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Ortenauhalle Kongress 1
Tiefe Geothermie

Thursday, 20 February 2025, 4.40 pm
Ortenauhalle Congress 1
Deep geothermal energy

Highlighting the hydraulic extension of a fault zone by analyzing the temperature gradients

Aufzeigen der hydraulischen Ausdehnung einer Störungszone durch Analyse der Temperaturgradienten

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In general, crossing a fault zone creates a variation of petrophysical parameters inferred from the geophysical logs, as well as the local disturbance of the natural tectonic stress field.

Within the current study, the abnormal changes throughout the temperature gradients trend over the fault area, were correlated with uranium content, breakout orientation, bedding walkout plot variation, fracture type and fracture density from borehole images, borehole inclination as well as with lithology.

Thru first phase the fault zone (3093.5-3108.5 m) is being highlighted following the interpretation of the high-resolution micro-resistivity borehole image data, throughout a limestone lithology which begins with the occurrence of large breakouts and higher conjugated natural fracture density (Fig. 1). Over this interval, a change in the imager azimuth of Pad 1 (blue curve on static images) and a rotation of the breakouts can be noted.

The faulted area and the near adjacent upper zone are characterized by high uranium values, element which is soluble in liquids and is usually accumulated or travelling within zones with higher secondary porosity. The uranium content decreases with the entry into the highly resistive zone below, which confirms the formation behavior of acting as a seal. Parallel analysis of the borehole trajectory in the fault zone and in the near-adjacent fault area is revealing a variation in the inclination of the borehole, while the azimuth has been remaining constant.

From temperature vs depth cross-plot analysis are identified 3 distinct zones (Fig.2):

- Zone 1 – 3019-3079m – with positive trend +0.036°C/m (blue)
- Zone 2 – 3079-3115m – high variations in temperature trend (yellow) – fault zone
- Zone 3 – 3115-3150m – with positive trend +0.0369°C/m (brown)

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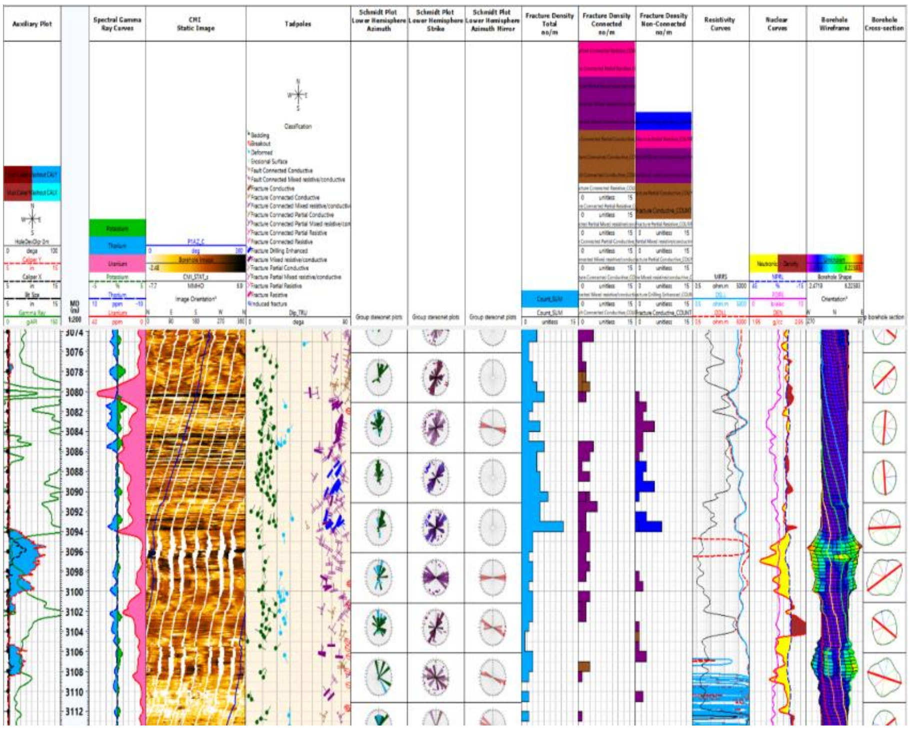

Figure 1 Fault zone composite plot

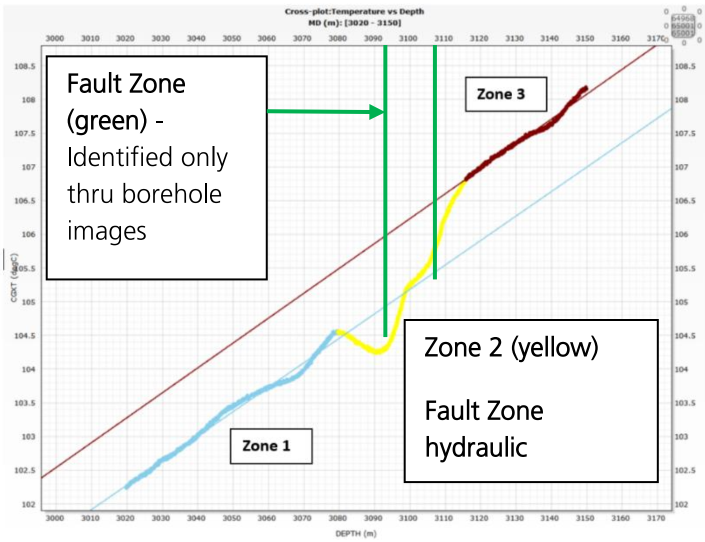

Figure 2 Temperature vs Depth crossplot

The penetration of the colder drilling fluid in the fault zone produced the rock cooling phenomena (zone 2 - yellow), temporarily disturbing the normal temperature gradient of the zone.

Although the temperature gradient trend is the same in zones 1 and 3, due to the cooling effects of the rocks in the fault zone, the highest point in zone 1 (104.6 °C at 3079m) is lower than the lowest point in zone 3 (106.8 °C at 3115m), suggesting a hydraulic isolation between fault compartments, sealing being the fault zone itself.

The presented study case is focusing on the importance showing that if the analysis is limited only to the classic combo logging suite and borehole imaging data (Fig. 1), there could be a constraint to delineate only the interval 3093.5-3108.5m as a fault zone, without considering the area of its influence in the near-adjacent zones, above and below, which in fact is representing the real fault zone 3079-3115m.

A general conclusion is that a precise characterization of faulted areas is a laborious process and requires the integration of as many geological and geophysical data as possible, for an accurate delineation of the zone. In this process the temperature measurements, analyzed as gradients, are bringing a great value into showing the hydraulic connectivity and influence of the fault zone and non-connectivity between fault compartments, which can further be used for the completion engineering design and production strategy.