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First Run of Geosphere HD 475 and Periscope HD Services Revealed a Greater Degree of Wellpath Optimization within the Reservoir, North Sea

Geosteering in complex environment used slimhole ultradeep-reading reservoir-mapping combined with multilayer, deep-reading high resolution bed-boundary detection

CHALLENGE

Successfully geosteer the slimhole section of a horizontal well in a thinly-bedded formation with low resistivity values and contrasts, while maximizing production value.

SOLUTION

Use 475 tool size of the GeoSphere HD* high-definition reservoir mapping-while-drilling service combined with Pericope HD* multilayer bed boundary detection service.

RESULTS

- Conducted the first worldwide combined run of the 475 tool for GeoSphere HD and PeriScope HD services, delivering ultra-high definition reservoir mapping.
- Detected multiple bed boundaries within a low resistivity contrast and with a depth of detection up to 40-ft TVD.
- Established true stratigraphic thickness (TST) of target to be ~60 ft, continuously throughout the section.
- Provided greater confidence in decision-making while drilling.
- Enabled the wellpath to be optimized within the reservoir interval and therefore higher flow rates to be achieved.

Understand stratigraphic complexity to geosteer slim hole within the highest productivity intervals, yielding maximum along-the-section production

Cygnus Field is located in the UK Southern North Sea and has producing wells targeting the Carboniferous Ketch and the Permian Leman Sandstone formations. The Leman Sandstone Formation here is thinly bedded and, in some places, the presence of subseismic scale faults adds even more complexity and can easily throw the wellbore out of the optimal producing interval. Overall, the Leman Sandstone Formation is of a very low resistivity, with only small resistivity contrasts apparent. Fracture stimulation is often used to aid production in similar low-permeability reservoirs; this was originally a potential solution for some wells in the Cygnus Field.

Consequently, bed-boundary-mapping technology is required for drilling horizontal wells in this field, and the ability to resolve for bed boundaries converging on the wellbore is vital to remaining within the thin pay zones. The previous 6-in section horizontal wells within the Leman Sandstone Formation were drilled with geosteering technology comprising high-resolution, deep-reading electromagnetic (EM) propagation resistivity. Tools used included the PeriScope HD service and wellbore density imaging equipment. Conditions led to a shallow depth of investigation, meaning that despite resolving for the immediately adjacent beds both above and below the wellbore, at a vertical distance of 3–5-ft TVD, there were many unanswered questions on a larger scale. Such questions included the position and geometrical relationship of the Base Permian Unconformity at the base of the sequence and the presence of other sand successions.

To help mitigate the complexity introduced by the small-scale faulting and to aid in understanding the wellbores, stratigraphic position, wellbore density image interpretation was used to perform a TST computation in real time. This enabled correlation of the wellbore's position with respect to the formation. However, it required a certain amount of data and was time consuming, which slowed the decision-making process. A large sensor offset from the bit further exacerbated the situation because drilling further (MD) was required prior to logging the data.

Combine slimhole reservoir-mapping-while drilling with multilayer bed boundary detection service

The GeoSphere HD service in the 475 tool size makes ultradeep-reading EM propagation resistivity measurements possible in a slim hole. It uses a new high-power transmitter and higher-resolution deterministic inversion. Feasibility modelling illustrated that the GeoSphere HD 475 service alone can answer the larger scale questions, mapping the top and base contrasts of the Leman Sandstone Zone 5b gross package interval, but its vertical resolution was not designed to geosteer within such low contrast, thinly bedded intervals.

Schlumberger recommended that the PeriScope HD service combine with the GeoSphere HD service in the 475 tool size. Our teams illustrated how the high-resolution information derived from the PeriScope HD service can combine with the multiple investigation depths of the ultradeep-reading data from GeoSphere HD service. This unique tool integration would enable the resolution of all depths of detection required to successfully geosteer 6-in wellbores within the thin, low-contrast pay zones.

Achieved multiple bed boundary detection and target TST with a depth of detection up to 40 ft from wellbore

The first worldwide-combined run of the GeoSphere HD 475 and PeriScope HD services delivered a high resolution of precision information within the low resistivity contrast and thinly bedded environment of the Cygnus Field.

Multiple thin beds were resolved for the wellbore's immediate surroundings using the one-receiver data from the GeoSphere HD and PeriScope HD services (Fig. 1A) , with a depth of detection of up to 25-ft TVD, and these bed boundaries being validated using the PeriScope HD inversion (Fig. 1B). In tandem, the two-receiver data from the GeoSphere HD and PeriScope HD services successfully resolved for the resistive boundaries at the top and the base of the Leman Sandstone Zone 5b, at a distance of up to 40-ft TVD from the wellbore, and continuously identified the gross package at ~60-ft TST. These large-scale details are the first time this level of understanding has been achieved in the field.

Mapping the resistive base Permian unconformity was crucial for providing the the operator's Neptune team with a superior understanding of its geometrical relationship. This led to the modification of their structural model in real time, and also enabled them to plan geosteering decisions ahead of time to maximize along-hole production from contributing intervals identified from offset wells. Mapping the uppermost resistive boundary of the Leman Sandstone Zone 5b made it possible to continuously define the wellbore's true stratigraphic position. Together, these results not only delivered the geosteering capability within the challenging environment, but they also provided timely decision making, optimizing both the wellpath and associated access to the reserves in this area of the field. The unique pairing of this technology enabled the correct placement of the well within the most productive intervals and therefore avoided a potentially risky and costly fracture stimulation for Neptune.

Figure 1

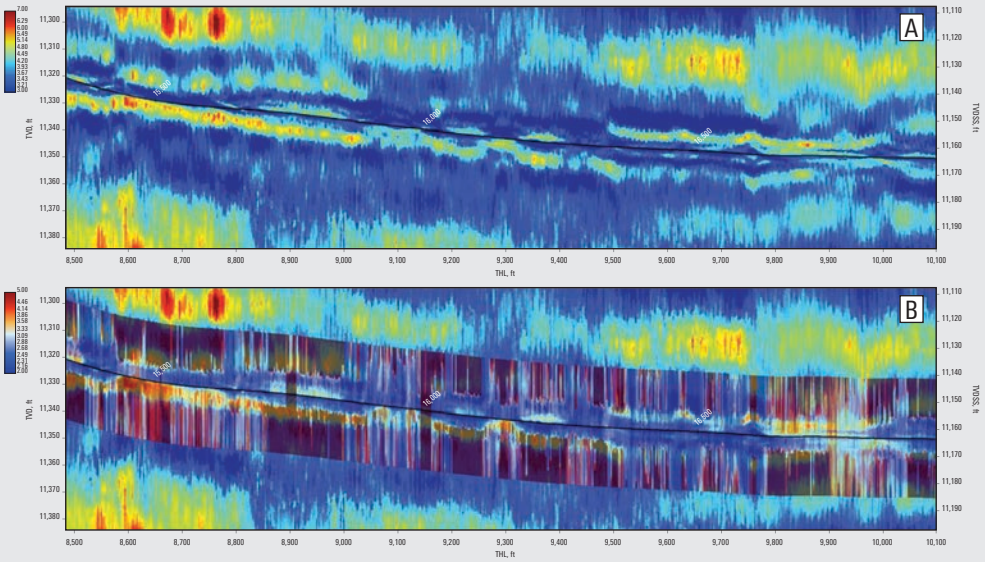

Figure 1A. 1-receiver tool for GeoSphere HD 475 service with PeriScope HD service inputs inversion for a zoom of the 6-in section. The high resolution of both the 1-receiver transmitter-receiver pairing in addition to the PeriScope HD service data highlights the low resistivity contrast and thin beds. The narrow color scale of 3 to 7 ohms highlights thin beds.

Figure 1B. The same inversion as Fig. 1A, overlaid with the PeriScope HD service inversion. The PeriScope HD service inversion has historically been used for geosteering within the man Sandstone Zone 5b, and is therefore trusted. PeriScope HD service combined with the QC of the GeoSphere HD service (rather than standalone) reinforces the results, giving Neptune confidence to move forward.

Figure 2

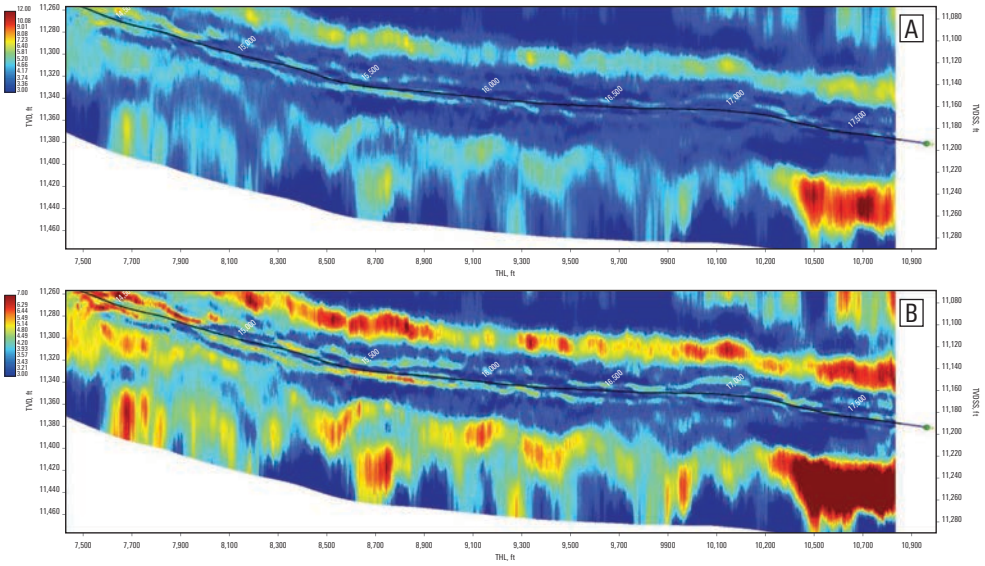

Figure 2A. 2-receiver tool for GeoSphere HD 475 service inversion, including PeriScope HD service inputs for the whole of the 6-in section, shows the high confidence resolution of the resistive top and base man Sandstone Zone 5b package. It illustrates the interpreted wellbore's true stratigraphic position within the formation. An approximate mapping reveals the thinly bedded Leman Sandstone interval that has a low resistivity contrast. Color scale is 3 to 12 ohms.

Figure 2B. Is the same image as Fig. 2A, but has a reduced scale of 3 to 7 ohms, which highlights beds in a low contrast environment.

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