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Baden Arena Kongress 1 – Tiefe Geothermie

Thursday, 29 February 2024, 4.20 pm
Baden Arena Congress 1 – Deep Geothermal Energy

Monitoring geothermal wells: from HT directional, pressure and temperature while drilling to advanced casing integrity services

Überwachung von Erdwärmebohrungen: von HT-Richtungs-, Druck- und Temperaturmessungen während der Bohrung bis hin zu fortschrittlichen Dienstleistungen für die Integrität der Verrohrung

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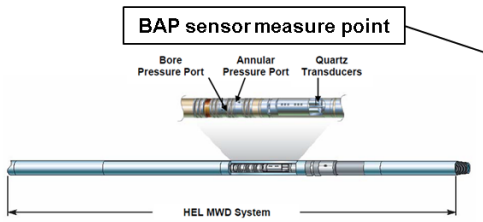
Nowadays the energy sector is undergoing a milestone turn into more environmentally responsible green industry to comply with ''net zero by 2050'' regulations. The clear goal is to reduce the footprint of the global greenhouse gases to alleviate the ongoing climate change. Thru this transformation the geothermal energy plays an essential part by emitting significantly less harmful carbon dioxide, being more environmentally friendly than fossil fuel energy sector. Apart from the differences in the design and overall approach from the geothermal wells with respect to the Oil&Gas wells, safety and integrity is invariably the uppermost common denominator. With this view, the monitoring of a well throughout its entire life is the most powerful instrument: from the early stage of drilling operations, to optimize trajectory and acquire formation evaluation data in real time to be able of taking immediate informed decisions, until the later stages of casing and cement operations, to evaluate the cement bond quality and inspect the casing integrity condition even after years.

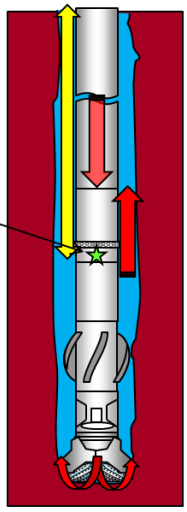
This paper describes a new set of high-temperature Logging-While-Drilling (LWD) and Pressure-While-Drilling (PWD) technologies for operating unshielded electronic components up to 210°C and will continue with defining the conventional methods as well as the state-of-the-art modern E-Line technologies for a comprehensive overview of the casing and cement integrity.

The use of directional drilling in a geothermal field is usually dictated by various objectives: geological targets, for example to intersect as many or as less formation fractures as possible, or the perimeter lease boundaries, institutional, legal, or topographic issues, and lastly but with major economic efficiency importance, it allows to drill several wells from one prepared surface site while avoiding collisions. The difficulties inherent in directional drilling are aggravated in the geothermal wells because of 2 major reasons: the electronic tools and elastomer elements in the motors, susceptible to high temperature. Within this abstract it is presented a new set of high-temperature Logging-While-Drilling (LWD) and Pressure-While-Drilling (PWD) technologies for operating unshielded electronic components up to 210°C. In particular, the BAP tool, a high temperature PWD sensor that provides bore and annular pressure and temperature, that was used in some high enthalpy deviated geothermal wells where lost circulation was expected, mainly related to the presence of natural highly productive fracture system.

Annular Pressure (AP) in yellow:
Temperature and hydrostatic density of the mud column plus frictional losses in the annulus from the pressure sensor to surface to monitor EMW and ECD.



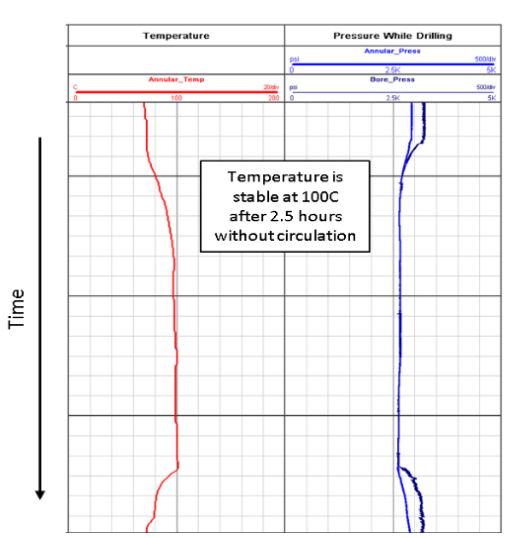
Continuous pressure and temperature and Max and Min values during pump off in real time

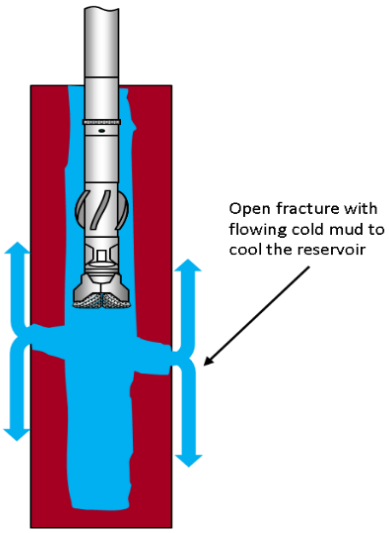


Bore Pressure (BP) in red:
hydrostatic density of the mud column plus frictional losses through the BHA below the pressure sensor (i.e. PDM motor, LWD, etc.), pressure drop through the bit and frictional pressure losses in the annulus from the bit to the surface.

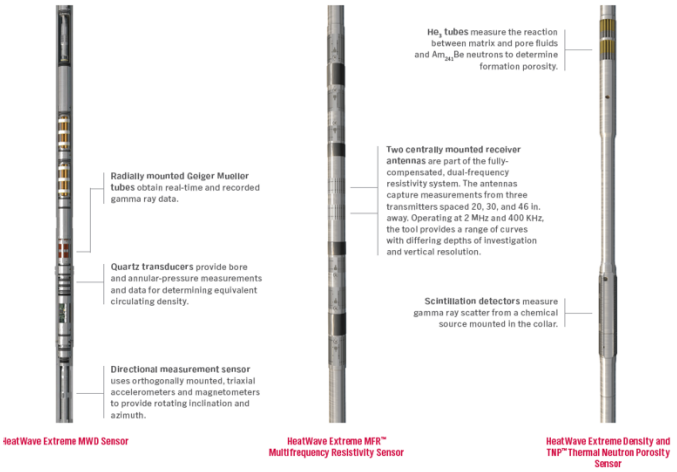
Differential Pressure (DP) = BP - AP:
difference in pressure between the bore and annulus pressure gauges which provides the pressure across the BHA and through the bit and is used to monitor motor performance, blockage at the bit, washout in the lower BHA, and evaluating where pack-off is occurring.

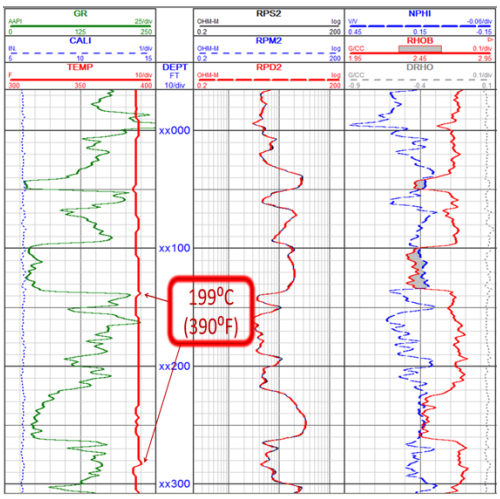
In addition to the applications commonly used in wells, the real time and cost-effective measurement of downhole pressure and temperature was attempted to be used to better understand hydraulic conditions of the reservoir, improve accuracy in fracture characterization and position, and prevent downhole equipment damage or NPT. In particular, the combined analysis of downhole pressure and temperature trends, measured by the BAP sensor, is used to discriminate between "open" versus "closed" circulating system (or "hot pot") and position the losses and fracture, which are all valuable data for drilling and completion plans. Although there are multiple variables to take into consideration, the concept proves to be valuable and deserves further discussion and case history.





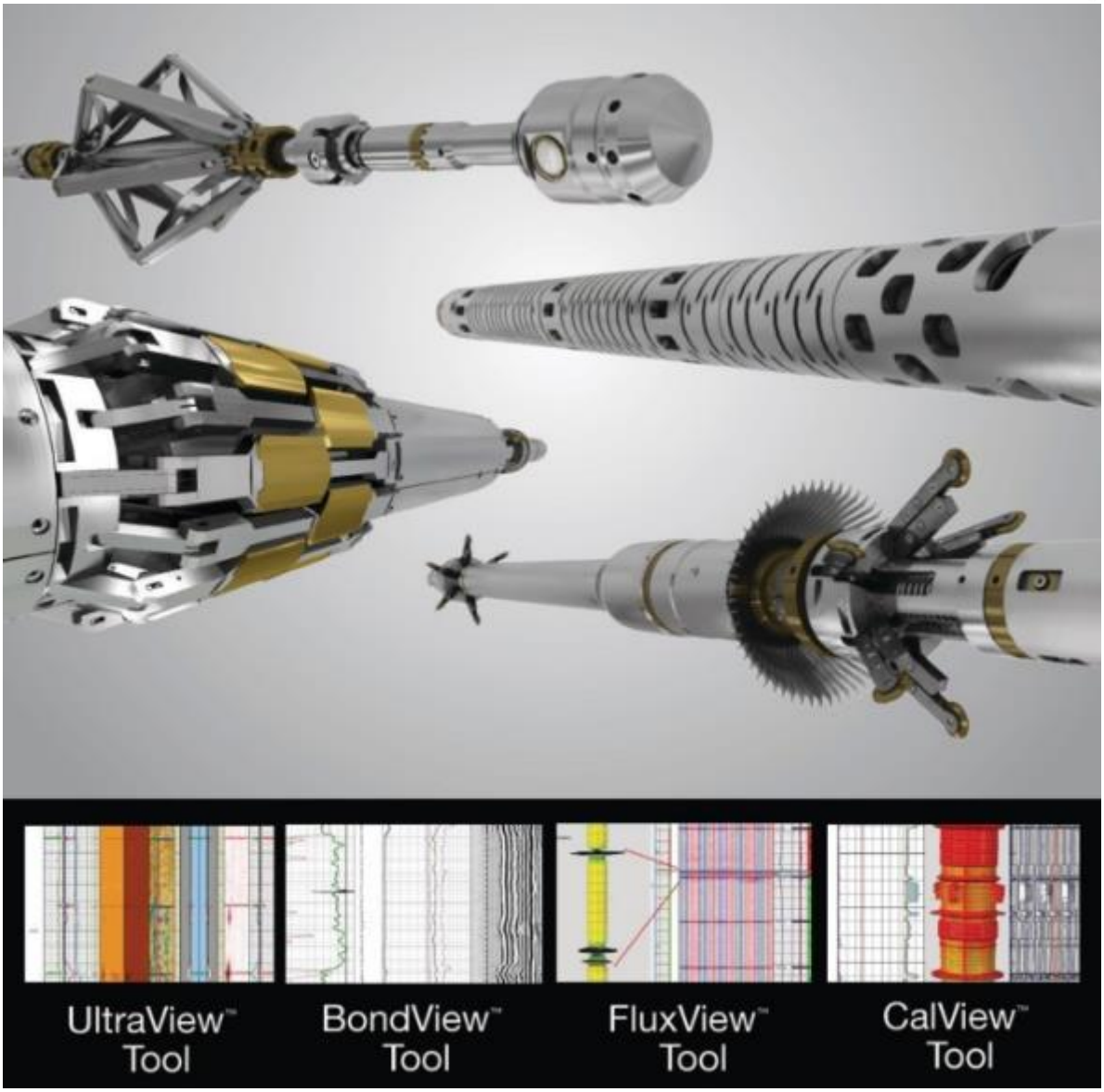
The presentation is also introducing the fleet of LWD sensors including all kinds of sensors for open hole data acquisition, for applications like standard correlation and formation evaluation to advanced ones like fracture identification and geosteering, from a minimum temperature of 165 to 180 °C using standard tools, to a high temperature of 200 – 210 °C using HeatWaveTM series of directional, gamma ray, pressure and temperature, resistivity, density and porosity tools.





After the well section is drilled and evaluated, possibly based on LWD data, casing can be run soon after, to isolate the formation and prevent borehole collapse events, further once the casing is set then cement job can be performed.

Historically the integrity of wellbores was assessed based on the temperature and cement bond log (CBL) surveys run on the electric cable. An increase in the temperature data logged shortly after cementing job, because of exothermic reaction, was good indication of the top of cement (TOC) depth. The bond quality itself was inferred from the attenuation of the low frequency sonic signal between transmitter and 2 dedicated magneto-strictive, or later piezoelectric, receivers with 3' and 5' span. Mechanical caliper log was run to assess condition of the inner side of the casing. These logging methods even though extremely reliable for qualitative analysis have been lacking in azimuthal sensitivity and overall resolution, that is required to get a complete quantitative picture of the wellbore conditions to successfully maintain the integrity of wells. Over the last decades developments in the E-Line technologies resulted in the broad range of the cased hole measurements portfolio offered by various service companies. Among them Weatherford offers one of the most competitive propositions on the marked called SecureView®; single-trip, high-resolution casing and cement diagnostics evaluation. SecureView® is a suite of technologies — UltraView®, CalView®, FluxView® and BondView® that provides a complete and comprehensive picture of the downhole condition as a necessary step to plan further remediation actions. The tools can be run in tandem which significantly reduces logging time, increasing overall performance of the workover operations. By utilizing cutting edge technologies SecureView® can identify the wellbore integrity problems that conventional tools standalone cannot do.



As most of the geothermal wells contain CO2, H2S and other corrosive elements it is extremely important to know the casing condition. Pulsed echo ultrasonic measurement (UltraView®) provides circumferential casing thickness, radiuses and amplitude maps which when combined with a high resolution 60-arm caliper (CalView®) and electromagnetic tool (FluxView®) will identify any type of casing imperfection, from general corrosion or wear towards to the small size pitting, including casing scale or solids buildup. That also involves any types of casing deformation caused by increased pressures, commonly observed in geothermal wells. Acoustic impedance of the material behind the casing from pulsed echo ultrasonic tools provides the means for detailed high resolution 360deg. coverage cement evaluation with the option to differentiate between water, cement and gas content within the casing annulus. This poses a high importance as the quick temperature cycling in the geothermal wells affects the effectiveness of the cementing job, creating leak paths like channels or microcannulas. Combination of the advanced UltraView® with conventional BondView® (CBL) measurements gives a complete picture of casing-cement and cement-formation bond quality. Broad range of the ultrasonic tool head sizes are increasing its application from small size API casings to large completions, dictated by the needs of high flow rates in geothermal wells. Applications of the UltraView® is not limited to the conventional wellbore completion based on steel or metal alloys and it can be successfully run as well thru fiberglass casings, extremely thick casings or to evaluate light weight foamed cements.
SecureView® extent far beyond the conveyance logging methods and equipment. Proprietary software, processing algorithms, sophisticated reporting and interactive 3D data manipulation and

presentation formats make SecurView® a comprehensive solution for identification of well integrity problems and recommendations on remedial options.