TIM PARKER, HALLIBURTON, USA

**Geosteering**
In unconventional reservoirs, placing wells and knowing their position, while minimising costs, are critical components in making a reservoir viable. The natural gamma-ray signatures in some of these formations can be complex, making the logs from conventional gamma-ray sensors confusing and difficult to interpret. The Radian™ azimuthal gamma-ray and inclination service from Halliburton Sperry Drilling provides high-quality images of the borehole wall, delivering a cost-effective solution for geosteering and reservoir evaluation at temperatures up to 175°C (347°F). The service provides 360° coverage of the borehole in real time, even while sliding, helping the operator to make better geosteering decisions to maximise reservoir contact. The tool can also be fitted with an inclinometer package, providing continuous, real-time inclination measurements, which give immediate feedback on the impact of steering decisions on the well trajectory. The Radian tool is a single, robust collar, which may be placed anywhere within the drilling assembly. This makes it a versatile solution, compatible with high-torque drilling motors when necessary, while some conventional gamma-ray tools lack this flexibility or the necessary torque capacity. The Radian service helps operators achieve improved reservoir understanding, better well placement and a quality wellbore, key factors for maximising production and long-term recovery.

In a recent case in the US, an operator needed help to understand the complexity of the reservoir structure, both in terms of small-scale geological features within the reservoir, and the overall shape of the structure. Images from the Radian revealed details in the structure that had not previously been appreciated, particularly in a packstone sequence that featured a complex series of beds with widely varying stratigraphic dip. Meanwhile, the continuous inclination measurement revealed fine detail in the well trajectory, which was not reflected in the conventional directional survey measurements. By using the high-resolution inclination data, the operator was able to refine the TVD position of the well, applying a total correction at the end of the lateral section of more than 15 ft relative to the conventional directional survey. This information, combined with structural dip measurements from the gamma-ray images, led directly to a refined structural map of the field, eliminating several anomalies arising from the use of conventional methods.

**Formation evaluation**
With poor seismic imaging below salt, operators often find it challenging to validate their geological models. This increases the risk associated with drilling into what is effectively an unknown zone immediately below the salt. Any structural information that
can be acquired during the drilling process is therefore valuable, as it reduces uncertainty and helps to minimise the risk associated with drilling the well. In many cases, this problem is exacerbated by the need to drill the section with a large-diameter drill bit, producing a borehole that is too large for normal LWD borehole imaging tools, and necessitating expensive wireline logging runs. One operator challenged Halliburton’s Sperry Drilling product service line to develop a solution that would provide the necessary structural information while minimising operating costs.

The solution was relatively simple: take an established borehole-imaging technology and build a version suitable for use in larger boreholes. Sperry Drilling developed a new Azimuthal LithoDensity (ALD™) tool, based on a 9 ½ in. drill collar, and with a stabilised detector blade of 14 ¼ in. This sensor is capable of acquiring formation density measurements and azimuthal borehole images for structural dip interpretations in borehole diameters of between 14 ½ and 17 ½ in. – a capability that is unique in the industry. Sperry also developed processing techniques for enhancing the quality of the acquired borehole images, so that they provide reliable dip information even in boreholes that would normally be considered over-gauge for the purposes of traditional LWD density measurements.

The net result was a solution that directly addressed the operator’s needs by providing borehole images in real time and eliminating the need for a dedicated wireline run. During a subsalt project in the Gulf of Mexico, in a water depth of over 5200 ft (1585 m), the operator obtained real time data from the new large-size LWD density service to determine accurate dip information, which correlated with the geological model at the salt exit point. The high quality of the images allowed the operator to cancel a run with a triaxial wireline resistivity tool, thus saving them approximately US$1 million in wireline service costs and rig time.