Impact of Oil Viscosity Variations and Mixing on SAGD Performance

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In Alberta, the most common in situ recovery process for Athabasca oil sands reservoirs is Steam Assisted Gravity Drainage (SAGD). One key controlling feature for production from these systems is the heterogeneity of the oil viscosity, which can vary by up to 50 times in a single reservoir due to compositional variations. Typically, as a result of biodegradation over geologic timescales, the oil viscosity is lowest at the top of the reservoir and higher towards the bottom. Also, variations in the horizontal direction can be large but are often less than that found in the vertical direction.

Here, we analyze the impact of viscosity variation on the performance of SAGD. Despite the heterogeneity of the oil viscosity at original reservoir conditions, the main control on production is due to heterogeneity at the conditions at which the majority of the oil is flowing, that is, the temperature of the majority of the mobile bitumen and the degree of mixing of the oils as flows occurs down the edges of the steam chamber. This implies that the timescale of mixing of oils is important. In turn, the degree of mixing is controlled by the relative motion of one oil with a given composition with respect to other oils of different compositions as drainage occurs from the steam chamber.

The properties of the reservoir used in this study are typical of that of an Athabasca oil sands reservoir. A comprehensive reservoir simulation sensitivity study, including simple 1D (vertical) and complex 3D viscosity variations, was completed to evaluate the performance of a single SAGD wellpair. Also, the impact on SAGD performance of an initial vertical linear temperature profile in the reservoir was also evaluated.

The results of this study demonstrate that the performance of SAGD is controlled by oil mobility variations in different ways. First, drainage rates are controlled by oil mobility which in turn is set by the temperature distribution beyond the chamber edge, oil effective permeability and composition. Second, mixing of mobilized oils of different compositions to enable drainage of higher viscosity oils from the reservoir is controlled by the individual mobility of the oils and the timescale of mixing of the oils as they drain through the reservoir. Third, the relative dependence of the oil viscosity on temperature of oils of different compositions controls mixing. Fourth, the impact of the initial temperature profile on SAGD performance is small.