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ANALYSIS OF THREE GEOPRESSURED GEOTHERMAL
AQUIFER-NATURAL GAS FIELDS; DUSON,
HOLLYWOOD, AND CHURCH POINT, LOUISIANA

MASTER

by

Leo A. Rogers
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C. K. GeoEnergy Corporation
Las Vegas, Nevada

May 1981

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ANALYSIS OF THREE GEOPRESSURED GEOTHERMAL
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HOLLYWOOD AND CHURCH POINT, LOUISIANA

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Department of Geothermal Energy

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ABSTRACT

The available well logs, production records and geological structure maps were analyzed for the Hollywood, Duson, and Church Point Louisiana Oil and Gas field to determine the areal extent of the sealed geopressured blocks and to identify which aquifer sands within the blocks are connected to commercial production of hydrocarbons. The analysis showed that over the depth intervals of the geopressured zones shown on the logs essentially all of the sands of any substantial thickness had gas production from them somewhere or other in the fault block. It is therefore expected that the sands which are fully brine saturated in many of the wells are the water drive portion of the producing gas/oil somewhere else within the fault block. In this study only one deep sand was identified, in the Hollywood field, which was not connected to a producing horizon somewhere else in the field. Estimates of the reservoir parameters were made and a hypothetical production calculation showed the probable production to be less than 10,000 b/d. The required gas price to profitably produce this gas is well above the current market price.

INTRODUCTION

The work reported here is an outgrowth of work and suggestions of the DOE/Industry Geopressured Geothermal Forum's Reservoir Continuity Study Group. This study group was organized because of the recognition by many of the people involved in the development of geopressured resources that more information needed to be developed concerning the sizes of volumes of the Gulf Coast geopressured aquifer systems. The study by this group involved analysis of some selected water drive gas reservoirs to determine the size of the aquifers that provided the water drive.

The gas fields evaluated in this report are three fields which were identified in the Continuity Study Group reports as having large aquifers (Boardman - 1980, 1981). Figure 1 shows their locations. This report extends the results of the Study Group work. The production/pressure data and available logs for other deep wells in the areas were analyzed to determine which sand units were gas productive within the fault blocks containing the geopressured reservoirs analyzed. For the DOE geopressured-geothermal energy program it is important to define which geopressured aquifers are a part of gas producing reservoirs since the object of the DOE program is to develop geothermal energy, and sources of gas from brine filled reservoirs that do not interfere with conventional gas production. The DOE had one experience of putting a substantial amount of effort into developing a prospect (the Cuero Prospect) before it was learned that the prospective aquifer was part of a producing gas field. Studies such as that reported herein are needed to identify areas for the DOE program to avoid unacceptable areas as well as identify possible new prospect areas.

In gathering data for this report and discussing the concepts with various persons it was found that the general concept of geopressured gas caps and aquifers being interconnected in a reservoir system was not always understood. Therefore, a brief section of background information to describe this concept is included in this report. It was apparent to the authors of this report that some of the early proponents of the Federal Geopressured Geothermal Energy Program were not aware of this situation and that the early estimates of the quantity of available geopressured brine did not take into account the water drive aquifers which are part of conventional gas production.

Evidence so far from the DOE tests suggest that the brines contained in the geopressured aquifers are essentially

saturated with natural gas. The actual concentration on dissolved gas depends on the pressure, temperature and salinity of the brine. If it is assumed that full saturation is the general case then most aquifers if not at all of them, should have free gas associated with them. This line of analysis leads to the hypothesis that the bulk of the geopressured-geothermal resource is hydraulically connected to commercial and/or non-commercial free gas accumulations. It is further logical to assume that some of these free gas accumulations have not yet been discovered.

BACKGROUND INFORMATION

The term "geopressured" is used to identify underground formations where the fluids in the pores of the rock are at a pressure above hydrostatic pressure. Hydrostatic pressure is simply the pressure that exists at different depths below a water surface, such as in the ocean. If the pore space in underground formation is filled with water and the water has a continuous path through the pore structure of the rock to the surface then the water will be hydrostatically or normally pressured.

Geopressure occurs when the oil, gas and water in a porous reservoir rock become trapped in a sealed rock compartment and additional rock sediments are placed on top of the reservoir. Over geological time the weight of the increased overburden rock sediments rock has squeezed the trapped fluids and raised the pressure above the normal hydrostatic values. The geopressured reservoirs are porous sandstones that are sealed by impervious shales and growth faults and the fluids trapped in the pore space have a pressure above hydrostatic pressure.

When geopressured zones are encountered during the drilling of a well this is clear evidence that the zone is in a geologically sealed unit. The size of the sealed unit may be small or large depending on the geological structure in the area and how the compartments are sealed. In the Gulf Coast there tend to be major growth faults every few miles and an intertwining of smaller faults on closer spacing. Faults with adequate displacement to surround a segment of a sandstone reservoir layer with a tightly sealing shale formation are the reason for many of the geopressured reservoirs. Thus, the geopressured sections in the Gulf Coast area of Texas and Louisiana are composed of literally thousands of individually sealed reservoir compartments.

Drilling a well through the geopressured section may encounter a numerous series of individually sealed and separate geopressured reservoirs. In practical drilling jargon the depth at which the first geopressured rock is encountered is called the "Top of Geopressure". If the well is completed in a particular geopressured reservoir and adequately cemented to seal off connections to overlying and underlying layers then production from the completed zone will have little or no effect on the other zones.

Over geological time the organic material in the sandstones and adjacent shales in the deep geopressured zones

reached a temperature and pressure condition such that it decomposed into gas, oil and heavier hydrocarbons. For the Gulf Coast deep reservoirs of interest for this program the "thermal maturation" is such that natural gas was preferentially produced with lesser amounts of oil. Initially the shales were less compacted and more permeable such that water and gas could move through them in a general upwards direction. With this motion the gas would tend to collect in the porous sandstone and the shales would dewater to become less permeable and a better seal to further flow.

With this geopressure forming and self sealing mechanism operative, all of the geopressured sands would be expected to initially contain significant amounts of gas and possibly have free gas caps in excess of the dissolved gas. The gas originally trapped may not be there today, however. Upsets such as further fault motion could cause the gas to leak into other reservoirs.

Since gas and oil are less dense than water or brine they tend to collect in the high points of the individual geopressured compartments. Conventional oil and gas exploration strategy is therefore primarily directed towards locating these geological structure high points and to test these places for hydrocarbon accumulations. There has been little incentive to drill wells "down dip" where only brine and no hydrocarbons are expected.

For water drive gas reservoirs conventional wisdom is to not disturb the gas driving aquifer so long as the gas wells do not water out. The encroaching brine of "water-drive" helps maintain higher gas pressure and hence higher production. On the other hand the encroaching water traps a residual amount of high pressure gas in the sandstone matrix which would not normally be produced using conventional production practice of abandoning the well when it waters out. In this case there is the possibility that if brine is produced at a point down dip from the gas well the encroached brine will recede and thereby both free a portion of the trapped residual gas and/or move the gas/water interface sufficiently so as to return the well to production status. Some gas producing companies that have multiple wells in a water drive gas reservoir well produce the brine from the first few wells that water out in order to keep the remaining wells producing dry gas.

For a more complete description of the phenomena of geopressures the reader is referred to the article by Charles A. Stuart listed in the references.

HOLLYWOOD FIELD

The Hollywood gas/oil field is located in T17S, R17E Terrebone Parish, Louisiana, a few miles southwest of the city of Houma, Louisiana. This field has several gas wells that are producing from sandstone reservoirs in the geopressure horizons. In the previous study on reservoir continuity (Boardman-1981), production from the "T" sand was analyzed to estimate the extent of the resource. Reported production data showed that the gas production had water drive to help hold up the pressure and that the driving aquifer was of considerable size. For this study additional data were obtained beyond that in the previous study so as to assess the several potential production zones.

• Wells Investigated

Available logs were obtained for all deep wells in the fault compartment. These wells are listed in Table I and their locations are depicted in Figure 2.

TABLE I. Well logs examined in the Hollywood Field area.

<u>Operator</u>	<u>Well</u>	<u>Total Depth, ft.</u>
Union	J.E. Fookles #2	14,999
Getty	Southdown Unit 3, #1	14,450
Getty	Houma Community #4	16,426
Getty	Houma Community #6	15,525
Getty	Southdown Unit #11	17,000
Getty	Southdown Sugars #12	16,570
Getty	Southdown Sugars #14	19,512
Getty	Southdown Sugars #17	16,466

• "T" Sands

The "T" sand is a massive sand that occurs at a depth of about 14,500 feet and is 100-300 feet thick. This sand was originally thought to be two separate sands since there is a significant shale section in the middle of it. Subsequent drilling and production however has revealed that it is hydraulically connected. This was reported in hearings at the Louisiana Department of Natural Resources Conservation Division offices. In the previous reservoir continuity study, data from two wells (Houma Community #4 and Houma Community #6) were used to determine the extent of the water drive aquifer. The analysis of this sand and extension to possible production from deeper zones for this study are based on the wire line logs, well completion and production reports and the geological structure map provided by the Louisiana State University (Dr. Don Bebout).

• Aquifer Extent

The Houma Community #4 and the Houma Community #6 wells

FIGURE 2.

were completed about 2½ years apart. Both were drilled into the same "T" sand reservoir. Since the gas production is via water drive the analysis was based on the assumption that the pressure in the gas cap would be essentially uniform. Thus, when the second well was drilled into the producing gas cap the initial pressure would be lower because of the production from the first well. This was indeed the case and the initial pressure in the second well was 60 psi lower than the initial pressure of the first well. During the 2½ year time some 20 BCF of gas had been produced from the first well.

The aquifer extent was calculated from the pressure drop associated with the 20 BCF production and the 60 psi pressure drop combined with the reported reservoir parameters reported by the operating company engineers at the hearings. An average sand thickness of 208 feet and an average porosity of 22% were reported. Using these values and typical values for compressibilities etc. leads to a calculated volume of water in the aquifer of 4.06 billion barrels and an areal extent of 27.9 square miles.

- Fault Compartment Delineation

The geological structure map provided by LSU was used to identify the fault compartment and to correlate it with the area determined from the production data. Figure 2 shows the LSU reported fault structure and the locations of the wells within the fault block which were used in this study. As seen in this figure there are two major growth faults that traverse the field. They are labeled "A" and "B" for this study. These two faults are shown to close on themselves to the east of the field in T17S, R18E. To the west, however, the LSU studies map is incomplete so it is not known where closure occurs. The Cambe structure map of this same area is significantly different in detail but shows the general features of the large growth faults. The Cambe map shows a large open structure to the west for many miles without major faults that could be sealing.

In matching the area of 27.9 square miles as determined from the production data to the structure map it is seen that the area between the two large growth faults is a fair match. Between the closure point on the east and the incomplected map on the west there is about 20 square miles within the fault compartment. This is a good match and further suggests that the smaller faults within the major block have hydraulic continuity across them. It therefore appears that the sealed fault compartment that drives the production from the "T" sand is the elongated east-west block delineated by the major growth faults.

- Other Gas Productive Sands

The strata in the producing area can be roughly characterized as a thick shale section above the producing Southdown and "T" sections and more thick massive section below the "T" sand with several interspersed thinner sand sections. Figure 3 is a section of the log from the Southdown Sugars #14 well which as one deep hole drilled in the block. The several sands can be seen on the log. Most of these sands intercepted by the several wells have been tested and found to be gas producing. Data found for this study are presented in Table II.

TABLE II. Hollywood Field Gas Productive Sands

<u>Sand</u>	<u>Depth</u>	<u>Producing Well</u>
Southdown	14,403-22	Southdown Unit 3, #1
T	14,565-90	Houma Community #4
U	15,040-50	Houma Community #4
V	15,182-188	Southdown Sugars #14
W	15,522-50	Southdown Sugars #12
X	16,462-72	Southdown Sugars #12

- Potential Geopressured Geothermal Aquifer Horizons

As noted in Table II and the well logs, essentially all of the major sand sections in the field are gas producing. While only the "T" sand was analyzed for areal extent it is assumed that the other sands within the block would have the same closure with the major growth faults so that any gas caps in these other sands would have a similar aquifer area for water drive production. No study of these other producing sands was made for this report. Nevertheless, it seems reasonable to assume that if brine is produced from any of the gas productive sands within the block it will have an effect on the water that helps keep the gas cap pressurized in that particular sand. Thus, all of these known producing sands can be excluded as possible candidate horizons for gas from geopressured aquifers.

One presently non-gas productive sand zone was identified below the producing horizons. This zone underlies a thick shale section at a depth of 18,680 to 19,045 feet. The only log data available was a gamma ray and induction log (see Figure 4).

Based on the estimates in Table III a calculation was made of the possible production from this deep sand.

FIGURE 3. Section of log from Southdown Sugars #14 which shows the "T" sand.

FIGURE 4. Section of log from Southdown Sugars #14 which shows the deep zone.

Table III

Approximations of Geopressured Geothermal Reservoir Properties
for Zone 18,860 to 19,045 feet in Southdown Sugars No. 14 Well

<u>Reservoir Property</u>	<u>Approximated Value</u>	<u>Basis for Approximation</u>
Formation density, ohm-m		Induction log
Avg. Porosity, %	12	Linear extrapolation from gamma ray log, assuming minimum radiation base line to be 20% sand porosity and maximum radiation base line to be 0%.
Temperature, °F	300	Maximum T @ 6 hrs. @ 19,00' was 298°
Maximum Formation Factor	40	$F = \phi^{-m}$
Water salinity, ppm	150,000	Computed from maximum formation factor and R_t
Pressure, psi	17,400	17.8#/gal mud. Midpoint of zone 18,880
Net sand thickness, feet	170	All sands with more than 50% sand content per gamma ray log.
Permeability, md	4	Bassionni correlation of F vs k for SE Pecan Island Prospect. SPE 7540. Reservoir Study of Southeast Pecan Island Geopressured Water Sands. Z.A.

Figure 5 is the computer print out which gives the input estimates and the calculated production. The highest production that could be predicted was about 10,000 b/day. With a low estimated permeability of 4 md, the well is predicted to produce at a declining rate to about 6,000 b/day in 25 years. If this brine is saturated it should contain approximately 30 SCF/bbl of natural gas. This translate to an initial daily gas production of 300 MCF/d. This is meager production for a well of this depth. The economic analysis performed for this estimated gas production is shown in Figure 6 and Table IV. Figure 7 is the print-out for one of the computer runs for the discounted cash flow economics model. The required gas price to make production from this sand is well above current or expected gas prices.

- Adjacent Prospect

When the well logs and completion data were gathered for the Hollywood field from the Louisiana Department of Conservation, additional data were also gathered for several wells outside the main fault block. Of this data there were two wells in the adjacent fault block to the south which suggested the possibility that this block could be a good prospect. These two wells are the Getty-Southdown Sugars #A-1 and the Mecom-South Shores #4. These two wells were plugged and abandoned without any gas production. There are good sand sections in this block and Figure 8 shows a section of the log from the #A-1 well where the "T" sand is offset downwards some 600 feet from the production fault block adjacent to the north. Some 200 feet of sand, more or less, are seen to occur between 15,470 and the bottom of the well at 16,020 where drilling ended in a sand section. The low resistivity associated with the sand sections indicate that the pore fluid is highly saline brine. These sand sections could be geopressured prospects provided that they are not the water-drive aquifers to some nearby gas wells. Whether this is the case cannot be determined in this current study. Further well logs and data would need to be gathered and another analysis made to determine the size of the fault block and to locate its boundaries to determine whether the geopressured sections connect into producing well.

DUSON FIELD

The Duson gas/oil field is located in T10S, R3E, Lafayette Parish, Louisiana, about 7 miles west of the city of Lafayette, Louisiana.

3
HOLLYWOOD DEEP SAND

WELLBORE RADIUS4 FT
EFFECTIVE RESERVOIR RADIUS 15735 FT
INITIAL RESERVOIR PRESSURE 17400 PSI
PERMEABILITY 4E-03 DARCYS
POROSITY12
RESERVOIR THICKNESS 170 FT
PORE VOLUME COMPRESSIBILITY 5E-06 1/PSI
BRINE COMPRESSIBILITY 3E-06 1/PSI
BRINE VISCOSITY399 CP
BRINE DENSITY 68.9 LBS/CU FT
COMPOSITE SKIN FACTOR 0

PRODUCTION STRING

SECTION	LENGTH (FT)	DIAMETER (FT)	SURFACE FINISH
1	18800	.42	AVERAGE

INITIAL BRINE IN RESERVOIR 2.82614735E+09 BBLs
TIME TO QUASI STEADY STATE 948.3 DAYS
HYDROSTATIC PRESSURE 8994 PSI
INITIAL WELL HEAD PRESSURE 8405 PSI
MAXIMUM ALLOWABLE FLOW RATE 15000 BBLs/DAY
MINIMUM ALLOWABLE WELL HEAD PRESSURE 200 PSI
MINIMUM ALLOWABLE FLOW RATE 1000 BBLs/DAY

TIME (DAYS)	FLOW (BBLs/DAY)	BOTTOM (PSI)	FRICTION (PSI)	WELL HEAD (PSI)	SKIN EFF (PSI)	CUM (BBLs)	PUMP (HP)
0	15000	17400	273	8132	0	0	
365	9894	9346	124	227	0	3611601	
730	9553	9350	116	238	0	7098677	
948	9458	9327	114	218	0	9164090	
1095	9317	9343	111	237	0	10530270	
1460	9178	9309	108	205	0	13880279	
1825	8995	9312	104	213	0	17163789	
2190	8817	9315	100	220	0	20382120	
2555	8642	9318	96	226	0	23536565	
2920	8470	9321	93	233	0	26628393	
3285	8344	9289	90	204	0	29674076	
3650	8178	9292	87	210	0	32659299	
4015	8016	9295	84	216	0	35585265	
4380	7857	9298	80	222	0	38453149	
4745	7701	9301	77	228	0	41264104	
5110	7586	9272	75	201	0	44033104	
5475	7435	9274	72	207	0	46747139	
5840	7288	9277	70	212	0	49407299	
6205	7143	9280	67	217	0	52014654	
6570	7001	9282	65	222	0	54570251	
6935	6862	9285	62	227	0	57075118	
7300	6760	9259	61	203	0	59542600	
7665	6626	9261	58	208	0	61961101	
8030	6494	9264	56	212	0	64331594	
8395	6365	9266	54	217	0	66655031	
8760	6239	9268	52	221	0	68932347	
9025	6115	9270	50	225	0	71164457	

PRODUCED 2.5 % OF THE BRINE IN PLACE

Figure 6. Required Gas prices versus Internal Rate of Return based on calculated brine production and costs scaled from the 1979 costs used in the NPC on Geopressured Brines.

TABLE IV

Data for Economic Analyses of
Deep Hollywood Sand *

Land (17,500 acres)	\$ 440,000
Geophysics	173,000
Production Well	4,600,000
Plant (10,000 b/d)	1,500,000
Fixed Operating Cost	280,000/year
Variable Operating Cost	.029/Bbl
Effective Tax Rate	48%
Royalty Rate	12.5%
Severance Tax	8%
Depletion Allowance	18%
Investment Tax Credit	20%
Well Cost	90% Expense 10% depreciable
Plant Cost	50% Expense 50% depreciable
Land & Geophysics	Expensed
Depreciation	Straight Line for 7 Years
Gas Used on Location	2 SCF/Bbl.

* This data based on the National Petroleum Council 1980 Report on Unconventional Gas Sources. The costs are 1979 constant dollars.

HOLLYWOOD DEEP SAND

GAS LOSS 2E-03 MCF/BRL
 ROYALTY 12.5 %
 SEVERENCE TAX 8 %
 EFFECTIVE TAX RATE 48 %
 INITIAL FIXED O&M COST \$280000 /YR
 INITIAL VARIABLE O&M COSTS \$.029 /BRL
 DEPLETION ALLOWANCE 18 %
 ANNUAL GAS PRICE INCREASE 0 %
 ANNUAL O&M COST INCREASE 0 %
 INVESTMENT TAX CREDIT 20 %

STRAIGHT LINE DEPRECIATION OVER 7 YEARS
 CALCULATE REQUIRED GAS PRICE FOR GIVEN IRR = 10 %

YR	INVESTMENT DEP. (K\$)	EXP. (K\$)	BRINE PROD (KBBL)	GROSS GAS (MMCF)	NET GAS (MMCF)	GAS PRICE (\$/MCF)	GROSS INCOME (K\$)	ROY. (K\$)	SEV. (K\$)	DEPL. ALLOW. (K\$)
1	1210	5500	3611	105	98	28.58	2817	378	241	439
2	0	0	3487	102	95	28.58	2721	365	233	424
3	0	0	3432	100	93	28.58	2679	359	230	417
4	0	0	3350	98	91	28.58	2615	350	224	407
5	0	0	3283	96	89	28.58	2562	343	219	399
6	0	0	3219	94	87	28.58	2511	336	215	391
7	0	0	3154	92	86	28.58	2460	330	211	383
8	0	0	3092	90	84	28.58	2412	323	207	376
9	0	0	3046	89	83	28.58	2375	318	203	370
10	0	0	2985	87	81	28.58	2330	312	200	363
11	0	0	2926	85	79	28.58	2282	306	195	355
12	0	0	2868	84	78	28.58	2237	300	192	348
13	0	0	2811	82	76	28.58	2194	294	188	342
14	0	0	2769	81	75	28.58	2159	289	185	336
15	0	0	2914	79	73	28.58	2105	284	181	327
16	0	0	2660	77	72	28.58	2074	278	178	323
17	0	0	2607	76	71	28.58	2034	272	174	317
18	0	0	2556	74	69	28.58	1994	267	171	310
19	0	0	2505	73	68	28.58	1954	262	167	304
20	0	0	2467	72	67	28.58	1925	258	165	300
21	0	0	2419	70	66	28.58	1888	253	162	294
22	0	0	2370	69	64	28.58	1848	247	158	288
23	0	0	2324	68	63	28.58	1813	243	155	282
24	0	0	2277	66	62	28.58	1776	238	152	276
25	0	0	2232	65	60	28.58	1741	233	149	271

FIGURE 7. Discounted cash flow economics calculation for the Hollywood Deep Sand using the production schedule from Figure 5 and the cost data from the Natural Petroleum Council 1980 report on Unconventional Gas Sources.

YR	DEPR. (K\$)	FIXED COST (K\$)	VAR. COST (K\$)	TAX CREDIT (K\$)	TAXABLE INCOME (K\$)	INCOME TAX (K\$)	NET PROFIT (K\$)	CASH FLOW (K\$)	D.C.F (K\$)	N.P.V. (K\$)
1	172	280	104	242	-4299	-2064	-1994	-1382	-1256	-8092
2	172	280	101	0	1144	549	595	1192	985	-7106
3	172	280	99	0	1119	537	582	1172	881	-6225
4	172	280	97	0	1082	519	562	1143	780	-5444
5	172	280	95	0	1051	504	546	1118	694	-4750
6	172	280	93	0	1021	490	531	1095	618	-4131
7	172	280	91	0	991	475	515	1072	550	-3581
8	0	280	89	0	1136	545	590	966	451	-3130
9	0	280	88	0	1114	534	579	949	402	-2727
10	0	280	86	0	1087	522	565	928	358	-2369
11	0	280	84	0	1059	508	551	906	317	-2051
12	0	280	83	0	1033	495	537	885	282	-1769
13	0	280	81	0	1008	483	524	866	250	-1518
14	0	280	80	0	987	474	513	850	223	-1294
15	0	280	84	0	947	454	492	820	196	-1098
16	0	280	77	0	937	450	487	810	176	-921
17	0	280	75	0	914	438	475	792	156	-765
18	0	280	74	0	890	427	463	774	139	-625
19	0	280	72	0	867	416	451	755	123	-502
20	0	280	71	0	850	408	442	742	110	-391
21	0	280	70	0	828	397	430	725	97	-293
22	0	280	68	0	804	386	418	706	86	-207
23	0	280	67	0	784	376	408	690	77	-130
24	0	280	66	0	762	366	396	673	68	-61
25	0	280	64	0	742	356	386	657	60	0

FIGURE 7 (CONTINUED)

FIGURE 8. Section from Southdown Sugars A1 showing offset "T" sand.

For the Duson Field, the Marginulina #7 production from the Sunray McConnell #3 well was analyzed in the previous study to determine the areal extent of the water drive aquifer. Based on available information the previous analysis indicated an area of 17.3 square miles.

For this current study, logs for deep wells in the vicinity of the McConnell #3 well were obtained and examined. The geological structure map of the area prepared by Louisiana State University was also obtained so as to orient the wells to the fault blocks. Tables V and VI lists the wells included in this study and Figure 9 is the LSU structure contour map with the subject deep wells located on it.

● Deep Production

For this study a search of the Louisiana Department of Natural Resources' Conservation Division files was made for production below 14,000 ft. in the vicinity of the McConnell #3 well (Duson, Ridge, Judice, So. Scott Fields). Depths of gas-producing zones are shown in Table VI. All of the thick (50' or more), deep (greater than 12,000 ft.), porous zones were found to be productive in one well or another. This was confirmed by Sun Gas Co. geologists in the area.

Thicknesses and depths of these thick zones in specific control wells are given in Table V.

TABLE V. Control Wells for the Duson Field Analysis

<u>Porous Zone</u>	<u>Control Well</u>	<u>Zone, Depth, Ft.</u>	<u>Net Thickness, Ft.</u>
Marg. Tex.	McConnell #7	12,475-12,812	250
Bol Mex #1	McConnell #7	13,255-13,425	140
Bol Mex #1	McConnell #5	14,135-14,328	90
	Stutes, et.al #1	18,000-18,250	150
Nonion Struma	Stutes, at.al #1	19,175-19,450	275+

Electrical logs of all these zones are presented in Figures 10 through 14.

● Hypothetical Marginulina Texana Prospect

Since current DOE policy precludes testing an aquifer that is known to be or suspected of being the production drive for a known commercial free gas accumulation, there are no acceptable design well prospects in the fault compartment containing the Marginulina #7 gas reservoir tapped by the McConnell #3 well. Consequently, the foregoing thick sands can only be treated hypothetically with regard to their

TABLE VI. Deep Wells in Vicinity of the Mary McConnell #3 Well, Lafayette Parish Louisiana

<u>Field</u>	<u>Well Name</u>	<u>Operator</u>	<u>(Sec-T-R)</u>	<u>TD,ft</u>	<u>Produced Sands Below 14,000'</u>
Ridge	Lafayette Ph. School Bd.#1	Warren	16-105-3E	15,765	14,130-365 & 14,880-965
Judice	A.Stutes Est.#1	J.P.Owen	13-105-3E	17,400	14,500-60
Judice	Stutes Et.Al.#1	McMoran	13-105-3E	19,500	18,000-250 & 19,175-450
Ridge	Foreman #1	Sunray	20-105-3E	15,497	14,005-60
Duson	Bruner #1	Sunray	17-105-3E	15,210	14,585-785
S. Scott	C.A.Stutes #1	P.Bass	12-105-3E	15,498	13,710-14,235
Duson	McConnell #5	Sunray	8-105-3E	15,264	14,234-44
Duson	McConnell #7	Sunray	8-105-3E	15,000	-
Duson	R.L. Smith #4	Exchange	17-105-3E	14,635	-

FIGURE 9. Structure Contour Map on a Deep Horizon in Vicinity of McConnell #3 Well, Debon Field, Lafayette Parish, Louisiana

FIGURE 10. IES Log - McConnell #7-Duson Field Marginulina Texana Zone

FIGURE 11. Electrical Log - McConnell #5 - Dusen Field Bol Mex #3 Zone.

FIGURE 12. Electrical Log-Stutes, et al (Reentry) #1
Judice Field-18,000'-18,250' Gas Producing Zone.

FIGURE 13. ISF Log - Stutes, et al (Reentry) #1
Judice Field - Nonion Struma #3 Zone.

FIGURE 14. IES Log - McConnell #7, Dusen Field
Bol Mex #1 Zone

potential for yielding solution gas and thermal energy on the assumption that one or more of these aquifer sands may occur in adjacent fault compartments in which the probable associated free gas cap has yet to be discovered by oil and gas operators. In such cases, the aquifer could be considered a legitimate target for the DOE testing program.

Since no acceptable aquifers were identified no production calculations or economics calculations were made. The reservoir parameters deduced from analysis of the logs are given in Table VII.

CHURCH POINT FIELD

The Church Point field is located in the area of T8S, R2E, Acadia Parish, Louisiana, about 15 miles northwest of Lafayette, Louisiana. For this field the previous analysis of the water drive used the NS-2 sand which occurs at a depth of 11,000-12,000 ft. Analysis of the gas production data indicated an areal extent of 15.7 square miles for the associated aquifer.

For this current study, review of the well completion records at the Louisiana Department of Conservation files was made and logs from four wells were obtained. Table VIII is a summary of the information. The geological structure map of the area determined by the Louisiana State University was also obtained and is shown in Figure 15.

Aquifer and Fault Compartment Delineation

The LSU structure map shows the field to be in a rather large block between the major growth faults. The block which includes area in both T8S-R2E and T8S-R3E is about 35 square miles which is significantly larger than the 15.7 square mile area estimated for the aquifer from the water drive gas production history. The Cambe map of the same area shows significant differences in location of both the major growth faults and the minor faults with a more limited structure. It is more difficult to estimate a related fault block or its size from the Cambe map. In either case the fault block is rather large and does not disagree with the area determined from the production data.

Gas Producing Zones

In the depth between about 10,000 feet and 15,000 feet there are some 4 major sections of sand which are in the order of 100 feet thick or more. All of these sections have gas production from them in one well or another in the field,

Table VII Approximations of aquifer properties for the Marginulina-Texana zone in the Duson Field, Louisiana area.

<u>Reservoir Property</u>	<u>Approximate Value</u>	<u>Basis for Approximations</u>
Net sand thickness, ft.	250	Rough average of several wells in Duson Field area.
Porosity, %	25%	Estimate from SP and Induction logs.
Temperature, °F	250°	Estimated from values on several logs in area.
Interval midpoint depth, ft.	12,700	Area near McConnell #3,5,7 wells.
Pressure, psi	11,000	Estimated from minimum drilling mud wt. of 17.6 lb/gal.
Permeability, md.	150	Bassiouni correlation (Bassiouni - 1978)
Brine Resistivity, ohm meters	.05	SP & Induction logs.
Brine Salinity, ppm	50,000	From Dresser Atlas Charts
Gas Content, scf/bbl	37	(Haas - 19)
Aquifer area, mi ²	17.4	Computed areal extent of Marg. 7 water drive aquifer in same fault compartment.

TABLE VIII.

<u>WELL NAME</u>	<u>OPERATOR</u>	<u>LOCATION</u> (Sec-T-R)	<u>TD,ft</u>	<u>PRODUCED ZONES</u> <u>DEPTH, ft.</u>	<u>NAME</u>
Z. T. Matte #1	Pan American	1-8S-2E	13,100	10,910-20 12,068-86	NS-1 NB-1
H. Thibodeaux #1	Tidewater	83-8S-2E	14,800	14,298-300 14,400-410	NB 3 L.ND1
E. Daigle #1	Texas I'ntl.	83-8S-2E	15,300	None	
T. R. Daigle #2	Tidewater	83-8S-2E	14,500	14,092-106 13,953-73	Lower ND 1

FIGURE 15. Structure Map of Church Point Field.

as shown in Table IX. There are also a number of small sand stringers, particularly at the shallower depths, which are also gas productive.

Geopressured-Geothermal Prospects

In the Church Point Field, there are no massive sands with average thicknesses of 100' below the 250°F isotherm to the depth of the deepest well of 15,300 ft. Since no well logs or other information was available concerning the horizons below the 15,300 feet depth no assessment of deeper horizons was made for this report. Also, since no aquifers acceptable to the DOE test program were identified no production calculations or economic calculations were made.

TABLE IX. Gas Producing Zones Deeper than 12,000 ft. in Church Point Field, Acadia Parish, Louisiana.

1956-1980

<u>OPERATOR</u>	<u>WELL</u>	<u>PRODUCING INTERVAL</u>	<u>TD, ft.</u>
Pan American	Daigle B2	12,313-36 12,370-378 12,387-94	12,595
Pan American	Daigle B3	12,290-300	16,160
Tidewater	T.R.Daigle 1	12,408-14	12,452
Tidewater	E.Thibodeaux	12,297-308 12,340-48	12,350
Tidewater	P.Thibodeaux 1	12,240-64	12,550
Tidewater	H.Thibodeaux 1	14,400-410 14,298-300 14,314-316	14,800
Tidewater	T.R.Daigle 2	14,092-106 13,953-73	14,500
Amoco	Matte 1	12,068-86	13,100
Getty	T.R.Daigle 3	13,993-99 14,089-98	14,550
Getty	#158376	12,289-292	-

CONCLUSION

The available well logs and production records for the Hollywood, Duson and Church Point field provided substantial information towards defining the geopressured aquifer zones and which of these zones contain free gas. The available geological structure maps were also very useful in delimiting the fault compartments that contain the reservoirs in the three fields.

Review of the various production horizons in the several wells in each field showed that essentially all of the sands of any substantial size in the field were productive some place or other in the field. Although many sands were seen to be completely wet in many of the wells the same sands in other wells were gas productive. The aquifer portion of the sand delimited by the fault compartment are thus the water drive associated with the free gas reservoirs which are now productive within the fields.

One deep sand was found in the Hollywood field for which we had no record of gas production from it anywhere in the area. For this sand at 18,000-19,000 ft. estimates of the reservoir parameter were made and a calculation of production was made. The maximum flow was estimated to be less than 10,000 b/d. An estimate of the cost to develop and produce this sand was made and an economic analysis was also made. This calculation indicated that a gas price well above current prices would be required to be profitable. The productivity is too low and the development cost are too high to be economically successful as a purely geopressured aquifer project in the current gas market.

The Department of Energy geopressured-geothermal program goal to locate and produce solution gas from aquifers not connected to commercial production. It is therefore important to perform analysis such is done in this report to define the fault block compartment areal extent around a potential site and to identify which geopressured aquifers within the block are not connected to producing reservoirs.

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