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Time-Lapse Gravity and Gravity Gradient Monitoring of SAGD Reservoirs

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Abstract

Monitoring steam-assisted gravity drainage (SAGD) projects is necessary to assess fluid flow during production and determine bitumen recoverability, and can be constrained by measuring gravity and gravity gradient signatures. There is currently a void in monitoring fluid migration during SAGD operations, which is limited to 3D seismic surveys, and borehole surveys. The iGrav portable superconducting instrument, with sub-microgal sensitivity, has the ability to measure time-lapse gravity and gravity gradient with high spatial focus.

The focus of this study is two-fold. The first part of the study is to develop geological models for a project that is undergoing SAGD production, and calculate specific gravity signatures related to fluid migration during production. The sedimentary structures and background density models will be integrated with time-lapse gravity and gravity gradient measurements, to isolate fluid migration patterns. As the steam chamber expands in those forward models, it alters the density distribution of the sedimentary layers, and the gravity responses are measured. The forward models indicate the required sensitivity needed for the gravimeters, to practically implement this technique. Inversions will be performed on the gravity observations to assess the resulting density change in the subsurface, using the knowledge of sedimentary features to assist in the inversion. The second part of the study is to execute sensitivity studies to evaluate if the relative gravimeters can achieve the required sub-microgal sensitivity, and to develop an optimal survey strategy.

The feasibility of applying the proposed technique to SAGD reservoirs was hindered by the lack of the required sensitivity, and high noise levels. These limitations can be overcome using superconducting gravimetry in time-lapse gravity gradient surveys. Results indicate that a pair of iGrav superconducting gravimeters meet the sensitivity requirements and the spatial focusing desired to monitor fluid migration at the reservoir scale, and greatly reduce noise.