IPTC-12332-PP

Effect of Mud Clasts on Stochastic Permeability Modeling for Steam Assisted Gravity Drainage (SAGD) Production Forecasting in the Athabasca Oil Sands, Canada

K. Kashihara, and K. Hosokoshi, Japan Petroleum Exploration

Abstract

Sub-seismic scale permeability heterogeneity due to the existence of mud clasts can adversely affect steam chamber growth during the steam assisted gravity drainage (SAGD) process. Using stochastic approach integrating core, log and seismic data from the Athabasca Oil Sands, Canada to obtain representative permeability values for grid modeling enables reconstruction of heterogeneity with sub-seismic scale resolution for flow simulation in SAGD production forecasting.

A procedure consisting of facies modeling, mud volume modeling and permeability transformation was applied to the field data set where facies modeling addresses difficulty in discriminating between sand with mud clasts facies and sand with thin mud layers facies, and permeability transformation upscales core scale permeability to grid scale permeability. Geostatistics in combination with probabilistic neural network implementing multiple seismic attributes successfully discriminates between the existence of mud clasts and thin mud layers. Core scale permeability is upscaled to modeling grid scale permeability using flow simulation applied to mini-models generated by randomly distributing ellipsoidal objects simulating mud clasts to provide a permeability reduction curve as a function of increasing mud clast volume.

Introduction

Bitumen reserves estimated as much as 175 billion barrels are contained within unconsolidated oil sands of northeastern Alberta, Canada where Steam Assisted Gravity Drainage (SAGD) is a commonly used in-situ bitumen recovery method of the Athabasca oil sands. Two horizontal wells of 750 m in length and vertically separated by 5m is the typical configuration of the SAGD where the upper well is used for steam injection to increase the mobility of the bitumen and the lower well is for production of the bitumen. Understanding the distribution of reservoir facies is essential for optimizing SAGD well configurations and deterministic geological models are constructed to understand the detailed distributions of the reservoir facies on seismic scale[1)].

SAGD production performance is subject to geological heterogeneity on a sub-seismic scale and mud clasts within the reservoir can reduce permeability and adversely affect the growth of steam chamber during the SAGD process. Currently, a wide range of uncertainty exists in SAGD production forecasting as quantitative evaluation of the effects of mud clasts on permeability is poorly understood.

For SAGD production forecasting purposes, flow simulation applied to reservoir models requires geological heterogeneity reconstructed on the models on a sub-seismic scale. This paper describes a procedure for quantitative permeability evaluation giving consideration to the effects of mud clasts. A stochastic approach of reservoir modeling successfully reconstructs geological heterogeneity at sub-seismic scale resolution.

Environment of Deposition

The Lower Cretaceous McMurray formation contains the reservoirs of the Athabasca Oil Sands with environment of deposition considered to be fluvial to upper-estuarine channel fill deposits. Typical litho-facies of the target formation are shown in Figure 1. Dark colors represent bitumen saturated sand and light colors represent mud that can adversely affect the steam chamber growth and SAGD production performance. For this study, litho-facies are classified into three categories: sand facies without mud (C1), sand with mud clasts facies (C2) and sand with thin mud layers facies (C3). The corresponding sedimentary facies are considered to be channel sand facies (C1), channel sand containing mud clasts facies (C2), point bar