

Dissecting the 4D Seismic Signature of the Clearwater Formation

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Summary

The Orion Project in the Cold Lake Area has been producing bitumen from the Clearwater Formation using the process of steam assisted gravity drainage (SAGD) for over 25 years. The Clearwater reservoir is a fine-grained feldspathic litharenite with few mud interbeds that was deposited in a marginal marine setting with total pay thickness between 16-25 meters. There are currently 55 SAGD WPs and 7 Lower Drainage Wells (LDWs) producing from the Clearwater Formation. Time-lapse (4D) seismic is a key component of Orion's reservoir surveillance strategy and offers 3D information on the dynamic performance of the Clearwater reservoir. Understanding the nuances of the steam chamber development and detecting reservoir changes due to production is key in optimizing well performance, future development and identifying zones of pooling bitumen below and between the existing wellpairs.

The fifth 4D monitor at Orion was acquired in 2023 and was the first high resolution 3D monitor acquired over this field. The SAGD well pairs and the LDW's imaged by this fifth monitor have varied production histories and are at different stages through the SAGD life cycle. Previous baseline and monitors were 2D swath seismic surveys. For the previous monitors the entirety of the interpretation was conducted on post-stack inverted volumes, which were instrumental in defining the steam chamber and identifying conformance along the wellpairs. With the uplift in data quality of the most recent monitor, pre-stack seismic inversion was applied to the baseline and monitor seismic surveys to obtain P-Impedance, S-Impedance and density estimates.

During the SAGD process changes to reservoir properties occur including pressure and fluid saturations in addition to potential alteration to the initial rock properties. Time-lapse seismic is a method utilized to capture these reservoir changes as they alter the elastic properties of the reservoir leading to changes in the seismic response. Due to the varying maturity of the Clearwater chambers at Orion, there are a variety of unique 4D signatures observed throughout the field. By utilizing all pre-stack inversion outputs and the rock physics templates to transform the data these reservoir changes are mapped. Identifying what each of these 4D responses relate to in terms of pressure, temperature, fluid or mineralogical changes has become increasingly important for optimizing well performance, future development and identifying zones of pooling bitumen below and between existing wellpairs.

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