

Reservoir Characterization and Heavy Oil Production

Larry Lines, Joan Embleton, and Ying Zou, University of Calgary, Calgary



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Abstract

Given the forecasts that more than 95% of Alberta oil production in the 21st Century will come from existing oil fields, there is a growing demand for synergistic integration of geology, geophysics and reservoir engineering to optimize production from these fields. The new field of reservoir characterization will involve the teamwork from both the geoscience and engineering cultures. Nowhere is this more true than in the development of heavy oil fields where there are dozens of wells to be combined with large volumes of seismic data. In the 2004 CSEG Workshop on this topic, we will examine case histories from a number of Canadian oil fields. This presentation will focus on the combined use of engineering and geoscience for heavy oil fields in Western Canada. It reviews many of the past results, discusses present state-of-the-art, and forecasts future directions.

Introduction

Heavy oil production represents a major part of the long-term petroleum production for Alberta and most of Western Canada. The vast reserves in the Athabasca, Wabasca, Cold Lake, and Lloydminster areas will undoubtedly be exploited during the coming decade. Enhanced oil recovery will involve the combined use of geology, geophysics, and reservoir engineering. This presentation will focus mainly on the geophysical part of this picture.

Methodology

Our research in heavy oil fields has involved the use of seismic monitoring over heavy oil fields that involve both hot and cold flow production. In both cases, we see a growing need for extensive use of multicomponent time-lapse seismology. In the case of monitoring steam injection, this presentation will review much of research summarized by Watson (2004) in the Lloydminster area. This thesis compared several methods of seismic monitoring including reflectivity differencing, impedance differencing and the computation of VP/VS ratios from multicomponent data. A case is made for the extensive use of multicomponent methods for mapping sand content and steam fronts.

In cold production, we emphasize the recent research of Lines et al. (2003) and Chen et al. (2004) in mapping both wormholes and foamy oil production. Mayo (1996) was among the first to show the seismic anomalies created by foamy oil and wormholes during cold production. This is a new and challenging area of applied seismology. Tremblay et al. (1999) and Sawatzky et al. (2002) have described the physics of cold production footprints and have laid the groundwork of reservoir characterization in cold production problems. Although much remains to be done in integration of petrophysical, geophysical methods to map subsurface changes, the initial findings of Chen et al. (2004) suggest that multicomponent seismology holds considerable promise.

In both hot and cold production, Zou et al. (2004) shows that we need to close the loop between geophysics and reservoir simulation models in a complete description of the reservoir. Zou's work maps out the future for integration of geoscience and reservoir engineering in reservoir characterization.

Modeling results and conclusions

Reservoir characterization is an evolving science. There is the constant need for integration and "closing the loop" between geoscience and reservoir engineering. The recent developments that have occurred in recent years include the following:

1. Integration of borehole and seismic information in the development of reservoir simulation models.
2. Increased use of AVO methods.
3. Optimized use of multicomponent seismology
4. Development of reservoir simulation models from geophysical and geological data.

This presentation will describe all of these methods and develop predictions as to future developments.

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