Improved Subsurface Characterization through Stochastic Modeling Techniques at Imperial's Kearl Mine, Alberta

Nathan R. Pittman, Adam E. Montgomery and Martin Huang
Imperial Oil Ltd.

Summary

Kearl is one of Canada's highest-quality oil sands deposits and represents the next generation of oil sands mining. Kearl has an estimated 4.6 billion barrels of recoverable bitumen resource with production levels of 220,000 bpd.

Stochastic modeling techniques have improved subsurface characterization at the Kearl oil sands mine through the integration of 3D interpretations with core data. Using depositional models, variograms, statistically controlled facies distributions and dipping model blocks the realism and predictive power of the Kearl model was improved.

Geological models used for mining applications face several unique challenges not posed in thermal or conventional reservoirs. In an environment where every block must be planned and accounted for, there is a significantly increased requirement for spatial certainty. As all material must be classified as ore or waste, the inherently different planning and handling required of these materials can lead to substantial operational cost when unplanned material classification changes occur. The impact of material misclassified as waste results in 0% recovery of those blocks and large extraction excursions are a common result of mischaracterized material processed as ore.

Commonly used deterministic modeling algorithms are simple, and while creating a representation of the subsurface at a resolution reasonable for use at larger scales, often require additional products to add realism and detail. These models are regularly accompanied by 2D interpreted cross sections to add the interpretational dipping overlay. It is common for these simplistic models to incorporate some geologic interpretation, such as facies and major surfaces, but lack the detail of dipping units.

By modeling using a combination of variograms and dip data, geologic interpretation was incorporated directly into the model. 2D seismic, dip and core data and regional sections are integrated to develop a comprehensive understanding of point bar geometries, and model layering made to honor this interpretation. Field observations, data analysis tools and depositional models inform stratigraphic geometries, which are then applied to model facies through variograms. Facies are then used to control the population of resource attributes such as bitumen saturation and fines which relate directly to ore classification and extraction performance. This approach results in a robust 3D interpretation where facies can vary in strike and dip directions in accordance with the input data and idealized depositional models. This also allows for improvements to be made to the model outside of the yearly drill program if there are changes to the understanding of the point bar system.

The use of stochastic modeling raises several challenges. The end product of statistical modeling is only one realization of a set of parameters. By populating the model using a new path or seed number, a different result can be realized. With the importance of spatial certainty in mining models, it is critical to communicate this uncertainty to end users. Similar or greater uncertainty exists between model and reality when using deterministic modeling techniques, however the single deterministic outcome provides users a false sense of certainty. It remains a challenge to quantitatively evaluate improvement to reservoir characterization as a result of new or different modeling techniques.

Applying statistically derived, dip-driven models to the Kearl oil sands mining asset allows geoscientists to incorporate interpretation directly into the model build process. It also provides a mechanism to improve subsurface characterization and add value outside of the costly pursuit of acquiring new drilling data while allowing for continuous improvement.