INTEREST OF ACCURATE 3D GEOMODELS FOR GEOTECHNICAL PROJECTS AND INTEROPERABILITY BETWEEN GEOLOGY AND BIM

Part 2 : Interoperability with RESQML Builder and RESQML-CAD

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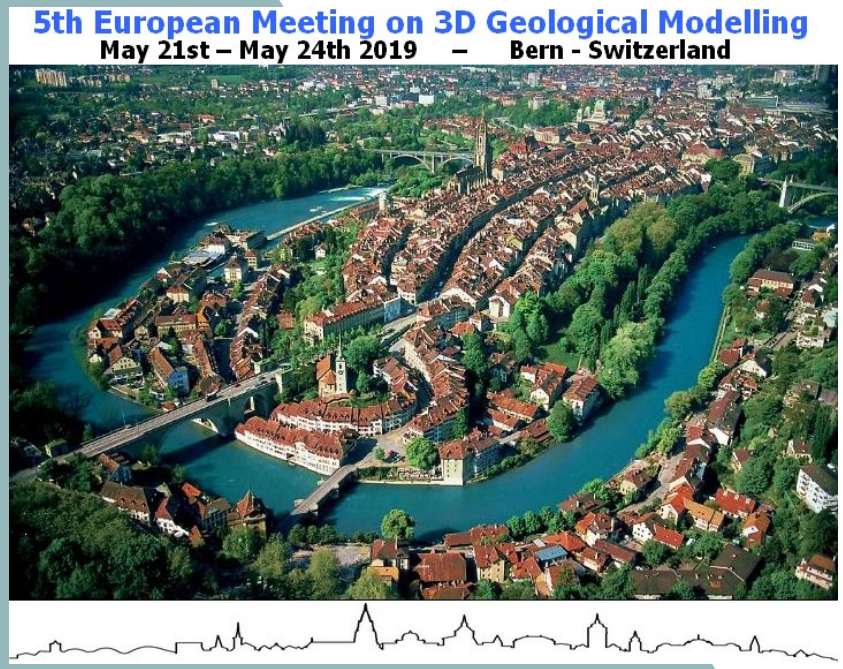


INTEROPERABILITY BETWEEN GEOLOGY AND BIM

1 – The problem

2 – The EGIS solution

3 – RESQML v2.2 Format

4 - RESQML – CAD : Civil 3D plug-in

A few examples with our projects

5 – Horizon import (Guadeloupe harbour expansion)

6 – DEM and boreholes import (EGIS Gold Mining)

7 – Faults import (Hinkley Point C EPR)

Another example initially built with GoCAD

8 – The Thurrock model of BGS

9 – Conclusion

INTRODUCTION

The problem

02.

INTRODUCTION

❑ Why to develop a solution of interoperability between GDM and Autodesk Civil 3D ?

- ❑ In civil engineering, to build a linear infrastructure (motorway, railway, subway, canal, tramway) or another industrial platforms (harbour, airport, factory, etc) needs to have plans in 2D (view plan, longitudinal profile and cross sections).
- ❑ The BIM (Business Information Modeling) is the set of processes for managing a project. Generally the project has a 3D digital model mixing the various models provided by different engineers of each discipline or speciality. Today the 2D plans are plan views or cross sections of the 3D model.
- ❑ Classically the plans are drawn with CAD (Computer-aided design) tools such as AutoCAD. The architects are the firsts to use 3D models and 3D CAD tools in the building world. For a house or a building, to have a 3D geomodel of the subsurface is not necessary. Then the CAD tools have basically no functionalities to import a 3D geomodel and CAD tools unknow what is a borehole !
- ❑ For a motorway, the cost of the earthworks represents about 30 % of the total cost. Then to be able to transfer and to upgrade easily the 3D geomodels and its boreholes from our geomodeling tool to our CAD tools allows us to bring together the geomodel with the civil engineering project .
- ❑ When I did the geomodels of the New Coastal Road (La Reunion Island) and of Hinkley Point EPR (UK), I had no solution of interoperability. We had to export and to import all the points for each horizon and each faults. But no solution for the boreholes.
- ❑ In 2013, I looked for a format file and I discovered the existing of RESQML. It was the beginning of a new challenge.

EGIS SOFTWARE DEVELOPMENTS

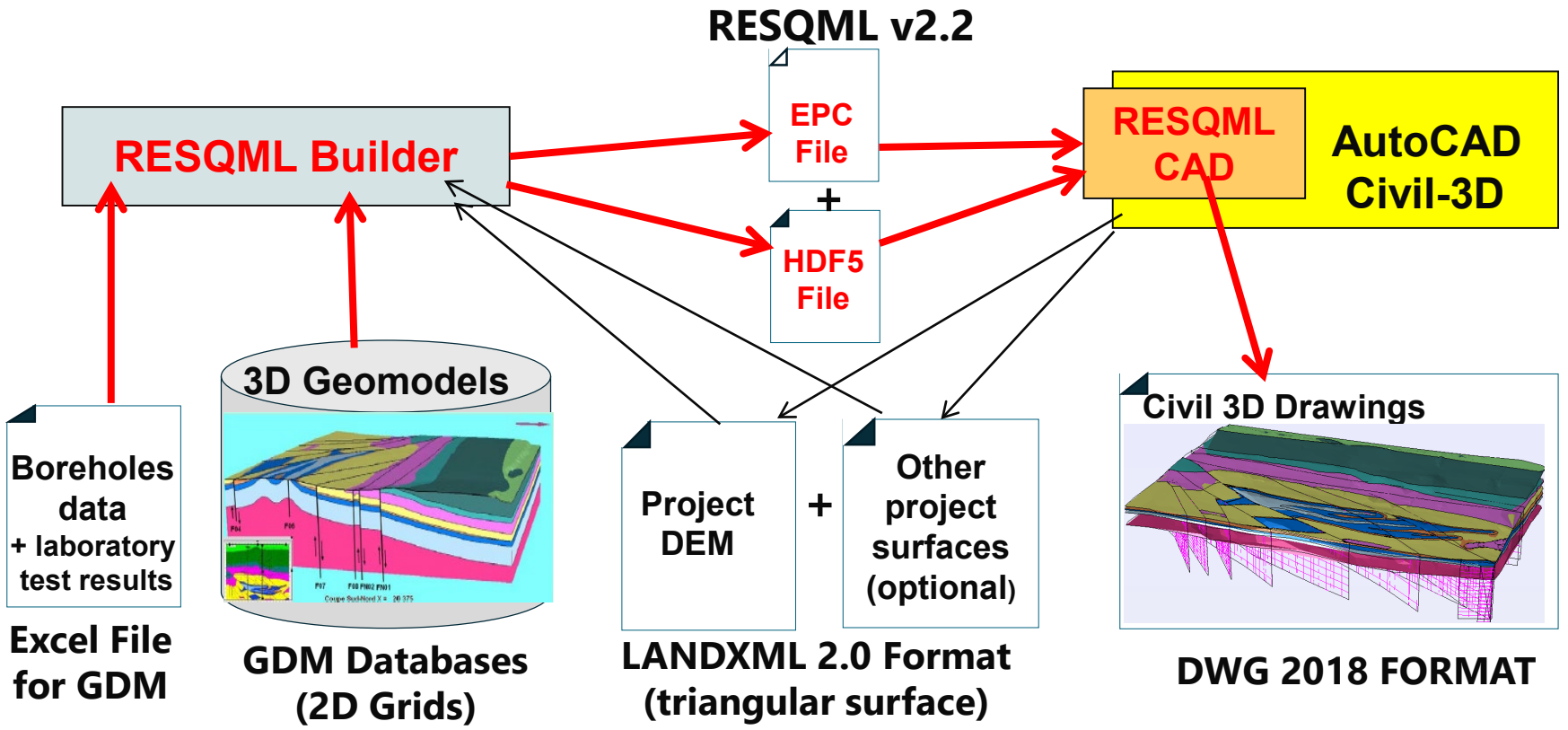
Software overview

02.

EGIS SOFTWARE DEVELOPMENTS

❑ Schema of interoperability from GDM to Civil-3D

- ❑ RESQML Builder reads the GDM models and the geotechnical data and stores them in RESQML files.
- ❑ RESQML-CAD reads the horizons or faults or boreholes data stored in the RESQML files and draw them in 3D in a DWG file.



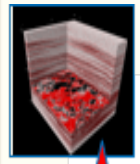
RESQML V2.2 FORMAT

Some particularities of this standard

03.

RESQML 2.2 SOLUTION SCOPE

A solution to exchange 3D Geomodels



On The entire workflow

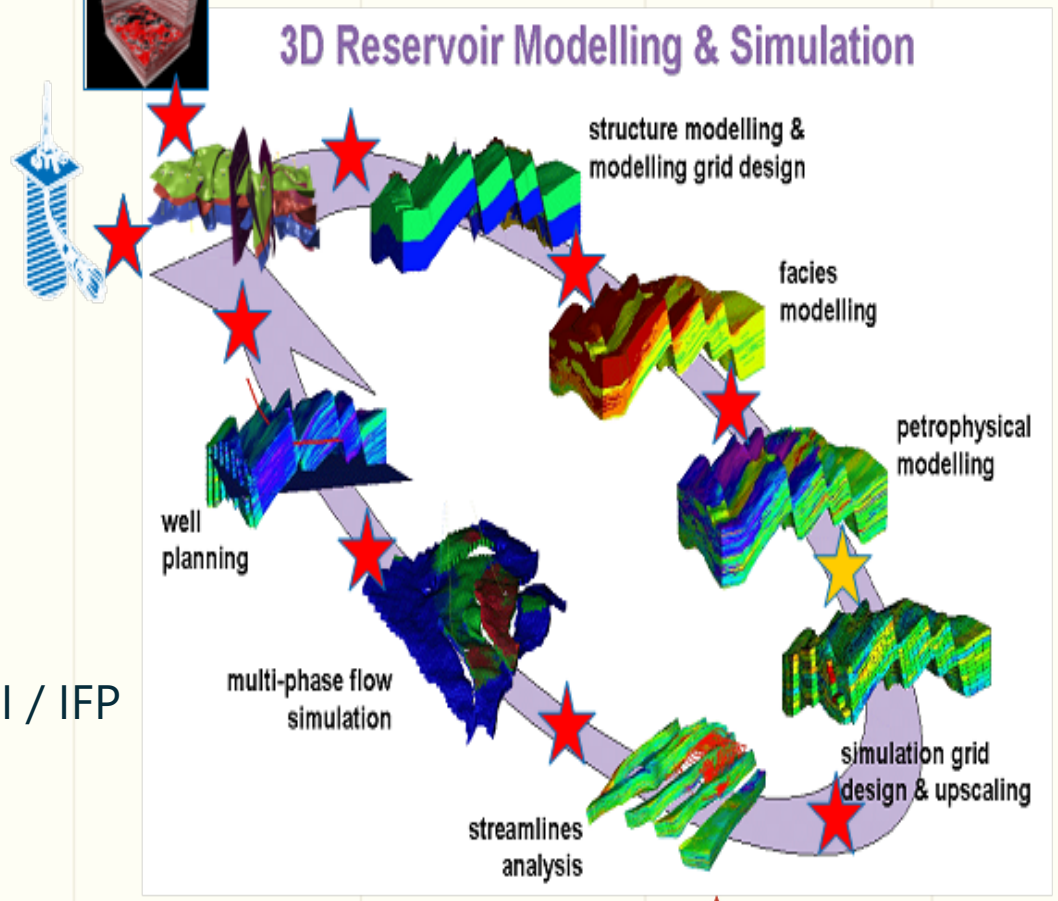
Seismic to simulation

All kinds of grids

Traceability via metadata

Coordinate systems, etc.

Supported by Geosciences Vendors



Already commercial

- Paradigm / Roxar / Schlumberger / CMG / DGI / IFP En Group

Internally used

- Total / Shell / BP / ExxonMobil/Equinor

Open and free of charge !

RESQML V2.2 FORMAT

❑ Separation of data and metadata in two files

❑ The EPC file :

It is an archive (as a ZIP file) containing two kinds of XML files (Text files in markup language readable by a human and a computer) :

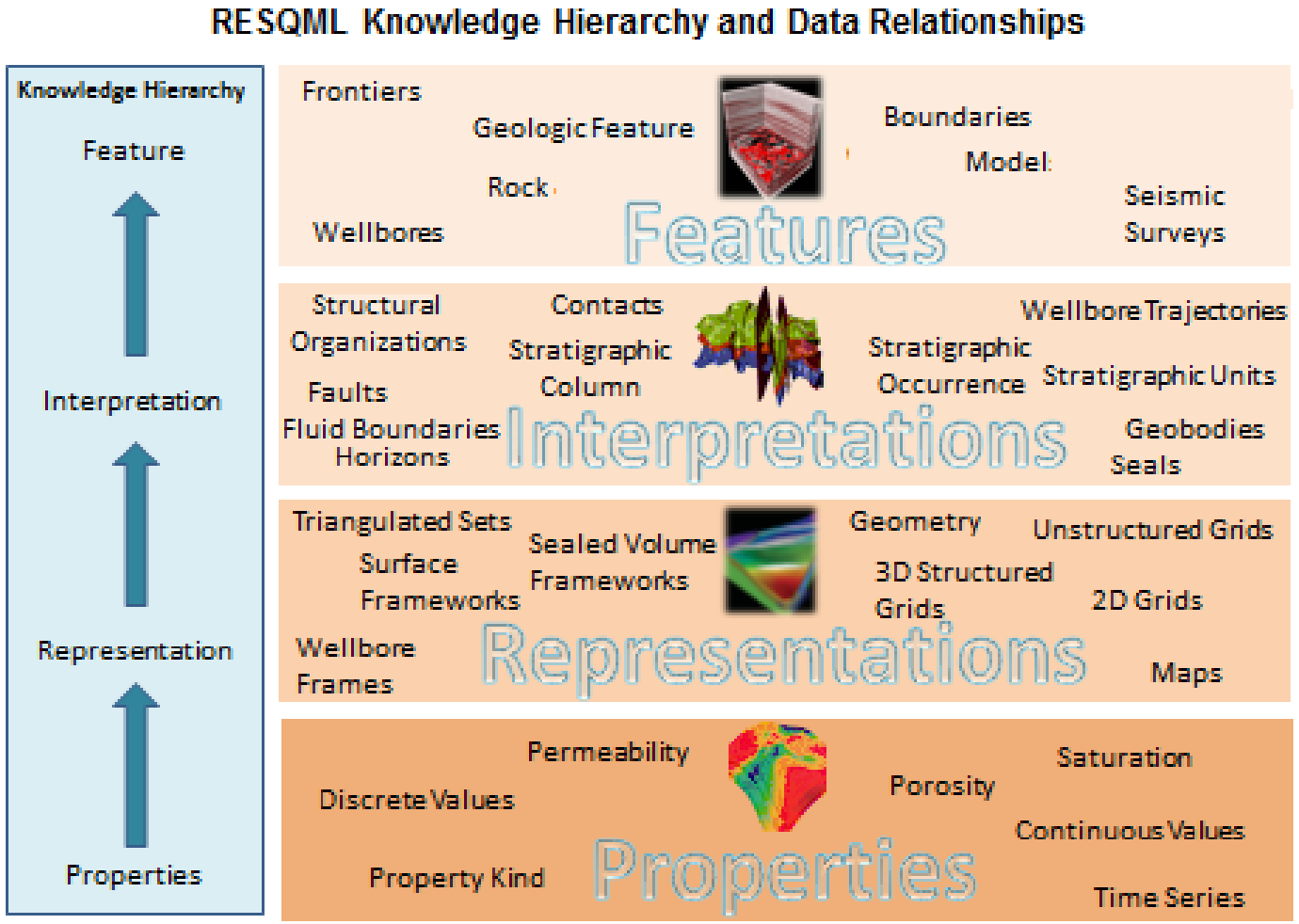
- **TopLevelElement files : they contain the description metadata** of any element of type Feature, Interpretation or Representation plus the associated properties. A topLevelElement is identified with an UUID (Universal Unique Identifiant).
- **Relation files :** they describe the relation between two TopLevelElements.

❑ The HDF5 file :

It is a structured binary file which allows us to store the numerical data such as the coordinates (X,Y,Z) of the summits and the edges of the triangles of a TriangulatedSetSurface (a TIN) or the values of pressuremeter data. A system of reference allows us to find the data associated to a TopLevelElement.

RESQML V2.2 FORMAT

❑THE FIRP : Feature / Interpretation/ Representation/ Properties



- Reference (Individuals and Models)
- Interpretation Meta Information
- Topology & Geometry
- Properties (attached to topology)

THE 3 TYPES OF HORIZON INTERPRETATION

❑ RESQML Horizon

❑ In RESQML to store a horizon data needs at least 3 kinds of TopLevelElements :

- **A feature (BoundaryFeature) : it corresponds to the concept of the limit between 2 layers.**
- **An interpretation (HorizonInterpretation) : With our solution we store the 3 possible interpretations of the feature (top, bottom or profile) in RESQML. These 3 different HorizonInterpretation elements is pointing to the same BoundaryFeature.**
- **A representation (TriangulatedSetRepresentation) : Each HorizonInterpretation is represented by a TriangulatedSetRepresentation element which is a TIN surface. RESQML Builder calculates the vertices of each triangles using the 2D Grids data stored in the GDM databases. Other representations (2D Grids) are available in the RESQML format but because we draw TinSurfaces with RESQML CAD, the TriangulatedSetRepresentation have been preferred.**

RESQML-CAD : CIVIL 3D PLUG-IN

Functionalities overview

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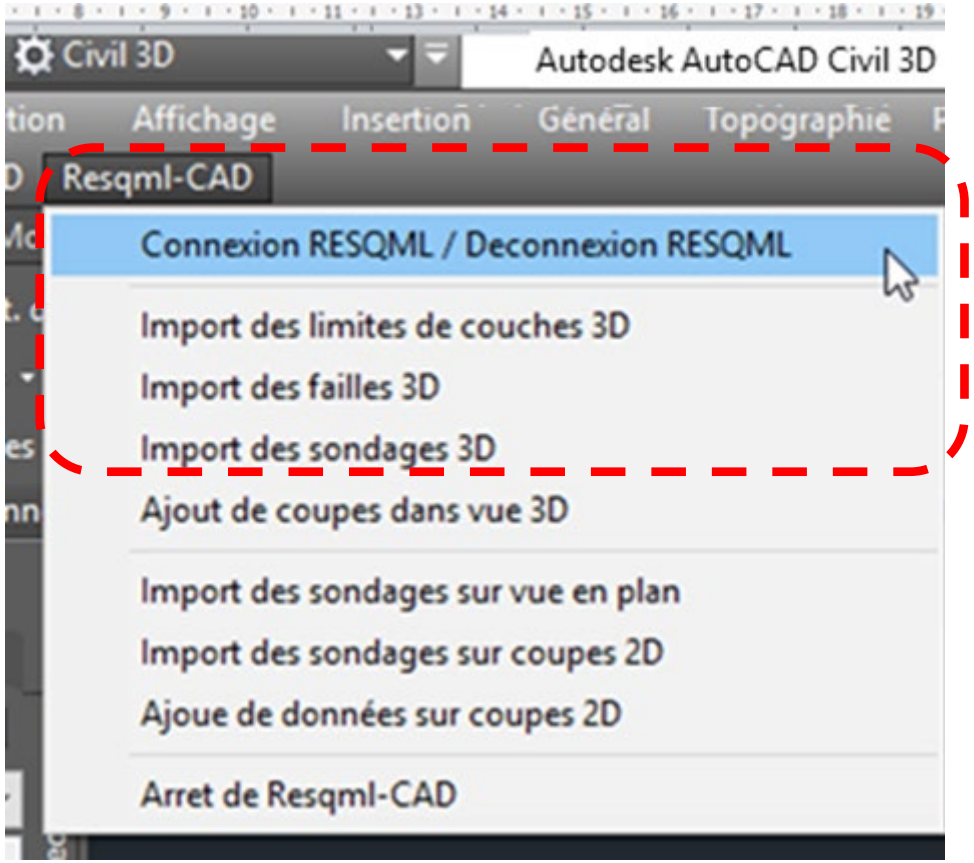
RESQML-CAD : CIVIL 3D PLUG-IN



❑ Operational Functionalities

- ❑ RESQML File Connection / Deconnection
- ❑ Horizons import in 3D
- ❑ Faults import in 3D
- ❑ Boreholes import in 3D

❑ In development

- ❑ Adding of 3D Fence-Diagrams
- ❑ Boreholes import on a plan view
- ❑ Boreholes import on 2D cross-sections
- ❑ Adding boreholes log data on 2D cross-sections (for vertical boreholes only)

HORIZON IMPORT

Example with the Guadeloupe Harbour Expansion project

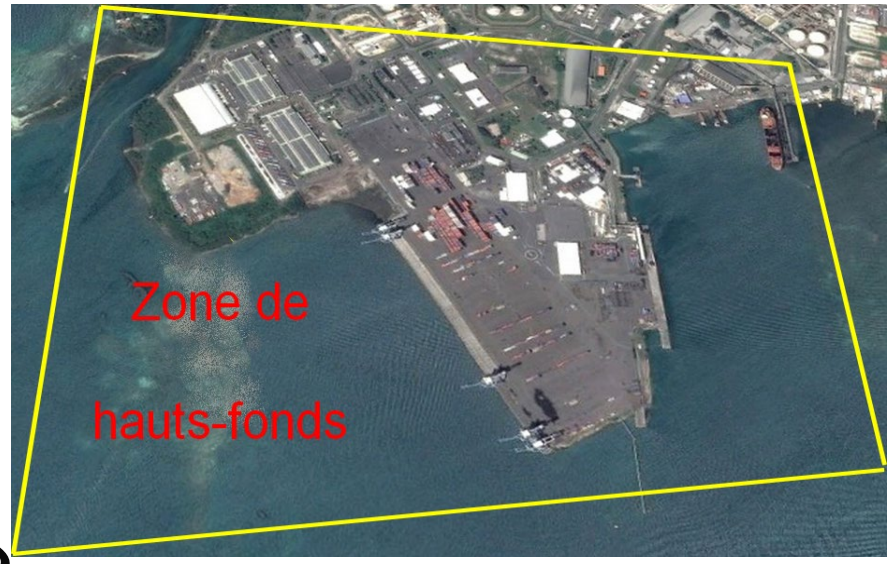
05.

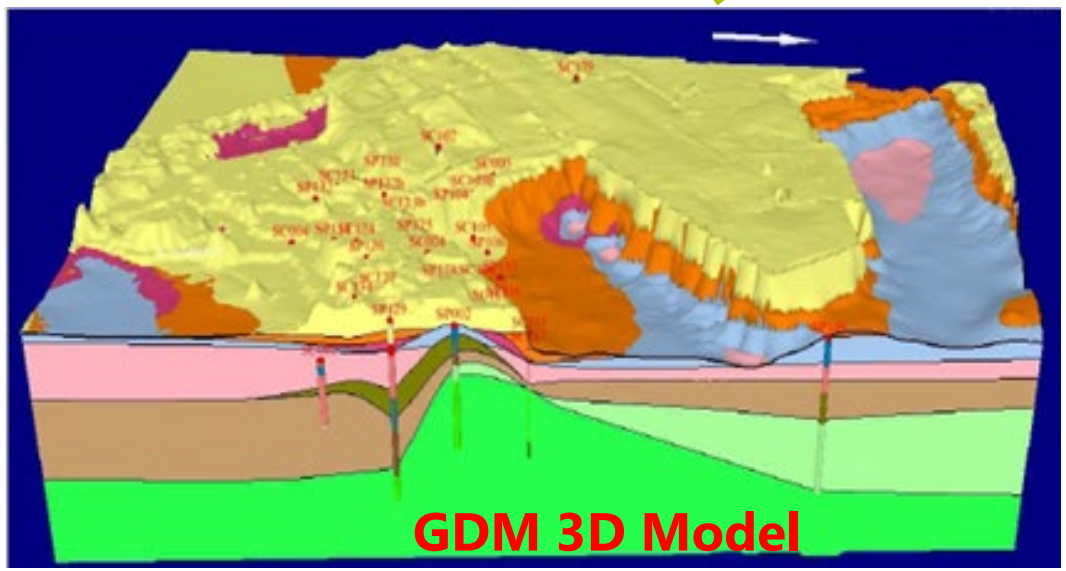
HORIZON IMPORT

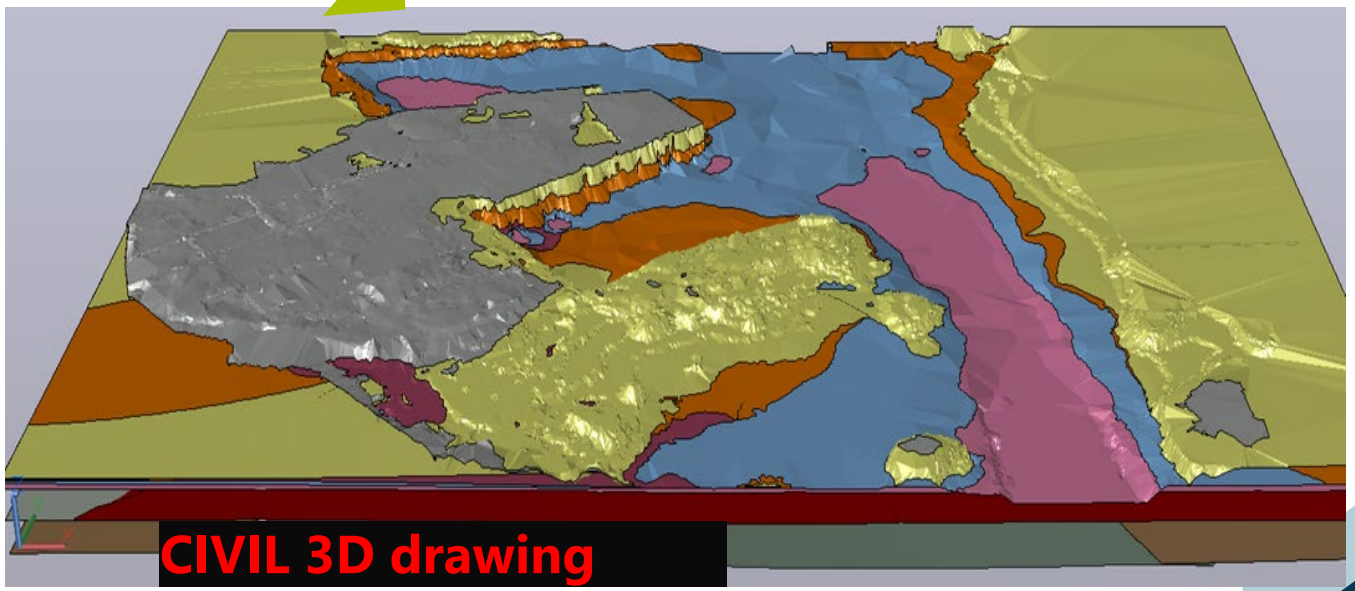
Formation	Type Surf.	Description
Rb	EROD	Remblai
3a1		Sables coquilliers
3a2		Vase, silts, sables argileux
3b		Tourbe
3c		Argiles bleues
4a		Argiles bariolées et tufs
4b1		Argiles d'altération
4b2		Argiles à blocs
4c		Calcaires altérés
4d		Calcaires sains

Guadeloupe Harbour expansion
3D Geotechnical Model

RESQML Builder → RESQML → RESQML CAD



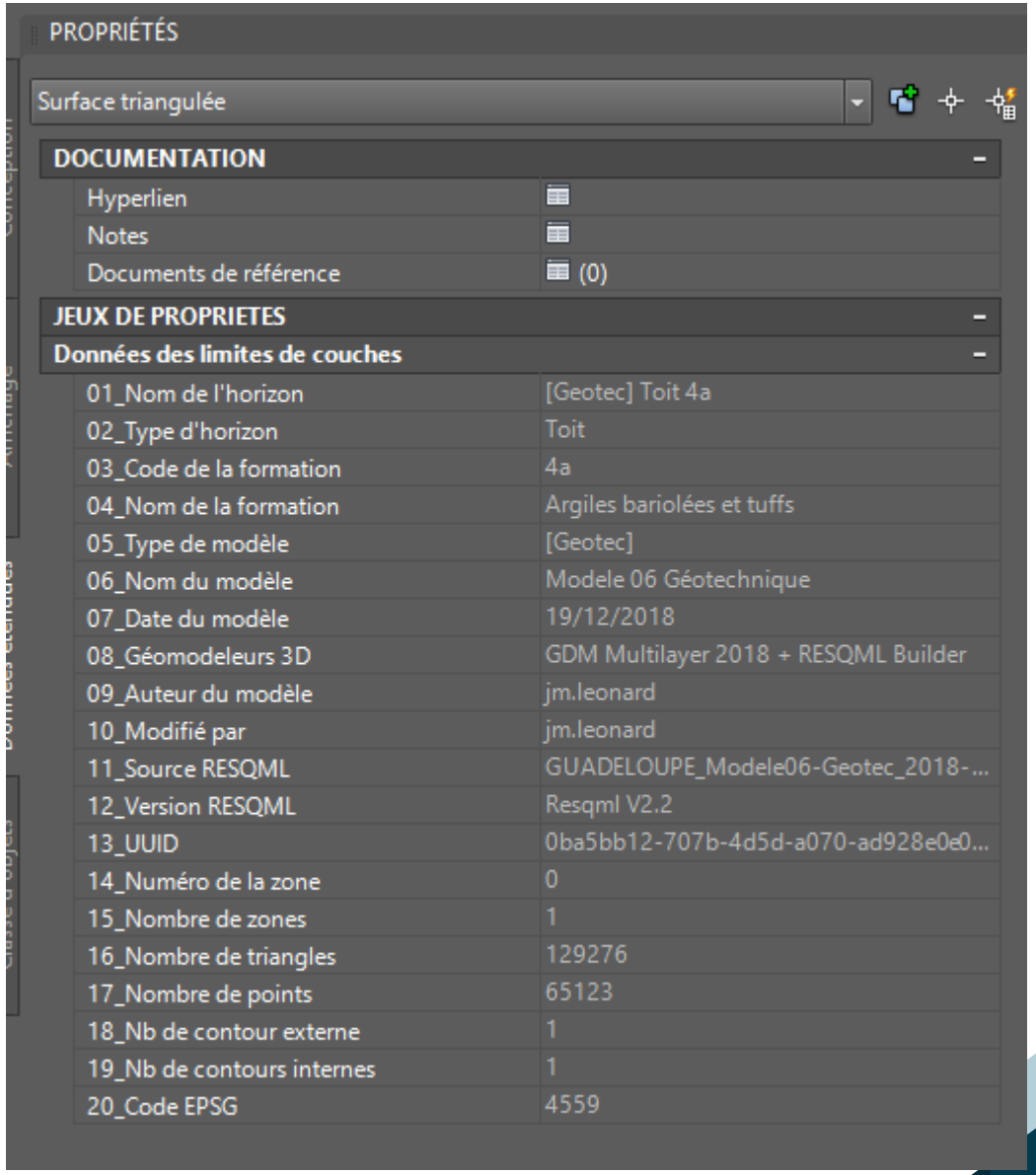




HORIZON IMPORT

❑ Extended Properties Set

- ❑ **Each TinSurface that represents a part of a horizon has an extended property set (attributes) which has been automatically associated.**
- ❑ **The properties include :**
  - ❑ The horizon name and the type of interpretation
  - ❑ The code and the name of the formation
  - ❑ Attributes of the model (type, name, date)
  - ❑ The name of the geomodeler
  - ❑ The authors of the model
  - ❑ The name of the RESQML file, the RESQML version
  - ❑ The topLevelElement UUID
  - ❑ Various information about the selected zone and the number of zones which form the complete surface of the horizon
  - ❑ The EPSG code of the coordinates system



egis

DEM AND BOREHOLES IMPORT

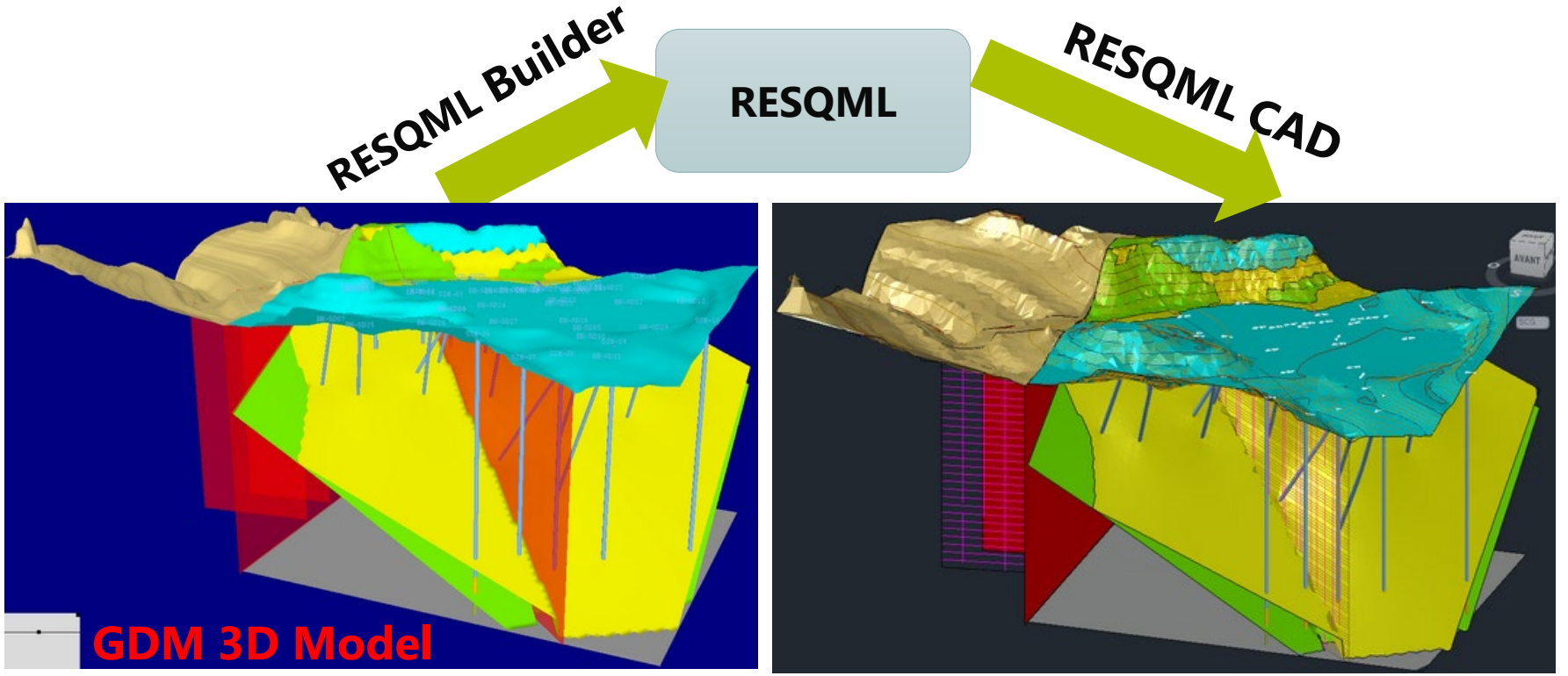
Example with the EGIS Gold Mining project

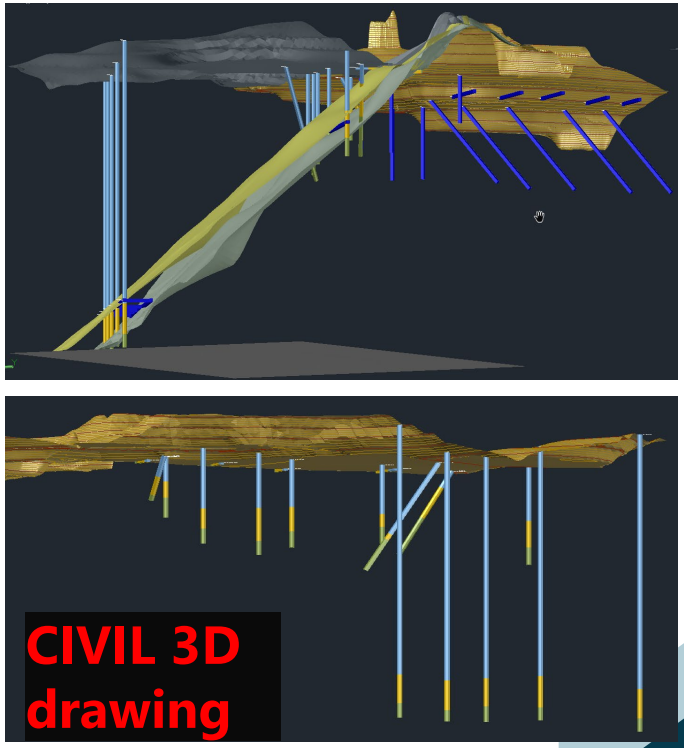
06.

DEM AND BOREHOLES IMPORT

❑ The EGIS Gold Mining Project : an imaginary project for our tests

- ❑ 3 layers : an overburden cover, an inclined gold vein, and an underburden substratum
- ❑ Many boreholes with various orientation (vertical, horizontal, inclined and deviated)
- ❑ The deviated boreholes have azimuth and inclination data
- ❑ Several faults, one of which crosses the vein and shifts the eastern compartment downward

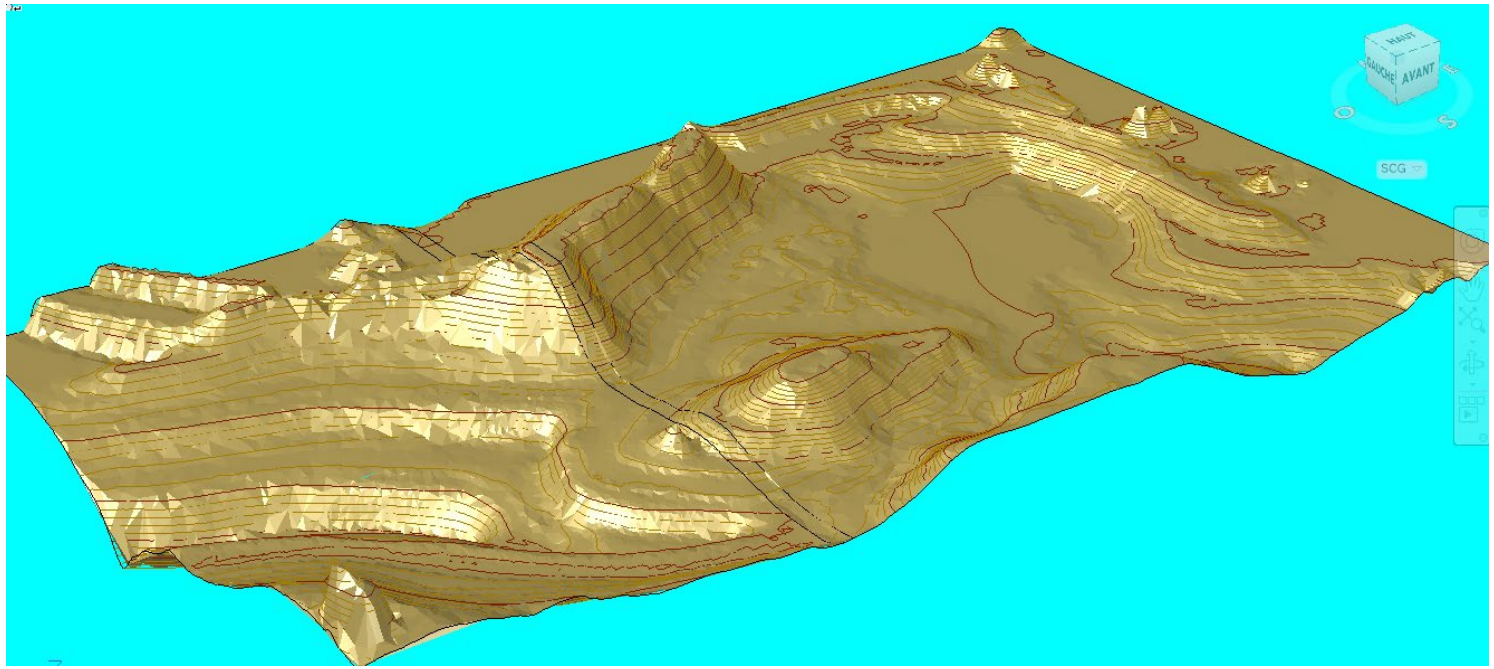




DEM AND BOREHOLES IMPORT

❑ DEM import and properties set

- ❑ The DEM is a particular horizon
- ❑ RESQML CAD draws it with its major and minor contours
- ❑ It has also extended properties (attributes)



PROPRIÉTÉS

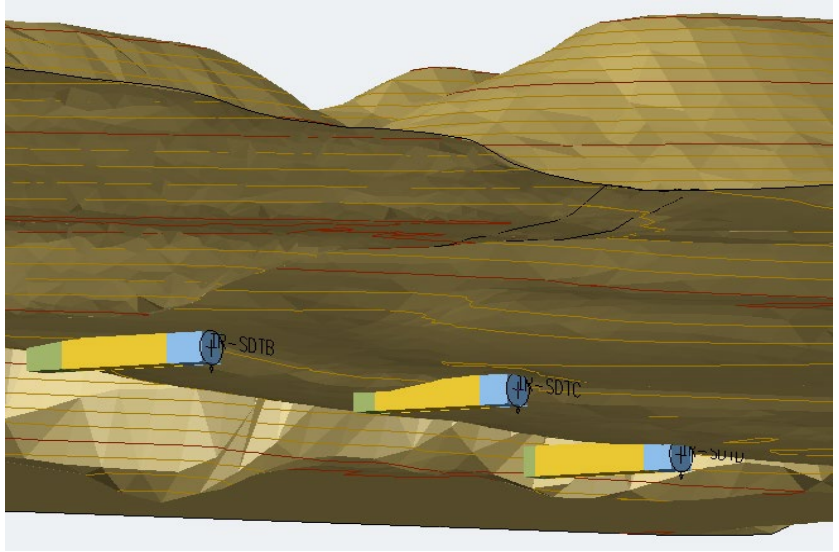
Surface triangulée

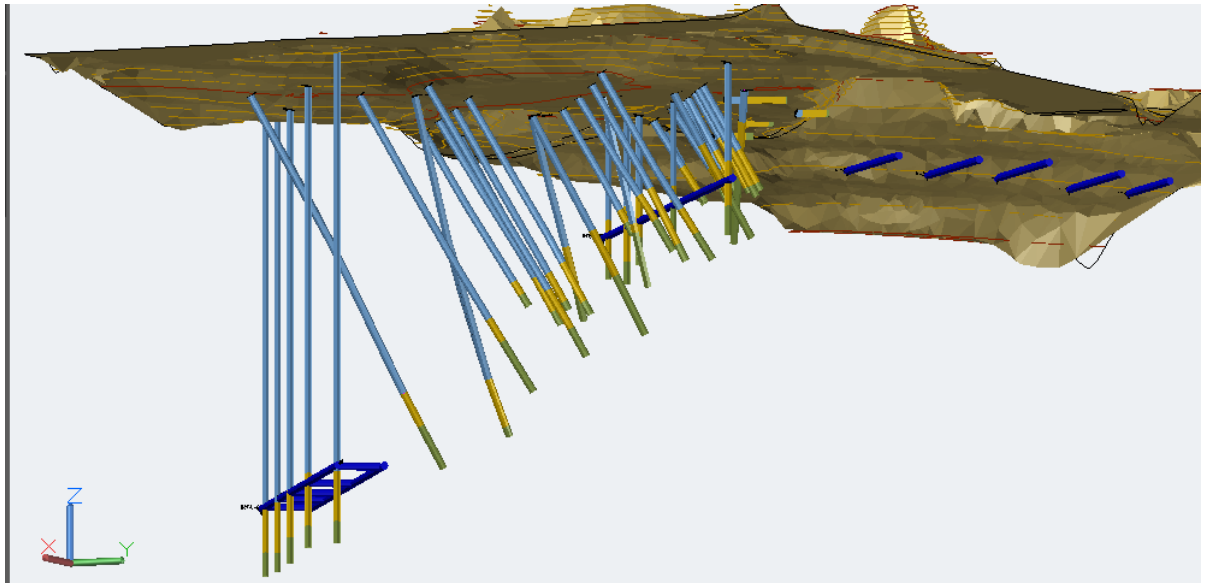
DOCUMENTATION	
Hyperlien	
Notes	
Documents de référence	(0)
JEUX DE PROPRIETES	
Données des limites de couches	
01_Nom de l'horizon	[Projet] surface MNT Est
02_Type d'horizon	surface
03_Code de la formation	MNT
04_Nom de la formation	
05_Type de modèle	[Projet]
06_Nom du modèle	
07_Date du modèle	15/03/2019
08_Géomodeleurs 3D	GDM Multilayer 2018 + RESQML Builder
09_Auteur du modèle	jm.leonard
10_Modifié par	jm.leonard
11_Source RESQML	Gold-Mining_Modele03_5x5m_2019-03-15.epc
12_Version RESQML	Resqml V2.2
13_UUID	e064d927-228c-4151-aa65-528a397e3619
14_Numéro de la zone	0
15_Nombre de zones	1
16_Nombre de triangles	25376
17_Nombre de points	12915
18_Nb de contour externe	0
19_Nb de contours internes	0
20_Code EPSG	4559

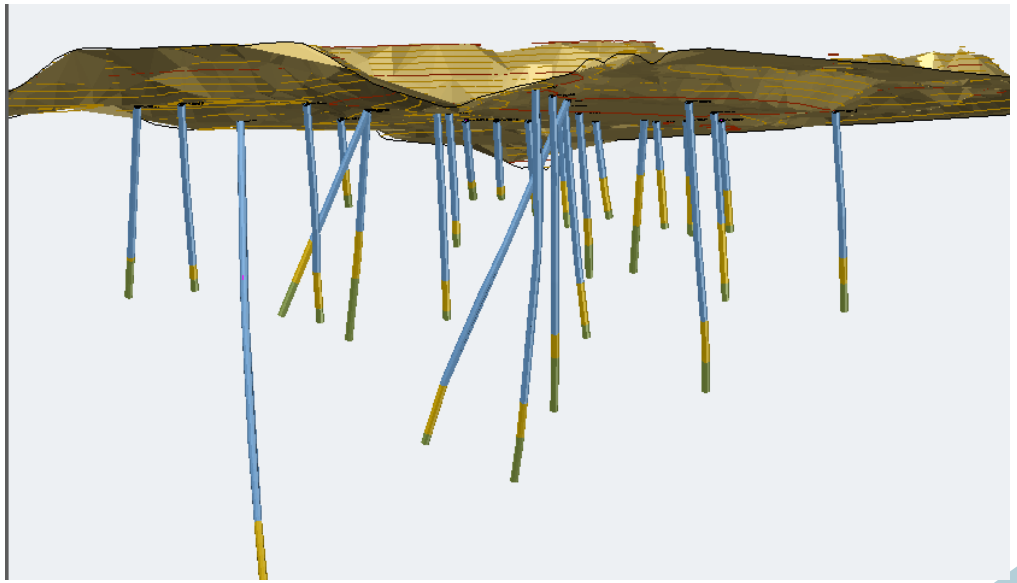
DEM AND BOREHOLES IMPORT

Boreholes import

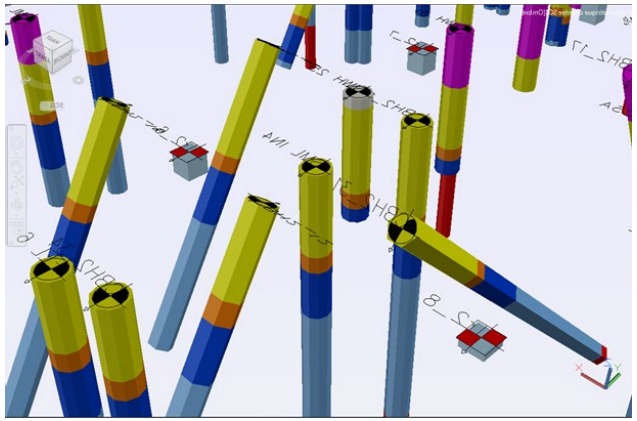
- **The boreholes to import can be selected according several criteria**
  - Existence kind : Realized, Simulated or Previsional
  - Interpretation : Lithological, geological, geotechnical, etc..
  - Orientation : Vertical, horizontal, inclined, deviated
  - Type : Trial pit, destructive drilling, core borehole, pressuremeter, etc.
  - Coordinates (Xmin, Xmax, Ymin, Ymax)
- **The user can specify the section shape and the diameter of the borehole**







DEM AND BOREHOLES IMPORT



Symbol and extended Properties Set

- **A property set is attached to each borehole label and to each borehole interval. The common properties (attributes) are :**
  - The borehole name, its type
  - Its existence kind (realized / simulated / previsional)
  - The dates of realization and interpretation
  - Attributes about the model (type, name, date)
  - The type, the name, the date of the model
  - The authors of the model
  - The orientation and the total depth
  - The RESQML filename and the topLevelElement UUID
- **For the borehole intervals, there are additional properties :**
  - Beginning depth and ended depth
  - Length
  - Lithological code, nature and detailed description

JEUX DE PROPRIETES	
ResqmlCAD Sondage Passe Properties	
01_Nom du sondage	BH-SD13
02_Type du sondage	TYPE NON DEFINI OU NON DISTINGUE
03_Statut du sondage	Sondage Réalisé
04_Date de réalisation	15/03/2019
05_Date d'interprétation	15/03/2019
06_Type de modèle	[Geolog]
07_Nom du modèle	
08_Date du modèle	15/03/2019
09_Auteur du modèle	jm.leonard
10_Modifié par	jm.leonard
11_Orientation du sondage	Dévié
12_Longueur du sondage	138.25 m
13_Source RESQML	Gold-Mining_Modele03_5x5m_2019-03-15.epc
14_UUID	cc517503-1a94-4ea5-b557-b757b8fe0330
15_Profondeur début passe	100.15 m
16_Profondeur fin passe	118.35 m
17_Longueur de la passe	18.2 m
18_Code litho de la passe	Vein
19_Nature de la passe	Filon
20_Description détaillée	

FAULTS IMPORT

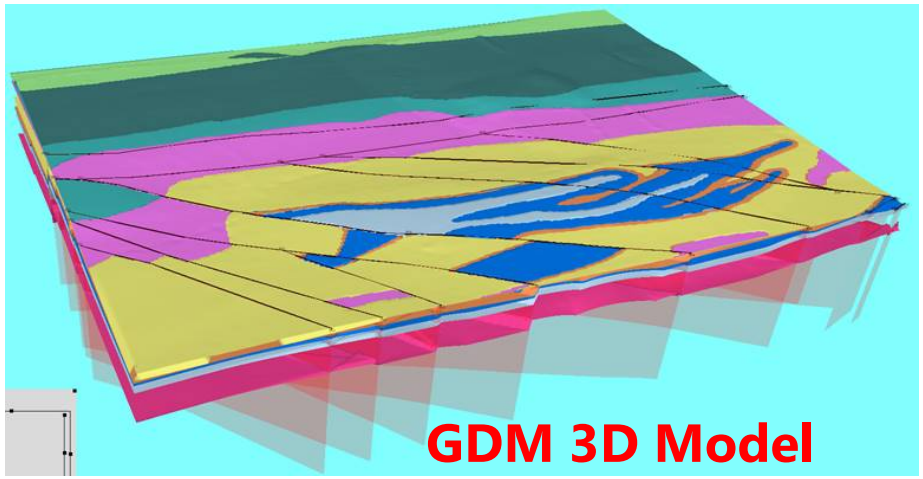
Example with the Hinkley Point EPR project

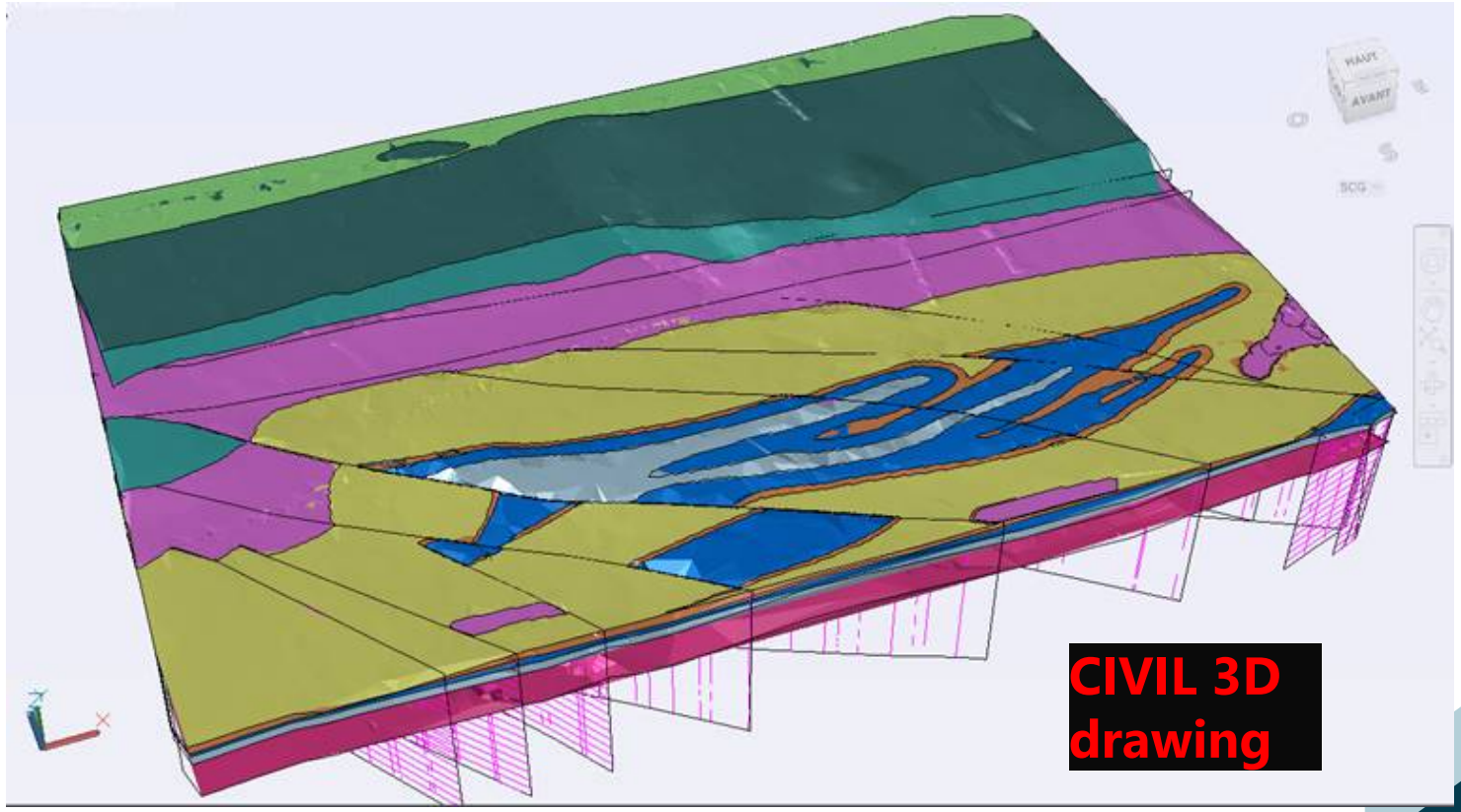
07.

FAULTS IMPORT

❑ The Hinkley Point C EPR project

- ❑ Geological model with 9 layers and a lot of vertical faults (Shear zone)
- ❑ Because GDM is a 2.5 geomodeller, the modeled faults are vertical
- ❑ But RESQML-CAD could import inclined faults
- ❑ Each fault also has its property set





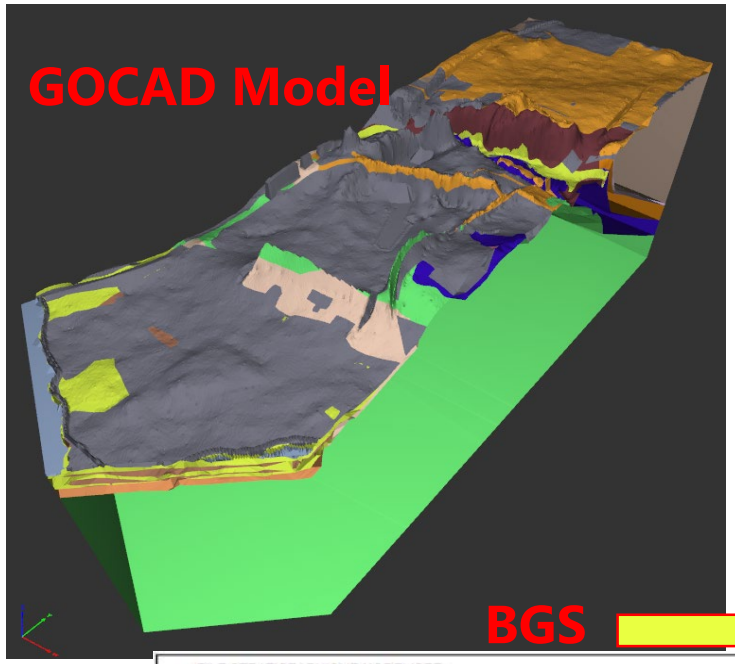
THE THURROCK PROJECT

A geomodel by BGS

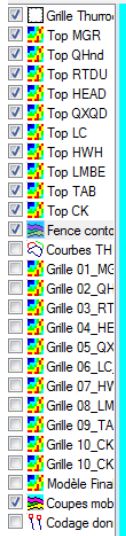
08.

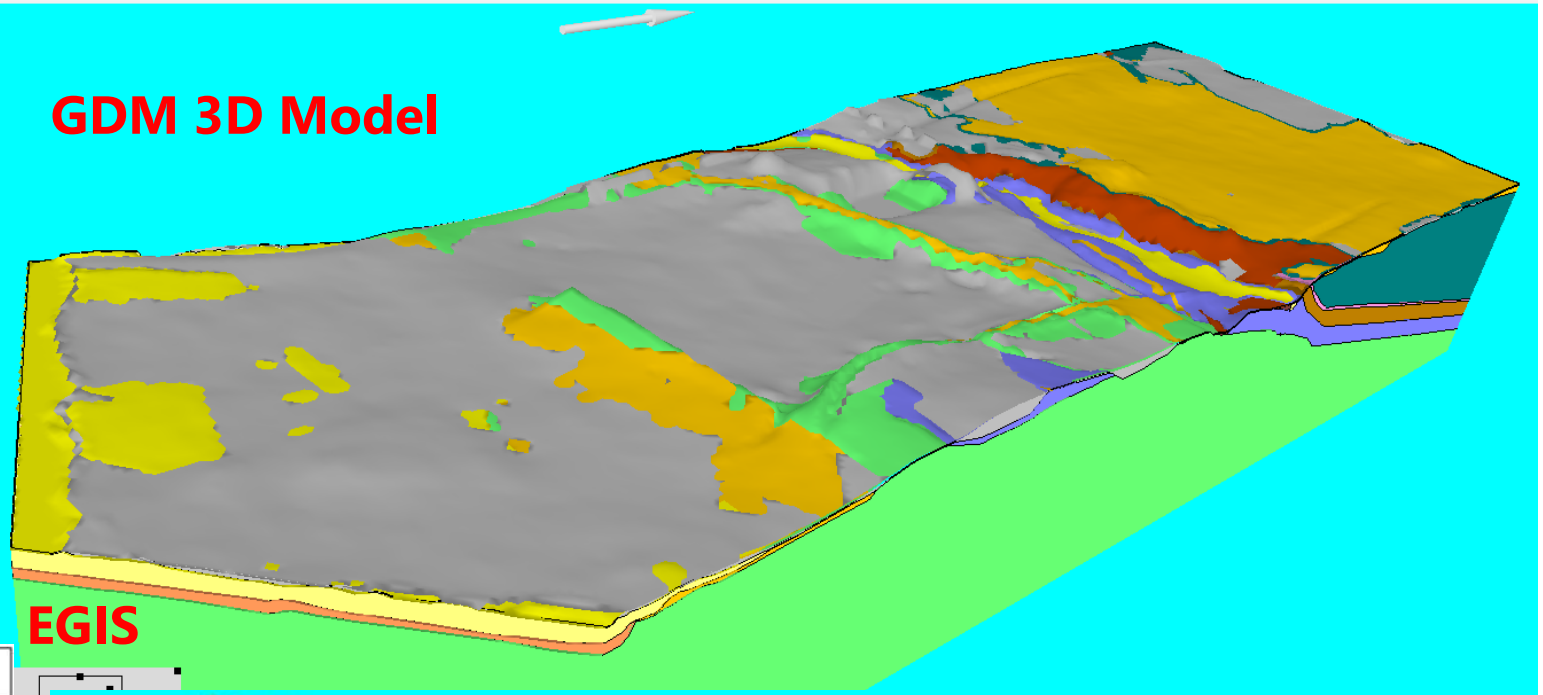
THE THURROCK PROJECT

https://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/minecraft/3d/thurrock.html

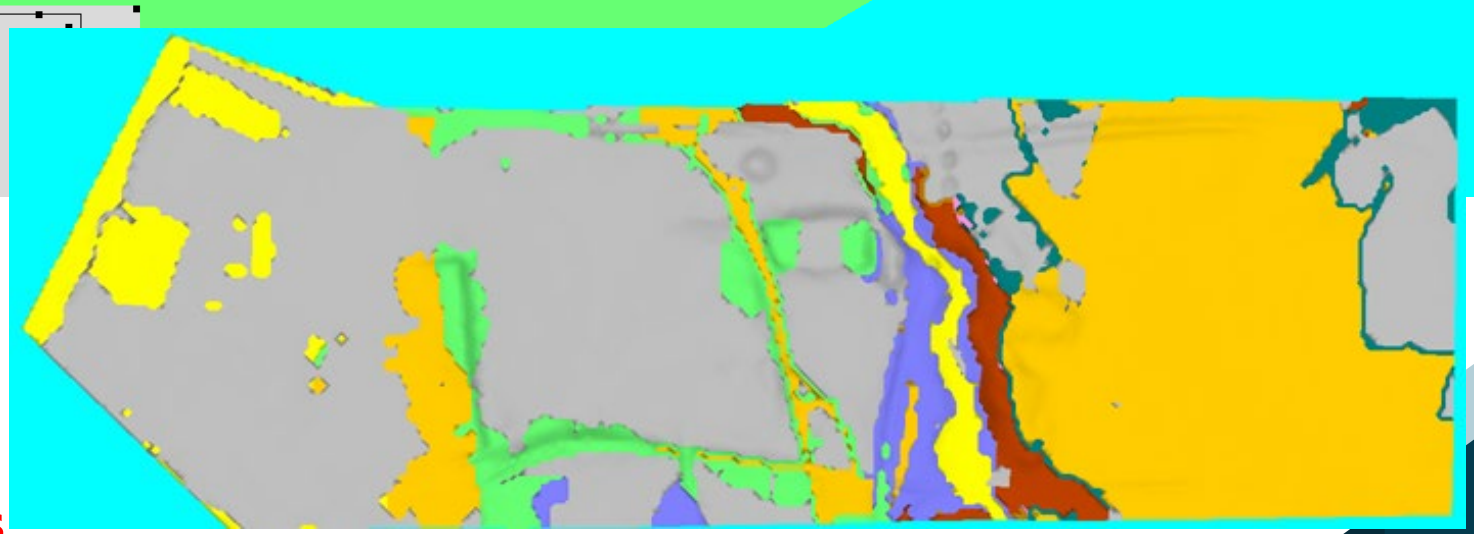


BGS





EGIS



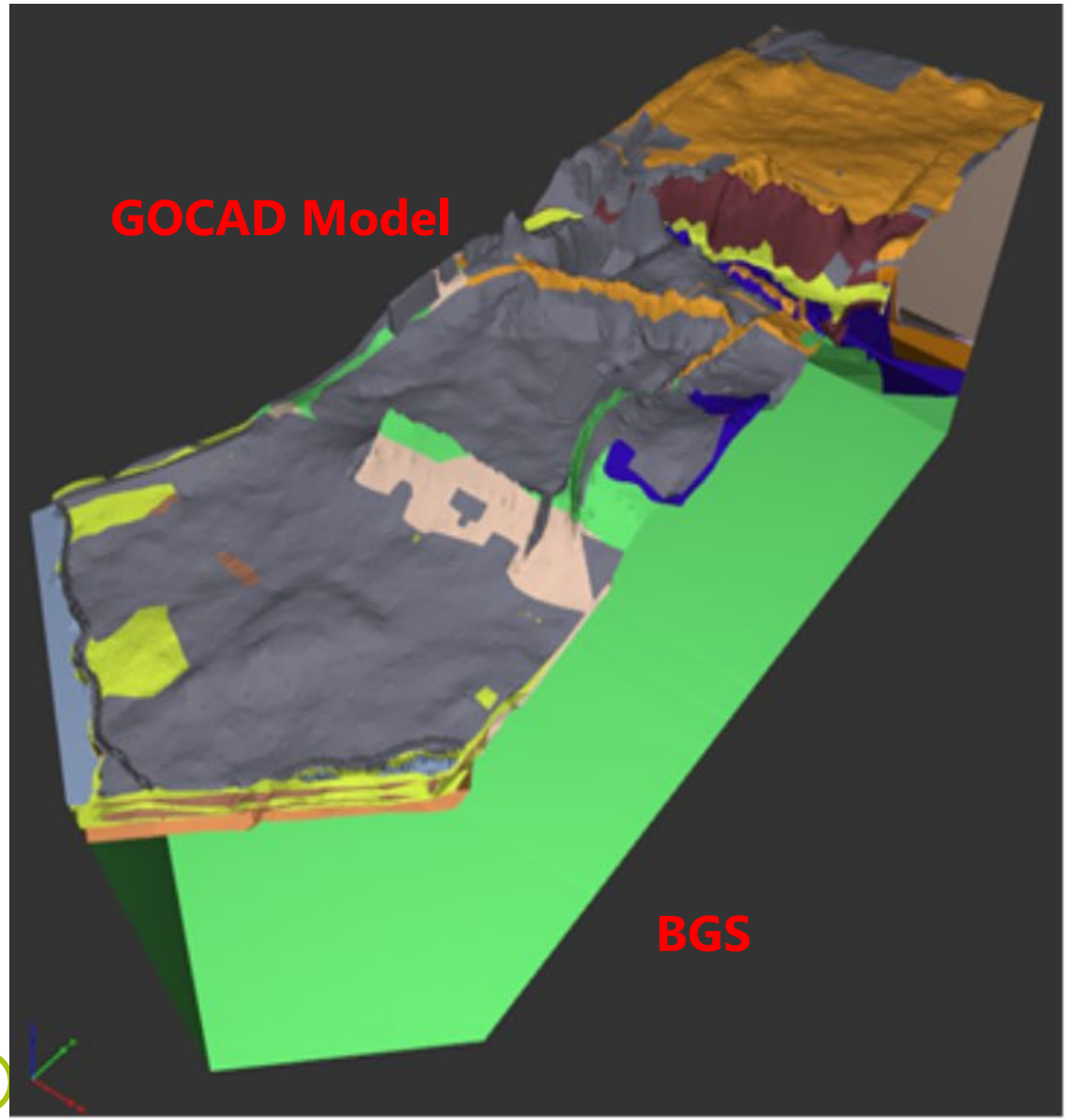
PILE STRATIGRAPHIQUE MODELISEE
D:\GBR\Thurrock\GDM\Strati01.mly

Formation	Type Surf.	Description	Nom Surf.	n° FORM
MGR	EROD	Made Ground	B10	F10
QHND	EROD	Tidal Flat Dep.+ Alluvium+Peat	B09	F09
RDTU	EROD	River Terrace Deposits	B08	F08
HEAD	EROD	Head	B07	F07
QXQD	EROD	Black Park+Lynch H+Taplow Gr	B06	F06
LC		London Clay Formation	T04	F05
HWH		Harwich Formation	T03	F04
LMBE		Lambeth Group	T02	F03
TAB	EROD	Thanet Formation	B02	F02
CK		Chalk Group		F01

egis

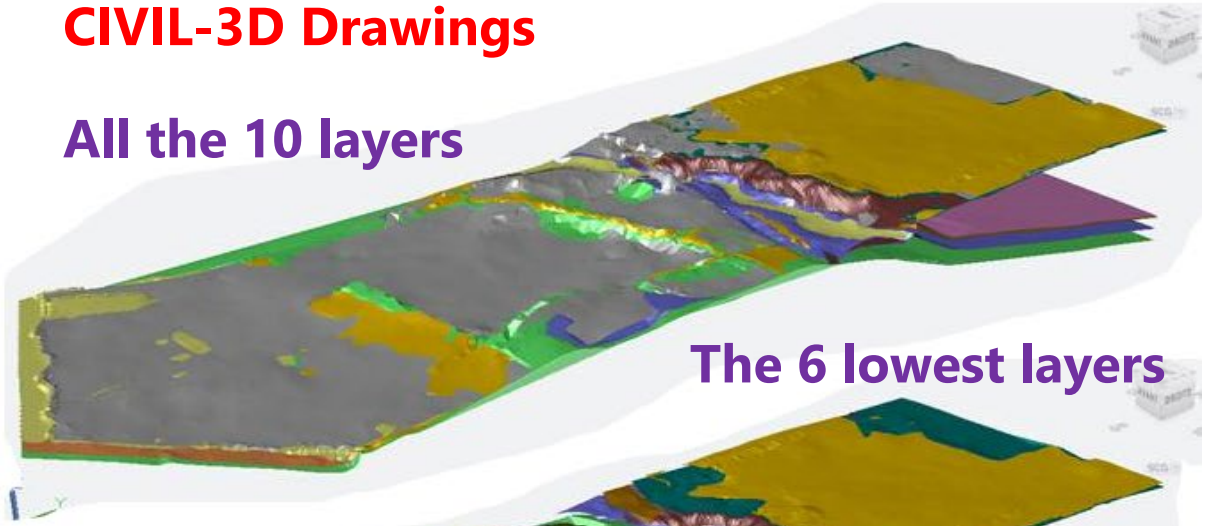
GDM simplified stack : 10 layers

THE THURROCK PROJECT

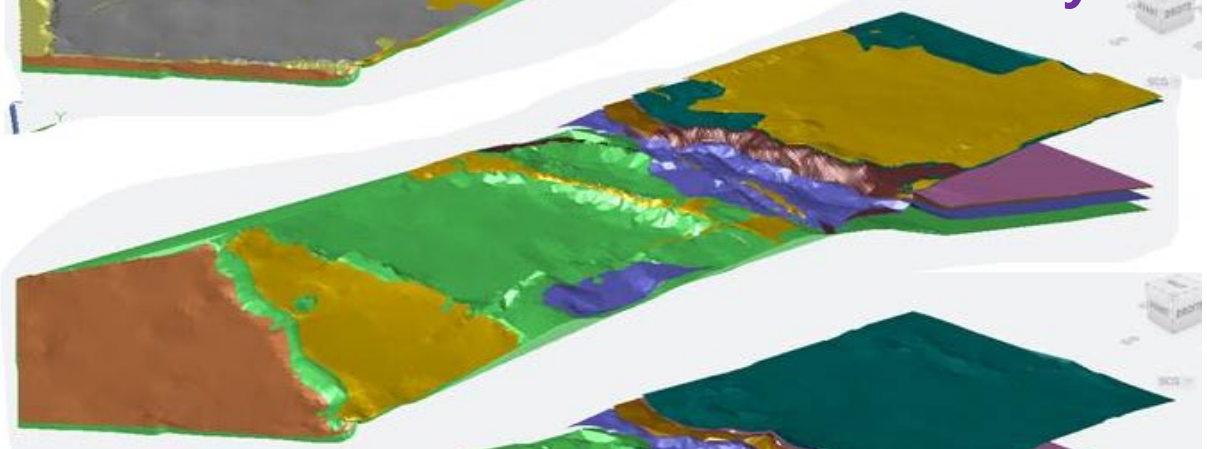


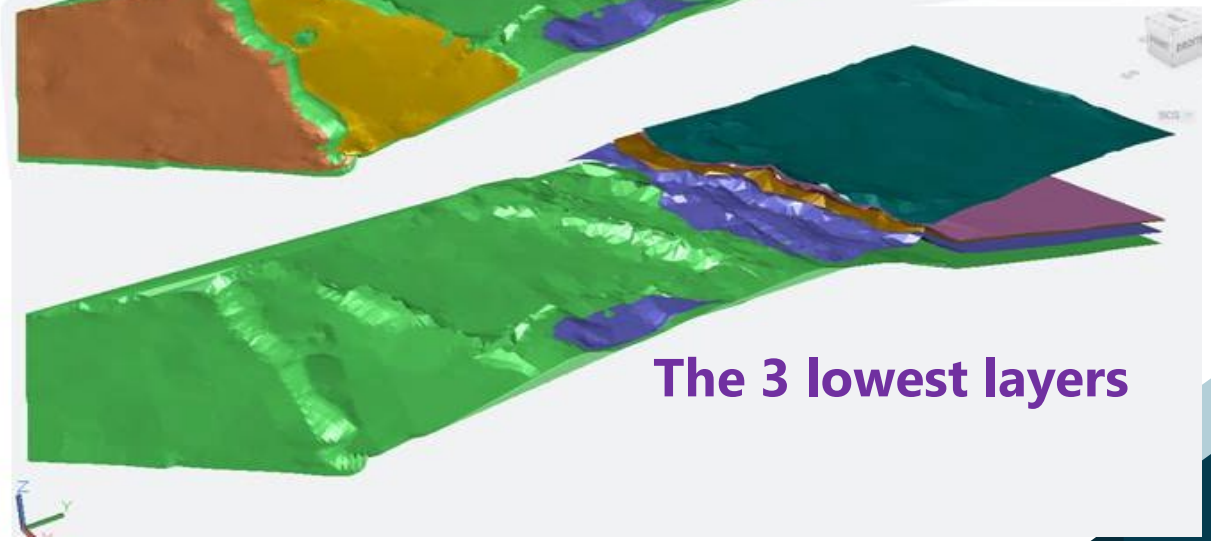
CIVIL-3D Drawings

All the 10 layers



The 6 lowest layers





The 3 lowest layers

CONCLUSION

Future development

09.

CONCLUSION

❑ RESQML : the missing IFC !

- ❑ IFC (Industrial Foundation Classes) are components for the interoperability supported by Building Smart International (BSi) and especially MINnD in France.
- ❑ Because there is no IFC for geology, geomodeling and geotechnics, RESQML can replace this lack.

❑ Our future developments

- ❑ We have to finalize the functionalities of drawing fence diagrams and to draw boreholes and their log data on the cross sections
- ❑ We are thinking of other smart functionalities
- ❑ We also have a project to develop connectors for ArcGIS or QGIS in order to share our 3D geomodels both with BIM and GIS

THANK YOU
FOR YOUR ATTENTION