# $QUEEZING VALUE FROM WELL DATA

MARIO CHIARAMONTE, ALBERTO MARTOCCHIA, ANDRES MATHESON AND ALAN MORRISON, **GEOLOG INTERNATIONAL**, DESCRIBE HOW SURFACE LOGGING CAN PROVIDE COST SAVINGS AND DRILLING EFFICIENCY THROUGH THE USE OF INNOVATIVE INTERPRETATION MODELS AND MODERN TECHNOLOGY.

When the decision to drill has been made, a vast data set becomes available that can not only assist with the drilling process as it proceeds, but can have a direct impact on future exploration and development decisions, in real, and near real time. This article describes some applications where real time surface data can help in making effective drilling decisions and have valuable geoscience benefits to help speed up decision-making and reduce non-productive time (NPT).

NPT is commonly addressed through the reduction of failures but hidden NPT can be present in the use of unnecessary processes, or perhaps the use of expensive methods when cheaper, fit for purpose alternatives are readily available. The measurement of real time operations using high-resolution surface drilling data, and its analysis through the use of GEOLOG's DrillBest service allows for the optimisation of processes and events, uncovering so-called hidden NPT. This service uses the large data set to perform analyses on both

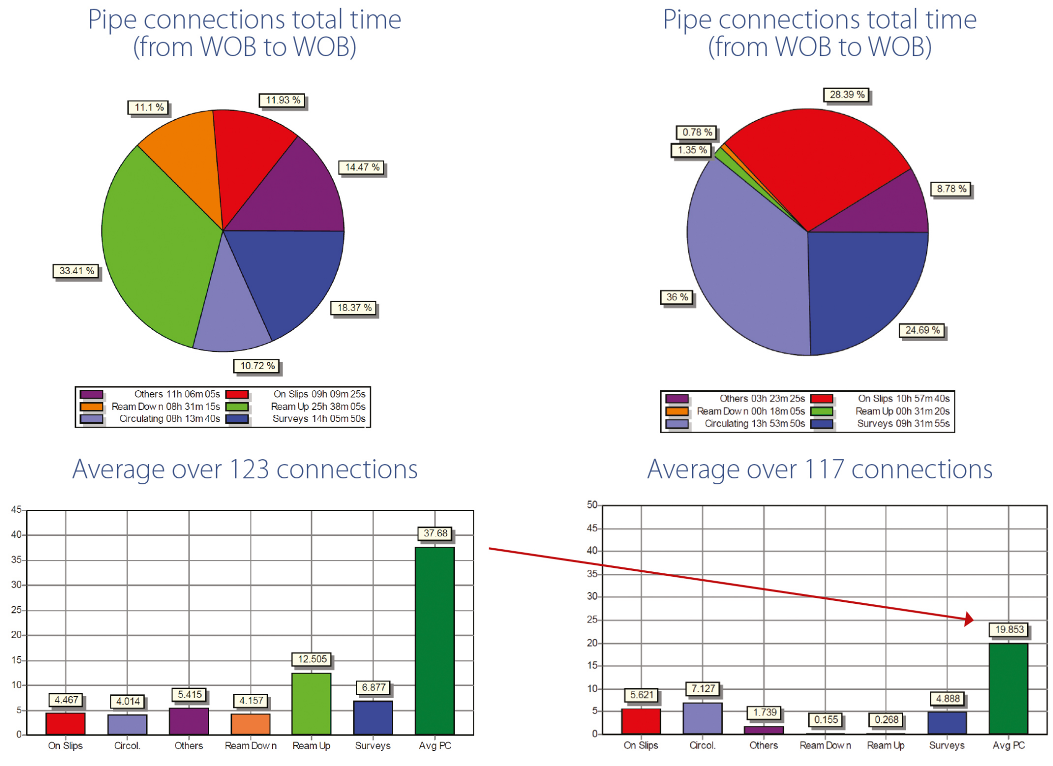


***Figure 1.*** *Left: Original WOB to WOB time distribution. Right: Reduction of time with new procedure.*

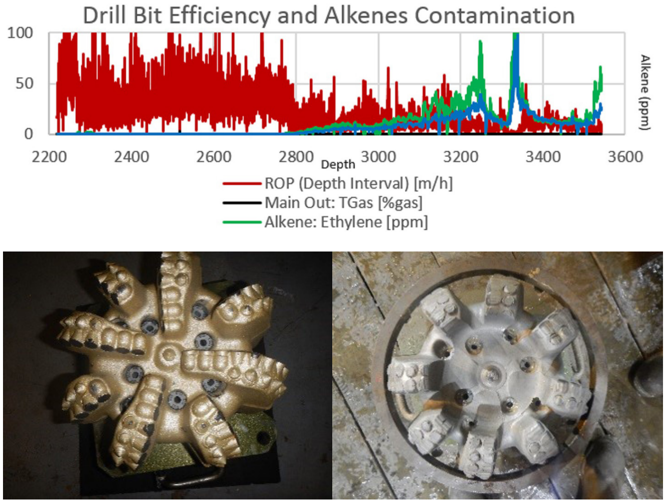


***Figure 2.*** *Rate of penetration (ROP) plotted against Alkene Gas Response, with images of the drill bit being monitored – before drilling, and after pulling out of hole at 3320 m when the ROP dropped to 0.6 m/hr.*

time and depth based data at a granularity not usually available with standard reporting methods. Figure 1 shows an analysis of events during a West African deepwater drilling operation. After reviewing hole conditions the extensive reaming and back-reaming operations were greatly reduced. The change in procedures displayed on the right of Figure 1 saved 36 hours of rig time.

Some further applications where surface data improves decision-making are as follows:

- Maintaining the most effective rate of penetration to acquire data and drill effectively requires the drill bit to maintain an effective ‘cutting’ action. A method has been developed that helps monitor drilling bit effectiveness.
- Borehole stability issues are a major cause of NPT in drilling operations. Geomechanical studies help identify best theoretical drilling directions and angles but the results of drilling need accurate real time monitoring to measure progress and ensure success.
- Fractured reservoirs pose problems for drilling and evaluation alike. Their identification and interpretation is required throughout the life of a well. This evaluation starts when they are first drilled and their presence identified through surface events.
- Well placement and casing point selection are critical events during the drilling process. Using wellsite chemostratigraphy to improve these drilling decisions forms a cost-effective methodology.

Technologies and their uses are evolving at an ever-increasing rate and the integration of these data sets is finding new applications that are helping improve drilling efficiency, safety and at the same time generating new reservoir insights, all while helping to reduce drilling costs.

## Background

Surface logging has offered a service tailored towards drilling safety, monitoring pit levels, return flow and hazardous gas levels at surface, aimed directly at the onsite drilling team. This was usually provided as a discrete application, distinct from the reservoir evaluation service provided through physically and visually examining cuttings, monitoring total gas and chromatographic evaluation of the basic C1-C5 components to determine a first assessment of hydrocarbon presence and possible prospectivity.

All of these components of the surface logging service are still valid, and, through the implementation of improved technology have themselves become more reliable in terms of data accuracy and quality.

With the target of improving drilling efficiency, through evaluation and analysis of the many factors that can lead to NPT and assisting in making better informed reservoir decisions, operators are deriving as much value as possible from a data set that comprises many direct measurements that are often a by-product of the drilling process and are largely available only once, while actually drilling.

## Measuring bit wear

Whilst measurements such as rate of penetration can be reviewed to see if drilling is continuing at a suitable rate, equations such as mechanical specific energy (MSE), the corrected drilling exponent (DxC) and others are used to assess drilling efficiency. No lithology independent method has been defined that captures the real time state of the bit while drilling. Gas measurements have now been developed to incorporate the measurement and evaluation of a range of gases, generated by high temperature cracking. These temperatures are reached when a bit is worn and the cutting surfaces have been reduced, generating a frictional effect that

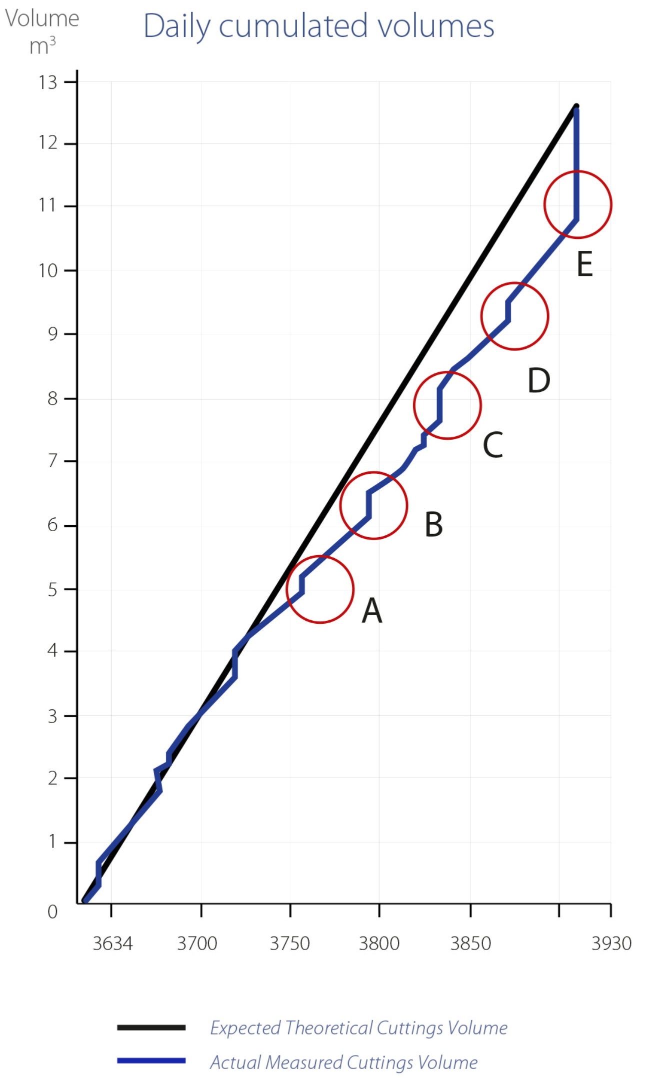


***Figure 3.*** *Shows a plot of actual cuttings removed from a well, versus expected theoretical cuttings. The steps identified at A, B, C, D, and E should the response of remedial action taking during drilling to improve the cuttings removal.*

metamorphoses rocks rather than delivering clean cuttings. The gases are both an indication of bit wear and a contaminant to standard hydrocarbon evaluation, hence their evaluation through the use of new chromatographs is of use for both drilling efficiency and improving formation evaluation. GEOLOG's BitLife service can be incorporated into a standard mud-gas acquisition system. Figure 2 shows another example from a deepwater offshore operation where drilling proceeded beyond the optimal point, and excessive wear was observed when the bit was finally pulled.

## Borehole stability

Wellbore hole cleaning has been monitored in a variety of ways over the years, from visually identifying possible cavings and making subjective assessments through to the current best practice of measuring the volume/weight of cuttings being returned from the wellbore and comparing that to expected volumes/weights from theoretical calculations. GEOLOG has developed its DrillClean service to provide real time feedback to the drilling team to ensure that successful practices and processes are used that help ensure adequate cuttings removal is occurring. By implementing accurate flow, fluid property and cuttings retrieval measurements, an accurate assessment of the hole cleaning occurring at any given time is possible. This is another application that can be further enhanced through the integration of additional data sets. By incorporating mineralogical analysis, better lithological assessments can be determined which in turn can help to elaborate not only the fact that cavings are occurring, but help to give an indication of their source and hence identify the problematic formations. This allows for specific solutions to be developed to resolve the borehole cleaning issue at the time of drilling and avoid costly retroactive activities. Numerous examples exist where accurate monitoring of borehole cleaning results have helped improve drilling practices and reduced time between drilling and logging or casing operations.

In Figure 3, an example from deepwater operations in Angola, back-reaming activities were initiated to improve hole cleaning. After four attempts to remove cuttings and clean the hole (A, B, C, and D) a hi-vis sweep was pumped and six full circulations planned to clean the hole. The correct volume of cuttings was observed to have been recovered after four circulations and drilling proceeded further without incident.

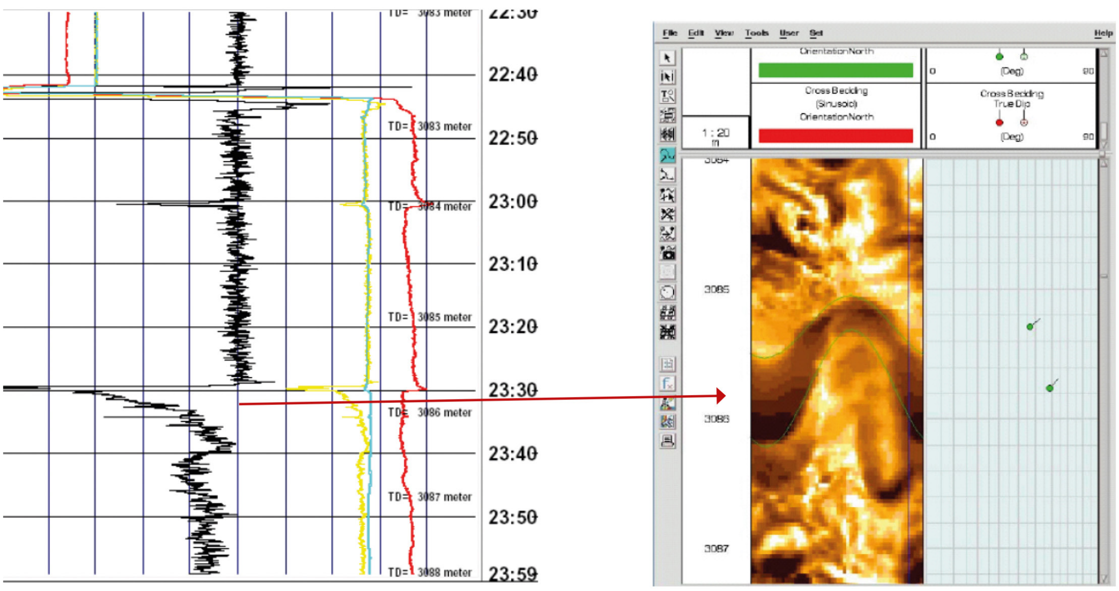


***Figure 4.*** *Left: The curve in black is the Delta Flow, which matches the signature of a natural open fracture in Figure 7. Right: Imaging log confirming a large open fracture.*

## Open fracture identification while drilling

Refinements in return flow measurements have now allowed for an effective fracture identification service that can be further integrated with downhole logs and images. Geolog has gained significant experience in performing successful installations and the ability to implement these technologies effectively through sensor selection, installation design and final implementation has allowed for the accurate identification of the full range of losses to the formation, from major cavernous total lost circulation to subtle micro-losses. GEOLOG's GeoFracture service incorporates the detailed interpretation of the pattern, timing and magnitude of these losses that can be used to help give excellent qualitative knowledge to understand the fracture system type. Successful implementations range from conventional carbonate reservoirs in Europe and the Middle East as well as clastic reservoirs in Europe, North Africa and Latin America. In North America, an application in unconventional plays has resulted in the service being used to aid in the running of smart completions. The entire range of functions provided by the integration of these surface monitoring and evaluation systems expands to provide pump efficiency, correct fluid displacement during cementing/pumping operations, more accurate hydraulics assessments, accurate fluid volume monitoring, kick and loss detection, identification of wellbore ballooning and open fracture identification and an assessment of their permeability.

Further geological knowledge about the fracture system is determined when accurate elemental analyses of cuttings are incorporated into these interpretations that include possible mineralised closed fractures, mineralisation along open fractures, chemostratigraphic zones and flow barrier estimation. By adding in the gas compositional data and response signatures, which may range from zero gas due to total loss of circulation, all the way to significant gas peaks measured at surface in hydrocarbon filled fractured oil and gas reservoirs, the fracture system can be analysed in yet more detail. Measurements of noble gases such as helium identify further details of microfractures, while complex hydrocarbon compositional data can provide indications of formation connectivity through the fracture network.

This data is continuously added into the overall interpretation model to give a very comprehensive qualitative first indication of a fracture system. The interpretation is enhanced as data points are delivered. The earliest real time drilling data provides the earliest indication of fracture systems, which are then potentially confirmed by the analysis of lagged cuttings and gas data, which in turn help to optimise the logging programme and further enhance the overall interpretation of results.

Figure 4 shows the reaction of the circulation system to what is interpreted as an open fracture (see pattern 1 in Figure 5). This is later confirmed by the image log on the right of Figure 4. Figure 5 shows four stylised fracture model responses used to compare results.

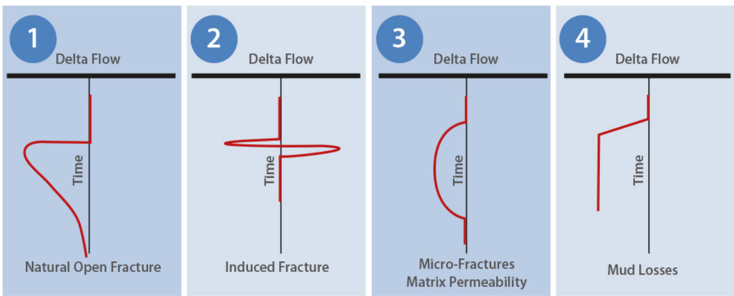


***Figure 5.*** *Fracture models used to compare responses in Delta Flow.*

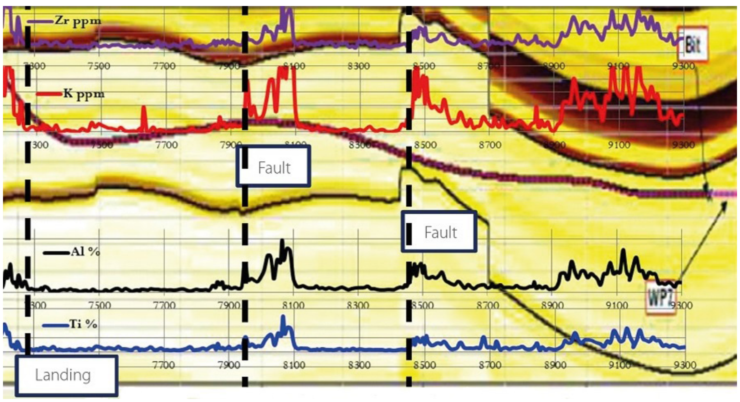


***Figure 6.*** *The horizontal plot highlights the elemental signatures used to identify the fault zones.*

## Well placement

The formation evaluation aspect of surface logging has developed significantly over the past decades with what were previously considered laboratory measurements now being routinely delivered at the wellsite. Interpretation by experts is available on a global basis through broadband real time data transmission of data. Through its GeoROX service GEOLOG has pioneered the ability to deliver accurate and integrated elemental and mineralogical determinations from cuttings and further evaluation of liquid hydrocarbon content, source potential and maturity in a manner, which is independent of hole size, bottom-hole temperature and pressure, thus ensuring that data is available no matter what the hole conditions may be. These more complex direct measurements have helped resolve aspects of petrophysical interpretation, but also opened up the use of this evaluation and interpretation of geological phenomenon into new applications such as 'geo-stopping' – using subtle chemical changes in lithology as chemostratigraphic markers to identify casing/coring points for example. The use of rock elemental analyses to perform geosteering is becoming more prevalent, especially when combined with high resolution gas chromatography to stay not only on target stratigraphically, but within specific hydrocarbon zones as well. This is being delivered as a highly cost-effective methodology in many geographies globally with successful case studies being available within conventional carbonates in the Middle East and clastic formations in Europe, as well as unconventional operations in both Europe and North America. Figure 6 shows a composite plot of wellbore, MWD Azimuthal tools and a range of elemental markers. The changes in elemental signature along the wellbore were able to identify fault zones along the horizontal well path. These zones were subsequently isolate with production packers and the well completed successfully.

As technology and interpretive models improve, further opportunities for the rapid integration of data sets to improve interpretation of the results from drilling activities will be identified. The integration of enhanced safety systems and geological data form an application being provided in numerous geographies. As a company that provides acquisition, analysis and the interpretation of a wide range of data sources, GEOLOG is actively researching applications that deliver value; the traditional separation between 'drilling services' and 'geological services' is being removed as technology innovation is implemented more widely.

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