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Gravity monitoring of 4D fluid migration in SAGD reservoirs incorporating sedimentology

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Summary

Monitoring steam-assisted gravity drainage (SAGD) projects is necessary to assess fluid flow during production and to determine bitumen recoverability, and can be constrained by measuring gravity and gravity gradient signatures. The focus of this study is two-fold. The first part of the study is to design representative geological reservoir models, and calculate specific gravity signatures related to fluid migration during production. As the steam chamber expands in those forward models, it alters the density distribution of the sedimentary layers, and different gravity responses are measured for the reservoir. The second part of the study is to execute sensitivity studies to assess if state of the art relative gravimeters can achieve the required sub-microgal sensitivity, and to develop an optimal survey strategy. The ultimate goal is to monitor spatial and temporal steam chamber growth and fluid migration at all stages of reservoir development, and assess and improve recovery of bitumen in each reservoir.

The reservoirs' internal sedimentary structures are a major control on steam chamber growth, and subsequent hydrocarbon drainage, and must be modeled to the finest detail possible. Sedimentary structures in fluvial-estuarine deposits that limit fluid migration include channel plugs, oxbow lakes, inclined heterolithic strata (IHS), shale drapes, and mudstone clasts. Thus, the depositional environment must be well understood and accurately modeled to create representative forward models of gravity signals. In addition, knowledge about sedimentary features assists in the inversion of gravity observations to constrain fluid migration.

This study aims to develop geological models with representative/realistic dimensions obtained for two projects that are currently undergoing the initial phases of SAGD production. For those reservoirs, the sedimentary structures and background density models will be integrated with time-lapse gravity and gravity gradient measurements, to isolate fluid migration patterns. The feasibility of applying the proposed technique to SAGD reservoirs was hindered by the lack of the required sensitivity, as well as, high noise levels. Both of these limitations can be overcome using superconducting gravimetry in time-lapse gravity gradient surveys, which achieves the sensitivity requirements and greatly reduces noise.