NMRT™ Sensor, HMI® Sensor Provide Fluid-Flow Imaging Data, Ensure Environmental Compliance

Objectives

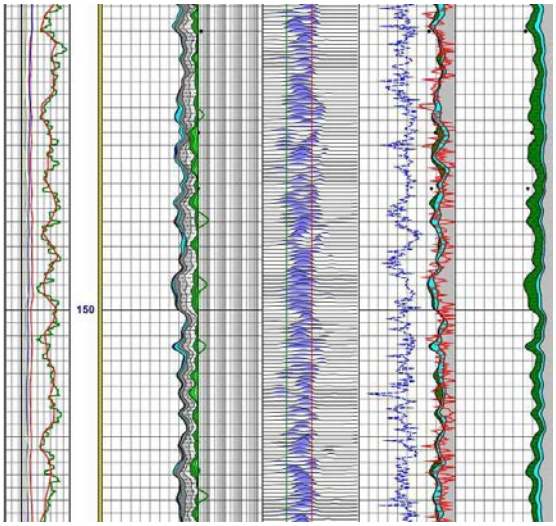
- Gather data that will be used to construct a fluid-flow model and evaluate potential brine flow paths into the caprock formation. The client—a salt mining company—extracts salt from the caprock, and injects waste brine into the basement rocks. The process has been used for many years and triggered concerns that brine might re-enter the caprock and a nearby river.
- Meet regulatory requirements for waste-brine flow-path modeling and volumetric calculations for the basement rock.

Our Approach

- Weatherford deployed the high-resolution microimager (HMI) to identify fractures and distinguish potentially open and transmissable fractures. The Weatherford team also deployed a nuclear magnetic resonance tool (NMRT) sensor to provide a lithology-independent porosity measurement and permeability index. The operator provided core NMR measurements and the conventional openhole logs necessary to calibrate the image petrophysical analyses.
- The team logged a total of four wells: HMI logs in three wells and HMI and NMRT logs in a fourth well.
- The image petrophysics analysis provided a qualitative estimation of the matrix porosity and permeability. Data interpretation included manual dip picking of bedding, fractures, and faults, along with advanced fracture characterization. The team examined cross-stratification in the sandstones because this type of bedding fabric may cause permeability anisotropy. Fracture density, length, and areal extent in the borehole sample volume were calculated, along with apparent fracture aperture.

Value to Client

- The Weatherford HMI and NMRT logs enabled the operator to calibrate the high-resolution NMR core data and create a fluid-flow model. This confirmed that most fractured zones were healed and did not contribute to regional flow. It also identified regional flow zones and updated the development model to identify moveable and non-moveable fluids.
- The data enabled the operator to meet regulatory requirements.



Above is a section of the Weatherford NMRT log, which helps determine clay-bound, capillary-bound, and free fluid (water) distributions. The log provided for log-to-core calibration after indicating a correlation with a core nuclear magnetic resonance (NMR) analysis. In the upper part of the hole, the NMR log showed a very high free-fluid content, which is a result of extreme washout.

LOCATION
Central Germany

INDUSTRY
Salt mining

WELL TYPE
Brine injection/monitoring, vertical

FORMATION TYPE
Sandstone and shale

NUMBER OF WELLS LOGGED
4

HOLE SIZES
8 1/8 in. and 8 1/2 in.

MEASUREMENT DEPTHS
984 to 1,968 ft (300 to 600 m)

PRODUCTS/SERVICES
- NMRT sensor
- HMI sensor

Weatherford®