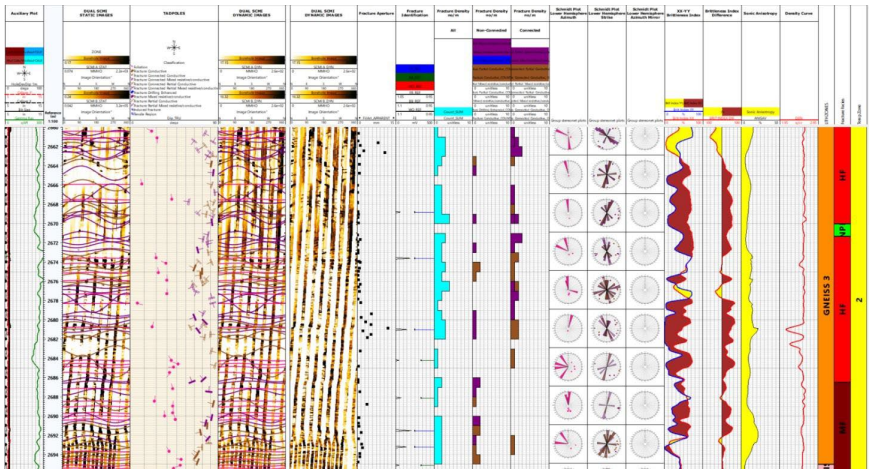
# Integrated Evaluation Solution

## Provides Full Characterization With Oilfield Tools in Harsh, Geothermal Reservoir Conditions



Integrated data interpretation revealed geological features as fracture presence, fracture type (open/closed), general geometrical trends, and fracture and lithological facies, which together helped to pinpoint the location of potentially hydraulic active zones.

## Objectives

- Acquire acoustic and borehole imaging data in geothermal reservoir conditions with very hard, resistive rocks; increased borehole rugosity; and a high fracture density.
- Perform a detailed structural analysis to understand the subsurface conditions and hydraulic potential of the crystalline basement.

## Our Approach

- The customer contacted Weatherford to help confirm the potential of a hydrothermal prospect well for generating geothermal energy.
- Weatherford recommended an integrated solution to acquire comprehensive data and Interpretation and Evaluation services to perform cross-correlative analysis.
- The Weatherford team deployed oilfield technologies that can handle harsh geothermal environments in an original combination. Technologies included the Compact™ cross-dipole sonic tool for acoustic measurements, the Compact photodensity tool for bulk density and lithology measurements, and dual slim Compact microimagers (CMIs) for borehole imaging.
- Notably, the dual slim CMIs feature a small diameter to overcome massive challenges caused by hole issues while providing proper wellbore coverage for confident identification of features and facies. Sixteen mechanical radii in the microimagers provided an accurate, three-dimensional wireframe to create the borehole shape.
- After data acquisition, the interpretation accounted for the new data as well as existing information, such as daily drilling reports.

**LOCATION**
Sweden

**WELL TYPE**
Onshore, hydrothermal

**FORMATION**
Metamorphic

**HOLE SIZE AND ANGLE**
6.125 in., vertical

**PRODUCTS/SERVICES**
- Interpretation and Evaluation Services
- Compact cross-dipole sonic (CXD) tool
- Compact photodensity (MPD) tool
- Compact microimager (CMI)

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### Our Approach (continued)

- The team performed sonic anisotropy by applying an Alford rotation algorithm to all in-line (XX and YY) and cross-line (XY and YX) waveforms. This step helped to understand the geological and geomechanical features linked to the development of fractures.
- Then, the team used Stoneley fracture identification by splitting the waveforms in direct, up-going, and down-going components to isolate the reflections. This step delineated open and closed fractures to understand flow.
- After that, the team conducted a detailed analysis based on the texture and features already recognized in the images. This analysis helped to identify many types of facies, such as foliated, enhanced fracture, artefact, highly fractured, moderately fractured, minimally fractured, non-foliated or poorly foliated, and poorly fractured and tight.
- As part of the detailed structural analysis, the team also completed the following tasks:
  - Established the relationship between structural and lithological facies. A statistical pie plot analysis helped to link these together.
  - Described the possible failure features in rocks using a brittleness index calculated from both Poisson's ratio and Young's modulus. Compressional and shear sonic and density data helped to derive the calculations.
  - Considered temperature versus depth to perceive anomalous behavior. The results closely connected with the interpretations of acoustic and microimager data, which suggested hydraulic activity in certain areas with atypical responses.
  - Integrated borehole geophysical and mudlogging data for comprehensive reservoir characterization.
- The team identified the potential hydraulically active zone of the target formation and presented its findings to the customer.

### Value to Customer

- The integrated evaluation solution used an unprecedented combination of oilfield tools to deliver borehole imaging, acoustic cross-dipole, density, temperature, and mudlogging data for full characterization in the harsh conditions of the geothermal reservoir.
- Interpretation and Evaluation Services cross-correlated all the available data to define the zones with the highest probability for hydraulic activity. Eliminating the need for formation testing or well testing services saved the customer considerable time and costs.

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