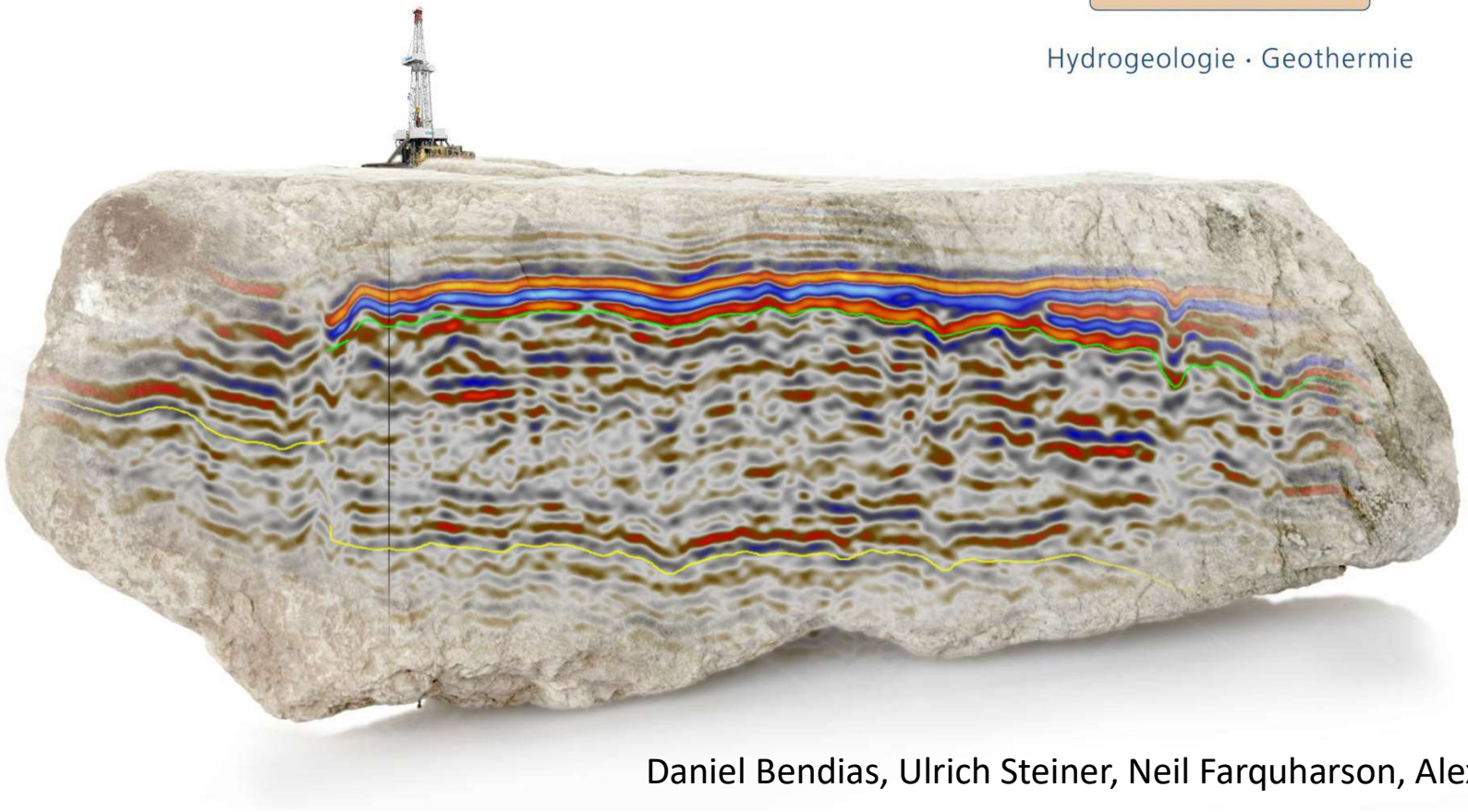
FROM VISION TO REALITY: Unlocking the Geothermal Potential

ERDWERK®

Hydrogeologie · Geothermie



Daniel Bendias, Ulrich Steiner, Neil Farquharson, Alexandros Savvatis

Outline

- Introduction/Motivation

- Oil & Gas vs Geothermal - What`s the Difference?

- Case Study: Schäftlarnstraße München

- How to unlock the potential

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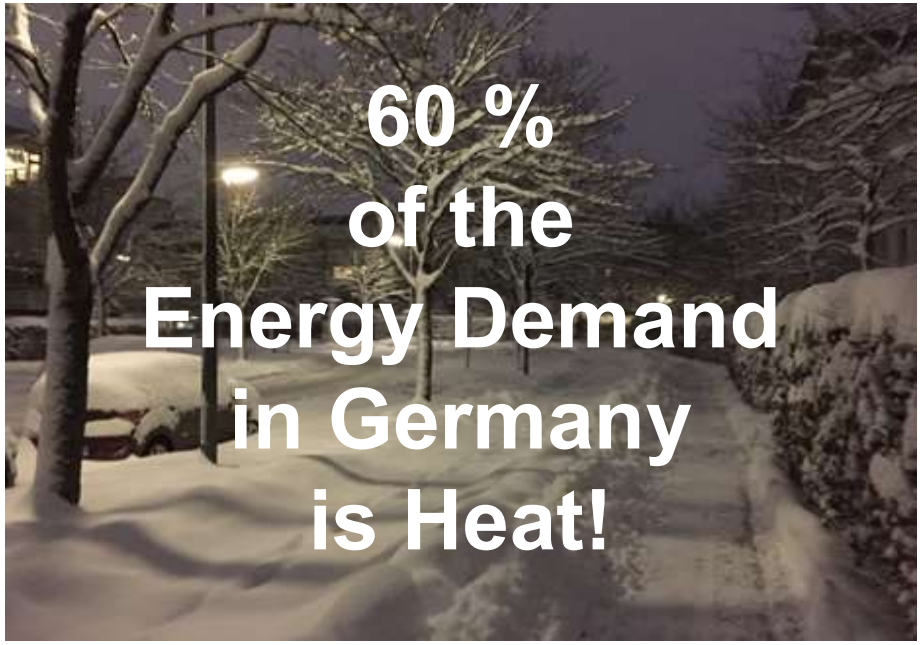
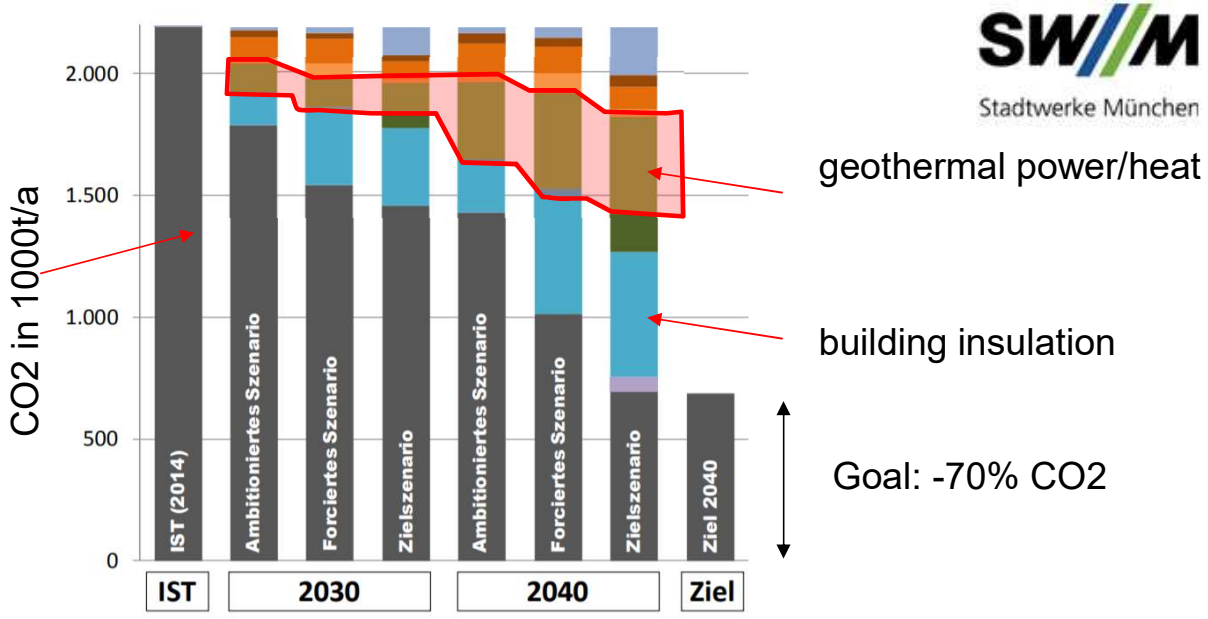
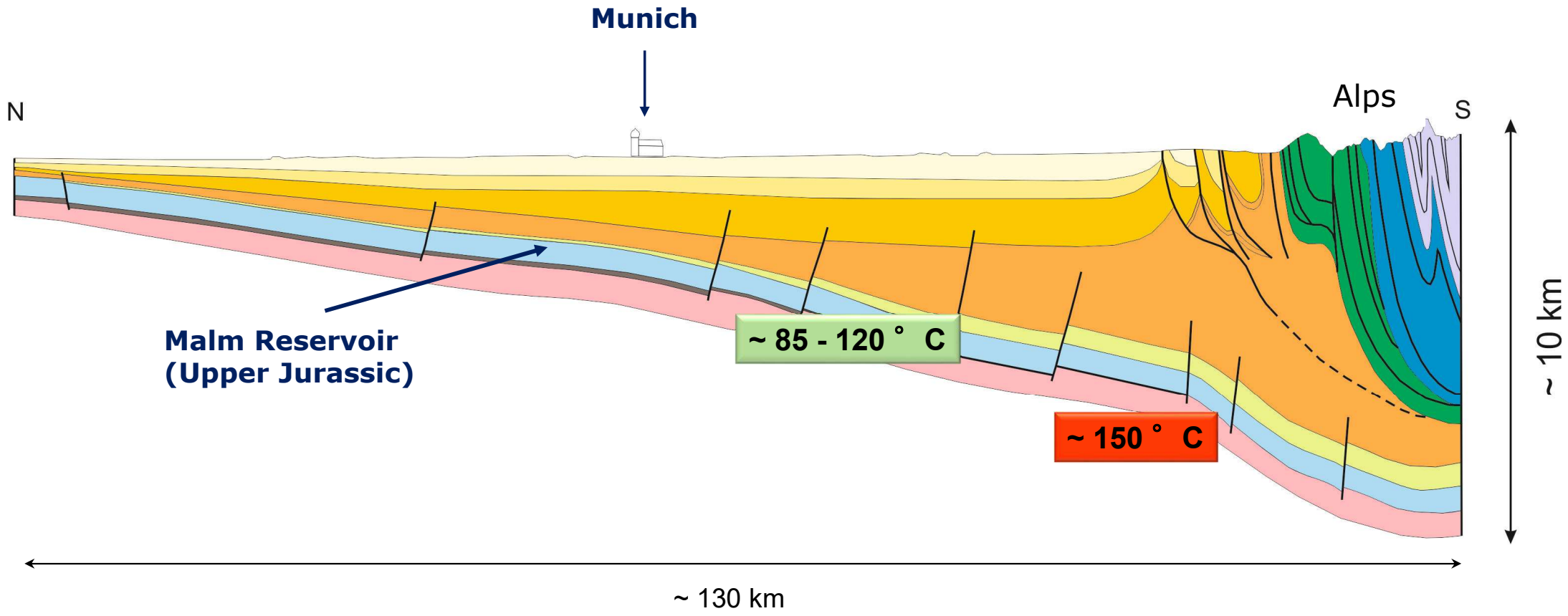
City of Munich: 70% CO2 reduction for 2040



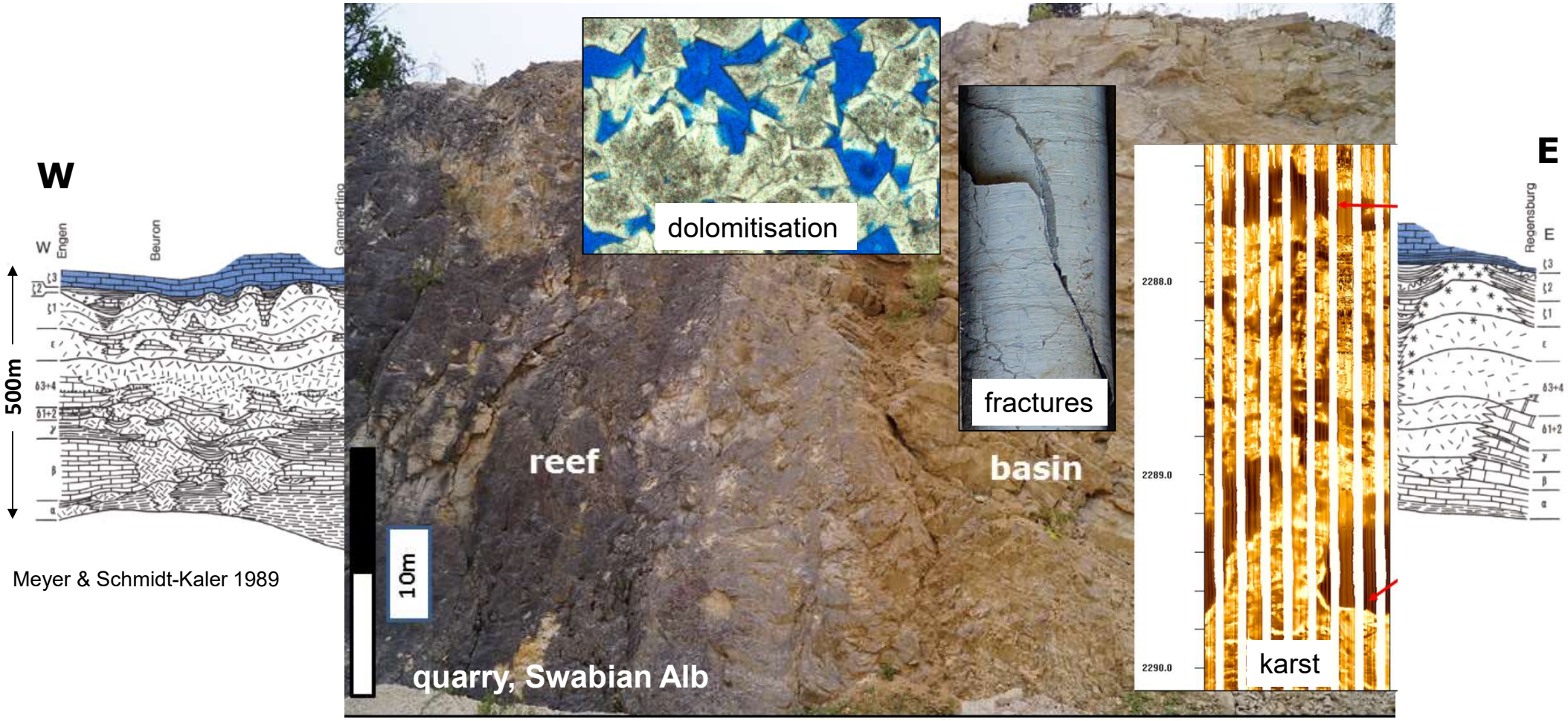


Geology of the molasse basin – N-S cross section



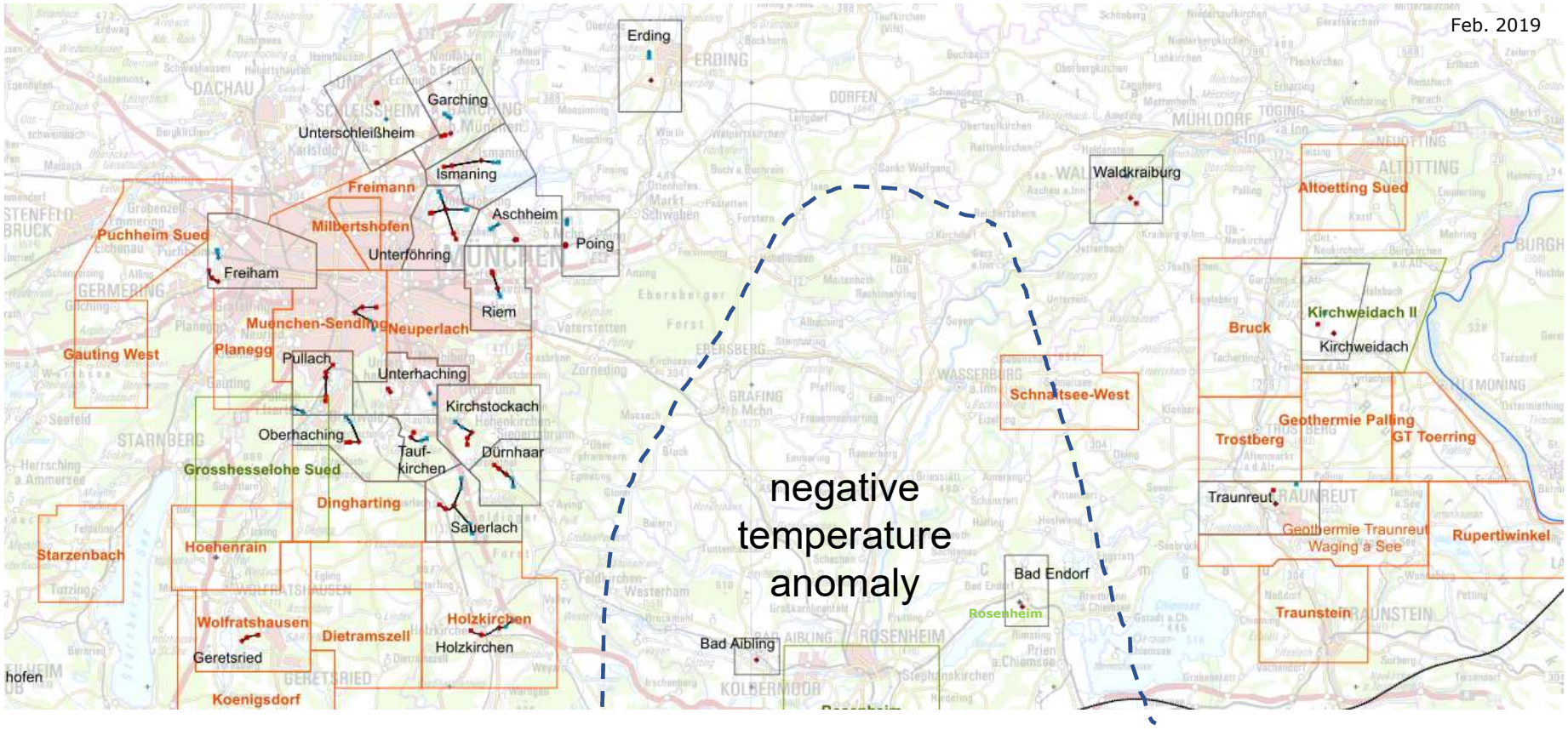
After: „Geologische Karte von Bayern 1:50000", Bayerisches Geologisches Landesamt, 1996

Reservoir Geology: Reef vs. Basin Carbonates



Meyer & Schmidt-Kaler 1989

Geothermal Concessions in Bavaria



Geothermal Concession Fields

- Production Permit
- Exploration Permit
- Large-Scale Permit

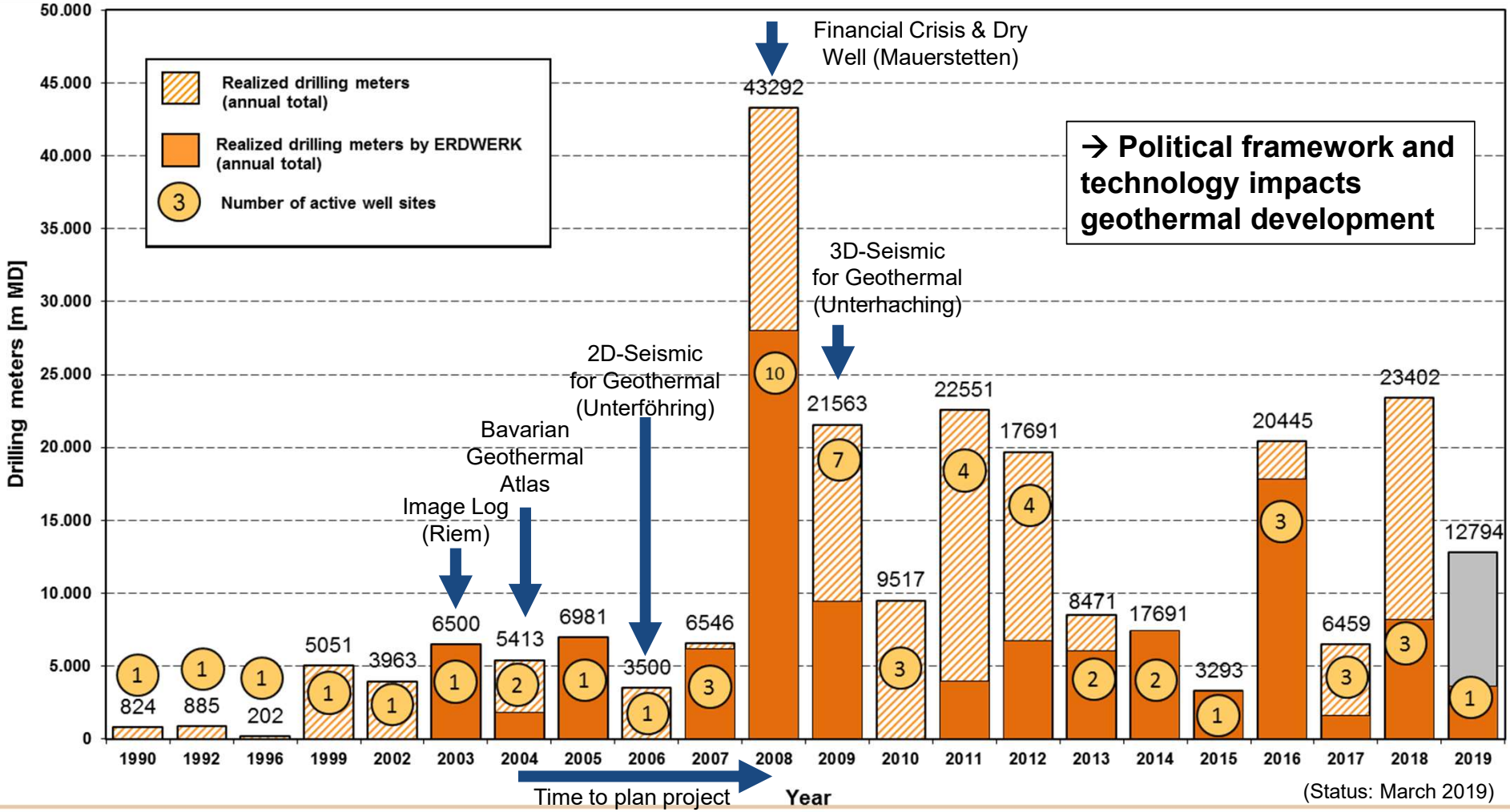
Geothermal Wells

- Production Well
- Injection Well

Development of the Concessions Fields in Bavaria

Year	Concessions
2002	4
2004	>40
2013	>80
today	ca. 50

Drilled Meters in Bavaria



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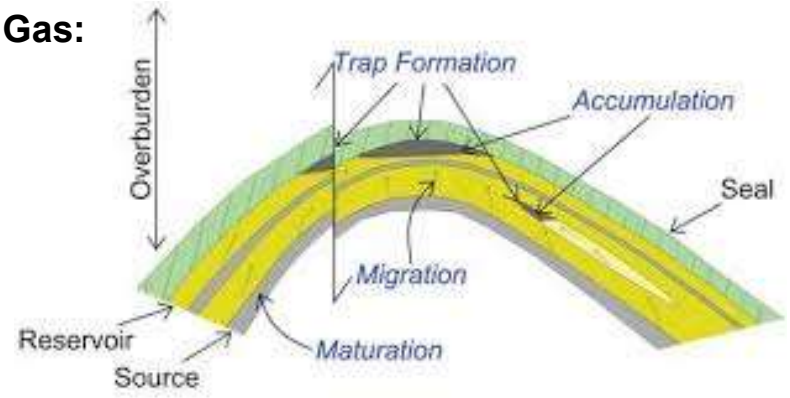
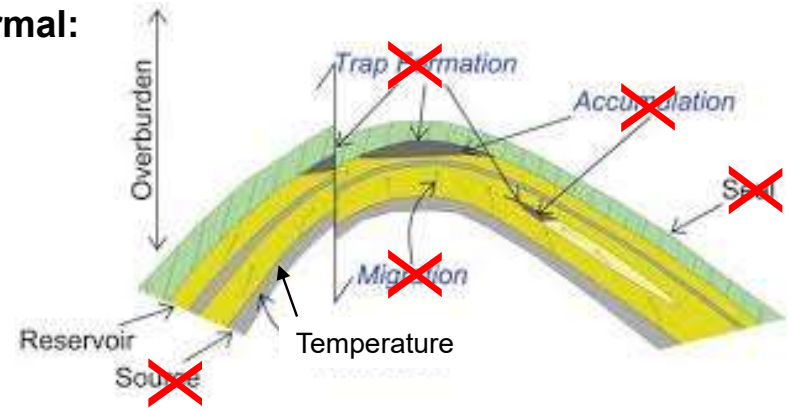
O&G vs Geothermal – What's the Difference?

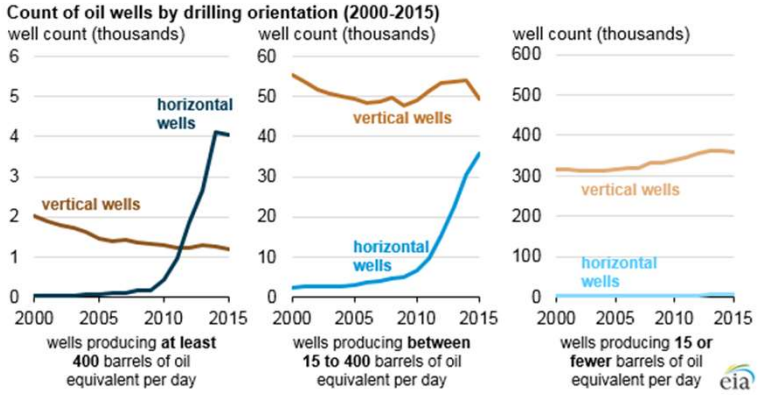
Oil & Gas:



Geothermal:



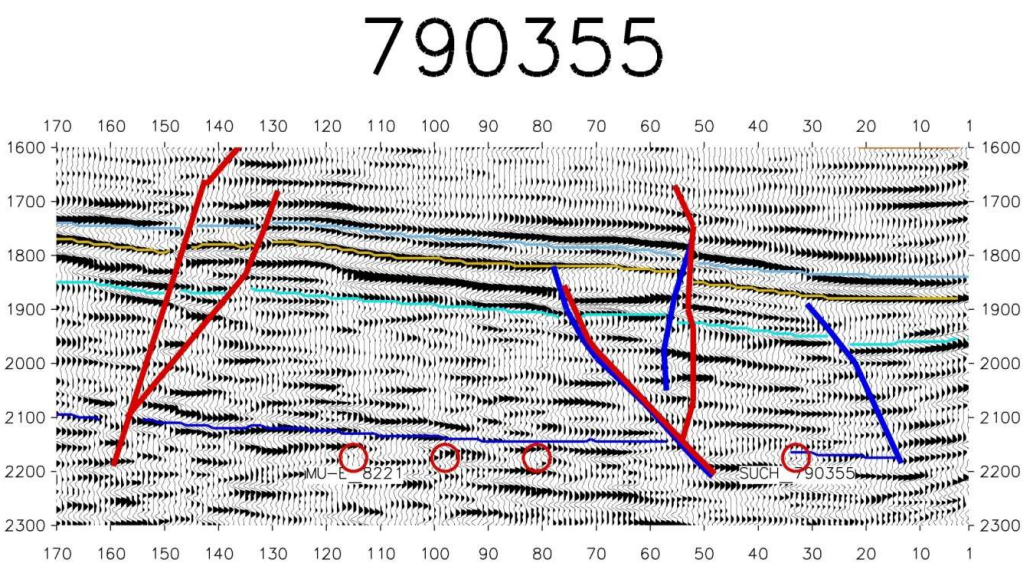
Production per oil well USA (eia):
<15 - 400 bbl/d // 0,02 - 0,75 l/s



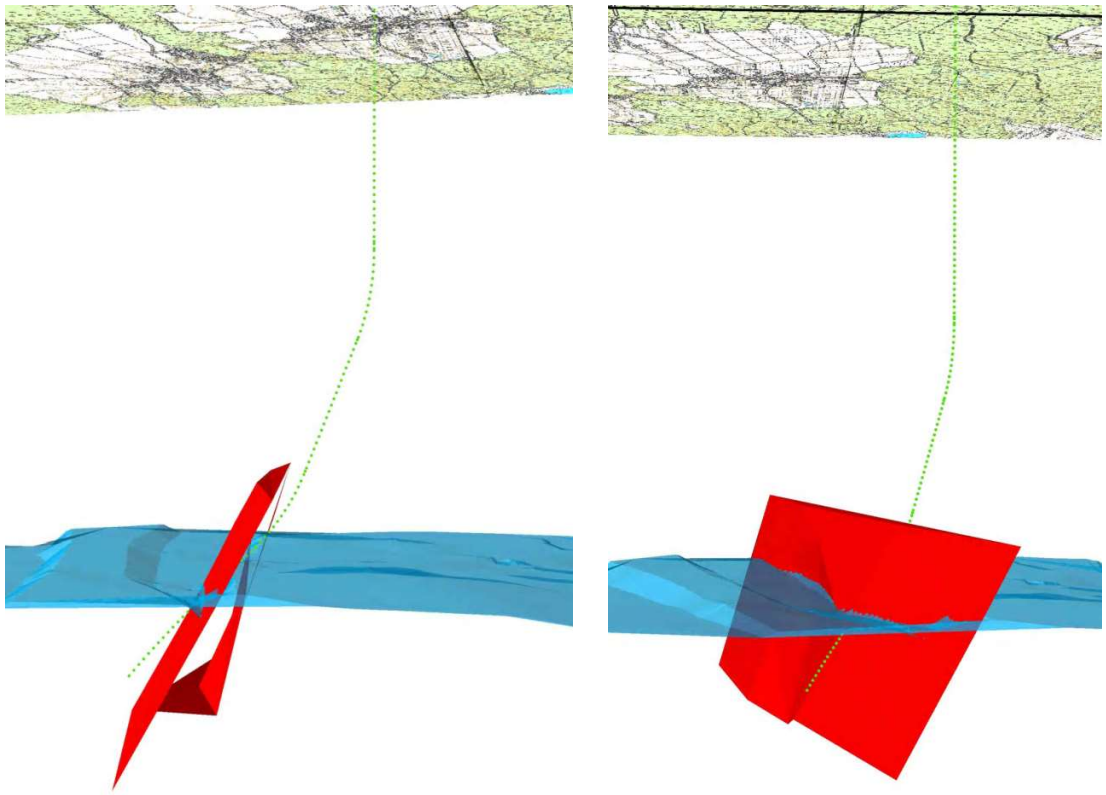
Production per geothermal well Bavaria:
27.000 – 71.000 bbl/d // 50-150l/s

→ Less geological elements but very productive reservoir needed

Technology in Geothermal: 2005



Seismic line and fault interpretation



Conceptual planning of a deviated well path

Exploration and Development – Gap Analysis?

Oil & Gas - G&G workflow:

Exploration: geological concepts & outcrop analogues, 2D / 3D seismic, numerical models

+ exploration wells, well-logs, cores, petrophysics

Development: detailed geological models, target planning, **development wells**…

Geothermal G&G workflow:

Exploration: geological concepts & outcrop analogues, 2D / 3D seismic, numerical models

- no exploration wells, well-logs, cores, petrophysics

Development: development wells, (some well logs)…

→Part of the O&G exploration phase is missing for typical small geothermal projects with local operators

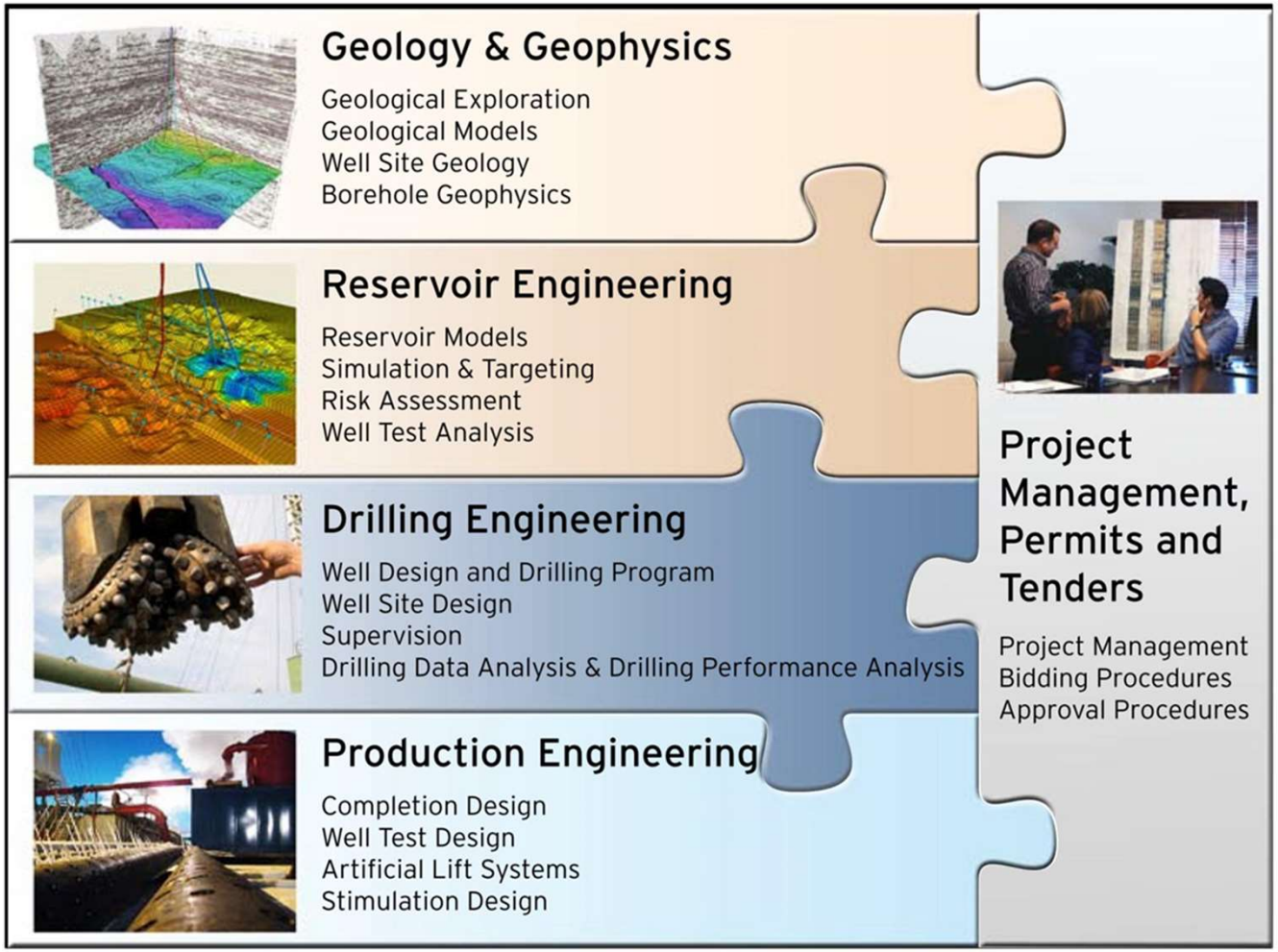
Exploration and Development – How to Close Those Gaps

1. Larger operators - multiple projects in one basin → exploration data

2. Contractor with multi project expertise – exploration without exploration

3. Political framework, R&D, publicly available data

State of the Art Geothermal Workflow



A solid geology is not enough!

Integration of all disciplines

Geology and drilling engineering are strongly linked – Life adjustment of geological model to reality needed

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Schäftlarnstraße Project – Operator Stadtwerke Munich:

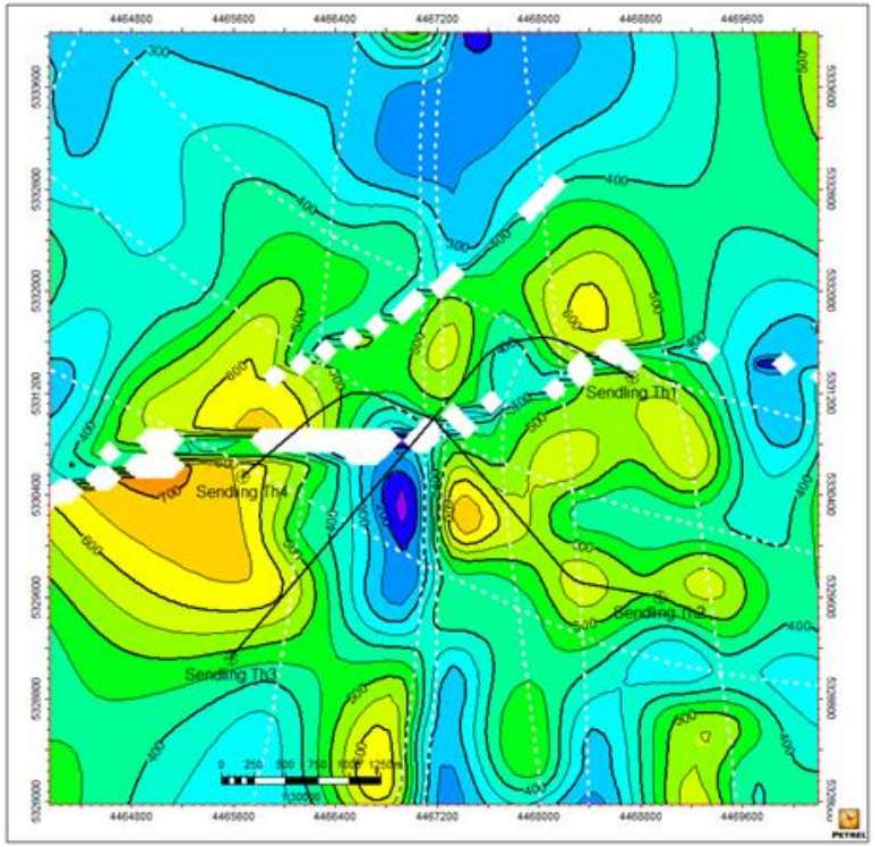
~50 MW th.

6 Wells (3 injectors, 3 producers)

+ First multilateral reservoir development

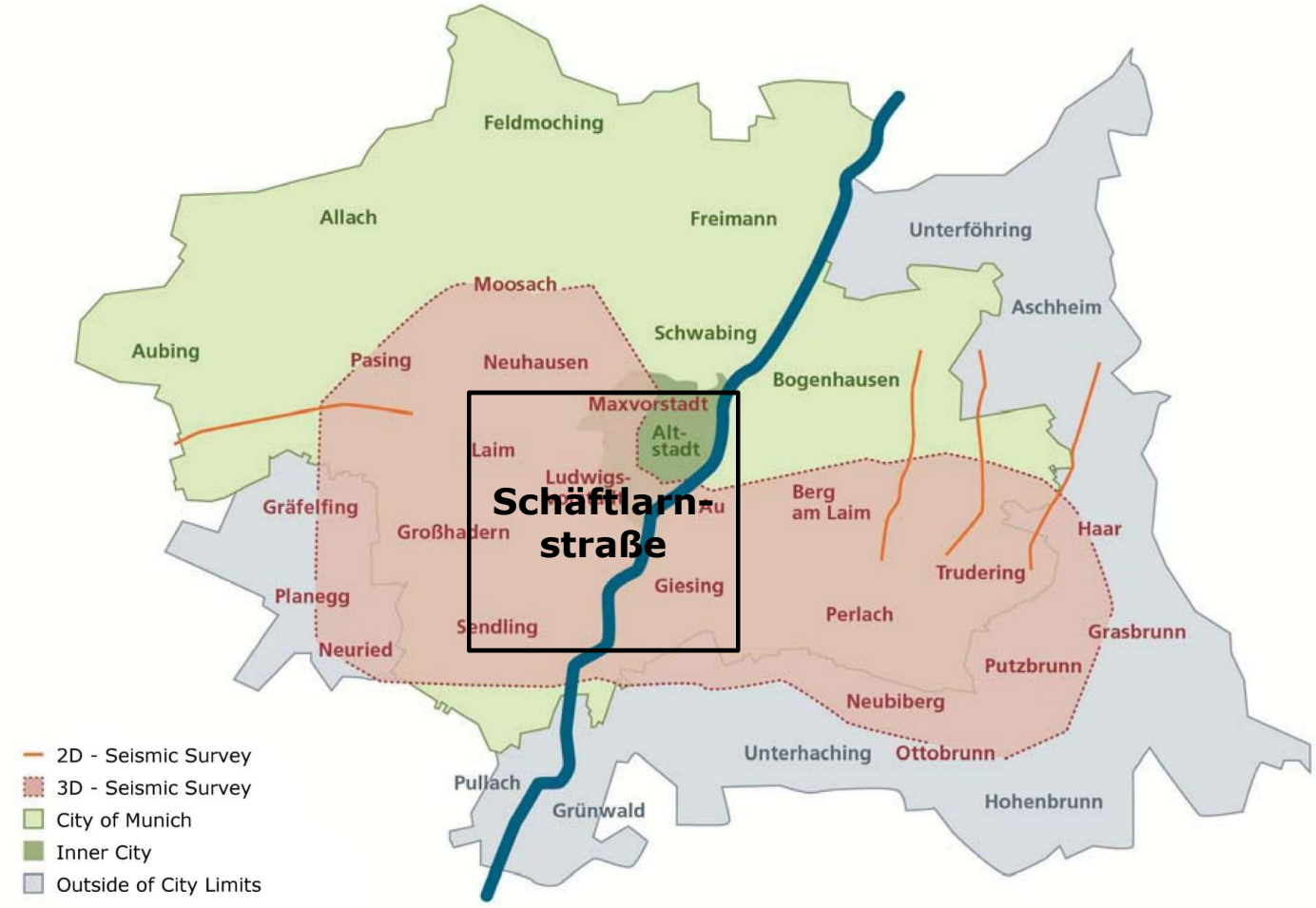
Target Planning Schäftlarnstraße 2014

Reservoir thickness map: 2014 based on 2D seismic:
4 wells



Source: M. Meinecke 2018

GRAME R&D Project: 2016 Large 3D Seismic in Munich



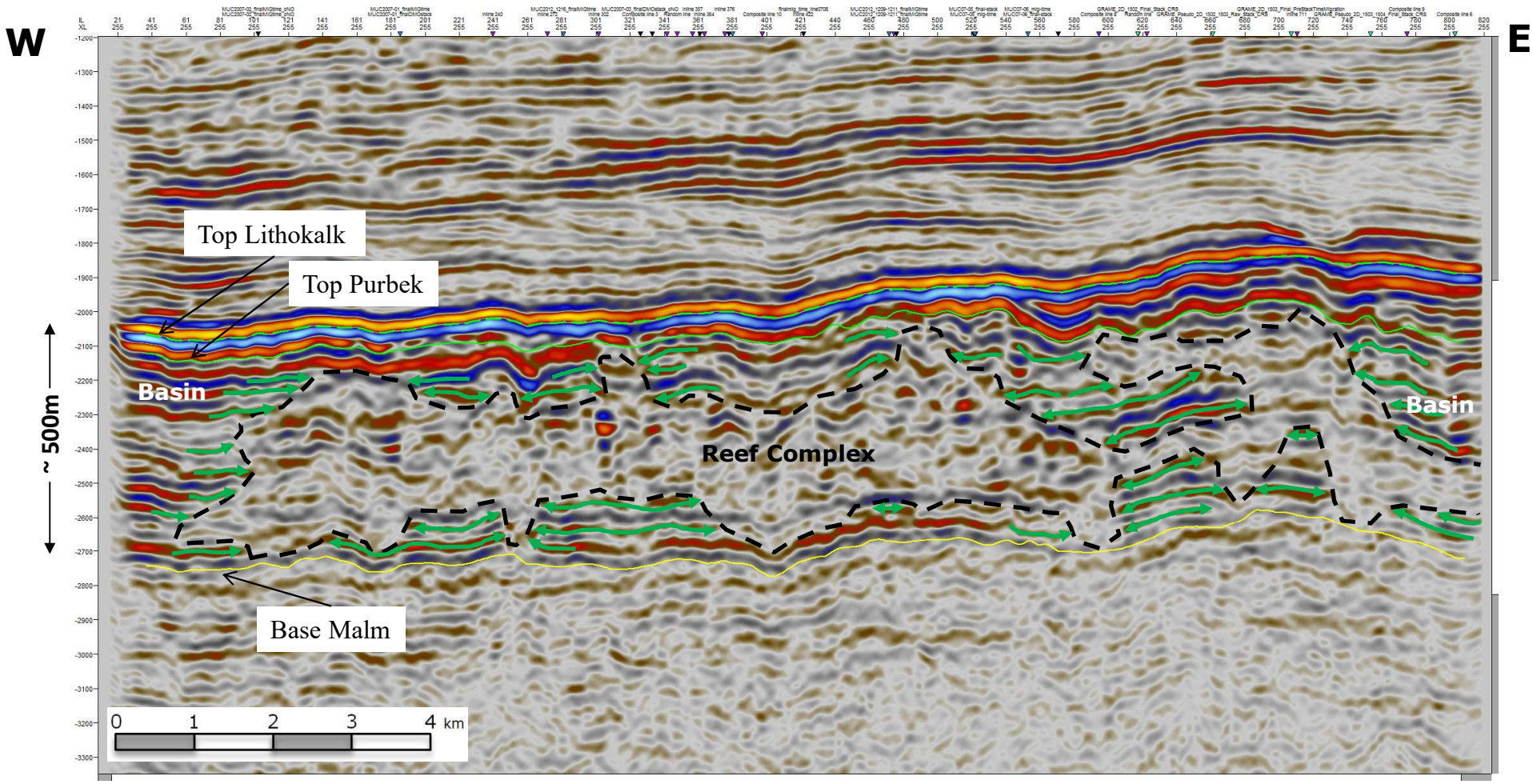
Stadtwerke München

Bundesministerium für Wirtschaft und Energie

aufgrund eines Beschlusses des Deutschen Bundestages

Hydrogeologie · Geothermie

Seismic Interpretation



Target Planning Schäftlarnstraße 2017

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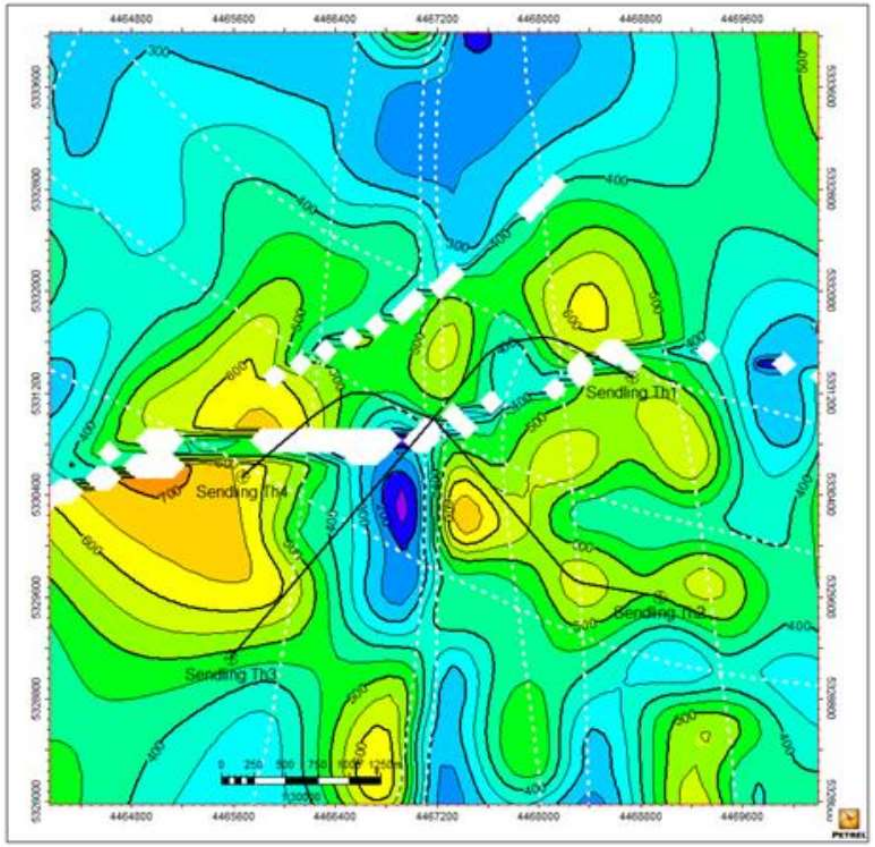

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Reservoir thickness map 2017 based on 3D seismic:
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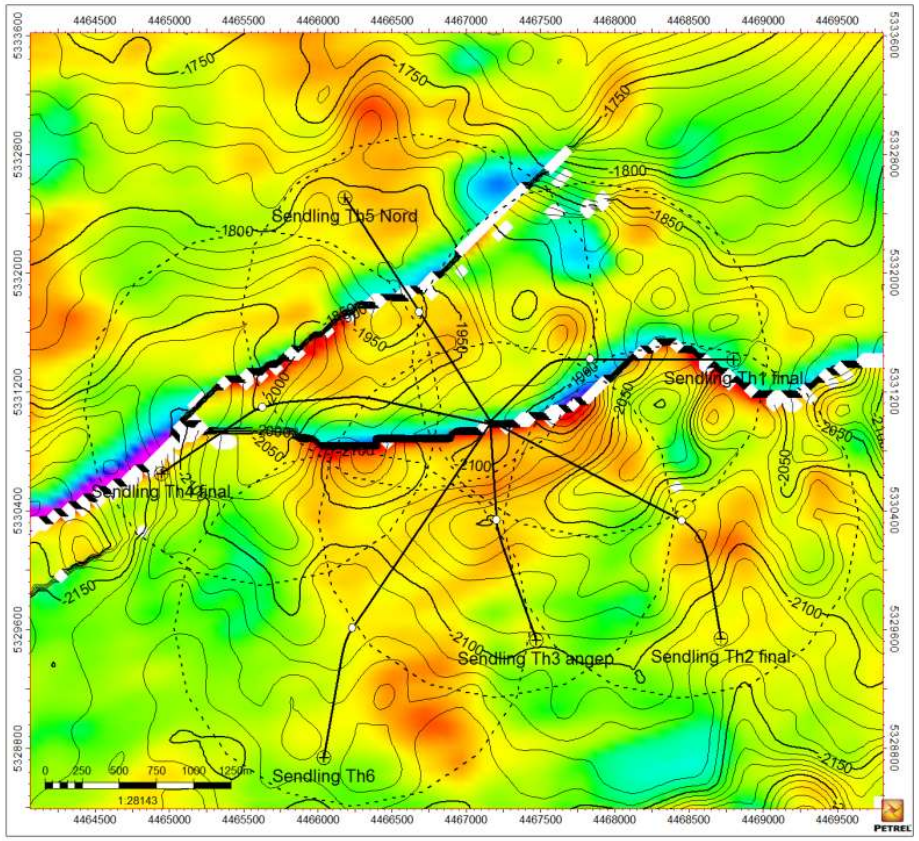


First Wells Successfully drilled!

Th1 first well:

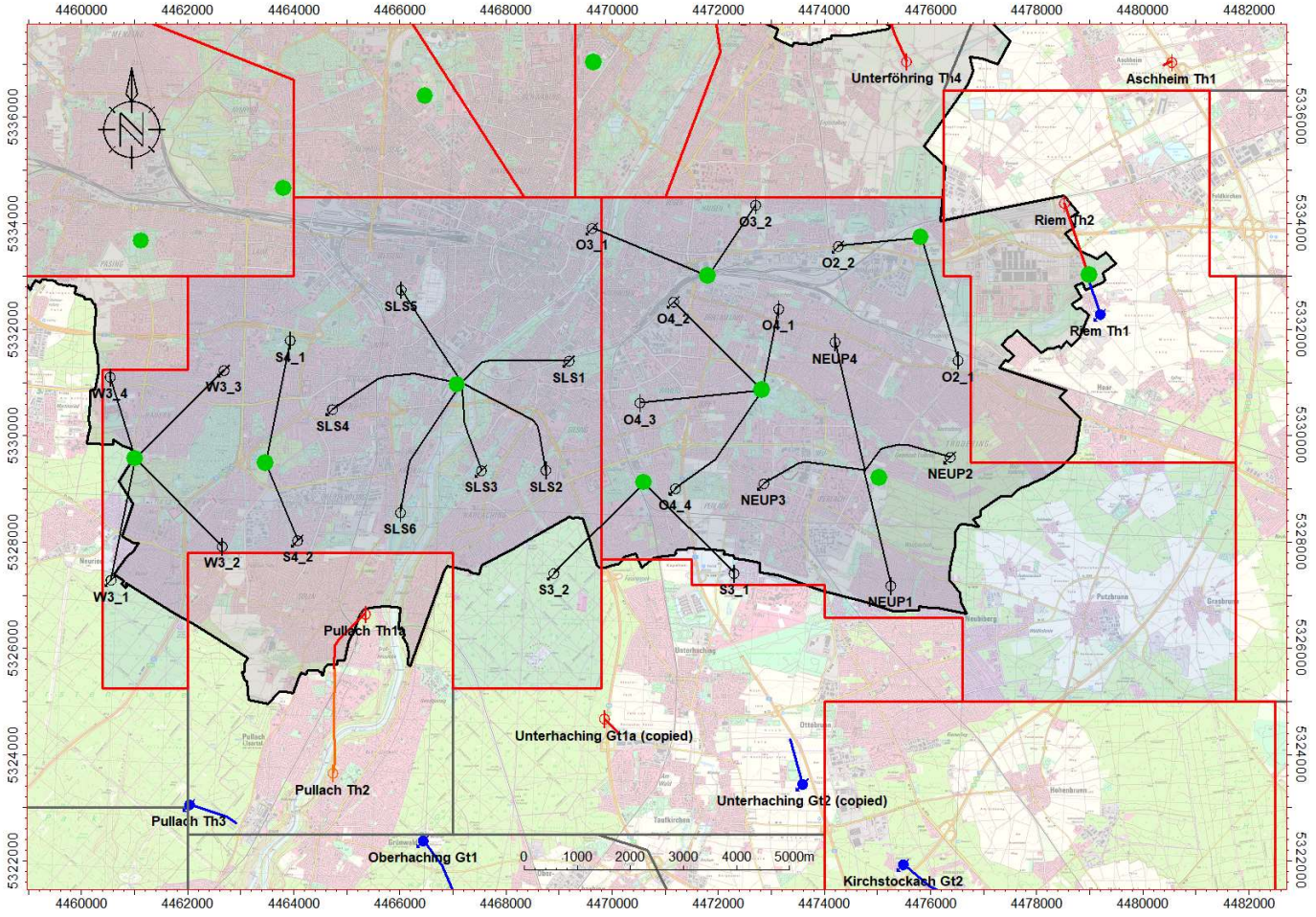
Depth:
3860 m MD / 2809 m TVD

Productivity:
120l/s (4,51 l/s/bar)

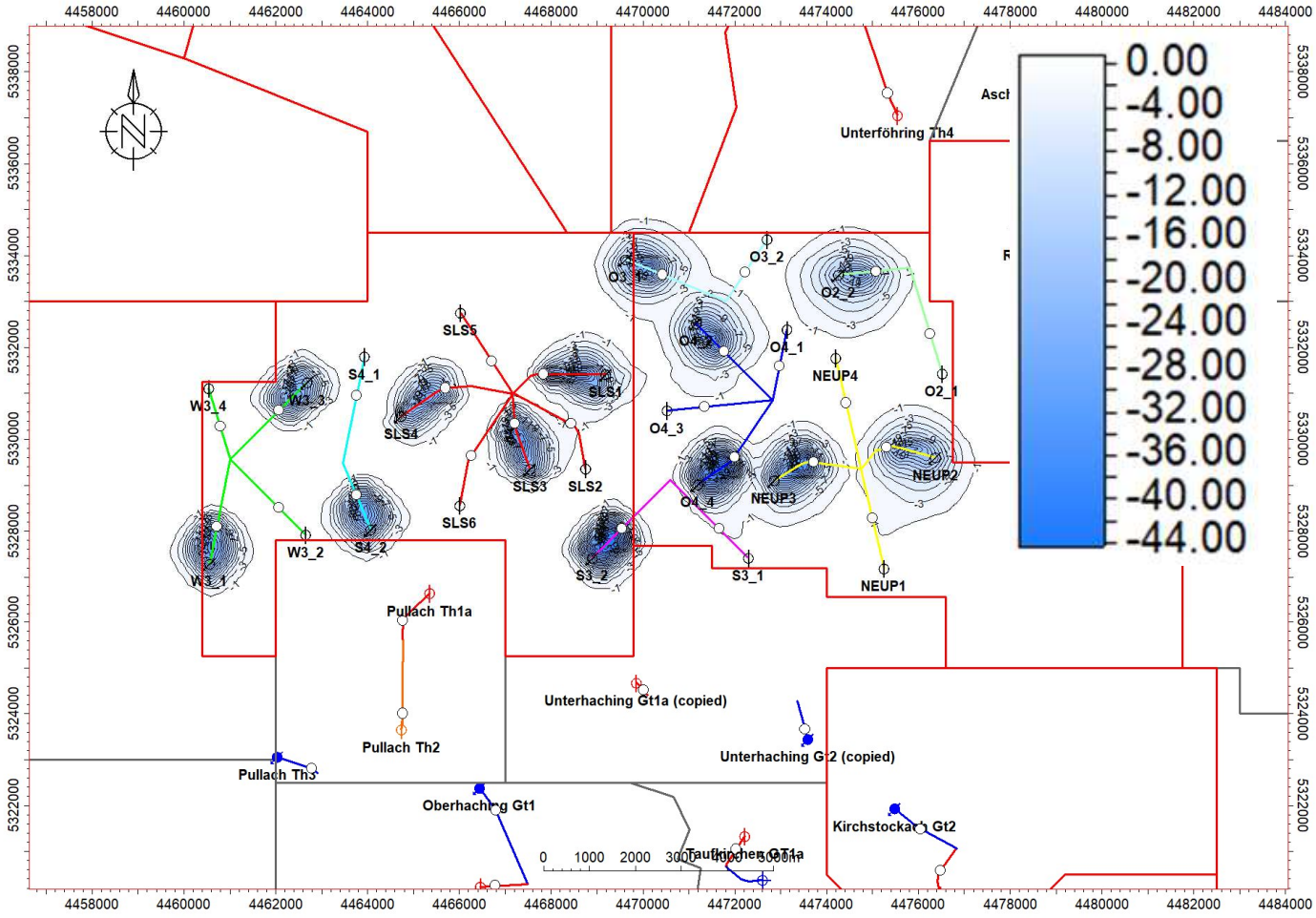
Temperature:
104° C

Source: S. Dirner 2018

Full Reservoir Development: Multi-Well Scenario in Munich



Simulation of Cooling Effect After 30 Years in Operation



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Lets unlock the potential?

- Political – Create a Thriving Environment:
  - Free Information (Geothermals Atlas of Bavaria)
  - R&D Initiatives
  - Risk Minimization – Exploration Insurance (Belgium), Subsidies …
- Technical – Close the Technology Gap:
  - Oil and Gas Workflow Adopted
  - Integration of all Disciplines
  - Think Big - Growing Project Scale / Portfolio Approach

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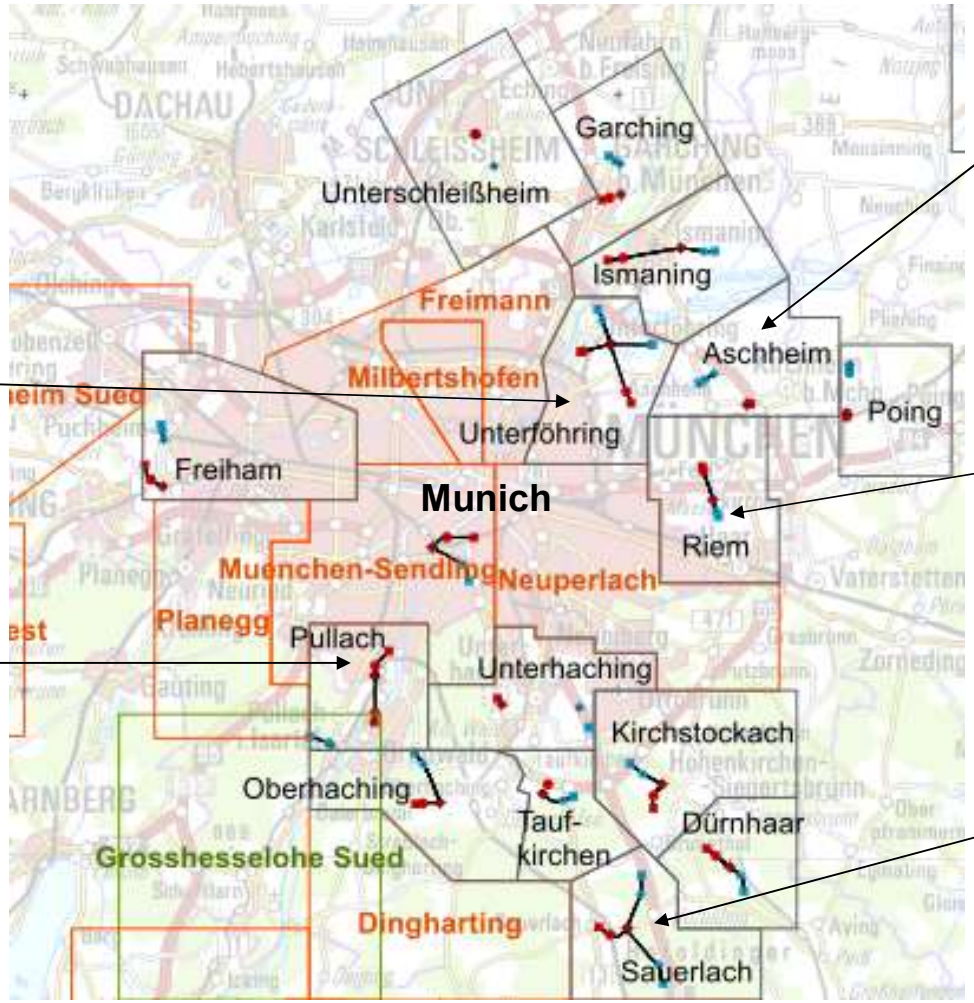
Geothermal Projects CO2 Savings Munich (compared to gas)



Aschheim: 6400 t/a

Unterföhring: 16000 t/a

Riem: 12000 t/a

Pullach: 6000 t/a

Sauerlach: 35000 t/a