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CHEMICAL FLOOD PROGRESS EVALUATION TEST
SOUTH PASS BLOCK 27 FIELD
PLAQUEMINES PARISH, LOUISIANA

Final Report
September 28, 1979—May 16, 1980

Work Performed for the Department of Energy
Under Contract DE-AC19-79ET14033

Date Published—February 1980

Shell Oil Company
New Orleans, Louisiana

U. S. DEPARTMENT OF ENERGY

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PLAQUEMINES PARISH, LOUISIANA

Final Report
September 28, 1979—May 16, 1980

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EXECUTIVE SUMMARY

The first step in starting this surfactant flooding pilot in a 170°F temperature, high salinity (as high as 120,000 ppm TDS), offshore reservoir was to drill, core and log the first pattern well at a depth of about 8000 feet. The well was designed for residual oil saturation evaluation and as the first injection well in the chemical flood pilot. The resulting ROS measurements are less than the 20-25% value (average about 16.4% from cores and between 11.0 and 12.5% from PNC log-inject-logs) required for continuation of the pilot at the planned "N₄" sand location in Shell's South Pass Block 27 field.

Oil saturation data from cores reported here are believed to be minimum values because of blowdown (failure to retain pressure on cores) and viscous stripping (cored with large pressure overbalance). Differences between core and log-inject-log results are not resolved. Intuitively, the core data with some reasonable correction for blowdown and viscous stripping, say to about 20 percent, are believed to be more representative of in situ residual oil saturation values for this high permeability sand. Other experiences in this geologic area (see References 3 and 4 for examples) indicate that the ROS values will be varied but generally the average will be about 25 percent.

FINAL REPORT
CHEMICAL FLOOD PROCESS EVALUATION TEST
SOUTH PASS BLOCK 27 FIELD
PLAQUEMINES PARISH, LOUISIANA

Shell Oil Company
P. O. Box 60123
New Orleans, Louisiana 70160

PROJECT SUMMARY

Enhanced oil recovery potential in Gulf Coast reservoirs is large. In near offshore areas where high permeability and low dip reservoir conditions often exist, chemical or surfactant flooding may be the most efficient EOR process. Certain reservoir conditions, namely high temperatures plus high salinity waters and offshore locations require an extension of the applicability of the process compared to previous tests.

A field test of a surfactant flooding process has been designed for a reservoir located in the South Pass Block 27 field, Plaquemines Parish, Louisiana. The objectives of the test are to continue chemical flooding research by applying the process in a reservoir which is a candidate for this enhanced oil recovery technique if the process is proved economically viable. The plan is to acquire field data which will lead to a better understanding of how the process works under reservoir conditions at a well-to-well distance intermediate to laboratory floods and economic well spacing. The field location is shown on Figure 1.

The initial step in starting the field test began late in 1979 when the first pilot injection-residual oil saturation determination well was drilled and pressured cored in the selected test reservoir, the "N₄" sand Reservoir B, at about 8000 feet. A log-inject-log measurement in this well has also been completed to provide an added evaluation. This report documents the results of the "N₄" sand residual oil saturation measurements in Well SL 1011 No. 88. The Shell-DOE contract is restricted to this phase of the field test.

Results indicate a waterswept residual oil saturation less than 20 percent at the objective location based on coring and PNC log-inject-log measurements. The value is lower than anticipated. Consequently, an alternate test site must be selected if the field test plans are continued.

RESERVOIR SELECTION AND CHARACTERISTICS

Test objectives are to measure in the field, where the surfactant flooding target exists, those things which cannot be measured in the laboratory.

Principally, the test will go beyond laboratory dimension constraints and will provide an opportunity to study the effects of reservoir geology on process performance. An unconfined five-spot (i.e., one producer and four injectors) with logging and sampling observation wells are planned to accomplish the objectives. Pattern size will be small to minimize uncertainties in interpretation and to keep flood life short.

The "N₄" sand, Reservoir B (N₄ RB) at South Pass Block 27 field was the reservoir selected for the pilot because the anticipated recovery by chemical flooding was large and because a geologically simple, waterswept location was available. Pertinent "N₄" RB reservoir parameters are:

Oil gravity 24° API
Oil Viscosity 2.6 cp at $P_b = 3721$ psi
Permeability 1000 md
Temperature 168°F
Expected S_{or} 25-30% (reservoir average)
Current Pressure 2600 psi

The reservoir is located on the west flank of the field and is bounded on the north, east and southeast by faulting and on the south and west by oil-water contacts. The accumulation is elongated in an east-west direction, being approximately four miles long and one mile wide. As shown in Figure 2, the structure rises to the east closing against major faults, flattens into a central saddle area and then rises again to the west into a broad, low-relief, anticlinal enclosure bisected by a small nonsealing fault. The test site is in the saddle area with dips of less than 1°. Typically, the deltaic "N₄" sand varies in thickness and deposition from massive distributary channel sands (50+ feet) in the western portion to thinner distributary channel mouth bars and fringe sands in the eastern part of the reservoir. At the test site, the sand consists primarily of channel-like sand with an average net thickness of approximately 28 feet (see Figure 3). Figure 4 is a cross section of the "N₄" sand at the test site. The "N₄" sand is overlain by transgressive silts and shales containing fauna indicating a marine environment. The "N₄" RB sand is separated from the underlying permeable sands by a silt and shale interval that is continuous in the area of oil accumulation.

RESIDUAL OIL SATURATION MEASUREMENTS

From the standpoint of chemical flood field test interpretation, a residual oil saturation (S_{or}) less than about 20-25 percent is not considered to be acceptable. Therefore, the objective of the first pilot well was to determine with better accuracy than before, the S_{or} at the "N₄" RB test location.

The well SL 1011 No. 88, which was drilled in November and December 1979, would also serve as the chemical flood injector located at the southwest corner of the pilot. Pressure cores and log-inject-log measurements were used for S_{or} determination.

Logging and Coring Results

Figure 5 shows logging results from the "N₄" sand in SL 1011 No. 88. Sand development is as expected but structurally about ten feet low. About five feet of pay were encountered in the transgressive-like sand at about 7915' on the resistivity log in Figure 5. The low resistivity from about 7926' to 7946' clearly defines the residual saturation interval. Difficulties in coring the "N₄" sand resulted in no recovery in the objective interval. Consequently, the well was sidetracked from 7475' to a bottom-hole location about 52 feet SW of the original hole. The "N₄" sand logs from the sidetrack are shown on Figure 6 and are little changed from the original hole logs.

Core recovery results from the two wells are presented in Table 1. Coring problems encountered in the original hole were overcome and, in the objective "N₄" sand, recovery was 17.3 feet or 91%. Pressure recovery was less successful--1150 psi in core 1, zero in core 2 and 3175 psi in core 3 compared to a hydrostatic coring pressure of 4000 psi and a formation pore pressure of 2600 psi. Photographs of slabs from the cores are presented as Figures 7 through 10.

The drilling mud used for coring the "N₄" sand was designed to minimize filtrate invasion. This was accomplished by incorporating polymers for reducing spurt and filter loss and solids of a size distribution to bridge and seal the pore structure of the formation. Table 2 summarizes the coring fluid properties and formulation. The pH was controlled at a value near 7.0 and interfacially active materials were excluded from the mud to lessen the chances of mobilizing oil during the coring operation.

Core Analyses

Core measurement results are plotted on Figure 11 and tabulated on Table 3. Unless otherwise noted, all measurements are from one inch OD plugs drilled with liquid nitrogen from cores frozen at dry ice temperatures. The oil saturations are from Dean Stark extractions and are based on stressed porosity measurements from adjacent plugs and are corrected to in situ volumes using the oil formation volume factor. Porosity and brine permeability measurements were made at an isostatic stress of 4800 psi. Average measurement results from cores 1 and 2 from well SL 1011 No. 88(ST) are:

<u>DATA SET</u>	<u>OIL SATURATION</u>	<u>PERMEABILITY</u>	<u>POROSITY</u>
All core values	16.7±6.3%	845 md	31.5%
One sample/ft. (circled) data in ROS region	16.4±7.1%	1220 md	32.3%

Other information plotted on Figure 11 are tracer data, a macrovisual description of the core, cation exchange capacities and log-inject-log oil saturation measurements. The tracer data (HTO vs. depth) are normalized to mud bottoms-up tritium measurements. In general, the amount of invasion is high, as anticipated because of the large mud weight overbalance. The partially pressured core No. 1 showed a more uniform HTO profile while the profile in core No. 2, the core with no pressure, decreases with depth and oil saturation. The cation exchange capacity (Q_v) data indicate a fairly uniform, clean sand; this conforms to the visual description. Log-inject-log results are discussed later. Table 4 presents additional core measurements.

Core Description

The cores between 7920' and 7950' (core depths) from well SL 1011 No. 88(ST) have been studied for a geologic description. The graphical representation of the description is shown as Figure 12. The interval is an upward coarsening unit which is muddy toward the base. There is a lack of large scale cross stratification and rippling in the section. Based on the grain size trends and sedimentary structures, the unit probably represents a delta fringe cycle, starting at the base with outer fringe, and grading upward into inner fringe.

There is only one possible vertical flow barrier in the unit, occurring at 7945'2", the base of the objective chemical flood test interval. This calcite cemented muddy sand effervesced vigorously with hydrochloric acid and appears very tight. This carbonate layer could be laterally pervasive over several hundred feet. The carbonaceous layers at 7925'6" and 7938'9" may also be prevalent over the area, but are not cemented and would probably not pose much of a flow barrier.

Log-Inject-Log Results

A log-inject-log procedure using stationery measurements with a pulsed neutron-capture sonde and time-of-flight analyzer was carried out in a ten foot interval (7936-7946)* of SL 1011 No. 88(ST) in the "N₄" sand (see Reference 1 for a description of techniques and procedures). At each station the time-of-flight data were analyzed to yield $\tau_{a,A}$, the apparent neutron decay time in the formation containing injected Brine A of 34,098 mg/liter TDS and $\tau_{a,B}$, the apparent neutron decay time in the formation containing injected Brine B of 163,742 mg/liter TDS. Both $\tau_{a,A}$ and $\tau_{a,B}$ were determined in a self-consistent way from the slope of neutron decay data in the time interval from $2.5 \tau_{a,A}$ to $5 \tau_{a,A}$ and $2.5 \tau_{a,B}$ to $5 \tau_{a,B}$ as recommended by Robinson².

The values of $\tau_{w,A}$ and $\tau_{w,B}$ were derived from measurements (conducted at Shell's Bellaire Research Center in Houston) of the neutron capture cross section of injection brines A and B samples.

The fraction of the bulk volume of the formation occupied by the aqueous phase ϕ_w ($\phi_w = S_w \phi_{total}$) can be calculated by the relationship:

$$\phi_w = \frac{\tau_{a,B}^{-1} - \tau_{a,A}^{-1}}{\tau_{w,B}^{-1} - \tau_{w,A}^{-1}}$$

At each station, ϕ_w was calculated and divided by the average porosity derived from stressed core measurements or the average log porosity derived from the formation density log to give S_w . Both porosities were used because of the discrepancy between the two measurements. The value of S_{or} was calculated by multiplying $(1 - S_w)$ by 1.12 to account for the volume change due to the removal of light hydrocarbon components by gas-free brine injection.

The results are summarized on Table 5 and indicate an average S_{or} in the log-inject-log interval of 0.110 with a maximum standard deviation of 0.038 using core porosity and 0.125 with a maximum standard deviation of 0.037 using formation density log porosity. The results using log porosities are plotted on Figure 11 for comparison with the core extraction results.

Calculation of S_{or} was also made from the conventional TDK-K measurements over the same interval. The average τ_a across the interval after Brine A injection was 188.8 μ sec. This value corrected according to the latest (1976) Schlumberger departure curves gives $\tau_{a,A} = 240.7$ μ sec. The average τ_a after injection B injection was 122.8 μ sec. This value when corrected gives $\tau_{a,B} = 145.8$ μ sec. After applying these corrections $\phi_w = 0.281$. Using stress core porosity of 0.322 yields an S_{or} of 0.143 and using a formation density porosity of 0.327 yields an S_{or} of 0.158.

Statistically (t-distribution) the core and log-inject-log mean values have a reasonably high confidence of being consistent. The lack of better agreement is not satisfying, however, not only because the mean values differ but because individual measurement and distribution differences from the two techniques are more than hoped. Intuitively, it seems that core data should result in minimal saturations because overbalanced coring and loss of pressure in core No. 2 probably caused some desaturation due to viscous stripping and due to blow-down. Lowering the oil saturation by viscous stripping during the LIL operation is a possible cause of low ROS values; however, precaution was taken to inject the brines at low rates.

CONCLUSIONS

Residual oil saturation measurements, at one location in "N₄" sand Reservoir B at South Pass Block 27 field is less than anticipated. Techniques used for this evaluation were pressure retaining cores which were not totally successful and PNC log-inject-log measurements from the same well bore. The average S_{or} from core data is 16.4% and between 11.0 and 12.5 percent from log-inject-log tests. These results differ from past measurements in this field (8)

and from a test in the nearby Main Pass Block 69 field⁽⁴⁾ where 25-35 percent values resulted. The effect of the "N₄" RB measurement is that the N₄ sand at the SL 1011 No. 88 location is not an acceptable chemical flood field⁴ test site.

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Mr. D. J. Lewis for work in performing log-inject-log and coring operations, Dr. D. E. Schwatz for the core description, Drs. R. K. Clark and A. Abrams for design and analysis of drilling fluids and Miss D. J. Tuttle for drilling engineering planning.

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TABLE 1
SUMMARY OF CORE RECOVERY
SL 1011 NO. 88, SOUTH PASS BLOCK 27 FIELD

WELL	CORE NO.	DEPTH INTERVAL		RECOVERY		PRESSURE, PSI	
		CORE	LOG	FT.	%	RETAINED	HYDROSTAT
No. 88(OH)*	1	7910-16	7910-16)	6.6	94	3,220	3,800
	2	7916-17	7916-17)			0	3,800
	3	7935-35	7935-35	0	0	4,150	4,150
	4	7942-45	7945-48	1.8	58	0	4,150
	5	7947-57	7950-60	5.8	58	0	4,150
	6	7957-67	7960-70	5.6	56	3,875	4,150
	7	7967-77	7970-80	7.8	78	3,725	4,150
	TOTAL			27.6	69% of 40'	4 of 7	
No. 88(ST)	1	7920-30	7930-40	9.5	95	1,150	4,150
	2	7930-40	7940-50	7.8	78	0	4,150
	3	7940-50	7950-60	5.7	57	3,175	4,150
	TOTAL			22.9	76% of 30'	2 of 3	

* Also cored for practice 7696-7706 feet (core depths) in the water bearing "N₂" sand.
Recovered 9.7 ft. or 97% with 3375 of 3800 psi.

TABLE 2
 DRILLING MUD PROPERTIES AND FORMULATION
 SL 1011 NO. 88, SOUTH PASS BLOCK 27 FIELD

	MEASURED MUD PROPERTIES				
	NO. 88(OH)			NO. 88(ST)	
	CORE 1	CORE 5	CORE 7*	CORE 1*	CORE 3*
Mud Weight, ppg	9.5	10.1	10.2	10.1	10.1
Plastic Viscosity, sec	15	17	21	19	19
Yield Point	10	14	26	18	18
Gel Strength	4/8	3/9	5/15	4/12	4/12
pH	7.0	NA	NA	7.8	7.5
Fluid Loss, ml	2.8	3.6	3.0	3.9	4.2
Calcium, ppm	840	1,480	1,800	2,200	2,300
Chlorides, ppm	16,500	17,000	17,000	16,800	16,500
Solids, %	6	11	12	10	10

* Sampled from core barrel; others from pit on bottoms up.

FORMULATION

Drispac Super Lo
 mud system prepared by
 Magcobar Division (of Dresser Ind.)

1 bbl. Water
 10 lb. Bentonite
 1/2 lb. Drispac
 8 lb. Magco Poly-Sal
 8 lb. Salt
 70 lb. Lo-Wate

Magco Poly-Sal is a water dispersible
 non-ionic polymer. (Product Sheet
 No. 1206)
 Lo-Wate is CaCO_3

TABLE 3
CORE ANALYSES, SL 1011 NO. 88(ST)
SOUTH PASS BLOCK 27 FIELD

Sample No.	Depth Ft.	Stressed Porosity, %	Stressed Brine Perm., md	Grain Density, g/cc	S _o , %	Q _v , meq/ml
1	7921'0"	29.0(assumed)	--	2.671	10.4	0.364
2	7922'0"	28.8	54.4	2.646	26.8	0.247
3	7922'7"	27.5	118	2.639	22.0	0.375
4	7923'0"	30.9	554	2.640	13.2	0.105
5	7924'0"	32.6	1530	2.640	13.3	0.061
6	7925'3"	31.1	330	2.648	13.9	0.134
7	7926'0"	32.1	363	2.639	19.6	0.061
8	7927'0"	31.8	335	2.641	20.7	0.051
9	7928'7"	31.4	1580	2.633	26.4	0.058
10	7929'8"	31.9	1380	2.632	22.3	0.056
11	7930'0"	32.1	1290	2.633	13.4	0.056
11A	7930'1"	32.1(assumed)		2.633(assumed)	18.7	
12	7932'0"	31.4	753	2.627	27.1	0.075
12A	7932'6"	31.5(assumed)		2.628(assumed)	19.9	
13	7933'0"	31.6	1210	2.629	15.0	0.046
14	7934'0"	32.9	1230	2.619	11.1	0.048
14A	7934'7"	33.1(assumed)		2.633(assumed)	13.1	
15	7935'6"	33.3	1010	2.648	14.8	0.100
16	7936'1"	33.4	1460	2.650	9.2	0.053
16A	7936'6"	33.4(assumed)		2.650(assumed)	8.8	
17	7937'0"	32.5	1050	2.641	8.5	0.055
17A	7937'7"	32.5(assumed)		2.640(assumed)	6.8	
18	7938'8"	31.3	116	2.650	19.9	0.248

Stressed porosities and permeabilities measured at 4800 psi.

Brine contained 100 g NaCl/liter.

S_o and Q_v values based on stressed porosities.

S_o corrected for loss of solution gas with a formation volume factor (1.17 RB/STB).

Oil density = 0.908 g/cc.

TABLE 4
MISCELLANEOUS CORE ANALYSES
SL 1011 NOS. 88(OH) AND 88(ST), SOUTH PASS BLOCK 27 FIELD

DESCRIPTION	WELL	CORE DEPTH	MEASUREMENT			
			ϕ^* (%)	Brine k^* (md)	S_o^* (%)	OTHER
Whole Core Extraction	No. 88(ST)	7929'0"-8"			25.5	
Resistivity Ratio	No. 88(OH)	7915'2"	29.3	108		m = 1.62 n = 1.87 Mean grain size = 0.102 mm
End-point Relative Permeability	No. 88(OH)	7915'3"	26.6	75.5		$S_w = 31.8\%$ (immobile) $S_w^{or} = 36.3\%$ $k_{oil}^{or} (@ S_w = 31.8) = 135$ md $k_{brine}^{or} (@ S_w^{or}) = 29.9$ md
Core Analysis	No. 88(OH)	7516'0"	30.2	279	14.6	$Q_v = 0.129$ meq/ml
Core Analysis	No. 88(OH)	7945'5"	5.0	0.080 air		$Q_v = 1.86$ meq/ml Grain den. = 2.703 g/cc
X-ray Diffraction	No. 88(OH)			WEIGHT PERCENT		
		CRYSTALLINE COMP.		7915'3"	7945'0"	
		Quartz		91	79	
		Feldspar		5	5	
		Calcite		3	15	
		Halite		1	1	
		Clay		None	None	

* Measured at isostatic stress conditions of 4800 psi. Oil saturations based on stressed porosity measurements from adjacent plugs.

TABLE 5
PNC LOG-INJECT-LOG RESULTS
(STATIONARY MEASUREMENTS)
SL 1011 NO. 88, SOUTH PASS BLOCK 27 FIELD

Log Depth, Ft	$\tau_{a,B}^{-1}, s^{-1}$	$\tau_{a,A}, s^{-1}$	ϕ_w	ϕ_{core}	Core Porosity Values		ϕ_{Log}	Log Porosity Values	
					S_w	S_{or}		S_w	S_{or}
7936	7093 $\pm$ 57.4	4336 $\pm$ 44.4	.287 $\pm$.0070	.322	.891 $\pm$.022	.122 $\pm$.025	.327	.878 $\pm$.021	.137 $\pm$.024
7938	7282 $\pm$ 52.9	4435 $\pm$ 38.2	.296 $\pm$.0087	.322	.919 $\pm$.027	.090 $\pm$.030	.327	.905 $\pm$.027	.106 $\pm$.030
7940	7154 $\pm$ 63.0	4381 $\pm$ 39.9	.289 $\pm$.0094	.322	.898 $\pm$.029	.114 $\pm$.032	.327	.884 $\pm$.029	.130 $\pm$.032
7942	7229 $\pm$ 48.6	4284 $\pm$ 34.1	.307 $\pm$.0084	.322	.953 $\pm$.026	.053 $\pm$.029	.327	.939 $\pm$.025	.069 $\pm$.029
7944	7232 $\pm$ 65.5	4553 $\pm$ 64.8	.279 $\pm$.0109	.322	.866 $\pm$.034	.15 $\pm$.038	.327	.853 $\pm$.033	.164 $\pm$.037
7946	7205 $\pm$ 63.6	4466 $\pm$ 49.0	.285 $\pm$.0099	.322	.885 $\pm$.031	.129 $\pm$.035	.327	.872 $\pm$.030	.144 $\pm$.034
					Mean = .110				
							Mean = .125		

$$\tau_{W,B}^{-1} = \tau_{W,A}^{-1} = 15,945 - 7,341 = 9604 \pm 177.1 \text{ s}^{-1}$$

LEGEND

- PRODUCER
- ▲ INJECTOR
- ✱ FORMER PRODUCER
- ✱ FORMER INJECTOR
- ✱ SHUT IN PRODUCER
- ✱ TA PRODUCER

PROCESS EVALUATION TEST STRUCTURE MAP CONTOURED ON "N₄" SAND "N₄"RB SU

SOUTH PASS BLK. 27 FIELD

FIGURE 2

-14-

PROCESS EVALUATION TEST
NET SAND ISOPACH MAP
"N₄" RB SU

SOUTH PASS BLK. 27 FIELD

FIGURE 3

Shell
St. 1. se. 1011

BLK. 27

Shell
O.C.S. 0352

PLAN
SCALE 1"=2000'

PROCESS EVALUATION TEST
CROSS SECTION
"N₄" SAND - N₄ RB SU
SOUTH PASS BLK. 27 FIELD

FIGURE 4

SOUTH PASS BLOCK 27
SL 1011 NO. 88 (OH)
N₄ SAND LOGS

FIGURE 5. WELL LOGS - N₄ SAND

SL 1011 NO. 88 (OH)

SOUTH PASS BLOCK 27
SL 1011 NO. 88 (ST)
N₄ SAND LOGS

NOTE: FDC DEPTHS ABOUT 3' SHALLOWER THAN ISF DEPTHS.

FIGURE 6. WELL LOGS - N₄ SAND

SL 1011 NO. 88 (ST)

FIGURE 7. CORE PHOTOGRAPHS (NO. 1-5) SL 1011 NO. 88 (OH)

FIGURE 8. CORE PHOTOGRAPHS (NO. 6-7) SL 1011 NO. 88 (OH)

FIGURE 9. CORE PHOTOGRAPHS (NO. 1-2) SL 1011 NO. 88 (ST)

FIGURE 10. CORE PHOTOGRAPHS (NO. 3) SL 1011 NO. 88 (ST)

SOUTH PASS BLOCK 27
SL 1011 NO. 88 ST CORE DATA

- NOTES:
1. SO VALUES ○ - BASED ON STRESSED POROSITY MEASUREMENTS
 2. SO VALUES △ - BASED ON ASSUMED POROSITY
 3. SOR VALUES □ - BASED ON LOG-INJECT-LOG (TDT-L) AND LCG (FDC) POROSITIES
 4. SO VALUE I - BASED ON WHOLE CORE ANALYSIS
 5. ALL SO VALUES ARE CORRECTED FOR B₀
 6. PERMEABILITY AND POROSITY MEASUREMENTS AT $\sigma = 4800$ FSI.

FIGURE 11. CORE ANALYSIS - SL 1011 NO. 88 (ST) N₄ SAND

STATE LEASE 1011 NO.88(ST)
SOUTH PASS BLOCK 27 FIELD, LOUISIANA

CORE NO.	DEPTH	RECOVERED SAMPLE	SEDIMENTARY STRUCTURES	GRAIN SIZE						SORTING				DIP $\angle^\circ$ FROM VERT	SHOWS (from core photos)	REMARKS
				CSAND	UM	LM	UF	LF	UVF	LVF	VPOOR	P	M	WELL	EXWELL	
1	7920															
	25															
2	7930															
	35															
3	7940															
	45															
	7950															

CORE DESCRIPTION - N₄ SAND

FIGURE 12

UNITED STATES DEPARTMENT OF ENERGY
BARTLESVILLE ENERGY TECHNOLOGY CENTER
P.O. BOX 1398
BARTLESVILLE, OKLAHOMA 74003

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