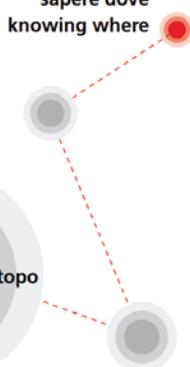




Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Office of Topography swisstopo
Geological data

wissen wohin
savoir où
sapere dove
knowing where



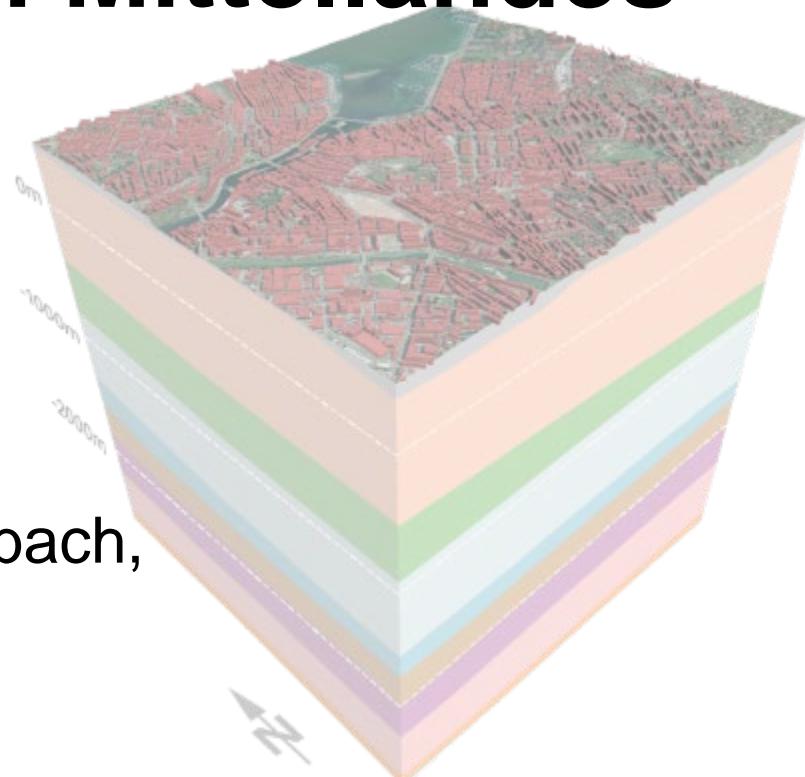
GeoMol

Geologisches 3D-Modell des

Schweizerischen Mittellandes

Kolloquium swisstopo

2. Dezember 2016
Salomè Michael, Robin Allenbach,
Roland Baumberger





To start with...

*“3D subsurface modeling is generally **not an end**, but a means of **improving data interpretation** through visualization and **confrontation of data with each other** and with the model being created,...”*

Caumon et al. (2009)

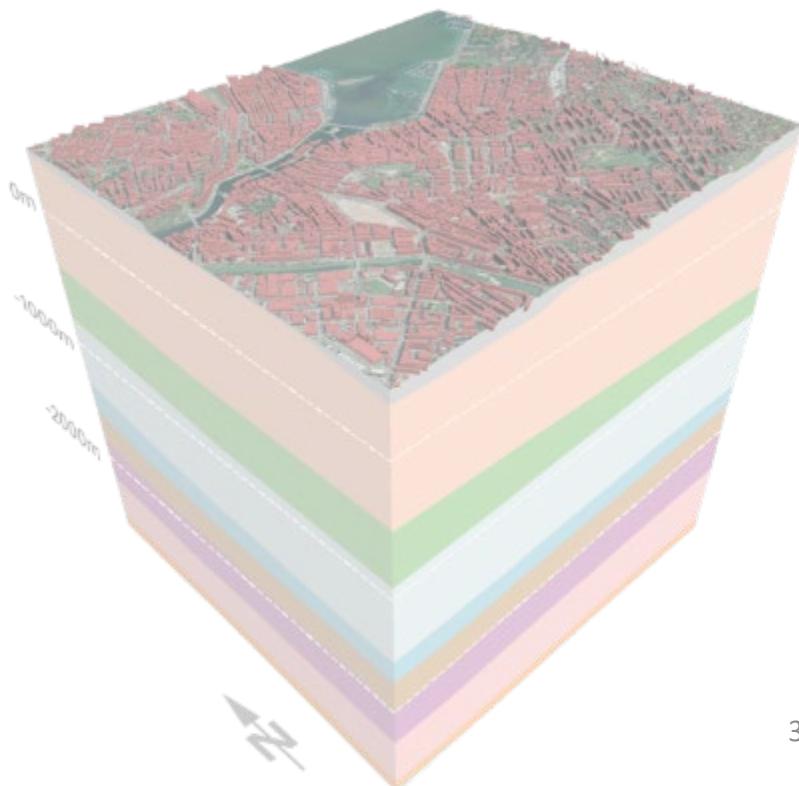
wissen wohin
savoir où
sapere dove
knowing where



Einleitung

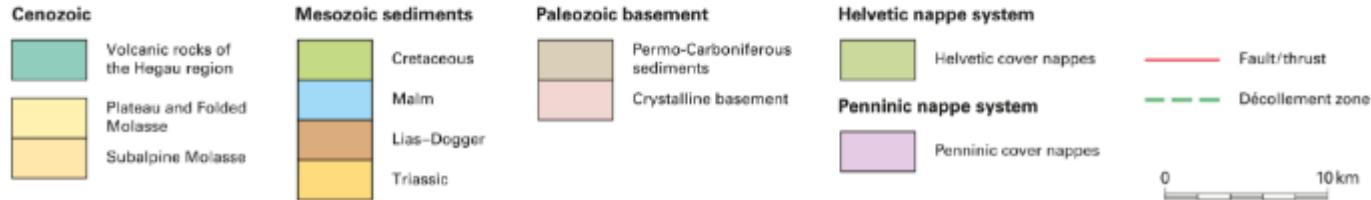
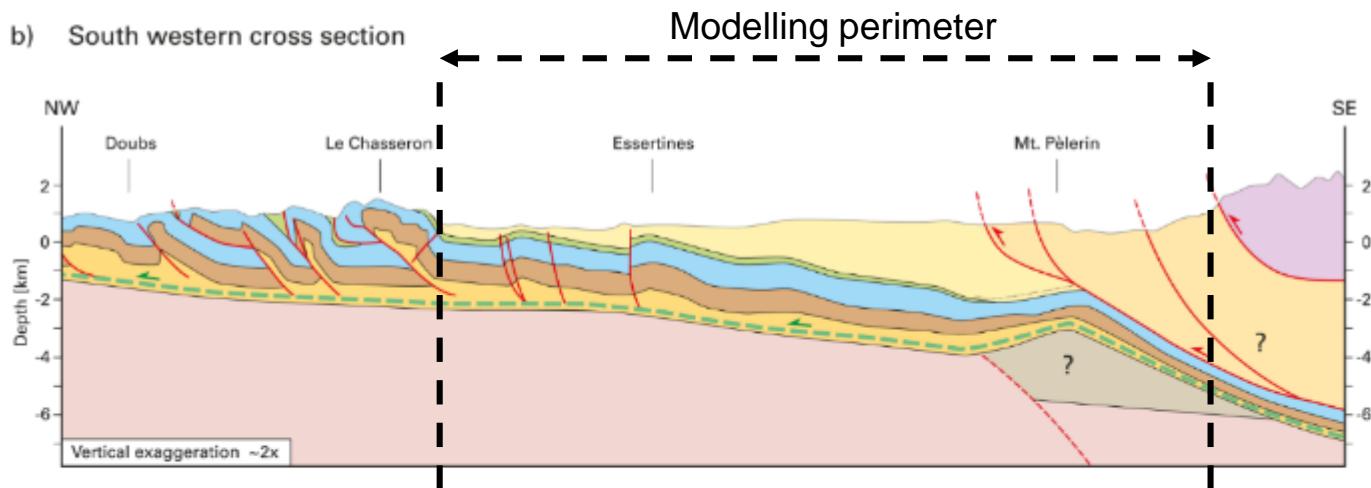
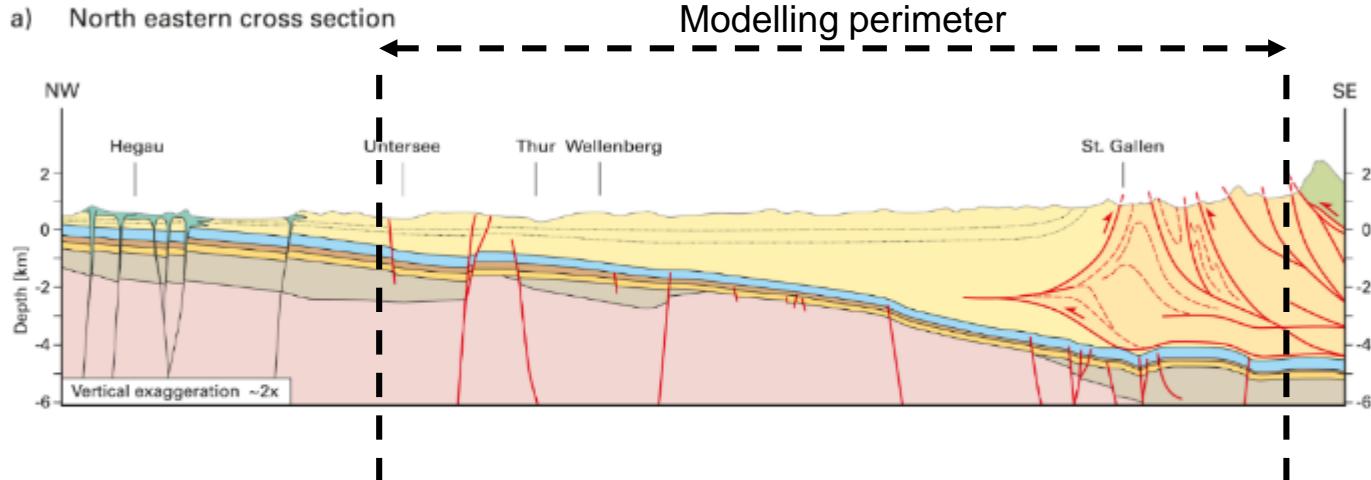
- Geologie
- Das Projekt “GeoMol”

Roland Baumberger





Geological setting



Sommaruga et al. (2012)



Stratigraphy

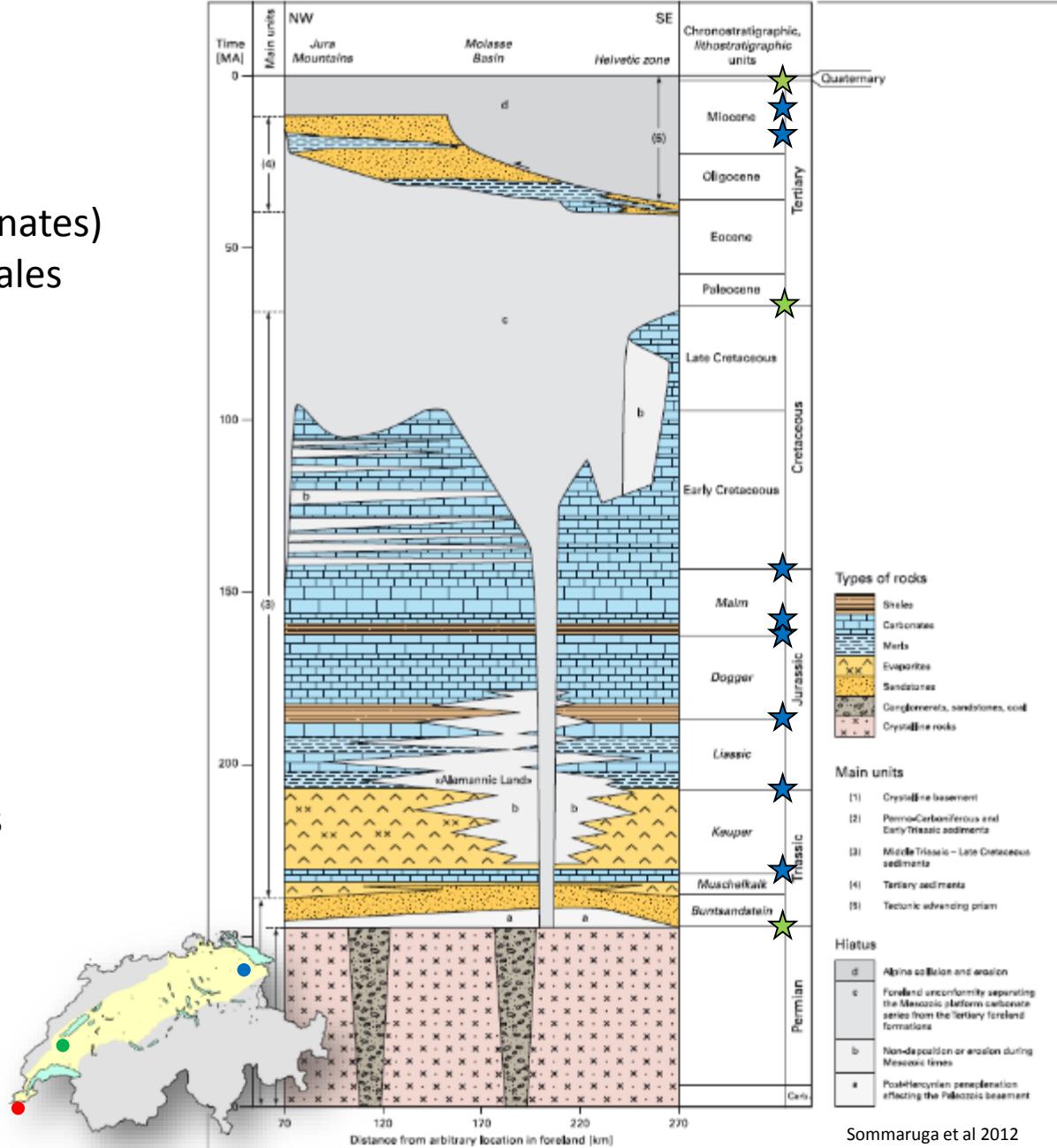
- Cenozoic: siliciclastics (& carbonates)
sandstones, conglomerates, shales
3805m in SGGT-1

- Cretaceous: carbonates
380m in Humilly-1

- Jurassic: carbonates & shales
1050m in Humilly-1

- Triassic: evaporites, carbonates
siliciclastics
>634m in Essertines-1

★ Modeled horizon (formation top)
★ Modeled horizon (formation base)



Sommaruga et al 2012



Rationale 1/3 (from 2012)

ÖV – Dichte der Haltesteller
(AdS3)





Rationale 2/3 (from 2012)

- **Importance**

- Geology is 3D
- Politics (motions Gutzwiller + Bourgeois)
- Technology
- E-Government (duty of disclosure, data exchange)

- **Geopotentials as a focal point**

- Renewable energies, deep aquifers, energetic and non-energetic raw materials, waste disposal, etc.

- **Usage conflicts**

- Spatial and infrastructural planning
- Resource management
- Natural Hazards

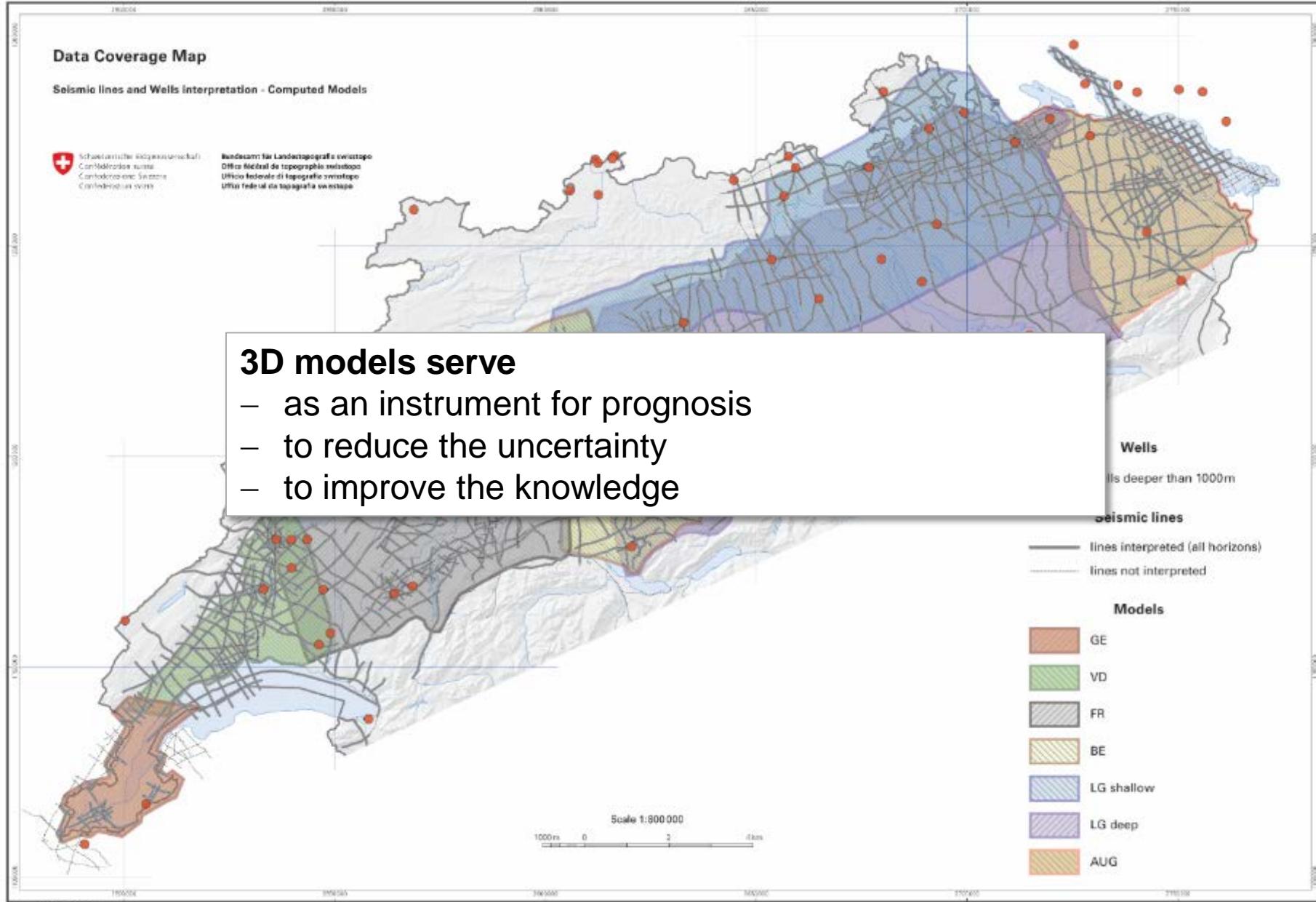
→ **No independent 3D basic data available**





Rationale 3/3

GeoMol Switzerland 2013 - Enclosure XY





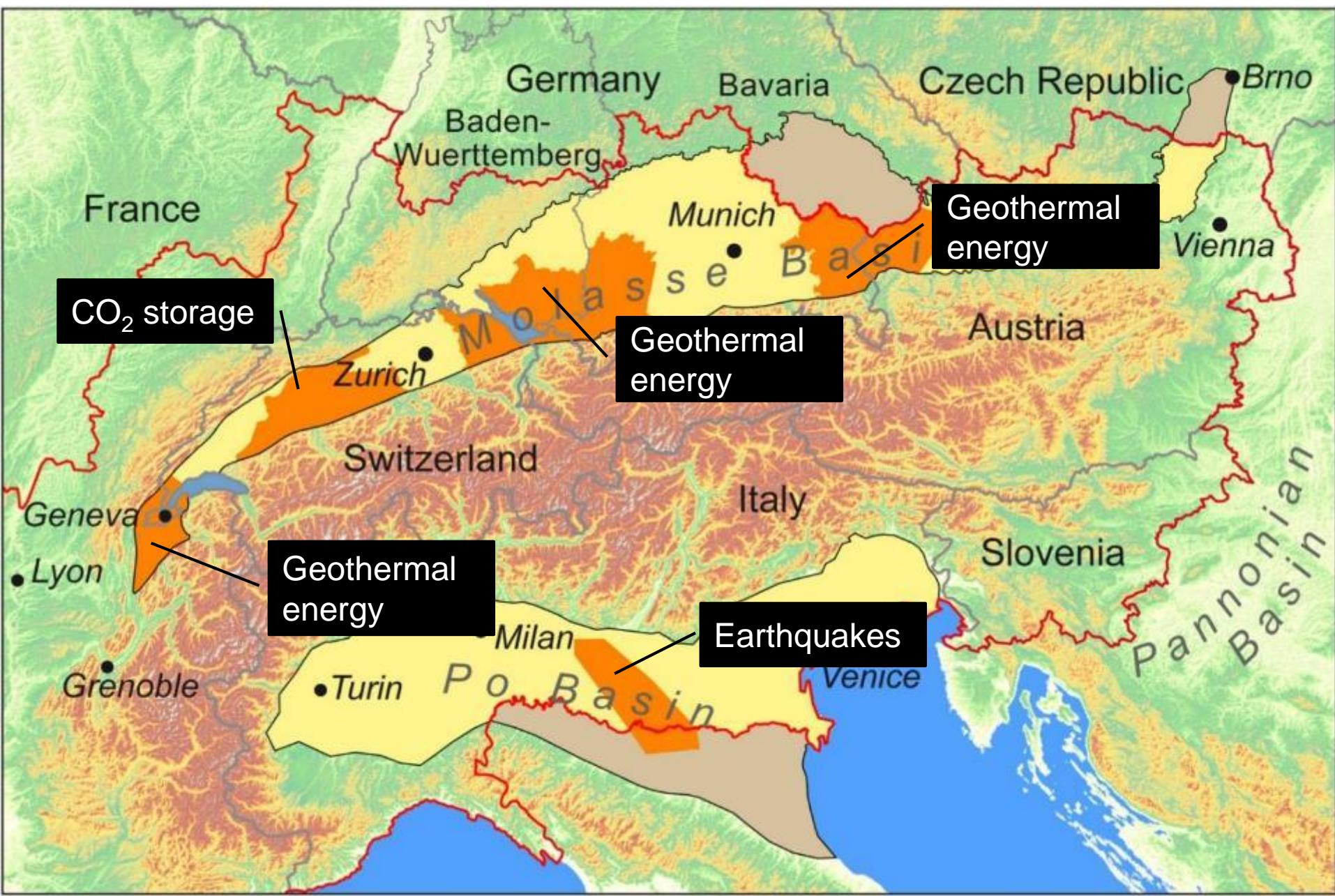
A brief introduction to GeoMol

GeoMol – Assessing the subsurface potentials of the Alpine Foreland Basins

- a project
- co-funded by the EU with €2.1 Mio,
- duration: 2012 - 2015
- jointly steered by 7 Geological Survey Organizations
- aimed for a trans-national, harmonized geological data set
- Assessed and described the existing and assumed potentials of the underground in 5 pilot areas

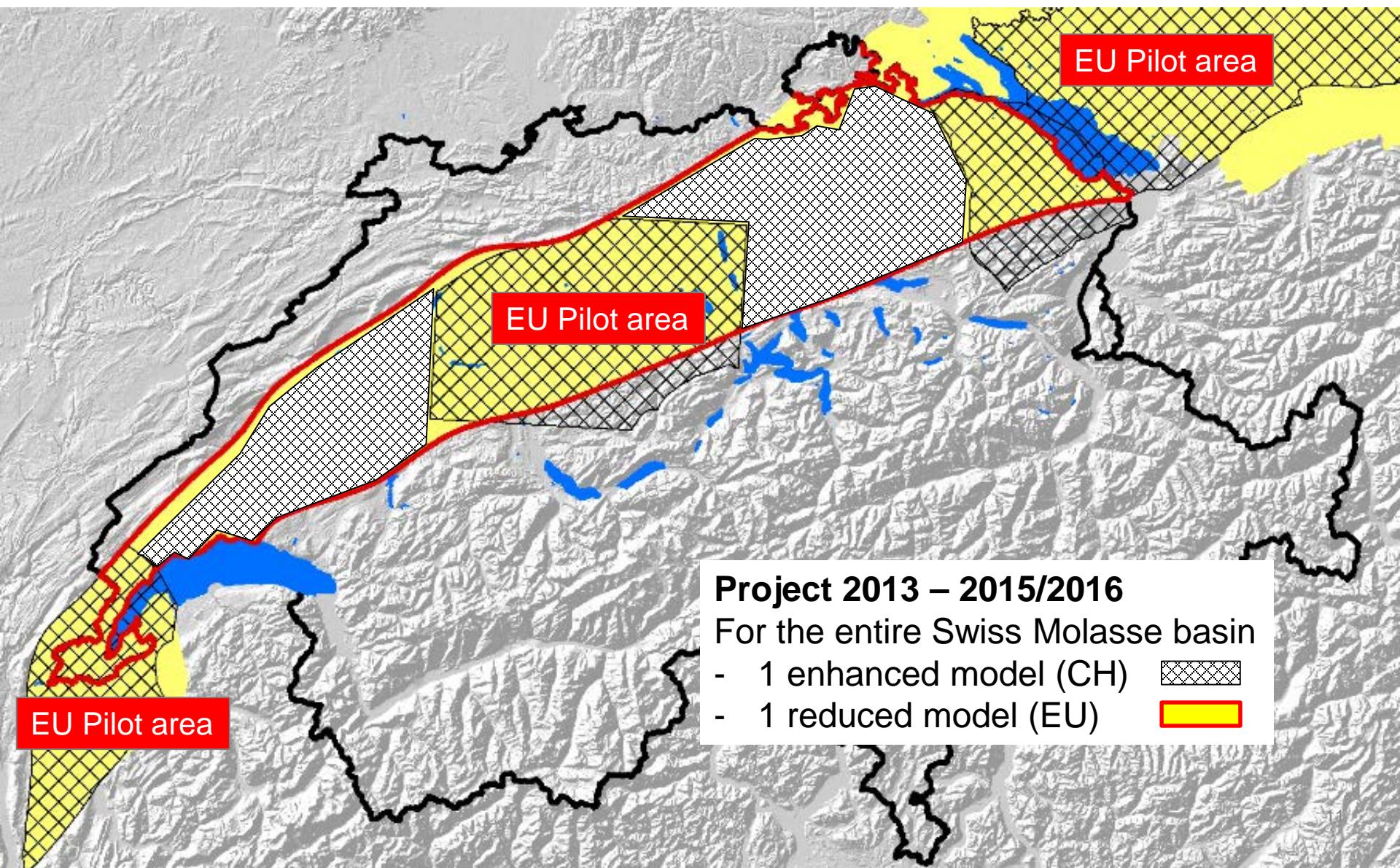


From the European branch...





... to the Swiss GeoMol project





GeoMol EU vs. GeoMol CH

	GeoMol EU	GeoMol CH
Project Area	Alpine Foreland Basins	Swiss Molasse Basin
Work Area CH	Swiss Molasse Basin	Swiss Molasse Basin
Level of Detail	Reduced (1:200'000)	Enhanced (1:50'000)
Model Label	Framework Model	Detailed Model
Partners	7 EU Geological Surveys Lead: Bavaria	6 national partners Lead: swisstopo
Input Data	Seismic Atlas of the Swiss Molasse Basin	Existing seismic interpretations, New interpretations of 2D seismic & wells Additional surface and near surface data
Speciality	Major Fault Zones	New interval velocities
Adjustments	Boundaries against EU Homogeneous Model	No internal adjustment Heterogeneous model
Access	Public, via viewer	Restricted until ~2019



EU – A Patchwork of 3D models



Assessing subsurface potentials of the Alpine Foreland Basins
for sustainable planning and use of natural resources

English Deutsch Français Italiano Slovenski



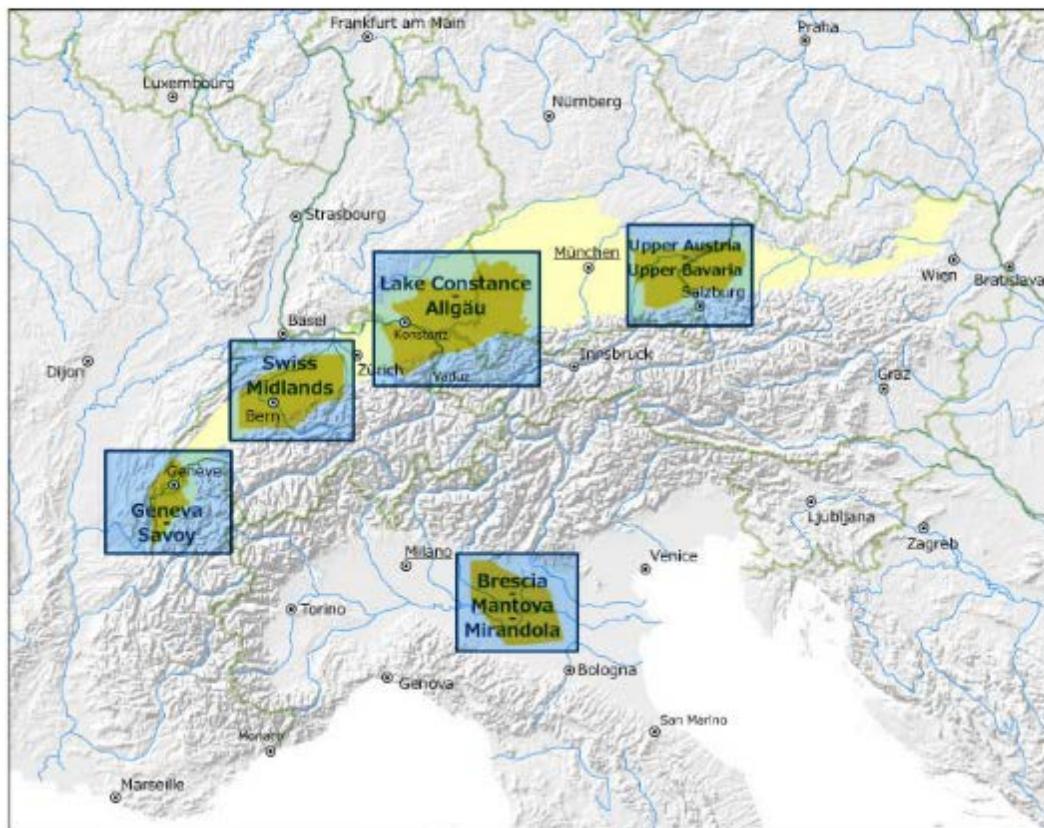
PROJECT | GEO-POTENTIALS | EVENTS | REPORT | MAPVIEWER | 3D-EXPLORER |

Search words



MapViewer

[Direct Link to MapViewer](#) or select area by clicking a highlighted box in the map



MapViewer

Events

[Kick-Off Conference](#)

[Brussels Information Day](#)

[Mid-term Conference](#)

Products

[Report](#)

[MapViewer](#)

[3D-Explorer](#)

Access to:

- Reports
- 3D models
- Map viewer

→ www.geomol.eu



CH – Framework Model

GeoMol CH
Framework Model
1 : 200'000



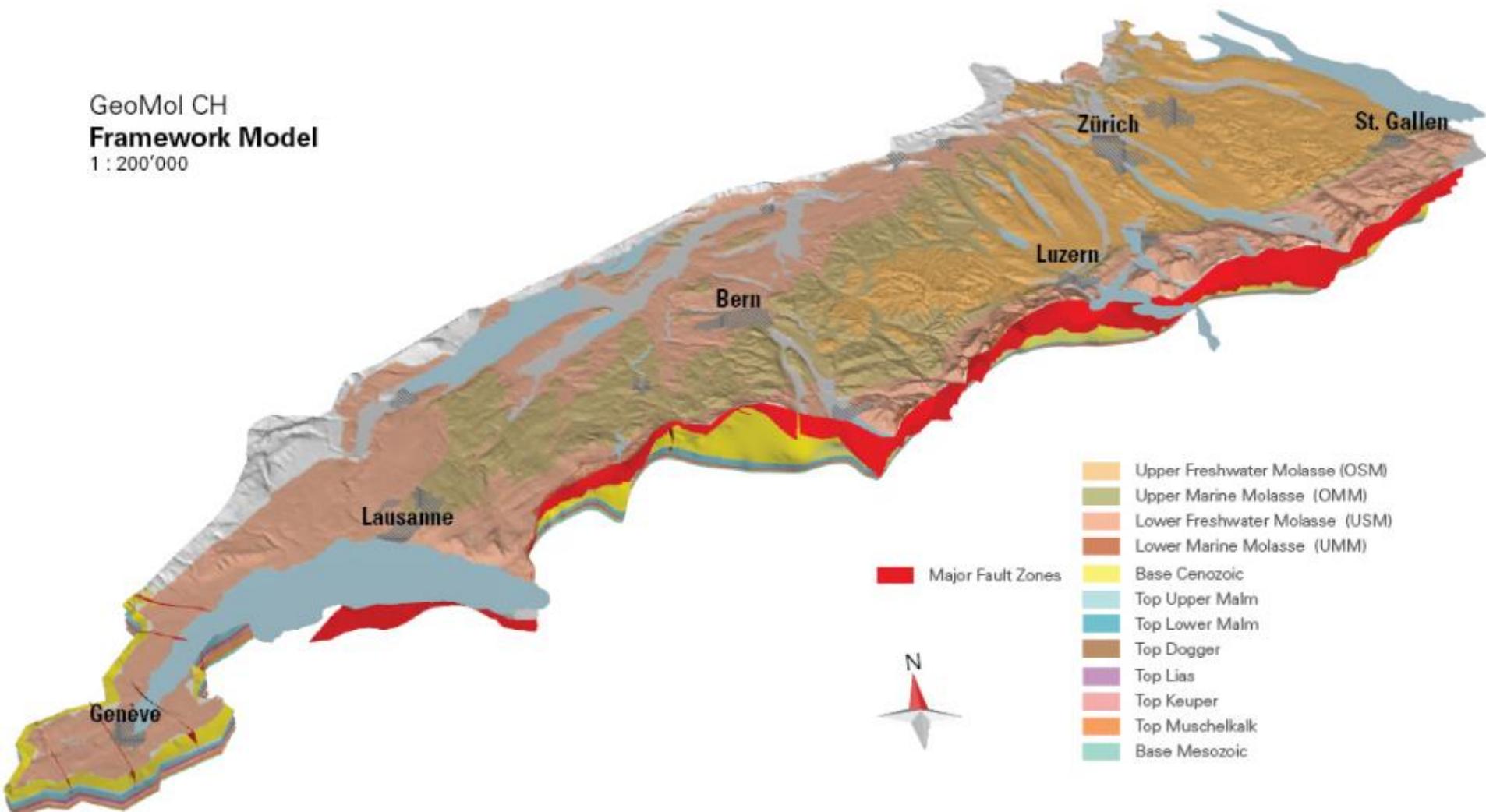
Major Fault Zones

- Upper Freshwater Molasse (OSM)
- Upper Marine Molasse (OMM)
- Lower Freshwater Molasse (USM)
- Lower Marine Molasse (UMM)
- Base Cenozoic
- Top Upper Malm
- Top Lower Malm
- Top Dogger
- Top Lias
- Top Keuper
- Top Muschelkalk
- Base Mesozoic



CH - Framework Model (reduced detail)

GeoMol CH
Framework Model
1 : 200'000

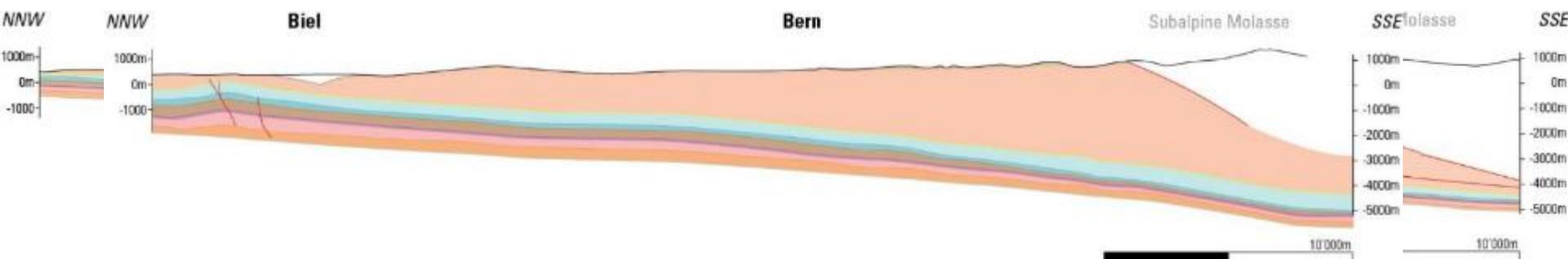




Framework Model (reduced detail)

GeoMol CH
Framework Model
1 : 200'000

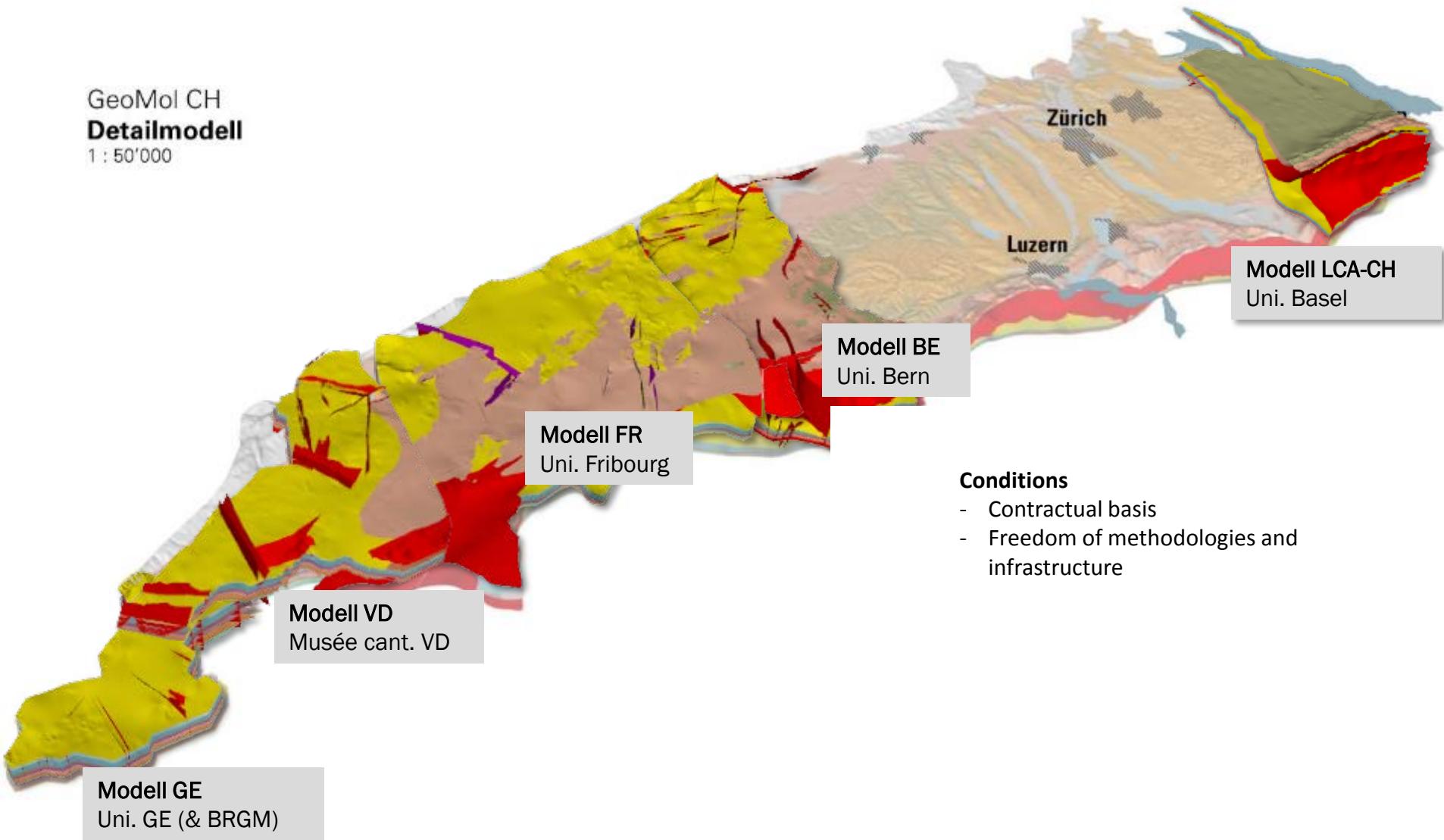
- Upper Freshwater Molasse (OSM)
- Upper Marine Molasse (OMM)
- Lower Freshwater Molasse (USM)
- Lower Marine Molasse (UMM)
- Base Cenozoic
- Upper Malm
- Lower Malm
- Dogger
- Lias
- Keuper
- Muschelkalk
- Base Mesozoic





Detailed model (enhanced detail)

GeoMol CH
Detailmodell
1 : 50'000

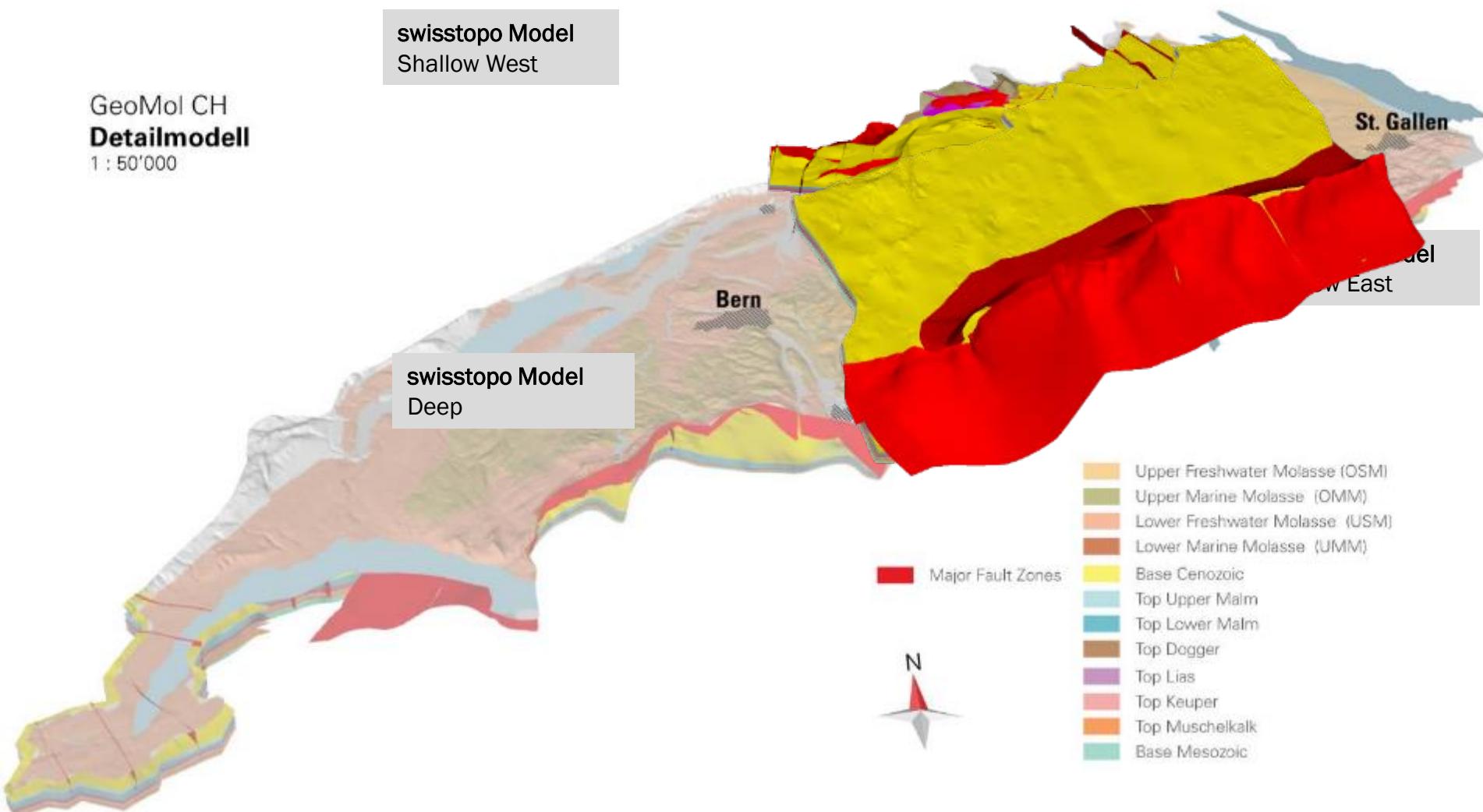


Conditions

- Contractual basis
- Freedom of methodologies and infrastructure



Detailed model (enhanced detail)





Detailed model (enhanced detail)

Upper Freshwater Molasse (OSM)

Upper Marine Molasse (OMM)

Lower Marine Molasse (UMM) and Lower Freshwater Molasse (USM)

Base Cenozoic

Upper part of Malm Group

Lower part of Malm Group

Dogger Group

Lias Group

Keuper Group

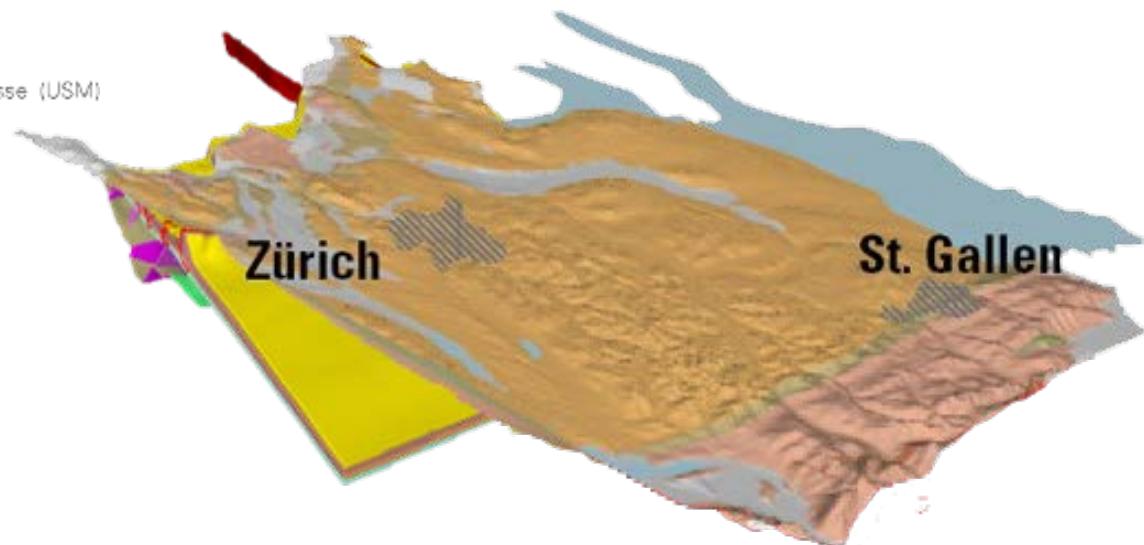
Buntsandstein Group and Muschelkalk Group

Base Mesozoic

Permo-Carboniferous trough sediments

Major Fault Zones

Pre-Mesozoic Fault Zones



NNW

Lägern

Zürich

SSE

1000m

0m

-1000m

1000m

0m

-1000m

-2000m

-3000m

-4000m

-5000m

10'000m



Shallow & deep areas



GeoMol Switzerland 2017 - Enclosure XY

Data Coverage Map

Swisstopo LG Computed Models

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Landestopografie swisstopo
Office fédéral de topographie swisstopo
Ufficio federale di topografia swisstopo
Ufficio federale da topografia swisstopo



1:250'000

1:250'000



1:100'000

1:100'000



1:50'000

1:50'000



1:10'000

1:10'000



1:5'000

1:5'000

version 2016.11.17 - DEM

2000000 1950000 1900000 1850000 1800000 1750000 1700000 1650000 1600000 1550000 1500000 1450000 1400000 1350000 1300000 1250000 1200000 1150000 1100000 1050000 1000000 950000 900000 850000 800000 750000 700000 650000 600000 550000 500000 450000 400000 350000 300000 250000 200000 150000 100000 50000 0

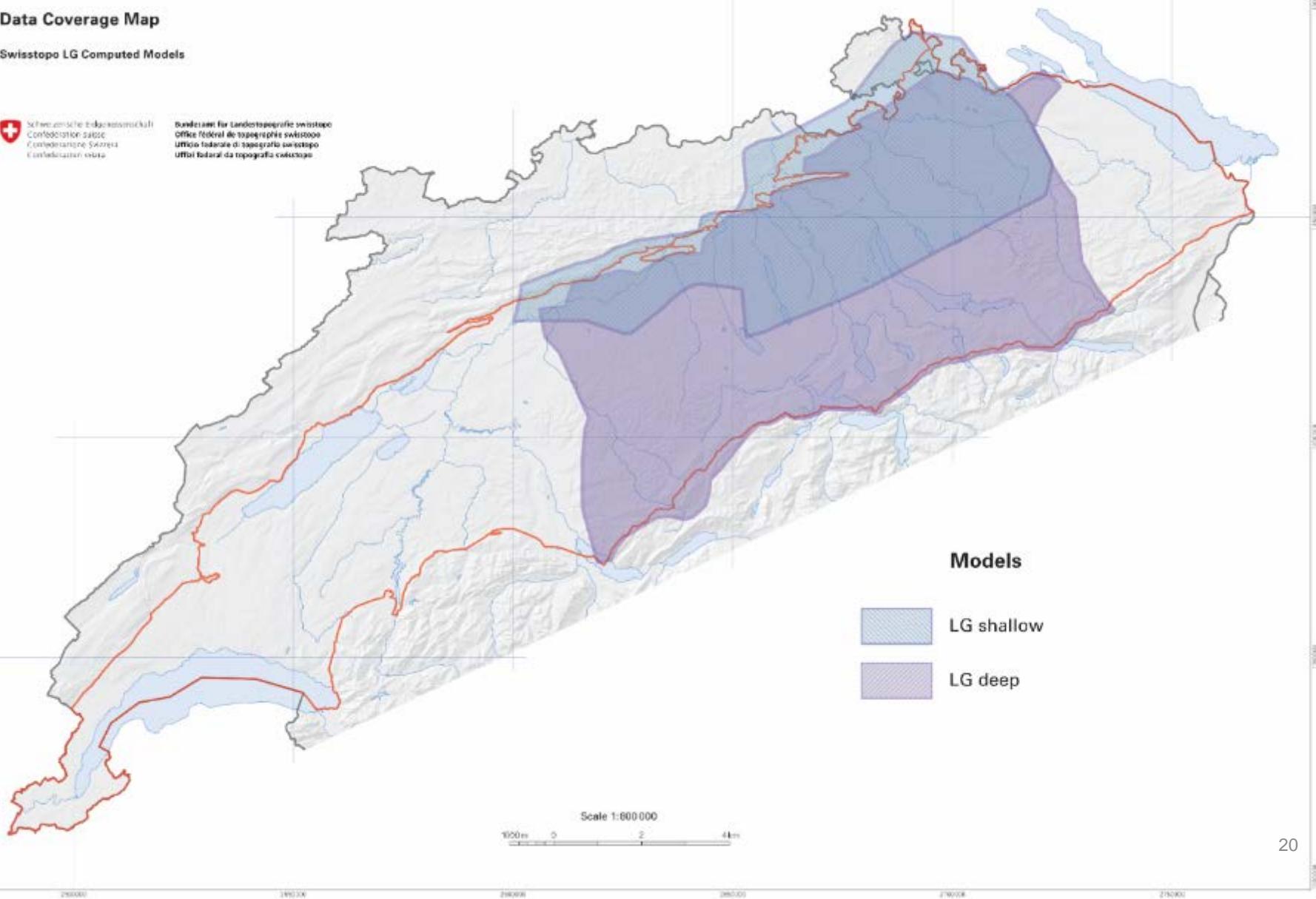
1000m 0 2 4km

Scale 1:800 000

Models

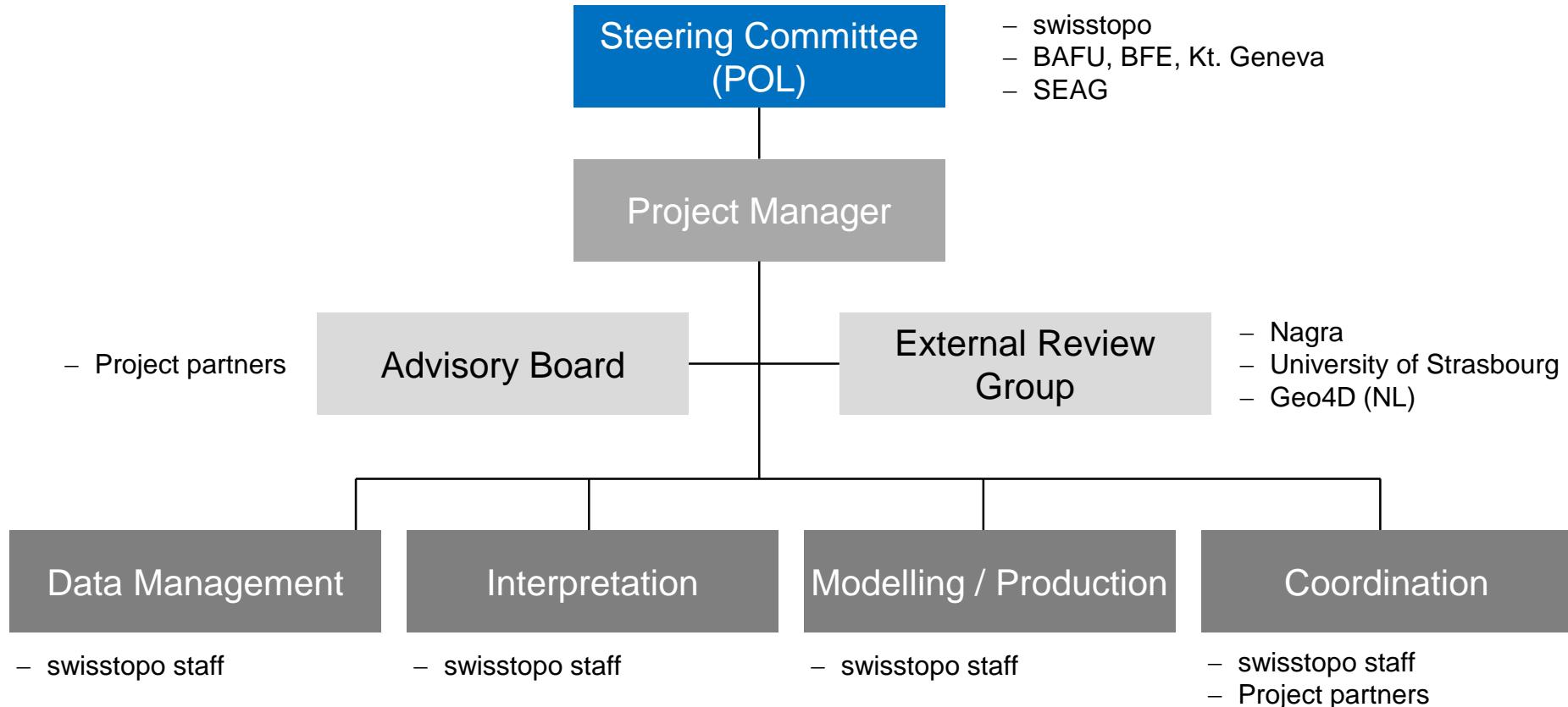
LG shallow

LG deep





Organization





Resources / Budget

Phase		Total CHF
Contributions CASH		
Federal Offices	swisstopo, BAFU, BFE, ARA	1'550'000.-
7 Cantons	GE, FR, VD, SO, AG, ZH, LU	660'000.-
Contributions in kind		
Data	SEAG, Nagra, swissgas, St. Galler Stadtwerke	
Personnel costs	swisstopo	1'300'000.-
Total contributions	in minimum	~3'500'000.-



Acknowledgements

Partners

- Swiss Confederation: swisstopo, OFEN, FOEN, ARE
- Cantons of AG, FR, GE, LU, SO, VD, ZH
- SEAG AG für Schweizerisches Erdöl (major data contributor)
- Nagra (data and know-how)

Data suppliers

- Swiss Confederation: ASTRA
- Cantons BE, NE, GL, SG, SH, SZ, TG, VS, ZG
- Industry: SBB, Stadtwerke St.Gallen, Swissgas

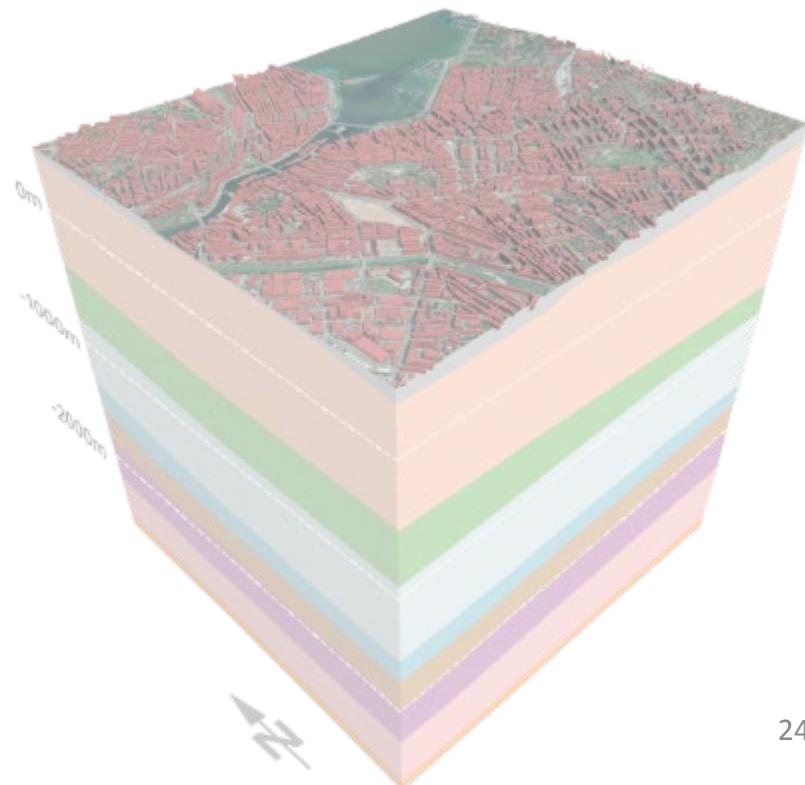
wissen wohin
savoir où
sapere dove
knowing where



Eingangsdaten Modell-Erstellung

- Eingangsdaten
- Workflow

Robin Allenbach



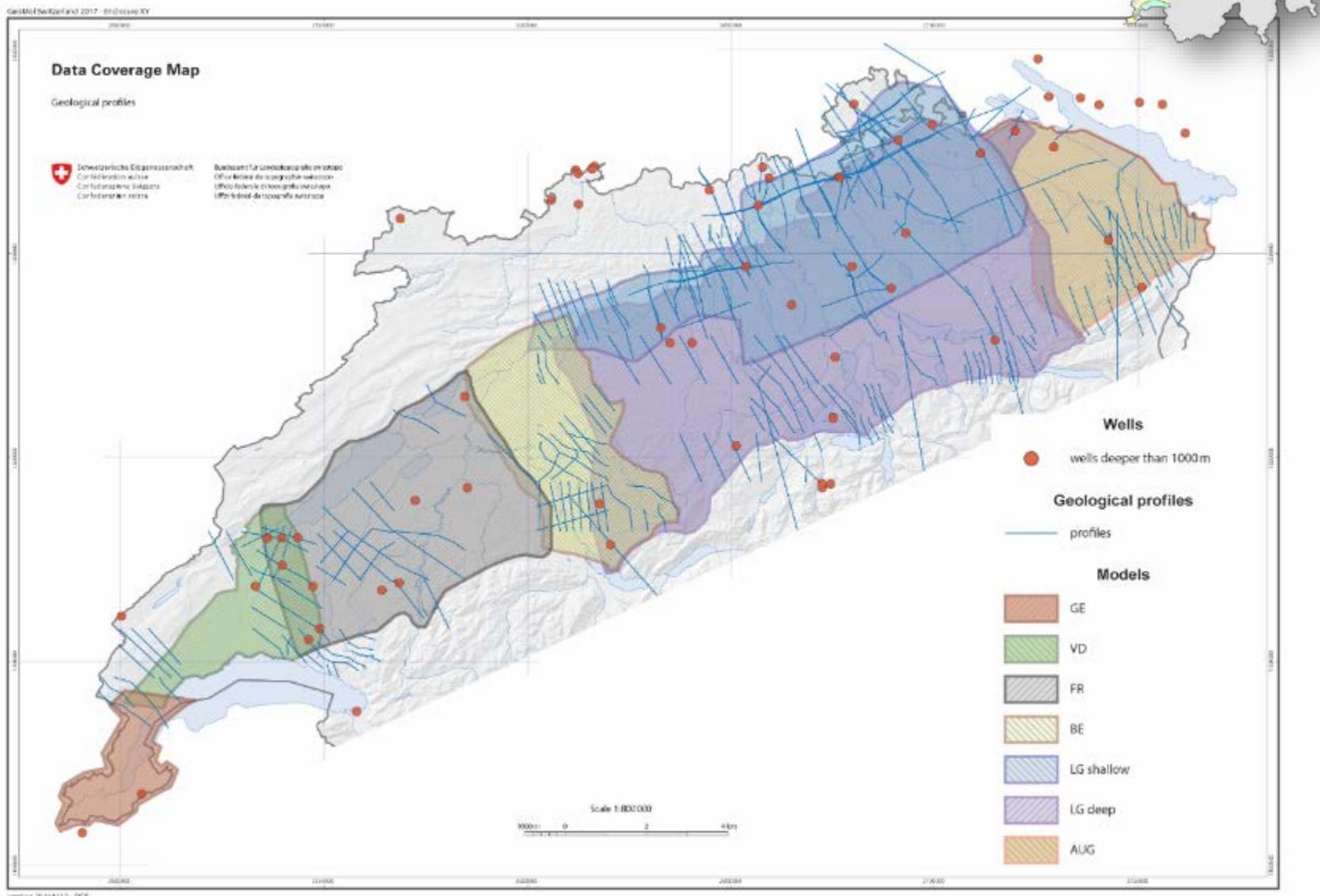


Röti / Topography and geology



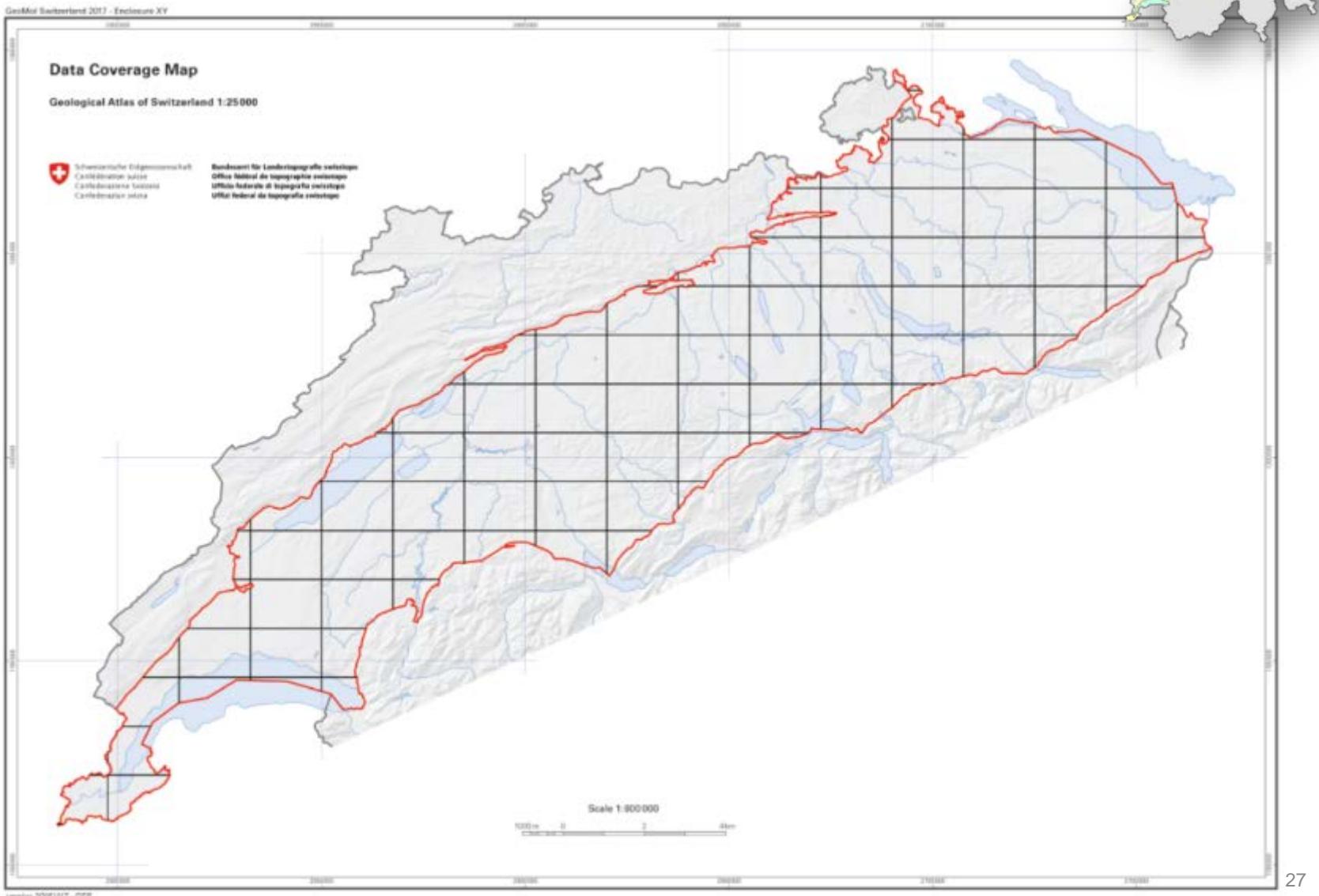


Input Data / Cross sections





Input Data / Geological maps





Input data / Well data



WellBore Information Manager - GeoModel 1.995 20190110 deleteMe - [C:\BM\2000\WBM02\20000779 - No active well filter]

File Edit View Layer Wells Filter Tools Window Web Help

Wells

WELL ID: CH02F75C20ABM02\20000779 - No active well filter

Operator: CH Casting: 1214884.3 Status: UNKNOWN Well: 2000

Existing: 20140301 Existing: Nothing Last: 1214884.3 Existing: Nothing

Time: 2014-03-01 Status: Unknown Revision: EW Last: 1214884.3 TWR: 0.000 Range: Elevation: 0.000 Elevation: 0.000

Log: Well: Filter: Test Track: Elevation: Display: Metric Internal Status: Exposed

Header Formations Zones Faults Survey BHT Core Completion Velocity IP Production Tools Production Towing Drilling Microseismic Remarks

Strat Column	Form Max	Source	Observation Number	Top MD	Top TVD	Top Subsea	Monthing	Casting	Base MD	Base TVD	Base Subsea	Qualifier	Gross Thickness	Net Thickness	TWT
TopShf	LG	1	0.00	0.00		1214885.0	2594885.3								
Orgezon	LG	1	0.00	0.00		1214885.3	2594885.9								
TS	Geostol	1	10.00	10.00		1214885.3	2594885.9								
TSHf	Geostol	1	10.00	10.00		1214885.3	2594885.9								
Top_USM	Prosser	1	10.00	10.00		1214885.3	2594885.9								
Base_Gau	Prosser	1	10.00	10.00		1214885.3	2594885.9								
E_Gau	MAGRBA	1	10.00	10.00		1214885.3	2594885.9								
Prote_Kreide	LG	1	246.00	246.43		1214885.3	2594887.7								
Scen	Geostol	1	246.00	246.94		1214885.3	2594887.7								
E_USM	MAGRBA	1	246.00	246.93		1214885.3	2594887.7								
TCst	Geostol	1	246.00	246.94		1214885.3	2594887.7								
Base_UBH	Prosser	1	246.00	246.95		1214885.3	2594887.7								
E_Tertiary	MAGRBA	1	246.00	246.93		1214885.3	2594887.7								
Top_Kreide	LG	1	246.00	246.93		1214885.3	2594887.7								
Base_Tertiary	Prosser	1	246.00	246.93		1214885.3	2594887.7								
TUMa	Geostol	1	460.00	359.95		1214885.3	2594887.7								
Top_Marl	Prosser	1	460.00	359.95		1214885.3	2594887.7								
Klimmerdawn	LG	1	463.00	463.90		1214885.4	2594887.6								
Detondale	LG	1	640.00	665.67		1214885.5	2594882.9								
TJf	Geostol	1	910.00	841.09		1214886.4	2594793.1								
I_BII	MAGRBA	1	910.00	841.09		1214886.4	2594793.1								
Top_Effinger	Prosser	1	910.00	841.09		1214886.4	2594793.1								
The	Geostol	1	1275.00	1068.10		1215001.4	2594704.0								
Calvertian	LG	1	1250.00	1068.32		1215003.9	2595004.0								
Base_Watt	MAGRBA	1	1250.00	1068.32		1215003.9	2595004.0								
Base_Watt	Prosser	1	1250.00	1068.32		1215003.9	2595004.0								
Base_Calvertian	Prosser	1	1311.00	1111.66		1215004.8	2595076.0								
Fathometer_Torqueline	LG	1	1457.00	1417.64		1215005.1	2595076.0								
Aalenian	LG	1	1685.00	1443.10		1215075.8	2595232.6								
Top_Hundschussen	Prosser	1	1850.00	1442.10		1215075.8	2595232.6								
Top	Geostol	1	1850.00	1455.94		1215076.3	2595234.5								
T_Ope	MAGRBA	1	1850.00	1455.94		1215076.3	2595234.5								
Top_CPA	Prosser	1	1760.00	1475.94		1215079.1	2595204.5								
TJ	Geostol	1	1762.00	1538.27		1215079.4	2595244.4								
E_Ope	MAGRBA	1	1762.00	1539.27		1215079.4	2595244.4								
Base_Ope	Prosser	1	1762.00	1539.27		1215079.4	2595244.4								
Fathometer	LG	1	1762.00	1538.27		1215079.4	2595244.4								
Tiles	Geostol	1	1850.00	1630.00		1215005.7	2595245.9								
E_Lies	MAGRBA	1	1850.00	1630.00		1215005.7	2595245.9								
Kasper	LG	1	1850.00	1630.00		1215005.7	2595245.9								
Base_Lies	Prosser	1	1850.00	1630.00		1215005.7	2595245.9								
Tiles	Geostol	1	2234.00	1988.46		1215100.6	2595204.7								
Top_MK	MAGRBA	1	2234.00	1988.46		1215101.4	2595204.7								
Top_MK	Prosser	1	2234.00	1988.46		1215101.4	2595204.7								
TD	Technical	1	2425.00	2181.45		1215101.4	2595205.9								

WellBore Viewer - CH02F75C20ABM02\20000779

Ready

SOM PUBLIC WELL BOUNDARY OverWell NUM



Map total measured depth [m]

2'550'000

2'650'000

2'750'000

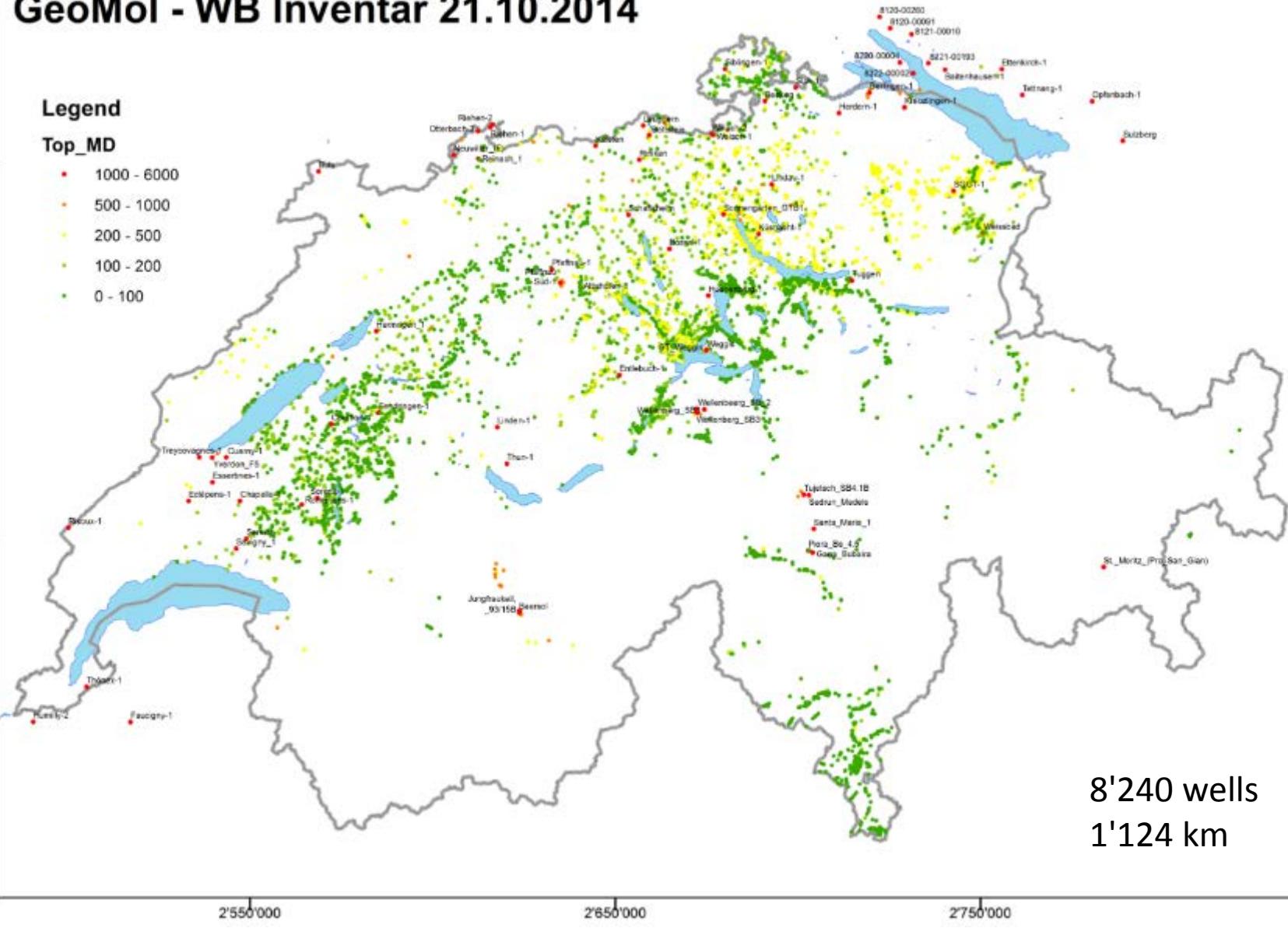
GeoMol - WB Inventar 21.10.2014

Legend

Top_MD

- 1000 - 6000
- 500 - 1000
- 200 - 500
- 100 - 200
- 0 - 100

1'260'000
1'160'000
1'060'000



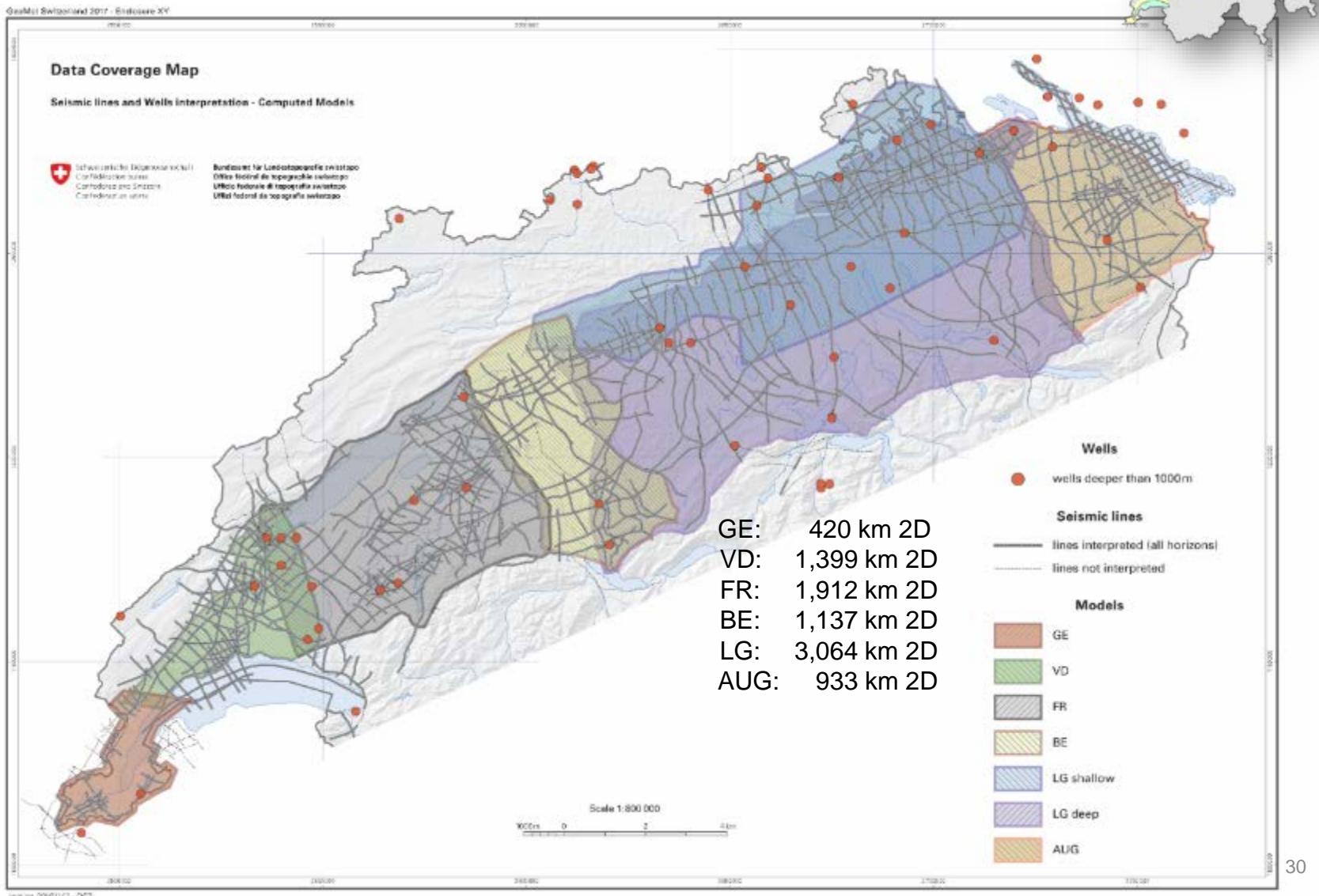
1'260'000

1'160'000

1'060'000



Input data / 2D seismic



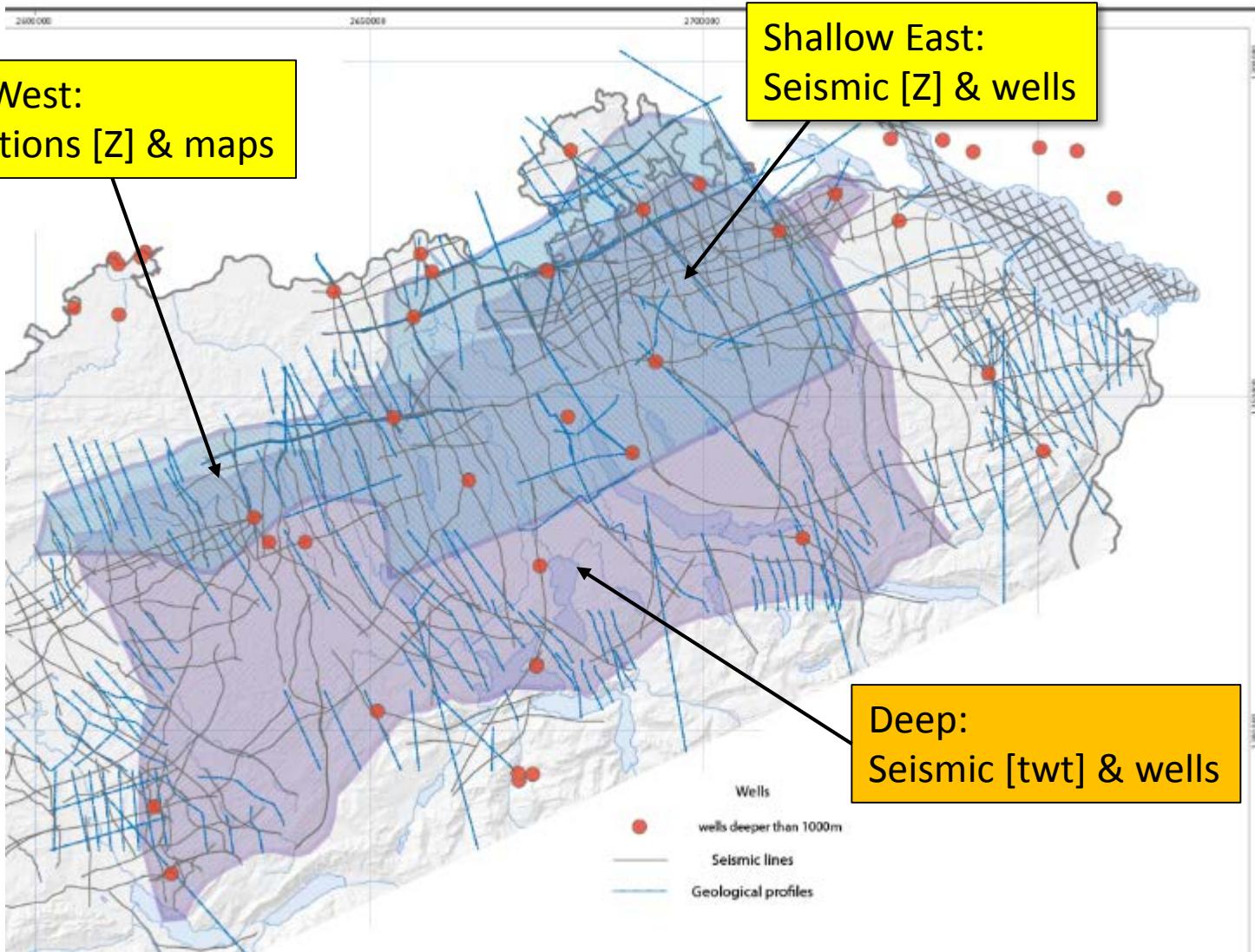


Shallow vs deep

Shallow West:
Geol. sections [Z] & maps

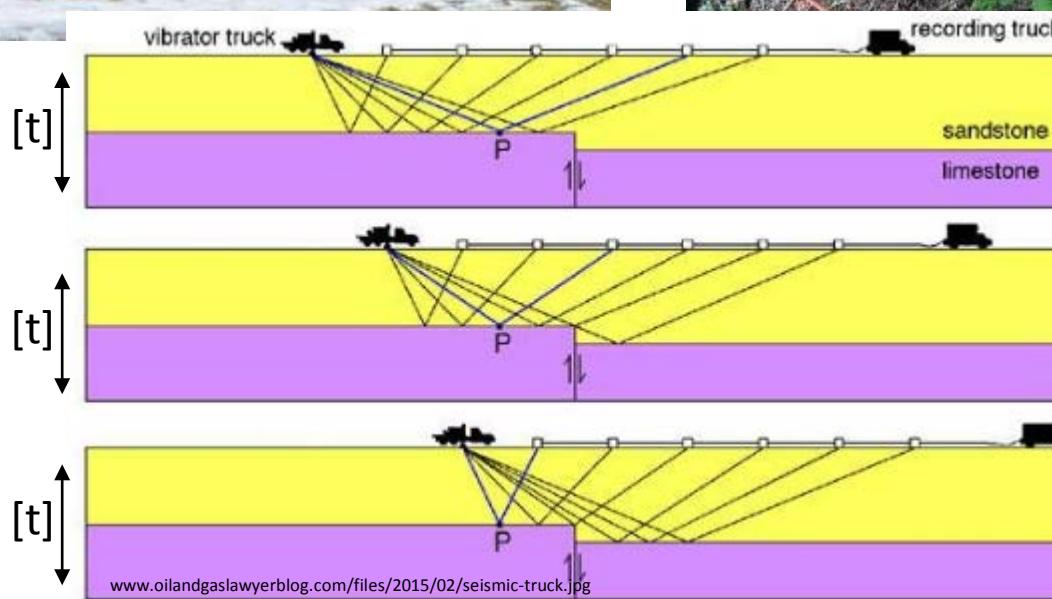
Shallow East:
Seismic [Z] & wells

Deep:
Seismic [twt] & wells



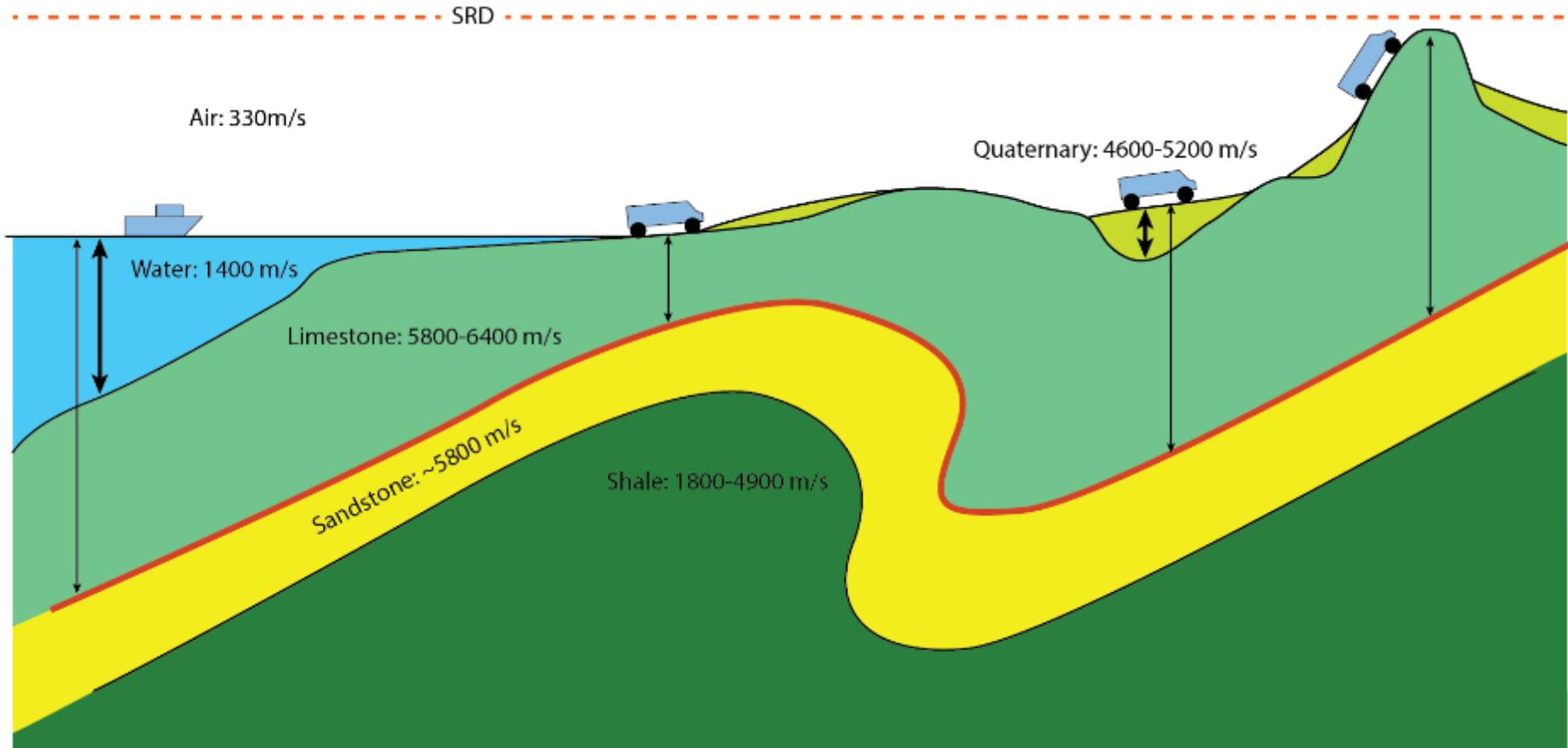


Seismic survey



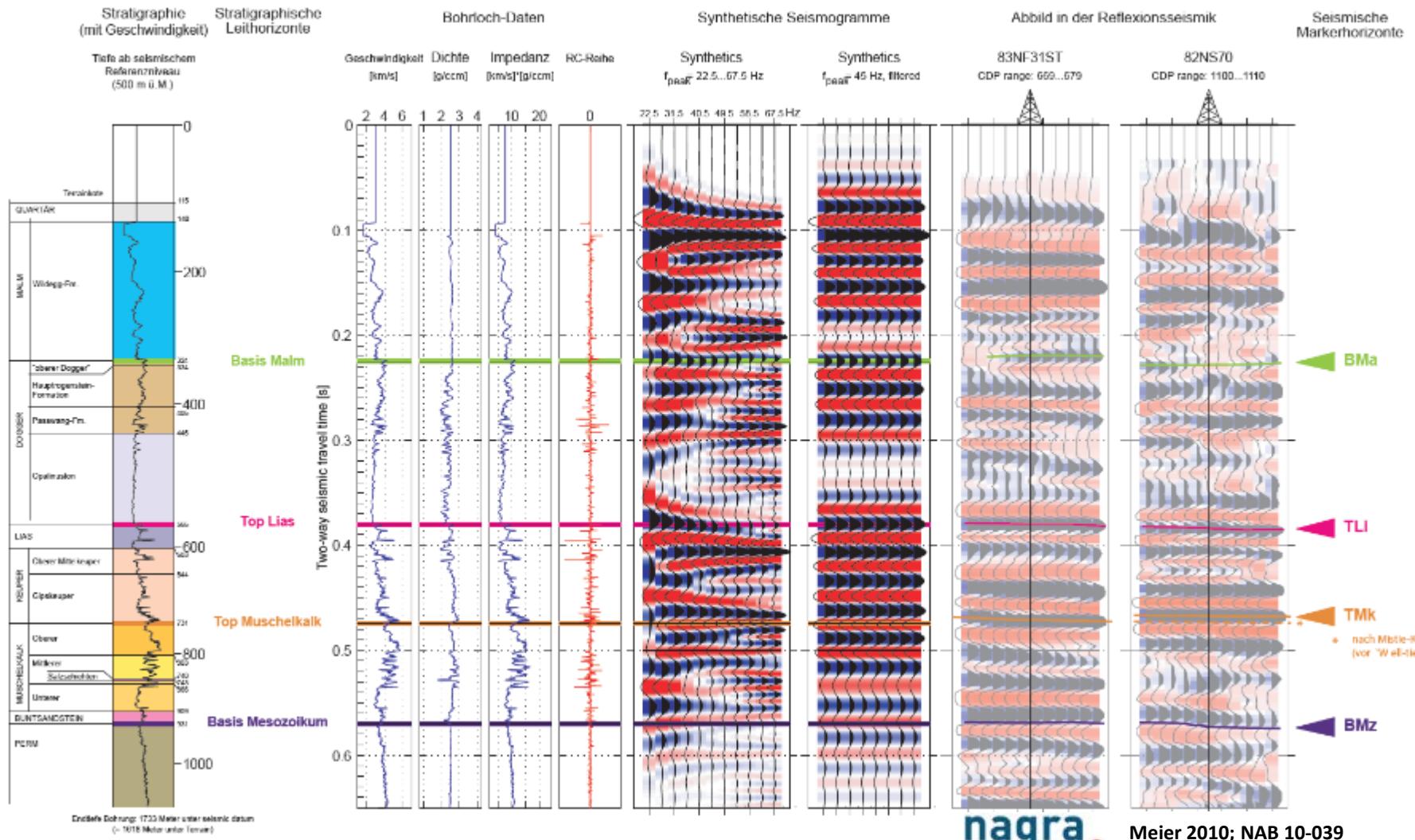


Topography & velocities





Synthetic seismogram Riniken

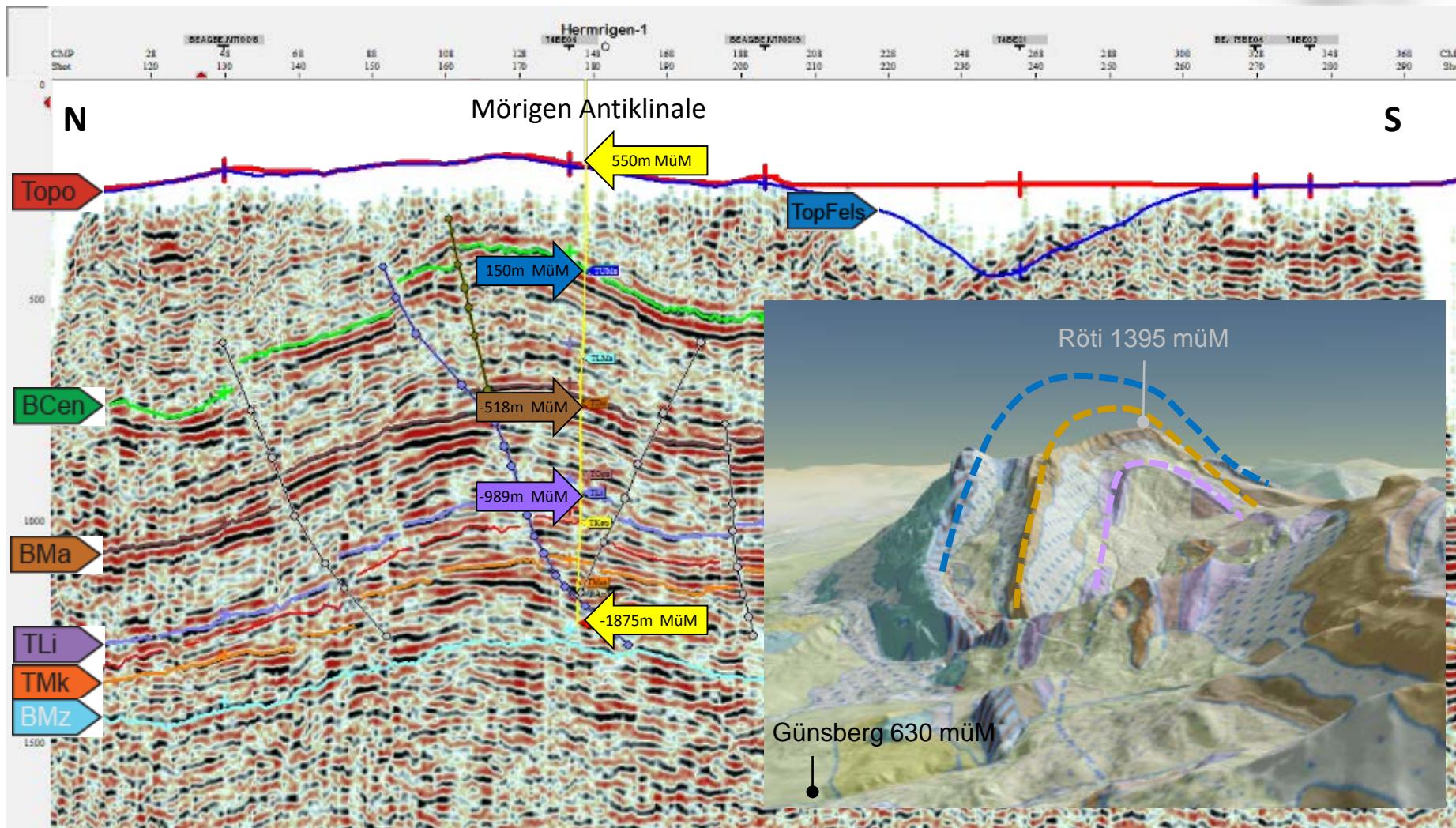


nagra

Meier 2010; NAB 10-039

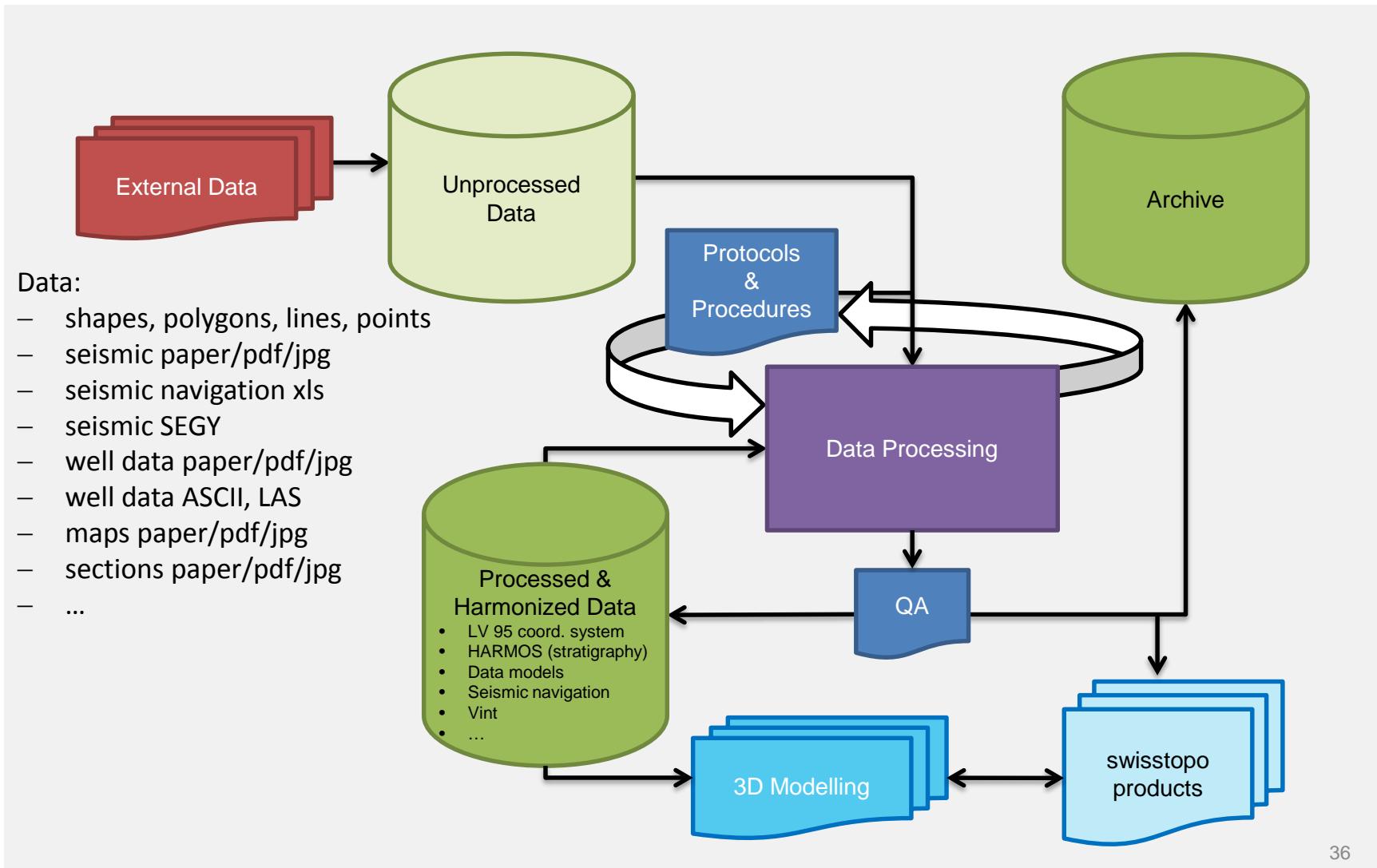


74BE07 / interpreted





General data workflow



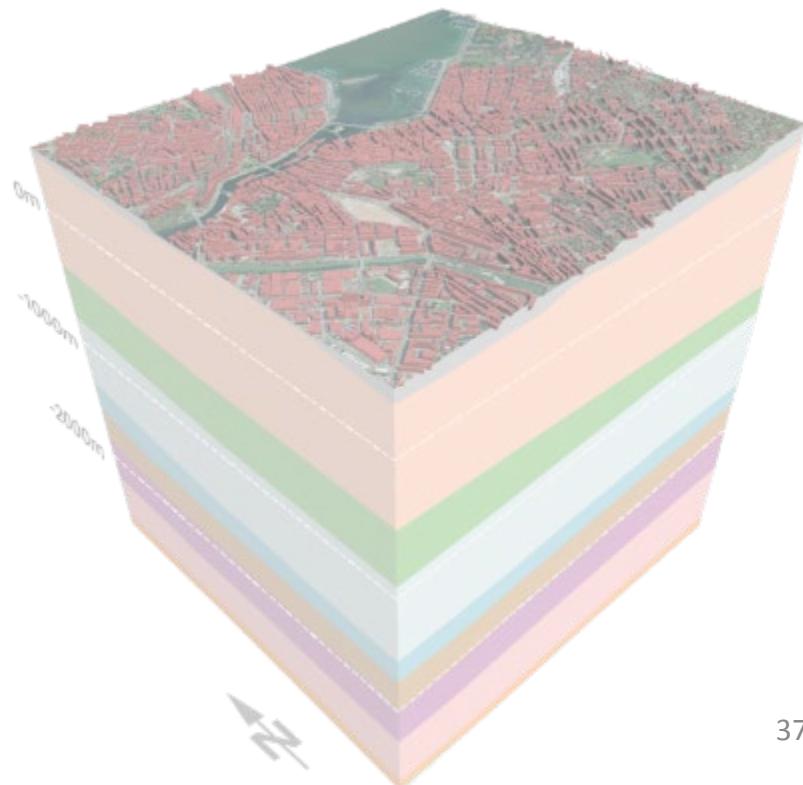
wissen wohin
savoir où
sapere dove
knowing where



Resultate & Produkte

- Felsoberfläche
- Geschwindigkeitsmodell
- Strukturmodell
- Beispiele & Live Demo

Salomè Michael





Top bedrock – Input data

Bestehende Felsmodelle

Geologischer Atlas 1:25'000
SO
GE
VD

Tafeln Graf
Klingelé
Wildi

Bohrungen mit TopFels

Dürst Stucki



Fiore



Jordan

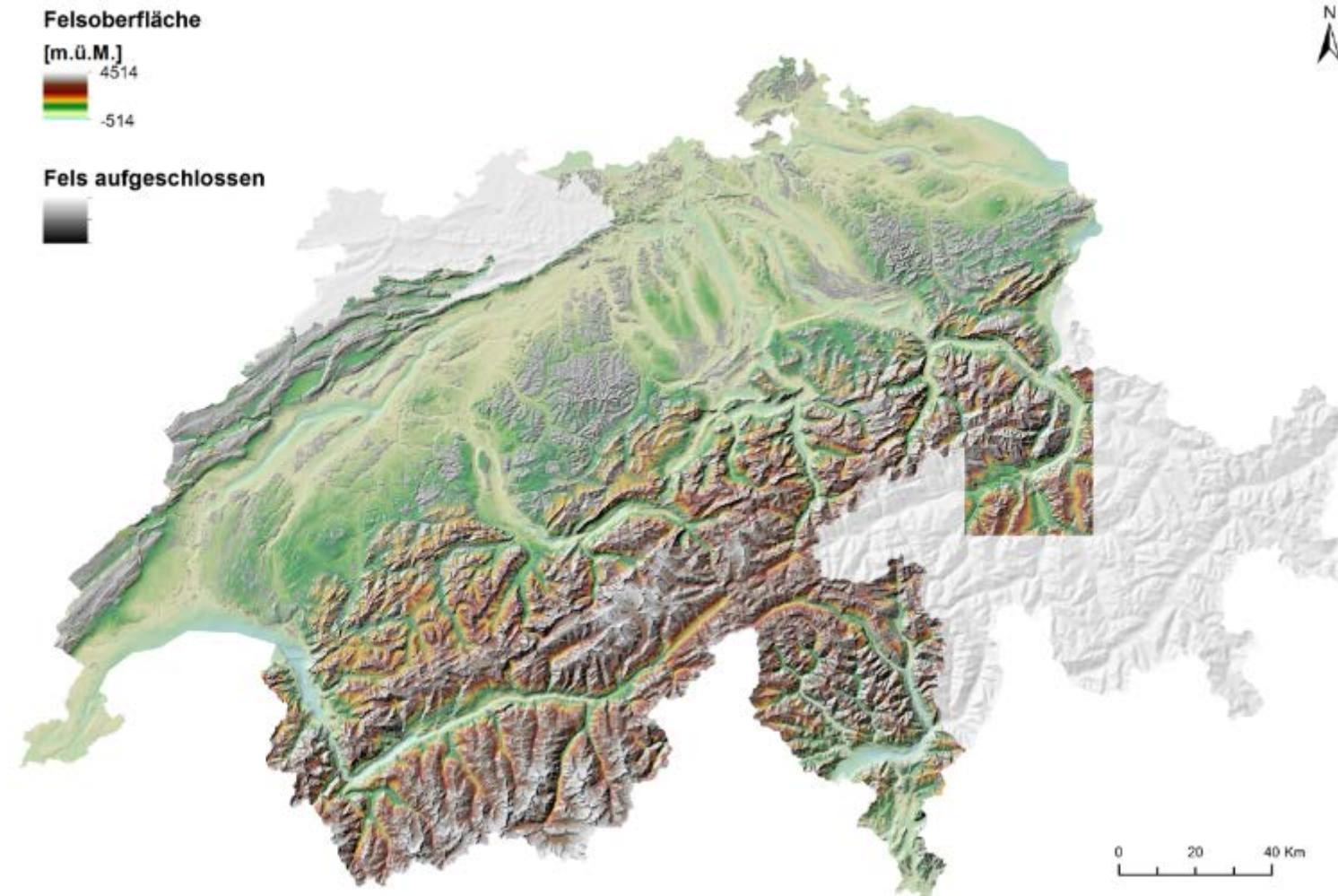


Schälli



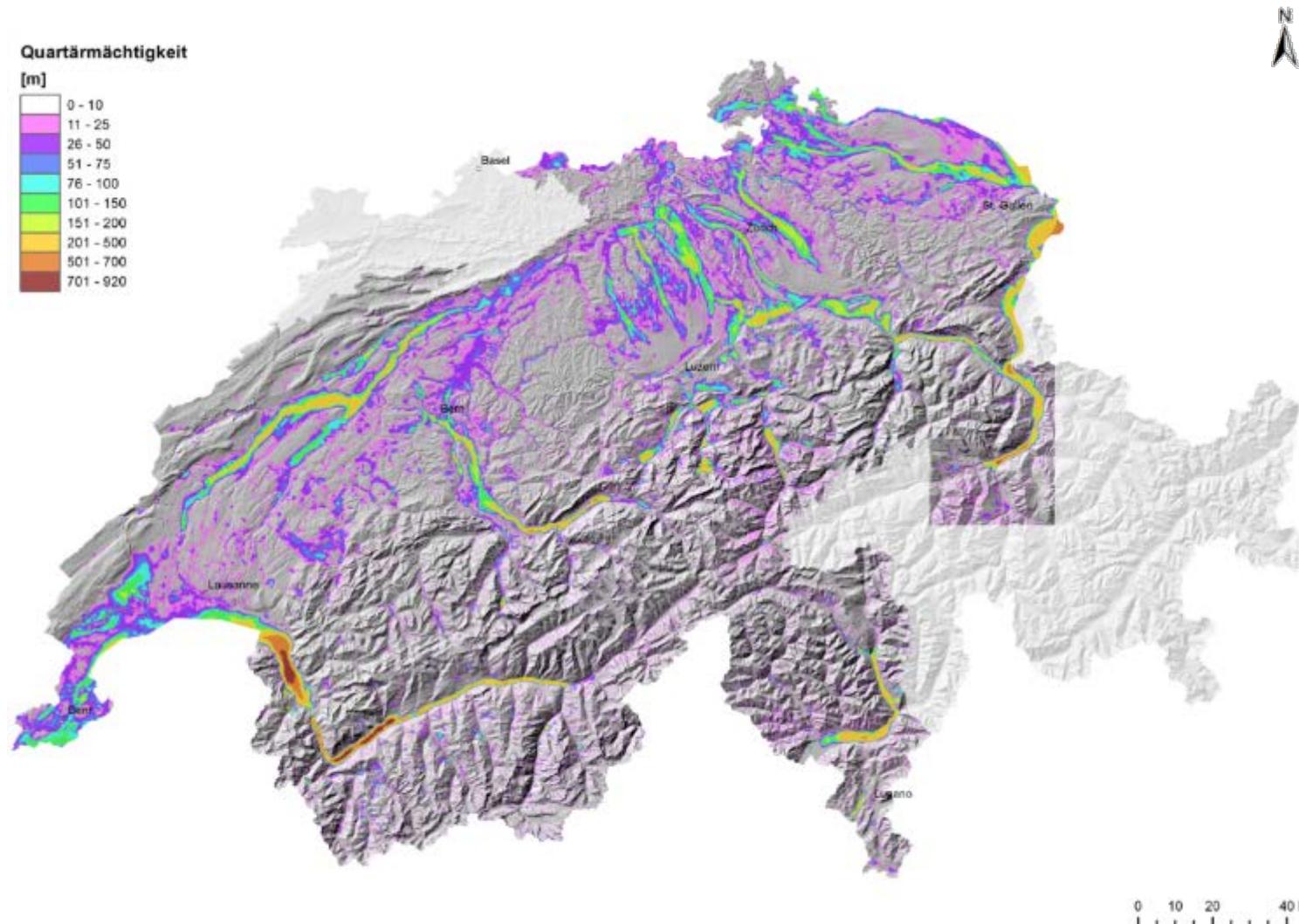


Top bedrock surface





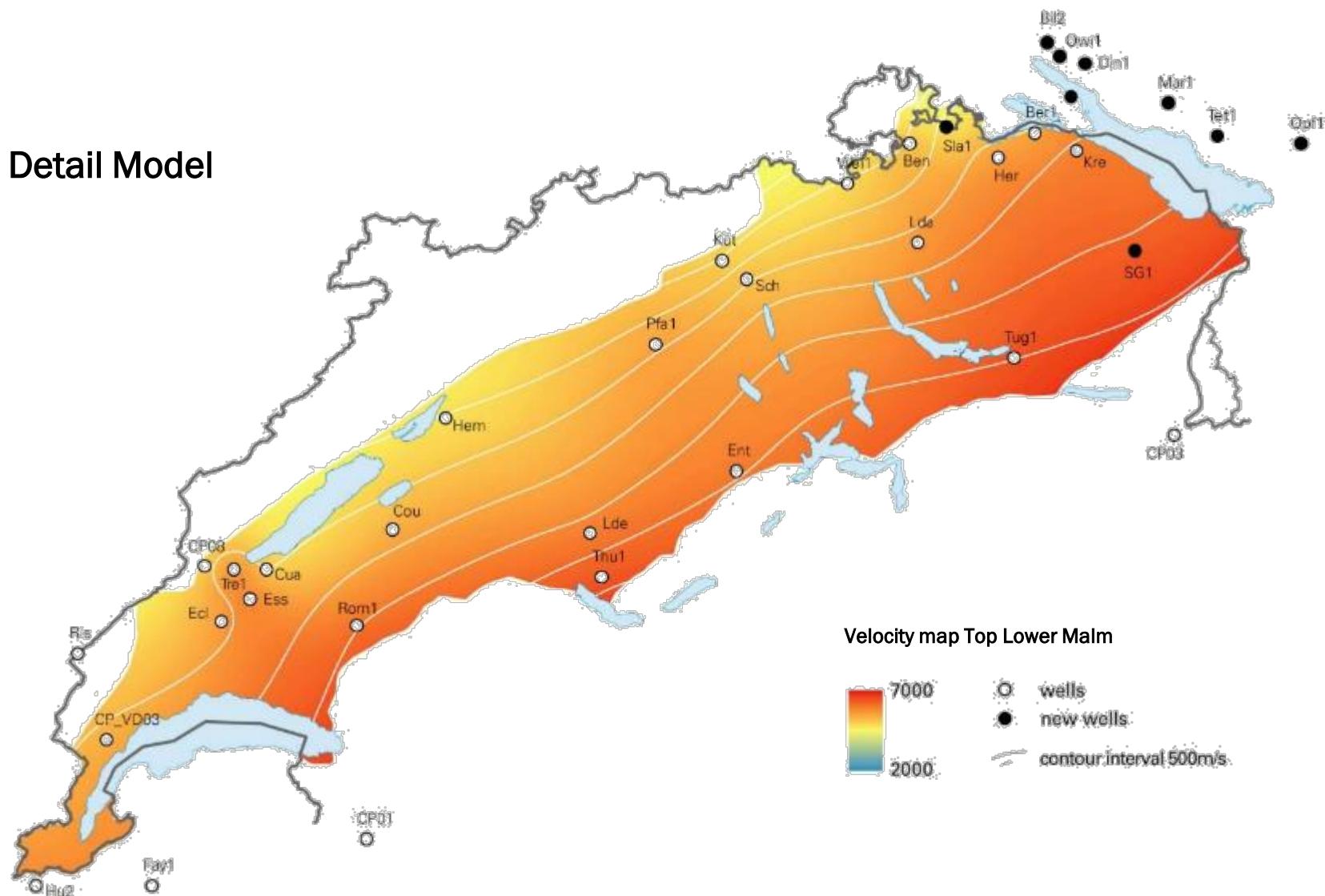
Thickness of Quaternary sediments





Velocity model

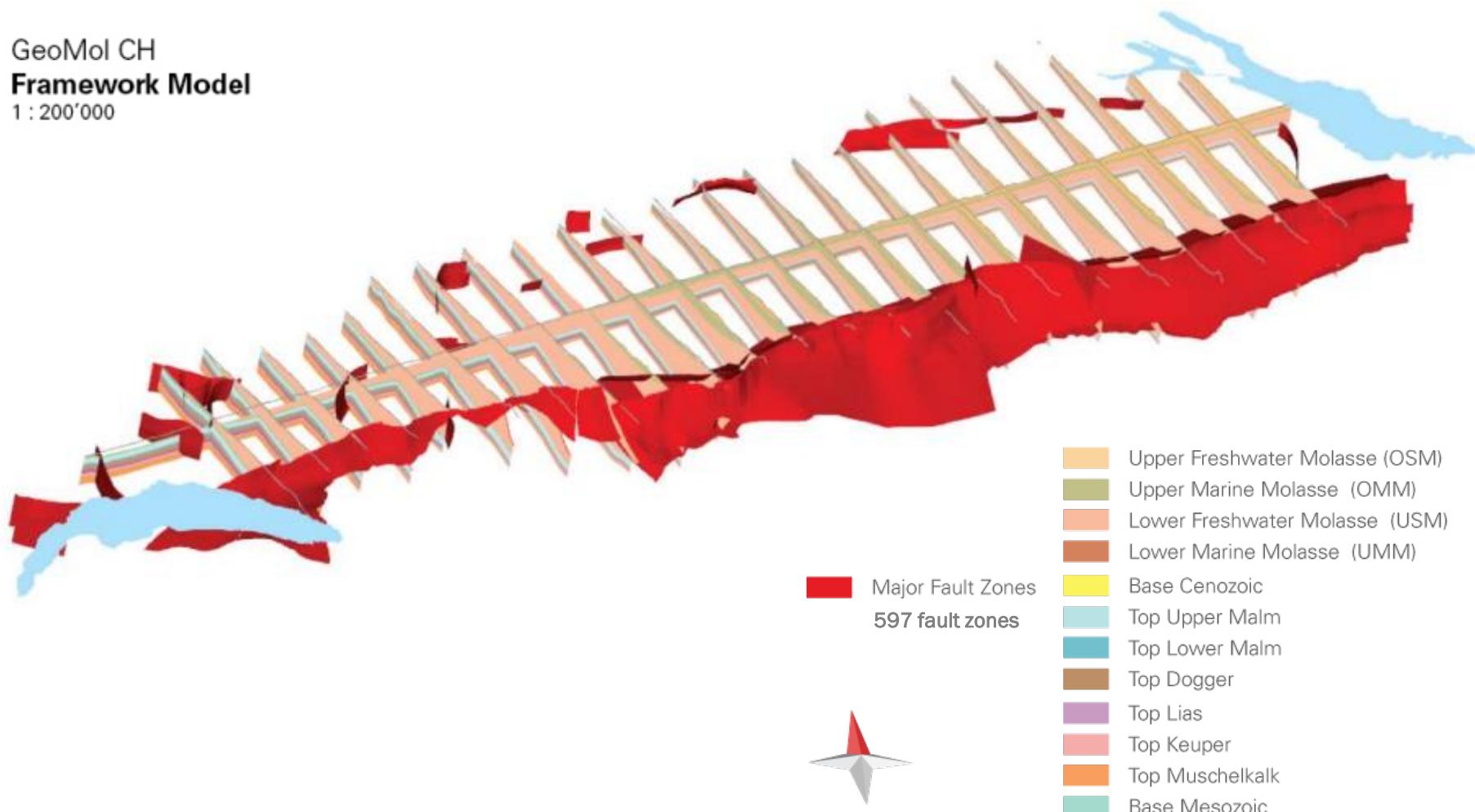
Detail Model





Fault modelling

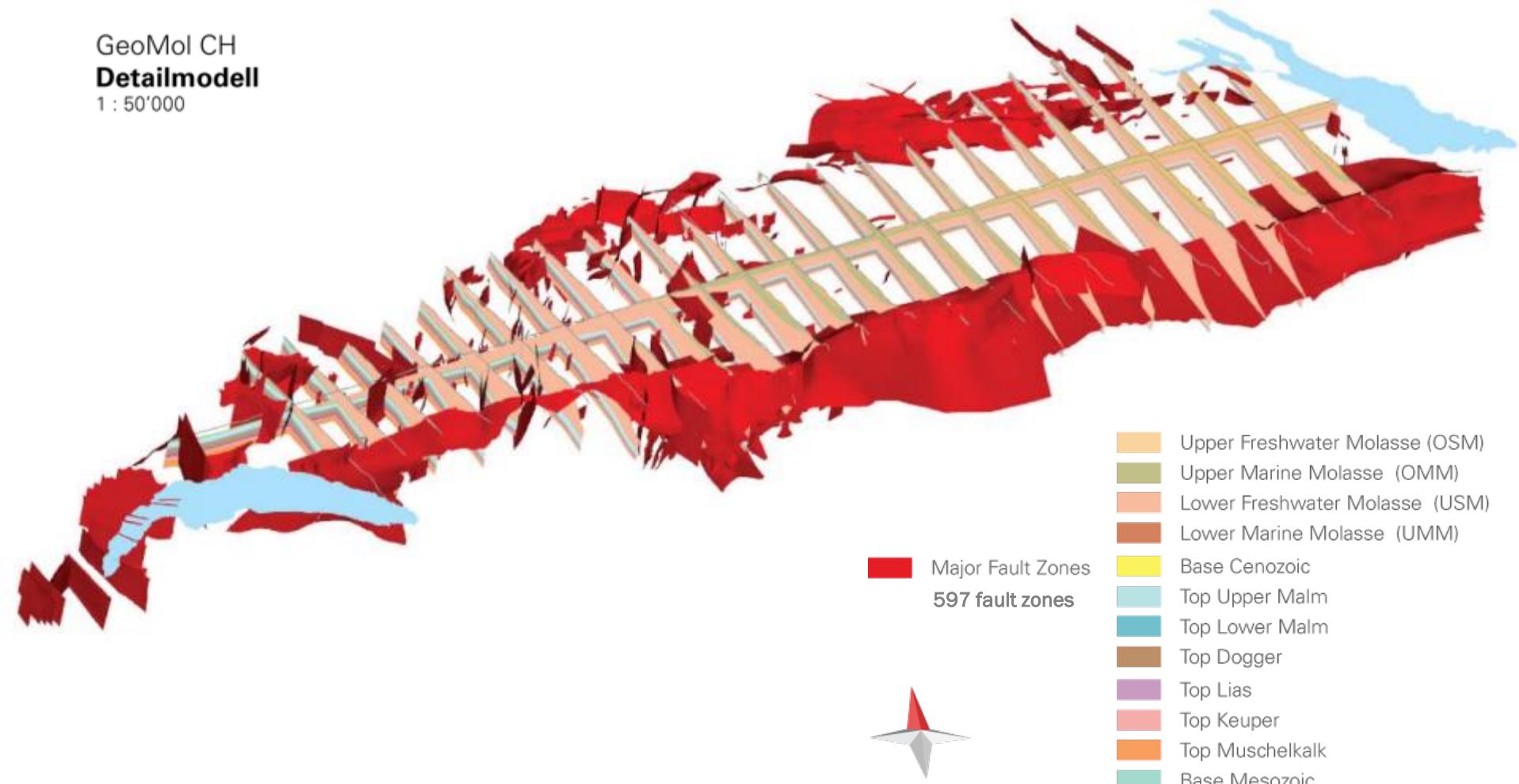
GeoMol CH
Framework Model
1 : 200'000





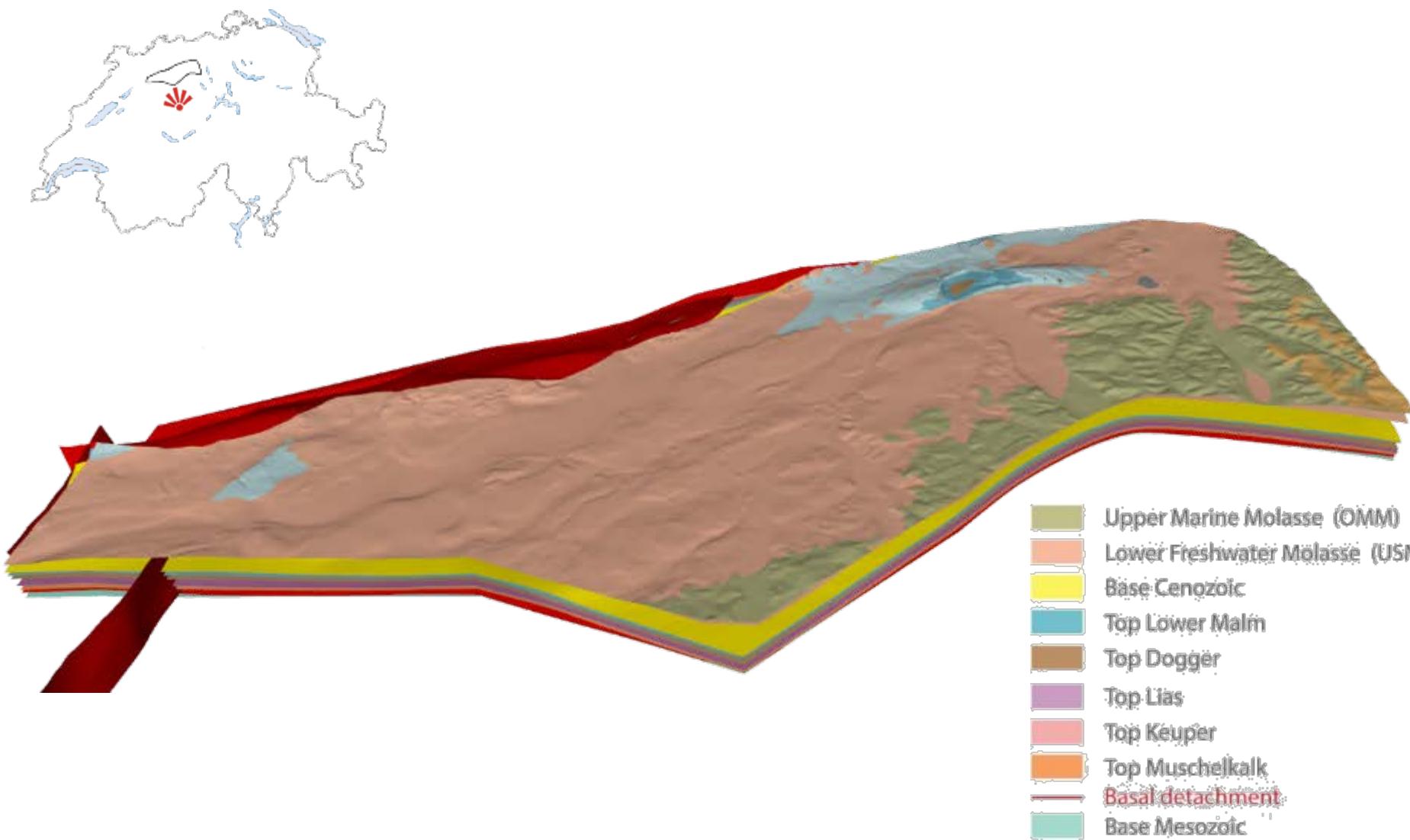
Fault modelling

GeoMol CH
Detailmodell
1 : 50'000





Detailed model – Top bedrock

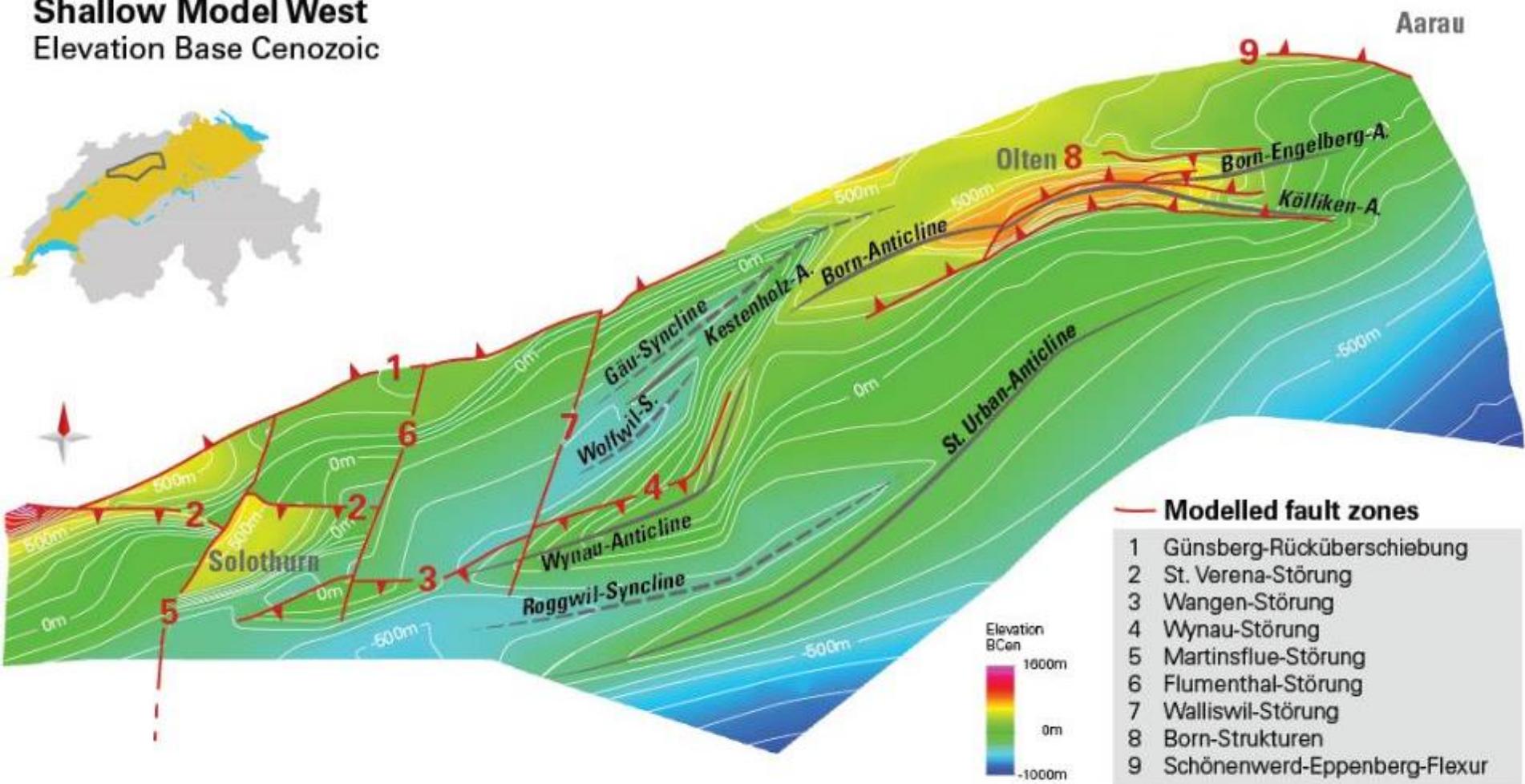




Modelled structures

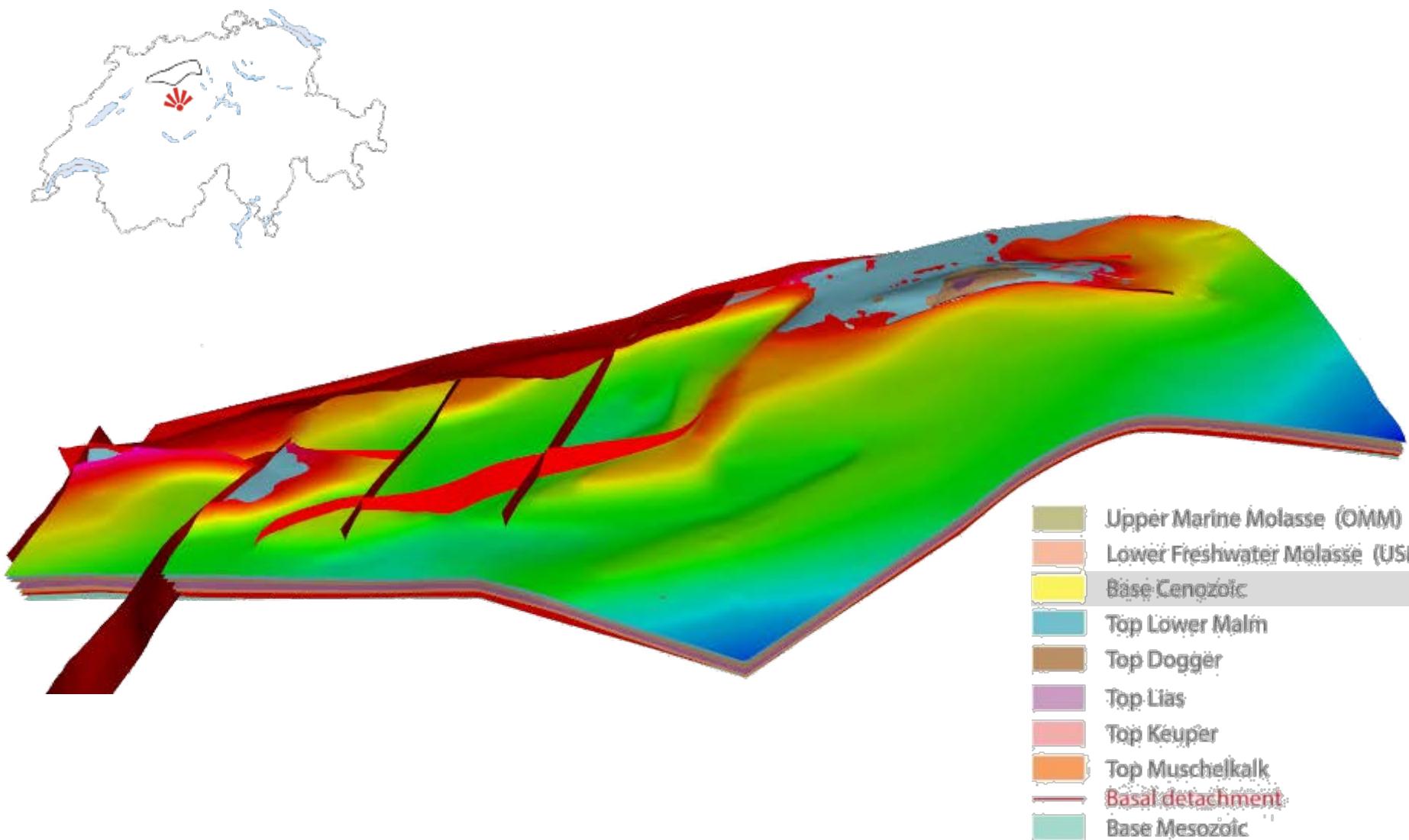
Shallow Model West

Elevation Base Cenozoic



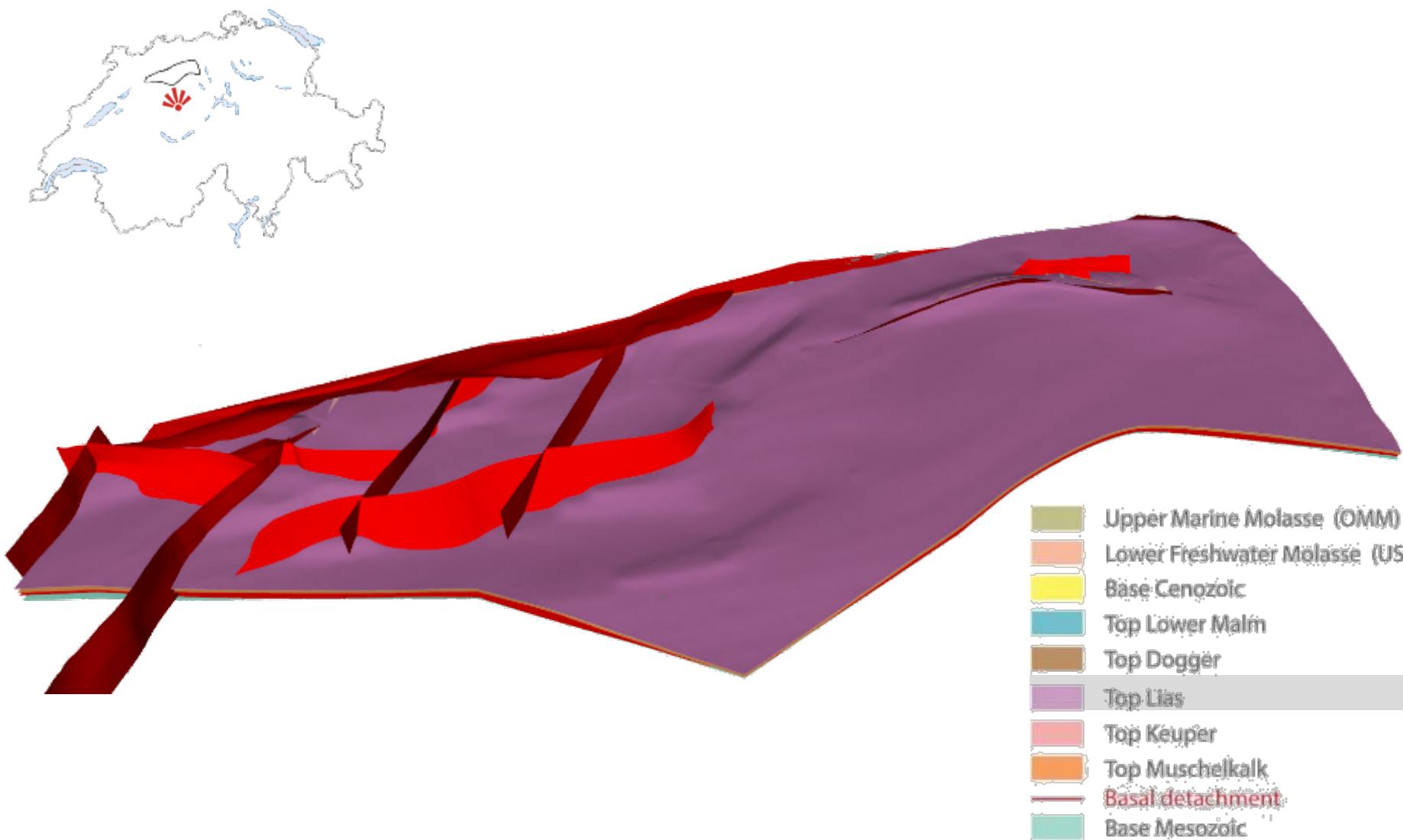


Modelled structures



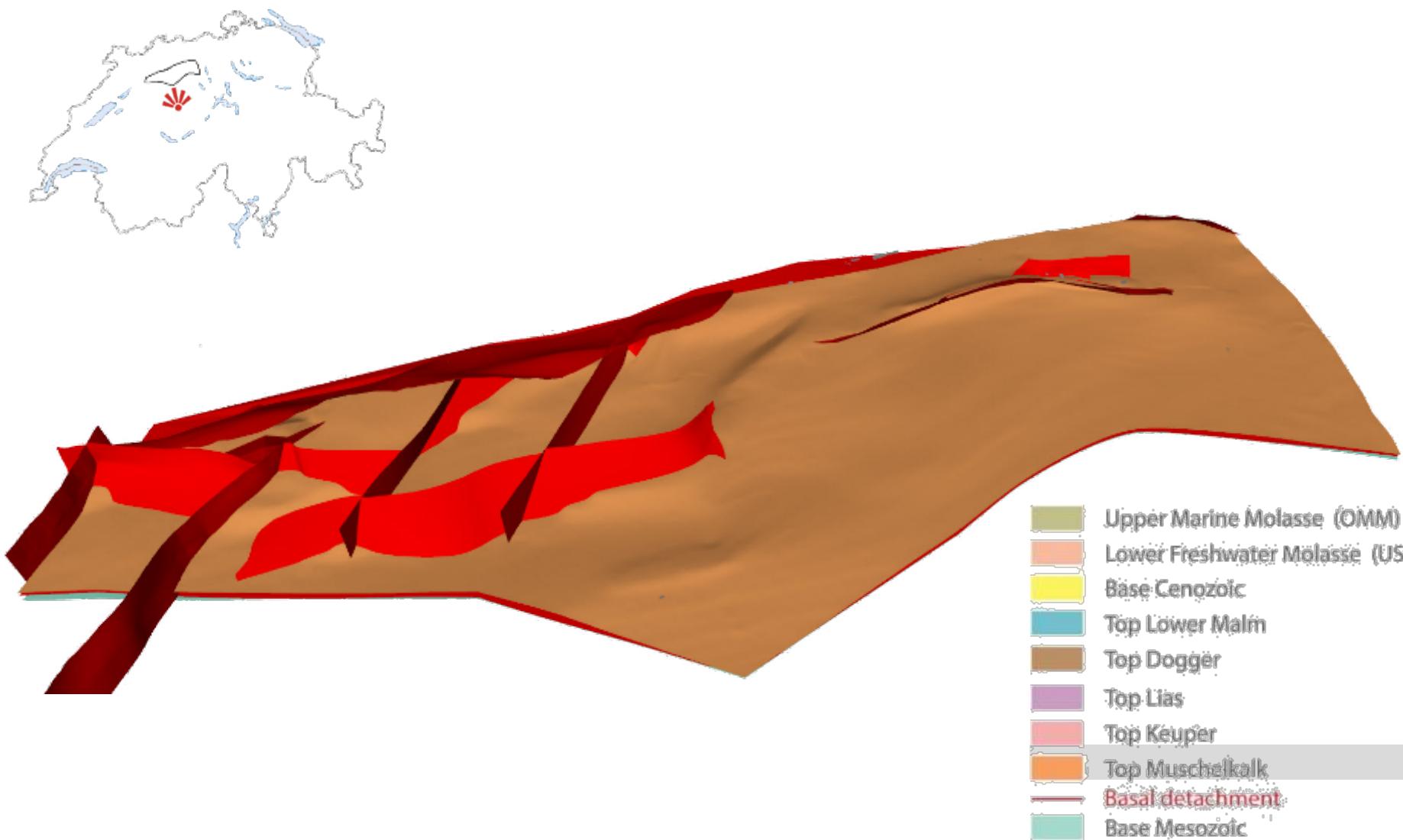


Modelled structures



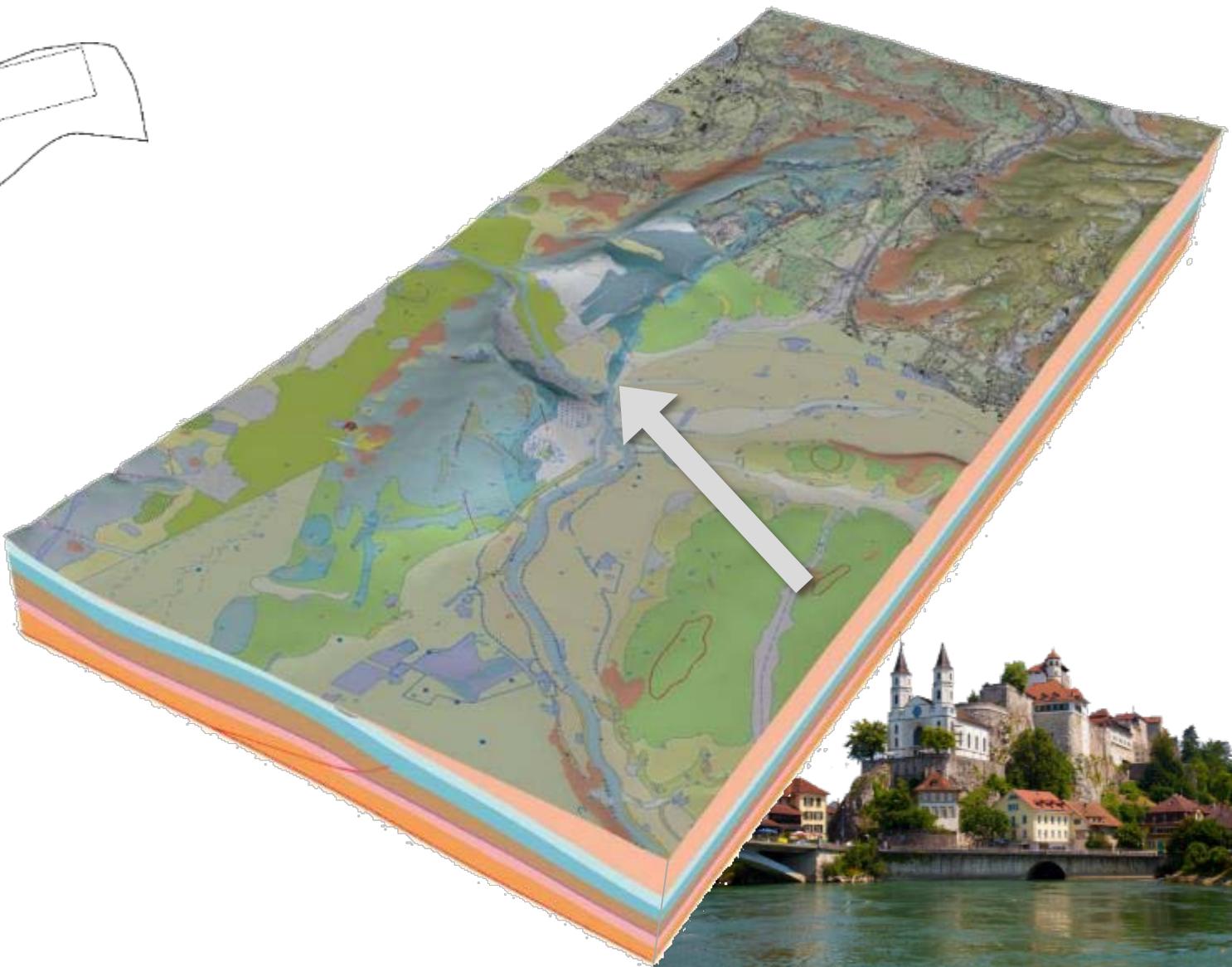


Modelled structures



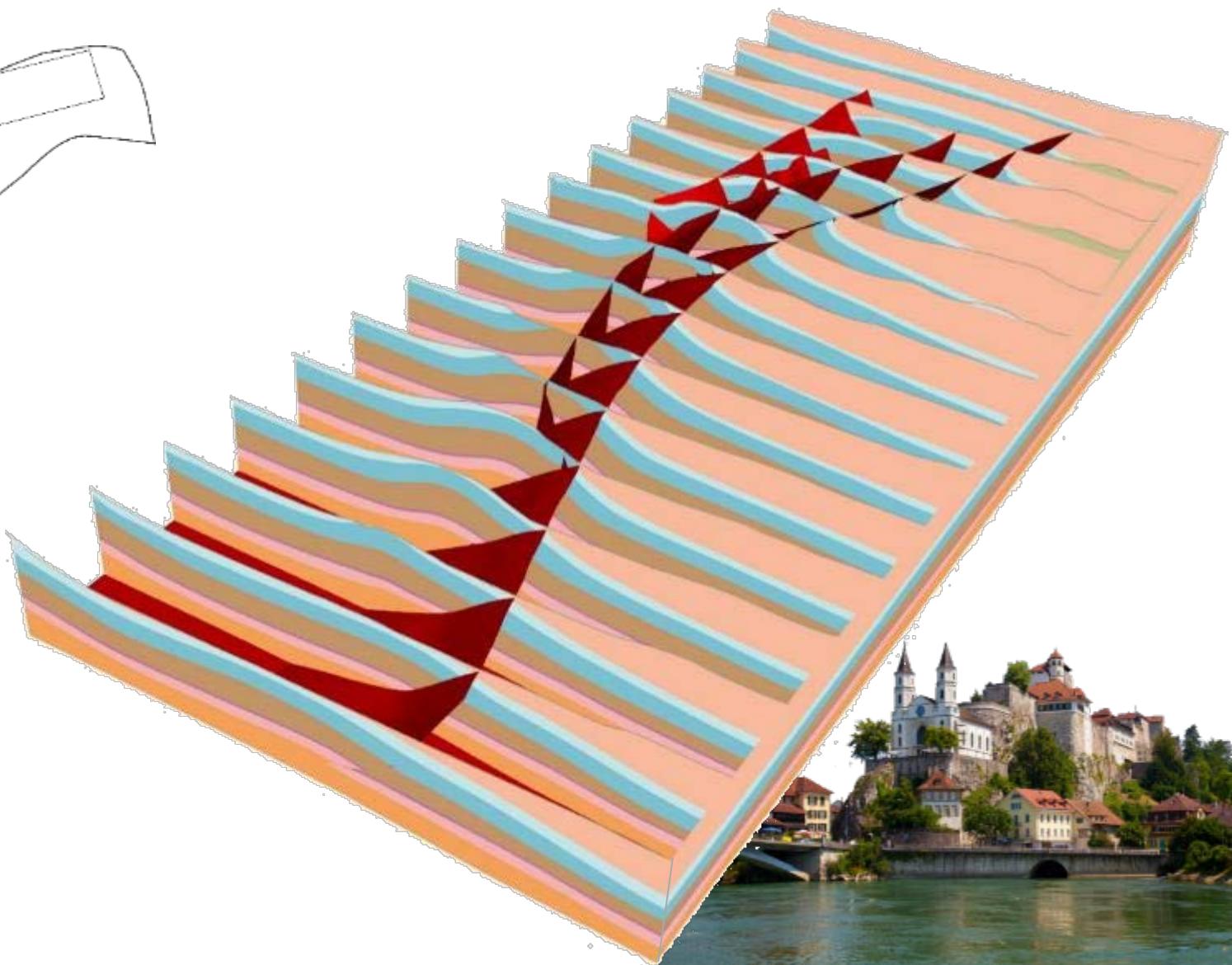


Born-Engelberg-Anticline



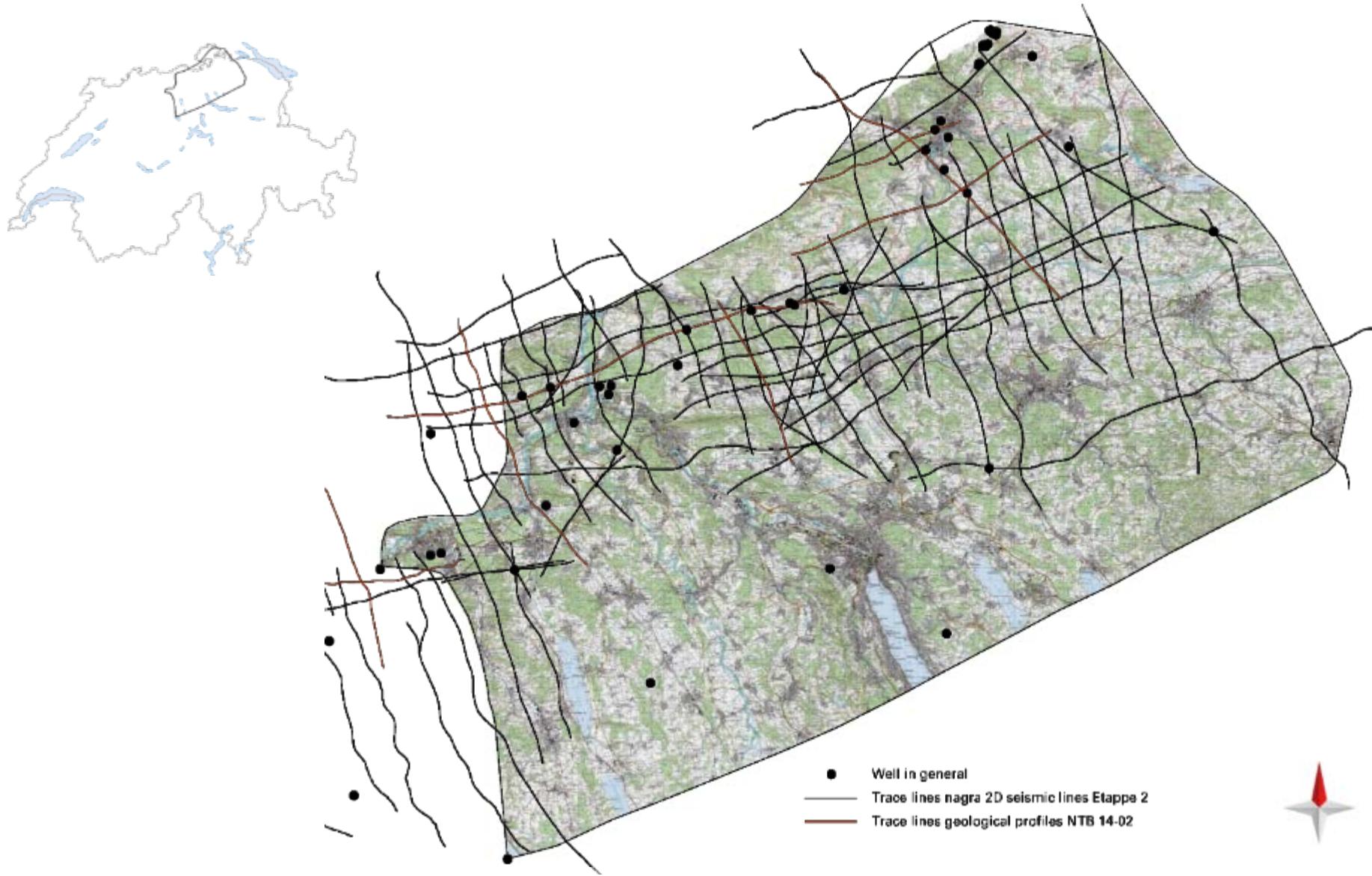


Born-Engelberg-Anticline



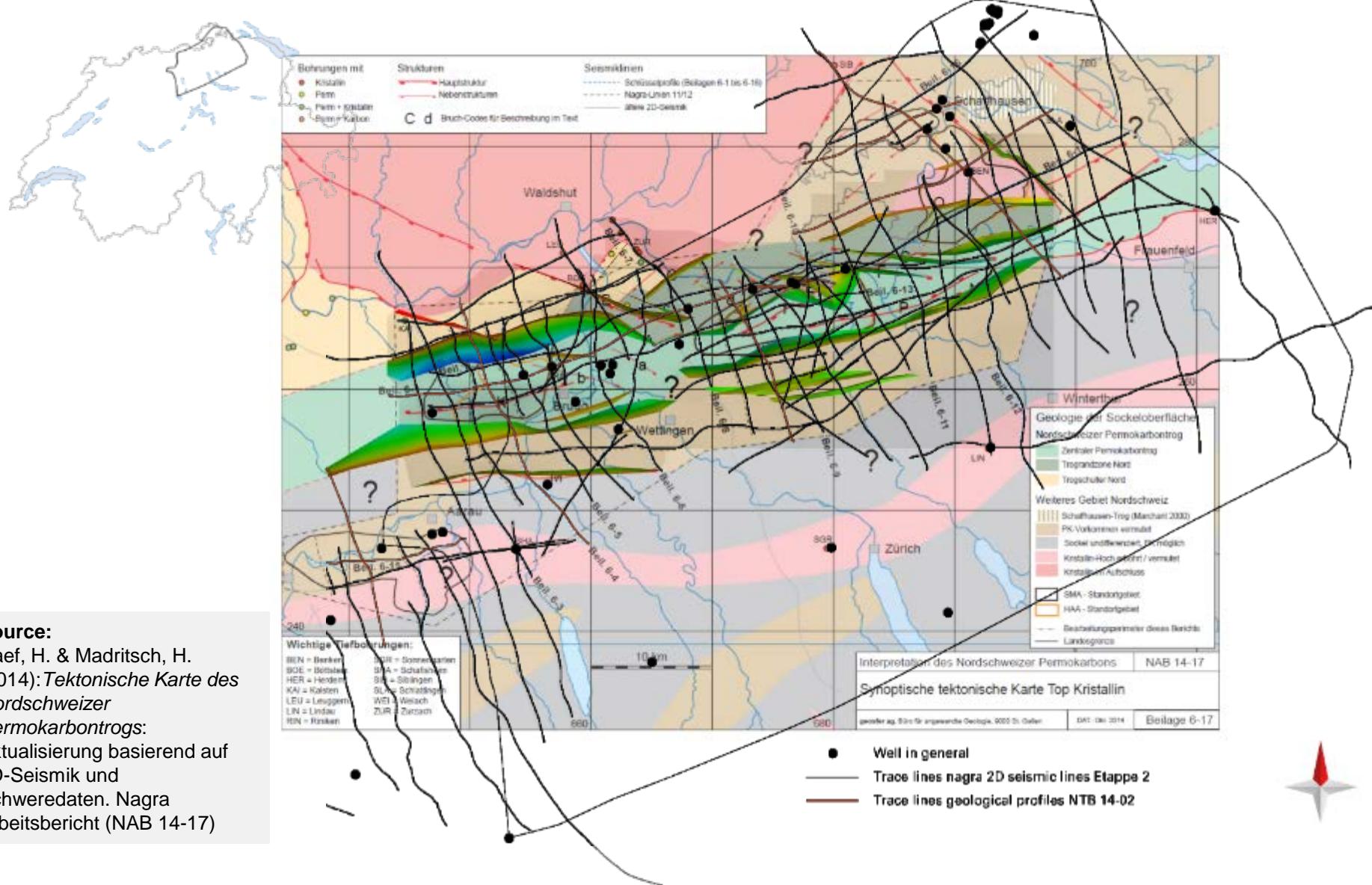


Shallow model with Permo-Carboniferous trough



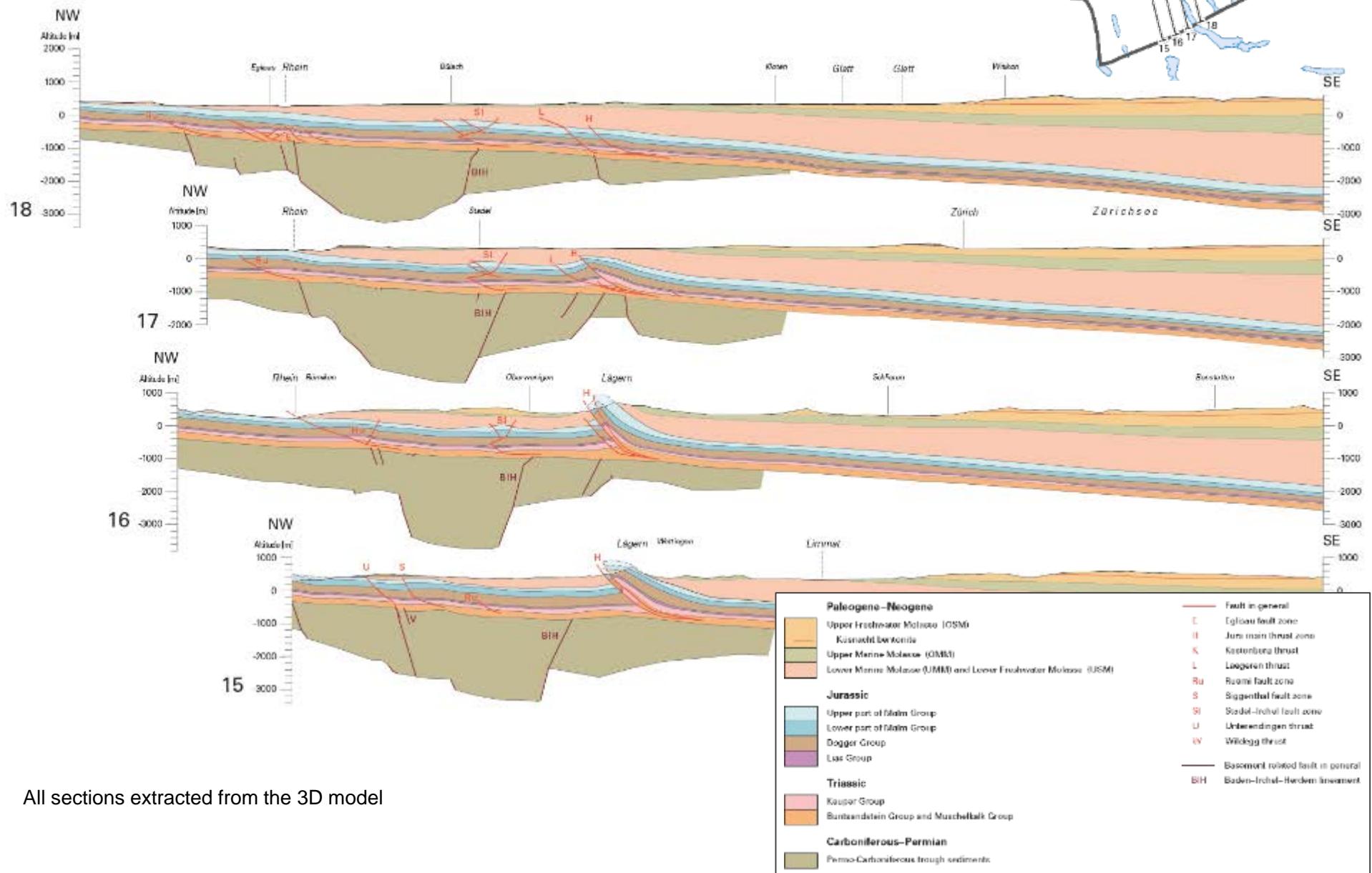


Shallow model with Permo-Carboniferous trough





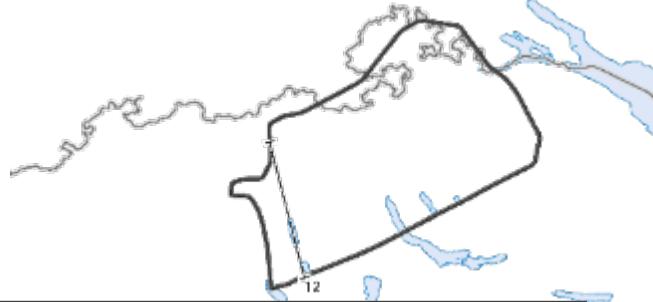
Section checks



All sections extracted from the 3D model



Section checks



NW

[m.s.l.]

2000

1000

0

-1000

-2000

-3000

-4000

-5000

-6000

-7000

-8000

-9000

-10000

-11000

-12000

-13000

-14000

-15000

-16000

-17000

-18000

-19000

-20000

-21000

-22000

-23000

-24000

-25000

-26000

-27000

-28000

-29000

-30000

-31000

-32000

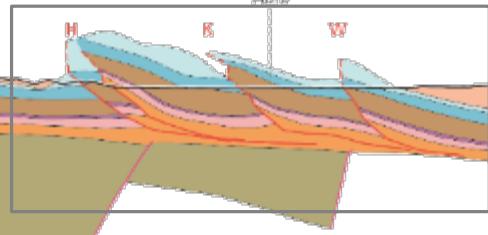
-33000

-34000

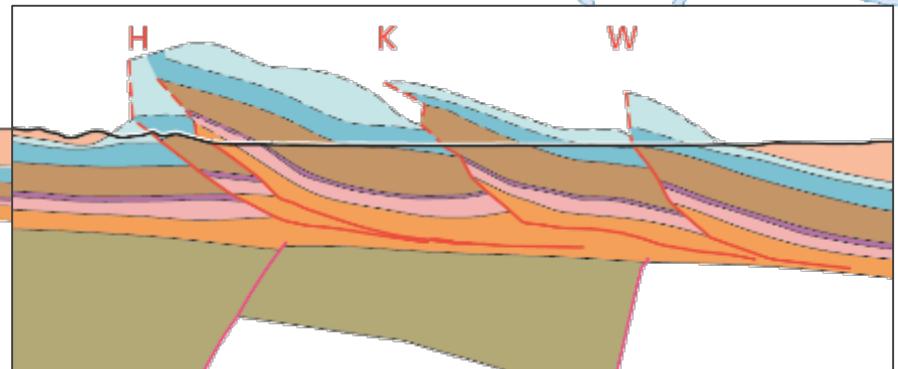
-35000

-36000

-37000



Laminated



First model version

12

NW

[m.s.l.]

2000

1000

0

-1000

-2000

-3000

-4000

-5000

-6000

-7000

-8000

-9000

-10000

-11000

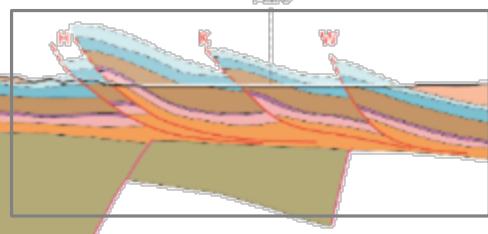
-12000

-13000

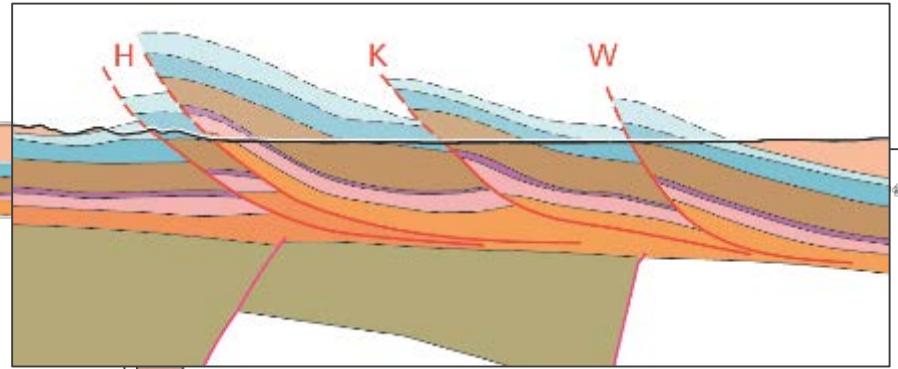
-14000

-15000

-16000



Laminated



After manual revisions of the 3D model

Lias Group

Triassic

Kaufer Group

Buntsandstein Group and Muschelkalk Group

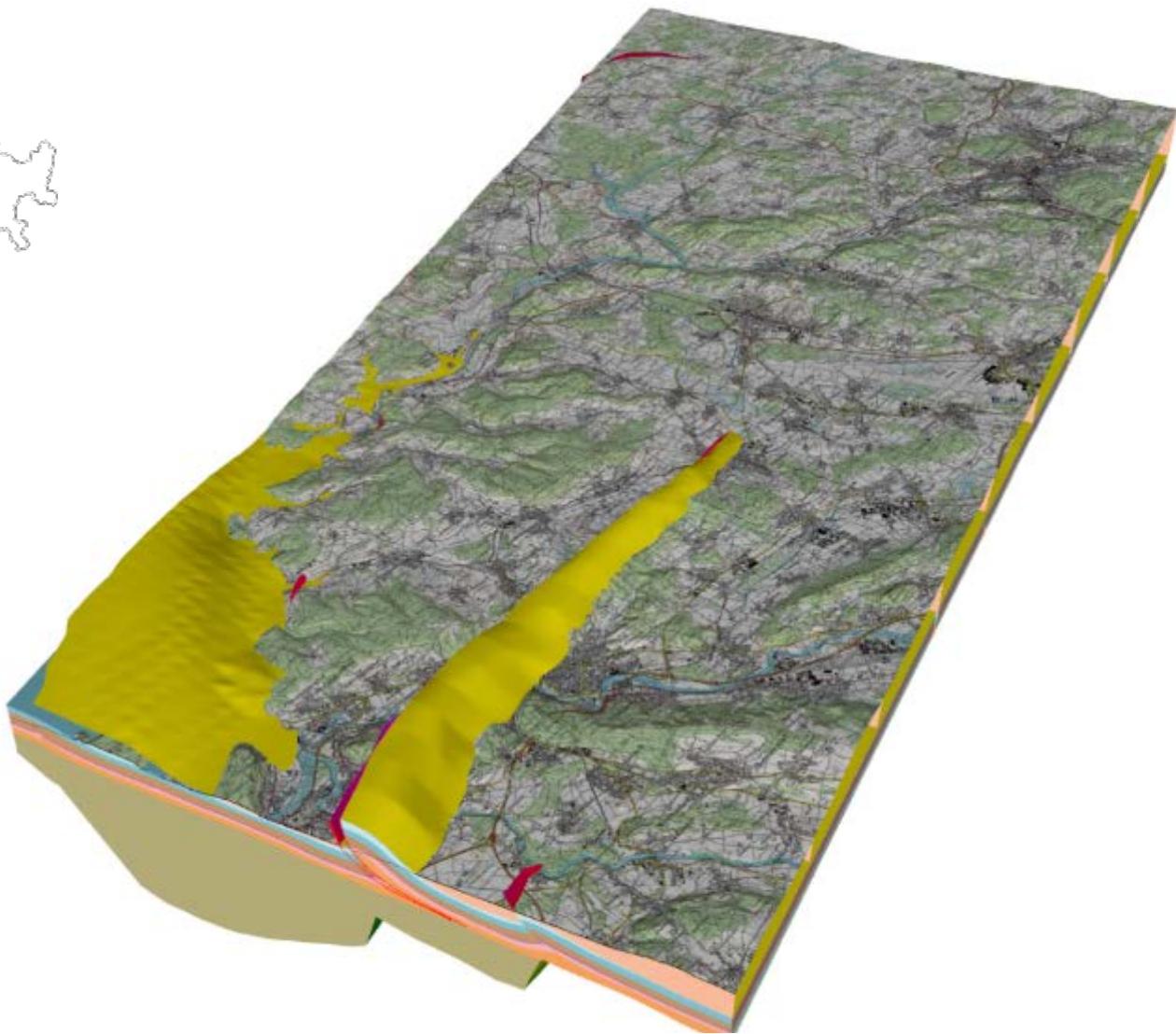
Carboniferous-Permian

Permio-Carboniferous trough sediments

12

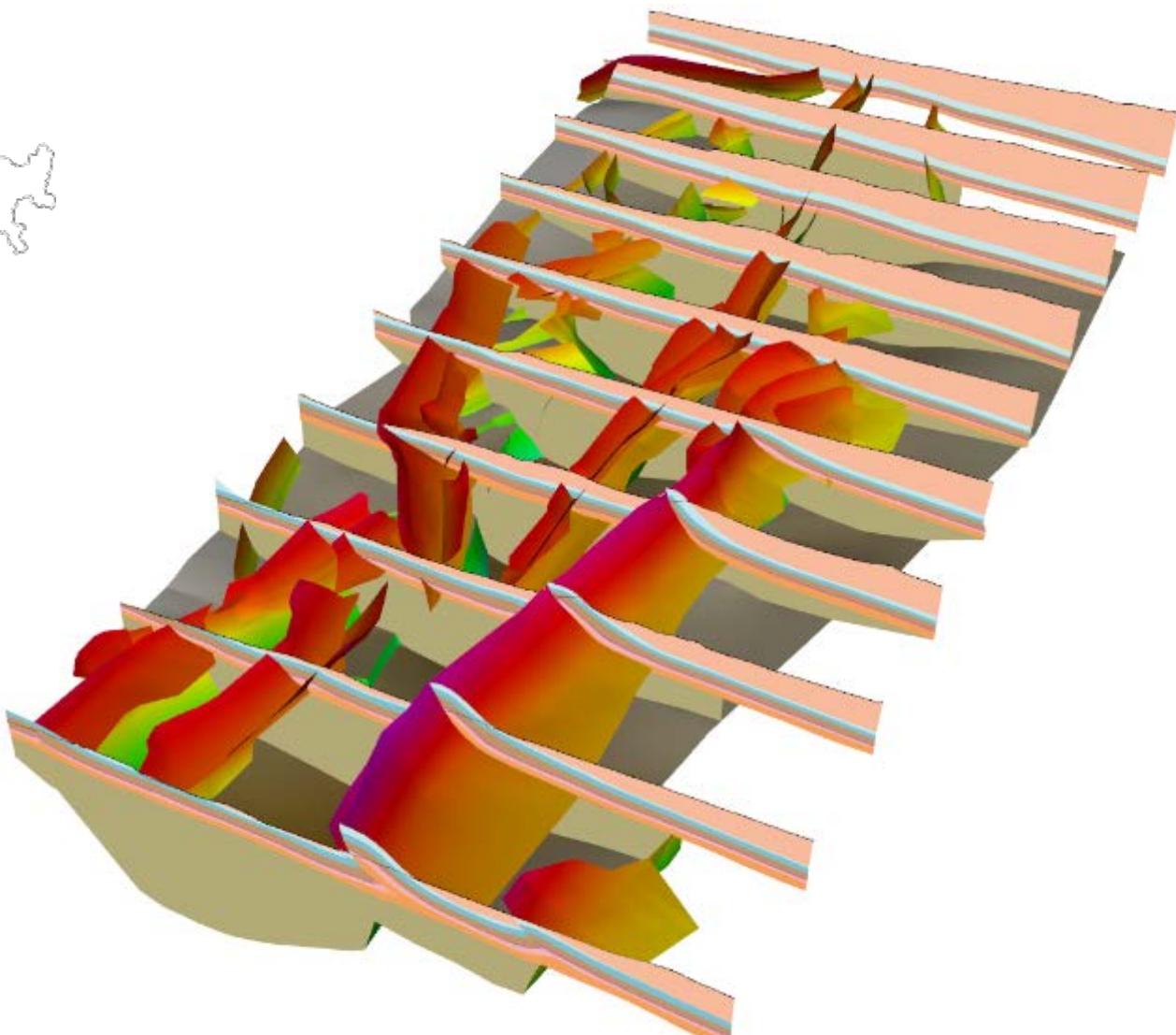


Permo-Carboniferous trough



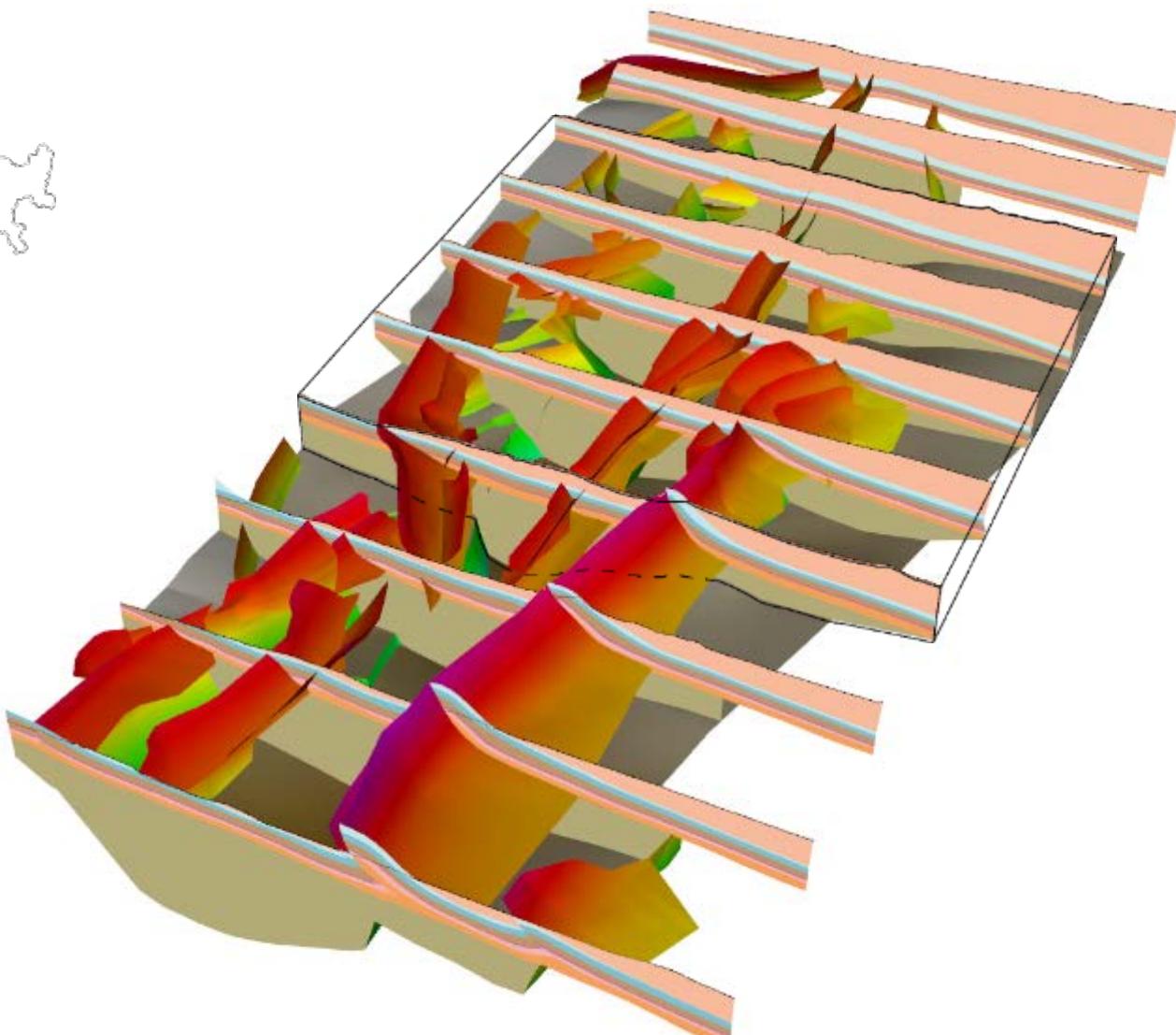


Permo-Carboniferous trough



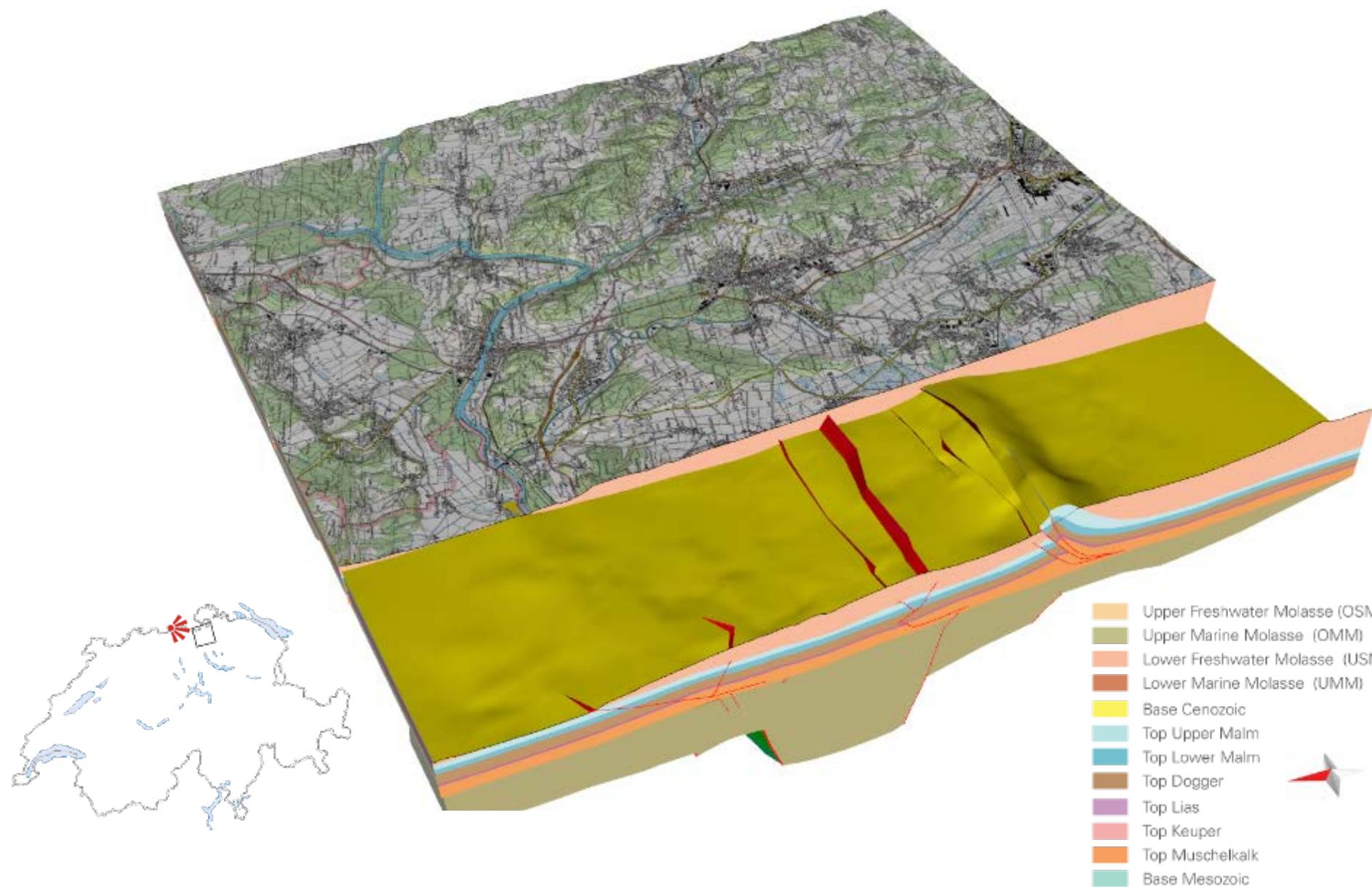


Permo-Carboniferous trough



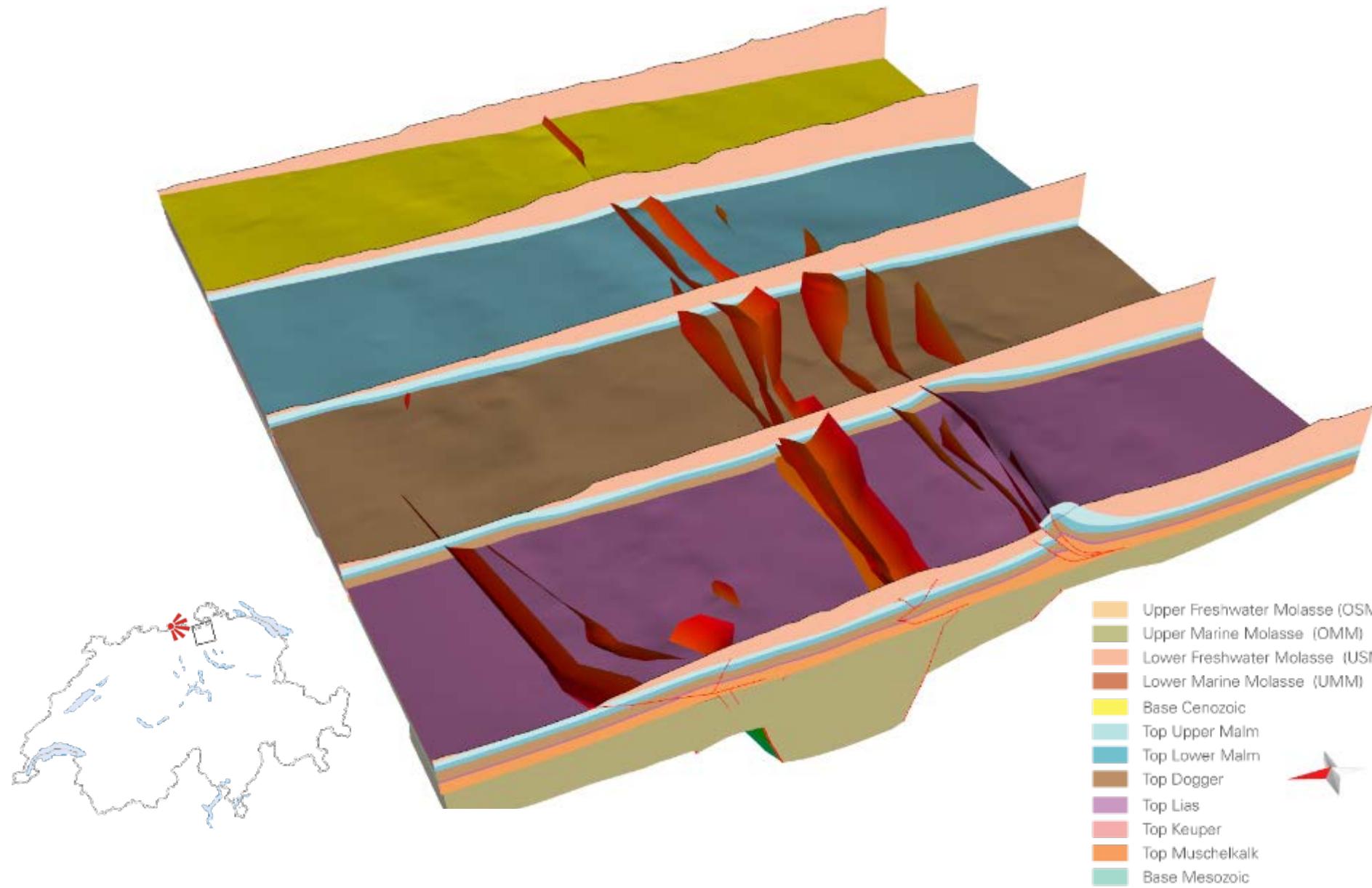


Permo-Carboniferous trough



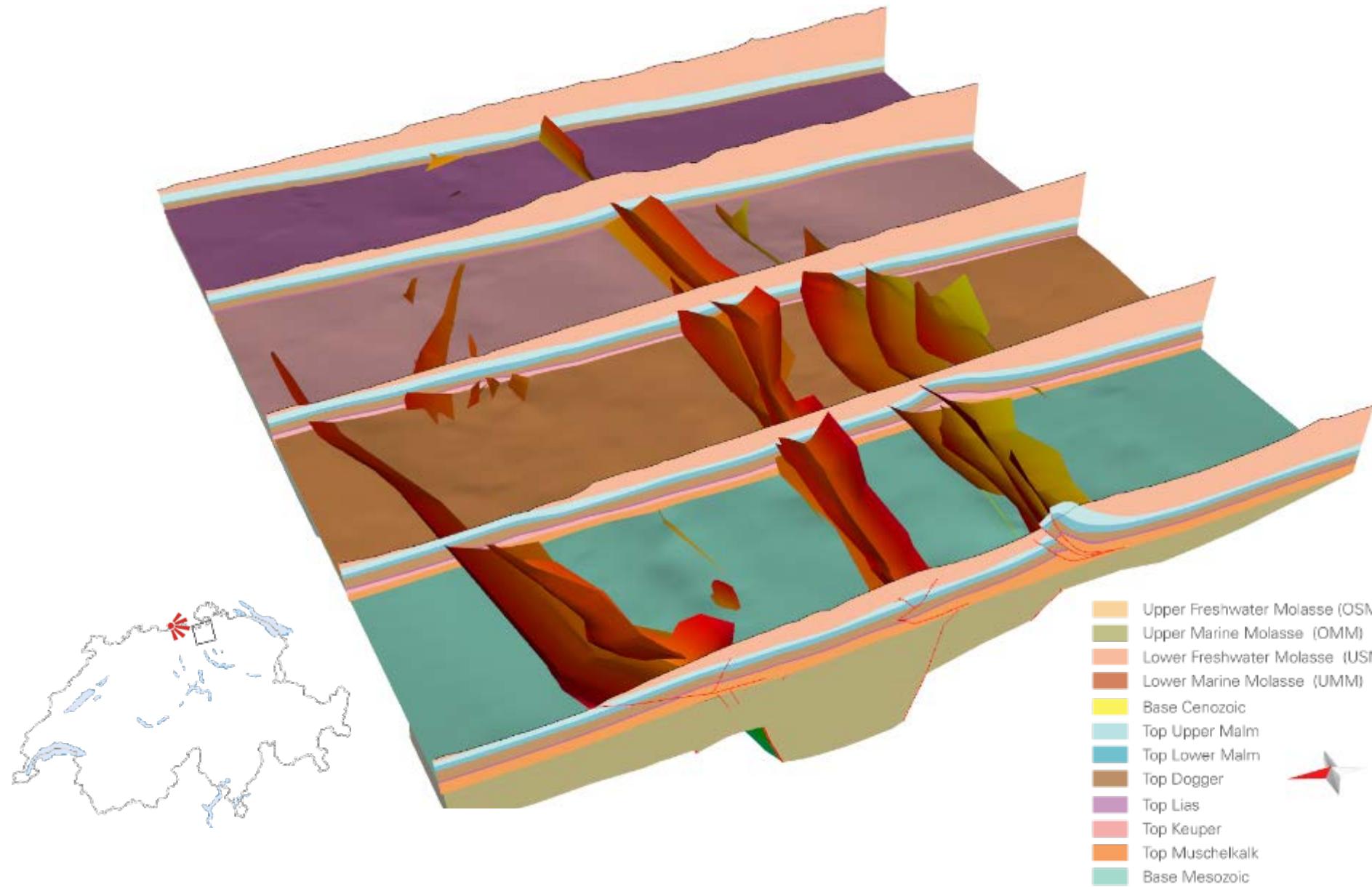


Permo-Carboniferous trough



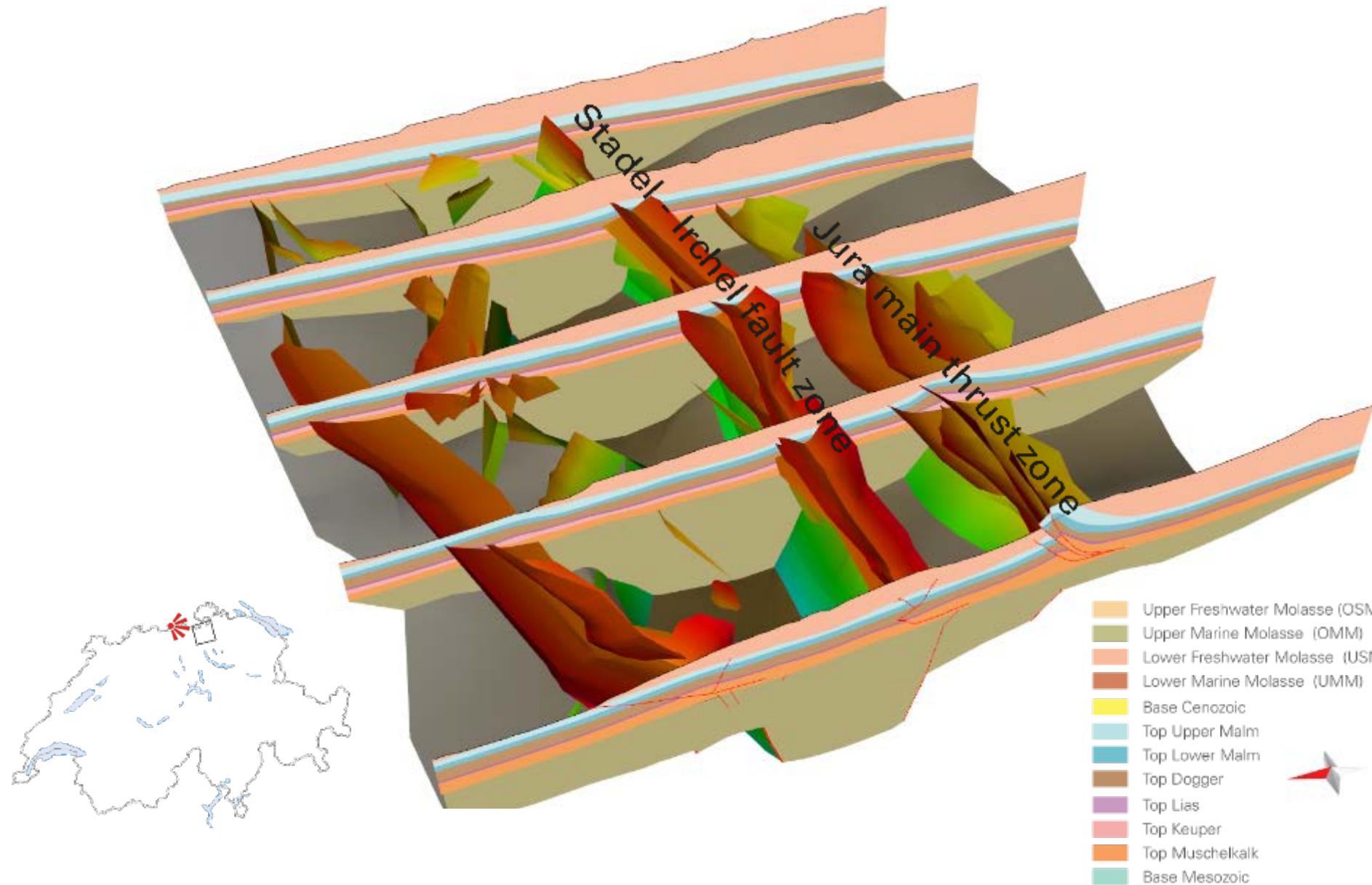


Permo-Carboniferous trough



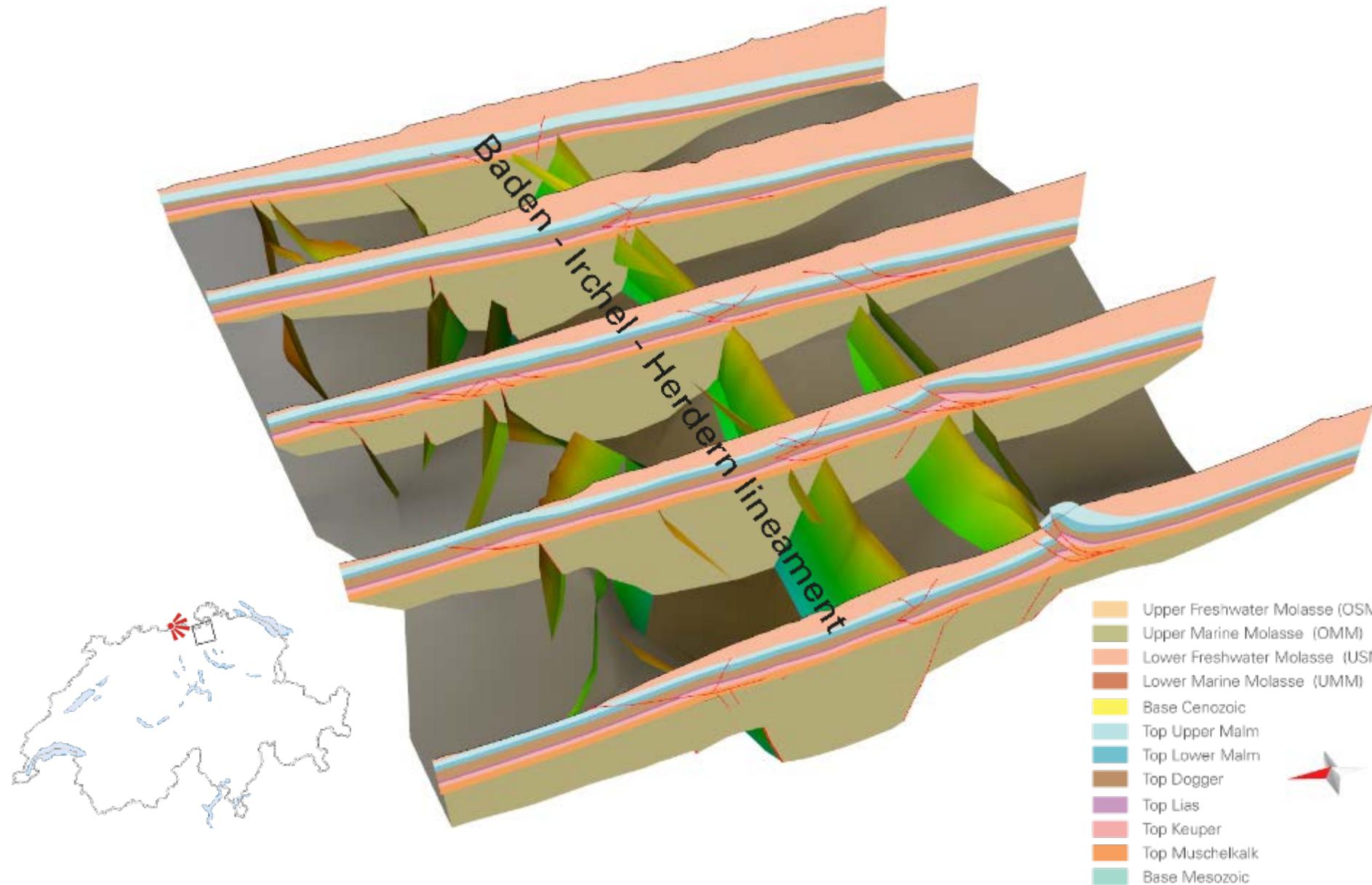


Permo-Carboniferous trough





Permo-Carboniferous trough





Results – <https://viewer.geomol.ch>

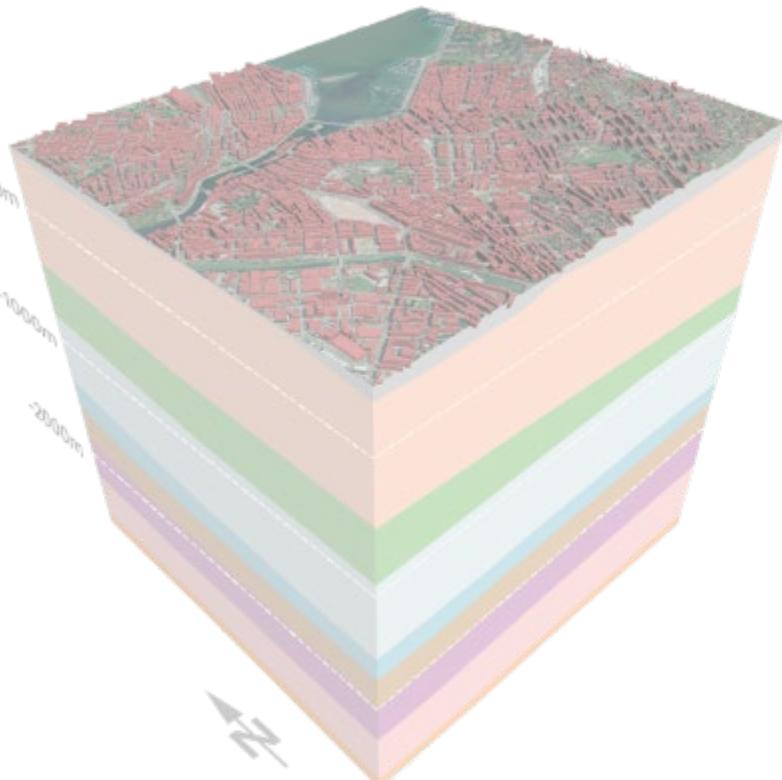
wissen wohin
savoir où
sapere dove
knowing where



Zusammenarbeit Qualitätssicherung

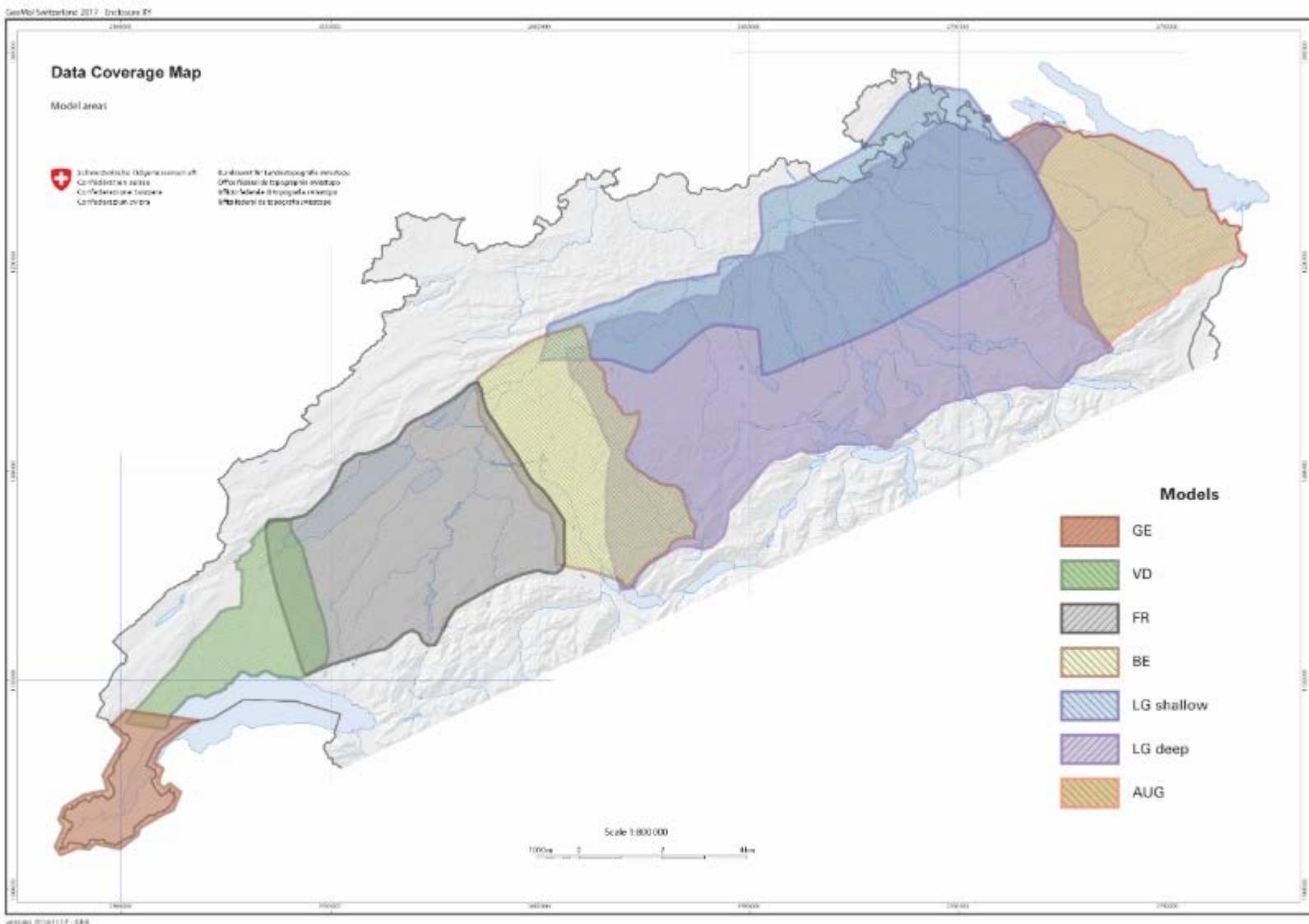
- Zusammenarbeit mit Partnern
- Interpretationsmöglichkeiten
- Modelltypen
- Reviews
- Qualitätssicherung

Robin Allenbach





Collaboration with partners





Modelling teams & partners

University of Geneva

- Nicolas Clerc, Andrea Moscariello

Musée cantonal de géologie du canton du Vaud

- Robin Marchand

University of Fribourg

- Marius Gruber, Anna Sommaruga, Jon Mosar

University of Bern

- Samuel Mock, Marco Herwegh

University of Basel

- Birte Anders, Horst Dresmann, Peter Huggenberger



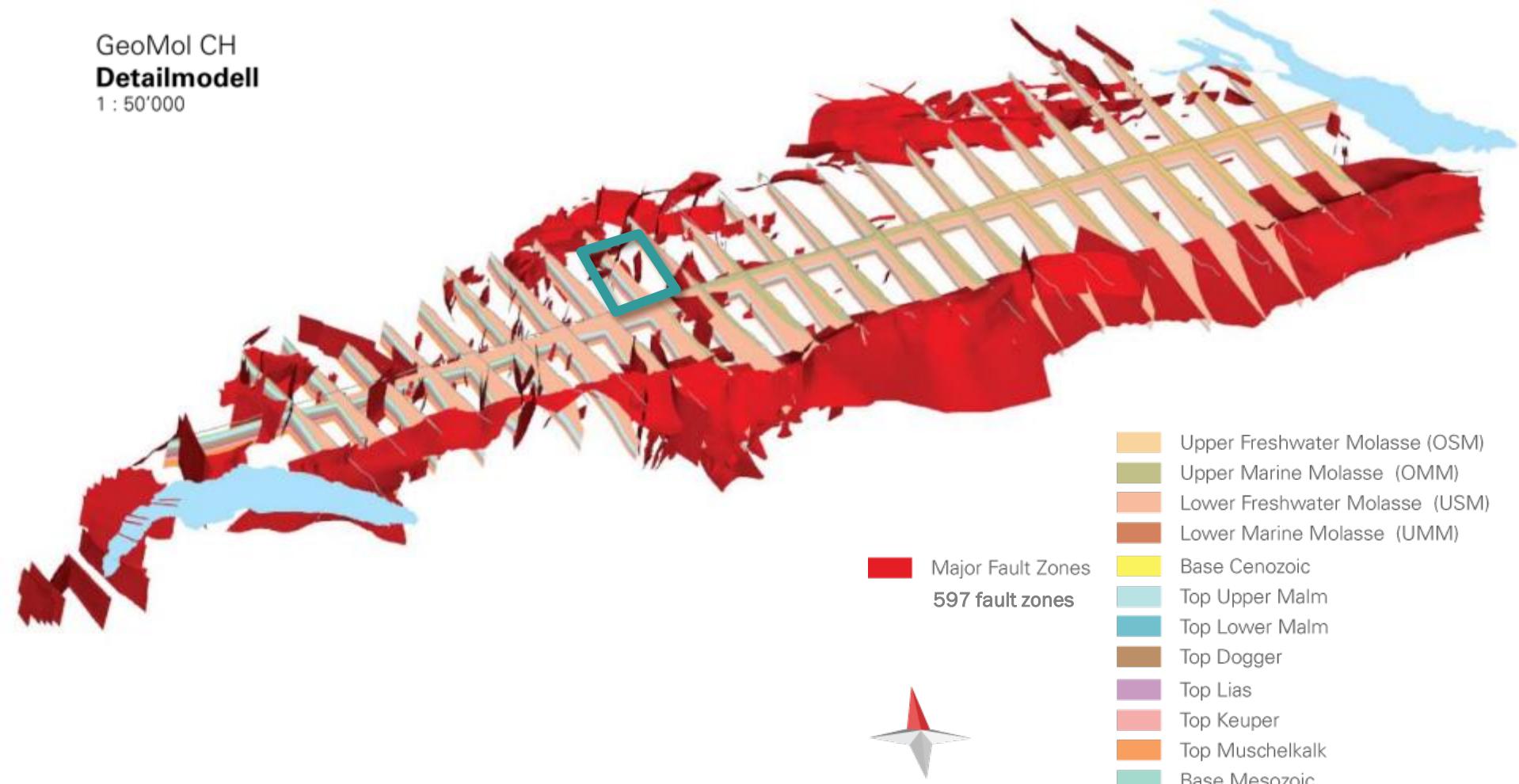
Collaboration with partners

- Collaboration & goals were contractually defined
- Partners were allowed to choose a preferred interpretation set
- Partners were allowed to choose software (education vs industry licences) and therefore also procedures
- Varying datasets, software and procedures combined with subjective interpretations can lead to lateral variations
- This is not necessarily a matter of right vs wrong, but reflects the unavoidable element of subjectivity found in interpretations



Structural Modelling

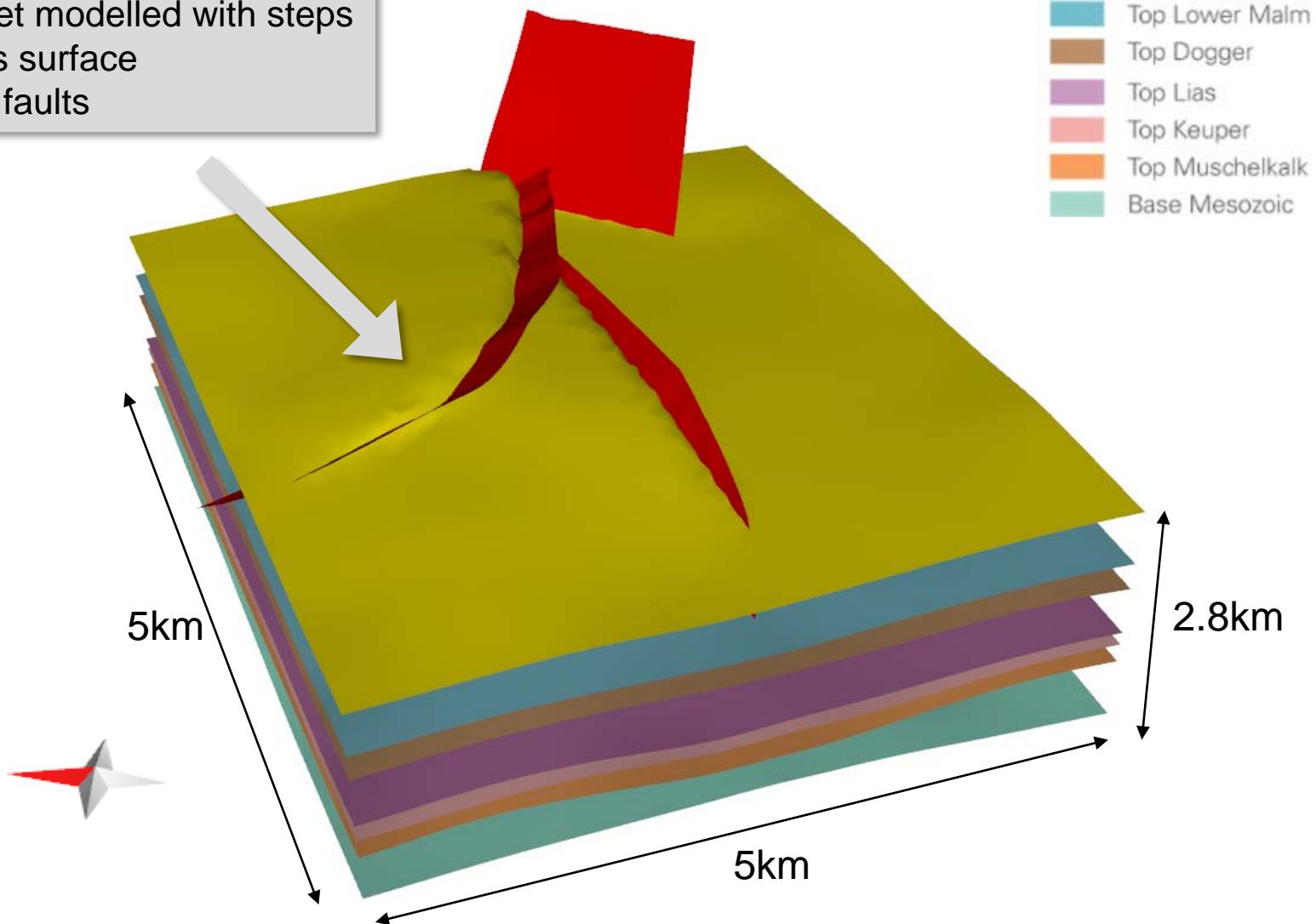
GeoMol CH
Detailmodell
1 : 50'000





Fault modelling examples

Fault offset modelled with steps
Continuous surface
No thrust faults

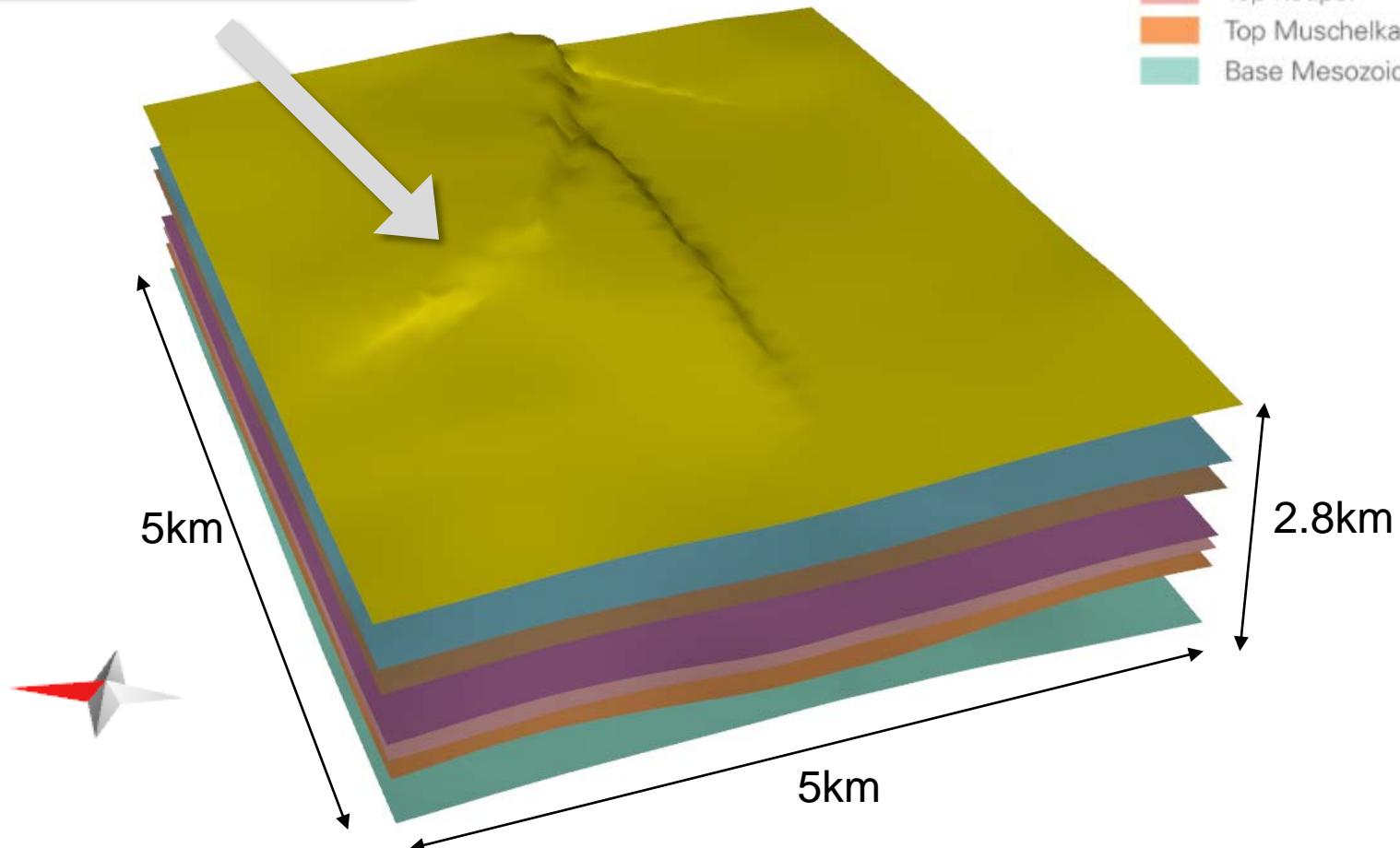




Fault modelling examples

Fault offset modelled with steps
Continuous surface
No thrust faults

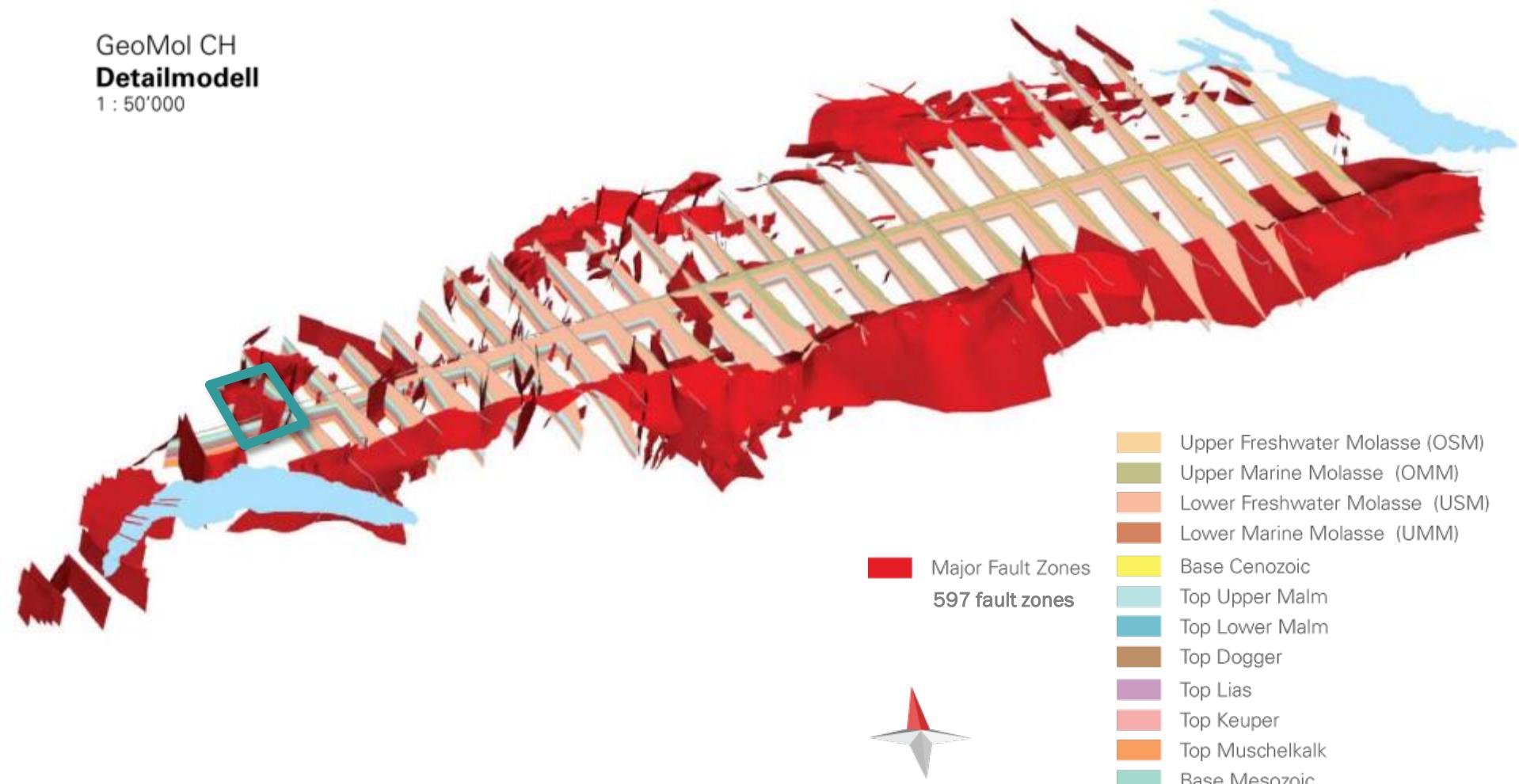
- Base Cenozoic
- Top Upper Malm
- Top Lower Malm
- Top Dogger
- Top Lias
- Top Keuper
- Top Muschelkalk
- Base Mesozoic





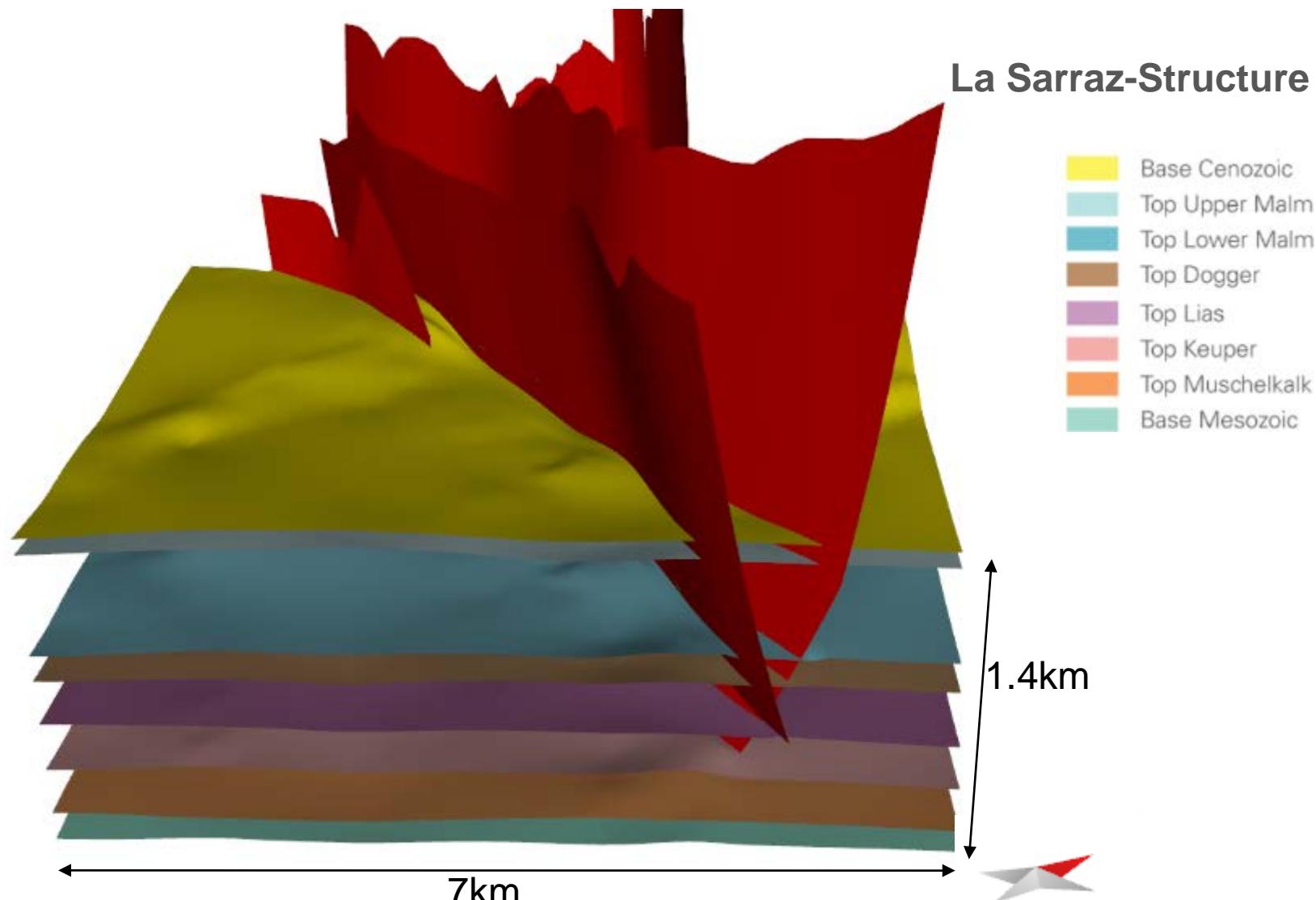
Structural Modelling

GeoMol CH
Detailmodell
1 : 50'000





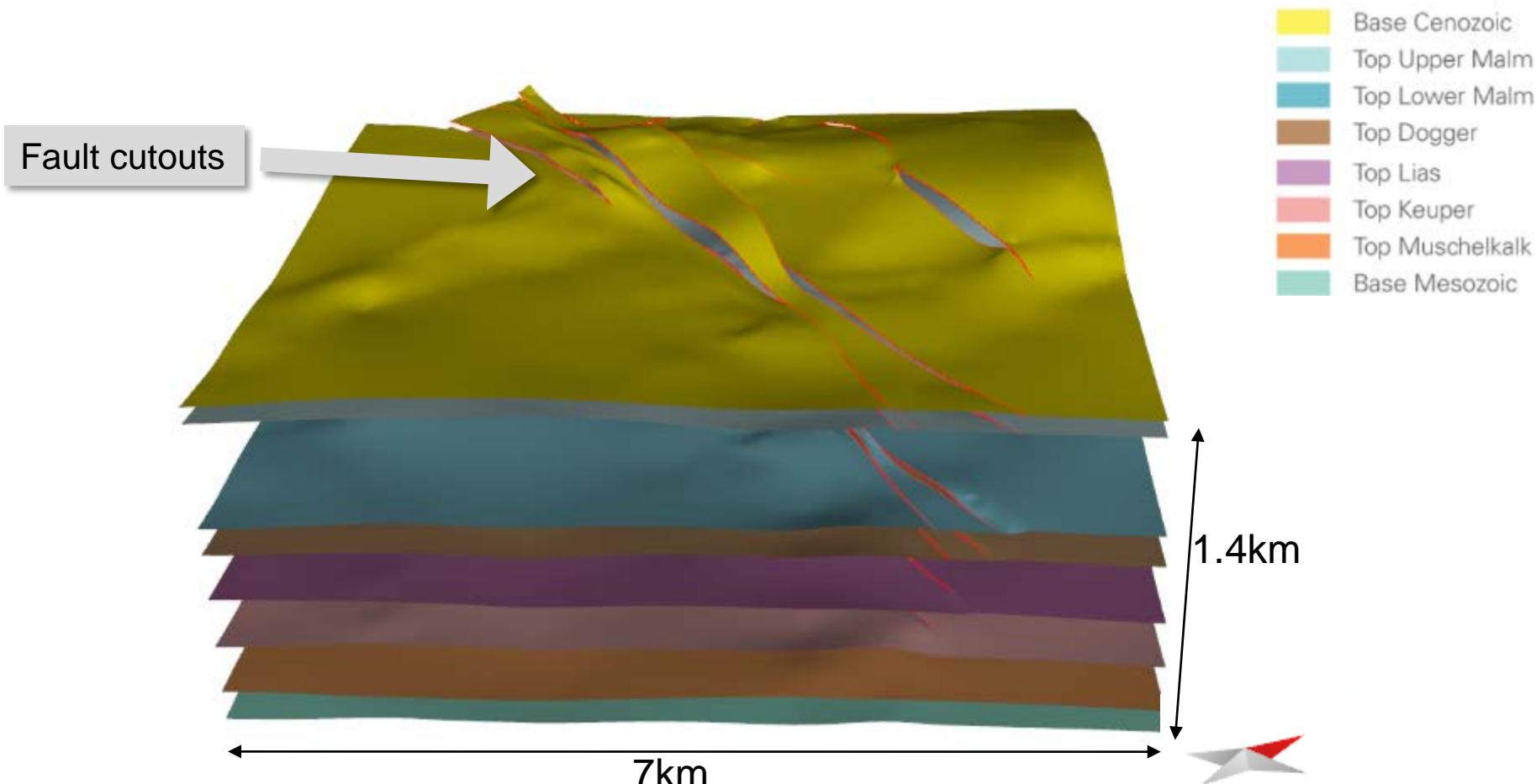
Fault modelling examples





Fault modelling examples

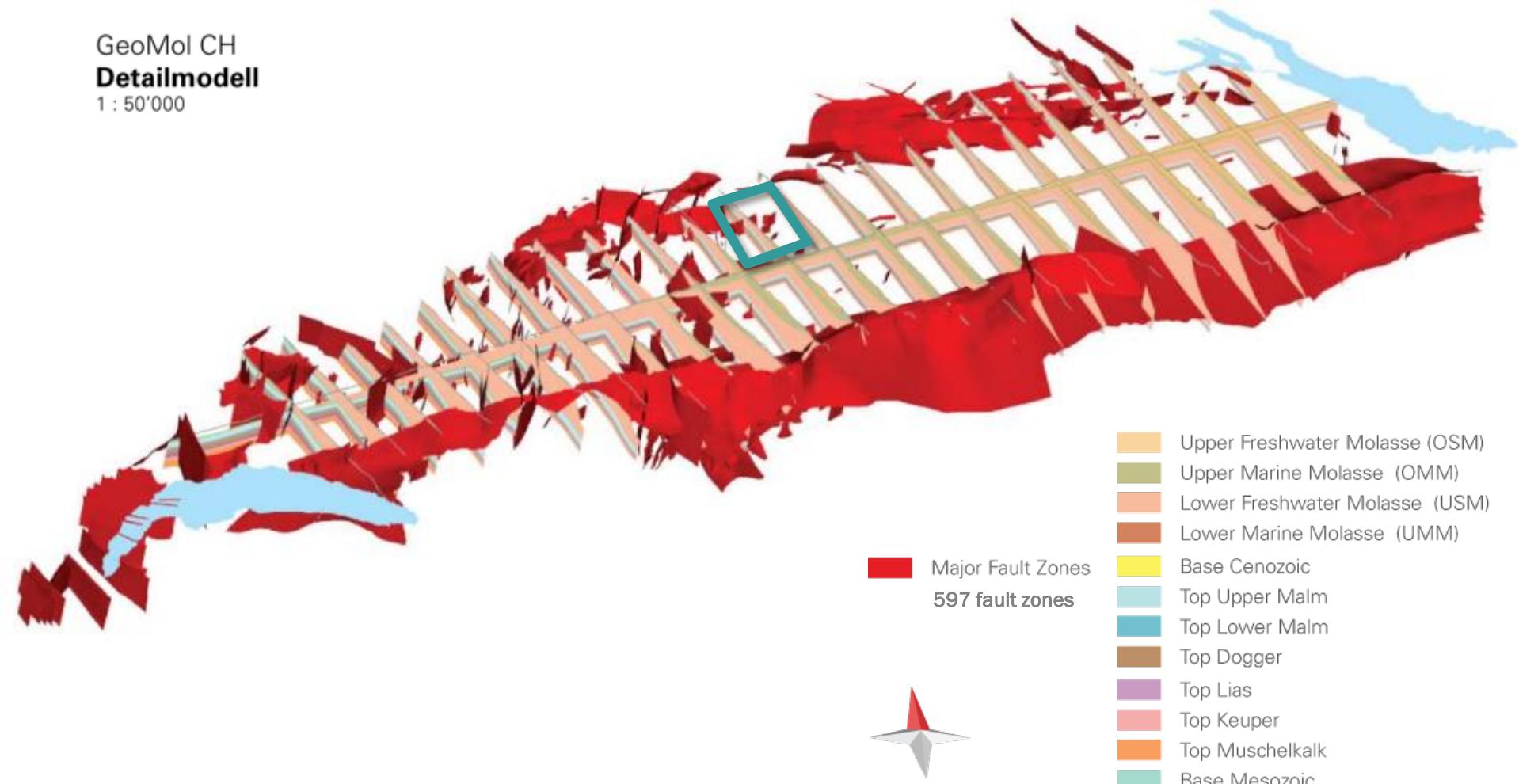
La Sarraz-Structure





Structural Modelling

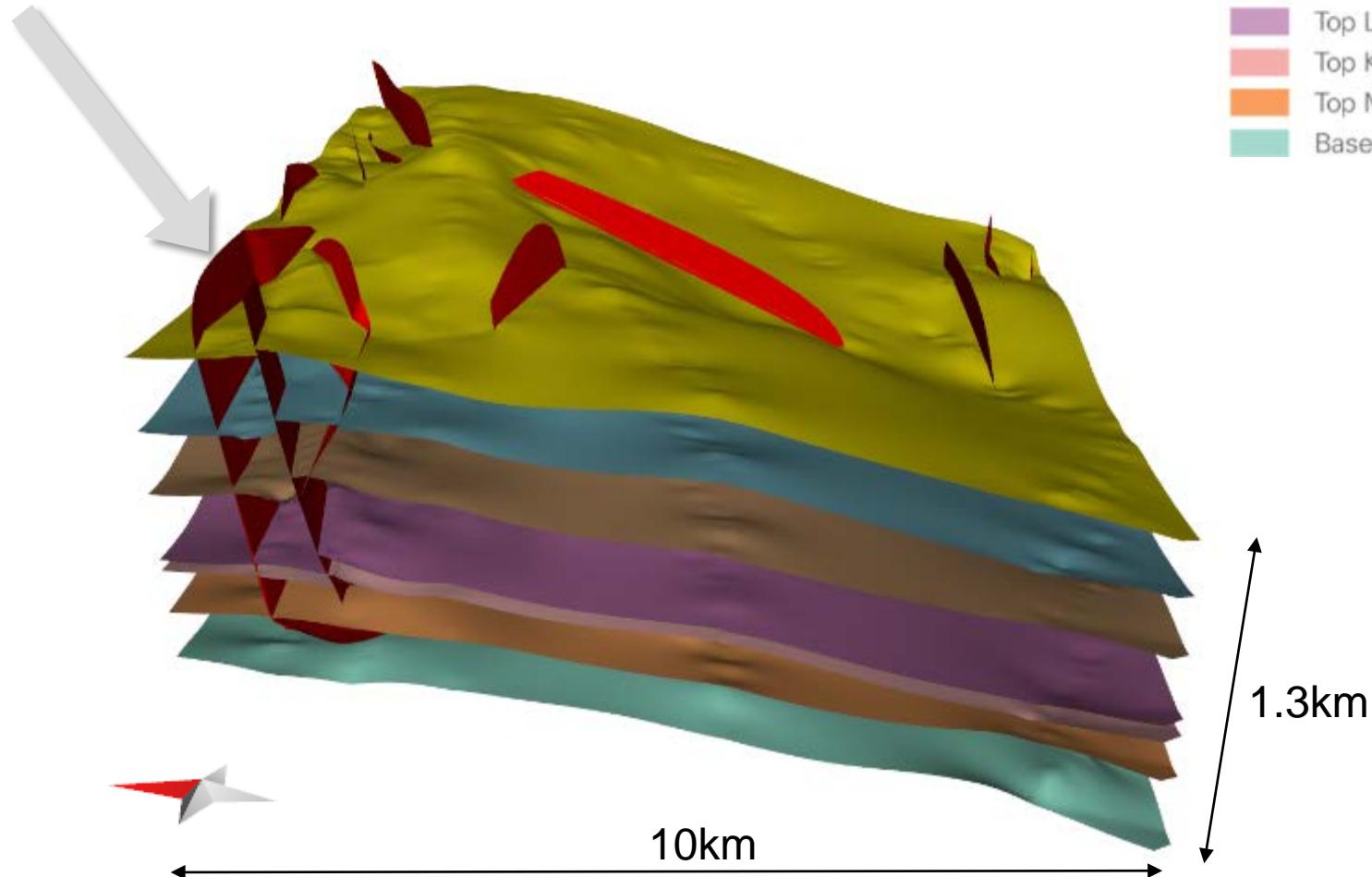
GeoMol CH
Detailmodell
1 : 50'000





Fault modelling examples

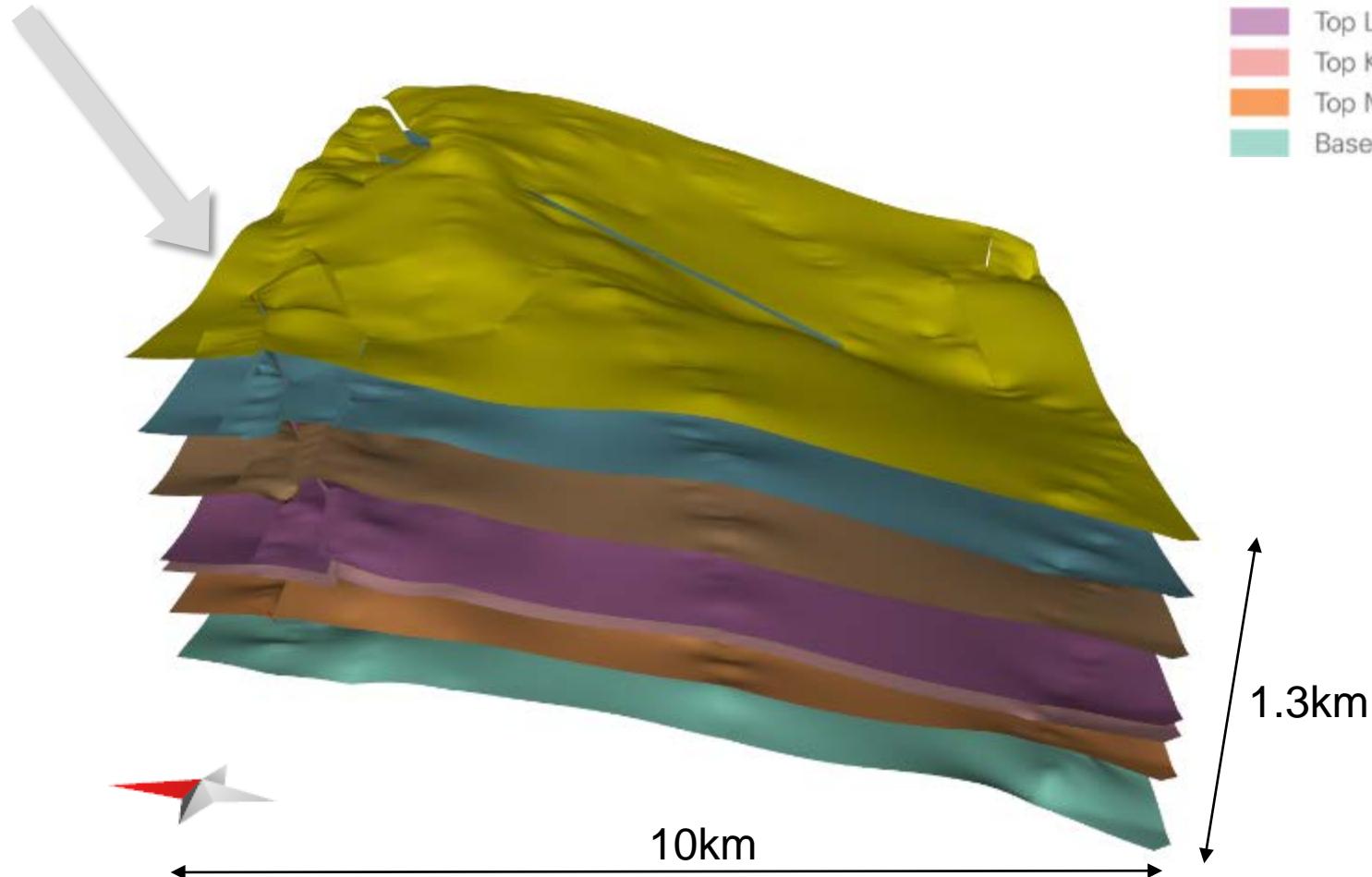
Thrust faults





Fault modelling examples

Thrust faults





Quality Assurance

- Review Gruppe
- POL
- Begleitgruppe
- External review
- Model consistency checks



Review board

- Philip Birkhäuser, Herfried Madritsch, Michael Schnellmann (Nagra)
- Armelle Kloppenburg (4DGeo)
- Gian-Reto Manatschal (U. Strassbourg & G-GeoMargins-M)

- 1-2 technical reviews per year (2013-2016)



Steering committee (*POL*)

- Patrick Lahusen (SEAG) & Werner Leu (SEAG & geoform)
- Nathalie Andenmatten (DETA)
- Gunter Siddiqi (BFE)
- Bernard Loup (BAFU)
- Urs Marti & Olivier Lateltin (swisstopo)

- 2 project reviews per year (2013-2015)



Advisory board (*Begleitgruppe*)

- Andreas Märki & Daniel Schaub (Kt AG)
- Jon Mosar (Uni FR)
- Marco Schwab (Kt FR)
- Felix Renner (Kt LU)
- Yvonne Kaufmann (Kt SO)
- David Georgis (Kt VD)
- Werner Blüm & Kurt Nyffenegger (Kt ZH)

- 2 project meetings & exchange with partners per year (2013-2015)



Quality Control

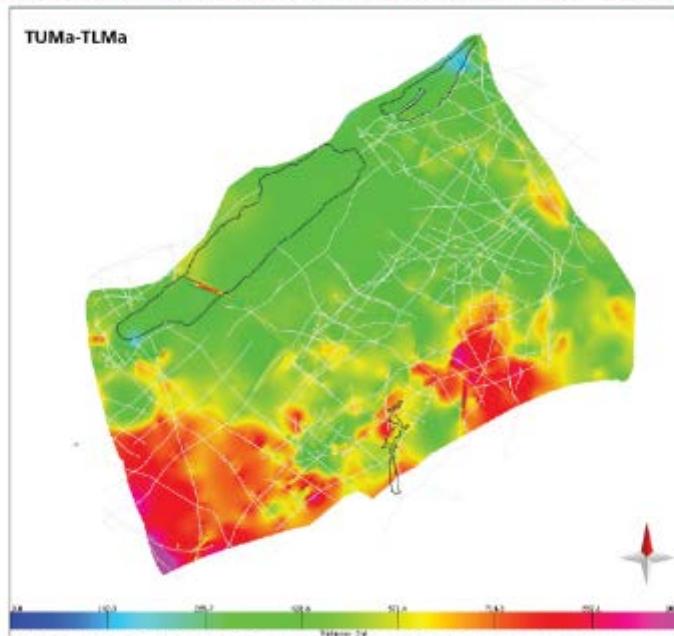
Vint Calculation



Well-tie

Profiles

Thickness maps



Federal Office of Topography swisstopo
Swiss Geological Survey

Evaluation 3D Model – GeoMol Model FR
23 February 2016

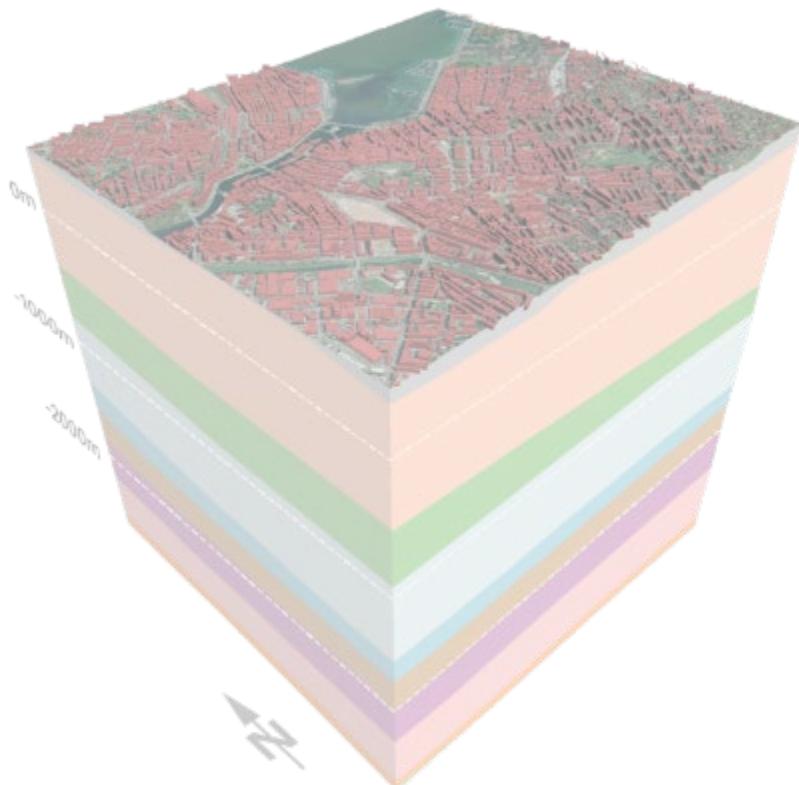
wissen wohin
savoir où
sapere dove
knowing where



Zusammenfassung

- Lessons learned
- Fortführung von GeoMol
- Ausblick

Roland Baumberger

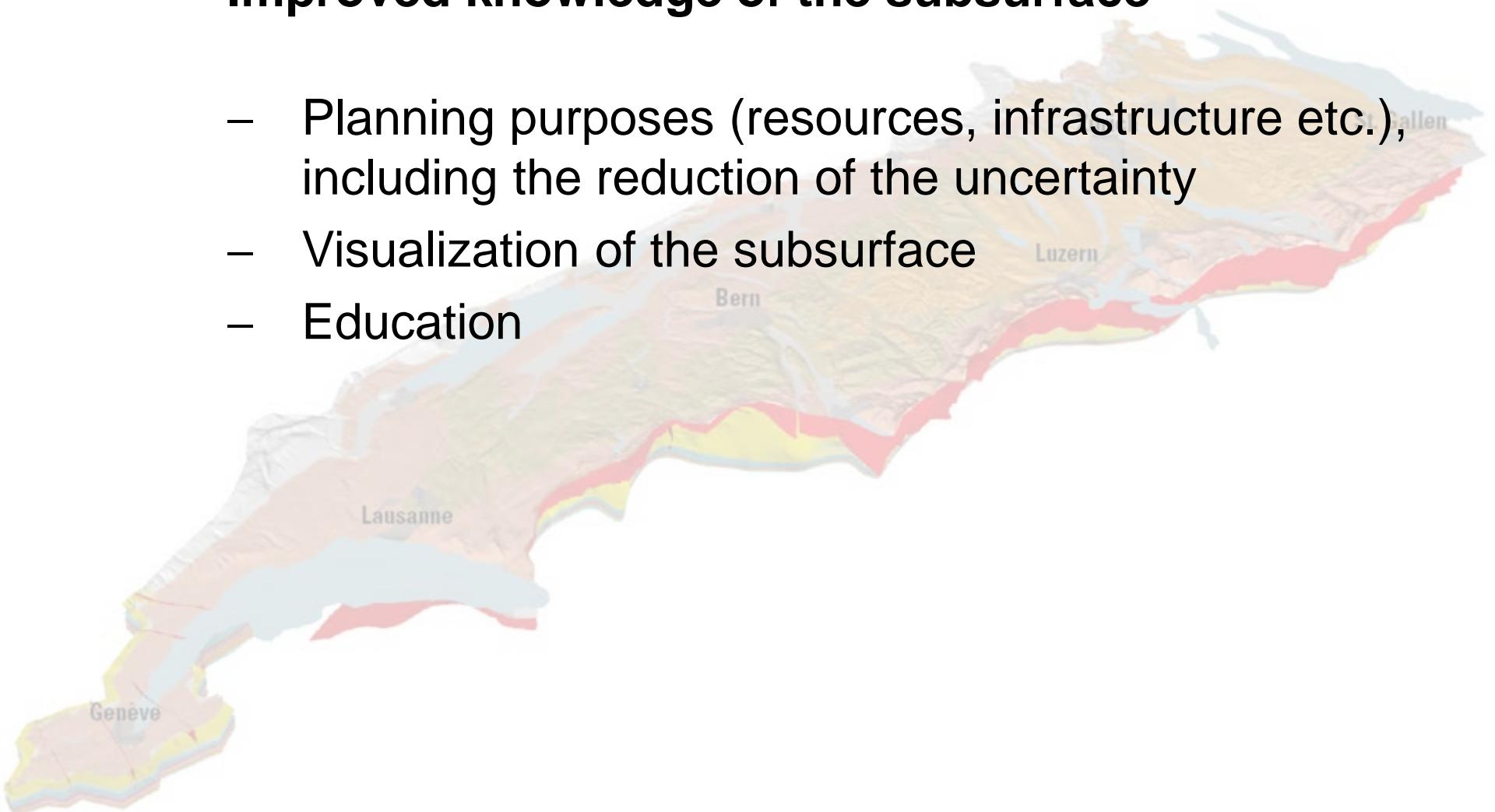




Uses of 3D models

Improved knowledge of the subsurface

- Planning purposes (resources, infrastructure etc.), including the reduction of the uncertainty
- Visualization of the subsurface
- Education



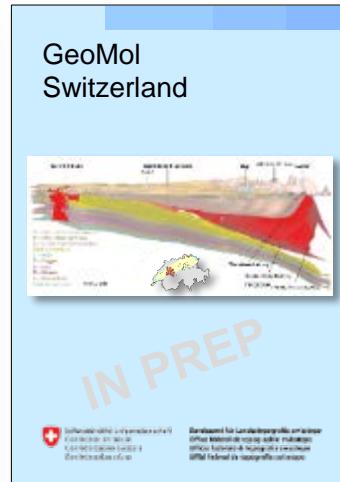


Access to the GeoMol 3D models

- Access to the reduced detail Framework Model is free and without restrictions
 - <https://viewer.geomol.ch>
 - see postcard
- Access to the enhanced detail model is currently restricted to project partners (review period and retention period)
- Unrestricted access to the high resolution model will be possible by 2019



Reports & Closing event



- GeoMol Switzerland closing event and report are due Q4 2017
- Road show to partner cantons in Q1/Q2 2017



Lessons learned

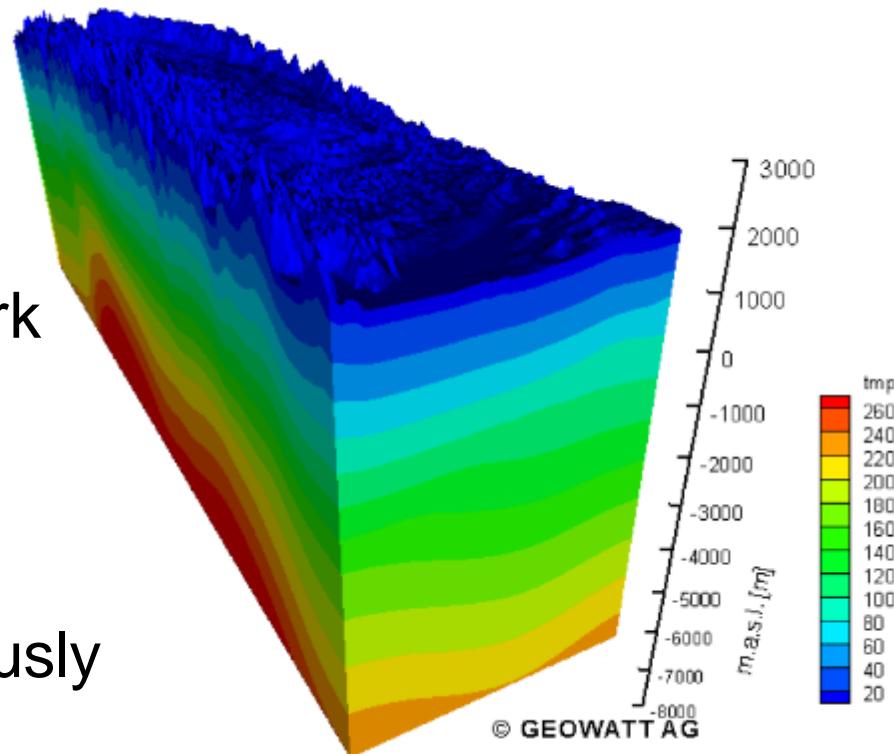
- GeoMol was planned and executed with a **minimum** of previous experience
- Collaborative 3D modelling works
- It's a matter of **definitions** and prescribed workflows
- QA and **QC** must be **defined** well in advance
- Deliverables & **formats** must be **defined** well in advance

→ **The project lead should not be part of the production team!**



Continuation of GeoMol

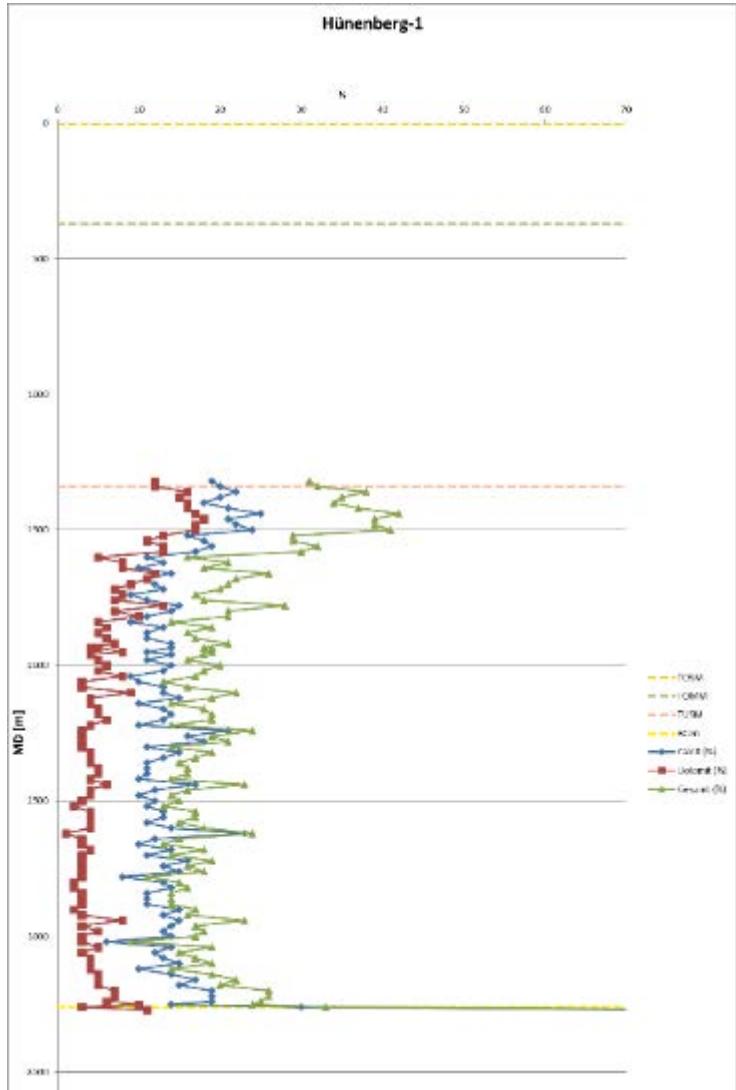
- **Finalize GeoMol CH**
Harmonization of all partner models
- **Parametrisation**
Populate the Framework Model with geothermal data
- **New data**
Addition of new, previously not used data (seismic data, wells)





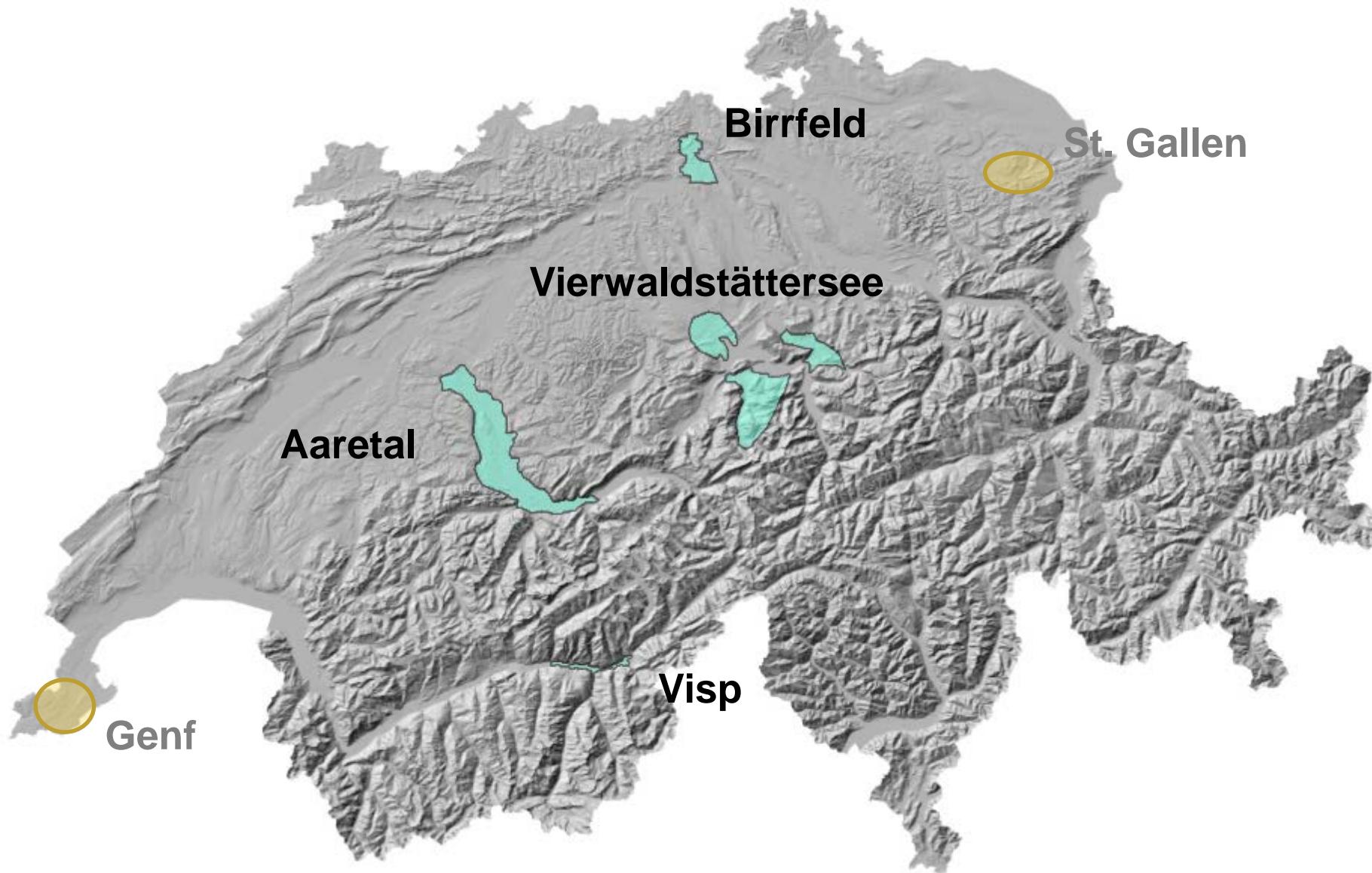
Continuation of GeoMol

- Update Top Bedrock in collaboration with the GeoQuat project
- Finalizing the Calcimetrie compilation for Eastern Switzerland (internal Molasse structure)
- Addition of energy resource potentials to the model





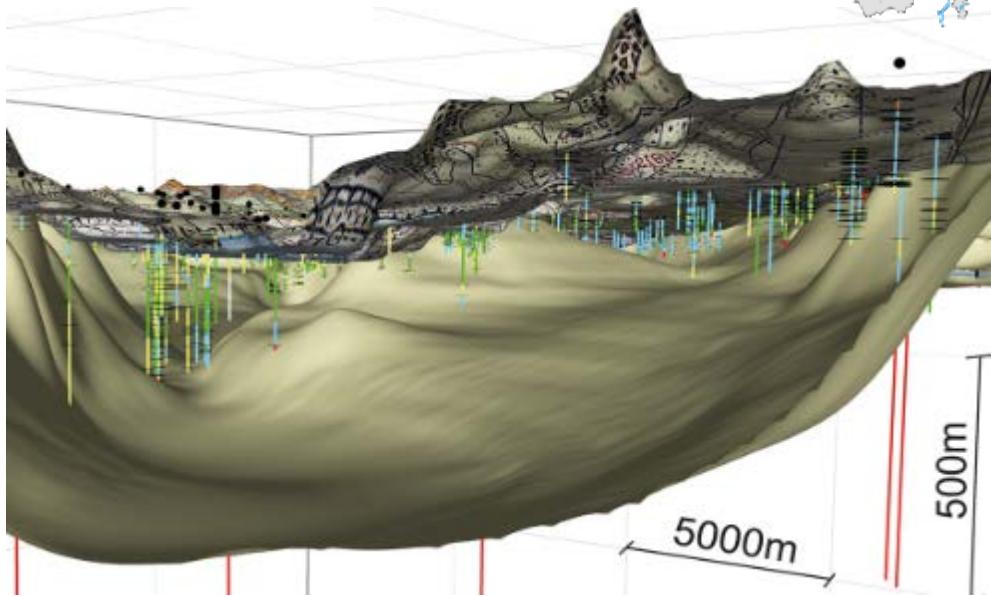
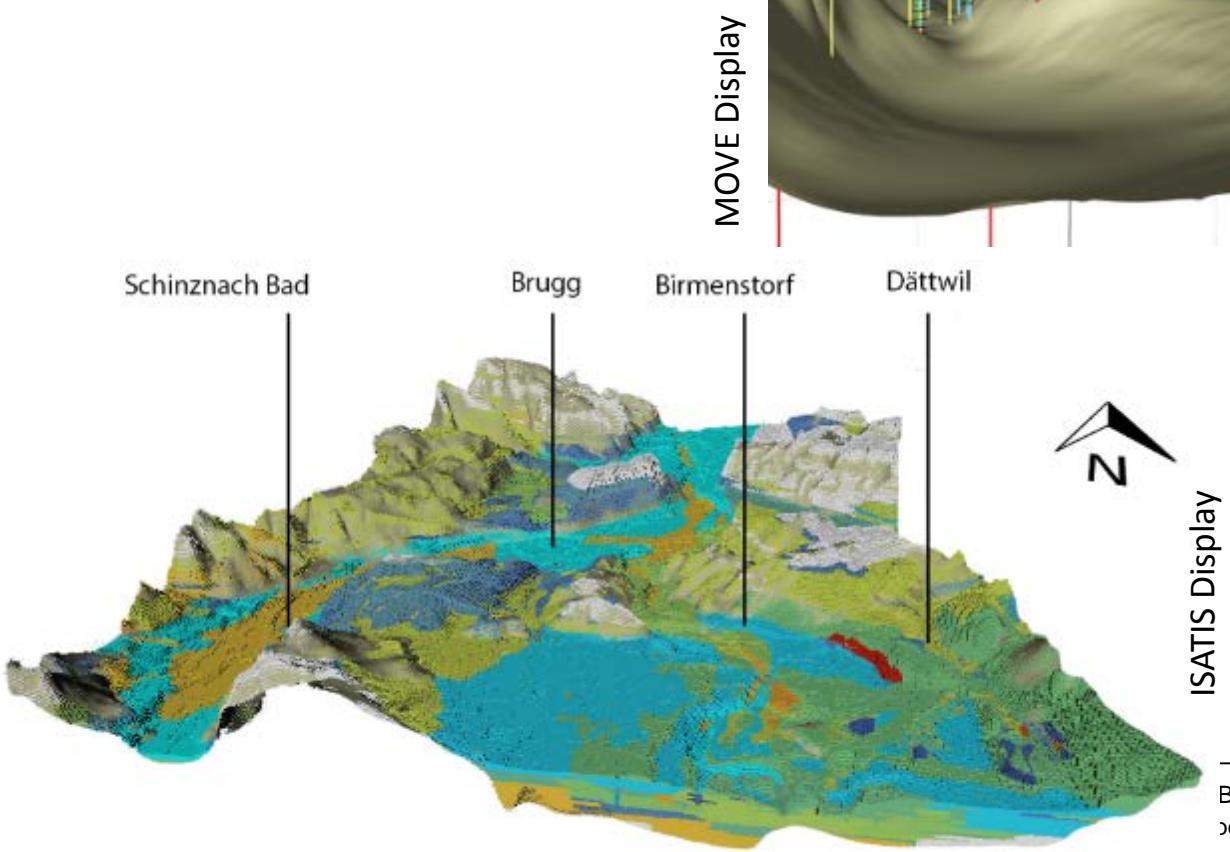
GeoQuat





GeoQuat

3D visualization of wells and geological layers based on interpretations and USCS classification.



Geological 3D model of the Birrfeld area.

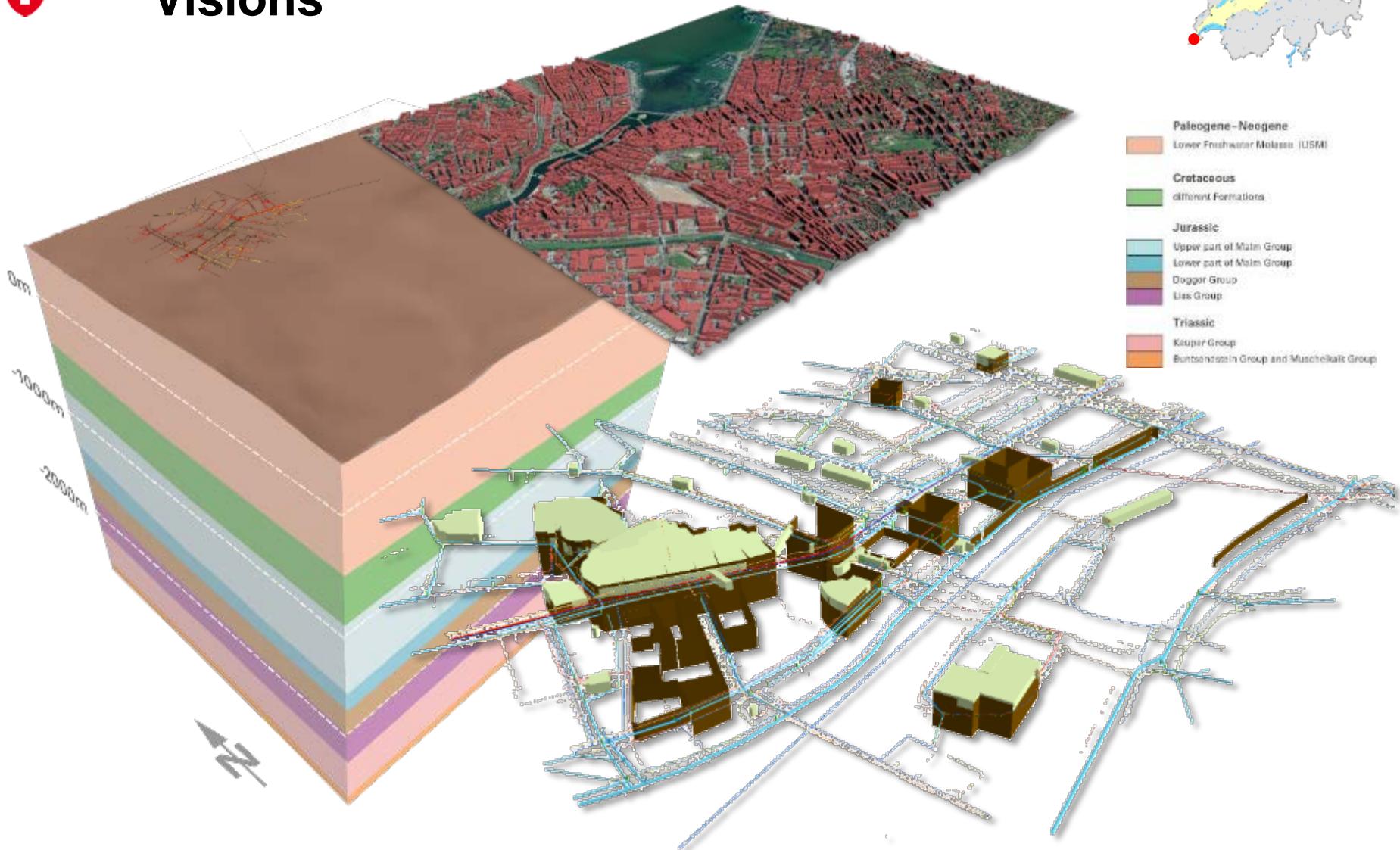


Models planned

- **2017+: GeoCover 3D**
Geological 3D model of the shallow subsurface
- **2017+: National Geological Model**
3D visualization tool for geological data of swisstopo and partners



Visions





GeoMol team @ swisstopo



Maria Ponzio



Angelo Milani



Valentin Zuchuat



Bastien Delacou



Gennaro Di Tommaso



Mirjam Dürst Stucki



Lance Reynolds



Eva Kurmann-Matzenauer



Philip Wehrens



Salomè Michael



Roland Baumberger



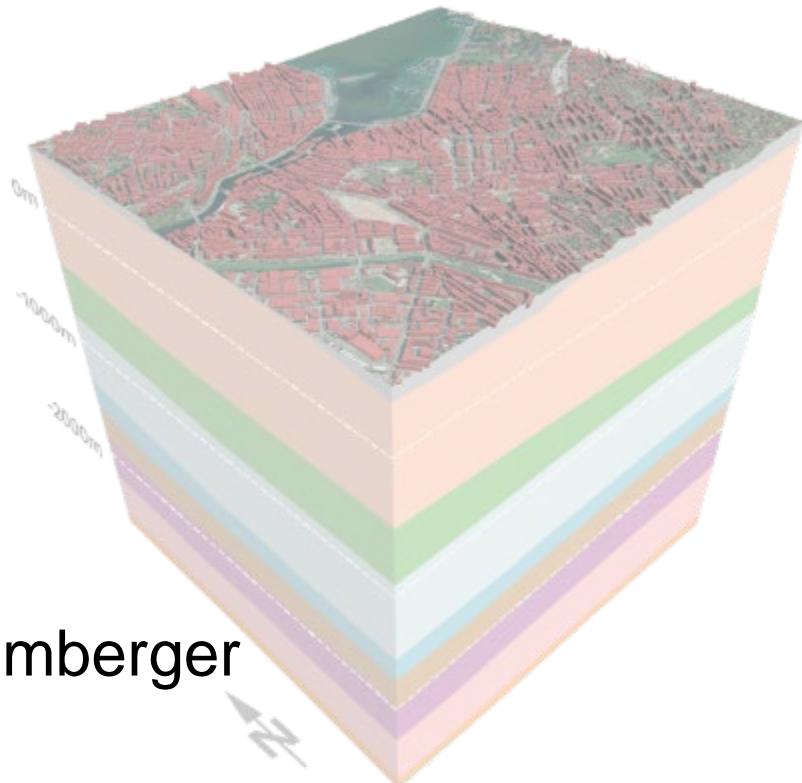
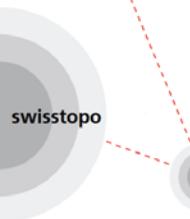
Pascal Kuhn



Robin Allenbach

wissen wohin
savoir où
sapere dove
knowing where

Fragen



Salomè Michael
Robin Allenbach, Roland Baumberger



Fragen & Antworten

«Geological 3D models are always wrong to some extent»

Danke für Ihre Aufmerksamkeit!

Contact

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roland.baumberger@swisstopo.ch

salome.michael@swisstopo.ch