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Geosteering a re-development well into an abandoned field

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Abstract

The field Suderbruch, situated at the Aller between Bremen and Hannover, produced 3.4 Mio tons of oil between 1951 and 1994 before being plugged and abandoned. New studies indicated a good remaining oil potential from the 1600 m deep Malm carbonate sequence, the so-called Gigas. This was one out of many producing reservoir sections. A dense drilling network of more than 90 wells did characterize the structure broadly. All wells were drilled in the late 50´s before any porosity logs were available. The reservoir was therefore only characterized by sporadic core data and resistivity logs. These showed a 10-meter thick upper layer with less than 1 to 300 mD permeability and around 12 % porosity. This data could also be turned into a rough static reservoir model which indicated a prospective undrained area. The model also showed, that only a horizontal well is able to drain this Malm-Gigas reservoir economically.

Plans were drawn up to drill a roughly 1000 m long horizontal well. No 3D seismic was available helping in the design of the well; neither were recent logs available for a geosteering response model. The significant uncertainties mandated the use of a very deep looking LWD resistivity tool, whereas the precise steering would have to be done with azimuthal density data because the GR within the carbonaceous Malm did not show enough features.

An S-shaped pilot well was initiated to retrieve new logs and core data. The analysis resulted in a subdivision of the formation into an upper and lower part, separated by a marl-rich waste-zone. Both parts consist of oolithic dolotomized limestones, rich in shells and often heavily affected by bioturbation. The Upper Gigas is substantially more dolomitized. Marly shill layers can often be found intercalated in the carbonate sediments, as well as occasional anhydrite banks. This information leads to the development of a facies model where the Gigas sediments were deposited in a paleocoastline-parallel shoal in a shallow-marine coastal setting, which was subsequently affected by calcite/dolomite cementation and dolomitization.

This new information populated a geosteering response model, and the horizontal well was started within two weeks after the pilot well was finished. Landing proved to be tricky and needed LWD assistance, because of lateral variation in the caprock. The first 150 m of the horizontal well were drilled in well-predicted rock, but then faulting occurred A small anhydrite layer that was not seen in the pilot well's logs was misinterpreted as the signature of the lower Gigas, and the well went off course. Eventually, the well was brought back on track by drilling upwards. Then another fault brought an anhydrite block down into the path. LWD data suggested that drilling through that block was not possible within a reasonable time frame. A quick analysis showed how a sidetrack could circumvent that block. This sidetrack was initiated low side in the open hole using techniques available with a rotary steerable assembly. The anhydrite block was successfully navigated, and the well was steered back into the best reservoir section. Formation pressure measured while drilling indicated the presence of a new block. The well was continued another 300 m before the targeted total length was reached and the liner run in hole successfully without problems.