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DEVELOPMENT OF COST-EFFECTIVE SURFACTANT FLOODING TECHNOLOGY

Quarterly Report for the Period
January 1994 – March 1994

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Work Performed under Contract No. DE–AC22–92BC14885

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DEVELOPMENT OF COST-EFFECTIVE SURFACTANT FLOODING TECHNOLOGY

Contract No. DE–AC22–92BC14885

The University of Texas
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OBJECTIVES

The objective of this research is to develop cost-effective surfactant flooding technology by using surfactant simulation studies to evaluate and optimize alternative design strategies taking into account reservoir characteristics, process chemistry, and process design options such as horizontal wells. Task 1 is the development of an improved numerical method for our simulator that will enable us to solve a wider class of these difficult simulation problems accurately and affordably. Task 2 is the application of this simulator to the optimization of surfactant flooding to reduce its risk and cost.

SUMMARY

The goal of Task 2 is to understand and generalize the impact of both process and reservoir characteristics on the optimal design of surfactant flooding. We have studied the effect of process parameters such as salinity gradient, surfactant adsorption, surfactant concentration, surfactant slug size, pH, polymer concentration and well constraints on surfactant floods. In this report, we show three dimensional field scale simulation results to illustrate the impact of one important design parameter, the salinity gradient. Although the use of a salinity gradient to improve the efficiency and robustness of surfactant flooding has been studied and applied for many years, this is the first time that we have evaluated it using stochastic simulations rather than simulations using the traditional layered reservoir description. The surfactant flooding simulations were performed using The University of Texas chemical flooding simulator called UTCHEM.

The reservoir description was an idealization of an actual mid-Continent U. S. sandstone oil reservoir that is a potential candidate for surfactant flooding. The complete description of the reservoir is the same as the base case given in our first annual report. The stochastic reservoir descriptions were generated using a University of Texas program based upon the matrix decomposition method. The Dykstra-Parsons coefficient is 0.8, the geometric mean permeability is 50 md, and the vertical-to-horizontal permeability ratio is 0.1. A quarter five spot well pattern with 20 acres well spacing is simulated. The reservoir thickness is 140 ft. The grid is 11x11x5 and the gridblocks are 60 ft in the x and y directions and 28 ft in the z direction. To mimic conditions before the start of tertiary oil recovery, the reservoir was first waterflooded until a water cut of 0.98 was reached. After waterflooding, 0.25 pore volumes of 0.8 vol.% of surfactant was injected. The surfactant slug contained 1,000 ppm polymer and was followed by 0.5 pore volumes of polymer at the same concentration and finally by water for another 3.25 pore volumes. The surfactant has a lower and upper effective salinity window of 0.55 and 0.916 meq/ml.

We show a comparison between a slightly below optimum and constant salinity of 0.611 meq/ml (35,700 ppm TDS) and a salinity gradient surfactant flood design where the initial salinity was 0.97 meq/ml, the surfactant slug salinity was 0.611 meq/ml, and polymer drive had a salinity of 0.4 meq/ml. As shown in Fig. 1, the initial salinity is type II(+) and the drive salinity is Type II(-). This forces the salinity to pass through the type III window as desired. Figure 2 shows a 5% increase in the cumulative oil recovered when this salinity gradient design wa implemented. The oil recovery increase for the salinity gradient design was due mainly to lower surfactant adsorption compared to that for constant salinity. Although this is a smaller difference in oil recovery than typically found in the past, it does show that the concept is still valid when a very small amount of surfactant is used because it increases the efficiency of the process without increasing the cost. To achieve such high oil recovery (more than 50% of the residual oil in this salinity gradient illustration) requires a surfactant with very low adsorption and all other mechanisms of retention must be very low as well. Recent literature on dilute surfactant and polymer mixtures with highly effective and tolerant surfactants such as the ethoxylated sulfonates with branched hydrophobes indicates that this is indeed feasible. In any case, we consider these simulations to be more realistic than those done in the past because of both improvements in the reservoir description and process modeling.

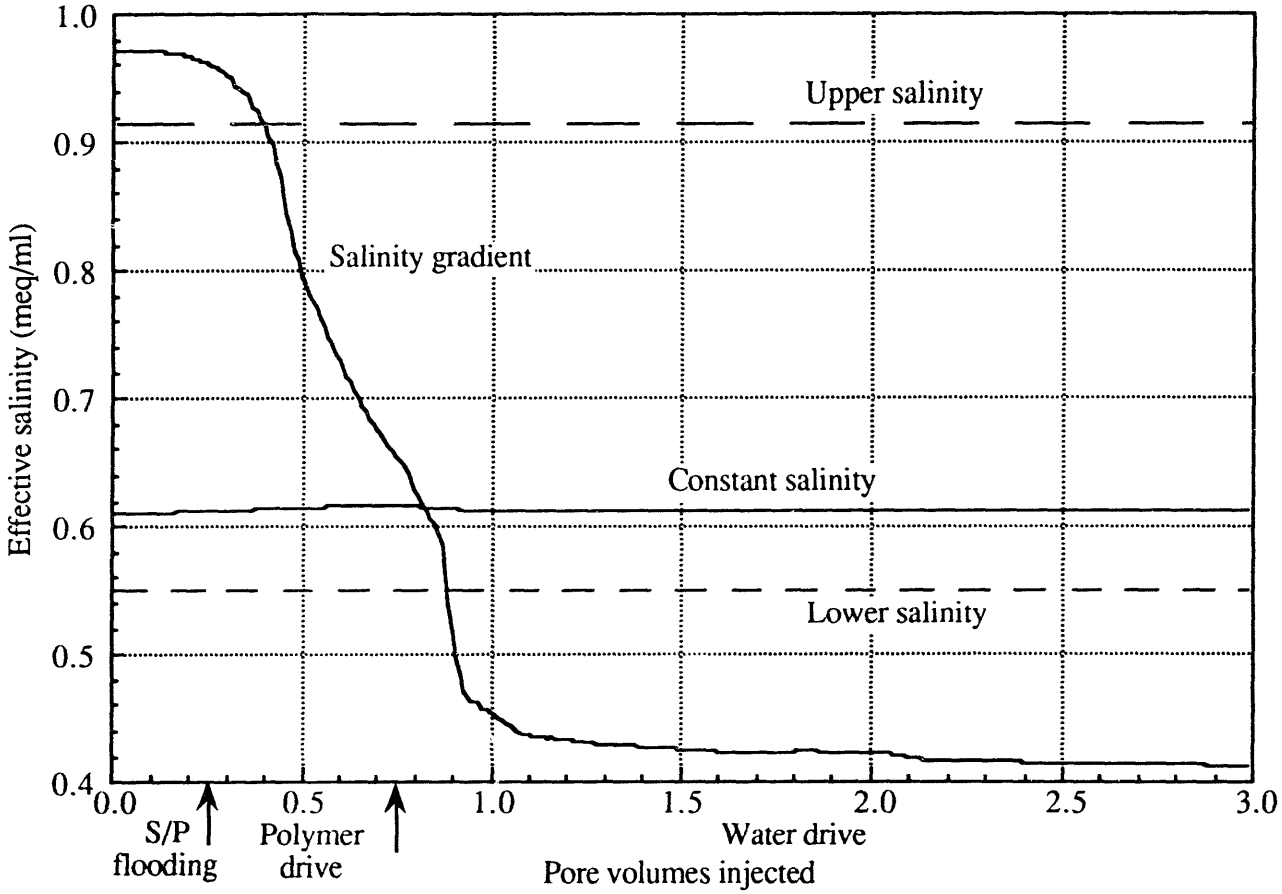

Fig. 1. Effective salinity plot for a constant salinity and salinity gradient surfactant designs.

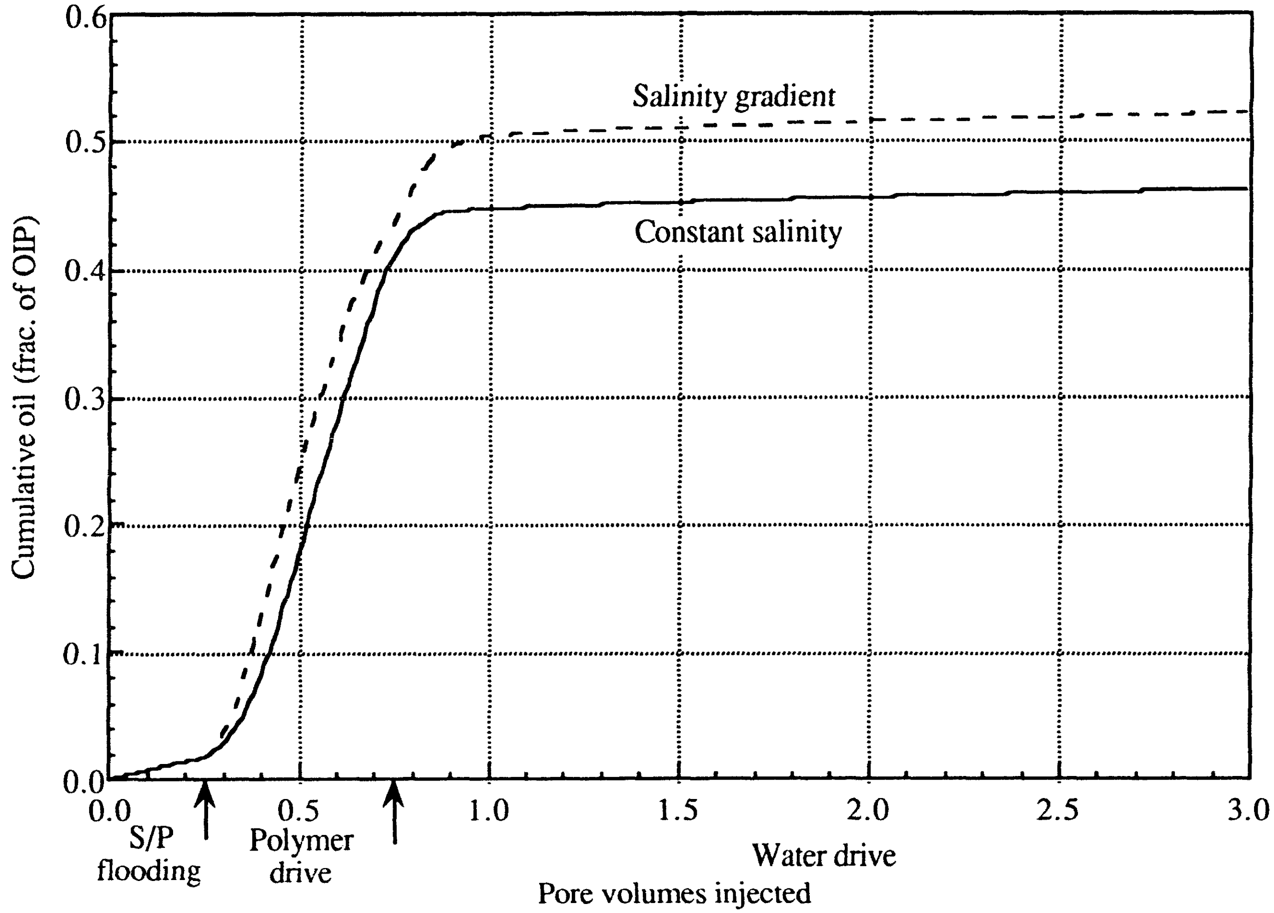

Fig. 2. Effect of salinity gradient on oil recovery.

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