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FIELD PROJECT TO OBTAIN PRESSURE CORE, WIRELINE LOG, AND PRODUCTION TEST DATA FOR EVALUATION OF CO_2 FLOODING POTENTIAL

CONOCO MCA UNIT WELL NO. 358

MALJAMAR FIELD, LEA COUNTY, NEW MEXICO

By

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Work Performed for the Department of Energy
Under Contract DE-AC21-79MC08341

GRUY FEDERAL, INC.
Houston, Texas 77063

DISCLAIMER

GRUY FEDERAL, INC.

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EXECUTIVE SUMMARY

This report describes part of the work done to fulfill a contract[1,2] awarded to Gruy Federal, Inc. by the Department of Energy (DOE) on February 12, 1979. The requirements of the contract are summarized in Enclosure I-1, Appendix A. The work includes pressure-coring and associated logging and testing programs to provide data on in-situ oil saturation, porosity and permeability distribution, and other data needed for resource characterization of fields and reservoirs in which CO_2 injection might have a high probability of success. This report details the second such project. The Grayburg-San Andres was one of the reservoirs identified by Gruy's earlier work (Task One of the contract) as having CO_2 flooding potential. Conoco indicated to Gruy that it had tentative drilling plans in the Maljamar and Ford-Geraldine fields. After several meetings of technical personnel from both companies, a proposal was submitted recommending that DOE provide funds to support a pressure-coring project in the MCA Unit No. 358. The site was recommended as pressure cores and related data should: advance the state of the art of CO_2 flooding in general; provide Conoco with information that could accelerate their justification for installing a CO_2 displacement project on the MCA unit; and provide information not otherwise available in the public domain (private project results will probably be kept confidential for a considerable period of time).

This would serve to advance toward DOE's stated goal of producing 124,000 incremental barrels of oil per day from CO_2 flooding by 1985.

Field operations, which were conducted as a cooperative effort between Conoco and Gruy Federal, began on January 16, 1980 when the well was spudded. The well was drilled to a depth of 3,635 feet, casing was set and cemented and the casing shoe drilled out to a depth of 3,692 feet where pressure coring operations began on February 19, 1980. Pressure Coring, Inc., PCI, recovered 18 cores in 18 core-barrel runs (144 feet) of which 14 (112 feet) were recovered with pressure in the intervals 3,692 to 3,740 feet, 3,803 to 3,827 feet, and 4,035 to 4,108 feet, for a 78 percent success ratio. Three cores lost pressure because core blocked the ball valve. Pressure was lost on one core as a result of swelling of the sliding sleeve. All cores were tagged with top and bottom depths. Of the 14 cores recovered with pressure, 13 were packed in dry ice and sent to Core Laboratories in Dallas. The remaining pressure core was sent to Geo-Chem Research, Inc., Houston. Cores recovered without pressure were sent to Core Laboratories' Midland, Texas office. Mud samples were sent to Teledyne Isotopes for determination of concentration of tritium tracers run in the mud system.

Upon completion of the coring phase, the hole was drilled to a total depth of 4,150 feet and a complete suite of geophysical logs was run by Schlumberger. Logging was then followed by completion and testing by Concoco.

Core analysis performed by Core Laboratories, Inc. and Geo-Chem Research, Inc. included measurement of porosity, fluid saturations, permeabilities and pore water chlorides and gas chromatography was used to determine the composition of gas released from cores recovered with pressure. Fluid samples were also selected for determination of the concentration of the tracers in the pore water by Teledyne Isotopes.

Core porosities agreed well with computed log porosities. Core water saturation and computed log porosities agree fairly well from 3,692 to 3,712 feet, poorly from 3,712 to 3,820 feet and in a general way from 4,035 to 4,107 feet. Computer log analysis techniques incorporating the a, m, and n values obtained from Core Laboratories analysis did not improve the agreement of log versus core derived water saturations. However, both core and log analysis indicated the ninth zone had the highest residual hydrocarbon saturations and production data confirmed the validity of oil saturation determinations. Residual oil saturation, for the perforated and tested intervals were 259 STB/acre-ft for the interval from 4,035 to 4,055 feet, and 150 STB/acre-ft for the interval from 3,692 to 3,718 feet. Nine BOPD was produced from the interval 4,035 to 4,055 feet and no oil was produced from interval 3,692 to 3,718 feet, qualitatively confirming the relative oil saturations as calculated. The low oil production in the zone from 4,022 to 4,055 and the lack of production from 3,692 to 3,718 feet indicated the zone to be at or near residual waterflood conditions as determined by log analysis.

This project demonstrates the usefulness of integrating pressure core, log, and production data to realistically evaluate a reservoir for carbon dioxide flood. The engineering of tests and analysis of such experimental data requires original thinking, but the reliability of the results is higher than data derived from conventional tests.

INTRODUCTION

This report describes part of the work required to fulfill a contract[1,2] awarded to Gruy Federal, Inc. by the Department of Energy (DOE) on February 12, 1979. The requirements of the contract are summarized in Enclosure I-1, Appendix A. The contract, originally awarded by DOE's Oak Ridge Operations Office[3] and now administered by the Morgantown Energy Technology Center[4], provides for DOE funding of research and development in the following areas:

- summary of available CO_2 field test data;
- summary of existing reservoir and geological data for carbonate reservoirs in West Texas, southeast New Mexico, and the Rocky Mountain states;
- selection of target reservoirs;
- selection of specific reservoirs for CO_2 injection tests;
- selection of specific sites for test wells;
- drilling and coring activities.

This program is designed to provide a solid engineering foundation upon which field mini- and pilot tests or full-scale projects can be implemented in carbonate reservoirs.

The pressure-coring and associated logging and testing programs in selected wells are intended to provide data on in-situ oil saturation, porosity and permeability distribution, and other data needed for resource characterization of fields and reservoirs in which CO_2 injection might have a high probability of success. This report presents detailed information on one such project.

General Background Information

As a result of Gruy Federal's early work devoted to reviewing field test data (Task One of the contract) and summarizing existing reservoir and geologic data for selected carbonate reservoirs in west Texas, southeast New Mexico, and the Rocky Mountain states (Task Two of the contract), it was recognized that the contract program could be expedited by an "early wells" effort in reservoirs clearly identified as having CO_2 flooding potential. This program was planned to parallel continued work on contract Tasks One and Two.

To accomplish this, Gruy sought operators who planned, for their own purposes, to drill infill or replacement wells to or through reservoirs identified as having CO_2 flooding potential. These wells could be utilized to carry out a proposed coring and logging program.

The program provides for taking cores through the reservoir intervals of interest, using a core barrel that retains the cores under pressure for subsequent analysis. This would provide a more direct measure of in-situ oil and water saturations as well as porosity and permeability for comparison with data obtained from a comprehensive suite of wireline logs.

If, for the operator's purposes, a well is to be completed in the target reservoir, Gruy would propose to conduct or monitor production tests to obtain further data on the CO_2 flooding potential. These tests would be designed by Gruy on the basis of data from core and log analysis.

Specific Project Background

Conoco, Inc. is the operator of the MCA waterflood unit in the Maljamar field, Lea County, New Mexico. The unit had approximately 300 million barrels of oil originally in place in the Grayburg-San Andres reservoirs at depths of 3,600 to 4,000 ft. This field, along with several other similar fields nearby, was identified by Gruy Federal's screening as a target reservoir for CO_2 flooding. Conoco is planning to drill several wells to implement a CO_2 injection tertiary recovery pilot project. The operator responded to contacts made by Gruy Federal and was willing to provide the opportunity to obtain pressure cores and other data in one of these wells.

Conoco Well Site Selection

Conoco indicated to Gruy that it had tentative drilling plans in the Maljamar and Ford-Geraldine fields. Several meetings of technical personnel from both companies discussed methods by which pressure cores and related data could be obtained in the MCA Unit No. 358 well, programmed for drilling as a Grayburg-San Andres producer in the MCA waterflood unit of the Maljamar field.

Following these meetings, a proposal was submitted recommending that DOE provide funds to support a pressure-coring project in the MCA Unit No. 358.[7] This recommendation was based on the conclusion that use of DOE funds to pay for pressure cores and related data would:

- advance the state of the art of CO_2 flooding in general;
- provide Conoco with information that could accelerate their justification for installing a CO_2 displacement project on the MCA unit; and
- provide information not otherwise available in the public domain (private project results will probably be kept confidential for a considerable period of time).

This would serve to advance toward DOE's stated goal of producing 124,000 incremental barrels of oil per day from CO_2 flooding by 1985. Approval of this proposal was received in January 1980.[8]

Business Arrangements. The basic business arrangements agreed to before the start of field operations provided for reimbursement of Conoco for the additional costs incurred as a result of well plan revisions necessitated by pressure-coring operations including:

- additional drilling-rig, mud, casing, cementing, and tool rental costs during actual pressure coring and related operations;
- additional logging costs over those that would have been required for Conoco's normal evaluation procedures;
- direct subcontracting by Gruy Federal for pressure-coring services, core analysis services, and related tracer material and services, transportation, etc.; and
- direct subcontracting by Gruy Federal for any special production or other tests not related to the operator's original well completion plans.

Estimated costs to Conoco of the project as proposed are shown in Table 1. These arrangements proved both workable and economical.

TABLE 1

Cost Estimate for Pressure-Coring Project
MCA No. 358.

Item	Estimated cost
Additional rig costs: 15 days @ $4100/day plus 2 days @ $900/day	$ 63,300
Additional mud costs	20,000
Additional cementing costs	17,000
Special drilling tool rentals	25,000
Additional logging costs	12,000
Additional casing costs	70,050
Additional footage drilling costs	2,750
Additional taxes (federal, state, local)	9,400
TOTAL ESTIMATED ADDED COSTS	$219,500

MALJAMAR FIELD INFORMATION

The material that follows is based on information supplied by Conoco. This information provided the basis for Gruy's pressure-coring proposal and recommendation.

Location and History

The Maljamar Field is approximately 40 miles northwest of Hobbs, N. M., in the northwest shelf area of the Permian basin which underlies west Texas and eastern New Mexico (Figure 1). It is one of several fields in western Lea County and eastern Eddy County (Figure 2). The field was discovered in 1926; the bulk of development drilling took place in the early 1940's. Maljamar field encompasses 8,040 acres and produces from the Grayburg dolomitic sands (Permian) and the San Andres dolomite (Permian) at depths ranging from 3,600 to about 4,100 ft. The oil gravity is 35° to 37°API. The field was originally developed on 40-acre spacing; 20-acre infill development followed in the years 1971-1973.

The general geologic column and stratigraphic nomenclature for this portion of the Permian basin are given in Figure 3.

Geologic and Petrophysical Data

The Maljamar field is an anticline that plunges in an easterly direction and has steep dips on the south side of the structure. Oil production is limited on the north by porosity and permeability pinchout and on the south and east by an oil-water contact. A structure map contoured on the top of the San Andres is shown in Figure 4.

Five Grayburg-San Andres pay zones are under waterflood in the Maljamar Field:

Grayburg Sands	Zone 6
San Andres Dolomite	Zone 7 (upper)
	Zone 7 (lower)
Lovington Sand	Zone 8 (nonproductive)
San Andres Dolomite	Zone 9 (upper)
	Zone 9 (massive)

A type log showing the depth relationships of these zones and their thicknesses is shown in Figure 5. The zones are described in detail below. The total gross section from the top of the sixth zone to the bottom of the ninth massive pay is generally 320 to 400 feet.

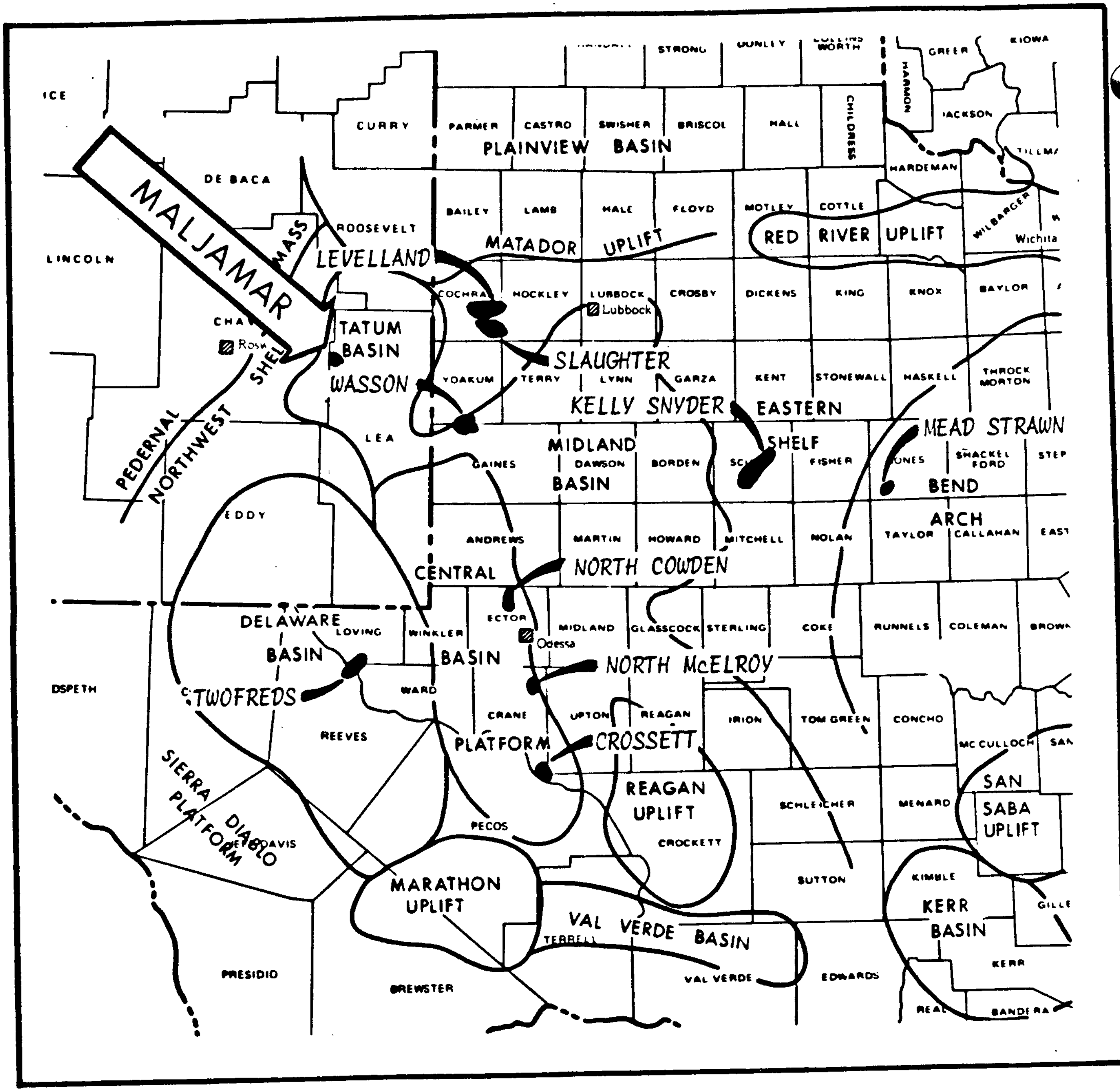


Figure 1.--Gruy Federal, Inc. index map of CO_2 projects.

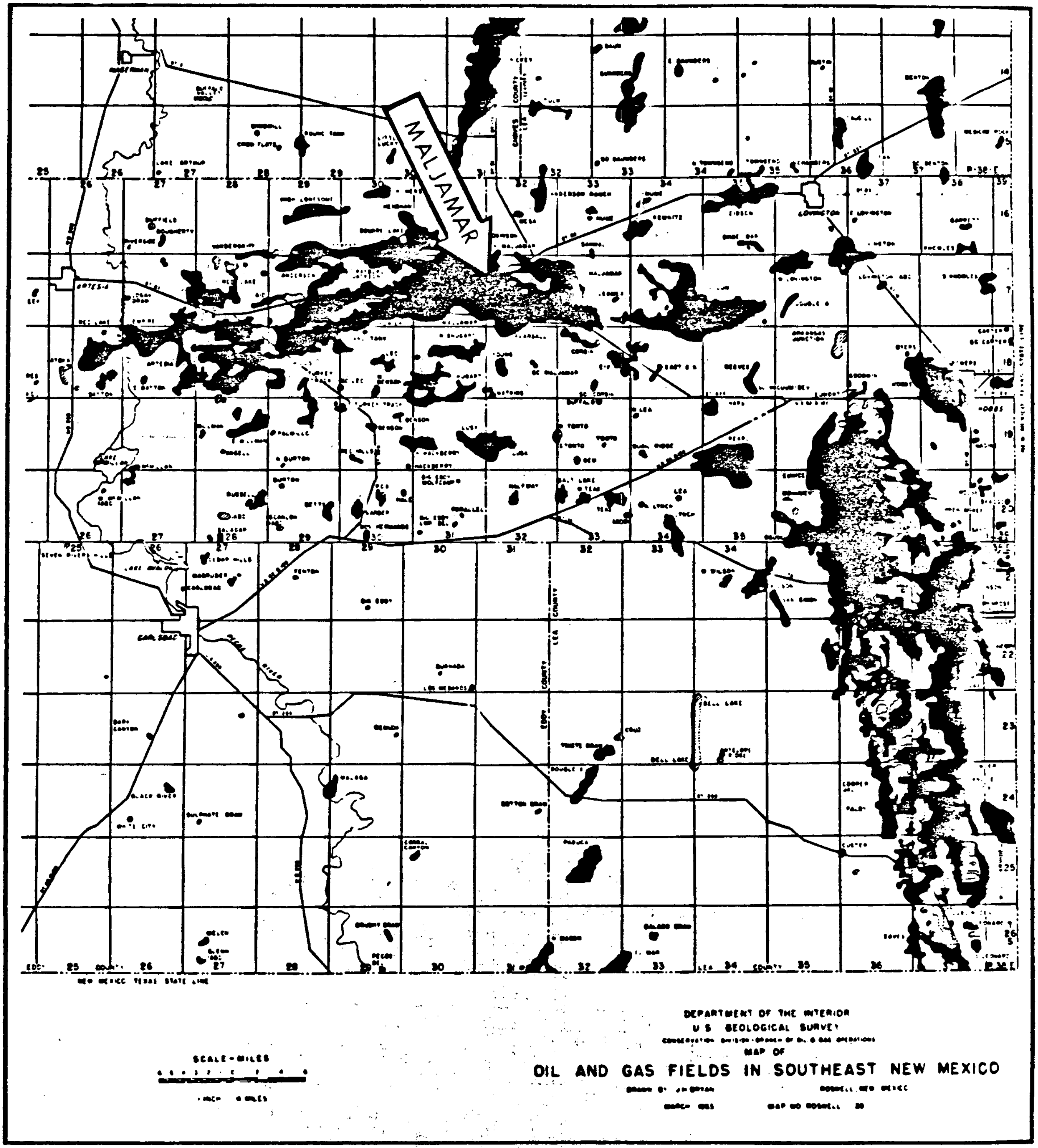


Figure 2.--Location of Maljamar field in southeast New Mexico.

GENERALIZED SECTION

PRODUCING FORMATIONS LEA COUNTY, NEW MEXICO

SYSTEM	SERIES	FORMATION	LEA COUNTY POOLS
PERMIAN	OCHOA	SALADO	2500'± NONPRODUCTIVE BEDS ARE NOT INCLUDED
PERMIAN	GUADALUPE	TANSILL	
PERMIAN	GUADALUPE	YATES	ARROW, BAISH, CORBIN, EAVES, EUMONT, GEM, HALFWAY, JALMAT, LUSK, LYNCH, NORTH LYNCH, RHODES, SAN SIMON, TEAS, TONTO, WILSON, NORTH WILSON
PERMIAN	GUADALUPE	SEVEN RIVERS	ARROW ,BOWERS, COOPER, JAL, EAVES, EUMONT, SOUTH EUNICE, EAST HOBBS, JALMAT, LANGLIE MATTIX, LEONARD, TONTO, WATKINS, WEST WILSON
PERMIAN	GUADALUPE	QUEEN	ARROW, CAPROCK, NORTH CAPROCK, COOPER JAL, CORBIN, DOLLARHIDE, E.K., EUMONT, LANGLIE MATTIX, SOUTH LEONARD, PEARSALL, PENROSE SKELLY, YOUNG
PERMIAN	GUADALUPE	GRAYBURG	ARROWHEAD, EUNICE-MONUMENT, HARDY, HOBBS, MALJAMAR, EAST MALJAMAR, NORTH MALJAMAR, SOUTH MALJAMAR, PENROSE SKELLY, ROBERTS, SKAGGS, VACUUM, WATKINS
PERMIAN	GUADALUPE	SAN ANDRES	SOUTH CARTER, E.K., EIGHTY FOUR DRAW, EUNICE-MONUMENT, GARRETT, HOBBS, EAST HOBBS, HOUSE, LITTMAN, LOVINGTON, WEST LOVINGTON, MALJAMAR, EAST MALJAMAR, NORTH MALJAMAR, SAN MAL, SAWYER, VACUUM
PERMIAN	LEONARD	GLORIETA	JUSTIS, LOVINGTON, MONUMENT, MALJAMAR, PADDOCK
PERMIAN	LEONARD	YESO DRINKARD — UPPER	BLINEBRY, FOWLER, EAST HOBBS, LOVINGTON, MONUMENT, TERRY
PERMIAN	LEONARD	YESO DRINKARD — MIDDLE	LOVINGTON, TUBB
PERMIAN	LEONARD	YESO DRINKARD — LOWER	DOLLARHIDE, DRINKARD, FOWLER, HOBBS, HOUSE, NADINE, SKAGGS, WARREN, WEIR
PERMIAN	WOLFCAMP	ABO-HUECO	ANDERSON RANCH, EAST BAGLEY, BAUM, BRONCO, BUFFALO, EAST CAPROCK, CAUDILL, DENTON, D-K, GLADIOLA, SOUTH GLADIOLA, KING, LAND, LOVINGTON, MOORE, TOWNSEND, TULK, WANTZ
PENNSYLVANIAN			ALLISON, BAGLEY, BOUGH, CASS, CROSSROADS, DEAN, EIDSON, HIGHTOWER, LAZY J, EAST LOVINGTON, MESCALERO, MOORE, SOUTH ROBERTS RANCH, SAUNDERS, SOUTH SAUNDERS, SHOE BAR, WILLIAMS
MISSISSIPPIAN		MISS. LS.	DENTON
MISSISSIPPIAN		WOODFORD SH.	
DEVONIAN			ANDERSON RANCH, BAGLEY, BRONCO, EAST CAPROCK, CAUDILL, CROSBY, CROSSROADS, SOUTH CROSSROADS, DEAN, DENTON, SOUTH DENTON, DOLLARHIDE, DUBLIN, ECHOL, NORTH ECHOL, FOWLER, GLADIOLA, HIGHTOWER, KNOWLES, SOUTH KNOWLES, MALAJMAR, MESCALERO, MOORE, SOUTH ROBERTS RANCH, SAWYER, SHOE BAR, TEAGUE
SILURIAN		FUSSELMAN	DOLLARHIDE, FOWLER, MC CORMICK
ORDOVICIAN	UPPER	MONTOYA	CARY
ORDOVICIAN	MIDDLE	SIMPSON	HARE, SOUTH HARE, TEAGUE, WARREN, NORTH WARREN
ORDOVICIAN	LOWER	ELLENBURGER	BRUNSON, DOLLARHIDE, DUBLIN, FOWLER, TEAGUE
PRE-CAMBRIAN			

Figure 3.--Generalized stratigraphic section for Maljamar field.

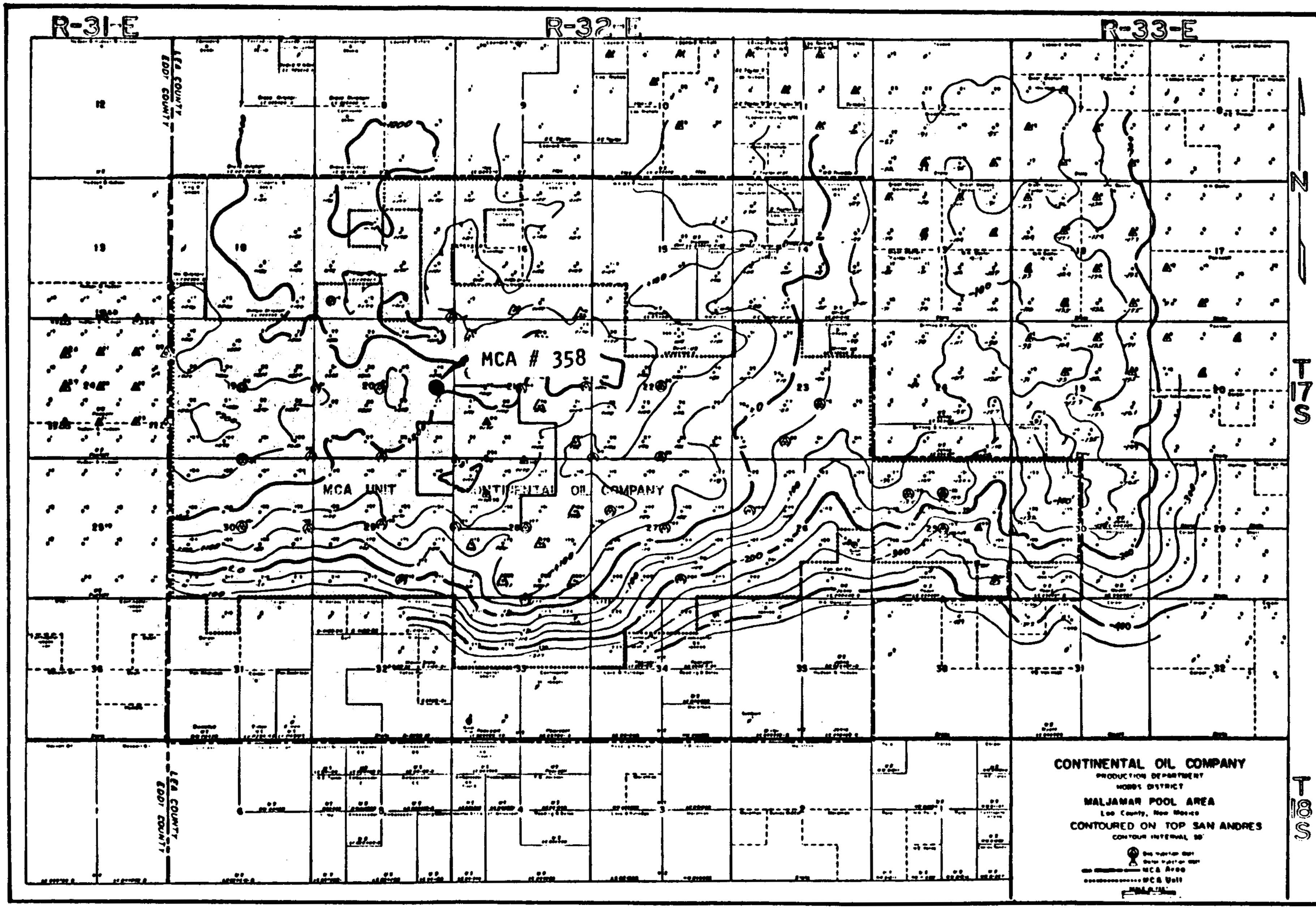


Figure 4.--Structure map on top of the San Andres.

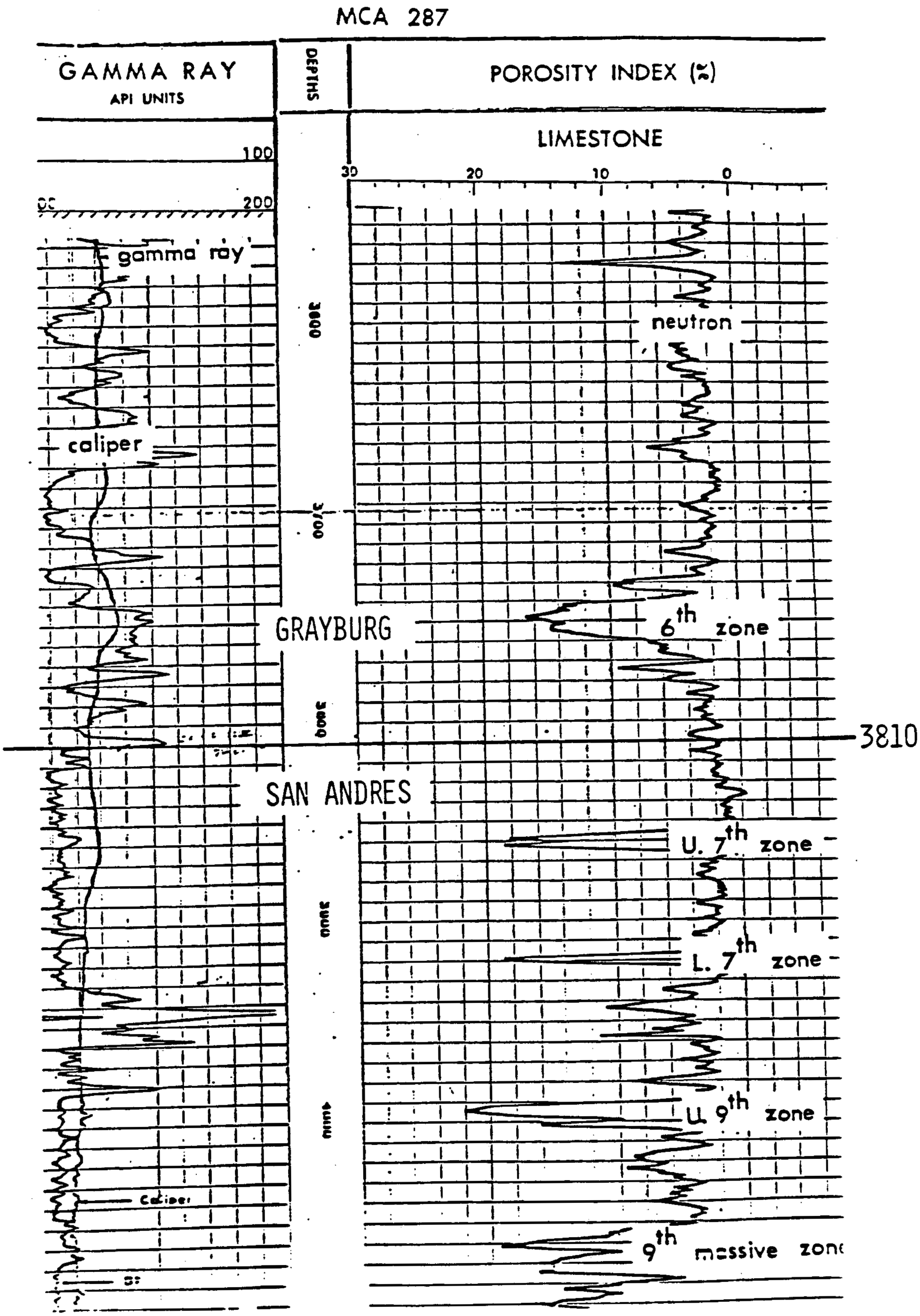


Figure 5.--Well log MCA Unit #287.

Zone 6

Zone 6 consists of several sand bodies, tending to be dolomitic, lying above the San Andres and generally within 100 feet of the San Andres top. The sands, which are separated by dolomite stringers, are very fine-grained subangular quartz sand with dolomitic cementing material. Oolites and pellets are common. There is some intercrystalline porosity, but it is highly erratic. Sands found immediately on top of the San Andres (Premier) are usually nonproductive in the MCA area, although they produce in the Grayburg Jackson pool to the west. Figure 6 is a composite isopach map of the sands in this zone.

Zone 7

Zone 7 is the upper part of the San Andres section. Porosity usually starts within a few feet of the San Andres top. The zone extends down to the Lovington sand and is approximately 120 to 150 feet thick. The dolomite is predominantly light-colored, with traces of shale and sand near the base of the section. The porous and permeable portions are generally pelletoid, oolitic, or granular, with varying amounts of intercrystalline or interparticle anhydrite which in some cases has been leached to create the porosity. Porosities are generally low in this zone, although there is a scattering of high porosity due to vuggy zones. Permeability is better distributed; there are some high permeabilities due to hairline or microfractures on the order of 0.1 mm. Generally there is a very dense dolomite development in the middle of the seventh zone, which provides the distinction between upper and lower pay. Isopach maps of the upper and lower seventh zone pays are shown in Figure(s) 7 and 8.

Zone 8

This zone is the Lovington Sand and, except for some rare cases, it is nonproductive in the MCA area of the Maljamar field. Total thickness is generally 40 to 60 ft.

Zone 9

Zone 9, lying immediately above the Lovington Sand, has been subdivided into "upper" and "massive" porosity zones. The upper ninth zone is a light-colored dolomite approximately 50 to 100 feet thick. Anhydrite is less common. Figure 9 is an isopach map of the upper ninth zone. The massive ninth zone was so named because of the thick massive character shown on some of the early SP logs. This is also indicated on some of the gamma-ray logs by a homogeneous pure dolomite; less pure material is generally found in the upper ninth zone. This dolomite is also light in color, with pelletoid and oolitic porosity and well leached interparticle porosity. An isopach map of the massive ninth zone is shown in Figure 10.

Bottom water is found in the ninth zone, occurring most often at about -65 ft in the upper ninth and about -80 ft in the massive ninth. The water top is somewhat erratic, probably complicated by the erratic porosity development.

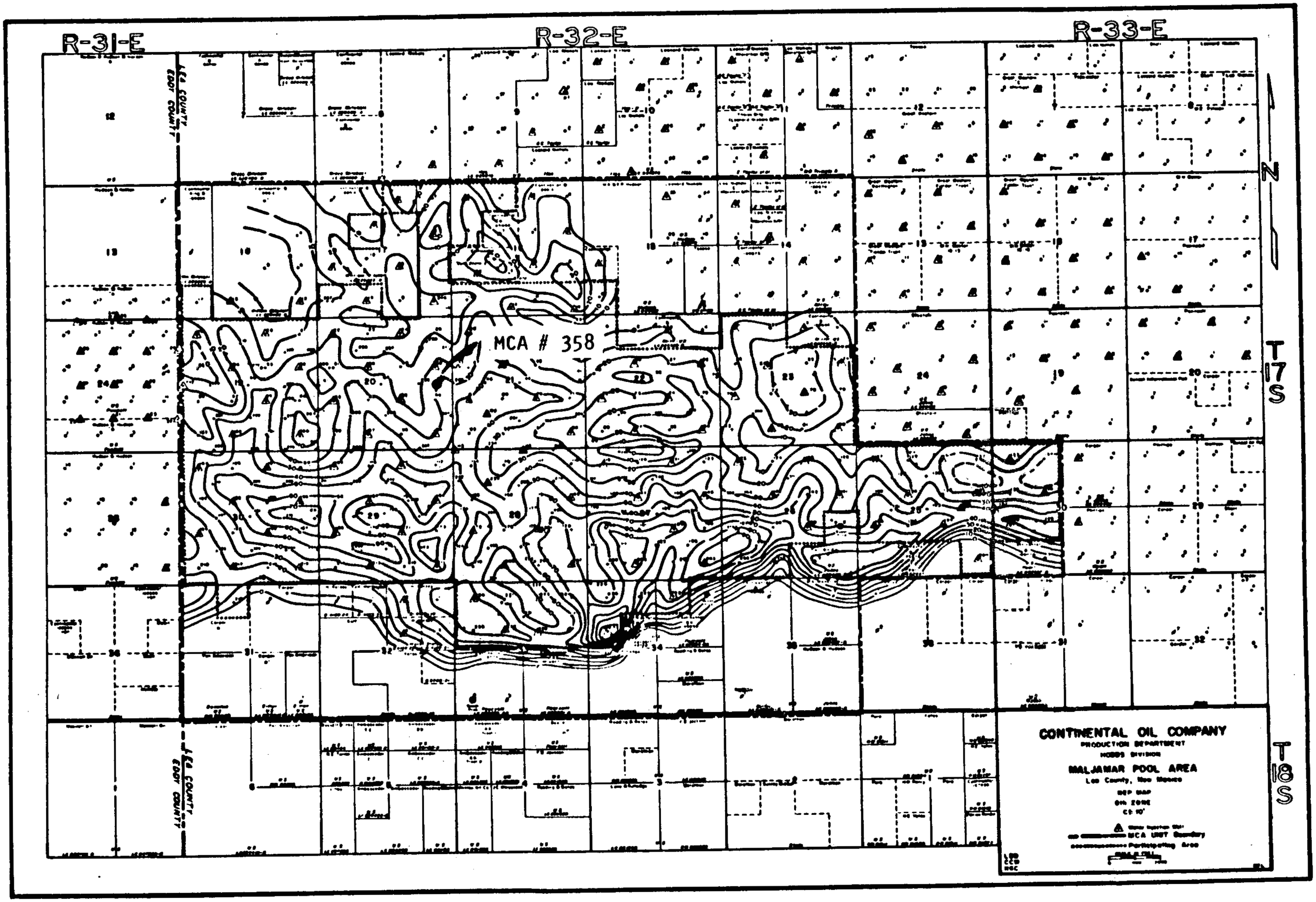


Figure 6.--Isopach map, zone 6.

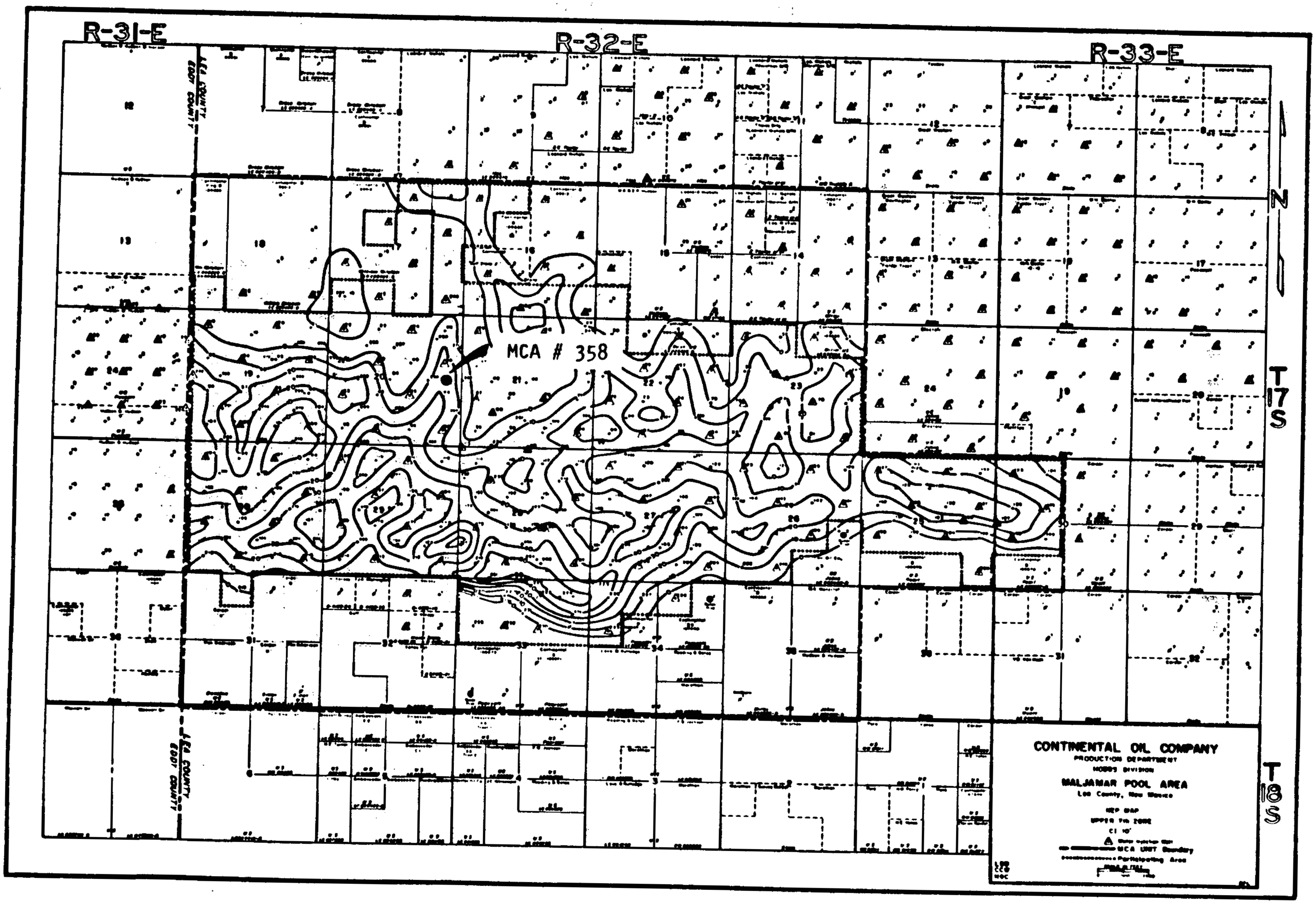


Figure 7.--Isopach map, zone 7 (upper).

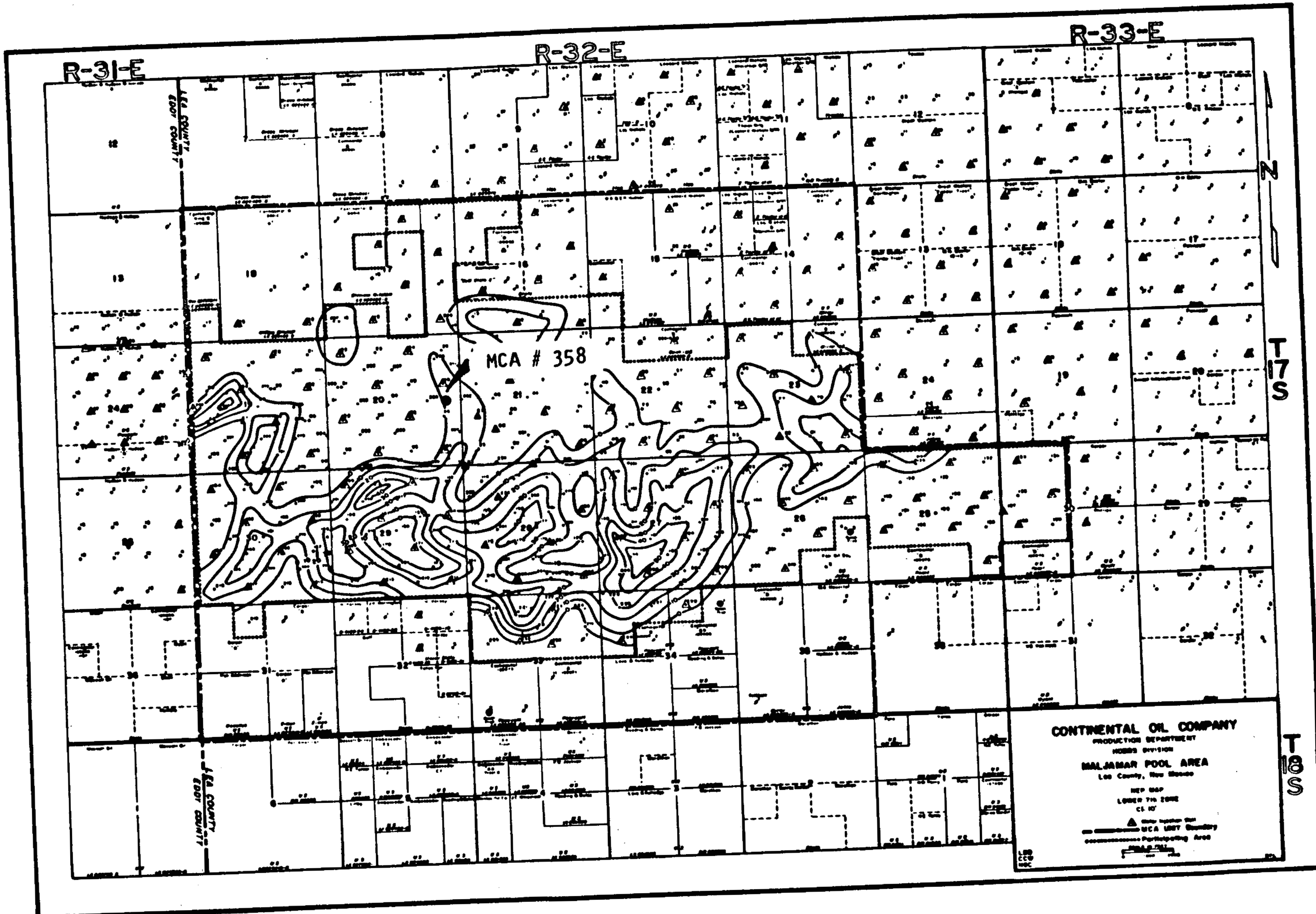


Figure 8.--Isopach map, zone 7 (lower).

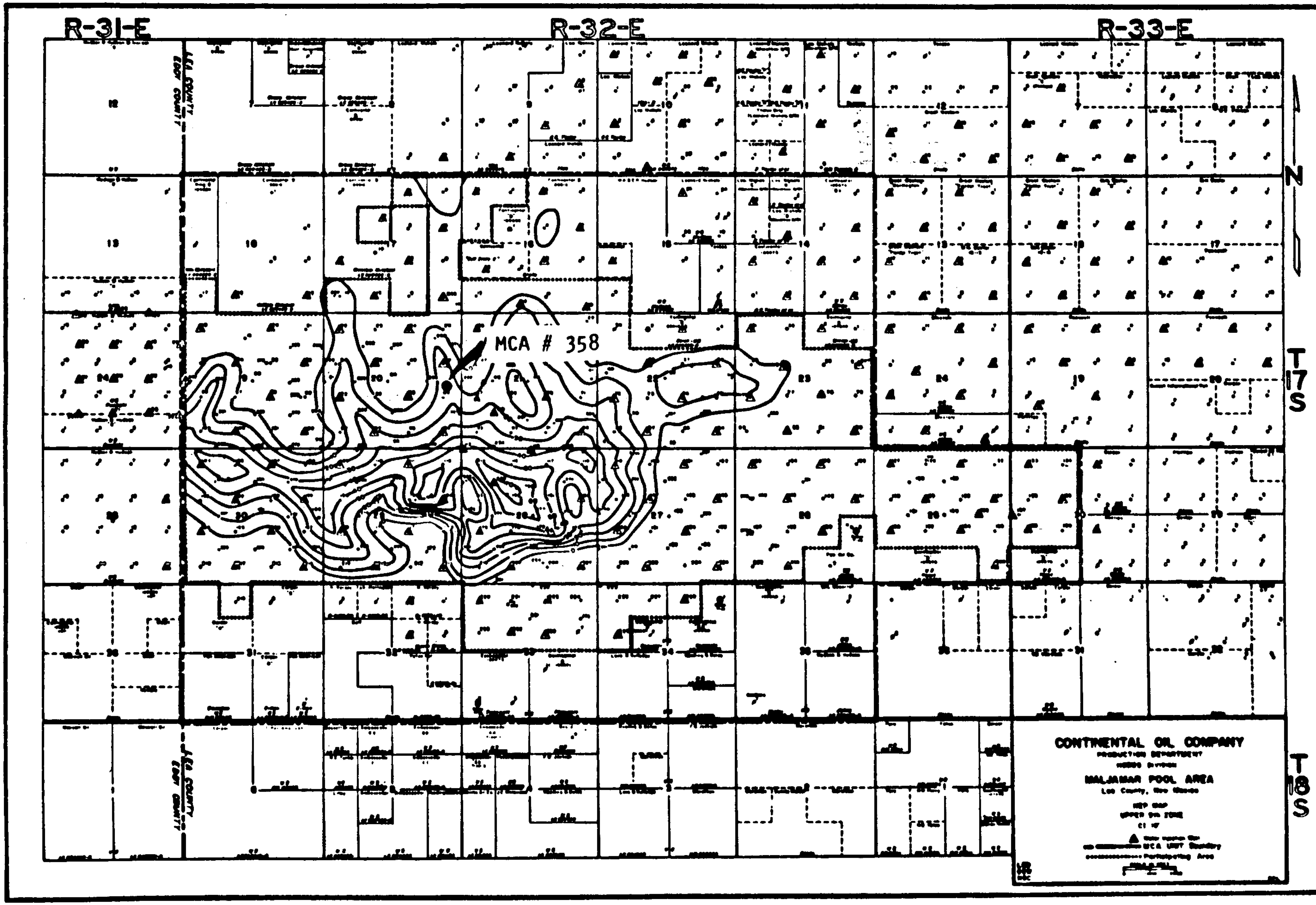


Figure 9.--Isopach map, zone 9 (upper).

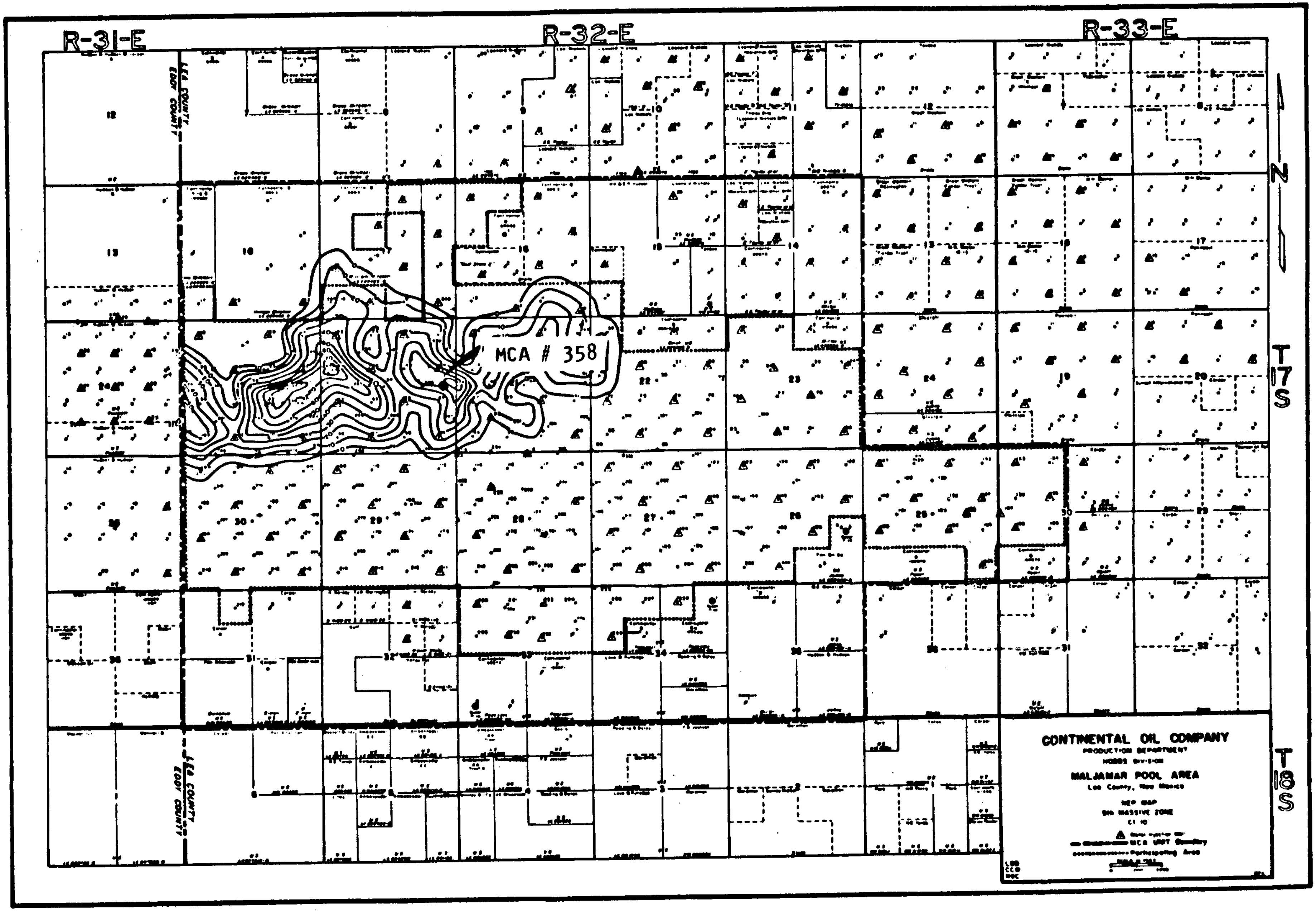


Figure 10.--Isopach map, zone 9 (massive).

Core Data

An extensive infill drilling program during 1971-73 provided the opportunity to core the various zones in selected locations and sample the entire MCA area. Weighted average porosities determined from this coring program are:

6th zone	12.3%
Upper 7th zone	9.0%
Lower 7th zone	7.6%
Upper 9th zone	9.1%
9th Massive zone	11.0%

Permeabilities vary widely but are predominantly 3 md or less.

Calculation of Reservoir Volume

Each zone was considered separately in calculating the volume of each reservoir. Isopach maps (Figs. 6 through 10) were used to calculate acre-feet of porosity present. Core data and other information were used to determine stock tank oil initially in place. The following tabulation summarizes these calculations by zones.

	6th Zone	Upper 7th Zone	Lower 7th Zone	Upper 9th Zone	9th Massive Zone
Porosity cutoff, %	7	6	6	6	6
Acre-feet of porosity	265,490	143,310	64,090	72,950	51,310
Areal extent, acres	7,804	6,479	4,006	3,292	1,942
Average thickness, ft	34	22	16	22	26
Average porosity, %	12.3	9.0	7.6	9.1	11.0
Water saturation, %	23.5	14	16	19	16.5
Formation volume factor	1.25	1.25	1.25	1.25	1.25
Stock tank oil in place (STOIP), B/AF	584	480	396	457	570
Total STOIP, Mbbl	155,046	68,789	25,380	33,338	29,247

Total STOIP, all zones: 311,800,000 bbl.

Because of their larger areal extent, the 6th and Upper 7th Zones contained 71 percent of original oil in place (223 million barrels).

Development and Production History

The Maljamar accumulation was discovered in 1926 and extensive development drilling took place in the early 1940's. This competitive primary development was done on 40-acre spacing.

In 1942, Grayburg-San Andres gas injection was initiated in what was called the Maljamar Cooperative Repressuring Agreement (MCRA). This was a cooperative project encompassing the boundaries of the present MCA unit. Lean produced gas was injected into 14 infill gas injection wells drilled on 160-acre spacing. This program was successful in enhancing the recovery of oil from the reservoir. Continental Oil Company acquired its leases in the Maljamar area by purchase from Buffalo and Kewanee companies in 1958 and 1960.

Original oil in place is estimated at 311 million barrels; ultimate recovery, including primary and waterflood, is projected to be 95 million barrels, giving a recovery efficiency of 30.5 percent. This combined primary and secondary (waterflood) recovery leaves a field-wide target of 217 million barrels for enhanced oil recovery methods.

Reservoir Fluid Data

The oil from the Maljamar San Andres reservoir has a stock-tank gravity of 38°API and a bubble-point viscosity of 1.09 cp. Original reservoir pressure was 1,350 psi and bubble-point pressure was 590 psi. The original formation volume factor was 1.19.[9]

MCA UNIT INFORMATION

The following material is also based on information furnished by Conoco.

General. Authority to form the MCA unit and to inject water into the Grayburg-San Andres formations was granted by New Mexico Oil Conservation Division Order No. RR-2403 dated December 31, 1962. Conoco, a 74.65 percent working interest owner, is the operator of this unit (a unit map is given in Figure 11). The other MCA unit working interest owners are listed in Table 2; they include Arco and Cities Service, both active in CO_2 flooding research and application.

History and Waterflood Performance. In November 1963, shortly after unitization, a water injection pilot was commenced in the MCA unit. The pilot area was centered around the southwest quarter of Sec. 21 and the northwest quarter of Sec. 28. Water was first injected into four wells: MCA Unit No(s). 68, 113, 116, and 235, referred to as the "Central Pilot". After the injection appeared successful, the program was expanded over the unit area in four major stages between August 1965 and February 1969. The gas injection program was phased out as the various areas were put under flood. Performance data for the waterflood are shown in Figure 12. This response indicates good pay continuity and oil bank buildup in this commingled waterflood.

During 1971, Conoco started an infill development program which was gradually expanded over the entire MCA unit area. The infill pattern was designed to provide five-spot well patterns in the older 40-acre development. The infill program was intended to accelerate and improve the recovery of waterflood reserves. Additional recovery was attributed to better interconnection with reservoir heterogeneity and improved well completions.

The operating statistics for June 1979 (Figure 12) are:

Average oil production	17,000 B/D
Average water production	6,000 B/D
Average water injection	35,000 B/D

As of November 1979, the MCA unit had 199 oil-producing wells, 108 water-injection wells, and 50 inactive wells.

The operator estimates that primary production supplemented by gas injection would have recovered approximately 50 million barrels of oil, or about 16 percent of the oil originally in place (Table 3). Waterflood operations are expected to recover an additional 45.6 million barrels (14.6 percent). Total recovery from primary plus waterflood is expected to be some 95 million barrels (30.6 percent of ISTOIP), leaving an enhanced recovery "target" volume of 217 million barrels, not adjusted for shrinkage.

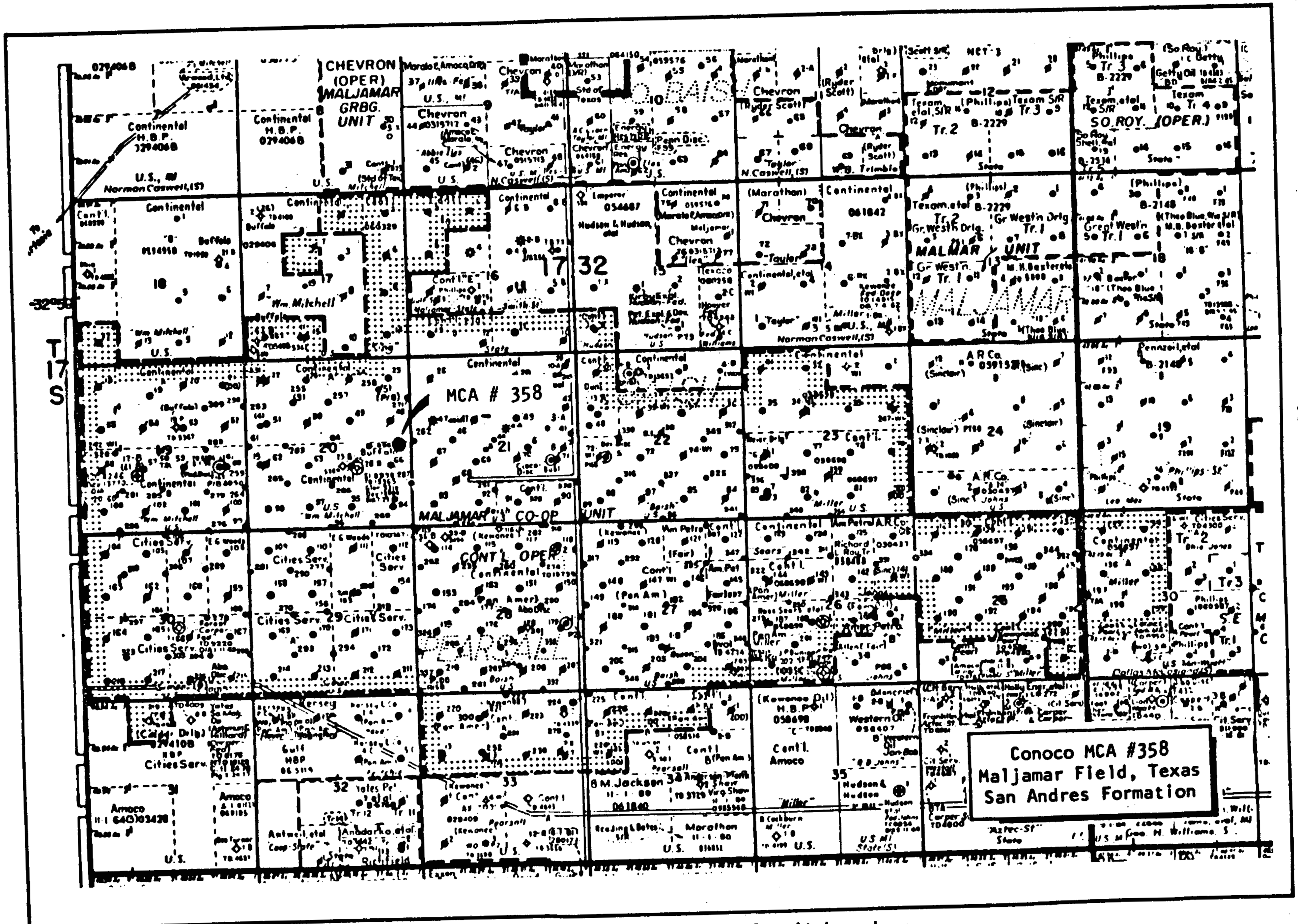


Figure 11.--Participation MCA unit boundary.

TABLE 2

Working interest owners in the MCA unit, Maljamar field
Lea County, New Mexico.

Conoco, Inc.	Houston, Texas
Jack B. Shaw, for Emily Katherine Flint Boyd Virginia Woods Shaw	Artesia, N. M.
Rosemary Flint Wayte	Oklahoma City, Okla.
Cities Service Company	Tulsa, Okla.
Cockburn Trust	Houston, Texas
ARCO Oil and Gas Company	Los Angeles, Calif.
Richard L. Ray, trustee for Fair N & N Trust	Tyler, Texas
J. P. Pierce	Ft. Worth, Texas
Mary Katherine Fowles	Napa, Calif.
Shirley Runyan Rich	Wynnewood, Okla.
Tom Woods Runyan	Hope, N. M.
Virginia Sears	Artesia, N. M.
Mary Jo Vandriver	Artesia, N. M.
Sally Seeber	Artesia, N. M.
Jewell Smith	Ft. Worth, Texas
Cal Farley's Boys Ranch	Amarillo, Texas
American Petrofina Company of Texas	Dallas, Texas

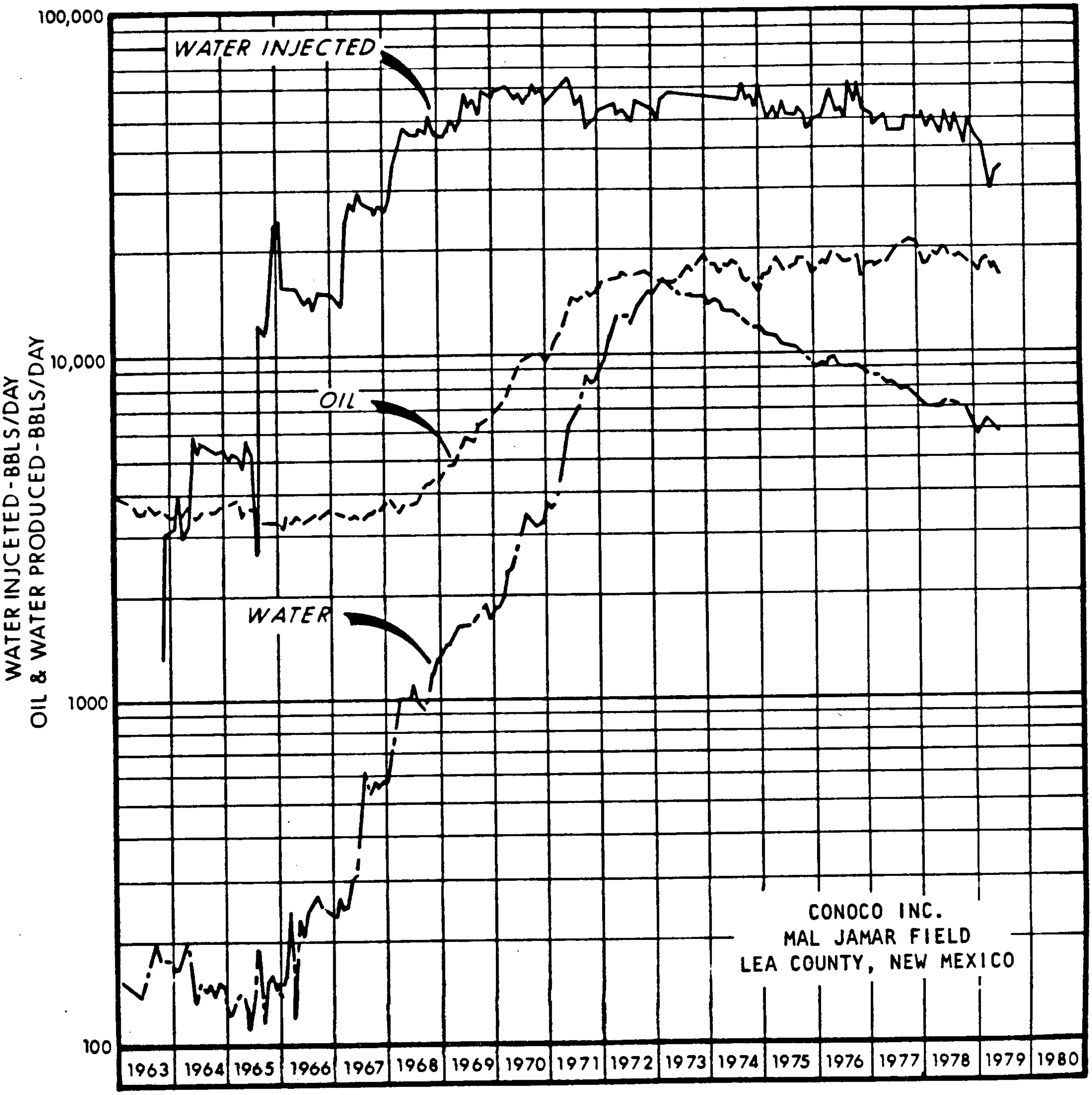


Figure 12.--MCA unit performance curve.

TABLE 3

Cumulative production, estimated ultimate recovery and reserves from primary and waterflood operations MCA unit, Maljamar field Lea County, New Mexico.

	barrels
Oil recovery at flood start (11/1/63)	38,666,000
Estimated remaining primary at flood start	10,334,000
Estimated ultimate primary recovery, including gas injection	49,550,000
Oil recovery since flood start (to 1/1/78)	44,232,000
Estimated remaining reserves (from 1/1/78)	9,876,000
Estimated ultimate waterflood oil recovery (less primary and gas injection)	45,648,000
Estimated total ultimate recovery	95,198,000
Target oil for enhanced recovery (without shrinkage)	217,000,000

CO_2 Flooding Potential

The Maljamar Field was selected as a target reservoir in the data base screening work done to date by Gruy Federal, Inc. as part of Task Two of contract DE-AC21-79MC08341 (see Table 4). Published estimates[1] of CO_2 flooding potential in the region indicate that CO_2 flooding could recover some 15 percent of the original oil in place, or about 47 million barrels.

The CO_2 pilot will provide the basic information necessary to evaluate the use of this process on an expanded basis in the MCA unit.

It was proposed that pressure cores be taken in the first of the seven pilot wells to be drilled. This well, MCA Unit No. 358, located 660 feet from the east line and 2,600 feet from the north line of Sec. 20, T. 17 S., R. 32 E., was intended to serve as the injection well in the pilot project (see Figure 13). The operator planned to spud this well during the third week of December 1980 and expected to reach the coring point in about seven days. It was planned that the well would be dually completed for separate injection into the 6th and 9th Massive Zones. An extensive program of pulse and other transient pressure tests was also envisioned as part of project planning and implementation.

Conoco Inc. is currently evaluating the CO_2 enhanced oil recovery process in the Maljamar Grayburg-San Andres by installing a five-acre inverted five-spot pattern within an existing waterflood pattern in the MCA unit flood project (as shown on Figure 13). This proposed pilot project will require drilling seven wells, two logging observation wells and five pattern wells. The pilot wells will be completed to provide separate Grayburg 6th and San Andres 9th Massive zone injection and production, thereby allowing an evaluation of the CO_2 enhanced recovery process in the two major MCA unit producing intervals. The two logging observation wells will be drilled between the injector and two of the producers to provide a study of zone isolation, vertical heterogeneity, the CO_2 displacement process, and reservoir directional variation.

The purpose of the CO_2 pilot will be to determine:

- if CO_2 can mobilize oil in flooded-out Grayburg-San Andres waterflood intervals;
- the CO_2 process recovery efficiency (amount of CO_2 required per barrel of oil recovered);
- CO_2 injection rates.

The pilot will be located in one quadrant of an 80-acre five-spot waterflood pattern, an area bounded by MCA No(s). 48, 66, 256, and 262. This area was chosen because the 6th and 9th Massive zones here are believed to be some of the best pay quality in the field at an advanced waterflood life. Figure 14 shows the operating plan for this CO_2 pilot.

TABLE 4

FIELDS SELECTED AS CANDIDATES
FOR CO_2 DISPLACEMENT IN THE PERMIAN BASIN*

Field Name	District/ State	Major Reservoir	Cumulative** production to 1976, bbl	Hypothesized recovery, MMbbl
Wasson	8A/Texas	San Andres	875,657,116	670
Slaughter	8A/Texas	San Andres	642,687,368	260
Levelland	8A/Texas	San Andres	242,675,781	200
Seminole	8A/Texas	San Andres	203,777,244	80
Fullerton	8/Texas	Permian	177,379,697	160
Kelly-Snyder	8A/Texas	Canyon	816,372,830	310
Diamond M	8A/Texas	Canyon Lime	196,622,305	60
Goldsmith	8/Texas	San Andres	285,990,706	130
North Cowden	8/Texas	Permian	259,005,979	130
South Cowden	8/Texas	San Andres	105,536,037	80
Foster	8/Texas	Grayburg	177,647,850	90
Howard-Glasscock	8/Texas	Yates	302,775,723	230
Ward Estes	8/Texas	Yates-Seven Rivers	315,080,915	120
Sand Hills	8/Texas	San Andres	94,933,812	220
McElroy	8/Texas	Grayburg	321,110,539	380
Yates	8/Texas	Grayburg-San Andre	619,642,206	500
Hobbs	N.M.	San Andres	226,978,885	160
Vacuum	N.M.	Grayburg	159,307,712	270

* Doscher, T. M., and Wise, F. A.: "Enhanced Crude Oil Recovery Potential--An Estimate," J. Pet. Tech. (May 1976), 575-585.

** Texas Railroad Commission Annual Report 1975 and Annual Report of the New Mexico Oil and Gas Engineering Committee, Hobbs, New Mexico, 1975.

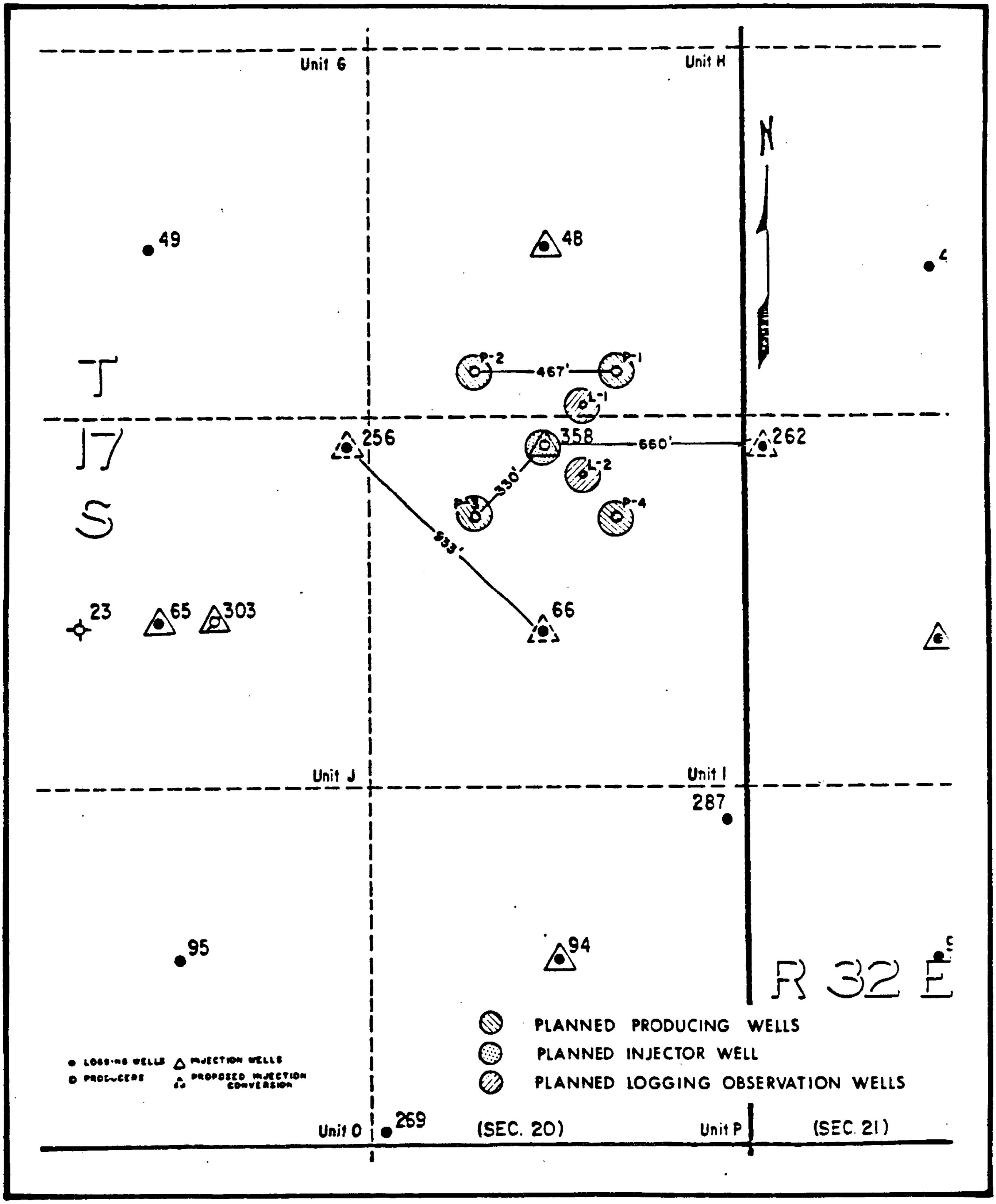


Figure 13.--Location of proposed pilot project.

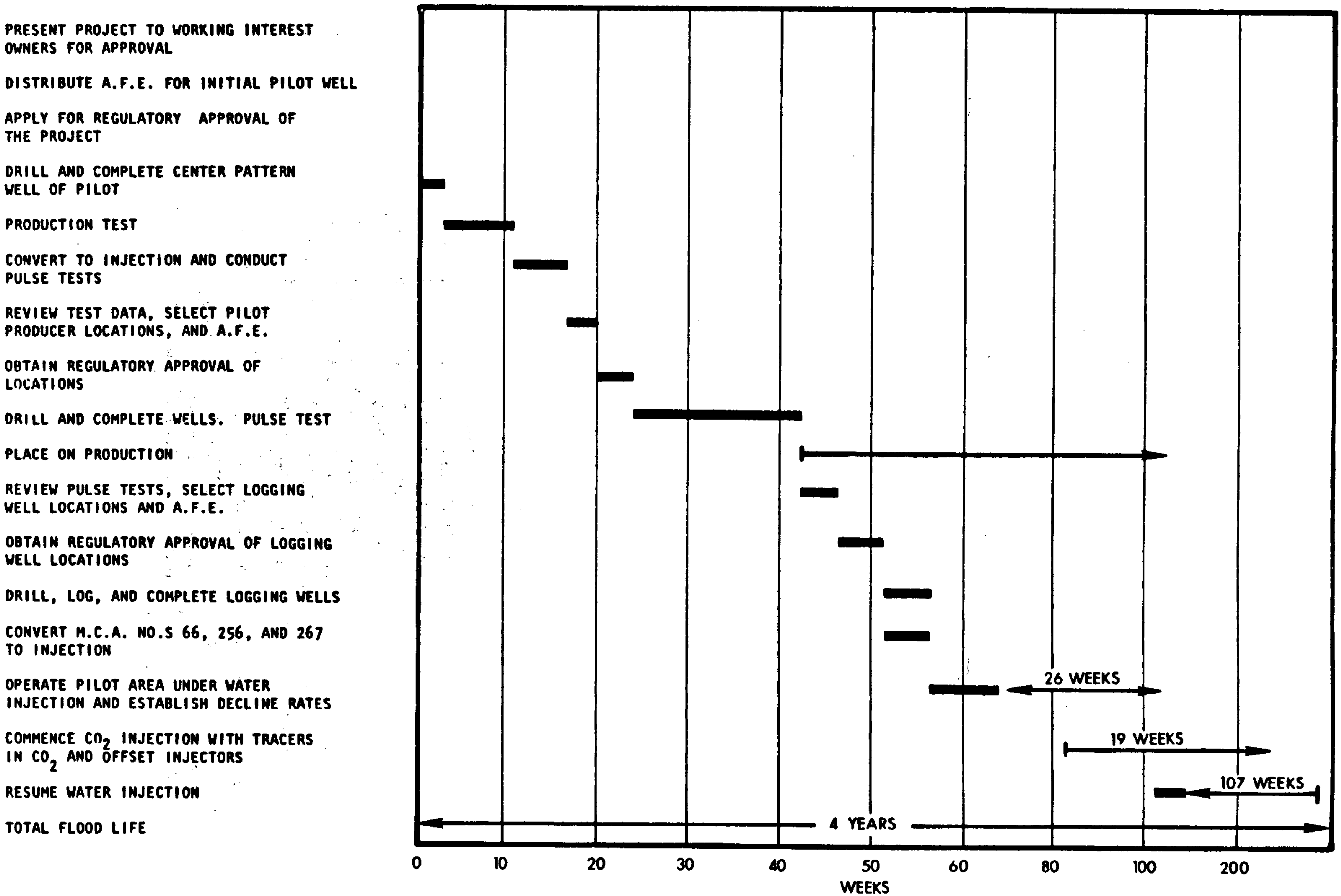


Figure 14.--Operating plan CO_2 pilot - MCA unit.

FIELD OPERATIONS IN MCA NO. 358

Field operations were conducted as a cooperative effort between Conoco and Gruy Federal with the understanding that Conoco had ultimate responsibility and authority for the operation at all times. The letter agreement between Conoco and Gruy Federal under which the operation was executed is included in this report as Appendix A. This agreement provided for reimbursement of Conoco for costs due to pressure coring over and above the costs provided for under the original well plan (illustrated in Figure 15a), in accordance with the schedule of costs outlined in Table 5. After coring and logging, when the hole was reamed down and full circulation established, Conoco assumed financial responsibility for running and cementing production casing preparatory to completion. The operation from spud-in to final completion is described in the following sections.

A. Drilling Operations

Conoco was responsible for all drilling operations on the MCA 358. The revised well plan to accommodate pressure coring operations is shown in Figure 15b. The well was spudded on January 16, 1980 and was drilled to a depth of 750 feet where 16-inch casing was run. The casing was cemented and then drilled out to a depth of 3,635 feet where 10-3/4 inch casing was set. The casing was cemented, then drilled out to a depth of 3,692 feet where pressure coring operations began on February 19, 1980.

B. Coring Operations

Before coring, Gruy Federal purchased two core bits equipped with STRATAPAX® cutters (Figure 16), dry ice, and fuel. Pressure-coring operations in the MCA 358 began on February 17, 1980. Pressure Coring, Inc. (PCI) was kept on standby until February 23. Conoco drilled into the sixth pay zone in the Grayburg at 3,692 feet, and PCI took six cores (48 feet) in this zone. Conoco then drilled to the seventh pay zone at the top of the San Andres (3,803 feet) and PCI took three cores (24 feet) to a depth of 3,827 feet. Conoco drilled to the ninth zone in the San Andres (4,035 feet). PCI cored 72 feet to a depth of 4,108 feet (nine cores). During the drilling of the 14th core, it was discovered that a tong die had dropped into the hole. Efforts to recover the die consisted of drilling one foot with a rock bit and junk basket and following up with a magnet and junk basket.

PCI recovered 18 cores (144 feet), of which 14 (112 feet) were recovered with pressure. Three cores lost pressure because core blocked the ball valve. Pressure was lost on one core as a result of swelling of the sliding sleeve. The final results indicate that PCI successfully recovered 78 percent of the cored interval with pressure. Table 6 summarizes the coring operation. For more complete details of pressure coring operation, refer to Dowdco Drilling reports in Appendix B.

DEPTH 50'/DIV.	FORMATION TOPS & TYPE	DRILLING PROBLEMS	TYPE OF FORMATION EVALUATION	HOLE SIZE (IN.)	CASING SIZE (IN.)	CASING DEPTH (IN.)	FRACTURE GRADIENT (PPG)	FORMATION PRESSURE GRADIENT (PPG)	MUD WEIGHT (PPG)	MUD TYPE
	CALICHE & RED BEDS RUSTLER 740'			$14\frac{3}{4}$	$10\frac{3}{4}$	750'	12.2	8.5	8.5 TO 9.5	FRESH SPUD MUD
1000 2000 3000 4000	SALADO SALT 850' SALT TANSILL ANHY 1900' YATES SS 2070' QUEEN SS 3050' GRAYBURG DOLO 3420' 6TH DOLO 3700' 7TH DOLO 3790' 9TH DOLO 3700' 9TH M 4040' T.D. 4150'	POSSIBLE WATER FLOWS FROM 850' TO 1900' POSSIBLE WATER FLOWS & PRESSURED 2500 PSI EXPECTED AT ± 3700'	10' SAMPLES 1800' TO 4150' LOGS: 1800' - 4150' SONIC/GR/CAL. CNL - DENSITY W/GR & CAL. DUAL LL - MSFL - CAL. W/GR CORES: 3650' - 3770' 3800' - 3850' 4020' - 4120'	$9\frac{1}{2}$	$7\frac{5}{8}$	4150'	16.0-17.0	LESS THAN 9.0 13.0-14.0	9.0-10.0 13.5-14.5	SALT WATER GEL

Figure 15a.--Original well plan for MCA #358.

GRUY FEDERAL, INC.

TABLE 5

Cost estimate for MCA No. 358 (CO_2 pilot well)

Estimated Costs with Pressure Coring

			Incremental $ over conv. Core case
Casing:	750 ft 16" 65# R-40 STC @ $25/ft	$ 18,800	$ (18,800)
	3650 ft 10-3/4" 51# C-75 STC @ $28.25/ft	103,100	(91,250)
	550 ft 7-5/8" 33.7# C-75 STC @ $17.75/ft	9,800	40,000
	8200 ft 2-3/8" 4.7# J-55 EUE 8RD tubing @ $2.50/ft	20,500	
	Coat tubing internally @ $1.05/ft	8,600	
	*3900 ft 1-1/4" 2.33# R-55 IJ 10RD tubing @ $2/ft	7,800	
	*1 Dual wellhead, complete	10,000	
Miscellaneous		6,200	
		184,800	(70,050)
403		6,000	
407		30,600	
411	3650 ft @$15/ft	54,750	(2,750)
412	18 days @ $4100/day plus 8 days @ $900/day	81,000	(63,300)
416	Mud	25,500	(20,000)
417	Cement	40,000	(17,000)
418	Non-cont. mtls.	15,000	
421	Special drilling tools	40,000	(25,000)
425	Coring cost: Dowdco 200', $140,000; analysis, $92,000**	232,000	(211,000)
427	Perforating	3,000	
428	Acidizing and fracturing	40,000	
429	Well surveys, electric and mud logs	28,000	(12,000)
431	Transportation	3,000	
437	Div. exp.	1,000	
438	Co. labor and supervision	2,000	
439	Contract labor	7,000	
444	Tax	18,700	(9,400)
445	Misc.	25,000	
		652,000	(360,450)
		$836,850	(430,500)
	Less Conoco's estimate of coring and core analysis costs		211,000
	Conoco's incremental cost		$(219,500)

*Both cases--conventional and pressure core.
**To be subcontracted separately by Gruy Federal, Inc.

DEPTH 50'/DIV.	FORMATION TOPS & TYPE	DRILLING PROBLEMS	TYPE OF FORMATION EVALUATION	HOLE SIZE (IN.)	CASING SIZE (IN.)	CASING DEPTH (IN.)	FORMATION PRESSURE GRADIENT	FRACTURE GRADIENT	MUD WEIGHT	MUD TYPE
							(PPG)	(PPG)	(PPG)	
	CALICHE & RED BEDS RUSTLER ANHY			20	16	750'	12.2	8.5	8.5 TO 9.5	FRESH SPUD MUD
1000 2000 3000	740' SALADO SALT 850' SALT TANSILL ANHY 1900' YATES SS 2070' QUEEN SS 3050' GRAYBURG DOLO 3420'	POSSIBLE WATER FLOWS FROM 850' TO 1900'	10' SAMPLES 1800' TO 4150' LOGS: 1800'-4150' SONIC/GR/CAL. CNL-DENSITY W/GR & CAL. DUAL LL-MSFL -CAL. W/GR	14 ¾	10 ¾	TOL 3600 3650	16.0-17.0	LESS 9.0	9.0-10.0	SALT WATER GEL
4000	6TH DOLO 3700' 7TH DOLO 3790' 9TH DOLO 3700' 9TH M 4040' T.D. 4150'	POSSIBLE WATER FLOWS & PRESSURED 2500 PSI EXPECTED AT ± 3700'	PRESSURE CORES -3700'-3760' -3810'-3830' -4010'-4110'	8 ¾	7 ⅝	4150'	16.0-17.0	13.0-14.0	13.5-14.5	
				LINER 3600' TO 4150'						

Figure 15b.--Pressure coring well plan for MCA #358.

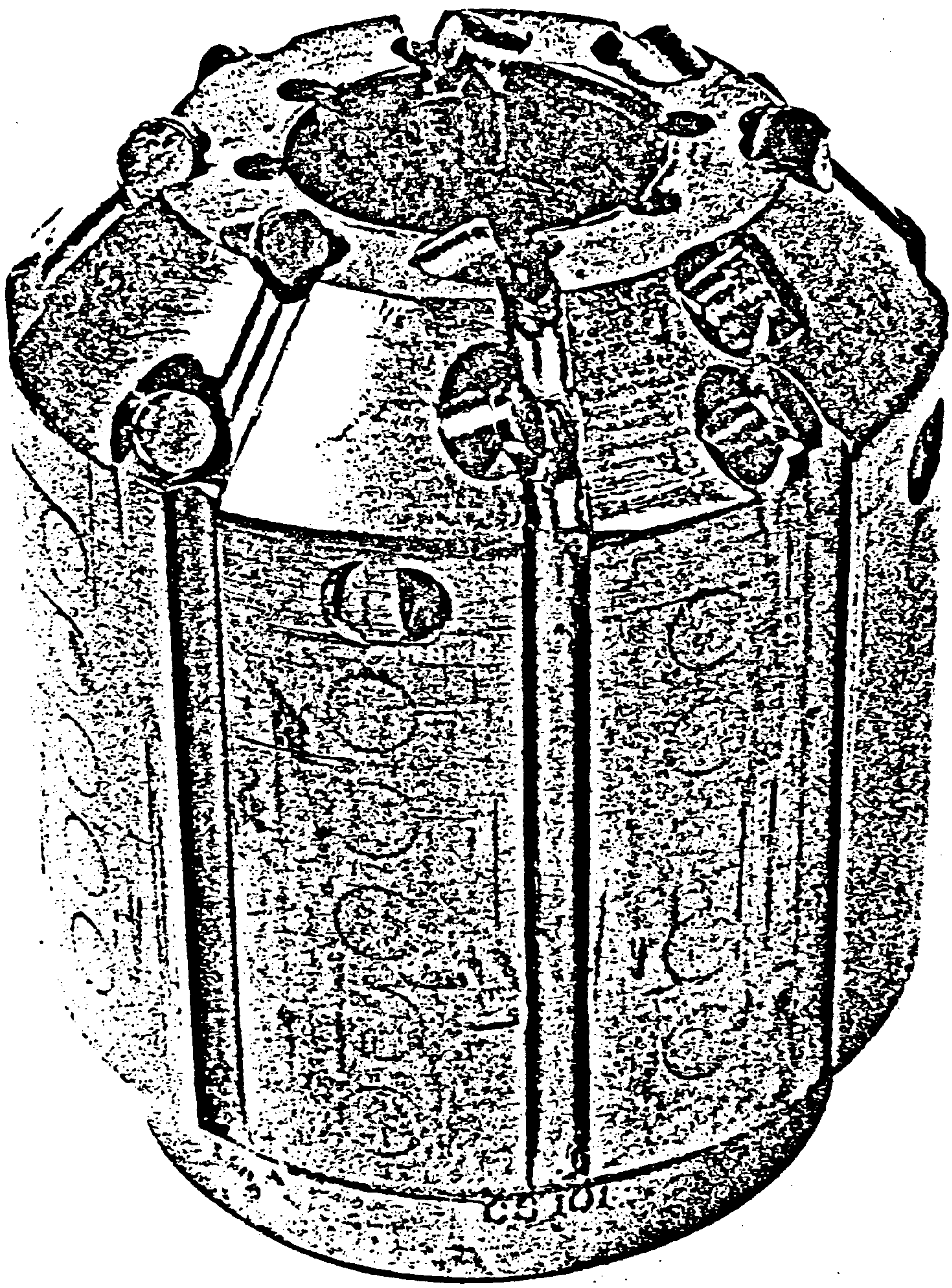


Figure 16.--Photograph of stratapax® bit.

TABLE 6

Coring Record, MCA 358

Core no.	Depth	Feet	Hours	Bit no.	Remarks
First sequence					
1	3692-3700	8	1-1/2	CS118	Dummy run; pressure OK
2	3700-3708	8	1-3/4	CS118	Pressure OK
3	3708-3716	8	1-1/4	CS118	No pressure; core blocked ball valve
4	3716-3724	8	2-1/4	CS118	OK
5	3724-3732	8	4-3/4	CS118	OK, 2150 psi
6	3732-3740	8	2	CS118	No pressure; ball valve malfunctioned
Second sequence					
7	3803-3811	8	2-3/4	CS114	OK, 2000 psi
8	3811-3819	8	1	CS114	OK
9	3819-3827	8	2	CS114	No pressure; recovered 6 ft; core blocked ball valve
Third sequence					
10	4035-4043	8	3/4	CS114	No pressure; recovered 8 ft 10 in.; core blocked ball valve
11	4043-4051	8	1	CS114	OK, 2200 psi
12	4051-4059	8	1-1/4	CS114	OK, 1950 psi
13	4059-4067	8	1-1/4	CS114	OK, 2100 psi
14	4067-4075	8	1	CS114	1000 psi; tong die
15	4076-4084	8	1	CS114	OK
16	4084-4092	8	1	CS114	OK, 2150 psi
17	4092-4100	8	3/4	CS114	OK, 2100 psi
18	4100-4108	8	1	CS114	OK, 2050 psi

All cores were tagged with top and bottom depths. Cores recovered with pressure were packed in dry ice and sent to Core Laboratories in Dallas. Unpressured cores were sent to Core Laboratories' Midland (Tex.) labs. One pressured core (No. 15) was sent to Geo-Chem in Houston.

Time components of coring operations and penetration rates are listed in Table 7. Daily sequence of events during coring is shown in Figure 17.

C. Coring Mud Properties

Coring mud properties as recorded by daily checks during the operation are listed in Table 8.

TABLE 7

Time components of coring operations and penetration rates during experimental bit comparisons.

Core no.	Bit no.	Pick up and run in hole, hours	Coring time, hours	Pick up and lay down, hours	Total time, hours	Footage cored, feet	Coring rate, ft/hr
First sequence							
1	CS118	4-1/2*	1-1/4	3	9	8	5.3
2	CS118	2-3/4**	1-3/4	3-3/4	8-1/4	8	4.5
3†	CS118	3-1/2	1-1/4	4-3/4	9-1/2	9'2.5"	7.4
4	CS118	3-1/4	2-1/4	2-3/4	8-1/4	8	3.5
5	CS118	2-3/4	4-3/4	4	11-1/2	8	1.7
6†	CS118	2-1/2	2	3-1/2	8	8	4.0
Second sequence							
7	CS114	4-1/2††	2-3/4	4-1/2	11-3/4	8	2.9
8	CS114	2-3/4	1	3	6-3/4	8	8
9†	CS114	2-1/4	2	3-1/2	7-3/4	5'9"	2.9
Third sequence							
10†	CS114	4	3/4	5-3/4§	10-1/2	8	10.6
11	CS114	2-3/4	1	2-1/2§§	6-1/4	8	8
12	CS114	1-1/4	1-1/4	2-3/4	5-1/4	8	6.4
13	CS114	2-3/4	1-1/4	4-1/4	8-1/4	8	6.4
14	CS114	3	1	3 ¶	7	8	8
15	CS114	4	1	3-1/2	8-1/2	8	8
16	CS114	2	1	2-1/2	5-1/2	8	8
17	CS114	2-1/4	3/4	3-3/4¶¶	6-3/4	8	10.6
18	CS114	2-1/2	1	3-1/2	7	8	8

* Excludes 3-1/2 hours to wash to bottom.
**Excludes 15 hours to condition mud.
† Core recovered with no pressure.
††Includes reaming.
§ Excludes 6-1/2 hours to condition mud.
§§Excludes 2-3/4 hours to condition mud.
¶ Excludes 10-1/2 hours for fishing.
¶¶Excludes 6-3/4 hours to change brakes.

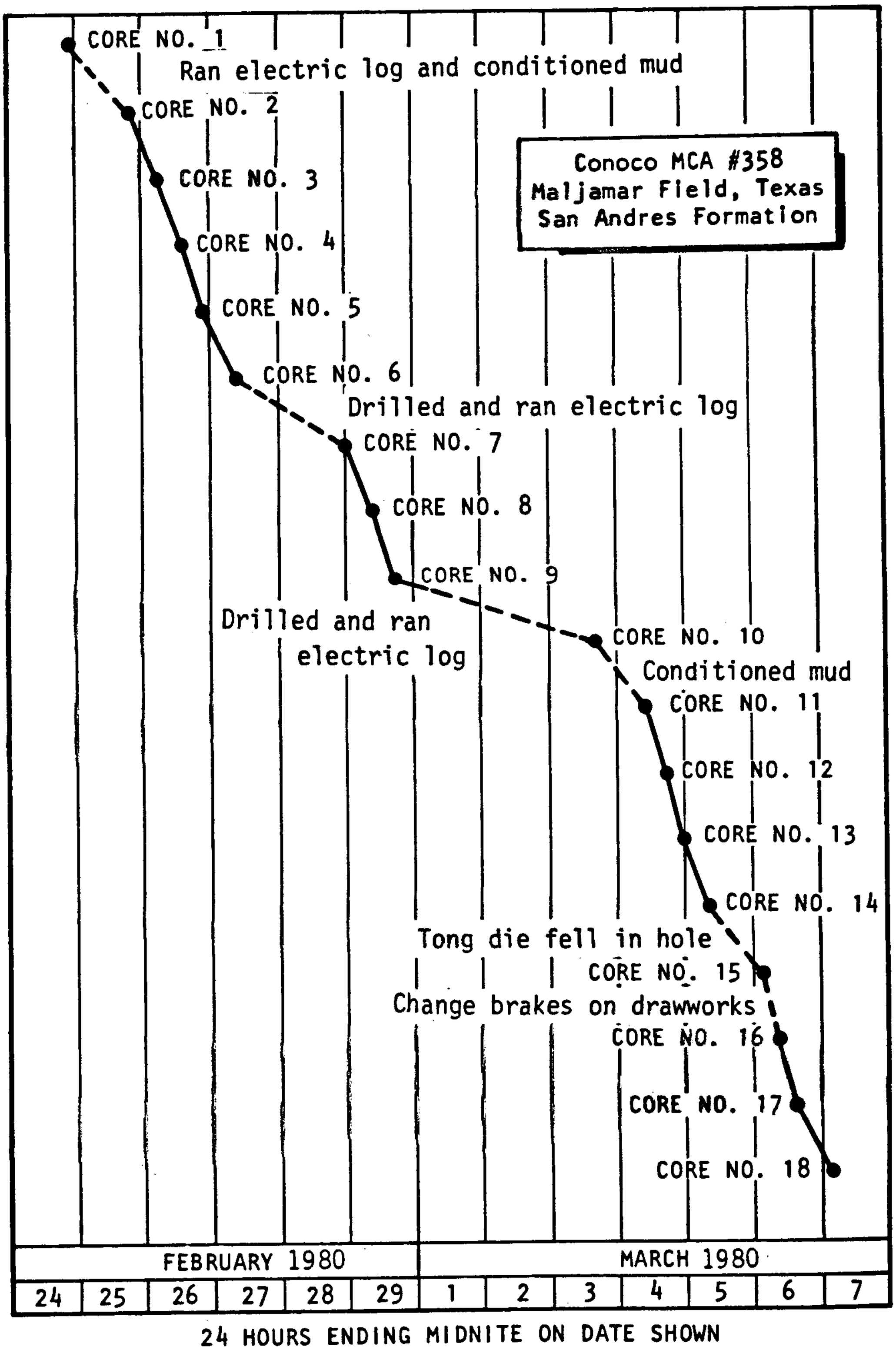


Figure 17.--Daily sequence of pressure coring for MCA #358.

TABLE 8

Mud properties, MCA 358

Date	Depth, ft	Mud wt., lb/gal	Viscosity, funnel	Pl. vis. cp	Yield point	Gels	pH	Filtrate, API	Cl, ppm	Ca, ppm	Tritium, 10^{-5} pC
2/23/80	3547	12.7	51	35	22	2/15	10.0	4.2	3800	--	--
2/24/80	3694	12.8	66	66	37	4/10	10.0	4.0	4600	--	22.0
2/26/80	3700	10.7	46	18	16	2/10	9.0	5.0	3100	--	22.0
2/26/80	3718	10.3	58	58	28	4/12	9.0	3.8	3600	--	6.56
2/28/80	3790	10.1	49	24	16	4/10	7.5	5.4	2900	120	6.38
2/29/80	3803	10.1	68	24	20	4/15	8.5	5.2	2900	--	5.35
2/30/80	3820	10.0	67	28	21	2/13	8	4.1	2400	--	5.35
3/01/80	----	9.9	67	--	--	----	8	5.6	2500	trace	--
3/02/80	----	10.0	61	19	14	4/15	8	6.2	2500	trace	--
3/03/80	----	10.4	72	28	25	8/23	8.5	4.1	3100	trace	--
3/05/80	4059	10.4	62	23	26	3/18	8.5	4.9	3000	trace	6.01
3/05/80	4076	10.4	68	26	26	3/18	8.5	4.2	3200	--	5.18
3/07/80	4100	10.5+	71	21	25	5/25	8.5	3.5	2900	trace	4.93

Logging Operations

Because of the experimental nature of the MCA 358, a comprehensive logging program was planned and implemented. Schlumberger well-logging services were called out to the location on five occasions. Two open-hole logging suites were run and three open-hole pressure tests were made. A brief summary of these log runs is given below.

Date	Interval, ft	Logs run
2-14-80	1,800-3,640	CNL/FDC/GR DLL/MSFL/GR BHC/GR
2-24-80	3,640-3,691	RFT
2-27-80	3,640-3,803	RFT
3-02-80	3,640-4,034	RFT
3-07-80	3,640-4,136	CNL/FDC/GR DLL/MSFL/GR BHC/GR NGT

Glossary of Log Abbreviations

CNL - Compensated Neutron Log
FDC - Compensated Formation Density
GR - Gamma Ray
DIL - Dual Induction Laterolog
MSFL- Spherically Focused Micro Log
BHC - Borehole Compensated Sonic
RFT - Repeat Formation Tester
NGT - Natural Gamma Ray Spectroscopy

Preliminary analysis of the logs at the wellsite indicated movable hydrocarbons in all of the cored intervals. Recorded porosities were in the expected range, 5 to 15 percent. The RFT tools indicated lower pressures than expected before drilling. However, during drilling of the 50-foot rat hole required to log the hole at total depth (4,150 feet), Conoco operators were forced to weight up the mud system from 10.7 to 11.8 lb/gal. Mud samples and fluid samples were taken during coring operations to assist in the determination of mud filtrate invasion (the coring mud was tagged with a tritium tracer).

Figures 18 and 19 show the complete suite of logs taken in the cored interval.

Core data, combined with results from the comprehensive logging suite, should greatly enhance the reliability of the porosity and water saturation calculations in this part of the Maljamar field.

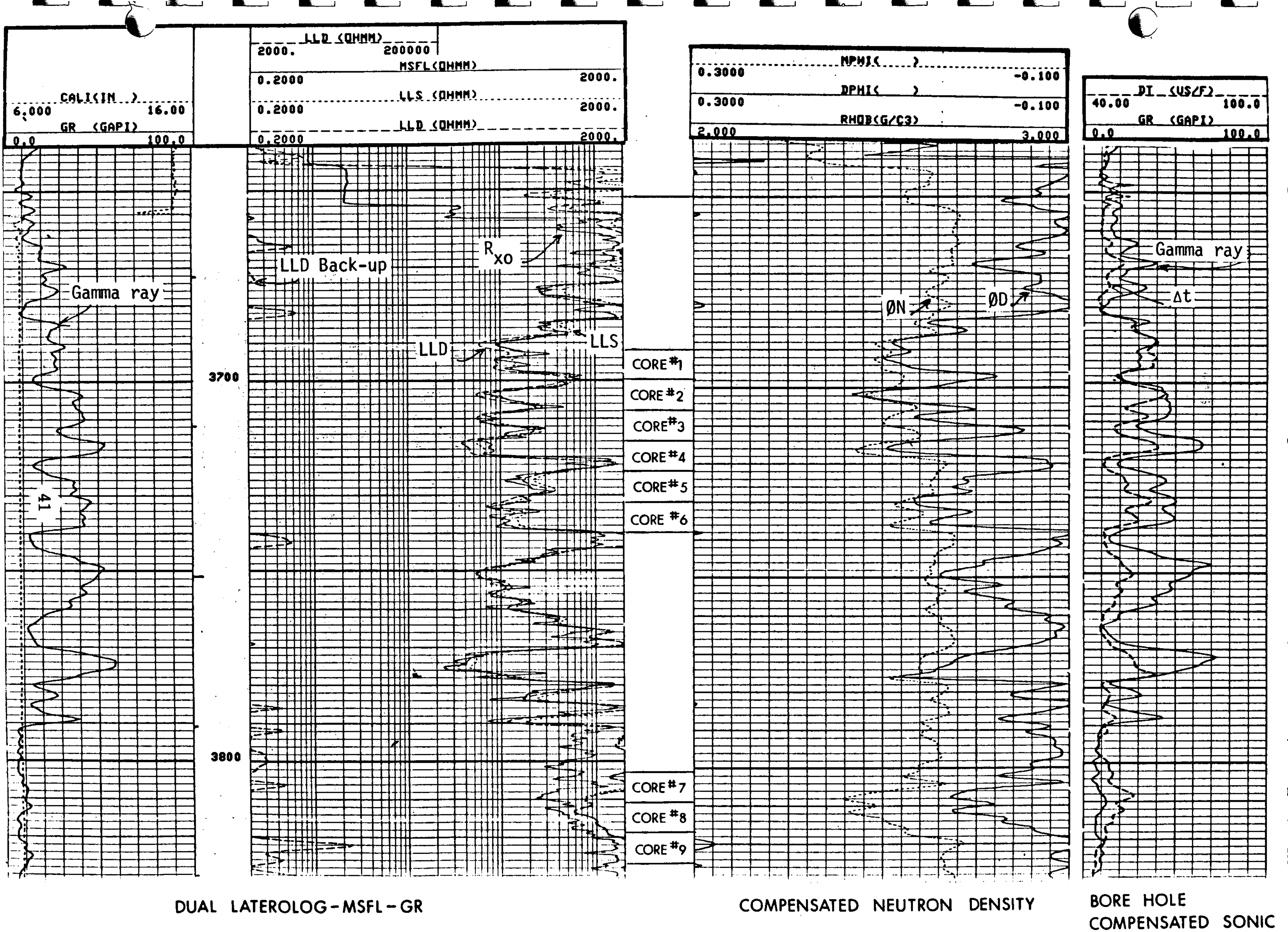
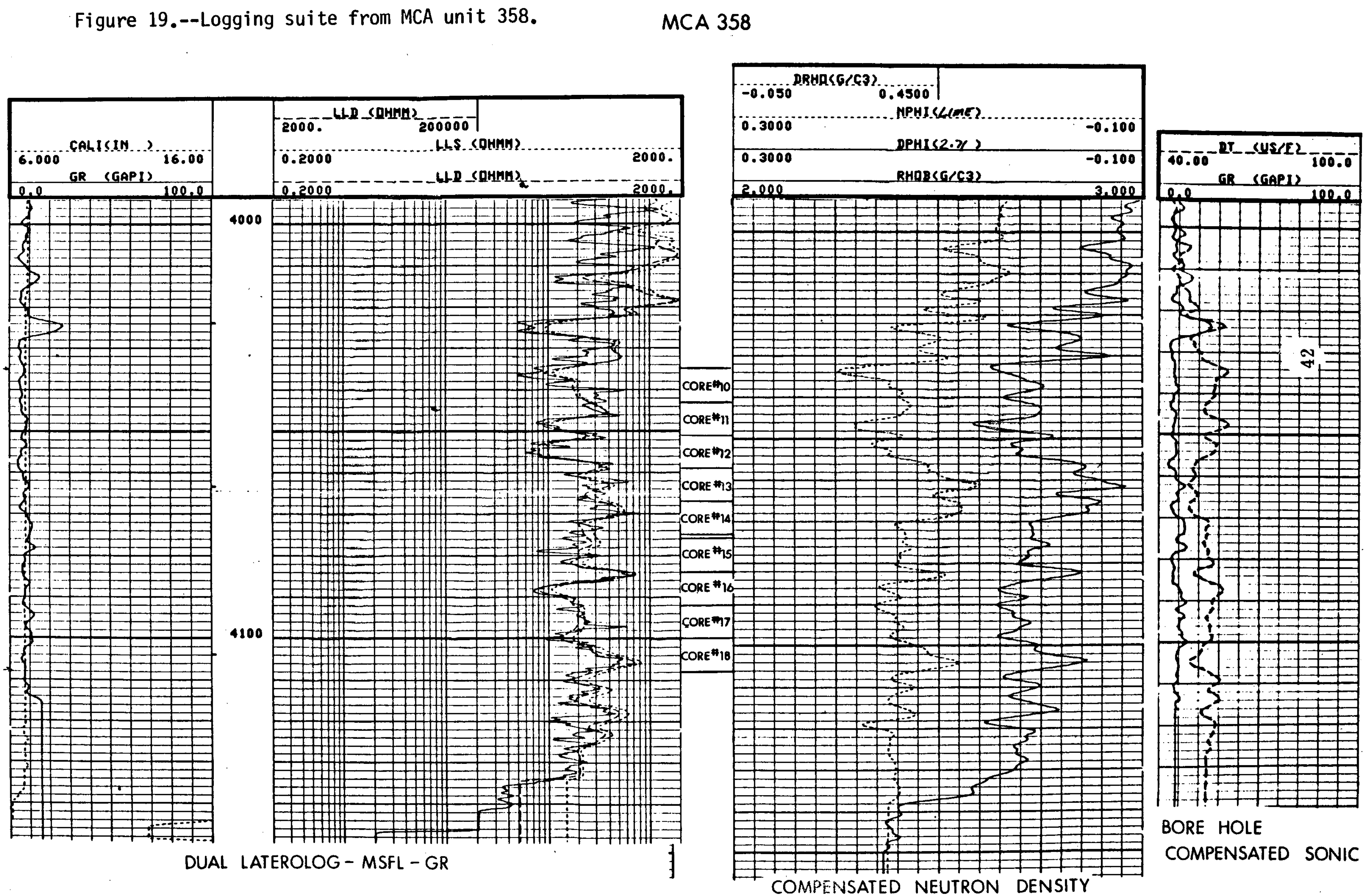


Figure 18.--Logging suite from MCA unit 358.

Figure 19.--Logging suite from MCA unit 358.



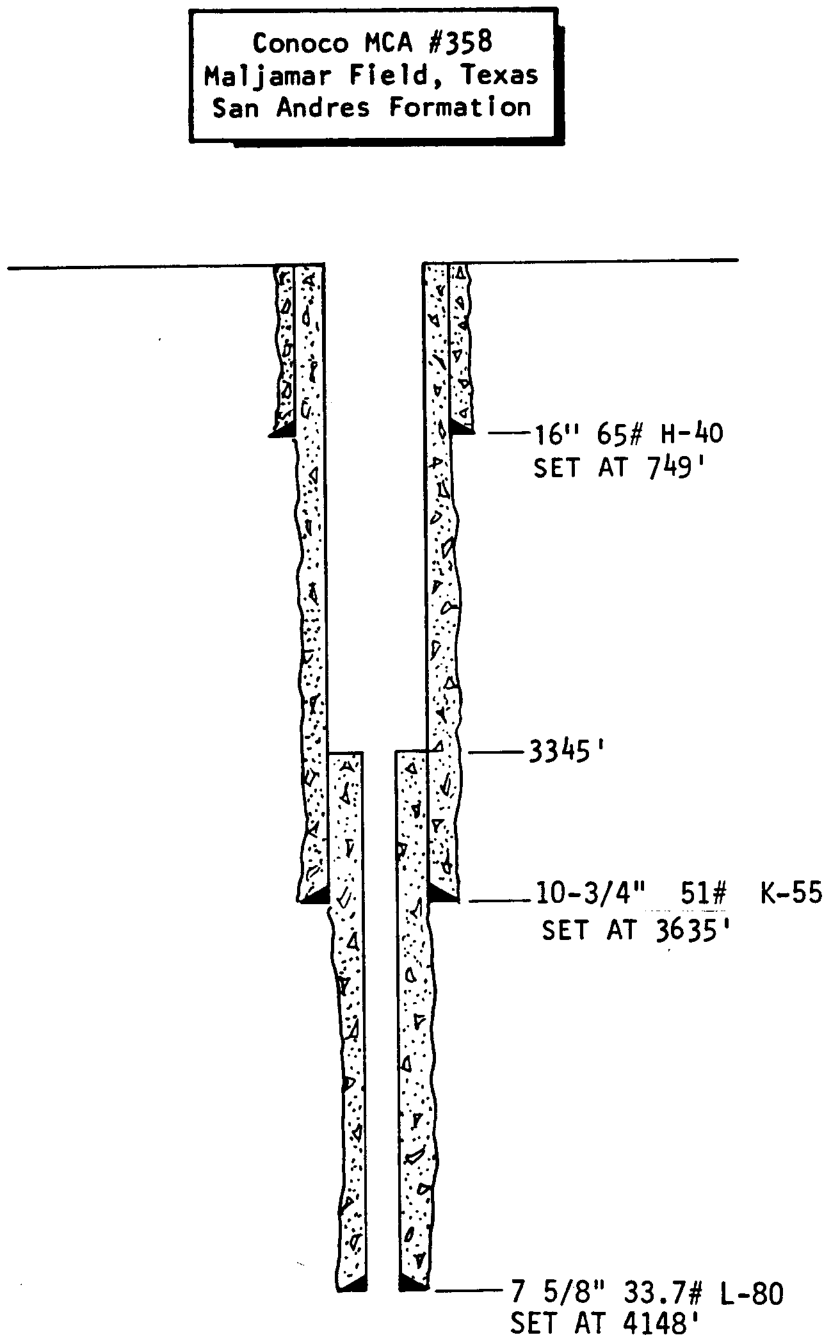
Completion Operations

Following the logging of the MCA 358, Conoco began completion procedures. The 6-1/2-inch hole was reamed with an 8-3/4-inch bit. On March 16, 1980, a 7-5/8-inch liner was cemented with float collar located at 4,107 feet. The remaining completion operations were performed during production testing procedures. Figure 20 is a completion schematic for the well.

Production Testing Procedures. After completion of log analysis, test intervals were selected, and test procedures began on March 17, 1980. These procedures comprised two separate phases. Two intervals were isolated, perforated, and treated with 15 percent HCl-NE acid. Both intervals were swab tested for a minimum of one day.

Production pumping tests were run from August 24 to October 6, 1980.

A summary of production testing procedures is given in Table 9.



Completion diagram.

Figure 20.--Completion diagram, MCA unit 358.

TABLE 9

DETAILS OF MCA NO. 358 COMPLETION

CASING RECORD: 16 inches 65 lb, H-40 at 749 feet with 755 sx. (circ. 342 sx.)
10-3/4 inches, 51 lb, C-75 at 3625 feet with 755 sx. in 1st stage, (circ. 20 sx.), 2275 sx. in 2nd stage (circ.)
7-5/8 inches, 33.7 lb, L-80 at 3545-4148 feet with 100 sx. (float collar at 4107 feet.

Phase I

Moved in rig-up completion unit. Prepare to drill cement plugs.

Went in hole with 9-1/2-inch bit, no cement to top of liner at 3545 feet. Pressure tested casing to 850 lbs for 20 minutes.

Went in hole with 7-1/2-inch bit, tagged cement at 4107 feet, drill out to 4118 feet. Pressure tested casing at 1000 lbs, held O.K.

Ran gamma ray spectroscopy and cement bond log. Cement bond log showed poor and no bond from 3545 to 3638 feet, 4035 to 4058 feet and 4074 to 4090 feet.

Ran bottom hole location survey: horizontal displacement of 20.64 feet at north 5-1/2° east.

Spotted 200 gallons 15 percent HCL-NE acid from 3980 to 4090 feet.

Perforated Ninth Massive Zone from 4022 to 4055 feet with four jets/ft.

Washed acid across perforations for one hour, circulated out.

Swabbed 103 bbls fluid with trace oil at rate of 10-12 bbls fluid/hour. Swabbing level at 3700 feet. Six hundred lb shut-in tubing pressure the following a.m.

Ran injectivity test: pump at rate of 60 bbls/D, surface pressure had built up to 1070 lb at end of 4-1/2 hours.

Acidized with 1800 gal 15 percent NE-HCL at average rate of .3 bbls/min, average pressure of 950 lbs; shut-in tubing pressure, 650 lbs.

Swabbed 602 bbls fluid with trace of oil at rate of 40-50 bbls fluid/hour. Swabbing fluid level at 1200-1500 feet. Well will flow at rate of 17 bbl fluid/hour; shut-in tubing pressure the following a.m., 650 lbs.

Ran pump-in temperature and radioactive tracer survey: showed behind-pipe channel downward from perforations 4055-4060 feet. Survey also showed hole in pipe from 4092-4095 feet. (Re-set packer at 4075 feet and pumped into hole at 1/2 bbls/min at 1000 lb)

Perforated at 4090 feet with two jet shots for cement squeeze.

Pumped-in at rate of 1-1/2 bbls/min at 800 lb. Circulated out annulus which confirmed behind-pipe channel.

Spotted 35 sx. of Class "C" cement mixed at 14.8 lb/gal and squeezed away at 500-1000 lb. Reversed out two bbls cement. Hold 500 lb and WOC.

Swabbed 68 bbls fluid with trace of oil at rate of 10-12 bbls fluid/hour from perforations 4022-4055 ft. Swabbing fluid level at 2000-2500 ft; shut-in tubing pressure the following a.m., 400 lb.

Ran pump-in temperature and radioactive tracer survey at 250 bbls/D rate and 1000 lb: no indication of behind pipe channelling.

Phase 2

Set Backer Model "FA" packer at 3900 lb.

Spotted 200 gal 15 percent HCL acid from 3650-3730 ft.

Perforated Sixth Zone from 3682-3718 ft with four jets/ft.

Washed acid across perforations for one hour and reversed out.

Acidized with 1800 gal 15 percent NE-HCL. Could only pump acid at rate of 1/3 gal/hr at 600-800 lb. After 12 hours, increased pressure to 2000 lb and formation broke down. Treated at one bbl/min at 1500-1800 lb. Had pressure increase on casing-tubing annulus after approximately 1/2 the acid was pumped away.

Ran pump-in temperature and radioactive tracer survey: showed a behind-pipe channel from 3682 feet to liner top.

Set cement retainer at 3660 feet.

Spotted 50 sx. of Class "C" cement mixed at 14-15 lb/gal. Squeezed away at 200-500 lb. Reversed out. WOC.

Lost four of the six bow springs off the retainer-setting tool.

Went in hole with 9-1/2-inch bit - no cement to top of liner.

Went in hole with 6-1/2-inch bit - no cement to top of retainer.

Milled on junk and retainer.

Drilled cement from retainer across perforations.

Tested perforations to 1000 lb - held O.K.

Went in hole with Vann perforating gun and packer.

Pumped 1000 gal mixture of 50 percent Xylene and 15 percent HCL acid down tubing and up annulus to liner top. Let set one hour and reverse out.

Set packer and swab tubing down.

ANALYSIS OF DATA

Laboratory Core Analysis

Thirteen of the fourteen cores recovered with pressure were sent to Core Laboratories' special core analysis laboratories in Dallas; the remaining core was sent to Geochem Research, Inc., Houston. Full-diameter segments of the recovered cores were selected for measurement of porosities, fluid saturations, permeabilities, and pore-water chlorides. "Plug" and "donut" portions cut from full-diameter segments were chosen for testing to determine the concentrations of the tracers in the pore water. Gas chromatography was used to determine the composition of the gases liberated from the full-diameter cores recovered with pressure.

Cores recovered without pressure were sent to Core Laboratories in Midland, Texas, for routine core analysis. Porosities, fluid saturations, and permeabilities were measured for full-diameter, plug, and donut cores. The procedures used in the pressured and nonpressured core analyses are presented, along with the data obtained, in Appendix C.

Porosity, Saturation, and Permeability Data. The cores recovered with pressure are identified in Figure(s) 21 and 22. These figures show plots of core analysis data showing total fluid saturation, oil saturation, water saturation, and porosity versus depth. Porosity measurements from both pressured and nonpressured cores are similar and correlate well with electric-log porosity data, as discussed later. However, both oil and water saturations in the nonpressured cores (Core(s) 3, 6, and 10) are considerably lower than those measured in comparable pressured cores. The average of total fluid saturation (oil and water) values for nonpressured cores was 61 percent, whereas the average of total fluid saturation values for pressured cores was 86 percent.

Maximum horizontal and vertical permeability to air are plotted on Figure(s) 23 through 26. The variation of vertical permeability with depth shows a pattern comparable to that of horizontal permeability. The vertical permeability is less than the horizontal by one order of magnitude in the sixth and seventh zones, while in the upper ninth zone these permeabilities are generally in the same range.

In a few instances, high horizontal and vertical permeabilities indicated the presence of fractures. The available data do not indicate whether these fractures are natural or were induced during drilling.

For a water-wet rock surface, the immobile (irreducible) water saturation is dependent on the porosity of the rock. Since permeability is also dependent on porosity (Figure(s) 27, 28, and 29), the irreducible water saturation should also be related to the permeability. The interrelationship suggests that irreducible water saturation should be a function of the logarithm of permeability. For water-wet systems known to be at irreducible water saturation, a plot of water saturation against the logarithm of permeability is linear. Figure(s) 30, 31, and 32 are semilogarithmic plots of water satur-

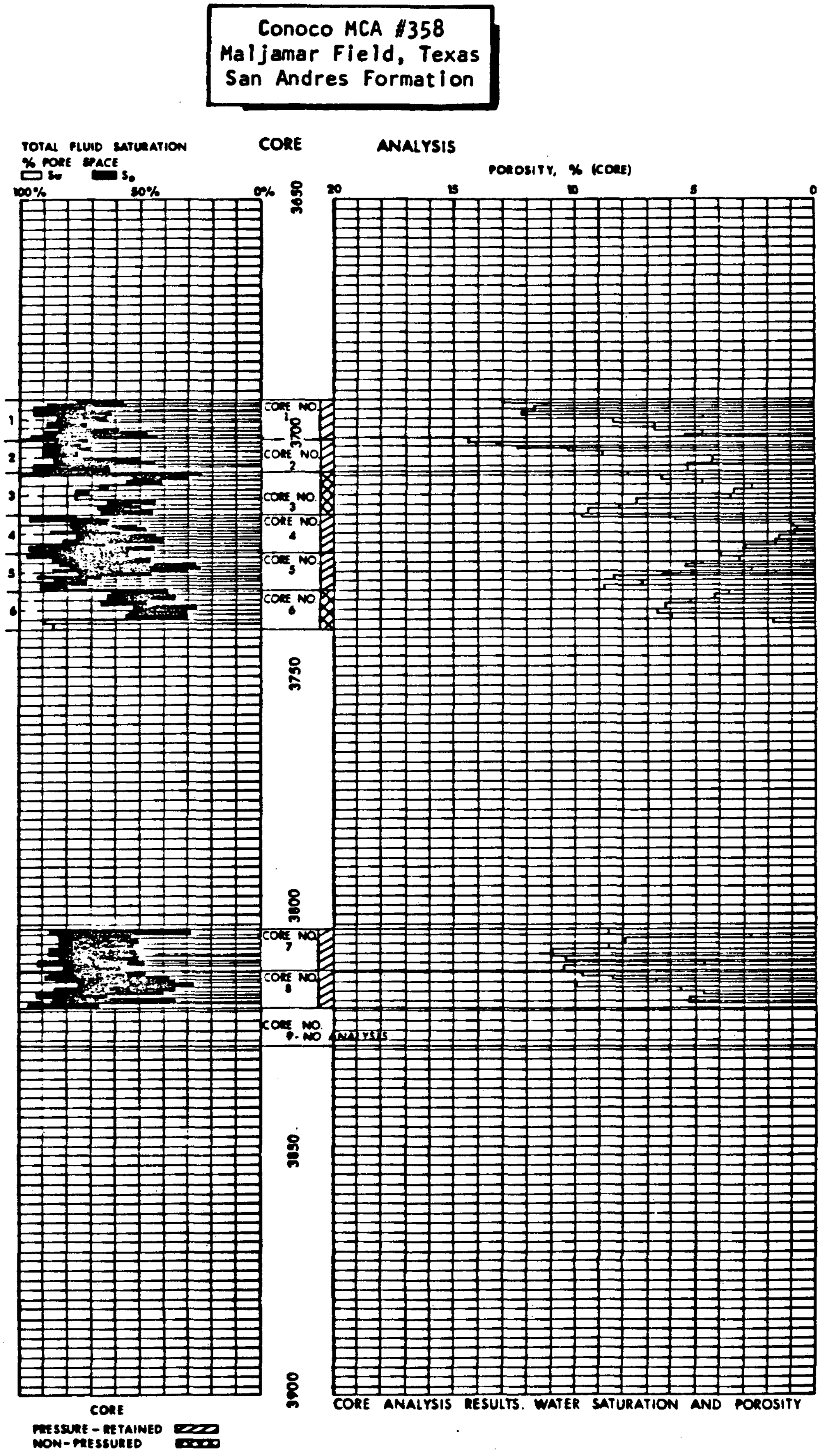


Figure 21.--Core analysis results: water saturation & porosity.

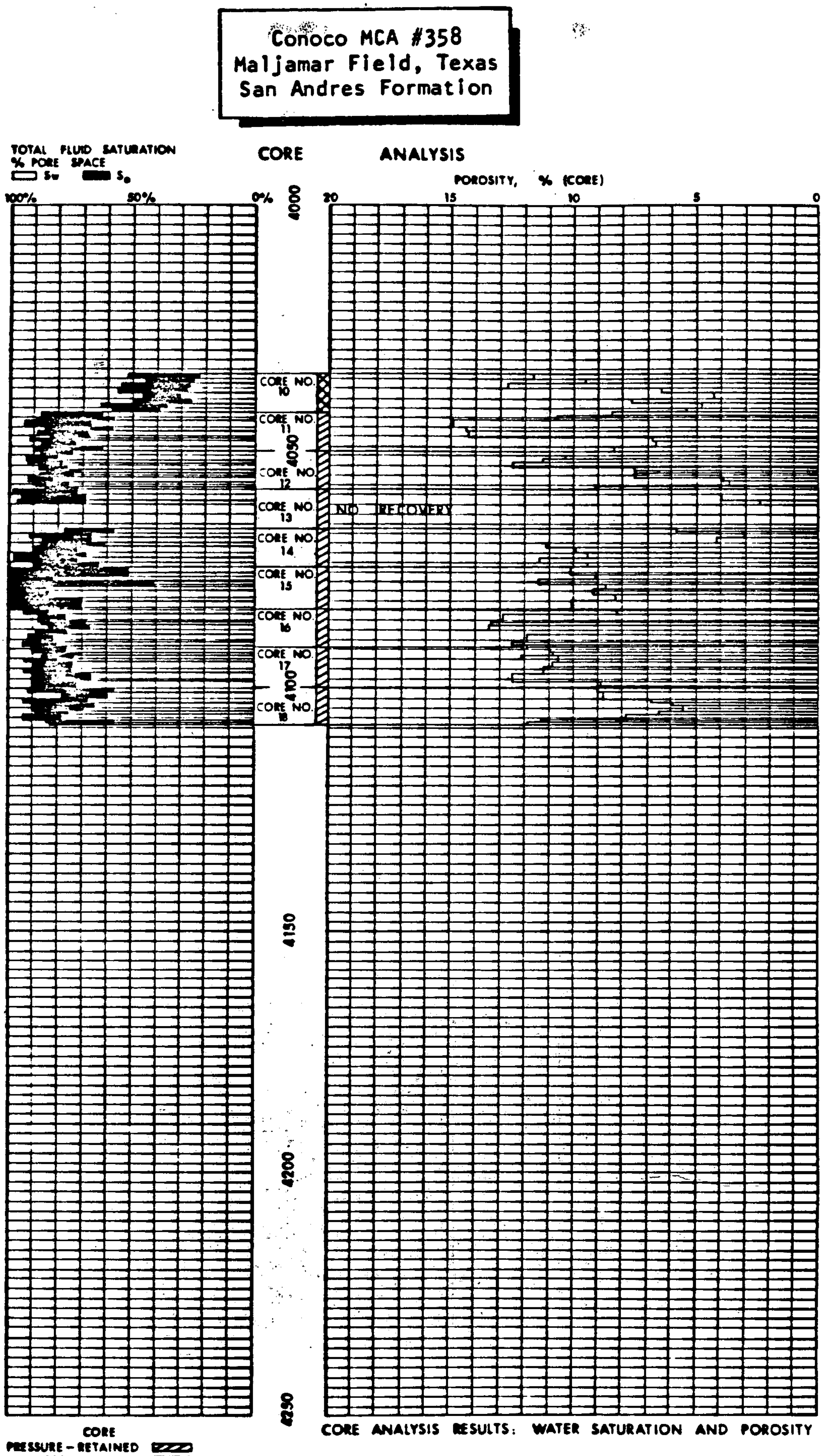


Figure 22.--Core analysis results: water saturation & porosity.

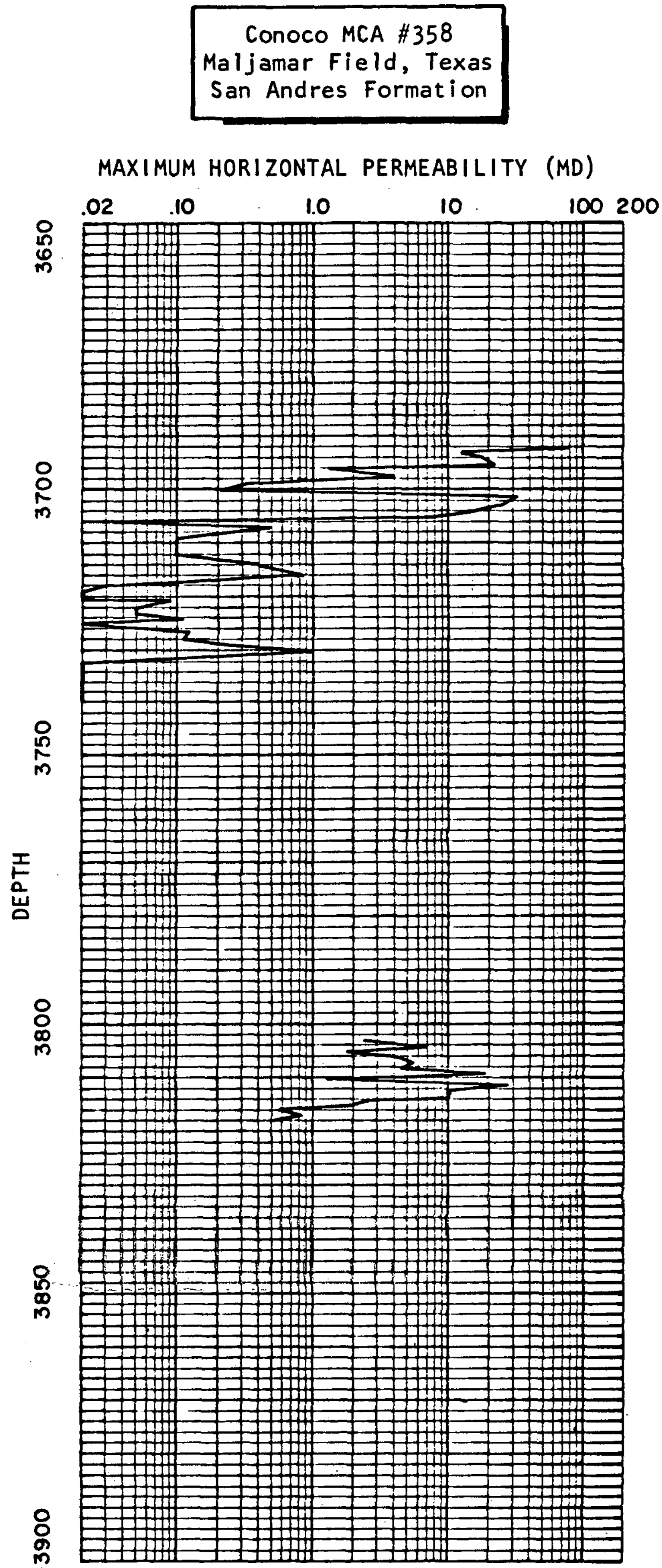


Figure 23.--Core data: maximum horizontal permeability to air vs. depth.

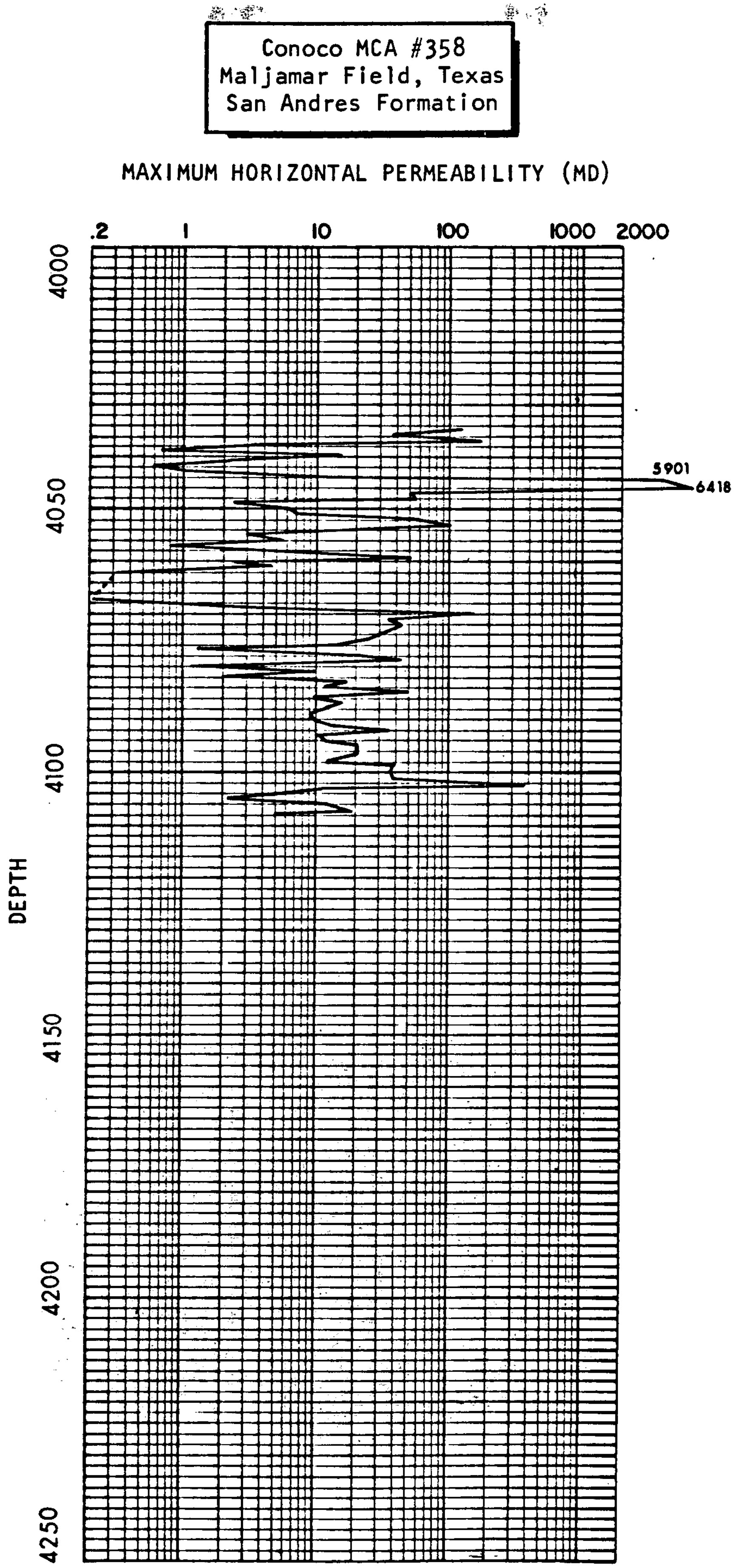


Figure 24.--Core data: maximum horizontal permeability to air vs. depth.

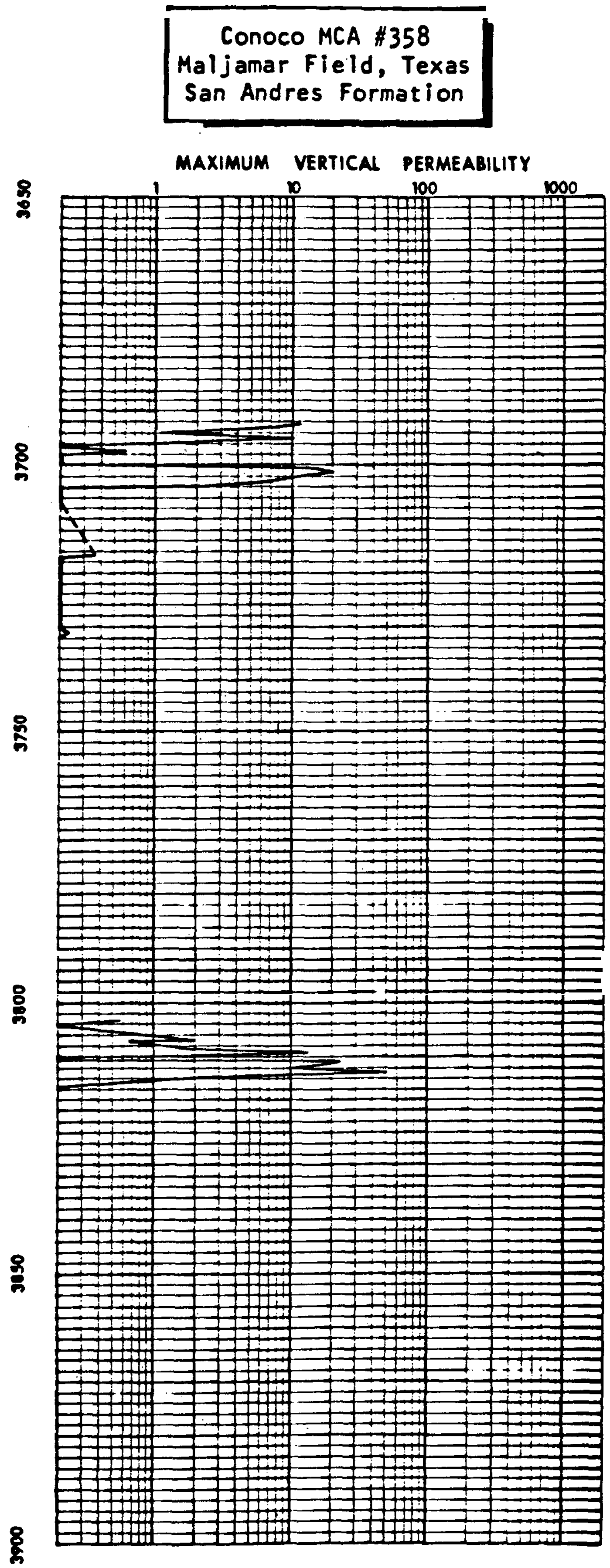


Figure 25.--Core data: maximum vertical permeability to air vs. depth.

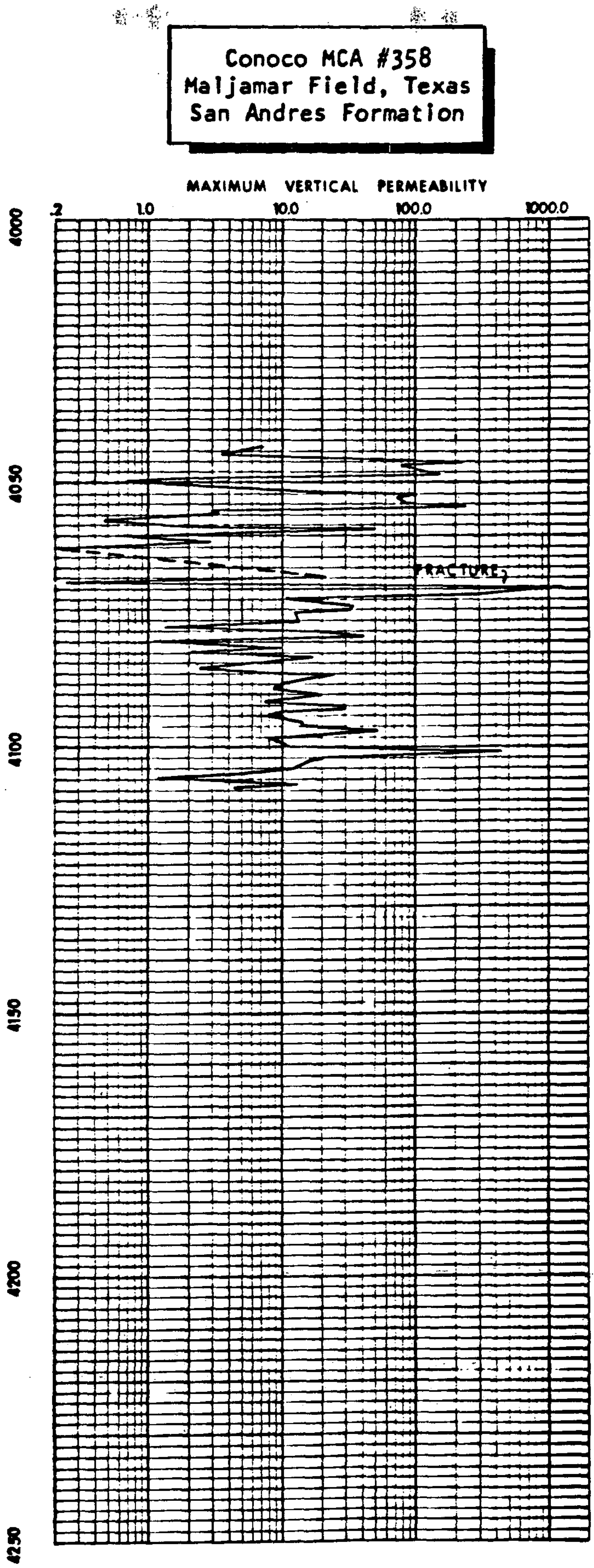


Figure 26.--Core data: maximum vertical permeability to air vs. depth.

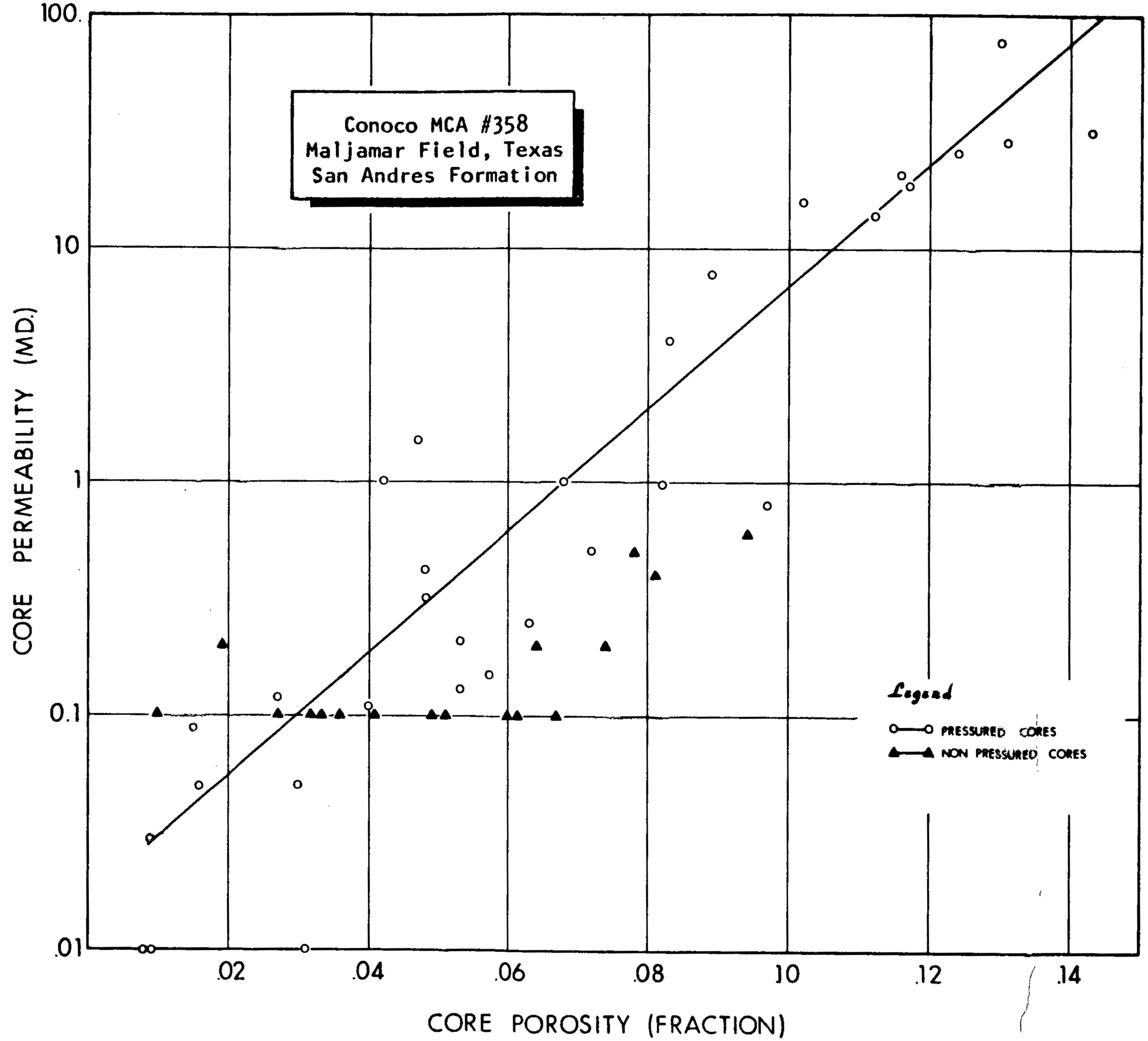


Figure 27.--Porosity versus maximum horizontal permeability to air, zone 6, cores 1-6.

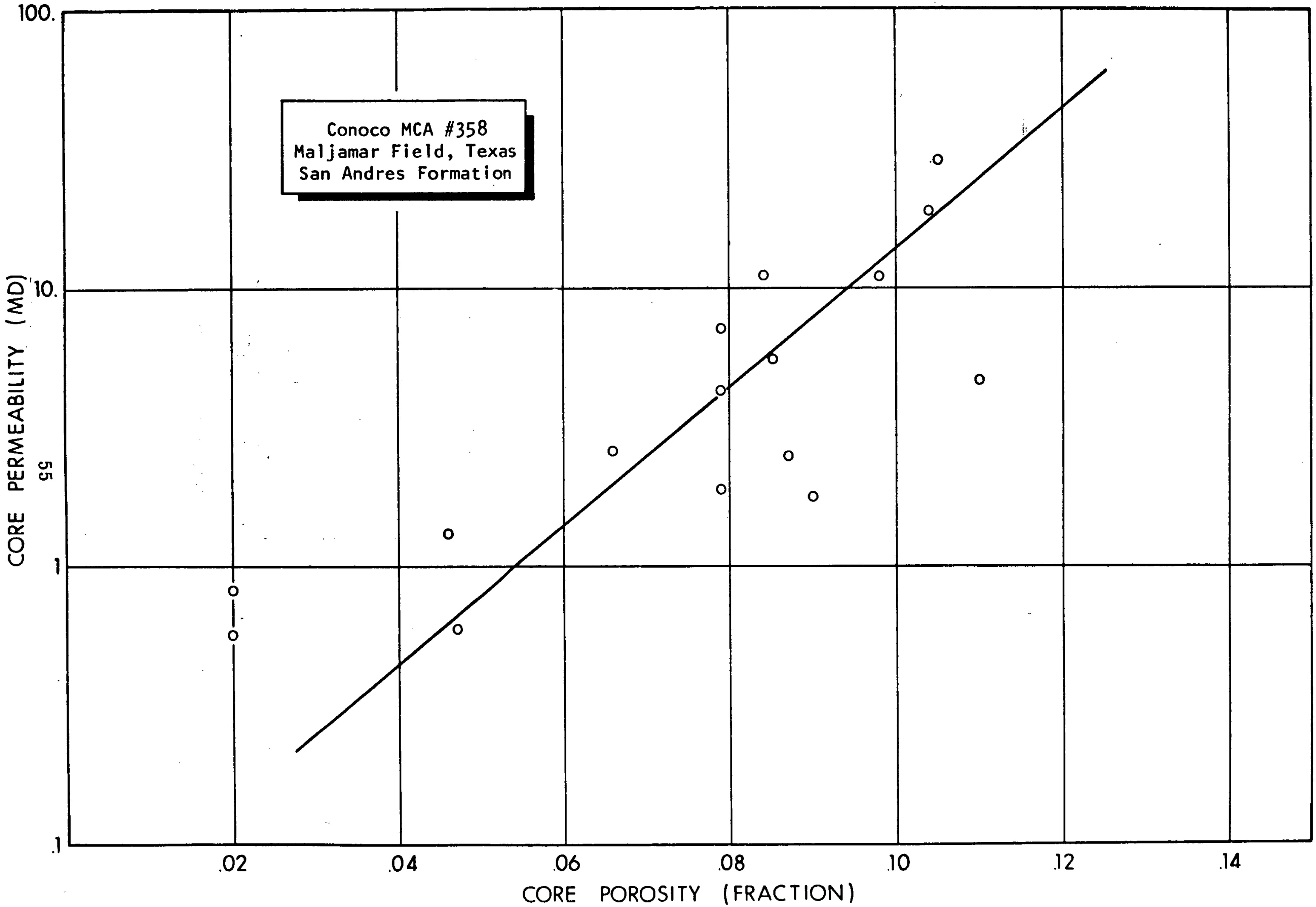


Figure 28.--Porosity versus maximum horizontal permeability to air, zone 7, cores 7-9.

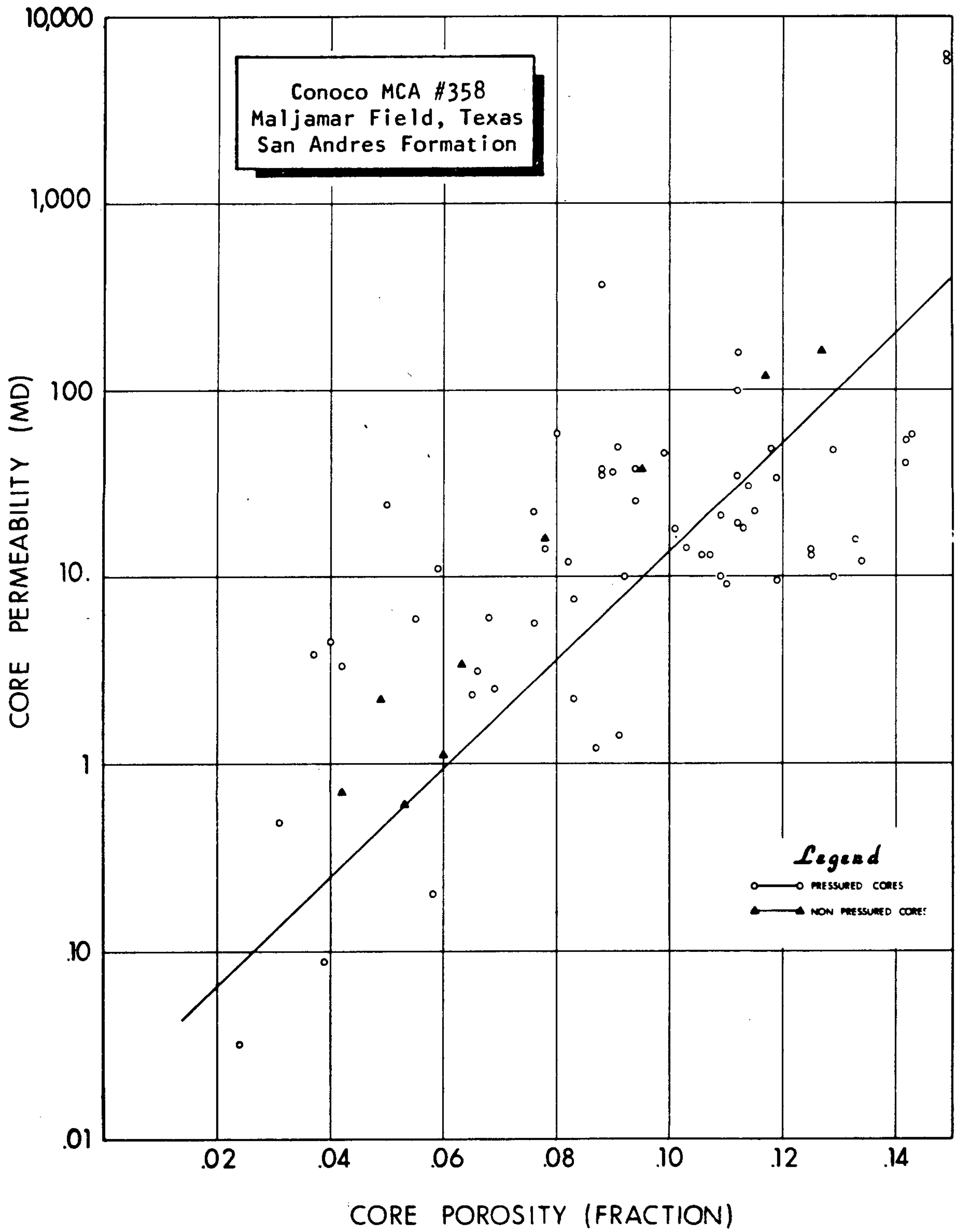


Figure 29.--Porosity versus maximum horizontal permeability to air, zone 9, cores 10-18.

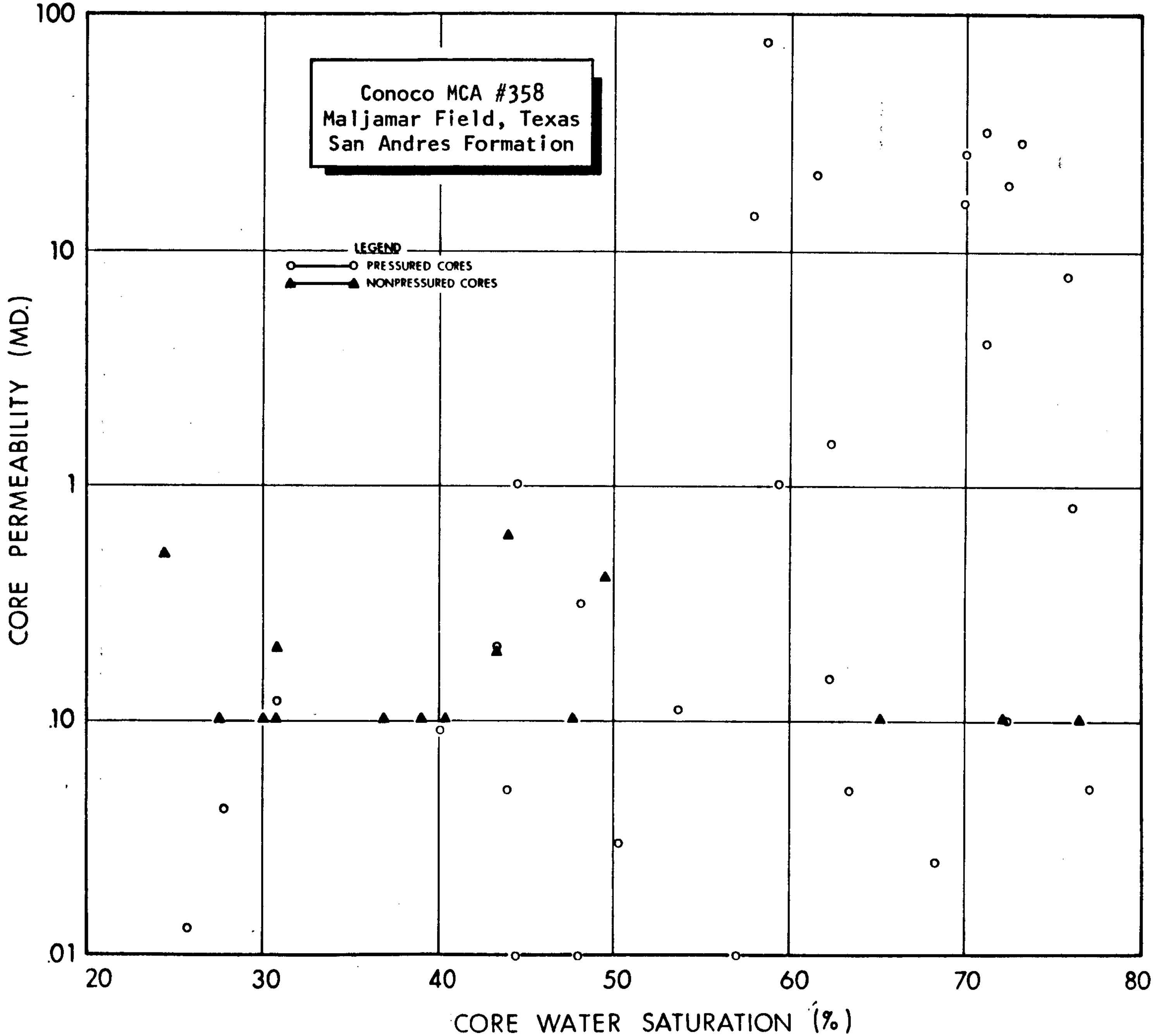


Figure 30.--Salt water saturation versus maximum horizontal permeability to air, zone 6, cores 1-6.

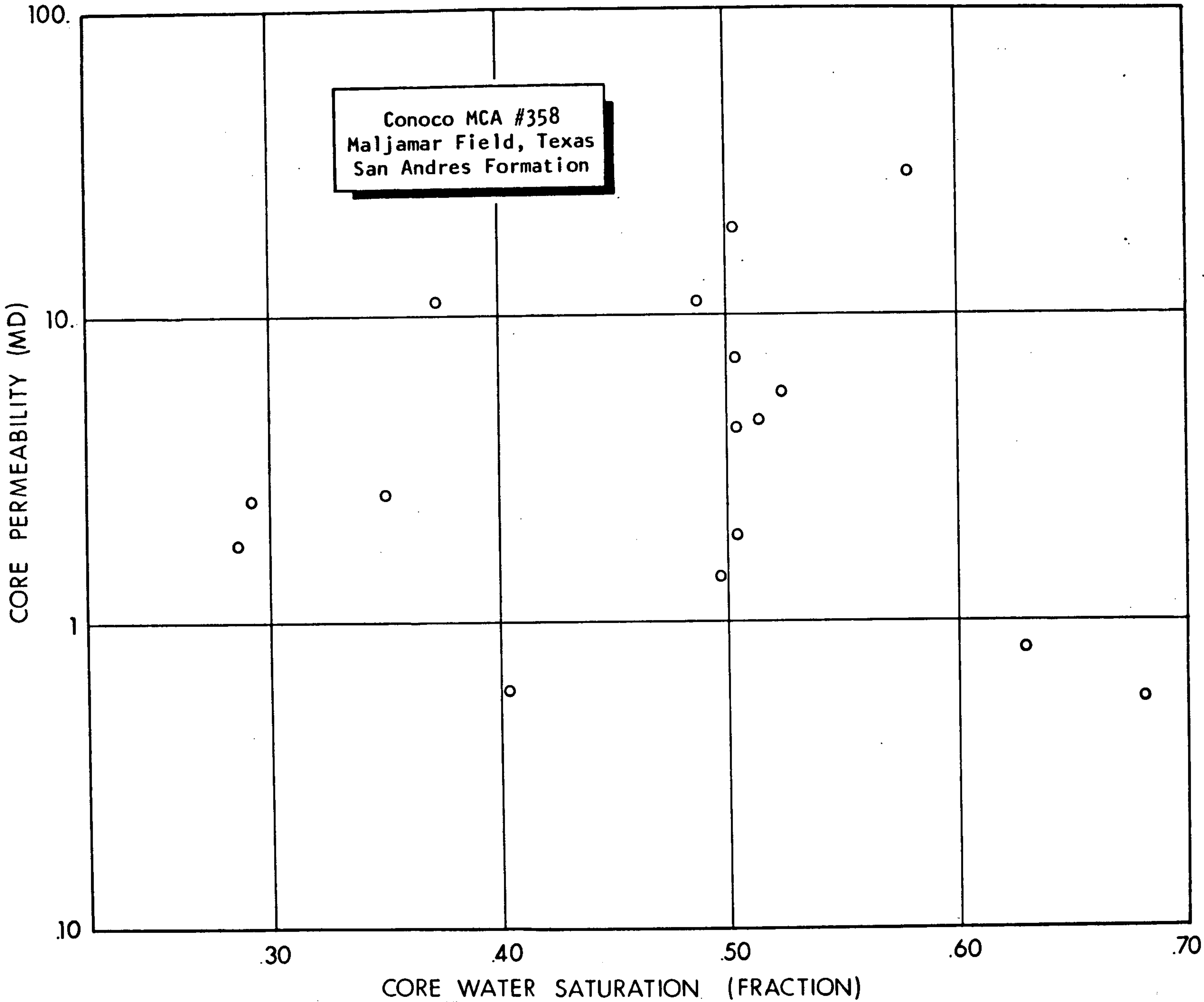


Figure 31.--Salt water saturation versus maximum horizontal permeability to air, zone 7, cores 7-9.

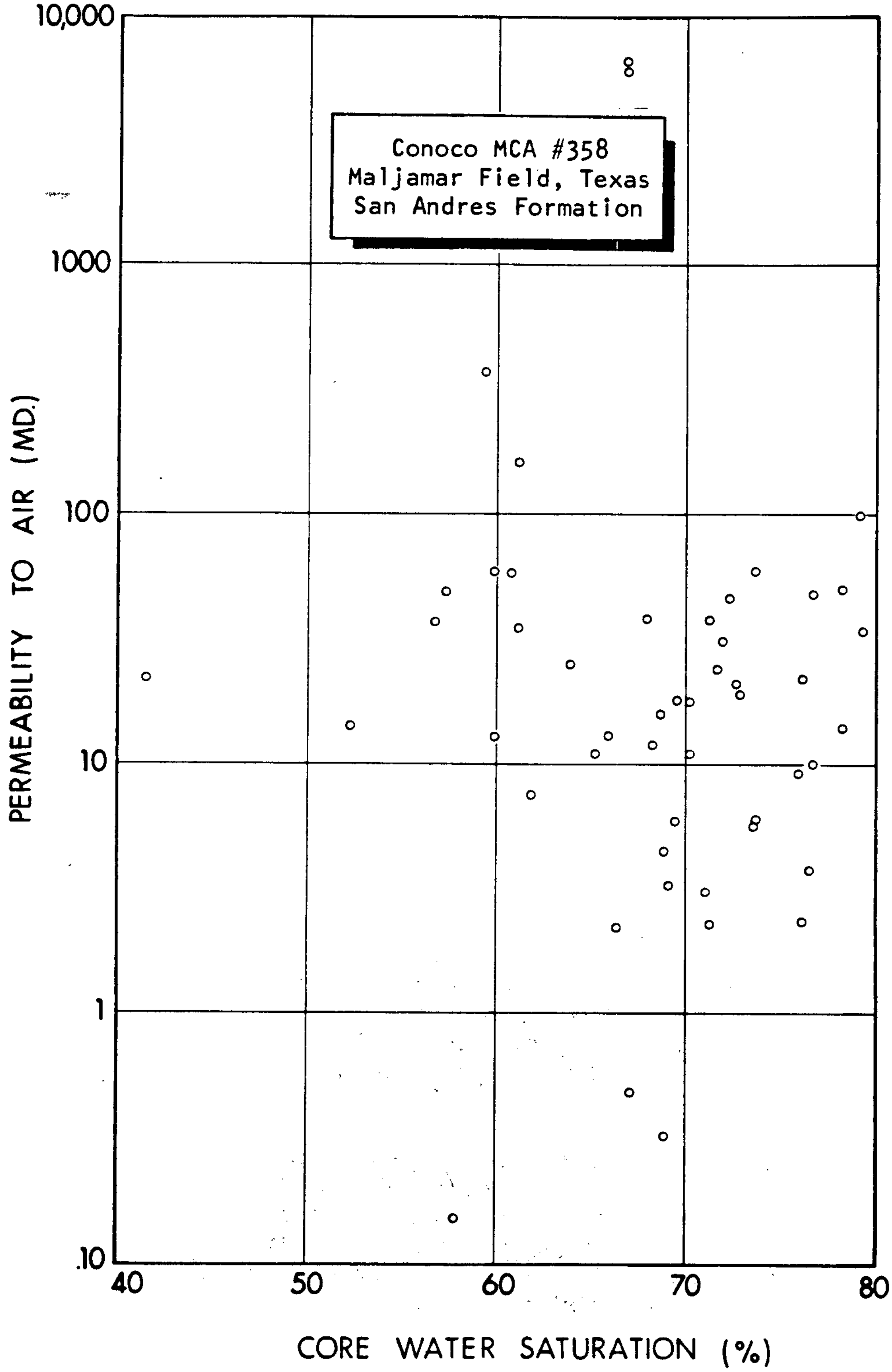


Figure 32.--Salt water saturation versus maximum horizontal permeability to air, zone 9, cores 10-18.

ation against permeability for all the zones that were pressure-cored. The plots do not show a linear trend, suggesting either that these zones are not at irreducible water saturation or that the rock surfaces are partially oil-wet. Additional analysis indicates that both conditions are possible. However, these zones are too large to eliminate the possibility that specific intervals may be at the irreducible water saturation limits.

Grain Density and Chloride Data. Grain density measurements were taken and are plotted against depth in Figure(s) 33 and 34. The Grayburg Sandstone grain densities vary because of the varying composition of the samples. The pure dolomites were in the range expected (2.8 to 2.9 gm/cc). Core descriptions and grain densities show that the sandstones in the Grayburg are not pure but contain some calcareous material, which could increase the grain density.

Chloride content of the mud, which ranged from 2,400 to 4,600 ppm, was considerably lower than that of the cores, which ranged from 42,700 to 171,000 ppm. The range of chloride concentrations from the cores was also above the values indicated by produced water measurements for each zone. Core chlorides in the ninth zone perforated interval ranged from 58,400 to 112,100 ppm, while ninth zone produced water measurements indicated a chloride concentration of 40,000 ppm. Core chlorides from the sixth zone perforated interval ranged from 97,500 to 162,000 ppm, compared to a concentration of about 16,000 indicated by produced water measurements.

The use of high chloride low-invasion gel may have affected chloride concentrations, making direct determinations of core chlorides impractical.

Invasion Data. Permeability, porosity, and water saturation were measured for 18 plug and donut samples taken from full-diameter cores recovered with pressure. This method of core sampling provides a means of evaluating the degree of mud filtrate invasion into the full-diameter cores. Figure(s) 35 and 36 are plots of porosity and water saturation for plugs and donuts. As a limiting assumption, the water saturation of the plug represents in-situ formation water saturation (i.e., not invaded by mud filtrate), while the water saturation of the donut represents the water saturation of the flushed formation (i.e., invaded by mud filtrate). The difference between the in-situ and flushed water saturations represents the change in water saturation due to core invasion.

The plots show that the water saturation of the donut was generally higher than that of the plug, indicating a degree of invasion. In the depth interval 4,066 to 4,072 feet (Figure 36), the donut had a considerably lower water saturation than the plug. This could be related to the fact that the plug is more porous than the donut, a situation that could be caused by fractures or by a nonhorizontal porosity zone. This situation causes the permeability of the plug to be larger than that of the donut and also increases the plug's water saturation compared to that of the donut. Furthermore, the porosities of the plugs are slightly higher than those of the donuts.

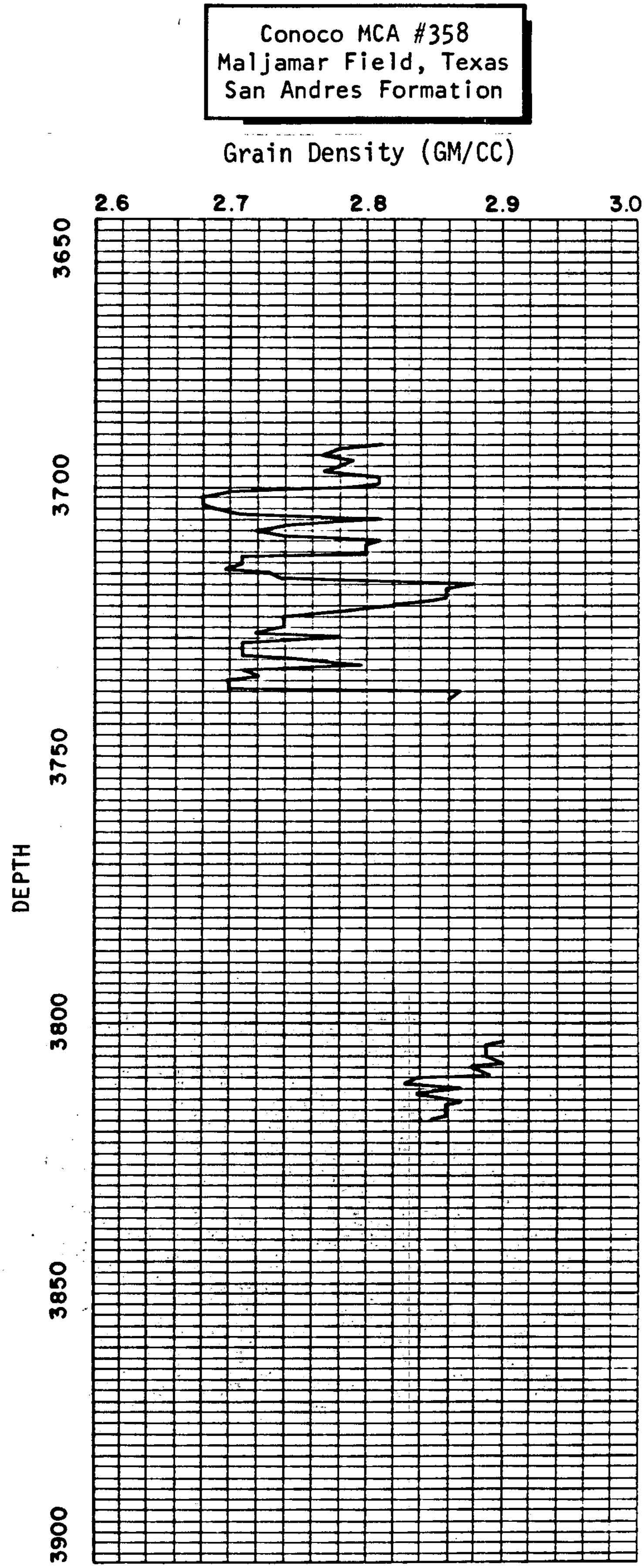


Figure 33.--Core data: grain density of recovered cores.

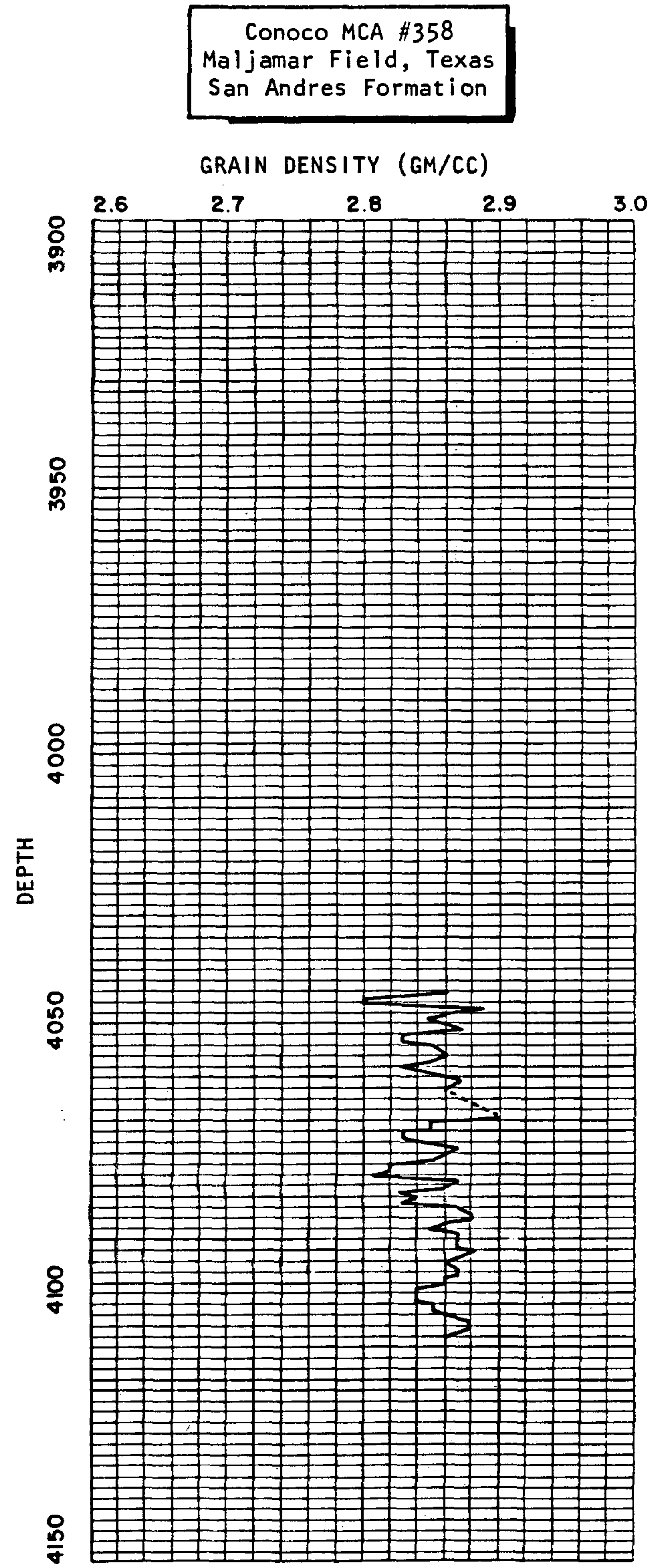


Figure 34.--Core data: grain density of recovered cores.

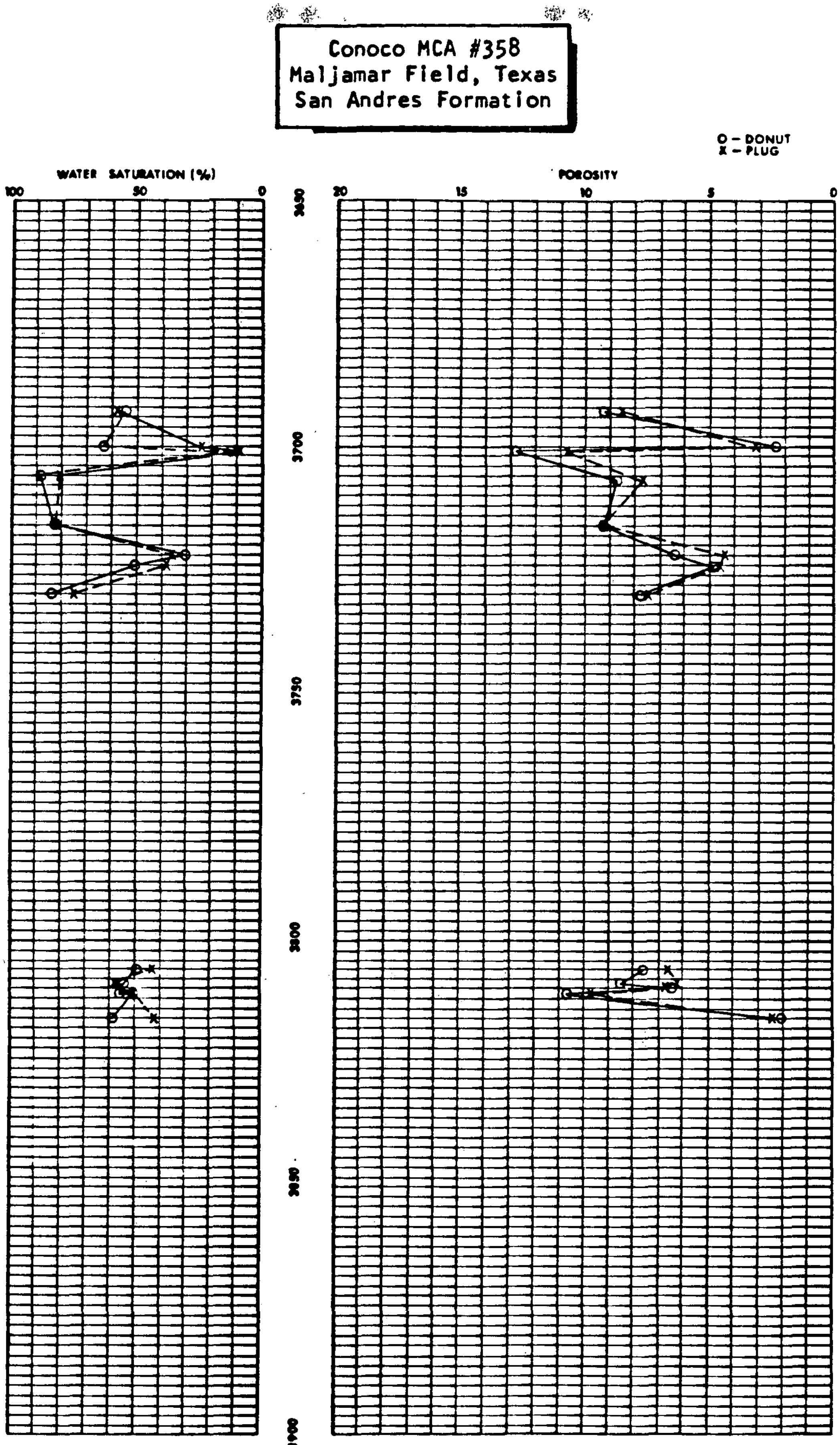


Figure 35.--Porosity and water saturation of plug and donut core samples.

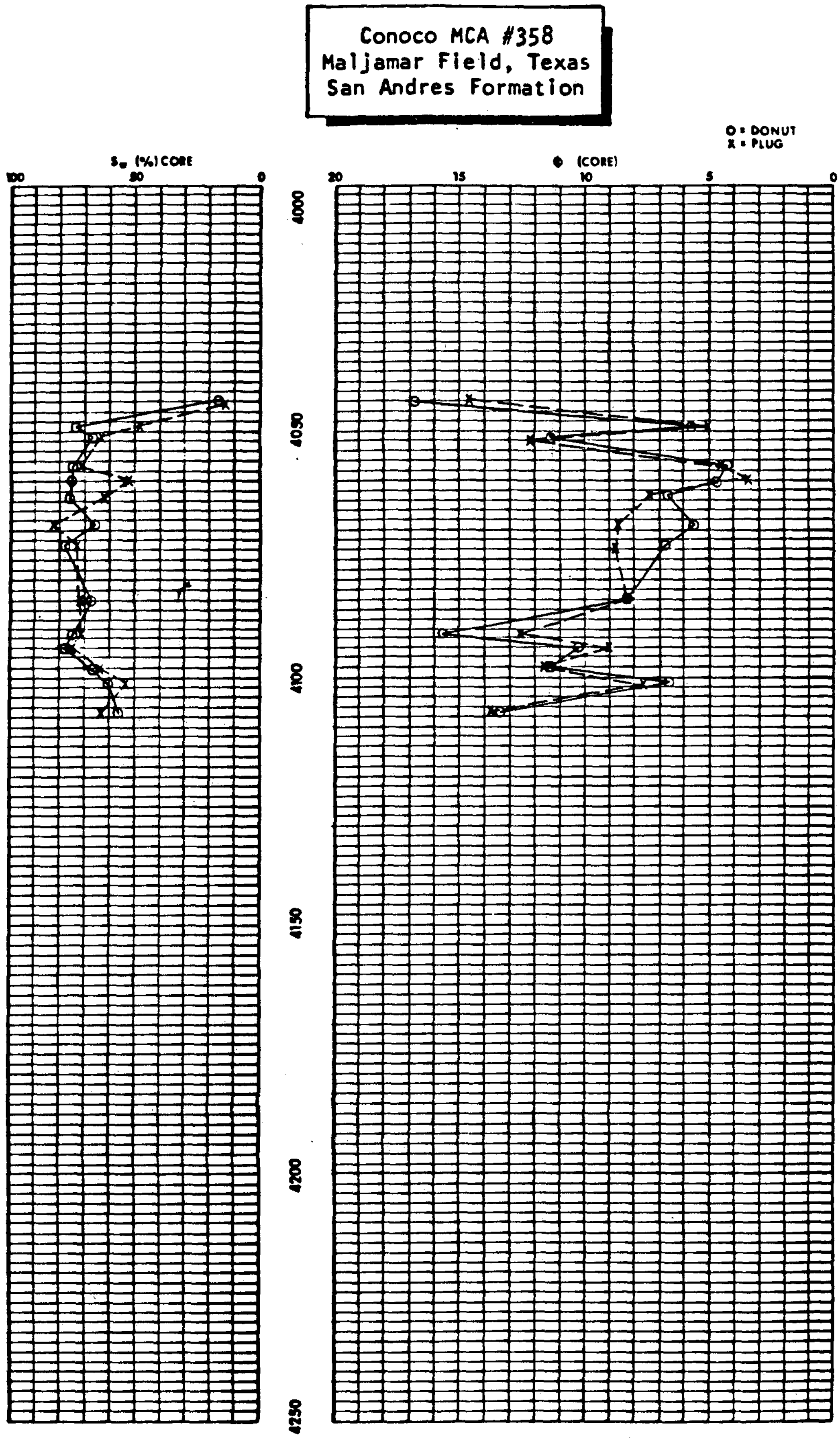


Figure 36.--Porosity and water saturation of plug and donut core samples.

The pore water extracted from the plugs and donuts was sent to Teledyne Isotope Laboratories for determination of tritium content. Mud filtrate collected during drilling was similarly analyzed. A total of 18 mud filtrate samples were taken to tag the initial mud mixture. Figures 37 and 38 are plots of Teledyne's results for the plug and donut pore-water samples. Generally, the tritium activity of the donut was greater than that of the plug; furthermore, the mud filtrate tritium activity was greater than that in both plugs and donuts, indicating incomplete mud-filtrate invasion. A complete listing of Teledyne's analyses of cores and mud filtrate is provided in Appendix D.

The low-invasion fluid was tagged with sodium nitrate to allow estimation of mud-filtrate invasion. However, since Core Laboratories has had little success with this method, no nitrate analyses were run (see Appendix D).

The degree of contamination by mud filtrate was determined from the ratio of the tritium activity of the pore water to that of the mud filtrate. Results for the donut samples are plotted in Figure 39. Even though low-invasion gel was used, significant amounts of mud filtrate contamination occurred in the sixth and seventh zones and lesser amounts in the ninth zone. The ninth zone had generally the same permeability and porosity as the sixth and seventh zones.

The percentage of total invasion was determined from the differences in water saturations of the plugs and donuts. The tritium data were then used to determine whether the invading fluid was mud filtrate, low-invasion fluid, or a combination of the two. As Table 10 shows, invasion was generally fairly low and, in most of the samples, contamination was due to low-invasion fluid.

Gas Liberation. The validity of the fluid saturation measurements from pressure core analysis can be checked by computing the summation of core fluids, the gas-to-oil ratio (GOR), and the oil formation volume factor. All gas was assumed to have been evolved from the oil. The corrected oil and water volumes were then compared to the total pore volume to determine whether all pore fluids had been accounted for. An average of the reservoir corrected fluid saturations in Table 11 showed 100 percent of the original fluids were obtained. The gas liberation data were used to determine the gas-to-oil ratio (scf/STB) for cores recovered with pressure. Figure(s) 40 and 41 are plots of the GOR and the concentration of the nonhydrocarbon gas. A low GOR correlated well with low permeability and high mol percentages of nitrogen and carbon dioxide in the liberated gas. Low-porosity intervals had low GOR's, consistent with the fact that low-porosity intervals have a higher percentage of pore water and yield a lower volume of extracted oil. This small volume of oil is subject to a larger relative error in measurement than a larger volume of oil extracted from a more porous interval.

A statistical analysis of the GOR values gave a mean value of 520 scf/STB. The average oil volume factor was 1.55 RB/STB.

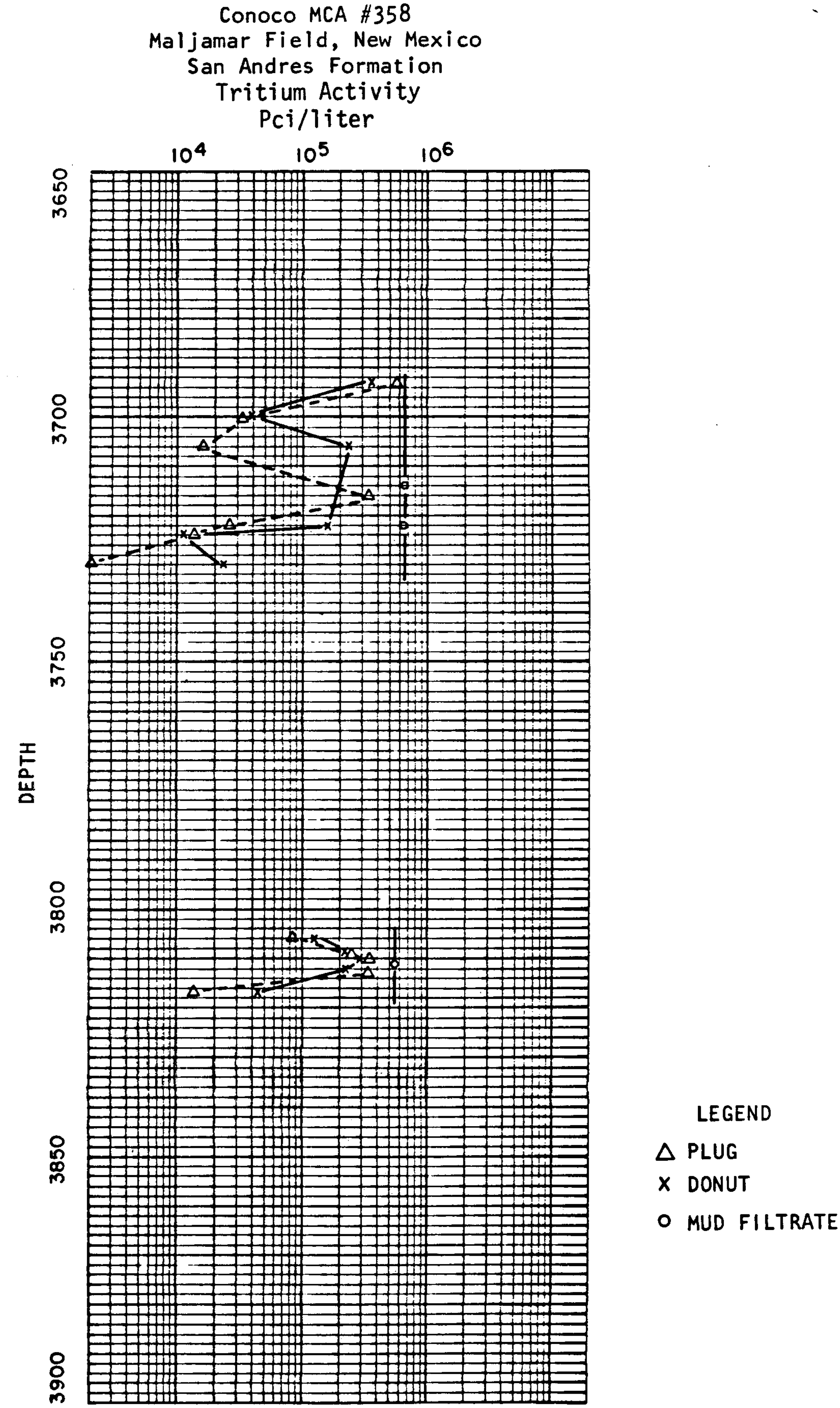


Figure 37.--Tritium activity of plug and donut pore water.

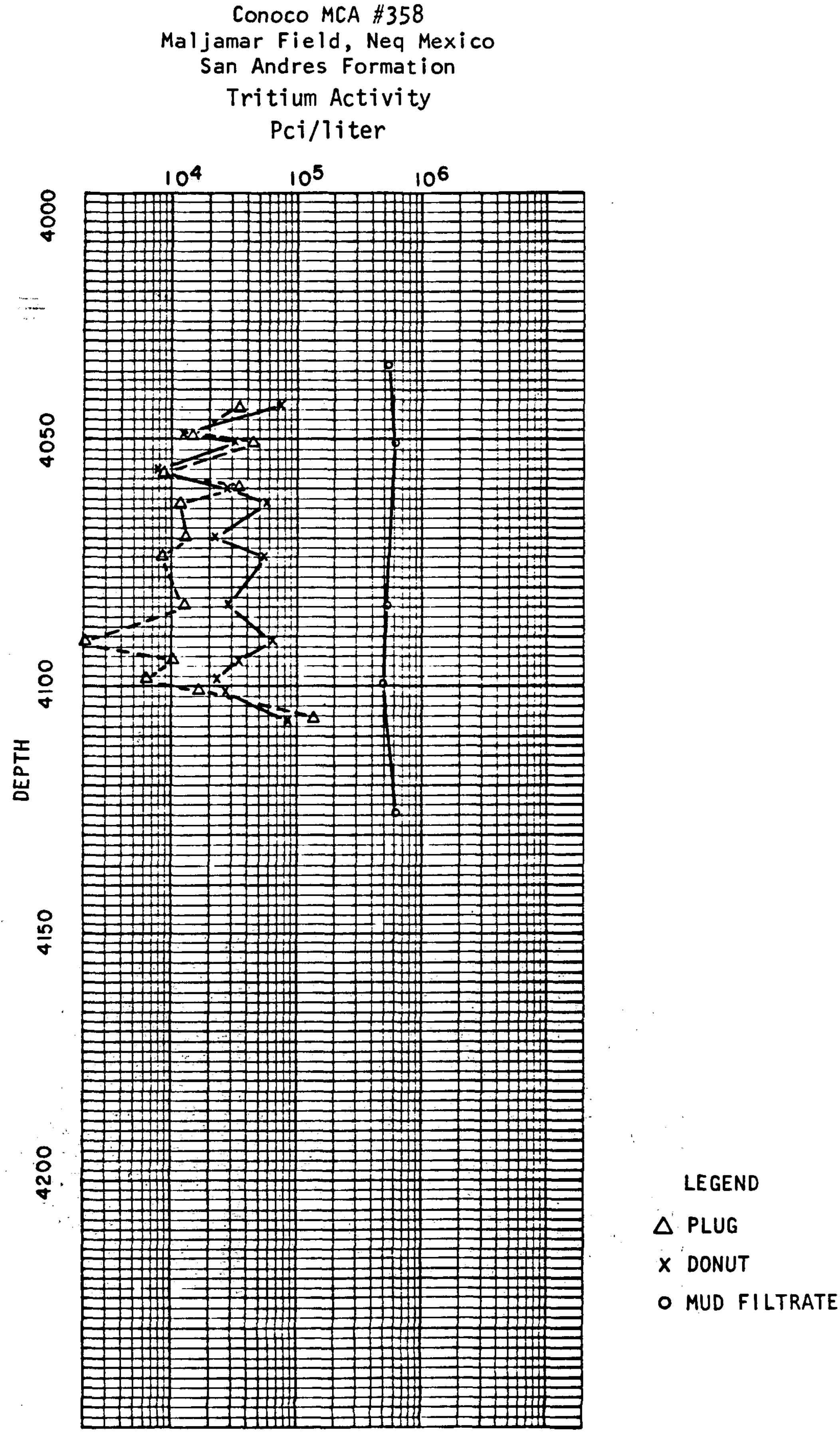


Figure 38.--Tritium activity of plug and donut pore water.

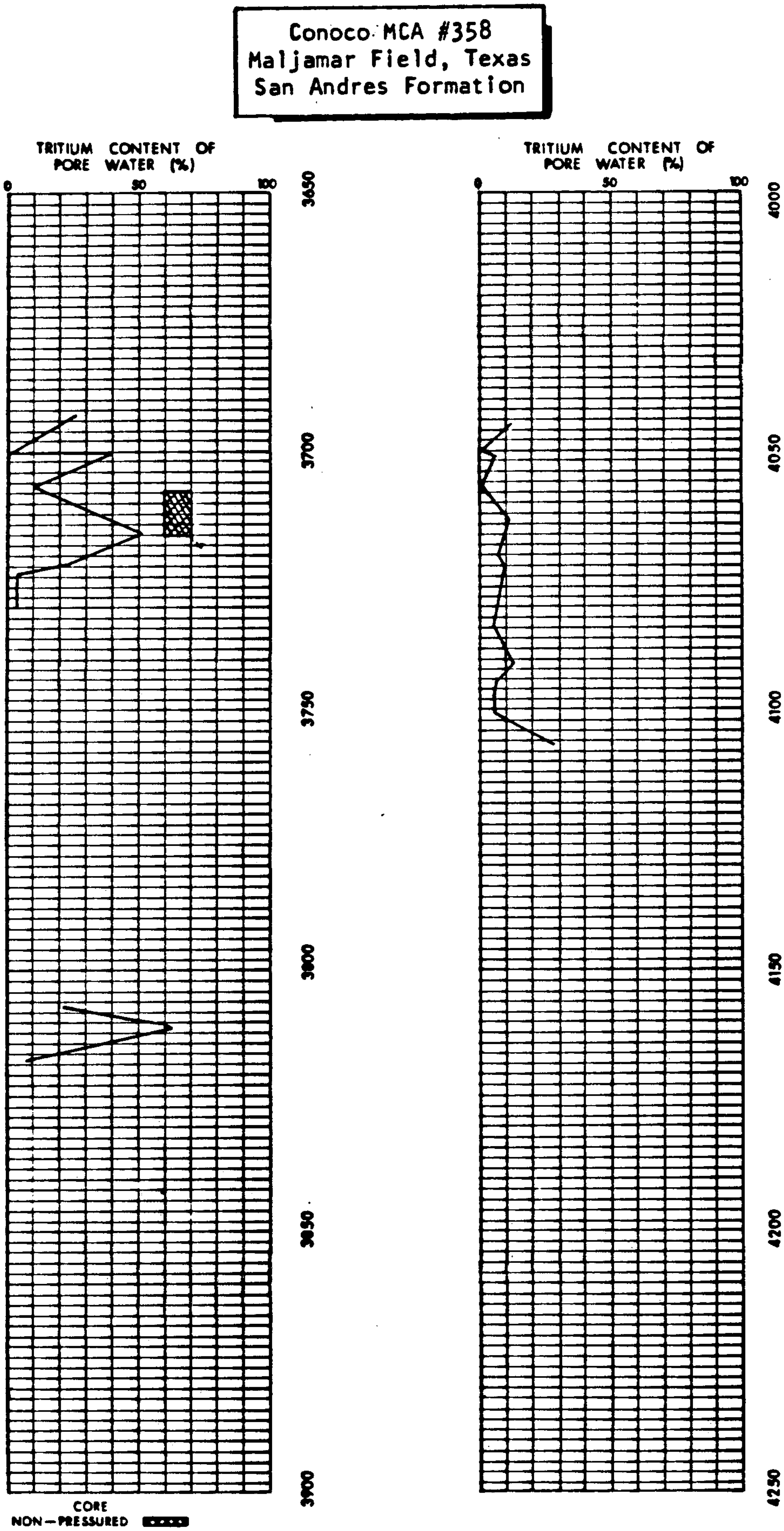


Figure 39.--Percent tritium content of pore water.

TABLE 10

PERCENTAGE INVASION
TOTAL AND MUD FILTRATE

Depth, ft	Percent total flushing	Percent mud filtrate
3693	0	26
3700	19	2
3706	7	40
3716	0	10
3722	0	51
3725	11	22
3731	8	2
3806	7	4
3809	0	22
3810	4	44
3812	0	58
3817	19	63
4044	2	8
4050	23	12
4051	6	3
4057	2	7
4060	22	1
4063	17	6
4070	0	11
4073	4	4
4084	0	10
4091	3	6
4095	3	12
4099	0	7
4101	7	5
4107	0	28

TABLE 11

SUMMATION OF CORE FLUID SATURATION

Depth, ft	Oil sat. at stock-tank conditions	Water saturation	Gas-oil ratio	Oil formation volume factor	Oil sat. at reservoir conditions	Sum of reservoir oil + water saturation	Core porosity
3692	0.161	0.588	300	2.60	0.42	0.988	0.13
3692	0.306	0.580	261	1.38	0.42	1.000	0.11
3693	0.213	0.725	276	1.30	0.28	1.01	0.11
3694	0.315	0.617	221	1.22	0.38	1.00	0.12
3695	0.213	0.624	575	1.77	0.38	1.00	0.047
3696	0.160	0.713	556	1.80	0.29	1.00	0.083
3697	0.234	0.594	494	1.74	0.41	1.00	0.068
3698	0.417	0.482	378	1.25	0.52	1.00	0.048
3699	0.520	0.438	368	1.09	0.57	1.01	0.053
3700	0.132	0.712	538	2.19	0.29	1.00	0.143
3701	0.162	0.731	426	1.66	0.27	0.97	0.131
3701	0.201	0.701	343	1.49	0.30	1.00	0.124
3702	0.200	0.700	324	1.51	0.30	1.00	0.102
3703	0.161	0.758	367	1.51	0.24	1.00	0.08
3704	0.356	0.505	485	1.39	0.49	1.00	0.04
3705	0.416	0.446	346	1.34	0.56	1.01	0.04
3705	0.308	0.630	330	1.21	0.37	1.00	0.06
3716	0.172	0.761	478	1.39	0.24	1.00	0.09
3716	0.325	0.623	364	1.17	0.38	1.00	0.05
3717	0.290	0.503	319	1.72	0.50	1.00	0.09
3718	0.293	0.488	418	1.75	0.51	1.00	0.08
3719	0.311	0.570	319	1.39	0.43	1.00	0.09
3720	0.343	0.428	308	1.67	0.57	1.00	0.08
3720	0.417	0.401	141	1.44	0.60	1.00	0.015
3721	0.282	0.638	189	1.29	0.36	1.00	0.016
3722	0.500	0.440	266	1.13	0.57	1.01	0.030
3724	0.423	0.537	415	1.10	0.47	1.01	0.040
3725	0.421	0.444	441	1.33	0.56	1.00	0.031
3725	0.547	0.278	188	1.32	0.72	0.998	0.048
3726	0.538	0.257	510	1.39	0.75	1.01	0.053

TABLE 11--Continued (Second Page)

Depth, ft	Oil sat. at stock-tank conditions	Water saturation	Gas-oil ratio	Oil formation volume factor	Oil sat. at reservoir conditions	Sum of reservoir oil + water saturation	Core porosity
3727	0.543	0.308	367	1.28	0.70	1.01	0.027
3728	0.295	0.683	267	1.85	0.42	1.10	0.018
3728	0.228	0.078	440	1.39	0.32	1.10	0.063
3729	0.131	0.723	784	2.12	0.28	1.00	0.082
3730	0.147	0.770	641	1.57	0.23	1.00	0.072
3730	0.104	0.806	775	1.87	0.19	1.00	0.088
3803	0.570	0.292	471	1.25	0.71	1.00	0.087
3803	0.292	0.535	835	1.60	0.47	1.01	0.028
3804	0.311	0.504	785	1.60	0.50	1.00	0.079
3807	0.299	0.524	840	1.60	0.48	1.00	0.085
3807	0.374	0.514	602	1.30	0.49	1.00	0.11
3808	0.310	0.503	451	1.61	0.50	1.00	0.10
3809	0.418	0.497	672	1.21	0.51	1.01	0.046
3810	0.226	0.579	102	1.87	0.42	1.00	0.10
3811	0.374	0.487	537	1.38	0.52	1.01	0.09
3812	0.509	0.373	469	1.24	0.63	1.00	0.08
3813	0.498	0.350	427	1.31	0.65	1.00	0.06
3813	0.467	0.286	424	1.53	0.71	1.00	0.09
3815	0.496	0.357	472	1.30	0.64	1.00	0.055
3815	0.513	0.403	380	1.17	0.82	1.22	0.047
3816	0.288	0.629	366	1.30	0.37	1.00	0.020
3817	0.509	0.338	552	1.31	0.67	1.01	0.052
3818	0.284	0.681	576	1.13	0.32	1.00	0.026
4043	0.255	0.628	636	1.50	0.38	1.00	0.086
4043	0.291	0.599	515	1.38	0.40	1.00	0.10
4046	0.265	0.669	582	1.25	0.31	0.91	0.14
4046	0.247	0.599	633	1.63	0.66	1.26	----
4047	0.278	0.608	700	1.42	0.64	1.25	0.14
4048	0.196	0.713	655	1.47	0.28	1.00	0.06
4049	0.142	0.737	667	1.86	0.26	1.00	0.06
4050	0.276	0.619	464	1.39	0.38	1.00	0.08

TABLE 11--Continued (Third Page)

Depth, ft	Oil sat. at stock-tank conditions	Water saturation	Gas-oil ratio	Oil formation volume factor	Oil sat. at reservoir conditions	Sum of reservoir oil + water saturation	Core porosity
4051	0.146	0.737	642	1.81	0.26	1.00	0.08
4052	0.118	0.806	603	1.65	0.19	1.00	0.10
4053	0.13	0.792	580	1.61	1.29	2.09	0.12
4053	0.08	0.783	742	2.72	0.22	1.00	0.125
4054	0.114	0.762	869	2.09	0.24	1.00	0.07
4055	0.141	0.771	655	2.05	0.29	1.03	0.07
4055	0.140	0.735	704	1.89	0.26	1.00	
4056	0.089	0.829	659	1.93	0.17	0.999	0.3
4057	0.127	0.765	482	1.86	0.24	1.01	0.3
4058	0.076	0.783	862	2.86	0.22	1.003	0.09
4059	0.259	0.717	235	1.10	0.28	1.00	0.05
4060	0.257	0.689	532	1.22	0.31	1.00	0.04
4061	0.274	0.689	462	1.14	0.31	1.00	0.02
4067	0.191	0.579	528	2.21	0.42	1.00	0.05
4068	0.240	0.671	361	1.37	0.33	1.001	0.03
4068	0.160	0.672	359	2.05	0.33	1.00	0.04
4069	0.257	0.612	364	1.51	0.80	1.41	0.11
4072	0.284						
4073	0.240	0.720	460	1.17	0.28	1.00	0.94
4074	0.242	0.639	493	1.50	0.36	1.00	0.82
4084	0.113	0.824	711	1.56	0.18	1.00	0.129
4085	0.109	0.767	863	2.14	0.23	1.00	0.133
4086	0.172	0.687	764	1.82	0.31	1.00	0.134
4087	0.152	0.683	953	2.09	0.32	1.00	0.110
4088	0.137	0.760	833	1.76	0.24	1.00	0.119
4089	0.104	0.813	718	1.80	0.19	1.00	0.125
4090	0.123	0.808	648	1.57	0.19	1.00	0.119
4091	0.085	0.794	929	1.43	0.122	0.904	0.110
4092	0.132	0.761	787	1.82	0.24	1.00	0.109
4092	0.151	0.703	684	1.97	0.30	1.00	0.121

TABLE 11--Continued (Fourth Page)

Depth, ft	Oil sat. at stock-tank conditions	Water saturation	Gas-oil ratio	Oil formation volume factor	Oil sat. at reservoir conditions	Sum of reservoir oil + water saturation	Core porosity
4093	0.121						
4093	0.117	0.739	680	2.16	0.26	1.00	0.106
4094	0.158	0.727	767	1.73	0.27	0.997	0.109
4095	0.188	0.729	546	1.45	0.27	0.999	0.112
4097	0.232	0.668	638	1.47	0.34	1.008	0.125
4098	0.184	0.713	702	1.56	0.29	1.003	0.088
4100	0.341	0.568	532	1.27	0.43	0.998	0.09
4101	0.18	0.544	964	2.54	0.46	1.004	0.088
4102	0.26	0.673	623	1.26	0.33	1.003	0.068
4103	0.246	0.653	650	1.42	0.35	1.003	0.09
4104	0.203	0.645	615	1.75	0.36	1.005	0.055
4105	0.127	0.762	606	1.88	0.24	1.002	0.064
4106	0.150	0.783	430	1.45	0.22	1.003	0.078
4106	0.158	0.696	713	1.93	0.30	0.996	0.113
4107	0.264	0.574	662	1.63	0.43	1.004	0.118

Conoco MCA #358
Maljamar Field, Texas
San Andres Formation

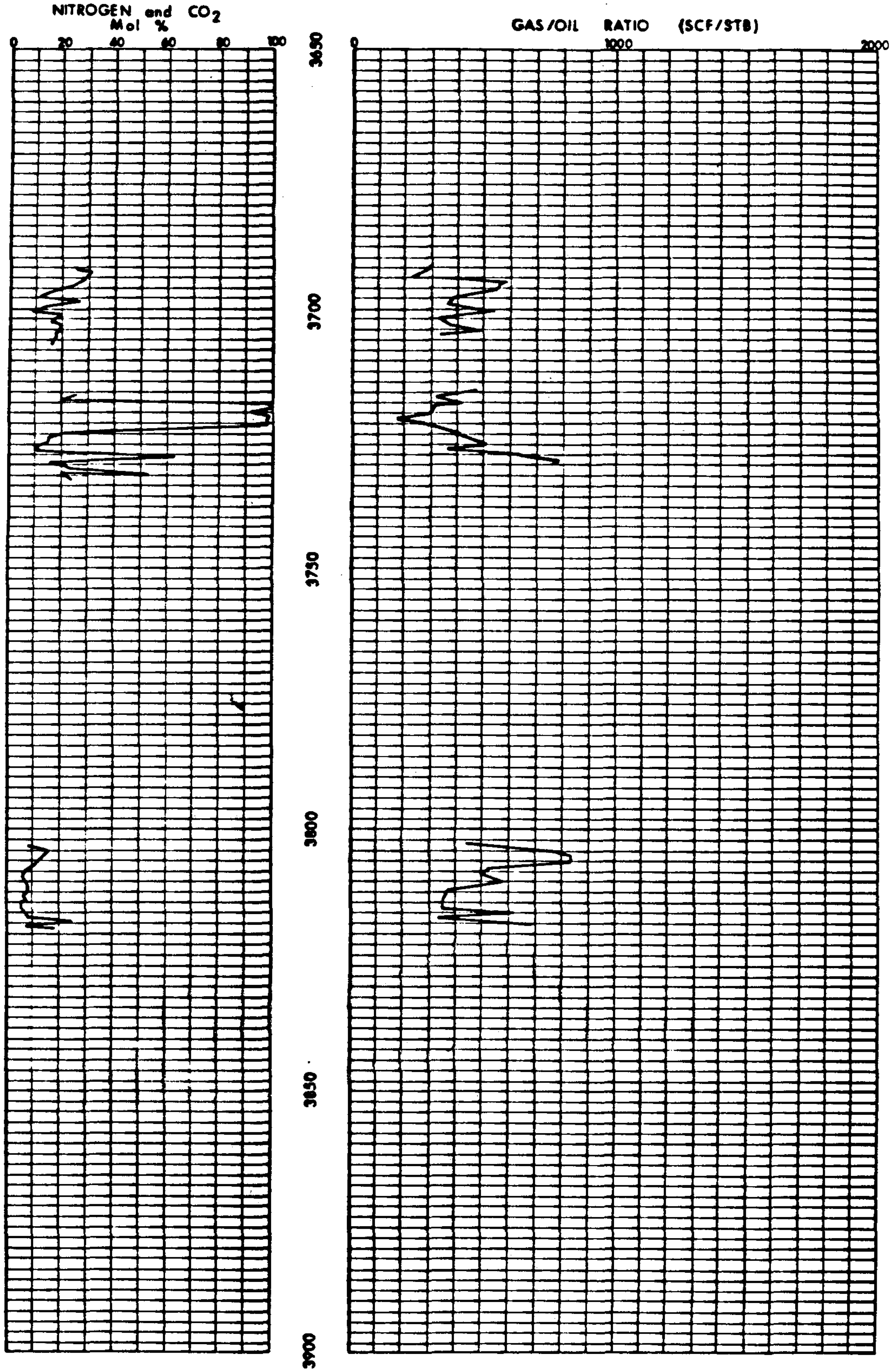


Figure 40.--N_2 and CO_2 concentration and gas/oil ratio for full diameter cores recovered with pressure.

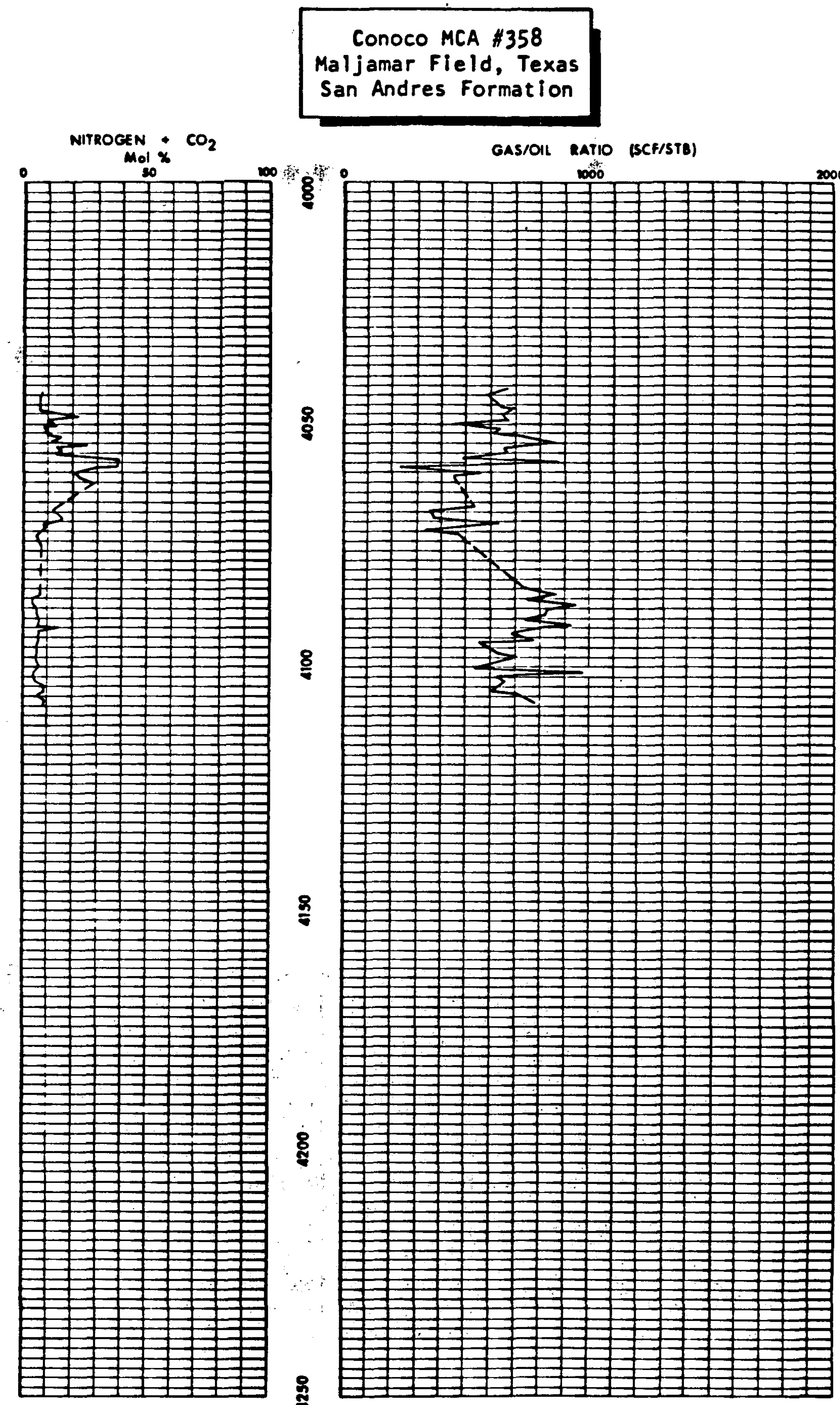


Figure 41.--N_2 and CO_2 concentration and gas/oil ratio for full diameter cores recovered with pressure.

Electrical Resistivity Core Analysis. Special core analysis was performed by Core Laboratories to determine the formation resistivity factors and saturation exponents for selected rock samples. Hydrocarbons present were extracted using toluene, any salts present were leached with methyl alcohol, and the sample was then dried. Samples used for formation resistivity measurements were evacuated and then pressure saturated with a brine containing 16,000 ppm sodium chloride to which calcium sulfate had been added to inhibit possible mineral dissolution. The report submitted by Core Laboratories is included as Appendix D.

Measurements from these studies were obtained to provide empirical data for evaluation of unknowns a, m, and n in the basic log analysis equations:

$$(S_w)^n = R_0/R_t$$

and $$R_0 = F \cdot R_w,$$

where
$F = a/(\emptyset_e)^m$,
S_w = water saturation (fraction),
n = saturation exponent,
R_0 = resistivity of water zone at 100% S_w,
R_t = true resistivity of zone being evaluated,
F = formation factor,
R_w = resistivity of formation water,
a = tortuosity constant,
$\emptyset_e$ = porosity,
and m = cementation exponent.

The tortuosity constant a and the cementation exponent m are interrelated as

$$\log F = a - m \log \emptyset e,$$

where a can be determined when log F = 0 and where m is defined as the slope of the line; a and m may be determined graphically. The results for MCA 358 samples are shown in Figure(s) 42 and 43. An a value of 1.00 appears justified from the fit of the line for sandstone samples and dolomite samples (Fig(s). 42 and 43, respectively). The slope m of the line for sandstone samples (Fig. 42) was 1.68, while that for dolomite samples (Fig. 43) was 1.93.

The saturation exponent was similarly determined as

$$\log (R_0/R_t) = n \log S_w,$$

by plotting resistivity index measurements against brine saturation. The slope of the line shown in Figure 44 establishes a composite n value of 1.57 for sandstone samples whose individual n's ranged from 1.53 to 1.74. The slope of the line shown in Figure 45 establishes a composite n value of 2.06 for dolomite samples whose individual n's ranged from 1.78 to 2.62. Results of determinations of n for individual samples are given in Appendix D.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

File SCAL-308-80533

Company Gruy Federal, Inc.
Formation Grayburg
Well MCA No. 358
County Lea
Field Maljamar
State New Mexico

Sandstone Samples

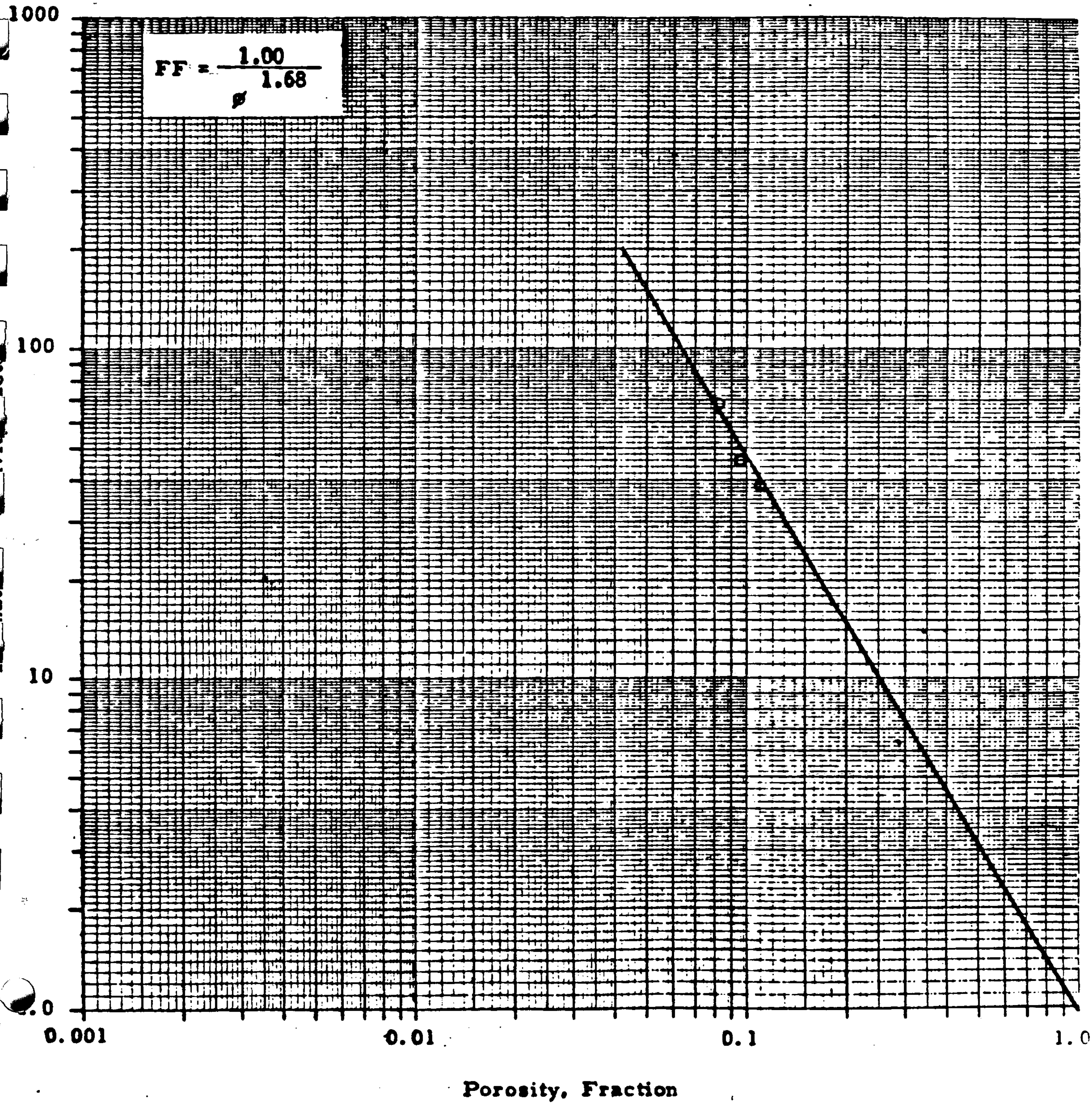


Figure 42.--Determination of cementation exponent m for sandstone samples.

Company Gruy Federal, Inc.
Well MCA No. 358
Field Maljamar
Formation Grayburg
County Lea
State New Mexico

Dolomite Samples

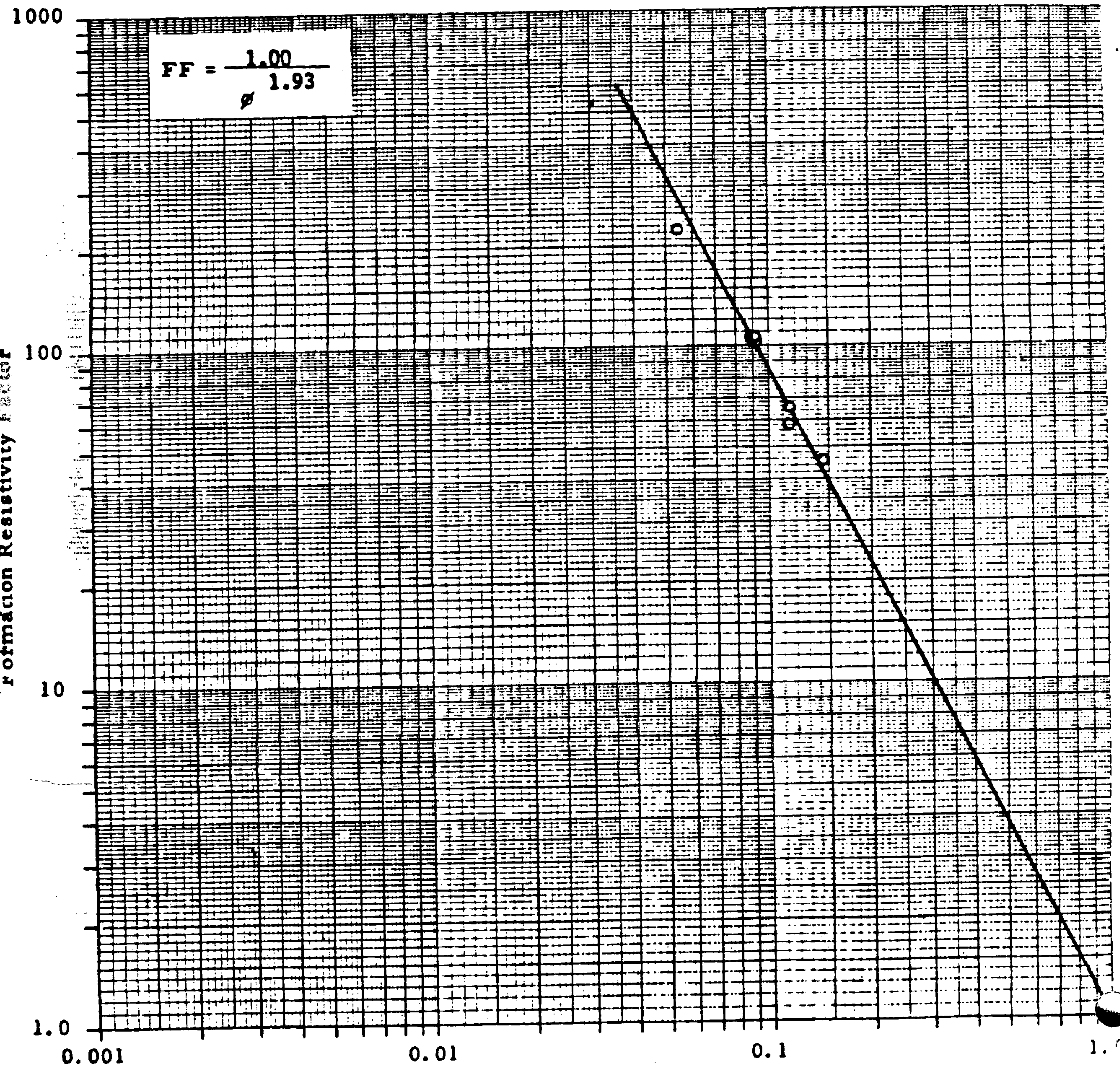
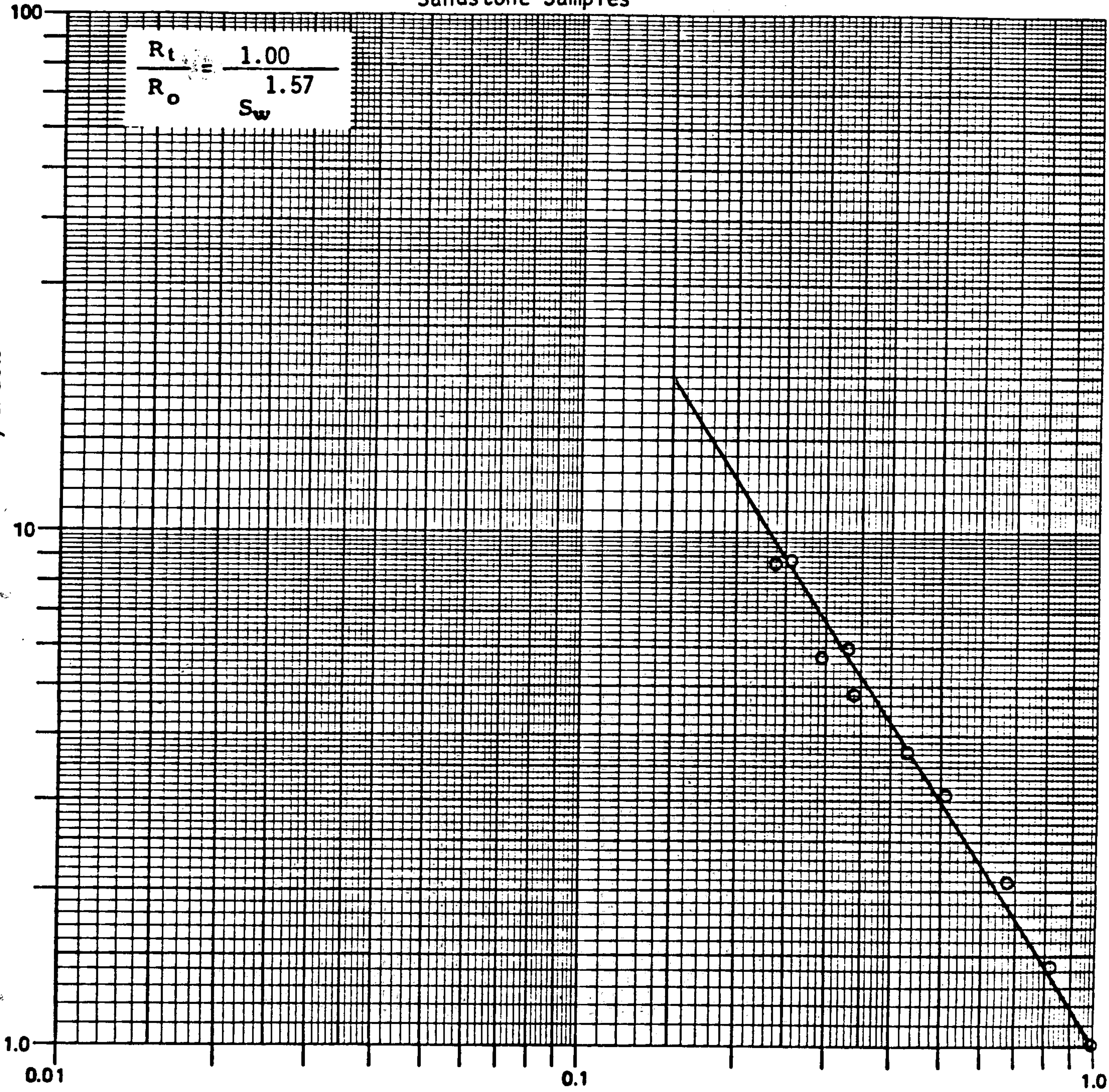


Figure 43.--Determination of cementation exponent m for dolomite samples.

Company Gruy Federal, Inc.
Well MCA No. 358
Field Maljamar
Formation Grayburg
County Lea
State New Mexico

Composite
Sandstone Samples



Brine Saturation, Fraction

Figure 44.--Determination of saturation exponent n composite for sandstone samples.

CL 847/SCAL 4006

Company Gruy Federal, Inc. Formation Grayburg
Well MCA No. 358 County Lea
Field Maljamar State New Mexico

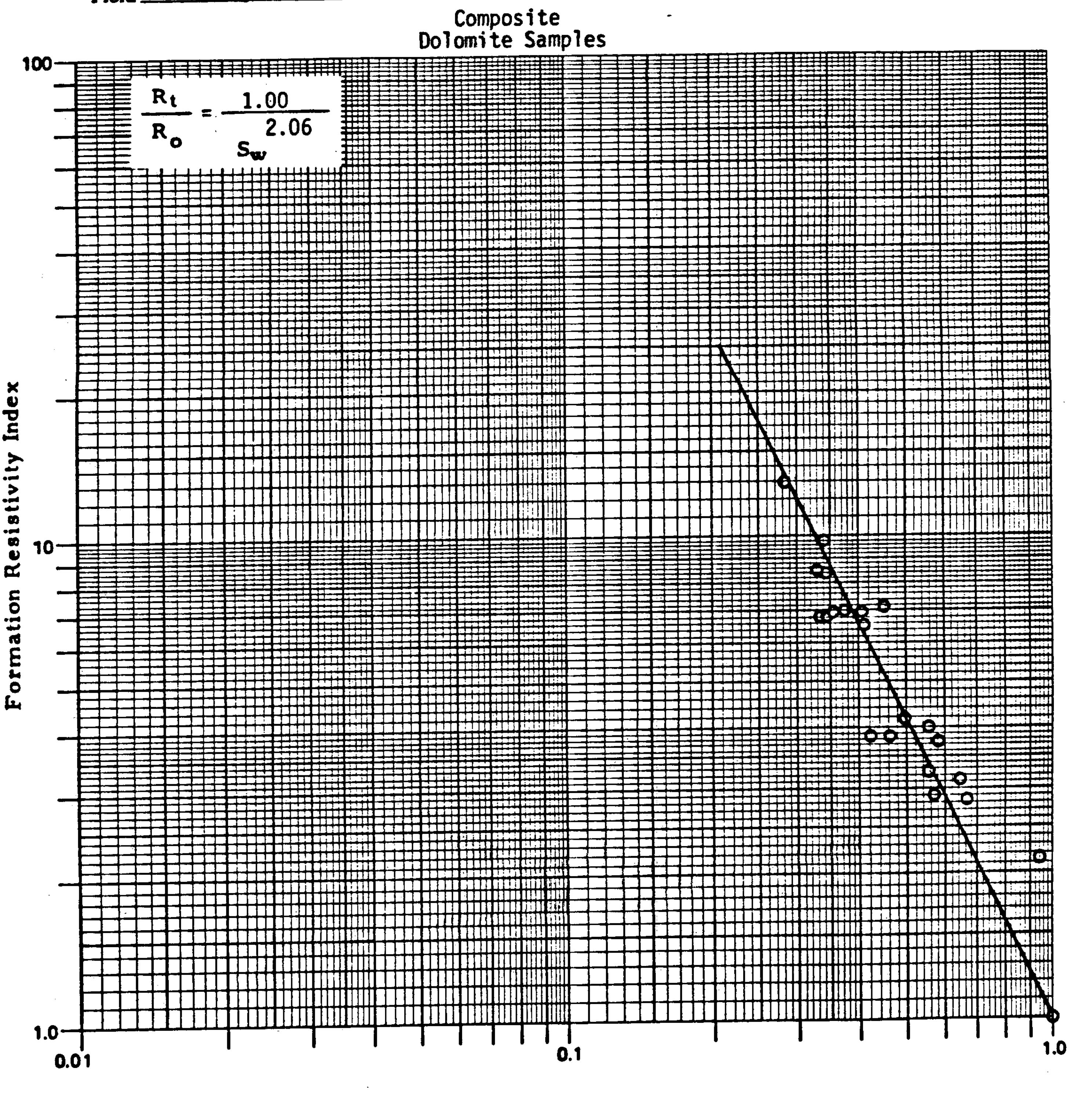


Figure 45.--Determination of saturation exponent n composite for sandstone samples.

Values for the cementation and saturation exponents were fairly consistent with those found in the literature.[12] The generally accepted value of n for dolomite is 2.0; it can be decreased by a partial sand matrix or increased by oil-wetting. Core samples 4, 5, and 6, having n values of 2.3, 2.62, and 2.60, respectively, could be oil-wet dolomites, while samples 9 and 10 (n = 1.83 and 1.78, respectively), could be sandy dolomites. Sandstone has a generally accepted value of 2.0 for n. All samples from MCA 358 had n values less than 2. The value of n may be lowered by non-compaction or a partial shale matrix. Core Laboratories reported that samples were moderately indurated and very fine grained; analysis of the gamma-ray log showed an estimated 20 to 30 percent shale content for the depths at which these samples were taken. The data indicate that low n values could result from the sand's being moderately compacted and slightly dirty. Additionally, the method of measurement necessarily alters the wettability of the reservoir rock, introducing some uncertainty.[13]

GEOLOGY

Geologic cross-sections were made using the wells and cross-section lines shown on Figure 46. The cross-sections, Figure(s) 47 and 48, show the formations dip gently to the southeast. The Grayburg 6th Zone and the San Andres Upper 7th Zone thicken away from MCA No. 358 in both cross-section lines while the 7th Zone thins away from MCA No. 358.

PETROPHYSICAL DATA AND LOG ANALYSIS

The method used to determine the effective porosity and water saturation in the San Andres formation from logs is presented below.

The San Andres has a complex lithology of limestone, dolomite, anhydrite, shale, and other deposited minerals. To solve for four different mineral compositions, three porosity devices and a shale indicator are required. However, in carbonate reservoirs direct solutions for shale volume and mineral composition are not widely accepted. This log analysis method uses the responses of the density, sonic, and neutron logs to evaluate the effective porosity of the formation. The resistivity log is then used to determine water saturations based on effective porosity. The analysis assumes fluid densities in the range of the density of water, a nonlinear neutron porosity response, and a pseudo anhydrite-dolomite content. These assumptions will be presented in more detail after a discussion of the basic and generally accepted log analysis equations.

The basic bulk density-porosity relation is given in Equation 1, which is simply a material balance on a given unit volume of formation:

$$b = (1 - \phi_e - V_{sh})\rho_{ma} + \phi_e \rho_f + V_{sh}\rho_{sh}, \qquad (1)$$

where b = bulk density (gm/cc),

ϕ_e = effective porosity (decimal fraction),

V_{sh} = volume of shale (decimal fraction),

ρ_{ma} = apparent matrix density (gm/cc),

ρ_f = fluid density (gm/cc),

and ρ_{sh} = shale density (gm/cc).

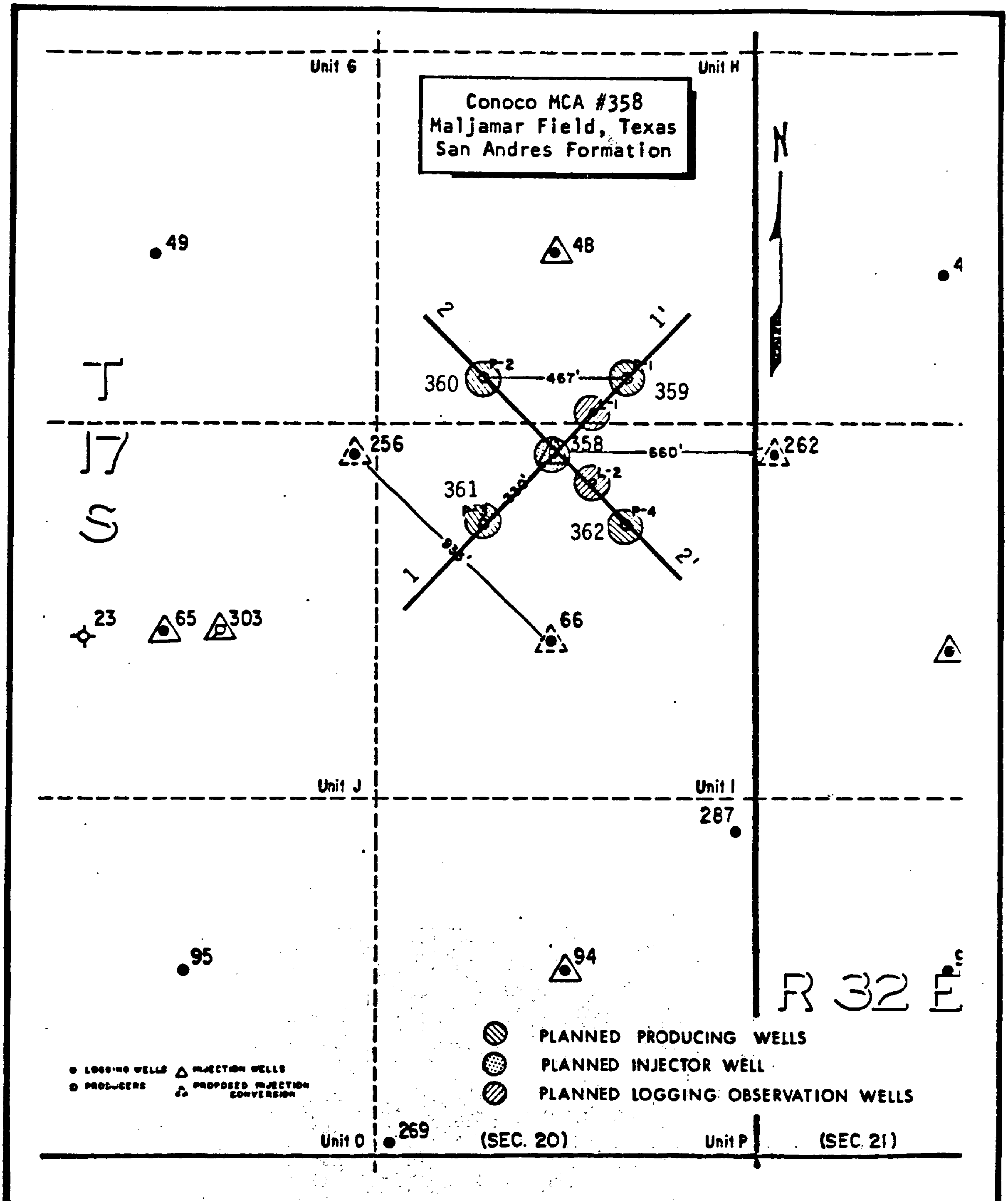


Figure 46.--Location of wells in geologic correlation and cross-section lines.

Conoco MCA #358
Maljamar Field, Texas
San Andres Formation

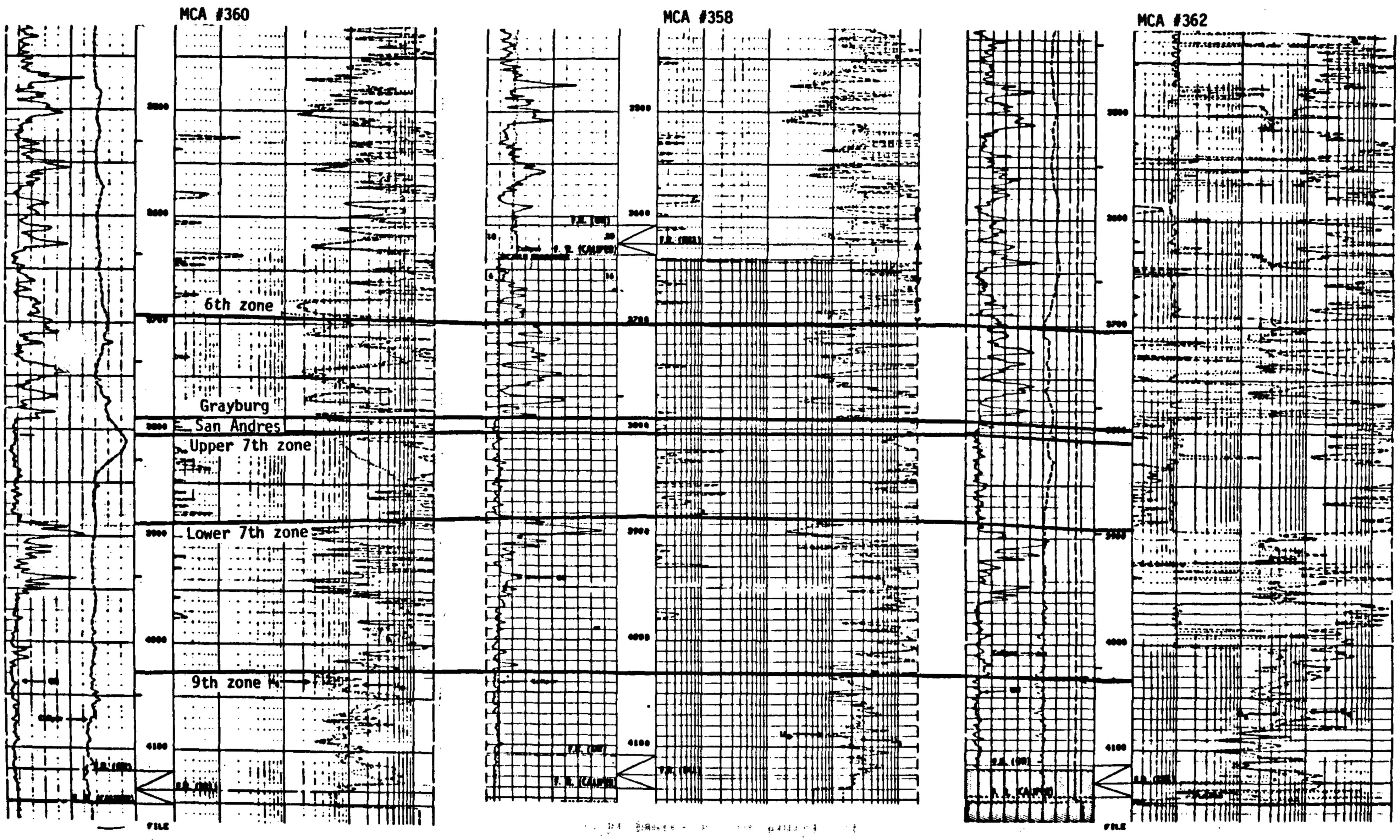
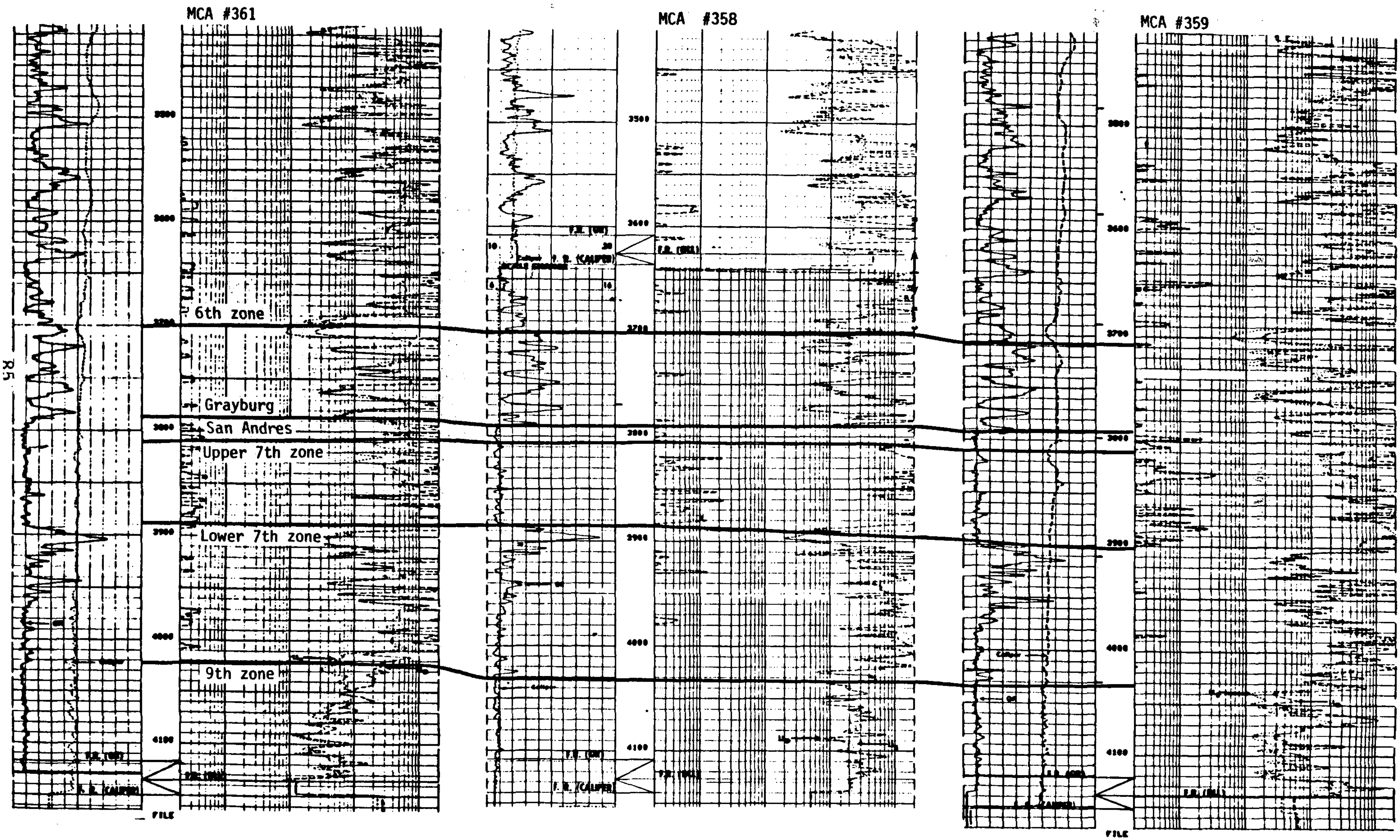


Figure 47.--Cross-section line 2-2'.

Conoco MCA #358
Maljamar Field, Texas
San Andres Formation

Figure 48.--Cross-section line 1-1'.



The basic relation for the sonic log is given by Equation 2, an empirical relation known as the Wyllie time-share formula:

$$\Delta t_b = (1 - \emptyset_e - V_{sh}) \Delta t_{ma} + \emptyset_e \Delta t_f + V_{sh} \Delta t_{sh}, \qquad (2)$$

where Δt_b = bulk travel time (μ sec/ft),
$\emptyset_e$ = effective porosity (decimal fraction),
V_{sh} = volume of shale (decimal fraction),
Δt_{ma} = apparent matrix travel time (μ sec/ft),
Δt_f = fluid travel time (μ sec/ft),
and Δt_{sh} = shale travel time (μ sec/ft).

For most porosity ranges, porosity can be determined from the neutron log, using Equation 3:

$$\emptyset N_2 = (\emptyset N_{sd} - H_{ma}2 - \nabla)/(H_f - H_{ma}2 - V_{sh}\emptyset N_{sh}, \qquad (3)$$

where $\emptyset N_2$ = final neutron porosity,
$\emptyset N_{sd}$ = neutron porosity in sandstone,
$H_{ma}2$ = final hydrogen index of the matrix,
H_f = final hydrogen index of the fluid,
∇ = neutron deviation function,
V_{sh} = volume of shale (decimal fraction),
and $\emptyset N_{sh}$ = neutron shale porosity.

This equation was specially developed to obtain lithology corrections. The correction assumes an initial hydrogen index of one for the fluid. A more detailed explanation of this correction cannot be released at this time; however, the same corrections can be made using the Schlumberger charts for neutron lithology corrections.

To arrive at effective porosity corrected for shale and lithology, a series of cross-plotting techniques was applied (Figure(s) 49 through 54). With the aid of core analysis the maximum and minimum effective porosities were determined. The raw data were then normalized and cross-plotted to agree with the known porosity limitations. In effect, this normalization procedure corrects the data for shale and lithology. The shift and sensitivity corrections for the three porosity devices are:

Density: $\rho b_N = 0.740\, \rho b_{log} + 0.640$ (4)

Sonic: $\Delta t_N = 1.011\, \Delta t_{log} - 0.012$ (5)

Neutron: $\phi N_N = 0.980\, \phi N_{log} - 0.007$ (6)

Once normalized, the data were then cross-plotted on the density-neutron and density-sonic Schlumberger interpretation charts. The apparent true porosity was taken from each chart and averaged to arrive at the effective porosity. Statistical comparisons of the two apparent true porosities showed an average deviation of less than one porosity unit. It should be noted, however, that the actual normalization constants shown above are site-specific; therefore the normalization constants must be determined for each site before analysis. Having arrived at a value for effective porosity, it is possible to compute an indexed volume of shale. If the apparent matrix density is assumed, Equation 1 can be used to determine the approximate volume of shale. This approximate volume can then be used to compute the most probable volume of shale.

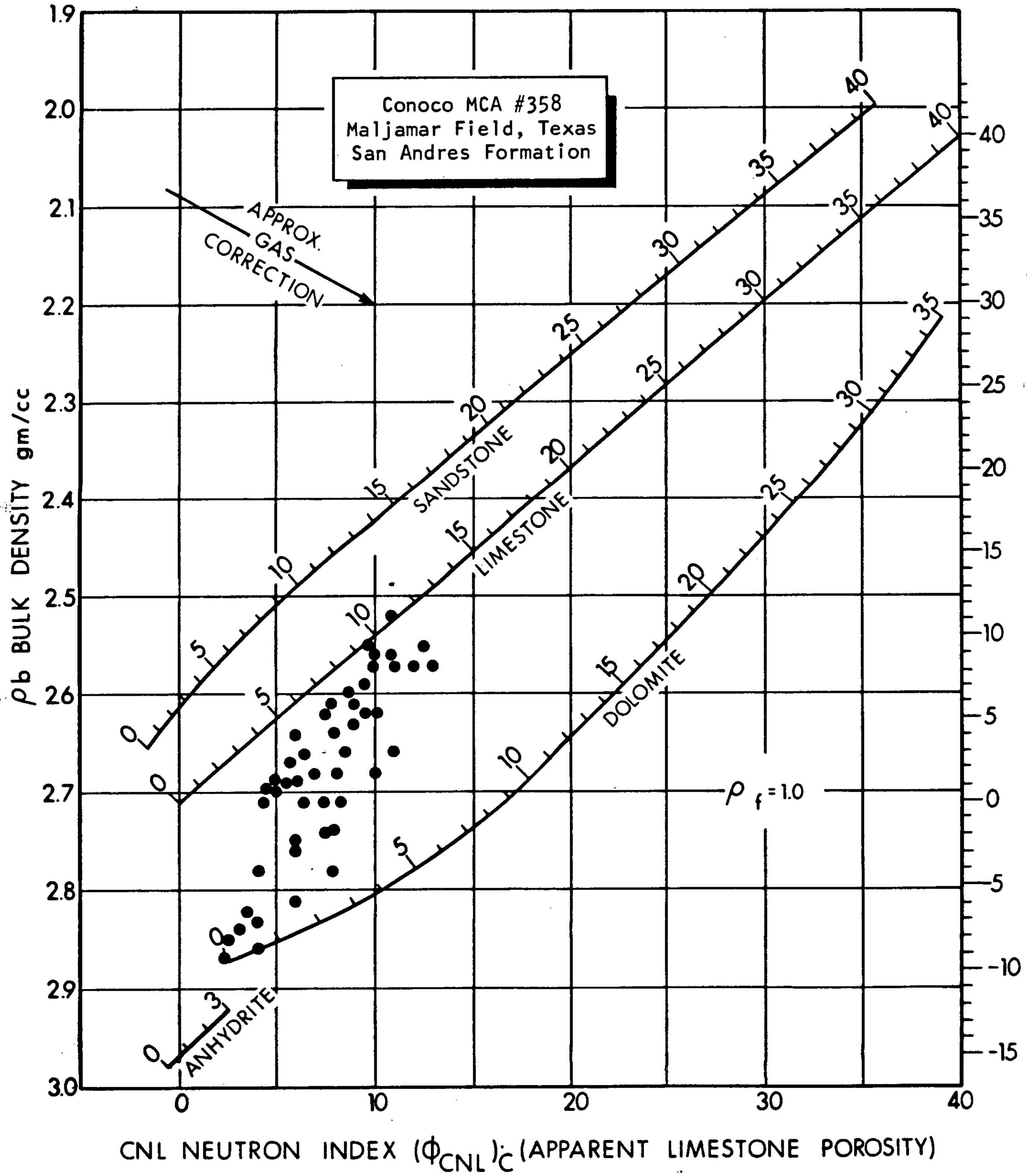


Figure 49.--Density-neutron cross plot, zone 6, cores 1-6.

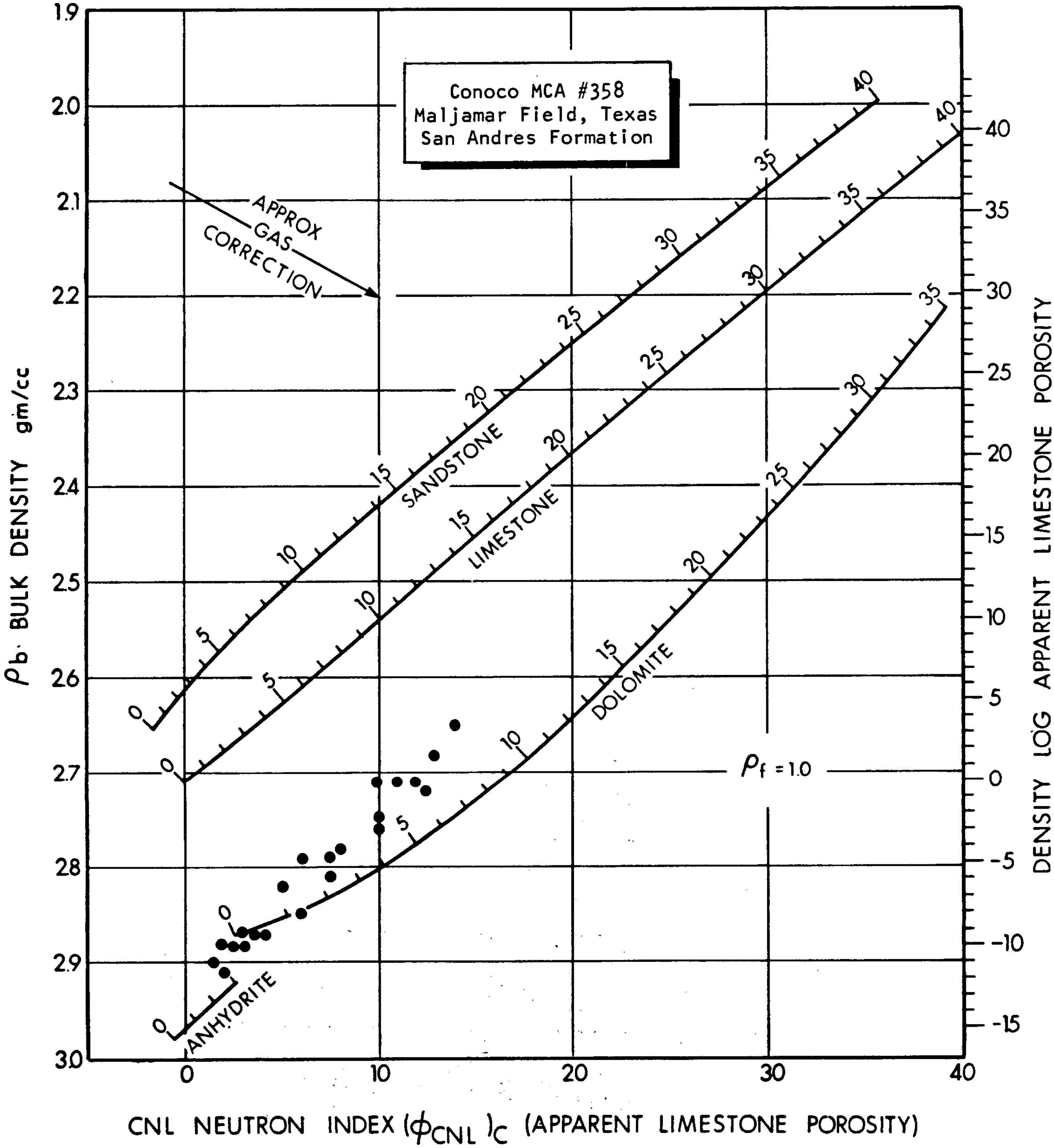


Figure 50.--Density-neutron cross plot, zone 7, cores 7-9.

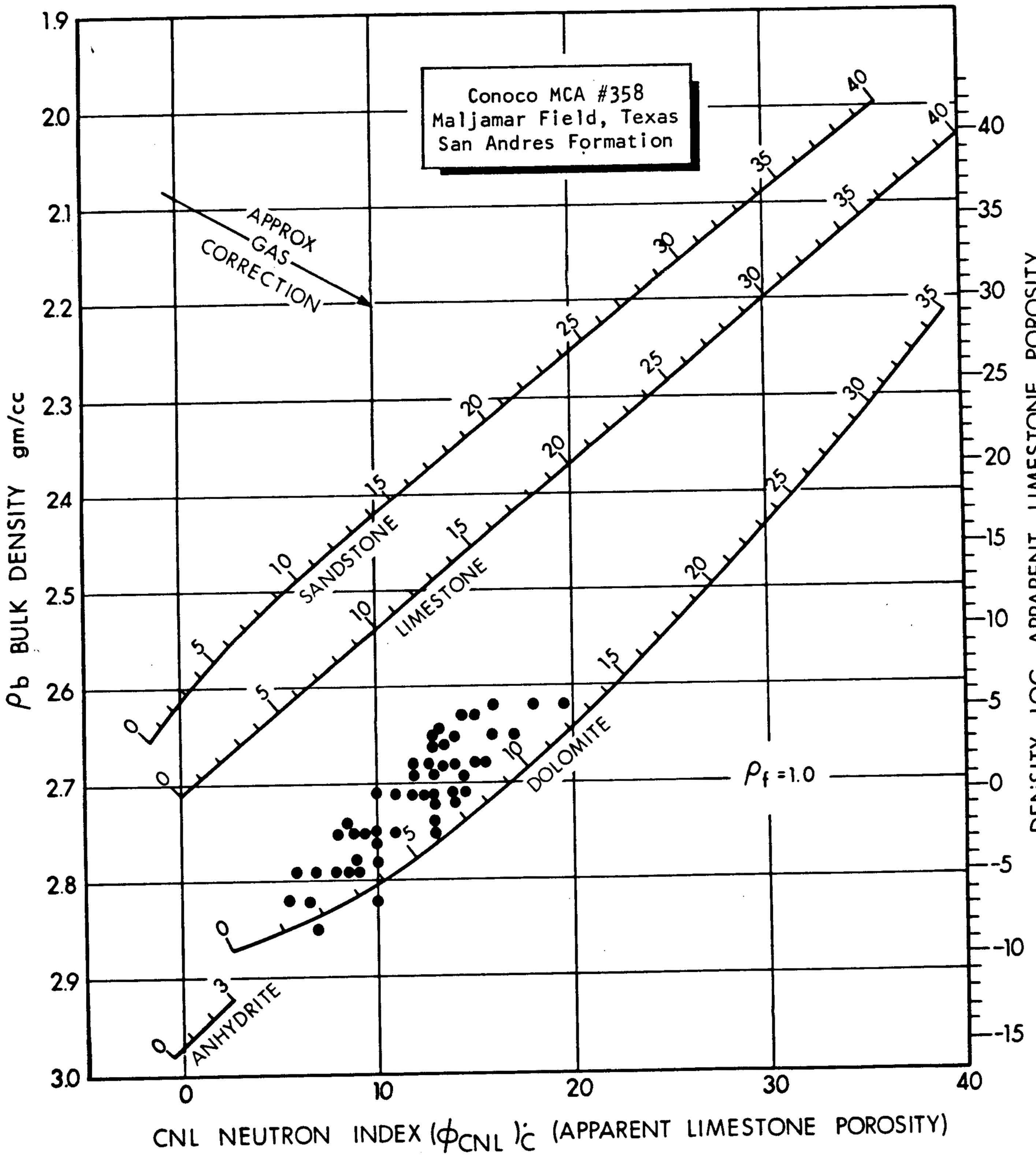


Figure 51.--Density-neutron cross plot, zone 9, cores 10-18.

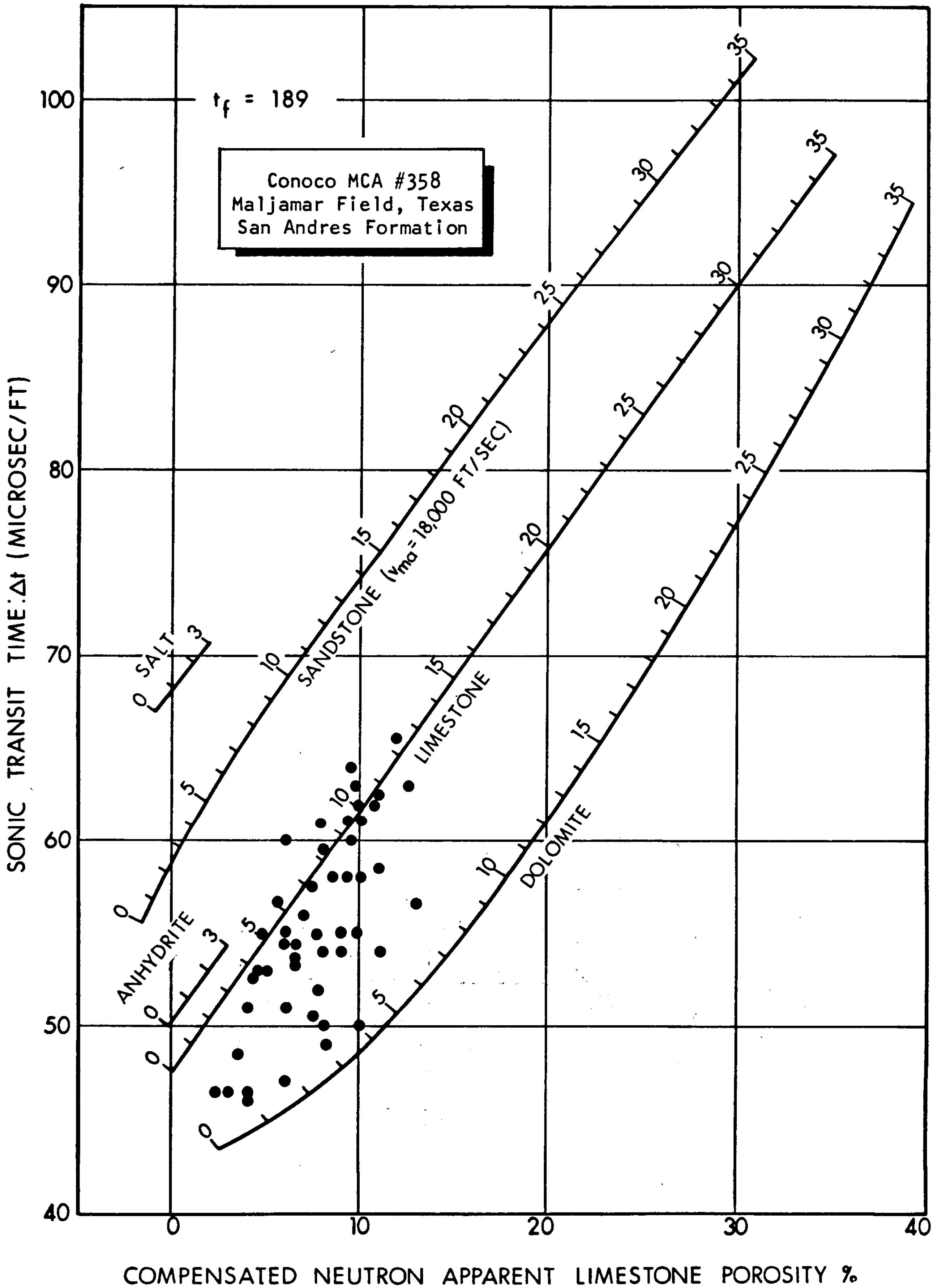


Figure 52.--Sonic-neutron cross plot, zone 6, cores 1-6.

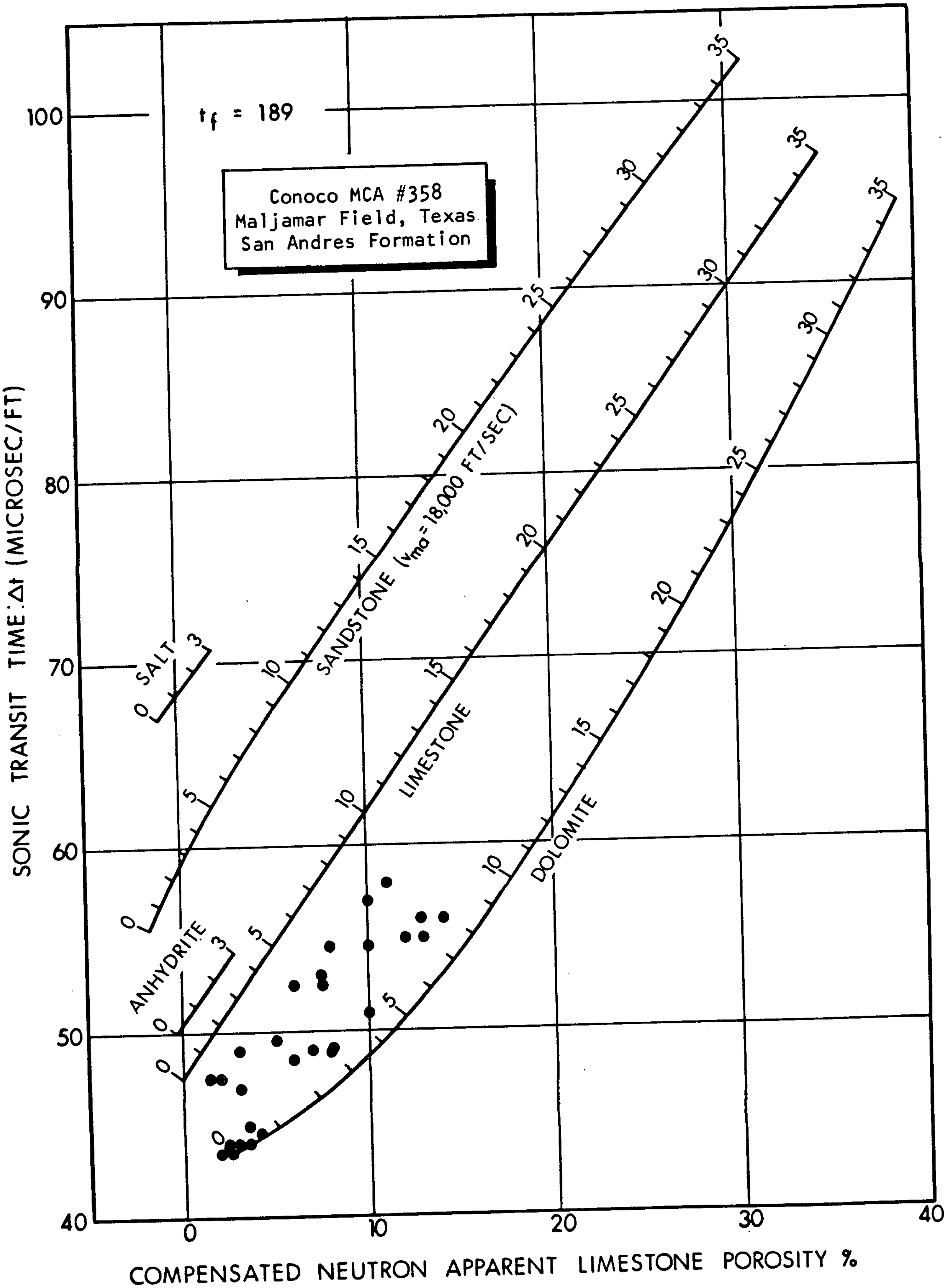


Figure 53.--Sonic-neutron cross plot, zone 7, cores 7-9.

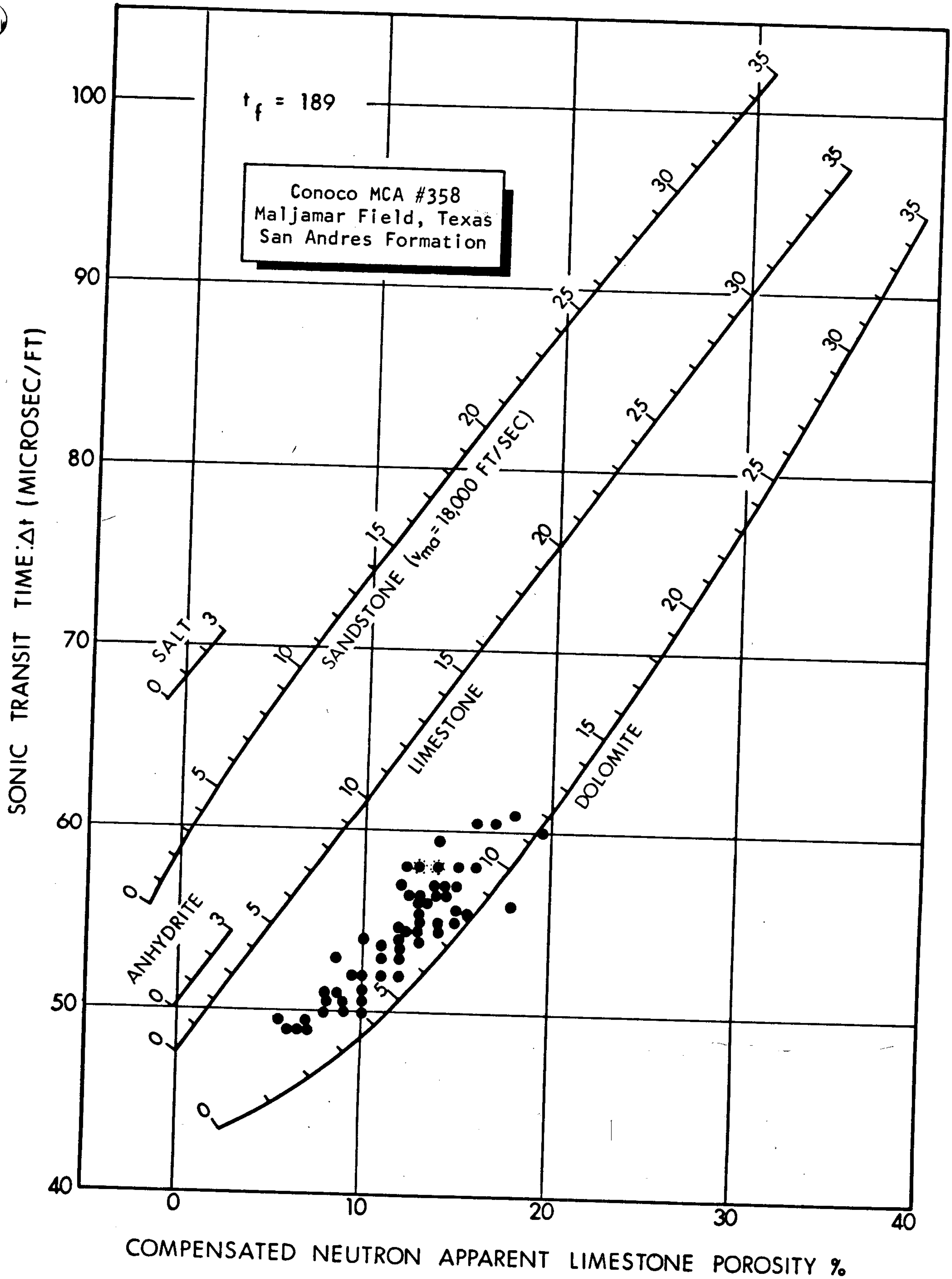


Figure 54.--Sonic-neutron cross plot, zone 9, cores 10-18.

The indexing procedure for the MCA No. 358 assumes a pseudo-dolomite matrix with shale volumes ranging from zero to 30 percent.

Water saturations can be computed from the resistivity index:

$$(S_w)^n = R_0/R_t, \tag{7}$$

where S_w = water saturation (fraction),
n = saturation exponent,
R_0 = resistivity of water zone at 100% water saturation (ohm-m),
and R_t = true resistivity of zone being evaluated (ohm-m), as taken from the log.

R_0 may be estimated for any core using the equation:

$$R_0 = FR_w, \tag{8}$$

where $F = a/\emptyset^m$,
a = constant,
$\emptyset$ = porosity (fraction),
R_w = resistivity of formation water,
and m = cementation factor.

Combining Equations 7 and 8 yields the general expression for water saturation calculations:

$$(S_w)^n = aR_w/(\emptyset e^m R_t), \tag{9}$$

Given core water saturation, core porosity, and resistivity from the log, the values for R_w, a, m, and n can be determined. Conoco's analysis of water produced during swab tests gave R_w values for the sixth and ninth zones of 0.165 ohm-m and 0.35 ohm-m, respectively. After obtaining these values it was necessary to determine the remaining unknown parameters (a, m, and n).

It is generally accepted[14] that $a = 1$ for carbonate reservoirs. The values of m and n must be determined. For consolidated and reef carbonates the value of n can range from 2.2 to 2.4. The exponent n for most formations is assumed equal to 2; for oil-wet formations n may be as high as 4.

As a first approximation, the value of n was taken to be 2 and the value of m was determined. It can be shown that a log-log plot of $(S_w)^n R_t$ versus porosity has an intercept of (aR_w) and a slope of m. The core water saturation, core porosity, and log resistivity are plotted in Figure 55 for the First Porosity zone. This plot has a linear-regression fit with a slope of 2.2. The same technique was used for the Main Pay data shown in Figure 56, which has a linear-regression fit with a slope of 2.4. These values of m for the First Porosity and Main Pay agree well with values found in the literature.

A final cross-plotting technique was applied to approximate the value of n. Equating the cementation factor m and the saturation exponent n,

$$(\phi S_w)^n = aR_w / R_t. \tag{10}$$

It can be seen from Equation 10 that a log-log plot of (ϕS_w) versus R_t has an intercept of (aR_w) and a slope of n. Cross-plots of the core bulk water (ϕS_w) versus log resistivity R_t indicated that the cementation factor m and the saturation exponent n could be equated and determined by regression. This technique resulted in a saturation exponent of 2.2 for the First Porosity zone and a value of 2.2 for the Main Pay. Figure 57 shows graphically the solution for the Main Pay. The final equations derived using core water saturation, core porosity, and log resistivity are given below (Eq(s). 11 and 12). Equation 11 was used for First Porosity zone computations and Equation 12 for Main Pay computations.

$$S_w^{2.2} = 0.35/(\phi_e^{2.2} R_t) \tag{11}$$

$$S_w^{2.2} = 0.165/(\phi_e^{2.2} R_t). \tag{12}$$

The flow chart shown in Figure 58 gives the procedure used in the log analysis. The computed effective porosities and water saturations are presented in Figure(s) 59 and 60, along with the core data for comparison.

Core porosity data agree well with computed log values, while water saturation core data and computed log data agree fairly well from 3,692 to 3,712 feet, poorly from 3,712 to 3,820 feet, and in a general way from 4,035 to 4,107 feet. Computer log analysis techniques incorporating the a, m, and n values obtained from Core Laboratories did not agree as well as the analysis results shown in Figure(s) 58 and 59.

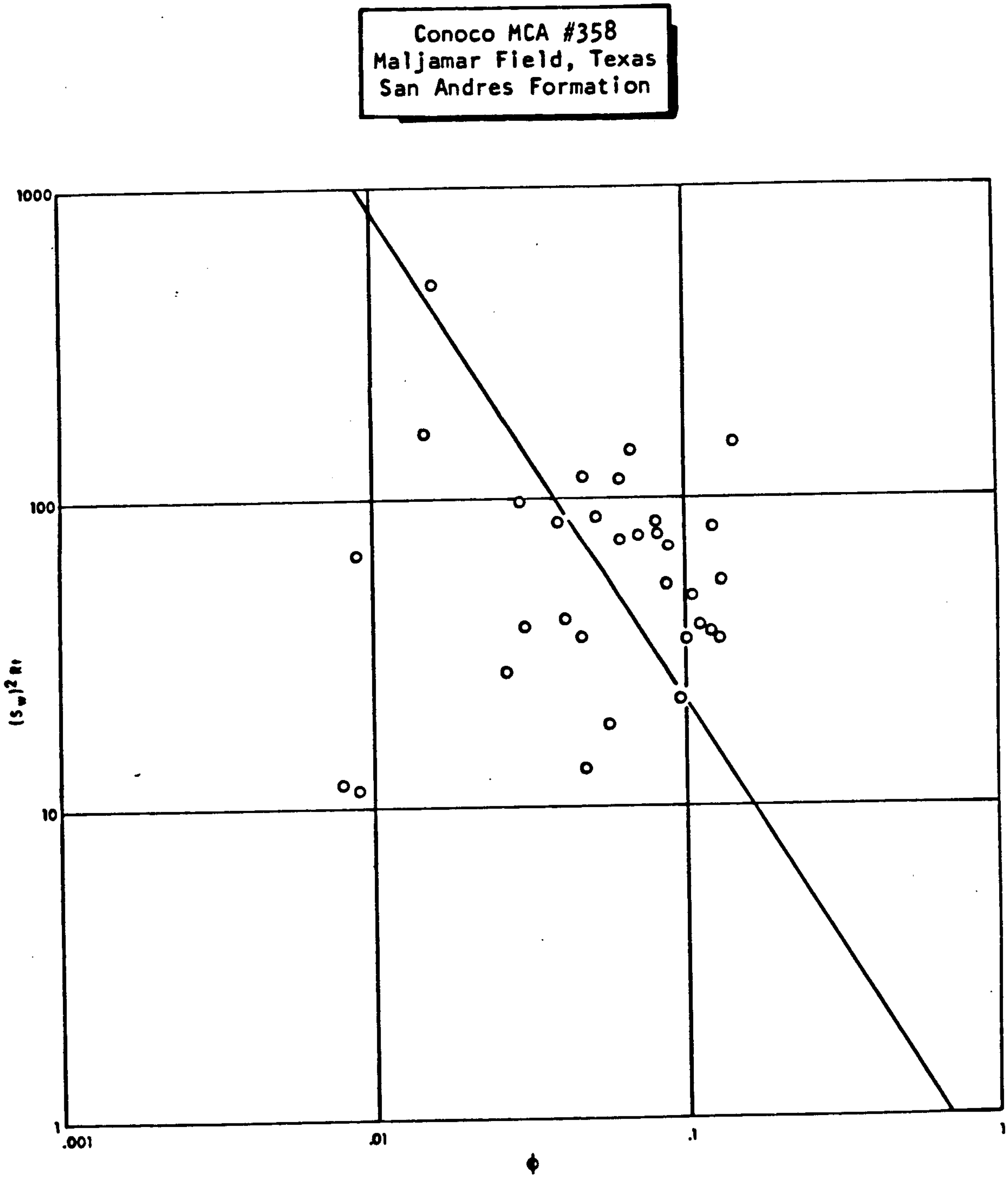


Figure 55.--$(S_W)^n$ Rt versus porosity, zone 6, cores 1-6.

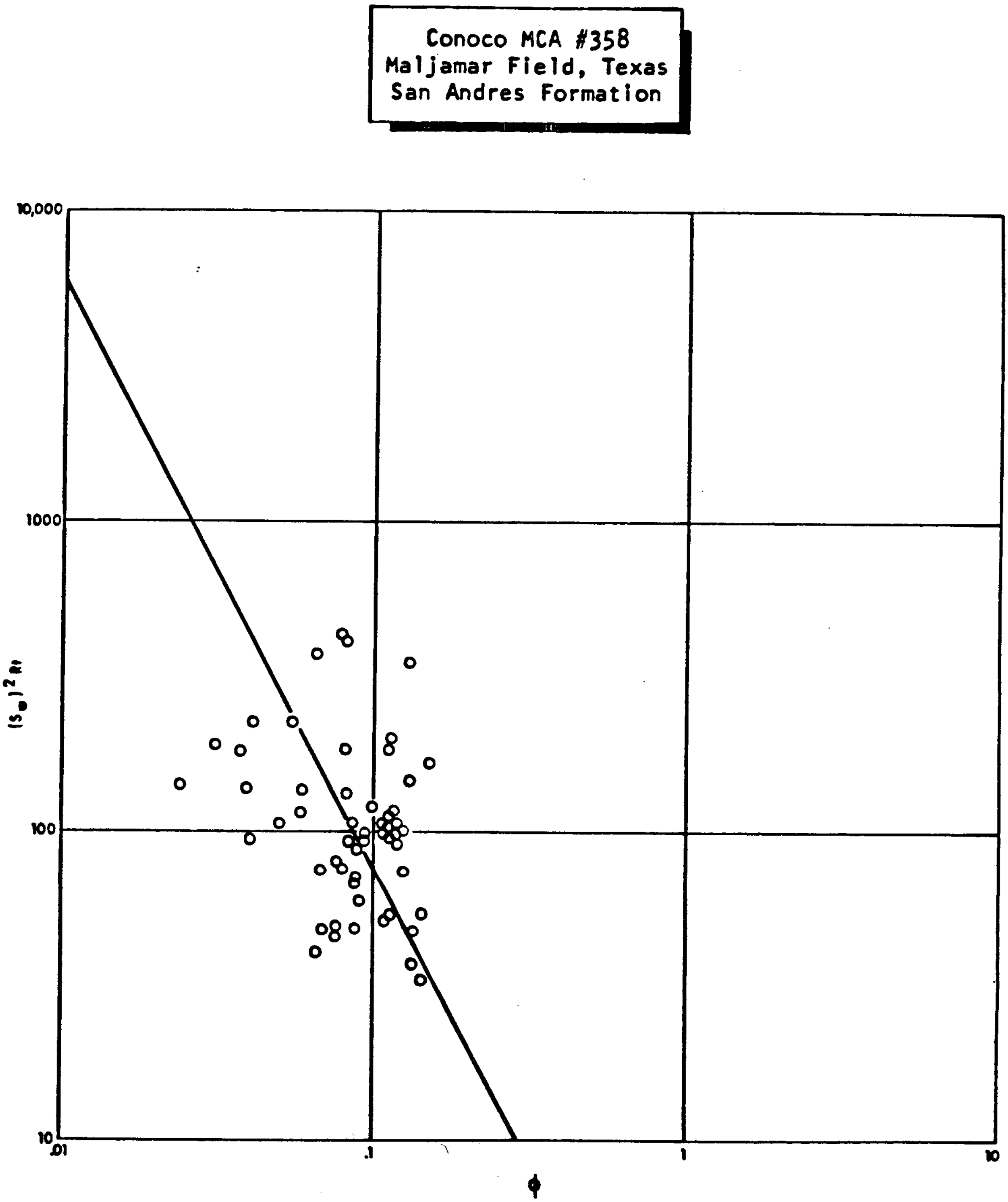


Figure 56.--$(S_w)^n$ Rt versus porosity, zone 9, cores 10-18.

Conoco MCA #358
Maljamar Field, Texas
San Andres Formation

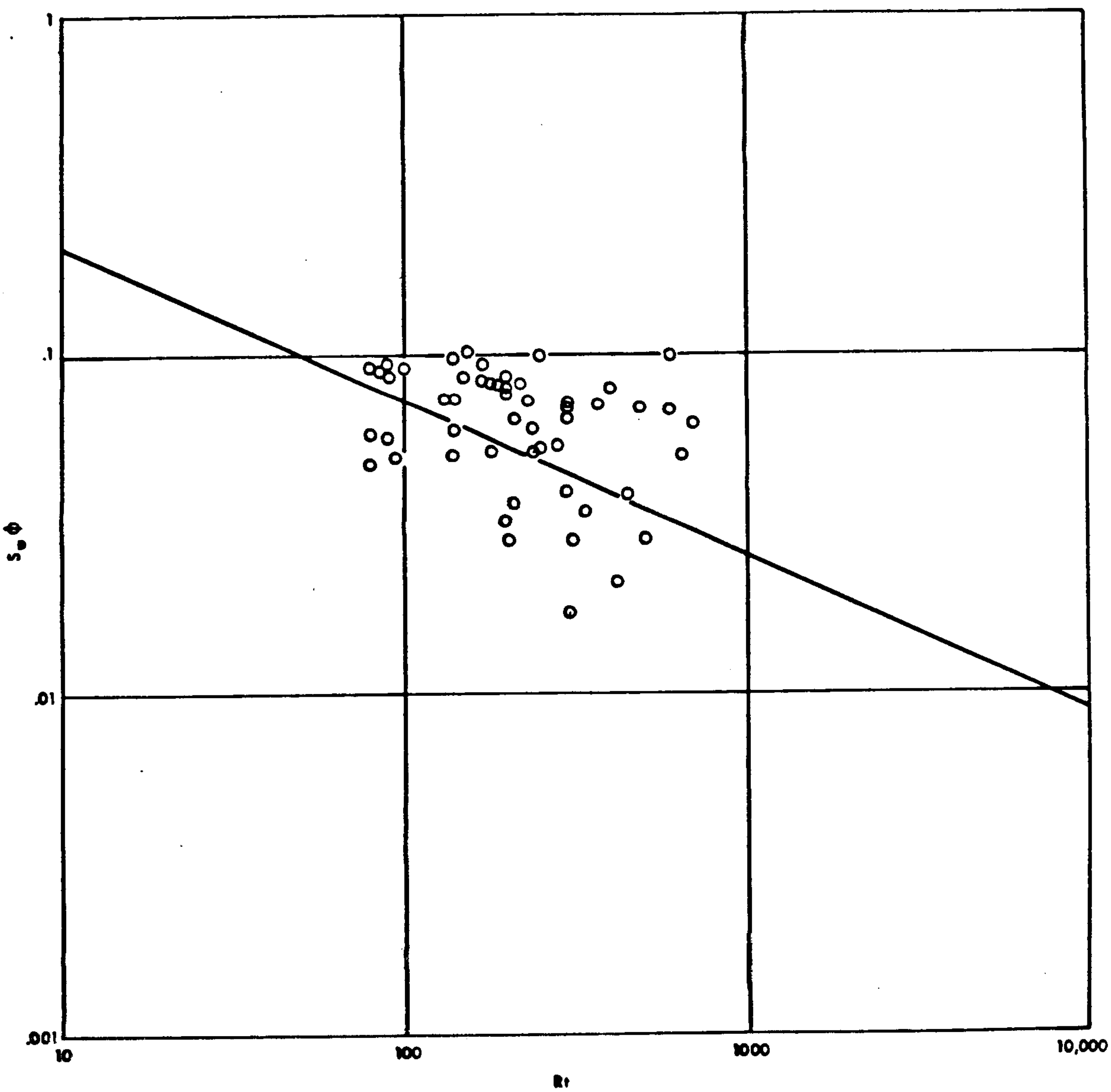


Figure 57.--Bulk core water versus log resistivity, main pay, cores 10-18.

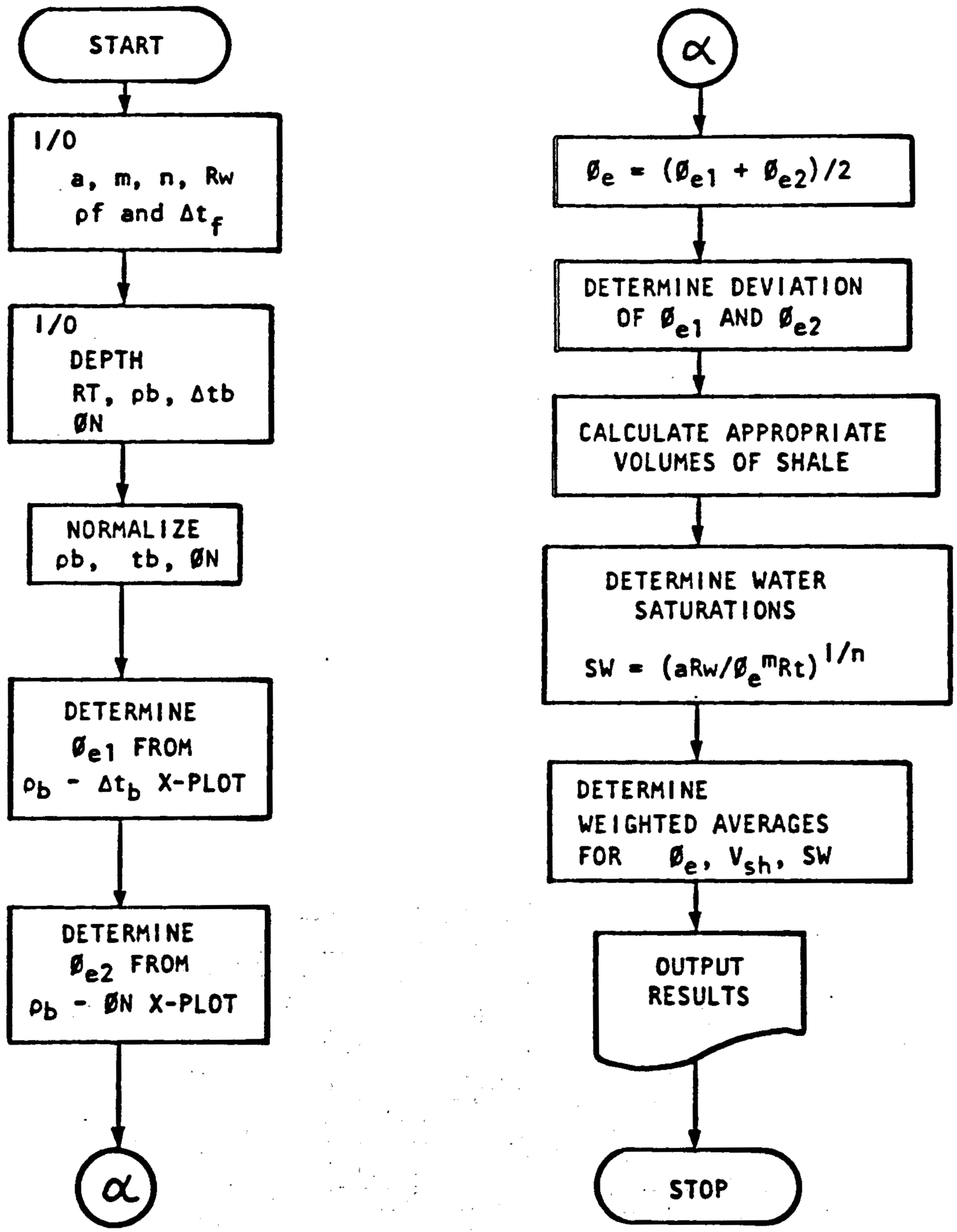


Figure 58.--Flow chart for log analysis procedures.

Conoco MCA #358
Maljamar Field, Texas
San Andres Formation

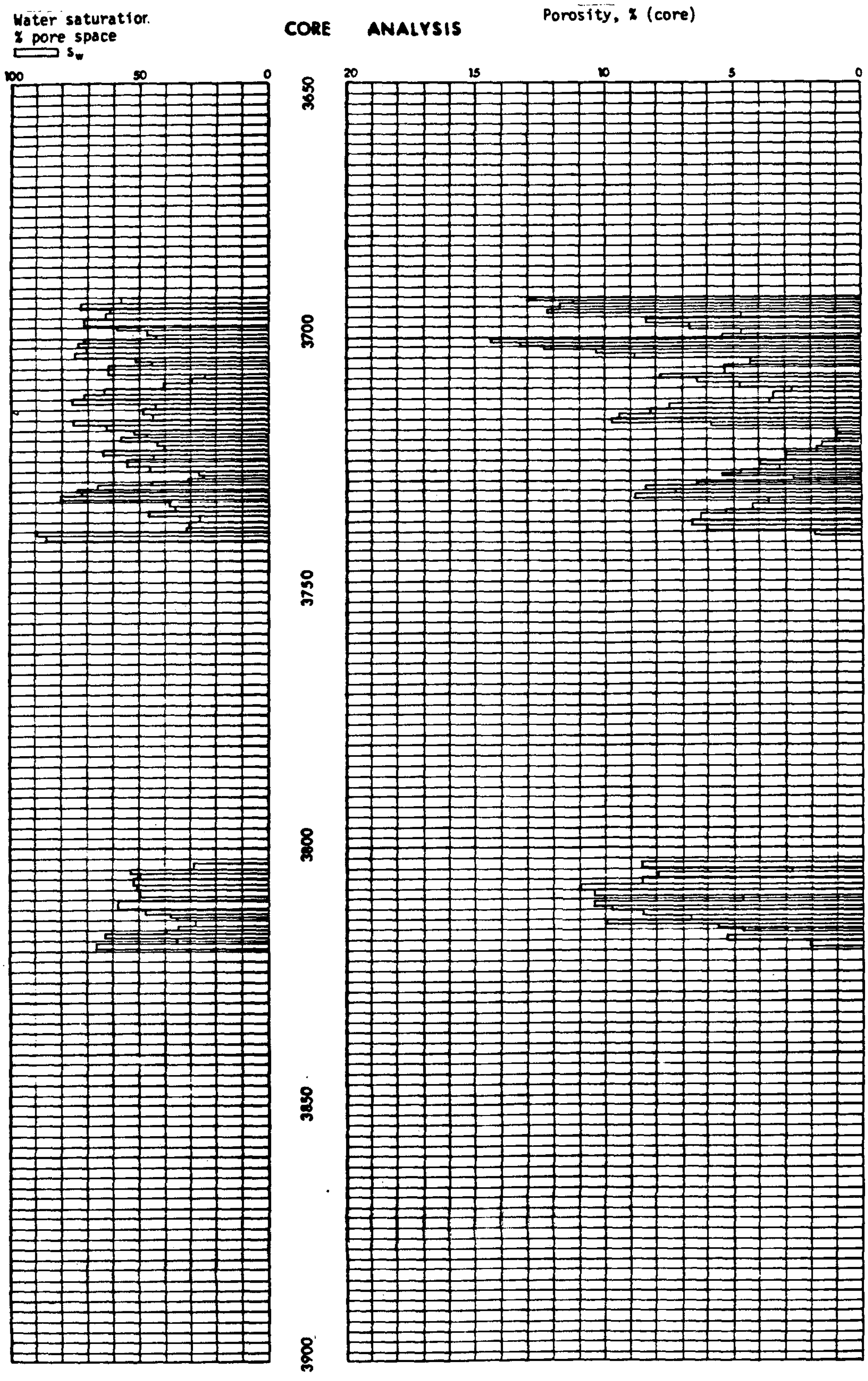


Figure 59.--Comparison of core and log analysis.

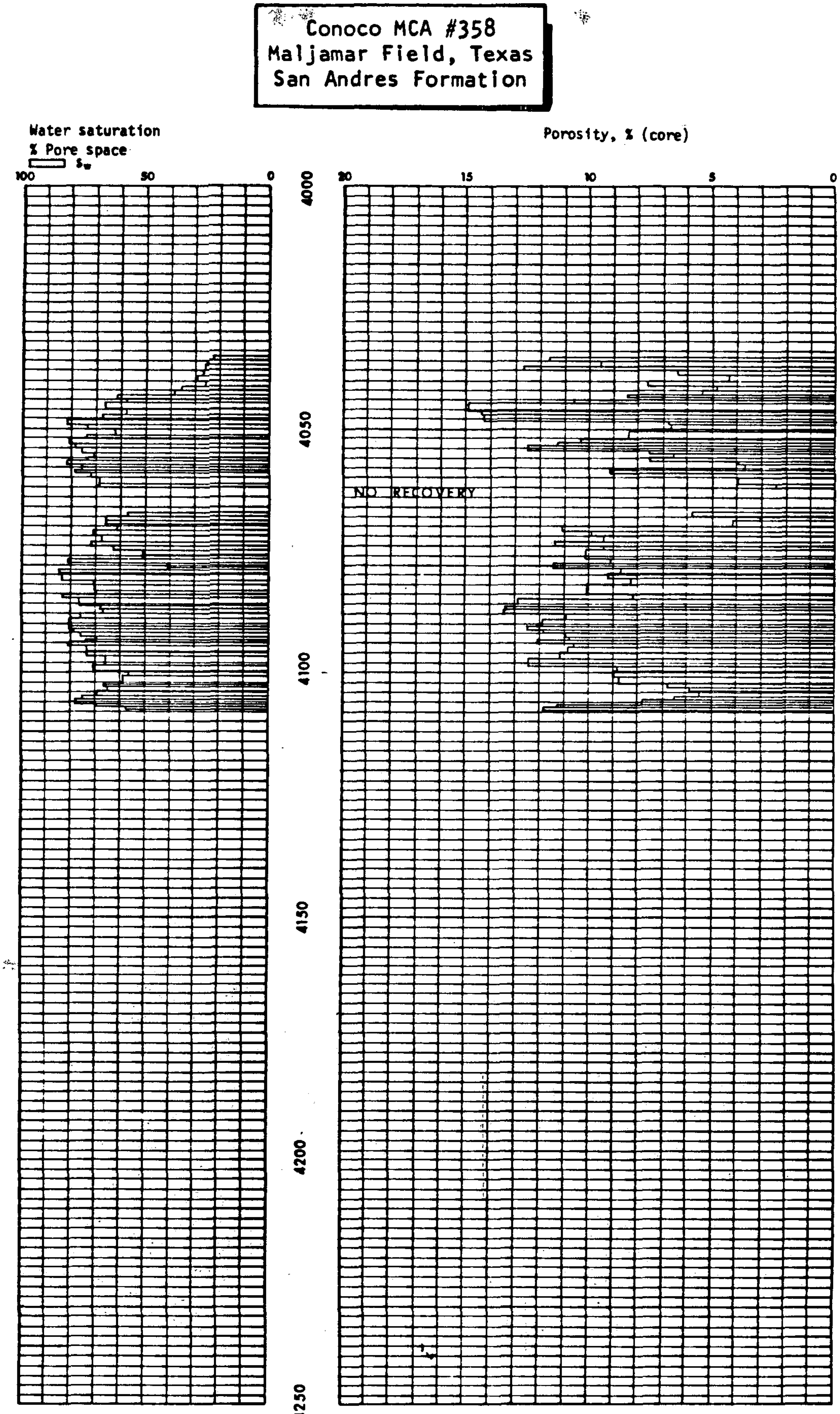


Figure 60.--Comparison of core and log analysis.

PRODUCTION TEST DATA

Production Data by Intervals

Production testing, supervised by Conoco, began in March 1980 and was completed the following October. Two intervals were separately swab-tested by selectively setting bridge-plug and packer combinations. The intervals were tested sequentially from deepest to shallowest, with results as follows:

Interval, ft	Swab test results
4,022-4,055	Rec. trace oil, 68 bbl fluid at rate of 10-12 bbl/hr
3,682-3,718	Swab tested water only

The test intervals are shown on the plots of depth versus pressure core analysis data (Fig(s). 61 and 62). The interval 4,022-4,055 ft is the main pay of the San Andres in the Maljamar field. Following swab-testing, both intervals were placed on production pump test. Average results from the last 72 hours of production testing were:

Interval, ft	Production test results
4,022-4,055	7 BOPD, 332 BWPD, 5 Mcf/D gas
3,682-3,718	Trace oil, 130 BWPD, TSTM gas.

Fluid Production from Computed Log Data

A plot of porosity versus water saturation can aid in determining the type of fluid expected to be produced. High volumes of bulk water ($\emptyset_e S_w$) are associated with water production, whereas low volumes are indicative of hydrocarbon production. Figure 63 is a plot of computed porosity versus computed water saturation. Since the product of porosity and water saturation is approximately constant for a homogeneous formation at irreducible water saturation then a hyperbolic curve for constant bulk water ($\emptyset S_w$ = constant) illustrates the expected production trends. Points falling above the curve should produce water; points falling below it should produce hydrocarbons. Average bulk water for both zones in the MCA 358 (Zone 9 = 0.057, Zone 6 = 0.049) is quite high. Production test data are consistent with this; both zones produced traces to small amounts of hydrocarbons.

Figure 64 is a plot of average computed porosity versus average computed water saturation. The hyperbolas shown are plots of average weighted porosity times 50 percent water saturation for each zone (average weighted bulk water saturation). Production trends for each zone are indicated by the distance above the lines for the respective zones. Production potential is inversely proportional to the height of a point above its respective line. Zone 6, which produced no hydrocarbons, has an average water saturation 12 percent above that predicted by its hyperbola, while Zone 9, which produced seven BOPD, has an average water saturation seven percent above that predicted by its hyperbola.

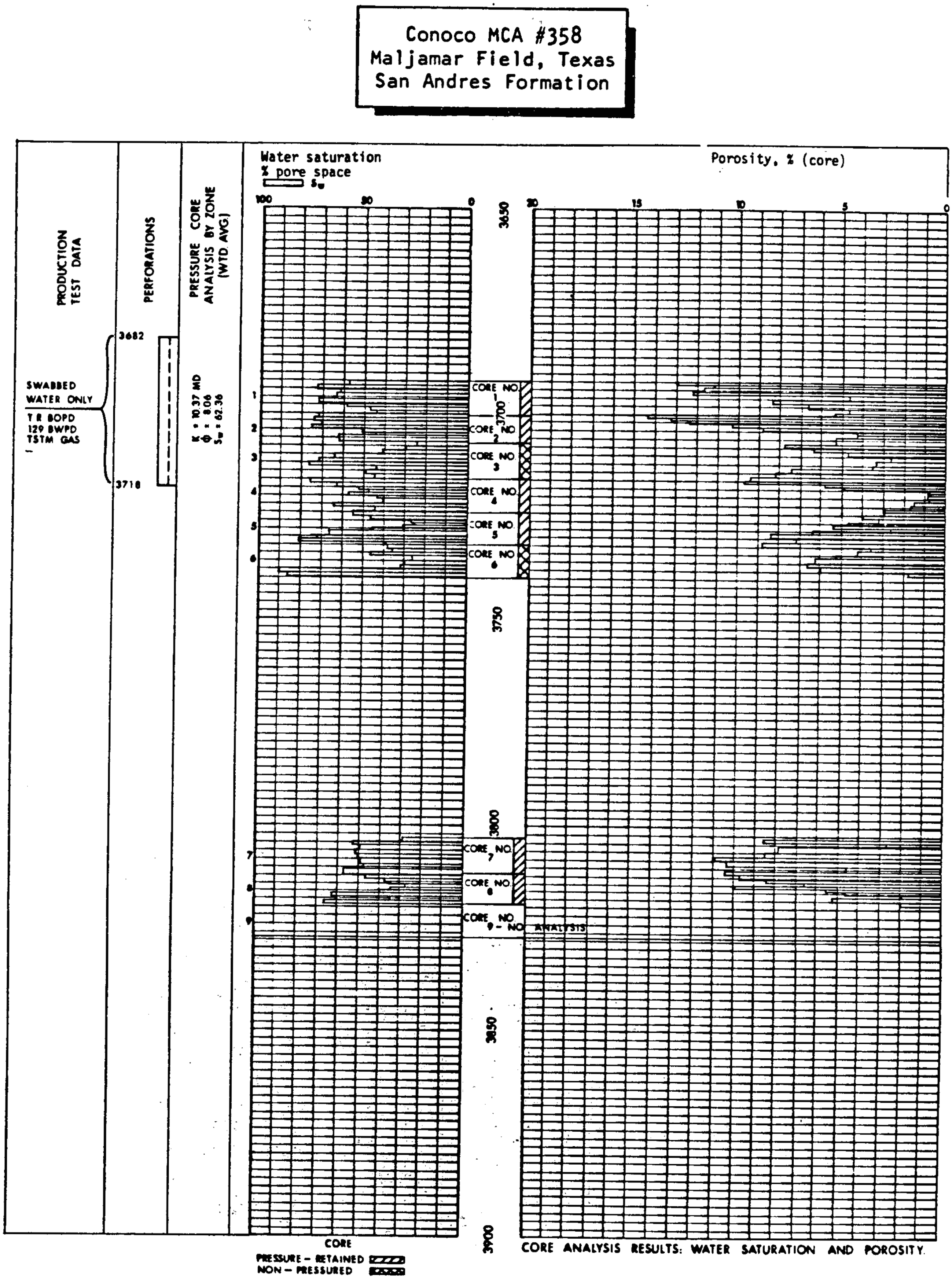


Figure 61.--Comparison of production test results and core analysis data.

Conoco MCA #358
Maljamar Field, Texas
San Andres Formation

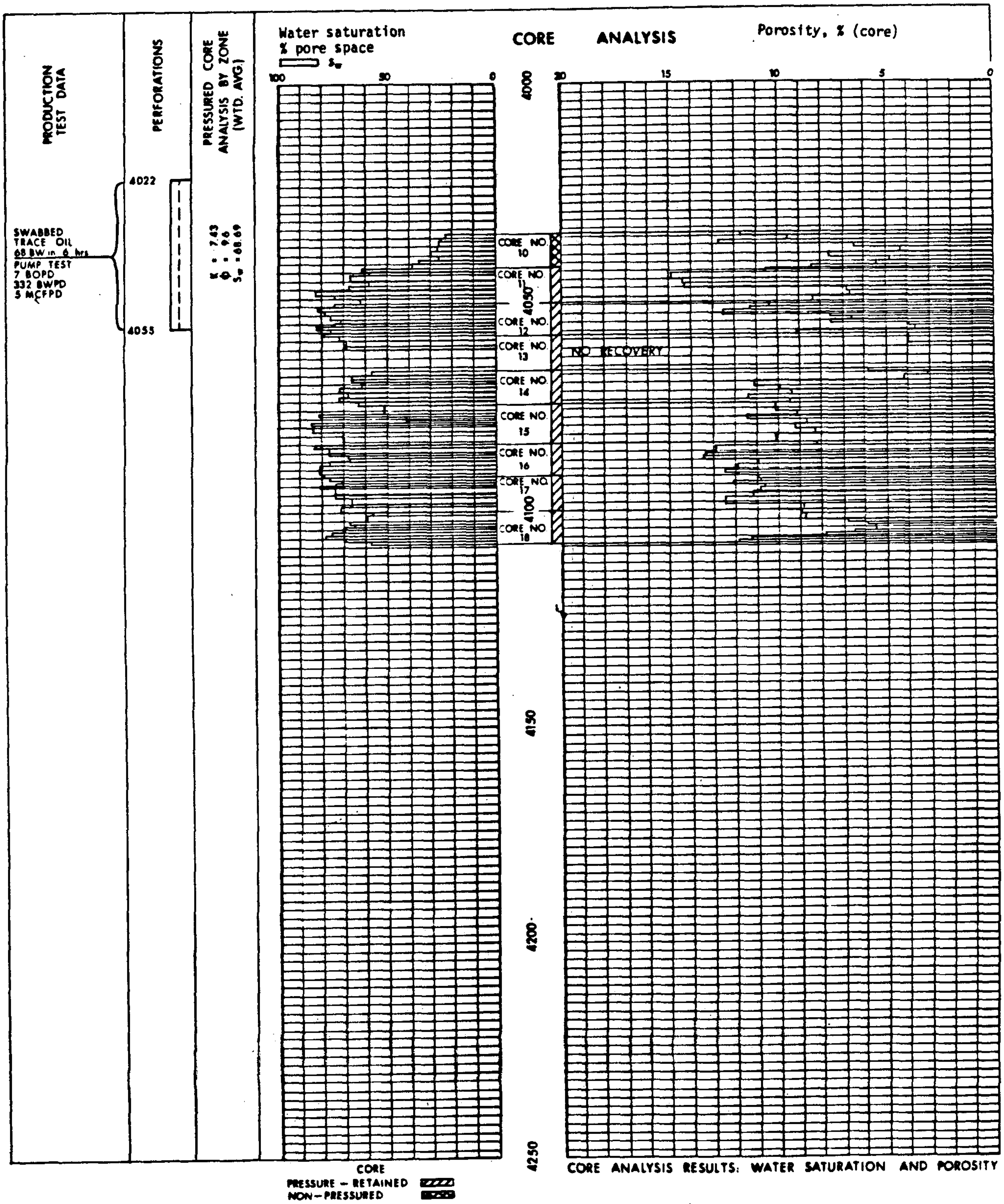


Figure 62.--Comparison of production test results and core analysis data.

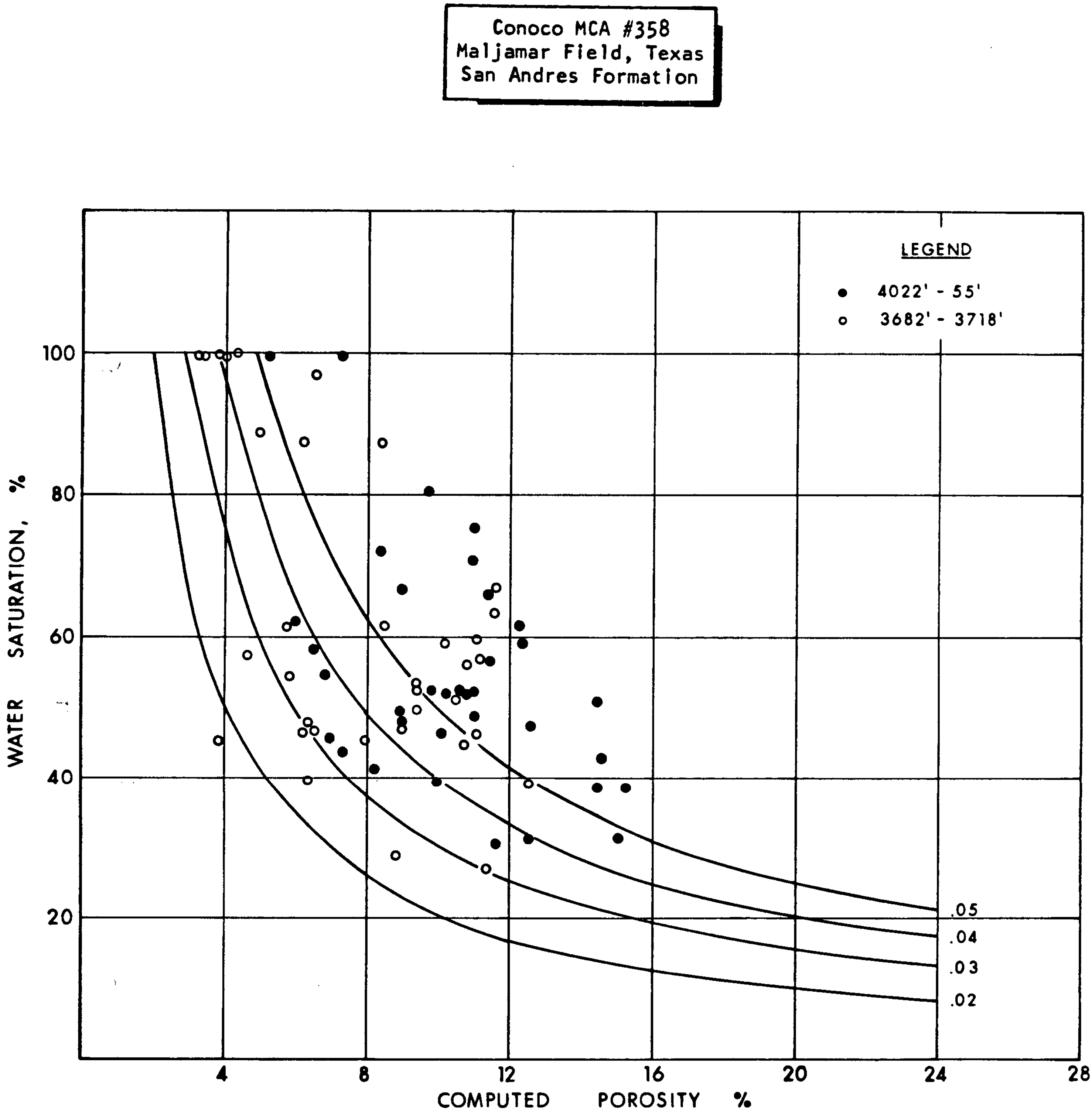


Figure 63.--Computed porosity versus computed water saturation.

Conoco MCA #358
Maljamar Field, Texas
San Andres Formation

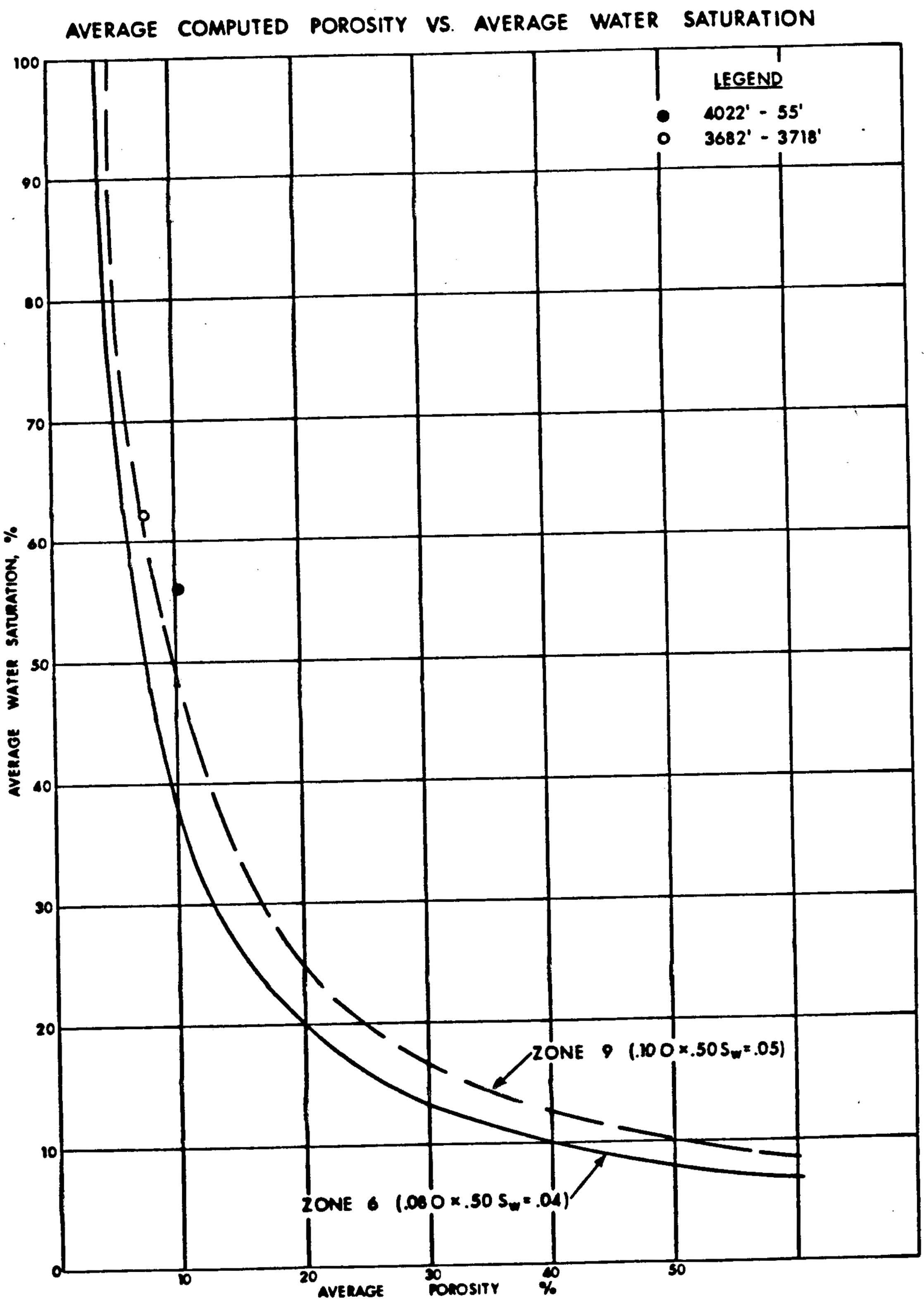


Figure 64.--Average computed porosity versus average water saturation.

SUMMARY OF CORE, LOG AND PRODUCTION DATA ANALYSIS

Production Test Data

Zone 9 (4,022 to 4,055 ft). This interval swab-tested 68 bbl fluid with a trace of oil at a rate of 10 to 12 bbl/hr.

Zone 6 (3,682 to 3,718 ft). This interval swab-tested water only.

Residual Oil Saturation from Core Data

The zone-by-zone production test data suggest both zones are near residual oil saturation. To aid in the determination of the residual oil saturation, the stock tank oil saturation produced by pressure depletion was plotted against the total stock tank oil saturation (Figure 65). The core data were plotted only for the perforated intervals. Conventional cores would have plotted at zero stock tank oil saturation produced by pressure depletion, represented by the dashed line. Neither zone shows appreciable amounts of oil available for pressure depletion, which is consistent with production tests.

The stock tank oil produced by pressure depletion is also referred to as "blowdown" oil. The percent blowdown oil versus water saturation is plotted in Figure 66 for both perforated zones. A definite trend exists between blowdown percent and water saturation. As the percent of blowdown oil decreases, the water saturation increases until the percent of blowdown oil reaches zero. At that point, residual water saturation after waterflood may be determined as $S_{or} = (1 - S_{wr})$. Analysis of the Main Pay defined an average blowdown of 5.1 percent. Using the trend line in Figure 51, residual water saturation after waterflood is estimated at 76 percent. The 5.1 percent average blowdown value and 64 percent water saturation is very close to calculated residual waterflood conditions, which is consistent with production test results.

The following table summarizes the estimates of residual water and oil saturations for the two zones, as determined from core data.

Zone	Depth, ft	Residual saturation, % water	Residual saturation, % oil
9th	4,044-4,055	64	36
6th	3,692-3,718	65	35

Conoco MCA #358
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San Andres Formation

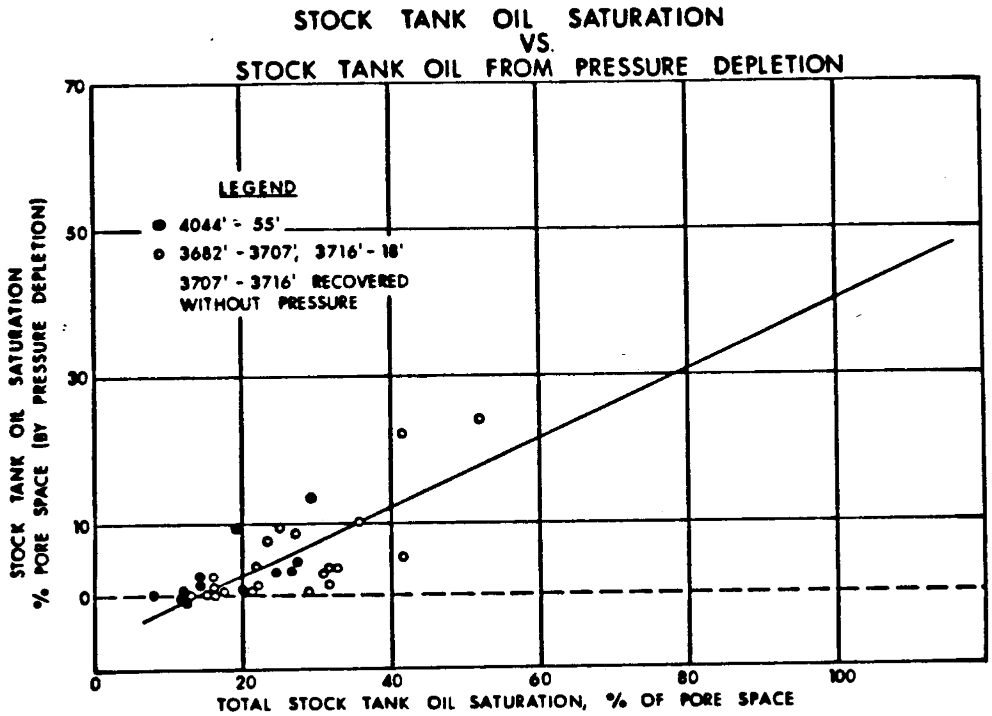

Figure 65.--Stock tank oil saturation cross-plot.

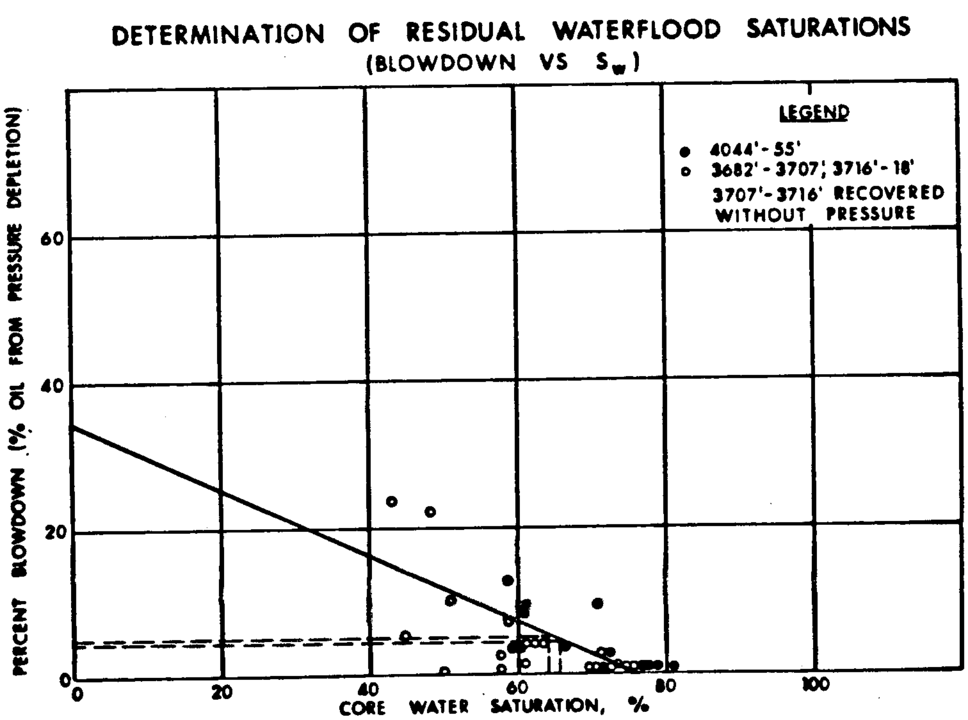

Figure 66.--Determination of residual waterflood saturation.

SUMMARY AND CONCLUSIONS

Field operations for pressure coring in the MCA No. 358 required some 8-1/2 days, during which 18 pressure core barrel runs were made. Eighteen cores amounting in all to 144 feet of Grayburg and San Andres formations were recovered in the intervals from 3,692 to 3,740 feet, 3,803 to 3,827 feet, and 4,035 to 4,108 feet. To conduct pressure coring operations, hole stability considerations required that the well design provide for 10-3/4-inch casing set and cemented in the Grayburg at 3650 feet. No operational difficulties due to pressure coring were experienced.

Of the 18 core-barrel runs that recovered core material, 14 recovered cores under pressure, a 78 percent success ratio. Failure to obtain pressured cores in the remaining runs was attributed to the core blocking the ball valve in three cases and to malfunction of the ball valve in one case. In one instance the ball valve was blocked by a core almost a foot longer than the 8-foot limit. This emphasizes the need for careful kelly and pipe measurements during on-bottom coring operations.

Evaluation of the well through use of pressure cores, wireline logs, and production testing was fairly consistent. Core and log analysis for the tested intervals indicated high water saturations with little or no mobile oil in both zones. The well was completed and production test data indicated only small amounts of produced oil, as has been tabulated in the previous section. These data are consistent with log and core analyses and indicate that waterflood is largely complete in the Sixth and Ninth zones.

Pressure cores were taken in these zones to assess the amount of immobile (to water) oil saturation and the potential of CO_2 displacement for recovering the oil present. Figure(s) 67 and 68 are plots of bulk residual oil saturation ($S_{or} \cdot \emptyset$) versus depth opposite a plot of maximum horizontal permeability versus depth. As bulk oil saturation is proportional to the residual oil saturation per acre-foot by a factor of 7,758 B/AF, the plot of bulk oil saturation may be used to delineate zones with the best potential for carbon dioxide flooding. The intervals 3,692 to 3,718, 3,803 to 3,820, and 4,035 to 4,055 feet are zones more than 10 feet thick having bulk oil saturations well above the mean. The interval 3,803-3,820 feet presents a smaller target than indicated by bulk oil saturation alone, since permeabilities less than 5 md effectively reduce the interval to five feet (3,807 to 3,813 feet). The remaining intervals (3,692 to 3,718 and 4,035 to 4,055 feet) have permeabilities high enough to permit production from the entire interval. Results of oil-in-place calculations for these zones using core data are:

Depth, ft	Interval	Current oil in place
4035-4055	Ninth zone	259 STB/acre-ft
3692-3718	Sixth zone	150 STB/acre-ft

If a residual oil saturation to carbon dioxide flooding of 10 percent is assumed, Zones 9 and 6 contain "target" oil for carbon dioxide flooding

Conoco MCA #358
Maljamar Field, Texas
San Andres Formation

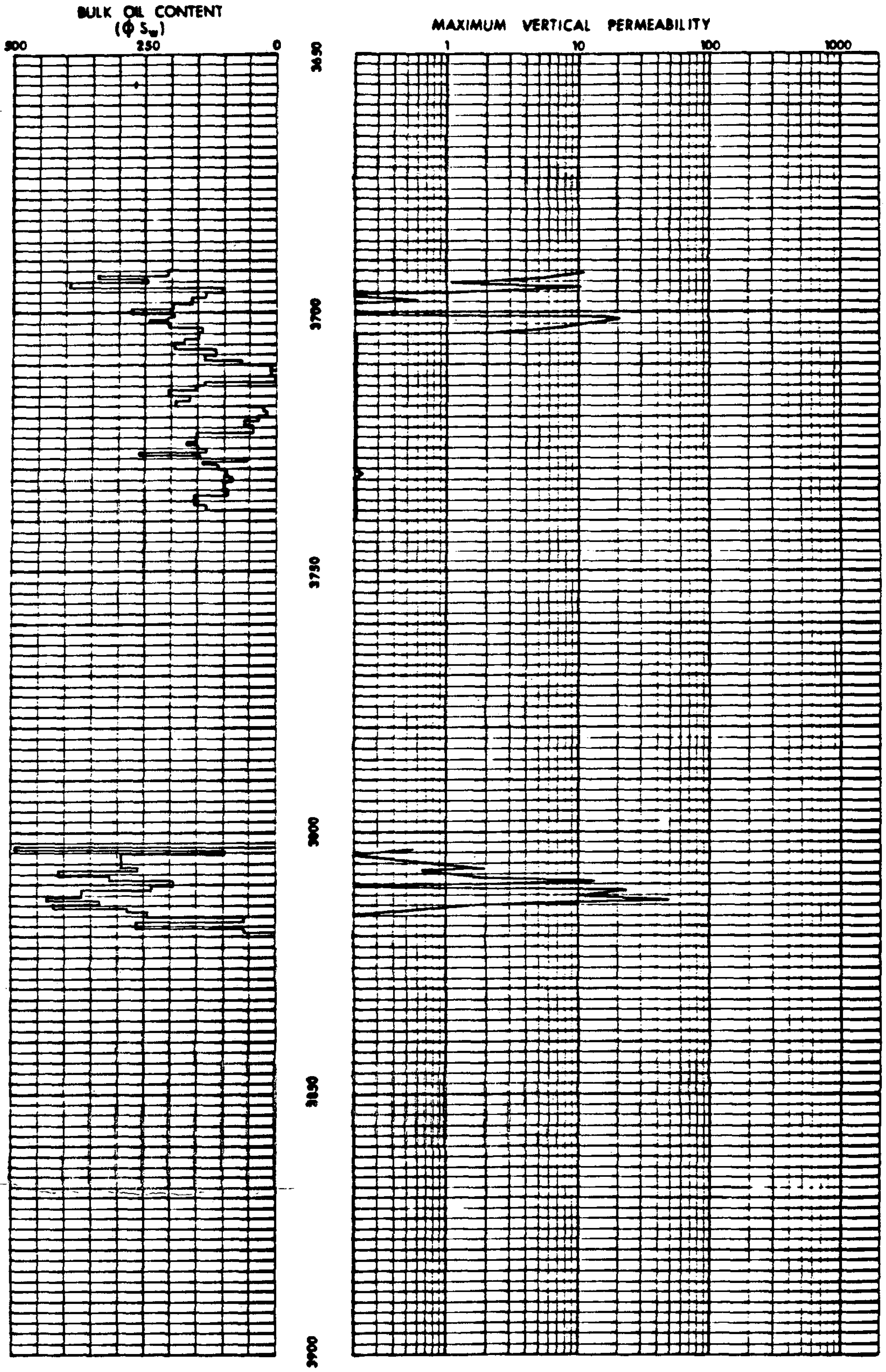

Figure 67.--Bulk residual oil saturation and maximum horizontal permeability versus depth.

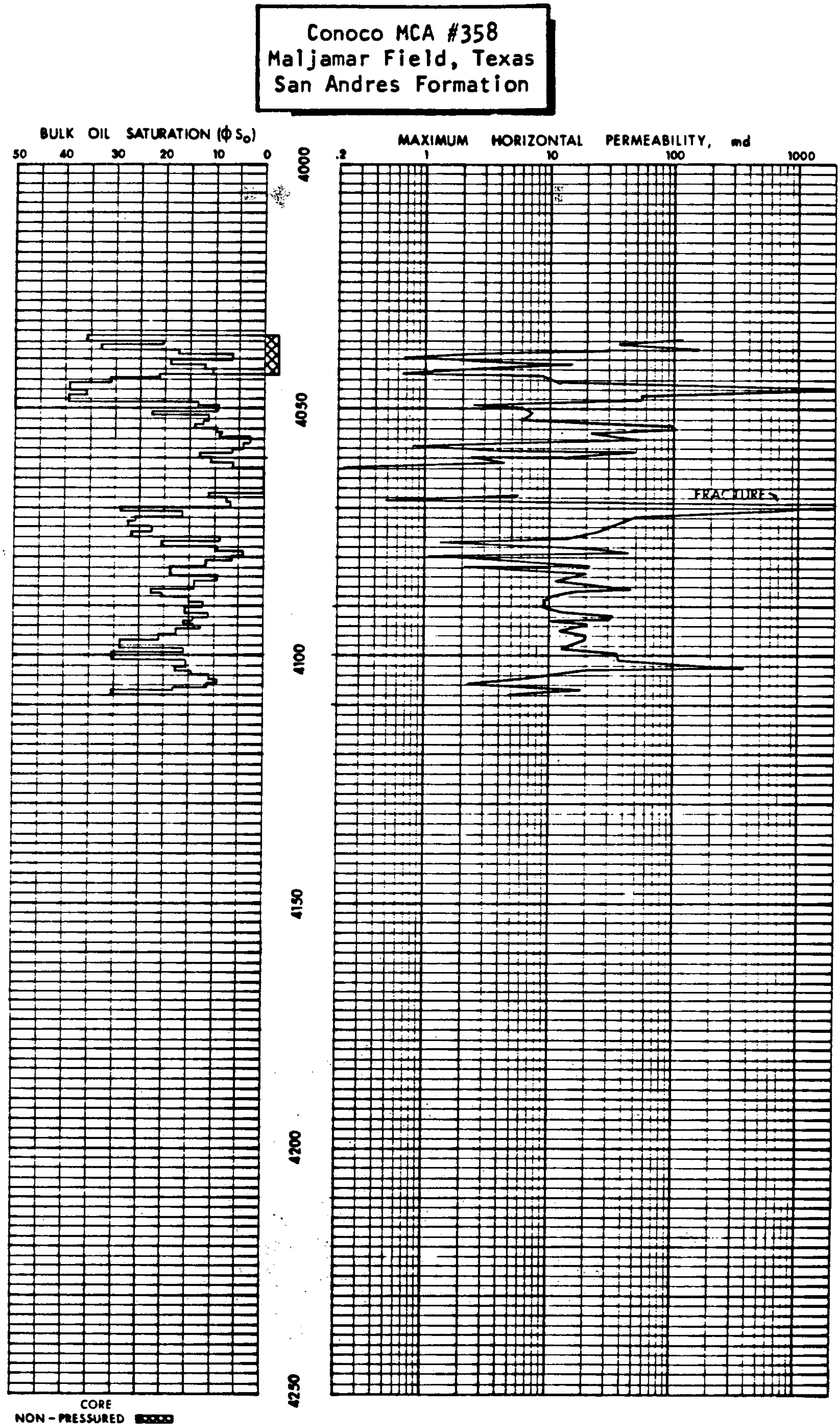

Figure 68.--Bulk residual oil saturation and maximum horizontal permeability versus depth.

averaging 233 and 135 stock tank barrels per acre-foot, respectively. Additional residual oil is seen from 4,067 to 4,775 foot and from 4,084 to 4,108 feet. Residual oil saturation at present is calculated for these intervals as an average 131 STB/acre-foot. If residual oil saturation to carbon dioxide flooding of 10 percent is assumed, these intervals would add additional target oil for CO_2 flooding averaging 118 B/AF.

Standard log analysis did not provide accurate oil saturation data because of variable lithologies, R_w's, oil saturation, and wettability of the reservoir rocks. A foot-by-foot analysis and adjustment of these variables might improve calculated oil saturations, if collection of accurate values for the variables were practical. Substitution of Core Laboratories' experimentally derived values of a, m, and n for specific samples did not cause calculated water saturations (and hence residual oil saturations) to approach saturation values determined by direct measurement. Hence pressure coring provided data for evaluating residual oil saturation not obtainable by the other means used in this project.

Pressure coring offers a straightforward method of evaluating reservoirs for enhanced oil recovery projects. Not only does it provide the means of determining residual oil saturation, but it also provides the means for determining permeability and zone isolation, which are also important factors in evaluating a reservoir for tertiary recovery. Pressure coring is a valuable complement to drilling, logging, and production data, useful to the engineer for determining realistic values for carbon dioxide project potential.

REFERENCES

1. "Target Reservoirs for Carbon Dioxide Miscible Flooding," contract no. DE-AC21-79MC08341 between U.S. Dept. of Energy and Gruy Federal, Inc., Feb. 12, 1979.

2. "Target Reservoirs for Carbon Dioxide Miscible Flooding," request for proposal no. EW-78-R-05-8341, U.S. Dept. of Energy, Oak Ridge Operations Office, May 15, 1978.

3. Letter, DOE to Gruy Federal, Inc. transmitting fully executed contract, March 9, 1979.

4. Letter, DOE to Gruy Federal Inc., subject: contract no. DE-AC21-79MC-08341, March 15, 1979.

5. Personal communication from Conoco.

6. Letter, Conoco to Gruy Federal, Inc., submitting MCA unit as possible pressure-coring site.

7. Gruy Federal, Inc.: "Specific Site Report -- Conoco, Inc. MCA Unit No. 358 Well -- Pressure Coring Proposal," submitted to U.S. Dept. of Energy, Morgantown Energy Technology Center, Nov. 5, 1979.

8. Letter, DOE to Gruy Federal, Inc., subject: DOE Contract No. DE-AC21-79-MC08341, Proposed Well Site Plan, Jan. 7, 1981.

9. Personal communication from Conoco district engineer.

10. Doscher, T. M., and Wise, F. A.: "Enhanced Crude Oil Recovery: An Estimate," J. Pet. Tech., May 1976.

11. Swift, T.: "Summary of Pressure Coring Operations, Conoco, Inc. MCA No. 358, Lea County, New Mexico," interoffice memo to J. H. Goodrich, April 24, 1980.

12. Winn, R. H.: "Log Interpretation in Heterogeneous Carbonate Reservoirs," Trans., AIME, 210, 1957.

13. Schneider, F. N., and Owens, W. W.: "Relative Permeability Studies of Gas-Water Flow Following Solvent Injection in Carbonate Rocks," Trans., AIME, 258 (1976).

14. Fons, L. C., et al.: "Formation Evaluation Data Handbook," Gearhart-Owens Industries, Inc., 1976.

GRUY FEDERAL, INC.

ENCLOSURE I - 1

"TARGET RESERVOIRS FOR
CARBON DIOXIDE MISCIBLE FLOODING"

Contract No. DE-AC21-79MC08341

APPENDIX A
STATEMENT OF WORK

1.0 OBJECTIVE

1.1 The objective is to build a solid engineering foundation upon which field mini- and pilot tests may be conducted in both high and low oil saturation carbonate reservoirs for the purpose of extending the technology base in carbon dioxide miscible flooding.

2.0 SCOPE OF WORK

2.1 Summary of Available CO_2 field Test Data

Data will be collected, categorized and interpreted from all significant past and on-going CO_2 field operations in order to evaluate the relative success of each test. This information will include oil gravity, reservoir pressure, depth, temperature, porosity, permeability, and net/gross pay. Also, these data must include pattern size, estimated incremental oil production due to CO_2 injection, CO_2 concentration and slug size, CO_2 injection rates and sequencing, CO_2 breakthrough and production rates, and any indications of formation damage or corrosion.

2.2 Summary of Existing Reservoir and Geological Data

The following reservoir geology will be determined on carbonate reservoirs located in west Texas, southeast New Mexico, and the Rocky Mountain states: stratigraphy, structure, mineralogy, porosity, permeability, gross and net thickness, and any other geological properties deemed significant regarding CO_2 injection. Reservoir data will be collected on hydrocarbon content, composition and distribution; connate water content and composition; pressure and production data from primary and/or secondary recovery operations; PVT analysis; and well test data and analysis. Guidelines for selecting reservoirs to be included are as follows:

Average formation permeability -	$\geqq$ 5 md
Average current oil saturation -	$\geqq$ 38%
Oil gravity --------------------	$\geqq$ 36 deg API
Oil viscosity ------------------	$\geqq$ 10 cp

In addition, no extremely high-permeability, stratigraphic, thief zones should exist. However, no consideration should be given to the proximity of CO_2 sources at this point. The objective here is to "characterize the resource" for possible future CO_2 injection.

2.3 Selection of Target Reservoirs

By analyzing available reservoir and geological data, and comparing the results of various CO_2 field tests, a priority list will be developed based primarily on potential incremental oil recovery and the projected CO_2 requirements and availability. CO_2 requirements can be based on estimates from data collecteds in Task 1 and CO_2 supply data can be obtained from existing public documents on the subject (e.g. "The Supply of Carbon Dioxide for Enhanced Oil Recovery: by Pullman Kellogg, September, 1977).

2.4 Selection of Specific Reservoirs for CO_2 Injection Tests

A selection will be made from the priority list based on demonstrating the technology in those reservoirs with the greatest potential influence toward stimulating new projects capable of meeting the 1985 incremental oil production of 124,000 barrels per day stated in the Technical Implementation Plan for reservoirs in these target areas. For the reservoirs selected, the owners and operators will be identified. Also, company officials who have the authority or influence to bring about commercialization of CO_2 recovery processes will be contacted. This is absolutely necessary since it is these companies which must eventually initiate and carry out commerical demonstrations of CO_2 injection if the full potential of the target reservoirs is realized.

2.5 Selection of Specific Sites for Test Wells (Carbonate Reservoirs)

Using all useful available knowledge from previous CO_2 field tests, reservoir and geological compilations, conventional production data, PVT analysis, log analysis, core analysis and well test analysis, specific sites will be selected for drilling test wells for further delineation and substantiation of the reservoir properties prior to conducting CO_2 injection tests. These sites must be in the Rocky Mountain and west Texas-southeast New Mexico areas. A minimum of eight and a maximum of twelve sites are to be selected.

2.6 Drilling and Coring Activities

Depending on the availability of data at each site selected, test wells will be drilled, cored, logged, tested and analyzed to confirm initial oil saturation parameters and to design mini-test CO_2 injection programs. It is expected that one test well will be drilled at each site selected. However, the exact number and location of wells to be drilled will be negotiated to be consistent with the amount of additional engineering and geological information required, drilling costs in the area at the time of execution, and any other economic and engineering factors that may arise.

GRUY FEDERAL, INC.

CONSULTANTS IN ENERGY SYSTEMS

July 11, 1979

2500 TANGLEWILDE, SUITE 150
HOUSTON, TEXAS 77063
713/785-9200

2001 JEFFERSON DAVIS HWY., SUITE 701
ARLINGTON, VIRGINIA 22202
703/892-2700

Mr. F. E. Ellis
Vice President North American Operations
Conoco, Inc.
P. O. Box 2197
Houston, Texas 77001

Dear Mr. Ellis:

Gruy Federal, Inc. ("Gruy") is party to a contract with the United States Department of Energy ("DOE") under which Gruy will manage a program to locate test sites having Enhanced Oil Recovery (EOR) potential in carbonate reservoirs in the Rocky Mountain and West Texas - Southeast New Mexico areas. The program will provide financial support for coring, logging and testing selected wells drilled on the identified and approved sites to evaluate the CO_2 flooding potential for possible pilot or full-scale projects. The program envisions taking cores through the reservoir intervals thought to have secondary or tertiary carbon dioxide flooding potential. The cores will be cut using a core barrel that will retain the cores under pressure for subsequent analysis in order to obtain a more direct measure of in-situ oil and water saturations as well as porosity and permeability for comparison with data obtained from a comprehensive suite of wire-line logs.

Gruy is seeking operators who plan, for their own purposes, to drill infill wells to or through reservoirs thought to have CO_2 flooding potential. These wells would be utilized to carry out the proposed coring and logging program.

For chosen and agreed upon well sites, subject to DOE approval, Gruy will separately contract and pay for all coring, core analysis, and logging services and also contract to pay directly for rig time, mud services, and all other related costs during the coring and logging operations. Gruy will provide a prognosis of the work to be done but ultimate control of all operations would remain with you.

If, for your purposes, the well is to be completed in the target reservoir, Gruy would propose to conduct or monitor production tests in order to obtain further data on the CO_2 flooding potential. During the period of those tests, Gruy would contract directly for workover rig services and any perforating, stimulation, and equipment services needed to obtain satisfactory test data. Design of these tests would be done by Gruy based on data from core and log analysis, and would be subject to your approval and control for execution.

In return for, and as an incentive to you for this use by Gruy of the operator's well, Gruy will provide timely copies of all logs, core analysis, and other data obtained. Gruy's interpretation of these data will ultimately be reported to the DOE in formal reports that also will be supplied to you.

Gruy will have no interest in the well, in the leases or in any production therefrom. You are under no obligation to either Gruy or DOE to consider CO_2 flooding now or in the future.

Upon selection by Gruy, and approval by the DOE, Gruy will provide experienced engineering and drilling personnel to work with your technical or operating staff in both the planning and execution phases. Gruy will designate the coring point and select the coring and logging service companies to be used on the project. Such companies will be approved by you. You will be under no obligation other than to make a good faith effort to carry out the designated coring and logging program in accordance with established oil field procedures and a plan provided by Gruy.

The Gruy Companies have been in the energy consulting business since 1950. Professional services rendered in the private sector and for governmental agencies range from energy related research and planning to estimating reserves and forecasting future production. Gruy also evaluates drilling prospect plans from the exploration phase through final development. In a management capacity, it drills and operates fields for its clients.

Gruy will stand between you and the DOE and be responsible for any and all contacts and communications with the DOE.

Attached to this letter, as Exhibit A, is a brief summary of the "Target Reservoirs for Carbon Dioxide Flooding" project, which outlines the proposed program. An objective of the program is to find ways of making carbon dioxide flooding more economically viable for application by private industry. In assisting with the program, you will receive data that perhaps may allow you to benefit in your own operations and planning.

If your company is interested in participating in this program, we can meet with your staff to discuss details as needed.

Very truly yours,

Richard J. Dobson
Vice President, Operations

RJD:cas
Attachment

cc: Mr. John H. Goodrich

GRUY FEDERAL, INC.

WELL USE/OPERATOR AGREEMENT CONTRACT NO. 27-109

CONOCO, INC.

This Contract is made and entered into effective the 14th day of January 1980, between GRUY FEDERAL, INC., 2500 Tanglewilde, Suite 150, Houston, Texas 77063, hereinafter called "GRUY", and CONOCO, INC., 5 Greenway Plaza East, Houston, Texas 77046, hereinafter called "CONOCO".

In consideration of the mutual promises hereinafter contained, both parties agree that this Contract will be performed in accordance with the following conditions:

I. SCOPE OF WORK

GRUY is a party to a Contract, No. DE-AC21-79MC08341, with the United States Department of Energy, to pressure core, log, and evaluate wells, at various sites, having potential for CO_2 flooding and enhanced oil recovery. As CONOCO is drilling a well, MCA Unit No. 358 located 660' FEL and 2600' FWL of Sec. 20, T-17S, R-32E, Maljamar Field, Lea County, New Mexico which exhibits such a potential, CONOCO agrees to cooperate with GRUY in the drilling, pressure coring, logging and evaluation of said well. CONOCO shall remain the "OPERATOR", and have sole control, direction, and responsibility during the required operations. GRUY shall have the right to have engineers, drilling supervisors and geologists on site to observe and to consult with CONOCO on the various operations, to concur on the coring point; and GRUY shall select, contract, and pay for the pressure coring services, radioactive tracer services and other required services and materials during the coring and logging operations

CONOCO agrees to start the actual drilling of the well, on or about 14 January 1980, and thereafter to continue drilling of said well with due diligence, dispatch and in a workmanlike manner in accordance with the below:

A. Drill a 20" hole to 750', set 16" surface casing and cement to surface.

B. Drill a 14-3/4" hole to 3650', run open hole logs up to base of salt, set 10-3/4" production casing and cement to surface.

C. Selection of pressure coring intervals; ream hole to 8-3/4", log open hole, and set a 7-5/8" liner from 3600' to 4150'.

D. Act as Operator and provide supervision to accomplish the logging and coring programs as established by GRUY.

E. Consult with GRUY on all significant operations.

F. Carry out the coring and logging programs as concurred with GRUY, in accordance with established oilfield procedures.

G. Cease operation, for GRUY account, when advised by GRUY in writing.

H. Provide GRUY with the results of CONOCO's production and pressure transient testing.

I. Provide living and office space for two (2) GRUY employees.

II. CONSIDERATION

A. SCHEDULE

In consideration for the above, and to reimburse CONOCO for the additional cost of the well, above those planned under it's original well plan, GRUY will pay CONOCO in accordance with the estimated schedule set forth below, however, all costs must be documented (copies of invoices, drilling time curve, etc.):

(a)	Additional rig costs - 15 days @ $4100./day plus 2 days @ $900./day.	$ 63,300.
(b)	Additional mud costs	20,000.
(c)	Additional cementing costs	17,000.
(d)	Special drilling tool rental costs	25,000.
(e)	Additional logging costs	12,000.
(f)	Additional casing costs	70,050.
(g)	Additional footage drilling cost	2,750.
(h)	Additional taxes, federal, state & local	9,400.
	TOTAL ESTIMATED COSTS	$ 219,500.

B. FUNDING LIMITATION

CONOCO shall not incur, for GRUY's account, expenditures in excess of $219,500. without prior approval of GRUY and Modification of this Contract.

III. OTHER PROVISIONS

A. INSURANCE

1. CONOCO shall maintain insurance, by reliable and responsible insurance companies licensed to do business in the State of New Mexico, in the amount as set forth in GRUY's General Provisions, or at its option, CONOCO agrees to self-insure up to the minimal amount set forth in the General Provisions.

2. CONOCO shall not be liable for any injury or loss to GRUY employees, in the conduct of normal operations hereunder, but CONOCO shall be liable for injuries only or loss caused by CONOCO employees acting legally and within the scope of their employment in conducting operations hereunder.

GRUY FEDERAL, INC.

3. CONOCO shall endeavor to carry out its obligations hereunder in a good and workmanlike manner. However, CONOCO makes no warranty of any kind whatsoever as to the acceptability to any person or suitability for any purpose of the work to be carried out hereunder by or on behalf of CONOCO. CONOCO shall have no liability to GRUY or any entity claiming through GRUY for any failure to complete such work or for work deemed unacceptable or suitable by any person.

4. GRUY shall maintain General Liability and Underground Property Damage Insurance in the amount of $20,300,000.

B. GENERAL PROVISIONS

1. GRUY's General Provisions are attached hereto and by this reference made a part hereof, with the exceptions of clauses No. 10 "Disputes", No. 12 "Personnel", and No. 22 "Payment of Interest on Contractor's Claims" which are hereby deleted.

C. ADDITIONAL PROVISIONS

1. GRUY's Additional Provisions "SP", Safety Policy, is attached hereto and by this reference made a part hereof.

2. GRUY, as soon as available, agrees to provide CONOCO with all logs, core analysis and other data obtained.

D. INTEREST

1. Neither GRUY nor DOE shall have any interest in the well, or in the oil and gas lease, minerals, production, or energy recovered from the well, or in any surface or subsurface equipment therein or thereon.

ACCEPTED AND AGREED:

GRUY FEDERAL, INC.	CONOCO, INC.
By: Calvin E. Bowie	By: G. E. Davis
Purchasing Agent Title	Attorney-in-Fact Title
Jan 22, 1980 Date	January 22, 1980 Date

JHG

GRUY FEDERAL, INC.

DOWDCO DRILLING REPORTS

APPENDIX B
PCI RUN REPORTS

DOWDCO PCI DOWDCO PRESSURE CORING, INC.

P. O. BOX 5551 • MIDLAND, TEXAS 79701 • 915: 563-4400

PCI RUN REPORT

A. Date 2-23-80 Job No. 27 Bit No. CS-118 Well No. MCA-358 Run No. 1

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 3,692' Ending Depth 3,700'

B. Time - Through Table 11:45 a.m. On Surface 1:15 a.m.

Tag Bottom 8:35 p.m. Drilling Time 66 minutes

Drop Ball 10:41 p.m. Ball Time 7 minutes Close 10:48 p.m.

C. Reaming (Yes)/No

D. String weight start 64,000

E. Feathered in (Yes)/No

F. Tag Bottom a. right depth (Yes)/No (If no, remarks)

G. Starting RPM 58 Drilling RPM 80

H. Average weight on Bit 6,000-8,000

I. Maximum weight on Bit 8,000

J. String weight end 64,000

K. Tool Trip (Yes)/No — if no, spudded twice

L. (Ball caused) Pressure Increase 2,800

M. Extension 17-1/2" In

N. Ball closed (Yes)/No

O. Pressure on Dome (expected) 2,600

P. Pressure on Core 2,550

Q. Good Flush (Yes)/No — If no, remarks:

R. Mud Weight 12.8

S. Mud Viscosity 54

T. Any change Yes/(No) — If yes, remarks:

U. Pump PSI 650 (Drilling)

V. G P M 140 (Drilling)

W. P V 35 Y P 22

X. Extraction time 15 minutes

Y. Core cut and transferred (Yes)/No

Z. All records up-to-date (Yes)/No

REMARKS: Sandstone

PCI Engineer: COMPANY Engineer:

DOWDCO **PCI** DOWDCO PRESSURE CORING, INC.

P. O. BOX 5551 • MIDLAND, TEXAS 79701 • 915: 563-4400

PCI RUN REPORT

A. Date 2-24-80 Job No. 27 Bit No. CS-118 Well No. MCA-358 Run No. 2

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 3,700' Ending Depth 3,708'

B. Time - Through Table 12:06 p.m. On Surface 12:25 a.m.

Tag Bottom 6:49 p.m. Drilling Time 71 minutes

Drop Ball 8:14 p.m. Ball Time 12 minutes Close 8:26 p.m.

C. Reaming Yes/No (No circled)

D. String weight start 66,000

E. Feathered in Yes/No (Yes circled)

F. Tag Bottom a. right depth Yes/No (Yes circled) (If no, remarks)

G. Starting RPM 60 Drilling RPM 80

H. Average weight on Bit 6,000

I. Maximum weight on Bit 6,000

J. String weight end 66,000

K. Tool Trip Yes/No (Yes circled) — if no, spudded twice

L. (Ball caused) Pressure Increase 250 psi

M. Extension 17-1/2" In

N. Ball closed Yes/No (Yes circled)

O. Pressure on Dome (expected) 2,000

P. Pressure on Core 2,100

Q. Good Flush Yes/No (Yes circled) — If no, remarks:

R. Mud Weight 10.5

S. Mud Viscosity 54

T. Any change Yes/No (Yes circled) — If yes, remarks: Mud Weight from 13.0 to 10.5

U. Pump PSI 350 (Drilling)

V. G P M 140 (Drilling)

W. P V 35 Y P 22

X. Extraction time 15 minutes

Y. Core cut and transferred Yes/No (Yes circled)

Z. All records up-to-date Yes/No (Yes circled)

REMARKS:

PCI Engineer: COMPANY Engineer:

DOWDCO PCI DOWDCO PRESSURE CORING, INC.

P. O. BOX 5551 • MIDLAND, TEXAS 79701 • 915 563-4400

PCI RUN REPORT

A. Date 2-24-80 Job No. 27 Bit No. CS-118 Well No. MCA-358 Run No. 3

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 3,708' Ending Depth 3,716'

B. Time - Through Table 1:35 a.m. On Surface 10:00 a.m.

Tag Bottom 4:00 a.m. Drilling Time 60 minutes

Drop Ball 5:24 a.m. Ball Time 10 minutes Close 5:34 a.m.

C. Reaming Yes/No (No circled)

D. String weight start 66,000

E. Feathered in Yes/No (Yes circled)

F. Tag Bottom a. right depth Yes/No (Yes circled) (If no, remarks)

G. Starting RPM 60 Drilling RPM 80

H. Average weight on Bit 6,000-8,000

I. Maximum weight on Bit 8,000

J. String weight end 66,000

K. Tool Trip Yes/No (Yes circled) — if no, spudded twice

L. (Ball caused) Pressure Increase 250psi

M. Extension 16-1/2" In

N. Ball closed Yes/No (No circled)

O. Pressure on Dome (expected) 2,000

P. Pressure on Core -0-

Q. Good Flush Yes/No (Yes circled) — If no, remarks: none

R. Mud Weight 10.5

S. Mud Viscosity 46

T. Any change Yes/No (Yes circled) — If yes, remarks: Viscosity Change

U. Pump PSI 400-500 (Drilling)

V. G P M 140 (Drilling)

W. P V 35 Y P 22

X. Extraction time none

Y. Core cut and transferred Yes/No (Yes circled)

Z. All records up-to-date Yes/No (Yes circled)

REMARKS: Core in ball -- 9'2-1/2" core in barrel -- Top 3 ft. were undersized to 2 inches

PCI Engineer: COMPANY Engineer:

DOWDCO **PCI** DOWDCO PRESSURE CORING, INC.

P. O. BOX 5551 • MIDLAND, TEXAS 79701 • 915: 563-4400

PCI RUN REPORT

A. Date 2-25-80 Job No. 27 Bit No. CS-118 Well No. MCA-354 Run No. 4

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 3,716' Ending Depth 3,724'

B. Time - Through Table 10:33 a.m. On Surface 6:00 p.m.

Tag Bottom 1:15 p.m. Drilling Time 101 minutes

Drop Ball 3:45 p.m. Ball Time 10 minutes Close 3:55 p.m.

C. Reaming Yes/No (No circled)

D. String weight start 65,000

E. Feathered in Yes/No (Yes circled)

F. Tag Bottom a. right depth Yes/No (Yes circled) (If no, remarks)

G. Starting RPM 60 Drilling RPM 80

H. Average weight on Bit 8,000

I. Maximum weight on Bit 9,000

J. String weight end 65,000

K. Tool Trip Yes/No (Yes circled) — if no, spudded twice

L. (Ball caused) Pressure Increase 300 psi

M. Extension 17-1/2" In

N. Ball closed Yes/No (Yes circled)

O. Pressure on Dome (expected) 2,000

P. Pressure on Core 2,150

Q. Good Flush Yes/No (Yes circled) — If no, remarks:

R. Mud Weight 10.7

S. Mud Viscosity 44

T. Any change Yes/No (Yes circled) — If yes, remarks: mud changed

U. Pump PSI 400 (Drilling)

V. G P M 140 (Drilling)

W. P V 18 Y P 16

X. Extraction time 20 minutes

Y. Core cut and transferred Yes/No (Yes circled)

Z. All records up-to-date Yes/No (Yes circled)

REMARKS:

PCI Engineer: COMPANY Engineer:

PCI DOWDCO PRESSURE CORING, INC.

P.O. BOX 5551 • MIDLAND, TEXAS 79701 • 915: 563-4400

PCI RUN REPORT

A. Date 2-25-80 Job No. 27 Bit No. CS-118 Well No. MCA-358 Run No. 5

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 3,724' Ending Depth 3,732'

B. Time - Through Table 6:50 p.m. On Surface 5:35 a.m.

Tag Bottom 8:56 p.m. Drilling Time 261 minutes

Drop Ball 1:54 a.m. Ball Time 9 minutes Close 2:03 a.m.

C. Reaming Yes/No (No circled)

D. String weight start 67,000

E. Feathered in Yes/No (Yes circled)

F. Tag Bottom a. right depth Yes/No (Yes circled) (If no, remarks) ____

G. Starting RPM 60 Drilling RPM 80

H. Average weight on Bit 8,000

I. Maximum weight on Bit 8,000

J. String weight end 67,000

K. Tool Trip Yes/No (Yes circled) — if no, spudded ____

L. (Ball caused) Pressure Increase 250 psi

M. Extension 17-1/2" In ____

N. Ball closed Yes/No (Yes circled)

O. Pressure on Dome (expected) 2,000

P. Pressure on Core 2,150

Q. Good Flush Yes/No (Yes circled) — If no, remarks: ____

R. Mud Weight 10.7

S. Mud Viscosity 46

T. Any change Yes/No (No circled) — If yes, remarks: ____

U. Pump PSI 400-350 (Drilling)

V. G P M 140 (Drilling)

W. P V 18 Y P 16

X. Extraction time 15 minutes

Y. Core cut and transferred Yes/No (Yes circled)

Z. All records up-to-date Yes/No (Yes circled)

REMARKS: ____

PCI Engineer: ____ COMPANY Engineer: ____

DOWDCO PCI DOWDCO PRESSURE CORING, INC.

P. O. BOX 5551 • MIDLAND, TEXAS 79701 • 915: 563-4400

PCI RUN REPORT

A. Date 2-26-80 Job No. 27 Bit No. CS-118 Well No. MCA-358 Run No. 6

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 3,732' Ending Depth 3,740'

B. Time - Through Table 6:00 a.m. On Surface 1:30 p.m.

Tag Bottom 8:13 a.m. Drilling Time 110 minutes

Drop Ball 10:37 a.m. Ball Time 10 minutes Close 10:47 a.m.

C. Reaming Yes/No (No circled)

D. String weight start 67,000

E. Feathered in Yes/No (Yes circled)

F. Tag Bottom a. right depth Yes/No (Yes circled) (If no, remarks)

G. Starting RPM 60 Drilling RPM 90

H. Average weight on Bit 10,000

I. Maximum weight on Bit 12,000

J. String weight end 67,000

K. Tool Trip Yes/No (Yes circled) — if no, spudded

L. (Ball caused) Pressure Increase 200 psi

M. Extension 17" In

N. Ball closed Yes/No (No circled)

O. Pressure on Dome (expected) 2,000

P. Pressure on Core -0-

Q. Good Flush Yes/No (No circled) — If no, remarks: No flush

R. Mud Weight 10.3

S. Mud Viscosity 61

T. Any change Yes/No (Yes circled) — If yes, remarks: Mud changed

U. Pump PSI 350 (Drilling)

V. G P M 140 (Drilling)

W. P V 23 Y P 21

X. Extraction time None

Y. Core cut and transferred Yes/No (Yes circled)

Z. All records up-to-date Yes/No (Yes circled)

REMARKS: Ball did not close -- Sliding sleeve swelled -- We are now drilling to next core point.

PCI Engineer: COMPANY Engineer:

DOWDCO PCI DOWDCO PRESSURE CORING, INC.

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PCI RUN REPORT

A. Date 2-27-80 Job No. 27 Bit No. CS-114 Well No. MCA-358 Run No. 7

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 3,803' Ending Depth 3,811'

B. Time - Through Table 7:15 p.m. On Surface 6:20 a.m.

Tag Bottom 11:52 p.m. Drilling Time 152 minutes

Drop Ball 2:51 p.m. Ball Time 7 minutes Close 2:58 p.m.

C. Reaming (Yes)/No 60 ft.

D. String weight start 68,000

E. Feathered in (Yes)/No

F. Tag Bottom a. right depth (Yes)/No (If no, remarks)

G. Starting RPM 50 Drilling RPM 75

H. Average weight on Bit 7,000

I. Maximum weight on Bit 14,000

J. String weight end 68,000

K. Tool Trip (Yes)/No – if no, spudded twice

L. (Ball caused) Pressure Increase 100 psi

M. Extension 18-1/4" In

N. Ball closed (Yes)/No

O. Pressure on Dome (expected) 2,000

P. Pressure on Core 2,000

Q. Good Flush (Yes)/No – If no, remarks:

R. Mud Weight 10.3

S. Mud Viscosity 52

T. Any change Yes/(No) – If yes, remarks:

U. Pump PSI 400 (Drilling)

V. G P M 140 (Drilling)

W. P V 23 Y P 21

X. Extraction time 15 minutes

Y. Core cut and transferred (Yes)/No

Z. All records up-to-date (Yes)/No

REMARKS: Driller ran into ledge--Set 20,000 lbs. on bit--Pulled 20,000 over string weight to break loose--Brakes faulty

PCI Engineer: COMPANY Engineer:

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PCI RUN REPORT

A. Date 2-28-80 Job No. 27 Bit No. CS114 Well No. MCA-358 Run No. 8

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 3,811' Ending Depth 3,819'

B. Time - Through Table 7:30 a.m. On Surface 1:30 p.m.

Tag Bottom 9:55 a.m. Drilling Time 41 minutes

Drop Ball 11:05 a.m. Ball Time 6 minutes Close 11:11 a.m.

C. Reaming Yes/**No**

D. String weight start 66,000

E. Feathered in **Yes**/No

F. Tag Bottom a. right depth **Yes**/No (If no, remarks) ______

G. Starting RPM 60 Drilling RPM 80

H. Average weight on Bit 6,000

I. Maximum weight on Bit 6,000

J. String weight end 66,000

K. Tool Trip **Yes**/No — if no, spudded ______

L. (Ball caused) Pressure Increase 600

M. Extension 17-1/2" In ______

N. Ball closed **Yes**/No

O. Pressure on Dome (expected) 2,000

P. Pressure on Core 2,200

Q. Good Flush **Yes**/No — If no, remarks: ______

R. Mud Weight 10.1

S. Mud Viscosity 71

T. Any change Yes/**No** — If yes, remarks: ______

U. Pump PSI 425 (Drilling)

V. G P M 140 (Drilling)

W. P V 25 Y P 26

X. Extraction time 15 minutes

Y. Core cut and transferred **Yes**/No

Z. All records up-to-date **Yes**/No

REMARKS: ______

PCI Engineer: ______ COMPANY Engineer: ______

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PCI RUN REPORT

A. Date 2-28-80 Job No. 27 Bit No. CS-114 Well No. MCA-358 Run No. 9

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 3,819' Ending Depth 3,827'

B. Time - Through Table 2:30 p.m. On Surface 9:00 p.m.

Tag Bottom 4:32 p.m. Drilling Time 66 minutes

Drop Ball 6:02 p.m. Ball Time 8 minutes Close 6:10 p.m.

C. Reaming Yes/No (No circled)

D. String weight start 64,000

E. Feathered in Yes/No (Yes circled)

F. Tag Bottom a. right depth Yes/No (Yes circled) (If no, remarks)

G. Starting RPM 60 Drilling RPM 80

H. Average weight on Bit 8,000

I. Maximum weight on Bit 10,000

J. String weight end 64,000

K. Tool Trip Yes/No (Yes circled) — if no, spudded

L. (Ball caused) Pressure Increase 300 psi

M. Extension 16-1/2" In

N. Ball closed Yes/No (No circled)

O. Pressure on Dome (expected) 2,000

P. Pressure on Core -0-

Q. Good Flush Yes/No (No circled) — If no, remarks:

R. Mud Weight 10.0 +

S. Mud Viscosity 68

T. Any change Yes/No (No circled) — If yes, remarks:

U. Pump PSI 450 (Drilling)

V. G P M 140 (Drilling)

W. P V 20 Y P 24

X. Extraction time -0-

Y. Core cut and transferred Yes/No (Yes circled)

Z. All records up-to-date Yes/No (Yes circled)

REMARKS: Core in ball -- 5'9" of core in barrel

PCI Engineer: COMPANY Engineer:

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PCI RUN REPORT

A. Date 3-2-80 Job No. 27 Bit No. CS-114 Well No. MCA-358 Run No. 10

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 4,035' Ending Depth 4,043'

B. Time - Through Table 10:35 p.m. On Surface 5:40 p.m.

Tag Bottom 4:45 p.m. Drilling Time 48 minutes

Drop Ball 11:55 p.m. Ball Time 6 minutes Close 12:01 a.m.

C. Reaming Yes/No (No circled)

D. String weight start 68,000

E. Feathered in Yes/No (Yes circled)

F. Tag Bottom a. right depth Yes/No (Yes circled) (If no, remarks)

G. Starting RPM 60 Drilling RPM 80

H. Average weight on Bit 6,000

I. Maximum weight on Bit 8,000

J. String weight end 68,000

K. Tool Trip Yes/No (Yes circled) – if no, spudded twice

L. (Ball caused) Pressure Increase 2,400 lbs.

M. Extension 17-1/8" In

N. Ball closed Yes/No (No circled)

O. Pressure on Dome (expected) 2,050

P. Pressure on Core -0-

Q. Good Flush Yes/No (No circled) – If no, remarks:

R. Mud Weight 9.9 +

S. Mud Viscosity 61

T. Any change Yes/No (No circled) – If yes, remarks:

U. Pump PSI 450 (Drilling)

V. G P M 140 (Drilling)

W. P V 26 Y P 23

X. Extraction time none

Y. Core cut and transferred Yes/No (Yes circled)

Z. All records up-to-date Yes/No (Yes circled)

REMARKS: Standpipe pressure gauge climbed to 2,400 lbs. -- Spudded barrel and got normal trip

PCI Engineer: COMPANY Engineer:

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PCI RUN REPORT

A. Date 3-3-80 Job No. 27 Bit No. CS-114 Well No. MCA-358 Run No. 11

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 4,043' Ending Depth 4,051'

B. Time - Through Table 6:40 a.m. On Surface 2:20 a.m.

Tag Bottom 8:55 a.m. Drilling Time 49 minutes

Drop Ball 10:25 a.m. Ball Time 8 minutes Close 10:33 a.m.

C. Reaming Yes/No (No circled)

D. String weight start 69,000

E. Feathered in Yes/No (Yes circled)

F. Tag Bottom a. right depth Yes/No (Yes circled) (If no, remarks)

G. Starting RPM 60 Drilling RPM 80

H. Average weight on Bit 6,000

I. Maximum weight on Bit 8,000

J. String weight end 69,000

K. Tool Trip Yes/No (Yes circled) — if no, spudded once

L. (Ball caused) Pressure Increase 300 psi

M. Extension 17-1/2" In

N. Ball closed Yes/No (Yes circled)

O. Pressure on Dome (expected) 2,050

P. Pressure on Core 2,200

Q. Good Flush Yes/No (Yes circled) — If no, remarks:

R. Mud Weight 10.4

S. Mud Viscosity 61

T. Any change Yes/No (No circled) — If yes, remarks:

U. Pump PSI 400 (Drilling)

V. G P M 140 (Drilling)

W. P V 23 Y P 21

X. Extraction time 20 minutes

Y. Core cut and transferred Yes/No (Yes circled)

Z. All records up-to-date Yes/No (Yes circled)

REMARKS:

PCI Engineer: COMPANY Engineer:

DOWDCO **PCI** DOWDCO PRESSURE CORING, INC.

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PCI RUN REPORT

A. Date 3-3-80 Job No. 27 Bit No. CS-114 Well No. MCA-358 Run No. 12

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 4,051' Ending Depth 4,059'

B. Time - Through Table 3:10 a.m. On Surface 9:30 a.m.

Tag Bottom 5:30 a.m. Drilling Time 58 minutes

Drop Ball 7:05 a.m. Ball Time 5 minutes Close 7:10 a.m.

C. Reaming Yes/No (No circled)

D. String weight start 69,000

E. Feathered in Yes/No (Yes circled)

F. Tag Bottom a. right depth Yes/No (Yes circled) (If no, remarks)

G. Starting RPM 60 Drilling RPM 80

H. Average weight on Bit 7,000

I. Maximum weight on Bit 8,000

J. String weight end 69,000

K. Tool Trip Yes/No (Yes circled) — if no, spudded

L. (Ball caused) Pressure Increase 375 psi

M. Extension 19" In

N. Ball closed Yes/No (Yes circled)

O. Pressure on Dome (expected) 2,050

P. Pressure on Core 1,950

Q. Good Flush Yes/No (Yes circled) — If no, remarks:

R. Mud Weight 10.5 +

S. Mud Viscosity 62

T. Any change Yes/No (No circled) — If yes, remarks:

U. Pump PSI 500 (Drilling)

V. G P M 140 (Drilling)

W. P V 25 Y P 26

X. Extraction time 15 minutes

Y. Core cut and transferred Yes/No (Yes circled)

Z. All records up-to-date Yes/No (Yes circled)

REMARKS:

PCI Engineer: COMPANY Engineer:

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PCI RUN REPORT

A. Date 3-3-80 Job No. 27 Bit No. CS-114 Well No. MCA-358 Run No. 13

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 4,059' Ending Depth 4,067'

B. Time - Through Table 9:45 p.m. On Surface 5:35 a.m.

Tag Bottom 12:29 a.m. Drilling Time 46 minutes

Drop Ball 2:00 a.m. Ball Time 7 minutes Close 2:07 a.m.

C. Reaming Yes/No (No circled)

D. String weight start 70,000

E. Feathered in Yes/No (Yes circled)

F. Tag Bottom a. right depth Yes/No (Yes circled) (If no, remarks)

G. Starting RPM 60 Drilling RPM 80

H. Average weight on Bit 8,000

I. Maximum weight on Bit 8,000

J. String weight end 70,000

K. Tool Trip Yes/No (Yes circled) — if no, spudded twice

L. (Ball caused) Pressure Increase 350 psi

M. Extension 17-1/2 In

N. Ball closed Yes/No (Yes circled)

O. Pressure on Dome (expected) 2,050

P. Pressure on Core 2,100

Q. Good Flush Yes/No (Yes circled) — If no, remarks:

R. Mud Weight 10.5

S. Mud Viscosity 62

T. Any change Yes/No (No circled) — If yes, remarks:

U. Pump PSI 450 (Drilling)

V. G P M 140 (Drilling)

W. P V 25 Y P 26

X. Extraction time 15 minutes

Y. Core cut and transferred Yes/No (Yes circled)

Z. All records up-to-date Yes/No (Yes circled)

REMARKS:

PCI Engineer: COMPANY Engineer:

PCI DOWDCO PRESSURE CORING, INC.

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PCI RUN REPORT

A. Date 3-4-80 Job No. 27 Bit No. CS114 Well No. MCA358 Run No. 14

COMPANY Conoco Location: Maljamar

Starting Depth 4067 Ending Depth 4075

B. Time - Through Table 6:15 A.M. On Surface 1:00 A.M.

Tag Bottom 8:45 AM Drilling Time 43

Drop Ball 10:25 AM Ball Time 5 Close 10:30 AM

C. Reaming Yes/No (No circled)

D. String weight start 67K

E. Feathered in Yes/No (Yes circled)

F. Tag Bottom a. right depth Yes/No (Yes circled) (If no, remarks)

G. Starting RPM 60 Drilling RPM 30

H. Average weight on Bit 8K

I. Maximum weight on Bit 8K

J. String weight end 69K

K. Tool Trip Yes/No (Yes circled) — if no, spudded

L. (Ball caused) Pressure Increase 200

M. Extension 17 1/4 In

N. Ball closed Yes/No (Yes circled)

O. Pressure on Dome (expected) 2050

P. Pressure on Core 1000

Q. Good Flush Yes/No (Yes circled) — If no, remarks:

R. Mud Weight 10.5

S. Mud Viscosity 62

T. Any change Yes/No (No circled) — If yes, remarks:

U. Pump PSI 450 (Drilling)

V. G P M 140 (Drilling)

W. P V 25 Y P 20

X. Extraction time 25

Y. Core cut and transferred Yes/No (Yes circled)

Z. All records up-to-date Yes/No (Yes circled)

REMARKS: Hung up Coming out of hole, dragged for 3 Stands - pulled 30K over STRing WT. 1/3 of Tong die STuck on Top of Bit at SurFace, when Broke Drive head from STRing. Flushing head STarted LeaKing.

PCI Engineer: COMPANY Engineer:

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PCI RUN REPORT

A. Date 3-4-80 Job No. 27 Bit No. CS-114 Well No. MCA-358 Run No. 15

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 4,075' Ending Depth 4,083'

B. Time - Through Table 11:45 p.m. On Surface 7:15 a.m.

Tag Bottom 3:27 a.m. Drilling Time 35 minutes

Drop Ball 4:44 a.m. Ball Time 8 minutes Close 4:52 a.m.

C. Reaming Yes/No (No circled)

D. String weight start 70,000

E. Feathered in Yes/No (Yes circled)

F. Tag Bottom a. right depth Yes/No (Yes circled) (If no, remarks)

G. Starting RPM 60 Drilling RPM 80

H. Average weight on Bit 8,000

I. Maximum weight on Bit 8,000

J. String weight end 70,000

K. Tool Trip Yes/No (Yes circled) — if no, spudded

L. (Ball caused) Pressure Increase 350 psi

M. Extension 17-3/4" In

N. Ball closed Yes/No (Yes circled)

O. Pressure on Dome (expected) 2,050

P. Pressure on Core 2,050

Q. Good Flush Yes/No (Yes circled) — If no, remarks:

R. Mud Weight 10.5

S. Mud Viscosity 6.2

T. Any change Yes/No (No circled) — If yes, remarks:

U. Pump PSI 450 (Drilling)

V. G P M 140 (Drilling)

W. P V 25 Y P 26

X. Extraction time 15 minutes

Y. Core cut and transferred Yes/No (Yes circled)

Z. All records up-to-date Yes/No (Yes circled)

REMARKS: Junk basket and magnet -- Tripped and cut 1 ft. -- Changed geolograph.

PCI Engineer: COMPANY Engineer:

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PCI RUN REPORT

A. Date 3-5-80 Job No. 27 Bit No. CS-114 Well No. MCA-358 Run No. 16

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 4,084 ' Ending Depth 4,092 '

B. Time - Through Table 7:45 a.m. On Surface 1:15 p.m.

Tag Bottom 9:45 a.m. Drilling Time 32 minutes

Drop Ball 10:40 a.m. Ball Time 5 minutes Close 10:45 a.m.

C. Reaming Yes/No (No circled)

D. String weight start 71,000

E. Feathered in Yes/No (Yes circled)

F. Tag Bottom a. right depth Yes/No (Yes circled) (If no, remarks)

G. Starting RPM 60 Drilling RPM 80

H. Average weight on Bit 7,000

I. Maximum weight on Bit 8,000

J. String weight end 71,000

K. Tool Trip Yes/No (Yes circled) — if no, spudded

L. (Ball caused) Pressure Increase 225

M. Extension 17-3/8 In

N. Ball closed Yes/No (Yes circled)

O. Pressure on Dome (expected) 2,050

P. Pressure on Core 2,150

Q. Good Flush Yes/No (Yes circled) — If no, remarks:

R. Mud Weight 10.5

S. Mud Viscosity 65

T. Any change Yes/No (No circled) — If yes, remarks:

U. Pump PSI 350 (Drilling)

V. G P M 140 (Drilling)

W. P V 25 Y P 26

X. Extraction time 20 minutes

Y. Core cut and transferred Yes/No (Yes circled)

Z. All records up-to-date Yes/No (Yes circled)

REMARKS:

PCI Engineer: COMPANY Engineer:

DOWDCO **PCI** DOWDCO PRESSURE CORING, INC.

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PCI RUN REPORT

A. Date 3-5-80 Job No. 27 Bit No. CS-114 Well No. MCA-358 Run No. 17

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 4,092' Ending Depth 4,100'

B. Time - Through Table 1:30 p.m. On Surface 2:00 a.m.

Tag Bottom 3:28 p.m. Drilling Time 40 minutes

Drop Ball 4:48 p.m. Ball Time 5 minutes Close 4:53 p.m.

C. Reaming Yes/(No)

D. String weight start 71,000

E. Feathered in (Yes)/No

F. Tag Bottom a. right depth (Yes)/No (If no, remarks)

G. Starting RPM 60 Drilling RPM 80

H. Average weight on Bit 7,000

I. Maximum weight on Bit 8,000

J. String weight end 71,000

K. Tool Trip (Yes)/No — if no, spudded

L. (Ball caused) Pressure Increase 200 psi

M. Extension 17-3/4 In

N. Ball closed (Yes)/No

O. Pressure on Dome (expected) 2,050

P. Pressure on Core 2,100

Q. Good Flush (Yes)/No — If no, remarks:

R. Mud Weight 10.6

S. Mud Viscosity 68

T. Any change Yes/(No) — If yes, remarks:

U. Pump PSI 400 (Drilling)

V. G P M 140 (Drilling)

W. P V 25 Y P 26

X. Extraction time 20 minutes

Y. Core cut and transferred (Yes)/No

Z. All records up-to-date (Yes)/No

REMARKS: Circulated bottom after tripping barrel while rig crew replaced brake pads.

PCI Engineer: ______ COMPANY Engineer: ______

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PCI RUN REPORT

A. Date 3-6-80 Job No. 27 Bit No. CS-114 Well No. MCA-358 Run No. 18

COMPANY Conoco Location: Maljamar, New Mexico

Starting Depth 4,100' Ending Depth 4,108 '

B. Time - Through Table 2:30 a.m. On Surface 8:30 a.m.

Tag Bottom 5:08 a.m. Drilling Time 47 minutes

Drop Ball 6:33 a.m. Ball Time 6 minutes Close 6:39 a.m.

C. Reaming Yes/No (No circled)

D. String weight start 71,000

E. Feathered in Yes/No (Yes circled)

F. Tag Bottom a. right depth Yes/No (Yes circled) (If no, remarks) ____

G. Starting RPM 60 Drilling RPM 80

H. Average weight on Bit 8,000

I. Maximum weight on Bit 8,000

J. String weight end 71,000

K. Tool Trip Yes/No (Yes circled) — if no, spudded ____

L. (Ball caused) Pressure Increase 200 psi

M. Extension 17-1/2" In ____

N. Ball closed Yes/No (Yes circled)

O. Pressure on Dome (expected) 2,050

P. Pressure on Core 2,050

Q. Good Flush Yes/No (Yes circled) — If no, remarks: ____

R. Mud Weight 10.5

S. Mud Viscosity 71

T. Any change Yes/No (No circled) — If yes, remarks: ____

U. Pump PSI 250 (Drilling)

V. G P M 140 (Drilling)

W. P V 25 Y P 26

X. Extraction time 15 minutes

Y. Core cut and transferred Yes/No (Yes circled)

Z. All records up-to-date Yes/No (Yes circled)

REMARKS: ____

PCI Engineer: ____ COMPANY Engineer: ____

DESCRIPTION OF ANALYSIS PROCEDURE FOR PRESSURE CORES (FROM A CORE LABORATORIES BROCHURE)

APPENDIX C
CORE DATA

The growing significance of evaluating a reservoir for its susceptibility to one or a combination of conventional and exotic enhanced recovery techniques, as well as the economic feasibility of a long-range commitment, magnifies the value of obtaining accurate comprehensive formation data.

No two reservoirs are alike, either in material arrangement, flow mechanics, or fluid composition. Ideally, the nearer to an in situ condition core can be brought to the surface, preserved, and delivered to a lab for analysis, the more dependable the data.

This information plays an important role in Core Lab's Special Core Analysis Department enhanced recovery services, ranging from basic bench top evaluations of mobility control agents and surfactants to tertiary oil recovery tests on reservoir cores at reservoir temperature.

With the advent of manufacturers' improved design and performance of pressure core barrels, Core Lab has established extensive modern facilities in Dallas, Texas, for performing analysis of cores taken under pressure.

Cores are received at the laboratory encased in the inner core barrel in lengths of approximately three to 4½ feet – frozen in chests of dry ice. (The concept of preserving cores through use of the "quick freeze" technique was originally introduced by Core Lab.) Each length is placed in a dry ice-filled trough attached to a milling machine. Two diametrically opposed grooves are milled down the length of the steel tubing to a depth slightly less than the maximum tubing wall thickness. Liquid nitrogen is directed to the point of milling to ensure that the temperature of the tubing and the core remain at or below that of frozen carbon dioxide. The grooved tubing lengths containing the frozen core are immediately returned to the dry ice chest. The tubing is then wedged apart into two halves and removed from the core.

Drilling mud is removed from the core by chipping and abrasive action. As before, liquid nitrogen is periodically sprayed into the chest to ensure the proper cryogenic temperature.

Cores are then visually examined for lithological characteristics and samples are selected for analysis. Each sample consists of one or more full-diameter core segments having a total length of 12 inches, or less. Both ends of each core segment are faced with a diamond saw, again using liquid nitrogen to maintain the core in a frozen state.

The segments comprising a sample are placed in thin-walled metal thimbles, quickly weighed, and placed in a low-temperature retort which is closed immediately. This retort and its attached fluid-collecting system are evacuated for 45 seconds to remove as much air as possible before gas begins to evolve from the rock. The system is then sealed and the frozen core is allowed to thaw at room temperature. Water and oil expelled by the evolving gas are collected in a graduated receiving tube, while the gas is collected in the retort void space and in an attached gas-collecting cell. This system is equipped with a gauge to allow monitoring the pressure inside both the retort and fluid-collection system.

Barometric pressure, room temperature, retort pressure, and produced liquid volumes are recorded periodically. Thawing of the core is considered complete when consecutive readings indicate no additional liquids or gas are being expelled. Portions of the gas in the retort and in the gas cell are collected separately for analysis to determine gas gravity and the mole percent of various components. Collected volumes of oil and water are also measured, as well as the chloride content of the produced water.

Upon completion of this phase of testing, the sample and its thimble are removed from the retort, weighed, and placed in a Dean-Stark (toluene distillation) apparatus. The remaining water content in the cores, as well as some additional oil are removed. When this process is completed, the volume of water recovered is measured.

The sample is removed from the Dean-Stark apparatus and placed in a vacuum oven at 240°F to dry. When drying is complete, the sample is allowed to cool in the presence of a desiccant and then reweighed. The volume of additional oil extracted is determined gravimetrically, using a stock tank oil density corrected to room temperature. The volume of water distilled is corrected to reflect the equivalent volume of water having the same salinity as the retorted water indicated by the chloride determination.

The core is taken from the thimble, all loose grains are removed from each segment of core, and the segments are encased in surgical stocking material to minimize grain loss. The cores are then subjected to further extraction, using carbon dioxide-charged toluene heated to 180°F to extract any remaining oil. When this step is completed, the cores are leached with carbon dioxide-charged methanol to remove the salt content.

Weight loss occurring during the extraction and leaching processes, corrected for salt content, is the weight of oil removed which is then converted into a volumetric value, using the above mentioned oil density.

Porosities and horizontal and vertical air permeabilities are determined on each core segment. Liquid saturations at stock tank conditions are calculated by using the measured total pore volume of all core segments and the total oil and water contents recovered from these segments. The volume of gas collected from the sample is determined from the known volume of the retort and fluid collection system, corrected for the grain and thimble volumes, as well as the total liquid and salt contents. This gas volume is further corrected to standard conditions.

During the course of some pressure coring operations, drilling fluid is tagged with a tracer such as

(Continued)

tritium. This is done to afford some insight as to the degree of flushing of the core by mud filtrate. Under such circumstances, additional core samples are selected for analysis. These samples, each a full-diameter core segment about 1½ to 2 inches in length, are picked at specified depth intervals to determine the tritium content of the pore water. A cylindrical plug is drilled concentrically to the diameter of each frozen core segment, and hence along its vertical axis. Liquid nitrogen is used as a bit lubricant to sustain proper cryogenic temperature level.

Water contents in the drilled plug and in the resulting "donut" portion of the core are recovered separately by the Dean-Stark method, and both portions of the water are analyzed for the presence of tritium. These data, together with the tritium content of the mud system, are used to determine the degree of filtrate invasion which, in turn, is useful in evaluating saturations measured in the cores. Porosities of the plug and the "donut" portion are measured, as well as the vertical air permeability of the plug.

The low temperature retort equipment and associated techniques for pressure blowdown were designed by Shell Development Company.

7501 STEMMONS FREEWAY, BOX 47547, DALLAS, TEXAS 75247 · 214/631-8270

CORE LABORATORIES, INC.

August 24, 1981

Gruy Federal, Inc.
2500 Tanglewilde, Suite 150
Houston, Texas 77063

Attention: Mr. Raymond Marlow

Gentlemen:

Replying to your inquiry concerning sodium nitrate tracer data for the Conoco MCA No. 358 Well, these tests were not performed in conjunction with the pressure-retained core analysis study. During the tracer phase of testing, the plug and donut samples were inadvertantly analyzed for tritium tracer only.

Replacement samples were selected. However, during subsequent phone conversations with representatives of Gruy Federal, Inc., it was decided to omit the sodium nitrate analysis. This decision was largely due to the erratic and questionable nature of sodium nitrate tracer results obtained during the analysis of pressure-retained cores from the Texas Pacific BRU no. 310 Well.

If you have any further questions, please don't hesitate to contact us.

Very truly yours,

Core Laboratories, Inc.

C.W. Marquis
Technical Director
Special Core Analysis

CWM:bb

Special Core Analysis Study

for

Gruy Federal, Inc.

MCA No. 358 Well
Lea County, New Mexico

7501 STEMMONS FREEWAY, BOX 47547, DALLAS, TEXAS 75247 · 214/631-8270

CORE LABORATORIES, INC.
Special Core Analysis

July 22, 1981

Gruy Federal, Inc.
2500 Tanglewilde, Suite 150
Houston, Texas 77063

Attention: Mr. John Goodrich

Subject: Special Core Analysis Study
Conoco
MCA No. 358 Well
Maljamar Field
Lea County, New Mexico
Purchase Order Number: 27-82
File Number: SCAL-308-80533

Gentlemen:

A purchase order dated February 21, 1980, and identified by Number 27-82 authorized a study on core material obtained from the subject well. The Formation Resistivity Factor and Formation Resistivity Index Measurements requested in the subject purchase order have been performed by the Special Core Analysis Department of Core Laboratories, Inc., at Dallas, Texas, and the results are reported herein. Also reported are the results of Permeability to Air and Porosity Determinations for sample selection purposes. A separate report on the remaining portion of the study has already been issued (File Number: SCAL-308-80111).

Full-diameter core segments representing depth intervals ranging from approximately 3692 feet to approximately 4107 feet were submitted for use in this study. Upon completion of the requested nitrate analyses, plug-sized samples were obtained from the depth intervals specified by a representative of Gruy Federal, Inc., using a diamond core drill with water as the bit coolant and lubricant. The sixteen 1-1/2 inch in diameter cylindrical core samples thus obtained were extracted of any hydrocarbons present using toluene, leached of any salts present using methyl alcohol, and oven-dried. Permeability to air and Boyle's Law porosity were determined on each core plug, and these data are presented in tabular form on Page 2 and in graphical form on Page 3.

In a letter dated March 24, 1981, and signed by Mr. Raymond Marlow, ten samples were designated for use in the requested electrical resistivity tests. The core plugs selected for these additional tests are lithologically described and identified as to sample number and depth interval on Page 1. It should be noted that the samples exhibit two different lithologies.

The selected samples were evacuated and pressure-saturated with a brine containing 16,000 ppm sodium chloride to which calcium sulfate had been added in order to inhibit possible mineral dissolution. The electrical resistivities of the brine and the brine-saturated core plugs were next measured repeatedly over a period of several days until the electrical resistivities stabilized, indicating that ionic equilibrium within the core plugs had been attained. Desaturation of the core plugs was then commenced using a porous-plate cell with an air-brine system, and the electrical resistivities were measured at several equilibrium saturations for each sample. The results of these formation resistivity factor and formation resistivity index measurements are presented in tabular form on Pages 4 and 5, and in graphical form on Pages 6 through 19. It should be noted that the test results are presented according to the different lithologies exhibited by these samples, with the data for the sandstone and dolomite samples grouped separately. Using Archie's equation, respective cementation exponents "m" of 1.68 and 1.93 are calculated for the sandstone and for the dolomite samples. The formation resistivity index-saturation relationships yield calculated saturation exponents "n" ranging from 1.53 to 1.74 for the sandstone samples and from 1.78 to 2.62 for the dolomite samples. For convenience, composite plots of the formation resistivity index-saturation relationships are presented on Pages 11 and 19 and yield composite saturation exponents of 1.57 and 2.06 for the sandstone and dolomite samples, respectively.

It has been a pleasure performing this study on behalf of Gruy Federal, Inc. Should there be any questions concerning the reported test results, or if we could be of any further assistance, please do not hesitate to contact us.

Very truly yours,

Core Laboratories, Inc.

John A. Koerner

John A. Koerner, Laboratory Supervisor
Special Core Analysis

JAK:PSD:yo
10 cc. - Addressee
1 cc. - H. J. Gruy & Associates, Inc.
Attn: Terry Swift
150 W. Carpenter Frwy.
Irving, TX 75062
1 cc. - Conoco, Inc.
Attn: Preston Grant
Box 1267
Ponca City, OK 74601

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

File SCAL-308-80533

Company	Gruy Federal, Inc.	Formation	Grayburg
Well	MCA No. 358	County	Lea
Field	Maljamar	State	New Mexico

Identification and Description of Samples

Sample Number	Depth, Feet	Lithological Description
1	3694-95	Ss, wht, fn gr, well indurated
2	3702-03	Ss, wht, fn gr, well indurated
3	3731-32	Ss, tan, fn gr, well indurated
4	3808-09	Dol, tan, fn xln, pp vugs
5A	3814-15	Dol, tan, fn xln, pp vugs
6	4044-45	Dol, tan, fn xln, pp vugs
7	4047-48	Dol, tan, fn xln, pp vugs
8A	4070-71	Dol, tan, fn xln, vugs
10	4105-06	Dol, tan, fn xln, vugs

Permeability and Porosity

Sample Number	Depth, feet	Air Permeability, Millidarcies	Porosity, Percent
1	3694-95	34	11.0
2	3702-03	13	9.6
3	3731-32	0.54	8.3
3A	3731-32	0.69	9.1
4	3808-09	20	11.6
4A	3808-09	8.5	6.0
5	3814-15	4.8	10.4
5A	3814-15	0.62	9.3
6	4044-45	34	8.9
7	4047-48	38	14.5
8	4070-71	14	6.6
8A	4070-71	28	11.5
9	4089-90	23	9.2
9A	4089-90	28	13.0
10	4105-06	2.6	5.4
10A	4105-06	66	8.2

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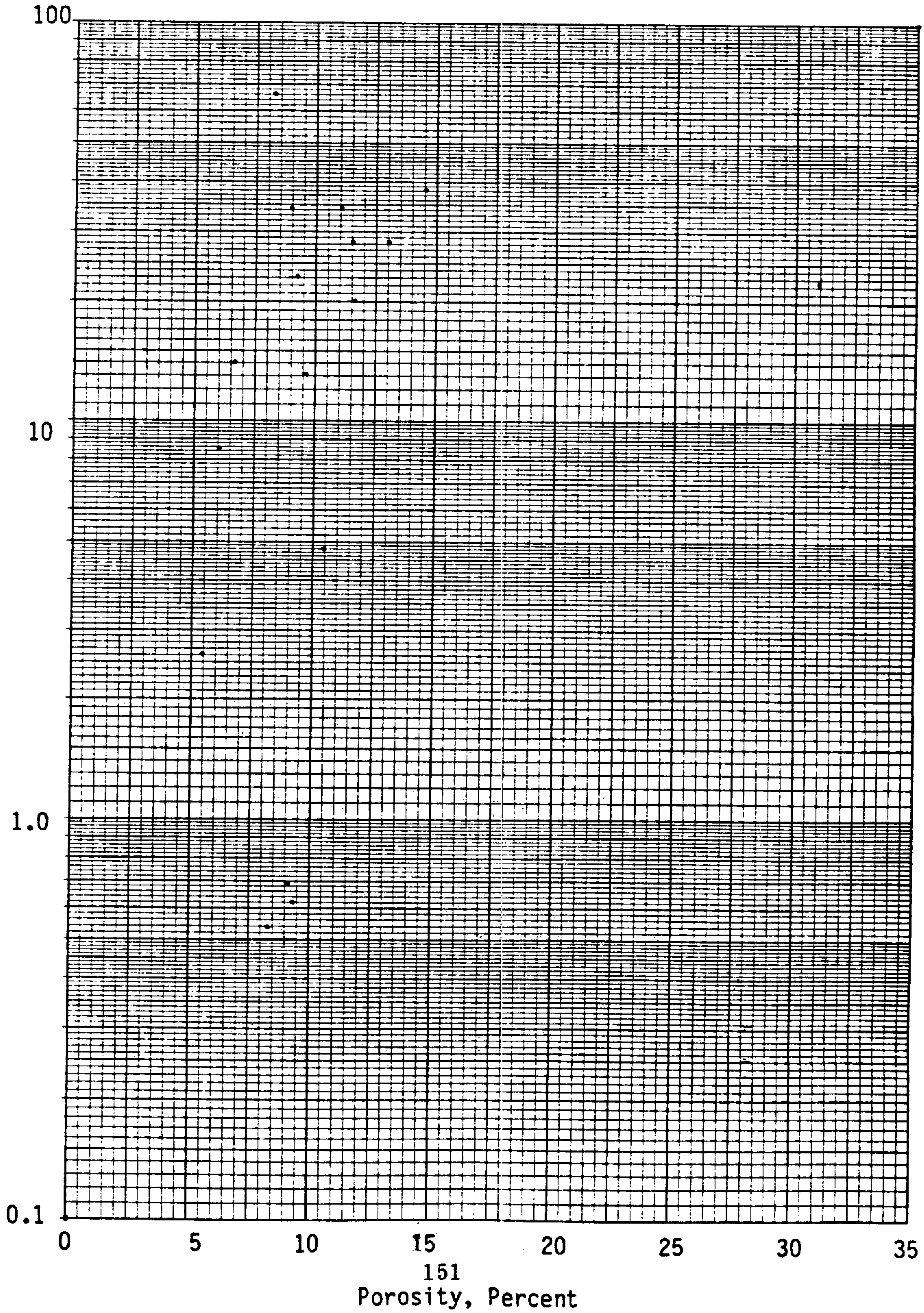
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

File SCAL-308-80533

Company Gruy Federal, Inc.
Well MCA No. 358
Field Maljamar

Formation Grayburg
County Lea
State New Mexico



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Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

Formation Factor and Resistivity Index Data

Resistivity of Saturating Brine, Ohm-Meters: 0.340 @ 70.8°F.

Sample Number	Air Permeability, Millidarcies	Porosity, Percent	Formation Factor	Brine Saturation, Percent Pore Space	Resistivity Index
		Sandstone Samples			
1	34	11.0	38.6	100.0	1.00
				51.2	3.09
				29.5	5.76
				24.0	8.67
2	13	9.6	46.2	100.0	1.00
				43.0	3.75
				34.2	4.81
				25.7	8.84
3	0.54	8.3	68.1	100.0	1.00
				82.2	1.43
				67.0	2.08
				33.0	5.97

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

File SCAL-308-80533

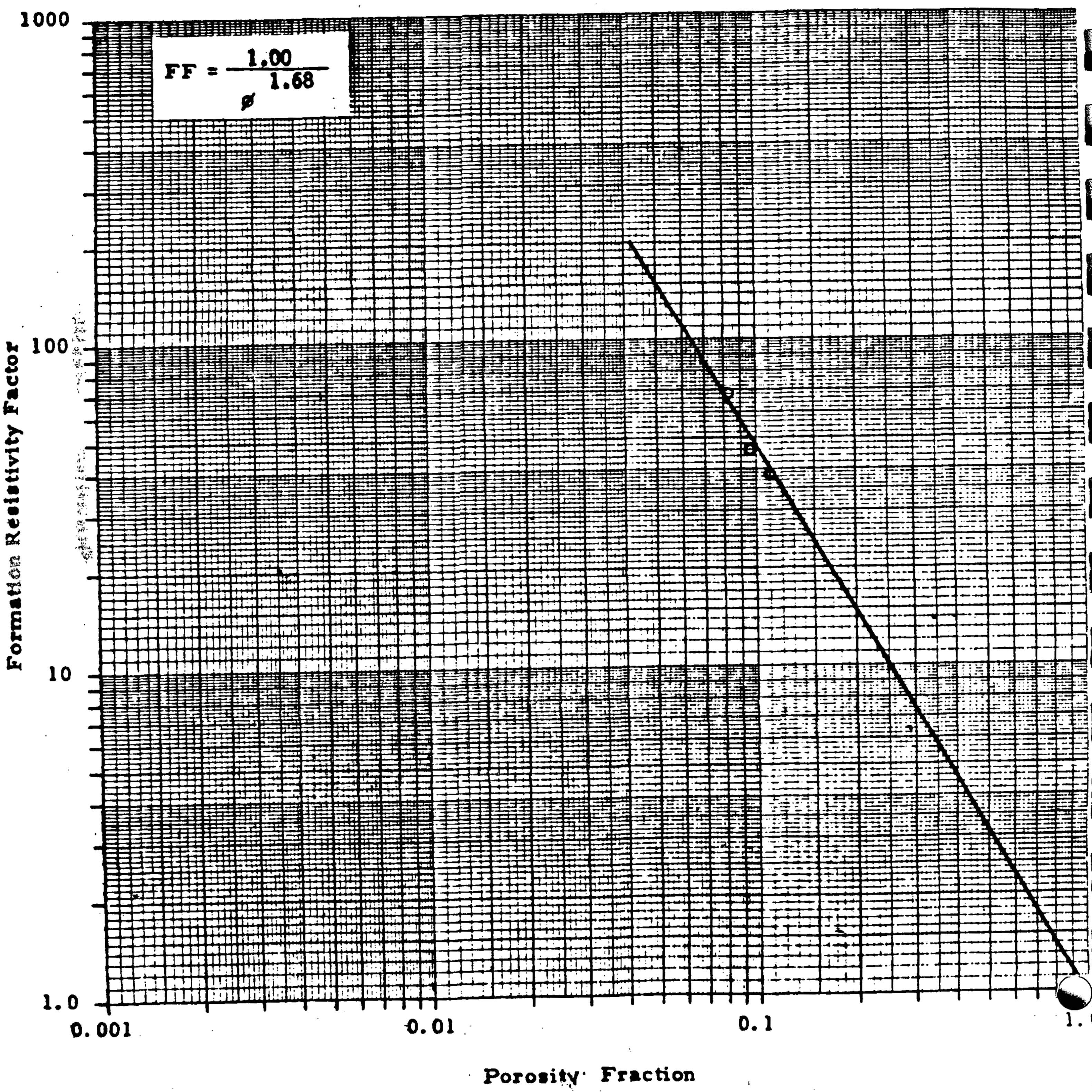
Formation Factor and Resistivity Index Data

Resistivity of Saturating Brine, Ohm-Meters: 0.340 @ 7.8 °F.

Sample Number	Air Permeability, Millidarcies	Porosity, Percent	Formation Factor	Brine Saturation, Percent Pore Space	Resistivity Index
			Dolomite Samples		
4	20	11.6	58.6	100.0	1.00
				55.7	4.00
				40.7	6.98
				34.1	9.84
5	0.62	9.3	102	100.0	1.00
				94.6	2.14
				64.6	3.13
				35.6	6.94
6	34	8.9	105	100.0	1.00
				68.8	2.85
				58.2	3.74
				45.6	7.15
7	38	14.5	45.5	100.0	1.00
				49.7	4.16
				37.3	6.98
				32.9	8.48
8A	28	11.5	65.4	100.0	1.00
				40.9	6.55
				34.6	8.38
				28.1	12.9
9	23	9.2	106	100.0	1.00
				57.0	2.92
				46.5	3.86
				34.5	6.81
10	2.6	5.4	223	100.0	1.00
				55.4	3.24
				42.2	3.85
				33.7	6.94

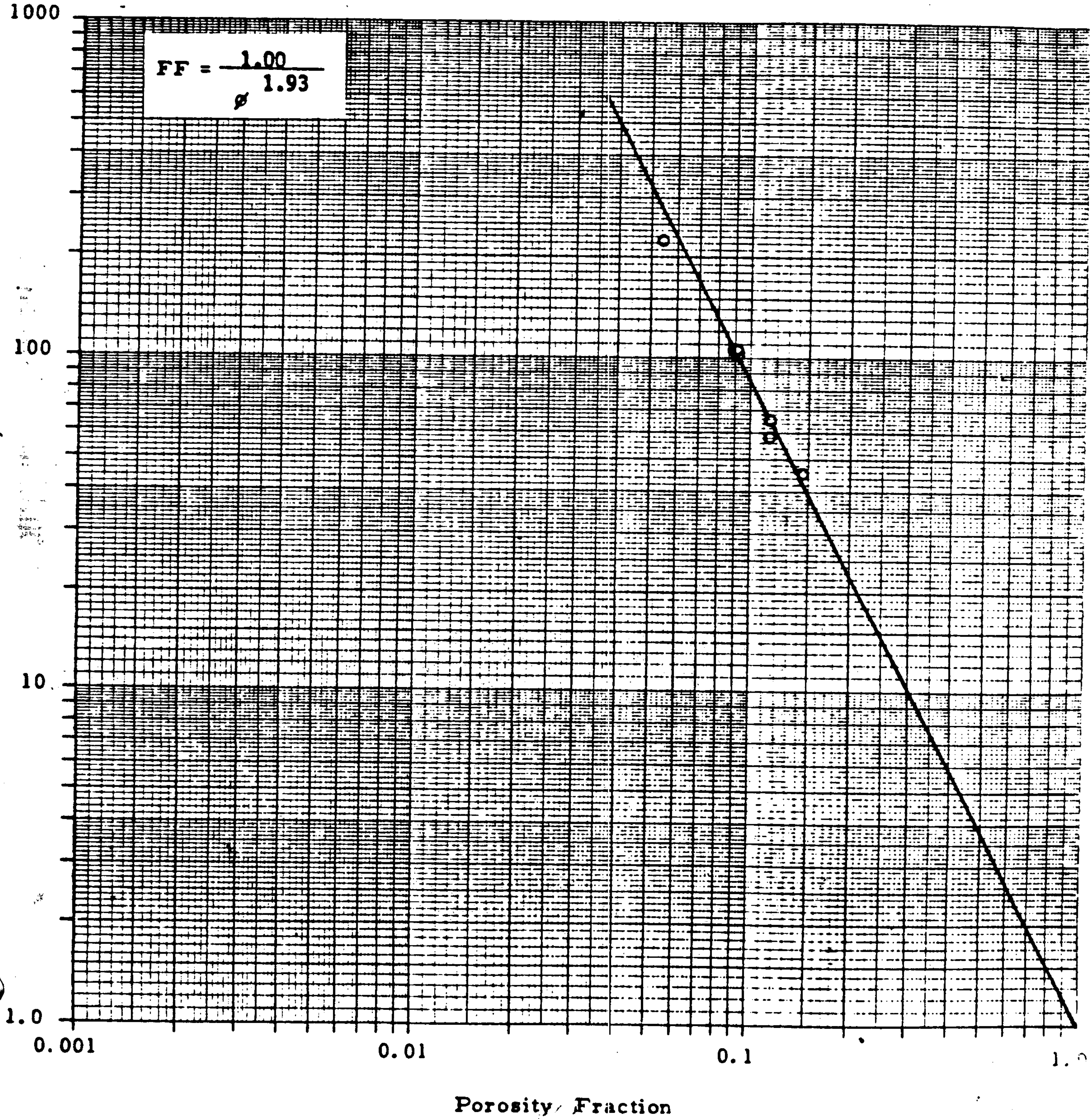
Company Gruy Federal, Inc. Formation Grayburg
Well MCA No. 358 County Lea
Field Maljamar State New Mexico

Sandstone Samples



Company Gruy Federal, Inc.
Well MCA No. 358
Field Maljamar
Formation Grayburg
County Lea
State New Mexico

Dolomite Samples



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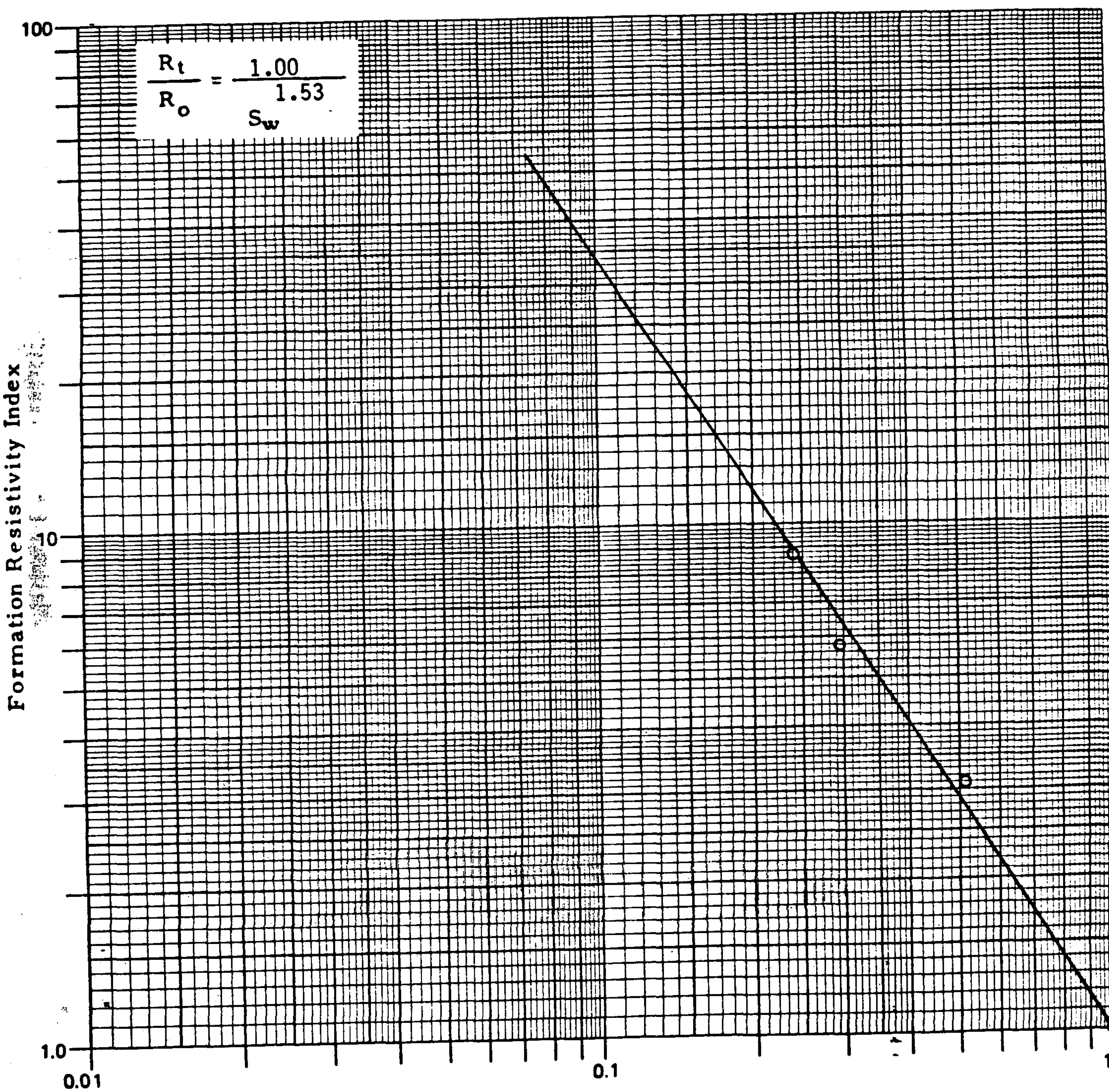
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company Gruy Federal, Inc.
Well MCA Nc. 358
Field Maljamar
Formation Grayburg
County Lea
State New Mexico

Sample Number 1

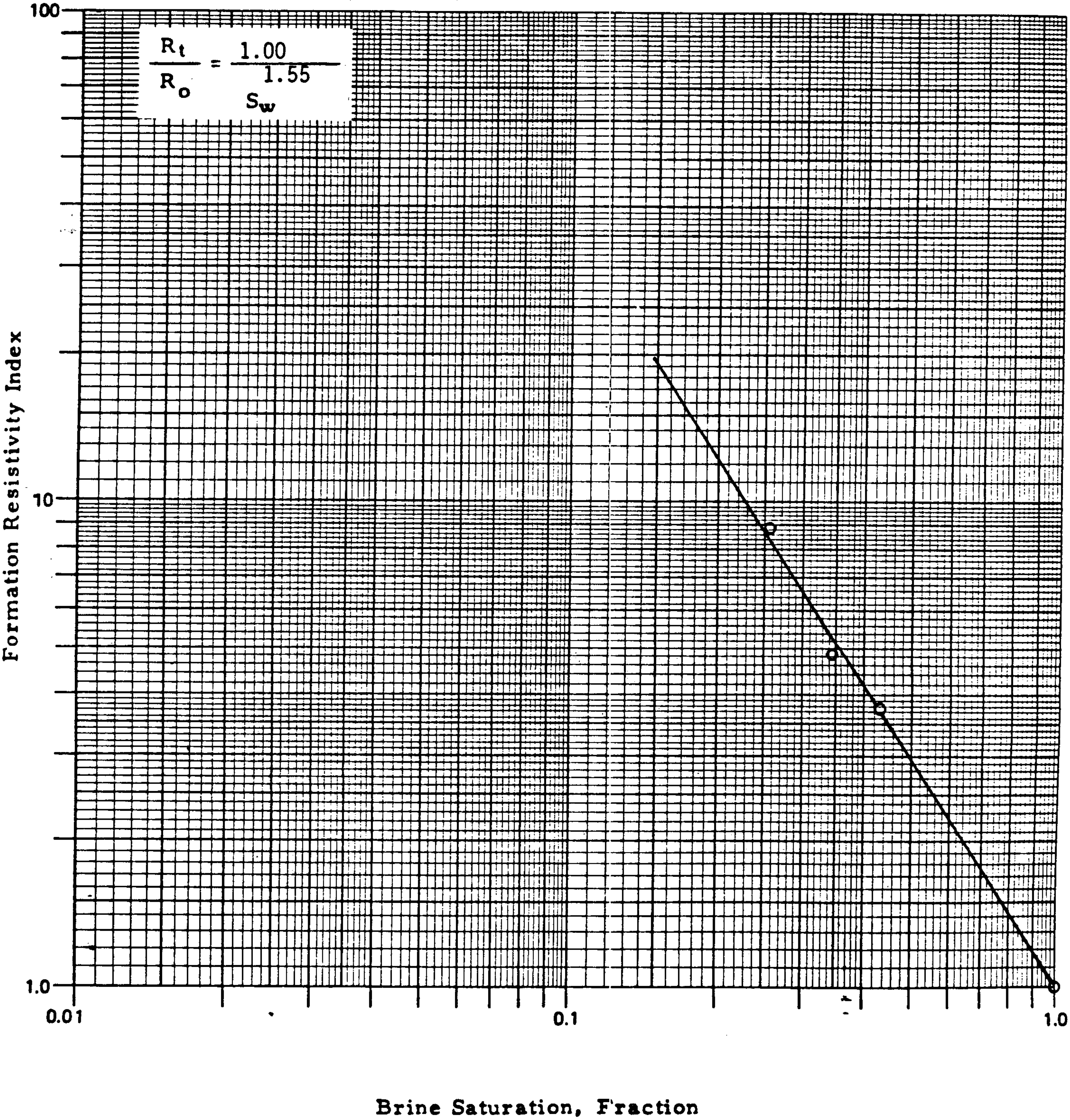


Brine Saturation, Fraction

CL 847/SCAL 4006

Company Gruy Federal, Inc.
Well MCA No. 358
Field Maljamar
Formation Grayburg
County Lea
State New Mexico

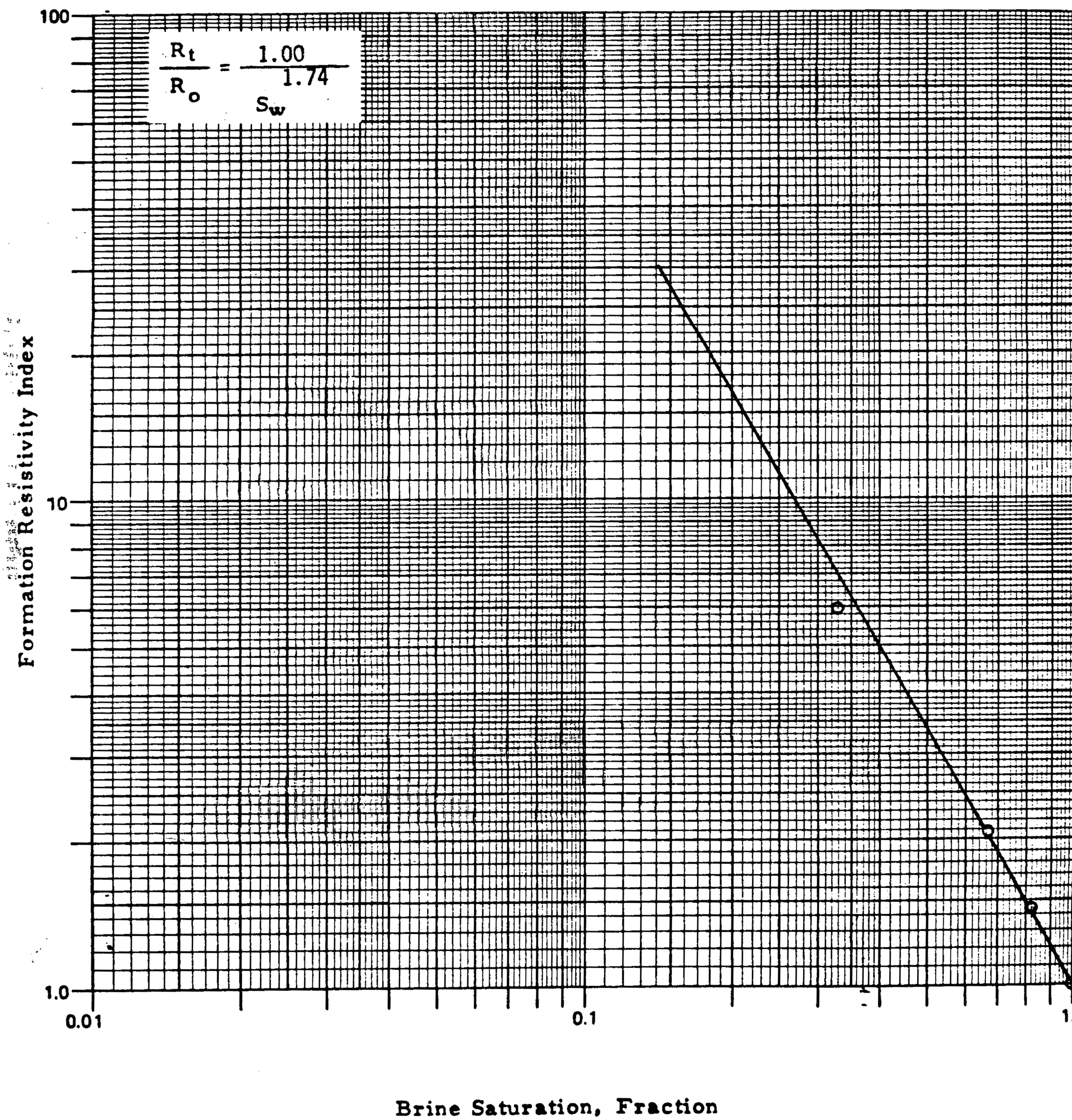
Sample Number 2



CL 847/SCAL 4006

Company Gruy Federal, Inc.
Well MCA No. 358
Field Maljamar
Formation Grayburg
County Lea
State New Mexico

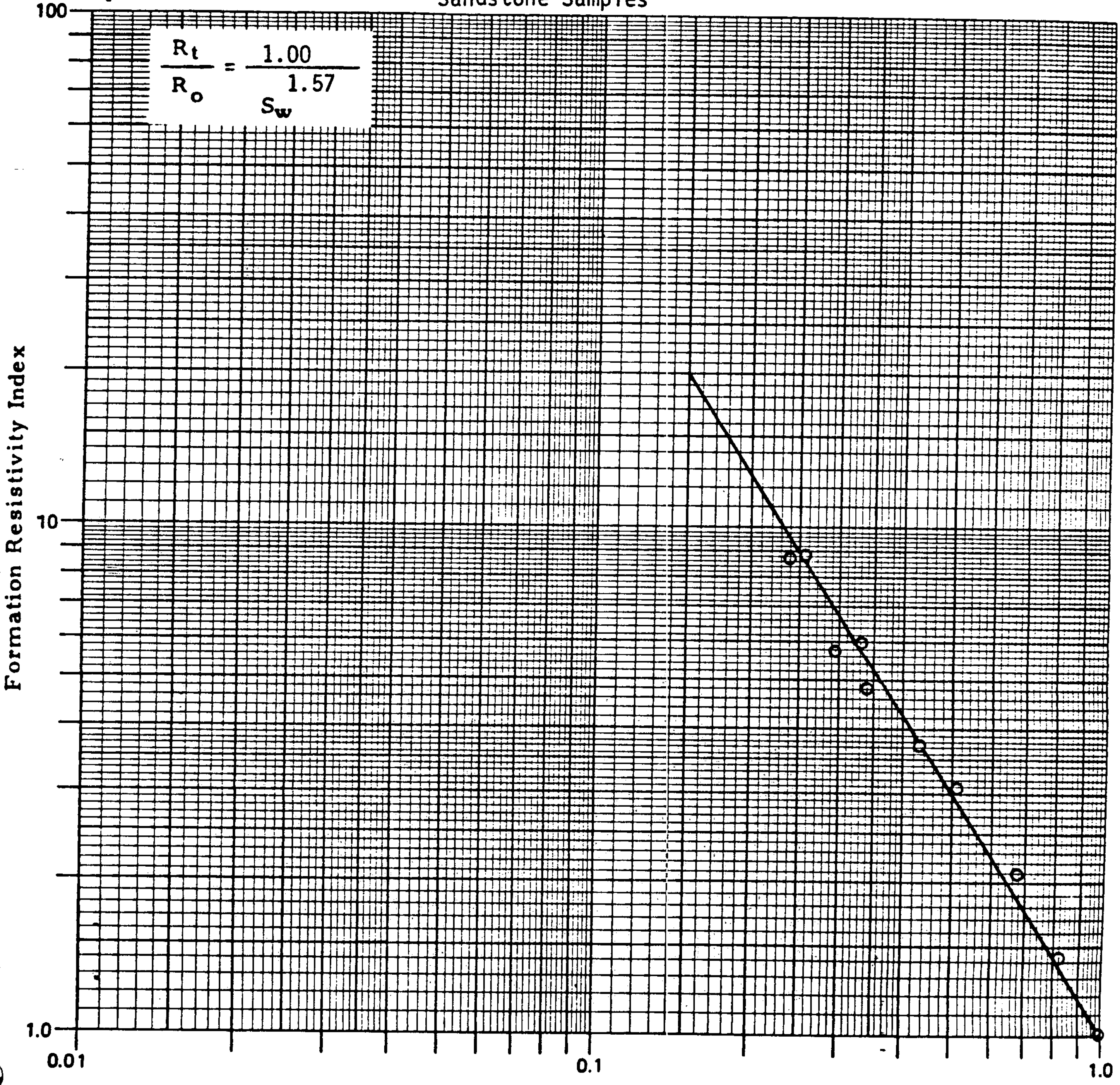
Sample Number 3



CL 847/SCAL 4006

Company Gruy Federal, Inc.
Well MCA No. 358
Field Maljamar
Formation Grayburg
County Lea
State New Mexico

Composite
Sandstone Samples



Brine Saturation, Fraction

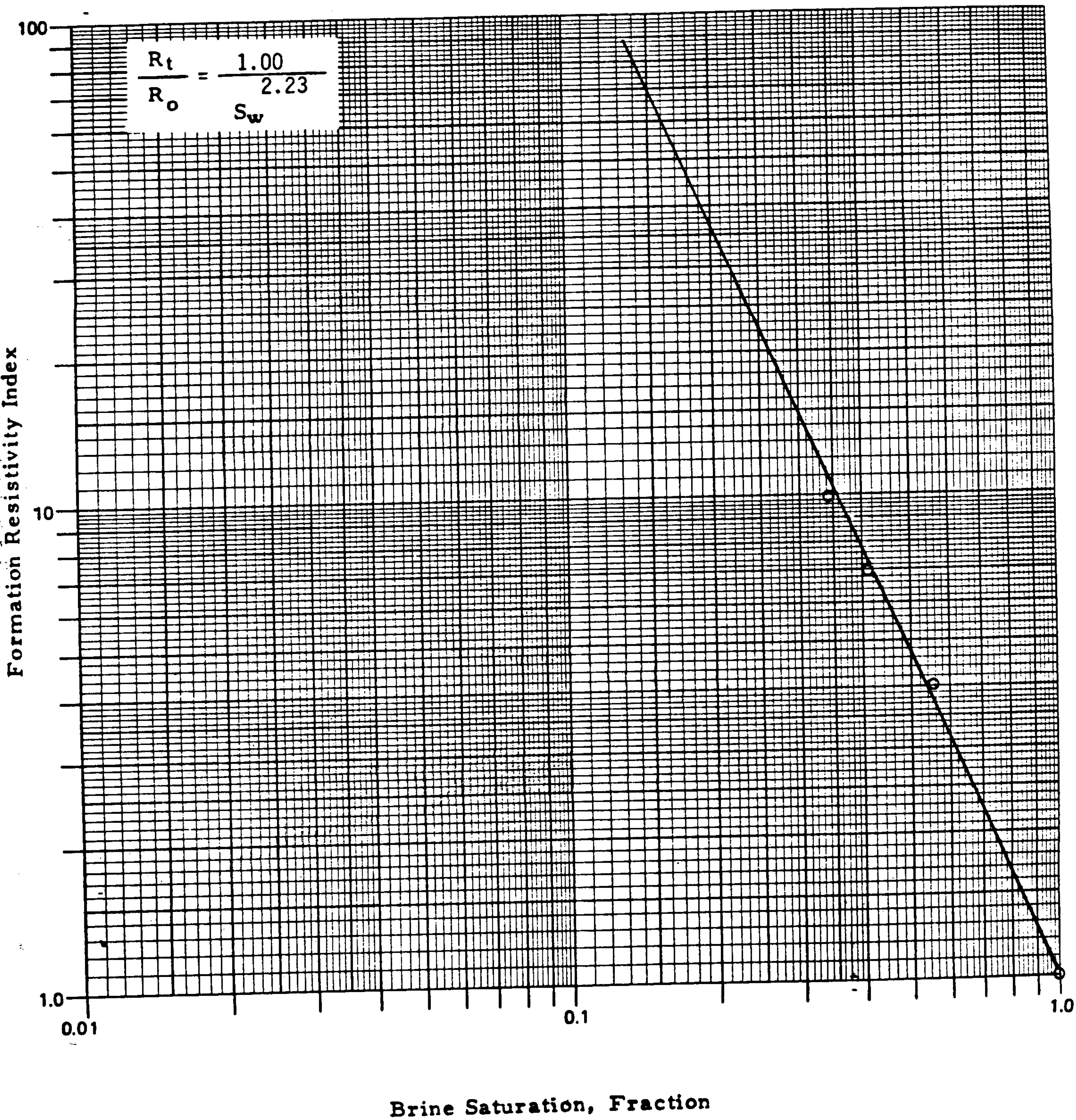
CL 847/SCAL 4006

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

File SCAL-308-80533

Company Gruy Federal, Inc.
Well MCA No. 358
Field Maljamar
Formation Grayburg
County Lea
State New Mexico

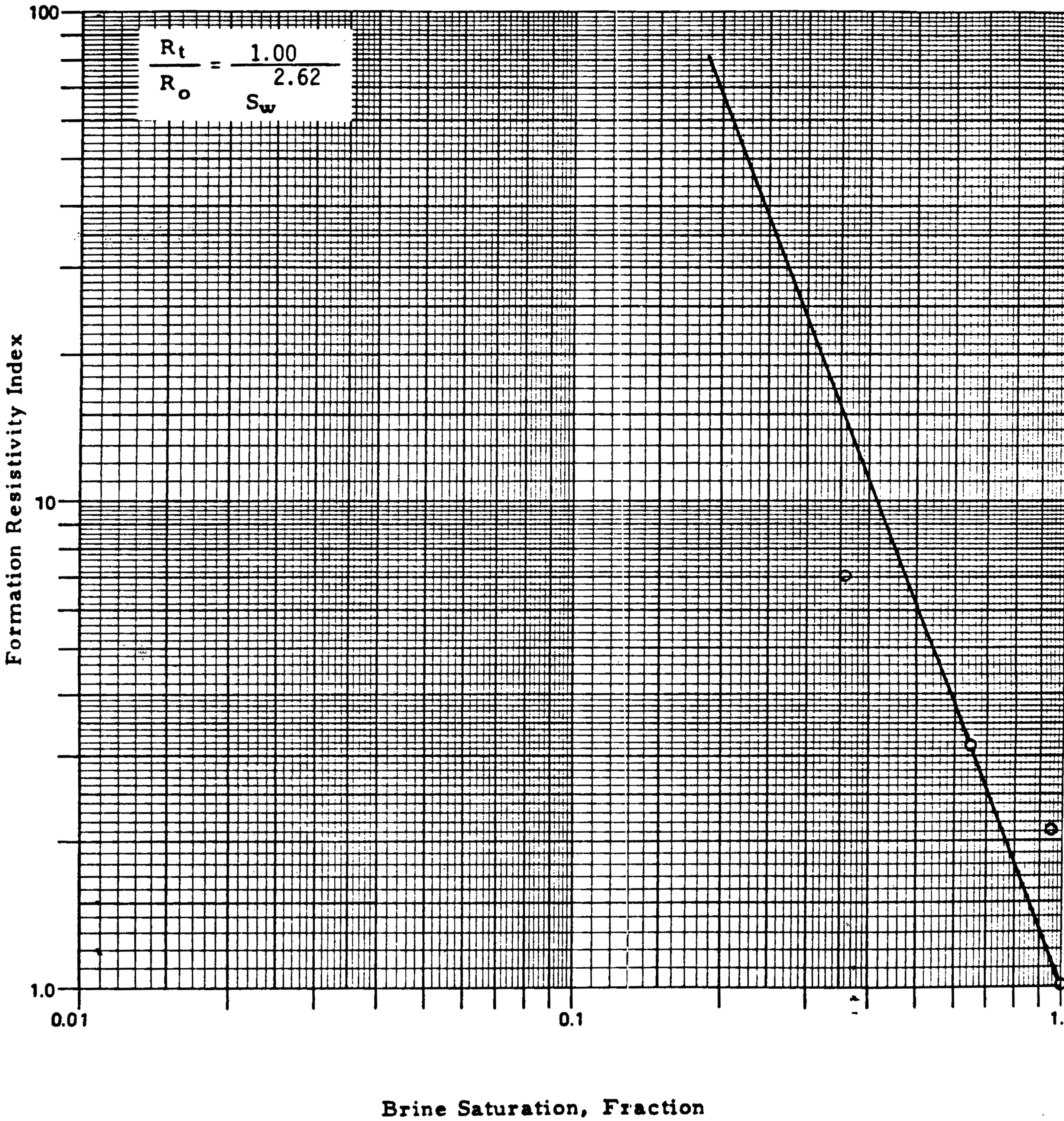
Sample Number 4



CL 847/SCAL 4006

Company Gruy Federal, Inc. | Formation Grayburg
Well MCA No. 358 | County Lea
Field Maljamar | State New Mexico

Sample Number 5



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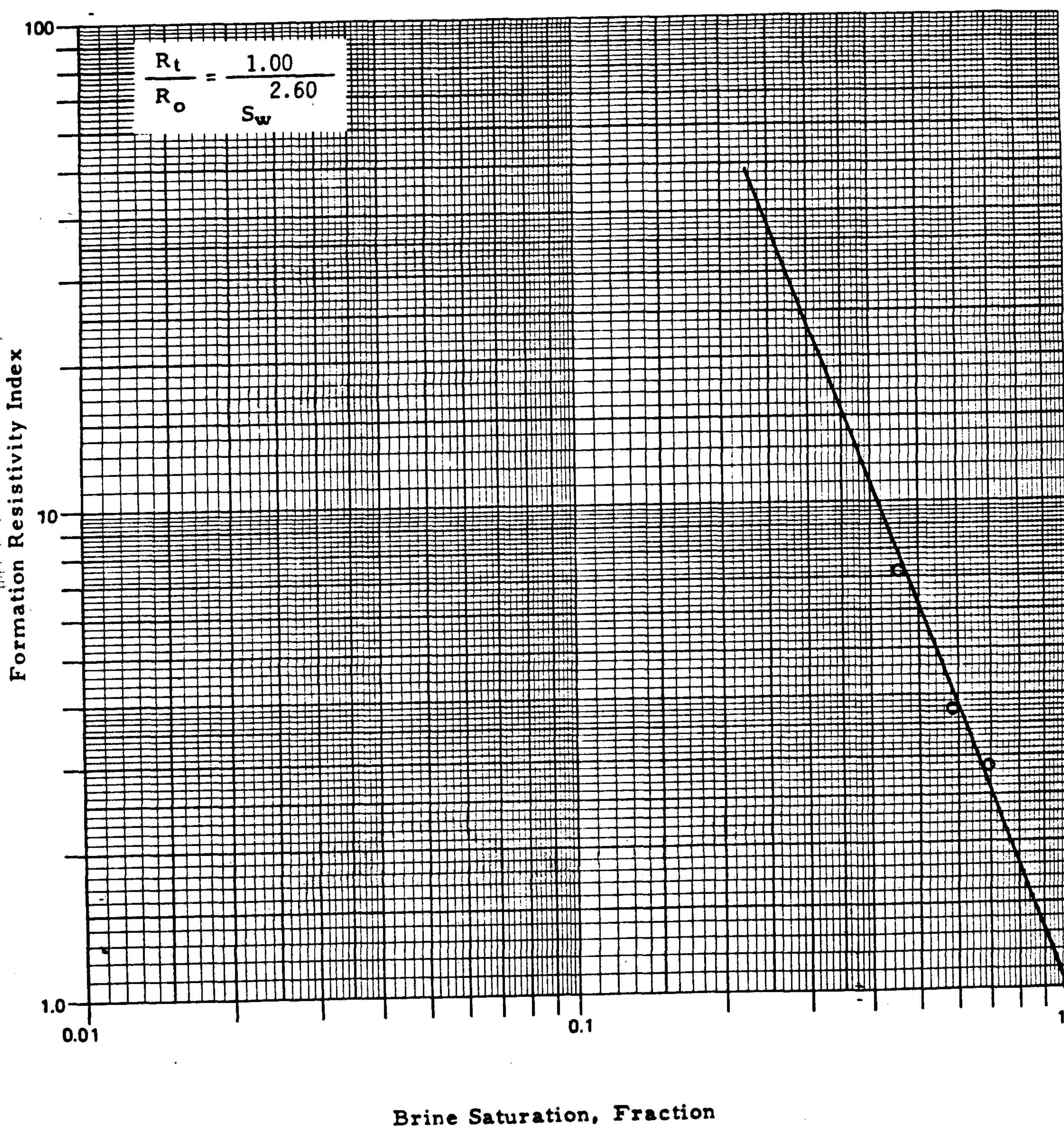
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company Gruy Federal, Inc. Formation Grayburg
Well MCA No. 358 County Lea
Field Maljamar State New Mexico

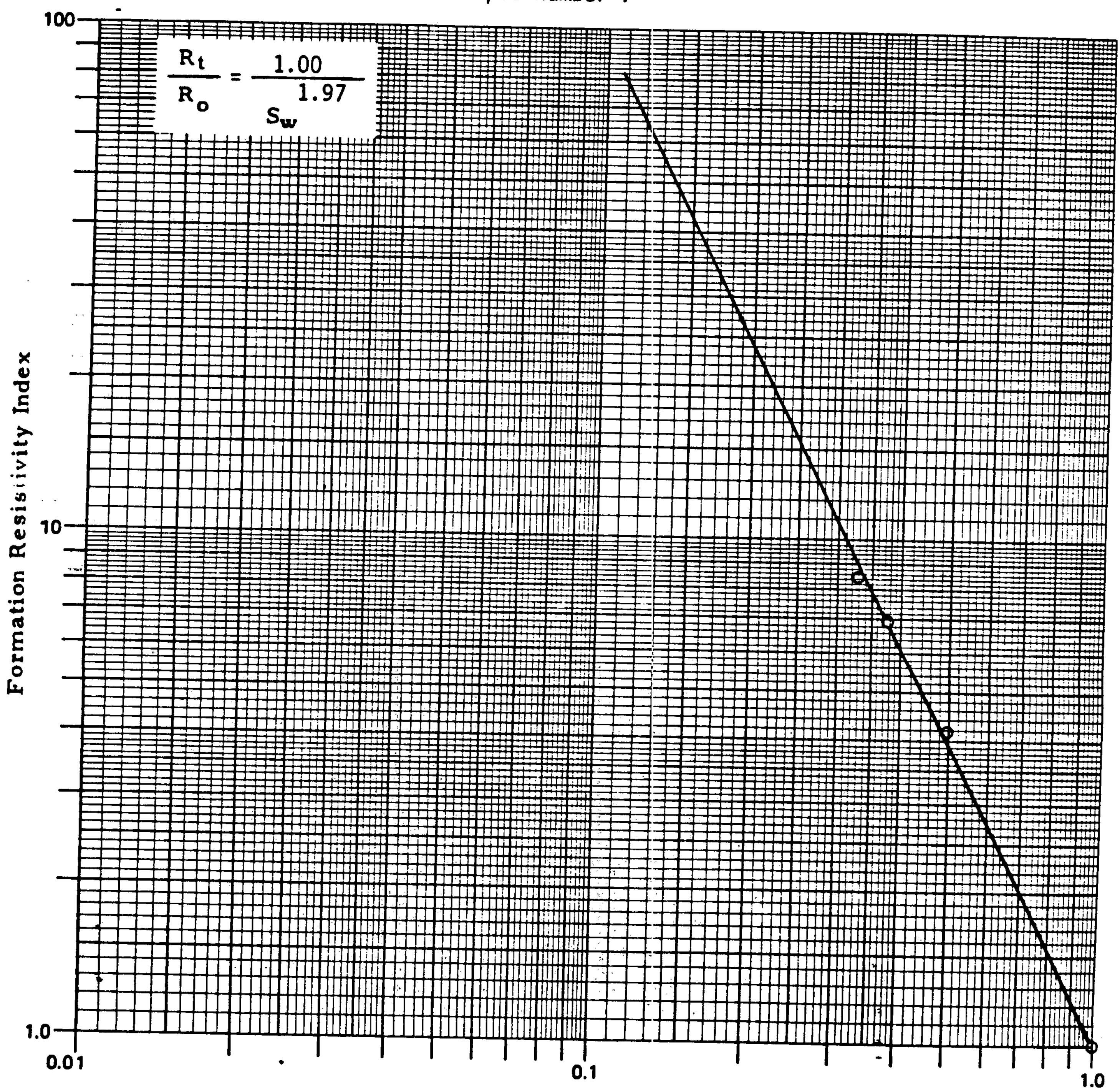
Sample Number 6



CL 847/SCAL 4006

Company Gruy Federal, Inc.
Well MCA No. 358
Field Maljamar
Formation Grayburg
County Lea
State New Mexico

Sample Number 7

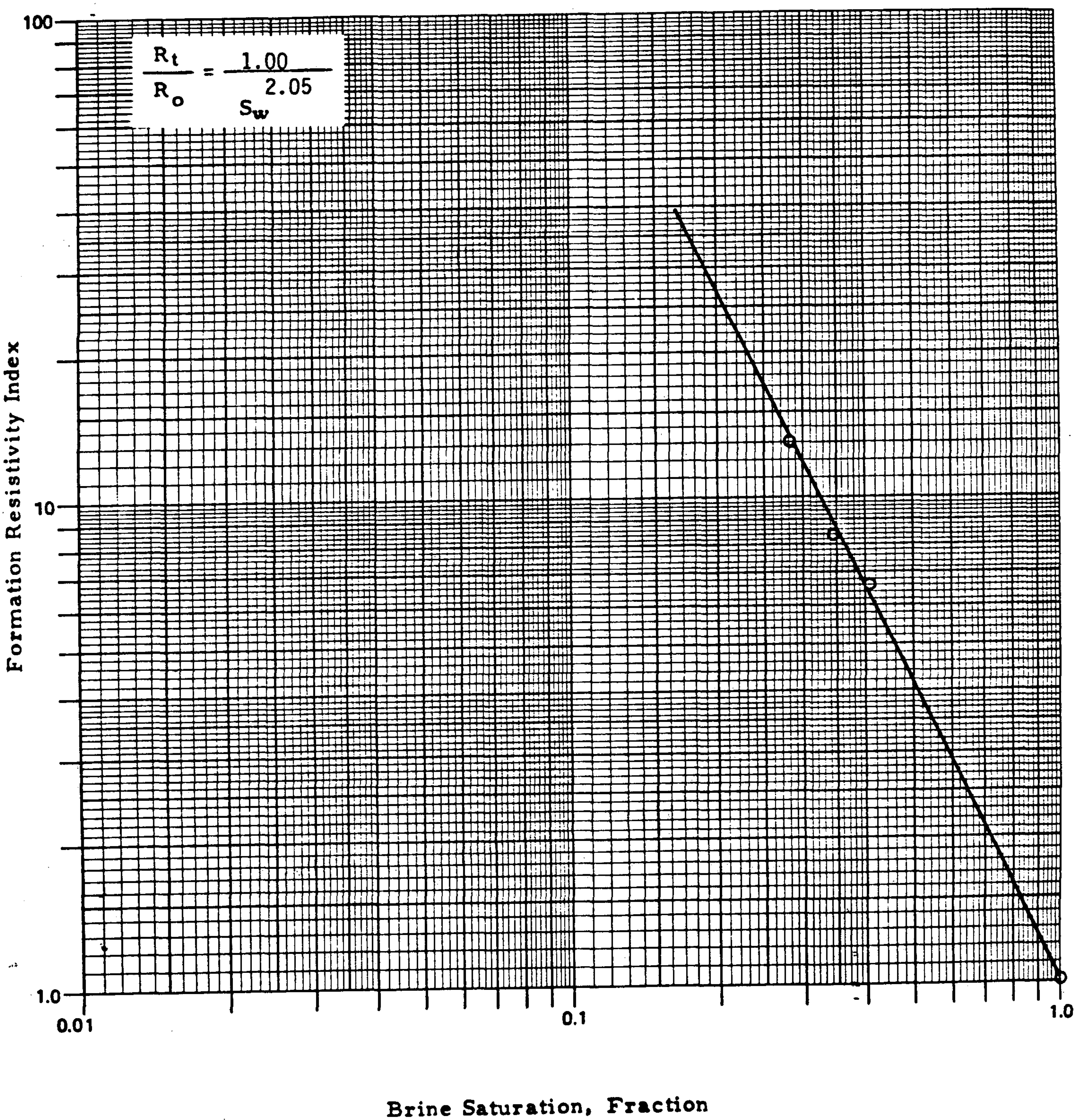


Brine Saturation, Fraction

CL 847/SCAL 4006

Company Gruy Federal, Inc. Formation Grayburg
Well MCA No. 358 County Lea
Field Maljamar State New Mexico

Sample Number 8A



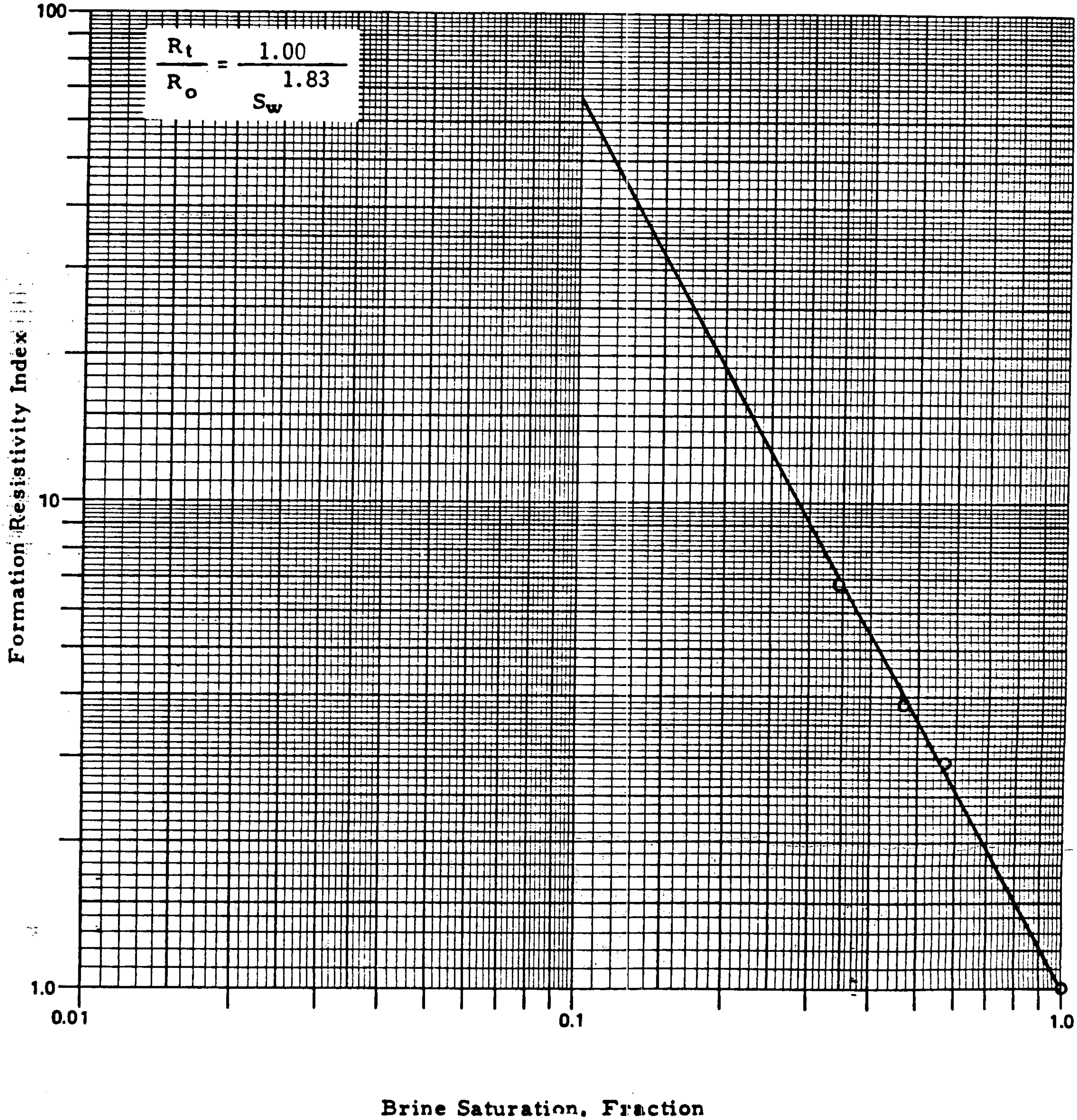
CL 847/SCAL 4006

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

File SCAL-308-80533

Company Gruy Federal, Inc.
Well MCA No. 358
Field Maljamar
Formation Grayburg
County Lea
State New Mexico

Sample Number 9

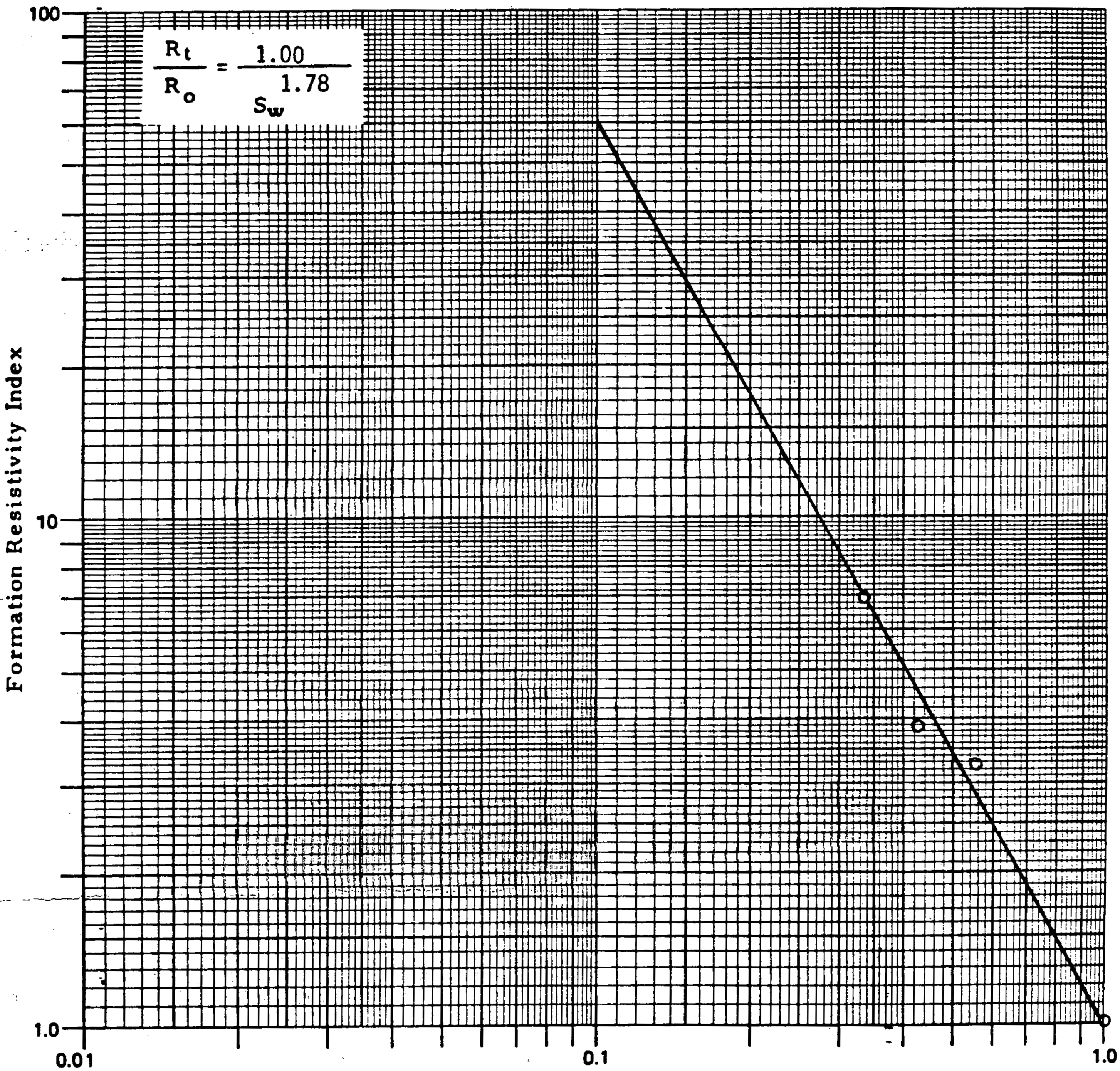


CL 847/SCAL 4006

Company Gruy Federal, Inc.
Well MCA No. 358
Field Maljamar

Formation Grayburg
County Lea
State New Mexico

Sample Number 10

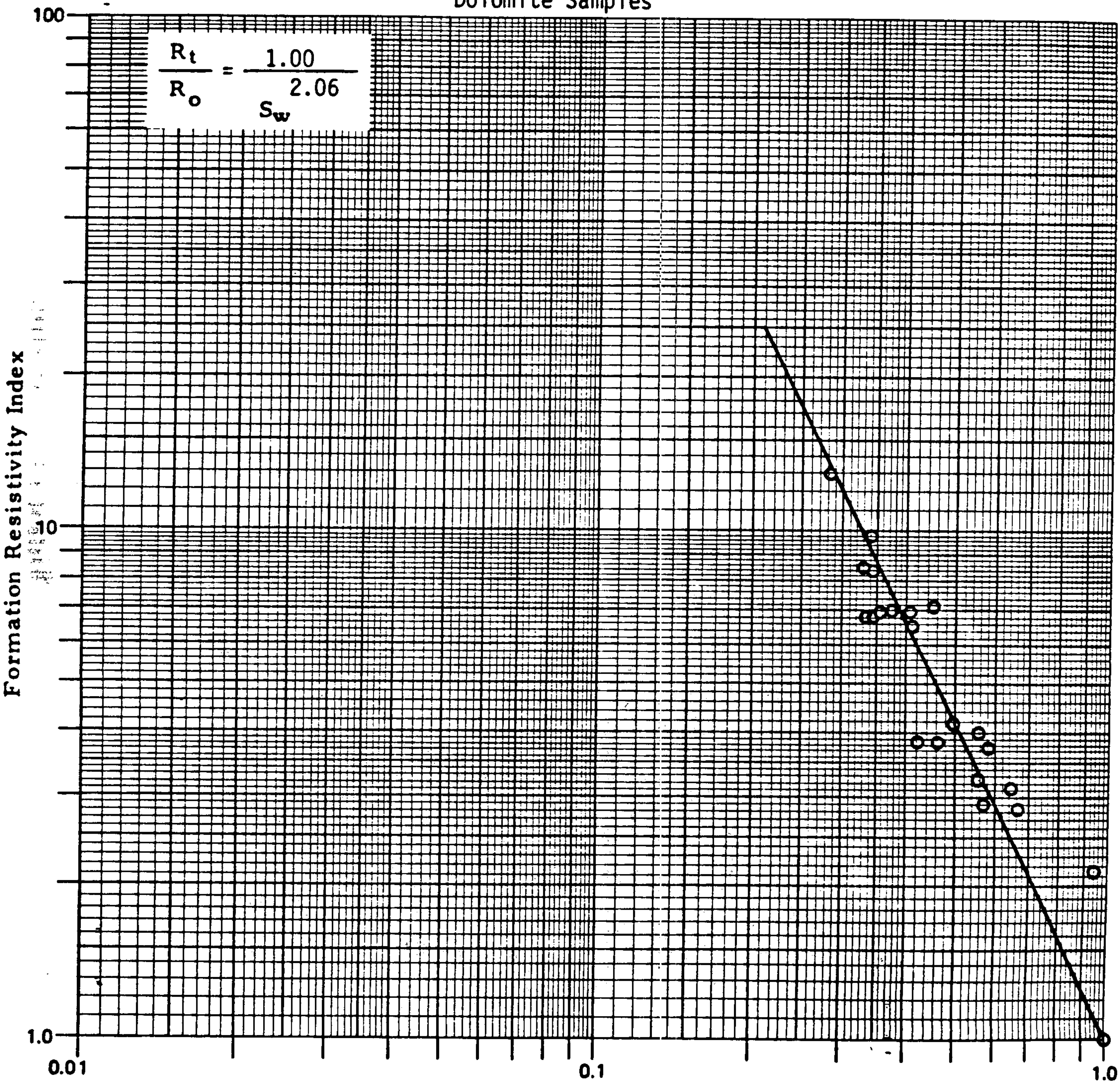


Brine Saturation, Fraction

CL 847/SCAL 4006

Company Gruy Federal, Inc.
Well MCA No. 358
Field Maljamar
Formation Grayburg
County Lea
State New Mexico

Composite
Dolomite Samples



Brine Saturation, Fraction

Special Core Analysis Study

for

GRUY FEDERAL

Conoco, Inc.
MCA No. 358 Well
Maljamar Field
Lea County, New Mexico

7501 STEMMONS FREEWAY. BOX 47547. DALLAS. TEXAS 75247 · 214/631-8270

CORE LABORATORIES, INC.
Special Core Analysis

October 31, 1980

Gruy Federal, Inc.
2500 Tanglewilde, Suite 150
Houston, Texas 77063

Attention: Mr. John H. Goodrich

Subject: Special Core Analysis Study
MCA No. 358 Well
Maljamar Field
Lea County, New Mexico
File Number: SCAL-307-80111

Gentlemen:

Presented in this report are the results of core analysis measurements performed on Grayburg Formation recovered from the subject well, as authorized by your Purchase Order No. 27-88.

The cores used in this study were recovered using pressure-retaining coring equipment and water-base mud tagged with tritium as a tracer. This tracer was used as an aid to determine the degree of flushing of the core by the mud filtrate. Also, prior to coring, the inner core barrel was filled with a low invasion gel in an effort to minimize filtrate invasion of the core after it entered the barrel.

All of the cores recovered under pressure at the surface were frozen at the well site. These frozen cores, which were still encased in the inner core barrel, were packed in chests of dry ice and transported to our Dallas laboratory.

Full-diameter segments of the recovered core were selected for analysis by a low temperature retort method. In addition, certain portions of the recovered core were chosen for testing to determine the concentration of tritium tracer in the pore water. Procedures for preparing the cores for analysis, as well as the analysis procedures, are presented on Pages 1 through 4.

The data obtained on the full-diameter samples are tabulated on Pages 5 through 18, along with lithological descriptions. The analysis results of the gas collected from these samples during pressure depletion are given on Pages 19 through 22. The components of the gas collected from the depth interval 3717.65 to 3722.5 were not detectable due to the limited volume of evolved hydrocarbon gas. The chloride contents of the pore water expelled during pressure depletion are tabulated on Pages 23 and 24.

Permeability, porosity, and water saturation data measured on the portions of core selected for the tracer concentration determinations are given on Pages 25 and 26. As indicated, these results were obtained on "plugs" and "donuts." The plug represents the inner portion of the full-diameter core while the donut represents the outer core portion encompassing the plug. This method of core sampling was utilized to provide a means of evaluating the depth and degree of filtrate invasion into the full-diameter core.

The samples of pore water containing the tritium were submitted to Teledyne Isotopes, Inc., for analysis. Hence, the tritium concentration data are not included in this report, but will be submitted to you by Teledyne Isotopes, Inc.

It was a pleasure working with you on this study. Should you have any questions pertaining to these test results, or if we could be of further assistance, please do not hesitate to contact us.

Very truly yours,

Core Laboratories, Inc.

C. Ed York

C. Ed York
for Duane L. Archer, Manager
Special Core Analysis

7 cc. - Addressee
1 cc. - Conoco
Attention: Mr. Preston Gant
R & D Building
Ponca City, Oklahoma 74601

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

Well Conoco MCA No. 358
File SCAL-307-80111

Core Preparation Procedures

1. Core samples, encased in steel tubing and frozen in chests of dry ice, were submitted to our Dallas laboratory.

2. Each length of tubing-encased frozen core was placed in a dry ice filled trough attached to a milling machine. Two diametrically opposed grooves were milled down the length of the steel tubing to a depth slightly less than the wall thickness of the tubing. Liquid nitrogen was directed at the point of milling to ensure that the temperature of the tubing and core was maintained at or below that of frozen carbon dioxide.

3. The grooved tubing and encased frozen core were returned to the dry ice chest. The tubing, after being separated into two halves by wedging a tool into the milled grooves, was removed from the frozen core.

4. Drilling mud and/or low invasion gel was removed from the frozen core by chipping and abrasive action. As before, liquid nitrogen was sprayed periodically into the chest to ensure that the proper cryogenic temperature was maintained.

5. The cores were visually examined for lithological characteristics and samples were selected for analysis. One group of selected samples was specified for testing using a low-temperature retort method. The other group of cores was designated for use in determining tracer concentrations in the pore water.

6. Both ends of each selected core segment were faced with a diamond saw using liquid nitrogen to maintain the segment in a frozen state. The faced frozen core segments were stored under dry ice while awaiting testing.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

Well Conoco MCA No. 358
File SCAL-307-80111

Low Temperature Retort Procedures

1. The faced frozen core segments, comprising a retort sample, were placed in a thin-walled metal thimble, quickly weighed, and placed in a low temperature retort. The retort was closed immediately.

2. The retort and its attached fluid-collecting system were evacuated for 45 seconds to remove as much air as possible before gas began to evolve from the core. The system was then sealed and the frozen core allowed to thaw at room temperature.

3. Water and oil expelled by the evolving gas were collected in a graduated receiving tube.

4. The evolved gas was collected in the void space in the retort. The system is equipped with a gauge to allow monitoring of the pressure inside the retort. If the retort pressure exceeded 0 psig, an attached and previously evacuated gas-collection cell was then connected to the retort to collect additional evolved gas.

5. Barometric pressure, room temperature, retort pressure, and produced liquid volumes were recorded periodically. Thawing of the core was considered complete when consecutive readings indicated no additional liquid or gas were being produced.

6. Portions of the evolved gas were collected separately from the retort and from the gas-collection cell, if used. The gas samples were analyzed to determine gas gravity and mole percent of the various components. The volumes of oil and water collected were also measured. The chloride content of the produced water was determined.

7. Upon completion of this phase of testing, the sample and its thimble were removed from the retort, weighed, and placed in a Dean-Stark (toluene distillation) apparatus. The remaining water content of the core, as well as some additional oil, were removed by toluene distillation.

8. When distillation was complete, the volume of water recovered was measured volumetrically. The sample and the thimble were removed from the Dean-Stark apparatus and placed in a vacuum oven at 240°F to remove the toluene. When drying was complete, the sample and thimble were removed from the oven and allowed to cool in the presence of a desiccant and then reweighed.

9. The volume of additional oil extracted was determined gravimetrically using the stock tank oil density (corrected to room temperature) of 0.849 gram/cc as was indicated by analysis of the retorted oil. The volume of water distilled was corrected to reflect the equivalent volume of water having the same salinity as the retorted water, as was indicated by the chloride determination.

10. The core was removed from the thimble. All loose grains were removed from each segment of core, and the segments were encased in surgical stocking material to minimize grain loss. These cores were then subjected to further extraction using carbon dioxide-charged toluene heated to 180°F to extract any oil still remaining in the core. When this extraction process was completed, the cores were leached with carbon dioxide charged methanol to remove the salt content. The weight loss occurring upon extraction was taken as the weight of oil removed which was converted into a volumetric value using the above mentioned oil density.

11. Porosities and horizontal and vertical air permeabilities were measured on each core segment.

12. Liquid saturations at stock tank conditions were calculated using the measured total pore volume of all of the core segments comprising the retort sample and the total oil and water contents recovered from these segments. The volume of gas collected from the sample was determined from the known volume of the retort and fluid-collection system, corrected for the grain and thimble volumes as well as the total liquid. This gas volume was further corrected to standard conditions.

Tracer Sample Analysis Procedures

1. A cylindrical plug was drilled from each frozen core segment selected for tracer concentration determinations. The plug was drilled concentrically to the circumference of the core segment and, hence, along its vertical axis. Liquid nitrogen was used as the bit lubricant to ensure the core remained at the proper cryogenic temperature level. The drilled plug and the remaining portion of the core segment, herein after referred to as the "donut," were labeled and returned to the freeze chest.

2. The plug and donut samples were removed from the freeze chest, quickly weighed, and immediately returned to the freeze chest for transport to the Dean-Stark (toluene distillation) apparatus. Metal extraction thimbles to be used with these samples to minimize grain loss were also weighed.

3. The plug and donut samples were removed from the freeze chest, promptly inserted into their respective thimbles, and placed in their individual Dean-Stark sample chambers. The chambers were closed immediately. Heat was applied to the toluene, and distillation of the water contents from the cores was initiated.

4. When distillation was complete, the volume of water recovered from each sample of core was recorded. The heat was removed from the apparatus and the samples were allowed to cool to room temperature while inside the sample chambers. The water recovered from each sample was transferred to a glass bottle which was subsequently sealed. The bottle and its contained water were submitted to Teledyne Isotopes, Inc., for determinations of the tritium concentration.

5. The plug and donut samples were weighed while in their thimbles to determine their individual weight loss.

6. All loose grains were removed from the plug and donut samples. The samples, after being encased in surgical stocking material to minimize grain loss, were subjected to further extraction and leaching using CO_2-charged toluene and methanol. The samples were dried and their porosities measured. Water saturations for the plug and donut samples were calculated from the volume of water, corrected for salinity, recovered during the toluene distillation. The air permeability of the plug was measured.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

Well Conoco MCA No. 358
File SCAL-307-80111

Full-Diameter Core Analysis Data of Pressure-Retained Cores

Depth, feet	Air Permeability, md. Horizontal Max.	90°	Vertical	Porosity, Percent	Pore Volume, cc	Grain Density, gm/cc	Stock Tank Fluid Saturations, Percent Pore Space Oil*	Oil**	Water	Description
3692.00-92.55	77	60	12.5	13.0	44.7	2.81	0.0	16.1	58.8	Ss, tan, v/fn gr, sl/calc, mod/ indurated, dns, dolo
3692.55-93.20	14	14	6.3	11.2	60.9	2.78	2.6	30.6	58.0	Ss, tan, v/fn gr, sl/calc, mod/ indurated, dns, dolo
3693.20-94.25	19	19	1.2	11.7	82.0	2.77	0.0	21.3	72.5	Ss, tan, v/fn gr, sl/calc, mod/ indurated, dns, dolo
3694.25-95.15	21	21	10.8	12.1	83.2	2.79	1.1	31.5	61.7	Ss, tan, v/fn gr, sl/calc, mod/ indurated, dns, dolo
3694.25-95.15	17	16	6.0							Ss, tan, v/fn gr, sl/calc, mod/ indurated, dns, dolo
3695.15-96.60	1.5	1.4	<0.01	4.7	37.3	2.78	4.6	21.3	62.4	Ss, tan, v/fn gr, sl/calc, mod/ indurated, dns, dolo
3696.60-97.55	4.0	3.7	0.60	8.3	70.0	2.77	2.3	16.0	71.3	Ss, tan, v/fn gr, clayey, mod/ indurated, dns, anhy
3697.55-98.50	1.0	1.0	<0.01	6.8	52.7	2.81	7.6	23.4	59.4	Ss, gry, fn gr, calc, mod/ indurated dns, dolo
3697.55-98.50	0.57	0.52	0.14							Ss, gry, fn gr, calc, mod/ indurated dns, dolo
3698.50-99.30	0.32	0.20	<0.01	4.8	33.7	2.81	22.3	41.7	48.2	Dolo, gry, fn xln, calc, mod/ indurated, dns,
3699.30-3700.15	0.21	0.17	<0.01	5.3	29.1	2.79	24.4	52.0	43.8	Dolo, gry, fn xln, calc, mod/ indurated, dns,
3700.15-00.95	32	31	16	14.3	63.1	2.70	0.0	13.2	71.2	Ss, gry, v/fn gr, clayey, mod/ indurated, dns, slty

*By pressure depletion
**Total Oil

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

Well Conoco MCA No. 358
File SCAL-307-80111

Full-Diameter Core Analysis Data of Pressure-Retained Cores

Depth, feet	Air Permeability, md. Horizontal Max.	Air Permeability, md. Horizontal 90°	Air Permeability, md. Vertical	Porosity, Percent	Pore Volume, cc	Grain Density, gm/cc	Stock Tank Fluid Saturations, Percent Pore Space Oil*	Oil**	Water	Description
3700.95-01.50	29	28	21	13.1	59.1	2.68	0.0	16.2	73.2	Ss, gry, v/fn gr, clayey, mod/ indurated, dns, slty
3701.50-02.30	26	25	10	12.4	85.6	2.68	0.0	20.1	70.1	Ss, gry, v/fn gr, clayey, mod/ indurated, dns, slty
3702.30-03.05	16	16	7.0	10.2	62.6	2.69	0.0	20.0	70.0	Ss, gry, v/fn gr, sl/calc, mod/ indurated, dns, dolo
3703.05-04.05	7.7	7.6	2.5	8.9	74.0	2.71	0.0	16.1	75.8	Ss, gry, v/fn gr, clayey, mod/ indurated, dns, slty
3704.05-04.90	0.25	0.23	<0.01	4.2	32.7	2.75	10.1	35.6	50.5	Dolo, gry, fn xln, calc, well indurated, dns
3704.90-05.75	<0.01	<0.01	<0.01	4.2	29.8	2.81	5.7	41.6	44.6	Dolo, gry, fn xln, calc, well indurated, dns
3705.75-07.00	0.20	0.18	<0.01	6.3	45.6	2.77	4.1	30.8	63.0	Dolo, gry, fn xln, sl/calc, well/indurated, dns
3716.00-16.80	0.80	0.60	0.36	9.7	48.3	2.73	0.0	17.2	76.1	Ss, gry, v/fn gr, sl/calc, mod/ indurated, dns, dolo
3716.80-17.65	0.15	0.12	<0.01	5.7	41.7	2.74	4.1	32.5	62.3	Ss, gry, v/fn gr, calc, mod/ indurated, dns, dolo
3717.65-18.45	0.03	<0.01	<0.01	0.9	6.7	2.88	0.0	29.0	50.3	Dolo, gry, fn xln, sl/calc, well indurated, dns
3717.65-18.45	0.02	<0.01	<0.01							Dolo, gry, fn xln, calc, well indurated, dns
3718.45-19.25	<0.01	<0.01	<0.01	0.8	4.1	2.86	0.0	29.3	48.8	Dolo, gry, fn xln, sl/calc, well/indurated, dns

*By pressure depletion
**Total oil

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

Well Conoco MCA No. 358
File SCAL-307-80111

Full-Diameter Core Analysis Data of Pressure-Retained Cores

Depth, feet	Air Permeability, md. Horizontal Max.	Air Permeability, md. Horizontal 90°	Air Permeability, md. Vertical	Porosity, Percent	Pore Volume, cc	Grain Density, gm/cc	Stock Tank Fluid Saturations, Percent Pore Space Oil*	Oil**	Water	Description
3718.45-19.25	0.05	<0.01	<0.01							Dolo, tan, fn xln, sl/calc, well/indurated, dns
3719.25-20.05	<0.01	<0.01	<0.01	0.9	6.1	2.86	0.0	31.1	57.0	Dolo, gry, fn xln, sl/calc, well/indurated, dns
3720.05-20.75	<0.01	<0.01	<0.01	0.8	4.6	2.88	0.0	34.3	42.8	Dolo, gry, fn xln, sl/calc, well/indurated, dns
3720.75-21.80	0.09	0.06	<0.01	1.5	13.4	2.85	0.0	41.7	40.1	Dolo, gry, fn xln, sl/calc, well/indurated, dns
3720.75-21.80	0.08	0.04	<0.01							Dolo, tan, med xln, sl/calc, well/indurated, dns
3721.80-22.50	0.05	0.02	<0.01	1.6	7.1	2.82	0.0	28.2	63.8	Dolo, tan, fn xln, sl/calc, well indurated, dns
3722.50-23.25	0.05	<0.01	<0.01	3.0	19.4	2.79	0.0	50.0	44.0	Dolo, tan, fn xln, sl/calc, well/indurated, dns
3723.25-24.00										No analysis, no recovery
3724.00-25.00	0.11	0.06	<0.01	4.0	27.9	2.74	5.7	42.3	53.7	Ss, tan, v/fn gr, sl/calc, mod/indurated, dns, dolo
3725.00-25.90	<0.01	<0.01	<0.01	3.1	26.1	2.74	7.7	42.1	44.4	Ss, tan, v/fn gr, sl/calc, mod/indurated, dns, dolo
3725.90-26.50	0.42	0.20	<0.01	4.8	25.4	2.74	18.5	54.7	27.8	Ss, tan, v/fn gr, sl/calc, mod/indurated, dns, dolo
3726.50-27.15	0.13	0.12	<0.01	5.3	28.9	2.72	22.5	53.8	25.7	Ss, tan, v/fn gr, sl/calc, mod/indurated, dns, dolo

*By pressure depletion
**Total oil

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

Well Conoco MCA No. 358
File SCAL-307-80111

Full-Diameter Core Analysis Data of Pressure-Retained Cores

Depth, feet	Air Permeability, md. Horizontal Max.	Horizontal 90°	Vertical	Porosity, Percent	Pore Volume, cc	Grain Density, gm/cc	Stock Tank Fluid Saturations, Percent Pore Space Oil*	Oil**	Water	Description
3727.15-27.95	0.12	0.05	0.15	2.7	12.0	2.78	0.0	54.3	30.8	Ss, tan, v/fn gr, sl/calc, mod/ indurated, dns, dolo
3727.95-28.75	<0.01	<0.01	<0.01	1.8	12.9	2.82	0.0	29.5	45.7	Dolo, tan, fnly xln, calc, well indurated, dns
3728.75-29.40	0.25	0.25	<0.01	6.3	34.0	2.71	5.6	22.8	68.3	Ss, tan, v/fn gr, clayey, mod/ indurated, dns, slty
3729.40-30.00	0.98	0.96	0.18	8.2	44.3	2.71	0.0	13.1	72.3	Ss, tan, v/fn gr, clayey, mod/ indurated, dns, slty
3730.00-30.80	0.51	0.50	0.23	7.2	49.0	2.71	0.0	14.7	77.0	Ss, tan, v/fn gr, clayey, mod/ indurated, dns, slty
3730.80-31.95	0.56	0.53	0.11	8.8	65.7	2.70	0.0	10.4	80.6	Ss, tan, v/fn gr, clayey, mod/ indurated, dns, slty
3730.80-31.95	0.67	0.67	0.14							Ss, tan, v/fn gr, clayey, mod/ indurated, dns, slty
3803.00-03.45	2.5	2.0	0.57	8.7	30.4	2.90	4.3	57.0	29.2	Dolo, tan, fnln xln, calc, well indurated, vug
3803.45-04.10	0.50	0.12	0.19	2.8	15.0	2.90	3.3	29.2	53.5	Dolo, tan, med xln, calc, well indurated, dns
3804.10-07.10	7.2	3.8	2.0	7.9	60.6	2.89	7.8	31.1	50.4	Dolo, tan, med xln, calc, well indurated, dns
3804.10-07.10	1.9	1.5	0.16							Dolo, tan, fnly xln, calc, well indurated, dns
3804.10-07.10	4.3	2.7	2.4							Dolo, tan, fnly xln, calc, well indurated, dns

*By pressure depletion
**Total oil

Well Conoco MCA No. 358
File SCAL-307-80111

Full-Diameter Core Analysis Data of Pressure-Retained Cores

Depth, feet	Air Permeability, md. Horizontal Max.	Air Permeability, md. Horizontal 90°	Air Permeability, md. Vertical	Porosity, Percent	Pore Volume, cc	Grain Density, gm/cc	Stock Tank Fluid Saturations, Percent Pore Space Oil*	Oil**	Water	Description
3807.10-07.60	5.6	4.0	6.3	8.5	32.6	2.90	3.4	29.9	52.4	Dolo, tan, fnly xln, calc, well indurated, dns
3807.60-08.40	4.7	4.4	1.8	11.0	76.1	2.88	11.0	37.4	51.4	Dolo, tan, fnly xln, calc, well indurated, vug
3808.40-09.75	19	16	14	10.4	77.5	2.89	8.8	31.0	50.3	Dolo, tan, fnly xln, calc, well indurated, vug
3808.40-09.75	2.2	1.8	1.4							Dolo, tan, fnly xln, calc, well indurated, vug
3809.75-10.45	1.3	1.1	<0.01	4.6	26.6	2.84	11.7	41.8	49.7	Dolo, tan, fnly xln, calc, well indurated, vug
3810.45-11.20	29	24	23	10.5	38.9	2.83	3.3	22.6	57.9	Dolo, tan, fnly xln, calc, well indurated, vug
3811.20-12.20	11	8.5	10	9.8	61.8	2.87	9.7	37.4	48.7	Dolo, tan, fnly xln, calc, well indurated, vug
3811.20-12.20	17	7.7	18							Dolo, tan, fnly xln, calc, well indurated, vug
3812.20-13.20	11	5.3	15	8.4	67.9	2.84	19.6	50.9	37.3	Dolo, tan, fnly xln, calc, well indurated, vug
3812.20-13.20	0.79	0.39	2.9							Dolo, tan, med xln, calc, well indurated, vug
3813.20-13.95	2.6	2.5	2.3	6.6	44.0	2.87	21.4	49.8	35.0	Dolo, tan, med xln, calc, well indurated, vug
3813.95-15.10	1.8	1.5	0.53	9.0	62.4	2.86	19.6	46.7	28.6	Dolo, tan, med xln, calc, well indurated, vug

*By pressure depletion
**Total oil

Well Conoco MCA No. 358
File SCAL-307-80111

Full-Diameter Core Analysis Data of Pressure-Retained Cores

Depth, feet	Air Permeability, md. Horizontal Max.	90°	Vertical	Porosity, Percent	Pore Volume, cc	Grain Density, gm/cc	Stock Tank Fluid Saturations, Percent Pore Space Oil*	Oil**	Water	Description
3813.95-15.10	0.91	0.86	0.53							Dolo, tan, med xln, calc, well indurated, vug
3815.10-15.85	1.5	0.39	0.16	5.5	24.6	2.85	24.4	49.6	35.7	Dolo, tan, med xln, calc, well indurated, vug
3815.85-16.55	0.60	0.21	0.20	4.7	25.0	2.86	16.4	51.3	40.3	Dolo, tan, med xln, calc, well indurated, vug
3816.55-17.70	0.82	0.38	<0.01	2.0	10.2	2.86	0.0	28.8	62.9	Dolo, tan, med xln, calc, well indurated, vug
3816.55-17.70	1.2	0.41	<0.01							Dolo, tan, med xln, calc, well indurated, vug
3816.55-17.70	0.84	0.72	0.14							Dolo, tan, med xln, calc, well indurated, vug
3817.70-18.20	0.18	0.18	<0.01	5.2	14.9	2.86	23.5	50.9	33.8	Dolo, tan, med xln, calc, well indurated, vug
3818.20-18.70	0.57	0.21	<0.01	2.0	6.8	2.85	0.0	28.4	68.1	Dolo, tan, med xln, calc, well indurated, vug
3818.20-18.70	1.2	0.10	2.1							Dolo, tan, med xln, calc, well indurated, vug
4043.00-43.45	8.8	6.3	7.3	8.6	27.1	2.85	9.6	25.5	61.8	Dolo, tan, fnly xln, calc, well indurated, vug, anhy
4043.45-44.85	13	11	3.7	10.7	63.4	2.86	13.7	29.1	59.9	Dolo, tan, fnly xln, calc, well indurated, vug, anhy
4043.45-44.85	1950	795	1010							Dolo, tan, fnly xln, calc, well indurated, frac, anhy

*By pressure depletion
**Total oil

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

Well Conoco MCA No. 358
File SCAL-307-80111

Full-Diameter Core Analysis Data of Pressure-Retained Cores

Depth, feet	Air Permeability, md. Horizontal Max.	Air Permeability, md. Horizontal 90°	Air Permeability, md. Vertical	Porosity, Percent	Pore Volume, cc	Grain Density, gm/cc	Stock Tank Fluid Saturations, Percent Pore Space Oil*	Oil**	Water	Description
4044.85-46.10	5900	177	246	14.9	57.8	2.80	3.5	26.5	66.9	Dolo, tan, fnly xln, calc, well indurated, frac, anhy
4044.85-46.10	6420	44	84							Dolo, tan, fn xln, calc, well indurated, frac, anhy
4044.85-46.10	6950	4.7	72							Dolo, tan, fn xln, calc, well indurated, frac, anhy
4046.10-47.15	53	52	80	14.3	97.5	2.89	3.1	24.7	59.9	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4046.10-47.15	40	38	57							Dolo, tan, fn xln, calc, well indurated, vug, anhy
4047.15-48.30	55	38	161	14.2	120	2.86	4.4	27.8	60.8	Dolo, tan, fn xln, calc, well indurated, frac, anhy
4047.15-48.30	29	28	18							Dolo, tan, fn xln, calc, well indurated, vug, anhy
4048.30-49.05	2.5	1.2	1.5	6.9	42.7	2.85	9.4	19.6	71.3	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4049.05-50.25	6.0	0.91	0.42	6.8	44.4	2.86	2.9	14.2	73.7	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4049.05-50.25	6.8	1.4	7.3							Dolo, tan, fn xln, calc, well indurated, vug, anhy
4050.25-50.95	7.5	5.8	4.1	8.3	31.0	2.87	8.7	27.6	61.9	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4051.00-52.40	59	57	100	8.0	95.5	2.83	1.1	14.6	73.7	Dolo, tan, fn xln, calc, well indurated, vug, anhy

*By pressure depletion
**Total oil

Well Conoco MCA No. 358
File SCAL-307-80111

Full-Diameter Core Analysis Data of Pressure-Retained Cores

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Depth, feet	Air Permeability, md. Horizontal Max.	90°	Vertical	Porosity, Percent	Pore Volume, cc	Grain Density, gm/cc	Stock Tank Fluid Saturations, Percent Pore Space Oil*	Oil**	Water	Description
4052.40-52.90	64	60	77	10.3	41.0	2.83	0.0	11.8	80.6	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4052.90-53.75	99	94	82	11.2	84.0	2.83	0.0	13.0	79.2	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4053.75-54.30	121	74	214	12.5	53.2	2.83	0.0	8.0	78.3	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4054.30-54.95	22	19	3.1	7.6	30.3	2.85	0.0	11.4	76.2	Dolo, tan, fn xly, calc, well indurated, vug, anhy
4054.95-55.40	3.1	3.0	3.3	6.6	23.9	2.86	0.0	14.1	71.1	Dolo, tan, fn xly, calc, well indurated, vug, anhy
4055.40-56.10	5.6	1.4	3.0	7.6	53.9	2.86	7.4	14.0	73.6	Dolo, tan, fn xly, calc, well indurated, vug, anhy
4056.10-57.10	0.88	0.62	0.49	3.9	25.1	2.85	0.0	8.9	82.9	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4057.10-58.25	3.8	2.4	2.3	3.7	29.8	2.83	0.0	12.7	76.5	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4058.25-59.00	50	48	51	9.1	44.8	2.86	0.0	7.6	78.3	Dolo, tan to gry, fn xln, calc, well indurated, vug
4058.25-59.00	16	1.8	***							Dolo. tan to gry, fn xln, calc, well indurated, vug, anhy
4059.00-60.10	2.4	2.1	0.47	5.0	15.5	2.87	0.0	25.9	71.7	Dolo, tan, fn xln, calc, well indurated, vug
4059.00-60.10	4.4	4.2	2.1							Dolo, tan to gry, fn xln, calc, well indurated, vug

*By pressure depletion
**Total oil
***Open vertical fracture

Full-Diameter Core Analysis Data of Pressure-Retained Cores

Depth, feet	Air Permeability, md. Horizontal Max.	90°	Vertical	Porosity, Percent	Pore Volume, cc	Grain Density, gm/cc	Stock Tank Fluid Saturations, Percent Pore Space Oil*	Oil**	Water	Description
4060.10-61.20	4.5	3.3	2.9	4.0	20.1	2.87	7.0	25.7	68.9	Dolo, tan to gry, fn xln, calc, well/indurated, vug
4060.10-61.20	0.94	0.82	0.26							Dolo, tan to gry, fn xln, calc, well/indurated, vug, anhy
4060.10-61.20	1.7	0.92	0.35							Dolo, tan to gry, fn xln, calc, well/indurated, vug, anhy
4061.20-62.00	0.32	0.28	0.20	2.4	12.9	2.86	6.2	27.4	68.9	Dolo, tan to gry, fn xln, calc, well, indurated, vug, anhy
4062.00-64.00										No analysis, highly broken
4064.00-67.00										No analysis, no recovery
4067.00-67.90	20	5.9	22	5.8	28.4	2.90	3.9	19.1	57.9	Dolo, tan to gry, fn xln, calc, well/indurated, vug, anhy
4067.00-67.90	1.3	1.2	0.63							Dolo, tan, fn xln, calc, well/indurated, vug, anhy
4067.90-68.75	0.48	0.30	0.24	3.1	15.0	2.85	0.7	24.1	67.1	Dolo, tan, fn xln, calc, well/indurated, vug, anhy
4067.90-68.75	1.1	0.89	1.5							Dolo, tan, fn xln, calc, well/indurated, vug, anhy
4068.75-69.85	3830***	3.1	1380***	4.2	19.0	2.85	4.7	16.0	67.3	Dolo, tan, fn xln, calc, well/indurated, vug
4068.75-69.85	3.3	1.9	2.4							Dolo, tan, fn xln, calc, well/indurated, vug, anhy

*By pressure depletion
**Total oil
***Open vertical fracture

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

Well Conoco MCA No. 358

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Full-Diameter Core Analysis Data of Pressure-Retained Cores

Depth, feet	Air Permeability, md. Horizontal Max.	90°	Vertical	Porosity, Percent	Pore Volume, cc	Grain Density, gm/cc	Stock Tank Fluid Saturations, Percent Pore Space Oil*	Oil**	Water	Description
4069.85-71.00	160	19	263	11.2	64.2	2.83	4.1	25.7	61.2	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4069.85-71.00	35	33	33							Dolo, tan, fn xln, calc, well indurated, vug
4071.00-72.00	46	38	11	9.9	48.8	2.85	2.1	16.8	72.3	Dolo, tan, fn xln, calc, well indurated, vug
4072.00-73.30	38	27	35	9.4	65.5	2.87	2.0	28.4	68.0	Dolo, tan, fn xln, calc, well indurated, vug
4072.00-73.30	14	11	6.2							Dolo, tan, fn xln, calc, well indurated, vug
4073.30-74.00	31	23	32	11.4	41.5	2.86	2.2	24.0	72.0	Dolo, tan, fn xln, calc, well indurated, vug
4074.00-74.75	25	8.0	13	9.4	50.9	2.85	5.3	24.2	63.9	Dolo, tan, fn xln, calc, well indurated, vug
4084.00-85.00	12	9.9	2.4	8.2	42.9	2.87	1.8	11.3	82.4	Dolo, tan, fn xln, calc, well indurated, dns
4085.00-86.20	48	40	25	12.9	94.8	2.88	0.3	10.9	76.7	Dolo, tan, fn xln, calc, well indurated, dns
4085.00-86.20	9.9	9.7	9.6							Dolo, tan, fn xln, calc, well indurated, dns
4086.20-87.20	16	15	16	13.3	84.0	2.86	0.1	17.2	68.7	Dolo, tan, fn xln, calc, well indurated, dns
4086.20-87.20	11	9.2	15							Dolo, tan, fn xln, calc, well indurated, dns

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*By pressure depletion
**Total oil

Full-Diameter Core Analysis Data of Pressure-Retained Cores

Depth, feet	Air Permeability, md. Horizontal Max.	90°	Vertical	Porosity, Percent	Pore Volume, cc	Grain Density, gm/cc	Stock Tank Fluid Saturations, Percent Pore Space Oil*	Oil**	Water	Description
4086.20-87.20	9.1	8.8	9.8							Dolo, tan, fn xln, calc, well indurated, dns
4087.20-88.00	12	11	12	13.4	93.2	2.85	0.6	15.2	68.3	Dolo, tan, fn xln, calc, well indurated, dns
4088.00-89.05	9.1	8.3	8.6	11.0	57.3	2.87	0.4	13.7	76.0	Dolo, tan, fn xln, calc, well indurated, dns
4088.00-89.05	10	7.2	11							Dolo, tan, fn xln, calc, well indurated, dns, anhy
4088.00-89.05	11	10	12							Dolo, tan, fn xln, calc, well indurated, vug, anhy
4088.00-89.05	31	26	21							Dolo, tan, fn xln, calc, well indurated, vug, anhy
4089.05-90.40	9.6	8.6	19	11.9	85.7	2.87	0.6	10.4	81.3	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4089.05-90.40	28	26	29							Dolo, tan, fn xln, calc, well indurated, dns, anhy
4089.05-90.40	30	24	36							Dolo, tan, fn xln, calc, well indurated, dns
4089.05-90.40	28	27	30							Dolo, tan, fn xln, calc, well indurated, vug, anhy
4090.40-91.40	14	11	7.3	12.5	104.1	2.87	2.3	12.3	80.8	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4091.40-92.00	34	22	29	11.9	41.1	2.88	0.1	8.5	79.4	Dolo, tan, fn xln, calc, well indurated, vug, anhy

*By pressure depletion
**Total oil

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

Well Conoco MCA No. 358
File SCAL-307-80111

Full-Diameter Core Analysis Data of Pressure-Retained Cores

Depth, feet	Air Permeability, md. Horizontal Max.	90°	Vertical	Porosity, Percent	Pore Volume, cc	Grain Density, gm/cc	Stock Tank Fluid Saturations, Percent Pore Space Oil*	Oil**	Water	Description
4092.00-92.60	31	22	30	11.0	48.9	2.86	0.0	13.2	76.1	Dolo, tan, fn xln, calc, well indurated, vug
4092.00-92.60	11	9.6	13							Dolo, tan, fn xln, calc, well indurated, vug
4092.60-93.20	11	11	10	10.9	46.8	2.87	0.0	15.1	70.3	Dolo, tan, fn xln, calc, well indurated, vug
4093.20-93.90	21	16	8.0	12.1	70.2	2.89	2.1	12.1	73.9	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4093.90-94.90	13	13	15	10.6	77.5	2.86	2.3	11.7	81.3	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4093.90-94.90	7.0	5.0	6.0							Dolo, tan, fn xln, calc, well indurated, vug, anhy
4094.90-95.95	21	20	15	10.9	59.3	2.87	2.7	15.8	72.7	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4094.90-95.95	21	17	12							Dolo, tan, fn xln, calc, well indurated, vug, anhy
4095.95-97.10	19	9.9	52	11.2	71.4	2.86	1.1	18.8	72.9	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4095.95-97.10	13	13	14							Dolo, tan, fn xln, calc, well indurated, vug, anhy
4095.95-97.10	26	21	7.7							Dolo, tan to gry, fn xln, calc, well/indurated, vug, anhy
4095.95-97.10	17	14	22							Dolo, tan, fn, xln, calc, well indurated, vug, anhy

*By pressure depletion
**Total oil

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

Well Conoco MCA No. 359
File SCAL-307-80111

Full-Diameter Core Analysis Data for Pressure-Retained Cores

Depth, feet	Air Permeability, md. Horizontal Max.	Air Permeability, md. Horizontal 90°	Air Permeability, md. Vertical	Porosity, Percent	Pore Volume, cc	Grain Density, gm/cc	Stock Tank Fluid Saturations, Percent Pore Space Oil*	Oil**	Water	Description
4097.10-98.60	13	9.1	8.4	12.5	55.6	2.85	4.9	23.2	66.0	Dolo, tan, fn xln, calc, well indurated, vug, anhy
4097.10-98.60	4240***	35	1320***							Dolo, tan fn xln, calc, well indurated, frac, anhy
4097.10-98.60	9760***	25	2850***							Dolo, tan, fn xln, calc, well indurated, frac, anhy
4097.10-98.60	887	3.1	1390							Dolo, tan, fn xln, calc, well indurated, vug
4098.60-99.85	38	31	12	8.8	62.0	2.84	3.2	18.4	71.3	Dolo, tan, fn xln, calc, well indurated, vug
4098.60-99.85	3.6	2.1	4.8							Dolo, tan, fn xln, calc, well indurated, vug
4098.60-99.85	36	26	27							Dolo, tan, fn xln, calc, well indurated, vug
4100.00-00.90	37	8.3	430	9.0	55.6	2.84	14.0	34.1	56.8	Dolo, tan, fn xln, calc, well indurated, frac
4100.00-00.90	961	13	436							Dolo, tan, fn xln, calc, well indurated, frac
4100.00-00.90	4120***	2.6	1020***							Dolo, tan, fn xln, calc, well indurated, frac
4100.90-02.05	368	4.2	22	8.8	62.9	2.85	12.6	18.0	59.4	Dolo, tan, fn xln, calc, well indurated, frac
4100.90-02.05	9.7	4.7	15							Dolo, tan, fn xln, calc, well indurated, vug

*By pressure depletion
**Total oil
***Open vertical fractures

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Full-Diameter Core Analysis Data of Pressure-Retained Cores

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Depth, feet	Air Permeability, md. Horizontal Max.	Air Permeability, md. Horizontal 90°	Air Permeability, md. Vertical	Porosity, Percent	Pore Volume, cc	Grain Density, gm/cc	Stock Tank Fluid Saturations, Percent Pore Space Oil*	Stock Tank Fluid Saturations, Percent Pore Space Oil**	Stock Tank Fluid Saturations, Percent Pore Space Water	Description
4102.05-02.90	22	1.9	17	6.8	41.2	2.84	12.9	26.0	67.3	Dolo, tan, fn xln, calc, well indurated, vug
4102.05-02.90	2.9	2.8	4.1							Dolo, tan, fn xln, calc, well indurated, vug
4102.05-02.90	29	2.6	846***							Dolo, tan, fn xln, calc, well indurated, vug
4102.90-03.80	11	9.7	13	5.9	39.8	2.85	12.8	24.6	65.3	Dolo, tan, fn xln, calc, well indurated, vug
4102.90.03.80	6.2	3.2	1.3							Dolo, tan, fn xln, calc, well indurated, vug
4103.80-04.65	5.9	3.0	5.2	5.5	33.5	2.86	6.9	20.3	69.5	Dolo, tan, fn xln, calc, well indurated, vug
4103.80-04.65	2.2	2.0	1.8							Dolo, tan, fn xln, calc, well indurated, vug
4104.65-05.75	2.3	1.4	1.3	6.5	54.1	2.88	2.0	12.7	76.2	Dolo, tan, fn xln, calc, well indurated, vug
4104.65-05.75	40	26	21							Dolo, tan, fn xln, calc, well indurated, vug
4105.75-06.40	14	10	6.7	7.8	36.0	2.88	0.3	15.0	78.3	Dolo, tan, fn xln, calc, well indurated, vug
4106.40-07.00	18	16	14	11.3	54.2	2.87	2.6	15.8	69.6	Dolo, tan, fn xln, calc, well indurated, vug
4107.00-07.65	4.9	4.1	4.3	11.8	44.9	2.86	10.9	26.4	57.4	Dolo, tan, fn xln, calc, well indurated, vug

*By pressure depletion
**Total oil
***Open vertical fractures

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

File SCAL-307-80111

Analysis of Liberated Gas by Gas Chromatography

Depth, feet	H_2S	CO_2	N_2	C_1	C_2	C_3	IC_4	NC_4	IC_5	NC_5	C_6	C_{7+}	Calc. Gas Gravity (Air=1.0)	Gas Volume cc @ STP
	Component Analysis, Mole Percent													
3692.00-92.55	0.00	20.70	5.79	0.74	18.25	28.65	4.25	11.44	3.50	3.48	1.27	1.34	1.580	417
3692.55-93.20	0.00	26.55	4.82	0.65	23.49	24.26	3.24	8.51	2.31	2.46	1.83	1.38	1.529	941
3693.20-94.25	0.00	22.73	5.96	1.01	27.84	24.94	3.11	7.78	1.98	1.90	1.14	0.98	1.467	930
3694.25-95.15	0.00	19.81	4.86	8.24	26.34	23.52	3.02	7.74	2.09	2.00	1.18	0.79	1.410	1121
3695.15-96.65	0.00	10.40	5.26	25.86	20.40	19.26	2.71	7.44	2.27	2.44	1.94	1.99	1.307	884
3696.65-97.55	0.00	6.71	6.25	33.69	21.53	18.39	2.32	6.08	1.69	1.68	1.01	0.64	1.158	1205
3697.55-98.50	0.00	7.99	6.22	31.97	19.86	18.05	2.50	6.78	2.09	2.10	1.40	1.04	1.209	1178
3698.50-99.30	0.00	7.43	5.86	27.35	19.86	19.68	2.99	8.30	2.68	2.68	1.86	1.32	1.289	1027
3699.30-00.00	0.00	5.76	3.89	31.26	20.30	19.33	2.85	8.04	2.70	2.78	1.84	1.25	1.257	1080
3710.15-00.95	0.00	12.51	8.05	2.53	27.21	24.35	3.73	10.56	3.24	3.54	2.43	1.85	1.528	866
3700.95-01.50	0.00	7.76	8.24	1.00	30.61	27.23	3.94	11.04	3.16	3.39	2.18	1.45	1.515	788
3701.50-02.30	0.00	9.07	7.85	0.72	32.91	28.65	3.71	9.73	2.57	2.53	1.38	0.88	1.464	1141
3702.30-03.05	0.00	8.52	11.34	1.14	29.57	27.78	3.68	9.77	2.66	2.69	1.64	1.21	1.470	785
3703.05-04.05	0.00	8.51	11.21	13.25	27.23	24.27	2.89	7.34	1.78	1.78	1.00	0.74	1.313	845
3704.05-04.90	0.00	8.18	10.13	31.12	19.34	16.50	2.25	6.23	1.99	2.03	1.34	0.89	1.188	1091
3704.90-05.75	0.00	10.17	7.90	34.77	16.53	14.15	2.10	6.15	2.16	2.45	2.01	1.61	1.208	829
3705.75-07.00	0.00	11.76	5.07	32.03	19.42	16.25	2.20	6.07	1.92	2.16	1.70	1.42	1.222	900
3716.00-16.80	0.00	13.41	12.47	28.65	18.32	16.85	1.96	5.02	1.12	1.12	0.57	0.51	1.161	769
3716.80-17.65	0.00	11.37	8.61	32.64	18.53	15.29	2.01	5.63	1.78	1.86	1.32	0.96	1.179	953
3717.65-18.45	0.00	68.99	30.09	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.344	120
3718.45-19.25	0.00	59.32	40.27	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.293	97
3719.25-20.05	0.00	69.57	23.19	4.37	0.55	0.28	0.07	0.26	0.17	0.24	0.00	1.30	1.379	117
3720.05-20.75	0.00	76.88	22.53	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.389	94
3720.75-21.80	0.00	65.49	33.27	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.324	152
3721.80-22.50	0.00	66.36	31.52	2.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.325	73
3722.50-23.25	0.00	15.83	12.38	36.30	13.22	10.38	1.49	4.35	1.56	1.75	1.47	1.27	1.145	499
3724.00-25.00	0.00	8.60	7.47	41.81	16.07	12.43	1.75	5.08	1.77	2.03	1.60	1.39	1.119	948
3725.00-25.90	0.00	8.79	6.65	41.94	16.09	12.84	1.82	5.31	1.87	2.06	1.47	1.16	1.118	937
3725.90-26.50	0.00	7.28	4.75	39.55	17.36	14.57	2.14	6.24	2.21	2.43	1.92	1.55	1.173	1175
3726.50-27.15	0.00	6.23	5.82	38.58	18.60	15.77	2.24	6.38	2.06	2.13	1.31	0.88	1.145	1534

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

File SCAL-307-80111

Analysis of Liberated Gas by Gas Chromatography

Depth, feet	Component Analysis, Mole Percent													Calc. Gas Gravity (Air=1.0)	Gas Volume cc @ STP
	H_2S	CO_2	N_2	C_1	C_2	C_3	IC_4	NC_4	IC_5	NC_5	C_6	C_{7+}			
3727.15-27.95	0.00	11.11	13.33	33.62	13.76	11.72	1.72	5.25	2.05	2.41	2.07	2.96		1.223	462
3727.95-28.75	0.00	36.74	26.87	15.84	6.49	5.50	0.80	2.48	0.93	1.19	1.13	2.03		1.281	196
3728.75-29.40	0.00	9.28	6.56	39.86	17.66	14.09	1.80	5.00	1.60	1.75	1.31	1.09		1.120	916
3729.40-30.00	0.00	10.52	10.80	36.89	17.14	14.53	1.74	4.57	1.16	1.23	0.73	0.69		1.100	880
3730.00-30.80	0.00	11.34	11.85	37.66	17.41	13.78	1.53	3.86	0.87	0.87	0.43	0.40		1.064	893
3730.80-32.00	0.00	11.23	9.35	38.79	17.41	14.24	1.62	4.22	0.99	1.01	0.57	0.57		1.078	1024
3803.00-03.45	0.00	4.36	5.23	51.76	15.11	11.89	1.59	4.50	1.44	1.57	1.20	1.35		1.022	1577
3803.45-04.10	0.00	9.47	7.15	51.79	12.73	8.91	1.20	3.35	1.17	1.29	1.23	1.71		1.017	708
3804.10-07.10	0.00	5.66	4.95	51.24	15.58	11.92	1.54	4.31	1.30	1.45	1.09	0.96		1.013	1746
3804.10-07.10	0.00	6.62	4.53	55.81	15.64	10.14	1.21	3.16	0.91	0.90	0.63	0.45		0.938	1117
3807.10-07.60	0.00	2.76	5.38	54.49	15.42	11.41	1.49	4.16	1.31	1.44	1.08	1.06		0.981	1585
3807.60-08.40	0.00	3.12	4.13	49.04	17.22	14.42	1.92	5.31	1.56	1.57	1.02	0.69		1.035	1959
3807.60-08.40	0.00	4.84	4.95	53.68	17.02	11.35	1.33	3.58	1.01	1.04	0.71	0.49		0.956	1358
3808.40-09.75	0.00	2.35	5.03	51.59	16.30	13.30	1.77	4.89	1.50	1.54	0.99	0.74		1.007	2095
3809.75-10.45	0.00	3.58	4.92	52.55	15.90	12.04	1.57	4.40	1.42	1.53	1.11	0.98		1.002	1446
3810.45-11.20	0.00	3.15	5.33	53.14	15.86	12.07	1.57	4.33	1.34	1.42	0.97	0.82		0.987	1722
3811.20-12.20	0.00	3.14	3.58	44.95	18.87	16.17	2.14	5.87	1.72	1.77	1.04	0.75		1.078	1731
3811.20-12.20	0.00	4.25	5.42	47.00	18.68	14.03	1.73	4.67	1.34	1.41	0.93	0.54		1.028	668
3812.20-13.20	0.00	3.92	2.75	40.43	19.95	17.96	2.47	6.69	1.95	1.94	1.12	0.82		1.134	1299
3812.20-13.20	0.00	4.31	2.52	42.75	20.35	17.16	2.24	5.97	1.65	1.60	0.90	0.55		1.091	1839
3813.20-13.95	0.00	3.67	2.39	42.16	20.47	16.92	2.27	6.21	1.89	1.92	1.20	0.90		1.115	1810
3813.95-15.10	0.00	3.94	2.20	34.77	23.03	20.07	2.65	7.17	2.05	2.06	1.22	0.84		1.184	1052
3813.95-15.10	0.00	5.30	1.68	35.18	22.74	19.49	2.54	6.92	2.03	2.09	1.19	0.84		1.182	1340
3815.10-15.85	0.00	5.26	2.28	39.50	19.91	16.82	2.38	6.70	2.20	2.28	1.58	1.09		1.163	1113
3815.85-16.55	0.00	7.35	2.29	38.39	18.78	16.04	2.28	6.57	2.31	2.50	1.93	1.56		1.196	942
3816.55-17.70	0.00	21.31	3.95	33.94	14.00	11.11	1.60	4.84	1.94	2.14	2.23	2.94		1.266	208
3817.70-18.20	0.00	5.93	2.39	40.88	17.52	14.86	2.19	6.46	2.42	2.68	2.32	2.35		1.201	810
3818.20-18.70	0.00	13.44	4.35	34.92	15.55	13.01	1.97	5.89	2.35	2.76	2.68	3.08		1.273	215
4043.00-43.45	0.00	5.28	3.89	38.03	18.00	16.37	2.44	6.89	2.30	2.46	2.19	2.15		1.212	850
4043.45-44.85	0.00	4.20	3.59	41.50	19.67	16.76	2.33	6.20	1.81	1.82	1.24	0.88		1.117	1838

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

File SCAL-307-80111

Analysis of Liberated Gas by Gas Chromatography

Depth, feet	Component Analysis, Mole Percent H_2S	CO_2	N_2	C_1	C_2	C_3	IC_4	NC_4	IC_5	NC_5	C_6	C_{7+}	Calc. Gas Gravity (Air=1.0)	Gas Volume cc @ STP
4044.85-46.10	0.00	3.66	3.86	41.06	19.90	17.38	2.41	6.39	1.77	1.73	1.13	0.71	1.114	1723
4046.10-47.15	0.00	3.54	3.53	50.09	20.60	14.05	1.58	3.93	0.90	0.86	0.55	0.37	0.977	1927
4046.10-47.15	0.00	2.35	3.37	31.14	18.02	22.58	3.62	10.09	2.93	2.88	1.78	1.24	1.288	1024
4047.15-48.30	0.00	20.47	2.43	24.60	15.91	19.11	2.84	7.77	2.26	2.24	1.35	1.02	1.328	1468
4047.15-48.30	0.00	27.46	2.76	36.82	16.38	10.71	1.21	2.90	0.66	0.60	0.34	0.16	1.110	3051
4048.30-49.05	0.00	6.66	4.76	36.56	18.22	16.17	2.37	6.64	2.23	2.31	2.56	1.52	1.209	1060
4049.05-50.25	0.00	9.50	4.69	36.45	17.85	15.97	2.35	6.49	2.03	2.10	1.54	1.03	1.182	813
4050.25-50.95	0.00	5.49	3.92	37.25	18.30	16.56	2.45	6.87	2.36	2.49	1.99	2.32	1.219	767
4051.00-52.40	0.00	7.00	4.66	40.91	20.28	16.30	2.03	5.05	1.28	1.20	0.70	0.59	1.082	1732
4052.40-52.90	0.00	10.31	5.30	35.78	17.42	15.83	2.33	6.31	1.77	1.84	1.35	1.76	1.194	564
4052.90-53.75	0.00	7.41	5.31	40.53	19.72	16.21	2.05	5.07	1.21	1.16	0.71	0.62	1.085	1225
4053.75-54.30	0.00	7.80	6.16	36.59	17.48	16.15	2.40	6.72	2.05	2.08	1.30	1.27	1.178	611
4054.30-54.95	0.00	8.54	5.05	36.58	18.04	16.23	2.50	6.91	2.16	2.33	0.87	0.79	1.170	581
4054.95-55.40	0.00	11.68	5.34	34.95	16.62	14.53	2.22	6.40	2.11	2.36	1.94	1.85	1.224	427
4055.40-56.10	0.00	9.13	5.13	38.10	17.75	15.21	2.24	6.25	2.04	2.08	1.26	0.81	1.154	1028
4056.10-57.10	0.00	29.49	9.59	27.24	11.29	10.23	1.57	4.54	1.56	1.69	1.24	1.56	1.260	285
4057.10-58.25	0.00	28.23	10.25	26.69	11.19	10.26	1.63	4.64	1.67	1.80	1.71	1.93	1.280	353
4058.25-59.00	0.00	20.20	9.04	32.19	13.54	12.45	1.86	5.15	1.63	1.65	1.08	1.21	1.200	568
4059.00-60.10	0.00	6.46	14.83	30.47	14.15	13.03	2.09	6.19	2.46	2.84	2.91	4.57	1.302	182
4060.10-61.20	0.00	12.90	10.16	33.20	14.47	12.93	1.96	5.75	2.15	2.34	1.97	2.17	1.227	532
4061.20-62.00	0.00	19.41	9.46	27.30	13.15	12.20	1.88	5.74	2.21	2.59	2.42	3.64	1.333	316
4067.00-67.90	0.00	4.73	8.20	37.61	16.55	15.47	2.33	6.45	2.16	2.31	1.81	2.38	1.192	554
4067.90-68.75	0.00	6.84	9.37	31.64	14.57	14.33	2.32	7.02	2.79	3.20	3.15	4.77	1.339	252
4068.75-69.85	0.00	9.77	6.68	32.45	16.51	15.61	2.44	6.99	2.55	2.68	2.27	2.05	1.261	505
4069.85-71.00	0.00	3.77	4.24	40.63	20.58	17.30	2.27	6.00	1.72	1.71	1.08	0.70	1.109	1162
4071.00-72.00	0.00	5.52	3.90	36.99	18.66	16.99	2.46	6.90	2.21	2.33	1.80	2.24	1.213	976
4072.00-73.30	0.00	3.30	4.23	41.21	20.79	17.22	2.25	5.88	1.66	1.63	1.09	0.74	1.101	1227
4073.30-74.00	0.00	3.67	3.46	39.02	19.75	17.80	2.52	6.85	2.04	2.05	1.59	1.25	1.163	886
4074.00-74.75	0.00	5.28	3.18	38.07	19.39	17.37	2.44	6.76	2.15	2.23	1.66	1.47	1.183	1175
4084.00-85.00	0.00	5.14	3.60	40.62	18.15	16.00	2.29	6.36	2.09	2.22	1.65	1.88	1.166	667

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

File SCAL-307-80111

Analysis of Liberated Gas by Gas Chromatography

Depth, feet	H_2S	CO_2	N_2	C_1	C_2	C_3	IC_4	NC_4	IC_5	NC_5	C_6	C_{7+}	Calc. Gas Gravity (Air=1.0)	Gas Volume cc @ STP
	Component Analysis, Mole Percent													
4085.00-86.20	0.00	1.73	3.27	46.00	20.66	16.51	2.11	5.50	1.52	1.43	0.79	0.48	1.045	1725
4086.20-87.20	0.00	0.98	3.18	46.43	21.15	16.81	2.07	5.38	1.38	1.34	0.81	0.47	1.036	2085
4087.20-88.00	0.00	2.62	3.08	51.52	20.53	14.25	1.55	3.93	0.91	0.88	0.44	0.29	0.963	1765
4087.20-88.00	0.00	2.06	2.42	34.21	17.21	22.61	3.77	10.26	2.76	2.59	1.34	0.77	1.249	848
4088.00-89.05	0.00	2.35	3.03	45.31	19.27	16.70	2.26	6.00	1.69	1.65	1.06	0.68	1.075	1265
4089.05-90.40	0.00	2.78	3.48	47.82	18.50	15.49	2.06	5.45	1.50	1.47	0.85	0.60	1.040	1238
4090.40-91.40	0.00	2.11	3.48	49.01	19.04	14.97	1.97	5.15	1.45	1.41	0.88	0.53	1.022	1604
4091.40-92.00	0.00	11.86	3.75	40.56	15.35	13.67	2.04	5.64	1.93	2.05	1.44	1.71	1.165	628
4092.00-92.60	0.00	2.87	3.46	44.54	18.93	15.77	2.20	6.01	1.79	1.84	1.24	1.35	1.100	983
4092.60-93.20	0.00	3.14	3.30	43.72	18.91	15.90	2.23	6.16	1.86	1.94	1.28	1.56	1.116	935
4093.20-93.90	0.00	2.44	3.38	44.86	19.17	15.58	2.15	5.83	1.77	1.83	1.36	1.63	1.102	1117
4093.90-94.90	0.00	2.69	3.42	46.32	19.96	15.52	2.03	5.38	1.52	1.51	0.93	0.72	1.051	1367
4094.90-95.95	0.00	1.96	3.26	46.26	19.73	16.18	2.18	5.74	1.60	1.55	0.96	0.58	1.055	1391
4095.95-97.10	0.00	2.78	3.35	46.12	19.76	15.51	2.05	5.42	1.54	1.54	1.06	0.87	1.060	1417
4097.10-98.60	0.00	2.17	3.38	47.06	19.43	15.34	2.04	5.47	1.61	1.61	1.04	0.85	1.053	1593
4098.60-99.85	0.00	3.52	3.58	46.38	19.27	15.48	2.00	5.28	1.48	1.48	0.88	0.65	1.050	1549
4100.00-00.90	0.00	1.49	3.53	47.26	19.46	15.72	2.10	5.63	1.63	1.62	0.97	0.59	1.046	1951
4100.90-02.05	0.00	1.55	3.10	38.22	17.64	18.56	2.95	8.59	2.87	3.01	1.98	1.53	1.222	683
4100.90-02.05	0.00	1.80	7.46	48.67	18.48	13.61	1.76	4.35	1.23	1.21	0.84	0.59	0.997	1428
4102.05-02.90	0.00	1.77	3.69	44.93	19.18	15.93	2.24	6.11	1.91	1.95	1.36	0.93	1.090	1291
4102.90-03.80	0.00	2.81	5.98	41.98	18.27	15.71	2.24	6.26	2.02	2.12	1.52	1.09	1.119	1232
4103.80-04.65	0.00	2.80	6.29	41.82	17.63	15.31	2.25	6.41	2.18	2.36	1.64	1.31	1.133	809
4104.65-05.75	0.00	2.34	4.52	44.68	18.69	15.41	2.14	5.90	1.86	1.92	1.32	1.22	1.093	805
4105.75-06.40	0.00	2.72	7.17	42.51	17.59	15.05	2.17	5.96	1.86	1.92	1.59	1.46	1.114	449
4106.40-07.00	0.00	3.07	6.45	42.71	18.48	15.71	2.13	5.79	1.74	1.77	1.26	0.89	1.092	1181
4107.00-07.65	0.00	2.77	5.80	42.54	19.02	15.97	2.14	5.84	1.79	1.84	1.22	1.07	1.099	1517

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

File SCAL-307-80111

Chloride Data

Depth, feet	Chloride as Cl^-, mg/L
3692.00-92.55	125,662
3692.55-93.20	98,804
3693.20-94.25	121,487
3694.25-95.15	97,551
3695.15-96.60	127,192
3696.60-97.55	138,603
3697.55-98.50	111,050
3698.50-99.30	145,979
3699.30-00.15	157,738
3700.15-00.95	137,908
3700.95-01.50	133,385
3701.50-02.30	126,218
3702.30-03.05	109,380
3703.05-04.05	119,817
3704.05-04.90	169,358
3704.90-05.75	*
3705.75-07.00	149,875
3716.00-16.80	146,118
3716.80-17.65	162,400
3717.65-18.45	*
3718.45-19.25	*
3719.25-20.05	*
3720.05-20.75	*
3720.75-21.80	*
3721.80-22.50	*
3722.50-23.25	*
3724.00-25.00	*
3725.00-25.90	*
3725.90-26.50	*
3726.50-27.15	*
3727.15-27.95	*
3727.95-28.75	*
3728.75-29.40	114,946
3729.40-30.00	99,082
3730.00-30.80	94,977
3730.80-32.00	106,457
3803.00-03.45	139,508
3803.45-04.10	122,043
3804.10-07.10	136,099
3807.10-07.60	151,824
3807.60-08.40	*
3808.40-09.75	122,043
3809.75-10.45	139,578
3810.45-11.20	90,176
3811.20-12.20	113,763
3812.20-13.20	144,448
3813.20-13.95	163,513
3813.95-15.10	159,617
3815.10-15.85	171,863
3815.85-16.55	161,565
3816.55-17.70	*
3817.70-18.20	126,357
3818.20-18.70	*

*No water produced during pressure depletion

Chloride Data

Depth, feet	Chloride as Cl^-, mg/L	Depth, feet	Chloride as Cl^-, mg/L
4043.00-43.45	108,962	4073.30-74.00	53,159
4043.45-44.85	104,788	4074.00-74.75	50,098
4044.85-46.10	112,093	4084.00-85.00	70,554
4046.10-47.15	103,953	4085.00-86.20	87,393
4047.15-48.30	97,551	4086.20-87.20	78,208
4048.30-49.05	93,794	4087.20-88.00	67,075
4049.05-50.25	65,266	4088.00-89.05	70,972
4050.25-50.95	66,797	4089.05-90.40	58,239
4051.00-52.40	91,080	4090.40-91.40	62,065
4052.40-52.90	76,677	4091.40-92.00	42,722
4052.90-53.75	96,160	4092.00-92.60	73,337
4053.75-54.30	85,305	4092.60-93.20	98,525
4054.30-54.95	63,318	4093.20-93.90	67,353
4054.95-55.40	58,447	4093.90-94.90	76,260
4055.40-56.10	63,318	4094.90-95.95	85,166
4056.10-57.10	90,454	4095.95-97.10	80,156
4057.10-58.25	104,509	4097.10-98.60	84,749
4058.25-59.00	68,188	4098.60-99.85	79,321
4059.00-60.10	87,532	4100.00-00.90	123,157
4060.10-61.20	92,681	4100.90-02.05	77,095
4061.20-62.00	89,062	4102.05-02.90	76,816
4067.00-67.90	113,137	4102.90-03.80	68,188
4067.90-68.75	121,069	4103.80-04.65	61,926
4068.75-69.85	106,805	4104.65-05.75	60,674
4069.85-71.00	86,558	4105.75-06.40	55,107
4071.00-72.00	72,920	4106.40-07.00	54,690
4072.00-73.30	72,781	4107.00-07.65	58,865

Vertical Plug and Donut Data

Sample Number	Sample Type	Depth, feet	Vertical Permeability, Millidarcies	Porosity, Percent	Water Saturation, Percent PV
1	Plug	3693.20-93.40	0.83	8.5	58.8
1	Donut	3693.20-93.40		9.3	58.5
2	Plug	3700.00-00.15	0.02	3.1	23.6
2	Donut	3700.00-00.15		2.4	62.1
3	Plug	3700.15-00.35	13	10.9	72.7
3	Donut	3700.15-00.35		12.9	72.9
4	Plug	3706.70-07.00	0.50	7.7	81.0
4	Donut	3706.70-07.00		8.7	88.5
5	Plug	3716.00-16.30	6.2	9.1	80.1
5	Donut	3716.00-16.30		9.1	80.7
6	Plug	3722.30-22.50	0.07	4.4	35.8
6	Donut	3722.30-22.50		6.2	30.0
7	Plug	3724.80-25.00	0.05	4.7	39.2
7	Donut	3724.80-25.00		4.8	50.6
8	Plug	3730.80-31.10	3.3	7.6	74.9
8	Donut	3730.80-31.10		7.7	83.1
9	Plug	3806.50-06.80	0.04	6.6	42.2
9	Donut	3806.50-06.80		7.6	49.4
10	Plug	3809.00-09.30	0.16	6.2	58.0
10	Donut	3809.00-09.30		8.4	56.5
11	Plug	3810.40-10.70	48	6.6	52.9
11	Donut	3810.40-10.70		6.3	57.7
12	Plug	3811.70-11.90	14	9.8	50.3
12	Donut	3811.70-11.90		10.7	50.0

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS 75247

Vertical Plug and Donut Data

Sample Number	Sample Type	Depth, feet	Vertical Permeability, Millidarcies	Porosity, Percent	Water Saturation, Percent PV
13	Plug	3816.90-17.10	0.05	2.5	41.1
13	Donut	3816.90-17.10		2.2	59.9
14	Plug	4044.50-44.70	164	14.6	56.5
14	Donut	4044.50-44.70		16.9	58.4
15	Plug	4049.50-49.80	0.11	5.0	49.3
15	Donut	4049.50-49.80		5.5	72.7
16	Plug	4051.00-51.30	2.3	12.2	62.5
16	Donut	4051.00-51.30		11.1	68.4
17	Plug	4057.10-57.40	13	4.6	72.3
17	Donut	4057.10-57.40		4.5	73.8
18	Plug	4060.10-60.30	0.01	3.5	52.9
18	Donut	4060.10-60.30		4.8	75.2
19	Plug	4063.00-63.30	10	7.3	71.6
19	Donut	4063.00-63.30		6.6	88.6
20	Plug	4069.90-70.20	2.3	8.5	81.1
20	Donut	4069.90-70.20		5.5	65.5
21	Plug	4073.30-73.60	18	8.9	72.9
21	Donut	4073.30-73.60		6.4	77.3
22	Plug	4084.00-84.30	18	8.2	71.7
22	Donut	4084.00-84.30		8.2	69.6
23	Plug	4091.80-92.00	95	12.6	71.8
23	Donut	4091.80-92.00		15.7	75.0

Vertical Plug and Donut Data

Sample Number	Sample Type	Depth, feet	Vertical Permeability, Millidarcies	Porosity, Percent	Water Saturation, Percent PV
24	Plug	4094.90-95.10	8.5	9.0	75.8
24	Donut	4094.90-95.10		10.2	78.7
25	Plug	4098.60-98.80	15	11.6	64.7
25	Donut	4098.60-98.80		11.4	65.1
26	Plug	4101.35-01.55	2.0	7.8	52.8
26	Donut	4101.35-01.55		6.7	60.1
27	Plug	4107.50-07.65	27	13.7	64.2
27	Donut	4107.50-07.65		13.4	57.4

CONOCO, INC.

MCA NO. 358

MALJAMAR FIELD

LEA COUNTY, NEW MEXICO

BOX 4337. MIDLAND. TEXAS 79701

CORE LABORATORIES, INC.

CONOCO, INC.
P. O. Box 460
Hobbs, New Mexico 77063

Date : June 3, 1980
File : 3202-11593
Subject: Core Analysis
MCA No. 358
Maljamar Field
Lea County, New Mexico

Gentlemen:

The subject well was cored using a pressure core barrel and special drilling fluid to obtain 2½ inch cores under pressure from the Grayburg-San Andres formation. The intervals from 3707 to 3716, 3732 to 3740 and 4035 to 4044 failed to hold pressure and were delivered to Core Lab in Midland for analysis.

Fluid removal was achieved from full diameter right cylinder samples, each foot using a gas driven solvent extraction method. Fluid saturations were determined using Dean Stark techniques. Following oven drying, porosity and grain density were determined using Boyle's law. Air permeability was measured in two horizontal directions and vertically while each sample was held in a Hassler rubber sleeve. Results of these analysis are listed in the "Full Diameter" report.

Following the full diameter analysis, plugs were drilled vertically every 3rd foot from unanalyzed end pieces. Each plug was cut in half. One half was sent to Ecology Audits, Inc. in Dallas for nitrate analysis and the other half was analyzed to determine porosity, grain density, air permeability and fluid saturations using the same techniques as above. Results of these analysis are listed in the "Plug Analysis" report.

The remaining portions of core from which the plugs were drilled (the doughnuts) were then analyzed. Porosity was determined using toluene saturation. Fluid removal, permeability and fluid saturation measurement were achieved using techniques described above. Water samples from the plug and doughnut core samples were sent to Teledyne Isotype, Inc. in Westwood, New Jersey. Results of these analysis are listed in the "Doughnut Analysis" report.

We trust these data will be useful in the evaluation of your property and thank you for the opportunity of serving you.

Very truly yours,

CORE LABORATORIES, INC.

Jack H. Neff
Jack H. Neff
Laboratory Manager

JHN/dmh/dh

CONOCO, INC.
MCA No. 358
File No. 3202-11593
Procedural Page

The cores were transported to Core Laboratories, Inc. by Conoco, Inc. personnel.

A Core Gamma Log was recorded for downhole E-log correlation.

Core analysis was made from intervals requested on full diameter samples and non-pressurized plug and donut samples were analyzed every third foot.

Attached are the results of the nitrate analysis on seven (7) core plug samples from the Conoco MCA #358 Well.

These samples were pulverized and a weighed portion submitted to distilled water digestion with magnetic agitation for a period of two (2) hours, then allowed to stand (covered) for approximately twenty-four (24) hours. Each sample was then filtered, water washed and made up to volume. Aliquot portions of each filtrate were taken for nitrate-nitrogen determination by the Brucine Method, measuring the intensity of color development at 410 nm on the spectrophotometer.

The tabulation listing of three (3) columms is as follows:

(a) the NO_3-N value as read on the spectrophotometer in ugs/gm rock

(b) NO_3-N X 4.4268 = up/gm rock as NO_3

(c) NO_3-N X 6.06815 = up/gm rock as $NaNO_3$

The core was boxed after the analysis and was picked up by Conoco, Inc. personnel.

CORE ANALYSIS REPORT

FOR

CONOCO, INC.

MCA NO. 358
MALJAMAR FIELD
LEA COUNTY, NEW MEXICO

201

Conoco Well MCA #358

Nitrate in Crushed Core Plug

	Sample Depth in feet	Sample weight in grams	ugs NO_3-N per gm rock	ugs NO_3 per gm rock	ugs $NaNO_3$ per gm rock
1.	3709	30.4992	0.790	3.50	4.79
2.	3712	30.3411	0.877	3.885	5.32
3.	3715	30.5167	0.905	4.01	5.49
4.	3734	30.4691	2.82	12.49	17.11
5.	3738	30.1944	1.02	4.52	6.19
6.	4035	30.0839	1.06	4.68	6.41
7.	4041	30.6876	1.33	5.87	8.05

LITHOLOGICAL ABBREVIATIONS

NH(Y)	ANHYDRITE, ANHYDRITIC
RK	ARKOSE, ARKOSIC
AN	BAND, BANDED
REC	BRECCIA, BRECCIATED
ALC	CALCITE, CALCAREOUS
ARB	CARBONACEOUS
G	COARSE GRAINED
HK(Y)	CHALK, CHALKY
HT(Y)	CHERT, CHERTY
ONGL	CONGLOMERATE, CONGLOMERITIC
XLN	COARSELY CRYSTALLINE
NS	DENSE
OL(C)	DOLOMITE, DOLOMITIC
	RANDOMLY ORIENTED FRACTURES
G	FINE GRAINED
OSS	FOSSILIFEROUS
R	FRIABLE
XLN	FINELY CRYSTALLINE
AL	GALENA
LAUC	GLAUCONITE, GLAUCONITIC
RAN	GRANITE
YP	GYPSUM, GYPSIFEROUS
F	PREDOMINANTLY HORIZONTALLY FRACTURED
NC	INCLUSION
NTBD	INTERBEDDED
AM	LAMINATED

LM(Y)	LIMESTONE, LIMY
MG	MEDIUM GRAINED
MTX	MATRIX
NA	INTERVAL NOT ANALYZED (AT REQUEST OF CLIENT)
NOD	NODULE, NODULAR
OOL	OOLITIC
PISO	PISOLITIC
PP	PINPOINT POROSITY
PT	PARTING
PYR	PYRITE, PYRITIC
SD(Y)	SANDSTONE, SANDY
SH(Y)	SHALE, SHALY
SHR	SOLID HYDROCARBON RESIDUE
SL/	SLIGHTLY
SLT(Y)	SILT, SILTY
STY	STYLOLITE, STYLOLITIC
SUC	SUCROSIC
SUL	SULPHUR
TBFA	TOO BROKEN FOR ANALYSIS
TRIP	TRIPOLITE
V/	VERY
VF	PREDOMINANTLY VERTICALLY FRACTURED
VGY	VUGULAR
XBD	CROSSBEDDED
XLN	MEDIUM CRYSTALLINE
XTL	CRYSTAL

THE FIRST WORD IN THE DESCRIPTION COLUMN OF THE CORE ANALYSIS REPORT DESCRIBES THE ROCK TYPE. FOLLOWING ARE ROCK MODIFIERS IN DECREASING ABUNDANCE AND MISCELLANEOUS DESCRIPTIVE TERMS.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CONOCO, INC.
MCA NO. 358
MALJAMAR FIELD
LEA COUNTY, NEW MEXICO

DATE : 3-6-80
FORMATION : GRBG/SAN ANDRES
DRLG. FLUID:
LOCATION : 2600' FNL & 600' FEL, SEC. 20, T-17, R-32

FILE NO : 3202-11593
ANALYSTS : MCCLARNEY
ELEVATION: 4028' KB

FULL DIAMETER ANALYSIS

SAMPLE NUMBER		DEPTH	PERM. TO AIR (MD)	90 DEG	POR. He	FLUID SATS. OIL	WTR	GRAIN DEN	DESCRIPTION
P	A	3709.0	0.02	*	1.9	21.3	36.2	2.88	DOL,ANHY
D	A	3709.0		*	2.0	35.2	33.0	2.84	DOL,ANHY
P	B	3712.0	0.05	*	2.8	20.3	48.4	2.84	DOL,SL/ANHY
D	B	3712.0		*	2.8	35.0	41.7	2.79	DOL,SL/ANHY,SL/SDY
P	C	3715.0	0.40	*	9.4	15.1	47.5	2.72	SD,DOLC
D	C	3715.0		*	8.0	8.6	48.8	2.64	SD
P	D	3734.0	0.08	*	5.1	11.8	41.2	2.74	DOL,V/SDY
D	D	3734.0		*	4.7	17.6	42.8	2.71	DOL,V/SDY,ANHY
P	E	3738.0	0.05	*	1.7	24.4	41.5	2.89	DOL,V/SDY
D	E	3738.0		*	1.4	27.3	63.6	2.87	DOL,ANHY
P	F	4035.0	330.	*	14.8	33.3	23.0	2.82	DOL
D	F	4035.0		*	9.0	34.0	52.7	2.63	SD
P	G	4041.0	1.00	*	7.3	20.0	34.7	2.81	DOL
D	G	4041.0		*	6.3	16.7	43.3	2.78	DOL,SDY

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* INDICATES PLUG PERM

P INDICATES PLUG

D INDICATES DONUTS

CONOCO, INC.
MCA NO. 358
MALJAMAR FIELD
LEA COUNTY, NEW MEXICO

DATE : 3-6-80
FORMATION : GRBG/SAN ANDRES
DRLG. FLUID:
LOCATION :

FILE NO : 3202-11593
ANALYSTS : DAVIS
ELEVATION: 4028' KB

FULL DIAMETER ANALYSIS

SAMPLE NUMBER	DEPTH	PERM. TO AIR (MD) MAXIMUM	90 DEG	VERTICAL	POR. He	FLUID SATS. OIL	WTR	GRAIN DEN	DESCRIPTION
	CORE NO. A 3707.0-3716.0 CUT 9'								
1	3707.0-08.0	0.5	0.4	0.2	7.8	15.6	24.4	2.74	SD,DOLC
2	3708.0-09.0	0.2	<0.1	<0.1	6.4	21.6	30.8	2.72	SD,DOLC
3	3709.0-10.0	<0.1	<0.1	<0.1	4.9	14.1	40.4	2.74	SD,DOLC
4	3710.0-11.0	<0.1	<0.1	<0.1	2.7	3.3	65.2	2.81	DOL,SL/ANHY,SH LAM,SDY
5	3711.0-12.0	<0.1	<0.1	<0.1	3.2	4.0	72.2	2.80	DOL,SL/ANHY,SDY,STY
6	3712.0-13.0	0.1	<0.1	<0.1	3.3	0.0	76.5	2.80	DOL,SL/ANHY,SL/SDY,STY
7	3713.0-14.0	0.2	0.2	<0.1	7.4	19.3	43.4	2.71	SD,DOLC
8	3714.0-15.0	0.4	0.4	<0.1	8.1	18.9	49.5	2.71	SD,DOLC,PYR
9	3715.0-16.0	0.6	0.6	0.2	9.4	23.2	44.1	2.70	SD,DOLC
	3716.0-32.0								NOT SUBMITTED FOR ANALYSIS
	CORE NO. B 3732.0-3740.0 CUT 8'								
10	3732.0-33.0	<0.1	<0.1	<0.1	3.6	21.9	39.0	2.75	DOL,SDY
11	3733.0-34.0	<0.1	<0.1	<0.1	4.1	24.6	36.9	2.80	DOL,SL/ANHY,SDY,STY
12	3734.0-35.0	<0.1	<0.1	<0.1	5.1	17.9	47.7	2.71	DOL,SL/ANHY,SDY
13	3735.0-36.0	0.1	0.1	<0.1	6.1	24.8	27.5	2.72	DOL,SL/ANHY,SH LAM,SDY
14	3736.0-37.0	0.1	0.1	<0.1	6.7	23.0	30.7	2.70	DOL,SL/ANHY,SDY
15	3737.0-38.0	0.1	<0.1	<0.1	6.0	23.3	31.0	2.70	SD,DOLC
16	3738.0-39.0	0.2	0.2	<0.1	1.9	0.0	90.0	2.87	DOL,ANHY,F,STY
17	3739.0-40.0	<0.1	<0.1	<0.1	1.0	0.0	87.5	2.86	DOL,SL/ANHY,STY
	3740.0-35.0								NOT SUBMITTED FOR ANALYSIS
	CORE NO. C 4035.0-4044.0 CUT 9'								

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

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CORE ANALYSIS REPORT

FOR

CONOCO, INC.

MCA NO. 358
MALJAMAR FIELD
LEA COUNTY, NEW MEXICO

LITHOLOGICAL ABBREVIATIONS

ANH(Y)	ANHYDRITE, ANHYDRITIC
ARK	ARKOSE, ARKOSIC
BAN	BAND, BANDED
BREC	BRECCIA, BRECCIATED
CALC	CALCITE, CALCAREOUS
CARB	CARBONACEOUS
CG	COARSE GRAINED
CHK(Y)	CHALK, CHALKY
CHT(Y)	CHERT, CHERTY
CONGL	CONGLOMERATE, CONGLOMERITIC
CXLN	COARSELY CRYSTALLINE
DNS	DENSE
DOL(C)	DOLOMITE, DOLOMITIC
F	RANDOMLY ORIENTED FRACTURES
FG	FINE GRAINED
FOSS	FOSSILIFEROUS
FR	FRIABLE
FXLN	FINELY CRYSTALLINE
GAL	GALENA
GLAUC	GLAUCONITE, GLAUCONITIC
GRAN	GRANITE
GRAN WASH	GRANITE WASH
GYP	GYPSUM, GYPSIFEROUS
HF	PREDOMINANTLY HORIZONTALLY FRACTURED
INC	INCLUSION
INTBD	INTERBEDDED
LAM	LAMINATED
LM(Y)	LIMESTONE, LIMY
MG	MEDIUM GRAINED
MTX	MATRIX
NOD	NODULE, NODULAR
OOL	OOLITIC
PISO	PISOLITIC
PP	PINPOINT POROSITY
PT	PARTING
PYR	PYRITE, PYRITIC
SD(Y)	SANDSTONE, SANDY
SH(Y)	SHALE, SHALY
SHR	SOLID HYDROCARBON RESIDUE
SL/	SLIGHTLY
SLT(Y)	SILTSTONE, SILTY
STY	STYLOLITE, STYLOLITIC
SUC	SUCROSIC
SUL	SULPHUR
TBFA	TOO BROKEN FOR ANALYSIS
TRIP	TRIPOLITE
V/	VERY
VF	PREDOMINANTLY VERTICALLY FRACTURED
VGY	VUGULAR
XBD	CROSSBEDDED
XLN	MEDIUM CRYSTALLINE
XTL	CRYSTAL

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THE FIRST WORD IN THE DESCRIPTION COLUMN OF THE CORE ANALYSIS REPORT DESCRIBES THE ROCK TYPE. FOLLOWING ARE ROCK MODIFIERS IN DECREASING ABUNDANCE AND MISCELLANEOUS DESCRIPTIVE TERMS.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CONOCO, INC.
MCA NO. 358

DATE : 3-6-80
FORMATION : GRBG/SAN ANDRES

FILE NO : 3202-11593
ANALYSTS : DAVIS

FULL DIAMETER ANALYSIS

SAMPLE NUMBER	DEPTH	PERM. TO AIR (MD) MAXIMUM	90 DEG	VERTICAL	POR. He	FLUID SATS. OIL	WTR	GRAIN DEN	DESCRIPTION
18	4035.0-36.0	121.	118.	18.	11.7	30.4	20.3	2.81	DOL,V,FOSS,PP
19	4036.0-37.0	38.	30.	4.9	9.5	22.8	25.7	2.82	DOL,SL/ANHY,SL/V,SL/F,FOSS
20	4037.0-38.0	164.	114.	126.	12.7	26.1	26.1	2.82	DOL,SL/ANHY,SL/V,FOSS,OOL
21	4038.0-39.0	3.4	2.5	0.2	6.3	27.6	27.6	2.81	DOL,SL/ANHY,FOSS,OOL,F,STY
22	4039.0-40.0	0.7	0.6	0.3	4.2	15.4	30.8	2.87	DOL,V/ANHY,PP,SL/F
23	4040.0-41.0	16.	0.2	1.9	7.8	23.3	26.7	2.86	DOL,ANHY,PP,F
24	4041.0-42.0	2.2	1.4	0.2	4.9	26.6	35.5	2.83	DOL,ANHY,F,PP
25	4042.0-43.0	0.6	0.4	0.5	5.3	19.6	39.2	2.84	DOL,SL/ANHY,SL/F,SL/V
26	4043.0-44.0	1.1	0.2	<0.1	6.0	15.7	35.8	2.83	DOL,SL/ANHY,F,SL/V,FOSS

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Pressure Core Analysis

Analytical Report
Prepared for Gruy Federal, Inc.
Malgimar Core
Hobbs, New Mexico

Report Prepared By:

Charles F. Bohnstedt

June 27, 1980

GEOCHEM RESEARCH INCORPORATED
16920 PARK ROW · HOUSTON, TEXAS 77084 · (713) 492-2510

DISTRIBUTION OF FINAL REPORTS

15 Copies	GRUY FEDERAL 2500 Tanglewood Suite 150 Houston, Texas 77063 Attn: Mr. John Goodrich
10 Copies	CONOCO, INC. P. O. Box 460 Hobbs, New Mexico 88240 Attn: Mr. Lowell Deckert
1 Copy	CONOCO, INC. P. O. Box 2197 Houston, Texas 77001 Attn: Mr. Assem Mostafa

TABLE 1

Physical Properties of Core

GRI Sample Number	Depth Interval (ft)	Core Density (cleaned core) (gm/cc)	Permeability (Millidarcys)	Porosity (Percent)
R750-001	4076.0-4076.5	2.40	14.2	10.3
R750-003	4076.9-4077.3	2.50	1.4	9.1
R750-005	4077.8-4078.2	2.30	22.2	11.5
R750-007	4078.6-4079.0	2.30	41.3	14.2
R750-009	4079.5-4079.9	2.55	1.2	8.7
R750-011	4080.4-4080.9	2.30	9.9	9.2
R750-013	4081.3-4081.8	2.50	2.2	8.3
R750-015	4082.3-4082.8	2.35	17.9	10.1

TABLE 2

Hydrocarbon Content of Samples

GRI Sample Number	Hydrocarbon[1] Gas Content (cu.ft/bbl)	Gasoline/Kerosene Content (% of Total Oil)	C_{14}+ Oils[2] Content (% of Total Oils)	Residual Oil Saturation (% of Pore Volume)
R750-001	61.9	2.8	97.2	52.9
003	202.7	1.3	98.7	26.6
005	129.8	7.8	92.2	40.5
007	270.7	9.7	90.3	11.0
009	297.1	8.4	91.6	14.4
011	352.3	9.8	90.2	17.3
013	267.7	5.0	95.0	39.0
R750-015	64.1	3.8	96.2	33.5

1 Hydrocarbon gas composition is listed in Table 3.
2 Characteristics of C_{14}+ Oil extracted are given in Table 4

TABLE 3

Hydrocarbon Gas Composition (Percent of Total Hydrocarbon Gas)

GRI Sample Number	Total Hydrocarbon Gas Content (Cu ft/bbl)	Methane %	Ethane %	n-Propane %	i-Butane %	n-Butane %	C_5-C_7 %
R750-001	61.9	54.3	26.4	15.1	1.55	2.67	0.00
003	202.7	51.7	25.8	16.1	1.92	3.87	0.65
005	129.8	51.5	26.1	16.3	1.73	3.31	1.11
007	270.7	53.9	25.9	14.8	1.62	2.95	0.85
009	297.1	48.2	24.5	17.5	2.35	4.83	2.58
011	352.3	48.0	25.3	17.8	2.19	4.48	2.23
013	267.7	46.7	25.7	18.2	2.29	4.70	2.42
R750-015	64.1	60.3	25.0	11.8	1.18	1.73	0.02

TABLE 4

Characteristics of Extracted C_{14}+ Hydrocarbons

GRI Sample Number	Density (gm/cc)	Specific Gravity	API Gravity (degrees)
R750-001	0.8209	0.8217	40.70
003	0.8021	0.8029	44.74
005	0.8794	0.8803	29.24
007	0.8989	0.8998	25.76
009	0.8900	0.8909	27.33
011	0.8630	0.8630	32.46
013	0.8339	0.8347	38.02
R750-015	0.8551	0.8560	33.81

TABLE I

GRI Sample Number	Volume of Water (cc)	Volume of Oil[1] (cc)	Volume of Pore Space[2] (cc)	Volume of Pore Space[3] (cc)
R750-001	28.6	26.05	54.65	49.26
003	41.0	8.82	49.82	33.16
005	13.5	19.04	32.54	47.05
007	51.7	6.98	58.68	63.74
009	31.3	4.86	36.16	33.73
011	46.7	7.28	53.98	42.07
013	29.4	14.89	44.29	38.16
R750-015	45.1	19.04	64.14	56.79

1. Volume of extracted oil is corrected for reservoir conditions and gas content.

2. Volume of pore space calculated as the summation of pore fluids.

3. Volume of pore space calculated from the porosity and bulk volume of sample.

TABLE 2

GRI Sample Number	Percent Fluid Saturation[1] Water %	Oil %	Percent Fluid Saturation[2] Water %	Oil %
R750-001	52.3	47.7	58.1	52.9
003	82.3	17.7	123.6	26.6
005	41.5	58.5	28.7	40.5
007	88.1	11.9	81.1	11.0
009	86.6	13.4	92.8	14.4
011	86.5	13.5	111.0	17.3
013	66.4	33.6	77.0	39.0
R750-015	70.3	29.7	79.4	33.5
Average	71.7%	28.3%	81.5%	29.4%

1. Percent fluid saturation using pore volume calculated from summation of fluids.

2. Percent fluid saturation using pore volume calculated from porosity and bulk volume of the sample.

TRITIUM DATA

TELEDYNE
ISOTOPES
50 VAN BUREN AVENUE
WESTWOOD, NEW JERSEY 07675
(201) 664-7070
TELEX 134474 TDYISOT WTWD

RECEIVED
GRUY FEDERAL, INC.
HOUSTON, TEXAS
MAY 12 1980

29 April 1980

Mr. John Goodrich
Gruy Federal Inc.
Suite 150
Houston, TX 77063

Re: W. O. No. 3-1787

Dear Mr. Goodrich:

Enclosed is the Report of Analysis for the above referenced work order. It summarizes the tritium data obtained from seven butt and plug sets collected from coring operations in the Maljamar field in conjunction with the 200 mCi HTO mud tag of 16 February 1980.

Unfortunately, several "less than" (L.T.) numbers are reported due to low initial sample volumes. We need at least 1.0 mℓ of water to obtain the optimum counting efficiency.

All values are reported in picocurie/ℓ. Should you have any questions concerning the data format, please feel free to call me.

Yours truly,

Andrew Carmichael
TeleTrace Project Coordinator

AC:hp
enclosures

cc: Mr. T. Calhoun w/encl.

TELEDYNE ISOTOPES

REPORT OF ANALYSIS

RUN DATE 04/24/80

	WORK ORDER NUMBER	CUSTOMER P.O. NUMBER	DATE RECEIVED	DELIVERY DATE	PAGE 1
MR John Goodrich - MALJAMAR	3-1787		04/16/80	04/30/80	

GRUY FEDERAL INC
SUITE 150
HOUSTON TX 77063

WATER - GROUND

TELEDYNE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION	STA NUM	COLLECTION-DATE START DATE	TIME	STOP DATE	TIME	NUCLIDE	ACTIVITY (pCi/liter)	NUCL-UNIT-% U/M *	MID-COUNT TIME DATE	TIME	VOLUME - UNITS ASH-WGHT-% *	LAB.
87718	A 3709 BUTT (1)		04/08				H-3	3.3 +-1.1 E 03		04/22			5
87719	A 3709 PLUG (1)		04/08				H-3	L.T. 1.5 E 04		04/22			5
87720	B 3712 BUTT (1)		04/08				H-3	L.T. 2. E 03		04/22			5
87721	B 3712 PLUG (1)		04/08				H-3	L.T. 7.2 E 03		04/22			5
87722	C 3716 BUTT (1)		04/08				H-3	1.63+-0.16E 04		04/22			5
87723	C 3715 PLUG (1)		04/08				H-3	L.T. 2. E 03		04/22			5
87724	D 3734 BUTT (1)		04/08				H-3	L.T. 2. E 03		04/22			5
87725	D 3734 PLUG (1)		04/08				H-3	L.T. 3. E 03		04/22			5
87726	E 3738 BUTT (1)		04/08				H-3	3.3 +-1.1 E 03		04/22			5
87727	E 3738 PLUG (1)		04/08				H-3	L.T. 2.0 E 04		04/22			5
87728	F 4035 BUTT (2)		04/08				H-3	5.01+-0.50E 04		04/22			5
87729	F 4035 PLUG (1)		04/08				H-3	4.02+-0.40E 04		04/23			5
87730	G 4041 BUTT (2)		04/08				H-3	4.7 +-1.1 E 03		04/23			5
87731	G 4041 PLUG (1)		04/08				H-3	L.T. 4. E 03		04/23			5

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LAST PAGE OF REPORT

APPROVED BY K. ROACH 04/24/80

SEND 1 COPIES TO GRUY MR John Goodrich - MALJAMAR
SEND 1 COPIES TO PERSON MR T CALHOUN

2 - GAS LAB. 3 - RADIO CHEMISTRY LAB. 4 - Ge(Li) GAMMA SPEC LAB. 5 - TRITIUM GAS/L.S. LAB.

TELEDYNE
ISOTOPES
50 VAN BUREN AVENUE
WESTWOOD, NEW JERSEY 07675
(201) 664-7070
TELEX 134474 TDYISOT WTWD

20 June 1980

Mr. John Goodrich
Gruy Federal Inc.
2500 Tanglewilde
Suite 150
Houston, TX 77063

Re: W. O. No. 3-2162

Dear Mr. Goodrich:

Enclosed is the Report of Analysis for the above referenced work order.

Sample D-5, Teledyne number 90449 was not analyzed due to insufficient sample volume.

Yours truly,

Andrew Carmichael
TeleTrace Project Coordinator

AC:hp
enclosures

cc: Mr. T. Calhoun, w/encl.

TELEDYNE ISOTOPES

REPORT OF ANALYSIS

RUN DATE 06/17/80

WORK ORDER NUMBER	CUSTOMER P.O. NUMBER	DATE RECEIVED	DELIVERY DATE	PAGE 1
3-2162	27-83	05/27/80	06/11/80	

MR JOHN GOODRICH - MALJAMAR
GEUY FEDERAL INC
2500 TANGLEWILDE
SUITE 150
HOUSTON TX 77063

WATER - GROUND

TELEDYNE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION	STA NUM	COLLECTION-DATE START DATE	START TIME	STOP DATE	STOP TIME	NUCLIDE	ACTIVITY (pCi/liter)	NUCL-UNIT-% U/M *	MID-COUNT TIME DATE	MID-COUNT TIME	VOLUME - UNITS ASH-WGHT-% *	LAB.
90440	P 1 CONOCO MCA 358		05/16				H-3	5.85+-0.59E 05		06/10			5
90441	D 1 CONOCO MCA 358		05/16				H-3	3.51+-0.35E 05		06/10			5
90442	P 2 CONOCO MCA 358		05/16				H-3	3.36+-1.08E 04		06/10			5
90443	D 2 CONOCO MCA 358		05/16				H-3	3.53+-0.35E 04		06/10			5
90444	P 3 CONOCO MCA 358		05/16				H-3	8.92+-0.89E 05		06/10			5
90445	D 3 CONOCO MCA 358		05/16				H-3	4.02+-0.40E 05		06/10			5
90446	P 4 CONOCO MCA 358		05/16				H-3	1.58+-0.16E 04		06/10			5
90447	D 4 CONOCO MCA 358		05/16				H-3	2.26+-0.23E 05		06/10			5
90448	P 5 CONOCO MCA 358		05/16				H-3	3.39+-0.34E 05		06/10			5
90449	D 5 CONOCO MCA 358		05/16				H-3	NOT ANALYZED					5
90450	P 6 CONOCO MCA 358		05/16				H-3	2.66+-0.42E 04		06/10			5
90451	D 6 CONOCO MCA 358		05/16				H-3	1.50+-0.30E 05		06/10			5
90452	P 7 CONOCO MCA 358		05/16				H-3	1.30+-0.19E 04		06/10			5
90453	D 7 CONOCO MCA 358		05/16				H-3	1.16+-0.14E 04		06/10			5

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TELEDYNE ISOTOPES

REPORT OF ANALYSIS

RUN DATE 06/17/80

	WORK ORDER NUMBER	CUSTOMER P.O. NUMBER	DATE RECEIVED	DELIVERY DATE	PAGE 2
MR JOHN GOODRICH - MALJAMAR	3-2162	27-83	05/27/80	06/11/80	

GRUY FEDERAL INC
2500 TANGLEWILDE
SUITE 150
HOUSTON TX 77063

WATER - GROUND

TELEDYNE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION	STA NUM	COLLECTION-DATE START DATE	START TIME	STOP DATE	STOP TIME	NUCLIDE	ACTIVITY (pCi/liter)	NUCL-UNIT-% U/M *	MID-COUNT TIME DATE	MID-COUNT TIME TIME	VOLUME - UNITS ASH-WGHT-% *	LAB.
90454	P 8 CONOCO MCA 358		05/16				H-3	L.T. 2. E 03		06/11			5
90455	D 8 CONOCO MCA 358		05/16				H-3	2.26+-0.23E 04		06/11			5
90456	P 9 CONOCO MCA 358		05/16				H-3	8.16+-0.82E 04		06/11			5
90457	D 9 CONOCO MCA 358		05/16				H-3	1.17+-0.12E 05		06/11			5
90458	P 10 CONOCO MCA 358		05/16				H-3	2.35+-0.24E 05		06/11			5
90459	D 10 CONOCO MCA 358		05/16				H-3	2.29+-0.23E 05		06/11			5
90460	P 11 CONOCO MCA 358		05/16				H-3	3.10+-0.31E 05		06/11			5
90461	D 11 CONOCO MCA 358		05/16				H-3	2.93+-0.29E 05		06/11			5
90462	P 12 CONOCO MCA 358		05/16				H-3	3.36+-0.34E 05		06/11			5
90463	D 12 CONOCO MCA 358		05/16				H-3	2.11+-0.21E 05		06/11			5
90464	P 13 CONOCO MCA 358		05/16				H-3	L.T. 1.5 E 04		06/11			5
90465	D 13 CONOCO MCA 358		05/16				H-3	4.23+-0.42E 04		06/11			5
90466	P 14 CONOCO MCA 358		05/16				H-3	3.31+-0.33E 04		06/11			5
90467	D 14 CONOCO MCA 358		05/16				H-3	7.36+-0.74E 04		06/12			5

TELEDYNE ISOTOPES

REPORT OF ANALYSIS

RUN DATE 06/17/80

WORK ORDER NUMBER	CUSTOMER P.O. NUMBER	DATE RECEIVED	DELIVERY DATE	PAGE 3
3-2162	27-83	05/27/80	06/11/80	

MR JOHN GOODRICH - MALJAMAR
GRUY FEDERAL INC
2500 TANGLEWILDE
SUITE 150
HOUSTON TX 77063

WATER - GROUND

TELEDYNE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION	STA NUM	COLLECTION-DATE START DATE	START TIME	STOP DATE	STOP TIME	NUCLIDE	ACTIVITY (pCi/liter)	NUCL-UNIT-% U/M *	MID-COUNT TIME DATE	MID-COUNT TIME	VOLUME - UNITS ASH-WGHT-% *	LAB.
90468	P 15 CONOCO MCA 358		05/16				H-3	1.51+-0.20E 04		06/12			5
90469	D 15 CONOCO MCA 358		05/16				H-3	1.32+-0.15E 04		06/12			5
90470	P 16 CONOCO MCA 358		05/16				H-3	4.32+-0.43E 04		06/12			5
90471	D 16 CONOCO MCA 358		05/16				H-3	3.14+-0.31E 04		06/12			5
90472	P 17 CONOCO MCA 358		05/16				H-3	8.6 +-1.7 E 03		06/12			5
90473	D 17 CONOCO MCA 358		05/16				H-3	6.9 +-1.2 E 03		06/12			5
90474	P 18 CONOCO MCA 358		05/16				H-3	3.62+-0.36E 04		06/12			5
90475	D 18 CONOCO MCA 358		05/16				H-3	2.78+-0.28E 04		06/12			5
90476	P 19 CONOCO MCA 358		05/16				H-3	1.15+-0.14E 04		06/12			5
90477	D 19 CONOCO MCA 358		05/16				H-3	5.86+-0.59E 04		06/12			5
90478	P 20 CONOCO MCA 358		05/16				H-3	1.28+-0.15E 04		06/12			5
90479	D 20 CONOCO MCA 358		05/16				H-3	2.24+-0.22E 04		06/13			5
90480	P 21 CONOCO MCA 358		05/16				H-3	8.4 +-1.3 E 03		06/13			5
90481	D 21 CONOCO MCA 358		05/16				H-3	5.31+-0.53E 04		06/13			5

TELEDYNE ISOTOPES

REPORT OF ANALYSIS

RUN DATE 06/17/80

WORK ORDER NUMBER	CUSTOMER P.O. NUMBER	DATE RECEIVED	DELIVERY DATE	PAGE 4
3-2162	27-83	05/27/80	06/11/80	

MR JOHN GOODRICH - MALJAMAR
GRUY FEDERAL INC
2500 TANGLEWILDE
SUITE 150
HOUSTON TX 77063

WATER - GROUND

TELEDYNE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION	STA NUM	COLLECTION-DATE START DATE	TIME	STOP DATE	TIME	NUCLIDE	ACTIVITY (pCi/liter)	NUCL-UNIT-% U/M *	MID-COUNT TIME DATE	TIME	VOLUME - UNITS ASH-WGHT-% *	LAB.
90482	P 22 CONOCO MCA 358		05/16				H-3	1.26+-0.15E 04		06/13			5
90483	D 22 CONOCO MCA 358		05/16				H-3	2.87+-0.29E 04		06/13			5
90484	P 23 CONOCO MCA 358		05/16				H-3	L.T. 2. E 03		06/13			5
90485	D 23 CONOCO MCA 358		05/16				H-3	6.43+-0.64E 04		06/13			5
90486	P 24 CONOCO MCA 358		05/16				H-3	1.0 +-0.13E 04		06/13			5
90487	D 24 CONOCO MCA 358		05/16				H-3	3.38+-0.34E 04		06/13			5
90488	P 25 CONOCO MCA 358		05/16				H-3	6.3 +-1.2 E 03		06/13			5
90489	D 25 CONOCO MCA 358		05/16				H-3	2.26+-0.23E 04		06/13			5
90490	P 26 CONOCO MCA 358		05/16				H-3	1.65+-0.18E 04		06/13			5
90491	D 26 CONOCO MCA 358		05/16				H-3	2.52+-0.25E 04		06/13			5
90492	P 27 CONOCO MCA 358		05/16				H-3	1.39+-0.14E 05		06/13			5
90493	D 27 CONOCO MCA 358		05/16				H-3	8.45+-0.85E 04		06/13			5

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LAST PAGE OF REPORT

APPROVED BY K. ROACH 06/17/80

SEND 1 COPIES TO GR830T MR JOHN GOODRICH - MALJAMAR
SEND 1 COPIES TO PE850N MR T CALHOUN

2 - GAS LAB. 3 - RADIO CHEMISTRY LAB. 4 - Ge(Li) GAMMA SPEC LAB. 5 - TRITIUM GAS/L.S. LAB.

TELEDYNE
ISOTOPES
50 VAN BUREN AVENUE
WESTWOOD, NEW JERSEY 07675
(201) 664-7070
TELEX 134474 TDYISOT WTWD

13 May 1980

Mr. John Goodrich
Gruy Federal Inc.
2500 Tanglewilde
Suite 150
Houston, TX 77063

Re: W. O. No. 3-1900

Dear Mr. Goodrich:

Enclosed is the Report of Analysis for the above referenced work order.

Yours truly,

Andrew Carmichael
TeleTrace Project Coordinator

AC:hp
enclosure

cc: Mr. T. Calhoun w/encl.

TELEDYNE ISOTOPES

REPORT OF ANALYSIS

RUN DATE 05/08/80

	WORK ORDER NUMBER	CUSTOMER P.O. NUMBER	DATE RECEIVED	DELIVERY DATE	PAGE 1
MR JOHN GOODRICH - MALJAMAR	3-1900	27-83	04/28/80	05/12/80	

GRUY FEDERAL INC
SUITE 150
2500 TANGLEWILDE
HOUSTON TX 77063

WATER - GROUND

TELEDYNE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION	STA NUM	COLLECTION-DATE START DATE	START TIME	STOP DATE	STOP TIME	NUCLIDE	ACTIVITY (pCi/liter)	NUCL-UNIT-% U/M *	MID-COUNT TIME DATE	MID-COUNT TIME TIME	VOLUME - UNITS ASH-WGHT-% *	LAB.
88496	MCA 358 1MPB .0-0		04/17				H-3	2.0 +-1.0 E 03		05/05			5
88497	MCA 358 2MPB 3700		04/16				H-3	2.20+-0.22E 06		05/05			5
88498	MCA 358 3MPB 3724-32		04/17				H-3	6.56+-0.66E 05		05/05			5
88499	MCA 358 4MPB 3732-40		04/16				H-3	6.38+-0.64E 05		05/05			5
88500	MCA 358 5MPB 3811-19		04/16				H-3	5.35+-0.54E 05		05/05			5
88501	MCA 358 6MPB 4035-43		04/16				H-3	5.35+-0.54E 05		05/05			5
88502	MCA 358 7MPB 4043-51		04/16				H-3	6.01+-0.60E 05		05/05			5
88503	MCA 358 8MPB 4084		04/16				H-3	5.18+-0.52E 05		05/05			5
88504	MCA 358 9MPB 4100-08		04/16				H-3	4.93+-0.49E 05		05/05			5
88505	MCA 358 10MPB 4126		04/16				H-3	6.17+-0.62E 05		05/05			5
88506	MCA 358 1MPA 3700		04/0R				H-3	2.22+-0.22E 06		05/05			5
88507	MCA 358 2MPA		04/0R				H-3	7.70+-0.77E 05		05/05			5
88508	MCA 358 3MPA 3724-32		04/0R				H-3	5.01+-0.50E 05		05/06			5
88509	MCA 358 4MPA 3732-40		04/0R				H-3	6.30+-0.63E 05		05/06			5

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TELEDYNE ISOTOPES

REPORT OF ANALYSIS

RUN DATE 05/08/80

PAGE 2

	WORK ORDER NUMBER	CUSTOMER P.O. NUMBER	DATE RECEIVED	DELIVERY DATE
MR JOHN GOODRICH - MALJAMAR	3-1900	27-83	04/28/80	05/12/80

GRUY FEDERAL INC
SUITE 150
2500 TANGLEWILDE
HOUSTON TX 77063

WATER - GROUND

TELEDYNE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION	STA NUM	COLLECTION-DATE START DATE	START TIME	STOP DATE	STOP TIME	NUCLIDE	ACTIVITY (pCi/liter)	NUCL-UNIT-% U/M *	MID-COUNT TIME DATE	MID-COUNT TIME TIME	VOLUME - UNITS ASH-WGHT-% *	LAB.
88510	MCA 358 5MPA 3732-40		04/0R				H-3	5.45+-0.55E 05		05/06			5
88511	MCA 358 6MPA 4084		04/0R				H-3	6.35+-0.64E 05		05/06			5
88512	MCA 358 7MPA 4126		04/0R				H-3	6.25+-0.63E 05		05/06			5
88513	MCA 358 8MPA		02/27				H-3	5.20+-0.52E 05		05/06			5

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APPROVED BY K. ROACH 05/08/80

K Roach

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