

Direct estimation of SAGDable volumes from geological models using oilsands net pay connectivity criteria for ranking and planning

David L. Garner, TerraMod Consulting

Sasan Ghanbari, Emerson

Summary

Athabasca oilsands field development planning involves many decisions that rely on integrated subsurface characterization using geomodel based applications. At early stages, the resources favourable for in-situ extraction are assessed to infer the best development areas. Later planning stages involve horizontal well placement and pad locations for final decisions on project scale for each tranche. Geological modeling is generally a catalyst for improved development decision making under technical and economic criteria when using best practices for an oilsands type field.

Using sound geological concepts which includes deposition, stratigraphy and structure, the current industry best practice for modeling reservoir heterogeneities related to flow is to apply a hierarchical workflow of simulation of facies first, followed by property simulations within each modeled facies. Fluid distributions as well as flow and mechanical properties are dependent on the characterization by each facies. For oilsands models accounting for known physical behavior, percolation and capillarity, when distributing properties in 3D such as permeability and fluid saturations by each facies facilitates reasonable physical responses in thermal or hybrid flow models (Garner et al., 2014; Martinius et al., 2017). These heterogeneous models can be used for evaluation of resources in place, for evaluating net pay and connectivity criteria related to in-situ recovery, ranking models and associated mappable uncertainties. Direct estimation of recoverable resources from static models without flow simulation is possible with properly constructed geomodels and specific connectivity criteria that relates to the steam assisted gravity drainage or hybrid processes (Garner, et al. 2005; Garner et al., 2014). Commonly used terms are SAGDable bitumen, net continuous bitumen, and net connected pay. Our goal is to have a screening method fairly correlated to thermal flow simulation that can be scaled for comparisons, across well pair slots, pad drainage areas, or large delineation areas. There are numerous other methods, not cited here, to estimate 3D connectivity for late stage development after well pair elevations and slot locations are fixed. It is worth noting that conventional calculations of net pay volumetrics on a cell-by-cell basis without accounting for appropriate connectivity are poorly correlated with the thermal simulations and lead to bad decisions.

Methods and Workflow

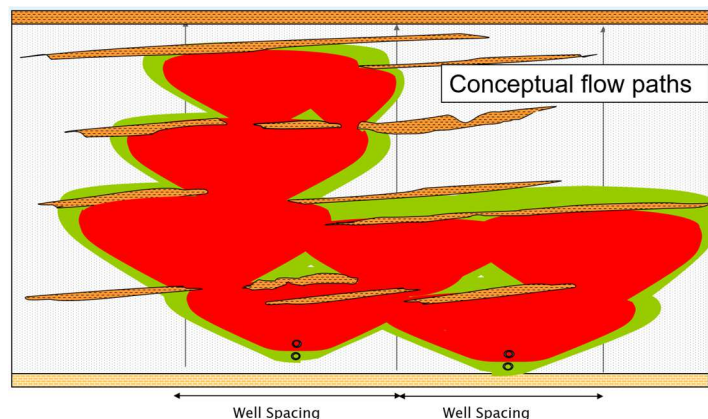
Best practice issues will be briefly summarized for geomodelling workflows to account for the requirements of the thermal reservoir engineering and to honour geological concepts. These impactful steps include choices on grid designs, facies log quality, porosity, horizontal and vertical permeability, and saturation distributions and trends. Other parameters, volume of shale and geomechanical properties may be considered.

Regarding the connectivity workflow, we illustrate conceptual thermal flow paths in Figure 1. When mudstone or shale interbeds exist, irregular steam chambers will form as the result of these heterogeneities. Interbeds between the injector and producer can prevent local communication causing a non-uniform startup. This relates to step one in our scripting. Horizontal mudstone beds can act as barriers, preventing steam chamber growth, increasing pressures locally and creating hotspots or flashing in the producers. For this process of defining the top of the connected bitumen pay column, we consider mud beds or thief zones as step two in our approach. We also note that at the top of a thick zone, the mudstone or shale can act as a pressure seal on the reservoir, or as a cap rock which is an evaluation outside the scope of this presentation.

Step one is the establish steam circulation step. To define continuous bitumen pay zones based on SAGD development criteria we define a base of continuous bitumen elevation from the lowest high quality interval using bulk oil weight, $BOW > 0.10$ over an entire interval or 5-8 meters. The thickness sensitivities depend on model artefacts and reservoir geometry. *Step two* is to define a top of net continuous bitumen elevation above the well pair circulation interval. The top criteria are low BOW (e.g. ≤ 0.06) over a minimum thickness (e.g. > 1.5 m). Scenario sensitivities are typically applied. Low BOW is ambiguous in that it can indicate either low porosity with high saturation in mudstones or wet, high porosity thief zones. *An optional third step* to differentiate the type of top is to similarly check the elevation for a defined thickness (1-2m) and width (25-50m) of low vertical permeability since K_v is the dominant gravity flow factor. This differentiates wet thief zones from muds and can be used to assess the impacts and type of reservoir. The results using stochastic models can be summarized into probability maps of Top, Base continuous bitumen, gross and net thickness, hydrocarbon pore thickness maps, etc.

Best practices can improve dynamic simulation results and the ability to correlate static models with flow response. Our goal is to identify sufficient reservoir quality and thickness for the SAGD-like process to be both effective and economical with an understanding of risk and uncertainty. Understanding reservoir heterogeneities is important to reservoir management, planning and mitigation.

Figure 1. A purely conceptual thermal flow path is illustrated. Convective flow gives way to conductive heating above local mud barriers and beyond the flanks of the steam chamber.



References

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