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Seismic Mapping and Monitoring for Well Optimization

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Abstract

Grane is one of the main producers in the Norwegian offshore sector. The reservoir consists of massive, predominantly fine to medium grained, moderately to well sorted, turbidite sandstones of the Heimdal Formation of Palaeocene age, enclosed in Lista Formation shales, at a depth of around 1700m below sea level.

The Grane reservoir has proven to be a difficult reservoir for ordinary seismic data. The PP imaging problem is partly caused by the structurally complex reservoir boundaries. For seismic imaging it is an additional problem that both top and base Heimdal have a class II AVO and that the underlying top Cretaceous chalks, close to base Heimdal, have a very high acoustic impedance. The broken up reservoir boundaries reduce the effective contrast seen by the seismic wave, and the class II AVO reduces the robustness of the stack. The top Cretaceous surface reveals a number of breaks that generate migration noise that contributes to the rather weak signal in the reservoir area. In addition, the top Cretaceous reflection interferes with the base Heimdal signal in some areas. Owing to these imaging problems mapping of small and moderate scale topography of the reservoir boundaries, faults and lithological heterogeneity, all of significant importance for drilling and well optimization, are a major challenge.

Prior to production there was no gas cap. Grane is produced with pressure support from gas injection and a gas cap is developing. This situation comprises a good starting point for seismic monitoring. The normal objectives such as mapping of the evolving gas cap, detection of possible barriers etc. are important. For Grane the additional information with respect to the structural shape of top reservoir is just as important.

The main aim of this paper is to show why and how we apply seabed/multicomponent, PS in particular, and seismic monitoring to solve the seismic mapping challenges on Grane.

Introduction

The Grane oil field is located in the Norwegian North Sea, about 200 km NW of Stavanger, Norway (Fig.1) and contains heavy (19°API), high viscosity (12cP), biodegraded and undersaturated oil with no initial gas cap. The expected oil in place volumes amounts to about 209 Mill.Sm³ and the expected reserves are 120 Mill.Sm³. The field has been successfully producing since the start-up in September 2003, and the present production is more than 220,000 barrels of oil per day.

Figure 1. Location map of the Grane Field, Norwegian North Sea.

The stratigraphic and structural setting of the Grane Field, in an E-W cross-section of the North Sea, is shown in Figure 2. The reservoir consists of predominantly fine to medium grained, very friable, slightly quartz cemented massive sands (Fig.3), and displays excellent reservoir properties with permeabilities commonly in the 5-10 Darcy range and with an average porosity of 33%.