

THE CHALLENGES IN MEASURING PERMEABILITY AND HYDRAULIC HEAD AT DEPTHS EXCEEDING ONE KM

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Intact Crystalline Rock

- Despite regional measurements showing high k , locally the k maybe much lower.
- Many measurements on core from locations around the world.
- Typically range from 1×10^{-18} to 1×10^{-21} m².
- Significant paucity of in-situ measurements particularly at depths > 500 m.

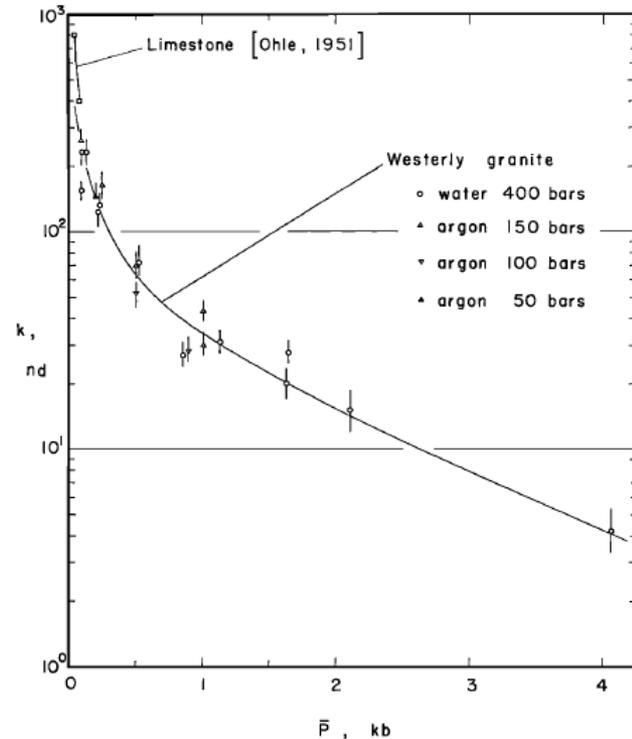
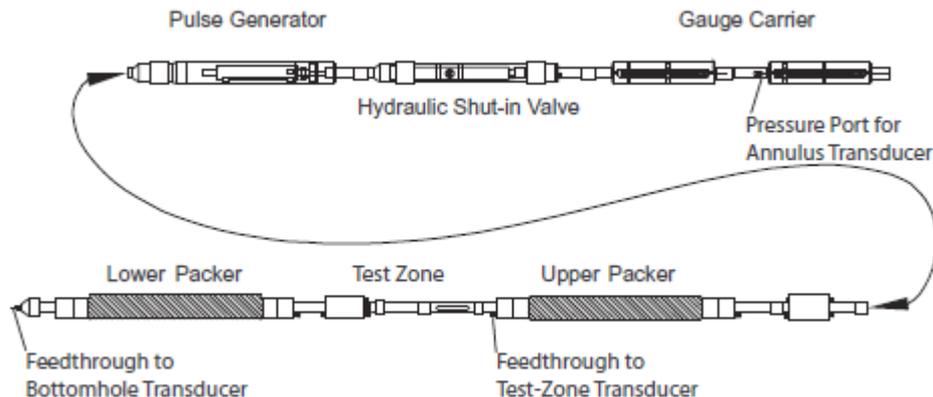


Fig. 5. Permeability k as a function of effective confining pressure \bar{P} . Length of short bars indicates probable error for each measurement.

(Brace et al., Permeability of Granite under High Pressure, JGR, 1968)

Measuring k In-Situ

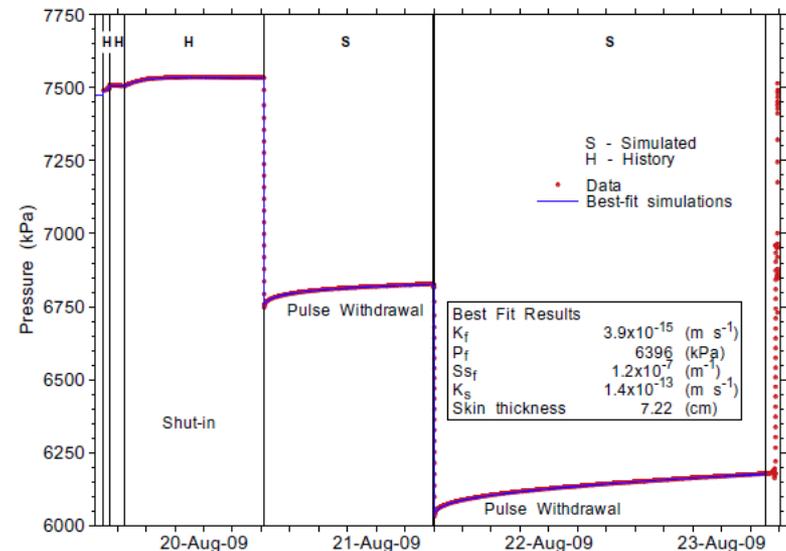
- Possible methods include DST, slug tests, and pulse tests all conducted using straddle packers to isolate zones.
- Testing is influenced by:
 - Wellbore skin effects;
 - Compressibility of the test section;
 - Borehole pressure history;
 - Temperature conduction through the equipment, and other effects.



(Beauheim et al., Journal of Hydrology 509 (2014) 163–178.)

Challenges in k Measurement

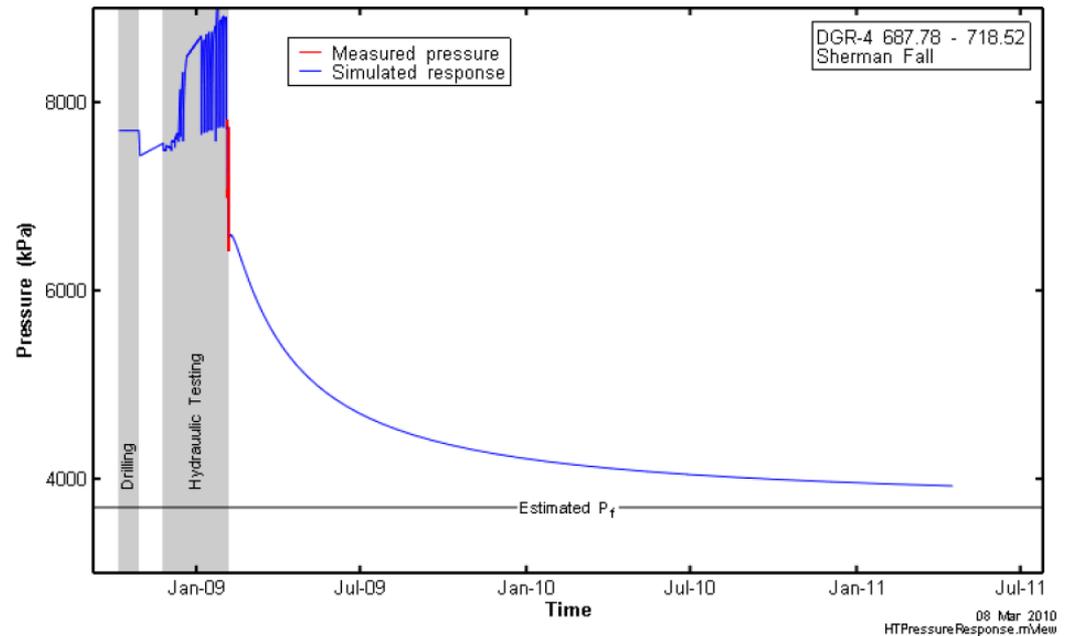
- Experience in North America and Europe measuring $k \geq 1 \times 10^{-22} \text{ m}^2$ at depths $< 1 \text{ km}$ in boreholes and mine access.
- Challenges specific to the Deep Borehole Disposal Program:
 - Depth – small-diameter tubing support may not work;
 - Hole quality – deformation may make testing difficult (ie artificially raise pressure in test section);
 - Large bottom hole size, particularly for Borehole Emplacement Test;
 - Time – there is a need for contiguous measurements;
 - Borehole should be inclined.



(Beauheim et al., Journal of Hydrology 509 (2014) 163–178.)

Challenges in Pressure Measurement

- Possible methods include measurement during hydraulic testing, grouted-in transducers, and permanent multi-level casing.
- Recent results show that measurement during hydraulic testing can be reliable for both under pressured and over pressured conditions at low k .



(Sterling and Raven, DGR Site Characterization Document, TR-08-31, 2011)

Conclusions and Recommendations

- Possible to conduct in-situ tests at the depths required but not a lot of experience.
- Several challenges not the least of which is time.
- In order to establish the presence of zones of very low permeability, contiguous in-situ measurement is required.
- Consideration should be given to incline the characterization borehole, so that sub-vertical structure can be targetted.