

Enhanced oil production by microbial free phase gas production

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Summary

Natural *in situ* biochemical gas production to the point of free phase gas (FPG) formation in the subsurface can cause over-pressurization, faulting, well blow-outs, and other geomechanical phenomena. We seek to demonstrate the impact of *in situ* biochemical FPG (i.e. gas bubbles) production on enhanced oil recovery by facilitating biochemical gas production in laboratory microcosms.

The experiments were conducted in customized laboratory testing cells (microcosms) that were packed with sand before being i) injected with oil, ii) water flooded to residual oil saturation, and iii) saturated with a solution containing appropriate substrates and microbes to promote N₂ production by heterotrophic denitrifying bacteria (hNRB; *Thauera* sp. isolated from oil field produced water). Total dissolved gas and water pressure (P_{TDG} and P_w) were monitored *in situ* to evaluate the rate of dissolved gas production, and the point at which bubbling pressure was exceeded, and FPG production was expected.

To evaluate the effect of FPG formation on enhanced oil production, two sets of triplicate microcosms were prepared as described above with i) light oil (37.9° API gravity), and ii) heavy oil (15.6° API gravity). After biochemical gas production was allowed to occur, pumping was mimicked by attaching helium-filled vials to the top of the microcosms, which released pressure built up inside the microcosm. The relative rates of oil and/or water collection were compared to assess the degree of enhanced recovery by FPG production.

Significant *in situ* biogeochemical dissolved gas production was monitored with P_{TDG}, as was the point of FPG production and over-pressurization was observed in all microcosms. The over-pressurization enhanced oil recovery by FPG production, increasing the amount of residual light oil recovery by 30 to 50%, compared to 9 to 12% for heavy oil. This study confirmed that FPG production causes over-pressurization, and can be effective for enhanced oil recovery.