Mississippian Madison and Jurassic Gravelbourg Low-gravity Oil Accumulations in Southwestern Saskatchewan: Examples of Unconformity Traps Related to Regional Hydrodynamics, Basement Structure and Local Paleotopography

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ABSTRACT

The Mississippian Madison Formation of western Saskatchewan is part of a continuum of Mississippian rocks draped over the Sweetgrass Arch in eastern Alberta. The Jurassic Gravelbourg Formation onlaps the Madison on the eastern flank of the Arch in the southwestern part of Saskatchewan. Madison rocks have been known to contain oil staining since the early days of exploration on the Arch, but only a few of the oil stained intervals were drill stem tested as the low API gravity of the oil in the shows suggested it was uneconomical to produce. Exploratory drilling in western Saskatchewan in the 1950's and 1960's identified a number low-gravity oil shows in both core and drillstem tests. The most significant was the Coop et al Battle Creek 1-27 well (Lsd 1-27-3-26W3), which recovered 1262 m of oil with a density of 997 kg/cm^2 (11° API) in a drillstem test. The tested interval was immediately beneath the sub-Mesozoic unconformity, at the top of the eroded Madison Formation (Kent and MacEachern, 1990). Additional drill stem tests produced water and the well was abandoned. However, a step-out well, Western Decalta Battle Creek 6-27 (Lsd 6-27-3-26W3 was drilled in 1966 and has produced 13° oil from the same stratigraphic level, on and off, for the past 35 years. In 1987 Mississippian production in the Battle Creek area was enhanced by several horizontal wells (Kent, 1995). In addition there were new discoveries in the mid- to late-1990's at Battle Creek West, Rangeview, Rangeview East and Divide. Total oil output from these five areas is approximately 2.4 x 10^6 BO. Two-thirds of this production (1.8 x 10^6 BO) is from Battle Creek.

The reservoir rocks at all five locations are within about ten metres of the sub-Mesozoic unconformity. These subcropping rocks cover the spectrum of carbonate textures from lime mudstones to grainstones. The dominant skeletal components are crinoid columnals, fragmented bryozoan zoaria and brachiopod valves. Dolomitization is extensive and appears to be also confined to that ten-metre interval immediately beneath the sub-Mesozoic unconformity. It is particularly well developed in both depositional micrites and those formed diagenetically. Significantly, dolomitization of the subcropping Madison rocks is largely confined to the area overlain by the onlapping lower member of the Jurassic Gravelbourg Formation. Based on this apparent relationship, Kent and Kreis (1995) proposed a method of reflux dolomitization of the Madison rocks by near-normal marine sea water during transgression of the Gravelbourg sea.

Porosity in the dolomicrites is intercrystal, microvuggy and moldic. By contrast, the grainstones and packstones have macrovugs, moldic and interparticle pores. Some of the latter may be solution-enhanced. Fractures probably related to paleokarst collapse also enhance the reservoir capabilities of these rocks. The oil is trapped in paleo-hills on the sub-Mesozoic unconformity. The producible oil accumulations appear to be confined to paleo-hills on the north-facing flank of an antiform produce by drape over the Battle Creek basement structure. Regional formation water migration is from south to north due to recharge from Tertiary uplifts in Montana, suggesting that hydrodynamics may have played a role in filling paleo-hills on the north face of the structure. Low-gravity oil in the Gravelbourg is the result of vertical seepage from the Mississippian reservoirs and has accumulated in a fine quartz sandstone in the upper part of the lower member. Oil output from the Gravelbourg is limited to one well that was drilled in 1971 with cumulative production over that period of 137,000 BO.

References

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