Integrated 3D information model of surface and subsurface

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Why should there be a subsurface model?

- It is (probably) easy…but is it really necessary?
- Present practice in large civil engineering projects:
  During one and the same project, data is often obtained multiple times (boreholes re-drilled, etc.)
- Reasons:
  - data lost, or
  - data quality not known, or
  - same data obtained for different purposes

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Why should there be a subsurface model?

- Subsurface data generally consists of:
  - point,
  - line, and
  - surface(*)

  information,

  but not of volume information;

  hence, not the whole subsurface space is described

(*) Surfaces in the subsurface are, for example, boundaries between different materials

- The point, line, and surface information consists of:
  - exact data (i.e. strength values of borehole sample tests),
  - not-exact (descriptive) data (i.e. material descriptions)

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Why should there be a subsurface model?

But:

What is wanted?

- Not only point, line and surface data;
  but a model of the whole subsurface.

The model is in general made (interpreted) by a geologist/geotechnical engineer based on the information from (often) incomplete subsurface data.

The interpretation of the descriptive data and the process to make the model are depending on the specialist and the a-priori knowledge of the geologist or geotechnical engineer.

Why should there be a subsurface model?

But:

What is then the quality of this information?

(or: What is the quality of the interpreter?)

Usually, no quality indicators for interpretative data of the subsurface are known.

The best option to assess the quality of subsurface data is, thus, by assessing

- the underlying original data, and
- the thinking process leading to the model

Hence, original subsurface data should be available for this assessment if the data is to be re-used.

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Why should there be a subsurface model?

BUT:

Since surface and subsurface data may interact…

…it would be easier to have the same geo-information environment for both surface and subsurface information.

…and to include all information (also regarding uncertainty) in one integrated model.

Thus…

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Short summary of the Atlanta presentation

- What do we need?
  - Integrated 3D information model (3DIM) including (sub-)surface real world and design information
- What do we have?
  - CityGML information model
- What did we do?
- 1st Extension by Ludvig Emgård using:
  - NEN 3610 – Dutch harmonized base model of geo-information
  - INSPIRE 02.5
- 2nd Extension by Wiebke Tegtmeier using:
  - Dutch Standard Geotechnical Exchange Format (GEF)
  - GeoSciML information model

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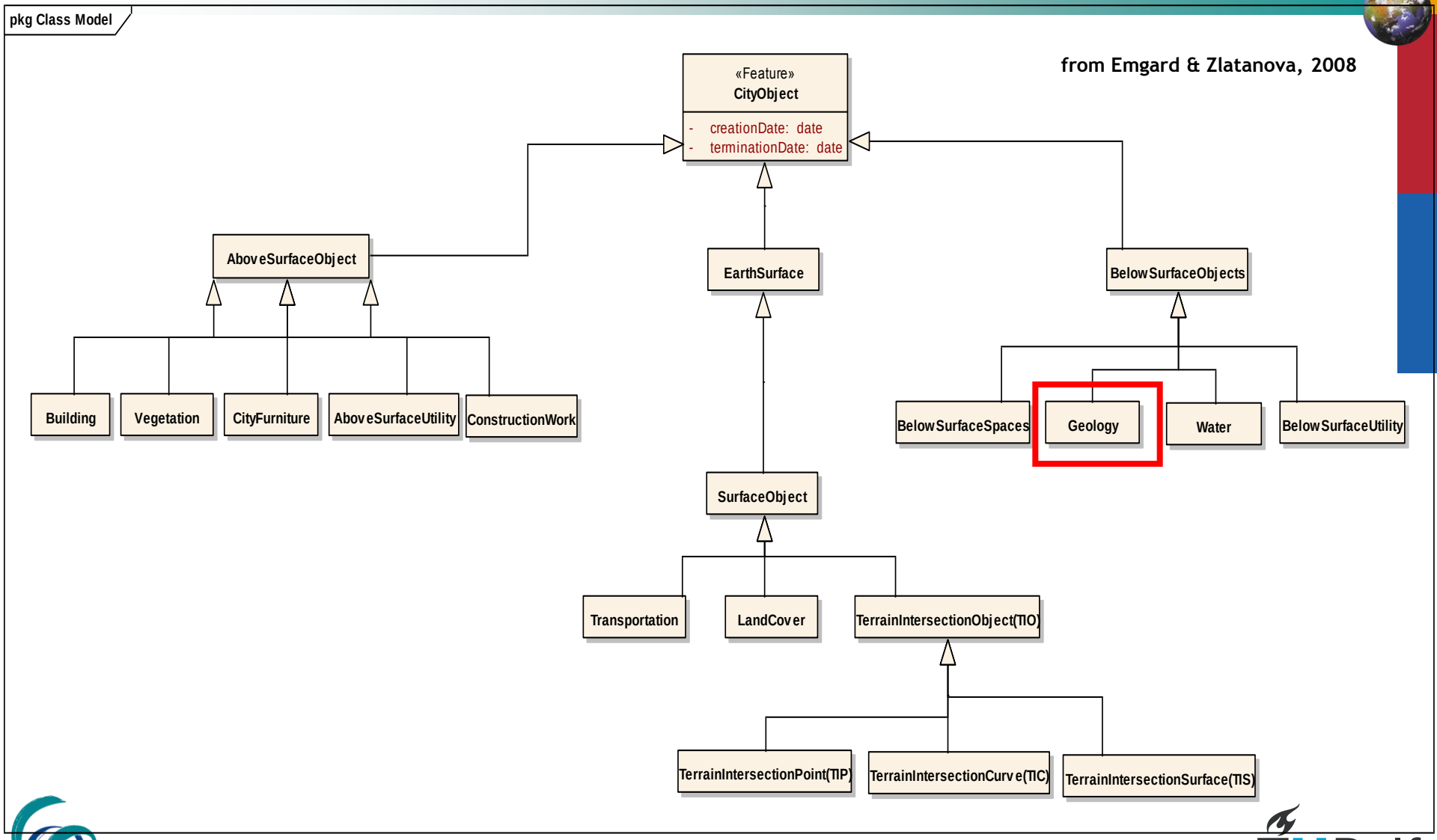
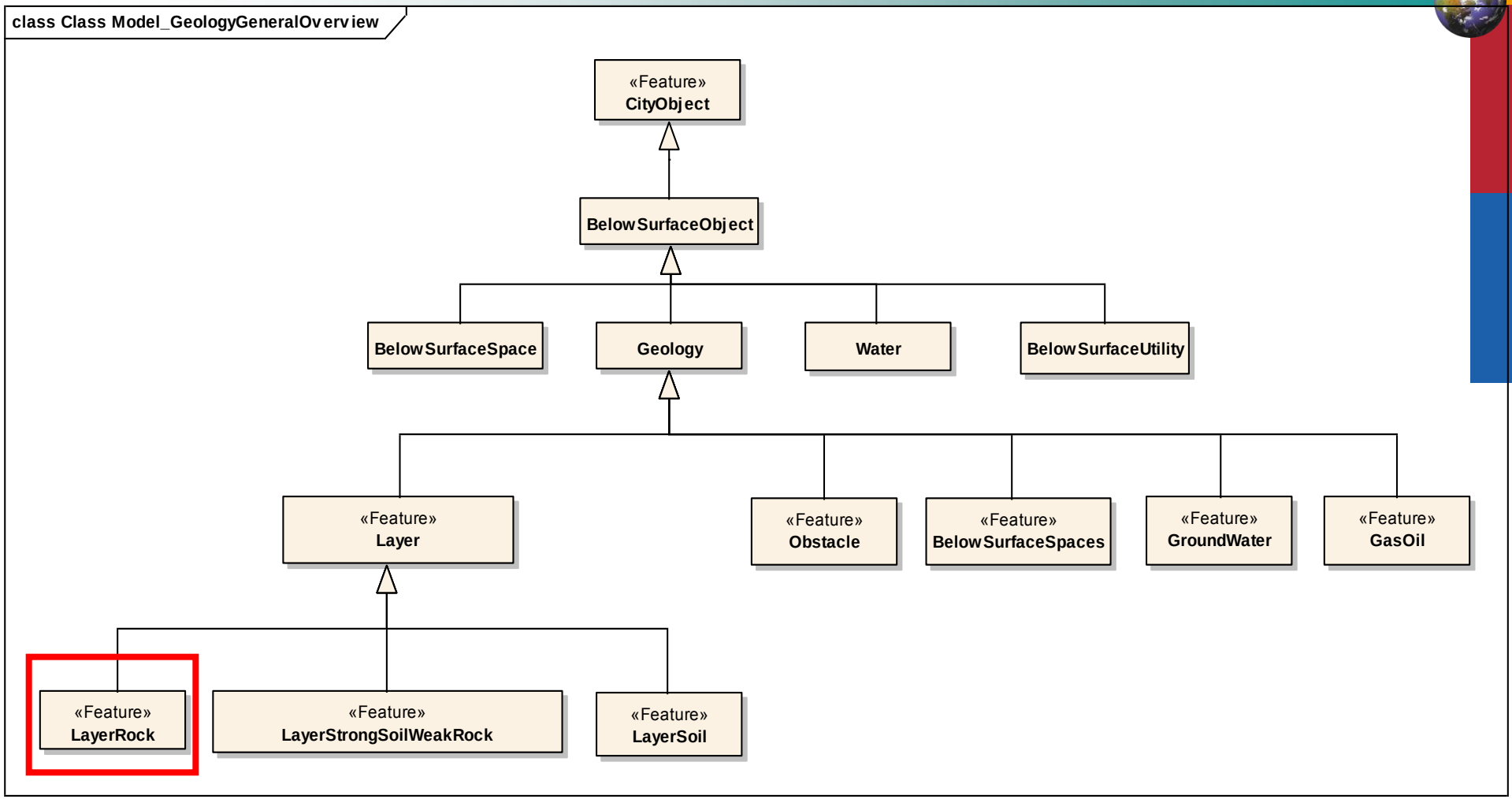
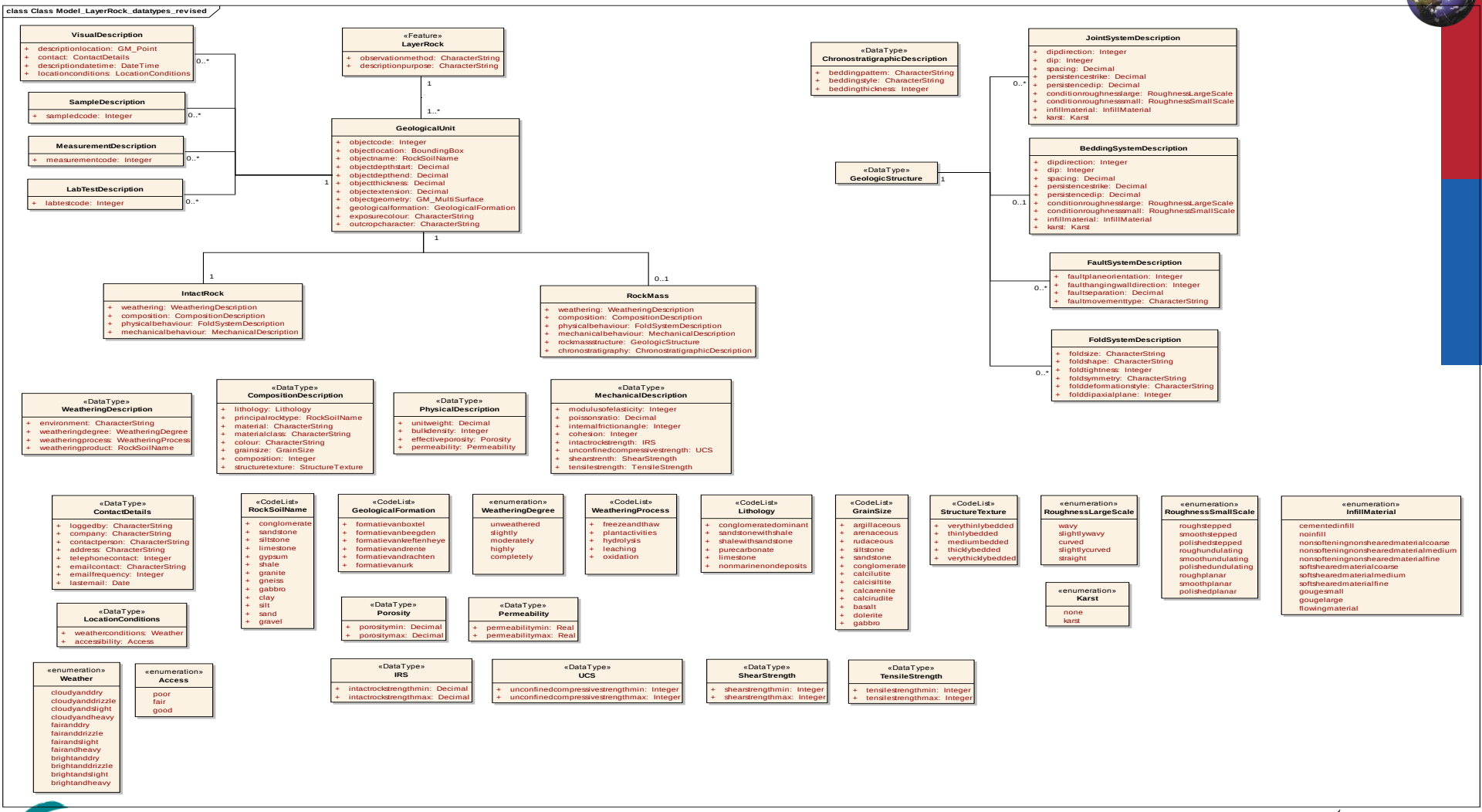
1st Extension of CityGML by Emgard



2nd Extension of CityGML and 3DIM by Tegtmeier



Example: Geological feature ‘LayerRock’



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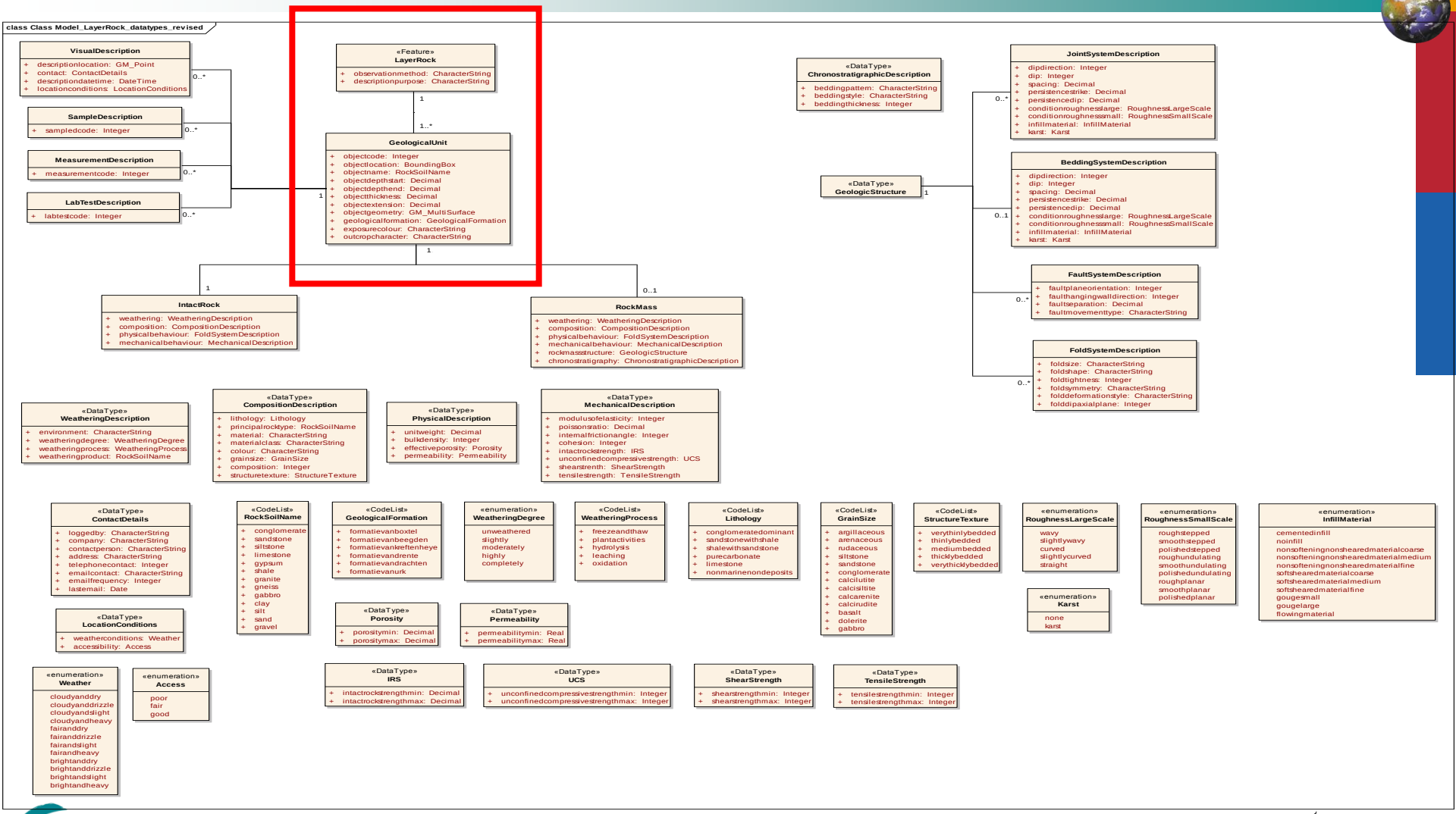
‘LayerRock’ - General description



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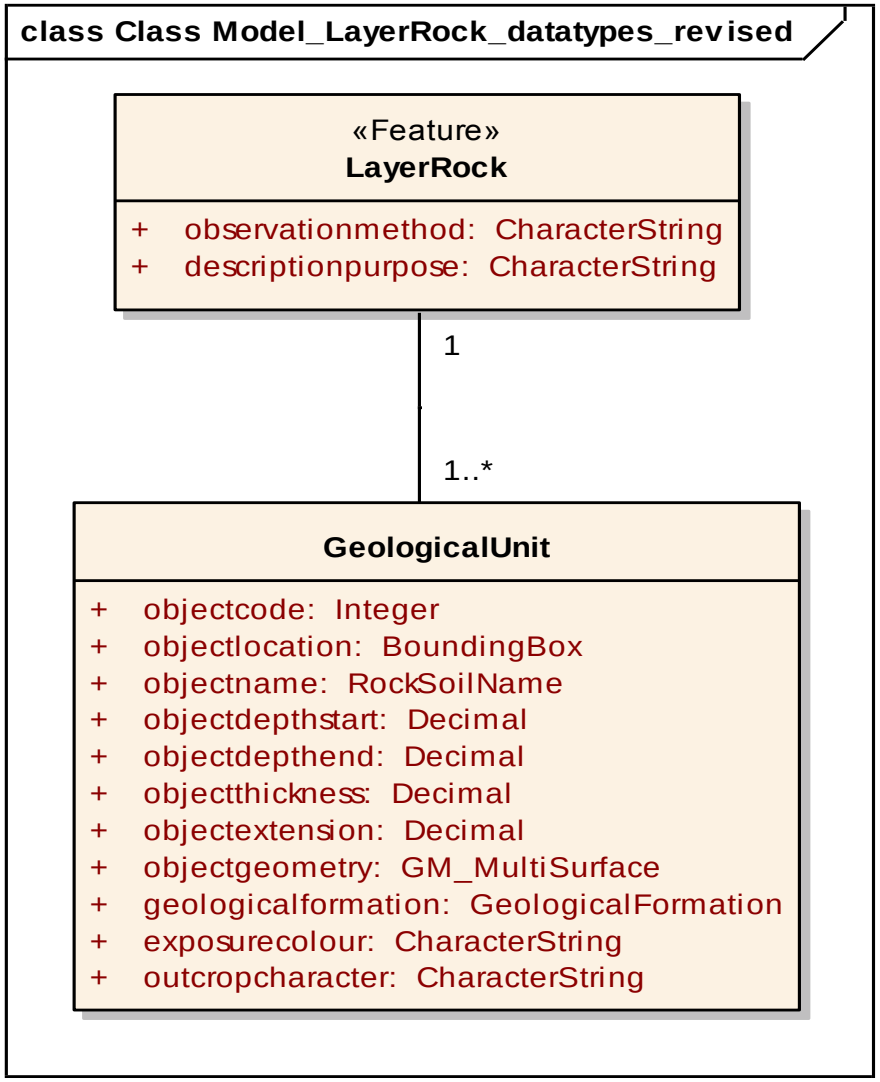
‘LayerRock’ - General description



- General information on the geological feature ‘LayerRock’; described in 1 to many ‘GeologicalUnits’

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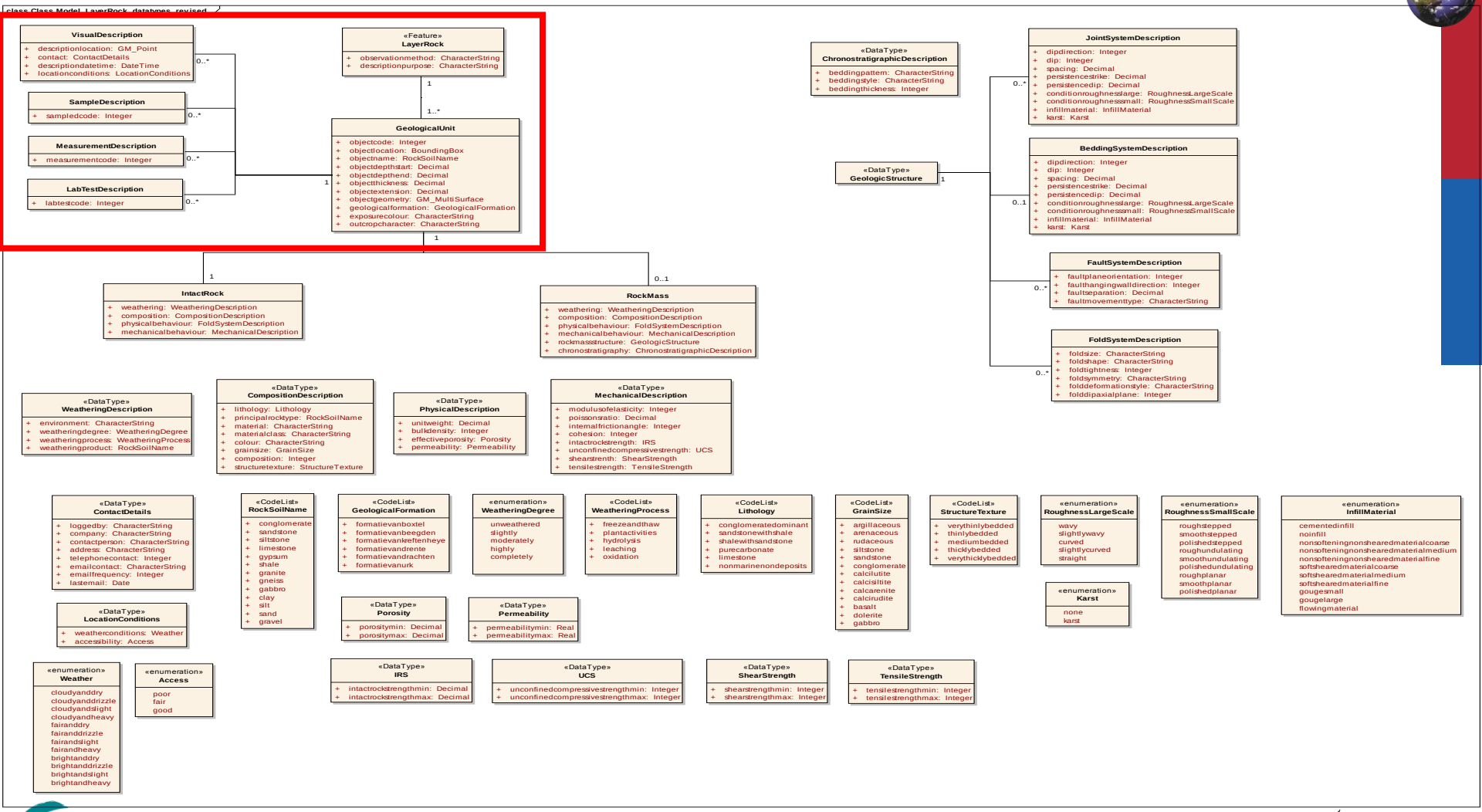
‘LayerRock’ - Types of description



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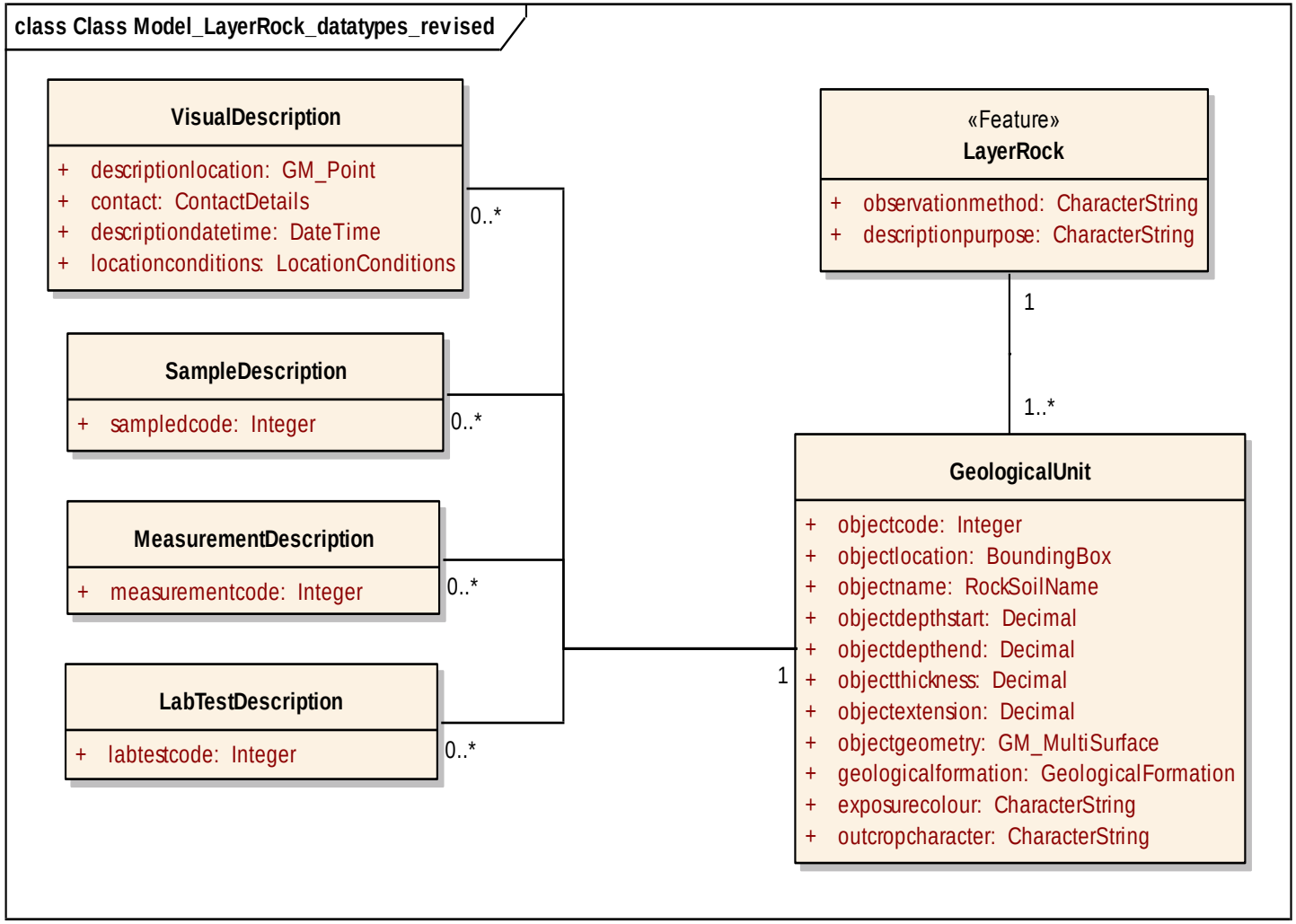
‘LayerRock’ - Types of description



- Different types of description for each ‘Geological Unit’ of the geological feature ‘LayerRock’

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‘LayerRock’ – The Dictionary

Attribute	Notes
objectcode Integer Public	ObjectCode: Unique code linking to the specific object 'GeologicalUnit' within the geological feature 'LayerRock'.
objectlocation BoundingBox Public	ObjectLocation: Location and extension of the geological unit described by a Bounding Box.
objectname RockSoilName Public	ObjectName: Name of the rock of this geological unit. Naming according to international standards; examples given in the 'CodeList' 'RockSoilName'.
objectdepthstart Decimal Public	ObjectDepthStart: Depth (m), at which the geological unit starts (i.e. top level rock layer).
objectdepthend Decimal Public	ObjectDepthEnd: Depth (m), at which the geological unit ends (i.e. bottom level rock layer).
objectthickness Decimal Public	ObjectThickness: Vertical thickness (m) of the geological unit (i.e. thickness of the rock layer).
objectextension Decimal Public	ObjectExtension: Horizontal extension (m) of the geological unit (i.e. extension of the rock layer).
objectgeometry GM_MultiSurface Public	ObjectGeometry: Geometrical description of the geological feature; according to ‘The OpenGIS Abstract specification "Feature Geometry" ' (OGC 2001).

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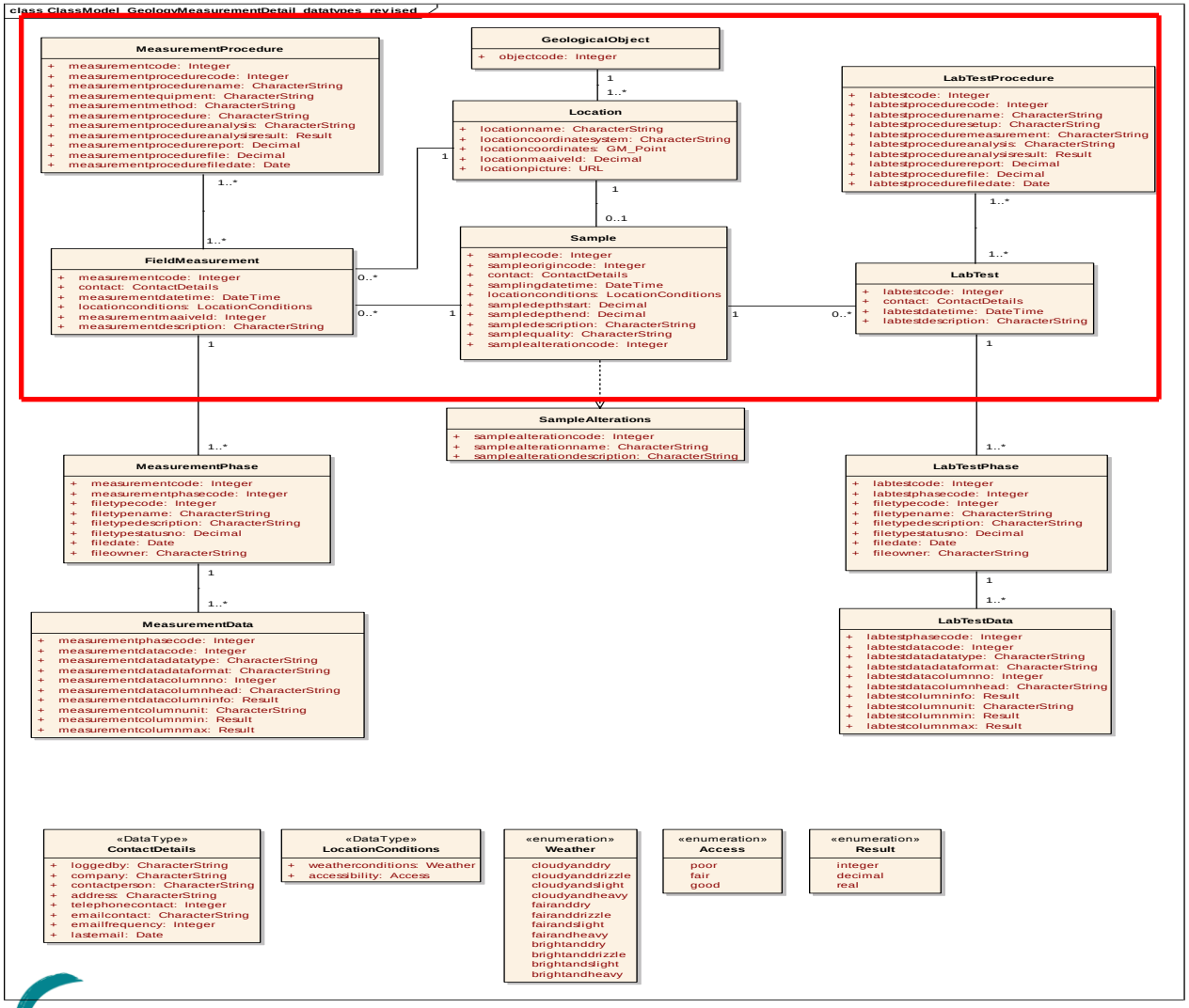
Description scheme for various descriptive methods



- 'Geology Measurement Scheme' for the handling of geological and geotechnical field and laboratory test data as well as material sampling

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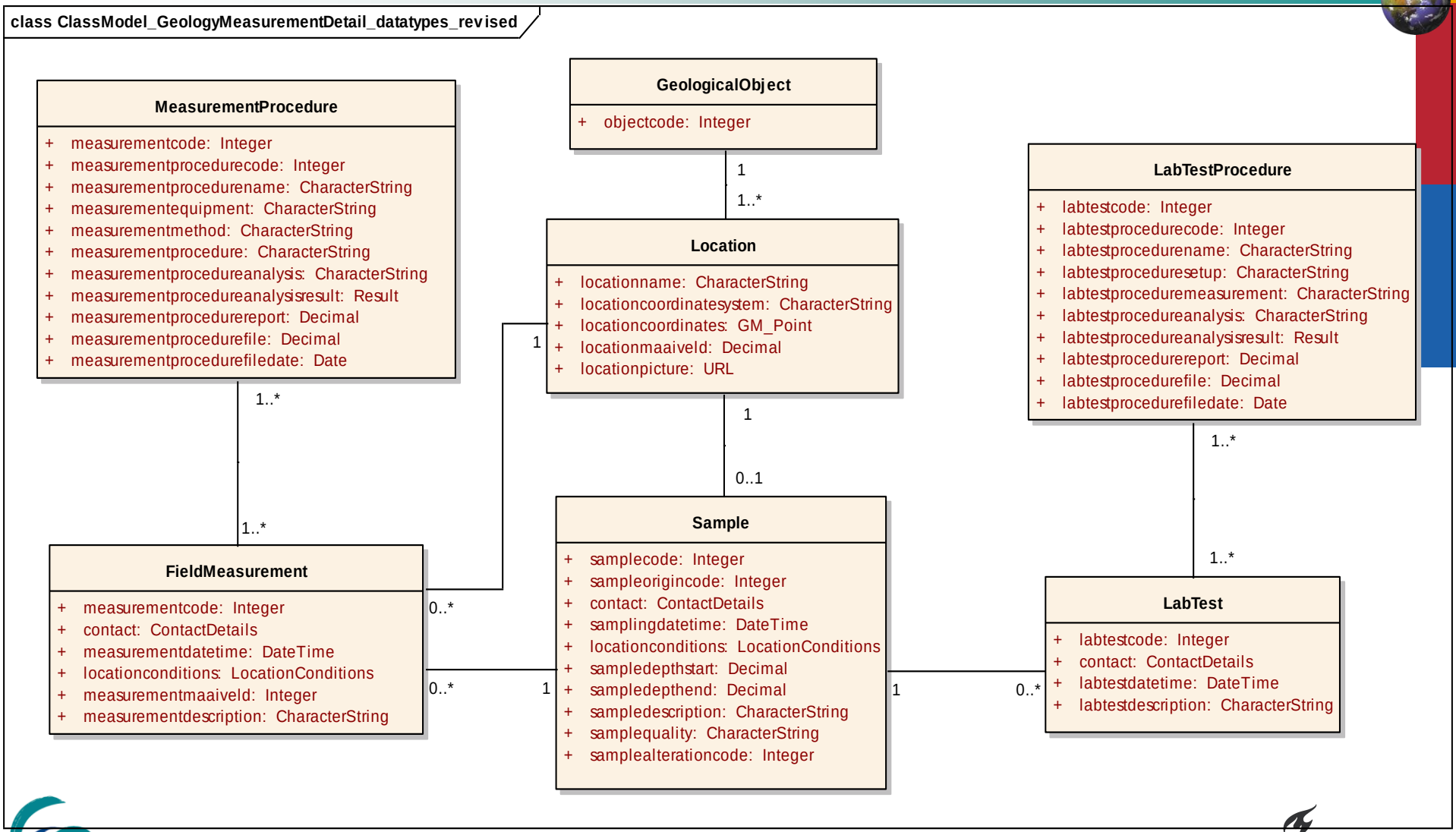
The Geology Measurement scheme



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Current activities

- Transformation of the Enterprise Architect (EA) UML models into SQL scripts
  - using EA Add-In's developed by Jan van Bennekom-Minnema (see MSc research 'The Land Administration Domain Model 'Survey Package' and Model Driven Architecture' on www.gdmc.nl)
- Development of SQL scripts for the creation of:
  - Indexes, types, objects, geometry, tables, constraints, sequences, etc.
- Implementation of the SQL scripts into Oracle Spatial

Current activities (Cont.)

```
CREATE TABLE bedding_system_description (
     oid                    INTEGER  /* the default for
bedding_system_description_oid_seq.nextval must be added
manually */                 NOT NULL,
     dipdirection           INTEGER                NOT NULL,
     dip                    INTEGER                NOT NULL,
     spacing                NUMBER(10,3)           NOT NULL,
     persistencestrike      NUMBER(10,3)           NOT NULL,
     persistencedip         NUMBER(10,3)           NOT NULL,
     conditionroughnesslarge VARCHAR(30)              NOT NULL,
     conditionroughnesssmall VARCHAR(30)              NOT NULL,
     infillmaterial         VARCHAR(30)            NOT NULL,
     karst                  VARCHAR(30)            NOT NULL
);
-- echo table BEDDING_SYSTEM_DESCRIPTION created, check
comments
```

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Current activities (Cont.)

- Model testing and validation with real world Case Study data; two Case Studies:
  - Pilot ViA15
  - Pilot Spoorzone Delft

- Development of an 'Uncertainty model' linked to various models describing 1) the geological features and 2) the geological measurements
  - Describing quality and possible uncertainties of the geo-information contained within each model

- Combined visualization of the various types of geo-information

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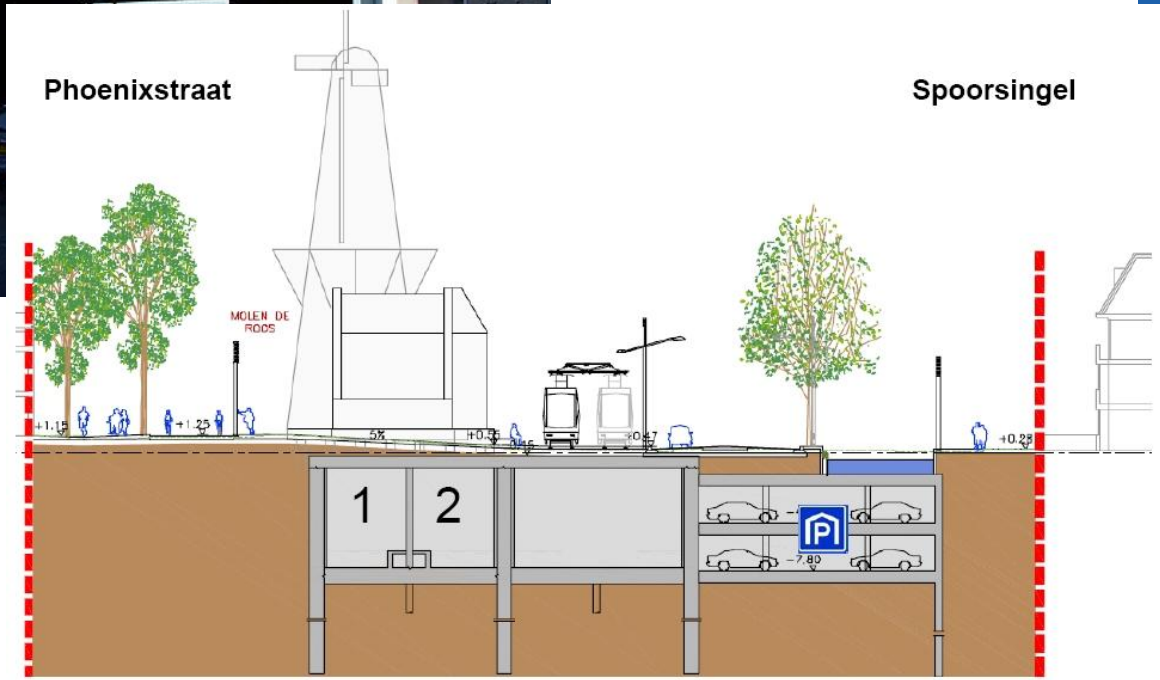
Pilot Spoorzone Delft

Present

Courtesy: Tukka, http://nl.wikipedia.org/wiki/Afbeelding:Treinbrug_Delft_9838792.JPG /

Future



Courtesy: http://www.spoorzonedelft.info/

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