MRI-LWD technology could cut costs, add reserves

MAGNETIC RESONANCE imaging is a useful tool for reservoir evaluation. Now MRI has been developed into a while-drilling technology that offers to reduce well costs and provide better information that can increase recoverable reserves.

Charley Siess, Manager for Commercialization of the **Numar** Technologies and the Magnetic Resonance Imaging-Logging While Drilling (MRI-LWD™) tool, speaks to the subject of **Halliburton**'s move beyond MRI wireline development into the new MRI-LWD technique:

"We are engaged in a more efficient approach to reservoir evaluation in Halliburton Company, founded in measuring the reservoir fluids first, then deciding what other pieces of reservoir information are truly needed. We began with MRI fluid measurements derived on wireline, and we are now advancing into MRI-derived reservoir fluids properties obtained during the drilling of the well in LWD.

"The next phase will be to further enhance client reservoir fluids knowledge by providing for the first time ever direct measurements of in-place hydrocarbon properties. We are able to measure viscosity and gas oil ratio at reservoir temperature and pressure in the well via the new MRILab™ wireline device which is an integral part of the new Reservoir Characterization Instrument (RCI)."

Each of these MRI fluid measuring devices is part of an ongoing evolution towards comprehensive reservoir fluid evaluation, said Mr Siess. "Our goal is to optimize the value and return in produced hydrocarbons from the clients' reservoirs."

THE GREEN COMPONENT

The oil industry can use this non-radioactive technology to return to old, abandoned fields and possibly reclaim hydrocarbons that were overlooked or misidentified with early conventional technologies conveyed by wireline.

"There are documented cases and publications written by clients I have worked with who have employed both the new MRI technology and 3-D seismic in revisiting abandoned fields in the Gulf of Mexico," said Mr Siess. "As a direct result of the use of new reservoir knowledge, their company has benefited by producing more oil in 1 year from a single newly-drilled well than from 14 prior wells drilled and produced over 12 years before, after which time the field was abandoned."

One focus will be on existing producing areas. Another will be on optimizing deepwater areas through the MRI-LWD technique where rig time is at premium day rates, and time saved through reservoir evaluation while drilling will pay for itself by saving time and money.

Charley Siess, Numar, presents MRI-derived data to a client group and explains the benefits of the technology's log while drilling capability.

FLUID TYPING

Use of magnetic resonance imaging began in the medical field. When the human body is scanned, MRI records signals coming only from fluid-rich tissue and not the bone.

When this technology is transferred to downhole measurements, it capitalizes on gathering signals only from the fluids such as gas, oil, and water held in the small pores of the reservoir rock, with no influence from the surrounding rock.

In downhole MRI measurements (wireline or LWD), a magnet in the tool energizes the protons of the hydrogen atoms of the fluids inside the pore spaces of the rock.

Next, a radio-frequency signal is used to orient the proton into a spin. As these protons spin, they form a coherent signal called an echo, which is recorded by the tool as an amplitude. This amplitude is directly translated into the amount of fluid that the rock holds, or the porosity.

The received signal carries additional information. The tool records additional echoes with increasing time, measured in milliseconds or 1/1000 of a second. For example, if the amplitude of each echo dies off quickly with increasing time, the pores holding the fluid are small and less able to transport fluid (the rock is not permeable).

If the echoes continue to give high amplitude as time increases, either larger pores are present, or a light hydrocarbon (oil) is available to be produced.

There are many applications of MRI technology, such as determining:

• Total quantity of fluid in the reservoir, its total porosity;

• Quantity of fluids in the reservoir that are not bound to clay mineral surfaces, its effective porosity;

• Types of reservoir fluids present—oil, gas, and water have distinct MRI-characteristic signatures and can be differentiated from each other;

• The type of oil that is present—light, intermediate or heavy;

• How much of the water is contained in small pores and will not move out of the reservoir, its capillary bound water—this tells the user how much oil or gas can be in the reservoir, its value in dollars;

• Amount of small pores versus big pores tells the user how fast the fluid will come out of the reservoir, its permeability.

THE NEXT STEP

Wireline logging and wireline MRI logging techniques take place after the well has been drilled. The additional time required to log after drilling has two major costs above those of the services being provided: the cost to run and operate the rig, and the risk of damage to or loss of the well during the logging operation.

For these reasons, the industry has pushed for more logging technologies to be performed during the drilling process. Thus, the next logical step was to investigate whether MRI measurements could be made in a while-drilling mode. Clearly, when the earlier MRI data are available, value is added to the evaluation operation.

Numar, a research division of Halliburton in Malvern, Pa, began research into while-drilling MRI technology about 10 years ago. A major hurdle had to be overcome in order for this technology to work properly in a while-drilling mode. It was believed that while-drilling measurements would not be possible due to the random and violent motion of the tool string. This motion is detrimental to the accuracy of an MRI reading, obliterating fluid typing and pore size information.

Two energy states exist in which the hydrogen protons can reside for an MRI measurement to take place. The wireline MRI tool measures hydrogen residing in a transverse orientation known as a transverse relaxation time or T2. The second energy state is a longitudinal orientation known as a longitudinal relaxation time or T1. This T1 hydrogen orientation is not sensitive to tool motion and provides many of the benefits of the traditional T2 measurement. This discovery allowed Numar to develop an MRI logging-while-drilling device which is motion-tolerant of the drillstring movement.

FIELD EXPERIENCE

Numar had fielded experimental versions of their MRI-LWD tool to prove an innovative concept for while-drilling measurements. In a field test campaign spanning 1½ years, the MRI-LWD tool logged several test wells and customer wells. The purpose of these tests was to establish that the MRI-LWD tool:

Steve Zannoni inspects MRI-LWD tool at Numar where research into the technology began.

- Measures rock porosity independent of lithology;
- Does not use radioactive materials, therefore preventing contamination of the well site (All measurements are made without radioactive emitters like Cs137 or AmBe.);
- Collects a spectrum of MRI relaxation times suitable for estimating pore sizes, bound-fluid volume, and permeability;
- Enables fluid typing;
- Can withstand shock, vibration, and erosion associated with drilling;
- Does not interfere with the drilling process;
- Does not interfere with any other LWD or MWD measurements.

RESULTS COMPARED

Although MRI-LWD data look in many respects like wireline data, the MRI-LWD tool itself does not share any physical components with the wireline MRIL-Prime™ tool. Rather, the MRI-LWD tool was built from the ground up to have exceptional strength and longevity in a very adverse environment.

Wireline tools are powered through a cable from the surface. Since there is no such umbilical in LWD, the developers of the MRI-LWD tool had only two options for generation of power: a turbine or batteries.

Here again, the T1 mode made the choice easy. This measurement mode turned out to be a real power miser, and a single battery charge is sufficient to power the tool continuously for 200 hr.

Wireline cables also function as a transport medium for data up and down the line. In LWD, most of the data acquired is recorded. In the case of the MRI-LWD tool, a permanent memory of 200 MB can hold data acquired in 200 hr or more and can be downloaded at the surface within minutes. A real-time data link for an important subset of the data will also be supported in the future.

The MRI-LWD can provide real time reservoir fluid data describing bound and free fluid, as well as comprehensive answer products containing all MRI data within 12-14 hr after pulling out of the hole. Rig time saved can be as much as 12 to 36 hr versus securing MRI data on wireline.

This is such a savings to well operators that eventually, Mr Siess and his Numar Team One predict, the use of wireline devices in the highest-cost rig operating environments will be eliminated in favor of obtaining data while drilling.

Also, the LWD device will acquire data earlier than usual through wireline data acquisition, and before the impact of invasion by mud filtrate, which over time tends to sweep away hydrocarbons present near the borehole.

WHERE TO NEXT?

"We have repeatedly run the MRI-LWD tool and found good agreement between it and the wireline MRIL-Prime tool," said Mr Siess. "We plan to repeat this result at a revenue-generating job in a commercial well for a major E&P company in deepwater in the Gulf of Mexico. Next there will be deployments to the North Sea and a response to inquiries in the Middle East and West Africa."

One of the most exciting prospects of MRI-LWD technology is the eventuality that clients can access this device in their well as it works, as will also be possible with the MRILab device.

"The MRI-LWD device is prepared as an Ethernet web site itself," said Mr Siess, "hence offering direct access from any computer to the downhole device as it obtains reservoir fluids information in the future."