

IPS 2024



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

Model Data

Options Layers Log Data Completion Gravel Pack

Lp Correlation Type Synthetic

Calculate Non-Darcy Skin Yes

Activity New Well

Well Type Deviated

Inflow Equation Fetkovich

Log Data Input Porosity & Permeability

Perforating Method Single Run

Invasion Method Calculate invasion

Sanding Model None

Crushed Zone Model Entered

Lower Completion Type Cased and Perforated

Pressure Transform Pressure Squared

Use Downhole Standoff Yes

Enter Gun per Layer No

Use SPOT IPR Extensions Yes

Input Phase Ratios No

Deviation Survey

Invasion Calculation Inputs

Drilling Fluid Weight

Total Drilling Time

Downtime

QinetiQ Sanding Model Inputs

Sand Particle Diameter

Sand Density

Perforation Angle

Perforation Wall Roughness

Crushed Zone Inputs

Permeability Factor

Thickness

Downhole StandOff

Downhole StandOff

Options Layers Log Data Completion Gravel Pack

Well Radius inches

Drainage Radius feet

Perforation Efficiency fraction

Select Gun

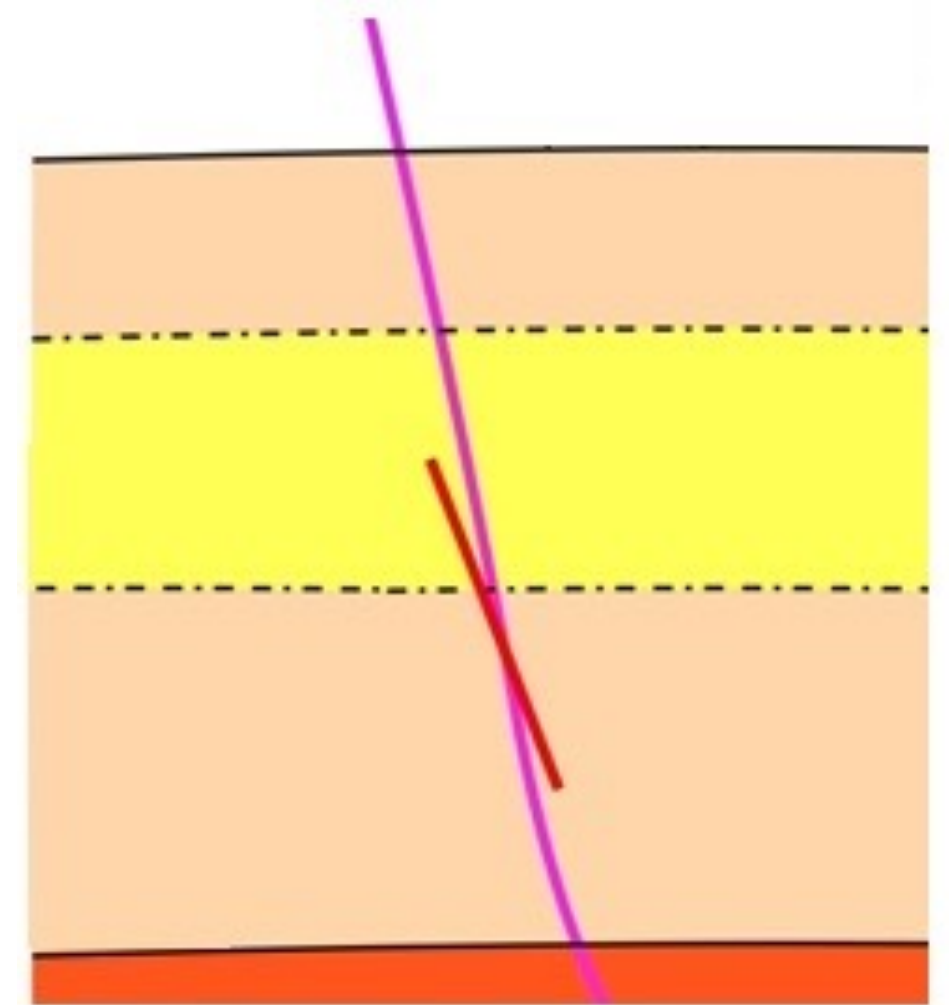
	Top MD	Bottom MD	Layer Pressure	Under Balance Pressure	Overburden Pressure Gradient	Water Saturation	Relative Permeability	Invasion Data	Bottom Hole Temperature	Kv/Kh	Downhole Rock Type
	feet	feet	psig	psi	psi/ft	fraction			deg F		
1							Edit	Edit			Sandstone

Options Layers Log Data Completion Gravel Pack

	Measured Depth	True Vertical Depth	Porosity	Permeability	UCS	TWC	Perforated
	feet	feet	fraction	md	psig	psig	
1							<input type="checkbox"/>
2							<input type="checkbox"/>

Modelling Potential Well Performance

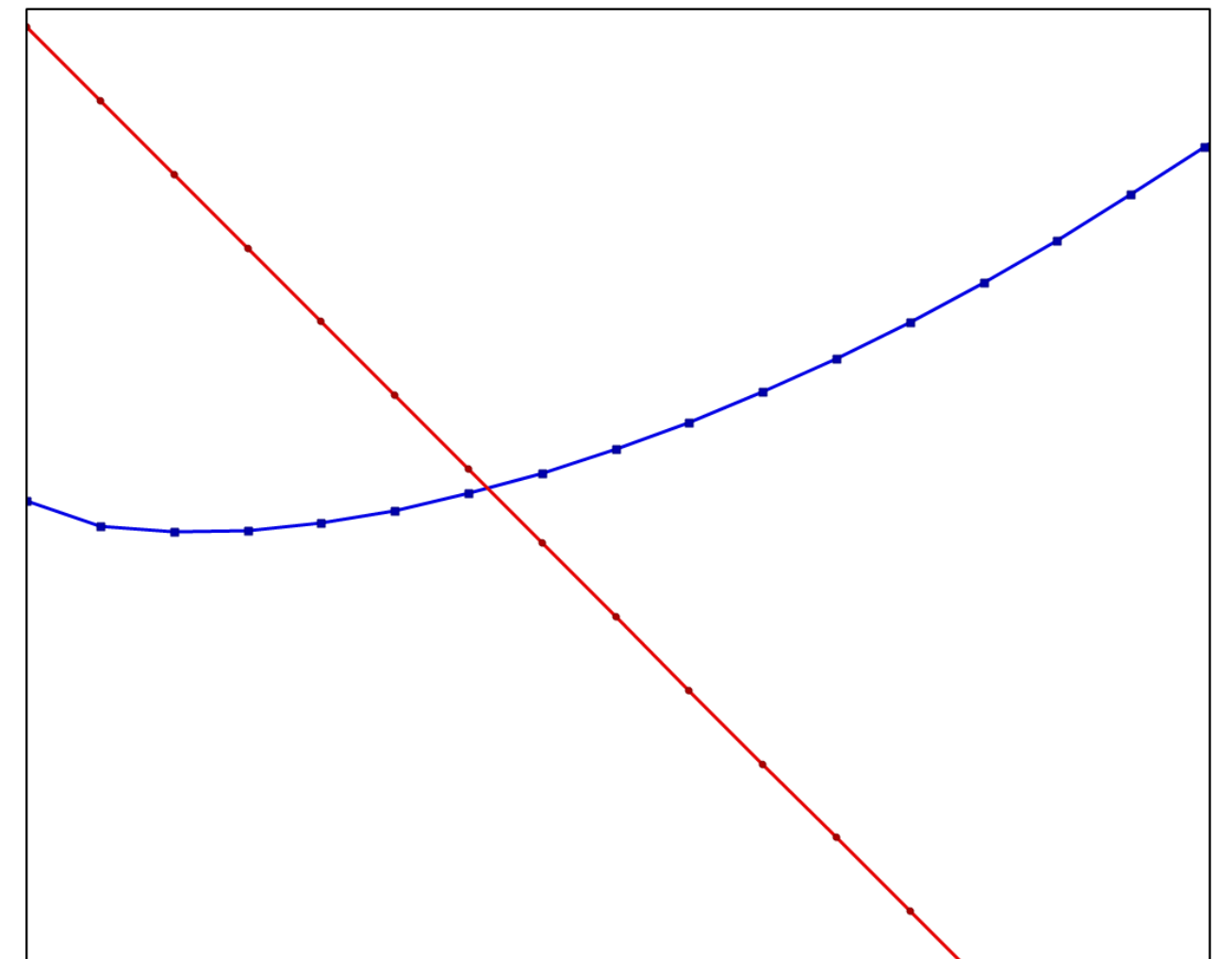
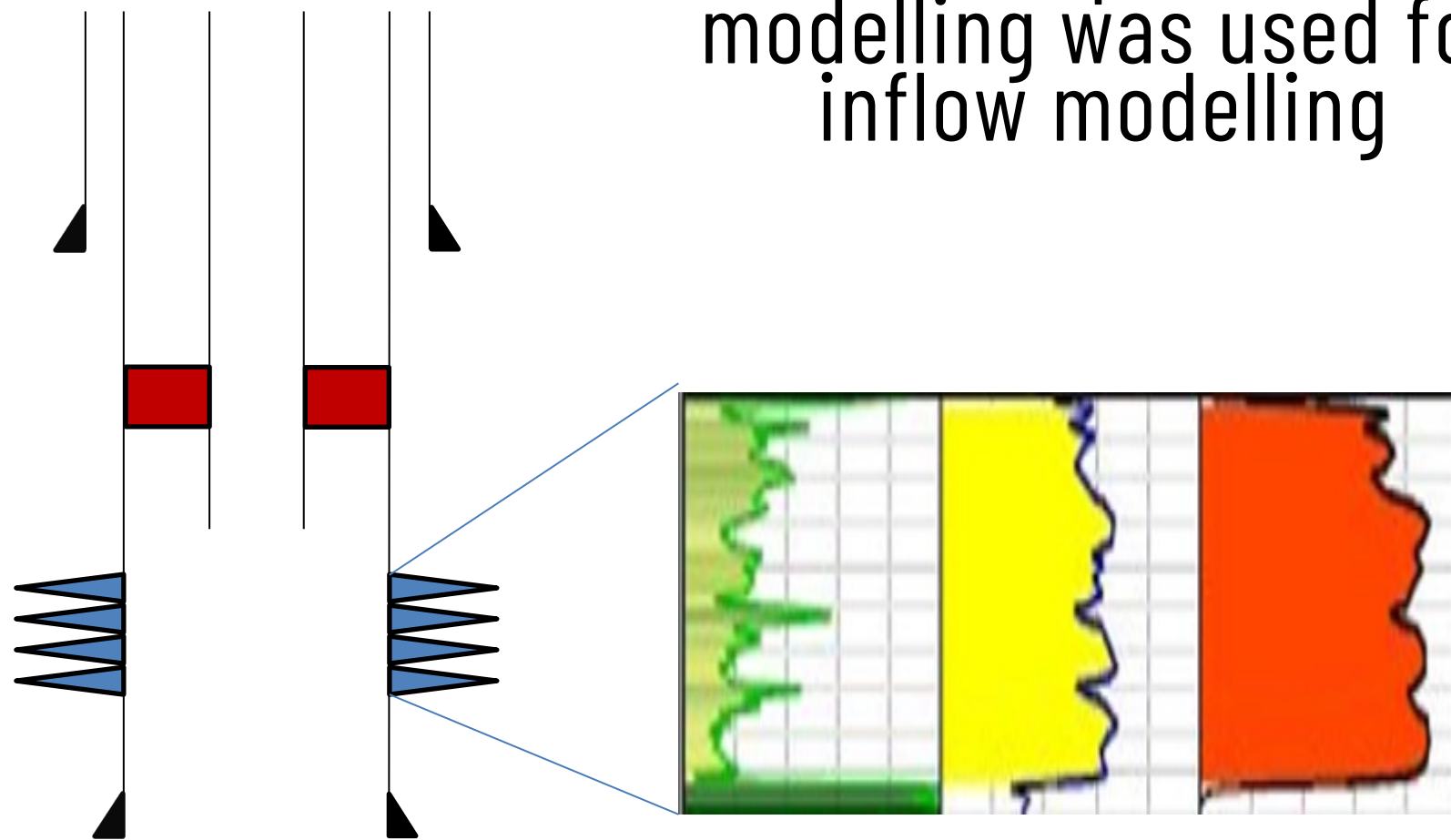
- A deviated well was drilled intersecting a fault deeper than the zone of interest.
- The fault is seismically visible and expected.
- Analogue log from a neighbouring well is available for reservoir properties.
- The well was designed as a cased and perforated well completed with a packer
- 4.5" TCP 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.

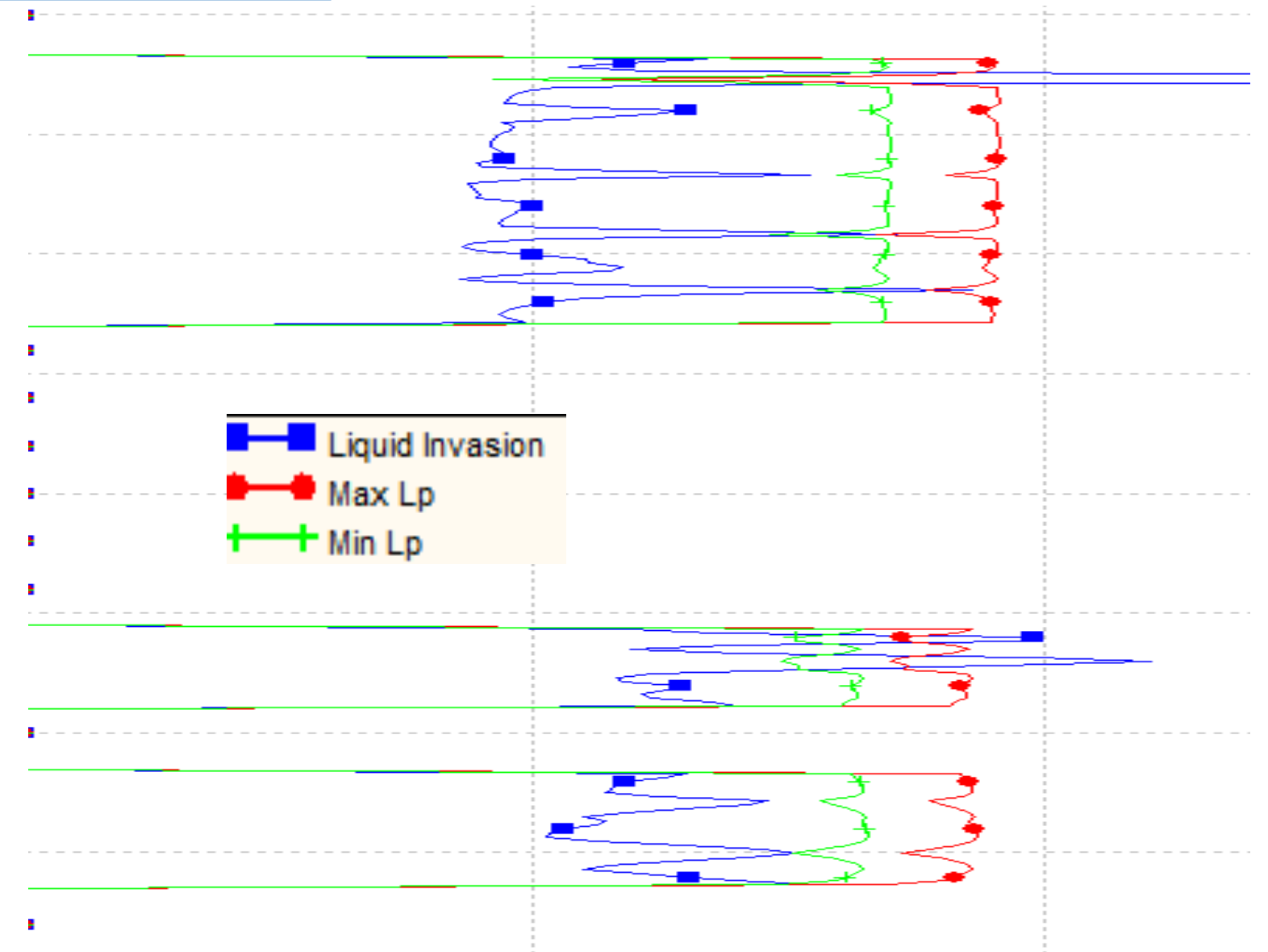
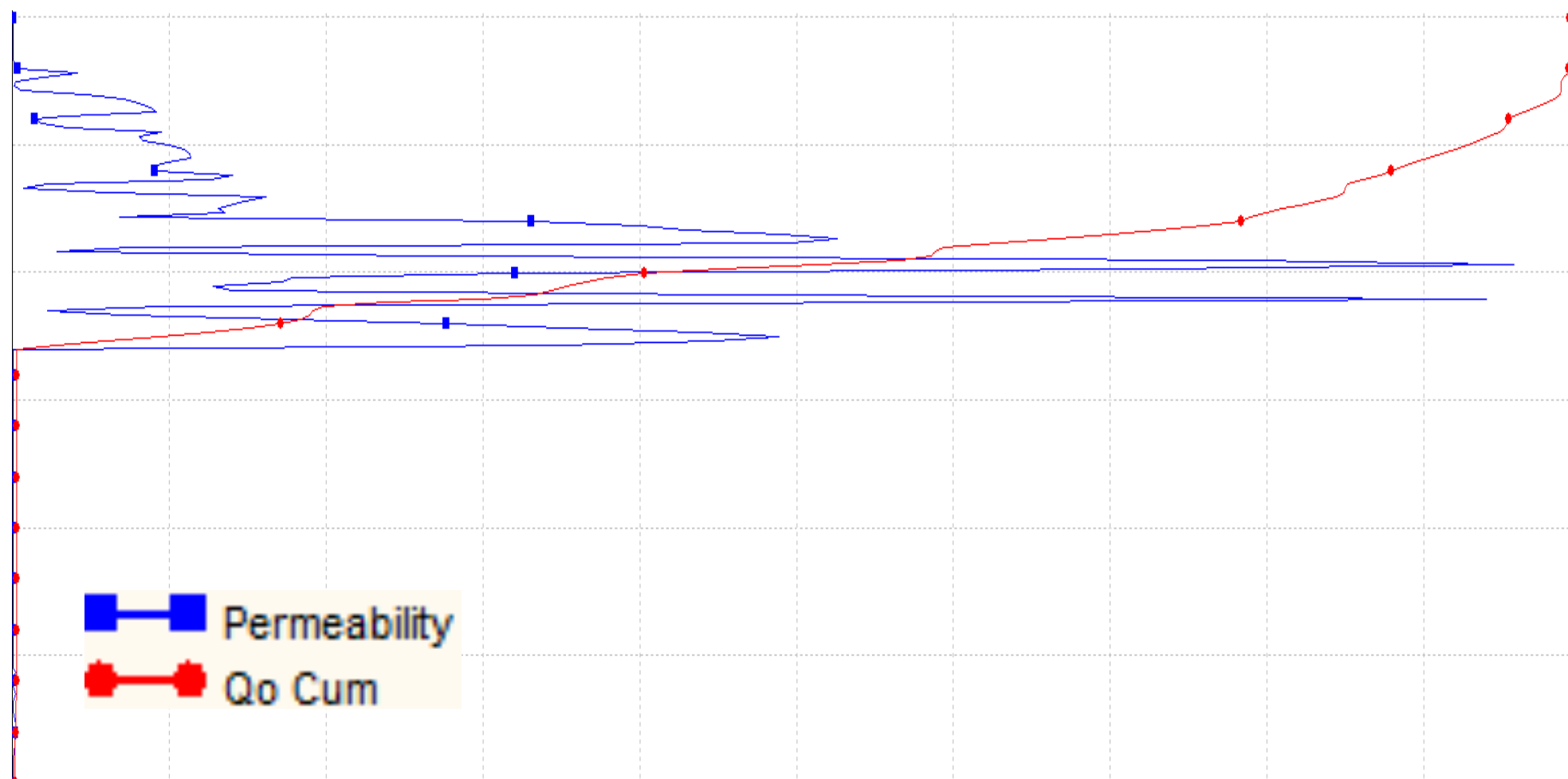
A detailed perforation modelling was used for inflow modelling



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.

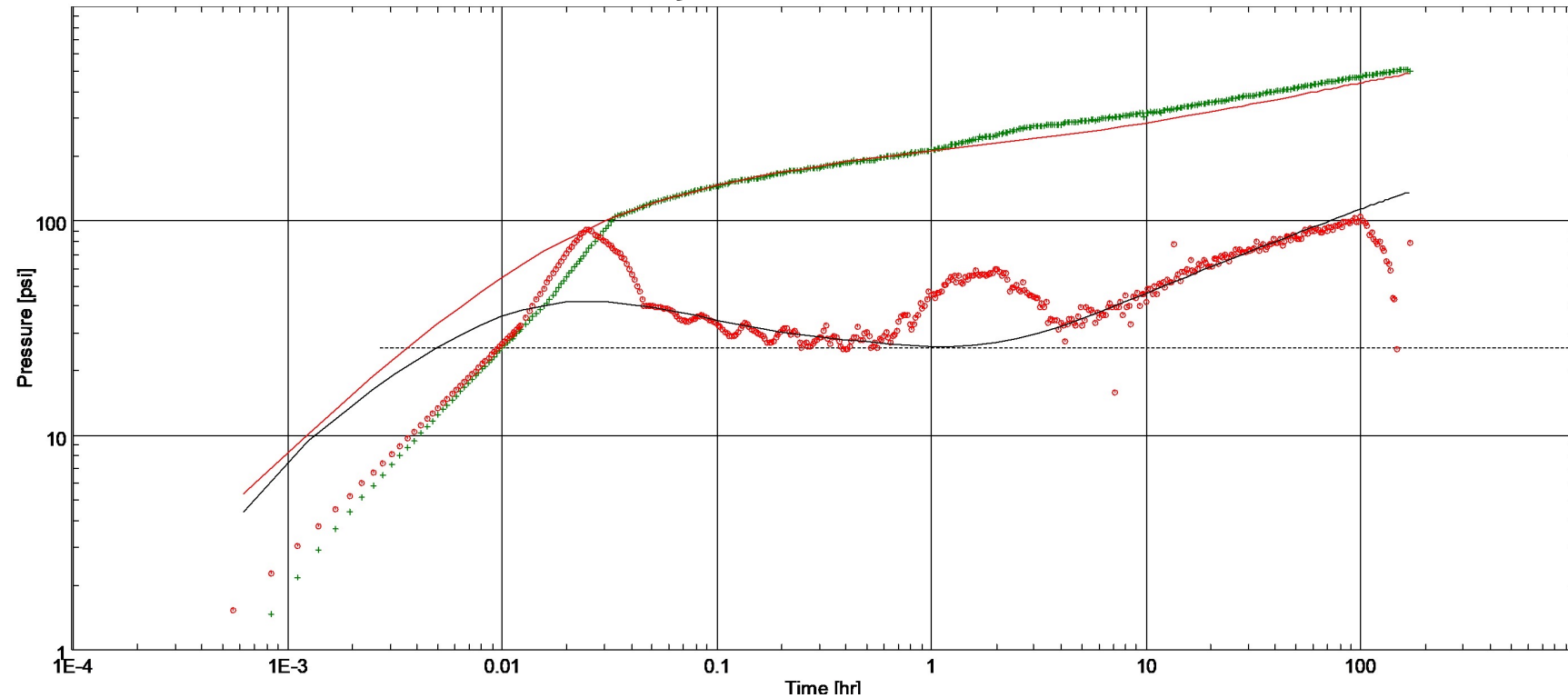


- Production and productivity are calculated based on their reservoir properties, invasion depth and DOP.
- Flow plotted as a pseudo PLT that shows zonal contributions.

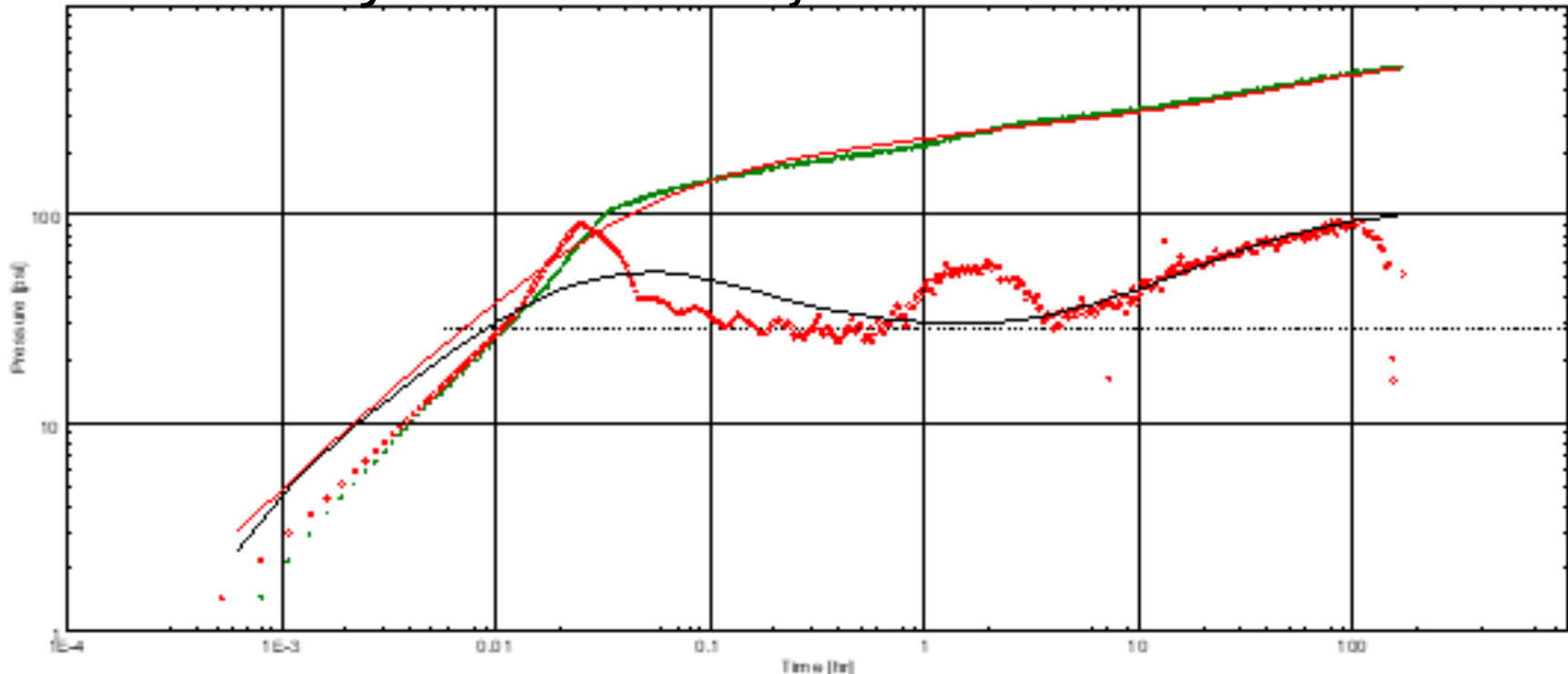
Matching With Pressure Transient

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.

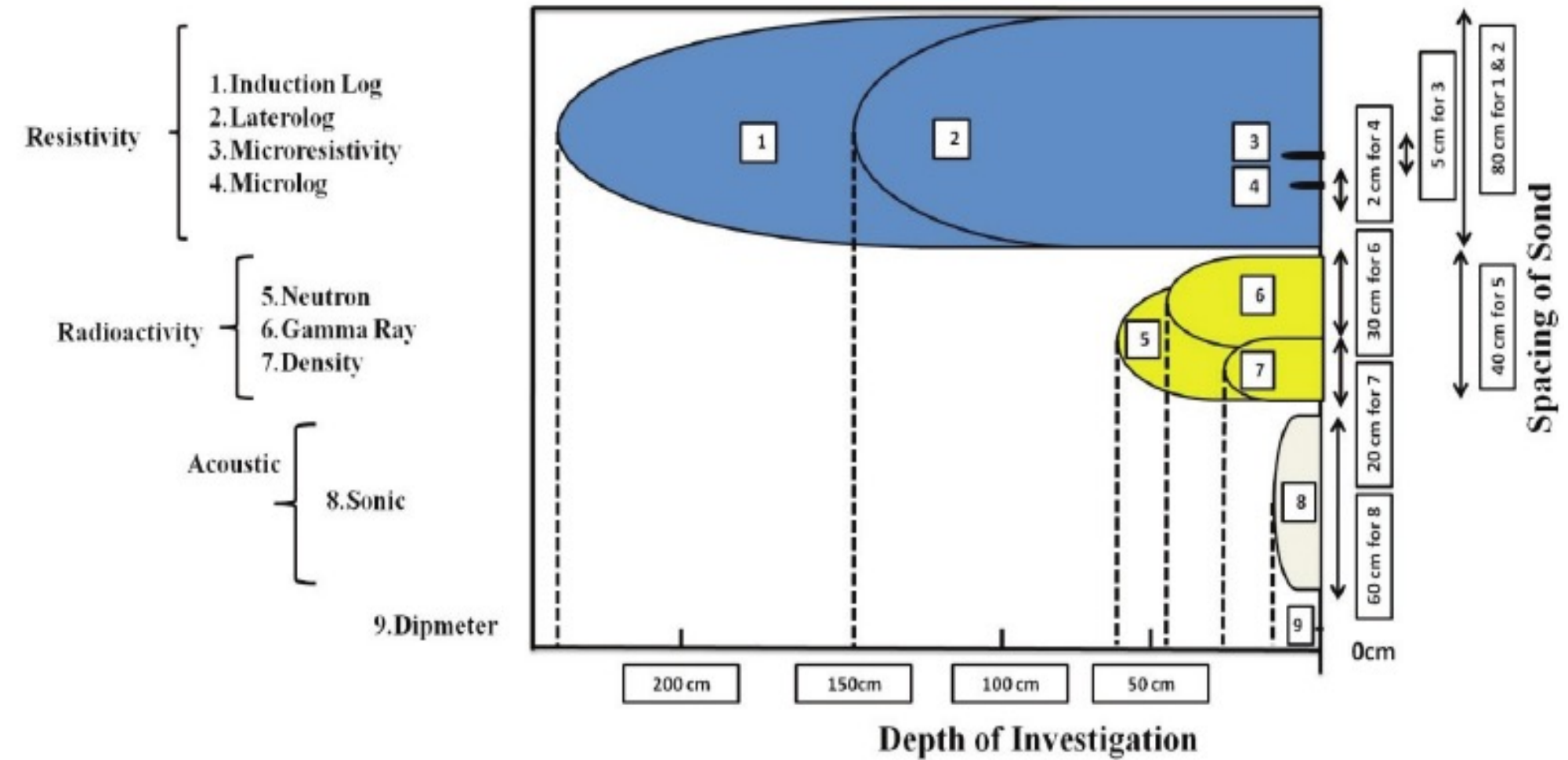
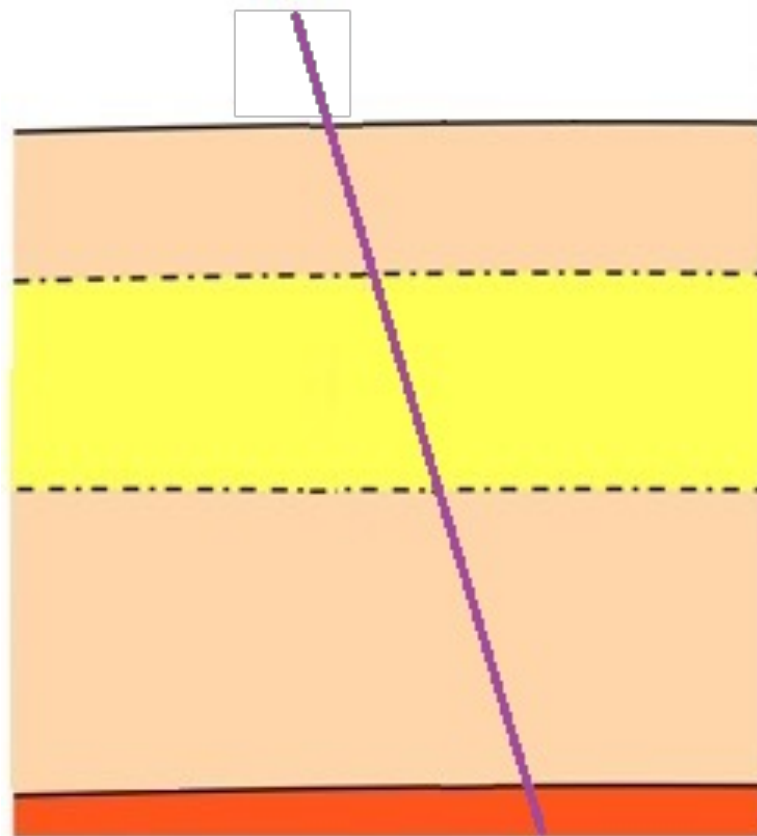


Image Citation: Mazaheri, atie & Memarian, Hossein & Tokhmechi, Behzad & Araabi, Babak. (2015). Developing Fracture Measure as an Index of Fracture Impact on Well-Logs. Energy, Exploration & Exploitation. 33. 555-574. 10.1260/0144-5987.33.4.555.

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.

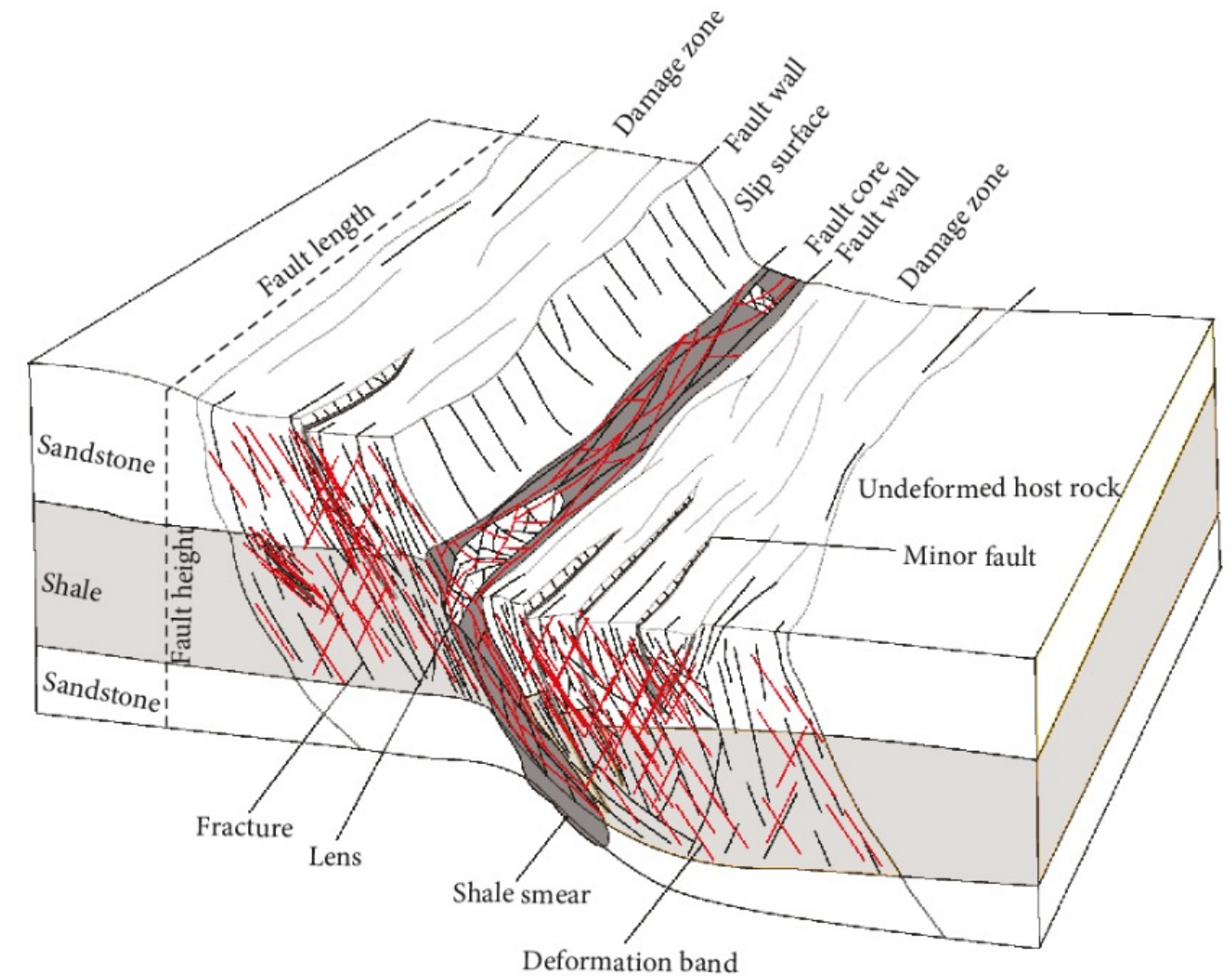
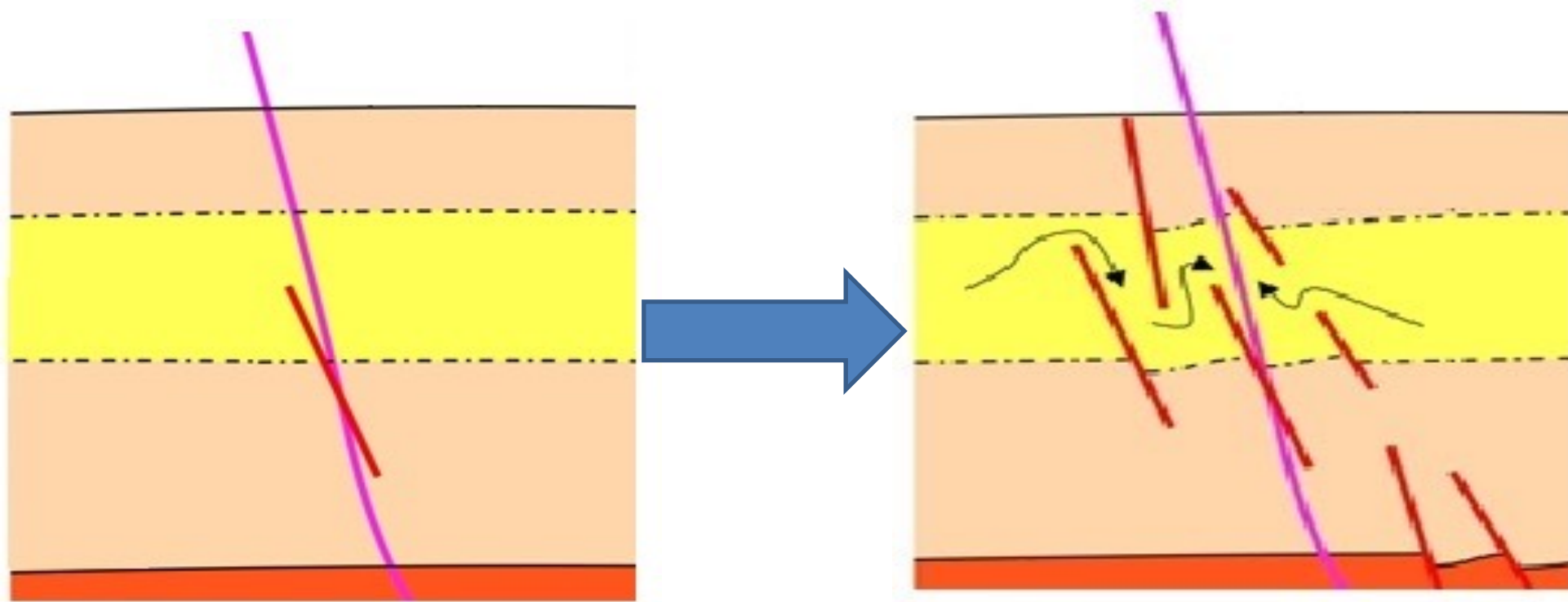


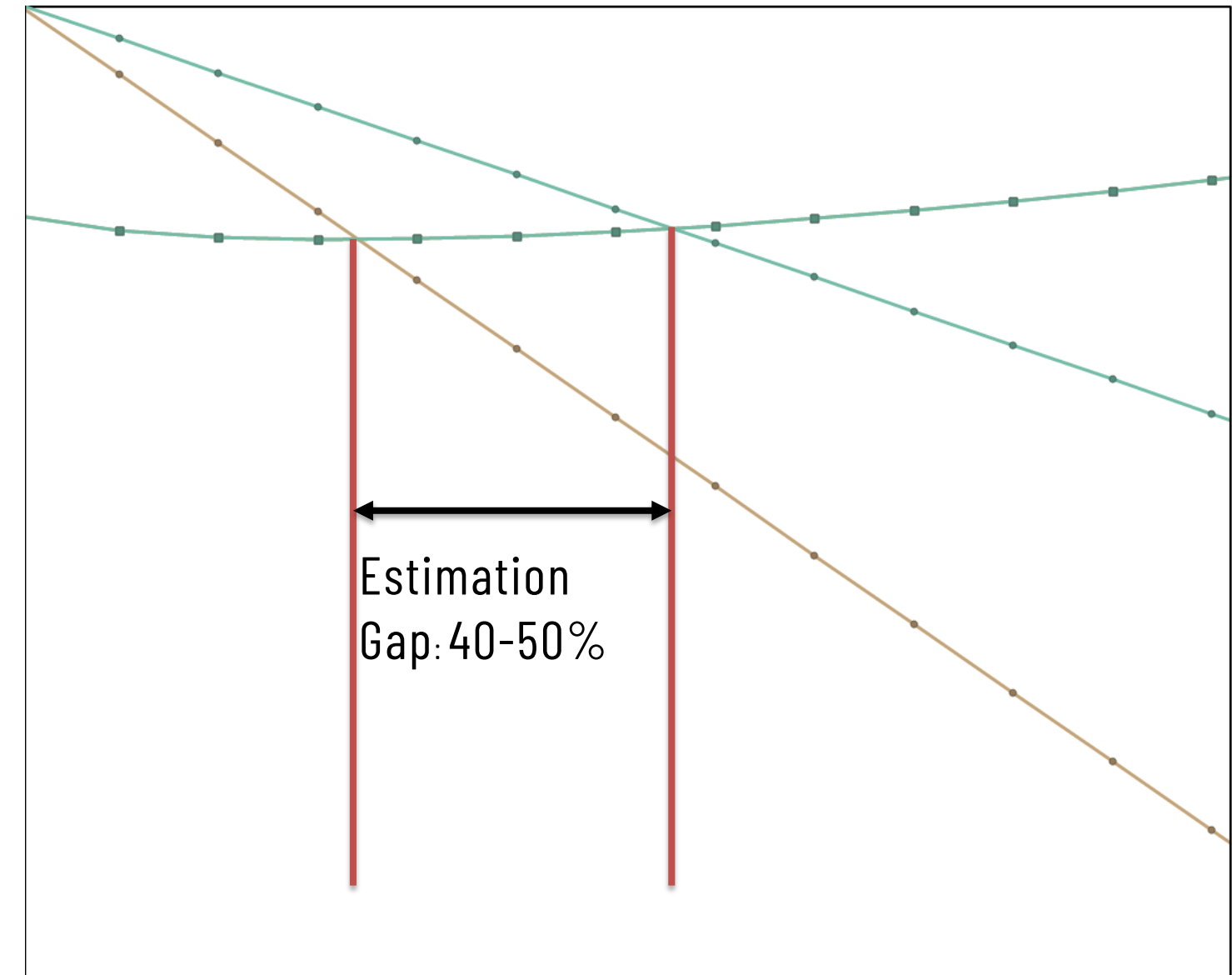
Image Citation: A. Torabi, M. U. Johannessen, T. S. S. Ellingsen, "Fault Core Thickness: Insights from Siliciclastic and Carbonate Rocks", *Geofluids*, vol. 2019, Article ID 2918673, 24 pages, 2019. <https://doi.org/10.1155/2019/2918673>

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?

MAY 13-15



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