EVALUATION OF UNDERPRESSURED RESERVOIRS AS POTENTIAL REPOSITORIES FOR LIQUID WASTE

By

JAMES O. PUCKETTE

Bachelor of Science
Oklahoma State University
Stillwater, Oklahoma
1976

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1990

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Dedication

This dissertation is dedicated to Mr. J. B. Red whose hard work and perseverance have allowed his business to prosper and provide me the financial support necessary to complete this research.

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Dissertation Approved:

Zuhair Al-Shaieb
Dissertation Advisor

Vernon E. Mast

Brian J. Carter

Douglas C. Kent

John S. Bradley

Thomas C. Collins
Dean of the Graduate College

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CHAPTER I

INTRODUCTION

The evaluation of a subsurface rock unit as a potential receptacle of injected liquid waste streams generally focuses on the reservoir characteristics of the disposal zone and its confining units. Measurements of reservoir porosity/permeability, thickness and areal extent, as well as confining strata thickness, continuity, and distribution are used to evaluate the feasibility of injecting fluid into and confining them in a rock unit. While these parameters are essential to disposal zone evaluation, another important component in the process has been widely overlooked. This factor is reservoir fluid pressure. The evolution and maintenance of reservoir pressures over periods of geologic time involved the interplay of several geologic processes. These processes controlled the type of pressure domain in the rock column and the evolution of the confining and reservoir beds themselves.

The geologic evaluation of potential subsurface fluid injection zones should include an interpretation of the evolution of their pore network and pressure regimes in the context of basin evolution. The generation of porous/permeable zones receptive to fluid injection and their relatively impermeable confining strata are functions of specific geologic processes. These include: depositional processes that governed the type and thickness of sediments present, post-depositional diagenesis that enhanced or diminished pore space in the rock, burial and hydrocarbon generation, and tectonism.

This study is designed to evaluate selected subsurface strata in Oklahoma and assess their suitability as potential repositories for liquid hazardous waste. Several important geological concepts are addressed in this study. These include: 1) What are the fundamental differences between subsurface strata that dictate their pressure regimes? 2) Do completely sealed pressure compartments (compartmentalized reservoirs) exist that are separated from zones of regional fluid flow?, and 3) What depositional and diagenetic processes determine the ultimate reservoir characteristics of disposal zones?

This study is an aspect of a larger ongoing project at Oklahoma State University to evaluate the configuration and evolution of pressure domains within the Anadarko Basin. This project established the existence of compartmentalized and non-compartmentalized reservoirs in the deep Anadarko Basin. The compartmentalized rocks tend to have abnormally high fluid pressures (overpressured) while non-compartmentalized reservoirs have near-normal fluid pressures (Al-Shaieb et al., 1992 and 1994). In addition, it has been recognized that many shallow reservoirs outside the deep basin have abnormally low pore-fluid pressures and are considered underpressured. This latter group of reservoirs are the primary focus of this research.

The data used in this study are primarily reported pressure measurements provided by the petroleum industry. The concepts of abnormal or normal pore-fluid pressures and the techniques used to evaluate these data are also those of the industry. Consequently, the size of the pressure data set for a given stratigraphic interval or area is a function of its interest to the petroleum industry. Pressure data are clustered in those areas where the reservoirs of interest are known to contain petroleum and scarce where they are barren.

The Oklahoma portion of the Hugoton Embayment of the Anadarko basin (Figure 1) was chosen as the region in which to research underpressured reservoirs. This area was proposed for underground injection by Bradley (1985) and contains a wealth of geologic and pressure data that were generated through oil and gas exploration.

The Arbuckle Group was included in this study because it is utilized for disposal by Class I and Class II injection wells and is recognized as a regional aquifer in northern Oklahoma, southern Kansas and southwestern Missouri (Carr et al., 1986).

Since this study relies heavily on commercially

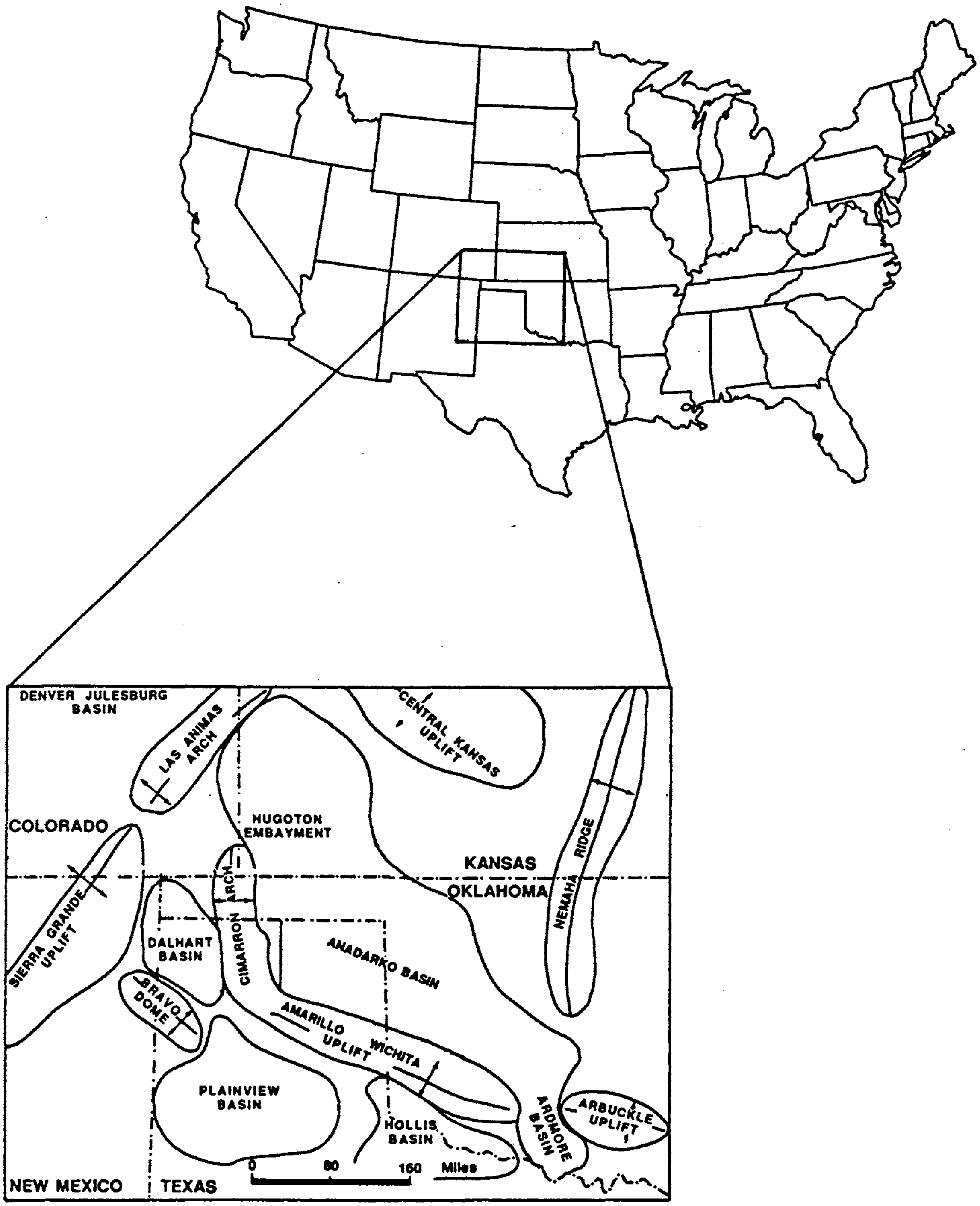


Figure 1. Location of the study area within the southern Midcontinent region.

available petroleum industry pressure data, an effort was made to evaluate the reliability of these data and describe the screening techniques used to improve data quality.

Objectives

The primary objectives of this study were as follows:

1) Determine the pressure regimes for the rock units in the Oklahoma Panhandle and establish the pressure architecture of the region.

2) Determine if compartmentalized reservoirs exist in the region and examine the continuity of their confining units.

3) Interpret the depositional and diagenetic histories of selected rock units and describe their evolution as reservoir or confining zones.

4) Establish the fundamental differences in the lithology, burial history, and diagenesis that determined if a rock unit became abnormally pressured or remained near-normally pressured.

5) Characterize and classify reservoir compartments based on their lithology and disposal capacity and compare them with presently used disposal zones.

Methods of Investigation

This study was designed to systematically review and characterize underpressured reservoirs in Oklahoma. This included an evaluation of the pore-fluid-pressure and reservoir characteristics for 1) the post-Mississippian rock column in the Oklahoma Panhandle, and 2) the Arbuckle aquifer in Oklahoma and the Texas Panhandle. An important aspect of this study was the deciphering of the evolution of these reservoirs and the sedimentary, diagenetic, and tectonic processes that controlled their formation. The following methodology was employed to accomplish these tasks.

1) A literature search was conducted regarding abnormal pressures, reservoir compartmentalization, geology of the Hugoton Embayment and the Arbuckle Group, and liquid waste disposal.

2) Pressure data were collected for all reservoirs in the Oklahoma Panhandle part of the Hugoton Embayment and for the Arbuckle Group across the entire state of Oklahoma and the Texas Panhandle.

3) Regional stratigraphic and pressure cross-sections were constructed to relate pressure regimes to stratigraphy, document the changes in reservoir fluid-pressures, and delineate confining units across the study areas.

4) Reservoirs were selected, analyzed, and mapped to determine their size, geometry, and fluid capacities.

5) Internal features of these reservoirs, including detrital constituents, texture, and pore types, volumes and geometry were analyzed using thin sections of core

samples, whole core, and wire-line logs of representative wells.

6) The evolution of reservoir pressure and pore networks via depositional, diagenetic, and tectonic processes was interpreted in the context of basin evolution.

7) Statistical analyses were performed to evaluate the reliability of petroleum industry data used in pressure characterization studies.

CHAPTER II

DISPOSAL ZONES AND WASTE TYPES

Introduction

"The ultimate in waste disposal technology would be a system which would accept an unlimited volume of waste and contain it forever outside of man's sphere of life"

Galley, 1968

The geologic suitability of a deep-injection disposal well depends on the ability of the injection zone to accept large volumes of fluids. Furthermore, the injection zone should have sufficient porosity, permeability, thickness, and areal extent (capacity) to serve as a effective storage reservoir at reasonable injection pressures. The storage reservoir should be adequately confined to prevent migration of wastes into any conduit that could result in the contamination of soil, water, or mineral resources in the area.

Past deep-well injection studies have stressed the need to dispose clear liquid wastes into porous clastic and carbonate beds in synclinal basins. Thick shales and salt or anhydrite beds were considered essential elements to effectively confine wastes and eliminate any chance of vertical migration. These considerations all have merit and were partially based on the premise that basins acted as fluid sinks and water that recharged strata outcropping on basin rims gravitated downward toward the basin axis. Flow rates for fluid through these basins was considered very slow, though the processes that controlled flow were not well understood.

The discovery of abnormally pressured fluids in deep basins altered the conventional interpretation of basin fluid flow. Drilling in these basins has established two general pressure domains: abnormal (over- and underpressured) and hydrostatic or normal (Powley 1987).

Hydrostatic Reservoir Pressures

A normal hydrostatic gradient would be the pressure generated by a column of water that extended to surface. This column must be static with essentially no lateral movement. As a result, the maximum pressure gradient is vertical and attributable to the gravitational weight of the overlying fluid column (Dahlberg, 1995). A saline water column has been used by the petroleum industry because fluids at depth in basins generally increase in salinity. As a result, an average gradient for a Gulf Coast Basin brine with 100,000 ppm TDS (total dissolved solids) became the benchmark for a normal hydrostatic gradient (Stuart, 1970; Bradley, 1975). This benchmark gradient of 0.465 psi/ft is graphically compared with other common subsurface fluids in Figure 2.

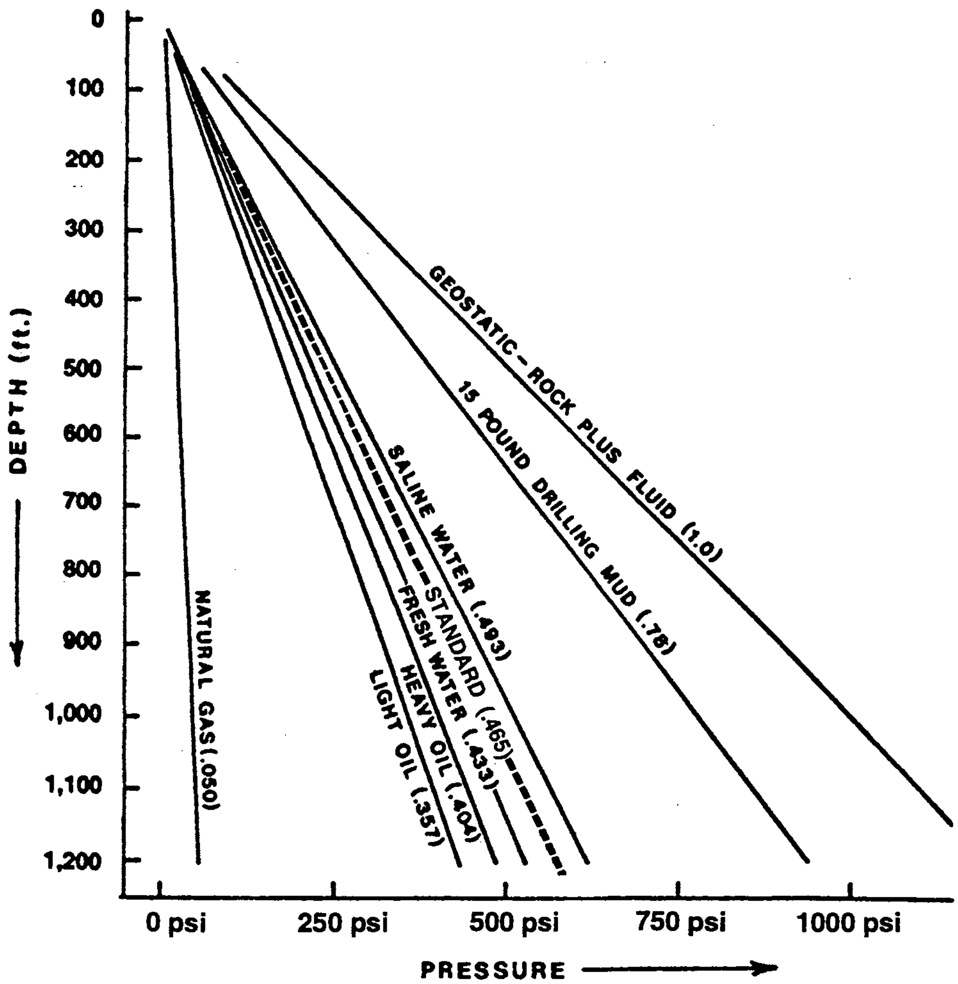


Figure 2. Pressure-depth gradient plot showing static gradients for common subsurface fluids (after Dahlberg, 1995).

Abnormal Reservoir Pressures

Abnormal reservoir pressures are pressures that are either above or below a normal hydrostatic pressure for a given depth. The first abnormal pressures that were studied extensively were the overpressured reservoirs discovered by deep drilling in the Gulf Coast Basin. Overpressure, which is commonly called geopressure, were later discovered in the Anadarko and other deep basins. This recognition was soon followed by the revelation that underpressured reservoirs existed as well. Bradley (1975) proposed that these abnormal fluid pressures, which vary widely from the hydrostatic pressure domain, require a seal that prevents them from equalizing over geologic time.

Compartment Concept

Based on the premise that seals have existed over periods of geologic time, geologists John Bradley and Dave Powley (Bradley and Powley, 1987) of Amoco Production Company analyzed pressure data from basins worldwide and developed the compartment concept. This idea states that compartmentalized reservoirs exist in sedimentary basins. These compartments are completely isolated from their surroundings by top, bottom, and side seals. Bradley and Powley (1987) presented evidence that sedimentary basins are typically divided into a network of individual compartments that are separated by sealing rocks. Compartments are highly variable in size; ranging from less the 1 mi^2 to tens or hundreds square miles in areal extent. Individual compartments can be recognized by their distinct pressure regimes, which separate them from other reservoirs.

Large fluid compartments situated well below the base of fresh water (outside the sphere of man's activities) and located in geologically stable areas would seem to be ideal repositories for the most toxic liquid wastes. Furthermore, if these compartments were underpressured relative to the rocks located above and below them, any leaks or punctures of the enclosing seal would result in a net hydraulic flow into the compartment.

Reduction of Fluid Pressures By Oilfield Activity

The internal pressure in a compartmentalized reservoir could be reduced further by the the removal of the natural saturating fluids. These resident fluids (fresh water, hydrocarbons, and/or brines) limit the storage capacity of the pores and increase the displacement energy required to replace them with injected fluids. However, if these reservoir fluids are partially extracted and the fluid pressure is decreased, storage capacity is increased and the energy required to displace the remaining fluid decreases. The disposal of toxic substances in deeply buried strata that contained petroleum is a potentially valuable use of subsurface spaces with decreased fluid pressures.

Withdrawal of oilfield fluids does not completely empty pore space. Instead, it reduces the fluid pressures so that other fluids can move in and replace the produced ones. In the case of strong water drive (hydrodynamic) reservoirs, water usually encroaches and occupies the former petroleum-bearing pores (Dahlberg, 1995). This encroachment or coning is common in reservoirs that compose hydrodynamic pressure systems. On the other hand, in gas solution-drive reservoirs, which typify compartmentalized intervals, the pore space is occupied by natural gaseous hydrocarbons that exist at substantially lower pressures than the original (pre-drilling) reservoir fluid pressure.

Space is created for injected fluids by the pressure of injection. This may be hydrostatic pressure generated by the weight of the column of fluid in the tubular injection string or pressure that is artificially increased by pumping. Capacity limitation and the possible resultant increase in pressure are important restrictions that mediate the efficiency that a volume of fluid can be injected into a reservoir (van Everdingen, 1968).

Ideal Reservoirs

The ideal reservoirs suitable for deep-well fluid disposal are thick columns of porous strata that underlie a large basinal area, and are confined above and below by impermeable seals. Furthermore, this reservoir should be laterally confined at a distal point by the convergence of the underlying and overlying low-permeability confining beds.

If the permeable bed is areally limited, or injection rates exceed local reservoir capacity, reservoir pressures may increase and exceed the pressure required to fracture the reservoir and the encompassing confining beds. Propagation of fractures during oil field secondary recovery operations (Trantham et al., 1980) demonstrates the critical need to control injection pressures. In most cases, fracturing of the confining beds may be avoided by simply maintaining reservoir pressures below original (pre-petroleum extraction) pressures.

Fracturing within the reservoir itself is generally not harmful and is often beneficial. Pre-injection artificial stimulation of the reservoir rock may increase the permeability and enhance the ability of the rock to receive fluids. Reservoirs in tectonically active areas where extensive faults and fractures are prevalent should be avoided. These zones of weakness are potential fluid conduits.

The longevity of reservoir compartments in stable cratonic areas such as the Midcontinent can be predicted. These compartments are not likely to be breached until their confining units are removed by erosion. Using an average uplift rate of 100 ft/million years for the Oklahoma Panhandle (6500 ft of uplift since the Laramide Orogeny at 65 mya), a moderately deep compartment (2500 feet below the surface) will remain intact for tens of millions of years before it is breached by erosion.

Calculation of the effective confinement times for waste in hydrodynamic reservoirs is more problematic since these reservoirs compose regional aquifers with active recharge areas. Present calculations of natural lateral flow rates in these aquifers suggest very slow movement and brine residence times that exceed 100 million years (Christenson, 1988). However, where the natural flow in these reservoirs has been disrupted by withdrawal and injection, lateral flow rates may be increased dramatically.

General Waste Types

Industrial and Oil Field

Deep well injection is an important part of liquid waste disposal. In particular, the injection of brine recovered in oil and gas production has dramatically reduced the amount of soil, surface water, and ground water contamination attributable to petroleum operators. Injection wells are also commonly being used for the disposal of various industrial wastes, including wastes generated by chemical, petrochemical, and pharmaceutical plants; metal-products plants, paper mills, uranium processing facilities, airline maintenance facilities, nylon plants, coking plants, aerospace facilities, and photo processing laboratories (Warner, 1968).

Disposal of industrial and radioactive wastes presents several concerns that are not common to oil-field wastewater disposal. Warner (1968) described the following differences between injecting oil-field brine and industrial/radioactive wastes.

1) Preinjection waste treatment to prevent corrosion of well tubulars or precipitation can be very difficult with some industrial wastes.

2) There is abundant subsurface control in developed oil fields while there is a scarceness of data for sites often considered for industrial waste injection.

3) Oil-field injection is commonly into depressured reservoirs, and often into the same reservoir where the fluid was produced, while industrial wastes are more likely to be injected into reservoirs with virgin fluid pressures.

4) Industrial-waste injection wells are typically constructed with elaborate precautions to insure safe operations and reduce the risk of contamination.

5) Oil-field waste waters are generally naturally occurring waters that are similar to brines in the

injection zone, so there is little concern about their subsurface distribution. On the other hand, industrial wastes are often of such noxious character that it is important to know their distribution within the injection zone and where they are likely to migrate.

Radioactive Waste

Solutions to the nuclear waste disposal problems require special consideration so that no hazard is created far into the future. Certain industrial wastes are as toxic as radioactive wastes, but their long-term toxicity does not compare to the half-life of certain fission products. There are three broad categories radioactive wastes based on emission levels; low, medium, and high.

Low-level waste. De Laguna (1968) reports that low level liquid radioactive wastes come from three general sources: condensates from the evaporators used to reduce the volume of high-level wastes, water from plant operations that is contaminated with variable quantities of fission products, and chemical/water solutions containing significant quantities of acids, bases, detergents, complexing agents, or organic compounds from separation processes and decontamination operations.

Typically, low-level wastes are treated to remove most fission-product contaminant. The treated effluent was once commonly discharged into surface streams, ground water aquifers, or the ocean (DeLaguna, 1968).

Medium-level waste. Medium-level wastes are typically produced by fuel decladding and decontamination of low-level wastes. In the past, medium-level wastes at the Oak Ridge and Hanford facilities were allowed to seep into the ground from cribs or seepage pits. In addition, some medium-level wastes at Oak Ridge were disposed in hydraulically fractured shale (DeLaguna, 1968).

High-level waste. High level wastes produced by nuclear fuel reprocessing plant are typically reduced by evaporation until the short-lived nuclides have decayed. Next they are converted to a solidified waste and stored. High-level wastes have relatively small volume and can be shipped from their source to disposal sites.

Summary

Disposal into deep permeable formations has been suggested for medium and high-level radioactive wastes. The disposal of large quantities of highly concentrated radioactive fluids would require a detailed knowledge of the subsurface environment to insure the wastes are isolated over geologic time. Compartmentalized underpressured reservoirs would seem ideal for the disposal of radioactive and toxic industrial liquid wastes. The sealed nature and projected life of these reservoirs suggest they would sequester the waste for periods of geologic time. Furthermore, the use of depleted petroleum reservoirs would benefit from decreased injection pressures, knowledge of pre-production reservoir pressures, and subsurface geologic control to properly delineate the compartment. On the other hand, a deep-well injection facility sited in an area with little previous drilling may require an extensive drilling program to properly characterize the subsurface geology. This is currently being done at the Yucca Mountain facility in Nevada (Nicholl 1996, personal communication).

Deep-Well Injection in the Midcontinent

Introduction

The feasibility of deep-well injection for the disposal of any liquid hazardous waste depends on several factors. These include:

1) The geologic suitability of the injection zone and surface facility.

2) The volume and physical and chemical characterization of the injected waste.

3) Economics of transporting, treating, and disposing wastes at the site.

4) Legal, political, and social considerations regarding the site locality including real and perceived risks.

The primary focus of this research is to assess the geologic suitability of particular reservoirs for waste disposal. Consequently, the geotechnical aspects of the liquid waste disposal problem will be emphasized.

Authority

Injection wells disposing of industrial wastes (Class I wells) are regulated by the Safe Drinking Water Act and permitted under the Underground Injection Control Program (UIC); Section 40 of the Code of Federal Regulations; Part 144 (Federal Register, 1995). Industrial wastes are authorized by permit to be disposed below the depth of fresh water. While these guidelines appear to address concerns about contaminating the fresh water supply, they seem inadequate in light of the possible migration paths that can develop in confining units as a result of drilling activity and injection pressure-induced hydraulic fracturing.

Present Waste Disposal

In 1993, there were nine (9) active industrial waste disposal facilities in Oklahoma that were injecting in a total of 12 wells. Five (5) of these facilities were permitted to inject hazardous waste and four (4) are permitted to inject non-hazardous waste. All of these wells inject large volumes of water with varying levels of chemical contamination into the Ordovician Simpson and/or Cambro-Ordovician Arbuckle Groups. General information

TABLE I

Oklahoma Waste Injection Wells
Calendar Year Cumulative Totals
(volumes in gallons)

Facility	1988	1989	1990	1991	1992
Agricultural Minerals Corp.	76,180,190	46,926,000	31,383,802	46,344,090	24,045,935
American Airlines (2 wells)	139,332,159	147,349,214	165,994,947	171,081,382	154,577,833
IMCO Recycling*	Not Built	Not Built	15,765,490	14,228,169	14,890,435
Kaiser Chemical (2 wells)**	27,617,881	29,917,476	35,156,460	31,213,044	36,256,688
Macklanburg-Duncan	52,604,356	56,921,826	53,936,598	53,585,070	56,688,408
Residual Technologies	18,535,181	16,670,234	10,949,349	3,698,608	5,275,930
Rockwell International	16,967,986	18,809,043	13,139,550	11,472,231	9,664,398
Wilgro Fertilizer*	49,974,497	36,037,084	46,754,493	45,969,347	42,790,095
Zinc Corporation of America*	221,731,200	197,593,200	228,378,240	186,781,660	215,560,780

*Stormwater from surface facility is included in injected volumes (may compose 25% to 40% of volume)
**Plant not in operation: volume is 100% stormwater
Note: None of these facilities receive off-site waste

Table I. Volumes of liquid waste injected in Class I wells in Oklahoma, 1988 through 1992 (after Robertson, 1993).

TABLE II

Oklahoma Waste Injection Wells
Disposal Zones and Depths

Facility	Injection Zone	Depth (ft. below surface)
Agricultural Minerals Corp.	Arbuckle	1382-2733
American Airlines Well #1	Arbuckle	1729-3060
American Airlines Well #2	Arbuckle	1745-3110
IMCO Recycling	Simpson and Arbuckle	2380-4055
Kaiser Chemical Well #1	Arbuckle	355-820
Kaiser Chemical Well #2	Arbuckle	345-789
Macklanburg-Duncan	Simpson	6595-6892
Residual Technologies	Arbuckle	2090-3364
Rockwell International	Arbuckle	1800-3100
Wilgro Fertilizer	Arbuckle	395-912
Zinc Corp. of America Well #1	Arbuckle	1820-2251
Zinc Corp. of America Well #2	Arbuckle	1825-2246

Table II. Oklahoma Class I injection wells: disposal zones and depths (Robertson, 1993).

concerning these wells is shown in Tables 1 and 2.

Since the Arbuckle Group is the primary disposal zone in Oklahoma, it was of great importance to this study. The geohydrology of the Arbuckle Group has been studied extensively in the Tri-State region of northeastern Oklahoma, southeastern Kansas, and southwestern Missouri, where the Roubidoux Formation, Jefferson City and Cotter dolomites are important sources of freshwater (Christenson and Adams, 1990; Macfarlane and Hathaway, 1987; and Carr et al., 1986). Information on the regional flow patterns and dissolved-solids concentrations in the Arbuckle for northern Oklahoma are available in Jorgensen et al.(1986).

This dissertation extends the pressure and potentiometric head studies for the Arbuckle Group across the entire state of Oklahoma and the Texas Panhandle. In addition, the pressure architecture of the Oklahoma Panhandle is analyzed and defined using pressure data from petroleum exploration and production activities. The data and techniques utilized in this study should be applicable to any sedimentary basin where underground injection is proposed to dispose of liquid wastes.

CHAPTER III

RESERVOIR PRESSURE MEASUREMENTS

Introduction

The acquisition of quality reservoir-pressure data is essential to defining subsurface fluid flow patterns and pressure regimes. The paucity of data in relatively undrilled sedimentary basins makes their evaluation for deep injection difficult at best. On the other hand, basins with the best pressure characterization are those that have been intensively explored for petroleum. Typically, there are adequate data from these areas to accurately define pressure regimes, predict subsurface flow paths, and evaluate the integrity of confining intervals.

Sources of Pressure Data

Reservoir pressure data acquired during petroleum exploration and production activities come from a variety of sources including: 1) drill stem tests (DST) taken during the drilling or completion phases of wells, 2) wire-line formation tests (WFT) taken during the drilling phase, 3) static bottom hole (reservoir) pressures calculated from initial well-head shut in pressures

(IWHSIP) following well completion, 4) wire-line bottom-hole pressure measurements, and 5) estimates from 4-point production tests on completed wells. In this study, the more commonly available data were from drill stem tests, calculated bottom hole pressures from static IWHSIP tests, and reported bottom-hole pressure measurements from shut-in or flowing well completion tests.

The validity of measurements is dependent on a number of variables that are introduced by reservoir characteristics, fluid types, and the mechanics of petroleum exploration and production techniques. Distortion of the data by these variables can be eliminated by screening the sources and selecting only those data that meet specific criteria.

Drill Stem Tests

Drill stem tests provided most of the pressure information used in this study. These data were reported on completion/"scout tickets" that were from a variety of sources. These included the School of Geology subsurface library at Oklahoma State University, the company library at KOPCO INC. in Stillwater Oklahoma, the Oklahoma City Geological Society Library, and AMOCO Production Co. in Tulsa.

Introduction to Variability in Drill Stem Test Data. Faulty drill stem test measurements are the result of three primary causes: (1) reservoir characteristics that prevent measurement of true reservoir pressures, (2) mechanical failures of the drill stem test apparatus, and (3) alteration of the reservoir conditions by the drilling fluid system. Error introduced by each of these causes can be eliminated or drastically reduced through the careful review of each drill stem test report.

Mechanics of the Drill Stem Test. The drill stem test is designed to be a temporary completion or an opportunity to allow the fluids in the rock to flow into the drill pipe (drill stem) and to the surface. In modern rotary drilling operations, drilling fluid (drilling mud) is circulated in the hole and keeps the wellbore full of fluid at all times. The three primary purposes of the mud system are to remove the cuttings of rock produced by the bit, cool the bit, and prevent the flow of fluid from the reservoir rocks into the borehole. The column of drilling fluid in the hole generates a hydrostatic potential that typically overbalances reservoir pressures and prevents the "blowouts" of oil and gas that were common to pre-rotary drilling technologies.

The drill stem test is designed to remove the mud column from the reservoir and allow fluid movement from the rock into the inside of the drill pipe (Figure 3). This is achieved by using flexible rubber packers that expand against the side of the borehole and separate the

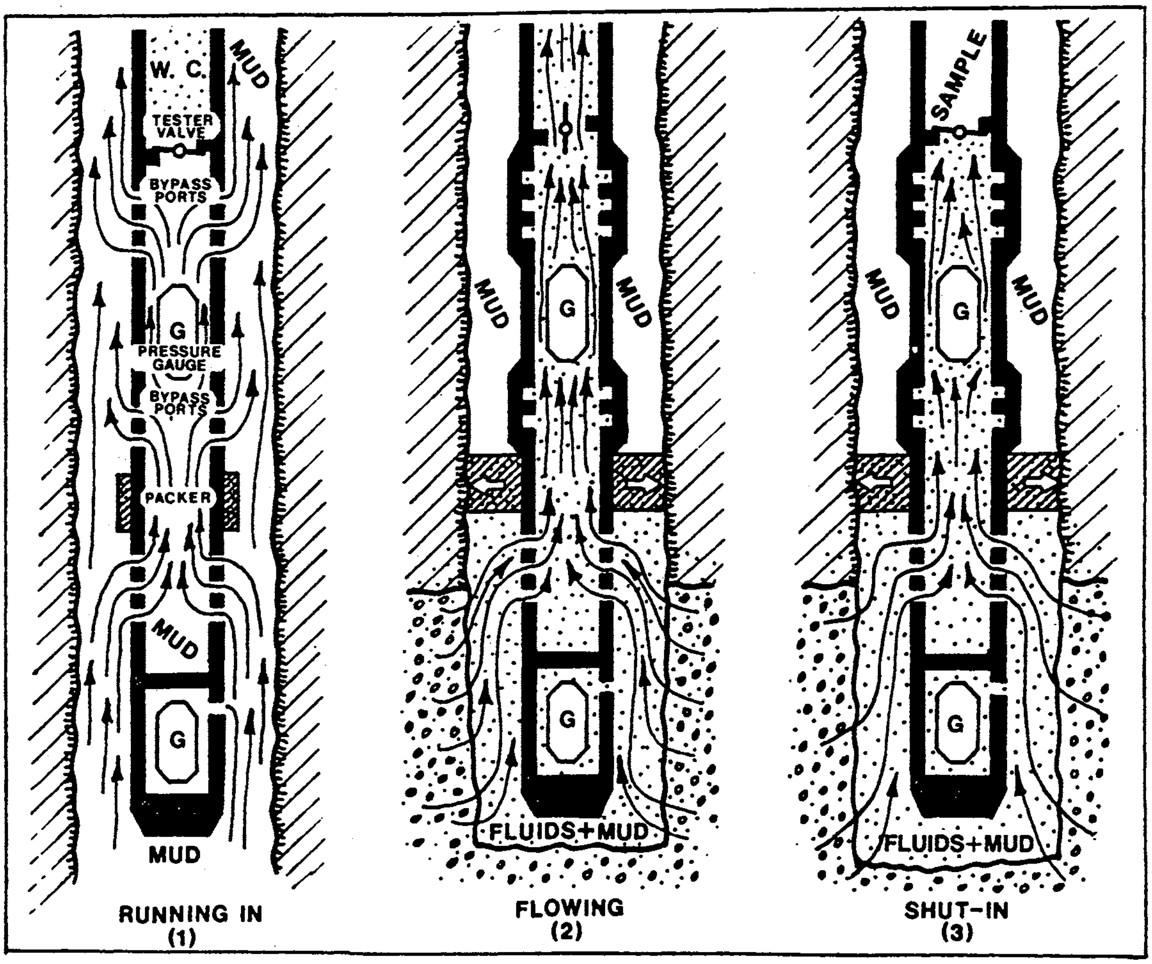


Figure 3. Simplified schematic diagram of a DST tool and formation test (Dahlberg, 1995).

reservoir from the mud column. When the packers are expanded, fluid moves from the reservoir to the inside of the drill pipe through perforations in the test tool. In relatively shallow wells (<7,000-8,000 ft) the inside of the drill pipe contains air at near atmospheric pressure. In deeper wells, the inside of the drill pipe is partially filled with water to prevent the hydrostatic pressure of the mud in the annulus from collapsing the drill pipe.

The removal of the hydrostatic column from the reservoir allows pore fluids to move from the rock, through the test tool and into the lower pressured interior of the drill pipe. If reservoir permeability is high, large volumes of fluid will enter the drill pipe. Downhole pressures are measured within the test tool. Flow pressures are recorded while the tool is open and shut in pressures (reservoir pressures) are measured with the tool closed. Fluid column weight (hydrostatic pressure) is recorded as well (Figure 4).

<u>Mechanical Test Failures</u>. Drill stem tests fail mechanically for a variety of reasons. The most common failure is an inadequate packer seat. If the hole is too irregular or large for the packers to seat (seal), the drilling fluid will flow past them and fill the drillpipe. In some instances, packers are seated in fractured rocks that allow the flow of fluid around the packer. These

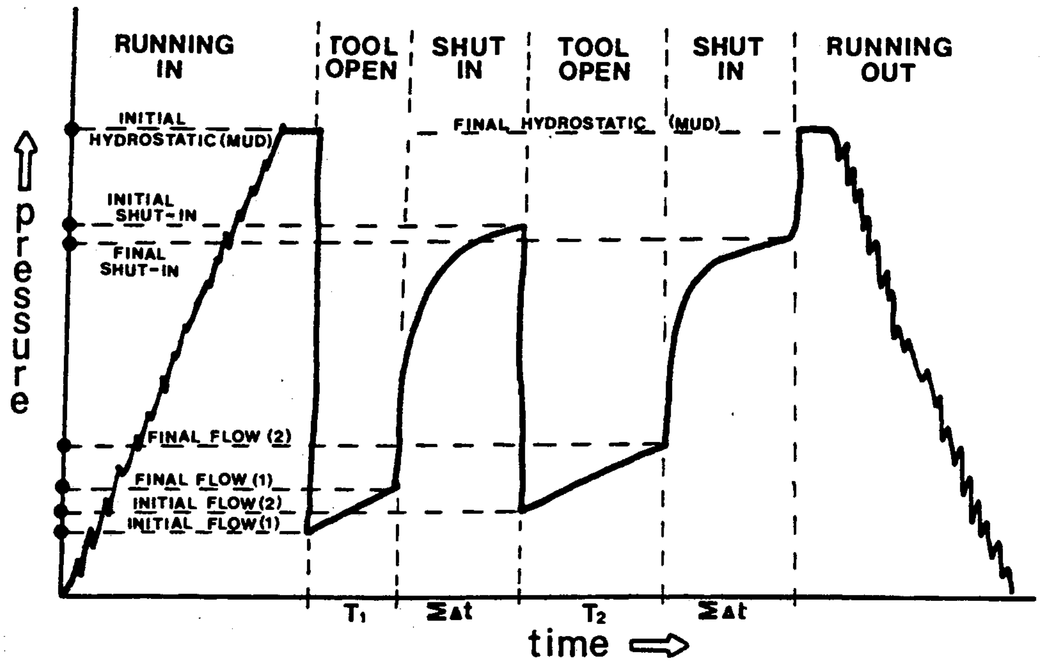


Figure 4. Diagram of a typical DST chart explaining the pressure-time graph components

failures are usually reported as "test failed." When tests with packer failures are reported, they are easily recognized by large-volume drilling mud recoveries and pressures that approach hydrostatic pressure. Rarely, a drill stem test tool will fail to open or close. In some instances, pressure recording devices will fail, but most test tools contain a backup recorder.

Reservoir Characteristics and Test Data

The most crucial factor affecting drill stem test data is reservoir permeability. Permeability in a reservoir may vary naturally or be changed by the invasion of the reservoir by drilling fluid. Drill stem tests in low-permeability rocks are unreliable unless the test periods are sufficiently long to allow the measurement of true (static) reservoir fluid pressures. A drill stem test reduces the pressure in the borehole and partially depletes the adjacent reservoir. In low permeability rocks, it may take hours for the original (pre-test) pressure to be restored. Since most tests are not conducted for adequate time intervals to record static reservoir pressure in low permeability rocks, these data should not be used.

Recognition of Tests In High Permeability Reservoirs. Drill stem tests conducted in high permeability rocks are identified by their fluid recoveries. Gas-bearing reservoirs with low liquid volumes will flow gas to the surface within a few minutes. Oil-bearing reservoirs usually flow gas to the surface within one hour and recover tens to thousands of feet of oil or oily fluid in the drillpipe. Water bearing zones normally recover several hundred to thousands of feet of water in the pipe. Oil and water bearing reservoirs may flow liquids to the surface. Deeper boreholes utilizing a water cushion inside the drill pipe will often flow the water cushion to the surface ahead of formation fluids.

Drill stem data in the public domain are reported on completion reports ("scout tickets") (Figure 5). The test results will often include the flow pressures, shut in pressures, hydrostatic pressures, and fluid recoveries. If two shut-in pressures are reported, these pressures may be compared. Shut in pressures from tests of high permeability reservoirs with considerable areal extent should be within a few pounds of the same reading. If a significant drop in shut-in pressure (>2-3%) occurs during the test and the recording times are adequate, the reservoir may be small and the pressures unreliable because of depletion. Severe pressure depletion is often recorded in low-volume high-permeability reservoirs such as fractured and vuggy or cavern porosity zones in carbonates and thin, high porosity sandstones with very limited spatial dimensions.

Some tests conducted during the 1950 to 1960 time

FORM 1-A OKLA 6-20-58

ELEV. 3143 DF, 3133 Grd 2-10 MAP NO.

STATE Okla COUNTY Texas SEC. 21 TWP. 6N RGE. 16ECM

OPERATOR Republic Natural Gas Co LOC. C NW SE

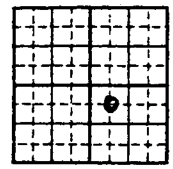
WELL NO. 1-M FARM NAME A. F. Witt - "A" FT. FROM LINE

POOL N. E. DAGUE FT. FROM LINE

CONT./GEOL. Moran Brothers

CO. INT.

FR. 9-26-60 SPUD 9-29-60 COMP. 12-21-60



COMPLETION RECORD

T.D. 6540 P.B.T.D. 6508 D&A ( )

NAME PRODUCING INTERVAL	FROM — TO	PERF. W/HOLES	TREATMENT RECORD
Keyes Sd (L. Morrow)	6481-88	28	None
	Shut in Gas Well		

Fm Keyes IP Flow 4,499,000 CFGD & 14 bbls dist/14 hrs, 1/2" TC, FTP 700, FCP 1030, Sep Press 500, Gvty 64, SITP 1695/27 hrs

Fm IP

CASING - CEMENT RECORD

SIZE	DEPTH	W/SAX.	SIZE	DEPTH	W/SAX.
8-5/8"	2991	1852			
5-1/2"	6530	100			

OPERATOR Republic Natural Gas Co. WELL NO. 1-M Witt "A"

SAMPLE TOPS	DEPTH	SUB SEA	ELEC. TOPS	DEPTH	SUB SEA

10-5 Spud 9-29-60
10-12 8-5/8" @ 2991 w/1852 sx (Circulated to Surface)
10-19 Drlg 4790
10-26 DST (Marmaton) 5397-5445, open 1 hr 10 mins
Rec 500' muddy SW,
ISIP 1632/40 mins, FP 105-274, FSIP 1525/40 mins
DST (Morrow) 6403-20, open 1 hr, GTS 35 mins,
1,552,000 CFGD/40 min & at end of test,
ISIP 1974/30 min, FP 20-71, FSIP 2017/1 hr
Drlg 6515
11-2 DST (Keyes & Chester) 6472-6540, open 1 hr, GTS 2 min,
2,977,000 CFGD/2 mins, Spray Dist 30 mins
8,618,000 CFGD/40 min & stabilized
Rec 1 gal dist, Gvty 57, ISIP 1997/30 min
FP 1182-1430, FSIP 1977/30 min
TD 6540; Schl 6535:

Council Grove	3050
Toronto	4340
Lansing	4454

Continued

Figure 5. Example of an petroleum industry completion card or "scout ticket" showing the results of several drill stem tests.

FORM 1-C OKLA. 6-26-58

SHEET NO. 2 2-10 MAP NO.
STATE Okla COUNTY Texas SEC. 21 TWP. 6N RGE. 16ECM
OPERATOR Republic Natural Gas Co LOC. C NW SE
WELL NO. 1-M FARM NAME Witt- "A"

Schl Cont'd:

Marmaton	5186
Cherokee	5608
Atoka	5989
Morrow	6046
U. Morrow Sd	6107-12
M. " "	6406-18
Keyes Sd	6470-90
Chester	6490

5-1/2" @ 6530 w/ 100 sx
RUCT; PBD 6508
Perf (Keyes) 28/6481-88
Flow 4,499,000 CFGD & 14 bbls Dist/14 hrs,
1/2" TC, FTP 700, FCP 1030, Sep Press 500,
SITP 1695/27 hrs, Gvty 64 (Cont'd)

OPERATOR Republic Natural Gas Co WELL NO. 1-M Witt "A"

Keyes Sd Pay Perfs 6481-88

11-9 to 12-21: S.I. - Helf for further tests
No Further Tests; No Treatment

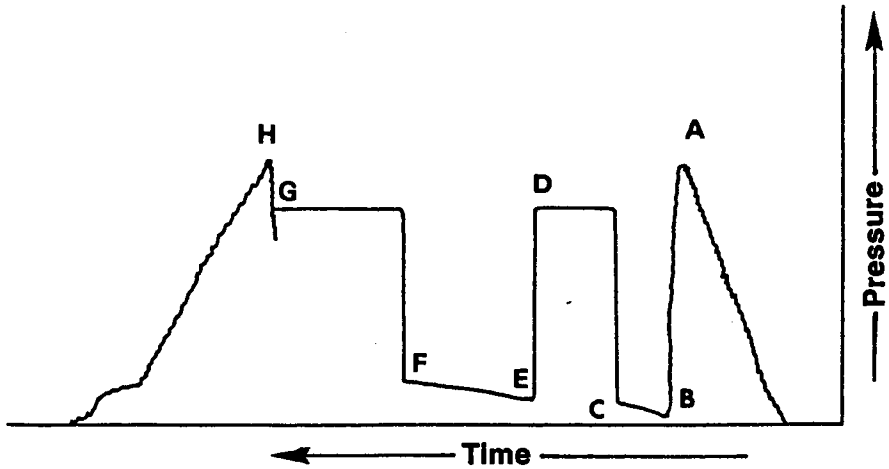
Completed as Shut in Gas Well

Figure 5. Continued.

frame did not run a flow period before the initial shut in period. Without an initial flow period to flush the reservoir, these initial shut in pressures may be high as a result of supercharging of the reservoir by an overbalanced (hydrostatic pressure higher than reservoir pressure) mud column. If drill stem test recorder charts are available, the shape of the curves will indicate if static reservoir pressure was reached during the shut in or flow periods. Examples of recorder charts and fluid recoveries from reservoirs with a range of permeabilities are shown in Figure 6.

If a test is terminated before maximum reservoir pressure is reached, a graphical procedure (Horner Plot) may be used to predict the ultimate pressure as if the shut-in period had been infinitely long. Since most of the readily available data are only reported values and charts are only rarely available, it is necessary for geologist to interpret the accuracy of test pressures using the recoveries, test times, and pressures.
A comparison of extrapolated reservoir (shut in) pressures and commercially reported pressures from wells in western Canada found the average difference for 27 tests was around 1.1 percent (Dahlberg, 1995).

Individual pressure-build-up charts were not available for the drill-stem tests used in this study, so Horner-type (Horner, 1951) plots were not calculated. To insure pressure data quality, DST data were screened as



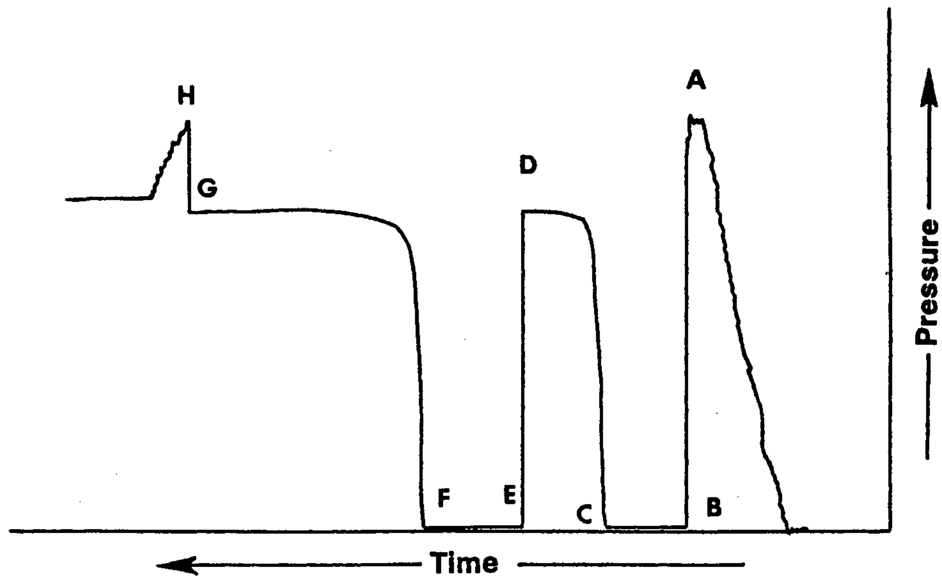
HIGH RECOVERY: HIGH PERMEABILITY WATER-FILLED RESERVOIR (Useable static closed-in pressures)

PRESSURES

(A) Initial Hydrostatic	**2258 PSI**
(B) First Initial Flow	**71 PSI**
(C) First Final Flow	**207 PSI**
(D) First Closed-In	**2017 PSI**
(E) Second Initial Flow	**235 PSI**
(F) Second Final Flow	**398 PSI**
(G) Second Closed-In	**2017 PSI**
(H) Final Hydrostatic	**2254 PSI**

RECOVERY: 800 ft. of brine and 60 ft. of gas in pipe.

Figure 6. Examples of fluid recoveries and DST recorder charts from reservoirs with distinctly different permeabilities.



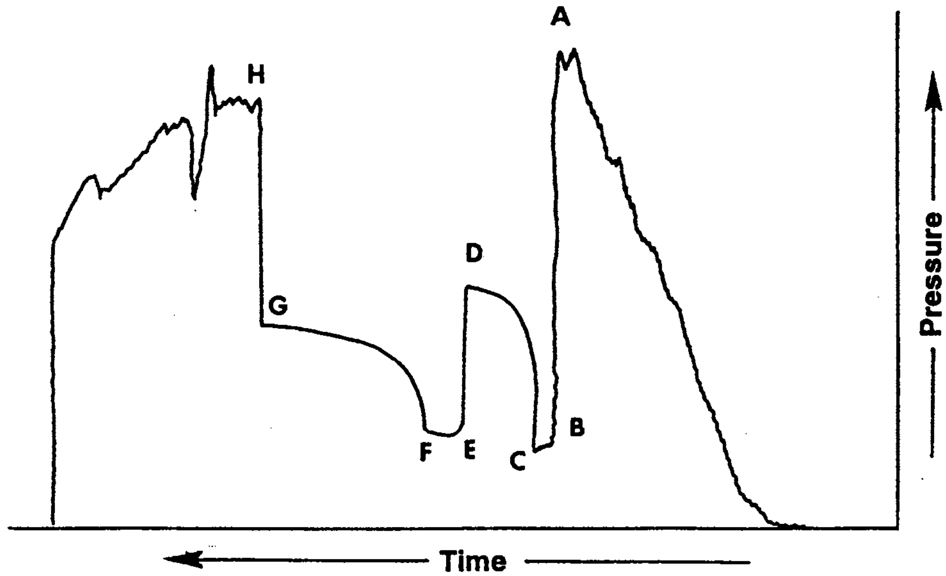
MODERATE RECOVERY: INTERMEDIATE PERMEABILITY OIL & GAS RESERVOIR WITH ADEQUATE LENGTH CLOSED-IN PERIODS TO GIVE NEAR-STATIC PRESSURES (Useable data)

PRESSURES

(A) Initial Hydrostatic	2078 PSI
(B) First Initial Flow	18 PSI
(C) First Final Flow	20 PSI
(D) First Closed-In	1680 PSI
(E) Second Initial Flow	15 PSI
(F) Second Final Flow	15 PSI
(G) Second Closed-In	1676 PSI
(H) Final Hydrostatic	2062 PSI

RECOVERY: 10 ft. of mud. Maximum gas gauged 40.7 MCF.

Figure 6. Continued.



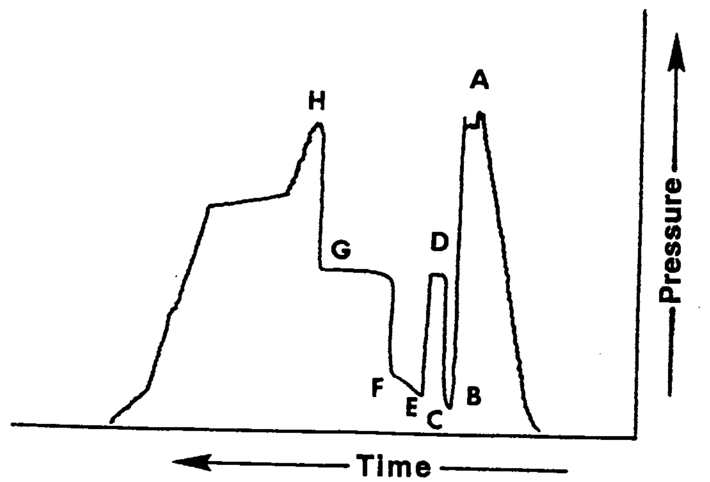
HIGH RECOVERY: HIGH PERMEABILITY LOW-VOLUME RESERVOIR THAT PARTIALLY DEPLETED (PRESSURES DROPPED) DURING TEST (Unuseable data)

PRESSURES

(A) Initial Hydrostatic	3317 PSI
(B) First Initial Flow	631 PSI
(C) First Final Flow	600 PSI
(D) First Closed-In	1822 PSI
(E) Second Initial Flow	712 PSI
(F) Second Final Flow	761 PSI
(G) Final Closed-In	1523 PSI
(H) Final Hydrostatic	3220 PSI

RECOVERY: 900 ft. of clean oil, 615 ft. of oily mud. Maximum gas gauged 300 MCF.

Figure 6. Continued.



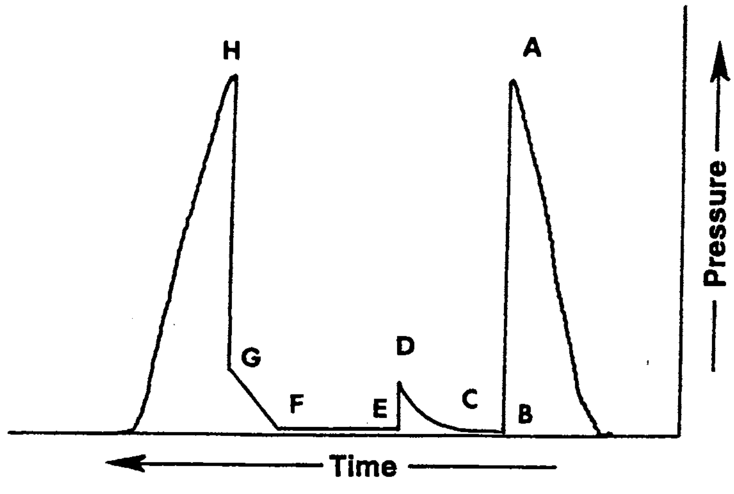
HIGH RECOVERY: HIGH PERMEABILITY GAS RESERVOIR
(Useable static closed-in pressures)

PRESSURES

(A) Initial Hydrostatic	3084 PSI
(B) First Initial Flow	234 PSI
(C) First Final Flow	337 PSI
(D) First Closed-In	1630 PSI
(E) Second Initial Flow	379 PSI
(F) Second Final Flow	595 PSI
(G) Second Closed-In	1629 PSI
(H) Final Hydrostatic	3050 PSI

RECOVERY: 360 ft. of oil, 196 ft. of mud, and 180 ft. of water. Maximum gas gauged 1,278 MCF.

Figure 6. Continued.



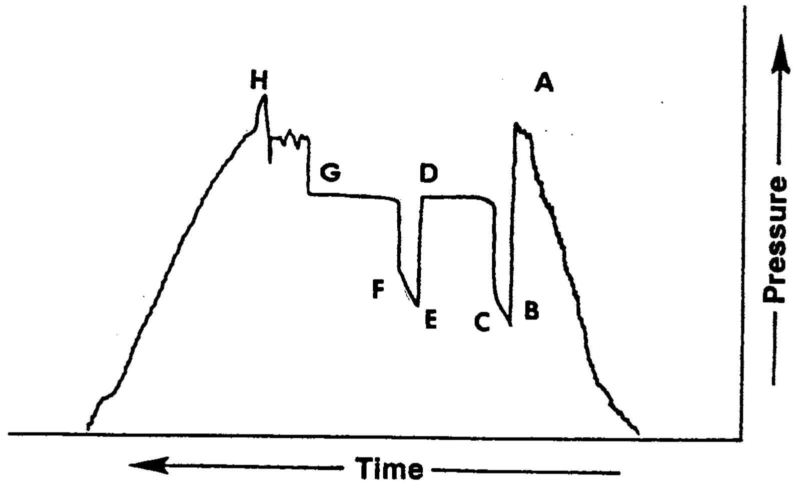
LOW RECOVERY: LOW PERMEABILITY RESERVOIR
(No useable pressure data)

PRESSURES

(A) Initial Hydrostatic	**2103 PSI**
(B) First Initial Flow	**24 PSI**
(C) First Final Flow	**26 PSI**
(D) First Closed-in	**317 PSI**
(E) Second Initial Flow	**28 PSI**
(F) Second Final Flow	**33 PSI**
(G) Second Closed-in	**373 PSI**
(H) Final Hydrostatic	**2095 PSI**

RECOVERY: 550 ft. of gas in pipe and 15 ft. of mud.

Figure 6. Continued.



HIGH RECOVERY: HIGH PERMEABILITY OIL RESERVOIR
(Useable data)

PRESSURES

(A) Initial Hydrostatic	2321 PSI
(B) First Initial Flow	840 PSI
(C) First Final Flow	1077 PSI
(D) First Closed-In	1812 PSI
(E) Second Initial Flow	990 PSI
(F) Second Final Flow	1233 PSI
(G) Second Closed-In	1810 PSI
(H) Final Hydrostatic	2295 PSI

RECOVERY: 4,765 ft. of oil and 120 ft. of brine. Maximum gas gauged 133 MCF.

Figure 6. Continued.

to 1) their relative age to other measurements and production in an area, 2) test duration, and 3) fluid recovery. When available, initial and final shut-in pressures were compared for similarity. When a significant discrepancy (>10%) between the initial and final shut in pressure values occurred, the final shut-in pressure was used. This was particularly important for wells where potential supercharging was a concern.

The relative age of measured pressures to other tests and well completions was examined closely to detect any pressure drawdown due to production. Pressure data for the discovery wells in each reservoir were used when possible.

The temporal length of each test and its fluid recovery were examined to determine if the test was measuring static reservoir pressure. Reservoirs with lower permeability or skin damage from drilling fluids usually fail to reach static reservoir pressure during short duration tests and typically recover very small volumes of reservoir fluids. On the other hand, recovery of large volumes of drilling fluids (mud) during a DST suggests packer failure or drilling fluid supercharging. Data from tests with low reservoir fluid recoveries, large volume drilling mud recoveries, and short time durations were culled. The DST data selected for inclusion in the database for this study are in Appendix A.

Repeat Formation Tester (RFT) and Wireline Formation Tests (WFT)

Wireline formation tests are advantageous because they allow the collection of fluid samples and pressures without having to trip the drill pipe for each test. These tests allow the gathering of fluid samples at different depths and obtain formation pressure at various intervals in the hole. Wire-line formation tests have not been utilized extensively in Oklahoma and these data are only rarely encountered. Like drill stem test data, rft and wft data should be analyzed for formation fluid recovery. Tests that recover gas, oil or formation water may be useful if they meet other criteria. On the other hand, tests that recover only drilling mud likely did not sample the reservoir and should not be considered.

Static Bottom-Hole Pressures Calculated from Initial Well-Head Shut in Pressures (IWHSP)

Reservoir pressures calculated from static initial well-head shut-in pressures (Appendix II) provide good estimates of true reservoir pressures if the gradient of the fluids in the casing or production tubing are known. Static reservoir pressures calculated from well-head shut-in pressures for new pool discovery wells in the Ardmore basin, Oklahoma, were considered the most reliable data (Powley, 1994). In the deep Anadarko basin, bottom-hole pressure measurements for dry gas reservoirs indicate a strong positive correlation between pressures calculated from IWHSIP and those from DST and wire-line sources (Al-Shaieb et al., 1992).

A strong correlation between pressures calculated from IWHSIP and those from DST was also evident in the Oklahoma Panhandle. A data set of 120 measurements from various reservoirs were analyzed using SAS Statistical Inc. (1987) software. The DST data were screened for test duration and fluid recovery. Pressures calculated from IWHSIP were screened to insure they were gas wells (low-liquid or liquid-free production) with shut-in periods of adequate duration. The statistical analysis indicated that the two pressure values (variables) correlated remarkably well (Pearson Correlation Coefficient, R=.95780). A scatter plot (Figure 7) graphically represents the positive correlation between the DST (X variable) and calculated (Y variable) measurements. The supporting data for this analysis are found in Appendix III.

The composition of fluid gradients in liquids-producing wells is seldom known, so calculated reservoir pressures from IWHSIP were only used from gas wells with negligible condensate, oil, or water production.

Bottom hole pressures were calculated using computer software developed by the Echometer Company (1986). With this program, pressure exerted by the gas column in a

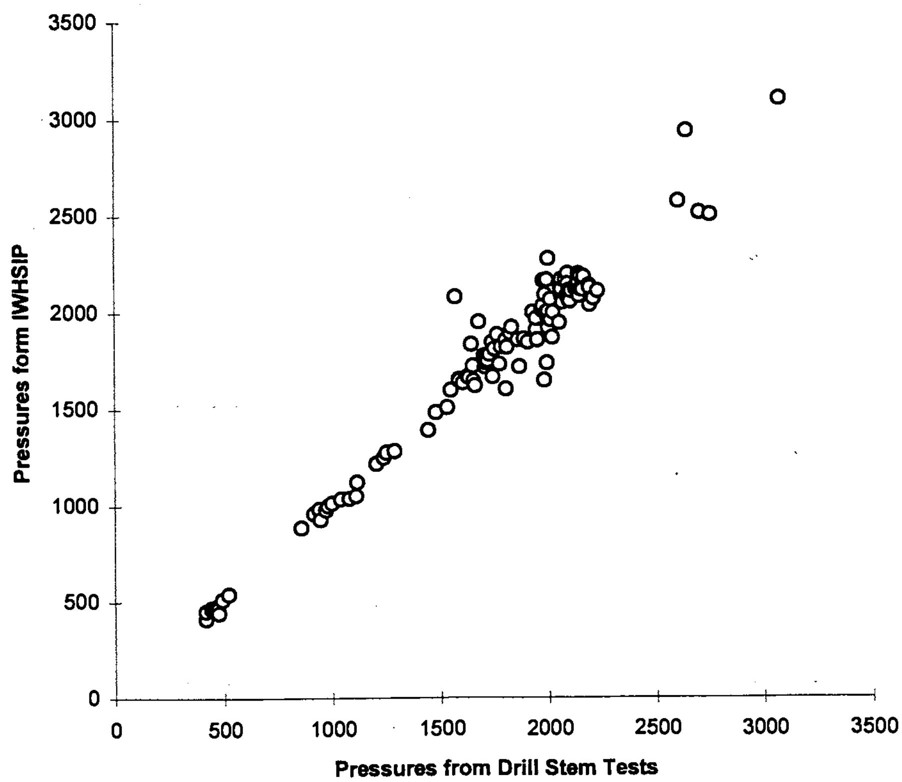


Figure 7. Scatter plot comparing values of reservoir pressures from DST's (X-variable) and those calculated from IWHSIP (Y variable) following completion of the well.

borehole may be calculated using an estimated Z-factor (compressibility factor based on gas composition). This requires knowledge of the temperature gradient, surface pressure, and gravity and composition of the gas in the borehole. This information is readily available from gas production records (Dwight's, 1990) and data reported by the U.S. Bureau of Mines (Moore, 1980).

The greatest potential for error in these calculations arises from inaccurate measure of surface pressure and the uncertainty in estimating composition of liquid in the fluid column. To avoid error caused by estimating liquid column heights and composition, all fluid columns were considered to be liquid free and composed of uniform composition gas. Wells that did not fit the screening parameter of negligible liquid production were eliminated from the calculated data set.

The relative age of IWHSIP measurements to existing production was closely examined to detect pressure drawdown due to depletion. Shut-in duration and other factors such as total production were also examined. Reservoirs with extremely limited areal extent will experience significant pressure depletion (as much as 20-30% of original reservoir pressure) on production tests of several days duration.

Downhole Production Test Measurements

Infrequently, downhole "pressure bomb" pressure measurements are reported with completion or scout data. These data were used when available and correlated very well with calculated and DST measurements.

Pressure Data: Presentation and Interpretation

A variety of methods are available to display pressure data for reservoirs in a basin. The more commonly used graphical representations are pressure-depth gradient diagrams (often called pressure-depth-profiles or PDPs), gradient maps, potentiometric surface profiles, and potentiometric surface plots.

Pressure-Depth Gradient Plots

The pressure-depth gradient plot (PDP) is a simple graph made by plotting reservoir pressures against their depth below the surface. This method is an effective means for displaying gradient patterns that can be used to predict gas-oil-water phase boundaries within a given reservoir, estimating oil and gas pay thicknesses, and correlating hydrogeological fluid systems (reservoirs) in the subsurface (Dahlberg, 1995). In this study, PDP's will be used primarily to examine subsurface reservoirs for indications of communication (correlation) or isolation.

A pressure-depth plot for various types of fluid columns and the geostatic (rock and fluid) column is shown in Figure 2. The angles between the vertical axis and the lines reflect the magnitude of the gravity-induced, density-dependent gradients. The slopes of the individual gradients express the rate at which the pressure increases with depth for each fluid (Dahlberg, 1995). In petroleum industry publications, the benchmark gradient of 0.465 psi/ft is commonly used to represent "normal hydrostatic" pressure. As the result of its widespread use, this gradient is used in this study to represent the "normal" hydrostatic pressure-depth gradient.

The term "pressure gradient" is slightly confusing and ambiguous. When individual pressure-depth values are plotted, a line connecting that value to the origin (usually surface) establishes a pressure-depth gradient. This is sometimes called a surface gradient or overall interval gradient. Often in the petroleum industry, the actual pressure-depth value itself is called a pressure gradient measurement. Gradients should be used describe the rate of change in pressure with depth between or within reservoirs. Within a reservoir, the gas, oil, and water phases all have different fluid gradients (Figure 2). In the overpressured domain of the Anadarko basin, pressure changes across seals between reservoirs can create significant pressure-depth gradients. In the Southwest Leedey field (Figure 8), pressure-depth plots of Skinner and Red Fork sandstone pressure measurments indicate gas/oil gradients within the respective

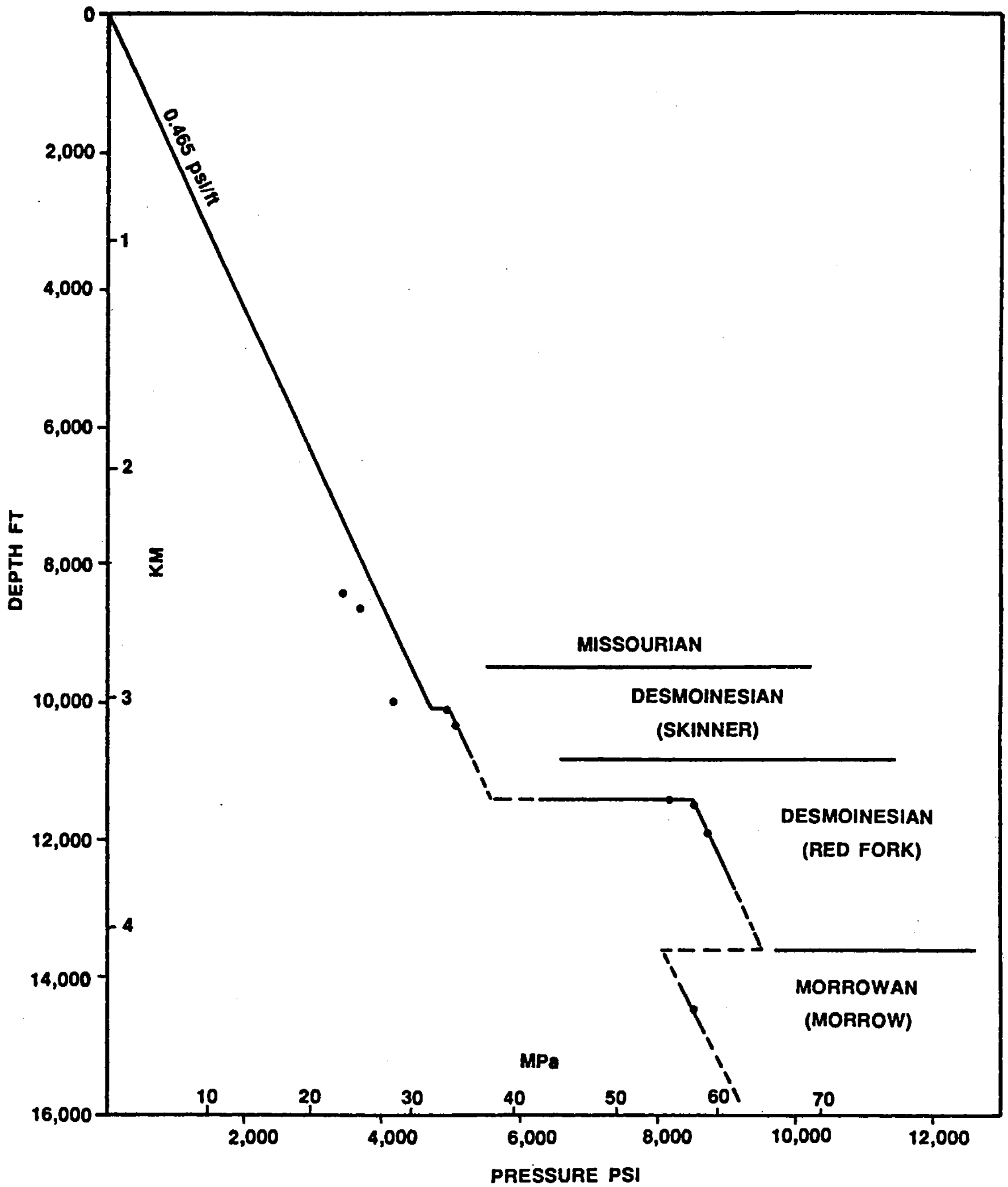
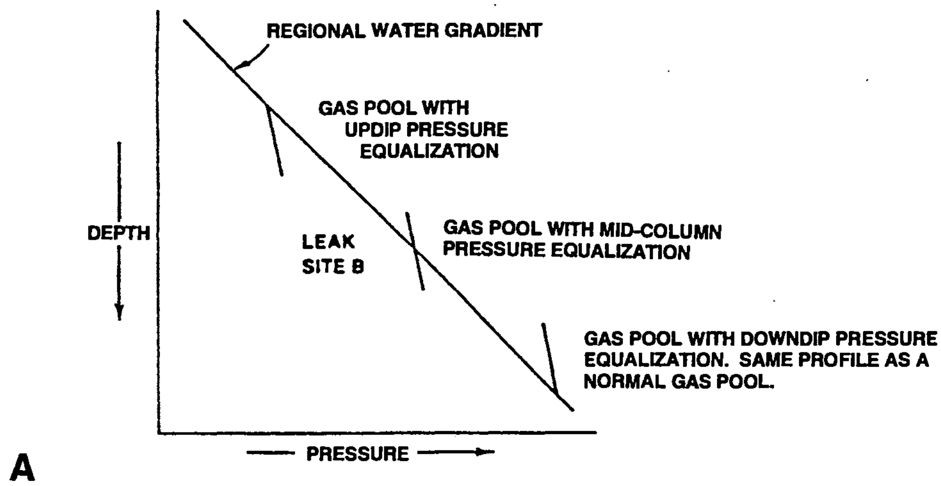


Figure 8. Pressure-depth profile from the Southwest Leedey Field in Roger Mills County, Oklahoma illustrating fluid gradients (0.465 psi/ft.) within the Skinner and Red Fork reservoirs and a higher gradient (2.20 psi/ft.) between the reservoirs.

reservoirs, while the pressure gradient between the two reservoirs is 2.2 psi/ft.

In this study, the individual pressure-depth measurements will be called pressure-depth values and the slopes of a set of related values will be called pressure-depth gradients. Gradients between reservoirs will be distinguished by references to the reservoir interval. Fluid gradients within reservoirs will be referenced to their respective fluid (gas, oil, or brine).

The recognition of reservoir continuity and communication or isolation is a critical element to selecting a suitable waste disposal zone. Reservoirs that are presently in communication or have been connected to the hydrostatic regime display certain characteristic pressure patterns. Powley (1993) described three (3) distinct pressure-depth (p-d) gradient patterns related to reservoirs that leak or pressure equalize with the hydrostatic domain. These are 1) a reservoir that communicates with the hydrostatic regime at its base, 2) a reservoir that communicates or leaks at its top (updip limit), and 3) a reservoir that has a mid-column leak and displays fluid gradients that extend above and below the hydrostatic gradient (Figure 9). Reservoirs that are not in communication with hydrostatic regime have pressure-depth gradients that do not intersect the hydrostatic gradient. Pressure-depth gradients for these isolated reservoirs tend to parallel the hydrostatic. The



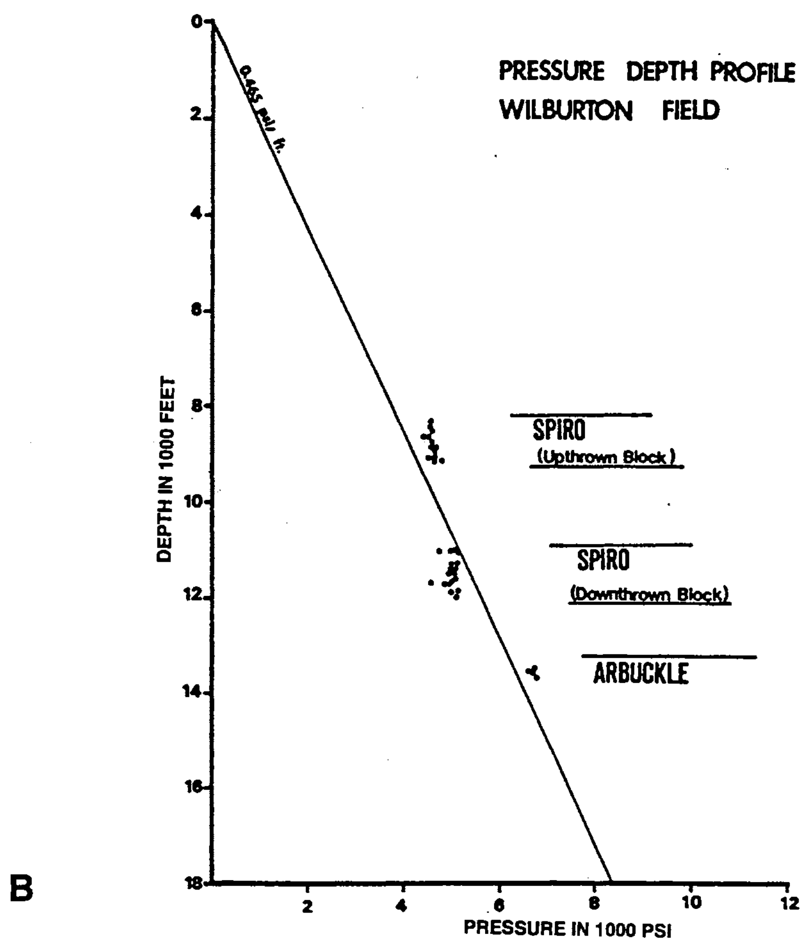


Figure 9. Pressure-depth profiles of compartments leaking to the hydrostatic domain.
(A) Schematic representation of pressure plots (Powley, 1993).
(B) Downdip and updip pressure equalization with hydrostatic conditions (fault) in Wilburton field, Latimer Co., Oklahoma.

amount a pressure-depth plot deviates from the hydrostatic indicates that degree the respective reservoir is abnormally over- or underpressured. Examples of abnormally pressured isolated compartments are shown in Figure 10.

Pressure-depth gradients for the same stratigraphic interval can be plotted on maps to illustrate lateral changes in pressure regimes within the interval. A simplified pressure-depth gradient map of western Oklahoma and the Texas Panhandle (Figure 11) indicates how the deep overpressured (>0.5 psi/ft.) values for Morrow reservoirs in the Anadarko basin become near-normal (0.40-0.50 psi/ft.) on the shelf and underpressured (<0.40 psi/ft.) in the Oklahoma Panhandle (Hugoton Embayment). Since the Anadarko Basin is a senile basin (no longer subsiding) and the Morrowan shales are no longer generating hydrocarbons (Hubert, 1995), overpressuring cannot be attributed to hydrocarbon generation or transformation. On the other hand, underpressuring may be attibuted to cooling and shrinking of pore fluids in compartments that have been brought closer to the surface by uplift and overburden erosion. The Midcontinent region has experienced slow epeirogenic uplift for approximately 65 million years (Schmoker, 1986). Consequently, overpressures must have been generated and encapsulated before 65 mya. The lateral changes in the Morrowan p-d gradients indicate the pressures have not equalized during this time.

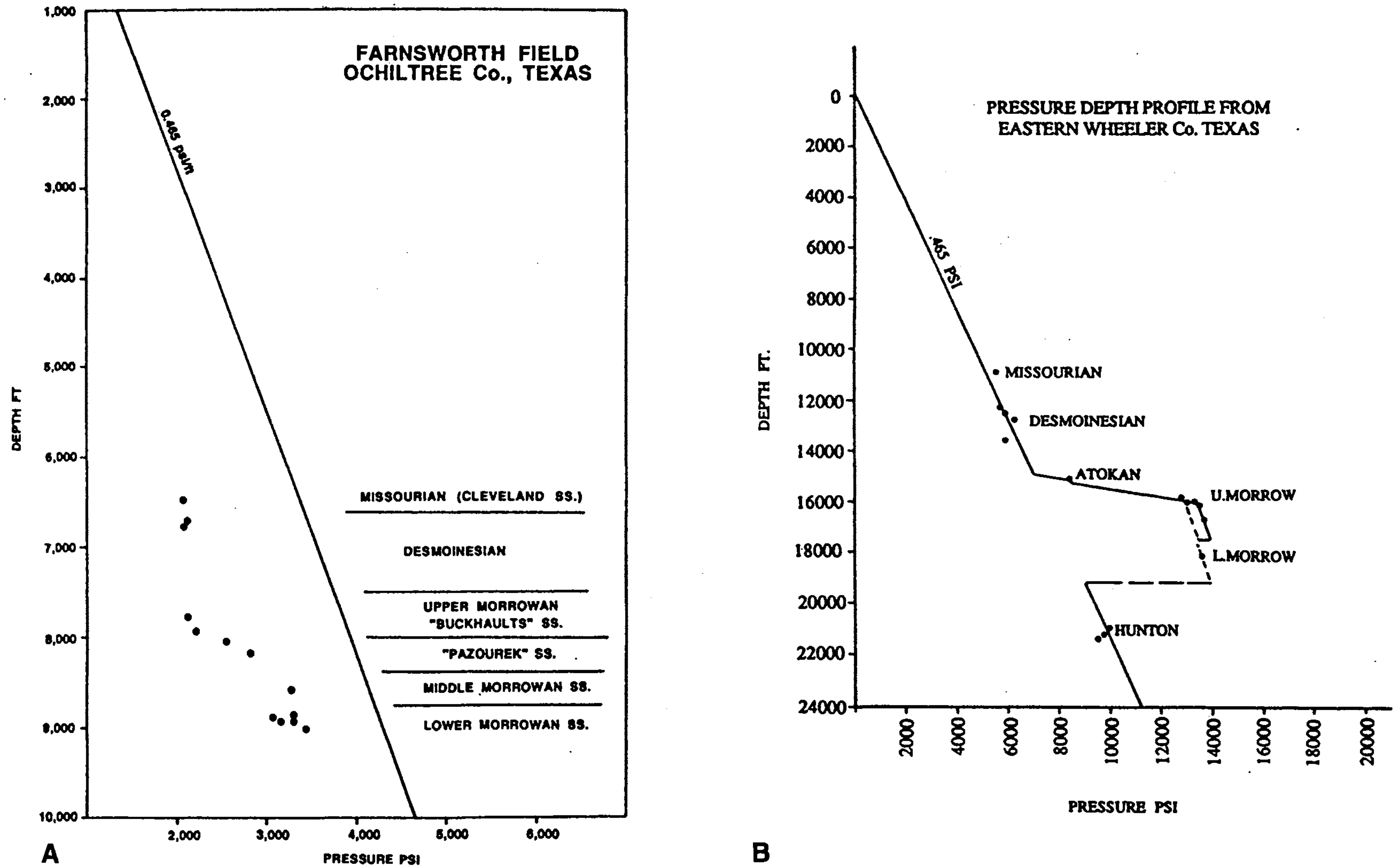


Figure 10. Pressure-depth profiles illustrating isolated abnormally pressured reservoir compartments.
(A) Underpressured (B) Overpressured

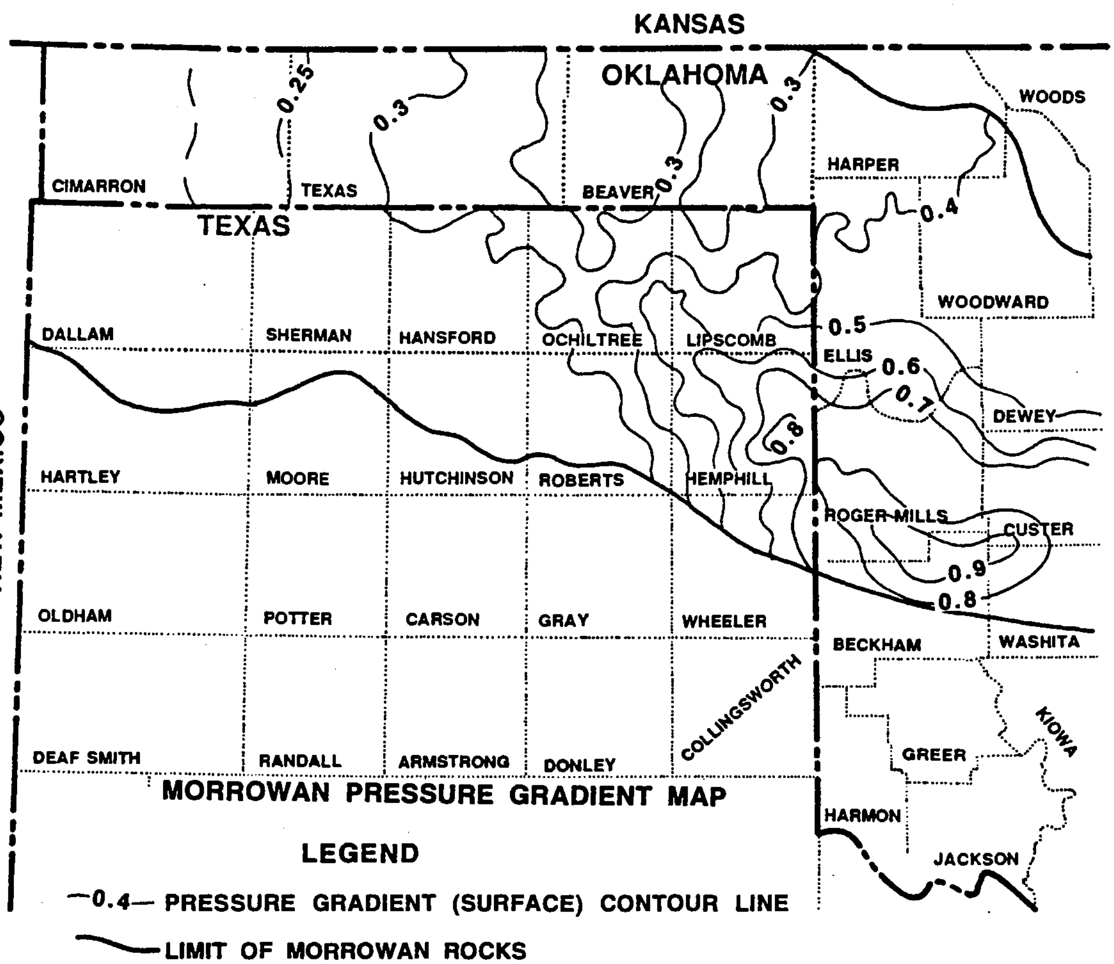


Figure 11. Pressure-depth gradient map for western Oklahoma and the Texas Panhandle showing lateral changes in values within the Morrow interval (After Al-Shaieb et al., 1994).

Therefore, pressure seals must isolate the extremely overpressured reservoirs in the basin from the underpressured ones in the Hugoton Embayment. These seals divide the Morrowan interval into many isolated reservoir compartments distinct pressures. The effect of sealing is seen as the drastic change in p-d gradient contour values across the map. On the other hand, if the Morrowan reservoirs were all related to a regional aquifer, the gradient contours would be widely separated and similar. The Hunton gradient map (Figure 12) illustrates the latter case. Pressure-depth gradients are similar in regional aquifers and slight deviations in gradients can be attributed to measurement error, buoyancy effect (Figure 13), and changes in brine and petroleum specific gravities with depth.

Potentiometric Surfaces

The pressure-dependent height (potentiometric surface) to which fluid will rise in a well (piezometer) can be used to illustrate pressure communication or isolation. Potentiometric surfaces are imaginary pressure surfaces, whose relief reflects the fluid potential in the reservoirs. The height or "head" of a water column is an approximation of the potential energy of the water at the point concerned and reflects the reservoir pressure and to some extent the density of the water (Dahlberg, 1995). Potentiometric surface values (hw) were calculated

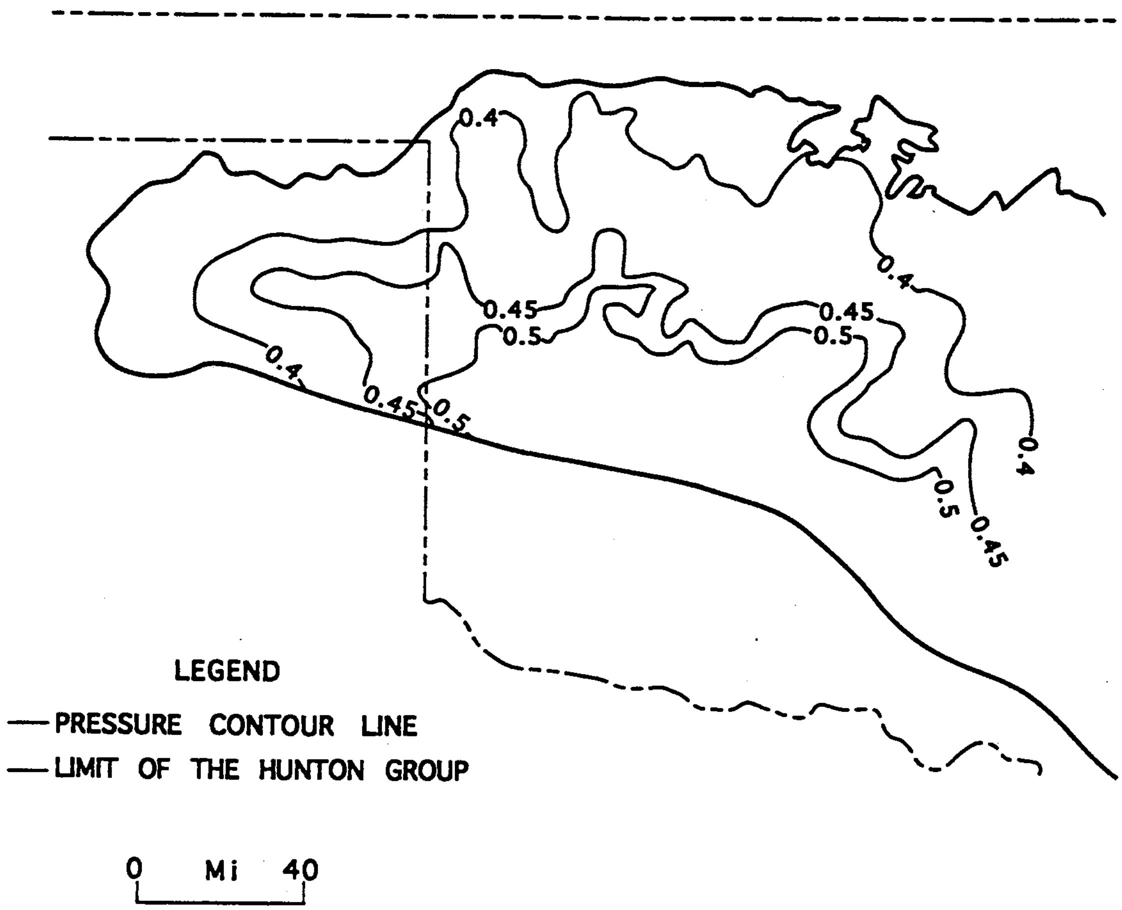


Figure 12. Pressure-depth gradient map for the Hunton Group reservoirs in the Anadarko basin. Values are similar and near normal (0.40 to 0.50 psi/ft.) over the entire area (After Al-Shaieb et al., 1994).

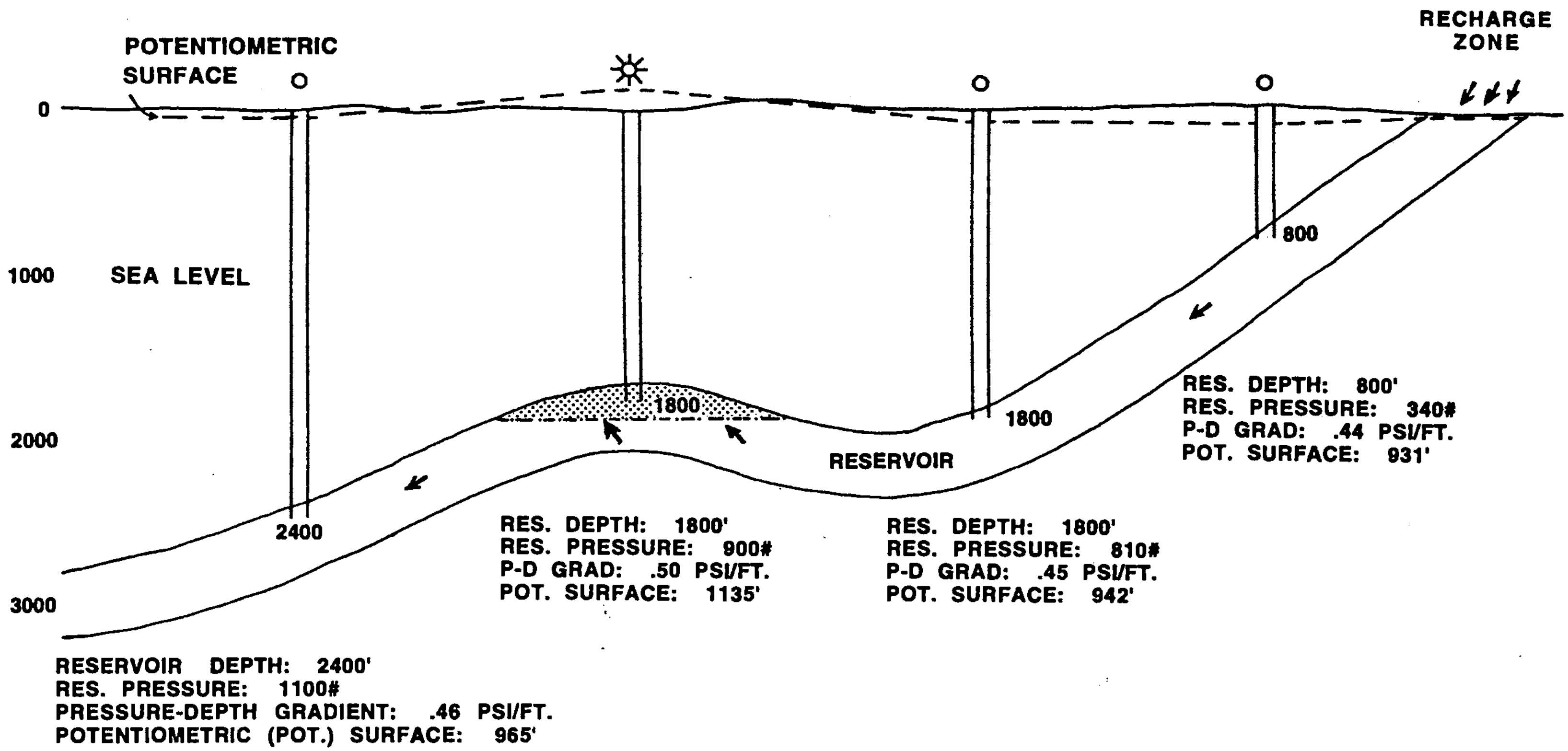


Figure 13. Schematic diagram illustrating overpressuring in a regional aquifer caused by buoyancy effect or hydraulic compression.

using Dahlberg's formula (1995):

$$hw = Z + \frac{P}{\text{grad } p}$$

P - reservoir pressure (psi)
hw - hydraulic head (potentiometric surface: elevation in feet)
Z - elevation in feet above or below an arbitrary datum
grad p - static pressure gradient (0.465 psi/ft)

A constant fluid gradient of 0.465 psi/ft was used in the conversion of bottom hole (reservoir) pressures to potentiometric head values. All head values are standardized to sea level.

Potentiometric head values can be used to predict the direction of fluid flow within and between aquifers. In aquifers such as the Arbuckle and Simpson Groups, regional fluid flow patterns can be used to predict the general migration paths of wastes that are injected into these zones. Head values can be used locally to identify the subsurface intervals with the highest energies and reservoir pressures. Since fluid flows from higher energy zones to lower ones, the relative flow direction between two communicating reservoirs can be predicted. In the context of waste disposal, the relative energy of the injection zone to its surroundings will determine if fluids will flow into the disposal zones from the surrounding reservoirs or outward from the injection zone into the nearby reservoirs if communication is established. This concept is schematically illustrated in Figure 14.

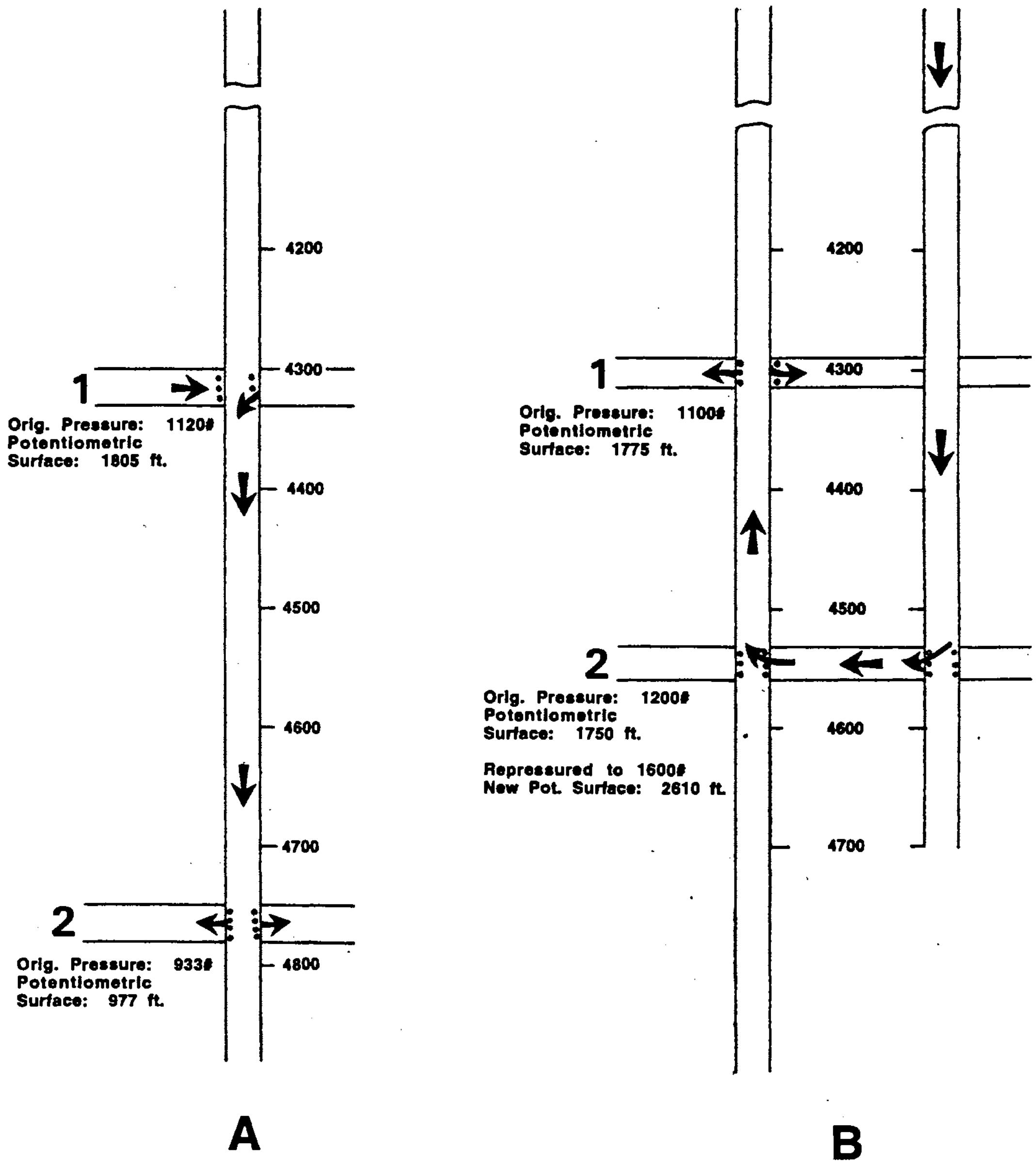


Figure 14. Diagram illustrating fluid flow from a higher energy reservoirs to a lower energy ones.
(A) Inward flow into underpressured reservoir.
(B) Outward flow from supercharged injection zone.

The heights of the imaginary water columns can be used to identify and delineate isolated reservoirs in a region. Isolated reservoirs often display distinct potentiometric heads that map as divergent flow patterns (Figure 15). On the other hand, reservoirs that are in communication exhibit head values that map as general trends with flow converging toward lower energy areas (Figure 16).

Pressure Compartments

Reservoirs that have remained isolated from their immediate surroundings over geologic time are fluid-pressure compartments. The concept of compartmentalization was introduced by Bradley (1975) and Powley (1987) who described a compartment as a two-component system that consists of a porous internal rock volume and a surrounding low-permeability seal. Abnormal pressured (under- or overpressured) compartments are most easily recognized on pressure-gradient profiles by their deviation form the hydrostatic gradient. Abnormal pressures can not exist without a seal since a small amount of fluid flow across a seal will equalize the pressures to hydrostatic (Bradley, 1975). A considerable amount of research has been conducted regarding overpressured reservoir compartments in the Anadarko basin (Al-Shaieb et al., 1992, 1994; Ortoleva et al., 1995). This research suggests that diagenetic seals may develop

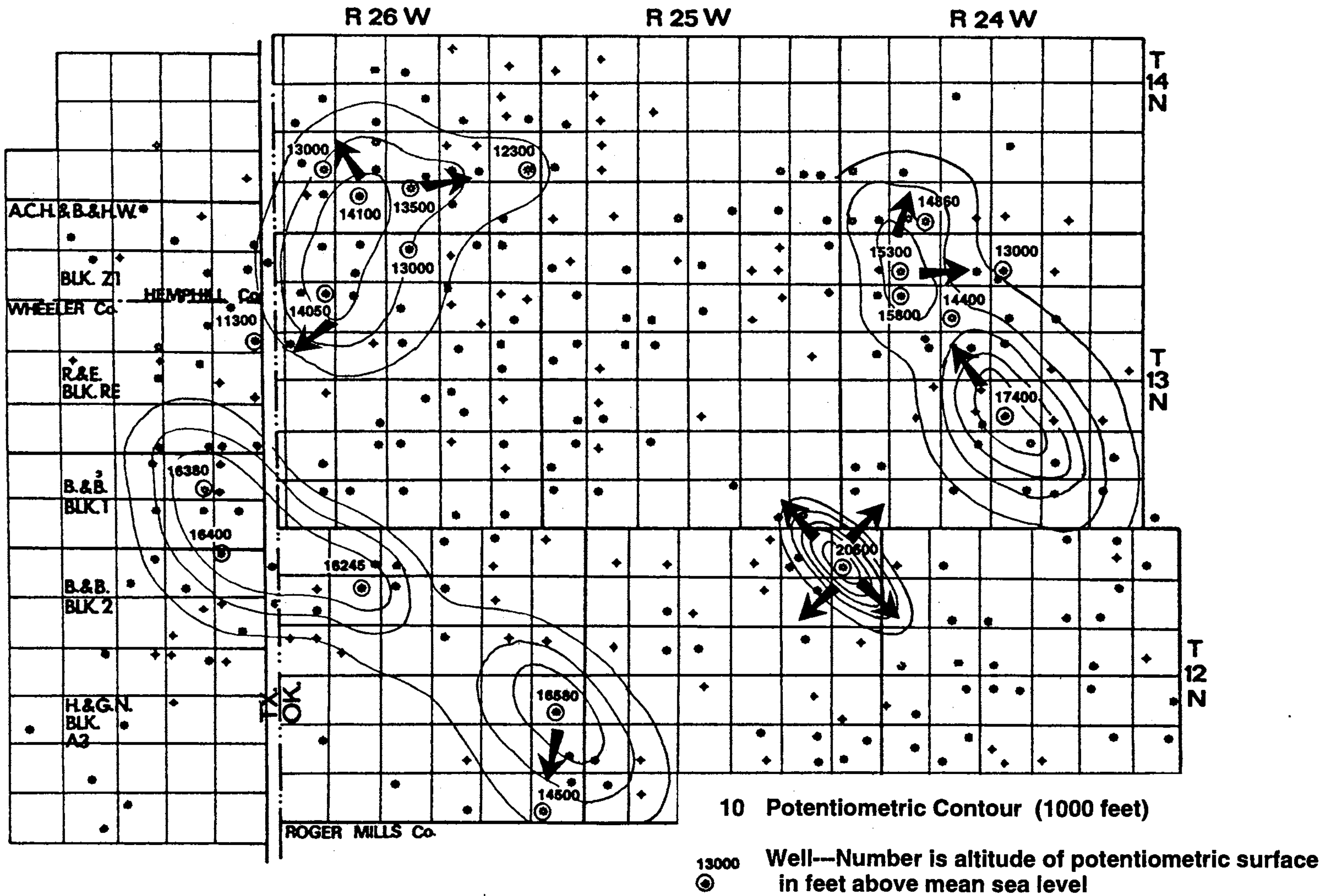
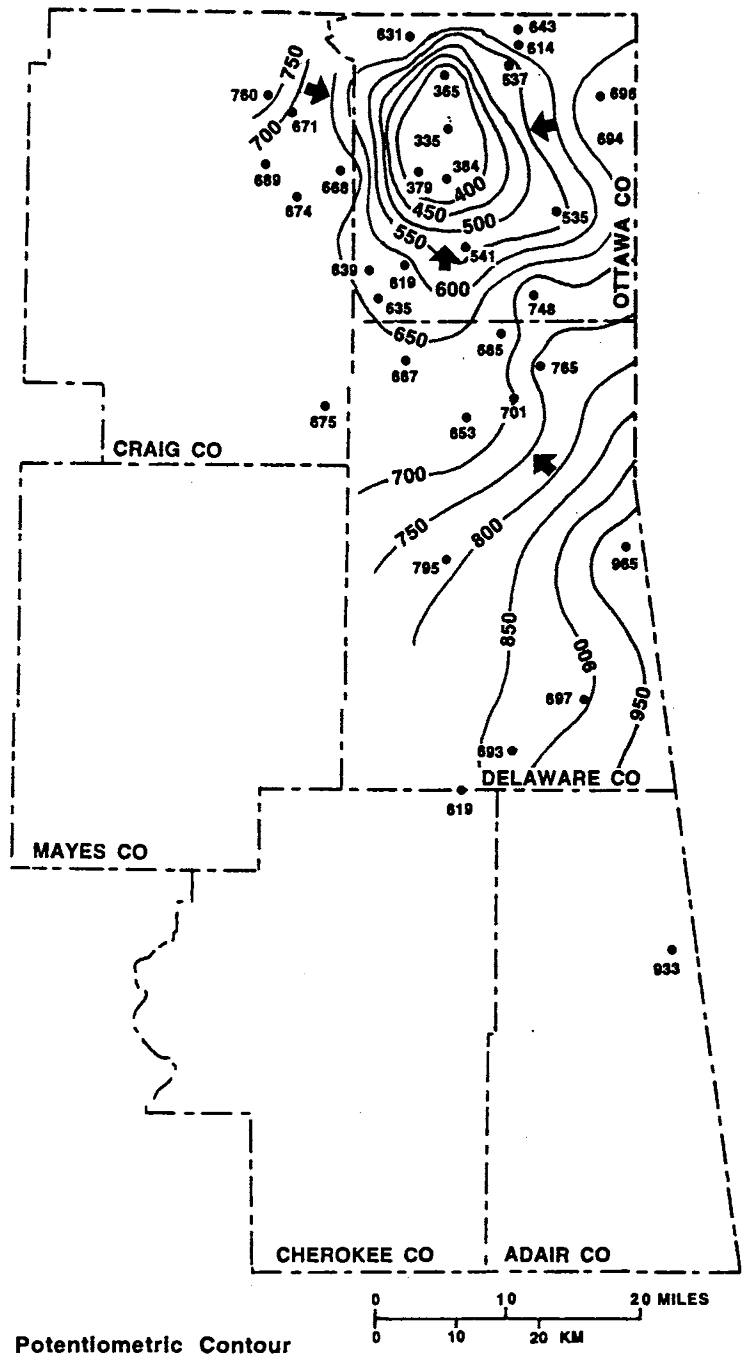


Figure 15. Isolated (compartmentalized) reservoirs with distinct potentiometric heads and divergent flow patterns.



700 Potentiometric Contour

● 655 Well--Number is altitude of potentiometric surface in feet above mean sea level

Figure 16. Common aquifer (Arbuckle) with flow patterns converging toward lower energy areas where pumping has lowered the potentiometric surface (after Christenson et al., 1990).

through stress-induced mechano-chemical processes that intensify cementation and reduce permeability in seal rocks. Seal maturation apparently occurred during the rapid subsidence phase of the basin in the thermal and pressure regimes generated by burial to around 10,000 ft. These seals have apparently confined the highly overpressured reservoirs in the deep Anadarko basin over geologic time (see page 51) and prevented them from pressure equalizing with underpressured reseroirs within the same stratigraphic unit (Al-Shaieb et al., 1994).

Salt and anhydrite are effective seals without being subjected to the thermal and pressure regimes required to generate the diagenetic seals in the Anadarko basin (Powley, 1987).

CHAPTER IV

THE ORIGIN OF COMPARTMENTALIZED AND HYDRODYNAMIC RESERVOIRS

Introduction

The pressure characterization of the deep Anadarko Basin (exclusive of the Hugoton Embayment) has shown that rock column is divided into three general pressure domains: 1) shallow normally pressured, 2) overpressured mega-compartment complex (MCC), and 3) deep normally pressured (Al-Shaieb et al., 1994). This phenomenon clearly demonstrates that reservoir fluid pressures do not continuosly increase with depth and that seals exist that separate these diverse pressure domains. Similarly stratified pressure intervals exist in basins worldwide (Powley, 1990).

One of the fundamental questions addressed in this dissertation concerns basin pressure stratification. Why do selected intervals become sealed and overpressured while others remain normally pressured? The answer to this question can be found in part by examining the stratigraphy and pressure regimes of the Anadarko Basin.

Pressure Stratification of The Anadarko Basin

The pressure stratification of the Anadarko Basin has been described in detail by Al-Shaieb et al. (1994) as part of an extensive study of basin compartmentalization. In this study, pressure-depth profiles were constructed for various regions of the basin. These profiles established the following general relationships:

1. Normal to near-normal pressure-depth values are observed in all stratigraphic horizons down to approximately 7,500 to 10,000 ft below the surface.

2. Overpressuring is observed in all reservoirs from approximately 7,500 to 10,000 ft deep and the Mississippian or Woodford intervals.

3. A return to normal and near-normal pressure gradients is observed in the Hunton and older Paleozoic reservoirs. This pattern is repeated in all areas of the basin that contain overpressured reservoirs.

Al-Shaieb et al. (1994) constructed pressure-depth gradient maps for selected stratigraphic intervals: the Missourian/Virgilian, Desmoinesian, Morrowan, and Hunton (Ordovician-Silurian-Devonian). These horizons were selected on the basis of their stratigraphic position, pressure regimes, and data availability. The maps and pressure-depth-profiles indicate that the overpressured megacompartment complex (MCC) is an elongated body of overpressured rocks that is approximately 150 miles long and 70 miles wide and has a maximum thickness of 16,000 ft (Figure 17). The MCC is divided into a multitude of isolated overpressured compartments that typically conform to the configuration of a single reservoir or trend. These compartments are recognized as closed and isolated features on pressure-depth gradient contour maps (Figure 18), as spires or anomalous peaks on potentiometric 3-D diagrams (Figure 19), or can be indicated by the "stairstep" pattern on pressure-depth profiles (Figure 20).

The overpressuring and compartmentalization of the rock columns in the Anadarko basin begins around 7,500 to 10,000 ft. below the surface. Near the basin axis, abnormal pressures begin in the Missourian-age Marchand sandstone and Granite Wash intervals. On the shelf regions, overpressuring begins in Desmoinesian or Morrowan reservoirs. In either region, the base of overpressuring coincides with the Woodford Shale (Figure 20).

The normally pressured reservoirs below the Woodford Shale are sandstones and carbonates of the Hunton, Simpson, and Arbuckle Groups. These rocks have great lateral continuity and remain normally pressured over most of the basin. Local areas of overpressuring (satellite compartments) occur where facies changes, diagenesis, and/or faulting have sealed portions of the reservoirs.

In contrast, the overpressured MCC in the Anadarko

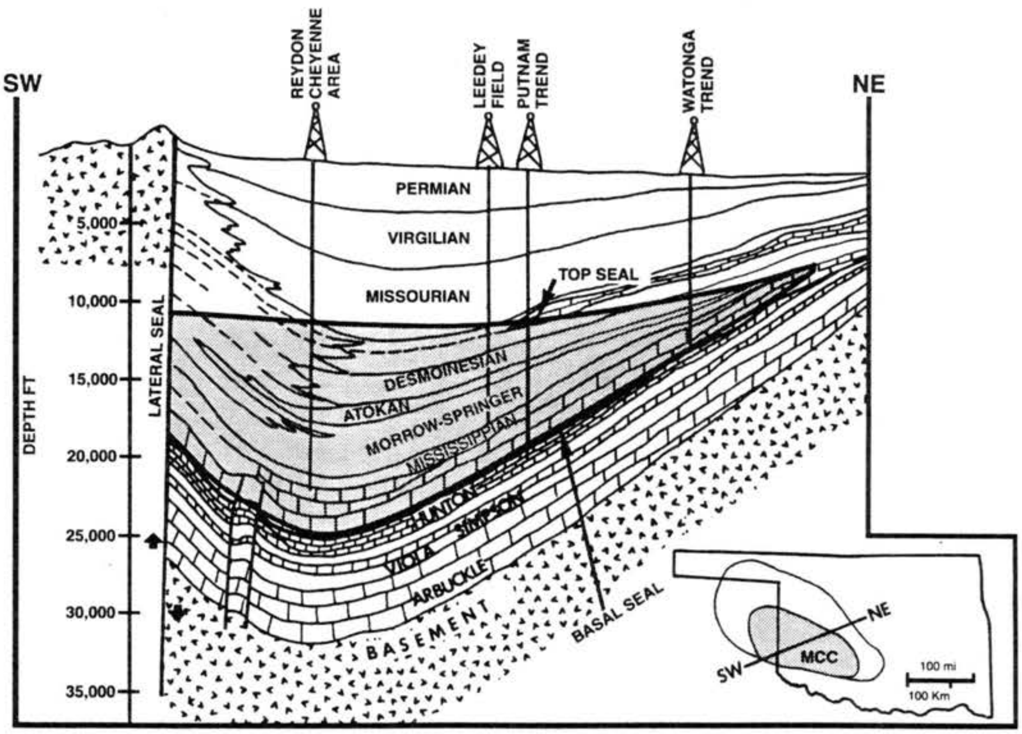


Figure 17. Schematic representation of the overpressured megacompartment complex in the Anadarko basin (After Al-Shaieb et al., 1994).

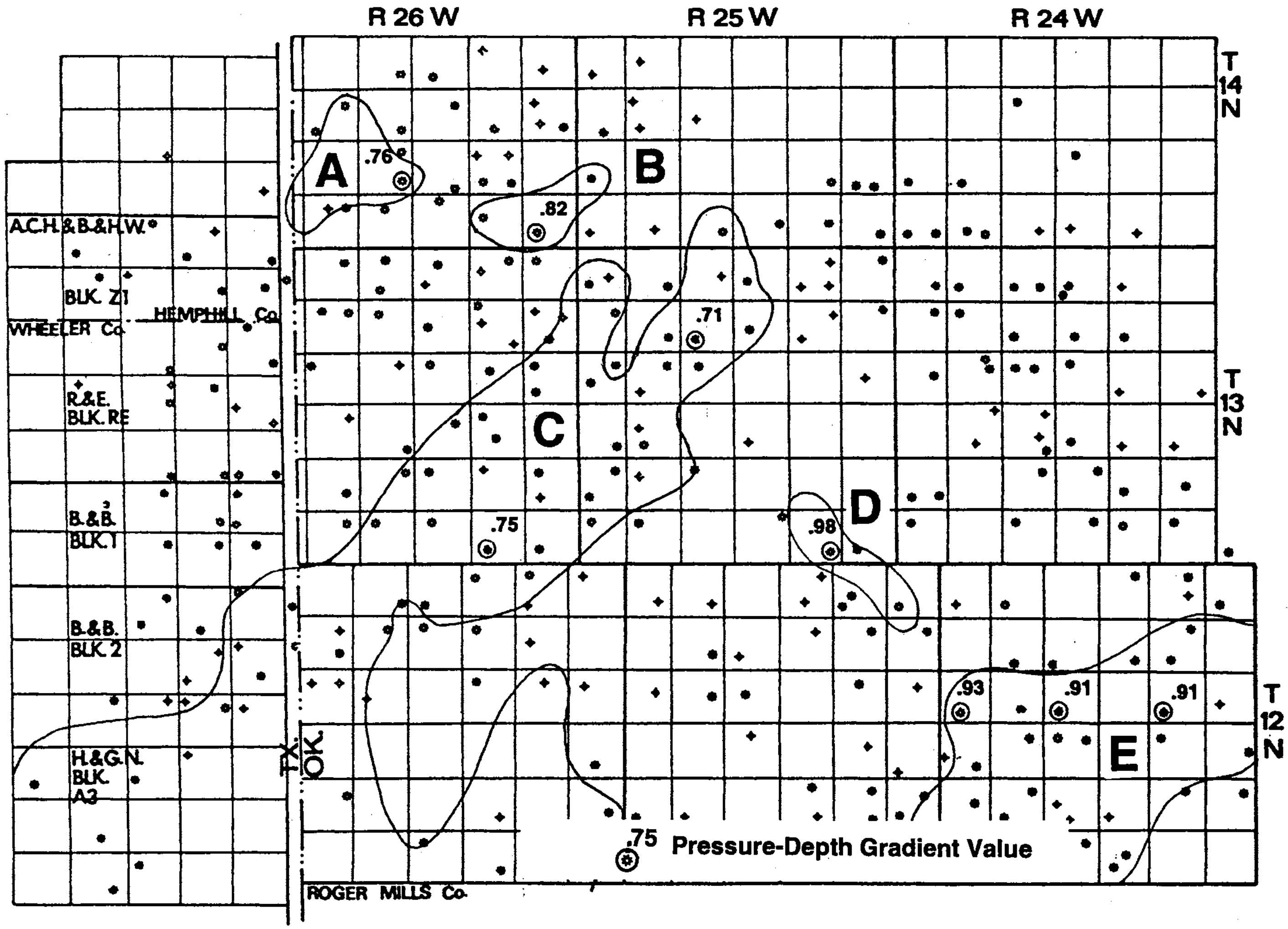


Figure 18. Isolated reservoir compartments (A, B, & C) that are defined by p-d gradient values. Upper Morrow Pierce chert conglomerate reservoir, Roger Mills County, Oklahoma (After Al-Shaieb et al., 1994).

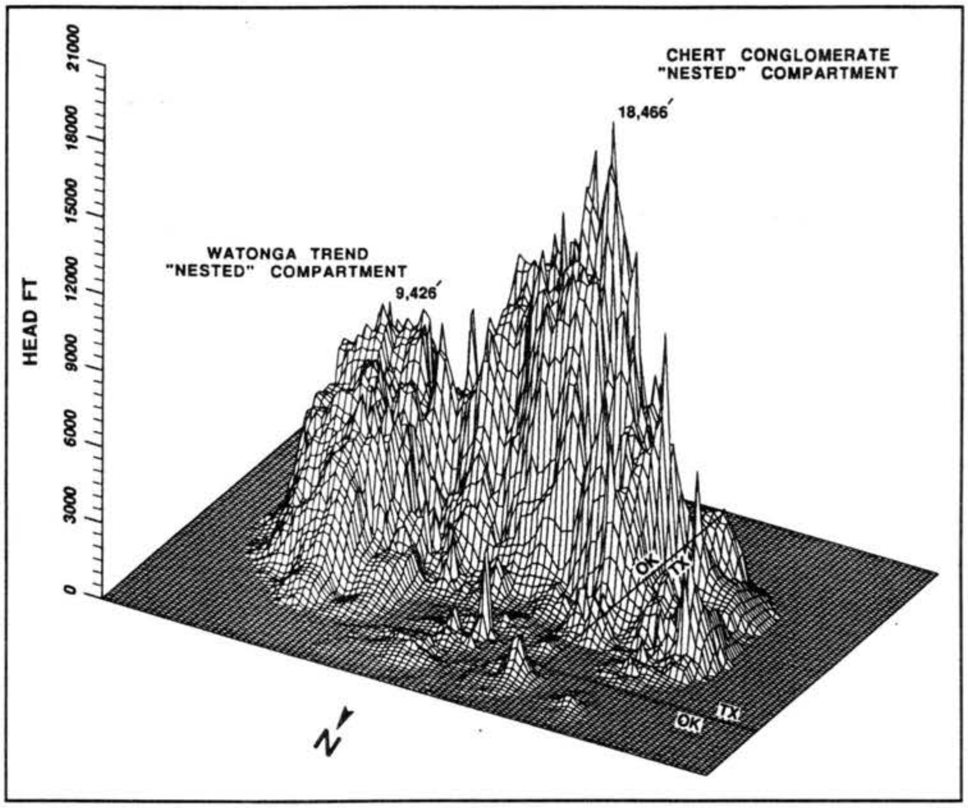


Figure 19. 3-D diagram of potentiometric surface values of the Morrowan Series, Anadarko basin. Each spire represents an individual compartment (After Al-Shaieb et al., 1994).

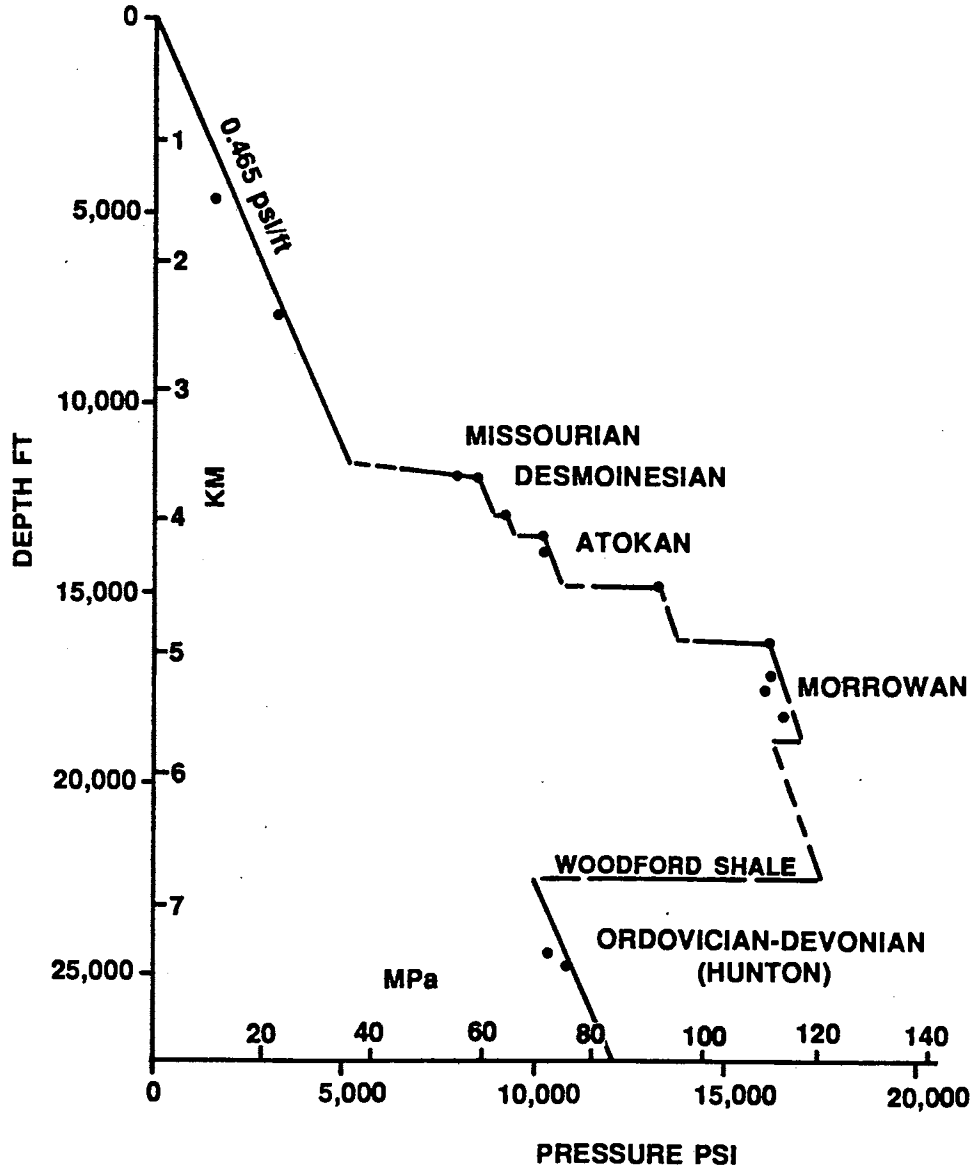


Figure 20. Pressure-depth profile from western Roger Mills County, Oklahoma with characteristic "stairstep" pattern that identifies overpressured reservoir compartments with distinct pressure regimes. Note the return to normal pressures in the Hunton interval around 24,000 ft. (Al-Shaieb et al., 1994).

Basin is dominated by shale deposition in all areas except along the southern margin. The depositional style of the sandstone-shale sequences apparently provided the textural variation and mineralogic diversity conducive to seal formation. Thick shales that form conventional seals were modified by porosity/permeability reducing diagenetic bands induced by the mechano-chemical processes associated with burial below 10,000 ft (Al-Shaieb et al., 1994). In addition, textural boundaries within sandstones were the loci for dissolution and precipitation that produced intralithology diagenetic seals. These sealing processes promoted the localized compartmentalization of stratigraphic intervals (Al-Shaieb et al., 1994a).

The southern boundary of the MCC documents another interesting sealing process. Here, along the frontal fault zone of the Wichita Mountain Uplift, thick intervals of relatively homogeneous coarse clastics became tightly cemented due to the lateral migration of fluids from the MCC toward the fault zone (Al-Shaieb et al., 1994). This sealing apparently occurred during the subsidence phase of the basin and generated a tightly cemented fairway that prevented the lateral venting of the extremely high pressures observed in overpressured reservoirs located a few miles north of the fault (Al-Shaieb et al., 1994).

The normally pressured lower Paleozoic rocks in the Anadarko Basin must have been subjected to the same burial-induced mechano-chemical processes that led to the compartmentalization and overpressuring of the rocks in the MCC. This recognition raises the following question: What prevented the Lower Paleozoic rocks from becoming highly compartmentalized and overpressured like the shallower Mississippian and Pennsylvanian interval?

Evolution of The Lower Paleozoic Reservoirs In The Anadarko Basin

The Lower Paleozoic section in the Anadarko Basin experienced the same burial, hydrothermal expansion, and hydrocarbon generation processes that are proposed to explain the formation of the abnormally high reservoir pressures found in the younger Mississippian and Pennsylvanian rocks. However, due to a lack of competent seals, the reservoirs in these thick older carbonate and sandstone intervals failed to generate and/or maintain abnormal pressures over geologic time. The failure of rocks to seal and compartmentalize is closely linked to their depositional, diagenetic and tectonic history.

Arbuckle Group Carbonates

Arbuckle rocks represent deposition in a broad shallow epicontinental sea where carbonate accumulation was able to keep pace with increasing accomodation space. The Arbuckle is characterized by numerous and repetitive shallowing-upward, peritidal carbonate cycles (Lynch and Al-Shaieb, 1993). Specific depositional facies include subtidal mudstones and wackestones, intertidal bioclastic packstones and grainstones, and restricted, upper intertidal algal boundstones. Supratidal, evaporite-dominated sabkha facies are not well developed. The shallowing-upward depositional cycles often culminate with an intraformationation conglomerate that represents a period of subaerial exposure, erosion, and redeposition (Lynch and Al-Shaieb, 1993).

Arbuckle deposition extended throughout the Midcontinent region and present carbonate thickness ranges from >6000 ft along the depocenter of the Oklahoma Basin to around 2000 ft in the Oklahoma Panhandle. This carbonate is a massive section of limestone and dolomite with only minor amounts of sandstone and shale. Limestone is more prevalent in southern Oklahoma, while dolomite is dominant in northern Oklahoma (Lynch and Al-Shaieb, 1993; Ham, 1969).

Arbuckle rocks experienced uplift, subaerial exposure and erosion numerous times since their deposition. Subaerial exposure generated an extensive pore network that ultimately affected the pressure regimes of the interval. The initiation of karst probably began with the dissolution of the carbonates along fractures and bedding planes. As conduit or focused flow continued, solution channels were enlarged until they became caverns. Cavernous porosity can be inferred from cavern-fill found in cores (Lynch, 1990) and has been reported by the petroleum industry (Read and Richmond, 1993). In addition to conduit flow features, the Arbuckle rocks also contain evidence of diffuse flow dissolution. Moldic and intergranular porosity common in the packstones and grainstones contribute to the pore network. The extensive dolomitization in the northern part of Oklahoma generated intercrystalline porosity that augments and connects moldic and intergranular pores.

The paucity of shales in the Arbuckle Group prevented the generation of stratabound seals that were barriers to vertical fluid movement. The widespread distribution of dolomitized grain-rich facies in combination with karstic dissolution contributed to the evolution of regionally extensive reservoirs in the Arbuckle.

Walters (1958) speculated that the entire thickness of the Arbuckle Group in Kansas functioned as a vast regional aquifer during the Pennsylvanian, similar to its present state in the Tri-State region of Kansas, Missouri, and Oklahoma (Christenson et al., 1990; Macfarlane and Hathaway, 1987; Carr, et al., 1986; and Jorgensen et al., 1986). This reservoir continuity allowed Arbuckle rocks to continually or episodically vent any geopressure that formed as the reservoirs were buried and heated. Pressure could have been released to present or paleooutcrops, or to fault conduits connected to the hydrostatic regime.

The hydraulic continuity in the Arbuckle implies these intervals contained a porosity network that extended for tens to hundreds of miles and communicated with the hydrostatic environment.

Hunton Group Carbonates

The Hunton Group carbonates in Oklahoma also behave as a regional aquifer. The Hunton is primarily shallow-marine subtidal, intertidal, and supratidal carbonates. Depositional facies and dolomitization contributed to the generation of an early porosity network that was also enhanced by karstic processes. Diffuse-flow porosity was best developed in intertidal facies, especially in bioturbated and burrowed wackestones (Matthews, 1992). Burrowing enhanced permeability by redistributing the finer particles and allowing the subsequenct dissolution of nondolomitized matrix and grains (Al-Shaieb et al., 1993). The highest porosity values in the Hunton generally correspond to the highest values of dolomitization.

The Hunton Group has also experienced several episodes of uplift, subaerial exposure, and extensive karsting. In addition to the well-recognized pre-Woodford exposure and beveling of the Hunton Group, Matthews (1992) presented evidence of "local karst" or intraformational karst near the base of the Hunton Group. Amsden (1975) suggests the Hunton contains significant time-stratigraphic gaps over large areas of the Arbuckle Mountains - Criner Uplift outcrop areas in southern Oklahoma. Sea-level curves and the stratigraphic superposition of Frisco limestone on older Hunton units, indicate a major episode of Hunton uplift and erosion occurred prior to Frisco deposition.

During the early part of the Pennsylvanian Orogeny, extensive uplift and erosion exposed Hunton rocks on anticlinal folds along the Nemaha Ridge (Figure 21) where they were subjected to karstic processes and porosity enhancement. These paleooutcrops and the resultant shallow subcrops likely served as part of the venting system that released pressure generated by the deep burial of the Hunton during the rapid subsidence stage of the Anadarko basin.

Isolated overpressured areas (satellite compartments) occur in the Hunton Group where low permeability facies have formed localized seals. These compartments are not common and can be recognized as anomalous spikes on the Hunton potentiometric surface diagram (Figure 22).

Simpson Group Sandstones

The Ordovician-age Simpson Group sandstones also have remained near-normally pressured over much of Oklahoma and the Anadarko basin. The Simpson Group consists of thick (fifty to one-hundred feet) shallow-marine sandstones that are separated by thinner carbonates and shales. These

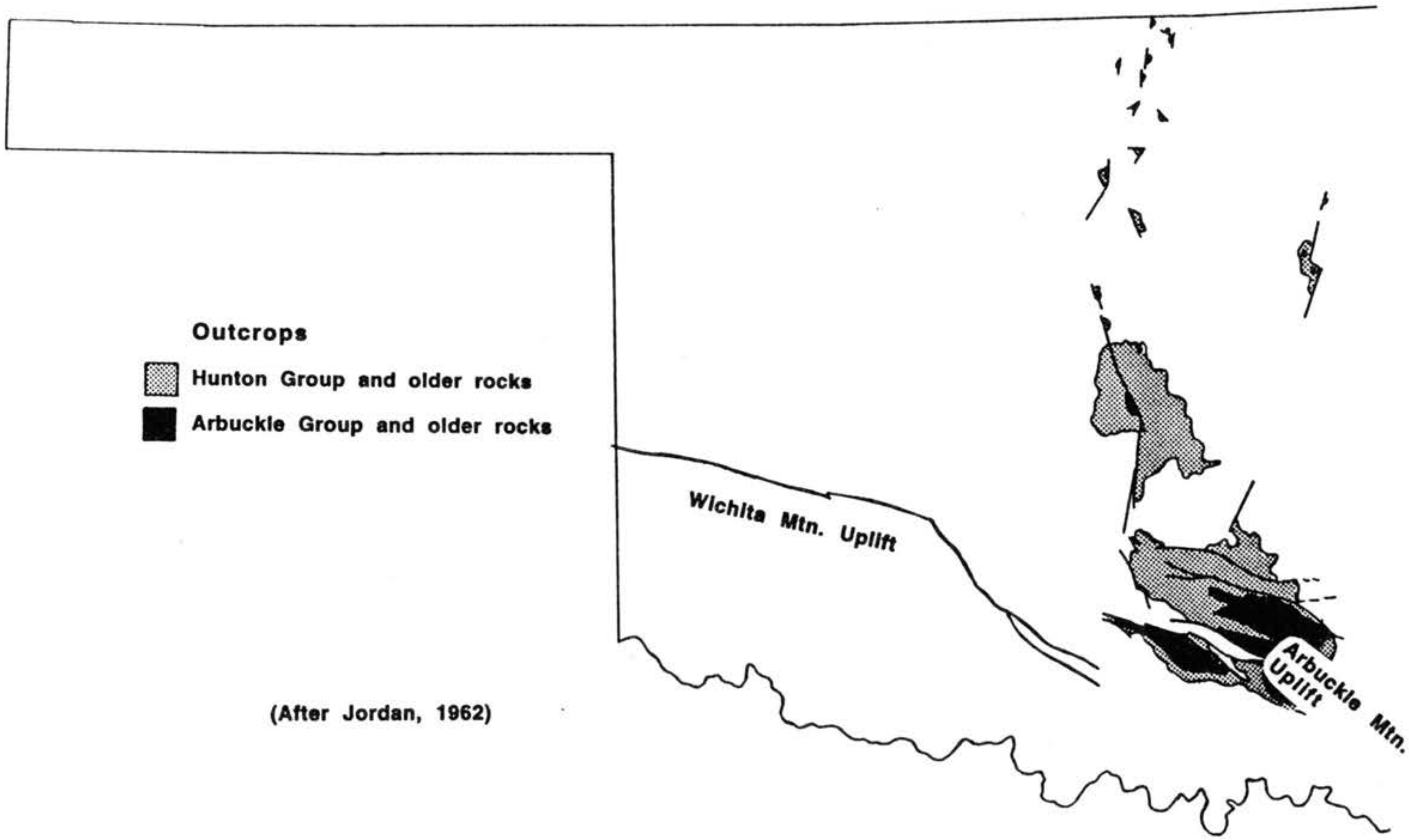


Figure 21. Anticlinal folds along the Nemaha Ridge and other uplifts where Hunton, Simpson, and Arbuckle rocks were subaerially exposed and eroded during the Pennsylvanian.

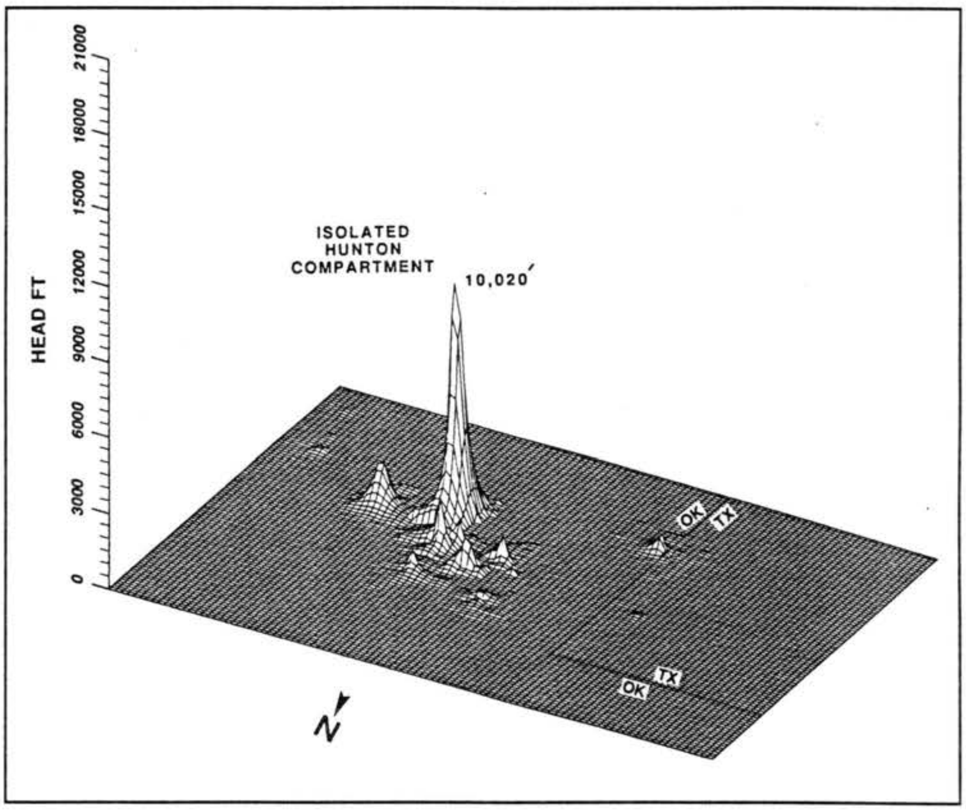


Figure 22. 3-D diagram of potentiometric surface values of the Hunton Group. The anomalous spike represents a satellite compartment (Al-Shaieb et al., 1994).

rocks often maintain an extensive primary porosity network due to clay grain coatings that have inhibited overgrowth nucleation (Tigert, 1989). This regional aquifer subcrops below the Woodford Shale in northeastern Oklahoma and below Pennsylvanian shales on anticlinal folds along the Nemaha ridge.

The Simpson Group has apparently remained near normally pressured over much of the basin (Figure 23) as the result of the widespread distribution and high porosity of the component sandstone units. This aquifer system was able to vent pressure and equalize with the hydrostatic domain in paleooutcrop or along shallow subcrop relationships. In some instances, the Simpson Group may have been in fluid/pressure communication with the Arbuckle Group along fault conduits or by fault juxtaposition, thereby improving its chances for pressure nomalization.

Satellite compartments exist in the Simpson Group as the result of faulting and diagenetic seals. These features are described in Tigert (1989), Al-Shaieb et al., (1993) and Ortoleva et al., (1995).

Summary

The keys to maintaining hydrostatic pressure regimes over geologic time are 1) development of thick and regionally extensive aquifer systems, and 2) maintaining communication with the hydrostatic domain through uplift

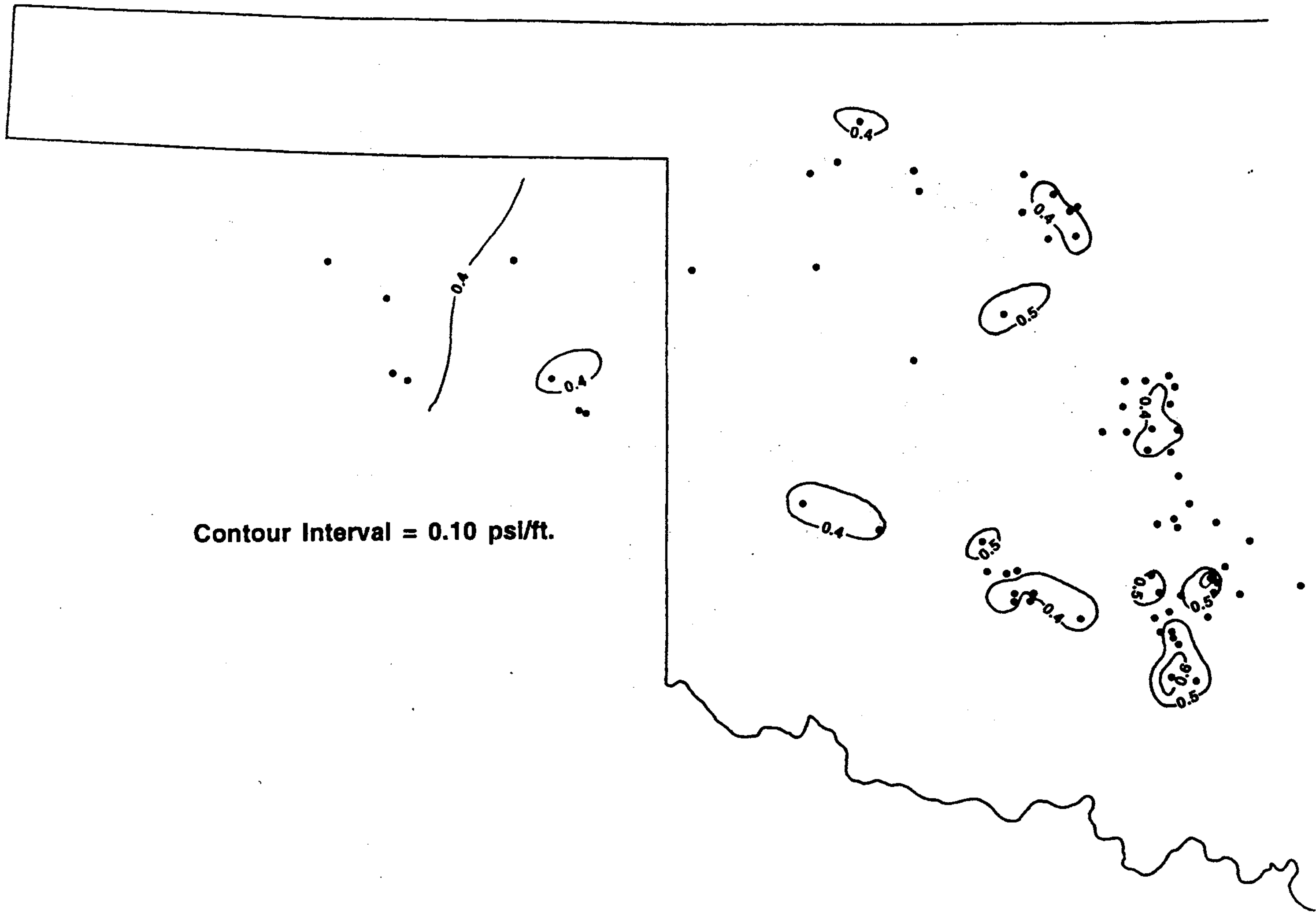


Figure 23. Pressure-depth gradient map of the Simpson Group. Contour lines indicate a predominantly normal pressure regime.

and subaerial exposure. In the case of thick carbonate sequences such as the Arbuckle and Hunton Groups, karstic dissolution was crucial in developing the regional reservoirs. For the Simpson Group, maintaining the primary porosity network was essential to distributing and alleviating geopressure. The Arbuckle, Simpson, and Hunton Groups were all uplifted and subaerially exposed multiple times following deposition. This process allowed continuous or episodic opportunities for these reservoirs to pressure-equalize with the hydrostatic environment.

The shale-dominated intervals of the Pennsylvanian and the low-porosity carbonates of the Mississippian did not develop laterally extensive reservoirs. They were prone to porosity occlusion via diagenetic processes and tended to compartmentalize. In addition, the Pennsylvanian rocks over much of Oklahoma subsided continually until the Cretaceous Laramide Orogeny and were not uplifted and breached by regional erosional events.

CHAPTER V

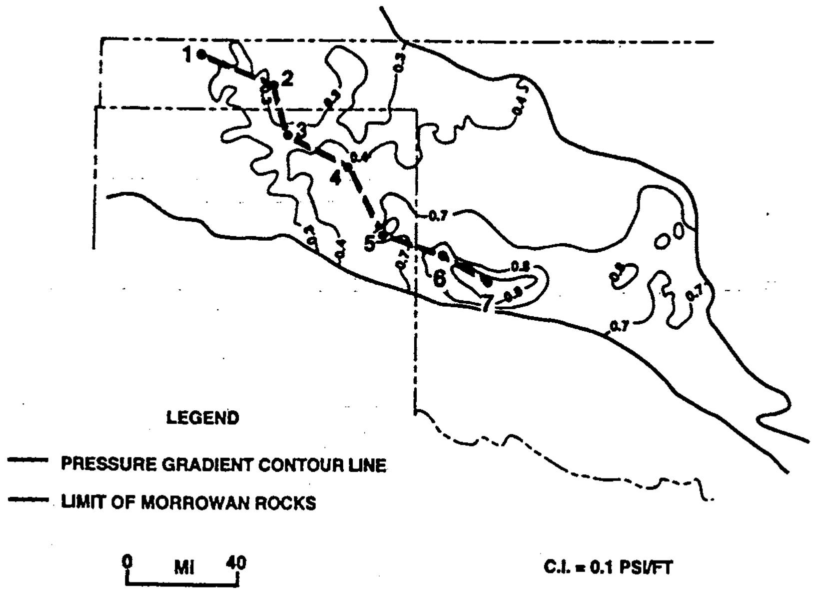
STRATIGRAPHY AND PRESSURE ARCHITECTURE IN THE OKLAHOMA PANHANDLE

Introduction

The Oklahoma Panhandle region of the Hugoton embayment is used to demonstrate the pressure characterization of an area. Pressure measurements from the Pennsylvanian Morrowan reservoirs illustrated the change in pressure across the region. The distinct difference between highly overpressured reservoirs in the deep basin (p-d values >0.8 psi/ft.) to underpressured reservoirs in the panhandle (p-d values <0.3 psi/ft.) indicates reservoir isolation (compartmentalization) and that no regional fluid flow occurs in the Morrow.

A generalized potentiometric surface diagram that illustrates the regional changes in Morrow pressure (fluid energy) from the deep Anadarko basin to the Oklahoma Panhandle is shown in Figure 24. Potentiometric surfaces measured relative to sea level, regional pressure seals and surface topography are shown. If regional basinal fluid flow had occurred in this region, these distinct potentiometric surfaces would not exist.

Close examination of pressure measurements within



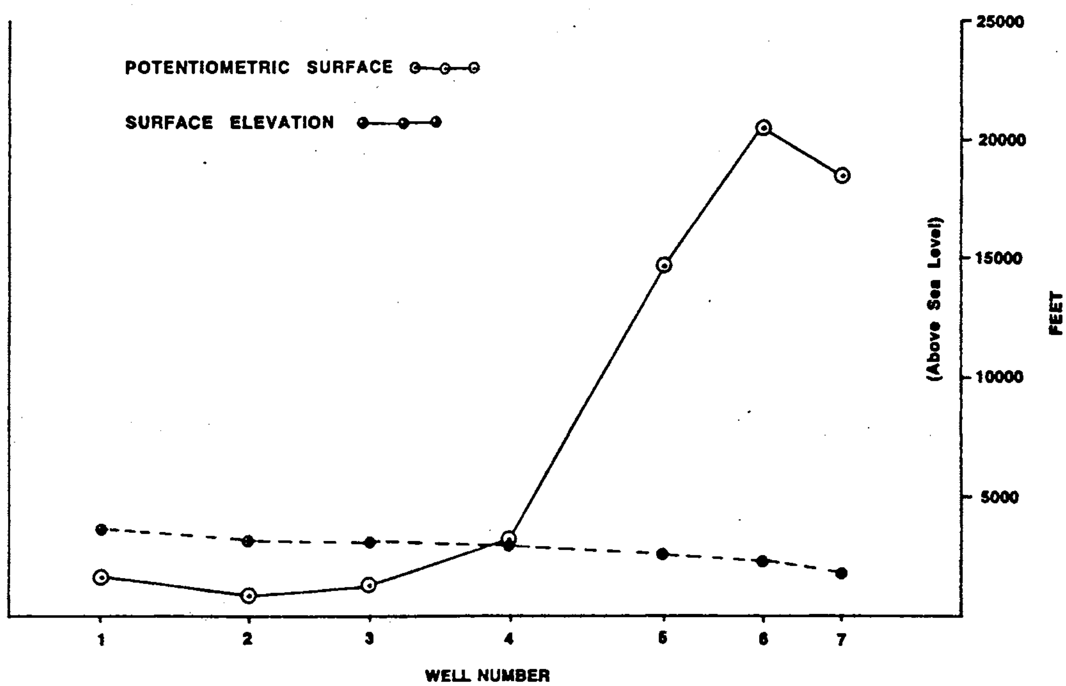


Figure 24. Cross section depicting potentiometric surfaces for upper Morrow reservoirs. This section illustrates the wide differences between pore-fluid energy for deep Anadarko basin reservoirs and those in the Oklahoma Panhandle.

the Panhandle suggests that interstratum fluid flow does not occur on the local level. Pressure-depth profiles and potentiometric surface maps demonstrate the significant vertical differentiation in pressure across the stratigraphic column.

Changes in Pressure Across the Stratigraphic Column

Pressure measurements indicate seal zones divide the stratigraphic column in the Oklahoma Panhandle into separate pressure domains. In the Keyes Dome area (T.5N., R.10ECM. and T.6N., R.10ECM.), five distinct groupings of similar pressure measurements are recognized. These groups are separated by relatively flat-lying stratigraphic seals that correlate to evaporites or shales (Figure 25).

The shallowest pressure domain is the near-hydrostatic one associated with the ground water system and the regional Ogalalla aquifer. Original (pre-irrigation) potentiometric surfaces for this aquifer were close too or intersected the surface (Schoff and Stovall, 1943) indicating a freshwater gradient of approximately 0.433 psi/ft. This pressure domain would have extended to the Blaine Anhydrite and included all fresh water aquifers in the area. The second significant pressure domain is below the Blaine Anhydrite and above the Wellington shale/evaporite intervals. The reservoirs in this

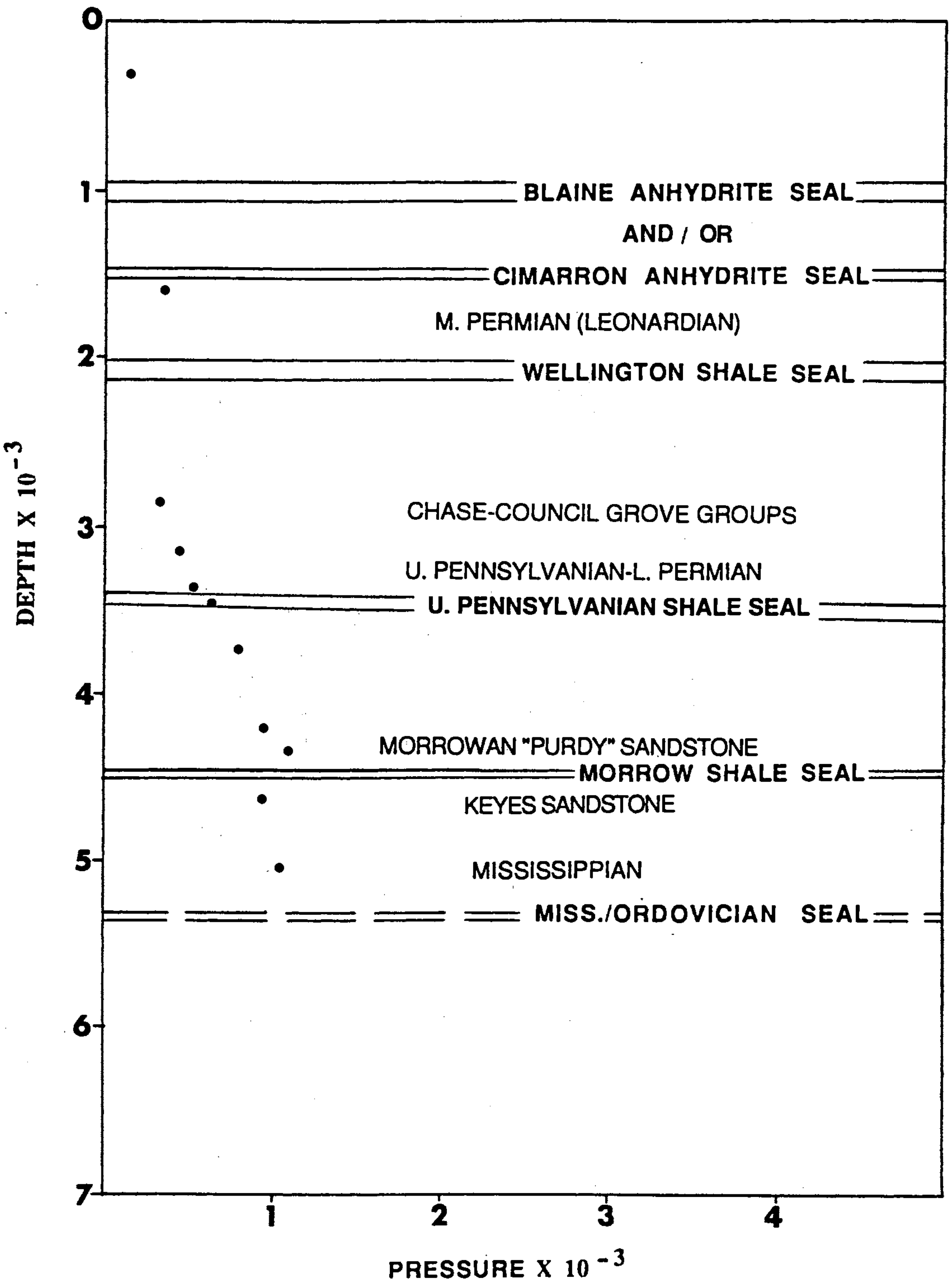


Figure 25. Pressure-depth profile illustrating seal zones that separate pressure data into distinct groups. Keyes Dome area, Cimarron and Texas Counties, Oklahoma.

interval have pressure-depth gradients around 0.24 psi/ft and potentiometric surfaces around 2500 feet above sea level. The third important pressure domain includes the reservoirs of the Permian Chase Group that are found below the Cimarron/Wellington seal interval. In the Keyes area, these reservoirs have pressure-depth gradients around 0.15 psi/ft and potentiometric surfaces around 700 feet above sea level.

The highest pressure measurements recorded in pre-Permian rocks in this area are found in the Upper Morrowan reservoirs. Upper Morrow (Purdy) sandstones have pressure-depth values that range from 0.25 to 0.29 psi/ft and potentiometric surfaces around 2600 ft. These values are significantly higher than the p-d gradients of 0.20 and potentiometric surfaces of 1500 ft. that are measured in the underlying Lower Morrowan (Keyes) and Mississippian reservoirs. The Lower Morrowan Keyes Sandstone is separated from the Upper Morrowan Purdy Sandstone by a shale interval that serves as a seal between the two pressure domains. The pressure regime below the Mississippian interval is not well defined. Simpson/Arbuckle pressure measurements are not available in the profile area, but deeper pressure measurements in nearby areas suggest a return to higher pressures.

Important components of the regional and local pressure distribution (pressure architecture) can be identified by comparing p-d profiles. This information includes the lateral continuity of seal horizons, changes in relative pressure with depth, and compartmentalization. Twelve pressure-depth profiles were constructed that define pressure distribution in different areas of the Oklahoma Panhandle (Plate I). These profiles illustrate the gradual increase in pressure with increasing depth, compartmentalization, and the continuity of the seal horizons identified on the profile from the Keyes dome area.

Changes in Pressure with Depth

The increase in pressure with depth can be tracked by comparing Morrow pressure measurements from the Keyes area in Cimarron county with those from Beaver county. In the Keyes area (T.5-6N., R.10ECM.), upper Morrow reservoir pressures range from 1000 psi to 1150 psi at a depth of approximately 4400 ft (Figure 25). Upper Morrow reservoirs in T.1N., R.20-23ECM., Beaver County, are from 7100-7600 ft deep and have reservoir pressures between 1500 and 1800 psi (Figure 26). This general trend of increasing pressure with depth is evident in the other stratigraphic intervals. Lower Morrow sandstones in the Keyes area have reservoir pressures around 1000 psi at 4700 to 4800 ft deep (Figure 25). Lower Morrow reservoirs in Beaver County are found approximately 7700 to 8100 ft deep and have pressures between 2100 to 2300 psi (Figure 26).

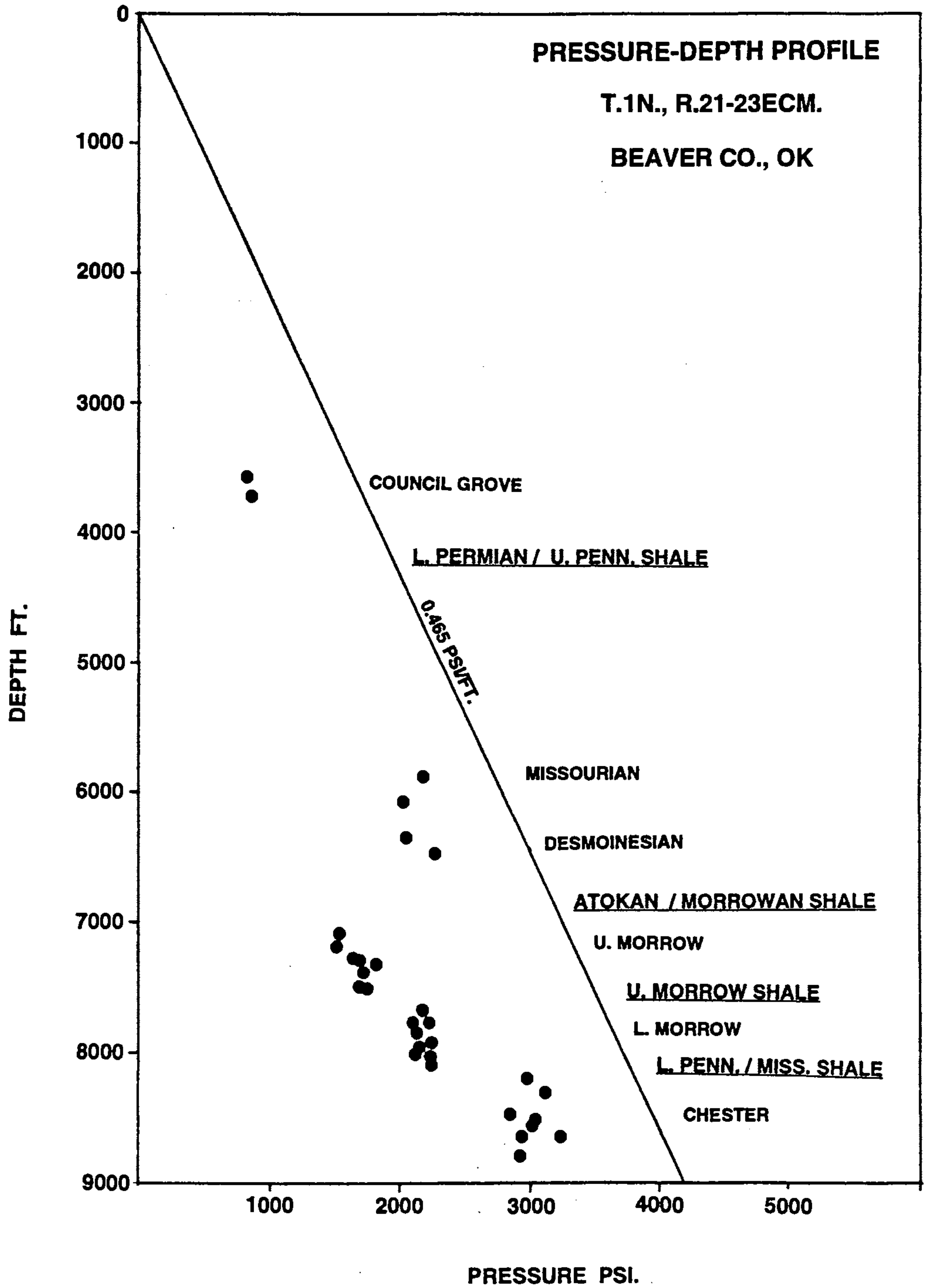


Figure 26. Pressure-depth profile from T.1N., R.20-23ECM., Beaver County, Oklahoma.

These changes do not occur as consistent incremental increases. Instead, pressure increases at a faster rate in some stratigraphic horizons. As a result, the p-d values for reservoirs become more distinct and the effects of compartmentalization more evident.

Compartmentalization

Compartmentalization of reservoirs within the same stratigraphic interval is recognized when distinct pressures and fluids identify isolated reservoirs. The pressure studies conducted on the deep Anadarko basin (Al-Shaieb et al., 1992 and 1994) documented the compartment concept and demonstrated the change in Morrowan pressure regimes from the deep basin to the shelf regions. The regional change from highly overpressured reservoirs to normally pressured and ultimately underpressured reservoirs indicates these reservoirs have not equilibrated over geologic time.

The pressure data in the panhandle indicate that the underpressured Morrowan reservoirs are compartmentalized. In the Keyes area, the lower Morrowan Keyes Sandstone and Mississippian Chester reservoirs have p-d gradients (0.2 psi/ft) that are considerably less than those for the Upper Morrowan reservoirs (0.25 psi/ft) (Figure 25). In T.1N., R.20-23ECM., Beaver County, the Keyes and Chester p-d gradients have increased to around 0.28 and 0.36 psi/ft respectively, while the Upper

Morrowan gradients are still approximately 0.23 to 0.25 psi/ft. As a result, the Upper Morrowan reservoirs, which were the highest pressured reservoirs in the Keyes area, are more underpressured in Beaver County (Figure 26). This change in relative pressure suggests these reservoirs operate as independent fluid-pressure systems that are isolated by impermeable barriers or seals.

Seals in the Panhandle Region

Several regional horizontal seal zones are recognized in the Panhandle. Pressure information represented on the p-d profiles identifies six seals that extend across the region (Figure 27). In descending depth from the surface, the first seal zone occurs below the base of the fresh water aquifers and above the Red Cave reservoirs. This zone includes several potential seals. The role of these beds can not be specified because of a lack of pressure data in this interval. Important Permian-age seal rocks include the shales of the Cloud Chief Formation and Whitehorse Group, the Dog Creek Shale, Blaine Gypsum, Hennessey Shale (shale and salt) and the "Cimarron" Anhydrite (Plate II). The second is the lower part of the Hennessey Shale that contains Lower "Cimarron" salt. This seal separates the Tubb and Red Cave reservoirs from the underlying Chase Group. The third seal is the shale-rich interval below the Permian-age Council Grove Group that

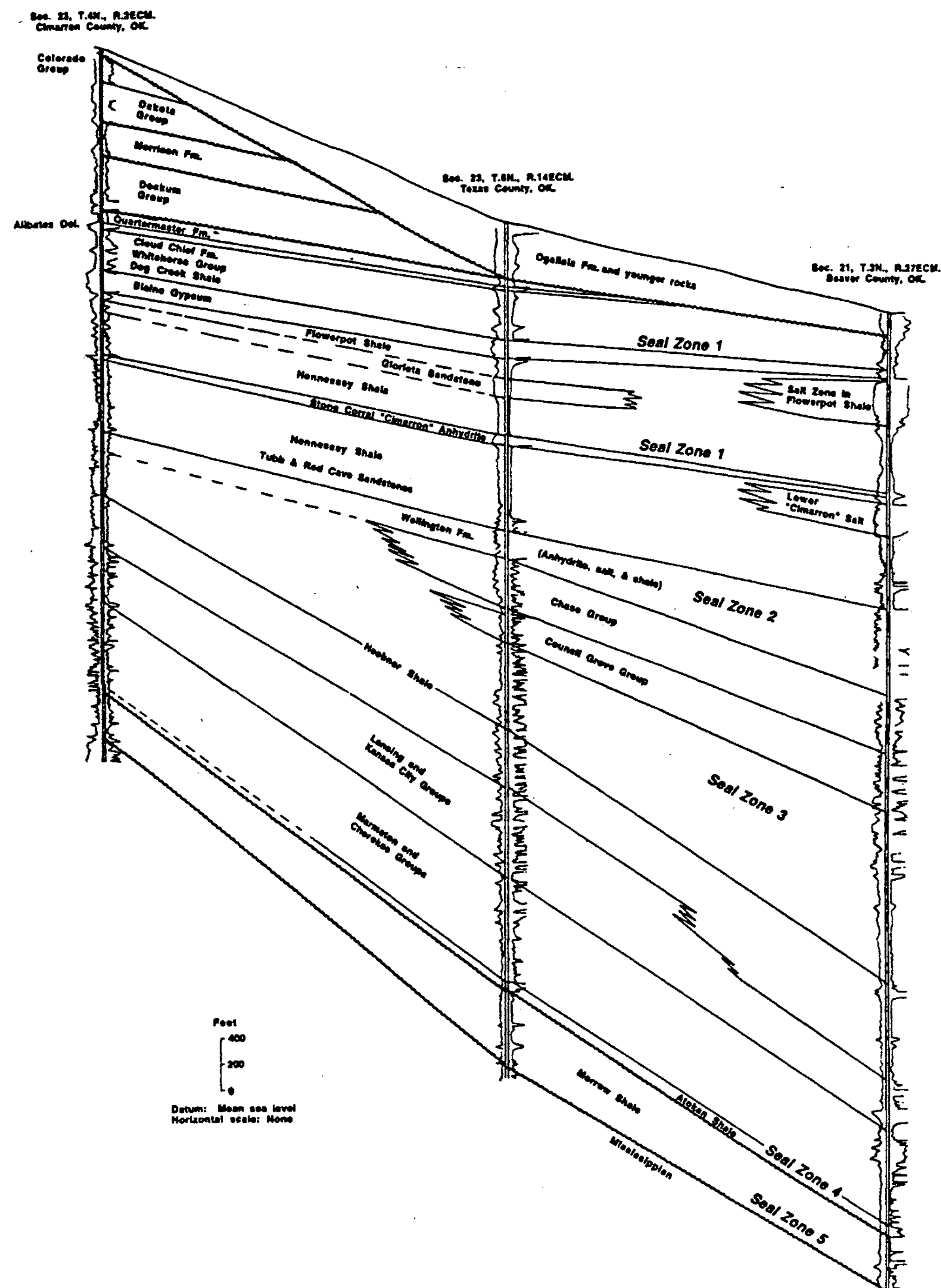


Figure 27. Schematic diagram illustrating the positions of the regional seals in the Oklahoma Panhandle.

separates it from the underling reservoirs (Cisco, Tonkawa, Hoover) in the Pennsylvanian Virgilian and Missourian Series. The next easily recognizable seal separates Pennsylvanian Missourian and Desmoinesian reservoirs from those in the Morrowan interval. This seal coincides with the Cherokee or Atokan shales. The fifth seal separates the Upper Morrowan and Lower Morrowan reservoirs. This seal is associated with the thick shales in the Upper Morrowan interval. The sixth seal occurs in the Mississippian and older rocks and separates the Lower Morrow and Chester reservoirs from those in the Ordovician Simpson and Cambro-Ordovician Arbuckle Groups.

Evidence from the deep basin compartmentalization study indicates that seal zone shales in the overpressured interval are diagenetically altered (Al-Shaieb, et al., 1994b). In some cases, this diagenetic enhancement is expressed as banded structures composed of cement and relatively unaltered shale (Al-Shaieb et al., 1994b). The diagenetic alteration of shale reduces pore-throat radii (Powers, 1992) and apparently contributes to the integrity of pressure seals. Other processes that may contribute to seal integrity include capillarity (Surdam, 1994) and the precipitation of organic compounds (Whelan et al., 1994). These processes (singularly or in combination) have generated low permeability rocks that form seals for highly overpressured reservoirs that remained intact through geologic time.

In the normally and underpressured regime, seal integrity is less problematic. The dewatering and compaction of shales during burial may reduce porosity and permeability levels that will confine reservoir pressures (Powley, 1990). Other processes, such as capillarity (Hubert, 1995) may augment seal itegrity. Evaporite-rich strata in the Panhandle are ideal lithologic seals with extremely low permeabilities (Bradley and Powley, 1994).

Three-dimensionally isolated pressure compartments and seal zones are integral components of liquid waste-disposal systems that are designed to control vertical and horizontal migration. Within the Panhandle region, several intervals can be identified that fit the no-migration criteria of an ideal disposal zone. Two obvious examples are the Chase and Morrowan reservoirs.

Morrowan Sandstones. Sandstones in the Pennsylvanian Morrowan Series are potential disposal zones. They have lower p-d values than the overlying Desmoinesian/Missourian and underlying Ordovician reservoirs. This relationship is depicted in Figures 24, 25 and 26. These figures illustrate the changes in depth to the Morrow sandstones in different areas of the Panhandle and identify the shale seal zone that separates the upper and lower Morrow sandstones. The primary concern with the Morrowan sandstones is their lateral continuity. Some Morrowan reservoirs have produced tens of millions of barrels of liquids, but none have the seemingly limitless capacity of regional aquifers like the deep Simpson and Arbuckle Group reservoirs. Due to their smaller capacity, disposal zones such as the Morrowan Sandstones may be best suited as repositories for somewhat limited volumes of extremely toxic waste whose migration must be closely monitored.

Chase Group Carbonates. The Chase Group reservoirs represent another porous zone with lower pressures than both the overlying and underlying units. The Chase Group, which is found between 2500 and 3500 feet deep, is composed of porous dolomites that have exceptional lateral permeability and constitute a single regional compartment. Pressure communication within the Chase reservoir has been documented since the early development of the Hugoton Gas Field (Mason, 1968; Pippen, 1968). The exceptionally high fluid storage capacity makes the Chase an exceptional disposal zone. The primary drawbacks to using the Chase Group as a disposal zone are the scarceness of pressure data in the overlying strata and its relatively close proximity to the High Plains Aquifer and other fresh water supplies.

In order to appraise reservoir compatibility for underground injection, they were classified by type and size. Several were selected for systematic evaluation as potential disposal sites.

CHAPTER VI

CHARACTERIZATION AND CLASSIFICATION OF UNDERPRESSURED COMPARTMENTALIZED RESERVOIRS

Introduction

Underpressured reservoirs in the Oklahoma Panhandle were characterized for geologic suitability as disposal zones. Specific criteria for suitability included sufficient porosity and permeability, thickness, areal extent (capacity) and total confinement or compartmentalization.

Porosity and permeability measurements were determined from thin section petrography of core samples, wire-line logs, and reported in the literature. Qualitative predictions of permeabiity were based on flow rates and fluid recoveries. Thickness and areal extent of reservoirs were determined by mapping wire-line log-derived data. Fluid type and pressure data were used to delineate individual compartments.

The integrity of confining units was evaluated using a variety of techniques. The primary focus of this phase was to determine the lithology, thickness, continuity, and spatial distribution of confining units. Lithologies, thicknesses and spatial distribution were determined by examining wire-line logs. Continuity was evaluated by examining the site vicinity for faults or fractures that could transect the confining units and contribute to fluid migration from the disposal zone. Remote sensing analysis of the area to detect surface lineaments (faults or fractures) was conducted using B&W aerial photography and U.S.G.S. topographic maps. Subsurface structure maps were constructed using standard petroleum industry data including wire-line logs, completion "scout" cards, and completion reports.

Underpressured reservoir compartments were classified based on their host lithology and size. These two features were controlled by the depositional setting and resulting depositional environment. Two general groups of underpressured compartments were distinguished by their host lithologies: carbonates or siliciclastics. These groups were subdivided by size, which was based on the amount of liquid petroleum or equivalent volumes gas removed from the reservoir and reported in industry publications.

Large compartments are those reservoirs that have produced more than 1,000,000 barrels of oil. To insure communication throughout the reservoir, each compartment was analyzed for characteristics that suggested a common source of supply. These included same apparent depositional environment, correlatable wireline-log signatures, fluid types that suggested communication between wells and a common reservoir and pressure decline data. Though several fields had cumulative production volumes that exceed 1 million barrels of oil, they were not classified as large compartments because the production came from several separate reservoirs and not a single common source.

Intermediate compartments have produced between 100,000 and 1,000,000 barrels of petroleum liquids. These compartments are typically well defined by drilling and pressure data, especially where there is only one productive horizon in the field.

Small compartments have produced less than 100,000 barrels of liquids. In some cases, a single well surrounded by well bores that lack the reservoir horizon defines these compartments.

The type and size of the compartments are strongly influenced by the depositional environment of the host rock. Individual channel filling sandstones within a valley fill sequence tend to form small compartments. On the other hand, sandstones that formed from sediments that were reworked and redistributed my marine processes formed intermediate or large compartments. Within the carbonate domain, thick grain-rich shelf limestones that experienced significant dissolution and dolomitization may form large reservoirs, while thin grainstone shoals within cyclic heterolithic assemblages typically form small compartments. Examples and characteristics of these compartments are shown in Table III.

Guymon Area Disposal Site:
A Large- (Regional) Sized Compartment in
Chase Group Carbonate Reservoirs

The Guymon Area disposal site is an example that utilizes the regional-sized Chase Group reservoir compartment as a potential disposal zone. The Chase Group in this area is composed of Permian (Wolfcampian) dolomites, limestone and shales. The porous dolomites are the primary reservoir rocks within the Hugoton Gas Field. The dolomites were deposited primarily as shallow water limestones on a broad carbonate shelf. These limestones were partially dissolved to form vuggy porosity and dolomitized. As a result, broad belts of porous dolomite developed that subsequently partially filled with gas and formed the Hugoton field. This field is part of a huge common reservoir (Mason, 1968; Pippin, 1968) known as the Panhandle-Hugoton Gas Field. It includes 19 counties in three states, is 275 miles long and ranges in width from 5 to 57 miles (Figure 28). It is the largest gas field in the United States and contains approximately 5 million productive acres (Pippin, 1968).

The stratigraphic sequence in the Panhandle and Hugoton fields is shown in Figure 29. The entire productive area originally had the same reservoir pressure and apparently the same hydrocarbon source. The Panhandle

Field Name	Wells	Reservoir	Thickness (feet)	Production	Size
Camrick	45	sandstone (A) (U. Morrow)	30	26,257,734 mcf	Intermediate
Carthage	58	sandstone (A) (U. Morrow: gas) (L. Morrow: oil)	24	266,543,509 mcf 1,675,502 bo	Large-Int.
Carthage, NW	24	sandstone (B) (Keyes)	23	40,671,356 mcf	Intermediate
Hugoton (OK)	1565	dolomite (C) (Chase)	40	20,000,000,000 mcf 1,524,424 bo	Regional (Large)
Keyes	132	sandstone (B) (Keyes)	35	563,958,402 mcf 2,063,512 bo	Large
Logan	16	sandstone (A) (L. Morrow)	12	5,91,230 mcf 79,382 bo	Int.-Small
Logan, SE	13	sandstone (A) (L. Morrow)	20	8,146,653 mcf 84,032 bo	Intermediate
Rice, NE	21	sandstone (A) (U. Morrow)	24	3,990,327 mcf 1,043,981 bo	Intermediate
Sampsel	37	sandstone (A) (U. Morrow)	16	60,369,552 mcf 341,681 bo	Intermediate
Sturgis, NW	2	sandstone (A) (U. Morrow)	17	2,773,905 mcf	Small
Unity, E	12	sandstone (A) (Morrow)	8	3,452,359 mcf 333,931 bo	Int.-Small

A - Dominantly channel-fill sandstones with considerable heterogeneity in valley-fill deposits

B - Reworked channel/valley fill deposits with considerable areal extent and lateral continuity

C - Shelf carbonate with extensive (regional) porosity network

Table III. Generalized Classification Underpressured Compartments Based on host rock and size.

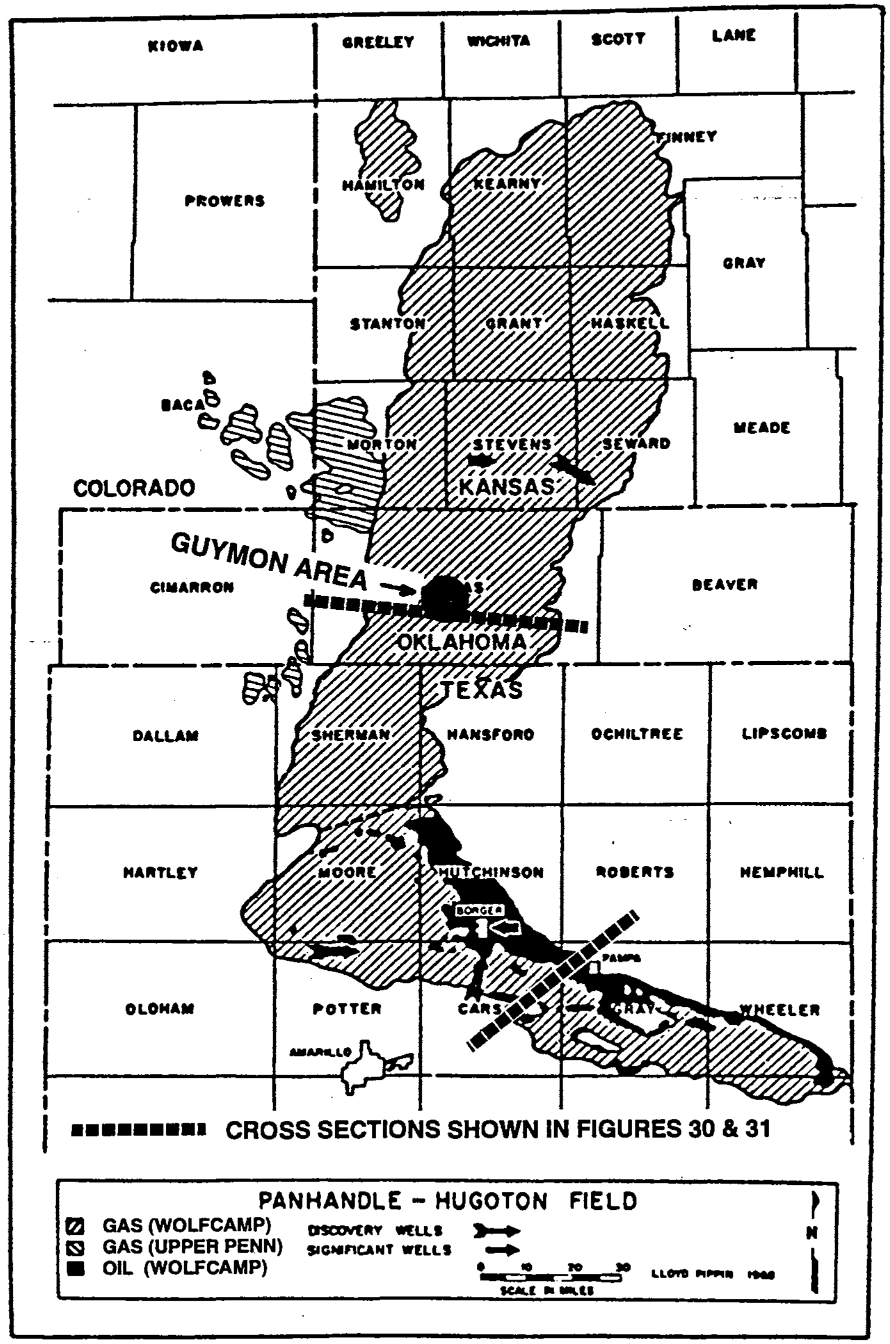


Figure 28. Location and limits of the Panhandle-Hugoton gas field in Texas, Oklahoma and Kansas (After Pippen, 1968).

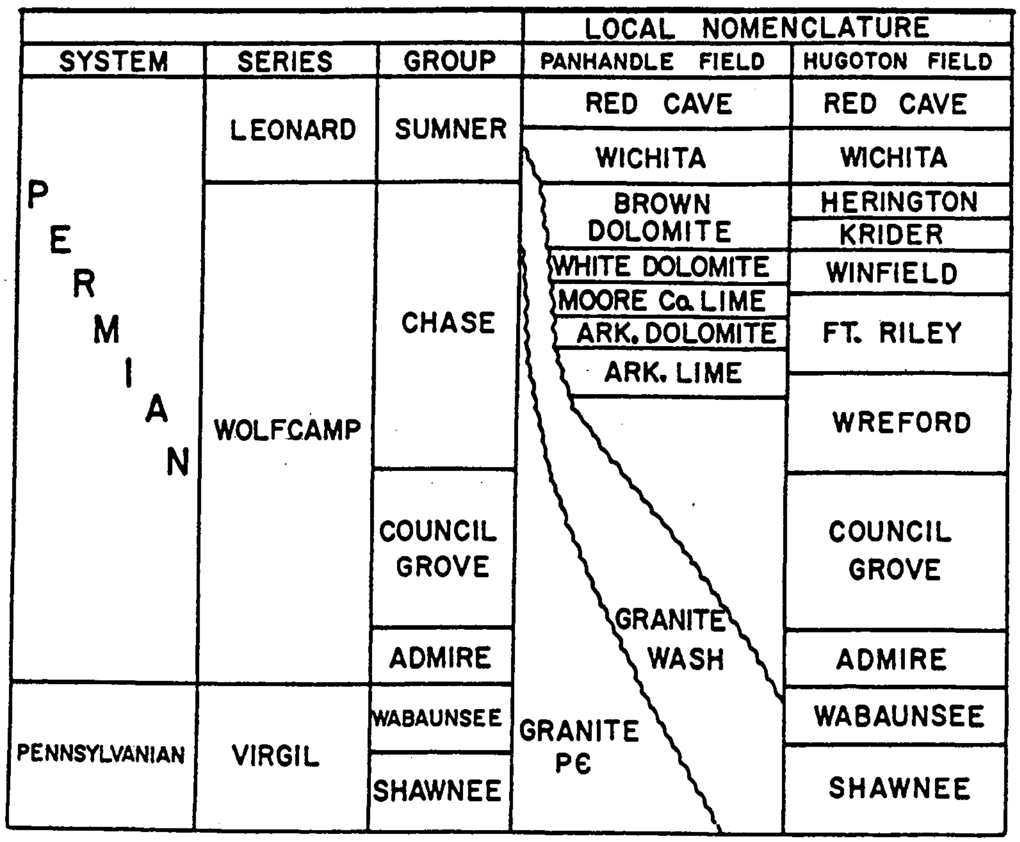


Figure 29. Stratigraphy of the Panhandle-Hugoton field (Pippen, 1968).

field has an associated oil column while the Hugoton contains dry gas. The Panhandle field is primarily structurally trapped over basement highs of the buried Amarillo Mountains (Figure 30). The Hugoton field is a stratigraphic trap with a tilted water column (Figure 31) (Mason 1968; Pippin, 1968). Production in the Kansas and Oklahoma parts of the field is limited both updip and downdip by water. The updip presence of water is believed to be related to the decrease in permeability and porosity related to the facies change from porous shelf carbonates to red shales (Mason, 1968). No significant water encroachment has occurred as gas pressure drops in the field, suggesting it is not a hydrodynamic system with an active water drive (Mason, 1968). The Chase Group reservoirs terminate to the east as the shelf carbonates thin and the section becomes shale dominated (Plate II). In the Oklahoma portion of the Hugoton field, most gas production is from the Krider Dolomite of the Chase Group. Additional important reservoirs are the Winfield (including the Towanda) and Ft. Riley carbonates below the Krider and the Herington Dolomite above. There is vertical fluid communication between the Herington, Krider and Winfield (Pippin, 1968). This section represents the last episode of widespread shelf carbonate deposition that preceded restricted-basin deposition of redbeds and evaporites (Mason, 1968).

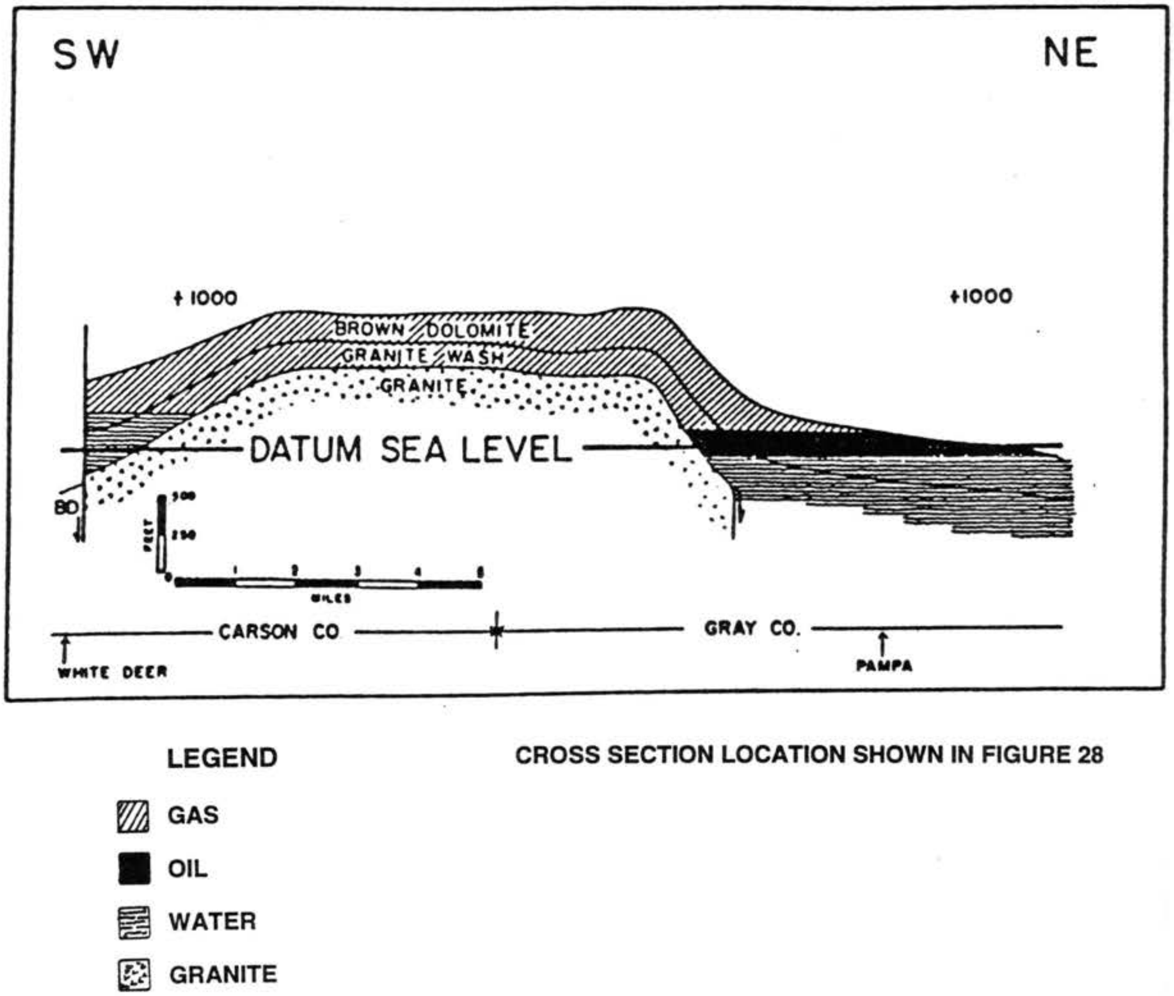


Figure 30. Cross section through the Panhandle field depicting structurally trapped petroleum over basement highs known as the Amarillo Mountains (After Pippen, 1968).

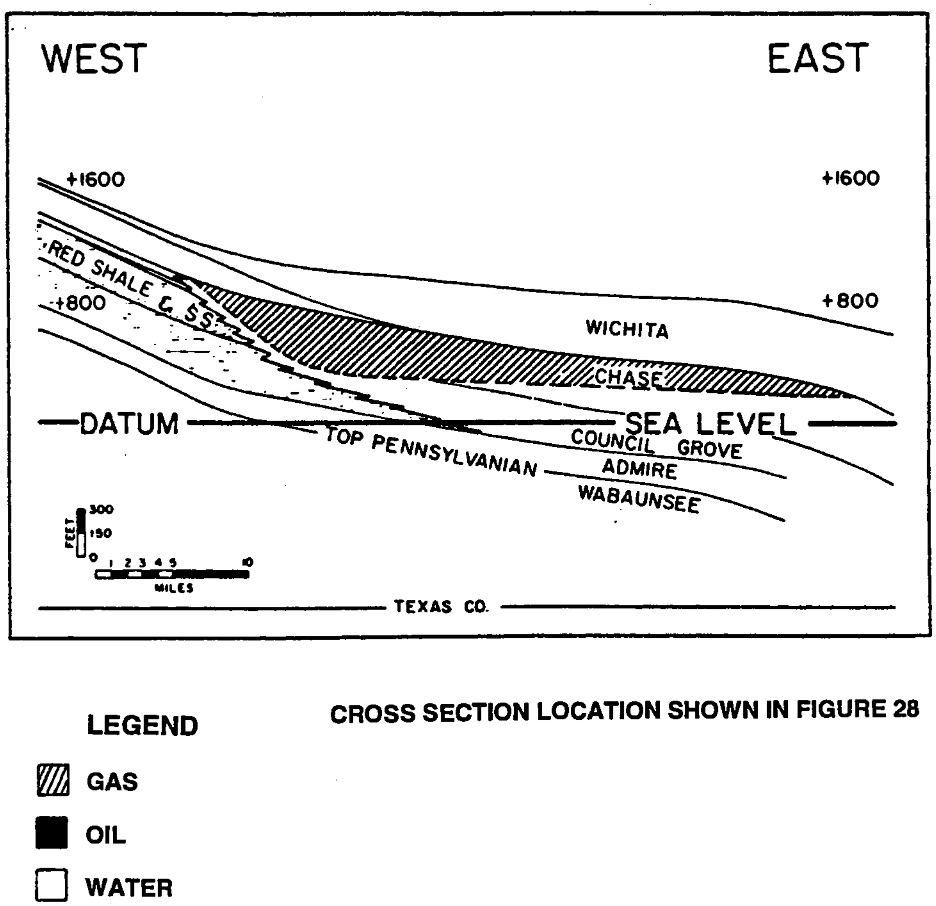


Figure 31. Cross section through the Hugoton field in the Oklahoma Panhandle (After Pippen, 1968).

The Hugoton field filled with hydrocarbons that are believed to have migrated out of the thermally mature Anadarko basin sometime prior to the Laramide Orogeny. Coarse clastics ("Granite Wash") on the flanks of the Amarillo Uplift served as the conduit for migration from the basin into the reservoir facies (Mason, 1968). Upward migration was halted by the sealing anhydrite and dolomite of the Wichita Formation. Lateral seals are also depositional and formed where shale was deposited instead of carbonate. The basal seal in the Hugoton field occurs in the Upper Pennsylvanian and separates similarly pressured Chase and Council Grove reservoirs from higher pressured Pennsylvanian ones (Figure 32).

Regional compartments form where continuous reservoir facies evolved through an interplay of depositional setting and diagenesis. Chase Group carbonates were deposited on a shallow shelf where limestone production kept pace with increased sediment accommodation space. Tectonically or glacially induced sea level changes were more gradual and lower frequency than those in the underlying Council Grove Group. As a result, thick carbonates accumulated that were subsequently subjected to dissolution and dolomitization. On the other hand, higher frequency sea level oscillation in the Council Grove Group resulted in the deposition of a thick interval of thinner carbonates separated by redbed claystones and shales.

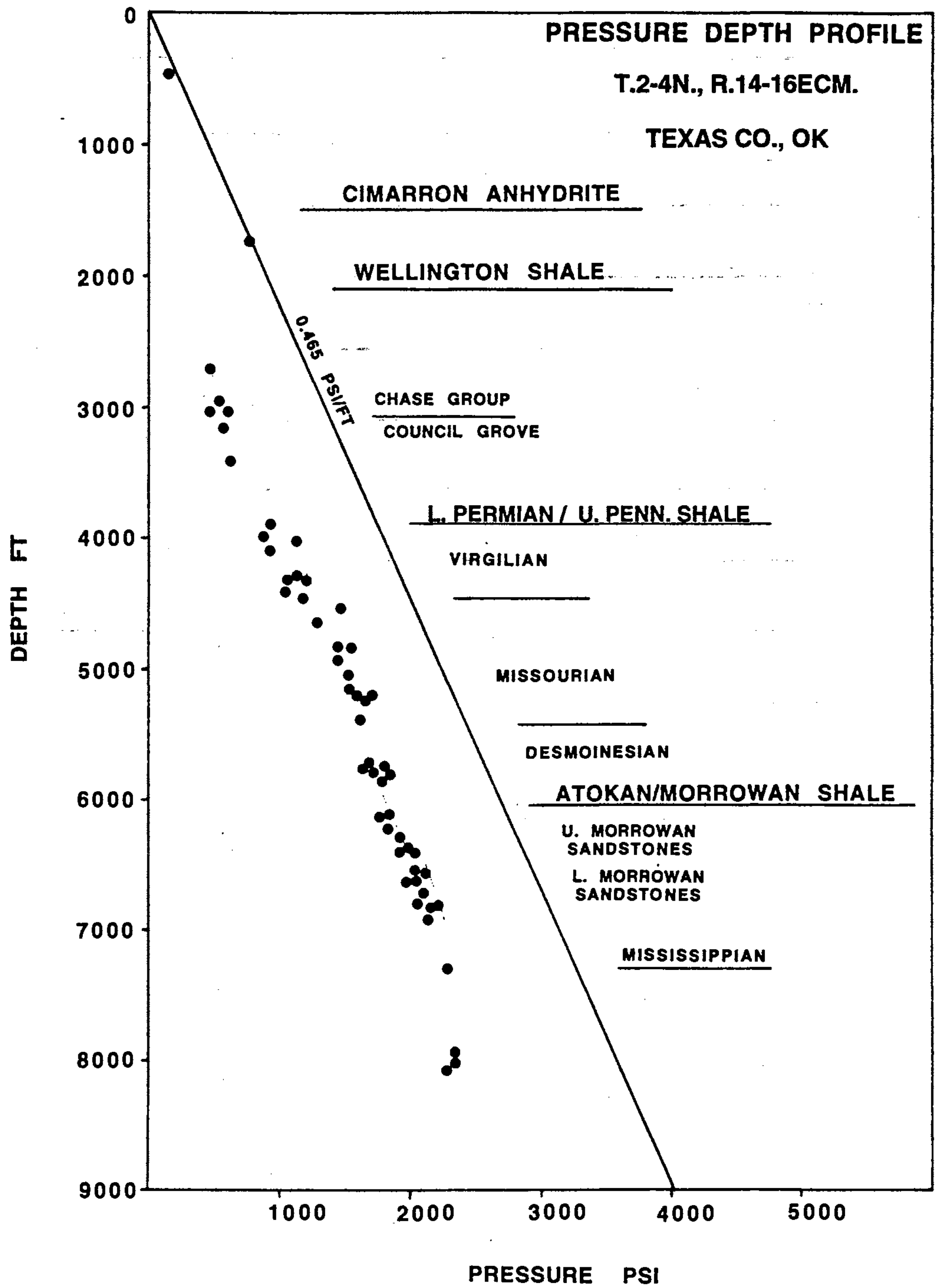


Figure 32. Pressure-depth profile from the Hugoton Field showing the seal zone between the Chase/Council Grove compartment and the underlying Pennsylvanian reservoirs.

The underpressured nature of the Chase Group (Krider Dolomite) in the Guymon area is indicated by pressure depth profiles based on pressure-depth (p-d) gradients calculated from drill stem test and initial well-head shut in pressure data (Figure 32). These data indicate the original low pressures and p-d gradients common to the Chase and Council Grove Groups and their position between higher p-d gradients in the overlying Middle Permian and underlying Pennsylvanian rocks.

Reservoir Characteristics

The Krider reservoir is vuggy dolomite (Figure 33) that contains up to 16% porosity based on log measurements (Figure 34) and thin-section microscopy (Figure 35). Reported porosity and permeability measurements for the Chase Group carbonates average 14% and 5 md respectively (Mason, 1968).

To estimate reservoir continuity, the thicknesses of the Krider and Winfield reservoirs were mapped across the Guymon Area (T.2-3N., R.13-15 ECM.). These maps (Figures 36 and 37) delineate areas of thicker reservoir development that would be more suitable as injection zones.

Integrity of Confining Units

Pennsylvanian- and Permian-age shales and evaporites confine the Chase Group (Figure 32; Plates II & III).

Figure 33. Core photograph of the Krider Dolomite reservoir. Santa Fe Min., Knop 1-A, Sec. 24, T.6N., R.18ECM., Texas, Co. Oklahoma. Depth 2732 ft.

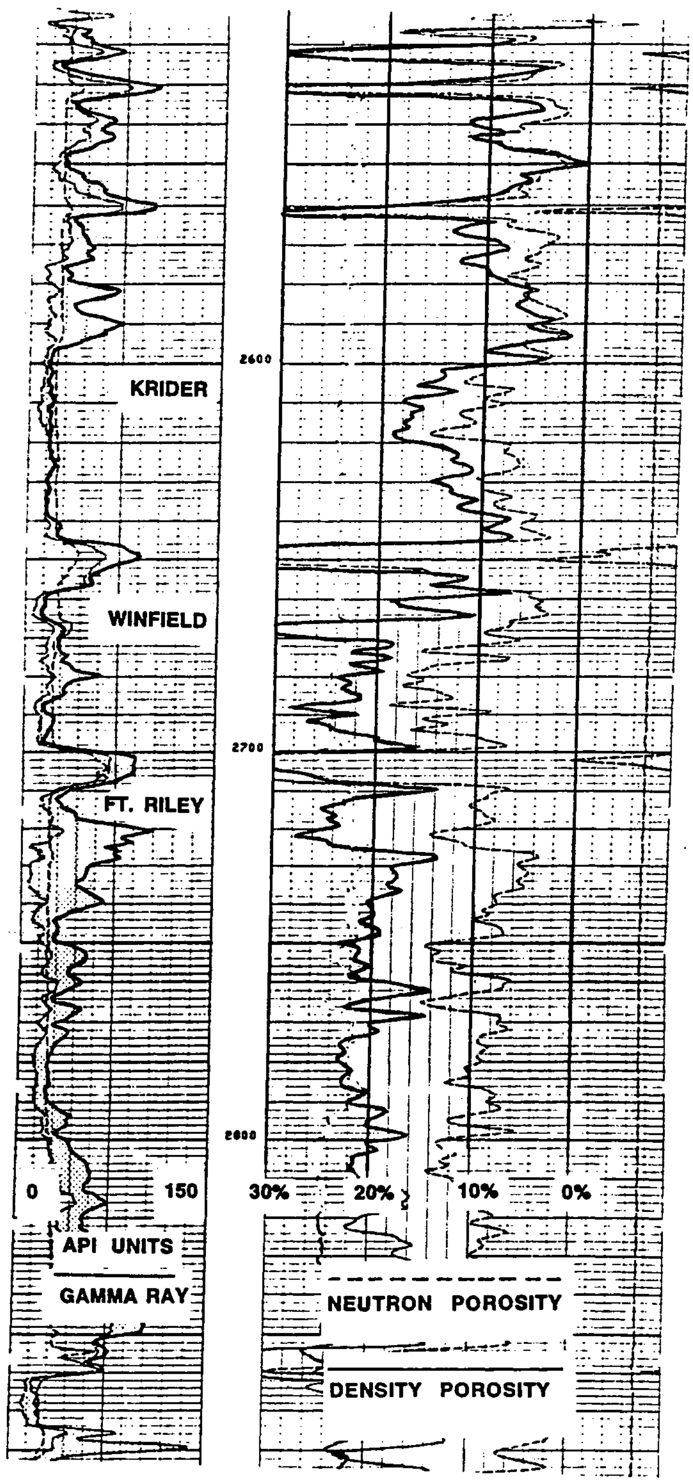


Figure 34. Neutron-density porosity log signature through the Chase Group. Cabot, Shaffer Land & Cattle Co. 1-34, Sec. 12, T.3N., R.14ECM., Texas Co. Oklahoma.

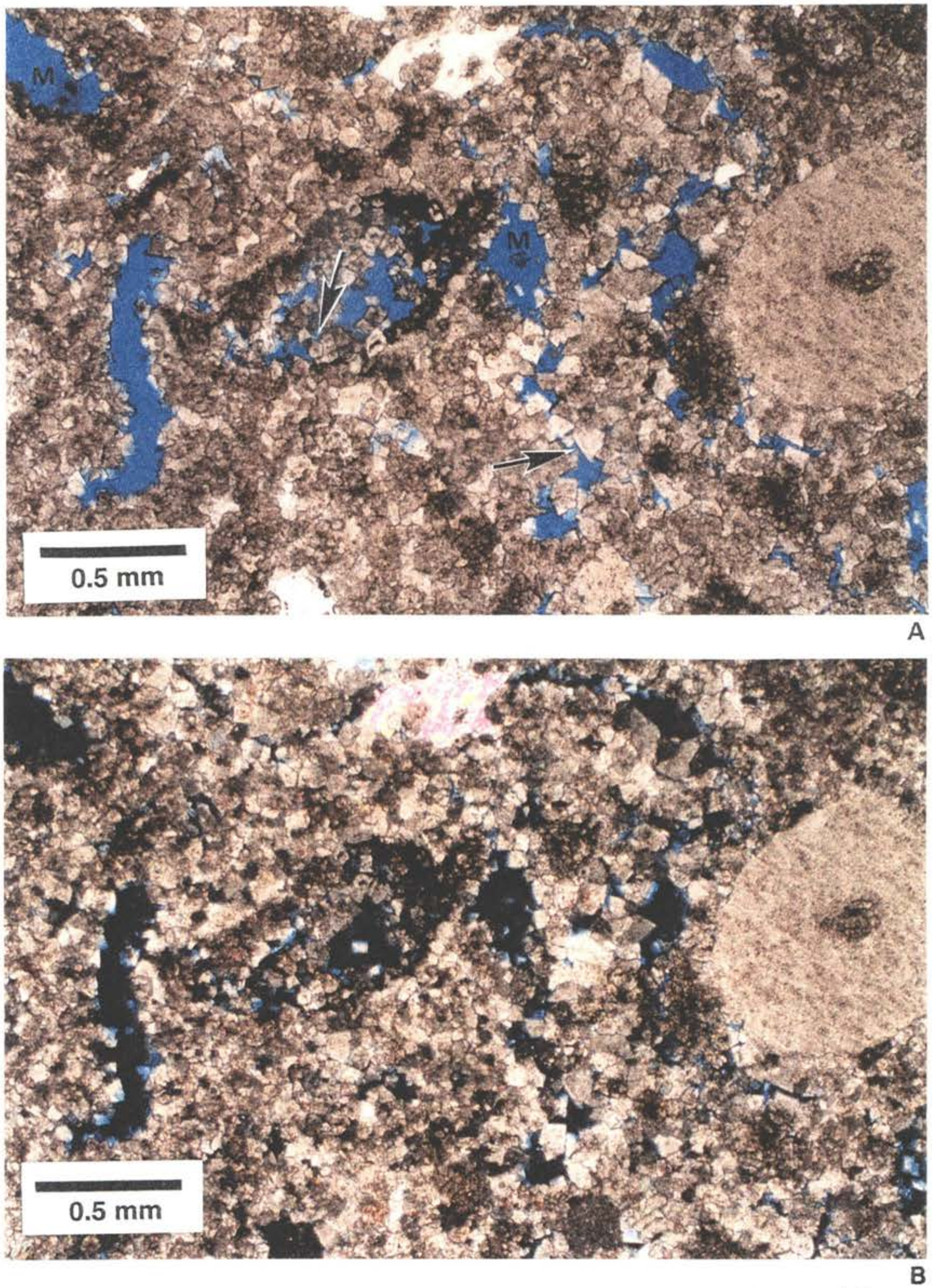


Figure 35. Thin section photomicrograph of the Krider Dolomite reservoir facies. Porosity (blue) is moldic (M) and intercrystalline (arrows). Santa Fe, Knop 1A.
(A) Plane-polarized light.
(B) Cross-polarized light.

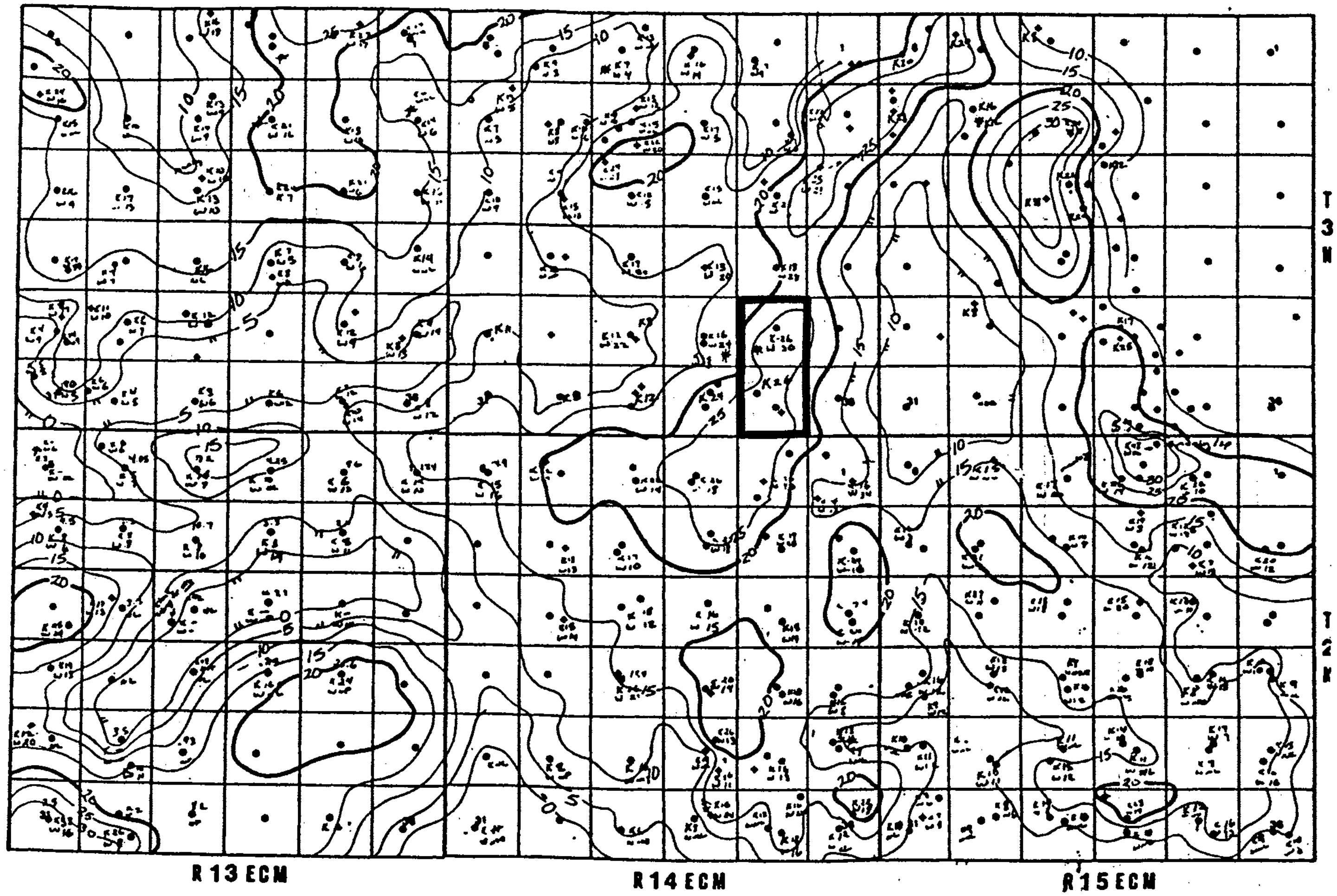


Figure 36. Thickness map of the Krider Dolomite reservoir facies.

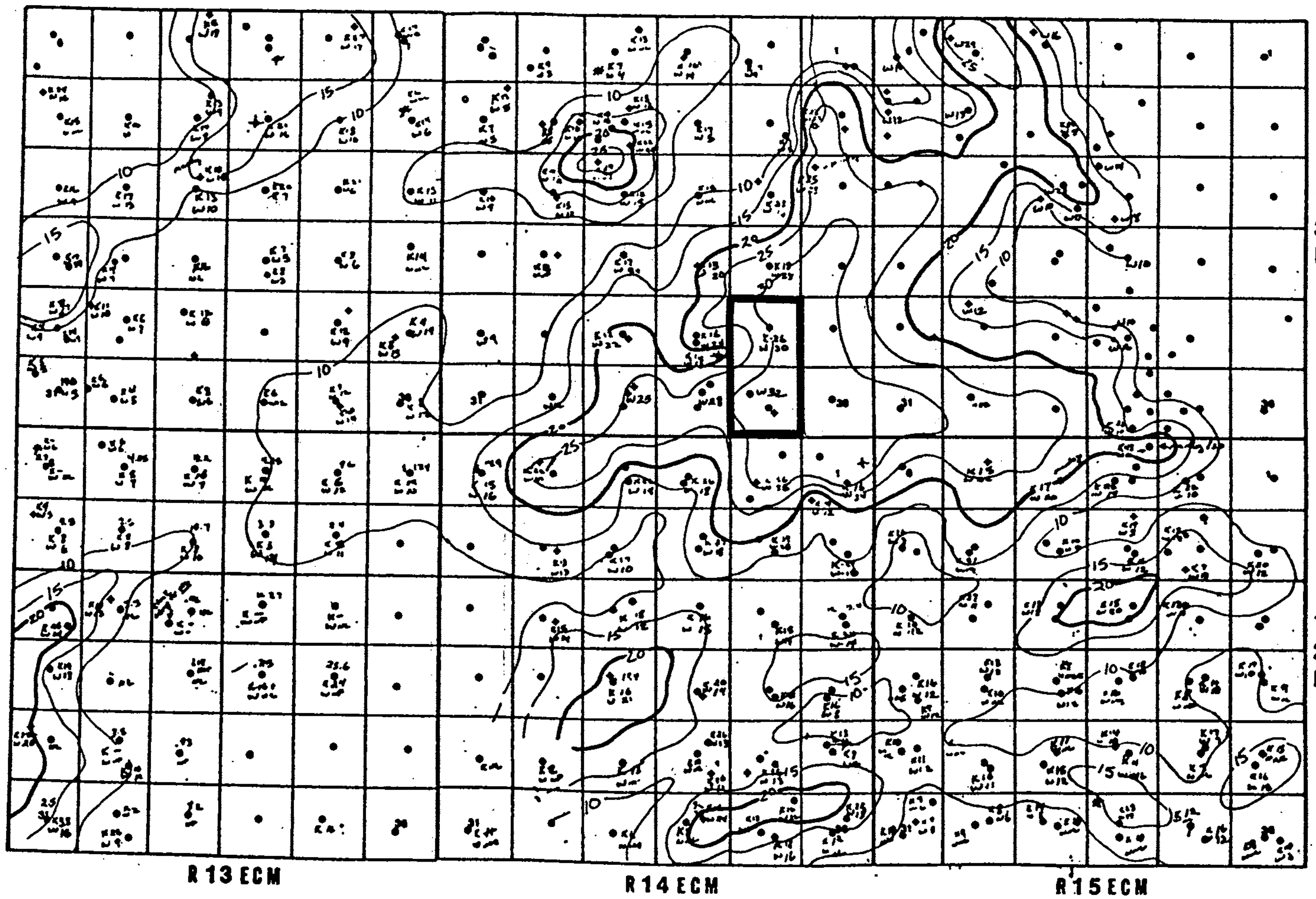


Figure 37. Thickness map of the Winfield reservoir.

Although the likelyhood of open high-rise fractures extending from these underpressured reservoirs is very low (Powley, 1993), a structural contour map was constructed on the base of the Stone Corral Anhydrite (Figure 38) to locate faults that might weaken the structural integrity of the confining units. This map indicates that there are no anomalous data values or contour deviations that would suggest strong folding or faulting at Stone Corral depth. The continuity of these confining units is essential for insuring seal integrity above and below the injection zone. This is especially critical above the disposal zone since the area underlies the Ogallala aquifer.

Remote sensing techniques were used to detect surface expressions of potential zones of weakness. Black and white aerial photography and topographic maps were analyzed for lineaments (Appendix D) that might reflect fractures or faults. No lineaments were detected that would suggest post-Ogallala deformation and zones of weakness in the confining units.

Reservoir Capacity

Bradley (1985) proposed that a disposal well in the Chase Group could dispose of 16.67 million barrels at certain reservoir conditions. These include 45 ft. of average net pay over the primary dolomite reservoirs, porosity of 14%, water saturation of .25, and the raising of reservoir pressure from 360 psi to 1160 psi (Bradley,

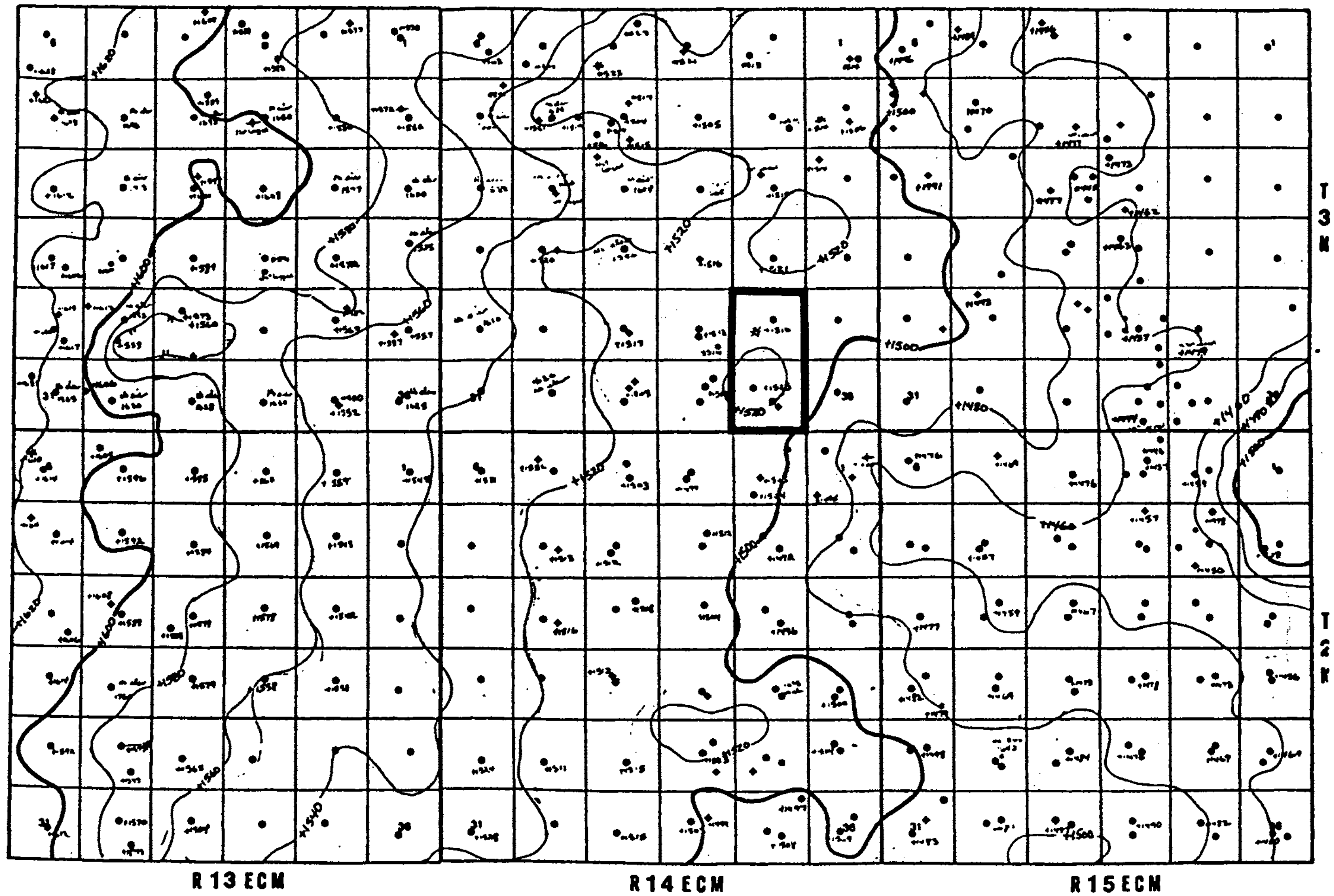


Figure 38. Structural contour map: Stone Corral Anhydrite. Contours indicate the anhydrite is not displaced by faults or tightly folded.

1985). Using more modest reservoir reservoir parameters of 30 ft. of porosity and increasing reservoir pressure from the present 85 psi to the original pressure of 485 psi, the disposal volume per well still exceeds 13 million barrels (Appendix E). In this case, original reservoir pressure is not exceeded because it is likely that this pressure has been confined for tens of millions of years. Porosity and permeability data for the confining units of the Chase Group are not published, but measured values for similar lithologies are available. The Chase reservoirs in the study area are overlain by approximately 300 ft of anhydrite and dense dolomites (Wellington Fm.), 600 ft. of shale, 100 ft. the Stone Corral Anhydrite and 400 ft. of shale that separate the prospective disposal zone from the groundwater aquifers. Jiao and Zheng (1995) conducted a flow modeling study across these low permeability units that was based on the parameters originally proposed by Bradley (1985). Their simulations (Jiao and Zheng, 1995) suggest the low permeability of the confining units will prevent injected waste from contaminating the shallow Ogallala aquifer for (geologic) time.

Keyes Dome Disposal Site

A Large Sandstone Reservoir Compartment

The Keyes Dome disposal site is located in the Keyes field in T.4-5N., R.8-10ECM., Cimarron and Texas Counties, Oklahoma (Figure 39). The Keyes field primarily

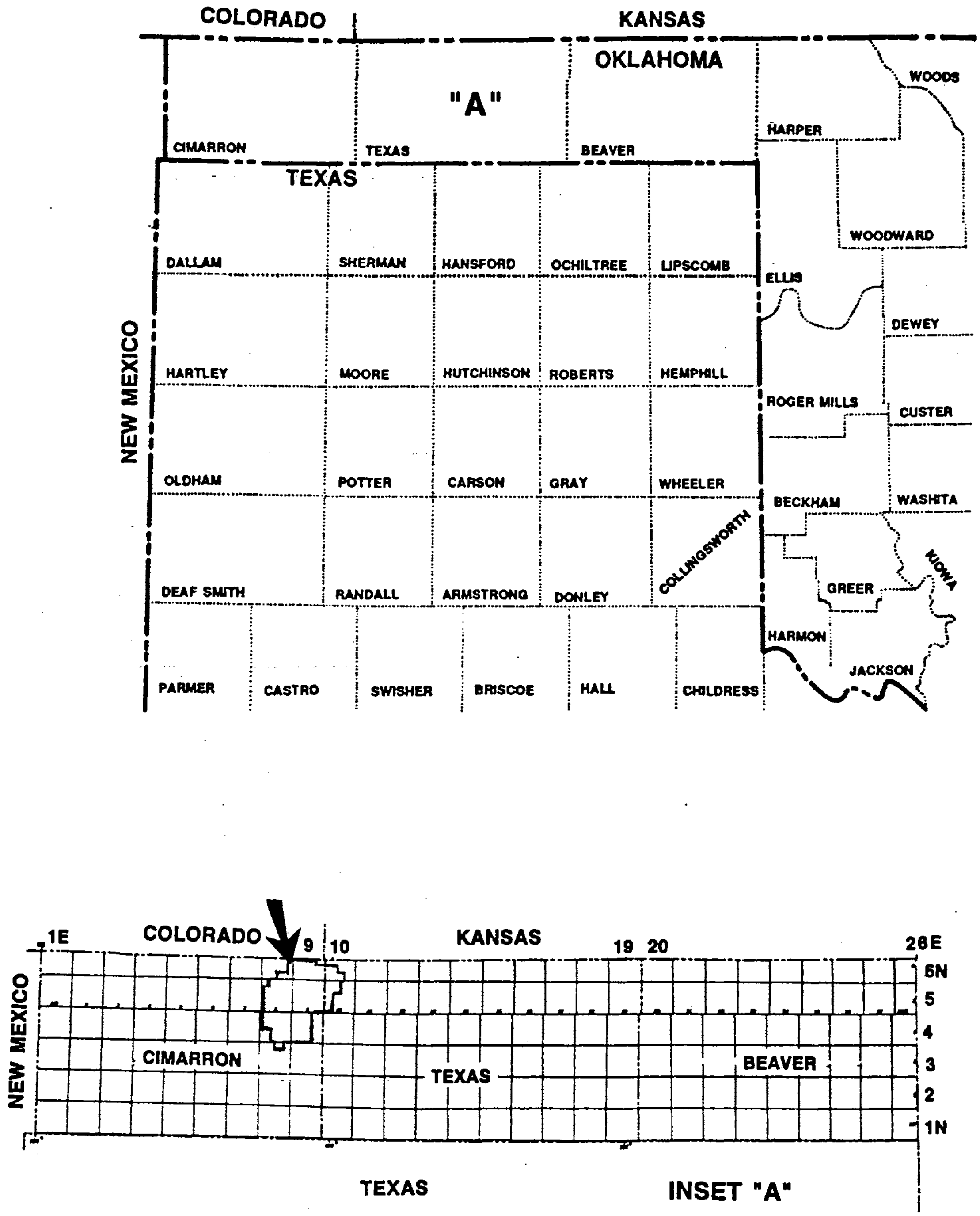


Figure 39. Location and limits of the Keyes field: Cimarron and Texas Counties, Oklahoma.

produces from the Keyes Sandstone, a Pennsylvanian (Morrowan) age sandstone. The field contains over 130 wells and covers some 100,000 acres. It produces where the Keyes reservoir has been folded over the Keyes structure, a north-south trending anticline. The sandstone fills valleys on the eroded Mississippian topography and was reworked during a marine transgression to form a sheet-like deposit that covers most of the area. As a result, the thickest sandstone is found in the valleys of the paleodrainage system (Figure 40). Sandstone thickness is highly variable and reservoir facies are absent in some intervalley areas (Figures 41 and 42).

Pressure depth profiles from the Keyes area indicate the Keyes reservoir is underpressured and lower pressure than overlying Upper Morrow Purdy Sandstone reservoirs and underlying Ordovician reservoirs (Figure 25).

Reservoir Characteristics

Two maps were constructed to determine the trends and thicknesses of the Keyes reservoirs. The total sandstone thickness map (Figure 41) delineates the thicker sandstone accumulations along the paleodrainage system. Figure 42 is a reservoir thickness map. Reservoir was defined as sandstone with positive filtercake accumulation, spontaneous potential (sp) deflection >60 millivolts, neutron-density porosity >10%, and/or positive

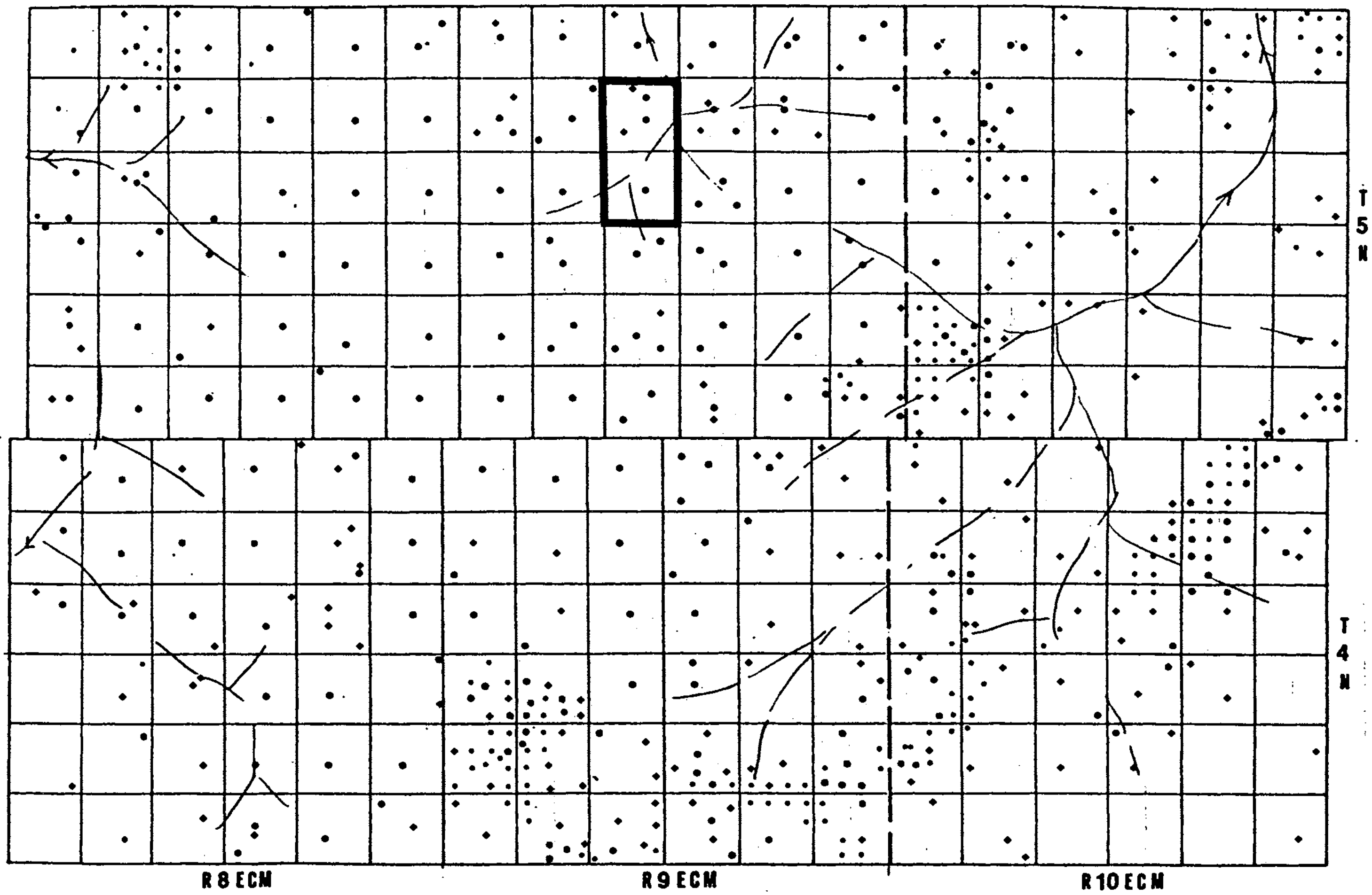


Figure 40. Trends of paleovalleys eroded into the post-Mississippian topography. This paleodrainage system is delineated by thicker Keyes sandstone accumulation and increased Morrow thickness.

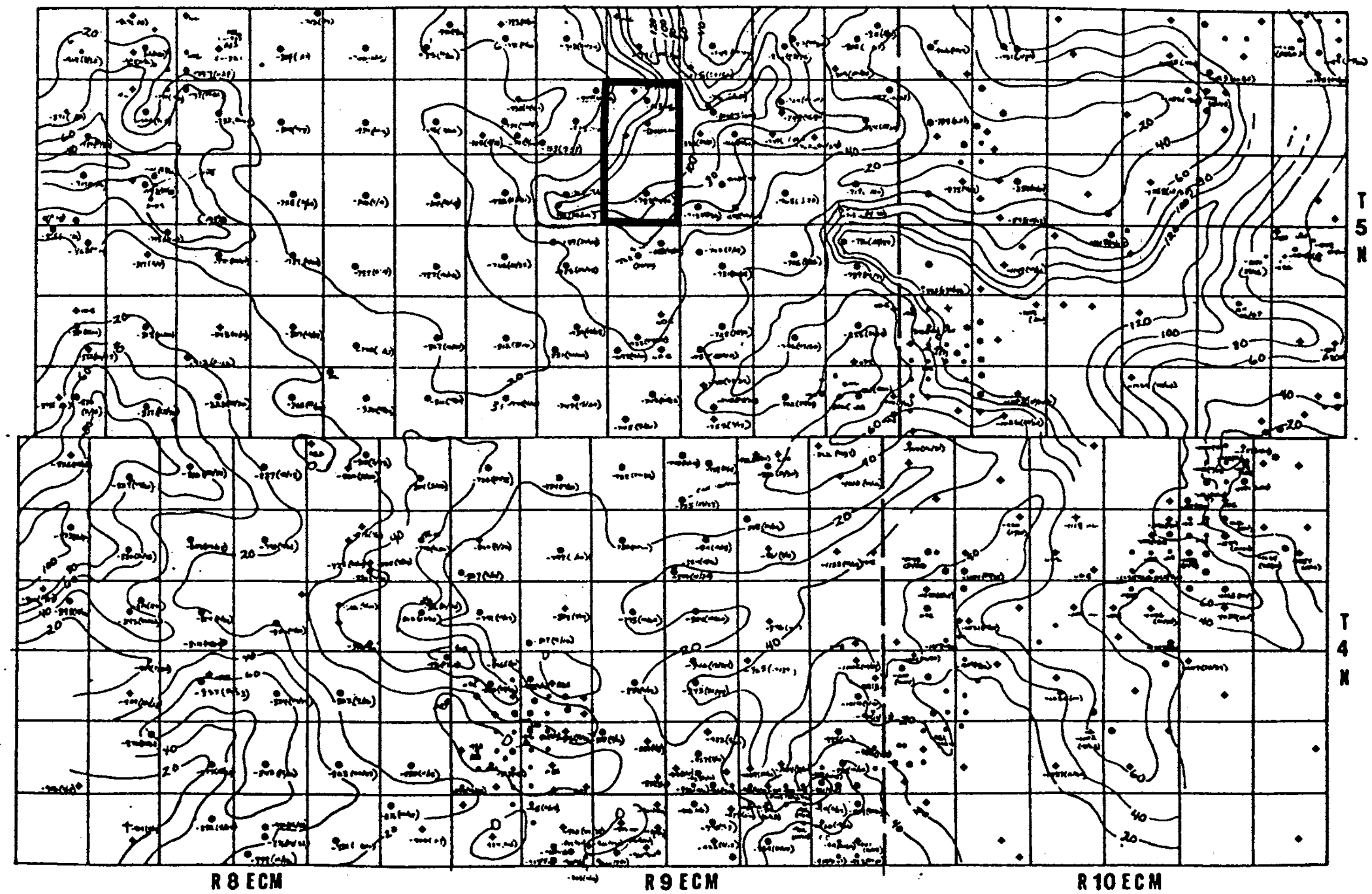


Figure 41. Keyes sandstone thickness. Thicker sandstone fills paleovalleys while the surrounding terrane is covered by thinner sandstone formed from reworked/redistributed sands deposited during the lower Morrow marine transgression.

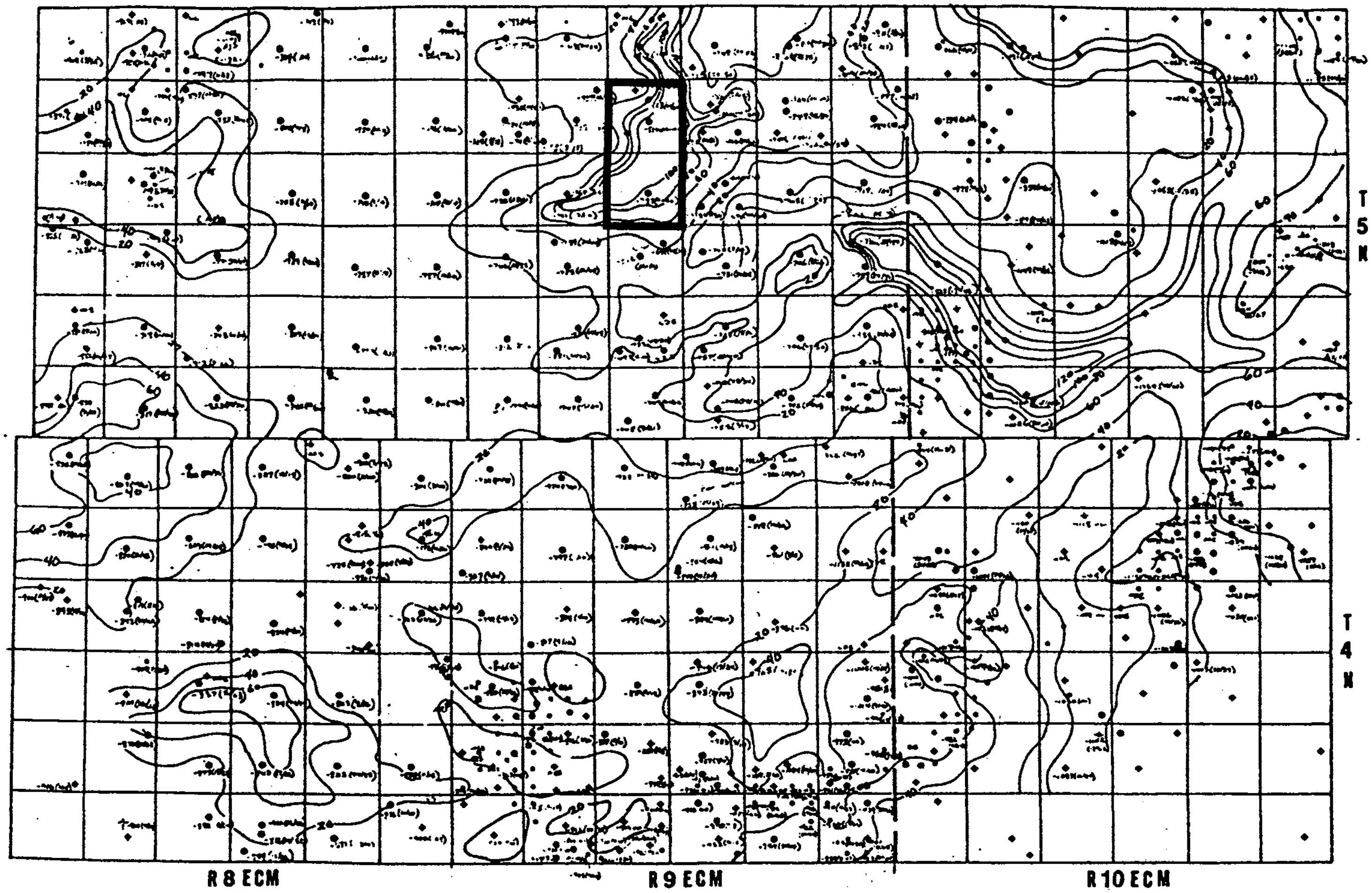


Figure 42. Keyes sandstone reservoir thickness. Thicker reservoir generally follows the trend of thicker sandstone

microresistivity separation (Figure 43). Maximum reservoir thicknesses (>100 ft.) were identified in T.5N., R.9ECM. in a northwest/southeast trending paleovalley.

Thin section microscopy, wire-line logs and reported data indicate average porosity in the Keyes reservoir facies is around 15%. Porosity is both primary (Figure 44) and secondary. Secondary porosity resulted mostly from the dissolution of chert, quartzose metamorphic rock fragments and feldspar (Figure 45). Carbonate cements are common and can occlude porosity in a given interval (Figure 46). Permeability averages 58 md (Kansas Geological Society, 1959), but is highly variable due to diagenetic history of the reservoir.

The variability of the Keyes reservoir is not unique. Therefore, it is important to determine the distribution and geometry of the reservoir facies as part of the disposal suitability evaluation. Another important factor in this analysis is the amount of fluid the reservoir has produced. Theoretically, reservoirs that have produced large volumes of liquids should be able to receive similar volumes if converted to an injection zone.

Integrity of Confining Units

The integrity of the confining units was examined using subsurface mapping and remote sensing techniques to identify faults. Though the pressure data indicate that

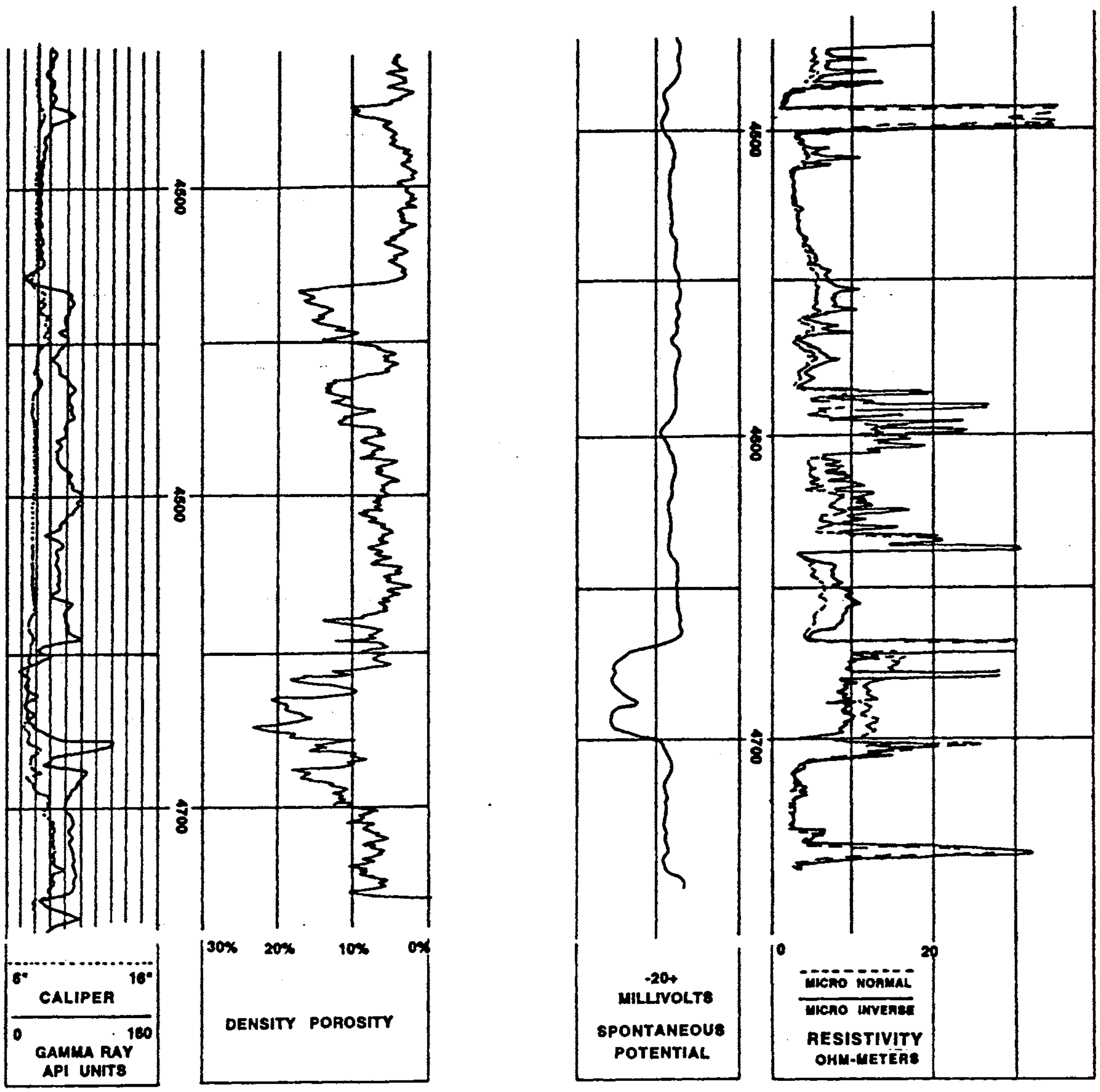


Figure 43. Wire-line log signatures across the Keyes Sandstone. Reservoir facies have positive filtercake accumulation, sp deflection >60 mv., density porosity >10% and/or positive microresistivity separation. Sec. 8, T.5N., R.9ECM., Cimarron Co., Oklahoma.

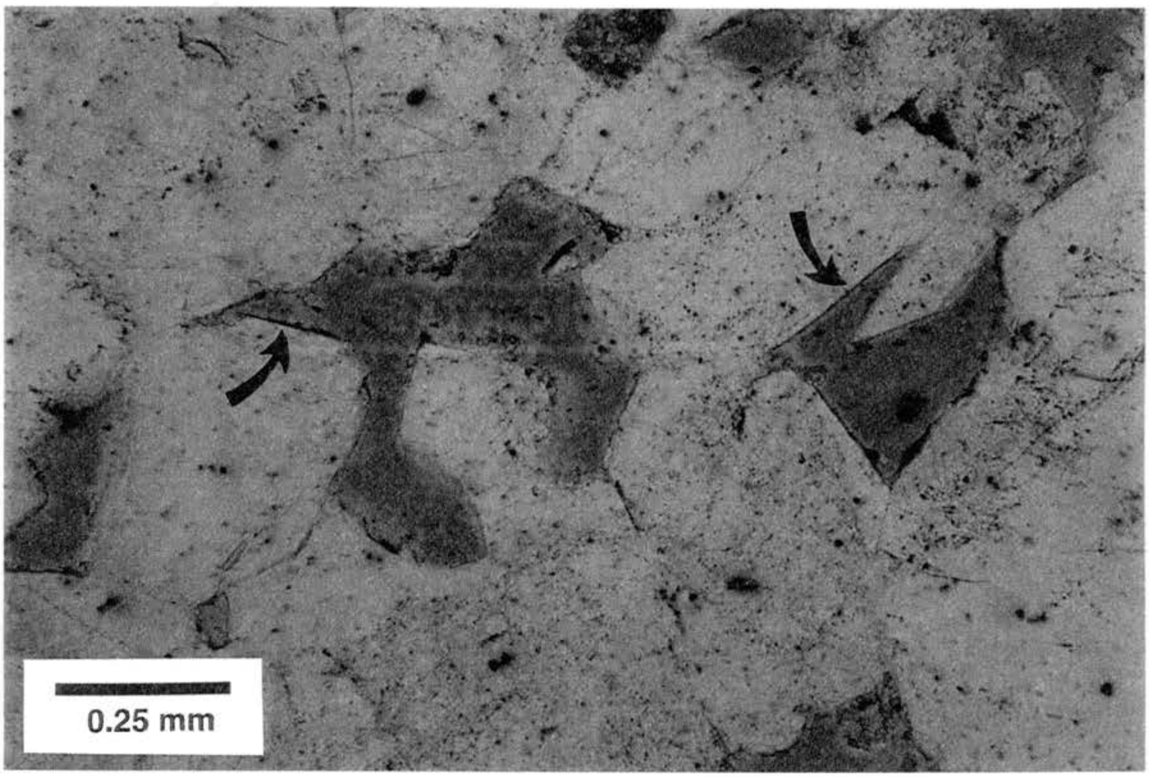


Figure 44. Primary porosity (arrows) in the Keyes Sandstone that is bordered by planar faces of syntaxial quartz overgrowths. Blue epoxy fills pore space in photomicrograph. Gulf, Kelly, Sec. 1, T.4N., R.10ECM., Texas County, Oklahoma. Depth 4728 ft. Plane-polarized light.

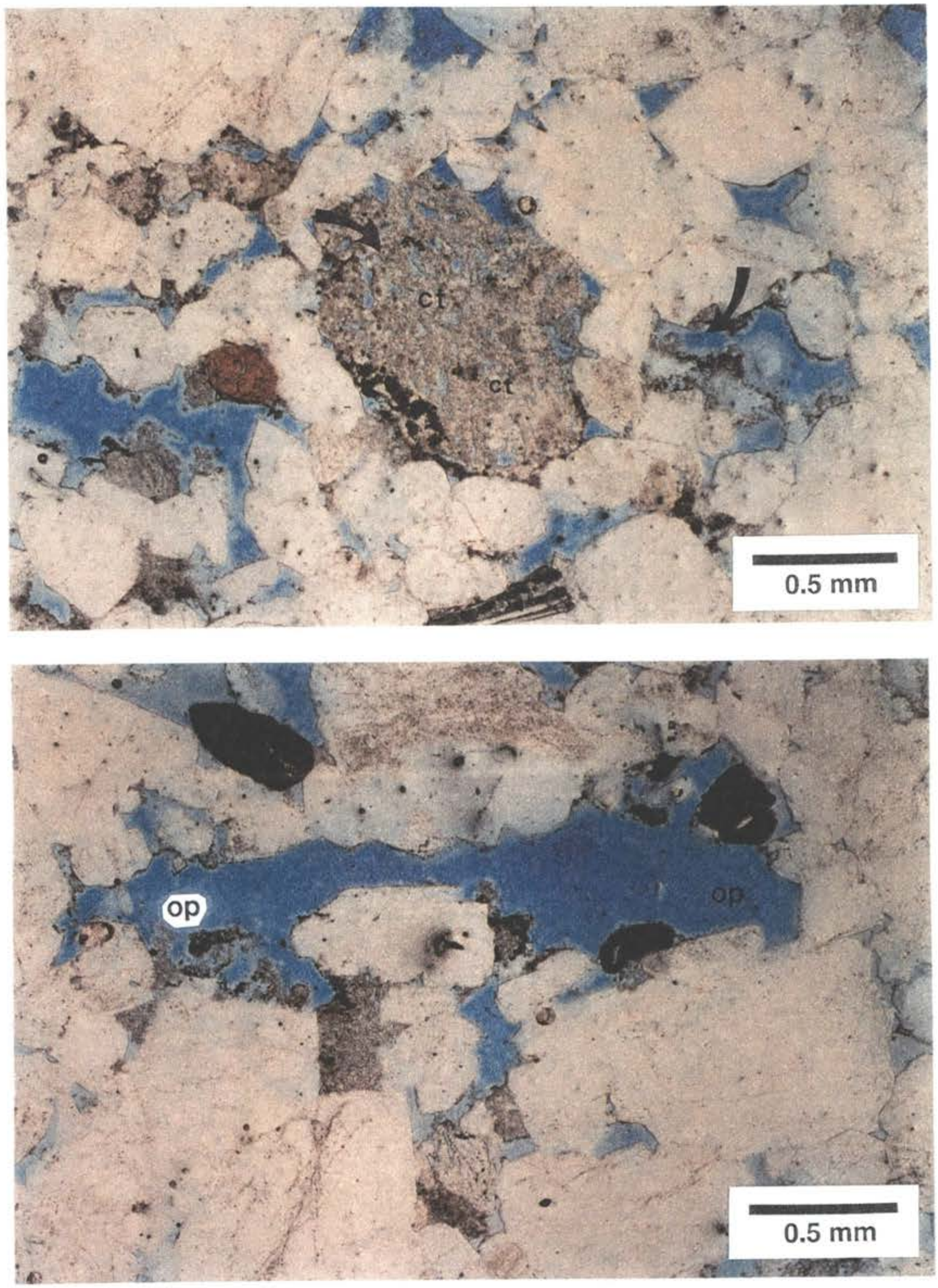


Figure 45. Photomicrograph of secondary porosity (arrows) developed by the dissolution of chert (ct) and metamorphic rock fragments. Gulf, Ferguson. Depth 4786 ft.
(A) Partially dissolved chert (ct) grain.
(B) Oversized pore (op).

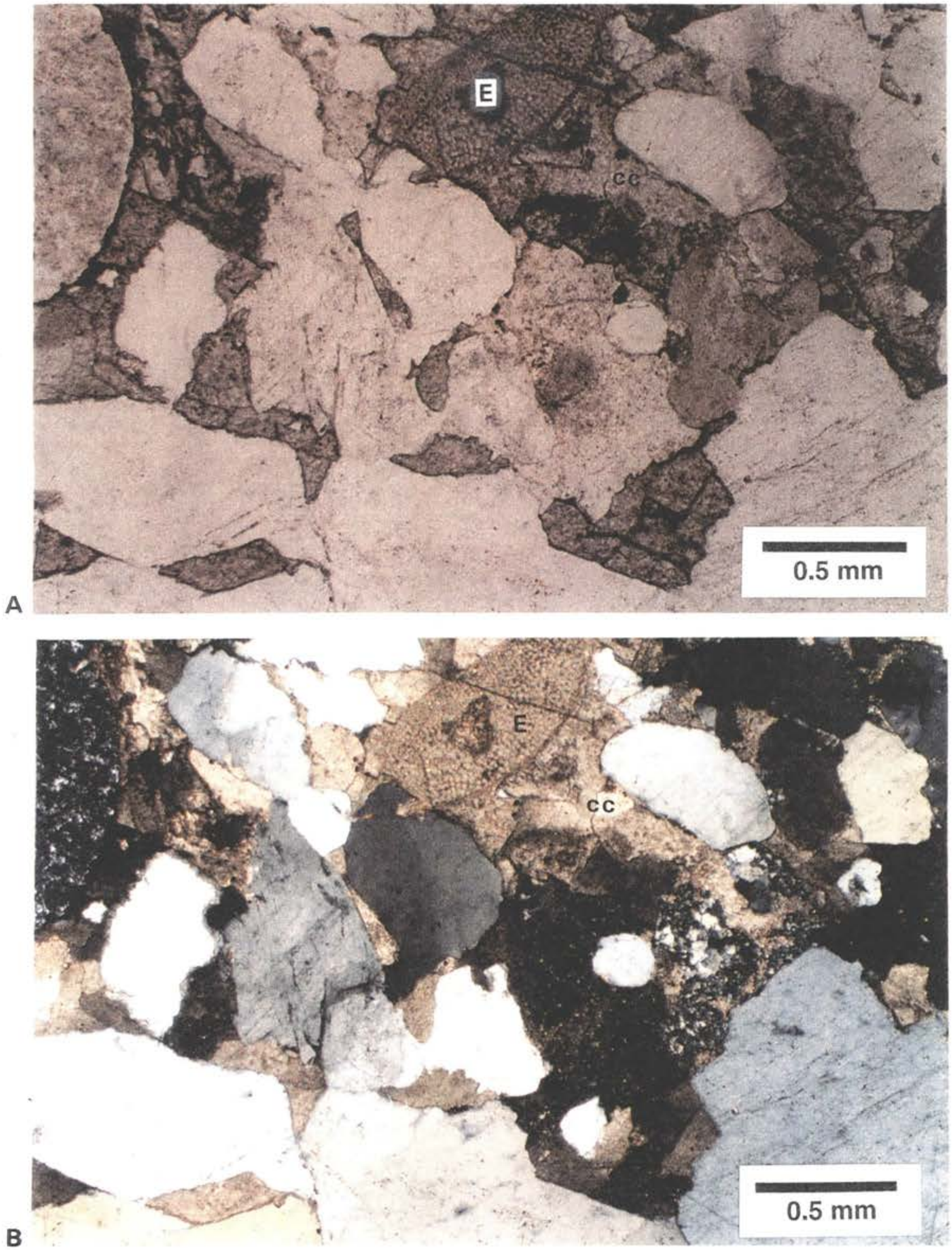


Figure 46. Photomicrograph of Keyes sandstone with porosity occluding carbonate cement (cc) and echinoderm fragment (E). Gulf, Kelly. Depth 4790 ft.

(A). Plane-polarized light.

(B). Cross-polarized light.

the Keyes reservoir was sealed at original reservoir conditions, knowledge of any zones of potential weakness in the confining beds should be considered in the siting of an injection facility. Structural contour maps were constructed for two horizons in the area: (1) the top of the Morrow shale (base of the Atokan Marker called the "Thirteen Finger Limestone"), and (2) the base of the Stone Corral "Cimarron" Anhydrite.

The Morrow shale map (Figure 47) indicates the eastern third of the area is traversed by a series of southwest - northeast trending normal faults. These faults mark the eastern boundary of the Keyes field and are generally upthrown to the west. As a result, the area of widespread Keyes sandstone production ends in R.9ECM. and the reservoir is water bearing in much of R.10ECM.

The second map was constructed on the base of the shallower Stone Corral Anhydrite. This map (Figure 48) indicates the faulting evident in the Morrow did not offset the anhydrite. Instead, a flexure (represented by increased dip and increased contour spacing) is present along the boundary of T.5N., R.9ECM. and R.10ECM. This southwest - northeast trending fold extends across T.4N., R.9ECM. These maps suggest the shallow Sumner Group evaporites and shales should be unbroken across the area and that upward migration of fluid through fractures is unlikely.

Surface lineament analyses were conducted using black

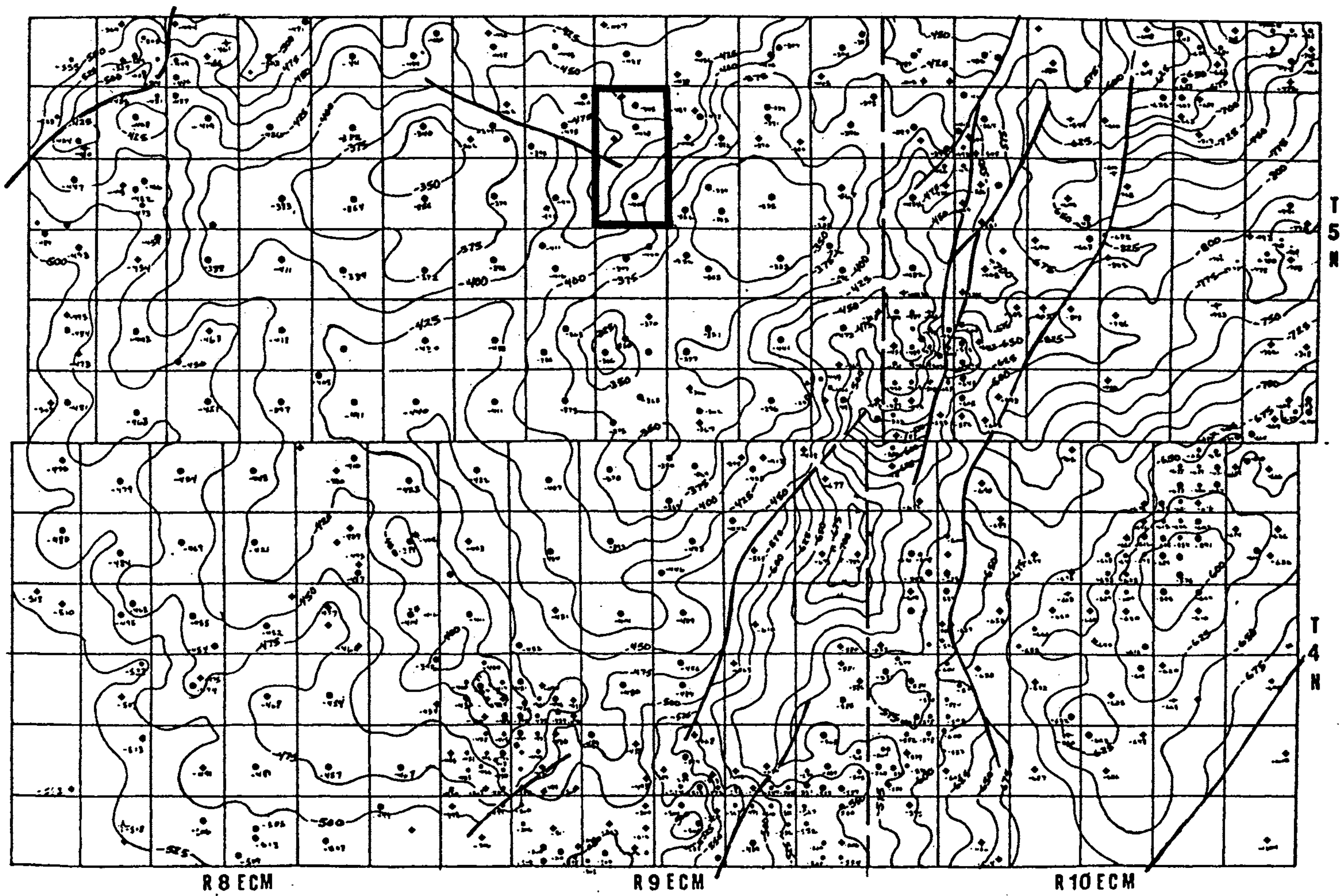


Figure 47. Morrow shale structural contour map that identifies fault and fold trends. The proposed disposal site in T.5N., R.9E.C.M. is located distal to these potential zones of weakness.

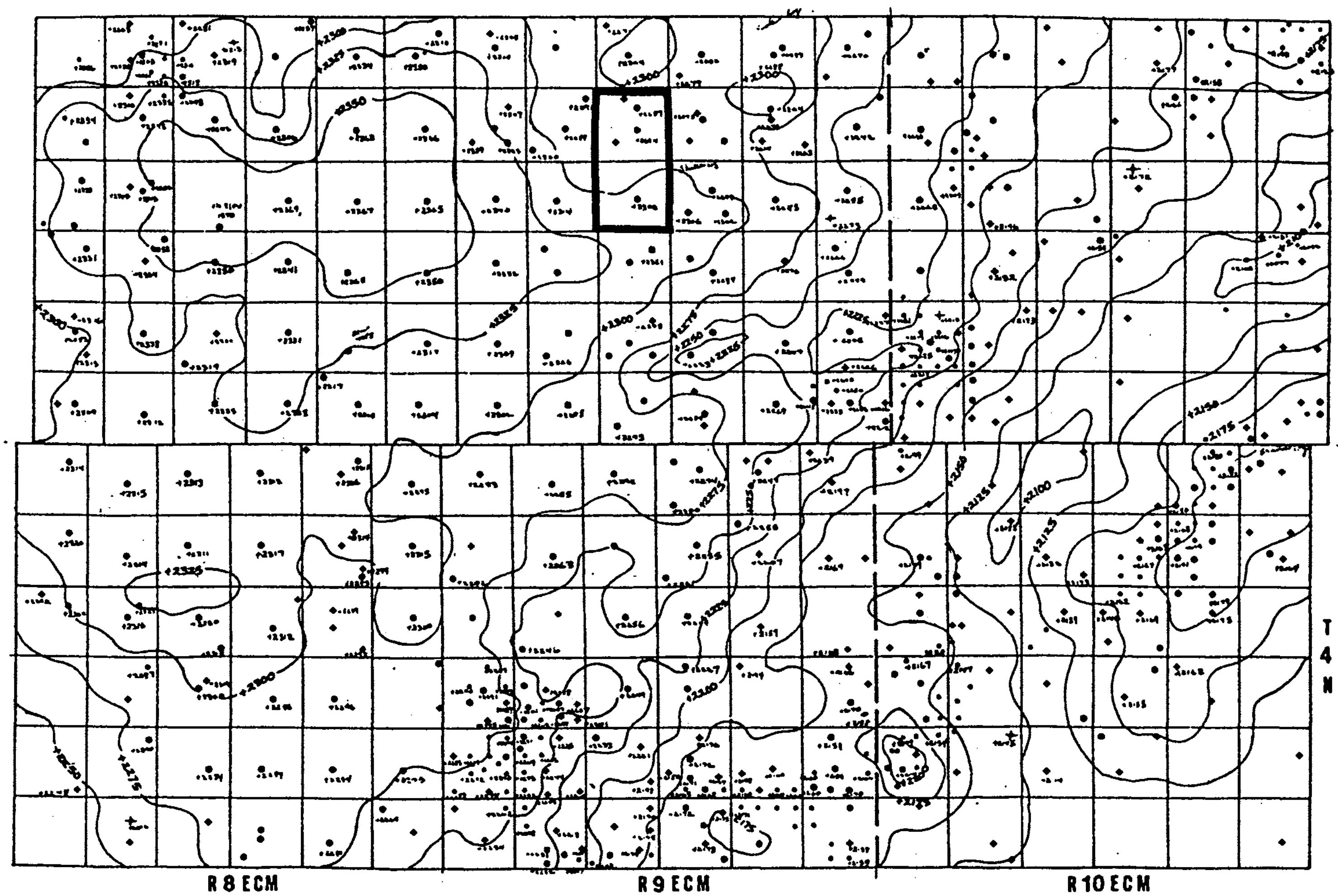


Figure 48. Cimarron anhydrite structure map. Uniform contour spacing and gentle dip indicate folds and faults evident in the Morrow (Figure 47) did not disrupt the Permian strata.

and white aerial photography and topographic maps. No lineaments were detected in the Ogallala and younger units (Appendix D).

Reservoir Capacity

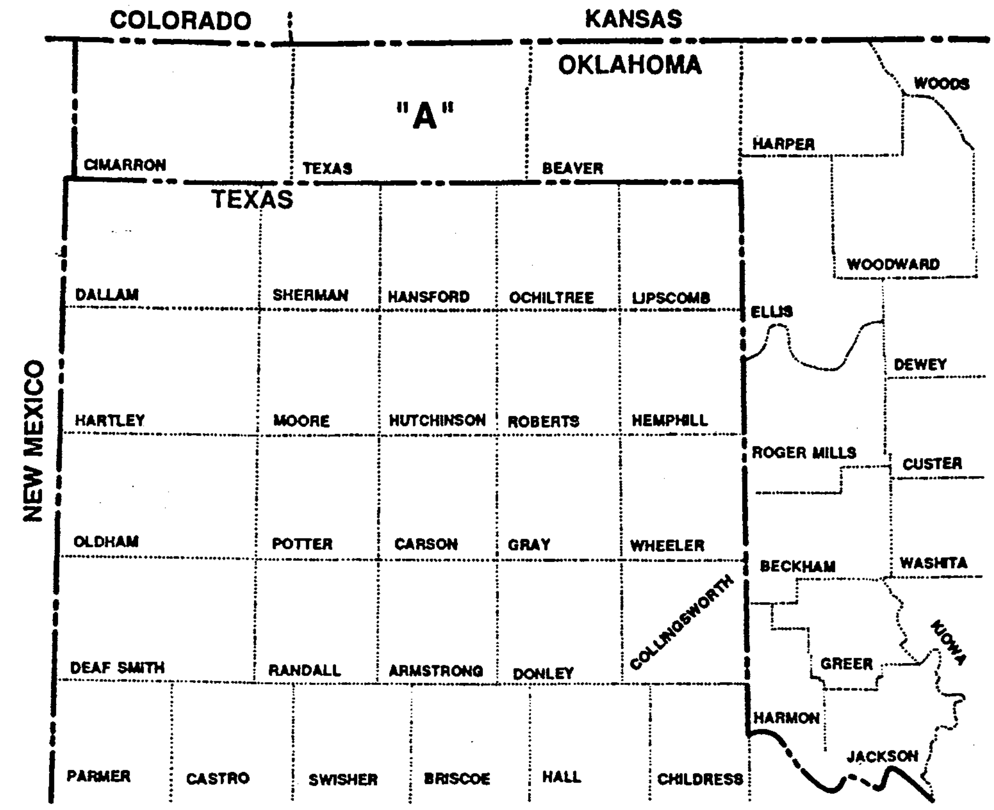
An appropriate site for injection into the Keyes reservoir might be in the central part of T.5N., R.9ECM. The thick reservoir facies is correlatable across approximately 4500 acres. Using the equations of Bradley (1985) and the reservoir characteristics derived from the literature, production, wire-line and rock data, each 640 acre disposal unit in this area could accommodate approximately 21,400,000 bbls of liquid without exceeding the original reservoir pressure (Appendix E).

Northeast Rice Field

Lower Purdy (Morrow) Sandstone

An Intermediate-Sized Reservoir Compartment

The Northeast Rice field is located in parts of sections 14, 15, 16, 21, 22, 23, and 27 of T.3N., R.10 ECM., Texas County, Oklahoma (Figure 49). The field has produced around 1 million barrels of oil from the upper Morrow Purdy reservoirs. Harrison (1990) subdivided the Purdy into "upper" and "lower" sandstones. These sandstones are separate reservoirs that can be differentiated on the basis of their relative stratigraphic positions, trends, and oil/water contacts.



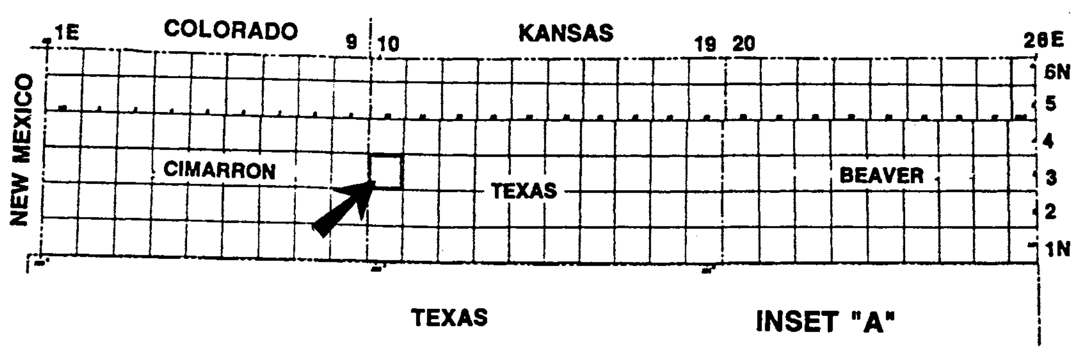
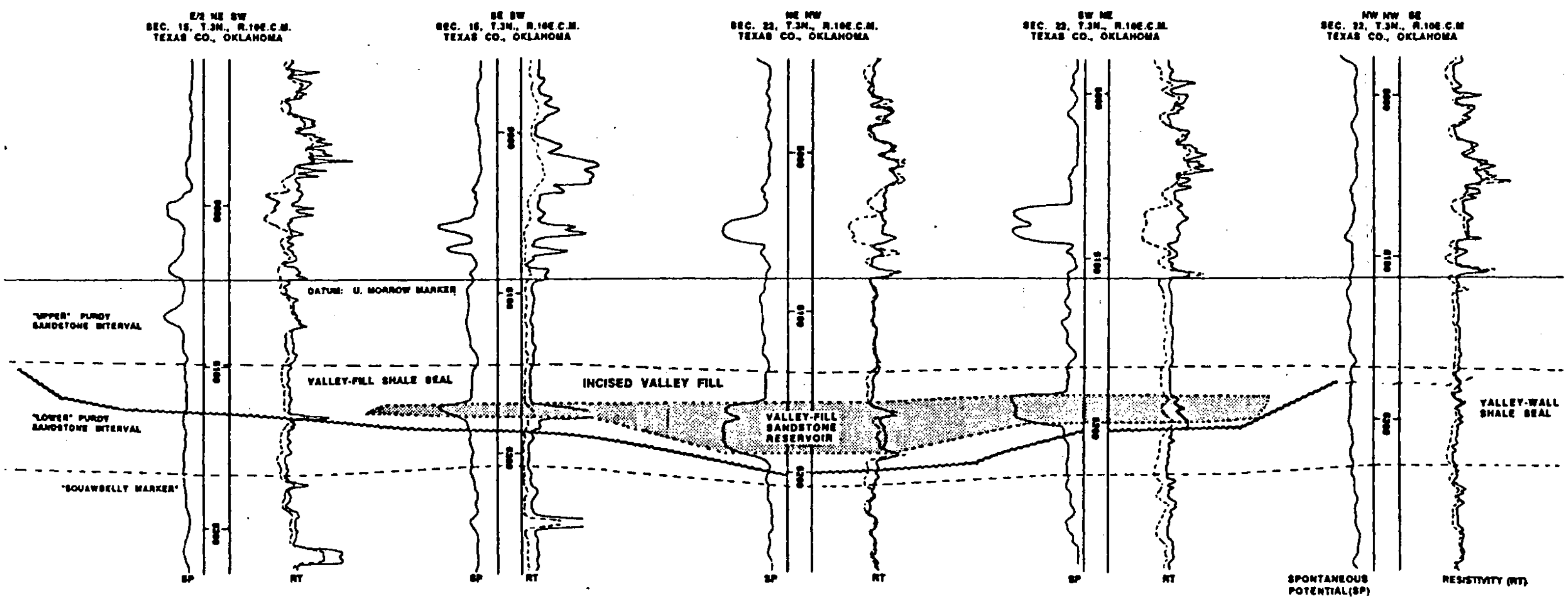


Figure 49. Location of the Northeast Rice Field in T.3N., R.10ECM., Texas County, Oklahoma.

The "lower" Purdy will be used to illustrate the isolation of valley-fill reservoirs at this proposed site.

The distribution and geometry of reservoir facies in the "lower" Purdy sandstone are shown by maps and cross sections constructed by Harrison (1990). The cross-section (Figure 50) shows the stratigraphy, the channel that eroded into the Morrow shale, and the termination of valley-fill sandstone against impermeable shales. Longintudinal termination of reservoir facies within the channel occurs when the sandstone pinches out and the channel is filled with shale and siltstone (Figure 51).

The total sandstone thickness map (Figure 51) and net sandstone isolith map (Figure 52) illustrate the distribution of channel-filling sandstone and reservoir facies within the channel trend. Production data suggest the "lower" Purdy sandstone within the NE Rice field is a common reservoir that is enclosed by low permeability shales and siltstones. The sandstone limits are restricted within the channel and the southern terminus of the field is the result of the up-dip pinch-out of the sandstone into impermeable channel-fill shales. The reservoir is water-bearing to the north before it apparently terminates against channel-fill shales. Integrated production and structural data indicate the NE Rice reservoir is separated from productive reservoirs to the east where oil is found downdip (structurally lower) to water. Likewise, it is separated from the field to the



CROSS SECTION LOCATION SHOWN IN FIGURE S 51 & 52

Figure 50. Cross section through the NE Rice field, Texas County, Oklahoma. Lower Purdy valley fill sandstone terminates laterally against valley wall shales.

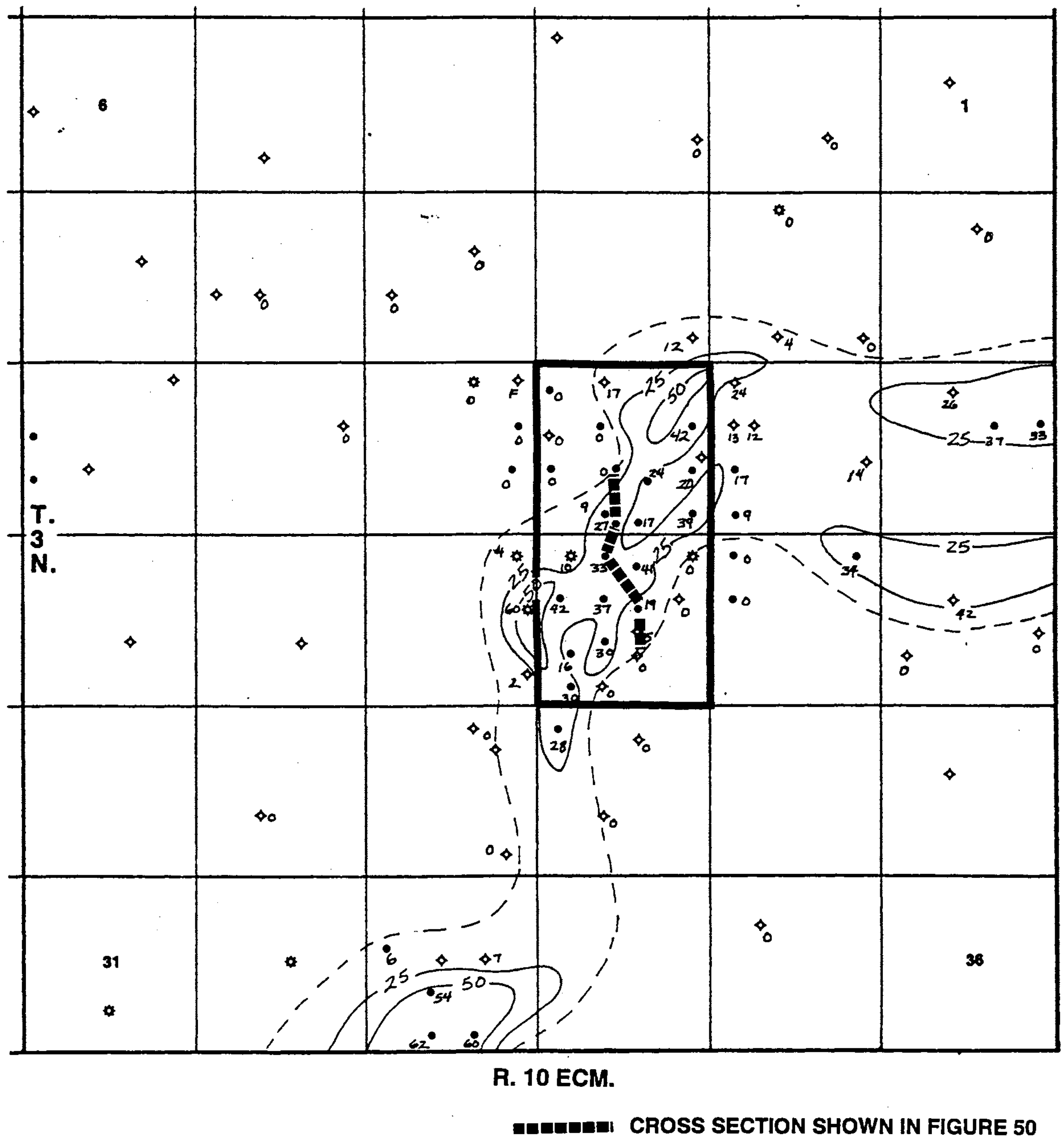


Figure 51. Total sandstone thickness: lower Purdy sandstone, NE Rice field. Valley-filling shale seals isolated sandstone accumulations along the valley trend.

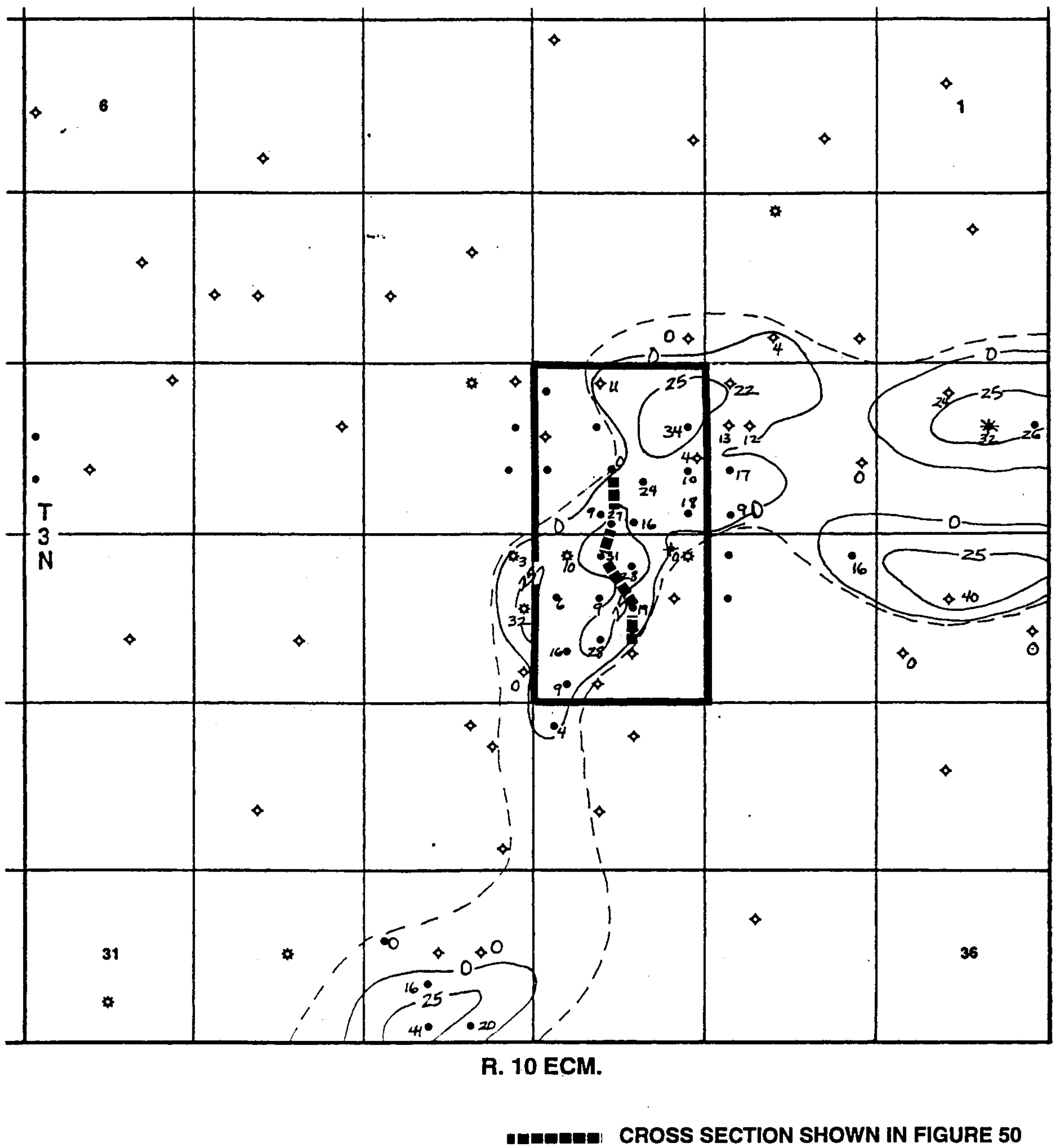


Figure 52. Net sandstone isolith map that delineates the distribution of lower Purdy reservoir facies. Net sandstone is defined by: sp deflection >60 mv., gamma-ray <75 units, and/or <10% porosity.

south where oil is found updip (structurally higher) to gas.

Reservoir Characteristics

Lower Purdy porosity values range from 8% to 25% and average around 21% in the productive reservoir (Harrison, 1990). Porosity is both primary and secondary (Figure 53). Williams (1961) reported that the "typical" permeability measurement for the "lower" Purdy in the nearby Northwest Eva field was 557 md.

Integrity of Confining Units

The Northeast Rice field is located immediately east of a northeast/southwest trending fault that is evident on the upper Morrow structure map (Figure 54). The fault is not apparent on the Cimarron Anhydrite (Figure 55) and no surface lineaments were detected over the field (Appendix D). The total sandstone thickness map (Figure 51) indicates shale separates the lower Purdy reservoir in Northeast Rice field from the fault.

The lower Purdy is a valley fill sandstone that resulted when rising sea level caused sand aggradation within a flooding incised valley (Harrison, 1990; Al-Shaieb et al., 1995; Puckette et al., 1995). As a result, the sand was encased by: (1) shales or mud that formed the valley floor and walls, and (2) mud and silt that filled the valley as it was flooded during the transgression.

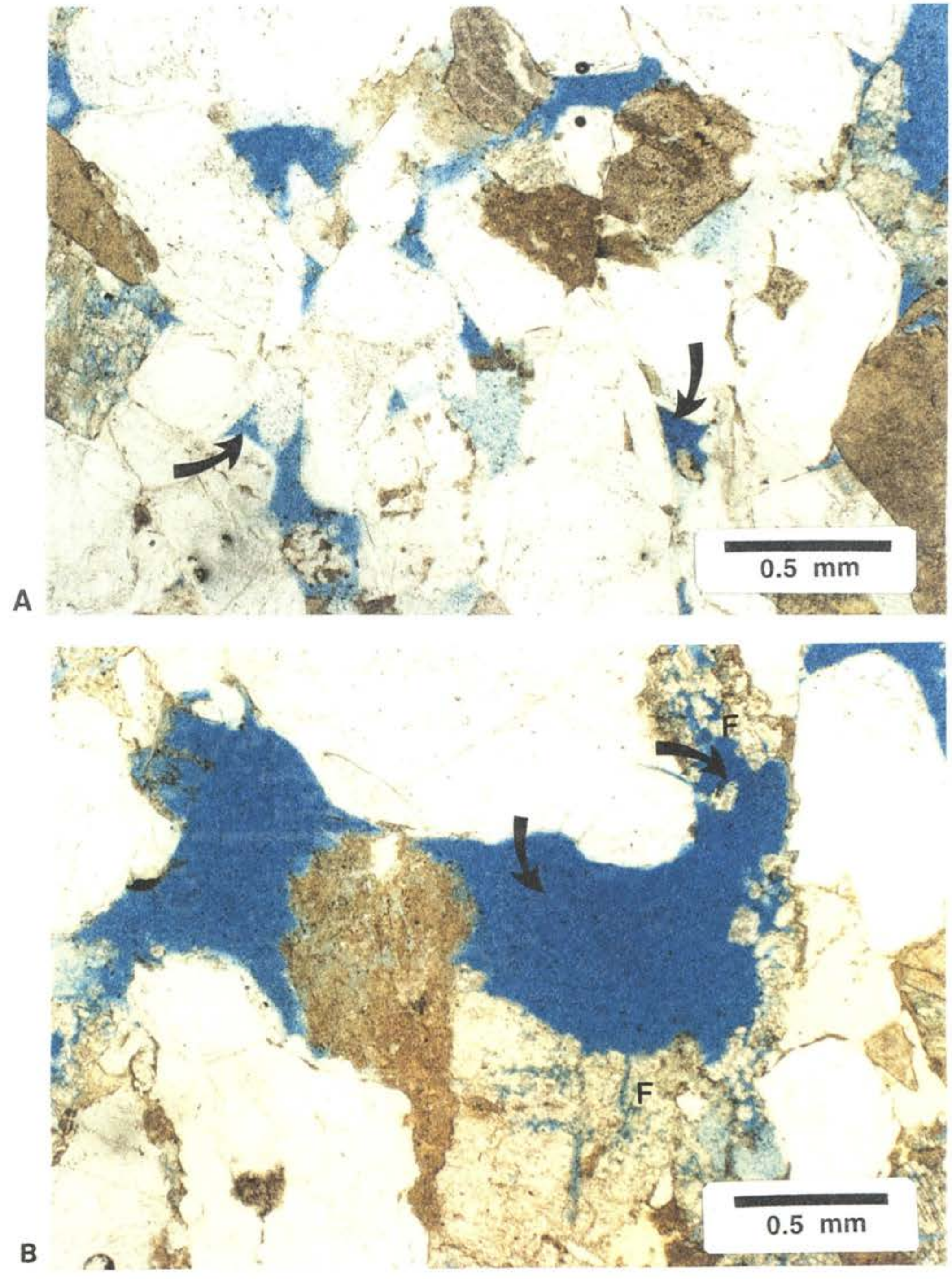


Figure 53. Photomicrographs of porosity development in the Purdy sandstone. Gulf, Ferguson, Sec. 2, T.4N., R.10ECM., Texas County, Oklahoma. Plane-polarized light.
(A) Primary porosity (arrows) with planar quartz overgrowths bordering pore
(B) Secondary porosity (arrows) formed primarily by the dissolution of feldspar (F).

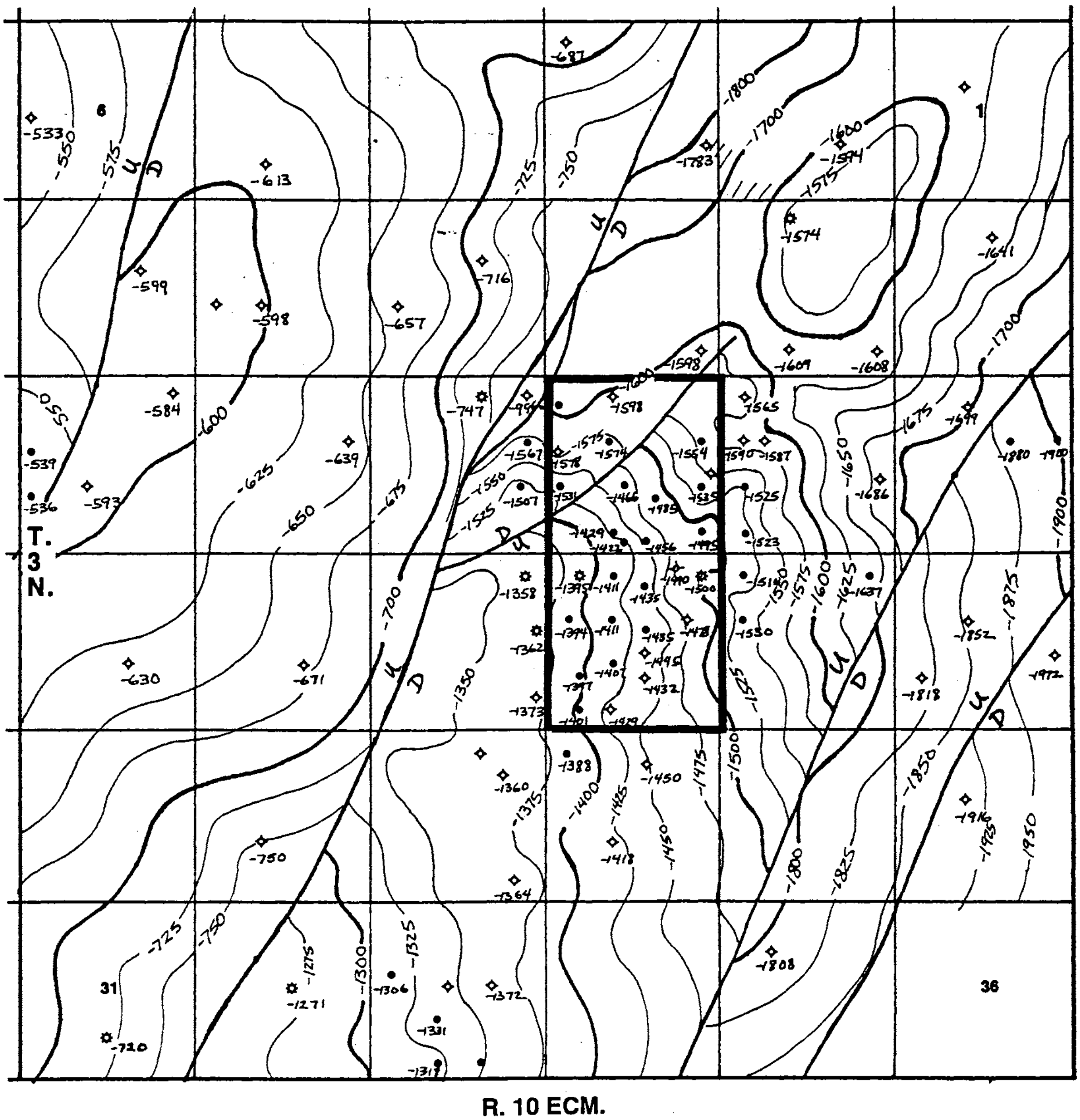


Figure 54. Upper Morrow structure map that identifies fault and fold trends in the NE Rice area.

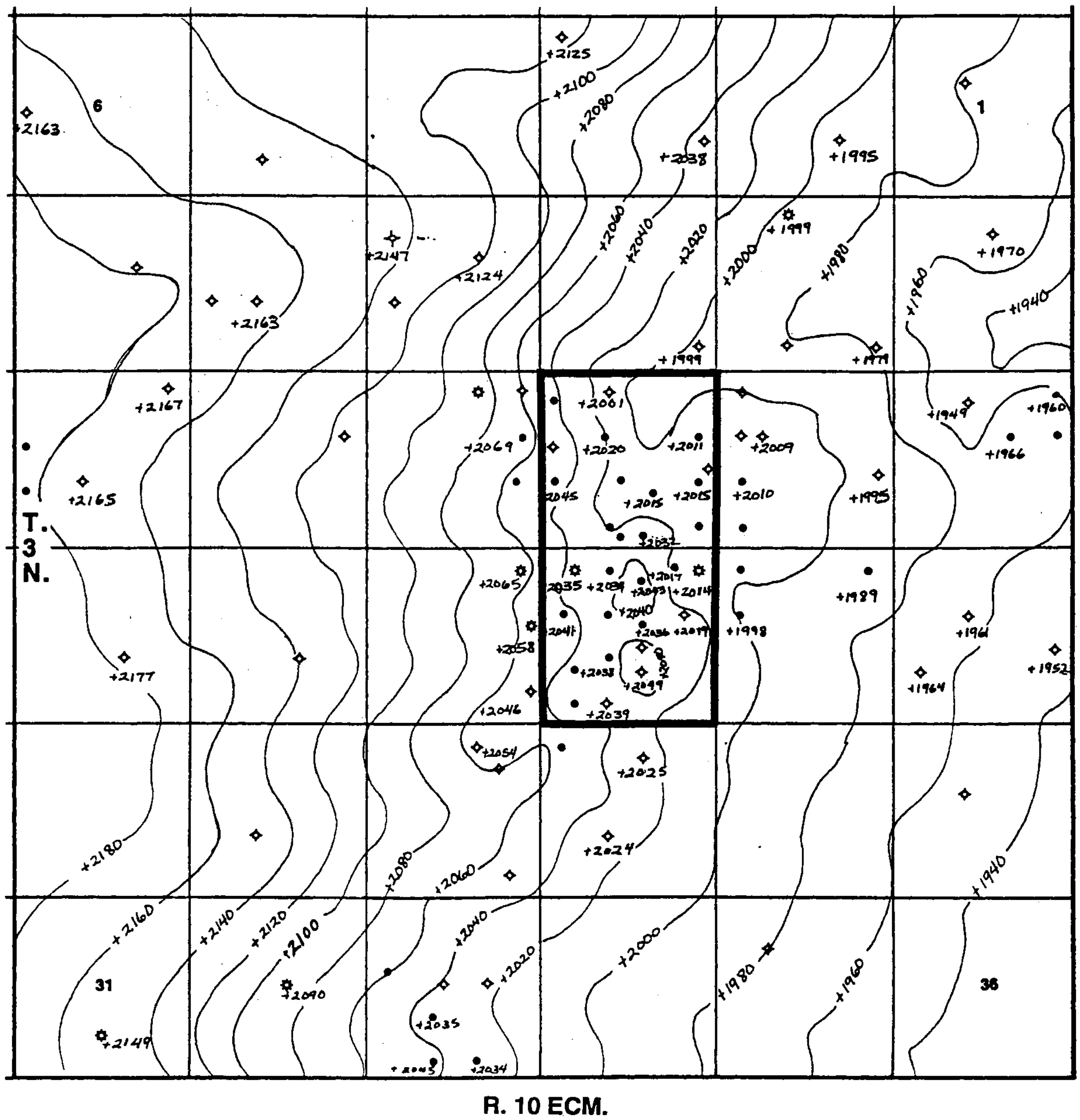


Figure 55. Cimarron Anhydrite structure map. Gentle dips indicate that faults evident on the Morrow shale do not impact the Permian strata.

The low-permeability Morrow shales that encapsulate the lower Purdy sandstone have segregated hydrocarbon accumulations along the paleovalley trend and separate the upper and lower Purdy reservoirs. If the sandstone is not repressured above original reservoir pressure, it should maintain the static conditions that have existed for geologic time.

Reservoir Capacity

The "lower" Purdy sandstone is filled with gas, liquid hydrocarbons and water. Using the equation from Bradley (1985), an injection unit of 40 acres, an average reservoir thickness of 20 ft. and an increase in pore fluid pressure from 250 psi to 1300 psi, it is estimated a total of 480,000 bbls of liquid could be disposed per well in the depleted gas cap (Appendix E).

The encasement of valley fill reservoirs in shale makes them ideal for the disposal of extremely toxic liquid waste. Though these reservoirs are typically volumetrically smaller than other types, their three-dimensional confinement by low permeability rocks insures their meeting the no-migration criterion of an ideal disposal zone.

CHAPTER VII

PRESSURE AND RESERVOIR CHARACTERIZATION OF THE ARBUCKLE AQUIFER DISPOSAL ZONE

Introduction

The Arbuckle Group is utilized as a disposal zone in most Class I and many Class II injection wells in Oklahoma. Class I wells injected approximately 556 million gallons (13 million stock tank barrels) of liquids in 1992 (Robertson, 1993). The volumes of brine injected into the Arbuckle in Oklahoma are unknown, but net (injected volume - produced volume) estimates in Kansas approach 31 billion gallons (728 million stock tank barrels) per year (Carr et al., 1986). In an effort to understand the subsurface flow path these injected liquids might follow, a regional pressure characterization of the Arbuckle aquifer was completed.

Arbuckle Aquifer

The Arbuckle Group aquifer includes all Upper Cambrian and Lower Ordovician rocks that overlie the Timbered Hills Group (Reagan Sandstone and Honey Creek Limestone) and underlie the Simpson Group (Figure 56). The Upper Cambrian rocks include the Fort Sill and Signal

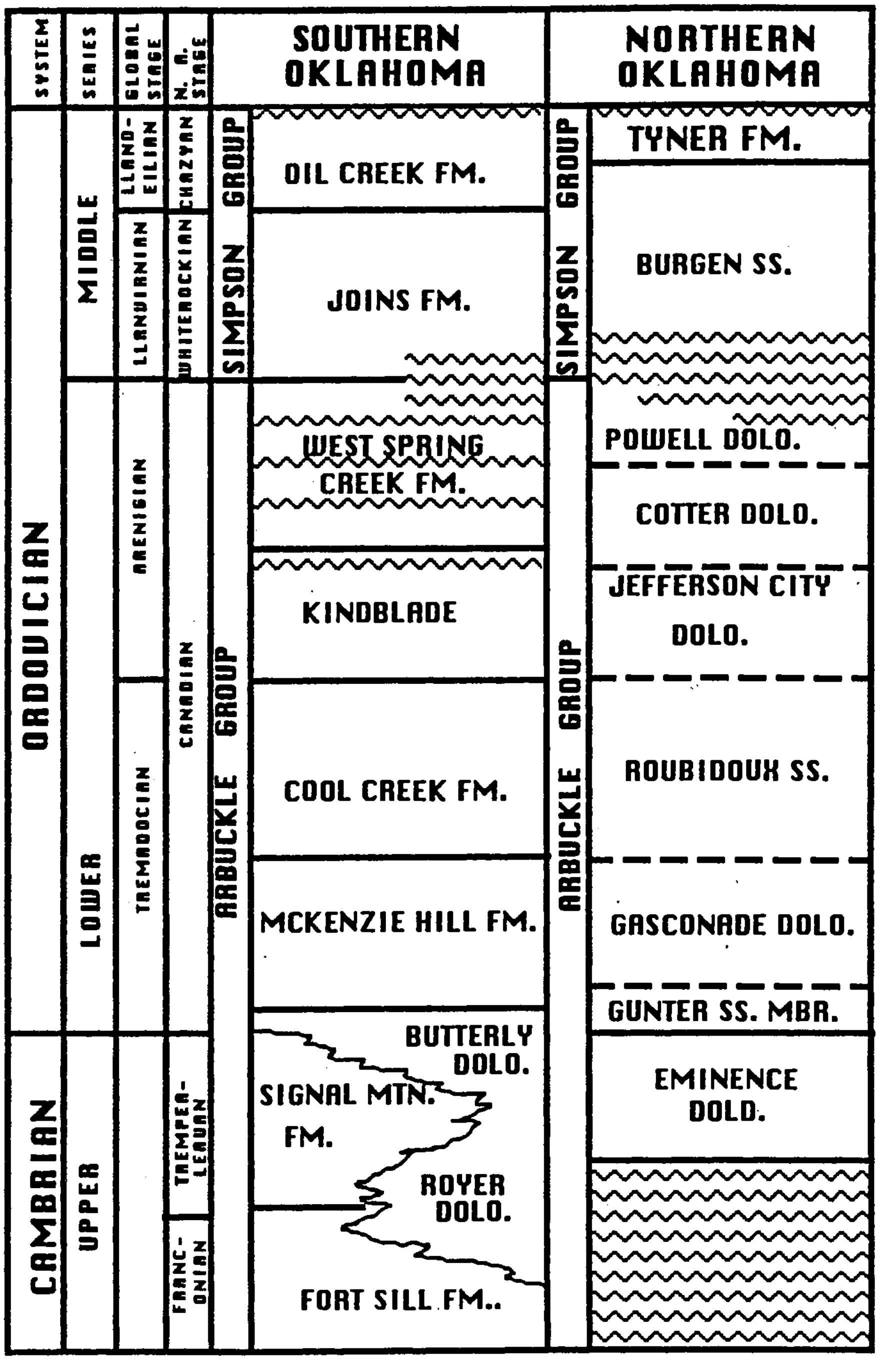


Figure 56. Stratigraphic nomenclature of the Arbuckle Group in the Midcontinent region (Musselman 1994).

Mountain Limestones. The Lower Ordovician rocks include in ascending order the McKenzie Hill, Cool Creek, Kinblade, and West Spring Creek limestones. The principal producing zones in southern Oklahoma (Wade, Bray and Brown) are karsted intervals in the West Spring Creek and Kinblade Formations. The majority of pressure data are from these horizons. In southern, central and western Oklahoma, most pressure data are from the West Spring Creek and Kinblade. In northeastern Oklahoma, the majority of pressure measurements come from the upper part of the Arbuckle Group in the Powell and Cotter dolomites.

Distribution Of Pressure Measurements In The Arbuckle Aquifer

The sources of Arbuckle pressure data range from measured elevations of the ground water table in and near recharge areas to drill-stem tests from ultra-deep gas wells near the axis of the Anadarko Basin (Appendix F).

Drill-stem tests were the primary source of Arbuckle pressures. Well completion information ("scout tickets") were examined for the entire state of Oklahoma and parts of the Texas Panhandle. Over 10,000 tickets were examined and scanned for Arbuckle completion or test information. All reported Arbuckle tests were closely scrutinized and screened as described in Chapter III.

Approximately 550 drill-stem tests were selected for inclusion in the Arbuckle data set. Drill-stem tests in the water-bearing part of the aquifer were used when available. These tests give more accurate indications of true reservoir pressure than those in the oil and gas column. Petroleum, in particular gas, will compress at depth by the upward forces of the underlying water and overpressure according to Pascal's Principle (volume decrease with corresponding increase in internal pressure) (Dahlberg, 1995). Hydraulic compression in the Wilburton gas field is illustrated in Figure 57.

Arbuckle pressure measurements were converted to pressure-depth and elevation values. Potentiometric surfaces were calculated using reservoir pressures and the standard fluid gradient of 0.465 psi/ft.

Arbuckle water quality data collected from Oklahoma and Kansas (Jorgensen et al., 1986) indicated that the concentrations of dissolved solids increased basinward away from recharge areas. These data were used to corroborate flow directions suggested by the potentiometric surface map generated in this study.

Pressure data were concentrated in areas where petroleum accumulated in Arbuckle rocks. Since the Arbuckle aquifer is mostly a non-compartmentalized hydrodynamic system, petroleum accumulations typically occurred where buoyant hydrocarbons collected near the crests of anticlinal folds. Gas chromatography of oils from Arbuckle reservoirs in southern Oklahoma suggests

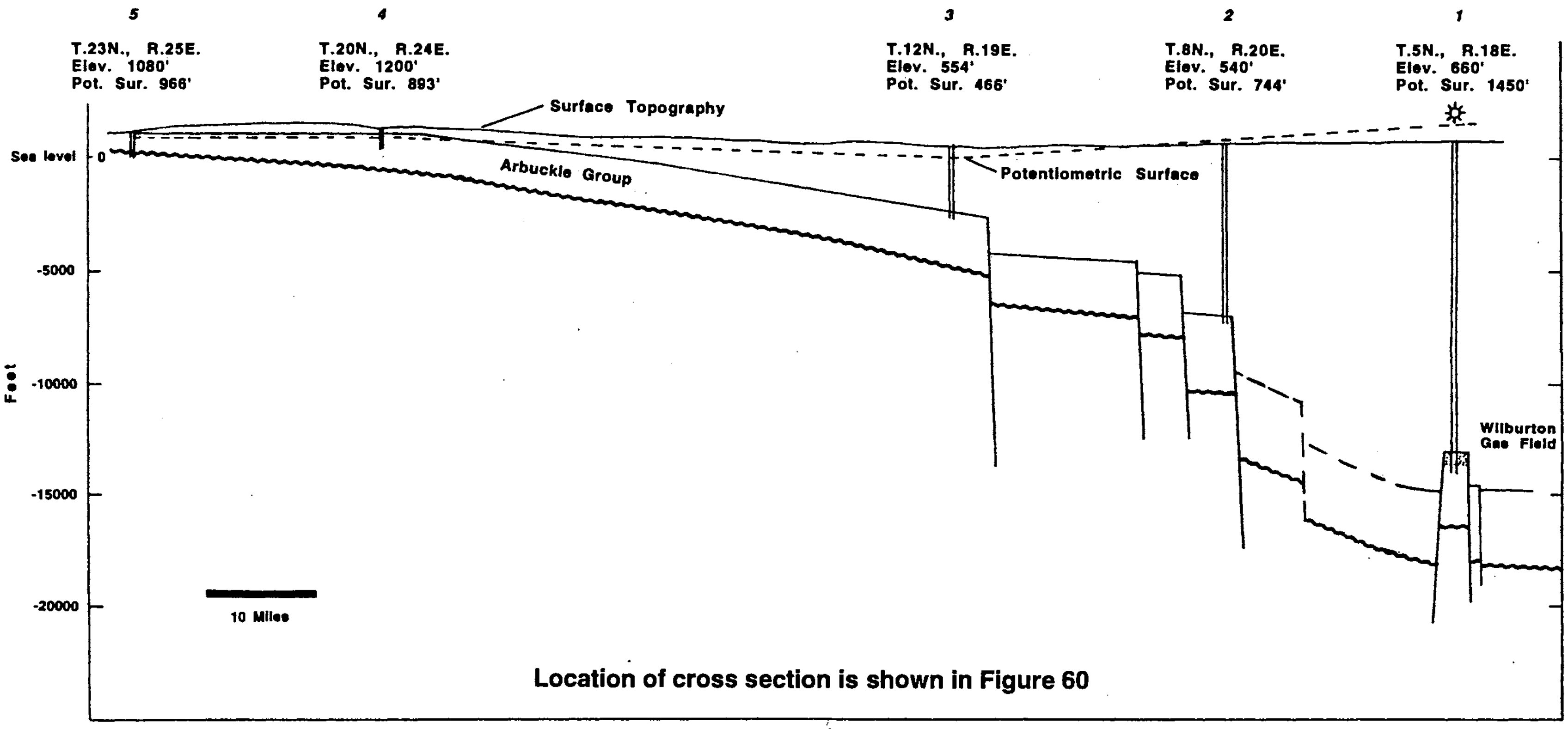


Figure 57. Schematic illustration depicting hydraulic compression that generates overpressuring in Wilburton field, Latimer County, Oklahoma. Gas trapped in horst was compressed by the underlying water that has the potential energy of the recharge area on the Ozark dome.

sourcing by both Woodford and Simpson shales (Wavrek, 1992). Hydrocarbons were generated during the rapid subsidence phases of the Anadarko and Arkoma Basins as the Lower Paleozoic shales reached thermal maturity. Petroleum-bearing fluids migrated from the basinal areas through the aquifer and filled existing structures with oil and gas. Consequently, Arbuckle Group production and data are concentrated in central, southern and northeastern Oklahoma. Here, basement faulting formed pre- and early Pennsylvanian structures; and younger anticlinal folds or fault blocks were juxtaposed against source rocks by faulting or unconformities.

Arbuckle Pressure-Depth Gradient Map

The Arbuckle pressure-depth gradient map (Figure 58) illustrates the uniform distribution of near-normal gradients across Oklahoma. These values confirm that the Arbuckle is a regional aquifer that equalized with the hydrostatic domain over geologic time. Gradients for original reservoir pressures range from 0.37 psi/ft. in Osage County to 0.59 psi/ft. in the highly faulted area of southern Oklahoma. The clustering of most values around those for fresh (0.433 psi/ft.) to brine (0.465 psi/ft.) water indicates that the Arbuckle has maintained regional hydraulic connectivity. This allowed for the effective dissipation of overpressures and prevented the generation of underpressured compartments. The significance of

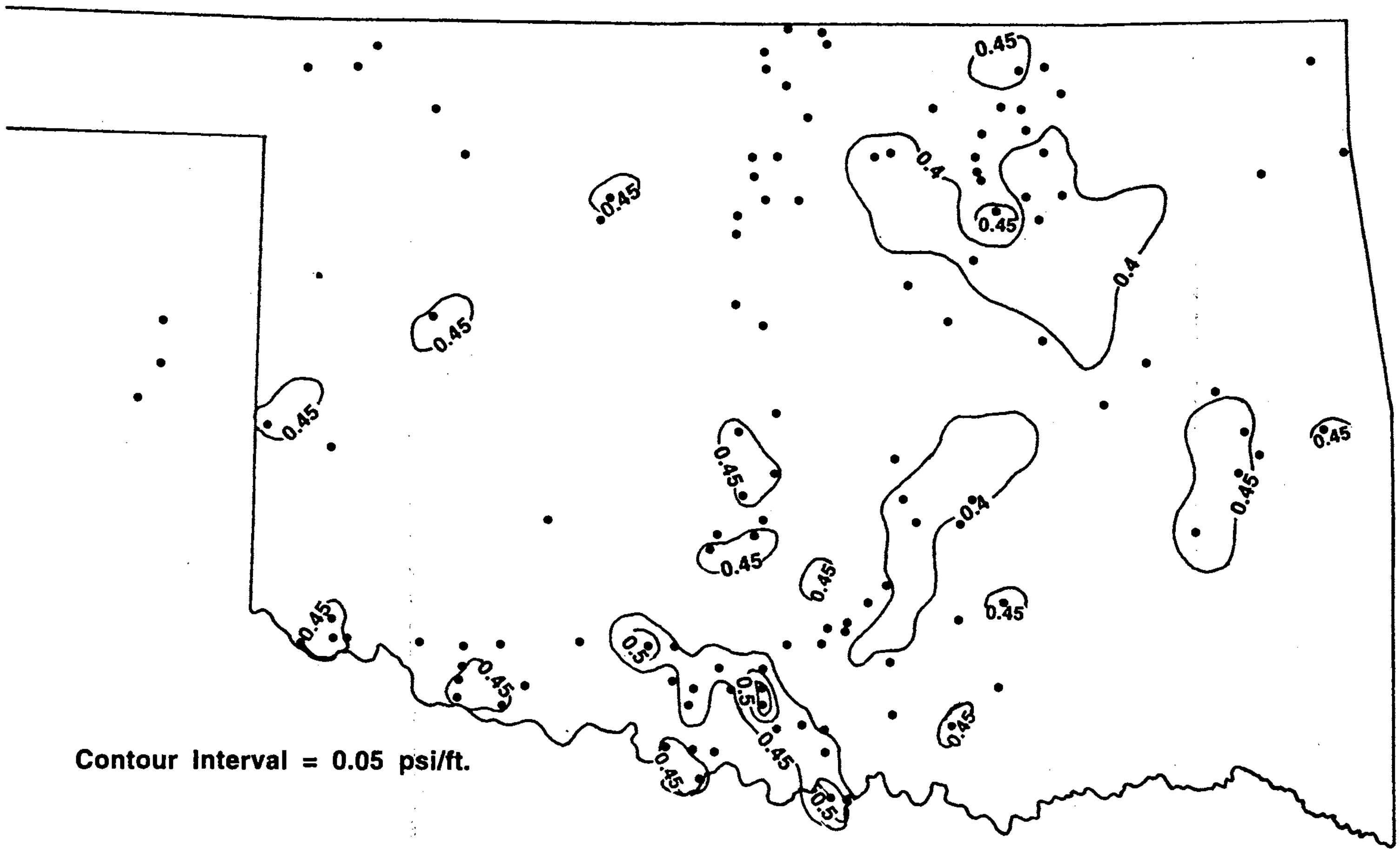


Figure 58. Pressure-depth gradient map of the Arbuckle Group. The similar p-d gradient values indicate the Arbuckle is a regional aquifer that maintains hydraulic continuity and pressure communication with the outcrop recharge areas.

regional hydraulic continuity in the Arbuckle can be appreciated when its p-d gradient values are compared with those of the Upper Morrowan interval (Figure 59). In the case of the Arbuckle, there is no significant deviation from the normal gradient with depth. Shallow (surface and near surface) p-d gradients are similar to those calculated for reservoirs below 18,000 feet. On the other hand, Upper Morrowan pressure measurements illustrate the effects of abnormally low and high pressures generated within compartmentalized reservoirs. Upper Morrowan reservoirs below approximately 10,000 feet have p-d gradients that are displaced from the normal gradient into the overpressured domain. In contrast, pressure measurements from shallower reservoirs in the Hugoton Embayment identify p-d gradients that have shifted into the underpressured domain. The highly compartmentalized nature of the Morrowan interval has prevented the pressure equalization that is apparent in the Arbuckle.

Arbuckle Potentiometric Surface Map

A regional potentiometric surface map was constructed to predict fluid migration pathways in the Arbuckle aquifer. Potentiometric values came from a variety of sources. In the Arbuckle Mountains and Ozark Uplift where Arbuckle rocks outcrop, elevations of water in springs and wells were used. When drill-stem tests were available, reservoir pressure measurements were converted to

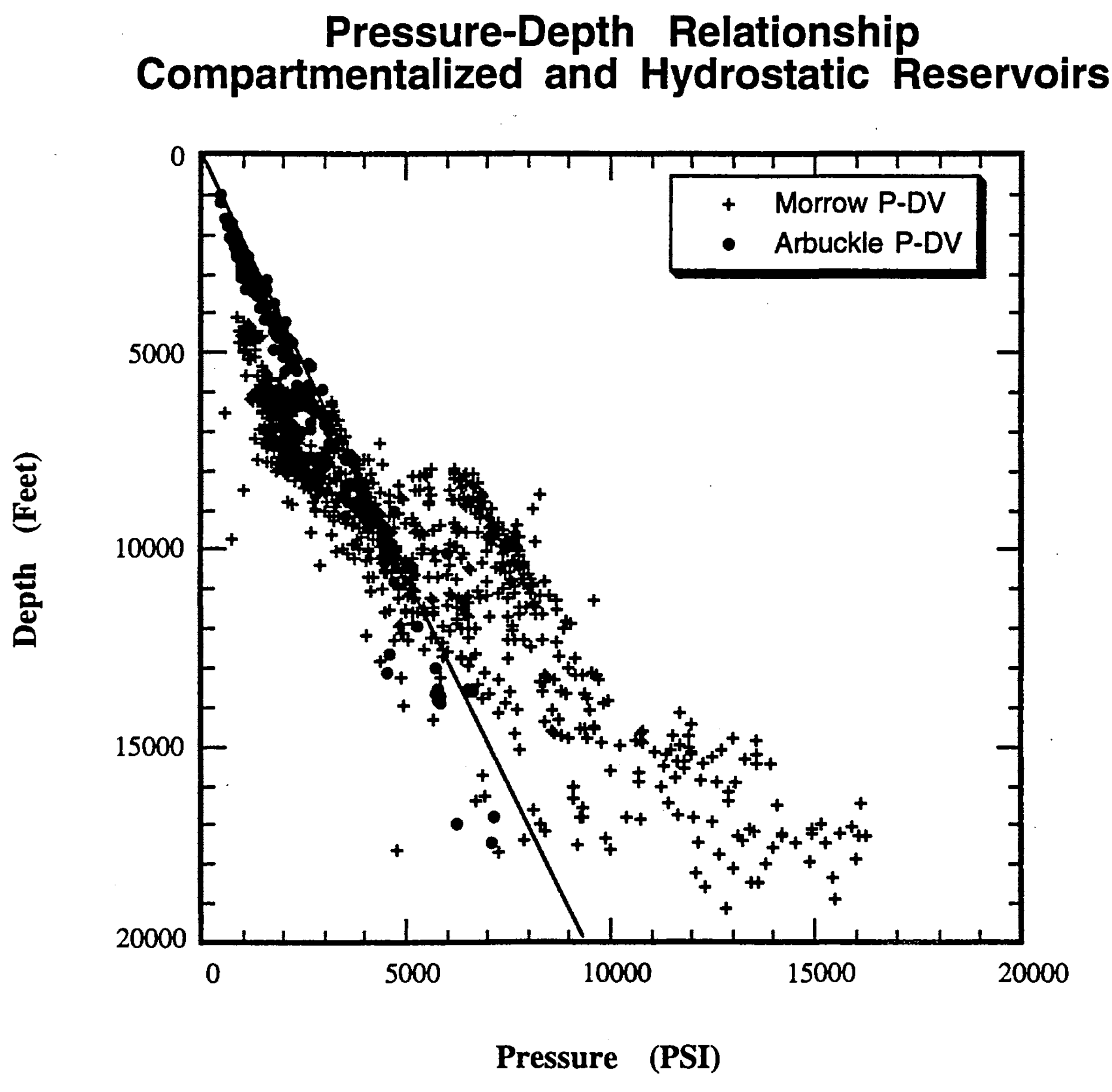


Figure 59. Pressure-depth profile for the Morrow and Arbuckle reservoirs. The abnormal pressure gradients (under- and overpressured) depicted by the Morrow data are not evident for the normally pressured Arbuckle.

potentiometric surfaces. Caution was exercised when it was necessary to derive potentiometric surfaces from reservoir pressure measurements calculated from shut-in gas wells. These measurements are relatively accurate in compartmentalized non-hydrodynamic (static) systems, but can be artificially high in hydrodynamic systems as the result of hydraulic compression (Figure 57).

The potentiometric surface map (Figure 60) indicates several directions of regional flow in the Arbuckle aquifer. The overall flow is affected by major structural features including the Nemaha Ridge, Arbuckle Mountains, Wichita Mountains, and the Ozark Uplift.

Flow in the far northeastern part of the State is westward from the outcrop of the Arbuckle in the Ozark Uplift. Here, freshwater flows from the uplift to the west until it comes in contact with a larger saline-water flow. A north-south trending transition or mixing zone occurs in T.18-29N., R.15-16E. (Jorgensen et al., 1986).

In the early 1900's, artesian flow from the Arbuckle aquifer was common from wells drilled to the east of this transition zone (Sibenthal, 1908). Present potentiometric surfaces (Figure 16) indicate that near-hydrostatic conditions exist where large-volume pumping (see Ottawa County; Figure 16) has not occurred.

In the Arbuckle Mountains, freshwater flows from topographically high recharge areas toward the basins. As a result, flowing wells are found on the fringe of the

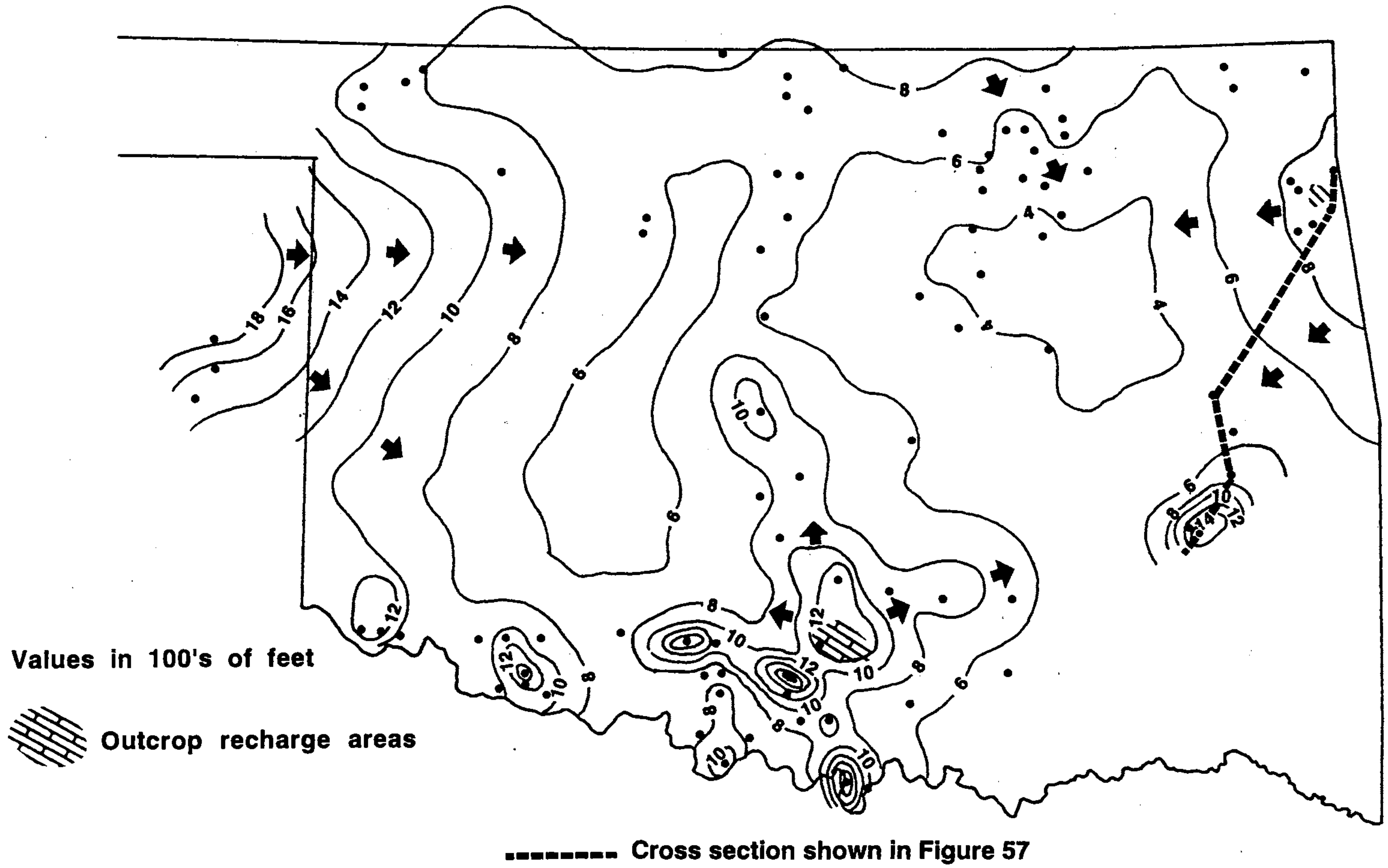


Figure 60. Arbuckle Group potentiometric surface map. Potentiometric surfaces suggest localized flow directions (arrows) from recharge areas toward the basins. Historical (pre-1910) values were used to restore the surface in northeastern Oklahoma.

uplift that have potentiometric surfaces approaching those in the recharge area.

Flow patterns in western Oklahoma suggest a general eastward flow toward the central part of the state. Density corrected potentiometric surfaces indicate near-hydrostatic natural conditions exist in the aquifer in this region.

Reservoir Characteristics

Dissolution and dolomitization have combined to make the Arbuckle Group reservoirs some of the more permeable and porous rock units in the Midcontinent region. They can consist of low-porosity mudstones or dolomudstones that change to porous dolomites with vuggy to cavern porosity. As a result, some reported porosity measurements in high-fluid-volume reservoirs are extremely low and do not reflect the characteristics of the entire reservoir interval. As an example, wire line log porosity measurements across the high-volume (>4000 BOPD) producing dolomite section in the Cottonwood Creek field, Carter County, Oklahoma seldom exceed 3%. Sidewall cores are similarly low (2%) and permeability measurements are typically <0.01 millidarcies (Read and Richmond, 1993). Much of this disparity between fluid-production rates and measured porosity and permeability can be explained by the nature of the karsted rock. During coring, low-porosity intervals remain intact, while porous breccia and cavern porosity zones do not. On the other hand, porous dolomites with extensive intergranular and vugular porosity are competent enough to be preserved. In Wilburton field, Latimer County, fractured, vuggy dolomites with 4 to 18% porosity and permeability exceeding 900 millidarcies have been cored (Meschner et al., 1993). This high variability also occurs in Kansas where drill-stem-test derived permeabilities range from 1 to 755 millidarcies and core-derived permeabilities range from 0.001 to 50 millidarcies (Carr et al., 1986 and Doveton, 1986).

Core from the American Airlines #2 well in T.20N., R.13E. illustrates reservoir characteristics introduced by depositional fabric and dissolution. This Class I Injection Well (Table I) disposes into the Arbuckle, Reagan Sandstone, and Precambrian basement. Porosity is primarily intercrystalline, moldic and vugular. Wire-line log measurements indicate maximum porosity exceeds 20% (Figure 61). Core analysis reveals these zones are dolomite with enlarged moldic (vuggy) (Figure 62) and solution-enlarged fracture porosity (Figure 63). Cored low porosity rocks also contain evidence of dissolution such as cavern-filling breccias (Figure 64).

The high permeability of the Arbuckle carbonates in the American Airlines Injection Well #2 is indicated by the results of a drill stem test taken across the cored interval. This test flowed water to the surface

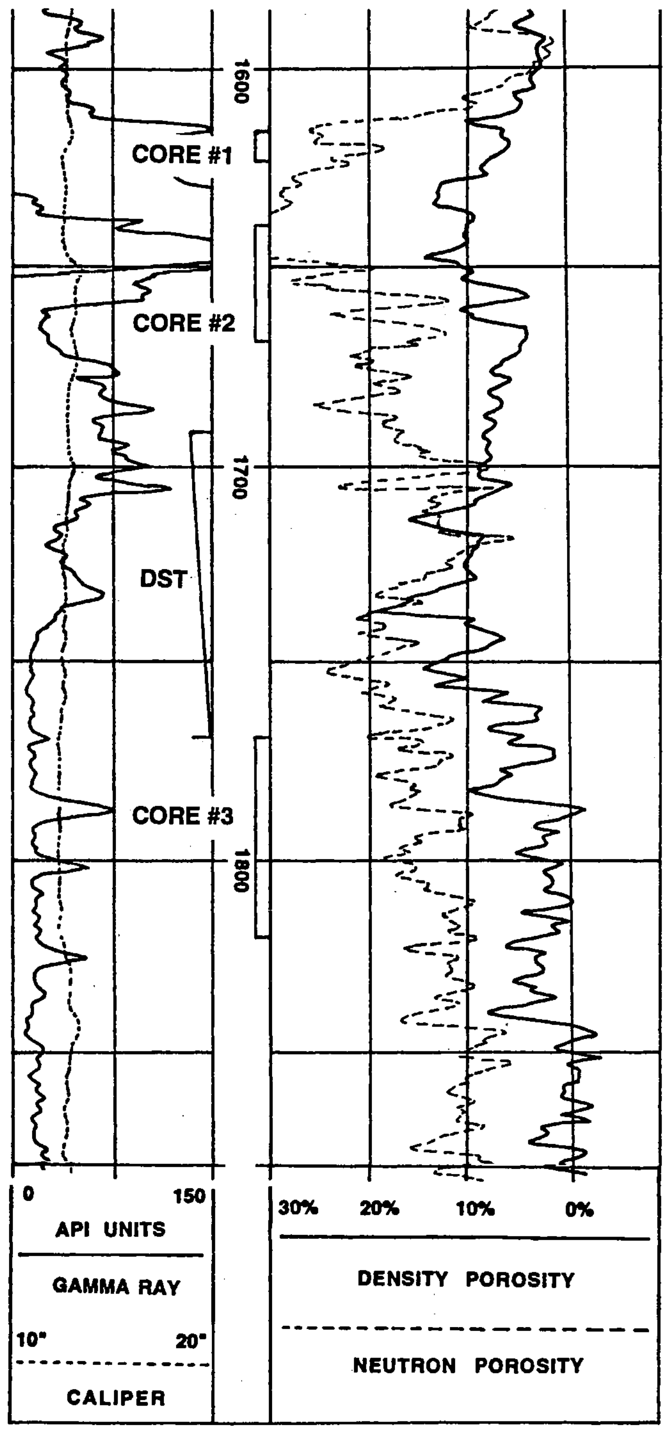


Figure 61. Wire-line log signatures (gamma-ray and porosity) across the upper part of the Arbuckle Group. The Woodford Shale is a seal that has penetrated by numerous drill holes. Cored Woodford/Arbuckle interval is identified. American Airlines Injection Well #2, Section 23, T.19N., R.20E., Tulsa County, Oklahoma.

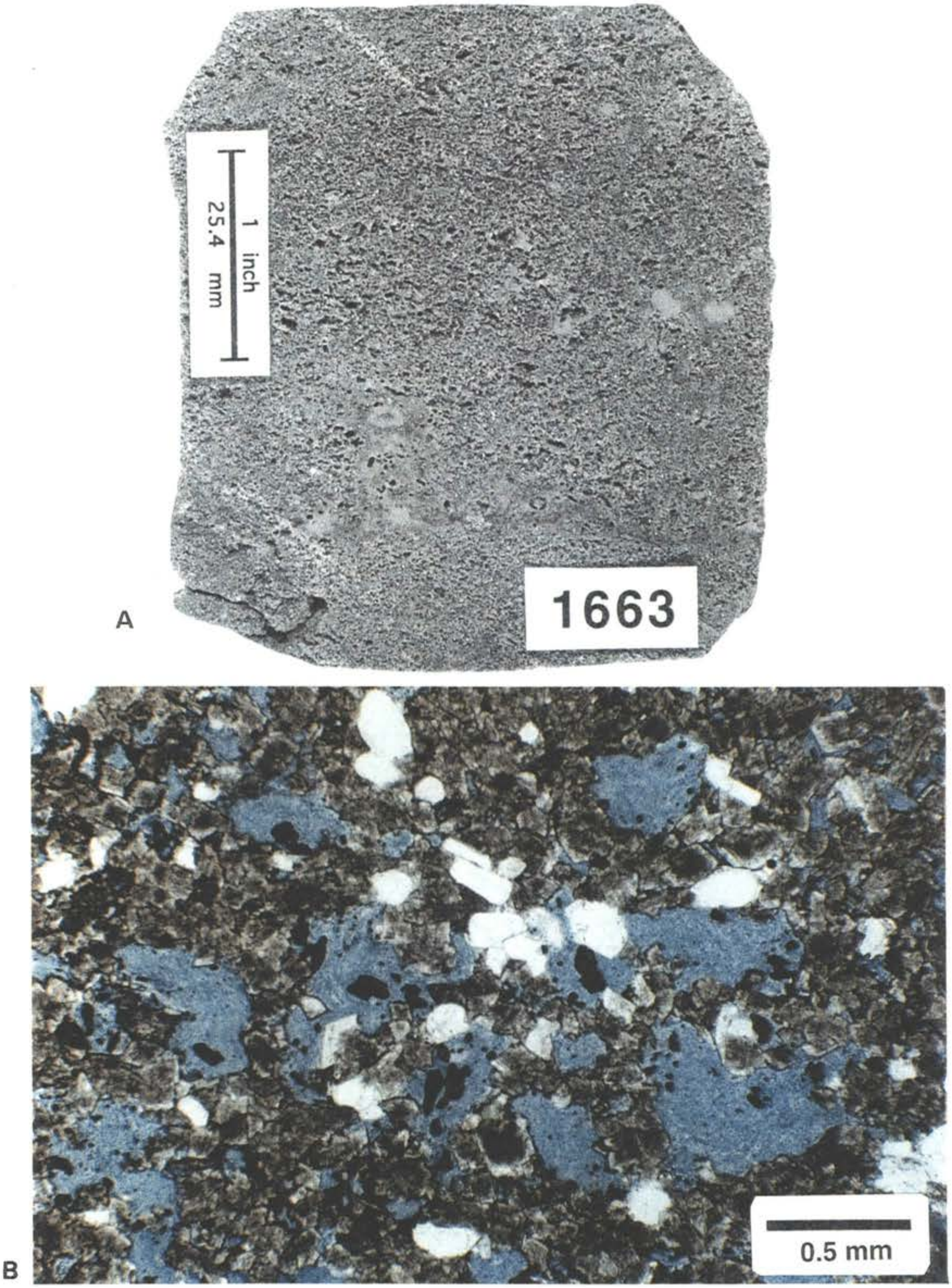


Figure 62. Core photograph (A) with photomicrograph (B) showing enlarged moldic/vuggy porosity in the Arbuckle Group. Porosity in (B) is filled with blue epoxy. Plane-polarized light. American Airlines Injection Well #2. Depth 1663 ft.

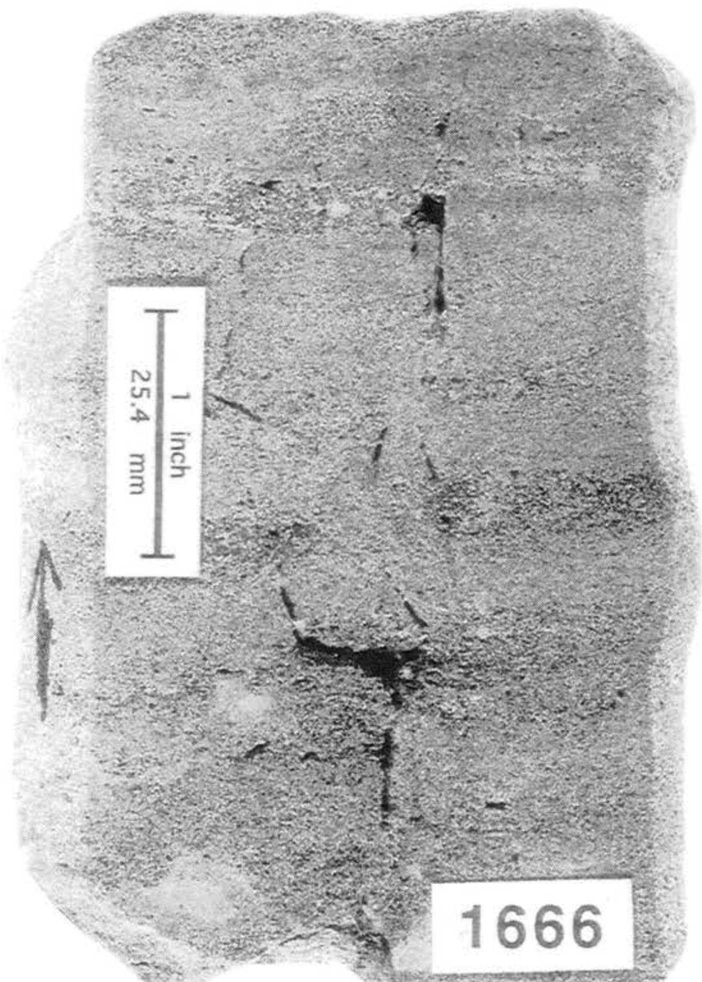


Figure 63. Solution-enlarged fractures in porous dolomite. American Airlines Injection Well #2. Depth 1666 ft.

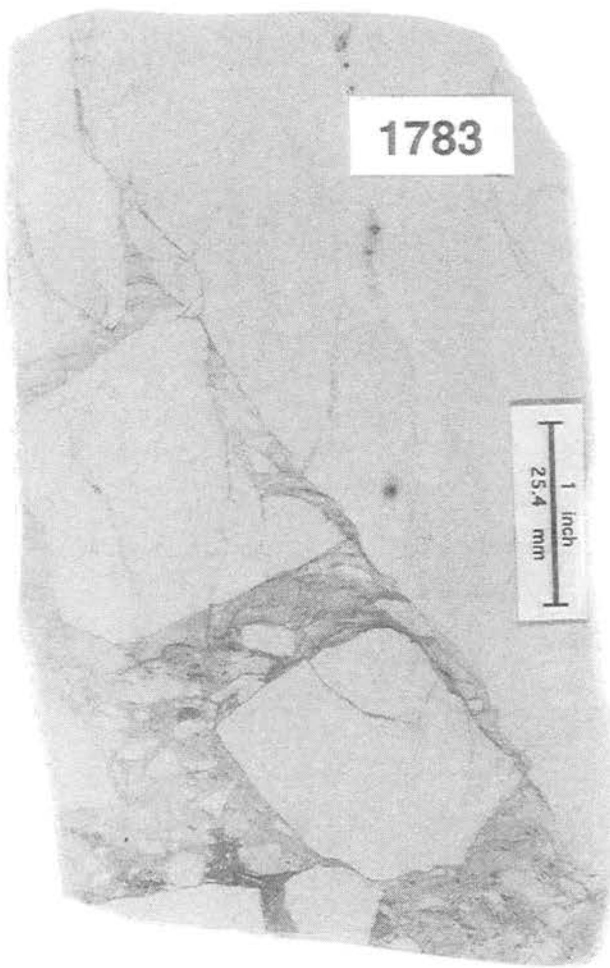


Figure 64. Cavern-filling breccia that indicates former cave passage in the Arbuckle dolomite. American Airlines Injection Well #2. Depth 1783 ft.

(elevation 620 ft) and recorded a reservoir pressure of 837 psi. This value converts to a potentiometric surface of 663 ft., which is slightly higher than the expected 620 ft. surface for this location. The flowing drill stem test apparently concerned the operators of the facility, because the drilling well records indicate that the nearby American Airlines Injection Well #1 was shut down 60 minutes into the test.

The water-flowing drill stem test suggests higher than expected reservoir pressures that may have resulted from several sources including: 1) localized interference between the two disposal wells and a supercharged reservoir, 2) artesian flow due to higher elevations in the recharge area on the Ozark Dome, and 3) solution gas charging.

Gas in solution will reduce fluid density in the drill pipe and help lift the liquid to the surface. However, the drilling records make no mention of gas and the fluid gradient calculated by dividing the final flow pressure by the fluid column height (807 psi/1758 ft. = .45 psi./ft.) suggests a saline liquid column.

The regional Arbuckle potentiometric map (Figure 60) indicates the potentiometric surface for the Arbuckle reservoir in this area should be approximately 600 ft. The value (663 ft.) for Well #2 is anomalously high and may result from another factor besides regional fluid energy. The American Airlines Injection Well #2 is located approximately 1200 feet north of Injection Well #1 and 4500 feet north of the Rockwell International Class I Injection Well. According to the available information, the drill stem test was conducted above the injection intervals in both wells. The composition of the fluid recovered by the drill stem test was not reported, so direct interference between wells can not be documented. However, the flowing well illustrates the possible contamination problems that could occur under circumstances when the reservoir has been pressured (supercharged) above original reservoir pressure or fluid is injected into zone whose natural potential energy is adequate to lift liquid to the surface.

The drill stem test interval in the American Airlines Injection Well #2 is shallower than the disposal interval in the neighboring wells. Therefore, if the pressurization of the upper part of the Arbuckle Group (above the injection interval) is the result of fluid injection, vertical fluid movement occurs within the reservoir. This is not unexpected, considering the frequency of vertical conduits in karsted rocks and the extensive post-depositional dissolution of the Arbuckle Group.

Summary

The porosity and permeability, thickness and lateral extent of the Arbuckle aquifer make it an excellent choice for the disposal of large volumes of liquids. It is ideal for the injection of oil field waste or other waters that have similar chemical compositions to the resident pore fluids in a given area. The use of the Arbuckle for oil field waste water disposal has prevented untold amounts of soil and groundwater contamination. However, the tendency for liquids to freely migrate within this aquifer (no lateral seals) make it unsuitable for the disposal of extremely toxic wastes. This failure to meet the no migration rule, combined with the natural reservoir-liquid energy, injection supercharging of the aquifer, and improperly plugged oil and gas wells, could generate a serious contamination problem through the vertical and lateral migration of liquid wastes.

CHAPTER VII

DISCUSSION AND CONCLUSIONS

The selection of an underground injection disposal site should be a systematic process that considers all aspects of subsurface geology. Properly integrated rock, fluid, and pressure data cam be used to select disposal zones that will accept fluid and confine it for periods of geologic time.

Pressure studies have shown that the Anadarko basin and Hugoton Embayment contain two distinct reservoir types: 1) abnormally pressured compartmentalized reservoirs that have remained isolated for millions of years and 2) regional, normally pressured, and noncompartmentalized aquifers that are hydraulically connected to the recharge areas.

Class I injection wells in Oklahoma currently use the normally pressured Arbuckle aquifer as a disposal zone. This reservoir has tremendous capacity, but lacks lateral confining beds and fails to meet the no migration criterion. Furthermore, injection into the fluid-filled Arbuckle aquifer displaces existing pore fluids (primarily water), supercharging the reservoir and disrupting natural flow.

Underpressured reservoirs offer an attractive alternative to the present practice of injecting waste into normally pressured liquid-filled aquifers. The underpressured reservoirs examined in the Oklahoma Panhandle have variable fluid storage capacities, but several common features including:

1) Original pore-fluid pressure-depth gradients that are less than than those in reservoirs above and below,

2) A mappable three-dimensionally isolated or compartmentalized structure,

3) Well-documented, thick confining beds that are not disrupted by faults and fractures, and

4) Reduced pore-fluid pressures (the result of petroleum production) that lower injection and displacement pressures.

Naturally underpressured reservoirs meet the no-migration criterion of an ideal liquid waste disposal zone. Their confining beds should remain intact as long as they are not repressured above the original (pre-production) values that they have maintained for millions of years. In addition, these reservoirs are delineated by oil and gas drill holes that could be used to monitor reservoir pressure response during injection.

Depleted gas reservoirs such as the Chase Group in Hugoton field offer the lowest reservoir pressures and injection and displacement energies. Oil-bearing reservoirs are often involved in secondary or enhanced recovery projects that repressure the reservoirs. In these cases or in naturally brine-filled reservoirs, it may be feasible to pump out the pore fluids prior to injecting liquid waste.

This study was designed to evaluate the feasibility of using underpressured reservoirs as disposal zones for liquid wastes and demonstrate a methodology for assessing their storage capacities and confining unit integrities. To address various aspects of the evaluation process. it was necessary to: 1) characterize the pressure domains in the Oklahoma Panhandle using conventional industry data, 2) determine if compartmentalized reservoirs exist, 3) compare the Panhandle pressure regimes with those in the deep basin, 4) establish the fundamental differences in reservoir evolution that determined if they became compartmentalized or remained in the hydrostatic domain, and 5) compare characteristics of underpressured reservoirs with those of the Arbuckle injection zone that is presently used by Class I Injection Wells in Oklahoma.

This process resulted in the following conclusions:

1) Petroleum industry drilling, completion and production data can be used to characterize the pressure architecture within basins,

2) Pressure data must be screened and only measurements from higher-permeability reservoirs that give

near-static pressure values should be used,

3) The Oklahoma Panhandle (Hugoton Embayment) contains naturally underpressured reservoir compartments that have been effectively isolated over geologic time by lithologic seals,

4) These compartments, which can be identified and delineated by their distinct pressure-depth values, can be classified on the basis of their host lithology and size,

5) Depleted, gas-bearing compartments with low pore-fluid pressures may make ideal injection zones as the result of their low displacement pressures,

6) In contrast, the Arbuckle aquifer that is used as a disposal zone for Class I Injection Wells in Oklahoma has liquid-filled pores and will supercharge when large volumes of liquids are injected (see page 156),

7) Increasing the pore-fluid pressure above original hydrostatic values in noncompartmentalized aquifers could disrupt regional fluid flow patterns and increase the likelihood of lateral and vertical migration of liquid wastes.

8) The total encasement of some underpressured reservoirs in low permeability shales may make them ideal repositories for extremely toxic liquid wastes.

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APPENDIX A

PRESSURE DATA FROM DRILL STEM TESTS

APPENDIX A KEY

1. Operator: Petroleum company that drilled the well providing the DST data

2. Lease: Lease or well name

3. Location: Legal location given by Section(S), Township(T), and Range(R). All townships are north of the Panhandle Base Line and all ranges are east of the Cimarron Meridian.

4. Zone: Reservoir where pressure measurement was taken

5. Depth: Depth to the base of the drill stem test tool or reservoir

6. Pressure: Reported closed (shut) in pressure (usually final closed in pressure)

7. P-D Gradient: Pressure-depth gradient calculated by dividing reservoir pressure by depth

Operator	Lease	Location S.,T. & R.	Zone	Depth	Pressure	P-D Grad.
Phillips	Reese	25-2-14	Admire	3896	905	0.23
Brown	Niles	32-6-10	Altamont	3835	736	0.19
Brown	Niles	32-6-10	Altamont	3835	736	0.19
Horizon	Terrell	5-1-12	Atoka	5814	2130	0.37
Cities	Wilson	24-5-15	Atoka	6075	1858	0.31
Halliburton	Duckett	25-6-9	Atoka	4019	835	0.21
Fortune	Van Tine	11-1-15	C. Grove	3002	550	0.18
Phillips	Lil	21-1-15	C. Grove	3280	621	0.19
Phillips	Hitch	34-1-15	C. Grove	3250	661	0.20
Phillips	Atkins	15-1-17	C. Grove	3031	610	0.20
Phillips	York	29-1-20	C. Grove	3760	866	0.23
Cleary	Barker	3-1-24	C. Grove	3903	1457	0.37
Pet. Inc.	Koch	28-1-25	C. Grove	3952	1180	0.30
Cabot	Nash	5-2-15	C. Grove	3186	555	0.17
Skelly	Joliffe	3-2-19	C. Grove	2969	700	0.24
Sinclair	Jones	15-2-26	C. Grove	3637	1096	0.30
Cities	Stonebraker	35-3-12	C. Grove	3420	572	0.17
Zoller	Graham	8-3-18	C. Grove	3208	938	0.29
Sinclair	Perry	5-3-24	C. Grove	3433	1175	0.34
Cabot	Barby	14-3-25	C. Grove	3590	1063	0.30
Am. Public	Edwards	3-3-27	C. Grove	3265	1064	0.33
Am. Public	Edwards	3-3-27	C. Grove	3265	1029	0.32
Cabot	Barby	7-3-27	C. Grove	3354	910	0.27
Cabot	Barby	18-3-27	C. Grove	3448	1058	0.31
Hall	O'Neill	32-3-27	C. Grove	3555	1006	0.28
Cities	Klingsick	23-4-15	C. Grove	3062	550	0.18
Phillips	Blakemore	12-4-22	C. Grove	3470	2045	0.59
Monsanto	Beaver	1-4-23	C. Grove	3170	908	0.29
Cleary	Pruett	22-4-24	C. Grove	3258	1000	0.31
Cleary	Pruett	22-4-24	C. Grove	3334	941	0.28
Cleary	Pruett	22-4-24	C. Grove	3358	1040	0.31
Sinclair	Cole	32-4-24	C. Grove	3375	970	0.29
Sinclair	Allen	33-4-24	C. Grove	3365	998	0.30
Kerr	Coulson	35-4-24	C. Grove	3300	945	0.29
Bridger	Barby	2-4-26	C. Grove	3496	1080	0.31
NRM	Leland	7-4-26	C. Grove	4090	1351	0.33
Cabot	Barby	13-4-26	C. Grove	3312	1032	0.31
Cabot	Barby	13-4-26	C. Grove	3352	1004	0.30
Cabot	Barby	13-4-26	C. Grove	3440	1081	0.31

Cabot	Barby	14-4-26	C. Grove	3239	960	0.30
Cabot	Barby	14-4-26	C. Grove	3328	997	0.30
Cabot	Barby	35-4-26	C. Grove	3465	1115	0.32
Cabot	Barby	36-4-26	C. Grove	3238	1010	0.31
Pet. Inc.	Goodwin	9-4-27	C. Grove	3532	1250	0.35
Cabot	Barby	18-4-27	C. Grove	3484	997	0.29
Cabot	Barby	18-4-27	C. Grove	3579	1052	0.29
Cabot	Allen	22-4-27	C. Grove	3336	966	0.29
Cabot	Allen	22-4-27	C. Grove	3390	1057	0.31
Anabaco	Allen	26-4-27	C. Grove	3250	1035	0.32
Sohio	Wolf	16-4-28	C. Grove	3019	900	0.30
Cities	Hier	21-5-15	C. Grove	3095	528	0.17
Shenandoah	Foster	32-5-20	C. Grove	3155	777	0.25
Humble	Miller	10-5-23	C. Grove	3315	960	0.29
Anadarko	Pfeifer	26-5-23	C. Grove	3290	878	0.27
Dyco	Perkins	5-5-24	C. Grove	3316	934	0.28
Dyco	Mayo	24-5-24	C. Grove	3265	929	0.28
Stekoll	Albert	4-5-26	C. Grove	3431	1040	0.30
Cabot	Sargent	12-5-26	C. Grove	3403	926	0.27
Cleary	Albert	17-5-26	C. Grove	3406	946	0.28
Cleary	Albert	17-5-26	C. Grove	3493	960	0.27
Cleary	Street	21-5-26	C. Grove	3395	970	0.29
Champlin	Dixon	23-5-26	C. Grove	3438	975	0.28
Anabaco	Arnett	27-5-26	C. Grove	3396	860	0.25
Anabaco	Smith	33-5-26	C. Grove	3400	945	0.28
Anabaco	Smith	33-5-26	C. Grove	3450	1005	0.29
Cleary	Alexander	35-5-26	C. Grove	3279	940	0.29
Cleary	Alexander	35-5-26	C. Grove	3512	1051	0.30
Cabot	Hamilton	18-5-27	C. Grove	3321	926	0.28
Kerr	Dixon	28-5-27	C. Grove	3350	1020	0.30
Phillips	State	29-5-27	C. Grove	3418	1004	0.29
Eisner	Adams	13-6-24	C. Grove	3114	930	0.30
Unit	Roepke	19-6-24	C. Grove	3190	804	0.25
Cities	Eagan	28-6-24	C. Grove	3159	840	0.27
Cities	Eagan	28-6-24	C. Grove	3255	905	0.28
Cities	Girk	35-6-24	C. Grove	3165	831	0.26
Cities	Girk	35-6-24	C. Grove	3305	897	0.27
King	Dickey	12-6-25	C. Grove	3178	1000	0.31
King	Dickey	12-6-25	C. Grove	3307	1037	0.31
Philcon	Judy	23-6-25	C. Grove	3250	975	0.30
May	Myers	18-6-25	C. Grove	3168	1062	0.34
May	Myers	18-6-25	C. Grove	3188	1062	0.33
Cleary	Dickerson	19-6-26	C. Grove	3045	972	0.32

Cleary	Dickerson	19-6-26	C. Grove	3230	1112	0.34
Cleary	Dickerson	19-6-26	C. Grove	3110	973	0.31
Phillips	Sargent	24-6-26	C. Grove	3045	915	0.30
Cleary	School Land	25-6-26	C. Grove	3032	916	0.30
Dyco	Staffeld	36-6-26	C. Grove	3270	1005	0.31
Hermann	Sutherland	31-6-27	C. Grove	3100	915	0.30
Swala	Sutherland	32-6-27	C. Grove	3075	950	0.31
O'Neil	Sutherland	32-6-27	C. Grove	3070	995	0.32
Petrofina	Lotspeich	10-6-28	C. Grove	2947	1015	0.34
May	Myers	18-6-25	Chase	2715	885	0.33
Kerr	Adams	36-6-24	Checkbrd	5423	1694	0.31
Texaco	Pack	14-1-9	Cherokee	4378	1000	0.23
Texaco	Pack	14-1-9	Cherokee	4356	970	0.22
Jennings	Bedell	23-1-27	Cherokee	7663	2580	0.34
Argonaut	Durham	10-2-9	Cherokee	4221	950	0.23
Argonaut	Zimmerman	11-2-9	Cherokee	4193	945	0.23
Texaco	Sleeper	4-2-10	Cherokee	4665	1147	0.25
Massed	Elliott	21-2-10	Cherokee	4698	1026	0.22
Sands	State	32-2-10	Cherokee	4709	1250	0.27
Cities	State	29-2-11	Cherokee	5318	1422	0.27
Cities	Stonebraker	32-3-12	Cherokee	5443	1588	0.29
Cities	Stonebraker	19-3-13	Cherokee	5492	1516	0.28
Cities	Stonebraker	9-3-14	Cherokee	5740	1180	0.21
Pet. Inc.	State	34-3-14	Cherokee	5720	1729	0.30
Cities	Hart	4-4-1	Cherokee	4867	1143	0.23
Anadarko	Gilmore	2-4-7	Cherokee	4264	836	0.20
Anadarko	Burton	30-4-9	Cherokee	4135	828	0.20
Vanderbilt	Harder	1-4-10	Cherokee	4070	886	0.22
Blaik	Ferguson	12-4-10	Cherokee	4050	864	0.21
Oil Capitol	White	15-4-10	Cherokee	4070	820	0.20
Oil Capitol	White	15-4-10	Cherokee	4045	800	0.20
Cities	Hart	4-4-11	Cherokee	4867	1143	0.23
Cities	Interstate	4-4-12	Cherokee	5130	1446	0.28
Stone	Long	7-4-14	Cherokee	5760	1865	0.32
Funk	Hinds	22-5-7	Cherokee	4085	740	0.18
First Nat.	Pugh	17-5-8	Cherokee	4115	820	0.20
Texaco	State	35-5-10	Cherokee	4114	805	0.20
Hamilton	Harley	8-5-11	Cherokee	4385	890	0.20
Pet. Inc.	Sleeper	11-5-11	Cherokee	4863	1380	0.28
Pet. Inc.	Steink.	15-5-11	Cherokee	4358	1140	0.26
Pet. Inc.	Steink.	15-5-11	Cherokee	4616	1320	0.29
Pet. Inc.	Steink.	15-5-11	Cherokee	4700	1260	0.27
Cities	Interstate	34-5-11	Cherokee	4970	1249	0.25

Anadarko	Ullom	1-5-12	Cherokee	5556	1613	0.29
Anadarko	Cowherd	3-5-12	Cherokee	5090	1250	0.25
Anadarko	Rutledge	12-5-12	Cherokee	5470	1530	0.28
Cities	State	22-5-12	Cherokee	5223	1738	0.33
Cities	Eckstein	27-5-12	Cherokee	5084	1430	0.28
Republic	Week	10-5-13	Cherokee	5678	1650	0.29
Cities	Schmalfdt	19-5-13	Cherokee	5500	1281	0.23
Republic	Price	27-5-13	Cherokee	5740	1566	0.27
Anadarko	Bawbell	27-6-13	Cherokee	5622	1317	0.23
Northern	Naylor	32-1-22	Chester	8473	2447	0.29
Northern	Naylor	32-1-22	Chester	8294	2446	0.29
Apache	Copple-Bell	9-1-27	Chester	8480	2780	0.33
Resources	Bell	9-1-27	Chester	8500	3641	0.43
Resources	Bedell	22-1-27	Chester	8884	2913	0.33
Argonaut	Sparkman	7-2-9	Chester	5000	980	0.20
Mayflo	Wilson	26-2-20	Chester	7606	2143	0.28
Aikman	Bridges	22-2-23	Chester	7930	2957	0.37
British	Dean	32-2-24	Chester	8480	3257	0.38
Pacific	Livingston	20-3-21	Chester	7171	2620	0.37
Kennedy	Law	24-3-21	Chester	7675	3130	0.41
Seneca	Brinkman	12-3-22	Chester	7255	2226	0.31
Shenandoah	Neufeld	18-3-22	Chester	7680	3632	0.47
Cities	Benjegerdes	3-3-23	Chester	7280	1954	0.27
Pet. Expl.	Brown	4-3-23	Chester	7204	1830	0.25
Pet. Expl.	Brown	4-3-23	Chester	7274	2105	0.29
Natural Gas	Kile	7-3-23	Chester	7212	2147	0.30
Sinclair	Epp	10-3-23	Chester	7195	2145	0.30
Sinclair	Potter	23-3-23	Chester	7448	2175	0.29
Cities	Ferguson	1-3-24	Chester	7416	2160	0.29
Sinclair	Ullrich	10-3-24	Chester	7358	2277	0.31
Colorado	Armagest	27-3-27	Chester	7775	2110	0.27
Northern	Banker	34-3-27	Chester	7900	2205	0.28
Smith	Stickler	22-4-20	Chester	6506	1950	0.30
Argonaut	Rock	36-4-22	Chester	6932	2050	0.30
Sinclair	Hancock	24-4-24	Chester	6943	2125	0.31
Sinclair	Hancock	24-4-24	Chester	7032	2175	0.31
Sinclair	McGrew	26-4-24	Chester	7042	2160	0.31
Kerr	Thompson	36-4-24	Chester	7330	2250	0.31
Hamilton	Evans	8-4-25	Chester	6834	2010	0.29
Cabot	Barby	16-4-25	Chester	6896	2056	0.30
Cabot	Davis	21-4-25	Chester	6912	2060	0.30
Cabot	Barby	22-4-25	Chester	6990	2167	0.31
Cabot	Barby	20-4-26	Chester	7052	2160	0.31

Cabot	Allen	23-4-27	Chester	7090	2191	0.31
Cabot	Wolf	20-4-28	Chester	7083	2245	0.32
Gulf	Koran	22-4-28	Chester	6838	2190	0.32
Tuthill	Harman	27-5-14	Chester	6850	2483	0.36
Shenandoah	King	13-5-19	Chester	6870	2300	0.33
Shenandoah	Evans	30-5-20	Chester	6910	2732	0.40
Shenandoah	Haller	31-5-20	Chester	7035	2541	0.36
Ambassador	Winsted	20-5-22	Chester	6679	2060	0.31
Kerr	Underwood	9-5-23	Chester	6650	2120	0.32
Cabot	Hodges	2-5-24	Chester	6350	2055	0.32
Cabot	Hodges	2-5-24	Chester	6590	1666	0.25
Dyco	Perkins	5-5-24	Chester	6329	2351	0.37
Sinclair	Maple	25-5-24	Chester	6700	2130	0.32
Sinclair	Maple	35-5-24	Chester	6867	1949	0.28
Sinclair	Maple	36-5-24	Chester	6808	2105	0.31
Pure	Kamas	11-5-25	Chester	6620	2128	0.32
Buttes	Berends	5-5-27	Chester	6800	1972	0.29
Atlantic	Long	4-5-28	Chester	6359	1940	0.31
Statex	Kasper	10-5-28	Chester	6410	2165	0.34
Stekoll	Patten	34-5-28	Chester	6730	2085	0.31
Nortex	Smith	28-6-19	Chester	6903	2003	0.29
Elder	Meador	35-6-23	Chester	6532	2105	0.32
Allied	Hodges	27-6-24	Chester	6310	2005	0.32
Cities	Eagan	28-6-24	Chester	6248	1972	0.32
Dyco	Sutherland	31-6-27	Chester	6614	2107	0.32
Petrofina	Lotspeich	10-6-28	Chester	6045	2000	0.33
Petrofina	Hennigh	15-6-28	Chester	6035	2074	0.34
Petrofina	Thomas	22-6-28	Chester	6070	2035	0.34
Sunray	Mills	6-1-21	Chkbd	5862	2190	0.37
Amax	Presnal	17-1-22	Chkbd	6314	2042	0.32
Ong	Custer	31-2-23	Chkbd.	6216	2225	0.36
Cleary	Albert	17-5-26	Chkbrd	5766	1995	0.35
Sands	Blakely	15-5-10	Cim.	1600	385	0.24
Hamilton	Harley	8-5-11	Cim.	1535	360	0.23
Phillips	Atkins	15-1-17	Collier	3479	825	0.24
Colorado	Conover	5-5-8	Conover	4610	1163	0.25
Phillips	Allen	28-4-24	Cottage	3420	995	0.29
Braxton	Barby	31-4-24	Cottage	3410	770	0.23
Cities	Mathewson	19-1-19	Douglas	4610	1382	0.30
Cleary	Barker	3-1-24	Douglas	5540	1084	0.20
Hendrick	Heatley	24-6-11	Elmont	3225	420	0.13
Hendrick	Richterberg	26-6-11	Elmont	3181	420	0.13
Huber	Tucker	34-6-11	Elmont	3252	444	0.14

Texaco	Sleeper	4-2-10	Foraker	2967	766	0.26
Skelly	Hurliman	16-3-15	Ft. Riley	2705	475	0.18
Cleary	Albert	17-5-26	Ft. Riley	3280	750	0.23
Monsanto	Beaver	1-4-23	Hodges	4830	1870	0.39
Eisner	Adams	13-6-24	Hodges	5168	1685	0.33
Cities	Girk	35-6-24	Hodges	5417	1729	0.32
Colorado	Motern	11-2-26	Hoover	4757	1560	0.33
Wheeler	Webb	23-3-26	Hoover	4650	1360	0.29
Cabot	Barby	7-3-27	Hoover	4474	1397	0.31
Texaco	McGarraugh	26-2-9	K. City	3865	825	0.21
Texaco	Hawkins	26-1-9	K. City	3900	680	0.17
Pet. Inc.	Hitch	9-1-16	K. City	5297	1540	0.29
Hall	Gheen	23-1-24	K. City	6594	1682	0.26
Dyco	Joliffe	3-2-19	K. City	4909	1609	0.33
Cox	Pugh	10-2-22	K. City	6113	2192	0.36
Hamilton	Cities	14-3-14	K. City	4663	1295	0.28
Cabot	Jackson	7-3-15	K. City	5060	1514	0.30
Anadarko	Johnson	7-3-22	K. City	6555	1907	0.29
Allied	Jordan	36-3-23	K. City	5965	1920	0.32
Colorado	Armagest	27-3-27	K. City	6253	2355	0.38
Ashland	Brumley	19-4-10	K. City	3650	655	0.18
Anadarko	Franz	4-4-21	K. City	5335	1837	0.34
Northern	Myers	23-4-21	K. City	5449	1879	0.34
Monsanto	Beaver	1-4-23	K. City	4809	1626	0.34
Mid-America	Fields	30-4-23	K. City	5068	1704	0.34
Cities	Benjegerdes	34-4-23	K. City	5800	1980	0.34
Cities	Benjegerdes	35-4-23	K. City	6150	2140	0.35
Cabot	Barby	20-4-27	K. City	5806	2056	0.35
Goex	Tucker	24-5-11	K. City	4106	936	0.23
Tuthill	Harman	27-5-14	K. City	5050	1326	0.26
Anadarko	Franz	14-5-21	K. City	5270	1811	0.34
Txo	Smyres	16-5-21	K. City	5427	1852	0.34
Anadarko	Dorman	23-5-21	K. City	5265	1761	0.33
Stekoll	Kamas	1-5-25	K. City	4953	1630	0.33
Pure	Kamas	11-5-25	K. City	5355	1241	0.23
Anabaco	Smith	33-5-26	K. City	5630	1765	0.31
Anabaco	Smith	33-5-26	K. City	5790	1838	0.32
Kerr	Adams	36-6-24	K. City	5075	1551	0.31
Phillips	McCamant	17-1-14	Keyes	6972	2260	0.32
Allied	Patterson	15-3-8	Keyes	4874	1030	0.21
H&L	Omohundro	21-3-8	Keyes	4913	983	0.20
Texaco	Carey	1-3-9	Keyes	4640	965	0.21
Woods	Hanes	16-3-9	Keyes	4803	837	0.17

Cities	Stonebraker	32-3-12	Keyes	6432	1803	0.28
Cities	Stonebraker	20-3-13	Keyes	6428	1943	0.30
Cities	Stonebraker	20-3-13	Keyes	6468	1942	0.30
Cities	Stonebraker	35-3-13	Keyes	6698	1854	0.28
Cities	Stonebraker	8-3-14	Keyes	6705	2000	0.30
Cities	Stonebraker	27-3-14	Keyes	6630	2061	0.31
Pet. Inc.	State	34-3-14	Keyes	6670	2018	0.30
Cotton	Harder	1-4-10	Keyes	4721	918	0.19
Vanderbilt	Harder	1-4-10	Keyes	4743	978	0.21
Cities	Reeves	4-4-10	Keyes	4768	897	0.19
Oil Captiol	White	15-4-10	Keyes	4685	1030	0.22
Ashland	Brumley	19-4-10	Keyes	4446	1040	0.23
Energy	Foreman	3-4-11	Keyes	5910	1497	0.25
Oil Capitol	Lamar	18-4-11	Keyes	5627	1550	0.28
Cities	Buzzard	22-4-12	Keyes	6410	1693	0.26
Cities	Webb	30-4-12	Keyes	6220	1689	0.27
Anadarko	Cities	14-4-13	Keyes	6446	1619	0.25
Cities	Bartles	11-4-15	Keyes	6553	1969	0.30
Funk	Hinds	22-5-7	Keyes	4820	849	0.18
Funk	Hinds	22-5-7	Keyes	4816	856	0.18
H&L	Nash	7-5-9	Keyes	4704	819	0.17
Sands	Blakely	15-5-10	Keyes	4802	995	0.21
Consol.	Whisenhand	20-5-11	Keyes	4850	1021	0.21
Cimarron	Brewer	32-5-11	Keyes	4700	923	0.20
Cities	State	22-5-12	Keyes	6082	1629	0.27
Cities	Eckstein	27-5-12	Keyes	5880	1636	0.28
Cities	Interstate	28-5-12	Keyes	6090	1636	0.27
Cities	Interstate	28-5-12	Keyes	6003	1662	0.28
Cities	Wolf	29-5-12	Keyes	6149	1588	0.26
Cities	Interstate	33-5-12	Keyes	5942	1643	0.28
Republic	Ferguson	13-5-13	Keyes	6580	1985	0.30
Cities	Bollinger	29-5-13	Keyes	6503	1824	0.28
Pet. Inc.	McGarrough	12-5-14	Keyes	6591	1980	0.30
Cities	Hampy	23-5-14	Keyes	6580	1922	0.29
Cities	Blake	1-5-15	Keyes	6596	1992	0.30
Cities	Symunds	3-5-15	Keyes	6580	1984	0.30
Cities	Gibson	10-5-15	Keyes	6552	1992	0.30
Cities	Gibson	10-5-15	Keyes	6578	1992	0.30
Cities	Symunds	11-5-15	Keyes	6581	1944	0.30
Cities	Symunds	11-5-15	Keyes	6601	1976	0.30
Cities	Symunds	12-5-15	Keyes	6577	1992	0.30
Cities	Symonds	14-5-15	Keyes	6525	2000	0.31
Cities	Dailey	17-5-15	Keyes	6604	1960	0.30

Cities	Wilson	23-5-15	Keyes	6569	1928	0.29
Cities	Herzig	31-5-15	Keyes	6620	1954	0.30
Pet. Inc.	Howell	21-5-16	Keyes	6506	1764	0.27
Marsh	Davis	22-5-16	Keyes	6400	1765	0.28
Cities	Allen	28-5-16	Keyes	6614	1946	0.29
Tipperary	Dacoma	36-6-7	Keyes	4774	866	0.18
Shenandoah	State	15-6-9	Keyes	4635	909	0.20
Texaco	Schrauner	13-6-10	Keyes	4741	930	0.20
Anadarko	Boaldin	20-6-10	Keyes	4592	862	0.19
Anadarko	Boaldin	20-6-10	Keyes	4580	862	0.19
Anadarko	Welsh	21-6-10	Keyes	4600	735	0.16
Cox	Buck	20-6-11	Keyes	5001	1045	0.21
Cities	Denny	21-6-11	Keyes	4960	985	0.20
Champlin	Hawkins	29-6-11	Keyes	4832	1015	0.21
Pet. Inc.	Denning	30-6-11	Keyes	4845	979	0.20
Hamilton	Griffith	16-6-12	Keyes	5993	1550	0.26
Cities	Ellis	18-6-12	Keyes	5391	1160	0.22
Anadarko	Roesler	28-6-13	Keyes	6488	1900	0.29
Wilson	Witt	33-6-16	Keyes	6556	1922	0.29
Humble	Barngrover	22-6-22	Keyes	6336	1645	0.26
Panhandle	Boates	34-6-22	Keyes	6430	2017	0.31
Cabot	Barby	12-4-26	Krider	2870	776	0.27
Horizon	Terrell	5-1-12	L-K. City	4345	850	0.20
Texaco	Hawkins	26-1-9	L-Kc	3900	645	0.17
Phillips	Bobarr	27-1-15	L. Morrow	6808	1960	0.29
Graham	Trent	30-1-19	L. Morrow	6815	1535	0.23
Santa Fe	Schultz	30-1-24	L. Morrow	8930	3261	0.37
Mid-America	Sweet	33-1-24	L. Morrow	8788	3502	0.40
Anderson	Flock	14-1-25	L. Morrow	8378	2900	0.35
Phillips	Young	1-1-27	L. Morrow	8200	2920	0.36
Mid-America	Pierce	3-2-20	L. Morrow	6950	1569	0.23
Mayflo	Jones	25-2-25	L. Morrow	8145	2700	0.33
Baker	Hanes	2-3-9	L. Morrow	4569	980	0.21
Baker	Hanes	15-3-9	L. Morrow	4660	930	0.20
Pet. Inc.	Drum	21-3-23	L. Morrow	7270	1890	0.26
Shell	Cole	3-3-24	L. Morrow	7130	2140	0.30
Sinclair	Boston	7-3-24	L. Morrow	7277	2230	0.31
NRM	Ferguson	7-3-25	L. Morrow	7411	2788	0.38
Marlin	Bockelman	29-3-28	L. Morrow	7306	2290	0.31
Cities	Reeves	4-4-10	L. Morrow	4352	923	0.21
Anadarko	Gregg	22-4-23	L. Morrow	6831	2370	0.35
Mid-America	Phelps	29-4-23	L. Morrow	6950	2155	0.31
Cabot	State	31-5-10	L. Morrow	4367	847	0.19

Dyco	Kamas	1-5-25	L. Morrow	6601	2122	0.32
Pure	Kamas	11-5-25	L. Morrow	6628	2100	0.32
Cabot	Sargent	12-5-26	L. Morrow	6626	2090	0.32
Champlin	Dixon	23-5-26	L. Morrow	6855	2060	0.30
Little	Hoggatt	23-6-22	L. Morrow	6325	1555	0.25
Texaco	Smith	25-1-9	Lansing	3767	612	0.16
Texaco	Smith	25-1-9	Lansing	3881	668	0.17
Texaco	McGarraugh	26-2-9	Lansing	3752	750	0.20
Cabot	Ennis	4-2-15	Lansing	4826	1430	0.30
Phillips	Pansy	22-2-16	Lansing	4859	1503	0.31
Zoller	Longcor	4-2-24	Lansing	6058	2236	0.37
Cities	Stonebraker	32-3-12	Lansing	4670	1019	0.22
Cities	Stonebraker	35-3-12	Lansing	4480	1042	0.23
Cities	Stonebraker	35-3-13	Lansing	4858	1240	0.26
Cities	Stonebraker	16-3-14	Lansing	4925	1414	0.29
Pet. Inc.	State	34-3-14	Lansing	5220	1568	0.30
Texaco	State	20-4-7	Lansing	3706	1038	0.28
Energy	Stout	27-4-9	Lansing	3713	673	0.18
Cities	Beer	4-4-14	Lansing	4640	1280	0.28
Cities	Cooper	30-4-15	Lansing	4757	2233	0.47
CIG	Mendenhall	12-4-19	Lansing	4899	1544	0.32
Cabot	Barby	35-4-26	Lansing	5800	2158	0.37
Cities	Eckstein	27-5-12	Lansing	4645	1299	0.28
Cities	Interstate	33-5-12	Lansing	4202	1038	0.25
Cities	Interstate	33-5-12	Lansing	4401	1152	0.26
Cities	Ralstin	19-5-15	Lansing	4780	1396	0.29
Butte	Jones	19-5-22	Lansing	5276	1670	0.32
BWAB	State	14-6-4	Lansing	3870	938	0.24
Shenandoah	State	15-6-9	Lansing	3490	645	0.18
Cox	Williams	13-6-11	Lansing	3650	530	0.15
Humble	Heatley	14-6-11	Lansing	3640	672	0.18
Cities	Hicks	13-6-12	Lansing	4730	1217	0.26
Eisner	Adams	13-6-24	Lansing	4670	1666	0.36
Eisner	Adams	13-6-24	Lansing	5030	1901	0.38
Unit	Roepke	19-6-24	Lansing	4620	1358	0.29
Gas Prod.	Hodges	22-6-24	Lansing	4704	1447	0.31
Irex	Reckard	31-6-24	Lansing	4709	1485	0.32
Cabot	Barby	1-3-26	Lovell	4989	1589	0.32
Cabot	Barby	13-4-26	Lovell	4950	1400	0.28
Phillips	Reese	25-2-14	M. Morrow	6770	2095	0.31
Forest	Hether.	30-4-9	M. Morrow	4480	1050	0.23
Sullivan	Houston	30-4-10	M. Morrow	4411	1084	0.25
Elder	Waller	28-5-10	M. Morrow	4685	845	0.18

Kimbark	Addington	36-5-10	M. Morrow	4463	977	0.22
Marlin	Boren	12-5-24	Marm.	5485	1678	0.31
Smith	Harland	7-1-9	Marmaton	4381	1350	0.31
Texaco	Pack	14-1-9	Marmaton	4334	920	0.21
Texaco	Chuman	24-1-9	Marmaton	4060	857	0.21
Phillips	McCamant	17-1-14	Marmaton	5813	1763	0.30
Phillips	Rick	17-1-16	Marmaton	5326	1667	0.31
Hall	George	2-2-20	Marmaton	5916	1231	0.21
H&L	Omohundro	21-3-8	Marmaton	3960	719	0.18
Dyco	McDonald	30-3-8	Marmaton	4055	942	0.23
Cities	Stonebraker	20-3-13	Marmaton	5197	1528	0.29
Pet. Inc.	State	34-3-14	Marmaton	5400	1613	0.30
Pan Eastern	Jones	4-3-22	Marmaton	6050	1990	0.33
Ong	Kenneck	17-3-24	Marmaton	6273	2300	0.37
Cabot	Barby	14-3-25	Marmaton	6296	2161	0.34
Pet. Inc.	Williams	6-4-11	Marmaton	3904	740	0.19
Anadarko	Marr	35-4-13	Marmaton	5665	1586	0.28
Stone	Long	7-4-14	Marmaton	5347	1372	0.26
Northern	Myers	23-4-21	Marmaton	5645	1875	0.33
Phillips	Blakemore	12-4-22	Marmaton	5542	1918	0.35
Maguire	Blakemore	12-4-22	Marmaton	5530	2090	0.38
Monsanto	Beaver	1-4-23	Marmaton	5535	1529	0.28
Anadarko	McFarland	6-4-23	Marmaton	5735	2030	0.35
Anadarko	Blakemore	6-4-23	Marmaton	5532	2031	0.37
Mid-America	Tretbar	27-4-23	Marmaton	5883	2160	0.37
Mid-America	Tretbar	27-4-23	Marmaton	5912	2170	0.37
Mid-America	Fields	30-4-23	Marmaton	5507	1870	0.34
Marlin	Brown	31-4-23	Marmaton	5575	1919	0.34
Cities	Benjegerdes	34-4-23	Marmaton	6020	2108	0.35
Braxton	Barby	31-4-24	Marmaton	5867	2132	0.36
Paradox	State	19-5-6	Marmaton	4153	797	0.19
Paradox	State	19-5-6	Marmaton	4080	822	0.20
Apache	State	20-5-6	Marmaton	4185	790	0.19
Apache	State	29-5-6	Marmaton	4257	865	0.20
Apache	State	29-5-6	Marmaton	4141	820	0.20
Texaco	Middleton	33-5-7	Marmaton	4213	820	0.19
Ashland	Ross	28-5-9	Marmaton	3642	737	0.20
Texaco	Carter	18-5-11	Marmaton	3884	868	0.22
Anadarko	Miller	8-5-13	Marmaton	5236	1515	0.29
Northern	Curry	10-5-20	Marmaton	5756	1862	0.32
Elder	Still	4-5-22	Marmaton	5980	1305	0.22
Elder	Beard	5-5-22	Marmaton	5434	1829	0.34
Cleary	Albert	17-5-26	Marmaton	6025	1737	0.29

Shenandoah	State	15-6-9	Marmaton	3745	798	0.21
Halliburton	Duckett	25-6-9	Marmaton	3977	824	0.21
Cities	McClung	28-6-11	Marmaton	4000	824	0.21
Republic	Witt	21-6-16	Marmaton	5445	1525	0.28
Patrick	Smith	17-6-19	Marmaton	5255	1684	0.32
Apache	Buffalow	14-6-22	Marmaton	5501	1860	0.34
Anadarko	Judy	36-6-25	Marmaton	5595	1737	0.31
Phillips	Karel	8-1-15	Miss.	6903	2750	0.40
Mid-America	Devers	28-1-24	Miss.	8900	3255	0.37
Phillips	William	34-2-25	Miss.	8480	2940	0.35
Phillips	Taft	3-2-28	Miss.	7705	2328	0.30
CSG	Stickler	6-3-21	Miss.	8043	2821	0.35
Dyco	Barr	28-4-20	Miss.	6900	2481	0.36
Smith	Kulow	33-4-20	Miss.	6600	1435	0.22
Monsanto	Beaver	1-4-23	Miss.	6554	2045	0.31
Phillips	Blakemore	6-4-23	Miss.	6624	2051	0.31
Cabot	Barby	21-4-27	Miss.	7303	1981	0.27
Cabot	Barby	21-4-27	Miss.	7224	2000	0.28
Hunt	Heglin	6-4-28	Miss.	6862	2125	0.31
Cabot	Whisenhunt	26-4-28	Miss.	6930	2140	0.31
Cities	Interstate	34-5-12	Miss.	6029	1596	0.26
Anadarko	Miller	8-5-13	Miss.	6947	2045	0.29
Petrofina	Barby	20-6-27	Miss.	6345	1751	0.28
Atlantic	Harrison	16-2-23	Missouri	6058	2184	0.36
Oil Capitol	Lamar	18-4-11	Missouri	4109	925	0.23
Castleman	Lee	1-1-8	Morrow	4970	2386	0.48
Colorado	Gowdy	11-1-9	Morrow	4687	1015	0.22
Texaco	Smith	25-1-9	Morrow	4664	1126	0.24
Phillips	Obin	26-1-15	Morrow	6696	2000	0.30
Ferguson	Thoresun	35-1-16	Morrow	6610	1879	0.28
Cities	Girouard	19-1-19	Morrow	6555	1486	0.23
Cities	Mathewson	19-1-19	Morrow	6616	1604	0.24
Calvert	James	29-1-19	Morrow	6894	1539	0.22
Horizon	Todd	9-1-20	Morrow	7069	1560	0.22
Horizon	Baker	22-1-20	Morrow	7310	1480	0.20
Hamon	Bell	24-1-20	Morrow	7481	1700	0.23
Hamon	Bell	24-1-20	Morrow	7486	1760	0.24
Atlantic	Williams	25-1-20	Morrow	7460	1750	0.23
Horizon	Lowery	26-1-20	Morrow	7305	1850	0.25
Hamon	Allen	28-1-20	Morrow	7345	1592	0.22
Hamon	Allen	28-1-20	Morrow	7308	1572	0.22
Sunray	Boese	28-1-20	Morrow	7393	1745	0.24
Hunt	Anderson	34-1-20	Morrow	7347	1750	0.24

Hamon	Miller	5-1-23	Morrow	7547	2149	0.28
Hamon	Cates	5-1-23	Morrow	7565	2111	0.28
Hamon	Cates	5-1-23	Morrow	7575	2110	0.28
Hamon	Cates	5-1-23	Morrow	7680	2265	0.29
Hamon	Smith	5-1-23	Morrow	7530	2011	0.27
Hamon	Smith	5-1-23	Morrow	7540	2066	0.27
Hamon	Cates	5-1-23	Morrow	7495	2035	0.27
Hamon	Cates	5-1-23	Morrow	7550	2202	0.29
Hamon	Cates	5-1-23	Morrow	8204	2467	0.30
Hamon	Miller	5-1-23	Morrow	7542	2070	0.27
Hamon	Miller	5-1-23	Morrow	7659	2120	0.28
United	Bedell	11-1-23	Morrow	7773	1566	0.20
Phillips	Cates	16-1-23	Morrow	8315	3274	0.39
Txo	Sam	25-1-23	Morrow	8120	2706	0.33
Hoover	Schoenhals	20-1-24	Morrow	8118	1649	0.20
Hoover	Henry	20-1-24	Morrow	8107	2103	0.26
Ferguson	Dowell	20-1-24	Morrow	8104	1795	0.22
Dyco	Getz	22-1-24	Morrow	8690	3201	0.37
Mid-America	Devers	28-1-24	Morrow	8670	3277	0.38
Humble	Bowden	7-1-25	Morrow	7856	2150	0.27
Cities	Beck	12-1-25	Morrow	7874	2176	0.28
Cities	Sanger	12-1-25	Morrow	7864	2192	0.28
Mayflo	Foster	13-1-25	Morrow	7893	2175	0.28
Pet. Inc.	Ray	15-1-25	Morrow	7925	2150	0.27
UNOCAL	Williams	29-1-25	Morrow	8504	3075	0.36
Humble	Baldwin	10-1-26	Morrow	8307	2639	0.32
Jennings	Bedell	23-1-27	Morrow	8536	3195	0.37
UNOCAL	Roach	29-1-28	Morrow	8421	3315	0.39
Cities	Inkerton	4-2-8	Morrow	4498	1080	0.24
Argonaut	Smalts	12-2-9	Morrow	4557	1239	0.27
Pioneer	Smalts	14-2-9	Morrow	4452	1268	0.28
Pioneer	Smalts	14-2-9	Morrow	4570	1351	0.30
Ambassador	Stafford	33-2-9	Morrow	4855	1198	0.25
Texaco	Sleeper	4-2-10	Morrow	5120	1278	0.25
Fitkin	Cooke	4-2-10	Morrow	5181	1108	0.21
Ferguson	Mead	5-2-10	Morrow	5142	1201	0.23
Ferguson	Hitch	8-2-10	Morrow	4950	1002	0.20
Ferguson	Hitch	8-2-10	Morrow	5082	1165	0.23
Argonaut	Treece	17-2-10	Morrow	5047	1240	0.25
Argonaut	Elliott	20-2-10	Morrow	5014	1235	0.25
Argonaut	Elliott	20-2-10	Morrow	5116	1289	0.25
Barnett	Mayer	3-2-11	Morrow	5967	1711	0.29
Cabot	Nash	5-2-15	Morrow	6801	2220	0.33

Ampeco	Hank	19-2-16	Morrow	6768	1860	0.27
Ampeco	Hitch	30-2-16	Morrow	5875	1877	0.32
Stekoll	Plynell	16-2-19	Morrow	6530	1700	0.26
Shenandoah	Stollings	16-2-19	Morrow	6539	1651	0.25
Shenandoah	Gibson	16-2-19	Morrow	6541	1668	0.26
Shenandoah	Lee	16-2-19	Morrow	6590	1693	0.26
Shenandoah	Gibson	16-2-19	Morrow	6654	1627	0.24
Graham	Joliffe	6-2-20	Morrow	6469	1545	0.24
Panhandle	Pyle	17-2-21	Morrow	7129	1717	0.24
Cabot	Sturdivant	23-2-20	Morrow	7102	1688	0.24
Cabot	Sturdivant	23-2-20	Morrow	7130	1672	0.23
Sun	Wahl	16-2-21	Morrow	7121	1315	0.18
Anadarko	Weaber	17-2-21	Morrow	7142	1587	0.22
Cities	Penner	18-2-21	Morrow	7130	1664	0.23
Bridger	Cornelsen	24-2-21	Morrow	7280	1694	0.23
Lyons	Cornell	29-2-23	Morrow	7335	2140	0.29
Walbert	Cramer	32-2-23	Morrow	7455	2145	0.29
Anadarko	Frazee	33-2-23	Morrow	7575	2235	0.30
Pet. Inc.	Woodbury	2-2-24	Morrow	7435	2210	0.30
Cities	Baggerly	3-2-24	Morrow	7347	1984	0.27
Ambassador	Eis	6-2-24	Morrow	7229	1995	0.28
Ricks	Lockhart	19-2-24	Morrow	7860	2573	0.33
Pickens	Naylor	36-2-24	Morrow	7907	2090	0.26
Apache	McCall	20-2-27	Morrow	7806	2605	0.33
Anadarko	Anderson	34-2-27	Morrow	8174	2750	0.34
Ong	Robertson	16-2-28	Morrow	7662	2650	0.35
Texaco	Conner	18-3-8	Morrow	4524	980	0.22
H&L	Omohundro	21-3-8	Morrow	4470	900	0.20
Cities	Hurst	31-3-8	Morrow	4531	997	0.22
Baker	Hanes	2-3-9	Morrow	4293	1115	0.26
Texaco	Hanes	10-3-9	Morrow	4184	900	0.22
Woods	Hanes	16-3-9	Morrow	4069	855	0.21
Argonaut	Clark	21-3-10	Morrow	5025	1176	0.23
Pet. Inc.	Cunningham	30-3-11	Morrow	5674	1457	0.26
Cities	Stonebraker	24-3-12	Morrow	6140	1513	0.25
Cities	Stonebraker	24-3-12	Morrow	6001	1410	0.23
Cities	Stonebraker	26-3-12	Morrow	6059	1234	0.20
Cities	Stonebraker	26-3-12	Morrow	6160	1644	0.27
Cities	Stonebraker	32-3-12	Morrow	6405	1778	0.28
Cities	Stonebraker	35-3-13	Morrow	6239	1486	0.24
Cities	Stonebraker	9-3-14	Morrow	6740	1954	0.29
Samedan	McNally	10-3-15	Morrow	6227	1807	0.29
Skelly	Hurliman	16-3-15	Morrow	6115	1685	0.28

Skelly	Hurliman	16-3-15	Morrow	6575	2127	0.32
Anadarko	NEHU	9-3-18	Morrow	6330	2301	0.36
Cities	Benjegerdes	3-3-23	Morrow	6902	1872	0.27
Hunt	Overton	23-3-23	Morrow	6972	2005	0.29
Sinclair	Ullrich	10-3-24	Morrow	7227	2079	0.29
Ong	Kenneck	17-3-24	Morrow	7073	2155	0.30
Anadarko	Potter	27-3-24	Morrow	7138	1645	0.23
Resources	Moore	25-4-3	Morrow	5180	2092	0.40
Paradox	Moore	28-4-3	Morrow	5344	1621	0.30
Anadarko	Gilmore	2-4-7	Morrow	4601	1026	0.22
DaMac	Shaw	27-4-9	Morrow	4431	1063	0.24
Ambassador	Cluck	29-4-9	Morrow	4467	1097	0.25
Humble	Bryan	34-4-9	Morrow	4758	933	0.20
Superior	Bryant	35-4-9	Morrow	4332	1120	0.26
Panhandle	Kelly	2-4-10	Morrow	4459	947	0.21
Ashland	Brumley	19-4-10	Morrow	4435	1115	0.25
Pet. Inc.	Williams	6-4-11	Morrow	4429	923	0.21
Cities	Buzzard	23-4-12	Morrow	6097	1249	0.20
Cities	Webb	30-4-12	Morrow	5794	1567	0.27
Bracken	Webb	30-4-12	Morrow	5865	1450	0.25
Cities	Kennedy	33-1-12	Morrow	6100	1554	0.25
Anadarko	Price	16-4-13	Morrow	6120	1604	0.26
Anadarko	Price	16-4-13	Morrow	6218	1239	0.20
Anadarko	McClelland	28-4-13	Morrow	6161	1665	0.27
Cities	Heard	3-4-14	Morrow	6175	1756	0.28
Cities	Heard	3-4-14	Morrow	6602	1922	0.29
Cities	Beer	4-4-14	Morrow	6217	1586	0.26
Stone	Long	7-4-14	Morrow	6205	1613	0.26
Anadarko	Cities	17-4-14	Morrow	6163	1528	0.25
Anadarko	Interstate	29-4-14	Morrow	6164	1568	0.25
Anadarko	Interstate	29-4-14	Morrow	6120	1546	0.25
Anadarko	Interstate	30-4-14	Morrow	6105	1775	0.29
Anadarko	Webb	31-4-14	Morrow	6560	1838	0.28
Paradox	Kessler	1-4-15	Morrow	6186	1842	0.30
Cities	Murdock	10-4-15	Morrow	6120	1602	0.26
Cities	Cooper	30-4-15	Morrow	6230	1442	0.23
Cities	Cooper	30-4-15	Morrow	6576	2021	0.31
Cities	Crump	31-4-15	Morrow	6641	2031	0.31
Shell	Long	17-4-16	Morrow	6220	1600	0.26
Shell	Fisher	20-4-16	Morrow	6565	2125	0.32
Peerless	Hoeme	20-4-17	Morrow	6255	1634	0.26
Peerless	Petrowsky	21-4-17	Morrow	6257	1634	0.26
Sohio	Balzer	26-4-17	Morrow	6290	1743	0.28

Hamilton	Yauk	27-4-17	Morrow	6608	2215	0.34
Peerless	White	30-4-17	Morrow	6248	1589	0.25
Peerless	White	30-4-17	Morrow	6552	2017	0.31
Monsanto	Beaver	1-4-23	Morrow	6283	1831	0.29
Monsanto	Beaver	1-4-23	Morrow	6457	1899	0.29
Monsanto	Dune	2-4-23	Morrow	6284	1890	0.30
Monsanto	Dune	2-4-23	Morrow	6294	1920	0.31
Cities	Miles	5-4-24	Morrow	6410	1867	0.29
Cities	Miles	15-4-24	Morrow	6630	1870	0.28
Graham	Smylie	17-4-24	Morrow	6450	1880	0.29
Kingwood	McCune	23-4-24	Morrow	6860	2150	0.31
Sinclair	Hancock	24-4-24	Morrow	6680	3350	0.50
Kerr	Thompson	36-4-24	Morrow	6961	2085	0.30
Cabot	Barby	12-4-25	Morrow	6930	2158	0.31
Cabot	Barby	15-4-25	Morrow	6863	2140	0.31
Cabot	Barby	22-4-25	Morrow	6871	2152	0.31
Cabot	Barby	20-4-26	Morrow	6932	1485	0.21
Pet. Inc.	Goodwin	9-4-27	Morrow	6978	1530	0.22
Cabot	Allen	13-4-27	Morrow	6821	2127	0.31
Cabot	Barby	21-4-27	Morrow	6280	2074	0.33
Cabot	Allen	22-4-27	Morrow	6957	1686	0.24
Sinclair	Weeks	17-4-28	Morrow	6750	2170	0.32
Cabot	Wolf	20-4-28	Morrow	6827	2189	0.32
Colorado	Conover	5-5-8	Morrow	4520	1142	0.25
Cabot	State	31-5-10	Morrow	4348	1089	0.25
Thomas	Sealey	1-5-11	Morrow	5546	1600	0.29
Harris	Oswald	3-5-11	Morrow	4750	1393	0.29
Texaco	Hamby	6-5-11	Morrow	4618	1220	0.26
Texaco	Hamby	6-5-11	Morrow	4570	1274	0.28
Pet. Inc.	Miller	7-5-11	Morrow	4640	918	0.20
BWAB	Damac	10-5-11	Morrow	4705	1097	0.23
Cities	Sleeper	11-5-11	Morrow	5606	1608	0.29
Pet. Inc.	Sleeper	11-5-11	Morrow	5663	1500	0.26
Pet. Inc.	Sleeper	11-5-11	Morrow	5957	1520	0.26
Amarex	Sleeper	22-5-11	Morrow	5630	1588	0.28
Cities	Interstate	25-5-11	Morrow	5545	1530	0.28
Vanderbilt	Addington	30-5-11	Morrow	4377	1206	0.28
Vanderbilt	Addington	31-5-11	Morrow	4412	1190	0.27
DaMac	Addington	31-5-11	Morrow	4299	1113	0.26
Ladd	Iclo	33-5-11	Morrow	5336	1460	0.27
Cities	Interstate	34-5-11	Morrow	5483	1525	0.28
Anadarko	Pollock	4-5-12	Morrow	5654	1678	0.30
Anadarko	Phillips	5-5-12	Morrow	6032	1546	0.26

PEPL	Hensley	6-5-12	Morrow	5590	1260	0.23
PEPL	Hensley	6-5-12	Morrow	5667	1580	0.28
PEPL	Hensley	6-5-12	Morrow	5879	1500	0.26
PEPL	Woodward	9-5-12	Morrow	5665	1650	0.29
Anadarko	Biggs	9-5-12	Morrow	5880	1488	0.25
Republic	Finfrock	2-5-13	Morrow	6118	1615	0.26
Republic	Talbot	2-5-13	Morrow	6110	1590	0.26
Republic	Talbot	2-5-13	Morrow	6145	1620	0.26
Republic	Langston	4-5-13	Morrow	6103	1635	0.27
Republic	Langston	4-5-13	Morrow	6435	1895	0.29
Republic	Welch	9-5-13	Morrow	6160	1650	0.27
Republic	Wilson	9-5-13	Morrow	6170	1565	0.25
Republic	Week	10-5-13	Morrow	6155	1550	0.25
Republic	Week	10-5-13	Morrow	6550	1955	0.30
Republic	Blake	11-5-13	Morrow	6120	1595	0.26
Republic	Blake	11-5-13	Morrow	6500	1910	0.29
Republic	Ferguson	13-5-13	Morrow	6184	1655	0.27
Republic	Ferguson	13-5-13	Morrow	6214	1635	0.26
Cities	Schmalfdt	19-5-13	Morrow	6055	1528	0.25
Graham	Walter	24-5-13	Morrow	6190	1627	0.26
Republic	Horner	24-5-13	Morrow	6180	1615	0.26
Republic	Witt	26-5-13	Morrow	6111	1910	0.31
Republic	Price	27-5-13	Morrow	6184	1617	0.26
Cities	Hinds	29-5-13	Morrow	6166	1654	0.27
Cities	Bollinger	29-5-13	Morrow	6140	1695	0.28
Republic	Cities	32-5-13	Morrow	6135	1645	0.27
Republic	Cities	32-5-13	Morrow	6128	1595	0.26
Republic	Cities	32-5-13	Morrow	6284	1725	0.27
Republic	Lunsford	33-5-13	Morrow	6149	1605	0.26
Mobil	Mitchell	35-5-13	Morrow	6169	1642	0.27
Mobil	Miller	24-5-14	Morrow	6211	1372	0.22
Cities	Blake	1-5-15	Morrow	6220	1652	0.27
Cities	Humble	2-5-15	Morrow	6133	1670	0.27
Cities	Humble	2-5-15	Morrow	6212	1714	0.28
Cities	Humble	2-5-15	Morrow	6595	1922	0.29
Cities	Symunds	3-5-15	Morrow	6170	1450	0.24
Cities	Symunds	3-5-15	Morrow	6280	1436	0.23
Cities	Jackson	4-5-15	Morrow	6245	1722	0.28
Cities	Jackson	4-5-15	Morrow	6163	1672	0.27
Cities	Gibson	10-5-15	Morrow	6157	1714	0.28
Cities	Symunds	11-5-15	Morrow	6223	1722	0.28
Cities	Symunds	11-5-15	Morrow	6343	1652	0.26
Cities	Symunds	12-5-15	Morrow	6201	1638	0.26

Cities	Myers	13-5-15	Morrow	6200	1588	0.26
Cities	Symonds	14-5-15	Morrow	6180	1756	0.28
Cities	Symonds	14-5-15	Morrow	6280	1688	0.27
Cities	Symonds	15-5-15	Morrow	6175	1620	0.26
Cities	Hier	21-5-15	Morrow	6126	1972	0.32
Cities	Wilson	22-5-15	Morrow	6150	1706	0.28
Cities	Wilson	24-5-15	Morrow	6198	1680	0.27
Cities	Wilson	27-5-15	Morrow	6143	1702	0.28
Cities	Hinds	28-5-15	Morrow	6160	1652	0.27
Cities	Wilson	34-5-15	Morrow	6117	1750	0.29
Pet. Inc.	Howell	21-5-16	Morrow	6140	1662	0.27
Anadarko	Ogletree	1-5-19	Morrow	6062	1770	0.29
Harper	Schmidt	12-5-21	Morrow	6574	1188	0.18
Humble	Buffalow	4-5-23	Morrow	6442	2136	0.33
Humble	Buffalow	4-5-23	Morrow	6403	2101	0.33
Kerr	Underwood	9-5-23	Morrow	6484	2150	0.33
Cities	Miles	31-5-24	Morrow	6574	2040	0.31
Sinclair	Maple	35-5-24	Morrow	6742	2029	0.30
Maguire	Kamas	3-5-25	Morrow	6515	2085	0.32
Maguire	Kamas	12-5-25	Morrow	6616	1974	0.30
Cabot	Barby	13-5-26	Morrow	6700	2078	0.31
Cabot	Barby	16-5-26	Morrow	6761	2185	0.32
Kingwood	Sheppard	15-5-27	Morrow	6455	1910	0.30
Cabot	Hamilton	18-5-27	Morrow	6683	2140	0.32
United	Maphet	20-5-27	Morrow	6660	2089	0.31
PEPL	Allen	21-5-27	Morrow	6561	2135	0.33
Kerr	Dixon	28-5-27	Morrow	6739	2195	0.33
Jones	State	15-6-5	Morrow	5323	1134	0.21
Carey	Mathis	13-6-8	Morrow	4662	890	0.19
Anadarko	Quigley	23-6-10	Morrow	4462	1253	0.28
Pet. Inc.	Quigley	25-6-10	Morrow	4565	1111	0.24
Pet. Inc.	Quigley	25-6-10	Morrow	4590	1180	0.26
Pet. Inc.	Horner	25-6-10	Morrow	4534	1251	0.28
Pet. Inc.	Horner	25-6-10	Morrow	4609	1273	0.28
Brown	Niles	32-6-10	Morrow	4310	1089	0.25
Graham	State	36-6-10	Morrow	4526	1255	0.28
Graham	Dively	36-6-10	Morrow	4547	1467	0.32
Century	McClanahan	21-6-10	Morrow	4460	940	0.21
Anadarko	Davis	23-6-10	Morrow	4462	1253	0.28
Anadarko	Davis	23-6-10	Morrow	4476	1300	0.29
Anadarko	Webster	25-6-10	Morrow	4580	1233	0.27
Pet. Inc.	Quigley	25-6-10	Morrow	4590	1180	0.26
Pet. Inc.	Horner	25-6-10	Morrow	4534	1235	0.27

Pet. Inc.	Horner	25-6-10	Morrow	4609	1240	0.27
Brown	Niles	32-6-10	Morrow	4310	1086	0.25
Graham	State	36-6-10	Morrow	4526	1240	0.27
Graham	Diveley	36-6-10	Morrow	4547	1467	0.32
Cox	Williams	13-6-11	Morrow	4530	1288	0.28
Cox	State	16-6-11	Morrow	4580	1320	0.29
Atlantic	McClung	18-6-11	Morrow	4444	1250	0.28
Atlantic	McClung	18-6-11	Morrow	4454	1245	0.28
Graham	Cheeley	19-6-11	Morrow	4580	1261	0.28
Graham	Tucker	19-6-11	Morrow	4474	1200	0.27
Graham	Walker	19-6-11	Morrow	4490	1270	0.28
Cities	Denny	21-6-11	Morrow	4606	1350	0.29
Hendrick	Sleeper	22-6-11	Morrow	4605	1370	0.30
Cities	McClung	28-6-11	Morrow	4575	1230	0.27
Cities	McClung	28-6-11	Morrow	4700	1315	0.28
Cities	McClung	28-6-11	Morrow	4970	999	0.20
Cities	McClung	29-6-11	Morrow	4584	1094	0.24
Cities	McClung	29-6-11	Morrow	4670	1094	0.23
Cities	Loofburrow	29-6-11	Morrow	4680	1100	0.24
Cities	Roofner	29-6-11	Morrow	4624	1260	0.27
Cities	Roofner	29-6-11	Morrow	4695	1195	0.25
Cities	Roofner	29-6-11	Morrow	4900	1020	0.21
Cities	Loofburrow	29-6-11	Morrow	4680	1100	0.24
Cities	McClung	29-6-11	Morrow	4685	1230	0.26
Champlin	Hawkins	29-6-11	Morrow	4540	1215	0.27
Champlin	Hawkins	29-6-11	Morrow	4608	1225	0.27
Pet. Inc.	Denning	30-6-11	Morrow	4600	1305	0.28
Texaco	Palmer	31-6-11	Morrow	4525	1375	0.30
Texaco	Hamby	31-6-11	Morrow	4598	1375	0.30
Texaco	Graves	31-6-11	Morrow	4536	1300	0.29
Cox	Hopps	32-6-11	Morrow	4680	1215	0.26
Pet. Inc.	Green	33-6-11	Morrow	4830	1102	0.23
Resources	Hershberger	35-6-11	Morrow	5075	1141	0.22
Cities	Hicks	13-6-12	Morrow	5958	982	0.16
Cities	Hicks	13-6-12	Morrow	6346	1804	0.28
H&L	McClure	30-6-12	Morrow	5890	1472	0.25
H&L	Drosselmyr	34-6-12	Morrow	5986	1296	0.22
Anadarko	Hicks	18-6-13	Morrow	6377	1796	0.28
Anadarko	Lynch	20-6-13	Morrow	4957	1300	0.26
Anadarko	Mowbray	28-6-13	Morrow	4791	1440	0.30
Hamilton	Roesler	29-6-13	Morrow	6466	1875	0.29
Republic	Wiegel	18-6-16	Morrow	6530	1705	0.26
Republic	Witt	21-6-16	Morrow	6420	2017	0.31

Republic	Witt	21-6-16	Morrow	6540	1997	0.31
Republic	Swinger	32-6-16	Morrow	6874	1702	0.25
Pet. Inc.	Cook	14-6-20	Morrow	6163	1320	0.21
Anadarko	Pryor	16-6-22	Morrow	6327	1970	0.31
Ridgeway	Taylor	17-6-22	Morrow	6365	2000	0.31
Mayflo	Flanigan	27-6-22	Morrow	6303	2065	0.33
Apache	Blucher	28-6-22	Morrow	6102	1905	0.31
Elder	Simmons	25-6-23	Morrow	6080	1934	0.32
Unit	Roepke	19-6-24	Morrow	6080	1974	0.32
First	Adams	24-6-24	Morrow	6062	2051	0.34
Allied	Hodges	27-6-24	Morrow	6265	2092	0.33
Pioneer	Girk	34-6-24	Morrow	6220	2000	0.32
Petrofina	Barby	20-6-27	Morrow	6094	2090	0.34
Huber	Shaffer	22-6-27	Morrow	6097	2150	0.35
Huber	Shaffer	22-6-27	Morrow	6152	2126	0.35
Petrofina	Dyer	29-6-27	Morrow	6158	2147	0.35
Petrofina	Sutherland	30-6-27	Morrow	6210	1798	0.29
Phillips	Karel	8-1-15	Neva	3370	648	0.19
Argonaut	Elliott	20-2-10	Neva	3554	589	0.17
Paradox	Lively	15-4-8	Neva	4420	854	0.19
Phillips	Dakar	4-1-15	Oswego	5715	1735	0.30
Phillips	Bobarr	27-1-15	Oswego	5800	1926	0.33
Hunt	Anderson	34-1-20	Oswego	6462	2280	0.35
Phillips	Florence	26-2-14	Oswego	5730	1808	0.32
Kimbell	Gray	16-2-16	Oswego	5890	1432	0.24
Zoller	Messner	30-2-28	Oswego	6703	2600	0.39
Sinclair	Overton	13-3-23	Oswego	6320	2240	0.35
Monsanto	Beaver	1-4-23	Oswego	5789	1746	0.30
Cabot	Davis	21-4-25	Oswego	5895	2105	0.36
Elder	Beard	5-5-22	Oswego	5908	1306	0.22
Mobil	Smith	27-6-20	Oswego	5760	1942	0.34
Kerr	Adams	36-6-24	Oswego	5622	1763	0.31
Bradley	McDonald	18-1-20	Purdy	7140	1529	0.21
Dyco	McDonald	30-3-8	Purdy	4574	1016	0.22
Dyco	Matheson	30-3-8	Purdy	4518	1016	0.22
First Nat.	Pugh	17-5-8	Purdy	4515	721	0.16
Cotton	Lee	8-5-10	Purdy	4430	1100	0.25
Cotton	Lee	8-5-10	Purdy	4259	1084	0.25
Morgan	Reiss	11-5-10	Purdy	4513	1101	0.24
Texaco	State	35-5-10	Purdy	4309	1065	0.25
Hawkins	Brewer	21-5-11	Purdy	5625	1039	0.18
Colorado	Schoolfield	18-6-9	Purdy	4365	995	0.23
Texaco	Pack	14-1-9	Red Cave	1694	510	0.30

Texaco	Hawkins	26-1-9	Red Cave	1770	460	0.26
Cities	Inkerton	4-2-8	Red Cave	1758	385	0.22
Pan Eastern	State	6-2-9	Red Cave	1725	485	0.28
Allied	Patterson	15-3-8	Red Cave	2698	870	0.32
Daube	Gardner	34-3-8	Red Cave	1750	410	0.23
Cities	Murdock	10-4-15	Red Cave	1758	758	0.43
Republic	Week	10-5-13	Red Cave	1833	600	0.33
Massed	Elliott	21-2-10	Shawnee	3501	636	0.18
Cabot	Barby	28-4-26	St. Gen.	7725	2382	0.31
Shenandoah	Sharp	18-5-20	St. Gen.	6860	2281	0.33
Cities	Inkerton	4-2-8	St. Louis	5034	1695	0.34
Anadarko	Johnson	7-3-22	St. Louis	7754	2730	0.35
Energy	Foreman	3-4-11	St. Louis	6280	1614	0.26
Shenandoah	Blakemore	8-4-22	St. Louis	7412	2570	0.35
First Nat.	Pugh	17-5-8	St. Louis	4999	852	0.17
Cabot	State	30-5-10	St. Louis	5000	1032	0.21
Pet. Inc.	Parks	25-5-19	St. Louis	7087	2402	0.34
Anadarko	Slatten	23-5-20	St. Louis	7180	2333	0.32
Eisner	Adams	13-6-24	St. Louis	6513	2204	0.34
Cities	Girk	35-6-24	St. Louis	6690	2213	0.33
Kerr	Adams	36-6-24	St. Louis	6617	2128	0.32
Hall	Gheen	23-1-24	Tonkawa	6130	1740	0.28
Mid-America	Devers	28-1-24	Tonkawa	6150	2011	0.33
Mid-America	Sweet	33-1-24	Tonkawa	6169	1825	0.30
Cities	Mercer	1-1-25	Tonkawa	6025	1876	0.31
Sunray	Robins	11-1-25	Tonkawa	6005	1908	0.32
Cities	Sanger	12-1-25	Tonkawa	5965	1926	0.32
Humble	Bechtold	13-1-25	Tonkawa	5989	1968	0.33
Pet. Inc.	Ray	15-1-25	Tonkawa	5975	1911	0.32
Phillips	Custer	21-1-25	Tonkawa	6083	2022	0.33
UNOCAL	Mercer	22-1-25	Tonkawa	6167	1912	0.31
UNOCAL	Mercer	27-1-25	Tonkawa	6187	1981	0.32
Pet. Inc.	Helfenbein	28-1-25	Tonkawa	6068	1930	0.32
Pet. Inc.	Koch	28-1-25	Tonkawa	6150	1917	0.31
Pet. Inc.	Koch	28-1-25	Tonkawa	6160	2020	0.33
Cities	Davis	30-1-25	Tonkawa	6079	1944	0.32
Biddick	Harper	35-1-25	Tonkawa	6136	1910	0.31
Falcon	Nicholson	29-1-26	Tonkawa	6101	1910	0.31
Falcon	Nicholson	29-1-26	Tonkawa	6104	2061	0.34
Falcon	House	32-1-26	Tonkawa	6125	2095	0.34
Apache	Nicholson	33-1-26	Tonkawa	6130	2064	0.34
Jennings	Bedell	23-1-27	Tonkawa	6350	2085	0.33
Phillips	Lips	5-1-28	Tonkawa	6090	1838	0.30

Mayflo	Jones	25-2-25	Tonkawa	5993	2100	0.35
Sunray	Fry	5-2-26	Tonkawa	5783	1845	0.32
Shell	Miller	6-2-26	Tonkawa	5757	1840	0.32
Pet. Inc.	Nelson	7-2-26	Tonkawa	5760	1860	0.32
Harper	Jones	10-2-26	Tonkawa	5815	1875	0.32
Colorado	Motern	11-2-26	Tonkawa	5745	1888	0.33
Cabot	Barby	4-2-27	Tonkawa	5743	1873	0.33
Shenandoah	Barby	5-2-27	Tonkawa	5760	1810	0.31
Cabot	Barby	8-2-27	Tonkawa	5666	1830	0.32
Txo	Barby	9-2-27	Tonkawa	5800	1845	0.32
Sinclair	Armstrong	16-2-27	Tonkawa	5672	1895	0.33
Northern	Stabler	32-2-27	Tonkawa	5830	1845	0.32
Cities	Fickel	12-3-24	Tonkawa	5393	1760	0.33
Cabot	Barby	1-3-26	Tonkawa	5400	1782	0.33
Natural Gas	Hester	35-3-26	Tonkawa	5765	1604	0.28
Cabot	Barby	7-3-27	Tonkawa	5444	1803	0.33
Bridger	Long	17-3-27	Tonkawa	5492	1799	0.33
Colorado	Armagest	27-3-27	Tonkawa	5657	1740	0.31
Colorado	Haskell	35-3-27	Tonkawa	5695	1845	0.32
Marlin	Bedell	20-3-28	Tonkawa	5591	1763	0.32
Cabot	Barby	36-4-26	Tonkawa	5285	1803	0.34
Cabot	Barby	28-4-27	Tonkawa	5438	1797	0.33
Cabot	Barby	29-4-27	Tonkawa	5330	1825	0.34
Cabot	Barby	32-4-27	Tonkawa	5395	1824	0.34
Shenandoah	Spence	13-1-9	Topeka	3387	465	0.14
Argonaut	Rowan	1-2-9	Topeka	3303	475	0.14
Argonaut	Smalts	12-2-9	Topeka	3355	519	0.15
Service	Castleman	16-2-9	Topeka	3445	540	0.16
Texaco	Dencker	27-2-9	Topeka	3438	520	0.15
Ferguson	Hitch	8-2-10	Topeka	3560	632	0.18
Cities	State	29-2-11	Topeka	3622	641	0.18
Texaco	Hanes	10-3-9	Topeka	3292	505	0.15
Argonaut	Clark	21-3-10	Topeka	3406	474	0.14
Cities	Stonebraker	9-3-14	Topeka	4000	866	0.22
Cities	Stonebraker	9-3-14	Topeka	4095	914	0.22
Ashland	Brumley	19-4-10	Topeka	3180	415	0.13
Cities	Quinn	27-4-15	Topeka	3700	756	0.20
Cities	Sparkman	10-5-9	Topeka	3250	446	0.14
Anadarko	Carter	1-5-10	Topeka	3165	421	0.13
Halliburton	Duckett	25-6-9	Topeka	3052	450	0.15
Texaco	Schrauner	13-6-10	Topeka	3180	460	0.14
Anadarko	Boaldin	20-6-10	Topeka	2995	469	0.16
Anadarko	Quigley	23-6-10	Topeka	3059	415	0.14

Pet. Inc.	Quigley	25-6-10	Topeka	3105	460	0.15
Texaco	Schrauner	13-6-10	Topeka	3180	460	0.14
Anadarko	Boaldin	20-6-10	Topeka	2995	469	0.16
Anadarko	Welsh	21-6-10	Topeka	3055	440	0.14
Pet. Inc.	Quigley	25-6-10	Topeka	3215	470	0.15
Pet. Inc.	Quigley	25-6-10	Topeka	3105	460	0.15
Hendrick	Reiss	15-6-11	Topeka	3110	490	0.16
Hendrick	Reiss	15-6-11	Topeka	3180	485	0.15
Cox	State	16-6-11	Topeka	3160	485	0.15
Graham	Tucker	18-6-11	Topeka	3109	490	0.16
Cities	Denny	21-6-11	Topeka	3100	440	0.14
Hendrick	Sleeper	22-6-11	Topeka	3128	450	0.14
Hendrick	Heatley	24-6-11	Topeka	3320	460	0.14
Hendrick	Richterberg	26-6-11	Topeka	3270	460	0.14
Cities	Reiss	27-6-11	Topeka	3155	440	0.14
Cities	McClung	28-6-11	Topeka	3145	454	0.14
Cities	McClung	29-6-11	Topeka	3090	440	0.14
Cities	Roofner	29-6-11	Topeka	3111	480	0.15
Cox	Hopps	32-6-11	Topeka	3150	440	0.14
Pet. Inc.	Green	33-6-11	Topeka	3190	437	0.14
Kickapoo	State	36-6-11	Topeka	3331	455	0.14
Kickapoo	State	36-6-11	Topeka	3480	505	0.15
Cities	Ellis	18-6-12	Topeka	3260	470	0.14
Cities	Davis	30-1-25	Toronto	5705	1586	0.28
Aycock	Fry	18-2-11	Toronto	4058	780	0.19
Tuthill	Sellens	8-3-9	Toronto	3488	530	0.15
Cox	Mensch	11-3-11	Toronto	4186	910	0.22
Cities	Stonebraker	9-3-14	Toronto	4410	1010	0.23
Pet. Inc.	State	34-3-14	Toronto	4330	1191	0.28
Cities	Schnurr	35-3-14	Toronto	4321	1062	0.25
American	Grounds	13-4-19	Toronto	4541	1632	0.36
Cabot	Barby	35-4-26	Toronto	4900	1605	0.33
Cabot	Barby	20-4-27	Toronto	5060	1548	0.31
Cities	Whisennand	1-5-9	Toronto	3389	519	0.15
Cabot	Hodges	2-5-24	Toronto	4750	1124	0.24
Eisner	Adams	13-6-24	Toronto	4560	1375	0.30
Elder	Adams	16-6-24	Toronto	4490	1254	0.28
Hamilton	Allen	26-4-5	Tubb	1996	440	0.22
Ambassador	Cluck	29-4-9	Tubb	1745	443	0.25
Baker	Hinds	33-6-8	Tubb	1726	430	0.25
Graham	Barnum	30-1-19	U. Morrow	6704	1592	0.24
Cabot	Mills	1-1-20	U. Morrow	7282	1700	0.23
Shenandoah	Kerns	1-1-20	U. Morrow	7243	1659	0.23

Hall	Gheen	23-1-24	U. Morrow	8156	2744	0.34
UNOCAL	Mercer	15-1-25	U. Morrow	8006	2225	0.28
Cities	Harper	8-2-8	U. Morrow	4525	966	0.21
Cities	Harper	8-2-8	U. Morrow	4580	974	0.21
Sun	Sargent	13-2-20	U. Morrow	6898	1429	0.21
Brewer	Reimann	15-2-20	U. Morrow	6873	1300	0.19
Mid-America	Ratzlaff	27-2-20	U. Morrow	7017	1729	0.25
Mid-America	Muse	33-2-20	U. Morrow	7050	1679	0.24
Kingwood	Just	1-2-21	U. Morrow	7185	3290	0.46
Buchanan	Heier	14-2-21	U. Morrow	7220	1584	0.22
Mid-America	Bartel	17-2-23	U. Morrow	7325	2066	0.28
Mid-America	Bartel	18-2-23	U. Morrow	7298	2187	0.30
Lyons	Cornell	29-2-23	U. Morrow	7288	2145	0.29
Aycock	Gowdy	24-3-10	U. Morrow	5585	2680	0.48
Pet. Inc.	Brecheisen	29-3-15	U. Morrow	6301	1717	0.27
Ambassador	Weins	4-3-18	U. Morrow	6318	1774	0.28
Ambassador	Weins	4-3-18	U. Morrow	6328	1735	0.27
Ambassador	Weins	10-3-18	U. Morrow	6352	1723	0.27
NRM	Ferguson	7-3-25	U. Morrow	7120	2541	0.36
Anadarko	Burton	30-4-9	U. Morrow	4410	968	0.22
Oil Capitol	White	15-4-10	U. Morrow	4262	1110	0.26
Cities	Stelzer	15-4-14	U. Morrow	6265	1615	0.26
Shell	Finfrock	12-4-16	U. Morrow	6542	2050	0.31
Mid-America	Gregg	26-4-23	U. Morrow	6572	1355	0.21
King	Phelps	29-4-23	U. Morrow	6653	1771	0.27
Mid-America	Phelps	29-4-23	U. Morrow	6680	1722	0.26
Sinclair	McGrew	26-4-24	U. Morrow	6737	2070	0.31
Texaco	Carter	18-5-11	U. Morrow	4549	1336	0.29
Consol.	Whisenhand	20-5-11	U. Morrow	4590	1216	0.26
Cities	Dailey	17-5-15	U. Morrow	6185	1672	0.27
Marsh	Davis	22-5-16	U. Morrow	6110	1680	0.27
Eisner	Barby	24-5-26	U. Morrow	6784	2145	0.32
Century	McClanahan	21-6-10	U. Morrow	4460	940	0.21
Smith	State	25-4-20	Viola	7963	2757	0.35
Aikman	Briggeman	21-6-17	Viola	7770	2524	0.32
Cities	Stonebraker	9-3-14	Wabaunsee	3443	620	0.18
Allred	Purdy	19-6-9	Wabunsee	2889	344	0.12
Phillips	Reust	20-1-15	Wr-C. G.	3105	645	0.21
Humble	Lehmann	31-1-20	Wreford	3585	820	0.23
Anadarko	Frazee	33-2-23	Wreford	3663	1000	0.27

APPENDIX B

RESERVOIR PRESSURE DATA CALCULATED FROM FROM STATIC INITIAL WELLHEAD SHUT-IN PRESSURES

APPENDIX B KEY

1. Operator: Petroleum company that drilled the well providing the DST data

2. Farm: Lease or well name

3. Location: Legal location given by Section(S), Township(T), and Range(R). All townships are north of the Panhandle Base Line and all ranges are east of the Cimarron Meridian.

4. Depth: Depth to the base of the perforated (screened) interval

5. Interval: Name of reservoir that was perforated and completed to flow gas (producing reservoir)

6. Gr.: Specific gravity of the produced gas

7. WHSIP: Static shut-in pressure measured at the wellhead when the well was completed

8. BHP: Bottom-hole (reservoir) pressure calculated from WHSIP, weight of gas column in pipe, compressibility, and temperature

9. P-D Gradient: Pressure-depth gradient calculated by dividing reservoir pressure (BHP) by depth

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Cabot	Morgan	1-1-20	7752	Chester	.64	1713	2116	0.27
Oxy	Allen	2-1-20	7630	L. Morrow	.70	1551	1975	0.26
Kaiser	Cowan	4-1-20	7406	M. Morrow	.71	1689	2132	0.29
Sparks	Todd	5-1-20	6936	U. Morrow	.71	1379	1708	0.25
Hondo	State A	6-1-20	6852	U. Morrow	.71	1459	1805	0.26
Hondo	Flowers A	7-1-20	6937	U. Morrow	.71	1400	1736	0.25
Hondo	Flowers B	8-1-20	7318	Morrow	.71	1461	1837	0.25
Panhandle	Helflnbn	10-1-20	7759	Chester	.67	1346	1704	0.22
Kimball	Lowery	11-1-20	7720	L. Morrow	.77	1408	1780	0.23
Oryx	Wood	12-1-20	7868	Mor-Chest.	.68	1644	2100	0.27
Oryx	McCarter	13-1-20	7404	U. Morrow	.70	1392	1746	0.24
Oryx	McCarter	13-1-20	7910	Chester	.62	1595	2042	0.26
Panhandle	Vogt	15-1-20	7743	Chester	.62	1370	1738	0.22
Abercrombie	Hamilton C	16-1-20	7178	U. Morrow	.62	1248	1551	0.22
Abercrombie	Hamilton T	16-1-20	7531	Morrow	.70	1480	1877	0.25
Arco	Bryan	17-1-20	7380	Morrow	.70	1569	1973	0.27
Hondo	State B	18-1-20	6978	U. Morrow	.72	1379	1711	0.25
Exxon	Campbell	19-1-20	7412	Morrow	.67	1859	2317	0.31
Arco	McDonald	20-1-20	7435	Morrow	.67	1792	2277	0.31
Oxy	Smart	21-1-20	7626	Morrow	.70	1790	2283	0.30
Unit	Williams	26-1-20	7684	Morrow	.70	1475	1899	0.25
Exxon	Collins	27-1-20	7698	Morrow	.68	1601	2035	0.26
Phillips	York	29-1-20	7469	Morrow	.69	2103	2686	0.36
Exxon	Lehman	30-1-20	7478	Morrow	.70	1998	2558	0.34
Hawkins	Apple	32-1-20	7574	Morrow	.67	1940	2488	0.33
Arco	Bransgrove	33-1-20	7698	Morrow	.67	1644	2126	0.28
Hunt	Anderson	34-1-20	7722	Morrow	.67	1991	2545	0.33
Cross Timb.	Sager	35-1-20	7461	Morrow	.67	1768	2258	0.30
Exxon	Sager	35-1-20	7461	Morrow	.67	1768	2258	0.30
Cross Timb.	Sims	36-1-20	7840	Morrow	.63	2022	2547	0.32
Berexco	Delk	1-1-21	8505	Chester	.65	2408	3043	0.36
Texaco	Bell	3-1-21	7777	Morrow	.68	1745	2231	0.29
Heading.	Wilson	5-1-21	7672	Morrow	.68	1712	2181	0.28
Crawley	Gray	7-1-21	7889	Chest/Mor	.63	1338	1644	0.21
Kaiser	Sargent	8-1-21	7436	Morrow	.66	1481	1840	0.25
Anadarko	Seago	9-1-21	7766	Morrow	.73	1482	1906	0.25
Apache	Franz	10-1-21	7943	L. Morrow	.66	1500	1877	0.24
Petrocorp	Bechtold	12-1-21	7930	Chester	.66	1319	1652	0.21
Universal	Weaber	13-1-21	7903	Morrow	.63	1809	2267	0.29
Tipco	Pribble	14-1-21	7860	Morrow	.67	1699	2158	0.27
Oryx	Bartel	17-1-21	7916	Morrow	.72	1662	2154	0.27
Oryx	Brown	18-1-21	7840	Morrow	.73	1646	2148	0.27
Oryx	Sims	20-1-21	7436	Morrow	.70	1689	2137	0.29
Zinke	Mounts	21-1-21	7986	Morrow	.70	1641	2133	0.27
Vintage	Weaber	24-1-21	7940	Morrow	.66	1770	2242	0.28
Oryx	Palmer	28-1-21	8066	Morrow	.72	1553	2036	0.25

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Pardee	Sims	29-1-21	7992	Morrow	.71	1604	2065	0.26
Exxon	Gray	34-1-21	8134	Morrow	.70	1667	2155	0.26
Kennedy	Fronk	1-1-22	8484	Chester	.62	2272	2860	0.34
Kennedy	Saunders	3-1-22	8200	Chester	.62	2415	2985	0.36
Hawkins	Stewart	7-1-22	8676	Chester	.64	2531	3216	0.37
New Lond.	Clenney	12-1-22	8536	Chester	.64	2378	3005	0.35
Skelly	Wilson	19-1-22	8020	Morrow	.66	1800	2264	0.28
Blackjack	Noe	20-1-22	7992	Morrow	.64	1712	2127	0.27
Maxus	Naylor	28-1-22	8603	Chester	.62	2249	2808	0.33
Maxus	Weaber	28-1-22	8030	Morrow	.67	1443	1824	0.23
H&L	Padget	29-1-22	8000	Morrow	.65	1464	1820	0.23
H&L	West	30-1-22	7994	L. Morrow	.67	1723	2178	0.27
Nat. Gas	Zenith	32-1-22	8082	L. Morrow	.66	1774	2236	0.28
Buttonwood	Long	33-1-22	8053	Morrow	.64	1585	1989	0.25
Caspen	Mitchel	3-1-23	7644	Morrow	.66	1682	2151	0.28
Kennedy	Clenney	6-1-23	8642	Chester	.62	2354	2954	0.34
Ricks	Buechner	7-1-23	8846	Chester	.65	2335	2991	0.34
Falcon	Cates	8-1-23	8796	Chester	.62	2325	2916	0.33
Phillips	Fowler	9-1-23	7792	Morrow	.65	1676	2137	0.27
Helendale	Cates	16-1-23	8369	Morrow	.63	2511	3153	0.38
Petrodyn.	Dragoun	20-1-23	8277	Morrow	.67	2460	3147	0.38
Falcon	Ogilvie	22-1-23	7890	Morrow	.71	1820	2341	0.30
Coastal	Horton	24-1-23	7968	Morrow	.70	1836	2379	0.30
TXO	Sam	25-1-23	9438	Chester	.65	2348	3050	0.32
Exxon	Hoover	4-1-24	7835	Morrow	.65	1585	2032	0.26
Exxon	Williams	4-1-24	8490	Morrow	.65	2462	3185	0.38
Anson	Simpson	4-1-24	8260	Morrow	.71	2102	2752	0.33
Anson	Marshall	6-1-24	8098	Morrow	.71	1995	2617	0.32
Thomas	Jenkins	9-1-24	8047	Morrow	.71	2165	2797	0.35
Cimarron	Winters	11-1-24	7792	Morrow	.65	1378	1703	0.22
Texaco	Winters	11-1-24	3938	C. Grove	.74	718	870	0.22
Cleary	Bowden	12-1-24	5525	Douglas	.73	1540	1849	0.33
Cabot	Howard	13-1-24	5954	Tonkawa	.66	1650	1780	0.30
Grace	Gheen	14-1-24	5594	Douglas	.70	1590	1898	0.34
Coastal	Gheen	23-1-24	8154	Morrow	.65	1798	2276	0.28
Union	Anderson	24-1-24	5999	Tonkawa	.71	1617	1947	0.32
Universal	Meier	25-1-24	6025	Tonkawa	.65	1564	1889	0.31
Sun	Larson	26-1-24	6106	Tonkawa	.68	1606	1939	0.32
Texstar	Devers	28-1-24	6114	Tonkawa	.66	1615	1960	0.32
May	Fry	34-1-24	6112	Tonkawa	.66	1587	1916	0.31
Beeler	Wood	36-1-24	6023	Tonkawa	.68	1645	1987	0.33
LVO	Altmiller	2-1-25	5974	Tonkawa	.68	1602	1952	0.33
Dillon	Miller	3-1-25	6040	Tonkawa	.68	1589	1926	0.32
Amoco	Hildebrand	4-1-25	6005	Tonkawa	.70	1630	1977	0.33
Pet. Inc.	Cook	5-1-25	5534	Cisco	.70	1542	1856	0.34
Kaiser	Palmer	6-1-25	5543	Cisco	.69	1473	1775	0.32

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Exxon	Bowden	7-1-25	5568	Cisco	.67	1484	1786	0.32
Pet. Inc.	Bowden	7-1-25	7891	Morrow	.65	1626	2058	0.26
Amoco	Haines	8-1-25	5918	Tonkawa	.66	1592	1899	0.32
Amoco	Haines	8-1-25	7864	Morrow	.66	1613	2030	0.26
Amoco	Custer	9-1-25	7884	Morrow	.66	1601	2043	0.26
Amoco	Custer	9-1-25	5906	Tonkawa	.64	1625	1966	0.33
Oxy	Sanger	12-1-25	7864	Morrow	.64	1604	2039	0.26
Phillips	Gilger	12-1-25	7863	Morrow	.61	1640	2074	0.26
Anadarko	Ray	15-1-25	5903	Tonkawa	.64	1585	1914	0.32
Shell	Custer	16-1-25	5942	Tonkawa	.67	1639	1982	0.33
Phillips	Mahaffey	17-1-25	8446	Chester	.61	2273	2831	0.34
Cabot	Mahaffey	18-1-25	5990	Tonkawa	.64	1615	1939	0.32
Cabot	Mahaffey	18-1-25	5554	Cisco	.67	1441	1721	0.31
Cabot	Mahaffey	18-1-25	8442	Mor/Chest.	.60	2297	2845	0.34
Phillips	Mein	19-1-25	6065	Tonkawa	.67	1637	1988	0.33
Phillips	KNowles	20-1-25	8483	Morrow	.68	2598	3349	0.39
Natomas	Depew	26-1-25	6094	Tonkawa	.67	1620	1989	0.33
Natomas	Depew	26-1-25	6191	Tonkawa	.67	1691	2080	0.34
Unocal	William	29-1-25	8504	Morrow	.59	2515	3099	0.36
Oxy	Davis	30-1-25	6064	Tonkawa	.64	1614	1968	0.32
McGee	McClury	1-1-26	8135	Morrow	.70	2091	2705	0.33
Exxon	Baldwin	10-1-26	8305	Morrow	.67	2308	2935	0.35
Presidio	Bourquin	13-1-26	8438	Morrow	.67	2205	2828	0.34
Wessely	Ondracek	15-1-26	8300	Morrow	.70	2150	2749	0.33
NGC	Bourquin	24-1-26	8135	Morrow	.74	1903	2520	0.31
Wessely	Bourquin	24-1-26	8535	Morrow	.64	2144	2714	0.32
Continental	Towle	26-1-26	8486	Morrow	.65	2197	2811	0.33
Kaiser	Hennigh	28-1-26	8432	Morrow	.65	2044	2595	0.31
Arco	Nicholoson	29-1-26	8424	Morrow	.73	1971	2525	0.30
Service	Baldwin	31-1-26	6136	Tonkawa	.70	1605	1966	0.32
Oleum	House	32-1-26	6120	Tonkawa	.70	1687	2061	0.34
Parker	Schwab	33-1-26	8410	Morrow	.65	2010	2542	0.30
Cross Timb.	Schwab	34-1-26	8442	Morrow	.69	2115	2745	0.33
Meridian	Schneider	36-1-26	8560	Morrow	.69	2332	3035	0.35
Phillips	Young	1-1-26	8180	Morrow	.67	2125	2726	0.33
Oryx	O'Hern	2-1-27	8152	Morrow	.68	2121	2722	0.33
Enron	Jett	6-1-27	8210	Morrow	.68	2185	2779	0.34
Scarth	Bell	8-1-27	8321	Morrow	.72	2200	2882	0.35
Union	Thompson	11-1-27	8406	Morrow	.67	2136	2841	0.34
Union	Jett	14-1-27	8396	Morrow	.67	2065	2670	0.32
Zgen	Bedell	15-1-27	8455	Morrow	.66	2000	2563	0.30
Berry	Hendricks	17-1-27	8313	Morrow	.69	2175	2801	0.34
Mewbourne	Bourquin	18-1-27	8376	Morrow	.63	2141	2703	0.32
Mewbourne	Hendricks	18-1-27	8357	Morrow	.63	2138	2691	0.32
TXO	Towle	28-1-27	8564	Morrow	.72	2149	2821	0.33
Kaiser	Craft	31-1-27	8600	Morrow	.65	2405	3043	0.35

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Mustang	Martin	32-1-27	8282	Morrow	.72	2140	2826	0.34
TXO	Barton	34-1-27	8790	Morrow	.65	2108	2719	0.31
Brock	Terrel	36-1-27	8648	Morrow	.70	2110	2770	0.32
Phillips	Kamp	3-1-28	8222	Morrow	.65	2116	2668	0.32
UNOCAL	O'Hair	4-1-28	8340	Morrow	.67	2067	2648	0.32
Phillips	Lipps	5-1-28	8268	Morrow	.67	2156	2747	0.33
Phillips	Lipps	5-1-28	8340	Morrow	.67	2087	2673	0.32
UNOCAL	Fox	6-1-28	8226	Morrow	.66	1947	2470	0.30
Scarth	Dyche	7-1-28	8374	Morrow	.68	2102	2722	0.33
UNOCAL	Dyche	8-1-28	8228	Morrow	.67	2132	2718	0.33
Phillips	Gardner	9-1-28	8223	Morrow	.66	2111	2676	0.33
PHillips	Crail	16-1-28	8298	Morrow	.68	2101	2725	0.33
Couroi;	Bockelman	17-1-28	8437	Morrow	.68	1943	2509	0.30
Oryx	Fox	18-1-28	8341	Morrow	.68	2098	2702	0.32
Lear	Messner	21-1-28	8330	Morrow	.67	1994	2565	0.31
BHP	Fox	23-1-28	8280	Morrow	.69	2097	2726	0.33
CNG	Piersall	23-1-28	8616	Morrow	.71	2015	2648	0.31
Anson	Cowan	2-1-20	6988	Morrow	.63	1670	2051	0.29
Faulconer	Pierce	3-2-20	6948	Morrow	.60	1706	2077	0.30
Faulconer	Jollife	5-2-20	6580	Morrow	.71	1328	1665	0.25
Faulconer	Cowan	7-2-20	6558	Morrow	.72	1446	1814	0.28
Cabot	Claybrook	9-2-20	7007	Morrow	.70	1397	1735	0.25
UNOCAL	Sargent	11-2-20	7086	Morrow	.68	1643	2067	0.29
Brothers	Penner	12-2-20	7380	Morrow	.65	1543	1925	0.26
Oryx	Penner	12-2-20	7308	Morrow	.68	1647	2052	0.28
Oryx	Sargent	13-2-20	7254	Morrow	.66	1669	2076	0.29
Thomas	Reimann	15-2-20	7298	Morrow	.65	1749	2185	0.30
Cimarron	Harrison	19-2-20	6635	Morrow	.70	1373	1698	0.26
Cabot	Sturdivan	23-2-20	7626	Morrow	.64	1706	2111	0.28
Vintage	Leatherman	25-2-20	7738	Morrow	.63	1676	2074	0.27
Samson	Wilson	26-2-20	7606	Morrow	.62	1708	2085	0.27
Cimarron	Gulf	29-2-20	6828	Morrow	.69	1406	1739	0.25
Geodyne	Harrison	30-2-20	6738	Morrow	.69	1411	1745	0.26
Texaco	Freeman	31-2-20	6795	Morrow	.69	1404	1762	0.26
Cabot	Leatherman	34-2-20	7457	Morrow	.75	1686	2209	0.30
TXO	Leatherman	35-2-20	7666	Miss.	.65	1693	2124	0.28
UNOCAL	Frantz	2-2-21	7112	Morrow	.71	1330	1664	0.23
Faulconer	Wahl	3-2-21	7070	Morrow	.69	1447	1820	0.26
Grace	Penner	8-2-21	7095	Morrow	.69	1681	2130	0.30
UNOCAL	Karber	9-2-21	7127	Morrow	.69	1398	1742	0.24
UNOCAL	Frantz	10-2-21	7130	Morrow	.68	1410	1751	0.25
Faulconer	Penner	11-2-21	7160	Morrow	.70	1425	1800	0.25
Kennedy	Janzen	13-2-21	8165	Chester	.63	2048	2571	0.31
Anadarko	Pyle	17-2-21	7126	Morrow	.69	1429	1790	0.25
Texaco	Roper	21-2-21	7824	Chester	.63	2165	2679	0.34
Crown	Lane	26-2-21	7699	Morrow	.64	1742	2155	0.28

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Mobil	Speer	27-2-21	7684	Morrow	.64	1535	1931	0.25
Patrick	Neufeld	28-2-21	7646	Morrow	.62	1556	1923	0.25
Anson	Perkins	29-2-21	7691	Morrow	.64	1635	2051	0.27
Abarr	Pittman	32-2-21	7336	Morrow	.64	1538	1891	0.26
Texaco	Wilson	34-2-21	7757	Morrow	.66	1754	2211	0.29
Kaiser	Delano	35-2-21	7786	Morrow	.65	1700	2145	0.28
Presidio	Wood	19-2-22	8140	Chester	.62	2162	2692	0.33
Huber	Sager	29-2-22	8018	Chester	.63	2378	2948	0.37
Cimarron	Naylor	31-2-22	8122	Chester	.65	2250	2828	0.35
Hamon	Greensmith	32-2-22	8060	Chester	.64	2318	2910	0.36
Courson	Case	33-2-22	8387	St. Louis	.60	2272	2833	0.34
Hamon	Case	33-2-22	7279	Morrow	.65	1901	2366	0.33
Hamon	Rorabough	33-2-22	8436	St. Louis	.65	2064	2575	0.31
Gasanadarko	Sager	34-2-22	8190	Chester	.61	2314	2885	0.35
Kennedy	Wells	35-2-22	8296	Chester	.62	2197	2730	0.33
Courson	Turner	1-2-23	7188	Morrow	.70	1540	1962	0.27
UNOCAL	Parker	11-2-23	7128	Morrow	.73	1729	2210	0.31
Calvert	Bartel	17-2-23	7334	Morrow	.65	1659	2050	0.28
Unit	Yates	24-2-23	7858	Morrow	.64	2175	2719	0.35
Caspen	Sleeper	25-2-23	7700	Morrow	.64	1676	2066	0.27
Lyons	Cornell	29-2-23	7334	Morrow	.64	1753	2157	0.29
Amoco	Cornell	30-2-23	7310	Morrow	.71	1720	2167	0.30
Arco	Custer	31-2-23	7421	Morrow	.72	1667	2132	0.29
Anabaco	Cramer	32-2-23	7504	Morrow	.71	1681	2126	0.28
Amoco	Bass	1-2-24	7545	Morrow	.71	1580	2014	0.27
Pet. Inc.	Woodbury	2-2-24	7418	Morrow	.75	1596	2072	0.28
Oxy	Baggerly	3-2-24	7343	Morrow	.76	1271	1650	0.22
Amoco	Campbell	5-2-24	7272	Morrow	.72	1544	1983	0.27
Anadarko	EIS	6-2-24	7229	Morrow	.72	1371	1737	0.24
Amoco	Longcor	8-2-24	7190	Morrow	.78	1528	2030	0.28
Arco	Longcor	9-2-24	7255	Morrow	.78	1790	2357	0.32
Oxy	Bass	12-2-24	7550	Morrow	.79	1620	2175	0.29
May	Gray	15-2-24	7435	Morrow	.79	1500	1996	0.27
Samson	Smith	22-2-24	8012	Morrow	.69	1951	2494	0.31
Graham	Cates	23-2-24	8004	Morrow	.66	2208	2775	0.35
Ladd	Gray	23-2-24	8013	Morrow	.66	1887	2376	0.30
Amoco	Evans	24-2-24	7674	Morrow	.80	1610	2193	0.29
Samson	Cates	26-2-24	8209	Morrow	.60	2309	2833	0.35
Woods	McKeever	27-2-24	8201	Morrow	.66	2197	2693	0.33
Sec	McKeever	33-2-24	8092	Morrow	.74	1533	2044	0.25
Sonat	McKeever	35-2-24	8147	Morrow	.61	2268	2807	0.34
Exxon	Reiswig	36-2-24	7701	Morrow	.61	1596	2071	0.27
Mesa	Reiswig	36-2-24	7782	Morrow	.74	1525	2012	0.26
Arco	Dunlop	1-2-25	5639	Tonkawa	.69	1588	1912	0.34
Exxon	Moore	2-2-25	5639	Tonkawa	.66	1530	1826	0.32
Oxy	Conners	3-2-25	5634	Tonkawa	.67	1514	1805	0.32

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Amoco	Baggerly	6-2-25	5682	Tonkawa	.67	1520	1834	0.32
Oxy	Woodbury	7-2-25	7886	Chester	.65	1884	2383	0.30
Hawkins	Meek	9-2-25	3550	C. Grove	.70	883	1003	0.28
Arco	Baggerly	15-2-25	7611	Morrow	.81	1476	1990	0.26
Graham	Sprague	18-2-25	7580	Morrow	.79	1454	1960	0.26
Beeler	Reiswig	19-2-25	3598	C. Grove	.68	860	995	0.28
Suoco	Reiswig	19-2-25	7572	Morrow	.65	1607	2012	0.27
Samson	Baggerly	21-2-25	7579	Morrow	.76	1594	2115	0.28
Singer	Baggerly	23-2-25	8094	Morrow	.71	1775	2332	0.29
Scarth	Jones	25-2-25	8161	Morrow	.72	1912	2515	0.31
Phillips	Burditt	26-2-25	8234	Morrow	.71	1869	2439	0.30
Phillips	William	34-2-25	6066	Tonkawa	.71	1527	1877	0.31
Phillips	Beck	36-2-25	8279	Morrow	.73	1984	2638	0.32
Hamilton	Hennigh	2-2-26	4728	Hoover	.70	1441	1689	0.36
Pet. Inc.	Nelson	7-2-26	5312	Lovell	.70	1438	1705	0.32
Pet. Inc.	Nelson	7-2-26	5750	Tonkawa	.68	1557	1858	0.32
Braden	Abraham	7-2-26	7938	Morrow	.70	1471	1888	0.24
Shell	Jones	8-2-26	5733	Tonkawa	.64	1555	1838	0.32
Apache	Jones	10-2-26	5760	Tonkawa	.66	1554	1863	0.32
TXO	Matern	11-2-26	5759	Tonkawa	.66	1554	1863	0.32
Nicor	Exline	12-2-26	7830	Morrow	.66	1610	2021	0.26
Gasanadarko	Bayliff	17-2-26	8040	Morrow	.73	1678	2203	0.27
H&L	Bayliff	18-2-26	8098	Morrow	.73	1720	2251	0.28
Phillips	Burditt	30-2-26	8344	Miss.	.73	1994	2536	0.30
Huber	Beck	31-2-26	8246	Morrow	.72	1970	2591	0.31
Samson	Howard	34-2-26	8182	Morrow	.69	1678	2180	0.27
Gas Futures	Farrell	6-2-27	5693	Tonkawa	.68	1534	1856	0.33
Arco	Anderson	7-2-27	8680	Tonkawa	.67	1580	1906	0.22
Cabot	Barby	8-2-27	5655	Tonkawa	.67	1603	1922	0.34
Gas Comp.	Alexander	17-2-27	7743	Morrow	.67	1696	2142	0.28
Gas Comp.	Woodson	19-2-27	7936	Morrow	.67	1653	2093	0.26
Maxus	McCall	20-2-27	7805	Morrow	.68	2036	2575	0.33
Kaiser	Anderson	22-2-27	8869	Chester	.59	2564	3191	0.36
Amoco	Erickson	29-2-27	7883	Morrow	.71	1482	1929	0.24
Enron	Senn-Hull	302-27	8034	Morrow	.65	1829	2300	0.29
Anadarko	Anderson	34-2-27	8178	Morrow	.65	1950	2504	0.31
Brock	Schuster	36-2-27	8089	Chester	.68	1896	2447	0.30
Phillips	Ham	2-2-28	7544	Morrow	.72	1906	2459	0.33
U.M.C.	Taft	3-2-28	7334	Morrow	.68	2134	2676	0.36
Oneok	Taft	10-2-28	6924	Cherokee	.74	1503	1911	0.28
Marathon	Jennings	14-2-28	7822	Morrow	.69	1821	2321	0.30
Marathon	Taft	14-2-28	7685	Morrow	.69	1805	2317	0.30
Kerr KcGee	Robertson	20-2-28	7846	Morrow	.70	1845	2375	0.30
Samson	Spear	23-2-28	7885	Morrow	.67	1863	2379	0.30
Anson	Eades	27-2-28	7996	Morrow	.71	1708	2203	0.28
Anson	Schuster	27-2-28	7930	Morrow	.63	1929	2395	0.30

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
UNOCAL	Gardiner	31-2-28	8075	Morrow	.66	1950	2536	0.31
Ladd	Chester	5-3-20	6960	Chester	.67	1592	2003	0.29
Faulconer	Pierce	33-3-20	6825	Morrow	.71	1578	1974	0.29
Mid America	Pierce	34-3-20	6614	U. Morrow	.66	1180	1419	0.21
Faulconer	Pierce	34-3-20	6908	Morrow	.64	1982	2407	0.35
Exxon	Wahl	36-3-20	7174	Chester	.66	1365	1699	0.24
Texaco	Ratzlaff	5-3-21	6673	Chester	.66	1771	2180	0.33
Samson	RAtzlaff	8-3-21	6810	Chester	.65	1758	2137	0.31
Anadarko	Davis	11-3-21	7431	Chester	.65	2137	2660	0.36
Golden	Kliener	25-3-21	7629	Chester	.61	2108	2576	0.34
Ladd	Mary	6-3-22	7380	Chester	.64	1892	2350	0.32
Ladd	C.S.	8-3-22	7551	Chester	.64	2090	2593	0.34
Panhandle	Williams	9-3-22	7100	Morrow	.64	1622	1961	0.28
United	Brinkman	12-3-22	7151	Morrow	.63	1702	2102	0.29
Ladd	Ruby	28-3-22	7836	Chester	.65	1957	2452	0.31
Apache	Miller	1-3-23	7145	Morrow	.62	1823	2220	0.31
Oxy	Benjegerdes	2-3-23	7090	Morrow	.61	1629	1990	0.28
Oxy	Benjegerdes	3-3-23	6870	Morrow	.80	1524	1974	0.29
Parker	Brown	4-3-23	7098	Chester	.68	1661	2095	0.30
Kaiser	Spangler	9-3-23	6778	Morrow	.70	1661	2089	0.31
Phillips	Bridgewater	12-3-23	6918	Morrow	.70	1151	1423	0.21
Amoco	Bridgewater	12-3-23	7368	Chester	.64	1738	2154	0.29
Smith	Kenneck	25-3-23	7122	U. Morrow	.61	1483	1786	0.25
Stekoll	Ellis	26-3-23	7496	B. Morrow	.66	1587	2004	0.27
Cross Timb.	Ellis	26-3-23	7481	Morrow	.68	1630	2069	0.28
Amoco	Venable	27-3-23	7444	Morrow	.68	1609	2025	0.27
Gasandarko	V-bar	27-3-23	8068	St. Louis	.61	1642	2039	0.25
Gasanadarko	Venable	28-3-23	7940	St. Louis	.60	1998	2451	0.31
Kaiser	Venable	34-3-23	7133	Morrow	.61	1719	2078	0.29
Stekoll	Laughrin	35-3-23	7537	L. Morrow	.68	1775	2243	0.30
Cross Timb.	Laughrin	35-3-23	7532	Morrow	.68	1720	2167	0.29
Oxy	Ferguson	1-3-24	7392	Chest/Mor.	.68	1695	2117	0.29
Oxy	Fickel	2-3-24	7208	Chester	.66	1659	2042	0.28
Shell	Cole	3-3-24	7126	Morrow	.63	1769	2154	0.30
Shell	Cole	3-3-24	3376	C. Grove	.65	916	1037	0.31
Shell	Calhoon	4-3-24	3341	C. Grove	.66	917	1024	0.31
Burk	Perry	5-3-24	7256	Morrow	.61	1818	2213	0.30
Pan Am	Miller	6-3-24	7161	L. Morrow	.63	1600	1940	0.27
Harken	Miller	6-3-24	7182	Morrow	.62	1568	1924	0.27
Arco	Boston	7-3-24	7288	Morrow	.65	1718	2111	0.29
Arco	Parker	10-3-24	7358	Chester	.60	1589	1931	0.26
Arco	Parker	10-3-24	7252	Morrow	.62	1726	2108	0.29
Arco	Parker	10-3-24	3401	C. Grove	.65	891	978	0.29
Arco	Goetzinger	11-3-24	3252	C. Grove	.68	712	803	0.25
Arco	Goetzinger	11-3-24	5164	Tonkawa	.60	1614	1870	0.36
Cities	Fickel	12-3-24	5393	Tonkawa	.68	1365	1609	0.30

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Oxy	Fickel	12-3-24	7094	Morrow	.76	1646	2159	0.30
Arco	Taylor	13-3-24	7536	Morrow	.66	1816	2269	0.30
Buttonwood	Bass	14-3-24	5388	Tonkawa	.68	1536	1848	0.34
Headington	Goetzinger	15-3-24	7373	Morrow	.63	1716	2120	0.29
Texcon	Perry	16-3-24	3414	C.Grove	.67	852	944	0.28
Exxon	Kenneck	17-3-24	7058	Morrow	.76	1629	2121	0.30
Cory	Boston	18-3-24	7350	Morrow	.60	1759	2134	0.29
Humble	Graff	20-3-24	7101	U. Morrow	.66	1537	1867	0.26
Exxon	Graff	20-3-24	7445	Morrow	.70	1752	2230	0.30
BB&S	Gregory	21-3-24	7496	Morrow	.64	1646	2022	0.27
Shell	Evans	22-3-24	5259	Tonkawa	.67	1549	1839	0.35
Buttonwood	Will	23-3-24	5375	Tonkawa	.68	1536	1842	0.34
Buttonwood	Shadden	24-3-24	5496	Tonkawa	.67	1537	1851	0.34
Buttonwood	Ulrich	24-3-24	7598	Morrow	.67	1787	2271	0.30
Oxy	Shadden	25-3-24	5503	Tonkawa	.66	1522	1789	0.33
Texcon	Gregory	28-3-24	7168	Morrow	.73	1606	2068	0.29
Texcon	Gregory	28-3-24	3266	C. Grove	.65	800	902	0.28
Texcon	Seese	29-3-24	7531	Morrow	.71	1630	2083	0.28
Apache	Barker	30-3-24	7188	U. Morrow	.66	1732	2136	0.30
Apache	Barker	30-3-24	7548	L. Morrow	.70	1852	2354	0.31
Maxus	Gregory	31-3-24	7212	Morrow	.71	1608	2029	0.28
Stekoll	Shadden	34-3-24	5358	Tonkawa	.68	1575	1863	0.35
Cross Timb.	Shadden	34-3-24	7197	Morrow	.73	1596	2033	0.28
Helmerich	Bennett	2-3-25	7414	Chester	.66	1370	1722	0.23
Texok	Bennett	2-3-25	5430	Tonkawa	.70	1484	1777	0.33
Arco	Bennett	3-3-25	7175	Morrow	.69	1725	2181	0.30
Arco	Bennett	3-3-25	5314	Tonkawa	.70	1559	1856	0.35
Amoco	State	4--3-25	7191	Morrow	.72	1651	2126	0.30
Texaco	Hall	5-3-25	5258	Tonkawa	.66	1508	1783	0.34
Texaco	Hall	5-3-25	7199	Chester	.64	1318	1600	0.22
Kaiser	Bennett	6-3-25	5341	Tonkawa	.65	1510	1776	0.33
Kaiser	Bennett	6-3-25	7042	Morrow	.72	1662	2112	0.30
Kaiser	Bennett	6-3-25	7398	Chester	.69	1365	1704	0.23
Oxy	Ferguson	7-3-25	5365	Tonkawa	.67	1512	1802	0.34
Kaiser	Bennett	9-3-25	5484	Tonkawa	.66	1585	1896	0.35
Marlin	Nicholson	10-3-25	7384	Chest/Mor.	.65	1631	2205	0.30
Arco	Ridgeway	11-3-25	7386	Chester	.65	1496	1869	0.25
Arco	Ridgeway	11-3-25	5484	Tonkawa	.68	1497	1804	0.33
Arco	Ridgeway	11-3-25	7298	Morrow	.70	1522	1911	0.26
Arco	Mosburg	11-3-25	7370	Morrow	.69	1702	2161	0.29
Arco	Mosburg	12-3-25	5490	Tonkawa	.69	1526	1820	0.33
Helmerich	Wilson	13-3-25	5524	Tonkawa	.67	1522	1812	0.33
Cabot	Barby	14-3-25	5562	Tonkawa	.67	1524	1825	0.33
Exxon	Fickel	16-3-25	5538	Tonkawa	.66	1597	1894	0.34
Oxy	Fickel	17-3-25	7488	Chester	.69	1479	1759	0.23
Oxy	Ferguson	18-3-25	7586	Chester	.67	1711	2169	0.29

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Exxon	Fickel	20-3-25	5439	Tonkawa	.66	1518	1809	0.33
Exxon	Fickel	21-3-25	5580	Tonkawa	.67	1523	1832	0.33
Marathon	Leonard	23-3-25	5529	Tonkawa	.68	1589	1895	0.34
Helmerich	Barby	24-3-25	5538	Tonkawa	.67	1529	1820	0.33
Shell	Atkins	25-3-25	5578	Tonkawa	.64	1527	1841	0.33
Shell	Atkins	26-3-25	5601	Tonkawa	.65	1530	1796	0.32
Marlin	Leonard	27-3-25	7598	Morrow	.68	1336	1668	0.22
Exxon	State	28-3-25	5619	Tonkawa	.66	1542	1825	0.32
Oxy	Shadden	30-3-25	5548	Tonkawa	.66	1515	1801	0.32
Oxy	Shadden	31-3-25	3608	C. Grove	.69	822	916	0.25
Oryx	Conner	33-3-25	5700	Tonkawa	.66	1532	1810	0.32
Arco	Eyer	34-3-25	5656	Tonkawa	.68	1527	1838	0.32
Kaiser	Burns	36-3-25	5638	Tonkawa	.65	1576	1868	0.33
Cabot	Barby	1-3-26	4989	Lovell	.70	1400	1646	0.33
Cabot	Barby	1-3-26	5404	Tonkawa	.68	1540	1821	0.34
Phillips	Muehlebach	3-3-26	5338	Tonkawa	.68	1594	1894	0.35
Cabot	Barby	3-3-26	7378	Chester	.66	1800	2256	0.31
Cabot	Barby	3-3-26	5423	Tonkawa	.68	1563	1856	0.34
Buttonwood	Barby	4-3-26	7388	Chester	.65	1536	1920	0.26
Harper	Barby	4-3-26	5478	Tonkawa	.67	1580	1868	0.34
Samson	Overton	6-3-26	7416	Chester	.67	1765	2201	0.30
Oneok	Ridgeway	7-3-26	5496	Tonkawa	.66	1535	1869	0.34
Oneok	Ridgeway	7-3-26	7232	Morrow	.69	1483	1858	0.26
Samson	Ridgeway	9-3-26	7474	Chester	.68	1755	2225	0.30
Amoco	Chockley	10-3-26	7478	Chester	.67	1705	2153	0.29
Phillips	State	11-3-26	7376	Chester	.63	1724	2131	0.29
Phillips	State	11-3-26	5472	Tonkawa	.68	1524	1831	0.33
Cabot	Barby	12-3-26	5028	Cisco	.70	1426	1686	0.34
Phillips	State	14-3-26	7465	Chester	.63	1700	2101	0.28
Marathon	Snell	16-3-26	7636	Chester	.65	1763	2197	0.29
Marathon	Snell	16-3-26	7443	Morrow	.68	1571	1976	0.27
Marathon	Snell	16-3-26	5636	Tonkawa	.68	1517	1816	0.32
Marathon	Overton	17-3-26	5554	Tonkawa	.68	1537	1844	0.33
Cabot	Barby	18-3-26	5510	Tonkawa	.68	1585	1882	0.34
Marathon	Gardner	19-3-26	7453	Morrow	.68	1500	1872	0.25
Marathon	Gardner	19-3-26	5578	Tonkawa	.71	1532	1849	0.33
Marathon	Wilkerson	20-3-26	5630	Tonkawa	.68	1534	1834	0.33
Shell	Hauth	28-3-26	5705	Tonkawa	.67	1545	1841	0.32
Shell	Riemann	29-3-26	5740	Tonkawa	.66	1536	1832	0.32
Arco	Gardner	31-3-26	5685	Tonkawa	.67	1543	1856	0.33
Shell	Thorne	32-3-36	5751	Tonkawa	.66	1565	1872	0.33
Coral	Woodson	36-3-26	7740	Morrow	.67	1101	1372	0.18
Shell	Barby	1-3-27	4424	Hoover	.67	1358	1560	0.35
Arco	Nelson	2-3-27	4364	Hovver	.67	1338	1551	0.36
Phillips	Richards	3-3-27	4380	Hoover	.66	1335	1550	0.35
Phillips	Richards	4-3-27	5411	Tonkawa	.68	1444	1707	0.32

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Phillips	Beard	5-3-27	5410	Tonkawa	.68	1545	1828	0.34
Phillips	Beard	5-3-27	4404	Hoover	.68	1325	1517	0.34
Cabot	Barby	6-3-27	4393	Hoover	.68	1330	1523	0.35
Cabot	Barby	7-3-27	5445	Tonkawa	.69	1548	1855	0.34
Arco	Vernon	8-3-27	4432	Hoover	.66	1540	1771	0.40
Phillips	Vernon	9-3-27	5480	Tonkawa	.67	1535	1855	0.34
Phillips	Schonlau	10-3-27	4466	Hoover	.67	1340	1563	0.35
Cabot	Sizelove	12-3-27	4422	Hoover	.64	1343	1542	0.35
Redstone	Jennings	12-3-27	7202	Morrow	.70	1054	1300	0.18
Shell	Bozarth	14-3-27	4480	Hoover	.66	1326	1544	0.34
Phillips	Schonlau	15-3-27	4530	Hoover	.66	1368	1579	0.35
Phillips	Schonlau	15-3-27	5550	Tonkawa	.69	1584	1906	0.34
Shell	OSU	16-3-27	4515	Hoover	.65	1327	1523	0.34
Cabot	Barby	18-3-27	7522	Chester	.63	1585	1943	0.26
Cabot	Barby	18-3-27	5087	Cisco	.70	1392	1672	0.33
Buttonwood	Eades	20-3-27	5678	Tonkawa	.65	1554	1860	0.33
Mobil	Nine	21-3-27	4612	Hoover	.65	1322	1512	0.33
Phillips	Hildebrand	22-3-27	4584	Hoover	.65	1349	1581	0.34
Shell	Bellamy	23-3-27	5656	Tonkawa	.69	1550	1873	0.33
Shell	Hildebrand	24-3-27	4500	Hoover	.70	1329	1534	0.34
Shell	Hildebrand	24-3-27	5665	Tonkawa	.70	1540	1872	0.33
Eason	State	26-3-27	5616	Tonkawa	.70	1530	1838	0.33
Golden	Swallow	26-3-27	5616	Tonkawa	.64	1531	1797	0.32
Colorado	Armagest	27-3-27	5656	Tonkawa	.70	1536	1845	0.33
Colorado	Armagest	27-3-27	7561	Morrow	.67	1629	2032	0.27
Chapman	Nelson	28-3-27	7443	Morrow	.67	1679	2104	0.28
Chapman	Nelson	28-3-27	5678	Tonkawa	.68	1517	1835	0.32
Chapman	Nelson	28-3-27	3514	C. Grove	.67	987	1098	0.31
Arco	Eades	29-3-27	5696	Tonkawa	.69	1547	1851	0.32
Maxus	Eades	30-3-27	5695	Tonkawa	.70	1551	1864	0.33
Chaparral	Whitaker	35-3-27	7877	Chester	.63	1356	1695	0.22
Coastal	Haskell	35-3-27	7551	Morrow	.66	1316	1650	0.22
Home	Holmes	36-3-27	7818	Chester	.66	1467	1832	0.23
JCR	Holmes	36-3-27	7432	Morrow	.67	1274	1583	0.21
Arco	Hendricks	2-3-28	7119	Chester	.63	1794	2182	0.31
Whitaker	Riggs	2-3-28	7094	Morrow	.73	1658	2109	0.30
Arco	Whisehunt	3-3-28	7212	Chester	.65	1770	2173	0.30
Arco	Hendricks	2-3-28	4310	Hoover	.65	1193	1351	0.31
Arco	Whisehunt	3-3-28	4379	Hoover	.66	1198	1391	0.32
Arco	Whisehunt	3-3-28	7062	Morrow	.75	1577	2042	0.29
Arco	Whisehunt	3-3-28	4400	Hoover	.70	1284	1459	0.33
Cabot	Sexton	4-3-28	7241	Chester	.66	1791	2223	0.31
Cabot	Sexton	4-3-28	7115	Morrow	.73	1735	2212	0.31
Cabot	Sexton	4-3-28	4401	Hoover	.65	1329	1507	0.34
Cabot	Barby	5-3-28	4378	Hoover	.68	1335	1558	0.36
Shell	Barby	6-3-28	4410	Hoover	.67	1318	1507	0.34

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Vintage	Otto	7-3-28	4490	Hoover	.64	1327	1517	0.34
Shell	Barby	8-3-28	4519	Hoover	.65	1354	1639	0.36
Shell	Barby	8-3-28	7236	Morrow	.70	1652	2086	0.29
Cabot	Ryser	9-3-28	7333	Chester	.68	1750	2194	0.30
Cabot	Ryser	9-3-28	4474	Hoover	.67	1350	1547	0.35
Samson	Carlisle	10-3-28	4380	Hoover	.66	1375	1564	0.36
Samson	Carlisle	15-3-28	7352	Chester	.69	1541	1956	0.27
Samson	Carlisle	15-3-28	4400	Hoover	.66	1374	1564	0.36
Tenneco	Carlisle	15-3-28	7161	Morrow	.73	1774	2248	0.31
Tenneco	Carlisle	16-3-28	4467	Hoover	.67	1353	1583	0.35
Samson	Carlisle	16-3-28	7203	Morrow	.75	1590	2012	0.28
Marlin	Sizelove	17-3-28	7266	Morrow	.70	1578	2004	0.28
Montgomery	Bedel	20-3-28	7412	Chester	.67	1518	1885	0.25
Shell	Bedel	20-3-28	4434	Hoover	.66	1332	1530	0.35
Ashland	Carlisle	21-3-28	4390	Hoover	.65	1343	1523	0.35
Samson	Carlisle	21-3-28	7252	Morrow	.77	1812	2321	0.32
Phillips	Mulberry	26-3-28	7269	Morrow	.68	1820	2293	0.32
Montgomery	Bockelman	29-3-28	7426	Chester	.67	1427	1775	0.24
PNG	Wells	30-3-28	4474	Hoover	.66	1321	1536	0.34
Huber	Sitton	33-3-28	7321	Morrow	.72	1757	2243	0.31
Couroil	Stevens	34-3-28	7401	Morrow	.72	1786	2278	0.31
Phillips	Baker	35-3-28	4356	Hoover	.78	1334	1556	0.36
Dawson	Ellexson	10-4-20	6558	Chester	.64	1477	1791	0.27
Dawson	Crawford	14-4-20	6554	Chester	.65	1651	2010	0.31
Anadarko	Ellexson	15-4-20	6838	Chester	.65	1625	1985	0.29
Dawson	Mendenhall	21-4-20	6577	Chester	.67	1580	1949	0.30
Dawson	Stickler	22-4-20	6468	Chester	.64	1532	1858	0.29
Triton	Knight	23-4-20	7912	Viola	.71	2123	2735	0.35
Dawson	Knight	23-4-20	6441	Chester	.64	1598	1926	0.30
Dawson	Brown	25-4-20	6560	Chester	.65	1651	2021	0.31
Dawson	Knight	26-4-20	6984	Chester	.65	1705	2097	0.30
Weco	Pyle	26-4-20	7892	Viola	.65	2021	2523	0.32
Phillips	Cleo	27-4-20	4537	Douglas	.70	1591	1861	0.41
Ladd	Myra	31-4-20	6914	Chester	.69	1588	1969	0.28
Ashland	State	36-4-20	6418	Chester	.65	1545	1874	0.29
Amarillo	Blakemore	9-4-21	6604	Chester	.65	1615	1966	0.30
Anadarko	Blakemore	9-4-21	6719	Chester	.65	1579	1915	0.29
Hosco	Blakemore	15-4-21	6612	Chester	.65	1621	1967	0.30
Amarillo	Price	19-4-21	6694	Miss.	.65	1629	1987	0.30
Dawson	Blakemore	30-4-21	6382	Chester	.65	1506	1818	0.28
Triton	Blakemore	30-4-21	6489	Chester	.67	1584	1923	0.30
Amarillo	Brown	31-4-21	6374	Chester	.67	1651	1998	0.31
Dawson	Brown	32-4-21	6548	Morrow	.65	1453	1764	0.27
Ladd	Rheva	36-4-21	7328	Chester	.65	1841	2274	0.31
Couroil	Guymon	1-4-22	6844	Chester	.64	1579	1923	0.28
Aexco	Blakemore	2-4-22	6413	Morrow	.73	1566	1950	0.30

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Burk	Blakemore	3-4-22	6438	Morrow	.73	1561	1955	0.30
Burk	Blakemore	3-4-22	6684	Chester	.61	1771	2140	0.32
Ladd	Blakemore	8-4-22	6323	Morrow	.61	1288	1595	0.25
Phillips	Blakemore	10-4-22	6326	Morrow	.73	1201	1483	0.23
Phillips	Guymon	11-4-22	6385	Morrow	.70	1542	1890	0.30
Couroil	Guymon	11-4-22	6398	Morrow	.78	1500	1910	0.30
Maguire	Blakemore	12-4-22	6647	Chester	.70	1584	1972	0.30
Elder	McCay	14-4-22	6753	Chester	.61	1797	2162	0.32
Anadarko	Blakemore	15-4-22	6430	Morrow	.62	1532	1826	0.28
Cory	Gregg	23-4-22	6834	Chester	.61	1820	2186	0.32
Argonaut	Gregg	26-4-22	6902	Chester	.63	1710		0.00
Ladd	Leroy	31-4-22	7318	Chester	.64	1844	2263	0.31
Bhp	Beaver	1-4-23	6260	Morrow	.67	1450	1746	0.28
Bhp	Dune	2-4-23	6320	Morrow	.68	1860	2268	0.36
Aikman	State	4-4-23	6591	Morrow	.68	1619	1978	0.30
Nat. Gas	State	5-4-23	6663	Chester	.69	1650	2044	0.31
Anadarko	Blakemore	6-4-23	6394	Morrow	.70	1584	1941	0.30
Phillips	Blakemore	7-4-23	6624	Miss.	.63	1625	1946	0.29
Phillips	Blakemore	7-4-23	6324	Morrow	.68	1575	1911	0.30
Pet. Inc.	McFarland	10-4-23	6602	Chester	.61	1665	2000	0.30
Curran	McFarland	11-4-23	6558	Chester	.64	1808	2195	0.33
Triad	McFarland	12-4-23	6275	Morrow	.61	1409	1674	0.27
Triad	McFarland	12-4-23	4494	Cisco	.68	1249	1432	0.32
Beeler	Maxine	14-4-23	4785	Lansing	.73	1390	1671	0.35
Beeler	McFarland	15-4-23	6762	Mor/Chest.	.61	1801	2199	0.33
Elder	Blakemore	16-4-23	6698	Morrow	.63	1658	1999	0.30
Anson	Fowler	17-4-23	6775	Morrow	.67	1790	2219	0.33
Phillips	Womack	17-4-23	5518	Marmaton	.70	1605	1903	0.34
Otc	Crabtree	18-4-23	6499	Morrow	.67	1349	1631	0.25
Harper	Hayes	18-4-23	6644	Morrow	.64	1750	2109	0.32
Harper	Hayes	18-4-23	6782	Chester	.63	1685	2027	0.30
Amoco	Lierman	19-4-23	6554	Morrow	.72	1506	1889	0.29
Continental	Thomas	19-4-23	6588	Morrow	.62	1713	2061	0.31
Amoco	Osborne	20-4-23	6860	Chester	.62	1560	1906	0.28
Nielson	Wilmoth	21-4-23	6880	Chester	.61	1543	1855	0.27
Anadarko	Gregg	22-4-23	6815	Morrow	.61	1811	2185	0.32
Anadarko	Gregg	22-4-23	6854	Chester	.62	1764	2145	0.31
Mid-America	Baxter	23-4-23	6494	Morrow	.61	1421	1679	0.26
Mid-America	Greg	26-4-23	6548	Morrow	.62	1475	1755	0.27
Mid-America	Greg	26-4-23	6893	L. Morrow	.61	2137	2561	0.37
Mid-America	Tretbar	27-4-23	6987	L. Morrow	.61	2054	2466	0.35
J Brex	Noble	28-4-23	6904	Morrow	.60	1682	2036	0.29
Beeler	Phelps	29-4-23	6942	Chester	.61	1736	2111	0.30
Texaco	Phelps	30-4-23	6622	Morrow	.79	1538	1929	0.29
Arco	Phelps	32-4-23	7000	Chester	.64	1808	2195	0.31
Oxy	Benjeg	33-4-23	7012	Chester	.62	1798	2169	0.31

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Kimball	Benjeg	34-4-23	6796	Morrow	.60	1654	2034	0.30
Lobo	Goodner	36-4-23	7135	Morrow	.63	1818	2219	0.31
Samson	Mayo	1-4-24	6800	Chester	.66	1779	2168	0.32
Samson	May	1-4-24	6728	Morrow	.63	1765	2130	0.32
Oxy	Miles	4-4-24	6679	Morrow	.64	1782	2151	0.32
Cities	Miles	5-4-24	6416	Morrow	.68	1416	1718	0.27
Vintage	Pioneer	6-4-24	6558	Morrow	.70	1647	2051	0.31
Jcr	Miles	7-4-24	6279	Morrow	.71	1477	1831	0.29
Marathon	Miles	8-4-24	6587	Morrow	.63	1775	2127	0.32
Hamilton	Miles	10-4-24	6800	Chester	.66	1766	2152	0.32
Hamilton	Miles	10-4-24	6553	Morrow	.72	1647	2068	0.32
Oxy	Miles	12-4-24	6698	Chest/Mor.	.64	1725	2080	0.31
Cities	Miles	15-4-24	6624	Morrow	.66	1427	1725	0.26
Cities	Miles	16-4-24	6616	Morrow	.66	1524	1846	0.28
Mayflo	Smylie	17-4-24	6404	Morrow	.68	1600	1946	0.30
Vintage	Maynard	21-4-24	3301	C. Grove	.65	899	984	0.30
BB&S	Pruett	22-4-24	3334	C. Grove	.65	932	1036	0.31
Kingwood	McCune	23-4-24	6880	Morrow	.66	1650	2015	0.29
Kaiser	McCune	23-4-24	6950	Chester	.64	1770	2165	0.31
Sinclair	Hancock	24-4-24	7014	Chester	.64	1600	1946	0.28
Arco	Thompson	25-4-24	6822	Morrow	.80	1653	2134	0.31
Sinclair	McGrew	26-4-24	7040	Chester	.66	1750	2147	0.30
Arco	Hancock	27-4-24	3246	C. Grove	.68	896	1004	0.31
Vintage	Barby	30-4-24	6923	Chester	.66	1794	2202	0.32
Arco	Allen	33-4-24	3339	C. Grove	.67	907	1014	0.30
Chevron	Cole	34-4-24	3348	C. Grove	.66	884	991	0.30
Texaco	Berry	3-4-25	6771	Morrow	.75	1770	2279	0.34
Samson	USA	5-4-25	6807	Chester	.63	1782	2146	0.32
Samson	Mayo	7-4-25	6806	Chester	.66	1786	2179	0.32
Hamilton	Evans	8-4-25	6820	Chester	.65	1702	2066	0.30
Hamilton	Evans	9-4-25	6823	Morrow	.63	1685	2035	0.30
Samson	Barby	11-4-25	6886	Morrow	.64	1729	2126	0.31
Cabot	Barby	13-4-25	7004	Chester	.66	1740	2132	0.30
Cabot	Barby	16-4-25	6857	Chester	.68	1717	2126	0.31
Cabot	Davis	21-4-25	6904	Chester	.67	1726	2120	0.31
Cabot	Barby	23-4-25	7034	Chester	.67	1708	2115	0.30
Berry	Rock	30-4-25	7078	Morrow	.68	1726	2168	0.31
Anabaco	Smith	31-4-25	7156	Morrow	.70	1736	2198	0.31
Exxon	Hageman	33-4-25	7022	Morrow	.67	1681	2076	0.30
Exxon	Hageman	33-4-25	5234	Tonkawa	.68	1482	1753	0.33
Cory	Bennett	34-4-25	7110	Chester	.68	1749	2151	0.30
Mobil	Bennett	34-4-25	7024	Morrow	.69	1731	2160	0.31
Whitehall	Barby	5-4-26	6970	Morrow	.67	1700	2090	0.30
Beeler	Barby	21-4-26	3460	C. Grove	.69	933	1055	0.30
Cabot	Barby	24-4-26	4969	Cisco	.69	1395	1646	0.33
O'Neill	Barby	26-4-26	5248	Tonkawa	.70	1185	1394	0.27

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Anadarko	Overton	31-4-26	7336	Chester	.65	1785	2208	0.30
Cabot	Barby	33-4-26	7333	Chester	.65	1797	2222	0.30
Pacific	Carrier	1-4-27	6804	Morrow	.65	1691	2051	0.30
Kennedy	Carrier	2-4-27	6837	Morrow	.69	1620	2014	0.29
Otc	Elsie	3-4-27	6868	Morrow	.73	1651	2108	0.31
Otc	Guy	4-4-27	6935	Morrow	.74	1673	2139	0.31
BB&S	Carrier	6-4-27	3561	C. Grove	.70	900	1002	0.28
Singer	Beard	7-4-27	6881	Morrow	.70	1692	2135	0.31
Search	Poorbaugh	8-4-27	6928	Morrow	.70	1402	1746	0.25
Chester	Longmate	9-4-27	5050	Cisco	.69	1339	1586	0.31
Anabaco	Barby	10-4-27	6942	Morrow	.68	1617	2009	0.29
Pet. Res.	Barby	10-4-27	5055	Cisco	.67	1368	1612	0.32
Cabot	Allen	13-4-27	6796	Morrow	.69	1754	2204	0.32
Chester	Pope	16-4-27	7182	Chester	.67	1703	2136	0.30
Chester	Pope	16-4-27	6908	Morrow	.72	1726	2173	0.31
Cabot	Barby	17-4-27	7022	Morrow	.72	1651	2089	0.30
Cabot	Barby	17-4-27	5045	Cisco/Dou	.71	1366	1627	0.32
Cabot	Barby	19-4-27	5428	Tonkawa	.72	1556	1864	0.34
Cabot	Barby	21-4-27	7268	Chester	.70	1705	2169	0.30
Cabot	Barby	21-4-27	6996	Morrow	.69	1706	2121	0.30
Cabot	Allen	23-4-27	7036	Chester	.68	1709	2128	0.30
Smith	Allen	24-4-27	6829	Morrow	.69	1650	2043	0.30
Otc	Allen	24-4-27	6881	Chest/Mor.	.71	1726	2189	0.32
Cabot	Allen	25-4-27	3212	C. Grove	.68	984	1087	0.34
Cabot	Barby	28-4-27	5349	Tonkawa	.74	1533	1871	0.35
Cabot	Barby	29-4-27	5367	Tonkawa	.75	1538	1892	0.35
Cabot	Barby	31-4-27	5323	Tonkawa	.72	1570	1888	0.35
Cabot	Sizelove	34-4-27	4316	Hoover	.67	1368	1564	0.36
Cabot	Sizelove	35-4-27	4303	Hovver	.67	1349	1536	0.36
Cabot	Barby	36-4-27	4320	Hoover	.68	1334	1531	0.35
Arco	Heglin	6-4-28	6712	Morrow	.66	1764	2189	0.33
Brg	Stanely	9-4-28	6875	Chester	.60	1699	2093	0.30
Marathon	Butler	14-4-28	6702	Morrow	.65	1737	2102	0.31
Gulf	Koran	15-4-28	6828	Chester	.63	1780	2147	0.31
Arco	Weeks	17-4-28	6760	Morrow	.68	1590	1972	0.29
Oneok	Laverty	19-4-28	6792	Morrow	.68	1730	2098	0.31
Cabot	Wolf	20-4-28	6792	Morrow	.68	1763	2140	0.32
Texcon	Wolf	21-4-28	6851	Chester	.65	1794	2200	0.32
Texcon	Wolf	21-4-28	6791	Morrow	.67	1816	2259	0.33
Graham	Barby	23-4-28	6796	Chester	.63	1669	2008	0.30
Cabot	Whisenhunt	26-4-28	6903	Chester	.63	1821	2198	0.32
Cabot	Whisenhunt	27-4-28	6927	Chester	.70	1814	2272	0.33
Marathon	Barby	28-4-28	6800	Morrow	.68	1740	2139	0.31
Cabot	Laverty	29-4-28	4274	Hoover	.65	1337	1542	0.36
Otc	Laverty	30-4-28	6809	Morrow	.67	1716	2103	0.31
Cabot	Barby	31-4-28	4334	Hoover	.68	1346	1551	0.36

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Cabot	Rohm	32-4-28	7027	Mor/Chest.	.72	1794	2275	0.32
Cabot	Barby	33-4-28	7106	Chester	.67	1805	2230	0.31
Cabot	Barby	33-4-28	4326	Hoover	.66	1336	1527	0.35
Cabot	Whisenhunt	34-4-28	7076	Chester	.65	1788	2215	0.31
Cabot	Whisenhunt	34-4-28	4311	Hoover	.66	1334	1518	0.35
Arco	Lamaster	35-4-28	6986	Chester	.65	1780	2204	0.32
Unit	Windsor	3-5-20	6534	Chester	.62	1392	1663	0.25
Ladd	Rindon	7-5-20	6110	Morrow	.69	1047	1254	0.21
Unit	Peters	11-5-20	6583	Chester	.62	1192	1444	0.22
Enron	Strickland	13-5-20	6621	Chester	.63	1342	1606	0.24
Ladd	Penner	22-5-20	6978	Chester	.66	1530	1898	0.27
Anadarko	Huebner	23-5-20	6914	Chester	.65	1940	2368	0.34
Spess	Lyles	30-5-20	6872	Chester	.65	1432	1762	0.26
Texocan	Plett	4-5-21	6564	Chester	.65	1485	1810	0.28
Oxy	Dirks	6-5-21	6420	Chester	.62	1640	1952	0.30
Marathon	Smyres	16-5-21	6630	Chester	.65	1358	1643	0.25
Anadarko	Isaac	17-5-21	6552	Chester	.63	1369	1650	0.25
Courson	Huebner	18-5-21	6630	Chester	.63	1414	1698	0.26
Polk	Plett	29-5-21	6658	Chester	.63	1500	1816	0.27
Apx	Dick	31-5-21	6598	Chester	.63	1532	1845	0.28
Adobe	Regier	32-5-21	6998	Chester	.65	1582	1928	0.28
Crawley	Grove	1-5-22	6598	Chester	.64	1511	1814	0.27
Marlin	Grove	1-5-22	6250	Morrow	.70	1522	1874	0.30
Amoco	Becker	2-5-22	6291	Morrow	.77	1560	1971	0.31
Exxon	Still	4-5-22	6301	Morrow	.71	1587	1939	0.31
Oxy	Beard	9-5-22	6582	Chester	.63	1348	1628	0.25
Kaiser	Benker	10-5-22	6542	Morrow	.63	1615	1944	0.30
Texaco	Buffalo	11-5-22	6558	Morrow	.63	1547	1883	0.29
Curran	Noble	12-5-22	6463	Morrow	.63	1782	2150	0.33
Amoco	Lewis	14-5-22	6622	Morrow	.63	1703	2064	0.31
Oxy	Sharp	15-5-22	6667	Chester	.64	1447	1762	0.26
Anadarko	Winstead	20-5-22	6645	Chester	.63	1727	2086	0.31
Buttonwood	Richmond	22-5-22	6631	Morrow	.63	1675	1995	0.30
Anadarko	Long	23-5-22	6612	Chester	.62	1699	2029	0.31
Export	McFarland	24-5-22	6379	Morrow	.69	1561	1932	0.30
Kaiser	Rankin	25-5-22	6667	Chester	.63	1580	1917	0.29
Anadarko	Beard	33-5-22	6705	Chester	.62	1663	1987	0.30
Txo	Haight	35-5-22	6682	Chester	.70	1803	2233	0.33
Burk	Blakemore	36-5-22	6835	Chester	.66	1670	2048	0.30
Kaiser	Hodges	1-5-23	6345	Morrow	.65	1475	1779	0.28
Texaco	McGee	2-5-23	6378	Morrow	.64	1418	1718	0.27
Exxon	Immel	3-5-23	6404	Morrow	.64	1488	1775	0.28
Exxon	Buffalo	4-5-23	6395	Morrow	.64	1719	2057	0.32
Shell	Beard	6-5-23	6652	Chest/Mor.	.63	1782	2156	0.32
Kerr	Underwood	9-5-23	6650	Chester	.64	1769	2129	0.32
Exxon	Miller	10-5-23	6620	Chest/Mor.	.65	1633	1977	0.30

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Anadarko	Miller	11-5-23	6595	Chest/Mor.	.64	1586	1905	0.29
Bellwether	Judy	12-5-23	6380	Morrow	.64	1599	1908	0.30
Amoco	Coldwater	13-5-23	6560	Miss.	.65	1752	2136	0.33
Amoco	Coldwater	13-5-23	6399	Morrow	.63	1738	2073	0.32
Amoco	Angleton	14-5-23	6535	Morrow	.64	1451	1748	0.27
Amoco	Angleton	14-5-23	6661	Chester	.64	1602	1949	0.29
Marlin	Boates	19-5-23	6382	Morrow	.77	1357	1708	0.27
Elder	Lowry	22-5-23	6564	Morrow	.63	1530	1850	0.28
Exxon	Kinnamon	23-5-23	6510	Morrow	.66	1728	2084	0.32
Vintage	Beck	25-5-23	6278	Morrow	.67	1538	1847	0.29
Apx	Hodges	26-5-23	6657	Chester	.64	1593	1936	0.29
Sidwell	McFarland	32-5-23	6650	Chester	.61	1531	1835	0.28
Chapman	McFarland	33-5-23	6618	Morrow	.64	1620	1952	0.29
Sidwell	State	35-5-23	6358	Morrow	.64	1357	1636	0.26
Cabot	Hodges	1-5-24	6632	Miss.	.67	1706	2094	0.32
Cabot	Judy	1-5-24	6210	Morrow	.66	1756	2111	0.34
Exxon	State	4-5-24	6370	Morrow	.66	1640	1994	0.31
Dyco	Perkins	5-5-24	6289	Morrow	.66	1774	2129	0.34
Otc	Gulf	9-5-24	6608	Morrow	.66	1577	1919	0.29
Vintage	Hodges	9-5-24	6578	Chester	.60	1550	1860	0.28
Exxon	State	12-5-24	4690	Cisco	.69	1269	1466	0.31
Texaco	McFarland	16-5-24	6514	Chest/Mor.	.64	1742	2095	0.32
Texaco	McFarland	16-5-24	6490	Chester	.60	1667	1964	0.30
Apx	Hodges	20-5-24	6428	Morrow	.65	1658	2002	0.31
Texaco	Hodges	21-5-24	6520	Morrow	.64	1267	1516	0.23
Texaco	Hodges	21-5-24	6696	Chester	.64	1647	1986	0.30
Texaco	Hodges	22-5-24	6744	Chester	.64	1584	1925	0.29
Arco	Maple	25-5-24	6651	Chester	.63	1379	1672	0.25
Arco	Maple	26-5-24	6662	Chester	.63	1740	2118	0.32
Texaco	McFarland	27-5-24	6638	Chester	.64	1733	2099	0.32
Apx	Hodges	28-5-24	6762	Chester	.64	1701	2076	0.31
Apx	Hodges	29-5-24	6696	Chester	.64	1655	1993	0.30
Amoco	Barnett	30-5-24	6448	Morrow	.63	1502	1805	0.28
Allen	Miles	32-5-24	6662	Morrow	.63	1775	2130	0.32
Medallion	Miles	32-5-24	6626	Chester	.63	1733	2085	0.31
Texaco	McFarland	34-5-24	6681	Chester	.63	1761	2084	0.31
Arco	Maple	35-5-24	6918	Chester	.65	1703	2078	0.30
Arco	Maple	36-5-24	6770	Chester	.64	1726	2111	0.31
Questa	Kamas	1-5-25	6544	Morrow	.69	1538	1899	0.29
Maguire	Kamas	3-5-25	6517	Morrow	.66	1321	1613	0.25
Unocal	Judy	5-5-25	6200	Morrow	.66	1714	2055	0.33
Unocal	Judy	6-5-25	6146	Morrow	.65	1059	1267	0.21
Unocal	Judy	6-5-25	6535	Miss.	.67	1822	2230	0.34
Tema	Baldwin	7-5-25	6298	Morow	.67	1364	1634	0.26
Tema	Baldwin	7-5-25	3219	C. Grove	.68	818	905	0.28
Nielson	Judy	9-5-25	6563	Morrow	.69	1650	2048	0.31

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Vintage	Kamas	10-5-25	6662	Chester	.70	1640	2049	0.31
Unocal	Kamas	11-5-25	6770	Morrow	.72	1680	2129	0.31
Aexco	Kamas	12-5-25	6617	Morrow	.64	1686	2033	0.31
Maguire	Kamas	13-5-25	6778	Morrow	.70	1694	2130	0.31
Anabaco	Whitmarsh	14-5-25	6992	Morrow	.71	1425	1778	0.25
Exxon	St. Richard	16-5-25	7070	Chester	.68	1425	1783	0.25
Neilson	Mayo	20-5-25	6637	Morrow	.65	1712	2082	0.31
Anadarko	Canaday	21-5-25	6815	Morrow	.69	1585	1960	0.29
Texaco	Barby	23-5-25	6759	Morrow	.67	1502	1853	0.27
Cabot	Barby	24-5-25	3806	Morrow	.70	1655	2055	0.54
Cabot	Barby	25-5-25	6843	Morrow	.67	1362	1675	0.24
Esperanza	Barby	26-5-25	6799	Morrow	.67	1407	1716	0.25
Neilson	Mayo	28-5-25	6811	Morrow	.68	1744	2150	0.32
Cotton	Mayo	29-5-25	6648	Morrow	.67	1682	2053	0.31
Gruy	Mayo	29-5-25	6598	Morrow	.66	1605	1946	0.29
Aexco	Mayo	31-5-25	6730	Chester	.64	1660	2001	0.30
Aexco	Mayo	32-5-25	6748	Chester	.63	1692	2050	0.30
Neilson	Barby	35-5-25	6876	Morrow	.68	1593	1989	0.29
Samson	Barby	36-5-25	6920	Morrow	.65	1663	2089	0.30
Texcon	Barby	2-5-26	3337	C. Grove	.65	931	1036	0.31
UPRR	Albert	3-5-26	3399	C. Grove	.65	893	985	0.29
Unocal	Buis	8-5-26	6695	Morrow	.72	1685	2106	0.31
Cabot	Albert	9-5-26	6629	Morrow	.69	1670	2063	0.31
Cabot	Albert	9-5-26	3340	C. Grove	.67	886	991	0.30
Kaiser	Albert	10-5-26	3492	C. Grove	.68	927	1027	0.29
Kaiser	Albert	10-5-26	6596	Morrow	.73	1657	2075	0.31
McAdams	Haack	11-5-26	3392	C. Grove	.68	882	973	0.29
Cabot	Sargent	12-5-26	6602	Morrow	.67	1761	2146	0.33
Cabot	Barby	13-5-26	6728	Morrow	.70	1740	2167	0.32
Cross Timb.	Haack	14-5-26	6762	Morrow	.72	1725	2162	0.32
Unocal	Albert	16-5-26	3540	C. Grove	.69	875	988	0.28
Cleary	Albert	17-5-26	3376	C. Grove	.69	843	929	0.28
BB&S	Albert	17-5-26	3082	Chase	.71	683	749	0.24
Kennedy	Albert	17-5-26	6818	Morrow	.69	1664	2061	0.30
Crown	Fry	18-5-26	6712	Morrow	.70	1627	2016	0.30
BB&S	Street	21-5-26	3392	C. Grove	.68	887	979	0.29
UPRR	Dixon	23-5-26	6843	Morrow	.71	1725	2170	0.32
Thompson	Barby	24-5-26	6800	Morrow	.70	1653	2049	0.30
Samson	Barby	26-5-26	3578	C. Grove	.67	935	1069	0.30
Vintage	Barby	28-5-26	6822	Morrow	.70	1606	1999	0.29
Unocal	Dixon	29-5-26	6898	Morrow	.70	1232	1520	0.22
Unocal	Barby	30-5-26	6834	Morrow	.70	1210	1499	0.22
Samson	Barby	31-5-26	6954	Morrow	.70	1461	1834	0.26
Latigo	Barby	32-5-26	6909	Morrow	.69	1388	1712	0.25
Anabaco	Smith	33-5-26	6862	Morrrow	.71	1597	2016	0.29
Png	Barby	34-5-26	6799	Morrrow	.72	1439	1797	0.26

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
BB&S	Alexander	35-5-26	3279	C. Grove	.69	863	984	0.30
Follet	Beard	36-5-26	3555	C. Grove	.69	995	1109	0.31
Shell	Lonker	2-5-27	6252	Morrow	.67	1621	1999	0.32
Bhp	State	3-5-27	6248	Morrow	.68	1720	2102	0.34
Kerr	Paasch	4-5-27	6352	Morrow	.68	1690	2072	0.33
Ferraro	State	5-5-27	6419	Morrow	.68	1763	2143	0.33
Ferraro	State	5-5-27	6566	Chester	.68	1694	2095	0.32
Texaco	Sargent	7-5-27	6566	Morrow	.65	1620	2003	0.31
Kaiser	Wheeler	8-5-27	6540	Morrow	.66	1747	2121	0.32
Arco	Lowery	9-5-27	6413	Morrow	.66	1657	2002	0.31
H&L	Miller	9-5-27	6364	Morrow	.67	1675	2041	0.32
Kaiser	Shephard	15-5-27	6448	Morrow	.70	1717	2092	0.32
Pet. Inc.	State	16-5-27	6480	Morrow	.68	1730	2129	0.33
Valence	Botkin	17-5-27	6580	Morrow	.68	1738	2124	0.32
Cabot	Hamilton	18-5-27	6711	Morrow	.71	1739	2137	0.32
Dette	Maphet	20-5-27	6651	Morrow	.64	1755	2200	0.33
Anadarko	Allen	21-5-27	6548	Morrow	.70	1757	2112	0.32
Kingwood	Canfield	22-5-27	6542	Morrow	.71	1740	2158	0.33
Txo	Dondelinger	26-5-27	6600	Morrow	.72	1803	2226	0.34
Kerr	Dixon	28-5-27	6713	Morrow	.72	1669	2090	0.31
Kaiser	Dyer	29-5-27	6717	Morrow	.72	1594	1995	0.30
Patrick	Card	30-5-27	7018	Morrow	.70	1580	1975	0.28
Otc	Mathers	31-5-27	6892	Morrow	.72	1548	1976	0.29
Otc	Bond	32-5-27	6882	Morrow	.71	1855	2352	0.34
Huber	Carrier	34-5-27	6770	Morrow	.70	1713	2152	0.32
Marathon	Little	36-5-27	6635	Morrow	.65	1747	2124	0.32
Morgan	Hink	2-5-28	6404	Chester	.65	1710	2054	0.32
Morgan	Long	3-5-28	6417	Chester	.65	1702	2051	0.32
Arco	Long	4-5-28	6270	Chester	.63	1738	2067	0.33
Samson	Berends	8-5-28	6266	Morrow	.67	1625	1965	0.31
Statex	Kasper	10-5-28	6392	Chester	.63	1821	2183	0.34
Cross Timb.	Borth	11-5-28	6273	Morrow	.66	1759	2120	0.34
Williford	Stanley	14-5-28	6362	Chest/Mor.	.66	1787	2170	0.34
Kaiser	Long	15-5-28	6480	Chest/Mor.	.63	1948	2331	0.36
Huber	Long	16-5-28	6294	Morrow	.63	1590	1914	0.30
Ricks	Wolf	17-5-28	6226	Morrow	.65	1780	2138	0.34
Kaiser	Wolf	20-5-28	6387	Morrow	.71	1684	2082	0.33
Lear	Long	21-5-28	6380	Morrow	.69	1640	2004	0.31
Sec	Long	21-5-28	6382	Morrow	.69	1544	1889	0.30
Txo	Kern	28-5-28	6455	Morrow	.71	1712	2116	0.33
Maxus	Whisenhunt	29-5-28	6532	Morrow	.69	1692	2086	0.32
Gruy	Correll	31-5-28	6814	Chester	.65	1692	2057	0.30
Txo	Gate	33-5-28	6500	Morrow	.72	1672	2076	0.32
Walker	Patten	34-5-28	6678	Chester	.69	1547	1902	0.28
Argonaout	Terbush	35-5-28	6550	Chester	.66	1755	2145	0.33
Alladin	Cobb	16-6-20	6190	Morrow	.69	1461	1771	0.29

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Getty	Deedfield	18-6-20	6335	Morrow	.65	1559	1879	0.30
Anadarko	Gribi	19-6-20	6715	Chester	.70	1801	2237	0.33
Anadarko	King	30-6-20	6734	Chester	.72	1834	2309	0.34
Anadarko	King	30-6-20	6336	Morrow	.67	1380	1673	0.26
Oxy	Hamm	33-6-20	6533	Chester	.64	1629	1965	0.30
Oxy	Windsor	34-6-20	6547	Chester	.63	1583	1908	0.29
Anadarko	Fisher	7-6-21	4562	Lansing	.70	1142	1315	0.29
Anadarko	Fisher	7-6-21	6130	Morrow	.63	1317	1561	0.25
Huber	Light	9-6-21	6325	Chester	.63	1467	1748	0.28
Huber	Light	9-6-21	6275	Morrow	.63	1376	1651	0.26
Huber	Sharp	13-6-21	6001	Morrow	.63	1458	1727	0.29
Huber	Bryan	14-6-21	4620	K. City	.63	1250	1453	0.31
Huber	Heitschmidt	14-6-21	4610	K. City	.70	1242	1439	0.31
Huber	Heintz	15-6-21	6028	Morrow	.70	1475	1773	0.29
Huber	Hinz	22-6-21	6048	Morrow	.70	1430	1727	0.29
Huber	Wallace	22-6-21	4602	K. City	.70	1269	1468	0.32
Huber	Clapp	24-6-21	6181	Morrow	.65	1520	1811	0.29
Huber	Clapp	24-6-21	6265	Chester	.63	1561	1870	0.30
Panhandle	Clapp	25-6-21	6199	Morrow	.66	1551	1860	0.30
Huber	Stephenson	27-6-21	6465	Chester	.63	1387	1693	0.26
Huber	Zielke	28-6-21	6152	Morrow	.66	1259	1497	0.24
Cross Timb.	Amen	35-6-21	6530	Miss.	.63	1460	1750	0.27
Huber	Davis	36-6-21	6422	Morrow	.66	1657	2006	0.31
Anadarko	Pryor	9-6-22	6327	Morrow	.67	1512	1825	0.29
Texaco	Hall	21-6-22	6100	Morrow	.66	1516	1808	0.30
United	Kiser	22-6-22	6294	Morrow	.67	1504	1804	0.29
Natural Gas	Flannigan	27-6-22	6303	Morrow	.65	1472	1758	0.28
Natomas	Blucher	28-6-22	6101	Morrow	.74	1495	1846	0.30
Huber	Davis	30-6-22	6301	Chester	.65	1557	1861	0.30
Huber	Davis	30-6-22	6129	Morrow	.65	1554	1868	0.30
Apx	Humiston	31-6-22	6276	Morrow	.78	1550	1962	0.31
Hixon	Adams	11-6-23	4349	Cisco	.71	1380	1612	0.37
Escue	Adams	12-6-23	5888	Morrow	.70	1596	1930	0.33
Underwood	Adams	12-6-23	6246	Miss.	.69	1742	2137	0.34
Escue	Elliott	13-6-23	5938	Morrow	.69	1522	1830	0.31
Anadarko	Adams	16-6-23	5816	Morrow	.66	1560	1854	0.32
Anadarko	Radcliff	23-6-23	6116	Chest/Mor.	.65	1655	1977	0.32
Anadarko	Barnes	24-6-23	6252	Chester	.65	1945	2350	0.38
Indian	Nichols	24-6-23	6057	Morrow	.72	1635	2024	0.33
Continental	Rushton	30-6-23	6398	Morrow	.67	1571	1909	0.30
Hixon	Adams	9-6-24	6129	Chester	.66	1725	2077	0.34
Hixon	Adams	12-6-24	5848	Morrow	.66	1595	1919	0.33
Ashland	Adams	16-6-24	4470	Cisco	.66	1302	1500	0.34
Texaco	State	20-6-24	3130	C. Grove	.66	808	895	0.29
Spess	Adams	23-6-24	6189	Morrow	.67	1602	1942	0.31
Ladd	Jessie	25-6-24	6252	Morrow	.66	1576	1910	0.31

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Ensign	Eagan	28-6-24	6186	Morrow	.70	1610	1971	0.32
Pet. Inc	Mitchell	29-6-24	6033	Morrow	.70	1682	2055	0.34
Pet. Inc	Mitchell	29-6-24	4496	Cisco	.72	1249	1459	0.32
Elders	Reckand	30-6-24	6027	Morrow	.76	1694	2125	0.35
Marlin	Hodges	34-6-24	3286	C. Grove	.67	1279	1424	0.43
Oxy	Girk	35-6-24	6615	Chester	.68	1870	2295	0.35
Kerr	Adams	36-6-24	6106	Morrow	.67	1549	1858	0.30
Kerr	Adams	36-6-24	6463	Miss.	.67	1761	2162	0.33
Cross Timb.	XIT	29-6-25	6368	Morrow	.70	1652	2035	0.32
Kerr	Raymond	31-6-25	6089	Morrow	.67	1646	1986	0.33
Samson	Adams	31-6-25	6527	Miss.	.68	1801	2210	0.34
Enron	Judy	35-6-25	6451	Morrow	.69	1530	1887	0.29
Bhp	Dillon	13-6-26	6296	Chester	.64	1760	2118	0.34
Cleary	Anshutz	20-6-26	2997	C. Grove	.70	957	1056	0.35
BB&S	Barby	21-6-26	3220	C. Grove	.65	895	986	0.31
Lear	Barby	28-6-26	3256	C. Grove	.65	952	1065	0.33
Dyco	Stafford	36-6-26	6486	Chester	.64	1422	1707	0.26
Kelloil	Shaffer	9-6-27	6110	Chester	.64	1416	1678	0.27
Kelloil	Smith	13-6-27	6184	Chester	.70	1672	2048	0.33
Samson	Jackson	15-6-27	5997	Morrow	.69	1747	2122	0.35
Samson	Albert	18-6-27	6316	Chester	.69	1690	2047	0.32
Marlin	Barby	19-6-27	6210	Chester	.64	1573	1872	0.30
Rasmussen	Barby	20-6-27	6094	Morrow	.68	1522	1840	0.30
Samson	Smith	21-6-27	6271	Morrow	.65	1770	2120	0.34
Huber	Shaffer	22-6-27	6178	Morrow	.67	1764	2128	0.34
Amoco	Smith	23-6-27	6179	Chester	.69	1731	2087	0.34
Lamb	Smith	24-6-27	6108	Morrow	.69	1685	2045	0.33
Samson	Dillon	25-6-27	6008	Morrow	.67	1711	2053	0.34
Txo	Shaffer	27-6-27	6243	Chester	.67	1776	2144	0.34
Samson	Dyer	28-6-27	6107	Morrow	.65	1667	1987	0.33
Samson	Southerland	28-6-27	6118	Morrow	.68	1748	2117	0.35
Fina	Dyer	29-6-27	6130	Morrow	.68	1699	2062	0.34
Crown	Paasch	33-6-27	6222	Morrow	.70	1383	1687	0.27
Cng	Bailey	34-6-27	6112	Morrow	.68	1654	1999	0.33
Shell	Lonker	35-6-27	6247	Chester	.68	1664	2024	0.32
Shell	Lonker	35-6-27	6092	Morrow	.66	1612	1933	0.32
Shell	Lonker	35-6-27	6066	Morrow	.67	1735	2005	0.33
Parker	Hennigh	28-6-28	6081	Morrow	.67	1670	2012	0.33
Samson	Broadie	29-6-28	6034	Chester	.63	1732	2058	0.34
Graham	Fleming	2-1-9	3584	Topeka	.70	477	533	0.15
Graham	Fleming	2-1-9	4336	Oswego	.68	826	948	0.22
Exxon	Wells	10-1-9	4614	Cherokee	.67	840	960	0.21
Coastal	Gowdy	11-1-9	4376	Cherokee	.67	818	930	0.21
Crouch	Brook	13-1-9	3564	Topeka	.65	428	475	0.13
Texaco	Peck	14-1-9	3484	Topeka	.73	469	525	0.15
Texaco	Peck	14-1-9	4354	Atoka	.73	860	986	0.23

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Texaco	Youtsler	23-1-9	4297	Atoka	.73	860	992	0.23
Texaco	Youtsler	23-1-9	3920	K. City	.70	594	672	0.17
Texaco	Chuman	24-1-9	4118	Marmaton	.72	778	888	0.22
Texaco	Chuman	24-1-9	3460	Topeka	.74	470	522	0.15
Texaco	Hawkins	26-1-9	4310	Atoka	.71	830	946	0.22
Texaco	Hawkins	26-1-9	3476	Topeka	.72	476	567	0.16
Phillips	Polsey	30-1-9	1751	Red Cave	.72	209	220	0.13
Phillips	Bruere	31-1-9	3367	Topeka	.80	477	540	0.16
Wallace	Price	31-1-9	1698	Red Cave	.80	295	315	0.19
texaco	Niela	36-1-9	3482	Topeka	.84	820	946	0.27
Bumper	Prothbo	34-2-7	5183	Morrow	.67	997	1163	0.22
Oxy	Pinkerton	4-2-8	4452	Morrow	.69	912	1039	0.23
Oxy	Campbell	5-2-8	4506	Morrrow	.70	910	1042	0.23
Texaco	Taylor	9-2-8	4206	Cherokee	.70	776	873	0.21
Cities	Oyler	16-2-8	3431	Topeka	.70	475	523	0.15
Oxy	Ingle	17-2-8	4676	Morrow	.68	1032	1188	0.25
Oxy	Gowdy	20-2-8	4686	Morrow	.67	1007	1161	0.25
Oxy	Gowdy	20-2-8	3486	Topeka	.73	438	492	0.14
Kimball	Groseclose	28-2-8	4625	Morrow	.68	1027	1185	0.26
Anson	Cavis	30-2-8	4716	Morrow	.67	995	1143	0.24
Lmr	Pugh	3-2-9	4552	Morrow	.68	977	1114	0.24
Kaiser	Zimmerman	11-2-9	4565	Morrow	.66	1002	1143	0.25
Argonaut	Smalts	12-2-9	4554	Morrow	.68	1093	1251	0.27
Kaiser	Smalts	12-2-9	4554	Morrow	.66	1045	1209	0.27
Cotton	Treece	13-2-9	4557	Morrow	.68	990	1132	0.25
Crouch	Nash	22-2-9	3432	Topeka	.73	449	510	0.15
Marlin	Smalts	23-2-9	4616	Morrow	.68	1012	1163	0.25
Crouch	Hitch	25-2-9	3339	Topeka	.70	460	522	0.16
Texaco	McGarr.	26-2-9	3412	Topeka	.68	473	524	0.15
Texaco	Dencker	27-2-9	3440	Topeka	.72	473	540	0.16
Texaco	Dencker	27-2-9	4628	Morrow	.66	1009	1159	0.25
Crouch	Crone	28-2-9	4650	Morrow	.65	1052	1219	0.26
Texaco	Dencker	34-2-9	3983	Marmaton	.70	716	813	0.20
Texaco	Hawkins	35-2-9	3444	Topeka	.70	463	511	0.15
CIG	Delozier	3-3-8	4554	Keyes	.73	743	851	0.19
Bhp	Omohundra	21-3-8	4812	Keyes	.68	822	937	0.19
Yucca	Hanes	2-3-9	4556	Keyes	.76	856	1000	0.22
Yucca	Hanes	2-3-9	4295	Morrow	.71	979	1124	0.26
Crouch	Hanke	3-3-9	4492	Keyes	.78	835	982	0.22
Texaco	Hanes	10-3-9	4550	Morrow	.79	833	974	0.21
Texaco	Hanke	11-3-9	4564	Keyes	.77	835	977	0.21
Texaco	Hanes	11-3-9	4304	U. Morrow	.73	966	1109	0.26
Arco	Hanes	13-3-9	4625	Keyes	.65	840	960	0.21
Arco	Hanes	14-3-9	4346	U. Morrow	.76	923	1070	0.25
Cross Timb.	Phillips	8-4-8	4800	Keyes	.73	805	932	0.19
CIG	Cimarron	16-4-8	4080	Atoka	.80	808	937	0.23

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
CIG	Parker	34-4-8	4812	Keyes	.73	804	936	0.19
Amoco	Ferguson	2-4-9	4614	Keyes	.73	815	944	0.20
Samson	Spradlin	3-4-9	4560	Keyes	.74	816	961	0.21
Oxy	Spradlin	4-4-9	4560	Keyes	.73	830	945	0.21
Oxy	Spradlin	5-4-9	4632	Keyes	.73	828	959	0.21
Oxy	Spradlin	9-4-9	4609	Keyes	.73	826	955	0.21
Samson	Burkett	10-4-9	4602	Keyes	.73	817	942	0.20
Seewald	Kline	19-4-9	4426	Morrow	.74	990	1154	0.26
Mobil	Bryant	35-4-9	4362	Morrow	.73	978	1125	0.26
Mobil	Bryant	35-4-9	4620	Keyes	.77	841	989	0.21
CIG	Achenback	1-5-8	4633	Keyes	.76	831	959	0.21
CIG	Rooney	2-5-8	4636	Keyes	.73	817	944	0.20
Beard	Stallard	9-5-8	4738	Keyes	.73	813	943	0.20
CIG	Cox	16-5-8	4736	Keyes	.73	825	956	0.20
CIG	Jermyn	18-5-8	4854	Keyes	.73	821	954	0.20
CIG	Gross	25-5-8	4696	Keyes	.73	821	947	0.20
CIG	Rose	26-5-8	4666	Keyes	.73	834	965	0.21
CIG	Burford	29-5-8	4782	Keyes	.73	827	958	0.20
Cities	Whisenand	1-5-9	3272	Toronto	.70	429	471	0.14
Oxy	Whisenand	2-5-9	4658	Keyes	.73	834	965	0.21
Oxy	Sparkman	3-5-9	4674	Keyes	.73	834	964	0.21
Kp	Hayworth	5-5-9	4613	Keyes	.73	824	954	0.21
CIG	High	6-5-9	4586	Keyes	.73	823	950	0.21
Oxy	Sparkman	10-5-9	4652	Keyes	.73	834	963	0.21
Oxy	Sparkman	11-5-9	4590	Keyes	.73	828	951	0.21
Gasanadarko	Sparkman	12-5-9	4592	Keyes	.73	831	958	0.21
Oxy	Melton	15-5-9	4596	Keyes	.73	830	958	0.21
Superior	Harryman	17-5-9	4658	Keyes	.73	828	959	0.21
Oxy	Schnaufer	23-5-9	4466	Keyes	.73	833	959	0.21
Oxy	Turner	24-5-9	4614	Keyes	.73	833	966	0.21
Cross Timb.	State	25-5-9	4572	Keyes	.73	832	959	0.21
Cross Timb.	Ferguson	27-5-9	4527	Keyes	.73	832	957	0.21
Oxy	Sparkman	32-5-9	4590	Keyes	.73	828	954	0.21
Oxy	Bracken	34-5-9	4596	Keyes	.73	828	956	0.21
Oxy	Bracken	34-5-9	3110	Topeka	.77	418	464	0.15
Cities	Ferguson	35-5-9	3201	Topeka	.76	397	438	0.14
Cities	Ferguson	35-5-9	4240	Morrow	.74	908	1041	0.25
Oxy	Jordan	36-5-9	4618	Keyes	.78	833	968	0.21
Stromquist	Mathis	13-6-8	2824	Wabaunse	.80	438	491	0.17
Stromquist	Mathis	14-6-8	2882	Wabaunse	.82	436	481	0.17
Coastal	Mathis	23-6-8	4678	Keyes	.76	832	964	0.21
Cross Timb.	Halliday	34-6-8	4390	Morrow	.77	976	1135	0.26
Shell	Halliday	25-6-8	4669	Keyes	.73	832	964	0.21
Oxy	Purdy	20-6-9	4252	Purdy	.80	1061	1245	0.29
Shenandoah	Taylor	23-6-9	3810	Marmaton	.72	646	727	0.19
Edinger	Schfld	30-6-9	4567	Keyes	.73	834	963	0.21

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Oxy	Mingenbah	32-6-9	4620	Keyes	.73	836	972	0.21
Oxy	Mingenbah	33-6-9	4630	Keyes	.73	835	963	0.21
Oxy	Ford	34-6-9	4670	Keyes	.73	833	962	0.21
Shell	Sleeper	35-6-9	4668	Keyes	.73	832	964	0.21
Oxy	Kinsinger	36-6-9	4650	Keyes	.73	836	965	0.21
Kerr	Sweet	1-1-11	2694	Chase	.70	428	468	0.17
Texaco	Christian	14-1-11	6138	Morrow	.72	1317	1620	0.26
Phillips	Crimson	24-1-11	6232	Morrow	.70	1260	1537	0.25
Texaco	Bergner	27-1-11	2826	Chase	.70	425	467	0.17
Phillips	Alfa	18-1-12	2730	Chase	.70	430	468	0.17
Phillips	Gayle	21-1-12	3312	C. Grove	.75	467	566	0.17
Phillips	Pal	22-1-12	2930	Chase	.70	426	467	0.16
Phillips	Eli	29-1-12	2880	Chase	.70	426	466	0.16
Phillips	Berry	30-1-12	3279	C. Grove	.75	514	572	0.17
Kerr	Dotson	31-1-12	2892	Chase	.70	429	471	0.16
Phillips	Mitchell	35-1-12	6785	Morrow	.70	1264	1555	0.23
McKenzie	Pool	4-1-13	3260	C. Grove	.75	475	524	0.16
Amoco	Burrows	7-1-13	2890	Chase	.70	432	474	0.16
Phillips	Waugh	31-1-13	6735	Morrow	.71	1580	1964	0.29
Phillips	Lath	1-1-14	6765	Morrow	.71	1538	1912	0.28
Phillips	Mussman	9-1-14	2842	Chase	.70	423	463	0.16
Phillips	Carbon	20-1-14	2840	Chase	.70	425	465	0.16
Phillips	Kaser	1-1-15	6262	Morrow	.76	1612	1978	0.32
Phillips	Luman	3-1-15	6628	Morrow	.71	1558	1940	0.29
Phillips	Ratton	5-1-15	5711	Oswego	.71	1541	1854	0.32
Phillips	Atar	9-1-15	6890	Morrow	.71	1754	2194	0.32
Rupe	Vantine	11-1-15	6238	Morrow	.71	1618	1951	0.31
Phillips	Virgil	12-1-15	6274	Morrow	.68	1545	1870	0.30
Phillips	Virgil	12-1-15	2650	Chase	.70	424	461	0.17
Phillips	Pearl	16-1-15	5772	Marmaton	.68	1621	1953	0.34
Phillips	Pearl	16-1-15	6038	Cherokee	.74	1376	1693	0.28
Phillips	Wavia	17-1-15	3334	C. Grove	.70	572	630	0.19
Phillips	Wavia	17-1-15	4484	Douglas	.74	1065	1237	0.28
Phillips	Wavia	17-1-15	5756	Oswego	.69	1485	1778	0.31
Phillips	Naples	18-1-15	3241	C. Grove	.70	562	616	0.19
Phillips	Curt	19-1-15	3359	C. Grove	.70	624	691	0.21
Phillips	Reust	20-1-15	3542	C. Grove	.70	582	644	0.18
Phillips	Lil	21-1-15	2873	Chase	.70	424	465	0.16
Phillips	Oben	26-1-15	6707	Morrow	.73	1597	2004	0.30
Phillips	Hitch	34-1-15	6800	Morrow	.73	1604	2016	0.30
Phillips	Les	35-1-15	6764	Morrow	.73	1559	1958	0.29
Phillips	Alt	1-1-16	2715	Chase	.70	429	469	0.17
Phillips	Bon	2-1-16	2651	Chase	.70	427	464	0.18
Phillips	Gwen	3-1-16	2680	Chase	.70	427	464	0.17
Phillips	Hitch	4-1-16	2695	Chase	.70	437	478	0.18
Phillips	Place	6-1-16	6568	Morrow	.69	1653	2031	0.31

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Phillips	Puckett	7-1-16	6292	Morrow	.68	1596	1933	0.31
Phillips	Hitch	9-1-16	2710	Chase	.70	428	466	0.17
Phillips	Cab	11-1-16	2745	Chase	.70	430	471	0.17
Jma	Clawson	11-1-16	5811	Oswego	.70	1575	1902	0.33
Phillips	Lieb	12-1-16	2798	Chase	.70	427	470	0.17
Phillips	Beaver	13-1-16	2835	Chase	.70	435	478	0.17
Phillips	Rhoad	14-1-16	2842	Chase	.70	429	470	0.17
Phillips	Lola	15-1-16	6524	Morrow	.64	1639	1973	0.30
Phillips	Clip	16-1-16	6438	Morrow	.66	1639	1979	0.31
Phillips	Lassert	21-1-16	2860	Chase	.70	428	468	0.16
Phillips	Bernelle	22-1-16	5870	Oswego	.69	1530	1837	0.31
Phillips	Bernelle	22-1-16	6438	Morrow	.66	1632	1971	0.31
Phillips	Hugoton	23-1-16	6459	Morrow	.65	1578	1898	0.29
Santa Fe	Arnold	1-1-17	6818	Morrow	.67	1839	2260	0.33
Plains	Stinson	2-1-18	6479	Morrow	.73	1416	1760	0.27
Aexco	Miller	5-1-18	6804	Morrow	.61	1888	2255	0.33
SantaFe	Rhodes	6-1-18	6781	Morrow	.61	1909	2278	0.34
Plains	Hendricks	8-1-18	6812	Morrow	.60	1882	2242	0.33
Santa Fe	Becker	9-1-17	2780	Chase	.70	426	465	0.17
Phillips	Atkins	15-1-17	2770	Chase	.70	437	477	0.17
Phillips	Atkins	16-1-17	2800	Chase	.70	435	475	0.17
Phillips	Atkins	28-1-17	2770	Chase	.70	431	470	0.17
Phillips	Atkins	34-1-17	2750	Chase	.70	430	469	0.17
Plains	Stinson	4-1-18	2614	Chase	.70	430	469	0.18
Plains	Stinson	9-1-18	6404	Morrow	.62	1405	1661	0.26
Hamilton	Curtis	10-1-18	6680	Morrow	.65	1672	2021	0.30
Faulconer	State	16-1-18	6879	Morrow	.60	1906	2273	0.33
Faulconer	McCoy	17-1-18	6843	Morrow	.60	1844	2195	0.32
Plains	Blades	17-1-18	2638	Chase	.70	430	471	0.18
Plains	Westmorel	20-1-18	2670	Chase	.70	434	472	0.18
Plains	Shorb	23-1-18	7018	Chester	.61	1786	2148	0.31
Faulconer	Campbell	1-1-19	6827	Morrow	.72	1483	1862	0.27
Exxon	Campbell	2-1-19	6768	Morrow	.69	1382	1698	0.25
Exxon	Reuzer	3-1-19	6694	Morrow	.70	1403	1727	0.26
Exxon	Perry	4-1-19	6648	Morrow	.70	1350	1659	0.25
Exxon	State	5-1-19	6601	Morrow	.70	1432	1758	0.27
Otc	Farmers	7-1-19	6487	Morrow	.71	1369	1684	0.26
Texaco	Silsbee	8-1-19	6600	Morrow	.71	1394	1717	0.26
Hondo	Sheets	12-1-19	6906	Morrow	.73	1317	1650	0.24
Eland	Davis	13-1-19	6865	Morrow	.72	1318	1642	0.24
Petroleum	Brown	14-1-19	6774	Morrow	.74	1289	1615	0.24
Presidio	Winfrey	15-1-19	6815	Morrow	.72	1392	1739	0.26
Oxy	Squires	17-1-19	6620	Morrow	.68	1412	1718	0.26
Oxy	Johnson	19-1-19	6644	Morrow	.69	1413	1730	0.26
Oxy	Reynolds	20-1-19	6710	Morrow	.70	1414	1744	0.26
Oxy	Silsbee	21-1-19	6786	Morrow	.71	1412	1752	0.26

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Horizon	Littau	25-1-19	7230	Morrow	.65	1340	1631	0.23
Texaco	Flowers	26-1-19	6878	Morrow	.75	1391	1765	0.26
Graham	Trent	30-1-19	6815	U. Morrow	.71	1220	1508	0.22
Mayflo	Flowers	34-1-19	6711	U. Morrow	.71	1280	1579	0.24
Oxy	Miller	1-2-11	2726	Chase	.70	425	466	0.17
Barnett	Mayer	3-2-11	5967	Morrow	.75	1460	1737	0.29
Phillips	Hornet	36-2-11	2720	Chase	.70	425	463	0.17
Oxy	Stonebraker	1-2-12	3020	C. Grove	.79	499	559	0.19
Oxy	Stonebraker	1-2-12	2584	Chase	.70	432	470	0.18
Oxy	Stonebraker	2-2-12	2598	Chase	.70	432	469	0.18
Oxy	Stonebraker	3-2-12	2568	Chase	.70	431	471	0.18
Oxy	Stonebraker	4-2-12	2684	Chase	.70	430	470	0.18
Oxy	Stonebraker	8-2-12	2706	Chase	.70	425	465	0.17
Oxy	Stonebraker	9-2-12	2706	Chase	.70	429	470	0.17
Oxy	Stonebraker	10-2-12	2708	Chase	.70	430	472	0.17
Oxy	Stonebraker	15-2-12	2644	Chase	.70	426	465	0.18
Oxy	Stonebraker	16-2-12	2700	Chase	.70	426	464	0.17
Oxy	Stonebraker	17-2-12	2676	Chase	.70	427	467	0.17
Phillips	Hermitt	29-2-12	2700	Chase	.70	429	467	0.17
Graham	Cecil	32-2-12	6086	Morrow	.65	1461	1736	0.29
Oxy	Stonebraker	5-2-13	2730	Chase	.70	426	464	0.17
Oxy	Stonebraker	6-2-13	3064	C. Grove	.78	480	531	0.17
Oxy	Stonebraker	7-2-13	2818	Chase	.70	427	475	0.17
Paradox	Rowan	30-2-13	3232	C. Grove	.74	501	553	0.17
Mobil	Wiggins	1-2-14	2763	Chase	.70	425	465	0.17
Cabot	Oliver	3-2-14	6614	Morrow	.75	1607	2035	0.31
Oxy	Camp	9-2-14	6756	Morrow	.76	1548	1966	0.29
Oxy	Lohman	10-2-14	6658	Morrow	.74	1687	2130	0.32
Oxy	Olson	11-2-14	6692	Morrow	.73	1647	2067	0.31
Getty	Olson	13-2-14	6730	Morrow	.73	1633	2050	0.30
Texaco	Allen	14-2-14	6720	Morrow	.73	1656	2086	0.31
Oxy	Hall	16-2-14	6770	Keyes	.72	1715	2147	0.32
Phillips	Adlai	23-2-14	6708	Morrow	.72	1691	2115	0.32
Phillips	Rees	25-2-14	6754	Morrow	.71	1696	2113	0.31
Phillips	Florence	26-2-14	5722	Oswego	.73	1490	1819	0.32
Phillips	Melissa	35-2-14	6781	Morrow	.70	1705	2136	0.31
Phillips	McGarrough	36-2-14	6797	Morrow	.68	1764	2226	0.33
Getty	Olson	1-2-15	2779	Chase	.70	434	478	0.17
Getty	Lancaster	2-2-15	2763	Chase	.70	432	473	0.17
Texaco	Reynold	3-2-15	6682	Keyes	.69	1637	2023	0.30
Cabot	Ennis	9-2-15	6721	Morrow	.67	1652	2032	0.30
Yingling	Higgins	10-2-15	6744	Keyes	.69	1713	2114	0.31
Yingling	Higgins	10-2-15	6346	Morrow	.67	1596	1937	0.31
Getty	Montgomery	11-2-15	2768	Chase	.70	434	477	0.17
Texaco	Martin	14-2-15	2790	Chase	.70	434	474	0.17
Getty	Martin	14-2-15	6714	Keyes	.69	1703	2103	0.31

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Getty	Wiggens	15-2-15	6742	Keyes	.65	1705	2065	0.31
Yingling	Summers	16-2-15	6745	Keyes	.71	1702	2120	0.31
Yingling	Jackson	17-2-15	6764	Keyes	.71	1706	2126	0.31
Texaco	Wise	18-2-15	6738	Keyes	.73	1702	2142	0.32
Phillips	Vantine	33-2-15	6336	Morrow	.70	1646	2029	0.32
Phillips	Sheil	34-2-15	5798	Oswego	.69	1531	1838	0.32
Phillips	Mickey	36-2-15	6772	Morrow	.73	1697	2136	0.32
Santa Fe	Mitch	3-2-16	2752	Chase	.70	437	477	0.17
Getty	Truesdell	6-2-16	2777	Chase	.70	436	479	0.17
Getty	Phillips	11-2-16	2772	Chase	.70	428	468	0.17
Getty	Werner	12-2-16	2790	Chase	.70	432	472	0.17
Getty	Tryon	13-2-16	2778	Chase	.70	433	476	0.17
Getty	Miller	14-2-16	2808	Chase	.70	432	475	0.17
Getty	Hitch	16-2-16	2788	Chase	.70	428	471	0.17
Phillips	Hitch	21-2-16	5885	Oswego	.73	1539	1860	0.32
Phillips	Pansy	22-2-16	2776	Chase	.70	429	468	0.17
Phillips	Niesen	26-2-16	2595	Chase	.70	429	468	0.18
Phillips	Roscoe	34-2-16	2596	Chase	.70	435	470	0.18
Phillips	Prudential	35-2-16	2620	Chase	.70	433	466	0.18
Phillips	Art	36-2-16	2646	Chase	.70	436	472	0.18
Graham	Neff	1-2-17	6145	Morrow	.70	1045	1255	0.20
Phillips	Neff	1-2-17	6511	Morrow	.63	1846	2209	0.34
Graham	Mayer	2-2-17	6276	Morrow	.73	1370	1689	0.27
Getty	George	5-2-17	2758	Chase	.70	426	464	0.17
Getty	George	9-2-17	2764	Chase	.70	432	469	0.17
Santa Fe	Copple	12-2-17	6213	Morrow	.68	1399	1689	0.27
Santa Fe	Hughey	25-2-17	6738	Morrow	.60	1804	2143	0.32
Santa Fe	Hughey	27-2-17	2758	Chase	.70	425	463	0.17
Phillips	Cato	30-2-17	2615	Chase	.70	433	469	0.18
Santa Fe	Wall	33-2-17	2715	Chase	.70	426	462	0.17
Amoco	Randles	35-2-17	2777	Chase	.70	428	466	0.17
Santa Fe	State	36-2-17	2788	Chase	.70	434	473	0.17
Santa Fe	Phillips	36-2-17	6778	Morrow	.60	1702	2023	0.30
Graham	Joliffe	1-2-18	6400	Morrow	.72	1409	1735	0.27
Exxon	Joliffe	3-2-18	6284	Morrow	.72	1321	1619	0.26
Exxon	Joliffe	4-2-18	6293	Morrow	.71	1427	1746	0.28
KN Energy	Neff	6-2-18	6204	Morrow	.70	1322	1602	0.26
Amoco	Copple	7-2-18	2566	Chase	.70	433	468	0.18
Texaco	Joliffe	8-2-18	6270	Morrow	.71	1376	1679	0.27
Plains	State	9-2-18	2636	Chase	.70	434	470	0.18
Plains	State	9-2-18	6320	Morrow	.72	1418	1750	0.28
Plains	Richards	10-2-18	6348	Morrow	.72	1418	1747	0.28
Texaco	McBride	11-2-18	6426	Morrow	.71	1395	1721	0.27
Plains	Topping	12-2-18	6470	Morrow	.70	1433	1753	0.27
Plains	Topping	12-2-18	6808	Morrow	.74	1448	1826	0.27
Plains	Jones	13-2-18	6536	Morrow	.70	1417	1739	0.27

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Plains	Tharp	14-2-18	6432	Morrow	.71	1412	1745	0.27
Plains	State	16-2-18	6344	Morrow	.73	1401	1732	0.27
Santa Fe	Bingley	19-2-18	2700	Chase	.70	431	465	0.17
Kaiser	Fisher	20-2-18	2710	Chase	.70	425	458	0.17
Plains	McGarrough	21-2-18	2676	Chase	.70	432	468	0.17
Graham	Tharp	22-2-18	2670	Chase	.70	433	467	0.17
Plains	Tharp	22-2-18	6340	Morrow	.72	1421	1747	0.28
Plains	Martin	23-2-18	6485	Morrow	.69	1781	2185	0.34
Plains	Tharp	24-2-18	6600	Morrow	.70	1413	1734	0.26
Graham	Brown	25-2-18	6521	Morrow	.69	1424	1745	0.27
Plains	Graves	26-2-18	6457	Morrow	.74	1400	1744	0.27
Plains	Godley	27-2-18	6367	Morrow	.73	1425	1763	0.28
Plains	Godley	27-2-18	2672	Chase	.70	436	471	0.18
Santa Fe	Bingley	31-2-18	2730	Chase	.70	431	465	0.17
Plains	Etter	34-2-18	6690	Chester	.65	1484	1779	0.27
Plains	Williamson	35-2-18	6494	Morrow	.73	1423	1767	0.27
Plains	Richardson	36-2-18	6510	Morrow	.69	1423	1739	0.27
Palm	Gilbert	5-2-19	6470	Morrow	.71	1350	1657	0.26
Plains	State	7-2-19	6516	Morrow	.72	1426	1769	0.27
Sparks	Gilliland	14-2-19	6550	Morrow	.71	1405	1729	0.26
KNN	Greene	17-2-19	6629	Morrow	.71	1697	2106	0.32
Plains	Tharp	18-2-19	6584	Morrow	.71	1418	1748	0.27
Plains	Washburn	19-2-19	6597	Morrow	.71	1420	1753	0.27
Plains	Green	20-2-19	6548	Morrow	.73	1468	1829	0.28
Geodyne	Harrison	25-2-19	6780	Morrow	.70	1409	1738	0.26
Exxon	Wiebe	27-2-19	6639	Morrow	.70	1418	1746	0.26
Plains	Morris	30-2-19	6542	Morrow	.72	1421	1758	0.27
Plains	Stinson	31-2-19	6524	Morrow	.76	1432	1814	0.28
Exxon	Bowles	34-2-19	6659	Morrow	.70	1406	1731	0.26
Hondo	Speakman	35-2-19	6726	Morrow	.70	1458	1827	0.27
Argonaut	Clark	21-3-10	3348	Topeka	.71	400	442	0.13
Daco	Eggers	5-3-11	4624	Marmaton	.70	995	1144	0.25
Ricks	Christopher	28-3-11	5742	Morrow	.66	1338	1578	0.27
Zgen	Irvin	29-3-11	4886	Marmaton	.70	958	1113	0.23
Indian	Flanagen	32-3-11	4874	Marmaton	.65	929	1060	0.22
Oxy	Shubert	33-3-11	5035	Marmaton	.75	993	1174	0.23
Oxy	Shores	36-3-11	2686	Chase	.70	425	461	0.17
Apx	Curren	1-3-12	2716	Chase	.70	430	467	0.17
Anadarko	Stambaugh	1-3-12	6436	Morrow	.75	1475	1807	0.28
Oxy	Stonebraker	2-3-12	6008	Morrow	.69	1324	1591	0.26
Oxy	Johnston	4-3-12	2616	Chase	.70	432	468	0.18
Oxy	Terry	8-3-12	2632	Chase	.70	431	465	0.18
Oxy	Webb	8-3-12	6372	Morrow	.72	1403	1728	0.27
Oxy	Webb	8-3-12	5335	Cherokee	.72	1275	1518	0.28
Oxy	Stonebraker	15-3-12	2614	Chase	.70	431	466	0.18
Oxy	Stonebraker	16-3-12	6013	Morrow	.69	1333	1605	0.27

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Oxy	Waldron	17-3-12	2650	Chase	.70	430	463	0.17
Oxy	Coon	17-3-12	5338	Cherokee	.72	1270	1526	0.29
Oxy	Stonebraker	17-3-12	4646	Lansing	.74	918	1067	0.23
Oxy	Stonebraker	17-3-12	6331	Morrow	.74	1522	1906	0.30
Oxy	Stonebraker	17-3-12	4277	Lansing	.71	906	1034	0.24
Oxy	Stonebraker	20-3-12	6405	Morrow	.72	1332	1638	0.26
Oxy	Stonebraker	20-3-12	2690	Chase	.70	428	461	0.17
Oxy	Pierce	23-3-12	3014	C. Grove	.75	439	487	0.16
Oxy	Stonebraker	24-3-12	3043	C. Grove	.82	454	504	0.17
Oxy	Stonebraker	25-3-12	3102	C. Grove	.79	456	505	0.16
Oxy	Stonebraker	27-3-12	2684	Chase	.70	429	464	0.17
Oxy	Stonebraker	31-3-12	2688	Chase	.70	430	467	0.17
Oxy	Stonebraker	35-3-12	3094	C. Grove	.78	442	489	0.16
Oxy	Stonebraker	35-3-12	2644	Chase	.70	431	466	0.18
Oxy	Stonebraker	36-3-12	2552	Chase	.70	432	465	0.18
Oxy	Stonebraker	36-3-12	2984	C. Grove	.78	454	501	0.17
Anadarko	State	1-3-13	6215	Morrow	.66	1390	1665	0.27
Apx	Speakman	4-3-13	2750	Chase	.70	427	461	0.17
Amarex	Langston	6-3-13	6048	Morrow	.67	1254	1495	0.25
Oxy	Stonebraker	19-3-13	2608	Chase	.70	425	461	0.18
Oxy	Stonebraker	20-3-13	6430	Keyes	.69	1558	1908	0.30
Oxy	Stonebraker	27-3-13	2716	Chase	.70	427	463	0.17
Oxy	Stonebraker	29-3-13	2986	C. Grove	.80	450	499	0.17
Oxy	Stonebraker	30-3-13	2614	Chase	.70	432	467	0.18
Oxy	Stonebraker	30-3-13	2994	C. Grove	.80	490	542	0.18
Cities	Stonebraker	31-3-13	2970	C. Grove	.79	454	499	0.17
Oxy	Stonebraker	32-3-13	3060	C. Grove	.79	480	530	0.17
Oxy	Stonebraker	33-3-13	2736	Chase	.70	429	466	0.17
Oxy	Chenault	2-3-14	6094	St. Louis	.67	1358	1623	0.27
Anadarko	State	6-3-14	6176	Morrow	.66	1440	1722	0.28
Hamilton	Winter	11-3-14	6176	Morrow	.66	1381	1649	0.27
Oxy	Stonebraker	26-3-14	5148	Lansing	.71	1281	1514	0.29
Oxy	Stonebraker	27-3-14	6248	Morrow	.70	1441	1756	0.28
Oxy	Stonebraker	27-3-14	4276	Cisco	.70	1000	1140	0.27
Pet. Inc.	State	34-3-14	3975	Topeka	.72	1515	1738	0.44
Pet. Inc.	State	34-3-14	5710	Cherokee	.76	1446	1782	0.31
Pet. Inc.	State	34-3-14	6310	Morrow	.73	1486	1841	0.29
Pet. Inc.	State	34-3-14	4310	Cisco	.71	964	1104	0.26
Pet. Inc.	State	34-3-14	5164	Lansing	.71	1197	1410	0.27
Pet. Inc.	State	34-3-14	6648	Keyes	.70	1515	1871	0.28
Oxy	Stonebraker	35-3-14	6286	Morrow	.65	1350	1610	0.26
Oxy	Stonebraker	35-3-14	6630	Keyes	.70	1666	2057	0.31
Trek	Jackson	6-3-15	6126	Morrow	.70	1417	1719	0.28
Chiles	Lee	15-3-15	6095	Morrow	.70	1440	1745	0.29
Chiles	Lee	15-3-15	4184	Cisco	.76	1015	1173	0.28
Texaco	Nash	21-3-15	6610	Morrow	.75	1649	2088	0.32

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Texaco	Nash	21-3-15	4243	Cisco	.75	936	1078	0.25
Getty	Roseberry	22-3-15	6602	Morrow	.72	1685	2100	0.32
Getty	Schuckeb	35-3-13	2766	Chase	.70	432	469	0.17
Getty	Laird	36-3-13	2768	Chase	.70	434	473	0.17
KP	Hill	2-3-16	6602	Morrow	.60	1446	1705	0.26
KP	Long	4-3-16	6623	Morrow	.67	1502	1833	0.28
Cabot	Calvert	11-3-16	6630	Morrow	.59	1454	1708	0.26
Cabot	Calvert	11-3-16	2764	Chase	.70	426	462	0.17
Cabot	Calvert	13-3-16	2645	Chase	.70	439	475	0.18
Cabot	Calvert	14-3-16	2649	Chase	.70	433	470	0.18
Dorchester	Nash	18-3-16	2670	Chase	.70	429	462	0.17
Getty	State	22-3-16	2732	Chase	.70	436	472	0.17
Meridian	Janzen	1-3-17	6302	Morrow	.73	1191	1459	0.23
Santa Fe	Fast	2-3-17	2705	Chase	.70	430	466	0.17
Kaiser	Blehm	4-3-17	6520	Morrow	.60	1775	2103	0.32
Cabot	Casto	7-3-17	2640	Chase	.70	439	473	0.18
Sage	Balzer	8-3-17	6387	Morrow	.59	1800	2121	0.33
Sage	Balzer	8-3-17	6580	Chester	.60	1777	2101	0.32
Sage	Castro	8-3-17	6848	St. Louis	.77	1600	2061	0.30
Sage	Balzer	9-3-17	6866	St. Louis	.60	2426	2889	0.42
Sage	Balzer	9-3-17	6458	Morrow	.59	1800	2126	0.33
Cabot	Balzer	9-3-17	6020	U. Morrow	.64	1340	1579	0.26
Anadarko	Miller	13-3-17	6240	Morrow	.60	1440	1683	0.27
Sage	Mayer	16-3-17	6465	Morrow	.60	1762	2079	0.32
Sage	Mayer	16-3-17	6866	St. Louis	.77	1772	2288	0.33
Graham	Cabot	17-3-17	6408	Morrow	.60	1665	1961	0.31
Graham	Cabot	17-3-17	6790	St. Louis	.80	1786	2338	0.34
Cabot	Casto	17-3-17	2660	Chase	.70	440	474	0.18
Cabot	Casto	20-3-17	2661	Chase	.70	434	468	0.18
Cabot	State	21-3-17	6476	Morrow	.61	1618	1915	0.30
Cabot	State	21-3-17	4219	Cisco	.75	1088.	1264	0.30
Shell	State	21-3-17	6458	Morrow	.60	1692	1995	0.31
Apx	Beasley	23-3-17	6293	Morrow	.74	1208	1488	0.24
Apx	Ballew	24-3-17	6321	Morrow	.74	1321	1642	0.26
Apx	Fletcher	25-3-17	6228	Morrow	.75	1389	1736	0.28
Cabot	Casto	30-3-17	2683	Chase	.70	428	463	0.17
Santa Fe	Neff	36-3-17	2629	Chase	.70	431	468	0.18
Graham	Neff	36-3-17	6542	Morrow	.63	1539	1835	0.28
Meridian	Neff	36-3-17	6223	Morrow	.75	1311	1624	0.26
Santa Fe	Pauls	4-3-18	2665	Chase	.70	435	471	0.18
Apx	Allender	7-3-18	6305	Morrow	.69	1376	1668	0.26
Plains	Pauls	10-3-18	2672	Chase	.70	432	466	0.17
Plains	Elliot	16-3-18	6378	Morrow	.75	1319	1645	0.26
Apx	Schaeffer	17-3-18	6318	Morrow	.74	1301	1615	0.26
Apx	Enns	18-3-18	6272	Morrow	.73	1415	1745	0.28
Apx	Fletcher	19-3-18	6304	Morrow	.72	1408	1729	0.27

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Plains	Abraham	21-3-18	6407	Morrow	.75	1284	1599	0.25
Exxon	Joliffe	25-3-18	6470	Morrow	.71	1196	1459	0.23
Exxon	Joliffe	26-3-18	6477	Morrow	.71	1385	1702	0.26
Exxon	Joliffe	27-3-18	6350	Morrow	.73	1388	1712	0.27
Knn	Depuy	28-3-18	2792	Chase	.70	428	464	0.17
Apx	Graham	30-3-18	6293	Morrow	.75	1324	1645	0.26
Apx	Hopkins	32-3-18	6260	Morrow	.68	1346	1620	0.26
Exxon	Joliffe	34-3-18	6380	Morrow	.69	1335	1618	0.25
Exxon	Joliffe	35-3-18	6450	Morrow	.72	1409	1737	0.27
Exxon	Trust	36-3-18	6440	Morrow	.72	1463	1805	0.28
Kaiser	Atkins	25-3-19	6970	Morrow	.68	1558	1919	0.28
Exxon	Gilbert	31-3-19	6460	Morrow	.72	1293	1588	0.25
Tenneco	Kelly	2-4-10	2946	Topeka	.71	470	513	0.17
Excelsior	Dencker	8-4-10	3158	Topeka	.71	435	478	0.15
Ashland	Kelly	11-4-10	4676	Keyes	.70	885	1018	0.22
Tema	Kelly	11-4-10	4434	Morrow	.70	865	987	0.22
Tenneco	Kelly	11-4-10	2936	Topeka	.70	475	518	0.18
McBride	White	15-4-10	4262	Morrow	.70	926	1052	0.25
Tema	Burns	15-4-10	4430	Morrow	.76	1100	1283	0.29
Ashland	Brumley	19-4-10	3164	Topeka	.74	375	411	0.13
Crg	Conger	22-4-10	4664	Keyes	.65	790	894	0.19
Mesa	Hart	2-4-11	2433	Chase	.70	427	458	0.19
Mesa	Webb	12-4-11	2496	Chase	.70	427	461	0.18
Pnahandle	Hart	14-4-11	2484	Krider	.70	386	415	0.17
Oxy	Interstate	4-4-12	5893	Keyes	.74	1072	1299	0.22
Oxy	Interstate	4-4-12	5105	Cherokee	.71	1184	1392	0.27
Oxy	Interstate	4-4-12	2544	Chase	.70	429	462	0.18
Oxy	Morris	9-4-12	2620	Chase	.70	427	459	0.18
Oxy	Shaffer	12-4-12	6168	Morrow	.72	1326	1621	0.26
Anadarko	Messinger	13-4-12	6150	Morrow	.71	1014	1220	0.20
Oxy	Renfrew	16-4-12	2682	Chase	.70	428	462	0.17
Oxy	Buzzard	23-4-12	6053	Morrow	.71	1238	1491	0.25
Anadarko	Buzzard	25-4-12	6113	Morrow	.71	1394	1644	0.27
Oxy	Buzzard	26-4-12	6099	Morrow	.69	1298	1564	0.26
Jackson	Langston	32-4-12	2672	Chase	.70	430	464	0.17
Kaiser	Kennedy	33-4-12	2674	Chase	.70	427	462	0.17
Oxy	Webb	35-4-12	6086	Morrow	.72	1345	1641	0.27
Anadarko	Goodwin	36-4-12	6073	U. Morrow	.72	1346	1634	0.27
Apx	Broce	7-4-13	6105	Morrow	.71	1421	1729	0.28
Mobil	Cities	9-4-13	6019	Morrow	.66	1347	1606	0.27
Mobil	Cities	9-4-13	2640	Chase	.70	427	460	0.17
Gruenwald	Woodward	17-4-13	5583	Cherokee	.78	1225	1604	0.29
Anadarko	Wilson	23-4-13	4266	Cisco	.71	952	1084	0.25
Anadarko	Powell	35-4-13	6205	Morrow	.69	1231	1484	0.24
Anadarko	Keenan	36-4-13	6255	Morrow	.67	1393	1680	0.27
Anadarko	Cities	18-4-14	5660	Cherokee	.79	1247	1541	0.27

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Anadarko	Interstate	29-4-14	6145	Morrow	.71	1456	1777	0.29
Anadarko	Interstate	30-4-14	6088	Morrow	.73	1410	1732	0.28
Anadarko	Webb	31-4-14	6161	Morrow	.66	1390	1657	0.27
Anadarko	Hawkins	32-4-14	5680	Cherokee	.75	1205	1462	0.26
Oxy	Murdock	3-4-15	6090	Morrow	.74	1433	1765	0.29
Cities	Murdock	10-4-15	6096	U. Morrow	.73	1425	1751	0.29
Brock	Murdock	10-4-15	6078	Morrow	.78	1441	1813	0.30
Oxy	Royer	19-4-15	6580	Keyes	.68	1510	1840	0.28
Oxy	Bartels	29-4-15	6552	Morrow	.69	1412	1724	0.26
Oxy	Cooper	30-4-15	6564	Morrow	.66	1651	1999	0.30
Elder	Gruwell	33-4-15	6772	Chester	.67	1596	1949	0.29
Cabot	McKinley	2-4-16	6217	Morrow	.73	1354	1670	0.27
Shell	Remling	7-4-16	6187	Morrow	.64	1328	1573	0.25
KP	Randall	10-4-16	6248	Morrow	.70	1395	1698	0.27
KP	Lowry	11-4-16	6242	Morrow	.70	1420	1726	0.28
Shell	Finrock	12-4-16	6503	Keyes	.71	1764	2205	0.34
Sage	Finrock	13-4-16	6260	Morrow	.76	1405	1756	0.28
Sage	Fisher	20-4-16	6618	Morrow	.60	1796	2132	0.32
Cabot	Stamper	21-4-16	6535	Morrow	.62	1782	2123	0.32
Shell	Wright	24-4-16	6500	Keyes	.62	1748	2095	0.32
KP	Wacker	27-4-16	6639	Keyes	.59	1417	1668	0.25
Shell	Kerr	6-4-17	6246	Morrow	.70	1412	1718	0.28
Dorchester	State	15-4-17	2777	Chase	.70	425	462	0.17
Shell	Hanson	17-4-17	6281	Morrow	.69	1377	1667	0.27
Shell	Hanson	17-4-17	6252	Morrow	.69	1400	1696	0.27
Sage	Finrock	18-4-17	6240	Morrow	.75	1409	1751	0.28
Sage	Lundgrin	19-4-17	6227	Morrow	.79	1414	1795	0.29
Shell	Hoeme	20-4-17	6251	Morrow	.68	1378	1660	0.27
Santa Fe	Hoeme	25-4-17	2736	Chase	.70	430	467	0.17
Cory	Balzer	26-4-17	6290	Morrow	.68	1382	1666	0.26
Geodyne	Schnackbur	29-4-17	6225	Morrow	.70	1274	1552	0.25
Santa Fe	White	30-4-17	6240	Morrow	.69	1368	1653	0.26
Graham	Sylvester	32-4-17	6266	Morrow	.72	1382	1696	0.27
Santa Fe	Fast	35-4-17	2740	Chase	.70	425	459	0.17
Bp	Reswig	36-4-17	6284	Morrow	.69	1385	1678	0.27
Anadarko	Metcalf	2-4-18	6554	Chester	.69	1608	1972	0.30
Boyle	Metcalf	2-4-18	2662	Krider	.71	369	399	0.15
Santa Fe	Voiles	4-4-18	2677	Chase	.70	429	466	0.17
Knn	Pauls	10-4-18	2724	Chase	.70	432	468	0.17
Plains	Hamm	22-4-18	2696	Chase	.70	432	469	0.17
Smith	Stickler	22-4-20	6502	Chester	.65	1619	1951	0.30
Texaco	Friesen	28-4-18	2716	Chase	.70	427	463	0.17
Santa Fe	Kissinger	33-4-18	2693	Chase	.70	434	469	0.17
New London	Hill	1-4-19	6780	Chester	.65	1426	1721	0.25
Presedio	Lunceford	3-4-19	6704	Chester	.68	1607	1969	0.29
Txo	St. Clair	10-4-19	6574	Chester	.66	1477	1784	0.27

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Txo	Randles	12-4-19	7134	Chester	.62	1454	1773	0.25
Graham	Fatzer	2-5-10	3142	Topeka	.65	429	469	0.15
Cross Timb.	Sparkman	7-5-10	4552	Keyes	.72	834	958	0.21
Hendrick	Dennis	8-5-10	3120	Topeka	.73	450	498	0.16
Wolf	Quigley	8-5-10	4276	Morrow	.65	1000	1127	0.26
Apx	Kornele	10-5-10	4462	Morrow	.82	1024	1217	0.27
Covington	Sparkman	17-5-10	3163	Topeka	.73	423	465	0.15
Coastal	Herb	18-5-10	4613	Keyes	.73	831	963	0.21
Ncr	Blakely	21-5-10	4461	Morrow	.74	1053	1221	0.27
Texaco	Addington	36-5-10	4318	Morrow	.76	1050	1215	0.28
Hamilton	Reiss	2-5-11	3209	C. Grove	.70	420	463	0.14
Texaco	Palmer	6-5-11	4590	Morrow	.77	1149	1354	0.29
Unit	Sleeper	14-5-11	5596	Morrow	.75	911	1093	0.20
Geox	Tulka	24-5-11	4101	K. City	.73	721	817	0.20
Oxy	State	24-5-11	2464	Chase	.70	432	465	0.19
Oxy	Interstate	36-5-11	2566	Chase	.70	428	463	0.18
Anadarko	Ullom	1-5-12	6098	Morrow	.73	1226	1498	0.25
Anadarko	Tucker	2-5-12	5354	Cherokee	.73	1186	1414	0.26
Anadarko	Tucker	2-5-12	5962	Morrow	.72	1191	1439	0.24
Apx	Sturgeon	3-5-12	5894	Morrow	.72	1271	1538	0.26
Apx	Woodward	4-5-12	5841	Morrow	.76	1324	1629	0.28
Anadarko	Pollack	4-5-12	5654	Morrow	.69	1630	1950	0.34
Apx	Carder	5-5-12	2480	Chase	.70	429	460	0.19
PEPL	Hensley	6-5-12	5555	Morrow	.67	1155	1357	0.24
Oxy	Hicks	13-5-12	2660	Chase	.70	429	462	0.17
Hamilton	Hicks	13-5-12	6053	Morrow	.84	1102	1404	0.23
Hamilton	Hicks	13-5-12	5421	Cherokee	.82	1316	1666	0.31
Oxy	Archibald	19-5-12	2522	Chase	.70	428	460	0.18
Oxy	State	22-5-12	6058	Keyes	.75	1350	1668	0.28
Oxy	Eckstein	27-5-12	5098	Cherokee	.70	1401	1652	0.32
Oxy	Interstate	28-5-12	5978	Keyes	.74	1321	1620	0.27
Oxy	Inrerstate	29-5-12	2482	Chase	.70	432	464	0.19
Oxy	Interstate	33-5-12	5932	Keyes	.76	1317	1624	0.27
Cities	Interstate	33-5-12	5097	Cherokee	.70		1375	0.27
Oxy	Interstate	33-5-12	2406	Chase	.70	431	459	0.19
Mobil	Weeks	10-5-13	5660	Cherokee	.70	1308	1560	0.28
Republic	Weeks	10-5-13	6370	Morrow	.70	1432	1748	0.27
Mobil	Weeks	10-5-13	6386	Morrow	.70	1325	1615	0.25
Republic	Blake	11-5-13	5698	Cherokee	.69	1480	1767	0.31
Mobil	Blake	11-5-13	6376	Morrow	.70	1457	1782	0.28
Mobil	Blake	11-5-13	5688	Morrow	.70	1290	1542	0.27
Mobil	Weeks	12-5-13	6512	Keyes	.70	1556	1916	0.29
Mobil	Ferguson	13-5-13	6184	Morrow	.70	1608	1960	0.32
Pet. Inc.	Wilson	15-5-13	5699	Cherokee	.70	1261	1507	0.26
Oxy	Hiser	17-5-13	6142	Morrow	.70	1274	1533	0.25
Oxy	Steele	19-5-13	2674	Chase	.70	424	459	0.17

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Oxy	Hicks	19-5-13	5970	Morrow	.69	1494	1575	0.26
Oxy	Cavett	20-5-13	6130	Morrow	.73	1336	1608	0.26
Oxy	Hartman	20-5-13	5990	Morrow	.69	1345	1641	0.27
Oxy	Blauser	21-5-13	6150	Morrow	.70	1329	1607	0.26
Mobil	Horner	24-5-13	6572	Keyes	.70	1600	1971	0.30
Oxy	Sparks	29-5-13	5940	Morrow	.70	1310	1574	0.26
Oxy	Sparks	30-5-13	5985	Morrow	.71	1277	1543	0.26
Mobil	Cities	31-5-13	6034	Morrow	.68	1285	1537	0.25
Republic	Cities	32-5-13	6134	Morrow	.71	1515	1834	0.30
Republic	Golden	36-5-13	2682	Krider	.70	382	412	0.15
Republic	McBratney	17-5-14	2692	Krider	.71	364	393	0.15
Cities	Hampy	23-5-14	6135	Morrow	.71	1191	1443	0.24
Mobil	Miller	24-5-14	2753	Chase	.70	426	462	0.17
Cities	Blake	1-5-15	6207	Morrow	.70	1409	1722	0.28
Oxy	Symonds	1-5-15	6207	Morrow	.76	1419	1773	0.29
Oxy	Humble	2-5-15	6193	Morrow	.75	1414	1757	0.28
Oxy	Humble	2-5-15	6319	Morrow	.82	1393	1803	0.29
Oxy	Symonds	3-5-15	6150	Morrow	.75	1426	1768	0.29
Oxy	Symonds	3-5-15	6275	Morrow	.77	1410	1774	0.28
Oxy	Symonds	3-5-15	6562	Morrow	.74	1663	2090	0.32
Cities	Wear	6-5-15	3070	C. Grove	.69	389	454	0.15
Hamilton	Birt	8-5-15	6159	Morrow	.72	1398	1699	0.28
Hamilton	Birt	8-5-15	6252	Morrow	.78	1433	1811	0.29
Hamilton	Dutton	9-5-15	6150	Morrow	.74	1495	1849	0.30
Oxy	Gibson	10-5-15	6548	Morrow	.77	1695	2167	0.33
Oxy	Gibson	10-5-15	6150	Morrow	.79	1405	1776	0.29
Oxy	Symonds	11-5-15	6292	Morrow	.74	1698	2118	0.34
Oxy	Symonds	11-5-15	6168	Morrow	.77	1443	1812	0.29
Oxy	Symonds	11-5-15	6292	Morrow	.74	1416	1756	0.28
Cities	Symonds	11-5-15	6566	Keyes	.76	1698	2163	0.33
Oxy	Symonds	12-5-15	6174	Morrow	.77	1413	1772	0.29
Oxy	Myers	13-5-15	6545	Morrow	.77	1698	2158	0.33
Oxy	Myers	13-5-15	6184	Morrow	.82	1414	1822	0.29
Oxy	Myers	13-5-15	6288	Morrow	.80	1414	1810	0.29
Cities	Symonds	14-5-15	6252	L. Morrow	.66	1318	1575	0.25
Oxy	Symonds	14-5-15	6528	Morrow	.61	1910	2277	0.35
Oxy	Symonds	15-5-15	6665	Morrow	.62	1711	2044	0.31
Hamilton	Dailey	16-5-15	6160	Morrow	.68	1480	1783	0.29
Conoco	Daily	16-5-15	6149	Morrow	.71	1442	1760	0.29
Pepin	Heir	21-5-15	6150	Morrow	.71	1444	1751	0.28
Oxy	Wilson	22-5-15	6100	Morrow	.71	1419	1717	0.28
Oxy	Wilson	23-5-15	6530	Keyes	.61	1688	2000	0.31
Oxy	Wilson	27-5-15	6136	Morrow	.73	1442	1774	0.29
Plains	Mayer	33-5-15	2809	Winfield	.70	404	441	0.16
Oxy	Republic	33-5-15	6130	Morrow	.75	1436	1780	0.29
Oxy	Wilson	34-5-15	6111	Morrow	.77	1443	1810	0.30

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Plains	Baker	36-5-15	2672	Krider	.70	413	446	0.17
KP	Lolmaugh	5-5-16	6010	Atoka	.60	1278	1487	0.25
Cabot	Matter	9-5-16	6483	Keyes	.69	1570	1920	0.30
Sage	Baker	12-5-16	6207	Morrow	.74	1402	1735	0.28
Sage	Burdge	13-5-16	6144	Morrow	.69	1487	1799	0.29
Sage	Burdge	13-5-16	6468	Keyes	.63	1375	1636	0.25
Sage	Matter	14-5-16	6482	Morrow	.61	1675	1983	0.31
Sage	Matter	14-5-16	6136	Morrow	.73	1475	1816	0.30
Pet. Inc.	Howell	21-5-16	6506	Keyes	.60	1597	1884	0.29
Sage	Schafler	23-5-16	6138	Morrow	.69	1424	1722	0.28
Sage	Wilson	24-5-16	6161	Morrow	.73	1444	1776	0.29
Dorchester	Meisel	25-5-16	2835	Chase	.70	423	460	0.16
Cabot	Burwell	27-5-16	6073	Morrow	.70	1421	1720	0.28
Marsh	Fischer	28-5-16	6489	Keyes	.60	1468	1730	0.27
Cabot	Fischer	34-5-16	6170	Morrow	.70	1405	1704	0.28
Sage	Meisel	36-5-16	6205	Morrow	.69	1403	1697	0.27
Dorchester	Balzer	1-5-17	2790	Chase	.70	426	461	0.17
Dorchester	Ross	10-5-17	2802	Chase	.70	425	461	0.16
Santa Fe	Cramer	14-5-17	2797	Chase	.70	427	465	0.17
Sage	Conwill	19-5-17	6162	Morrow	.69	1455	1759	0.29
Santa Fe	Parham	26-5-17	2775	Chase	.70	429	466	0.17
Hamilton	Grounds	29-5-17	6234	Morrow	.69	1475	1788	0.29
Sage	Blackwdr.	31-5-17	6221	Morrow	.72	1387	1706	0.27
Sage	Blackwdr.	31-5-17	6501	Keyes	.66	1567	1891	0.29
TEL	Massa	34-5-17	2765	Chase	.70	427	464	0.17
Sparks	Gray	1-5-18	6430	Morrow	.68	1618	1976	0.31
Frontier	Rist	2-5-18	6422	Morrow	.69	1441	1746	0.27
Santa Fe	Duncan	2-5-18	2679	Chase	.70	434	472	0.18
Santa Fe	Shives	4-5-18	2750	Chase	.70	432	467	0.17
Dorchester	Philpott	4-5-18	2773	Chase	.70	432	468	0.17
Plains	Baughman	8-5-18	2775	Krider	.70	425	461	0.17
Knn	Asher	13-5-18	2702	Chase	.70	433	468	0.17
Santa Fe	Woods	17-5-18	2735	Chase	.70	428	464	0.17
Santa Fe	Stanford	20-5-18	2737	Chase	.70	432	470	0.17
Santa Fe	Chrispens	22-5-18	2720	Chase	.70	434	468	0.17
Santa Fe	Elmore	29-5-18	2720	Chase	.70	435	469	0.17
Santa Fe	Elmore	33-5-18	2688	Chase	.70	434	472	0.18
Meridian	Lyles	34-5-18	6592	Chester	.69	1408	1721	0.26
Apache	Stricklin	35-5-18	6624	Chester	.68	1432	1761	0.27
Ladd	Hood	2-5-19	6536	Chester	.68	1460	1777	0.27
Texaco	Hood	5-5-19	6491	Chester	.66	1897	2297	0.35
Texaco	Harrison	8-5-19	6439	Morrow	.67	1614	1957	0.30
Texaco	Lee	9-5-19	6408	Morrow	.67	1527	1847	0.29
Otc	Phillips	15-5-19	6363	Morrow	.67	1575	1903	0.30
Pet. Expl.	Pedigo	16-5-19	6426	Morrow	.67	1591	1935	0.30
Kaiser	Vantine	17-5-19	6412	Morrow	.66	1575	1901	0.30

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Kaiser	Arnsperger	21-5-19	6406	Morrow	.66	1508	1815	0.28
Txo	Martin	22-5-19	6366	Morrow	.66	1391	1670	0.26
Ladd	Ogletree	23-5-19	6370	Morrow	.65	1565	1874	0.29
Ladd	Martin	24-5-19	6487	Morrow	.66	1569	1895	0.29
Kaiser	Teegarden	35-5-19	6526	Chester	.66	1588	1928	0.30
New London	Clark	36-5-19	4447	Cisco	.67	1210	1382	0.31
Texaco	Schrauner	13-6-10	3045	Topeka	.76	450	514	0.17
Texaco	Schrauner	14-6-10	3184	Topeka	.76	413	457	0.14
Texaco	Munyon	15-6-10	4446	Morrow	.73	1069	1238	0.28
Anadarko	McMurray	15-6-10	3113	Topeka	.78	429	479	0.15
Anadarko	McMurray	16-6-10	3113	Topeka	.77	428	473	0.15
Panhandle	Boaldin	17-6-10	4588	Keyes	.78	834	977	0.21
Graham	Miller	18-6-10	4314	Purdy	.73	1094	1265	0.29
Anadarko	Welch	21-6-10	3152	Topeka	.76	429	469	0.15
Anadarko	Quigley	22-6-10	4506	Morrow	.76	1079	1255	0.28
Anadarko	Quigley	23-6-10	3062	Topeka	.73	412	451	0.15
Anadarko	Davis	23-6-10	4478	Morrow	.74	1102	1283	0.29
Anadarko	Schrauner	24-6-10	3078	Topeka	.76	416	461	0.15
Pet. Inc.	Horner	25-6-10	4524	Morrow	.66	1120	1275	0.28
Apx	Quigley	26-6-10	3083	Topeka	.77	426	470	0.15
Graham	Fincham	27-6-10	3098	Topeka	.77	415	460	0.15
Graham	Fincham	27-6-10	4460	Purdy	.85	1082	1303	0.29
Oxy	Manary	31-6-10	4644	Keyes	.73	840	971	0.21
Graham	Denning	35-6-10	3146	Topeka	.76	416	460	0.15
Graham	Denning	35-6-10	4505	Morrow	.73	1008	1156	0.26
Anadarko	State	36-6-10	3067	Topeka	.75	426	497	0.16
Graham	Williams	13-6-11	4556	Morrow	.75	1098	1284	0.28
Graham	Williams	13-6-11	3112	Topeka	.69	430	473	0.15
Hendrick	Reiss	15-6-11	3072	Topeka	.77	465	513	0.17
Anadarko	Reiss	15-6-11	4638	Morrow	.72	1203	1402	0.30
Graham	Tucker	18-6-11	3060	Topeka	.77	420	462	0.15
Oxy	Denney	21-6-11	3080	Topeka	.76	423	465	0.15
Pet. Expl.	Sleeper	22-6-11	3120	Topeka	.75	436	488	0.16
Ramco	Hanson	23-6-11	3196	Topeka	.78	428	476	0.15
Pet. Expl.	Heatley	24-6-11	3278	Topeka	.80	421	483	0.15
Coronado	Richterberg	26-6-11	3250	Topeka	.77	430	475	0.15
Cities	Reiss	27-6-11	3123	Topeka	.78	422	467	0.15
Huber	Tucker	34-6-11	3156	Elmont	.77	419	465	0.15
Pet. Inc.	Tucker	34-6-11	4768	Purdy	.72	1169	1366	0.29
Hamilton	Reiss	35-6-11	3228	Topeka	.78	460	513	0.16
Beta	State	36-6-11	5170	Morrow	.79	1150	1392	0.27
Oxy	Hicks	13-6-12	6316	Morrow	.71	1309	1603	0.25
Hamilton	Griffith	16-6-12	5954	Morrow	.70	1325	1597	0.27
Oxy	Griffith	16-6-12	2532	Chase	.70	431	464	0.18
Cities	Ellis	18-6-12	3232	Topeka	.77	419	464	0.14
Oxy	Carder	20-6-12	2505	Chase	.70	430	463	0.18

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Graham	Spierling	20-6-12	5818	Morrow	.73	1261	1534	0.26
Oxy	Griffith	22-6-12	5750	Morrow	.76	1163	1418	0.25
Oxy	Reiss	24-6-12	6010	Morrow	.80	1224	1539	0.26
Oxy	McKay	24-6-12	2715	Chase	.70	430	466	0.17
Anadarko	Powell	25-6-12	6050	Morrow	.78	1301	1621	0.27
Oxy	Simmons	26-6-12	5974	Morrow	.74	1240	1515	0.25
Oxy	Simmons	27-6-12	5790	Morrow	.78	1173	1445	0.25
Oxy	Tucker	29-6-12	2526	Chase	.70	431	465	0.18
Anadarko	McClune	30-6-12	5551	Morrow	.75	1297	1573	0.28
Apx	McClanahan	32-6-12	5726	Morrow	.78	1390	1733	0.30
Anadarko	Drosselmyr	33-6-12	5897	Keyes	.78	1100	1316	0.22
Anadarko	Drosselmyr	33-6-12	5748	Morrow	.70	1313	1573	0.27
Anadarko	Kuhn	34-6-12	5927	Morrow	.72	1178	1432	0.24
Anadarko	Simmons	35-6-12	5972	Morrow	.74	1205	1469	0.25
Anadarko	Riley	36-6-12	5944	Morrow	.75	1265	1551	0.26
Anadarko	Levalley	19-6-13	5971	Morrow	.78	1289	1604	0.27
Anadarko	Bawbell	27-6-13	5622	Cherokee	.81	1304	1638	0.29
Apx	Haar	30-6-13	6073	Morrow	.75	1315	1622	0.27
Anadarko	Haar	31-6-13	6096	Morrow	.75	1362	1685	0.28
Apx	Haar	32-6-13	6107	Morrow	.80	1357	1721	0.28
Anadarko	Green	33-6-13	6100	Morrow	.81	1386	1767	0.29
Mobil	Davis	25-6-14	3047	C. Grove	.71	242	285	0.09
Mobil	Church	27-6-14	3081	C. Grove	.70	267	327	0.11
Republic	Witt	21-6-15	6488	Morrow	.70	1695	2090	0.32
Sullivan	Dulabahn	21-6-15	6208	Morrow	.71	1352	1649	0.27
Mobil	Michael	22-6-15	6224	Morrow	.70	1326	1616	0.26
Mobil	Nordbury	27-6-15	6578	Morrow	.73	1715	2152	0.33
Mobil	Blake	34-6-15	6319	Morrow	.73	1252	1545	0.24
Mobil	Sledge	17-6-16	6430	Morrow	.73	1258	1550	0.24
Mobil	Burdge	20-6-16	6500	Morrow	.73	1448	1798	0.28
Mobil	Witt	21-6-16	6488	Keyes	.62	1654	1968	0.30
Dorchester	Roth	25-6-17	2807	Chase	.70	427	465	0.17
Santa Fe	Hoeme	27-6-17	2792	Chase	.70	433	469	0.17
Santa Fe	Knop	13-6-18	2731	Chase	.70	430	465	0.17
Parker	Pedigo	16-6-18	6322	Morrow	.70	1635	2001	0.32
Dorchester	Reese	19-6-18	2814	Chase	.70	428	465	0.17
Santa Fe	McGuire	22-6-18	2774	Chase	.70	431	468	0.17
Parker	Dennis	23-6-18	6402	Morrow	.64	1560	1862	0.29
Santa Fe	Compton	25-6-18	2731	Chase	.70	430	465	0.17
Santa Fe	Lutes	26-6-18	2738	Chase	.70	431	469	0.17
Parker	Rifle	26-6-18	6419	Morrow	.66	1487	1795	0.28
Meridian	Southern	27-6-18	6362	Morrow	.67	1573	1900	0.30
Santa Fe	Roth	33-6-18	2731	Chase	.70	430	465	0.17
Santa Fe	Reazin	35-6-18	2710	Chase	.70	432	466	0.17
Meridian	Realzin	35-6-18	6400	Morrow	.67	1629	1970	0.31
Frontier	Hamilton	36-6-18	6402	Morrow	.67	1605	1941	0.30

Operator	Farm	Location	Depth	Interval	Gr.	WHSIP	BHP	P-D Grad
Lindenmath	Blaser	13-6-19	6401	Keyes	.64	1630	1947	0.30
Santa Fe	Klassen	17-6-19	2715	Chase	.70	424	460	0.17
Anadarko	Apsley	24-6-19	6746	Chester	.69	1818	2246	0.33

APPENDIX C

CORRELATION OF RESERVOIR PRESSURE DATA FROM DRILL STEM TESTS AND INITIAL WELLHEAD SHUT-IN PRESSURES

APPENDIX C KEY

1. Operator: Petroleum company that drilled the well providing the reported DST pressure measurement and the initial Wellhead Shut-In Pressure (WHSIP) used to calculate the bottom hole or reservoir pressure.

2. Farm: Lease or well name

3. Location: Legal location given by Section, Township, and Range. All townships are north of the Panhandle Base Line and all ranges are east of the Cimarron Meridian.

4. Reservoir: Reservoir that was drill stem tested and perforated and completed to produce dry (low liquid content) gas

5. Depth: Depth to the base of the perforated interval

6. DST Press: Reservoir pressure recorded by the DST tool (usually final closed-in pressure)

7. Calc Press: Calculated reservoir pressure from static initial WHSIP

Operator	Farm	Location	Reservoir	Depth	DST Press.	Calc. Press.
Ashland	Brumley	19-4-10	Topeka	3164	415	411
Anadarko	Quigley	23-6-10	Topeka	3062	415	451
Cities	Denney	21-6-11	Topeka	3080	440	465
Cities	Reiss	27-6-11	Topeka	3123	440	467
Huber	Tucker	34-6-11	Elmont	3156	444	465
Texaco	Schrauner	13-6-10	Topeka	3180	460	457
Hendrick	Richterberg	26-6-11	Topeka	3270	460	475
Cities	Ellis	18-6-12	Topeka	3232	470	464
Argonaut	Clark	21-3-10	Topeka	3348	474	442
Hendrick	Reiss	15-6-11	Topeka	3072	490	513
Texaco	Dencker	27-2-9	Topeka	3440	520	540
Texaco	Chuman	24-1-9	Marmaton	4118	857	888
Cleary	School Land	25-6-26	C. Grove	3024	916	960
Cleary	Alexander	35-5-26	C. Grove	3279	940	984
Cleary	Albert	17-5-26	C. Grove	3376	946	929
Cleary	Street	21-5-26	C. Grove	3392	970	979
Baker	Hanes	2-3-9	Keyes	4456	980	1000
Sinclair	Allen	33-4-24	C. Grove	3339	998	1014
Cleary	Pruett	22-4-24	C. Grove	3334	1040	1036
Cities	Inkerton	4-2-8	Morrow	4452	1080	1039
Oil Capital	White	15-4-10	U. Morrow	4262	1110	1052
Baker	Hanes	2-3-9	Morrow	4293	1115	1124
Anadarko	Messinger	13-4-12	Morrow	6150	1204	1220
Argonaut	Smalts	12-2-9	Morrow	4557	1239	1251
Pet. Inc.	Horner	25-6-10	Morrow	4524	1251	1275
Cox	Williams	13-6-11	Morrow	4530	1288	1284
Cities	Interstate	4-4-12	Cherokee	5105	1446	1392
Mid America	Pierce	33-3-20	Keyes	6958	1482	1482
Graham	Trent	30-1-19	U. Morrow	6815	1535	1508
Hamilton	Griffith	16-6-12	Morrow	5954	1550	1597
Mid America	Pierce	3-2-20	Morrow	6950	1569	2077
Peerless	White	30-4-17	Morrow	6240	1589	1653
Cabot	Barby	1-3-26	Lovell	4989	1589	1646
Anadarko	Goodwin	36-4-12	U. Morrow	6073	1606	1634
Cities	State	22-5-12	Keyes	6058	1629	1668
Shell	Hoeme	20-4-17	Morrow	6251	1634	1660
Republic	Cities	32-5-13	Morrow	6135	1645	1834
Cities	Blake	1-5-15	Morrow	6207	1652	1722
Anadarko	Buzzard	25-4-12	Morrow	6113	1655	1644
Cities	Interstate	28-5-12	Keyes	5978	1662	1620
Anadarko	Pollack	4-5-12	Morrow	5654	1678	1950

Cities	Wilson	27-5-15	Morrow	6136	1702	1774
Cities	Wilson	22-5-15	Morrow	6100	1706	1717
Barnett	Mayer	3-2-11	Morrow	5967	1711	1737
Cities	Gibson	10-5-15	Morrow	6150	1714	1776
Cities	Humble	2-5-15	Morrow	6193	1714	1757
Cities	Murdock	10-4-15	U. Morrow	6096	1720	1751
Pet. Inc.	State	34-3-14	Cherokee	5710	1729	1782
Colorado	Armagest	27-3-27	Tonkawa	5656	1740	1845
Sohio	Balzer	26-4-17	Morrow	6290	1743	1666
Cities	Wilson	34-5-15	Morrow	6111	1750	1810
Pet. Inc.	Howell	21-5-16	Keyes	6506	1764	1884
Anadarko	Interstate	30-4-14	Morrow	6088	1775	1732
Cabot	Barby	1-3-26	Tonkawa	5400	1782	1821
Cabot	Barby	7-3-27	Tonkawa	5444	1803	1855
Cities	Hicks	13-6-12	Morrow	6316	1804	1603
Phillips	Florence	26-2-14	Oswego	5722	1808	1819
Cabot	Barby	29-4-27	Tonkawa	5330	1825	1892
Cabot	Barby	8-2-27	Tonkawa	5666	1830	1922
Pet. Inc.	Nelson	7-2-26	Tonkawa	5750	1860	1858
Cities	Miles	5-4-26	Morrow	6410	1867	1718
TXO	Motern	11-2-26	Tonkawa	5745	1888	1863
Apache	Blucher	28-6-22	Morrow	6101	1905	1846
Cities	Wilson	23-5-15	Keyes	6530	1928	2000
Cities	Stonebraker	20-3-13	Keyes	6428	1943	1908
Cities	Davis	30-1-25	Tonkawa	6064	1944	1968
Smith	Stickler	22-4-20	Chester	6468	1950	1858
Anadarko	Pryor	16-6-22	Morrow	6327	1970	2011
Maguire	Kamas	12-5-25	Morrow	6616	1974	2033
Cities	Symunds	11-5-15	Keyes	6566	1976	2163
Cities	Symunds	3-5-15	Morrow	6562	1984	2090
Cities	Bagerly	3-2-24	Morrow	7343	1984	1650
Maguire	Mayo	31-5-25	Mississippi	6730	1992	2001
Cities	Gibson	10-5-15	Keyes	6552	1992	2167
Ambassador	Eis	6-2-24	Morrow	7229	1995	1737
Republic	Witt	21-6-16	Keyes	6488	1997	1968
Pioneer	Girk	34-6-24	Morrow	6232	2000	1920
Cities	Symunds	14-5-15	Keyes	6525	2000	2277
Phillips	Oben	26-1-15	Morrow	6700	2000	2004
Hamilton	Evans	8-4-25	Chester	6820	2010	2066
Mid America	Devers	28-1-24	Tonkawa	6114	2011	1960
Pet. Inc.	State	34-3-14	Keyes	6648	2018	1871
Cities	Cooper	30-4-15	Morrow	6564	2021	1999
Phillips	Blakemore	6-4-23	Mississippi	6624	2051	1946
Cabot	Barby	16-4-25	Chester	6857	2056	2126
Anadarko	Winstead	20-5-22	Chester	6645	2060	2086

Cabot	Davis	21-4-25	Chester	6904	2060	2120
Champlin	Dixon	23-5-26	Morrow	6843	2060	2170
Mid America	Bartel	17-2-23	Morrow	7334	2066	2050
Cabot	Barby	13-5-26	Morrow	6728	2078	2167
Maguire	Kamas	3-5-25	Morrow	6515	2085	2083
United	Maphet	20-5-27	Morrow	6651	2089	2200
Cabot	Sargent	12-5-26	Morrow	6602	2090	2146
Phillips	Reese	25-2-14	Morrow	6754	2095	2113
Falcon	House	32-1-26	Tonkawa	6120	2095	2061
Humble	Buffalo	4-5-23	Morrow	6395	2101	2057
Sinclair	Maple	36-5-24	Chester	6770	2105	2111
Shell	Fisher	20-4-16	Morrow	6618	2125	2132
Huber	Schaffer	22-6-27	Morrow	6151	2126	2120
Anadarko	Allen	21-5-27	Morrow	6548	2135	2112
Lyons	Cornell	29-2-23	Morrow	7335	2140	2157
Cabot	Whisenhunt	26-4-28	Chester	6903	2140	2198
Cabot	Hamilton	18-5-27	Morrow	6711	2140	2137
Shell	Cole	3-3-24	Morrow	7126	2140	2154
Mayflo	Wilson	26-2-20	Morrow	7606	2143	2085
Anadarko	Gregg	22-4-23	Morrow	6815	2149	2185
Kerr	Underwood	9-5-23	Chester	6650	2150	2120
Exxon	Kenneck	17-3-24	Morrow	7058	2155	2121
Sinclair	McGrew	26-2-24	Chester	7042	2160	2147
Cities	Ferguson	1-3-24	Chester	7392	2160	2117
Statex	Kasper	10-5-28	Chester	6392	2165	2183
Cabot	Wolf	20-4-28	Morrow	6792	2189	2140
Cabot	Allen	23-4-27	Chester	7036	2191	2128
Cities	Sanger	12-1-25	Morrow	7864	2192	2039
Pet. Inc.	Woodbury	2-2-24	Morrow	7418	2210	2072
Sinclair	Boston	7-3-24	Morrow	7277	2230	2111
Maxus	McCall	20-2-27	Morrow	7805	2605	2575
Exxon	Baldwin	10-1-26	Morrow	8305	2639	2935
Mayflo	Jones	25-2-25	Morrow	8145	2700	2515
Anadarko	Anderson	34-2-27	Morrow	8174	2750	2504
UNOCAL	Williams	29-1-25	Morrow	8504	3075	3099

APPENDIX C

CALCULATION OF CORRELATION COEFFICIENTS: A MEASURE OF CO-RELATION BETWEEN DST PRESSURE MEASUREMENTS (X) AND CALCULATED RESERVOIR PRESSURES FROM INITIAL WELLHEAD SHUT-IN PRESSURES (Y)

```
options ps=60;
title 'Pressure correlation';
data wells;
input x y;
cards;
415 411
415 451
440 465
440 467
444 465
460 457
460 475
470 464
474 442
490 513
520 540
857 888
916 960
940 984
946 929
970 979
980 1000
998 1014
1040 1036
1080 1039
1110 1052
1115 1124
1204 1220
1239 1251
1251 1275
1288 1284
1446 1392
1482 1485
1535 1508
1550 1597
1569 2077
1589 1653
1589 1646
1606 1634
1629 1668
1634 1660
1645 1834
1652 1722
1655 1644
1662 1620
1678 1950
1702 1774
1706 1717
1711 1737
1714 1776
1714 1757
1720 1751
1729 1782
1740 1845
1743 1666
1750 1810
1775 1732
1782 1821
1803 1855
1804 1603
1808 1819
1825 1892
1830 1922
1860 1858
1867 1718
1888 1863
1905 1846
1928 2000
1943 1908
1944 1968
1950 1858
1970 2011
1974 2033
1976 2163
1984 2090
1984 1650
1992 2001
1992 2167
1995 1737
1997 1968
2000 1920
2000 2277
2000 2004
2010 2066
2011 1960
2018 1871
2021 1999
2051 1946
2056 2126
2060 2086
2060 2120
2060 2170
2066 2050
2078 2167
2085 2083
2089 2200
2090 2146
2095 2113
2095 2061
2101 2057
2105 2111
2125 2132
2126 2120
2135 2112
2140 2157
2140 2198
2140 2137
2140 2154
2143 2085
2149 2185
2150 2120
2155 2121
2160 2147
2160 2117
2165 2183
2189 2140
2191 2128
2192 2039
2210 2072
2230 2111
2605 2575
2639 2935
2700 2515
2750 2504
3075 3099
;
proc plot;
plot y*x;
proc corr;
run;
```

CORRELATION ANALYSIS

2 'VAR' Variables: X Y

Simple Statistics

Variable	N	Mean	Std Dev	Sum
X	120	1715	558.68111	205848
Y	120	1725	557.19981	206992

Simple Statistics

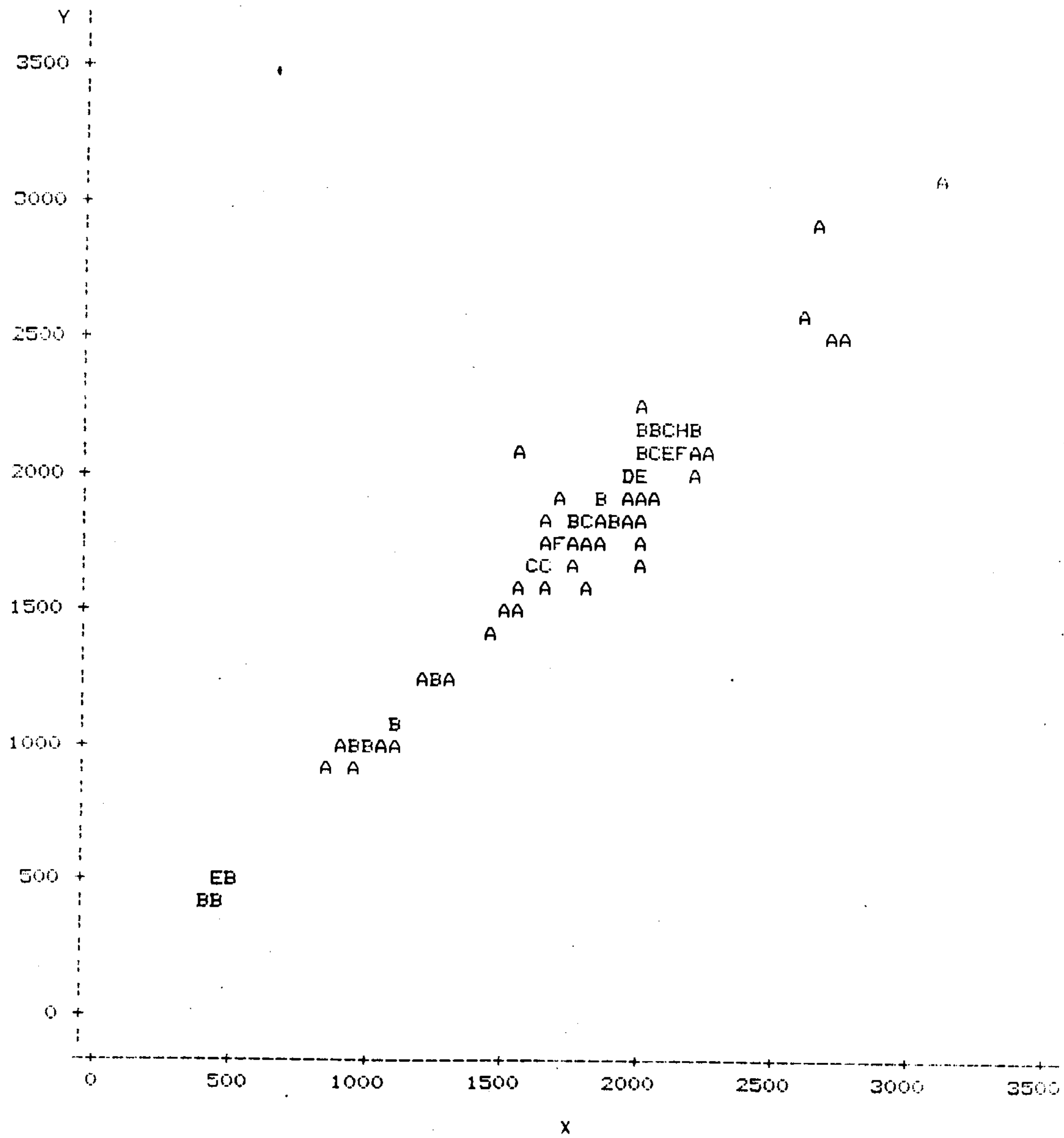
Variable	Minimum	Maximum
X	415.00000	3075
Y	411.00000	3099

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 120

	X	Y
X	1.00000 0.0	0.98345 0.0001
Y	0.98345 0.0001	1.00000 0.0

Pressure correlation 1
18:02 Tuesday, February 15, 1994

Plot of Y*X. Legend: A = 1 obs, B = 2 obs, etc.



```
NOTE: Copyright(c) 1985,86,87 SAS Institute Inc., Cary, NC 27512
NOTE: SAS (r) Proprietary Software Release 6.04
      Licensed to OKLAHOMA STATE UNIVERSITY, Site 11177001.

NOTE: AUTOEXEC processing completed.

        options ps=60;
        title 'Pressure correlation';
        data wells;
        input x y;
        cards;
        ;
NOTE: The data set WORK.WELLS has 120 observations and 2 variables.
NOTE: The DATA statement used 5.00 seconds.
        proc plot;
        plot y*x;RUN;
        proc corr;RUN;
NOTE: The PROCEDURE PLOT used 5.00 seconds.
NOTE: The PROCEDURE CORR used 4.00 seconds.
```

APPENDIX D

REMOTE SENSING ANALYSES

LINEAMENTS DETECTED ON TOPOGRAPHIC MAPS AND BLACK AND WHITE AERIAL PHOTOGRAPHY

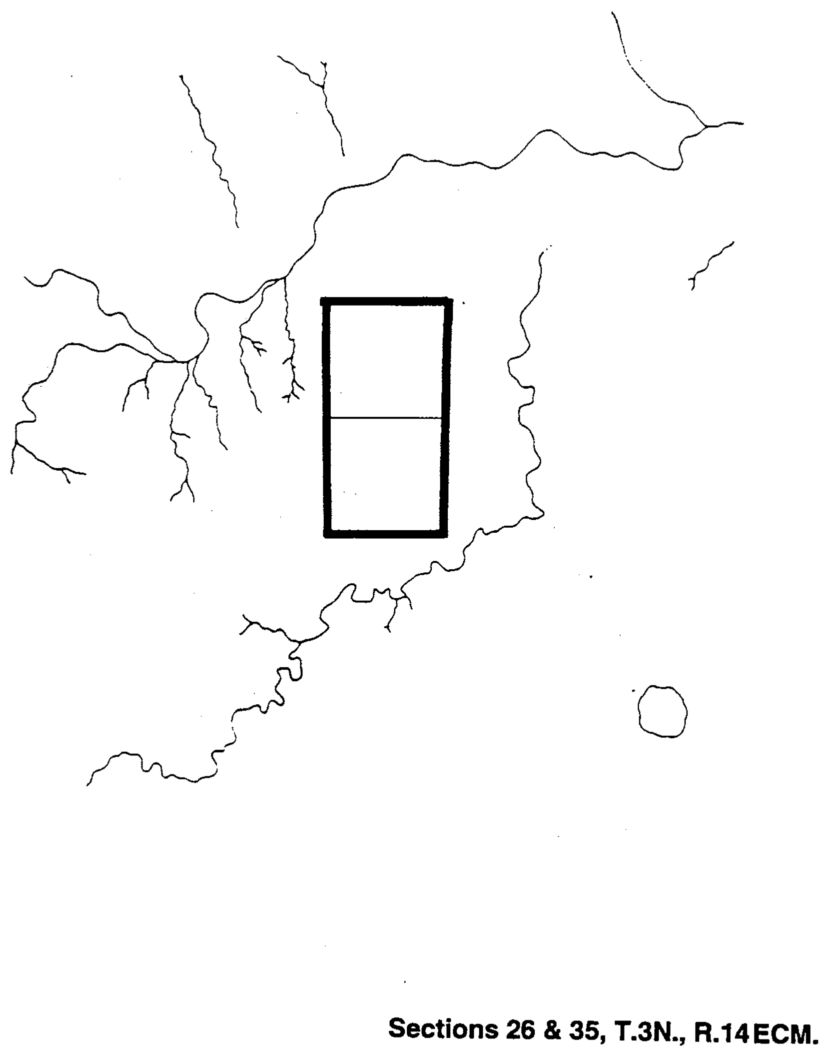
APPENDIX D

Remote sensing techniques were used to detect surface lineaments that could suggest zones of weakness in the confining units associated with the three disposal sites described in this research. No surface patterns were detected that appeared to reflect subsurface features.

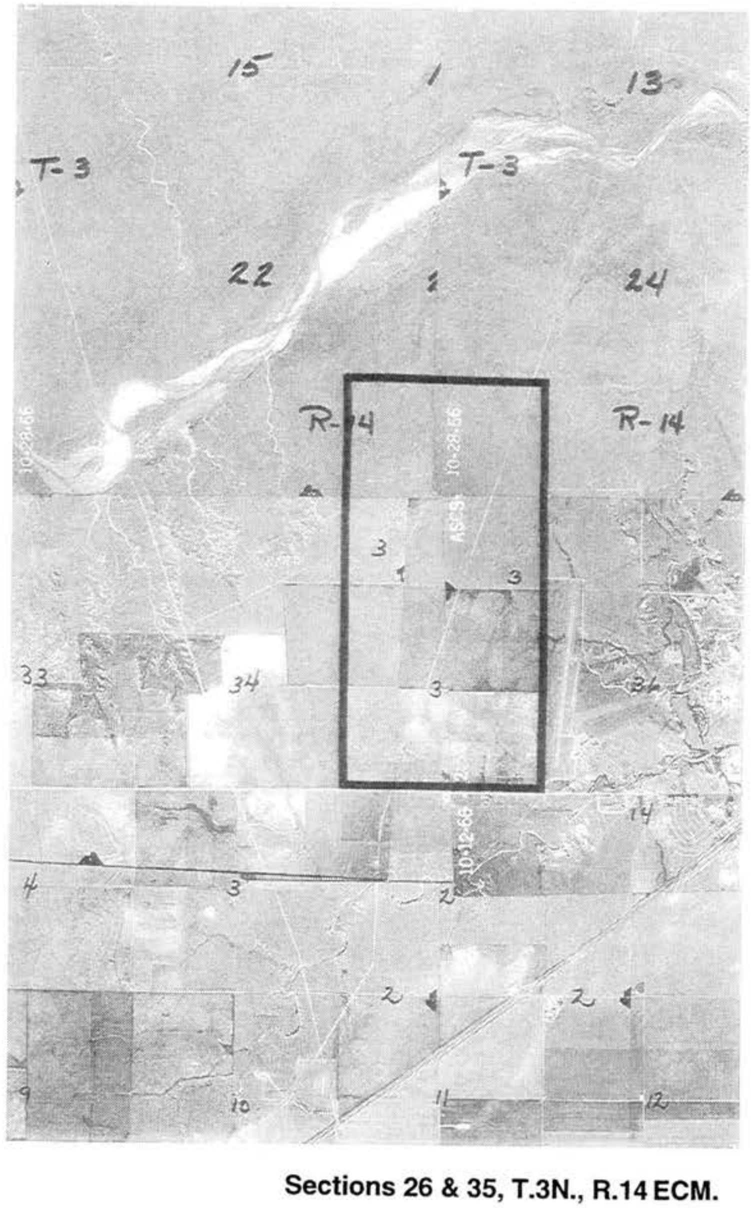
The paucity of lineaments is partially a result of the surficial geology. All areas are covered by Pleistocene and Quaternary sediments that have been redistributed by eolian and fluvial processes. Windblown deposits are evident as upland areas of light photo tones on the black and white (B & W) photographs and elongate ridges on the topographic maps. Disappearing drainages and the coarse dendritic drainage pattern across these areas also suggests coarse-textured soils.

Linear drainage patterns evident on the topographic maps were not obvious on the B & W photographs. The orientation and location of these lineaments does not suggest any relationship to the fault patterns evident in the Morrow shale.

Other interesting surficial features include oval depressions or playas that may be related to the dissolution of shallow Permian evaporites.

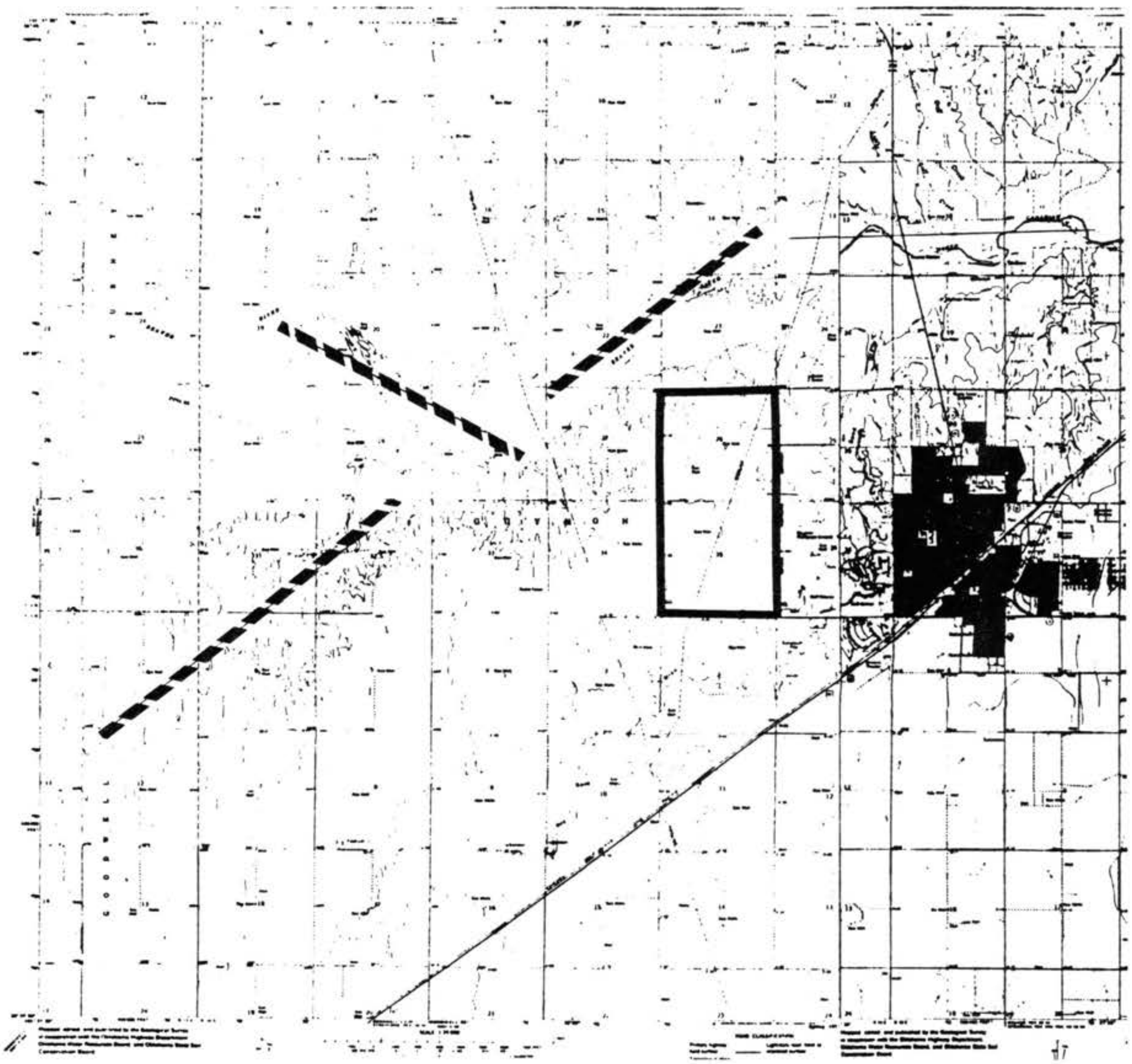


Drainage patterns from B & W aerial photography: Guymon area, Texas County, Oklahoma.



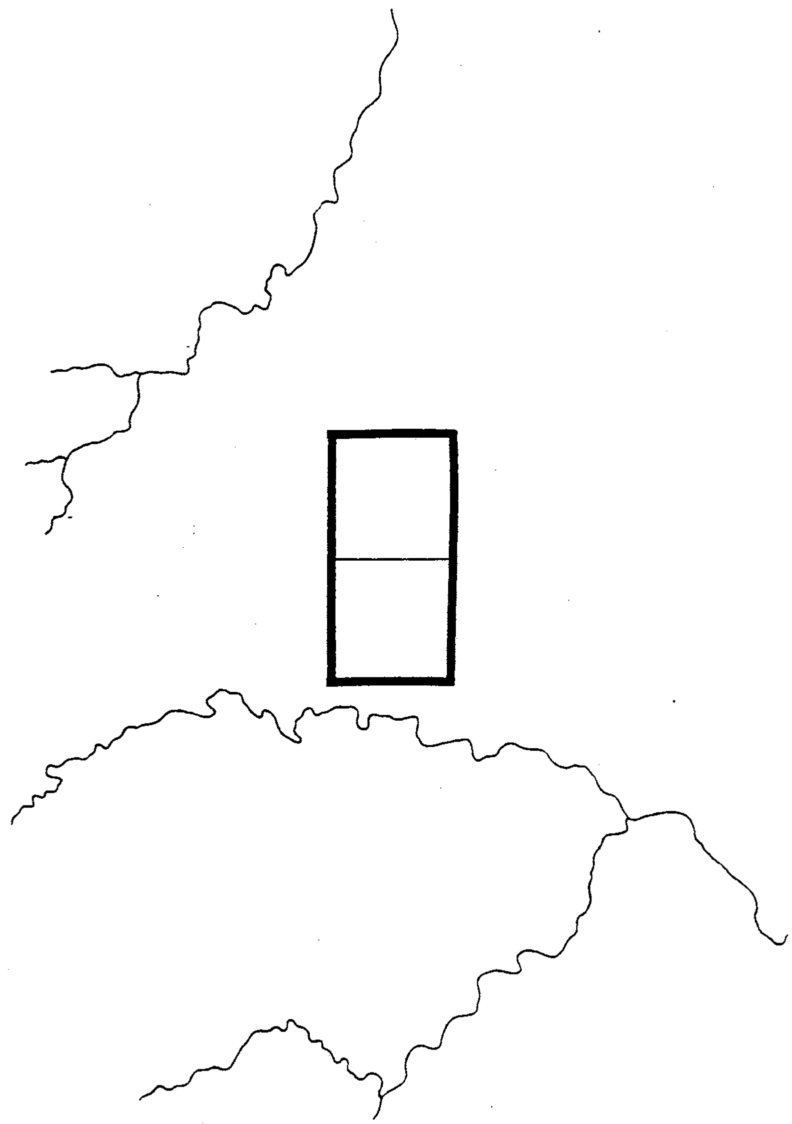
Sections 26 & 35, T.3N., R.14 ECM.

Black and white aerial photography of the Guymon area.



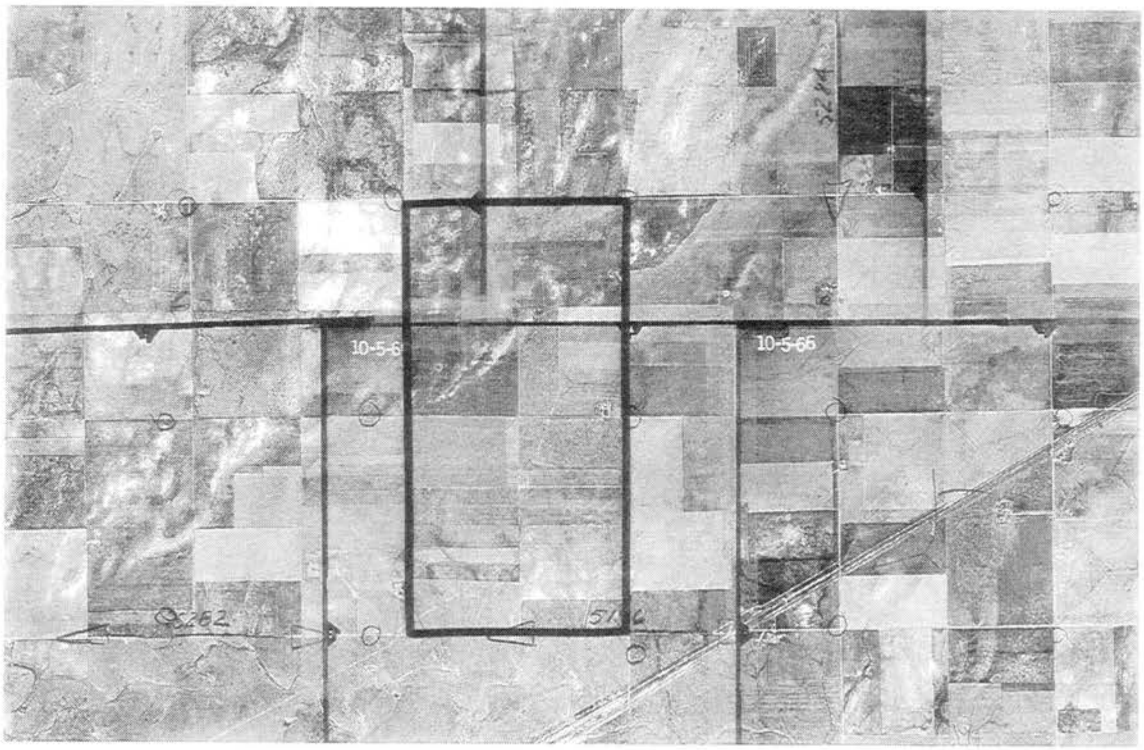
Sections 26 & 35, T.3N., R.14 ECM.

Drainage lineaments identified on U.S.G.S. topographic maps of the Guymon area.



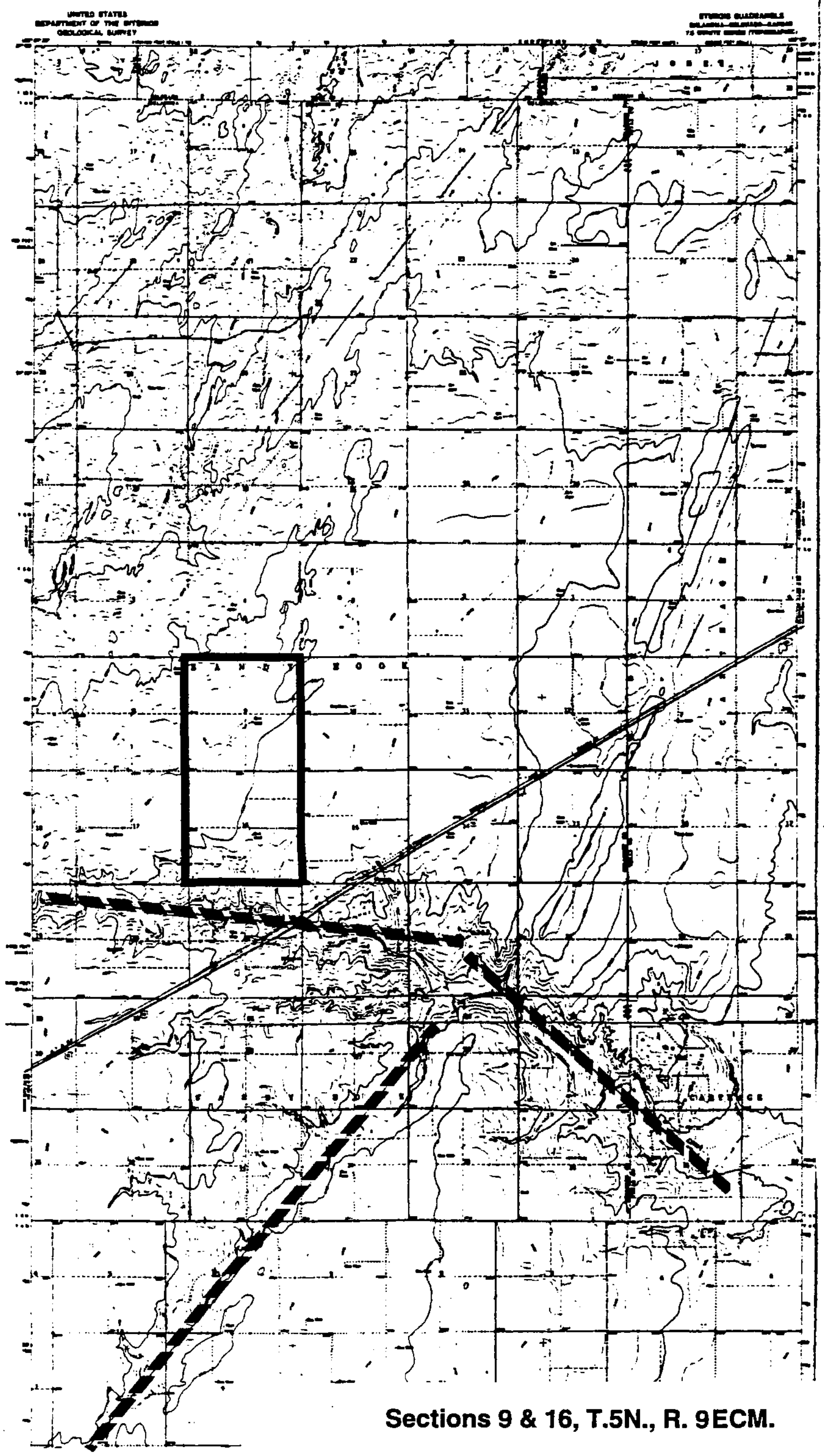
Sections 9 & 16, T.5N., R. 9ECM.

Drainage patterns from B & W aerial photography: Keyes Dome area, Cimarron County, Oklahoma.

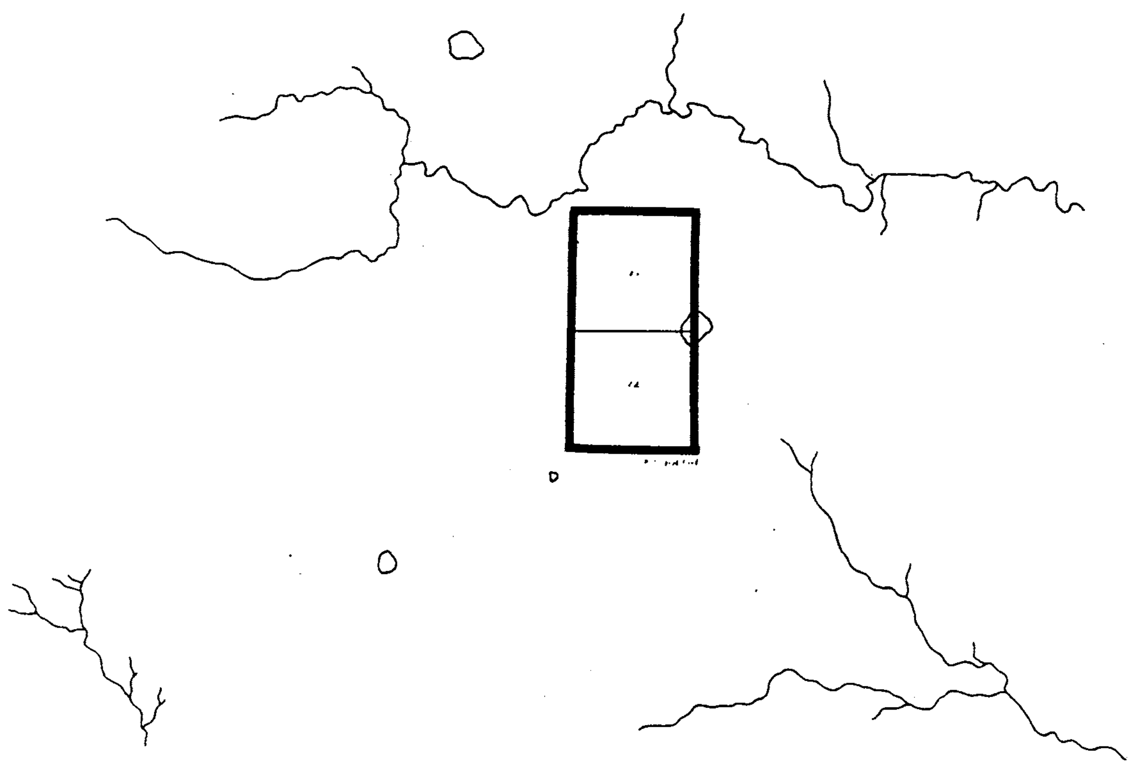


Sections 9 & 16, T.5N., R. 9ECM.

Black and white aerial photography of the Keyes Dome area.



Drainage lineaments identified on U.S.G.S. topographic maps of the Keyes area.

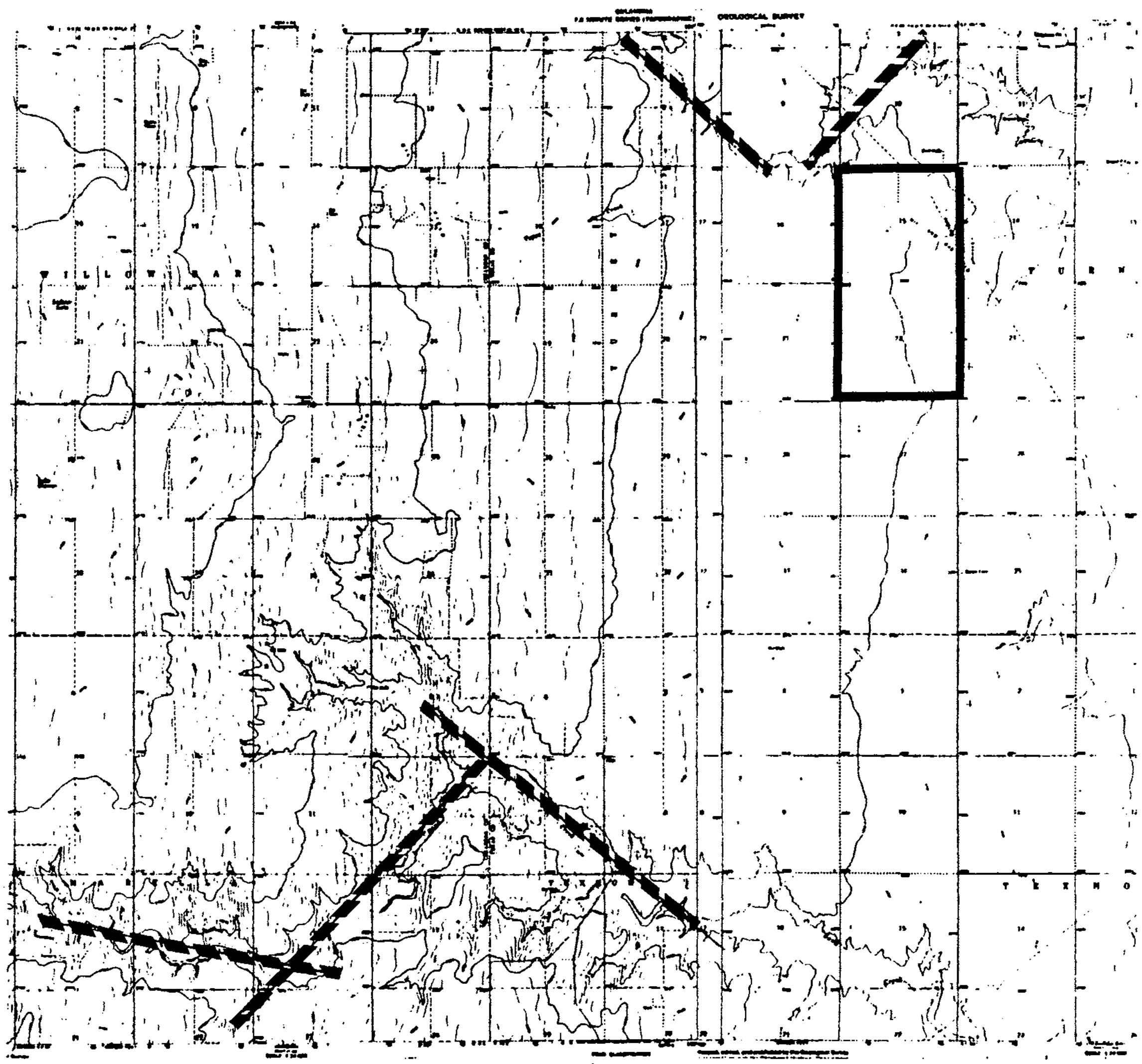


Sections 15 & 22, T.3N., R. 10 ECM.

Drainage patterns from B & W aerial photography: NE Rice area, Texas County, Oklahoma.

Sections 15 & 22, T.3N., R. 10ECM.

Black and white aerial photography of the NE Rice area.



Sections 15 & 22, T.3N., R. 10ECM.

Drainage lineaments identified on U.S.G.S. topographic maps of the NE Rice area.

APPENDIX E

DISPOSAL VOLUME CALCULATIONS

Calculations of Injection Volumes on a Per Well Basis

Liquid waste injection volumes were calculated using the equation and fluid properties from Bradley (1985) and reservoir characteristics derived from subsurface mapping, thin-section analyses, wire-line log surveys, and the literature.

The disposal volumes were calculated using the following general formula:

$$D = hA\phi\left\{ S_w C_L (P_2 - P_1)\left[1 + E_v (T_1 - T_2)\right] + S_G\left[1 - \left(\frac{P_1}{P_2}\right)\left(\frac{Z_2}{Z_1}\right)\left(\frac{T_2}{T_1}\right)\right] \right\}$$

where D is the disposal volume (ft^3); h is reservoir thickness (ft); A is reservoir area (ft^2), ϕ is porosity (decimal); C_L is liquid compressibility (ft^3/ft^3)/psi; S_w is water saturation (decimal); S_G is gas saturation (decimal); E_v is volume coefficient of expansion (ft^3/ft^3)/F^o; P_1 is pre-injection reservoir pressure (psi); P_2 is maximum post-injection reservoir pressure (psi); Z_1 and Z_2 are CH_4 gas correction values for pre- and post-injection stages; while T_1 and T_2 are reservoir temperatures at the pre- and post-injection stages (^{o} rankine).

Example 1: Krider Dolomite Reservoir in Hugoton Field (Guymon Area disposal site)

The Krider reservoir has the following characteristics: h = 30 ft (mapped porous/permeable dolomite); A = 640 acres x 43560 ft^2/acre = 27.9 x 10^6 ft^2; ϕ = 0.14 (pore volume/total rock volume); S_w = 0.25 (water-bearing pore volume/total pore volume); and S_G = 0.75 (gas-bearing pore volume/total pore volume). Initial reservoir pressure (P_1) for the Krider is approximately 85 psi (1992) and maximum reservoir pressure (P_2) is limited to 485 psi (original reservoir pressure). Reservoir temperature will remain constant T_1=T_2 = 90° F = 550° R. Liquid compressibility (C_L) = 3 x 10^{-6}(ft^3/ft^3)/psi; while the coefficient of expansion (E_v) = 400 x 10^{-6} (ft^3/ft^3)/°R.

$$D = 30ft \cdot 27.9\times10^{6} \cdot 0.14\left\{0.25\cdot 3\times10^{-6}(400)\left[1+400\times10^{-6}\cdot 0\right]+0.75\left[1-\left(\frac{85}{485}\right)\left(\frac{0.90}{0.96}\right)\left(\frac{550}{550}\right)\right]\right\}$$

$$D = 117.18\times10^{6}\left\{0.0003+0.75\left[1-(.18)(.94)(1)\right]\right\}$$

$$D = 117.18\times10^{6}\left\{0.0003+0.6225\right\} \qquad D = 73.3\times10^{6}\,ft^{3}$$

$$D = 73.3\times10^{6}\,ft^{3}\cdot 7.481 gal/ft^{3}\cdot 1bbl/42gal$$

$$D = 13.05\times10^{6}\,bbl/well$$

Example 2: Lower Morrow Keyes Sandstone Reservoir (Keyes Dome disposal site)

The Keyes Sandstone reservoir has the following characteristics: h = 50 ft (mapped porous/permeable sandstone); A = 640 acres x 43560 ft^2/acre = 27.9 x 10^6 ft^2; ϕ = 0.15 (pore volume/total rock volume); S_W = 0.35 (water-bearing pore volume/total pore volume); and S_G = 0.65 (gas-bearing pore volume/total pore volume). Initial reservoir pressure (P_1) for the Keyes is approximately 100 psi (1992) and maximum reservoir pressure (P_2) is limited to 800 psi (original reservoir pressure). Reservoir temperature will remain constant T_1=T_2 = 110° F = 570° R. Liquid compressibility (C_L) = 3 x 10^{-6}(ft^3/ft^3)/psi; while the coefficient of expansion (E_v) = 400 x 10^{-6} (ft^3/ft^3)/°R.

$$D = 50 ft \cdot 27.9 \times 10^6 \cdot 0.15 \left\{ 0.35 \cdot 3 \times 10^{-6} (700) \left[1 + 400 \times 10^{-6} \cdot 0 \right] + 0.65 \left[1 - \left(\frac{100}{800}\right)\left(\frac{0.90}{0.96}\right)\left(\frac{570}{570}\right) \right] \right\}$$

$$D = 209.25 \times 10^6 \left\{ 0.000735 + 0.65 \left[1 - (.125)(.94)(1) \right] \right\}$$

$$D = 209.25 \times 10^6 \left\{ 0.000735 + 0.57 \right\} \qquad D = 120 \times 10^6 ft^3$$

$$D = 120 \times 10^6 ft^3 \cdot 7.481 gal/ft^3 \cdot 1 bbl/42 gal$$

$$D = 21.4 \times 10^6 bbl/well$$

Example 3: Upper Morrow (Lower Purdy) Sandstone (Northeast Rice Field disposal site)

The Lower Purdy Sandstone reservoir has the following characteristics: h = 20 ft (mapped porous/permeable sandstone); A = 40 acres x 43560 ft^2/acre = 1.7 x 10^6 ft^2; $\phi = 0.15$ (pore volume/total rock volume); $S_w = 0.35$ (water-bearing pore volume/total pore volume); and $S_G = 0.65$ (gas-bearing pore volume/total pore volume). Initial reservoir pressure (P_1) for the L. Purdy is approximately 250 psi (1992) and maximum reservoir pressure (P_2) is limited to 1300 psi (original reservoir pressure). Reservoir temperature will remain constant T_1=T_2 = 120° F = 580° R. Liquid compressibility (C_L) = 3 x 10^{-6}(ft^3/ft^3)/psi; while the coefficient of expansion (E_v) = 400 x 10^{-6} (ft^3/ft^3)/°R.

$$D = 20ft \cdot 1.7 \times 10^6 \cdot 0.15\left\{ 0.35 \cdot 3 \times 10^{-6}(1050)\left[1 + 400 \times 10^{-6} \cdot 0 \right] + 0.65\left[1 - \left(\frac{250}{1300}\right)\left(\frac{0.90}{0.96}\right)\left(\frac{580}{580}\right)\right]\right\}$$

$$D = 5.1 \times 10^6\left\{ 0.0011 + 0.65\left[1 - (.19)(.94)(1)\right]\right\}$$

$$D = 5.1 \times 10^6\left\{ 0.0011 + 0.532\right\} \qquad D = 2.7 \times 10^6\, ft^3$$

$$D = 2.7 \times 10^6\, ft^3 \cdot 7.481 gal/ft^3 \cdot 1bbl/42gal$$

$$D = 4.8 \times 10^5\, bbl/well$$

APPENDIX F

ARBUCKLE PRESSURE DATA

APPENDIX F KEY

1. Spot Location: Legal location within blocks that subdivide the section

2. Sec., T.&R.: Section, Township, and Range of well where pressure or potentiometric surface was measured. All townships are north (N) or south (S) of the of Oklahoma Base Line. Ranges are east (E) and west (W) of the Indian Meridian.

3. Press.: Pressure measurement from DST or WHSIP measurements

4. Depth: Depth where pressure measurement was recorded

5. P-D Gradient: Pressure value divided by depth

6. Pot Surface: Potentiometric surface calculated from P-D gradient or measured in water well

7. Elev.: Surface elevation

8. Pot. Surface Sea Level: Potentiometric surface referenced to a mean sea level datum

Locations with only data for Elev. and Pot. Surface Sea Level are potentiometric surfaces measured in water wells (from Christenson et al., 1990; Sibenthal, 1908) or springs.

OKLAHOMA

Spot Location	Sec., T. & R.	Press.	Depth	P-D Gradient	Pot. Surface	Elev.	Pot. Surface Sea Level
SW-SE-NW	31-1S-1W	318	737	0.43	3	1200	1203
SW-SW-SE	3-1S-2W	550	1620	0.34	-341	971	630
NE-NE-SE	10-1S-2W	1105	2652	0.42	-82	1017	935
NW-SE-NE	14-1S-2W	450	1022	0.44	25	1050	1075
NW-SW-NE	14-1S-2W	597	1618	0.37	-230	1078	848
NW-SW-NE	141S-2W	645	1645	0.39	-145	1078	933
NW-SW-NE	14-1S-2W	811	1935	0.42	-49	1078	1029
NW-SW-NE	14-1S-2W	473	1214	0.39	-114	1078	964
NE-SW-SE	26-1S-7W	2780	5971	0.47	494	1103	1597
SE-NE-NW	13-1S-8W	2045	4706	0.43	50	1114	1164
SE-NE-NW	13-1S-8W	2040	4752	0.43	-8	1114	1106
NE-SE-NW	16-1S-8W	2700	5344	0.51	935	1212	2147
NW-NW-NW	18-1S-8W	1600	3655	0.44	66	1065	1131
SW-SW-SW	4-1S-11W	1780	4090	0.44	50	1029	1079
SW-SW-SW	4-1S-11W	2160	5000	0.43	23	1029	1052
SW-SW-SW	4-1S-11W	1715	3915	0.44	73	1029	1102
SW-SW-SW	4-1S-11W	2300	5382	0.43	-33	1029	996
SW-SE-SE	21-1S-15W	710	1700	0.42	-49	1158	1109
SW-SW-SW	23-1S-17W	1490	3487	0.43	-22	1219	1197
NE-NE	17-1S-22W	4108	9300	0.44	253	1447	1700
SW-NW	17-1S-24W	4224	9271	0.46	552	1481	2033
W/2 NE	31-1S-18W	2059	4698	0.44	90	1290	1380
NE-SW	24-1S-23W	4178	9045	0.46	671	1458	2129
NW-SE	36-2S-3W	4500	10182	0.44	283	1018	1301
NW-SE	36-2S-3W	4500	10464	0.43	1	1018	1019
NW-SE	36-2S-3W	4760	10464	0.45	606	1018	1624
SW-SW-NE	17-2S-5W	2852	6025	0.47	608	1048	1656
SW-NW	23-2S-5W	2965	6576	0.45	319	1052	1371
SW-SW-NW	29-2S-5W	1020	3014	0.34	-642	1008	366
NW-NW	31-2S-5W	650	1795	0.36	-283	1005	722
SE-SE-NW	5-2S-6W	1760	4429	0.40	-336	1007	671
NW-NE-SW	8-2S-6W	1400	3450	0.41	-194	1064	870
SE-NE-SE	33-2S-17W	2050	4774	0.43	-7	1233	1226
SE-SE-SE	33-2S-17W	2140	4773	0.45	204	1232	1436
SE-SW-SE	33-2S-17W	2125	4789	0.44	153	1236	1389
SW-NE	34-2S-17W	2540	5850	0.43	57	1231	1288
SW-NE	34-2S-17W	2500	5950	0.42	-136	1231	1095
SW-NW	34-2S-17W	2240	5006	0.45	203	1237	1440
SW-SW	34-2S-17W	2140	4735	0.45	242	1230	1472
SW-SW	34-2S-17W	2190	4875	0.45	218	1230	1448
SW-SE	34-2S-17W	2195	4780	0.46	325	1223	1548

NW-SE	34-2S-17W	2250	4953	0.45	280	1228	1508
SE-SW	34-2S-17W	2115	4630	0.46	289	1225	1514
NE-NE	1-3S-3W	3606	8995	0.40	-609	1109	500
NE-SE	1-3S-3W	6002	10109	0.59	3849	1062	4911
NE-SE	1-3S-3W	5207	10324	0.50	1785	1062	2847
SW-SE-NE	18-3S-4W	900	2215	0.41	-122	926	804
NW-SE-NE	3-3S-6W	2126	4800	0.44	144	976	1120
NW-SW-SE	9-3S-6W	1970	4350	0.45	231	903	1134
NW-NE-NE	3-3S-7W	2333	5313	0.44	113	1019	1132
NE-SE	21-3S-7W	3150	7292	0.43	34	1000	1034
NE	24-3S-14W	2100	4860	0.43	24	1031	1055
SW	3-3S-17W	2160	4768	0.45	255	1222	1477
SW	3-3S-17W	2125	4317	0.49	625	1225	1850
W/2	4-3S-17W	2095	4977	0.42	-105	1236	1131
SE-NE	23-3S-17W	2790	5967	0.47	521	1170	1691
NW-SW-NW	7-4S-2W	2695	6380	0.42	-113	907	794
NE-SE	31-4S-2W	2683	6092	0.44	148	888	1036
N/2-NE	36-4S-2W	3517	7700	0.46	479	847	1326
SW-NE-SE	2-4S-3W	1615	3029	0.53	727	882	1609
SW-NE-SE	2-4S-3W	1660	3790	0.44	70	882	952
SE-NW-SE	2-4S-3W	1585	2930	0.54	756	896	1652
SE-NW-SE	2-4S-3W	1600	3373	0.47	348	896	1244
SE-SW-NW	3-4S-3W	1670	3829	0.44	55	908	963
SE-SW-NW	3-4S-3W	1737	3945	0.44	95	908	1003
NE-SE-NW	3-4S-3W	1525	3340	0.46	207	897	1104
NE-SE-NW	4-4S-3W	1630	3880	0.42	-89	929	840
NE-NW-SE	4-4S-3W	1660	3890	0.43	-30	948	918
NE-SE-SE	8-4S-3W	1371	3482	0.39	-294	984	690
SW-SW-NE	11-4S-3W	1505	4063	0.37	-563	923	360
SE-NE-NW	12-4S-3W	1760	3757	0.47	336	888	1224
SE-NE-NW	12-4S-3W	1860	4224	0.44	102	888	990
NW-NW	12-4S-3W	1595	3124	0.51	585	914	1499
NW-NW	12-4S-3W	1910	4375	0.44	67	914	981
SE-SE-SE	22-4S-3W	1940	4530	0.43	-18	996	978
NW-NE-NE	2-4S-5W	1350	3161	0.43	-21	895	874
SE-SE-SE	8-4S-6W	3055	6613	0.46	492	973	1465
SE-SE-SE	8-4S-6W	3617	7760	0.47	652	973	1625
NE-NE-NE	27-4S-13W	1400	3840	0.36	-584	1078	494
NW-NE-SW	23-4S-15W	2040	4395	0.46	349	1107	1456
SE-SW	5-4S-17W	2979	6566	0.45	362	1113	1475
SE-SE-SW	2-5S-1W	3181	6700	0.47	698	901	1599
SW-NE	5-5S-1W	2632	5848	0.45	273	810	1083
SW-NE	5-5S-1W	2770	5896	0.47	546	810	1356
SE-NW-NE	12-5S-2W	3970	9180	0.43	53	841	894
SE-NW-NE	12-5S-2W	5650	12600	0.45	540	841	1381

SW-NE-NE	17-5S-2W	3857	8413	0.46	557	997	1554
SW-SE-NE	6-5S-7W	1300	3946	0.33	-923	970	47
SE-NE-SW	22-6S-5W	1080	2490	0.43	22	879	901
NW-SE-SE	28-6S-5W	720	1691	0.43	-17	847	830
NW-SE-SE	28-6S-5W	740	1711	0.43	10	847	857
SE-NE-SE	30-6S-5W	720	1919	0.38	-245	892	647
SE-NE-NW	14-6S-6W	1000	2665	0.38	-339	900	561
SW-NE-NE	17-6S-6W	2035	4625	0.44	108	892	1000
NW-NW-SE	6-6S-7W	1795	4569	0.39	-395	858	463
SE-NW	8-6S-7W	2012	4405	0.46	274	858	1132
SW-SW-SW	7-7S-6W	2650	6384	0.42	-221	936	715
NE-NE	32-7S-6W	2128	5078	0.42	-129	895	766
NW-SE-NW	35-7S-6W	2590	5287	0.49	736	781	1517
NW-SW	4-1S-1E	2250	6721	0.33	-1488	973	-515
W/2-SW-NE	4-1S-1E	2700	6790	0.40	-511	928	417
W/2-SW-NE	4-1S-1E	2900	6822	0.43	-78	928	850
W/2-SW-NE	4-1S-1E	2660	6934	0.38	-748	928	180
SE-SW-NE	5-1S-1E	3825	10163	0.38	-1268	1021	-247
NW-NW-NE	17-1S-3E	880	2210	0.40	-163	945	782
NW-SW-NW	2-2S-4E	990	2285	0.43	17	1034	1051
NW-SW-NW	2-2S-4E	1100	3373	0.33	-815	1034	219
S/2-NE-SW	9-3S-9E	810	1875	0.43	9	631	640
NW-SW-SE	35-4S-4E	2688	6000	0.45	251	873	1124
NW-NW	21-5S-1E	1679	4018	0.42	-113	976	863
NW-SE-NE	28-5S-7E	3140	6977	0.45	325	600	925
SW-NE	9-6S-1E	4320	9100	0.47	947	800	1747
NE-SW-NE	23-8S-1E	4716	9023	0.52	1944	706	2650
NW-SE-NW	29-8S-2E	2915	7870	0.37	-1091	885	-206
W/2-E/2	35-8S-2E	3184	6615	0.48	790	642	1432
SW-SW-SE	14-1N-1E	1835	4294	0.43	-27	818	791
SW-SW-SE	14-1N-1E	1980	4875	0.41	-270	818	548
SW-SW-SE	14-1N-1E	2192	5159	0.42	-61	818	757
SW-SW-SE	14-1N-1E	2400	6180	0.39	-599	818	219
SE-SE-SE	32-1N-1E	2760	6540	0.42	-121	989	868
SE-NE-NW	20-1N-1E	1174	3180	0.37	-450	942	492
NW-SE-SE	22-1N-1E	1125	2640	0.43	-24	872	848
SE-SW	34-1N-2E	2190	5350	0.41	-257	937	680
SW-SE	34-1N-2E	2140	5708	0.37	-731	925	194
SW-SE	34-1N-2E	2550	5894	0.43	36	925	961
NW-SE	12-1N-7E	2903	6979	0.42	-228	740	512
NE-NE-NW	2-2N-3E	867	2106	0.41	-90	1163	1073
NE-NE-NW	2-2N-3E	1589	3770	0.42	-75	1163	1088
NE-NE-NW	2-2N-3E	1755	4000	0.44	81	1163	1244
NW-NW	20-2N-3E	1720	4100	0.42	-100	1082	982
NE-SE-NE	30-2N-6E	728	1834	0.40	-141	1180	1039

N/2-NW-NE	31-2N-7E	1975	5198	0.38	-605	807	202
NE-SE	3-2N-8E	2280	5968	0.38	-666	714	48
NE-SW-SW	27-2N-9E	3600	7656	0.47	716	689	1405
SW-NW-SE	19-3N-1E	2936	5950	0.49	878	953	1831
S/2-NE-NW	22-3N-1E	2379	5419	0.44	114	861	975
SW-NW	34-3N-1E	1875	4618	0.41	-258	855	597
NW-NW	33-3N-4E	2386	5955	0.40	-406	1114	708
SE-SW	32-3N-5E	1740	4940	0.35	-893	1189	296
SW-SW	7-4N-4E	1035	2885	0.36	-478	1111	633
SW-SW	7-4N-4E	1316	3464	0.38	-404	1111	707
W/2-NE	13-5N-1E	2964	6900	0.43	-7	1068	1061
S/2-NE	14-5N-18E	6642	13594	0.49	1853	665	2518
SW-NE	15-5N-18E	6660	13531	0.49	1957	665	2622
SW-NE	16-5N-18E	6541	13540	0.48	1672	664	2336
C-SE	17-5N-18E	6687	13624	0.49	1927	660	2587
SW-SW-NE	34-6N-5E	1600	4111	0.39	-390	996	606
S/2-SW-NE	8-6N-7E	2080	5330	0.39	-493	885	392
NW-NW-NW	36-6N-7E	2000	4904	0.41	-253	808	555
SE-SW-SE	19-7N-5E	2000	5044	0.40	-393	927	534
SW-NW-SE	31-7N-8E	2008	5111	0.39	-441	953	512
SE-NW	22-8N-20E	3578	7533	0.47	788	540	1328
SE-NW	22-8N-20E	3640	7624	0.48	841	540	1381
SW-SW-NE	27-8N-20E	3463	7427	0.47	626	563	1189
E/2-SE-NW	36-8N-22E	3940	8600	0.46	563	663	1226
NE-SE	34-9N-6E	2058	5880	0.35	-1094	950	-144
SW-NW-SW	18-9N-15E	2070	5461	0.38	-647	660	13
SW-NE	29-9N-21E	2675	6022	0.44	199	614	813
NW-NE	36-10N-4E	2207	5165	0.43	-32	1033	1001
SW-NE	23-10N-20E	1845	4102	0.45	189	562	751
NW-SE	5-10N-24E	2024	4200	0.48	507	505	1012
SW-SE-NW	5-11N-14E	1360	3363	0.40	-200	771	571
NE-NW	34-12N-19E	1152	2565	0.45	114	554	668
SE-SE	7-13N-16E	1356	3194	0.42	-41	648	607
SW-SE-NW	11-14N-11E	1230	3059	0.40	-199	832	633
SE-SE-SW	6-15N-7E	1670	4065	0.41	-181	919	738
NW-SE-SW	6-15N-7E	1624	4082	0.40	-305	885	580
SW-NW-SE	6-15N-7E	1620	4034	0.40	-267	891	624
NE-SW	21-15N-7E	1890	4470	0.42	-75	790	715
NE-NE	25-15N-10E	1340	3571	0.38	-455	829	374
SW-NE	5-16N-10E	1344	3550	0.38	-424	898	474
SW-SW-SW	3-16N-22E	581	1450	0.40	-99	855	756
NW-SE	28-17N-5E	1857	4351	0.43	-32	890	858
SE-SE	5-17N-7E	1061	2915	0.36	-448	878	430
N/2-SE	36-17N-11E	946	3050	0.31	-850	886	36
E/2-SE	8-18N-7E	960	2809	0.34	-576	844	268

SW-SW-NE	8-18N-7E	920	2542	0.36	-402	753	351
SW-SW-NE	8-18N-7E	1040	2950	0.35	-531	753	222
SE-SW	33-18N-7E	995	2767	0.36	-453	812	359
C	22-18N-8E	1435	3657	0.39	-320	892	572
SW-NW	30-18N-11E	980	2971	0.33	-692	779	87
SE-SW	36-19N-8E	1264	3425	0.37	-485	800	315
SE-NW-SE	31-T18N-26E			0.43		1123	1023
SW-SE	1-20N-6E	1362	3558	0.38	-391	867	476
NW-NW	1-20N-7E	1027	3020	0.34	-632	1016	384
NE-NW	1-20N-7E	1039	2968	0.35	-552	1055	503
SW-NW	1-20N-7E	1057	2950	0.36	-492	1024	532
SW-SW	6-20N-7E	1350	3545	0.38	-405	896	491
SW-NE	32-20N-9E	1400	2878	0.49	378	806	1184
SW-NW	29-20N-11E	902	2449	0.37	-351	878	527
SW-SW-NW	34-20N-23E			0.43		1090	819
SW-SW-SW	17-20N-24E			0.43		1200	893
SE-SW	20-21N-8E	968	2629	0.37	-378	967	589
SE-SW	20-21N-8E	980	2680	0.37	-401	967	566
S/2-SE	8-21N-10E	831	2450	0.34	-517	842	325
SE-NW-NW	11-21N-10E	870	2425	0.36	-402	934	532
SE-NW-NW	11-21N-10E	840	2450	0.34	-497	934	437
NW-NW-SW	11-21N-10E	844	2438	0.35	-475	947	472
NW-NW-SW	11-21N-10E	844	2472	0.34	-509	947	438
NW-SE	12-21N-10E	915	2506	0.37	-378	918	540
SW-NW	5-21N-11E	725	2340	0.31	-654	894	240
NE-NE	6-21N-11E	812	2340	0.35	-452	867	415
NE-SW	17-21N-11E	875	2452	0.36	-417	907	490
NE-NW	18-21N-12E	849	2129	0.40	-155	714	559
NE-NE-NE	31-21N-25E			0.43		1205	897
NW-SW	1-22N-7E	1113	2960	0.38	-372	890	518
SW-SE	1-22N-7E	1030	3073	0.34	-678	978	300
NE-SE	2-22N-7E	1134	3024	0.38	-387	938	551
SE-NW-NW	3-22N-7E	1160	2872	0.40	-174	756	582
NW-SE	5-22N-7E	1160	3049	0.38	-351	1009	658
NW-NW	10-22N-7E	1140	2950	0.39	-299	816	517
NE-SW	12-22N-7E	1080	3025	0.36	-513	923	410
NE-NE	13-22N-7E	977	2894	0.34	-622	880	258
NE-SE	25-22N-7E	1100	2903	0.38	-345	811	466
NW-NE	25-22N-7E	1076	2946	0.37	-444	933	489
NW-NW	2-22N-8E	934	2730	0.34	-558	888	330
SW-NW	2-22N-8E	1067	2833	0.38	-352	922	570
SW-NW	4-22N-8E	1193	3093	0.39	-319	1055	736
NW	5-22N-8E	1337	3095	0.43	14	1065	1079
NE	5-22N-8E	1110	3048	0.36	-467	1020	553
SE-SW	10-22N-8E	995	2607	0.38	-293	931	638

NE-SE-SW	10-22N-8E	1087	2851	0.38	-323	931	608
NW-SE	16-22N-8E	989	2908	0.34	-608	973	365
NW-NW-SE	16-22N-8E	1049	2957	0.35	-517	1015	498
SW-NE	16-22N-8E	1071	2870	0.37	-379	976	597
SW-SW	19-22N-8E	1058	2982	0.35	-522	968	446
NE-SW	26-22N-8E	1011	2940	0.34	-589	963	374
NW-NW	30-22N-8E	1017	2942	0.35	-577	933	356
NW-NW	18-22N-9E	987	2625	0.38	-330	849	519
NW-NW	18-22N-9E	987	2641	0.37	-346	849	503
NE-NW	13-22N-9E	1006	2598	0.39	-258	840	582
NE-NW	13-22N-9E	1026	2635	0.39	-249	840	591
NE-NW	18-22N-9E	1035	2695	0.38	-288	824	536
NE-NW	18-22N-9E	1062	2720	0.39	-250	824	574
NW-NE	25-22N-9E	858	2528	0.34	-533	891	358
NW-NE	25-22N-9E	855	2528	0.34	-540	891	351
SE-SE	2-22N-10E	816	2185	0.37	-287	845	558
SE-SE	2-22N-10E	790	2210	0.36	-373	845	472
NW-NW-NW	12-22N-10E	819	2230	0.37	-325	830	505
SE-SW	4-22N-11E	745	2048	0.36	-315	930	615
SW-SW	9-22N-11E	710	2094	0.34	-443	854	411
NE-NW	19-22N-11E	763	2004	0.38	-230	735	505
NE-NW	17-22N-12E	817	2220	0.37	-320	771	451
NW-SW	18-22N-12E	790	2105	0.38	-268	726	458
SE-SW-NW	5-22N-23E			0.42		1100	795
SW-SW	24-23N-3E	1745	4425	0.39	-367	953	586
NW-SE-NE	21-23N-4E	1720	4450	0.39	-450	922	472
SW-NE	23-23N-7E	1042	2790	0.37	-367	893	526
SW-NE	23-23N-7E	1024	2810	0.36	-429	893	464
NE-SW	23-23N-7E	1091	2815	0.39	-278	911	633
SE-NW	23-23N-7E	1084	2885	0.38	-364	987	623
SW-SE	26-23N-7E	1080	2757	0.39	-245	866	621
SW-SE	26-23N-7E	1080	2774	0.39	-262	866	604
NE-SE	32-23N-7E	1130	3046	0.37	-418	913	495
NE-NE	35-23N-7E	970	2838	0.34	-582	915	333
NW-NW	36-23N-7E	1041	2790	0.37	-369	929	560
NW-NW	36-23N-7E	1034	2815	0.37	-410	929	519
SW-NW	7-23N-8E	1135	2955	0.38	-315	1021	706
NE-SW	8-23N-8E	1025	2793	0.37	-409	1075	666
NE-SW	8-23N-8E	1045	2766	0.38	-336	1033	697
SW	9-23N-8E	1070	2567	0.42	-79	985	906
NE-NE	14-23N-8E	888	2475	0.36	-410	811	401
NW-NW	18-23N-8E	1098	2975	0.37	-422	1031	609
SW-SE	20-23N-8E	998	2800	0.36	-479	1040	561
SW-SE	20-23N-8E	993	2845	0.35	-536	1040	504
NW-SE	24-23N-8E	1053	2770	0.38	-321	895	574

SE-NW	26-23N-8E	1150	2915	0.39	-241	916	675
NE	27-23N-8E	1040	2828	0.37	-409	894	485
NE-NW	29-23N-8E	1010	2796	0.36	-447	1054	607
NE-NW	29-23N-8E	1050	2890	0.36	-448	1054	606
NW-NW	29-23N-8E	1000	2835	0.35	-509	1055	546
SW-NW	30-23N-8E	1094	2878	0.38	-334	939	605
S/2-SE	32-23N-8E	1102	3050	0.36	-487	1035	548
NE-SE	33-23N-8E	1150	2792	0.41	-118	942	824
NW-SE	4-23N-9E	924	2574	0.36	-425	848	423
SW-SW	19-23N-9E	980	2482	0.39	-203	801	598
NE-SW	19-23N-9E	977	2514	0.39	-242	821	579
NE-SW	19-23N-9E	925	2519	0.37	-368	821	453
SW-SW	27-23N-9E	944	2609	0.36	-414	824	410
NW-SW	27-23N-9E	952	2541	0.37	-327	797	470
SE	27-23N-9E	900	2580	0.35	-487	756	269
NE-SE	29-23N-9E	1002	2523	0.40	-193	803	610
NW-SE	7-23N-10E	930	2557	0.36	-394	889	495
SW-NW	18-23N-10E	951	2589	0.37	-377	914	537
NW-SW	20-23N-10E	946	2522	0.38	-322	925	603
NE-SW	32-23N-10E	875	2517	0.35	-482	898	416
NE-SW	32-23N-10E	954	2530	0.38	-311	916	605
NE-NE	3-23N-11E	931	2407	0.39	-242	831	589
NE-SW	4-23N-11E	766	2022	0.38	-241	758	517
NE-SW	7-23N-11E	727	2130	0.34	-439	930	491
SW-SE	7-23N-11E	723	2130	0.34	-449	938	489
SW-SE	23-23N-11E	735	2084	0.35	-375	912	537
SE-NW	33-23N-11E	703	2118	0.33	-483	919	436
SW-SE	30-23N-12E	711	2074	0.34	-421	971	550
SE-SE-SW	33-23N-25E			0.43		1080	965
NW-SW	5-24N-8E	996	2880	0.35	-564	1047	483
SW-SE	6-24N-8E	1071	2877	0.37	-386	1073	687
NW-SE	6-24N-8E	1026	2850	0.36	-464	1071	607
SW-NE	7-24N-8E	990	2868	0.35	-566	1043	477
SE-SE	10-24N-8E	900	2605	0.35	-512	915	403
SE-NW	17-24N-8E	1103	2905	0.38	-340	962	622
SW-NE	18-24N-8E	1014	2888	0.35	-530	1007	477
NE-NE	19-24N-8E	1000	2920	0.34	-594	1010	416
NW-SE	21-24N-8E	995	2756	0.36	-442	1036	594
SE-NE	26-24N-8E	1100	2620	0.42	-62	858	796
NW-SW	30-24N-8E	1070	2924	0.37	-436	991	555
NW-SW	36-24N-8E	930	2463	0.38	-300	842	542
NW-SW	5-24N-9E	894	2602	0.34	-523	1021	498
NW-SW	7-24N-9E	969	2720	0.36	-467	1026	559
SW-NW	7-24N-9E	970	2673	0.36	-417	978	561
SE-NE	11-24N-10E	812	2178	0.37	-290	891	601

NW	12-24N-10E	835	2038	0.41	-96	752	656
SW-SE	5-24N-11E	819	2078	0.39	-173	820	647
N/2-SE	5-24N-11E	780	2114	0.37	-300	832	532
S/2-SE	8-24N-11E	789	2090	0.38	-255	845	590
S/2-SE	8-24N-11E	790	2105	0.38	-268	845	577
S/2-SE	8-24N-11E	789	2125	0.37	-290	845	555
SW-SE	8-24N-11E	794	2058	0.39	-211	791	580
NE-NE	13-24N-11E	717	2018	0.36	-351	906	555
SE-NE	16-24N-11E	815	2047	0.40	-152	785	633
NW-SE	17-24N-11E	782	2088	0.37	-269	803	534
NW-NE	19-24N-11E	780	2002	0.39	-188	775	587
SE-SW	4-24N-12E	770	2058	0.37	-267	853	586
NW-NE	32-24N-12E	680	1800	0.38	-219	744	525
NE-SE-NE	11-24N-21E			0.43		790	675
NE-NE-SW	15-24N-23E			0.43		805	653
SE-SW-NW	6-24N-24E			0.43		850	701
NW-SW-NW	21-25N-5E	1415	3580	0.40	-289	1026	737
NE-NE-NE	8-25N-6E	1470	3616	0.41	-197	1077	880
NE-NW-NE	26-25N-6E	1270	3353	0.38	-400	1060	660
NW-NW-NE	6-25N-7E	1235	3163	0.39	-291	1047	756
SW-SW-NE	9-25N-7E	1000	3062	0.33	-736	1069	333
NW-SE	10-25N-7E	1211	3113	0.39	-297	1106	809
SE-SE-SE	10-25N-7E	990	2650	0.37	-348	995	647
NW-SE-SE	17-25N-8E	1060	2762	0.38	-297	903	606
NW-NW-NE	20-25N-8E	1025	2756	0.37	-372	1021	649
NE-NE-SW	25-25N-8E	910	2716	0.34	-600	992	392
SW-NE	25-25N-8E	1006	2749	0.37	-409	1000	591
SW-SW	27-25N-8E	965	2749	0.35	-505	1084	579
SW-SW	27-25N-8E	965	2779	0.35	-535	1084	549
NW-NW-NW	28-25N-8E	918	2700	0.34	-565	1055	490
SW	30-25N-8E	1055	2745	0.38	-292	1059	767
NE-SW	30-25N-8E	995	2696	0.37	-382	1060	678
NW-NW	34-25N-8E	966	2693	0.36	-446	1091	645
NW-NW	34-25N-8E	995	2698	0.37	-384	1091	707
NE-SE-SE	35-25N-8E	964	2842	0.34	-600	1070	470
SE-SW	36-25N-8E	996	2861	0.35	-545	1099	554
SE-NW	3-25N-9E	935	2282	0.41	-108	836	728
NW-NE	10-25N-9E	849	2249	0.38	-275	805	530
SW-NE	10-25N-9E	930	2230	0.42	-67	804	737
SE-NE	32-25N-9E	895	2369	0.38	-288	922	634
SE-SW	3-25N-10E	870	2322	0.37	-299	907	608
SE-SW	8-25N-10E	1005	2349	0.43	-12	783	771
SW-NW	13-25N-10E	805	2191	0.37	-319	925	606
SW-NW	13-25N-10E	857	2196	0.39	-203	932	729
SE-SE	14-25N-10E	826	2212	0.37	-291	938	647

SW	5-25N-11E	831	2115	0.39	-182	891	709
SE-SW	9-25N-11E	800	2163	0.37	-303	955	652
SW-NE	20-25N-11E	793	2193	0.36	-349	938	589
NW-SW	23-25N-11E	754	2109	0.36	-356	935	579
S/2-NW	23-25N-11E	779	2067	0.38	-255	889	634
NE	25-25N-11E	750	2130	0.35	-386	937	551
S/2	27-25N-11E	730	2042	0.36	-344	920	576
SW-NW	30-25N-11E	827	2140	0.39	-217	899	682
SW-NW	16-25N-12E	757	2142	0.35	-382	991	609
SE-SW	18-25N-12E	772	2125	0.36	-330	956	626
SE-SE	28-25N-12E	824	2101	0.39	-185	992	807
SE-SE	28-25N-12E	753	2094	0.36	-343	969	626
NW-NE	32-25N-12E	804	2102	0.38	-232	943	711
NE-NE	32-25N-12E	777	2114	0.37	-307	940	633
NE-SE-NE	12-25N-20E			0.43		725	670
SW-SW-SE	23-25N-22E			0.43		925	667
NW-NW-NE	13-25N-23E			0.43		775	685
NE-NE-NE	28-25N-24E			0.43		805	765
N/2-NW-NE	28-26N-1E	1300	3888	0.33	-865	1139	274
SE	13-26N-6E	1135	3250	0.35	-610	1162	552
SW-NE-NE	2-26N-7E	985	2843	0.35	-552	1091	539
NW-SE-NW	29-26N-7E	991	3100	0.32	-795	1177	382
SE-NE-SW	26-26N-8E	995	2600	0.38	-286	888	602
NE-SE-NW	36-26N-8E	1004	2719	0.37	-384	998	614
NE-NE-SE	23-26N-9E	888	2382	0.37	-317	990	673
NE-NW-NW	30-26N-9E	1053	2648	0.40	-199	911	712
NW-SE	30-26N-9E	980	2480	0.40	-201	848	647
NE-SE-SE	36-26N-9E	903	2450	0.37	-350	887	537
NW-NE-NE	2-26N-10E	764	2235	0.34	-458	967	509
NE-NE-NW	2-26N-10E	845	2250	0.38	-285	931	646
NW-NE	2-26N-10E	837	2245	0.37	-298	987	689
NW-NE	8-26N-10E	877	2458	0.36	-418	939	521
SE-NE	30-26N-10E	965	2394	0.40	-150	882	732
NE-SE-SE	5-26N-11E	819	2102	0.39	-197	826	629
SW-SW-SW	36-26N-11E	709	1992	0.36	-343	902	559
NW-NW	31-26N-12E	816	2000	0.41	-102	872	770
SW-NW	31-26N-12E	806	1999	0.40	-125	898	773
NE-NW	31-26N-12E	777	1944	0.40	-137	822	685
SW-SE	33-26N-12E	720	1994	0.36	-320	940	620
SE-SE-SW	10-27N-6E	1230	3292	0.37	-432	1122	690
NW-NW-NE	9-27N-8E	960	2718	0.35	-485	1055	570
SW-SW-SW	15-27N-8E	966	2688	0.36	-441	1038	597
SE-SE-SW	20-27N-8E	1105	2881	0.38	-311	1074	763
S/2-N/2-SW	22-27N-8E	1265	3434	0.37	-492	1058	566
NE-SW-SW	29-27N-10E	828	2118	0.39	-192	894	702

SW-SW-NW	29-27N-10E	785	2136	0.37	-310	920	610
SE-SE-NW	5-27N-11E	870	2226	0.39	-203	889	686
SE-SE-NW	5-27N-11E	840	2264	0.37	-311	889	578
NW-NW-NE	10-27N-11E	970	2261	0.43	-5	904	899
NE-SW-SW	19-27N-11E	835	2001	0.42	-59	832	773
NE-NE-SE	20-27N-11E	840	2225	0.38	-272	956	684
NE-SE-SE	12-27N-20E			0.43		900	689
SE-SE-NE	12-27N-21E			0.43		876	668
SE-SW-SE	20-27N-21E			0.43		820	674
NW-NE-SW	5-28N-1E	1400	3315	0.42	-59	1104	1045
SW-SE-NW	5-28N-1E	1320	3413	0.39	-343	1089	746
N/2-SE-NW	6-28N-1E	1340	3368	0.40	-252	1080	828
SE-SE-NE	6-28N-1E	1380	3406	0.41	-197	1083	886
SW-NE-SE	17-28N-1E	1320	3341	0.40	-271	1135	864
NE-NW-SE	17-28N-1E	1280	3292	0.39	-315	1150	835
NE-NW-SE	17-28N-1E	1200	3323	0.36	-532	1150	618
NE-NW-SE	17-28N-1E	1225	3358	0.36	-509	1150	641
NE-NW-SE	17-28N-1E	1230	3370	0.36	-510	1150	640
SW-SW-SE	17-28N-1E	1285	3300	0.39	-312	1152	840
SE-SE-NW	17-28N-1E	1335	3306	0.40	-201	1148	947
NW-NE-SW	17-28N-1E	1340	3375	0.40	-259	1144	885
NW-NE-SW	17-28N-1E	1340	3444	0.39	-328	1144	816
NW-NE-SW	17-28N-1E	1460	3627	0.40	-232	1144	912
SE-SE-NE	19-28N-1E	1275	3313	0.38	-348	1101	753
SW-NE-NW	20-28N-1E	1291	3322	0.39	-320	1135	815
SW-SE-NW	20-28N-1E	1320	3400	0.39	-330	1130	800
SW-SE-NW	20-28N-1E	1155	3422	0.34	-736	1130	394
NE-SE-NW	20-28N-1E	1265	3402	0.37	-460	1144	684
SW-NW-NE	20-28N-1E	1325	3436	0.39	-355	1152	797
SE-NW-NW	20-28N-1E	1275	3280	0.39	-315	1117	802
NW-SW-SW	13-28N-20E			0.43		860	760
SW-NE-SW	29-28N-21E			0.43		845	671
NE-NE-SE	18-29N-1E	1200	3350	0.36	-559	1087	528
NE-NE-SE	18-29N-1E	1245	3377	0.37	-482	1087	605
NW-NW-NW	31-29N-1E	1360	3338	0.41	-175	1079	904
NW-NW-NW	31-29N-1E	1360	3422	0.40	-259	1079	820
SE-NW-NW	31-29N-1E	1335	3335	0.40	-230	1062	832
SW-SW	21-1N-23W	3964	8700	0.46	519	1460	1979
NE	11-4N-3W	3110	8165	0.38	-932	965	33
SW-NW	14-4N-3W	3500	9150	0.38	-1010	975	-35
W/2-SW	17-5N-3W	5386	11645	0.46	881	1029	1910
W/2-SW	17-5N-3W	5285	11910	0.44	381	1029	1410
SE-NW-NW	29-5N-3W	4305	11183	0.38	-1171	1051	-120
E/2-SW-SE	13-5N-5W	5760	13014	0.44	381	1055	1436
NW	31-5N-5W	8971	17008	0.53	3855	1100	4955

NE	36-5N-5W	5834	13714	0.43	-147	1010	863
NW-SE-NW	23-6N-3W	4550	10373	0.44	208	1088	1296
SW-SE-SW	26-6N-3W	4498	10307	0.44	153	1073	1226
SE-NW-NW	26-6N-13W	720	1620	0.44	54	1430	1484
NW-SW	26-6N-13W	1252	3185	0.39	-273	1420	1147
NW-NE-SE	26-7N-4W	5688	12585	0.45	643	1149	1792
SE-NW-SW	9-8N-2W	3915	8733	0.45	372	1167	1539
NE-NW	16-8N-2W	4005	8962	0.45	352	1177	1529
SE-NE-SE	19-8N-2W	4173	9184	0.45	521	1114	1635
NW-SE	30-8N-2W	3745	9207	0.41	-498	1149	651
NW-SE-NW	6-8N-21W	3624	8310	0.44	118	1842	1960
NW-SW-SE	9-9N-2W	3611	8453	0.43	-55	1163	1108
NW-NW-SW	14-9N-2W	3527	8448	0.42	-246	1175	929
SE-SE-SE	20-9N-2W	3693	8721	0.42	-133	1236	1103
N/2-NW-NW	28-9N-2W	3759	8813	0.43	-71	1225	1154
N/2-NW-NW	28-9N-2W	3737	9179	0.41	-488	1225	737
NW-NW-NW	33-9N-2W	3860	8948	0.43	29	1171	1200
SE-SW-NE	10-9N-23W	4600	10885	0.42	-187	1847	1660
SE-SW-NE	10-9N-23W	4700	10825	0.43	105	1847	1952
SW-SE	5-10N-3W	3835	9405	0.41	-486	1274	788
SW-NE-NE	26-10N-4W	4466	9687	0.46	699	1164	1863
NE	27-10N-26W	8503	18600	0.46	1174	2146	3320
NW-SE-NW	19-11N-2W	2250	6017	0.37	-784	1250	466
NW-SE-NW	19-11N-2W	2010	6200	0.32	-1526	1305	-221
NW-SE-NW	19-11N-2W	2400	6237	0.38	-656	1305	649
NW-SE-NW	19-11N-2W	2500	6337	0.39	-523	1305	782
NW-SE-NW	19-11N-2W	2590	6352	0.41	-329	1305	976
NW-SE-NW	19-11N-2W	2700	6461	0.42	-182	1305	1123
SE-SE-NE	12-11N-3W	2390	6328	0.38	-770	1223	453
NW-NE-NE	13-11N-3W	2327	6159	0.38	-747	1262	515
NE-SW	5-12N-8W	4535	13117	0.35	-2570	1399	-1171
SW-SE	26-15N-3W	3088	7215	0.43	-34	1089	1055
SE-NW	22-15N-16W	6230	16972	0.37	-2484	1829	-655
SE-NW-NE	6-15N-18W	8235	18276	0.45	875	1907	2782
SE-NW-NE	6-15N-18W	7102	17450	0.41	-934	1907	973
NW-NW	28-16N-4W	3748	8526	0.44	190	1026	1216
NW-NW	28-16N-4W	3864	8820	0.44	166	1026	1192
NW-NW	28-16N-4W	3667	9124	0.40	-596	1026	430
S/2-NE-NW	8-19N-4W	3025	6845	0.44	190	1036	1226
E/2-NE-NW	31-19N-4W	2790	6655	0.42	-167	998	831
SW-NE	10-20N-4W	2566	6327	0.41	-360	1056	696
SW-NE	10-20N-4W	2631	6430	0.41	-311	1056	745
SE-SE-SE	14-20N-10W	4033	9194	0.44	185	1150	1335
NW-SE-NW	32-21N-1W	2199	5427	0.41	-313	1074	761
SW-NE	36-21N-3W	2350	5820	0.40	-355	1171	816

SW-NE	36-21N-3W	2450	5820	0.42	-122	1171	1049
SW-NE	36-21N-3W	2773	6508	0.43	-59	1171	1112
NW-SE	34-21N-10W	4081	8912	0.46	579	1191	1770
NW-SE	34-21N-10W	4095	8960	0.46	563	1191	1754
SE-NE-NW	30-22N-3W	1865	4517	0.41	-180	1066	886
SE-NE-NW	30-22N-3W	1835	4530	0.41	-263	1066	803
SE-NE-NW	30-22N-3W	1815	4530	0.40	-309	1066	757
E/2-NE-NE	13-22N-4W	1695	4198	0.40	-256	1122	866
NE-SE	15-22N-4W	2100	5827	0.36	-943	1117	174
NE-SE	15-23N-2W	1530	4130	0.37	-572	968	396
NE-SE	15-23N-2W	1670	4400	0.38	-516	968	452
NW-SE-NE	19-23N-2W	2020	4754	0.42	-56	1037	981
NW-SE-NE	19-23N-2W	2020	4776	0.42	-78	1037	959
NE-SW	19-23N-3W	2514	6000	0.42	-153	1134	981
SE-SE-SW	31-23N-3W	2268	5420	0.42	-146	1132	986
SE-SE-SW	31-23N-3W	2314	5483	0.42	-102	1132	1030
SE-SE-SW	31-23N-3W	2324	5696	0.41	-291	1132	841
SE-SE-SW	31-23N-3W	2654	6256	0.42	-84	1132	1048
SE-NW	28-23N-17W	4106	9528	0.43	21	1655	1676
SW-NE	34-25N-1W	1736	4330	0.40	-293	971	678
NW-SE-SW	35-25N-1W	1827	4350	0.42	-101	968	867
SE-SE	17-25N-18W	3470	8614	0.40	-544	1729	1185
SE-NW	14-25N-24W	3640	9898	0.37	-1433	2071	638
NW-SE-SW	1-26N-2W	1590	3803	0.42	-105	1043	938
SE-NW	11-26N-24W	3730	9445	0.39	-771	2310	1539
SE-SE-SW	3-27N-1W	1490	3633	0.41	-168	1011	843
NW-NW	23-27N-3W	2700	6172	0.44	107	1066	1173
NW-SW-SW	2-27N-18W	2430	7000	0.35	-1349	1684	335
NE	9-27N-21W	2943	7600	0.39	-756	1781	1025
SW-SW	28-27N-21W	2773	7758	0.36	-1309	1749	440
NE-SE	1-27N-22W	3255	7943	0.41	-373	1765	1392
NW	11-27N-24W	3589	8780	0.41	-433	2014	1581
NE-NE-SW	5-28N-1W	1272	3395	0.37	-437	1052	615
NE-SE-SE	35-28N-3W	1960	4630	0.42	-72	1127	1055
NE-SW	22-28N-21W	3055	7598	0.40	-493	1828	1335
NE-SW	22-28N-21W	3055	7705	0.40	-600	1828	1228
NE-NE-SW	32-28N-21W	2517	7700	0.33	-1847	1798	-49
SW-SW	3-28N-22W	2970	7950	0.37	-1043	1920	877
SW-SW	5-28N-22W	2205	7620	0.29	-2492	1898	-594
SW-SW	5-28N-22W	2360	7660	0.31	-2172	1898	-274
NW-SE	6-28N-22W	2920	7778	0.38	-987	1930	943
SW-NE	6-28N-22W	2905	7672	0.38	-916	1905	989
SE-SW	6-28N-22W	2315	7660	0.30	-2276	1918	-358
NE-NW	7-28N-22W	3015	7891	0.38	-879	1967	1088
NW-NE	7-28N-22W	2700	7617	0.35	-1338	1910	572

NW-NE	7-28N-22W	2835	7677	0.37	-1084	1910	826
NW-NE	7-28N-22W	2980	7727	0.39	-797	1910	1113
NW-NE	7-28N-22W	2715	7687	0.35	-1373	1920	547
SW-NW	8-28N-22W	2500	7667	0.33	-1853	1913	60
NW-NW	8-28N-22W	2630	7665	0.34	-1549	1906	357
NE	24-28N-23W	3170	8050	0.39	-678	1938	1260
NW-NW-SE	21-29N-1W	1376	3483	0.40	-283	1110	827
SE-SW-NW	14-29N-2W	1735	4130	0.42	-95	1063	968
SE-SW-SW	15-29N-6W	2272	5262	0.43	22	1187	1209
SE-SW	20-29N-22W	3060	7836	0.39	-720	1910	1190
NW-SE	26-29N-22W	3065	7704	0.40	-576	1879	1303
SW-SE	32-29N-22W	3030	7780	0.39	-733	1877	1144
TEXAS							
Gray County, T Sec., Blk. & Sv.							
SE-NW	16-A6-H&GN	4628	12639	0.37	-1876	2865	989
SW-NE	18-A6-H&GN	5424	13203	0.41	-589	2720	2131
SE	23-A6-H&GN	5715	13675	0.42	-384	2856	2472
SE-SE	53-A6-H&GN	5622	13594	0.41	-520	2854	2334
Hemphill County, TX							
NW-NW	37-A2-H&GN	5770	13830	0.42	-411	2848	2437
SW-SW	40-A2-H&GN	5530	13446	0.41	-586	2815	2229
SW-SW	40-A2-H&GN	5826	13510	0.43	39	2815	2854
SW-SW	40-A2-H&GN	5889	13927	0.42	-232	2815	2583
Wheeler County, TX							
SW	92-A5-H&GN	5836	13864	0.42	-292	2831	2539
NE	99-A5-H&GN	6995	16715	0.42	-448	2756	2308
NW-SW	100-A5-H&GN	7143	16799	0.43	-187	2746	2559

VITA

James O. Puckette

Candidate for the Degree of

Doctor of Philosophy

Thesis: EVALUATION OF UNDERPRESSURED RESERVOIRS AS POTENTIAL REPOSITORIES FOR LIQUID WASTE

Major Field: Environmental Science

Biographical:

Education: Received Bachelor of Science Degrees in Geology and Secondary Education from Oklahoma State University at Stillwater in May 1976. Received Master of Science Degree from Oklahoma State University in July 1990; completed requirements for the Doctor of Philosophy degree at Oklahoma State University in December 1996.

Professional Experience: Chief Geologist, Rocky Mountain Production Co. and O.R.M. Exploration Co., Stillwater, Oklahoma, 1982 to 1987. Research Assistant, Oklahoma State University, 1987 to 1990. Research Associate, Oklahoma State University, 1990 to 1993. Senior Research Specialist, Oklahoma State University, 1993 to Present.

Professional Affiliations: American Association of Petroleum Geologists and Oklahoma City Geological Society