

GEOThermal

Encountering elevated temperatures is the key goal for geothermal projects, but brings unique drilling and formation evaluation challenges

The elevated temperatures encountered in the Geothermal environment exclude running most downhole tools which are the basis of conventional drilling and evaluation suites. GEOLOG's unique solutions to Geothermal problems allow wells to be drilled more safely, more efficiently and with better understanding.

The drilling and formation analysis solutions developed by GEOLOG's R&D subsidiary GEOTech, utilise surface measurements avoiding the risk of expensive downhole tool damage or failure whilst allowing a comprehensive understanding of the subsurface environment.

Geothermal Challenges

Keeping downhole tools cool when the temperature rises:

The high temperatures encountered during Geothermal operations exceed temperature capabilities of drilling and MWD/LWD tools resulting in lost data or failures or forcing use of expensive HT tools

Fracture Identification:

Natural fractures are key to many geothermal circulation systems but conventional imaging tools either have poor response in the formations drilled or their temperature limits are exceeded

Petrophysical understanding

With conventional wireline or LWD logging suites non-viable due to cost, temperature considerations and their non suitability in many geothermal environments, geological data is substantially reduced from that seen in oil & gas drilling

Drilling disfunction

Without data from downhole vibration monitoring, stick slip can go unnoticed until catastrophic bit or BHA damage occurs, a particular issue with the high strength formations commonly encountered during geothermal drilling

GEOLOG Solutions

Adriltech Continuous Circulation System

Maintain circulation of cooling mud all the time: reduce stress on downhole tools, reduce trips for tool failures, improve borehole cleaning and prevent stuck pipe / LIH events and allows the use of standard temperature tools for longer

High res flow monitoring

By accurately identifying differences between flow in and flow out, GEOLOG's custom software can identify and characterise the nature of fractures, helping to identify the most promising zones whilst improving safety

Advanced XRF/XRD

The use of advanced rigiste deployed XRF/XRD in combination with GEOLOG's innovative, proprietary mineralogical interpretation software allows improved subsurface information to be gathered and accurate identification of thermometer minerals to better understand the thermal setting

Surface Monitoring of downhole drilling dynamics

GEOLOG's surface systems can rapidly identify downhole stick slip allowing fast intervention to prevent bit and BHA damage and avoiding unnecessary tripping

Real-Time Geothermal Reservoir characterization in challenging High Temperature wells:

Temperature zonation within the geothermal environment based on thermometer mineral occurrences

The presence or absence of specific “thermometer” minerals allows the paleo temperature of the environment to be accurately defined. GEOLOG applies innovative hardware and software to identify these diagnostic mineralogical phases, at rig-site and in near real time, enabling the established relationships between specific minerals, lithology and temperature to become a powerful tool for defining the thermal environment in geothermal exploration and production drilling campaigns.

Figure 1 indicates the temperature ranges for specific mineral groups within different lithologies which can be identified and quantified at rig-site. This quantification can be carried out at temperatures above which LWD and Wireline measurements can be safely taken. Solid lines indicate a major presence, dashed lines a minor presence.

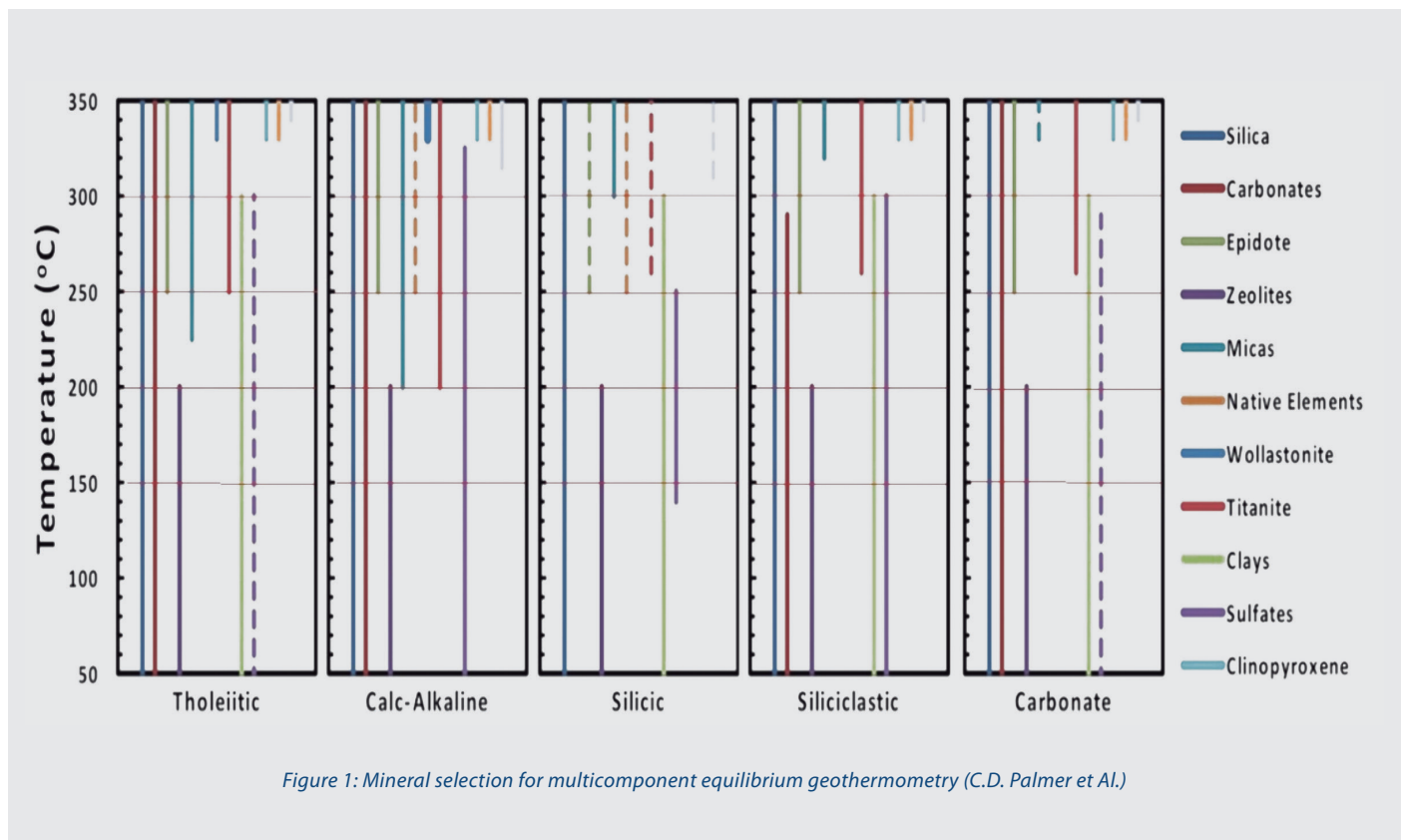


Figure 1: Mineral selection for multicomponent equilibrium geothermometry (C.D. Palmer et Al.)

In conjunction with GEOLOG’s advanced technology analysis, detailed description of the rock cuttings is provided along with composite thin sections for petrographic analysis, this methodology is especially valuable in igneous formations.

CHALLENGES AND APPLICATION

- Chemical cuttings characterisation
- Geothermal alteration mineral assemblage identification at rig-site;
- Reservoir zonation
- Shale stratigraphy for permeability barrier identification
- Thin section preparation at rig-site for petrographic analysis
- Gas composition

BENEFITS

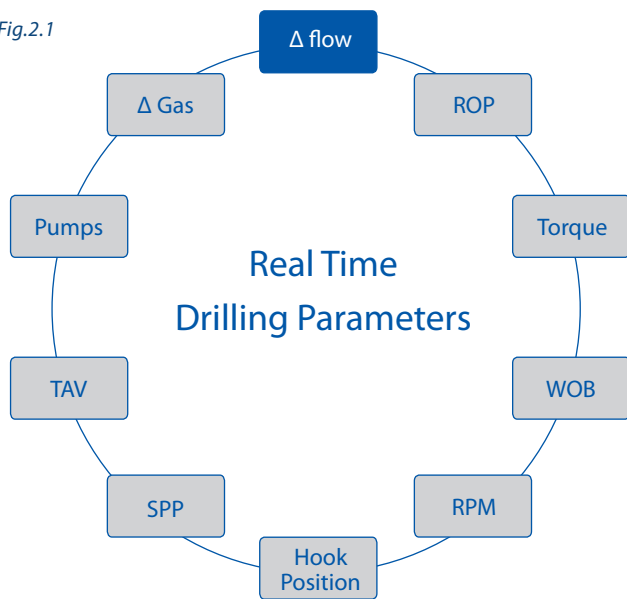
- Surface tools: not affected by down-hole conditions
- Non-destructive analyses
- Correctly locate the borehole within the regional geothermal environment by tracking Geothermometer minerals
- Improved completion outcomes in production wells
- Identification and quantification of minerals unaffected by PDC bit action

For further detail, please refer to:

[GeoRox Brochure \(www.geolog.com/our-services/71/georox\)](http://www.geolog.com/our-services/71/georox)

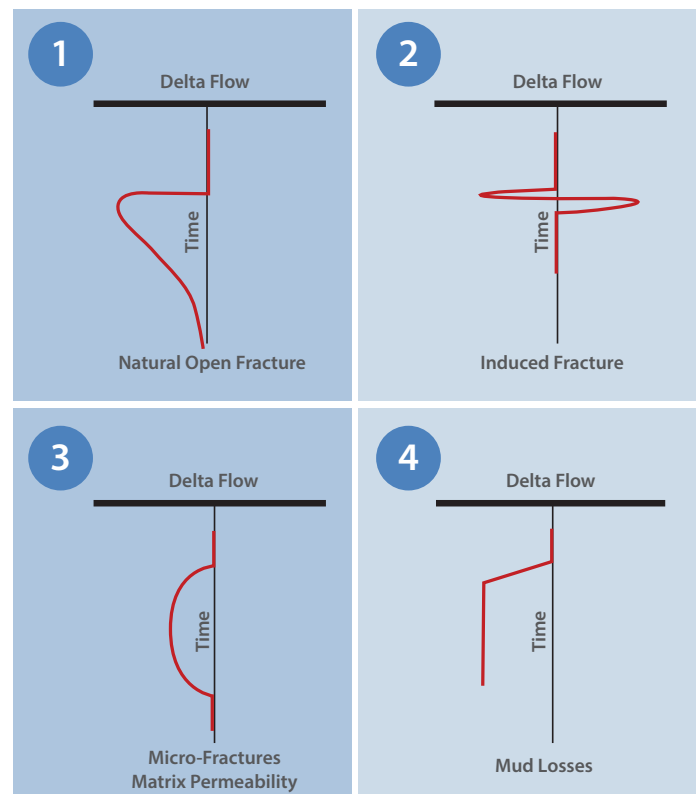
Rig-site high resolution fracture identification and well-bore stability to monitor, in real time, flow and hole conditions

Fig.2.1



- Fracture depth
- Fracture type
- Fracture density
- Volume mud lost

Fig.2.2



The shape of the response curves obtained from real-time monitored micro difference between Flow Out and Flow IN (Delta Flow, Fig. 2.2), integrated with drilling parameters (Fig. 2.1), are related to the permeability of the drilled formation, providing a complete fracture characterisation. As showed in the Fig. 2.3, the main outputs obtained are the Fracture depth, Density, Fracture type and total Volume of mud lost.

When imaging logs are not available due to temperature constraints, or results are poor due to well bore condition, this method of fracture charcaterisation becomes an important, inexpensive source of data in understanding fractured reservoir.

CHALLENGES AND APPLICATION

- Real-time loss and gain monitoring
- Eliminate down-hole logging risk
- Temperature non-dependent solution

BENEFITS

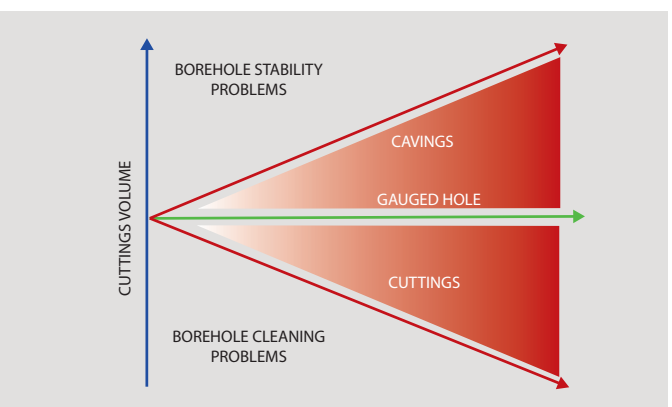
- Improved safety
- Conductive fracture characterisation
- High-permeability zone identification

DrillClean Real-Time Monitoring Service for Borehole Cleaning and Stability

The use of cuttings volume machines deployed at the shakers on the rig combined with GEOLOG proprietary software enables the real-time monitoring of hole cleaning, rapidly identifying cuttings transport and borehole stability problems (Fig. 3). Optimised drilling activity is assured thanks to active surveillance of hole cleaning efficiency and remedial action effectiveness, avoiding NPT associated with solids accumulation in the wellbore, stuck pipe incidents and poor cementing jobs due to inaccurate estimates of borehole volume.

CHALLENGES AND APPLICATION

- Temperature non-dependent solution
- Reduction of borehole stability issues
- Management of narrow ECD windows



BENEFITS

- Active hole-cleaning monitoring
- NPT reduction
- Pack-off and stuck BHA stuck prevention

For further detail, please refer to:

[GeoFracture Brochure \(www.geolog.com/our-services/81/geofracture\)](http://www.geolog.com/our-services/81/geofracture) | [DrillClean Brochure \(www.geolog.com/our-services/11/drillclean\)](http://www.geolog.com/our-services/11/drillclean)

Keep downhole tools cool and functional for longer whilst improving the management of downhole temperature and pressure with the Adrilltech Non-Stop Driller

Developed to fully comply with all industry standards, each stand is equipped with a side-entry sub to allow circulation during connections while the rig picks up the next stand of drill pipe when drilling or tripping



The Adrilltech Non-Stop Driller uses API rated high-pressure mud hoses and an integrated quick connect mechanism. It diverts flow from the mud pumps through a remote-controlled manifold. When the connection is completed, the flow of drilling mud is redirected through the Kelly/Top drive and drilling continues with the NSD sub now an integral part of the drill string.

CHALLENGES AND APPLICATION

- Protect downhole equipment by lowering temperatures
- Keep the wellbore clean with low rheology water-based drilling mud
- Avoid unnecessary tripping due to thermally induced failures
- Managed borehole stability

BENEFITS

- Reduced downhole temperatures
- Lowered Thermal Stresses on drill string components and drilling fluids
- Good Hole Cleaning
- Prevention of stuck pipe/lost BHA's
- Reduced NPT: Reduced Cost

DrillVibe Real-Time Vibration and Stick-Slip Monitoring to Improve Drilling Performance

Downhole stick-slip can rapidly destroy bit cutting structures and BHA components, however when temperatures rise, conventional MWD tools cannot be relied upon to get the required data. By analysing surface torque, GEOLOG can identify stick-slip drilling disfunction in real-time without the long wait for downhole data points and at temperatures which exclude the use of MWD tools.

CHALLENGES AND APPLICATION

- Analyse drilling disfunction without downhole tools
- Provide high-speed data
- Identify issues and provide intervention before damage occurs

BENEFITS

- Prevention of damage to drill bit cutting structures and BHA components
- Real-time data updates for speedy intervention
- Reduce NPT: Reduce Cost

For further detail, please refer to:

[Adrilltech Brochure](#) (www.adrilltech.com) | [DrillVibe Brochure](#) (www.geolog.com/our-services/41/drillvibe)