The Oklahoma Geological Survey,
The Petroleum Technology Transfer Council and
The University of Oklahoma

Present

The Marine Tonkawa Sands: Natural Gas and Associated Liquids Production In The Anadarko Basin

Part 1

Regional Synthesis of Marine Tonkawa Sand in the Anadarko Basin

Carlyle Hinshaw
Petroleum Geologist
Geo Information Systems

Part 2

Waynoka NE Field Tonkawa Sand Reservoir Study

Kurt Rottmann
Consulting Geologist

Oklahoma Geological Survey
Open File Report 3-97

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July 9, 1997

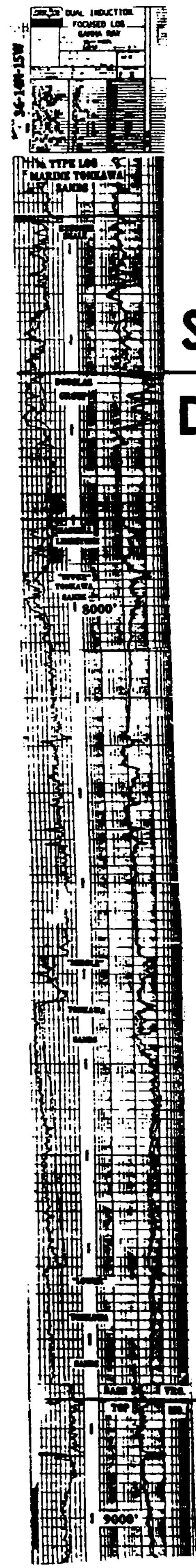
U. S. Postal Training Center
Norman, Oklahoma

Figure R1

Type Log Marine Tonkawa.

The well used is the Tenneco (Tidewater) Ashby-1, NE SW SW NE Sec 36-14n-15w, DF 1656, TD 16580, Weatherford N Fld, in eastern Custer Co., OK. The log is a Dual Induction Focused Log with Gamma Ray. The Tonkawa sands are in the Douglas Group of the Virgilian Series. The portion shown is the interval from the Heebner Shale of the Shawnee Group to the upper part of the Missourian Series. This well was chosen because it has Tonkawa sands in the lower, middle and upper parts of the Douglas Group. In addition, the "lower" and "middle" sands were cored, plus, the well is in Panel 2 of the E-W regional cross-section.

TYPE LOG MARINE TONKAWA



HEEBNER

SHAWNEE GROUP

DOUGLAS GROUP

HASKELL

"UPPER" SANDS

"MIDDLE" SANDS

"LOWER" SANDS

VIRGILIAN

MISSOURIAN

Figure 1

Figure R2

Tonkawa Production Map.

Tonkawa sand oil and gas production is limited to the Anadarko Basin, the Nemaha Uplift and the Nemaha Fault Zone. In Kansas, the equivalent sands are called Stalnaker. In the southeast corner of the Anadarko Basin, in the Cement area, the term Niles is used. In the Texas Panhandle, sands that may elsewhere be considered "upper" Tonkawa could be called Douglas. Production depths are as shallow as 2,075 feet on the Pauls Valley Uplift in Garvin County, Oklahoma to 10,420 feet in the southwestern corner of Roger Mills County, Oklahoma. The northeastern most production is in Sedgwick County, Kansas, near Wichita and the farthest west field is in Sherman County, Texas.

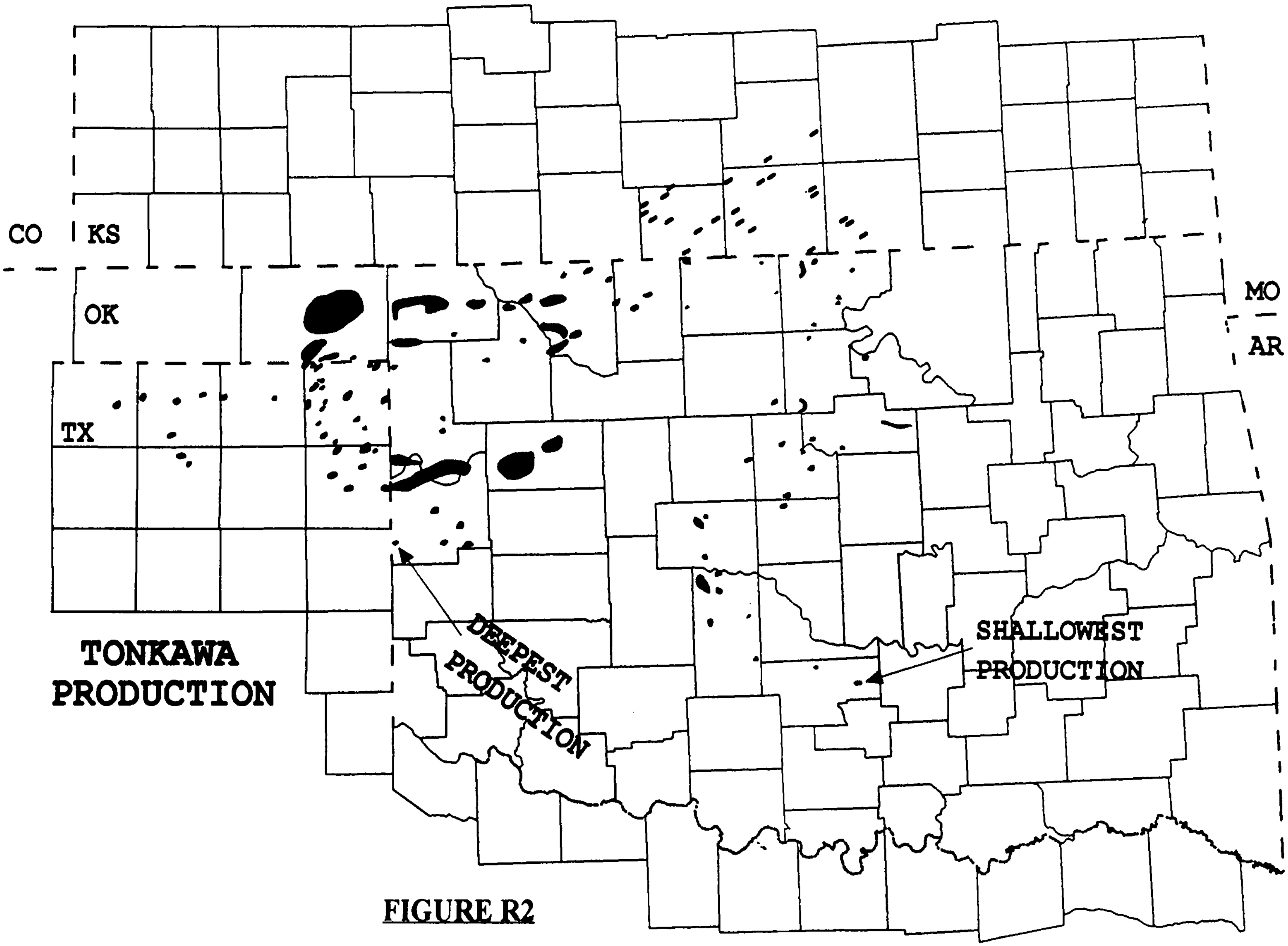

CO
KS
OK
TX
MO
AR
TONKAWA
PRODUCTION
DEEPEST
PRODUCTION
SHALLOWEST
PRODUCTION

FIGURE R2

Table R1

Production From The Tonkawa Sands

Kansas - Stalnaker reservoirs - Barber, Butler, Cowley, Harper, Kingman and Sumner Counties

	Oil	Gas
Leases	67	79
Cumulative 1970-1995	1,081,422 Bbl.	46,275,231 MCF

Oklahoma - FDD reservoirs - Alfalfa, Garfield, Grant, Kay, Lincoln, Logan, Noble, Osage, Pawnee and Payne Counties.

Tonkawa reservoirs only:	Oil	Gas
Leases	62	82
Cumulative 1/1/79-12/31/96	1,598,159 Bbl.	48,040,811 MCF

Oklahoma - Marine reservoirs - Beaver, Canadian, Custer, Dewey, Ellis, Garvin, Grady, Harper, Kingfisher, Major, Oklahoma, Roger Mills, Woods and Woodward Counties.

Tonkawa reservoirs only:	Oil	Gas
Leases	434	662
Cumulative 1/1/79-12/31/96	4,617,972 Bbl.	411,385,982 MCF

Texas - Marine reservoirs - Hansford, Hemphill, Hutchinson, Lipscomb, Ochiltree Sherman Counties.

729 wells	Oil	Gas
Cumulative to 12/31/96	33,662,186 Bbl.	578,367,441 MCF

Data sources: PI/Dwights, Oklahoma Tax Commission, Kansas Geological Survey.

Figure R3

Structure Map of the Heebner Shale.

Of the Virgilian subsurface markers, the Heebner Shale in the lower Shawnee Group is by far the one listed most by operators. Tonkawa workers may favor mapping on the Haskell Limestone in the upper Douglas Group but it is usually absent on a basinwide basis. A marker zone is frequently used in lieu of a developed limestone bed. As a matter of fact, most of the Douglas and lower Shawnee limestones are sporadically developed over the area of Tonkawa production. The contour interval is 250 feet. Dip is southerly and an increase in rate of dip occurs at the -3750 foot contour. Source of data is the NRIS well database.

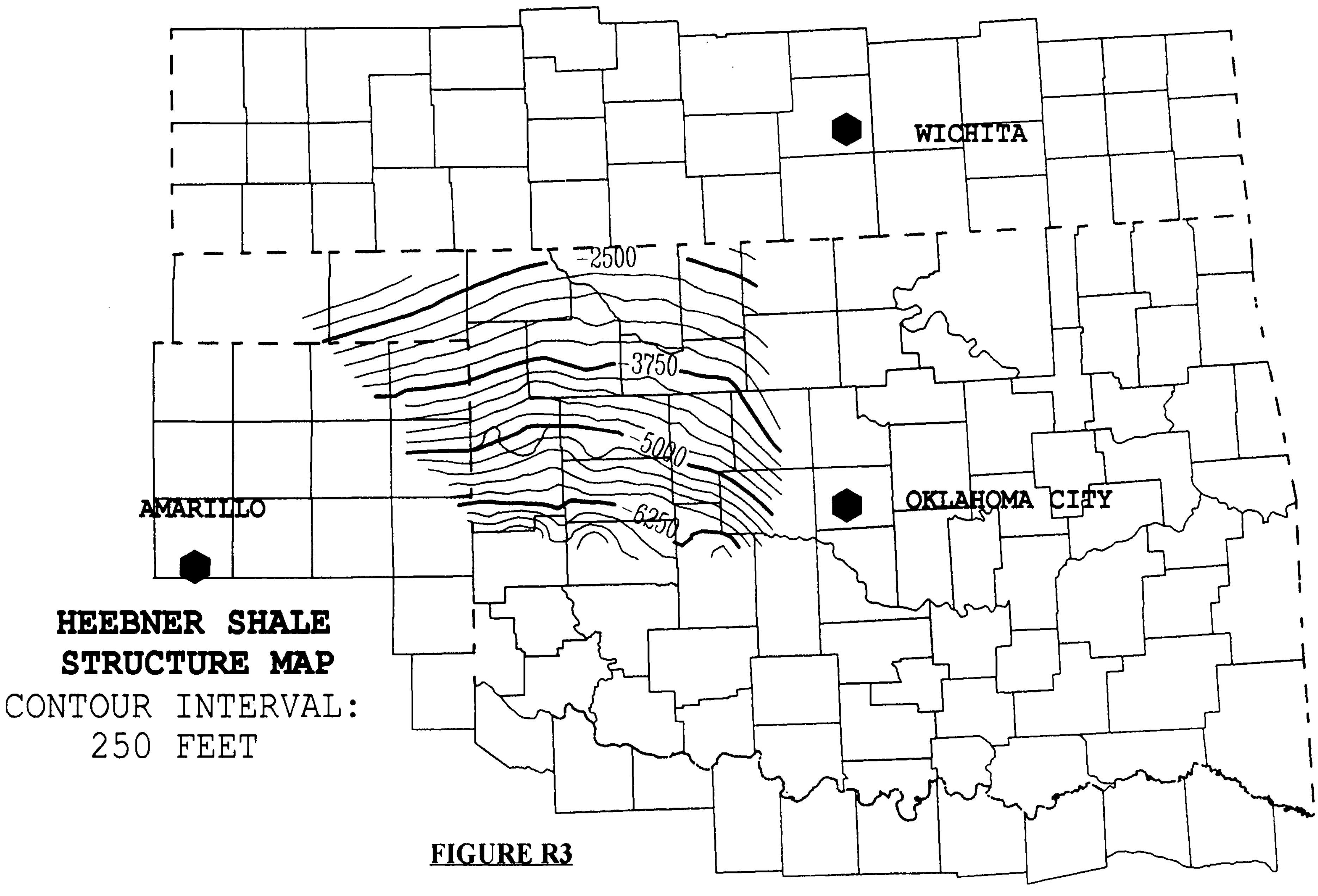
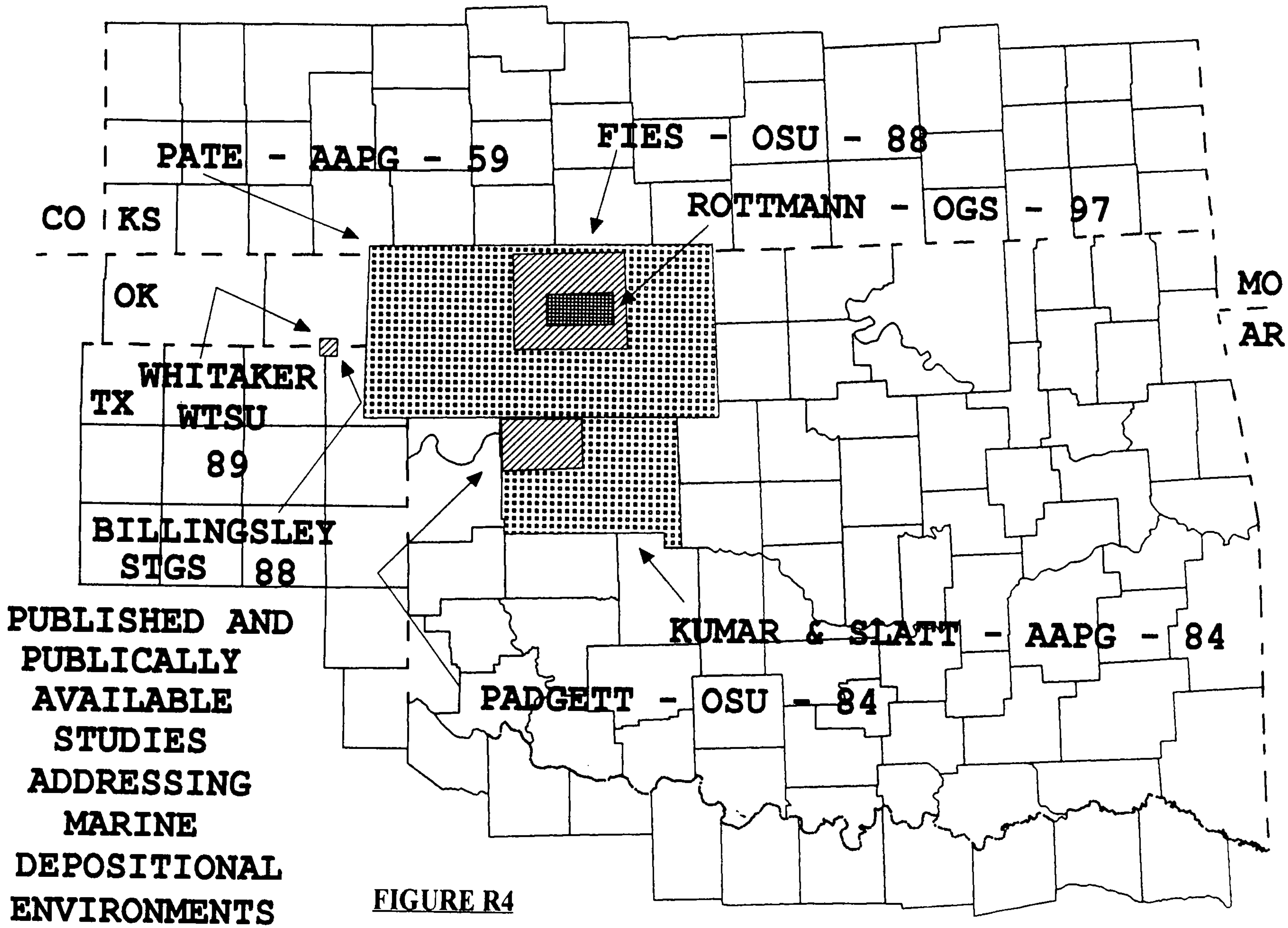

WICHITA
OKLAHOMA CITY
AMARILLO
-2500
-3750
-5000
-6250
HEEBNER SHALE
STRUCTURE MAP
CONTOUR INTERVAL:
250 FEET

FIGURE R3

Figure R4

Published and Publically available studies addressing Marine Depositional Environments.

Publications directed primarily at the Tonkawa are rather sparse and only a few of these address depositional environments. All but one of the environment articles listed have core descriptions. There are two AAPG bulletin papers, two Oklahoma State masters theses, one West Texas State University thesis, one article in the bulletin of the South Texas Geological Society and Part 2 of this Oklahoma Geological Survey's Open File Report. The two Texas articles cover the same land area almost exactly.



PATE - AAPG - 59
FIES - OSU - 88
ROTTMANN - OGS - 97
CO
KS
OK
MO
AR
TX
WHITAKER
WTSU
89
BILLINGSLEY
STGS
88
KUMAR & SLATT - AAPG - 84
PADGETT - OSU - 84
PUBLISHED AND
PUBLICALLY
AVAILABLE
STUDIES
ADDRESSING
MARINE
DEPOSITIONAL
ENVIRONMENTS

FIGURE R4

Figure R5

Core Descriptions.

Pate's interpretation of the depositional history of the Tonkawa interval is also shown on this map. On the shallow shelf in far northwestern Oklahoma and soutwestern Kansas, a facies change from siliclastic deposition to a carbonate shelf edge is postulated for the very uppermost Missourian Series. As a result, Pate envisions the Tonkawa sands to be Missourian in age rather than Virgilian.

In eastern Custer County, Kumar and Slatt interpreted a core from the lower Tonkawa to be from a submarine fan complex. A core from the middle Tonkawa in the same well was interpreted to be from a sequence deposited on the basin slope. Kumar and Slatt also described a middle Tonkawa core in southwestern Dewey County as being a slope deposit. They propose a Tonkawa age that spans the Missourian/Virgilian boundary.

In southwestern Dewey County, Padgett's work, which also covers the northwest quarter of Kumar and Slatt's study, five cores from the middle Tonkawa were described. One of the cores is the same one used by Kumar and Slatt above. His depostitional environment interpretation for the sands is one of a delta front prograding basinward, resulting in lobate, elongate sand bodies oriented primarily northeast-southwest. Padgett places the Tonkawa sands in the Virgilian.

Billingsley, et. al, in the Bechthold field of northwestern Lipscomb County, Texas, interpreted a middle Tonkawa core as being representative of a deep marine environment with submarine currents forming bar-shaped sand deposits.

In the same field as above, Whitaker studied middle Tonkawa cores in three different wells. He states that the middle Tonkawa sandstone represents the transition from deep marine basin deposition to slope/shelf deposition during a time of regression. Whitaker states that the Tonkawa Formation is upper Missourian in age. To the north and west of his study area, Whitaker states that the sandstone grades into shale and then into shelf carbonates of the Lansing Group.

Fies described four middle Tonkawa cores in Harper and Woods counties. His studies suggest a high-constructive, lobate delta depostitonal environment. Fies assigns the Tonkawa sands to the Virgilian Series.

Rottmann did the mapping and J. A. Campbell described the cores for the Waynoka NE Field reservoir study in south-central Woods County. The cores were the same two used by Fies (above). They interpret the depositional environment to be one of shallow marine shelf to open marine. Rottmann considers the Tonkawa to be in the Virgilian Series.

Thin section and scanning electron photomicrograph studies were made on several of the cores. Chemical processes were the primary factors affecting reservoir quality of the sands. Secondary porosity caused by dissolution is the main factor affecting the reservoirs. Precipitation of authigenic minerals in the pore spaces frequently reduced and even closed systems. As a result, porosity and permeability values are highly variable in the marine Tonkawa fields.

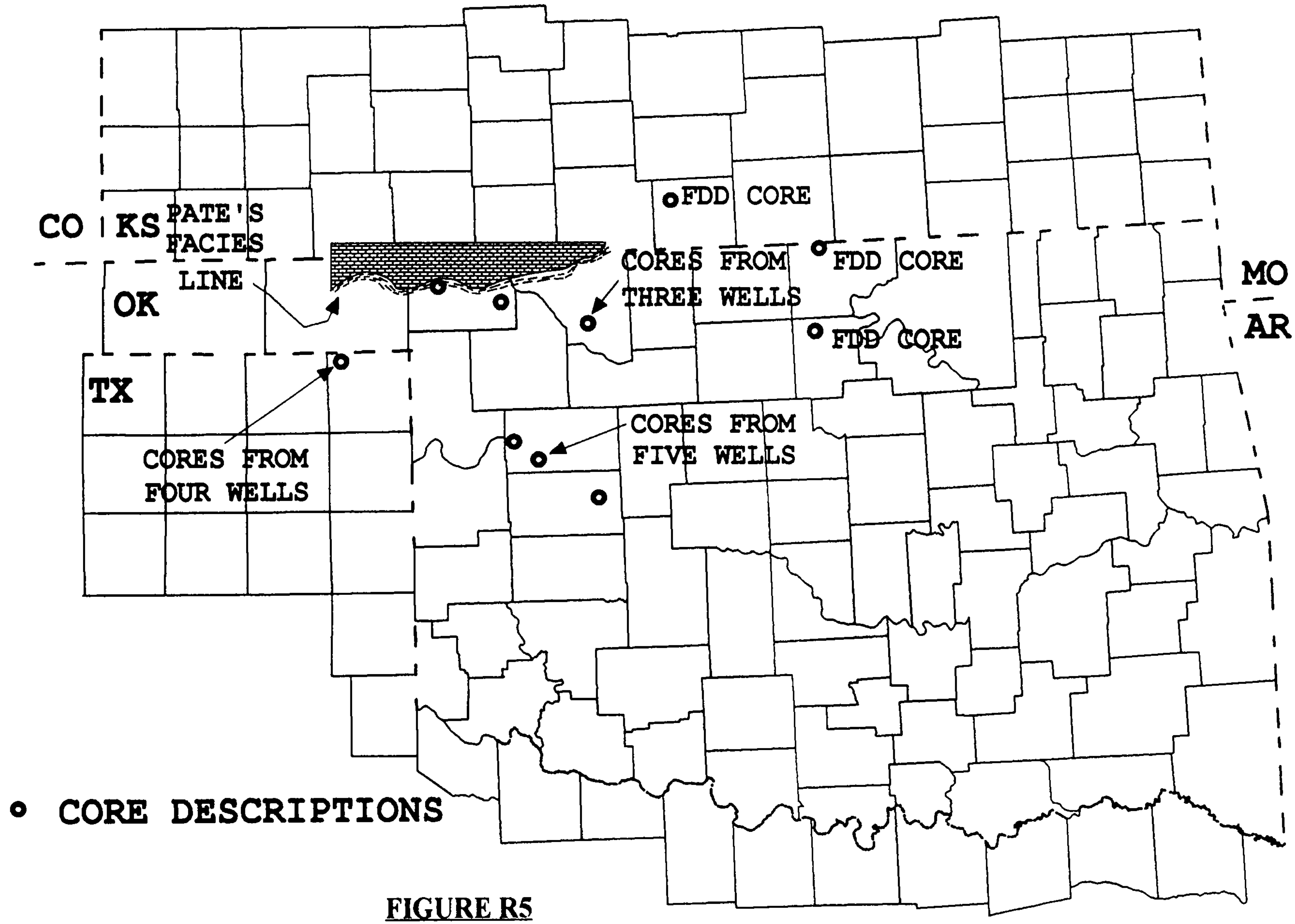

CO
KS
PATE'S
FACIES
LINE
OK
TX
FDD CORE
CORES FROM
THREE WELLS
FDD CORE
FDD CORE
MO
AR
CORES FROM
FOUR WELLS
CORES FROM
FIVE WELLS
CORE DESCRIPTIONS

FIGURE R5

Table R2

Location of Marine Tonkawa core descriptions.

1. Tenneco (Tidewater) 1-Ashby, NE 36-14N-15W, Custer Co.
2. McCulloch 1-Craig, SE 6-17N-20W, Dewey CO.
3. Texas Oil and Gas 1A-Saylor SE 24-17N-18W, Dewey Co.
4. Wessely 1- Ellington, NW 35-17N-19W, Dewey Co.
5. Wessely 2-Farris, NW 2-16N-19W, Dewey Co.
6. Wessely 2-Farris, NE 7-16N-18W, Dewey Co.
7. Sarkey's 1-Fancher, SW 17-16N-18W, Dewey Co.
8. Southland Royalty 1-Crawford, NW 34-27N-23W, Harper Co.
9. Shell 1-Waits, NE 12-26N-20W, Harper Co.
10. Earlsboro 1-Curtis-Stark, NE 20-25N-15W, Woods Co.
11. Gulf 1-Shade, SW 31-25N-14W, Woods Co.
12. Sandia 1-Bechthold, NW 24 HT&B RR Blk 10. Lipscomb Co.
13. J. M. Huber 2-Schultz "C", SW 62 HT&B Survey, Lipscomb Co.
14. J. M. Huber 3-Schultz "C", NW NW 62 HT&B Survey, Lipscomb Co.
15. J. M. Huber 4-Schultz "C", SW NW 62 HT&B Survey, Lipscomb Co.

Figure R6

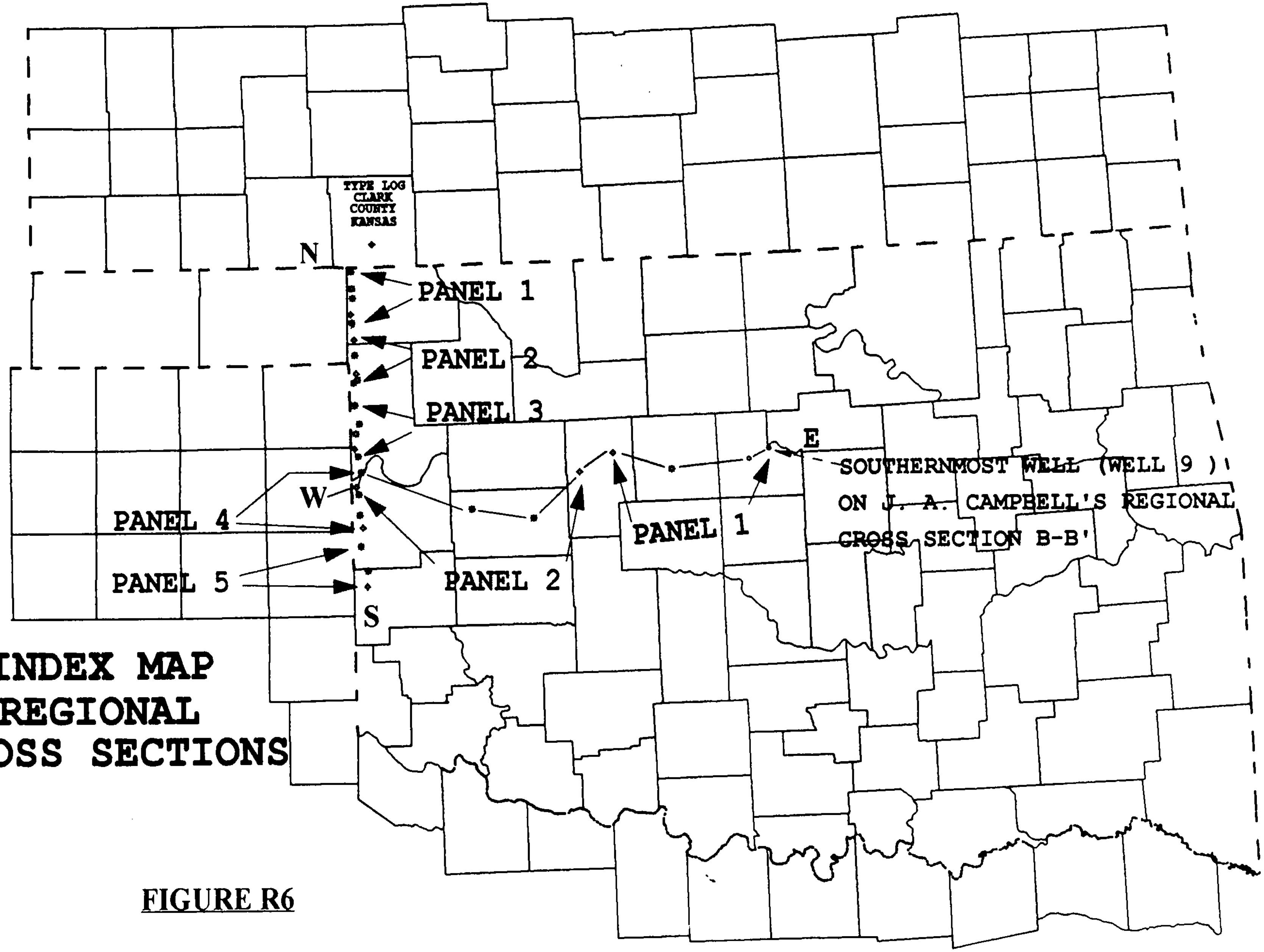
Index Map Regional Cross Sections.

The regional cross sections were compiled from 1"=100', mostly Gamma Ray Induction logs, taped together (there is no horizontal scale). The sections were made in panels of mostly five logs each for easier handling in making overheads for projection at the Tonkawa Workshop. The reader may tape the panels together for a complete section. Both are stratigraphic sections with the Heebner Shale as the datum.

The W-E section starts on the east end in northeastern Logan Co. with the southernmost well of J. A. Campbell's N-S FDD regional section B-B'. It extends east-west across the basin using one to two wells per county, ending up with two wells on the N-S regional cross section. The section has two panels.

A type log from Clark County, Kansas is included as Figure R9.

The N-S section starts in 29N-26W in Harper County, Oklahoma near the Kansas state line and extends southward to 10N-26W in Beckham County. The section has 23 wells with at least one well per township. As a result, there is one well about every six miles. There are five panels covering the N-S section.



INDEX MAP
REGIONAL
CROSS SECTIONS

FIGURE R6

Figure R7 In Pocket

W-E Cross Section - Panel 1.

This panel primarily illustrates the "upper" and "middle" Tonkawa intervals. The "lower" Tonkawa section pinches out between the Dreyfus Markus-1 and the Holke Carey-1. The Marjo Donoghue-1 is used to show the mapping interval for the regional thickness map which is from the Heebner Shale and the top of the Missourian Series. Sand development is indicative of the many delta lobes that occur in the Tonkawa interval. The lower part of the section is generally a deeper water shale section that starts to coarsen upward at the beginning of the "middle" Tonkawa interval. The two right hand or easternmost wells illustrate transition to delta front and offshore bar deposits capped by open marine carbonate and shale deposits. A repeat of the cycle is seen in the "upper" Tonkawa interval. The Dreyfus Markus-1 well is a good example of the lobate, progradational (regressive) nature of the depositional environments. The Haskell interval is replaced by a lobe starting out with a non-marine (delta) sand followed by delta front cycles and finally capped with an open marine limestone. Of note on this section is the location of the Avant Limestone which is not the top of the Missourian.

Figure R8 In Pocket

W-E Cross Section - Panel 2.

This section shows the only area that contains "lower" Tonkawa sands. The Tenneco Ashley-1 is the marine type log for this report and was cored both in the "lower" and "middle" Tonkawa sands. The "lower" sand is a slope to basin fill of fine to coarse turbidites having as much as 35% chert. This deposit probably was sourced from the Ouachita uplift. The uppermost core is from the top of a coarsening upward delta front sequence.

Figure R9

Type Log - Clark County, Kansas

TYPE LOGS of KANSAS 1966

KANSAS GEOLOGICAL SOCIETY

TYPE LOG FOR CLARK COUNTY

CATALOG NO. 18-33-23w

Published By
KANSAS GEOLOGICAL SOCIETY
508 East Murdock
Wichita, Kansas 67214
AMherst 5-8677

Compiled & Edited By
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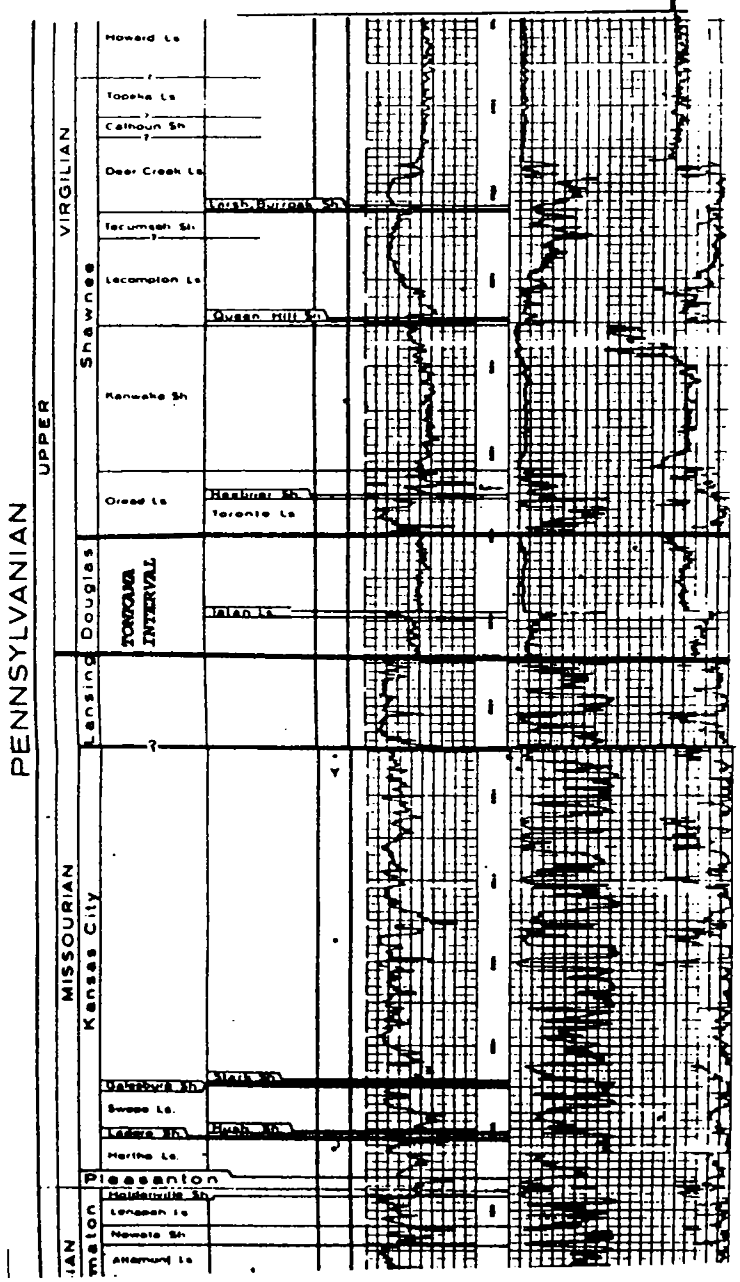


Figure R9

Figure R10 In Pocket

N-S Cross Section - Panel 1.

The northernmost or left hand log correlates with the Clark County, Kansas Type Log. Both illustrate the shelf limestone buildup in the upper Missourian. The "lower" Tonkawa interval contains no sand while the "middle" and "upper" zones have generally very thin delta front sands. The Douglas sea, on an overall basis, is one of mostly mud. The southernmost well is used to illustrate the interval of the regional thickness map.

Figure R11 In Pocket

N-S Cross Section - Panel 2

Nearly all of the Tonkawa production in the three state area is from the "middle" zone and this panel shows that most of the sand is in this interval. The two rightmost wells are in the same township the and Pintex Linscott-1 produces from the Tonkawa. The sequence here indicates that a non-marine channel cuts into pro delta shale and is followed by delta front and perhaps offshore bar deposits.

Figure R12 In Pocket

N-S Cross Section - Panel 3.

Again, most of the sand is in the "middle" zone although delta front sequences occuring in the "upper" interval. The sand development is shown as the finish of a classical upward coarsening sequence. The Tonkawa produces in the southernmost well.

Figure R13 In Pocket

N-S Cross Section - Panel 4

Again, the sand development is limited to the "middle" portion of the Tonkawa with one to several delta front pulses occuring. Two wells produce from the "middle" Tonklawa on this panel. The E-W regional cross section connects to this panel at the northernmost well.

Figure R14 In Pocket

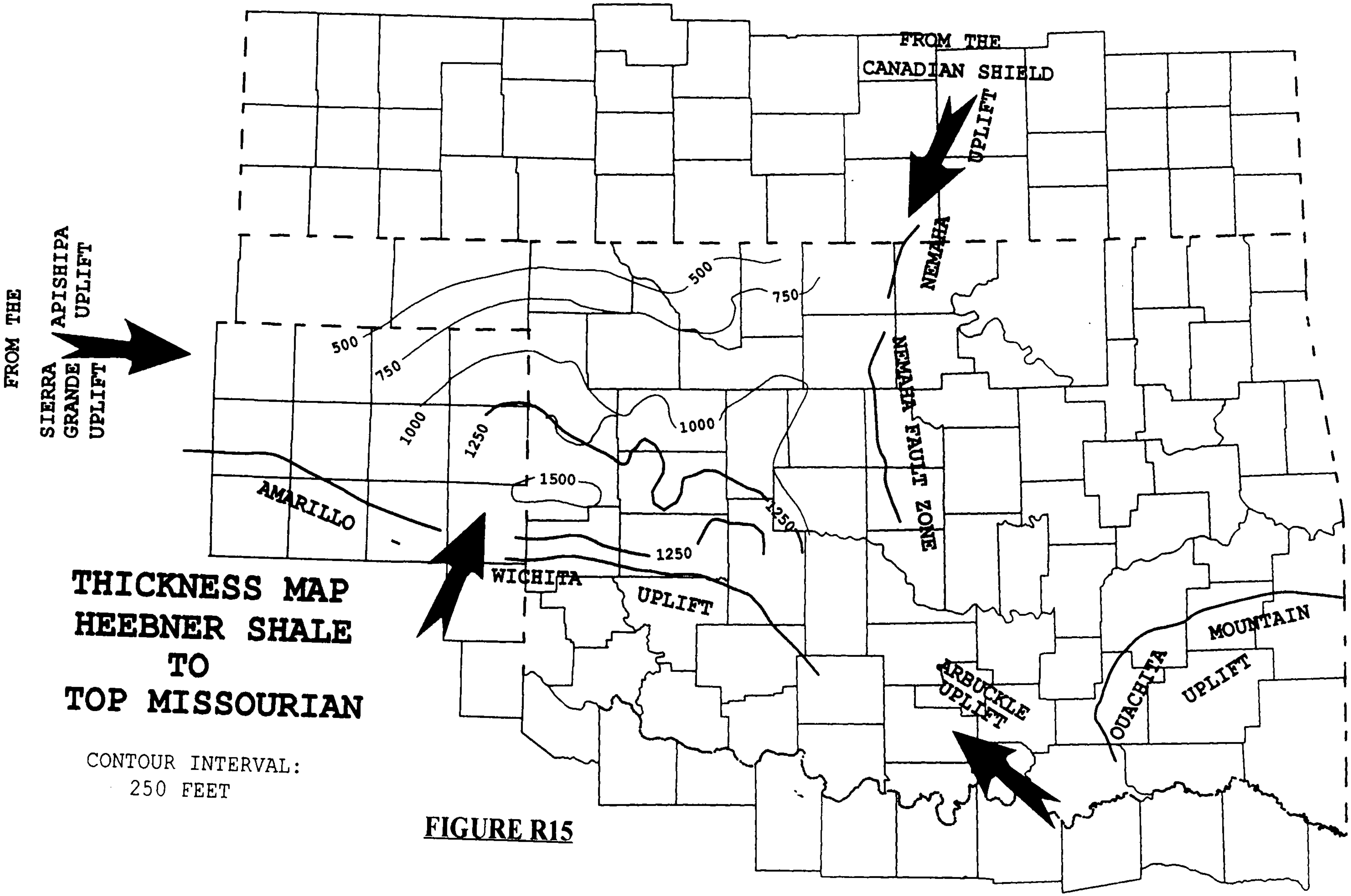
N-S Cross Section - Panel 5.

This short and last panel shows the basin axis during the period studied. The sands are limited to the "middle" part of the Tonkawa. At this position, the influence of the Wichita uplift is seen. The section ends in T10N-R26W. In the next township to the south (T9N-R26W), the influx of granite wash makes it difficult to impossible to correlate the Virgilian. In T8N-R26W, Permian sits on granite. The deepest Tonkawa production comes from the Exxon well.

Figure R15

Thickness Map of the interval Heebner Shale to top Missourian.

Because the Heebner and the top of the Missourian are marine deposits, the data are limited to the marine portion of the Anadarko Basin. Both are correlative sedimentary markers over most of the basin. As a result, the map is indicative of the filling of the basin during Douglas time. Major siliclastic sourcing was northerly from the Canadian Shield area although southeastern, southwestern and western highlands were contributors. Source of data is the NRIS well database.



THICKNESS MAP
HEEBNER SHALE
TO
TOP MISSOURIAN

CONTOUR INTERVAL:
250 FEET

FIGURE R15

Summary

The marine Tonkawa sands in the Anadarko Basin are in the Douglas Group of the Virgilian Series. These sands are located primarily in northwest Oklahoma and the Texas panhandle. There are three general parts of the Douglas where the sands are found, the "lower", "middle" and "upper". "Lower" Tonkawa sands are limited to a fairly small area centered in southeastern Custer County, Oklahoma. These "lower" sands are deep water slope and/or basinal turbidite deposits. "Middle" Tonkawa marine sands are shallow water shelf deposits at the delta front and in the offshore areas. Gas and oil production is limited to these "middle" sands. The "upper" sands are deposits similar to those in the "middle" section.

Over most of the producing area, the sands are fine to very fine in grain size. Sediments providing much of the basin fill came from the Canadian Shield. Other source areas are highlands to the southeast, southwest and west,

The combination of depositional environments resulting in marine bar development and diagenetic prosesses operating on the sands resulted in the development of stratigraphic traps across the northwest shelf of the Anadarko Basin in Oklahoma and Texas.

Tonkawa explorers need to focus their work on interpretation of the depositional environment framework. Part 2 to follow is an excellent example.

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Billingsley, Lee T., and Douglas A. Draves, 1988, Detailed reservoir analysis of Tonkawa Sandstone in Bechthold-Frass Field Extention, Texas Panhandle area: South Texas Geological Society Bulletin, v. 29, no. 3, p.13-25.

Fies, Michael W., 1988, Depositional environments and diagenesis of the Tonkawa format (Virgilian) in Woods and part of Woodward Counties, Oklahoma: Olahoma State University, unpublished M.S. thesis, 123 p.

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Craig Wahl of PI/Dwights provided production data from the Tonkawa in the Texas panhandle.

Oklahoma Geological Survey
and
Petroleum Technology Transfer Council
Present

Waynoka NE Field Tonkawa Sand Reservoir Study

T. 25 N., R. 14–17 W.
Woods County,
Oklahoma

By
Kurt Rottmann, Consulting Geologist
July 9, 1997

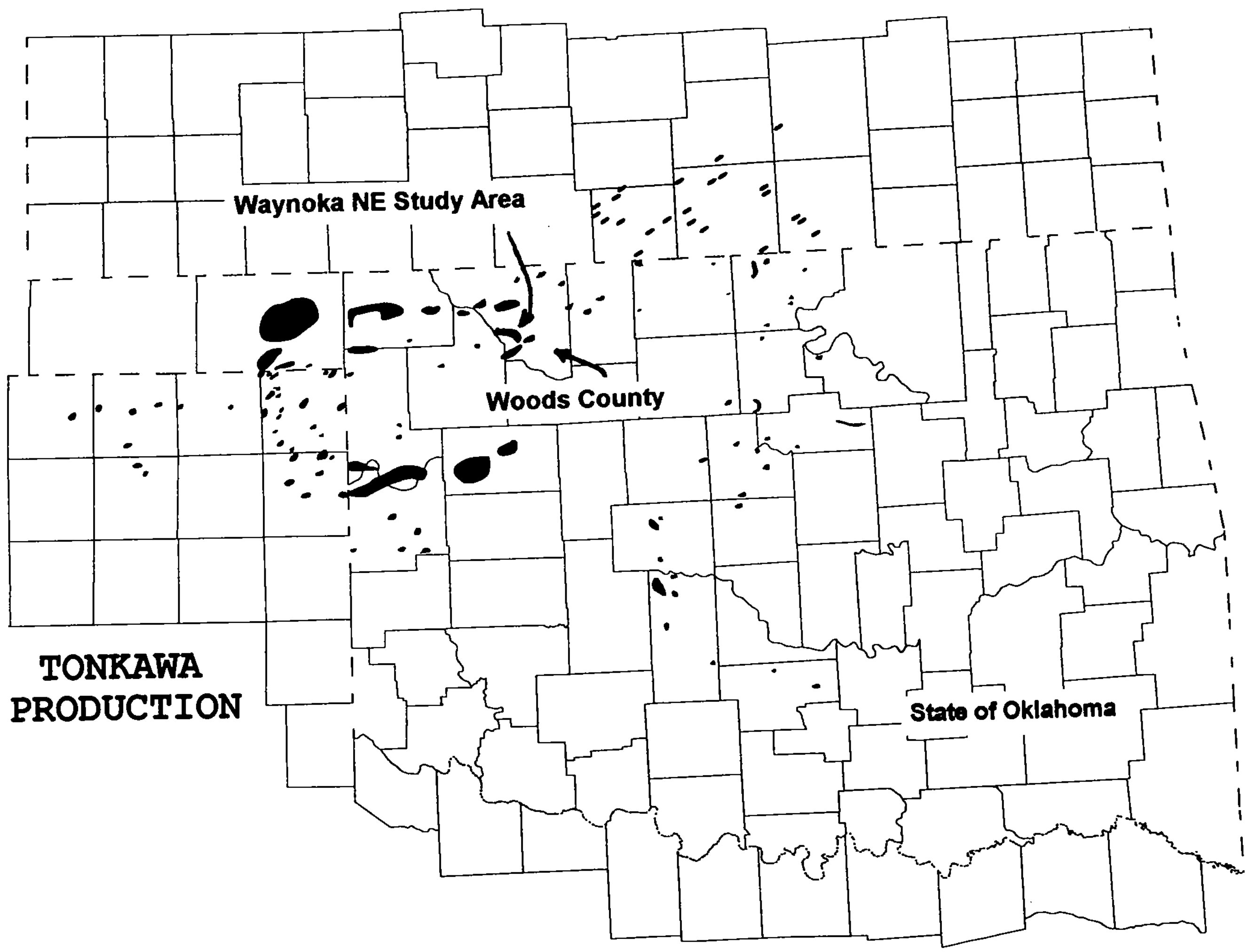


Figure W1. Regional position of the Waynoka NE field study with respect to all production from Tonkawa sand. The reservoir study area is located in the gas producing province of the Tonkawa sand, which was deposited primarily under marine conditions in the subject area. Sincere appreciation is extended to Mr. Randy Haley and Mr. Tom Farrell of RDH Enterprises, Inc. for their assistance with and support of this report. Special thanks also to Mr. Matt Garber of Schlumberger Well Services, for his assistance in interpretation of the FMI log used for this report.

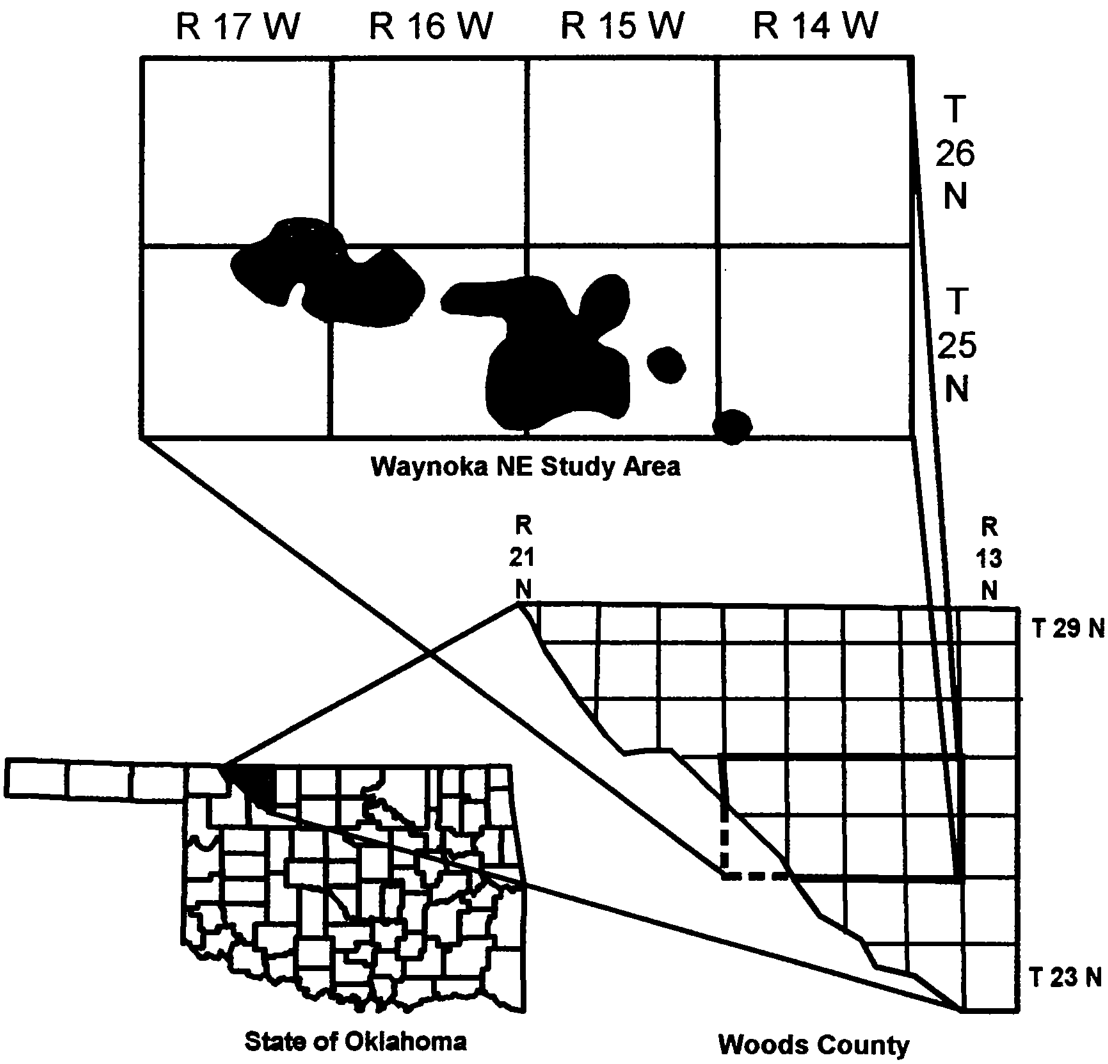


Figure W2. Location of the Waynoka NE field study area, Woods County, Oklahoma.

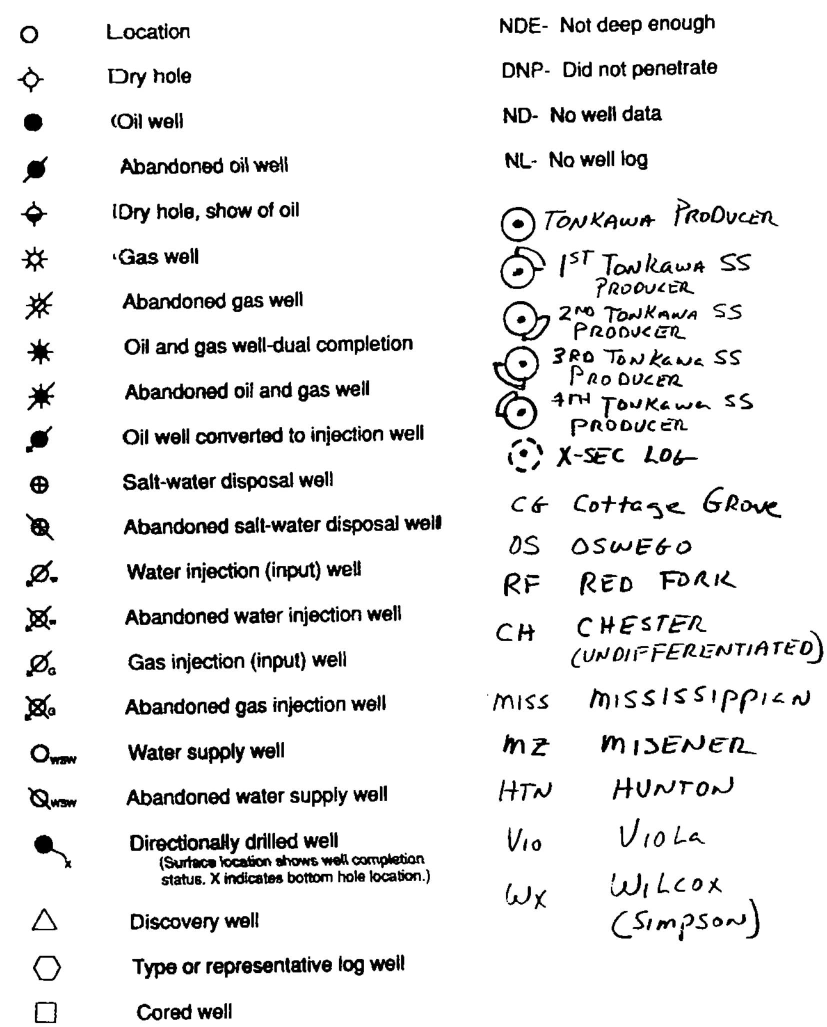


Figure W3. Symbols used for the maps included in the Waynoka NE field study area, Woods County, Oklahoma.

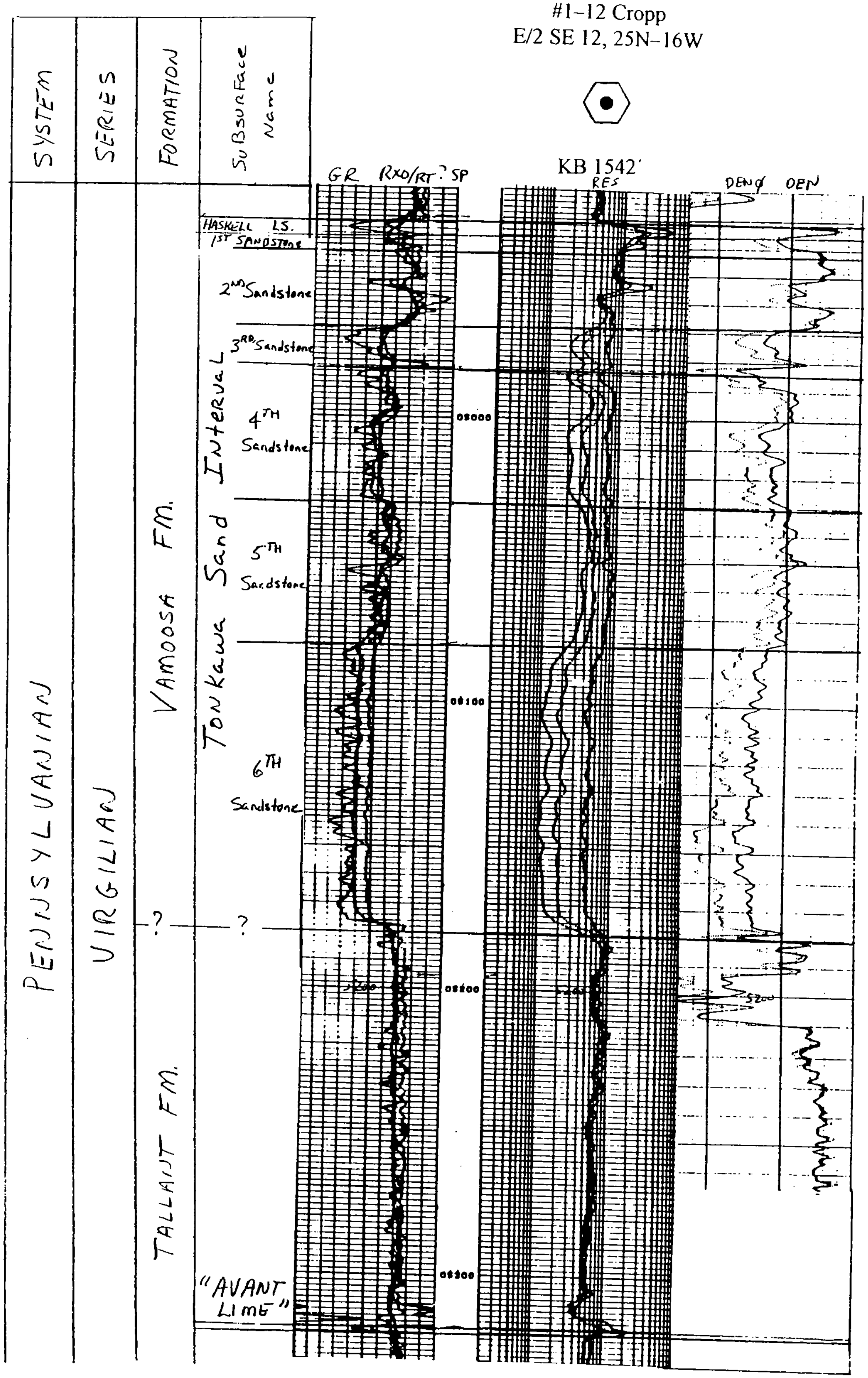
Figure W4 (in envelope). Index map identifying wells used to evaluate the Tonkawa sandstone reservoir in the Waynoka NE field study area. Producing formations for the productive wells are indicated by abbreviation. The discovery well, reference log, and the cored wells are marked and will be discussed in the following figures. The study area is larger in areal extent than most of the field studies associated with the FDD workshop series, in order to better understand the geometry of sandstone reservoirs, and depositional environments within the Tonkawa sand.

Figure W5 (in envelope). Structure map contoured on the top of the Haskell Limestone. The field study area occurs within a gentle homocline, with dip to the south at a rate of approximately 20 ft/mile. A closure located in section 31, T. 25 N., R. 14 W. produces from a number of formations, including the Tonkawa sand. A smaller closure is also present in sections 9, 10, and 11, T. 25 N., R. 16 W. This closure may be associated with compaction and draping of the Haskell Limestone over a local thick area of Tonkawa sandstone.

Figure W6. Reference log for the Tonkawa sand in the Waynoka NE field study area, Woods County, Oklahoma. Location of this well is shown on Figure W5. The Tonkawa sand occurs in the Vamoosa Formation, and the shale below the Tonkawa sand is probably in the Tallant Formation. However, the exact boundary between the two formations in the subsurface is not clear. A more detailed description of this relationship can be found in the general stratigraphy portion of the regional overview of the Tonkawa FDD workshop (Oklahoma Geological Survey, SP 97-3).

The Tonkawa sand has been separated into six regionally correlatable layers, which have been labeled in descending order 1^{st} sandstone through 6^{th} sandstone. The six layers are mapped individually. The primary characteristic of these layers is their consistent stratigraphic presence, and uniformity of thickness with respect to the Tonkawa interval. Cut and fill deposits seem to be lacking within the Tonkawa, as all of the layers seem to be associated with conformable, non-eroded interfaces. This concept has important application to hydrocarbon production from several Tonkawa producing layers, as will be shown in more detail in the following figures.

Tidemark Exploration
#1-12 Cropp
E/2 SE 12, 25N-16W



TD 6109′
Completed ?/??/83

Figure W6

TABLE 1. - Geological/Engineering Data for the Tonkawa Sandstone Waynoka NE Tonkawa Field Study Area, Woods County, Oklahoma

	Tonkawa Sand
Reservoir size (Oil)	Not Applicable
Reservoir size (Gas)	Variable
Well spacing (gas)	640 acres
Oil/water contact	Not Applicable
Gas/water contact	Variable
Porosity	8 - 20 %
Permeability	Unknown
Water saturation	~24 % - ~55%
Gas to Oil Ratio	Not Applicable
Thickness (net sand) (ø >8%)	Variable
Reservoir temperature	120° F
Oil gravity	Unknown (Condensate)
Initial reservoir pressure	~2000 PSI
Initial gas formation-volume factor	0.006
Original Oil in Place (volumetric)	(Condensate)
Cumulative condensate	Unknown
Recovery efficiency (oil)	Not Applicable
Cumulative gas	54.2 BCFG

Table W1. Geologic and engineering data for the Tonkawa sand reservoirs in the Waynoka NE field study area, Woods County, Oklahoma. Several of the data fields are variable because of the large number of separate reservoirs in the multiple layers of the Tonkawa sand.

Gulf Oil Corporation
No. 1 Shade
NE SE SW Sec. 31, T. 25 N., R. 14 W.
Woods County, Oklahoma

Core: 5,178–5,201 ft; rec. approx. 23 ft

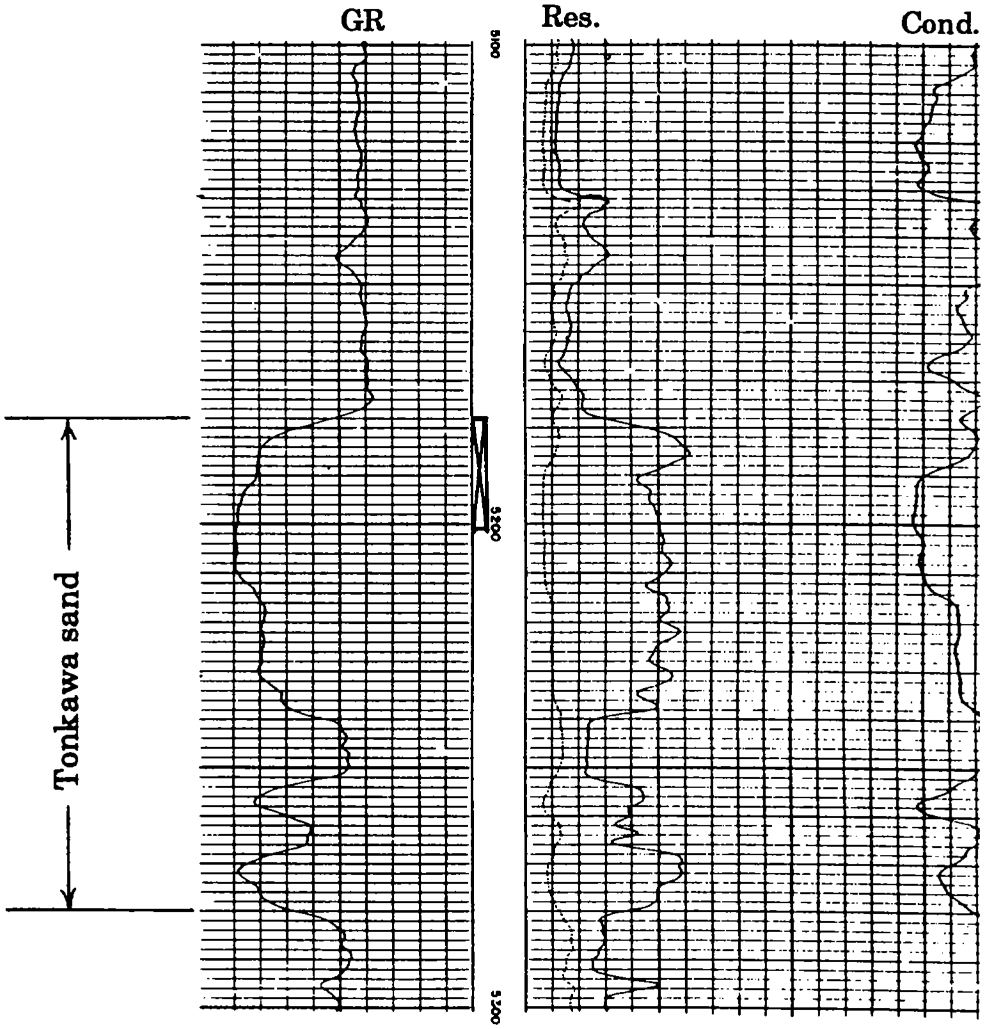
5,178–5,201	Sandstone, fine to very fine grained, micaceous. Bedding essentially horizontal and commonly indistinct. Small-scale ripple-bedding also common. Partings of organic matter occur mainly in association with ripple-bedding. • Red clay partings and/or clasts, 5,178.2–78.3; 5,180.3; 5,183.3; 5,198.9; and 5,201.3 ft • Minor soft-sediment deformation at 5,190.05 and 5,195.70 ft • Significant partings of brownish-black organic matter, 5,189.2; 5,190.1; 5,193.7–93.8; 5,196.0–96.3; and 5,199.9 ft • Small coal clast at 5,198.6 ft
Summary:	Core represents sand deposition on a shallow-marine shelf; an offshore bar (?)

Table W2. Description of core of Tonkawa sand in the #1 Shade well. The presence of micas in both cores indicates a granitic source, probably in the northern mid-continent.

Gulf Oil Corporation
No. 1 Shade
NE SE SW Sec. 31, T. 25 N., R. 14 W.
Woods County, Oklahoma

T.D. 7,995 ft

Core: 5,178–5,201 ft



Completed 2-14-1957
DST Tonkawa, 5,174–5,201: Rec. 120 ft sli. GCM;
Did not perforate Tonkawa
Completed in Hunton and Sylvan
IPF 51 BOPD and 54 BWPD

Earlsboro Oil and Gas Company
No. 1 Curtis-Stark
C SE NE Sec. 20, T. 25 N., R. 15 W.
Woods County, Oklahoma

Core: 5,055–5,116 ft, rec. approx. 56 ft

1. 5,055 — Black shale

2. 5,056.0–5,057.9 — Gray limestone, fossiliferous

3. 5,058.0–5,061.1 — Interbedded black silty shale and gray, micaceous siltstone to very fine-grained sandstone. Flat-bedded with small-scale cross-bedding in layers 0.1 in. to 1 in. thick.
   - Red oxidized clay (0.5 in. thick) at 5,058 ft
   - Soft-sediment deformation at 5,060.8

4. 5,061.2–5,064.8 — Sandstone, fine-grained, silty, slightly micaceous, with indistinct, flat bedding

5. 5,064.9–5,069.6 — Interbedded black silty shale and gray siltstone to very fine-grained, micaceous sandstone. Flat-bedded with small-scale cross-bedding.
   - Soft-sediment deformation at 5,064.8 ft
   - Bioturbation at 5,065.4–65.6 ft
   - Shale oxidized at 5,067.4–67.6 ft

6. 5,069.7–5,076.4 — Sandstone, fine grained, silty and micaceous. Ripple bedding with common partings of dark organic matter.

7. 5,076.5–5,091.0 — Interbedded very-fine-grained sandstone, slightly micaceous siltstone and black, silty shale. Variation from thin lamina (~0.1 in.) to 8 in. thick layers of sandstone. Bedding flat except for small-scale cross-bedding within layers.
   - Soft-sediment deformation at 5,075.5 and 5,080.8
   - Bioturbation at 5,077.8–77.9 and 5087.2–87.4 ft

8. 5,091.1–5,111.0 — Black shale with local thin (~0.1–0.5 in.) partings of gray siltstone with local bioturbations.

Summary: Most of core represents shallow marine deposition.

Open marine:	Intervals 1 and 2
Shallow marine shelf:	Intervals 3 through 7 Intervals 4 and 6 are offshore bars; thinner sandstones within intervals 3, 5, and 7 were deposited as incipient bars or sand waves
Open marine:	Interval 8

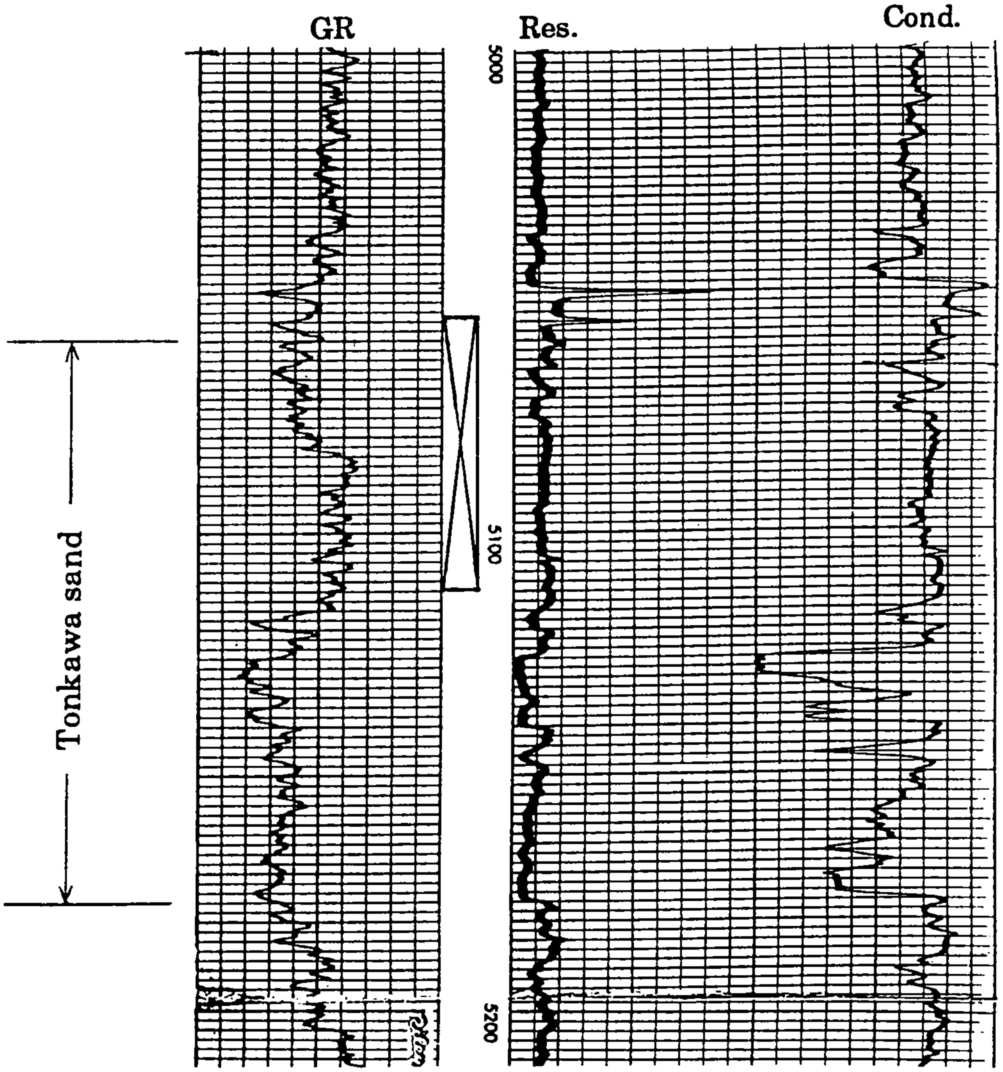
Intervals approximate; original core depths not well marked.
Core is about 7 ft low with respect to wireline log

Table W3. Description of core of Tonkawa sand in the #1 Curtis-Stark well.

Earlsboro Oil and Gas Company
No. 1 Curtis-Stark
C SE NE Sec. 20, T. 25 N., R. 15 W.
Woods County, Oklahoma

T.D. 5,552 ft

Core: 5,055–5,116 ft



Completed 7-23-1970

Perforated Cottage Grove Sandstone, 5,508–5,528 ft
Acidized/800 gal 15%
CAOF 2,432 MCFGPD

Table 4 - Gas Production Statistics for the Tonkawa Sand
Waynoka NE Field Study Area,
T. 25N., R. 15-17 W., Woods County, Oklahoma

Year	Number of Gas Wells	Annual Gas Production Per Well (MCF)	Average Annual Gas Production (MCF)	Average Daily Gas Production Per Well (MCF)	Cumulative Gas Production (MCF)
1967	11	386,980	35,180	96	386,980
1968	12	1,627,651	135,638	371	2,014,631
1969	14	2,837,544	202,682	554	4,852,175
1970	16	2,282,789	142,674	390	7,134,964
1971	19	2,985,974	157,157	429	10,120,938
1972	18	2,999,480	166,638	455	13,120,418
1973	20	3,098,405	154,920	423	16,218,823
1974	20	4,400,794	220,040	601	20,619,617
1975	21	3,482,436	165,830	453	24,102,053
1976	21	2,530,199	120,486	329	26,632,252
1977	22	2,369,109	107,687	294	29,001,361
1978	22	2,717,628	123,529	338	31,718,989
1979	23	1,953,007	84,913	232	33,671,996
1980	22	1,418,695	64,486	176	35,090,691
1981	20	1,456,447	72,822	199	36,547,138
1982	20	1,004,614	50,231	137	37,551,752
1983	21	575,110	27,386	75	38,126,862
1984	22	812,738	36,943	101	38,939,600
1985	22	604,296	27,468	75	39,543,896
1986	22	471,625	21,438	59	40,015,521
1987	22	248,109	11,278	31	40,263,630
1988	21	664,410	31,639	86	40,928,040
1989	21	625,472	29,784	81	41,553,512
1990	20	816,941	40,847	112	42,370,453
1991	22	1,248,197	56,736	155	43,618,650
1992	24	2,984,159	124,340	340	46,602,809
1993	26	2,997,108	115,273	315	49,599,917
1994	27	2,378,628	88,097	241	51,978,545
1995	24	1,290,780	53,783	147	53,269,325
1996	23	889,507	38,674	106	54,158,832

Table W4. Natural gas production statistics for the Waynoka NE field study area.

Figure W7 (in envelope). North–south stratigraphic cross section A–A′. Location shown on Figure W5. Cross section includes the reference log and identifies all six layers of the Tonkawa sand. Persistence, uniformity, and log character of intervals 1 through 6 indicates a marine depositional environment. There are no apparent cut and fill relations.

Figure W8 (in envelope). West–northeast stratigraphic cross section B–B′. Location shown on Figure W5. The #1 Claude Seaman Unit is the tie well for the two cross sections. The Tonkawa sand has been cored in the #1 Shade and the #1 Curtis-Stark wells (Tables W2 and W3). The #3-1 Lancaster was logged using Schlumberger′s FMI tool (Figures W10, W12, W13, W15, W17 and W18).

Figure W9 (in envelope). Isopach of the 6th sandstone layer of the Tonkawa sand. Stratigraphic position of the sandstone is shown on both cross sections A-A′ and B-B′. The sandstone exceeds 100 ft. in thickness in the central part of the study area, and is bounded by open marine silty and sandy shales. The immediate direction of sediment transport was probably from the southeast. The layer is not productive, however, this may be due to positions of existing wells, or lack of testing in the structurally updip part of the sandstone. The contact between the 6th and 5th sandstone layers over the study area is characterized by a regionally correlatable, non-erosional interface. This implies that a few feet of shale between these layers would be a permeability barrier that would isolate the two layers as separate reservoirs. This relationship can be seen on cross section A-A′ (Figure W7) between the #2 Fox and the #1 Stallings. The thin sandstone lenses of the 6th layer in the #1 Fox may locally have lower water saturations than those for the 5th layer located immediately above it. Therefore, it is possible that commercial gas reserves will be found below water bearing zones, which are separated by only a few feet of impermeable, non-fractured strata. This is an extremely important concept for Tonkawa exploration and development. The basal part of the 6th layer in the extreme northeastern part of the study area contains stringers of limestone. That limestone is mapped on Figure W9.

Contact between 5th sandstone and 6th sand interval

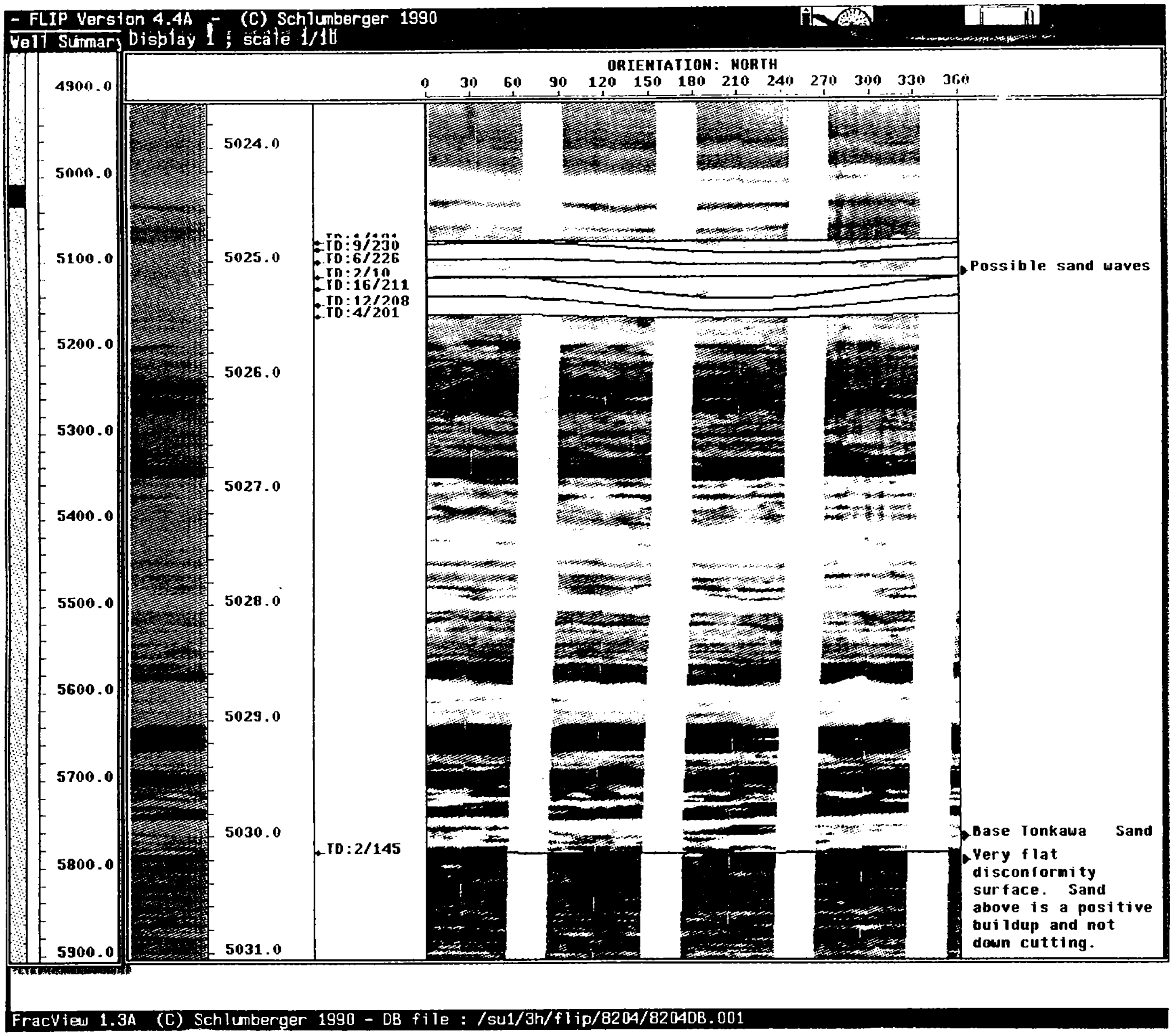


Figure W10. Part of FMI (Formation Imaging) log of the #3-1 Lancaster. The same interval is presented as the Lancaster gamma-ray and resistivity log on cross section B-B′ (Figure W8). The contact between the 5th and 6th layer is at 5030.0′. The basal part of the 5th sandstone is composed of thinly laminated siltstone and shale streaks. These were deposited under very low energy conditions.

Figure W11 (in envelope). Isopach of the 5th sandstone layer of the Tonkawa sand. The sandstone was deposited as a marine bar with the immediate source of sediment from the southeast. An apparent tidal channel separates the bar into two parts. The areas referred to as "low energy deposits" consist of thin shale and siltstone that are probably impermeable. The axis of the bar deposit is characterized by cleaner, better sorted and significantly more permeable siltstone and sandstone. Commonly abundant micas in the sandstone indicate that the ultimate sediment source was from the north. The 5th sandstone was not productive within the Waynoka NE field study area at the time of the preparation of this report.

"Shale" Interval within the 5th Sandstone Interval

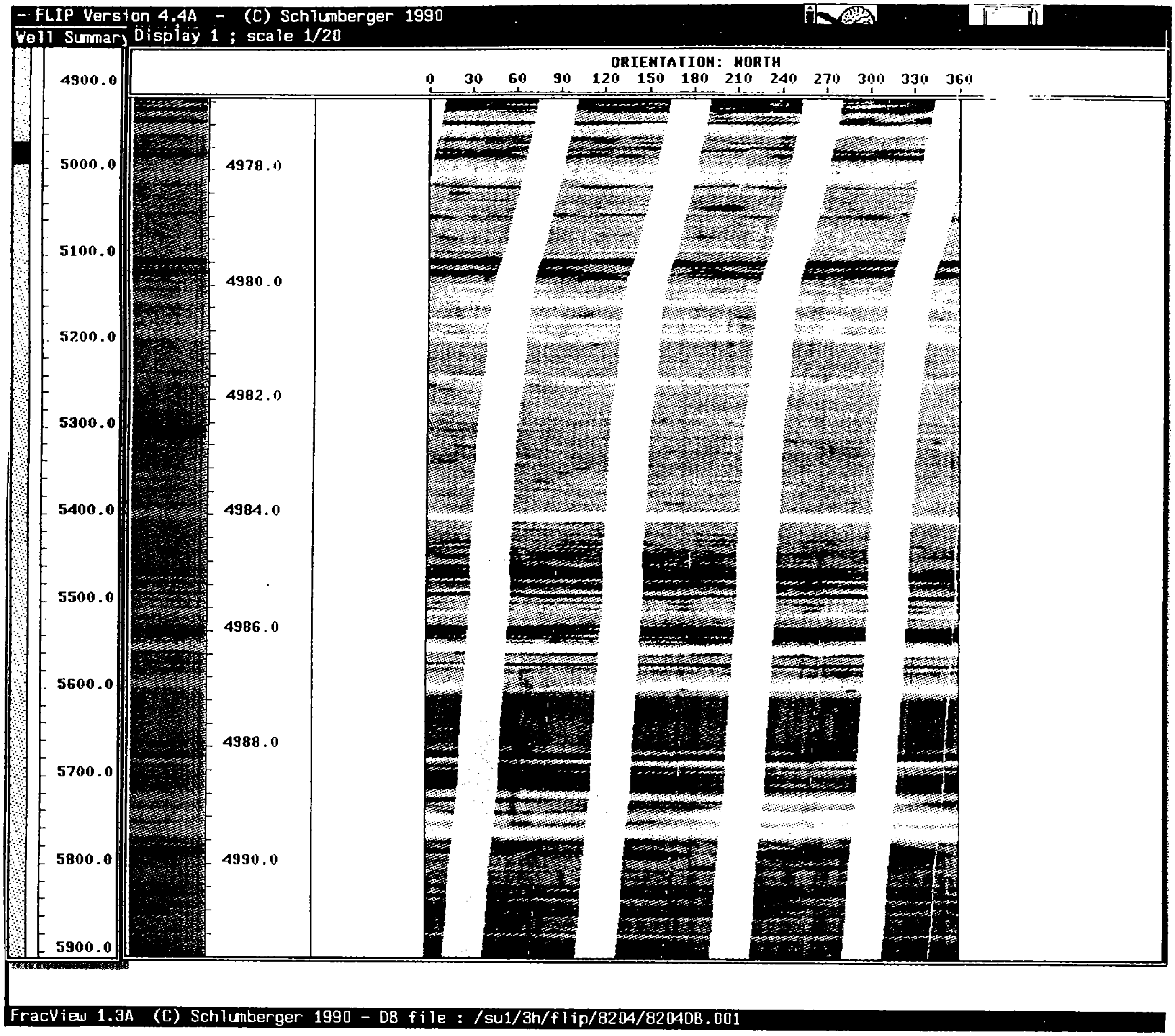


Figure W12. Part of FMI log of the #3-1 Lancaster. The same interval is presented as the gamma-ray and resistivity log on cross section B-B′ (Figure W8). The interval 4980 to 4984 ft is interpreted to be shale on the gamma ray curve, but appears as siltstone or very-fine grained sandstone on the FMI Log. The gamma-ray log is probably responding to radioactive materials present in the sandstone lenses.

Contact between 4th and 5th sandstone

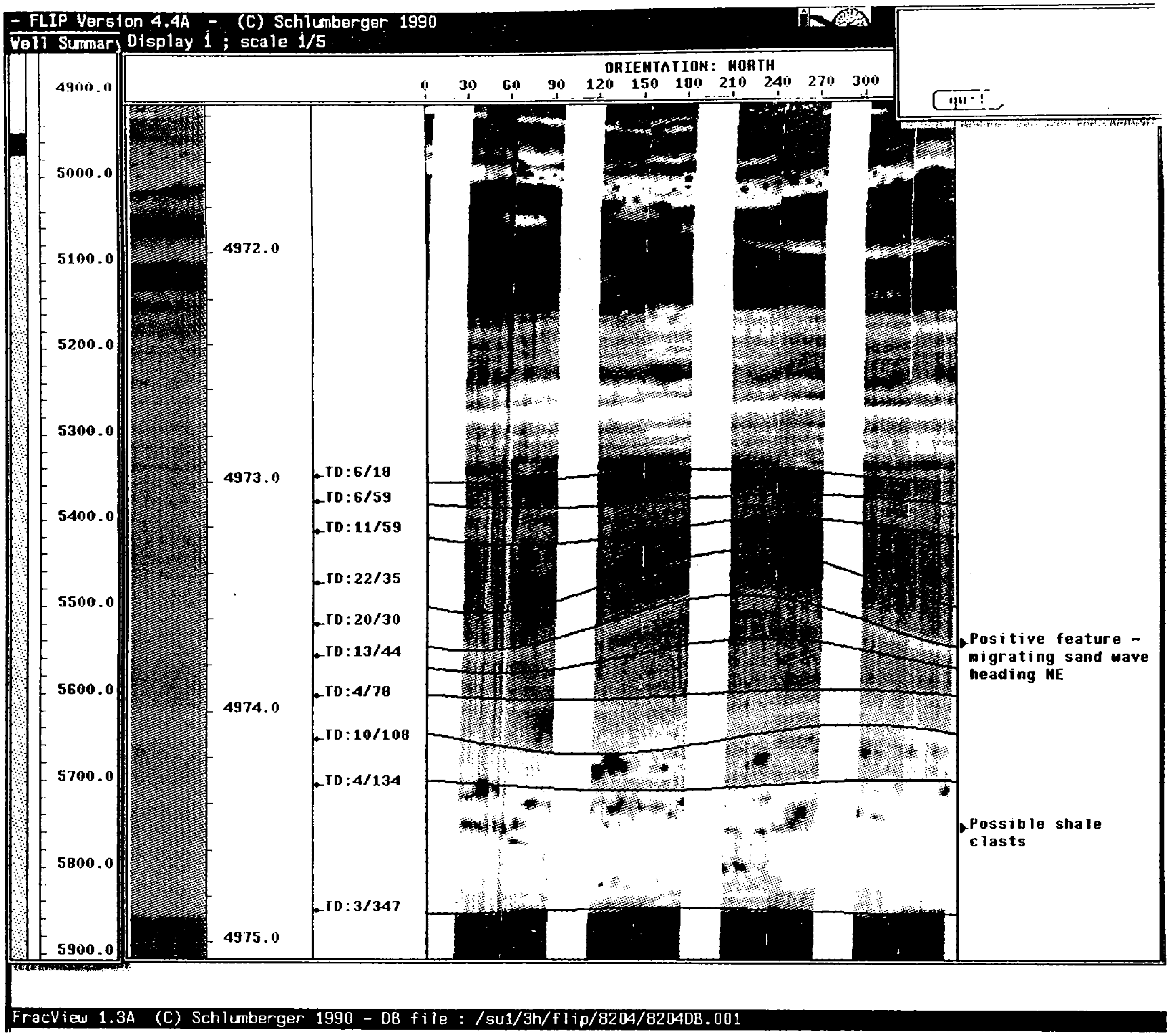


Figure W13. Part of FMI log of the #3-1 Lancaster well of Figure W8 illustrates the contact between the 4th and 5th sandstone layers. The lower part of the 4th sandstone is characterized by a slightly higher energy environment as suggested by the shale clasts embedded in that layer. The same interval is presented as the gamma-ray and resistivity log on cross section B-B′ (Figure W8).

Contact between 3rd and 4th sandstone

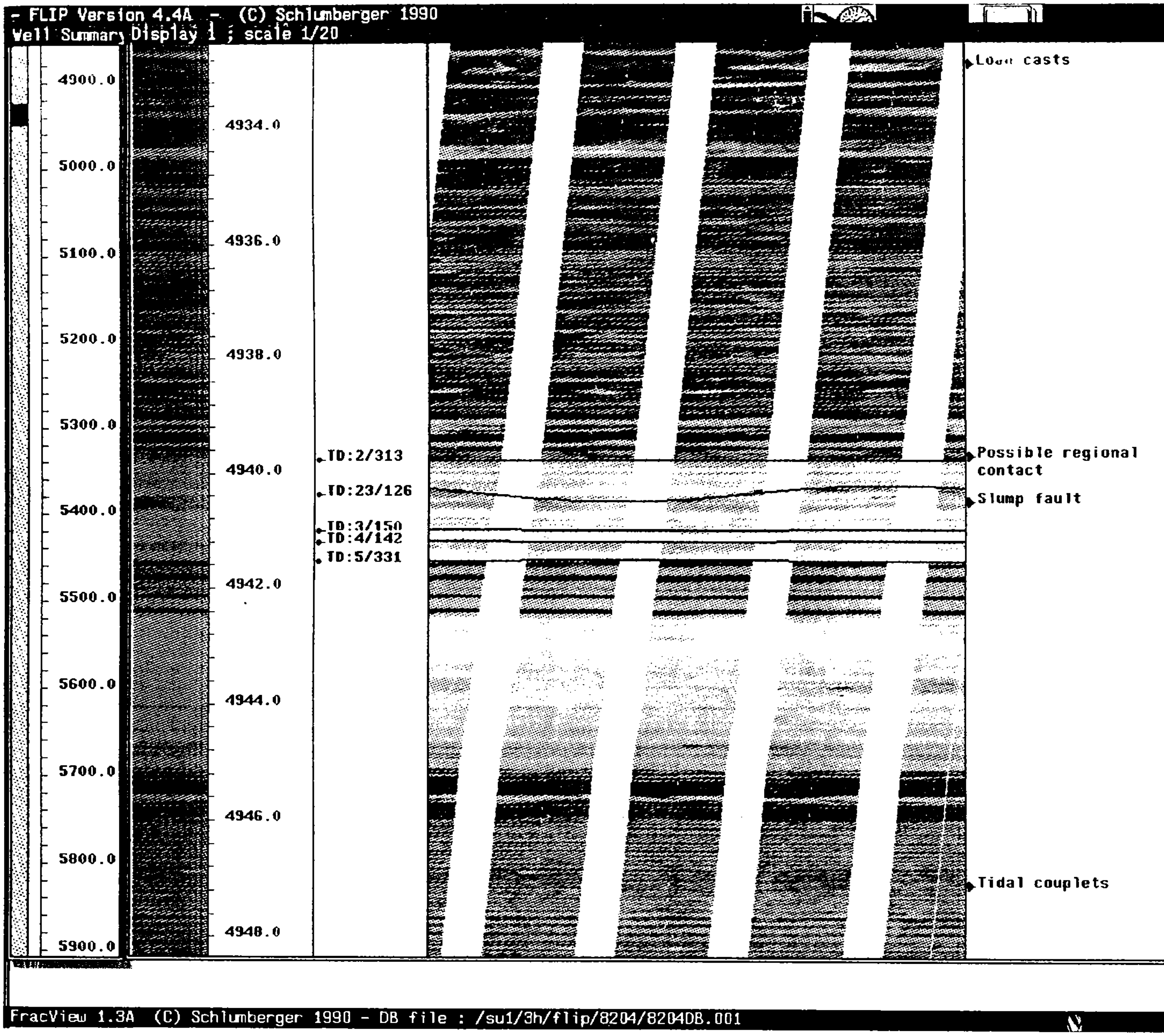


Figure W15. Part of the FMI log from the #3-1 Lancaster well of Figure W8 illustrates the contact between the 3rd and 4th sandstone layers. The very thin sandstone and shale laminations are sometimes known as tidal couplets.. These deposits are interpreted to occur in a very shallow, low energy tidal environment.

Figure W14 (in envelope). Isopach of the 4th sandstone layer of the Tonkawa sand. This layer was the first reservoir to be productive in the Waynoka NE field study area. The reservoir boundary of the group of producing wells labeled Reservoir C, located in the center of the study area, is bounded to the north, northeast, and east by shales filling the apparent tidal channel. The reservoir boundary to the northwest and west contains deposits of siltstone and very-fine grained sandstone that have been identified as "low–energy deposits". These deposits are characterized by an increase in the frequency of shale laminations and by generally low porosity values. The low–energy deposits are probably impermeable, which completes the reservoir seal to the west and northwest of Reservoir C. The presence of isolated commercial reservoirs sealed by impermeable strata located intermittently in the middle of large sandstone bodies is of great significance for Tonkawa exploration and development.

"Shale" Interval within the 5th Sandstone Interval

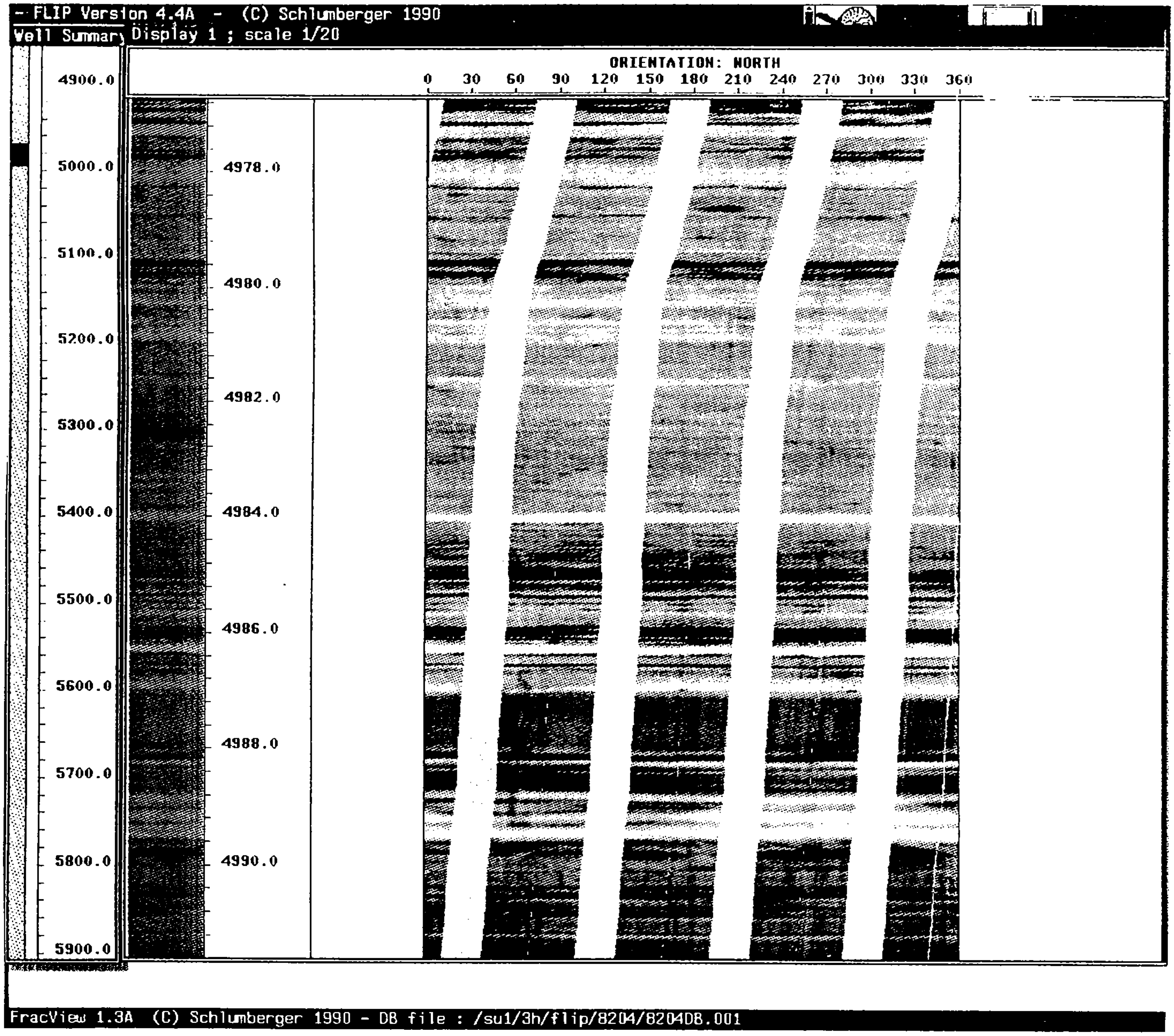


Figure W12. Part of FMI log of the #3-1 Lancaster. The same interval is presented as the gamma-ray and resistivity log on cross section B-B′ (Figure W8). The interval 4980 to 4984 ft is interpreted to be shale on the gamma ray curve, but appears as siltstone or very-fine grained sandstone on the FMI Log. The gamma-ray log is probably responding to radioactive materials present in the sandstone lenses.

Contact between 4th and 5th sandstone

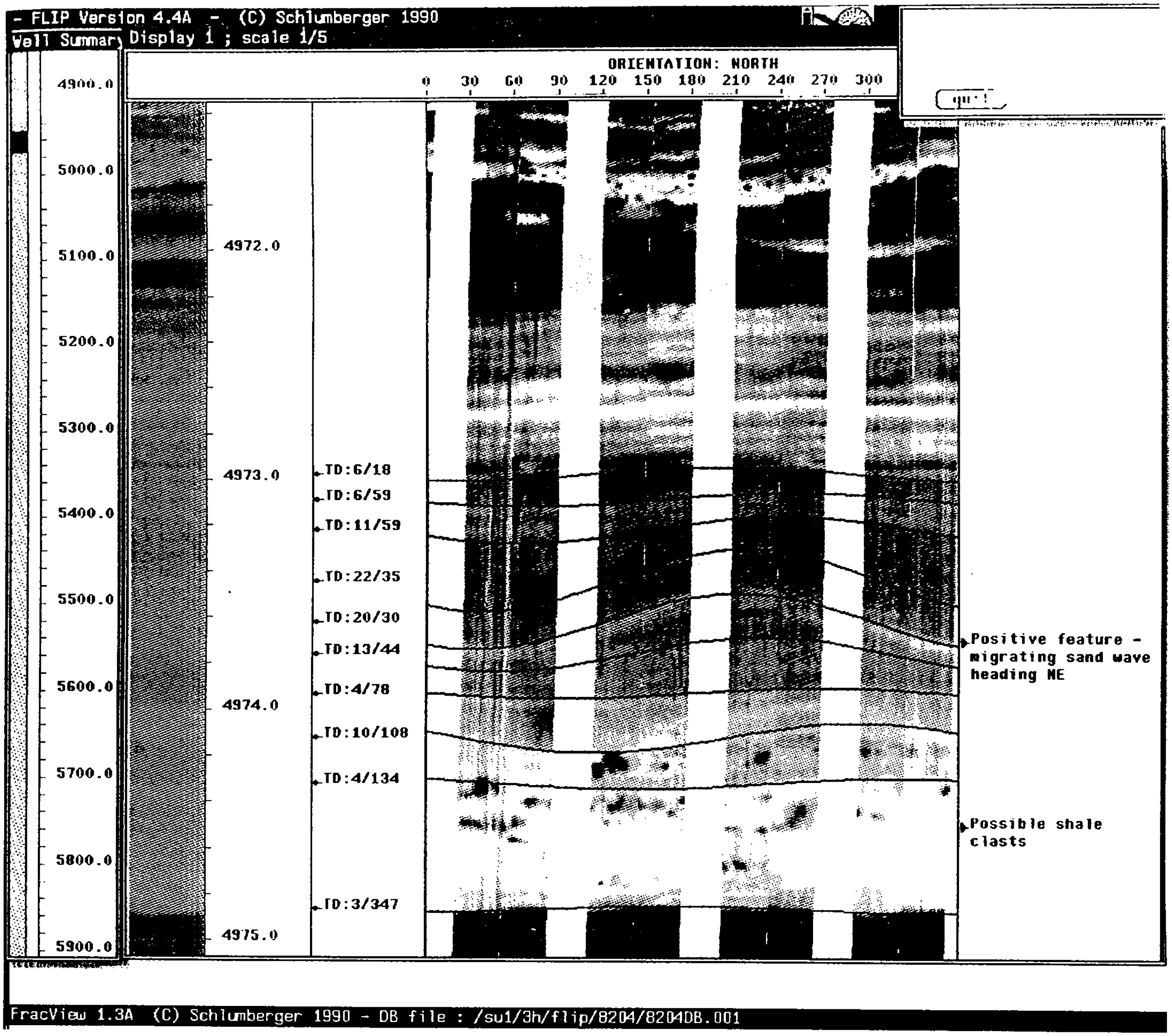


Figure W13. Part of FMI log of the #3-1 Lancaster well of Figure W8 illustrates the contact between the 4th and 5th sandstone layers. The lower part of the 4th sandstone is characterized by a slightly higher energy environment as suggested by the shale clasts embedded in that layer. The same interval is presented as the gamma-ray and resistivity log on cross section B-B′ (Figure W8).

Figure W14 (in envelope). Isopach of the 4th sandstone layer of the Tonkawa sand. This layer was the first reservoir to be productive in the Waynoka NE field study area. The reservoir boundary of the group of producing wells labeled Reservoir C, located in the center of the study area, is bounded to the north, northeast, and east by shales filling the apparent tidal channel. The reservoir boundary to the northwest and west contains deposits of siltstone and very-fine grained sandstone that have been identified as "low–energy deposits". These deposits are characterized by an increase in the frequency of shale laminations and by generally low porosity values. The low–energy deposits are probably impermeable, which completes the reservoir seal to the west and northwest of Reservoir C. The presence of isolated commercial reservoirs sealed by impermeable strata located intermittently in the middle of large sandstone bodies is of great significance for Tonkawa exploration and development.

Contact between 3rd and 4th sandstone

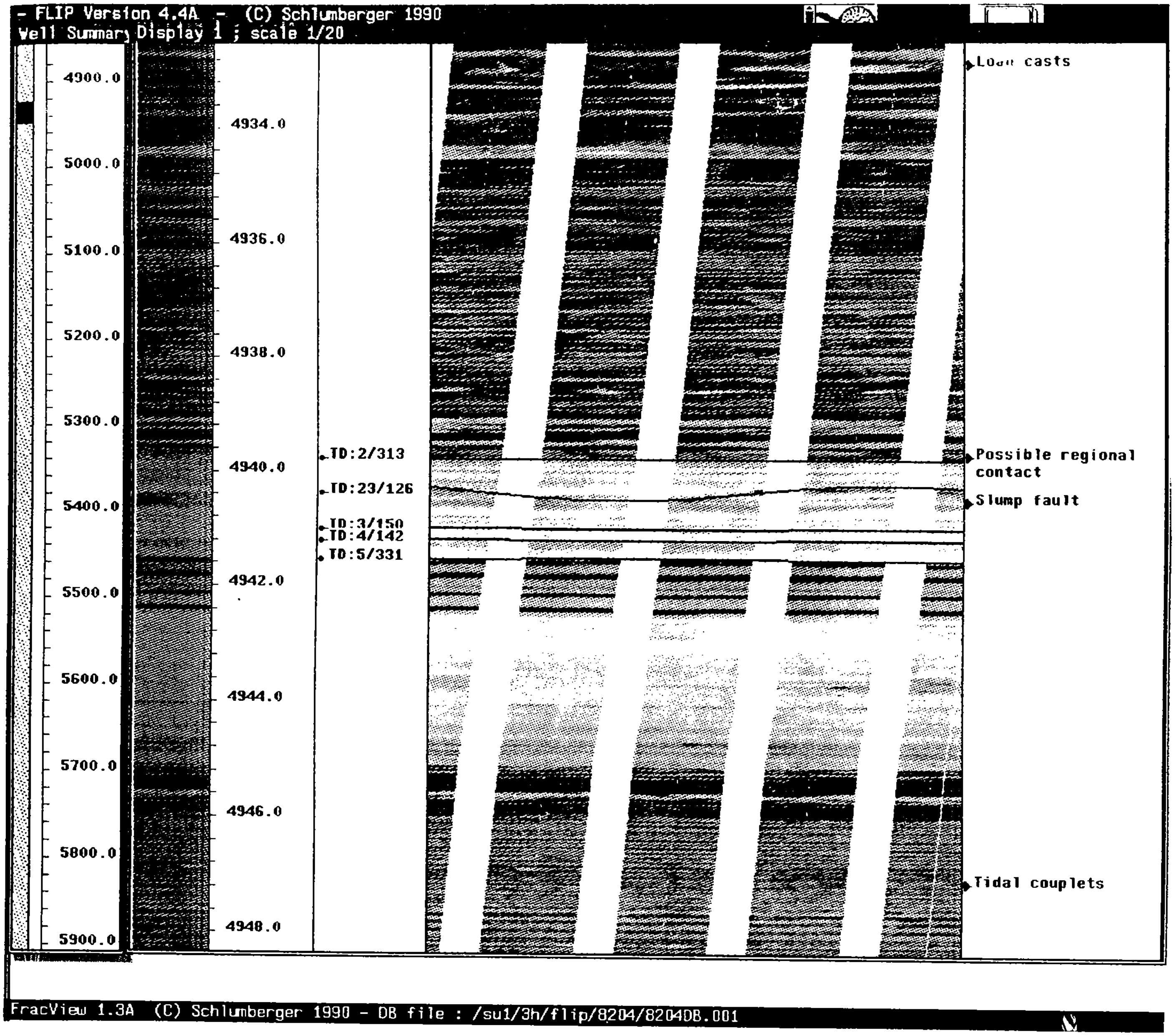


Figure W15. Part of the FMI log from the #3-1 Lancaster well of Figure W8 illustrates the contact between the 3rd and 4th sandstone layers. The very thin sandstone and shale laminations are sometimes known as tidal couplets.. These deposits are interpreted to occur in a very shallow, low energy tidal environment.

Figure W16 (in envelope). Isopach of the 3rd sandstone layer of the Tonkawa sand. The layer is composed of shale and isolated sandstone bars deposited in an open marine environment. Such a sandstone produces minor amounts of gas in section 30, T. 25 N., R. 15 W.

Contact between 2nd and 3rd sandstone

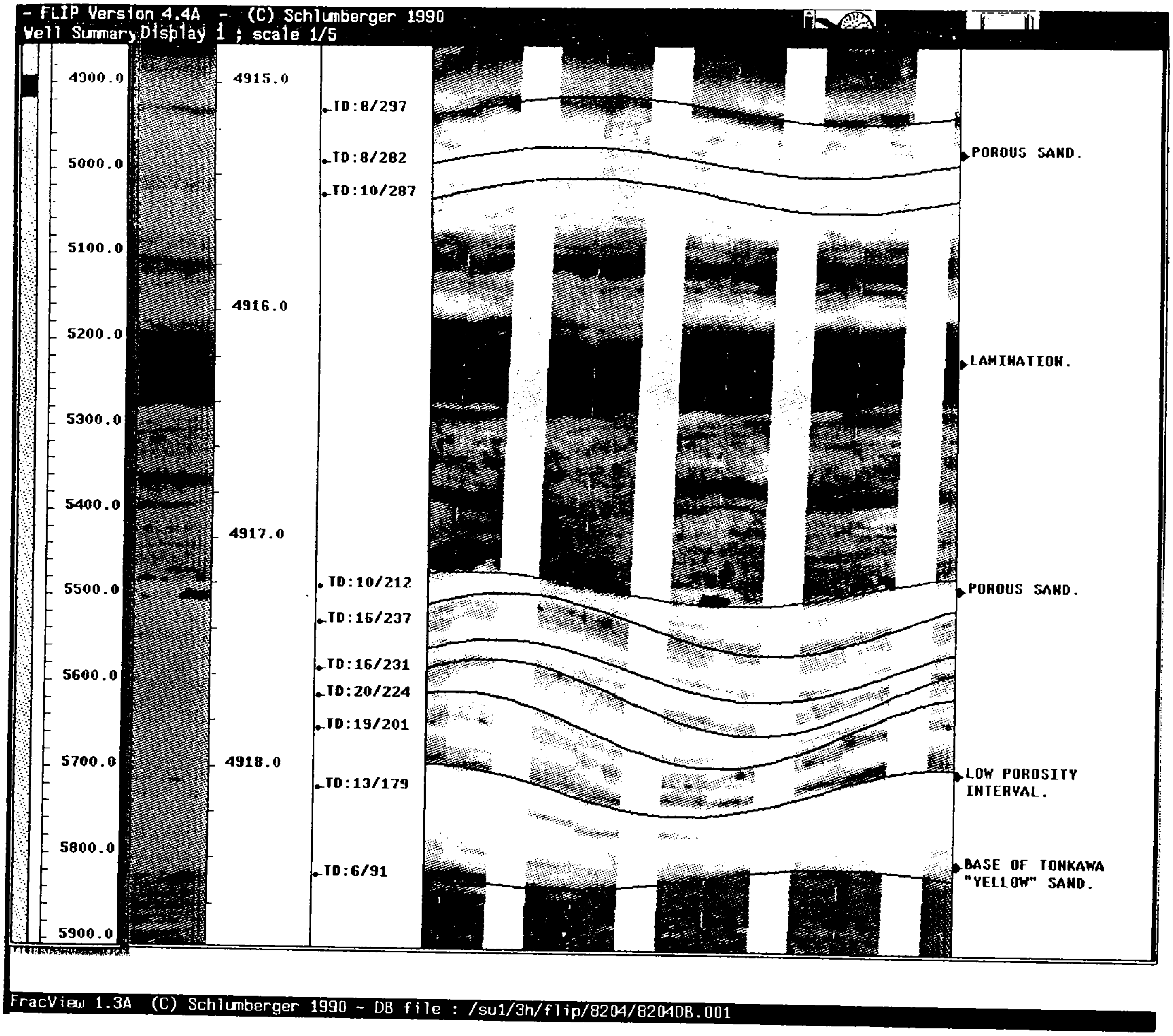


Figure W17. Part of FMI log of the #3-1 Lancaster illustrates the contact between the 2nd and 3rd sandstone layers. The 2nd sandstone layer is the productive interval of the #3-1 Lancaster. The same interval is presented as the gamma-ray and resistivity log on cross section B-B′ (Figure W8).

Upper portion of 2nd sandstone pay zone

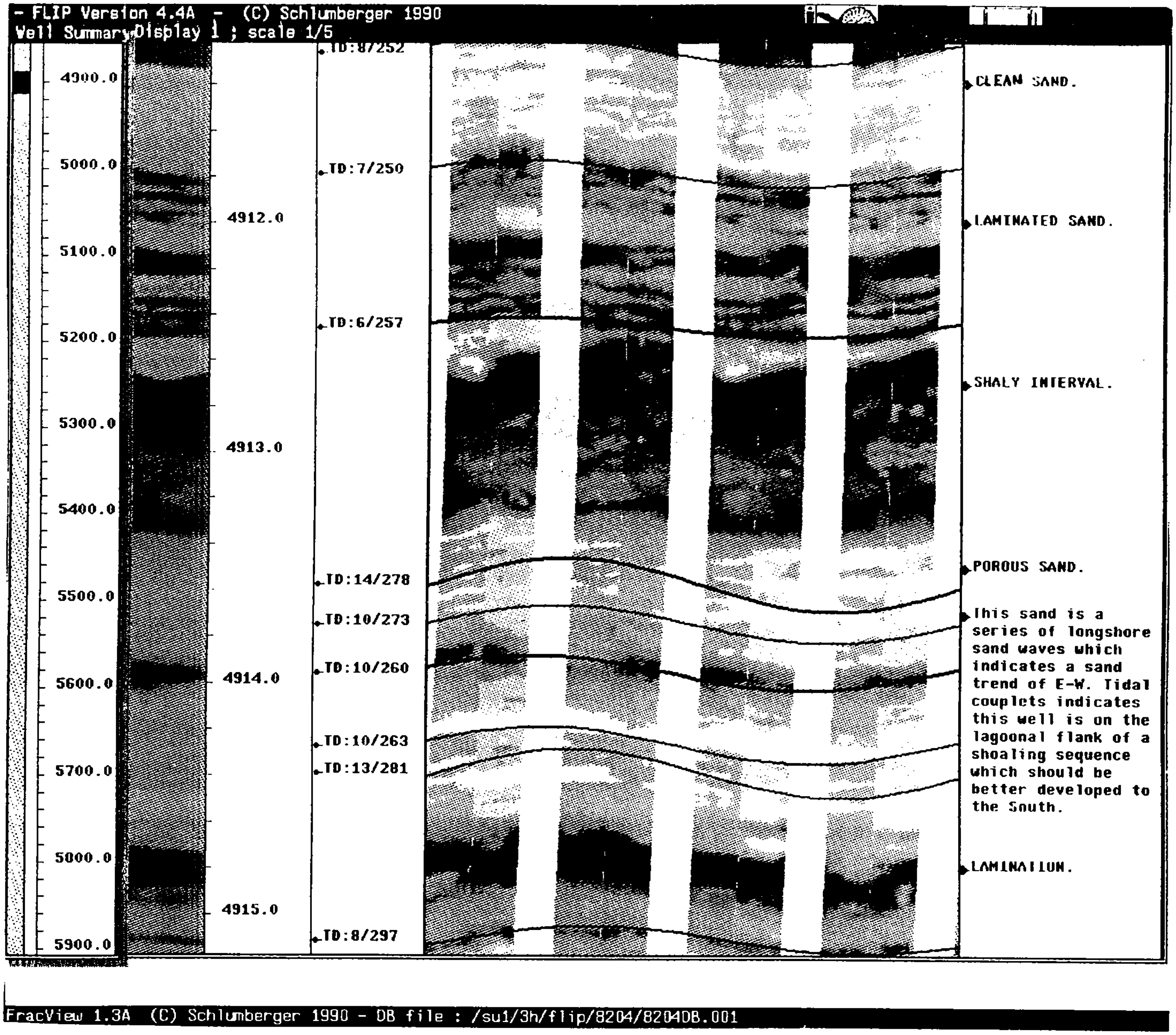


Figure W18. Part of FMI log of #3-1 Lancaster. The upper part of the 2nd sandstone layer is productive. The environment of deposition is noted on the log. The same interval is presented as the gamma-ray and resistivity log on cross section B-B′ (Figure W8).

Figure W19 (in envelope). Isopach of the 2nd sandstone layer of the Tonkawa interval. Geometry of the 2nd sandstone suggests a marine bar complex, dissected by a series of north–south tidal channels. The impermeable deposits of the tidal channels probably separates the reservoirs labeled A and B. The discovery well for the Waynoka NE field study area is the King Resources #1-4 Schmolcke, NW SE section 4, T. 25 N., R. 16 W. Completed in December of 1965, this well had an initial potential of 5.8 MMCFGPD.

Figure W20 (in envelope). Isopach of the 1st sandstone layer of the Tonkawa sand. This layer was deposited as marine shales and small offshore marine bars. The small size of the sandstone features suggests that the amount of clastic material available was decreasing. The Haskell Limestone is normally deposited directly over the 1st sandstone. The sandstone produces locally, and may be prolific, assuming the data for wells completed in the 1st sandstone is accurate.

Figure W21 (in envelope). Isopach of the interval from the top of the Haskell Limestone to the top of the "Avant lime". The "Avant lime" is commonly regarded as the base of the interval within which the Tonkawa sand occurs (Figure W6.). Minor thickening that is attributed to the presence of sandstone in the 5th and 6th layers is present in the center of the study area. Elsewhere, the isopach exhibits relatively uniform thickness except for thinning in the northwestern part of the field study area.

Figure W22 (in envelope). Natural gas production from Tonkawa sand for in the Waynoka NE field study area. The plat illustrates cumulative gas and condensate production, initial and final pressure test data with dates, and the production period for each well.

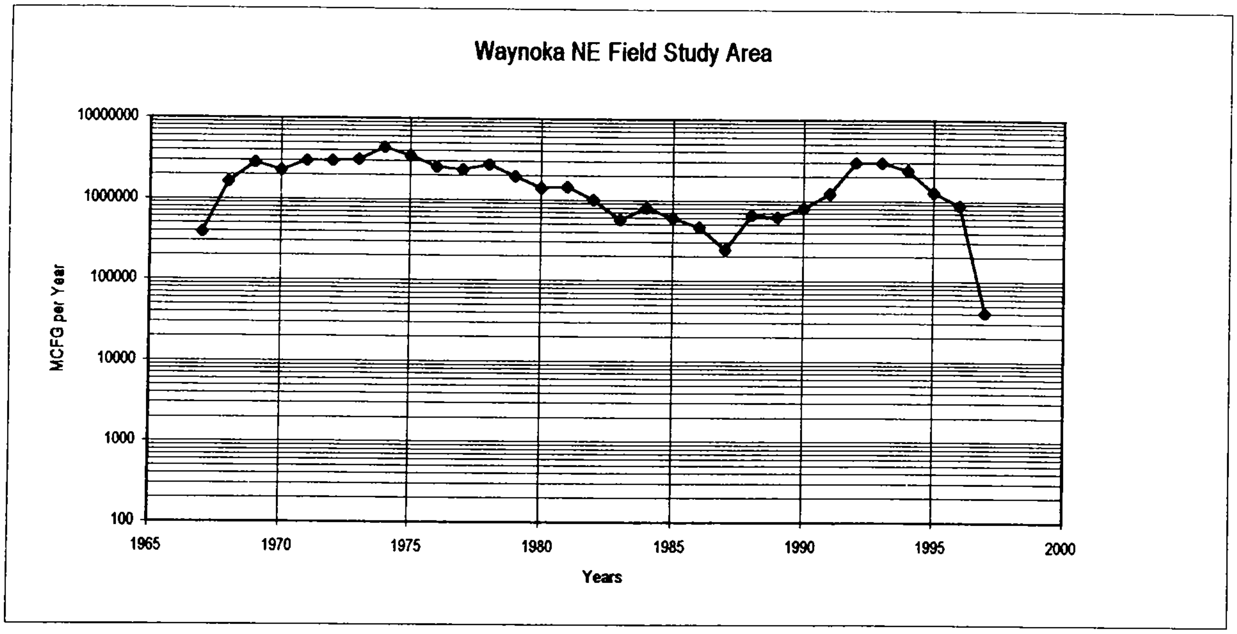


Figure W23. Decline curve for all natural gas Tonkawa production in T. 25 N., R. 15–17 W., of the Waynoka NE field study area.

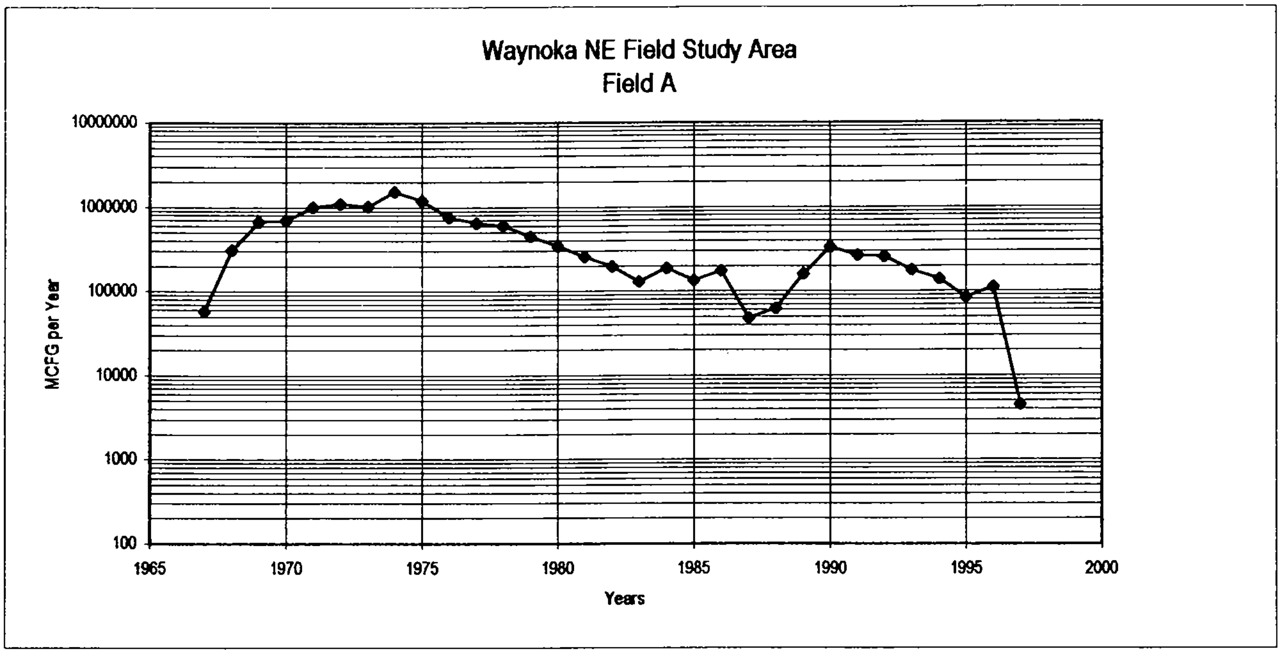


Figure W24. Decline curve for the producing wells in Reservoir A on Figure W19.

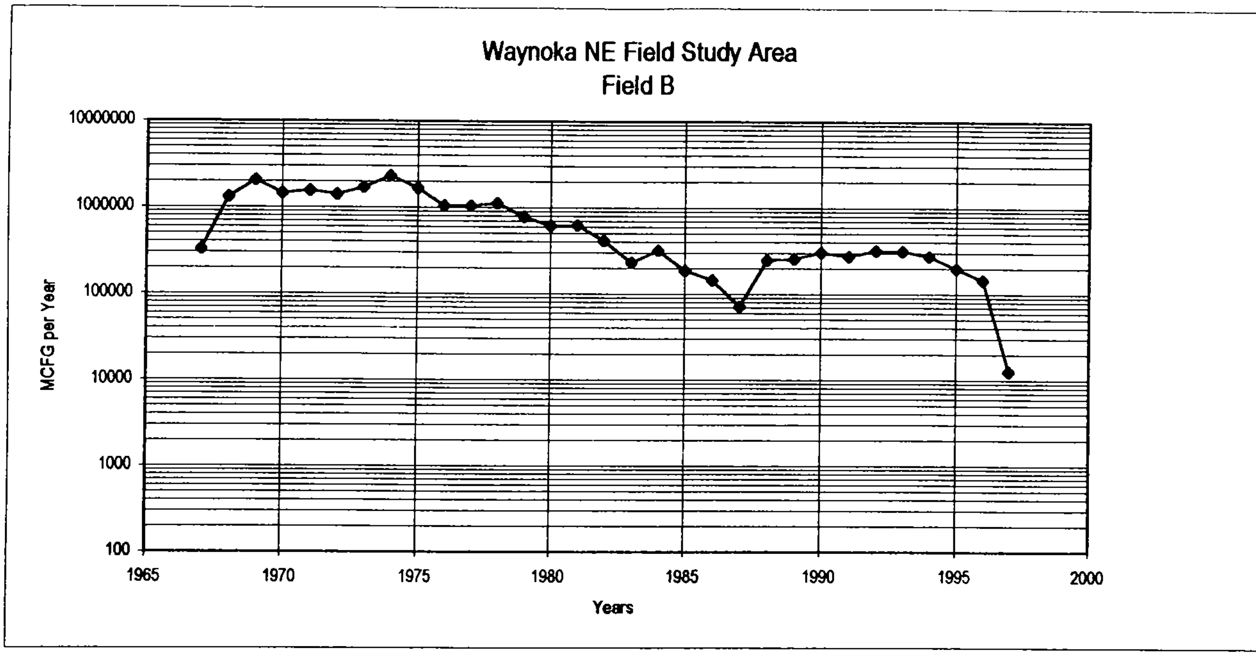


Figure W25. Decline curve for the producing wells in Reservoir B on Figure W19.

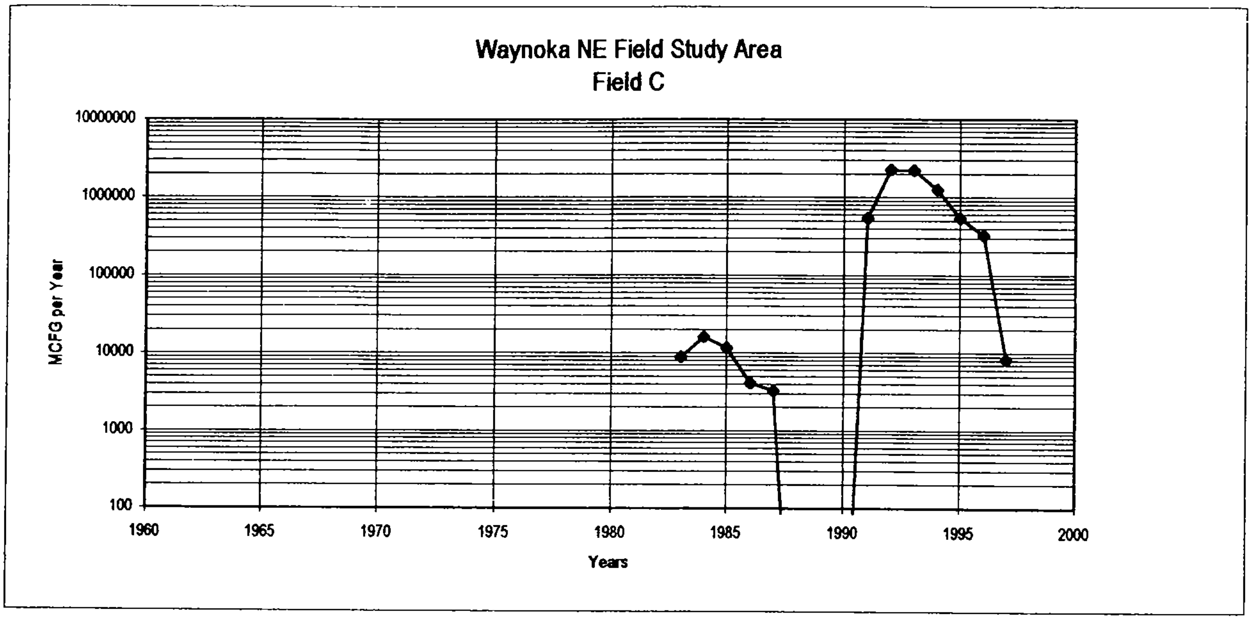


Figure W26. Decline curve for the producing wells in Reservoir C on Figure W14.

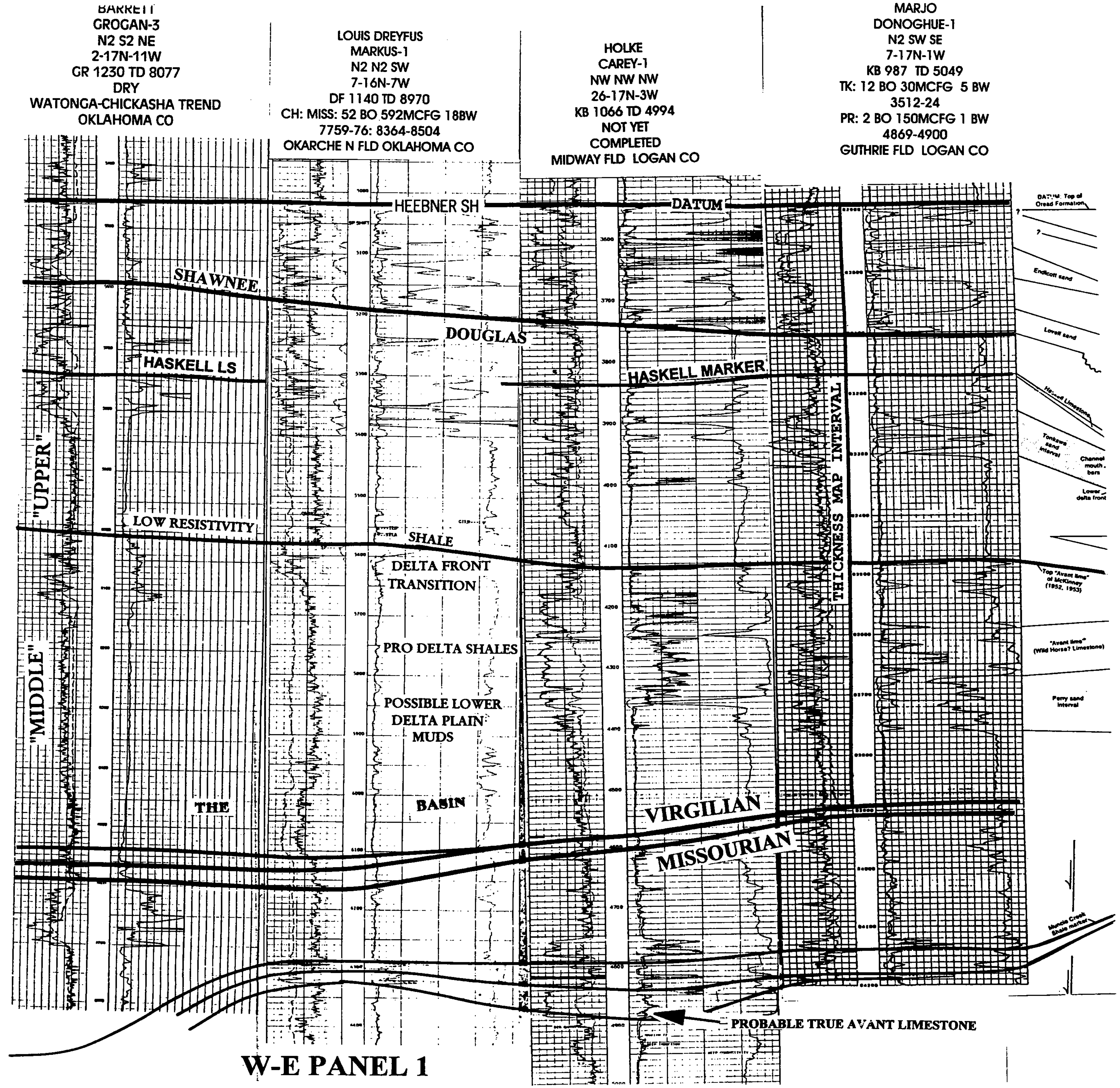
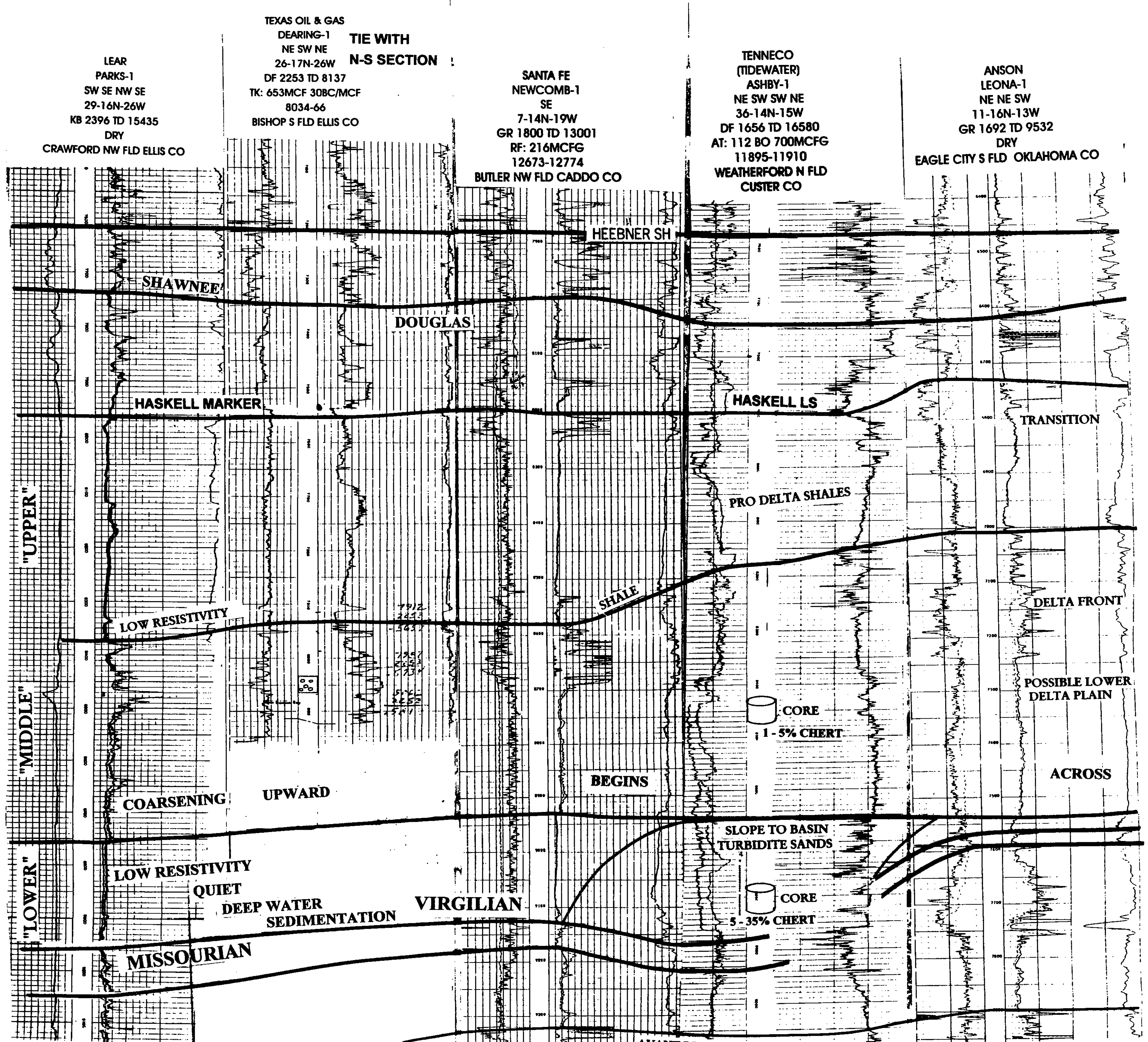
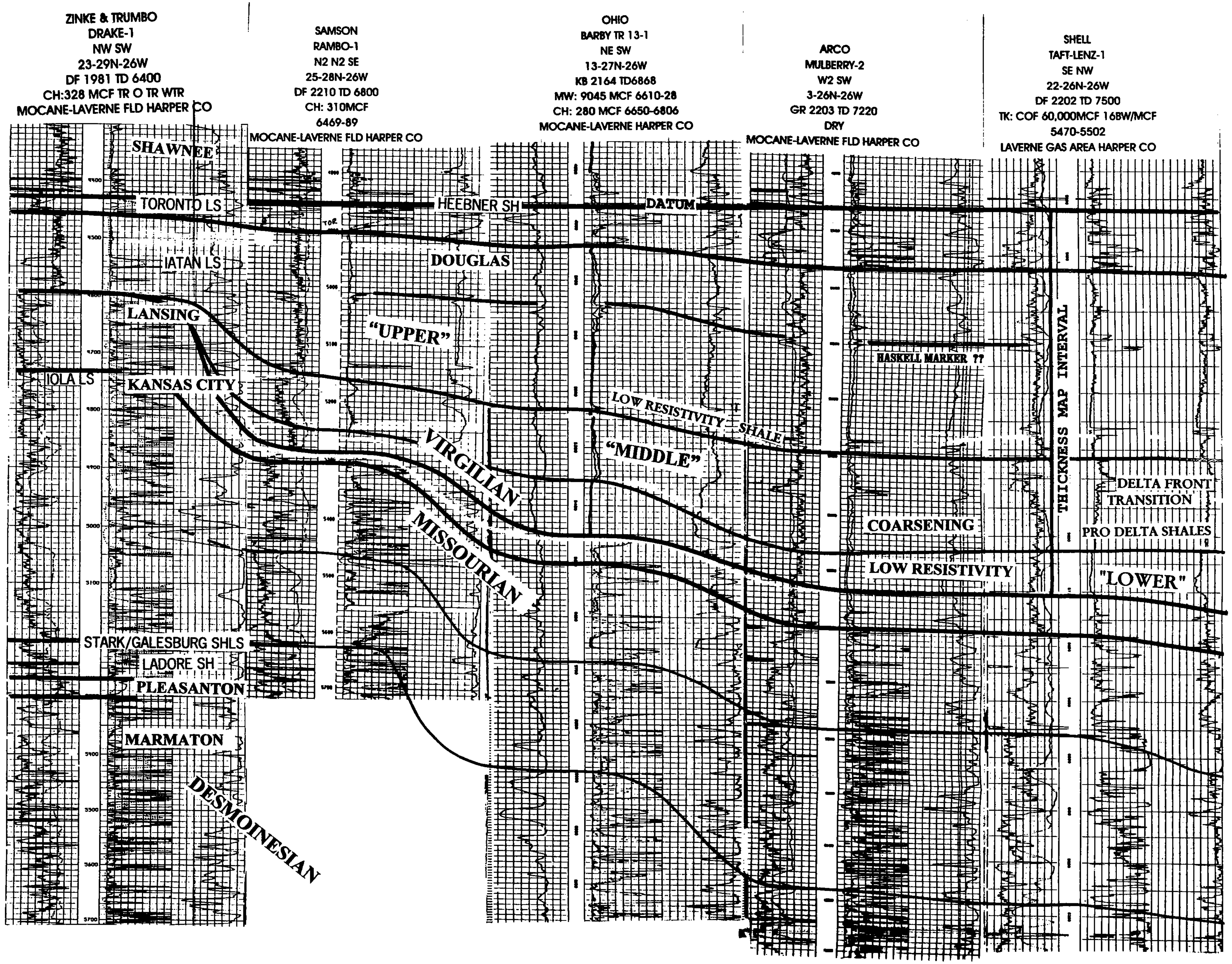

BARRETT
GROGAN-3
N2 S2 NE
2-17N-11W
GR 1230 TD 8077
DRY
WATONGA-CHICKASHA TREND
OKLAHOMA CO
LOUIS DREYFUS
MARKUS-1
N2 N2 SW
7-16N-7W
DF 1140 TD 8970
CH: MISS: 52 BO 592MCFG 18BW
7759-76: 8364-8504
OKARCHE N FLD OKLAHOMA CO
HOLKE
CAREY-1
NW NW NW
26-17N-3W
KB 1066 TD 4994
NOT YET
COMPLETED
MIDWAY FLD LOGAN CO
MARJO
DONOGHUE-1
N2 SW SE
7-17N-1W
KB 987 TD 5049
TK: 12 BO 30MCFG 5 BW
3512-24
PR: 2 BO 150MCFG 1 BW
4869-4900
GUTHRIE FLD LOGAN CO
HEEBNER SH
DATUM
SHAWNEE
DOUGLAS
HASKELL LS
HASKELL MARKER
"UPPER"
"MIDDLE"
LOW RESISTIVITY
SHALE
DELTA FRONT
TRANSITION
PRO DELTA SHALES
POSSIBLE LOWER
DELTA PLAIN
MUDS
THE
BASIN
VIRGILIAN
MISSOURIAN
THICKNESS MAP INTERVAL
Top of Oread Formation
Endicott sand
Lovell sand
Tonkawa sand interval
Channel mouth bars
Lower delta front
Top "Avant lime" of McKinney (1952, 1953)
"Avant lime" (Wild Horse? Limestone)
Perry sand interval
PROBABLE TRUE AVANT LIMESTONE
W-E PANEL 1

Figure R7



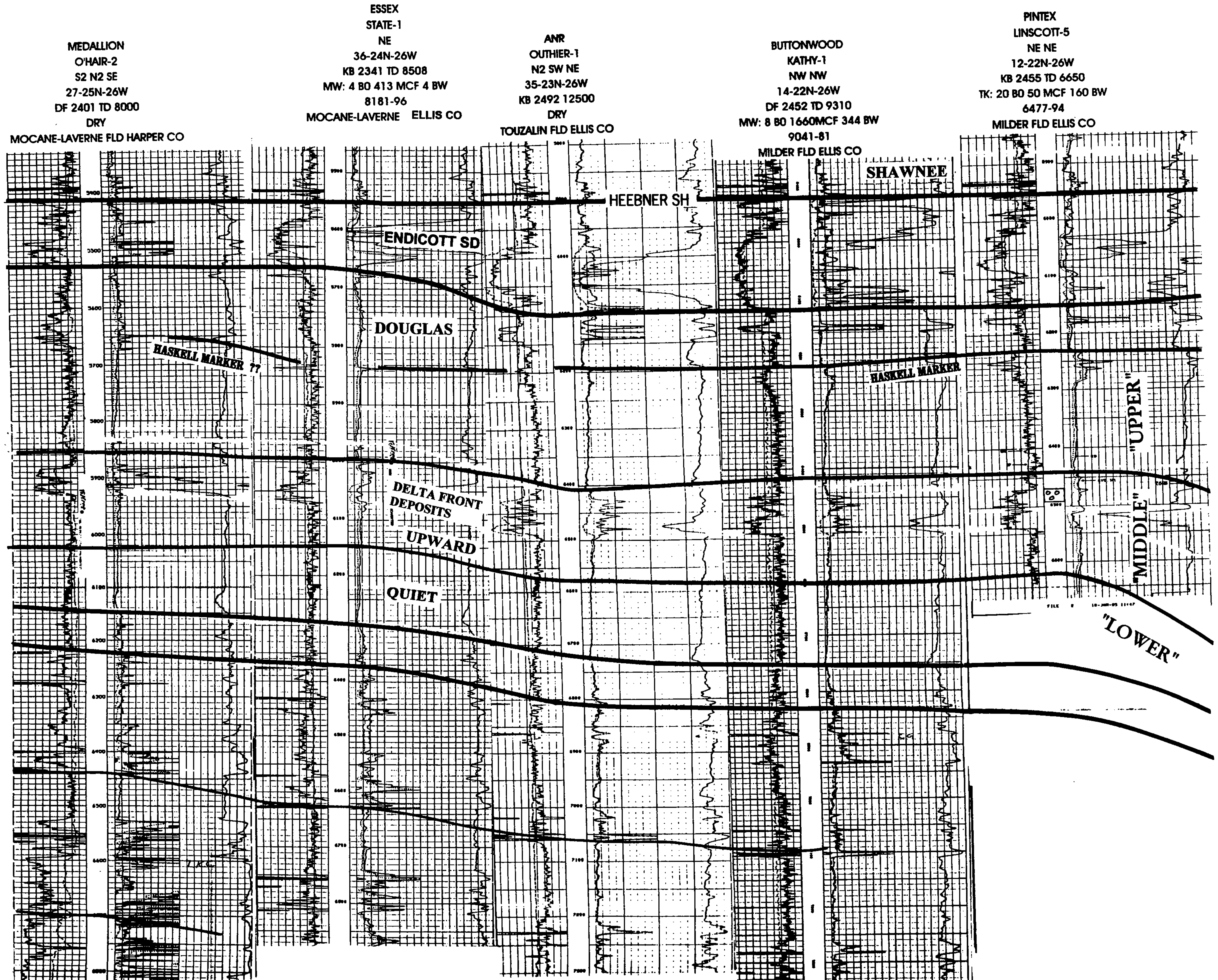
W-E PANEL 2

Figure R8



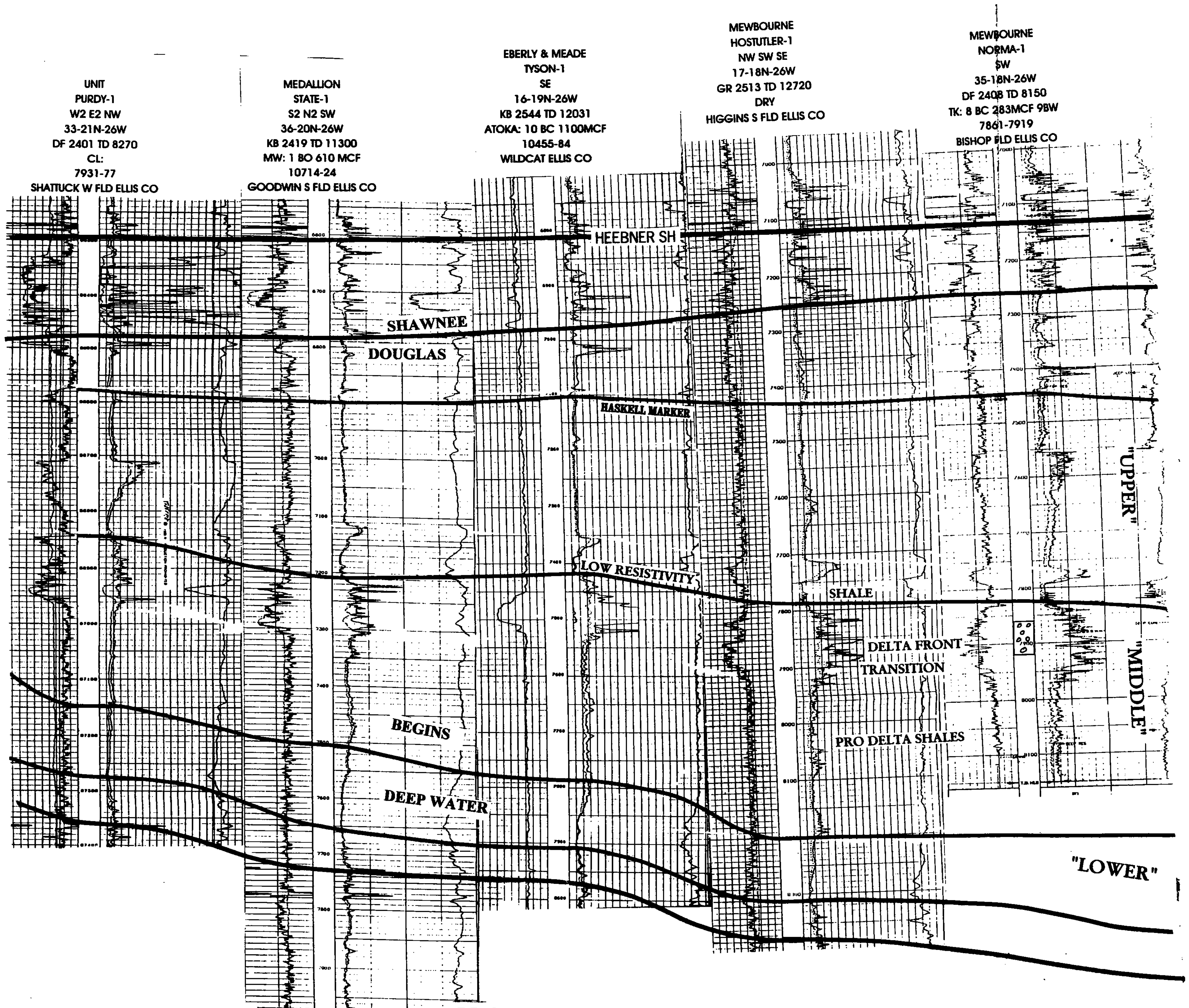
N-S PANEL 1

Figure R10



N-S PANEL 2

Figure R11



N-S PANEL 3

Figure R12

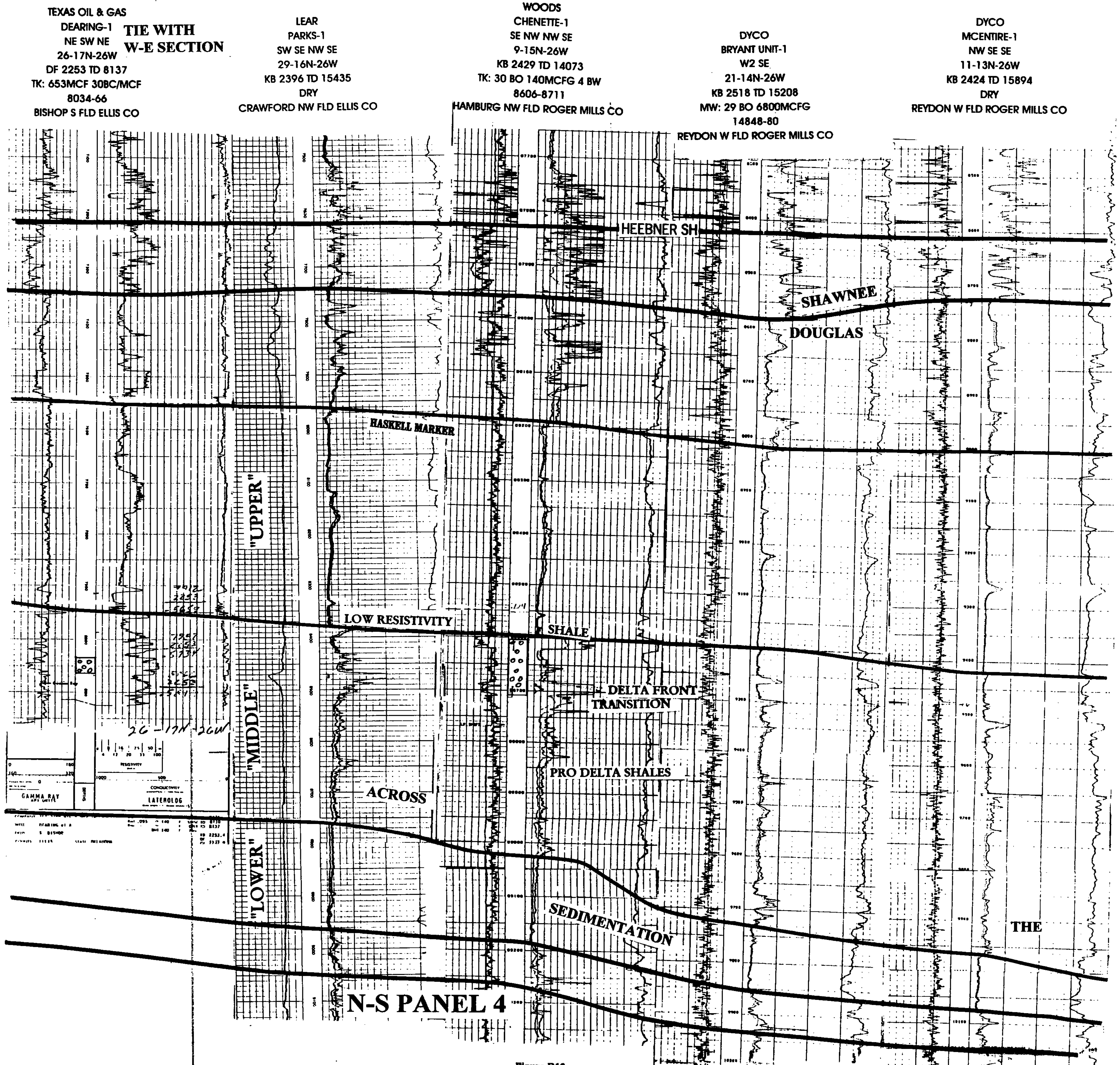
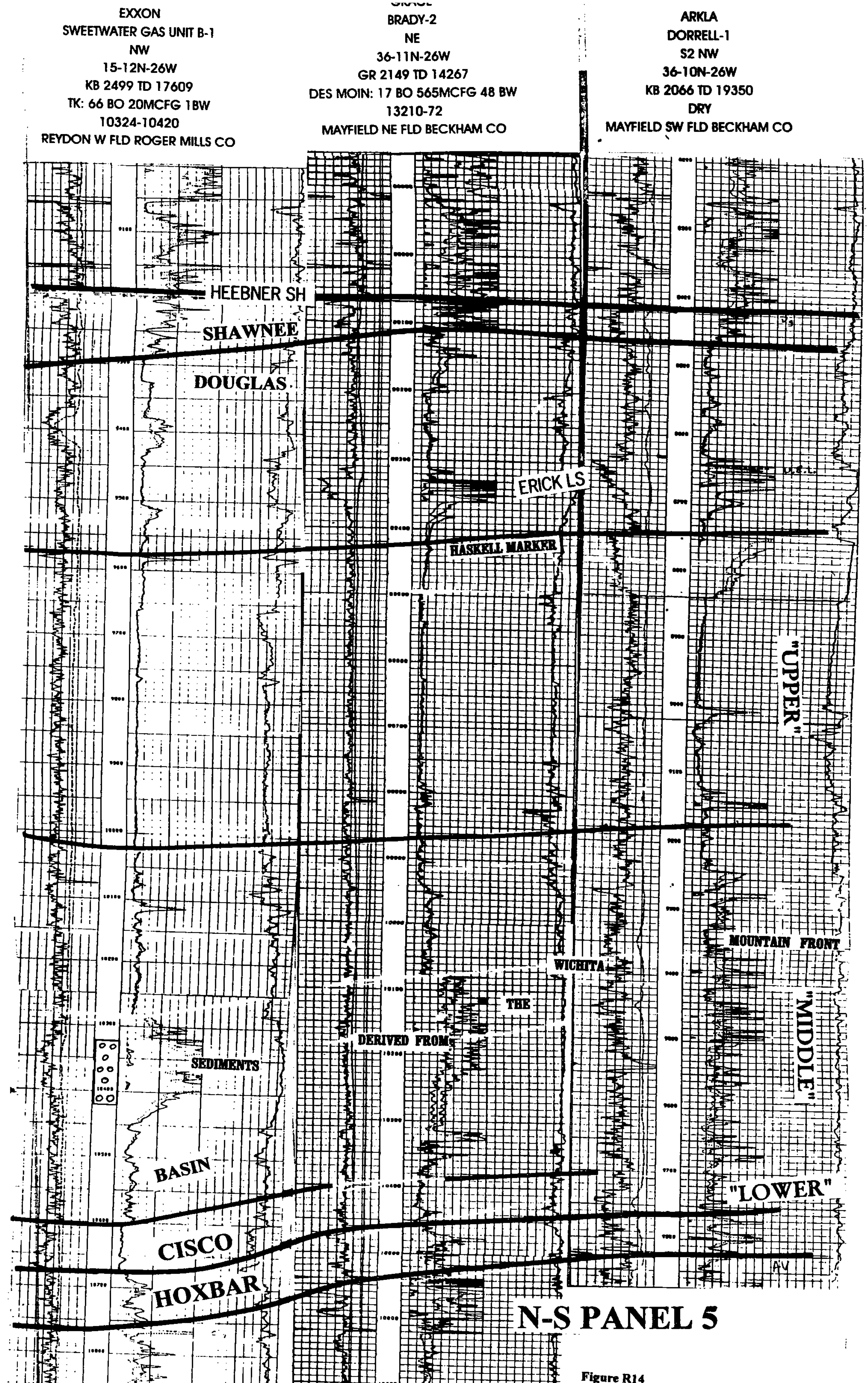

TEXAS OIL & GAS
DEARING-1
NE SW NE
26-17N-26W
DF 2253 TD 8137
TK: 653MCF 30BC/MCF
8034-66
BISHOP S FLD ELLIS CO
TIE WITH
W-E SECTION
LEAR
PARKS-1
SW SE NW SE
29-16N-26W
KB 2396 TD 15435
DRY
CRAWFORD NW FLD ELLIS CO
WOODS
CHENETTE-1
SE NW NW SE
9-15N-26W
KB 2429 TD 14073
TK: 30 BO 140MCFG 4 BW
8606-8711
HAMBURG NW FLD ROGER MILLS CO
DYCO
BRYANT UNIT-1
W2 SE
21-14N-26W
KB 2518 TD 15208
MW: 29 BO 6800MCFG
14848-80
REYDON W FLD ROGER MILLS CO
DYCO
MCENTIRE-1
NW SE SE
11-13N-26W
KB 2424 TD 15894
DRY
REYDON W FLD ROGER MILLS CO
HEEBNER SH
SHAWNEE
DOUGLAS
HASKELL MARKER
"UPPER"
LOW RESISTIVITY
SHALE
DELTA FRONT
TRANSITION
"MIDDLE"
PRO DELTA SHALES
ACROSS
"LOWER"
SEDIMENTATION
THE
N-S PANEL 4
26-17N-26W
GAMMA RAY
LATEROLOG

Figure R13



N-S PANEL 5

Figure R14

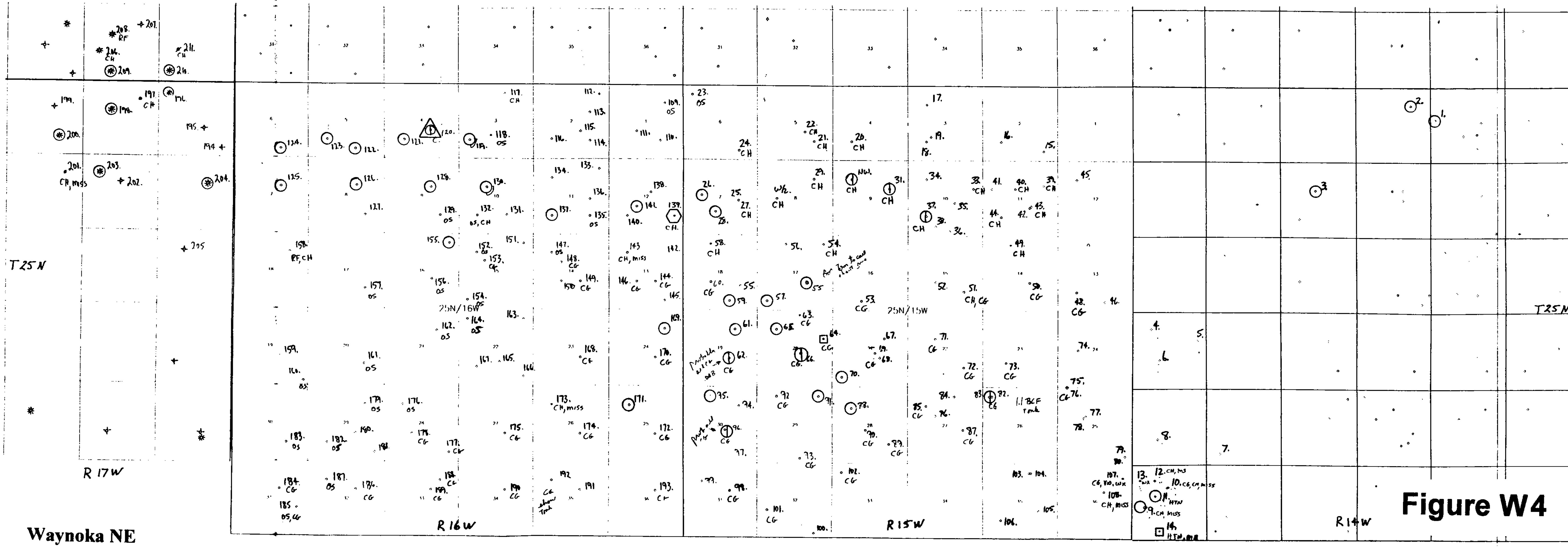


Figure W4

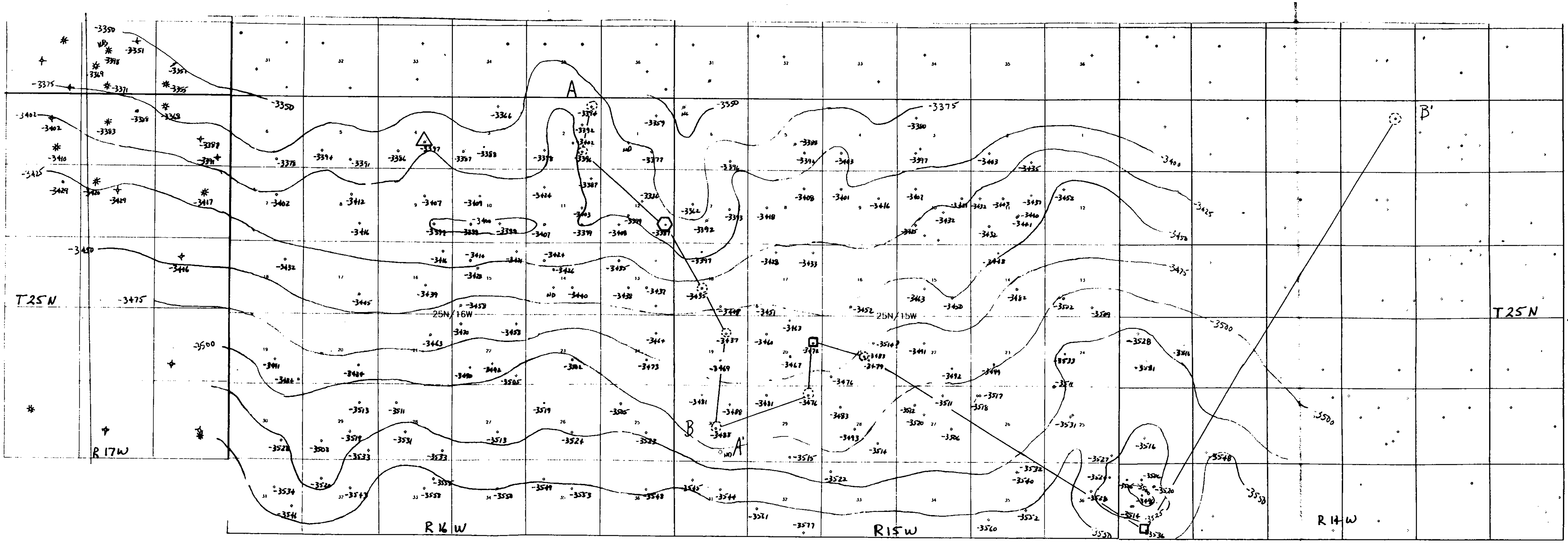
Waynoka NE Field Study Area

Woods County, Oklahoma

LEGEND

- ⊙ Tonkawa
- ⦶ Tonkawa Commingled
- CG Cottage Grove
- OS Oswego
- RF Red Fork
- CH Chester Undifferentiated
- Miss Mississippian
- MZ Misener
- HTN Hunton
- Vio Viola
- WX Wilcox (Simpson)

#	S2	S3	S4	SEC	TWP	RGE	OPERATOR	WELL	NUM
1	SW	SW	NW	2	25N	14W	RDH ENTERPRISES	MARY	1
2	E/2	W/2	NE	3	25N	14W	RDH ENTERPRISES	LANCASTER	1
3	E/2	SE	NW	9	25N	14W	TEX-STAR PRODUCTION	DICKSON	1
4			NW	19	25N	14W	PHILLIPS OIL OPERATING	GOUCHER	1
5		SE	NE	19	25N	14W	PETROLEUM INCORPORATED	GOUCHER	1
6		NE	SW	19	25N	14W	SLONE STAR PRODUCTION	M E MOSS	1
7	NE	SW	SW	29	25N	14W	WESTERN OIL AND GAS	AARON MORRIS	1
8	SW	NE	SW	30	25N	14W	GREAT WESTERN DRILLING	MORRIS	1
9	NE	NW	SW	31	25N	14W	PETRO-ENERGY INC	LITZENBERGER	1
10	NE	SE	NW	31	25N	14W	PETRO-ENERGY INC	KUTZ	1
11	SW	SE	NW	31	25N	14W	SAMEDAN OIL CORPORATION	KUTZ	1
12	SW	NE	NW	31	25N	14W	PETRO-ENERGY INC	AARON	1
13	SW	NW	NW	31	25N	14W	SAMEDAN OIL CORPORATION	SPELLMAN	1
14	NE	SE	SW	31	25N	14W	GULF OIL CORPORATION	SHADE	1
15	W2	SE	SE	2	25N	15W	R D H ENTERPRISES INC	GRANDAD	1
16			SW	2	25N	15W	FLAG-REDFERN	DUCK	1
17	NW	SE	NW	3	25N	15W	IREX	JACOBSON	2
18			SW	3	25N	15W	SOUTHLAND	JACOBSON	1
19	SW	NE	SW	3	25N	15W	IREX	JACOBSON	1
20			SW	4	25N	15W	SOUTHLAND	HAGLER	1
21			SE	5	25N	15W	SOUTHLAND	MOONEYHAM	1
22		NW	SE	5	25N	15W	CLEARY	FEESE	1
23		NW	NW	6	25N	15W	WARD	CURTIS	1
24		S2	SE	6	25N	15W	KAISER	BOSWELL	1
25			[illegible]	7	[illegible]	[illegible]		[illegible]	[illegible]
26	S2	S2	NW	7	25N	15W	ZOLLER	BUCKLAND	1
27	NE	NW	SE	7	25N	15W	PREMIER	BUCKLAND	1
28	SE	NE	SW	7	25N	15W	PET INC	WHIPPLE	1
29			NE	8	25N	15W	SOUTHLAND	BUCKLAND	1
30			W2	8	25N	15W	SOUTHLAND	BUCKLAND	2
31		S2	NE	9	25N	15W	COMANCHE RESOURCES CO	PHIL	1
32			NW	9	25N	15W	KENNEDY	BUCKLAND	1
33		SE	NE	10	25N	15W	W F D OIL CORP	MABEL WENZEL	1
34			NW	10	25N	15W	KENNEDY	DUCK	1
35	N2	NW	SE	10	25N	15W	GUNGOLL	WENZEL	1
36	SW	SW	SE	10	25N	15W	HAYNES	BUSKITT	1
37	S2	N2	SW	10	25N	15W	BEREN	BRADSTREET	1
38		SE	SW	10	25N	15W	BU-VI-BAR	FEE	1
39	NW	SE	NE	11	25N	15W	WFD	BROWN	3
40	E2	SE	NW	11	25N	15W	WFD	WEBER	1
41		SW	NW	11	25N	15W	GUNGOLL	BAYS	1
42		NW	SE	11	25N	15W	R D H	LORD	1
43	NE	NW	SE	11	25N	15W	BURNS	WENZEL	1
44			SW	11	25N	15W	BEREN	BUCKLAND	1
45			NW	12	25N	15W	W F D OIL CORP	WIEBENER	1
46		SW	SE	13	25N	15W	SUN	HOTZEL	1
47				14	25N	15W		Virginia	1
48			SW	13	25N	15W	BEREN	LAMBERT	1
49		NE	NW	14	25N	15W	AEXCO PETROLEUM INC	GILLOOLY	1
50		NW	SE	14	25N	15W	BURNS	RINGER	1
51			SE	15	25N	15W	BEREN	CRAWFORD	1
52		NE	SW	15	25N	15W	HENDRICK	BUCKLAND	1
53		SE	SW	16	25N	15W	TEXACO	KELSEY	1
54		NE	NE	17	25N	15W	JAY	FRITSCH	1
55		NW	SE	17	25N	15W	MEDALLION	STARK	
56		NE	NW	17	25N	15W	HENDRICK	HOBSON	1
57		SW	SW	17	25N	15W	LATIGO	BIXLER	1
58	W2	NE	NW	18	25N	15W	TIDEMARK	KELSEY	1
59		SW	SE	18	25N	15W	CIMARRON	OLSON	1
60		NE	SW	18	25N	15W	TEXACO	HARRISON	1
61	E2	W2	NE	19	25N	15W	D L B	NELLIE	8
62		NW	SE	19	25N	15W	TEXACO	OLSON	1
63	NW	NW	NE	20	25N	15W	TEXACO	MCANTIRE	1
64		SE	NE	20	25N	15W	EARLSBORO	CURTIS	1
65			NW	20	25N	15W	C N G	CURTIS	1
66	NW	NW	SE	20	25N	15W	TEXACO	NUTTER	1
67	[illegible]	SW	NE	21	[illegible]	15W	[illegible]	[illegible]	1
68		NW	SE	21	25N	15W	D L B	NUTTER	10
69	NW	NW	SE	21	25N	15W	TEXACO	GOOCH	1
70		SW	SW	21	25N	15W	D L B	GOOCH	1
71		SE	NW	22	25N	15W	TEXACO	BUELL	1
72			SE	22	25N	15W	TEXACO	BUELL	2
73	SW	NE	SW	23	25N	15W	EARLSBORO	JAMES	1
74	NW	NE	SW	24	25N	15W	TXO	LORD	1
75	S2	SW	SW	24	25N	15W	EARLSBORO	MORRIS	1
76	N2	NW	NW	25	25N	15W	EARLSBORO OIL & GAS CO INC	MORRIS-BUDY	1
77		SE	NW	25	25N	15W	AMERADA	MORRIS	1
78	SW	SE	NW	25	25N	15W	AMERADA PETROLEUM CORP	AARON MORRIS	1
79		SE	SE	25	25N	15W	EARLSBORO	OLSEN	1
80	SE	SE	SE	25	25N	15W	EARLSBORO OIL & GAS CO INC	OLSON UNIT	1
82		NW	NW	26	25N	15W	AMERADA	BEARD	1
83	W2	NW	NW	26	25N	15W	AMERADA PETROLEUM CORP	BEARD ESTATE	1
84		NW	NE	27	25N	15W	CIMARRON	BECKWITH	19
85			NW	27	25N	15W	AMARILLO OIL	NUTTER	1
86		SE	NW	27	25N	15W	TEXACO	NUTTER B	1
87	NE	NW	SE	27	25N	15W	IREX	WAYNOKA	1
88	N2	S2	NW	28	25N	15W	D L B	BIXLER	6
89			SE	28	25N	15W	K P L	BIXLER	1
90	NE	NE	SW	28	25N	15W	TEXACO	FULS	1
91	W2	NE	NE	29	25N	15W	LATIGO	HODGES	1
92		N2	NW	29	25N	15W	LATIGO	SEAMAN	1
93	SW	SW	SE	29	25N	15W	TEXACO	BARKER	1
94			NE	30	25N	15W	SANTO	OLSON	1
95		NE	NW	30	25N	15W	LATIGO	CHESTNUT BL	1
96	NW	NW	SE	30	25N	15W	TEXACO	SEAMAN	1
97		SW	SE	30	25N	15W	TEXACO	SEAMAN	2
98		SW	NE	31	25N	15W	TEXOMA	WHIPPLE	1
99			NW	31	25N	15W	ESSEX EXPL	WHIPPLE	2
100	S2	S2	SE	32	25N	15W	TEXOMA	SIMMONS	1
101		NW	SW	32	25N	15W	JONES&PELLOW	CALLISON	1
102		NW	NW	33	25N	15W	TEXACO	SHERFY	1
103		NW	NE	35	25N	15W	JACKSON	MCNALLY	1
104	E2	NW	NE	35	25N	15W	GUNGOLL		1
105		N2	SE	35	25N	15W	FUNK	MCNALLY	1
106			SW	35	25N	15W	BEREN	FRANKS	1
107	S2	NE	NE	36	25N	15W	GUNGOLL	LITZNBRGER	1
108		SW	NE	36	25N	15W	SAMEDAN	BEARD	1
109			NE	1	25N	16W	TUTHILL	CROPP	1
110	[illegible]	[illegible]	[illegible]	1	[illegible]	16W	[illegible]	[illegible]	1
111		NE	SW	1	25N	16W	BROOKS HALL	EGGLESTON	1
112		NE	NE	2	25N	16W	BONANZA	FOX	2
113		S2	NE	2	25N	16W	NOVA	FOX	1
114			SE	2	25N	16W	LPCX	YVONNE	1
115		NW	SE	2	25N	16W	BROOKS HALL	STALLINGS	1
116	S2	N2	SW	2	25N	16W	STEELE	SCHMOLCKE	1
117	SW	NW	NE	3	25N	16W	H & L	BIXLER	1
118	SE	NE	SW	3	25N	16W	KING RES	CAMP	1
119	E2	W2	SW	3	25N	16W	EARLSBORO	CAMP	1
120		NW	SE	4	25N	16W	KING RES	SCHMOLCKE	1
121	E2	E2	SW	4	25N	16W	EARLSBORO	SCHMOLCKE	1
122		SW	SE	5	25N	16W	KING RES	CAMP	1
123			SW	5	25N	16W	PHOENIX RES	CAMP	2
124		SW	SE	6	25N	16W	UNION TEXAS	OLSEN	1
125		SW	NE	7	25N	16W	KING RES	OLSEN	1
126		SW	NE	8	25N	16W	KING RES	OLSEN	1
127			SE	8	25N	16W	CUMMINGS	OLSON	1
128		SW	NE	9	25N	16W	SINCLAIR	CAMP	1
129			SE	9	25N	16W	ATLANTIC	CAMP	2
130		SE	NW	10	25N	16W	KING RES	CAMP	1
131	E2	W2	SE	10	25N	16W	BLACK	THORNE	1
132			SW	10	25N	16W	ATLANTIC	CAMP	2
133		NE	NE	11	25N	16W	WARD	IRA	2
134			NW	11	25N	16W	LPCX	SCHMOLKE	1
135			SE	11	25N	16W	PETRO-ENERGY	IRA	1
136	N2	N2	SE	11	25N	16W	WARD	IRA	1
137			SW	11	25N	16W	KING RES	RAUCH	1
138	SW	SW	NE	12	25N	16W	O N G	EGGLESTON	1
139		E2	SE	12	25N	16W	TIDEMARK	CROPP	1
140			SW	12	25N	16W	JAY	FOX	2
141		NE	SW	12	25N	16W	YINGER	FOX	1
142			NE	12	25N	16W	H T P	CROPP	1
143			NW	13	25N	16W	PETRO-ENERGY	OLSON	1
144		NW	SE	13	25N	16W	TEXACO	BIXLER	1
145		S2	SE	13	25N	16W	SANTO RESOURCES INC	EDSEL 1-13	1
146		NE	SW	13	25N	16W	EARLSBORO	OLSON	1
147			NW	14	25N	16W	PETRO-ENERGY	RAWSON	1
148		SE	NW	14	25N	16W	EARLSBORO	RAWSON	1
149		NW	SE	14	25N	16W	SHELL	OLSON	1
150		NE	SW	14	25N	16W	G M C	OLSON	1
151		NE	NE	15	25N	16W	STEELE	SNIDER	1
152			[illegible]	[illegible]	[illegible]	16W	[illegible]	[illegible]	1
153	NW	SE	NW	15	25N	16W	MONSANTO	FAIR	1
154		SW	SW	15	25N	16W	STEELE	DUNCAN	2
155		NE	NE	16	25N	16W	WIL-MC	STATE	1
156	NE	NW	SE	16	25N	16W	SO UNION	SIMPSON	1
157	S2	N2	SE	17	25N	16W	TENNECO	COHLMIA	1
158			NE	18	25N	16W	POST	OLSON	1
159		NW	SE	19	25N	16W	DAVON	U S	1
160	SE	SE	SE	19	25N	16W	TEXAS O&G	GOVERNMENT	1
161	SE	NW	SE	20	25N	16W	TENNECO	OLSON	1
162	NE	SW	NE	21	25N	16W	TENNECO	LIKE	1
163		NE	NE	22	25N	16W	WESTRN STATES	BARKER	1
164		NW	NW	22	25N	16W	WARD	CAMP	1
165	SW	NW	SE	22	25N	16W	TENNECO	HANAN	1
166		SE	SE	22	25N	16W	PET INC	HANAN	1
167			SW	22	25N	16W	BROOKS HALL	EGGLESTON	1
168		NW	SE	23	25N	16W	SUN	OLSON	1
169			NE	24	25N	16W	KAISER	BIXLER	1
170		NW	SE	24	25N	16W	MAYFLO	HULL	1
171	W2	E2	NW	25	25N	16W	REDLAND RESOURCES INC	FORD	1
172		NW	SE	25	25N	16W	TEXACO	BIXLER	1
173			NW	26	25N	16W	T N T	BIXLER	1
174		NW	SE	26	25N	16W	TEXACO	CLEMENCE	1
175		NW	SE	27	25N	16W	GULF	BIXLER	1
176			NW	28	25N	16W	TEXACO	BIXLER	2
177		SE	SE	28	25N	16W	TEXACO	BIXLER	3
178		NE	SW	28	25N	16W	TEXACO	BIXLER	1
179			NE	29	25N	16W	TEXAS O&G	CASEY	2
180		NW	SE	29	25N	16W	AN-SON	OLSON	1
181		SE	SE	29	25N	16W	G M C	OLSON	1
182			SW	29	25N	16W	TEXAS O&G	CASEY	1
183	E2	W2	SE	30	25N	16W	GUNGOLL	ABATA	1
184		SW	NE	31	25N	16W	HUBER	DOWNING	1
185	W2	NE	SE	31	25N	16W	ASHLAND	DOWNING	1
186		SW	NE	32	25N	16W	G M C	ROSE	1
187			NW	32	25N	16W	TEXACO	ROSE	2
188			NE	33	25N	16W	TEXACO	BIXLER C	2
189		SW	NE	33	25N	16W	TEXACO	BIXLER C	1
190		SW	NE	34	25N	16W	TEXACO	BIXLER B	1
191		SW	NE	35	25N	16W	TEXACO	MILLER	1
192			NW	35	25N	16W	K P L	BIXLER	1
193		SW	NE	36	25N	16W	SUPERIOR	GODFREY	1
194		SE	NE	1	25N	17W	UNION TEXAS	REDGATE	4
195		NW	SE	1	25N	17W	UNION TEXAS	REDGATE	1
196		NW	NW	1	25N	17W	BROOKS HALL OIL	REDGATE	2
197			NE	2	25N	17W	GULF OIL EXPLORATION	WANDA	2
198		SE	NW	2	25N	17W	GULF OIL CORP	WANDA	1
199		SW	NE	3	25N	17W	GULF OIL CORPORATION	FEDERAL	1
200			SE	3	25N	17W	JONES & PELLOW	WOOLLEY	1
201	SW	NE	NE	10	25N	17W	POST PETROLEUM	STATE	1
202			N/2	11	25N	17W	CLEARY PETROLEUM CORP	STATE	1
203	SE	NW	NW	11	25N	17W	JONES & PELLOW	STATE	1
204		SW	NW	12	25N	17W	KING RESOURCES	CHAMBERS	1
205		E/2	NW	13	25N	17W	GEODYNE RESOURCES	CASEY	1
206		N/2	SW	35	26N	17W	POST PETROLEUM	POST	1
207			NE	35	26N	17W	SHENENDOAH OIL	HALL	1
208		SE	NW	35	26N	17W	PANHANDLE DEV	URBAN	1
209		SE	SW	35	26N	17W	HALL-JONES OIL	WHOOLEY-HALL	1
210	NE	SW	SW	36	26N	17W	BROOKS HALL OIL	REDGATE	1
211			W/2	36	26N	17W	POST PETROLEUM	REDGATE	1



Scale 1:24000.

Figure W5

Top Haskell Limestone STRUCTURE
C.I. = 25'

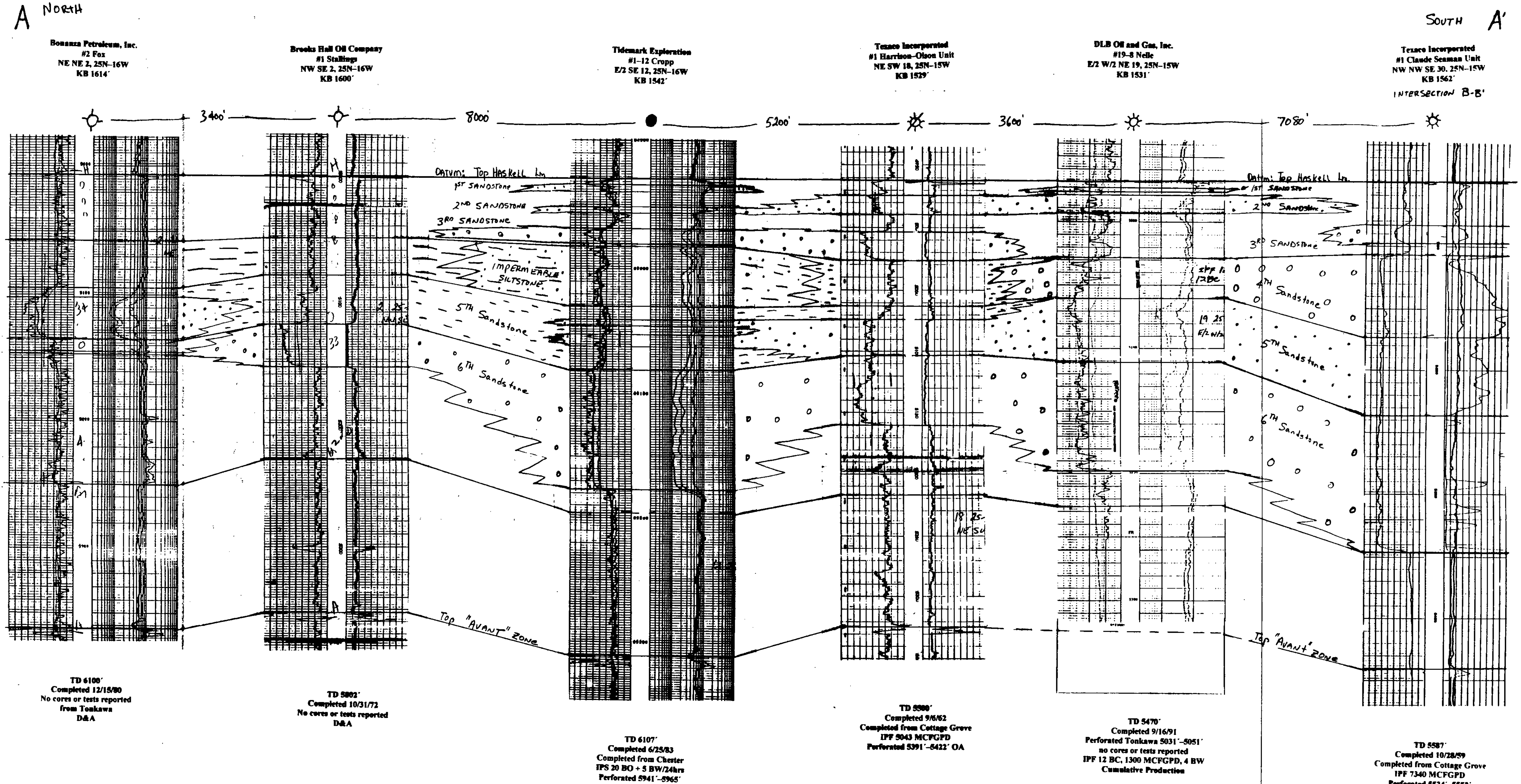

A NORTH
SOUTH A'
Bonanza Petroleum, Inc.
#2 Fox
NE NE 2, 25N–16W
KB 1614'
Brooks Hall Oil Company
#1 Stallings
NW SE 2, 25N–16W
KB 1600'
Tidemark Exploration
#1–12 Cropp
E/2 SE 12, 25N–16W
KB 1542'
Texaco Incorporated
#1 Harrison–Olson Unit
NE SW 18, 25N–15W
KB 1529'
DLB Oil and Gas, Inc.
#19–8 Nelle
E/2 W/2 NE 19, 25N–15W
KB 1531'
Texaco Incorporated
#1 Claude Seaman Unit
NW NW SE 30, 25N–15W
KB 1562'
INTERSECTION B-B'
3400'
8000'
5200'
3600'
7080'
DATUM: Top Haskell Lm
1ST SANDSTONE
2ND SANDSTONE
3RD SANDSTONE
IMPERMEABLE SILTSTONE
4TH Sandstone
5TH Sandstone
6TH Sandstone
Top "AVANT" ZONE
TD 6100'
Completed 12/15/80
No cores or tests reported
from Tonkawa
D&A
TD 5802'
Completed 10/31/72
No cores or tests reported
D&A
TD 6107'
Completed 6/25/83
Completed from Chester
IPS 20 BO + 5 BW/24hrs
Perforated 5941'–5965'
TD 5500'
Completed 9/6/62
Completed from Cottage Grove
IPF 5043 MCFGPD
Perforated 5391'–5422' OA
TD 5470'
Completed 9/16/91
Perforated Tonkawa 5031'–5051'
no cores or tests reported
IPF 12 BC, 1300 MCFGPD, 4 BW
Cumulative Production
TD 5587'
Completed 10/28/59
Completed from Cottage Grove
IPF 7340 MCFGPD
Perforated 5524'–5552'

Figure W7

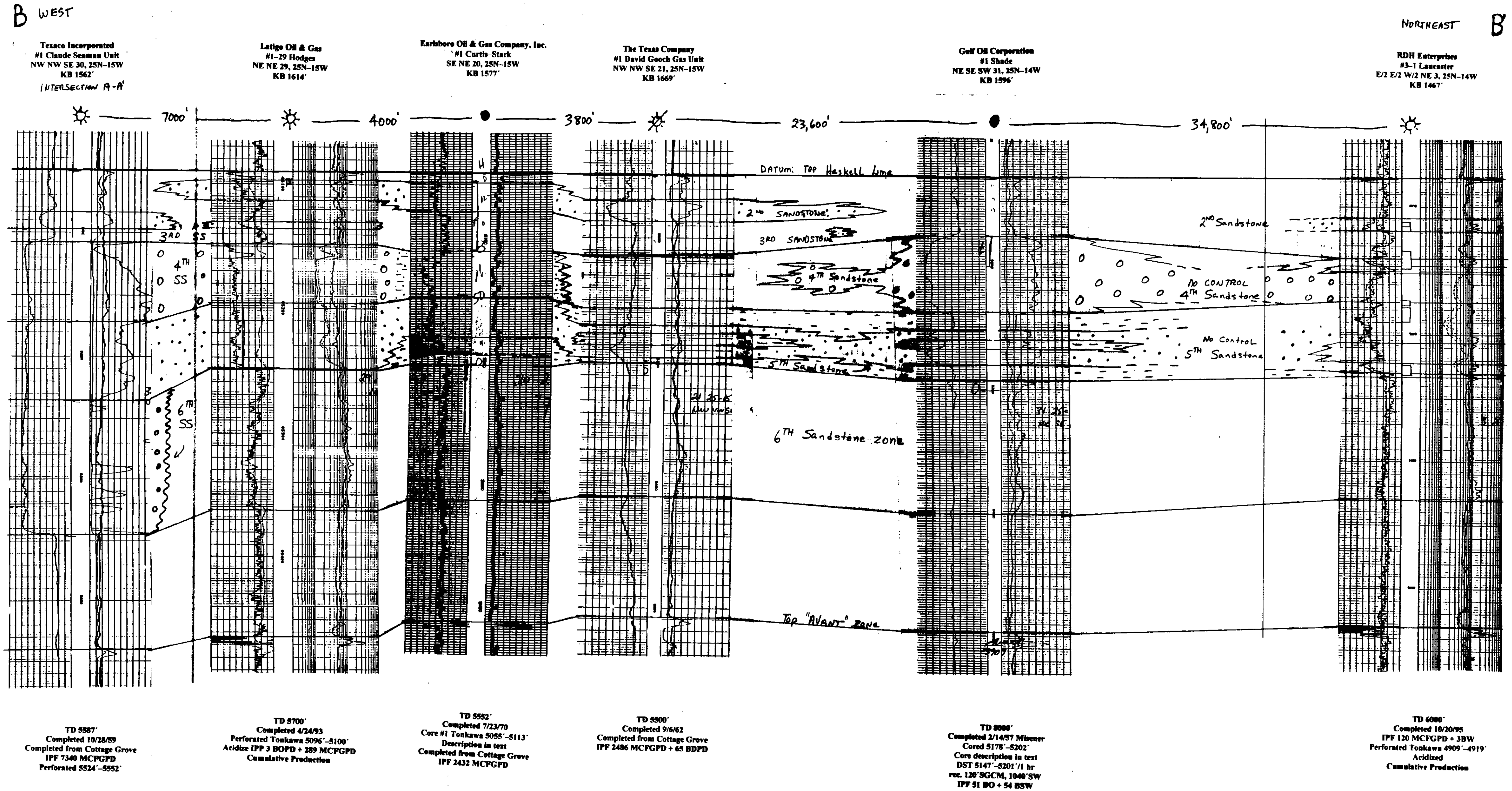
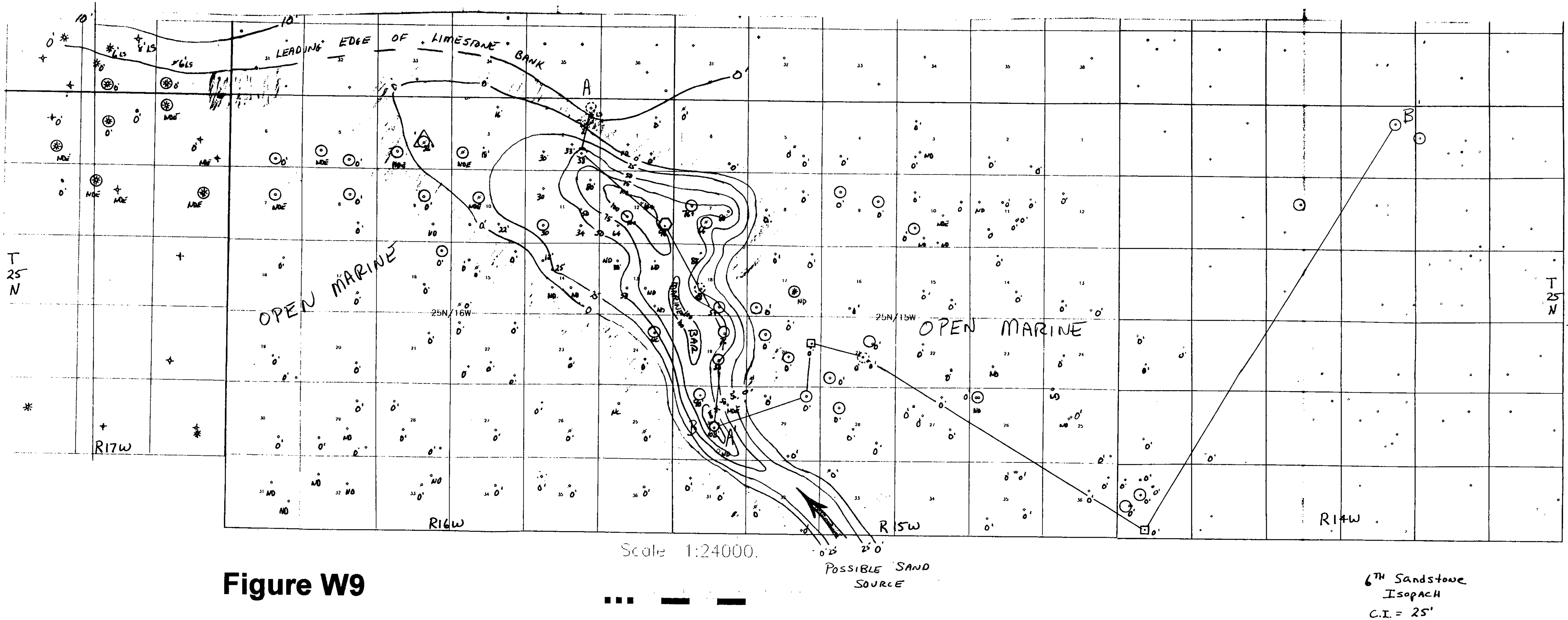
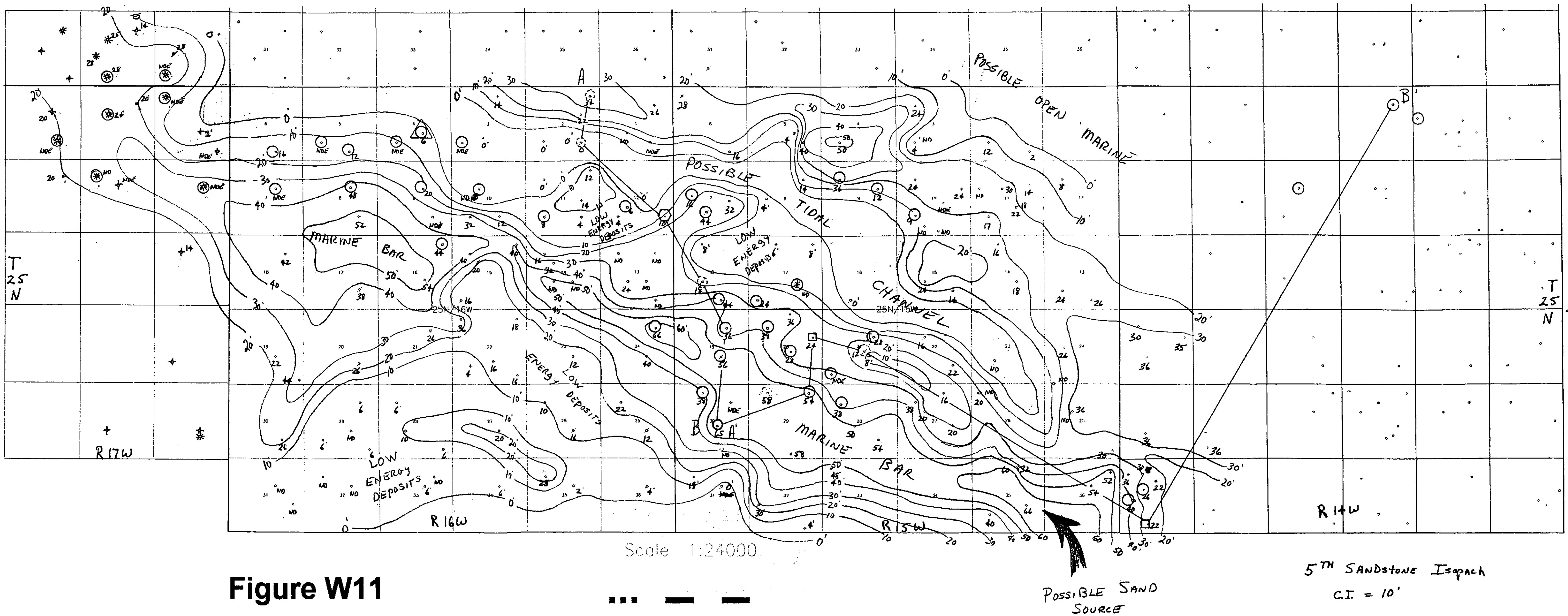

B WEST
NORTHEAST B'
Texaco Incorporated
#1 Claude Seaman Unit
NW NW SE 30, 25N–15W
KB 1562'
INTERSECTION A-A'
Latigo Oil & Gas
#1–29 Hodges
NE NE 29, 25N–15W
KB 1614'
Earlsboro Oil & Gas Company, Inc.
#1 Curtis–Stark
SE NE 20, 25N–15W
KB 1577'
The Texas Company
#1 David Gooch Gas Unit
NW NW SE 21, 25N–15W
KB 1669'
Gulf Oil Corporation
#1 Shade
NE SE SW 31, 25N–14W
KB 1596'
RDH Enterprises
#3–1 Lancaster
E/2 E/2 W/2 NE 3, 25N–14W
KB 1467'
7000'
4000'
3800'
23,600'
34,800'
DATUM: TOP Haskell Lime
2ND SANDSTONE
3RD SANDSTONE
3RD SS
4TH SS
4TH Sandstone
2ND Sandstone
NO CONTROL
4TH Sandstone
No Control
5TH Sandstone
6TH SS
6TH Sandstone zone
Top "AVANT" zone
TD 5587'
Completed 10/28/59
Completed from Cottage Grove
IPF 7340 MCFGPD
Perforated 5524'–5552'
TD 5700'
Completed 4/24/93
Perforated Tonkawa 5096'–5100'
Acidize IPP 3 BOPD + 289 MCFGPD
Cumulative Production
TD 5552'
Completed 7/23/70
Core #1 Tonkawa 5055'–5113'
Description in text
Completed from Cottage Grove
IPF 2432 MCFGPD
TD 5500'
Completed 9/6/62
Completed from Cottage Grove
IPF 2486 MCFGPD + 65 BDPD
TD 8000'
Completed 2/14/57 Misener
Cored 5178'–5202'
Core description in text
DST 5147'–5201'/1 hr
rec. 120'SGCM, 1040'SW
IPF 51 BO + 54 BSW
TD 6000'
Completed 10/20/95
IPF 120 MCFGPD + 3BW
Perforated Tonkawa 4909'–4919'
Acidized
Cumulative Production

Figure W8



Scale 1:24000.

Figure W9



POSSIBLE OPEN MARINE
POSSIBLE TIDAL CHANNEL
MARINE BAR
LOW ENERGY DEPOSITS
ENERGY LOW DEPOSITS
MARINE BAR
LOW ENERGY DEPOSITS
T 25 N
R 17W
R 16W
R 15W
R 14W
25N/16W
25N/15W
A
B
A'
B'
Scale 1:24000
POSSIBLE SAND SOURCE
5TH SANDSTONE ISOPACH
C.I. = 10'

Figure W11

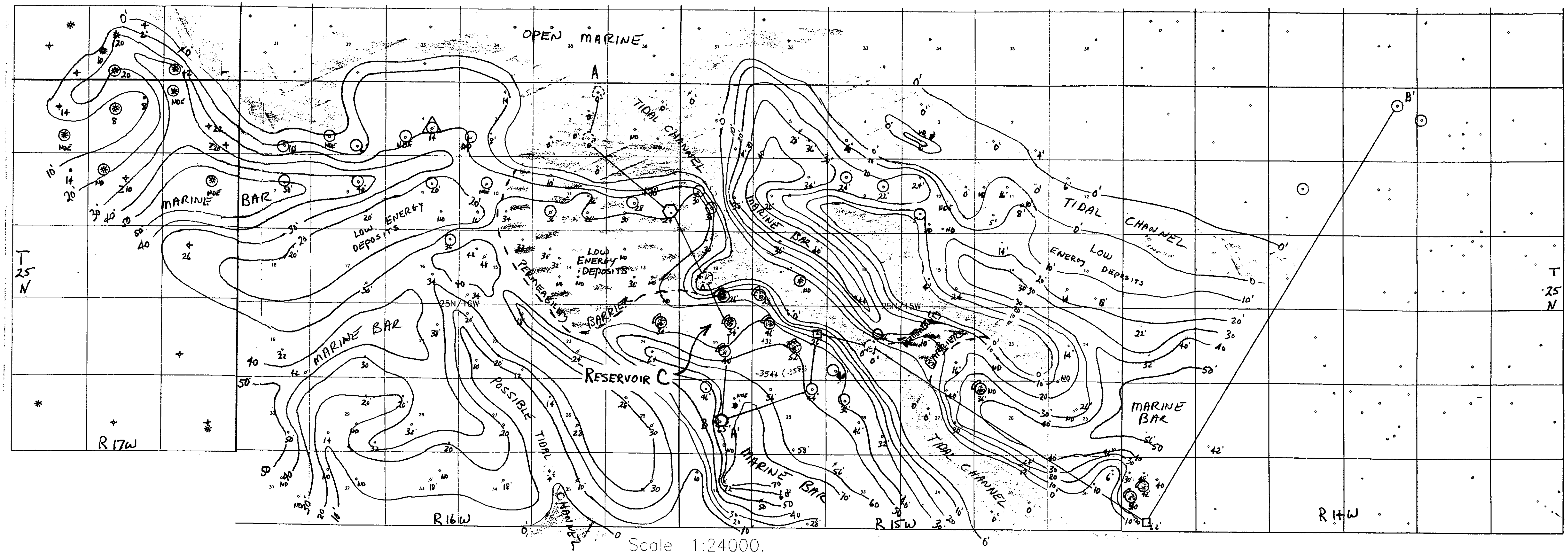


Figure W14

4TH SANDSTONE Isopach
C.I. = 10'

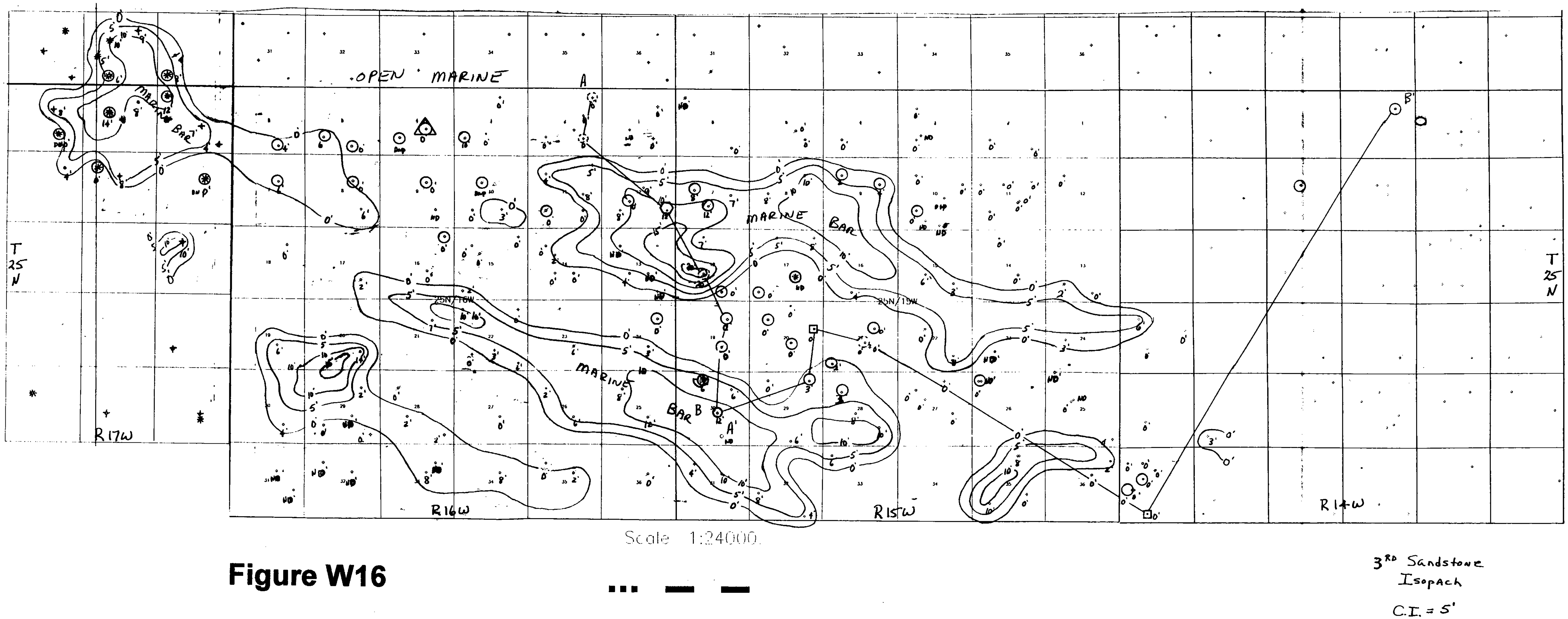

OPEN MARINE
MARINE BAR
MARINE BAR
MARINE BAR
MARINE BAR
A
A'
B
B'
T 25 N
T 25 N
R17W
R16W
R15W
R14W
25N/16W
25N/15W
Scale 1:24000
3RD Sandstone Isopach
C.I. = 5'

Figure W16

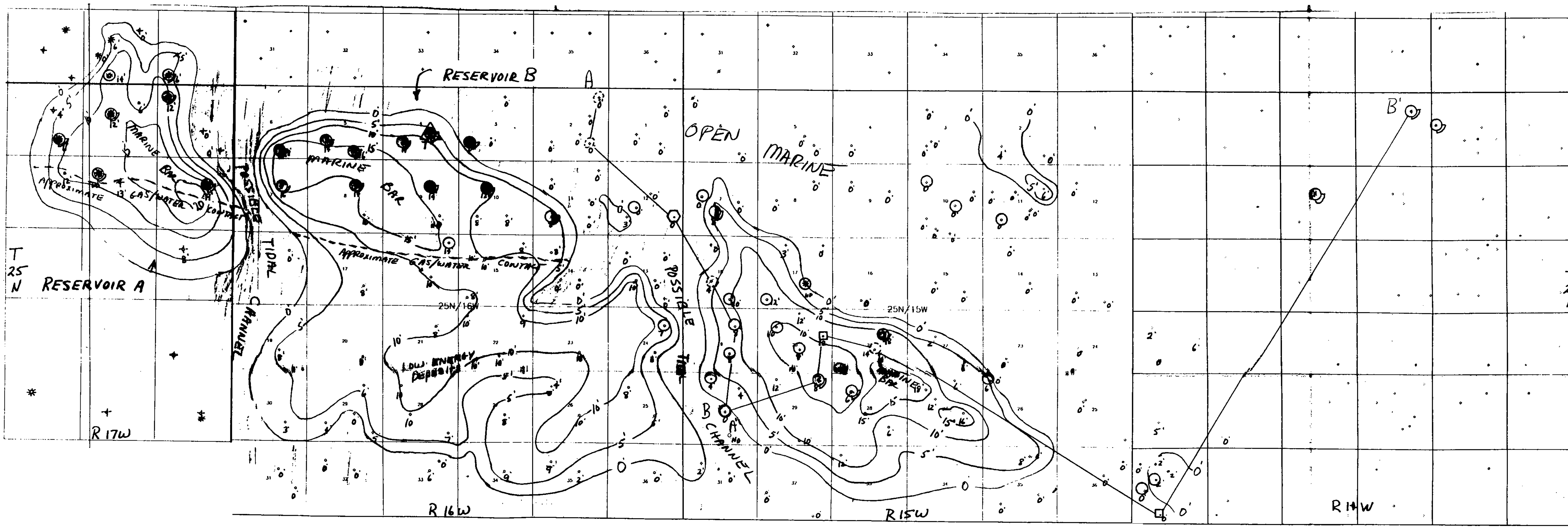
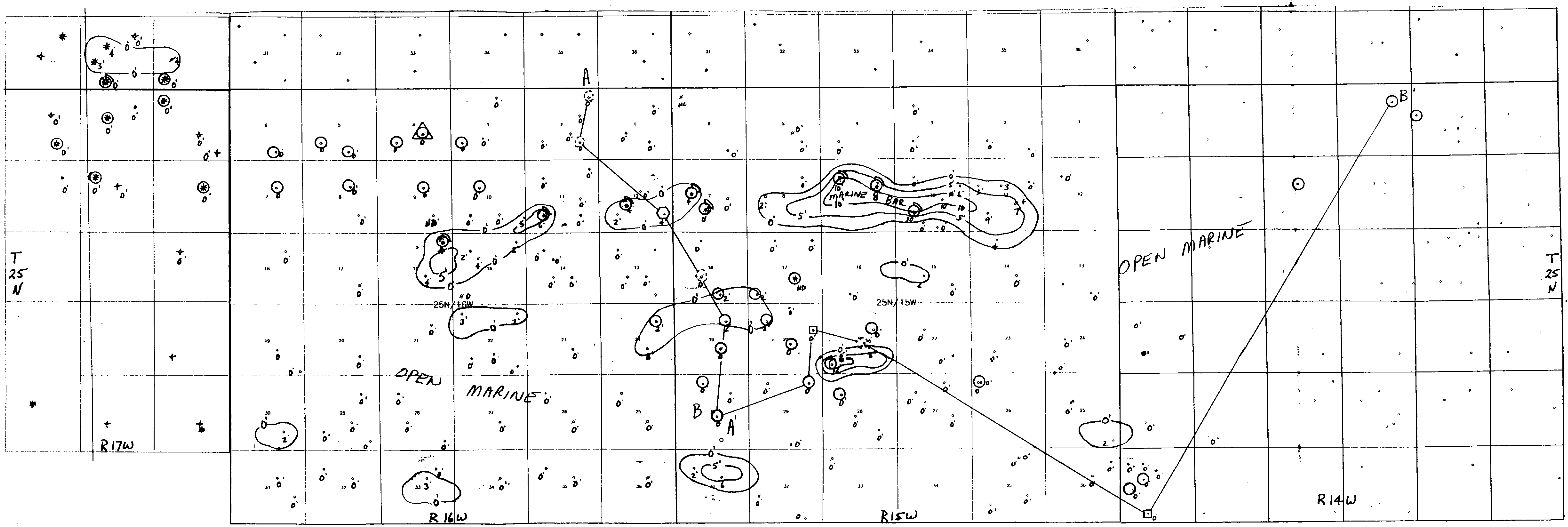


Figure W19

2nd Sandstone Isopach
C.I. = 5'



Scale 1:24000

Figure W20

1st Sandstone Isopach
C.I. = 5'

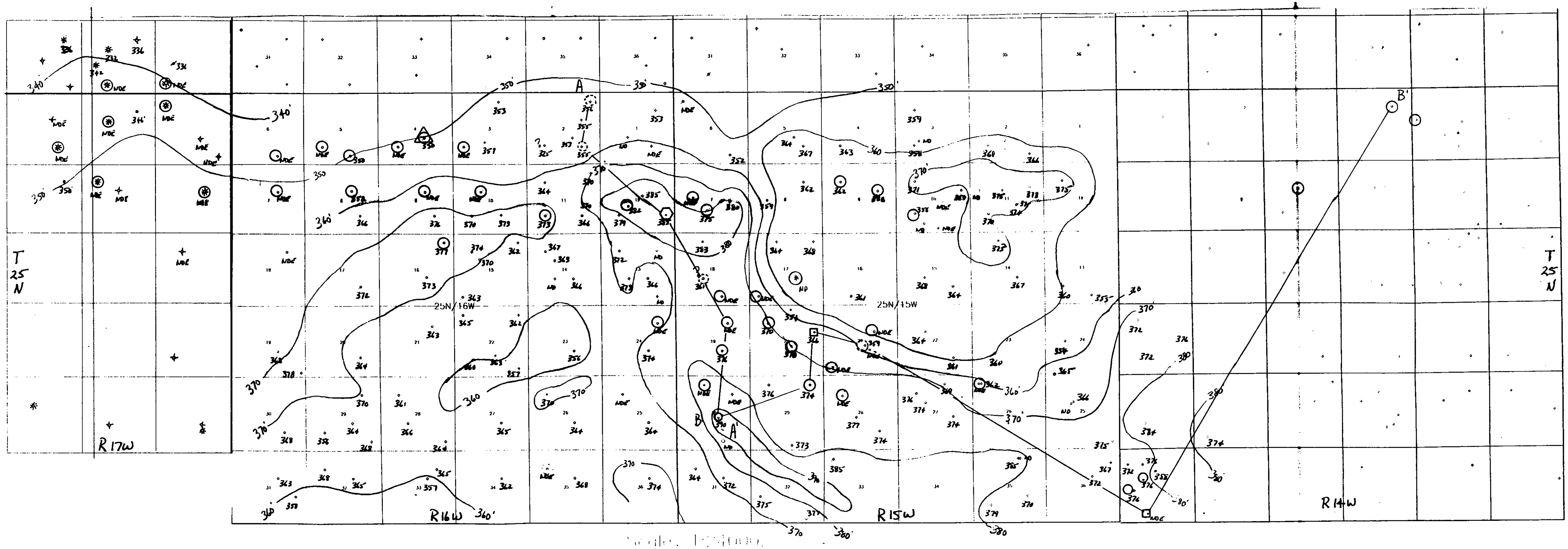


Figure W21

Tonkawa Zone
Isopach
C.I. = 10'

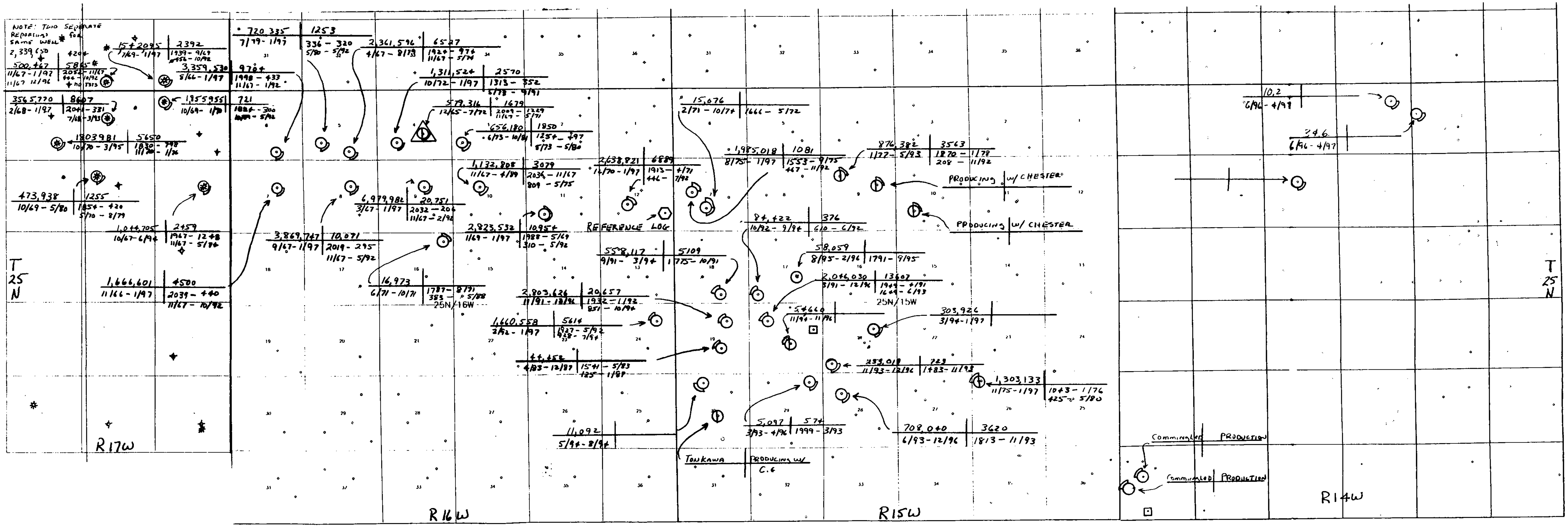


Figure W22

Waynoka NE Field Study Area
Production Plat

LEGEND

Cum Gas MCF	Cum Condensate &
Production Period	IBHSIP – FBHSIP Date – Date

1st Sandstone Producer
2nd Sandstone Producer
3rd Sandstone Producer
4th Sandstone Producer