A PROSPECTUS

GEOPRESSURED GEOTHERMAL PROSPECTS AND TEST-WELL SITES WILCOX GROUP AND FRIO FORMATION TEXAS GULF COAST

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December 21, 1978

Mr. Keith Westhusing
Department of Energy
Room 8620-U.S. Federal Building & Court
515 Rusk Avenue
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Dear Keith:

Enclosed is a copy of the prospect and well-site report. The distribution list on the last page indicates those to whom I have sent copies.

Very truly yours,

Don Bebout
Coordinator of Geothermal Studies

DB:gz

cc: B. G. DiBona
C. Carwile
R. T. Stearns
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INTRODUCTION

The four geopressured geothermal prospects and test-well sites described in this report (fig. 1 and table 1) are believed to represent the most favorable locations for testing the resource along the Texas Gulf Coast. The regional and site-specific studies used in selecting the Frio prospects have been published by the Bureau of Economic Geology (Report of Investigations 91); the supporting studies for the Wilcox prospects will be published by mid-1979. Detailed stratigraphic and structural cross sections and net-sandstone and structure maps have been prepared for the fairways in which these prospects are located. It is anticipated that other prospects will be identified in these and other fairways during the course of further study and will be reported on later. It should be emphasized that these prospects and sites have been chosen on the basis of geology alone and that equally important environmental and legal (surface and mineral rights) aspects have not been considered.

The total-resource values shown in the last two columns of Table 1 are very general estimates and are intended only to project an impression as to the magnitude of the resource in these local areas.

A significant departure has been made in the manner in which the top of geopressure is picked in this report. In previous Bureau of Economic Geology reports the top of geopressure is defined as the point at which the pressure gradient exceeds .7 psi/ft; the pressure gradient was determined primarily by plotting drilling-mud weights, a method recognized as highly tentative. For this report the top of geopressure is picked at the depth at which the plot of the shale resistivity from the electrical log departs from the normal compaction curve. This method is believed to be considerably more reliable.

Figure 1. Frio, Vicksburg, and Wilcox geothermal fairways and locations of test-well prospects.

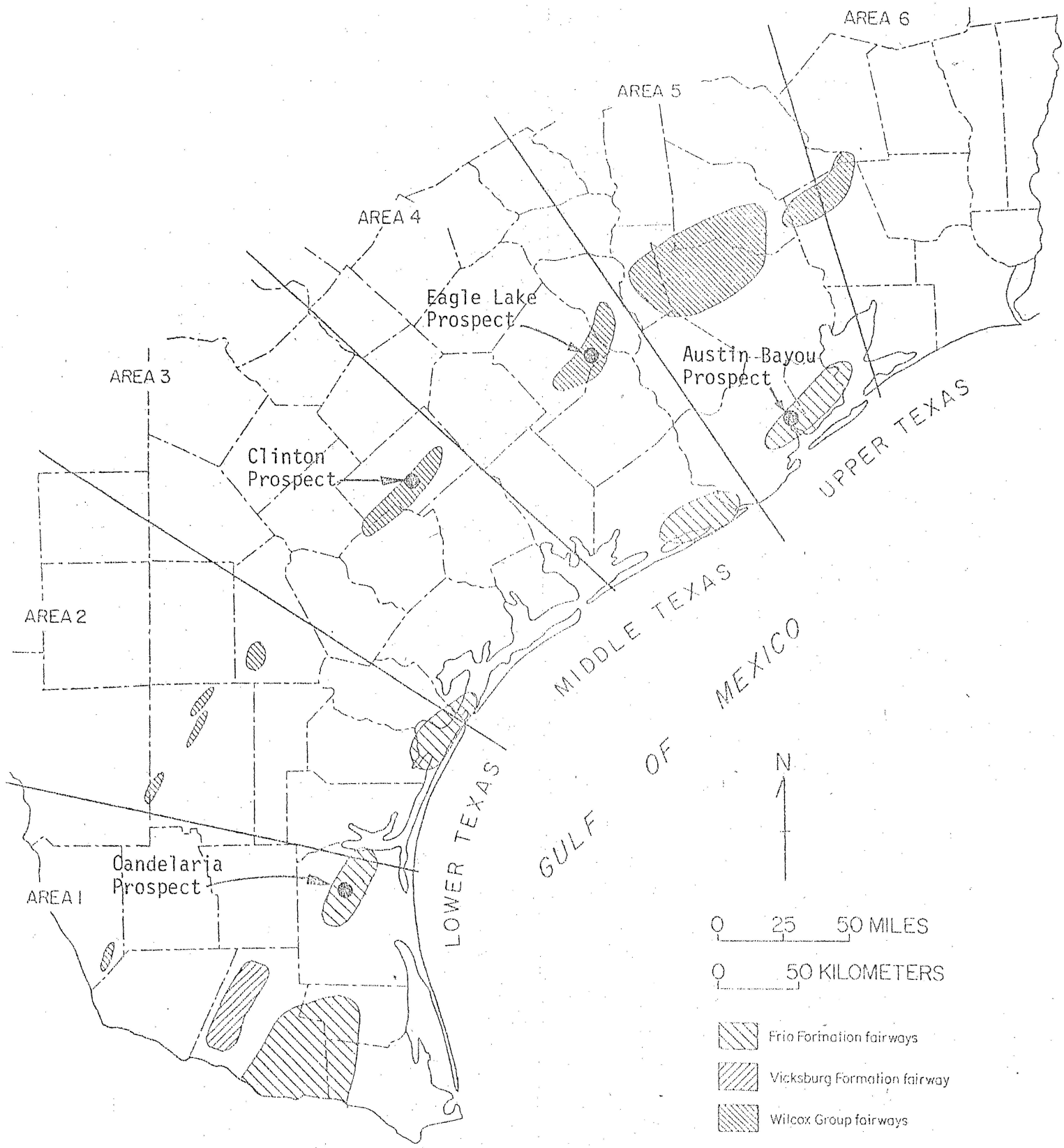

Table 1. Summary of data from prospective test-well site. Methane solubility calculated from a table by Haas (USGS Open File Report 78-1004).

PROSPECT	Clinton	Austin Bayou	Candelaria	Eagle Lake
LOCATION OF TEST WELL	DeWitt Co. 8S-22E-8	Brazoria Co. 6S-38E-7	Kenedy Co. 25S-18E-5	Colorado Co. 4S-30E-2
DEPTH OF RESERVOIR SANDSTONE	10,950 to 13,250 ft	12,000 to 17,000 ft	10,700 to 16,000 ft	11,280 to 12,880 ft
SANDSTONE THICKNESS	10,950-12,000 ft (645 ft proposed reservoir section) 12,000-13,250 ft (700 ft deeper section)	12,000-14,000 ft (220 ft top of geopressure to 300°F) 14,000-17,000 ft (900 ft greater than 300°F)	10,500-13,400 ft (865 ft top of geopressure to 300°F) 13,400-16,000 ft (635 ft greater than 300°F)	1050 ft
MINIMUM AREA	11.4 mi^2	18 mi^2	44 mi^2	10 mi^2
PERMEABILITY	.01 to 242 md	20 to 174 md - top of geopressure to 300°F; 8 to 1041 md - greater than 300°F	30 to 60 md - top of geopressure to 300°F; .1 to 10 md greater than 300°F	0 to 545 md
AVERAGE POROSITY	16% in proposed reservoir section	18% - top of geopressure to 300°F; 16% greater than 300°F	15% - top of geopressure to 300°F; 13% - greater than 300°F	13%
TEMPERATURE	Range: 280-350°F; average upper interval: 275°F; average lower interval: 325°F	Range: 270-360°F; average upper interval: 284°F; average lower interval: 332°F	Range: 240-340°F; average upper interval: 275°F; average lower interval: 325°F	Range: 280°-325°F; ave. 300°F
TOP OF GEOPRESSURE	10,500 ft	12,000 ft	10,700 ft	12,000 ft
SALINITY ppm; NaCl	Range: 30,000 to 100,000 average 60,000	Range: 40,000 to 90,000 average 60,000	Range: 35,000 to 110,000 average 75,000	Average: 90,000
FORMATION PRESSURE (PSI)	Average upper interval: 8250; average lower interval: 10,500	Average upper interval: 9500; average lower interval: 13,250	Average upper interval: 9750; average lower interval: 13,250	Average: 8500
METHANE SOLUBILITY ft^3/bbl H_2O (USGS tables; Haas, 1978)	Upper interval: 27.02 Lower interval: 39.06	Upper interval: 31.05 Lower interval: 46.80	Upper interval: 27.60 Lower interval: 41.26	26.29
IN-PLACE RESOURCE	H_2O (bbl) 1.22×10^{10} CH_4 (ft^3) 4.04×10^{11}	H_2O (bbl) 1.64×10^{10} CH_4 (ft^3) 7.12×10^{11}	H_2O (bbl) 4.64×10^{10} CH_4 (ft^3) 1.53×10^{12}	H_2O (bbl) 6.78×10^{9} CH_4 (ft^3) 1.78×10^{11}
RECOVERABLE RESOURCE (5% of in place)	H_2O (bbl) 6.1×10^{8} CH_4 (ft^3) 2.02×10^{10}	H_2O (bbl) 8.2×10^{8} CH_4 (ft^3) 3.56×10^{10}	H_2O (bbl) 2.32×10^{9} CH_4 (ft^3) 7.65×10^{10}	H_2O (bbl) 3.39×10^{8} CH_4 (ft^3) 8.91×10^{9}

CLINTON PROSPECT
DeWitt County, Texas
Wilcox Group

Location (figs. 1 and 2)

This prospect is in south-central DeWitt County and includes the Cook South and Cuero South Fields. The proposed test-well site (8S-22E-8) is 3 miles south of the town of Clinton.

Depth of Reservoir Sandstones (fig. 3)

The top of the prospective reservoir sandstones is at 10,815 (-10,530) feet on the type log. In other nearby wells the depth ranges from 10,860 to 10,990 feet. The base of the sandstone section on the type log is at 11,940 (-11,655), near the total depth of the well. In a nearby deeper well, additional sandstones occur to a total depth of 13,120 feet.

In the test well, the top of the reservoir sandstones should be at 10,950 feet.

Sandstone Thickness and Character (fig. 3)

On the type log 645 feet of sandstone occur in the proposed reservoir section. The sandstone beds range in thickness from 5 to 30 feet on the type log. The thicker beds are in the upper 300 feet of the reservoir section. Deeper sandstones were penetrated in a nearby well and cumulate to 700 feet in thickness; individual beds range from 5 to 40 feet in thickness. Similar sandstone thicknesses are expected in the test-well.

Areal Distribution and Reservoir Boundaries (fig. 2)

The prospect is approximately 1.75 miles wide (NW-SE) and 6.5 miles long (SW-NE) and 11.4 square miles in area. Major growth faults form boundaries on the updip (northwest) and downdip (southeast) side of the prospect. These faults, as shown on the map, are located with respect to the top of the Wilcox and dip to the southeast. Thus, the prospect area, shown by the hatchures, is shifted in that direction. Along strike to the southwest and northeast, faults and facies changes result in considerably less sandstone beyond the hatchured area.

Permeability, Porosity (fig. 3)

Whole-core analyses from the reservoir section in the type well show a range in porosity from 6 to 25 percent and permeability from 0.01 to 242 millidarcys. Highest permeability occurs in the top 300 feet of the prospective section, but the lower permeabilities are more common. In

the type well highest permeability (25-242 md) occurs between 10,978 and 10,985 feet. No analyses are available from the sandstones in the deeper section.

Temperature (figs. 3 and 4)

In the type well (fig. 3) a temperature of 200°F occurs at 7200 feet and 300°F at 11,400 feet. The maximum bottom-hole temperature recorded was 313°F corrected to the equilibrium value. The prospective reservoirs should have fluid temperatures ranging from 275° to 313°F. The temperature gradient is 2.6°F/100 feet at depths of interest for the DeWitt County area (fig. 4).

Pressure (fig. 5)

The top of geopressure on the type log is interpreted to be at 10,500 feet. Bottom-hole pressure from 10,816 to 10,876 feet was 7100 psi based on a one-hour shut-in pressure test.

Salinity (fig. 6)

Salinity calculated from log analysis ranges between 30,000 and 100,000 ppm total dissolved solids.

Operators of Nearby Wells

Atlantic Richfield, Exxon, Lone Star, Standard of Texas, Mitchel.

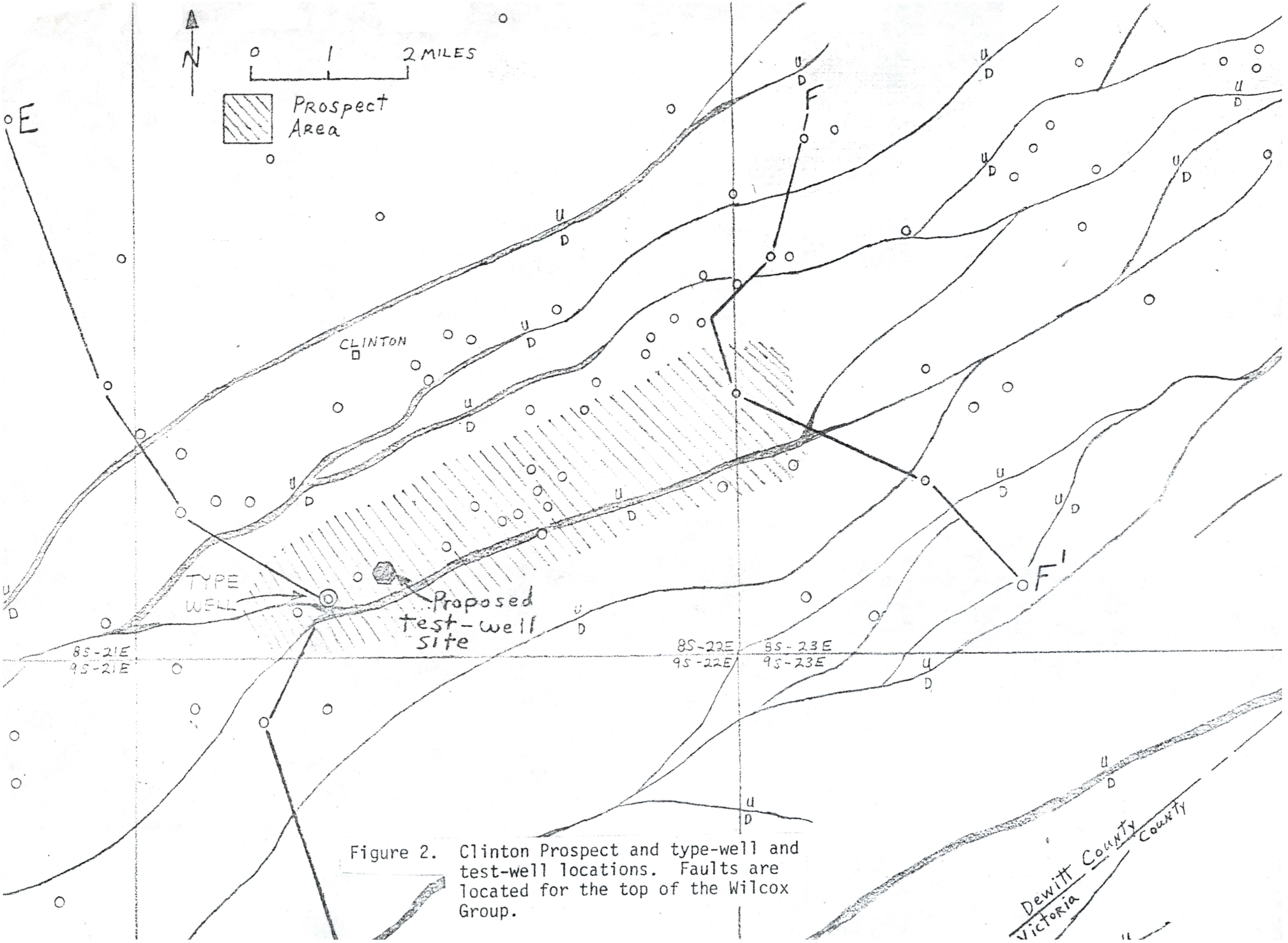

Figure 2. Clinton Prospect and type-well and test-well locations. Faults are located for the top of the Wilcox Group.

Figure 3
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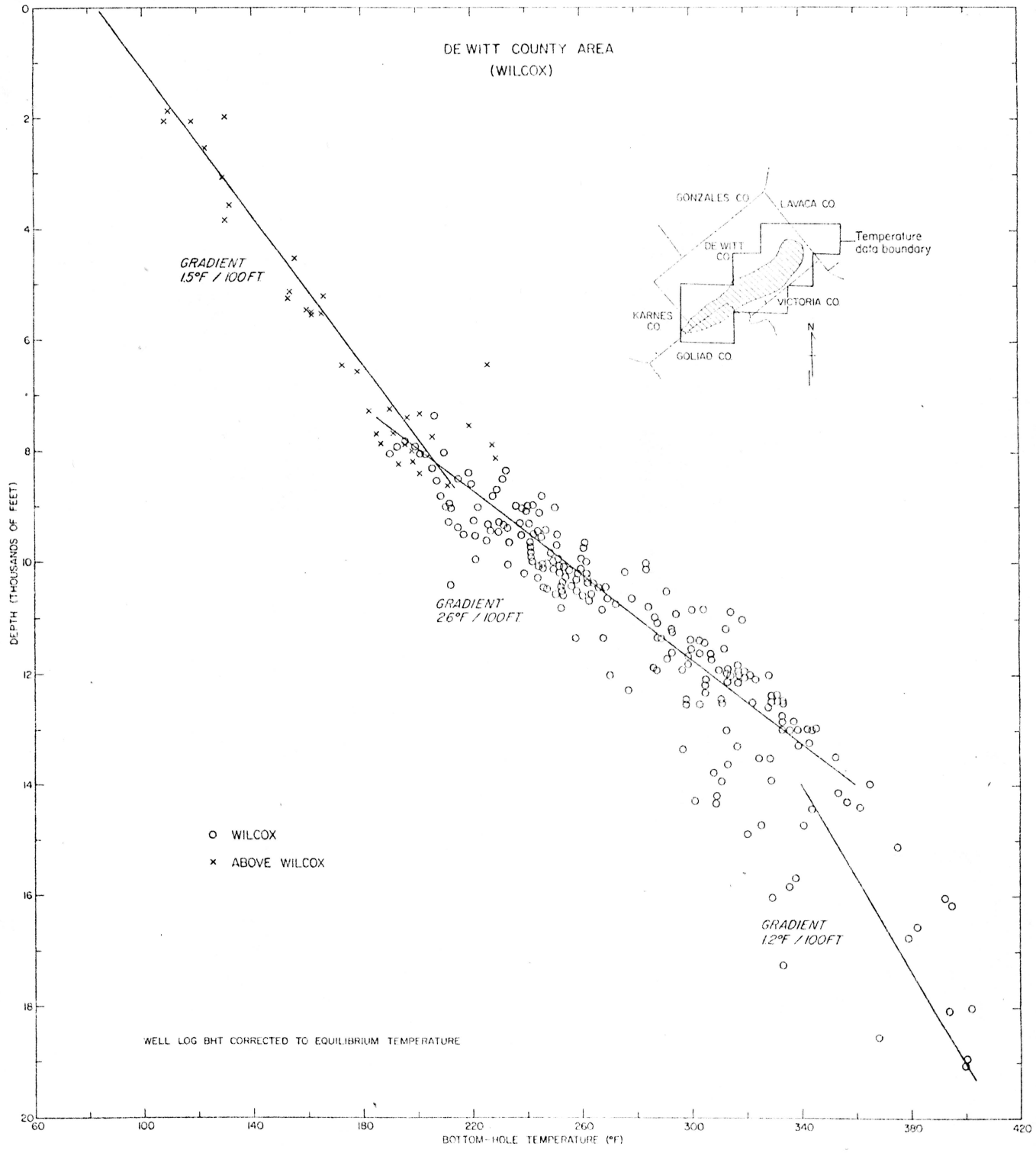

Figure 4. Temperature-versus-depth plot and geothermal gradients for DeWitt County area.

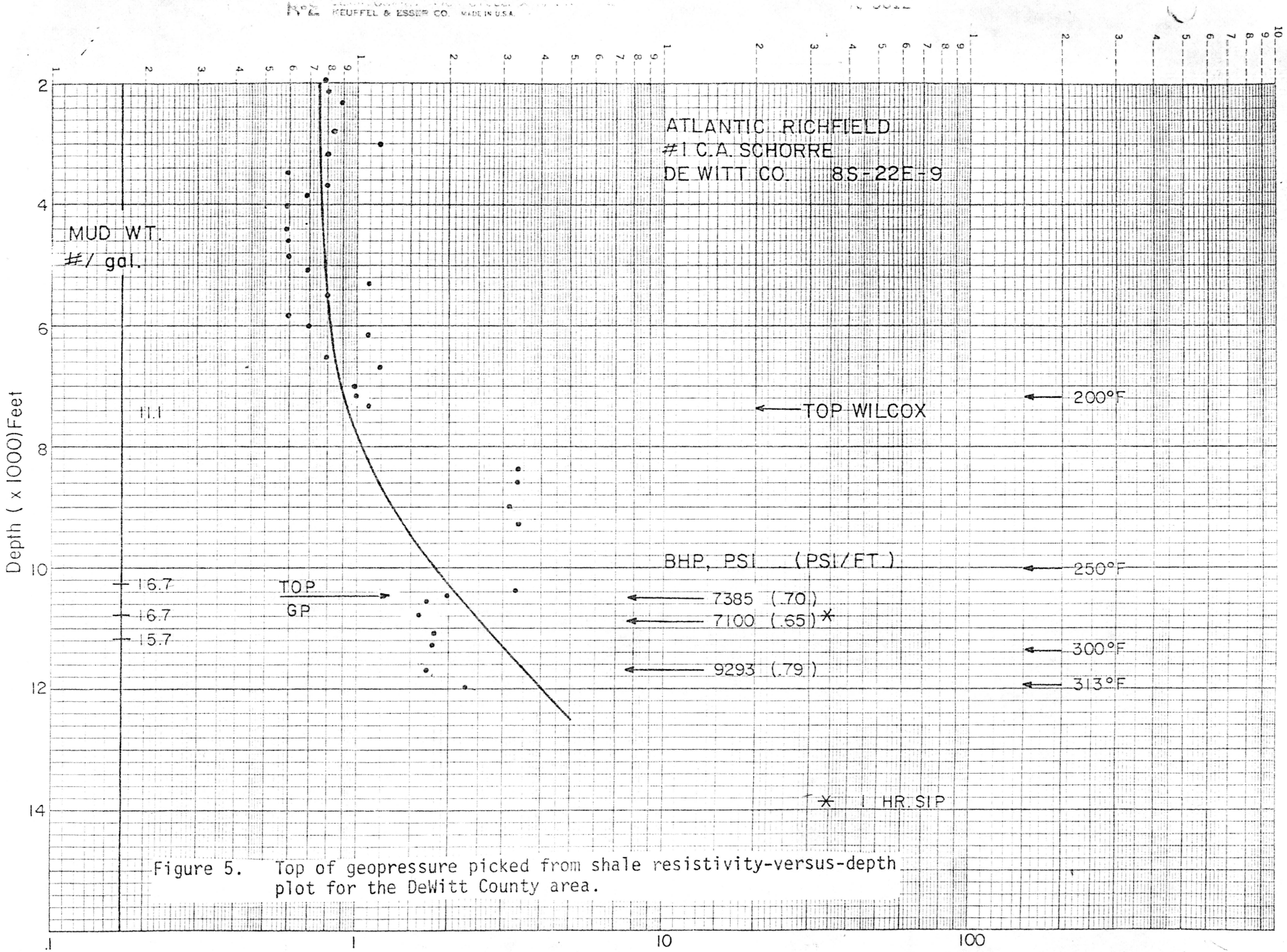

Figure 5. Top of geopressure picked from shale resistivity-versus-depth plot for the DeWitt County area.

SECOND TEST-WELL SITE
AUSTIN BAYOU PROSPECT
Brazoria County, Texas
Frio Formation

Location (figs. 1, 7, and 8)

This test-well site is in the Austin Bayou Prospect, Brazoria Fairway (6S-38E-7). It is two miles directly west of Department of Energy/General Crude No. 1 Pleasant Bayou geopressured geothermal well.

Depth of Reservoir Sandstones (fig. 8)

Depth to the top of the reservoir sandstones in the Austin Bayou Prospect is approximately 12,000 feet (top of geopressure). Depth to sandstones that have fluid temperatures greater than 300°F occur deeper than the Frio sandstone T5 marker (14,250 feet). Deepest prospective sandstones in the prospect are estimated to be at a depth of 17,000 feet.

Sandstone Thickness and Character (figs. 8, 9, and 10)

Approximately 220 feet of sandstone occur from the top of geopressure to the depth where 300°F is reached in the test well. As shown by the Texas Co. and Fort Bend Co. No. 2 Houston Farms and the No. 1 Pleasant Bayou well, the sandstones in this zone are in units up to 150 feet thick separated by shales up to 300 feet thick. Individual sandstone beds range in thickness from a few feet to 40 feet and are separated by shale up to 15 feet thick.

Sandstone thickness from the depth where 300°F is reached to the bottom of the prospective zone is approximately 900 feet. Sandstones in this zone are in units up to 800 feet thick, separated by shales up to 300 feet thick. Individual sandstones range in thickness from a few feet to 70 feet and are separated by shale beds up to 30 feet thick.

Total sandstone from the top of geopressure to the bottom of the prospective zone is estimated at 1120 feet.

Areal Distribution and Reservoir Boundaries (figs. 7 and 8)

The reservoir is bounded to the southwest by the Danbury salt dome and its associated faults, to the northwest by a large growth fault, to the northeast by a series of faults associated with the Chocolate Bayou area, and to the southeast by facies changes to shale. The prospect is estimated to be 18 square miles.

Permeability (fig. 10)

Whole-core analyses from the Department of Energy/General Crude No. 1 Pleasant Bayou well show that in the zone from the top of geopressure (approximately 12,000 feet) to the depth where 300°F is reached permeabilities range from 20 to as high as 174 millidarcys in the better quality sandstones. Average porosity in this zone is 18 percent. Below the depth where 300°F is reached, permeabilities are extremely poor (less than one millidarcy) in the thin sandstones but are very high (averaging 293 millidarcys with a range of 8 to 1041 millidarcys) in the thicker sandstones. Average porosity in this zone is 16 percent.

Temperature (fig. 11)

Measured temperatures of 200°F and 300°F in the area occur at depths of 8300 feet and 13,800 feet, respectively. The highest fluid temperature expected is approximately 360°F at 17,000 feet.

Pressure (figs. 12 and 13)

The top of geopressure is picked at about 12,000 feet.

Salinity (fig. 14)

Salinity is expected to be in the range from 40,000 to 90,000 ppm total dissolved solids.

Operators of Nearby Wells

Major operators in the area are Exxon Company, Phillips Petroleum Company, General Crude Oil Company, and Texaco Incorporated.

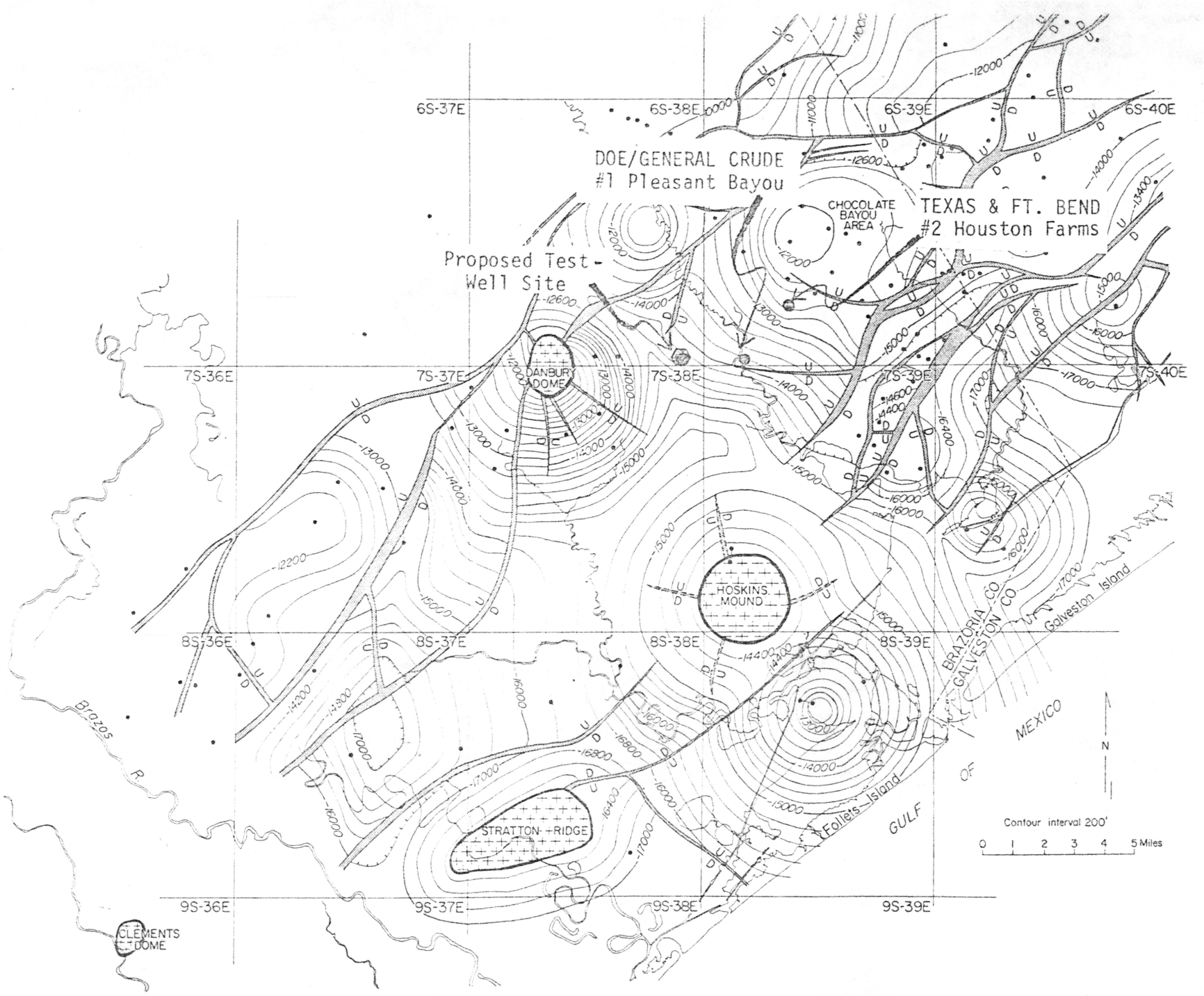

Figure 7. Structure on top of the T5 marker, Brazoria Fairway

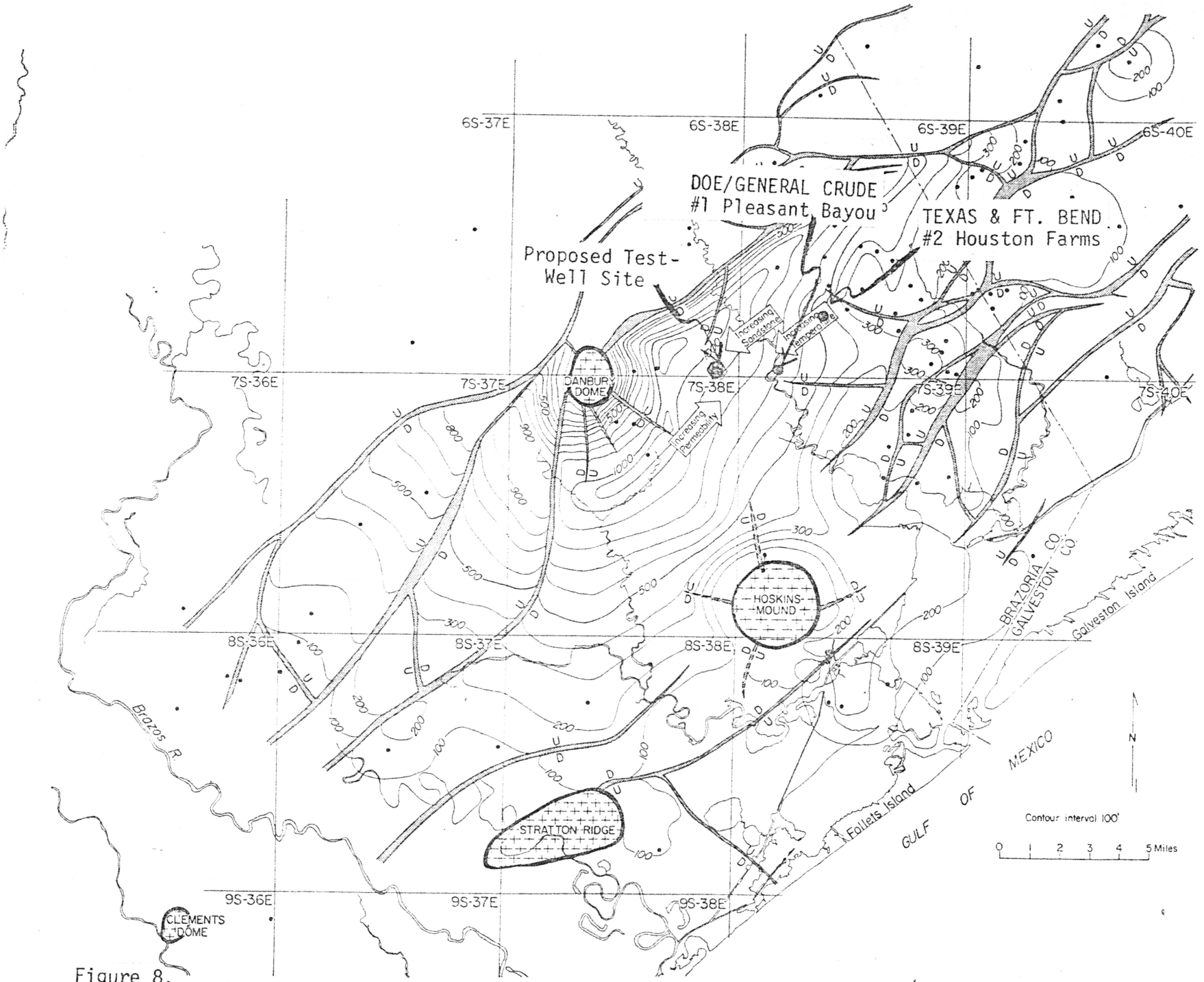

Figure 8. *Net-sandstone map, Austin Bayou Prospect and location of test well site, Brazoria County, Texas. Data are compiled from structure map and paleo net-sandstone maps.*

Figures 9 and 10
See oversized plates for these figures

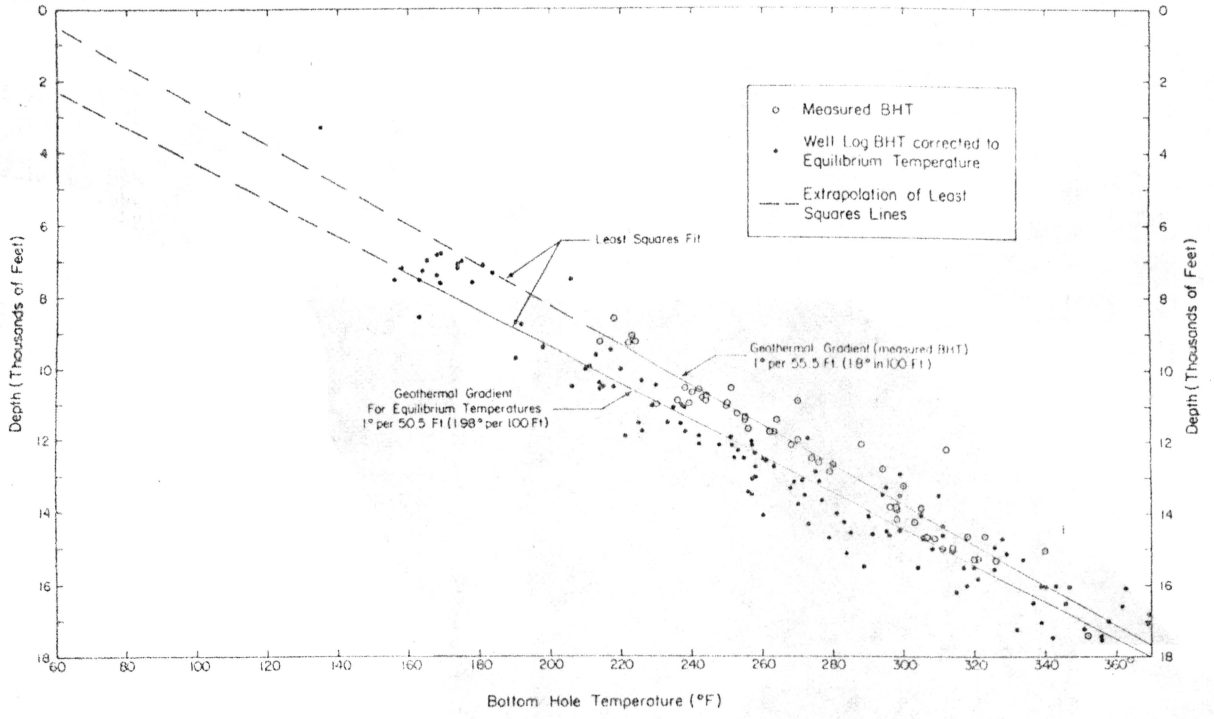

Figure 11. Comparison between measured bottom-hole temperatures (BHT) and equilibrium temperatures calculated from well logs, Brazoria County, Texas.

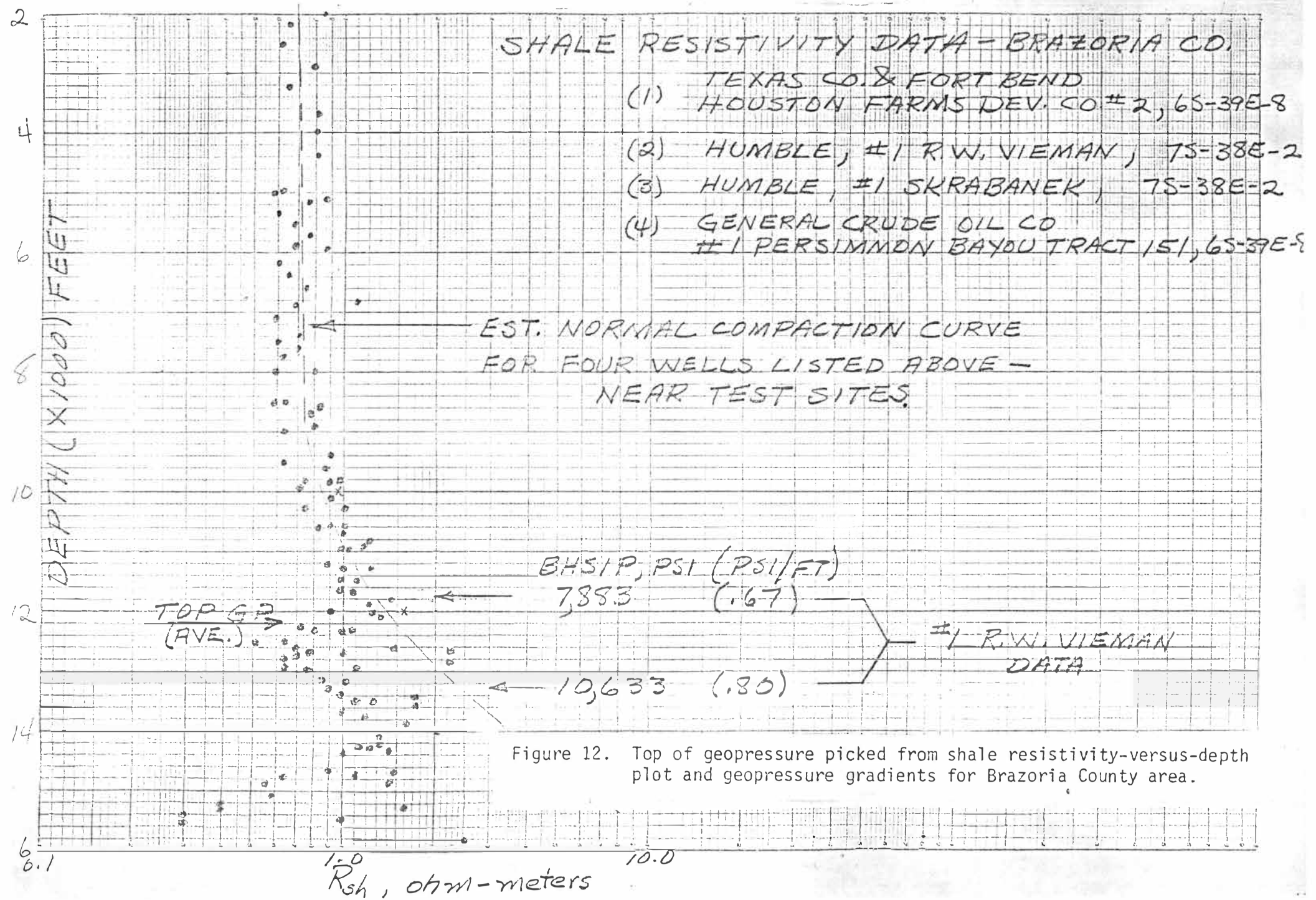

Figure 12. Top of geopressure picked from shale resistivity-versus-depth plot and geopressure gradients for Brazoria County area.

Figure 13
See oversized plates for this figure

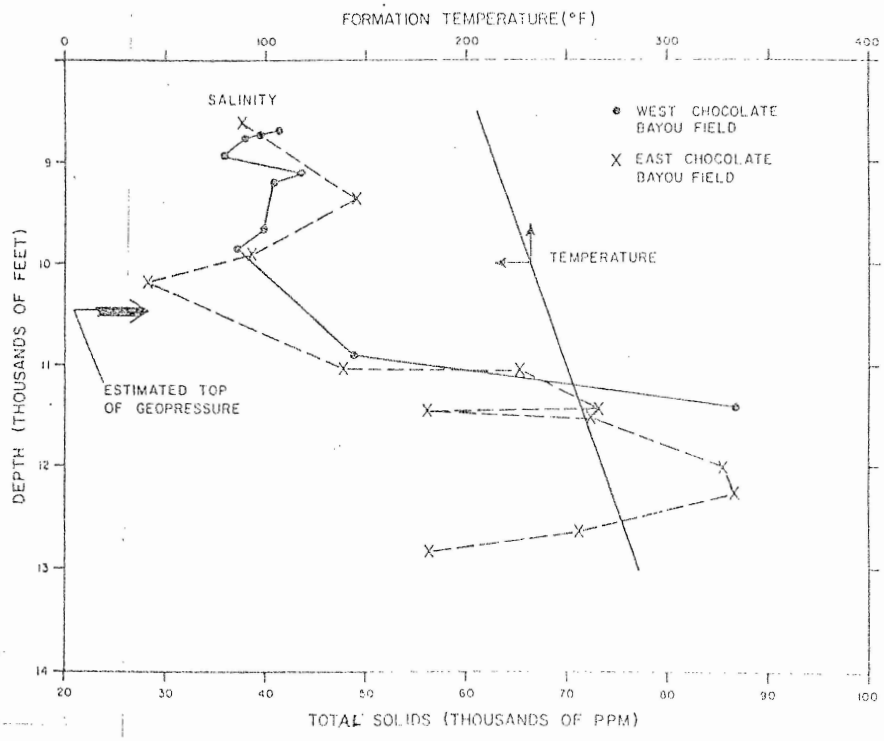

Figure 14. Salinity and temperature of formation waters, Chocolate Bayou field, Brazoria County, Texas.

CANDELARIA PROSPECT
Kenedy County, Texas
Frio Formation

Location (figs. 1 and 15)

The prospect is in the area of the Candelaria Field (Armstrong Fairway) in west-central Kenedy County, Texas. The test-well site is two miles north of the town of Armstrong (25S-18E-5).

Depth of Reservoir Sandstones (fig. 16)

Depth to the top of reservoir sandstones in the Candelaria Prospect is 10,700 feet (top of geopressure). Deepest prospective sandstones in the prospect are estimated to be at depths of 15,000 to 16,000 feet.

Sandstone Thickness and Character (fig. 16)

Sandstone thickness from top of geopressure to a temperature of 300°F on the type log is 1050. Sandstones in this zone are in units up to 250 feet thick separated by shales up to 70 feet thick. Individual sandstone beds range in thickness from a few feet to 20 feet and are separated by thin shales commonly less then 20 feet thick.

Sandstone thickness from a temperature of 300°F to the bottom of the prospective zone is more than 450 feet. Sandstones in this zone are in units 200 to 400 feet thick, separated by shales 200 to 500 feet thick. Individual sandstone beds range in thickness from a few feet to 10 feet and are separated by thin shales.

Total sandstone from the top of geopressure to the bottom of the prospective zone is more than 1500 feet in the type well. In a structurally lower area than the type well more sandstone should occur above a temperature of 300°F than in the type well. An estimated 635 feet of sandstone should be encountered with fluid temperature above 300°F.

Areal Distribution and Reservoir Boundaries (fig. 15)

The reservoir is bounded on the northwest, northeast, and southeast by faults. To the southwest the sandstones are expected to grade into shales. Estimated areal extent of the reservoir is at least 44 square miles.

Permeability, Porosity

Swanson and others (1975) in DOE contract report E(11-1)-2687 estimate representative permeabilities in the prospect area to range from

0.26 to 0.6 millidarcys for sandstones with temperatures greater than 300°F. Whole-core analyses in Kenedy County show that in the zone from the top of geopressure to a temperature of 300°F permeabilities range from 30 to 60 millidarcys in the better-quality sandstones. Average porosity in this zone is 15 percent. Deeper than 300°F, permeabilities are generally one millidarcy or less with a few sandstones having permeability readings between one to ten millidarcys. Average porosity in this zone is 13 percent.

Temperature (fig. 17)

Temperatures of 200°F and 300°F in the type well occur at 8100 feet, and 13,400 feet, respectively. Swanson and others (1975) have estimated the 300°F isotherm in the Candelaria Field to be at 12,800 feet. The highest fluid temperature expected is approximately 340°F.

Pressure (fig. 18)

The top of geopressure in the type well is at 10,700 feet as indicated by a shale resistivity-versus-depth plot.

Salinity

Swanson and others (1975) report salinities in deep sandstones of Kenedy County to range from 35,000 to 110,000 ppm total dissolved solids.

Operators of Nearby Wells

Exxon Company is sole operator in the Candelaria Field area.

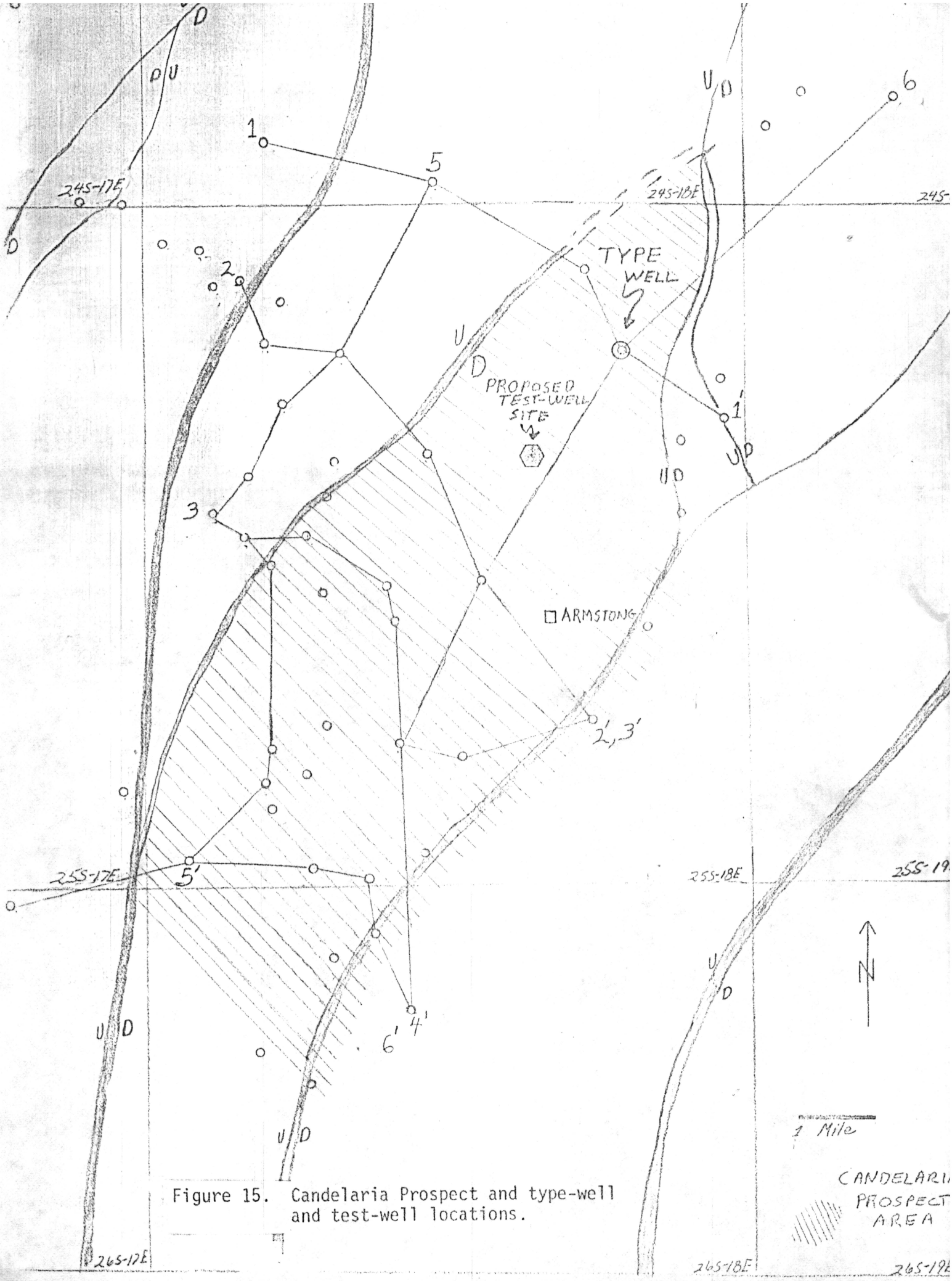

Figure 15. Candelaria Prospect and type-well and test-well locations.

Figure 16
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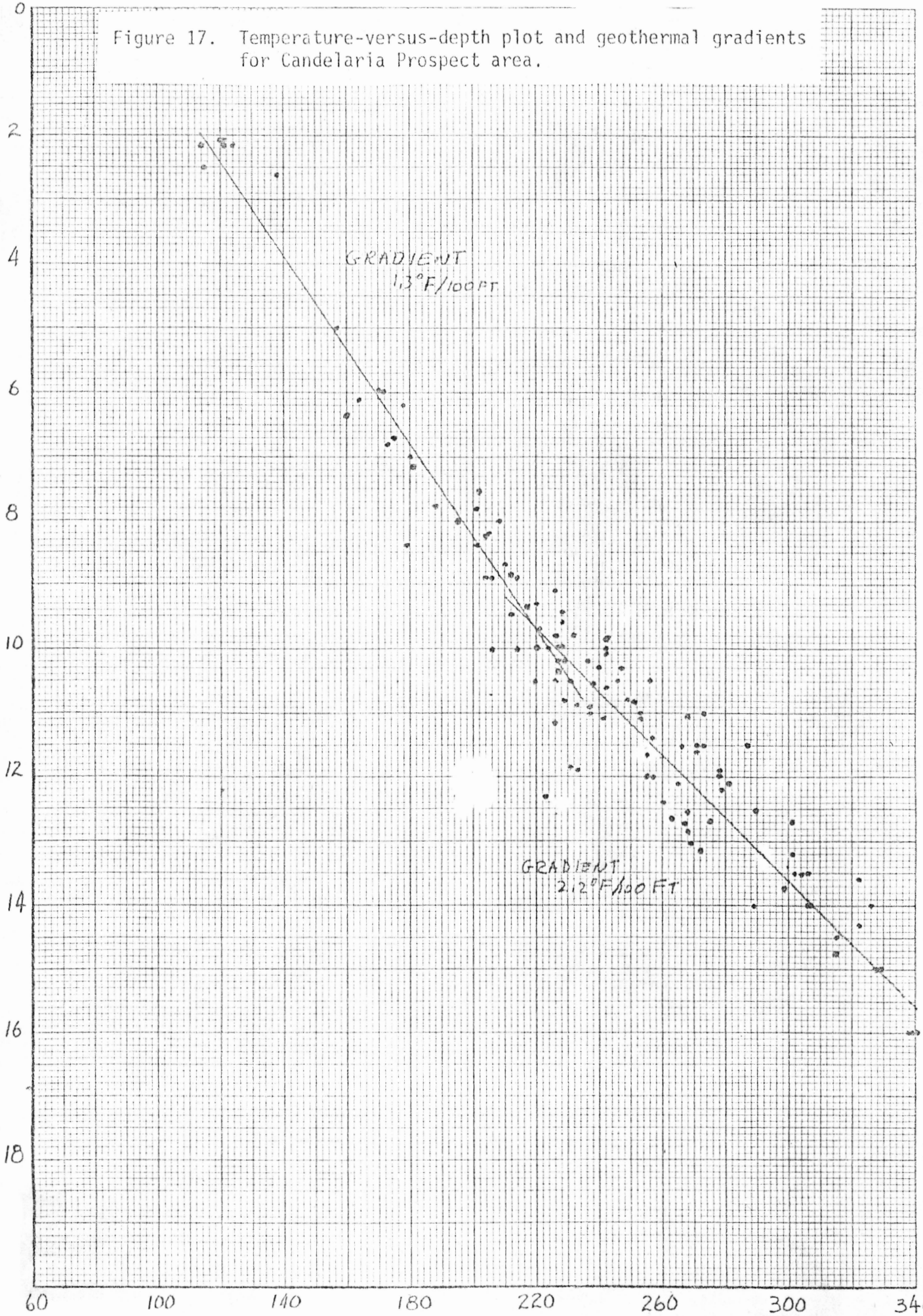
Figure 17. Temperature-versus-depth plot and geothermal gradients for Candelaria Prospect area.



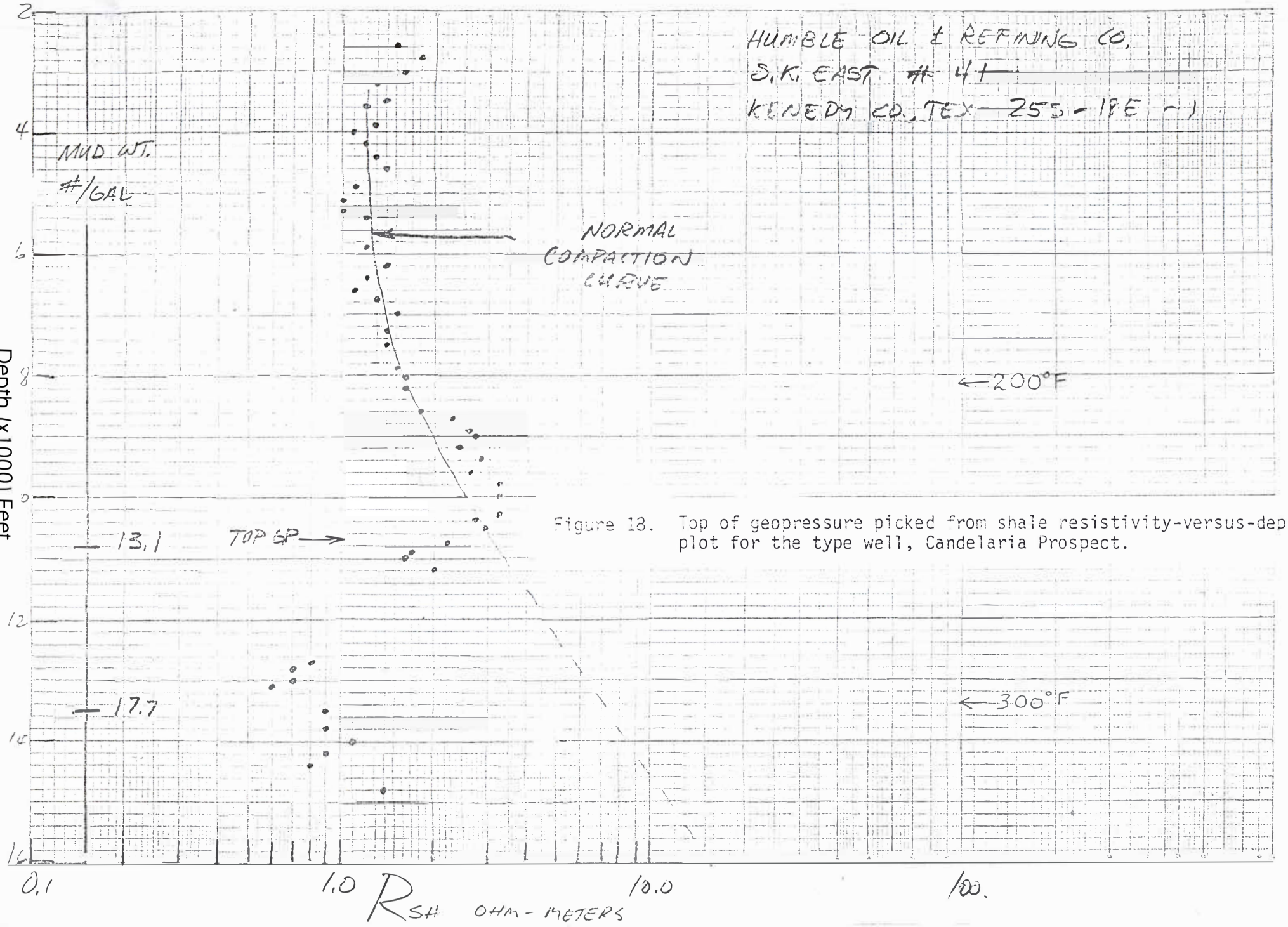


Figure 18. Top of geopressure picked from shale resistivity-versus-depth plot for the type well, Candelaria Prospect.

EAGLE LAKE PROSPECT
Colorado County, Texas
Wilcox Group

Location (figs. 1 and 19)

The prospect area in eastern Colorado County (3S-30E, 4S-30E) is centered approximately two miles northeast of the town of Eagle Lake. The Mohat gas field is located to the west of the prospect, the Eagle View and Chesterville North gas fields to the east and the Starr-Lite gas field to the south. None of these fields produce from the zone of interest in the Eagle Lake prospect area.

The proposed test-well site is two miles northeast of the town of Eagle Lake (4S-30E-2).

Depth of Reservoir Sandstones (fig. 20)

The top of the reservoir sandstones in the type well (Union No. A-1 Thomas) for the prospect area is at a depth of 11,180 feet (-10,976). Within the prospect area, the top of the reservoir sandstone interval ranges in depth from 10,960 feet to 11,400 feet. Although none of the existing wells in the prospect area penetrated the entire prospective interval, wells along strike but several miles from the prospect area indicate the total thickness of the prospective sandstone section to be approximately 1600 feet. Thus, the base of the reservoir sandstones in the prospect area should be at depths ranging from about 12,600 to 13,000 feet.

In the test well, the reservoir sandstone should occupy the interval from 11,280 to 12,880 feet.

Sandstone Thickness and Character (fig. 20)

On the basis of the sandstone percentage in the prospective interval of the type well and total interval thickness projected from adjacent areas, the net sandstone in the prospective reservoir is approximately 1050 feet. The sandstone beds range in thickness from 8 to 70 feet, and the intervening shale beds are from 5 to 40 feet thick. Similar sandstone thicknesses are expected in the test well.

Areal Distribution and Reservoir Boundaries (fig. 19)

The Eagle Lake Prospect, shown by the hatchured area on the map, covers approximately 10 square miles. The prospect area is elongate in a northeast direction and is bounded on the northwest and southeast by major faults. These faults are located on the map with respect to the top of the Wilcox. Both faults cut the top of the reservoir section farther to the southeast, however, so that the actual prospect area is

shifted in that direction. The area is bounded on the northeast and southwest by structural highs, where temperatures in the zone of interest are much cooler than in the prospect area.

Permeability, Porosity (fig. 20)

Whole-core analyses from the prospective interval in the type well show a range in porosity from 3.8 to 19 percent and in permeability from 0 to 545 millidarcys. Average porosity for the reservoir sandstone is 13 percent. Most of the reservoir sandstone section is characterized by low permeabilities; the very high permeabilities are found only in the core taken from 11,600 to 11,660 feet.

Temperature (fig. 21)

Temperatures in the prospect area are generally higher than the average temperatures at equivalent depths in other parts of the Harris-Colorado geothermal fairway. In the type well temperatures of 200°F and 300°F occur at depths of 6100 feet and 11,780 feet, respectively. Fluid temperatures in the reservoir section of the type well range from 275°F calculated for the top of the reservoir interval at 11,180 feet to 302°F recorded at the total depth of 11,826 feet.

In the test well, temperatures should range from approximately 280°F at the top of the reservoir interval to 325°F at the base.

Pressure (fig. 22)

As determined from mud weights, the highest pressure gradient in the type well is 0.634 psi/ft, which was reached at a depth of 11,300 feet. Bottom-hole pressure was calculated to be 7498 psi on the basis of that gradient. In the test well, the top of geopressure is expected to be at 12,000 feet or deeper.

Salinity

Salinity calculated from log analysis for the type well is approximately 90,000 ppm total dissolved solids.

Operators of Nearby Wells

Union, Shellworth, Davis, Ambassador, Mutex, Chicago, Victory, Alcoa and Lacy, Mosbacher.

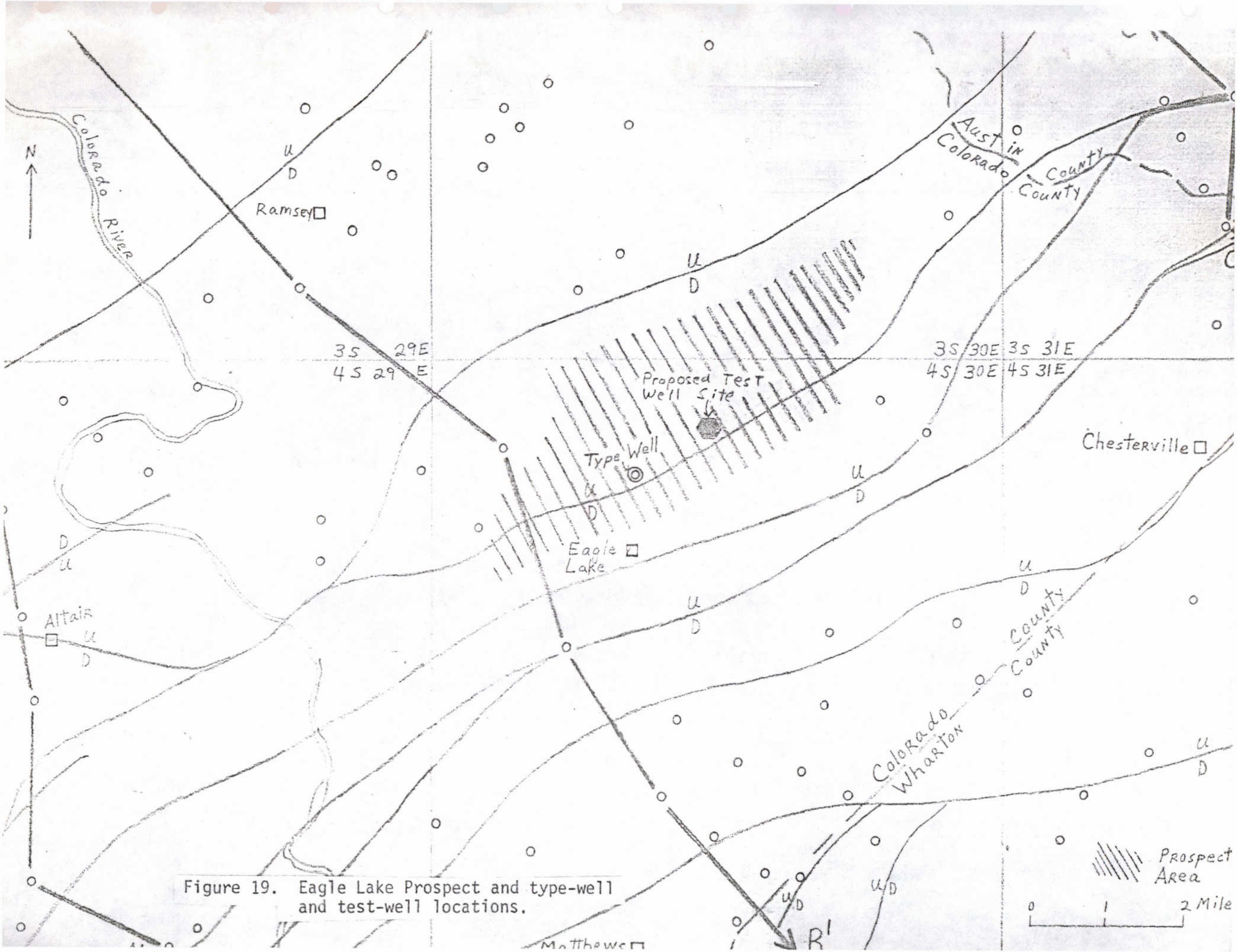


Figure 19. Eagle Lake Prospect and type-well and test-well locations.

Figure 20
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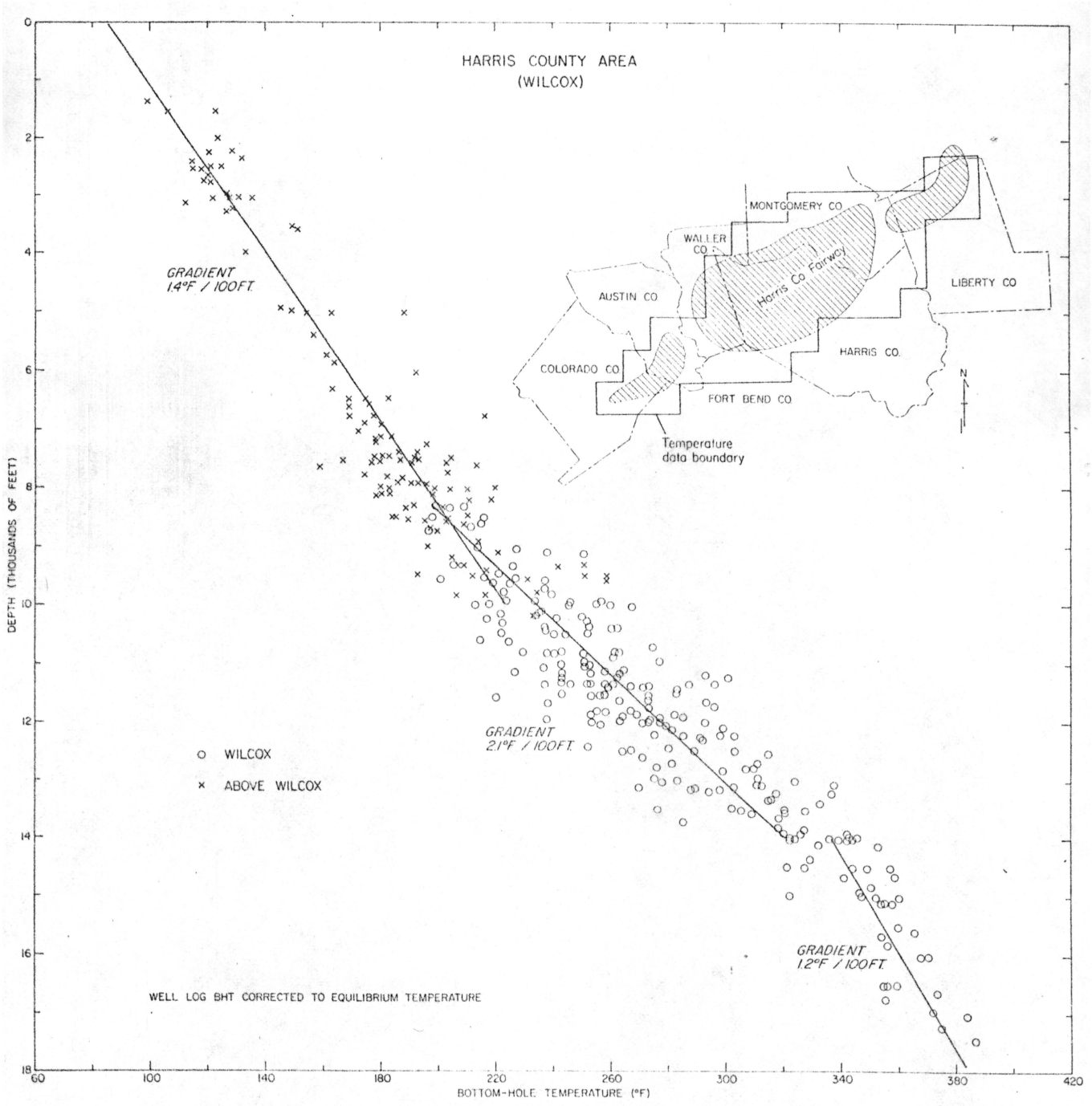

Figure 21. Temperature-versus-depth plot and geothermal gradients for the Liberty, Harris and Colorado County areas.

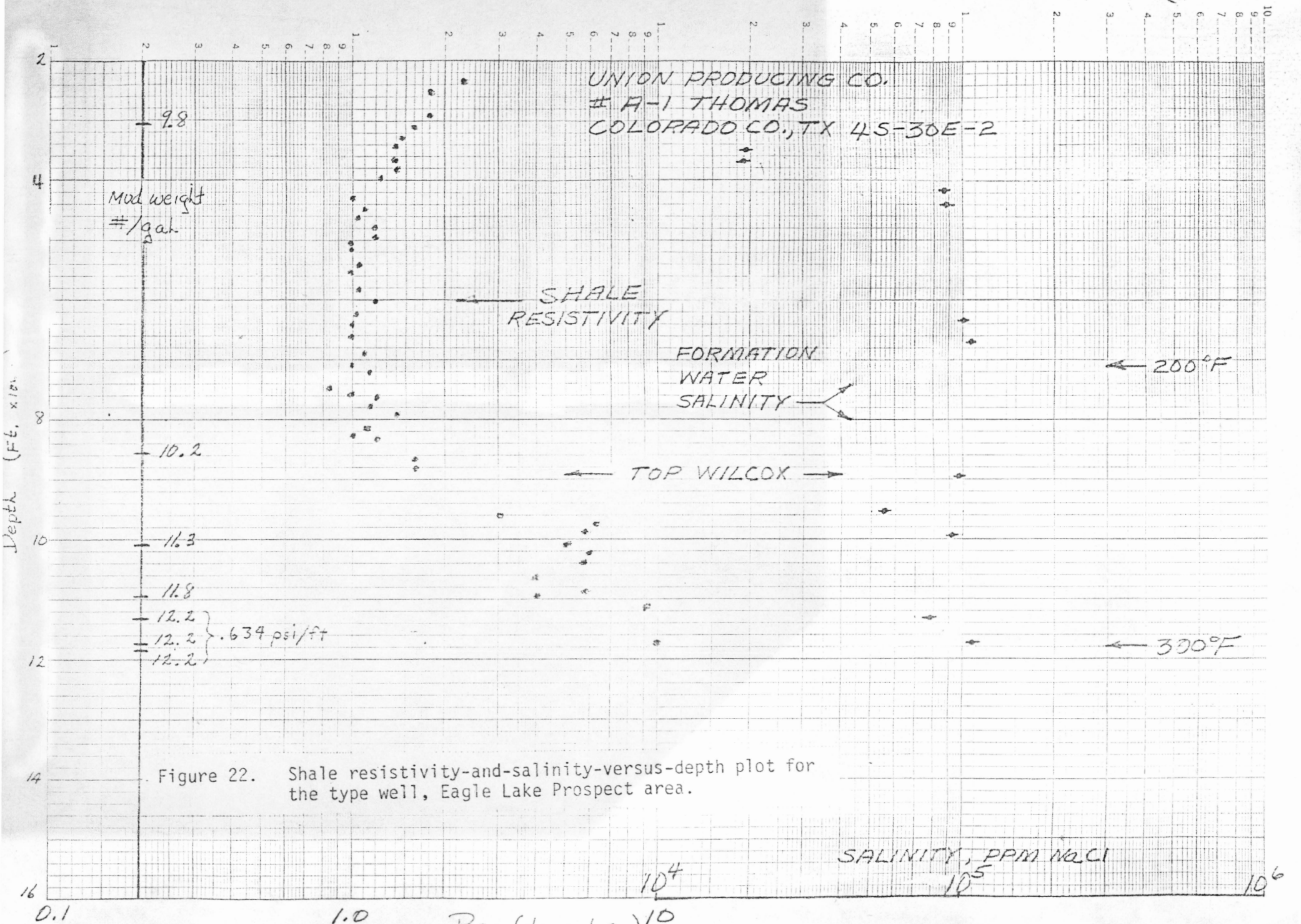

Figure 22. Shale resistivity-and-salinity-versus-depth plot for the type well, Eagle Lake Prospect area.

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