Pleasant Bayou, TX Geopressured-Geothermal Reservoir

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Acknowledgements

This presentation is based on the work of Shook (1992), John et al. (1998) and Griggs (2004).

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References

Griggs, Jeremy, 2004, A Re-evaluation of Geopressured-Geothermal Aquifers as an Energy Source: Louisiana State University, Department of Petroleum Engineering, Masters Thesis, Baton Rouge, LA, 82 p.

Griggs, Jeremy, 2005, A Re-evaluation of Geopressured-Geothermal Aquifers as an Energy Source: Proceedings, Thirtieth Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford CA, January 31-February 2, 2005, p. 501-508.

Shook, G. M.,1992, An Integrated Approach to Reservoir Engineering at Pleasant Bayou Geopressured-Geothermal Reservoir: Idaho National Laboratory Report EGG-EP-10557, Idaho Falls, ID, 49 p.

References

John, C. J., Maciasz, Gina, and Harder, B. J., 1998, Gulf Coast Geopressured-Geothermal Program Summary Report Compilation:

Vol. I Executive Summary: DOE/ID/1336—T1-Vol.-1, 12 p.

Vol. II –A Resource Description, Program History, Wells Tested, University and Company Based Research, Site Restoration: DOE/ID/1336—T1-Vol.-2A, p. i-xxvii and 1-165

Vol. II-B Resource Description, Program History, Wells Tested, University and Company Based Research, Site Restoration: DOE/ID/1336—T1-Vol.-2B, p. i-xxvii and 166-505

Vol. III Applied and Direct Uses, Resource Feasibility Economics: DOE/ID/1336—T1-Vol.-3, 145 p.

Vol. IV Bibliography (Annotated only for Major Reports): DOE/ID/1336—T1-Vol.-4, 207 p.

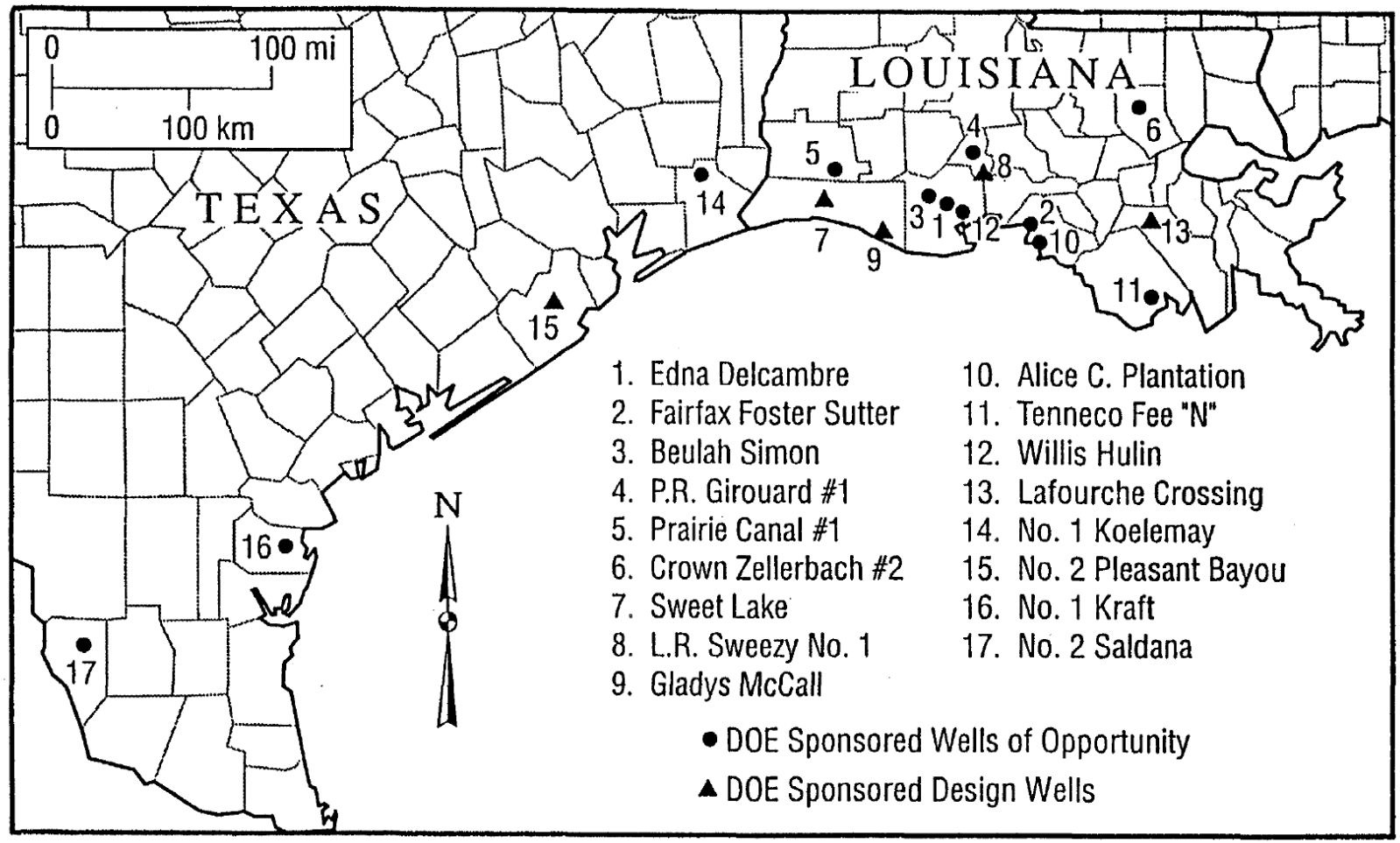


Figure 1. - - Location of wells investigated for the DOE geopressured - geothermal research program in the Gulf Coast.

- From John, et al., 1998, Vol. I, p.4.

TABLE 1
Summary of test results from the geopressured - geothermal test wells

Well Name	Depth (ft)	Pressure (psi)	Temp. (°F)	Salinity (ppm TDS)	Gas/Brine Ratio (SCF/STB)	Flow Rate (BPD)	Methane (mol%)	CO_2 (mol%)	Other Gases (mol%)	Porosity (%)	Permeability (mD)
Delcambre 3sd	-12,869	11,012	238	133,300	24.0	10,333	92.8	1.1	6.1	26.0	44.0
Delcambre 1sd	-12,573	10,858	234	113,000	24.0	12,653	95.4	2.0	2.6	29.0	364.0
F.F.Sutter	-15,781	12,220	270	190,904	24.9	7,747	89.6	7.9	2.5	19.3	14.3
Buelah Simon	-14,722	13,015	266	103,925	24.0	11,000	88.9	7.7	3.4	17.4	11.6
P.R. Giroud	-14,744	13,203	274	23,500	44.5	15,000	91.3	6.0	2.7	26.0	220.0
P. Canal	-14,976	12,942	294	43,400	47.0	7,100	88.4	8.4	3.2	22.5	90.0
C. Zellerbach	-16,720	10,144	330	31,700	55.7	3,887	71.0	23.5	5.5	17.0	14.1
Amoco Fee - Sweet Lake A	-15,387	11,974	298	160,000	34.0	34,000	88.7	8.6	2.6	20.0	400.0
Parcperdue - L. R. Sweezy No. 1	-13,395	11,410	237	99,700	30.0	10,000	94.0	2.5	3.5	29.4	500.0
Gladys McCall A	-15,508	12,936	298	95,500	30.4	36,500	86.9	9.5	3.6	24.0	90.0
Gladys McCall B	-15,158	12,821	288	94,000	30.4	36,000	85.9	10.6	3.5	22.0	130.0
Pleasant Bayou Well No. 2	-16,465	9,800	302	127,000	24.0	25,000	85.0	10.0	5.0	19.0	200.0
Hulin No. 1	-21,546	18,500	360	195,000	34.0	15,000	93	4.0	3.0	–	13.0
Riddle Saldana No. 2	-9,745	6,627	300	12,800	41.0	1,950	75.0	21.4	3.75	20.0	7.0
Lear Koelemay No. 1	-11,590	9,450	260	15,000	35.0	3,200	81.4	13.4	5.2	26.0	85.0
Ross Kraft No. 1	-12,750	10,986	263	23,000	45.0	–	–	–	–	23.0	39.0

From John et al., Vol. I, p.4.

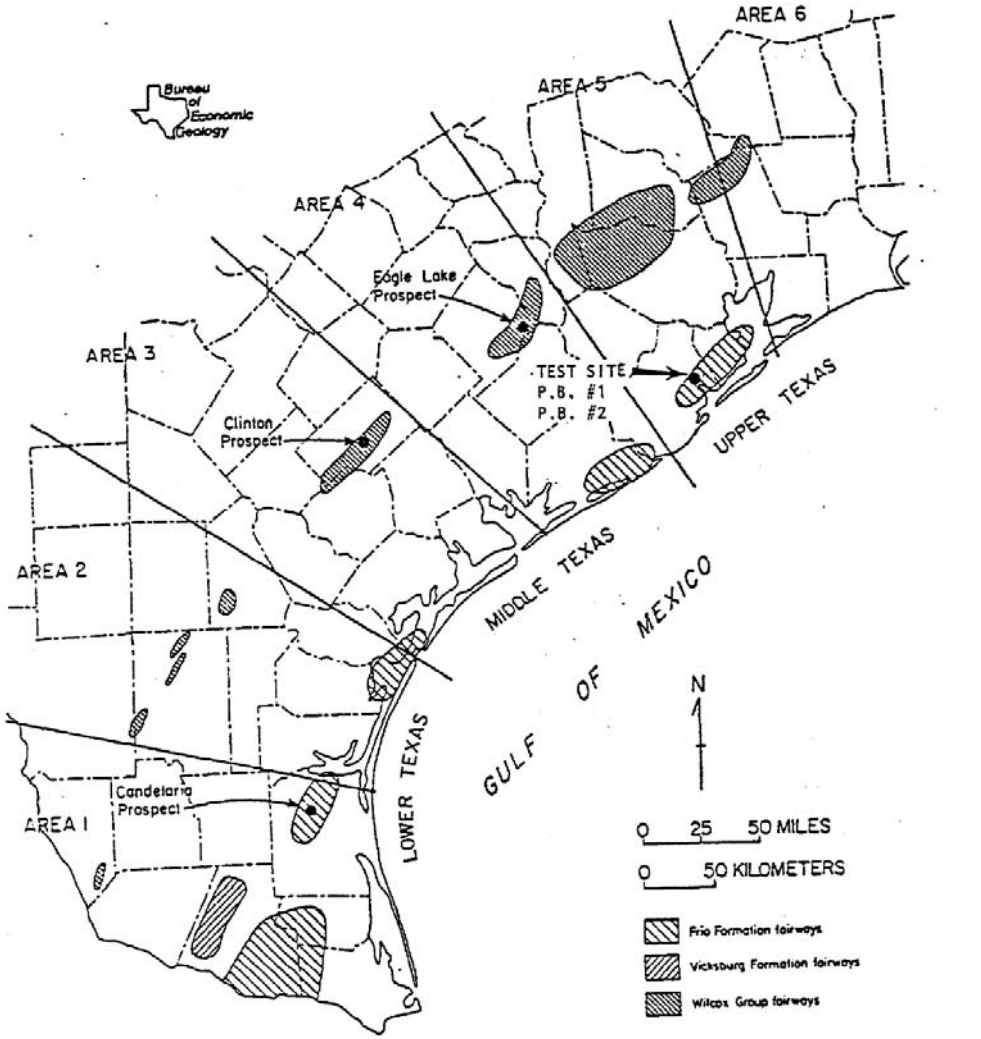
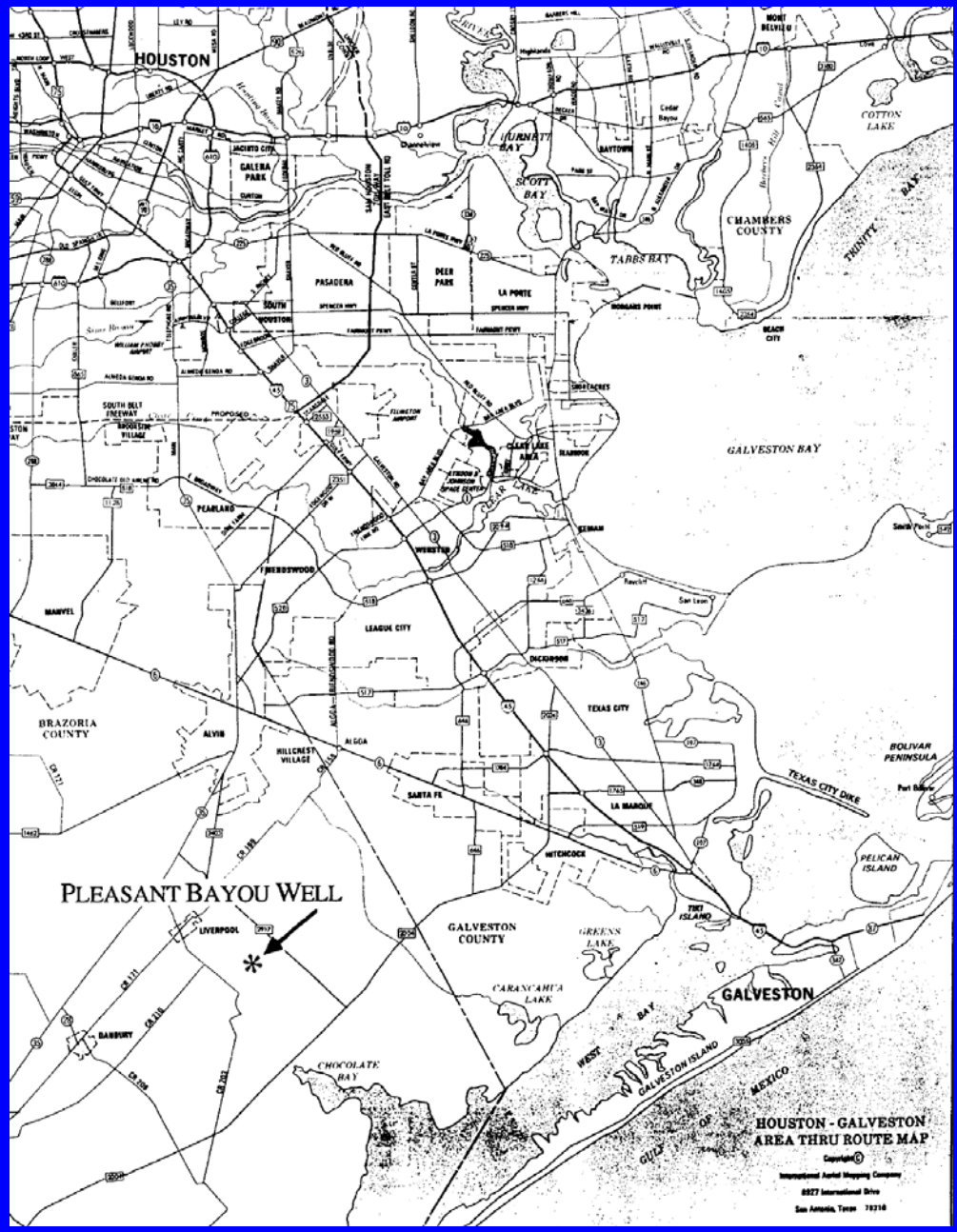


Figure 158. - - The Frio, Vicksburg and Wilcox geopressured - geothermal fairways and location of the Pleasant Bayou (#1 & 2) test well in the Frio fairway (from, Gruy Federal Inc., 1980).

From John et al, 1998, Vol. Ii-B, p. 365



From John, C. J., et al, 1998, Vol. II-B, p. 261

Pleasant Bayou 2

- 1978 Drilled to 16,500 ft
  - 12,000 bpd ave. flow rate; total 274,000 bbl
  - 6,000–19,200 bbl/d step test
- 1981 29,000 bbl/d max. flow rate
- 1982-1983 Flow test
  - 3.5 million barrels; 18,200 bpd ave. rate
- 1988-1992 Long-term flow test
  - 18,000 bbl/d ave. rate
  - 3,000 psi ave. wellhead pressure
  - 25 million bbl cumulative flow

Reservoir Model

Shook (1992) combined geology, well tests and reservoir simulation to:

- **Determine reservoir limits**
- **Estimate reservoir volume**

Table 2. Summary of parameters used in Pleasant Bayou Model

Rock Properties		
Total pore volume		4.2×10^{10} ft^3
Pore compressibility	distal volume	2.5×10^{-6} psi^{-1} (top, bottom layers)
	proximal volume	5×10^{-6} psi^{-1} (middle sand)
Porosity	distal volume	0.09 top, bottom layers
	proximal volume	0.18 middle sand
Fluid Properties		
Bubble point pressure at T_R		6500. psia
Viscosity		0.28 cp
Standard density		69. lb/ft^3
Formation Volume factor		1.049 rb/STB
Initial Conditions		
Pressure at 14,100 ft SS		10,716. psia
Temperature		306. °F
Mole fractions:	brine	0.9968
	methane	0.0032 (24 SCF/STB brine)

From Shook, 1992

Geology

- C-zone of the lower Frio sandstone
- Wave-modified deltaic sequence
- Production from distributory channels and channel-mouth bar sandstones
- Bounded by growth faults to west, north and east
- Shook (1992) suggests leaky, pressure-sensitive fault to south

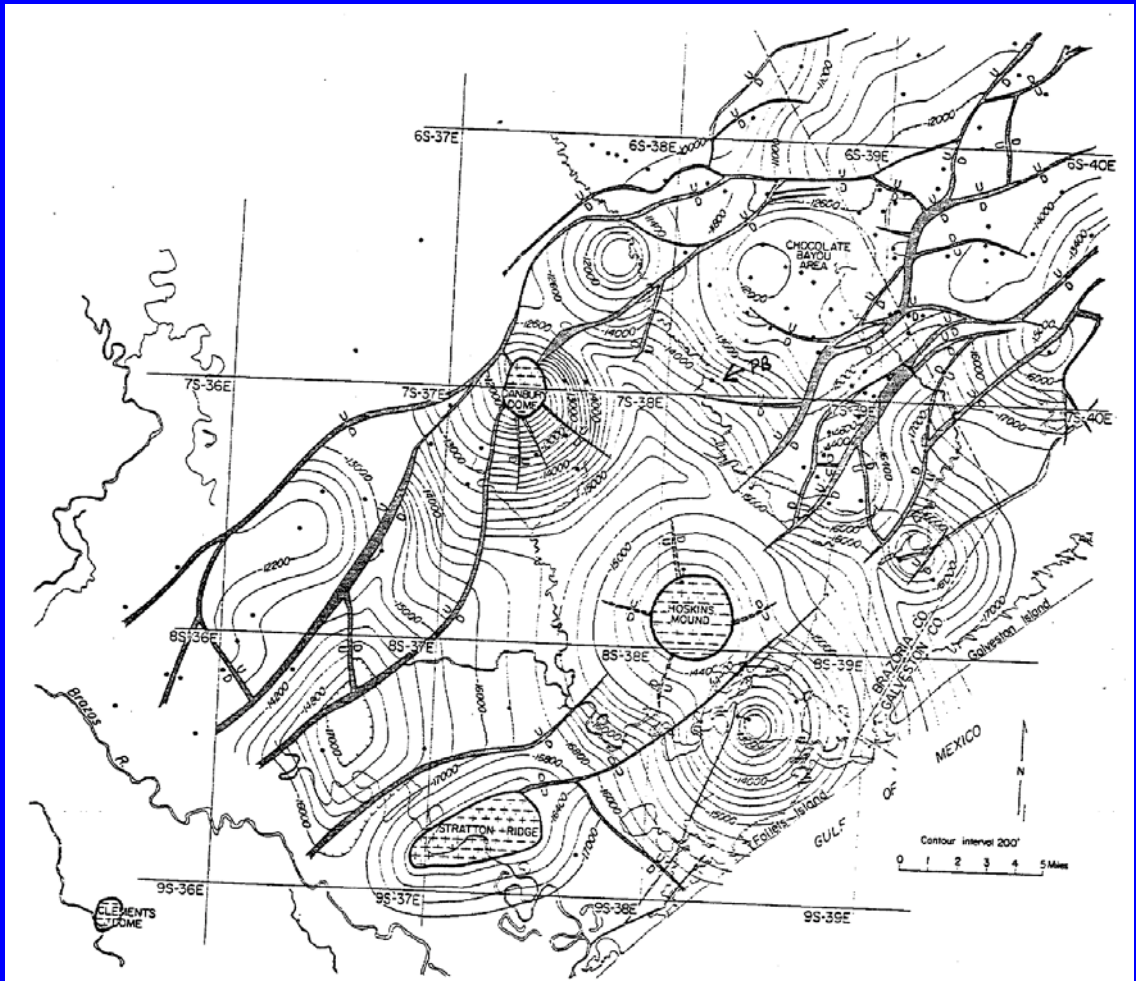


Figure 163. - - Structural map drawn on top of the T_5 marker, Brazoria Fairway. The Pleasant Bayou test well site is on the southwest flank of the Chocolate Bayou Domal Structural (from, Bebout, Loucks and Gregory, 1979).

From John et al., 1998, Vol. II-B, p. 373.

Leaky Fault Evidence

- Transient tests indicate boundary at 6,200 feet
- Tests indicate increase in reservoir size
- Reservoir analysis suggests reservoir recharge is pressure related
- Fault related leakage due to pressure difference

Shook's Conclusions

- **Reservoir is supported through communication along a leaky fault**
- **Pleasant Bayou 2 is capable of producing 20,000 bbl/day:**
  - **For 10 years**
  - **Minimum downhole pressure 8600 psi**

Economics

- Early 1990s economic studies suggested marginal economics
- Since then:
  - Higher natural gas prices
  - Higher electrical prices
- New economic study by Griggs (2004)

Griggs' (2004) Conclusion

"This study shows that the commercial production of geopressured-geothermal aquifers is feasible under reasonable assumptions of natural gas and electricity price. However, the near-term likelihood of large-scale developments of geopresssured aquifers is low."

Why?
(Griggs, 2004)

- Refined resource estimates - brine and methane
- System analysis of gas and energy production
- More efficient binary plants
- More precise economic analysis
- Legal status of development

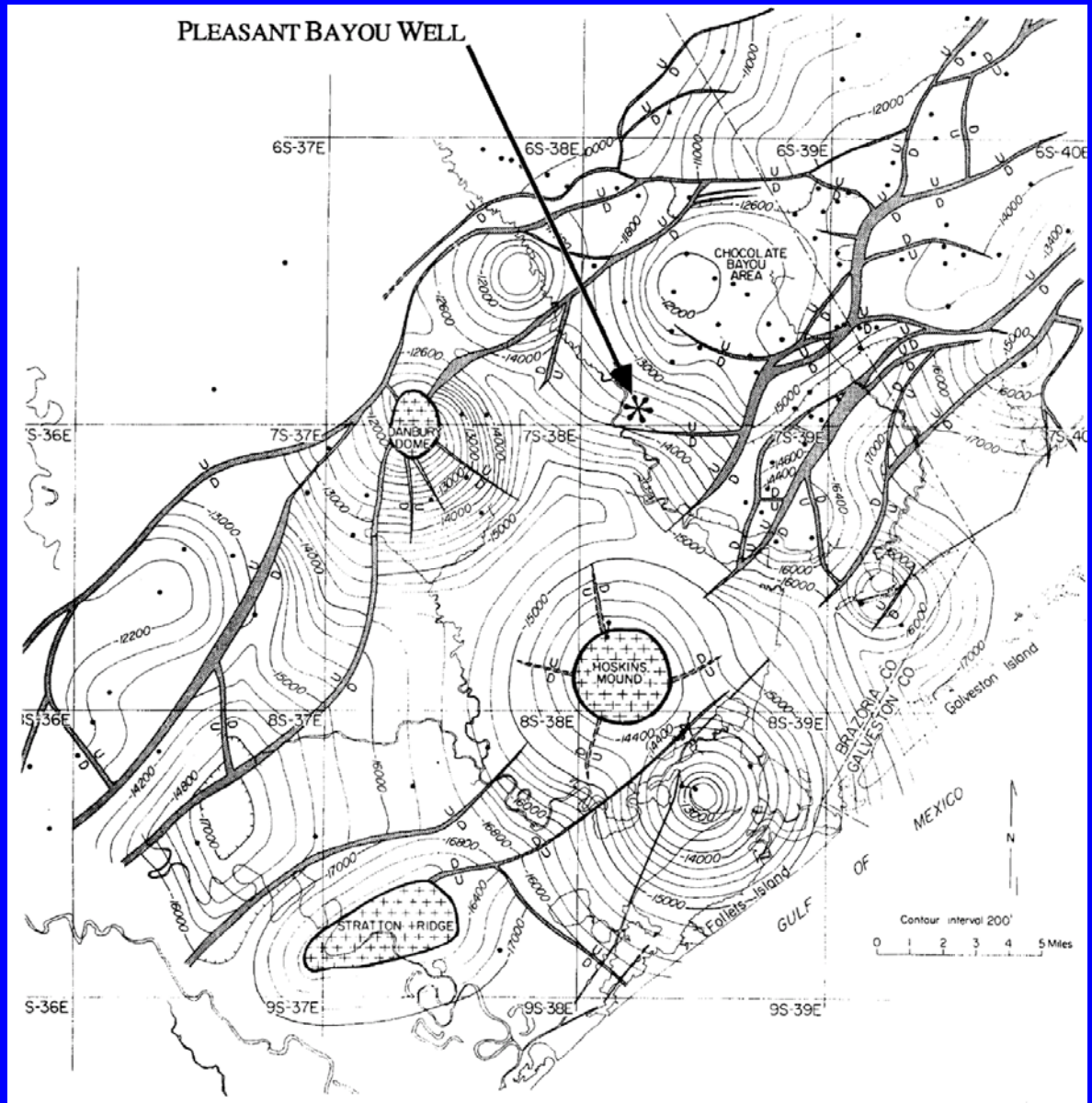


Exhibit 1.2-2. STRUCTURE MAP ON THE TOP OF THE T5 MARKER

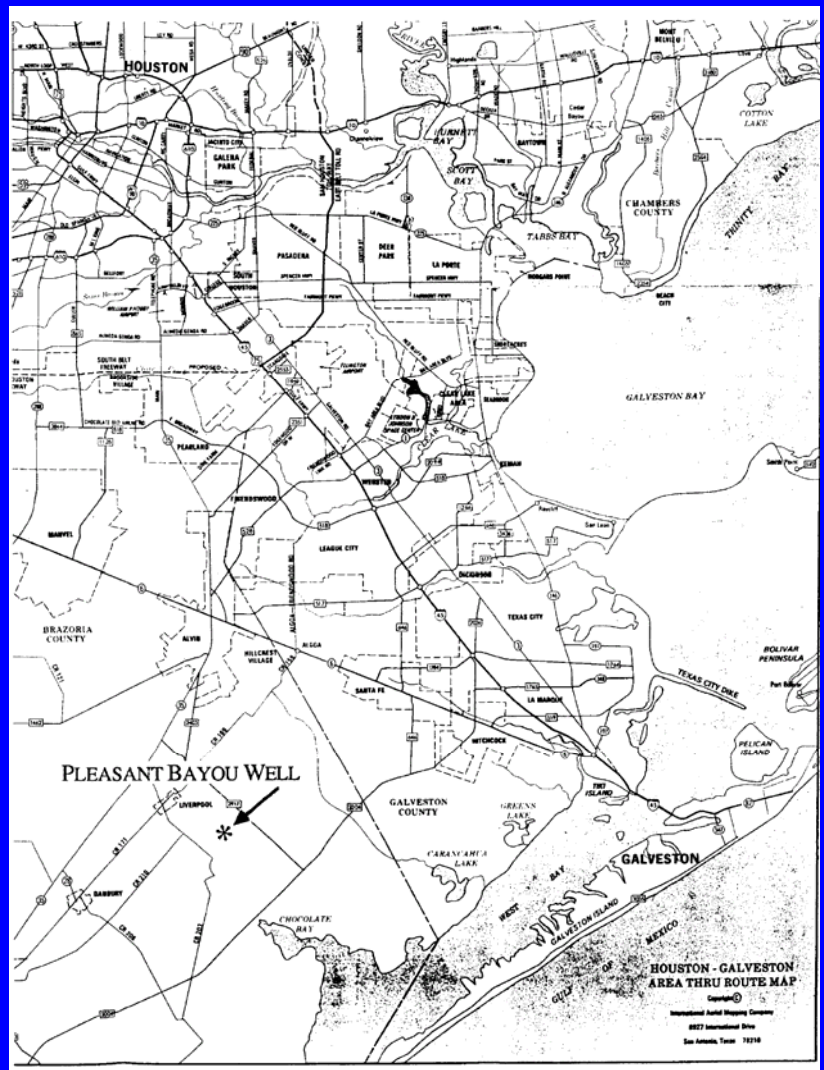


Exhibit 1.1-2. PLEASANT BAYOU PROJECT LOCATION ON A ROAD MAP

From John, C. J., et al, 1998, Vol. II-B, p. 261