

March 15, At the Field Scale Discussion Sessions

EM Deep Look Monitoring

Discussion Leader: Michael Wilt, Schlumberger Advisor Deep Reading Electromagnetic (EM) Technologies

The discussion led by Michael Wilt focused on the application of DLEM to Middle East oil fields and its limitations.

The following applications were listed and discussed by the group

Applications

- Waterfloods
- Steam Floods
- Gas (methane / CO₂) Floods if it moves water
- Reservoir Characterization
- Dynamic Modeling

In all of them it was stressed that the DLEM is a water tool. That is it is most sensitive to the water phase so if the injectate (ie methane, CO₂) moves formation water then we can image it otherwise the effect is not easily measured. We also discussed the dynamic modeling aspect where the interwell resistivity data is converted to water saturation which is subsequently used to constrain a dynamic model via smart history matching.

Limits

The limitations of this technology were largely due to well completion and well access. Although many wells are drilled into Middle east oil fields few are available for interwell measurements due to design and completion details. Steel well casing, slim tubings and highly deviated wells discourage use of this technology, and present application often rely on the drilling of new wells.

Future development may address this issue through drillstring applications and accommodation of deployments of tools in arbitrary deviations and completions. For the next several years the following are the tool specifications.

Tools

- Frequency 1-1000 Hz
- Tx 3 3/8" diameter, 4.5 meter long
- Rc 2 1/8" diameter, 4.5 meter/level...4 levels
- Prefer receiver in casing if one well OH and the other well CH

- Well Completion (steel casing limits the distance and gives a noisy signal)
- Well Separation (distance can reliably measure)
 - Steel Casing to Steel Casing ..not offered
 - OH to Steel Casing 500m
 - Chrome Casing to Chrome Casing 500m
 - OH to Chrome Casing 800m
 - OH to OH 1.0 km
- Tomography, (never obtain ideal aspect ratio – want to get below the reservoir)

- Vertical Resolution (~ 2 to 5% of well separation)
- Sensitivity to type of fluid (gas versus oil not distinguishable, water versus hydrocarbon distinguishable the higher the conductivity of the water the better)
 - Resistivity contrast required
- Well trajectories (Vertical wells now, Other well configurations under investigated - 3D modeling)
- Permanent sensor (trade space versus time, have to know where to place the sensors)

Deep Look Seismic Monitoring (Crosswell, VSP)

Discussion Leader: Jie Zhang, Geophysical Reservoir Monitoring Advisor, ZADCO/EM

Advantages

- Capable of seeing 1 to 2 Km
- Gas detection possible which EM cannot see.
- Provide much higher frequency seismic image than surface seismic and VSP
- Can deployed in steel cased wells

Tools

- Frequency 30-800 HZ (Z-track source) or 100-4000Hz (Piezoelectric source)
- Tx 3 1/2" diameter, 17.2 ft long
- Rc 1 2/3" diameter, variable length, depends on need

Applications

- Reservoir Characterization from high resolution seismic image
- Steam Floods
- Fractures (Shear wave)
- Gas (Methane / CO2) Floods
- Constrain Models for other monitoring such as EM
- Dynamic Modeling

Potential Applications

- Geomechanical
 - Effective Stress
 - Caprock Integrity

Limits and Issues

- Complexities with other effects (such as pressure changes)
- Insensitivity to liquid variations
- Competing effects of pressure and saturation
- Investigation area limited (along a plane)
- Crosswell (software) processing immature (such as seismic wave field is a 3D field, but 3D processing not available yet)