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GEOLOGY OF THE SWEET LAKE PROSPECT, CAMERON PARISH, LOUISIANA - AN UPDATE

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ABSTRACT

The Sweet Lake Prospect is located in a basin southeast of Lake Charles, Louisiana. The prospective sand is the Miogypsinoides ("Miogyp") sand of the Frio Formation of Upper Oligocene age, which is found at a depth of 15,000-15,640' in the test well. Porosity and permeability in one of the sands in the sequence are 24% and 3,600 md, respectively. Sands are medium to fine grained and consist of 75% quartz, 19% feldspar, and 6% clays. The cementing material is quartz overgowth; the clays are very fine hairs present in the pore spaces. Initial reservoir conditions are 299°F and 12,060 psi. Salinity of the brine is 140,000 ppm, and the gas content is 11-13 SCF/B.

INTRODUCTION

The Sweet Lake geopressured - geothermal prospect is located approximately 15 miles southeast of Lake Charles, Louisiana, in sec. 13, T12S, R8W. It is a basin on the north flank of an east-west salt ridge that contains the Hackberry, Big Lake, and Sweet Lake structures. The south side of the basin is bounded by a fault downthrown to the north. This converges eastward with a major east-west fault downthrown to the south to form a graben which is terminated to the east by the convergence of the faults and is open to the west. Dip is northwesterly into the basin (Durham and Parsons, 1978).

In this area, the Frio Formation is prospective for geopressured-geothermal energy. The thickest sand in this sequence is the Miogyp sand. A study of 17 deep wells and 27 miles of seismic lines resulted in the structure map in Fig. 1 (Durham and Parsons, 1978). The well site was located near three key control wells drilled by Union Oil of California - Sweet Lake #1, Pan Am Fee #1, and Pan Am Fee #2 (wells #3, #4, and #5 in Fig. 1).

The test well was spudded on August 22, 1980 and reached a total depth of 15,740' on January 16, 1981. The top of the Miogyp sand was encountered as expected at 15,000' and had an initial reservoir pressure of 12,060 psi and temperature of 299°F.

SUBSURFACE GEOLOGY

The drilling of the Magma Gulf-Technadril/Department of Energy Amoco Fee #1 well confirmed the geology depicted in Fig. 1. The well site was intentionally located on the 15,000' contour of the Miogyp sand. The Miogypsinoides microfossil, which occurs only slightly higher stratigraphically than the sand itself, was picked at 14,970' (Dunlap, 1981), and the first good sand appeared at 15,065'. The Miogyp sequence is 640' thick (15,000 - 15,640'), with 250' net sand. The dip is approximately 20° to the northwest, which agrees very well with the dip estimated from the seismic study (Durham and Parsons, 1978).

Correlation of the test well log with the three control wells shows significant thickening of the section below the first Camerina sand (12,900' in the test well). In addition, immediately above the Miogyp sand the section thinned considerably. In order to determine whether these variations were caused by faulting or stratigraphy, a thickening index diagram was prepared for the interval from the base of the massive sands (approximately 9,000') to the base of the Miogyp sand. In general, the section thickened towards the test well (into the basin). The thickening index diagram shows a considerable amount of thickening and thinning between the four wells over the entire 6,000'+ interval. There is no evidence for a fault cutting the test well.

RESERVOIR CONDITIONS

A temperature of 300°F was predicted for the midpoint of the Miogyp sand. A temperature log run on June 13, 1981, just prior to perforation, shows a temperature at the midpoint of 297°F. Reservoir Data, Inc. instruments yield a temperature of 299°F. Data from the temperature log and from RDI instruments show a definite break in the slope of the geothermal gradient at the top of the geopressure. The geothermal gradient calculated from the Schlumberger temperature log for the hydrostatic zone is 1.28°F per 100 feet, which is less than the average Gulf Coast gradient of 1.5°F. For the geopressured zone, however, the gradient is much higher; 1.88°F per 100 feet. The GRC probe used by RDI after perforation shows some difference in the values (1.06°F in the hydrostatic, 1.70°F in the geopressured zone) but the change in slope from less than the average to greater than the average is still present.

The expected reservoir pressure of the Miogyp sand was 10,000 psi, based on the mud weights used in the adjacent wells. A repeat formation test at a depth of 15,144' in the test well (the base of the top sand in the Miogyp sequence) yielded a pressure of 11,900 psi, almost 2,000 psi greater than expected. This is equivalent to a mud weight of 15.2 ppg. The initial reservoir pressure in the perforated zone (15,387 - 15,414') was 12,060 psi.

Salinity calculated from the control well logs for the Miogyp sand ranged from 46,000 to 100,000 ppm. The calculated SP salinity for the test well was 50,000 - 70,000 ppm. If Rw/2 is used instead of Rw, as has been suggested by work at the University of Texas at Austin, the calculated salinities increase to 125,000 - 140,000 ppm. Intercomp Resource

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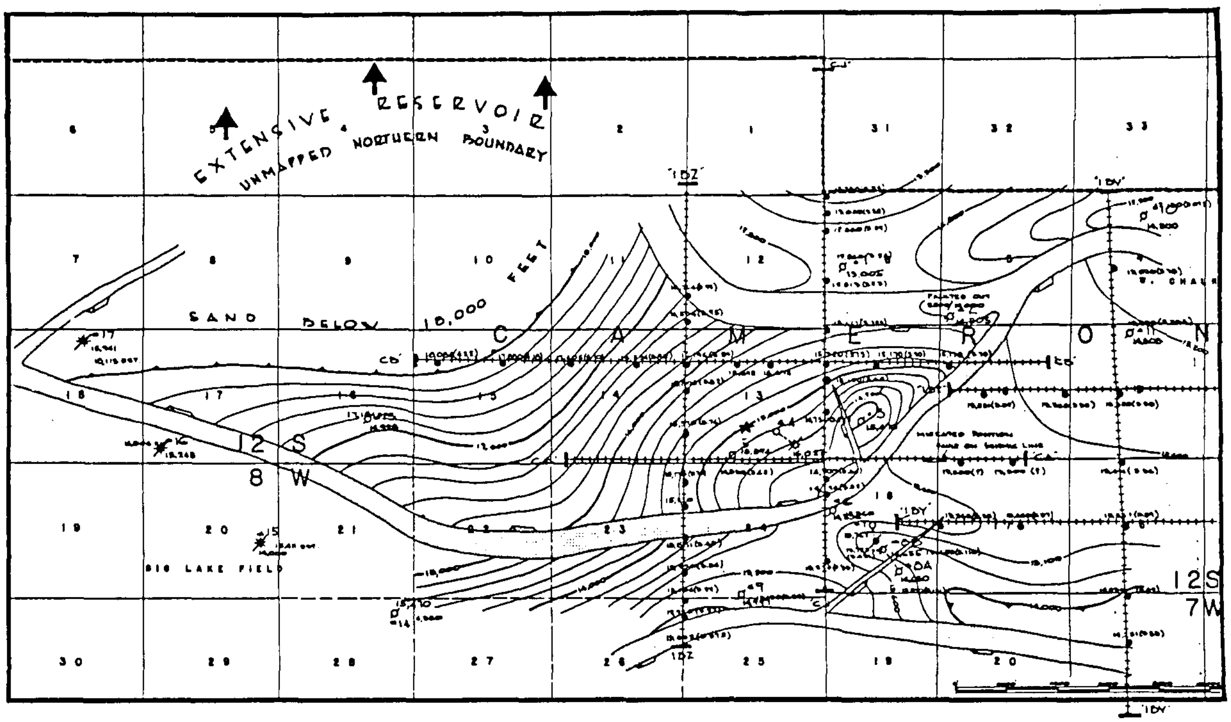

Fig. 1 Structure map of Sweet Lake prospect contoured on top of Miogyp sand. Location of test well is indicated by star.

Development and Engineering, Inc. also calculated salinity; in this case the values ranged from 100,000 to 175,000 ppm. Schlumberger calculated a Salinity Saraband log; their values were 68,000 - 125,000 ppm (Table 1.) For the one zone that has been perforated to date (15,387 - 15,414'), the calculated values were: SP-70,000; Rw/2 - 140,000; Intercomp - 175,000; Saraband - 125,000. The measured salinity of the brine from this zone is 140,000 ppm. This would indicate that the Rw/2 calculated salinity gives the most accurate calculation of salinity, but until additional zones are perforated and tested, this cannot be confirmed.

RESERVOIR SIZE

There are seven potentially productive sands within the Miogyp sequence. Each of these sands correlates very well with the sands in the three control wells (Fig. 2). Because of this excellent correlation, it was thought initially that these sands were blanket sands which extended throughout the graben, which has a width of 7,300' on a N-S line through the test well site. There are no wells in the western part of the graben, so this interpretation could not be confirmed. Early results from the reservoir limit test, however, indicate that there are barriers relatively close to the well. These may be small faults, pinchouts, or permeability changes. At the time the structure map in Fig. 1 was made, it was not known if the small fault at the western edge of the map extended northeast and enclosed the reservoir. After 20 days of flow testing, the reservoir had been explored to a distance of 4.55 miles. This indicates that this fault does not form the western extent of the reservoir. The reservoir size and testing will be discussed more fully in the paper by T.L. Gould and J.D. Clark which follows.

SAND CHARACTER

Four diamond cores were taken at the following depths: Core No. 1 15,144 - 15,179'; Core No. 2 15,185 - 15,197'; Core No. 3 15,389 - 15,405'; Core No. 4 15,600 - 15,632'. The cored intervals are

Table 1. Measured and Calculated Salinity for Miogyp sands, Sweet Lake Prospect, ppm x 1000

Sand Depth	Measured	SP	Rw/2	Saraband	Intercomp
15080 - 15144	-	50	125	76	100
15170 - 15240	-	50	125	68	100
15250 - 15285	-	70	140	98	125
15305 - 15355	-	70	140	125	175
15385 - 15414	140	70	140	125	175
15460 - 15505	-	50	125	74	175
15520 - 15600	-	70	140	103	175

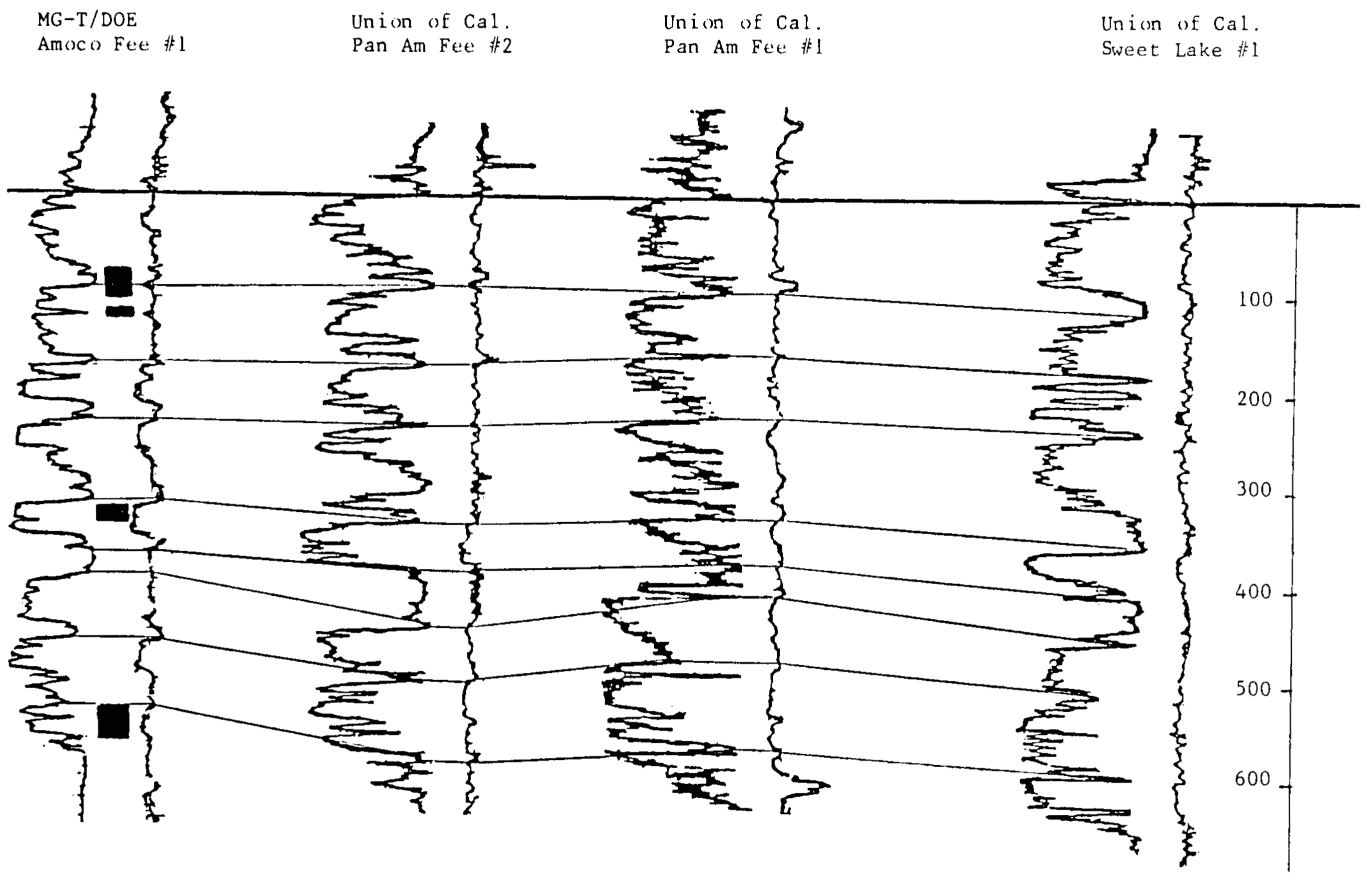

Fig. 2 Cross-section of Miogyp sand, Sweet Lake prospect. Datum is top of first good sand. Note that Pan Am Fee #1 is a gamma ray log.

shown in Fig. 2, and the porosities and permeabilities are given in Table 2. It should be noted that, with the exception of Core No. 3, the cores did not sample the zones that would most likely be perforated. Core Nos. 1 and 2 did sample the top two sands in the Miogyp sequence, but only at the sand/shale interface. These cores may not be representative of the main part of the sand. The exceptionally high porosity and permeability (24%, 3,600 md) of the sand in Core No. 3 had a major influence on the decision to test this sand first.

While the cores were still wrapped in the preservation material, they were X-rayed by Technical Welding Laboratories. A complete record of the internal structures was thus obtained. These X-rays show cross-bedding and some structures which may be worm burrows, as well as yet unidentified structures.

Sieve analyses of each core show that these sands are medium to fine-grained, with 1 - 2% silt. The median grain size is .01" (.26mm) (Core Laboratories, 1981). A small piece of Core No. 3 was impregnated with blue epoxy, and thin sections parallel and perpendicular to the axis of the core were made. The thin sections (Fig. 3) show that the grains are angular to sub-angular. Rock diagenesis will be discussed in the paper by R. Ferrell.

In order to investigate the possibility of sand production from the highly porous and permeable sand

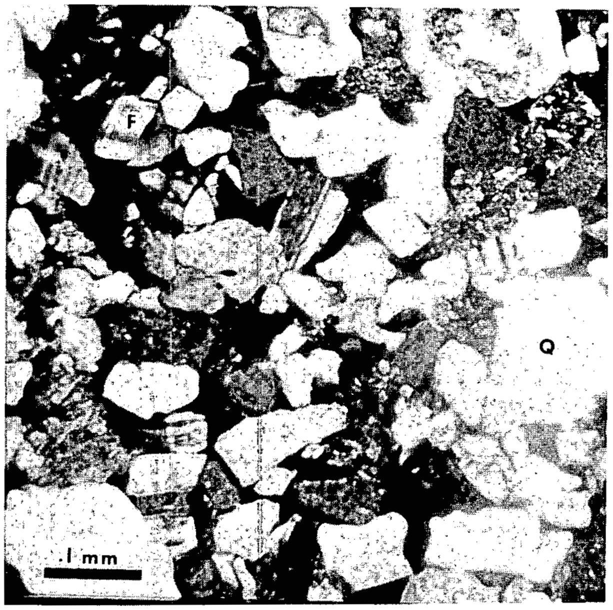

Fig. 3 Thin section parallel to axis of core. Note quartz (Q) and feldspar (F). Black material is blue epoxy. Crossed polars.

Table 2. Measured and Calculated Porosity and Permeability for Miogyp sands, Sweet Lake Prospect

Sand Depth	Porosity, %				Permeability, md				
	Core	Saraband	Neutron-Density Crossplot	Intercomp	Core, Air	Saraband, Air	Intercomp, Air	Estimated, Water	Effective, Water
15080 - 15144	16.6	12.3	15.7	16.34	30	175	275	20	-
15170 - 15240	16.3	12.1	14.6	13.86	122	143	48	20	-
15250 - 15285	-	15.4	20.0	20.42	-	700	140	-	-
15305 - 15355	-	15.3	18.8	18.12	-	750	690	140	-
15385 - 15414	24.3	19.0	23.2	20.84	3670	2960	2703	400	343
15460 - 15505	-	12.2	15.0	15.69	-	130	90	20	-
15520 - 15600	-	12.9	17.3	16.30	-	280	143	30	-

in Core No. 3, a small amount of material was given to Baker Sand Control for analysis. X-ray analysis shows that this sand consists of 75% quartz, 19% feldspar, 4% illite, 2% mixed layer clay (illite/smectite), and a trace of kaolinite. There was some concern as to whether this amount of clay would cause sand production when the well was flowed. Accumin Analysis did the SEM work for Baker Sand Control. The SEM photographs showed that the cementing material is quartz overgrowth, caused by the recrystallization of quartz under pressure. The clays are present as very fine hairs in the pore spaces (Fig. 4). Thus, although these clays are expected to move during production, the sand itself should be competent enough that no sand would be produced, and this in fact was the case.

Fig. 4 SEM photograph of very fine illite hairs in pore space. 1000X.

CONCLUSIONS

The geology of the Sweet Lake prospect as presented by Durham and Parsons (1978) has been confirmed by drilling. The Miogyp sand occurs at a depth of 15,065' in the test well and dips 20° to the northwest. The total interval is 640' thick, with 250' net sand. At least one of the seven potentially productive sands is not a blanket sand. Reservoir conditions (299°F and 12,060 psi) equal or exceed predicted values. One sand has porosity and permeability far greater than expected. The cementing material is quartz overgrowth and the small amount of clay present should not cause sand production.

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