Mapping Velocity Variations in the Reservoir Using Passive Seismicity Recorded with Permanent Downhole Arrays

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Abstract

In Shell Canada's heavy oil operations at Peace River, Alberta cyclically steamed multi-lateral horizontal wells are used to produce the mobilized bitumen. In order to optimize drilling and operational strategies, 24 bit distributed multi-Pad based microseismic monitoring systems have been installed to provide 24/7 feedback on reservoir behaviour and the effectiveness of the steaming process. In the past 3 years, triggered signals have been collected over multiple steam cycles and automated processors have been used to identify potential microseismic events which are evaluated for both location and source characteristics. These signals are further used to discern velocity variations in the reservoir and to re-locate the microseismic events based on the incorporation of the derived velocity variations (simultaneous inversion for velocity and event location). To accomplish this goal, we have utilized a Particle Swarm Optimization (PSO) approach, a variant search algorithm governed by an individual particle's best achievement and the best results achieved by a particle's neighborhood, to invert for both P- and S-wave velocity. Based on this approach, we observed P-wave velocity reductions up to 16% at the reservoir level for any given cycle. The re-located microseismic events appear 'well behaved' in the context of reservoir processes, and the location uncertainty of the re-located events dropped by approximately 21%.