="http://www.opengis.net/sampling/2.0" xmlns:om="http://www.opengis.net/om/2.0"
 xmlns:gsmlgu="http://xmlns.geosciml.org/GeologicUnit/3.2"
 xmlns:gsmlem="http://xmlns.geosciml.org/EarthMaterial/3.2"
 xmlns:gsmlga="http://xmlns.geosciml.org/GeologicAge/3.2"
 xmlns:gsmlgt="http://xmlns.geosciml.org/GeologicTime/3.0"
 xmlns:sams="http://www.opengis.net/samplingSpatial/2.0"
 xmlns:gsmltrs="http://xmlns.geosciml.org/TemporalReferenceSystem/3.2"
 xmlns:gsmlpp="http://xmlns.geosciml.org/PhysicalProperties/3.2"
 xmlns:wfs="http://www.opengis.net/wfs/2.0" xmlns:ows="http://www.opengis.net/ows/1.1"
 xmlns:fes="http://www.opengis.net/fes/2.0"
 xsi:schemaLocation="http://xmlns.geosciml.org/GeoSciML-Core/3.2 http://schemas.geosciml.org/geosciml-core/3.2/geosciml-core.xsd
 http://xmlns.geosciml.org/GeologicUnit/3.2 http://schemas.geosciml.org/geologicunit/3.2/geologicUnit.xsd
 http://www.opengis.net/wfs/2.0 http://schemas.opengis.net/wfs/2.0/wfs.xsd"
 numberMatched="14507" numberReturned="10" timeStamp="2013-03-05T16:05:36">
 <wfs:member>
  <gsml:MappedFeature gml:id="mf.16">
   <gsml:observationMethod>
    <swe:Category
     definition="http://resource.geosciml.org/classifierscheme/cgi/201211/mappedfeatureobservationmethod">
     <swe:extension>
```

```
      <swe:Category
        definition="http://resource.geosciml.org/classifierscheme/cgi/201211/valuequalifier">
        <swe:identifier>http://resource.geosciml.org/classifier/cgi/valuequalifier/always</swe:identifier>
        <swe:label>always</swe:label>
        <swe:codeSpace
          xlink:href="http://resource.geosciml.org/classifierscheme/cgi/201211/valuequalifier"
        />
      </swe:Category>
    </swe:extension>
    <swe:identifier>http://resource.geosciml.org/classifier/cgi/mappedfeatureobservationmethod/compilation</swe:identifier>
    <swe:label>Compilation</swe:label>
    <swe:codeSpace
      xlink:href="http://resource.geosciml.org/classifierscheme/cgi/201211/mappedfeatureobservationmethod"
    />
  </swe:Category>
</gsml:observationMethod>
<gsml:positionalAccuracy>
  <swe:Quantity>
    <swe:uom code="m"/>
    <swe:value>1000</swe:value>
  </swe:Quantity>
</gsml:positionalAccuracy>
<gsml:resolutionScale>
  <gmd:MD_RepresentativeFraction>
    <gmd:denominator>
      <gco:Integer>625000</gco:Integer>
    </gmd:denominator>
  </gmd:MD_RepresentativeFraction>
</gsml:resolutionScale>
<gsml:samplingFrame xlink:href="http://inspire.ec.europa.eu/codelist/MappingFrameValue/topOfBedrock"
  xlink:title="top of bedrock"/>
<gsml:shape>
  <gml:Polygon srsName="urn:ogc:def:crs:EPSG::4326" gml:id="LOCAL_ID_0">
    <gml:exterior>
      <gml:LinearRing>
        <gml:posList srsDimension="2" count="8">55.0760921318516 -3.31719604609088
          55.0833753209835 -3.31853455922777 55.0825574334633 -3.31921378657955
          55.0801997429522 -3.31978309699423 55.0768616358466 -3.3194575613054
```

```xml
        55.0741365291192 -3.31966903508197 55.0756843873373 -3.31747948721346
        55.0760921318516 -3.31719604609088</gml:posList>
      </gml:LinearRing>
     </gml:exterior>
    </gml:Polygon>
   </gsml:shape>
   <gsml:specification>
    <gsmlgu:GeologicUnit gml:id="INV-SDSM">
     <gml:description>INVERCLYDE GROUP</gml:description>
     <gsml:observationMethod nilReason="missing" xsi:nil="true"/>
     <gsml:purpose>typicalNorm</gsml:purpose>
     <gsml:relatedFeature>
      <gsmlga:GeologicHistory gml:id="LOCAL_ID_1">
       <gsml:relationship
        xlink:href="http://resource.geosciml.org/classifier/cgi/featurerelation/geologicfeaturegeneticevent"/>
       <gsml:sourceRole nilReason="missing" xsi:nil="true"/>
       <gsml:targetRole nilReason="missing" xsi:nil="true"/>
       <gsml:relatedFeature>
        <gsmlga:GeologicEvent gml:id="LOCAL_ID_2">
         <gsml:observationMethod nilReason="missing" xsi:nil="true"/>
         <gsml:purpose>instance</gsml:purpose>
         <gsml:relatedFeature nilReason="missing" xsi:nil="true"/>
         <gsml:classifier nilReason="missing" xsi:nil="true"/>
         <gsml:metadata gco:nilReason="missing" xsi:nil="true"/>
         <gsmlga:eventProcess
          xlink:href="http://resource.geosciml.org/classifier/cgi/eventprocess/mechanicalDeposition"
          xlink:title="mechanical deposition"/>
         <gsmlga:numericAgeDate nilReason="missing" xsi:nil="true"/>
         <gsmlga:olderNamedAge
          xlink:href="http://resource.geosciml.org/classifier/ics/ischart/Tournaisian"
          xlink:title="Tournaisian"/>
         <gsmlga:youngerNamedAge
          xlink:href="http://resource.geosciml.org/classifier/ics/ischart/Visean"
          xlink:title="Visean"/>
         <gsmlga:eventEnvironment>
          <swe:Category
           definition="http://resource.geosciml.org/classifierscheme/cgi/201012/eventenvironment">
           <swe:extension>
```

```xml
        <swe:Category
         definition="http://resource.geosciml.org/classifierscheme/cgi/201012/valuequalifier">
         <swe:identifier>http://resource.geosciml.org/classifier/cgi/valuequalifier/always</swe:identifier>
         <swe:label>always</swe:label>
         <swe:codeSpace
          xlink:href="http://resource.geosciml.org/classifierscheme/cgi/201012/valuequalifier"
         />
        </swe:Category>
       </swe:extension>
       <swe:identifier>http://resource.geosciml.org/classifier/cgi/eventenvironment/riverPlainSystemSetting</swe:identifier>
       <swe:label>River plain system setting</swe:label>
       <swe:codeSpace
        xlink:href="http://resource.geosciml.org/classifierscheme/cgi/201012/eventenvironment"
       />
      </swe:Category>
     </gsmlga:eventEnvironment>
     <gsmlga:prototype nilReason="missing" xsi:nil="true"/>
    </gsmlga:GeologicEvent>
   </gsml:relatedFeature>
  </gsmlga:GeologicHistory>
 </gsml:relatedFeature>
 <gsml:classifier nilReason="missing" xsi:nil="true"/>
 <gsml:metadata gco:nilReason="missing" xsi:nil="true"/>
 <gsmlgu:geologicUnitType
  xlink:href="http://resource.geosciml.org/classifier/cgi/geologicunittype/lithostratigraphicUnit"
  xlink:title="Lithostratigraphic Unit"/>
 <gsmlgu:bodyMorphology nilReason="unknown" xsi:nil="true"/>
 <gsmlgu:unitComposition nilReason="unknown" xsi:nil="true"/>
 <gsmlgu:exposureColor nilReason="missing" xsi:nil="true"/>
 <gsmlgu:outcropCharacter nilReason="missing" xsi:nil="true"/>
 <gsmlgu:rank xlink:title="Group"
  xlink:href="http://resource.geosciml.org/classifier/cgi/stratigraphicrank/group"/>
 <gsmlgu:unitThickness nilReason="missing" xsi:nil="true"/>
 <gsmlgu:composition>
  <gsmlgu:CompositionPart>
   <gsmlgu:role xlink:title="Unspecified part role"
    xlink:href="http://resource.geosciml.org/classifier/cgi/geologicunitpartrole/unspecifiedPertRole"/>
   <gsmlgu:material>
```

```xml
        <gsmlem:RockMaterial gml:id="LOCAL_ID_3">
          <gsmlem:color nilReason="missing" xsi:nil="true"/>
          <gsmlem:purpose>typicalNorm</gsmlem:purpose>
          <gsmlem:physicalProperty nilReason="missing" xsi:nil="true"/>
          <gsmlem:geochemistry nilReason="missing" xsi:nil="true"/>
          <gsmlem:metadata gco:nilReason="missing" xsi:nil="true"/>
          <gsmlem:compositionCategory nilReason="missing" xsi:nil="true"/>
          <gsmlem:geneticCategory nilReason="missing" xsi:nil="true"/>
          <gsmlem:constituent nilReason="missing" xsi:nil="true"/>
          <gsmlem:particleGeometry nilReason="missing" xsi:nil="true"/>
          <gsmlem:consolidationDegree nilReason="missing" xsi:nil="true"/>
          <gsmlem:lithology
            xlink:href="http://resource.geosciml.org/classifier/cgi/lithology/clastic_mudstone"
            xlink:title="Mudstone"/>
          <gsmlem:metamorphicProperties nilReason="missing" xsi:nil="true"/>
          <gsmlem:alterationProperties nilReason="missing" xsi:nil="true"/>
          <gsmlem:fabric nilReason="missing" xsi:nil="true"/>
        </gsmlem:RockMaterial>
      </gsmlgu:material>
      <gsmlgu:proportion>
        <GSML_QuantityRange xmlns="http://xmlns.geosciml.org/Utilities/3.2">
          <swe:uom code="%" xlink:href="http://unitsofmeasure/ucum.html#para-29" xlink:title="percent"/>
          <swe:value>5.0 50.0</swe:value>
          <lowerValue>5.0</lowerValue>
          <upperValue>50.0</upperValue>
        </GSML_QuantityRange>
      </gsmlgu:proportion>
    </gsmlgu:CompositionPart>
  </gsmlgu:composition>
  <gsmlgu:composition>
    <gsmlgu:CompositionPart>
      <gsmlgu:role xlink:title="Unspecified part role"
        xlink:href="http://resource.geosciml.org/classifier/cgi/geologicunitpartrole/unspecifiedPartRole"/>
      <gsmlgu:material>
        <gsmlem:RockMaterial gml:id="LOCAL_ID_4">
          <gsmlem:color nilReason="missing" xsi:nil="true"/>
          <gsmlem:purpose>typicalNorm</gsmlem:purpose>
          <gsmlem:physicalProperty nilReason="missing" xsi:nil="true"/>
```

```
     <gsmlem:geochemistry nilReason="missing" xsi:nil="true"/>
     <gsmlem:metadata gco:nilReason="missing" xsi:nil="true"/>
     <gsmlem:compositionCategory nilReason="missing" xsi:nil="true"/>
     <gsmlem:geneticCategory nilReason="missing" xsi:nil="true"/>
     <gsmlem:constituent nilReason="missing" xsi:nil="true"/>
     <gsmlem:particleGeometry nilReason="missing" xsi:nil="true"/>
     <gsmlem:consolidationDegree nilReason="missing" xsi:nil="true"/>
     <gsmlem:lithology
      xlink:href="http://resource.geosciml.org/classifier/cgi/lithology/clastic_sandstone"
      xlink:title="Sandstone"/>
     <gsmlem:metamorphicProperties nilReason="missing" xsi:nil="true"/>
     <gsmlem:alterationProperties nilReason="missing" xsi:nil="true"/>
     <gsmlem:fabric nilReason="missing" xsi:nil="true"/>
    </gsmlem:RockMaterial>
   </gsmlgu:material>
   <gsmlgu:proportion>
    <GSML_QuantityRange xmlns="http://xmlns.geosciml.org/Utilities/3.2">
     <swe:uom code="%" xlink:href="http://unitsofmeasure/ucum.html#para-29" xlink:title="percent"/>
     <swe:value>50.0 95.0</swe:value>
     <lowerValue>50.0</lowerValue>
     <upperValue>95.0</upperValue>
    </GSML_QuantityRange>
   </gsmlgu:proportion>
  </gsmlgu:CompositionPart>
 </gsmlgu:composition>
 <gsmlgu:composition>
  <gsmlgu:CompositionPart>
   <gsmlgu:role xlink:title="Unspecified part role"
    xlink:href="http://resource.geosciml.org/classifier/cgi/geologicunitpartrole/unspecifiedPartRole"/>
   <gsmlgu:material>
    <gsmlem:RockMaterial gml:id="LOCAL_ID_5">
     <gsmlem:color nilReason="missing" xsi:nil="true"/>
     <gsmlem:purpose>typicalNorm</gsmlem:purpose>
     <gsmlem:physicalProperty nilReason="missing" xsi:nil="true"/>
     <gsmlem:geochemistry nilReason="missing" xsi:nil="true"/>
     <gsmlem:metadata gco:nilReason="missing" xsi:nil="true"/>
     <gsmlem:compositionCategory nilReason="missing" xsi:nil="true"/>
     <gsmlem:geneticCategory nilReason="missing" xsi:nil="true"/>
```

```xml
          <gsmlem:constituent nilReason="missing" xsi:nil="true"/>
          <gsmlem:particleGeometry nilReason="missing" xsi:nil="true"/>
          <gsmlem:consolidationDegree nilReason="missing" xsi:nil="true"/>
          <gsmlem:lithology
           xlink:href="http://resource.geosciml.org/classifier/cgi/lithology/siltstone"
           xlink:title="Siltstone"/>
          <gsmlem:metamorphicProperties nilReason="missing" xsi:nil="true"/>
          <gsmlem:alterationProperties nilReason="missing" xsi:nil="true"/>
          <gsmlem:fabric nilReason="missing" xsi:nil="true"/>
         </gsmlem:RockMaterial>
        </gsmlgu:material>
        <gsmlgu:proportion>
         <GSML_QuantityRange xmlns="http://xmlns.geosciml.org/Utilities/3.2">
          <swe:uom code="%" xlink:href="http://unitsofmeasure/ucum.html#para-29" xlink:title="percent"/>
          <swe:value>5.0 50.0</swe:value>
          <lowerValue>5.0</lowerValue>
          <upperValue>50.0</upperValue>
         </GSML_QuantityRange>
        </gsmlgu:proportion>
       </gsmlgu:CompositionPart>
      </gsmlgu:composition>
      <gsmlgu:metamorphicCharacter nilReason="missing" xsi:nil="true"/>
      <gsmlgu:part nilReason="missing" xsi:nil="true"/>
      <gsmlgu:physicalProperty nilReason="missing" xsi:nil="true"/>
      <gsmlgu:alterationCharacter nilReason="missing" xsi:nil="true"/>
      <gsmlgu:bedding nilReason="missing" xsi:nil="true"/>
      <gsmlgu:geochemistry nilReason="missing" xsi:nil="true"/>
     </gsmlgu:GeologicUnit>
    </gsml:specification>
    <gsml:metadata gco:nilReason="missing" xsi:nil="true"/>
   </gsml:MappedFeature>
  </wfs:member>
</wfs:FeatureCollection>
```