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Hydrogeologie · Geothermie

First EAGE Workshop on Evaluation and Drilling of Carbonate Reservoirs

Kilian Beichel: Geologist – ERDWERK GmbH
Co-Authors: Steiner U., Savvatis A., Böhm F.

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Outline

1. ERDWERK GmbH at a Glance
2. The Southern German Molasse Basin
3. The Upper Jurassic in Southern Germany
4. Geological Exploration Targets – State of Play and Current Challenges
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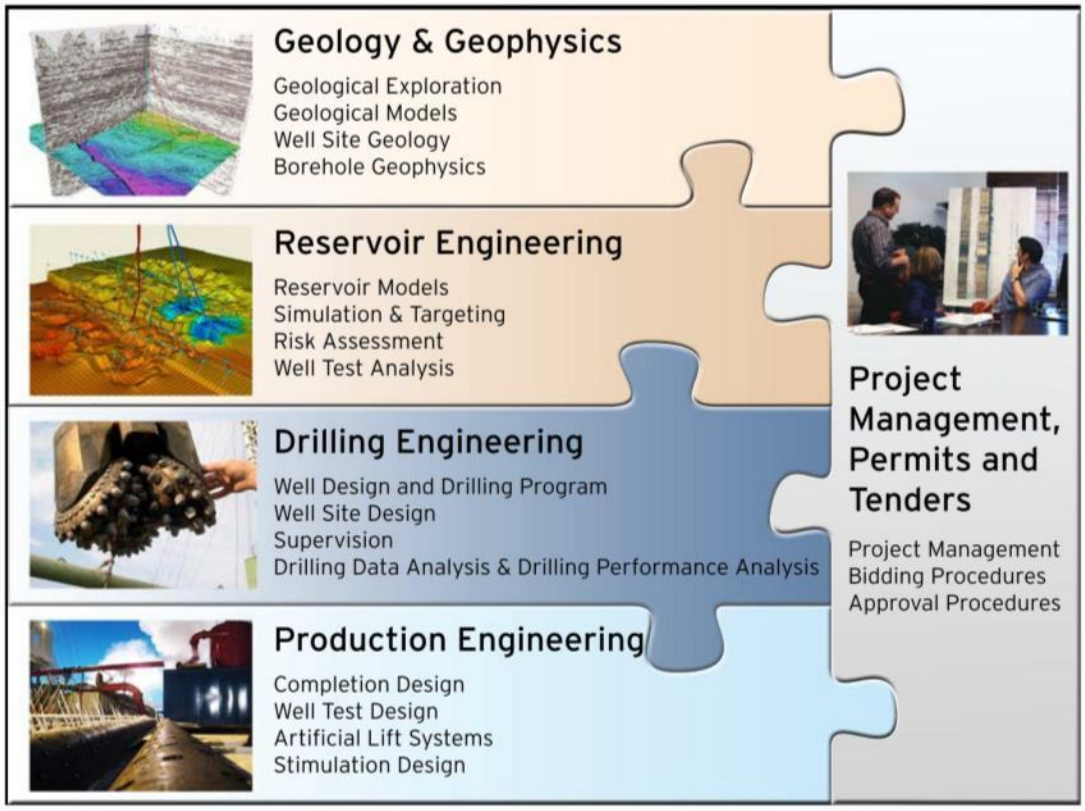
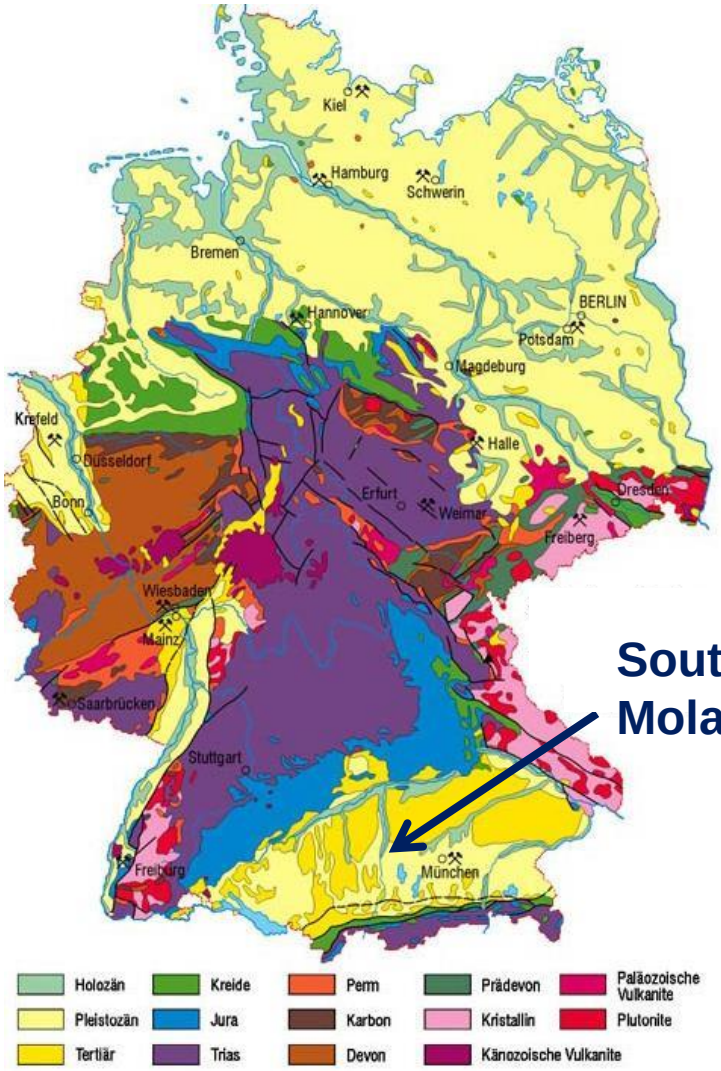
    2. Primary facies – Diagenesis
    3. Karstification
5. Conclusion
6. Discussion

ERDWERK at a glance …

- Founded in 2002 by Dr. Achim Schubert
- Leading consultant for design and project management of geothermal projects in South Germany
- Currently active in Germany, Belgium, Switzerland, UK, Costa-Rica and Tanzania.
- Over 110,000 m planned and drilled



Southern German Molasse Basin

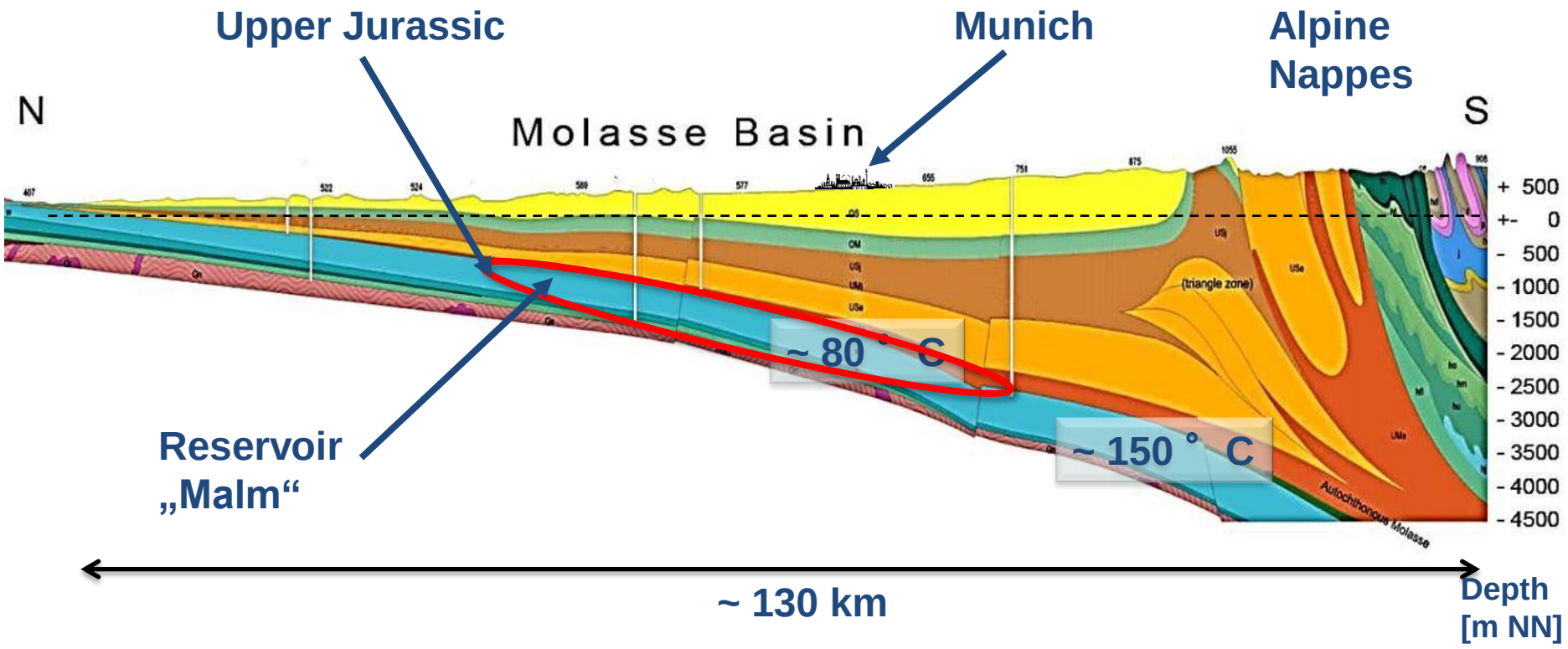


Source: ©BGR

Southern German Molasse basin

Source: udo-leuschner.de

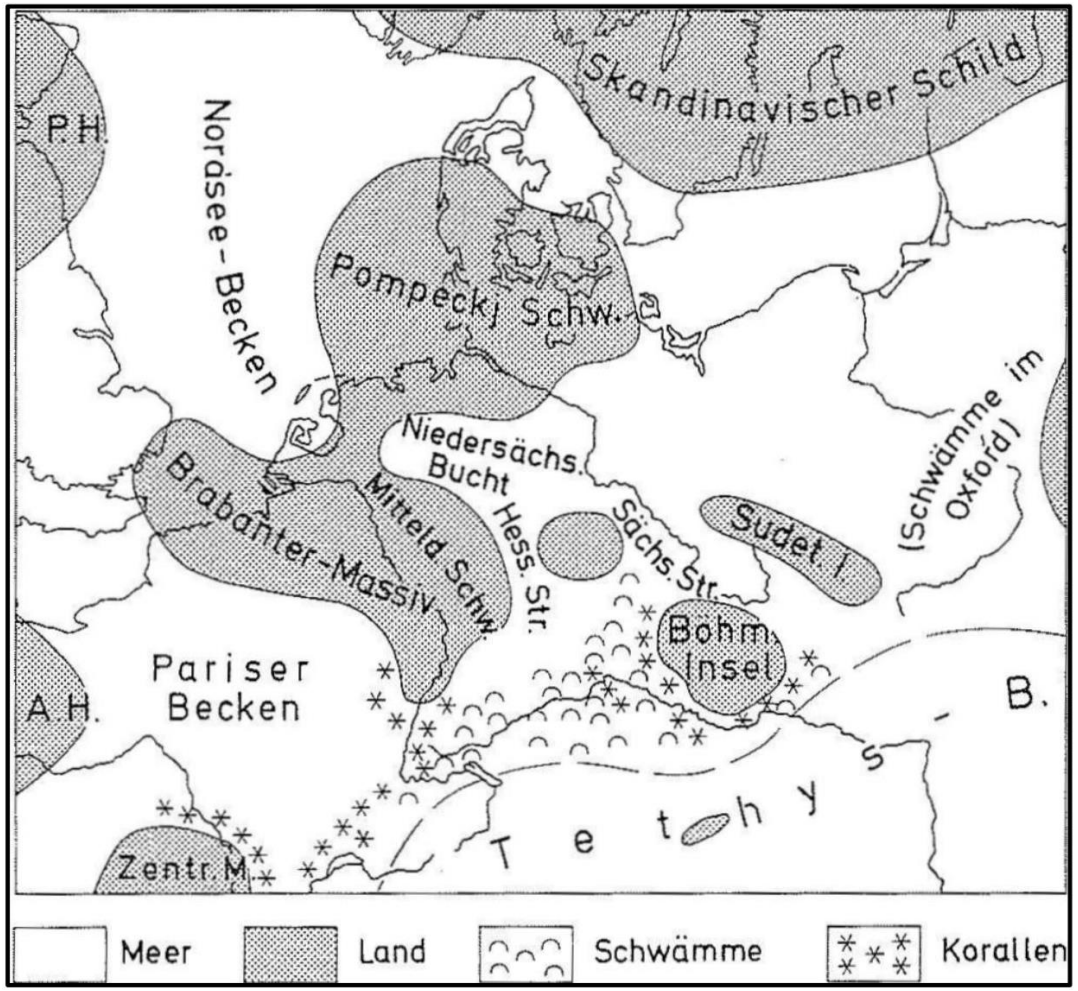
Geology of the Molasse Basin



Adapted from ‘Geologische Karte von Bayern 1:500000’, Bayerisches Geologisches Landesamt,1996

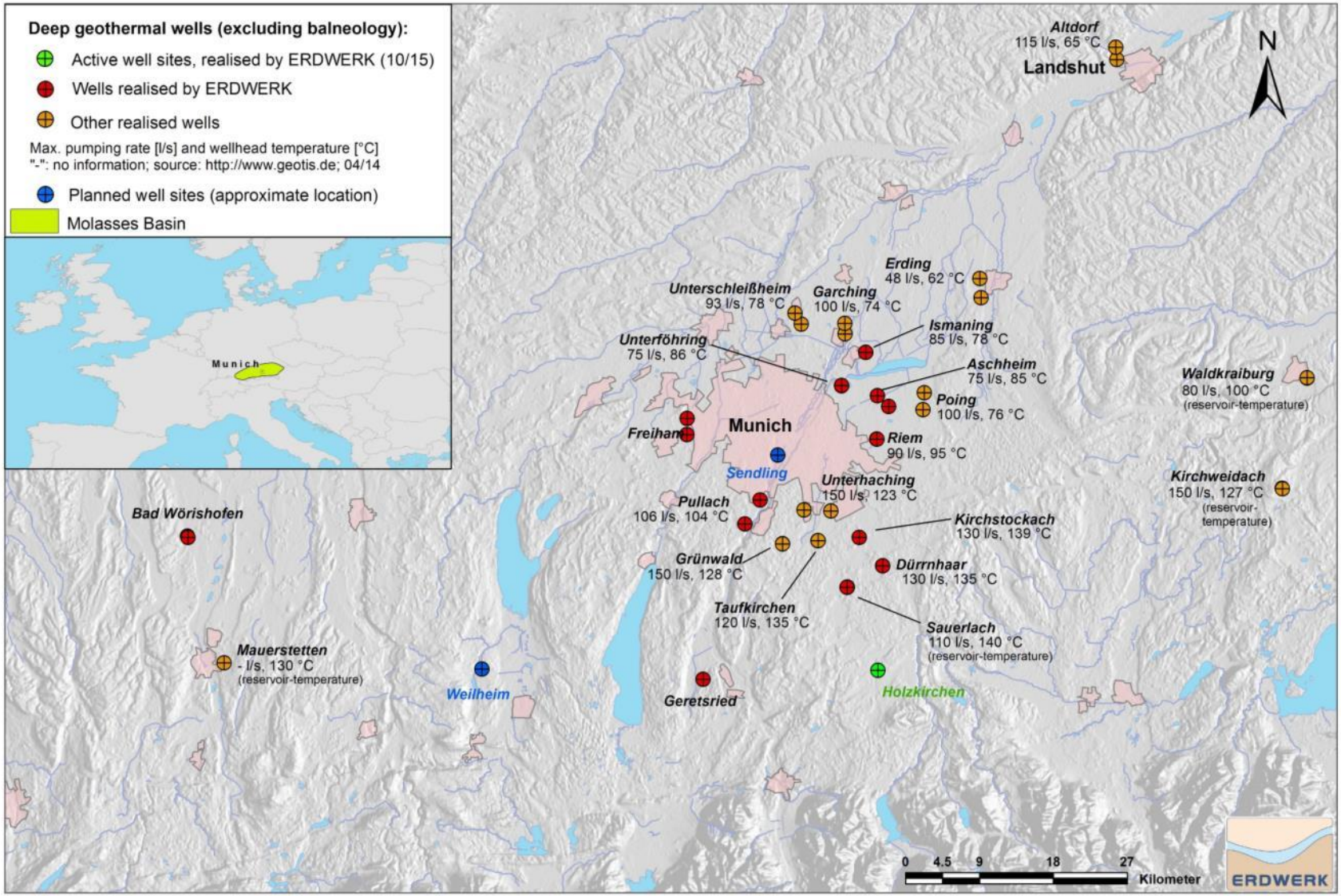
N-S Schematic Cross Section

Paleogeographic situation

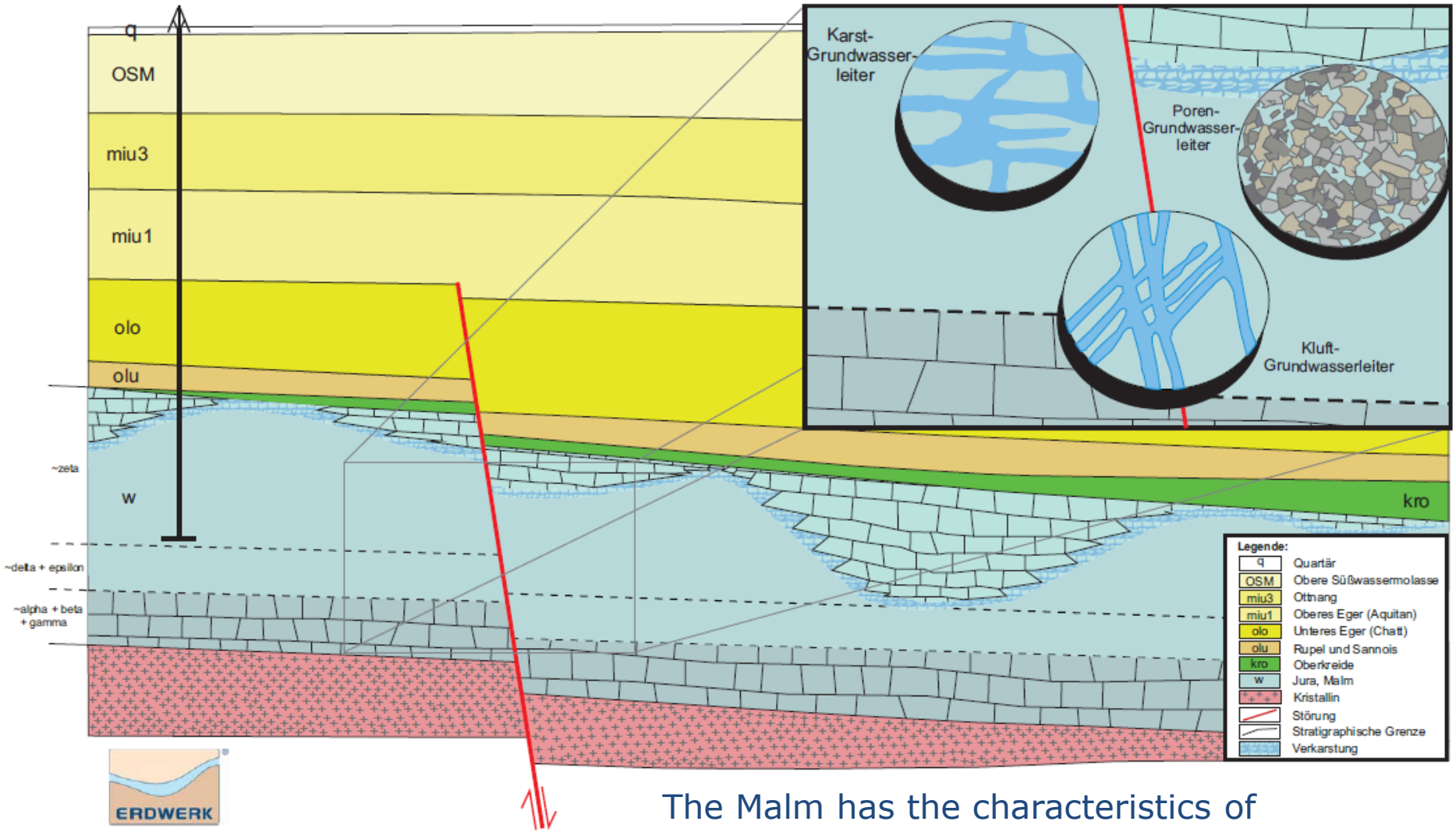


MEYER & SCHMIDT-KALER 1996

Geothermal Development in Bavaria



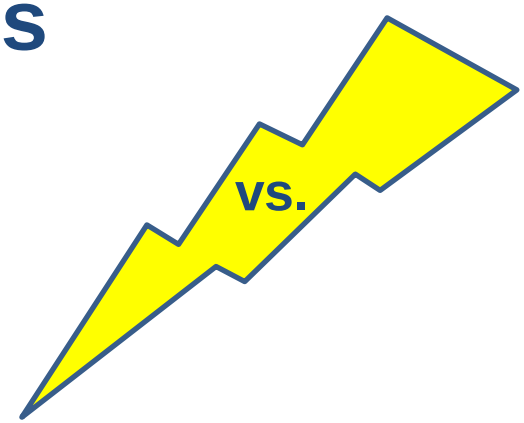
Characteristics of the Malm Aquifer



The Malm has the characteristics of many different aquifer types

History of Exploration Strategy

Faults



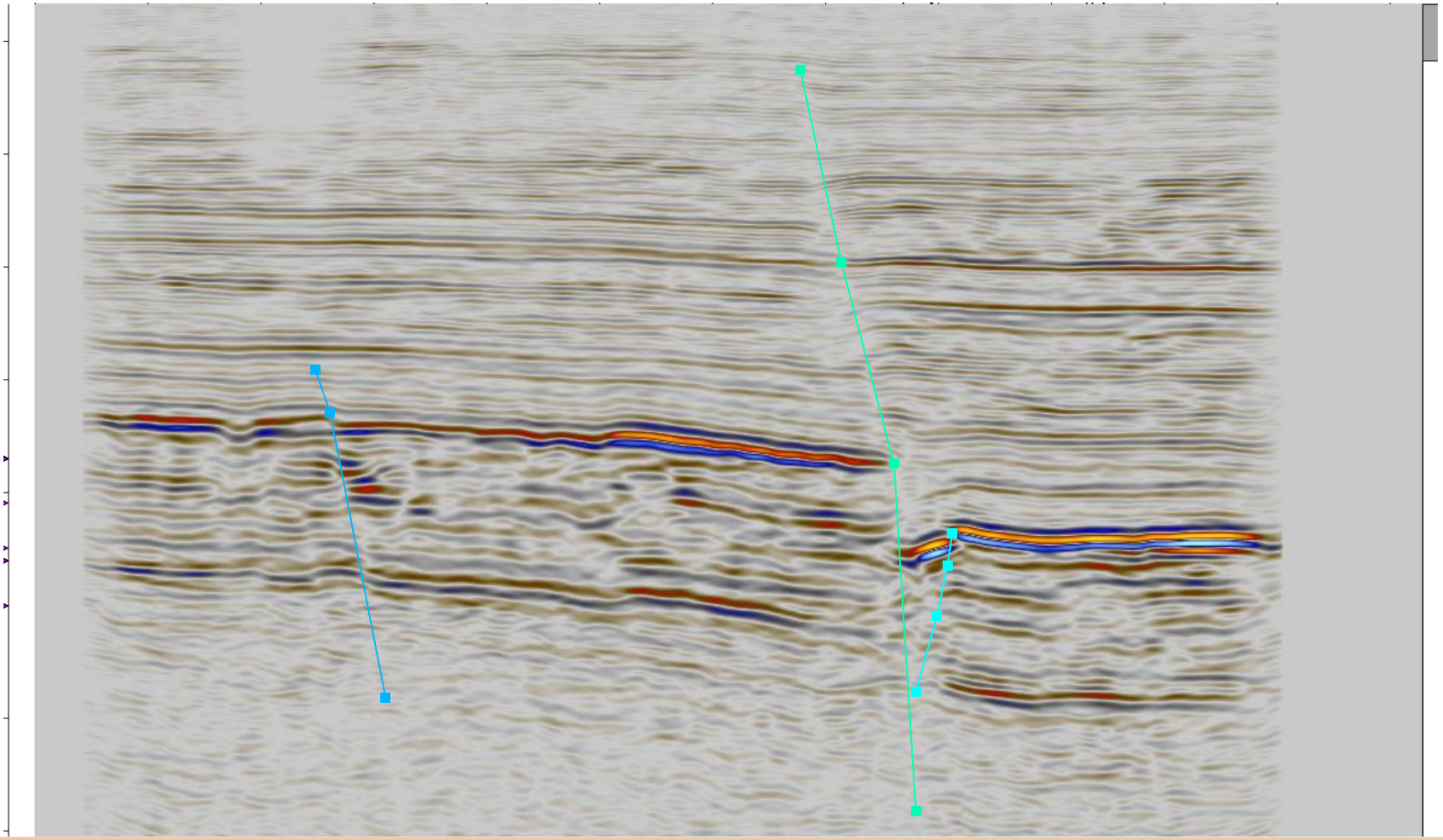
Facies

Key Factors for Productive Geothermal Wells

- Structural Geology – Faults/Fractures
- Primary Facies & Diagenesis – Matrix Porosity
- Karstifikation - Corrosion

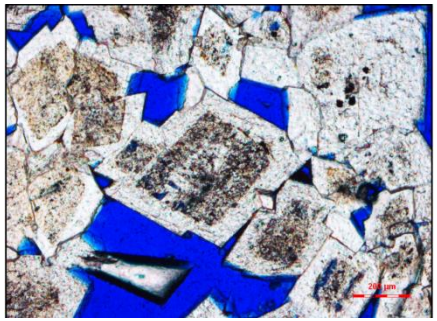
Key Factors for Productive Geothermal Wells

Structural Geology – Normal Faulting

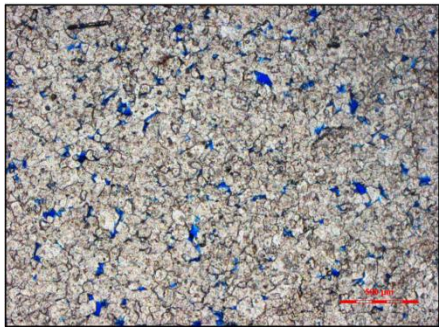


Key Factors for Productive Geothermal Wells

Primary Facies - Diagenesis



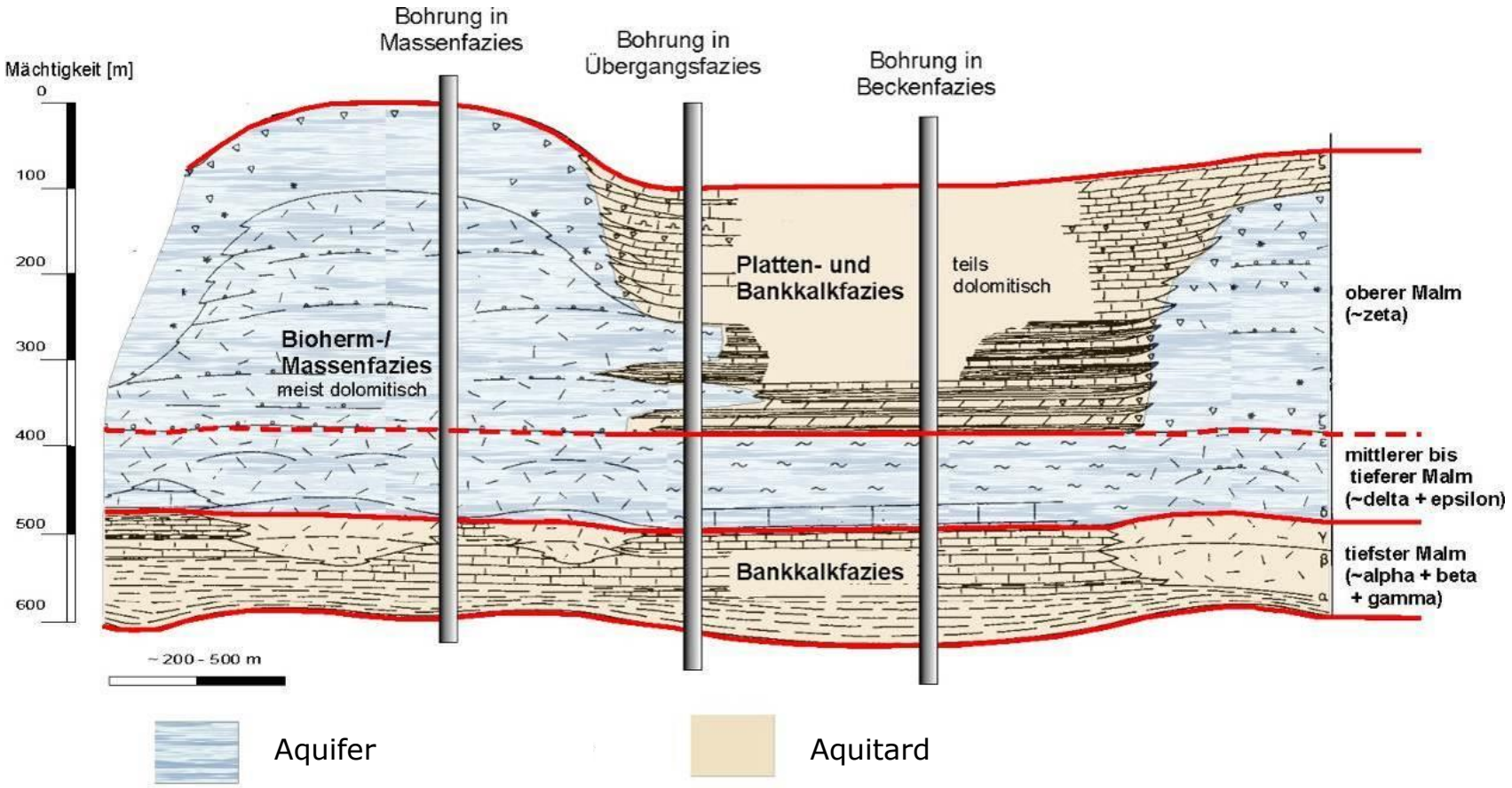
- High water-energy carbonates favour dolomitization
- Controlled by the degree of purity of the carbonates
- Size and shape of the dolomite crystals are controlled by the amount of insolvable residues inside the primary carbonate
- Size and shape of the dolomite crystals are controlling the porostity and permeability of the matrix



Koch 1997

Hydrostratigraphic Modell

Combination of Facies and Hydrostratigraphical Model

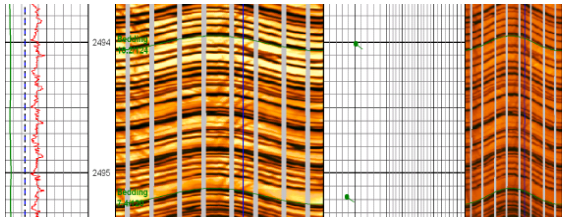


Analogous Studies Malm Relief

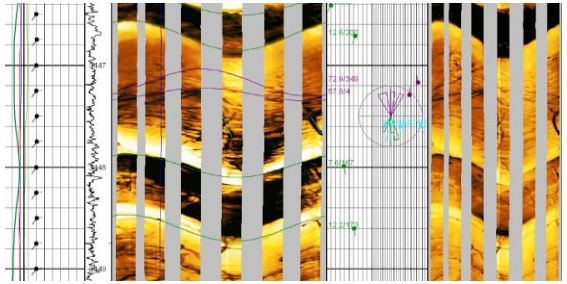
Facies Interpretation Using Imagelogs

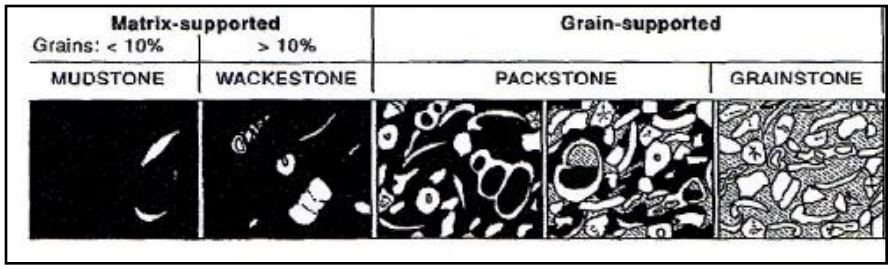
Bedded Facies

Type A - thin bedded facies



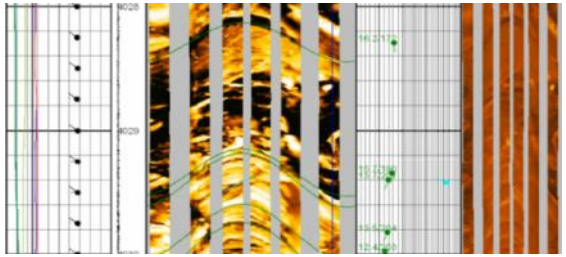
Type B - thick bedded facies



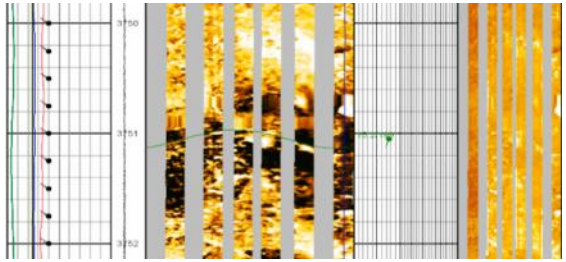


Massive Facies

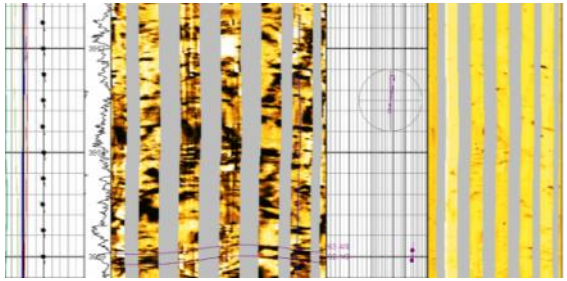
Type C – massive facies - limestone



Type D massive facies – bioherm



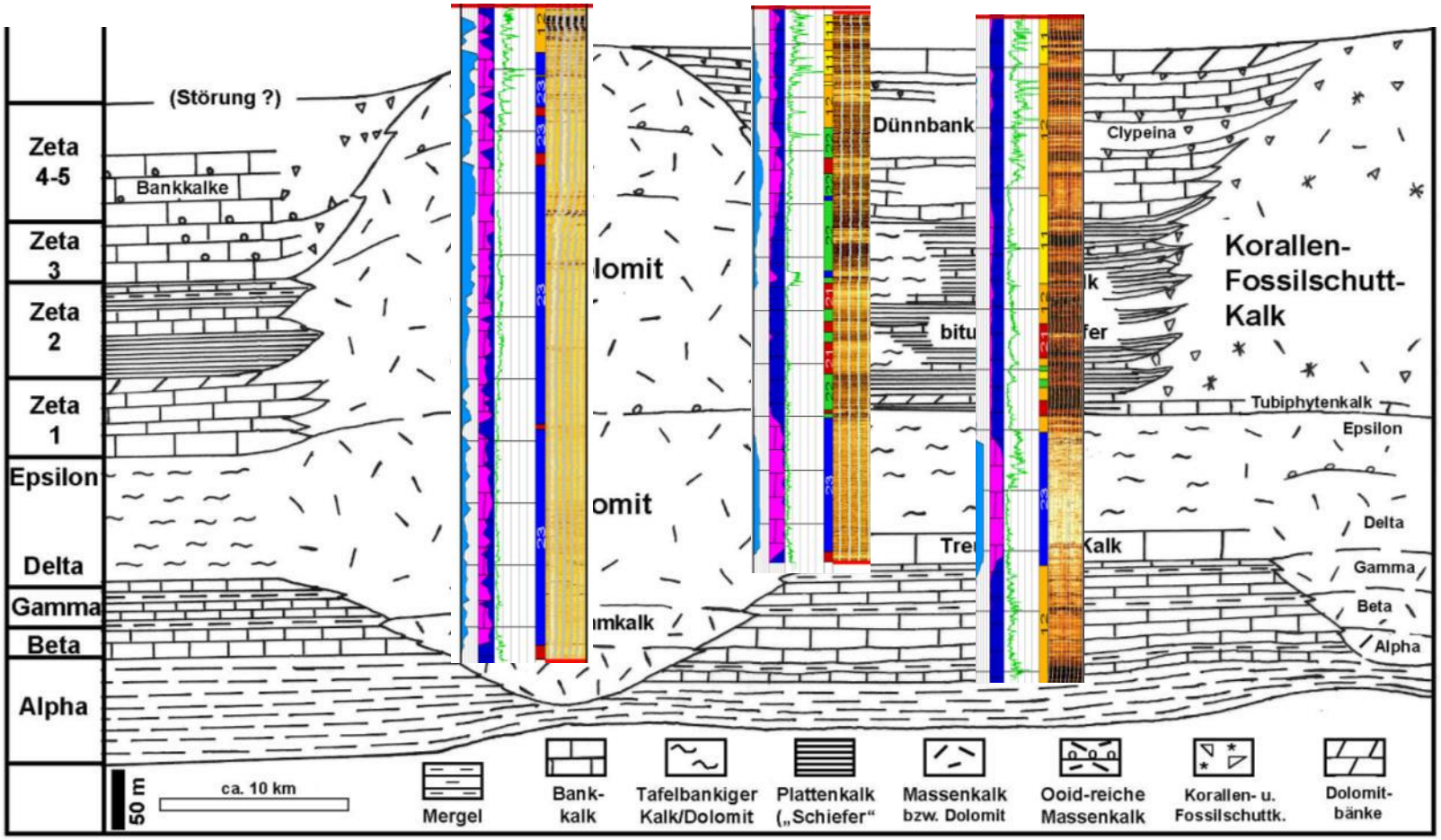
Type E – massive facies - dolomite



→ Essentially for the facies model

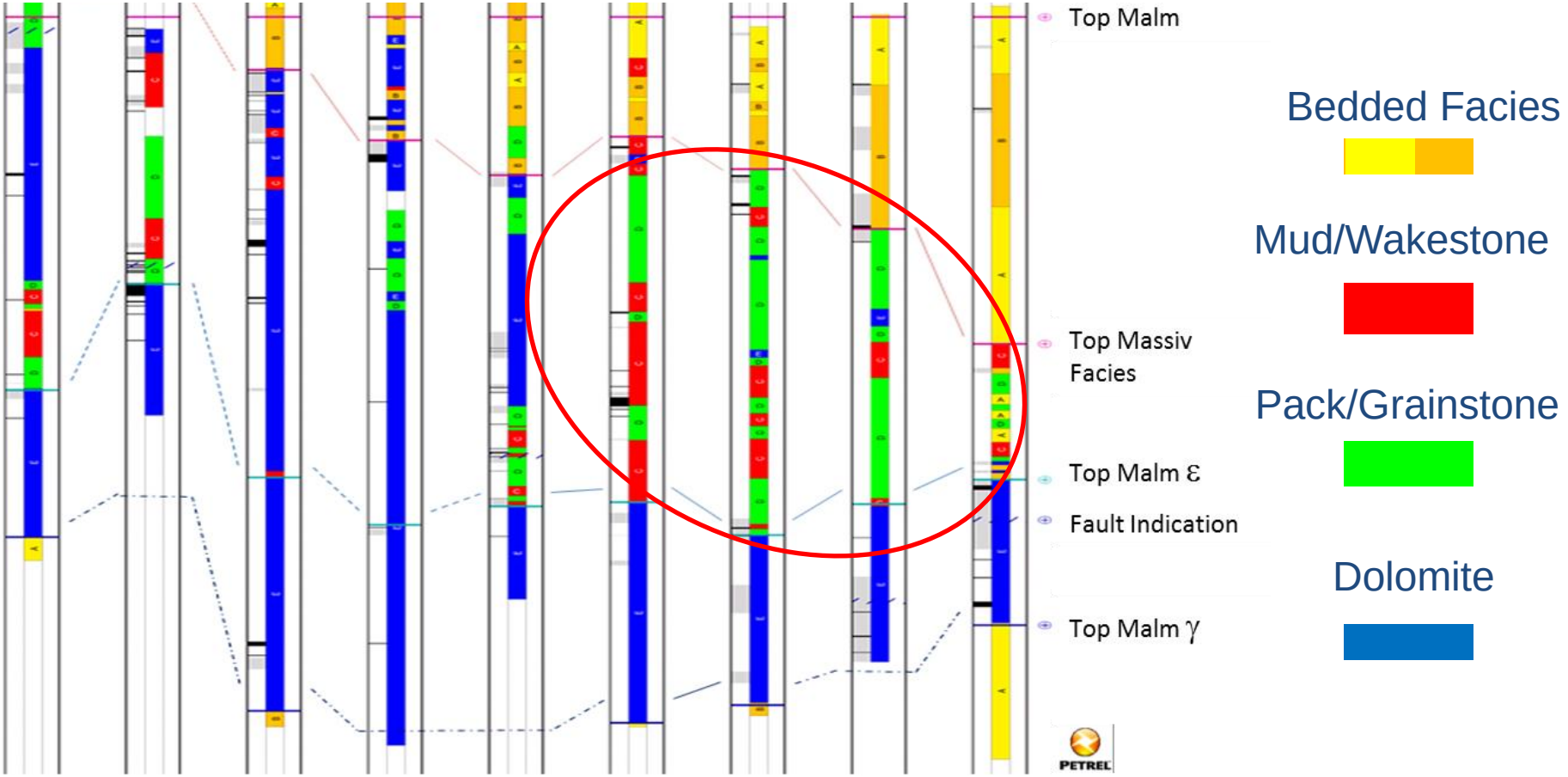
Facies Interpretation Using Imagelogs

Facies Model of the Malm in the Molasse Subsurface (after Mayer 1994)



Facies Interpretation Using Imagelogs

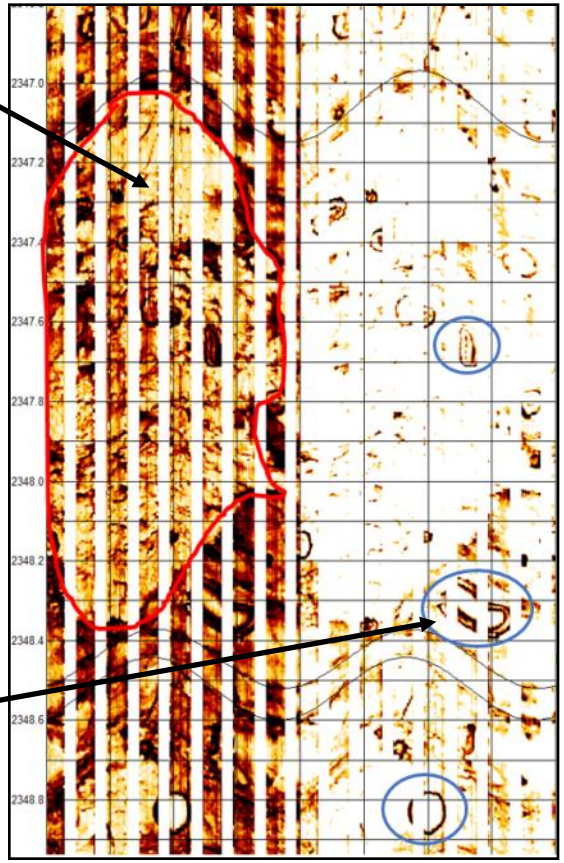
Imagelog classification

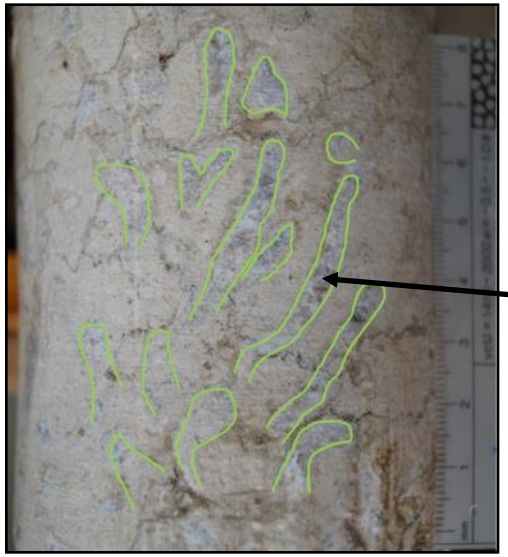


Facies Interpretation in Seismic Data

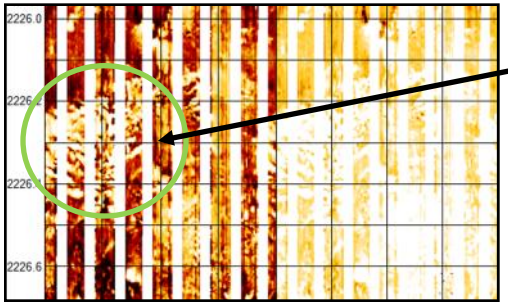
Dolomitization Processes in Massive Facies

Locally dolomitization of Bioherm Facies





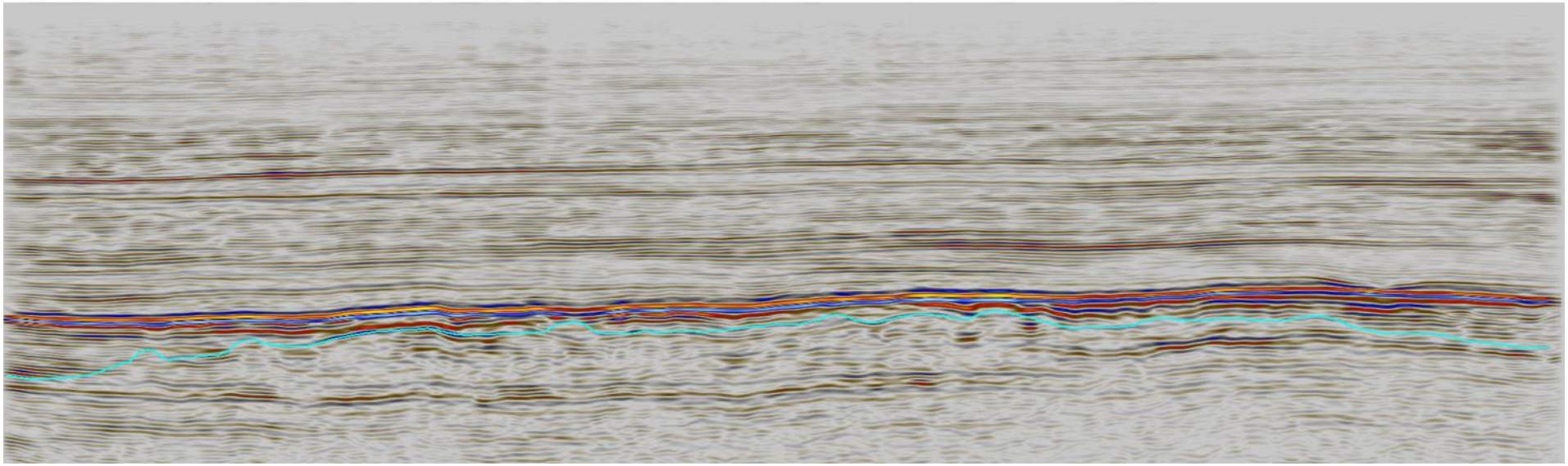
Coral in a well-core of the Upper Jurassic Malmian



Coral Bioclasts

Sponge Bioclasts

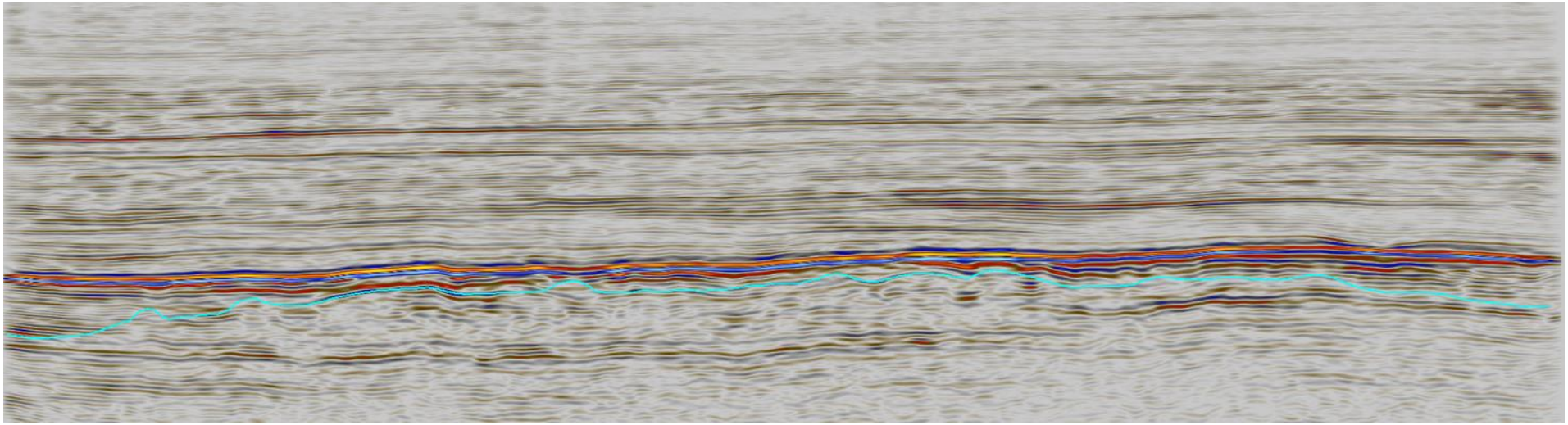
Facies Interpretation in Seismic Data



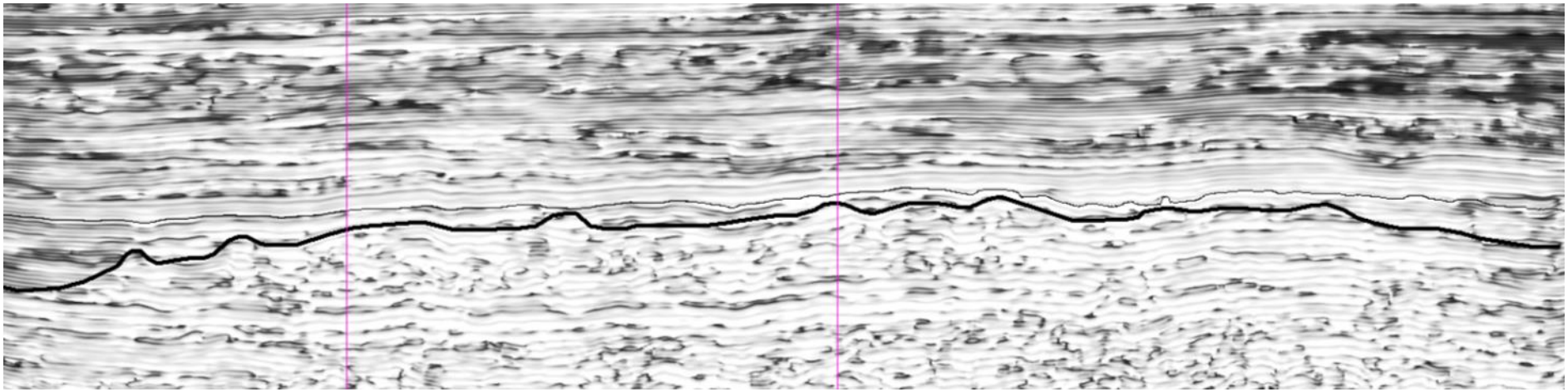
Light blue: Top Massfacies

Facies Interpretation in Seismic Data

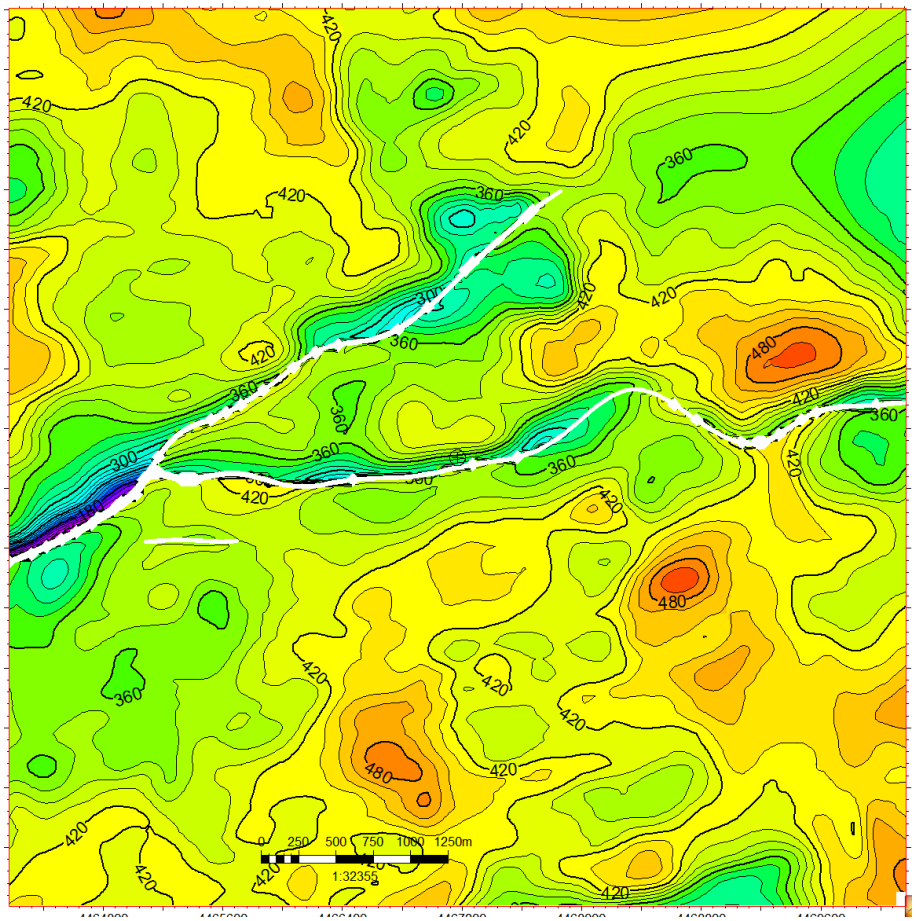
Facies Interpretation supported by seismic attributs



Attribut Isofrequency 15 Hz, spectral decomposition

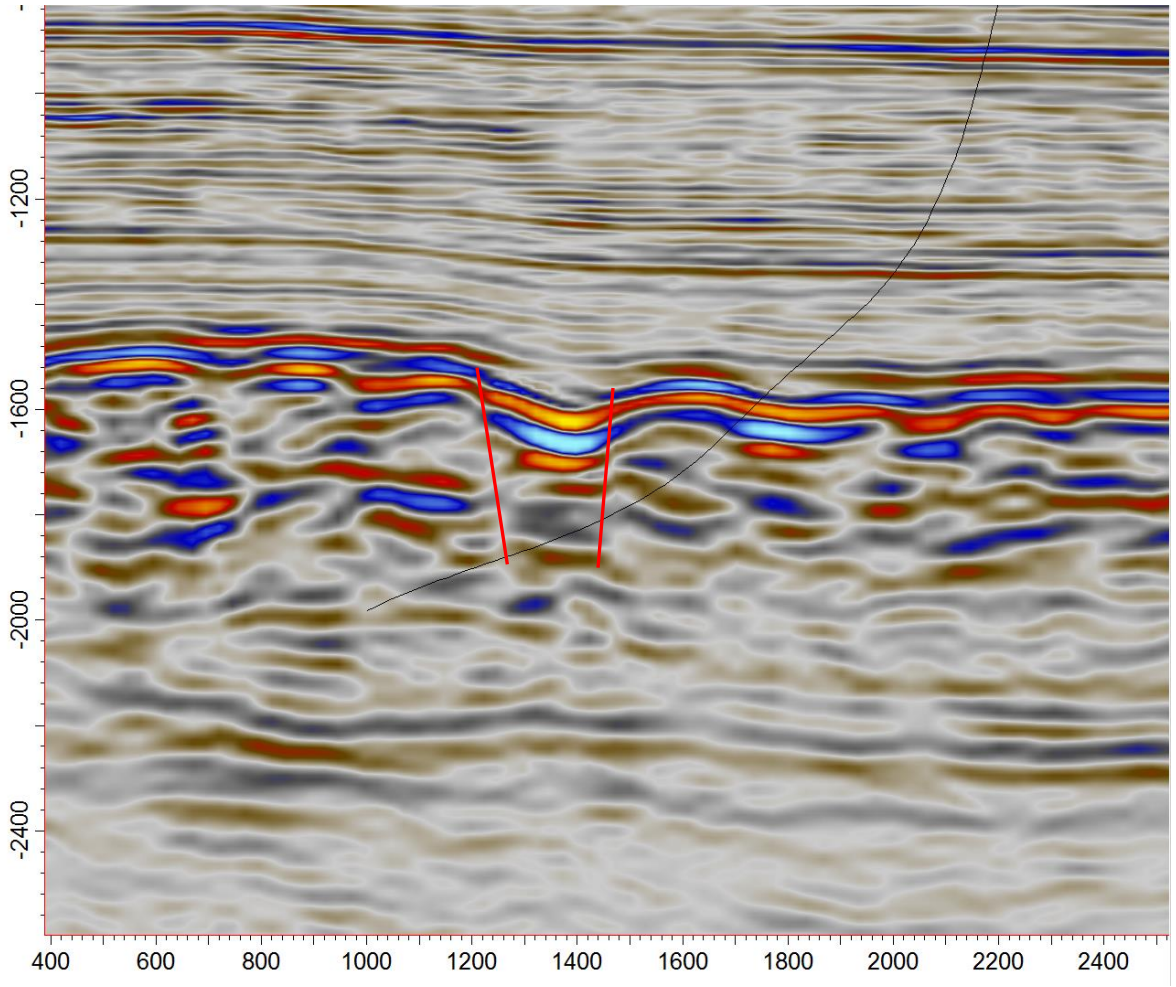


Facies Interpretation in Seismic Data



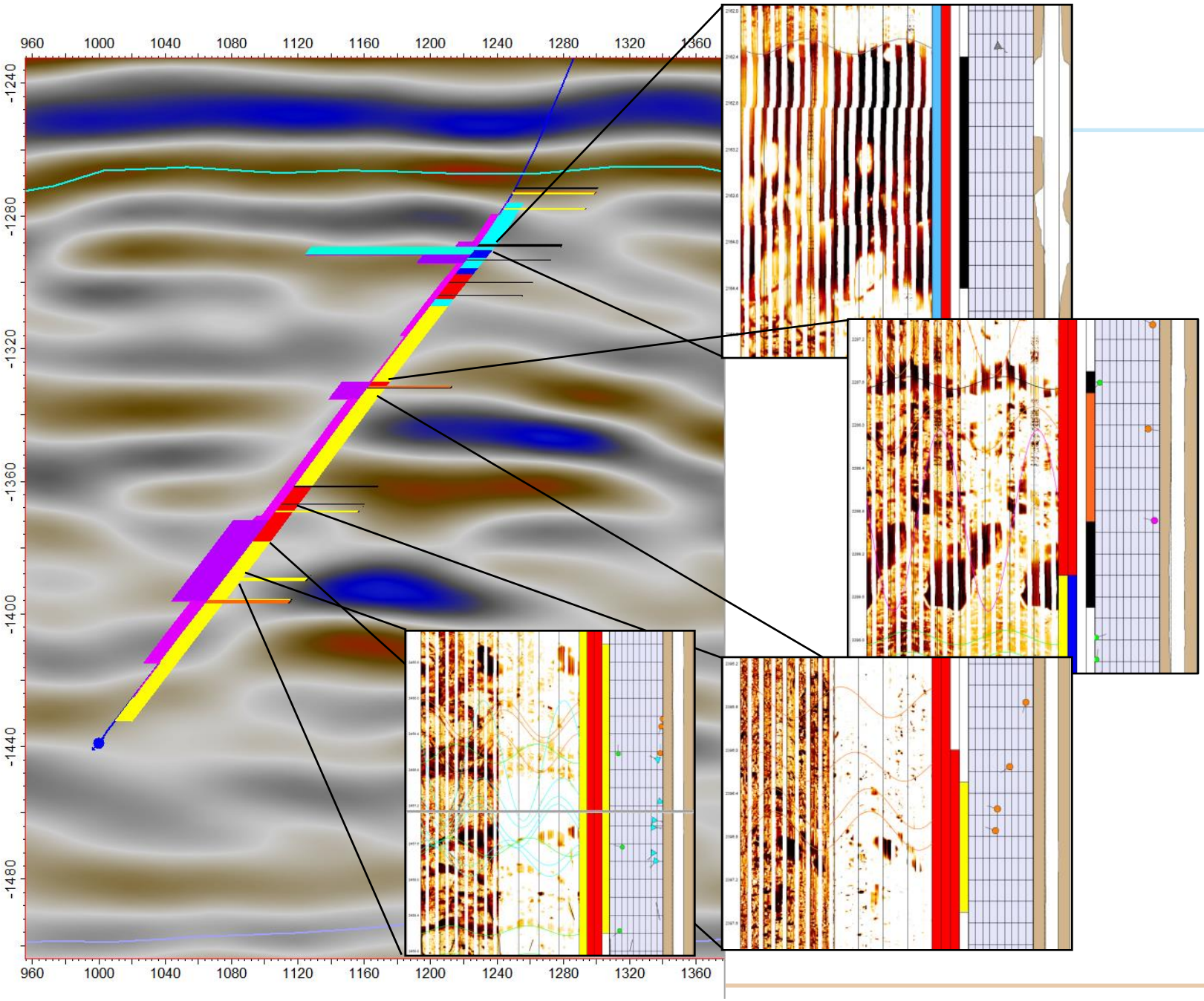
Example of a Relief Map of the Top Massive Facies

Karstification



Large-scale Karstification

Sinkholes – Collapse structures


960
1000
1040
1080
1120
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1200
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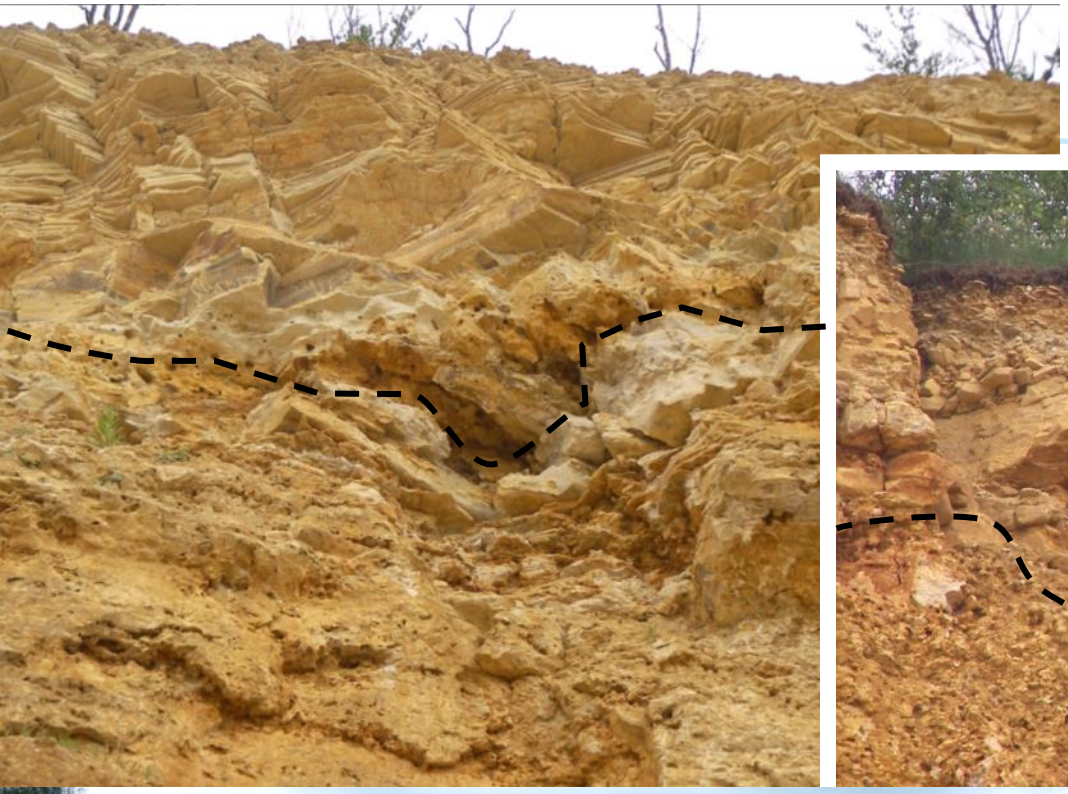

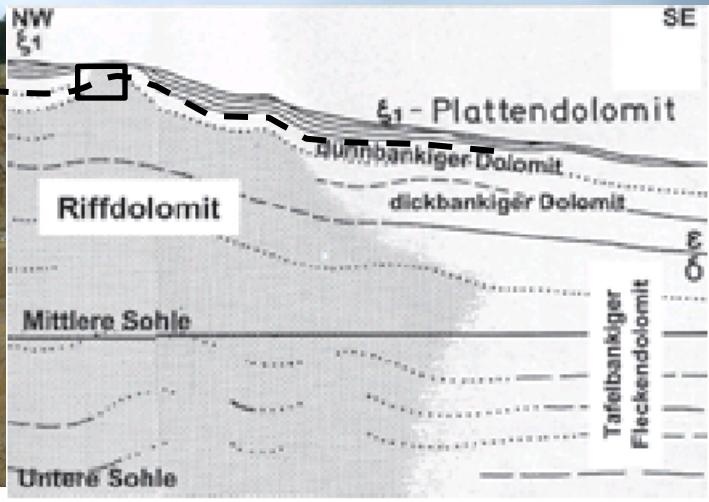
NW
SE
ξ_1
ξ_1 - Plattendolomit
dünnbankiger Dolomit
dickbankiger Dolomit
Riffdolomit
ξ_0
Mittlere Sohle
Tafelbankiger Fleckendolomit
Untere Sohle

Conclusion

The productivity of geothermal wells in the carbonate reservoir of the Malm not a question about a structural OR facies orientated exploration strategy, but is controlled by a complex interplay of different geological factors like primary facies, diagenesis, structural geology and especially karstification.

To further reduce the exploration risk, a deeper insight of the seismic data is nessecery. Profound knowledge of geology and hydrogeology of the Malm from drilled wells is the basic rerequisite for this.

Thank you!

Karstification