



**LITHOSTRATIGRAPHY & HISTORY FOR WELL: 2/4-20**

**Wellbore History**

**GENERAL**

Well 2/4-20 was drilled in the Feda Graben ca 8 km north of the Ekofisk Field and 5 km east of the Albuskjell Field in the Central Graben of the North Sea. The purpose of the 2/4-20 North Ekofisk exploration well was to test potential reservoirs in the pre-Cretaceous High-Pressure-High-Temperature play at both Jurassic and Permian Rotliegendes levels. The 2/4-17 Tjalve Discovery drilled in 1991ca 9 km to the north-east of 2/4-20 had proved condensate in deep Oxfordian sand and traces of hydrocarbons in the Rotliegendes Group. The main targets in the well were two Jurassic potential reservoir horizons: a primary target J50 (Oxfordian) sandstone and a secondary target J40 (Calloviaian) sandstone. In the Permian excellent reservoir sandstones analogous to 2/4-17 were expected to consist of Rotliegendes Group strata, largely of aeolian origin. Planned TD was at 5695 m with an expected TD temperature of 195 deg C.

**OPERATIONS AND RESULTS**

Wildcat well 2/4-20 was spudded with the jack-up installation Mærsk Galant on 22 November 2007 and drilled to TD at 5719 m in the Early Permian Rotliegendes Group. The 2/4-20 HPHT well was drilled within risked AFE time and cost. The well took a total of 189.1 days (including 7.9 days WOW). The R70 shallow gas reflector (Crenulate Reflector) was drilled at 645 m with 11.0 ppg mud and a gas peak of 4.4% recorded. The section was cased with a 16" liner. At 1786m, a 35 bbl kick of 13.65 ppg intensity was taken in a thin (1.5m thick) sand sitting directly on the Mid Miocene unconformity. The mud weight at the time was 13.0 ppg. The well was killed with 14.0 ppg mud using a modified driller's method. With a maximum measured temperature at TD of 194 deg C, Horner corrected to 197 deg C, this was the hottest well on the Norwegian continental shelf to date.

The well was drilled with seawater/hi-vis sweeps/spud mud down to 479 m, with Versatec OBM from 479 m to 2888 m, with Paratherm OBM from 2888 m to 4766 m, and with WARP OBM from 2888 m to TD. The WARP mud used in the 8 1/2" and 5 3/4" hole sections proved difficult to clean off the cuttings samples. It posed problems for biostratigraphic analyses and proved detrimental to organic geochemical analyses.

The Late Jurassic J60 - J70 Kimmeridge Clay equivalent (Draupne Formation) seen in the 2/4-19 B well was not present in 2/4-20 having been eroded down into the Farsund Formation at crest of structure. A significant thickness of sand was penetrated at a number of stratigraphic levels. The J50 target sands were not developed in the well location. Below this however, was encountered a thick J54 Lower Ula Sandstone sequence (top 5183.5 m); well developed sands of the J40-J22 Bryne Formation (top 5340 m); and a 51m-thick (gross) sandstone/shale unit of undifferentiated Jurassic/Triassic age (top 5453 m). Below the Zechstein evaporites, a sequence of Permian Rotliegendes sandstones was drilled down to the TD of the well.

Jurassic reservoir presence and quality was significantly greater than pre-drill estimates. Jurassic J54 net porosity-metres was seven times greater than the pre-drill P50 prediction with two, thick, stacked shoreface sequences totalling 156.5 m gross being penetrated. The J40 ? J22 fluvio-deltaic Bryne reservoir consisted of 113m gross of interbedded sands, silts and coals. Pre-drill there was estimated to be only a 20% chance of this reservoir being present. The Rotliegendes Auk Formation, penetrated at 5592.5 m, consisted of 99.5 m of an Upper Unit of very tight non-reservoir argillaceous sandstones, underlain by 35 m-thick Lower Unit of better quality sandstones down to TD.

Shows detection was made difficult by the Versatec, Paratherm and WARP oil based mud used as drilling fluids for the entire well below 479 m. The only shows encountered were in the top of the Ekofisk Formation where faint oil shows were observed, and in the upper part of the Rotliegendes Sandstone where very weak slow white cut fluorescence was noted. White fluorescent fluid inclusions in the Rotliegendes strata

No sidewall or conventional cores were cut in the well. No wire line fluid samples were taken. Pressure points were recorded with the XPT and MDT tools. In the Rotliegendes sandstone at TD pressures were acquired with the XPT-H tool, run in this well as the first in the world. The number of good pressure points obtained were in general sparse, but showed that the Jurassic and Permian reservoirs sections were in