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## **Focused Seismic Monitoring (FSM) on the Snorre Field**

Mark Thompson, Mona Andersen, Ottar Lyse/StatoilHydro

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### **Abstract**

The Snorre field is located in the Tampen area of the North Sea in 300-350m water depth. The field comprises a series of sandstone reservoirs in the Statfjord and Lunde formations, which are early Jurassic and Triassic in age, constrained structurally by several large fault blocks. Production started in 1992 and the current recovery factor is about 45%, but Snorre has an ambition to raise this to 55%.

Snorre has created a focused seismic monitoring (FSM) project, which has identified some of the actions required such that this ambitious recovery factor can be achieved. One action identified, with large potential, was the use of frequent time-lapse (4D) seismic over restricted areas. This could be achieved through the implementation of a permanent seismic solution, in this case utilizing fibre optic ocean bottom seismic (OBS) technology developed by Statoil in collaboration with Optoplan AS. The recommendation of such a solution was governed by business requirements, but also by Statoil's strengths in the development and implement of innovative technologies for reservoir geophysics over many years. This most notably has included technologies for multi-component and time-lapse seismic, when in the late 1980's StatoilHydro developed the SUMIC (Subsea seismicMIC) technique whereby both shear and compressional waves were recorded by sensors implanted in the seabed. In 1994 Statoil was one of the first companies to acquire time-lapse (4D) seismic. Today Statoil is one of the main users of 4D seismic in the world, where over 70% of all Statoil assets regularly utilize 4D seismic.

The findings and future plans for the Snorre FSM project will be presented.

### **Introduction**

The Snorre field (figure 1) is a large oil field in located in blocks 34/4 and 34/7 of the Tampen area of the Norwegian North Sea and is situated in 300-350m water depth. The field was discovered in 1979 and sanctioned in 1988, with production start-up in 1992. It covers an area of approximately 200km<sup>2</sup> with a series of reservoir units, which are approximately 1 km thick. The reservoirs at Snorre are characterized by a series of very complex thin layers, where sand connectivity and communication across faults are issues. In addition both the production and injection histories are complex. Many of the injectors are back-produced, and different reservoir levels are actively opened and closed to optimize the production and pressure support.

Time-lapse (4D) seismic has successfully been utilized at Snorre where it has been used to generate information, which can be used in the increased oil recovery program (IOR) in operation in this business unit. The 4D seismic data generated is used in the Target Remaining Oil (TRO) process by a multi-disciplinary team in order to improve the understanding of the drainage patterns in the reservoirs. The results are actively used in TRO-process and well planning. In addition, the 4D seismic data provides input in order to optimize the water-alternate-gas (WAG) injection, update the geological model, the simulation model and to identify possible well interventions.

### **Reservoir description**

The reservoir (Figure 2) is approximately 1km thick, and consists of a series of sandstone reservoirs in the Statfjord and Lunde formations, which were deposited in a fluvial regime. These range from Triassic to early Jurassic in age. The reservoir has undergone severe faulting, uplift and erosion, where diagenetic and structural influences post deposition have formed a reservoir characterized by a complex series of channels and internal flow barriers, dominated structurally by a series of large fault blocks. The reservoir is complex, and requires the use of three separate reservoir models, where each model has several pressure barriers, nine fault blocks, and several original oil-water contacts (OWC) per block.