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# Laboratory Investigation of Liquid Injectivity in Surfactant-Alternating-Gas Foam Enhanced Oil Recovery

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Foam can improve sweep efficiency in gas-injection enhanced oil recovery. Surfactant-alternating-gas (SAG) is a favored method of injection, in part because of excellent injectivity during gas injection. However, liquid injectivity is usually very poor in a SAG process, and fracturing of the well can occur. We report a coreflood study of liquid mobility under conditions like those near an injection well in SAG application in the field: i.e., after a prolonged period of gas injection following foam.

We inject foam, gas (nitrogen) and surfactant solution into a 17-cm-long Berea core at elevated temperature (90 ℃) with 40 bar back-pressure to minimize gas-expansion effects. Pressure differences are measured separately across five sections of the core and supplemented with CT scans to relate water saturation to mobilities. From these data we estimate the velocities, saturation changes, and mobilities of the various banks that determine liquid injectivity. We examine liquid injection directly following a period of foam injection, as in previous studies, and then following prolonged periods of gas injection following foam, to reflect injectivity near the well in a SAG process.

Liquid injectivity directly following foam is very poor, as shown in previous studies. Liquid first fingers through the trapped foam. It then dissolves gas trapped within the liquid fingers, and the overall mobility rises sharply. During prolonged gas injection following foam, however, a region forms near the inlet and slowly propagates downstream in which gas mobility is much greater. The abrupt rise in gas mobility appears to reflect the decline in water saturation below about 0.2 in our experiments. This decline in liquid saturation reflects in part liquid evaporation, and also pressure-driven flow and capillary effects on the core scale. In the region of lower liquid saturation, subsequent liquid mobility is much greater than downstream, and liquid sweeps the entire core cross-section rather than a single finger. Mobility in the region of liquid fingering is insensitive to the quality of foam injected before gas and the duration of the period of gas injection. These results suggest that there is a small region very near the well, crucial to overall injectivity, in which liquid mobility is much greater than that further from the well. These conditions are not described by current foam models. The results can inform a model for liquid injectivity based on radial propagation of the various banks seen in the experiments.

## References

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