



borehole geophysics / hydrophysics

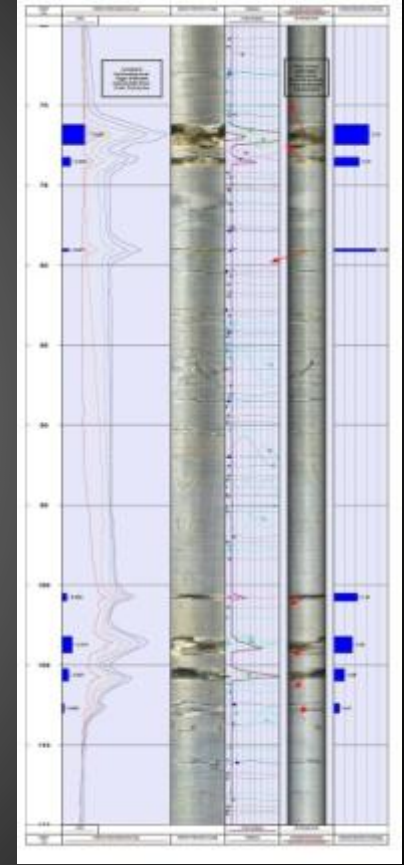
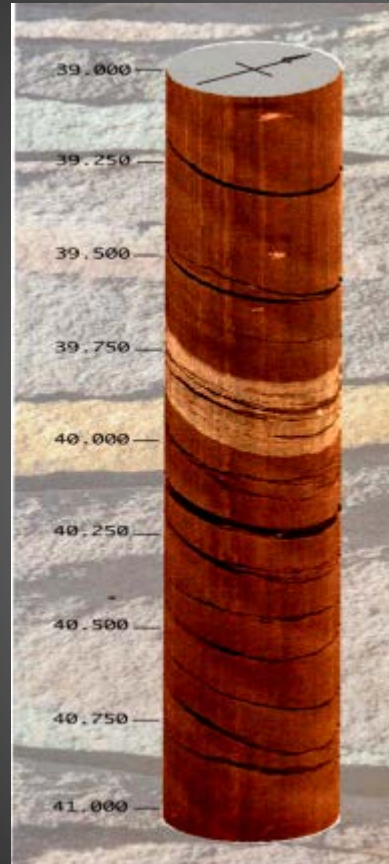
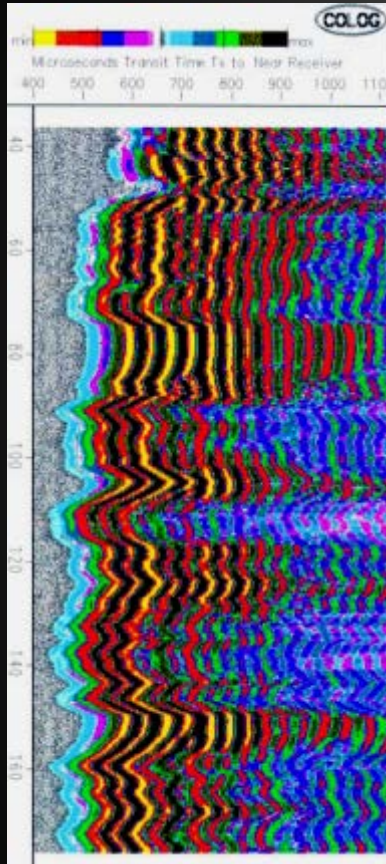
NMR and Microresistivity Logging are Bridging the Geophysical Data Gaps in Brine-Rich Environments

Presented to the Arizona Hydrological Society Symposium
September 14, 2023

OUTLINE

- What is Borehole Geophysics?
- Challenges of brine-rich environments
- Logging techniques ideal for Brine-rich environments
 - Microresistivity
 - NMR
- Sample data

Borehole Geophysics



Science of recording and analyzing measurements of physical properties made in wells or test holes

Borehole Geophysics

- why log?

- delineation of hydrogeologic units
- obtain information on rock lithology and fractures
- understanding subsurface conditions related to ground water flow
- provide measurements of porosity and permeability
- determination of well construction and conditions

Borehole Geophysics

Key Uses:

- **Create a complete geophysical model**
 - Utilize entire borehole for core orientation recovery
 - Minimize impact of poor ground conditions
 - No gaps in orientation data
 - Enhance characterization of geophysical model
- **Formation identification**
 - Mineralization/Staining
 - Porosity and Permeability
 - Rock Strength
- **Environmental Studies**
 - Dewatering
 - Groundwater Flow/Contaminant Plume Tracking

Borehole Geophysics

Lithium Exploration in Western Nevada



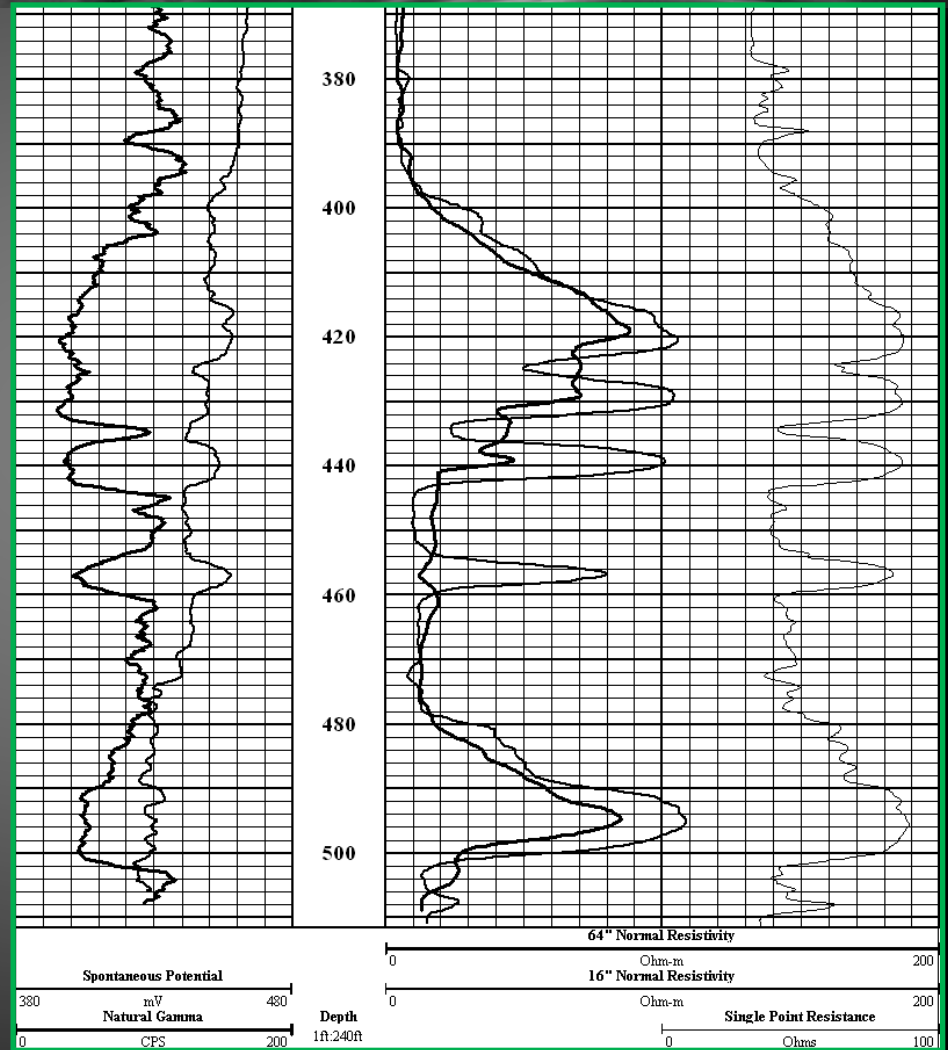
Challenges with Brine-rich Environments

- 3% to 25% salinity
- High Conductivity
 - ✓ tends to “short-circuit” traditional resistivity techniques
- High Mud Viscosity
 - ✓ Difficult or impossible to conduct traditional flow-logging or packer testing

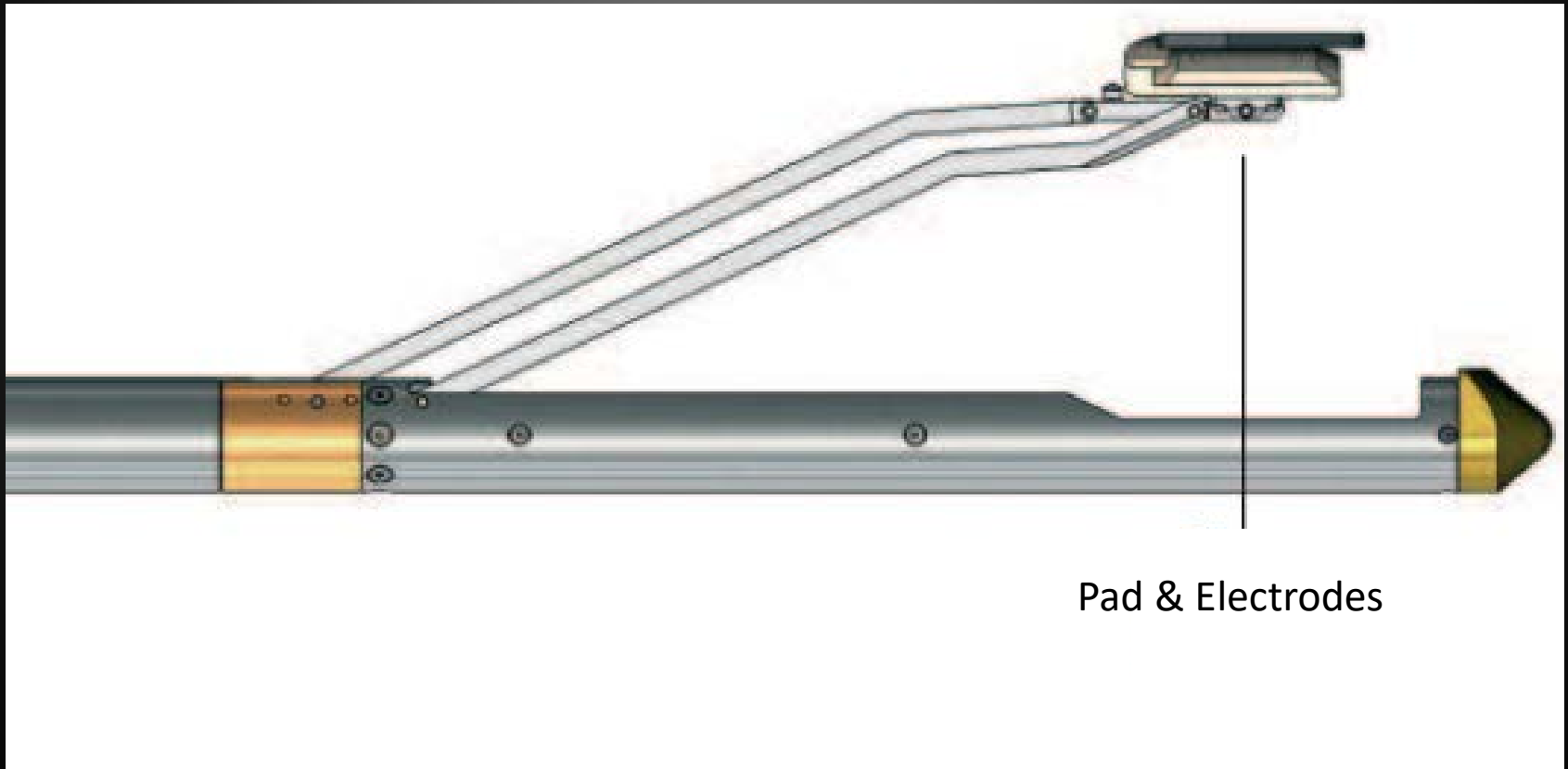


Electrical Measurements

- 16" & 64" Normal Res.
- Spontaneous Potential
- Single Point Resistance
- Induced Polarization
- Focused Resistivity
- Micro Resistivity
- 4-Arm Dipmeter



Microresistivity



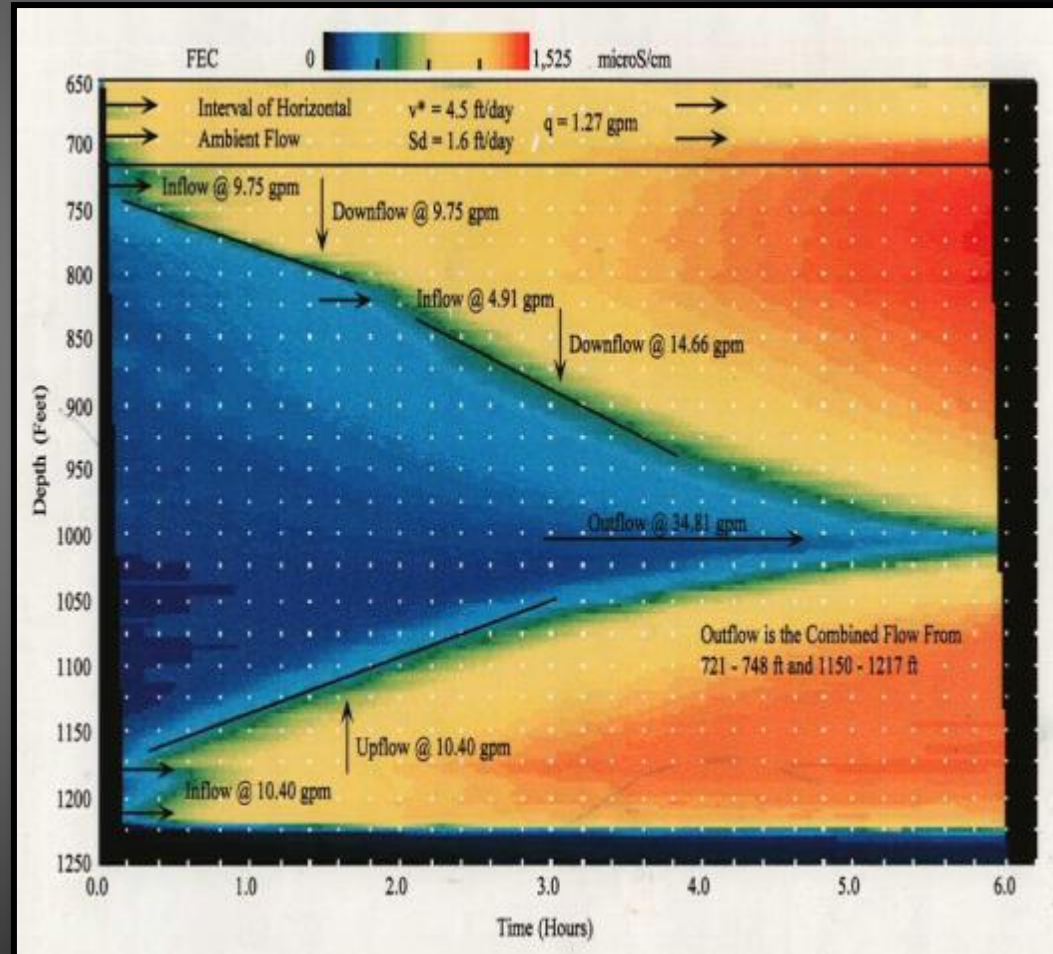
Microresistivity

- Measurement electrodes are mounted to a flexible pad.
- Single-arm caliper keeps the pad in direct contact with the borehole wall, reducing the “short-circuiting” effect.
- Excellent thin-bed resolution.
- Focused resistivity penetrates mud-cake.



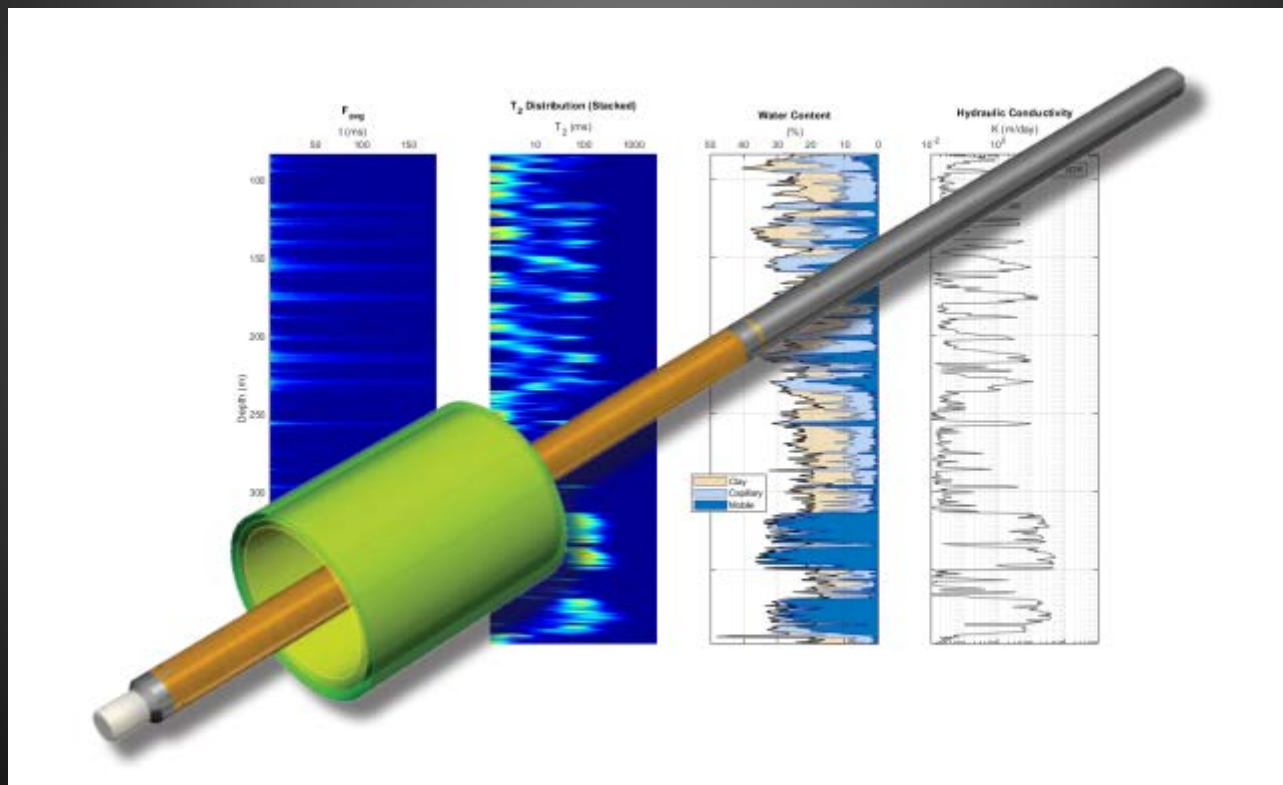
Flow Logging Techniques

- Corehole Dynamic Flowmeter (CDFM)
- Spinner Flowmeter
- Heat-Pulse Flowmeter
- Hydrophysical Logging (HpL)
- Colloidal Borescope
- Wireline Straddle-Packer Testing (WSP)



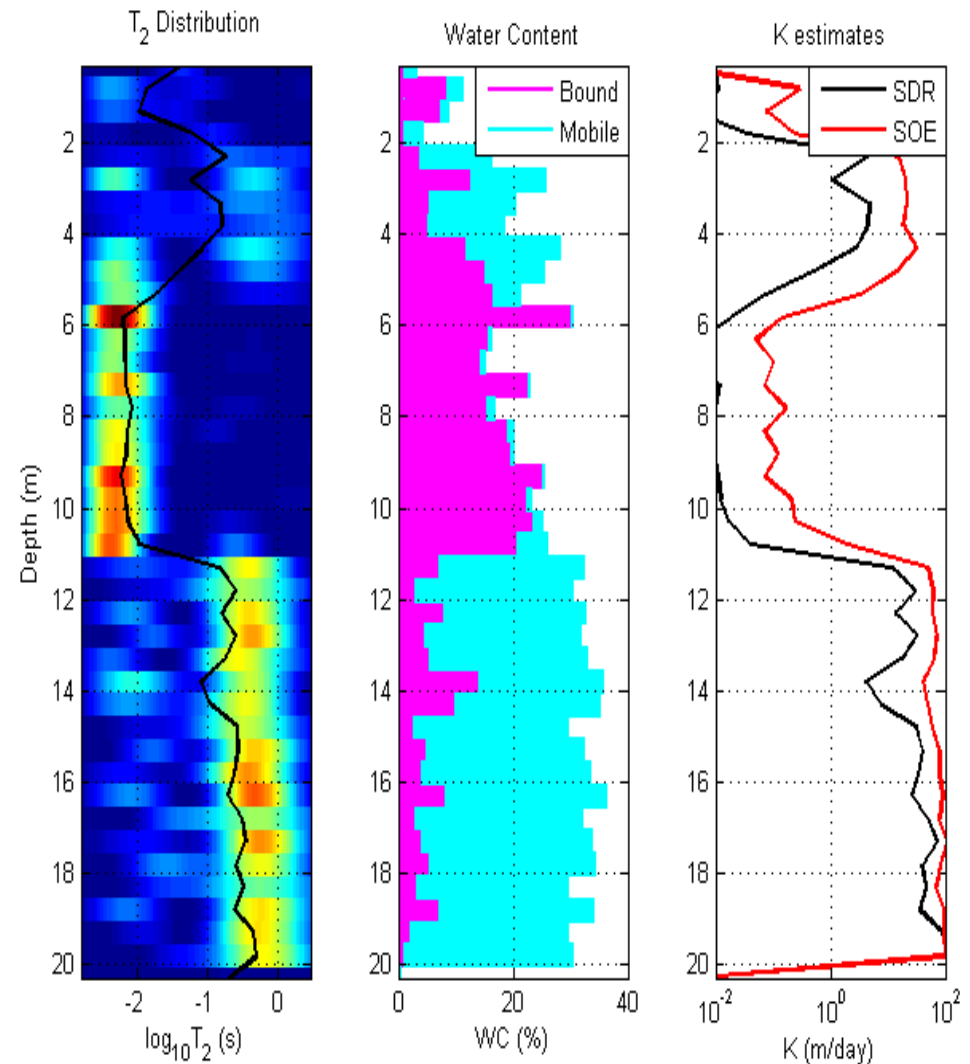
NMR Probe

Nuclear Magnetic Resonance Probe



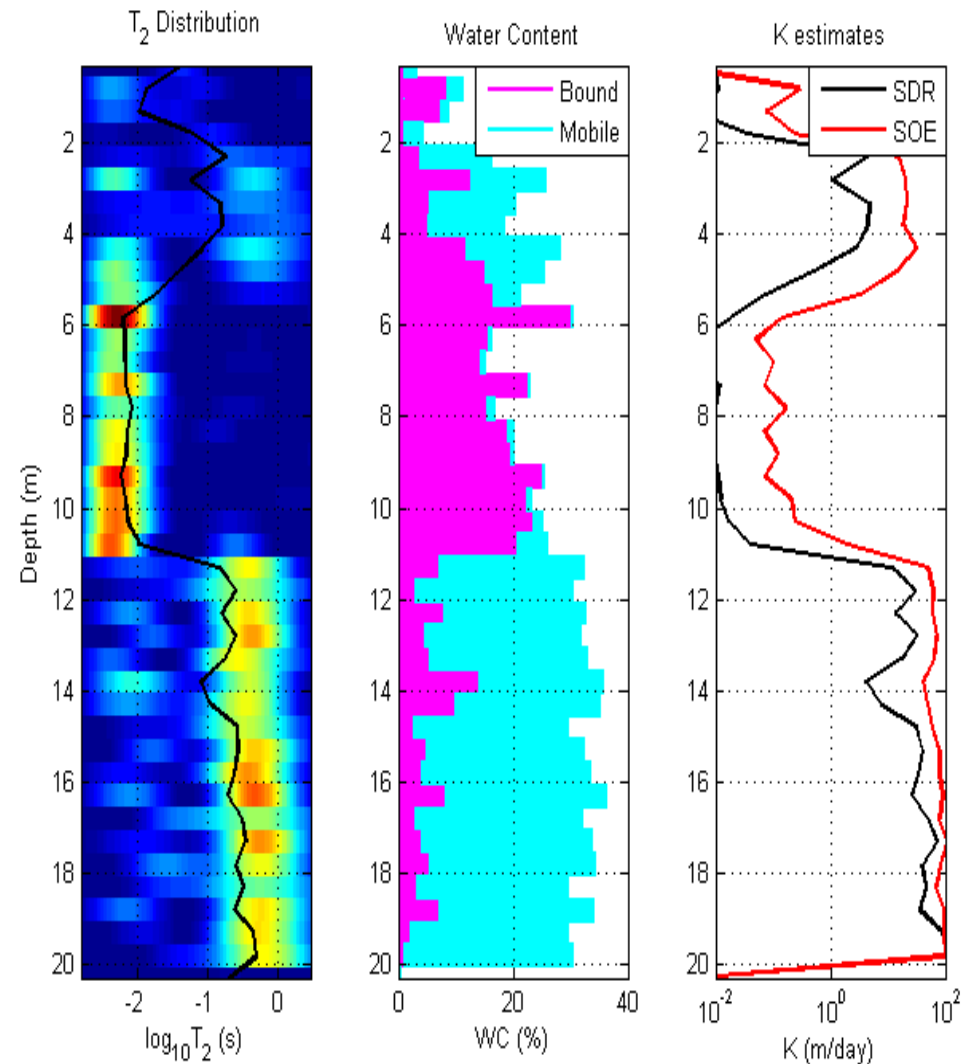
NMR Probe

- Differentiates clay-bound, capillary-bound and mobile water, determining preferential flow-pathways in sedimentary basins like lithium and potash explorations, landfills and environmental sites.
- Can “see” through PVC casing.
- No radioactive sources needed.



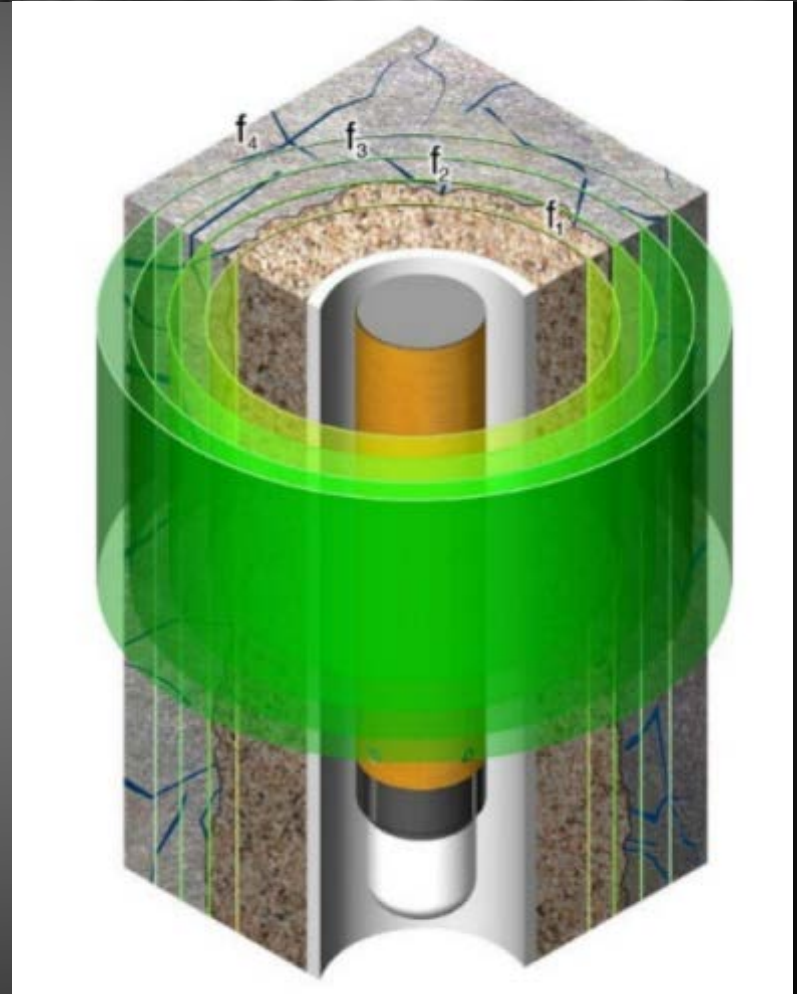
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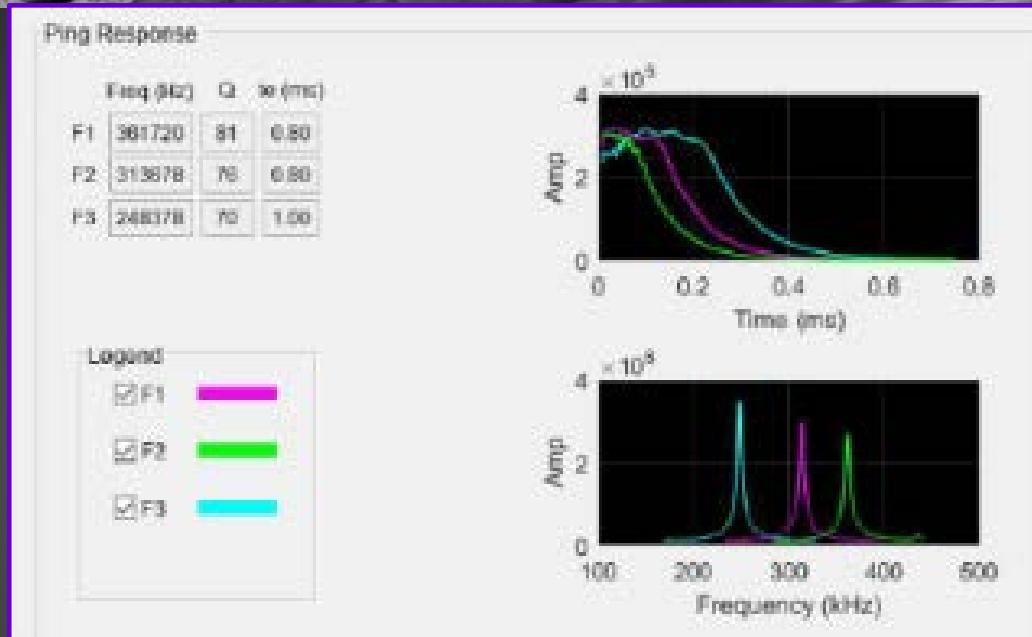


NMR Probe

- Toggle shells on/off depending on hole conditions
- Numerous frequencies allows for better signal to noise ratio
- Depths of investigations between 8 and 21 inches



NMR Probe



- Highly conductive fluids cause attenuation of the EM field, called EM Skin Effect.
- The higher the operating frequency the greater the EM skin effect.
- The Vista Clara NMR technology is designed to operate at the lowest frequency of any NMR technology.
- The Vista Clara NMR operates below the AM spectrum band, reducing foreign noise sources.

NMR Probe

The 5.25" Probe for Large Diameters



NMR Probes

3.50" Probe

5.25" Probe

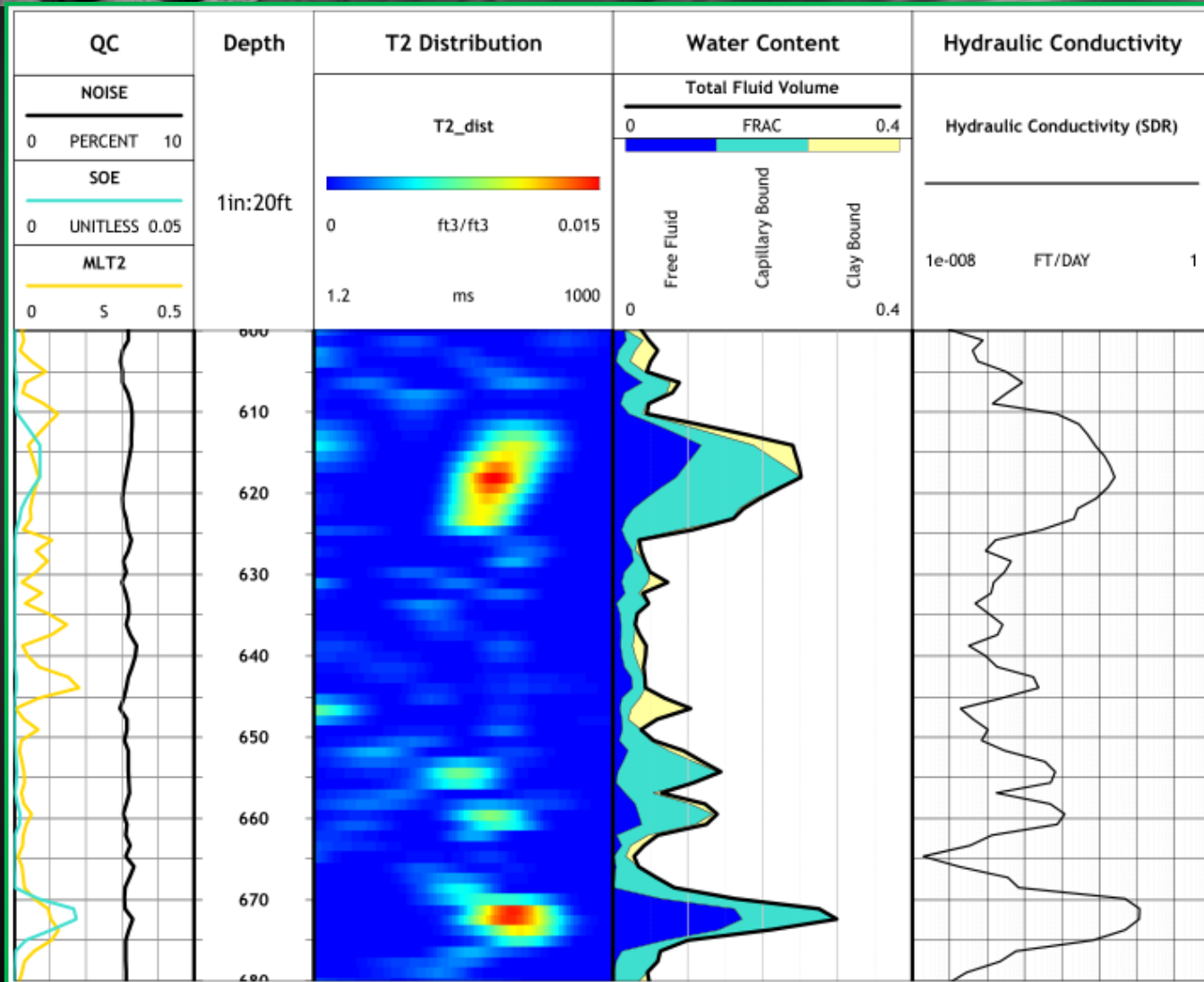


NMR Logger

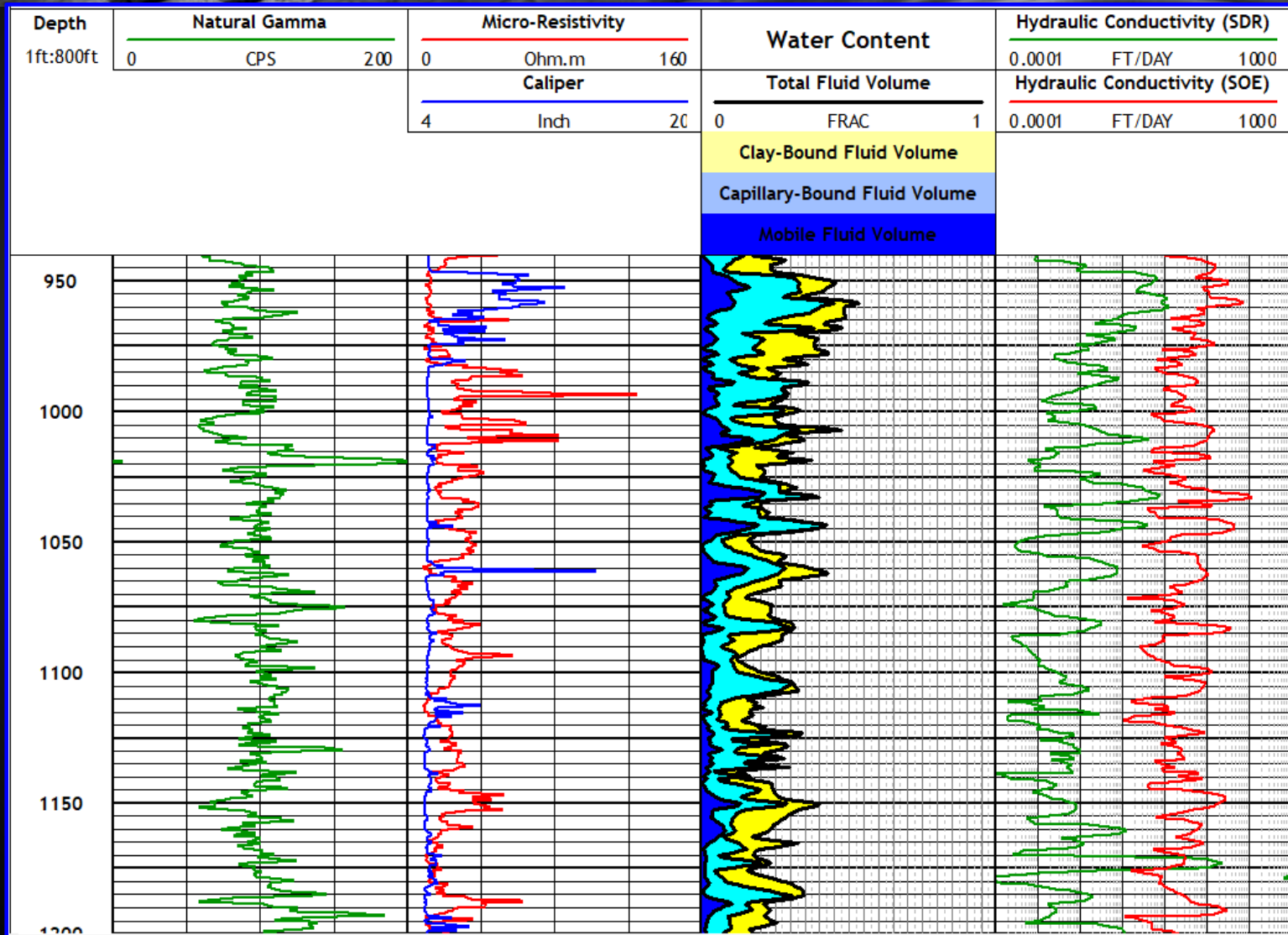


Sample Data

NMR

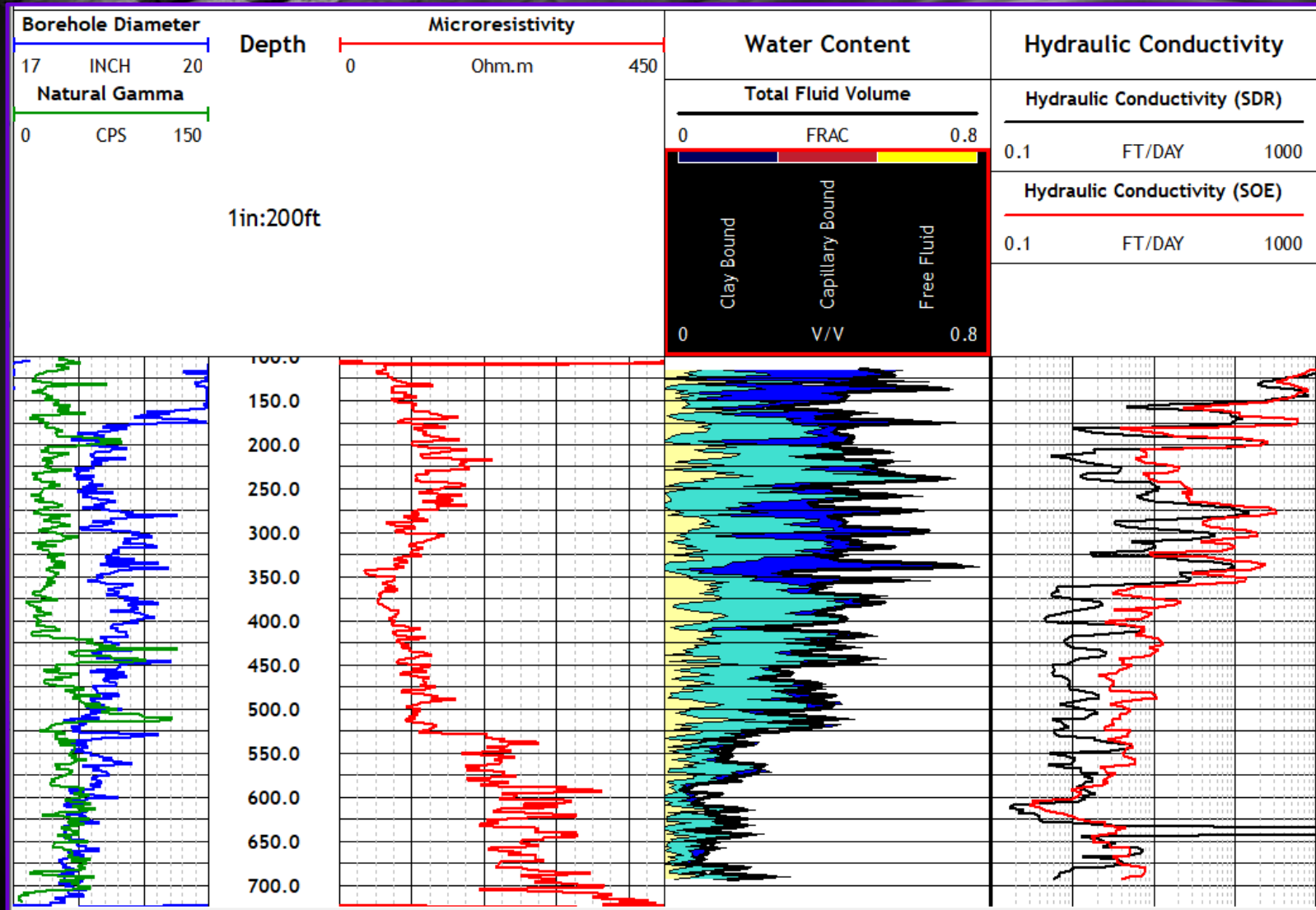


NMR+Microresistivity: Tricky Washouts



Sample Data

NMR with Microresistivity and Caliper



Thank you!



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Questions Please