Supporting Information

Estimation of Local Equilibrium Model Parameters for Simulation of Laboratory Foam Enhanced Oil Recovery (EOR) Process Using a Commercial Reservoir Simulator

Lei Ding a *, Leyu Cui b *, Stephane Jouenne b, Ouissama Gharbi b, Mayur Pal c, Henri Bertin d, Mohammad Azizur Rahman a, Carolina Romero b and Dominique Guérillot a *

a: Department of Petroleum Engineering, Texas A&M University at Qatar, P.O. Box 23874, Doha, Qatar

b: Total S. A., E&P, Pôle Economique 2 – BP 47, LACQ, 64170, France

c: North Oil Company, P.O. Box 21264, Doha, Qatar

d: I2M, CNRS, University of Bordeaux, Bordeaux INP, 33400 Talence, France

Corresponding Author:

*Lei Ding: dingleiriceowl@gmail.com

*Leyu Cui: leyu.cui@total.com

*Dominique Guérillot: dominique.guerillot@qatar.tamu.edu
S1 Experimental Procedures

The detailed procedure for foam tests without and with crude oil are elucidated in the following.

- **Foam tests without crude oil**
  - Restore the core sample by flushing 30 pore volume (PV) of 2 wt. % NaCl brine, after which the core permeability is measured;
  - Inject 4 PV of synthetic injection seawater brine (~44,000 TDS, total dissolved solids);
  - Pre-saturate the core by flushing with 3 PV 0.2 wt. % Alkyl-Poly-Glucoside (APG) in synthetic injection seawater brine;
  - Load N\(_2\) into ISCO pump and pressurize to target pressure;
  - Co-Injection of N\(_2\) and Surfactant solution at certain total flow rate and fixed foam quality (e.g., 0.96 ml/min, 4 ft./d, 60% foam quality);
  - Wait until the pressure is stabilized.

- **Foam tests with crude oil**
  - Restore the core sample by flushing 30 PV of 2 wt. % NaCl brine, after which the core permeability is measured;
  - Pre-saturate the core by injecting 4 PV of Synthetic Formation Brine (~150,000 TDS);
Oil flooding at 8 ft./d, until no water is coming out, then, the injection rate is decrease to 1 ft./d and 0.2 ft./.d step by step, during which the pressure drop was recorded to calculate the end-point oil relative permeability. Then, the core sample was being aged at reservoir conditions for 48 hours while keeping the injection rate of crude oil at 0.2 ft./d;

Inject about 5 PV of synthetic injection seawater brine, until no oil is coming out;

Inject 0.4 PV of 0.2 wt.% APG in synthetic injection seawater brine (Conditioning);

Co-Injection of N\(_2\) and Surfactant solution at a total superficial velocity of 4 ft./d (0.96 ml/min, 60% foam quality);

Wait until the pressure is stable, then increase the total superficial velocity to 8, 12 16 and 20 ft./d step by step;

Perform the oil fractional flow tests, where the foam quality and total superficial velocity of N\(_2\) and surfactant solution are fixed at 0.6 and 4 ft./d, respectively. The oil injection rate varies from 1 to 3 ft./d.

**S2 CMG STARS Foam Model**

There is one local equilibrium foam model in CMG STARS\(^{TM}\), which is the most widely used foam model for simulating steady state foam behavior in porous media\(^1\). It is believed that this empirical texture-implicit local equilibrium approach is more promising for field-scale applications. It has been experimentally verified that the water relative permeability is less influenced by foam, which is still largely a function of water saturation\(^2\). Contrarily, gas mobility will be substantially reduced by decreasing the gas relative permeability and increasing gas apparent viscosity. Since relative permeability and viscosity are always come together, STARS foam model only modifies the gas relative permeability by multiplying a foam mobility reduction factor (\(FM\)) as a result.
of the presence of foam. As discussed in the paper, the mobility reduction factor $FM$ describes the effect of different factors ($F_1$-$F_{dry}$) on gas mobility reduction.

$$k_{rg}^f = k_{rg}^{nf} \times FM \quad \text{Equation S1}$$

$$FM = \frac{1}{1 + FMMOB \times F_1 \times F_2 \times F_3 \times F_4 \times F_5 \times F_6 \times F_7 \times F_{dry}} \quad \text{Equation S2}$$

Where $k_{rg}$ and $k_{rg}^{nf}$ are the gas relative permeability in the presence and in the absence of foam, respectively. $FM$ is the dimensionless interpolation factor and $FMMOB$ is the maximum mobility reduction factor. The functions of surfactant concentration effect ($F_1$), oil saturation effect ($F_2$), shear thinning effect ($F_3$), foam generation effect ($F_4$), oil composition effect ($F_5$), salinity effect ($F_6$), permeability effect ($F_7$) and foam dry-out effect ($F_{dry}$) on foam mobility reduction factor are elaborately listed in Table S1.

All of the functions are made dimensionless except $F_7$, therefore, $fmper1$ and $fmperm2$ (in the manual, the range of $fmper1$ and $fmperm2$ are less than $10^{10}$) should be carefully selected in order to avoid numerical issues or non-physical results. It was recently proposed that the critical water saturation ($SFDRY$) in $F_{dry}$ could be described as a function of surfactant concentration, capillary number, salinity and oil saturation.
The plots of different functions ($F_1$-$F_{dry}$) in Equation S2 are exhibited in Figure S1. Moreover, the values used in the calculation are also marked in the figures. It is also worth noting whether all eight functions can be used simultaneously still needs to be justified further.

### Table S1. STARS LE Foam Model

| Model Description | Model Parameters |
|-------------------|------------------|
| $F_1 = (C_{surf}/f_{msurf})_{pursurf}$ | $S3$ $F_1$: function of surfactant concentration |
| $F_2 = \begin{cases} (C_{surf}/f_{msurf})_{pursurf}, & \text{if } C_{surf} < f_{msurf} \\ 1, & \text{if } C_{surf} \geq f_{msurf} \end{cases}$ | $F_2$: function of oil saturation |
| $F_3 = \begin{cases} (f_{moil} - S_0)/f_{moil} - f_{floil} \}_{pomof}^{f_{moil}} & \text{if } S_0 > f_{moil} \\ 1, & \text{if } S_0 < f_{floil} \end{cases}$ | $S4$ $F_3$: function of capillary number (shear) |
| $F_4 = \begin{cases} (f_{mgcp} - N_{ca}/f_{mgcp})_{pomof}^{f_{mgcp}}, & \text{if } N_{ca} > f_{mgcp} \\ 0, & \text{if } N_{ca} \leq f_{mgcp} \end{cases}$ | $F_4$: function of foam generation (capillary number) |
| $F_5 = \begin{cases} (f_{momf} - C_{a})/f_{momf}, & \text{if } C_{a} \leq f_{momf} \\ 0, & \text{if } C_{a} > f_{momf} \end{cases}$ | $S5$ $F_5$: function of oil composition |
| $F_6 = \begin{cases} (C_{surf} - f_{flsalt})/f_{msalt} - f_{flsalt})^{efsalt_{pursalt}}, & \text{if } f_{flsalt} \leq f_{msalt} \\ 1, & \text{if } f_{msalt} < f_{flsalt} \end{cases}$ | $F_6$: function of salinity |
| $F_7 = \frac{\arctan\left[epdry(S_{w} - f_{mdry})\right]}{\pi}$ | $F_7$: function of permeability |
| $F_{dry} = 0.5 + \frac{\arctan\left[ef_{bet}(S_{w} - SFDRY)\right]}{\pi}$ | $F_{dry}$: dry-out function |

**Model Parameters**

- $F_1$: function of surfactant concentration
- $F_2$: function of oil saturation
- $F_3$: function of capillary number (shear)
- $F_4$: function of foam generation (capillary number)
- $F_5$: function of oil composition
- $F_6$: function of salinity
- $F_7$: function of permeability
- $F_{dry}$: dry-out function
- $C_{surf}$: surfactant concentration
- $f_{msurf}$: reference surfactant concentration
- $\varepsilon_{surf}$: exponent of $F_1$
- $f_{moil}$: critical oil saturation 1
- $f_{floil}$: critical oil saturation 2
- $f_{mgcp}$: critical capillary number for foam generation
- $\varepsilon_{mgcp}$: exponent of $F_4$
- $f_{msalt}$: maximum capillary number
- $N_{ca}$: capillary number
- $N_{max}$: maximum capillary number
- $f_{momf}$: mole fraction of component in oil
- $\varepsilon_{momf}$: an exponent in $F_3$
- $f_{flsalt}$: critical salinity 1
- $f_{msalt}$: critical salinity 2
- $\varepsilon_{msalt}$: an exponent in $F_6$
- $f_{perm}$: parameter 1 in $F_7$
- $\varepsilon_{perm}$: parameter 2 in $F_7$
- $epdry$: a parameter regulating slope near $f_{mdry}$
- $f_{mdry}$: critical water saturation
- $sf_{bet}$: similar to $epdry$
- $SF$: similar to $f_{mdry}$, but depends on many factors

The values used in the calculation are also marked in the figures. It is also worth noting whether all eight functions can be used simultaneously still needs to be justified further.
Figure S1. Plots of $F_i$-$F_{dry}$ in CMG STARS

(a). $F_1$ as a function of surfactant concentration; (b). $F_2$ as a function of oil saturation; (c). $F_3$ as a function of capillary number; (d). $F_4$ as a function of capillary number; (e). $F_5$ as a function of oil composition; (f). $F_6$ as a function of salinity; (g). $F_7$ as a function of $f_{perm1}$ and $f_{perm2}$; (h). $F_{dry}$ as a function of water saturation

The effects of $f_{msurf}$ and $e_{surf}$ on the surfactant concentration function, $F_1$, are illustrated in Figure S2.
The effects of \textit{fmoil}, \textit{floid} and \textit{epoil} on the oil saturation function, \( F_2 \), are illustrated in Figure S3.

The effects of \textit{fmcap} and \textit{epcap} on the shear thinning function, \( F_3 \), are illustrated in Figure S4.
S3 Stone’s II Model for Three Phase Relative Permeability

Stone’s II model\(^3\) correlates the three phase relative permeability data from extrapolating two phase flow experiments.

- For water-oil two phase flow, it follows Corey’s correlation\(^4\):

\[
k_{rwo} = k_{rwo}^0 \left( \frac{S_w - S_{wcr} - S_{orw}}{1 - S_{wcr} - S_{orw}} \right)^{n_{w}}
\]

\[
k_{row} = k_{row}^0 \left( \frac{S_o - S_{orw}}{1 - S_{wco} - S_{orw}} \right)^{n_{o}}
\]

Where \(k_{rwo}\) and \(k_{row}\) are relative permeability of water and oil in oil-water two-phase flow, respectively. \(k_{rwo}^0\) and \(k_{row}^0\) are end point relative permeability of water and oil in oil-water two phase flow. \(S_w\) and \(S_o\) are the water saturation and oil saturation, individually. \(n_{w}\) and \(n_{o}\) are Corey’s exponents for water and oil relative permeability, respectively. \(S_{wcr}\) is the critical water saturation above which water starts to get mobilized in oil-water two phase flow. \(S_{wco}\) is the connate water saturation for oil-water two phase flow. \(S_{orw}\) and \(S_{orw}\) are the residual oil saturation by water flooding and irreducible oil saturation in oil-water two phase flow, respectively. In oil-wet
system, $S_{oirw}$ is interpreted as $S_{ocon}$, the connate oil saturation, while $S_{wcono}$ is interpreted as $S_{wirw}$, the irreducible water saturation.

- For gas-water two phase flow:

$$k_{rwg} = k_{rwg}^0 \left( \frac{S_w - S_{wcrig}}{1 - S_{wcrig} - S_{gcon}} \right)^{n_{wg}} \quad \text{Equation S.19}$$

$$k_{rg} = k_{rg}^0 \left( \frac{S_g - S_{gcrig}}{1 - S_{wcon} - S_{gcrig}} \right)^{n_g} \quad \text{Equation S.20}$$

Where $k_{rwg}$ and $k_{rg}$ are relative permeability of water and gas in gas-water two-phase flow, respectively. $k_{rwg}^0$ and $k_{rg}^0$ are end point relative permeability of water and gas in gas-water two phase flow. $S_w$ and $S_g$ are the water saturation and gas saturation, individually. $n_{wg}$ and $n_g$ are Corey’s exponents for water and gas relative permeability, respectively. $S_{wcrig}$ is the critical water saturation above which water starts to get mobilized in gas-water two phase flow. $S_{wcon}$ is the connate water saturation in gas-water two phase flow. $S_{gcon}$ and $S_{gcrig}$ are the connate gas saturation and critical gas saturation in gas-water two phase flow, respectively.

Stone’s II model\(^3\) for three phase relative permeability in terms of oil wet porous media: the oil relative permeability remains the same as that in water-oil two phase flow and the gas relative permeability remains the same as that in gas-water two phase flow. They are still only the function of oil and gas saturation, respectively.

$$k_{rwg} = k_{rwg}^0 \left( \frac{S_l - S_{lirw}}{1 - S_{gcon} - S_{lirw}} \right)^{n_{wg}} \quad \text{Equation S.21}$$

$$k_{rg} = k_{rg}^0 \left( \frac{S_g - S_{gcrig}}{1 - S_{lcon} - S_{gcrig}} \right)^{n_g} \quad \text{Equation S.22}$$

$$S_{lcon} = S_{oirw} + S_{wcon} \quad \text{Equation S.23}$$

$$S_{lrg} = S_{oirw} + S_{wcrig} \quad \text{Equation S.24}$$

Where $S_l$ is the liquid saturation, $S_{lrg}$ is the residual liquid saturation by gas, $S_{lcon}$ is the connate liquid saturation in three phase flow system.
For oil wet system, the water relative permeability in three phase flow is calculated as:

\[ k_{rw} = k_{rwco} \left( \frac{k_{row}}{k_{rwco}} + k_{ro} \right) \left( \frac{k_{rg}}{k_{rwco}} + k_{rg} \right) - k_{rg} - k_{ro} \]  \hspace{1cm} \text{Equation S.25}

Where \( k_{rwco} = k_{row}(S_o = S_{ocon}) = k_{row}(S_g = 0) \) to ensure that \( k_{rw} = k_{row} \) when \( S_g = 0 \); and that \( k_{rw} = k_{rg} \) when \( S_o = S_{ocon} \).

For water wet condition, the water relative permeability remains the same as that in water-oil two phase flow and the gas relative permeability remains the same as that in gas-oil two phase flow. They are still only a function of their own saturation. The oil relative permeability is calculated as:

\[ k_{ro} = k_{rocw} \left( \frac{k_{row}}{k_{rocw}} + k_{rw} \right) \left( \frac{k_{rg}}{k_{rocw}} + k_{rg} \right) - k_{rg} - k_{rw} \]  \hspace{1cm} \text{Equation S.26}

Where \( k_{rocw} = k_{row}(S_w = S_{wcono}) = k_{row}(S_g = 0) \) to ensure that \( k_{ro} = k_{row} \) when \( S_g = 0 \); and that \( k_{ro} = k_{rg} \) when \( S_w = S_{wcono} \).

Table S2 Template Data File for Foam LE Modeling

Data file for foam co-injection EOR, 60% foam quality and 4 ft/d

By CMG STARS 2017.10

** 2020-02-23, 9:09:03 AM, lei.ding
RESULTS SIMULATOR STARS 201710
** For foam EOR tests
** Relative permeability curve is adjusted on the basis of data published in literature
TITLE1 'Foam_1D_EOR'
TITLE2 'Co-Injection 60% foam quality at 4 ft/d and 55C'
TITLE3 '2000 psi confining and 1500 psi back pressure'
*INUNIT  *LAB *EXCEPT 3 1 ** psi instead of kPa
*EXCEPT 6 1 ** darcy instead of millidarcy
WRST 500
WPRN GRID 10
WSRF GRID 10
** special adsorption component (in ppm)
OUTPRN GRID ADSORP PPM ADSPCMP FRCFLOW KRG KRO KRW MOLDENG MOLDENO MOLDENW PRES RFG
SG SO SW VISG VISW W Y
OUTPRN WELL WELLCOMP
OUTPRN ITER NEWTON
**Commented out by CMOST WRST 500
**Commented out by CMOST WPRN GRID 500
WPRN ITER 1
WSRF WELL TIME
** special adsorption component (in ppm)
OUTSRF GRID ADSORP PPM ADSPCMP AQ-SP CMPDENO CMPDENW CMPVISG CMPVISO CMPVISW FLUXRC
FLUXSC GASFRFL
GASMOB KRG KRO KRW MASDENG MASDENW OILFRFL OILMOB OILPOT PCOW
PRES RFG RFO RFW SG SO SW TEMP VDISPL VISG VISW
W WATFRFL X Y Z
OUTSRF WELL WELLPI
OUTSRF WELL COMPONENT ALL

**  ==============  GRID AND RESERVOIR DEFINITION  ==============**
*GRID *CART 1 1 50 ** One-dimensional grid
*KDIR UP
*DI *CON 3.3676
*DJ *CON 3.3676
*DK *CON 0.3048
** 0 = null block, 1 = active block
NULL CON 1
*DTOP 1
*POR *CON 0.31255

*PERMI *CON 0.150
PERMJ EQUALSI
PERMK EQUALSI
** 0 = pinched block, 1 = active block
PINCHOUTARRAY CON 1

*END-GRID
ROCKTYPE 1

*PRPOR 1500.0
**  ============== FLUID DEFINITIONS  ==============**
** Model and number of components
** Lamellae is one of the components but have no effect on gas viscosity
** Lamellae for injection of pre-generated foam or PB model

MODEL 6 6 4 3
COMPNAME 'WATER' 'SURFACT' 'NACL' 'OIL_NOC' 'N2' 'LAMELLA'
** Gas-liquid K Value tables
KVTABLE 'WATER'
**
0 0
0 0
** Gas-liquid K Value tables
KVTABLE 'SURFACT'
**
0 0
0 0
** Gas-liquid K Value tables
KVTABLE 'NACL'
**
0 0
0 0
KVTABLE 'OIL_NOC'
**
0 0
0 0
** Reference conditions
PRSR 1500.0
TEMR 55
PSURF 1500.0
TSURF 25.0
XNACL 0.045
** Mass density based on 0.383 gmole/cm3
SOLID_DEN 'SURFACT' 0.16469 0 0
SOLID_DEN 'LAMELLA' 0.006894 0 0
MOLDEN
0.0 0.00233 0.00233 0.00426

AVG
0.042 0.042 0.042 0.042 0.042 0.042
BVG
0.0 0.0 0.0 0.0 0.0 0.0
** VISCTABLE **

** temp **

55  0.  10.000  0.55  40.6

** ============== ROCK-FLUID PROPERTIES =============== **

ROCKFLUID

DISP_WAT 'SURFACT' CON  0.092
DISP_WAT 'SURFACT' CON  0.092
DISP_WAT 'SURFACT' CON  0.092

**

** Curves for surfactant brine

RPT 1 OILWET

*INTCOMP 'SURFACT' WATER

IFTTABLE

** AQUEOUS MOLE FRAC   IFT **

Composition of component/phase Interfacial tension

| Composition | IFT |
|-------------|-----|
| 0.0000      | 50. |
| 0.0001      | 27  |
| 0.001       | 27  |

*INTLIN

** CRITICAL FOAM PARAMETERS **

Mobility Reduction Factor
FMMOB  42.16965
FMSURF  4.6238102E-06  ** Critical Surfactant Concentration, mole fraction
** Critical Oil Saturation for Foam Tolerance
FMOIL  0.249
FLOIL  0.0837

*EPSURF  1.59  ** Exponent for Surfactant Concentration Contribution
*FMCAP  1.2133889E-05
EPCAP  2.37  ** Exponent for Capillary Number Contribution
*EPOIL  1.0375  ** Exponent for Oil Saturation Contribution
EPGCP  4.9
FMGCP  2.6915348E-06
*EPOMF  0
*EPSALT  0
SFDRY  0.305
SFBET  79432.823

** SET # 1 : No Foam
*KRINTRP 1
*DTRAPW 1.0 ** No Mobility Reduction

*SWT ** Water-Oil Relative Permeability
**$ sw krw krow

| sw  | krw   | krow   |
|-----|-------|--------|
| 0.295500 | 0.00000000 | 0.92550000 |
| 0.324350 | 0.00000000 | 0.85798039 |
| 0.353200 | 0.00000000 | 0.79234944 |
| 0.382050 | 0.00000000 | 0.72864804 |
| 0.410900 | 0.00000000 | 0.6692023 |
| 0.439750 | 0.00000000 | 0.60721362 |
| 0.486800 | 0.00095677 | 0.51431323 |
| 0.533850 | 0.00727914 | 0.42716040 |
| 0.580900 | 0.02378300 | 0.34611149 |
| 0.627950 | 0.05509190 | 0.27146127 |
| 0.675000 | 0.10569757 | 0.20366586 |
| 0.722050 | 0.18000071 | 0.14328082 |
| 0.769100 | 0.28233119 | 0.09105097 |
| 0.816150 | 0.41696091 | 0.04805790 |
| 0.863200 | 0.58811290 | 0.01611913 |
| 0.910250 | 0.7996793 | 0.00000000 |
| 0.912150 | 0.80943754 | 0.00000000 |
| 0.914050 | 0.81898055 | 0.00000000 |
| 0.915950 | 0.82859725 | 0.00000000 |
| 0.917850 | 0.83828790 | 0.00000000 |
| 0.919750 | 0.84805277 | 0.00000000 |
| 0.921650 | 0.85879214 | 0.00000000 |
| 0.923550 | 0.86860628 | 0.00000000 |
| 0.925450 | 0.87779545 | 0.00000000 |
| 0.927350 | 0.88785994 | 0.00000000 |
| 0.929250 | 0.89800000 | 0.00000000 |

*SLT ** Liquid-Gas Relative Permeability
**$ sl krg krog

| sl  | krg   | krog   |
|-----|-------|--------|
| 0.114750 | 0.43900000 | 0.00000000 |
| 0.123820 | 0.42522531 | 0.00000000 |
| 0.132890 | 0.41171986 | 0.00000000 |
| 0.141960 | 0.39848165 | 0.00000000 |
| 0.151030 | 0.38550867 | 0.00000000 |
| 0.160100 | 0.37279891 | 0.00000000 |
| 0.195045 | 0.32625412 | 0.00012610 |
| 0.229990 | 0.28346873 | 0.00087217 |
| 0.264935 | 0.24432271 | 0.00270330 |
| 0.299880 | 0.20869334 | 0.0063216 |
| 0.334825 | 0.17645498 | 0.01124222 |
** SET # 2 : Corresponding to strong foam**
** Copy from first Set and then overwrite**

| KRINTRP 2 |
|-----------|
| DTRAPW 0.023713737 |

** Strong Foam - Inverse Mobility Reduction Factor (MRF = 42.17)**

| *SWT** | ** Water-Oil Relative Permeability** |
|--------|--------------------------------------|
| $\text{sw}$ | krw | krow |
| 0.295500 | 0.00000000 | 0.92550000 |
| 0.324350 | 0.00000000 | 0.85798039 |
| 0.353200 | 0.00000000 | 0.79234944 |
| 0.382050 | 0.00000000 | 0.72864804 |
| 0.410900 | 0.00000000 | 0.66692023 |
| 0.439750 | 0.00000000 | 0.60721362 |
| 0.486800 | 0.00096177 | 0.51431323 |
| 0.533850 | 0.00727914 | 0.42718040 |
| 0.580900 | 0.02378300 | 0.34611149 |
| 0.627950 | 0.05509190 | 0.27146127 |
| 0.675000 | 0.10569757 | 0.2036586 |
| 0.722050 | 0.18000007 | 0.14328082 |
| 0.769100 | 0.28233119 | 0.09105097 |
| 0.816150 | 0.41696091 | 0.04805790 |
| 0.863200 | 0.58811290 | 0.01611193 |
| 0.910250 | 0.79996793 | 0.00000000 |
| Liquid-Gas Relative Permeability |
|-------------------------------|
| **| ** sl | krg | krog |
|-------------------------------|
| 0.114750 0.43900000 0.00000000 |
| 0.123820 0.42522531 0.00000000 |
| 0.132890 0.41171986 0.00000000 |
| 0.141960 0.39848165 0.00000000 |
| 0.151030 0.38550867 0.00000000 |
| 0.160100 0.37279891 0.00000000 |
| 0.195045 0.32625412 0.00012610 |
| 0.229990 0.28346873 0.00087217 |
| 0.264935 0.24432271 0.00270330 |
| 0.299880 0.20869334 0.00603216 |
| 0.334825 0.17645498 0.01124222 |
| 0.369770 0.14747878 0.01869682 |
| 0.404715 0.12163242 0.02874413 |
| 0.439660 0.09877974 0.04172023 |
| 0.474605 0.07878030 0.05795118 |
| 0.509550 0.06148889 0.0775452 |
| 0.544495 0.04655490 0.10144047 |
| 0.579440 0.03442156 0.12931275 |
| 0.614385 0.02432493 0.16166932 |
| 0.649330 0.01629258 0.19880298 |
| 0.684275 0.01014188 0.24100179 |
| 0.719220 0.00557744 0.28854956 |
| 0.754165 0.00268727 0.34172610 |
| 0.789110 0.00093643 0.40080760 |
| 0.824055 0.00015445 0.46606684 |
| 0.859000 0.00000000 0.53777344 |
| 0.887200 0.00000000 0.60052217 |
| 0.915400 0.00000000 0.66778206 |
| 0.943600 0.00000000 0.73969077 |
| 0.971800 0.00000000 0.81638489 |
| 1.000000 0.00000000 0.89800000 |
SGR 0.2523  ** gas trapping
KRGCW 0.010410331

RPT 2 OILWET
*INTCOMP 'SURFACT' WATER
** SET # 1 : Corresponding to No Surfactant
KRINTRP 1
*DTRAPW 0   ** no surfactant
*SWT        ** Water-Oil Relative Permeability
**$ sw  kw  krow
| SW | KRW | KROW |
|----|-----|------|
| 0.548250 | 0.00000000 | 0.92800000 |
| 0.548550 | 0.00000000 | 0.92532912 |
| 0.548850 | 0.00000000 | 0.92266265 |
| 0.549150 | 0.00000000 | 0.92000061 |
| 0.549450 | 0.00000000 | 0.91734299 |
| 0.549750 | 0.00000000 | 0.91468978 |
| 0.574075 | 0.00092067 | 0.71407483 |
| 0.598400 | 0.00551842 | 0.54142125 |
| 0.622725 | 0.01573063 | 0.39559812 |
| 0.647050 | 0.03307694 | 0.27537801 |
| 0.671375 | 0.05886978 | 0.17941276 |
| 0.695700 | 0.09428816 | 0.10619763 |
| 0.720025 | 0.14041522 | 0.05401430 |
| 0.744350 | 0.19826058 | 0.02083024 |
| 0.768675 | 0.26877503 | 0.00408577 |
| 0.793000 | 0.35286079 | 0.00000000 |
| 0.802100 | 0.38798185 | 0.00000000 |
| 0.811200 | 0.42516689 | 0.00000000 |
| 0.820300 | 0.46445900 | 0.00000000 |
| 0.829400 | 0.50590068 | 0.00000000 |
| 0.838500 | 0.54953383 | 0.00000000 |
| 0.847600 | 0.59539979 | 0.00000000 |
| 0.856700 | 0.64353935 | 0.00000000 |
| 0.865800 | 0.69399279 | 0.00000000 |
| 0.874900 | 0.74679991 | 0.00000000 |
| 0.884000 | 0.80200000 | 0.00000000 |

*SLT        ** Liquid-Gas Relative Permeability
**$ sl  krg  krog
| SL | KRG | KROG |
|----|-----|------|
| 0.302250 | 0.87400000 | 0.00000000 |
| 0.335638 | 0.72291756 | 0.00619425 |
| 0.369025 | 0.59184600 | 0.01877746 |
| 0.402413 | 0.47902862 | 0.03592385 |
| 0.435800 | 0.38277503 | 0.05692262 |
| 0.469188 | 0.30146584 | 0.08134687 |
** SET # 2 : Foam, Corresponding to injection Surfactant Concentration
** Copy from first Set and then overwrite

| SWT | krw     | krow     |
|-----|---------|----------|
| 0.295500 | 0.00000000 | 0.92550000 |
| 0.324350 | 0.00000000 | 0.85798039 |
| 0.353200 | 0.00000000 | 0.79234944 |
| 0.382050 | 0.00000000 | 0.72864804 |
| 0.410900 | 0.00000000 | 0.66692023 |
| 0.439750 | 0.00000000 | 0.60721362 |
| 0.486800 | 0.00000000 | 0.51431323 |
| 0.533850 | 0.00000000 | 0.42718040 |
| 0.580900 | 0.00000000 | 0.34611149 |
| 0.627950 | 0.00000000 | 0.27146127 |
| 0.675000 | 0.010569757 | 0.20366586 |
| 0.722050 | 0.01800071 | 0.14328082 |
| 0.769100 | 0.028233119 | 0.09105097 |
| 0.816150 | 0.041696091 | 0.04805790 |
| 0.863200 | 0.058811290 | 0.01611913 |
| 0.910250 | 0.07996793 | 0.00000000 |
| 0.912150 | 0.80943754 | 0.00000000 |
| SLT | Liquid-Gas Relative Permeability |
|-----|---------------------------------|
|     | $ sl $ krg $ krog $               |
| 0.914050 | 0.81898055  | 0.00000000 |
| 0.915950 | 0.82859725  | 0.00000000 |
| 0.917850 | 0.83828790  | 0.00000000 |
| 0.919750 | 0.84805277  | 0.00000000 |
| 0.921650 | 0.85789214  | 0.00000000 |
| 0.923550 | 0.86780628  | 0.00000000 |
| 0.925450 | 0.87779545  | 0.00000000 |
| 0.927350 | 0.88785994  | 0.00000000 |
| 0.929250 | 0.89800000  | 0.00000000 |

KRTYPE CON 2

** Adsorption Data
**Data for reversible aqueous surfactant adsorption

*ADSCOMP 'SURFACT' *WATER  **Data for reversible aqueous surfactant adsorption

*ADMAXT 3.6475395E-06  **maximum adsorption

*ADSLANG 3.9810717 0  114815.36  ** Langmuir concentration coefficients at T=55C

** RRFT 6.7  ** Resistance factor

INITIAL
VERTICAL OFF

INITREGION 1

*PRES *CON 1500.0

*SW *CON 0.7525  ** So by difference

*TEMP *CON 55

MFRAC_WAT 'NACL' CON 0.045
MFRAC_WAT 'SURFACT' CON 0
MFRAC_WAT 'WATER' CON 0.955

NUMERICAL

**  ==============  NUMERICAL CONTROL  ======================

TFORM ZT

ISOTHERMAL

DTMAX 0.005

DTMIN 1E-6

MAXSTEPS 99999999

*RANGECHECK OFF

NORM PRESS 10 ZO 0.05 ZNCG 0.4 ZAQ 0.4

CONVERGE PRESS 0.01 ZO 0.001 ZNCG 0.001 ZAQ 0.001

*RANGECHECK *ON

*RUN

**  ==============  RECURRENT DATA  ======================

**TIME 0

DTWELL 0.005

WELL 'INJ-W'

INJECTOR UNWEIGHT 'INJ-W'

INCOMP WATER 0.95492 8.015e-005 0.045 0.0

OPERATE MAX BHW 0.96 CONT

**  rad geofac wfrac skin

GEOMETRY K 0.5 0.249 1.0 0.0

PERF GEOA 'INJ-W'

** UBA  ff  Status Connection

1 1 1  1.0 OPEN FLOW-FROM 'SURFACE'
WELL 'INJ-G'
INJECTOR UNWEIGHT 'INJ-G'
INCOMP GAS 0.0 0.0 0.0 0.0 0.9 0.1
OPERATE MAX BHG 0.0 CONT
**
rad geofac wfrac skin
GEOMETRY K 0.5 0.249 1.0 0.0
PERF GEOA 'INJ-G'
**
UBA ff Status Connection
1 1 1 1.0 OPEN FLOW-FROM 'SURFACE'

WELL 'PROD'
PRODUCER 'PROD'
OPERATE MIN BHP 1500.0 CONT
**
rad geofac wfrac skin
GEOMETRY K 0.5 0.249 1.0 0.0
PERF GEOA 'PROD'
**
UBA ff Status Connection
1 1 50 1.0 OPEN FLOW-TO 'SURFACE'

TIME 1
TIME 3
TIME 5
TIME 6
TIME 8
TIME 10
TIME 11
TIME 13
TIME 15
TIME 17
TIME 20
TIME 21
TIME 23
TIME 25
TIME 26
TIME 27
TIME 28
TIME 29
TIME 30
INJECTOR UNWEIGHT 'INJ-G'
INCOMP GAS 0.0 0.0 0.0 0.0 0.9 0.1
OPERATE MAX BHG 0.576 CONT
INJECTOR UNWEIGHT 'INJ-W'
INCOMP WATER 0.95492 8.015e-005 0.045 0.0
OPERATE MAX BHW 0.384 CONT
KRTYPE CON 1
RESULTS CMOST HEADER 0
RESULTS CMOST FOOTER 1074751496

RESULTS SPEC 'Permeability J'
RESULTS SPEC SPECNOTCALCVAL -99999
RESULTS SPEC REGION 'All Layers (Whole Grid)'
RESULTS SPEC REGIONTYPE 'REGION_WHOLEGRID'
RESULTS SPEC LAYERNUMB 0
RESULTS SPEC PORTYPE 1
RESULTS SPEC EQUALSI 0 1
RESULTS SPEC SPECKEEPMOD 'YES'
RESULTS SPEC STOP

RESULTS SPEC 'Permeability K'
RESULTS SPEC SPECNOTCALCVAL -99999
RESULTS SPEC REGION 'All Layers (Whole Grid)'
RESULTS SPEC REGIONTYPE 'REGION_WHOLEGRID'
RESULTS SPEC LAYERNUMB 0
RESULTS SPEC PORTYPE 1
RESULTS SPEC EQUALSI 0 1
RESULTS SPEC SPECKEEPMOD 'YES'
RESULTS SPEC STOP
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