Anisotropic Stress Modeling Reliably Determines Mud Weight to Improve Stability and Reduce Risk

Sonic Scanner acoustic scanning platform characterizes shale geomechanics in North Sea Eldfisk field more accurately than fracture gradient methods

CHALLENGE

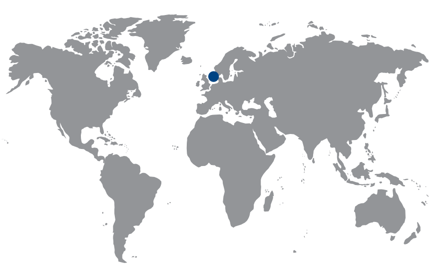
Develop a more accurate and reliable method to compute the mud-weight window and reduce risk by improving wellbore stability.

SOLUTION

Account for variation in the rock properties instead of assuming they are homogeneously isotropic by using 3D data from Sonic Scanner* acoustic scanning platform to determine the minimum horizontal stress.

RESULTS

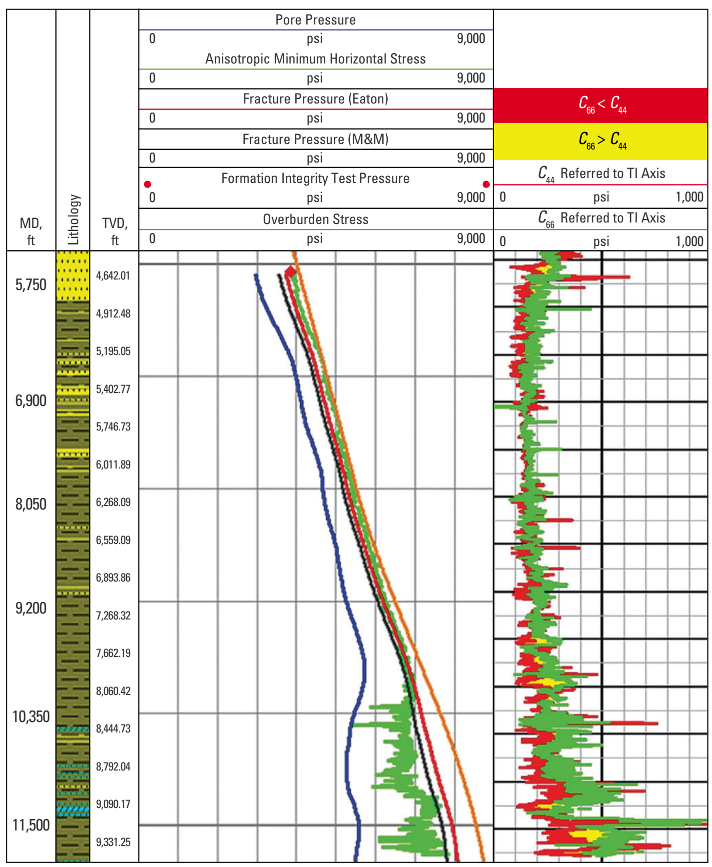
Improved wellbore stability while reducing risk, nonproductive time, and costs by basing the mud-weight window on the minimum horizontal stress calculated to account for shale anisotropy.



Difficulties in determining mud weight

Determining mud weight by using simple fracture gradient models was resulting in mud losses in the lower section of the shale overburden in wells in Eldfisk field. Using the fracture gradient was the preferred approach because isotropic stress models derived from conventional sonic and core measurements required significant adjustments to account for the anisotropic behavior of the shale overlying the reservoir. However, the fracture gradient's computation as a function of pore pressure and overburden stress cannot account for changes in rock properties, such as stiffness or deformation, resulting in overestimation of the stress regime and mud weights that were higher than necessary.

A North Sea operator needed a more reliable method that did not neglect shale anisotropy. Being able to specify the mud-weight window based on an accurate minimum horizontal stress would improve wellbore stability and avoid necessitating multiple sidetracks to land the casing.



The minimum horizontal stress (center track) calculated with the anisotropic equation using data from the Sonic Scanner platform and offset wells matches the conventionally calculated pressure gradients in the upper part of the well but is significantly lower than the overestimated gradients in the deeper section in the anisotropic shale overburden.

Full 3D acoustic characterization to account for anisotropy

The operator and Schlumberger petrotechnical specialists worked together to derive an alternative workflow that would fully characterize the transverse isotropy (TI) in the layered shale transected by the deviated wells. The Sonic Scanner acoustic scanning platform was used to acquire exceptional-quality compressional, shear, and Stoneley waveforms because it is the only wireline sonic tool that is fully characterized for tool effects and alteration in the near-wellbore region. The platform's multiple monopole and dipole transmitters accurately measure at multiple depths of investigation to provide a fully 3D acoustic characterization that addresses both intrinsic and drilling-induced anisotropy.

Mud weight based on accurate minimum horizontal stress

An anisotropic equation was developed to estimate the minimum horizontal stress from Sonic Scanner platform's dataset augmented with data from offset wells. The equation properly accounted for the shale anisotropy without requiring modifications to match the observed well conditions. The fracture gradient method was shown to have overestimated the minimum horizontal stress in the deeper section in the shale overburden by 500 to 600 psi compared with the anisotropic minimum horizontal stress.

Specifying the mud-weight window by using the minimum horizontal stress determined with Sonic Scanner platform data and the anisotropic equation has significantly improved wellbore stability while reducing risk, nonproductive time, and costs for the Eldfisk wells.

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