Integrated Use of Petrel and Modflow in the Modeling of SAGD Produced Water Re-injection

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Steam-Assisted Gravity Drainage (SAGD) is currently recognized as the most effective method to recover deep oil sands. The SAGD process consists of injecting steam into the reservoir to lower the viscosity of the bitumen, and pumping the bitumen to surface. During pumping, hot bitumen is recovered with production water, which consists of condensed steam and connate water. Production water is typically disposed of by re-injection into the subsurface.

A key element of a successful SAGD operation and a typical regulatory requirement for production water disposal is the ability to ensure that the re-injected production water will not adversely affect the quality of the surrounding fresh groundwater. A local-scale characterization of the geometry and hydraulic properties of the aquifers located in the area of re-injection is required to assess accurately the flow path and mixing potential of the re-injected water with groundwater.

This paper presents a study conducted to estimate the flow path and the time that produced water from a proposed re-injection well near a SAGD field in western Canada would take to reach an adjacent freshwater aquifer.

The approach was based on the use of Petrel, a petroleum reservoir engineering software package, to define the hydrogeological units in the re-injection area, and on the integration of Petrel results with Modflow, a widely used groundwater flow simulation program.
This approach includes two elements of innovation:
1.it is based on a non-conventional application of Petrel (typically used for oil reservoir modeling) in hydrogeologic characterization, and
2.it demonstrates the advantages offered by a conceptual modeling tool such as Petrel, which can integrate different types of geophysical data, in the development of a groundwater flow simulation for the oil industry.

Petrel was employed for a local-scale aquifer characterization of the re-injection area using data from shallow seismic interpretation and downhole geophysical surveys. The surfaces and maps produced by Petrel were used to construct a Modflow model for the re-injection area.

The Modflow simulation provided the following estimates:
a.flow path of the water after re-injection into a low-bitumen sand; and
b.time required by the re-injected water to reach the freshwater aquifer.

These estimates provided both the SAGD operator and the Regulatory Authority with information required to assess the feasibility of the SAGD project under study.