[PS]Evaluation of the Effect of Wettability Alteration on Oil Recovery in Carbonate Reservoirs*

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Search and Discovery Article #40537 (2010)
Posted June 14, 2010

*Adapted from poster presentation at AAPG GEO 2010 Middle East Geoscience Conference & Exhibition, Manama, Bahrain, March 7-10, 2010

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Abstract

More than 60% of the world's oil reserves are held in carbonate reservoirs. Many unfavorable factors contribute to low oil recovery in these reservoirs. Fractured and oil-wet are two leading factors. Therefore, many research foci have been placed on these factors. Apparently, there is an increasing interest in using chemicals to alter wettability. Injection of chemicals can result in various effects, for example, wettability alteration and reduction in interfacial tension (IFT). The question is how much is the contribution from each mechanism to the increase in oil recovery. There is lack of such information in the literature. The information is very important because it will guide us to select what chemicals to be used.

This paper is to evaluate the effect of wettability alteration on oil recovery in carbonate reservoirs. The main objective is to quantify different mechanisms of wettability alteration in oil recovery related to chemical EOR. Particularly, we compare the effects of wettability alteration and interfacial tension. Both fractured and non-fractured reservoirs are addressed. Analytical models and numerical simulation models are used. Our results show that wettability alteration only plays important roles when IFT is high, and it is effective in the early time. IFT plays very important roles with or without wettability alteration and is effective during the entire process. The implication is that anionics used to reduce IFT is preferred to cationics used to alter wettability. Another observation is that, in surfactant-induced wettability alteration with low IFT, gravity drive is a very important mechanism. Molecular diffusion of chemicals affects oil recovery rate in the early time, but not ultimate oil recovery.

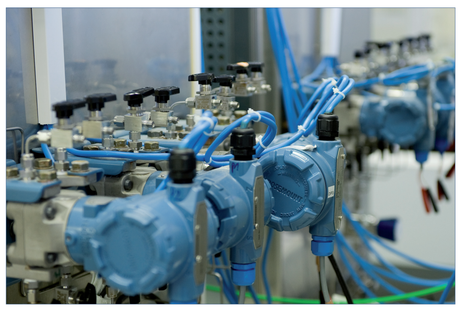
Reference

Hirasaki, G. and L. Zhang, 2004, Surface chemistry of oil recovery from fractured, oil-wet, carbonate formations: SPE Journal, v. 9/2, p. 151-162.

EXPLORATION & PRODUCTION

RESEARCH AND DEVELOPMENT

Evaluation of the Effect of Wettability Alteration on Oil Recovery in Carbonate Reservoirs



Questions

Adding surfactants, IFT is reduced, and wettability is altered from oil-to water-wet. Which mechanism is more important? What else is important?

Methodology

Numerical analysis of simulation results

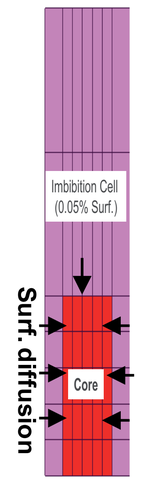
$$k_r = \omega k_r^{altered} + (1-\omega) k_r^{initial}$$

$$P_C = \omega P_C^{altered} + (1-\omega) P_C^{initial}$$

ω = surf. adsorp./total surf.

Brine

Alkali/Surfactant

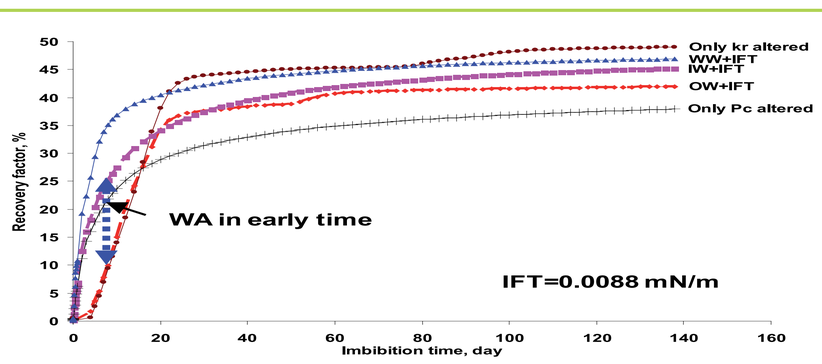


Model

Spontaneous imbibition test (Hirasaki & Zhang, 2004)

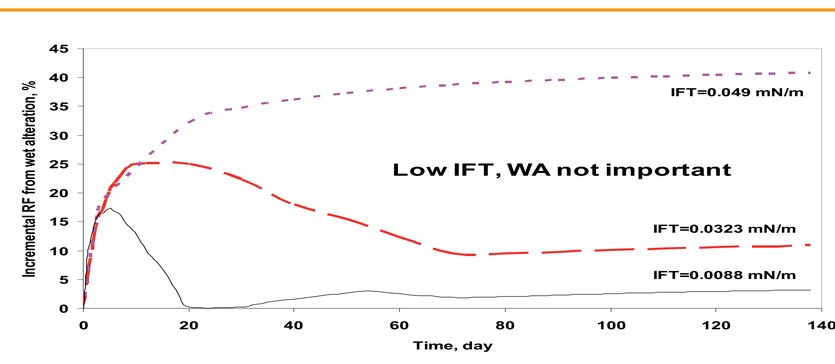
Effect of WA, Pc and kr

1



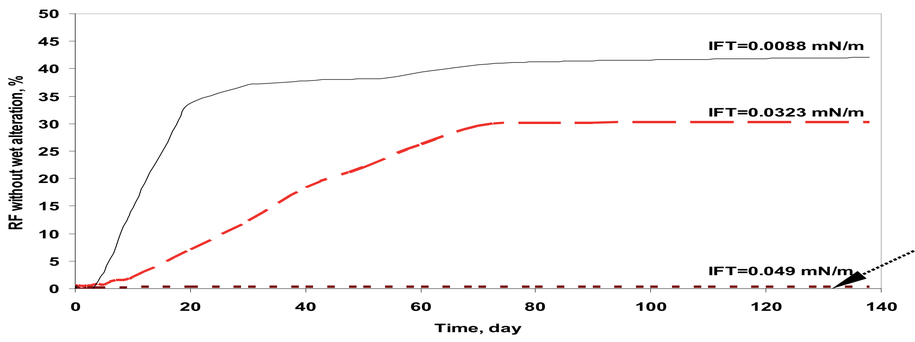
Effect of WA at different IFTs

2



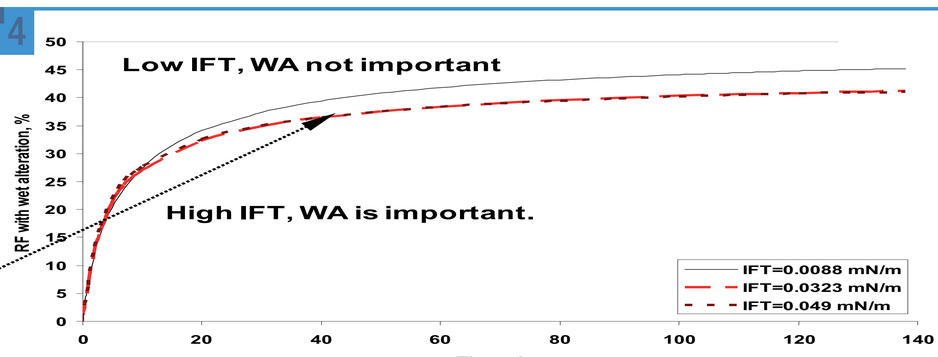
Effect of IFT (no WA)

3



Effect of IFT (with WA)

4



Abbreviation

IFT = InterFacial Tension, WA = Wettability Alteration, WW = Water-Wet, OW = Oil-Wet, IW = Intermediate-Wet, RF = Recovery Factor

TOTAL

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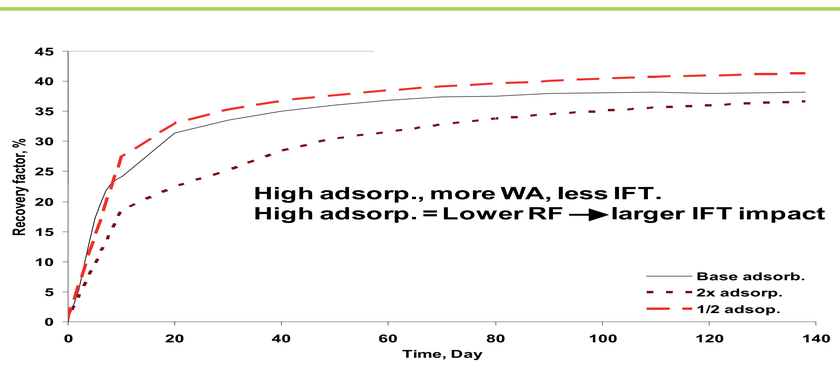
Evaluation of the Effect of Wettability Alteration on Oil Recovery in Carbonate Reservoirs (Cont'd)

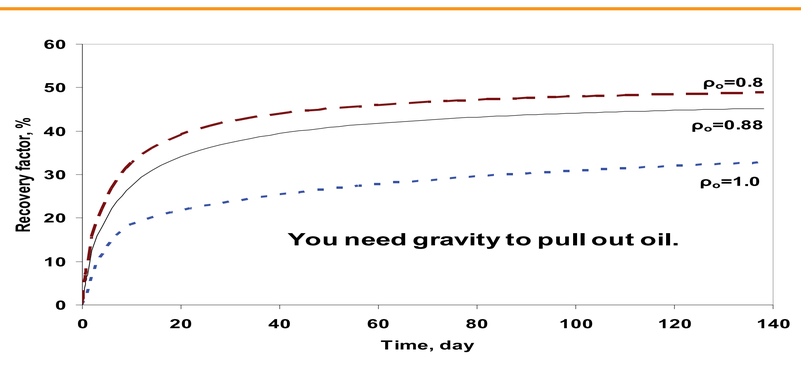
Effect of surfactant adsorption

5



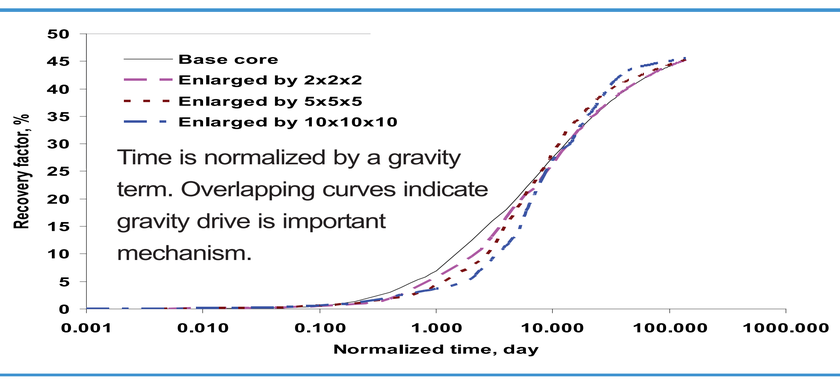
Effect of gravity

6



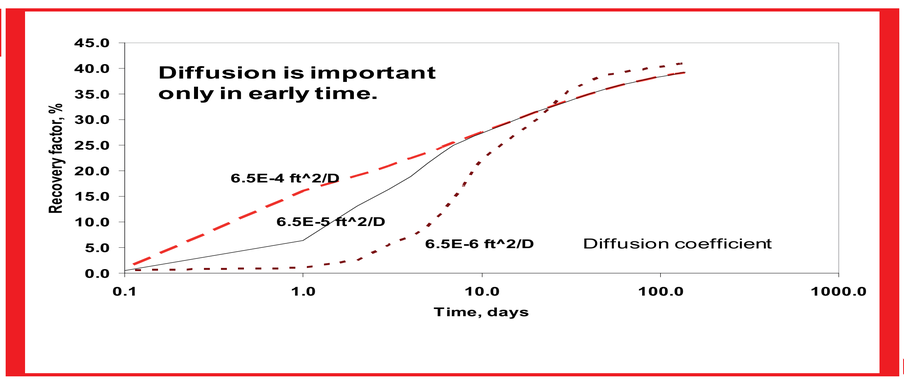
Effect of scale

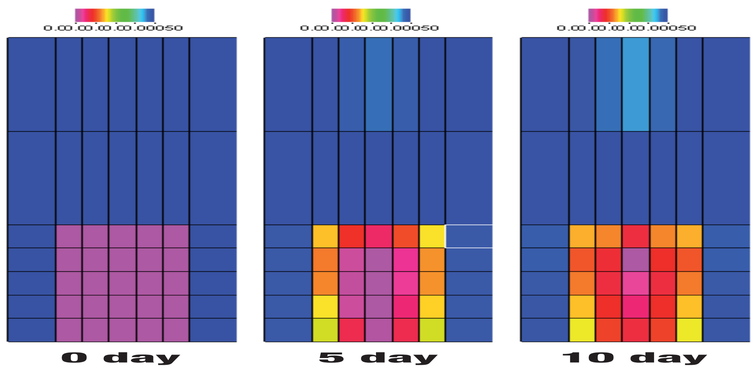
7



Effect of diffusion

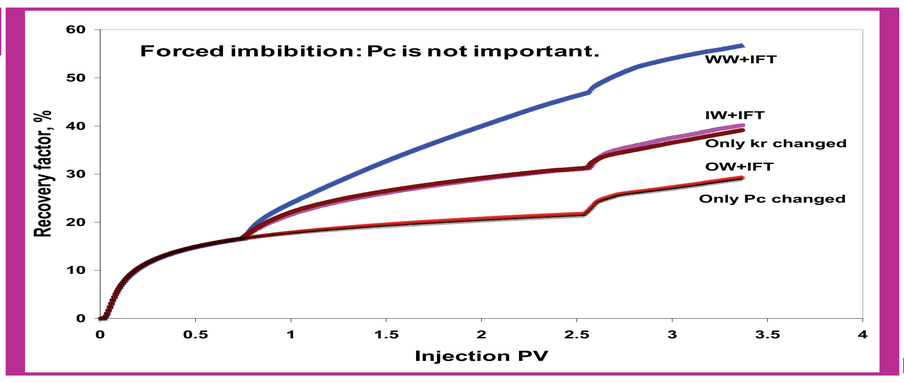
8





Forced imbibition

9



Abbreviation

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Conclusions

- ➔ WA is important only when IFT is high.
- ➔ WA is effective in the early time.
- ➔ IFT plays very important roles with or without WA.
- ➔ When IFT is low, gravity drive is an important mechanism, and WA is less important.
- ➔ Diffusion affects oil recovery in the early time, but not ultimate recovery.
- ➔ In forced imbibition, capillary pressure is not important, alleviating the effect of WA.

Authors

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Acknowledgements

Mojdeh Delshad's help in using UTCHEM, TOTAL management permission to publish this paper.

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