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HPHT Borehole Seismic Survey Below Chalk

SlimXtreme borehole seismic survey in a deviated, HPHT North Sea well accurately images reservoir beneath chalk layer

CHALLENGE

Obtain high-quality seismic data beneath North Sea chalk layer to interpret reservoir shape and extent.

SOLUTION

Run high-pressure, high-temperature (HPHT) seismic acquisition tool on the SlimXtreme* slimhole logging platform to acquire full vertical seismic profile (VSP) in the deviated HPHT well.

RESULTS

Used the more accurate velocities obtained both within and below the chalk by the borehole seismic survey to reprocess surface seismic data and obtain a much clearer image of the reservoir.

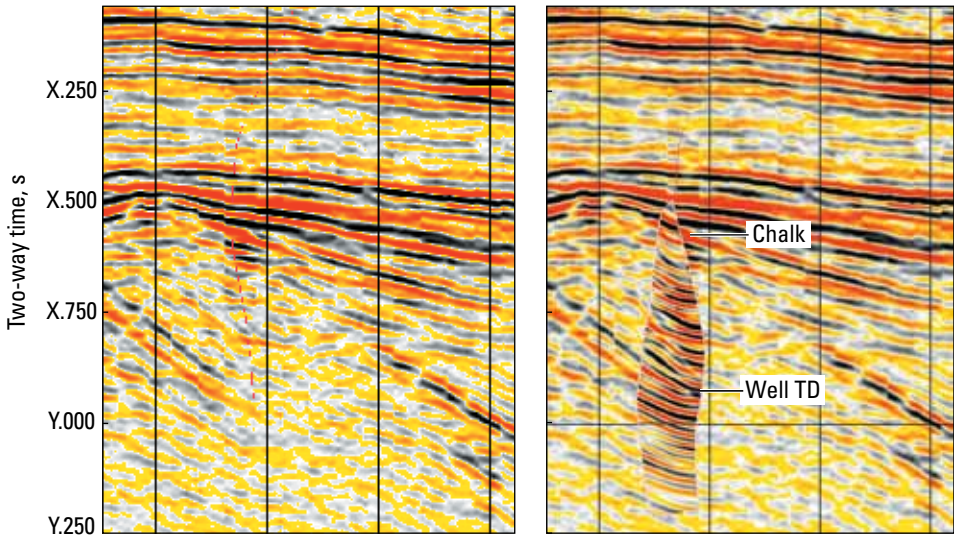
Seismic uncertainties below chalk

ConocoPhillips (UK) Limited needed better quality seismic data than the surface seismic obtained for a HPHT well in the central North Sea. The reservoir is below a chalk layer, which introduced velocity uncertainties and generated noise that interfered with the reservoir signals in surface seismic surveys. Acquiring VSP data unobscured by the chalk layer would enable correlating the VSP, well log, and surface seismic data to build a more accurate picture of the reservoir. However, conducting a borehole survey would be challenging: TD of the well is below 15,000 ft [4,600 m], temperatures approach 400 degF [204 degC], and the well trajectory was deviated above the chalk and then sidetracked out of the plane of deviation.

HPHT VSP acquisition

The 3⅜-in [8.6-cm] seismic acquisition tool of the SlimXtreme slimhole HPHT platform combines high-performance packaging with analog recording from a three-component set of receivers. The SlimXtreme family is engineered to operate in conditions up to 30,000 psi [207 MPa] and 500 degF [260 degC].

Because borehole seismic surveys record low-noise downgoing waves in addition to the reflected upgoing waves and feature multicomponent processing, the SlimXtreme seismic tool can obtain VSP images with fewer multiple reflections to give a more accurate picture of the reservoir structure, providing critical information that is poorly defined on surface seismic data.



Because the surface seismic image was produced using chalk velocities that are too low (left), it fails to tie with the VSP (small region with higher amplitudes and higher resolution, narrowing upward on the right). The mismatch is obvious in several intervals.

Accurate formation velocities for reservoir insight

Despite the extreme conditions, the SlimXtreme logging operation went smoothly. The tool acquired data at receiver stations every 50 ft [15 m] through the reservoir and into the chalk and at more widely spaced intervals in the chalk. At the deepest of the 73 stations, the temperature reached 380 degF [193 degC].

Processing of the three-component data included a correction for the 3D nature of the borehole trajectory to allow migrating the VSP data using a 2D algorithm. Differences in velocity models based on the surface seismic and VSP data indicated that the VSP detected higher velocities in the chalk layer and lower velocities below the chalk than in the surface seismic model. These differences translate into mis-ties between the VSP and surface seismic images below the chalk. However, the depths of the reflectors in the VSP image match those of a synthetic trace generated from sonic and density well logs, confirming the accuracy in VSP image depths. Conoco Phillips (UK) Limited is using these accurate velocities to reprocess the existing surface seismic data and better image the reservoir to reduce risk in future drilling.

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