OPEN HOUSE DISPLAY

OF

POTTER AND SPELLACY SANDS

From Midway-Sunset Field Kern Co., California

March 11 - April 1, 1994

Special Publication No. 4

California Well Sample Repository
California State University Bakersfield

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From
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Edited By:
Victor Church, Consultant
A. S. Wylie, Jr., Santa Fe Energy Resources, Inc.
R. H. Robinson, Curator

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ACKNOWLEDGEMENTS

The editors wish to acknowledge the support of J. C. Foster, L. M. Garrett, J. C. Wallace, D. B. Del Mar, and Santa Fe Energy Resources, Inc., in the preparation of the figures and papers in this volume. Important other contributors included L. C. Wylie; Dr. John Coash and Marie Covin of CSUB; Allen Briton and Dan Fargo of Core Laboratories; and King Vaughn of Goode Core Analysis Service. In addition, special thanks go to R. L. Gardiner, D. H. Sturm, M. Tiede, J. O. Ponder, and F. G. Armantrout for their assistance with the setting up and taking down of the core displays. Finally, thanks are extended to Mr. Russ Robinson, Curator of the California Well Sample Repository for his support during the open house and in the preparation of this publication.

Cover Background: California Oil & Gas Fields, 1985, Third Edition, Published by the California Department of Conservation Division of Oil & Gas.

INTRODUCTION

By

Victor Church
Consultant

During March, 1994, the California Well Sample Repository hosted the fifth of what we have called an "Open House" -- a display of cores and related materials from important hydrocarbon producing reservoirs of California. Prior "Open Houses" featured the Stevens sand, the Winters sand, the Monterey formation, and the Temblor formation. This "Open House" displayed the Late Miocene age Potter and Spellacy sands from the Midway-Sunset field, Kern County (Figure 1). Production from these clastic reservoirs greatly increased following the advent of thermal stimulation in the early 1960's (Figure 2). In fact, the incremental increase has been so significant that as of the present, the Midway-Sunset field has the highest daily production rate -- 168,000 barrels of oil per day -- of any field in the "Lower 48". Cumulative production now exceeds two billion barrels of oil, second only (exclusive of Alaska) to southern California's Wilmington field (over three billion barrels) (Figure 3).

Representative cores from the Potter and Spellacy sands were made available for this display through the generosity of Santa Fe Energy Resources, Inc.

A thorough review of the origin and history of the names "Potter" and "Spellacy" was made by David Del Mar (see his article in this volume). The names gradually came into common usage over the years, even though never formally proposed. An exhibit prepared by David Del Mar reviewing this history, with pictures of Joe Spellacy, early Midway-Sunset geologists (Arnold & Johnson), and copies of early newspaper articles mentioning Spellacy were displayed at the "Open House".

The primary focus of the display was the core material from two Santa Fe Energy Resources' wells: Spellacy-Well No. 232-8 (Sec. 8, T32S/R23E) and Potter-Well No. 371-21 (Sec. 21, T31S/R22E). Two intervals from the Spellacy well were exhibited with immediately adjacent foot-by-foot photos, showing (1) the boxed cores, (2) the cores in ordinary light, and (3) the same material in ultraviolet light. Santa Fe Energy Resources also provided colored, reduced "handout" copies of the electric logging responses for each well. Copies of these "handouts" are included in the Appendix of this publication.

It should be noted that the correlation charts from various sources are not in total agreement. Figure 4 shows the variations in nomenclature from north to south at Midway-Sunset. Certainly this variability in nomenclature comes as no surprise considering the mammoth size and complex structural and depositional history of this oil field. We will welcome, of course, any comments from our readers in this regard.

The Potter core, because of its shorter length, was able to remain fully displayed in the Repository following March 11th and 12th. Space limitations inside the Repository made it impossible to also display the Spellacy cores. However, it remained available on request for showings of selected intervals until April 1.

Various members of the Board of Governors of the Repository, including Dr. John Coash, Jack West, Ed Stinemeyer, and Dr. Robert Horton, Jr., contributed in many ways to the preparation and actual display, either prior to or during the "Open House". Coordination of all the display materials, as well as enumerous details, could not have been done without the tireless effort of our Curator, Russ Robinson. We sincerely thank each and every one for all their help.

Others deserving our gratitude are Allen Briton and Dan Fargo, Core Lab, for exhibiting on the opening two days their new Pressure-Decay Profile Permeameter (PDPK). Dan Fargo was available both days

to demonstrate how the PDPK operated, and has submitted a short description of it and how it works for this publication.

We are pleased to be able to include in this special publication abstracts of some pertinent papers dealing specifically with the Potter or Spellacy, or with their general relationship in the Midway-Sunset field. Some, but not all of these abstracts, are of papers presented at the Pacific Section AAPG Meeting in Long Beach, CA, May 5-7, 1993. Other articles in this publication include "A Note on the Fluid Level Traps in the San Joaquin Valley", first published in the Pacific Section AAPG 1972 Guidebook "Geology and Oil Fields, West Side Central San Joaquin Valley". This article may provide insight to the possible trapping mechanism of the Potter sand. We are also indebted to the summary information to the specific areas of the Potter and Spellacy displayed cores by David Sturm, Rande Gardiner, and A. S. (Buddy) Wylie, Jr., all of Santa Fe Energy Resources, Inc. A brief bibliography of publications dealing specifically with the Spellacy and Potter sands from the extensive list of publications available on the Midway-Sunset field is also included.

This special publication is designed to describe and supplement the CWSR "Open House". It could not, and does not, purport to be a comprehensive view of these two important reservoirs, but it is hoped it will serve as an aid for future study by geologists and engineers working on these Midway-Sunset field reservoirs.

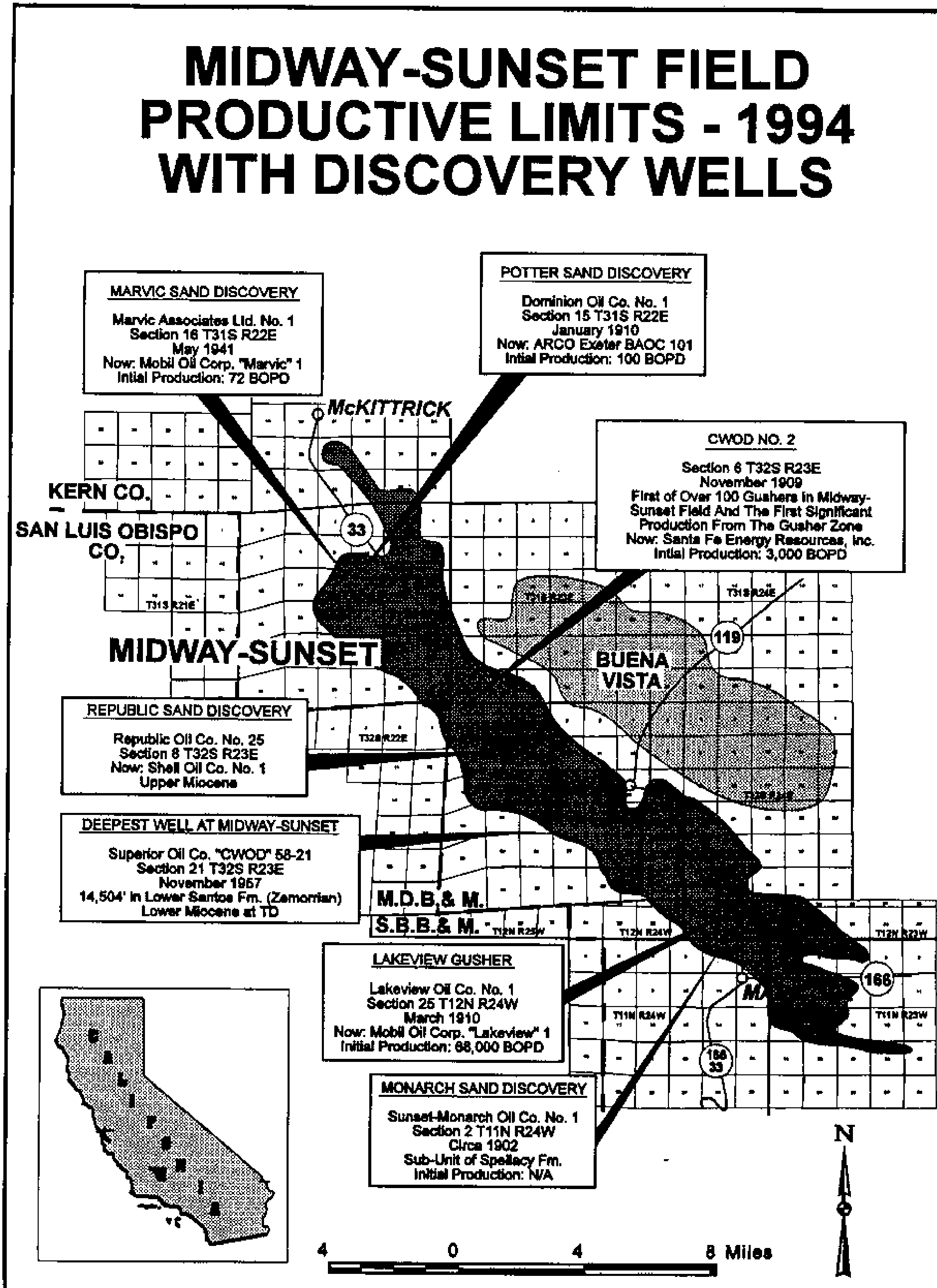


FIGURE 1 - Midway-Sunset Location Map

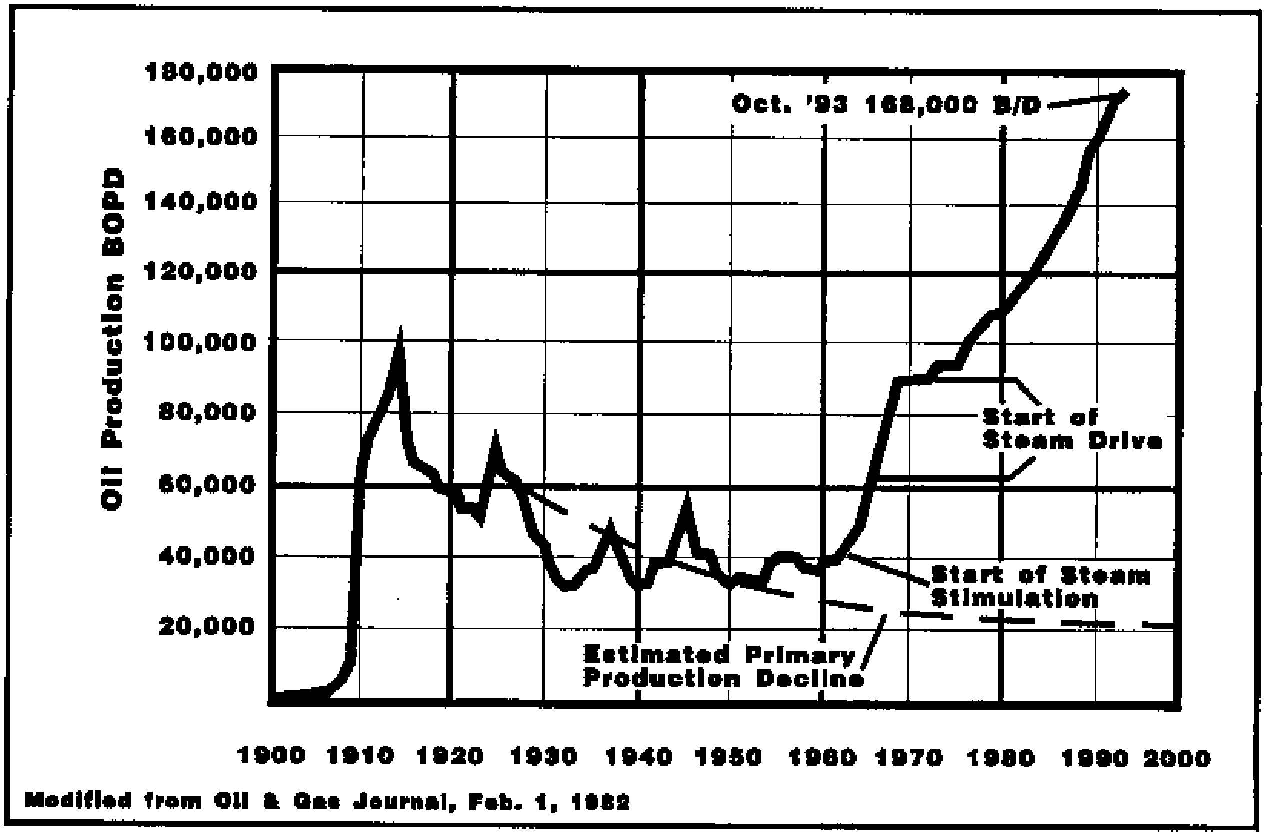


Figure 2 - Midway-Sunset Production 1900-1993.

- **2,190,000,000 BBLS OIL CUMULATIVE THROUGH END OF 1993 (2nd Only to Wilmington Field in "Lower 48")**
- **60,000,000 BBLS OIL CURRENT ANNUAL PRODUCTION**
- **913,000,000 BBLS OIL PRODUCED AT START OF THERMAL ENHANCED OIL RECOVERY IN 1965**
- **1,060,000,000 BBLS OIL PRODUCED THROUGH CYCLIC STEAM, STEAMFLOOD, AND FIREFLOOD PROCESSES**

Figure 3 - Midway-Sunset Field Production Facts.

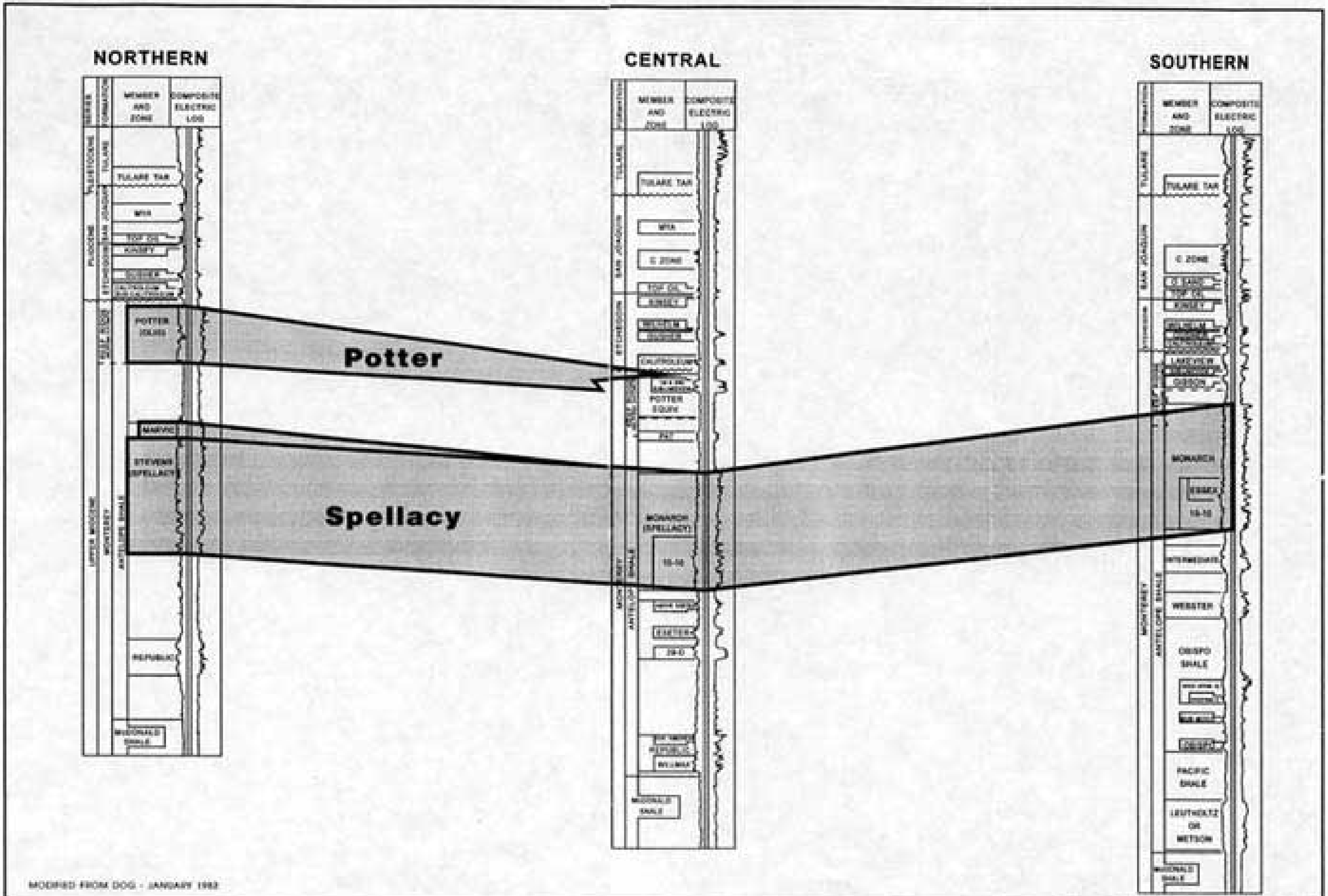


Figure 4 - Midway-Sunset Field
Generalized Stratigraphic Columns

THE ORIGIN OF THE NAME POTTER

By

David B. Del Mar, Sr. Staff Geologist
Santa Fe Energy Resources, Inc.

The name "Potter sand" originates from Potter Oil Company, which operated in the Southwest Quarter of Section 15, T31S/R22E. Although it came into gradual usage over a period of years, it first appeared in print in the March, 1952, **AAPG/SEPM/SEG Guidebook**, North Midway Area, by Victor Church and D. L. Kirkpatrick.

The discovery well for the Potter sand was drilled by Dominion Oil Co. in January, 1910, to a depth of 2,010 feet. Rich oil sands were found from 575 feet to 780 feet and the well was completed making 80 to 100 BOPD of 17° Baume' oil. Five years later, on April 12, 1915, Charles B. Bishop, Clarence J. Jacobs, and Harry W. Davis filed the incorporation papers for Potter Oil Co. On May 29, 1924, their name was changed to Barnsdall Oil. Years later, on July 11, 1950, Barnsdall merged into Sunray Oil, after which a series of complicated name changes took place.

The original Potter Oil Company lease in Section 15 consisted of eight 10-acre parcels, checkerboarded with eight other parcels belonging to Globe Oil Company. It has been said that the entire Southwest Quarter originally belonged to one family and was divided between two brothers after the death of their father. Whether this is true is not certain, but it makes a good story.

THE ORIGIN OF THE NAME SPELLACY

By

David B. Del Mar, Sr. Staff Geologist
Santa Fe Energy Resources, Inc.

According to Ralph Arnold and Harry R. Johnson in their 1910 **U.S.G.S. Bulletin 406** Preliminary Report on the McKittrick-Sunset Oil Region, Kern and San Luis Obispo Counties, California, Spellacy Hill "is the name proposed for the rather isolated hill [anticline] lying mostly in Sections 22, 23, 24, 25, and 26, of Township 32 South, Range 23 East. Spellacy Brothers of Los Angeles [Timothy and Peter] were among the earlier oil investors prominently connected with the development of the territory in this vicinity." The large sand body which underlies this area, particularly Section 26, eventually became known as the Spellacy sand.

Although no known formal adoption of the name "Spellacy sand" has ever taken place, it has gradually gained acceptance and first appeared in print in October 1962 in **Selected Papers Presented to the San Joaquin Geological Society**, Distribution of Upper Miocene Sands and Their Relation to Production in the North Midway Area, Midway-Sunset Field, California, by David C. Calloway.

Colonel Timothy Spellacy is first documented in Bakersfield church records on July 7, 1878, when he headed a committee under Bishop Francisco Mora to raise funds to construct the original St. Francis Catholic Church at 17th and K Streets. Spellacy then became a driller and is next mentioned on June 5, 1900 when he and J.H. Woods founded Spellacy, Woods & Co., an oil firm. They leased from J. A. Chanslor and C. A. Canfield the "Luck No. 3" Placer Mining Claim in Section 30, T28S/R28E (the present Texaco "Luck" lease) and drilled the original wells on the property. On July 10, 1900, Spellacy was on another committee to organize the oil producers of the area, and on September 5th, headed the committee. The result was the Independent Oil Producers Agency, which was organized on November 3, 1904. Timothy Spellacy was elected as the agency's "First Vice-President" and was one of its original directors.

During this time, 1902 through 1905, Timothy Spellacy was listed in the Bakersfield City Directory as Manager, National Supply Co. On September 11, 1901, Timothy Spellacy announced the leasing of 160 acres of land from the Mt. Diablo Co. in the NE/4 of Section 26, T32S/R23E, by Spellacy-Stroud (Mr. Stroud was involved in the Kern River "Monte Cristo" lease). Two wells were located, and drilling commenced immediately. On November 11, 1901, Mascot Oil was formally incorporated, taking over the Spellacy-Stroud Lease, and the next day the Mascot strike was announced by Mr. Stroud. According to The Bakersfield Californian, "when the prolific sand was encountered the oil came up in the casing to a height of 300 feet." According to White's book on the Formative Years in the Far West:[1]

> *The Midway lay atop the foothills of the west side of the San Joaquin Valley, some thirty-five miles southwest of Bakersfield. Geography gave the field its name, for it was halfway between the developed fields of McKittrick and Sunset. Both of these older fields were served by rail, but Midway remained neglected, needing transportation and higher prices. Its potential was known. Back in December, 1902, the Standard scout, C. F. Lufkin, had reported as "exceedingly promising" Tim Spellacy's Mascot property in the hills behind what is today the town of Taft. Spellacy, a jovial, elegantly attired ex-driller, proved the Mascot property was productive the next year. Toward the end of 1906, Standard ran right-of-way surveys to the Midway, and on January 3, 1907, Tilford authorized Scofield to spend $440,000 on a forty-three-mile, eight-inch pipeline, gathering lines, and two pump stations. For oil, Standard*

[1] Formative Years in the Far West, History of Standard Oil Co. of California and Predecessors through 1919, by Gerald T. White, published by Meredith Publishing Co., N. Y., 1962, p. 291.

turned to Spellacy and some of his associates, offering 25¢ a barrel. This was not a bad price in view of the Associated Agency contract and the cost of putting in a line, but Spellacy wanted 30¢. He got it in a three-year contract, signed February 4, that called for 10,500,000 barrels. Standard also lent him $70,000 to start drilling.

The October 1912 issue of Oil Brad Street shows Mascot Oil with 30 wells producing 34,000 bbls/month. Timothy Spellacy was President. About 1918, after Timothy's death, his brother, Peter E. (Pete) Spellacy became President and General Manager of Mascot Oil. At that time Joseph B. Spellacy, Tim's son, was a driller. P. E. remained President through 1942, dying a few years later at an age near 86. After the death of the two original Spellacy brothers, the story continues with J. B. Spellacy. In 1936, he was serviceman for the Baash-Ross Tool Co., living at 127 Quincy Street in Bakersfield. In 1938 and 1939, he was the Manager of McCullough Tool Co. in Bakersfield. He then rejoined Mascot Oil Co. on July 1, 1940, and became their Superintendent. That same year he was elected grand knight of the Knights of Columbus. After the war he left Mascot and in 1946 became a partner of Spellacy and Law, Inc., a Maricopa based oil company. They purchased and operated the present day Texaco "Heard and Painter" lease in Section 3, T11N/R24W. Son Joe E. Spellacy, a former Taft schoolmate of Bill Rintoul (local oil columnist/historian), was promoted to Superintendent, while Dorothy J. Spellacy served as Acting Secretary.

During the time J. B. owned Spellacy & Law, Inc., he served as the Director of the San Joaquin Valley Oil Producers Association in 1953, was a serviceman for Baash-Ross Tool Company in 1955, and was an employee of Pacific Perforating Co. in 1956. J. B. is listed in the Taft directory in 1959 and 1961, then apparently moved to Los Angeles, where he died on December 19, 1977. Spellacy & Law was sold to the Heard and Painter Co. in May of 1963.

Ralph Arnold and Harry Johnson, CIRCA 1908, at about the time they were doing their classic study of the McKittrick-Sunset Oil Region.

STRATIGRAPHY OF UPPER MIOCENE POTTER SANDS
MIDWAY-SUNSET FIELD
KERN COUNTY, CALIFORNIA

by

D. C. Balch and T. K. Martin
Sun Exploration and Production Company
Valencia, CA

Upper Miocene Potter sands in the northern part of the Midway-Sunset field were analyzed extensively using detailed electric-log correlations. Structural and stratigraphic cross sections and subsurface mapping demonstrate variations across four general areas in T31S, R22E, referred to as west (parts of Secs. 16, 17, 21), north (parts of Secs. 15, 16), east (part of Sec. 14), and south (within Sec. 27).

Potter sands deposited in the west area represent the oldest strata of the Potter sequence because they unconformably overlie older silts, diatomaceous shales, and isolated sand channels believed to be part of the Antelope Shale Member. These sands are interpreted to represent massive debris flows/grain flows deposited in a proximal channel-trough system that carried sediments from west to east, toward the low point of the Midway syncline.

In the north area, Potter sands change abruptly from massive sands in the eastern part of Sec. 16 to thinner sand channels with more correlative and continuous silt interbeds in Sec. 15. The massive sands are stratigraphically equivalent, if not slightly younger than, sands in the west. However, at the base, these sands depositionally onlap onto the southwest flank of the Globe anticline. The Potter sand channel packages thin in Sec. 15, which represents lateral facies changes within the system as the sand to silt ratios become lower and the silts become more continuous.

Potter sands in the east area are the uppermost and youngest strata encountered in the study area. Although massive sand channel packages are common, they show better lateral continuity and exhibit lower sand to silt ratios than the north sequences.

In the south area, Potter sands are interbedded with continuous silt units that can be mapped over much of the section. These sands and silts are thought to represent deposits similar in age to those in the west and north areas; however, their continuity and better sand to silt ratios are interpreted to represent facies changes that might occur as coarse detritus was introduced through a major channel-trough system near the west area and was carried laterally and southeasterly to a slightly more distal location, as seen in Sec. 27.

Detailed electric-log correlations within the four areas show that the sands become less massive and progressively younger, and have more continuous silt interbeds and lower sand to silt ratios as we move from the west area through the north to the east. This overall thinning upward suggests lower energy depositional processes and potential retrogradation of the channel-trough system through time.

April, 1986, A.A.P.G. Bulletin V. 70/4, p. 19

THE IMPACT OF SEQUENCE STRATIGRAPHY ON THERMAL OPERATIONS WITHIN THE UPPER MIOCENE POTTER SAND MIDWAY-SUNSET FIELD KERN COUNTY, CALIFORNIA

by

William T. Fedewa
ARCO Oil & Gas Company
Bakersfield, California

Sequence stratigraphy interpretation significantly affects prediction of heat distribution in cyclic steam and steamflood operations within the Potter sand at Midway-Sunset field, Kern County, California. Identification of shale-bounded parasequences within this 1000-ft thick oil-bearing sand results in the recognition of flow units.

Traditionally the Potter sand is considered to represent a homogeneous sequence of unconsolidated turbidite sands and gravels deposited in a restricted active-margin basin. However, core data and detailed correlation of more than 600 wells indicate that the Potter sand consists of a heterogeneous sequence of sand, gravel, and shale which was deposited along a shelf margin in a delta-front environment.

The top of the Potter sand is truncated by the Miocene-Pliocene angular unconformity and the base downlaps on the Antelope Shale. Individual shale-bounded parasequences are grouped into a series of highstand and lowstand systems tracts. The western-most highstand systems tract displays parasequences that extend from the truncation at the top of the Potter to downlap at the base of the Potter. The overlying lowstand systems tract downlaps at the base of the Potter and toplaps at a transgressive unconformity surface within the Potter. A younger highstand systems tract overlies and downlaps this unconformity surface and is in turn truncated by the angular unconformity at the top of the Potter. This highstand sequence extends eastward beyond the limits of the lowstand deposit.

Recognition of the parasequences within the Potter reservoir has impacted the design of steamflooding operations. Treating the Potter sand as a homogeneous reservoir would result in incomplete heating of the oil zones and heat loss to depleted intervals. Selectively perforating steam-injection wells into desired flow units results in optimal heat distribution and oil recovery from the Potter sand reservoir.

April, 1993, A.A.P.G. Bulletin V.77/4, p. 696
May 5-7, 1993, Pacific Section 68th Annual Meeting, Long Beach, CA

DEPOSITIONAL ENVIRONMENT AND RESERVOIR/SEAL CHARACTERISTICS OF THE MIOCENE POTTER SAND, NORTHERN MIDWAY-SUNSET FIELD KERN COUNTY, CALIFORNIA

By

James C. Pol and Steven R. Fekete
ARCO Exploration & Production Technology
Plano, Texas

The Miocene Potter sand is one of the primary reservoirs in the northern portion of the Midway-Sunset field, Kern County, California. More than 1200 ft. of whole core and approximately 500 sidewall cores from 31 wells were examined to help optimize steamflood development in the area. Specific goals of this study include facies interpretation, reservoir characterization, and wireline log calibration.

The Potter sand consists of three primary lithofacies: conglomeratic coarse-grained sand, coarse to medium-grained sand, and argillaceous sandy silt. In conglomeratic intervals, cobbles reduce reservoir pore volume and must be quantified to facilitate accurate reserve calculations. Clast percentages in the two most extensively cored wells were determined by visual estimation, point counting, and computer image analysis. Results show close agreement between all three methods. Core data were subsequently used to calibrate wireline logs to develop cutoffs for picking lithofacies from logs.

Argillaceous siltstones ranging from 1 cm to 10 m in thickness are important because they compartmentalize the reservoir and act as barriers to heavy oil and steam. High clay content and bound water cause a highly conductive log response that magnifies apparent bed thickness. Neutron/density logs offer better resolution, but only core and FMS logs allow direct detection of centimeter-scale silt beds.

Gross interval isolith mapping of log-derived lithofacies indicates stacked elongate conglomeratic bodies flanked by clean sands and minor silts. The Potter sand is interpreted to have been deposited in a subaqueous coarse-grained delta-front environment.

April, 1993, A.A.P.G. Bulletin V.77/4, p. 713
May 5-7, 1993, Pacific Section 68th Annual Meeting, Long Beach, CA

REGIONAL DISTRIBUTION PATTERNS OF MIDWAY-SUNSET SANDS RELATED TO HIGHSTAND/LOWSTAND SEQUENCES OF THE ANTELOPE SHALE

by

Michael Simmons
ARCO Western Energy
Bakersfield, California

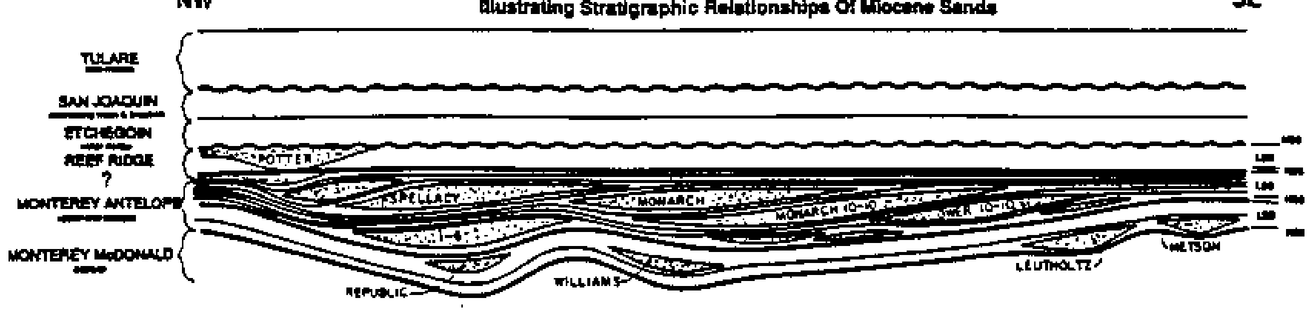
The Antelope Shale Member of the Monterey Formation can be subdivided into three informal units: two sand-rich lowstand sequences separated by a shale dominated highstand.

The earlier lowstand is characterized by three or four sand-rich submarine channel complexes, the Metson/Leutholtz, Williams, and Republic, which are recognized as getting progressively younger from south to north.

The intervening highstand or flooding event is dominated by the upper Obispo Shale, which contains very few sands. This unit may represent cessation of tectonic activity related to temporary stalling of the northward migrating Salinian block. During the highstand, sands sourced from the Salinian block were stranded on the shelf west of the depositional site of the Republic sand, the youngest of the previous lowstand channel sands.

The culminating lowstand of the Antelope Shale documents a major tectonic episode, possibly renewed northward translation of the Salinian block, and is dominated by sand in the stratigraphic record. The youngest sand, the 1-6, overlies the Obispo Shale and Republic sand and may represent remobilized coarse clastics which had been stranded on the shelf during the previous highstand. The other major sands within this interval document the filling of an intraslope basin from south to north and appear as thick, overlapping "shingles." The oldest of these major "shingles" is the lower Monarch 10-10, followed in ascending order by the Monarch 10-10, Monarch, Spellacy, and younger unnamed sands. Sand deposition ceased with the onset of another highstand marking the end of Antelope deposition.

DIAGRAMMATIC LONGITUDINAL CROSS-SECTION
Illustrating Stratigraphic Relationships Of Miocene Sands



April, 1993, A.A.P.G. Bulletin V.77/4, p. 715
May 5-7, 1993, Pacific Section 68th Annual Meeting, Long Beach, CA

CYCLIC-STEAM-INDUCED DIAGENESIS IN POTTER SAND MIDWAY-SUNSET FIELD, CALIFORNIA

by

Dawne A. Pennell and Robert A. Horton, Jr.
Department of Geology
California State University
Bakersfield, CA

Although steam injection is widely used in hydrocarbon extraction, little is known of the effects of steam on reservoir properties. This study documents mineralogic changes resulting from cyclic steam injection into the Potter sand (upper Miocene) at Midway-Sunset field. Samples were obtained from two cores recovered from wells located 200 m (650 ft) apart on the 120-acre ARCO Anderson-Goodwin lease, Section 21, T31S/R22E (Figure 1). This lease is located on the northwest edge of Midway-Sunset field (the reader is referred to the Introduction in this publication and R. L. Gardiner's article on the Potter for general location maps for this lease). The first well was drilled in 1984 prior to initiation of cyclic steam injection; the second well was drilled in 1991 following cumulative injection of 1,000,000 bbls of steam. Samples were obtained from the highest and lowest temperature zones of the reservoir in the post-steam well and from stratigraphic equivalents in the pre-steam well (Figure 2). Depths ranged from 122 m (401 ft) to 313 m (1026 ft). Samples were examined petrographically (stained for feldspars) and with x-ray diffraction.

In unsteamed samples, the Potter consists of fine to coarse-grained lithic arenites and conglomerates. Lithics are mainly granitic and volcanic grains with rare metamorphic and sedimentary grains. Pseudomatrix, formed by crushing of quartz, feldspars, and granitic grains and squashing of volcanic grains, ranges up to 18% but is generally less than 4%.

A number of mineralogic changes were noted in the steamed well. Grain dissolution increased dramatically. Quartz, feldspars, lithics, biotite, and pseudomatrix were all affected, with a resultant shift in QFL ratios toward feldspathic litharenite compositions (Figure 3). Traces of calcite cement and pyrite associated with alteration of biotite were observed in the post-steam well. Alteration of framework grains and pseudomatrix abundance were noticeably higher in the steamed well, as were clay coatings, bridges, and pore-filling cements. The relative percentages of clays, as determined by quantitative x-ray diffraction, increased from unsteamed to steamed samples (Figure 4). Changes in clay minerals included formation of smectite, loss of chlorite, a slight decrease in the percentage of clay-sized mica, a large decrease in kaolinite (9.7 to 2.5%), and changes in the composition of mixed-layer illite/smectite (Figure 5); random ordered illite/smectite disappeared in the steamed zone and the percentage of expandable layers in ordered illite/smectite decreased from 50 to 15-20% (Figure 6). Intragranular porosity increased from a pre-steam average of 0.4% to an average of 1.1%, mainly due to dissolution of lithics. However, average intergranular porosity decreased from 25.4 to 19.7% for a net decrease in total porosity (Figure 7).

The data collected during this investigation indicate that significant mineralogic changes have occurred as a result of cyclic steam injection. These were accompanied by a drop in thin-section intergranular porosity. We did not evaluate permeability or pore size and geometry, but the decrease in intergranular porosity suggests that permeability may have been affected as well.

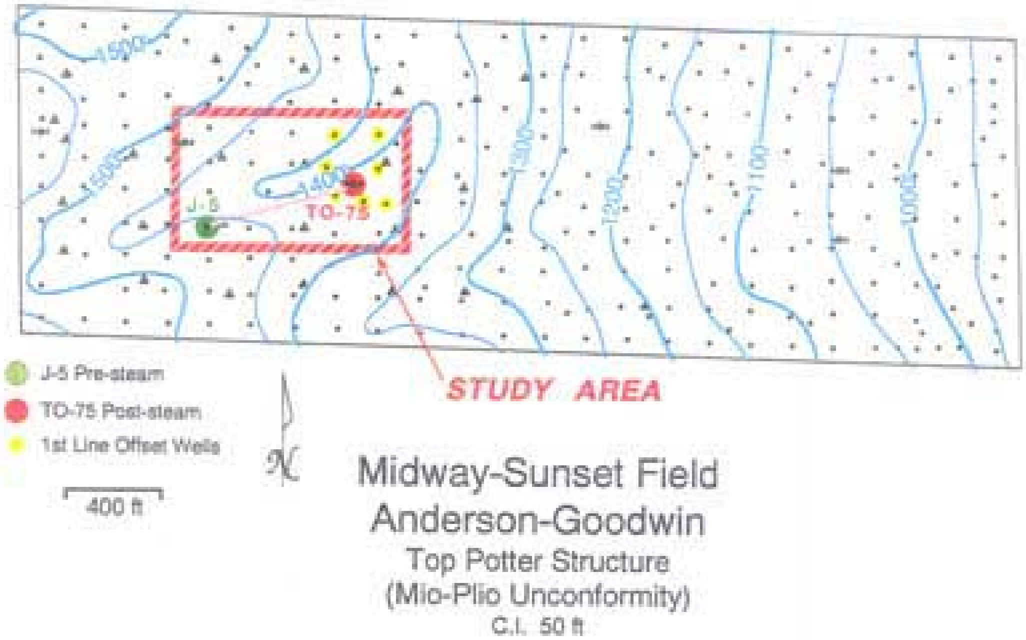


FIGURE 1 - Location of Study Area. Top of Potter Structure Map. Fedewa, 1991 (ARCO).

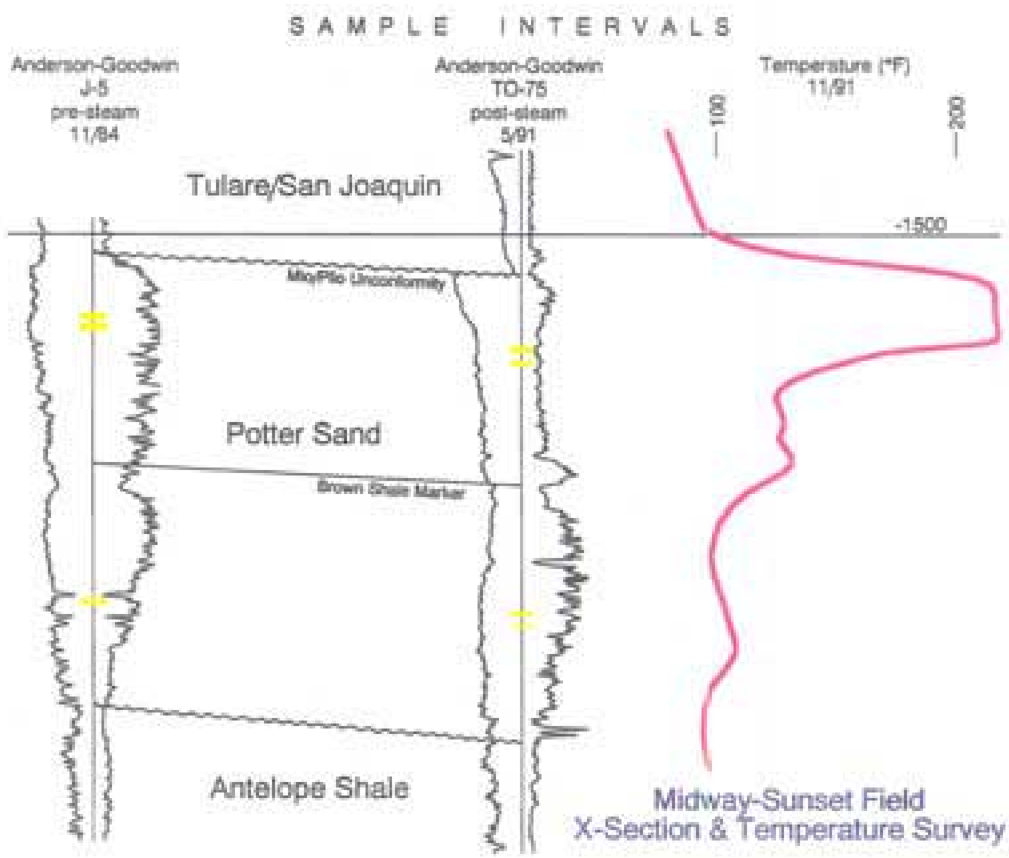
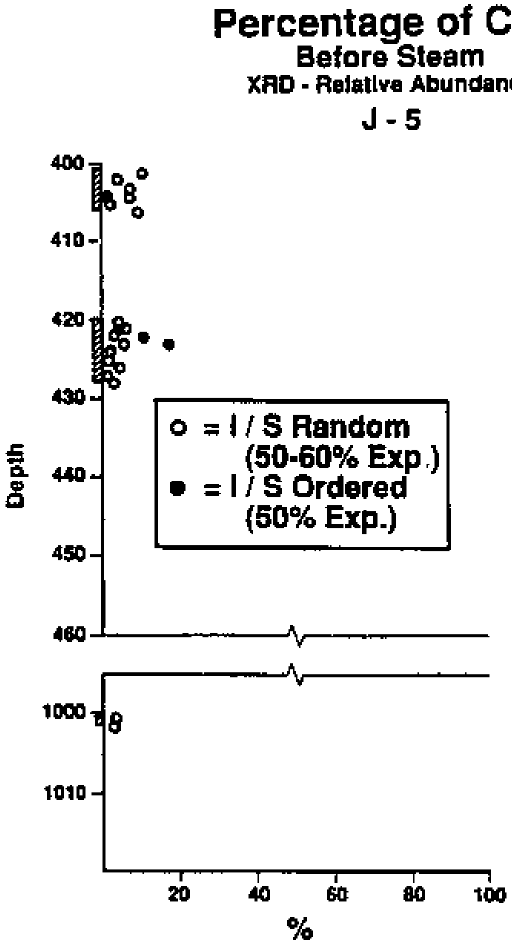


FIGURE 2 - Sample Intervals (shown in YELLOW) on Cross-Section.
(Pre-Steam and Post-Steam Wells)



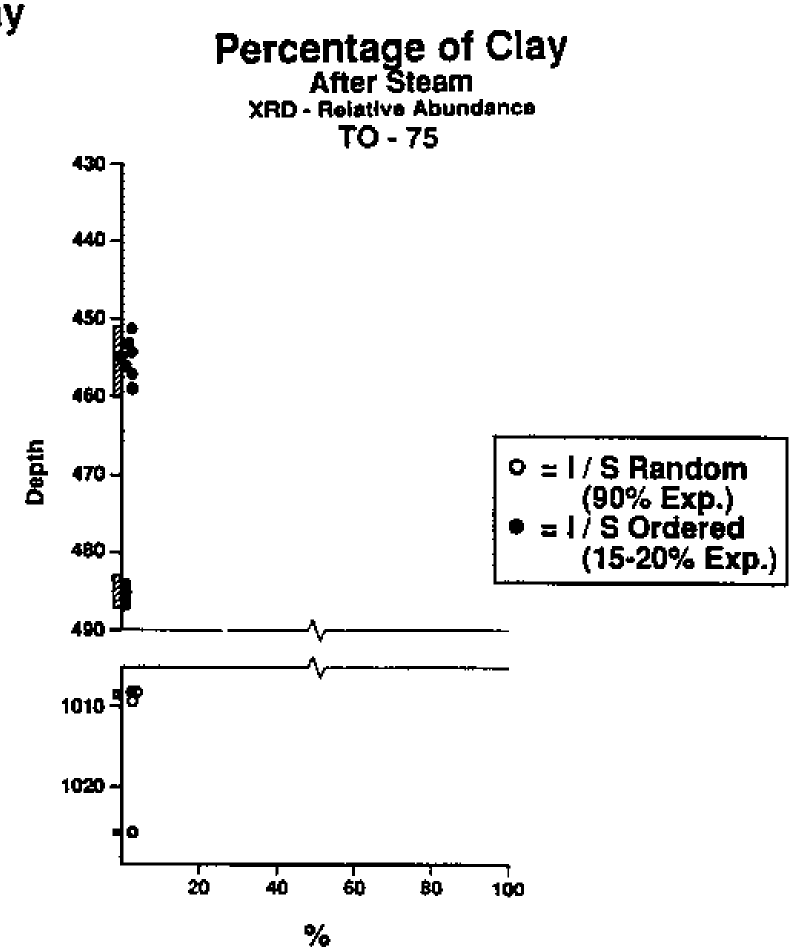
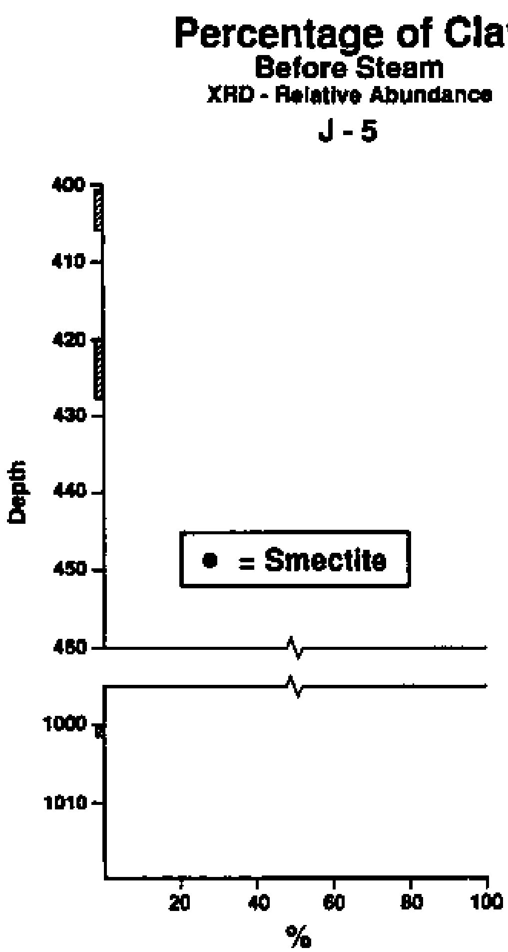


FIGURE 5 - Percentage of Clay (Illite/Mica) before and after Steam
(*Exp. refers to Expandable clay, smectite, layers).



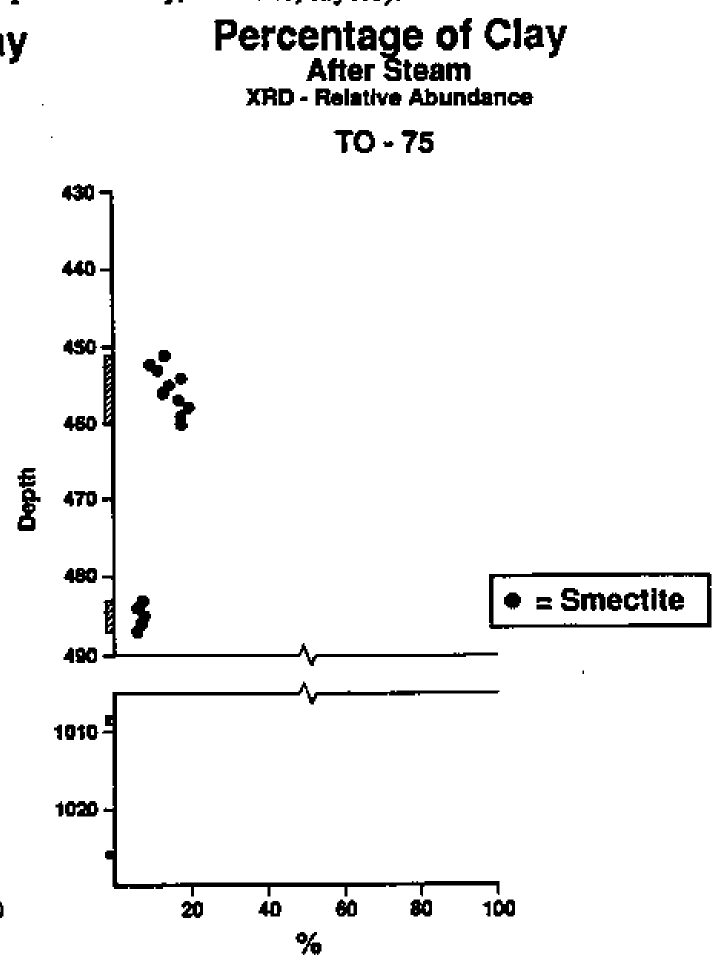


FIGURE 6 - Percentage of Clay, smectite, before and after Steam.

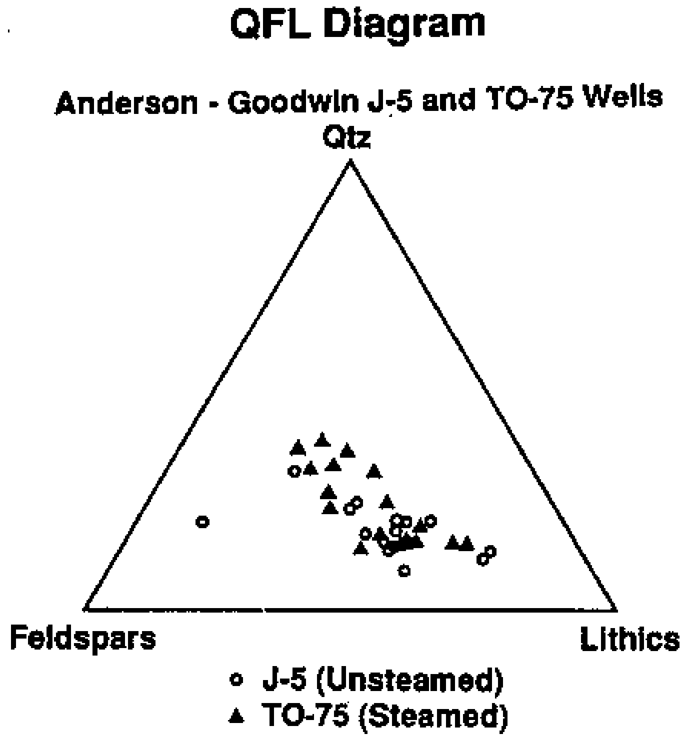


FIGURE 3 - QFL Diagram showing Pre-Steam and Post-Steam Sand Composition.

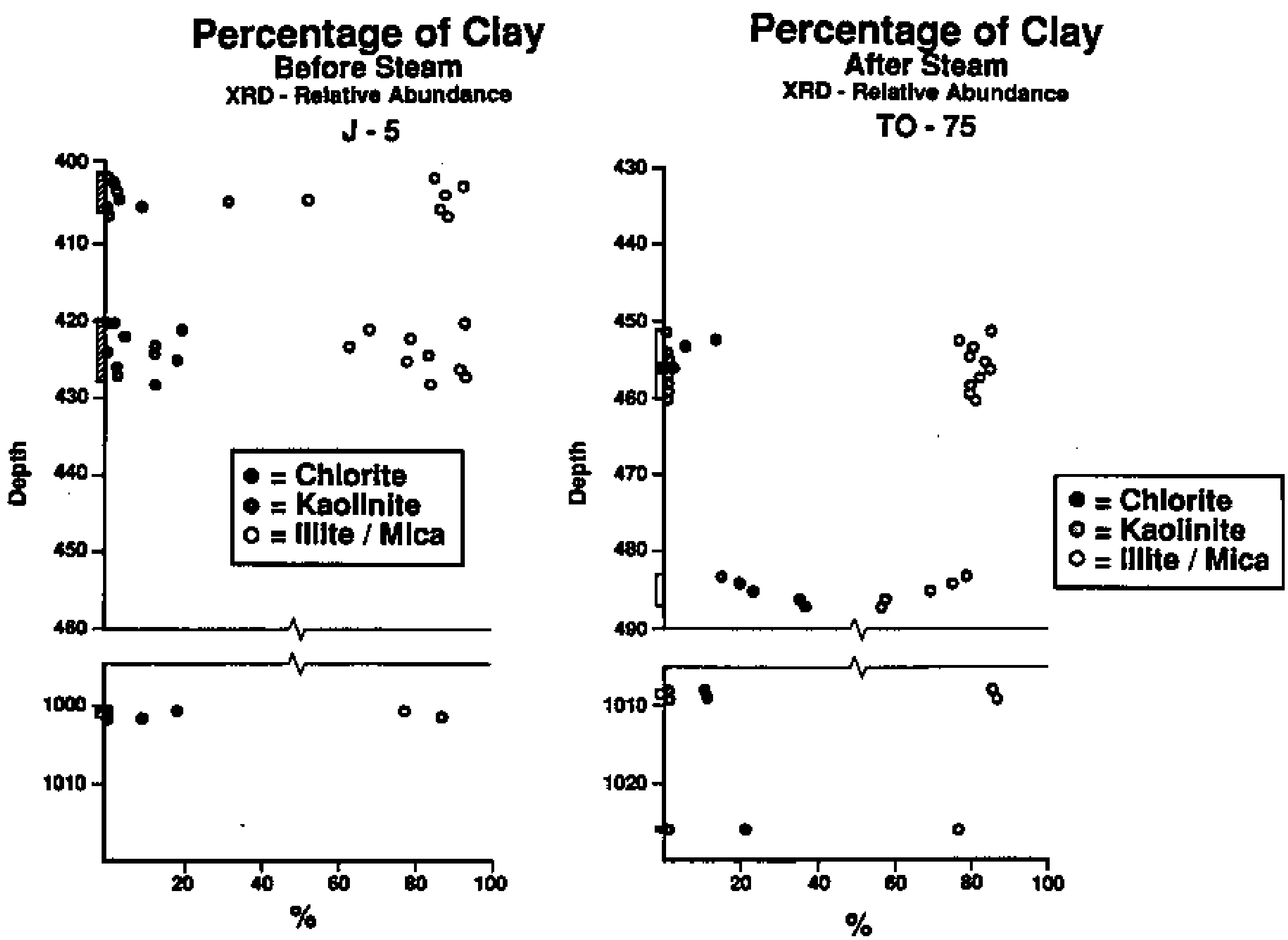


FIGURE 4 - Percentage of Clays (Chlorite, Kaolinite, and Illite/Mica) before and after Steam.

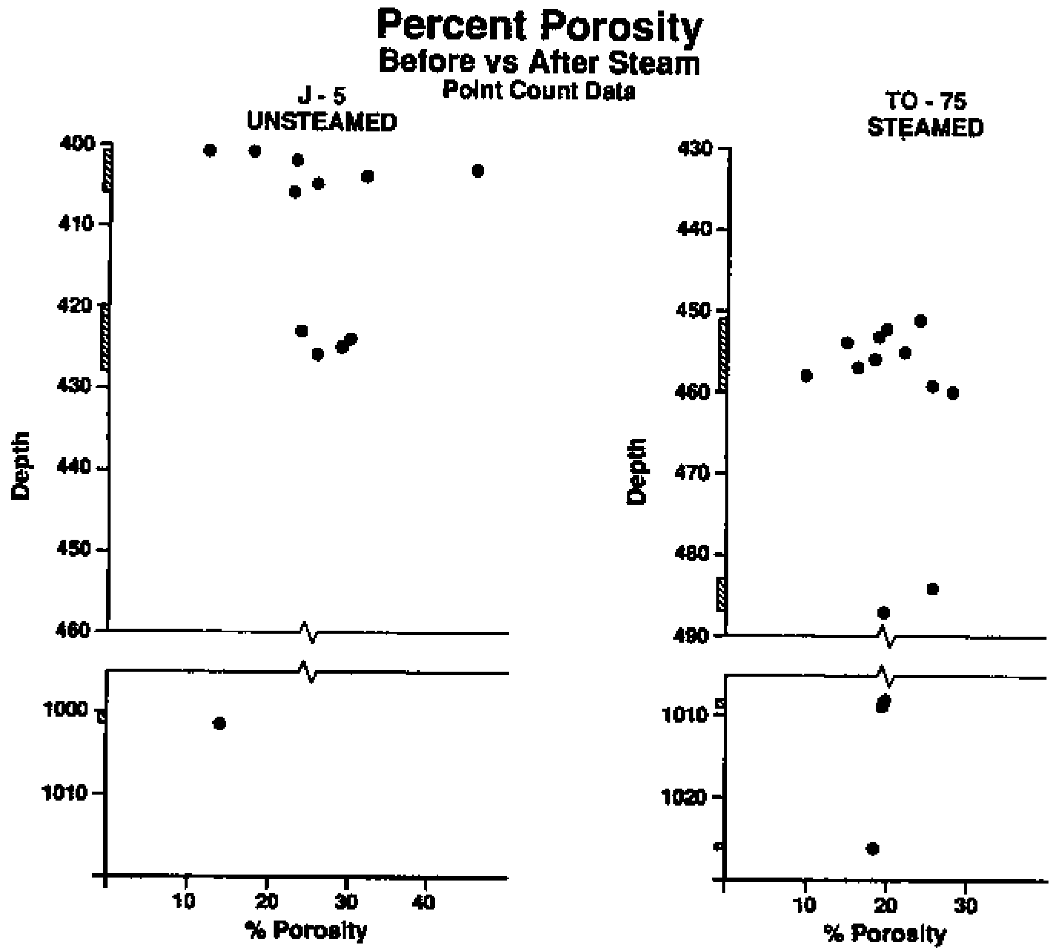


FIGURE 7 - Percent Porosity before and after Steam.