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Using a Seismically-derived Density Volume and Facies Characterization to Optimize Thermal Well Trajectories in the Clearwater Formation, Alberta

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Summary

The Clearwater Formation (Albian) is the longest producing and largest thermal recovery reservoir in the Cold Lake oil sands region where 59 billion barrels of bitumen in-place are found. Osum Oil Sands Corp will use a combination of steam-assisted gravity drainage (SAGD) and cyclic steam stimulation to produce bitumen from the Clearwater Formation in its Taiga Project (T64-65, R1-2W4).

The average net pay thickness in the Clearwater SAGD zone at Taiga is 12 meters; in thinner pay zones like these optimizing the well placement takes on greater importance. Osum's objective in SAGD development is to place the horizontal wells one meter above the base of the reservoir to maximize the bitumen pay above the production well without compromising the connectivity between injector and producer. Detailed facies characterization and seismic inversion were used to map the base of the reservoir and optimize well placement. The facies analysis was derived from the core and log data of 89 wells and an inverted 3D seismic survey that covers 31.5 km^2.

Clearwater sandstones are lithofeldspathic and were deposited under fluctuating sea level conditions in a north-south orientation within a range of near-shore environments. Seven facies associations were described using sedimentological and ichnofossil assemblages. The base of the main reservoir contacts underlying mudstones with the form of the contact ranging from sharp to gradational with underlying strata consisting of interbedded highly bioturbated beds and laminated sands. Calcite-cemented zones are predominantly found at the base of the main SAGD reservoir at the sand-mudstone interface. The facies model was incorporated into a full-field static model using PETREL. The model grid size was built with 10x10x1m grid cell blocks that cover the full Taiga project, with properties populated through a combination of sequential gaussian simulation, krigging, and co-krigging algorithms. The populated three-dimensional facies model was used to map facies contacts and to help guide the seismic inversion.

Pre-stack inversion of the 3D seismic was performed and inverted attributes (e.g. Vp/Vs ratio, P-impedance, density) were converted to depth and incorporated into the static model. Rock physics cross-plots of log-derived seismic attributes, constrained by facies and log-derived lithology logs (Vsh, Sw, etc.), show that bulk density correlates directly to lithology, thus assisting in the mapping of shale layers and carbonate nodules between wells. To refine the results, an iterative process of matching facies and the inverted density at finer scales continued. The final integration and analysis of the data helped in defining the base of the reservoir and the architecture of the thermal pay zone, thereby allowing the optimization of the placement of horizontal wells.