UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES
Earth and Environmental Sciences

CHART
Swiss Accelerator Research and Technology

Development of a high-resolution 3D geological model and associated GIS-based subsurface data set for the FCC tunnelling work

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GEo-Energy Group, Department of Earth sciences, University of Geneva

FCC

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RESERVOIR GEOLOGY
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a CERN FCC- UNIGE joint project

SCOPE OF WORK

For the design of FCC trajectory, a full understanding of the subsurface geology that will be crossed by both the tunnel and the access shafts is required.

Objective: A detailed knowledge of the regional rock composition and structural elements such as fault of the subsurface and the hydrogeological characteristics of the area across the FCC trajectory.

This project has two goals:

I) establish a Geographic Information System (GIS)-based subsurface data set and data base architecture in support of the feasibility and execution of the FCC tunneling work

II) establish a consistent high-resolution 3D geological model, supported by quantitative geological analytical investigations along the FCC trace aimed at predicting geological features and possible risks in support of tunneling design, planning and execution.

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GEOLOGICAL SETTING

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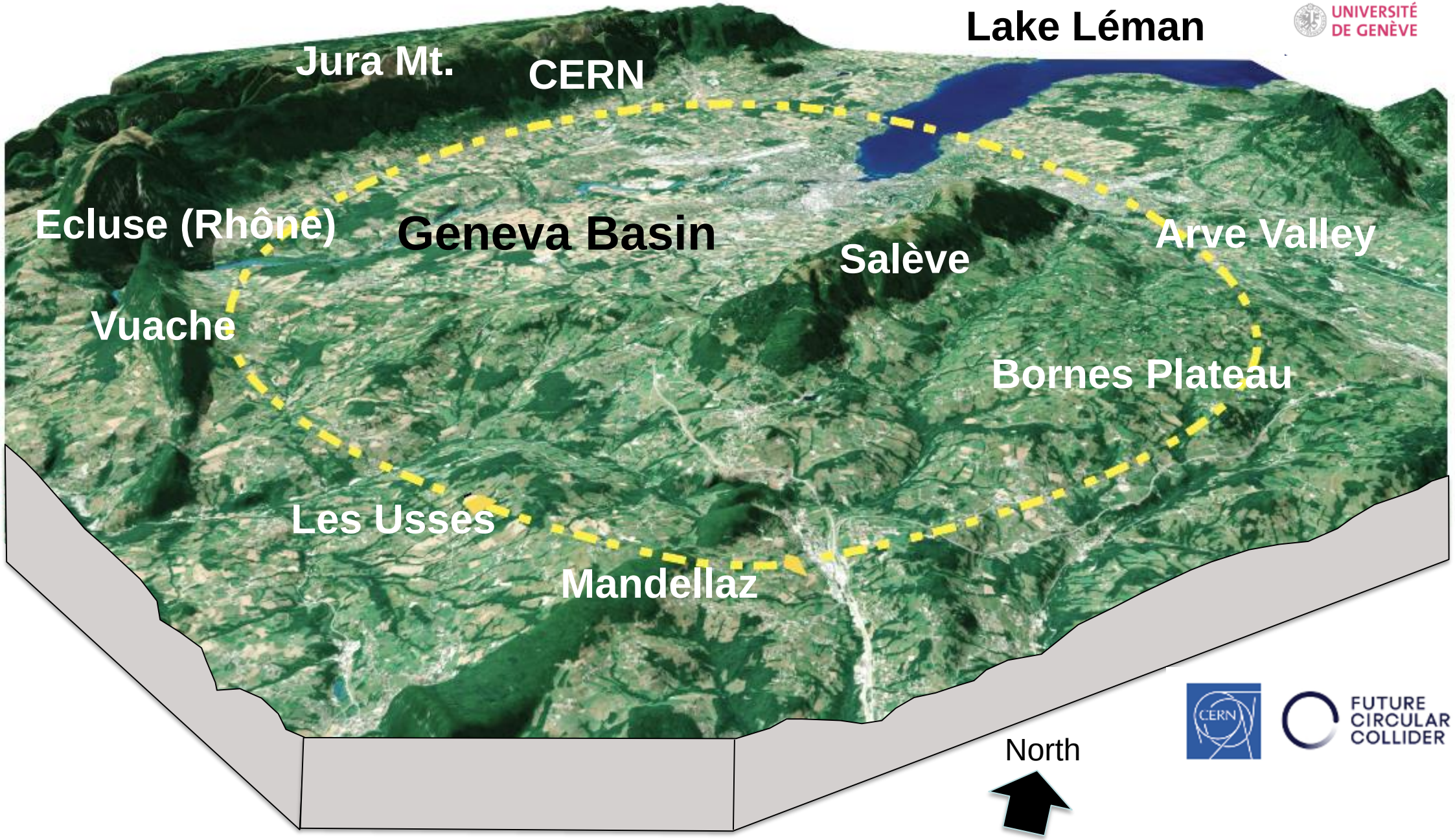
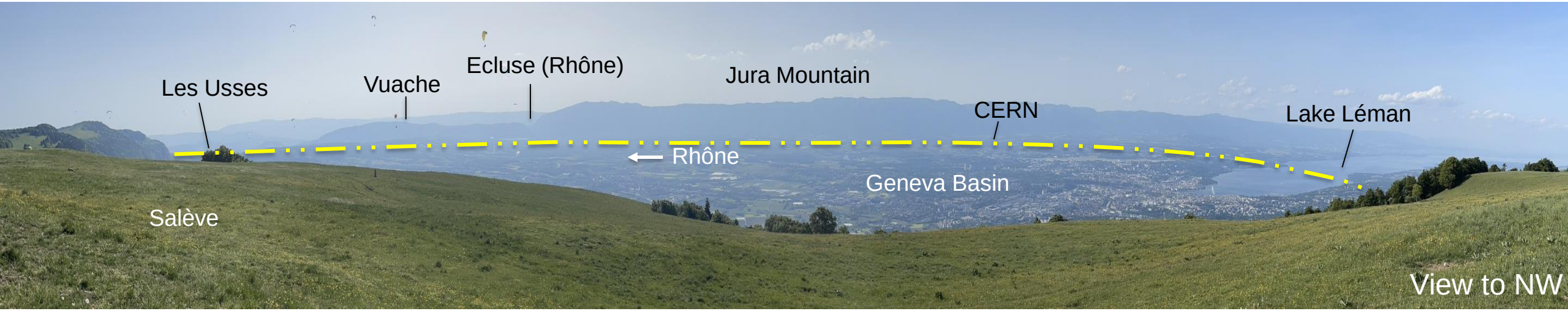

Lake Léman
Jura Mt.
CERN
Ecluse (Rhône)
Geneva Basin
Salève
Arve Valley
Vuache
Bornes Plateau
Les Usses
Mandellaz
North

FCC TRAJECTORY in the orographic context



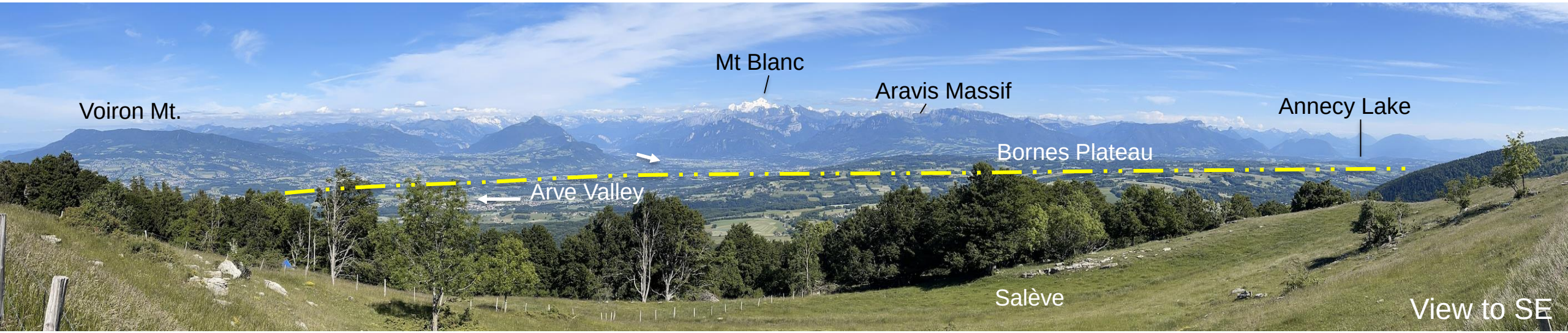
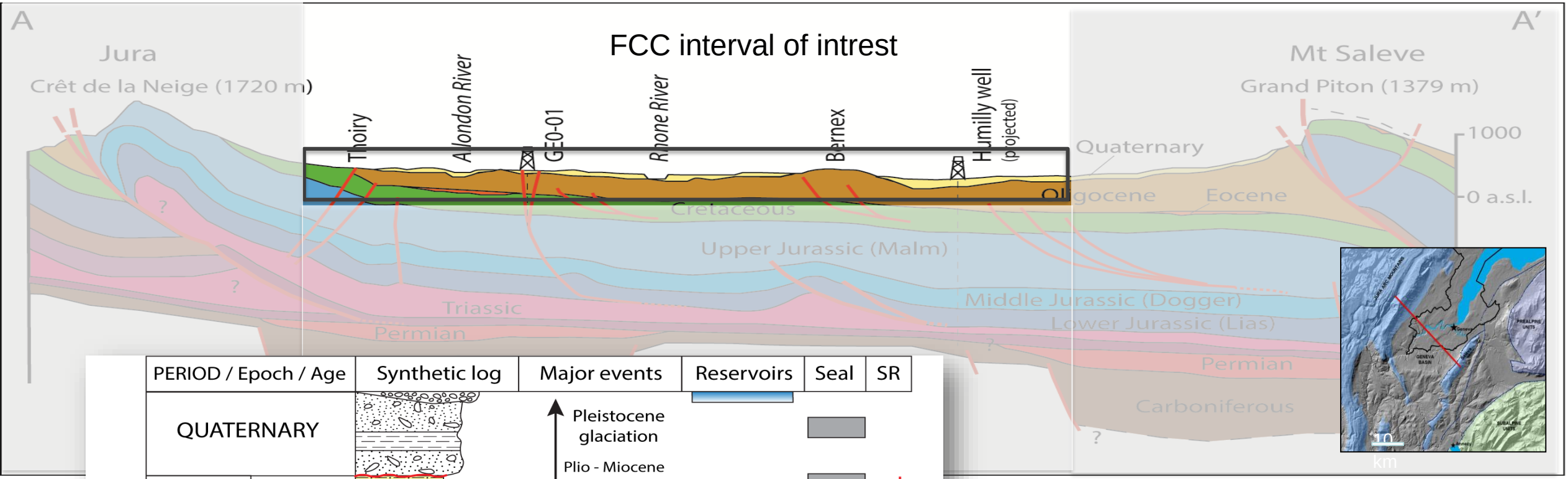
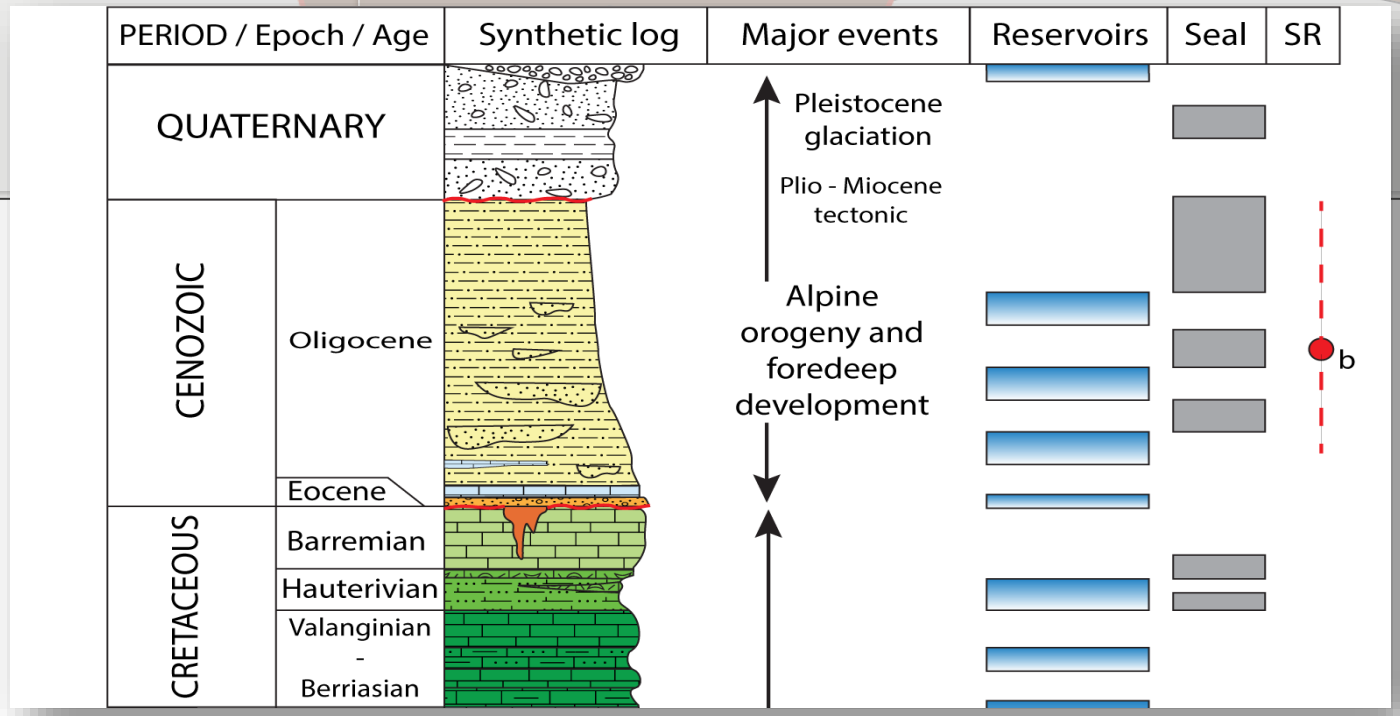


Photo A. Moscariello





Moscariello, 2019

FCC tunnel focus on the “150 - 250 m” deep range which is too deep for typical shallow hydro & geology (<100 m) but too shallow for current geothermal exploration effort (> 500 m)

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REPUBLIQUE
ET CANTON
DE GENEVE

POST TENEBRAS LUX

SUBSURFACE DATA BASE

DB3D
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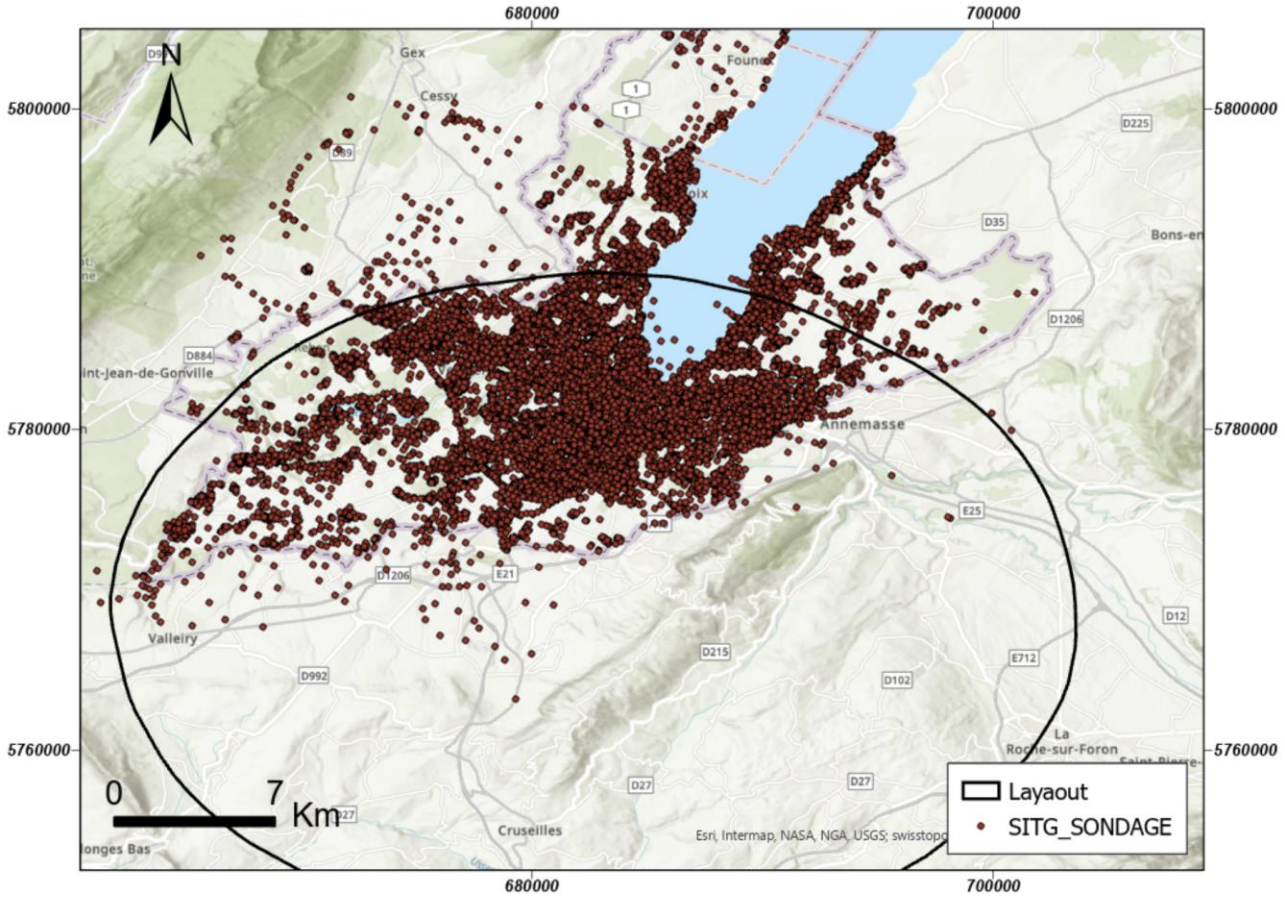
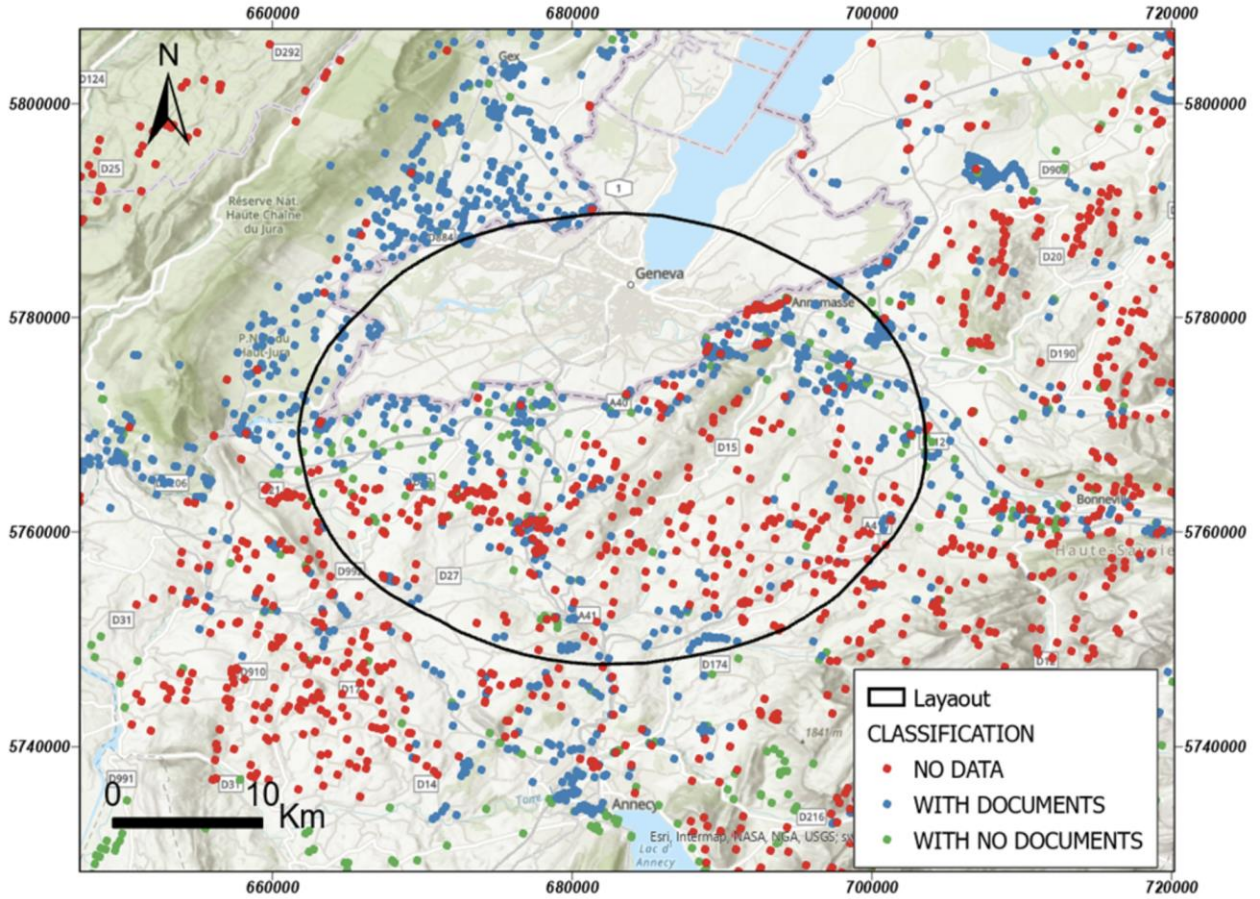
Boreholes data and classification



Source: SiTG (Canton of Geneva)

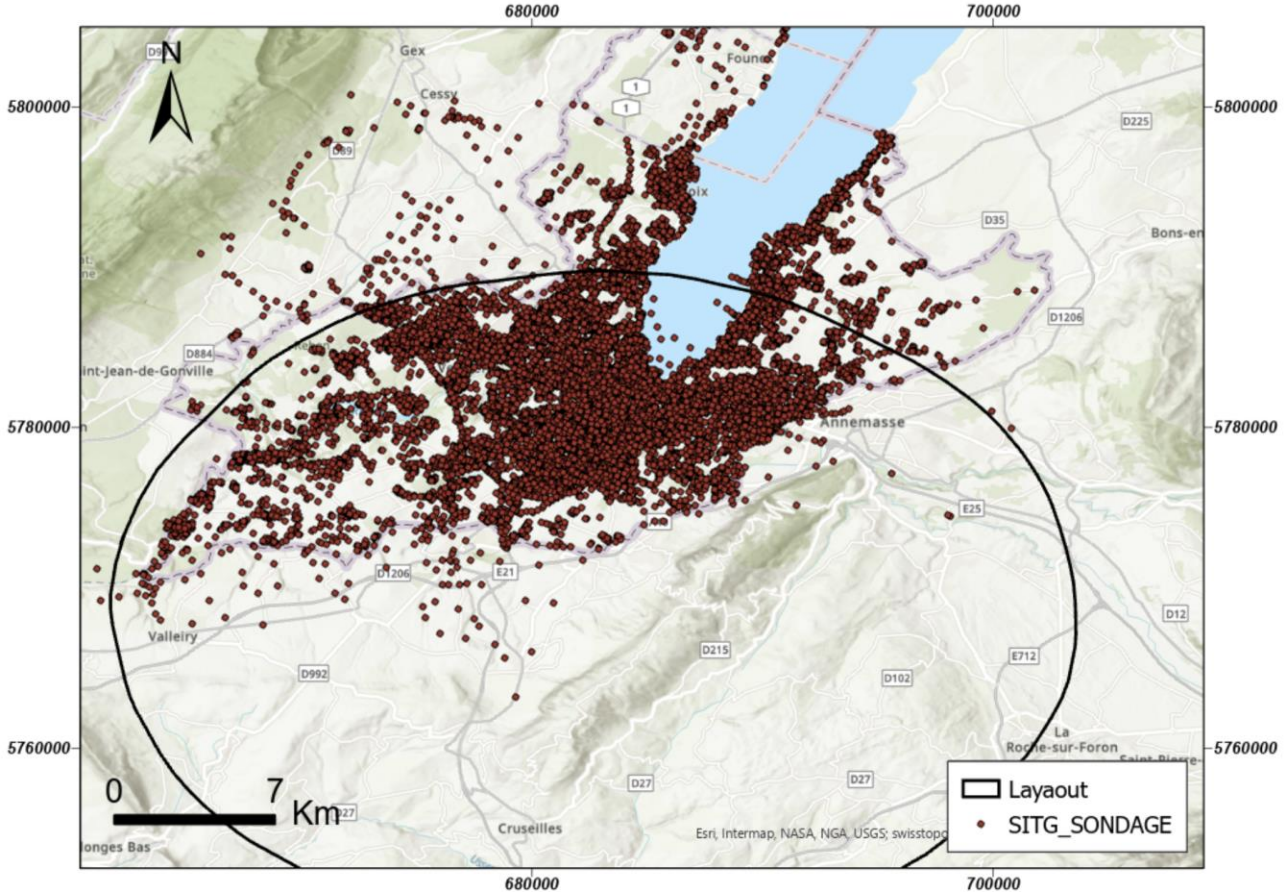
18’000 boreholes , 8969 public wells and 347 are >50m deep



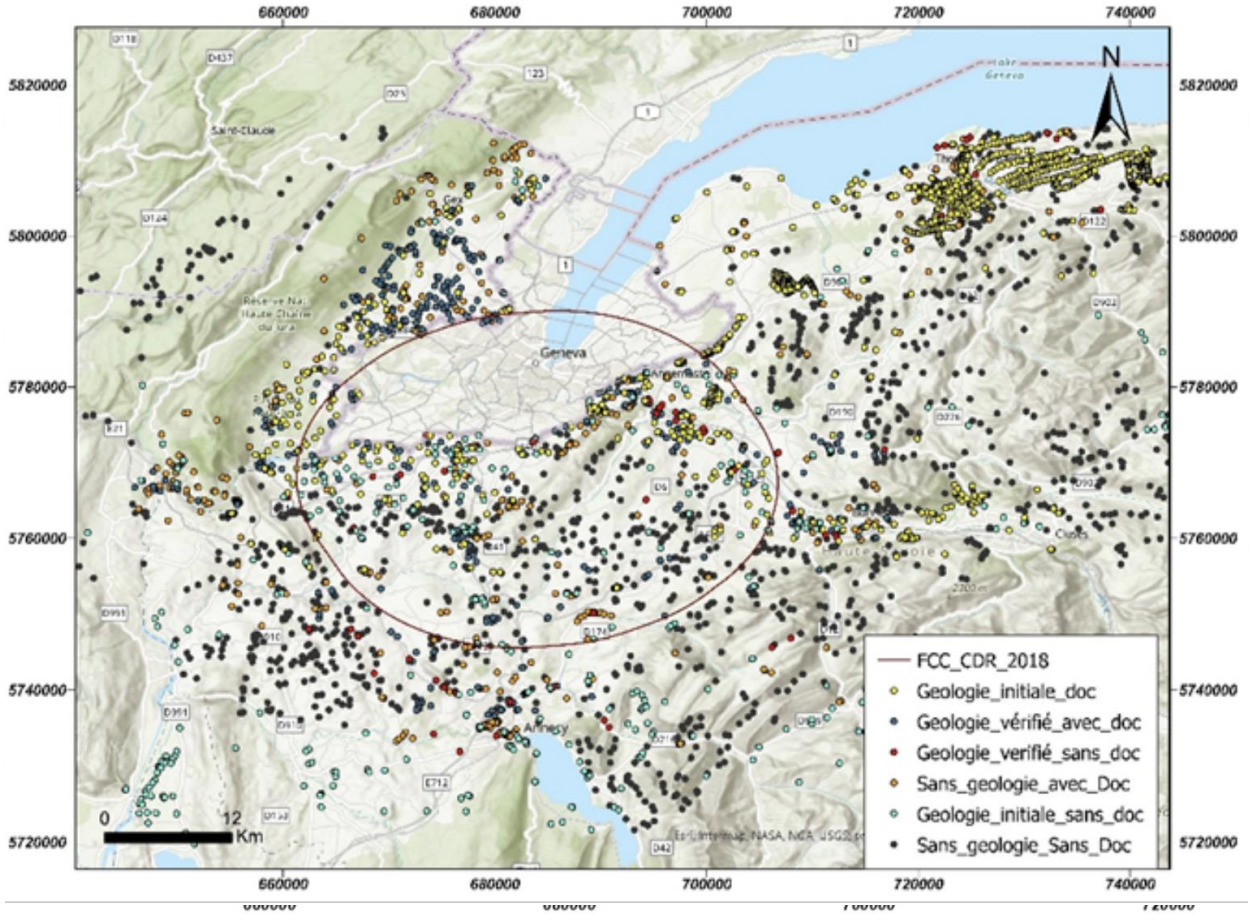
Source: BRGM

5078 boreholes , 1659 with documents

Boreholes data and classification

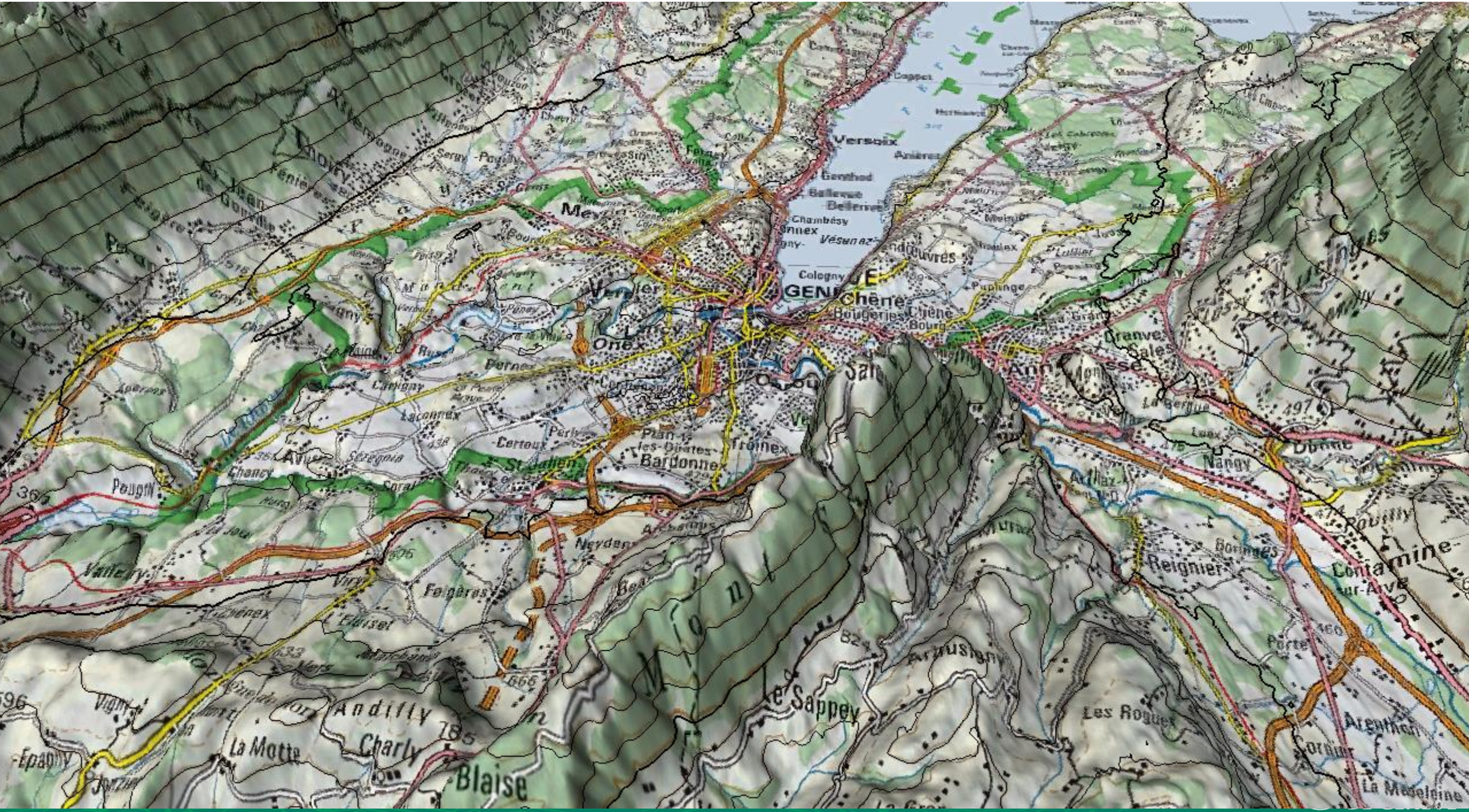


Source: SiTG (Canton of Geneva)



Source: BRGM

18’000 boreholes , 8969 public wells and 347 are >50m deep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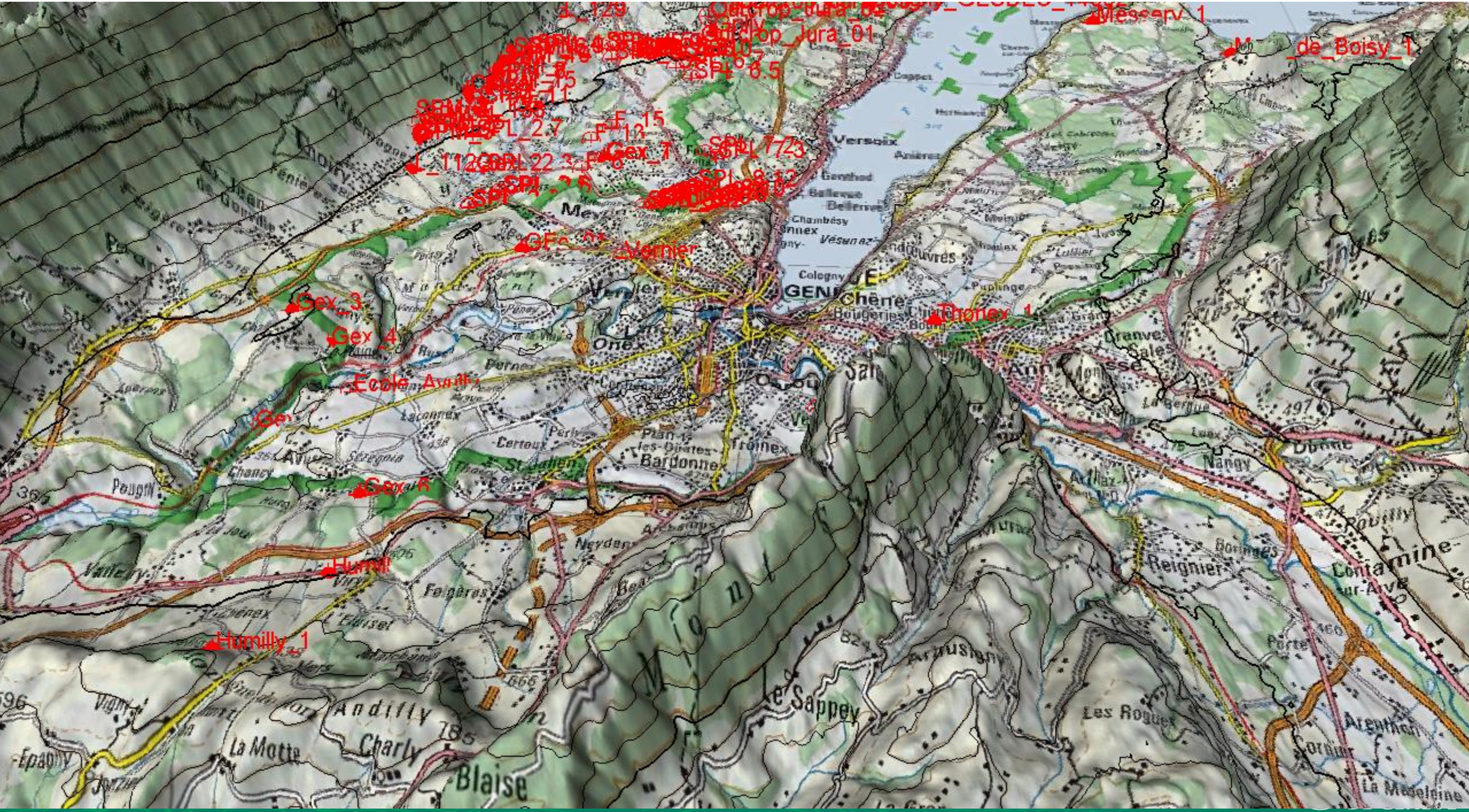
Bellevue
Bellerive
Chambésy
Vésenaz
Cologny
Onex
Bardonnex
Troinex
Plan-les-Ouates
Certoux
Laconnex
Carouge
Chêne-Bourg
Chêne-Bougeries
Puplinge
Cranves-Sales
Reignier
Nangy
Contamine-sur-Arve
Le Sappey
Les Roques
Andilly
Charly
La Motte
Blaise
Feigères
Neydens
Vulbens
Viry
Vallerry
Epagny
Vigny
Pougny
Chancy
Sézegnin
Coral
Laconnex
Perly
Carouge
Onex
Lancy
Vernier
Meyrin
Cointrin
Grand-Saconnex
Pregny
Bellevue
Genthod
Versoix
Anières
Corsier
Arenthon
La Madeleine
Porte
Boringes
Arthaz-Pont-Notre-Dame
Dingy-en-Vuache
Mont



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_de_Boisy_1
Gex_7
Gex_3
Gex_4
Ecole_Avril
Gex_R
Humilly_1
Thonex_1
Versoix
Chambésy
Vésenaz
Cologny
Chêne
Bougeries
Onex
Bardonnex
Troinex
Plan-les-Ouates
Certoux
St Julien
Laconnex
Pougny
Vallery
Feigères
Andilly
Charly
Blaise
La Motte
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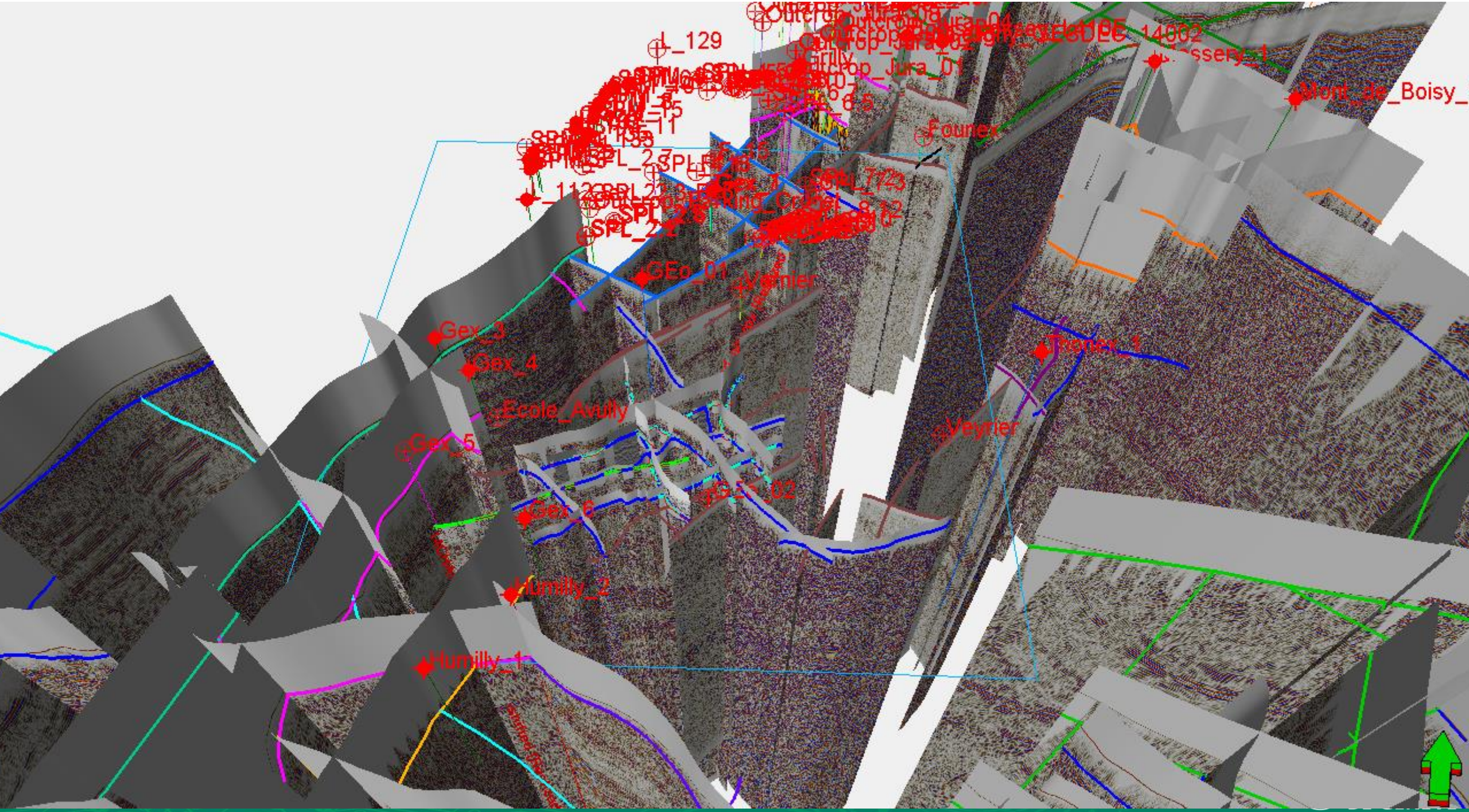
Cornier
La Madeleine
Arthusigny
Dranve
Sales
Lucinges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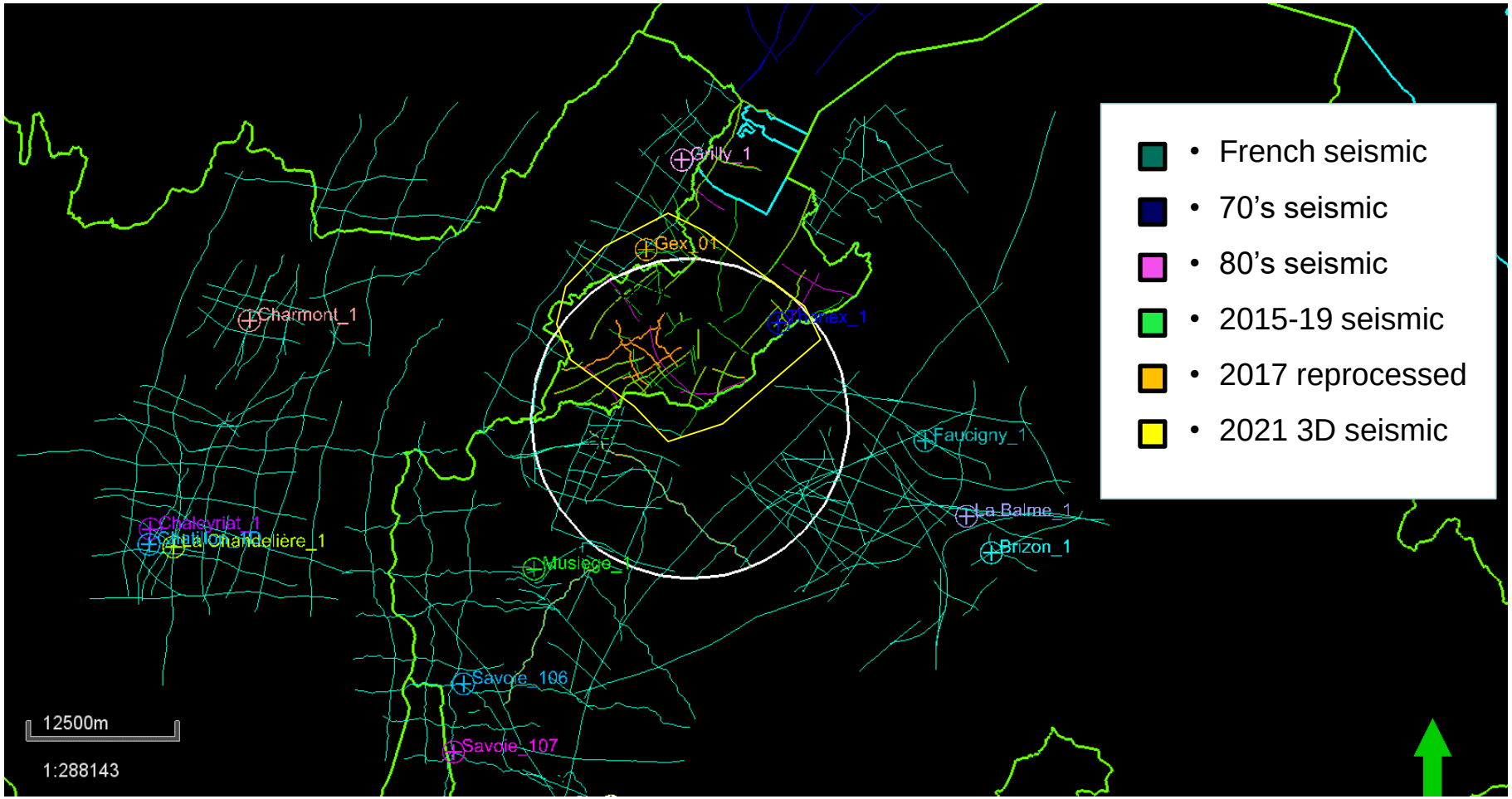
Outcrop_Jura_01
Fournex
Gex_1
GEo_01
Vernier
Gex_3
Gex_4
Ecole_Avully
Gex_5
Gex_6
Humilly_2
Humilly_1
Thonex_1
Veyrier
Mont_de_Boisy_

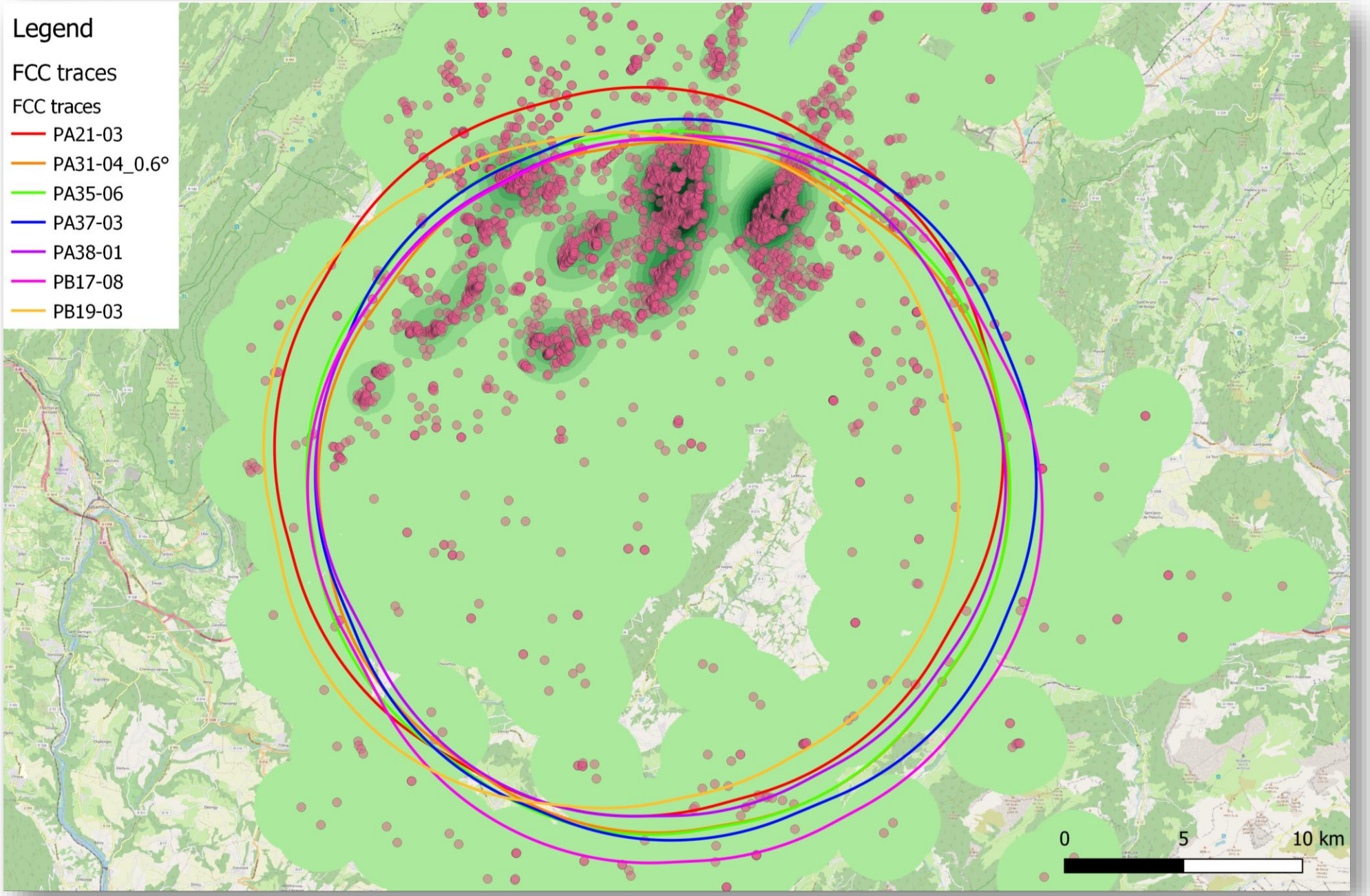
3D Geomodel dataset

- Deep boreholes with associated wireline data
- 2500 km of 2D seismic lines are available in the area – a large majority were not acquired and are not reprocessed for shallow depth interpretations



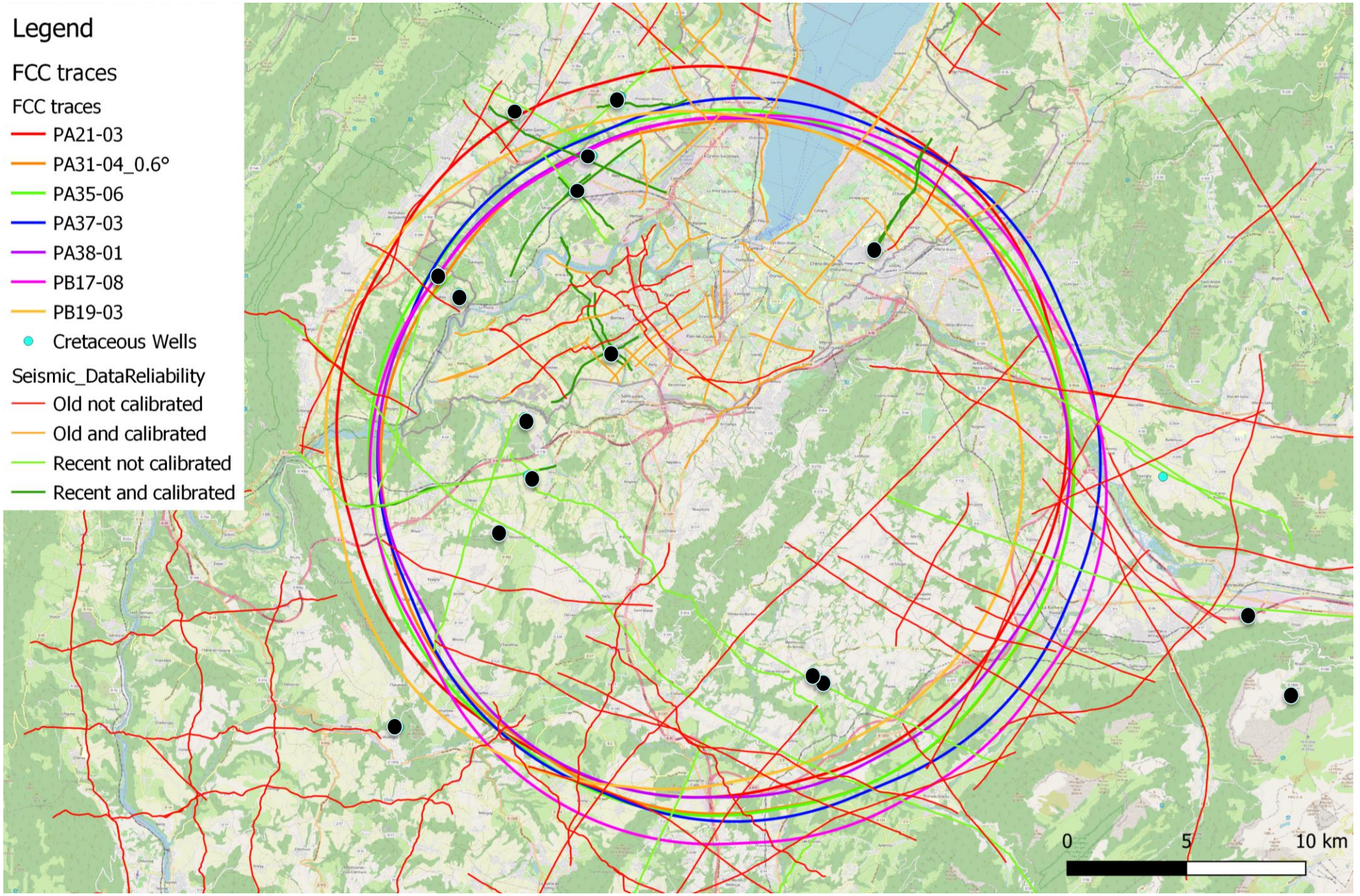
Data reliability along the FCC trace:

- Top **Molasse well** data points
- Strong well control in Geneva area compared to Bornes Plateau.



Data reliability along the FCC trace:

- Cretaceous **Limestones** data points
- 2D seismic data are key



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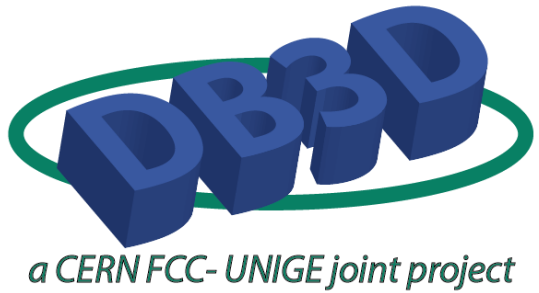
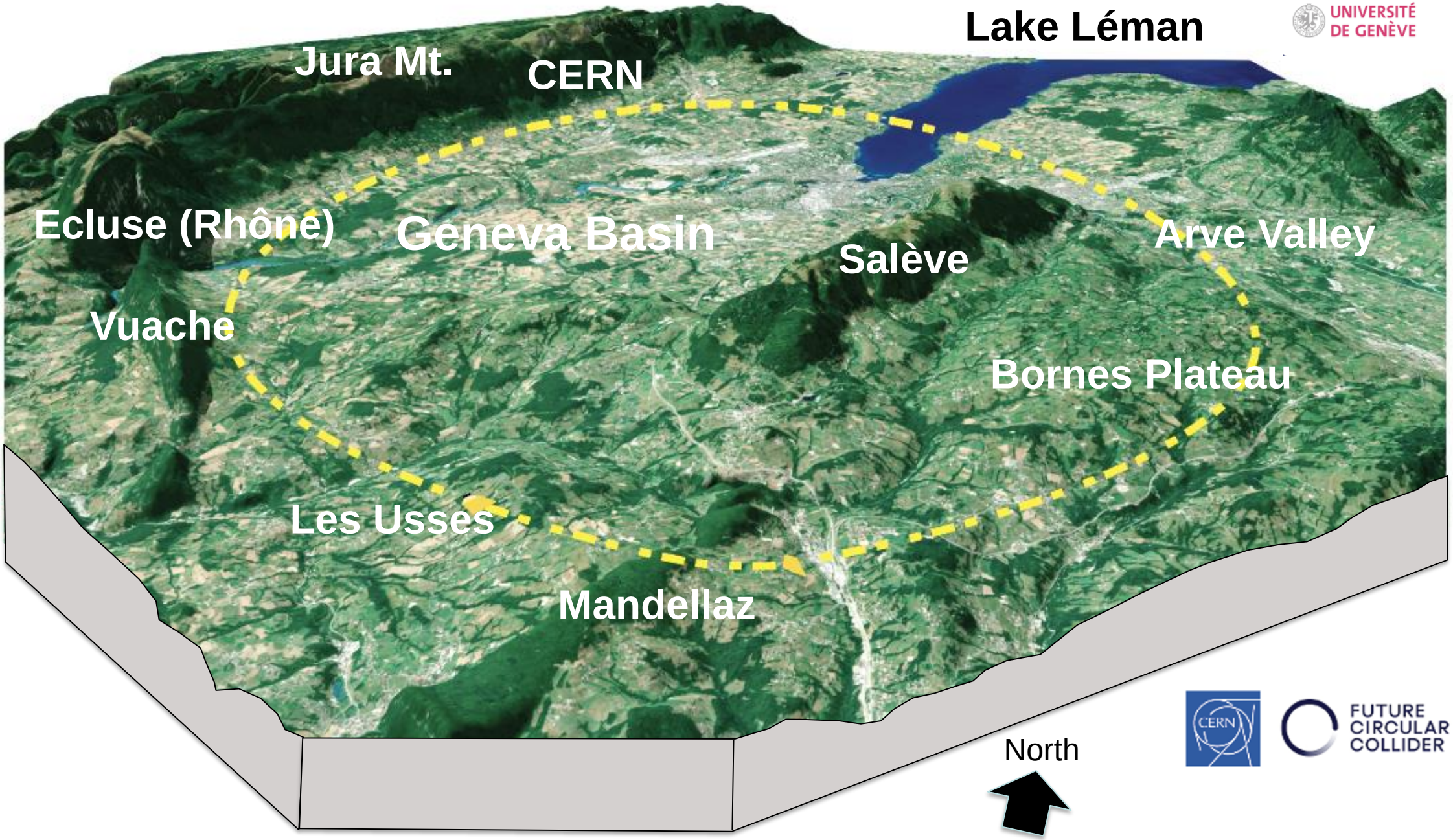
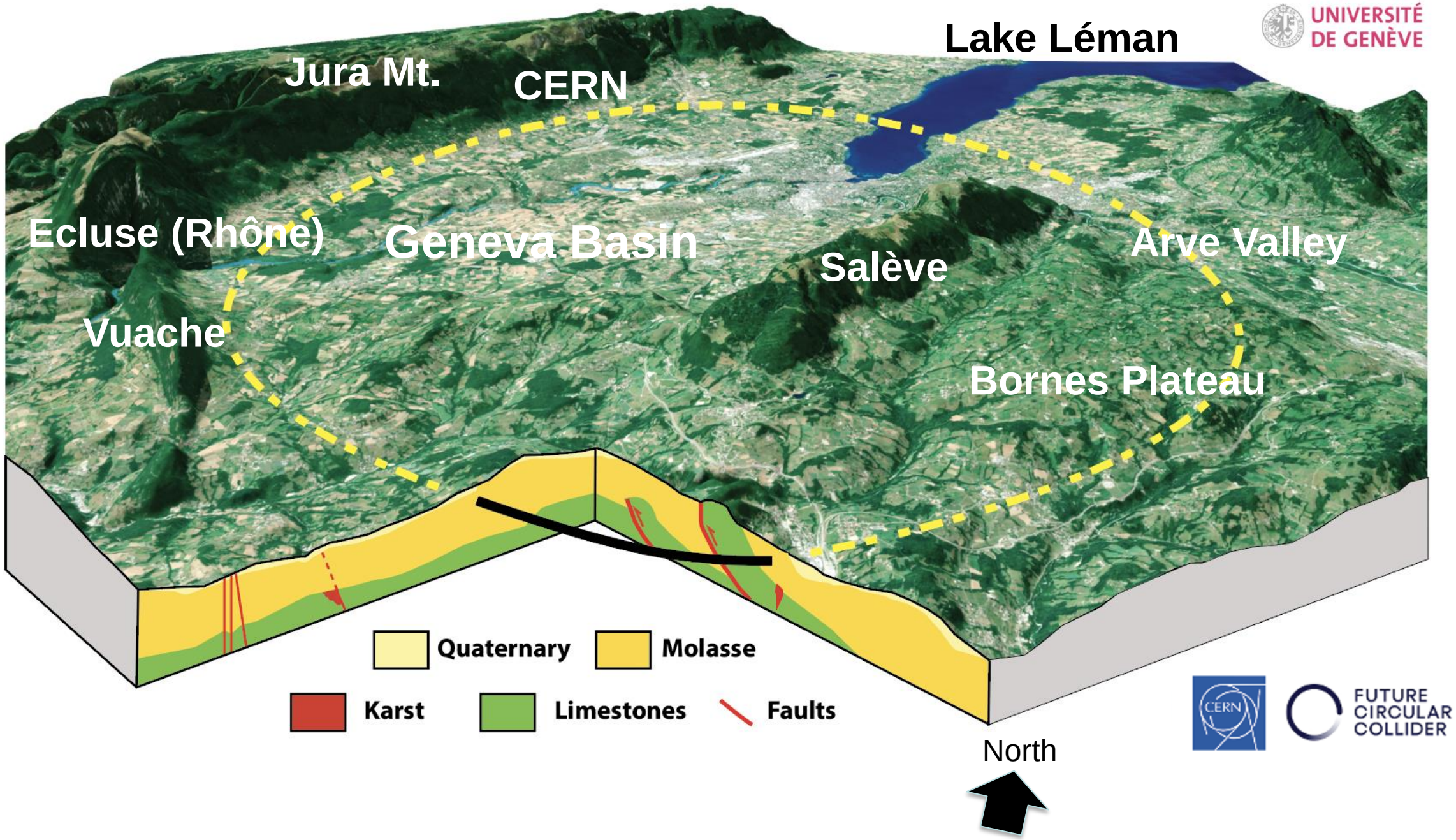
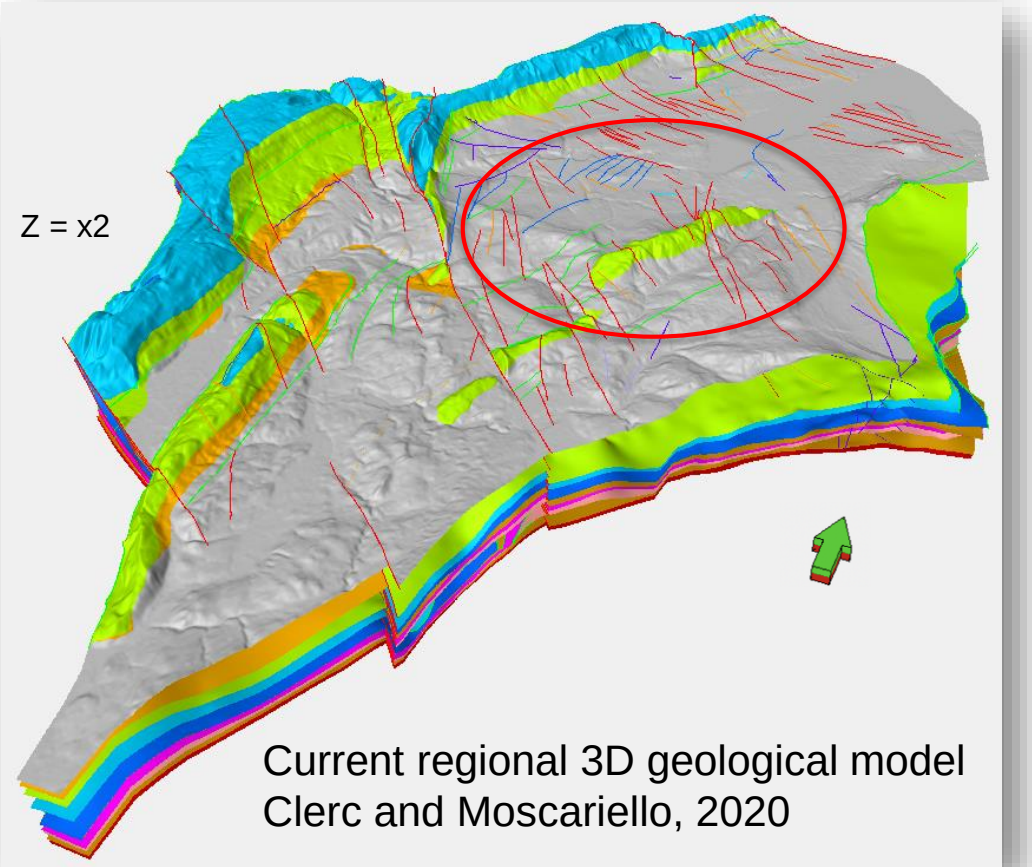
3D GEOLOGICAL MODEL



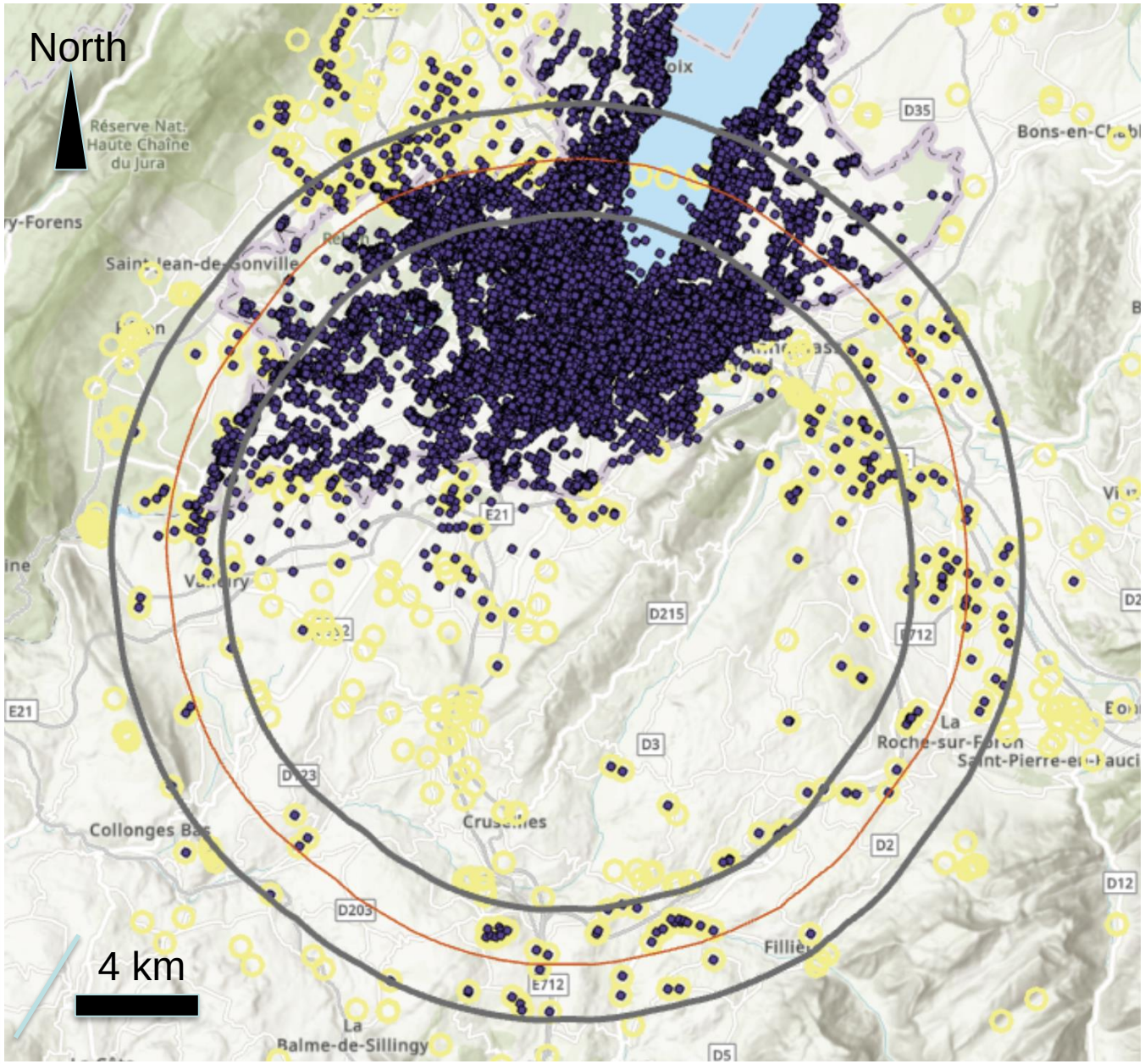

Lake Léman
Jura Mt.
CERN
Ecluse (Rhône)
Geneva Basin
Salève
Arve Valley
Vuache
Bornes Plateau
Les Usses
Mandellaz
North


Lake Léman
Jura Mt.
CERN
Ecluse (Rhône)
Geneva Basin
Salève
Arve Valley
Vuache
Bornes Plateau
Quaternary
Molasse
Karst
Limestones
Faults
North

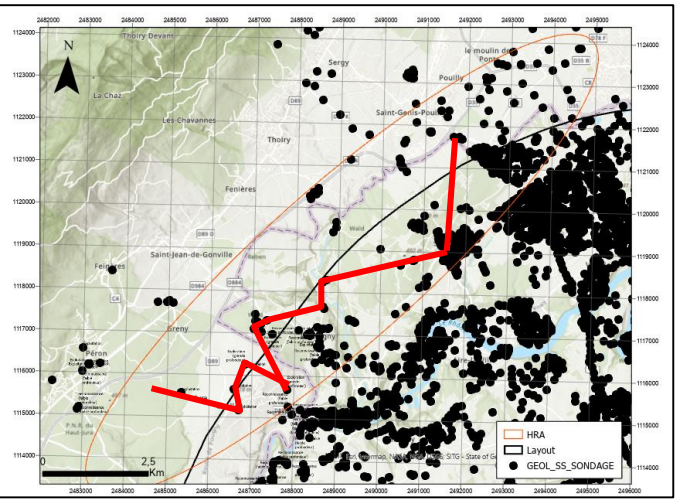
3D Modelling: Focus on a 4 km wide belt along the FCC trace



Current regional 3D geological model
Clerc and Moscariello, 2020



JURA area


N
HRA
Layout
GEOL_SS_SONDAGE
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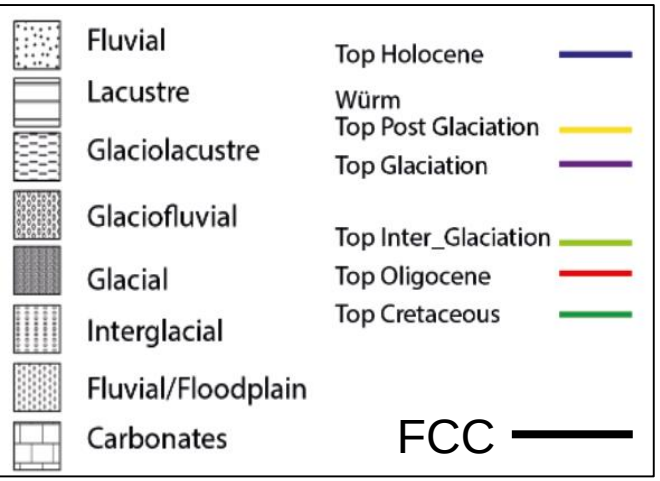
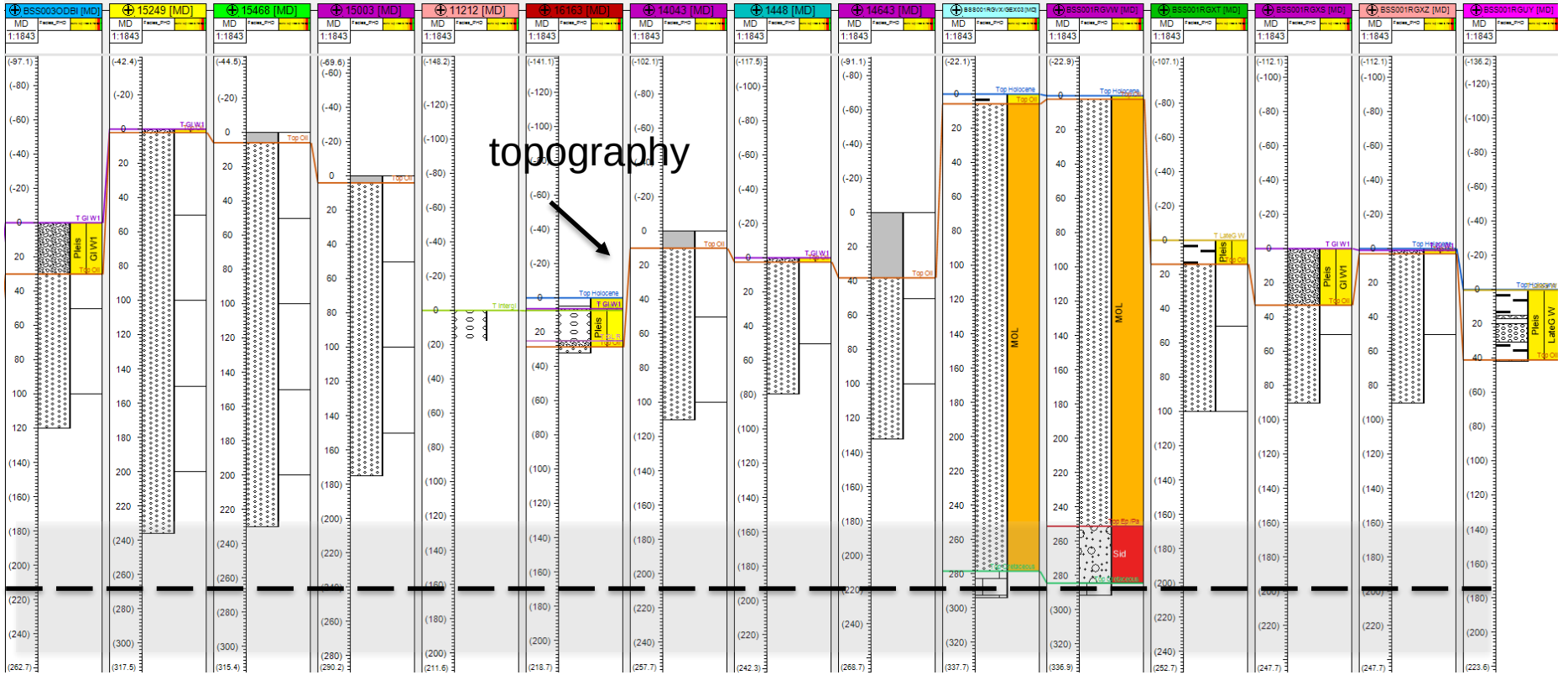
2,5
Km


Fluvial
Lacustre
Glaciolacustre
Glaciofluvial
Glacial
Interglacial
Fluvial/Floodplain
Carbonates
Top Holocene
Würm
Top Post Glaciation
Top Glaciation
Top Inter_Glaciation
Top Oligocene
Top Cretaceous
FCC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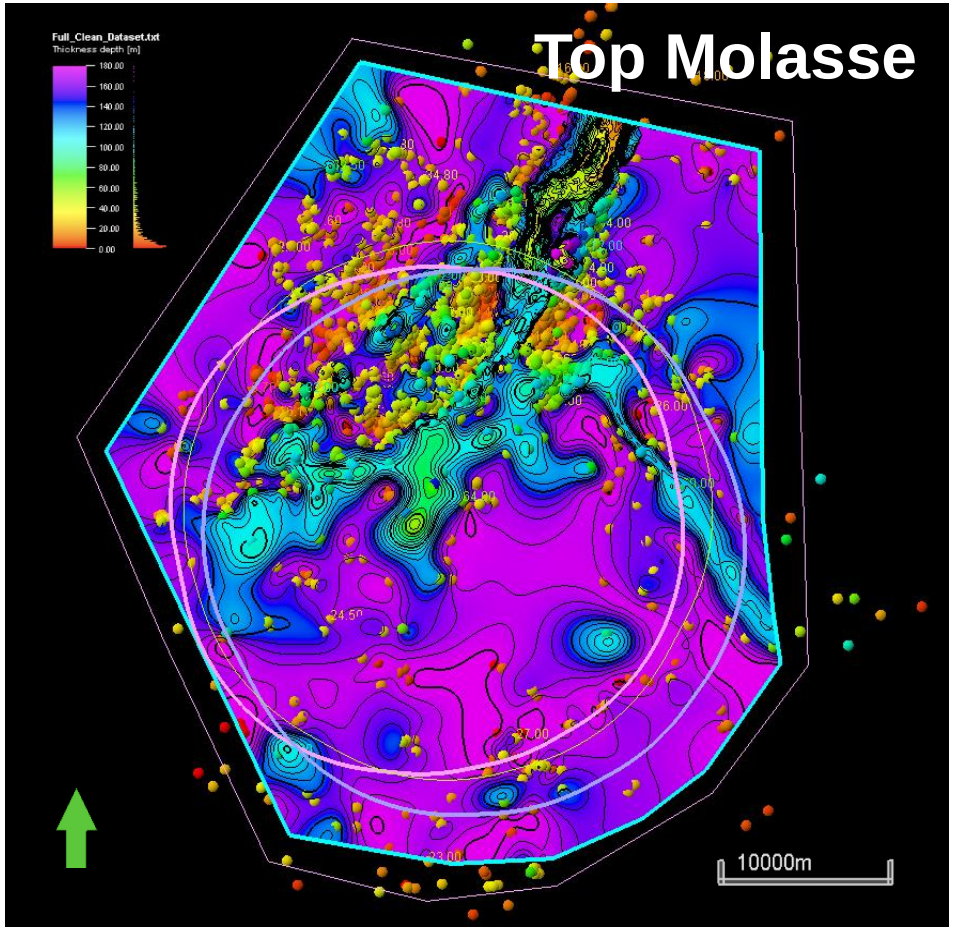
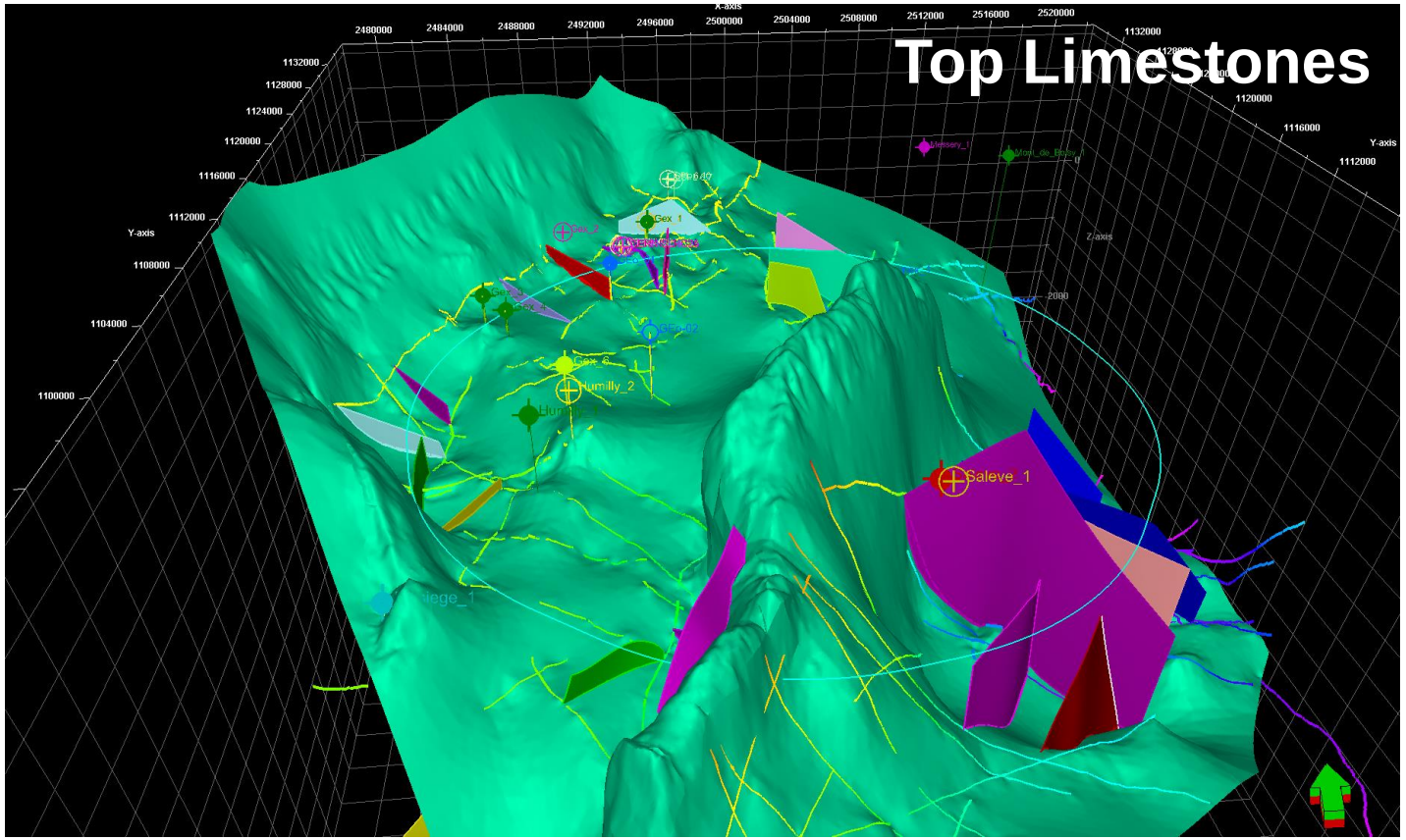
Top Holocene
Top Oligocene
MOL
Sid
Pleis
GI W1

2 Key surfaces in the 3D geological model

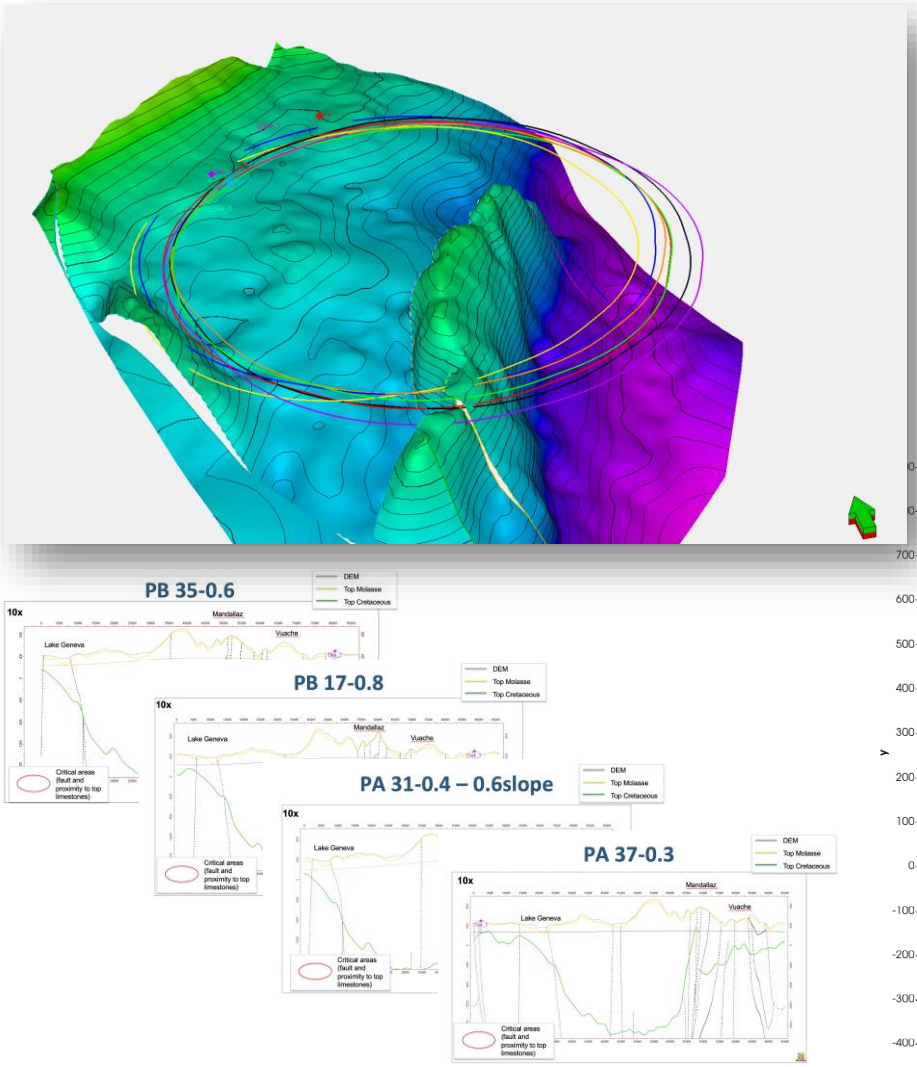


Mostly based on boreholes interpolation. High uncertainties when based on seismic only.



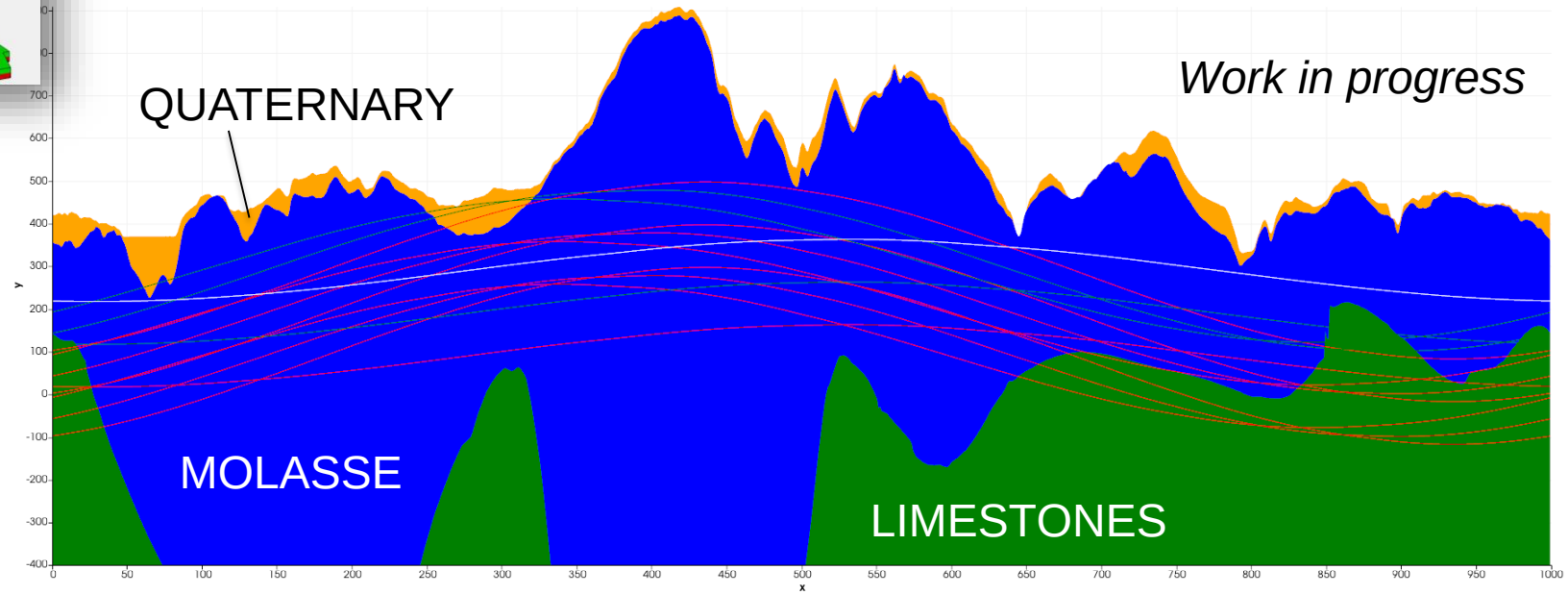
Interpolated and depth-converted top limestones (Cretaceous) layer. Mostly based on 2D seismic due to few borehole penetrations.

FCC trajectory sensitivity tests

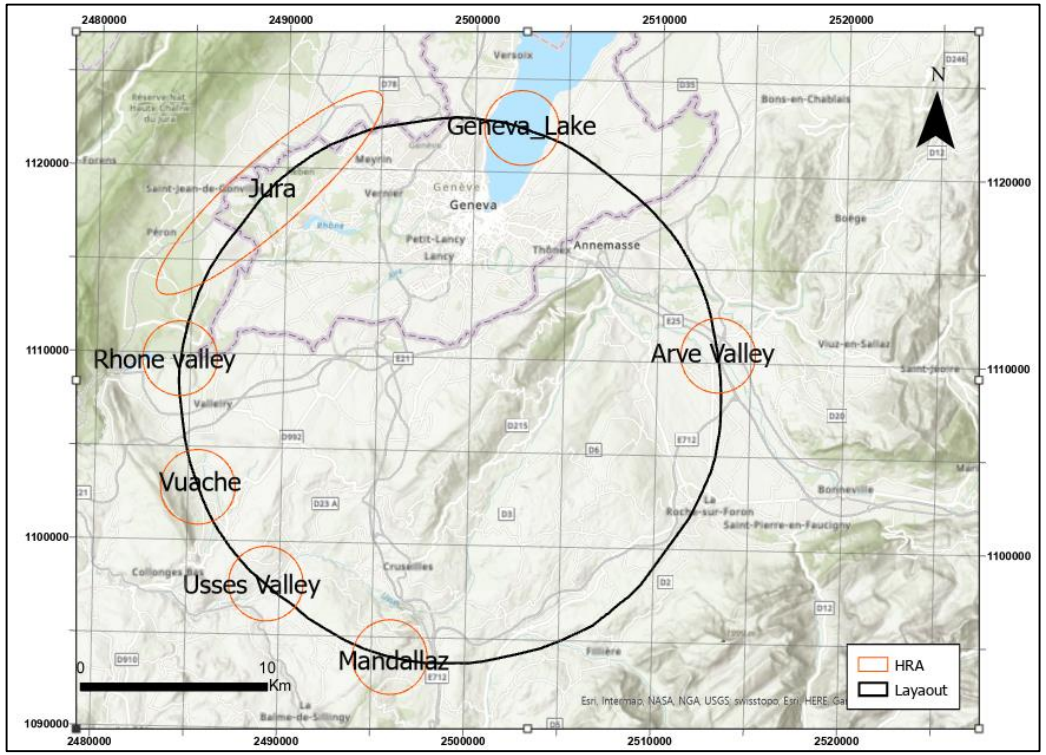


7 different trajectories have been evaluated and geological uncertainties/*risks* identified and assessed.

This led to the selection of a trajectory (31.10):
Azimuth, inclination and rotation of the FCC ring is tested and geological parameters extracted (depth from surface, thickness Quaternary, Molasse, depth Limestones, etc).



FUTURE CIRCULAR COLLIDER



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AREAS OF HIGH GEOLOGICAL UNCERTAINITIES

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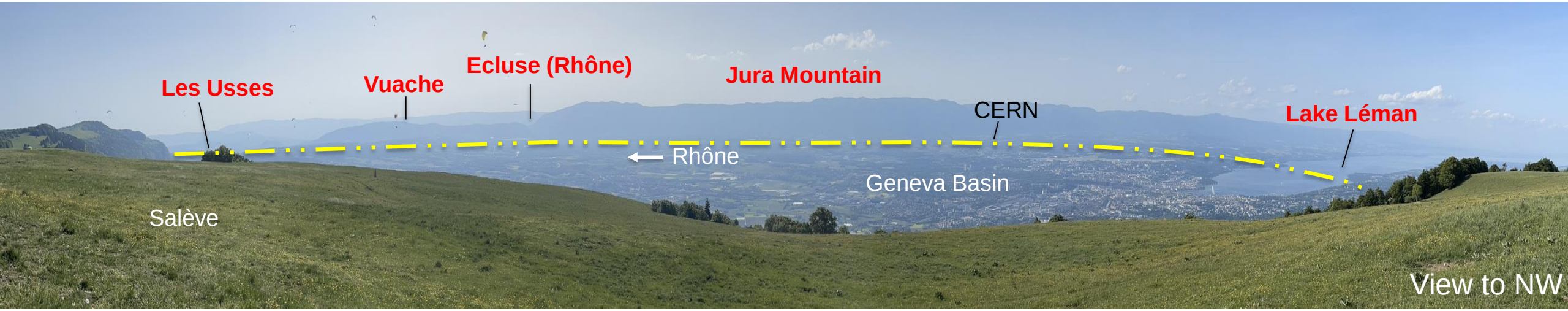
FCC TRAJECTORY in the orographic context



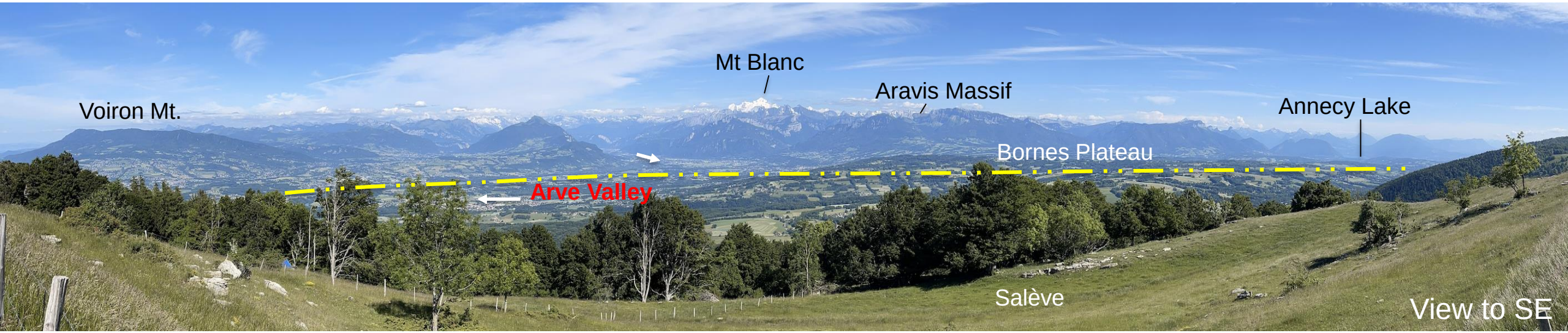
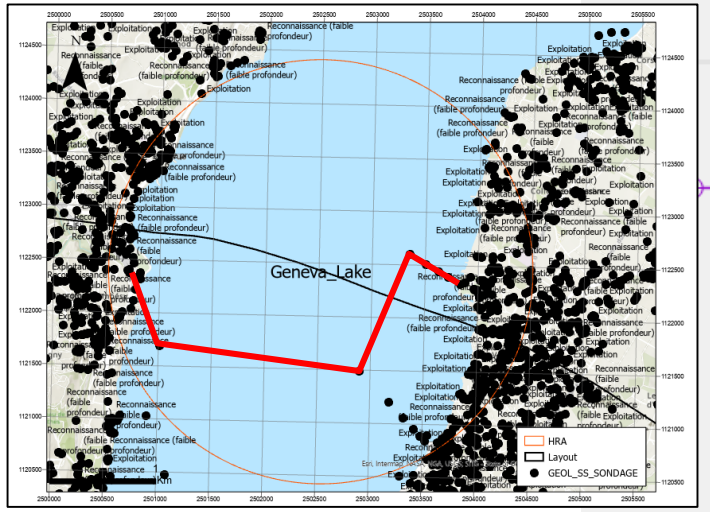
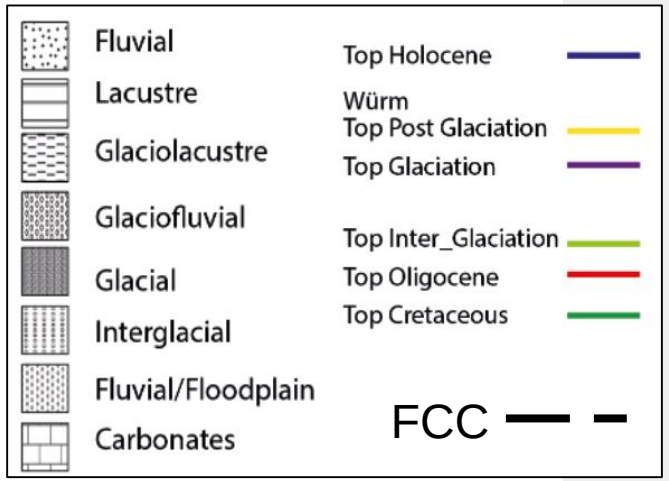


Photo A. Moscariello

GENEVA LAKE


Geneva_Lake
HRA
Layout
GEOL_SS_SONDAGE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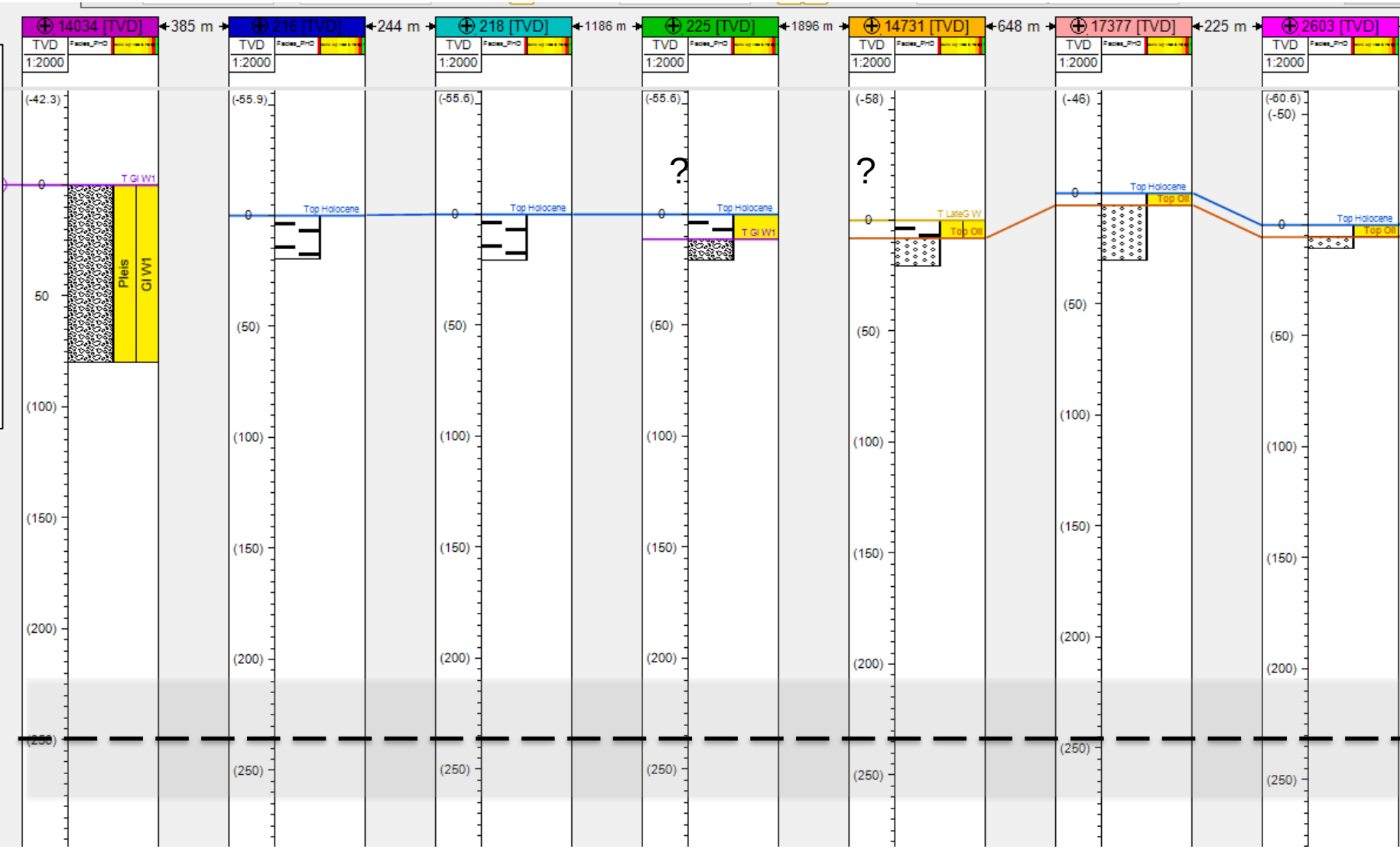
Lacustre
Glaciolacustre
Glaciofluvial
Glacial
Interglacial
Fluvial/Floodplain
Carbonates
Top Holocene
Würm
Top Post Glaciation
Top Glaciation
Top Inter_Glaciation
Top Oligocene
Top Cretaceous
FCC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225 m
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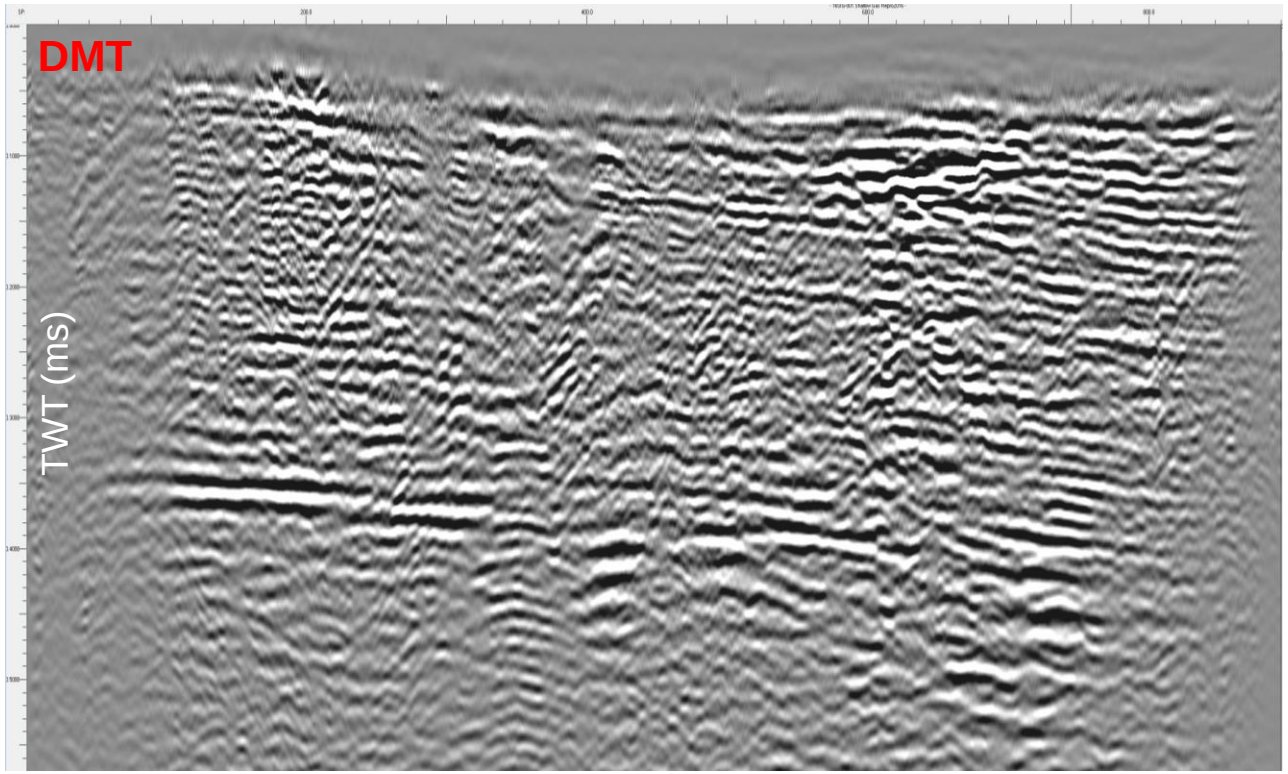
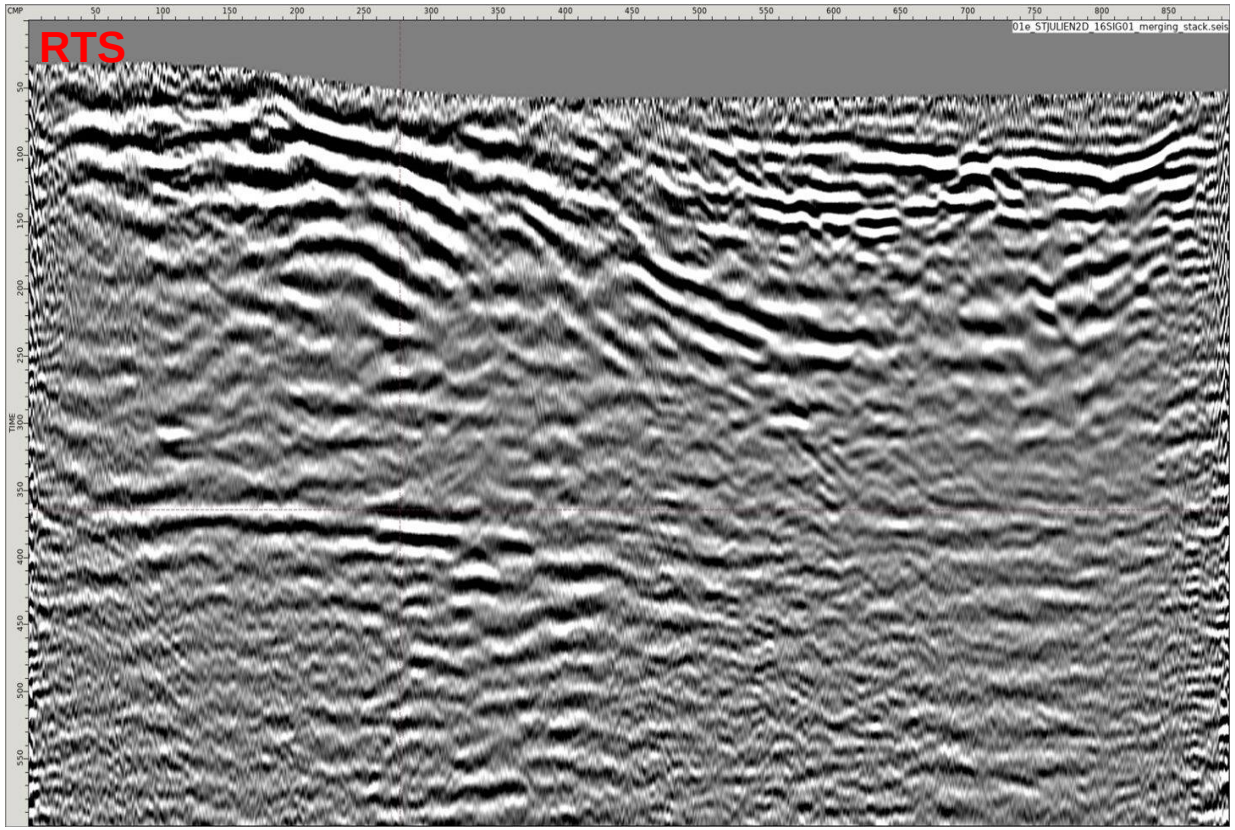
TVD
1:2000
T Gl W1
Pleis
Gl W1
Top Holocene
T LateG W
Top Oli
?

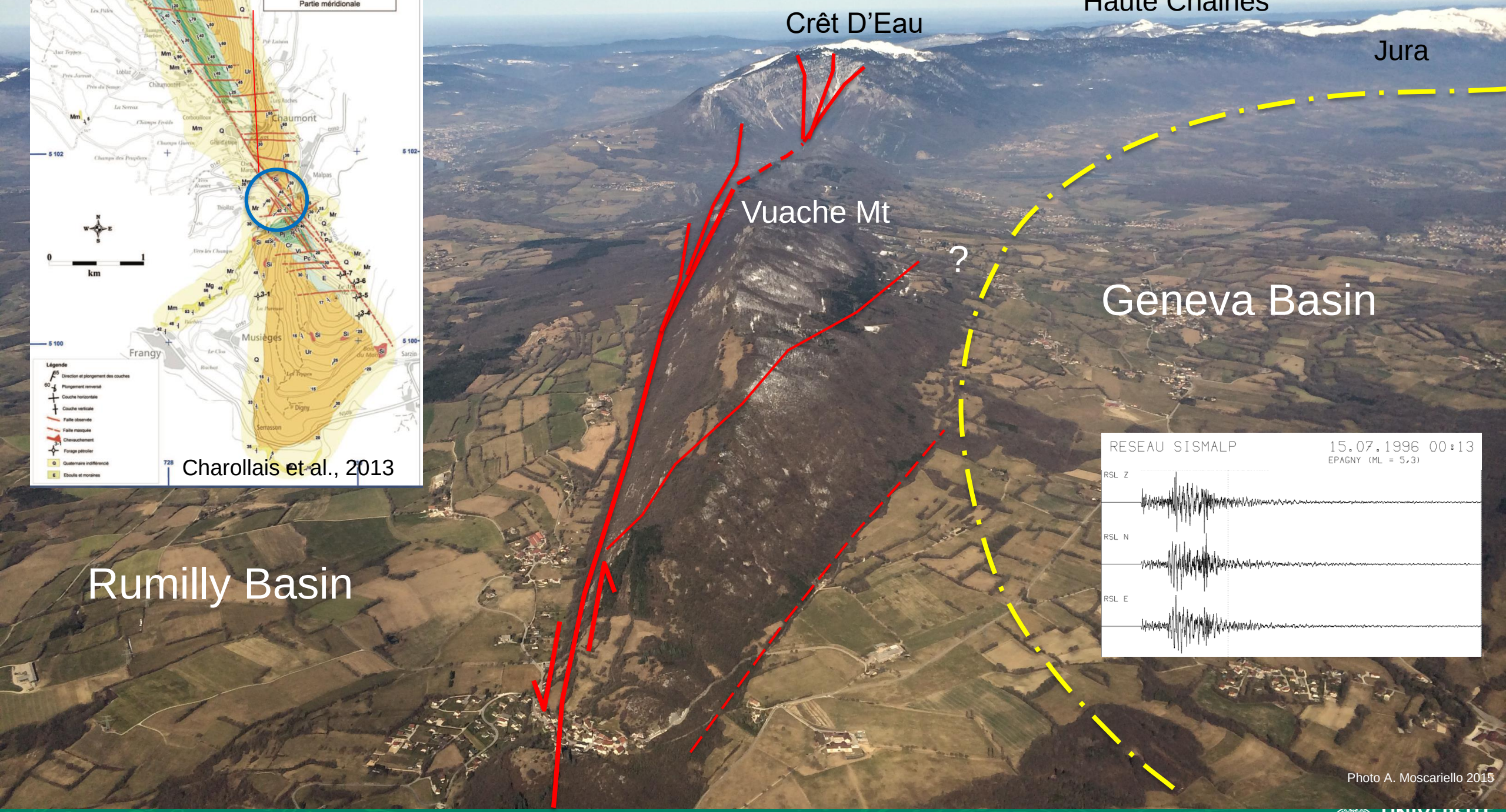
Geological Uncertainties vs DATA QUALITY :

Example of different seismic processing resulting in very different reflector architecture and hence geological interpretation.



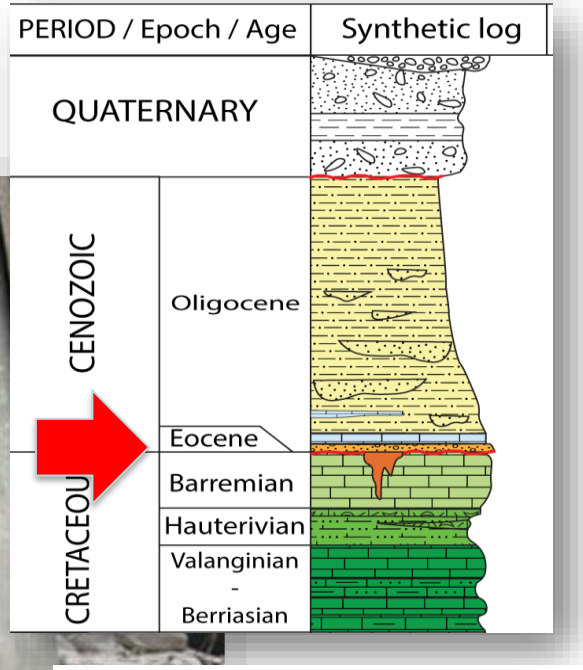


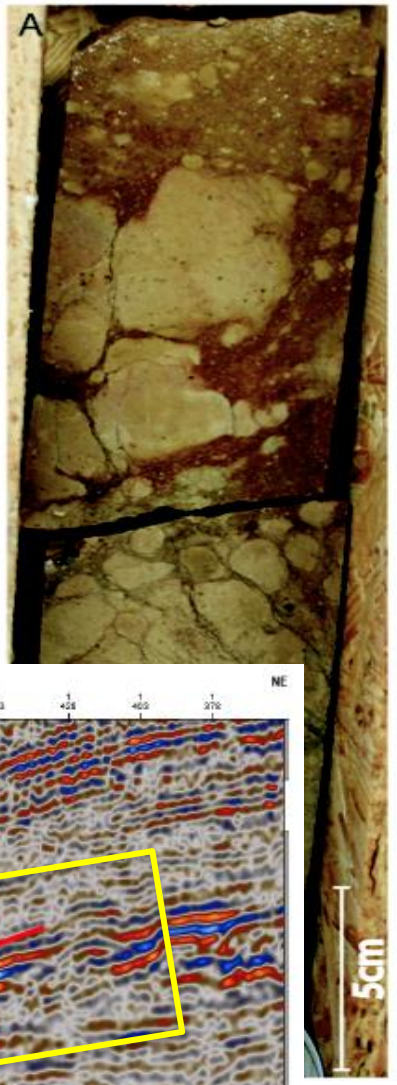
Courtesy of GER SA

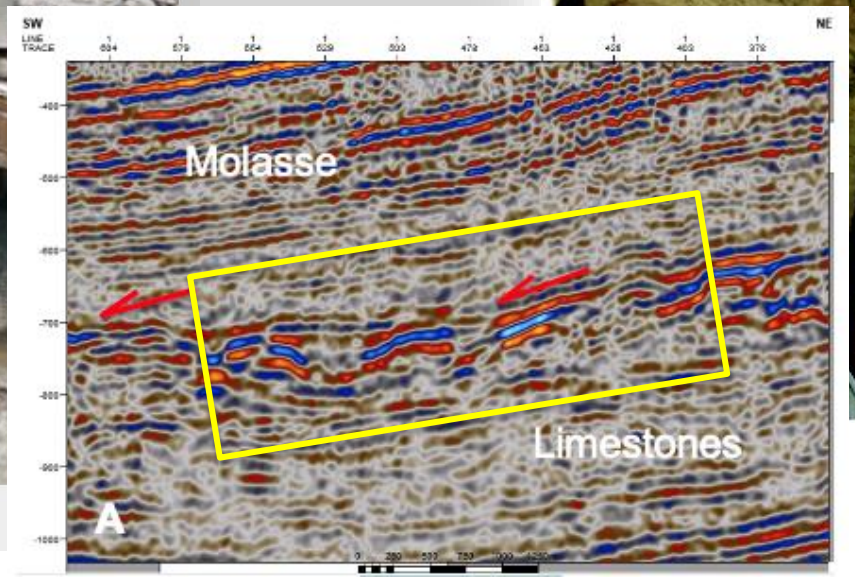

Crêt D'Eau
Haute Chaînes
Jura
Vuache Mt
?
Geneva Basin
Rumilly Basin
Partie méridionale
Chaumont
Malpas
Musièges
Frangy
Légende
Charollais et al., 2013
RESEAU SISMALP
15.07.1996 00:13
EPAGNY (ML = 5,3)
RSL Z
RSL N
RSL E
Photo A. Moscariello 2015

KARST: Something to avoid

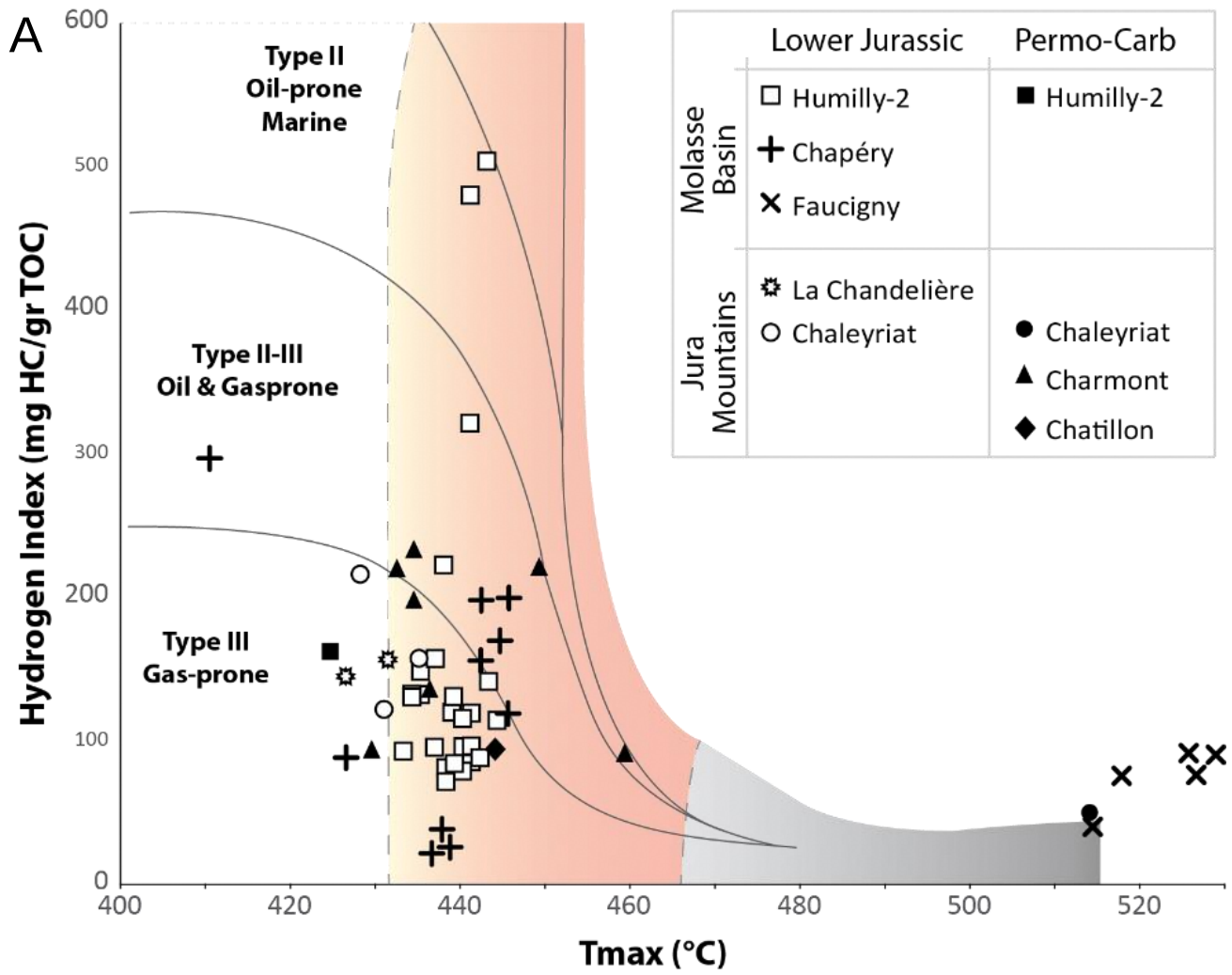
Water inrush through the end wall of the Pasar Rakyat station box from a network of karst features







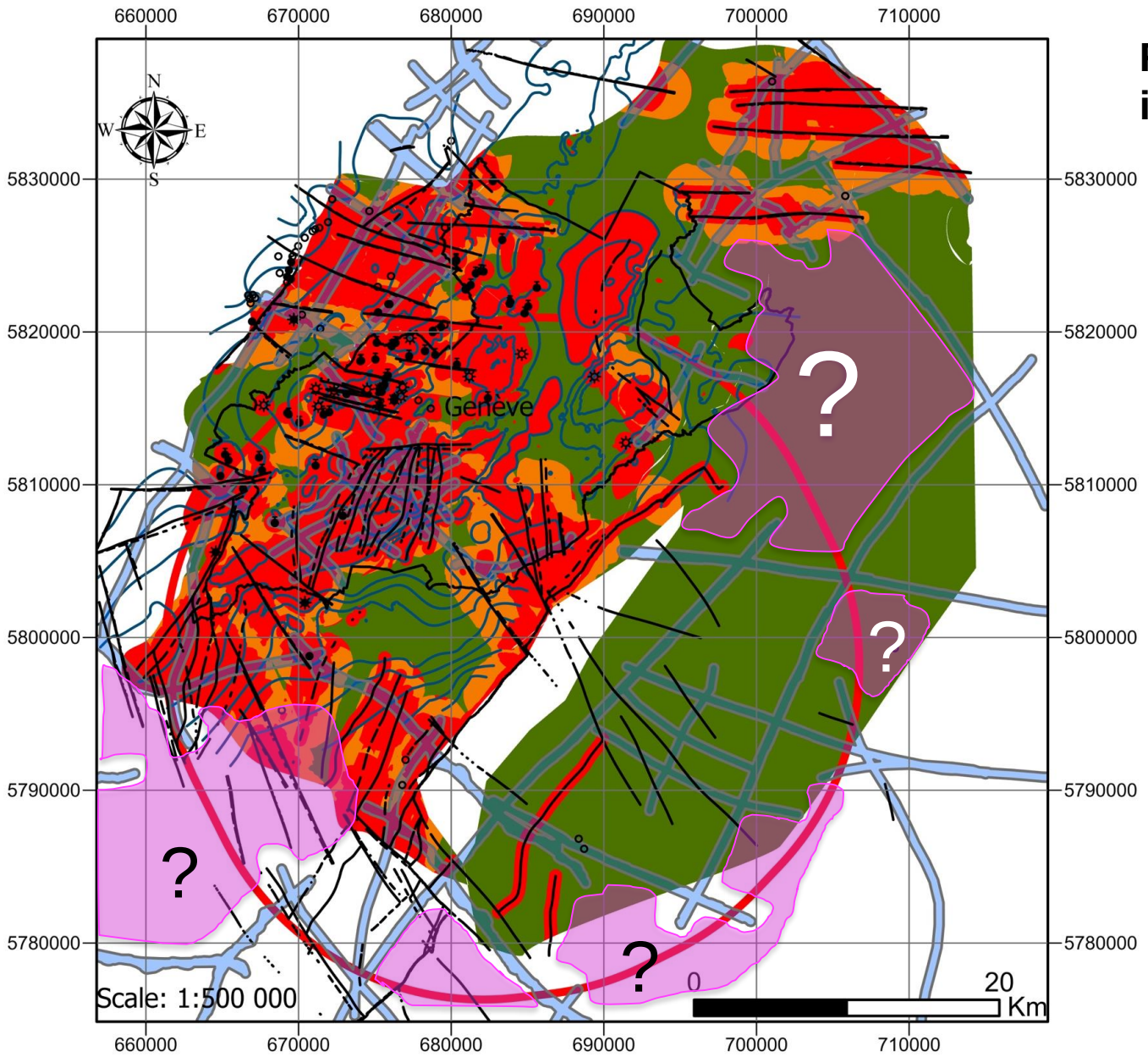
Uncertainty & Risk of HC occurrence



Moscariello, 2019

HC Risk Map

based on multiple combination of relevant "data layers"



Risk of HC Occurrence in the Molasse

- Genève_Canton

Wells_GGB

HC

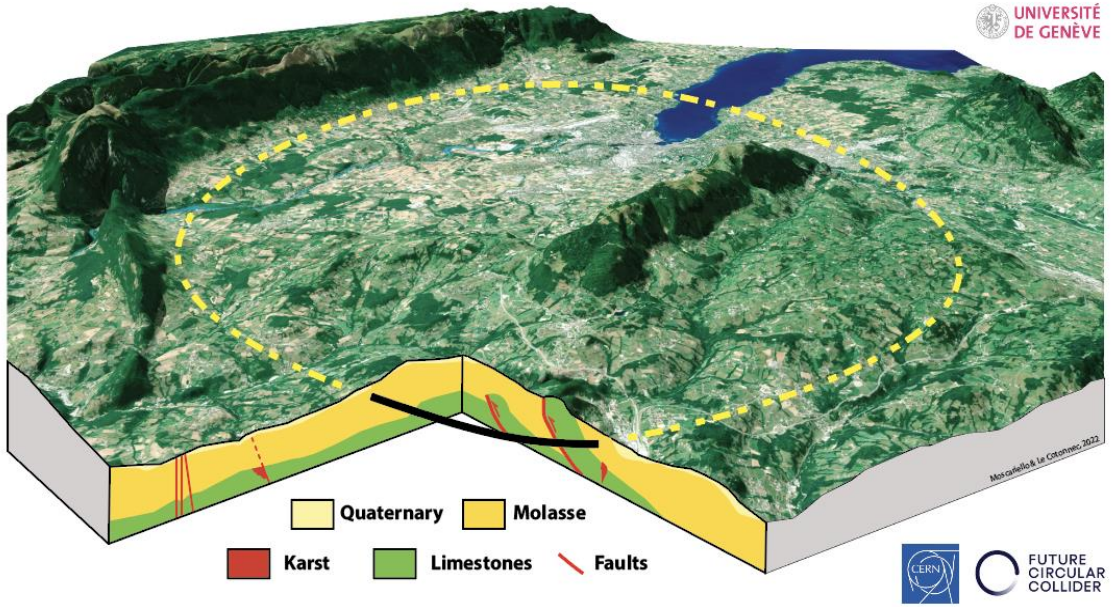
- Bitume
- Gas
- No_trace
- oil
- oil and Gaz
- Faults_Molasse
- Seismic lines
- Contour_Molasse_50m
- FCC_CDR

CCRS_GEo

- High risk
- Medium risk
- Low risk
- area with no data

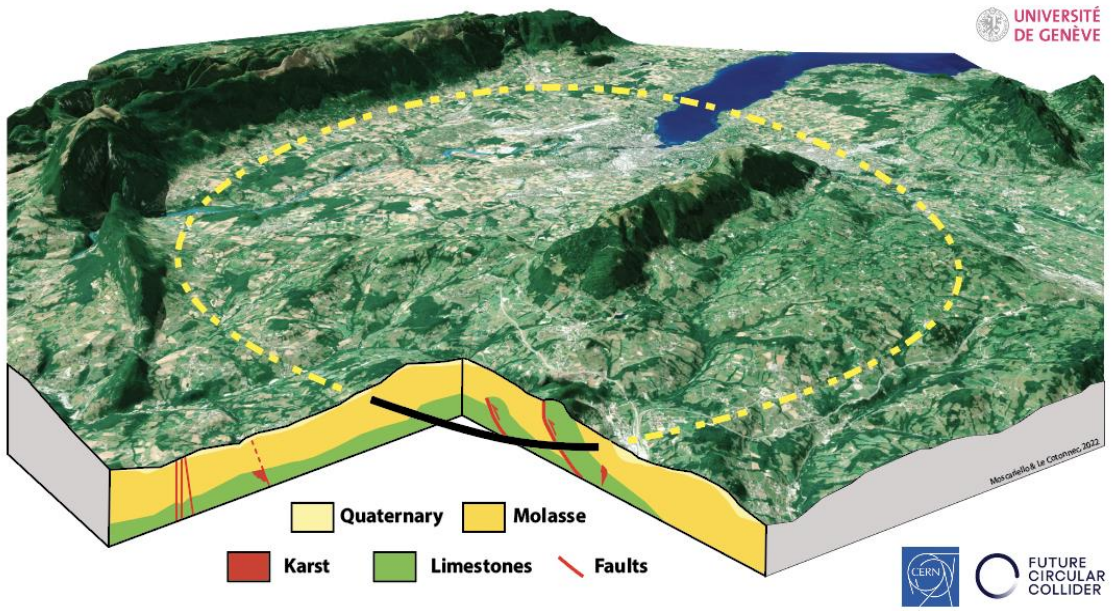
Conclusions

- The FCC data base has been completed and will serve as the basis for future engineering planning work
- 3D geological model to date provides a **solid knowledge framework** based on all available data known to date, highlighting the different lithological and structural heterogeneities crossed by the planned trace of the FCC tunnel.
- The model allows the **visualisation of the subsurface conditions** known to date in the areas of high geological uncertainty identified **enabling to take informed decisions during the forthcoming geotechnical and seismic investigation campaign** which will take place across the French and Swiss border.



Perspectives

- FCC subsurface data base will be managed by UNIGE and updated with new information acquired over the years to come
- Following this investigation campaign, the geological 3D model will be updated with the new acquired data and will therefore provide more accurate view of the subsurface.
- This 3D model represents therefore a practical working tool which will support the FCC projec throughout the different phases of tunnelling design, planning and execution.



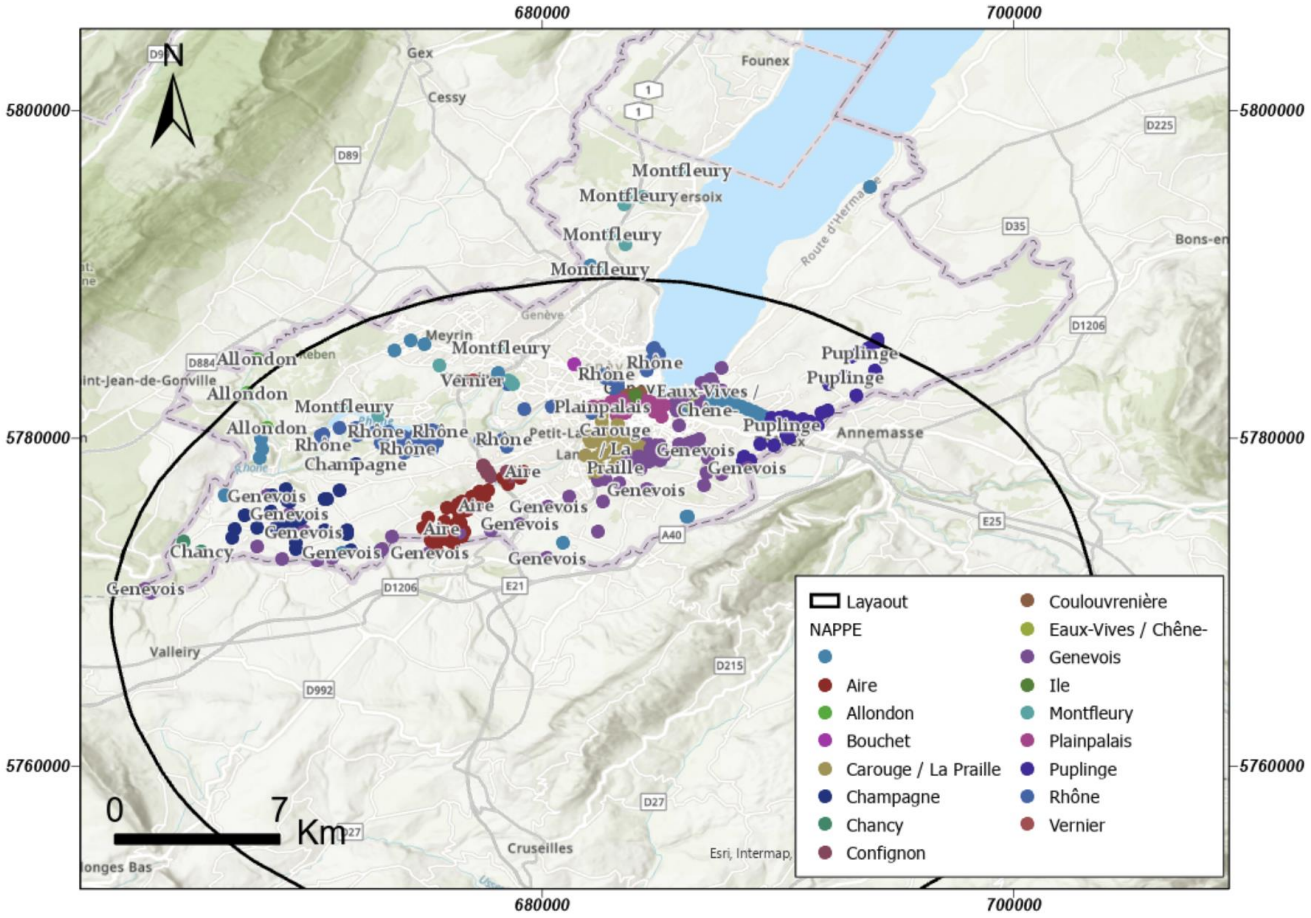
- **Thank you for your attention and financial support !**

Swiss Accelerator Research and Technology

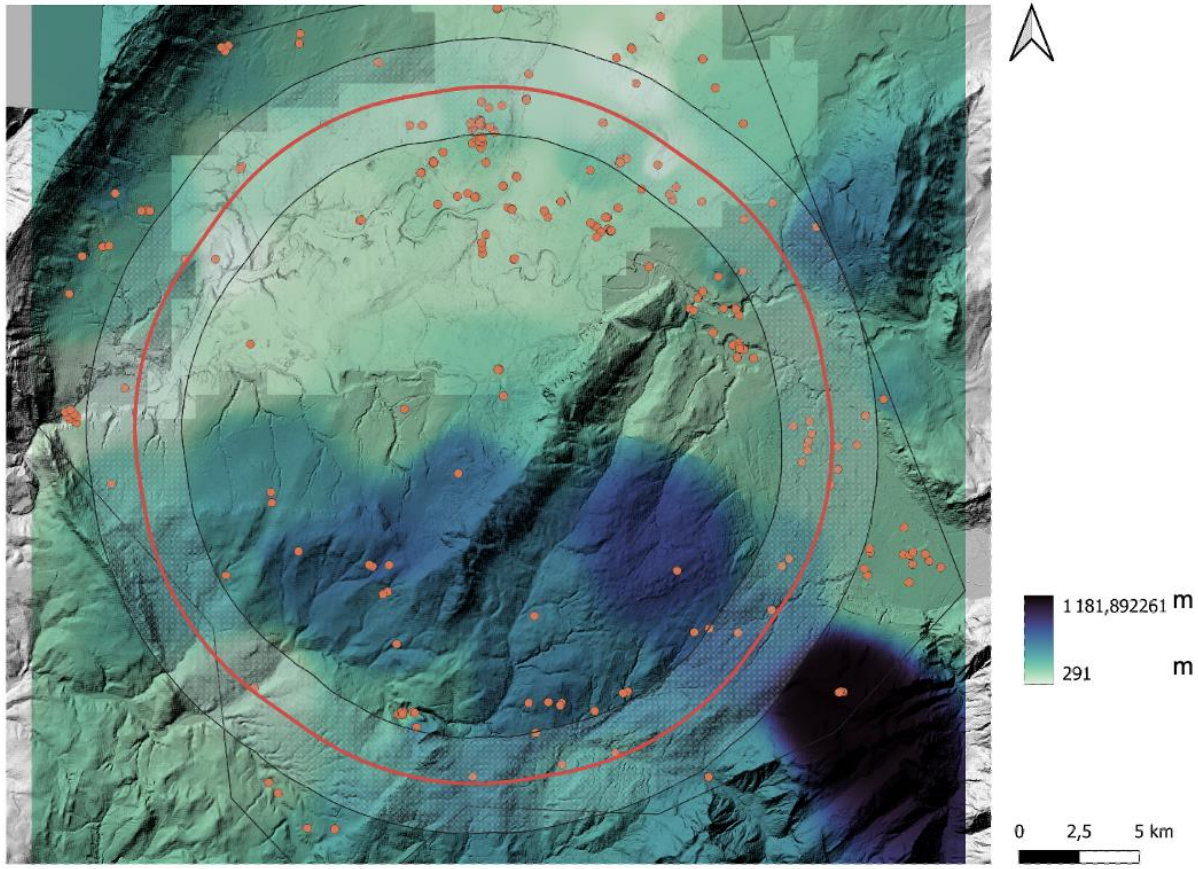
Thank you for your attention.

BACK UP

Hydrogeology



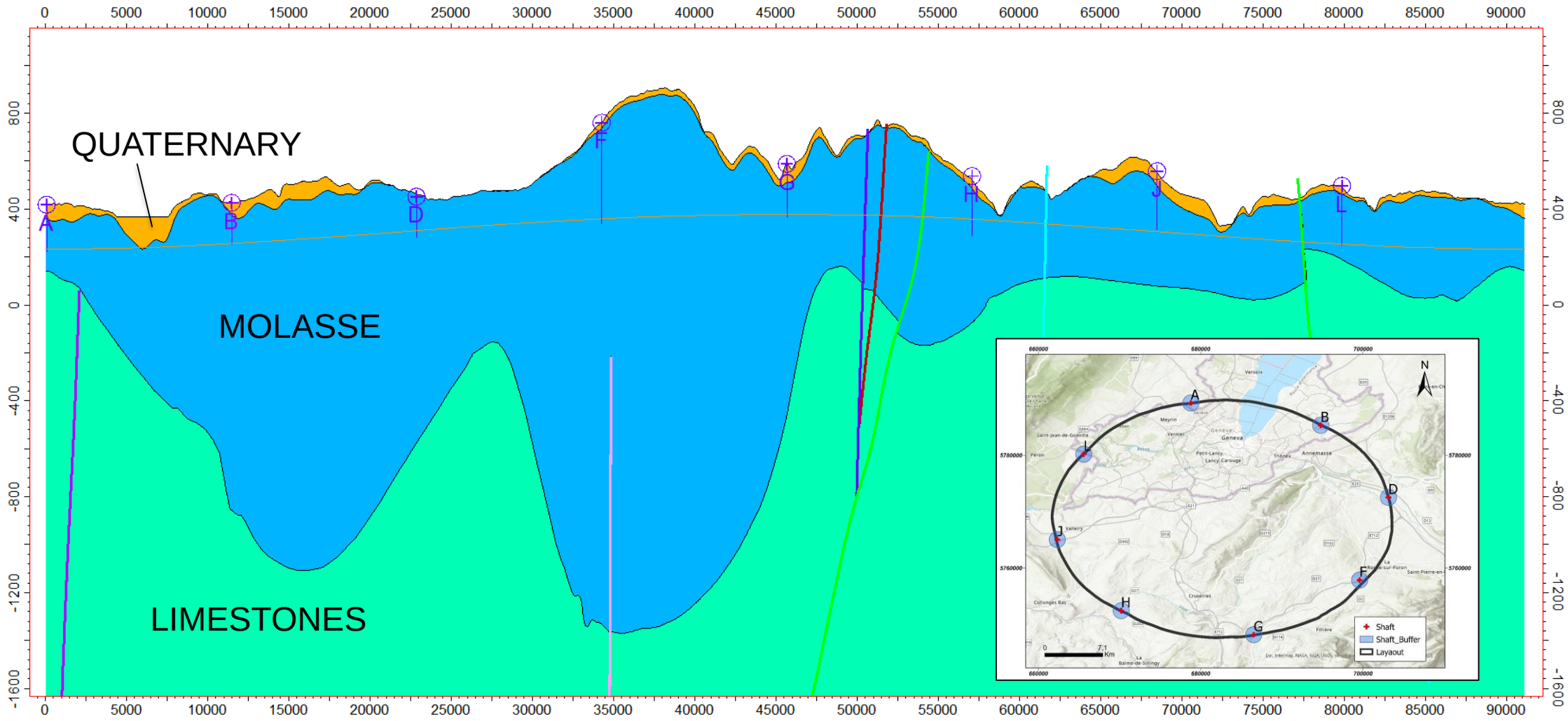
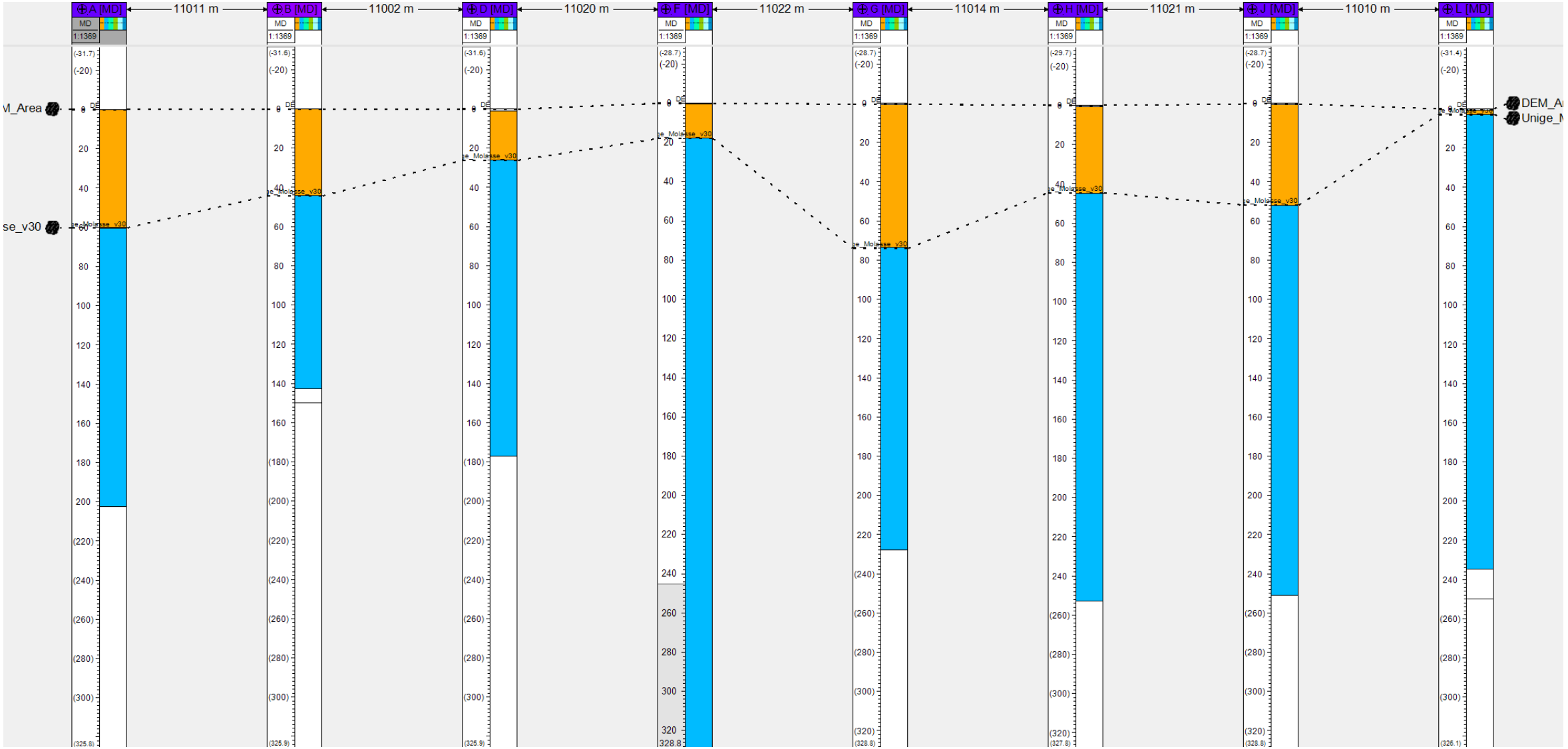
Source: SiTG (Canton of Geneva)



French dataset water table depth interpolated

Source: BRGM

Geological cross section along the FCC



Expected Stratigraphy at Shaft location