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EGU Vienna 2022

Transmissivity of fault zones in tight carbonates: Results from a reservoir-scale hydraulic field laboratory in the Franconian Alb, SE Germany

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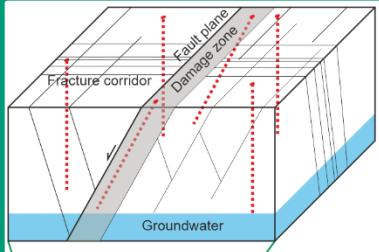
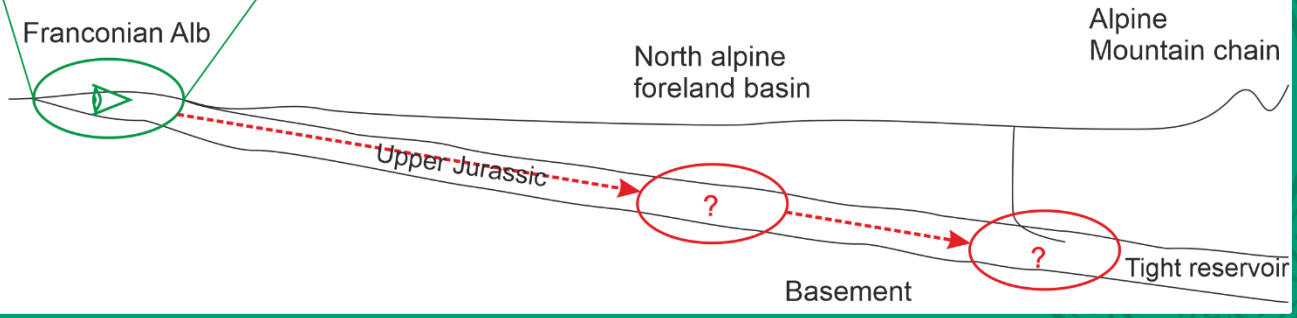
Motivation



Controls of hydraulic properties in tight reservoirs → fracture and fault systems

But:

- How are they really controlling the fluid flow?
- How can the exploration risk be minimized?



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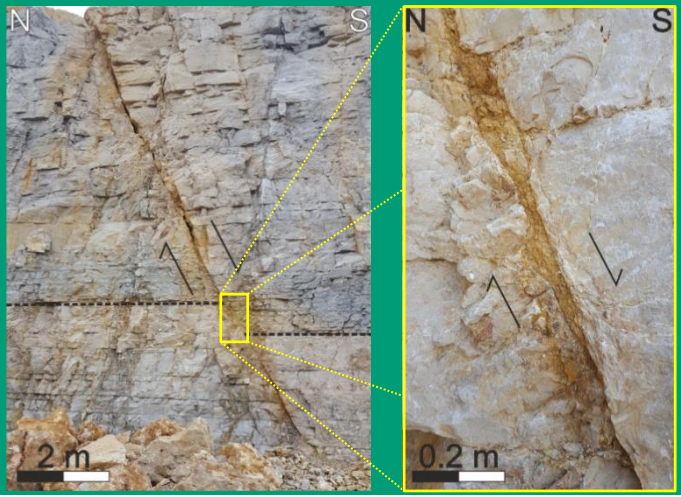
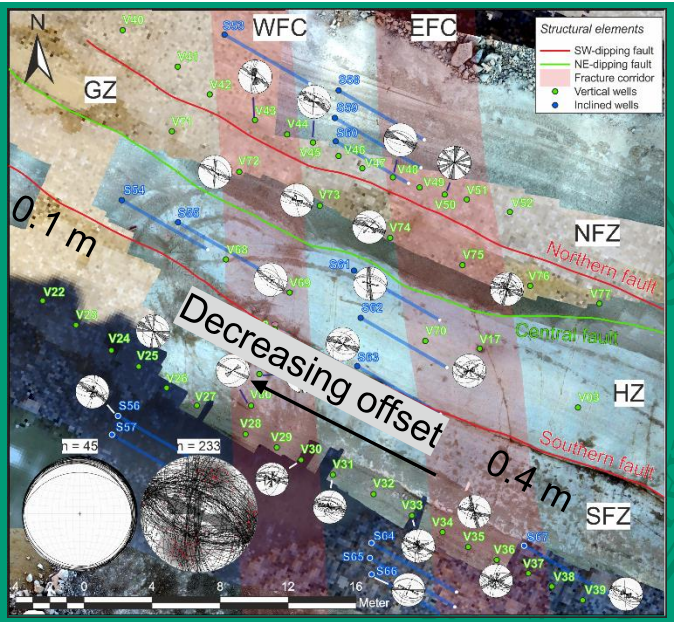
General setting

Short geological overview of the test field‘s location

Size of test field [m x m]	33 x 34
Aquifer thickness [m]	21
Matrix porosity [%]	1.4 – 5.1
Matrix permeability [m²]	<1.0E-16
Number of hydraulic tests	14

1. One major extensional phase
2. Reactivation of existing faults at least once
3. Strike-slip faults





Basics

What analysis methods do we have?

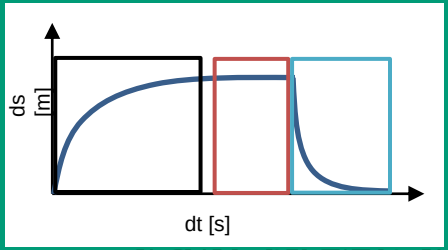
Drawdown **&** **Derivative analysis**

From the drawdown
→ *Transmissivity (T)*, *hydraulic conductivity (K_f)*, *storage coefficient (S)*

Non-steady or transient conditions (during drawdown):
→ Confined aquifer: Straight line method by Cooper & Jacob (1946)
→ **Unconfined aquifer**: Straight line method by **Neumann** (1975) or corrected drawdown after Jacob (1963a)

Apparent steady conditions:
→ **Dupuit-Thiem**

Non-steady or transient conditions (during recovery):
→ **Theis (1935) & Jacob (1963b)**



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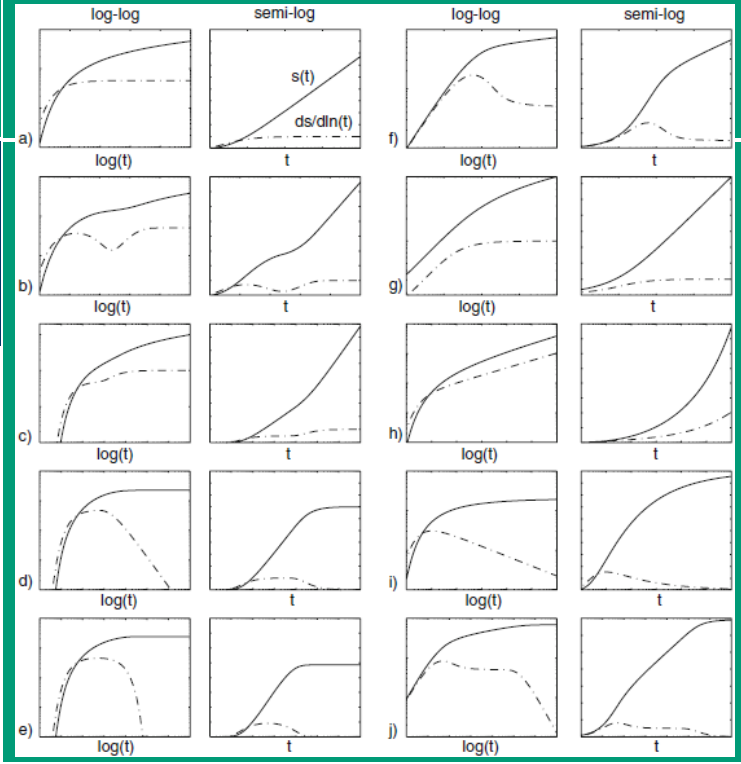
Basics

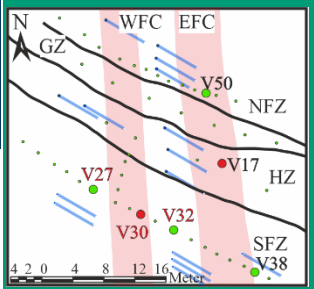


& **Derivative analysis**

- Selection of appropriate aquifer models
- Identification of flow regimes
- Detection of aquifer boundaries

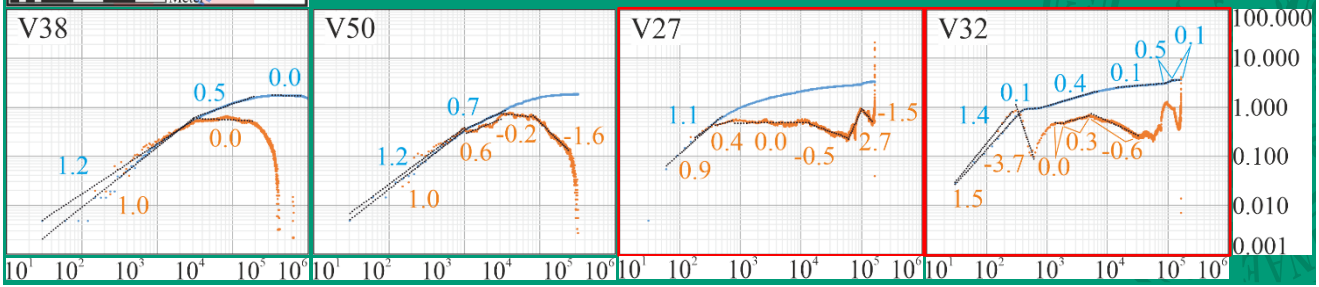
Renard et al., 2008 - Understanding diagnostic plots for well-test interpretation

Test results – Conclusions, supported by results of diagnostic plots



- Fluid flow in low-permeable DZ controlled by well-connected fractures→ strongly influenced by **fault complexity**
- Fault cores represent no-flow boundaries → aquifer compartmentalization → strongly influenced by **offset**
- Fractures in FCs enable cross-fault hydraulic communication
  - The larger fault offset (= thicker fault core), the less fractures penetrated fault

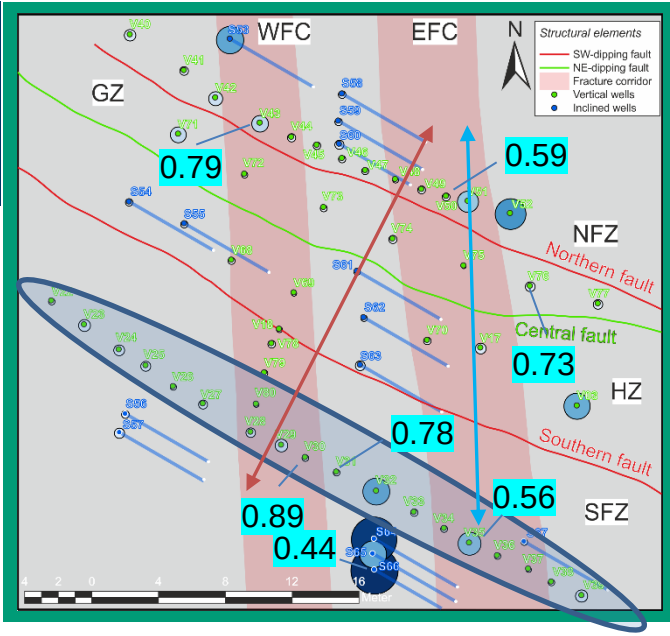
➔ Conduit-barrier-fault system



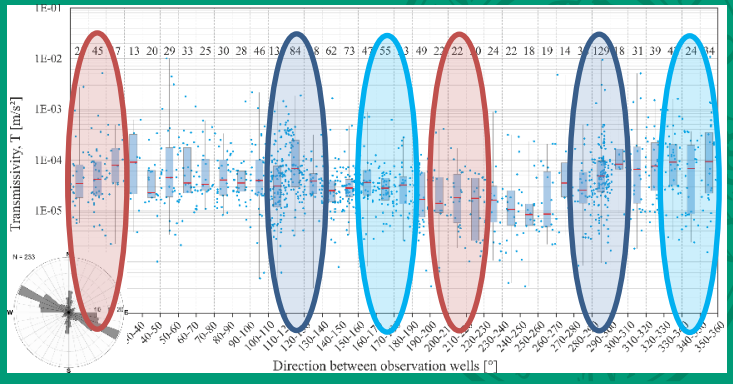
Interpretation based on Ferroud et al. (2019) and Renard et al. (2008)

Test results – Observations

Rel. transmissivities per well



- Low fault-parallel T
- No correlation with increased fracture density
- Bad hydraulic communication across faults except in FCs



Thank you for your time and interest!

For a numerical application of these results, see talk of Kottwitz et al. (2022) →

EGU 2022, ERE5.3, abs. 4116

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