Formation evaluation is a dark art of looking at something indirectly to see it directly. It aims to take some of the uncertainty out of oil and gas drilling, insuring a particular formation is commercially viable – or a pay zone – and enabling its exploitation in the most efficient manner possible. Mud and drilling fluids obscure the understanding of the well, and doubly so with more hostile drilling environments and unconventional reservoirs.

New technologies are opening the door to increased formation clarity, such as real time downhole feedback.

“Real-time feedback gives operators the opportunity to monitor the progress of a well during drilling and, if necessary, make decisions to change the plan while the job is still active and the drillstring is in the hole,” says Richard Pelling, Product Manager – Geolog, Paradigm. “The WITS/ML [Wellsite Information Transfer Standard Markup Language] standard format for real-time data transmission has helped to promote the use of real-time data by making it available in a format that is understood by all.”

While technology is enabling real time feedback, at the same time data transfer limitations represent a barrier to fuller exploitation of the available real-time data.

“Technological advances in the on-board processing available in logging tools have meant that more information is potentially available in real-time,” says Pelling. “The problem has always been getting enough of this data back to surface. While mud pulse telemetry remains the dominant means of transmission, new technologies such as wired drill pipe offer the prospect of massively increasing the volume of data that can be sent uphole in real-time – but this wired drill pipe technology comes at a price and always seems to be just around the corner.”

Unconventional Challenges

Pelling says the different types of unconventional assets such as shale gas, heavy oil, coal seam gas, or fractured basement each present different formation evaluation challenges. “These plays require a different mindset from the conventional clastic/non-clastic reservoirs, and to take shale gas as an example, require that we build up a detailed understanding of the mineralogy encountered in the rocks in each play in order to correctly identify the reservoirs.

“This challenge is being met both by a resurgence in conventional lab work on core in an effort to build up detailed play specific models to help refine our analytical routines and by a new generation of spectroscopy logging tools which help acquire this mineralogical information downhole.”

Another trend identified by Pelling is operators, in particular NOCs [National Oil Companies], wanting the ability to process more of the advanced logging tool data themselves in house. “Perhaps not on every
Paradigm announced the next version of its formation evaluation solution Geolog® 7 in May, which became available on both Windows and Linux platforms in the second half of 2011. Geolog is based on Paradigm’s Epos® 4 data management solution and is integrated with Paradigm’s StratEarth® and SKUA® geological interpretation and model-building solutions.

Geolog 7 features a complete interface redesign with easy user configuration and one click operation for routine tasks: drag & drop data loading greatly reducing the time taken to get the data you need where you want it; comprehensive audit trail; new interactive core analysis module, including capillary pressure and saturation height modeling; and interactive dip-azimuth walkout plots to help geologists analyze structural regimes.

“Geolog 7 is the result of a thorough re-engineering of the Geolog suite, with the aim of making our powerful and efficient formation evaluation offering even more productive and easier to use,” said Richard Pelling, solution manager for formation evaluation at Paradigm.

With comprehensive integration with the Paradigm solution suite, Geolog leverages strong interpretation, calibration, modeling and mapping capabilities across many workflows.

Pelling says Paradigm recently introduced new methods for quantifying uncertainty in Geolog®, “starting with the acquisition curves and working through to final fluid saturations and taking into account the uncertainty associated with the analytical models used to derive them. This information links directly into our existing reservoir modeling uncertainty workflows enabling the end user to make quantification of uncertainty a part of every analysis and, with a quantified +/- 5 value available, help make the business case for further investment in a field.”

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“Halliburton’s Drilling and Evaluation Division has worked closely with our Completion Tools group to form tech teams in these various shale play areas. This is an ongoing process as these discoveries evolve and more innovative solutions are being evaluated.”

Operators are also going into more hostile environments. “Our customers must exploit deeper and hotter environments in their quest for replacement of hydrocarbon reserves,” says Wilson. “These searches have ventured into more hostile environments than ever before. Higher temperatures and pressures are being encountered at these greater depths. Existing technologies are challenged to support drilling tools and LWD [logging while drilling] measurements at temperatures greater than 300° F [around 149° C].” Halliburton has already released systems that can handle temperatures up to 200° C and pressures up to 30,000 psi, and are currently developing systems for even higher temperatures.

**Toward Commonality**

Halliburton says that it is seeking to reduce time constraints and uncertainty associated with multiple data acquisition systems in formation evaluation. The company is employing common sensors, common analysis tools and common presentation formats across formation evaluation services. The goal is to lower total formation evaluation costs, reduce non-productive time and deliver improved efficiencies across the asset.

Wilson says there are three key thrusts:

- Reliability initiatives to reduce/eliminate flat or non-productive time;
- Provision of additional sensors to monitor and measure environmental parameters that impact reliability and durability of drilling bottom hole assemblies; and
- Higher temperature and pressure capability along with improved and more robust packaging permitting longer runs in more extreme environments.

**M/LWD sensors** are at the heart of technologies enabling real time downhole description of formations. “M/LWD sensors have expanded to nearly every measurement available in wireline,” says Wilson. In addition, real time applications to receive these data are being incorporated into personal computers and even smart phones.

**FSWD**

Advances have also been made in formation-sampling-while-drilling (FSWD) devices. “Previous formation sampling while drilling tools provided only pressure measurements,” says Wilson. “With the advent of formation sampling while drilling, operators will not only have the formation pressures, but also fluid identification via pump-out capabilities within the LWD, and the capability to capture multiple uncontaminated samples of formation fluids during the drilling operation.”

There are significant efficiencies to be gained. “Reduced pump-out times can be achieved due to the reduction and exposure time of the formation to the overbalance of the drilling fluids to obtain a comparably uncontaminated sample as wireline. This is not due to any technology improvements, merely the fact that the overbalance has only been on the formation for a few hours versus days.

“In many instances, the borehole condition deteriorates with time and sampling while drilling tools must have a quality borehole to seal against the formation and capture samples. Formation sampling while drilling tools have the benefit of being positioned in the BHA close to the drill bit, and as such, the wellbore has minimal time to deteriorate.”

**Future Technologies**

Customers are pushing for further technological advances. “Our customers want measurements as close to the drill bit as possible and

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even ahead of the bit,” says Wilson. “They want faster, more efficient data in real time to make decisions as you drill, not after you drill. If you steered or mapped incorrectly and incorrectly positioned the wellbore, you must re-drill a section of the wellbore to better exploit the reservoir. The quicker data is received the sooner action can be taken to reposition.”

Customers also seek multi-directional imaging. “The image gives us the entire borehole for evaluation as opposed to an instrument measuring one direction only (omni-directional) and providing average answers that may incorrectly represent the reservoir evaluation.”

In line with this, Halliburton is developing an imaging tool for synthetic oil-based muds (SOBM) drilling fluids that is currently not available in LWD. It will utilize both acoustic and resistivity measurements to create independent high resolution images of the borehole while drilling. These images may be used for fracture identification, stratigraphic and facies identification, dip picking, and standoff caliper and borehole shape and quality.

Halliburton also has its new XBAT cross-dipole azimuthal tool, launched in 2011, which Wilson says greatly enhances their acoustic services with full azimuthal capabilities including sonic velocity images and multi-axis caliper images. “These images can be used for enhanced rock mechanics and wellbore stability measurements such as stress anisotropy characterization. We can also use the sonic velocity images for geosteering and production enhancement in unconventional wells.”

**Radiological Replacement**

Formation evaluation has been further complicated by changes in the operating environment. According to the Society of Exploration Geophysicists, there is concern that sealed, chemical isotope radiation sources, which are currently used in the gas/oil well logging industry, “can be diverted and used in radiological dispersal devices” (dirty bombs). The Society says that alternatives, both radiological and non-radiological, are actively being sought within the oil-field services community. Also, the US National Nuclear Security Administration (NNSA) has developed a Radiological Source Replacement (RSR) Program, including projects investigating enabling technologies for non-nuclear and non-isotope-based well logging techniques.

“In recent years there has been a move to reduce our reliance on chemical neutron sources downhole,” says Pelling. “This is driven primarily by safety concerns about sources falling into the wrong hands or getting lost, or – even worse – compromised downhole. Unfortunately, these chemically sourced tools currently provide us with the most accurate estimates of in-situ porosity, so it is hard just to get rid of them.

“There are, of course, other independent (non-neutron) methods of determining porosity such as using sonic measurements or NMR [nuclear magnetic resonance], although these are not as accurate. Compact neutron generators – as used in the mineral spectroscopy tools mentioned above – offer an alternative (and increasingly popular) ‘sourceless porosity’ service, although in addition to requiring an additional electrical power sources the neutron signal from these generators differs from the discrete energy signal from a chemical source, so it’s not a simple one-for-one swap and there is still scope for much additional research in this area.

“Regulations may mean that over time we may need to get used to new tools and from our standpoint, we need to be sure that we can handle these and offer operators an easy means of dealing with their outputs and making meaningful comparisons between these and historical measurements from tools with chemical sources,” concludes Pelling.

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