PROSPECTUS FOR A DESIGN WELL

IN THE BLESSING AREA

MATAGORDA COUNTY, TEXAS

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DISCLAIMER

TABLE OF CONTENTS

INTRODUCTION

In recent years, the Bureau of Economic Geology has conducted regional subsurface studies of the Wilcox Group and Frio Formation of Texas as part of the U. S. Department of Energy's assessment of deep geopressured geothermal resources along the Gulf Coast. These studies resulted in two reports (Bebout and others, 1978; 1979) that describe several areas in Texas where temperatures are greater than 300°F and where the geology and reservoir conditions are suitable for resource testing by a design well.

Throughout the Texas Coastal Plain the 300°F isotherm generally occurs at depths ranging from 12,000 to 16,000 ft. The overlying geopressured sediments represent a substantial portion of the sedimentary column that contains significant quantities of entrained methane and as such they represent a substantial portion of the resource base (Gregory and others, 1980). The lower temperatures and pressures of these shallow geopressured sediments result in lower methane solubility, but drilling costs would be substantially lower and perhaps reservoir quality would be better in comparison to the deep geopressured intervals. Although the latter condition has not been substantiated, several areas that are geologically favorable for testing shallow geopressured aquifers with temperatures less than 300°F were identified in a recently completed study (Weise and others, 1980) funded by the Gas Research Institute. The Blessing Prospect (fig. 1), one of the shallow prospects in Matagorda County, Texas, is presented in this prospectus as a candidate for the DOE design well program. The prospectus focuses on the geological and engineering aspects of the test site. Although legal and environmental considerations are mentioned, they have not been studied in detail and additional work would necessarily follow if the prospect is approved for drilling and testing. Likewise, a drilling program and an economic analysis would be necessary before final approval of a design well.

Location of Blessing Prospect

The Blessing Prospect encompasses approximately 170 mi^2 of the Texas Coastal Plain in western Matagorda County (fig. 1). Within this area, the fault block of primary interest covers about 36 mi^2, and is centered in the western half of section 10S-31E (fig. 2). The proposed test area is about 4 mi south of the town of Blessing, on the southern flank of the Blessing Field, an established area of hydrocarbon production. The test area is accessible from State Highway 35 (fig. 21).

Type Well

The Texaco no. 16 Thomas (figs. 2 and 3) is characteristic of the wells that penetrate the Frio Formation near Blessing. Judging from the type well, the total depth of the proposed test should be about 11,500 ft. Log data for the type well indicate that the top of the transition zone (pressure gradient greater than 0.465 psi/ft) was encountered at about 8,500 ft and a pressure gradient of 0.7 psi/ft occurs at about 10,000 ft (fig. 3).

Test Site

For reference to figures presented in this report, the proposed test site is located between the Texaco no. 16 Thomas and the Superior no. 1 Nelson wells (figs. 2 and 6). This area east of the type well has favorable sand development and structural position but the leasing situation is presently unknown; consequently, a specific drilling site has not been selected.

RESERVOIR CHARACTERISTICS

Subsurface conditions likely to be encountered in a test well were estimated using standard techniques of well log correlation and log derivations.

Net Sandstone

The objective section occurs below the B5 marker (figs. 3 and 4) in the lower Frio Formation. This section contains up to 500 ft of net sandstone (fig. 5) in the fault block of interest. Thinning of net sandstone to the north is attributed to the strike orientation of the sand body as well as expansion of the section on the downthrown side of a major growth fault. Expansion of the section is also accompanied by increased thickness of shale and possibly increased frequency of shale breaks within the sandstone intervals.

In the type well and near the proposed test area, net sandstone thickness in the B5-B6 interval is 380 ft with individual beds ranging in thickness from 30 to 100 ft. Two massive sands (B Sand and C Sand) within the B5-B6 interval are prospective geopressured reservoirs (figs. 3 and 6). The northeast-southwest strike orientation of these two sands is reflected in the overall trends of the net sandstone and log pattern maps (figs. 7-10).

Areal Distribution and Reservoir Boundaries

The fault block of primary interest is 2 to 4 mi wide and 7 to 10 mi long (fig. 11) and encompasses a maximum area of about 36 mi^2. The reservoir section is bounded on the northwest and southeast by major growth faults (figs. 12 and 13) that exhibit vertical displacements of about 2,000 and 4,000 ft respectively at the B5 horizon. Cross faults with displacements of 300 to 1,000 ft form the eastern and western boundaries of the fault block. The southeastern boundary also coincides with a significant facies change, and a rapid thinning of individual sandstone units. Stratigraphic boundaries within the fault block are also suggested by the thinning of sandstone bodies to the northwest and southeast (figs. 7 and 9). Well control within the primary fault block shows that the best sand development covers a minimum area of about 15 mi^2.

Sandstone Thickness and Character

The B and C Sands generally exhibit similar spatial variations in thickness and SP character (figs. 7-10). The thickest and best sand development with the lowest frequency of major shale breaks occurs in the eastern part of the fault block (figs. 8 and 10). Northwest and southeast of the area of maximum sand development, sand thickness decreases and shale thickness increases as both sands grade into interbedded sand and shale. The B Sand ranges in thickness from 100 to 160 ft in the vicinity of the test site, whereas the C Sand varies in thickness from 70 to 120 ft. The lack of deep well control precludes precise definition of thickness and vertical distribution of the C Sand in the northwestern part of the fault block; however, inference can be made from the general sand trends in nearby areas.

Porosity and Permeability

Analyses of sidewall cores from the Texaco no. 16 Thomas well show a general decrease in porosity and permeability with depth (figs. 14 and 15). These analyses also show a reasonable positive correlation with each other (fig. 16). Sidewall samples from the B Sand have porosities ranging from 18 to 21% and permeabilities ranging from 17 to 28 md; average porosity and permeabilitv for this interval are 18% and 23 md respectively. Core analyses for the C Sand are similar to those for the B Sand. The C Sand has porosities ranging from 12 to 22% and permeabilities ranging from 5 to 56 md; average porosity and permeability for the C Sand are 21% and 26 md respectively. These measured permeabilities for the B and C Sands are comparable to permeabilities predicted by the linear relationship with porosity shown in figure 16.

The few core analyses for the B Sand suggest a slight upward increase in porosity and permeability, perhaps reflecting the coarsening upward trend within the sand body. Similar relationships of inferred grain size and reservoir quality are also present in the C Sand, which shows an upward decrease in porosity and permeability.

Formation Temperature

Measured temperatures corrected for equilibrium conditions in the type well increase linearly with depth and range from 200° to 300°F in the geopressured zone (fig. 17). From this trend, temperatures for the B and C Sands are estimated to be 241° and 248°F respectively (Table 1). These temperatures represent a thermal gradient of 2.2°F/100 ft; or a gradient comparable to the composite trend for the shallow geopressured zone in Matagorda County (Weise and others, 1980).

Minimum values for uncorrected measured temperatures in the type well near the zone of interest are 188°F at 9,800 ft and 246°F at 12,790 ft. Maximum bottom hole temperature measured at 15,000 ft in the Texaco no.16 Thomas well was 280°F which is equivalent to 310°F when corrected to equilibrium conditions.

Formation Pressure

In the absence of field measurements, formation pressures for the objective sands in the type well were calculated using a shale resistivity plot (fig. 18) in conjunction with bottom hole shut-in pressures from area wells. Pressures estimated for the B and C Sands from these data are 8,238 and 8,636 psi respectively. These values indicate corresponding pressure gradients of 0.76 and 0.77 psi/ft.

According to log header information from nearby wells, an intermediate casing string is commonly set where pressure gradients approach 0.7 psi/ft. The type well was drilled using mud with a weight of 11.8 lb/gal to 9,800 ft where 9 5/8 inch casing was run. Below casing, mud weighing 15.8 lb/gal was required to drill the deep geopressured zone (fig. 18).

Salinity of Formation Water

Because the objective sands are nonproductive near the test site. water samples have not been collected for chemical analyses and salinity measurements. Therefore salinities have been estimated with disparate results because of different methods of computation. The sonic log and Rmf (header) calculations are in close agreement whereas the Rmf curve method proposed by Henry Dunlap gives estimates more than twice those of the other two methods. Salinities calculated for the B and C Sands using the Dunlap curve are 97,000 and 85,000 ppm respectively (Table 1).

In contrast, salinities calculated by the Dunlap method for the same sands in the Superior No. 1 Nelson and Halbouty No. 1 McDonald wells range from 65,000 to 74,000 ppm.

Methane Solubility

The empirical relationships developed by Blount and others (1979) indicate that concentrations of dissolved gas in the B and C Sands should be 28 and 30 scf/bbl respectively, given the conservative estimates (highest salinity values) for in situ conditions described in preceeding sections. However, gas to water ratios reported for wells of opportunity typically are about 85% lower than predicted by theoretical equations. When adjusted for this discrepency, estimates of methane solubility for the two sands are 24 and 26 scf/bbl. These values, which were used to estimate the volume of methane in place, represent a minimum expected concentration of methane. The actual concentrations could be higher if salinities are lower, as indicated by estimates for adjacent wells, or if dispersed free gas is present, as indicated by sidewall core analyses at the top of the B Sand.

Resource Estimates

The volume of water and solution gas contained in the B and C Sands (Table 1) were estimated assuming average porosities of 18 and 21% and saturated conditions. Because of the uncertainties in parameters such as salinity, porosity, and areal extent, these estimates are intended to convey only the magnitude of the resource.

	Reservoir Area mi^{2}	Reservoir Water Volume $x\ 10^9$ bbl	Methane in place $x\ 10^9$ scf	Estimated Recoverable Methane (5%) $x\ 10^9$ scf
B Sand	36	2.9	69	3.5
C Sand	36	2.8	73	3.6

Collectively these estimates suggest an in-place resource of more than 140 billion scf of gas, of which approximately 7 billion scf is recoverable.

Character of Disposal Sands

Interbedded sands and shales of Miocene age occur down to about 5,800 ft in the Blessing Prospect area (fig. 3). The sands are 20 to 150 ft thick and are separated by 20 to 250 ft of intervening shale. These shallow aquifers represent the shallowest intervals suitable for brine injection. The primary disposal sand occurs at 5,650 ft in the type well (fig. 3) and has a net thickness of 130 ft.

This well developed sand occurs in a large fault block (fig. 19) and is laterally continuous east of the test area; however, it grades into thin sands and interbedded shales to the west and northwest of the test area (fig. 20). Subsurface conditions calculated for the disposal sand are as follows: porosity, 29%; temperature, 155°F; pressure, 2,650 psi; and salinity, 185,000 ppm.

Overlying sands at 5,300 and 5,110 ft are 70 and 60 ft thick, respectively. Other sands available for injection occur at depths between 2,000 and 2,800 ft. However, these sands are less attractive for disposal because they are thinner and less continuous than the sands below 5,000 ft.

According to records provided by the Texas Department of Water Resources, the nearest injection of industrial wastewater in Miocene sands occurs approximately 13 miles northeast of the test site. These injection wells, operated by the Celanese Chemical Company, should not interfere with disposal of geothermal brines because the wastewater is being injected in the shallow zones between 3,400 and 3,700 ft.

LEGAL CONSIDERATIONS

Surface Constraints

Potential geopressured reservoirs penetrated in the Blessing Prospect fault block are best developed in an area between the Texaco no. 16 Thomas and Superior no. 1 Nelson wells (fig. 6). Commercially available base maps for this area suggest that leasing for a design well would probably involve several land owners and several operators with extant leases (fig. 21). For this reason, a specific well site has not been identified. Furthermore, the Blessing Field infrastructure (wellheads, gathering systems, pipelines, utility lines) could partly determine the location of a design well.

Nearby Production

Frio sandstones are productive in the fault block of interest; however, most of the hydrocarbon production is at least 700 to 1,200 ft above the geopressured aquifers. Elsewhere, gas is produced from the objective interval in the Trull and Pheasant SW fields approximately 6 mi down local structural dip (southwest) from the test area. The structural configuration and production data from these fields indicate that the gas producing sands are not in communication with the objective aquifers. Also the potential injection sands in the Miocene section are not productive in the area of interest.

ENVIRONMENTAL CONSIDERATIONS

Land Use

The Blessing Prospect underlies crop lands, uncultivated rangeland and pastures, and the Blessing oil and gas field. Agricultural activities in the area are primarily directed toward production of rice and cotton. Native vegetation established in uncultivated fields is predominantly prairie grasses with some mesquite, huisache, chaparral, and cactus (McGowen and others, 1976).

Potential Environmental Impacts

Preliminary assessment of available data (McGowen and others, 1976) reveals that potentially adverse environmental impacts are similar to but less than those encountered at the site of the DOE-GCO No. 2 Pleasant Bayou. One major difference is that the Blessing Prospect is not in a flood-prone area or an area of known subsidence (Brown and others, 1974). The land is characterized by Pleistocene uplands with elevations of 25 to 30 ft above sea level. Surficial sediments are Pleistocene sands and silts of distributary origin and sand-veneered muds deposited in interdistributary areas (McGowen and others, 1976).

Surface drainage in the area is limited to one natural stream, Cashs Creek, and a network of man-made levees and drainage canals, including Turtle Creek, that are used for irrigating cultivated fields. Cashs Creek, which crosses the eastern part of the prospect, is a minor tributary to Tres Palacios Bay.

SUMMARY

The Blessing Prospect is recommended for drilling and testing as part of the Department of Energy's design well program for the following reasons.

- The prospective fault block is large.
- Geopressured aquifers occur at relatively shallow depths.
- Reservoir sandstones are well developed and laterally extensive.
- Estimated formation temperature, pressure, and salinity suggest that methane concentrations are attractive for a shallow test.
- Porosity and permeability of the objective sandstones indicate good reservoir quality.
- The potential for adverse environmental impacts is minimal.
- The site is adjacent to an area of hydrocarbon production including pipelines.
- Estimated in-place resources are substantial.

REFERENCES

Bebout, D. G., Loucks, R. G., and Gregory, A. R., 1978, Frio sandstone reservoirs in the deep subsurface along the Texas Gulf Coast: The University of Texas, Austin, Texas, Bureau of Economic Geology, Report of Investigations 91, 92 p.

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Brown, L. F., Jr., Morton, R. A., McGowen, J. H., Kreitler, C. W., and Fisher, W. L., 1974, Natural hazards of the Texas Coastal Zone; The University of Texas, Austin, Texas, Bureau of Economic Geology, 13 p.

Gregory, A. R., Dodge, M. M., Posey, J. S., and Morton, R. A., 1980, Volume and accessibility of entrained (solution) Methane in deep geopressured reservoirs — Tertiary formations of the Texas Gulf Coast: The University of Texas at Austin, Bureau of Economic Geology, Report to the Department of Energy, Division of Geothermal Energy Contract No. DE-AC08-78ET01580.

McGowen, J. H., Brown, L. F., Jr., Evans, T. J., Fisher, W. L., and Groat C. G., 1976, Environmental geologic atlas of the Texas Coastal Zone — Bay City-Freeport area: The University of Texas, Austin, Texas, Bureau of Economic Geology, 98 p.

Weise, B. R., Edwards, M. B., Gregory, A. R., Hamlin, H. S., Jirik, L. A., and Morton, R. A., 1980, Geologic studies of geopressured and hyrdopressured zones in Texas, test-well site selection: The University of Texas, Austin, Texas, Bureau of Economic Geology, Report to the Gas Research Institue, Contract No. 5011-321-0125, 349 p.

TEXAS PROSPECT EVALUATION FORM

PROSPECT: Blessing

LOCATION: Matagorda County

KEY WELL(S): Texaco H. H. Thomas # 16

TOTAL DEPTH: 15,000 ft

PRODUCING FORMATION(S): Frio

INTERVAL: 10,700 - 11,500

	Sand B	Sand C
DEPTH (BEST SAND): GROSS	10,790 ft	~~XXXX~~ 11,160 ft
SAND THICKNESS (BEST SAND):	100 ft	70 ft

OTHER SANDS - RANGE THICKNESS: ______ AVERAGE THICKNESS ______

SEPARATION DISTANCE: MAXIMUM 400 ft AVERAGE ______

	Sand B	Sand C
PRESSURE (BEST SAND): (psi)	8,238 (0.76 psi/ft)	8,636 (0.77 psi/ft)
TEMPERATURE (BEST SAND):	241°F	248°F
POROSITY/PERMEABILITY (BEST SAND):	18% 17-28 md	21% 5-56 md
SALINITY (BEST SAND): (ppm)	97,000 (sp-log) 67,000 (Rwa)	85,000 (sp-log) 23,500 (Rwa)
CO_2 / H_2S (EXPECTED ?; % ?):	<10% CO_2 no H_2S	
EXPECTED G/W RATIO (BEST SAND):	28 (24) scf/bbl	30 (26) scf/bbl

DISPOSAL FORMATION(S): Miocene

DEPTH (BEST SAND): 5,650 ft

SAND THICKNESS (BEST SAND): GROSS 150 ft NET 130 ft

OTHER SANDS - DEPTHS AND THICKNESSES: 5,300 (70 ft), 5,110 (60 ft)

Other sands in interval between 2,000 and 2,800 ft

POROSITY (BEST SAND): 29%

SALINITY: 185,000 ppm

PRESSURE: 2,650 psi

TEMPERATURE: 155°F

PROBABLE SWD WELLSITE LOCATION: Unknown, should check possibility of brine use in field pressure maintenance projects.

STRUCTURE: Major bounding growth faults with anti-regional dip

FAULT BLOCK / RESERVOIR EXTENT: 36 sq mi, reservoir probably less

PRODUCTION FROM AQUIFERS IN STRUCTURE: YES X NO

(EXPLAIN: Gas production in Trull and Pheasant SW fields approximately 6 mi downdip (southwest) from test site, reservoir not in communication with updip aquifers.)

PROBABLE WELLSITE LOCATION: East of Texaco Thomas #16

WELLSITE ADJUSTABLE UP TO 5,000+ FEET

LAND, MARSH, WATER: Land

LAND USE: hydrocarbon production

AGRICULTURE? CROPS?

FORESTED? FALLOW? uncultivated rangeland

PROBABLE RENTAL COST ACRE: MAXIMUM MINIMUM

LANDOWNERSHIP: Texaco, Southland, Halbouty, others

SMALL PARCELS, MANY OWNERS: yes

LARGE BLOCKS, ONE OWNER:

OTHER:

ENVIRONMENT: upland

POTENTIAL PROBLEMS? YES NO X

(EXPLAIN: potential less than at Brazoria, Blessing is an area of hydrocarbon production and not in flood prone area

LEASE POTENTIAL:

OWNERSHIP PLAT AVAILABLE:

MINERAL LEASE PLAT AVAILABLE:

AMOUNT OF ACREAGE REQUIRED:

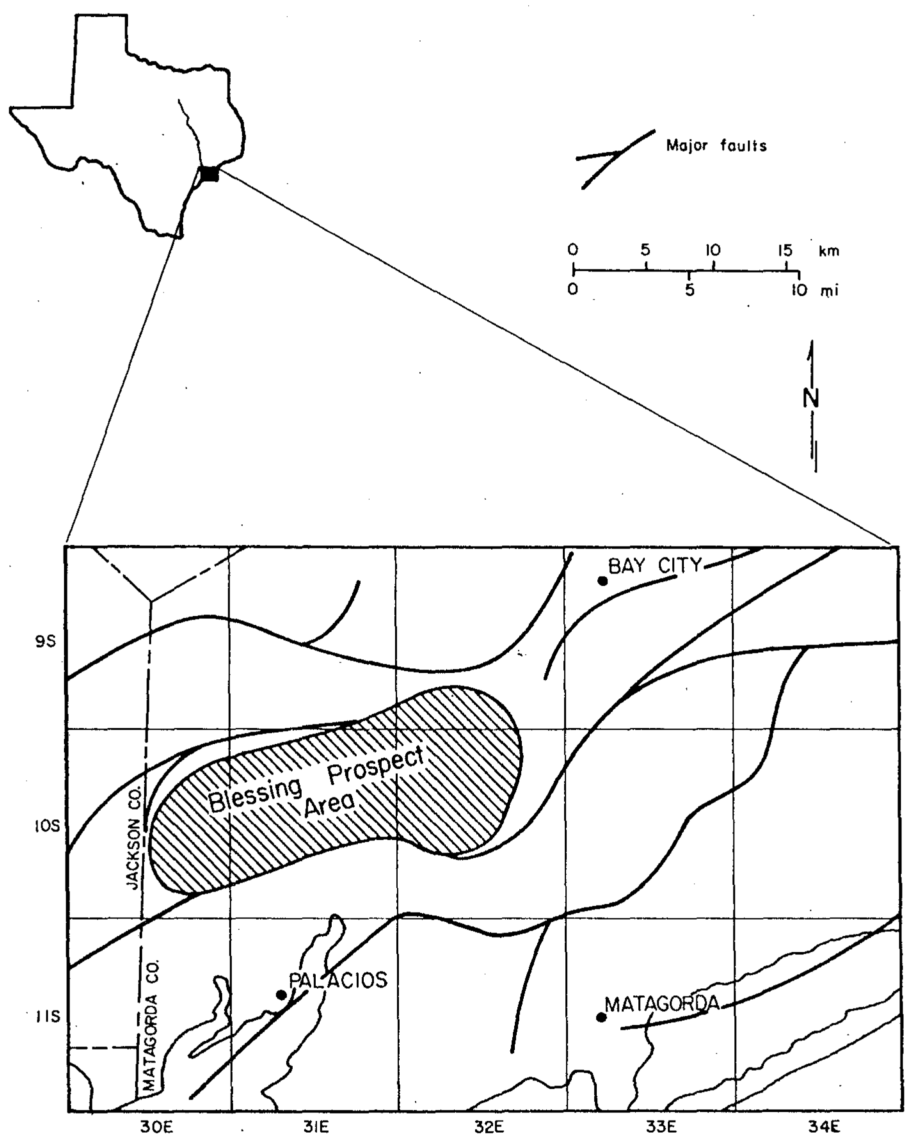

Figure 1. Location of Blessing Prospect area.

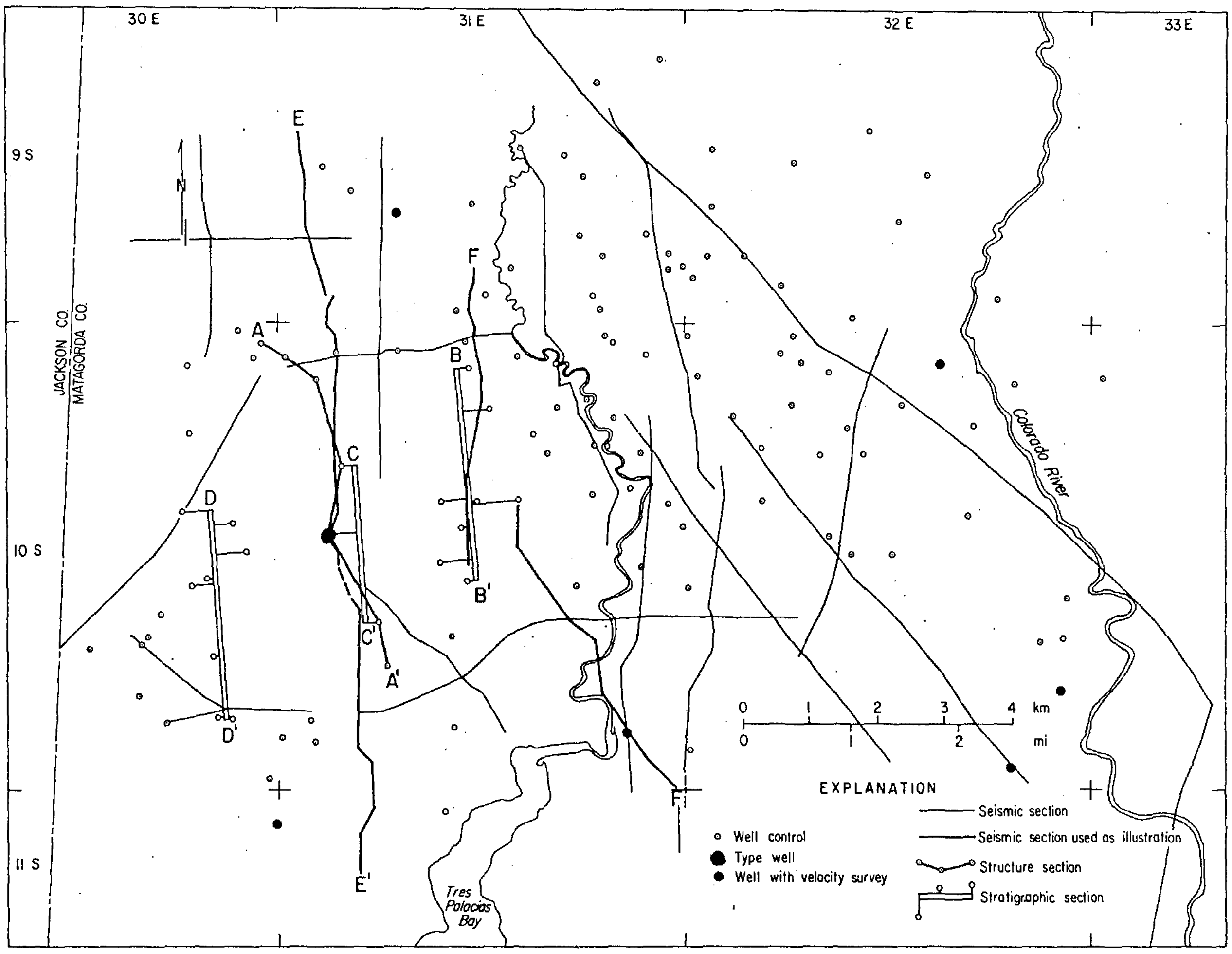

Figure 2. Base map showing locations of available deep well control, seismic sections, and velocity surveys.

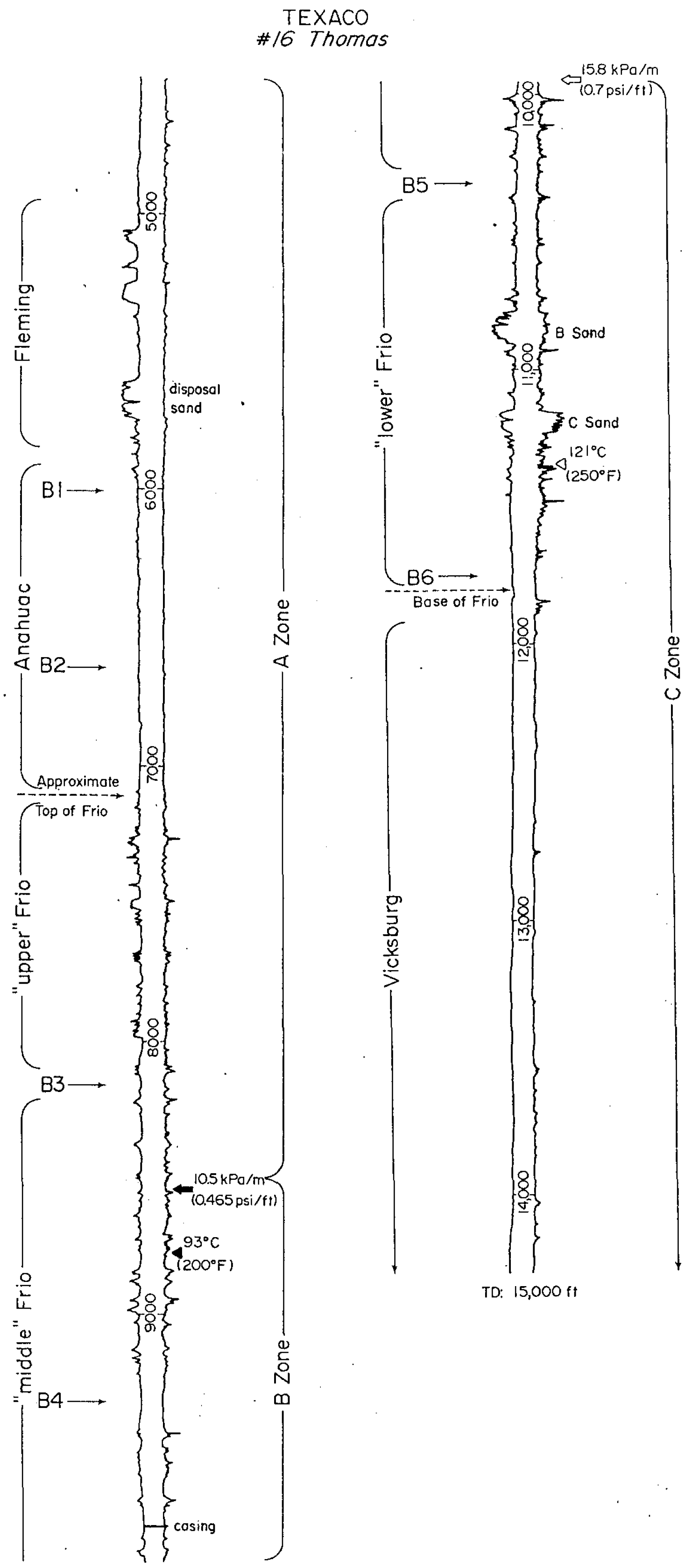

Figure 3. Induction log for the type well, Blessing Prospect area.

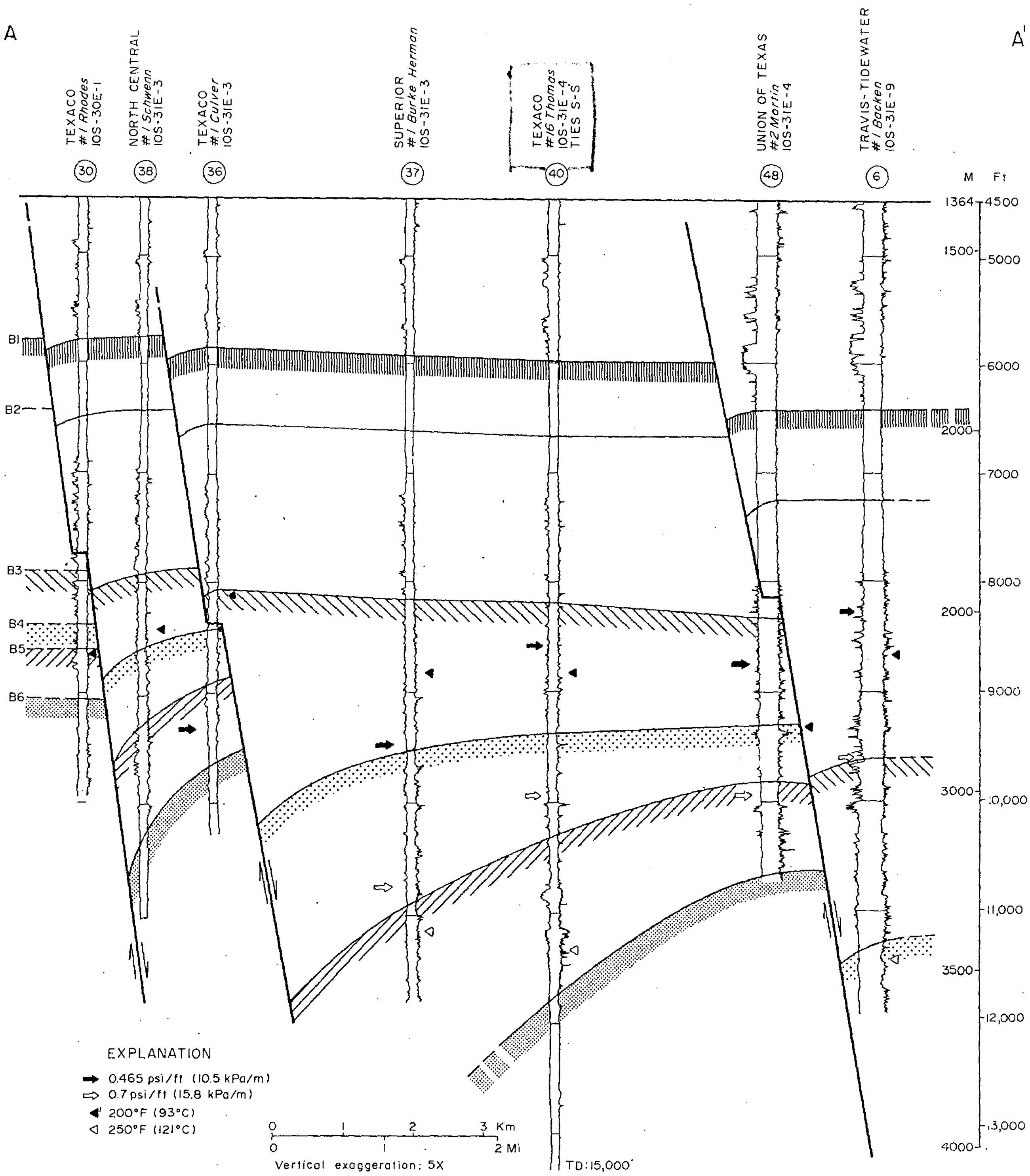

Figure 4. Structural dip section A-A', Blessing Prospect area. Location shown on Fig. 2.

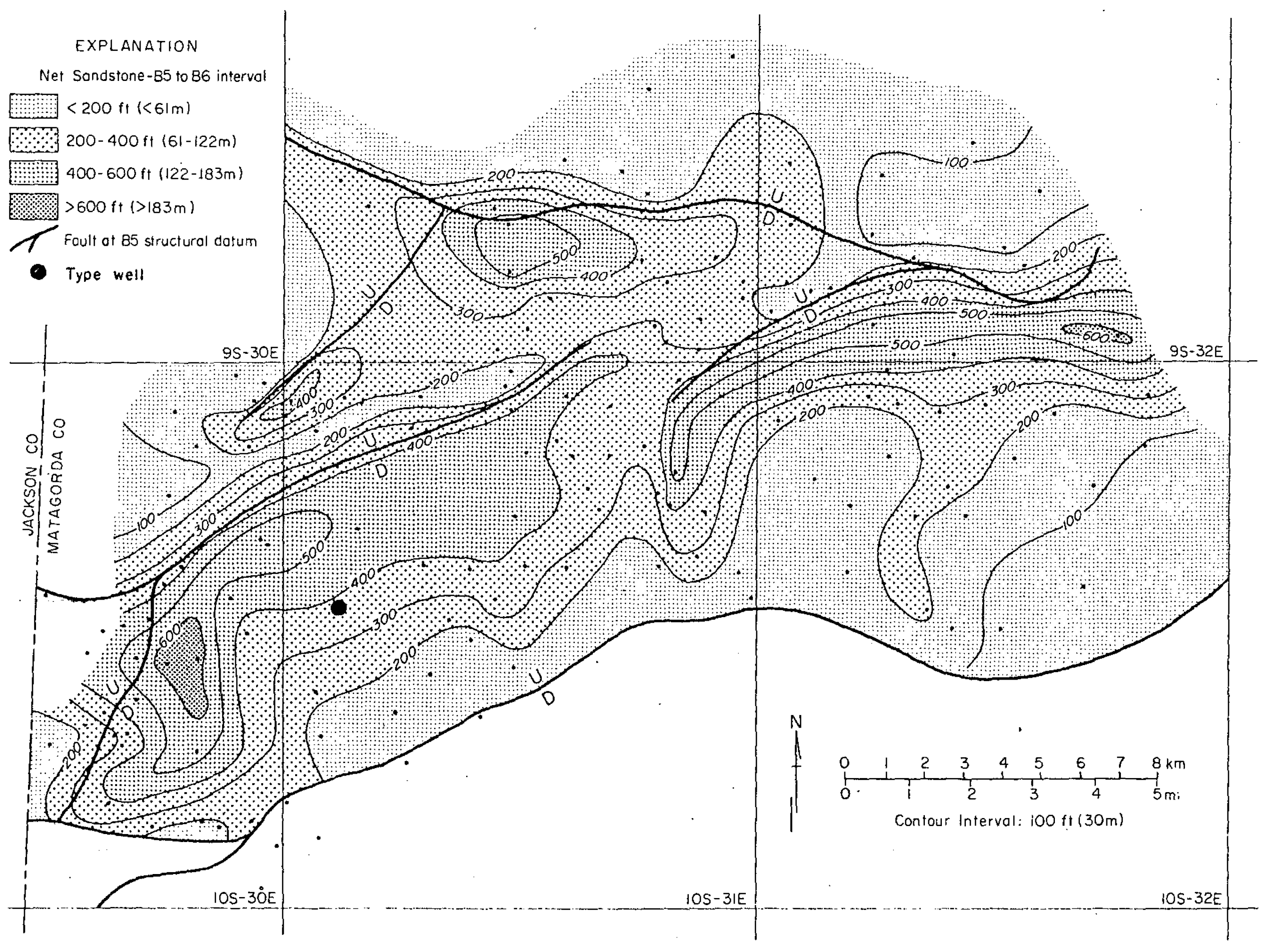

Figure 5. Net sandstone, B5 to B6 interval, Blessing Prospect area.

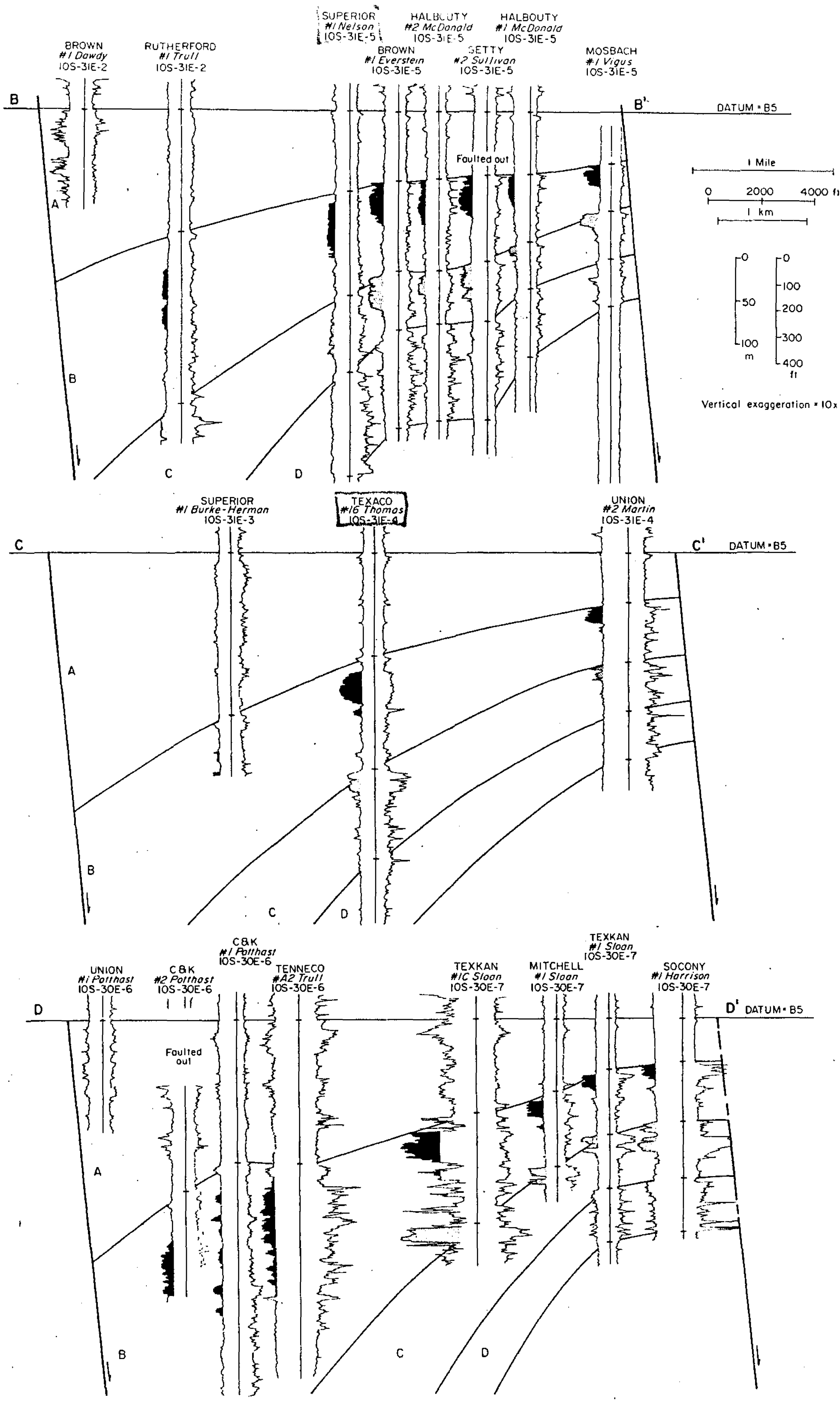

Figure 6. Stratigraphic dip sections B-B', C-C', and D-D', Blessing Prospect area. Locations shown in Fig. 2.

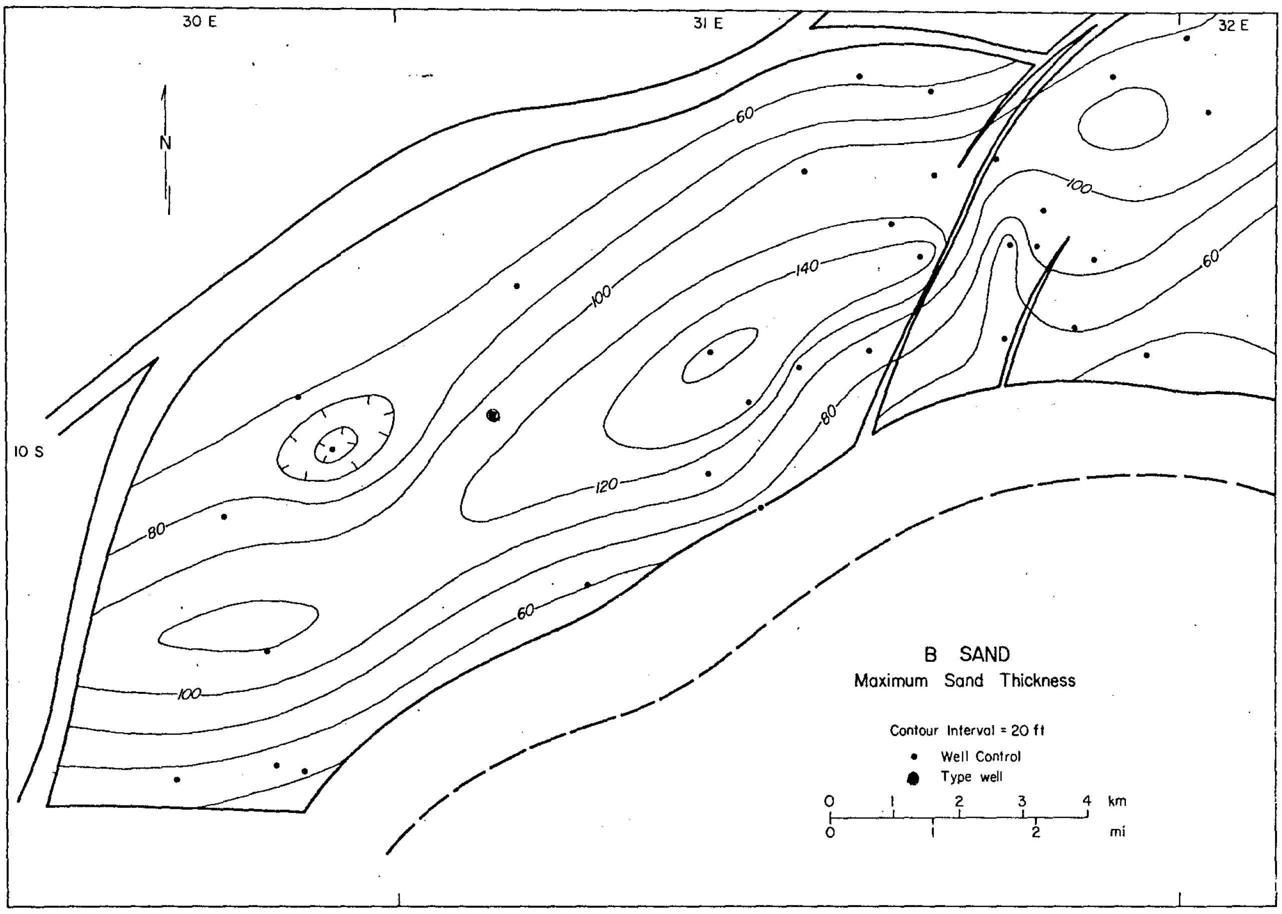

Figure 7. Net sandstone map B Sand, Blessing Prospect area. Structure mapped on B5 horizon.

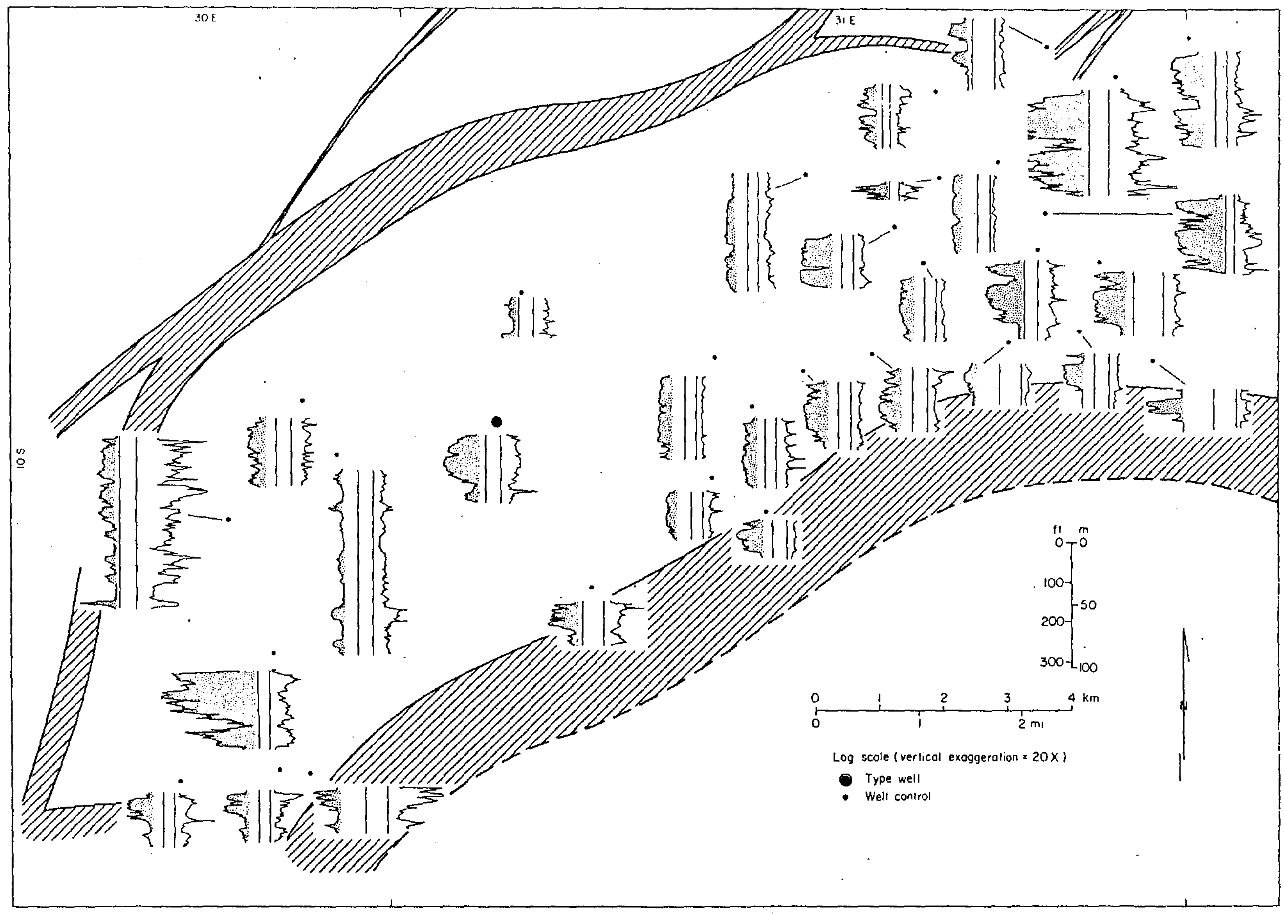

Figure 8. Log pattern map B Sand, Blessing Prospect area. Structure mapped on B5 horizon.

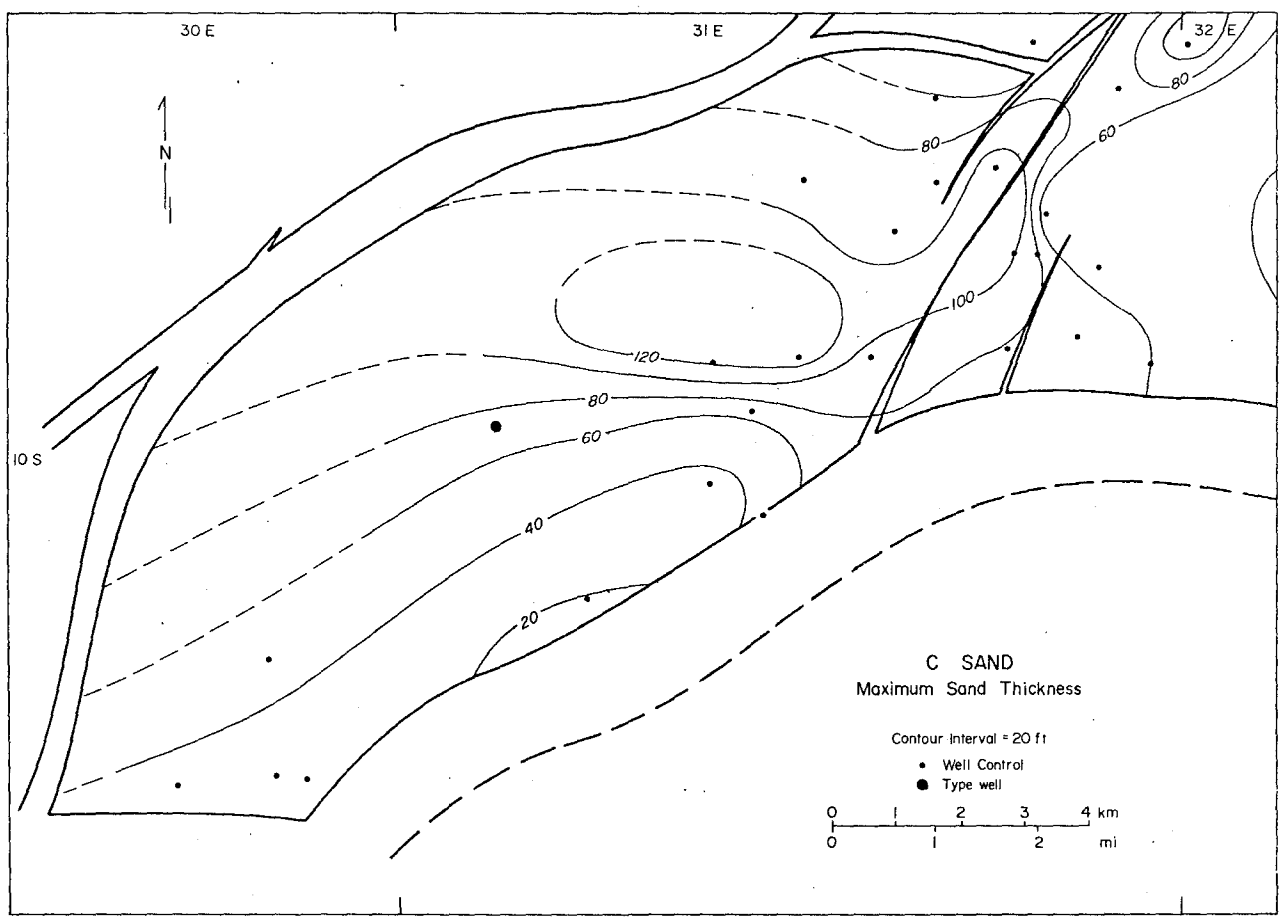

Figure 9. Net sandstone map C Sand, Blessing Prospect area.
Structure mapped on B5 horizon.

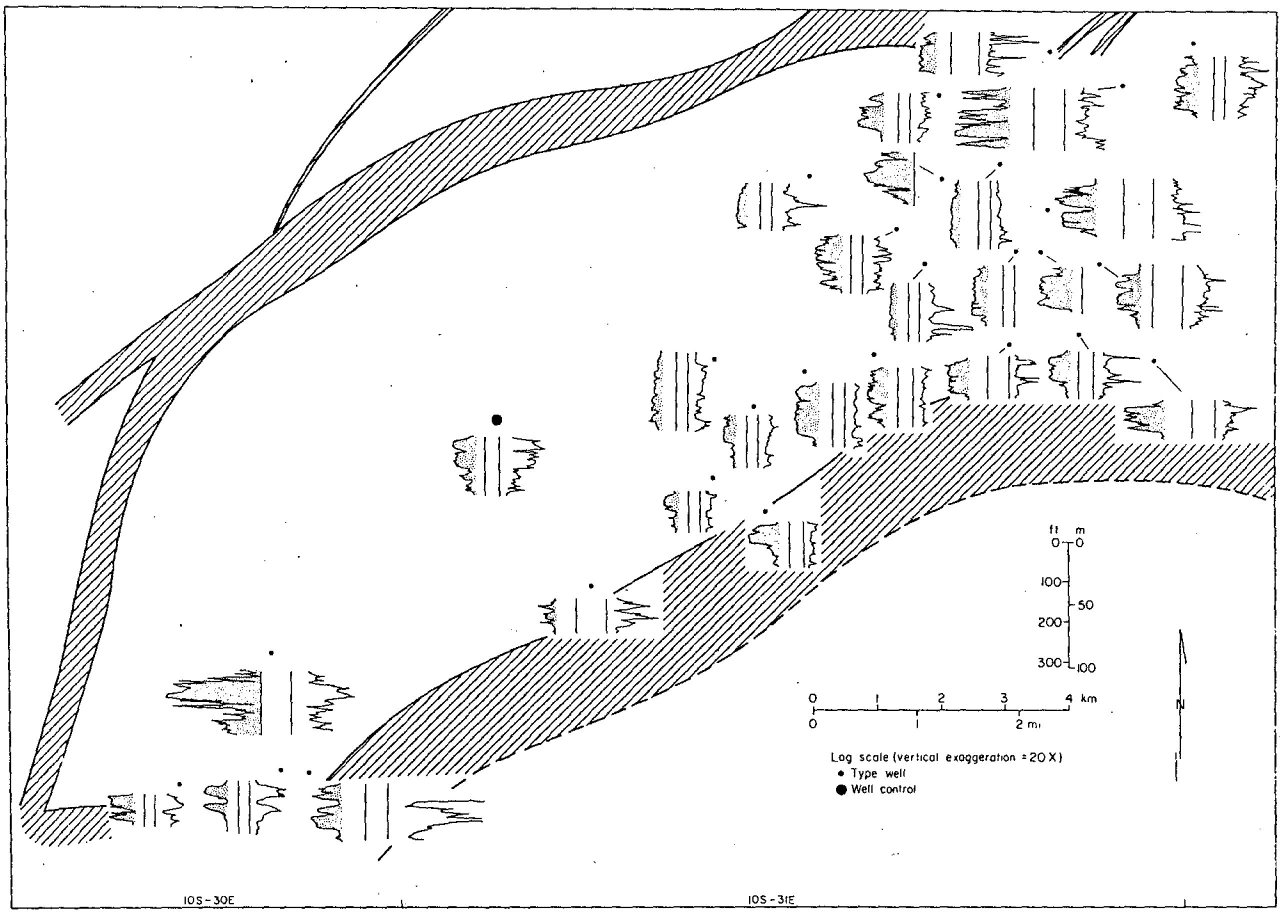

Figure 10. Log pattern map C Sand, Blessing Prospect area. Structure mapped on B5 horizon.

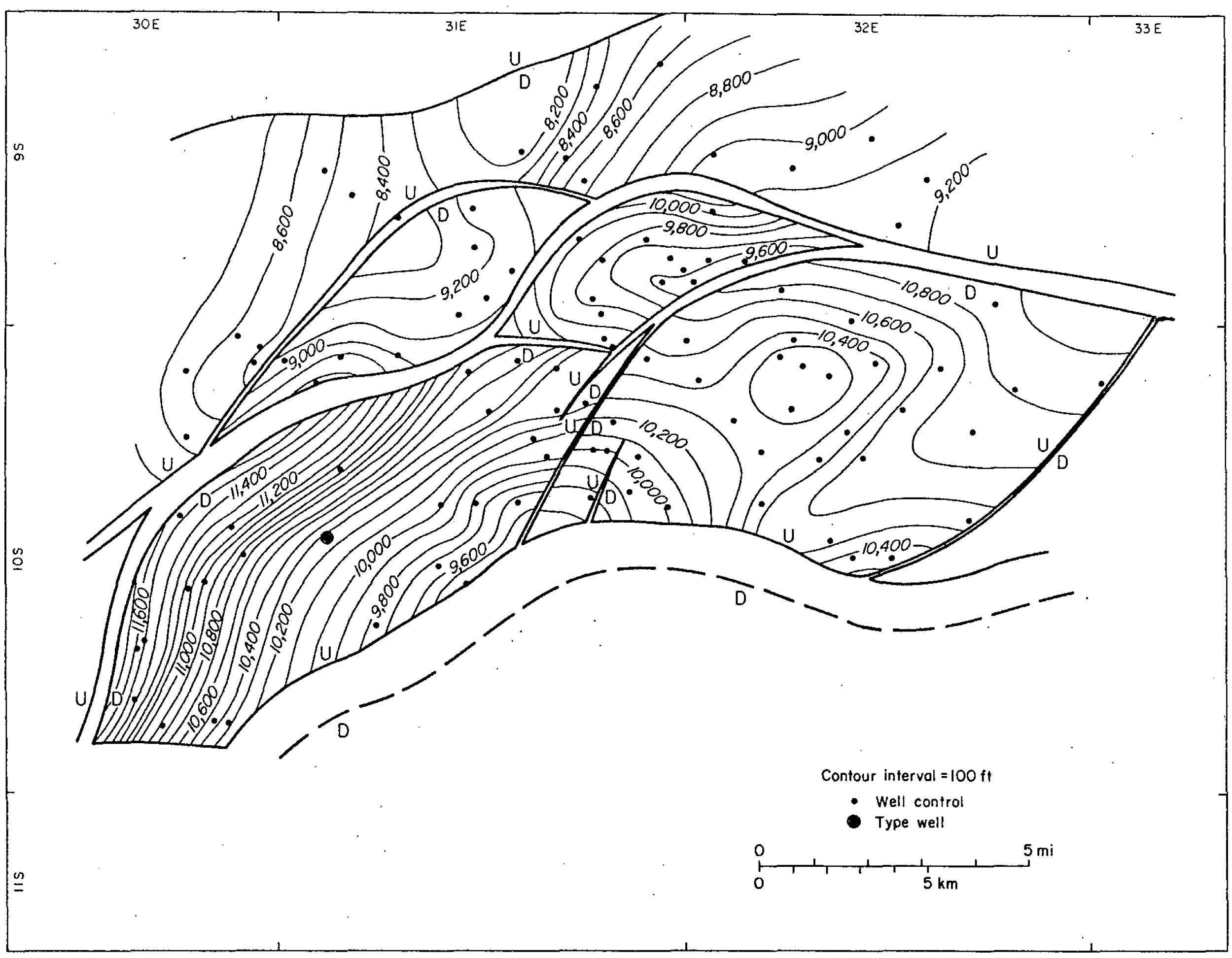

Figure 11. Structure map on top of B5 horizon, Blessing Prospect area.

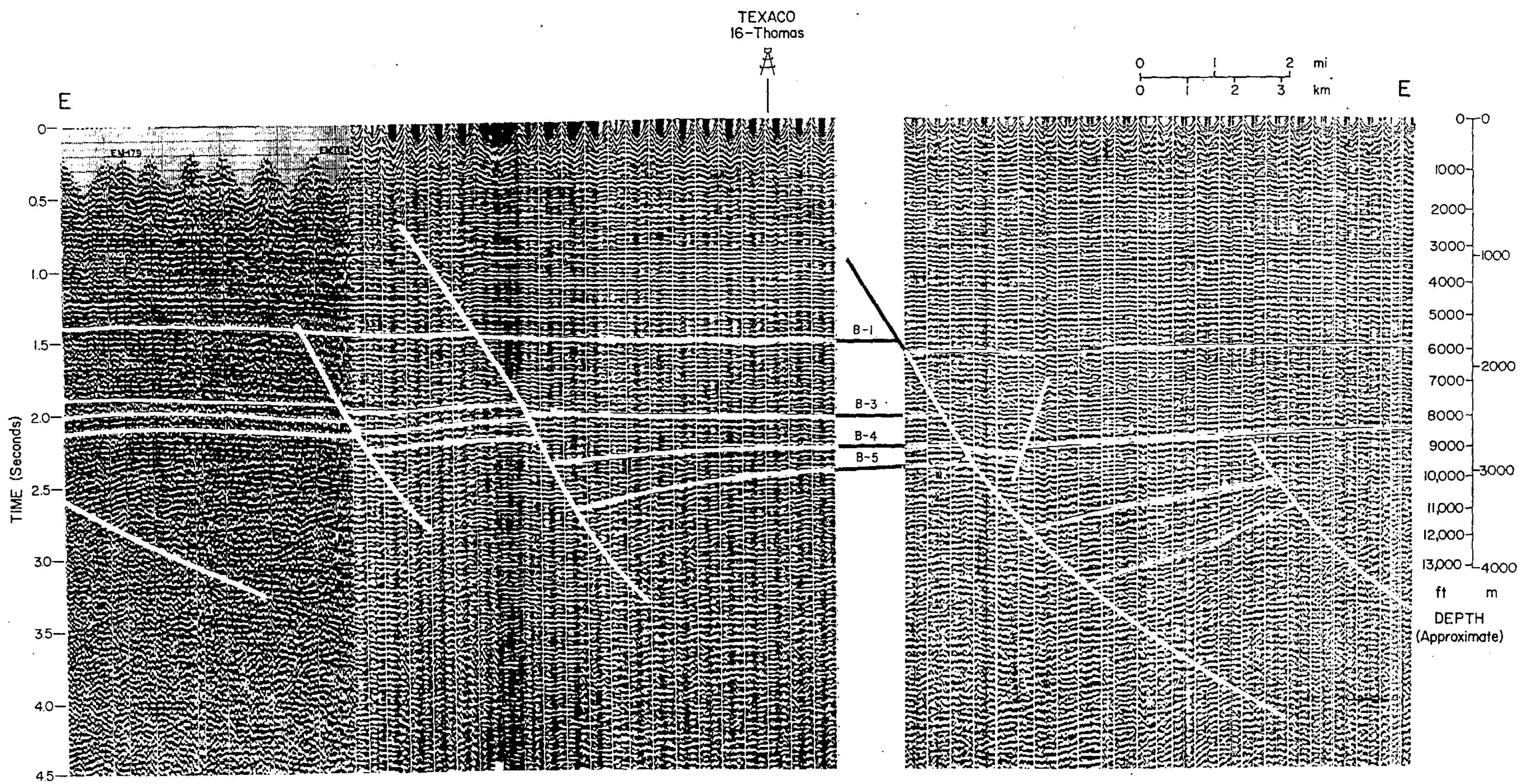

Figure 12. Seismic dip section BCH 27-29-30. Location shown in Fig. 2.

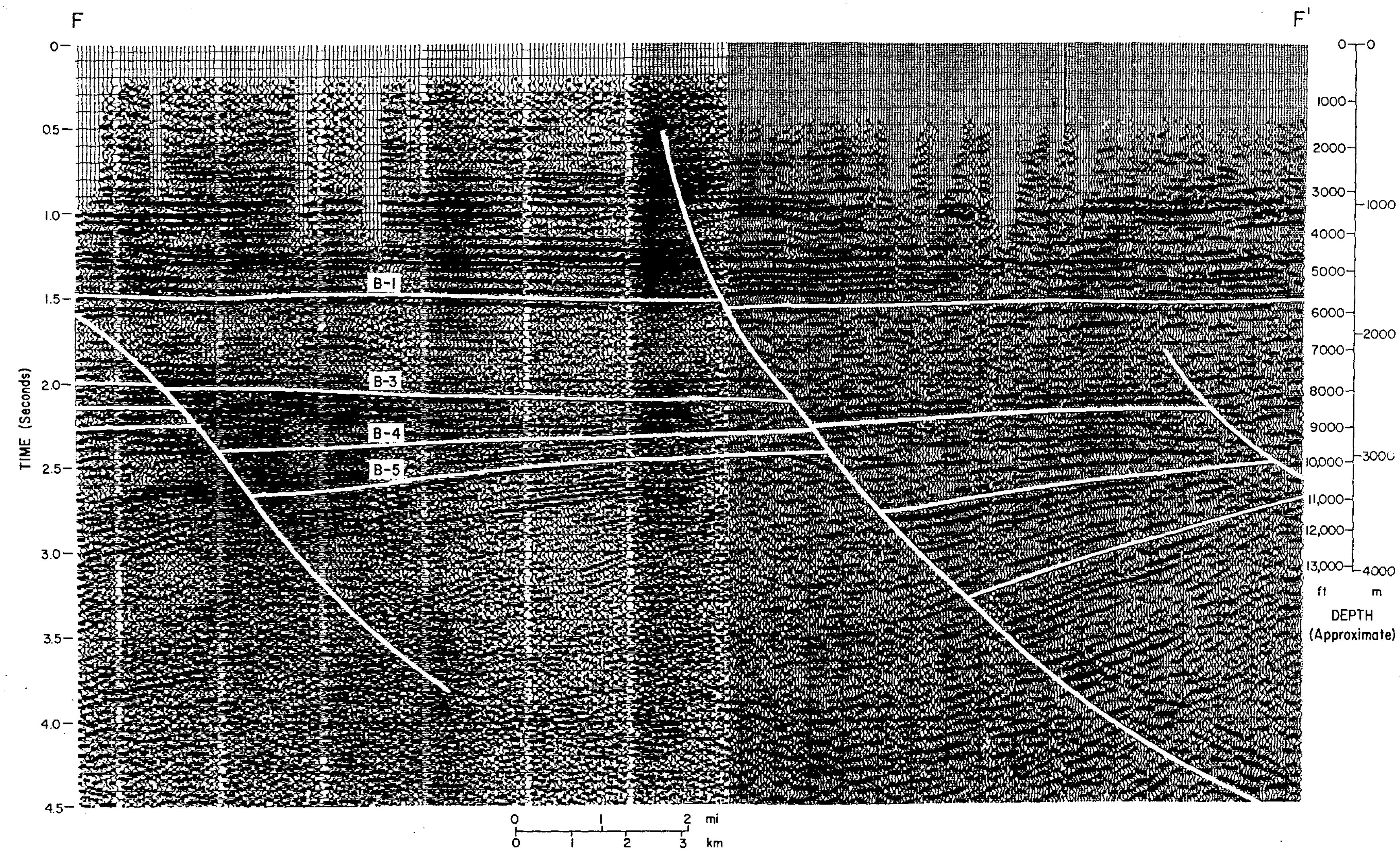

Figure 13. Seismic dip section CS2 and F. Location shown in Fig. 2.

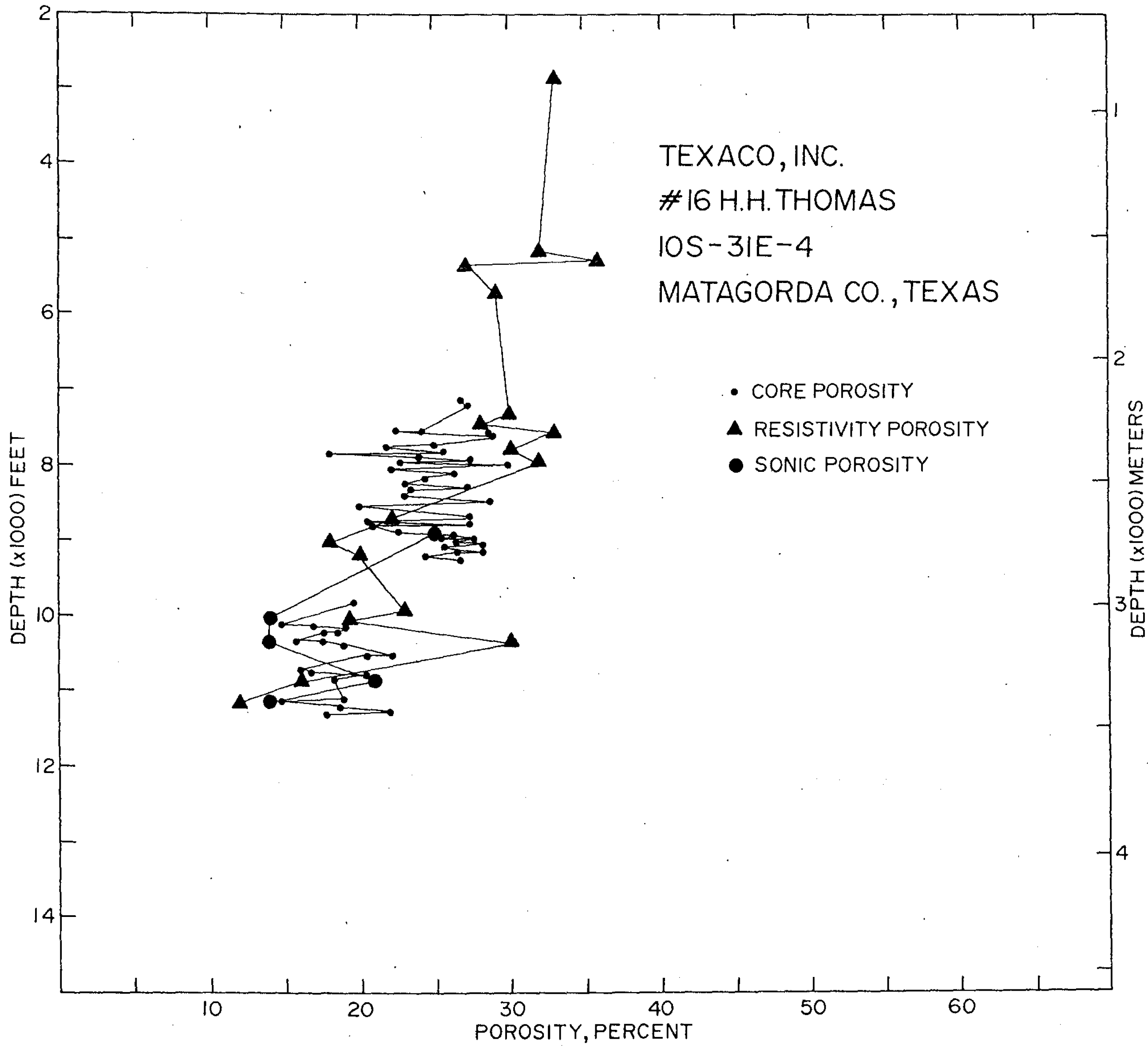

Figure 14. Comparison of porosity data from sidewall cores, resistivity log, and sonic log, Texaco no. 16 Thomas, Blessing Prospect area.

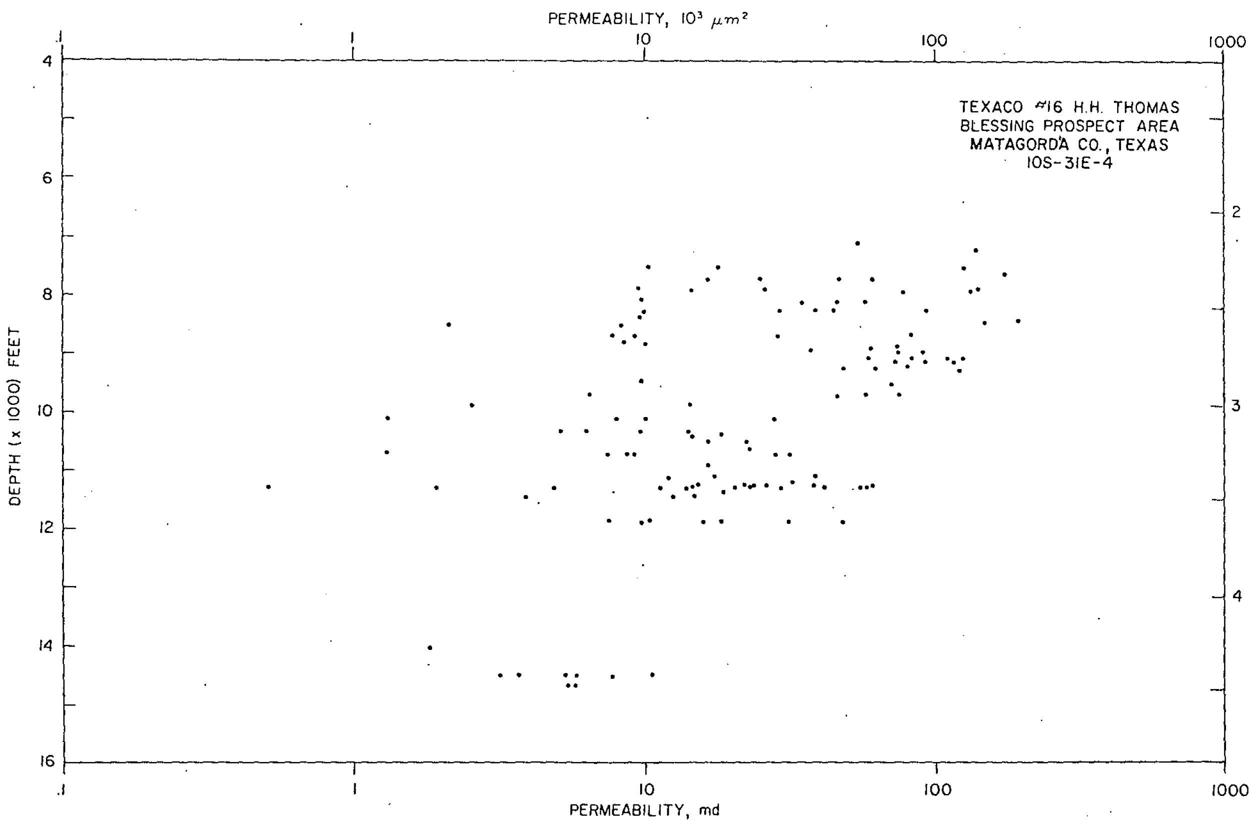

Figure 15. Sidewall core air permeability versus depth, Texaco no. 16 Thomas, Blessing Prospect area.

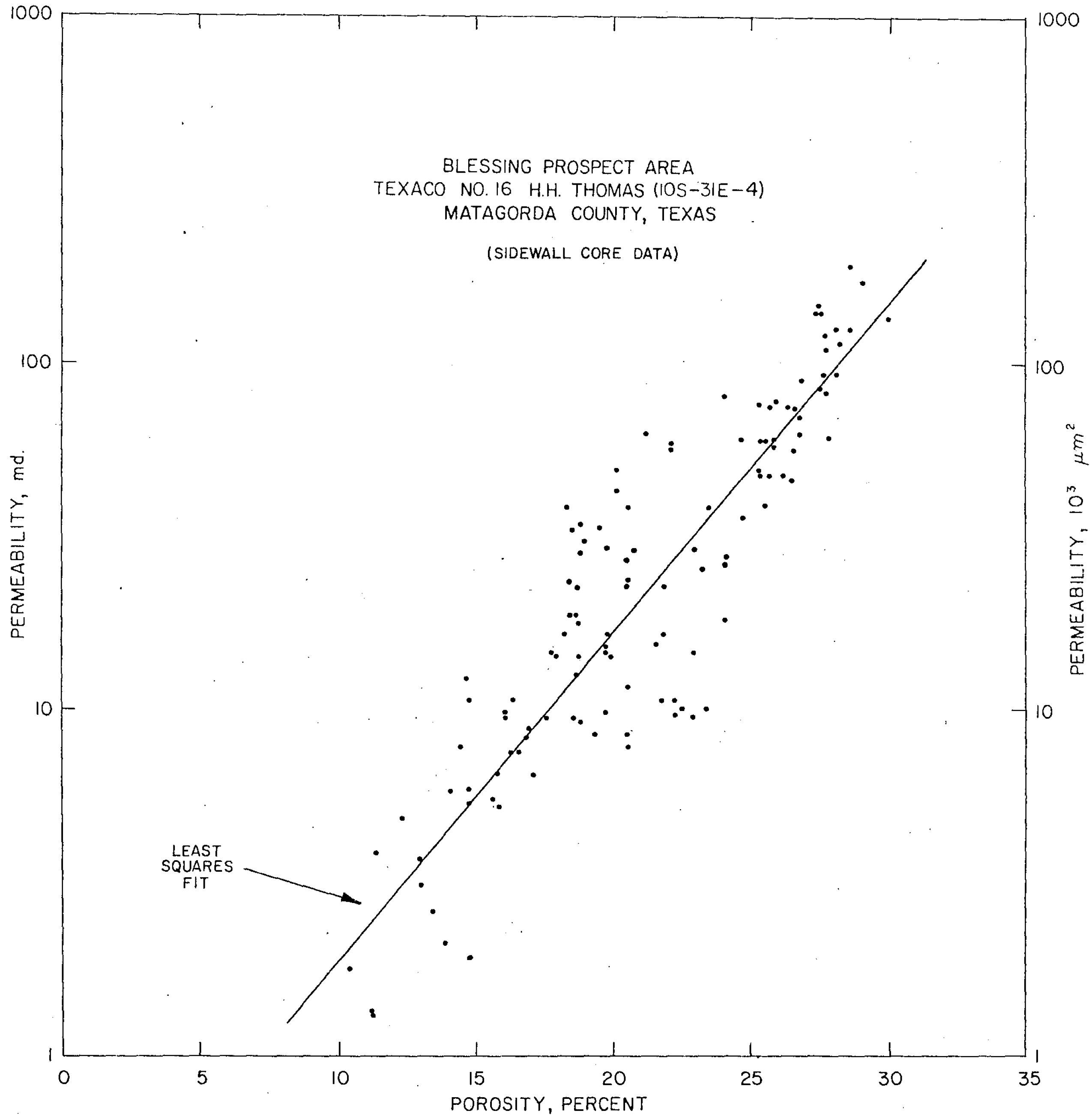

Figure 16. Sidewall core air permeability versus porosity, Texaco no. 16 Thomas, Blessing Prospect area.

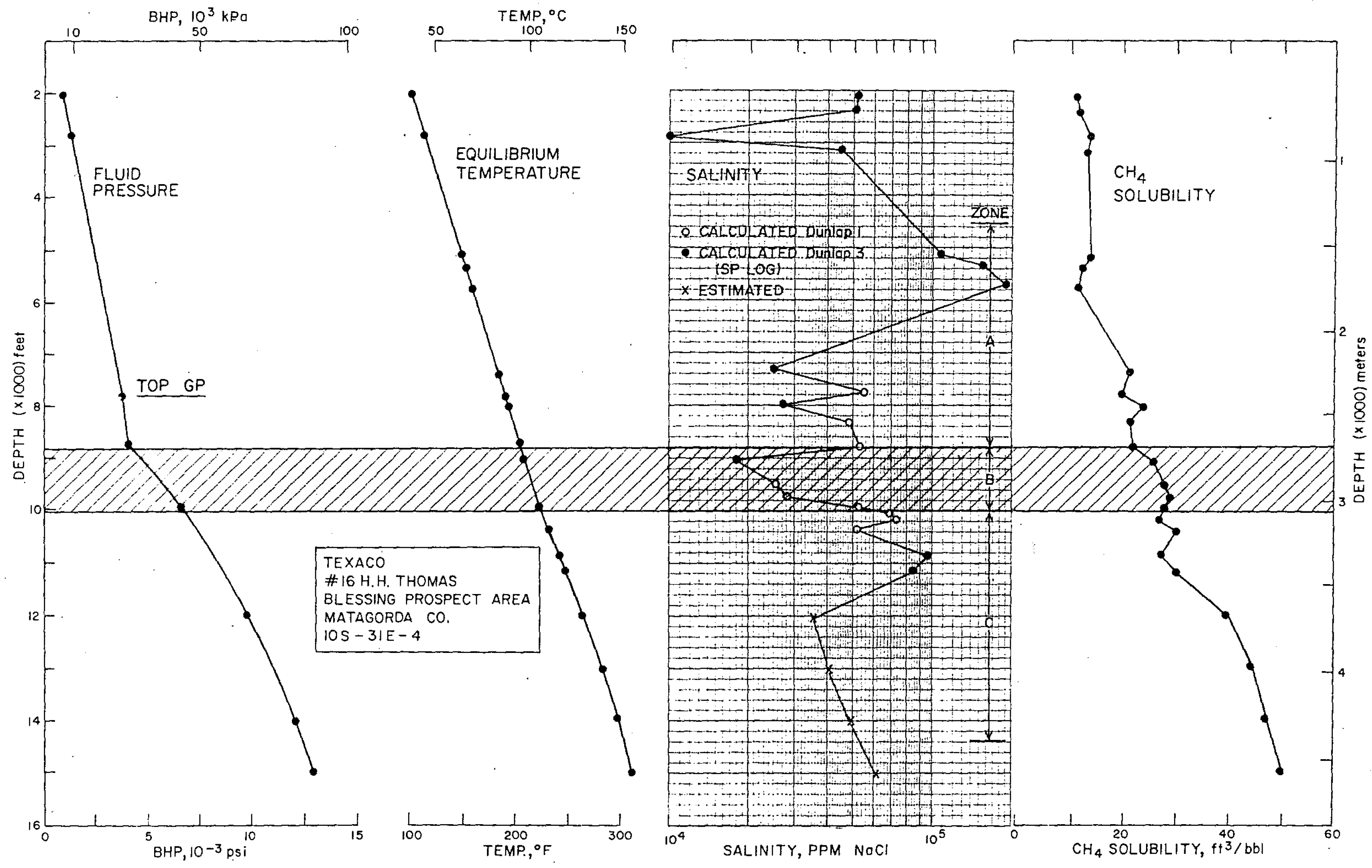

Figure 17. Formation pressure, equilibrium temperature, formation water salinity, and methane solubility estimated from log data for Texaco no. 16 Thomas, Blessing Prospect area.

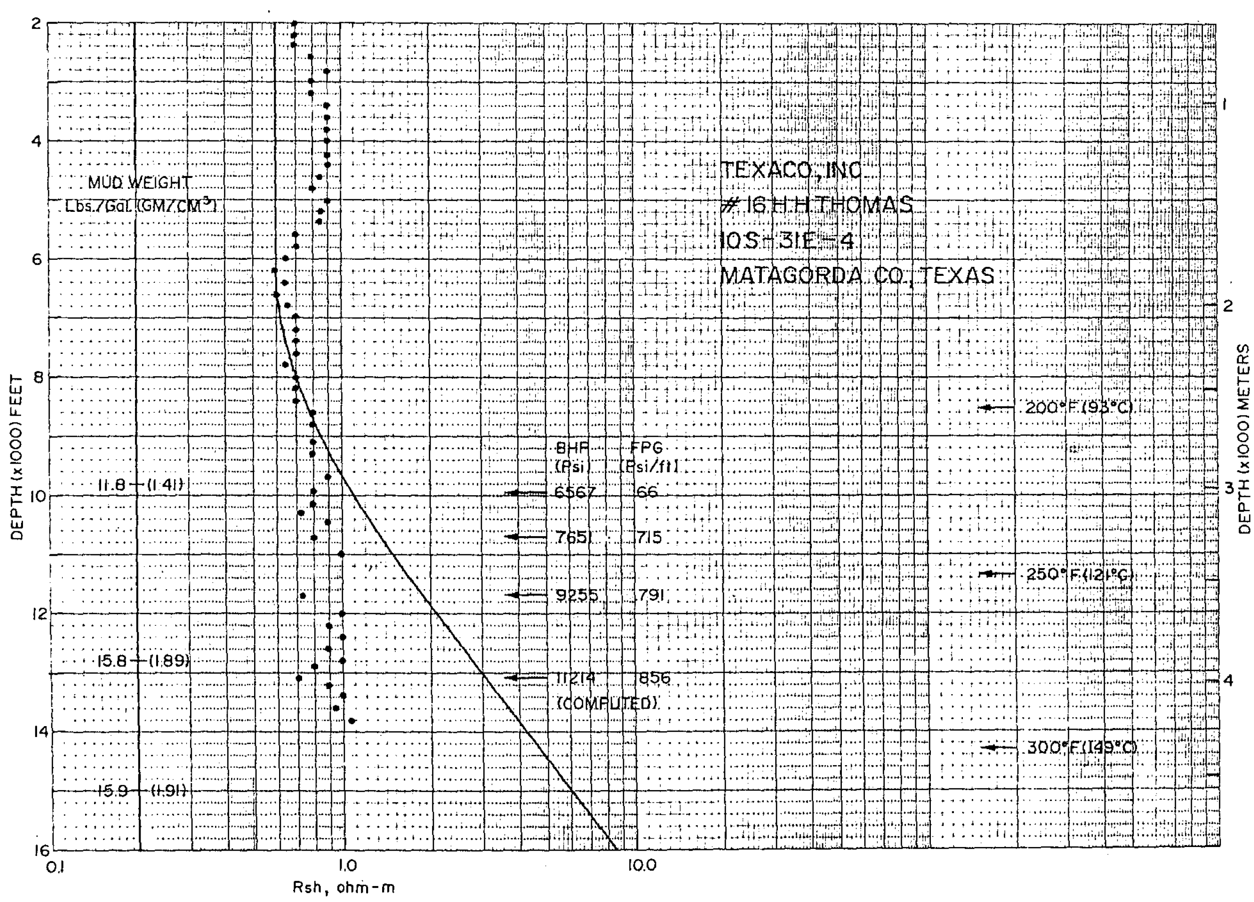

Figure 18. Shale resistivity, mud weight, isotherms, pressure zones, and computed bottom hole pressures versus depth, Texaco no. 16 Thomas, Blessing Prospect area.

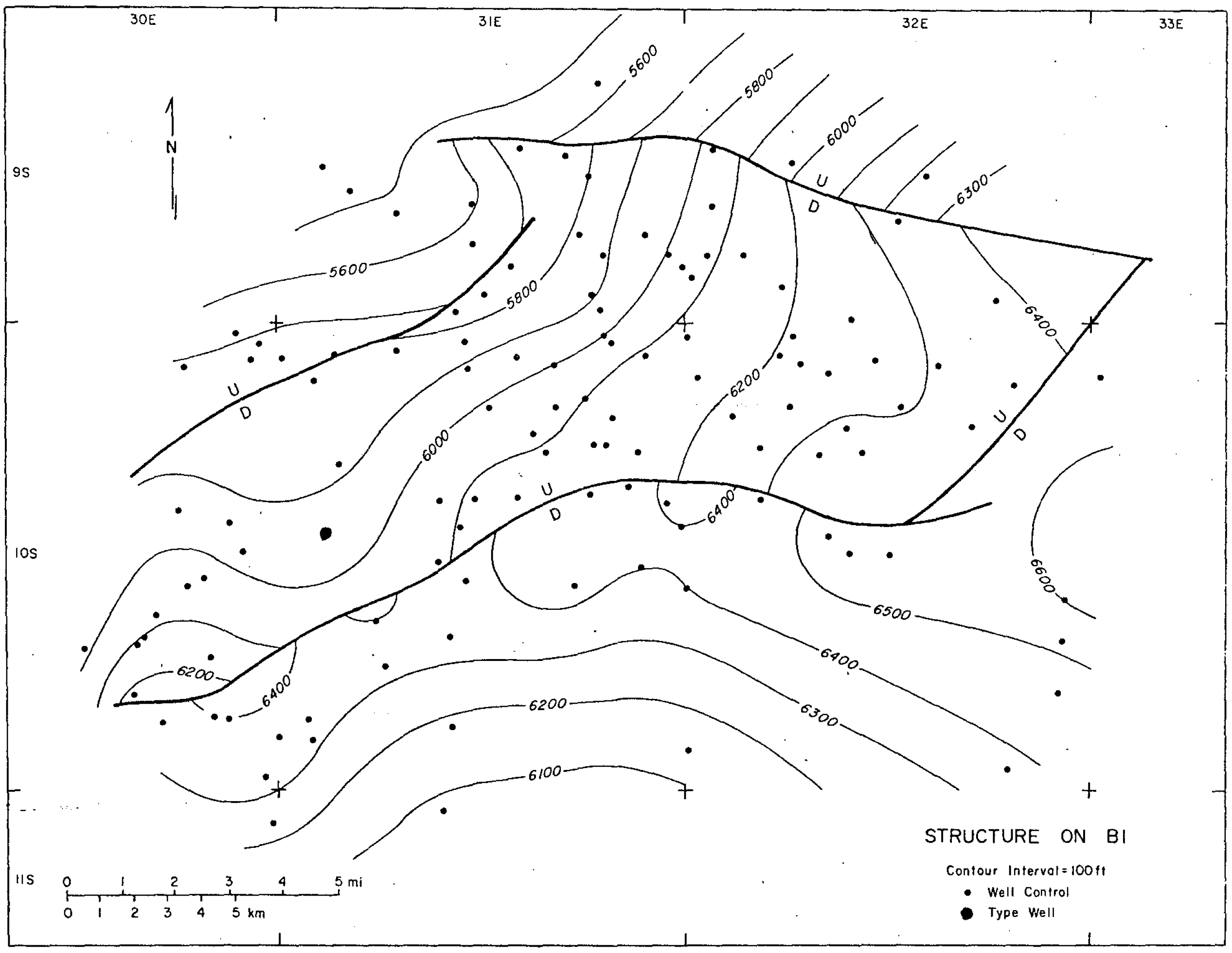

Figure 19. Structure map on top of B1 horizon, Blessing Prospect area.

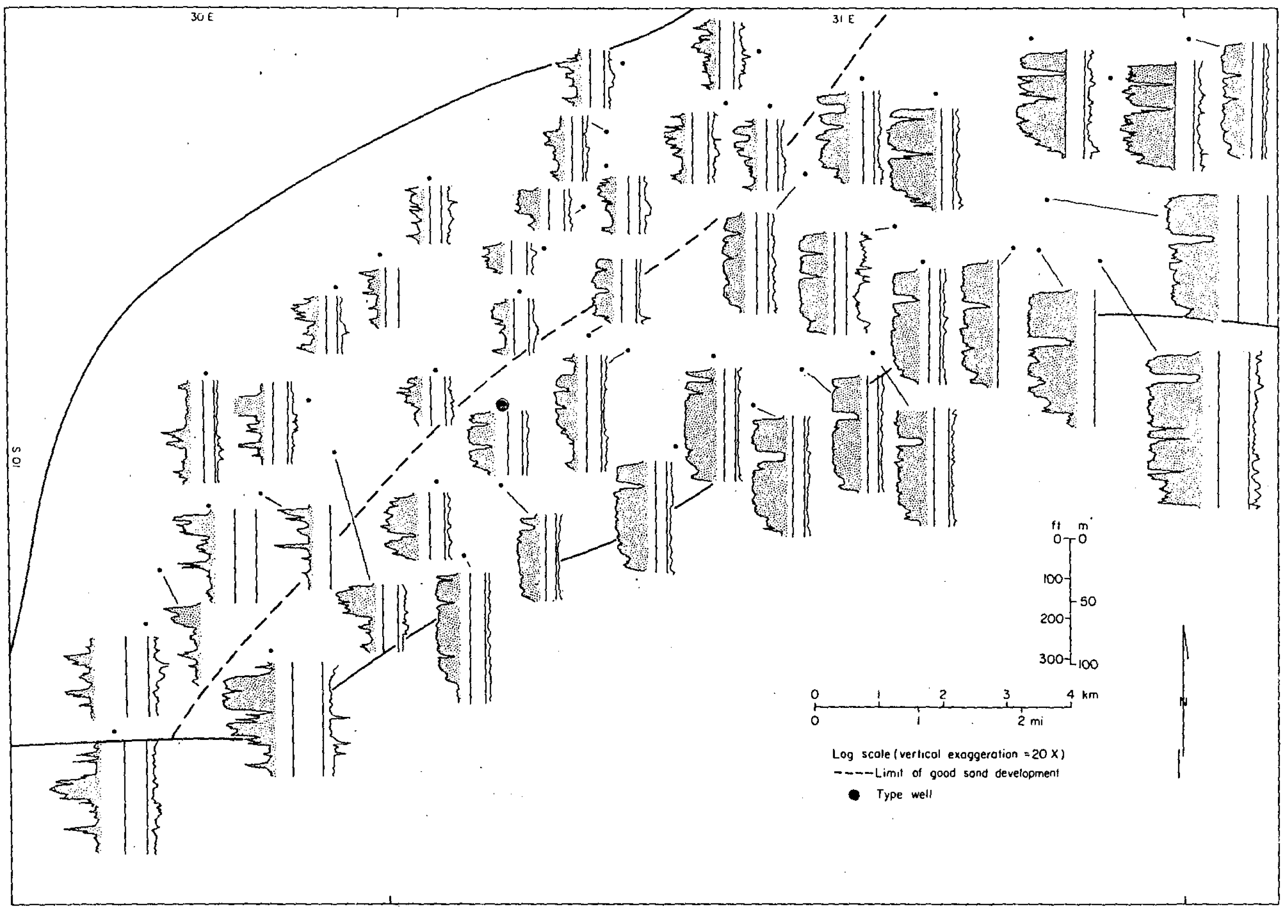

Figure 20. Log pattern map for the proposed injection sand.

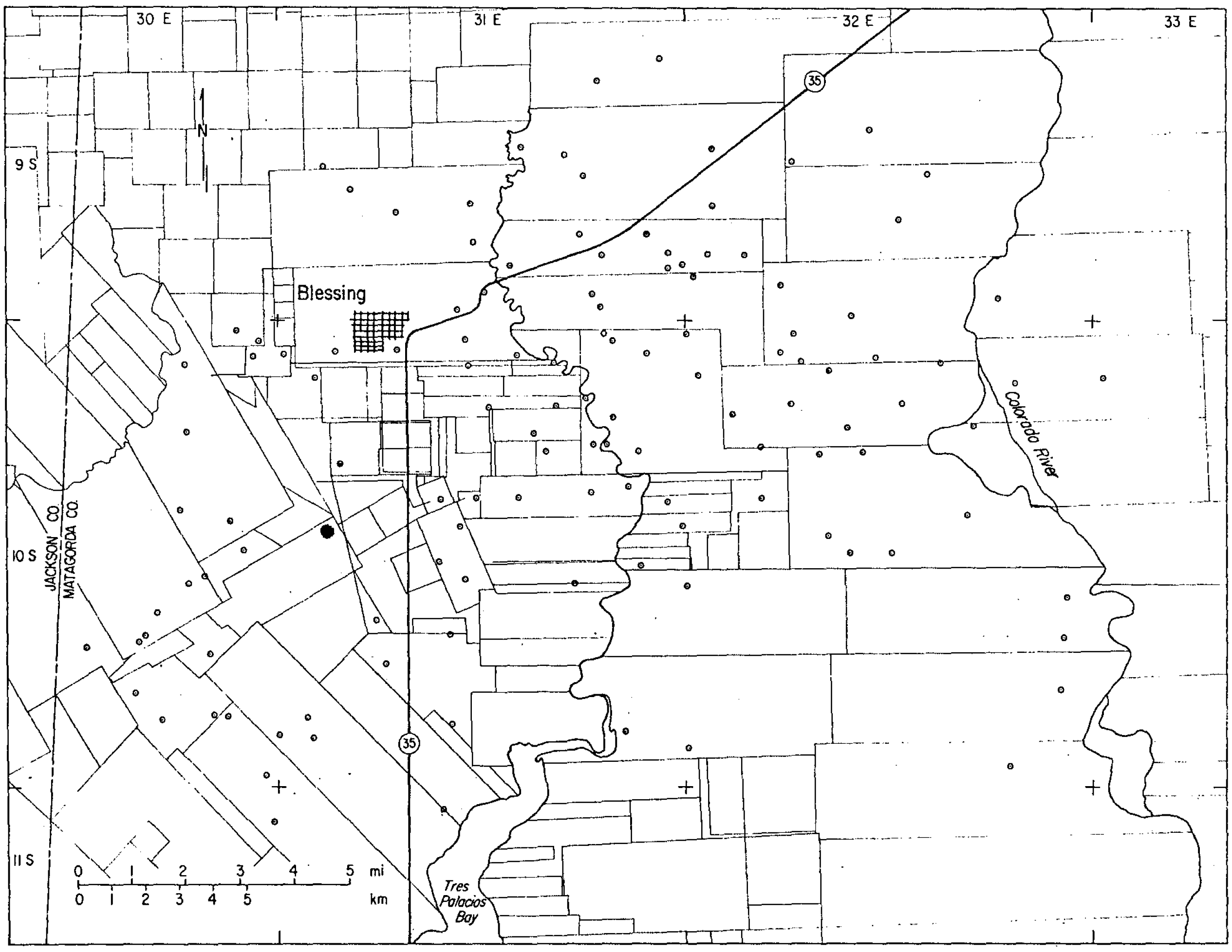

Figure 21. Major subdivisions of surface ownership. Blessing Prospect area.

Table 1. Summary of data for Blessing Prospect, Matagorda County Texas

Preliminary Location		10S - 31E	
Type Well		Texaco no. 16 H. H. Thomas	
Recommended Well Depth		11,500 ft	
Top of Geopressure		8,500 ft	
Pressure Gradient of 0.7 psi/ft		10,000 ft	
Net Sandstone Thickness		380 ft	
		<u>B Sand</u>	<u>C Sand</u>
Depth of Reservoir Sandstone		10,790 ft	11,160 ft
Thickness of Reservoir Sandstone		100 ft	70 ft
Porosity (average)		18%	21%
Permeability		17-28 md	5-56 md
Formation Temperature		241°F	248°F
Formation Pressure		8,238 psi	8,636 psi
Calculated Salinity		97,000 ppm (sp-log)	85,000 ppm (sp-log)
		67,000 ppm (Rwa)	23,500 ppm (Rwa)
Methane Solubility (uncorrected)		28 scf/bbl	30 scf/bbl
Maximum Area		36 mi	36 mi
Estimated In-place Resource	water	2.9×10^9 bbl	2.8×10^9 bbl
	methane	69 billion scf	73 billion scf
Estimated Recoverable Resource (5% of in-place estimate)	water	145 million bbl	140 million bbl
	methane	3.5 billion scf	3.6 billion scf