Research Summary

Pressure Dependent Fracture Permeability

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Scope of Research

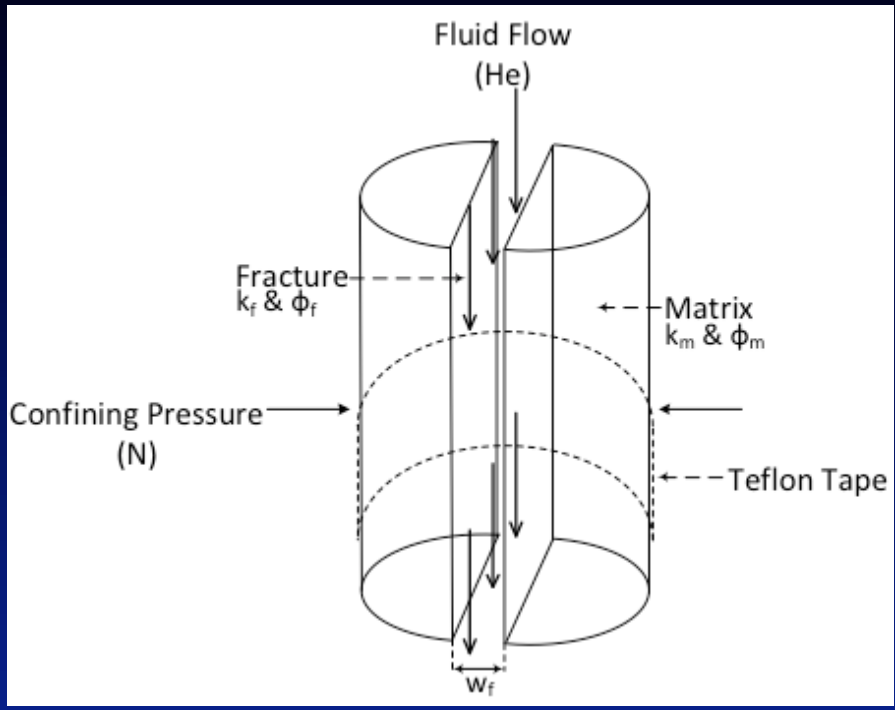
- Study the effect of pressure-dependent natural-fracture permeability on the productivity of shale reservoirs
  - Collect experimental data and information about the effect of stress sensitivity on natural-fracture permeability in shale
  - Develop practical correlations (as a first order approximation)
  - Incorporate pressure-dependent permeability correlations in trilinear model to assess the effect on productivity

Experimental Study

Middle-Bakken core samples (from 9,026 ft)

Measurements by CMS-300 Automated Permeameter (Core Labs, 2012)

To simulate natural fractures cores were cut vertically at the center

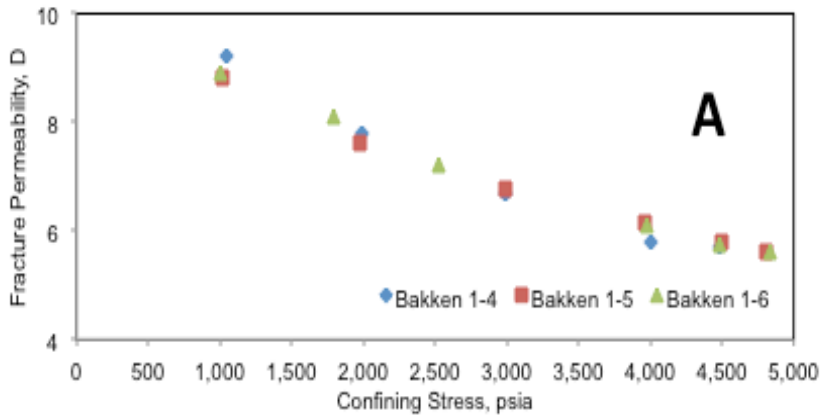


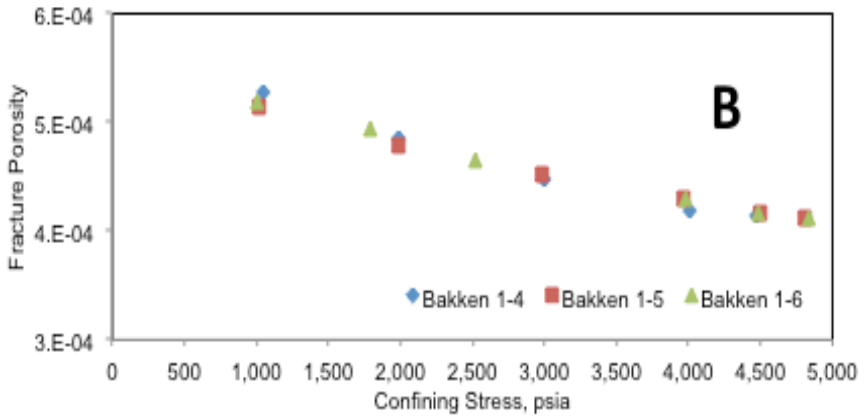
The cores were then held together with Teflon tapes.

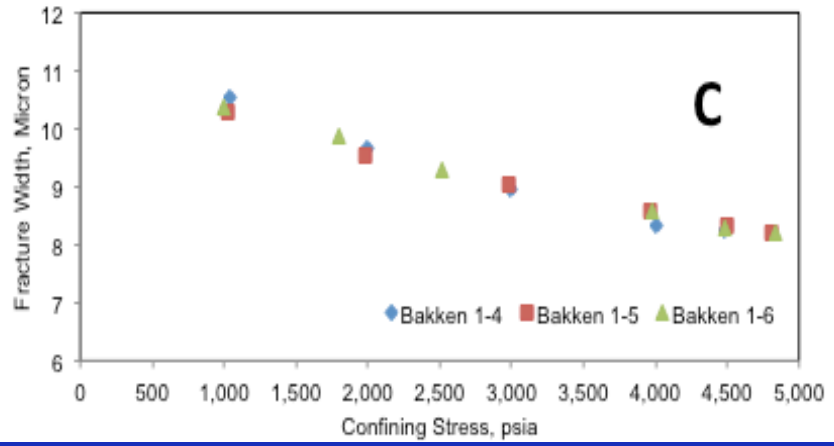
Confining stress was increased gradually from 1,000 psi to 5,000 psi by 1,000-psi increments to study the effect of stress on fracture closure.

Results

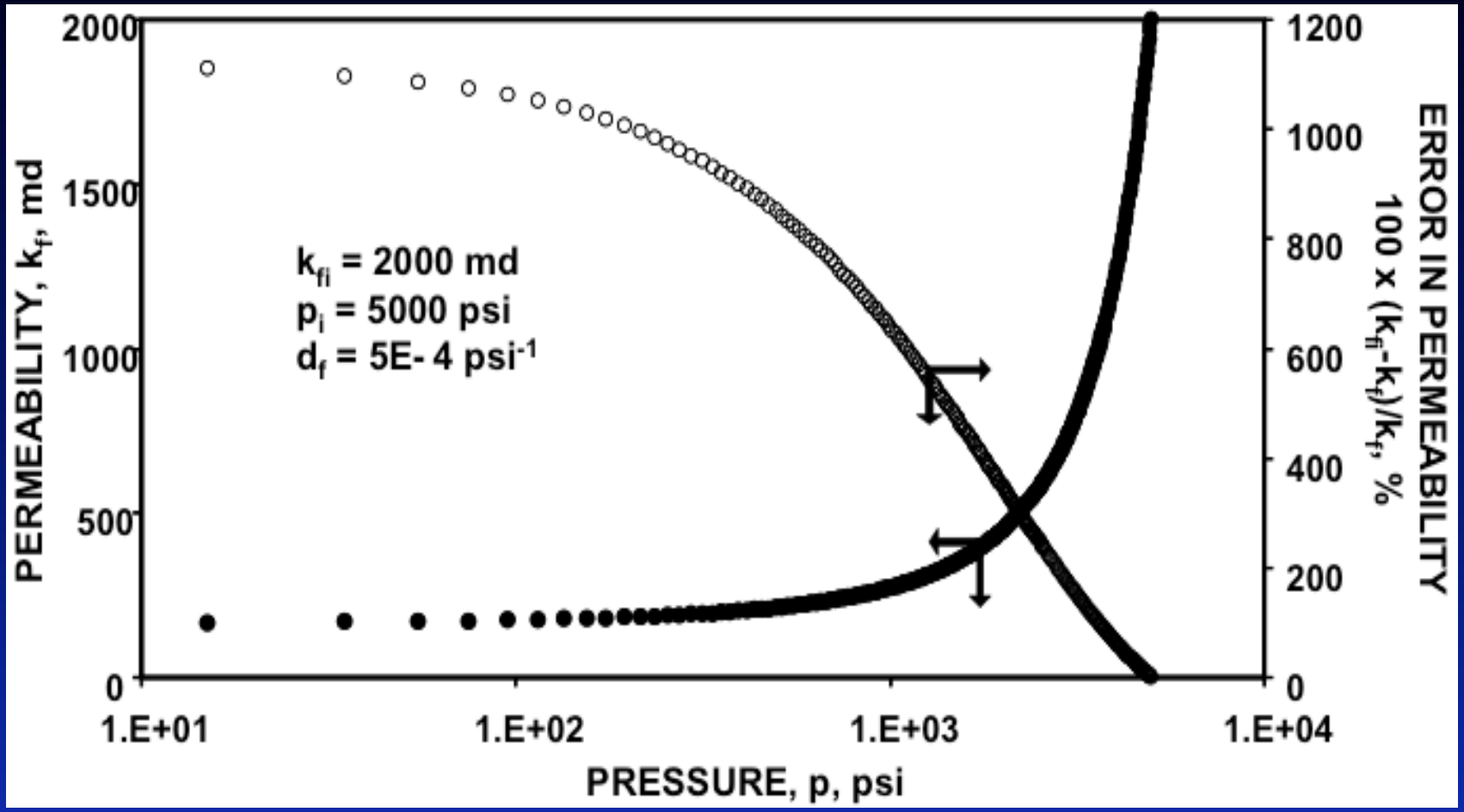
Bakken Core 1







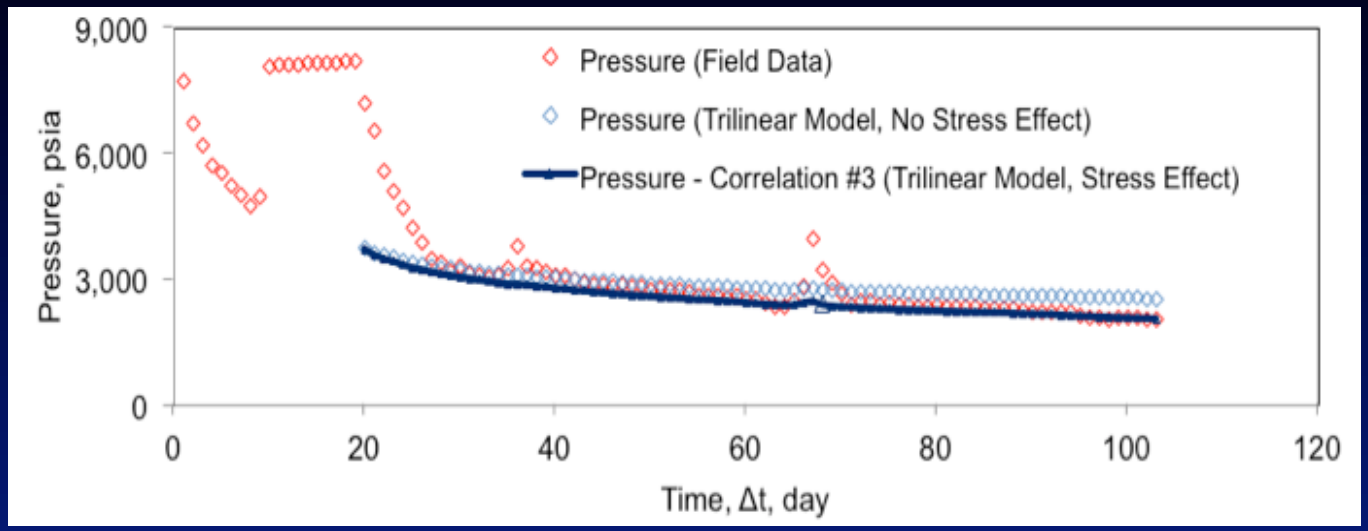
Example Correlation



Significant permeability reduction early on but stabilization around 200 md.

Do we need more than 200 md?

Pressure History Match Results

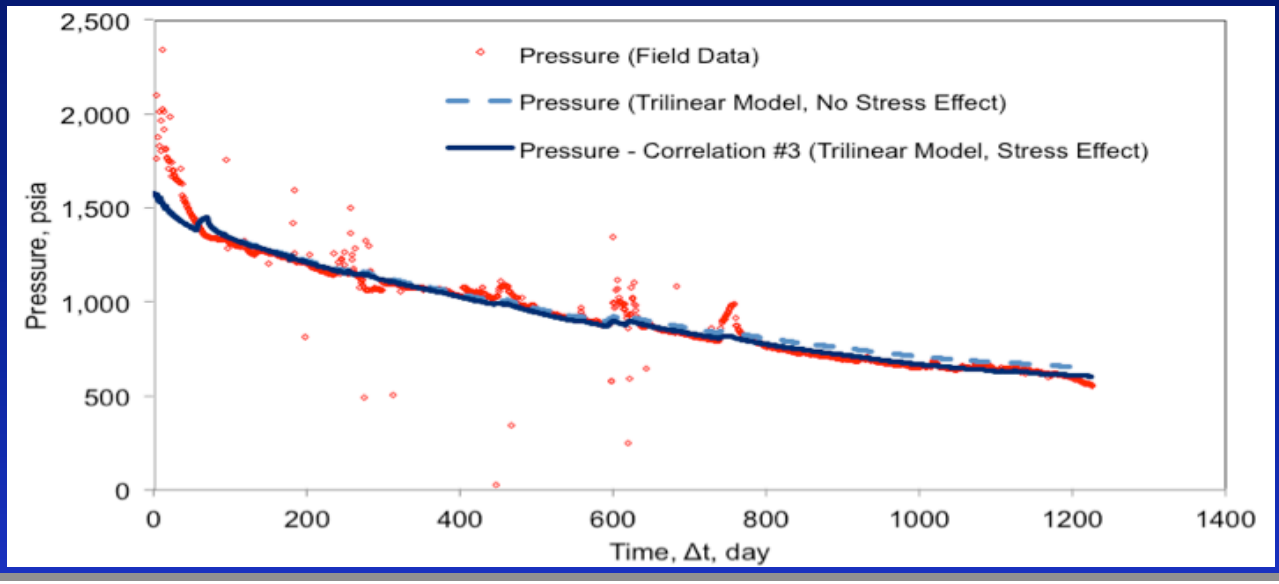


Haynesville shale-gas well (Wang and Liu, 2011)

Some effect

Barnett shale-gas well (Anderson et al., 2010)

No effect



Results

The results of this work indicate the following:

1. **Unpropped natural fractures lose a significant portion of their initial permeability under pressure depletion.**

2. **However, the permeability which is retained in the fractures may still be very large compared with the shale-matrix permeability (infinite-conductivity fracture effect) and sufficient to transmit the limited volume of fluid available to flow**

3. **Hence, fracture closure with pressure drop should not be used to infer the productivity loss as pressure drops without considering the complex interactions between the natural fractures and shale matrix**