

# 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

# 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)

# 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.



# 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...

# Short summary of the Atlanta presentation



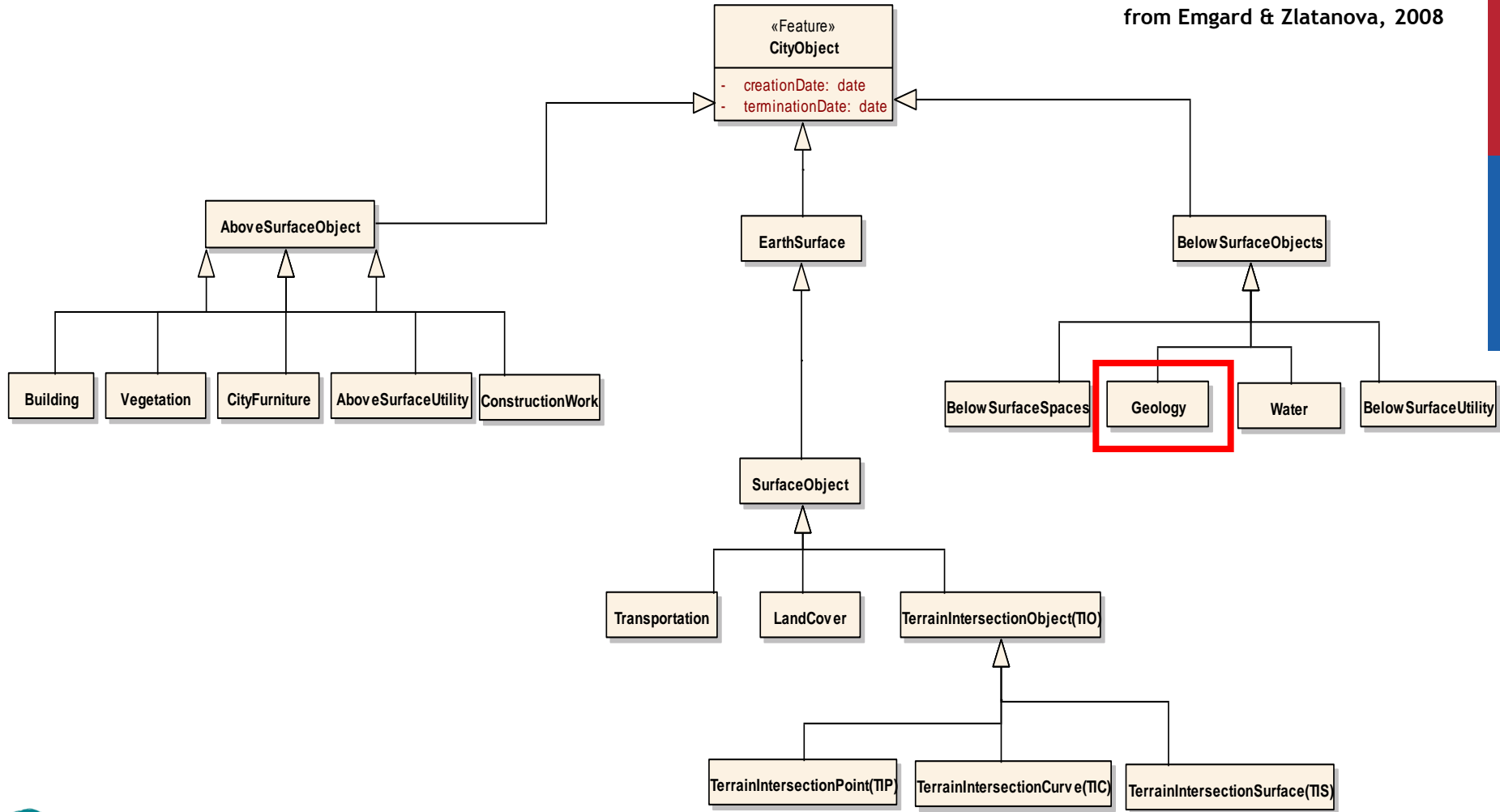
- What do we need?
  - Integrated 3D information model (3DIM) including (sub-)surface real world and design information
- What do we have?
  - CityGML information model
- What did we do?
- 1<sup>st</sup> Extension by Ludvig Emgård using:
  - NEN 3610 - Dutch harmonized base model of geo-information
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

# 1<sup>st</sup> Extension of CityGML by Emgard



pkg Class Model

from Emgard & Zlatanova, 2008

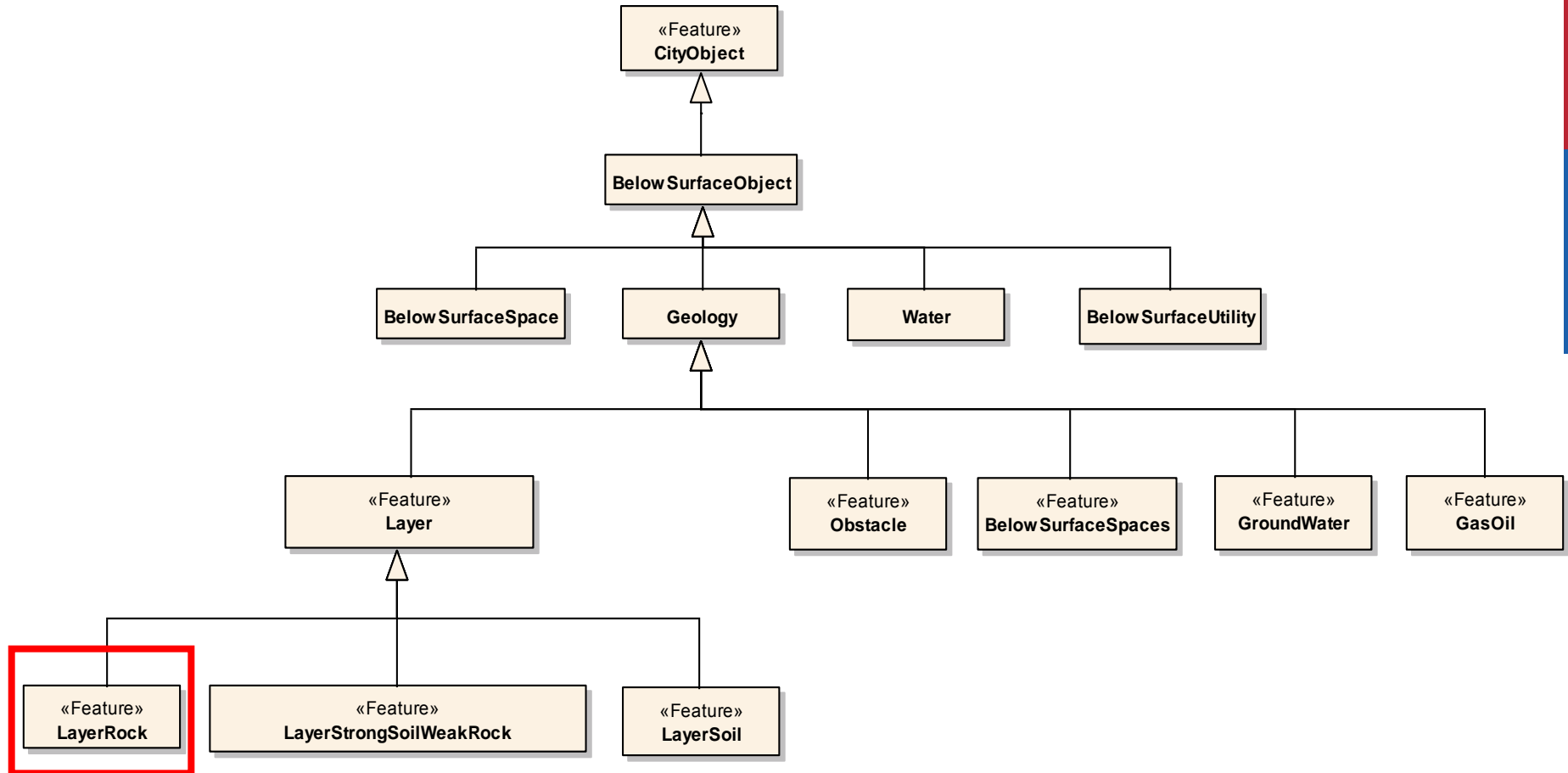




# 2<sup>nd</sup> Extension of CityGML and 3DIM by Tegtmeier



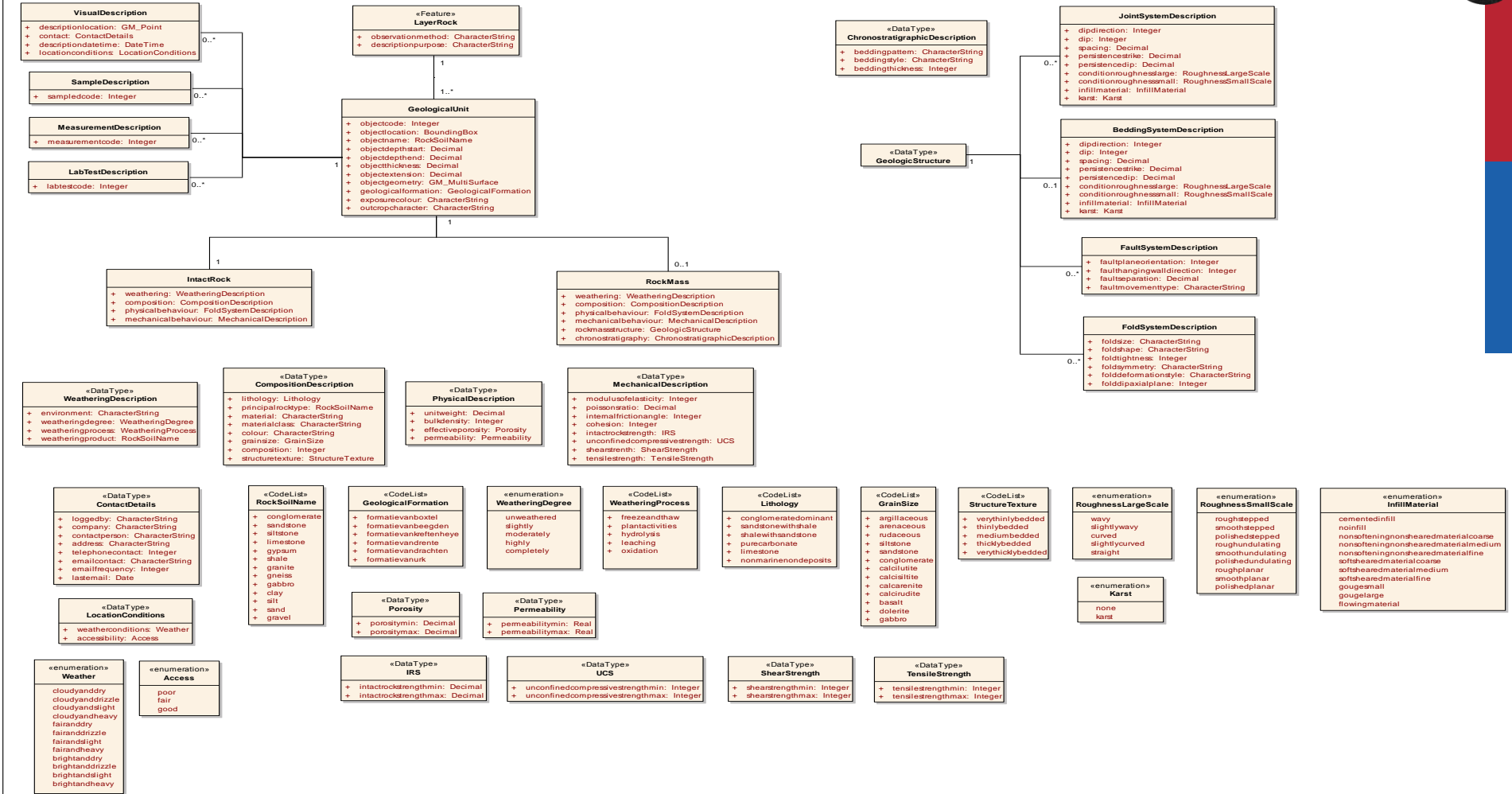
class Class Model\_GeologyGeneralOverview



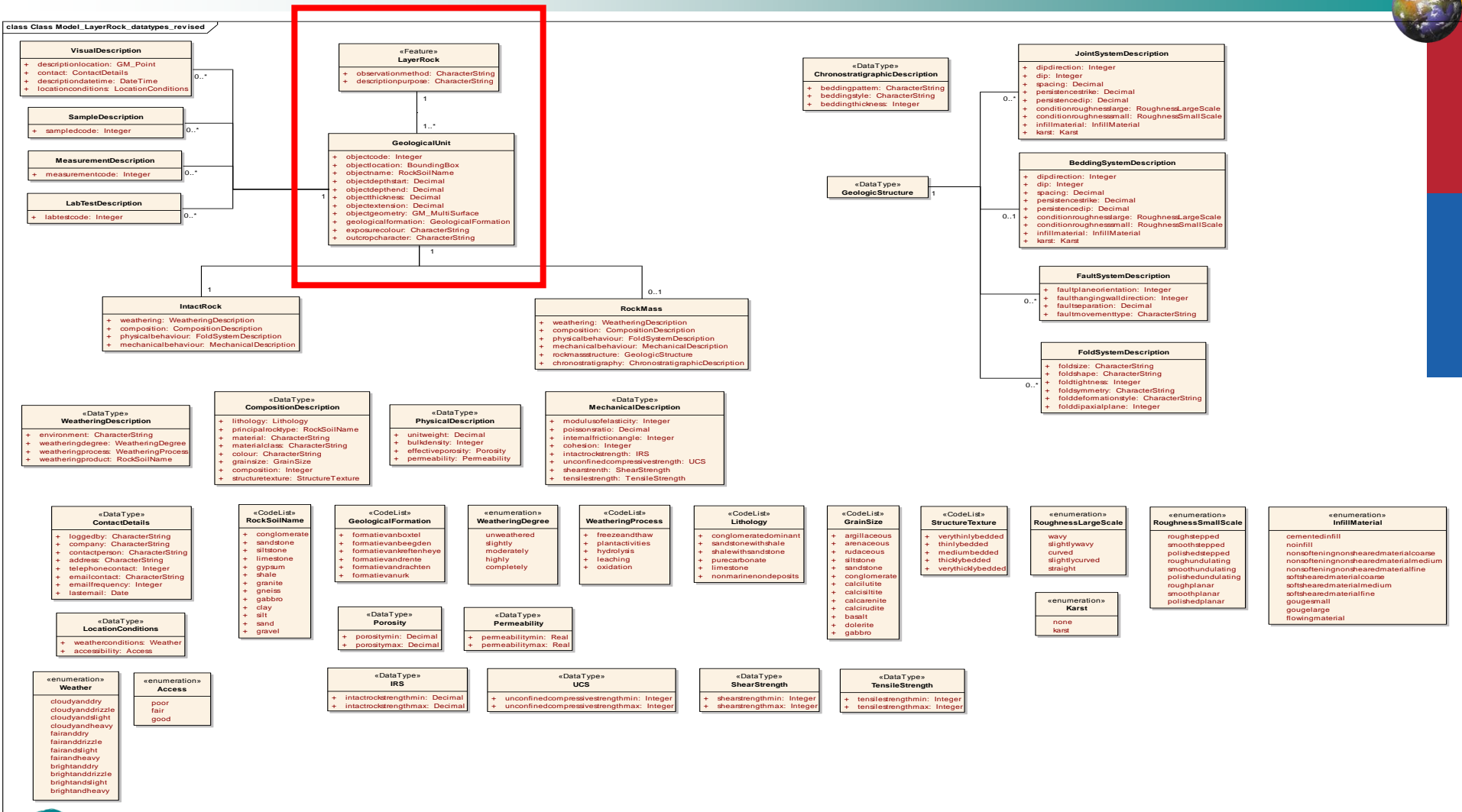
# Example: Geological feature 'LayerRock'



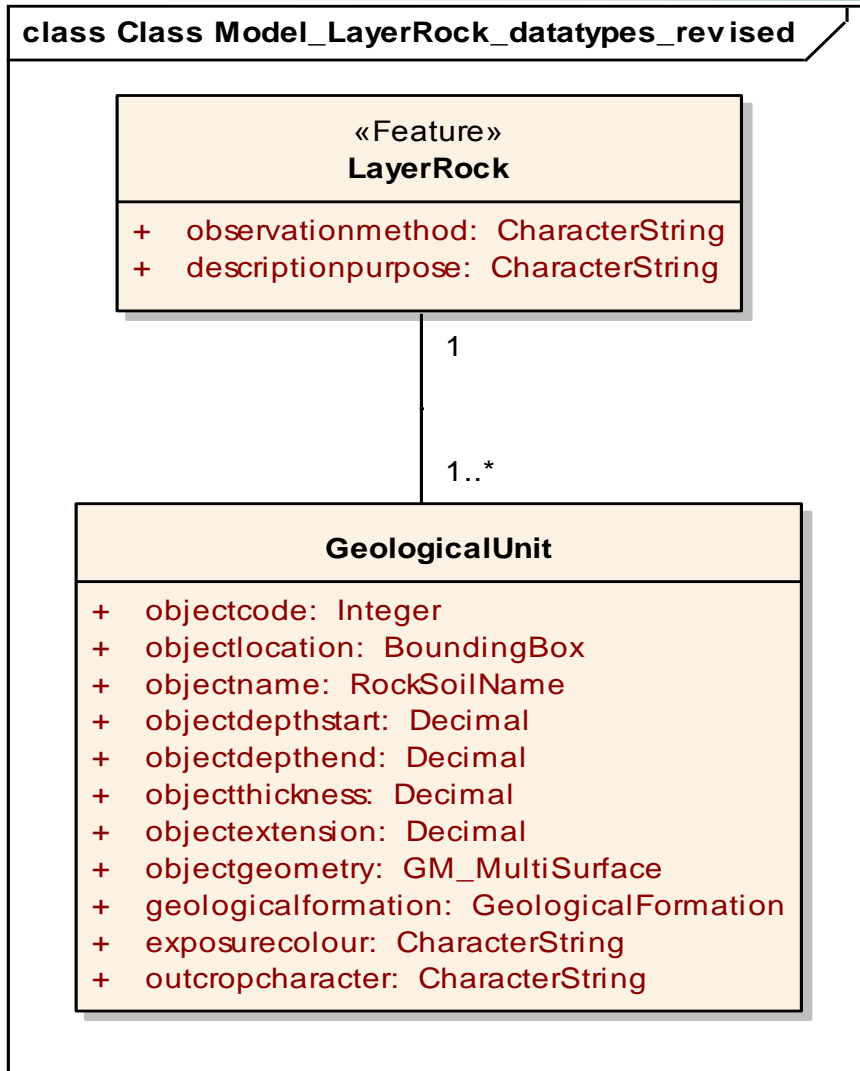
class Class Model\_LayerRock\_datatypes\_revised



# 'LayerRock' - General description



# 'LayerRock' - General description

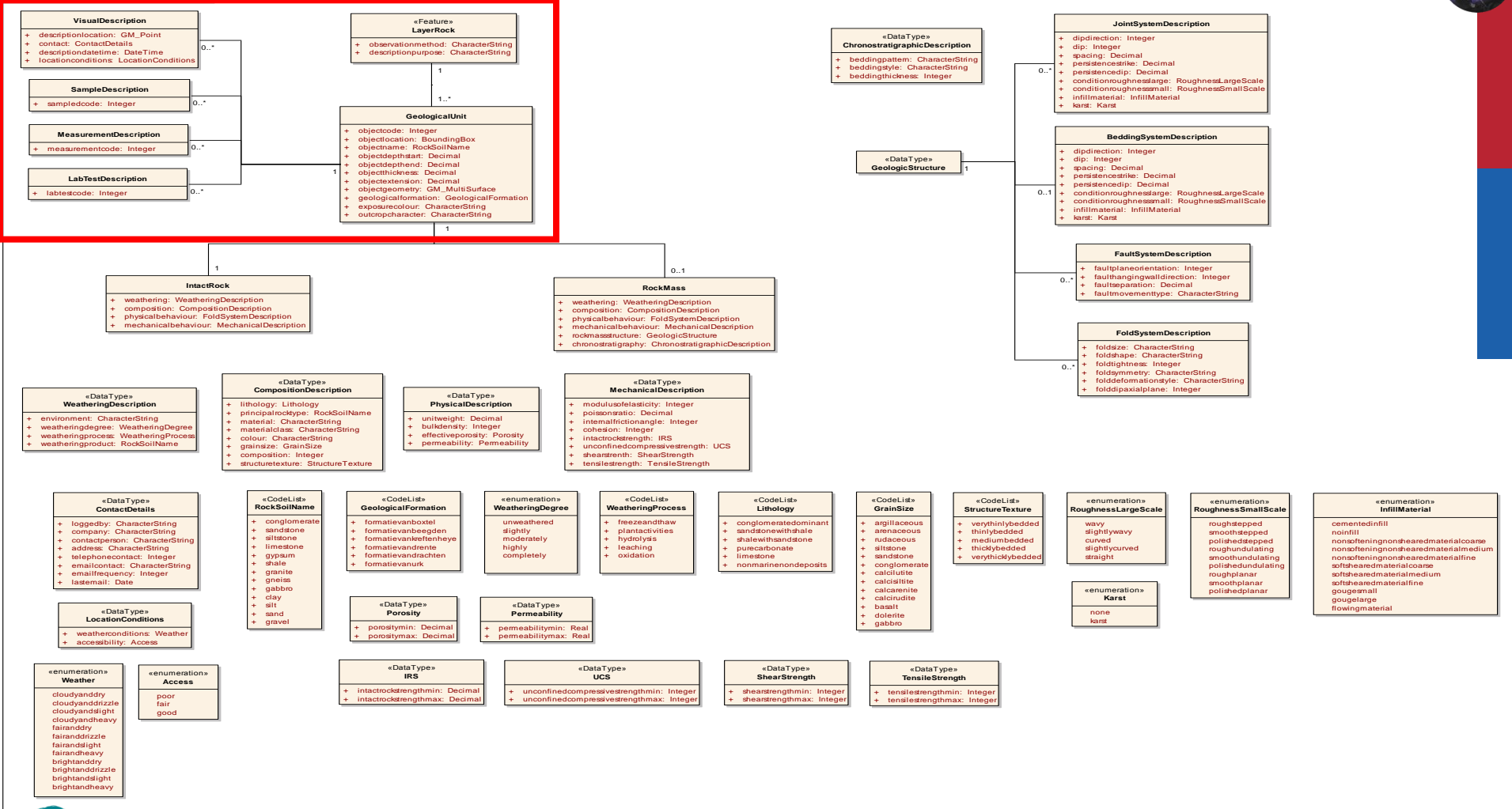


- General information on the geological feature 'LayerRock'; described in 1 to many 'GeologicalUnits'

# 'LayerRock' - Types of description



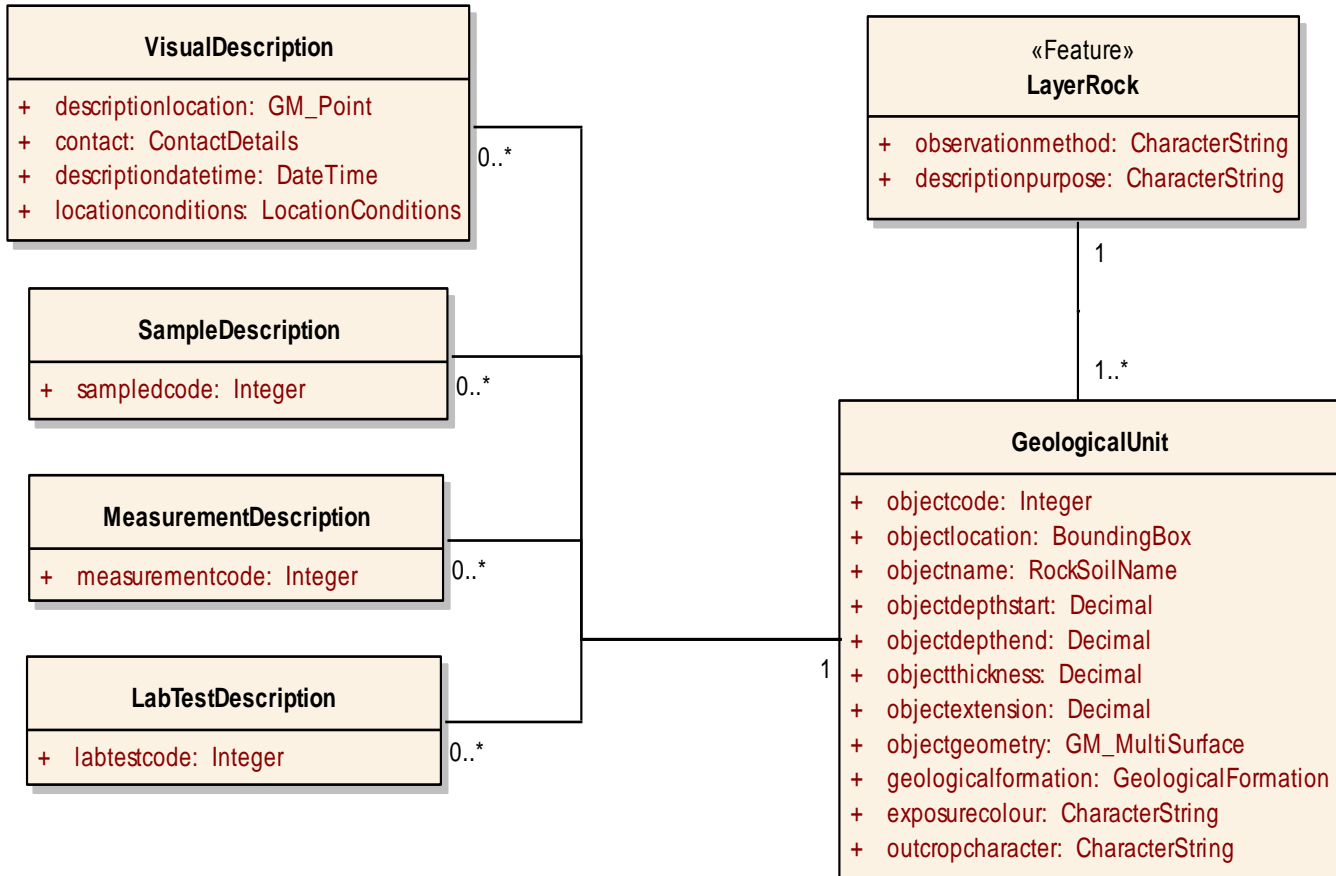
UML Class Model LayerRock\_database\_revised



# 'LayerRock' - Types of description



class Class Model\_LayerRock\_datatypes\_revised

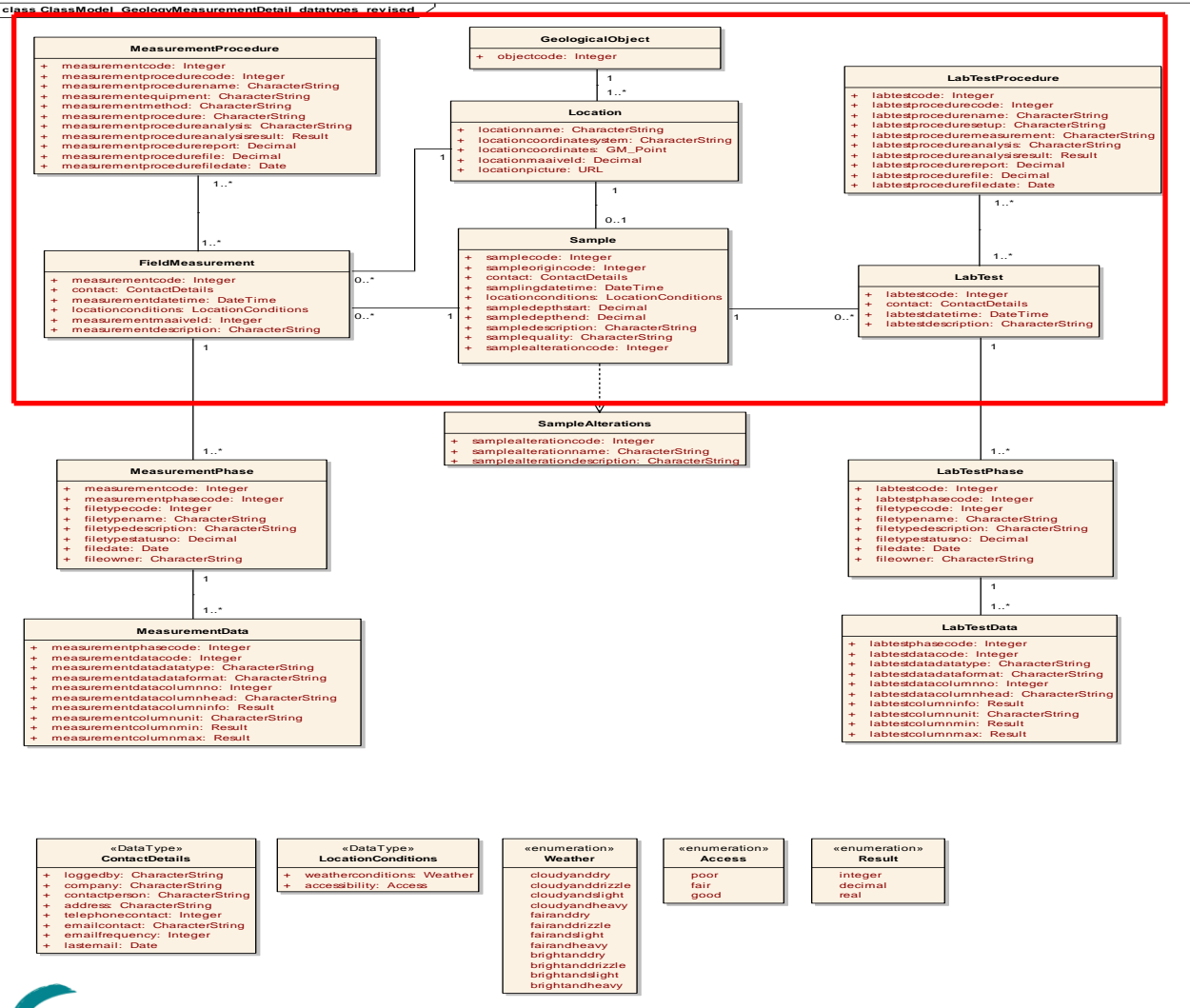


- Different types of description for each 'Geological Unit' of the geological feature 'LayerRock'

# 'LayerRock' - The Dictionary

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

# 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

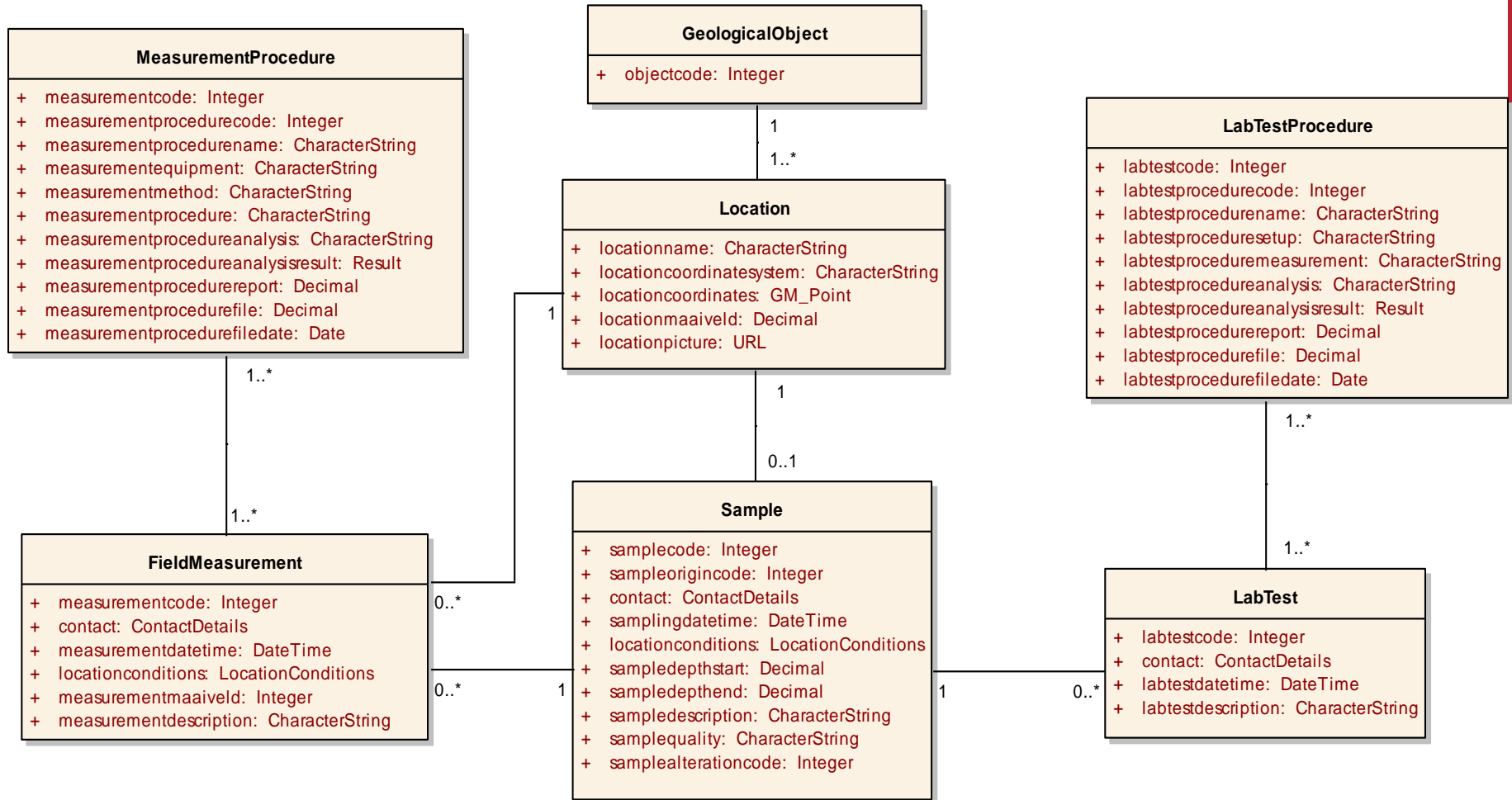




# The Geology Measurement scheme



class ClassModel\_GeologyMeasurementDetail\_datatypes\_revised



# 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](http://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,  
    persistence_dip    NUMBER(10,3)          NOT NULL,  
    condition_roughness_large VARCHAR(30)    NOT NULL,  
    condition_roughness_small VARCHAR(30)    NOT NULL,  
    infill_material    VARCHAR(30)           NOT NULL,  
    karst              VARCHAR(30)           NOT NULL  
);  
-- echo table BEDDING_SYSTEM_DESCRIPTION created, check  
comments
```

# 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

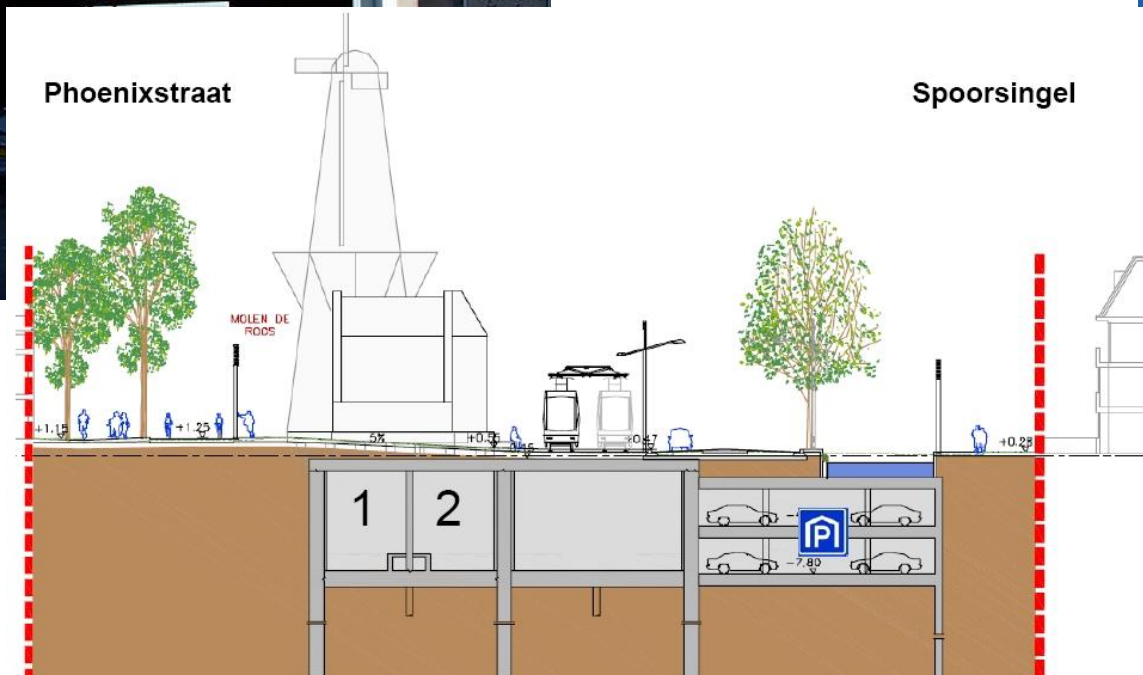


# Pilot Spoorzone Delft

Present



Future



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

Courtesy: Tukka, [http://nl.wikipedia.org/wiki/Afbeelding:Treinbrug\\_Delft\\_9838792.JPG](http://nl.wikipedia.org/wiki/Afbeelding:Treinbrug_Delft_9838792.JPG) /

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