UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES
Earth and Environmental Sciences

CERN

Geology of the Geneva Basin in the context of the FCC project

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17.10.2024

GE-RGBA
GEOENERGY
RESERVOIR GEOLOGY
AND BASIN ANALYSIS GROUP

FUTURE
CIRCULAR
COLLIDER

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Introduction

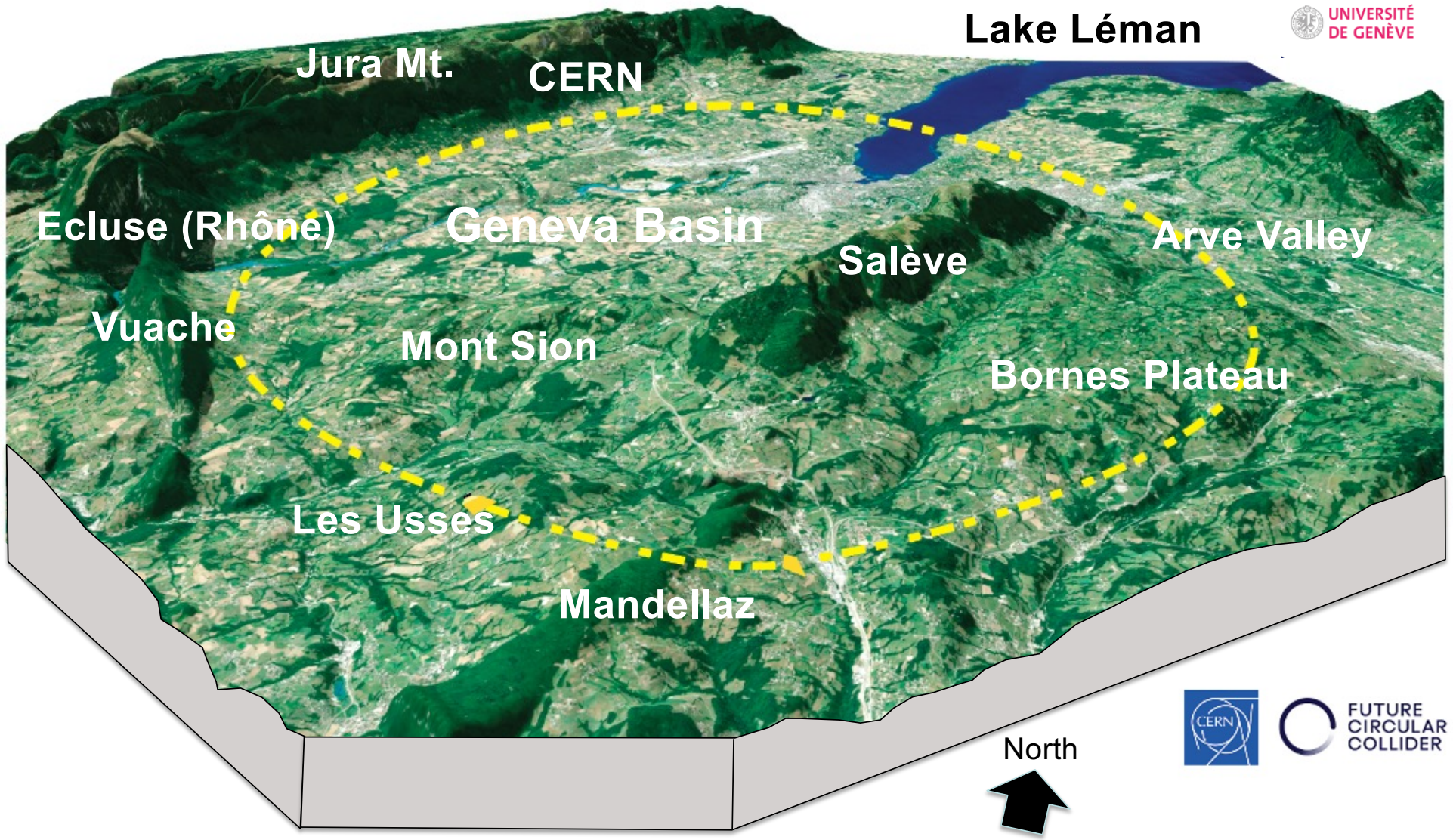
- Since 70s the Geneva Basin is a key area in the Swiss Plateau for active subsurface exploration (O&G 60s – 80s then Fundamental Physics LHC 70s – 80s and since late 90s later Geothermal)
- Exploration activities are driven by the Geneva Industrial Services (SIG) and the Canton in synergy with UNIGE and local service/consultancy providers and lately by CERN

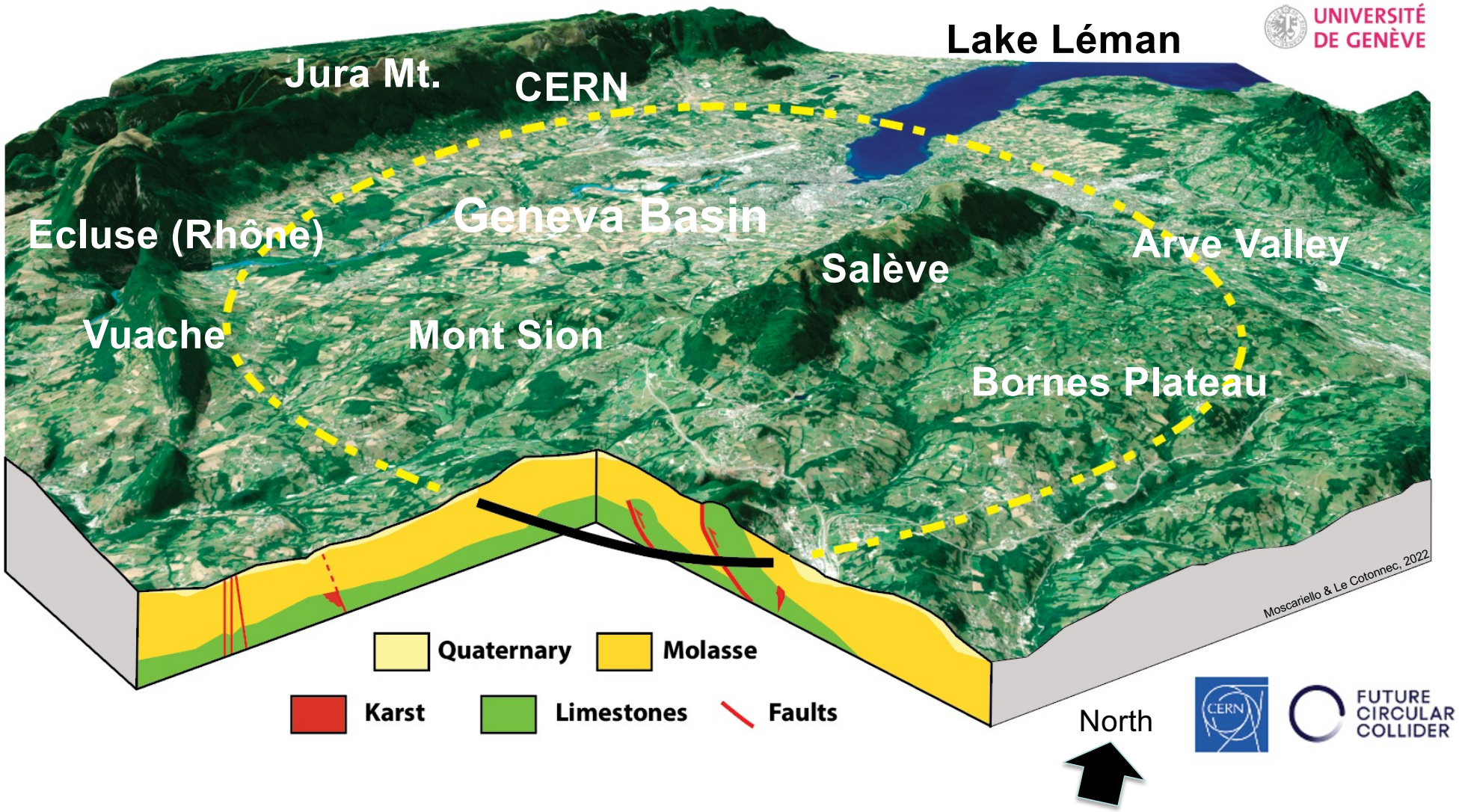
Content

- Why should we be interested about subsurface geology ?
  - General context & the FCC project
- Geological time & the evolution of the geological landscape through time
  - From Carboniferous to Quaternary
- What next ?

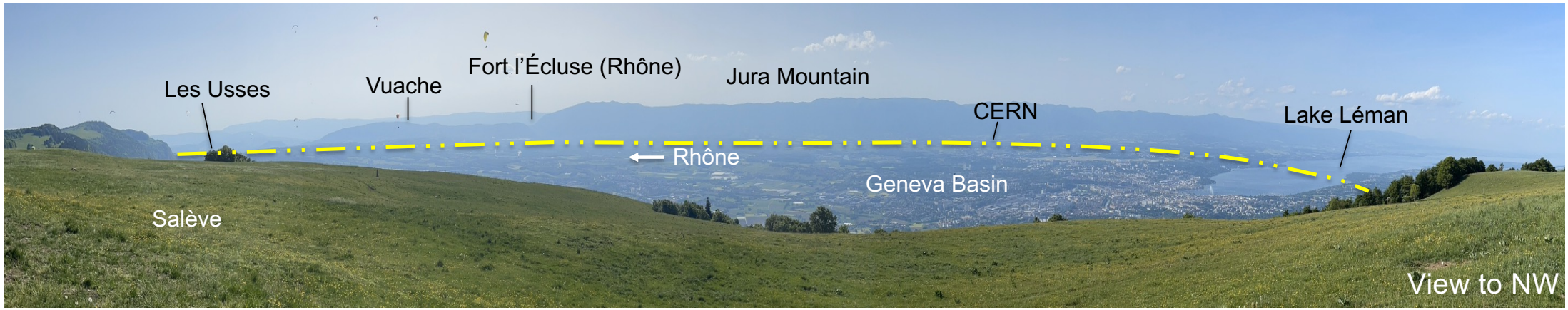
Why should we be interested about subsurface geology ?

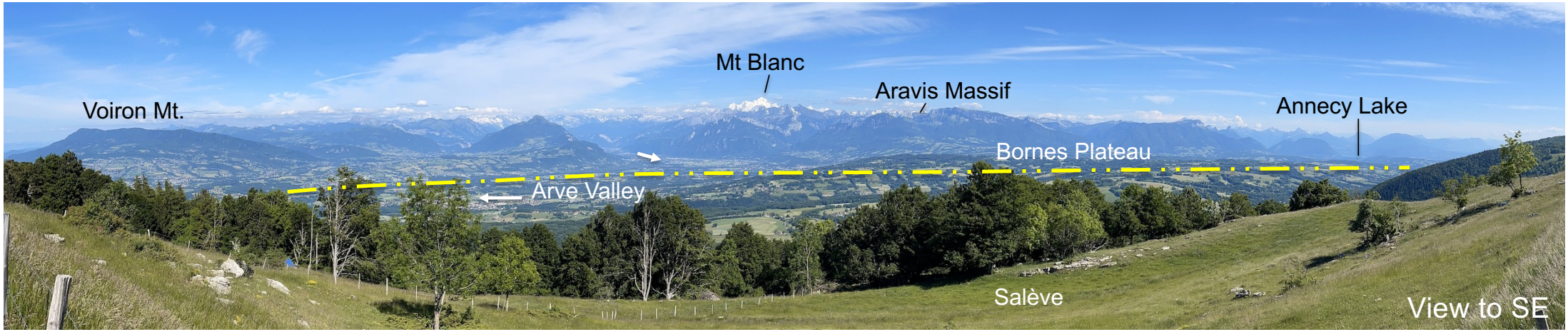
GENERAL CONTEXT & THE FCC PROJECT

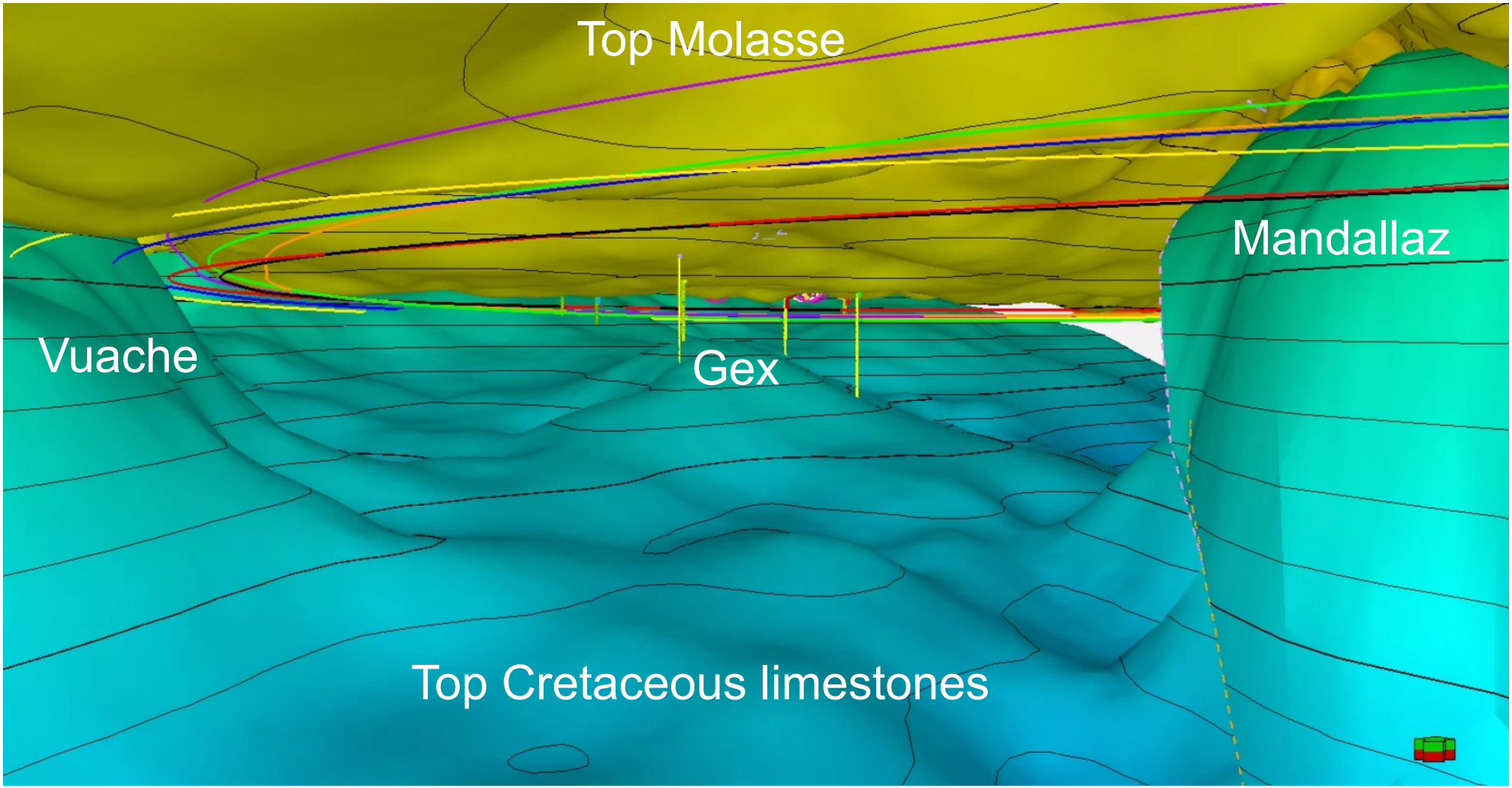

Lake Léman
UNIVERSITÉ DE GENÈVE
Jura Mt.
CERN
Ecluse (Rhône)
Geneva Basin
Salève
Arve Valley
Vuache
Mont Sion
Bornes Plateau
Les Usses
Mandellaz
North
CERN
FUTURE CIRCULAR COLLIDER

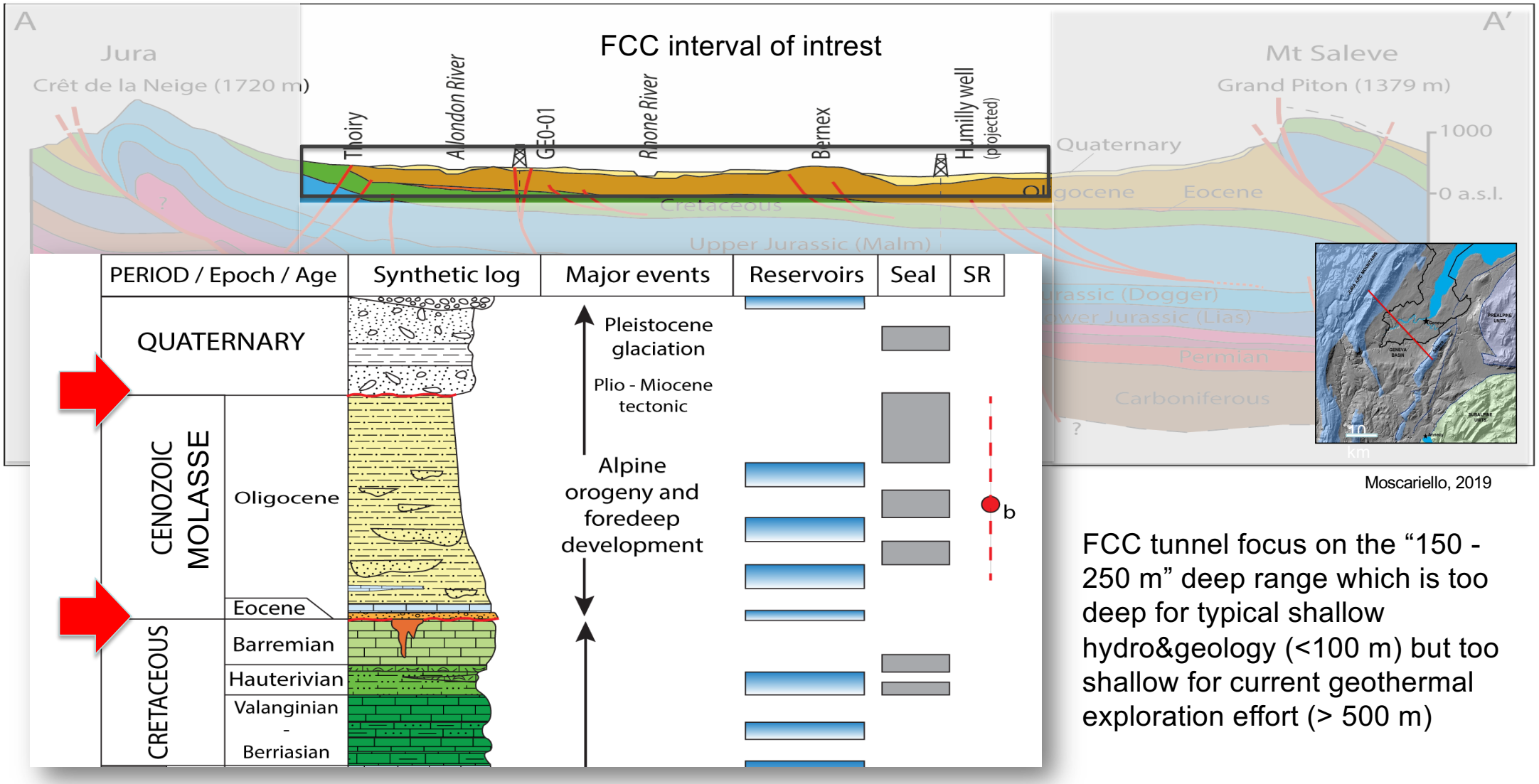

UNIVERSITÉ DE GENÈVE
Lake Léman
Jura Mt.
CERN
Geneva Basin
Ecluse (Rhône)
Salève
Arve Valley
Vuache
Mont Sion
Bornes Plateau
Moscariello & Le Cotonnec, 2022
Quaternary
Molasse
Karst
Limestones
Faults
North
CERN
FUTURE CIRCULAR COLLIDER

FCC TRAJECTORY in the orographic context






Top Molasse
Mandallaz
Vuache
Gex
Top Cretaceous limestones

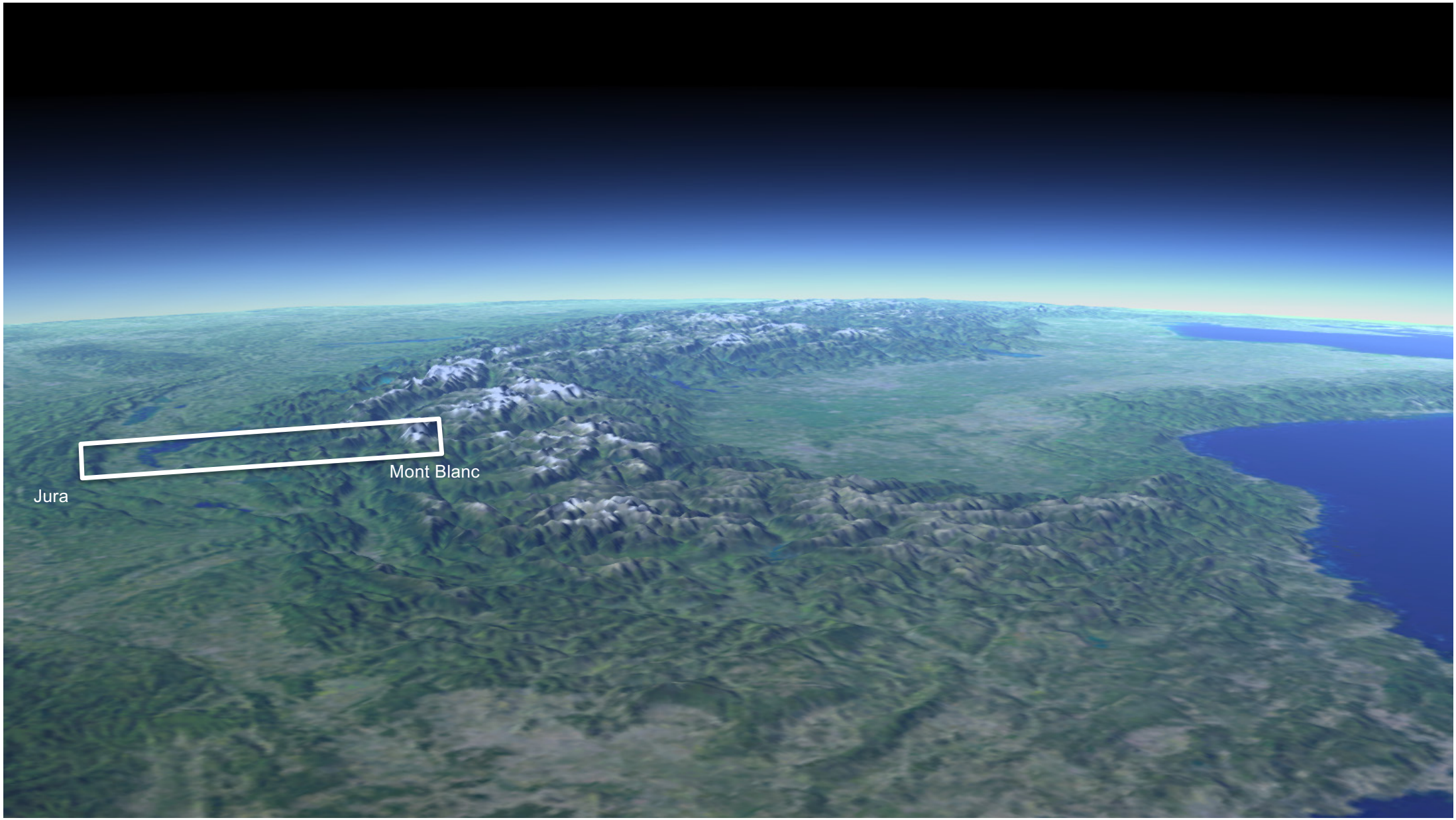


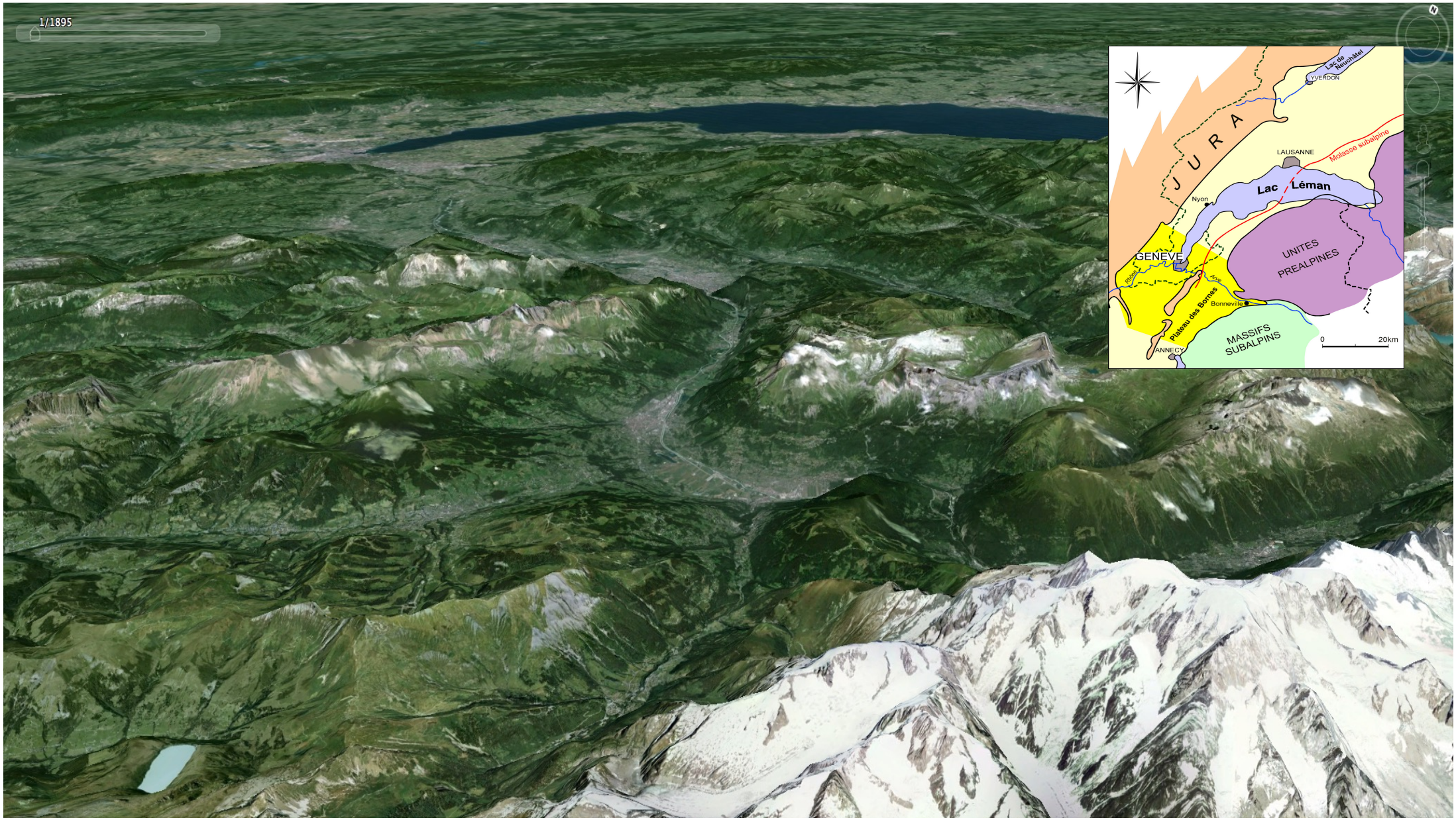
Moscariello, 2019

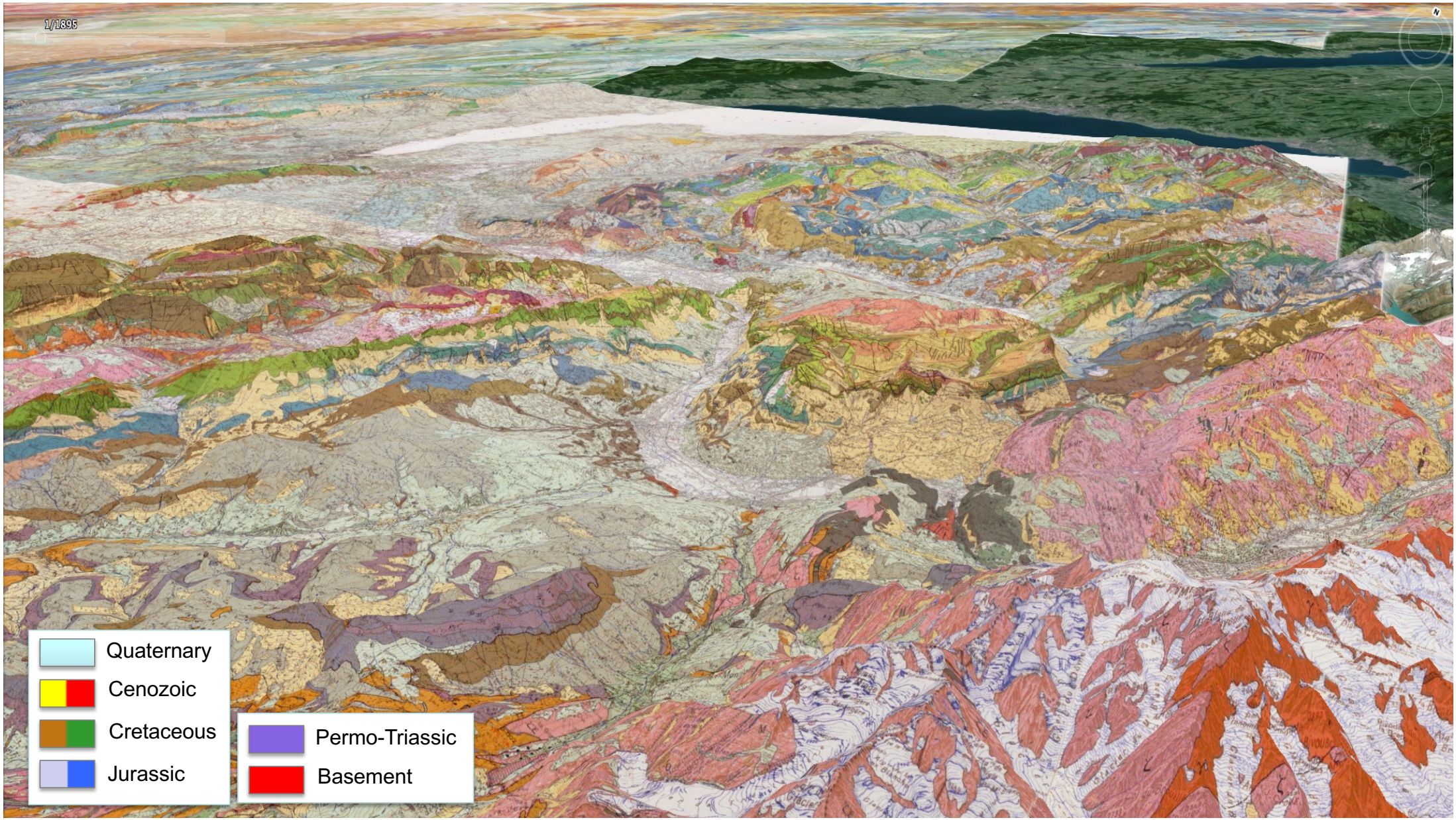
FCC tunnel focus on the “150 - 250 m” deep range which is too deep for typical shallow hydro&geology (<100 m) but too shallow for current geothermal exploration effort (> 500 m)

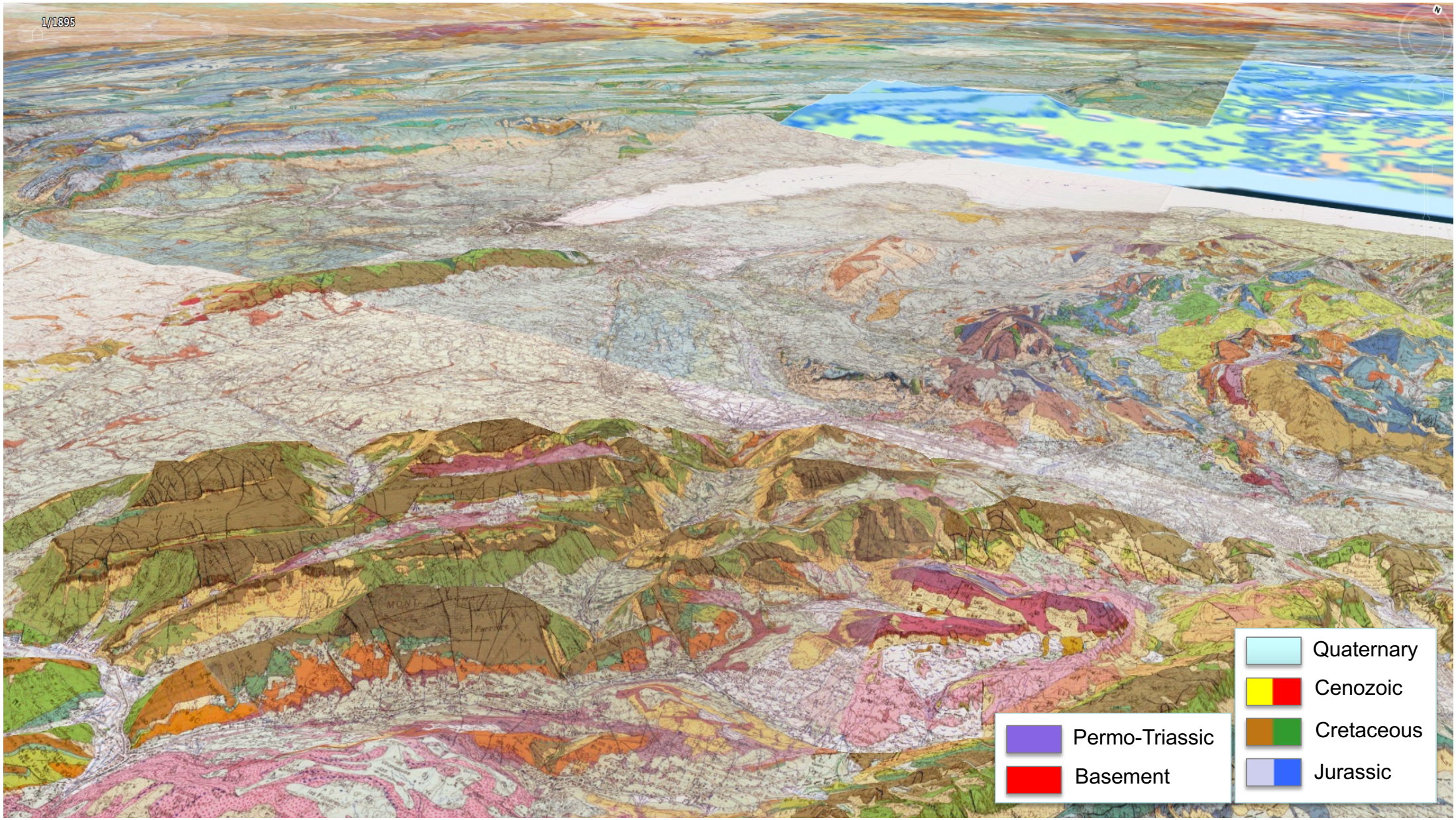
Geology of the Geneva Basin and neighbouring France

GEOLOGICAL TIME & THE EVOLUTION OF THE GEOLOGICAL LANDSCAPE THROUGH TIME

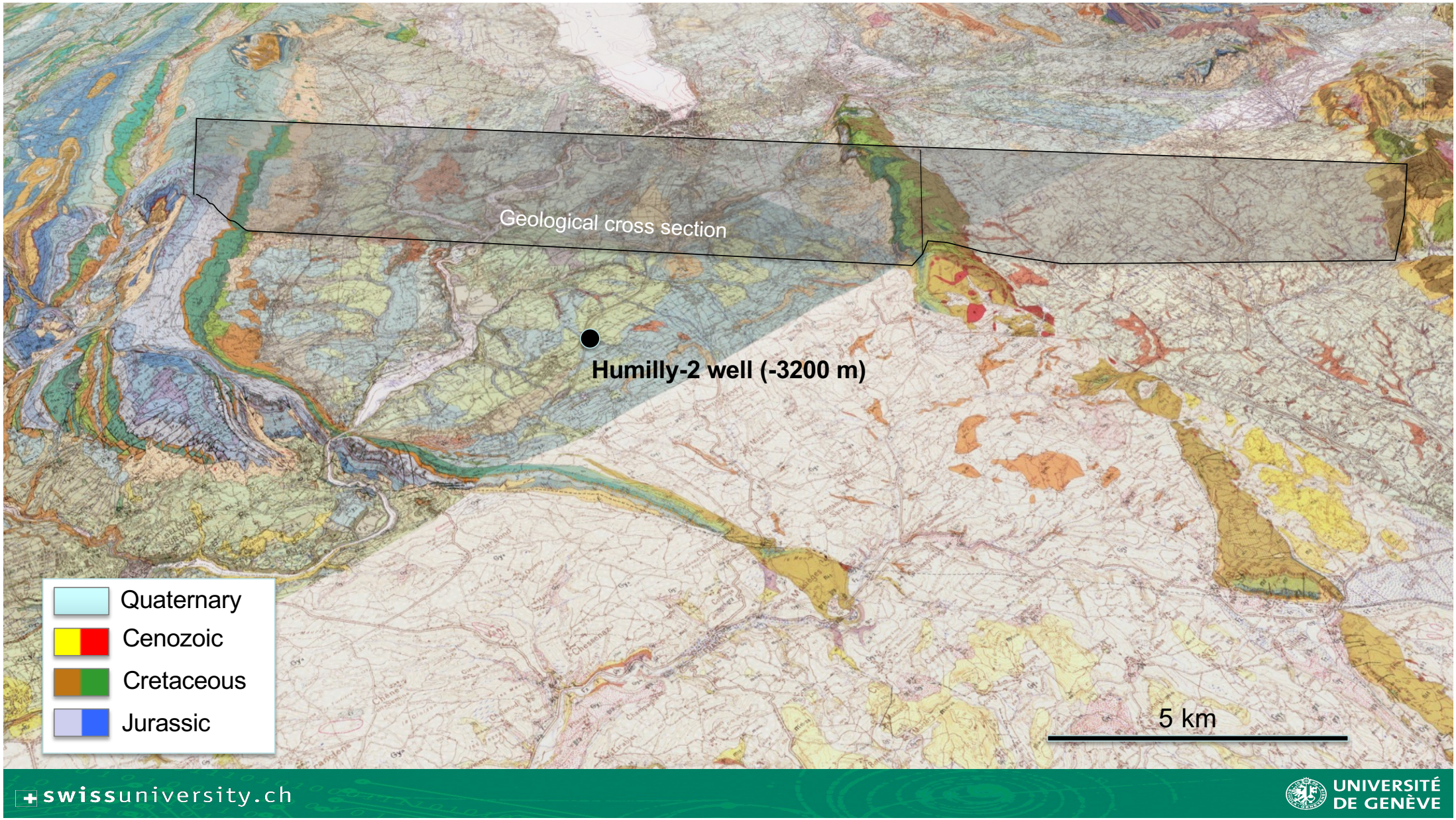

Mont Blanc
Jura

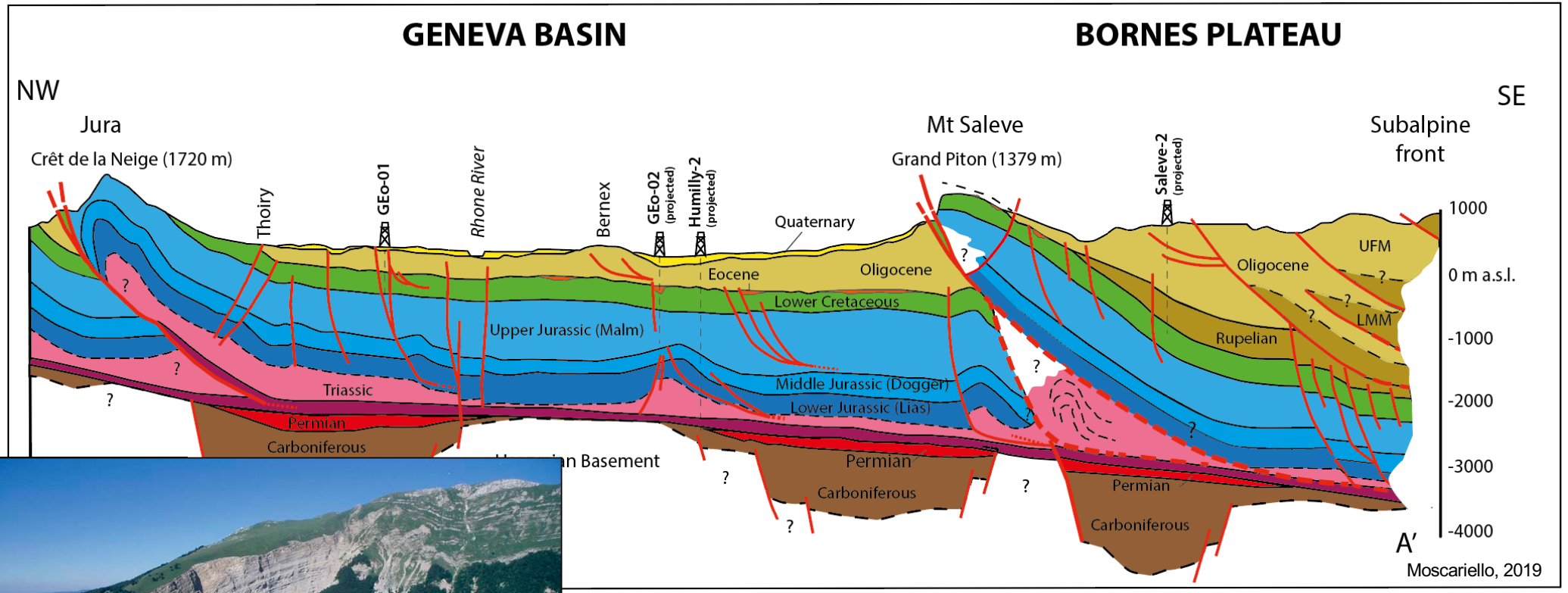

1/1895
JURA
Lac de Neuchâtel
YVERDON
LAUSANNE
Molasse subalpine
Lac Léman
Nyon
GENEVE
UNITES PREALPINES
Rhône
Arve
Plateau des Bornes
Bonneville
MASSIFS SUBALPINS
ANNECY
0
20km

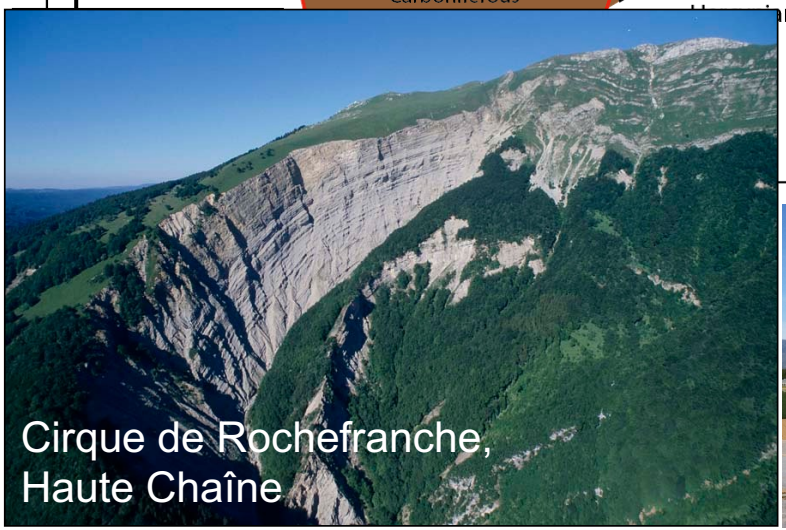

1/1895
Quaternary
Cenozoic
Cretaceous
Jurassic
Permo-Triassic
Basement

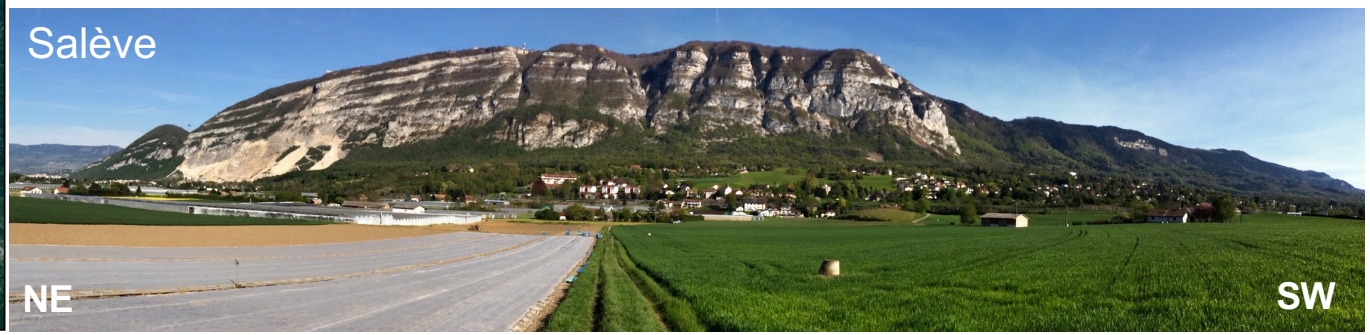

1/1895
Quaternary
Cenozoic
Cretaceous
Jurassic
Permo-Triassic
Basement


Quaternary
Cenozoic
Cretaceous
Jurassic


Geological cross section
Humilly-2 well (-3200 m)
Quaternary
Cenozoic
Cretaceous
Jurassic
5 km

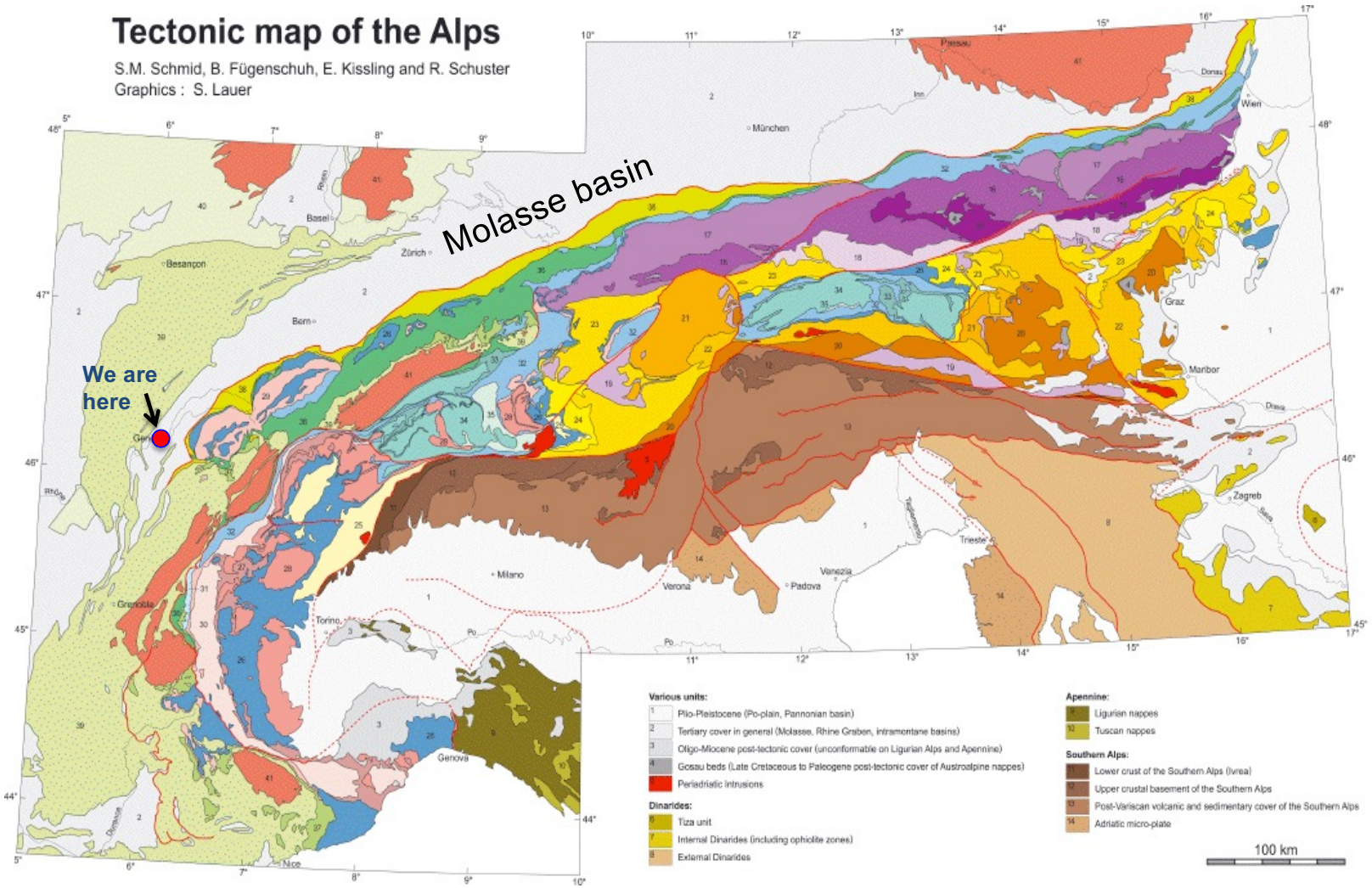

GENEVA BASIN
BORNES PLATEAU
NW
SE
Jura
Crêt de la Neige (1720 m)
Thoiry
GEo-01
Rhone River
Bernex
GEo-02 (projected)
Humilly-2 (projected)
Quaternary
Eocene
Oligocene
Lower Cretaceous
Upper Jurassic (Malm)
Middle Jurassic (Dogger)
Lower Jurassic (Lias)
Triassic
Permian
Carboniferous
Basement
Mt Saleve
Grand Piton (1379 m)
Saleve-2 (projected)
Subalpine front
Oligocene
UFM
LMM
Rupelian
Permian
Carboniferous
1000
0 m a.s.l.
-1000
-2000
-3000
-4000
A'
Moscariello, 2019


Cirque de Rochefranche,
Haute Chaîne

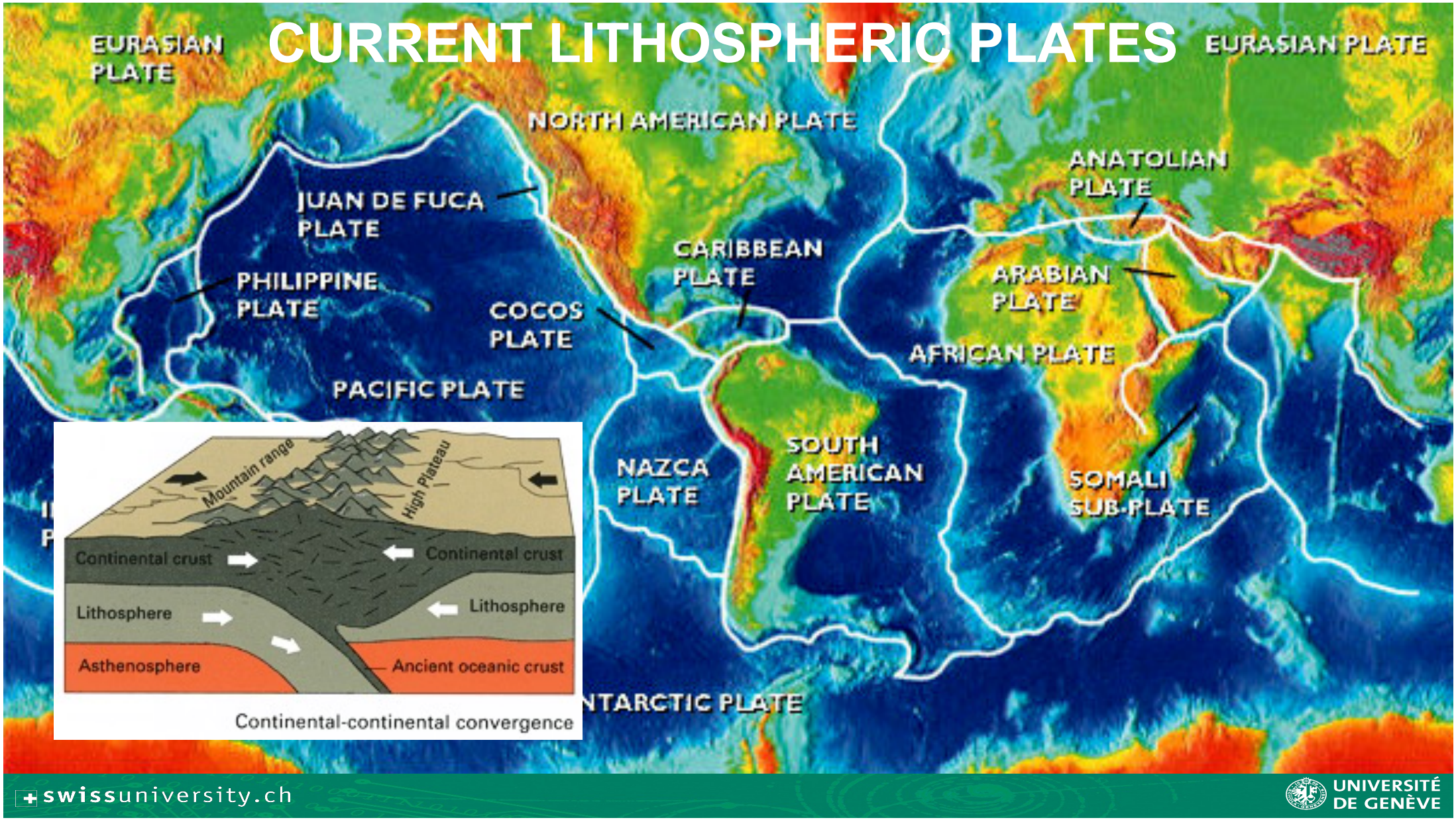

Salève
NE
SW

Tectonic map of the Alps

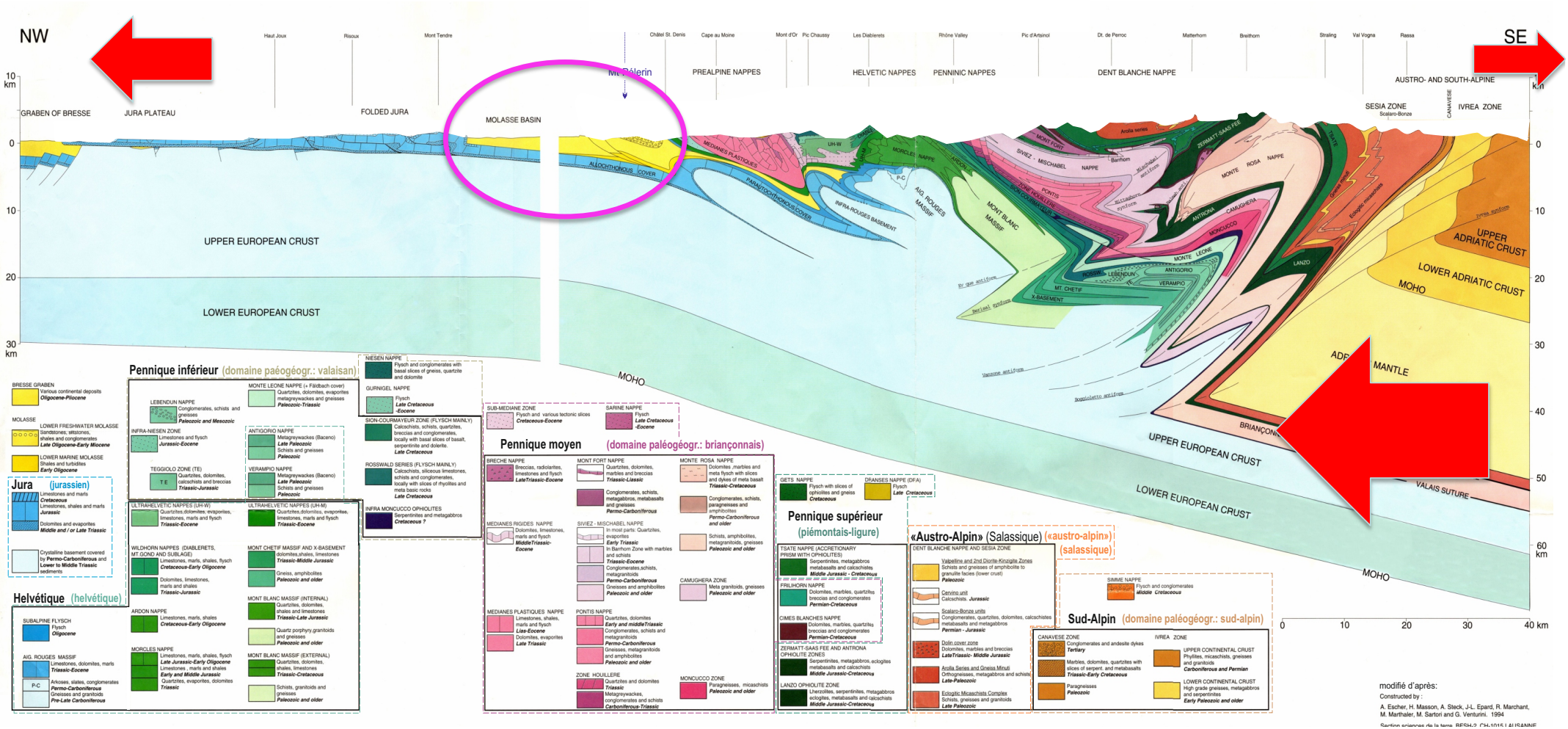
S.M. Schmid, B. Fügenschuh, E. Kissling and R. Schuster
Graphics : S. Lauer

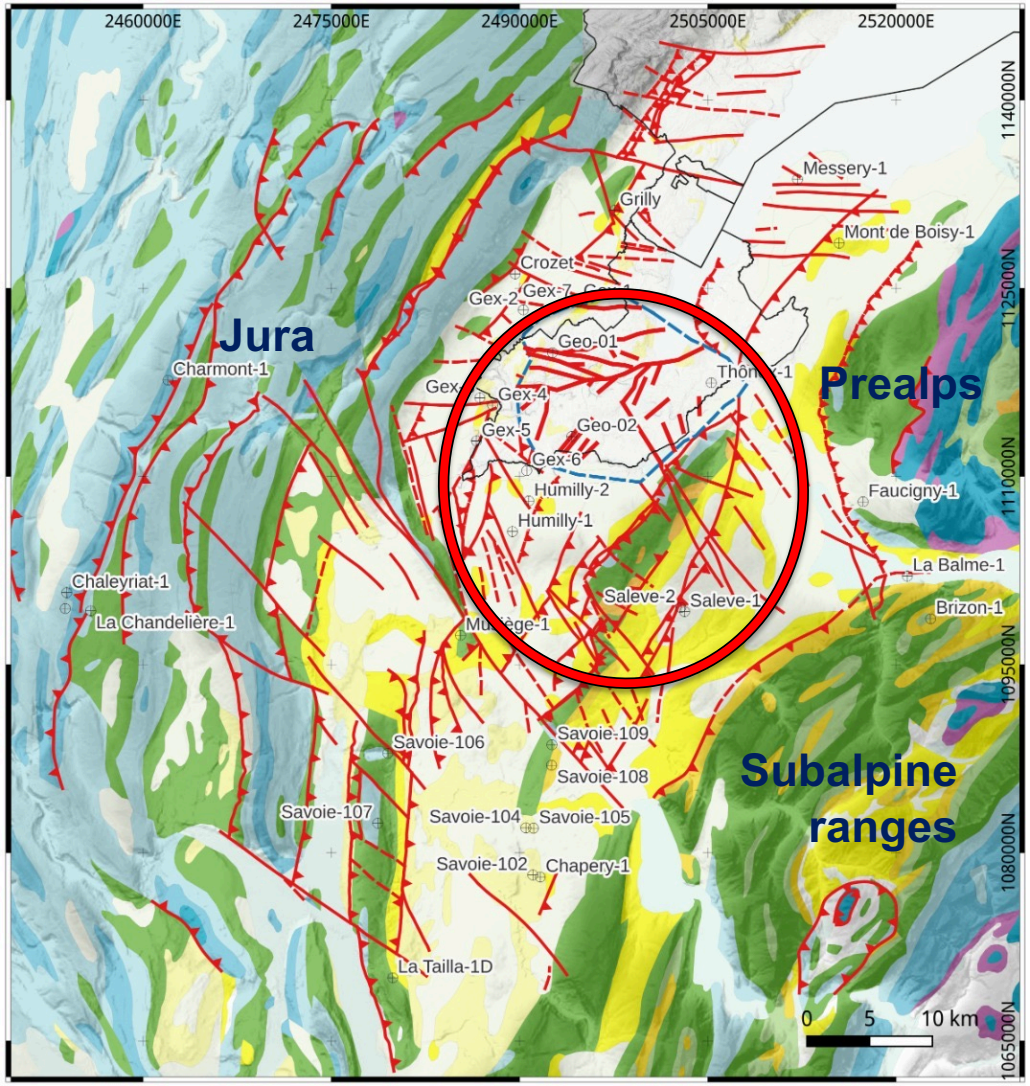


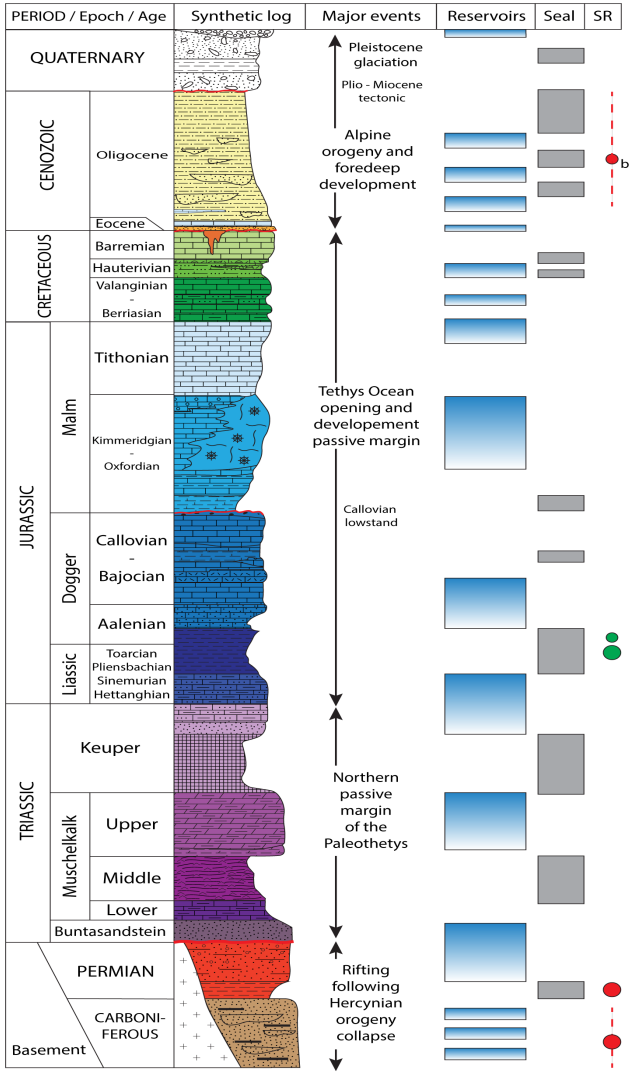
CURRENT LITHOSPHERIC PLATES

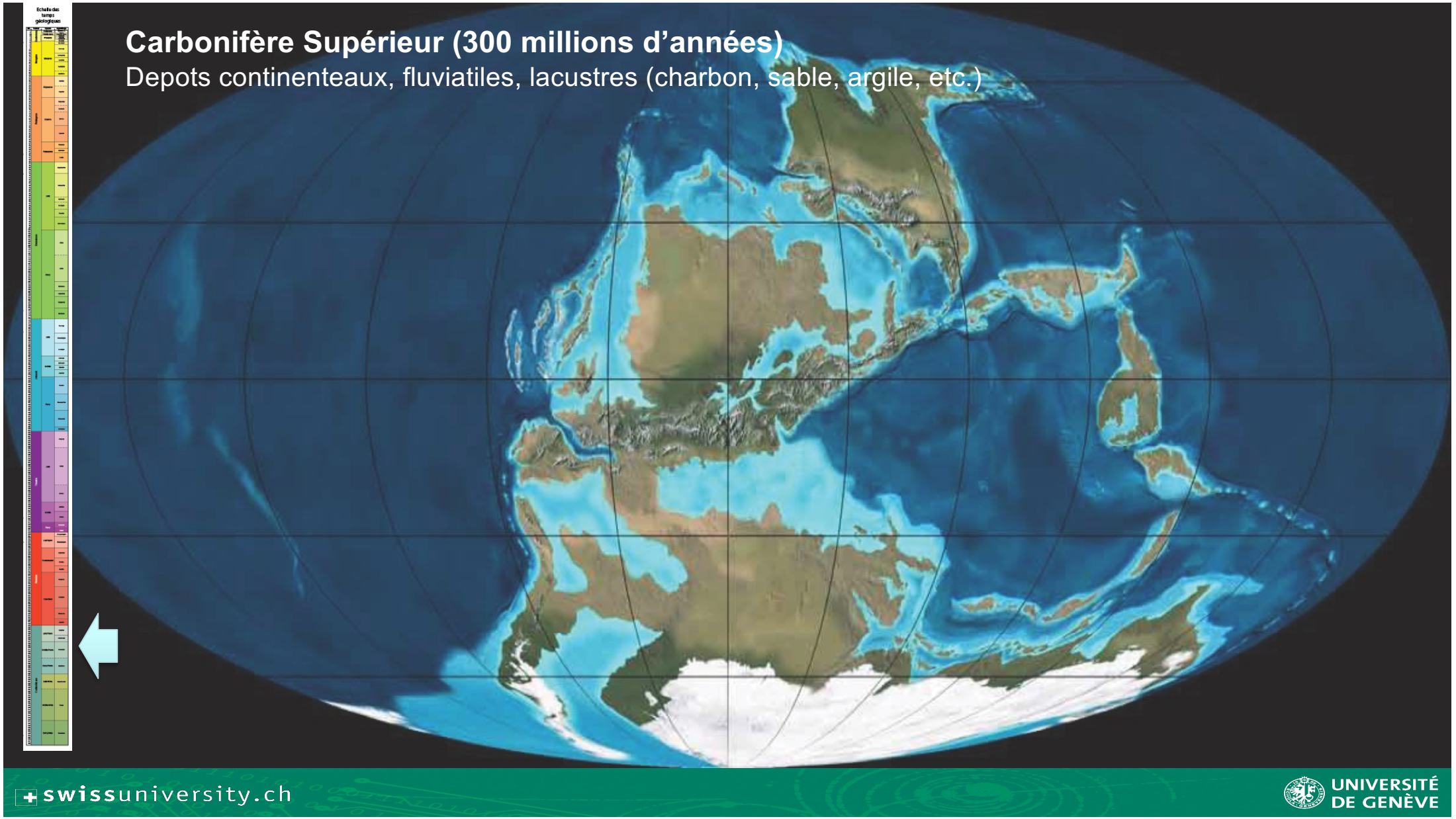


Geological cross section at the crustal scale – Western Switzerland




2460000E
2475000E
2490000E
2505000E
2520000E
1140000N
1125000N
1110000N
1095000N
1080000N
1065000N
Jura
Prealps
Subalpine ranges
Charmont-1
Gex-2
Gex-7
Geo-01
Gex-4
Gex-5
Geo-02
Gex-6
Humilly-2
Humilly-1
Grilly
Messery-1
Mont de Boisy-1
Crozet
Faucigny-1
La Balme-1
Brizon-1
Chaleyriat-1
La Chandelière-1
Saleve-2
Saleve-1
Savoie-106
Savoie-109
Savoie-108
Savoie-107
Savoie-104
Savoie-105
Savoie-102
Chapery-1
La Tailla-1D
0
5
10 km


PERIOD / Epoch / Age
Synthetic log
Major events
Reservoirs
Seal
SR
QUATERNARY
Pleistocene glaciation
Plio - Miocene tectonic
CENOZOIC
Oligocene
Eocene
Alpine orogeny and foredeep development
CRETACEOUS
Barremian
Hauterivian
Valanginian - Berriasian
JURASSIC
Malm
Tithonian
Kimmeridgian - Oxfordian
Tethys Ocean opening and developement passive margin
Dogger
Callovian - Bajocian
Aalenian
Callovian lowstand
Liassic
Toarcian
Pliensbachian
Sinemurian
Hettanghian
TRIASSIC
Keuper
Muschelkalk
Upper
Middle
Lower
Buntasandstein
Northern passive margin of the Paleothetys
PERMIAN
CARBONI-FEROUS
Basement
Rifting following Hercynian orogeny collapse
b


Echelle des temps géologiques
Carbonifère Supérieur (300 millions d'années)
Depots continenteaux, fluviatiles, lacustres (charbon, sable, argile, etc.)

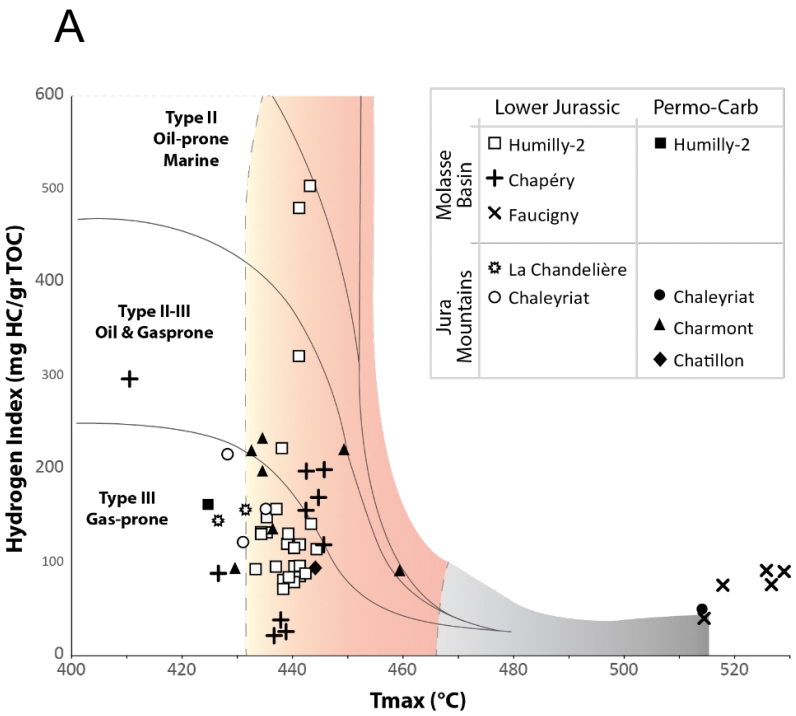

Variscan
Orogen
African promontory
Gondwanan plate
Paleotethys Ocean
South Caspian arc
Greater Caucus arc
300 Mln - Carbonifère sup.
0
400 km
0
400 mi

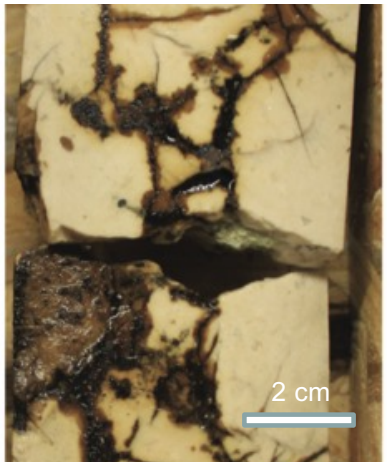
Late Carboniferous landscape in Switzerland; equatorial river systems, generated from ancient Variscan mountains in the south.

Wet alluvial plains with lakes and marshes were a common feature of the landscape 300 million years ago.

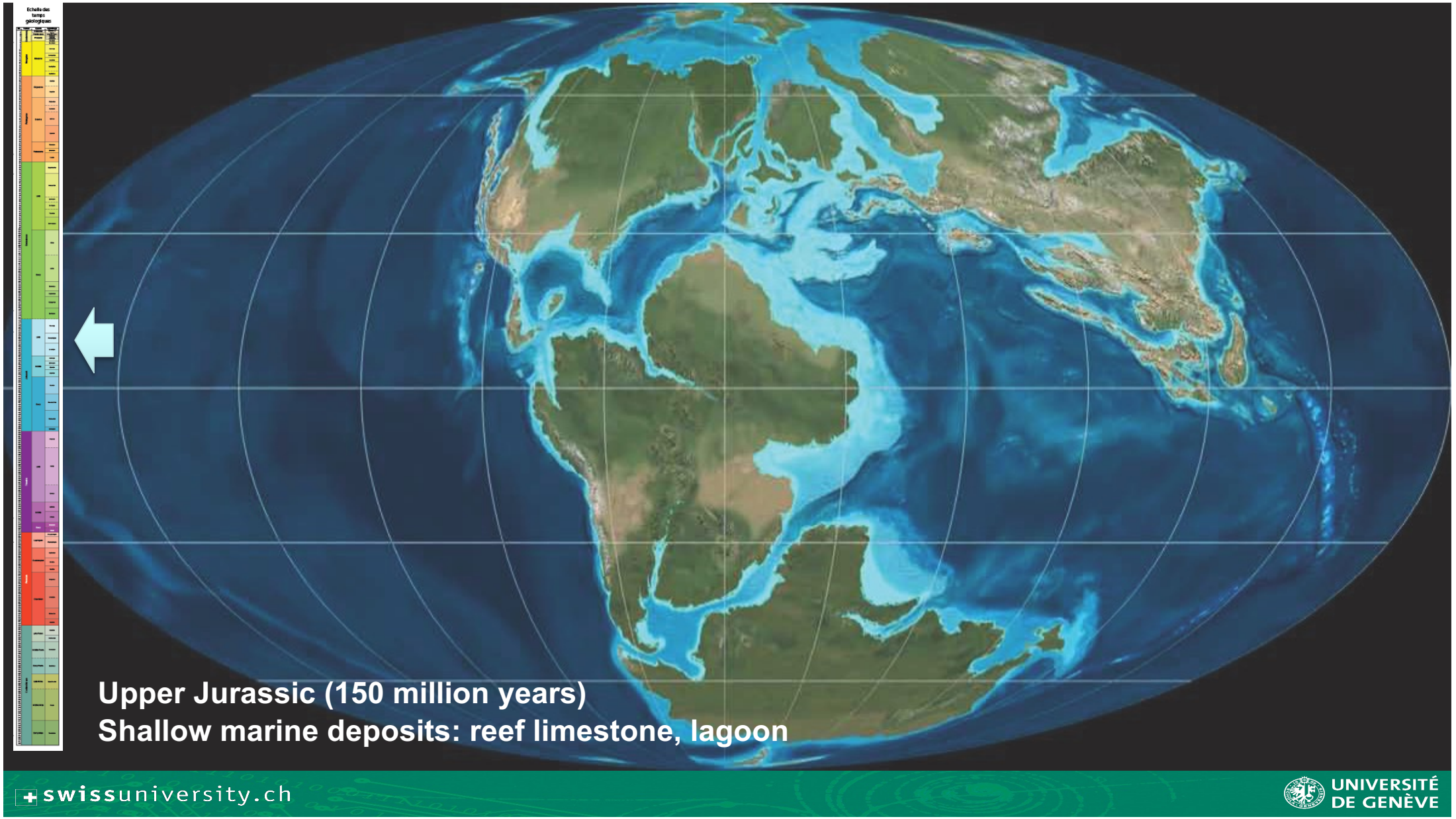
Eastern Kentucky, USA

Hydrocarbons occurrence





Moscariello, 2019

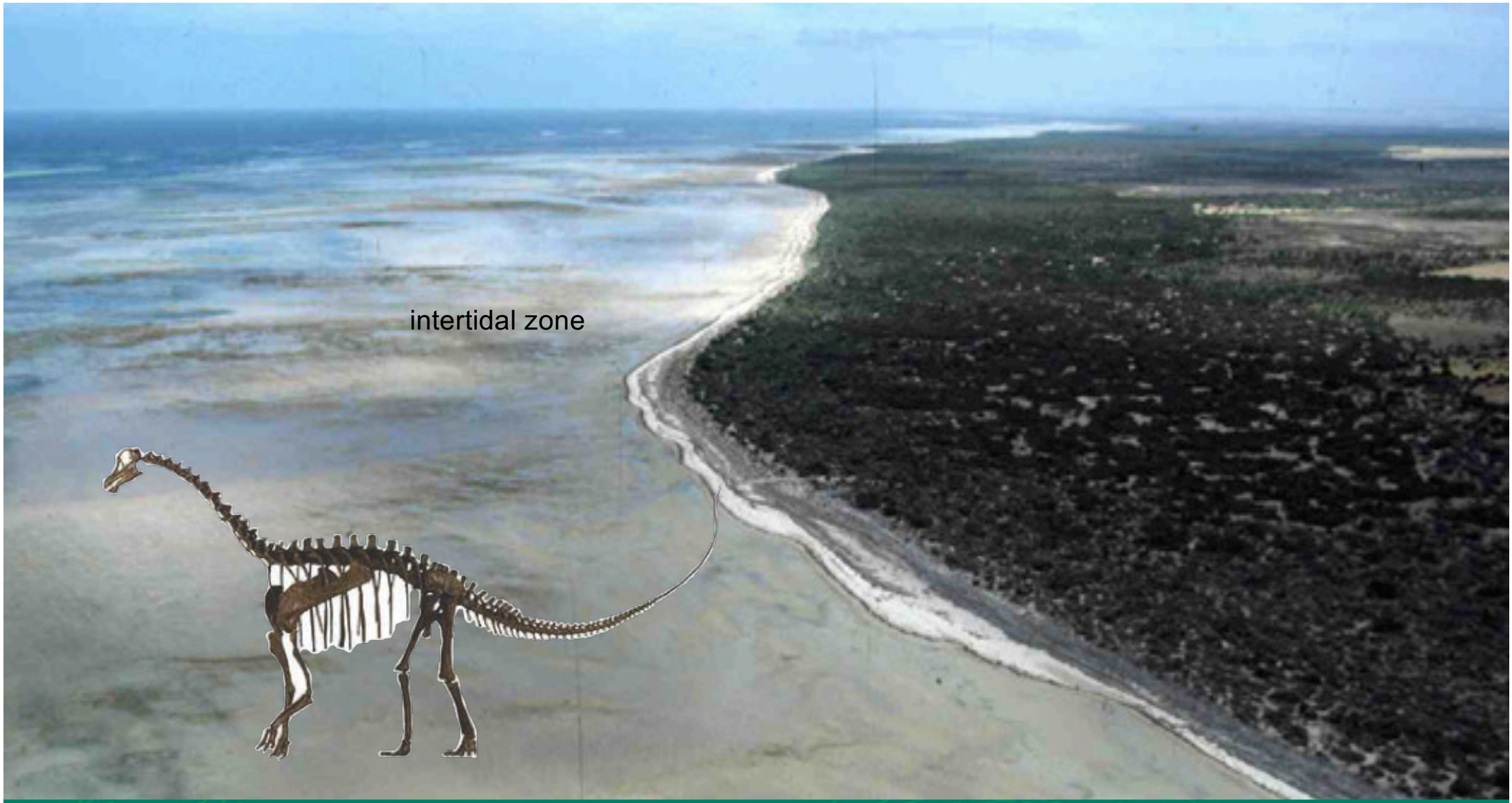

Upper Jurassic (150 million years)
Shallow marine deposits: reef limestone, lagoon


Atlantic Ocean
Iberia plate
Alpine Ocean
Tizia-AA b
Moesia b
TD b
Adria b
Pelegonia b
Vardar Plate
Cimmeria plate
Gondwanan (African) plate
Neotethys plate
Taurus plate
Neotethys Ocean
Gondwanan plate
0 400 km
0 400 mi
225 – 210 Mln – Upper Jurassic

Thecosmilia sp.

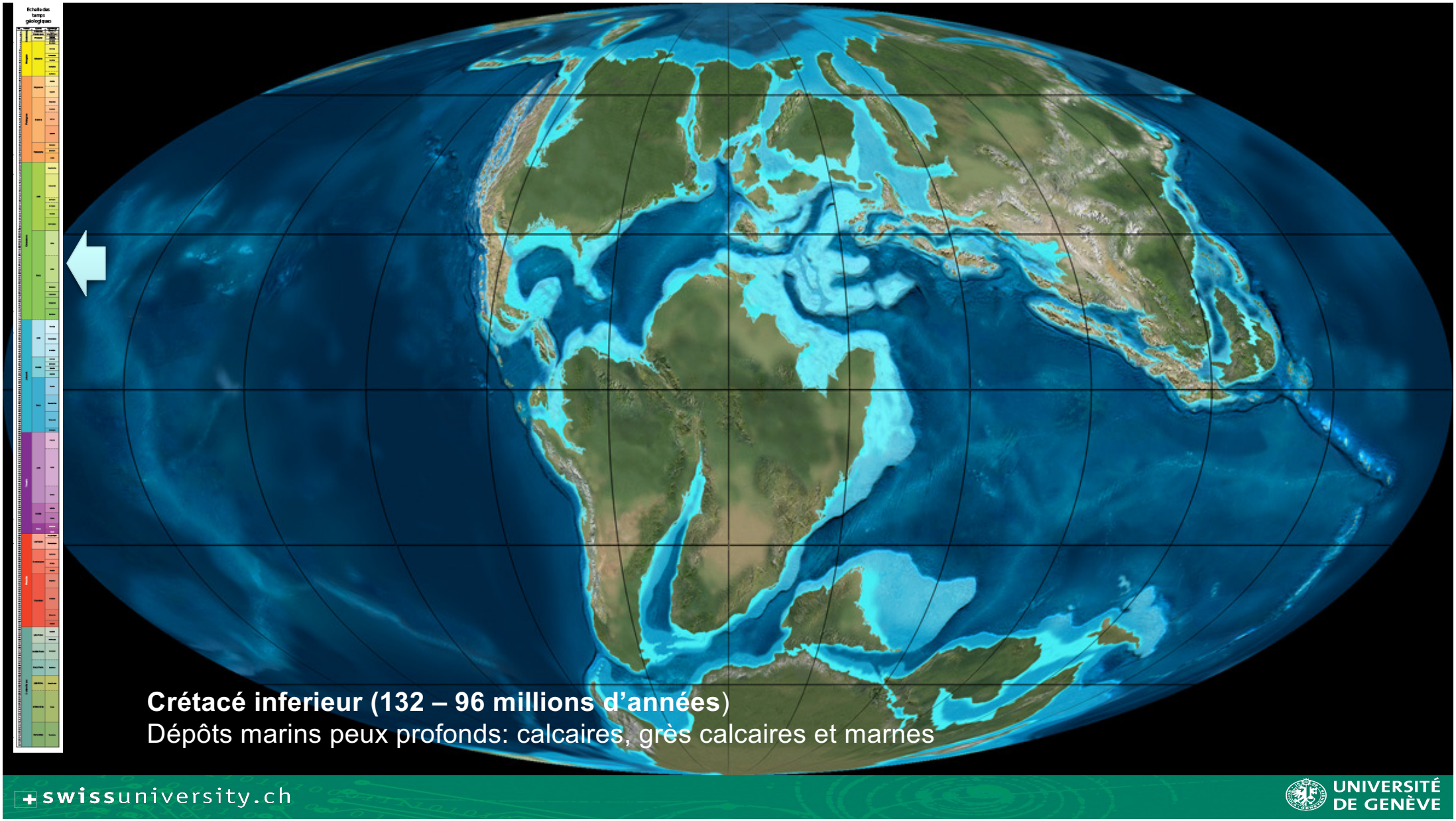
Upper Jurassic

Upper Jurassic coral reefs today...
Fort l'Écluse, 1225 AD

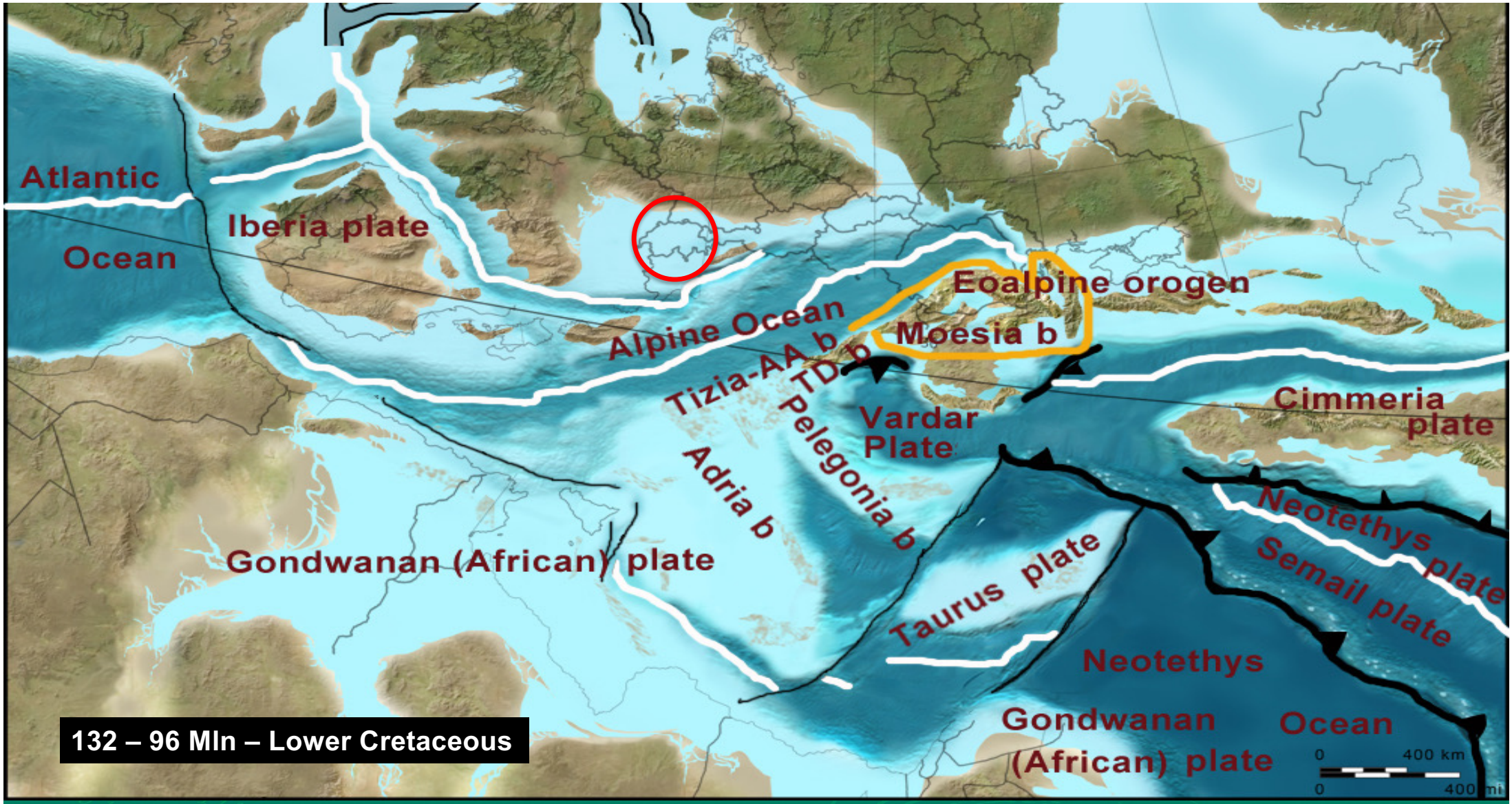

intertidal zone

Sauropod footprint, Plagne (Ain) - Oxfordian

Therapod footprint, Plagne (Ain) - Oxfordian

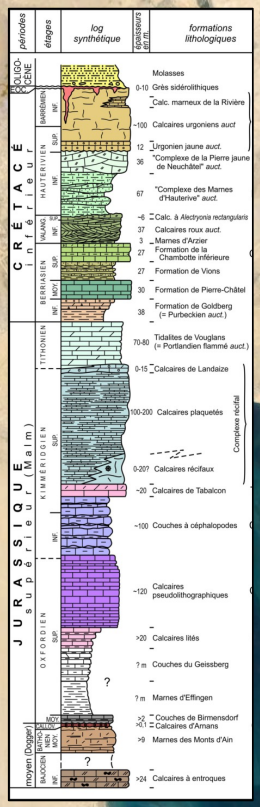


Crétacé inferieur (132 – 96 millions d'années)
Dépôts marins peux profonds: calcaires, grès calcaires et marnes


Atlantic
Ocean
Iberia plate
Alpine Ocean
Tizia-AA b
TD b
Pelegonia b
Adria b
Eoalpine orogen
Moesia b
Vardar
Plate
Cimmeria
plate
Neotethys plate
Semail plate
Taurus plate
Neotethys
Gondwanan
Ocean
Gondwanan (African) plate
Gondwanan (African) plate
0
400 km
0
400 mi
132 – 96 Mln – Lower Cretaceous

« Tidalites »: sediments formed under the influence of tides in coastal areas.

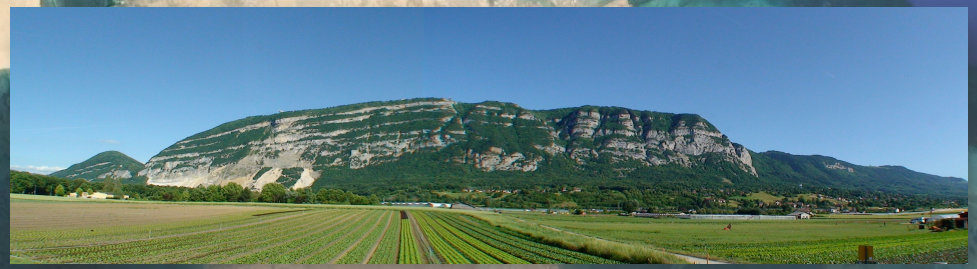
Persian Gulf

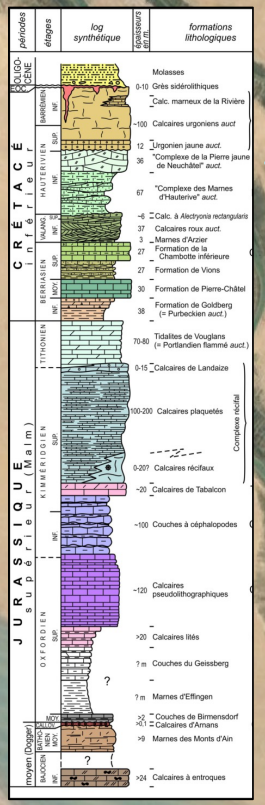


Kingdom of Saudi Arabia

Kingdom of Barhein

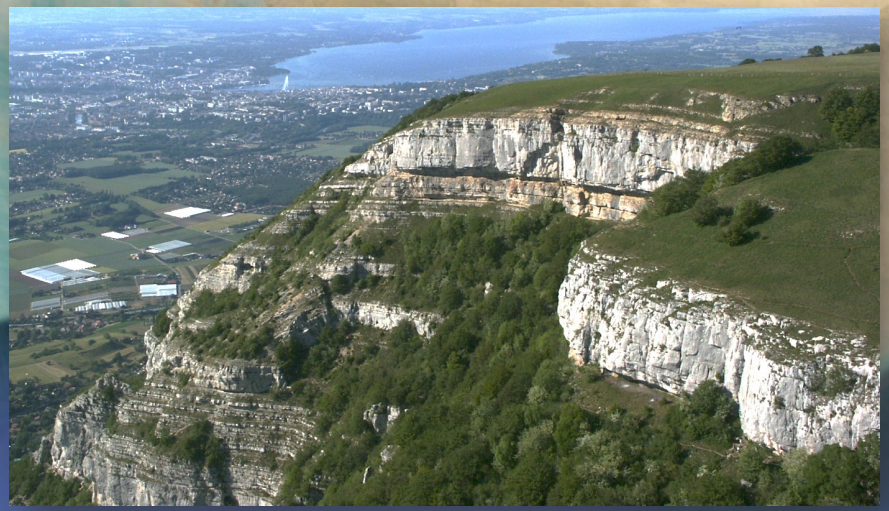
lagoon

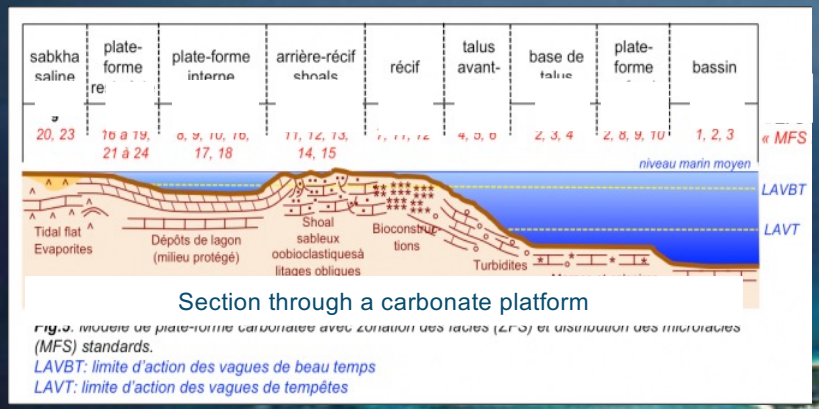




Internal lagoons

Tidal channels

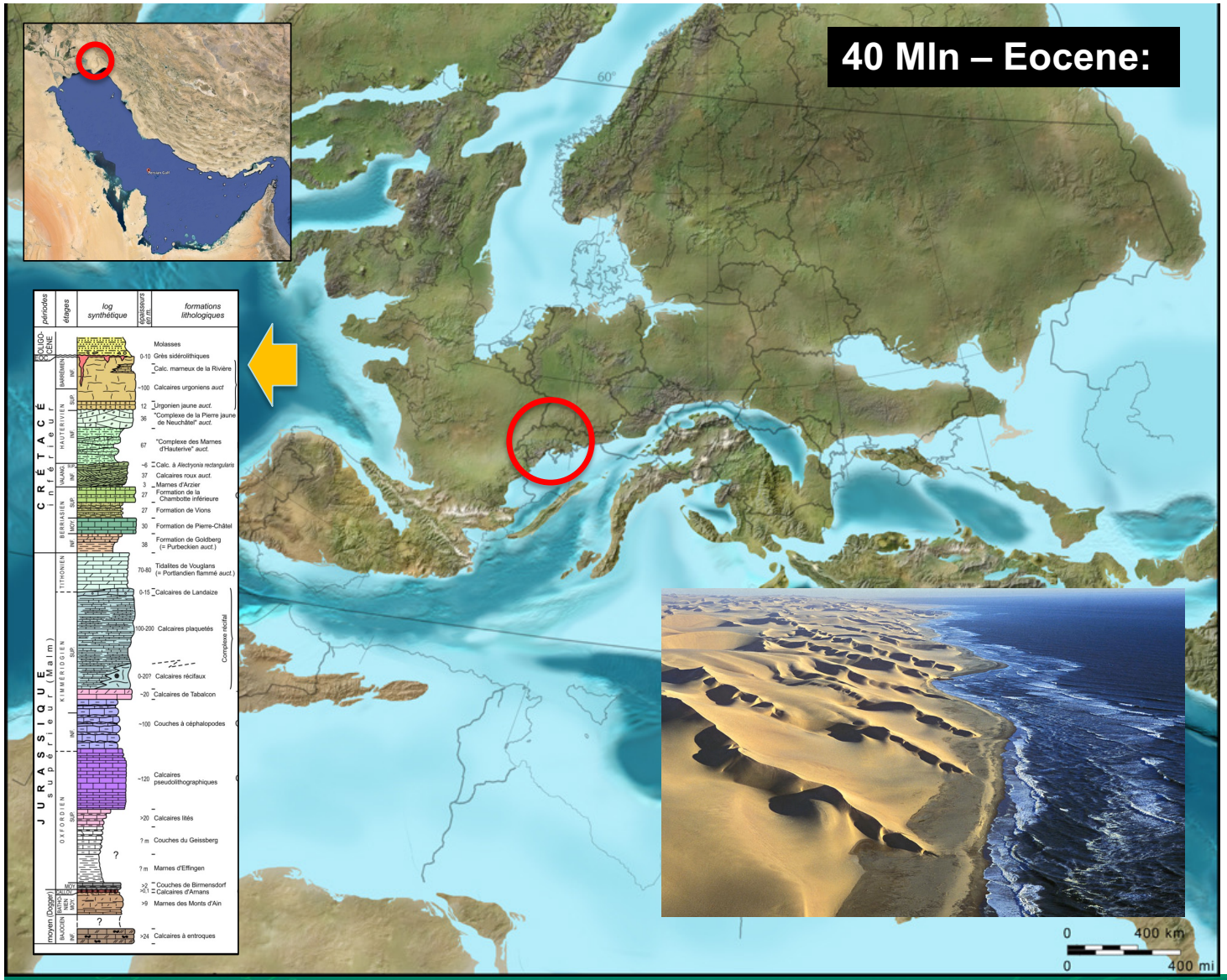




Section through a carbonate platform

(MFS) standards.
LAVBT: limite d'action des vagues de beau temps
LAVT: limite d'action des vagues de tempêtes

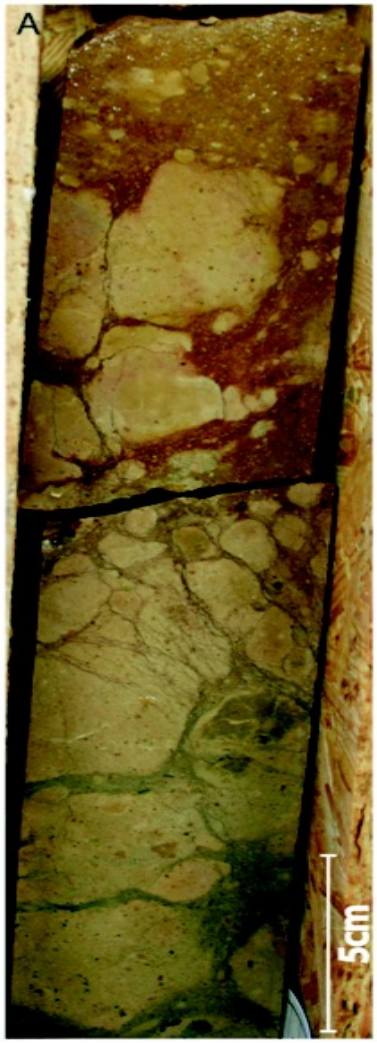
Late Upper Cretaceous: An extensive carbonate platform.
This interval in the geological history of the Geneva Basin is known as the "Urgonian".



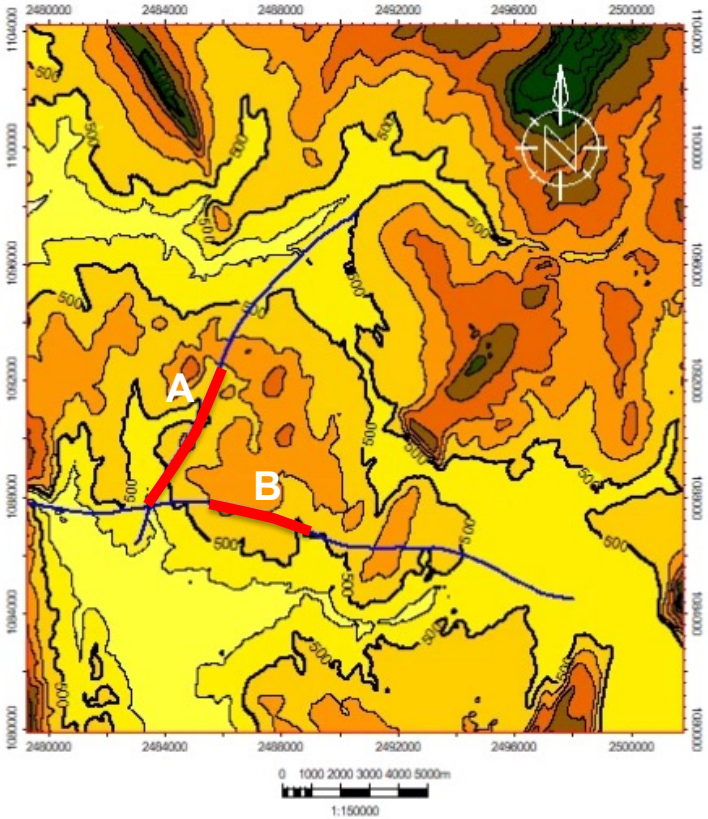
Salève “siderolithic sandstone”: with different colors (ochre, yellow and white), it was mined for several centuries from the 5th century onwards for a variety of uses (weapons, tools, mortar, house plaster and glass).

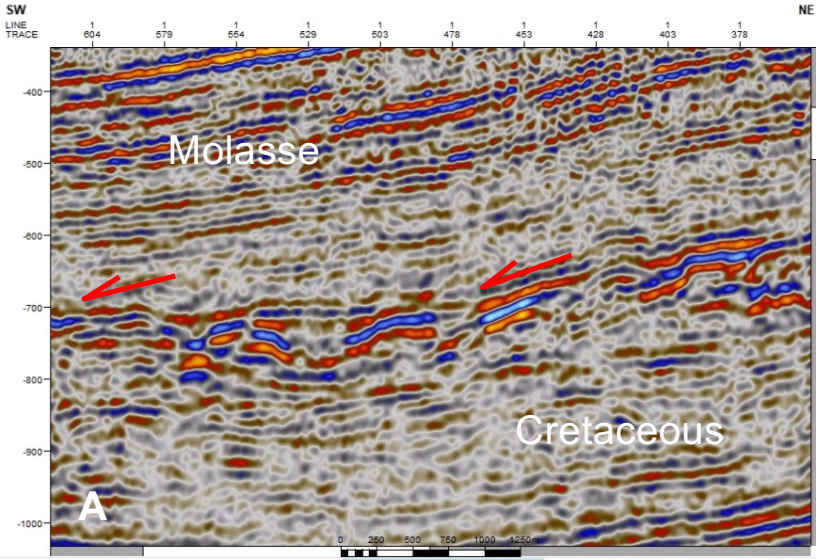
Little is known about its origins, but it is likely to have been deposited by large aeolian dunes.
Today, very little remains at the surface but…

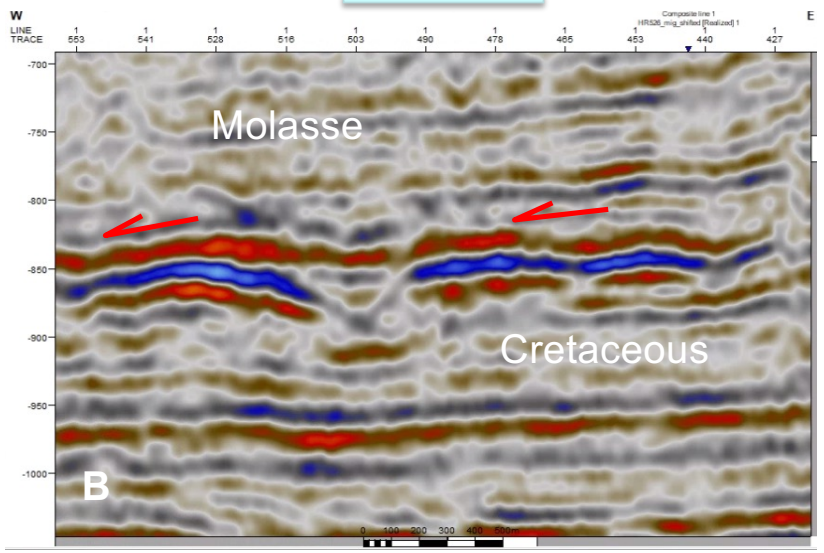
Karst at the top Cretaceous lmst



Exemples form the Rumilly Basin

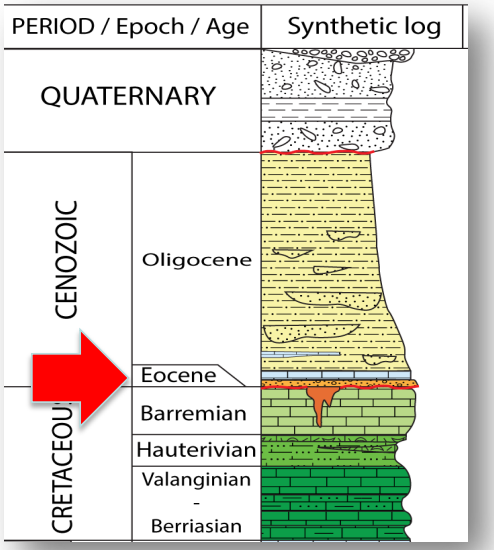


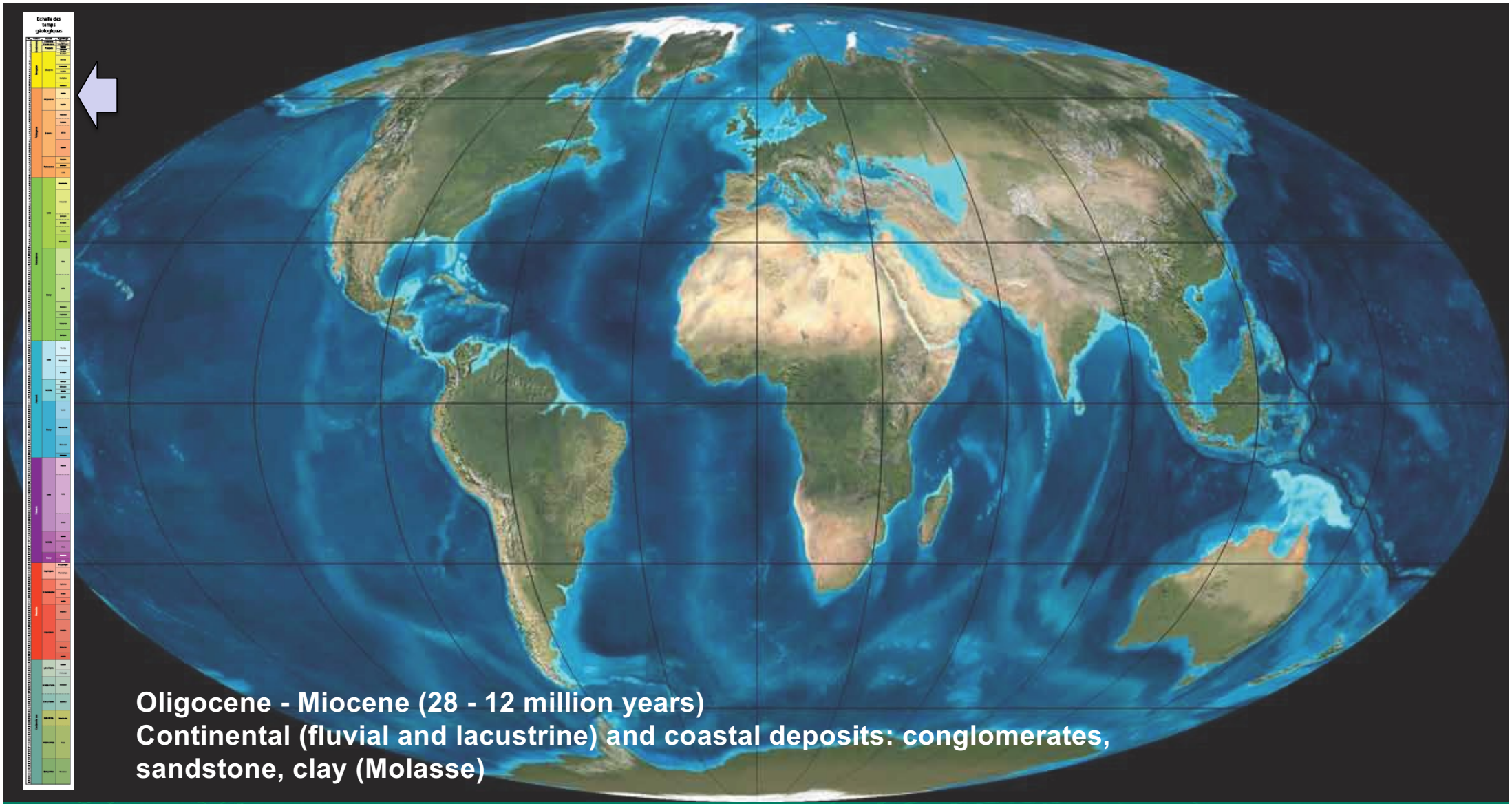




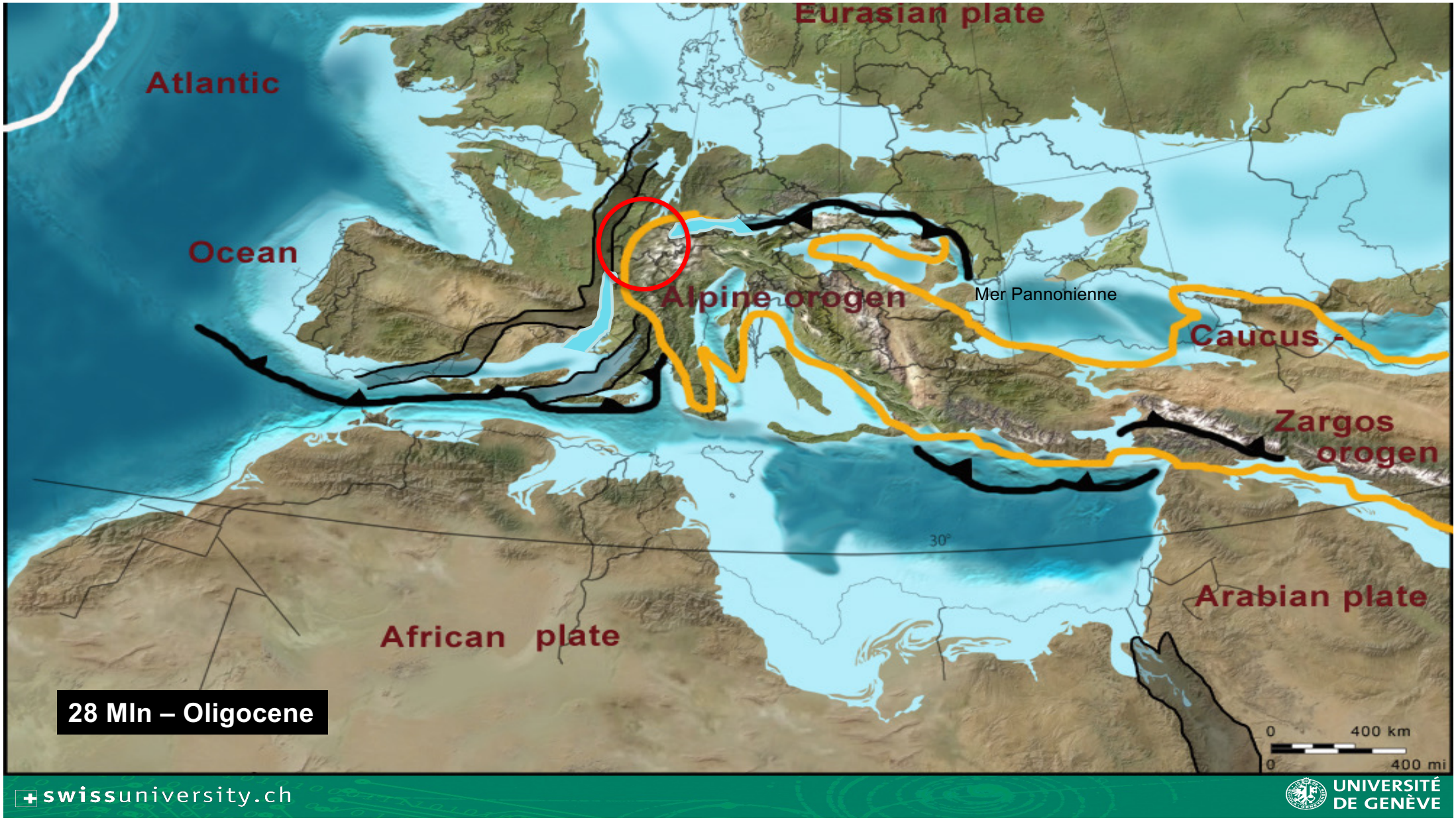
KARST

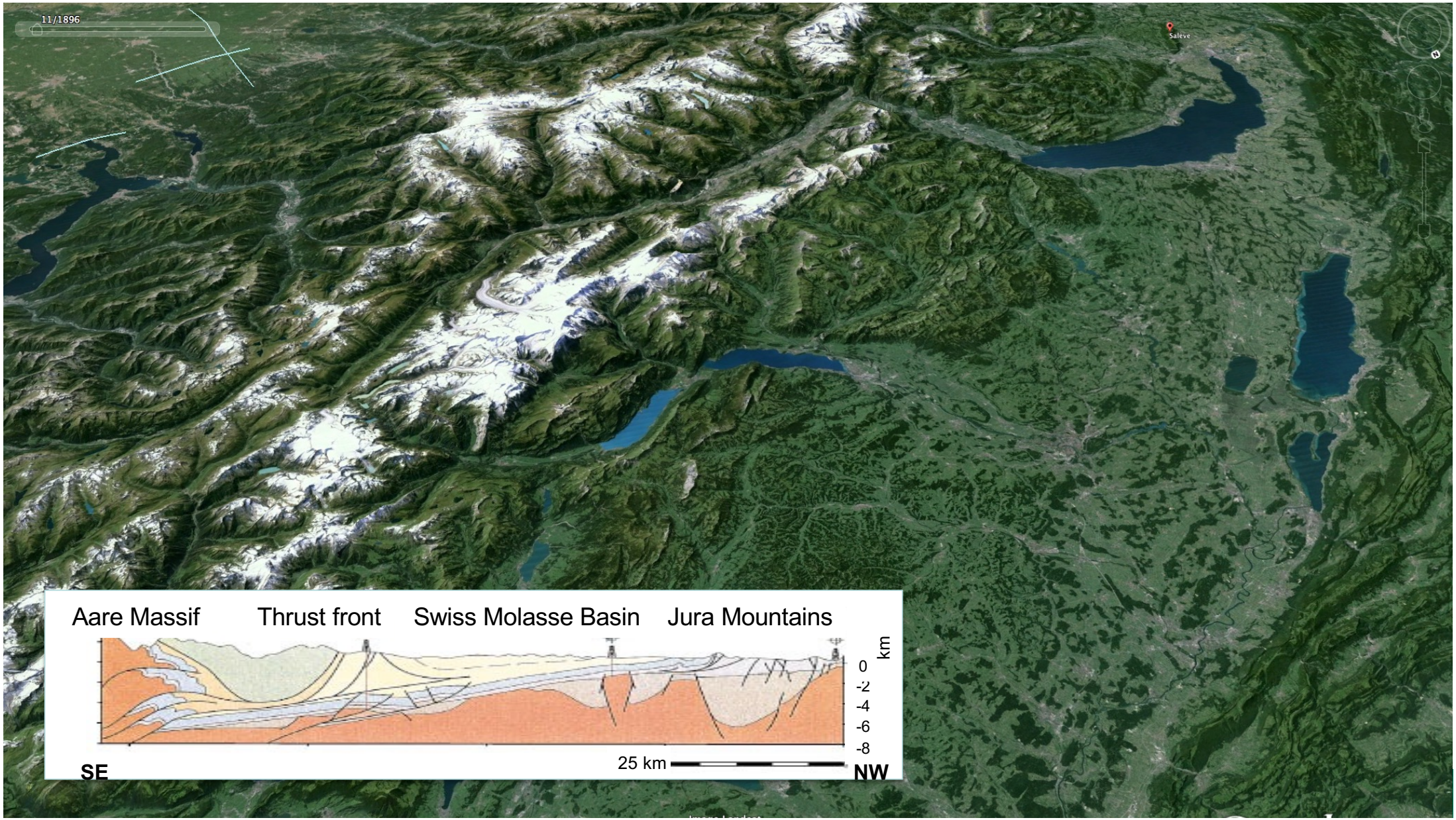
Water inrush through the end wall of the Pasar Rakyat station box from a network of karst features



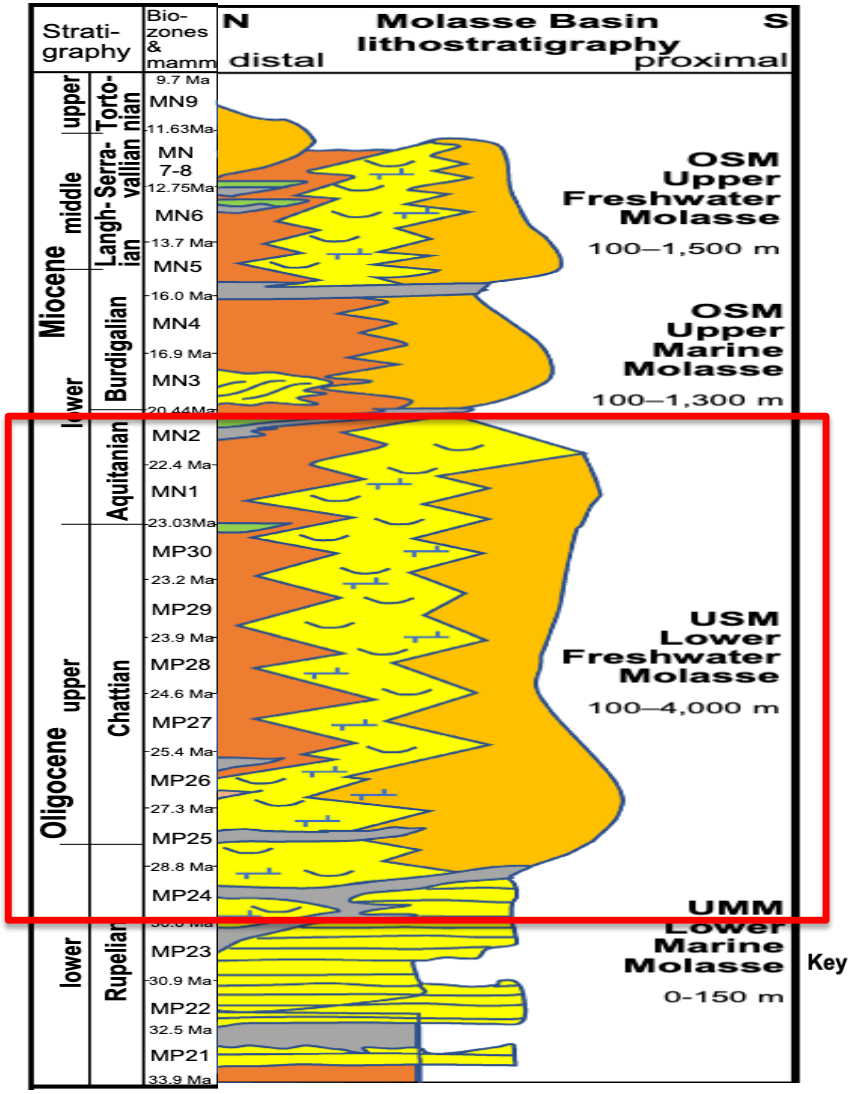


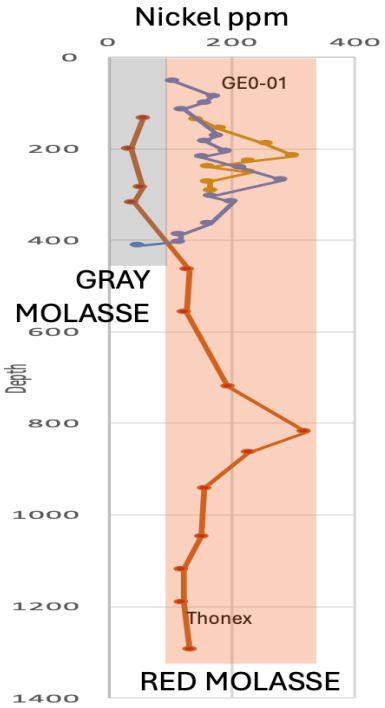
Oligocene - Miocene (28 - 12 million years)
Continental (fluvial and lacustrine) and coastal deposits: conglomerates, sandstone, clay (Molasse)

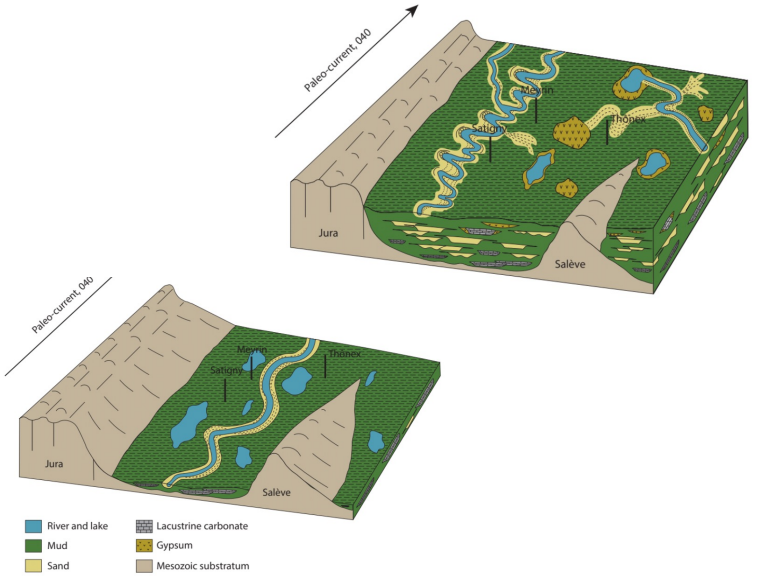

Eurasian plate
Atlantic
Ocean
Alpine orogen
Mer Pannonienne
Caucus
Zargos
orogen
30°
Arabian plate
African plate
28 Mln – Oligocene
0
400 km
0
400 mi


11/1896
Saleve
Aare Massif
Thrust front
Swiss Molasse Basin
Jura Mountains
km
0
-2
-4
-6
-8
25 km
SE
NW

The Molasse







The literature credits de Saussure (1779-1796) with introducing the word Molasse. Studer (1825) and Merian (1836, 1838) defined the stratigraphic succession that is still used today.

Molasse outcrops at the bottom of Lac Léman (Reposoir)

http://plongeesanssel.com/reposoir--ge-.html

traces of quarrying are clearly visible: from the digging of a dividing line to the cutting striations.

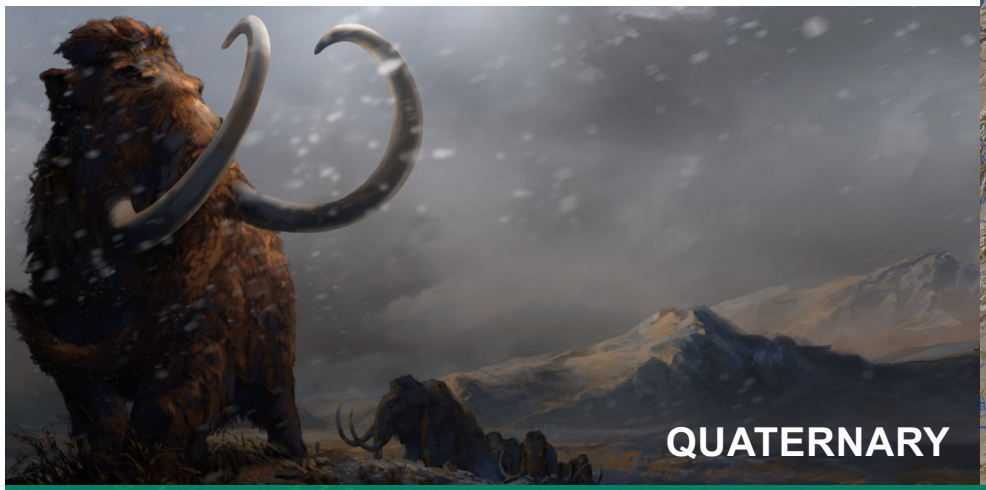
Wolhusen (Kleine Emme River), UFM

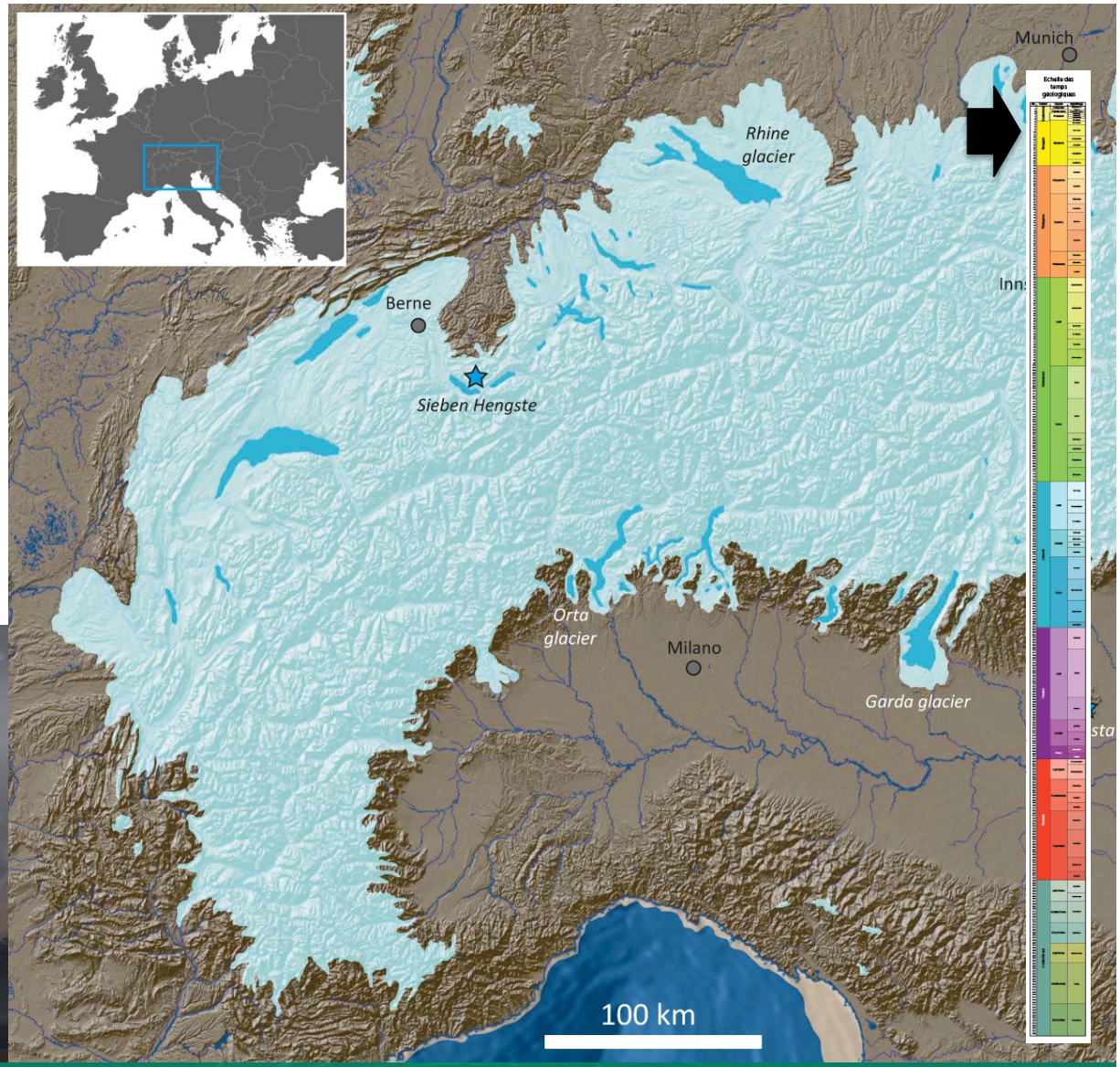
Stacked fluvial sandstone interbedded with flood plain shales

Fluvial deposits of the
Freshwater Molasse
Roulavaz (Allondon)

THE ICE AGE

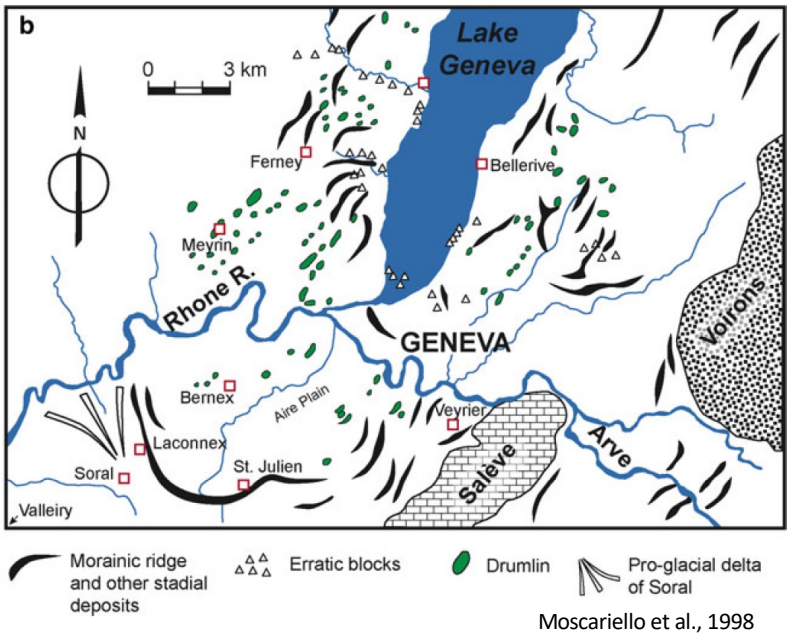
			Alpine stratigraphy	Nordic stratigraphy
	Holocene	11,7 Ka	Post-glacial	Holocene
Quaternary	Pleistocene	Late Pleistocene	Tardi-glacial	Weichselian
		115 Ka	Würm	
		130 Ka	Interglacial	Eemian
		300 Ka	Riss	Saalien
		Middle Pleistocene	Interglacial	Holsteinian
		650 Ka	Mindel	Elsterian
		780 Ka	Interglacial	Comarian complex
		Early Pleistocene	Gunz	Bavelian
				Menapian
			Interglacial	waalian
		2,6 Ma		Eburonian



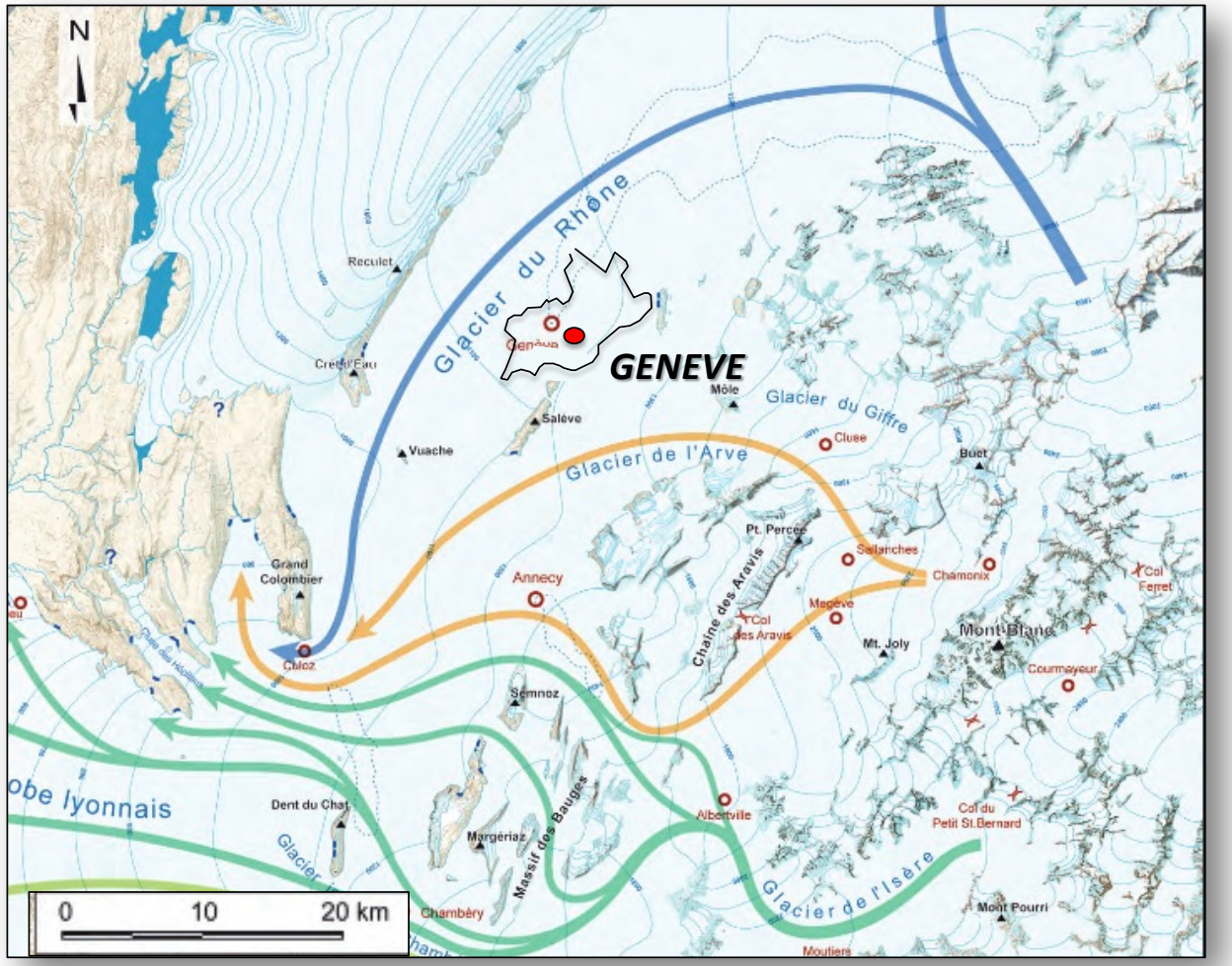


Chronostratigraphy

In the Geneva basin and neighboring France, only **two major glaciations** are recorded



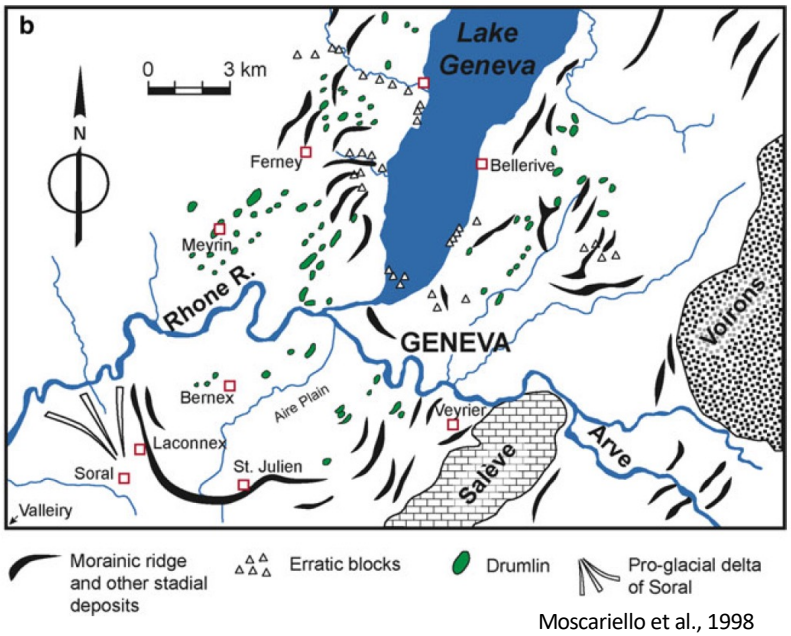
Moscariello et al., 1998



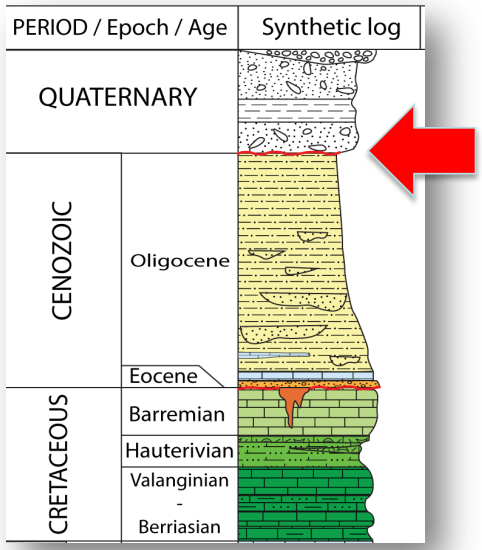
(modified after Coutterand, 2010)

Chronostratigraphy

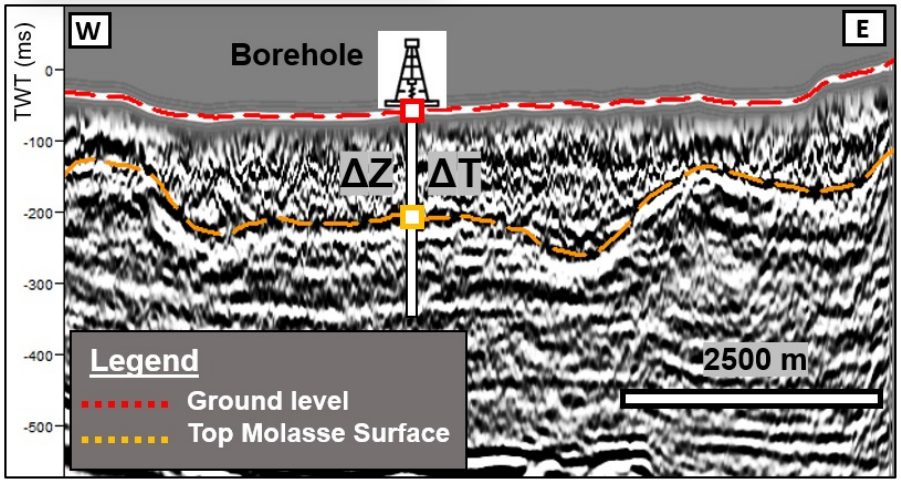
In the Geneva basin and neighboring France, only **two major glaciations** are recorded

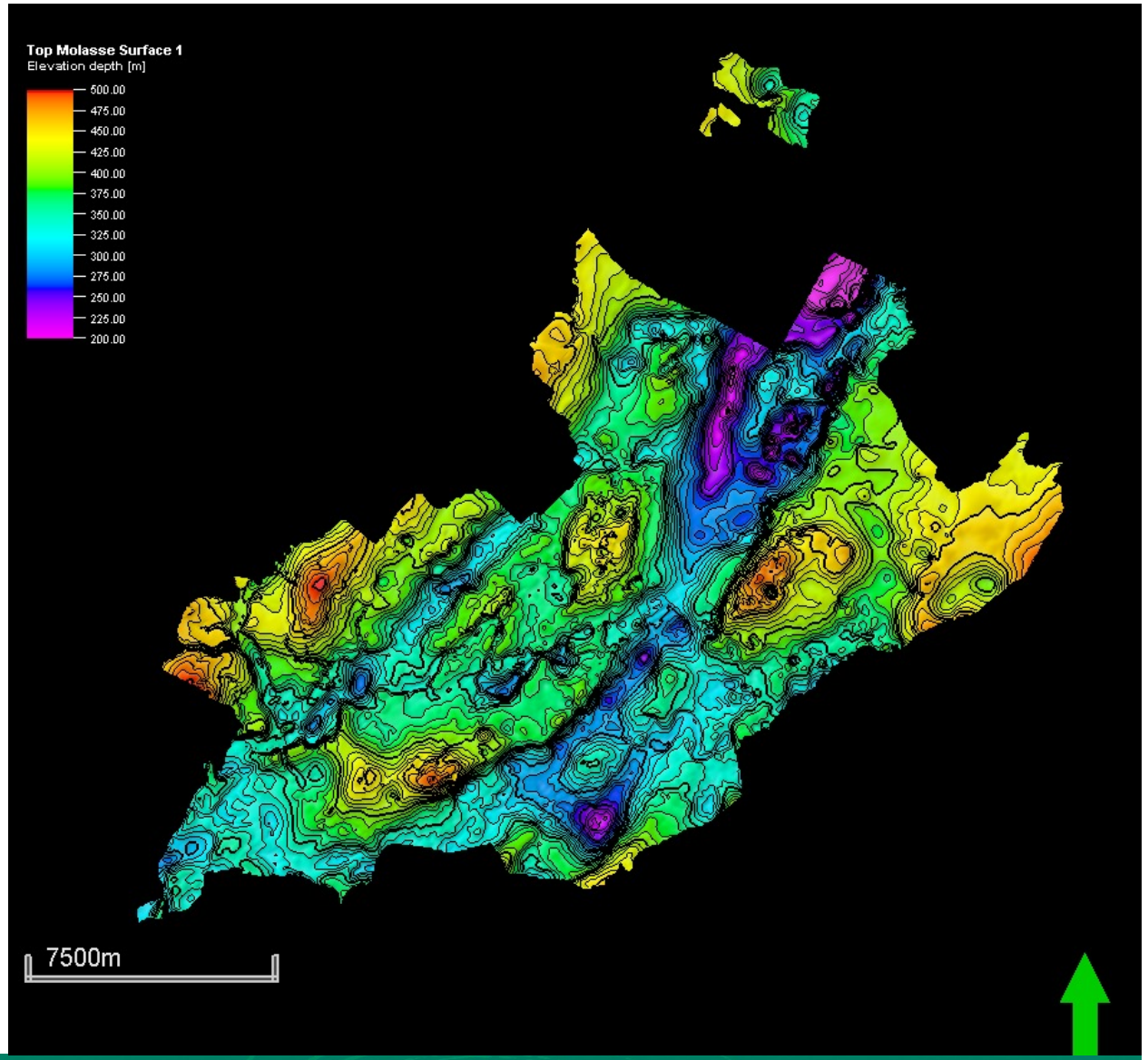


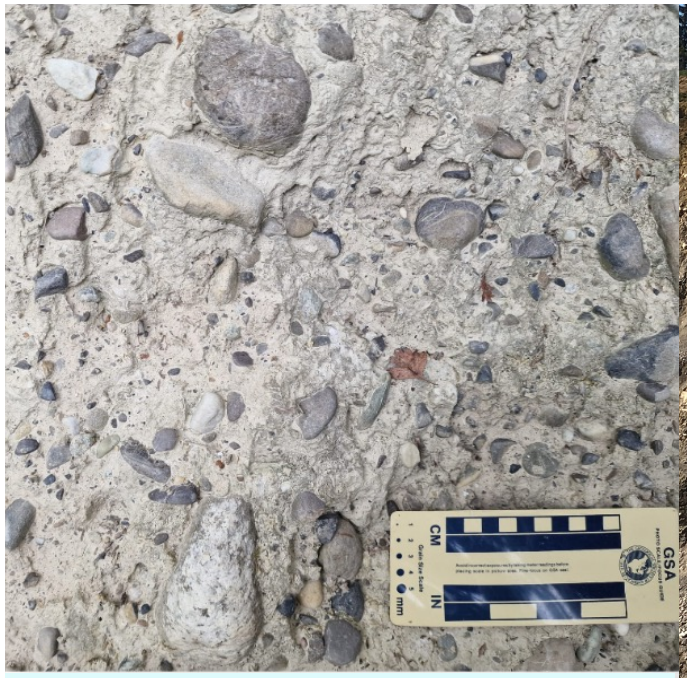
Moscariello et al., 1998



Base of Quaternary Deposits

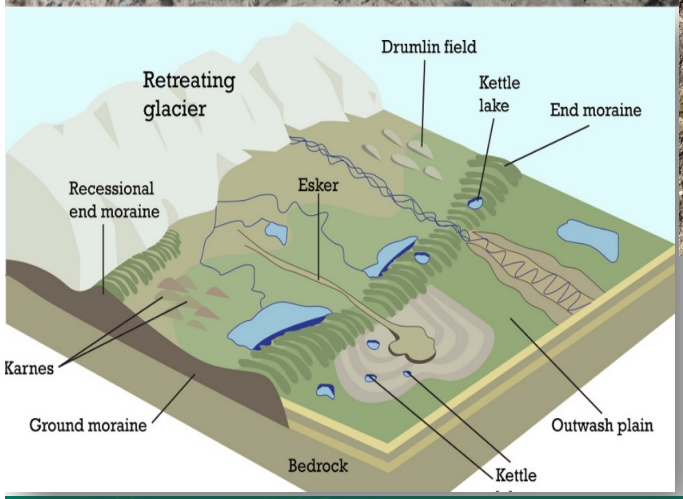


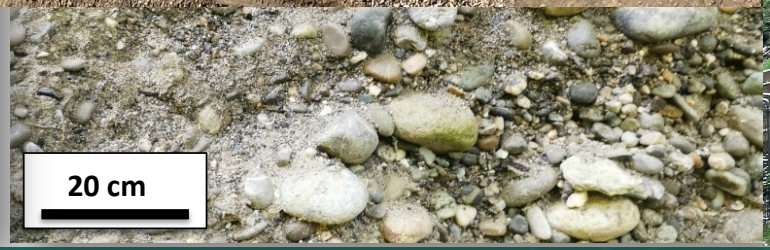



CM
GSA


5m


CM


Retreating glacier
Drumlin field
Kettle lake
End moraine
Recessional end moraine
Esker
Karnes
Ground moraine
Bedrock
Kettle
Outwash plain

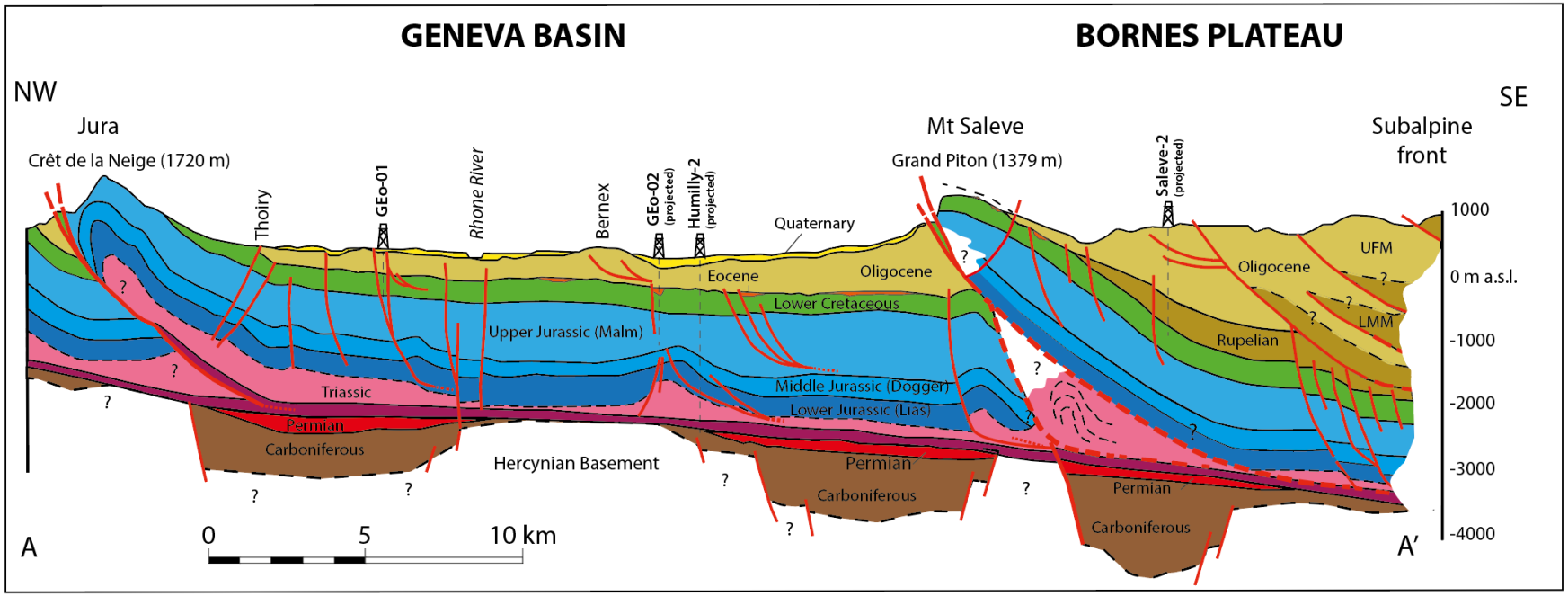

20 cm

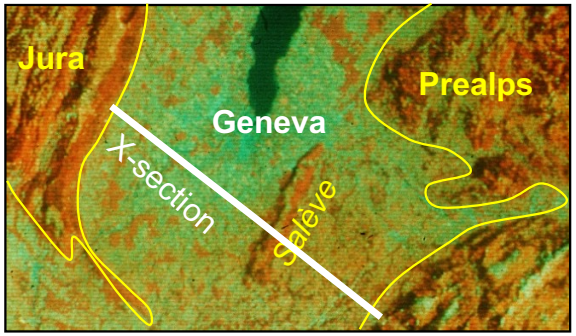

5m

Improving the understanding of the geology Geneva basin and neighbouring France

WHAT'S NEXT ?

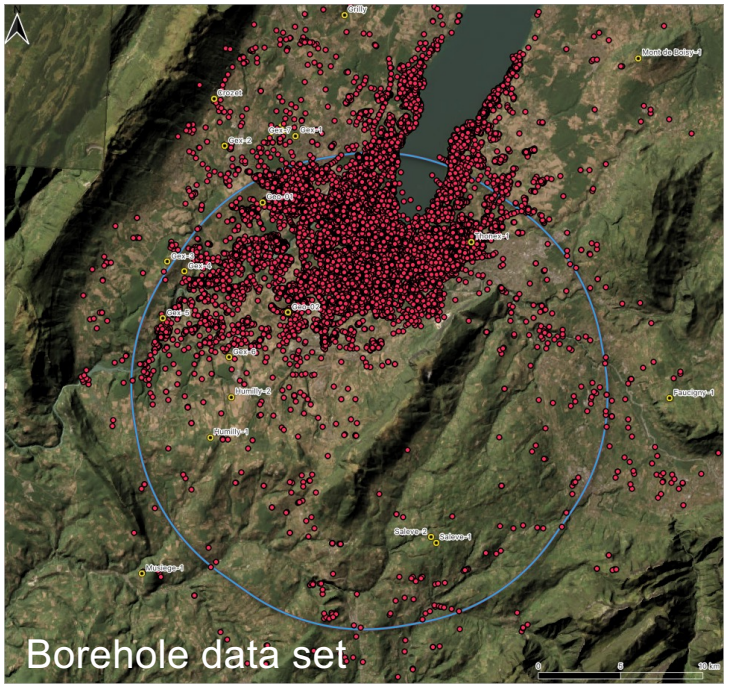
FAULTS AND FOLDING IN THE GENEVA REGION



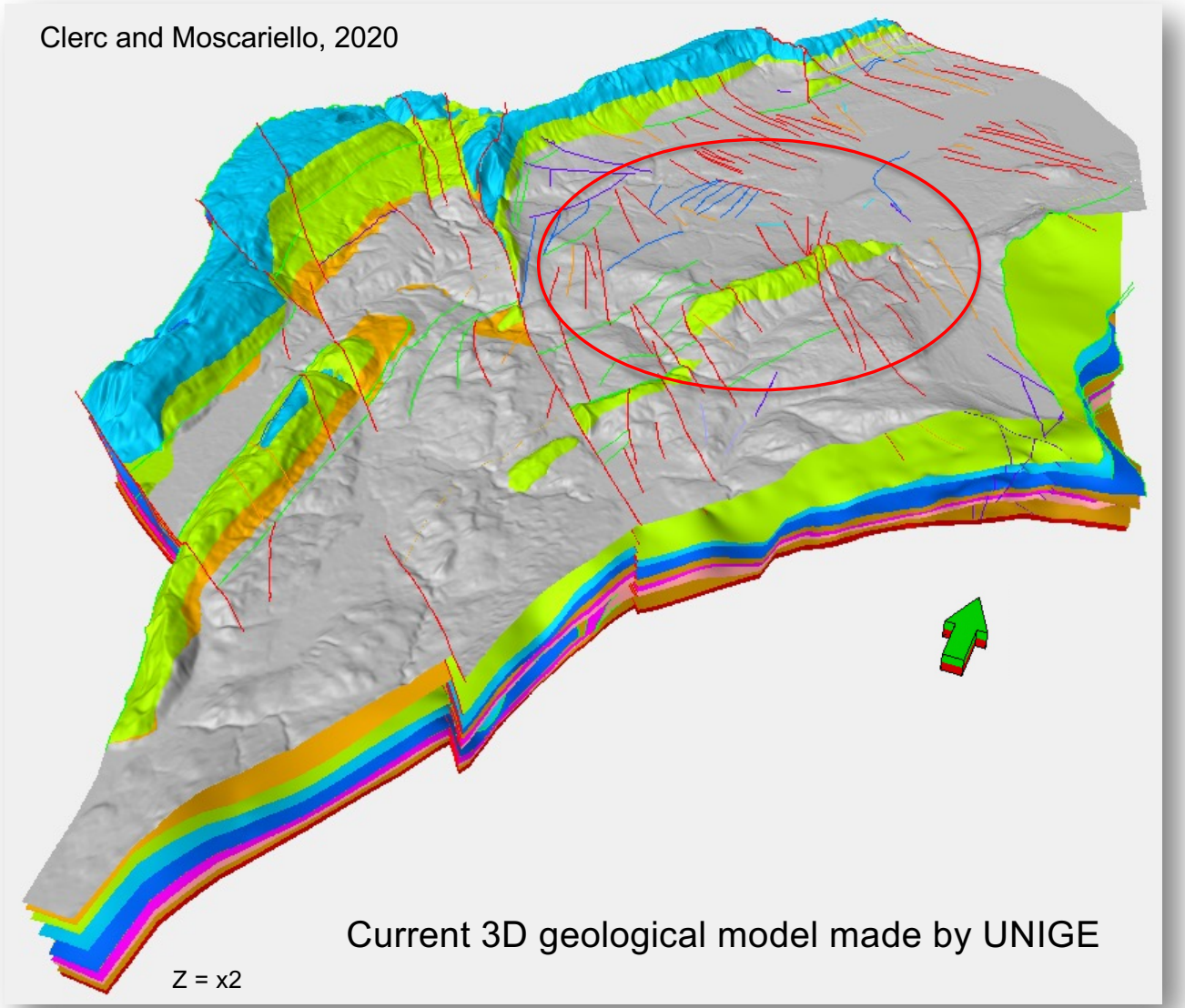


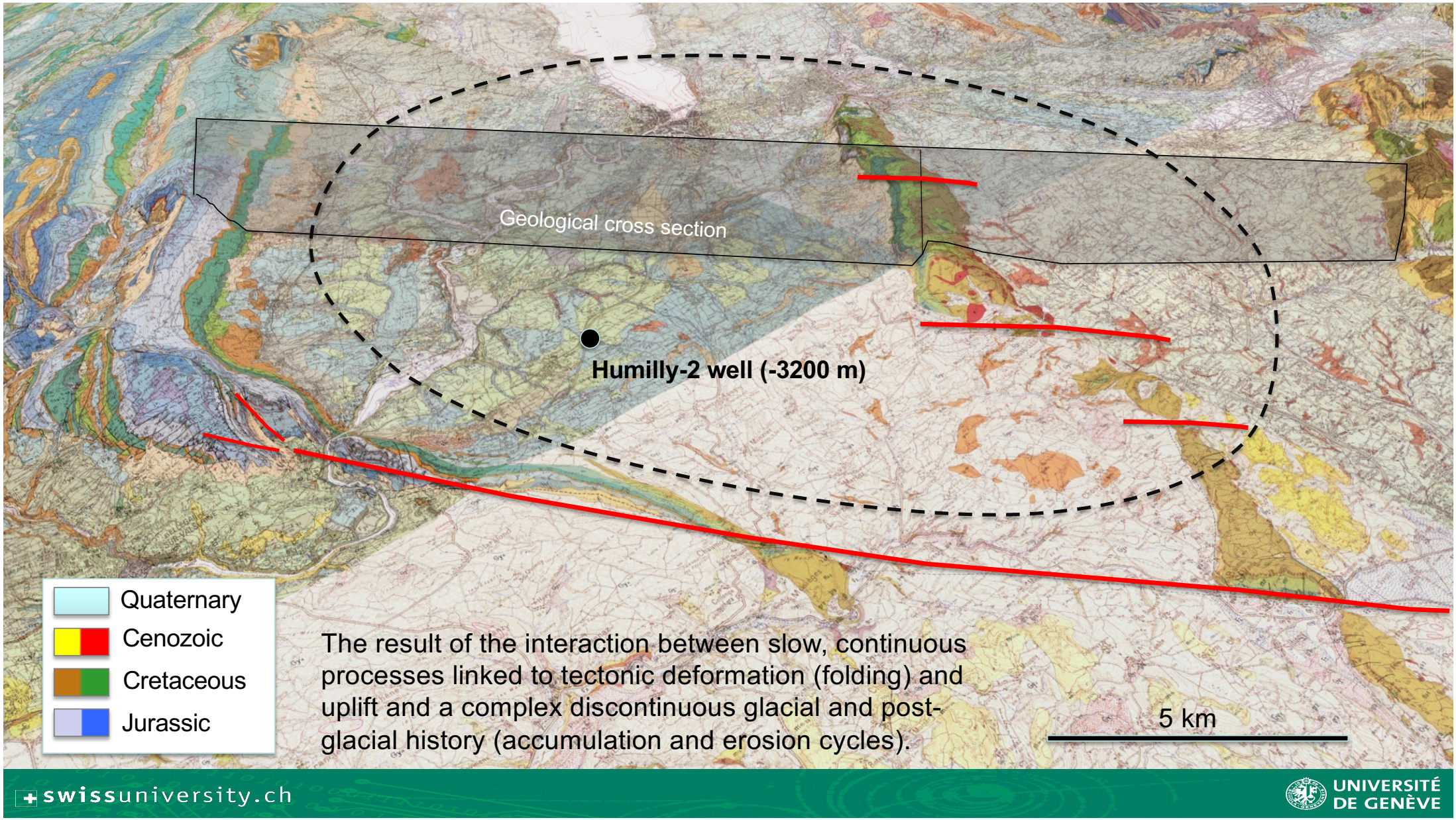
A record of sedimentary and tectonic process lasted of 300 mln of years

3D Geological model

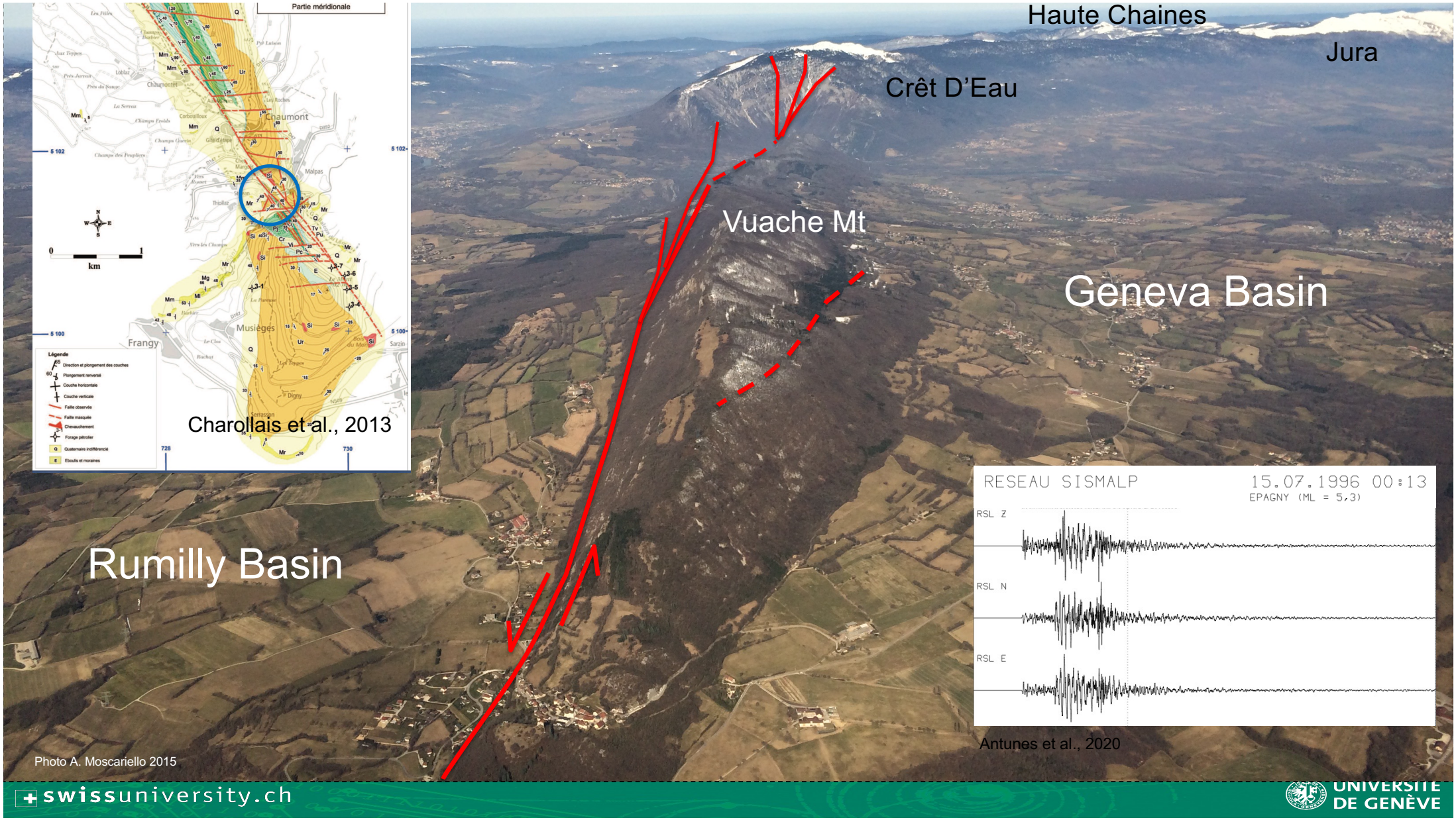


Clerc and Moscariello, 2020

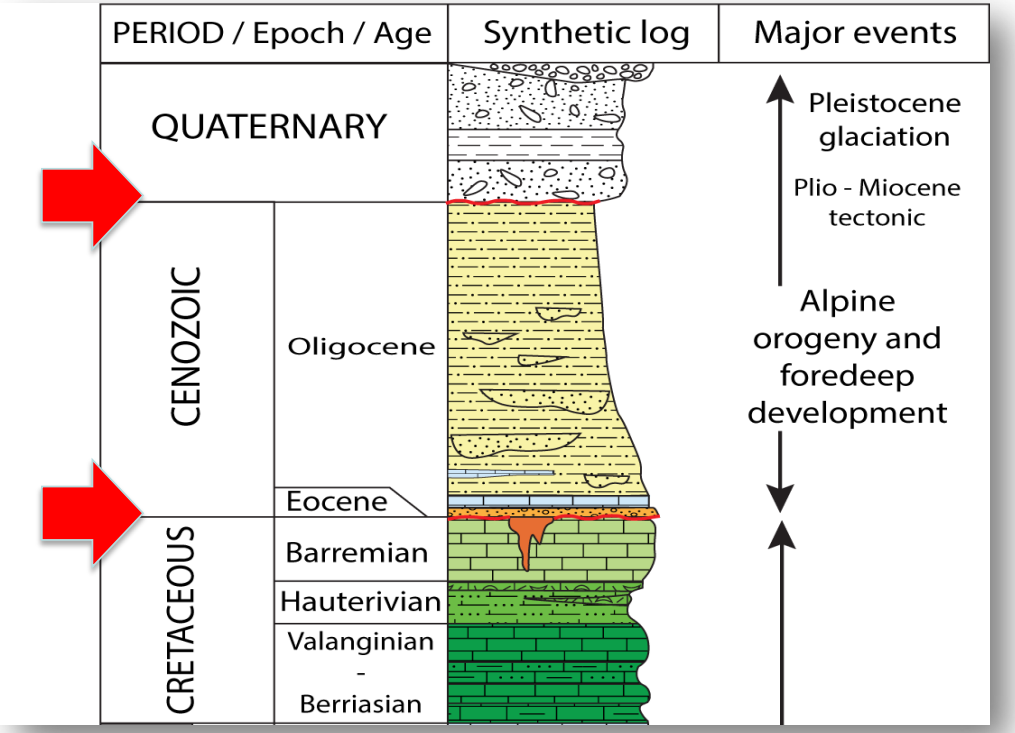


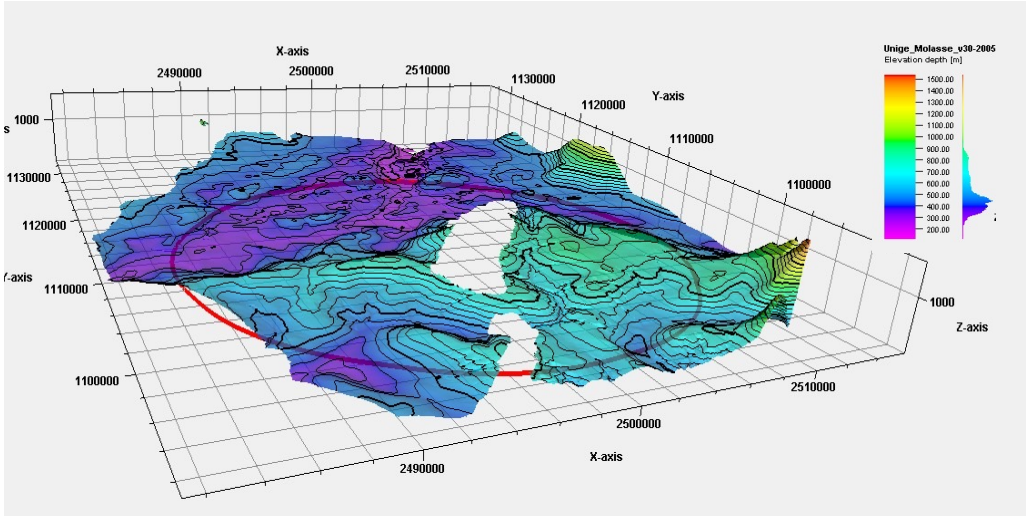


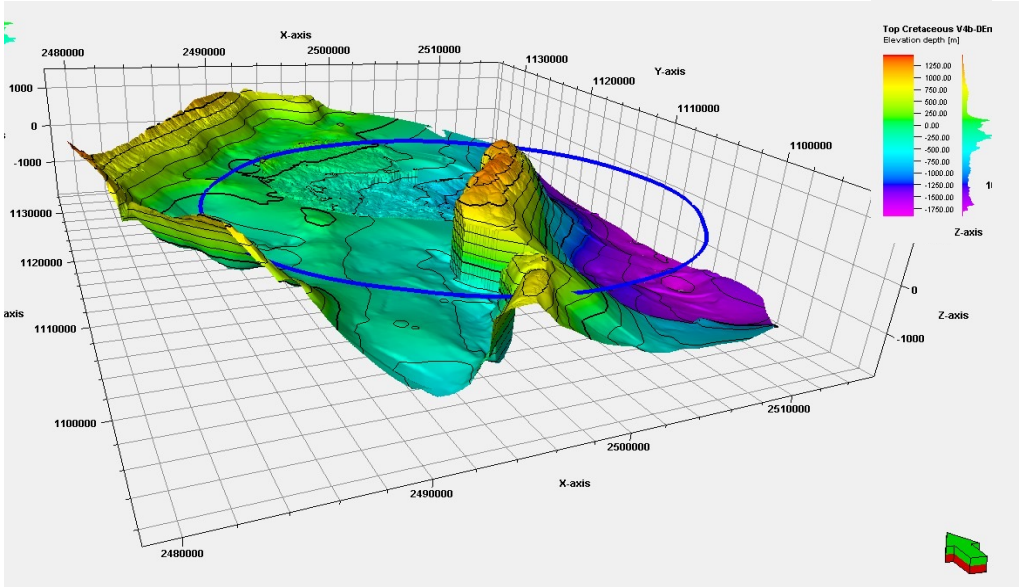
The result of the interaction between slow, continuous processes linked to tectonic deformation (folding) and uplift and a complex discontinuous glacial and post-glacial history (accumulation and erosion cycles).


Haute Chaines
Jura
Crêt D'Eau
Vuache Mt
Geneva Basin
Rumilly Basin
Partie méridionale
Chaumont
Malpas
Musièges
Frangy
Légende
km
Charollais et al., 2013
RESEAU SISMALP
15.07.1996 00:13
EPAGNY (ML = 5,3)
RSL Z
RSL N
RSL E
Antunes et al., 2020
Photo A. Moscariello 2015

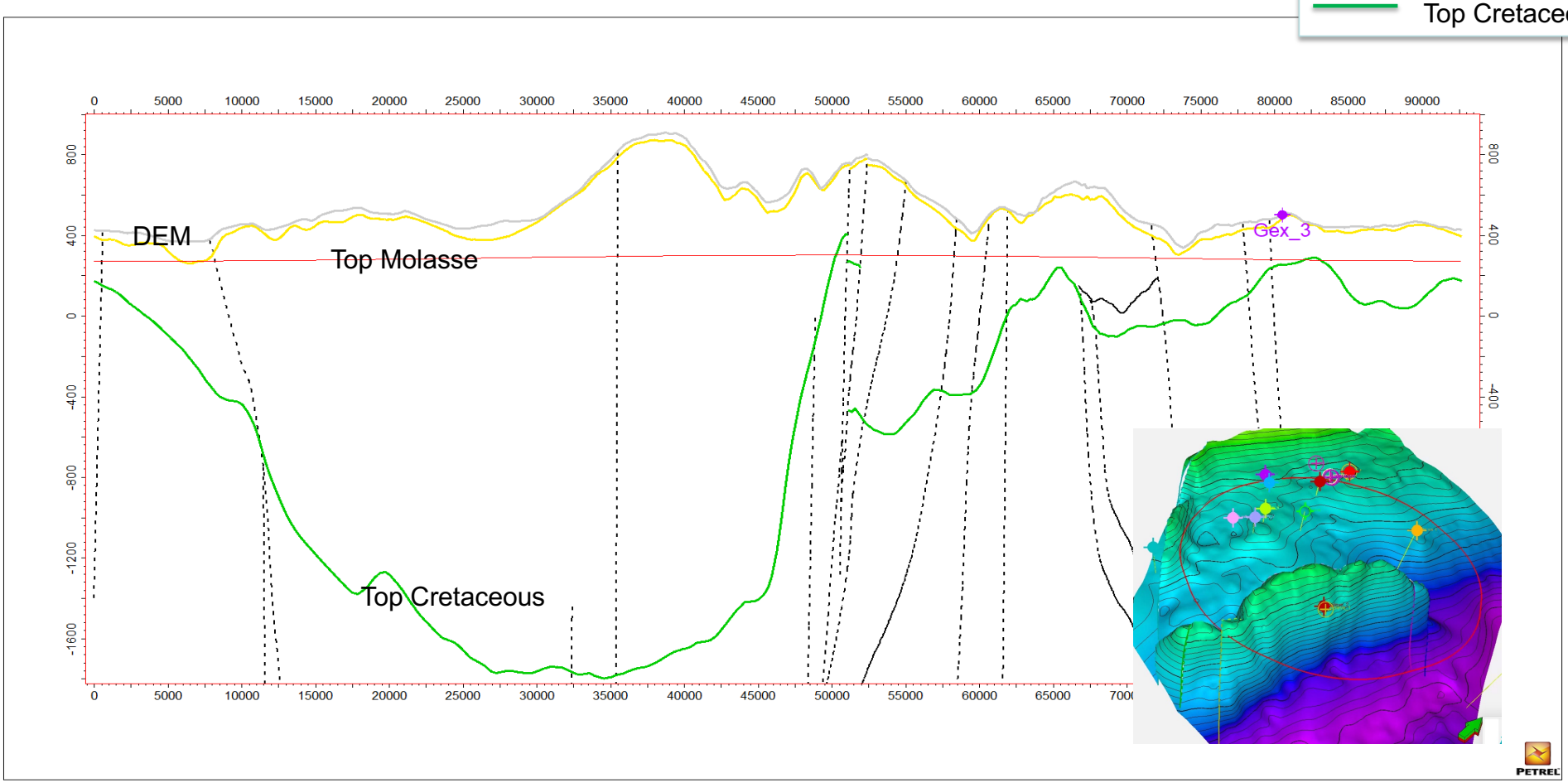
Subsurface modelling for the FCC trace



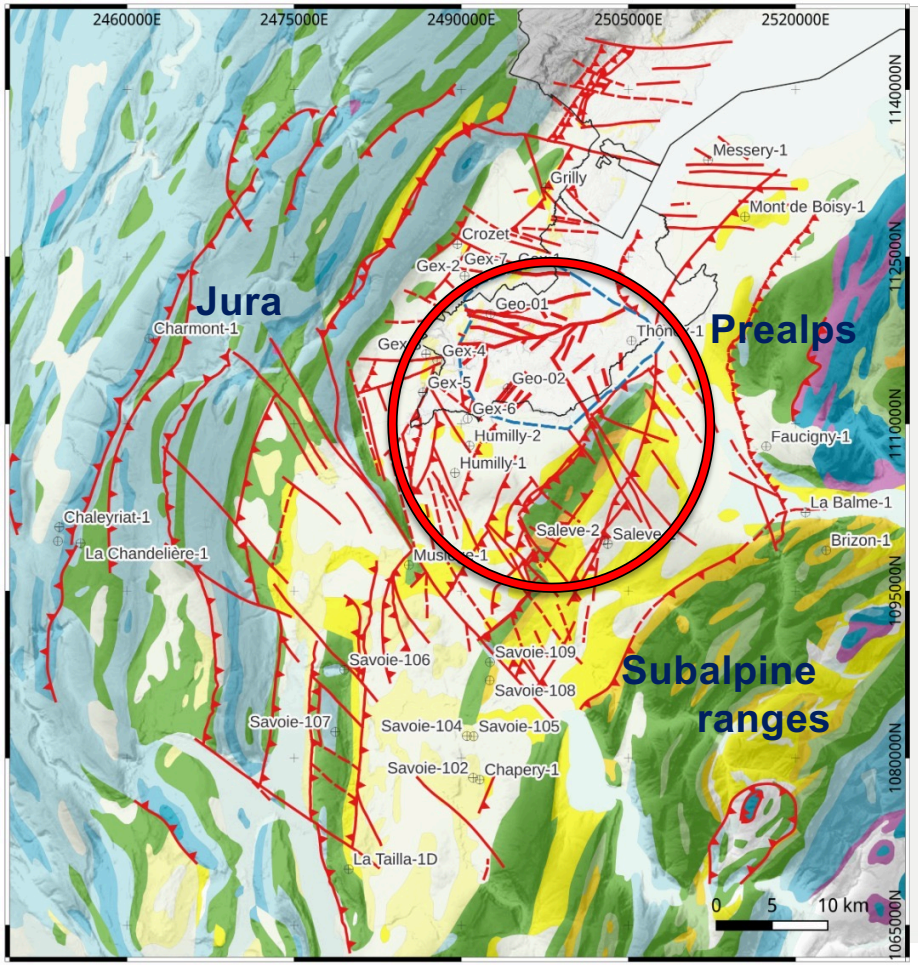


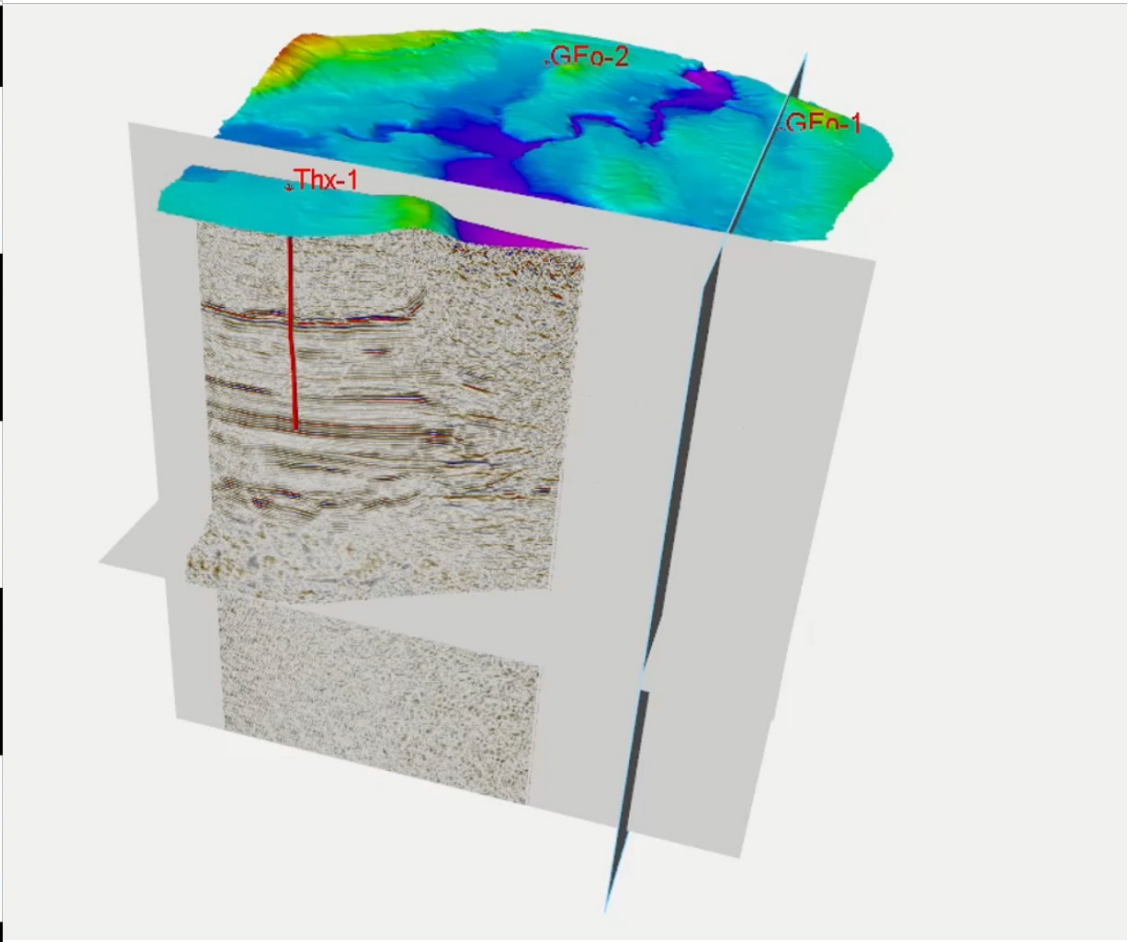


Section PA 3.5-06



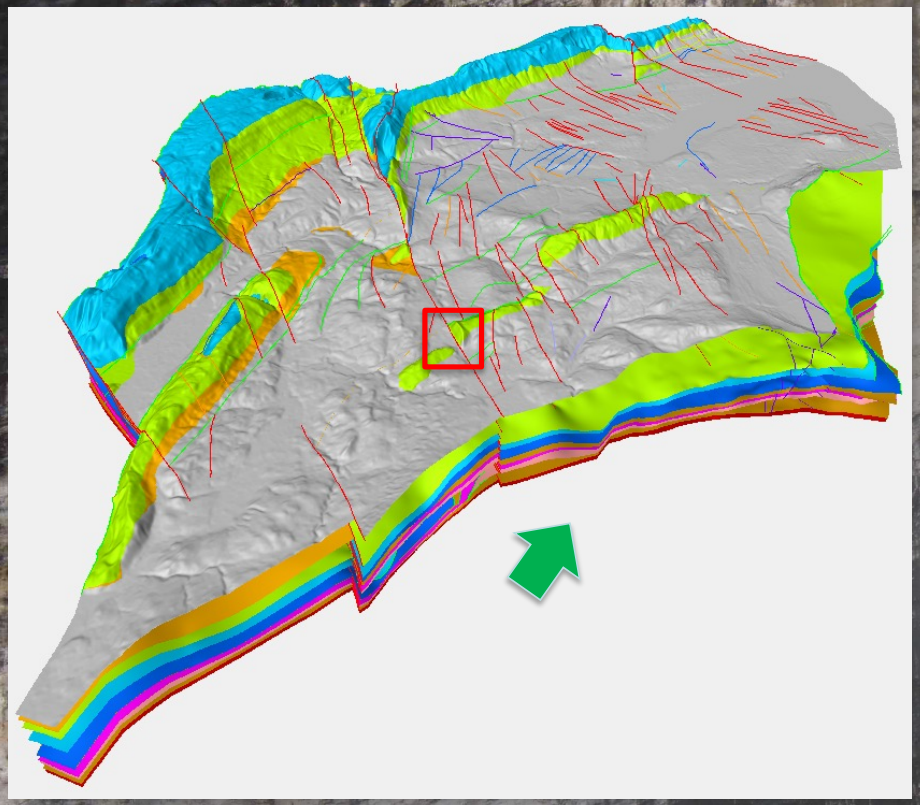
Continuous effort to improve the geological model

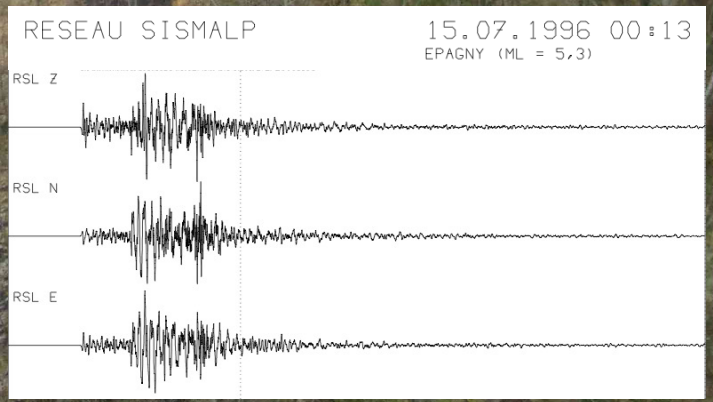




Conclusions

- The knowledge of the 300 mln years-old subsurface geology of the Geneva Basin has tremendously improved over the last 10 years.
- This provides a great benefit for the design and execution of large infrastructures such as the FCC.
- Still, areas of high geological uncertainties exist and will be addressed by further investigations aiming at improving the reliability of our subsurface geological model.





Vuache Fault, La Mandellaz Mt.

Aknowledgement

- CERN FCC Team
- UNIGE FCC TEAM


Emna Meftah


Ovie Eruteya


Yasin Makhloufi


Thank you
Photo C. Chelle-Michou