Seismic Monitoring of Cold Heavy Oil Production

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Summary

Cold production of heavy oil sands accounts for significant oil production in Canada. In order to enhance heavy oil cold production, seismic monitoring of the reservoir can be used to determine production footprints and allow for optimum infill drilling.

Introduction

The cold heavy oil production with sand (CHOPS) was pioneered in Canada, by mid 1990s, CHOPS became the primary heavy oil production method in Canada. To date CHOPS has achieved wide utilization in Canada and Venezuela, and there is successful use of the technology in China as well. CHOPS is a non-thermal process in which heavy oil and sand are simultaneously extracted and produced by using powerful progressive cavity pumps. The simultaneous extraction of oil and sand generates high porosity channels termed “wormholes”. It is believed that the wormholes play an important role in heavy oil production due to their permeability effects in the heavy oil reservoirs. The development of wormholes causes the reservoir pressure to fall below the bubble point, and the dissolved-gas comes out of solution to form foamy oil. The formation of foamy oil then causes a partially gas saturated reservoir.

In CHOPS, development of wormholes increases porosity in the reservoir. This could change the stress and rigidity of sand matrix in the reservoir, and the changes could result in velocity variations of the reservoir rocks. Based on laboratory experiments, Han et al. (1986) concluded that the measured Vp and Vs decreased dramatically with an increased porosity, and generally the effects of porosity on Vs is larger than on Vp.

Formation of foamy oil results in a higher gas saturation in the reservoir, and this could also affect seismic velocity. Toksoz et al. (1976) demonstrated that in partial gas saturation rocks, a small amount of gas can lower the Vp significantly, Domenico (1976, 1977) further concluded that a small amount of gas in sediments diminishes Vp significantly, whereas Vs is insensitive to the presence of gas. Based on the laboratory experiments, Lee (2004) found that the amount of gas and the mode of gas saturation in the pore space dramatically affects the Vp, but not the Vs.

Methodology and Results

Research results showed that the velocity variations cause changes in travel time and impedance (Watson et al., 2002), and the changes in velocity result in amplitude anomalies (Mayo, 1996).

For CHOPS, Researchers have conducted some related lab experiments and modeling studies to describe the cold production effects on reservoirs (Tremblay 1995, Chen 2004) Their research results show that the combined effects of both wormholes and foamy oil could cause seismic amplitude anomalies and travel-time delays within the drainage regions in the cold production reservoirs.

Conclusions and Plans for Future Research

The goal of our research is to solve the challenging engineering problems of characterizing cold production reservoirs. Our research includes systematic and comprehensive studies by using real seismic and well logging field data to monitor the wormhole and foamy oil in heavy oil cold production reservoirs. Results for both model and real data show that seismic monitoring can outline the cold production footprints and allow for optimum infill drilling.

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