

FLOW PROFILING OF A GAS RESERVOIR DURING A DEEP WATER WELL TEST ENHANCES SANDFACE EVALUATION

PRO-LOG

MARCH 2015

PRODUCT:

DATE:

LOCATION:

West Africa

SERVICE:

Well Test Evaluation

BENEFITS:

Improved Sandface Understanding

Reduced Rig time

Risk reduction avoiding PLT wireline operations

Continuous data throughout welltest

Improves transient analysis accuracy

CASE STUDY:
1004/01

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PRO-LOG	
MARCH 2015	
PRODUCT:	
DATE:	

A DEEPWATER DRILL STEM TEST UTILISED METROL'S WIRELESS THERMAL IMAGING ARRAY INSTALLED DIRECTLY ACROSS THE SANDFACE. CONTINUOUS WIRELESS TEMPERATURE FROM BELOW THE PACKER, AVOIDED THE NEED TO RISK WIRELINE TOOLS IN HOLE, IT IMPROVED SANDFACE UNDERSTANDING BY ELIMINATING PREDICTIVE MODELLING SCENARIOS AND SAVED RIG TIME AND COSTS

CHALLENGE

With so much depending on the results of the DST, the client wanted a good understanding of deliverability across the entire sandface. Metrol's PRO-LOG technology could capture and log the entire well test providing a thermal image that would map the performance and productivity of the sand face during the flow periods and build-ups.

The client was able to identify three technical challenges:

1. To monitor for the entire test period, which was to be an extended test with multiple choke changes. Any formation event would be recorded and viewed at surface in near real time.
2. The lower completion would be run with 60 metres of sand screens which would preclude any possibility of conducting a wireline Production Logging Tool (PLT).

A wireline PLT is also inadequate because it only provides a 'snapshot' image of the formation during a dedicated flow period and therefore missing significant events.

3. What was not known at the requirement stage but became apparent during the test was the value of information / crossflow collected during the build-up periods and the capturing of an unexpected clean-up event that influenced the production profile.

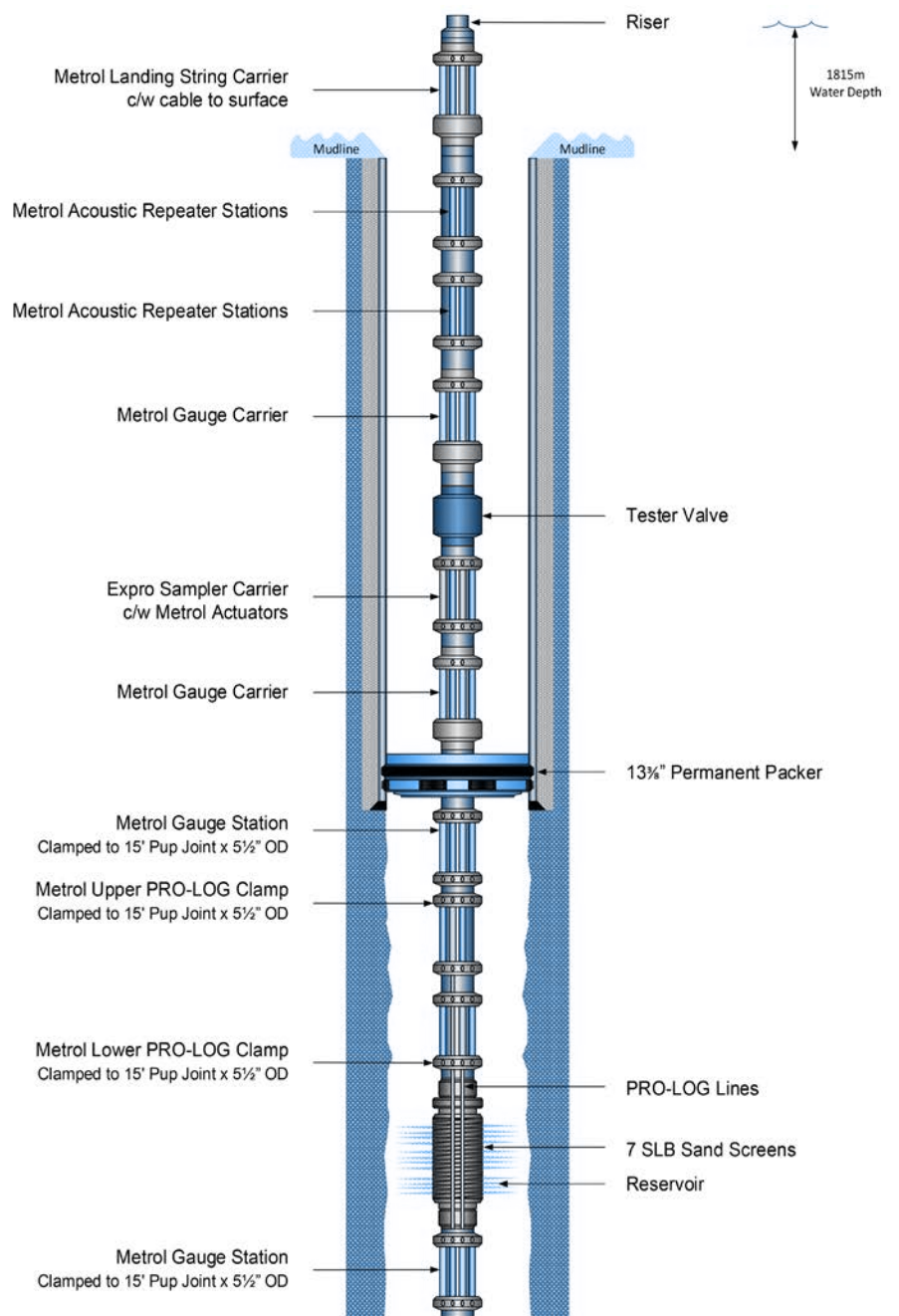


Fig. 1



METHOD

The lower completion was run with the following Metrol assemblies:

Above the sandscreens, two PRO-LOG tools were mounted. Each of these tools contained 0.25" control lines and ran across the sand screen joints to provide extensive temperature profiling across the formation during the DST.

The PRO-LOG comprises individual temperature sensors and is designed to be able to monitor any size of formation interval. These temperature sensors can be spaced to best suit the potential variations anticipated; the sensitivity/resolution of each sensor is 0.004°C so a 10 centimetre spacing is possible for a high resolution thermal image.

For this application, a spacing of 1 metre was chosen across a 60 metre interval.

Above and below the sand screens, Instrument Securing Devices (ISD) were run, each containing two Metrol ultra-high resolution pressure gauges and repeater stations, ported to read reservoir pressure and temperature.

These would provide a pressure gradient across the interval to help quantify flow as well as detect any sudden increase in differential and plugging of the screens. When the lower completion and screens were run, Metrol were able to confirm all instruments were functioning prior to running the DST string (see Fig. 1).

The ability to view the data in real time and confirm that the test objectives were met was invaluable, especially as the commercial decision had already been taken to abandon the PRO-LOG lower completion at the end of the test.

All useful data was wirelessly recovered from the PRO-LOG and sand face OCULUS gauges that provided a simultaneous pressure gradient across the screens.

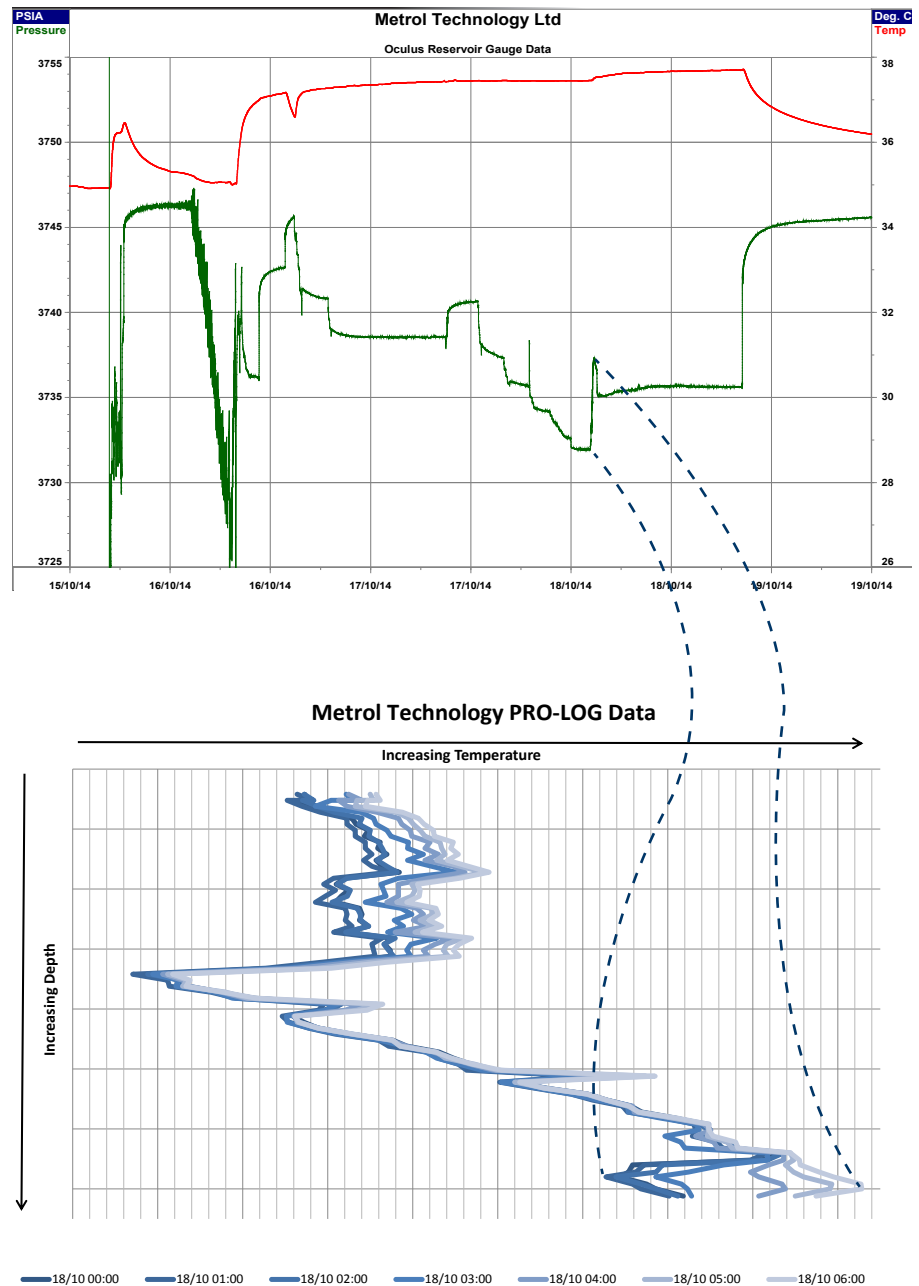


Fig. 2

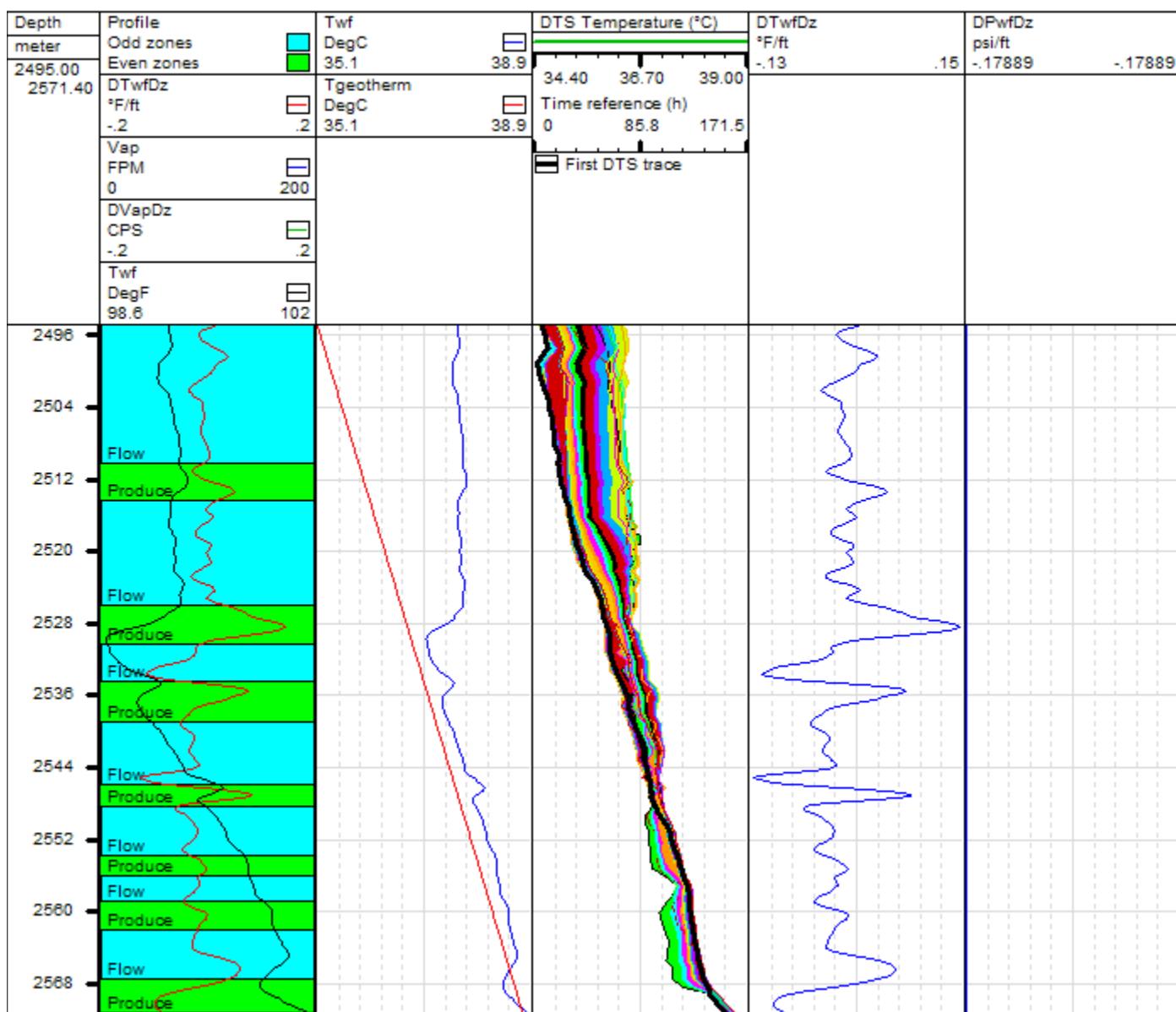
The project proceeded as expected and it was assumed after 160 hours of flow that the well was clean. Suddenly, after 161 hours of stable flow, a mud slug arrived at surface with a bottom hole pressure surge, and a clearly defined temperature change at the sand face; an event that would have been lost had the client been relying only on wireline PLT data. This additional formation clean-up led to a substantial increase in the flowrate, and qualified the interpretation of the drawdown data.

RESULTS

The well test concluded after 10 days. Every choke change was captured, every response monitored and correlated with the surface data. Apart from a slight interruption due to a short ESD surface shut down etc., the well was flowed continuously for 76 hours. This included 14 choke changes followed by a 48 hour build-up, during which the formation slowly recovered to the geothermal gradient at noticeably different rates. The in situ geothermal gradient was established / confirmed immediately prior to starting the DST.

Fig. 3

This plot shows the PRO-LOG history over the flow period of 171.5 hours. Twf(Temperature Well Flowing) is at a single point in time (early in the flow period) but could have been selected at any time. The temperature derivative is calculated at that same time. Producing zone allocation is made on the basis of rapid changes in the temperature derivative and deviations of Twf from the geothermal gradient. The rate of pressure change with depth (dP/dz) is a constant at this stage in the analysis, with the analysis calculating the theoretical pressure change with the depth from produced fluids composition.



RESULTS CONT...

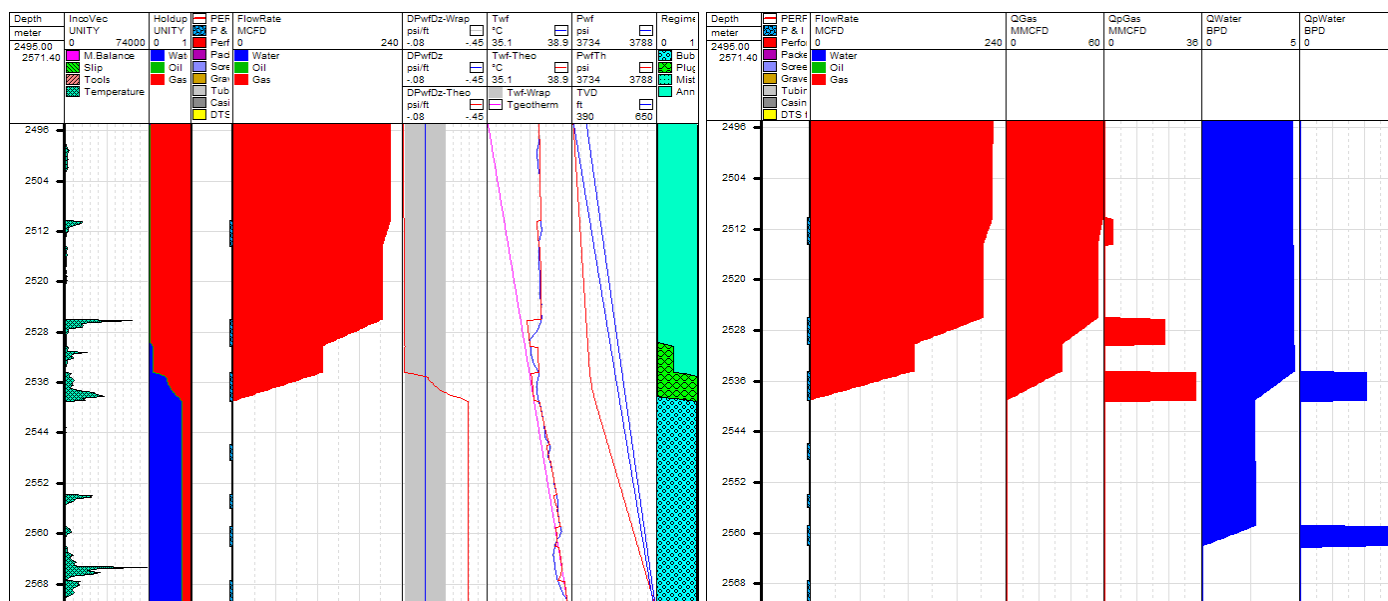
The graphs in Fig. 4 show the water hold up and gas producing zones when the well was flowing on 128/64" choke, just before a slug of mud and water was produced at surface. Note the bubble flow at the bottom of the well in the Regime column. The lower graphs show the same information 3 hours after the

slug was produced, and it is now clear how the production profile has changed once the water/mud slug was produced.

When plotting the flowrates against the well test events, it is apparent the major clean-up event triggered a surge in bottom hole pressure

that tapered off, but continued to the end of the flow period. There is also a slight but noticeable drop in flow rate post clean-up notwithstanding the fact that the whole reservoir section is now contributing to the flow.

Pre-Slug



Post-Slug

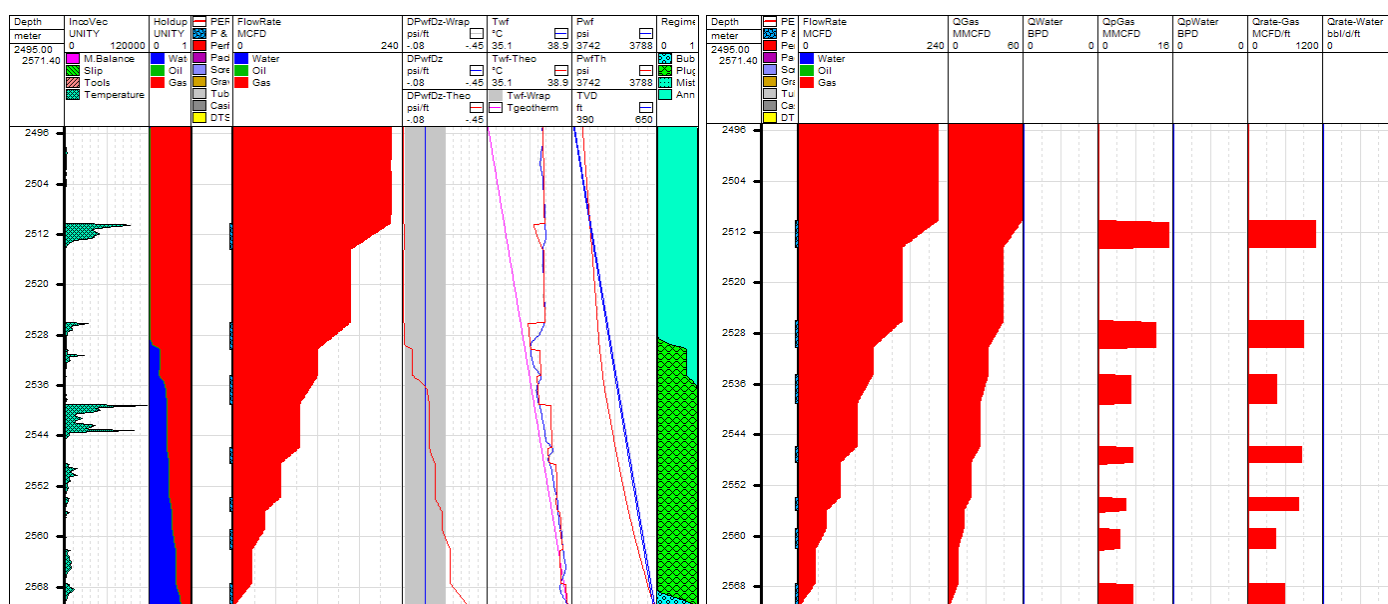


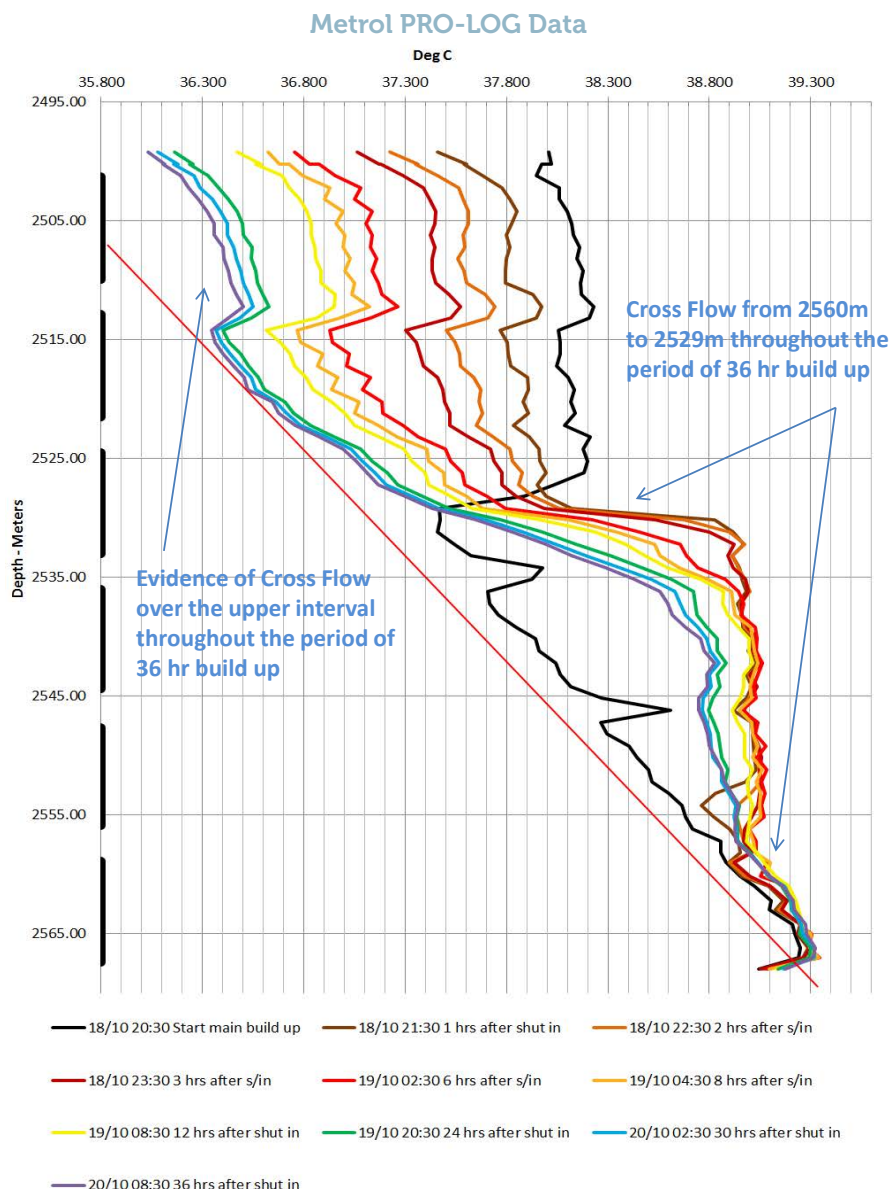
Fig. 4

The lower zones, which were not flowing, are now seen to be contributing approximately 50% of the flow. In fact, bottom hole pressure continued to increase for the rest of the flow period but this did not lead to an increase in overall production (see Fig. 6). There was also a significant corresponding reduction in drawdown on the upper zones which would help explain why not all of the mud/water was able to be produced.

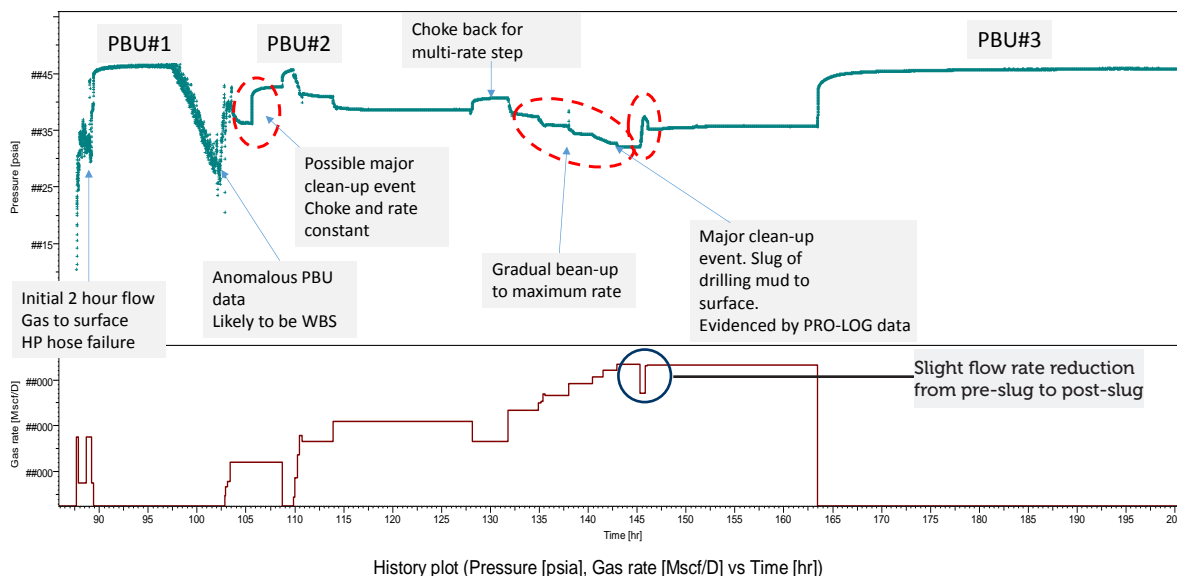
RESULTS CONT...

The other significant events that PRO-LOG has revealed occur during the build-ups. During flows, the sensors are measuring the temperature of the local production mixed with the cumulative production from deeper in the well, which can obscure small production changes. Capturing the temperature changes during the build-up revealed a far more accurate picture of the formation flow profile (see Fig. 5) and helped validate the final well test analysis.

In conclusion, calculations of the flow profile depend on an accurate geothermal gradient being known. In most well tests, the original well logged temperature may be widely inaccurate and therefore wrong to use as a basis for flow calculations. It can be a great advantage to monitor the recovering temperature profile for weeks after the conclusion of the well test. Metrol has a long history of recording data in suspended wells for purposes of field delineation, and any temperature data that improves the accuracy of the geothermal gradient maybe used to refine the analysis of the flow profile data delivered by Metrol's PRO-LOG.



SIGNIFICANT EVENT SEQUENCE



CASE STUDY INDEX

1001 – MULTI-ZONE TESTING

1002 – DEPTH-LOC

1003 – RETROFIT TECHNOLOGY

1004 – PRO-LOG

1005 – CROSS-FIRE

1006 – WIRELESS BARRIER MONITORING

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