Optimizing well design through the use of 3D pore pressure

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This article focuses on how a calibrated 3D pore pressure volume can be used effectively to optimize a well design when pore pressure and mud weight windows are the dominant issues.

3D Pore Pressure Data: A valuable tool for well design

Estimated pore and fracture pressure profiles for the wellpath have often been used as primary input into the overall well design due to their overriding influence on casing seat selection. This, in turn, is the primary driver for hole geometry, casing program and overall well cost. While this workflow has been used historically for wells in abnormally pressured areas, it also applies to wells drilled through depleted zones. Recently this has also applied to deepwater wells, even when normally pressured, due to issues surrounding support of the mud column in the riser.

The ability to generate high-quality 3D volumes of mechanical earth properties such as pore pressure and fracture gradient can provide detailed insight into relative pressure distributions within a volume. However, reliable quantitative calibration using data from drilled wells within the area can deliver a more accurate pressure model in which to plan the well.

Combining 3D visualization, interactive wellpath planning: A powerful combination

A typical well planning workflow

Pore pressure has a huge impact on drilling safety and the economics of drilling design and well construction.
can interactively create geometrically valid wellpaths in the 3D volume based on specified design the engineering constraints. Use of a well planning and design tool provides this capability in the conjunction with a volume-based seismic interpretation tool. The addition of 3D visualization to interactive wellpath planning tools provides a powerful combination for optimizing the wellpath pressure profile on a qualitative basis. For example, variable opacity displays can be used to visually identify areas where the pressure is above or below a certain gradient threshold. This can be very effective in identifying routes to reach specific targets, avoiding isolated areas of abnormally high pressure. Furthermore, the ability to display volume data as ribbons and curtains along any wellpath allows visual determination of the pressure profiles in any given well.

However, trajectory design alone cannot determine how easily or even whether, a well can be engineered and physically drilled.

A unified engineering solution facilitates optimal well plan selection. Due to the large number of interdependent variables involved in well design, it is not possible to identify a single “best” design for any well. While it is often possible to optimize for a subject of the variables, it is unrealistic in almost all cases to determine the absolute optimal design covering all aspects of the well trajectory, casing program, drill string, mud system, hydraulic and rig requirements. Thus, there is a need to be able to iterate rapidly through many design options, to identify practical alternatives and to focus engineering resources on the integrity of a chosen design.

In order to examine all the alternatives and converge on this optimal well design, it is vital that all engineering analysis functions be fully integrated within the same application as the well planning functions and reference a common drilling database. The Paradigm Sysdrill application provides such a unified drilling engineering solution. Use of a common data model ensures that any changes to the wellpath and wellpath-related data, such as the pressure profile, are...
Pressure profile – Initial proposed sidetrack B2

Pressure profile – Initial proposed sidetrack B3

Pressure profile – final proposed sidetrack B3

to drill, since it would require three casing strings within an almost impossibly small mud weight window.

A sidetrack from the bottom of the B3 well provides a better, although longer, option than the original B2 sidetrack. However, the mud weight window is extremely tight and this well would likely be difficult and expensive to drill due to the constraints on mud weight.

It appears from the pressure distribution within the well curtain that a kickoff from higher in the well could potentially avoid the high pressure area above the B-3 target. This indeed turns out to be the case, and in doing so, significantly widens the mud weight window.

In this case, of the options reviewed, the longer sidetrack proves to be the easiest to engineer, and probably the most economical to drill. In a few steps we have evaluated options that range from non-drillable, to challenging, through to a relatively straightforward sidetrack plan, just on the basis of spatial variations in 3D pressure data.

Multi-disciplinary application integration is the key to well design efficiency

Further engineering analysis would determine the actual drilling and casing programs required to drill this well in accordance with the geological constraints and company engineering design policies. This analysis, in some cases, might identify further issues or constraints that necessitate additional changes to the planned trajectory. It is therefore essential that the well planning and engineering functions are delivered as a unified solution, tightly integrated with the 3D visualization application, so that the workflow can be quickly re-run as required to optimize the well design.

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