IPTC 12333

Oil Sands Reservoir Monitoring Using Time-lapse 3D Seismic in Canada

T. Nakayama, and A. Takahashi, Japan Petroleum Exploration Co., Ltd; L. Skinner, Japan Canada Oil Sands Limited; and A. Kato, Japan Oil, Gas and Metals National Corporation

This paper was prepared for presentation at the International Petroleum Technology Conference held in Kuala Lumpur, Malaysia, 3–5 December 2008.

Abstract

Time-lapse 3D seismic monitoring study was conducted in the Hangingstone steam assisted gravity drainage (SAGD) operation area, Alberta, Canada. The objective of the study was to delineate areas of the reservoir infiltrated by steam using differences between two vintages of 3D seismic for efficient reservoir management.

The time-lapse surveys were acquired in February, 2002 and in March, 2006. As repeatability is important for the time-lapse survey, the two 3D seismic surveys were recorded with near identical field acquisition parameters and the data sets of both surveys were processed with identical processing flows. In addition, 3D P-SV converted wave processing and analysis were conducted using the second 3D seismic data recorded with three-component digital sensors for reservoir characterization study. P-wave and S-wave velocities of oil sands core samples were also measured with various pressures and temperatures, and the laboratory measurement results were combined to obtain a rock physics model to predict velocity changes induced by steam-injection.

The two seismic volumes show large differences in seismic character within the reservoir and time delays below the reservoir around the active SAGD well pairs. In order to evaluate seismic response changes of the time-lapse surveys, synthetic seismic data were analyzed under various reservoir conditions during the SAGD process based on the rock physics model. From our time-lapse data analysis, the differences of the seismic responses between the time-lapse seismic volumes can be quantitatively explained by P-wave velocity decrease of the oil sands layers due to the injection of steam. In addition, the data suggests that a larger area is influenced by pressure than by temperature.

In conclusion, our analysis of both time-lapse 3D seismic and 3D P-SV data along with the rock physics model can be used to monitor qualitatively and quantitatively the rock property changes of the inter-well reservoir sands in the field.

Introduction

The SAGD method is considered as one of the most effective in-situ methods for producing bitumen from oil sands reservoirs. In the SAGD process, two horizontal wells vertically separated by 5 meters are positioned where high pressure steam is injected through the upper well (injector) heating the oil sands, reducing viscosity and increasing the mobility of the bitumen. After steam chamber development, movable bitumen and over-saturated steam gravitationally move towards and are recovered from the lower well (producer) (Figure 1).

Steam chamber growth is strongly dependent on the reservoir facies adjacent to the SAGD well pairs and steam chambers spread irregularly through the reservoir zone. Understanding the development of the steam chambers under various reservoir geologies can help in planning further development in the field.

Japan Canada Oil Sands Limited (JACOS) has been developing and operating oil sands reservoirs since 1997 in the Hangingstone area which is 50km south-southwest of Fort McMurray, Alberta, Canada (Figure 2). The time-lapse 3D seismic monitoring study was conducted at the JACOS Hangingstone SAGD operation area in order to delineate steam chamber growth.

Geological Background

The oil sands reservoirs in the Hangingstone area occur in the Lower Cretaceous McMurray formation and are approximately 300m in depth. Sedimentary environments of the McMurray formation are considered as fluvial to upper-estuarine channel fill deposits. The oil sands reservoirs were formed as the vertically stacked incised valley fill sands very complexly distributed both vertically and horizontally.