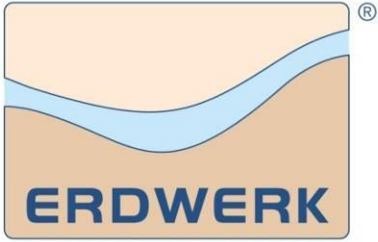
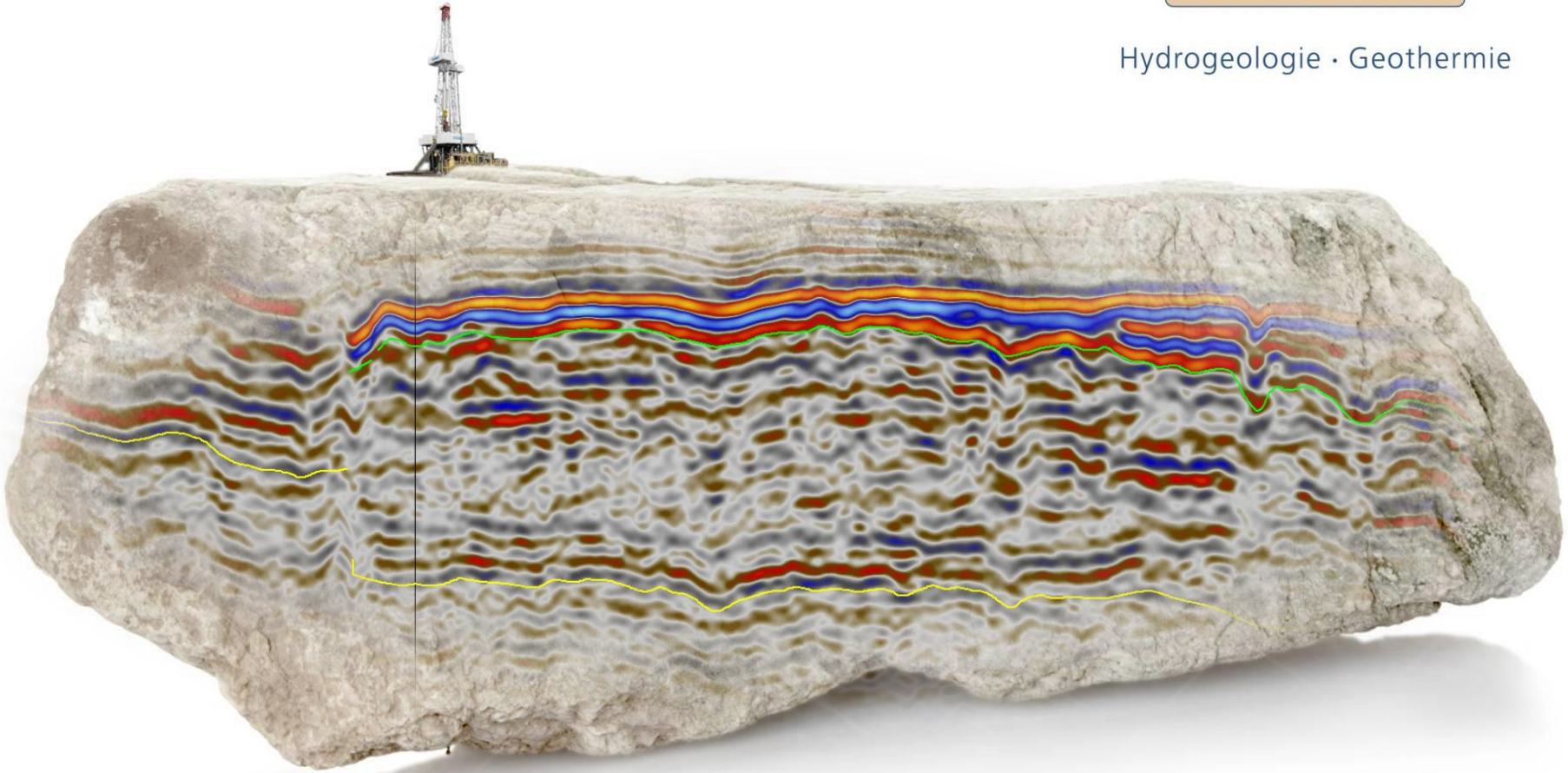


# Does Munich hold the Key to Unlock the Geothermal Potential of Saudi Arabia?



Hydrogeologie · Geothermie



# Outline



- Introduction



- Oil & Gas vs Geothermal



- Case Study: Munich



- Saudi Arabia – Germany Linked Through Geology



- How to Unlock the Potential

# Outline



- Introduction



- Oil & Gas vs Geothermal



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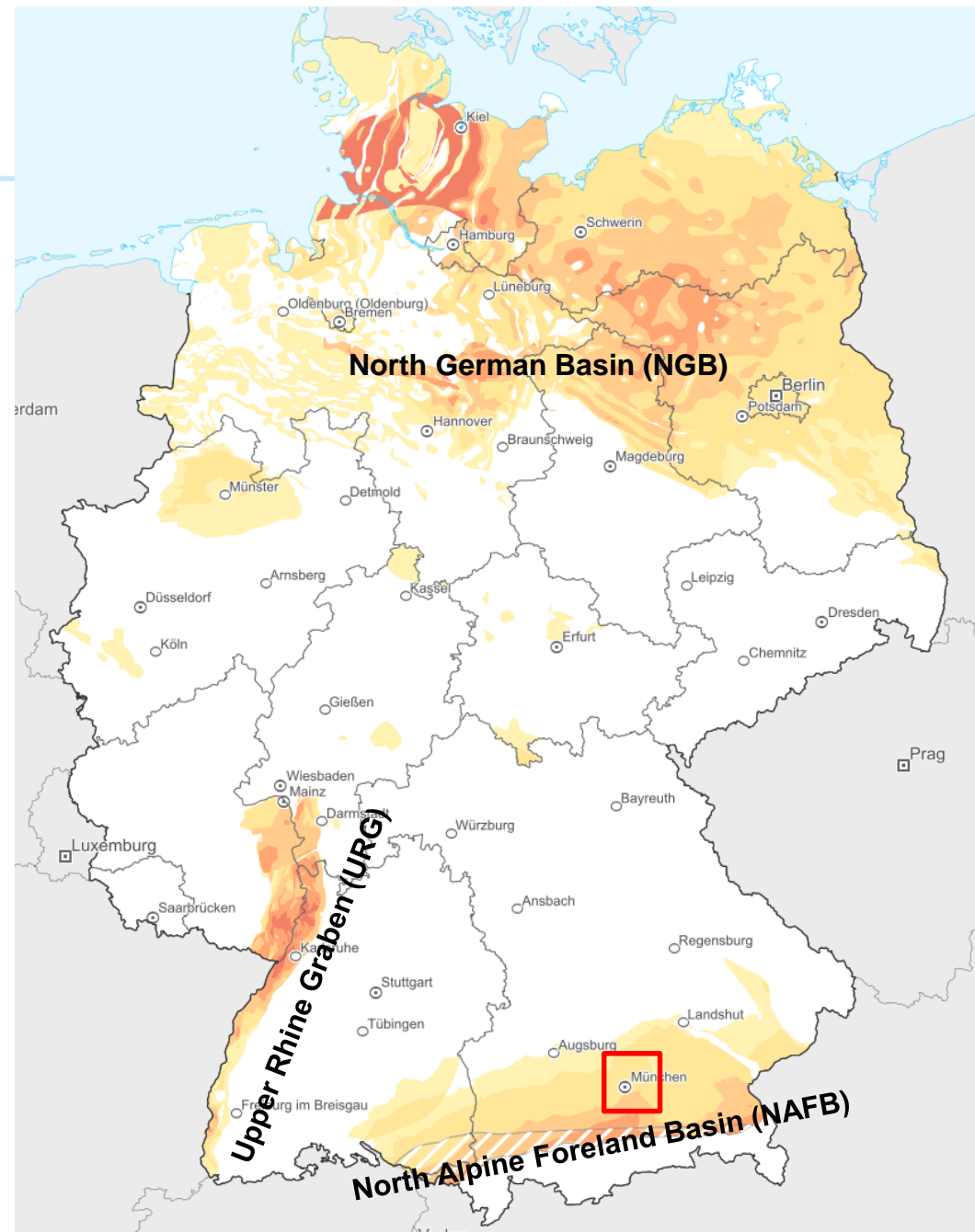


- Saudi Arabia – Germany Linked Through Geology



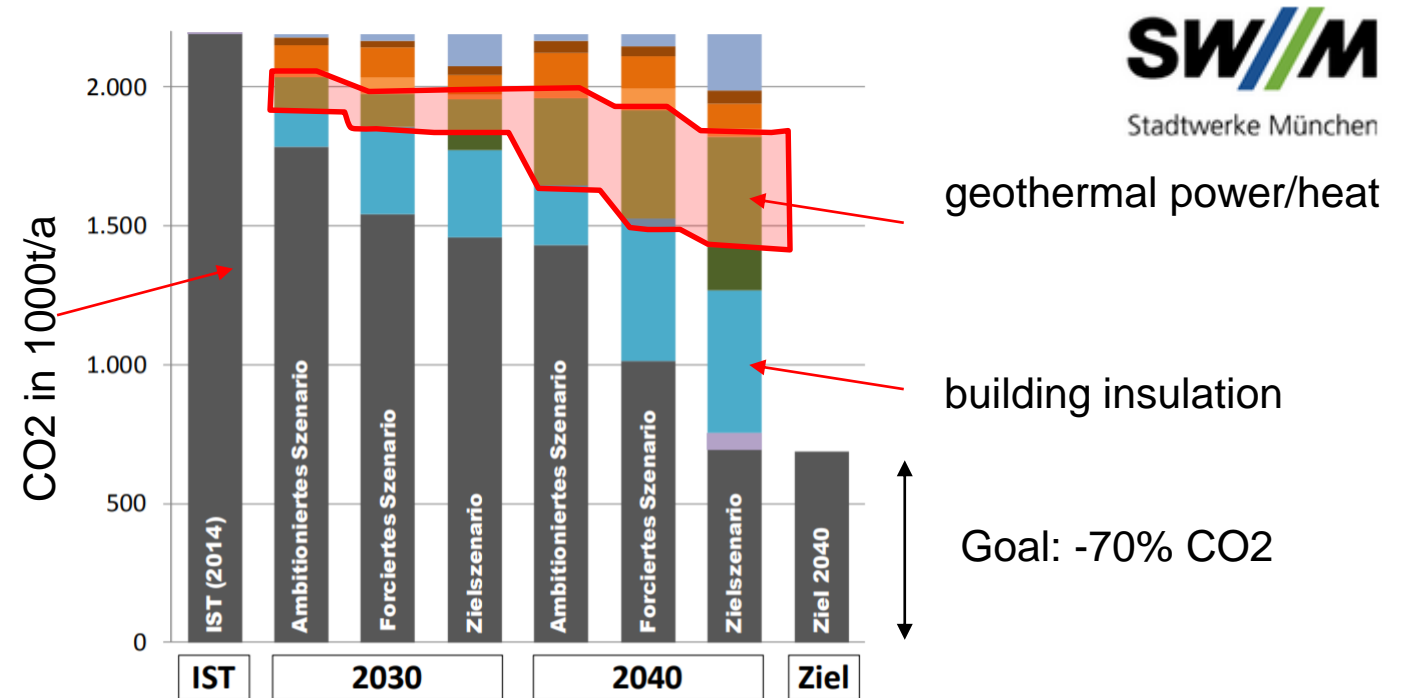
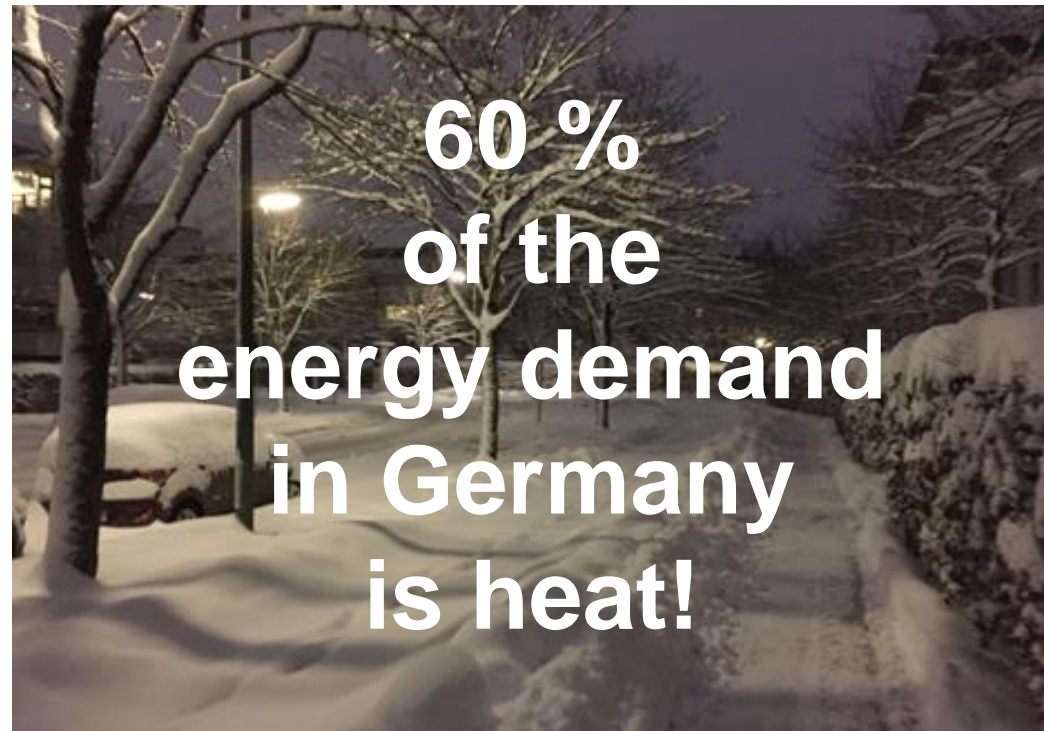
- How to Unlock the Potential

# Geothermal Plays in Germany

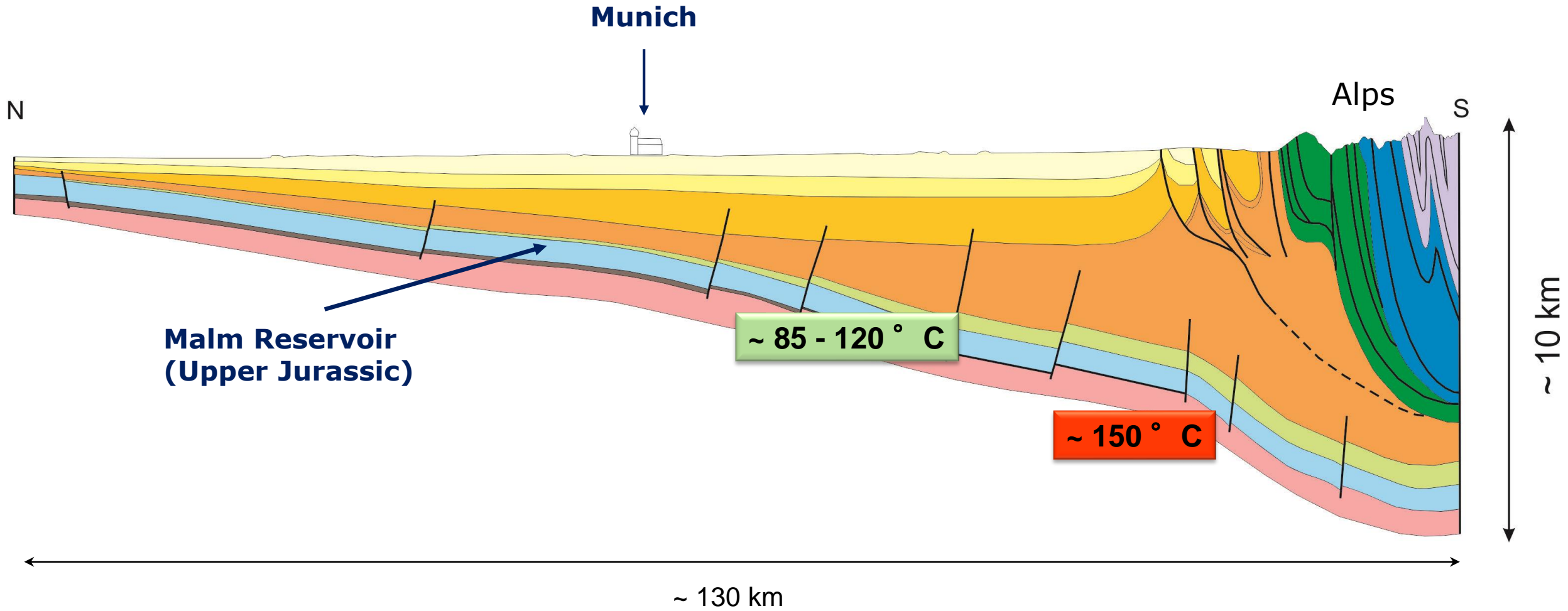


Source: BGK 2006

# City of Munich: 70% CO2 reduction for 2040

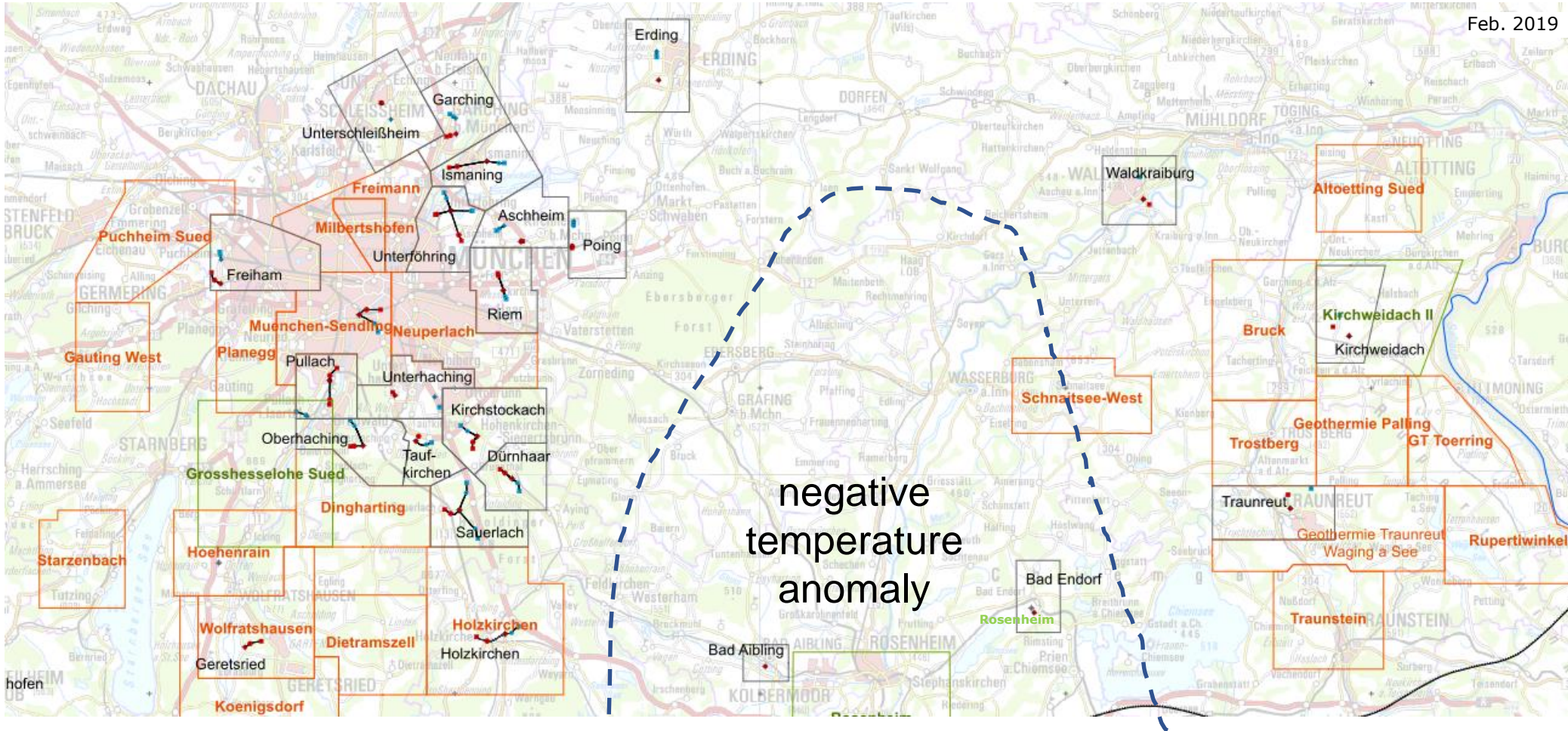


# Geology of the molasse basin – N-S cross section



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

# Geothermal Concessions in Bavaria



Feb. 2019

## Geothermal Concession Fields

- Production Permit
- Exploration Permit
- Large-Scale Permit

## Geothermal Wells

- ◆ Production Well
- ◆ Injection Well

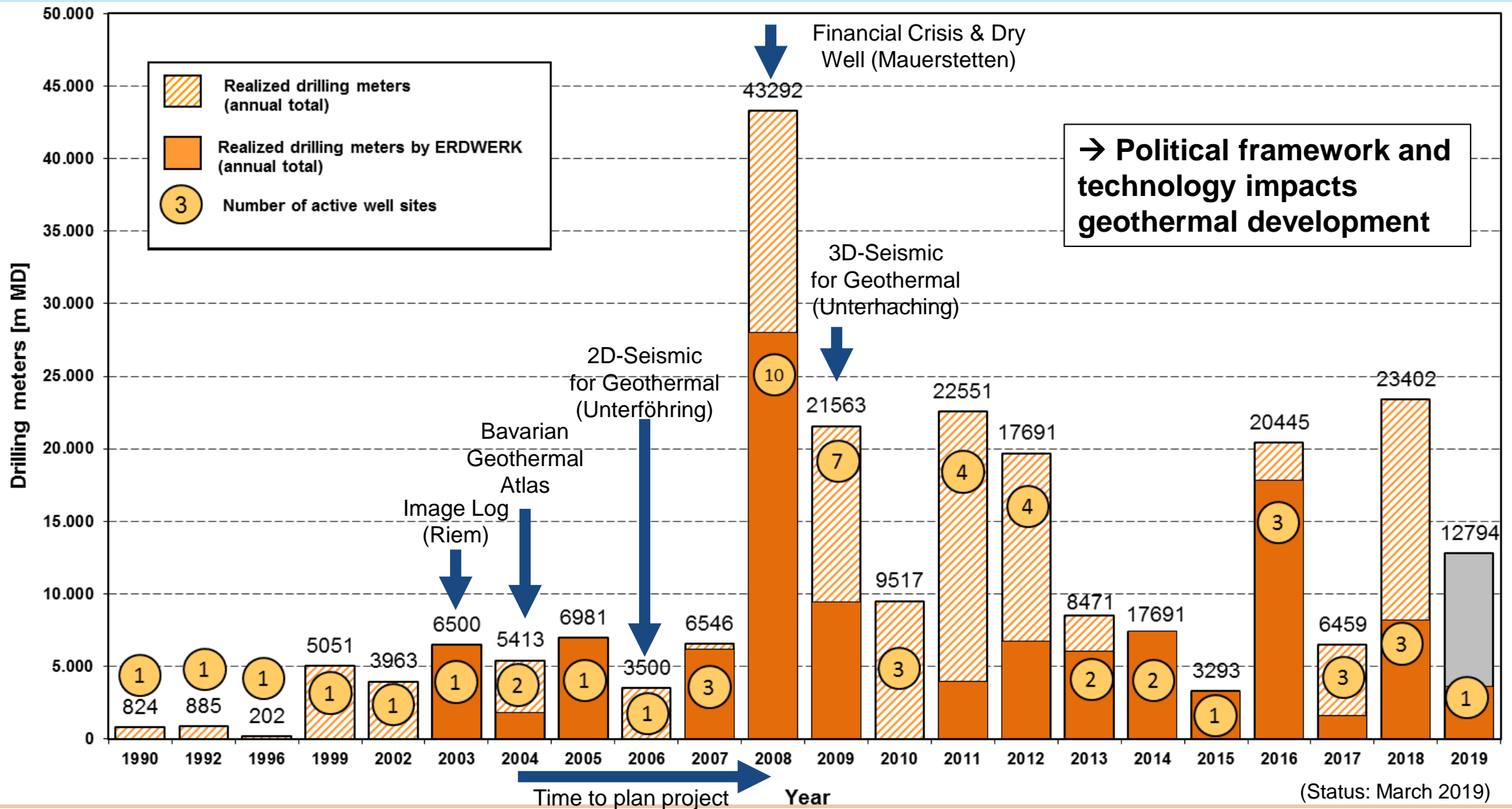
## Development of the Concessions Fields in Bavaria

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

negative temperature anomaly

~ 130 km

# Drilled Meters in Bavaria





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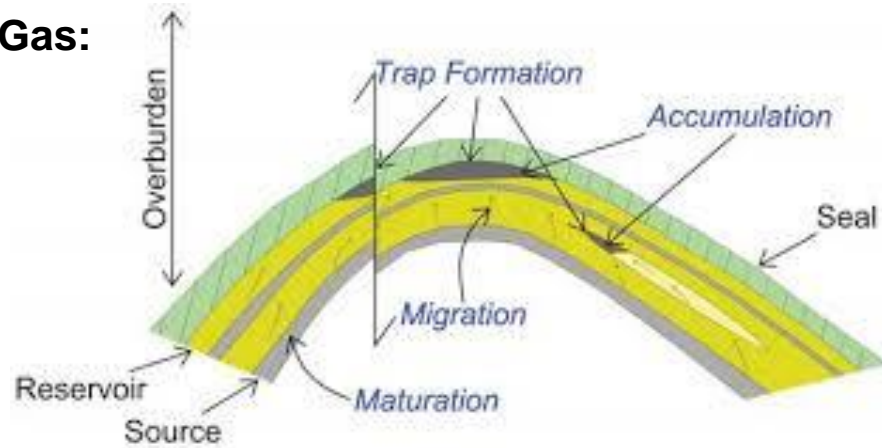
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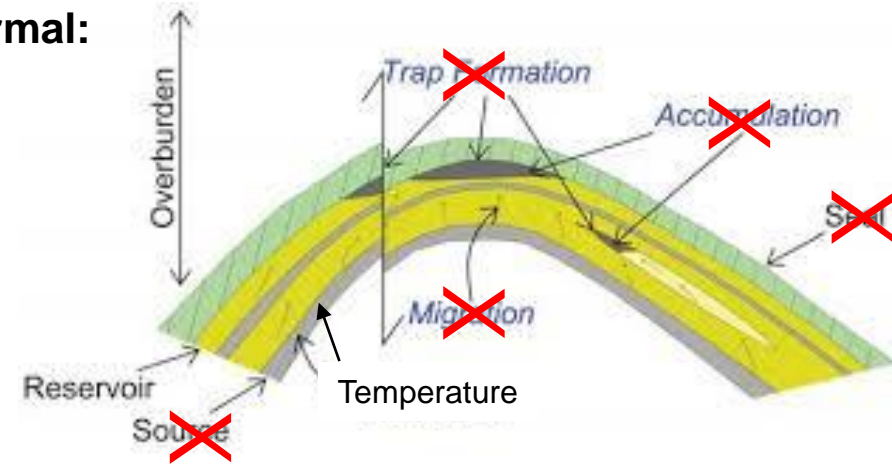
- How to Unlock the Potential

# O&G vs Geothermal – What’s the Difference?

## Oil & Gas:



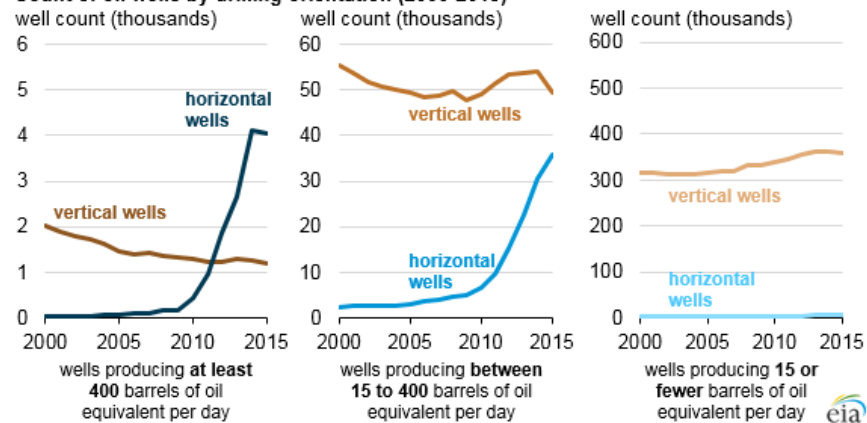
## Geothermal:



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

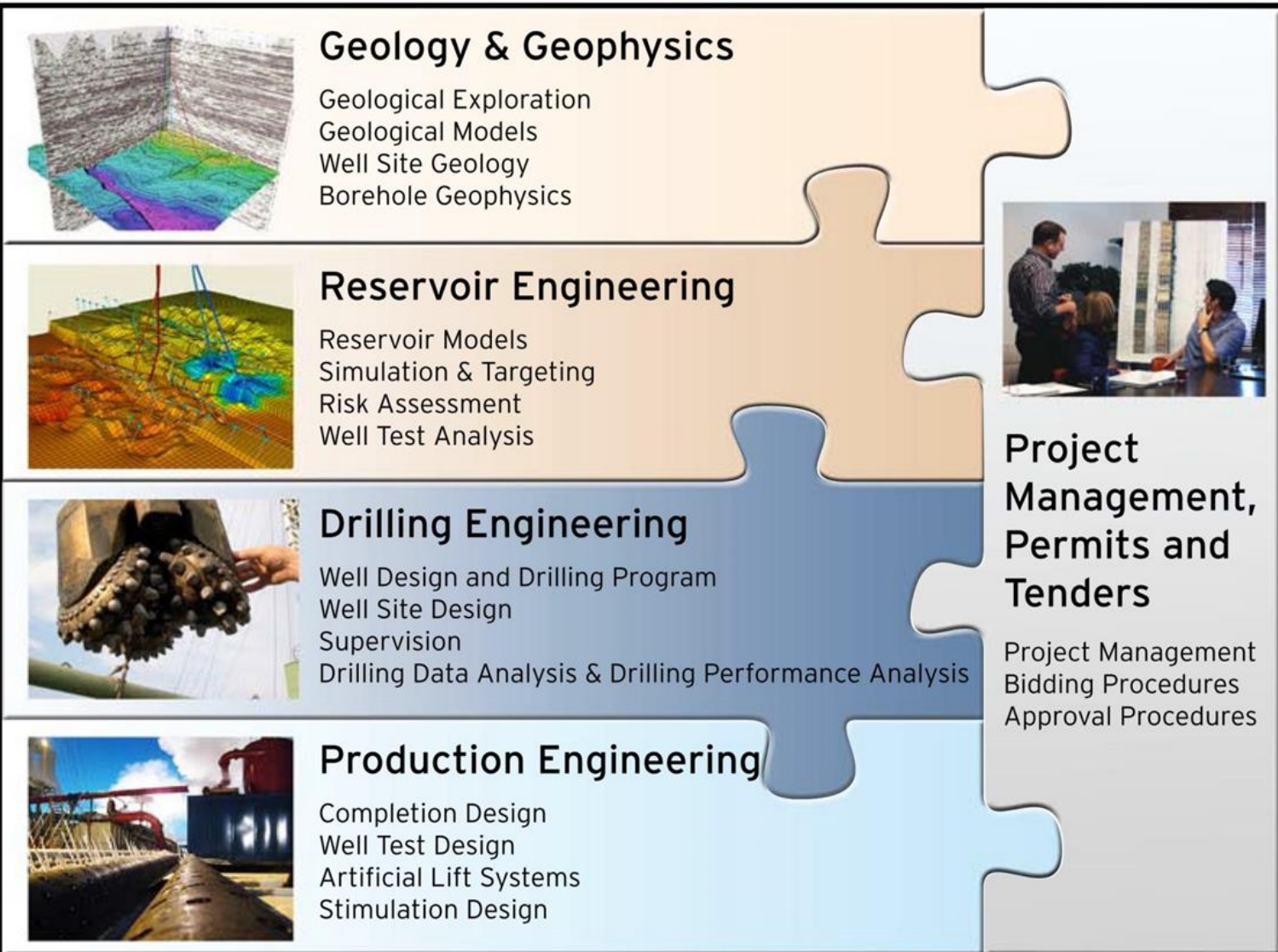
Count of oil wells by drilling orientation (2000-2015)



→ Less geological elements but very productive reservoir needed

→ No real exploration wells for geothermal

# 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)

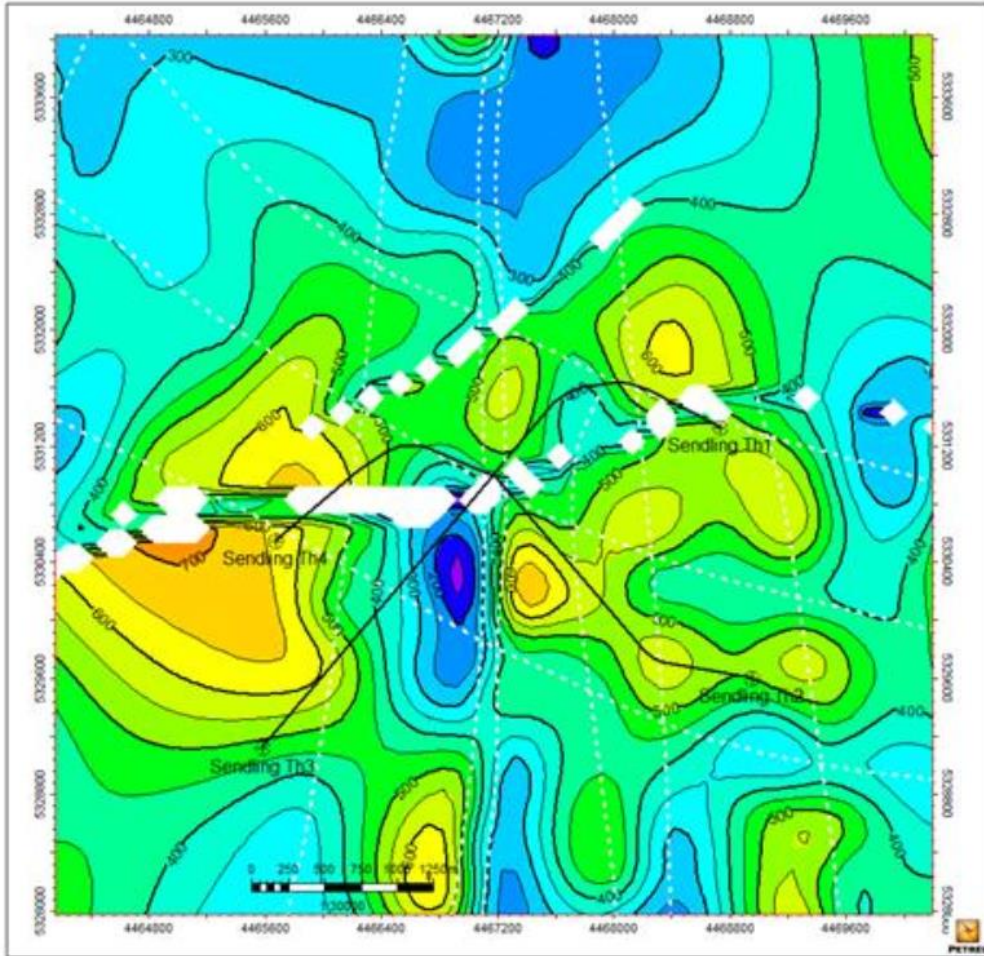
+ First multilateral reservoir development



# Target Planning Schäftlarnstraße 2014

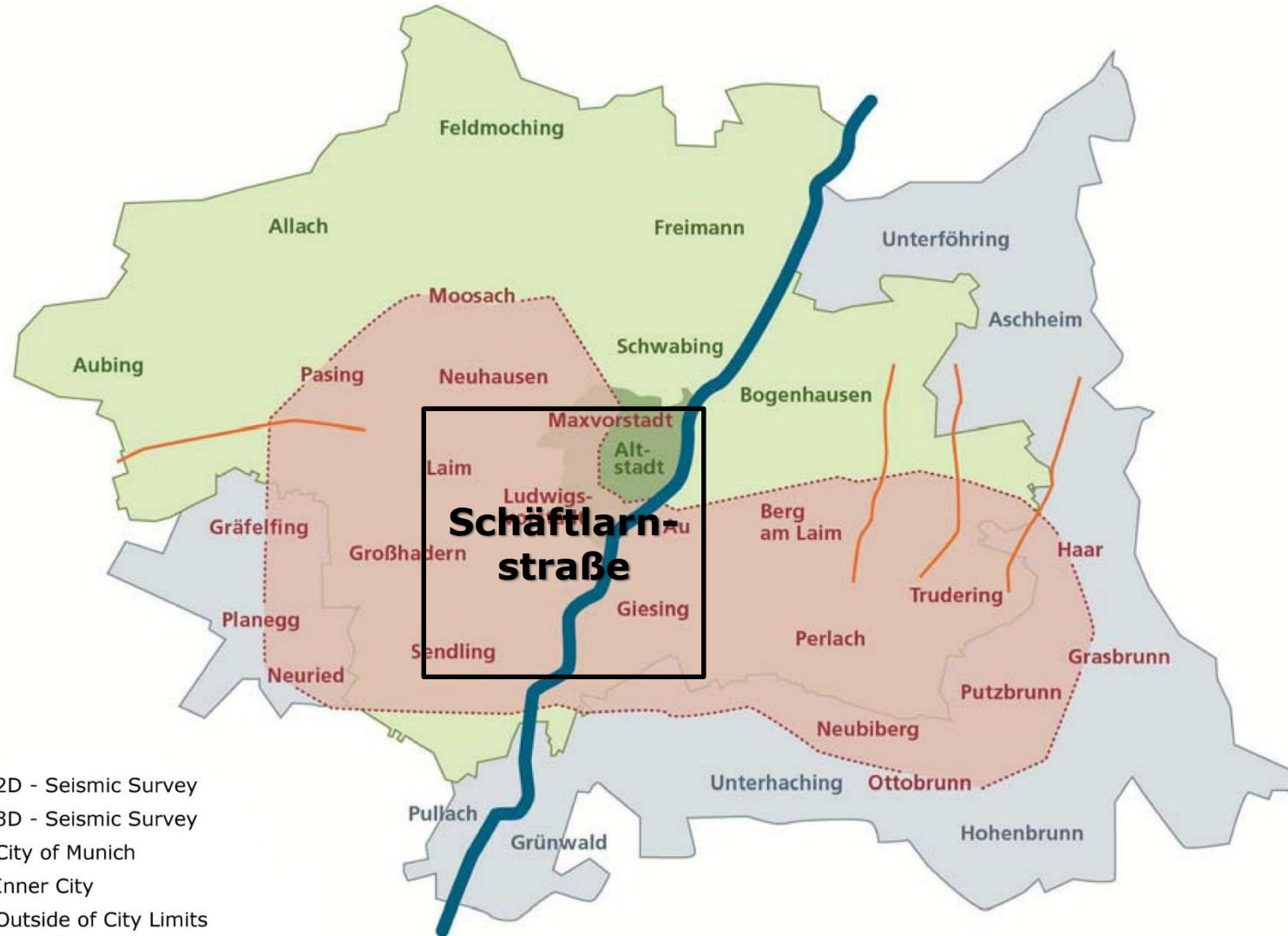


Reservoir thickness map: 2014 based on 2D seismic:  
4 wells



Source: M.  
Meinecke 2018

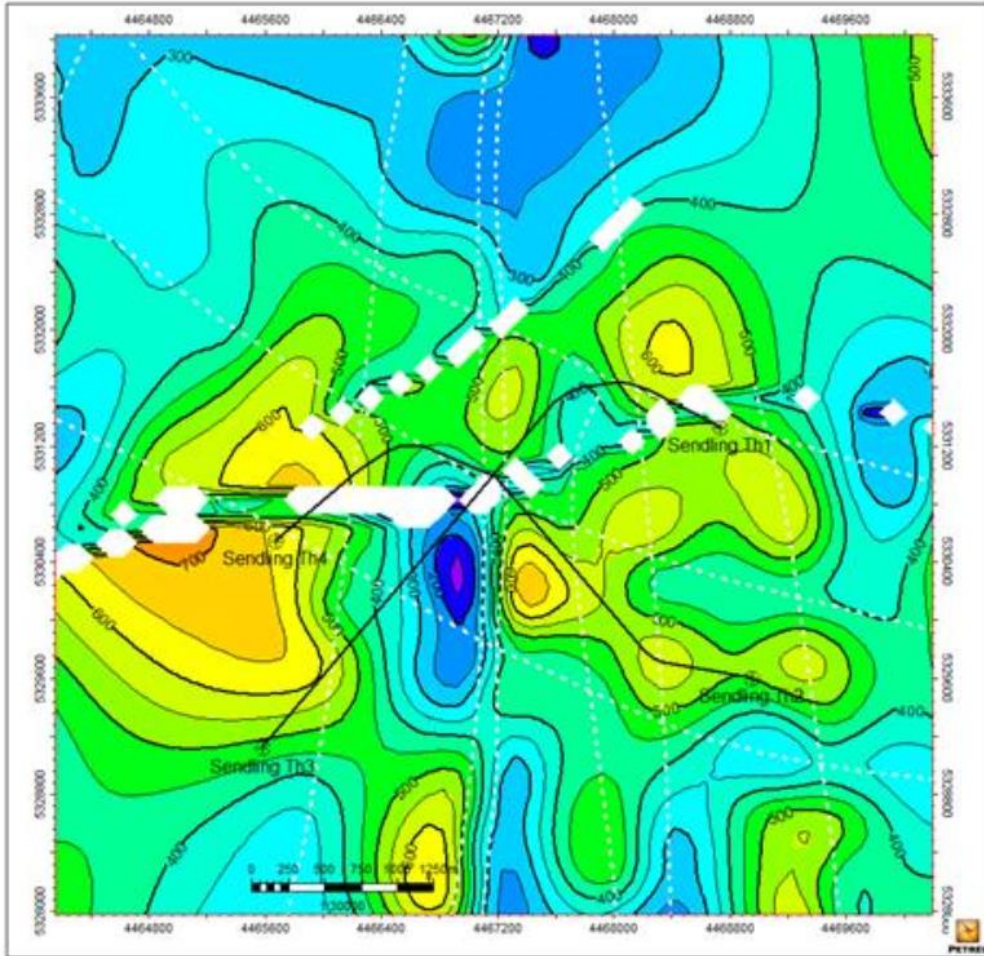
# GRAME R&D Project: 2016 Large 3D Seismic in Munich



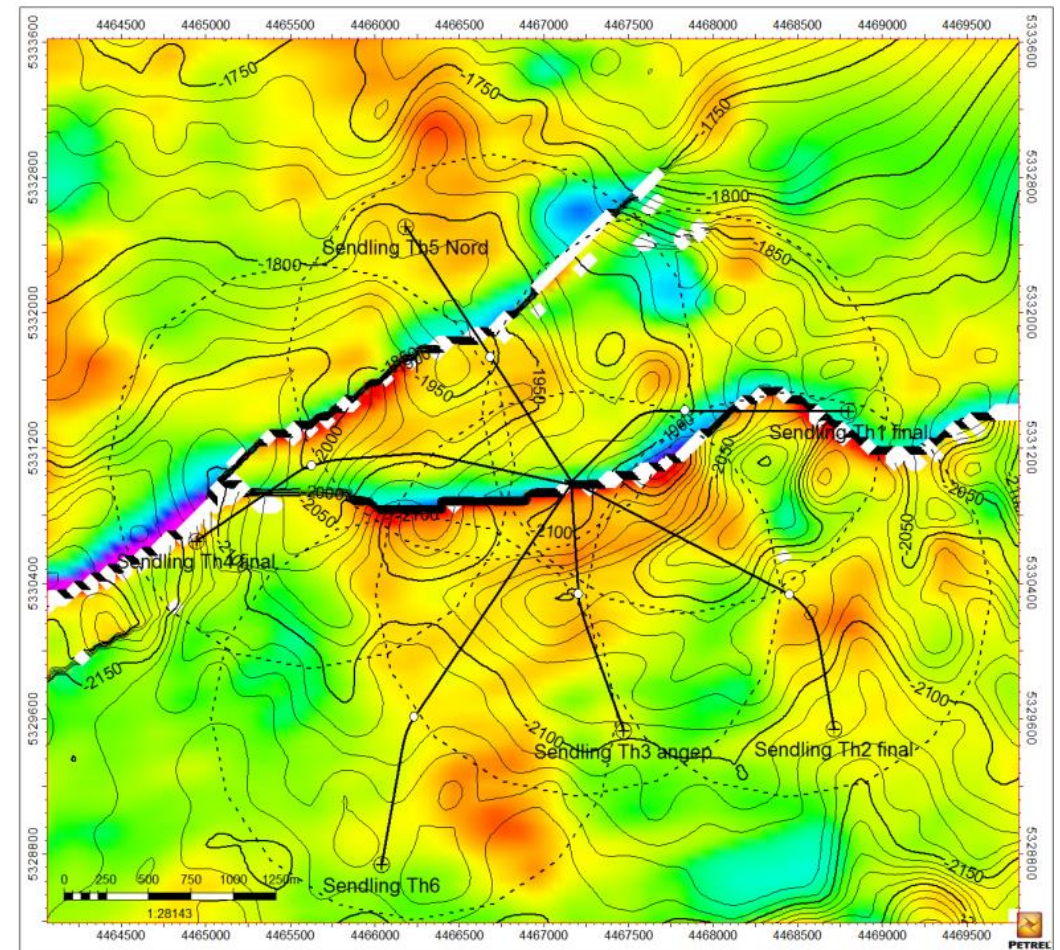
# Target Planning Schäftlarnstraße 2017



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



Reservoir thickness map 2017 based on 3D seismic:  
6 wells



Source: M.  
Meinecke 2018



# First Wells Successfully drilled!



Th1 first well:

Depth:  
3860 m MD / 2809 m TVD

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

Temperature:  
108° C

Source: S. Dirner 2018

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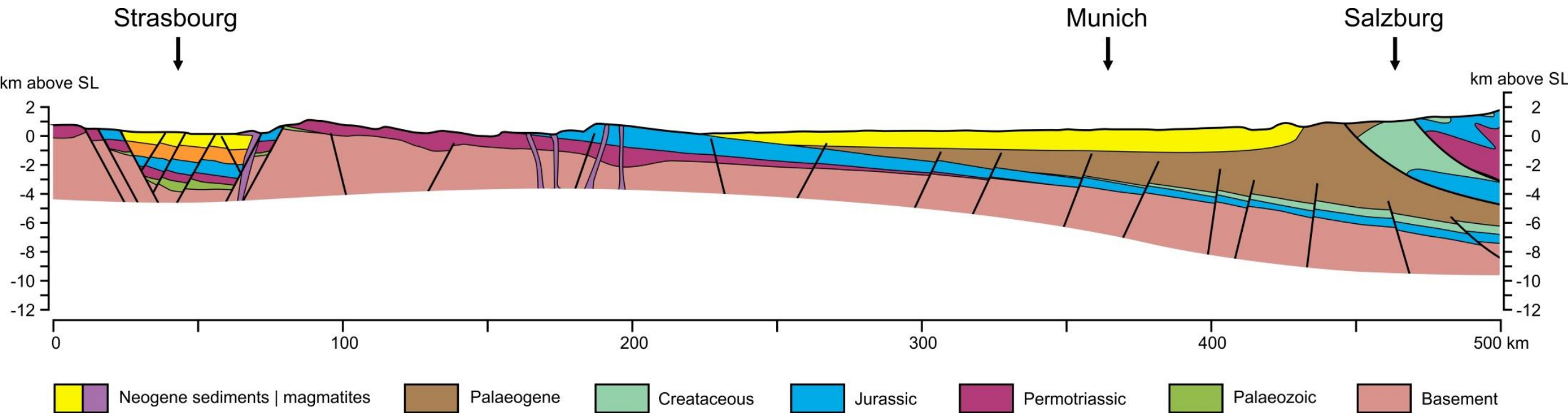
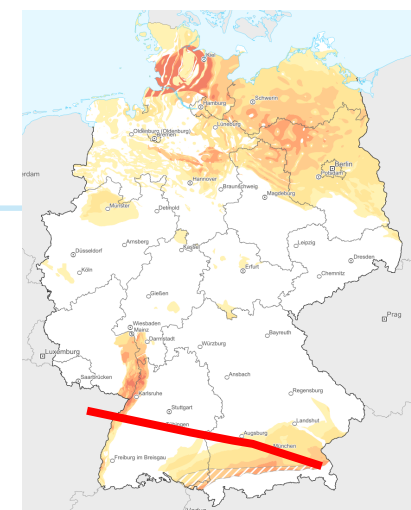


- Saudi Arabia – Germany Linked Through Geology



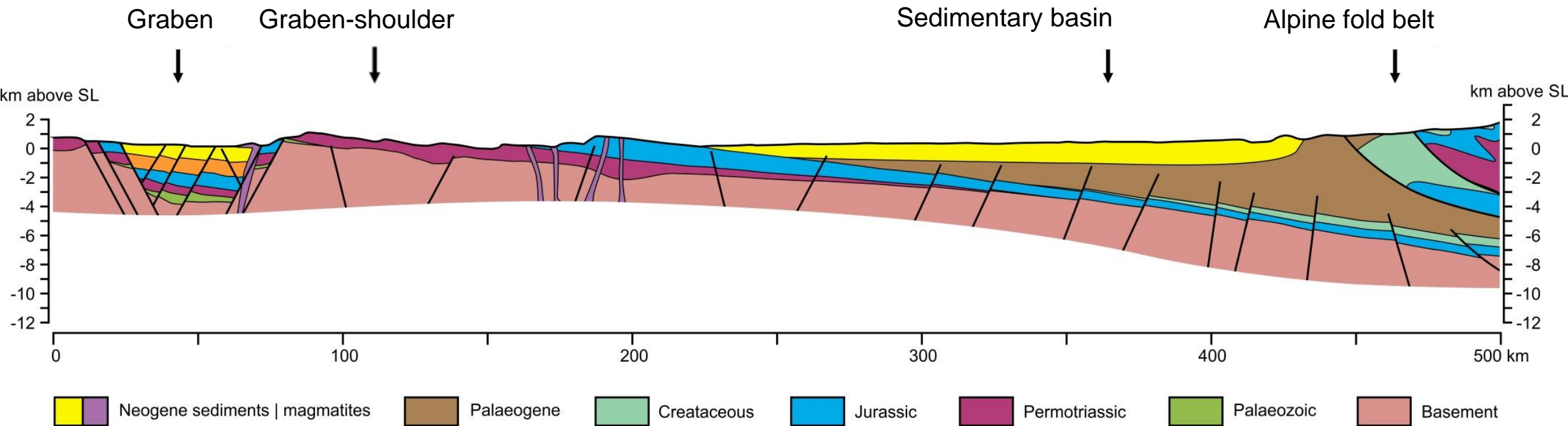
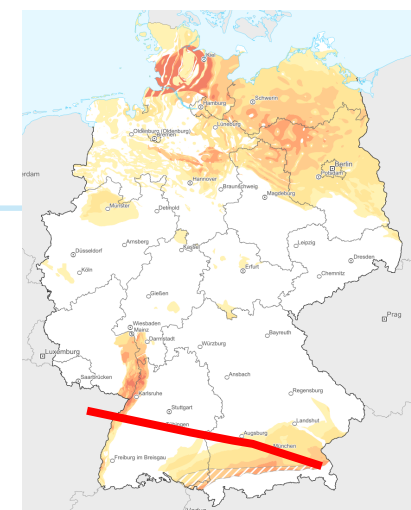
- How to Unlock the Potential

# Geological Cross Section Southern Germany



Drawn after GLA (1996), Rupf & Nitsch (2008)

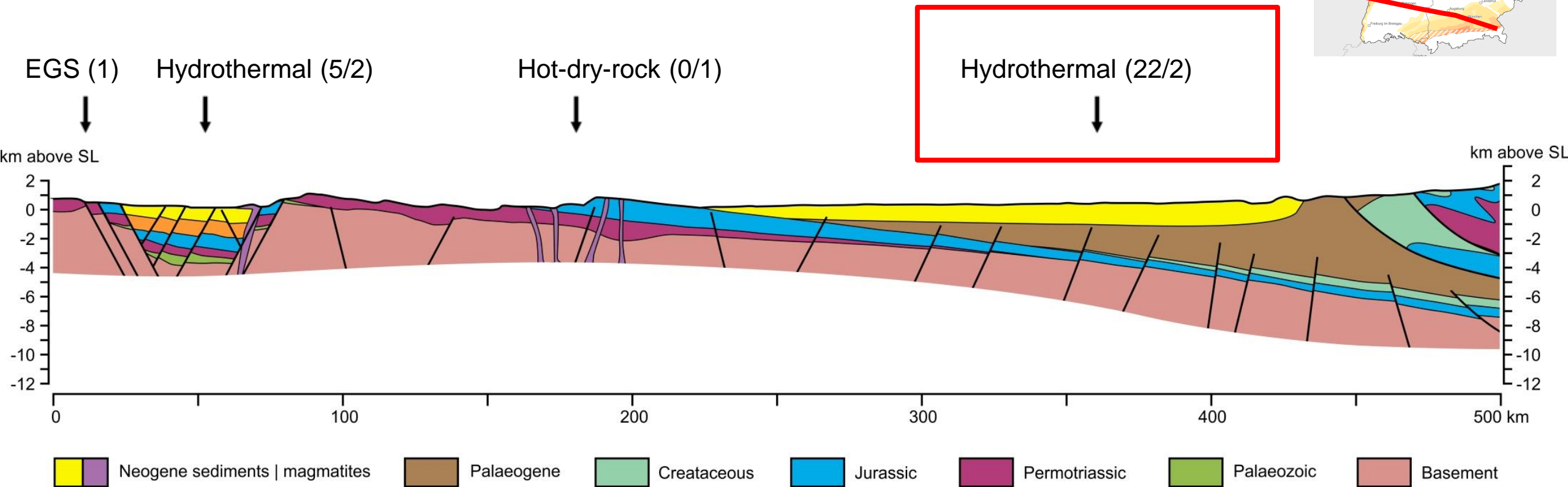
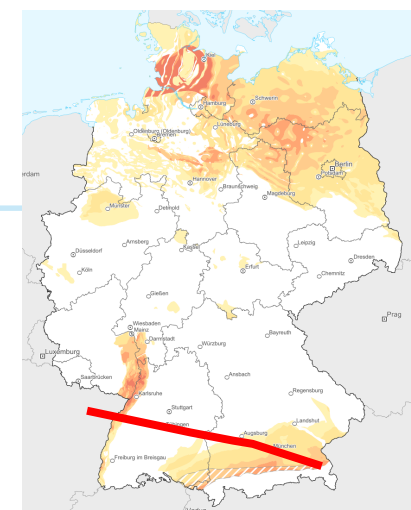
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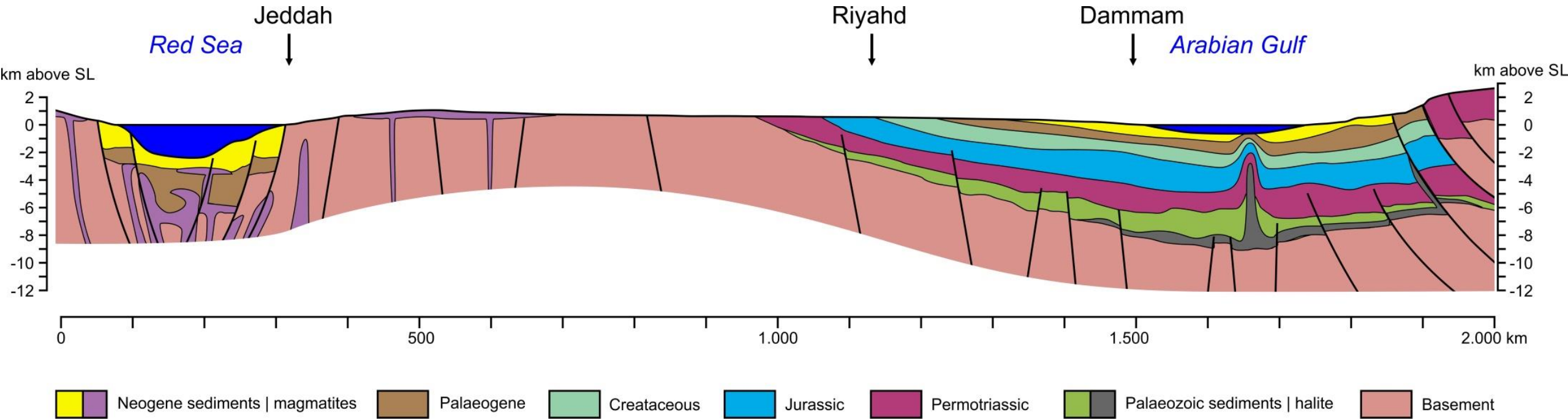
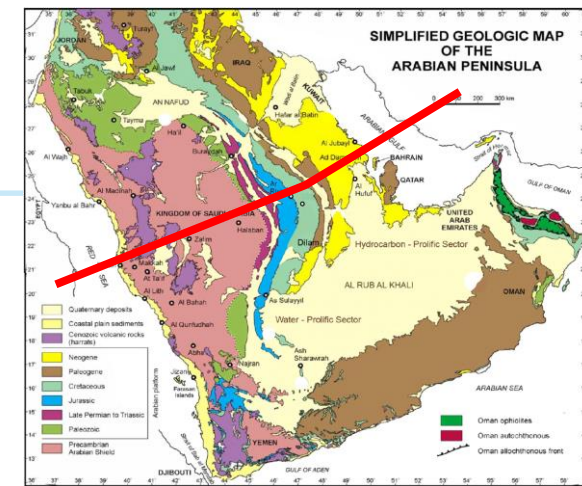
# Types of geothermal projects (in operation / in construction)

→ Most projects in Germany are hydrothermal within the North Alpine Foreland Basin (NAFB)



Drawn after GLA (1996), Rupf & Nitsch (2008)

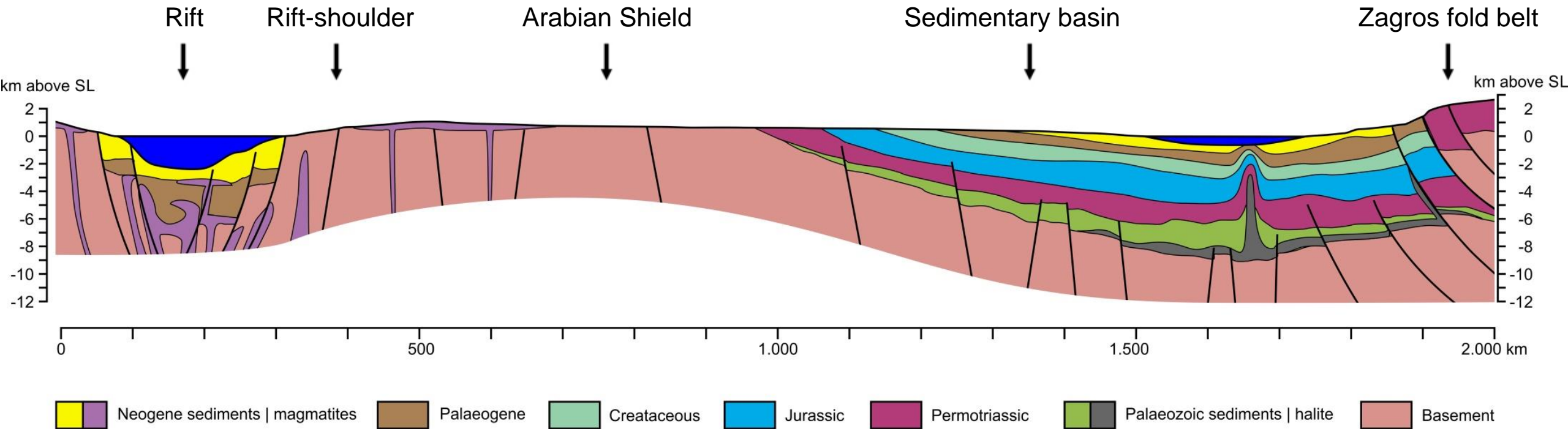
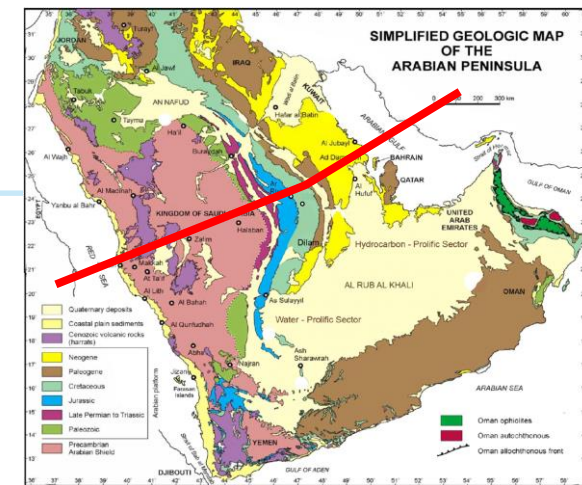
# Geological cross section Saudi-Arabia



Modified from Jaju et al. (2016)

# Geological cross section Saudi-Arabia

→ Striking similarities between Germany and Saudi Arabia



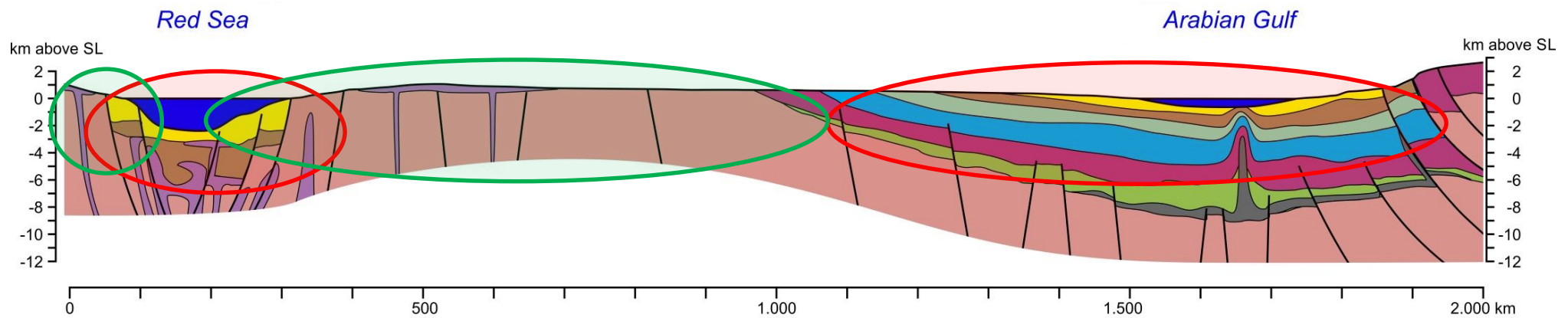
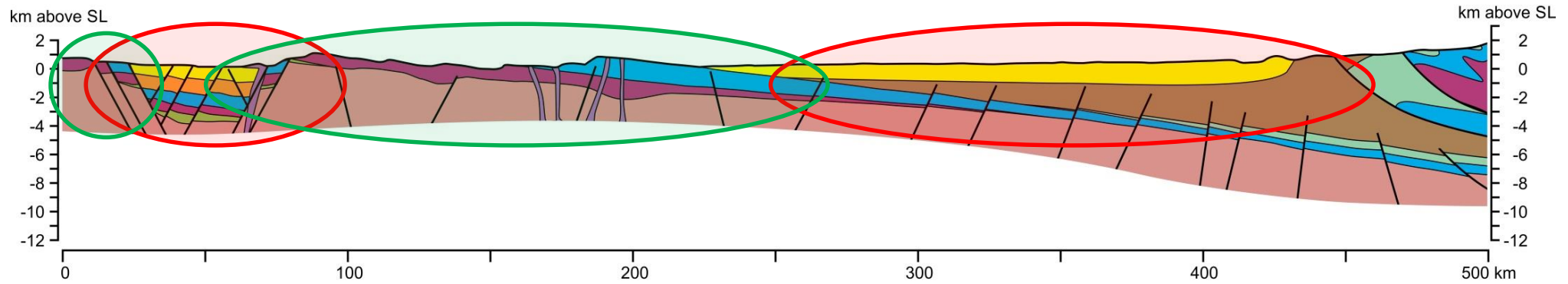
Modified from Jaju et al. (2016)

# Striking Similarity → Good Potential in Saudi Arabia



Hot Dry Rock / EGS

Hydrothermal





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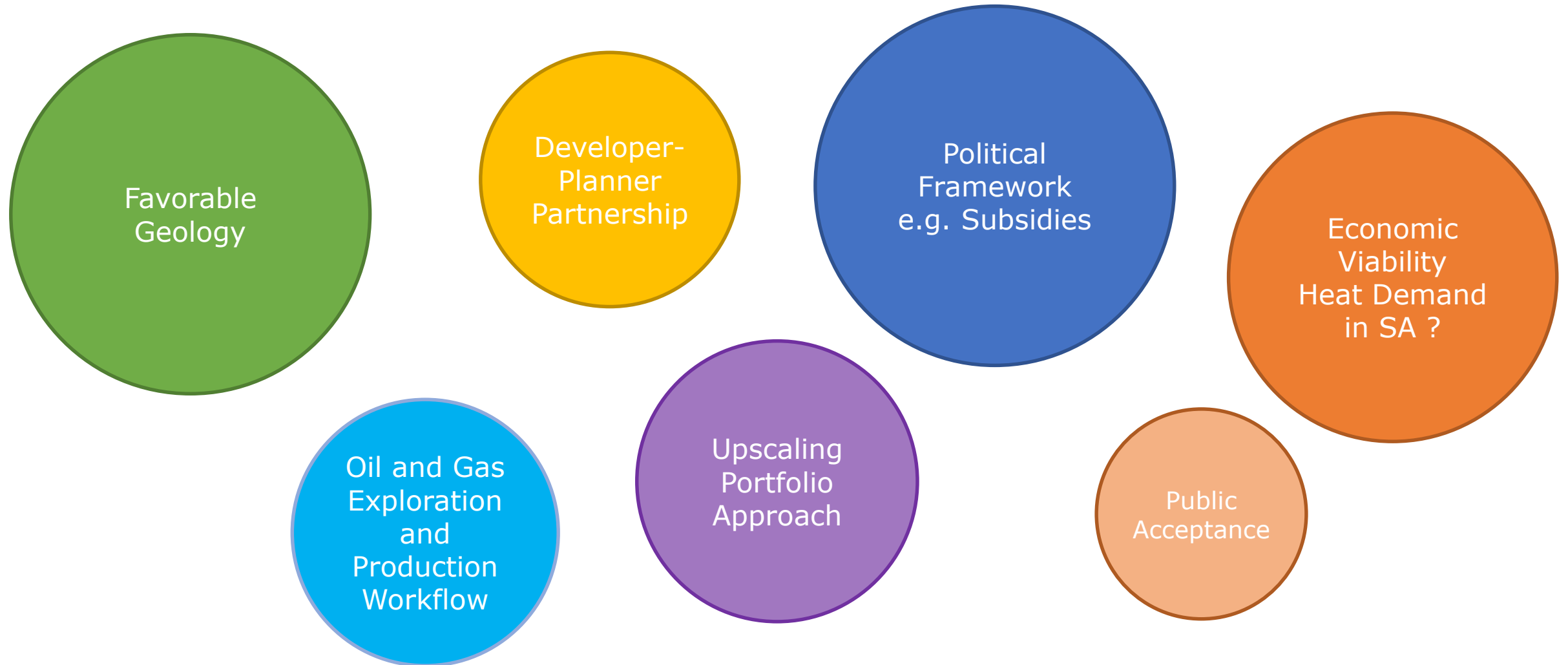


- Saudi Arabia – Germany Linked Through Geology



- How to Unlock the Potential

# Geothermal Development Ingredients for Success



# References



- [https://de.wikipedia.org/wiki/M%C3%BCnchen#/media/File:Luftbild\\_M%C3%BCnchen\\_Innenstadt.jpg](https://de.wikipedia.org/wiki/M%C3%BCnchen#/media/File:Luftbild_M%C3%BCnchen_Innenstadt.jpg)
- After: „Geologische Karte von Bayern 1:50000“, Bayerisches Geologisches Landesamt, 1996
- scotese.com
- Geothermal Atlas (2004) / <https://www.geotis.de/geotisapp/geotis.php>
- [www.eia.gov](http://www.eia.gov)
- Presentation SWM 2018 Michael Meineke F2.1 <https://www.der-geothermiekongress.de/tagungsband/>
- Presentation SWM 2018 Sebastian Dirner F2.2 <https://www.der-geothermiekongress.de/tagungsband/>
- Steiner U, Savvatis A, Boehm F, Schubert A. Explorationsstrategie tiefer geothermischer Ressourcen am Beispiel des sueddeutschen Oberjuras (Malm). In: Bauer M, Freeden W, Jacobi H, editors. Handbuch Tiefe Geothermie. Berlin Heidelberg: Springer Spektrum Verlag; 2014. p. 429–57. doi:101007/978-3-642-54511-5
- Boehm F, Savvatis A, Steiner U, Schneider M, Koch R. Lithofacies and characterization of the geothermal Malm reservoir in the greater area of Munich. Grundwasser. 2012;18(1):3–13. doi:10.1007/s00767-012-0202-4.
- <https://commons.wikimedia.org>