Discontinuous Shale Effects on the Efficiency of First Contact Miscible Water- Alternating –Gas (FCM WAG) Injection

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Abstract

Water and gas injection are the most widely used oil recovery processes. In order to increase the oil recovery efficiency, gas can be injected with water, either simultaneously or as alternating slugs. This process is called Water-Alternating Gas (W AG) and has been applied with success in many oil fields worldwide. However, there is a lack of basic understanding on how the fluids behave within the heterogeneous reservoir rock and its physics is still uncertain. At present there is no petroleum engineering literature on the experimental investigation of the effects of discontinuous shales on fluid displacement in porous media during WAG injection. Most studies are either theoretical or numerical investigations. Therefore the main aims of this research are:

- Determine the effect of discontinues shale on oil recovery efficiency of FCM WAG as a function of WAG ratio and slug size;
- Determine whether the trapped oil is located downstream or upstream of a shale unit during the WAG injection;
- Assess the error associated with numerical simulation of tertiary first- contact miscible WAG displacements.
- Provide a set of benchmark data for tertiary recovery of oil by miscible WAG injection around discontinuous shale.

In order to improve our understanding of the effects of discontinuous shales on fluid displacement in porous media during WAG process, a series of well- characterized, tertiary, water and solvent displacements were carried out at constant rate and various WAG ratios through visual bead-packs. Both simultaneous and slug injection were investigated. These were modeled by detailed simulation using an IMPES finite difference simulator. The experiments

have demonstrated that there is an optimal WAG ratio, for simultaneous injection, at which oil recovery is maximized. For simultaneous and slug injection the predicted oil recovery shows, in general, good agreement with the measured cumulative recovery. The experiments show that, the front is fingered and fluid prefer to flow in segregated paths rather than flowing simultaneously across the whole porous media. In addition, the residual and bypassed oil was mainly located on downstream of the shale. We find from these experiments that the presence of discontinuous shales does not significantly alter oil recovery in contrast to traditional reservoir engineering beliefs. The combination of experiments and simulation enable us to evaluate, for the fist time to our knowledge, fluid interactions within the heterogeneous reservoir rock during miscible WAG displacements. In addition, to providing a better understanding and performance characteristics of the WAG process within presence discontinuous shales, this study show directions for further research and presents delme aimed at improving filed scale oil recovery from miscible WAG projects.