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RadEx Technology

GREENZYME® FLOOD SUMMARY

Berea Test Sample #3

Berea Test Sample #4

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Enhanced Oil Recovery Testing

Experimental Objective: To Show the effects on residual oil saturation that the introduction of a GreenZyme solution will have in a homogeneous oil saturated sandstone formation.

1. Acquire a 1.5" X 2.5" Berea sandstone plug sample of around 500 mD. Air permeability and having a porosity of 25%. **Two different batches of Greenzyme will be used.**
2. Acquire filtered crude oil having an oil gravity of 20 degree API, and Synthetic brine of 35000 ppm NaCl, equivalent salinity.
3. Saturate sample using brine solution and measure Kw at 1000 psi. confining stress and **50 Deg.C. This condition to be maintained during the entire flooding test.**
4. Flow filtered crude oil across length of sample until the plug sample reaches Irreducible water saturation (Swi) conditions. Measure (KoSwi).
5. Flow brine solution across length of sample until the plug sample reaches residual oil saturation (Sor) condition, and measure Kw@ sor. Monitor pore volumes of brine solution vs oil cut until there is a 99.9% brine quality produced **using an injection rate of 1 feet/day.**
6. Age sample at 180 degree F. for two weeks (wettability restoration).
7. Flow 5 % of GreenZyme solution across length of core plug collecting effluent until there is a 99.9% brine quality produced **using an injection rate of 1 feet/day .**
8. Let sample soak for 2 days. Flush the sample with brine solution and collect any final effluent that might be removed from the core sample.
9. Determine final water permeability at residual oil saturation, (KwSor).
10. Calculate residual oil saturation (Sor) change triggered from the GreenZyme solution by Dean –Stark extracting the sample. Dean-Stark oil saturation combined with oil removed by GreenZyme flow will yield original residual oil saturation (Sor). Reduction of residual oil saturation created by GreenZyme influence will determine a calculated oil recovery percent using this methodology.
11. **Repeat test with the next blend of GreenZyme**

Greenzyme® Coreflood
Unsteady-State Method

- **Sample Preparation**

Two 1.50-inch diameter Berea core sample were selected for Greenzyme® coreflood tests under overburden conditions. The sample was cleaned, dried and properties were measured at 1000 psi net confining stress.

- **Fluid Preparation**

Synthetic brine of 35,000 ppm NaCl was prepared using deionized water and reagent grade chemicals. The brine was filtered and degassed prior to use. An approximately 20 gravity crude oil sample was selected for the test. The crude oil sample was filtered and degassed prior to use.

- **Pre-Test Procedure**

The sample was vacuum saturated with brine and loaded into overburden cells at 1000 psi simulated reservoir stress. To ensure full saturation, brine was injected against backpressure. Water permeability, K_w , was determined at 100 percent brine saturation. Crude oil was injected at constant rate to drive the sample to residual water saturation, S_{wr} . Water and oil volumes produced were recorded. Oil permeability at residual water saturation, K_{oSwr} , was determined.

- **Sample Aging**

Following the K_{oSwr} measurement, the sample was heated to 180°F while maintaining 1000 psi confining stress. The sample was aged under these conditions for two weeks. Upon completion of aging the sample was allowed to cool to 122 °F and oil permeability at residual water saturation, K_{oSwr} , was determined. Water was injected at a constant rate of 2 cc/minute to drive the sample to residual oil saturation, S_{or} . Incremental volumes of water and oil production were collected as a function of time. Permeability to water and residual oil saturation (K_{wSor}) was measured.

- **Greenzyme® Flood**

Five pore volumes of 5 % Greenzyme® was flowed through the sample at constant flow rate of 1 feet/day. The oil volumes produced were monitored and recorded. Once sufficient Greenzyme® was injected into the sample, flow was stopped and a 48 hour soak was conducted. After 48 hours flow was resumed using the simulated formation brine, flow was continued until a water cut of 99.9 percent was obtained. Oil volumes produced were monitored and recorded. Permeability to water at residual oil saturation (K_{wSor}) was measured at the end of the test.

Test results are presented in tabular and graphical format.

HOUSTON 5% STRENGTH GREENZYME® FLOOD SUMMARY

Simulated Reservoir Stress: 1000 psi
Test Temperature 122.0°F

Field: Berrea Test Sample #3
Location: Houston

Sample ID	Permeability to Air, millidarcies	Porosity, percent	Permeability to Brine, millidarcies	Initial Condition Data			Post Waterflood Data		
				Initial Water Saturation (Swi), percent	Initial Oil Saturation (So), percent	Permeability to Oil at Initial Water Saturation (KoS _{wi}), millidarcies	Residual Oil Saturation (Sor), percent	Oil Produced, percent OOIP	Permeability to Water at Residual Oil Saturation (KwSor), millidarcies
Berea #3	705	21.4	429	20.2	79.8	329	38.6	51.6	41.8

Sample ID	Post 5 PV Greenzyme@ Solution Flood			Post Water Flood After Greenzyme@		
	Residual Oil Saturation (Sor), percent	Additional Oil Produced percent OOIP	Permeability to Water at Residual Oil Saturation (KwSor), millidarcies	Residual Oil Saturation (Sor), percent	Additional Oil Produced percent OOIP	Permeability to Water at Residual Oil Saturation (KwSor), millidarcies
Berea #3	32.9	7.20	23.1	9.4	10.2	

Crude oil used in Greenzyme flood test

Density @ 70 ° F = 0.93295 g/CC
 Density @ 122 ° F = 0.91322 g/CC
 Viscosity @ 122 ° F = 101 Cp
 API

Asphaltene Content 12.2 weight %

NORWAY - GREENZYME® FLOOD SUMMARY

Simulated Reservoir Stress: 1000 psi

Test Temperature 122.0° F

Field: Berrea Test Sample
Location: N/A

Sample ID	Permeability to Air, millidarcies	Porosity, percent	Permeability to Brine, millidarcies	Initial Condition Data			Post Waterflood Data		
				Initial Water Saturation (Swi), percent	Initial Oil Saturation (So), percent	Permeability to Oil at Initial Water Saturation (KoS _w), millidarcies	Residual Oil Saturation (Sor), percent	Oil Produced, percent OOIP	Permeability to Water at Residual Oil Saturation (KwSor), millidarcies
Berea #4	697	21.7	420	23.3	76.7	329	35.4	53.8	37.9

Sample ID	Post 5 PV Greenzyme® Solution Flood			Post Water Flood After Greenzyme®		
	Residual Oil Saturation (Sor), percent	Additional Oil Produced percent OOIP	Permeability to Water at Residual Oil Saturation (KwSor), millidarcies	Residual Oil Saturation (Sor), percent	Additional Oil Produced percent OOIP	Permeability to Water at Residual Oil Saturation (KwSor), millidarcies
Berea #4	30.1	6.96	23.1	10.6	9.6	

Crude oil used in Greenzyme flood test

Density @ 70 ° F =	0.93295	g/cm ³	22.5	API
Density @ 122 ° F =	0.91322	g/cm ³	25.6	API
Viscosity @ 122 ° F =	101	Cp		
Asphaltene Content	12.2	weight %		