

Structure profonde du Bassin Molassique

Potentiel pour la géothermie et les hydrocarbures

(Potentiels pour les Ressources Naturelles)

Jon Mosar

Anna Sommaruga

Marius Gruber

Naomi Vouillamoz

Martinus Abednego

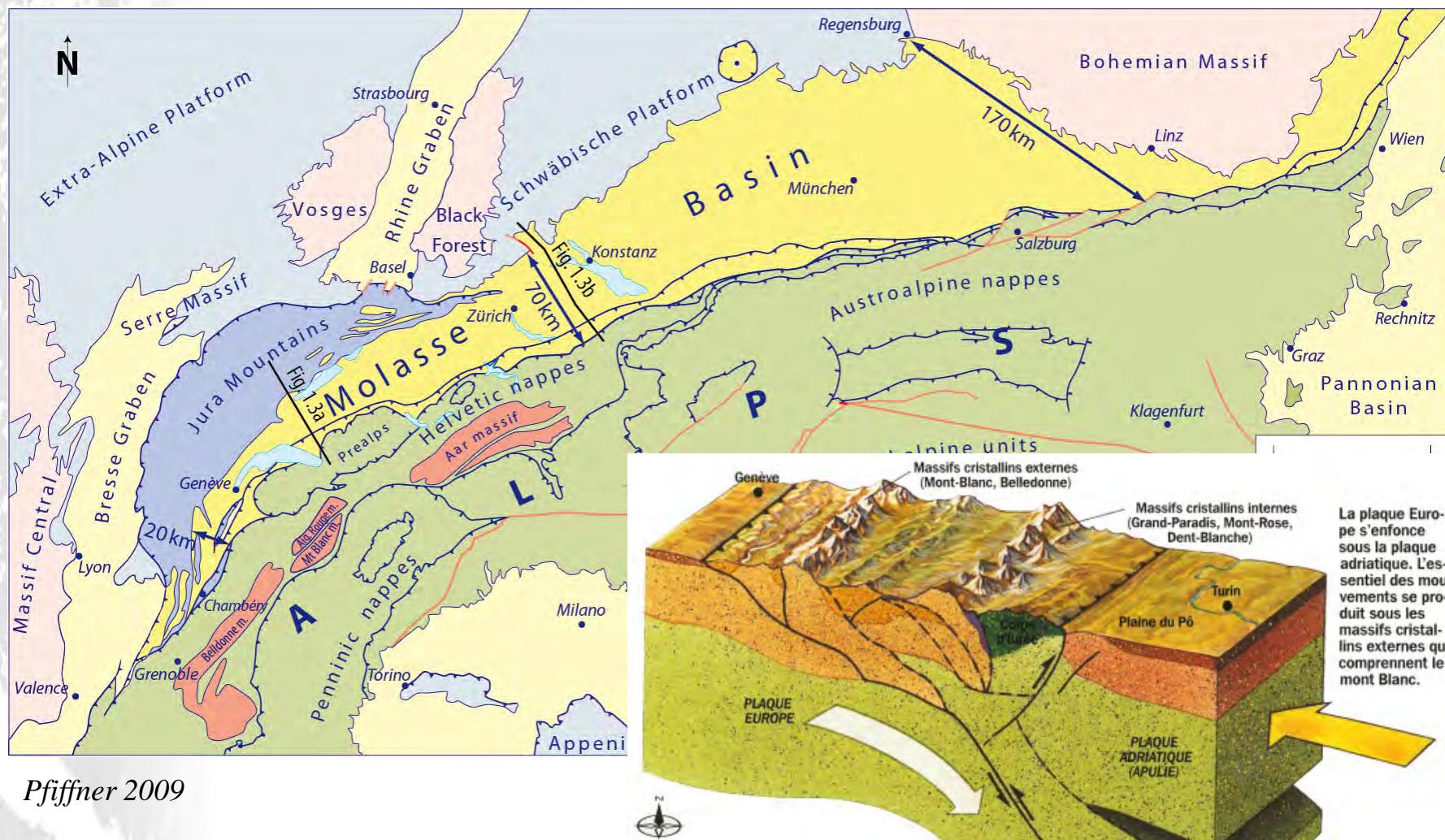
Daniel Egli

Tobias Ibele

Département de Géosciences
Sciences de la Terre
Université de Fribourg

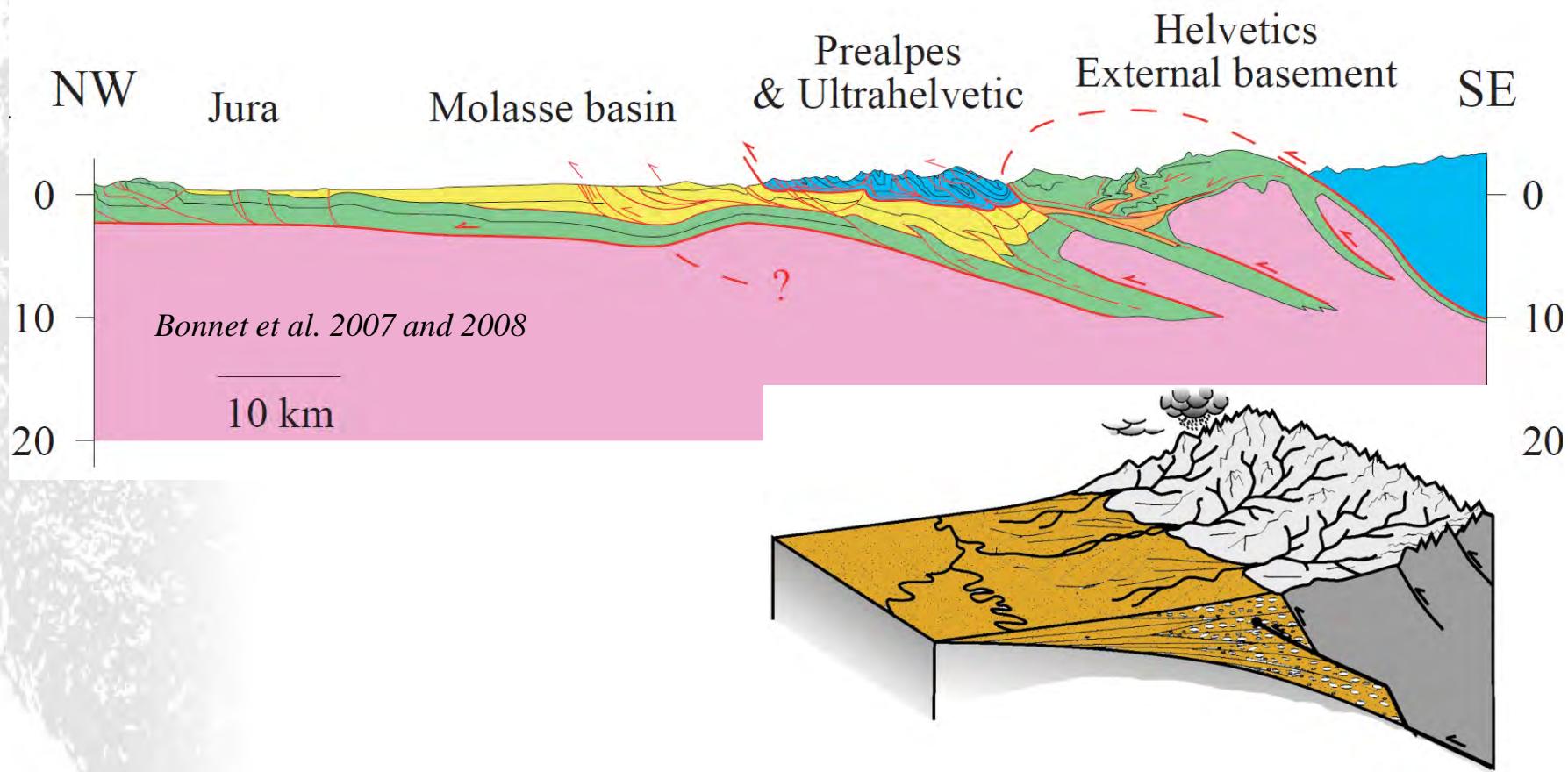
- *Géologie régionale 3D, fractures*
- *Potentiel des Ressources Naturelles*
(Hydrocarbures, Géothermie, Séquestration CO₂)
- *Méthodes d'exploration/exploitation vs. Risques*
(Hydrofracturation, Stimulation, Sismicité induite, Pollution)
- *Sismicité dans le canton de Fribourg*
- *Conclusions*
- *Perspectives*

Le Bassin Molassique dans la chaîne Alpine



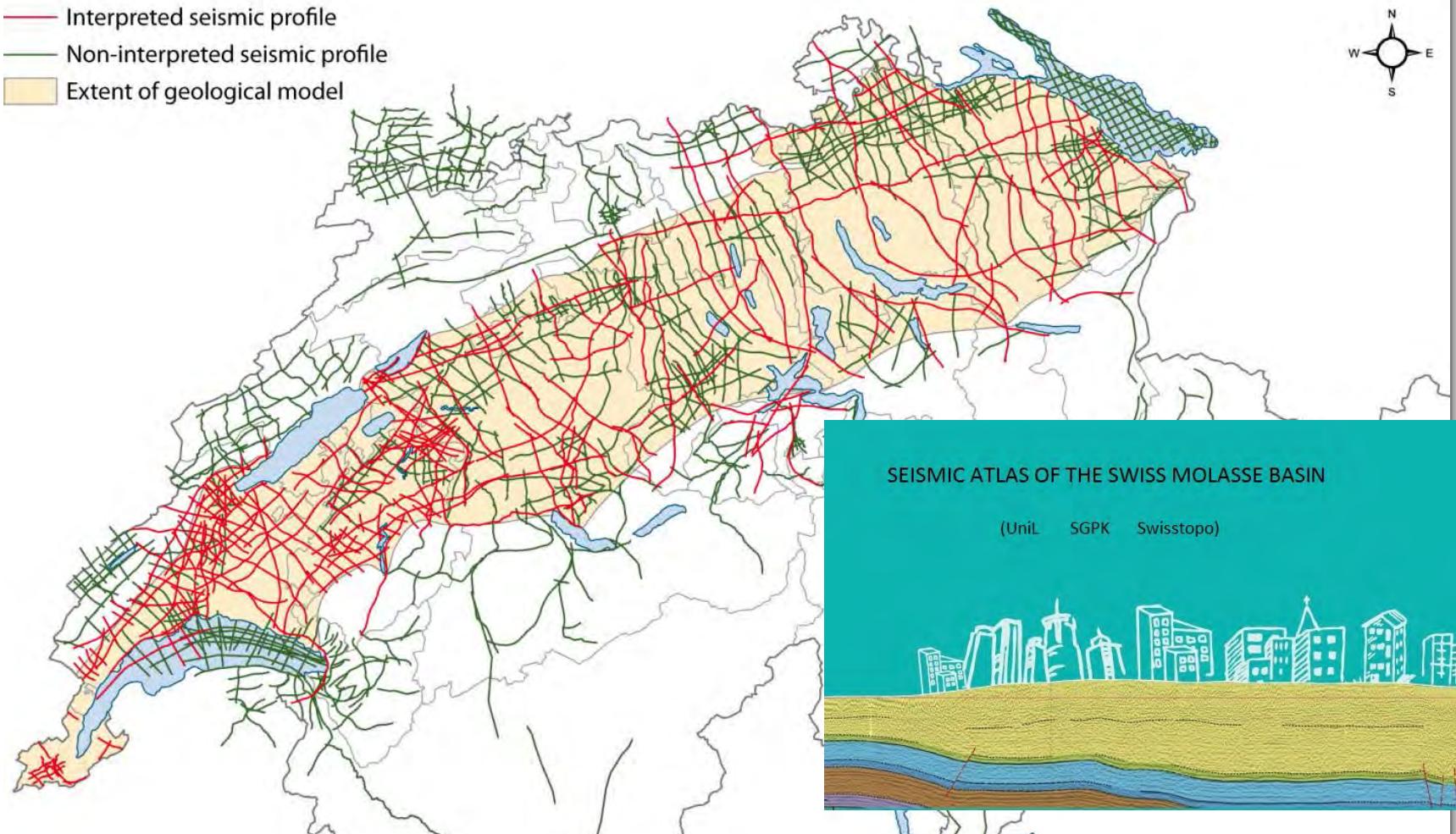
Pfiffner 2009

Bassin Molassique - Bassin d'avant pays



Profils sismiques / exploration pétrolière en Suisse

- Interpreted seismic profile
- Non-interpreted seismic profile
- Extent of geological model

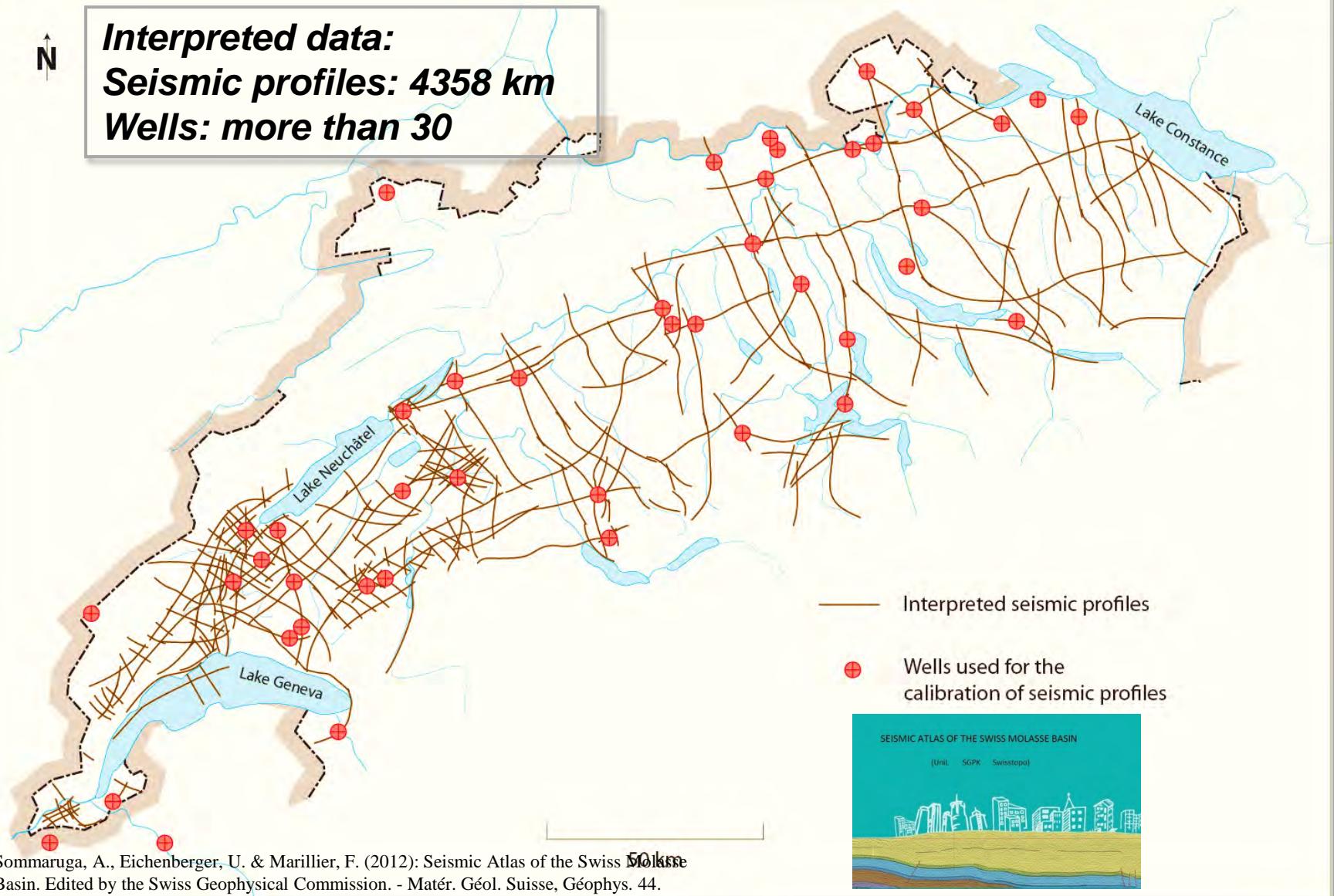


- 871 seismic lines in CH, 263 of which were interpreted in the SASMB project
- 12'039 km seismic profiles in CH, 4'358 km interpreted lines in the SAMB project

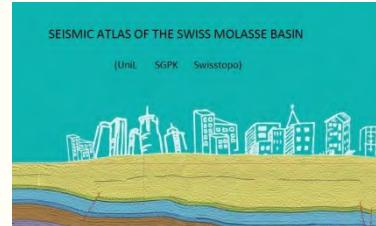
Profils sismiques interprétés et forages profonds

N

**Interpreted data:
Seismic profiles: 4358 km
Wells: more than 30**



Sommaruga, A., Eichenberger, U. & Marillier, F. (2012): Seismic Atlas of the Swiss Molasse Basin. Edited by the Swiss Geophysical Commission. - Matér. Géol. Suisse, Géophys. 44.



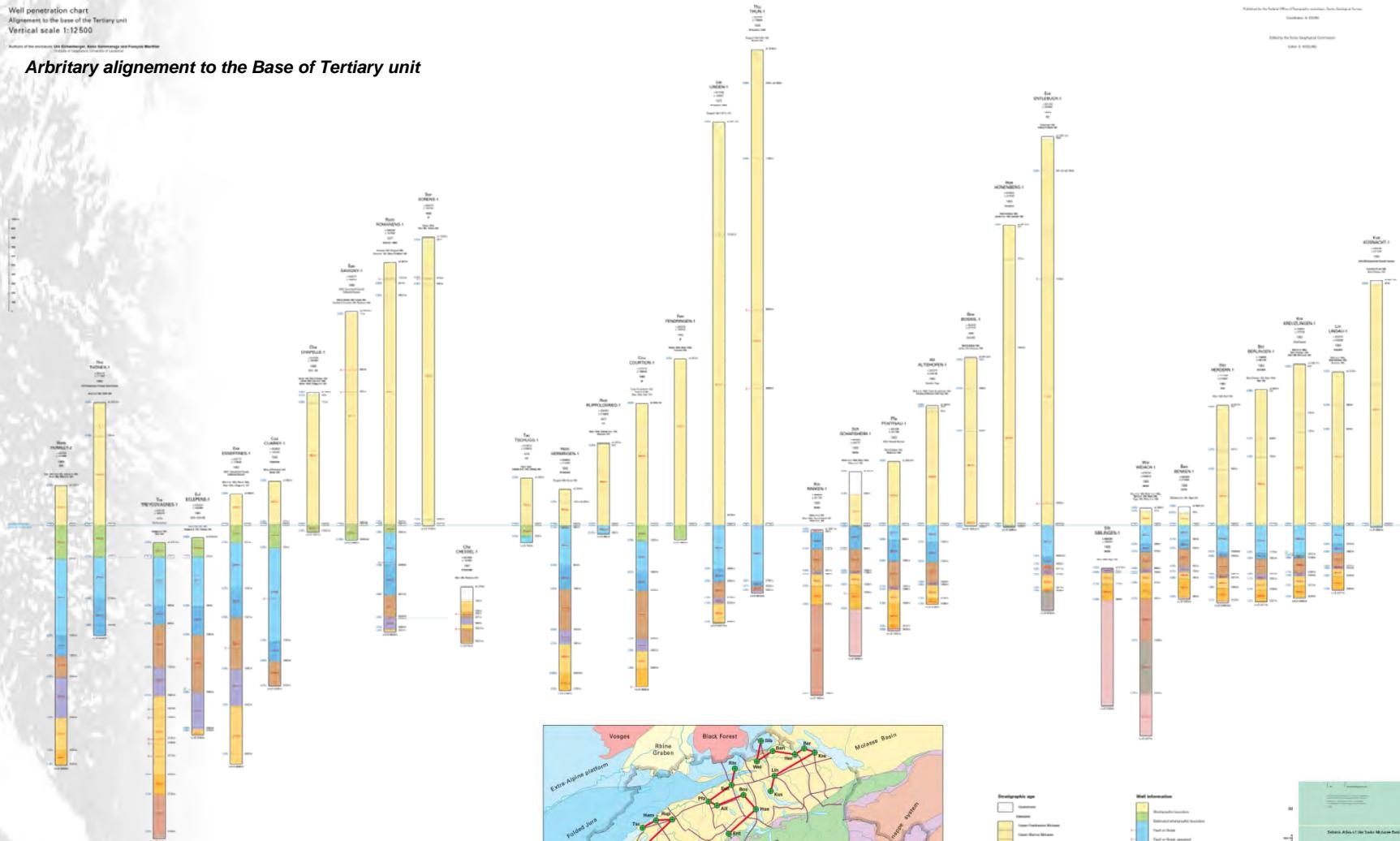
Bassin Molassique - Stratigraphie - Forages

Well penetration chart
Alignment to the base of the Tertiary unit
Vertical scale 1:12 500

Author of the enclosure: Ute Eichenberger, Anne Sommaruga and Philippe Marillier
Institute of Geological Sciences, University of Zurich

Attributed to the Federal Office of Topographic Survey, Swiss Federal Institute
Coordinate: N5400
Author of the Swiss Geophysical Commission
Coordinate: N5400

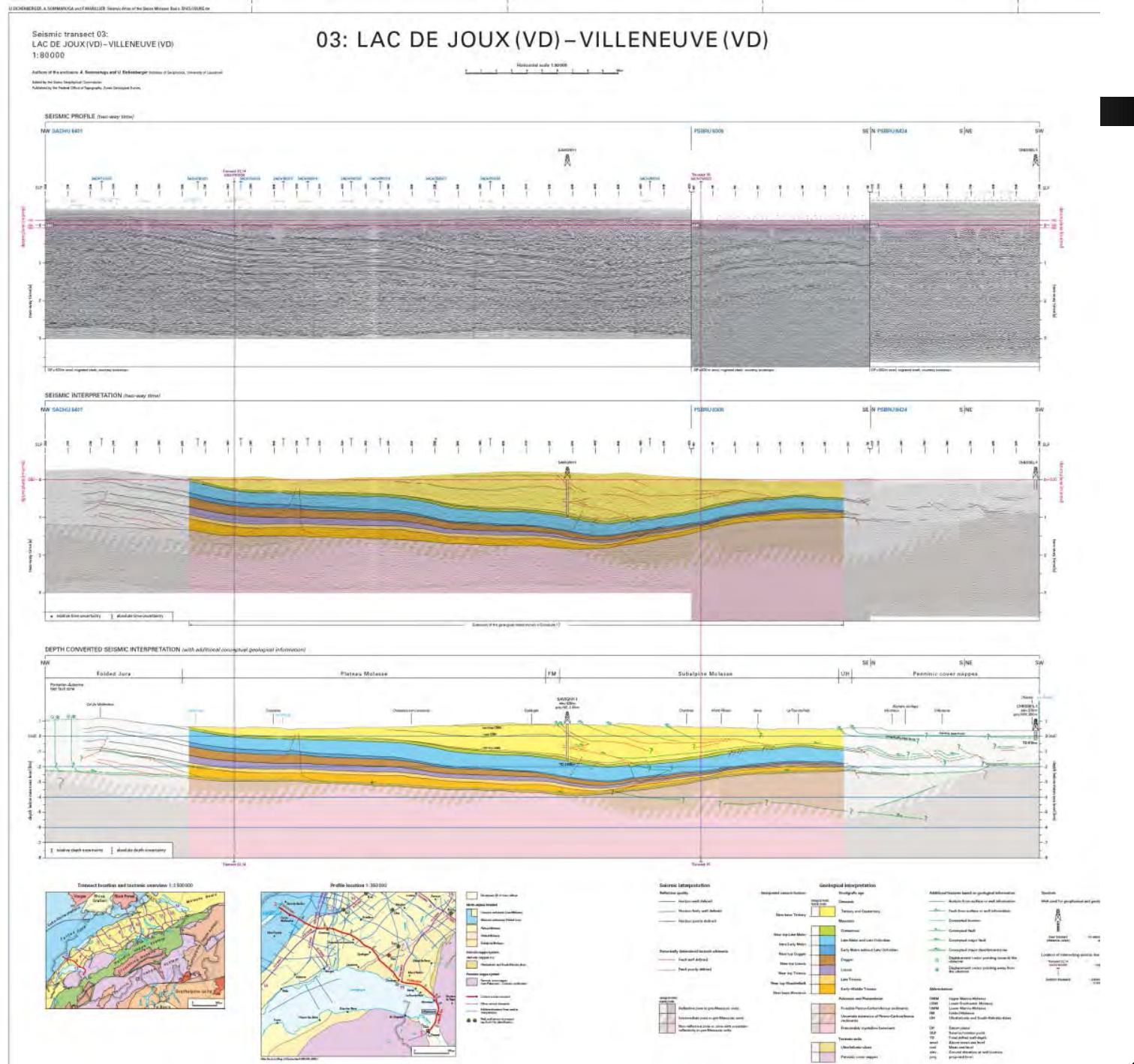
Arbitrary alignment to the Base of Tertiary unit



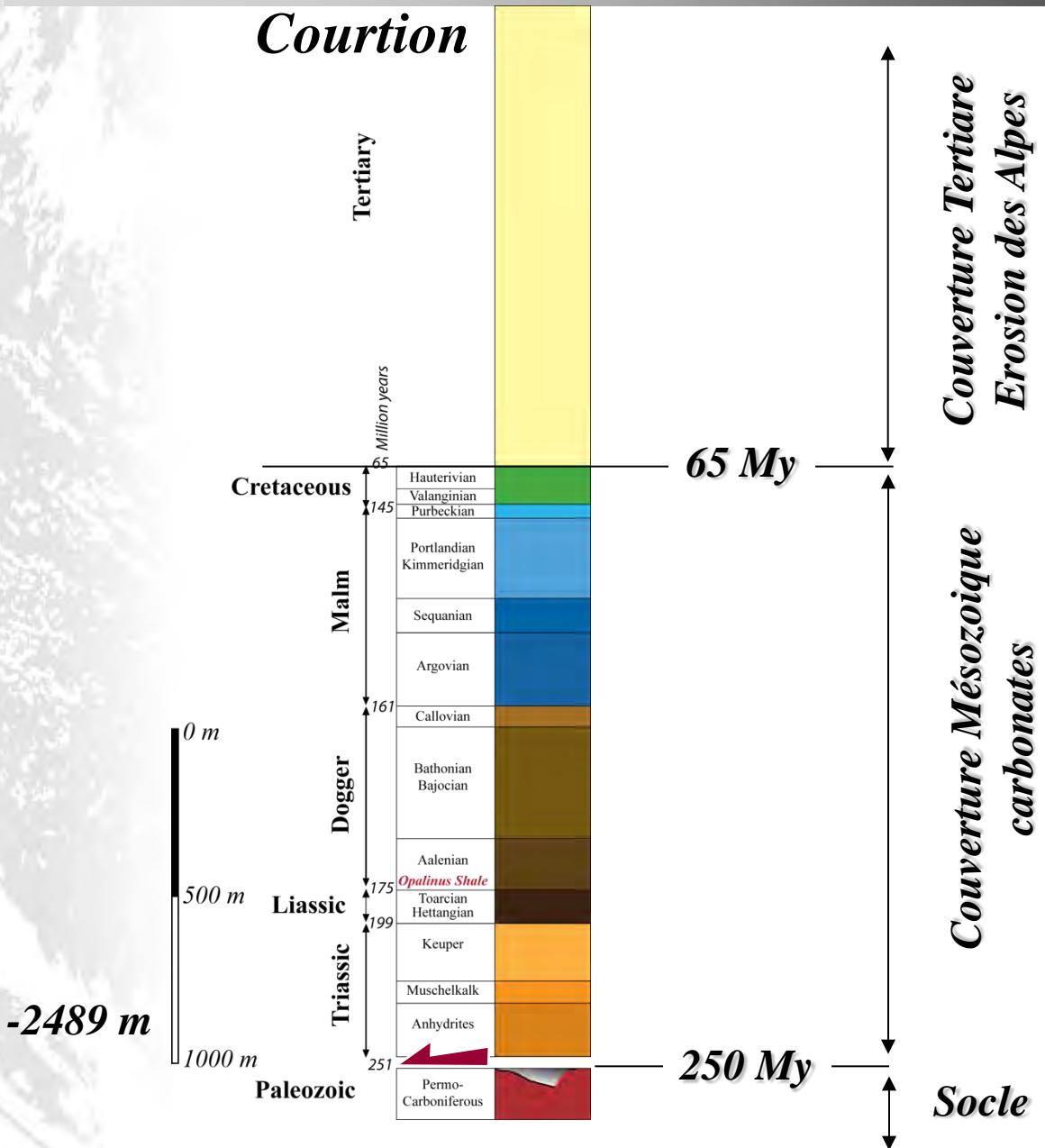
Atlas Enclosure 16

Sommaruga, A., Eichenberger, U. & Marillier, F. (2012): Seismic Atlas of the Swiss Molasse Basin. Edited by the Swiss Geophysical Commission. - Matér. Géol. Suisse, Géophys. 44.

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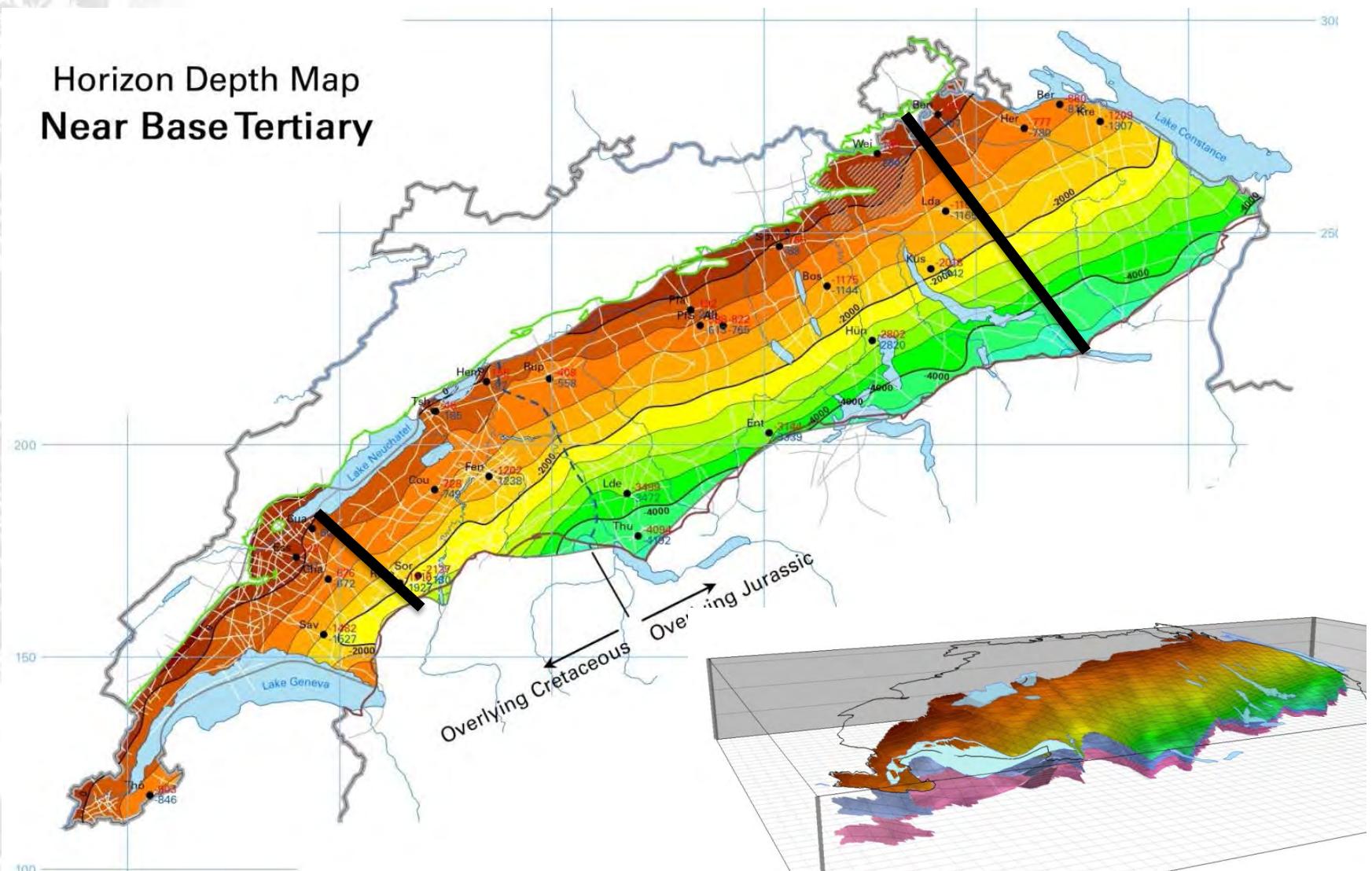


Bassin Molassique - Stratigraphie - Forages

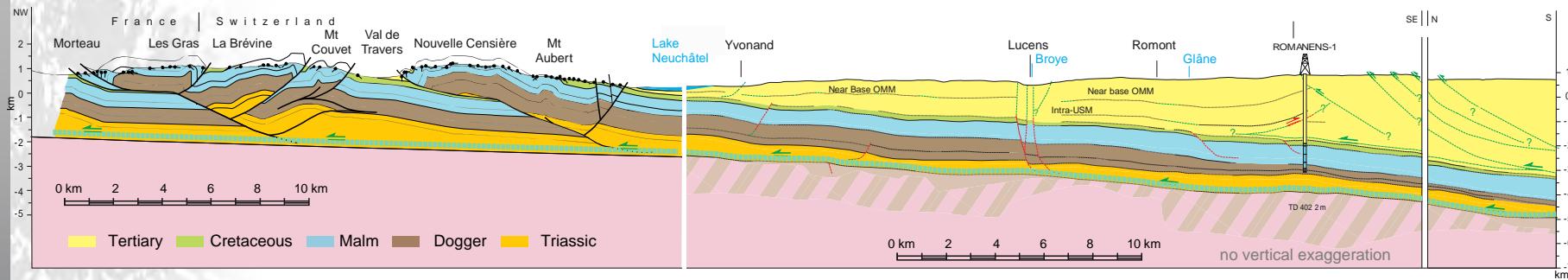


Bassin Molassique - 3D

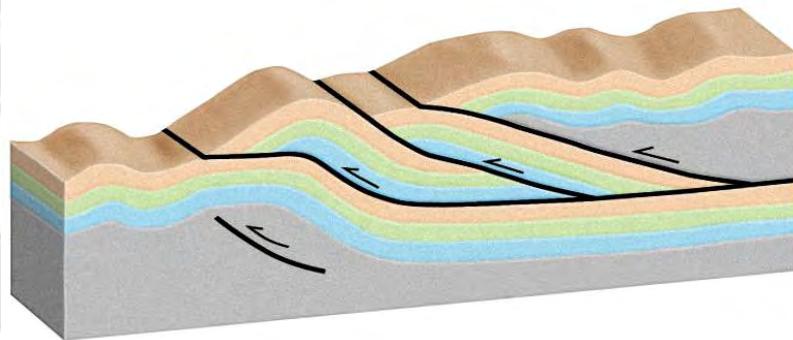
Horizon Depth Map
Near Base Tertiary



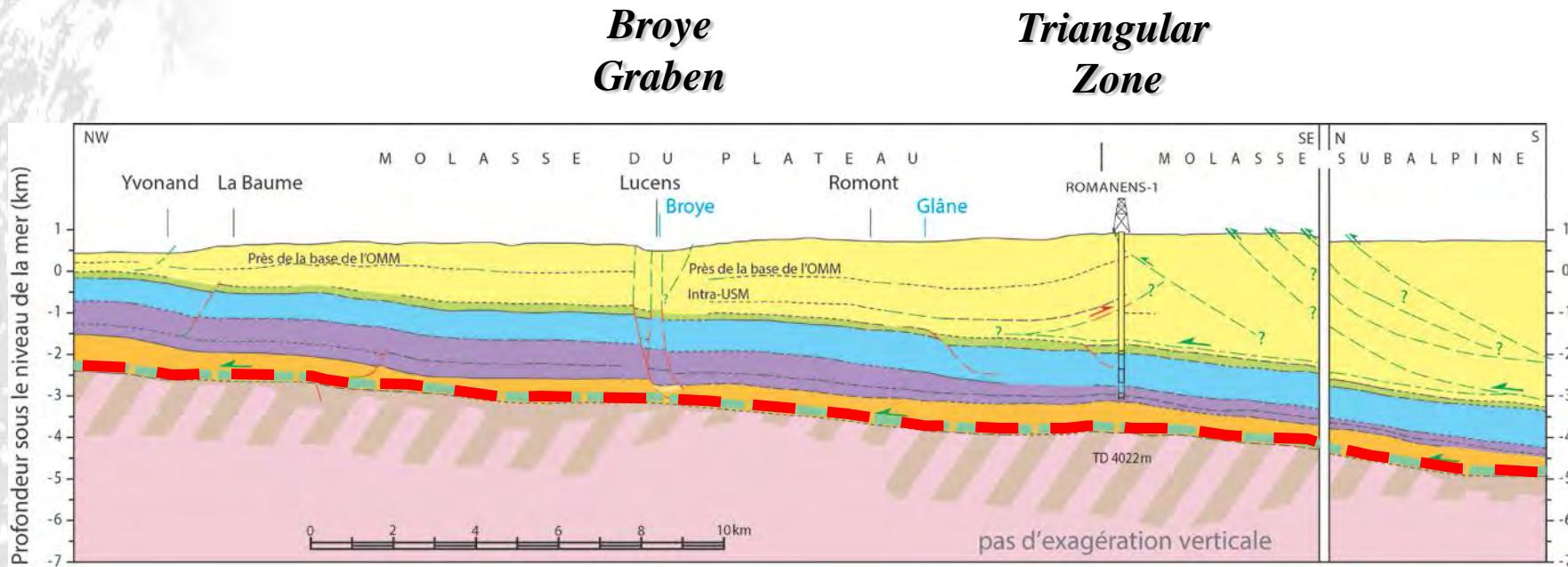
Jura - Molasse Basin - Subalpine Molasse



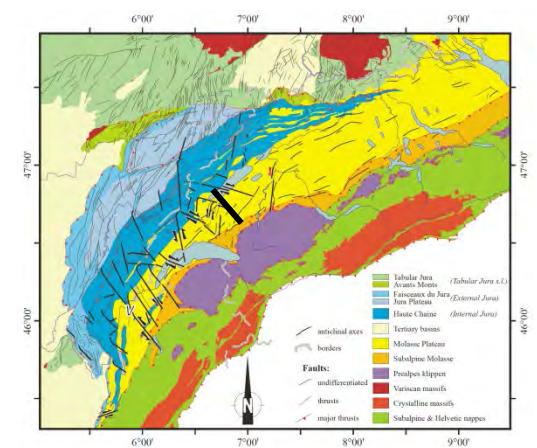
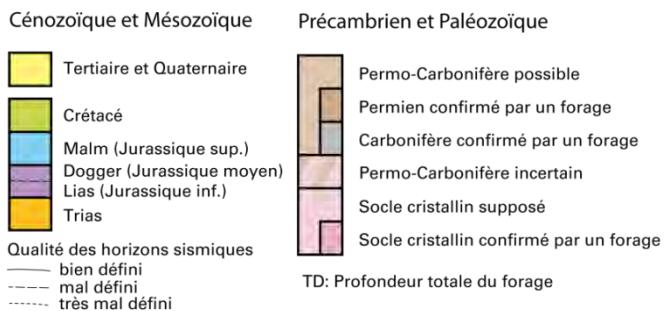
Sommaruga 2011



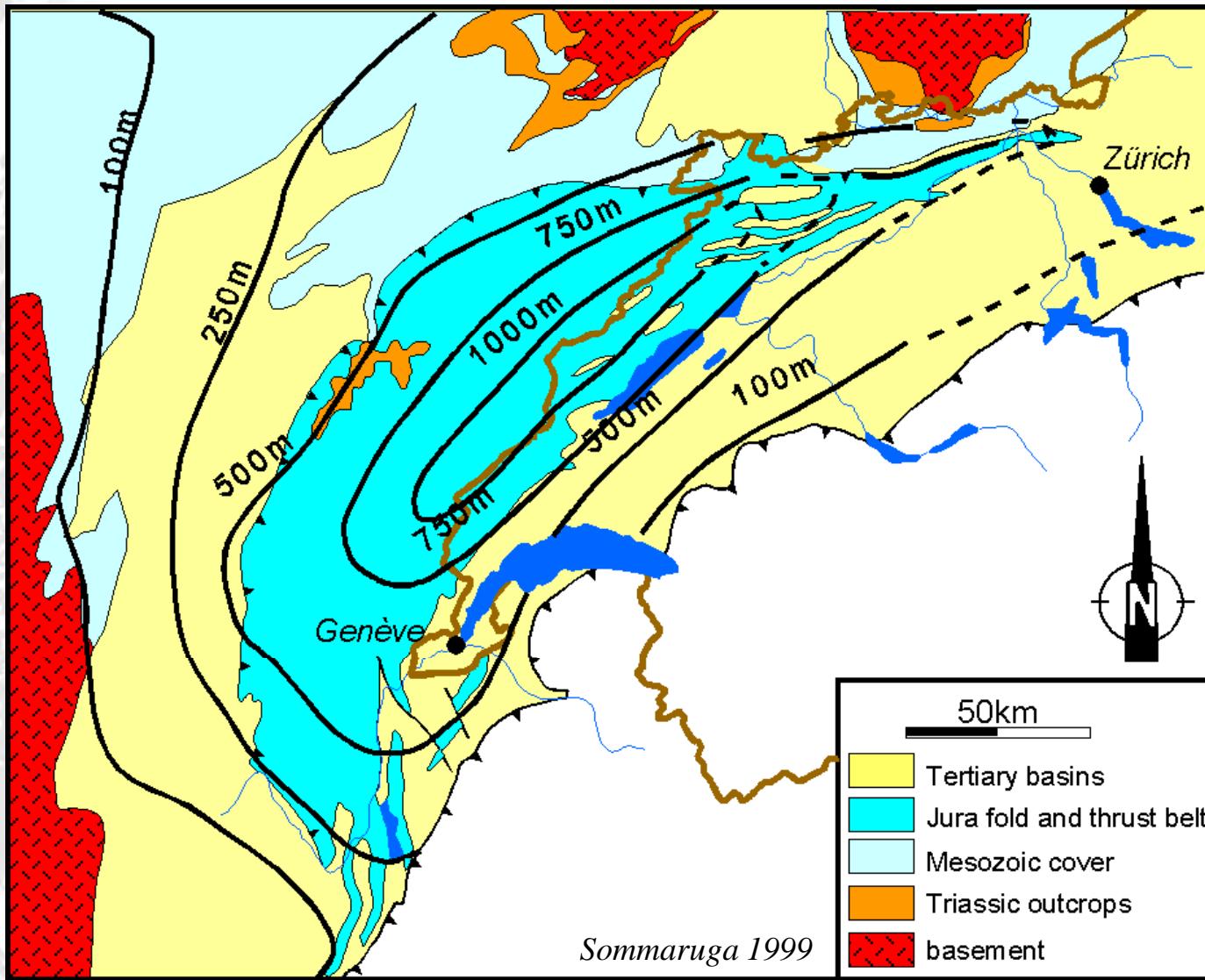
Structure 2D - Interprétation (profondeur)



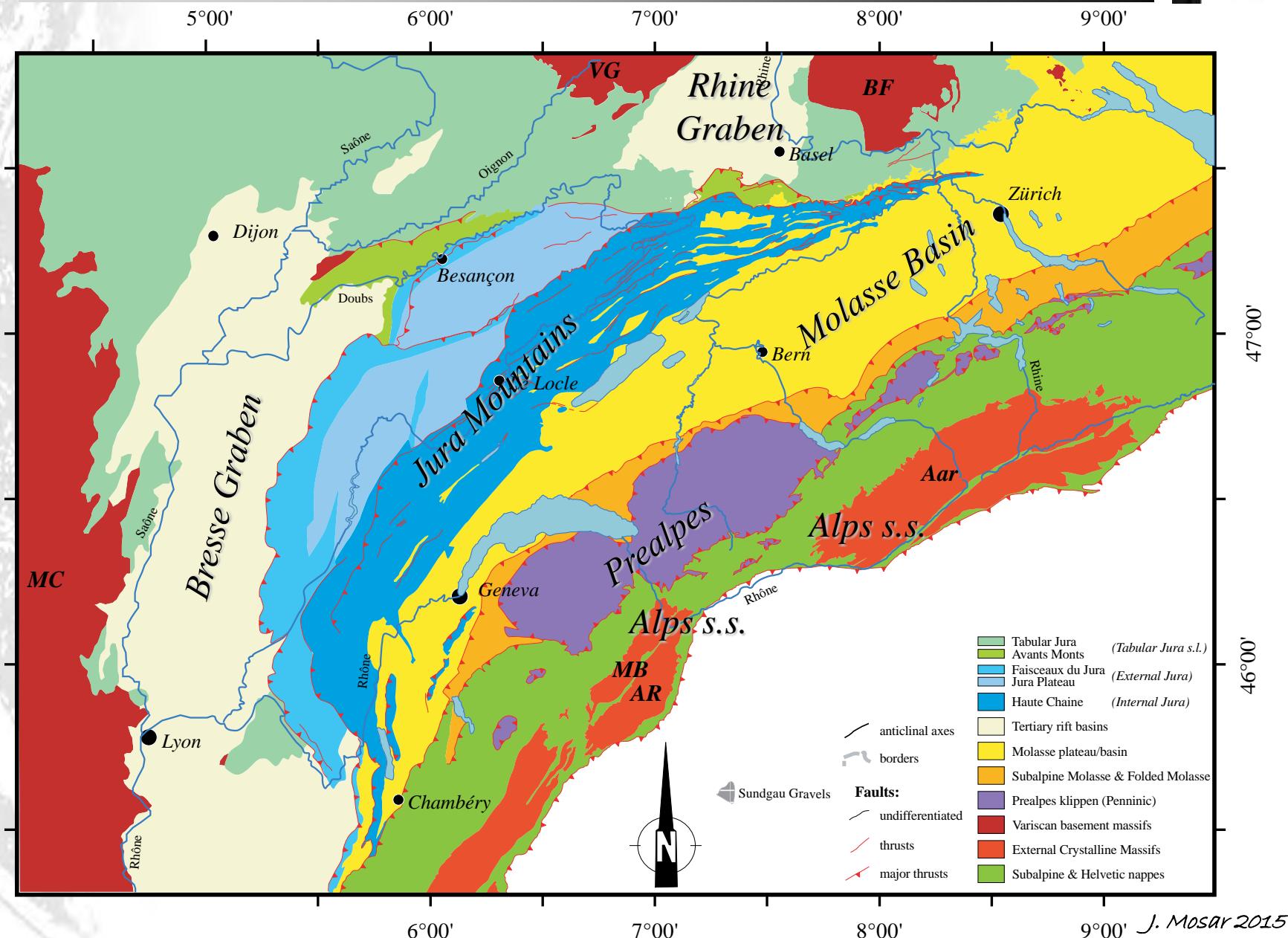
Profil tectonique 2D – conversion en profondeur basée sur profils sismiques



Jura - Triassic evaporites & Décollement level

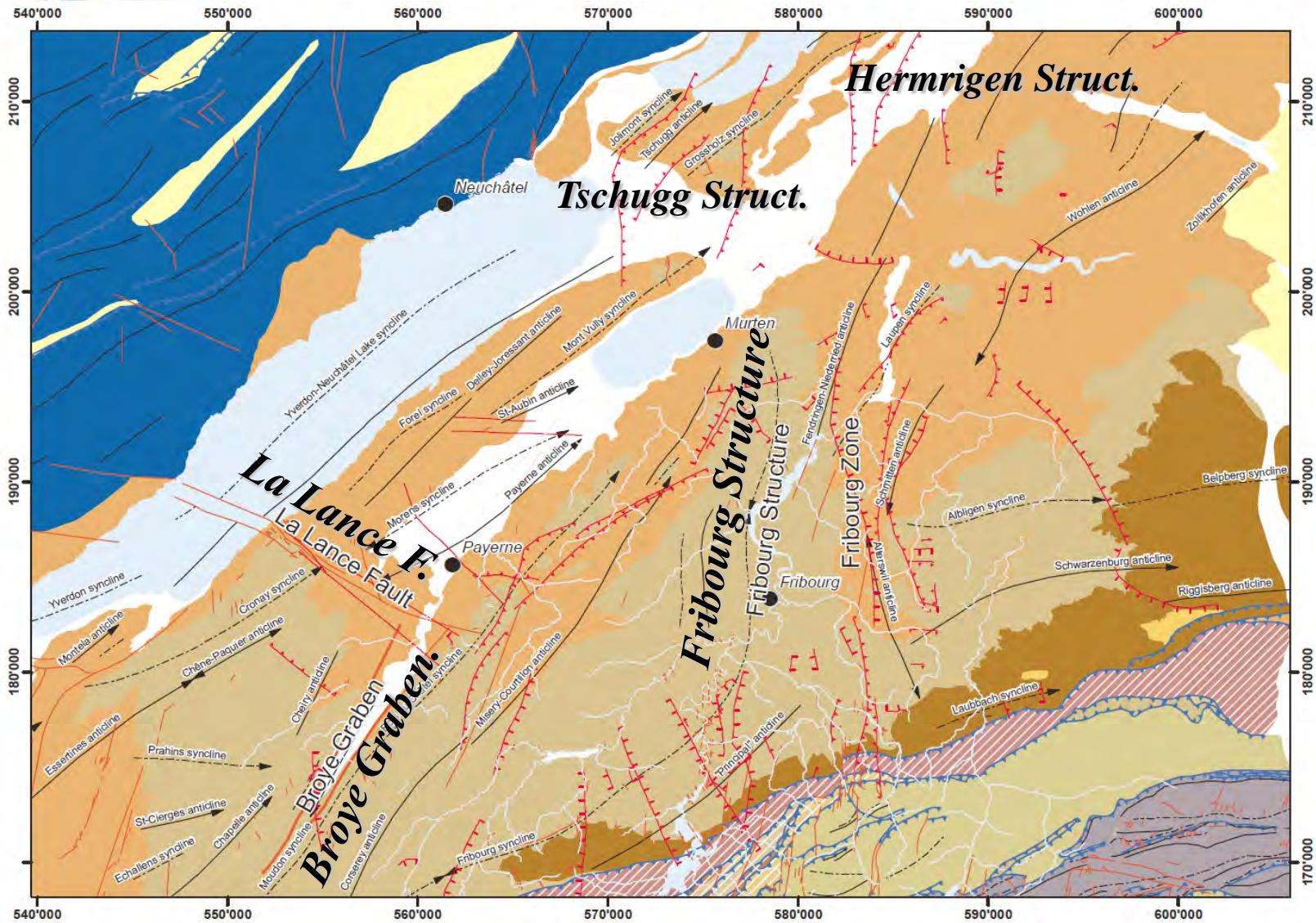


Tectonics in the Swiss Molasse Basin



Bassin Molassique - Tectonique - Données de surface

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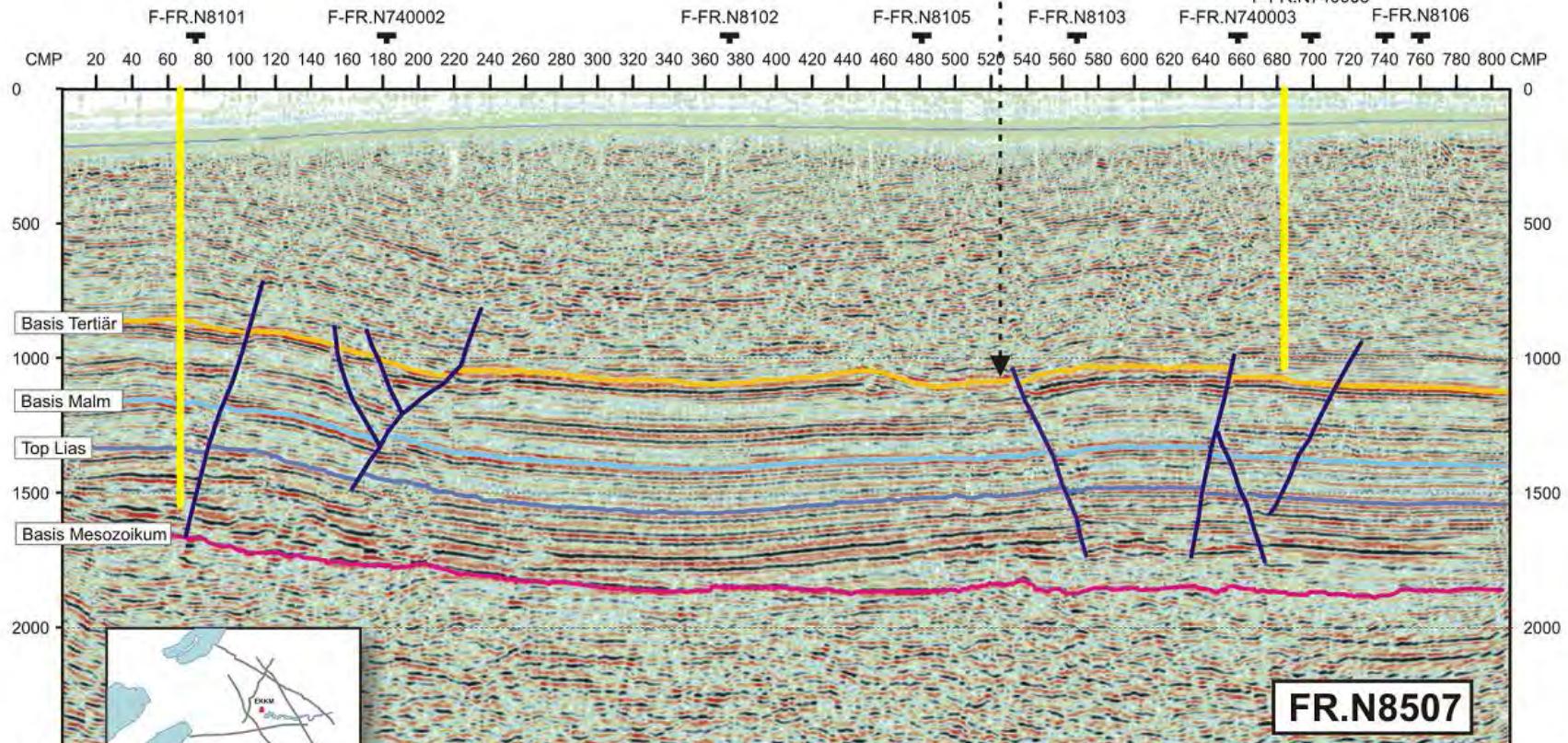


Fribourg Structure - Interprétation de ligne sismique

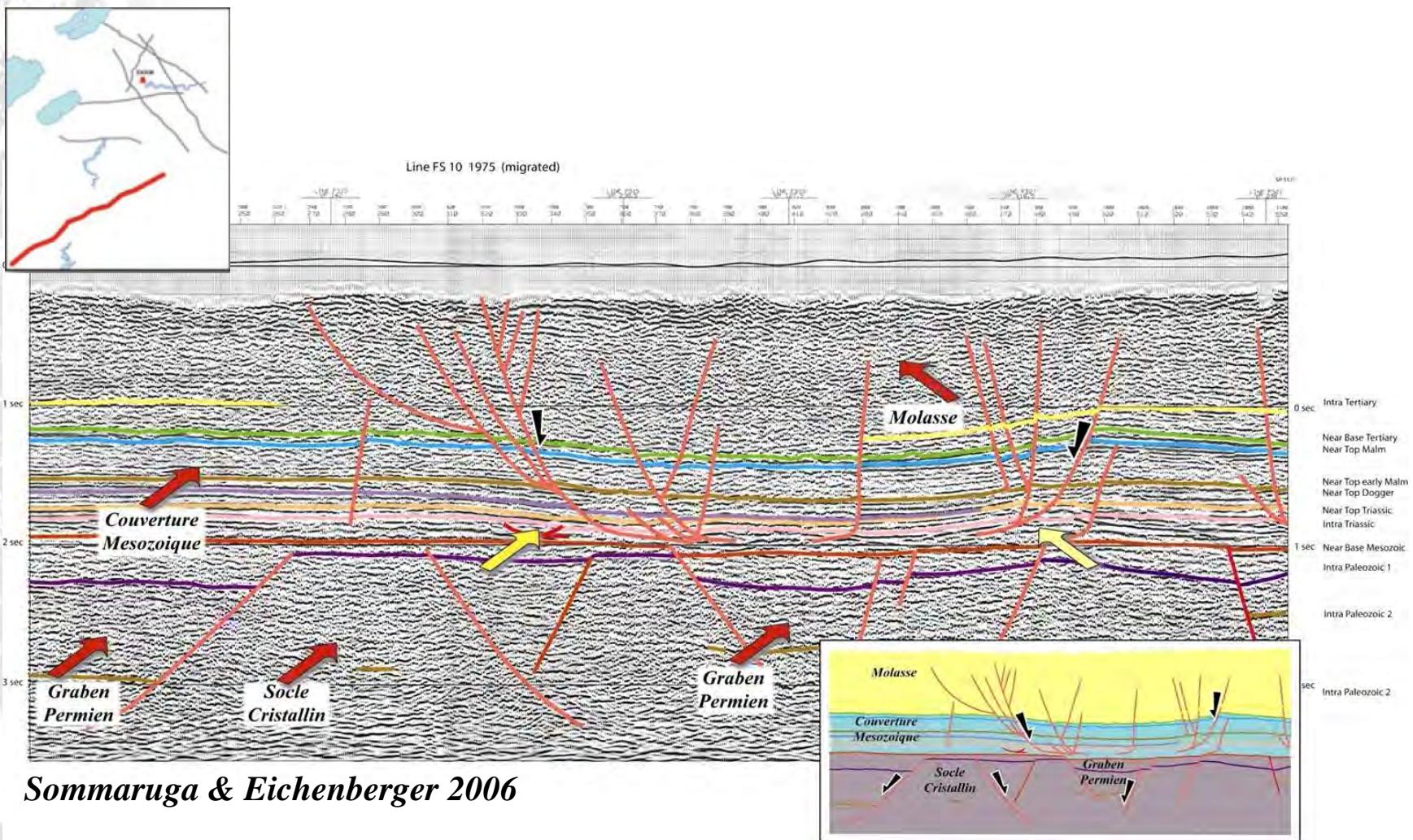
Fribourg Structure Fribourg Zone

Courtion-1 (proj.)

Fendringen-1

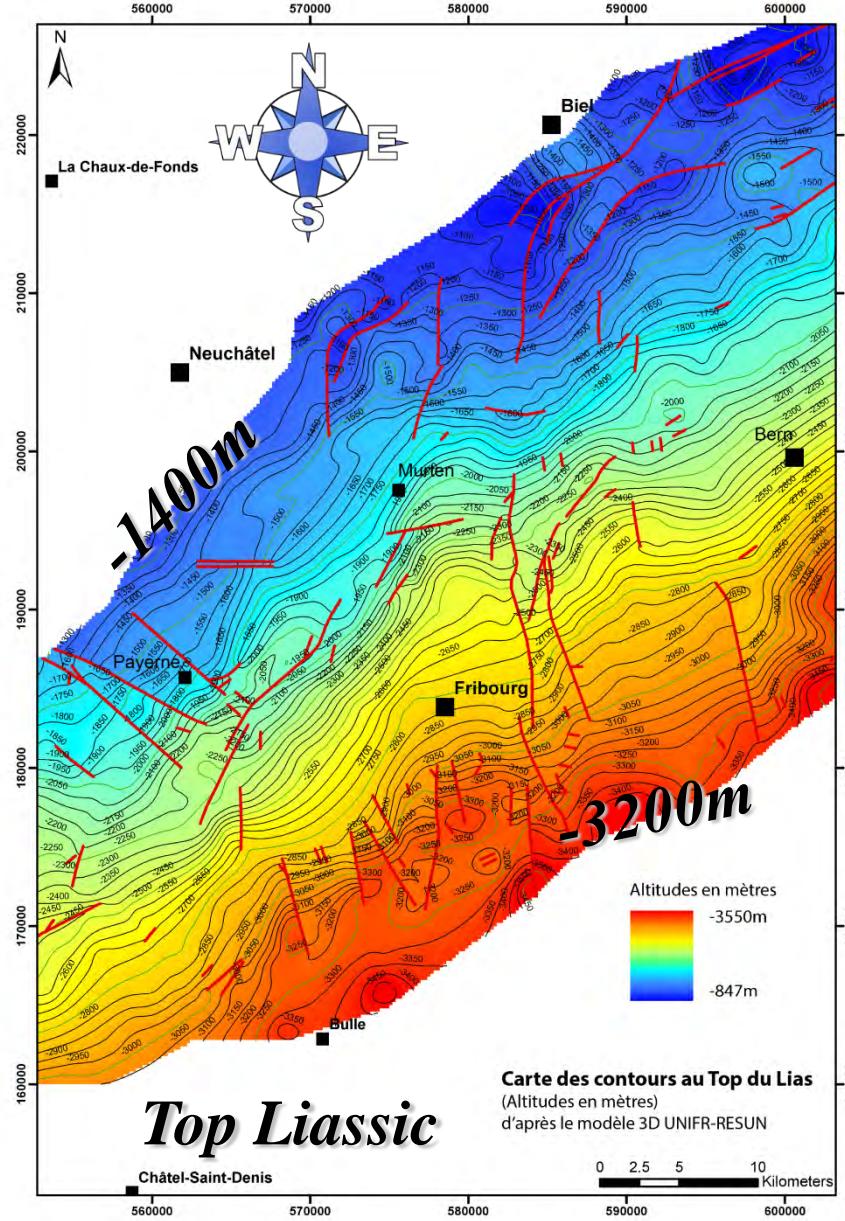
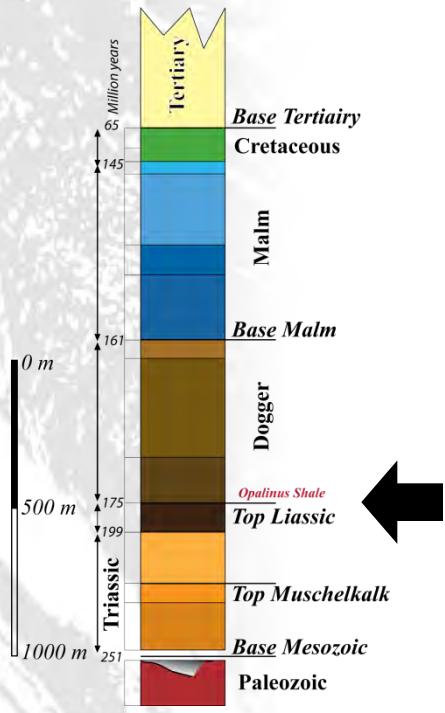


Fribourg Structure - Interprétation de ligne sismique

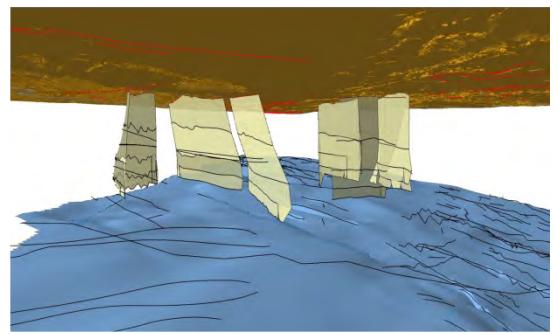
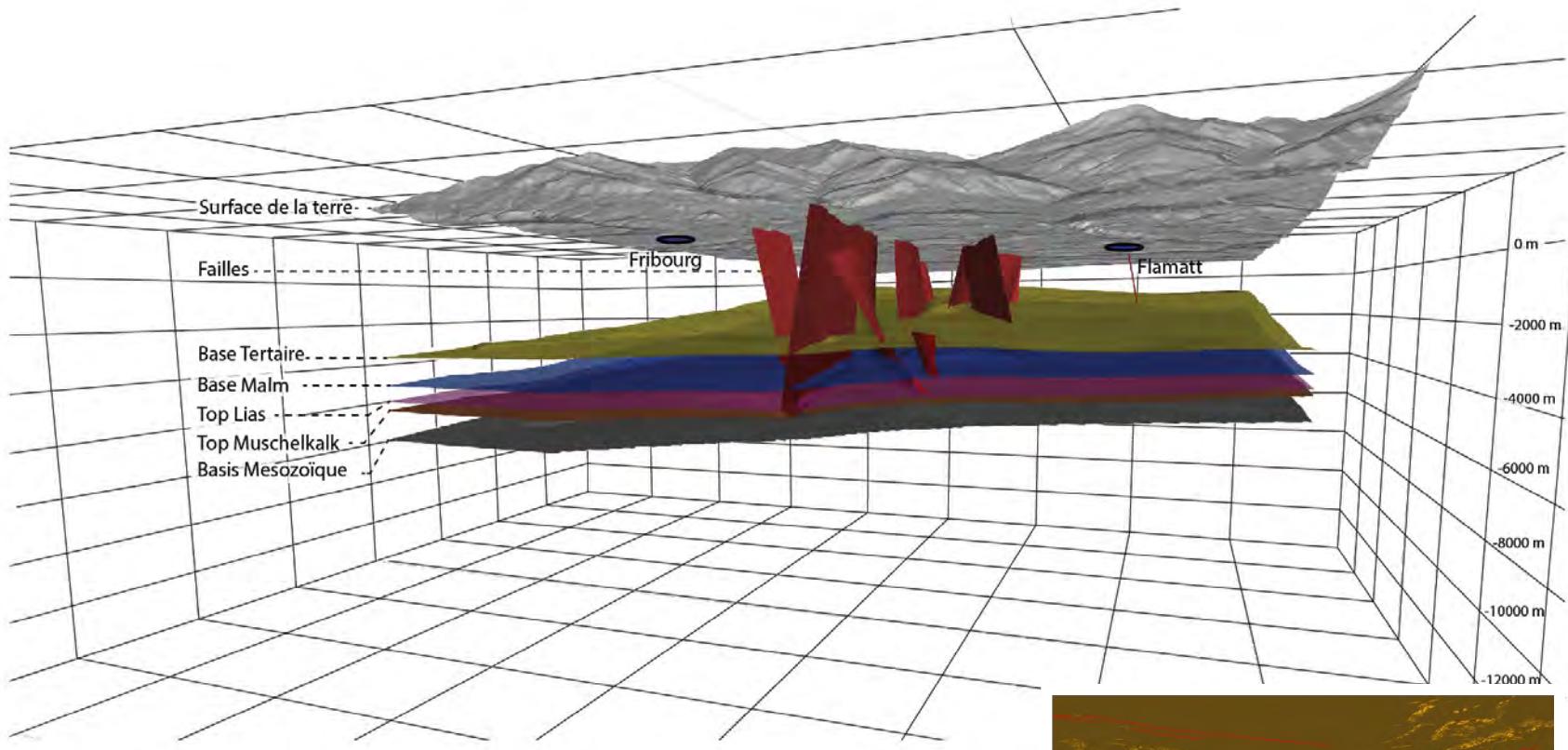


Sommaruga & Eichenberger 2006

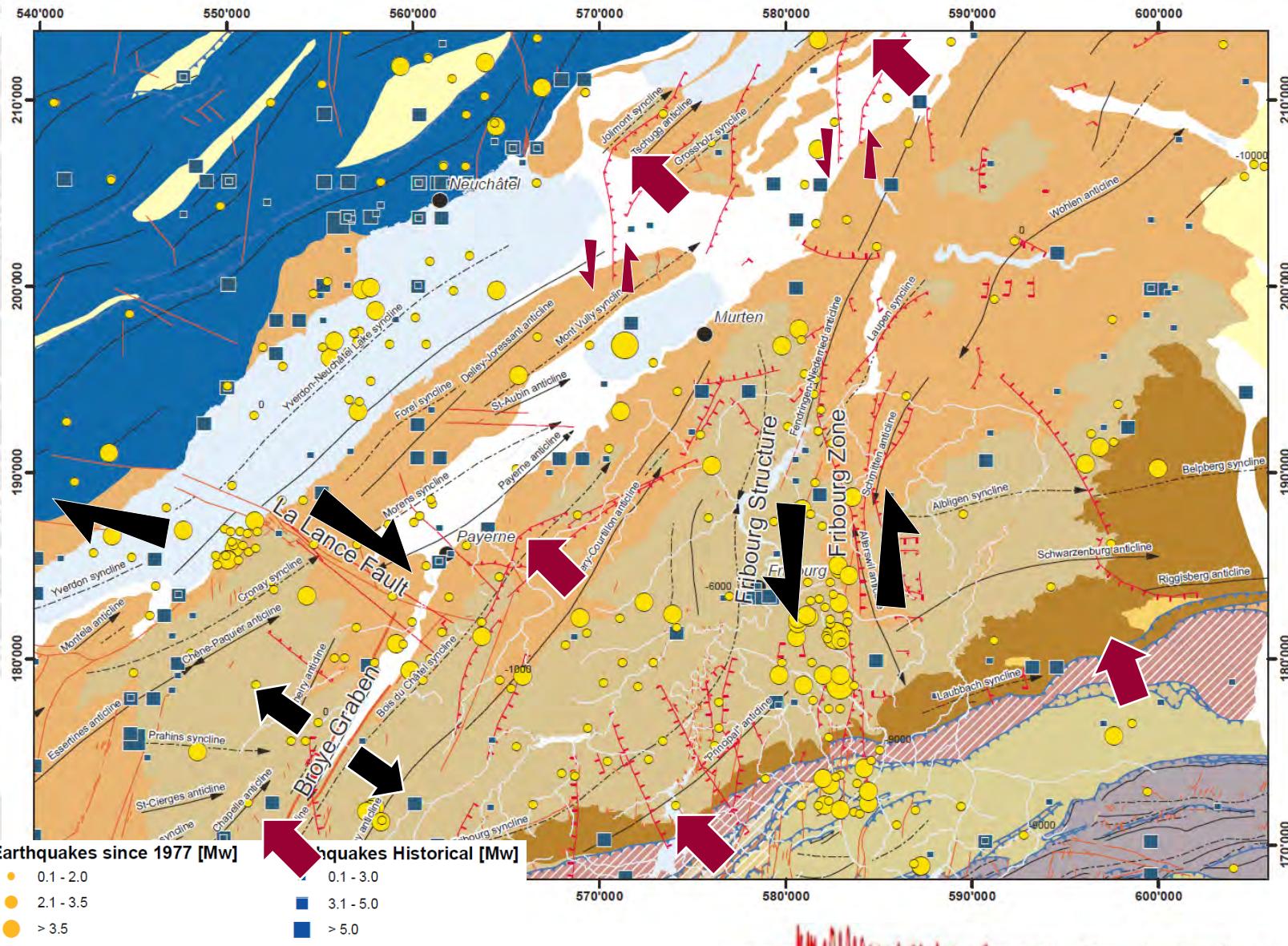
Structure 3D- Interprétation (profondeur)



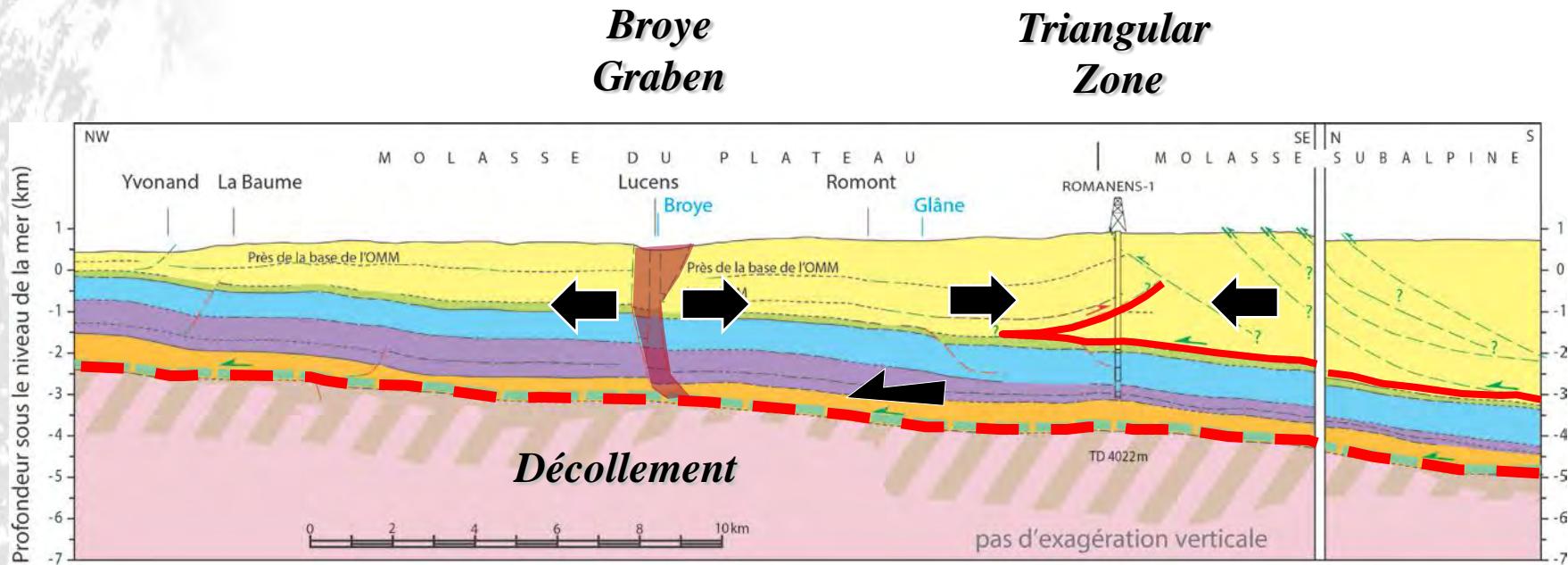
Modèle 3D Failles



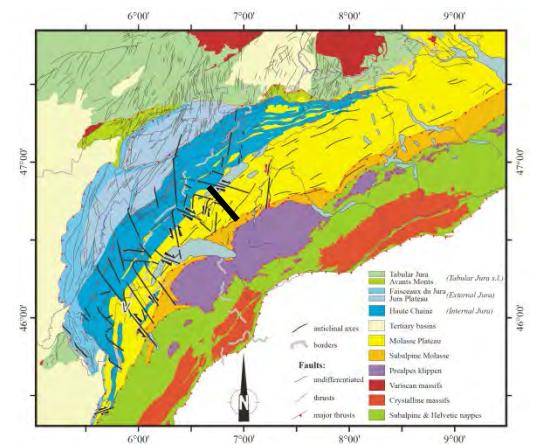
Seismicity - Fribourg Zone - Faults vs. Earthquakes



2D Structure - Interpretation (depth)



2D structural profile depth converted based on seismic profile

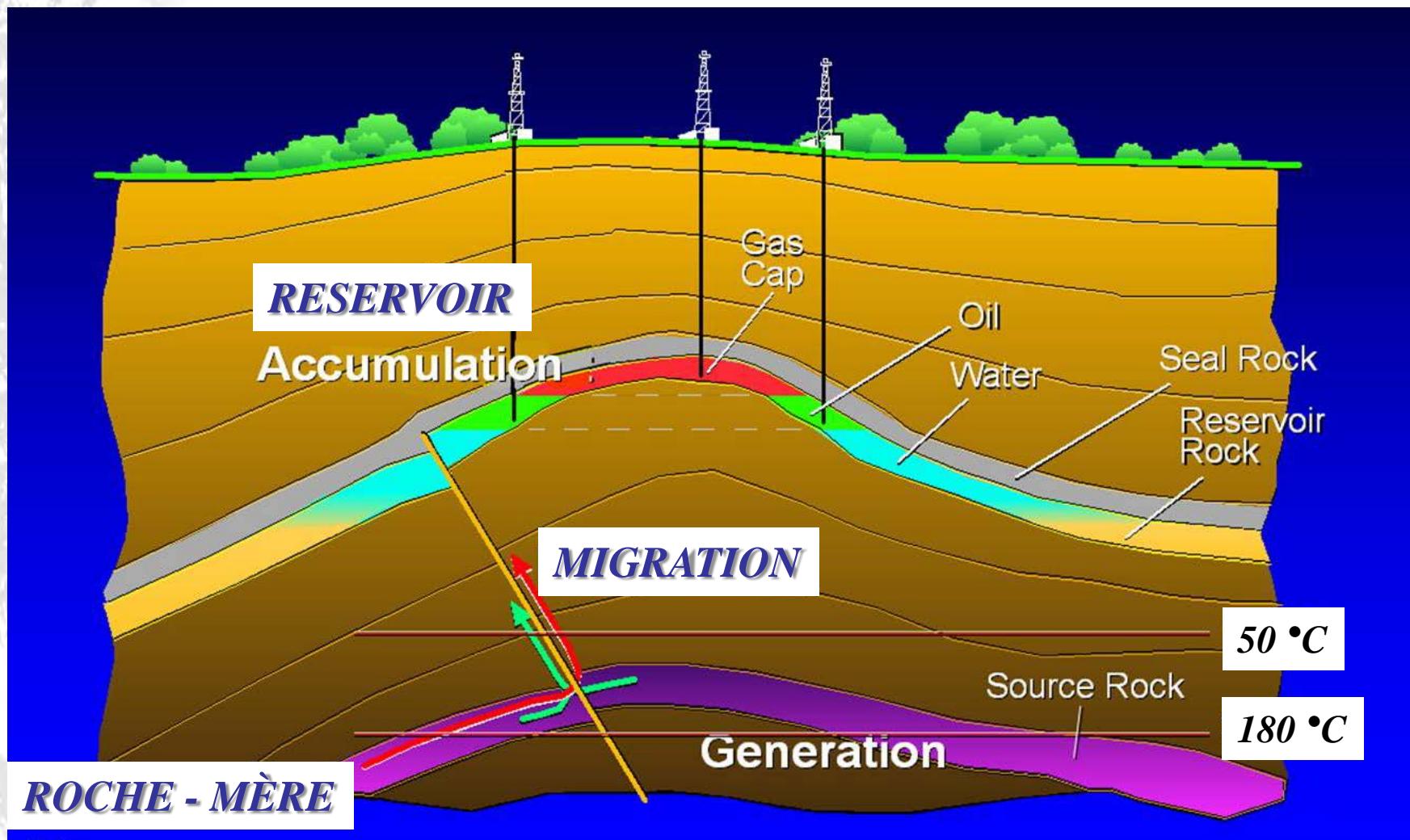


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Formation de Pétrole/GAZ



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JMA



Petroleum Support
"We Support Your Idea"

J. Mosar 2015

Conventionnal

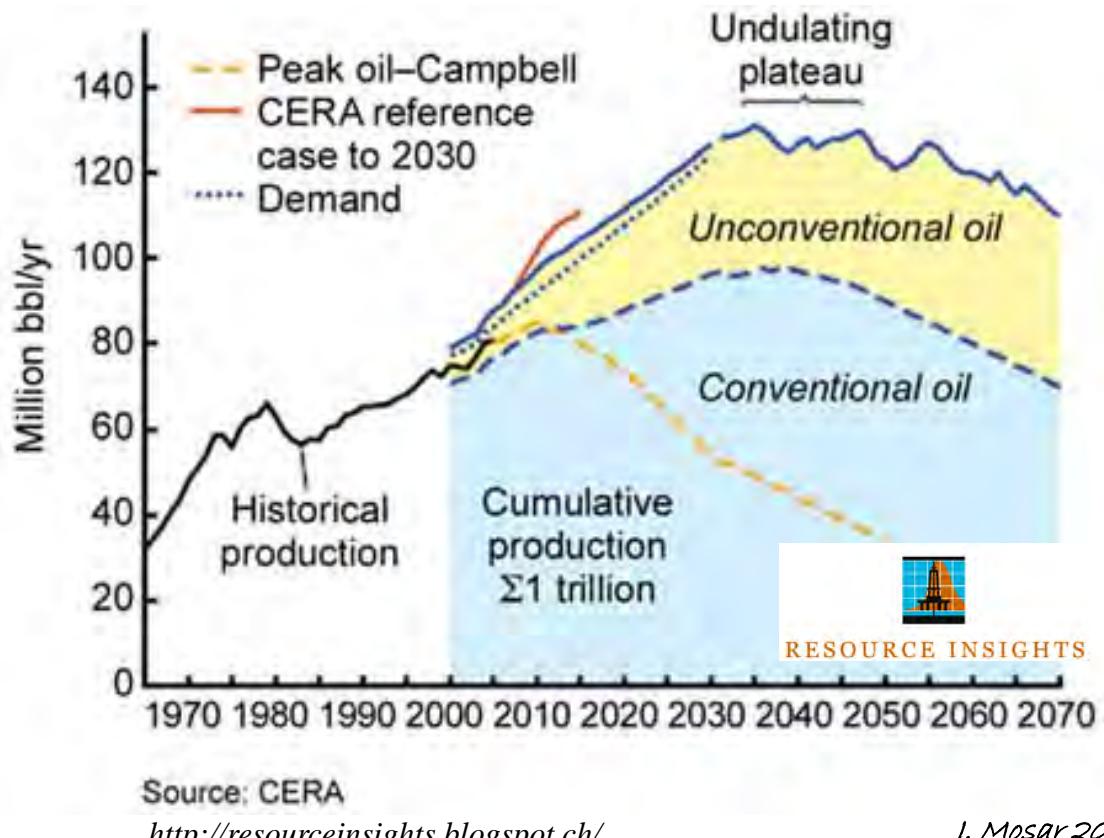
Unconventionnal

Gaz Compact (Tight Gas)

Gaz de Schistes

Gaz de Houille

Hydrates de gaz



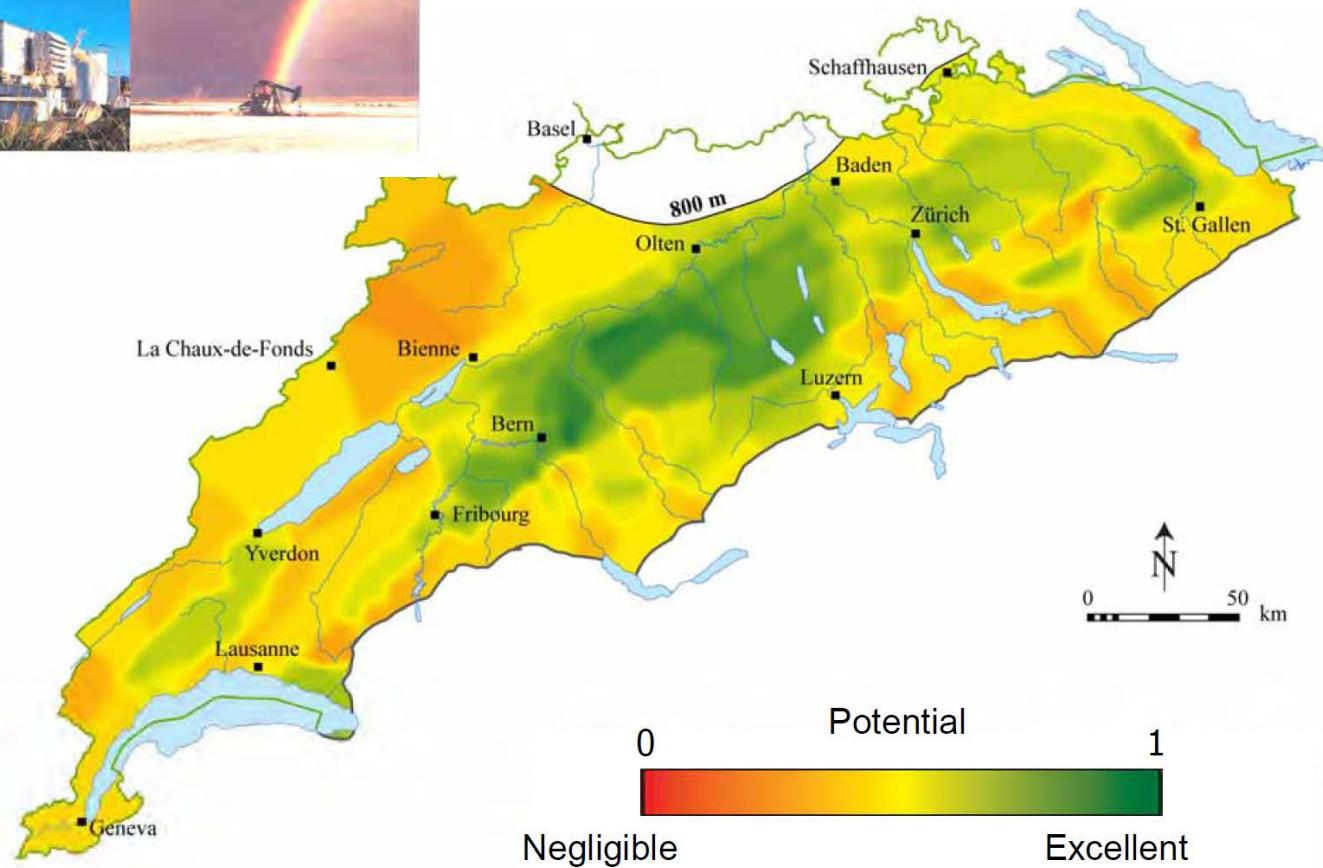
CO₂ Sequestration

Potential for deep geological sequestration of CO₂ in Switzerland: a first appraisal

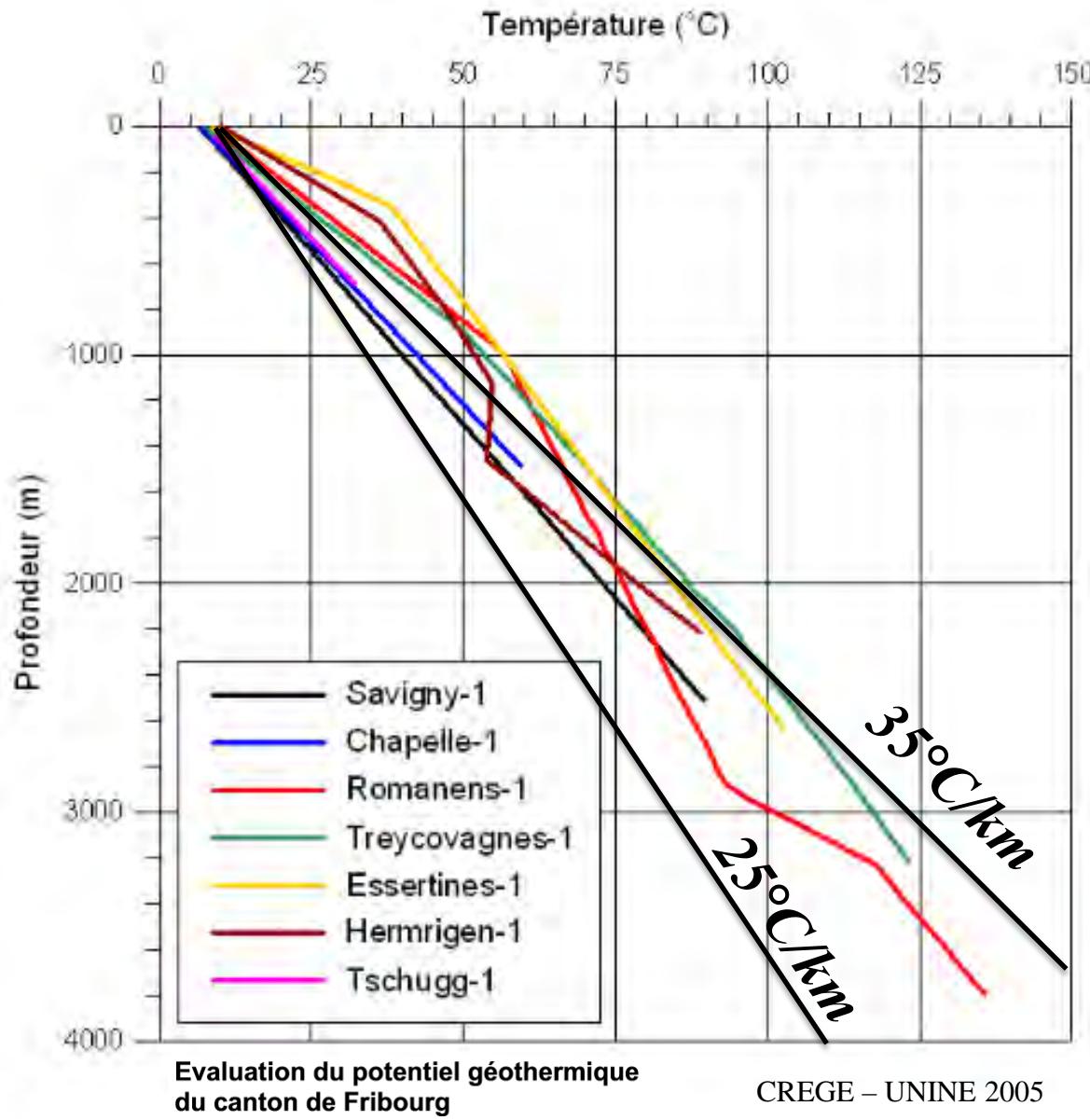
Gabriel Chevalier · Larryn W. Diamond ·
Werner Leu



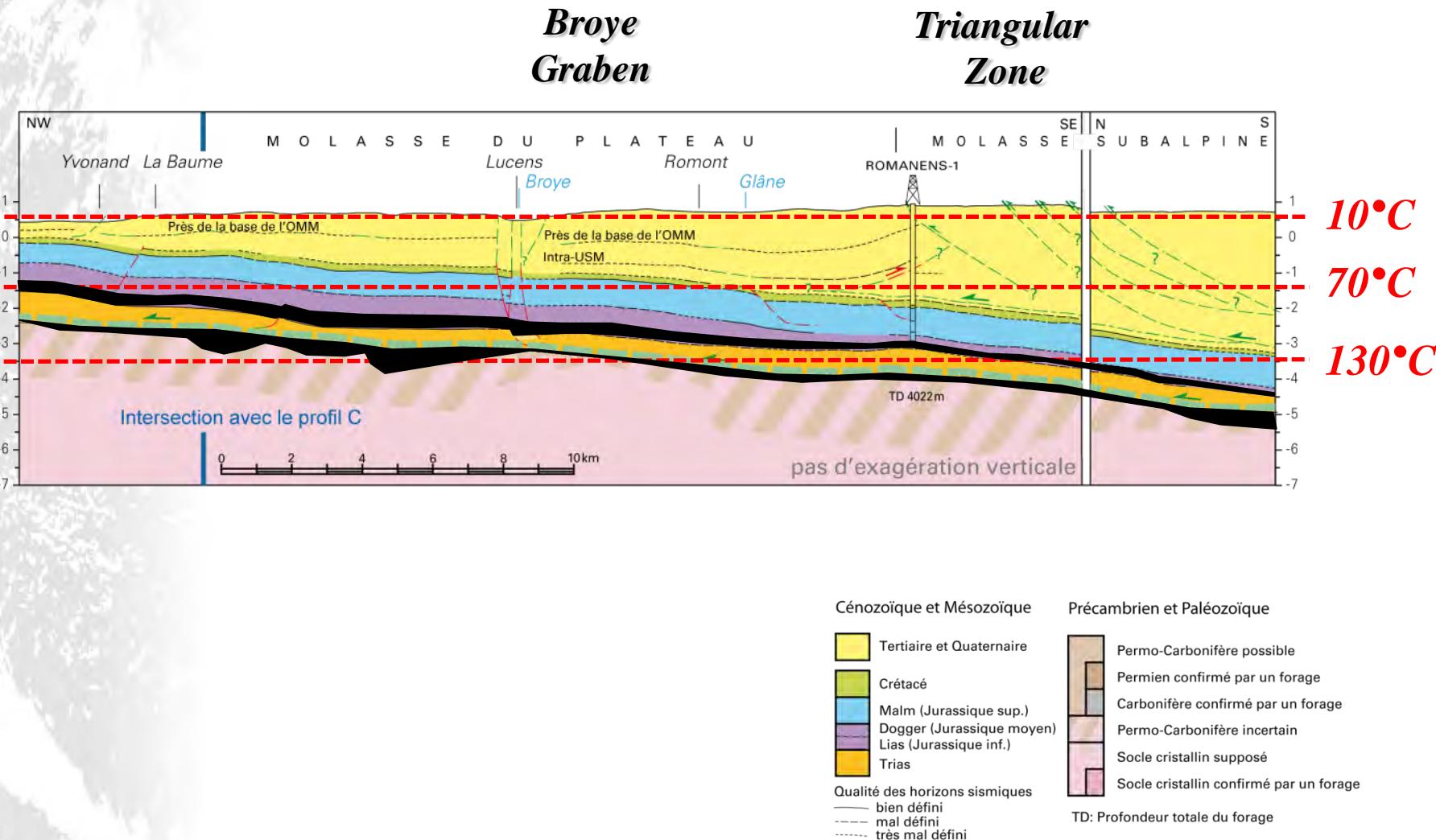
Swiss J Geosci
DOI 10.1007/s00015-010-0030-4



Géothermie



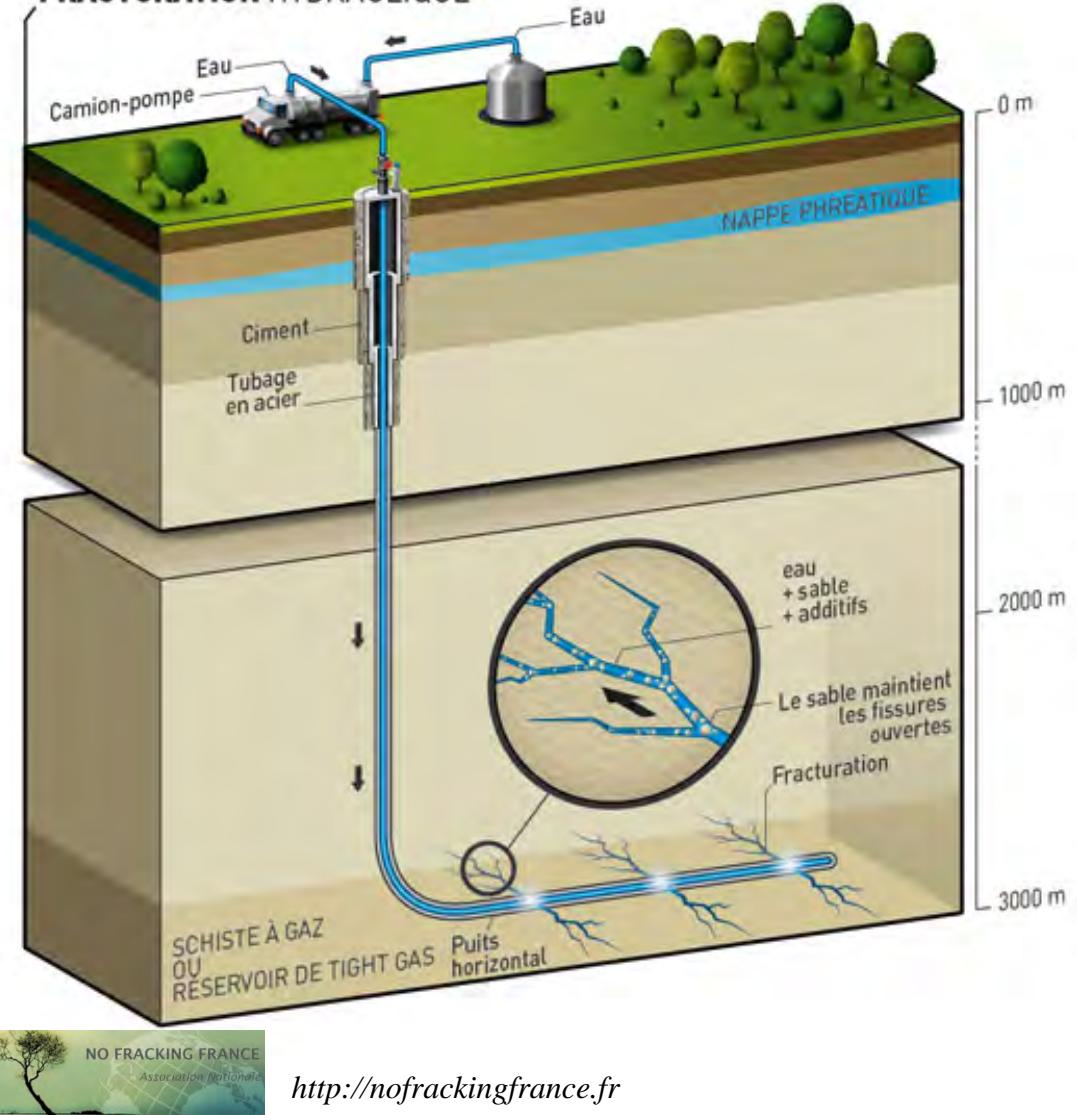
Hydrocarbures - géothermie - gaz



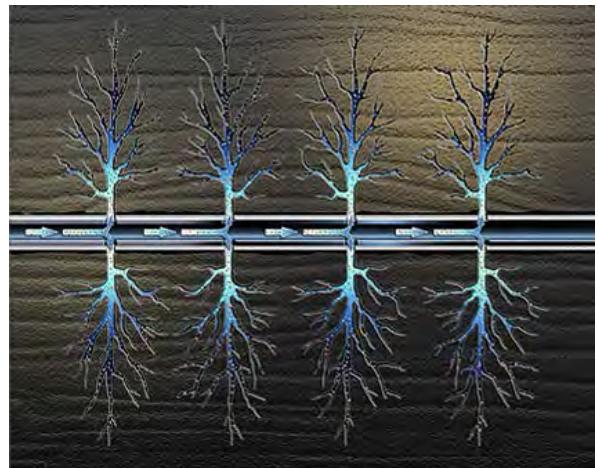
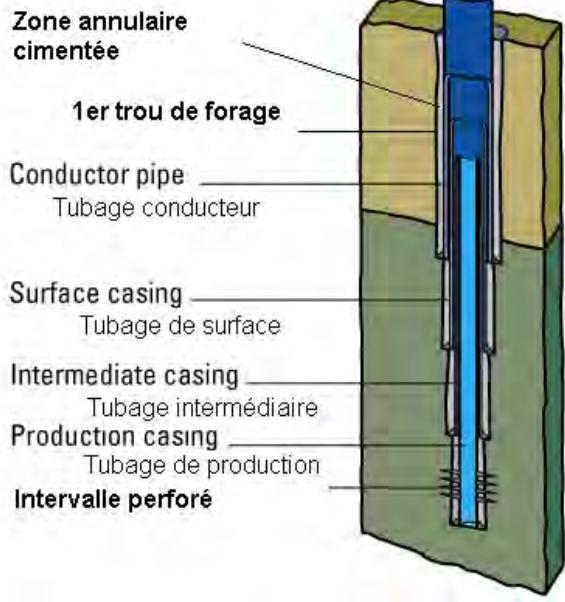
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Forage & Fracturation hydraulique

FRACTURATION HYDRAULIQUE



<http://nofrackingfrance.fr>

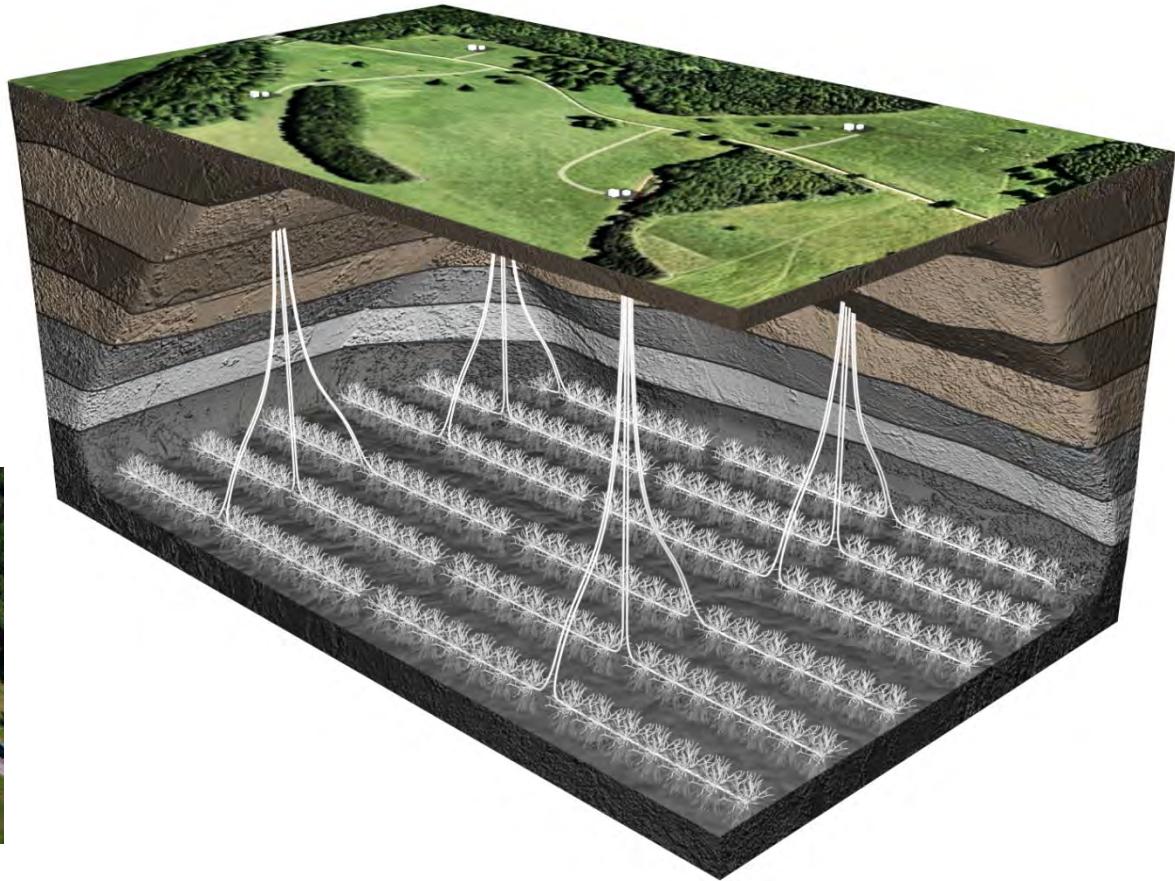




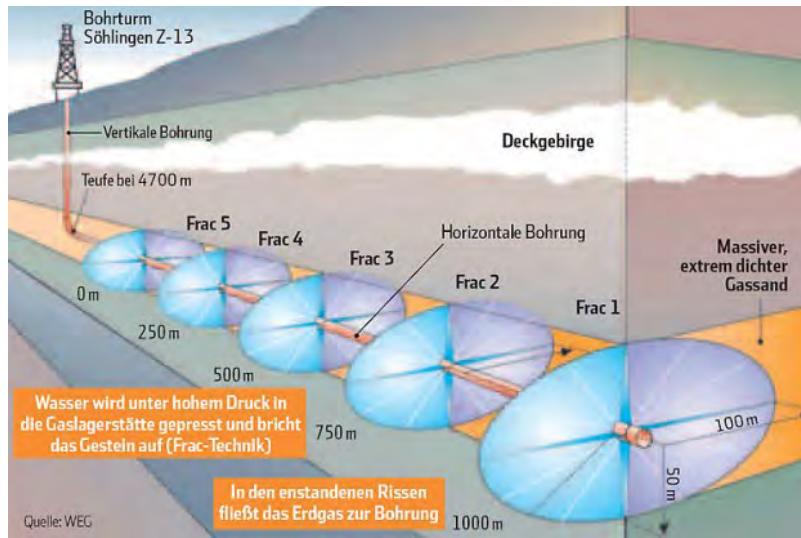
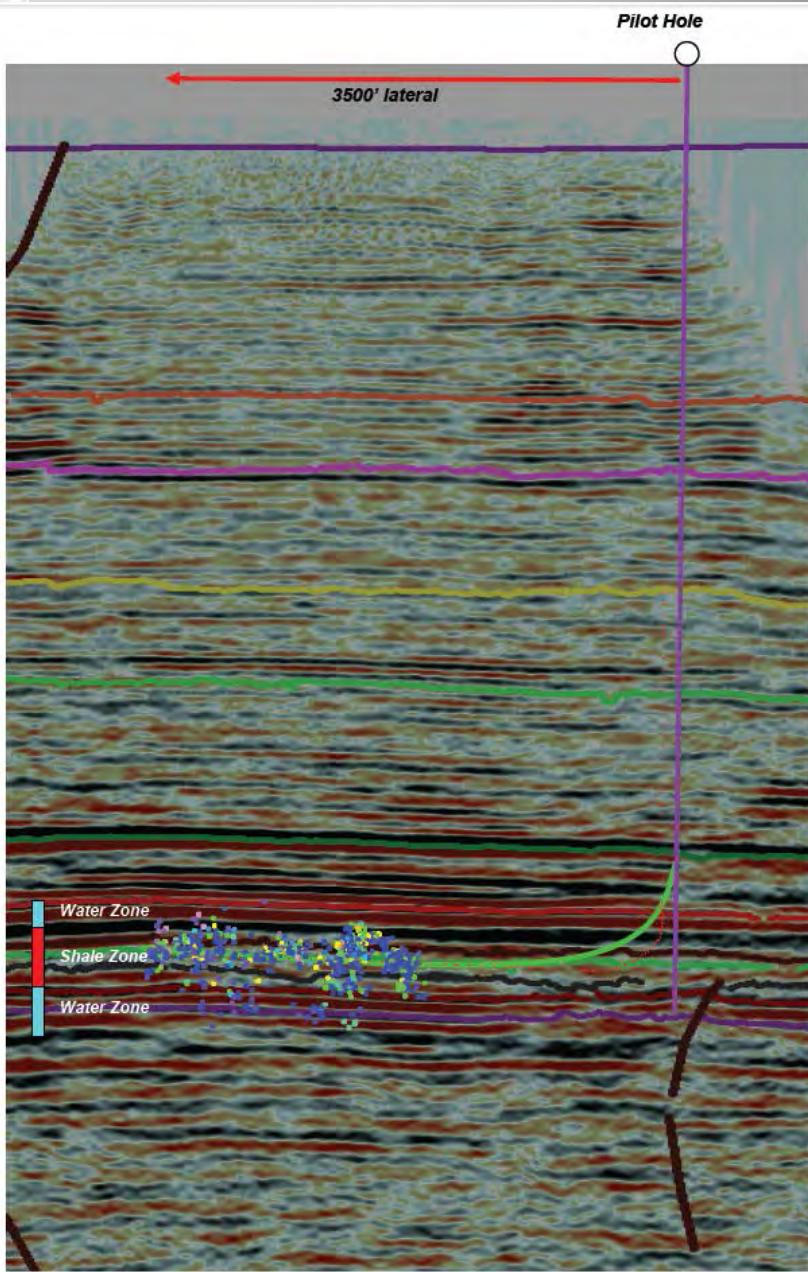
Sites de Forages multiples



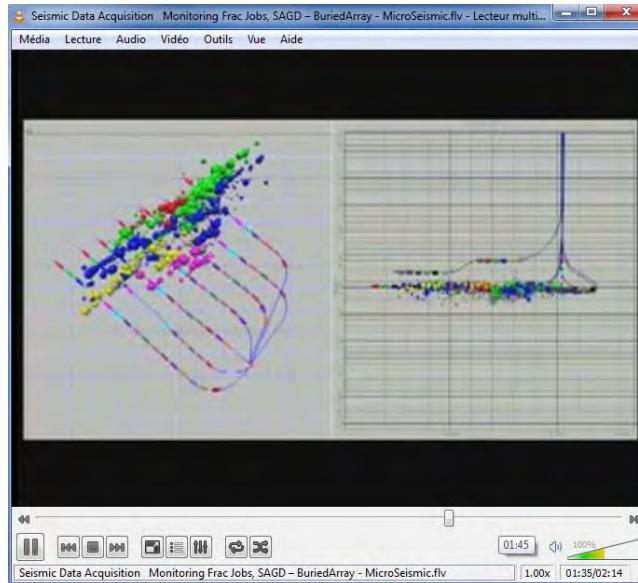
*6 forages sur 1 puit
longeur >3 km*



Hydrofracturation et séismicité



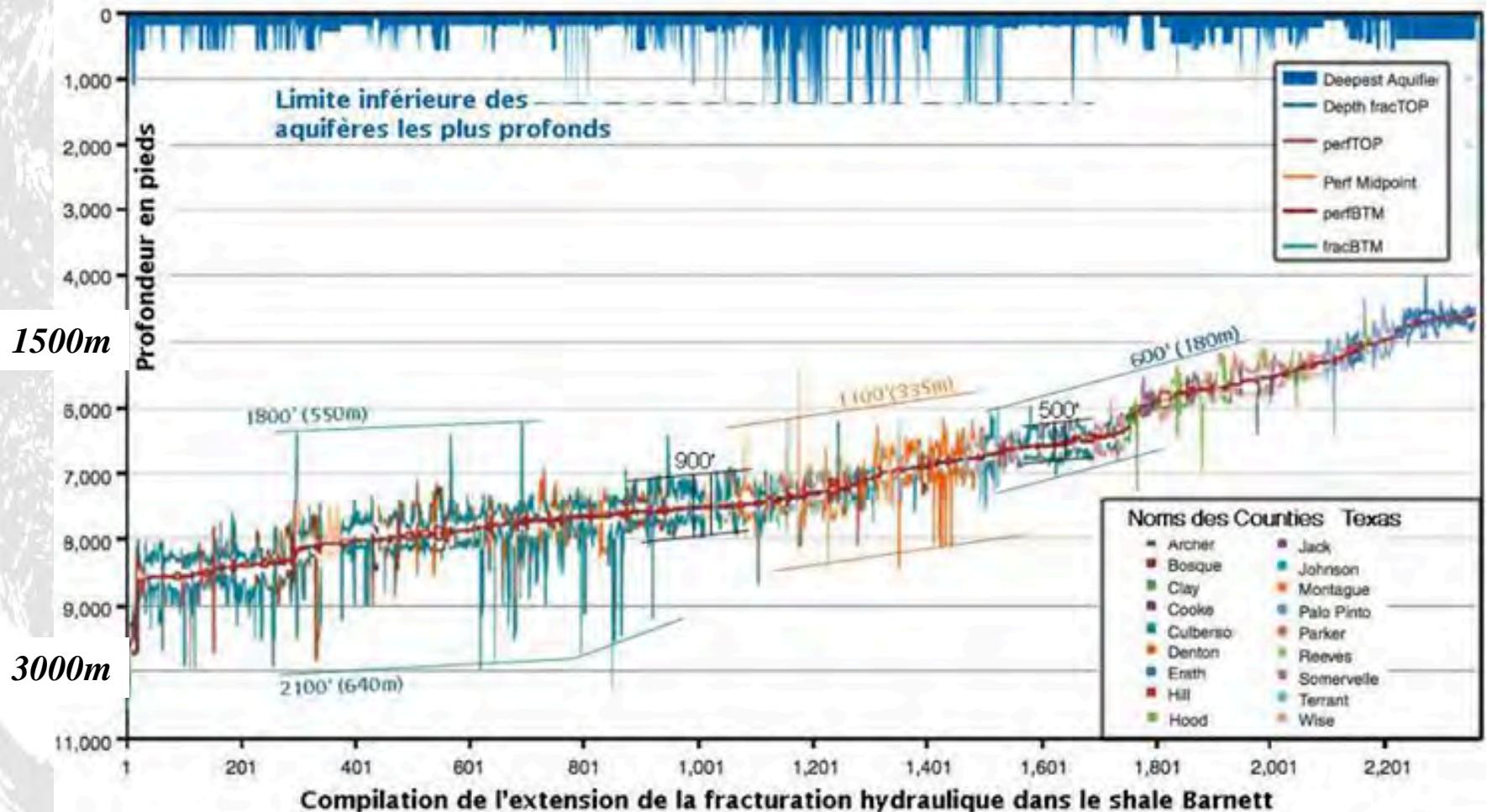
<http://www.bgr.bund.de/> - BRG 2011



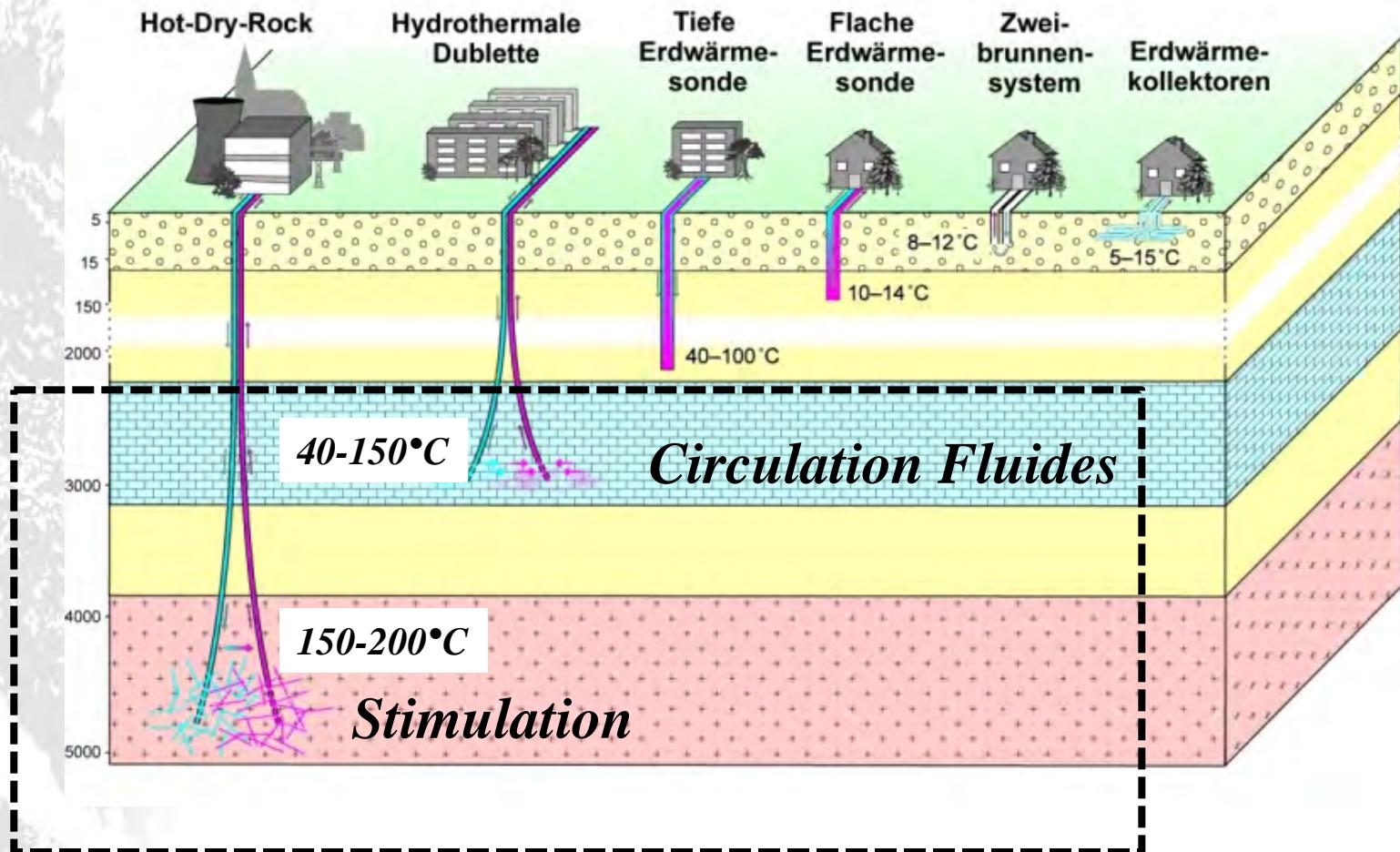
<http://www.microseismic.com/solutions/acquisition-products/buriedarray-service>

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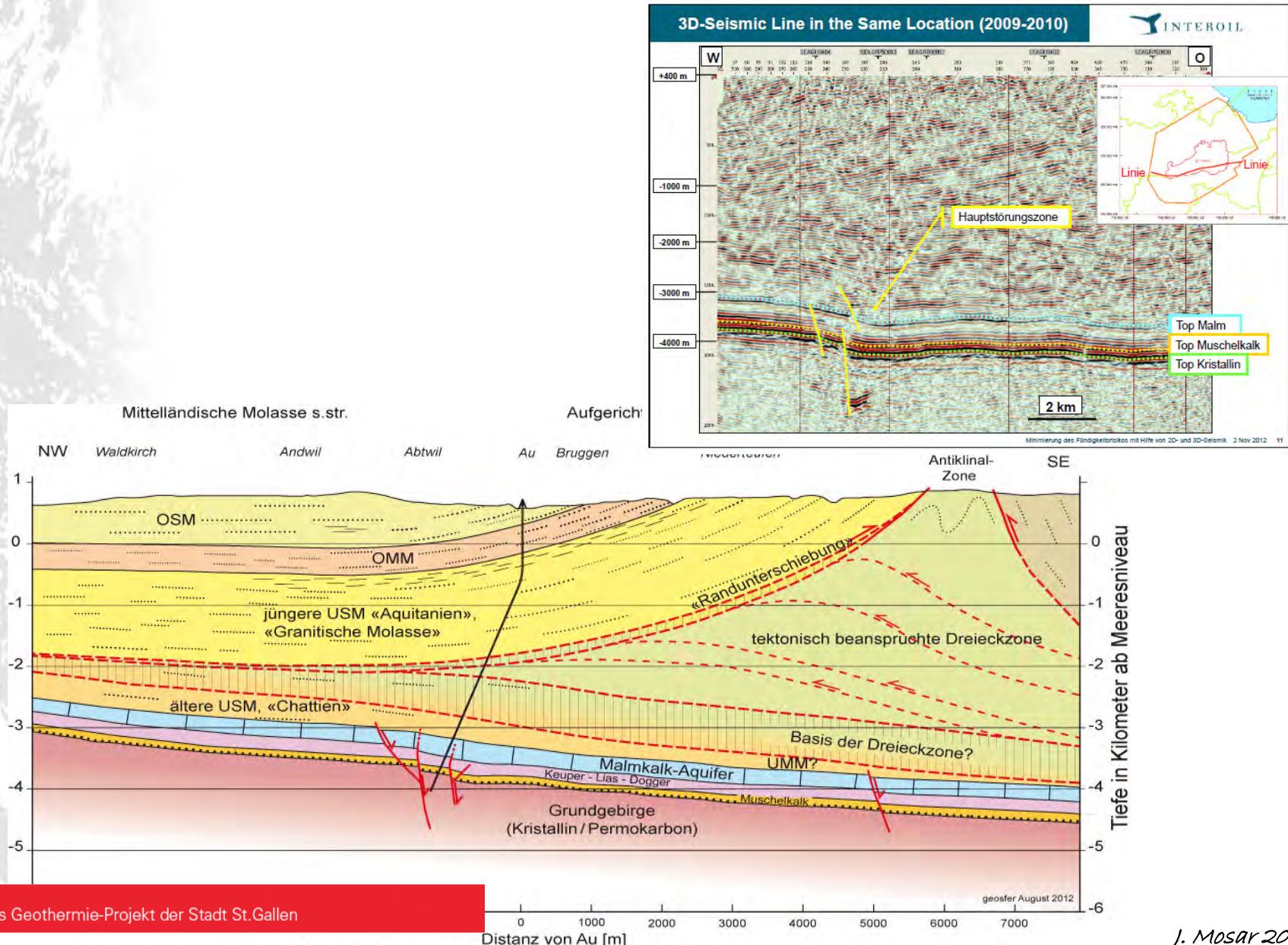
Hydrofracturation et séismes



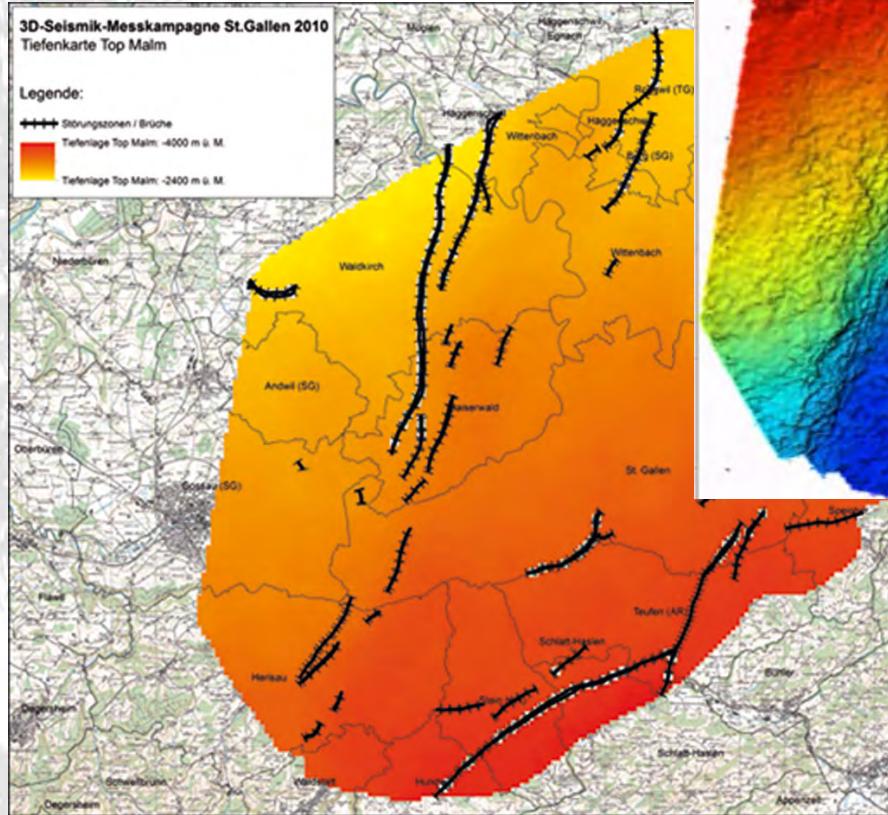
Géothermie profonde



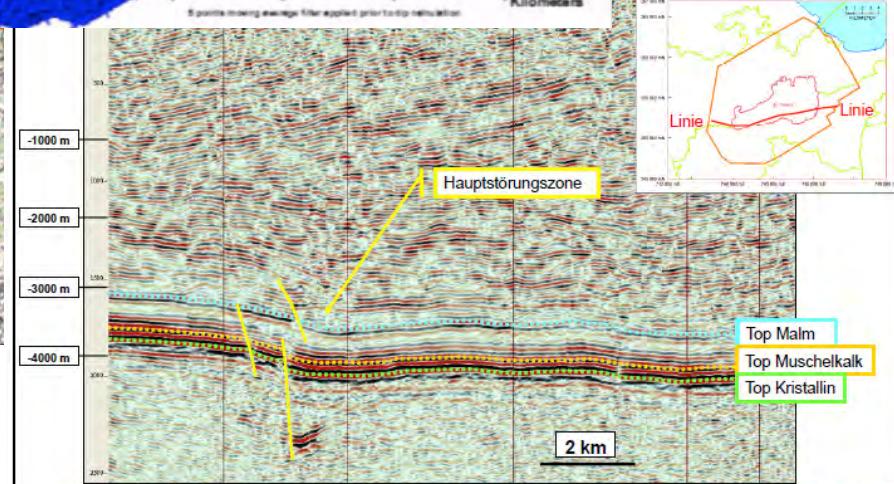
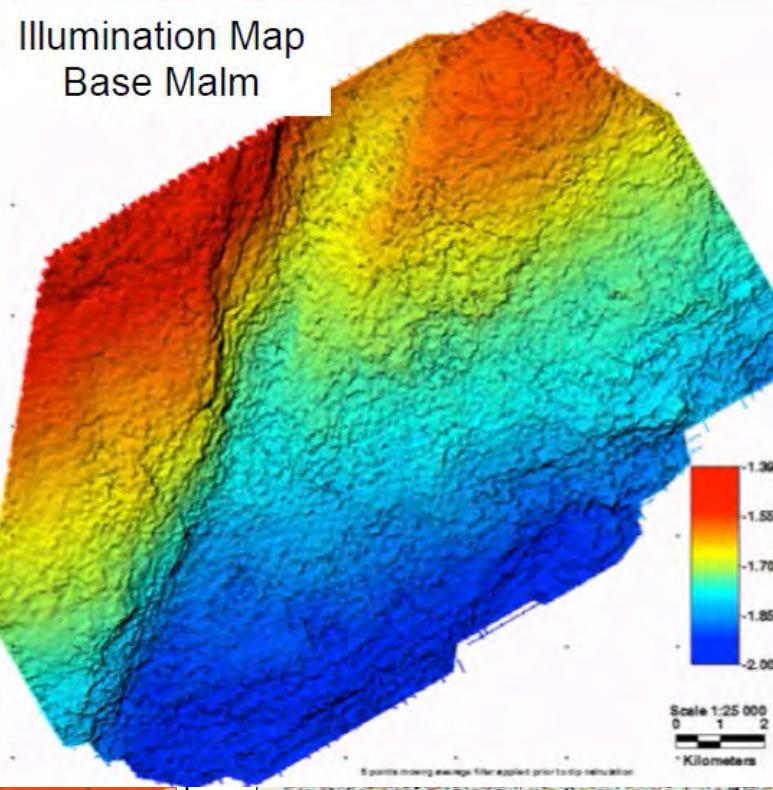
St. Gall- Géothermie profonde



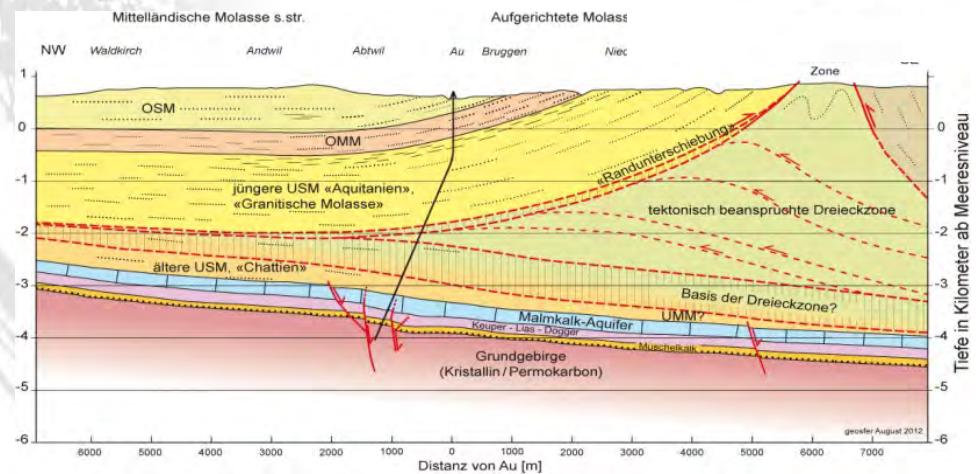
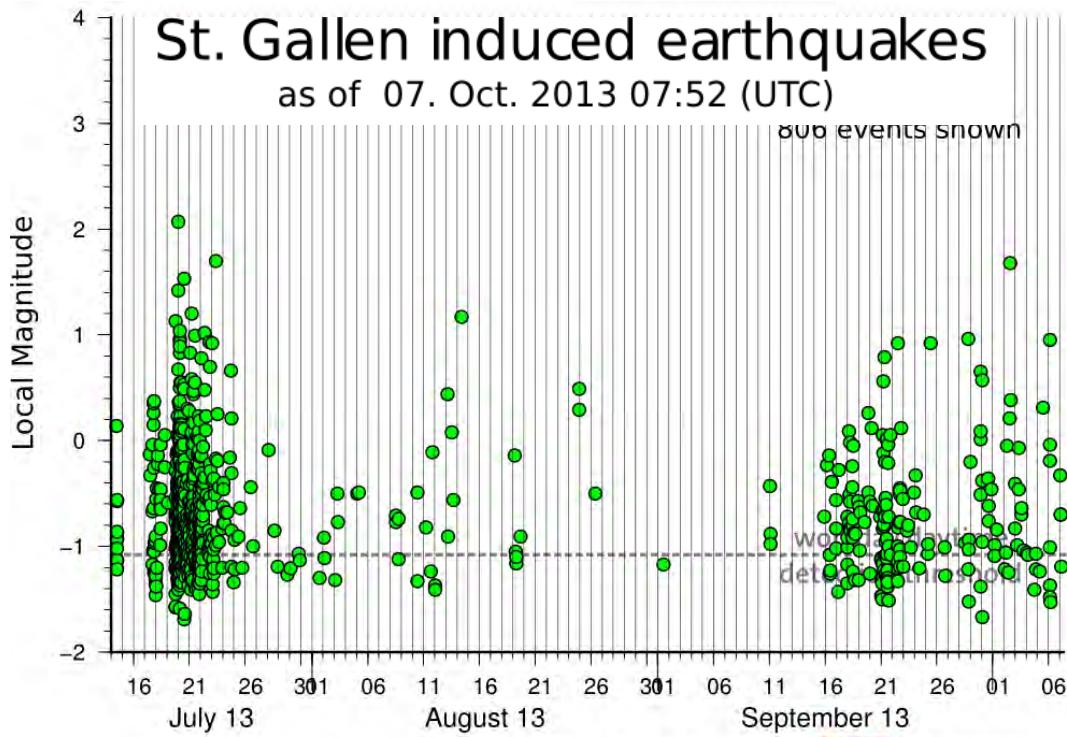
St. Gall - Faiile couverture - socle



Illumination Map
Base Malm



St. Gall- Couverte - Socle - critically stressed fault

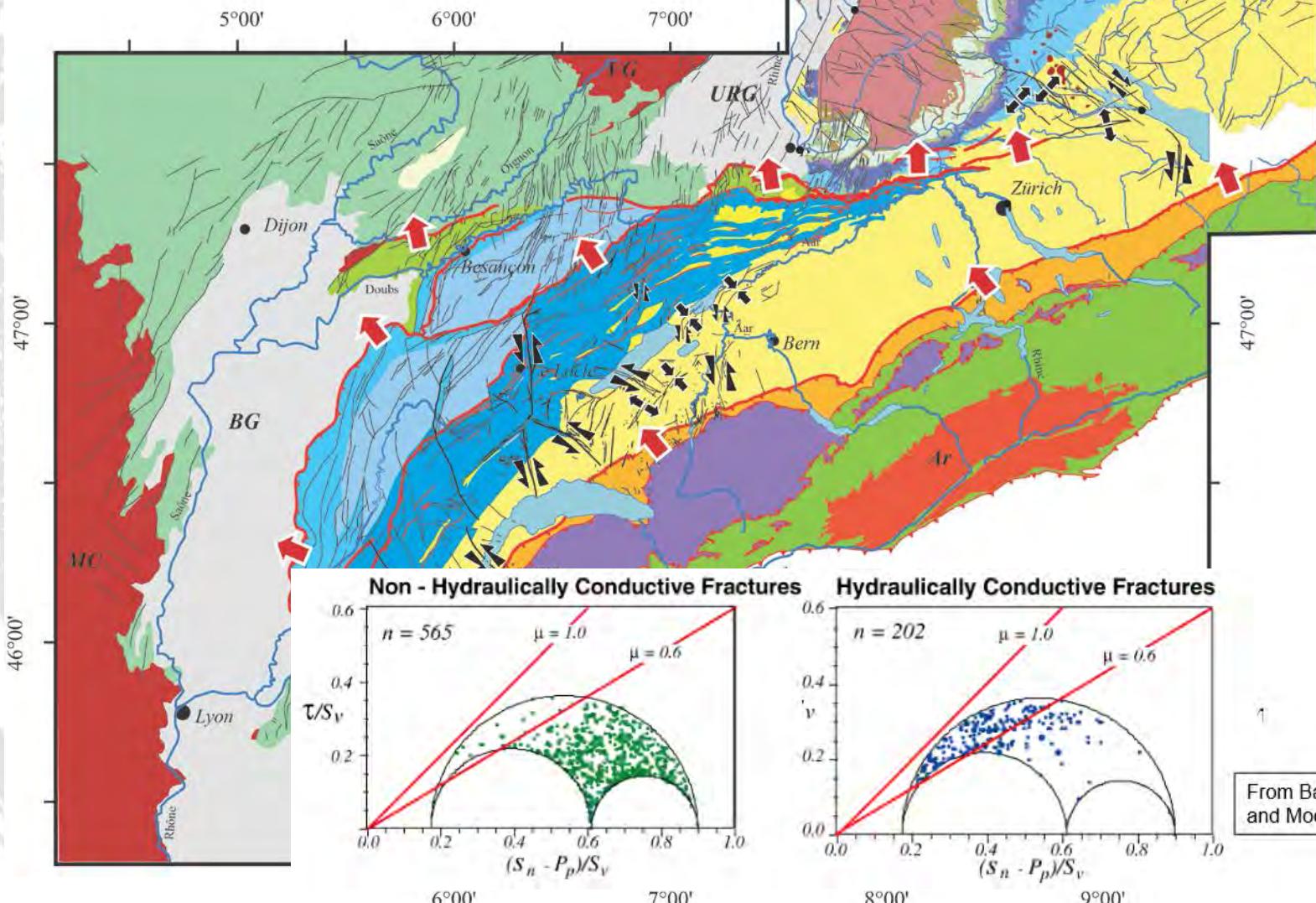


Schweizerischer Erdbebendienst
Service Sismologique Suisse
Servizio Sismico Svizzero
Servizi da Terremoti Svizzeri

Das Geothermie-Projekt der Stadt St.Gallen

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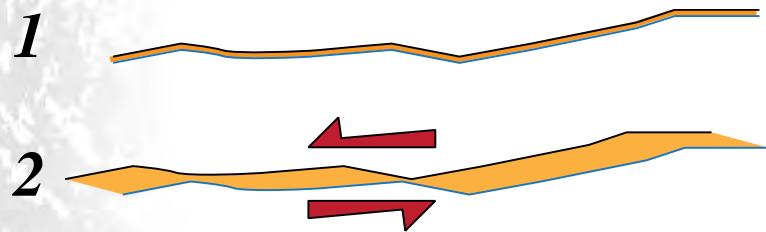
Faults Critically Stressed



Fracking vs. Stimulation

Géothermie Profonde (EGS – enhanced geothermal system)

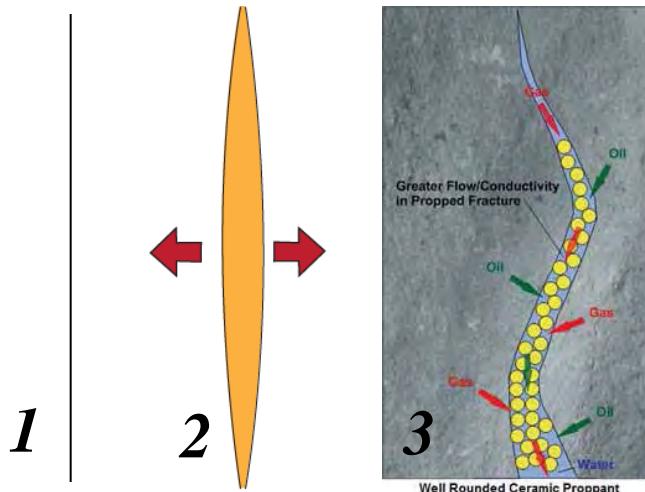
Stimulation



Réactivation de fractures existantes
Fractures cisailantes
«Selfpropelling»

Hydrocarbures non-conventionnels (gaz de schistes, tight sand)

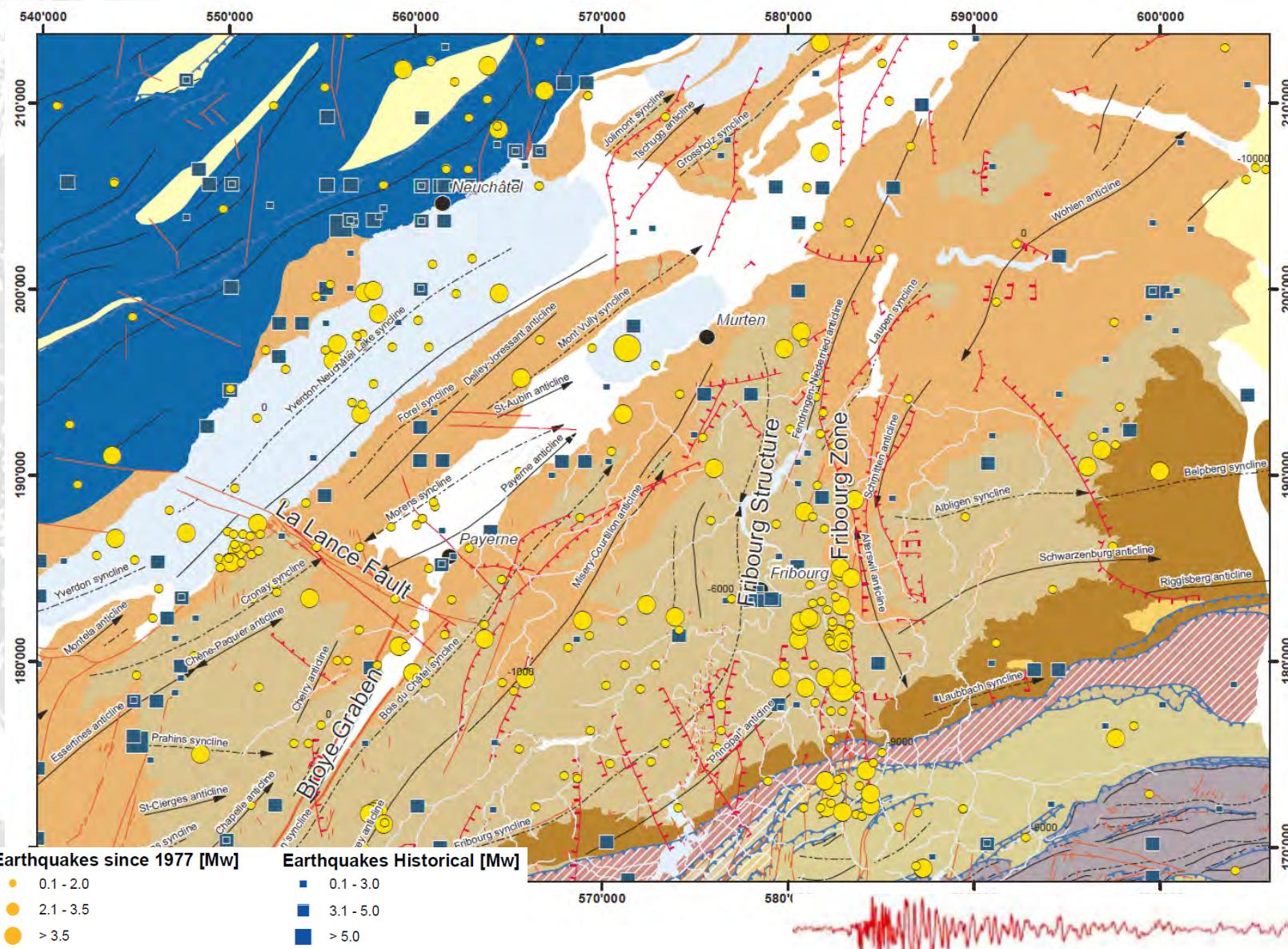
Fracking - Hydrofracturation



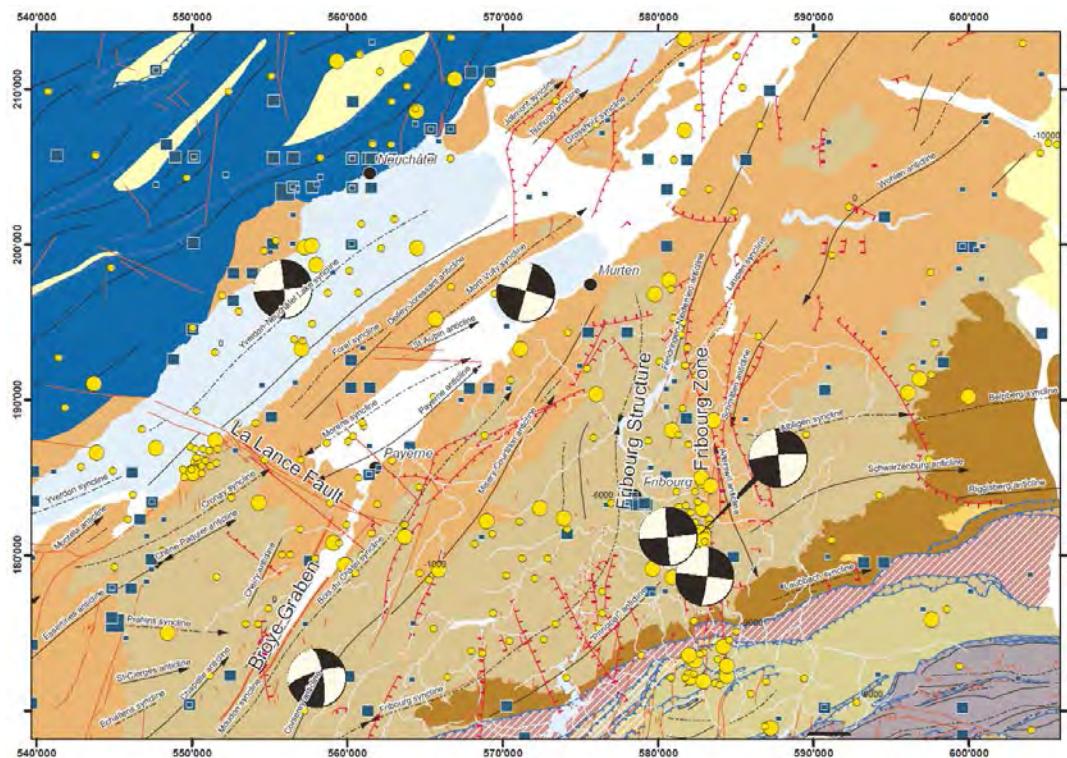
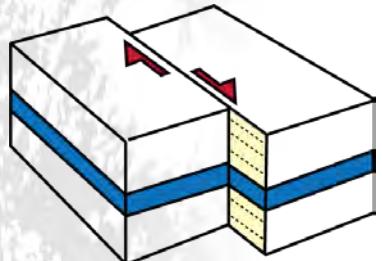
Formation de nouvelles fractures
Fractures simples
«Proppant est du sable»

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Sismicité - Région de Fribourg - Failles & Sismicité

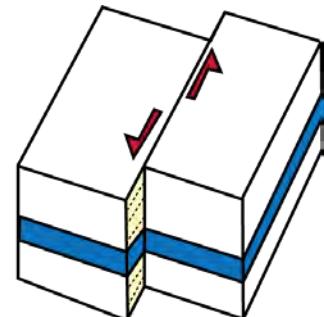
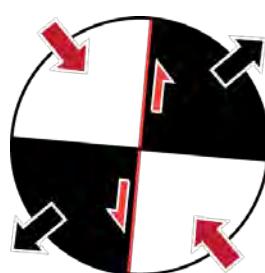


Seismicité - Mécanismes au foyer

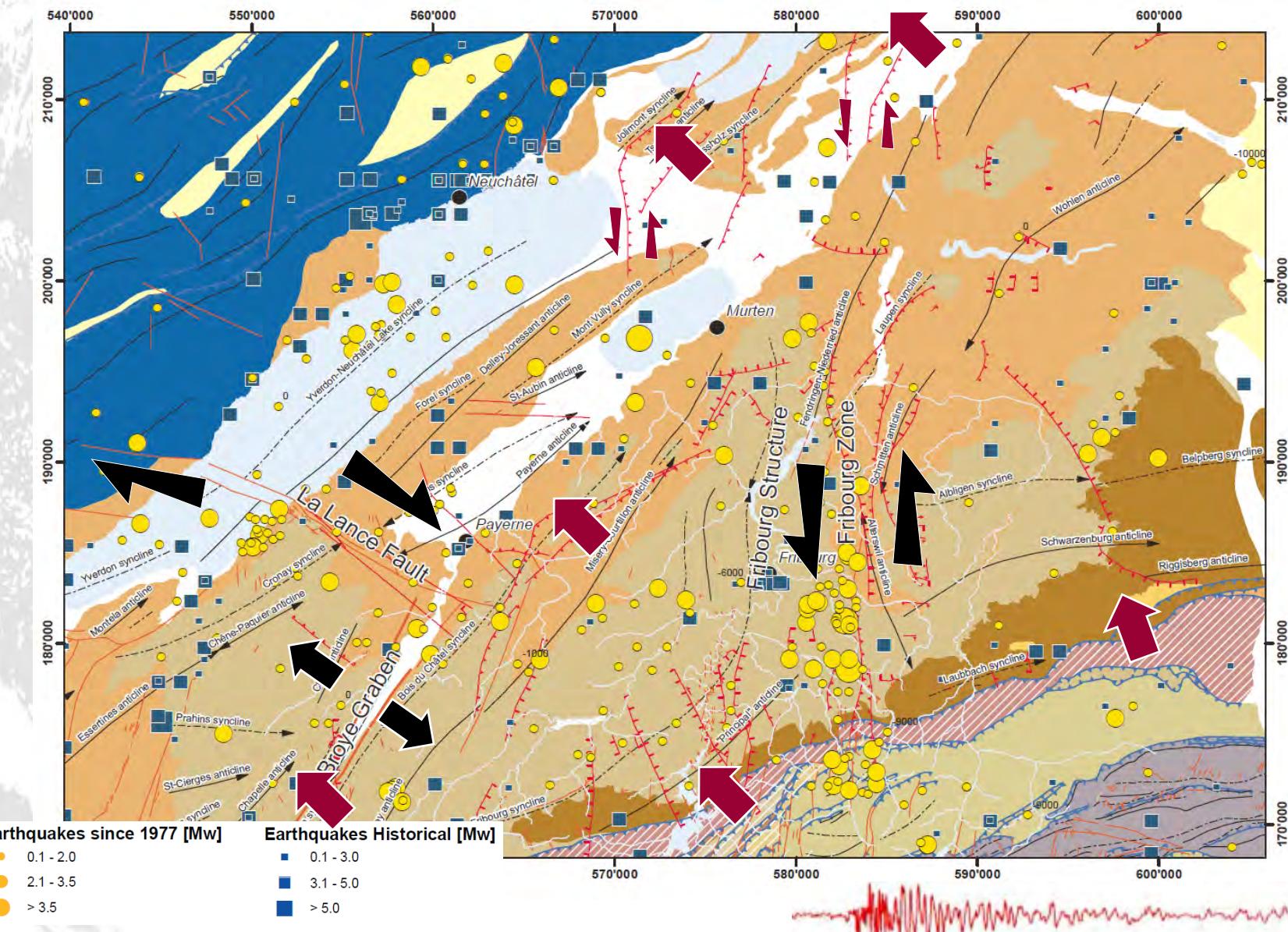


Molasse Basin

- Upper Freshwater Molasse (OSM)
- Belpberg beds (OMM)
- Upper Marine Molasse (OMM)
- Lower Freshwater Molasse (USM)
- Subalpine Molasse



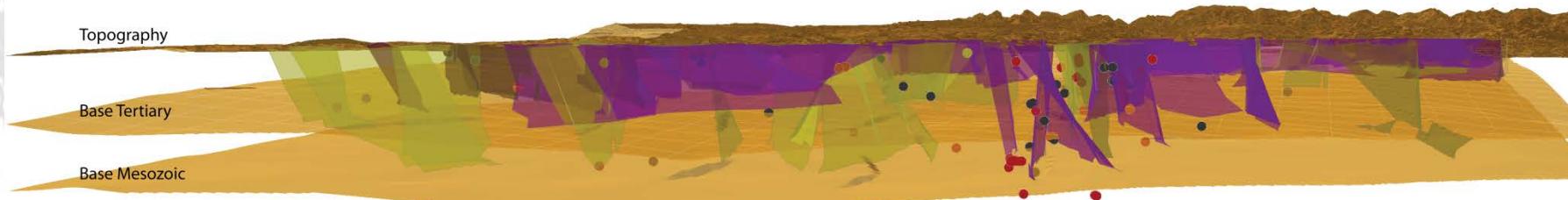
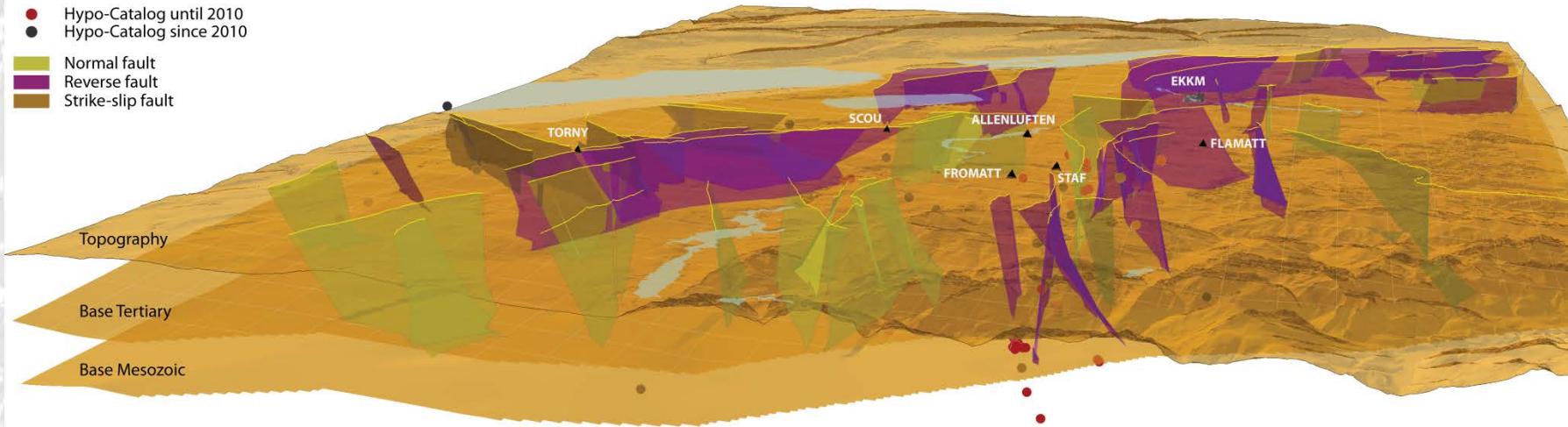
Seismicity - Fribourg Zone - Faults vs. Earthquakes



Modèle 3D Failles - Failles - Sismicité

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- Hypo-Catalog until 2010
- Hypo-Catalog since 2010
- Normal fault
- Reverse fault
- Strike-slip fault



⊕ *Structure 3D - contraintes:*

- ✓ *ouverture - socle*
- ✓ *système complexe de failles*
- ✓ *tectonique active - sismicité*
- ✓ *découplement socle - couverture*

⊕ *Ressources Naturelles*

- ✓ *potentiels :* *hydrocarbures* **OUI**
 ?
 OUI

⊕ *Contraintes*

- ✓ *tectonique active - sismicité*
- ✓ *«critically stressed faults»*
- ✓ *sismicité induite*