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IPS 24-6.3

Perforation Performance Modelling Challenges in the Presence of Faults

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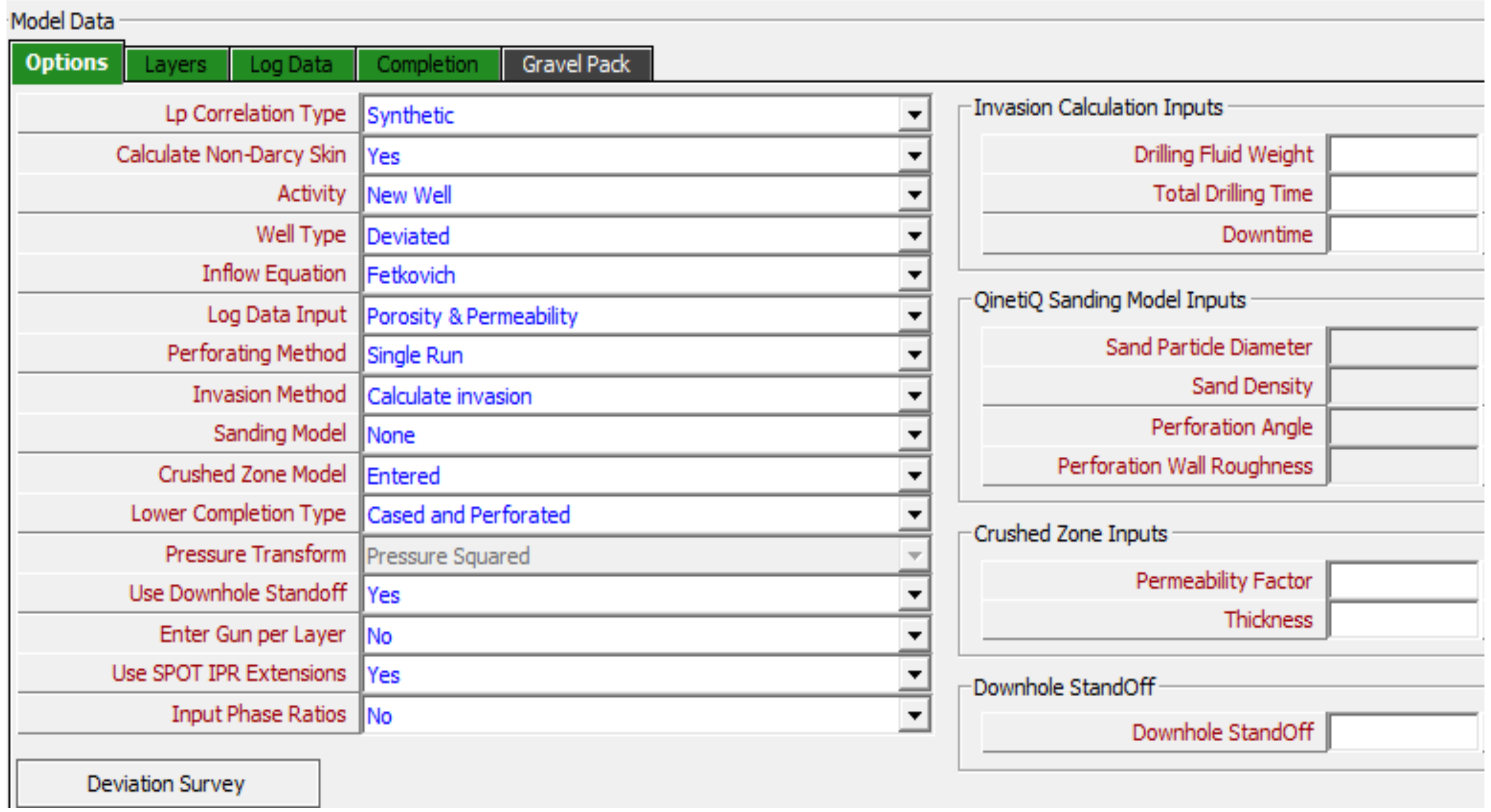
Factors Affecting Cased and Perforated Wells' Performance

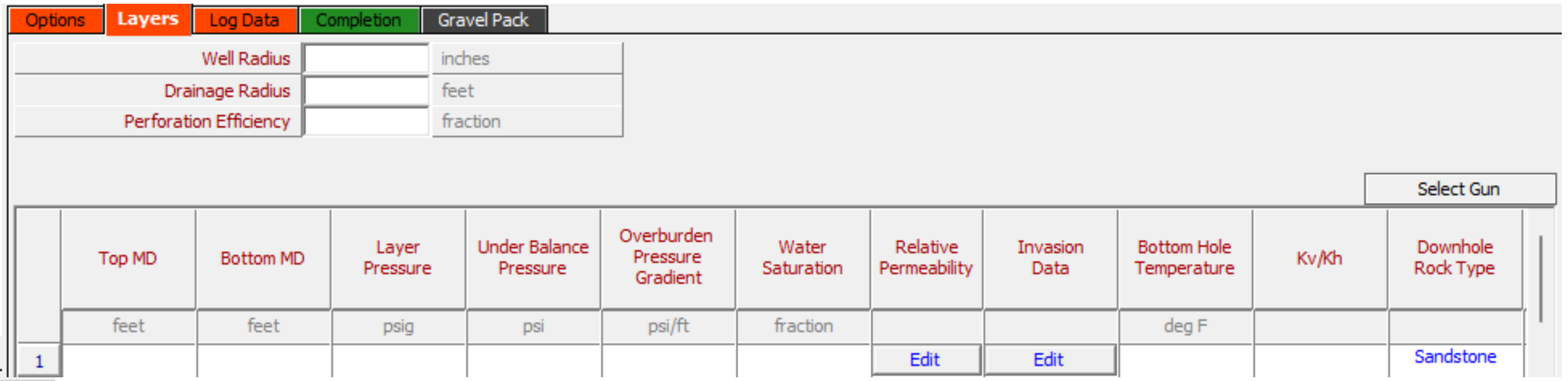
- Gun misfire
- Perforation efficiency
- Penetration depth
- Perforation tunnels clean-up
- Damage zone – Mud Filtrate
- Reservoir Properties

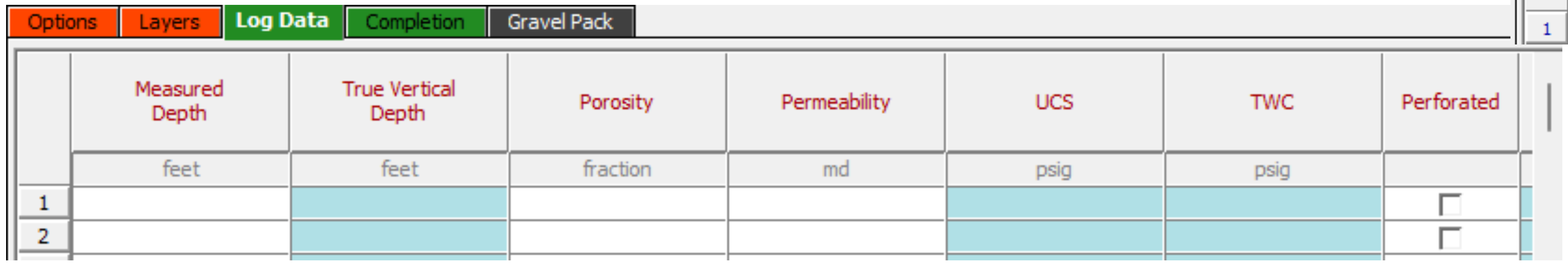
Perforation Inflow Performance

Input Data

- Porosity & Permeability
- Reservoir pressure , temperature
- Relative permeability & Drainage area
- Stress data UCS/TWC
- Drilling Invasion
- Perforation tunnel clean up
- Perforation Gun data

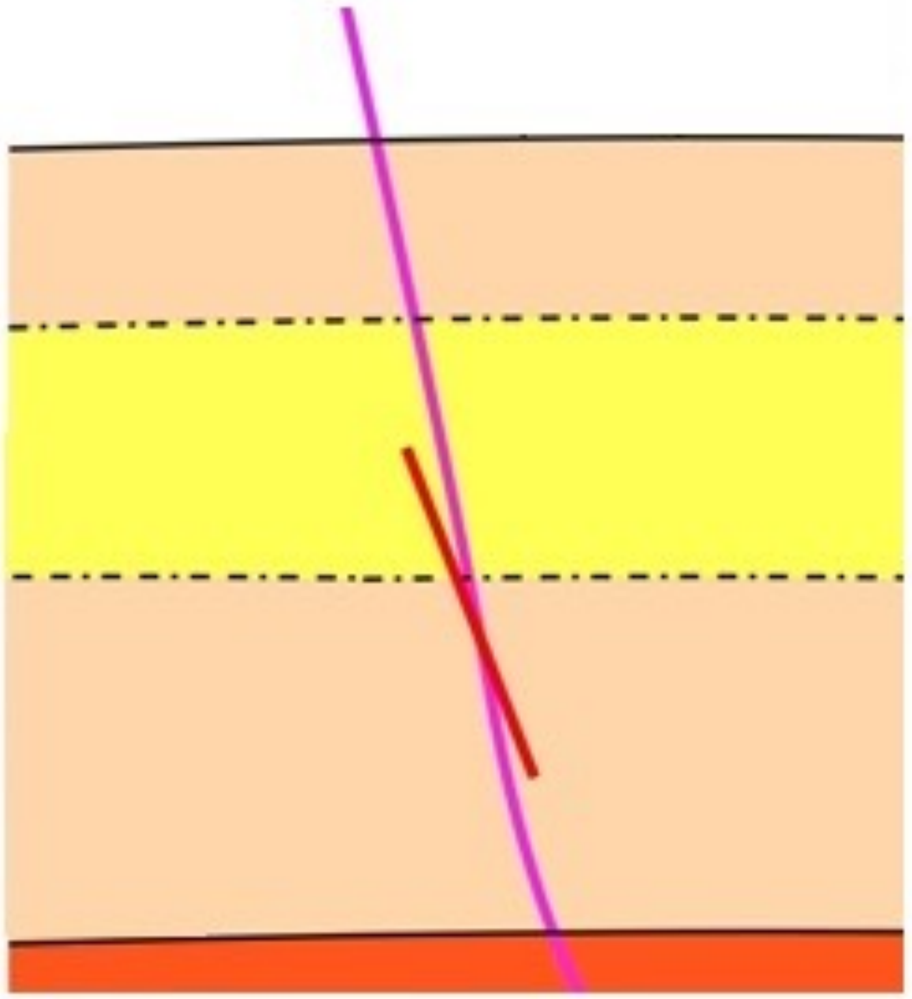






Modelling Potential Well Performance

- A deviated well was drilled intersecting a fault deeper than the zone of interest.

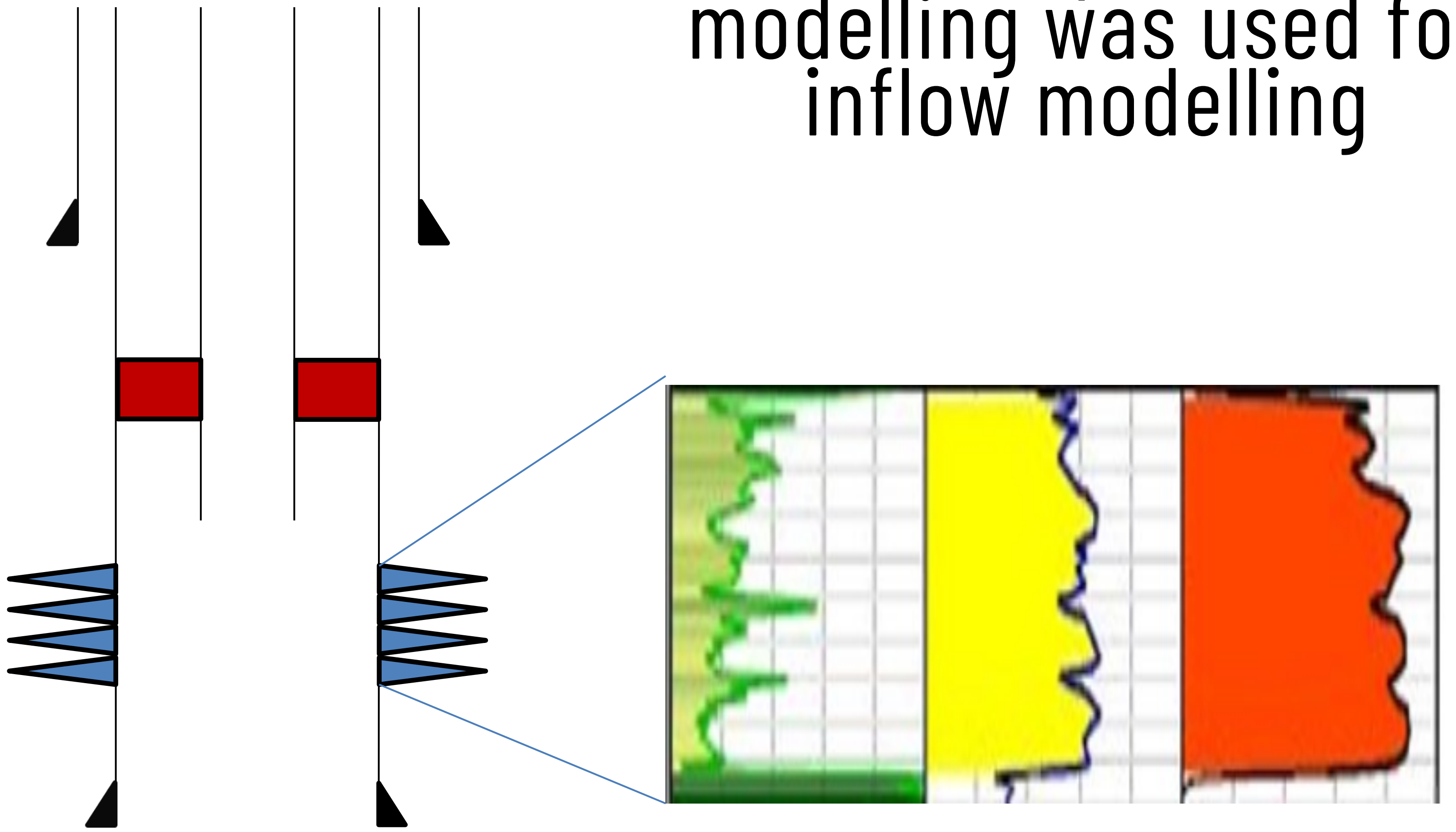


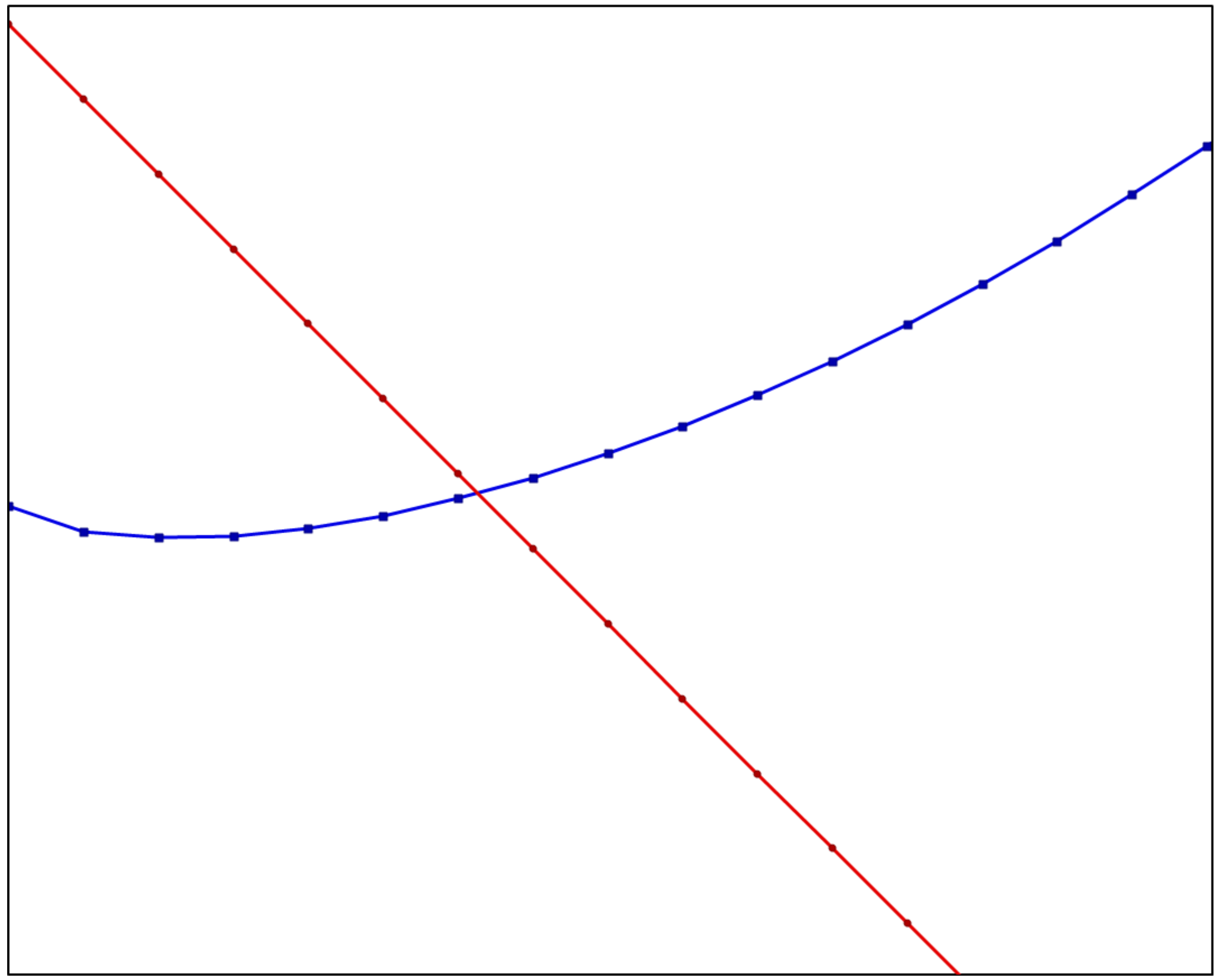
- The fault is seismically visible and expected.
- Analogue log from a neighbouring well is available for reservoir properties.
- The well was designed as a cased and perforated well completed with a packer
- 4.5″ TCP gun 5 SPF HMX was selected to perforate in a dynamic underbalanced condition.

Well Performance : Perforation Modelling

Nodal analysis was performed to assess the well productivity and estimate the production rates.

A detailed perforation modelling was used for inflow modelling

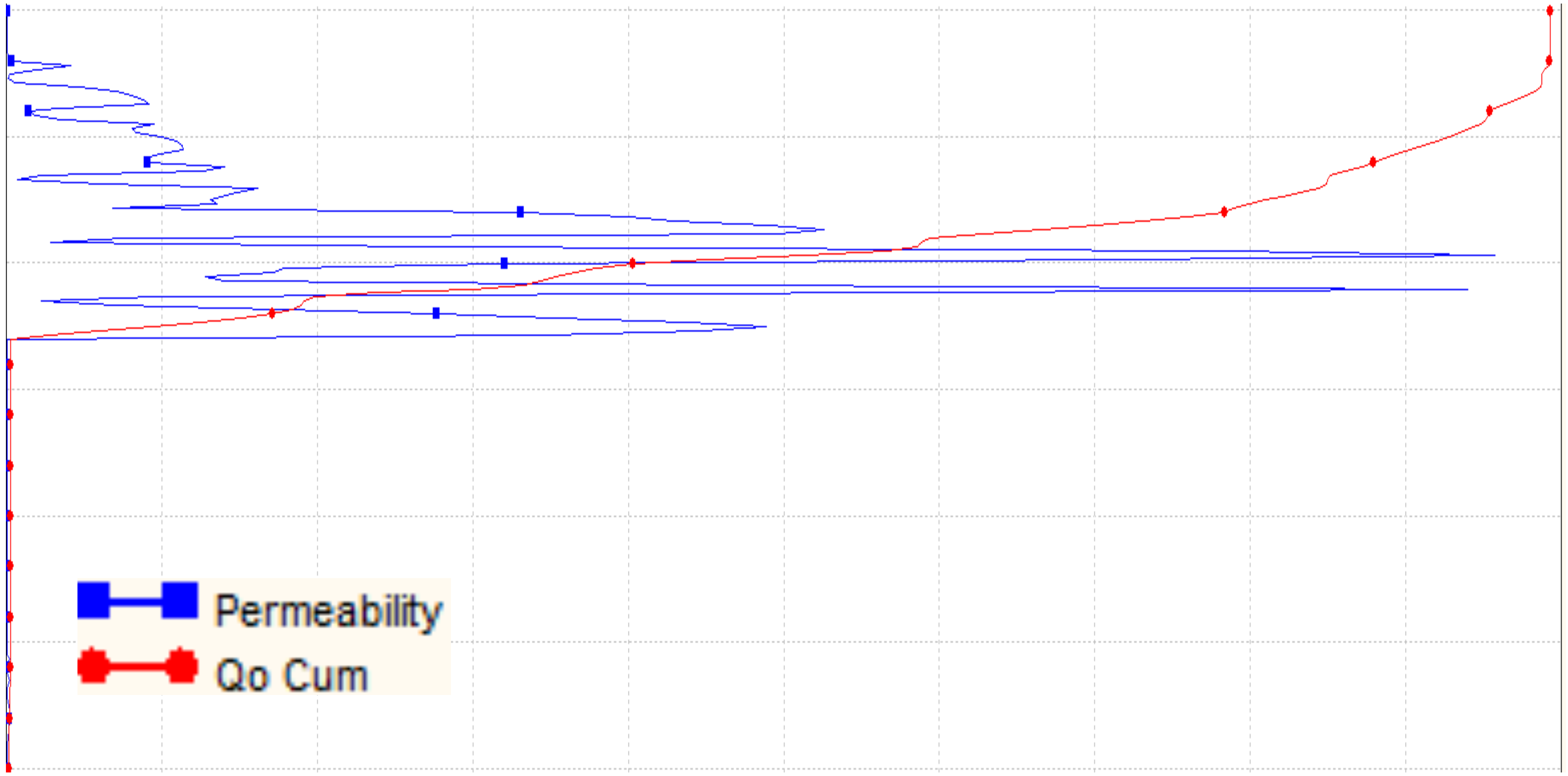


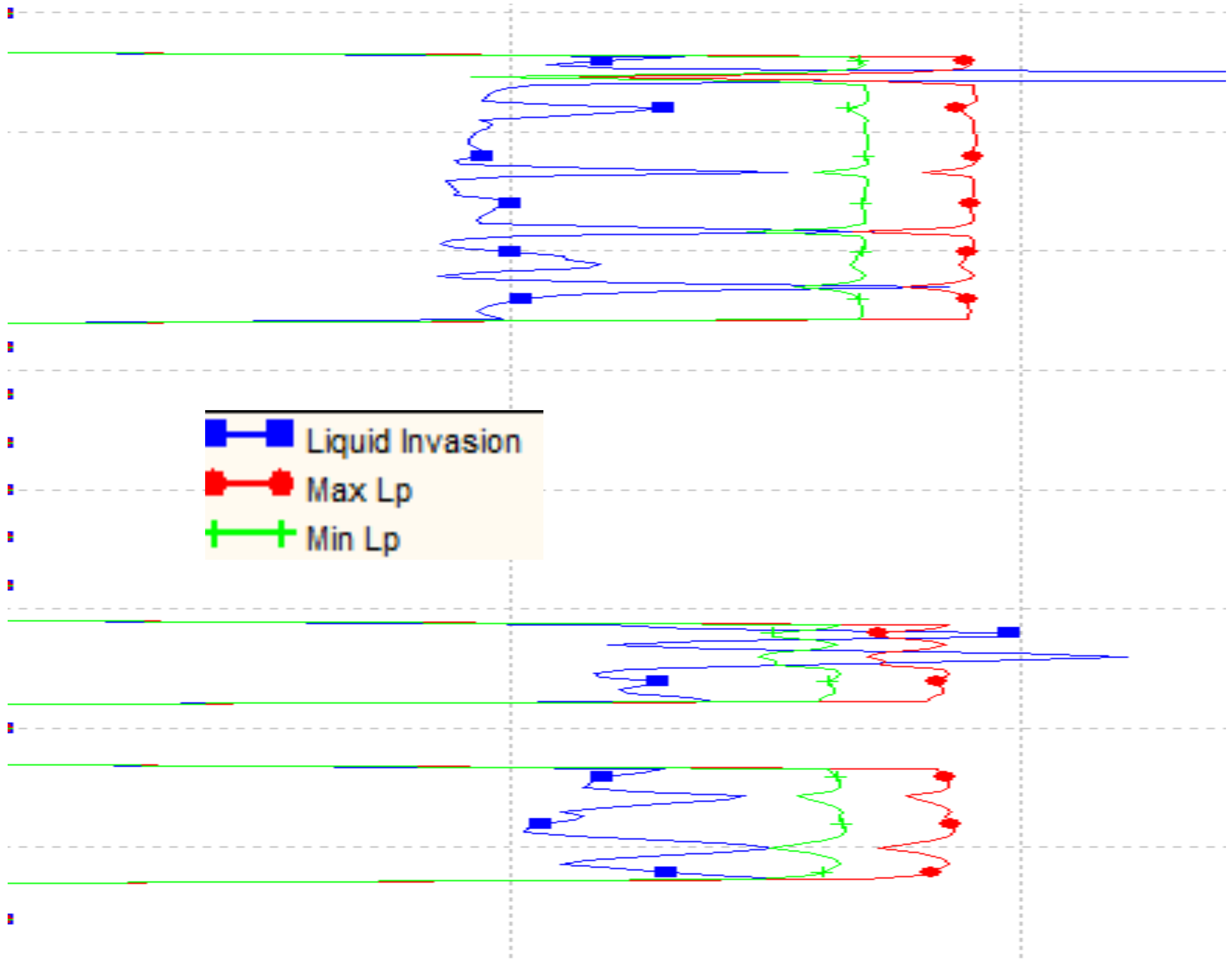


The inflow Modelling uses the reservoir properties (porosity and permeability) to calculate the inflow

Perforating Model Results

- The model accounts for the impact of the effective stresses on the depth of penetration and the well productivity.
- The model also calculates the effect of drilling mud invasion.

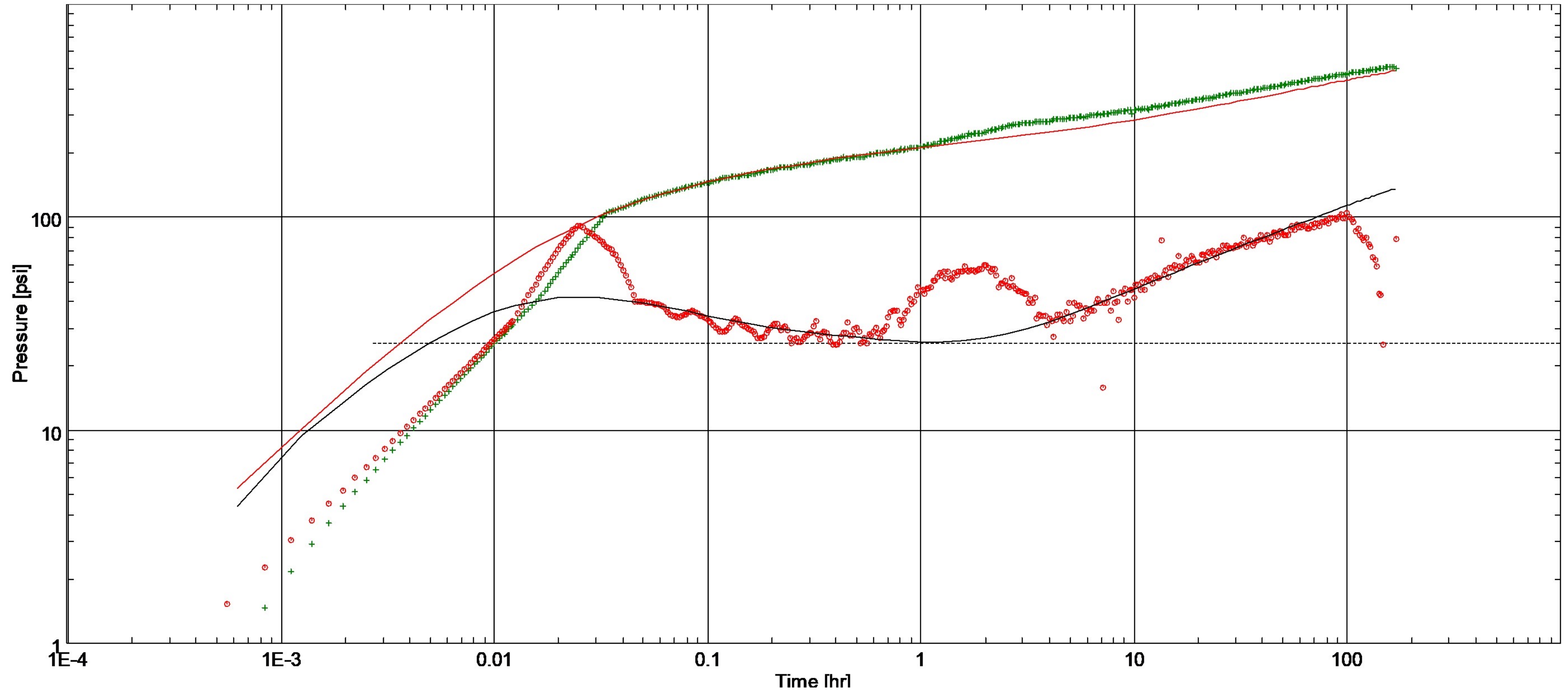




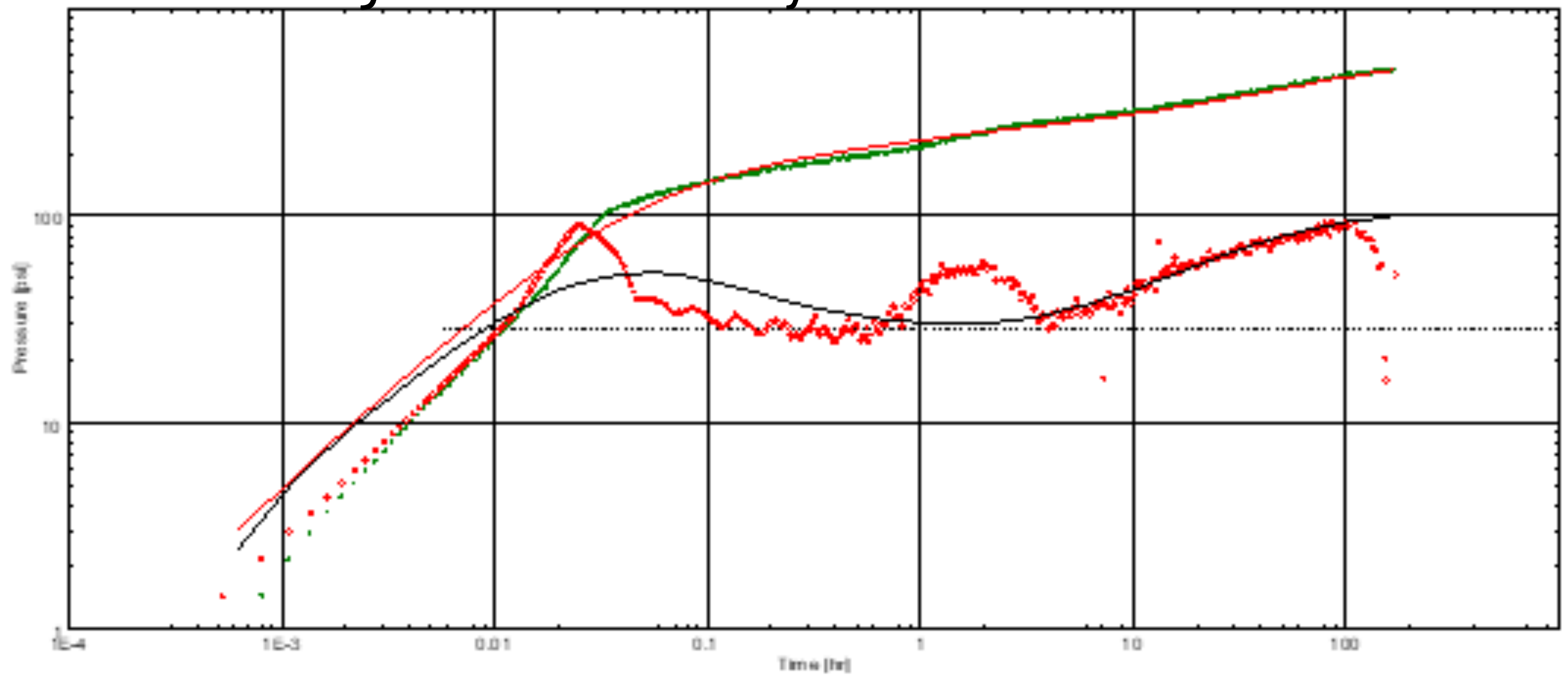
- Production and productivity are calculated based on their reservoir properties, invasion depth and DOP.
- Flow plotted as a pseudo PLT that shows zonal contributions.

Matching With Pressure Transient Analysis

Parallel Faults boundary model



Intersecting faults boundary model



- Pressure build-up and Pressure Transient analysis was performed to assess the well and reservoir properties
- Parallel and intersecting fault models allowed for good matches at late times
- Both models suggest the presence of a sub-seismic fault close to the wellbore.
- Permeability: ~ half log permeability

Assumptions and Uncertainties

- Logging tools have limited depth of investigation
- Invisible uncertainties related to sub-seismic features
- Performance models simplistically assume lateral continuity.

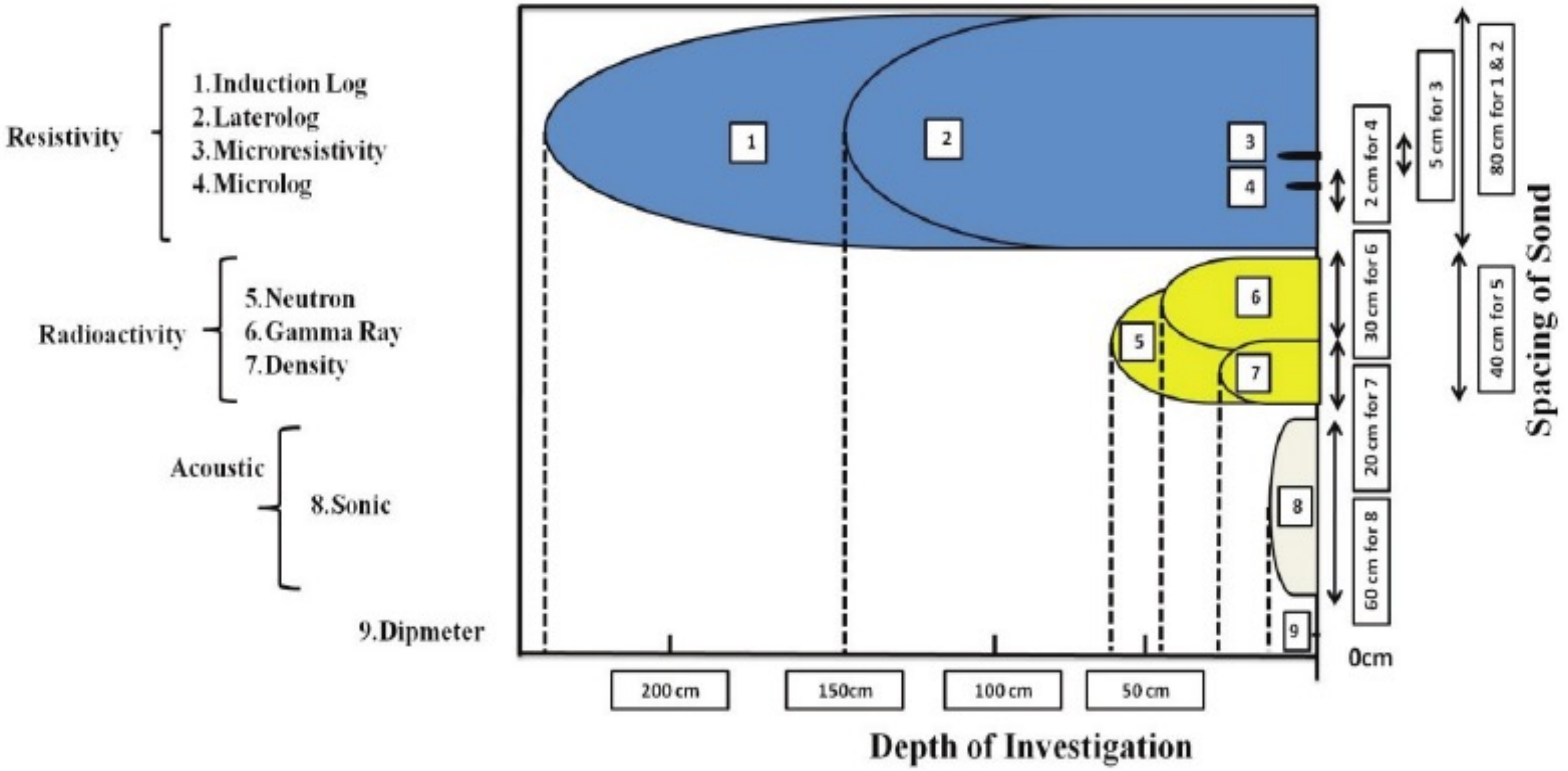
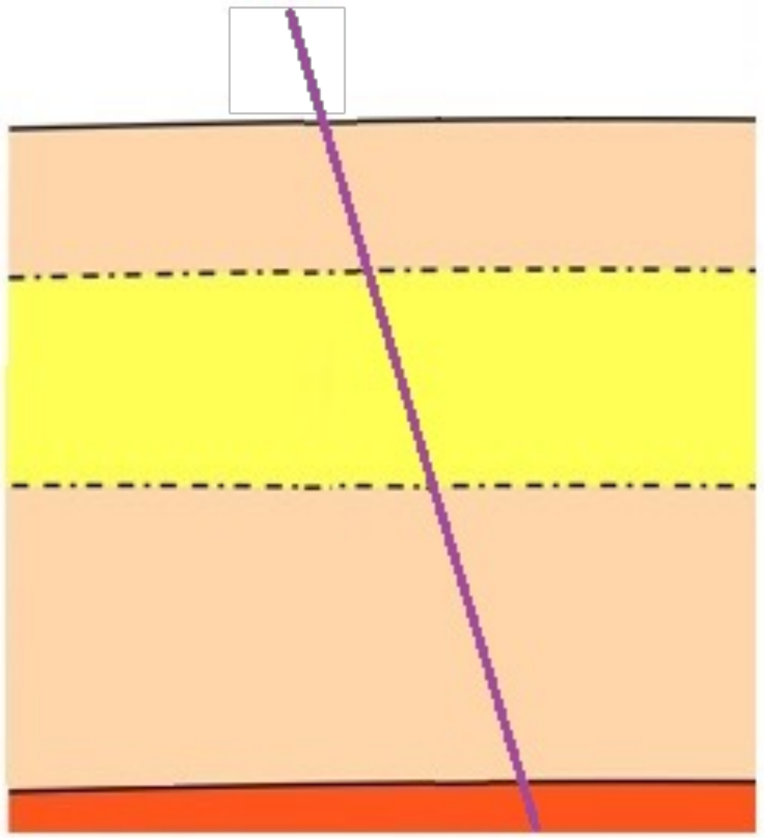


Image Citation: Mazaheri, atie & Memarian, Hossein & Tokhmechi, Behzad & Araabi, Babak. (2015). Developing Fracture Measure as an Index of Fracture Impact on Well-Logs. Energy, Exploration & Exploitation. 33. 555-574. 10.1260/0144-5987.33.4.555.



Subsurface Interpretation

- The damage zone in the presence of faults is well identified

- The properties of the damage zone differ from the original reservoir matrix properties depending on the movement, stresses and rock composition.

- Presence of sub-seismic faults in vicinity to a major fault can be expected.

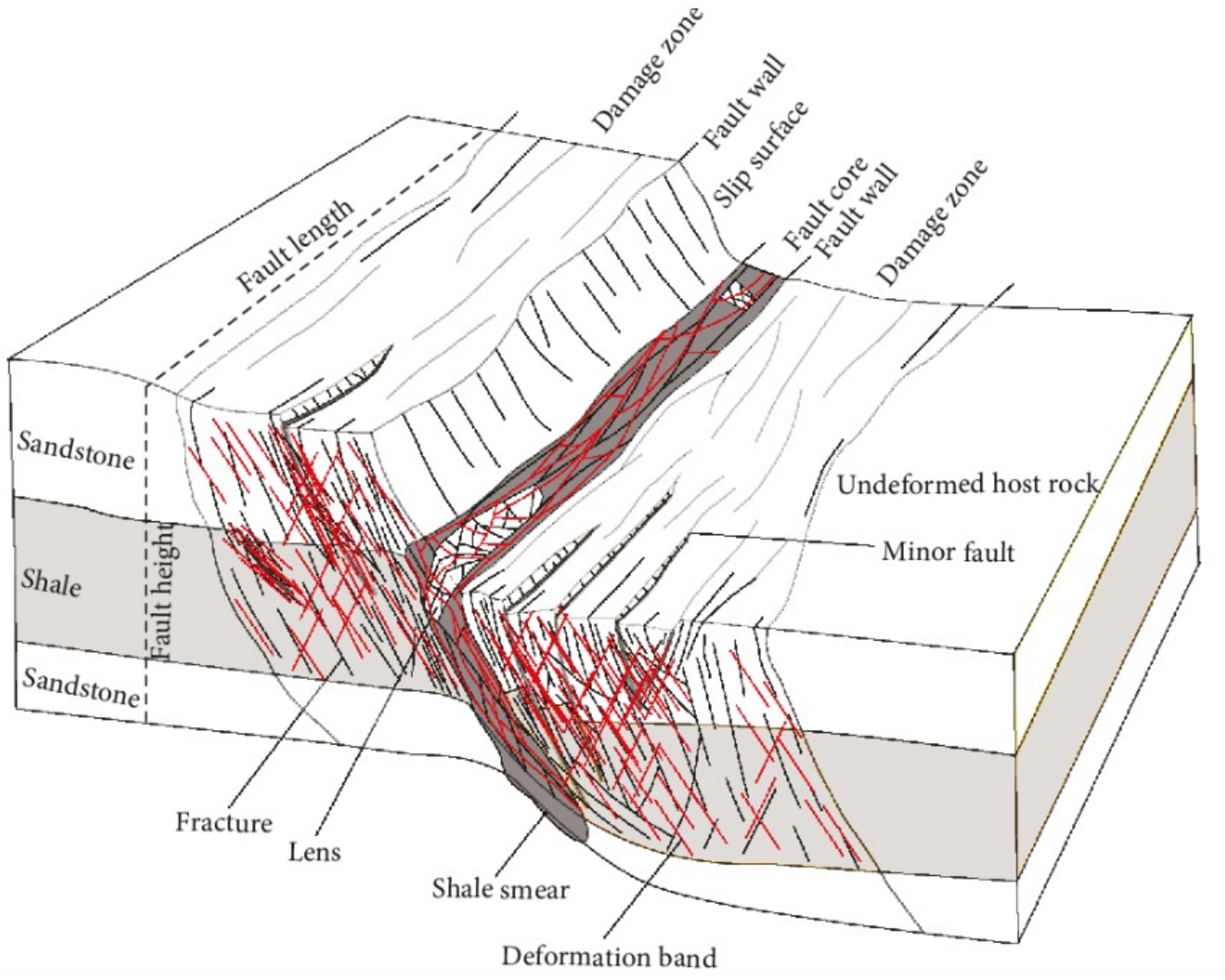


Image Citation: A. Torabi, M. U. Johannessen, T. S. S. Ellingsen, "Fault Core Thickness: Insights from Siliciclastic and Carbonate Rocks", Geofluids, vol. 2019, Article ID 2918673, 24 pages, 2019. https://doi.org/10.1155/2019/2918673

Potential Impact of Faults

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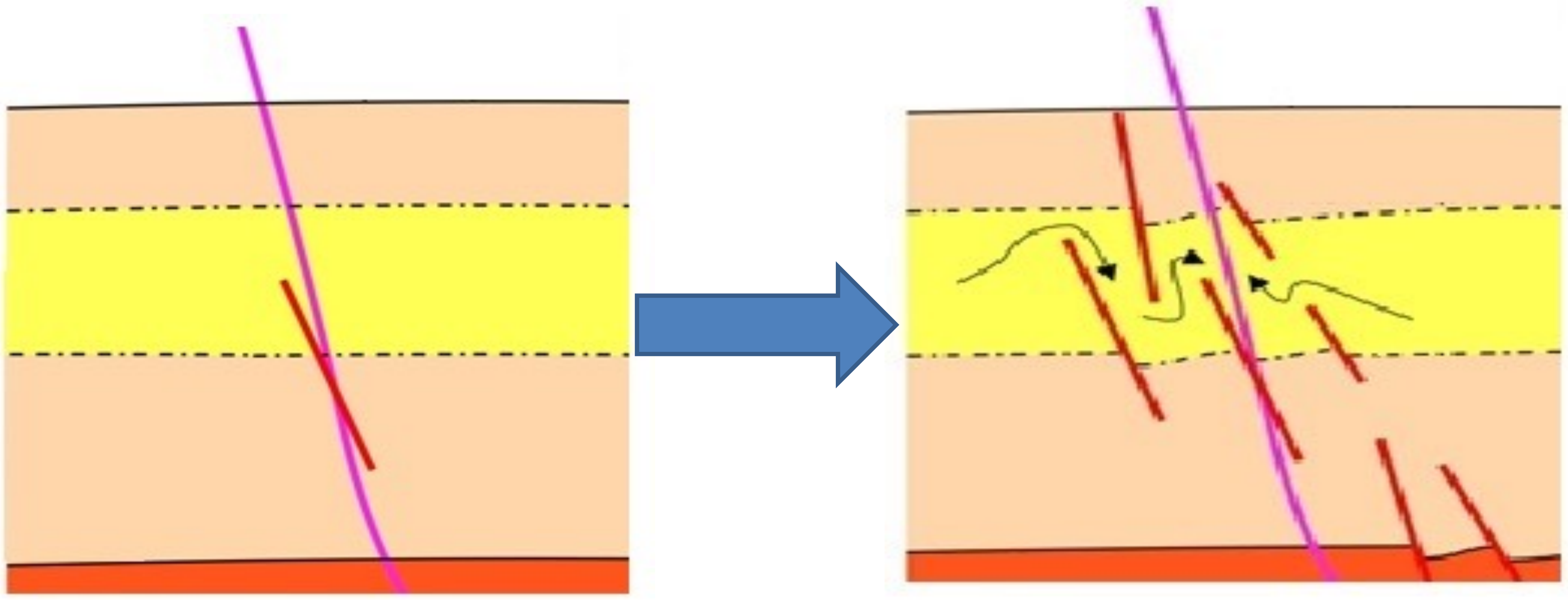

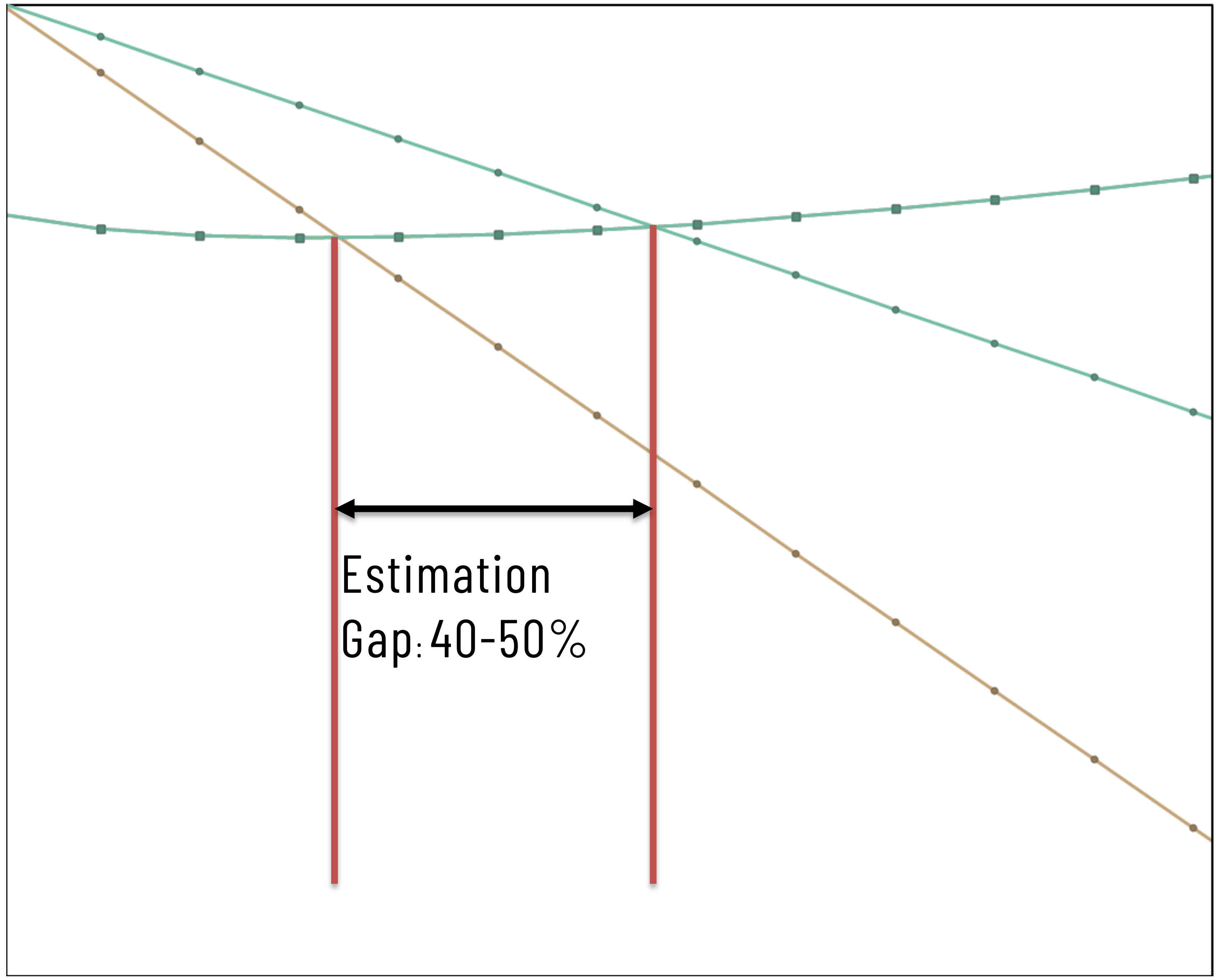

- Sub-seismic faults act as a "damage zone" and create a baffling effect within the reservoir, fluid flow is more torturous reducing the effective permeability

- A significant impact on the estimated well productivity and production rate ~ 50%.

Learnings

- Perforation Modelling is sensitive to subsurface uncertainties (stress, permeability and reservoir pressure)
- Faults can introduce hidden effective permeability impairment and perforation tunnel clean-up.
- Permeability multiplier to be considered when faults are suspected
- Accounting for subsurface uncertainties in perforation modelling assists in estimating perforation tunnel clean up, predicting well potential and preventing unnecessary re-perforation – saving cost and exposure.

QUESTIONS?

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