Geostatistical modelling of McMurray oil sands deposits

GEOLOGY

The McMurray formation in the Athabasca oil sands deposits of northern Alberta is part of the world's second largest proven crude oil reserves. There is little doubt that the future of Canada's energy economy will depend largely on the oil sands resources found in Alberta. Of the three main crude bitumen deposits, the Athabasca formation is by far the largest and most amenable to production using current surface mining technologies. The Athabasca deposit has a Devonian limestone base and consists of three main formations (in ascending order): McMurray, Clearwater, and Grand Rapids. The sands in the McMurray formation are host to the crude bitumen, in which three main lithofacies are recognized based on the depositional environments: Fluvial, Estuarine, and Marine, from the base to the top of the formation. These form the stratigraphic layers of interest for resource modelling.

Resource estimation for oil sands has traditionally relied on polygonal and inverse distance schemes. These resource models are usually combined with some type of geometric resource/reserve classification approach for public disclosure reporting. While simple and straightforward in practice, these resource estimation techniques do not permit reliable uncertainty assessment. This paper describes the modelling of the McMurray formation using modern geostatistical techniques. The methodology is illustrated for a small sanitized dataset, originally based on one of the current lease areas near Fort McMurray.

Geostatistical modelling should be performed within homogeneous geological facies. The methodology for geostatistical simulation within each of the identified facies involves: 1) assessing the most appropriate stratigraphic transformation for optimization of the correlation structure; 2) determining representative distributions with declustering and debiasing techniques; 3) modelling spatial continuity of the bitumen grade, fines grade, water saturation, and other petrophysical variables; 4) performing estimation and cross validation as checks against simulation results; 5) performing simulation for uncertainty quantification of bitumen and fines grade; and 6) model checking of simulation results against the input data and comparisons against the kriged models. These steps are described in detail. Although this is a fairly classical geostatistical simulation methodology, an important feature for the oil sands setting is the analysis of correlation at the very beginning of the modelling workflow.

The resulting geostatistical models are also models of uncertainty that can then be used for both long- and short-term decision-making, for example, resources/reserves can be estimated along with the uncertainty and hence risk associated to this estimate; grade control optimization can also be realized by way of optimizing dig limits, accurately predicting the head grade, identifying production periods of economic risk; and resources/reserves can be classified in accordance with National Instrument 43-101 for public disclosure. This last application is becoming more important as the modern classification approach is based on adopting a measure of uncertainty and then assessing the probability to be within this measure. Some of the world's leading mining companies have already begun to adopt this type of modelling workflow, realizing the advantages of these types of techniques over the more deterministic approaches currently used.

Estimation of Canada's vast oil sands resources is incredibly important to forecasting its availability and determining the feasibility of current mining practice for certain deposits. In this assessment, uncertainty is a key issue, which cannot be addressed using conventional estimation tools that are prevalent in the industry. The proposed geostatistical approach provides a number of advantages: 1) spatial correlations between the data are modelled and used to improve local grade estimates and uncertainty estimates; 2) an assessment and quantification of uncertainty is available and tractable; and 3) these uncertainty models can be used for risk qualified decision making for both long- and short-term mine planning. Further, this geostatistical approach is straightforward and is well positioned to satisfy the conditions and requirements set in the latest classification guidelines.

O. Leuangthong, Department of Civil and Environmental Engineering, University of Alberta, Calgary, Alberta,
E. Schnetzler, Statios LLC, San Francisco, California, United States, and
C.V. Deutsch, Department of Civil and Environmental Engineering, University of Alberta, Calgary, Alberta