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(DE82004828)

TARGET RESERVOIRS FOR CO_2 MISCIBLE FLOODING
TASK TWO: SUMMARY OF AVAILABLE RESERVOIR AND GEOLOGICAL DATA

Task Two Final Report

Vol. 2: Rocky Mountain States Geological and Reservoir Data
Part 4: Paradox, Uinta, Eastern Utah Overthrust, Big Horn, Wind River, Powder River, Red Desert, and Great Divide Basins
CACHE-Ismay through WERTZ-Madison

Work Performed for the Department of Energy
Under Contract No. DE-AC21-79MC08341

Date Published—January 1982

Gruy Federal, Inc.
Houston, Texas

Bartlesville Project Office
U. S. DEPARTMENT OF ENERGY
Bartlesville, Oklahoma

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UNITED STATES DEPARTMENT OF ENERGY

PREFACE

This report describes work performed by Gruy Federal, Inc. as the second of six tasks under contract no. DE-AC21-79MC08341 with the U.S. Department of Energy. The stated objective of this study is to build a solid engineering foundation to serve as the basis for field mini- and pilot tests in both high and low oil saturation carbonate reservoirs for the purpose of extending the technology base in carbon dioxide miscible flooding.

The six tasks in this study are:

I. Summary of available CO_2 field test data
II. Summary of existing reservoir and geological data
III. Selection of target reservoirs
IV. Selection of specific reservoirs for CO_2 injection tests
V. Selection of specific sites for test wells in carbonate reservoirs
VI. Drilling and coring activities.

The report for Task Two consists of a summary of existing reservoir and geological data on carbonate reservoirs located in west Texas, southeast New Mexico, and the Rocky Mountain states. It is contained in two volumes, each with several parts. The present volume, in four parts, is a summary of reservoir data for fields in the Rocky Mountain states. Volume One contains data for Permian basin fields in west Texas and southeast New Mexico.

In preparing this report we attempted to obtain all publicly available data for the fields considered; however, sufficiently reliable data on important reservoir parameters were not available for every field. We welcome comments from readers who can supply missing data or update the data included in this report.

We gratefully acknowledge permission to reproduce copyrighted material granted by the following organizations: the American Association of Petroleum Geologists, the Four Corners Geological Society, the Intermountain Association of Petroleum Geologists, the Montana Bureau of Mines and Geology, the Montana Geological Society, the North Dakota Geological Society, the Rocky Mountain Association of Geologists, the Society of Petroleum Engineers, and the the Wyoming Geological Association.

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DATA PRESENTATION

Data Source Code

Each field summary contains data from numerous sources; hence a data source code (defined in Table 1) is used to identify the source of each item of information contained on a data sheet. Frequently, information reported by different sources differs, either because numbers have been rounded off, because additional data were available in later reports, or because of errors. On each field data sheet, the sources of data items and the data reported by each source are shown as follows:

4c, 4d, 1 DISCOVERY YEAR 3-1950, 11-1949, 1949

In this example, data source 4c (from Table 1), Bureau of Mines Bulletin 629, reports the discovery year as March 1950; source 4d, North Dakota Geological Society 1967 Symposium, reports the discovery year as November 1949; and source 1, Petroleum Data System, reports the discovery year as 1949. When two or more sources agree on an item, the data are shown as follows:

4c, 4d, 1 DISCOVERY YEAR 1949

Field data were compiled by state; therefore the same reference may be listed under more than one code when used in several states. Table 1 notes the states for which each data source was used.

Oil and gas production data are reported for the latest year available in each state. Oil production is given in thousands of barrels and gas in millions of cubic feet throughout.

Explanation of Terms and Abbreviations

The abbreviations used in this report follow those used by state oil and gas reporting agencies. Table 2 provides a list of abbreviations and terms used in this report.

Williston Basin and Sweetgrass Arch

Figures 1 and 2 show the boundaries of the Williston basin and the Sweetgrass arch and the location of oil and gas production. Figure 3 is a composite correlation chart for the Williston basin of North Dakota and Montana. Figure 4 provides a cross section of the basin and a composite stratigraphic section indicating principal oil-producing zones. Figure 5 is a generalized stratigraphic section of Montana which shows a section with production zones in the Sweetgrass arch area.

TABLE 1

DATA SOURCE CODE FOR ROCKY MOUNTAIN STATES FIELDS

Code	Source of Information
1	Petroleum Data System, OILY data bases
Wyoming	
2a	Wyoming Oil and Gas Fields, Greater Green River Basin, Wyoming, Wyoming Geological Association (1979)
2b	Wyoming Oil and Gas Fields by Formation, Oil and Gas Fields Symposium Committee (1973)
2c	Petroleum and Natural Gas Fields in Wyoming, by Paul Biggs and Ralph H. Espach; U.S. Department of the Interior, Bureau of Mines, Bulletin 582 (1960)
2d	Wyoming Oil and Gas Statistics, Wyoming Oil and Gas Conservation Commission (1979)
Montana	
3a	Oil Fields in the Williston Basin in Montana, North Dakota, and South Dakota, by J. R. Hamke, L. C. Marchant, and C. Q. Cupps; U.S. Department of the Interior, Bureau of Mines, Bulletin 629 (1966)
3b	Oil and Gas Conservation Division Annual Review for the Year 1979 Relating to Oil and Gas, vol. 23, Dept. of Natural Resources and Conservation of the State of Montana
3c	First International Williston Basin Symposium, North Dakota Geological Society and Saskatchewan Geological Society (1956)
3d	Williston Basin Symposium, 1978, Economic Geology of the Williston Basin, 24th Annual Conference, Montana Geological Society.
3e	Oil and Gas in Montana, by Eugene S. Perry; Montana Bureau of Mines and Geology, Bulletin 15 (1960)
North Dakota and South Dakota	
4a	Official Oil in North Dakota, Production Statistics, First Half 1979, North Dakota Geological Survey (1980)
4b	Oil Production Report, North Dakota State Industrial Commission, North Dakota Geological Survey (1980)
4c	Oil Fields in the Williston Basin in Montana, North Dakota, and South Dakota, by J. R. Hamke, L. C. Marchant, and C. Q. Cupps; U.S. Department of the Interior, Bureau of Mines, Bulletin 629 (1966)
4d	Oil and Gas Fields of North Dakota, A Symposium, 1967 Supplement, North Dakota Geological Society
4e	Oil and Gas Fields of North Dakota, A Symposium, North Dakota Geological Society (1962)
4f	Williston Basin Sumposium, North Dakota Geological Society and Saskatchewan Geological Society (1956)
4g	Williston Basin Symposium, 1978, 24th Annual Conference, Montana Geological Society
Utah	
5a	Oil and Gas Fields of Utah, A Symposium, Intermountain Association of Petroleum Geologists (1961)
5b	Oil and Gas Fields of the Four Corners Area, Four Corners Geological Society (1978)
5c	Wyoming Oil and Gas Fields, Greater Green River Basin, Symposium, Wyoming Geological Association (1979)

TABLE 1 (continued)

Code	Source of Information
Colorado	
6a	Oil and Gas Field Volume, Colorado, Nebraska, The Rocky Mountain Association of Geologists (1961)
6b	Oil and Gas Fields of Colorado, The Rocky Mountain Association of Geologists (1954)
6c	Geology of the Southwestern San Juan Basin, Second Field Conference, Four Corners Geological Society (1957)
6d	Oil and Gas Fields of the Four Corners Area, Four Corners Geological Society (1978)
6e	Wyoming Oil and Gas Fields, Greater Green River Basin, Symposium, Wyoming Geological Association (1979)
6f	1979 Oil and Gas Statistics, State of Colorado Oil and Gas Conservation Commission, Department of Natural Resources
New Mexico	
7a	Annual Report of the New Mexico Oil and Gas Engineering Committee, Vol. II, Northwest New Mexico (1979)
7b	Geology of Southwestern San Juan Basin, Second Field Conference, Four Corners Geological Society (1978)
General	
8	Petroleum Geology of the United States, by K. S. Landes; John Wiley & Sons, New York (1970)
9	American Association of Petroleum Geologists, Bulletin
10	Journal of Petroleum Technology
11	Gruy Federal calculations for missing reservoir properties data
12	Other geological publications (referenced on field data sheet)
13	International Oil and Gas Development Yearbook, International Oil Scouts Association
14	Geologic Atlas of the Rocky Mountain Region, Rocky Mountain Association of Geologists (1972)

TABLE 2

ABBREVIATIONS AND TERMS

Abbreviation	Meaning
A, ABD	Abandoned
API	American Petroleum Institute
BBL(S)	Barrels
BOD	Barrels of oil per day
BHP	Bottomhome pressure
BW	Brackish water
CHEM	Chemicals, chemical treatment
CMT	Cement
CO	Company
CO_2	Carbon dioxide
COND	Condensate
CONS	Consolidated
CSG	Casing
CUM	Cumulative
CW	Carbonated water
D	Day
DEV	Devonian
DISC	Discovered, discovery, discontinued
DP	Disposal project
EB	Early breakthrough
EFF	Effective, effectiveness
EG	Excessive gas-oil ratio
EP	Excessive injection pressure
EST	Estimated
F	Fluid injection; flank; flow
FG	Flue gas
FLD(S)	Field(s)
FORM	Formation
FRAC	Fracture
FW	Fresh water
FT	Feet
G	Gas
GC	Gas cycling
GF	Gas field
GI	Gas injection
GL	Gas lift
GOR	Gas-oil ratio
GR	Gas repressure
GRAV	Gravity
GS	Gas storage
HORZ	Horizontal
HW	Hot water
I	Irregular; inverted spot; injection
ICP	Injection currently in progress
ID	Identification
IG	Inert gas
INHB	Inhibitors
INJ	Injection
IP	Injection well plugging
IPD	Injection permanently discontinued
ITD	Injection temporarily discontinued
LD	Direct line drive
LGS	Liquid petroleum gas storage
LM	Line
LPG	Liquid petroleum gas
M	One thousand
MAX	Maximum
MCF	Thousand cubic feet
MD	Millidarcies; miscible displacement
ME	Moderately effective
MF	Modified flank
MID	Middle
MLD	Modified line drive
MM	One million
MMCF	Million cubic feet
MP	Modified peripheral
MSL	Modified split line drive
N_2	Nitrogen
N	New; none
NE	Not effective
NO(S)	Number(s)
NRG	Nergas
OPR, OPER	Operator, operated
ORIG	Original
OTH	Other
P	Peripheral; pump
PA	Paraffin
P&A	Plug and abandon
PCG	Processed casinghead gas
PERM	Permeability
PGG	Processed gas well gas
PI	Peripheral and irregular; injection pressure increasing
PLG	Pipeline gas
PLUGG	Plugging
PM	Pressure maintenance
POR	Porosity
PPD	Production permanently discontinued
PPM	Parts per million
PRESS	Pressure
PRG	Plant residue gas
PROD	Production, producing, productive
PROJ(S)	Project(s)
PSI	Pounds per square inch
PTD	Production temporarily discontinued
REC	Recovery
RESP	Response
RGG	Raw gas well gas
SEC	Secondary
SD	Sand
SI	Shut in
SLD	Staggered line drive
SQZ	Squeeze

TABLE 2 (continued)

Abbreviation	Meaning
SR	Secondary recovery
SS	Sandstone
SSW	Surfactant and salt water
STM	Steam
SUC	Successful
SURF	Surface
SW	Salt water; single well
SWD	Salt water disposal
SYS	System
TBG	Tubing
TEMP	Temporary
TH	Thermal
TLW	Tank liquid waste
TOT	Total
TRT	Tertiary recovery test
TS	Total solids
UD	Undetermined
ULT	Ultimate
UNK	Unknown
VE	Very effective
VOL(S)	Volume(s)
W	Wells
W/	With
WF	Waterflood
WI	Water injection
WIW	Water injection well
WOR	Water-oil ratio
YR(S)	Year(s)
%	Percentage
°API	Degrees API

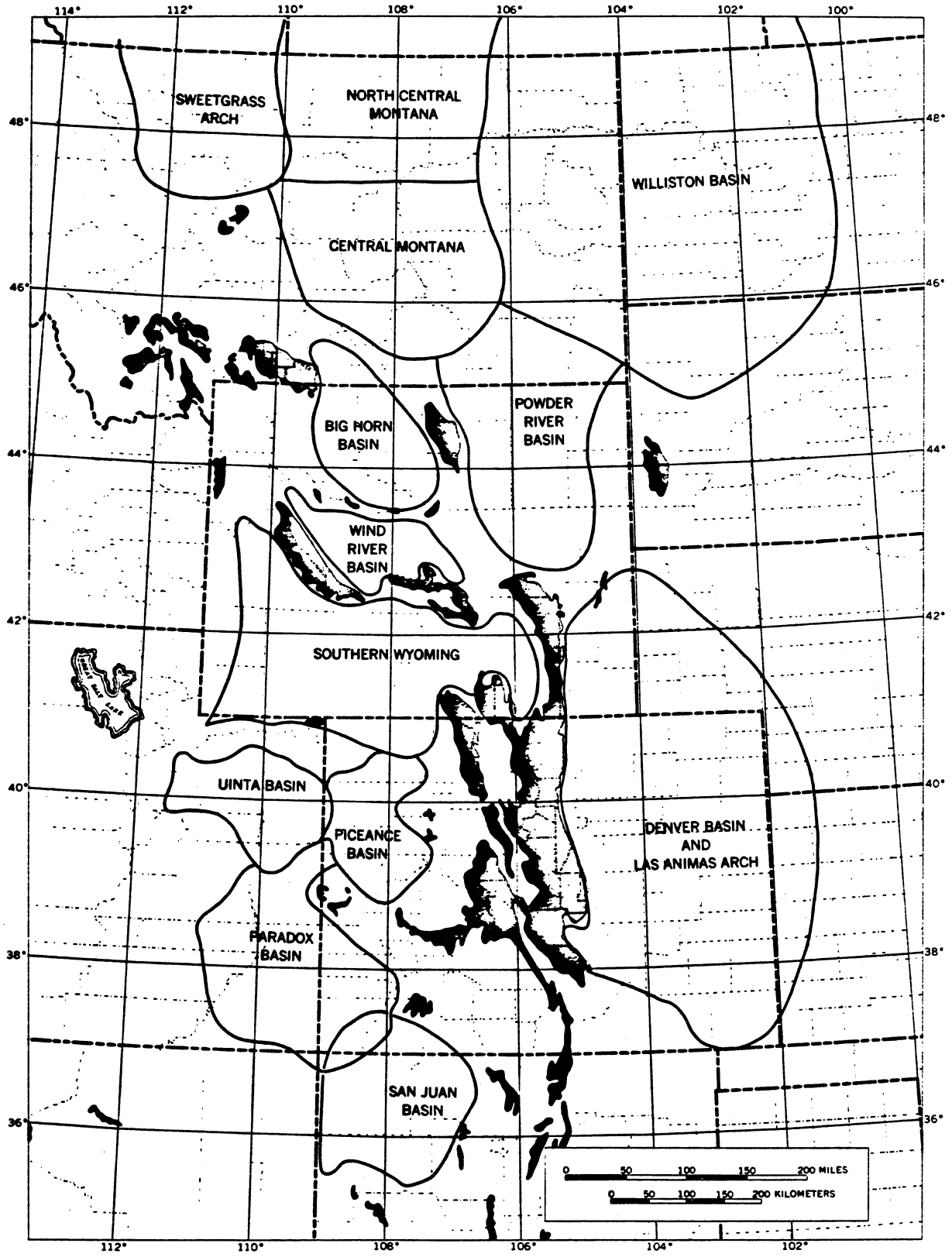

Figure 1.--General location of basins in the Rocky Mountain states (from Rocky Mountain Association of Geologists, 1972, Geologic Atlas of the Rocky Mountain Region)

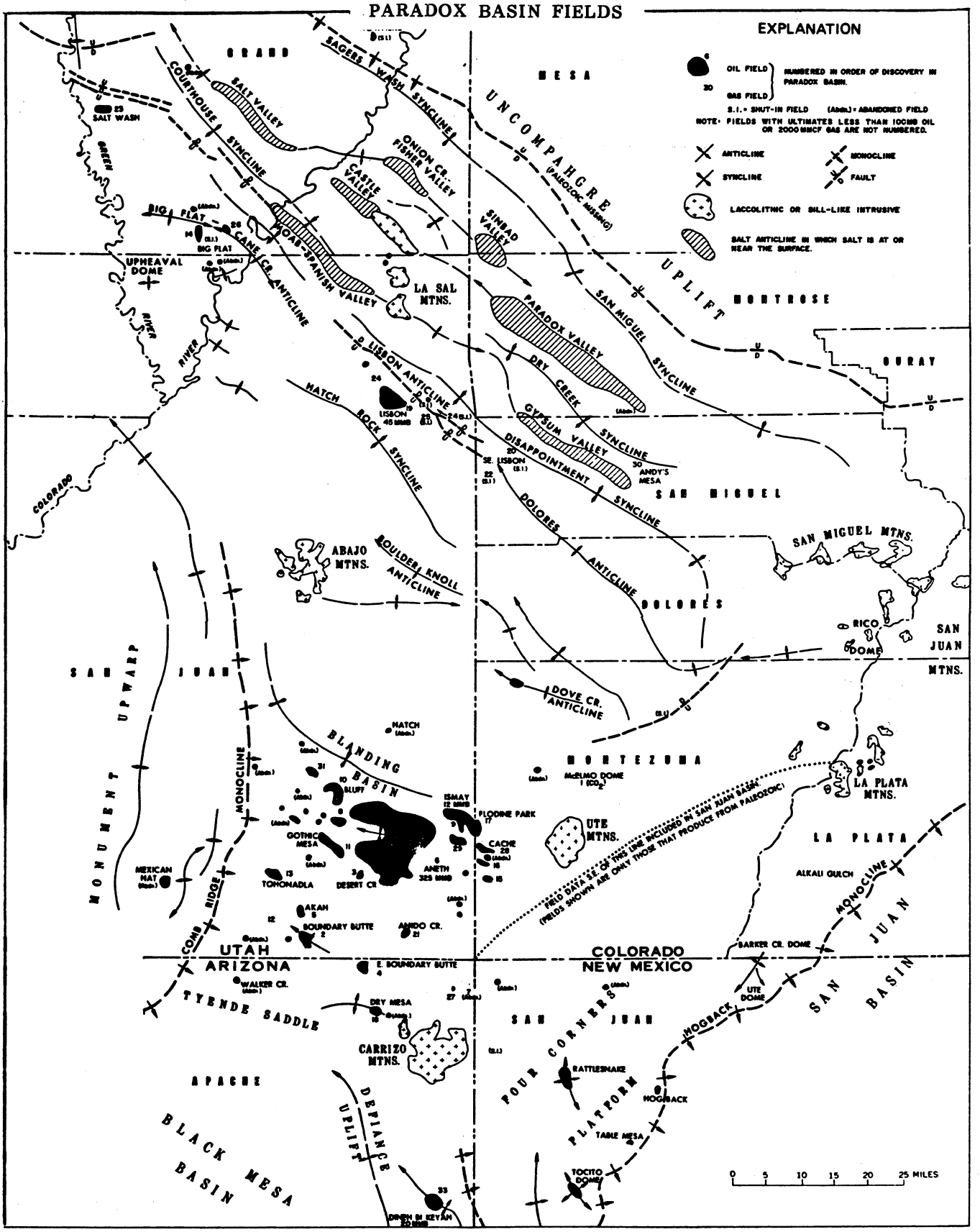

Figure 2.--Location of fields in the Paradox basin (from Rocky Mountain Association of Geologists, 1972, Geologic Atlas of the Rocky Mountain Region).

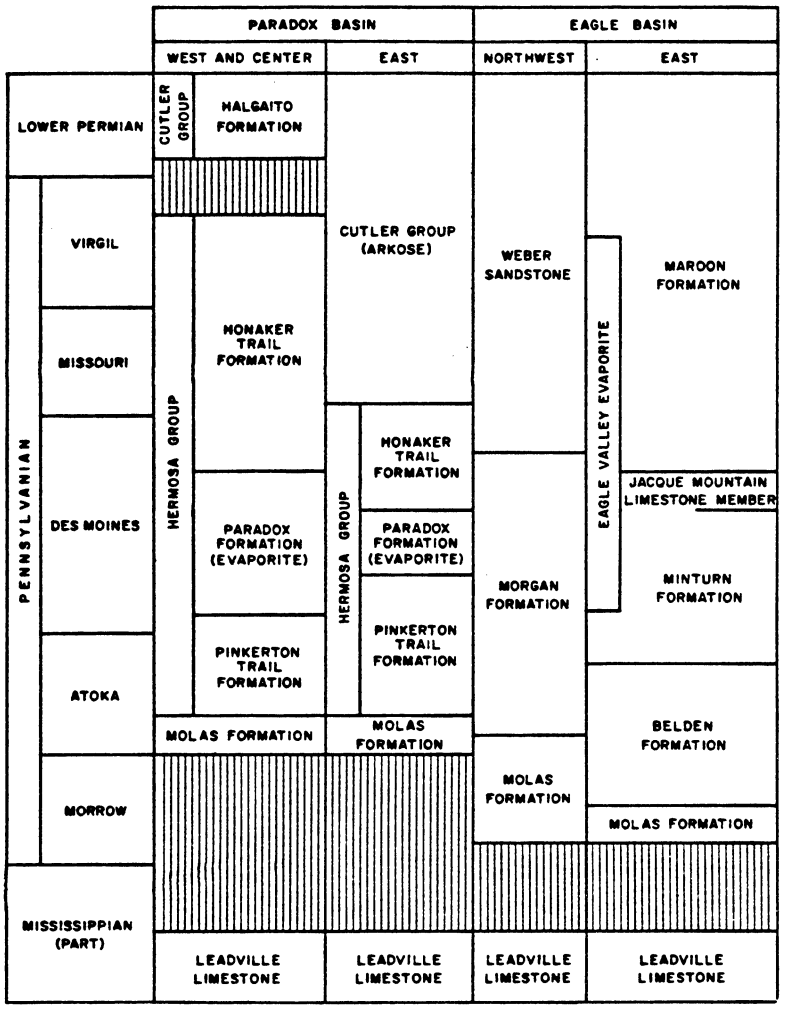

Figure 3.--Correlation chart, Pennsylvanian System, Paradox and Eagle basins. (From J. A. Peterson and R. J. Hite, 1969, Pennsylvanian evaporite-carbonate cycles and their relation to petroleum occurrence, southern Rocky Mountains, Bull., AAPG, v. 53, p. 884-908. This paper is included in the appendix to Part 1 of this volume.)

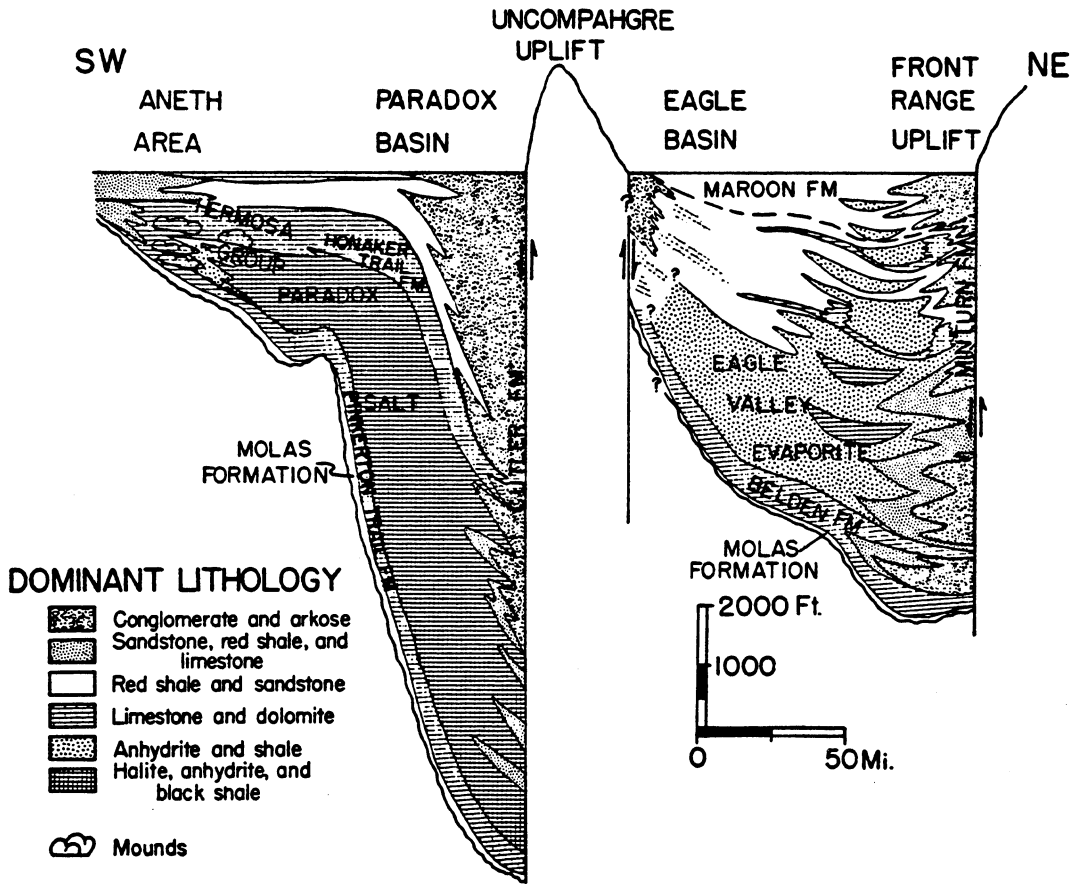

Figure 4.--SW-NE regional cross section showing gross facies relations across Paradox and Eagle basins. (From J. A. Peterson and R. J. Hite, Pennsylvanian evaporite-carbonate cycles and their relation to petroleum occurrence, southern Rocky Mountains, Bull., AAPG, v. 53, p. 884-908.)

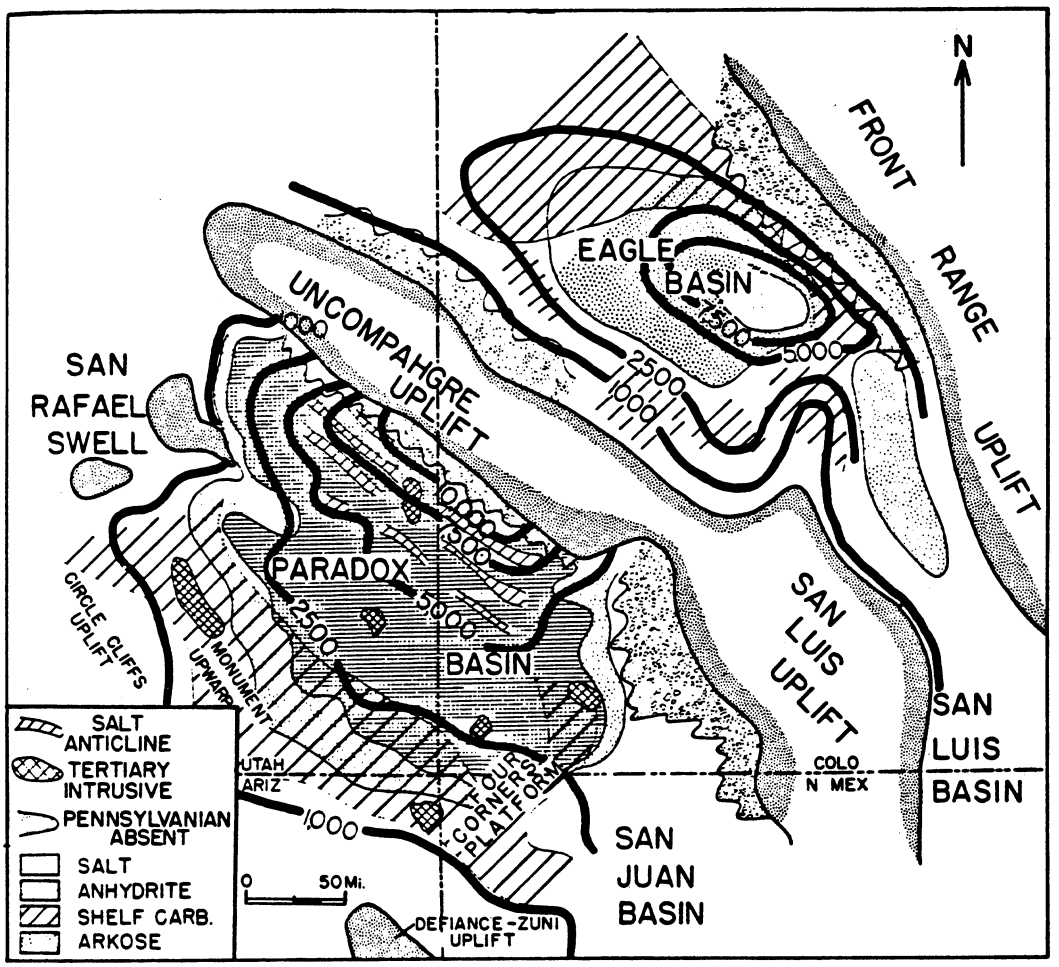

Figure 5.--Isopach-facies map, Pennsylvanian System of Paradox and Eagle basins; isopachs in feet. (From J. A. Peterson and R. J. Hite, 1969, Pennsylvanian evaporite-carbonate cycles and their relation to petroleum occurrence, southern Rocky Mountains, Bull., AAPG, v. 53, p. 884-908.)

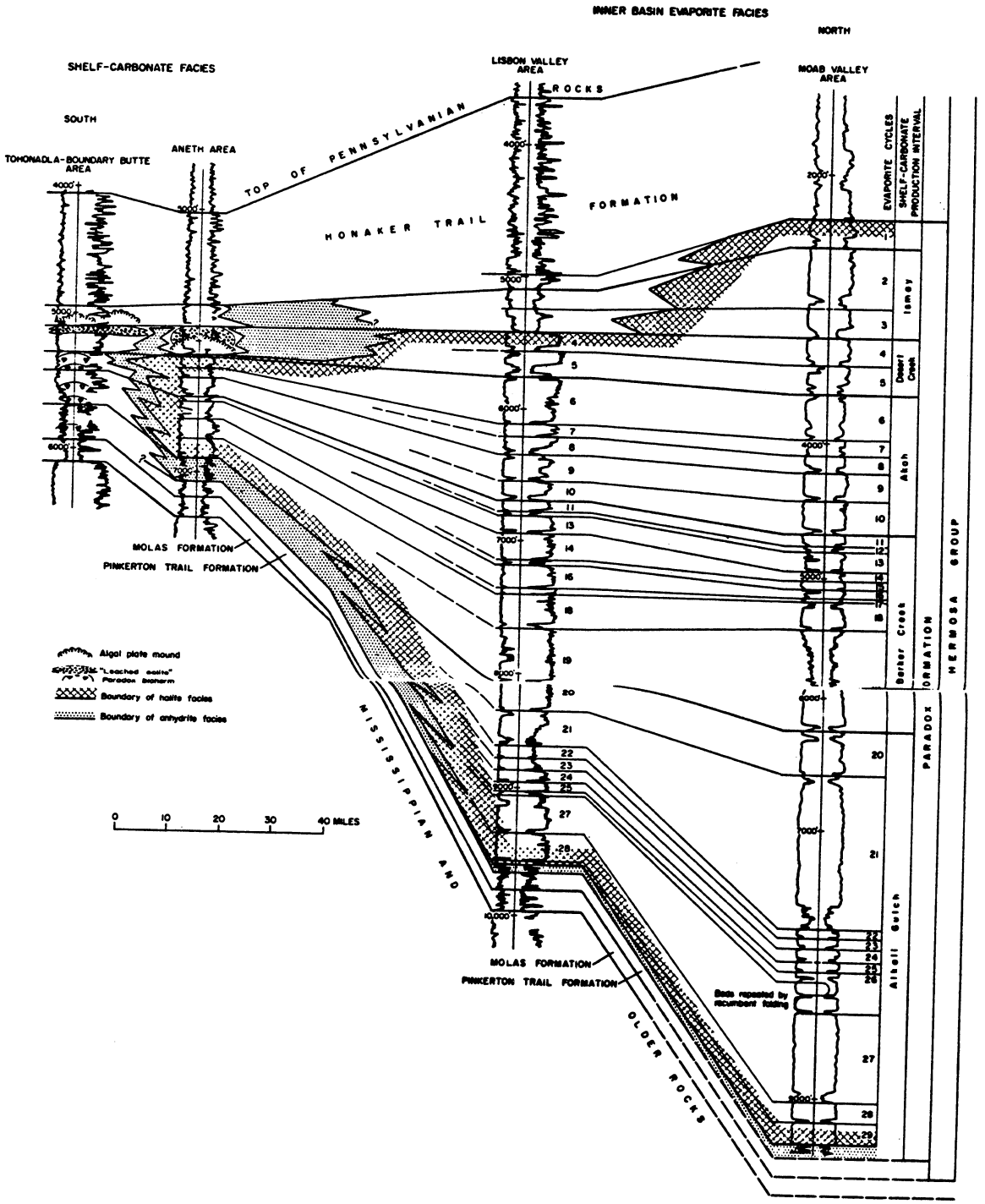

Figure 6.--Log correlations in the Paradox basin. (From J. A. Peterson and R. J. Hite, 1969, Pennsylvanian evaporite-carbonate cycles and their relation to petroleum occurrence, southern Rocky Mountains, Bull., AAPG, v. 53, p. 884-908.)

Colorado - Cache
Paradox - Ismay
Paradox Basin

DATA SOURCE CODE		
8,6d	STATE	Colorado
	COUNTY	Montezuma
	REGULATORY DISTRICT	
8,6d	BASIN	Paradox
	SUB-BASIN	
8,6d	FIELD	Cache
8,6d	RESERVOIR	Ismay zone of the upper Paradox Fm.
6d	GEOLOGIC AGE	Pennsylvanian
	AAPG STRATIGRAPHIC AGE CODE	325
8,6d	RESERVOIR LITHOLOGY	Porous strata in a group of "stacked" biohermal carbonate mounds and local zones of leached fossiliferous dolomite, interbedded shales, dolomites, and limestones with bioclastics.
8,6d	TRAPPING MECHANISM	Stratigraphic and structural; stratigraphic.
8, 13	DISCOVERY YEAR	1964
6d	PROVED ACREAGE	1040
6d	REGULAR WELL SPACING (acres/well)	40
8,13,6d	RESERVOIR DEPTH	5600, 5428, 5620
	RESERVOIR THICKNESS	
6d	NET PAY	57
6d	GROSS	180
6d	NET/GROSS RATIO	Acre feet of net pay: 38,581
	POROSITY	
6d	TYPE	Interparticle porosity - vugs & voids
6d	FRACTION	.1043
	PERMEABILITY	
6d	RANGE	1.4 to 27.2 md
6d	AVERAGE	12.3 md
	HORIZONTAL	
	VERTICAL	
	OTHER INFORMATION	
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
6d	TOTAL NUMBER OF WELLS	32 (11P, 9SI, 2A, 7I, 3DH)
	PRODUCTION 1976 oil (cum)	
6d	PRODUCTION 1977 oil (cum)	3231 mbbls; 6363.6 mmcf gas
	PRODUCTION 1978 oil (cum)	
6f	PRODUCTION 1979 oil (cum)	3376.9 oil; 6565.1 gas
6d	PRODUCTION PRESENT	230 BOD
6d	SECONDARY RECOVERY RECORDS?	waterflood
6d	WATER ANALYSIS RECORDS?	yes
	OTHER DATA	
6d	STRUCTURE CONTOUR?	yes
6d	LOGS?	yes
6d	STRUCTURE SECTION?	yes
6d	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
8,6d	FIELD:	Cache
6d	RESERVOIR:	Ismay zone
13	PROD. ACRES:	1040
	AVG. THICKNESS (FT.):	55
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
6d	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	.35
6d	OIL SATURATION (S_O):	
	PRIMARY DRIVE MECHANISM:	soln. gas; partial water
11	PRIMARY GAS CAP?:	
6d	TEMPERATURE (°F):	143
6d	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	2,165
	RESERVOIR PRESSURE INITIAL (psi):	2,170
	RESERVOIR PRESSURE LATEST (psi):	
6d	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
6d	GAS OIL RATIO LATEST (GOR) (cf/bbl):	918
6d	STOCK TANK OIL GRAVITY (°API):	45
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	.35 cp
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

OTHER INFORMATION:

6d Waterflood: began 3/1968 uses 11 producing wells and 7 injection wells

Water analysis:

Na	19,900 ppm
Ca	2,660 ppm
Mg	673 ppm
Cl	34,900 ppm
HCO_3	176 ppm
Total solids	62,700 ppm
Resistivity	.11 ohm
pH	7.5
sp.grav.	1.045

CACHE FIELD

(Oil)

T. 34 N., R. 20 W., NMPM

Montezuma County, Colorado

By: John T. Wold
Amoco Production Co.

GEOLOGY

Regional Setting: Colorado portion of Paradox Basin, Montezuma County, Colorado

Surface Formations: Jurassic, Morrison Formation

Exploration Method Leading to Discovery: Seismic, subsurface and surface geology

Type of Trap: Combination structural-stratigraphic

Producing Formation: Pennsylvanian, Paradox Formation (Ismay Member)

Gross Thickness and Lithology of Reservoir Rocks: 180 feet, interbedded shales, dolomites, and limestones with bioclastics

Geometry of Reservoir Rock: Bioclastic mound buildups

Other Significant Shows: None

Oldest Stratigraphic Horizon Penetrated: Pennsylvanian, Paradox Formation (Akah Member)

DISCOVERY WELL

Name: Pan American Petroleum No. 1 G. L. Veach

Location: NW NW sec. 2, T. 34 N., R. 20 W.

Elevation (KB): 4,922 feet

Date of Completion: October 26, 1964

Total Depth: 5,744 feet

Production Casing: 8 5/8" at 1,376 feet; 5½" at 5,744 feet

Perforations: 5,428 to 5,452 feet; 5,462 to 5,473 feet; 5,522 to 5,542 feet; 5,558 to 5,578 feet

Stimulation: Acid, 10,000 gallons

Initial Potential: 1,434 BOD

Bottom Hole Pressure: 2,170 psia

DRILLING AND COMPLETION PRACTICES

Set 8 5/8" surface casing at 1,368 feet with 490 sacks of cement. Set 5½" production casing at 5,744 feet. Perforated Ismay and acidized for completion.

RESERVOIR DATA

Productive Area:
- Proved (as determined geologically): 1,040 acres
- Unproved: 0 acres
- Approved Spacing: 40 acres
- No. of Producing Wells: 20 original, 11 present
- No. of Abandoned Wells: 2
- No. of Injection Wells: 7
- No. of Dry Holes: 3

Average Net Pay: 57.0 feet

Acre Feet of Net Pay: 38,581 acre feet

Porosity: 10.43 percent

Permeability: 12.3 millidarcies, ranges from 1.4 to 27.2 millidarcies

Water Saturation: 35 percent

Initial Field Pressure: 2,170 psia

Type of Drive: Solution gas and partial water

Gas Characteristics and Analysis: (In percent) CO_2 .55, methane 65.96, ethane 15.94, propane 9.31, normal butane 3.03, hexane .84; specific gravity .851; Btu 1,436

Oil Characteristics and Analysis: Viscosity .35 centipoise, bubble point 2,165 psia; 45° API gravity; gas-oil ratio 918

Associated Water Characteristics and Analysis: Na 19,900 ppm; Ca 2,660 ppm; Mg 673 ppm; Cl 34,900 ppm; HCO_3 176 ppm; solids 62,700 ppm; resistivity .11 ohm; pH 7.5; specific gravity 1.045

Contact Datum: Oil-water at -640 feet in upper Ismay, -670 feet in lower Ismay

Estimated Primary Recovery: Not available

Type of Secondary Recovery: Waterflood

Estimated Ultimate Recovery: Not available

Present Daily Average Production: Approximately 230 BOD

Market Outlets: Oil: Four Corners Pipeline; gas: El Paso Natural Gas Co.

FIELD COMMENTARY

The Cache field is the most productive oil field in the Colorado portion of the Paradox Basin. Oil and gas reservoirs are located along a northwest trend of carbonate structures in the Ismay Member (Des Moines age) of the Paradox Formation. The field is located in Montezuma County, Colorado, one mile east of the Utah state line and ten miles east of the prolific Aneth complex.

The Cache field was discovered in October, 1964, with the completion of the Cactus No. 2 discovery well, in the NW¼ NW¼ of sec. 2, T. 34 N., R. 20 W., later named the G. L. Veach No. 1. A total of 23 wells have since been drilled to the Pennsylvanian age Ismay reservoir. Of these, 20 have produced oil and three were dry holes. There are no plans for additional development drilling since the productive limits of the field have been defined on all sides by porosity pinchouts. Spacing is 40 acres per well.

The Ismay producing zone averages 180 feet in thickness and consists of interbedded shales, anhydrites, dolomites and limestones. The hydrocarbon source for the field is considered to be the dark shales and dark carbonaceous units that subdivide the Paradox Formation. The reservoirs, at an average depth of 5,620 feet, are largely stratigraphic in nature and are confined to porous and permeable zones within a group of stacked biohermal or biostromal carbonate (algal banks) mound buildups and local zones of tan-brown earthy dolomites. The favorable zones of porosity and permeability occur within the algal buildups which are composed principally of calcified leaves of the alga *Ivanovia*, along with foraminifers, brachiopods and encrusting bryozoan.

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, 1978, Four Corners Geological Society, Source 6d.

[Four Corners Geological Society

Excellent porosity is due to interparticle porosity between the leafy debris of the *Ivanovia* and the formation of vugs and voids. Where secondary leaching of *Ivanovia* has occurred, high porosity and permeability exists. Erratic porosities and permeabilities are found where cementation by calcite, dolomite and anhydrite has sealed or greatly reduced fluid mobility and where interparticle infilling has occurred.

Cyclic deposition which is strongly characteristic of the Paradox Formation also occurs within the Ismay on a smaller scale. The Ismay at Cache field is divided into upper and lower subzones which consist of at least twelve carbonate lithologic units. These units are indicative of shallow water conditions on a typical shelf or platform area. The lower subzone was deposited during a normal-marine environment similar to modern day carbonate deposition. The upper subzone represents an evaporitic cycle associated with anhydrites, extensive dolomitization, and the noticeable lack of fauna. Both subzones contribute to oil and gas production.

Shortly after the field dimensions were determined, it was realized that secondary recovery methods would be necessary to achieve maximum oil production. A Cache water injection program commenced in March, 1968, and has continued to the present. The waterflood utilizes 11 producing wells and seven injection wells. Cumulative production from the field through December 31, 1977, has totaled 3,230,610 BO. Cumulative gas production through the end of 1977 amounts to 6,363,642 MCFG.

The writer expresses appreciation to Amoco Production Company for permission to publish this paper and fully acknowledges the previous work on the Cache field by R. S. Gray.

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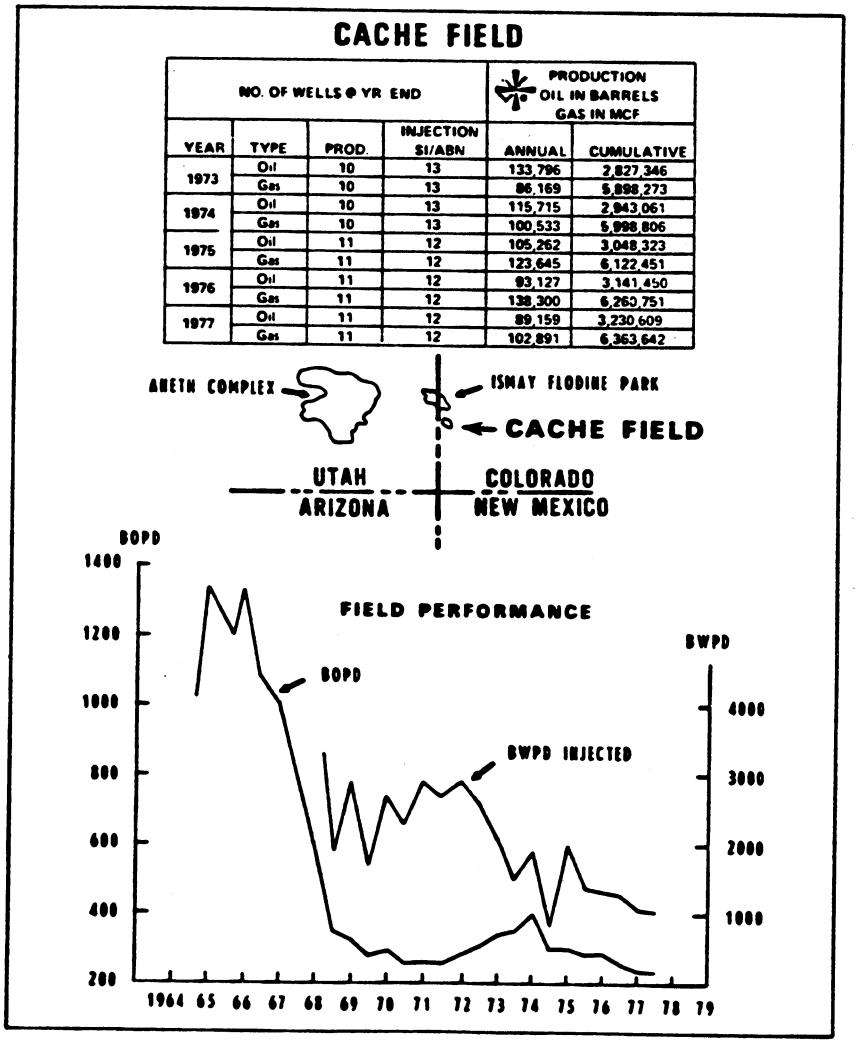
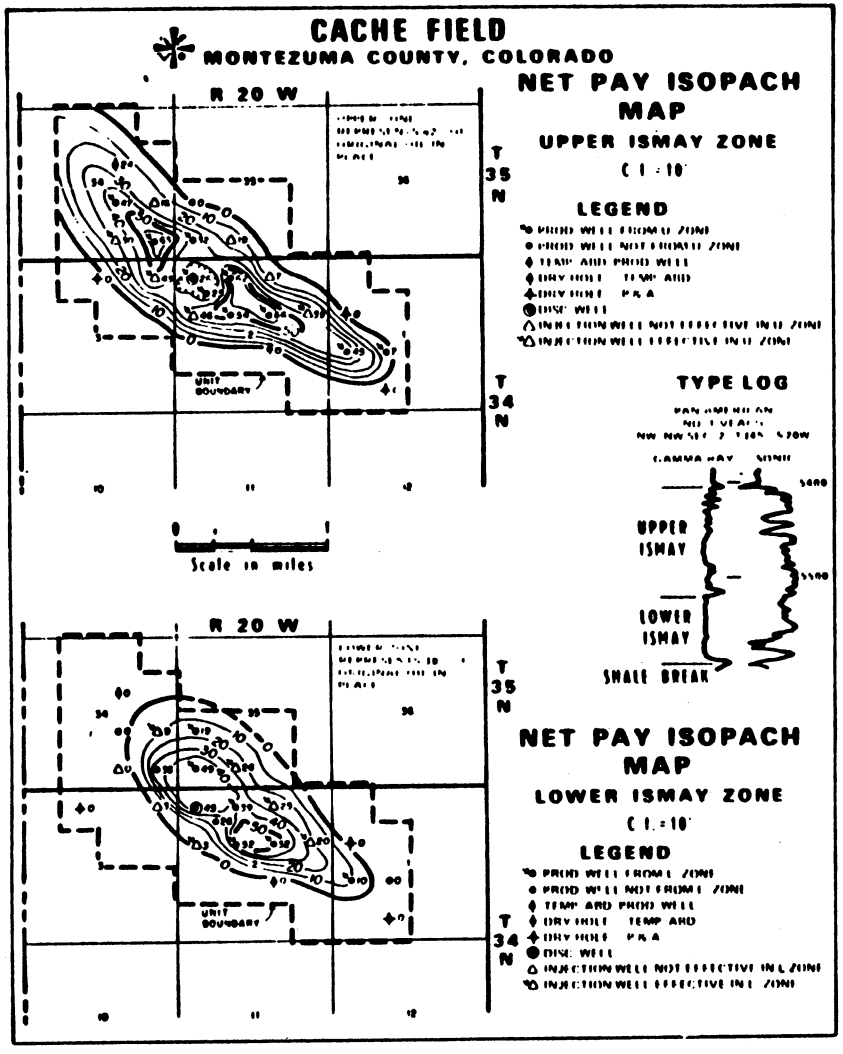
Amoco Production Company, unpublished reports.

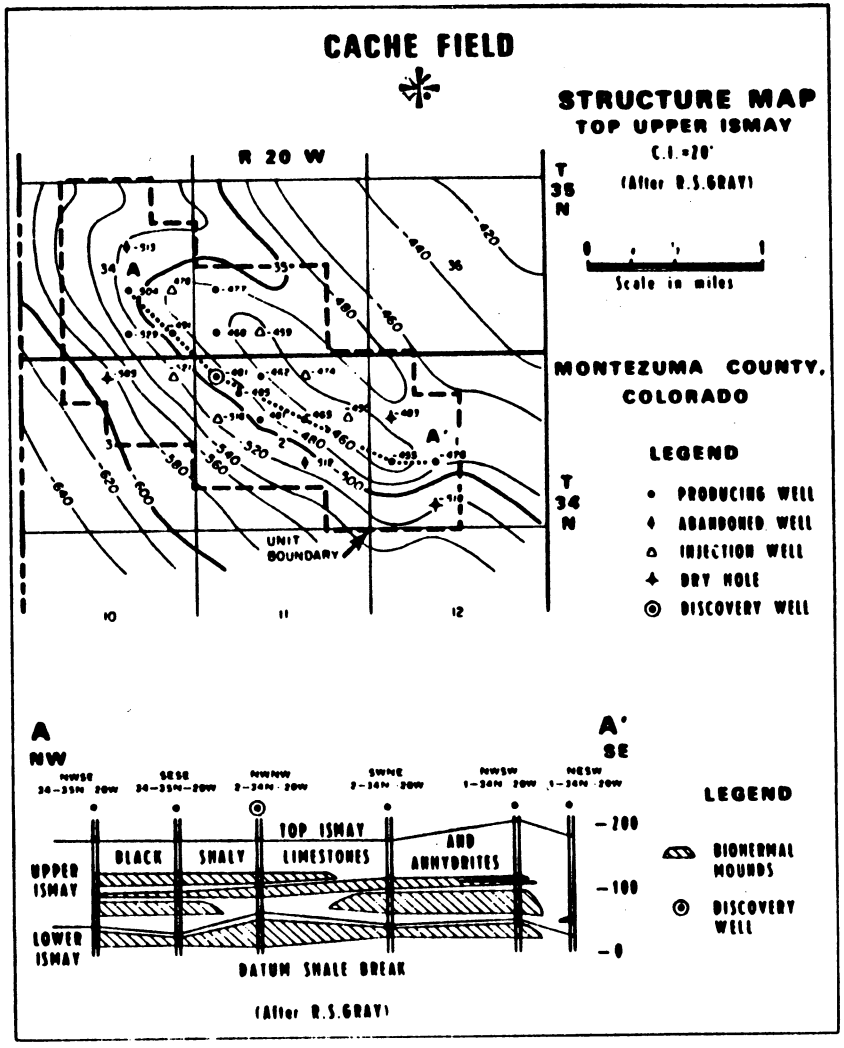
Gray, R. S., 1967, Cache Field—A Pennsylvanian Algal Reservoir in Southwestern Colorado: Am. Assoc. Petrol. Geol. Bull., Vol. 51, No. 10, p. 1959-1978.

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, 1978, Four Corners Geological Society, Source 6d.



Oil and Gas Fields of the Four Corners Area]





From: Oil and Gas Fields in the Four Corners Area, 1978; Four Corners Geological Society, source 6d.

Colorado - Flodine Park
Paradox - Ismay
Paradox Basin

DATA SOURCE CODE		
6a	STATE	Colorado
	COUNTY	Montezuma
	REGULATORY DISTRICT	
1, 6d	BASIN	Paradox
	SUB-BASIN	
6a,6d	FIELD	Flodine Park
6a,6d	RESERVOIR	Ismay zone (Hermosa)
6a	GEOLOGIC AGE	Mamaton Group of the Des Moines, Penn.
1	AAPG STRATIGRAPHIC AGE CODE	320
6a,6d	RESERVOIR LITHOLOGY	Algal-skeletal limestones with vug porosity and gray-tan dolomites; stacked mound-like carbonate buildups, generally elongated northeast.
6a, 6d	TRAPPING MECHANISM	Porous reefal carbonates grading to non-porous normal marine carbonates, evaporitic carbonates and evaporites; stratigraphic, markedly influenced by structure.
6d, 13,1	DISCOVERY YEAR	1959
6a,6d	PROVED ACREAGE	±500, 1440
6a, 1	REGULAR WELL SPACING (acres/well)	80
	RESERVOIR DEPTH	5860 - 5950 (2 zones)
	RESERVOIR THICKNESS	
6d	NET PAY	41 ft.
6a,6d	GROSS	78, 80 ft.
6d	NET/GROSS RATIO	200 ft. log
	POROSITY	
6a	TYPE	Intercrystalline and vuggy
6a,1,6d	FRACTION	.108, .108, .11
	PERMEABILITY	
	RANGE	
6a,1,6d	AVERAGE	3.84 md, 3.84 md, 13 md
	HORIZONTAL	
	VERTICAL	
	OTHER INFORMATION	
	1974 cum. oil is 1938 mbbls	
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
6d	TOTAL NUMBER OF WELLS	20 (9P, 1A, 10DH)
6d	PRODUCTION 1976 oil (cum)	2025
6d	PRODUCTION 1977 oil (cum)	2061
	PRODUCTION 1978 oil (cum)	
6f	PRODUCTION 1979 oil (cum)	2126.7 oil; 7820.0 gas
6f	PRODUCTION PRESENT	94 BOD, 432 mcfgd
6d	SECONDARY RECOVERY RECORDS?	none
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
12a,6a,6d	STRUCTURE CONTOUR?	yes
6a,6d	LOGS?	yes
12a,6a	STRUCTURE SECTION?	yes
6d	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Flodine Park
1	RESERVOIR:	Ismay
6a, 6d	PROD. ACRES:	±500, 1440
6d	AVG. THICKNESS (FT.):	41
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
6d	WATER SATURATION (S_W):	.41
	OIL SATURATION (S_O):	
6a,1,6d	PRIMARY DRIVE MECHANISM:	gas solution
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	146
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
6d	RESERVOIR PRESSURE INITIAL (psi):	2212
	RESERVOIR PRESSURE LATEST (psi):	
6d	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	820
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
6a,1,8a,6d	STOCK TANK OIL GRAVITY (°API):	43.9, 44, 44, 44.8
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL:	
6d	ESTIMATED PRIMARY OIL: (14% to 39%)	2300 to 8500 mbbls

OTHER INFORMATION:

12a Reference: Elias, Gregory K., 1963, "Habitat of Pennsylvanian Algal Bioherms, Four Corners Area", in Shelf Carbonates of the Paradox Basin - Symposium: Four Corners Geological Society.

6d Water analysis: "salt water"

Prepared by: R. N. MERCURIO
HUMBLE OIL & REF. CO.
AUGUST, 1961

FLODINE PARK FIELD

ISMAY POOL
T. 35 N., R. 20 W.
MONTEZUMA COUNTY, COLO.

DISCOVERY DETAILS

Method

Subsurface geology.

Well

Name: Lion Oil Division of Monsanto Chemical Co. No. 1 Retherford, 1880' FNL and 2310' FEL sec. 15, T. 35 N., R. 20 W.

Completed: April 18, 1959. Perforated 5862-5872, 5944-5950.

Treatment: Perfs. 5862-5872 w/500 gallons mud acid, perfs. 5944-5950 w/300 gallons mud acid.

Initial Potential: Well flowed 400 BOPD through 25/64" choke with a G.O.R. of 820 cu. ft./bbl.

GEOLOGY

Producing Zones

Ismay zone, Marmaton group of the Des Moines, Pennsylvanian system.

Other Shows

None.

Trap Type

Stratigraphic—Porous reefal carbonates grading to non-porous normal marine carbonates, evaporitic carbonates and evaporites.

Lithology

Buff to brown algal-skeletal limestones with vug porosity and gray-tan dolomites w/fine intercrystalline to vug porosity.

Maximum Reservoir Thickness

78'.

Regional Setting

The Flodine Park Pool is located on the northwest-southeast Ismay reefal trend. Approximately 1 mile east of the Ismay Field.

Deepest Formation Penetrated

Paradox Akah zone—Total depth 6100'.

DEVELOPMENT DATA

Total Wells

Completed Oil:	3
Producing Oil:	3
Abandoned Oil:	0
Gas:	0
Dry and Abandoned:	2

Well Spacing

80 acres.

Logging Practice

Induction-Electric log from surface casing to total depth. Radioactivity log or Gamma Ray-Sonic and Micro-log with caliper from top of Pennsylvanian to total depth.

Completion Practice

200 to 300 feet of 10¾" to 13-3/8" surface casing with 5½" production casing set through the producing interval and perforated. Produced flowing through choked tubing.

RESERVOIR DATA

Type of Drive

Gas solution.

Estimated Gas in Place

Not available.

Estimated Recoverable Oil

Not available.

Oil Zone Thickness

Maximum: 78' Average: 55'

Porosity

10.88%.

Permeability

3.84 md.

Area

± 500 acres

Gas Characteristics

Not available

Oil Characteristics

Gravity: 43.9° API
Sulphur: 0.07
Initial Solution GOR: 820:1
Base: Paraffin

Associated Water Characteristics

No formation water produced.

Pressure Maintenance or Secondary Recovery

None.

*PRODUCTION

Cumulative Production through 1960

40,505 bbls. and 94,507 MCFG

Production in 1960

9,947 bbls. and 34,760 MCFG

Market Outlet

Oil: Trucked to Aneth loading station, San Juan County, Utah.

Gas: El Paso Natural Gas Company pipeline.

(*NOTE: Taken from discovery well only. Two confirmation producing wells completed in 1961).

REFERENCES

Carr, W. E., and White, C. (1958). "The Ismay Oil Field." I.A.P.G. Guidebook To The Geology Of The Paradox Basin, ... pp. 278-280.

Carter, Kenneth E. (1958). "Stratigraphy of Desert Creek and Ismay Zones and Relationship to Oil, Paradox Basin, Utah." I.A.P.G. Guidebook To The Geology Of The Paradox Basin, ... pp. 138-146.

Wengerd, Sherman A. (1958). "Pennsylvanian Stratigraphy Southwest Shelf, Paradox Basin". I.A.P.G. Guidebook To The Geology Of The Paradox Basin, ... pp. 109-135.

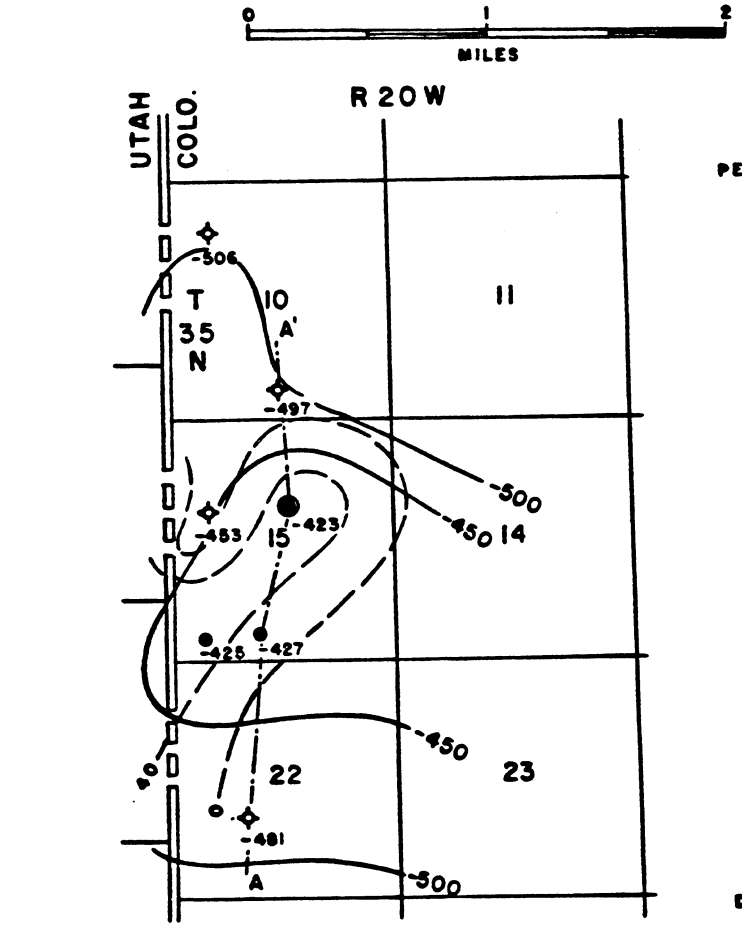
From: OIL AND GAS FIELD VOLUME, COLORADO-NEBRASKA, 1961,
The Rocky Mountain Association of Geologist, Source 6a.

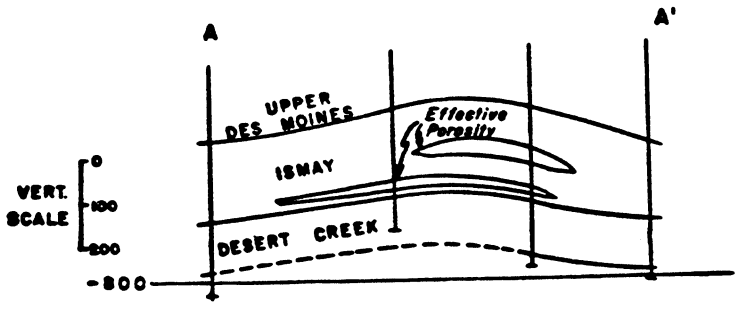
FLODINE PARK POOL

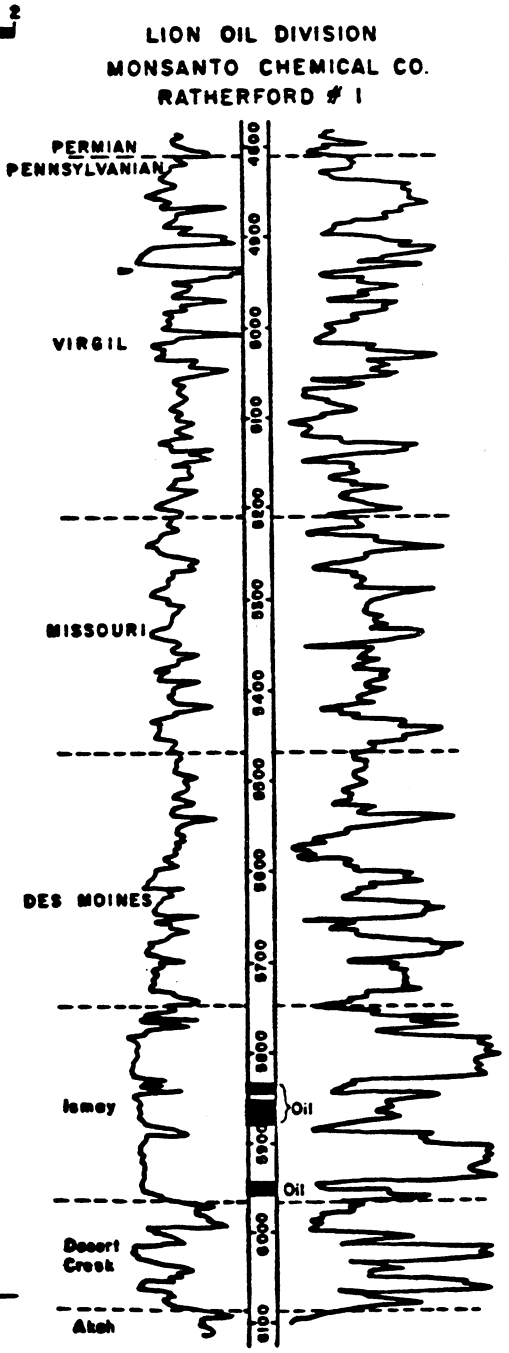
50' CONTOURS - ISMAY PAY

WITH

40' NET PAY CONTOURS SUPERIMPOSED







From: OIL AND GAS FIELD VOLUME, COLORADO-NEBRASKA, 1961, The Rocky Mountain Association of Geologist, Source 6a.

ROCKY MOUNTAIN ASSOCIATION OF GEOLOGISTS

September, 1961

FLODINE PARK

(Oil)

T. 35 N., R. 20 W., NMPM

Montezuma County, Colorado

By: D. F. Mecham
Marathon Oil Company

GEOLOGY

Regional Setting: Southeast part of Paradox Basin along north margin of a broad shallow marine platform

Surface Formations: Cretaceous, Dakota Sandstone and Burro Canyon Formation; Jurassic, Morrison Formation

Exploration Method Leading to Discovery: Surface mapping, subsurface geology, and minor geophysics

Type of Trap: Stratigraphic, markedly influenced by structure

Producing Formation: Ismay Zone of Paradox Formation

Gross Thickness and Lithology of Reservoir Rocks: Approximately 80 feet of lenticular bioclastic carbonates; two zones or three

Geometry of Reservoir Rock: Stacked mound-like carbonate buildups, generally elongate northeast

Other Significant Shows: None

Oldest Stratigraphic Horizon Penetrated: Akah Zone of Paradox Formation

DISCOVERY WELL

Name: Lion Oil, Division of Monsanto Chemical Co. No. 1 Retherford

Location: SW NE (1650' FNL and 2310' FEL) sec. 15, T. 35 N., R. 20 W.

Elevation (KB): 5,327 feet

Date of Completion: April 16, 1959

Total Depth: 6,100 feet

Production Casing: 5½" to 6,018 feet with 250 sacks of cement

Perforations: 5,862 to 5,872 feet (20 perforations), 5,944 to 5,950 feet (12 perforations)

Stimulation: Treated with mud acid (300 to 500 gallons)

Initial Potential: Flowed 400 BOD on 25/64" choke (gas-oil ratio 820:1, tubing pressure 125 psi, casing pressure 325 psi)

Bottom Hole Pressure: 2,212 psia

DRILLING AND COMPLETION PRACTICES

Surface casing 7 5/8" to 13 5/8", set from 100 to 300 feet, production casing, 4½" to 5½" to total depth, perforated from log interpretation, acidize with 3,000 to 7,000 gallons, 15 percent mud acid.

RESERVOIR DATA

Productive Area:

Proved (as determined geologically): 1,440 acres
Unproved: Unknown
Approved Spacing: 80 acres

No. of Producing Wells: 9
No. of Abandoned Wells: 1
No. of Dry Holes: 10

Average Net Pay: 41 feet

Porosity: 11 percent

Permeability: 13 millidarcies

Water Saturation: 41 percent

Initial Field Pressure: 2,212 psia

Type of Drive: Solution gas

Gas Characteristics and Analysis: 44.8° API gravity, low sulfur, green, paraffin base

Associated Water Characteristics and Analysis: Salt water

Original Gas, Oil, and Water Contact Datums: Oil-water -650 feet

Estimated Primary Recovery: 2,300,000 to 8,500,000 BO (14 to 39 percent)

Type of Secondary Recovery: None

Estimated Ultimate Recovery: Same as estimated primary recovery

Present Daily Average Production: 94 BOD, 432 MCFGD, 77 BWD (October 1977)

Market Outlets: Most of field through Texas-New Mexico pipeline

FIELD COMMENTARY

The Flodine Park field is located in southwest Colorado, approximately 15 miles north of the common corner of Utah, Colorado, Arizona, and New Mexico (the Four Corners). The field is bounded on the west by the Utah-Colorado state line and occupies parts of three sections in T. 35 N., R. 20 W. in Montezuma County, Colorado. The field is closely related to and is an extension of the Ismay field, to the west, in Utah. It is on the east end of the broad, gently west-dipping Ismay structural nose and produces from essentially the same interval and under stratigraphic and structural conditions similar to the Ismay field.

Production is from the Ismay Zone of the Paradox Formation of middle Pennsylvanian age. The reservoir rock is primarily lenticular deposits of bioclastic carbonates that often contain fragmented debris of calcareous algae as a major constituent. These buildups have been interpreted as generally flat-bottomed, convex-upward mounds that probably interfinger with adjacent facies. The lower Ismay buildup that occurs in Flodine Park and extends southwesterly into Utah has been described as roughly 10,000 feet long, up to 3,500 feet wide, and about 40 feet thick by Choquette and Traut (1963, p. 163). It is also of considerable importance that these buildups occur in stacked positions but are generally shifted laterally with respect to the underlying buildups. Two or three occur in the Flodine Park area.

Although the carbonate buildups vary from irregular to elongate, the general grain throughout (and markedly so in

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, 1978. Four Corners Geological Society, Source 6d.

the elongate type) is generally northeast at nearly right angles to the structural trend in the Ismay-Flodine Park area. This type of occurrence and trend is very prominently displayed in the Flodine Park area. Stacking of the individual buildups results in individual wells in various parts of the field encountering one, two, or all three buildup zones. The buildup in both the lower and upper Ismay at Flodine Park crosses into Utah and is there a part of the Ismay field (Choquette and Traut, 1963, p. 161-162). Within the area outlined, 20 wells have been drilled; 10 producers and 10 dry holes. One producer has been subsequently abandoned. Dry holes mark the northern and eastern limits of the field.

REFERENCES

Choquette, P. W., and Traut, J. D., 1963, Pennsylvanian Carbonate Reservoirs, Ismay Field, Utah and Colorado, *in* Four Corners Geological Society 4th Field Conference Guidebook, p. 157-184.

Elias, G. K., 1963, Habitat of Pennsylvanian Algal Bioherms, Four Corners Area, *in* Four Corners Geological Society 4th Field Conference Guidebook, p. 185-203.

Mercurio, R. N., 1961, Flodine Park Field, *in* Rocky Mountain Association of Geologists Oil and Gas Field Volume, Colorado-Nebraska, p. 128-129.

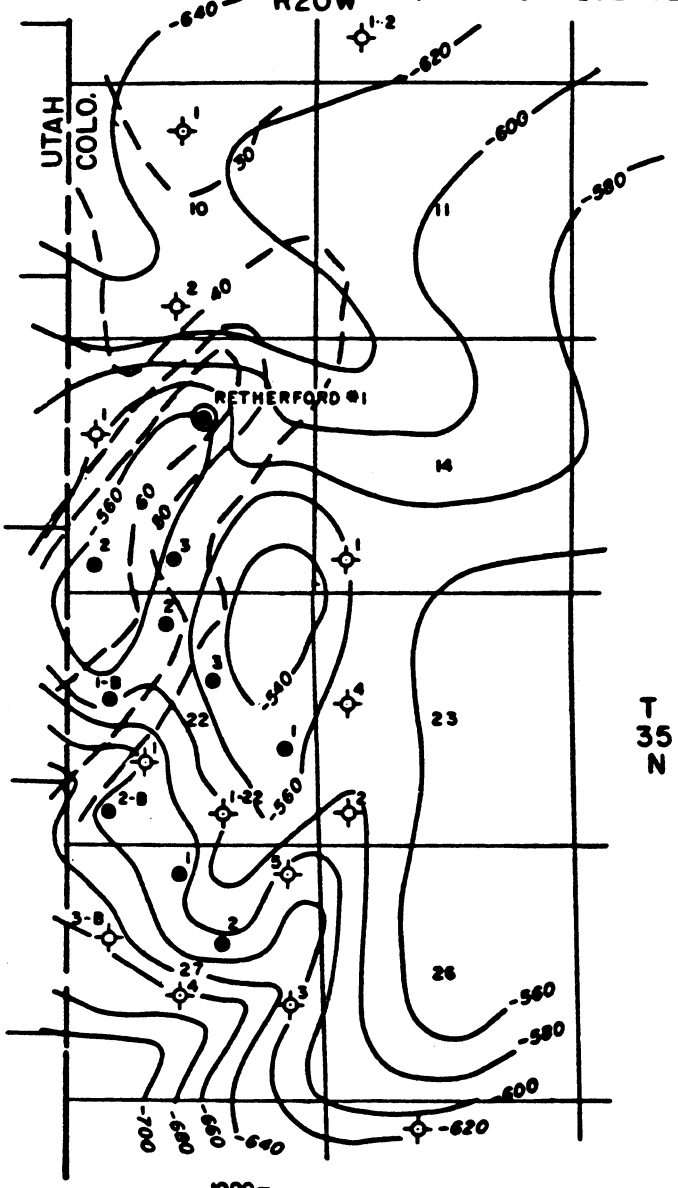
Stowe, C., 1970, Oil and Gas Production in Utah to 1970, *in* Utah Geological and Mineralogy Survey Bulletin no. 94, p. 108-110.

NO. OF WELLS @ YR. END				PRODUCTION OIL IN BARRELS GAS IN MCF	
YEAR	TYPE	PROD.	SI/ABN[1]	ANNUAL	CUMULATIVE
1959	Oil	1	3	55,887	55,887
	Gas			59,747	59,747
1960	Oil	1	4	9,947	45,834
	Gas			34,760	94,507
1961	Oil	3	4	50,129	95,963
	Gas			54,529	149,036
1962	Oil	5	5	182,320	278,283
	Gas			259,546	408,582
1963	Oil	5	6	335,150	613,433
	Gas			648,121	1,056,705
1964	Oil	10	6	253,898	867,331
	Gas			792,056	1,848,759
1965	Oil	10	9	226,468	1,093,799
	Gas			956,993	2,805,752
1966	Oil	10	10	171,092	1,264,891
	Gas			783,463	3,589,215
1967	Oil	10	10	140,944	1,405,835
	Gas			732,143	4,321,358
1968	Oil	10	10	116,479	1,522,314
	Gas			633,686	4,955,044
1969	Oil	8	12	90,369	1,612,683
	Gas			** 500,000	5,455,044
1970	Oil	9	11	83,348	1,696,031
	Gas			402,015	5,857,059
1971	Oil	9	11	73,805	1,769,836
	Gas			365,833	6,222,892
1972	Oil	9	11	57,267	1,827,103
	Gas			295,133	6,518,025
1973	Oil	9	11	56,867	1,883,970
	Gas			244,771	6,762,796
1974	Oil	9	11	50,165	1,934,134
	Gas			231,291	6,994,087
1975	Oil	9	11	47,375	1,981,510
	Gas			231,251	7,225,338
1976	Oil	9	11	43,287	2,024,797
	Gas			182,705	7,408,043
1977	Oil	9	11	* 36,000	2,060,797
	Gas			* 167,000	7,575,043
	Oil				
	Gas				

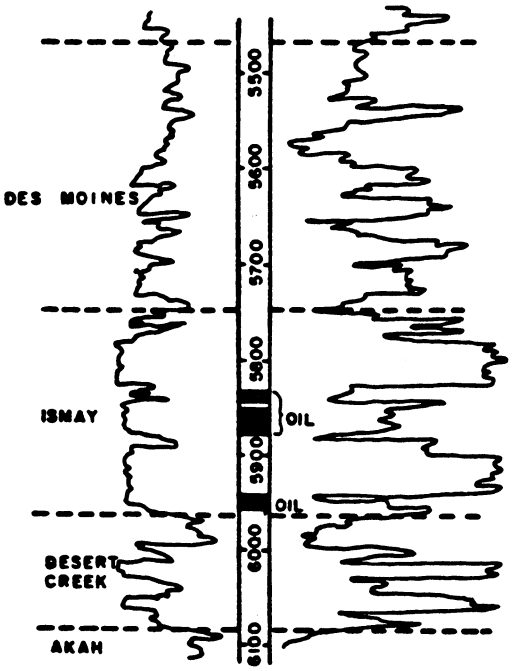
1) Includes dry holes in field area.
* Est. November-December 1977. ** Est.-figures not available.

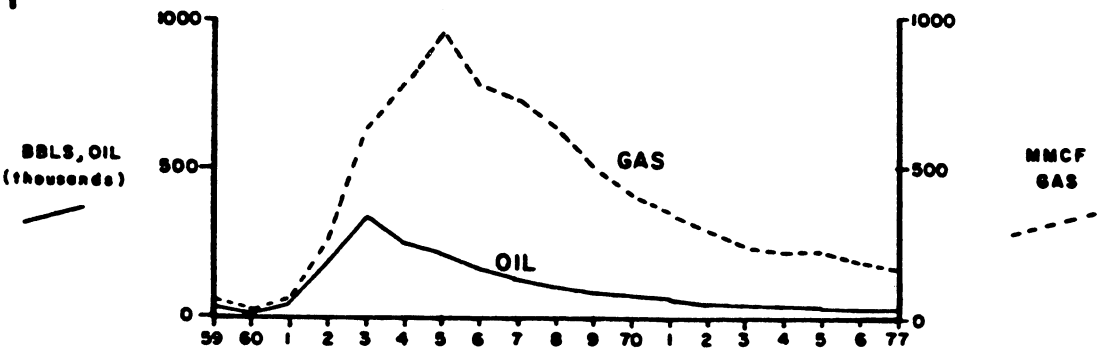
From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, 1978, Four Corners Geological Society, Source 6d. [Four Corners Geological Society

FLODINE PARK POOL
20' CONTOUR - LOWER ISMAY (A_3) ZONE
WITH
ISOPACH AT A_3-B SUPERIMPOSED
(FROM CHOQUETTE and TRAUT)



LION OIL DIVISION
MONSANTO CHEMICAL CO.
RETHERFORD # 1





Oil and Gas Fields of the Four Corners Area]

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, 1978, Four Corners Geological Society, Source 6d.

From: SHELF CARBONATES OF THE PARADOX BASIN, A SYMPOSIUM,1963,
Four Corners Geological Society, Source 12 a.

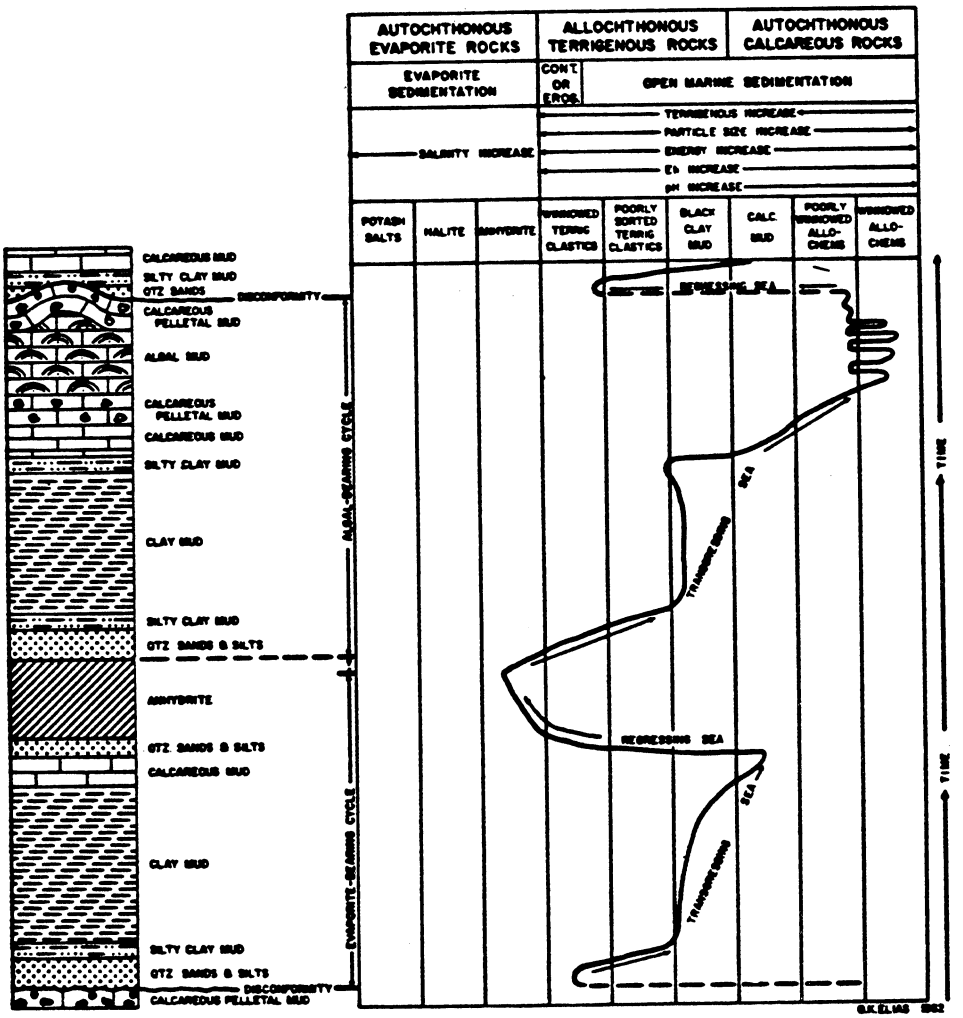


FIG. 4.——Two types of Pennsylvanian cycles of deposition found in the area of study, well within the basin of deposition. Phase curves of relative sea movement are based on the origin and size of sediments together with interpreted energy. The algal and pelletal mud limestones denote a shoal or shallow-water area, while the evaporites denote offshore shallow depressions. For convenience, the top of the evaporites is used as a boundary of the cycle instead of the regressive peak.

The illustrated Kansas cyclothem is a theoretically complete cyclothem, meaning that all components (members) are present. In nature, however, cyclothems at a given control point are usually incomplete, being governed by geographic location. Each facies in a cyclothem changes horizontally as well as vertically.

The purpose of comparing the Paradox basin cycles to the Midcontinent cyclothems is not to establish cyclothemic nomenclature for the Paradox basin (although this will no doubt eventually be attempted), but rather to compare the two provinces in terms of depositional similarity. It is the belief of this writer that the numerous cyclical deposits in the Pennsylvanian System of the Paradox basin resulted from numerous transgressions and regressions of the sea, just as in the Midcontinent area.

In viewing Figure 3 we note that emphasis is placed upon both lithology and the interpreted habitat of organic assemblages. Different combinations of these two factors are related to hypothetical distances from shore (shown along the abcissa of the

From: SHELF CARBONATES OF THE PARADOX BASIN, A SYMPOSIUM,1963,
Four Corners Geological Society, Source 12 a.

graph). Transgressive and regressive phases of sea movement are postulated according to the plot of the curve. Plots to the left denote a regressive sea movement; plots to the right, a transgressive movement. The cycle of deposition is identified (by some workers) as that interval of strata between major regressive peaks on the phase curve, and this is what the writer has used to establish cycles of deposition in the Paradox basin, although the parameters are somewhat different from those used for the Midcontinent cyclothem.

In Figure 4 the curve direction is based primarily on the origin of the sediment: allochthonous (derived from outside the basin) or autochthonous (derived from within the basin). The sediments are affected regionally and locally by energy, oxidation-reduction potential (Eh), alkalinity-acidity potential (pH), and salinity. An apparent feature of the cycle is the loss of terrigenous content in an upward (time) direction. This tendency for fewer terrigenous clastics (brought into the basin on a regional scale) with time is suggestive of a transgressive sea. On the other hand, a renewal of terrigenous clastic influx is considered to mark the beginning of a regressive sea.

On Figure 4 the terrigenous clastics and the calcareous sediments are subdivided by grain size; winnowed terrigenous clastics (quartz sands and silts) grade into clay muds, and the calcareous muds grade into the winnowed allochems (coarser calcareous particles). An influx of terrigenous material is believed to be the result of a regional control, and grain size is probably a valid criterion to use in determining transgression and regression. However, changes in grain size for calcareous sediments may be the result of strictly local conditions (biochemical and(or) physicochemical) and therefore do not necessarily reflect overall basin environment in regard to relative sea movement.

Evaporite deposits are placed in the regressive phase because they are found enclosed within terrigenous clastics. Also, the trapping and subsequent evaporation of sea water suggests an old relict sea rather than a young transgressing sea.

Facies Identification

Figure 5 shows the area of study used to identify the lithic and interpretive components of a single cycle of deposition in the Paradox basin. It also shows an isopach map of the carbonate-containing portion of cycle 1 of the Ismay zone, which reveals a northwest trend of "thicks and thins." The individual thicks or "pods" are aligned at

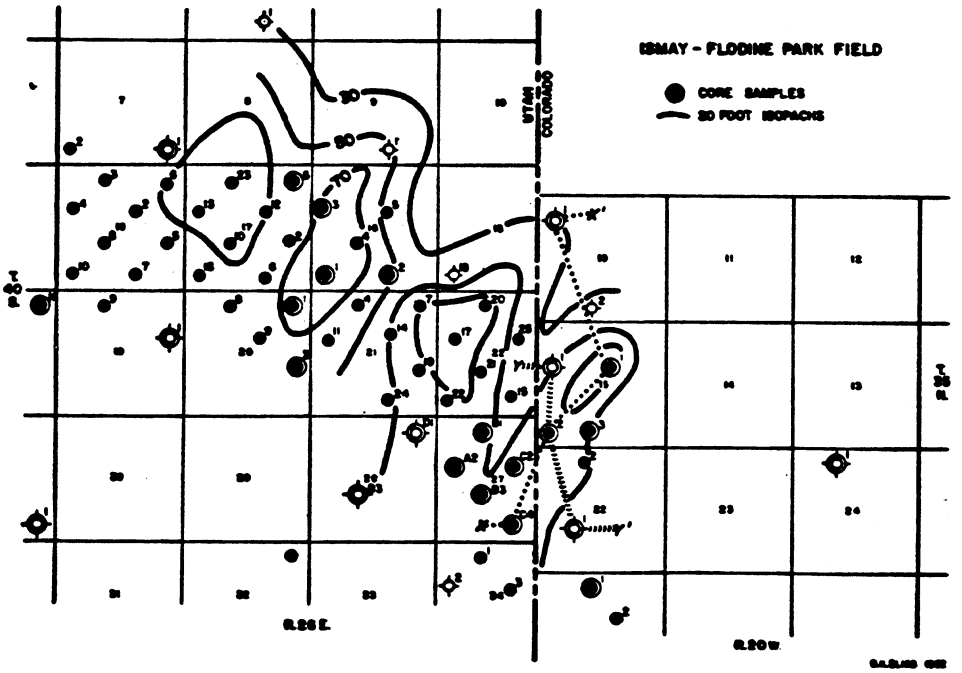


FIG. 5.——Isopach map of cycle 1 Ismay zone minus the basal sands and shales. Note that although the overall trend of thickening (mostly carbonates) is northwest-southeast, individual "pods" are aligned northeast-southwest.

From: SHELF CARBONATES OF THE PARADOX BASIN, A SYMPOSIUM,1963,
Four Corners Geological Society, Source 12 a.

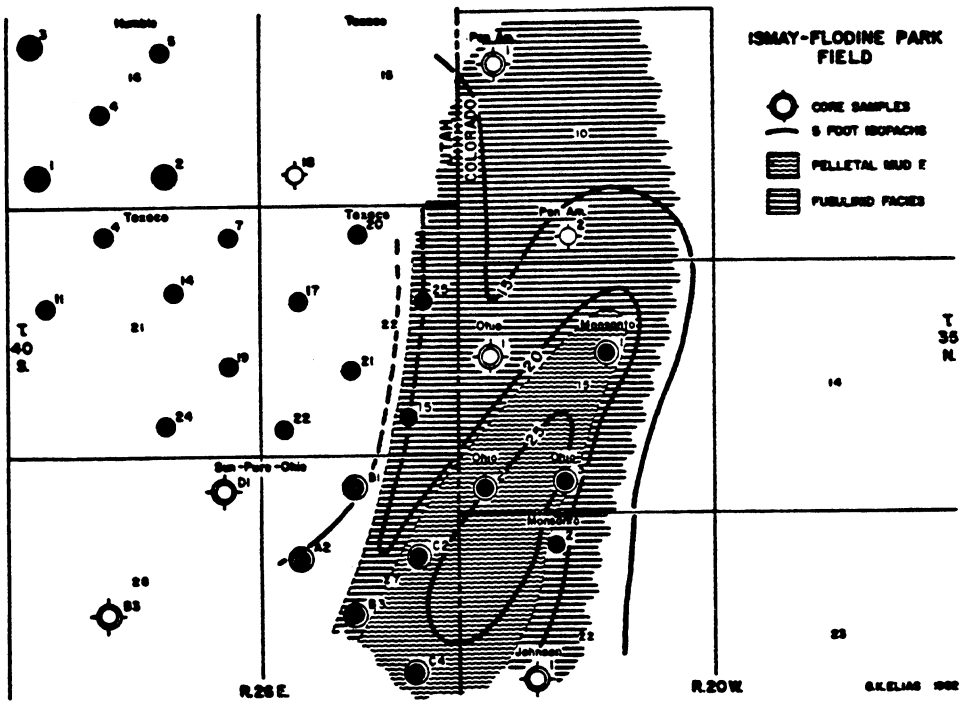


FIG. 8.——Isopach map representing the basal carbonate part of the transgressive phase of cycle 1 Ismay zone (just prior to Ivanovia growth). Note the incipient ridges already formed at this time. The thin veneer of fusulinid facies (clay muds) is found within the channels. Channels probably began to form during initial deposition of the pelletal mud facies.

buildup of the ivanovia facies, being thicker toward the deeper waters (Fig. 6). Life on a shoal was profusive and very likely included plant life other than Ivanovia. Some of the algae may have had a cycle like that of Penicillus, which upon death disintegrates into a multitude of carbonate crystals; these needle-like crystals form the bulk of the particles in many Recent calcareous muds. Suspension of such particles in the sea water of cycle 1 would have imparted turbidity which, if not removed, would have considerably reduced transmission of the sunlight so needed by many organisms. Assuming these particles were present, as evidenced by numerous mud lenses, then they must have been deposited quickly on the shoals or were washed away so as not to interfere with the life processes of associated organisms. In the channels, where mostly sponges lived, energy was low and the waters probably remained turbid. Channel water circulation was shoalward at the surface and off-shoalward on the bottom, which is comparable to circulation in modern estuaries. The shoalward currents winnowed away some of the suspended mud-size particles on the shoal, and countercurrents carried them into the channels and off-shoal area, dropping the particles as current capacity and competency diminished. Figure 9 illustrates the thickness and facies distribution at the end of deposition of the ivanovia facies.

Upshoal migration of the ivanovia facies ceased with the maximum transgression of the sea. Regression resulted in the restriction of the basin, and with the evaporation and increasing salinity of the confined waters, currents of denser brines began to flow into submarine depressions. The rapidity of regressive movement is suggested by the asymmetry of a Paradox basin phase curve (Fig. 4), which is comparable to the asymmetry found in a Midcontinent phase curve (Fig. 3).

The lowering of base level rejuvenated erosion on portions of the surrour 'ing highlands, and coarse terrigenous clastics again washed into the basin. On the shoals, sediments of the pelletal mud facies regressed over those of the ivanovia facies. Contemporaneous coarse terrigenous clastics, not found on the shoals, onlap the pelletal mud and ivanovia facies. In off-shore depressions, evaporites were precipitated in the order of deposition established by Usiglio (from Clarke, 1924, p. 220): calcium sulfate, sodium chloride, potash salts. Facies distribution at the end of cycle 1 is shown on Figure 10.

From: SHELF CARBONATES OF THE PARADOX BASIN, A SYMPOSIUM, 1963,
Four Corners Geological Society, Source 12 a.

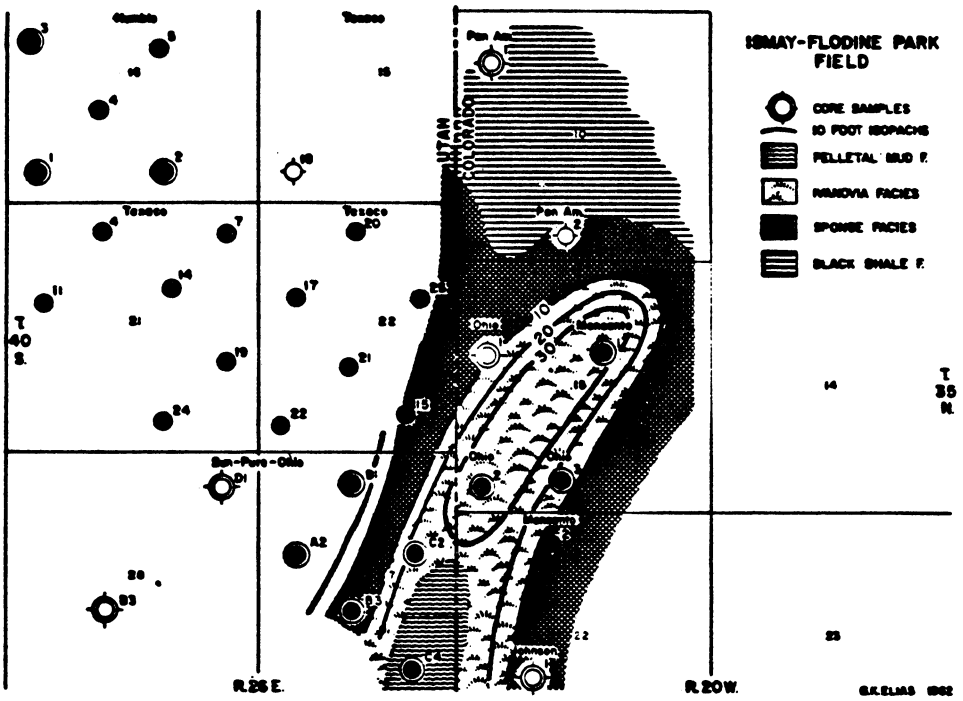


FIG. 9.——Isopach map and distribution of Ivanovia facies and contemporaneous facies at end of transgressive phase of cycle 1 Ismay zone. The Ivanovia plants grew only on carbonate-mud substrates located on earlier-formed ridges in the shoal environment. The best interparticle primary porosity, formed by winnowing of the Ivanovia facies, is commonly found near the channels and at the basinal edge of the bioherm.

SIGNIFICANCE OF BIOHERM-EVAPORITE-TECTONISM RELATIONSHIP

Figure 11 illustrates an area containing cycle 1 evaporites and also shows the axial trends of enclosing northwest-trending structures. Note that cycle 1 evaporites occupy a synclinal position. Since evaporites are likely to be deposited in submarine depressions, the synclinal position may suggest that the submarine depression was tectonically controlled and that it was into such tectonic sags that heavy salt-laden water flowed during the regressive phase of the depositional cycle. This concept is not out of harmony with other evidence for the age of folding. The anticlinal axes to the north, which parallel those enclosing the cycle 1 evaporites (Fig. 11), are the famous salt flowage anticlines of the Paradox basin. Work by Stokes (1956) and Elston (1960) have dated tectonic movement or the salt anticlines as far back as the Pennsylvanian Period.

If tectonic sags occurred, it stands to reason that tectonic highs also resulted. The area of study has revealed the presence of bioherms on the southern edge of cycle 1 evaporites. Other bioherms are also found in many cycles along the northern edge. The relationship between bioherm, evaporite, and structure strongly suggests that the northwest-trending folds are areas where bioherms are likely to be found.

PALEOGEOGRAPHY

The geometry and origin of local bioherms containing important reservoirs has been interpreted. It is equally important to reconstruct the ancient regional setting (paleogeography) in order to predict the probable geographic distribution of similar bodies. Interpretations of the paleogeography of a basin often arouse great controversy. However, virtually every worker who has described the Paradox basin has interpreted it to have been a shallow sea located on the western margin of the craton. Positive areas surrounding the basin are well-known. Nor is there any controversy over the origin of the evaporites; all agree that excessive evaporation of confined marine waters produced them. The major controversy, then, concerns the identity of the carbonate bioherms and the processes which produced the cyclical deposits.

From: SHELF CARBONATES OF THE PARADOX BASIN, A SYMPOSIUM,1963,
Four Corners Geological Society, Source 12 a.

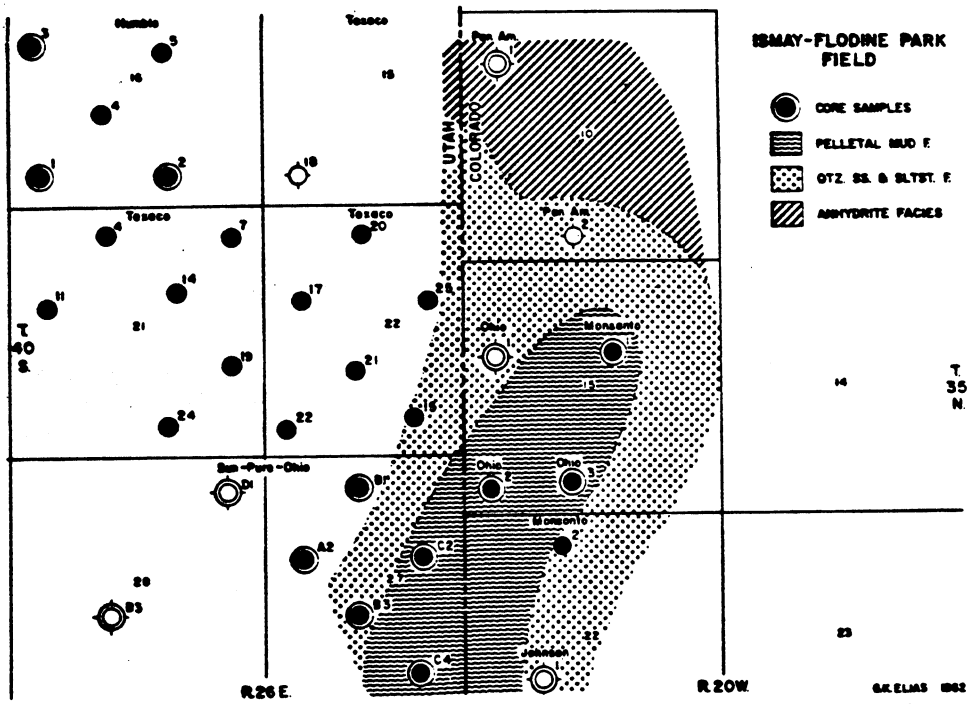


FIG. 10.—Geographic distribution of facies at the end of the regressive phase of cycle 1 Ismay zone. The pelletal mud facies regressed over the ivanovia facies on the ridges; quartz sands and silts were deposited in the channels and on the basinal edge of the bioherm; evaporites were precipitated in nearby, shallow topographic depressions.

The nature and amount of carbonate deposits found within the Paradox basin are evidence that the basin contained warm marine waters. The presence of evaporites implies a warm, arid climate. Work by Opdyke and Runcorn (1960) on ancient polar migration suggests that the equator was only slightly south of the Paradox basin during Pennsylvanian time and that the prevailing wind direction was from the north.

Thus, the Paradox basin was a rather quiet, broad, shallow sea lying on the western shelf of the craton. Within this semi-enclosed basin of warm water were tectonically produced shoals on which were deposited sediments of the pelletal mud facies and, occasionally, the ivanovia facies. The environment yielding the pelletal mud facies can be compared with the sheltered waters west of Andros Island in the Bahamas, or with Florida Bay where calcareous muds and stromatolitic algal mats abound. The environment yielding the ivanovia facies may possibly be compared with the area between the Florida Keys and their fringing reefs, where slightly energized shallow waters surround carbonate mud banks with erect algae. Ivanovia carpets may also be compared with the Halimeda meadows which are so common in lagoons throughout the equatorial belt. All of these analogies are in shallow-water areas on the leeward side of shelf or platform margins.

Occurrence of evaporites when considered together with tectonic framework provides a simple solution to the hydrography of the Paradox basin. On Figure 12, a scaled comparison is made between the interpreted paleogeography of the Paradox basin and the present-day geography of the Gulf of Karabugas, which lies on the eastern side of the Caspian Sea (Grabau, 1960, p. 353). At Karabugas, the hydrographic threshold consists of a narrow spit-like barrier, and Caspian Sea waters enter the restricted gulf by means of a strait through the barrier. Excessive evaporation within the gulf is causing sulfate salts to be precipitated. Should the threshold become a more effective barrier, salinity would increase and chlorides would be deposited. However, a rise in sea level with respect to the spit would freshen the enclosed Karabugas waters, and precipitation of salts would lessen or cease depending on the degree of circulation obtained.

Utah - Greater Aneth
(Aneth Unit)
Paradox - Ismay & Desert Creek
Paradox Basin

DATA SOURCE CODE		
5a	STATE	Utah
5a	COUNTY	San Juan
5a	REGULATORY DISTRICT	Paradox
1	BASIN	Paradox
	SUB-BASIN	
5a	FIELD	Greater Aneth area - Aneth field
5a	RESERVOIR	Ismay and Desert Creek
5a,1	GEOLOGIC AGE	Pennsylvanian - Des Moines
1	AAPG STRATIGRAPHIC AGE CODE	325
5a,	RESERVOIR LITHOLOGY	Reef limestone - dolomite
5a,12	TRAPPING MECHANISM	Carbonate-reeflike; anticlinal closure limited largely by the presence of a permeable reservoir.
5b,1,12,8	DISCOVERY YEAR	1956
5a,5b	PROVED ACREAGE	480, 16,720
12,5a,5b	REGULAR WELL SPACING (acres/well)	80, 80, 40
5a,1	RESERVOIR DEPTH	5550, 5670
	RESERVOIR THICKNESS	
5a,5b	NET PAY	19' Ismay & 50' Desert Creek; 49'
5b	GROSS	120-205 avg., 175 Desert Creek
	NET/GROSS RATIO	
	POROSITY	
5b	TYPE	Vuggy
5a,5b	FRACTION	.10, .103
	PERMEABILITY	
5b	RANGE	6 - 27 md
5a, 12	AVERAGE	3 md Ismay & 20 md Desert Cr.; 10 avg.
	HORIZONTAL	
	VERTICAL	
	OTHER INFORMATION	
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
1	TOTAL NUMBER OF WELLS	199P
1,5b	PRODUCTION 1976 oil (cum)	93,106; 93,710
5b	PRODUCTION 1977 oil (cum)	96,937.4 mbbls; 91,044.8 mmcf
	PRODUCTION 1978 oil (cum)	
	PRODUCTION 1979 oil (cum)	
12a	PRODUCTION 1-1-77 to 12-1-77	3,227.3 mbbls; 2,260.3 mmcf
12a	SECONDARY RECOVERY RECORDS?	yes
5a,5b	WATER ANALYSIS RECORDS?	yes
	OTHER DATA	
5a,5b	STRUCTURE CONTOUR?	yes
5a,5b	LOGS?	yes
	STRUCTURE SECTION?	
5a,5b	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Aneth
5a	RESERVOIR:	Ismay
5a,5b	PROD. ACRES:	480, 16,770
1	AVG. THICKNESS (FT.):	40
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
5b	WATER SATURATION (S_W):	.23
	OIL SATURATION (S_O):	
5a,5b	PRIMARY DRIVE MECHANISM:	solution gas
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	142 (GG=1.2)
11	SATURATION PRESSURE	2508
5b	RESERVOIR PRESSURE INITIAL (psi):	2170
5a	RESERVOIR PRESSURE LATEST (psi):	1163
5b,5a	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	661, 982
11	GAS OIL RATIO LATEST (GOR) (cf/bbl):	720 (1979)
5a,1,5b	STOCK TANK OIL GRAVITY (°API):	42, 41, 41-42
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
11	MINIMUM MISCIBILITY PRESSURE (MMP):	1757
	ESTIMATED ORIGINAL OIL IN PLACE:	
5b	ESTIMATED PRIMARY OIL RECOVERED:	58,416.6
5b	ESTIMATED ULTIMATE RECOVERY:	135,134.3

OTHER INFORMATION:

Source 12a Western Oil Reporter V-33, No. 10, p.25, October 1976.

5a Water salinity: 220,000 ppm

5b Water salinity: 125,000 - 175,000 ppm NaCl

12b Reference: Peterson, James A., and Ohlen, Henry R., 1963, "Pennsylvanian Shelf Carbonates, Paradox Basin", in Shelf Carbonates of the Paradox Basin-Symposium: Four Corners Geological Society.

et al., 1964, p. 58). The Hermosa is a Middle Pennsylvanian carbonate-evaporite rock section that includes salt and potash beds in the interior of the basin. Paradox is a sedimentary basin; the downwarping and basin filling took place in Pennsylvanian and Permian time. Pre-Pennsylvanian formations present are of Cambrian, Late Devonian, and Mississippian age. Triassic and Jurassic rocks overlie the Pennsylvanian-Permian sediments. The stratigraphic section has a total thickness of about 24,000 feet.

The Paradox basin extends eastward into southwestern Colorado. It is separated from the San Juan basin to the southeast by the Four Corners platform (Figure 32.2). Paradox is bounded on the east and northeast by the Uncompahgre uplift, and on the west and southwest by the San Rafael swell and the Monument uplift (Figure 36.2).

The stratigraphy and tectonic development of Paradox basin have been described by many, including, in more recent years, Parker and Roberts (1963), Ohlen and McIntyre (1965), and Baars (1966). Figure 36.7 (left) shows the column for Paradox basin as exposed on Elk Ridge (Figure 36.1).

The oil and gas production in the Paradox basin, the largest in Utah, is confined to two districts; the southeastern corner of the state in southeastern San Juan County, and to the north in northern San Juan and southern Grand Counties. The southern district is one of local folds, extensive reef mound development, and few faults. It also has much the greater part of the oil produced to date. The northern district has the thickest sedimentary section, most of the salt, all of the potash, and prominent salt-cored faulted anticlines. Oil and gas accumulation in the southern district will be discussed first. Field locations are given in Figure 36.2.

The discovery field for the Paradox basin, and the Four Corners area as well, was Mexican Hat (discussed on p. 432). The *Aneth* field, Utah's greatest, was discovered in 1956 and has subsequently produced over 200 million barrels of oil and has ¼ billion barrels in reserve. Subsequently to the original discovery at Aneth, a considerable number of satellitic fields with similar geology have been found, including the Cache in Colorado (see p. 391). Three close-in fields, the *McElmo Creek*, *Ratherford*, and *White Mesa*, merged with Aneth to become the *Greater Aneth* field (Picard, 1958). The names of the original fields have been retained as secondary recovery units. The reservoirs are two zones in the Hermosa Formation, the Ismay and the prolific Desert Creek (Figure 36.7, right). These are isolated bodies of porous carbonate rock, mainly limestone (Peterson, 1966). The carbonate reservoirs are referred to as algal mounds; they tend to be elliptical with a northwesterly trend. Black carbonaceous dolomite, commonly referred to as shale, which surrounds and overlies the mounds, is the probable source rock.

Regionally, the mounds developed on the southwest flank of the Paradox basin. The northwest trend of many of the mounds is therefore parallel to the regional strike. Figure 36.8 shows, by anticlinal axis symbols, the crests of the Desert Creek reservoir. This reservoir and the higher, scattered Ismay mounds appear to be the only sanctuaries for oil and gas in the Hermosa Formation in this area. The oil fields in Figure 36.8 are stippled. Wherever permeability permitted, the hydrocarbons accumulated in the higher parts of the reservoir. In the case of Greater Aneth, the oil and gas filled not only a large mound on the north side of the field, and the north flank of a faulted mound to the south, but also a considerable part of the intervening syncline. The impoundment of the hydrocarbons is due to both structural and stratigraphic factors. Accumulation in an Aneth type of trap is illustrated by the structure map and cross section in Figure 33.8 (Chapter 33).

The northern district of the Paradox basin is also the deepest part of the basin. It is dominated by the salt anticlines (Jones, 1959), which occur in a northwest-trending belt (Figure 36.2) about 100 miles long and 30 miles wide, nearly half of which is in Colorado. The major anticlines in this zone are elongate, ranging in length from 30 to 70 miles and in width from 2 to 5 miles (Cater and Elston, 1963). The salt cores themselves are "something like 2 miles high and 2 to 4 miles long" (Joesting and Case, 1960, p. B252). The maximum

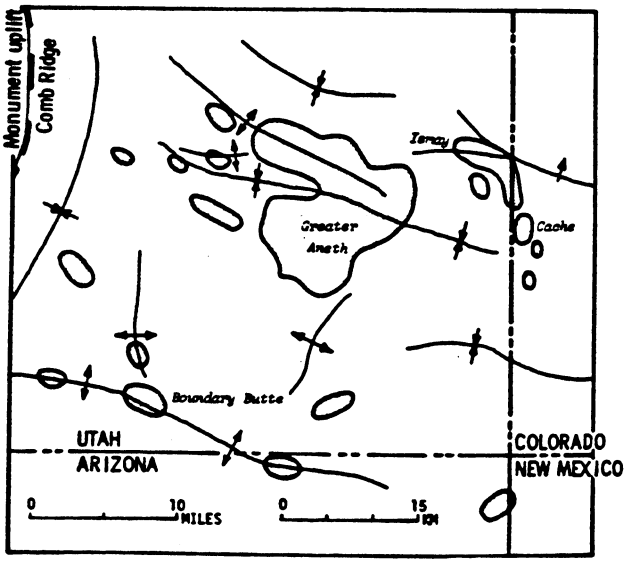


FIGURE 36.8 Aneth area, southeastern Utah and vicinity, showing major anticlinal and synclinal axes. Fields producing from Desert Creek and Ismay cycles are stippled. *Courtesy James A. Peterson (1966, Figure 13, p. 2079) and the American Association of Petroleum Geologists.*

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

ANETH FIELD

In southeastern Utah lies the largest oil field in the State, the Aneth complex. The field is located in San Juan County about twenty-five miles southeast of Blanding on the southern flank of the Paradox Basin. The Aneth complex is composed of four fields; Aneth, McElmo Creek, White Mesa and Ratherford. These fields are currently being formed into four separate Units to facilitate secondary recovery. The Aneth field (Unit) forms the north side of the horseshoe shaped complex and is the largest field of the four.

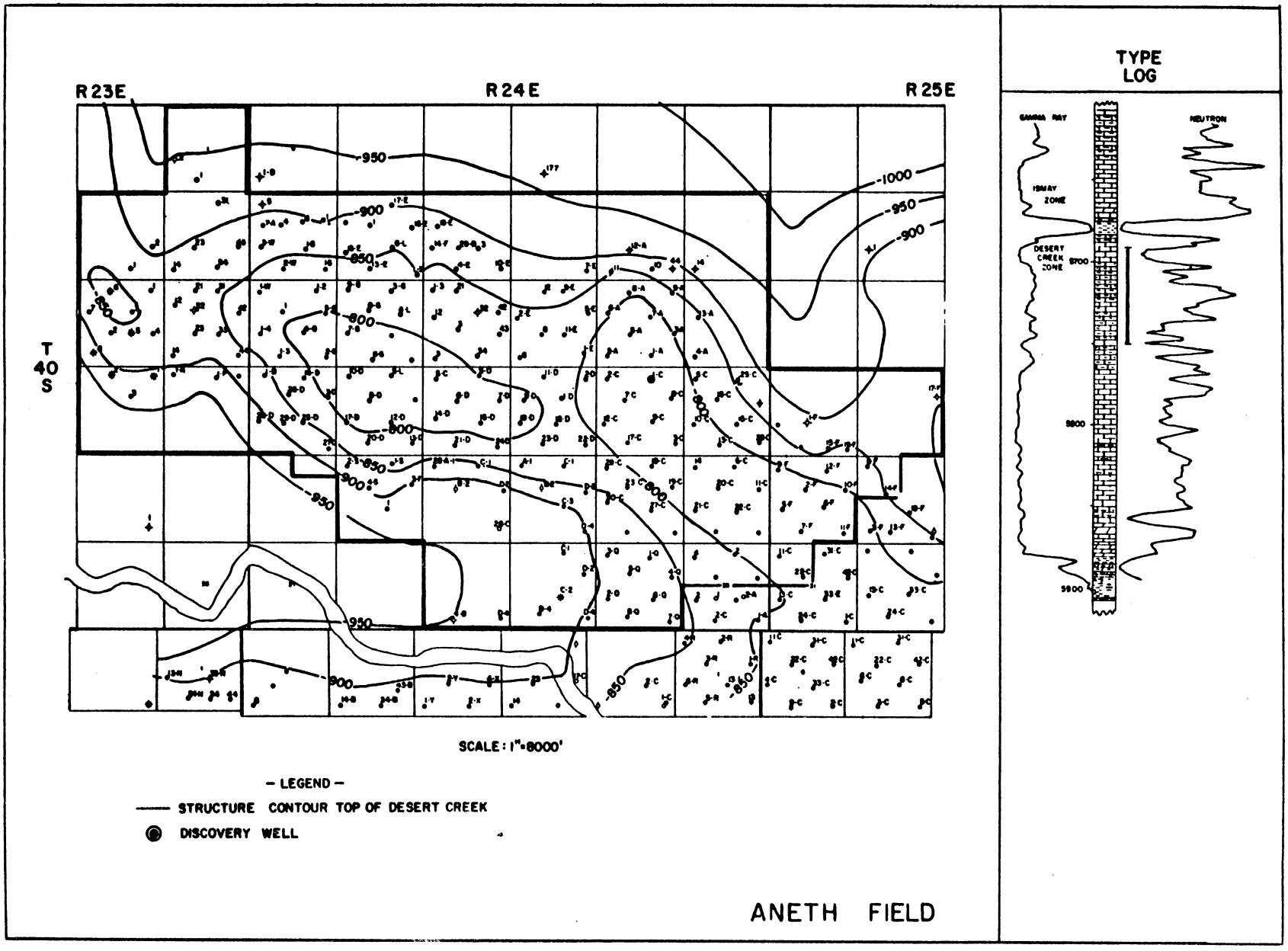
The main producing horizon in the Aneth field is the Desert Creek zone of the Pennsylvanian Paradox formation. The overlying Ismay zone is a minor producer at present. The Desert Creek production in the Aneth complex comes from a reeflike circular mound of porous, fossiliferous carbonates. Th carbonate buildup thins rapidly laterally as it grades into an impermeable shaly limestone section which in turn grades into a carbonate-evaporite facies. This permeability barrier forms the entrapment for oil. A medium gray to tan clastic limestone with lessor secondary dolomite is typical of the Desert Creek producing zone. The limestones are very fossilferous having a preponderance of benthonic forms. Brachiapods, foraminifera and crinoids are abundant whereas bryozoans and pelecypods are less common and corals are rare.

In the Aneth field (Unit) the Desert Creek zone has a maximum thickness of 205 feet. To the northeast, the zone thins abruptly to 120 feet in just over one mile. The average thickness of the Desert Creek zone within the unit is about 175 feet. Structurally, the Aneth field (Unit) is on a northwest trending nose which has about thirty feet of closure in the central part.

The Aneth field was discovered in February 1956 by the Texas Company. The discovery well was drilled in the NW¼ NE¼ of Section 23, Township 40 South, Range 24 East, having an initial flow of 1704 BOPD. The Texas Company discovery was located on a surface anticlinal trend.

REFERENCES

Carter, Kenneth E., 1958, *Stratigraphy of Desert Creek and Ismay Zones And Relationship to Oil, Paradox Basin, Utah, Intermountain Association of Petroleum Geologists Guidebook, Ninth Field Conference, Pages 138-145.*



ANETH FIELD

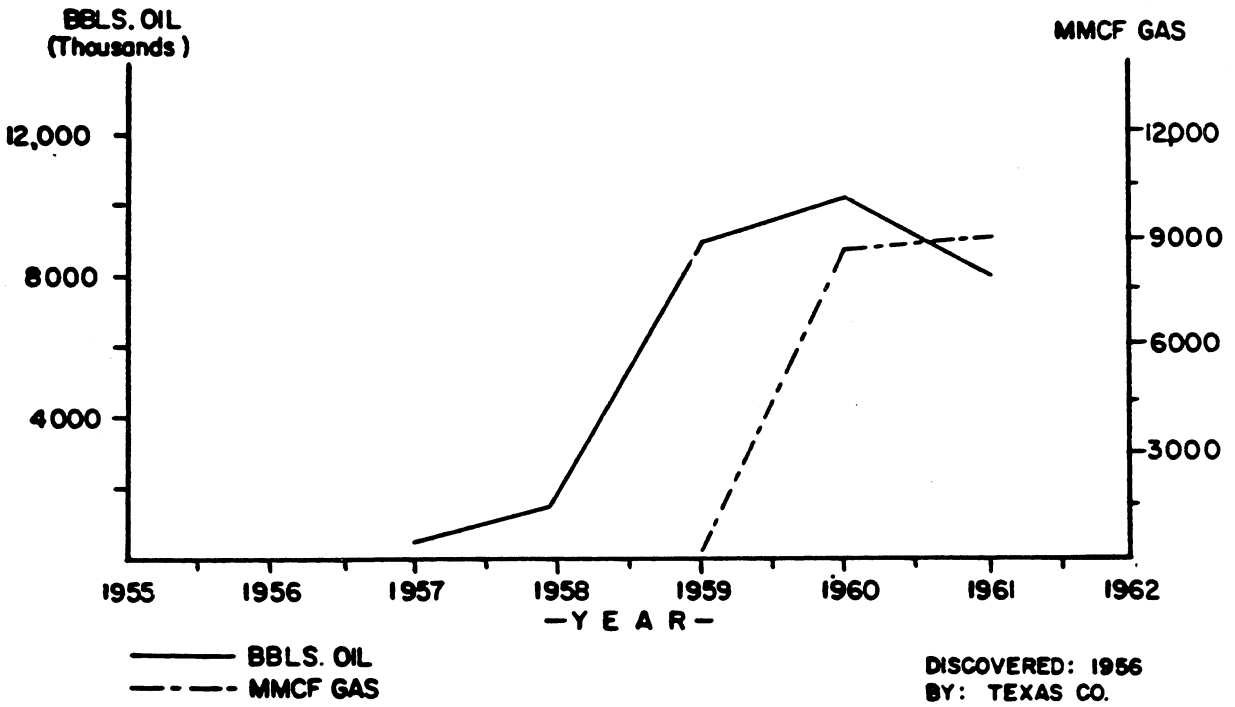
From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

PARADOX BASIN — ANETH FIELD

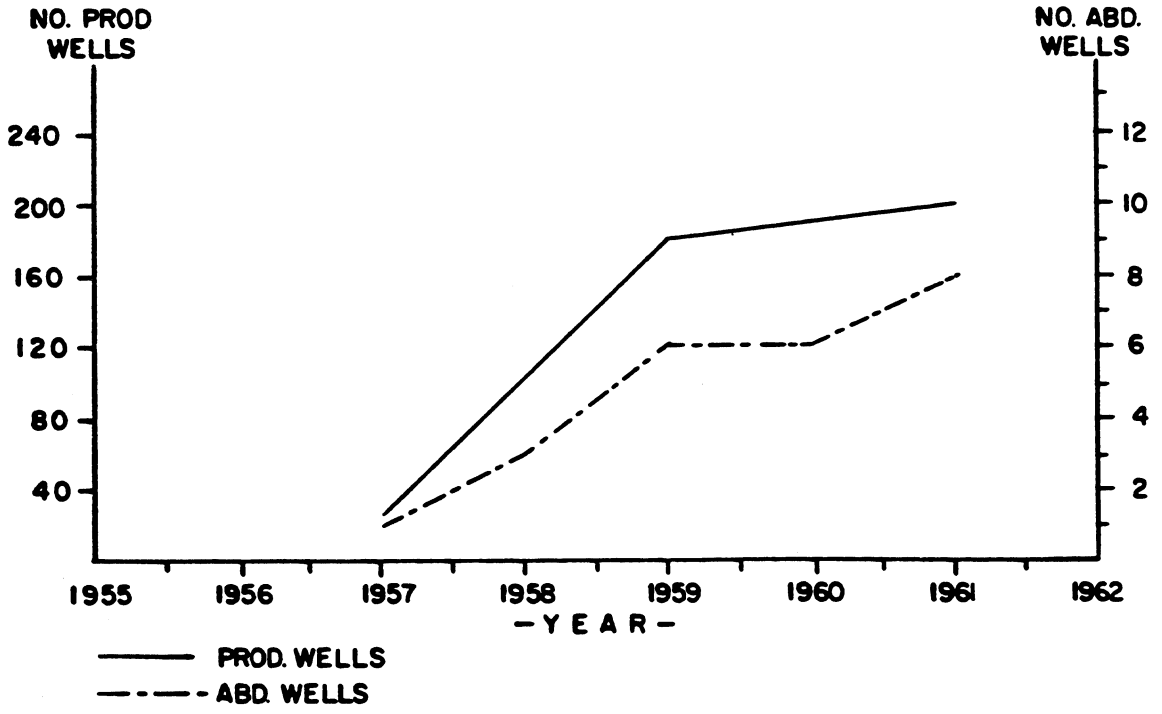
T 40 S , R 23,24,25 E — SAN JUAN COUNTY

HYDROCARBON PRODUCTION



DISCOVERED: 1956
BY: TEXAS CO.

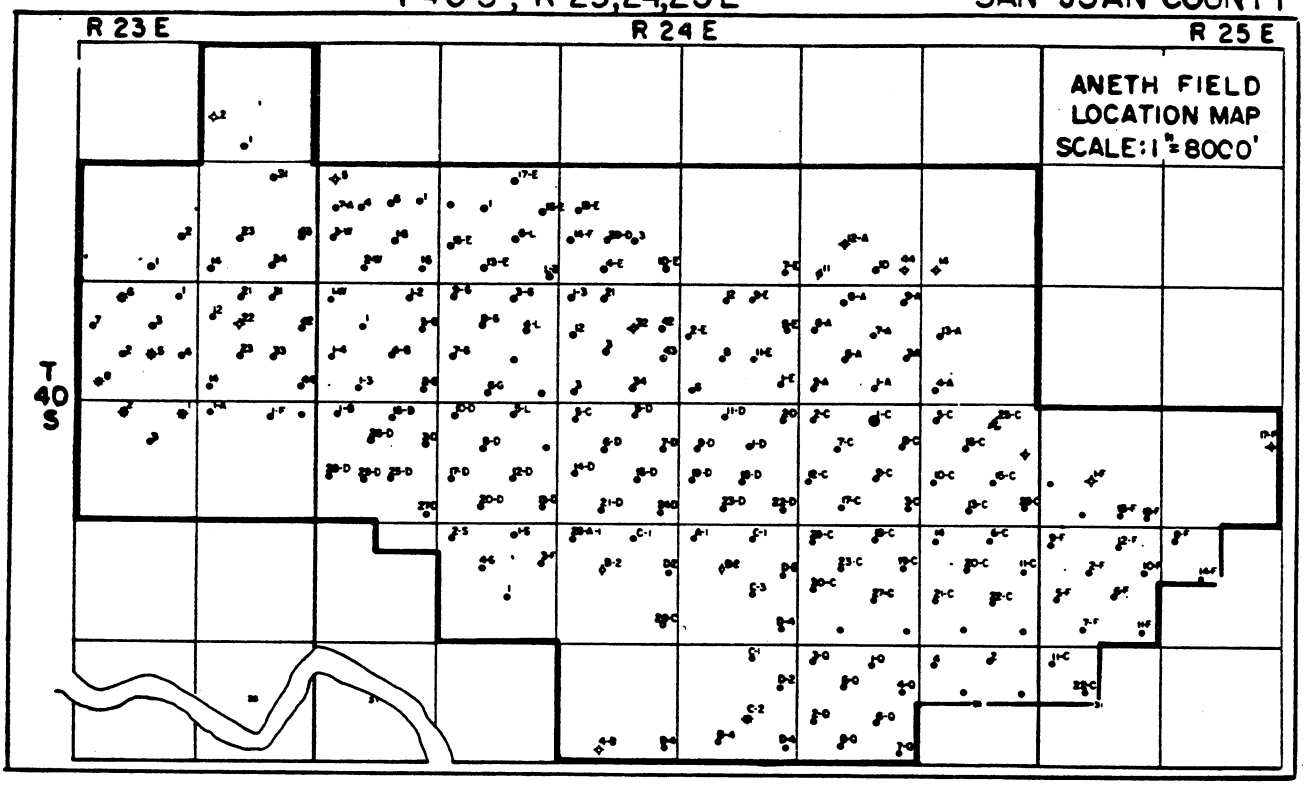
DEVELOPMENT DRILLING



From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

PARADOX BASIN — ANETH FIELD

T40S, R 23,24,25E — SAN JUAN COUNTY



PRODUCTION CHARACTERISTICS

RESERVOIR

FORMATION NAME	AGE	LITH.	AVE DEPTH	NET PAY	INIT. PRESS.	CURR. PRESS.	TYPE DRIVE	% POROS.	PERM dD
HERMOSA FORMATION									
Ismay zone	Penn	Ls & Dol	5550	19'			Sol-gas	10	3
Desert Creek zone	Penn	Ls & Dol	5600	80'	2160 PSI	1163 PSI	Sol-gas	12	20

FLUIDS

FORMATION NAME	GRAVITY	POUR POINT	SULFUR CONTENT	GOR	BTU/FT.³	METHANE	ETHANE	WATER SALINITY	OTHER FLUIDS
HERMOSA FORMATION Ismay zone & Desert Creek zone (Combined)	42° API		0.10	982				200,000 est.	

ECONOMICS

FORMATION NAME	PROD. WELLS	PROD. 1-1-60—1-1-61	CUMULAT. PROD. 1-1-61	$/BBL WELL HEAD	$/MCF WELL HEAD	ULT. RES.	PROVEN ACREAGE	TOTAL WELLS	SPACING
HERMOSA FORMATION Ismay zone & Desert Creek zone (Combined)	203 (includes 4 Ismay wells 197 Desert Creek wells & 2 commingled wells)	8,150,543	29,368,889	2.75	0.17		480 ac Ismay 16 000 ac Desert Creek	213	80 ac

SOURCE 12 b

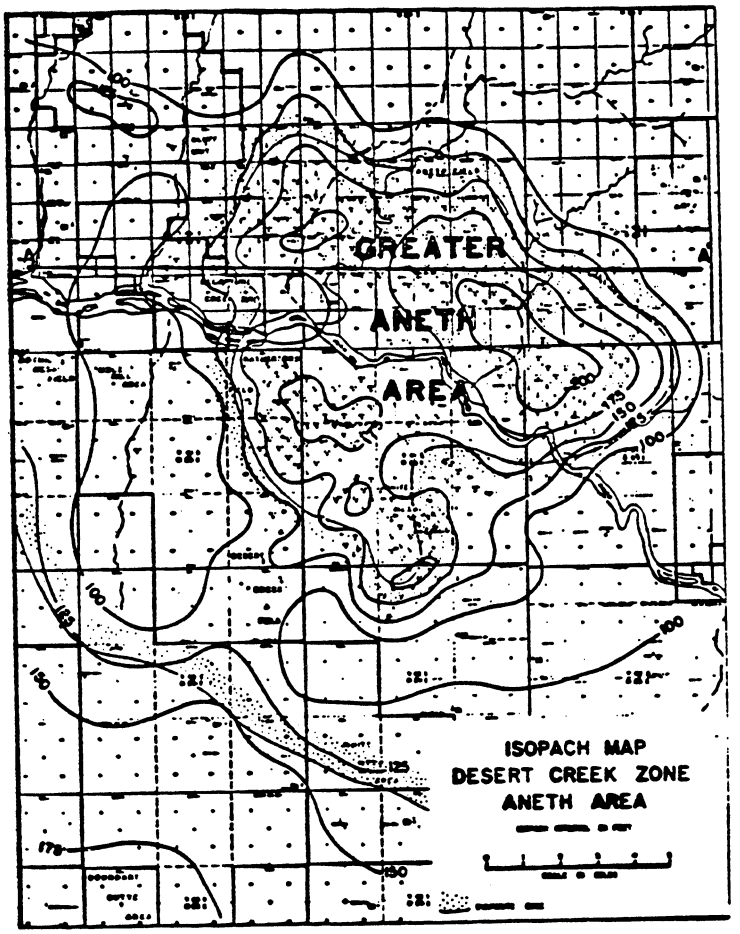


FIG. 12.—Generalized isopach, Desert Creek cycle, Aneth area (after Peterson, 1958). Interval isopached is carbonate-evaporite sequence between black shale intervals.

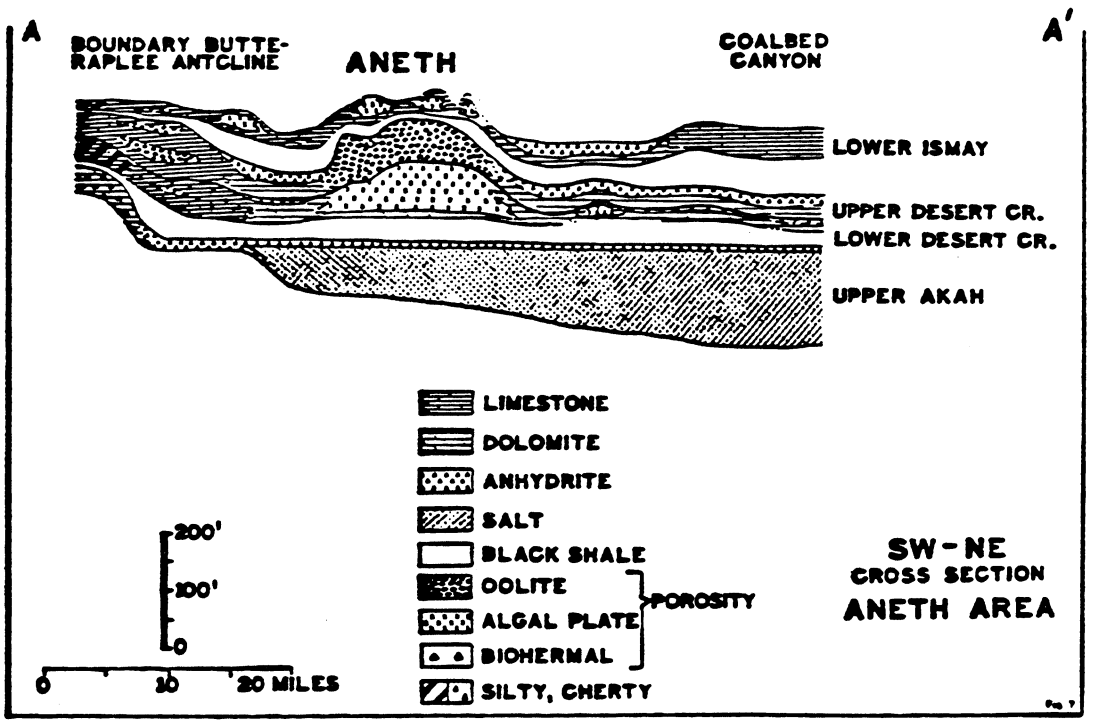


FIG. 11.—Schematic SW-NE cross-section of Ismay, Desert Creek, and Upper Akah cycles showing relation between shelf carbonate mound developments and evaporites. Position of cross-section is shown on Figure 6.

Reference: Peterson, James A., and Ohlen, Henry R., 1963, "Pennsylvanian Shelf Carbonates, Paradox Basin", in Shelf Carbonates of the Paradox Basin-Symposium: Four Corners Geological Society.

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 5b.

ANETH (ANETH UNIT)

(Oil)
T. 40 S., R. 23-25 E., SLPM
San Juan County, Utah

By: Paul E. Babcock
The Superior Oil Company

GEOLOGY

Regional Setting: Southeastern San Juan County, Utah

Surface Formations: Jurassic, Morrison Formation

Exploration Method Leading to Discovery: Subsurface geology

Type of Trap: Primarily stratigraphic

Producing Formation: Pennsylvanian, Desert Creek and Ismay Zones of Paradox Formation

Gross Thickness and Lithology of Reservoir Rocks: 130 to 195 feet limestones, both oolitic and algal

Geometry of Reservoir Rock: Bioherm

Other Significant Shows: None

Oldest Stratigraphic Horizon Penetrated: Mississippian

DISCOVERY WELL

Name: Texaco No. 1 Navajo C (currently known as Texaco No. G-123 Aneth Unit)

Location: NW NE sec. 23, T. 40 S., R. 24 E.

Elevation (KB): 4,922 feet

Date of Completion: February 6, 1956

Total Depth: 5,923 feet

Production Casing: 7 5/8" at 5,923 feet with 150 sacks of cement

Perforations: 5,828 to 5,874 feet with 4 shots per foot

Stimulation: Washed perforations with 500 gallons mud acid

Initial Potential: Flow 1,704 BOD

Bottom Hole Pressure: Shut-in pressure 2,170 psi at datum of -930 feet

DRILLING AND COMPLETION PRACTICES

8 5/8" surface casing at 550 feet with 200 sacks of cement, 5½" casing at total depth or 13 3/8" conductor casing at 100 feet, 8 5/8" surface casing at 1,500 feet, 5½" casing at total depth; perforate and stimulate with hydrochloric acid.

RESERVOIR DATA

Productive Area:
Proved (as determined geologically): 16,720 acres
Unproved: None
Approved Spacing: 40 acres
No. of Producing Wells: 194
No. of Injecting wells: 101
No. of Abandoned Wells: 19 (including temporarily abandoned)
No. of Dry Holes: 3

Average Net Pay: 49 feet

Porosity: 10.3 percent

Permeability: 6 to 27 millidarcies

Water Saturation: 23.3 percent

Initial Field Pressure: 2,170 psi at datum (-930 feet)

Type of Drive: Fluid expansion and solution gas drive

Gas Characteristics and Analysis: Solution gas, original gas-oil ratio 661

Oil Characteristics and Analysis: 41° to 42° API gravity, low sulfur, viscosity .540 cp

Associated Water Characteristics and Analysis: Salt water, 125,000 to 175,000 ppm NaCl concentration

Original Gas, Oil, and Water Contact Datums: Oil-water contact -960 feet

Estimated Primary Recovery: 58,416,612 BO (15.13 percent)

Type of Secondary Recovery: Water injection program

Estimated Ultimate Recovery: 135,134,265 BO (35 percent)

Present Daily Average Production: 8,677 BOD (November, 1977)

Market Outlets: Oil: Texas-New Mexico Pipeline; gas: El Paso Natural Gas Co.

FIELD COMMENTARY

The Aneth Unit of the Greater Aneth Field is located five miles northwest of the Navajo town of Aneth, San Juan County, Utah. The Aneth Unit extends 9½ miles from east to west with the western portion located off the Navajo Reservation. The Texas Company (later to become Texaco, and present unit operator) discovered the Greater Aneth Field in 1956 with the drilling of the No. 1 Navajo C. Numerous operators, through subsequent drilling, discovered several fields that were later defined as one continuous oil pool, the Greater Aneth Field.

The typical, Aneth Unit well log (on map), illustrates the number of subzones and various porous units in the Desert Creek. The Desert Creek was deposited upon the Chimney Rock Shale and is overlain and sealed vertically, by the black, sapropelic, Gothic Shale. The Aneth Unit produces from a lower, Zone II, which is predominately composed of algal plate mounds; and an upper, Zone I, an oolitic-pelletoidal limestone. In addition to the primary porosity associated with these limestones, the reservoir quality may be enhanced by solution formed vuggy porosity and secondary dolomitization.

A possible explanation for the algal carbonate mound placement at Greater Aneth Field is offered by Peterson and Hite (1969). They suggest the presence of a basal Desert Creek, longshore current-formed mud bar, which may have formed a slight high on the basin floor. This positive relief might have been the critical factor accounting for the proliferation of the phylloid algae, *Ivanovia*. In addition, a topographic high prior to the Desert Creek depositional cycle is considered as a possible cause for the anchoring of the algae. Environmental conditions including water depth, salinity, circulation, etc., were exceptionally suitable for the

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

ANETH (ANETH UNIT)

widespread growth of these algal mounds. These algae actually increased the carbonate thickness of the Desert Creek through supplying and trapping of sediments.

The rapid thinning of the Desert Creek limestone away from the field area is due to the absence of the algal mounds. Typically, the Desert Creek interval outside of the Greater Aneth complex is less than 100 feet thick; whereas, in the field area, the same interval has attained thicknesses of 200 feet. Combined pay thicknesses of the Zone I and II Desert Creek in the Aneth Unit reach 90 feet. Lateral productive limits in the Aneth Unit result from porosity and permeability pinchouts except for the southeastern unit area, where good porous intervals dip below an oil-water contact at -960 feet. The relief created by the variation between the thick productive intervals and the thinner regional Desert Creek was not sustained through later depositional environments. Hence, there is no surface expression for these Desert Creek productive fields.

The Aneth Unit is the result of the September, 1961, unitization of the Greater Aneth Field. Texaco as operator reported cumulative unit production through 1977, to be 96,937,388 BO and 91,044,754 MCF.

REFERENCES

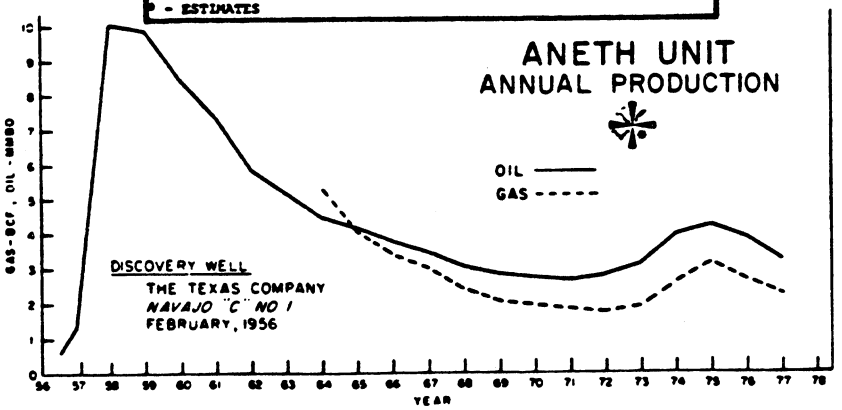
Peterson, V. A., and Hite, R. J., 1969, Pennsylvanian evaporite-carbonate cycles and their relation to petroleum occurrence, Southern Rocky Mountains: Amer. Assoc. of Petroleum Geologists Bull., v. 53, p. 884-908.

The Superior Oil Company files.

Texaco Oil Company (Operator—Aneth Unit) files.

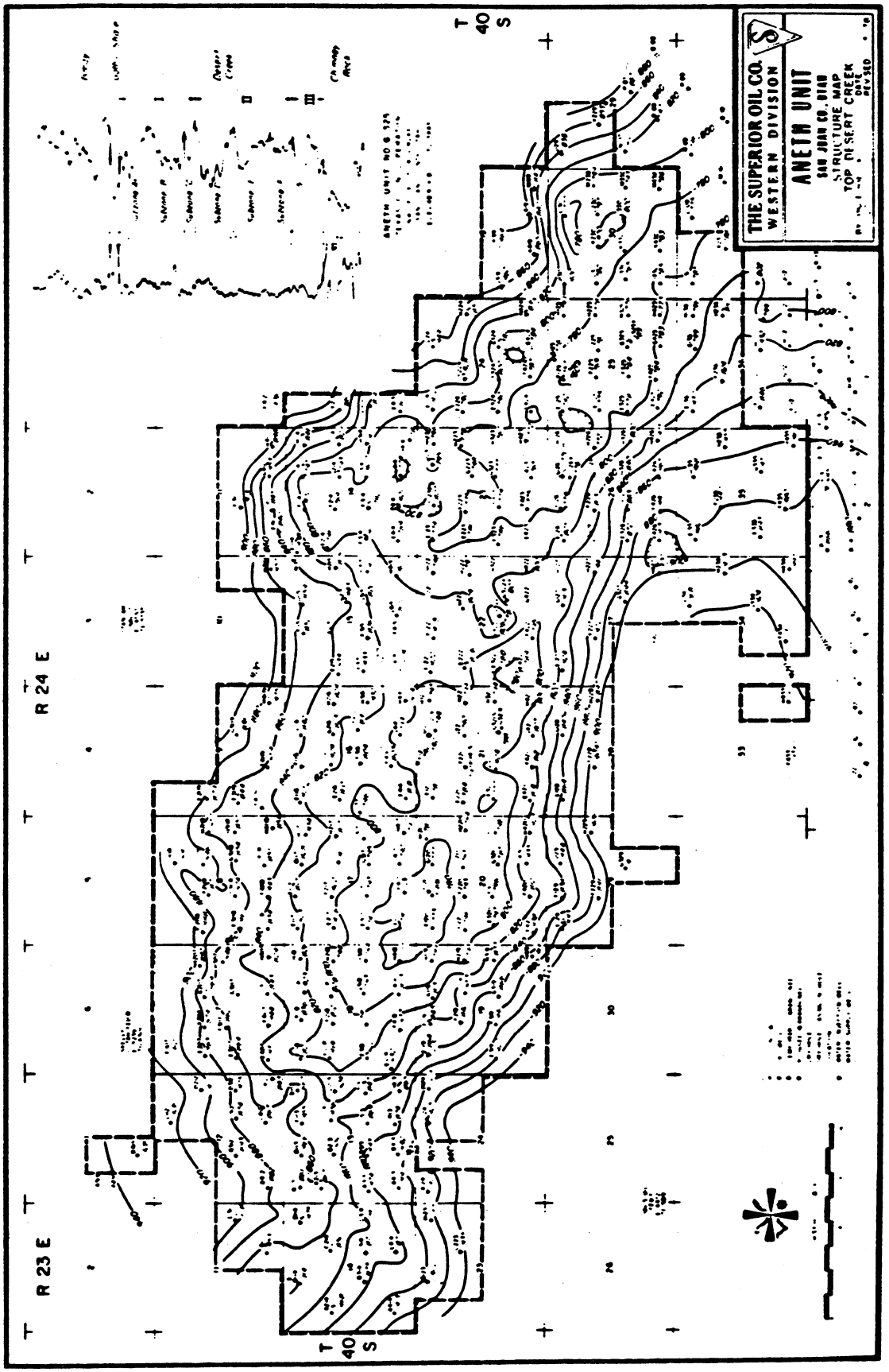
NO. OF WELLS @ YR. END					PRODUCTION OIL IN BARRELS GAS IN MCF	
YEAR	TYPE	PROD.	INJECT.	ST/ABN	ANNUAL	CUMULATIVE
•1956	OIL				543,560	543,560
	GAS					
•1957	OIL				1,345,600	1,889,160
	GAS					
•1958	OIL				10,026,375	11,915,535
	GAS					
•1959	OIL				9,860,200	21,775,735
	GAS					
•1960	OIL				8,408,600	30,184,335
	GAS					
•1961	OIL				7,341,200	37,525,535
	GAS					
1962	OIL	152	58	3	5,868,582	43,394,117
	GAS					45,981,809
1963	OIL	147	55	12	5,148,061	48,542,178
	GAS				6,622,273	52,604,082
1964	OIL	140	62	12	4,658,430	53,200,608
	GAS				5,328,874	57,932,956
1965	OIL	131	61	21	4,175,987	57,176,595
	GAS				4,076,450	62,009,406
1966	OIL	137	64	14	1,796,487	60,973,082
	GAS				3,417,490	65,426,896
1967	OIL	127	75	14	1,472,857	64,445,939
	GAS				1,010,116	65,437,012
1968	OIL	133	76	7	3,053,436	67,499,375
	GAS				2,421,946	70,856,958
1969	OIL	129	64	23	2,849,002	70,348,377
	GAS				2,073,471	72,932,429
1970	OIL	126	75	15	2,747,543	73,095,920
	GAS				1,945,142	74,877,571
1971	OIL	124	83	10	2,679,455	75,775,376
	GAS				1,845,169	76,722,740
1972	OIL				2,822,699	78,598,077
	GAS				1,762,537	78,485,277
1973	OIL	121	80	24	3,113,852	81,711,929
	GAS				1,910,632	80,395,909
1974	OIL	162	81	23	3,914,129	85,626,058
	GAS				2,592,250	82,988,159
1975	OIL	188	85	21	4,234,203	89,860,261
	GAS				3,140,739	86,128,898
1976	OIL	199	83	27	3,849,852	93,710,113
	GAS				2,655,531	88,784,429
1977	OIL	197	101	19	3,227,275	96,937,388
	GAS				2,260,325	91,044,754

• - ESTIMATES



[Four Corners Geological Society]

ANETH (ANETH UNIT)



From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

Utah - Greater Aneth (McElmo Creek Unit)
Paradox - Ismay & Desert Creek
Paradox Basin

DATA SOURCE CODE		
5a	STATE	Utah
	COUNTY	San Juan
	REGULATORY DISTRICT	
5a	BASIN	Paradox
	SUB-BASIN	
12,5a,5b	FIELD	Greater Aneth McElmo Creek
5a	RESERVOIR	Ismay & Desert Creek
5a	GEOLOGIC AGE	Pennsylvanian - Des Moines
1	AAPG STRATIGRAPHIC AGE CODE	325
5a	RESERVOIR LITHOLOGY	Ismay: limestone & dolomite; Desert Creek: limestone, lacerated, fossiliferous (algal) and oolitic.
5a,5b,12a	TRAPPING MECHANISM	Stratigraphic - algal mound; variable reservoir characteristics; combination stratigraphic and structural.
5b	DISCOVERY YEAR	1957
5a,5b	PROVED ACREAGE	8000, 12,640
5a, 5b	REGULAR WELL SPACING (acres/well)	80 with 160 flood; 40 with 80 flood
5a, 5b	RESERVOIR DEPTH	5500
	RESERVOIR THICKNESS	
5a,5b	NET PAY	58; 150 avg.; 15' Ismay, 50' Desert Cr
5b	GROSS	100-205 ft.
	NET/GROSS RATIO	
	POROSITY	
12	TYPE	V, IC - Desert Creek
5a,5b,12a	FRACTION	.076 Ismay & .15 Desert Cr.; .09-.13; .10-.12
	PERMEABILITY	
5b	RANGE	6-27 md
5a,12a	AVERAGE	10.4 md, 10 md
	HORIZONTAL	
	VERTICAL	
12a	OTHER INFORMATION	CO_2 prospect by Phillips, Superior and Continental
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
5b	TOTAL NUMBER OF WELLS	247 (164P, 63WI, 17A, 3DH)
5b	PRODUCTION 1976 oil (cum)	96,489 mbbls oil; 8453 mmcf gas
5b	PRODUCTION 1977 oil (cum)	100,129.1 mbbls oil; 8778 mmcf gas
	PRODUCTION 1978 oil (cum)	
	PRODUCTION 1979 oil (cum)	
	PRODUCTION 1-1-77 to 1-1-78	3640.3 mbbls oil; 2725.6 mmcf gas
5a,12a	SECONDARY RECOVERY RECORDS?	waterflood, tertiary prospect
5a,5b	WATER ANALYSIS RECORDS?	yes
	OTHER DATA	
5a	STRUCTURE CONTOUR?	yes
5a	LOGS?	yes
12a	STRUCTURE SECTION?	yes
5a	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	McElmo Creek
5a	RESERVOIR:	Ismay
5a, 5b	PROD. ACRES:	8000, 12,640
5a	AVG. THICKNESS (FT.):	150
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
5b	WATER SATURATION (S_W):	.22
	OIL SATURATION (S_O):	
5a, 5b	PRIMARY DRIVE MECHANISM:	solution gas
	PRIMARY GAS CAP?:	
	TEMPERATURE (°F):	
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
5b	RESERVOIR PRESSURE INITIAL (psi):	2170
	RESERVOIR PRESSURE LATEST (psi):	
5b, 5a	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	661, 696
5a	GAS OIL RATIO LATEST (GOR) (cf/bbl):	950 (1978)
5a, 5b	STOCK TANK OIL GRAVITY (°API):	41.6, 41-42
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
5a,5b	ESTIMATED ORIGINAL OIL:	120,000 mbbls; 137,500
5b	ESTIMATED PRIMARY OIL:	64,400 mbbls
5a	Estimated Secondary Oil:	62,000 mbbls
	OTHER INFORMATION:	

Source 12a: Western Oil Reporter V-33, No. 10, p.25, October 1976.

Source 5b: Includes both Ismay and Desert Creek.

5a Water salinity: 200,000 ppm

5b Water salinity 125,000 to 175,000 ppm NaCl

5a Waterflood - peripheral pattern - Texaco and Superior major operators

12b Reference: Peterson, James A., and Ohlen, Henry R., 1963, "Pennsylvanian Shelf Carbonate, Paradox Basin", in Shelf Carbonates of the Paradox Basin: Four Corners Geological Survey.

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

THE MC ELMO CREEK UNIT

On the southern margin of the Paradox Salt basin and within the Navajo Indian Reservation of southeastern Utah lies the largest oil field in the State – Aneth, now known as the Aneth Complex. In order to facilitate secondary recovery, this field, comprising over 550 wells, is being formed into four separate units: Aneth, Ratherford, White Mesa, and McElmo Creek.

The Aneth Complex is a distinctive geologic feature. On the surface it is faintly expressed in the gently dipping (dips are generally less than one degree) Morrison formation as a curved, elongate anticline, matching the Mississippian structure beneath it. In the subsurface the Complex is a circular mound or "build-up" in the Desert Creek zone, which lies in the upper part of the Paradox (evaporite) member of the Hermosa formation. Within the Complex the Desert Creek zone is a brecciated, fossiliferous (mainly algal), and oolitic limestone. This bioclastic limestone, the principal reservoir, appears to have been deposited on a submarine shelf – not a pronounced topographic high. Favorable current action and depth of water supported a biota predominantly composed of a blue-green algae (Ivanovia) and crinoids. Foraminifera, brachiopods, pelecypods, sponges, bryozoans and ostracods were present. Corals were rare. This luxuriant growth was repeatedly ravaged and broken up by storm waves and thus deposited. The build-up at times may have been above wave base. At any rate, most of the Complex was sufficiently high to avoid the anhydrite that was intermittently deposited around it. Water saturated with calcium sulfate could not have sustained the above mentioned biota; thus, the anhydrite beds may be represented in the Complex by diastems and/or beds of oolitic limestone. At the top of the Desert Creek zone the limestone containing abundant oolites and oocasts appears to be correlative with the anhydrite which caps this zone off the build-up.

Some geologists regard the build-up as a reef, and it indeed resembles the "Scurry reef" of West Texas. Bedding is poorly developed; and abrupt facies changes occur throughout the Complex – both vertically and horizontally.

At the edge of the build-up the Desert Creek zone thins sharply into a section of impermeable, shaley limestone interspaced with thin beds of anhydrite and dark gray shale. It is this permeability pinch-out along the southern edge of the Aneth Complex – the updip edge – that effects the entrapment. The gross oil column in the Desert Creek zone, measured from the structurally highest perforation to the oil-water contact (at approximately –960 feet), is 275 feet.

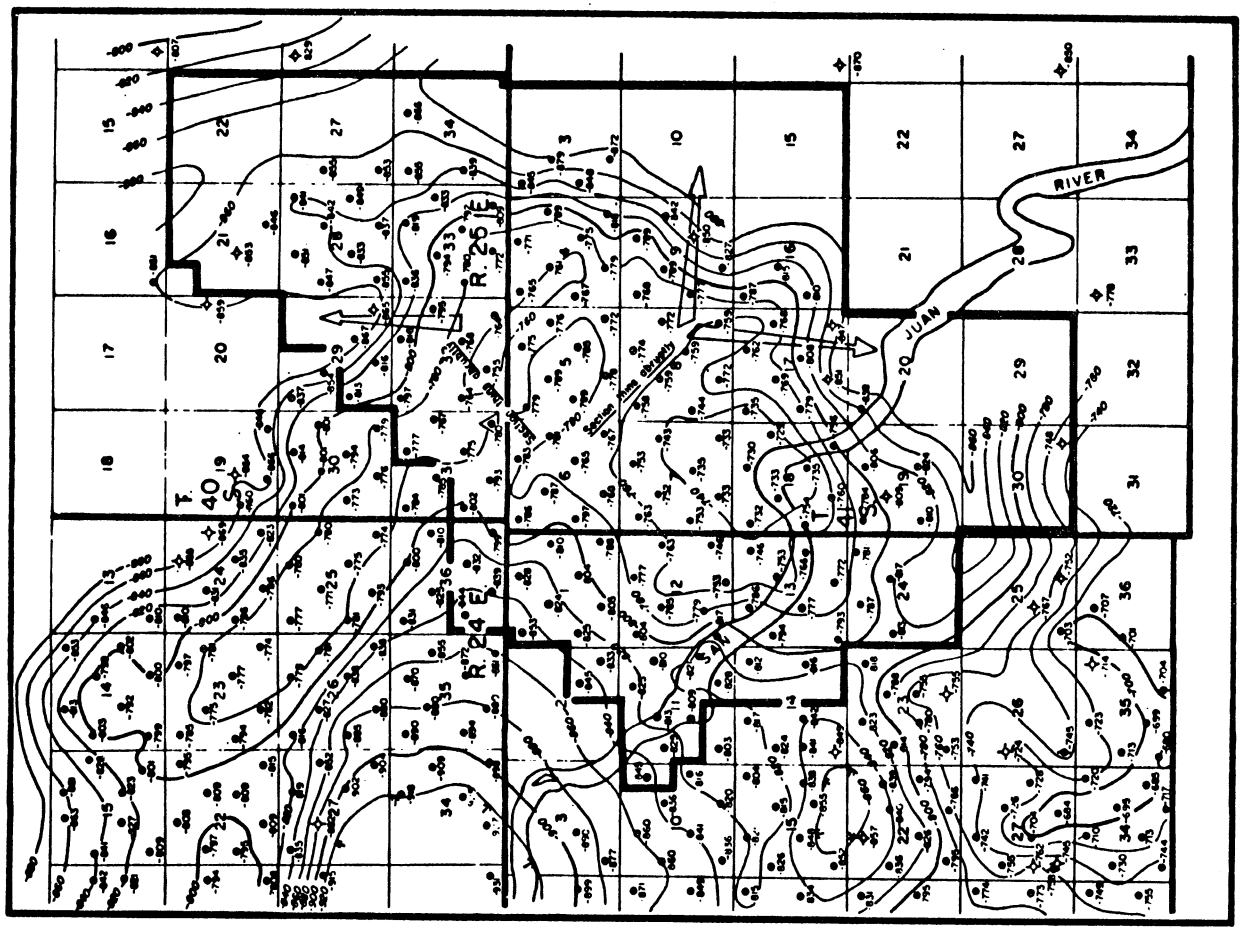
The Ismay zone, which lies above the Desert Creek zone and is separated from it by the Gothic shale (from 4 to 20 feet thick), is a poor and erratic limestone reservoir. The average total thickness of the Ismay zone is about 150 feet. The scant production is from the lower 50 feet of the zone where the net pay thickness averages about 15 feet.

The first well drilled in the Mc Elmo Creek was the Superior-Navajo "C-1 (SE-SE Section 31-T40S-R25E), completed in January, 1957 for 1215 BOPD. This well represented a three mile step-out from the closest well in the Aneth area, which, at that time, consisted of twenty-two producing wells and one dry hole, the Texas-Navajo "F"-1 (Section 19, T40S-R25E). The Mc Elmo Creek Unit, as delineated by the Mc Elmo Creek Engineering Committee, includes the old "Cahone Mesa" area. The companies represented are Phillips, Humble, Continental, Texaco, Aztec and Superior – the unit operator.

The average IP of the wells in the Mc Elmo Creek Unit is about 900 BOPD. Most of the 151 wells in the Unit are capable of producing the field allowable from the Desert Creek zone alone; thus, most of the production from the Ismay zone has been left "behind the pipe" for future exploitation. The oil-water contact in the Ismay varies from –709 to –822 feet.

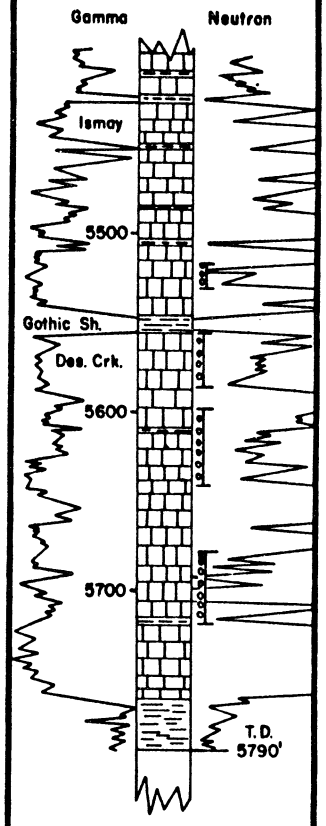
Of the estimated 363 million barrels of oil in place in the Mc Elmo Creek Unit the ultimate recovery will approximate 120 million barrels of "sweet" paraffinic oil, 62 million barrels of which will be attributed to secondary recovery. In the water-flood program now being initiated, water-injection wells around the margins of the Unit will flush the oil towards the center where it is structurally high. Water flooding programs are, of course, being initiated in the other units as well.

The Aneth Complex is served by two 16-inch crude-oil pipeline systems: The Four Corners Pipeline, which terminates at Los Angeles, and the Texas - New Mexico Pipe Line, which leads to Jal in southeastern New Mexico. In addition, El Paso Natural Gas Company operates a gasoline-extraction plant at the field. This plant, with a capacity of about 100,000 MCFPD, is connected to El Paso's plant at Chaco, New Mexico by a 6-inch products (liquids) line. A 16-inch line carries the sour gas residue (which contains about three grains of sulfur per MCF) to El Paso's San Juan plant at Farmington, New Mexico.



McELMO CREEK UNIT

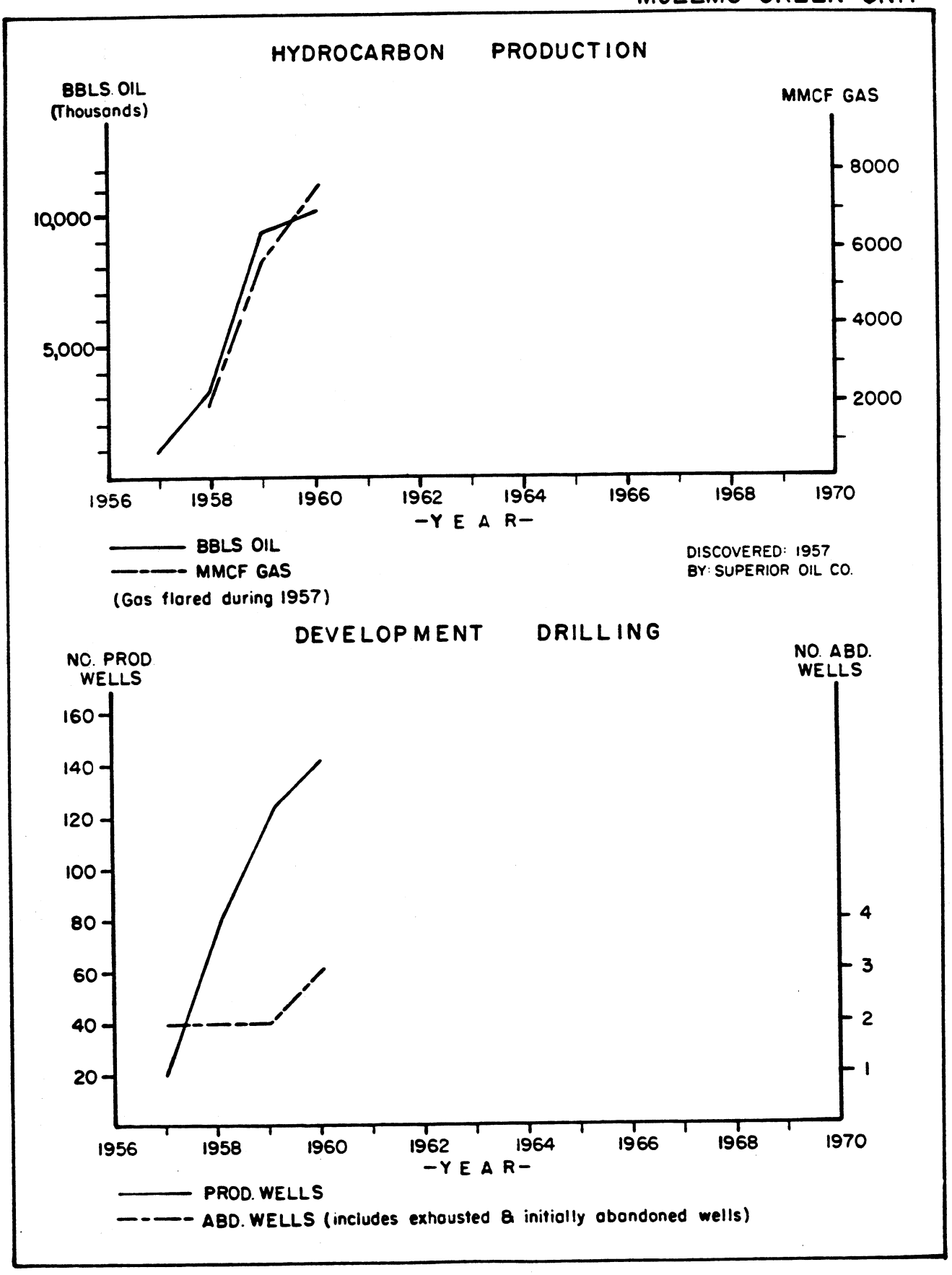
TYPE LOG



From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

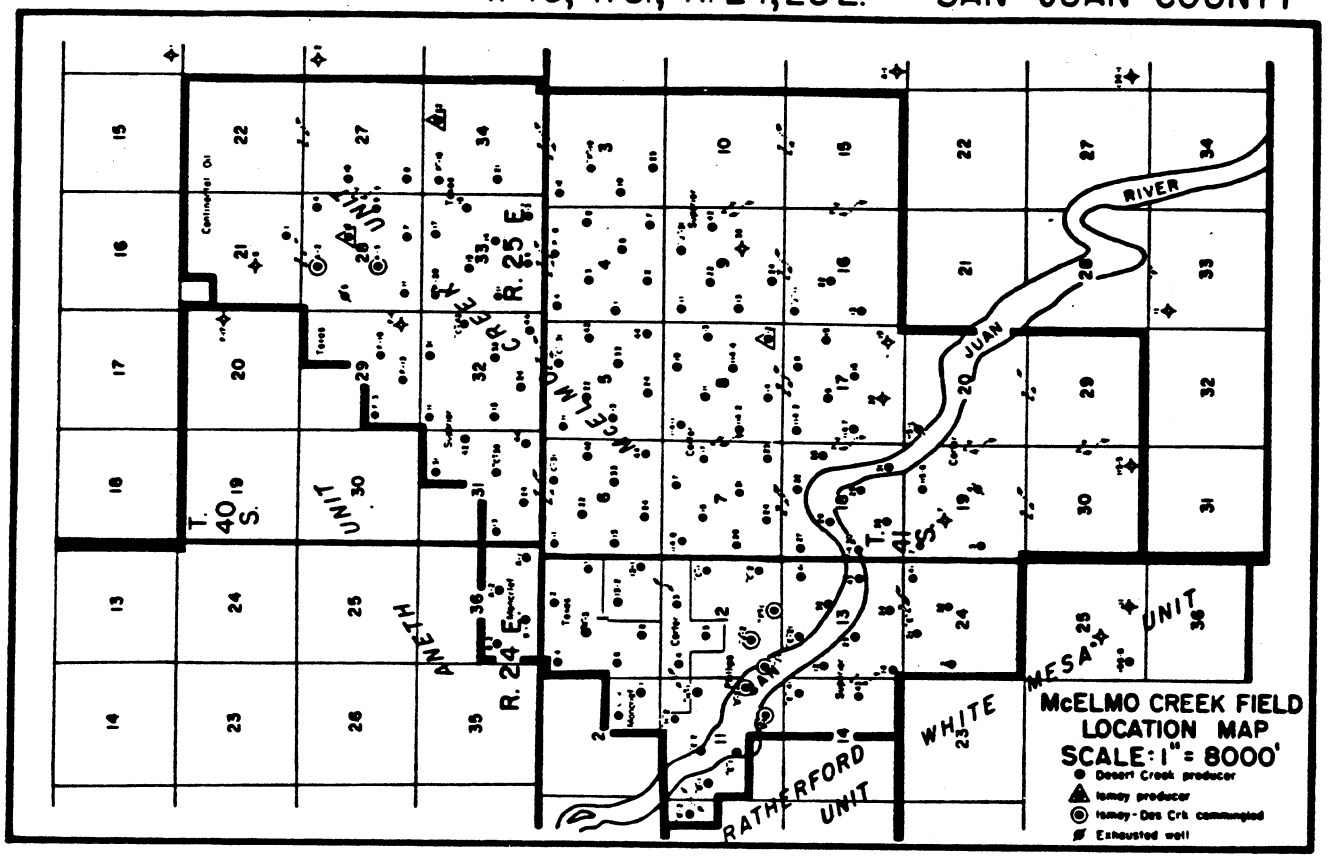
McELMO CREEK UNIT



From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

PARADOX BASIN
T. 40, 41 S., R. 24, 25 E.

McELMO CREEK UNIT
SAN JUAN COUNTY



PRODUCTION CHARACTERISTICS

(DATA SUPPLIED BY McELMO CREEK ENGINEERING COMMITTEE AND - CORE LABS INC.)

RESERVOIR

FORMATION NAME	AGE	LITH.	AVE. DEPTH	NET PAY	INIT. PRESS.	CURR. PRESS.	TYPE DRIVE	% POROS.	PERM. MD
HERMOSA FORMATION									
Ismay zone	Des Moines	Ls-Dol	5500'	15'			Sol-gas	7.6 in pay zone	10.4 av in pay zone
Desert Creek zone	Des Moines	Ls.	5550'	55'	2150 PSI	1055 PSI	Sol-gas	15 in pay zone	11 av in pay zone

FLUIDS

FORMATION NAME	GRAVITY	POUR POINT	SULFUR CONTENT	GOR	BTU/FT.^{3}	METHANE	ETHANE	WATER SALINITY	OTHER FLUIDS
HERMOSA FORMATION									
Ismay zone & Desert Creek zone (combined)	41.6 API	25°F	0.1%	Des Crk = 696 init. 950 curr.	1450 at separator	65%	20%	200,000 PPM (total solids)	

ECONOMICS

FORMATION NAME	PROD WELLS	PROD. 1-1-60 - 1-1-61	CUMULAT PROD. 1-1-61	$/BBL WELL HEAD	¢/MCF WELL HEAD	ULT. RES.	PROVEN ACREAGE	TOTAL WELLS	SPACING
HERMOSA FORMATION									
Ismay zone & Desert Creek zone (combined)	151 (includes 3 Ismay wells, 141 Des Crk wells, & 7 commingled wells)	10,181,422 bbls	23,047,360 bbls	$2.75 posted price	20¢/MCF (approx) for wet gas at well head 17.7¢/MCF for residue gas at the plant.	4.5 million bbls. pri from Ismay 5.3 million bbls pri from Des Crk.	8000 ac for Ismay 12,000 ac for Des. Crk	160 participating wells in unit (9 of these are non-prod)	80 ac

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 5b.

ANETH (McELMO CREEK UNIT)

(Oil)

T. 40-41 S., R. 24-25 E., SLPM

San Juan County, Utah

By: Paul E. Babcock
The Superior Oil Company

GEOLOGY

Regional Setting: Southeast San Juan County, Utah

Surface Formations: Jurassic, Morrison Formation

Exploration Method Leading to Discovery: Subsurface geology

Type of Trap: Primarily stratigraphic

Producing Formation: Pennsylvanian, Desert Creek and Ismay Zones of Paradox Formation

Gross Thickness and Lithology of Reservoir Rocks: 120 to 205 feet, oolitic, algal, fossil-hash, limestone

Geometry of Reservoir Rock: Bioherm

Other Significant Shows: None

Oldest Stratigraphic Horizon Penetrated: Mississippian

DISCOVERY WELL

Name: Texaco No. 1 Navajo C (currently known as the Texaco No. M-12 McElmo Creek Unit)

Location: SE SE (590' FSL and 585' FEL) sec. 31, T. 40 S., R. 25 E.

Elevation (KB): 4,752 feet

Date of Completion: January 14, 1957

Total Depth: 5,753 feet

Production Casing: 7" at 5,753 feet with 500 sacks of cement

Perforations: 5,640 to 5,691 feet with 6 jets per foot

Stimulation: Acidized with 500 gallons mud acid

Initial Potential: Flow 695 BOD (41.8° API gravity)

Bottom Hole Pressure: 2,166 psi at 5,600 feet

DRILLING AND COMPLETION PRACTICES

8 5/8" surface casing at 550 feet with 200 sacks of cement (surface casing should be into Chinle to protect from corrosive water in the Entrada Sandstone), 5½" casing to total depth (5,600± feet); perforate and stimulate Desert Creek with 28 percent hydrochloric acid.

NOTE: If surface elevation is less than 4,600 feet, a conductor string would be run.

RESERVOIR DATA

Productive Area:
- Proved (as determined geologically): 12,640 acres
- Unproved: 0 acres
- Approved Spacing: 40 acres
- No. of Producing Wells: 164
- No. of Injecting Wells: 63
- No. of Abandoned Wells: 17
- No. of Dry Holes: 3 (shut-in or temporarily abandoned)

Average Net Pay: 58 feet

Porosity: 9 to 13 percent

Permeability: 6 to 27 millidarcies

Water Saturation: 22.1 percent

Initial Field Pressure: 2,170 psi at datum of -930 feet

Type of Drive: Fluid expansion and solution gas drive

Gas Characteristics and Analysis: Solution gas, original gas-oil ratio of 661

Oil Characteristics and Analysis: 41° to 42° API gravity, low sulfur, viscosity .540 cp

Associated Water Characteristics and Analysis: Salt water 125,000 to 175,000 ppm NaCl concentration

Original Gas, Oil, and Water Contact Datums: Oil-water contact -960 feet

Estimated Primary Recovery: 68,400,000 BO (16.8 percent)

Type of Secondary Recovery: Waterflood

Estimated Ultimate Recovery: 137,500,000 BO (34 percent)

Present Daily Average Production: 10,600 BOD (November, 1977); gas-oil ratio 700

Market Outlets: Oil: Four Corners Pipeline and Texas-New Mexico Pipeline; gas: El Paso Natural Gas Co.

FIELD COMMENTARY

The McElmo Creek Unit of the Greater Aneth Field is located approximately 18 miles north-northwest of the Four Corners National Monument in San Juan County, Utah. The McElmo Creek Unit lies entirely upon the Navajo Reservation and is situated on the southwestern edge of the Paradox Basin. The Texaco No. M-12 McElmo Creek Unit well is considered to be the discovery well for the McElmo Creek portion of the Greater Aneth Field. This well was drilled less than a year after the Greater Aneth Field discovery, which is located three and one-half miles to the northwest. Although the No. M-12 well was originally thought to produce from a separate reservoir, later development demonstrated that the Aneth and McElmo Creek pools were one continuous oil field.

The McElmo Creek Unit oil is primarily produced from the Desert Creek reservoir with the remaining oil attributable to the overlying Ismay Zone. The lower Zone II of the Desert Creek is comprised of an algal mound reservoir, broken by fossil debris and mud lenses. In several areas, this algal carbonate is characterized by excellent vuggy development. The algal mound (primarily, leafy *Ivanovia*) increased the carbonate thickness of the Desert Creek by supplying and trapping sediments. This algal zone is overlain by the Zone I reservoir, a non-vuggy, primarily oolitic limestone. The Desert Creek carbonate is heterogenous with rapid vertical and lateral changes. Production analyses indicate that the majority of the producing intervals are in communication to some degree, probably due to a complex distribution of connecting porous intervals.

The steepest flanks of the Greater Aneth Field are situated on the northern and eastern edges of the McElmo Creek Unit

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

ANETH (McELMO CREEK UNIT)

(p. 582). These steeper dips are compatible with the probable north-northeast wind and south-southeast current directions existing in the basin at the time of deposition (Peterson and Ohlen, 1963). In addition, the porous intervals thin and the overall carbonate thickness decreases rapidly toward the flanks of the Greater Aneth feature. Actual porous pay values range from 100+ feet to zero feet at the unit boundaries, with an average pay value of 58 feet. The lateral extent of the McElmo Creek Unit oil accumulations is restricted to the north, east, and south by porosity and permeability pinch-outs. The porosity is continuous to the west with production limited by an oil-water contact at -960 feet.

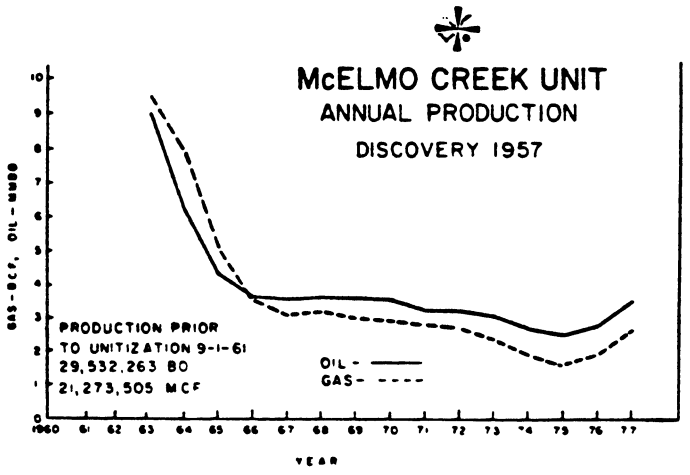
In September, 1961, the Greater Aneth Field was unitized and a water injection program initiated. The Superior Oil Company has been operator of the McElmo Creek Unit since that time. Current daily production is 10,600 BOD.

REFERENCES

Peterson, J. A., and Ohlen, H. R., 1963, Pennsylvanian shelf carbonates, Paradox basin, in Shelf carbonates of the Paradox Basin, a symposium: Four Corners Geological Society, 4th Annual Field Conf., p. 65-79.

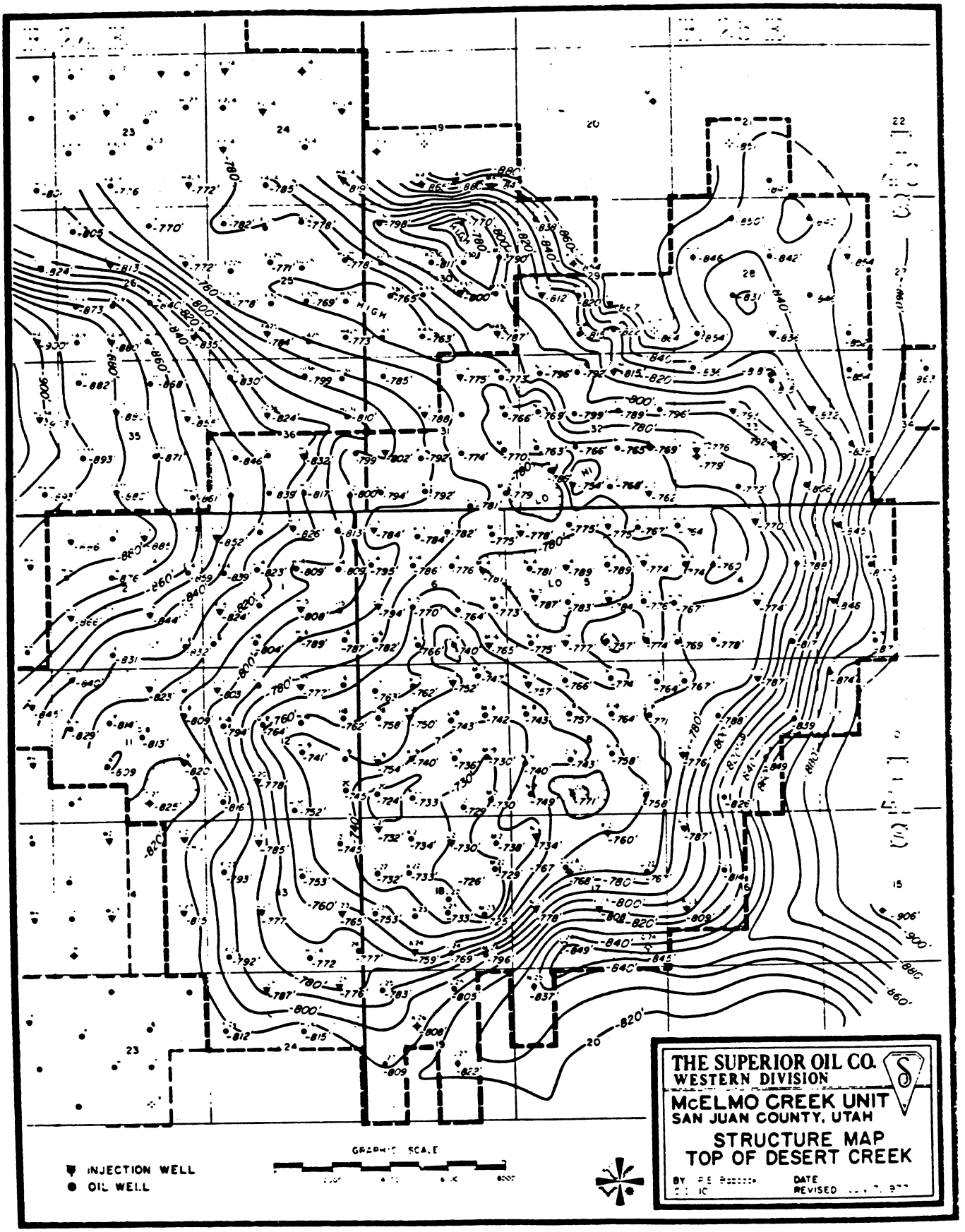
The Superior Oil Company (McElmo Creek Unit operator) files.

NO. OF WELLS @ YR. END					PRODUCTION OIL IN BARRELS GAS IN MCF	
YEAR	TYPE	PROD.	INJECT	SI/ABN	ANNUAL	CUMULATIVE
1957	OIL					
	GAS					
1958	OIL					
	GAS					
1959	OIL					At initization 9-1-61
	GAS					
1960	OIL					29,532,263
	GAS					21,273,505
1961	OIL	101	5	57		
	GAS					
1962	OIL	110	28	33	7,646,993	40,788,431
	GAS					32,631,224
1963	OIL	101	29	37	9,021,245	49,809,676
	GAS				9,554,439	42,185,663
1964	OIL	114	37	16	6,226,381	56,036,057
	GAS				7,938,910	50,124,573
1965	OIL	93	38	33	4,364,448	60,400,505
	GAS				5,120,846	55,245,419
1966	OIL	101	50	17	3,685,100	64,085,605
	GAS				3,573,492	58,818,911
1967	OIL	107	48	13	3,608,765	67,694,370
	GAS				3,123,033	61,941,944
1968	OIL	108	48	13	3,667,574	71,361,944
	GAS				3,268,185	65,210,129
1969	OIL	111	47	13	3,628,893	74,990,837
	GAS				3,053,180	68,263,309
1970	OIL	108	48	14	3,603,307	78,594,144
	GAS				2,980,057	71,243,366
1971	OIL	104	52	15	3,302,814	81,896,958
	GAS				2,874,126	74,117,492
1972	OIL	102	53	17	3,300,433	85,197,391
	GAS				2,762,186	76,879,678
1973	OIL	100	54	19	3,131,950	88,329,341
	GAS				2,439,940	79,319,618
1974	OIL	99	57	16	2,739,680	91,069,021
	GAS				1,989,135	81,308,753
1975	OIL	126	63	17	2,575,158	93,644,179
	GAS				1,656,921	82,965,674
1976	OIL	128	64	17	2,844,608	96,488,787
	GAS				1,987,328	84,953,002
1977	OIL	164	63	20	3,640,295	100,129,082
	GAS				2,725,610	87,678,612



From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

ANETH (McELMO CREEK UNIT)



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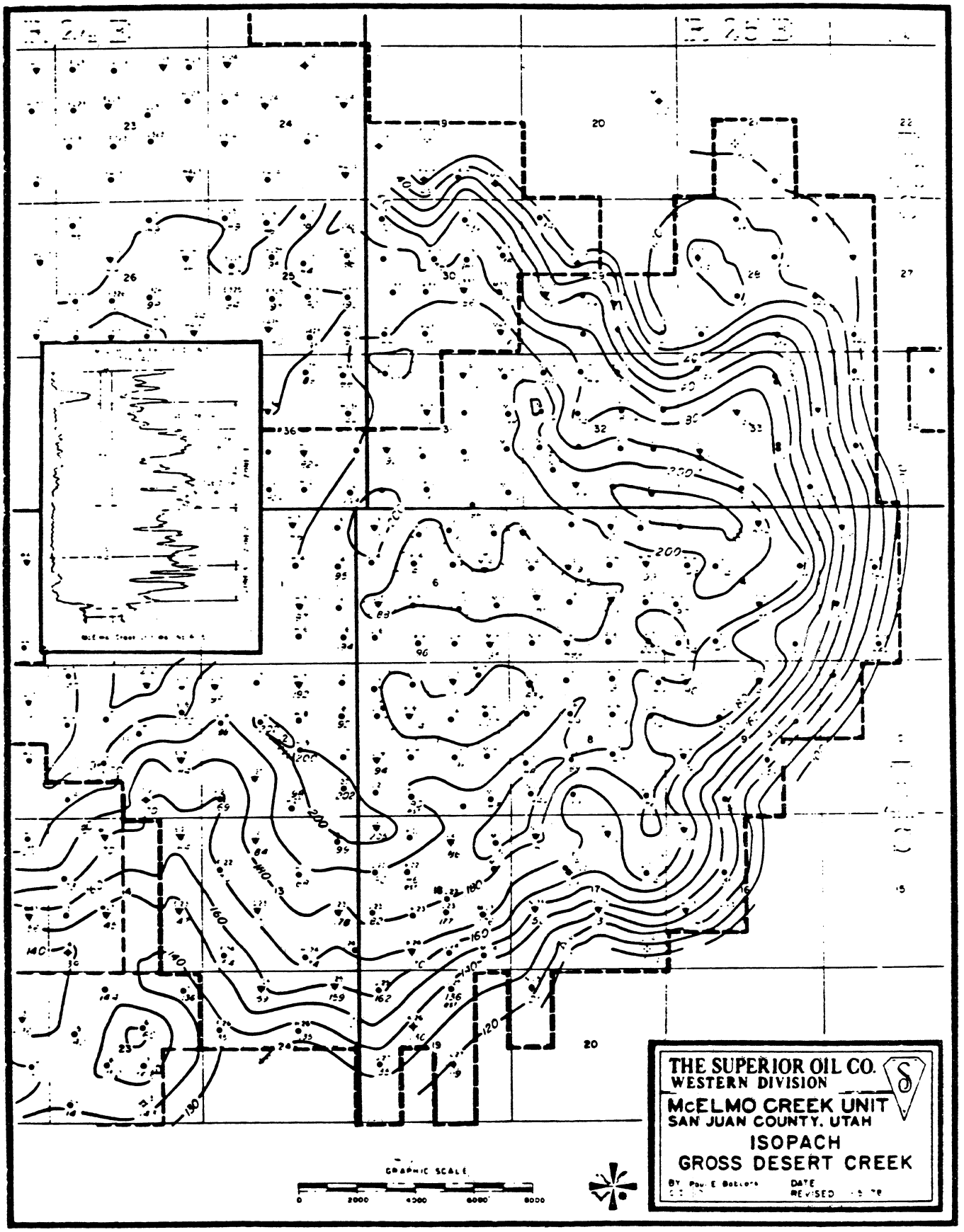
ANETH (McELMO CREEK UNIT)



SOURCE 12 b

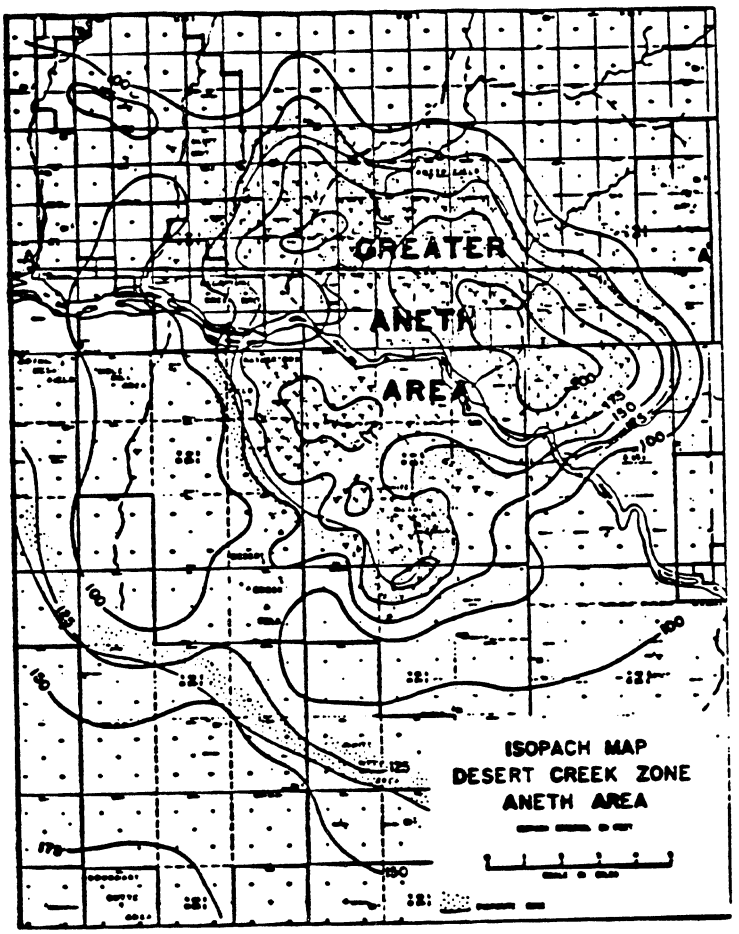


FIG. 12.—Generalized isopach, Desert Creek cycle, Aneth area (after Peterson, 1980). Interval isopached is carbonate-evaporite sequence between black shale intervals.

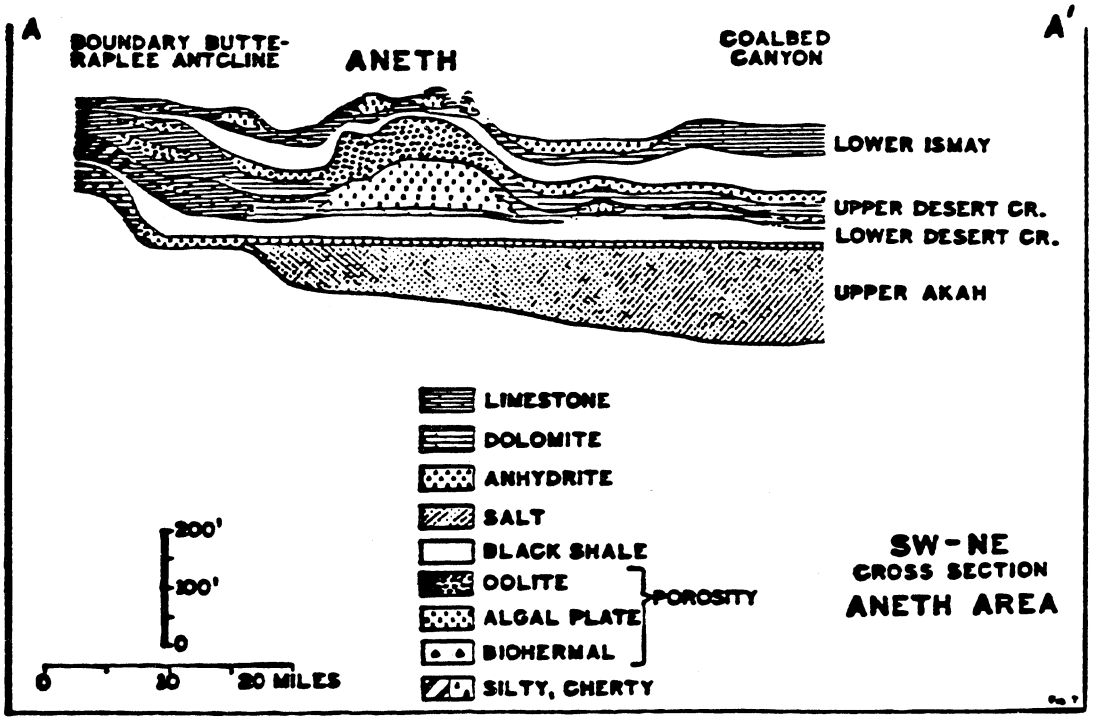


FIG. 11.—Schematic SW-NE cross-section of Ismay, Desert Creek, and Upper Akah cycles showing relation between shelf carbonate mound development and evaporites. Position of cross-section is shown on Figure 6.

Reference: Peterson, James A., and Ohlen, Henry R., 1963, "Pennsylvanian Shelf Carbonates, Paradox Basin", in Shelf Carbonates of the Paradox Basin-Symposium: Four Corners Geological Society.

Utah - Greater Aneth
(Ratherford Unit)
Paradox - Desert Creek
Paradox Basin

DATA SOURCE CODE		
	STATE	Utah
5a	COUNTY	San Juan
	REGULATORY DISTRICT	
5a	BASIN	Paradox
	SUB-BASIN	
5a	FIELD	Greater Aneth area - Ratherford
5a	RESERVOIR	Desert Creek
5a	GEOLOGIC AGE	Pennsylvanian - Des Moines
1	AAPG STRATIGRAPHIC AGE CODE	325
5a, 1	RESERVOIR LITHOLOGY	Limestone and dolomite
1,5b,5a	TRAPPING MECHANISM	Structural, stratigraphic; carbonate reef development consisting structurally of a regionally high area which is folded into small minor structures; anticlinal.
1, 5a	DISCOVERY YEAR	1956
5a,5b	PROVED ACREAGE	9680, 12,900
5b	REGULAR WELL SPACING (acres/well)	80
5a,1	RESERVOIR DEPTH	5500, 5546
	RESERVOIR THICKNESS	
5a,5b	NET PAY	55, 20
5b	GROSS	160-195
	NET/GROSS RATIO	
	POROSITY	
1	TYPE	IC, V
5a, 5b	FRACTION	.11, .102
	PERMEABILITY	
5a	RANGE	.01 to 800
5b	AVERAGE	3.2
	HORIZONTAL	
	VERTICAL	
5a, 12	OTHER INFORMATION	Another reservoir is the Ismay zone. Ratherford is being considered for CO_2 by Phillips Petroleum.
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
5b	TOTAL NUMBER OF WELLS	172 (90P, 77A, 5DH)
1,5b	PRODUCTION 1976 oil (cum)	61,067; 61,253 mbbls; 61,331 mmcf gas
	PRODUCTION 1977 oil (cum)	61,787 mbbls oil; 61,765 mmcf gas
	PRODUCTION 1978 oil (cum)	
	PRODUCTION 1979 oil (cum)	
	PRODUCTION 1-1-77 to 6-1-77	534.4 mbbls oil; 434.9 mmcf gas
5a	SECONDARY RECOVERY RECORDS?	yes
5a	WATER ANALYSIS RECORDS?	yes
	OTHER DATA	
5a,5b	STRUCTURE CONTOUR?	yes
5a,5b	LOGS?	yes
	STRUCTURE SECTION?	
5a,5b	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Ratherford
5a,5b	RESERVOIR:	Desert Creek
5a,5b	PROD. ACRES:	9680, 12,900
5a, 1	AVG. THICKNESS (FT.):	55, 56
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
5b	WATER SATURATION (S_W):	.25
	OIL SATURATION (S_O):	
5a	PRIMARY DRIVE MECHANISM:	solution gas
	PRIMARY GAS CAP?:	
12a	TEMPERATURE (°F):	141 (GG=1.2)
12a	SATURATION PRESSURE	2388
5a	RESERVOIR PRESSURE INITIAL (psi):	2080
5a	RESERVOIR PRESSURE LATEST (psi):	1050
5b,5a	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	697, 500
12a	GAS OIL RATIO LATEST (GOR) (cf/bbl):	681, (1979)
5a,1,5b	STOCK TANK OIL GRAVITY (°API):	41, 41, 40
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
12a	MINIMUM MISCIBILITY PRESSURE (MMP):	1745
	ESTIMATED ORIGINAL OIL:	
	ESTIMATED PRIMARY OIL:	
5b	Estimated Ultimate Oil:	75,000 mbbls

OTHER INFORMATION:

Source 12a Western Oil Reporter V-33, No. 10, p.25, October 1976.

5a Water salinity: 235,000 ppm

12a, 5b Phillips has secondary recovery operations, waterflood; plan CO_2.

12b Reference: Peterson, James A., and Ohlen, Henry R., 1963, "Pennsylvanian Shelf Carbonates, Paradox Basin", in Shelf Carbonates of the Paradox Basin Symposium, Four Corners Geological Society.

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

GREATER ANETH AREA – RATHERFORD FIELD

San Juan County, Utah

Merle Freeman

The Ratherford Field is located on the southwest flank of the Paradox Basin. It is 20 miles northwest of the common corner where Arizona, Colorado, New Mexico and Utah join. It is on the southern arm of the horseshoe formed by the Greater Aneth Area.

The accumulation is found primarily in a carbonate reef development of the Desert Creek zone of the Paradox formation. The upper part of the zone consists of oolitic limestone beds, the middle portion is made up of fine to coarse crystalline limestone with varying amounts of vugular and intercrystalline porosity. The lower part becomes dolomitic and throughout most of the field contains considerable silt. Toward the edges of the field the clean limestone becomes thin or is not present and the oolite beds are replaced by anhydrite. In the field proper the entire zone is from 160′ to 195′ thick but thins toward the outer edges of the field to a thickness of about 130 feet. The net pay thickness generally varies with the zone's total thickness.

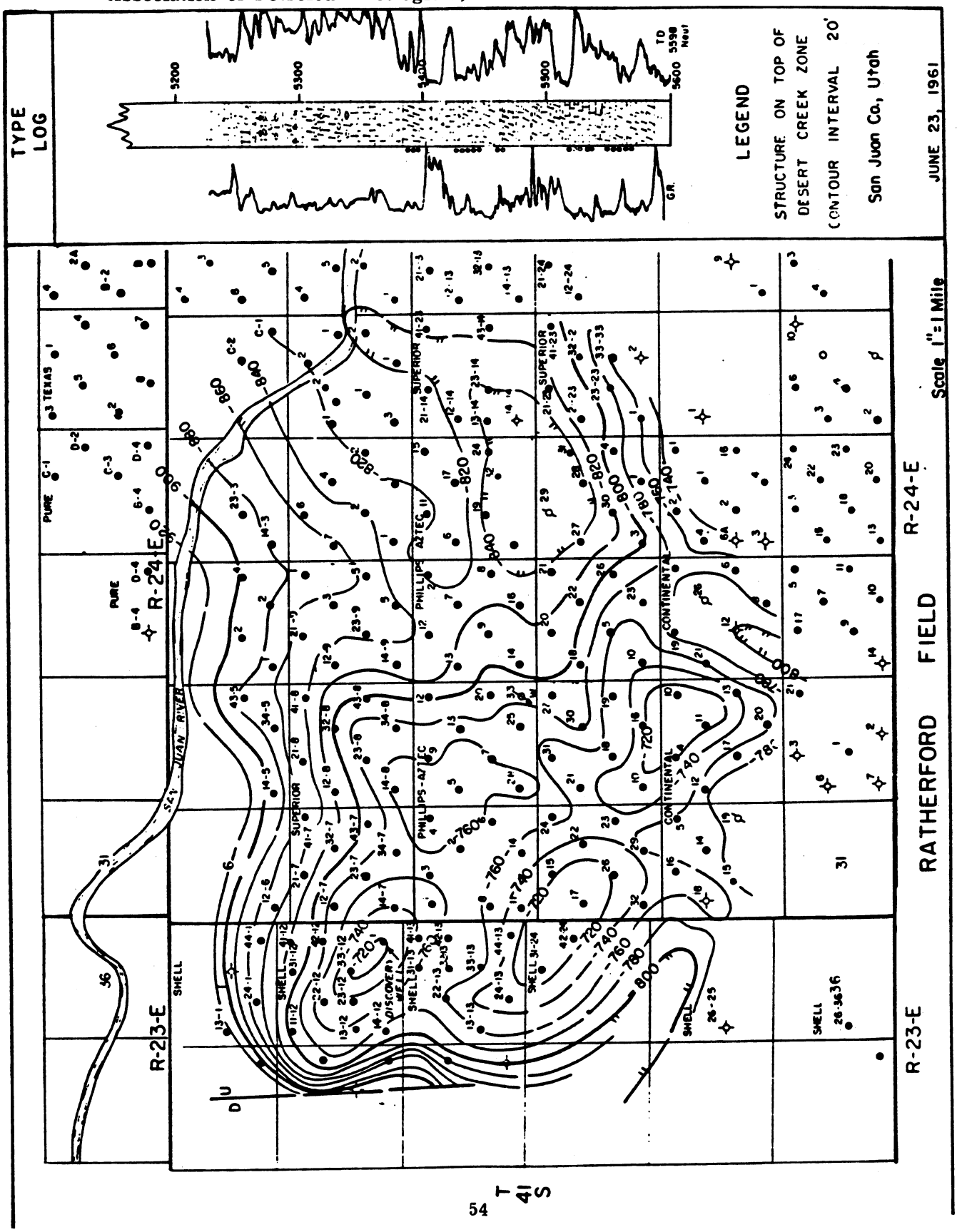
Structurally Ratherford consists of a regionally high area which is folded into small minor structures. Two anticlines, trending northwest-southeast, are present on the west side of the field. A third fold trending northeast-southwest is found in the northeastern portion. The structural relief of this local folding is from 40′ to 50′ but across the regionally high field area the relief amounts to 150 ft. High structural position is important but the oil accumulation is due to both stratigraphy and structure. On the south flank Ratherford is bordered by the White Mesa Area, but to the southwest it is limited stratigraphically by rapid gradation from limestone to silty dolomite and anhydrite. Production is limited to the west by a normal fault while the north flank is defined by down-folding which places the porosity below the oil-water contact. The accumulation continues to the east into the adjoining McElmo Area.

The source for the oil is believed to be the black carbonaceous shales which separate the Ismay, Desert Creek, and Akah zones. An additional source may be the numerous shales in the underlying Paradox salt section.

Extensive geophysical work was done in the area prior to discovery with seismograph exploration being the most commonly accepted method. This work led to the drilling of the large but essentially barren structures such as Bluff and the Desert Creek structure, two miles southwest, where the Shell Oil Co. drilled the first commercial oil well in the Paradox Basin in November, 1954. Seven months after the finding of Aneth in February, 1956, Shell completed the discovery well at Ratherford flowing 1440 BOPD.

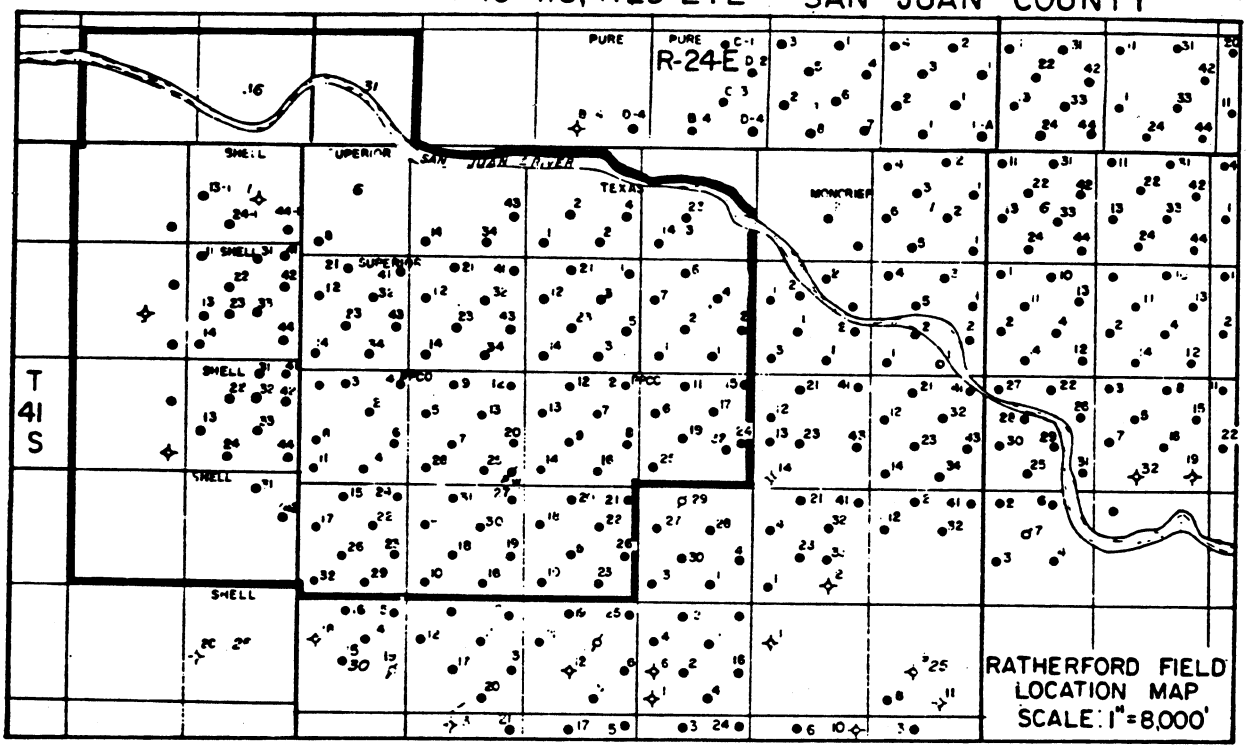
The field, with Phillips Petroleum Company as Operator, is now being unitized for purposes of secondary recovery. One injection well has been drilled and water flooding through this input well has been commenced.

From: A Symposium of the Oil and Gas Fields of Utah, 1961, Intermountain Association of Petroleum Geologists; source 5a



From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

PARADOX BASIN RATHERFORD FIELD
T 40-41S, R 23-24 E SAN JUAN COUNTY



PRODUCTION CHARACTERISTICS

RESERVOIR

FORMATION NAME	AGE	LITH	AVE DEPTH	NET PAY	INIT PRESS	CURR PRESS	TYPE DRIVE	% POROS	PERM MD
PARADOX									
Ismay Zone	Penn	Ls & Dol	5400'	0 - 25'	2000 lbs	1050 lbs	Solution Gas	11	
Desert Creek	Penn	Ls & Dol	5500'	55	2080 lbs	1050 lbs	Solution Gas	11	.01 - 800

FLUIDS

FORMATION NAME	GRAVITY	POUR POINT	SULFUR CONTENT	GOR	BTU / FT³	METHANE	ETHANE	WATER SALINITY	OTHER FLUIDS
PARADOX									
* Ismay Zone	41% API	40°F							
Desert Creek	41% API	40°F	3%	500/1	1485	59 Mol %	20 Mol %	235,000ppm	

ECONOMICS

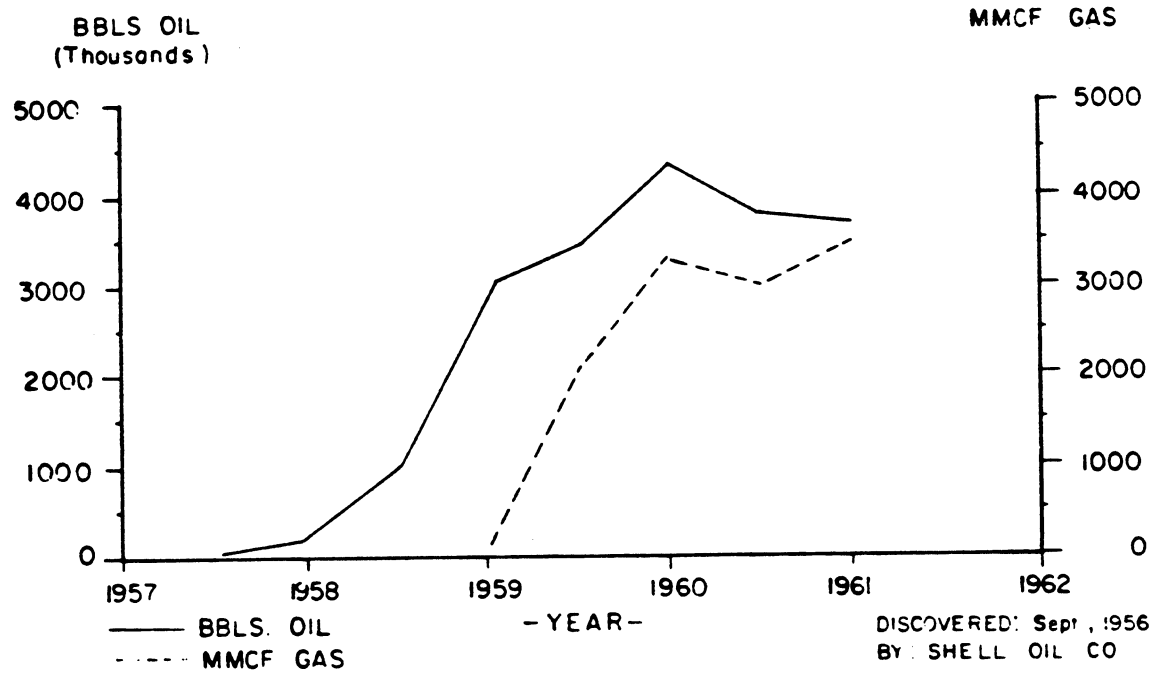
FORMATION NAME	PROD. WELLS	PROD 1-1-50—1-1-61	CUMULAT PROD 1-1-61	$ / BBL WELL HEAD	$ / MCF WELL HEAD	ULT RES	PROVEN ACREAGE	TOTAL WELLS	SPACING
PARADOX									
* Ismay Zone									
Desert Zone	125	7,424,237 Bbls. Oil	20,172,313 Bbls. Oil	$2.75	$ .17	60 Million Bbl Oil	9,660	129	80 Acres

* Production commingled with Desert Creek

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

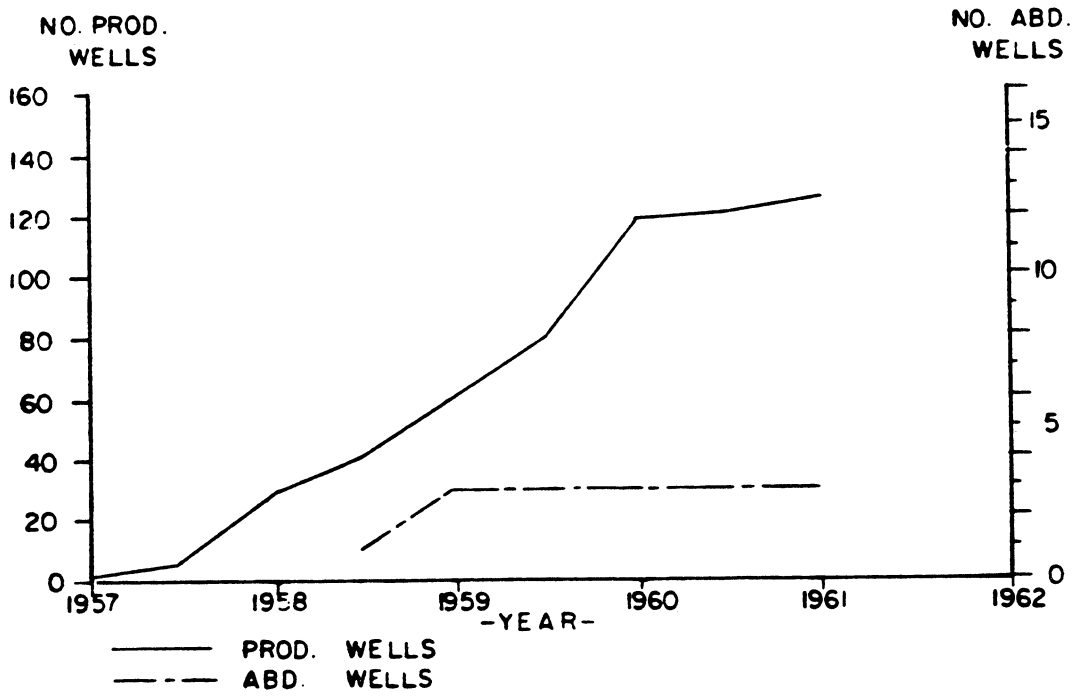
RATHERFORD FIELD

HYDROCARBON PRODUCTION



DISCOVERED: Sept, 1956
BY: SHELL OIL CO

DEVELOPMENT DRILLING



From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 5b.

ANETH (RATHERFORD UNIT)

(Oil)

T. 41 S., R. 23-24 E., SLPM
San Juan County, Utah

By: W. M. Freeman
Updated by R. G. Ghazal
Phillips Petroleum Company

GEOLOGY

Regional Setting: Southwest flank of the Paradox Basin

Surface Formations: Jurassic, Morrison Formation

Exploration Method Leading to Discovery: Seismic

Type of Trap: Carbonate reef development consisting structurally of a regionally high area which is folded into small minor structures

Producing Formation: Pennsylvanian, Desert Creek Member of the Paradox Formation

Gross Thickness and Lithology of Reservoir Rocks: 160 to 195 feet, oolitic limestone

Geometry of Reservoir Rock: Reef, thinning toward outer edges of field

Other Significant Shows: Pennsylvanian, Ismay Member, Paradox Formation

Oldest Stratigraphic Horizon Penetrated: Pennsylvanian, Akah Member of the Paradox Formation

DISCOVERY WELL

Name: Shell Oil Company No. 1 North Desert Creek

Location: SE SE (660' FSL and 660' FEL) sec. 12, T. 41 S., R. 23 E.

Elevation (KB): 4,713 feet

Date of Completion: September 27, 1956

Total Depth: 5,605 feet

Production Casing: 5½" at 5,614 feet with 250 sacks of cement

Perforations: 5,578 to 5,586 feet and 5,590 to 5,598 feet with 4 shots per foot

Stimulation: Acidized with 500 gallons mud acid followed by 5,000 gallons petrafrac

Initial Potential: 1,440 BOD flowing through 48/64" choke

Bottom Hole Pressure: Not available

DRILLING AND COMPLETION PRACTICES

Set 13 3/8" surface casing at 180 feet; run 8 5/8" intermediate casing to 1,500 feet; run 5½" through pay zone; perforate and acidize, run 2 7/8" tubing and flow through tubing.

RESERVOIR DATA

Productive Area:
Proved (as determined geologically): 12,900 acres
Unproved: 0 acres
Approved Spacing: 80 acres
No. of Producing Wells: 90
No. of Abandoned Wells: 77
No. of Dry Holes: 5

Average Net Pay: 20 feet

Porosity: 10.2 percent

Permeability: 3.2 millidarcies

Water Saturation: 25 percent

Initial Field Pressure: 2,170 psi

Type of Drive: Solution gas

Gas Characteristics and Analysis: Viscosity .017 centerpoise, Btu 1,450

Oil Characteristics and Analysis: Initial gas-oil ratio 697; oil viscosity .53; 40° API gravity

Associated Water Characteristics and Analysis: Since waterflood, water analysis not representative

Original Gas, Oil, and Water Contact Datums: Oil-water at -940 to -950 feet

Estimated Primary Recovery: Not available

Type of Secondary Recovery: Waterflood, CO_2 injection planned

Estimated Ultimate Recovery: 75,000,000 BO (30 percent) (waterflood only)

Present Daily Average Production: 3,000 BOD; 2,429 MCFGD

Market Outlets: Oil: Four Corners Pipeline; gas: El Paso Natural Gas Co. Pipeline

FIELD COMMENTARY

The Ratherford field is located on the southwest flank of the Paradox Basin. It is 20 miles northwest of the common corner where Arizona, Colorado, New Mexico and Utah meet. The accumulation is found primarily in a carbonate reef development of the Desert Creek Zone of the Paradox Formation. The upper part of the zone consists of oolitic limestone beds, the middle portion is made up of fine to coarse crystalline limestone with varying amounts of vuggy and intercrystalline porosity. The lower part becomes dolomitic and contains considerable silt. Toward the edges of the field the oolites become thin or absent and are replaced by anhydrite. In the field proper the entire zone is from 160 to 195 feet thick but thins toward the outer edges of the field to a thickness of about 130 feet.

Structurally, Ratherford consists of a regionally high area which is folded into small minor structures. Two anticlines, trending northwest, are present on the west side of the field. A third fold trending northeast is found in the northeastern portion. The structural relief of this local folding is from 40 to 50 feet, but across the regionally high field area, the relief amounts to 150 feet. High structural position is important but the oil accumulation is due to both stratigraphy and structure. On the south flank, Ratherford is bordered by the White Mesa area, but to the southwest it is limited stratigraphically by rapid gradation from limestone to silty dolomite and anhydrite. Production is limited to the west by a normal fault while the north flank is defined by down folding which places

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

ANETH (RATHERFORD UNIT)

the porosity below the oil-water contact. The accumulation continues to the east into the adjoining McElmo area. The source for the oil is believed to be the black carbonaceous shales which separate the Ismay, Desert Creek and Akah Zones. An additional source may be the numerous shales in the underlying Paradox salt section.

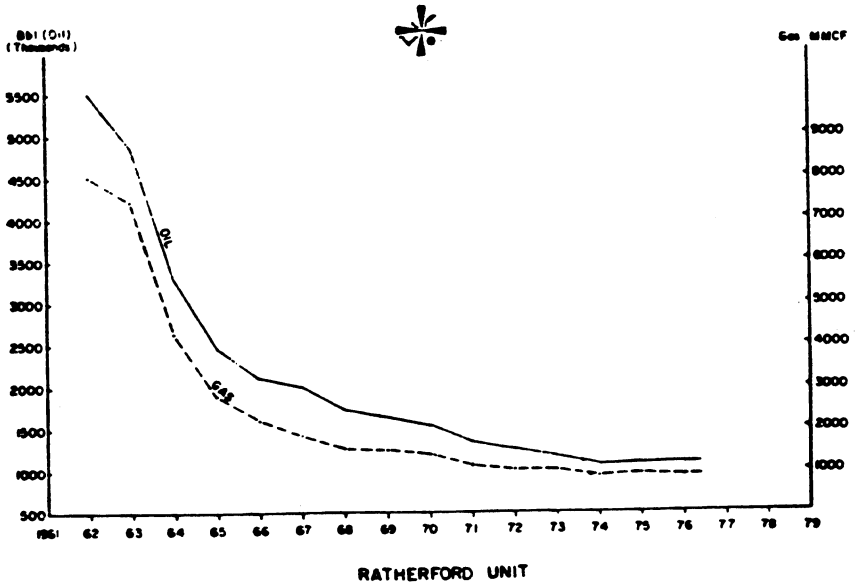
Extensive geophysical work was done in the area prior to discovery with seismograph exploration being the most commonly accepted method. This work led to the drilling of the large but essentially barren structures such as Bluff immediately west of Aneth field and also Desert Creek, two miles southwest, where Shell Oil Company drilled the first commercial oil well in the Paradox Basin in November, 1954. Seven months after the finding of Aneth in February, 1956, Shell completed the discovery well at Ratherford flowing 1,440 BOD. The field, with Phillips Petroleum Company as operator, is unitized for the purpose of secondary recovery. There are now 61 water injection wells and 90 producers completed in the Desert Creek at an average depth of 5,500 feet.

REFERENCES

Freeman, W. M., 1961, Greater Aneth Area-Ratherford Field, *in* Oil and Gas Fields of Utah, A symposium: Intermountain Association of Petroleum Geologists (no page numbers, field papers are in alphabetical order).

Phillips Petroleum Company files.

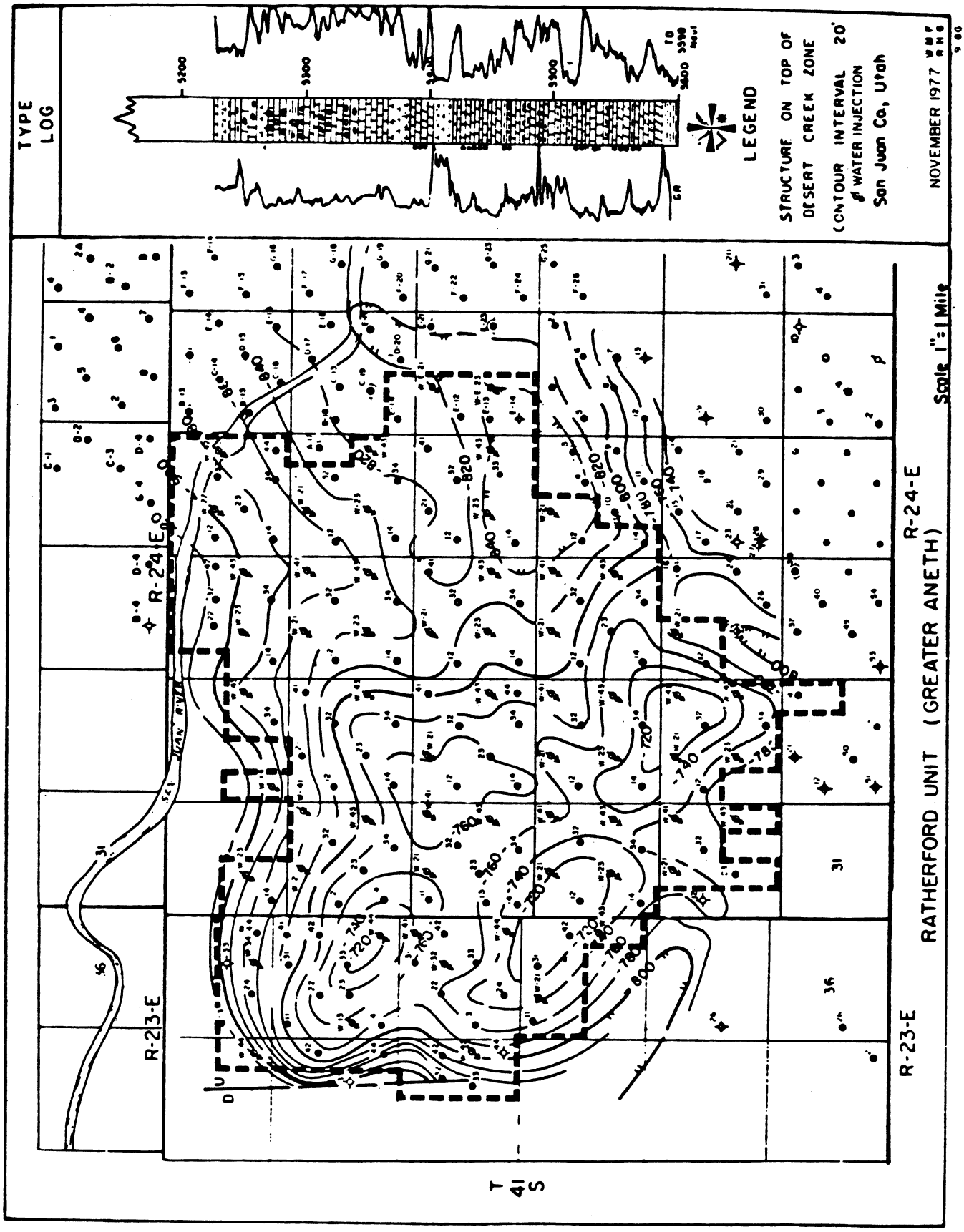
	NO. OF WELLS @ YR. END			PRODUCTION OIL IN BARRELS, GAS.	
YEAR	TYPE	PROD.	SI/ABND	MCF ANNUAL	MMCF CUMMULATIVE
1966	OIL	108	58	2,118,775	47,225,017
	GAS			2,262,425	49,034
1967	OIL	101	65	2,002,229	49,227,246
	GAS			1,852,656	50,884
1968	OIL	103	63	1,725,413	50,952,659
	GAS			1,585,939	52,472
1969	OIL	95	71	1,694,452	52,647,111
	GAS			1,498,503	53,976
1970	OIL	97	69	1,548,152	54,195,263
	GAS			1,423,701	55,400
1971	OIL	96	70	1,346,956	55,542,219
	GAS			1,163,824	56,564
1972	OIL	94	72	1,245,309	56,787,528
	GAS			1,040,797	57,605
1973	OIL	96	70	1,195,122	57,982,650
	GAS			1,011,732	58,617
1974	OIL	89	77	1,079,376	59,062,026
	GAS			880,767	59,498
1975	OIL	92	75	1,089,193	60,151,219
	GAS			947,016	60,445
1976	OIL	92	75	1,101,397	61,252,616
	GAS			886,230	61,331
1977 to JUNE	OIL	90	77	534,359	61,786,975
	GAS			434,926	61,765



RATHERFORD UNIT

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 5b.

ANETH (RATHERFORD UNIT)



SOURCE 12 b

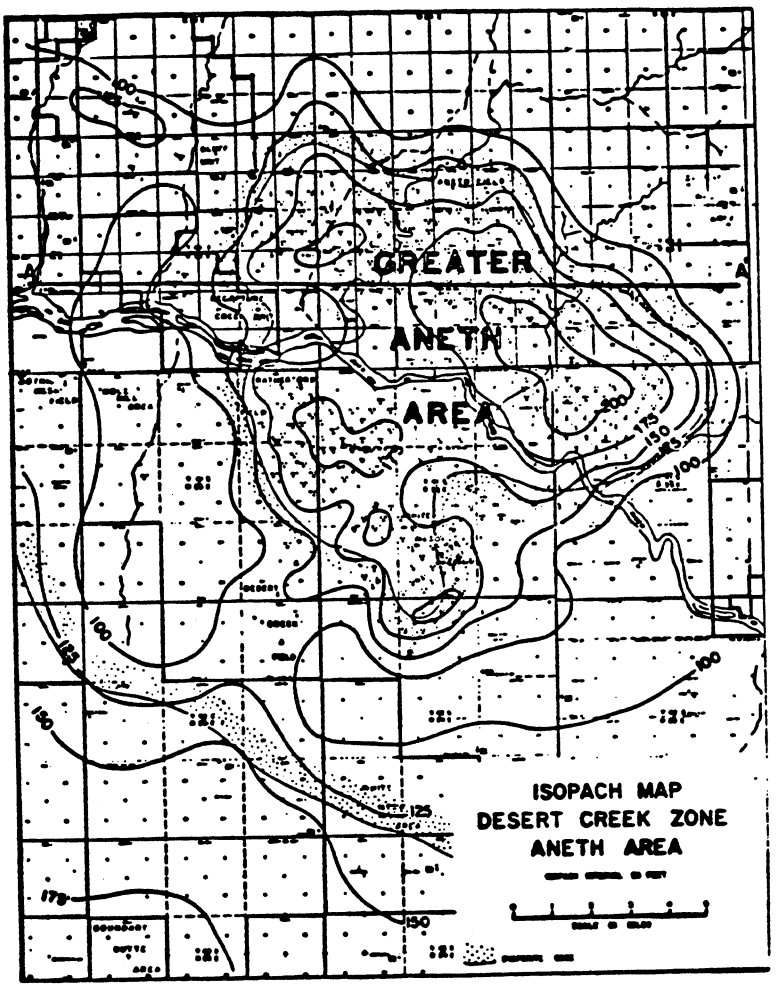


FIG. 12.—Generalized isopach, Desert Creek cycle, Aneth area (after Peterson, 1958). Interval isopached is carbonate-evaporite sequence between black shale intervals.

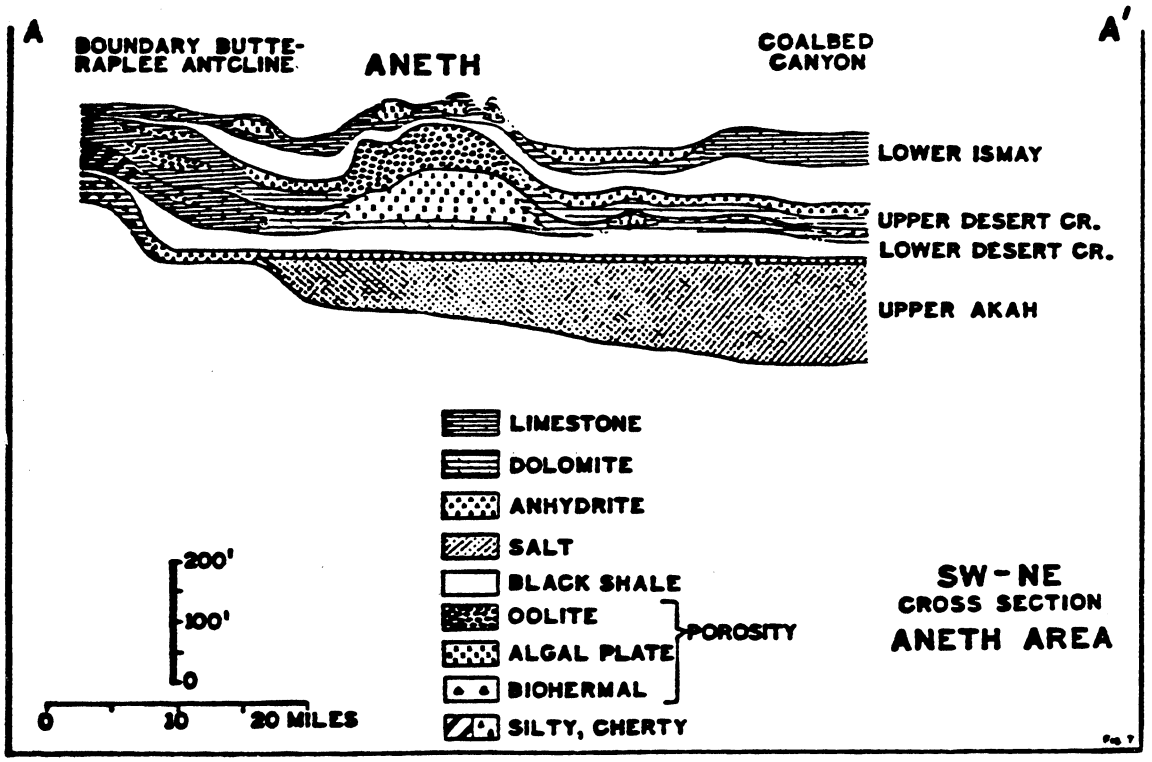


FIG. 11.—Schematic SW-NE cross-section of Ismay, Desert Creek, and Upper Akah cycles showing relation between shelf carbonate mound developments and evaporites. Position of cross-section is shown on Figure 6.

DATA SOURCE CODE		Utah - Greater Aneth (White Mesa Unit) Paradox - Desert Creek Paradox Basin
	STATE----------	Utah
5a	COUNTY----------	San Juan
	REGULATORY DISTRICT----------	
5a	BASIN----------	Paradox
	SUB-BASIN----------	
5a	FIELD----------	Greater Aneth area - White Mesa
5a	RESERVOIR----------	Paradox Fm., Desert Creek
5a	GEOLOGIC AGE----------	Pennsylvanian - Des Moines
1	AAPG STRATIGRAPHIC AGE CODE----------	325
5a,1,5b	RESERVOIR LITHOLOGY----------	Limestone and dolomite
5a,2,5b	TRAPPING MECHANISM----------	Entrapment is the result of a transition from vugular, biogenic, hydroclastic limestone and secondary, oolitic dolomite to dense, argillaceous limestone, dolomite & bedded anhydrite; anticline nose.
5a,5b	DISCOVERY YEAR----------	1957
5a	PROVED ACREAGE----------	5120
5a	REGULAR WELL SPACING (acres/well)-----	80
5a,1	RESERVOIR DEPTH----------	5600, 5505
	RESERVOIR THICKNESS	
5a,5b	NET PAY----------	41, 44
5a	GROSS----------	98 - 186
	NET/GROSS RATIO----------	
	POROSITY	
1	TYPE----------	Pinpoint, IG
5a,5b	FRACTION----------	.085, .09
	PERMEABILITY	
	RANGE----------	
5a,5b	AVERAGE----------	10
	HORIZONTAL----------	
	VERTICAL----------	
	OTHER INFORMATION----------	
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
1,5b	TOTAL NUMBER OF WELLS----------	76 (38P, 16WI, 1A, 21DH)
1,5b	PRODUCTION 1976 oil (cum)----------	22,150; 22,209 mbbls; 28,600.7 mmcf
5b	PRODUCTION 1977 oil (cum) (thru 10/77)	22,498.3 mbbls; 29; 288.5 mmcf
	PRODUCTION 1978 oil (cum)----------	
	PRODUCTION 1979 oil (cum)----------	
5b	PRODUCTION 1-1-77 to10-1-77----------	289.1 mbbls; 687.8 mmcf
	SECONDARY RECOVERY RECORDS?----------	
	WATER ANALYSIS RECORDS?----------	
5b	OTHER DATA	Isopach
5a,5b	STRUCTURE CONTOUR?----------	yes
5a,5b	LOGS?----------	yes
5a,5b	STRUCTURE SECTION?----------	yes
5b	ENGINEERING REPORTS?----------	yes
	CORE DESCRIPTIONS?----------	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	White Mesa
5a	RESERVOIR:	Desert Creek
5a	PROD. ACRES:	5120
5a,5b	AVG. THICKNESS (FT.):	41, 44
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
5b	WATER SATURATION (S_W):	.28
	OIL SATURATION (S_O):	
5a,5b	PRIMARY DRIVE MECHANISM:	solution gas
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	140 (GG=1.2)
11	SATURATION PRESSURE	6259
5a,5b	RESERVOIR PRESSURE INITIAL (psi):	2160
	RESERVOIR PRESSURE LATEST (psi):	
5b	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	667:1
11	GAS OIL RATIO LATEST (GOR) (cf/bbl):	2089 (1979)
5a,5b	STOCK TANK OIL GRAVITY (°API):	40.9
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
11	MINIMUM MISCIBILITY PRESSURE (MMP):	1736
	ESTIMATED ORIGINAL OIL:	
5b	ESTIMATED PRIMARY OIL:	22,500 mbbls
5b	Estimated Ultimate Oil:	30,000 mbbls
	OTHER INFORMATION:	

Source 12a Western Oil Reporter V-33, No. 10, p.25, October 1976.

12b Reference: Peterson, James A., and Ohlen, Henry R., 1963, "Pennsylvanian Shelf Carbonate, Paradox Basin", in Shelf Carbonates of the Paradox Basin Symposium, Four Corners Geological Society.

WHITE MESA FIELD
San Juan County, Utah

WILLIAM D. FENEX AND T. N. WEATHERS

Location

The White Mesa field is located on the southwestern edge of the Paradox salt embayment in Townships 41 and 42 South, Range 24 East, San Juan County, Utah. The field is twenty miles northwest of the Four Corners and about three miles south of the San Juan River. Field boundaries are those designated by the White Mesa Unit operators, who are Continental, Phillips, Humble, Superior, Aztec and Pure.

Type of Trap

Oil accumulation in the White Mesa field is primarily controlled by lithologic variations within the Desert Creek zone of Pennsylvanian age. Entrapment is the result of a transition from vugular, biogenic, hydroclastic limestone and secondary, oocastic dolomite to dense, argillaceous limestones, dolomites and bedded anhydrite. This has been referred to by Picard (1959b) as environmental entrapment. Thickness of the gross Desert Creek interval varies from 98 feet to 186 feet and thickening is due to buildup of the porous, fragmental limestone and dolomite. General disagreement in defining this lithic sequence prevails among workers in this area, but it is felt that the term biostromal complex proposed by Picard (1959b) is adequately descriptive.

Structure

The field area is located on the northwest flank of the northeast trending White Mesa anticline. Generally, contours indicate a gentle dip to the northwest of about 60 feet per mile. However, detailed contouring shows numerous small closures, which as noted by Picard (1959a) are not entirely due to crustal movement, but are the result of gross Desert Creek thickening. The striking similarity between the structural contour map on top of the Desert Creek and the isopachous map of the gross Desert Creek interval makes this readily apparent.

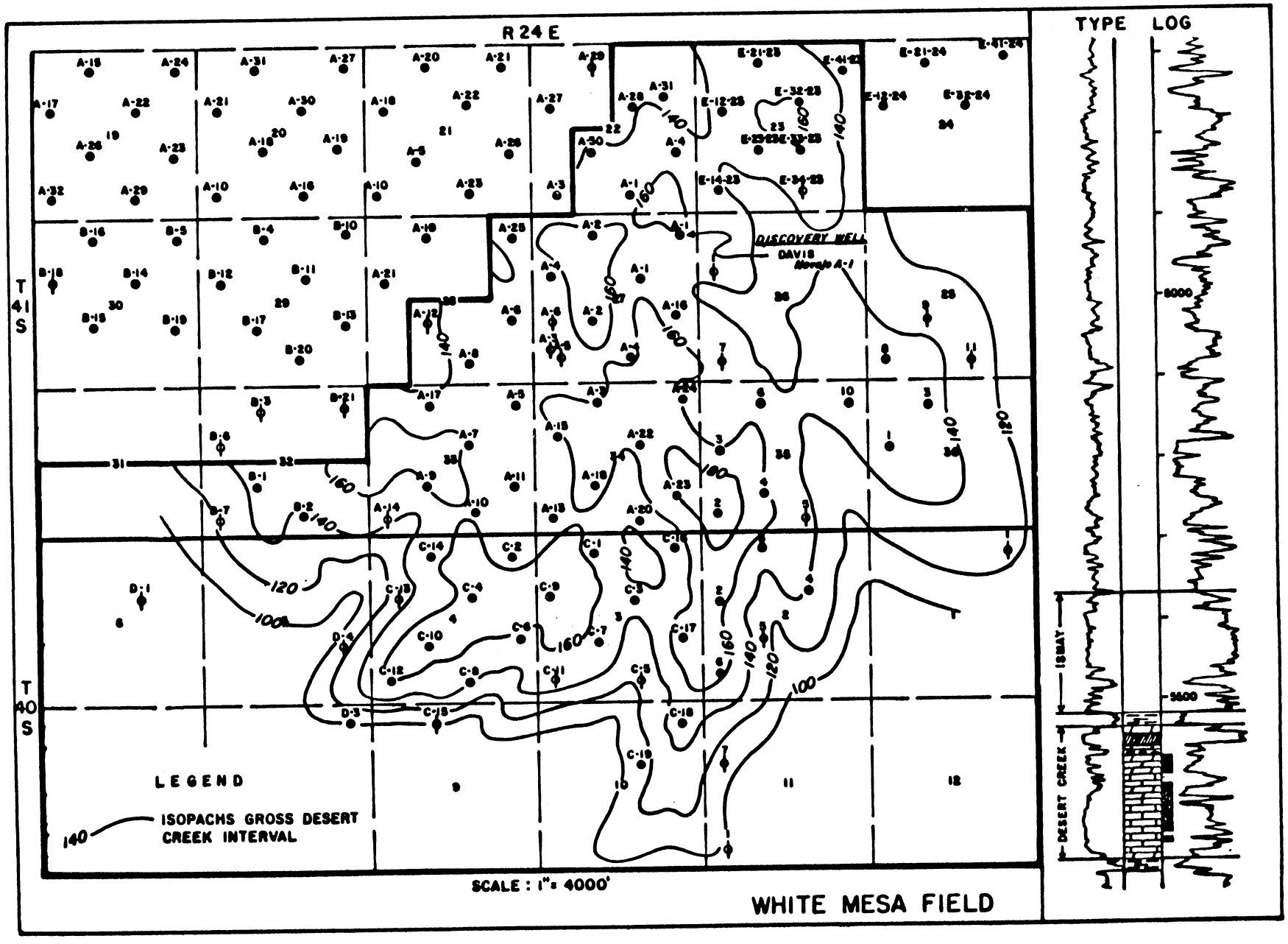
Development

The discovery well, Davis Oil Company's Navajo #A-1 (C NE NE 27-41S-24E), was completed March 17, 1957, for 1350 BOPD. Subsequent development drilling has now fully defined the limits of the field which includes a total of 5120 productive acres.

Bibliography

Picard, M. Dane, 1959 a, "Isopachous Relations and Probable Warping During Late Pennsylvanian Time in the Aneth Area, San Juan County, Utah" *Four Corners Geological Society, Bulletin No. 1,* 23 pp....., 1959 b, "The White Mesa Field, Environmental Trap, San Juan County, Utah," *Bulletin American Association of Petroleum Geologists,* Volume 43, pp. 2456-2469.

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

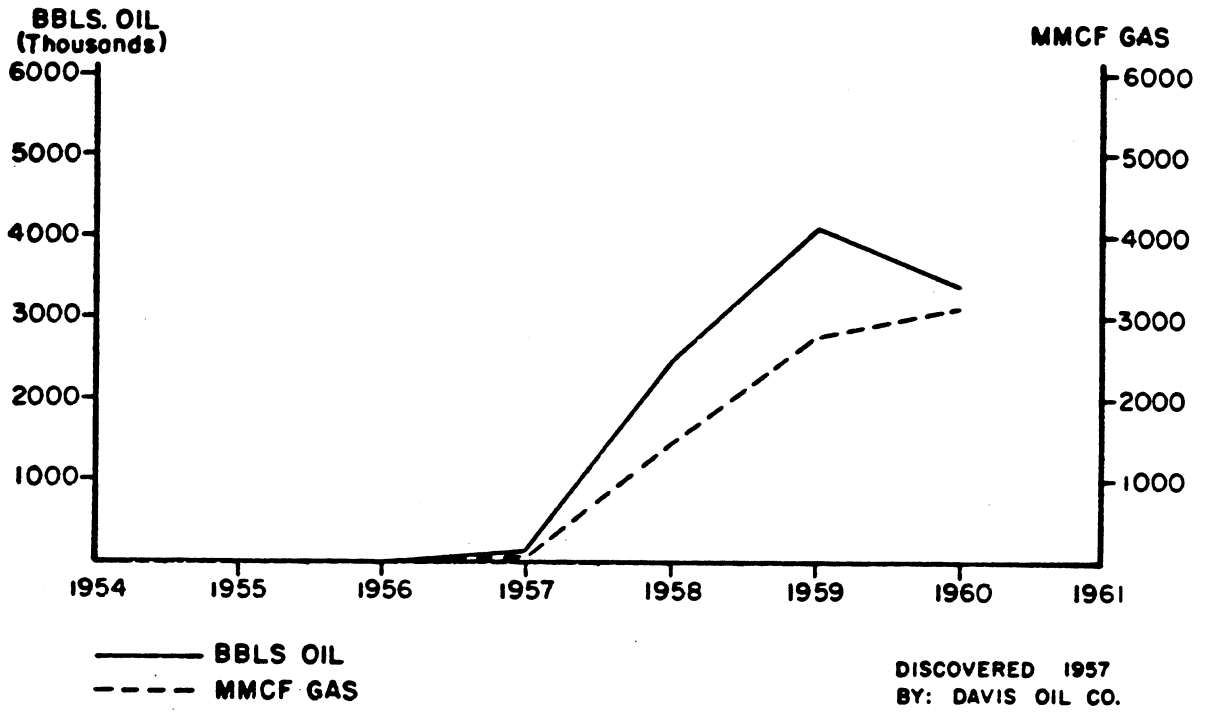


From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

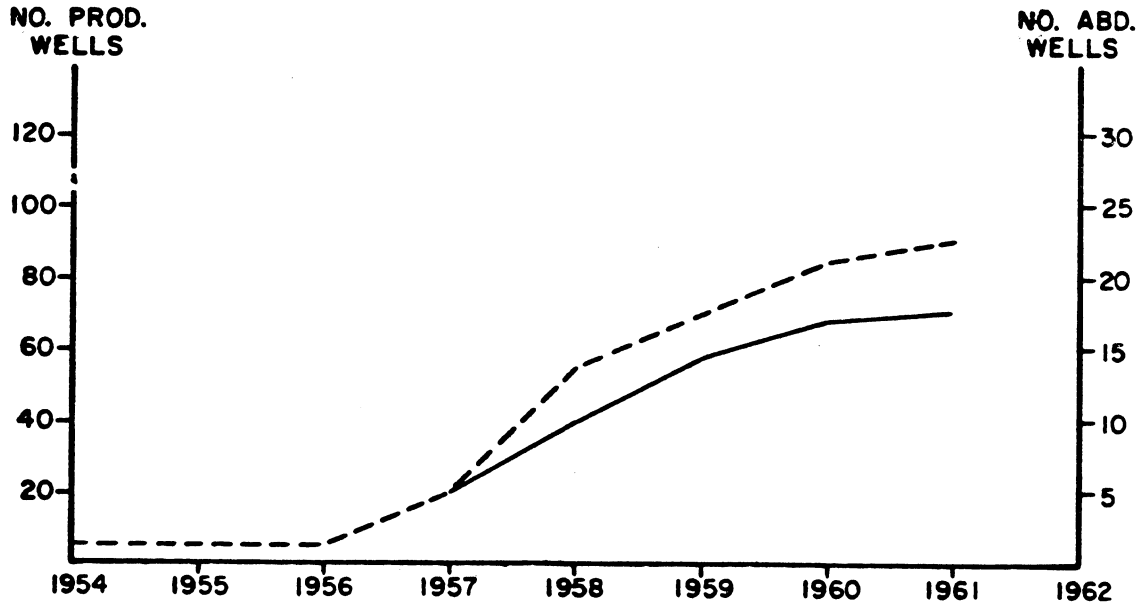
WHITE MESA FIELD

HYDROCARBON PRODUCTION



DISCOVERED 1957
BY: DAVIS OIL CO.

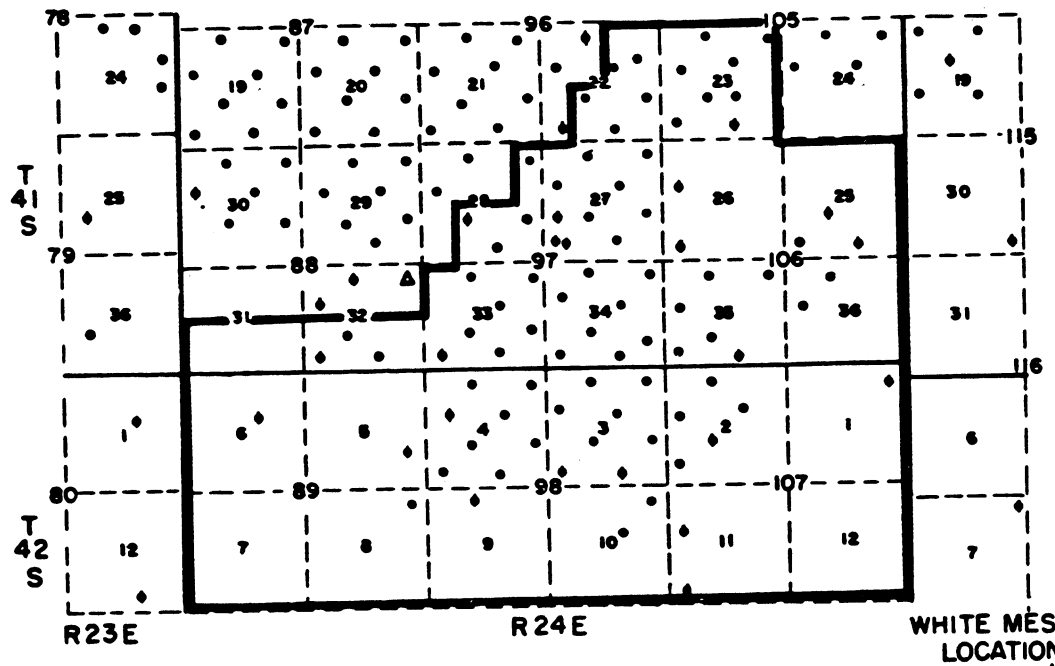
DEVELOPMENT DRILLING



From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

PARADOX BASIN
T41&42S, R24E

WHITE MESA FIELD
SAN JUAN COUNTY



PRODUCTION CHARACTERISTICS

RESERVOIR

FORMATION NAME	AGE	LITH.	AVE. DEPTH	NET PAY	INIT. PRESS.	CURR. PRESS	TYPE DRIVE	% POROS.	PERM. MD
PARADOX (Desert Creek)	PENN.	LS & Dol.	8600	41	2160	650	Sol. Gas	8.5%	10 MD

FLUIDS

FORMATION NAME	GRAVITY	POUR POINT	SULFUR CONTENT	GOR	BTU/FT^3	METHANE	ETHANE	WATER SALINITY	OTHER FLUIDS
PARADOX (Desert Creek)	40.9	10°F	.00	667		10.8%	5.9%		83.3%

ECONOMICS

FORMATION NAME	PROD. WELLS	PROD. 1-60 - 1-61	CUMULAT. PROD. 1-1-61	$ / BBL WELL HEAD	$ / MCF WELL HEAD	ULT. RES.	PROVEN ACREAGE	TOTAL WELLS	SPACING
PARADOX (Desert Creek)	70	3,389,447	10,036,190	2.75	.17		5,120	88	80-A

ANETH (WHITE MESA)

(Oil)

T. 41-42 S., R. 24 E., SLPM

San Juan County, Utah

By: Dennis Irwin, Consultant

GEOLOGY

Regional Setting: Southern shelf, Paradox Basin

Surface Formations: Cretaceous, Dakota Sandstone and Jurassic, Morrison Formation

Exploration Method Leading to Discovery: Subsurface geology and seismic

Type of Trap: Stratigraphic, algal mound

Producing Formation: Pennsylvanian, Desert Creek Member of Paradox Formation

Gross Thickness and Lithology of Reservoir Rocks: Maximum of 80 feet of algal limestone and 40 feet of oolitic and foraminiferal limestone

Geometry of Reservoir Rock: Algal mound with oolitic and foraminiferal cap that thickens around flanks

Other Significant Shows: None

Oldest Stratigraphic Horizon Penetrated: Pennsylvanian, Akah Member of Paradox Formation

DISCOVERY WELL

Name: Davis Oil Company No. 1 Navajo "A"

Location: NE NE (660' FNL and 560' FEL) sec. 27, T. 41 S., R. 24 E.

Elevation (KB): 4,688 feet

Date of Completion: February 25, 1957

Total Depth: 5,590 feet

Production Casing: 5½" to 5,590 feet

Perforations: 5,520 to 5,540 feet; 5,552 to 5,562 feet

Stimulation: Acidized

Initial Potential: Flow 1,680 BOD from a 1" choke

Bottom Hole Pressure: 2,160 psi

DRILLING AND COMPLETION PRACTICES

Surface casing is set through the Navajo Sandstone fresh water aquifer; this is usually 10¾" at about 1,100 feet with 800 sacks of cement. Production casing is run to total depth, this is usually 4½" or 5½" to about 5,600 feet. All porosity greater than 4½ percent is perforated and acidized.

RESERVOIR DATA

Productive Area:

Proved (as determined geologically): 5,680 acres
Unproved: 0 acres
Approved Spacing: 40 and 80 acres
No. of Producing Wells: 75 drilled, 16 converted to injection wells, 38 producing
No. of Abandoned Wells: 1
No. of Dry Holes: 21

Average Net Pay: 44 feet

Porosity: 9 percent

Permeability: 10 millidarcies

Water Saturation: 28 percent

Initial Field Pressure: 2,160 psi

Type of Drive: Solution gas, initial gas-oil ratio 667:1

Gas Characteristics and Analysis: Methane 10.8 percent, ethane 5.4 percent, remainder other fluids

Oil Characteristics and Analysis: 40.9° API gravity, 10°F pour point

Associated Water Characteristics and Analysis: 150,000 ppm total dissolved solids

Original Gas, Oil, and Water Contact Datums: Oil-water at -950 feet

Estimated Primary Recovery: 22,500,000 BO, 25 percent of oil in place

Type of Secondary Recovery: Water flood (Water injection was not successful and was stopped several years ago; without some type of secondary recovery it is doubtful if the field will produce over several million more barrels.)

Estimated Ultimate Recovery: 30,000,000 BO, 33 percent of oil in place

Present Daily Average Production: 889 BOD, 2,833 MCFGD

Market Outlets: Texas-New Mexico and Four Corners Pipelines

FIELD COMMENTARY

The White Mesa field constitutes the southeast portion of the Greater Aneth field complex and has contributed about 8 percent of the Greater Aneth total production. Algal mound development and a capping oolitic and foraminiferal limestone within the Desert Creek Member of the Paradox Formation provides the reservoir host rock. The Desert Creek consists of two depositional cycles and in the White Mesa-Aneth area a typical cycle consists of three facies which in ascending order are: 1) a basal shallow water skeletal limestone (much thicker and generally dolomitized under the lower cycle), 2) an *Ivanovia* algal mound, and 3) a capping leached oolite and foraminiferal limestone. The *Ivanovia* algae are best developed in the lower cycle while the cap rock facies is best developed in the upper cycle. Away from the field the *Ivanovia* zone is absent with the corresponding interval represented by a sparsely fossiliferous lime mud facies; both cycles contain an 8 to 10 foot thick anhydrite bed near the top. The anhydrite is younger than the *Ivanovia* and the increased salinity responsible for the anhydrite undoubtedly terminated the algal growth. Adjacent to the field, the anhydrite thickens markedly by metasomatic replacement into the reservoir host rock.

Both algal zones are highly developed in the McElmo Creek and Aneth field areas but in the White Mesa field only the algal zone in the lower cycle is well developed. The capping oolitic and skeletal limestone facies; however, displays an exceptional development and an excellent washover develop-

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 5b.

ment is shown by its thickening "doughnut fashion" around the mound. Unfortunately this zone is highly replaced by anhydrite throughout most of the field.

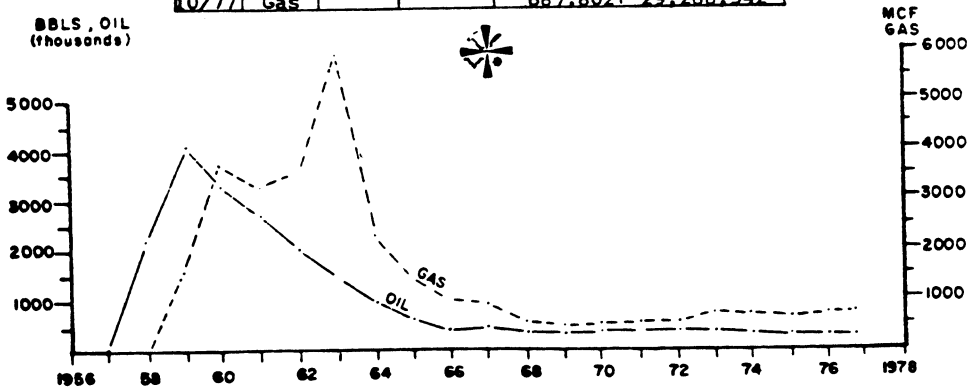
The three facies subdivisions are shown by number on the cross sections and three maps are presented to display the main features of the White Mesa field. The first is a total Desert Creek thickness map, the second is of the algal zone and capping facies in the lower cycle, and the third is the capping facies of the upper cycle. The principal production in the field comes from the algal mound with lesser amounts obtained from the upper oolitic-foraminiferal capping facies. Approximately 50 percent of the mound thickness can be considered effective pay, but the amount in the capping unit is considerably less.

The White Mesa field lies above the oil-water contact found in the syncline of the Aneth complex. The oil-water contact for the Aneth complex has a saucer shape, higher around the edges of the field because of lower permeabilities resulting from anhydrite infilling, but is usually found at about a -950 foot structural datum away from the edges of the field.

REFERENCE

Fenex, W. D., and Weathers, T. N., 1961, White Mesa field, *in* A Symposium of the Oil and Gas fields of Utah: Intermountain Association of Petroleum Geologists (no page numbers).

NO. OF WELLS @ YR. END				PRODUCTION OIL IN BARRELS GAS IN MCF	
YEAR	TYPE	PROD.	SI/ABN	ANNUAL	CUMULATIVE
1957	Oil	3		50,256	50,256
	Gas				
1958	Oil	48		2,249,659	2,299,915
	Gas				
1959	Oil	60		4,110,832	6,410,747
	Gas			1,607,928	1,607,928
1960	Oil	62		3,389,447	9,800,194
	Gas			3,863,116	5,471,044
1961	Oil	64		2,748,741	12,548,935
	Gas			3,404,116	8,875,160
1962	Oil	69		2,044,669	14,593,604
	Gas			3,660,592	12,535,752
1963	Oil	50		1,453,929	16,047,533
	Gas			5,964,275	18,500,027
1964	Oil	45		1,009,220	17,056,753
	Gas			2,345,062	20,845,089
1965	Oil	45		648,297	17,705,050
	Gas			1,526,254	20,931,528
1966	Oil	38		464,133	18,169,183
	Gas			1,067,275	21,998,803
1967	Oil	43		469,568	18,638,751
	Gas			969,234	22,968,037
1968	Oil	34		347,640	18,986,391
	Gas			557,317	23,525,354
1969	Oil	37		388,427	19,378,818
	Gas			518,093	24,043,447
1970	Oil	40		425,074	19,799,892
	Gas			505,867	24,549,314
1971	Oil	44		430,948	20,230,840
	Gas			534,173	25,083,487
1972	Oil	42		433,673	20,664,412
	Gas			568,790	25,586,673
1973	Oil	43		428,218	21,092,630
	Gas			779,197	26,365,870
1974	Oil	49		375,692	21,468,322
	Gas			750,508	27,116,378
1975	Oil	47		380,969	21,849,291
	Gas			727,670	27,844,048
1976	Oil	40		359,920	22,209,211
	Gas			756,692	28,600,740
thru 10/77	Oil	38		289,092	22,498,303
	Gas			687,802	29,288,542



From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

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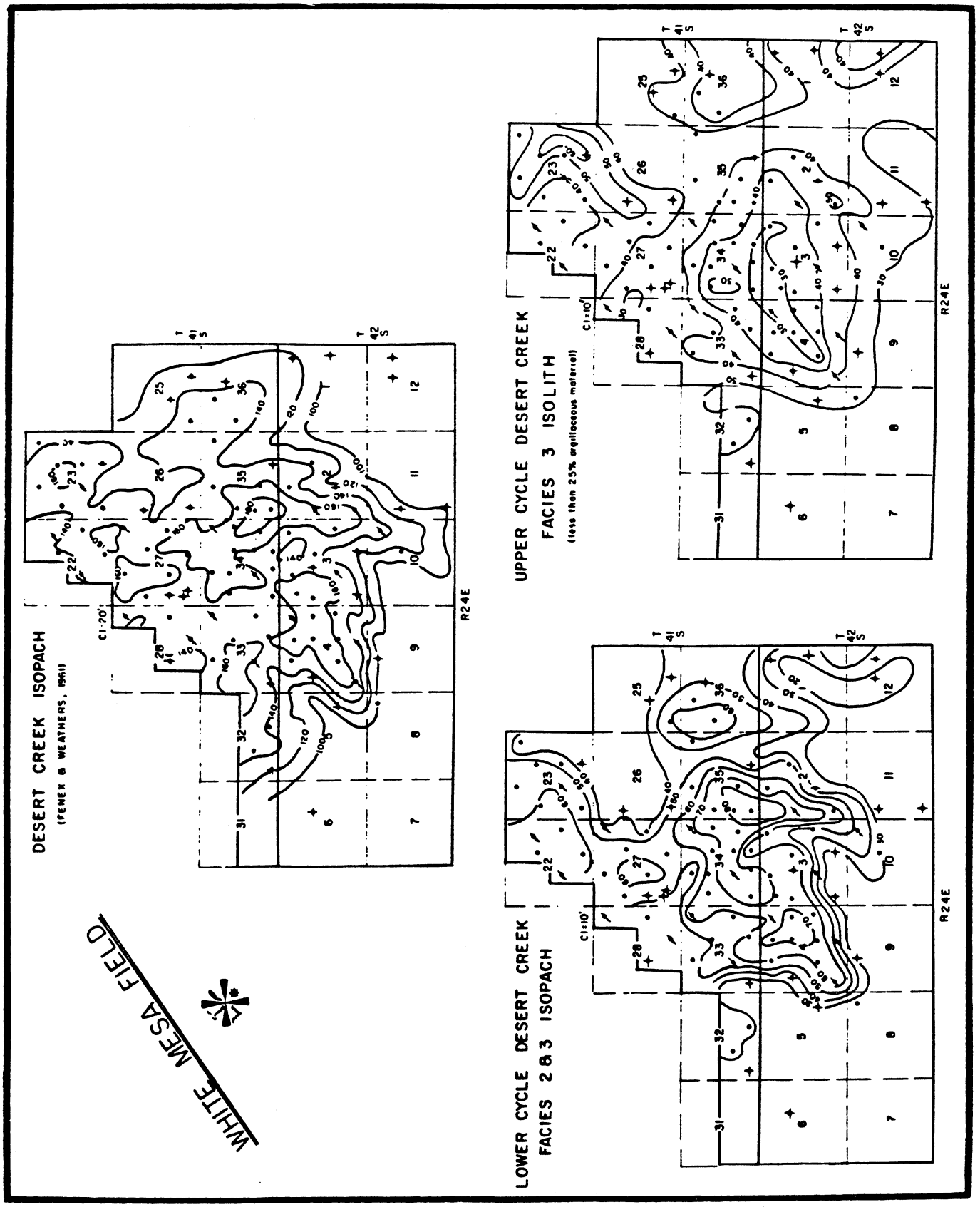
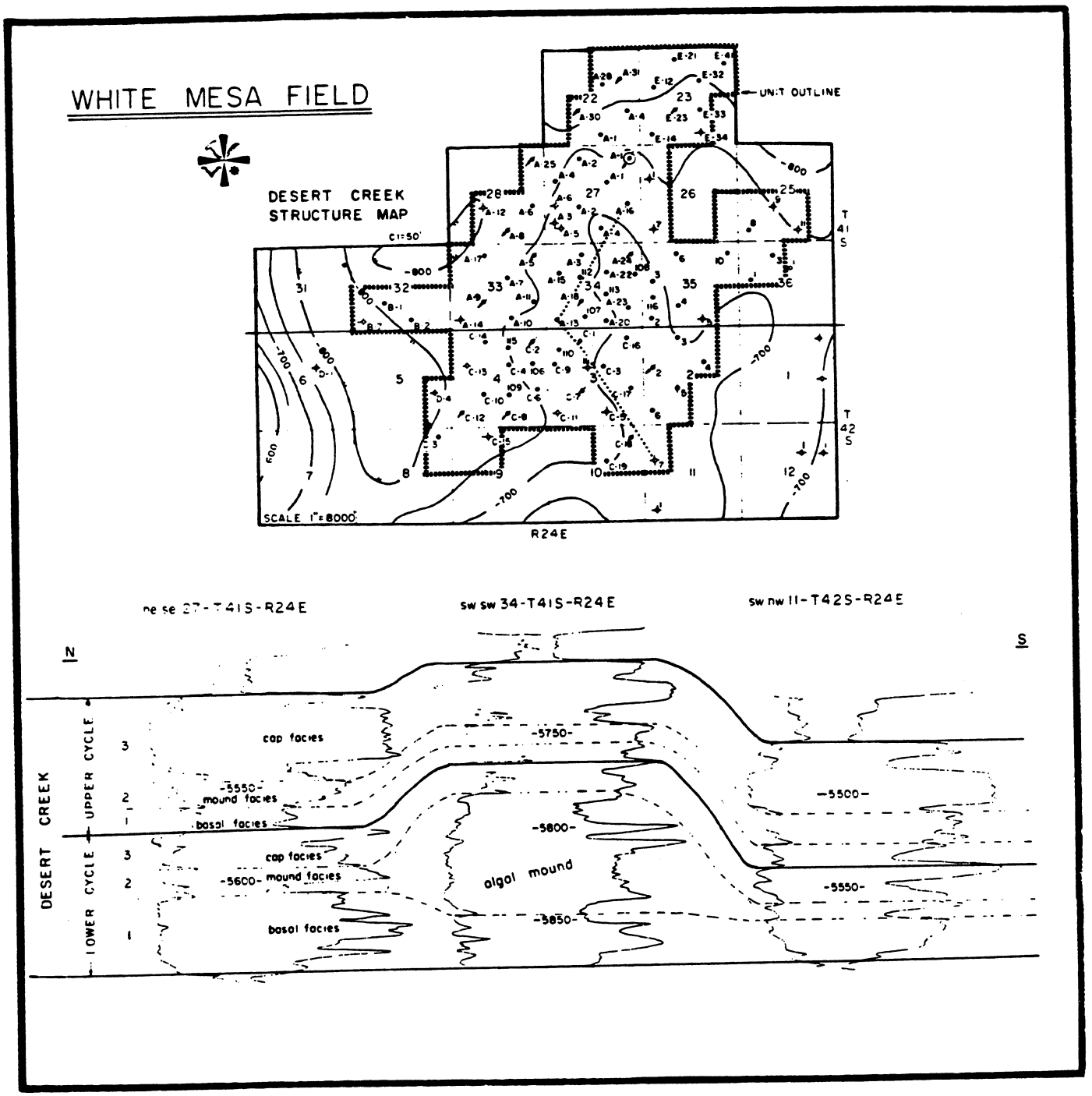
ANETH (WHITE MESA)



From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 5b.



From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

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Utah - Ismay
Ismay
Paradox Basin

DATA SOURCE CODE		
5a	STATE	Utah
	COUNTY	San Juan
	REGULATORY DISTRICT	
5a,1,5b	BASIN	Paradox
	SUB-BASIN	
5a,1	FIELD	Ismay (Flodine)
5a,1,5b	RESERVOIR	Lower Ismay, Hermosa, Ismay, Ismay
1,5b	GEOLOGIC AGE	Pennsylvanian
1	AAPG STRATIGRAPHIC AGE CODE	320
5a,1,5b	RESERVOIR LITHOLOGY	Limestone, limestone, bioclastic carbonate
5a,5b,1	TRAPPING MECHANISM	Plunging anticline and stratigraphic
8a,1,5b	DISCOVERY YEAR	1956
5a,8a,1,5b	PROVED ACREAGE	2800, 3600, 3600, 4370
5a,5b	REGULAR WELL SPACING (acres/well)	80
5a,8a,1	RESERVOIR DEPTH	5660, 5656, 5656
	RESERVOIR THICKNESS	
5a,5b	NET PAY	38, 24
5b,5a	GROSS	80, 7200 ft. (log)
	NET/GROSS RATIO	
	POROSITY	
5a,1	TYPE	Pinpoint and vugular, V
5a,1,5b	FRACTION	.13, .07*
5b	PERMEABILITY	**
	RANGE	
5a,1	AVERAGE	10 md, 7 md
	HORIZONTAL	
	VERTICAL	
5a	OTHER INFORMATION	Adjacent field in Colorado is the Flodine Park field
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
5b	TOTAL NUMBER OF WELLS	53 (29P, 16WI, 8DH)
1	PRODUCTION 1976 oil (cum)	9459, 9484 mbbls
5b	PRODUCTION 1977 oil (cum)	9711.6 mbbls; 16,613.5 mmcf gas
	PRODUCTION 1978 oil (cum)	
	PRODUCTION 1979 oil (cum)	
5b	PRODUCTION 1-1-77 to 1-1-78	123 mbbls oil; 220.6 mmcf gas
5b	SECONDARY RECOVERY RECORDS?	yes, water injection
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
5a,5b	STRUCTURE CONTOUR?	yes
5a,5b	LOGS?	yes
	STRUCTURE SECTION?	
5a,5b	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	

* Zone one .098
Zone two .077
Zone three .146

** Zone one 5.2 md
Zone two 28.1 md
Zone three 4.9 md

RESERVOIR DATA

DATA SOURCE CODE		
5a,5b	FIELD:	Ismay
	RESERVOIR:	Lower Ismay
5a,8a,1,5b	PROD. ACRES:	2800,3600,3600,4370
8a,1,5b	AVG. THICKNESS (FT.):	38, 38, 24
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
5b	WATER SATURATION (S_W):	.41
	OIL SATURATION (S_O):	
5b,5a,1	PRIMARY DRIVE MECHANISM:	solution gas
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	142 (GG=1.2)
11	SATURATION PRESSURE	3283
5b	RESERVOIR PRESSURE INITIAL (psi):	2205
	RESERVOIR PRESSURE LATEST (psi):	
5a	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	1000
11	GAS OIL RATIO LATEST (GOR) (cf/bbl):	1948 (1979)
5a,1,8a,5b	STOCK TANK OIL GRAVITY (°API):	41, 44, 44, 46.3
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
11	MINIMUM MISCIBILITY PRESSURE (MMP):	1745
	ESTIMATED ORIGINAL OIL:	
	ESTIMATED PRIMARY OIL:	
5b	Estimated Ultimate Oil:	12,000 mbbls; 21,500 mmcf

OTHER INFORMATION:

5b Active waterflood - Texaco

12a Reference: Choquette, P. W., and Traut, J. O., 1963, "Pennsylvanian Carbonate Reservoirs, Ismay Field, Utah and Colorado", in Shelf Carbonates of the Paradox Basin-Symposium: Four Corners Geological Society.

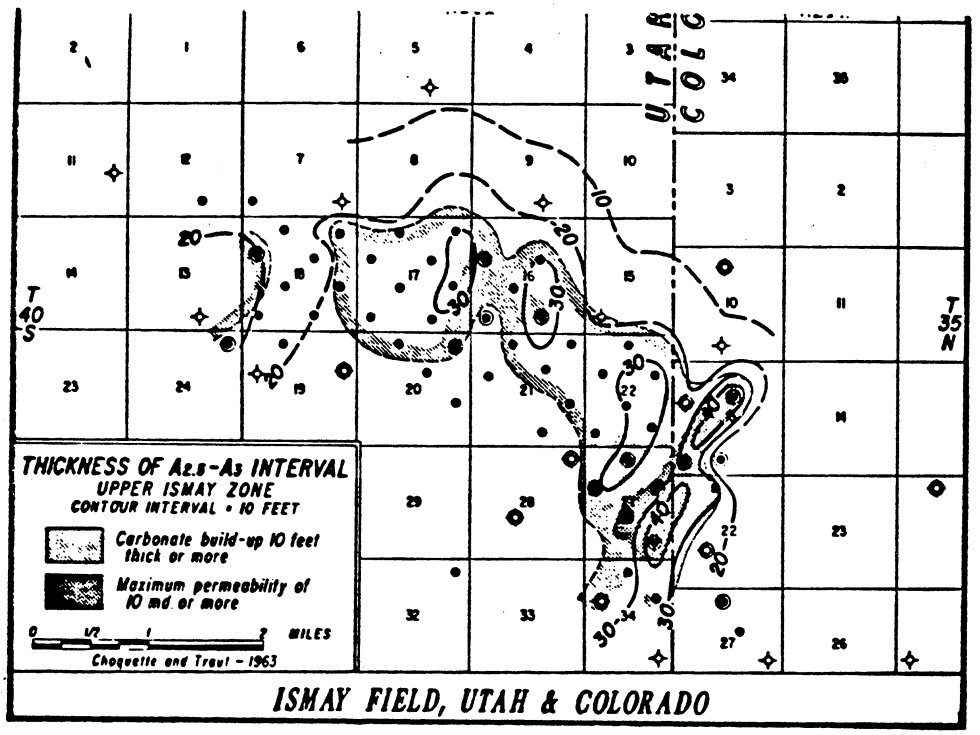


FIG. 5.——Isopach map of Az.s-As interval. Upper Ismay zone.. Notice the close superposition of these "thicks" over those shown in Figure 4.

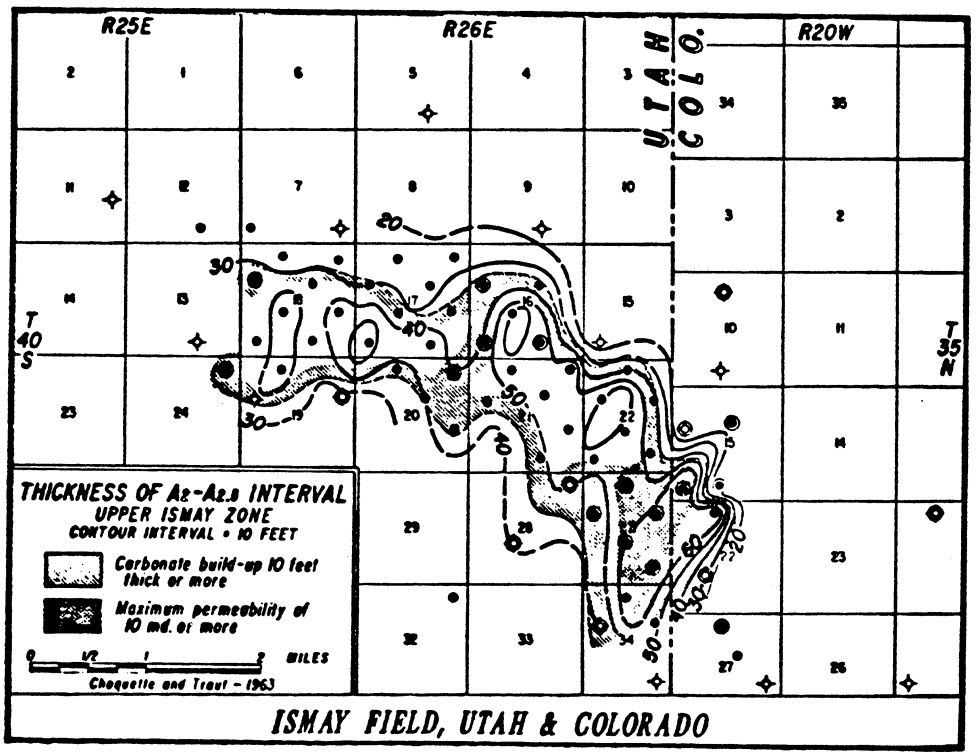


FIG. 6.——Isopach map of the Az-Az.s interval. Upper Ismay zone. Build-ups in this interval are comparable in thickness to those in the As-B interval.

Reference: Choquette, P. W., and Traut, J. O., 1963, "Pennsylvanian Carbonate Reservoirs, Ismay Field, Utah and Colorado", in Shelf Carbonates of the Paradox Basin-Symposium: Four Corners Geological Society.

SOURCE 12 B

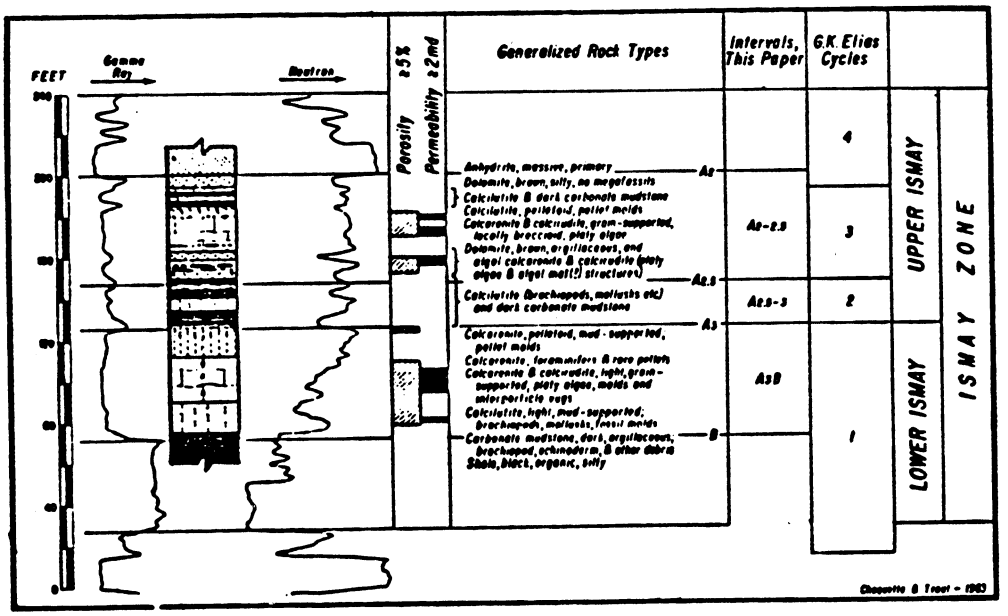


FIG. 2.—Lithology and radioactivity log characteristics of the cored portion of the Ismay zone in a typical well in the productive trend. Zones of optimum porosity and permeability, based on whole core analyses, are shown in the center column. Positions of the horizons and intervals mentioned in this report are shown in the right portion of the figure.

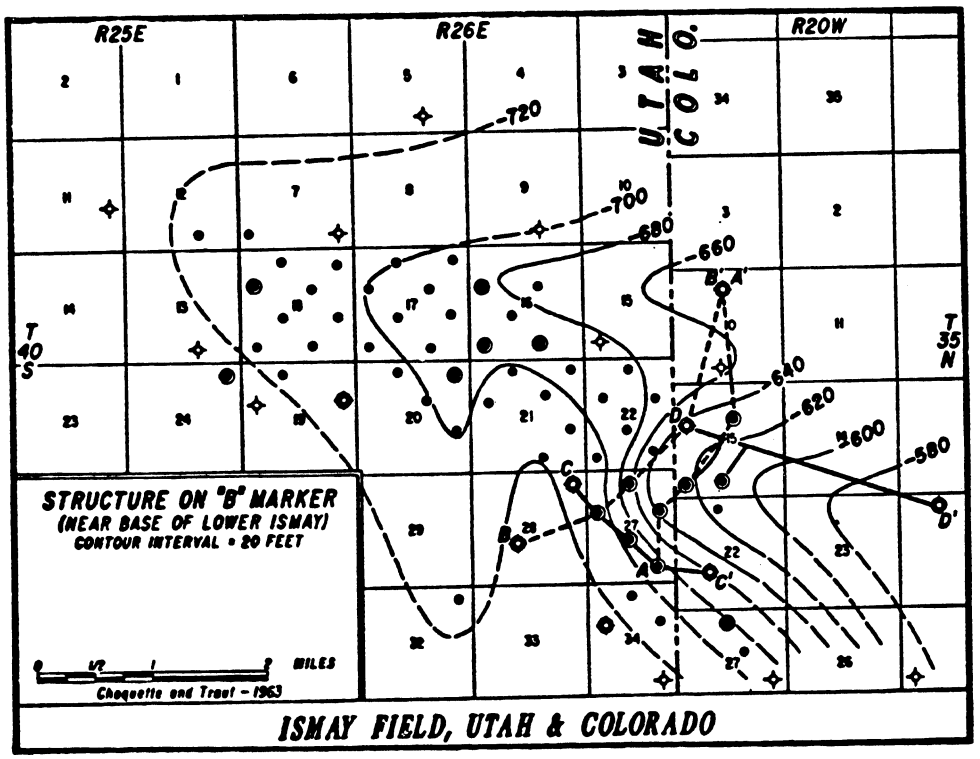
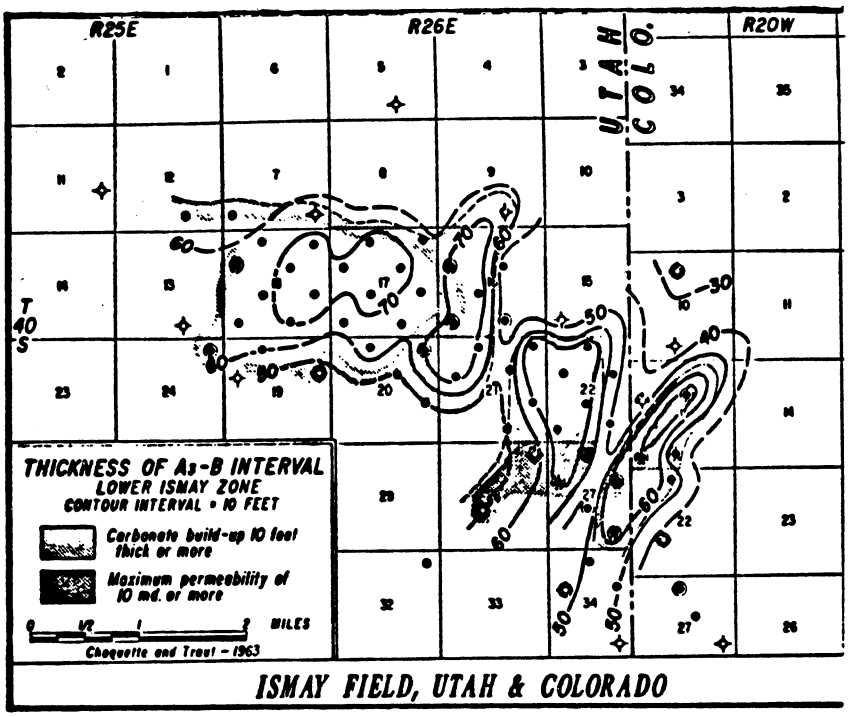


FIG. 3.—Structure of Ismay field, drawn on the "B" shale marker. Cross-sections shown in Figures 7 and 8 are located here. Circled wells are those from which cores or core chips were available for study.

Reference: Choquette, P. W., and Traut, J. O., 1963, "Pennsylvanian Carbonate Reservoirs, Ismay Field, Utah and Colorado", in Shelf Carbonates of the Paradox Basin-Symposium: Four Corners Geological Society.



SOURCE 12 B

—Isopach map of A3-B interval, Lower Ismay zone.

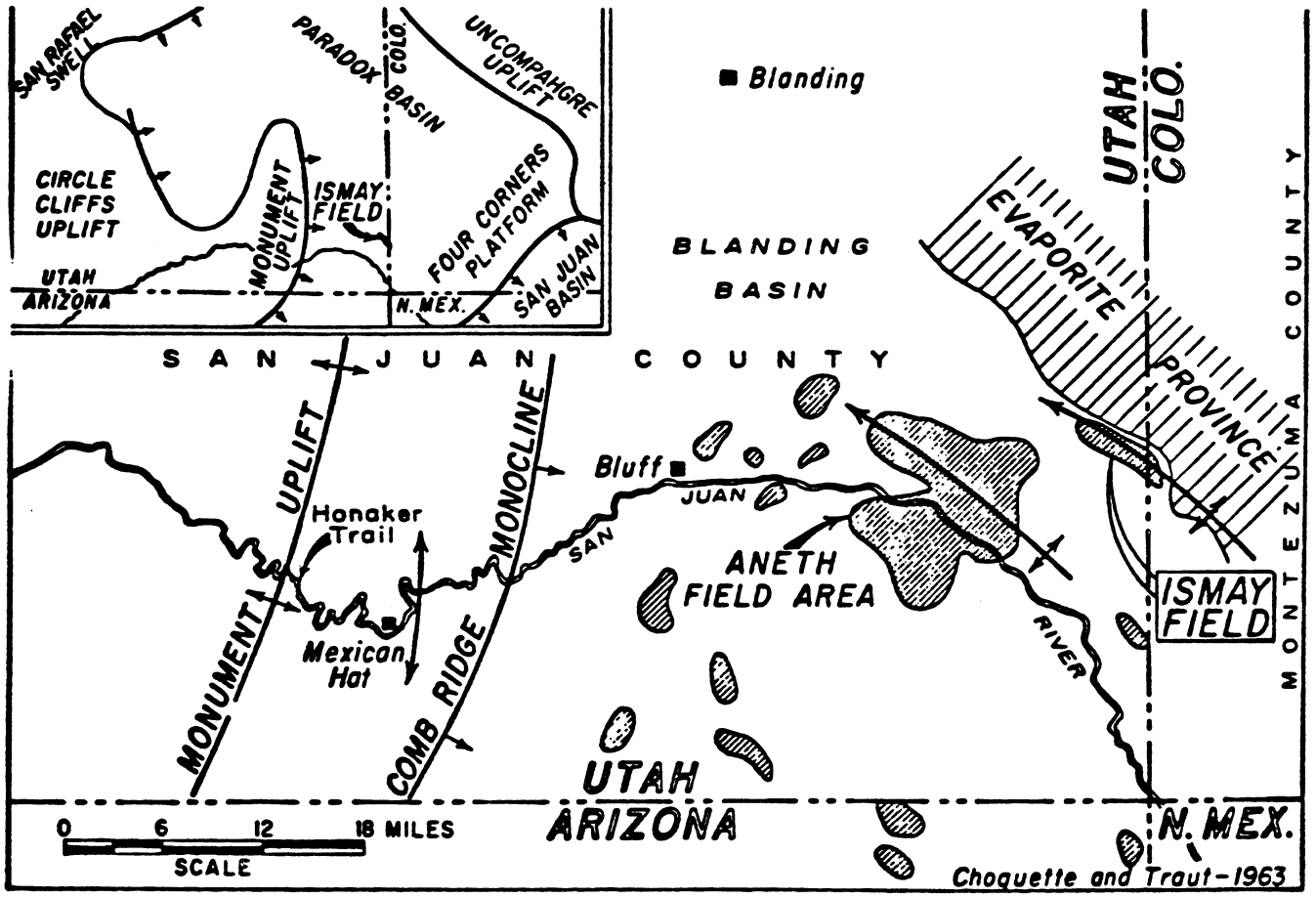


FIG. 1.——Index map showing location of Ismay field. Fields producing from Pennsylvanian carbonate reservoirs are shown by hachured areas.

Reference: Choquette, P. W., and Traut, J. O., 1963, "Pennsylvanian Carbonate Reservoirs, Ismay Field, Utah and Colorado", in Shelf Carbonates of the Paradox Basin-Symposium: Four Corners Geological Society.

ISMAY

(Oil)

T. 40 S., R. 25-26 E., SLPM

San Juan County, Utah

By: D. F. Mecham
Marathon Oil Company

GEOLOGY

Regional Setting: Southeast Paradox Basin (along north margin of a broad shallow marine platform)

Surface Formations: Jurassic, Morrison Formation; Cretaceous, Dakota Sandstone and Burro Canyon Formation

Exploration Method Leading to Discovery: Surface and subsurface geology, some seismic

Type of Trap: Stratigraphic, markedly influenced by structure

Producing Formation: Pennsylvanian, Ismay Zone of Paradox Formation

Gross Thickness and Lithology of Reservoir Rocks: Approximately 80 feet, lenticular bioclastic carbonates, variable over field

Geometry of Reservoir Rock: Stacked, mound-like carbonate buildups, generally elongate northeast

Other Significant Shows: Unknown

Oldest Stratigraphic Horizon Penetrated: Cambrian, Ignacio Quartzite

DISCOVERY WELL

Name: Texaco No. J-1 Navajo Tribal

Location: NE NE (660' FNL and 660' FEL) sec. 20, T. 40 S., R. 26 E.

Elevation (KB): 4,957 feet

Date of Completion: October 8, 1956 (some records show September 29, 1956)

Total Depth: 5,832 feet

Production Casing: 5½" to 5,817 feet with 500 sacks of cement

Perforations: 5,585 to 5,625 feet with 4 shots per foot

Stimulation: Wash perforations with 500 gallons mud acid

Initial Potential: 1,410 BOD, 1" choke (flowing)

Bottom Hole Pressure: 2,205 psi

DRILLING AND COMPLETION PRACTICES

Two methods common:

1. 13 3/8" (100 to 300 feet), 8 5/8" (1,200 to 1,500 feet), 5½" to total depth.
2. 8 5/8" to 13 3/8" (100 to 300 feet), 5½" (some 4½") to total depth, perforate from log interpretation, acidize 500 to 4,000 gallons.

RESERVOIR DATA

Productive Area:
Proved (as determined geologically): 4,370 acres
Unproved: Unknown

Approved Spacing: 80 acres
No. of Producing Wells: 29 (19 water injection)
No. of Abandoned Wells: 16 (some used for water injection)
No. of Dry Holes: 8 (some used for water injection)

Average Net Pay: 24 feet

Porosity: Zone one, 9.8 percent; zone two, 7.7 percent; zone three, 14.6 percent

Permeability: Zone one, 5.2 millidarcies; zone two, 28.1 millidarcies; zone three, 4.9 millidarcies

Water Saturation: 41 percent

Initial Field Pressure: 2,205 psi

Type of Drive: Solution gas

Gas Characteristics and Analysis: Unknown

Oil Characteristics and Analysis: 46.3° API gravity, low sulfur (.05 percent), brownish-green, paraffin base

Associated Water Characteristics and Analysis: Salt water

Original Gas, Oil, and Water Contact Datums: Oil-water -640 feet

Estimated Primary Recovery: Unknown

Type of Secondary Recovery: Water flood—active

Estimated Ultimate Recovery: Oil 12,000,000 BO (35 percent); gas 21,500,000 MCFG (51 percent)

Present Daily Average Production: 315 BOD, 537 MCFGD (October 1977)

Market Outlets: Texaco, operator; shipped through the Texas-New Mexico pipeline

FIELD COMMENTARY

The Ismay field is located in the northeastern corner of the Navajo Indian Reservation in T. 40 S., R. 25-26 E., San Juan County, Utah. It is bounded on the east by the Utah-Colorado state line. The field was referred to as East Aneth during some early work in the area and later (because Texaco the unit operator included two Colorado wells in their Ismay operation) was referred to as the Ismay-Flodine Park Unit. In this report a distinction is being made between the Ismay field in Utah and the Flodine Park field in Colorado, and all the Colorado wells are considered to be within the Flodine Park field.

The structure is a broad gently west dipping nose that was mapped by plane table in the early 1950's. Subsequently seismic added to the structural picture but the major effort was through subsurface mapping.

Production is almost exclusively from the Ismay Zone of the Middle Pennsylvanian Paradox Formation. The discovery well, Texas Company's Navajo J-1, was also the first Paradox Basin test to produce from the Ismay Zone. Production is found in bio-clastic carbonate buildups that occur stacked one above another in three intervals of the Ismay Zone. Individual buildups are often elongate northeast, essentially at right angles to the structural trend. Production is primarily from

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the porous and permeable zones within the individual buildups. These porous and permeable zones are related to the depositional fabric, extent of leaching, and degree of pore-filling by calcite and anhydrite. Production is confined, for the most part, to the crest and southwest flank of the structure. An area of particular interest is in the extreme southeastern part of the field, in sections 27 and 34, where the carbonate buildup is interpreted as a continuation of the Flodine Park buildup to the northeast in Colorado. Within the outlined area there have been 53 tests drilled; 8 were dry holes and 45 were completed as oil wells. Sixteen of the oil wells have been subsequently abandoned and many of these have been converted to water injection wells. There are also several dry holes outside the map area that help define the field limits.

REFERENCES

Choquette, P. W., and Traut, J. D., 1963, Pennsylvanian Carbonate Reservoirs, Ismay Field, Utah and Colorado, *in* Fourth Field Conference Guidebook: Four Corners Geological Society, p. 157-184.

Elias, G. K., 1963, Habitat of Pennsylvanian Algal Bioherms, Four Corners Area, *in* Fourth Field Conference Guidebook: Four Corners Geological Society, p. 185-203.

Mercurio, R. N., 1961, Flodine Park Field, Rocky Mountain Association of Geologists Oil and Gas Field Volume, Colorado-Nebraska, p. 128-129.

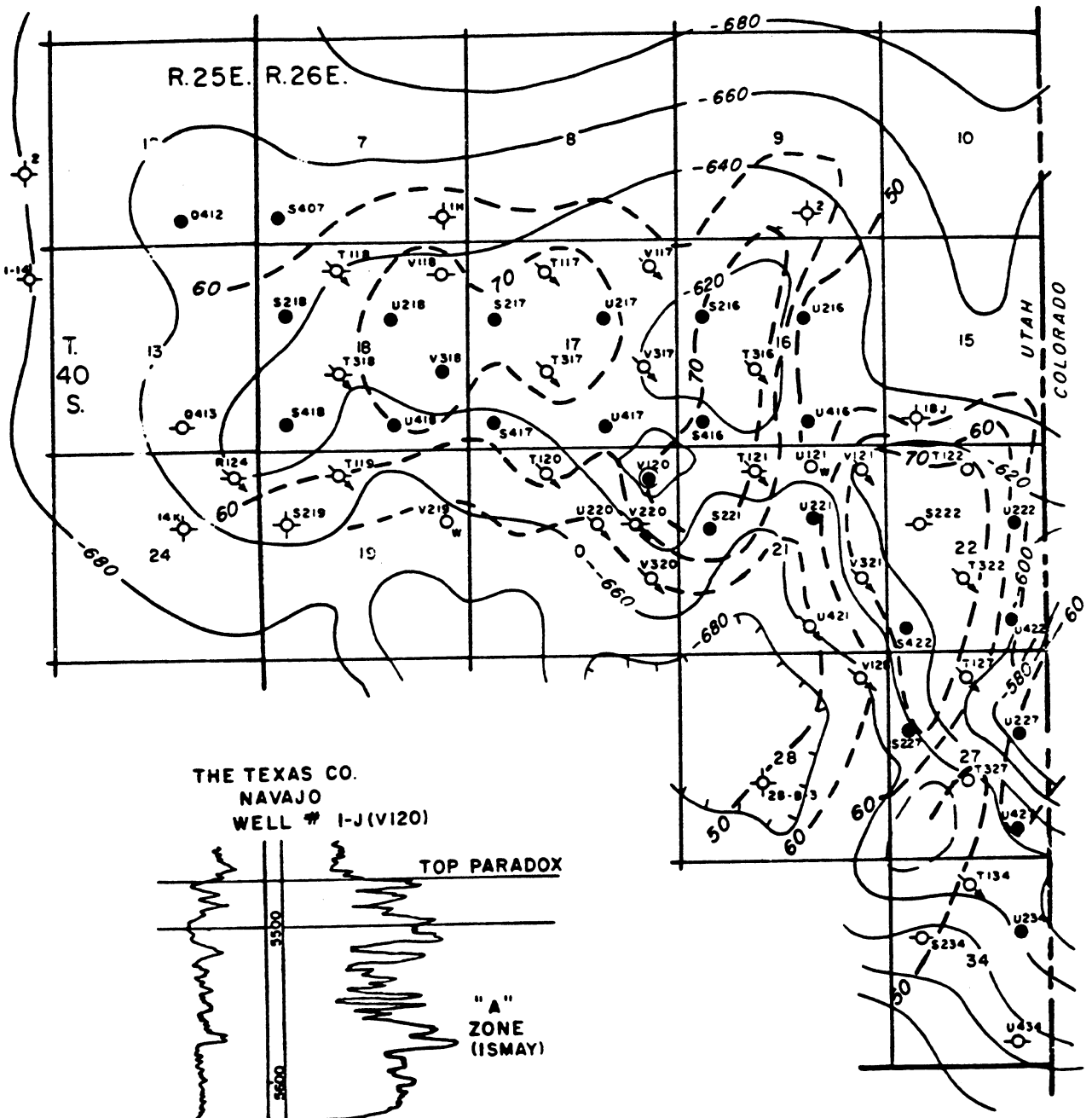
Stowe, C., 1970, Oil and Gas Production in Utah to 1970, Utah Geological and Mineralogy Survey, Bulletin 94, p. 108-110.

ISMAY FIELD [1]

NO. OF WELLS @ YR. END				PRODUCTION OIL IN BARRELS GAS IN MCF	
YEAR	TYPE	PROD.	SI/ABN[2]	ANNUAL	CUMULATIVE
1956	Oil	1		12,894	12,894
	Gas			13,720	13,720
1957	Oil	4	1	20,604	33,498
	Gas			15,000	28,720
1958	Oil	12	2	223,576	257,074
	Gas			157,917	186,637
1959	Oil	19	2	500,031	757,105
	Gas			284,100	470,737
1960	Oil	32	3	696,966	1,454,071
	Gas			665,034	1,135,771
1961	Oil	35	4	685,083	2,139,154
	Gas			783,106	1,918,877
1962	Oil	45	6	1,497,615	3,636,769
	Gas			2,074,689	3,992,566
1963	Oil	45	6	970,328	4,607,097
	Gas			1,461,060	5,455,626
1964	Oil	44	7	794,851	5,401,948
	Gas			1,367,063	6,820,689
1965	Oil	46	7	687,175	6,089,125
	Gas			1,591,588	8,412,277
1966	Oil	36	17	560,426	6,649,549
	Gas			1,040,684	9,452,961
1967	Oil	34	19	427,015	7,076,564
	Gas			976,409	10,429,370
1968	Oil	31	22	386,799	7,463,363
	Gas			959,628	11,388,998
1969	Oil	31	22	490,693	7,954,056
	Gas			795,333	12,184,331
1970	Oil	31	22	217,345	8,171,401
	Gas			559,332	12,743,653
1971	Oil	31	22	71,155	8,242,556
	Gas			637,934	13,381,587
1972	Oil	32	21	250,096	8,492,652
	Gas			595,399	13,976,986
1973	Oil	35	18	375,213	8,867,865
	Gas			443,753	14,420,739
1974	Oil	34	19	280,059	9,147,924
	Gas			1,151,374	15,572,113
1975	Oil	32	21	177,858	9,325,782
	Gas			334,182	15,906,295
1976	Oil	30	23	157,918	9,483,700
	Gas			302,073	16,208,368
1977[3]	Oil	29	24	123,000	9,711,615
	Gas			220,573	16,613,488

1) Some of the yearly figures (PI) differ from those published in Utah Geol. & Min. Survey Bulletin 94, but totals are approximately the same. These (PI) were used for consistency.
2) Includes D&A and TA within the outlined area.
3) Based on extrapolation for November-December.

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.



ISMAY FIELD

20' CONTOUR
LOWER ISMAY (A_3) ZONE
WITH
ISOPACH AT A_3-B SUPERIMPOSED

(FROM CHOQUETTE and TRAUT)

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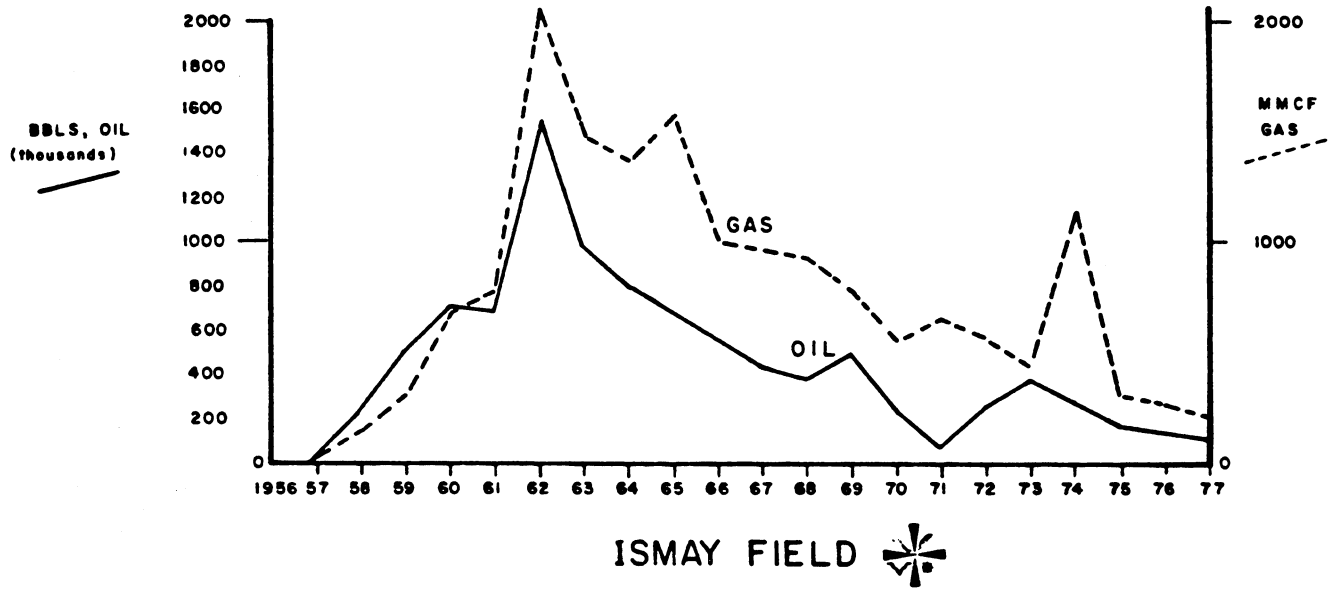
From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 5b.



ISMAY FIELD

El Paso Natural Gas Co.'s northwest district exploration crew in front of Project Gasbuggy display, December, 1967. From left to right, Jack Shaughnessy, Roy Pritchard, K. C. Bowman, M. E. Spitler, Bill Martin, Dick Ullrich, and C. F. "Chief" Brown. (Photo compliments of El Paso Natural Gas Co.)

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 5b.

ISMAY, SOUTH

(Oil)

T. 40 S., R. 26 E., SLPM

San Juan County, Utah

By: D. F. Mecham
Marathon Oil Company

GEOLOGY

Regional Setting: Paradox Basin

Surface Formations: Jurassic, Morrison Formation; Cretaceous, Dakota Sandstone and Burro Canyon Formation

Exploration Method Leading to Discovery: Subsurface geology, some seismic

Type of Trap: Stratigraphic with structural influence

Producing Formation: Ismay Zone of Paradox Formation

Gross Thickness and Lithology of Reservoir Rocks: Unknown

Geometry of Reservoir Rock: Unknown

Other Significant Shows: Unknown

Oldest Stratigraphic Horizon Penetrated: Pennsylvanian, Paradox Formation salt

DISCOVERY WELL

Name: Texaco No. 1 Navajo/U/NCT

Location: NE NE (600 ' FNL and 600 ' FEL) sec. 32, T. 40 S., R. 26 E., San Juan County, Utah

Elevation (KB): 4,828 feet

Date of Completion: August 15, 1960

Total Depth: 5,726 feet

Production Casing: 5½" at 5,518 feet with 250 sacks of cement

Perforations: 5,420 to 5,426 feet; 5,435 to 5,446 feet; 5,454 to 5,460 feet with two perforations per foot

Stimulation: Acidize 2,000 gallons

Initial Potential: 14 BOD, 17 BWD (pumping)

Bottom Hole Pressure: Unknown

DRILLING AND COMPLETION PRACTICES

10¾" to 13 3/8" at 100 to 200 feet, 8 5/8" to approximately 1,500 feet, 5½" to total depth, perforate from logs, acidize.

RESERVOIR DATA

Productive Area:
Proved (as determined geologically): 480 acres
Unproved: Unknown
Approved Spacing: Unknown
No. of Producing Wells: 1
No. of Abandoned Wells: 2
No. of Dry Holes: 1

Average Net Pay: 16 feet

Porosity: 9½ percent

Permeability: 24 millidarcies

Water Saturation: 28 percent

Initial Field Pressure: 2,100 psi

Type of Drive: Solution gas

Gas Characteristics and Analysis: Solution gas

Oil Characteristics and Analysis: 40 to 41° API gravity, low sulfur, paraffin base

Associated Water Characteristics and Analysis: Salt water

Original Gas, Oil, and Water Contact Datums: Unknown

Estimated Primary Recovery: Unknown

Type of Secondary Recovery: None

Estimated Ultimate Recovery: 200,000 BO, 275,000 MCFG

Present Daily Average Production: 10 BOD, 5 MCFGD, 5 BWD (Oct. 1977)

Market Outlets: Texas-New Mexico Pipeline

FIELD COMMENTARY

South Ismay is a small field south of Ismay proper. It is east of the giant Aneth complex and north of the McElmo Creek field. It is in the southern part of T. 40 S., R. 26 E. and includes parts of three sections (see map). Production is from the Ismay Zone of the Paradox Formation from a porosity condition that appears to be localized by a slight structural anomaly. Like a number of fields in this general area, the production is basically stratigraphic. The discovery well was drilled by Texaco in 1960 in the NE NE sec. 32, T. 40 S., R. 26 E., but resulted in only minor production. An offset was drilled in SW NW sec. 33 that produced for several years.

During that period of time the area was first considered to be an extension of the Ismay field but as later dry holes isolated it from the Ismay field proper, it was carried as undesignated. Early production records are confusing, being partly assigned to Ismay and partly to an unknown classification. It was not until 1966, following the drilling of an extension to the northwest in NE SW, sec. 29 by Union Oil Co., that production records were systematically assigned to the South Ismay field.

There have been four tests drilled in the outlined area; 1 marginal well (the discovery well), 1 dry hole, and 2 producing wells. Because of the time frame involved in the development, the field has been, except for one short period of time, a one-well field. During the final productive period of the Texaco well and the placing on production of the Union well, there was a short time where two wells were producing.

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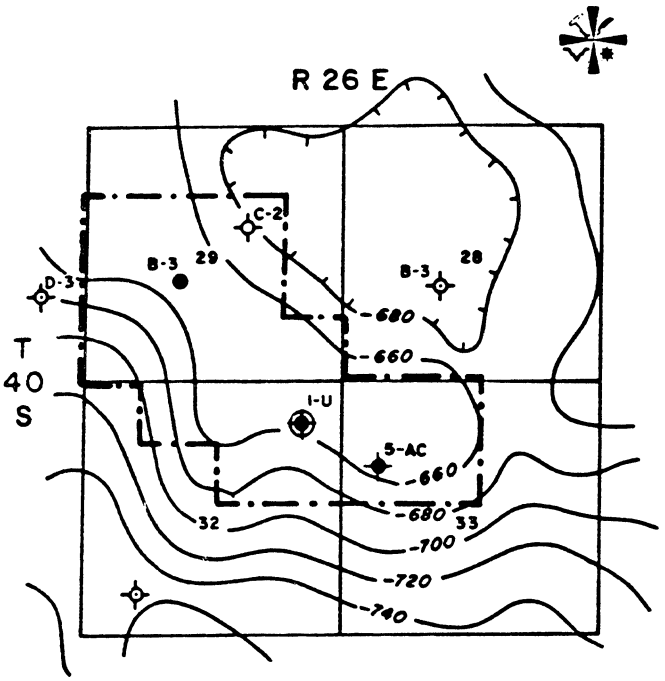
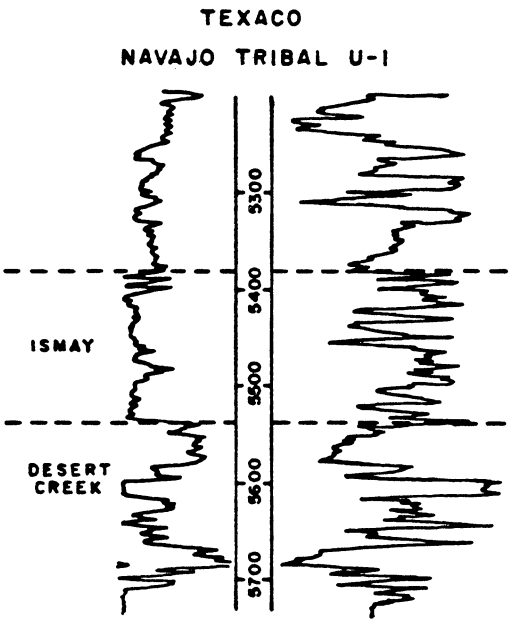
Stowe, C., 1970, Oil and Gas Production in Utah to 1970, Utah Geological and Mineralogy Survey, Bulletin 94, p. 108-110.

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

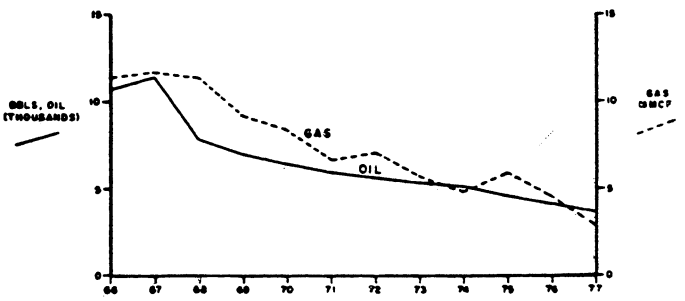
[Four Corners Geological Society

SOUTH ISMAY FIELD
20' CONTOUR-LOWER ISMAY





NO. OF WELLS @ YR. END				PRODUCTION OIL IN BARRELS GAS IN MCF	
YEAR	TYPE	PROD.	SI/ABN	ANNUAL	CUMULATIVE
1966	Oil	2	1	10,659	10,659
	Gas			11,406	11,406
1967	Oil	1	2	11,412	22,071
	Gas			11,629	23,035
1968	Oil	1	2	7,866	29,931
	Gas			11,343	34,378
1969	Oil	1	2	6,974	36,911
	Gas			9,102	43,480
1970	Oil	1	2	6,309	43,220
	Gas			8,311	51,791
1971	Oil	1	2	5,883	49,103
	Gas			6,612	58,403
1972	Oil	1	2	5,619	54,722
	Gas			7,083	65,486
1973	Oil	1	3	5,316	60,038
	Gas			5,689	71,175
1974	Oil	1	3	5,123	65,161
	Gas			4,891	76,066
1975	Oil	1	3	4,592	69,753
	Gas			5,942	82,008
1976	Oil	1	3	4,070	73,823
	Gas			4,589	86,597
1977	Oil	1	3	3,700	77,523
	Gas			2,860	89,457
Est. Prod. prior to 1966:				Oil 46,680	
				Gas 58,821	
Est. Gross				Oil	124,203
				Gas	148,278



Oil and Gas Fields of the Four Corners Area]

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

ISMAY OIL FIELD

San Juan County, Utah

The Ismay Oil Field is located along the Utah-Colorado border in the southeastern portion of the Paradox Basin, 8½ miles west of Aneth field.

As shown on the accompanying plat the production is for the most part confined to the crest of an irregular, westerly plunging anticline expressed on the Paradox "A-1" horizon. This feature exhibits minor closure primarily in Section 16 which undoubtedly effects accumulation; but as with the majority of Utah oil and gas fields the overriding factor in accumulation of hydrocarbons is stratigraphic. Although controversy exists as to the role of penecontemporaneous structural effect on development of reservoirs in the Paradox formation, the larger part of better oil production is associated with some structural relief.

Production at Ismay is from the lowermost Ismay zone from a predominately clastic carbonate section, containing minor amounts of anhydrite, shale, and calcarenite. Porosity, estimated at 13%, is pin-point and vugular: permeability is confined to the biostromal portions of the section. Tests of the Desert Creek zone show lack of reservoir development in that part of the section.

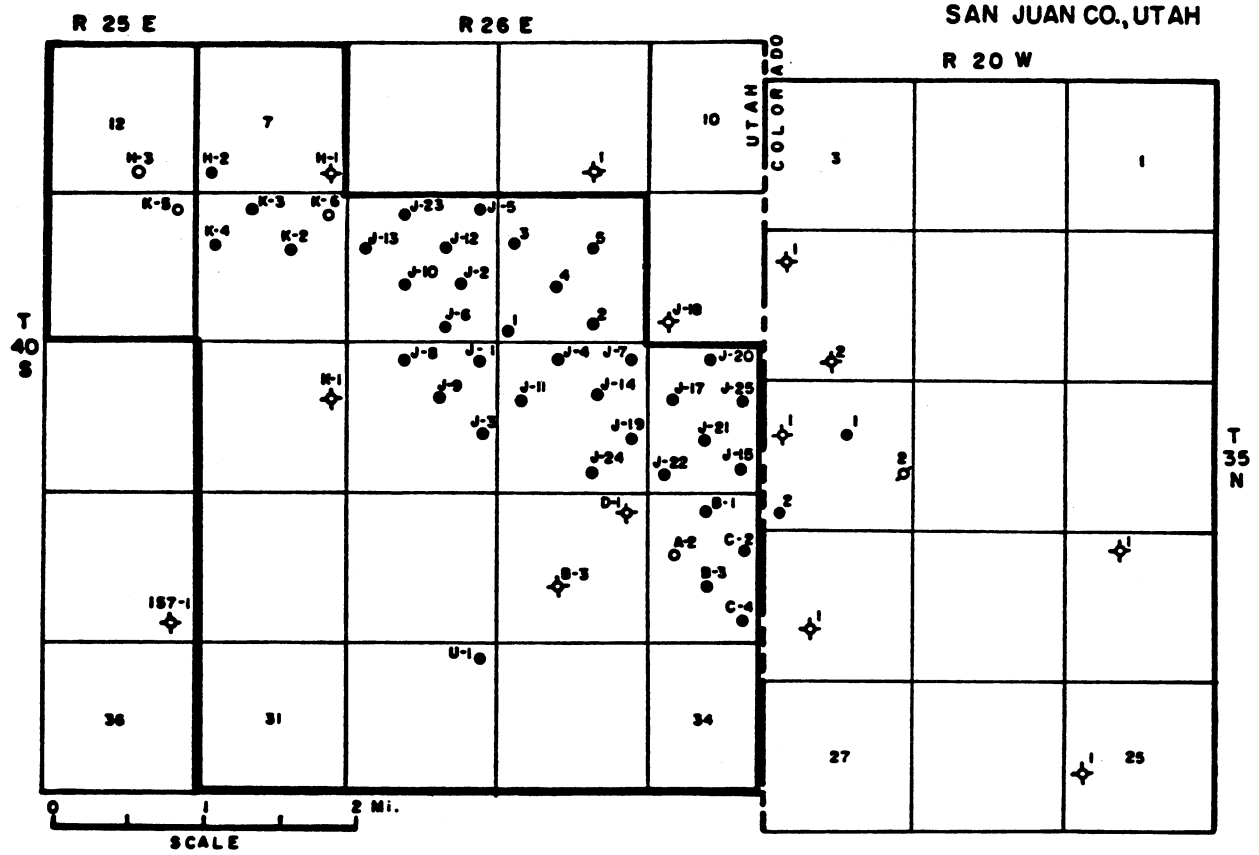
As of this writing there are 41 tests within the outline of the Ismay field; 37 productive wells and four abandoned.

The dark green, paraffinic base, 41° API gravity oil is transported to Jal, New Mexico via the Texas-New Mexico pipeline.

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

PARADOX BASIN
ISMAY FIELD
SAN JUAN CO., UTAH



PRODUCTION CHARACTERISTICS

RESERVOIR

FORMATION NAME	AGE	LITH.	AVE DEPTH	NET PAY	INIT. PRESS.	CURR PRESS.	TYPE DRIVE	% POROS.	PERM MD
HERMOSA (ISMAY)	PENN.	LS.	5660	38'			SOL. GAS	13%	10

FLUIDS

FORMATION NAME	GRAVITY	POUR POINT	SULFUR CONTENT	GOR	BTU/FT^3	METHANE	ETHANE	WATER SALINITY	OTHER FLUIDS
HERMOSA (ISMAY)	41° API		0.11	1000: 1					

ECONOMICS

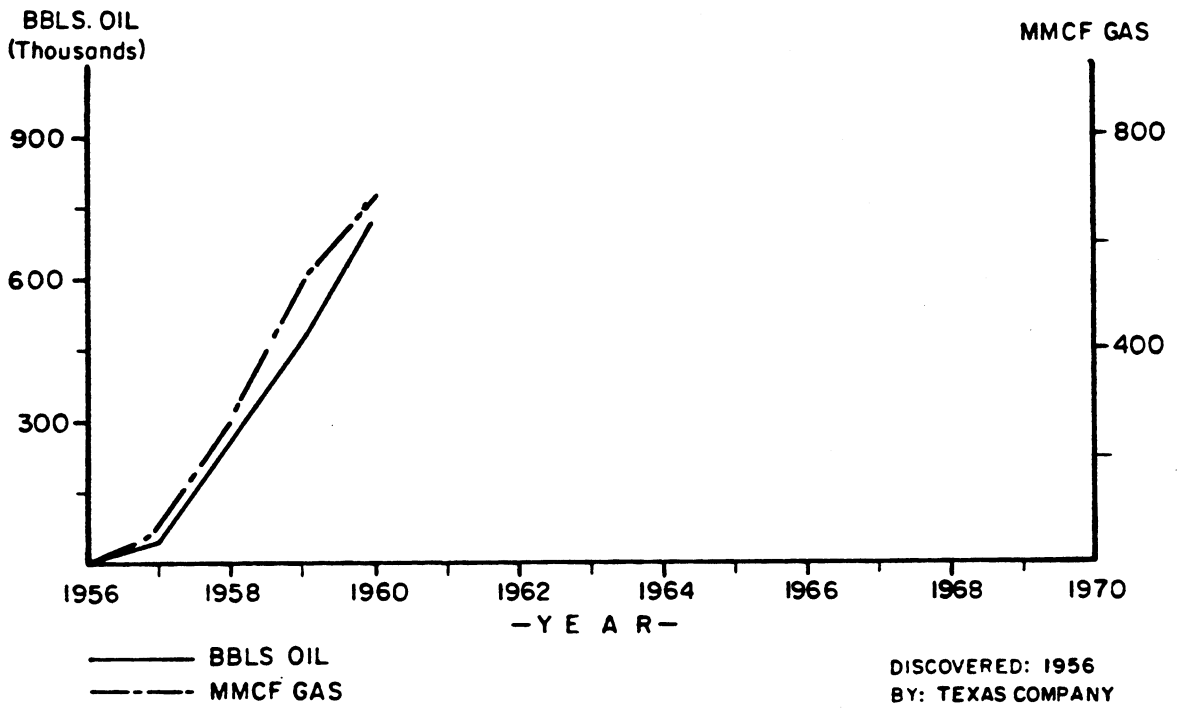
FORMATION NAME	PROD. WELLS	PROD. 1-1-60—1-1-61	CUMULAT. PROD. 1-1-61	$ / BBL WELL HEAD	$ / MCF WELL HEAD	ULT. RES.	PROVEN ACREAGE	TOTAL WELLS	SPACING
HERMOSA (ISMAY)	35	697,000 BBL.	1,480,000	$2.85 (Delhi.)		36,000,000	2800	39	80 ACRE

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

PARADOX BASIN
T 40 S, R 26 E

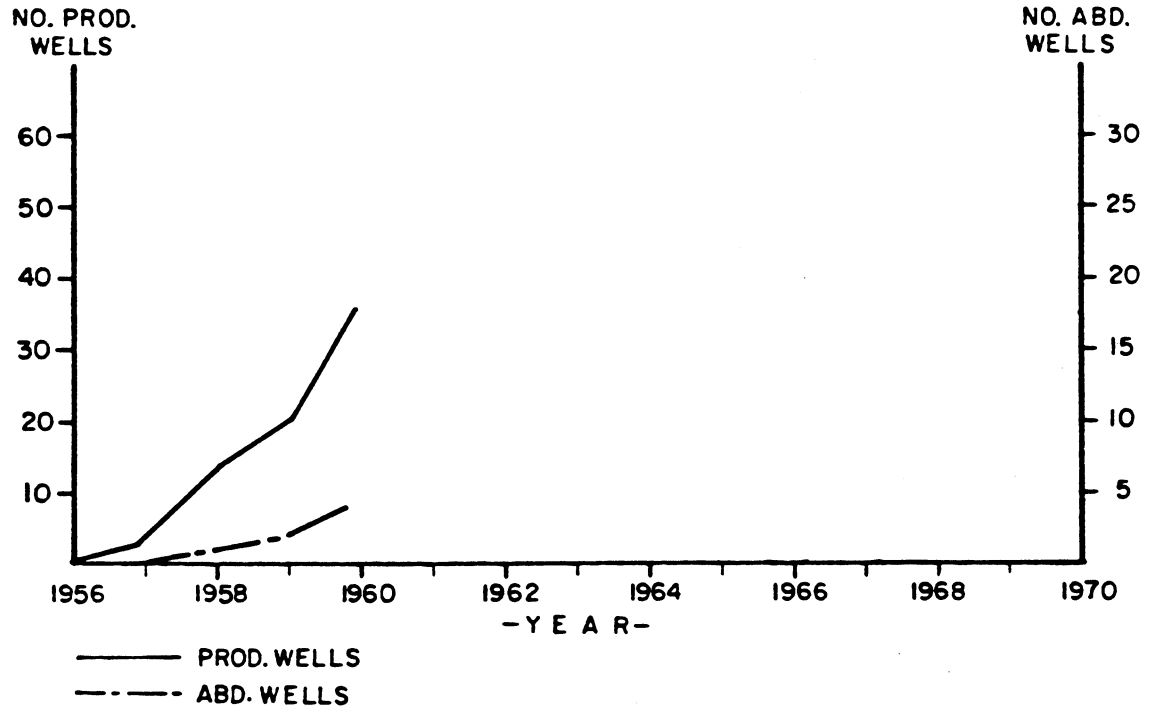
ISMAY FIELD
SAN JUAN CO., UTAH

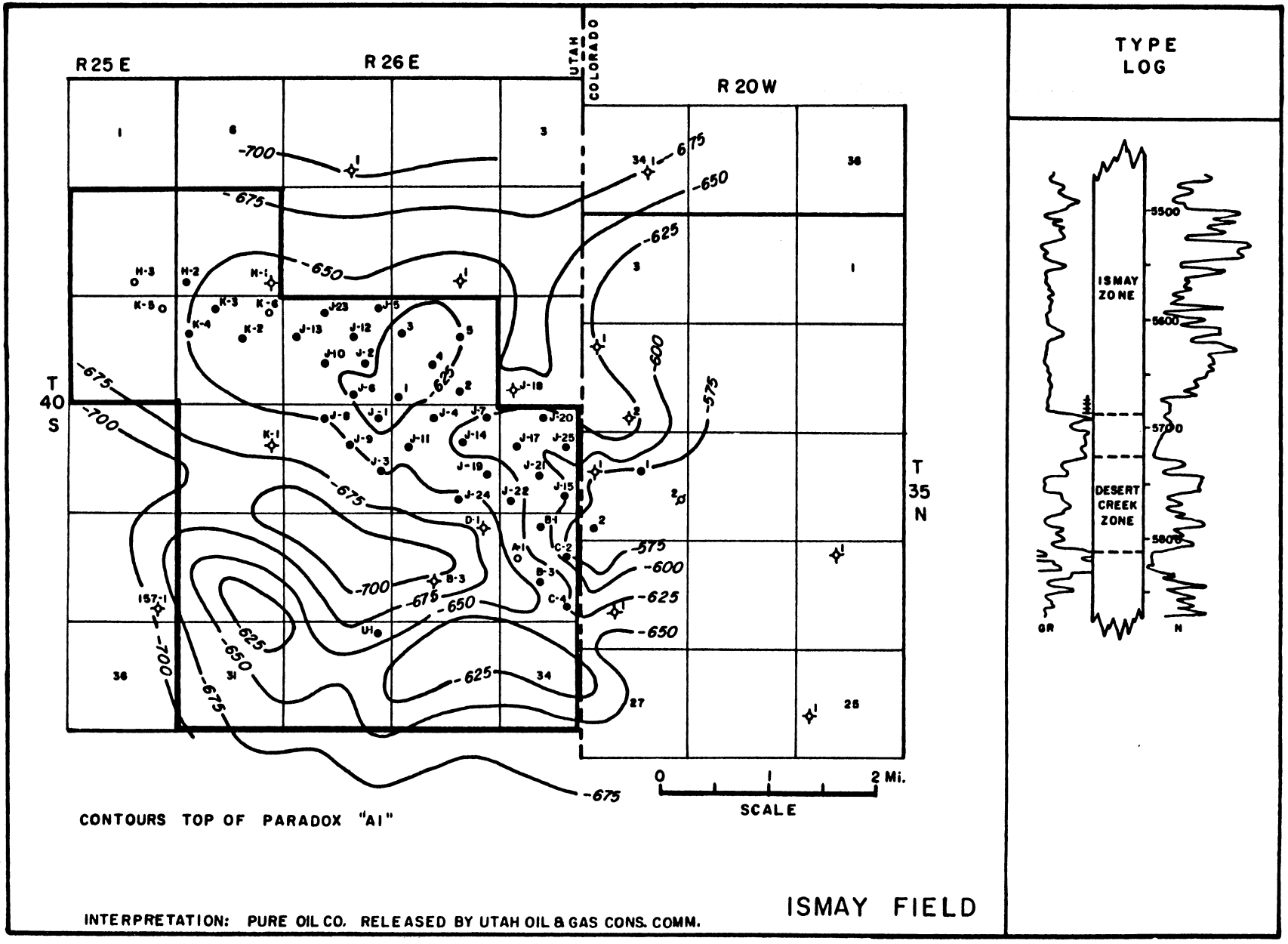
HYDROCARBON PRODUCTION



DISCOVERED: 1956
BY: TEXAS COMPANY

DEVELOPMENT DRILLING





From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

Utah - Lisbon
Madison - Mississippian
Paradox Basin

DATA SOURCE CODE		
5b,5a	STATE	Utah
	COUNTY	San Juan
	REGULATORY DISTRICT	
5a,8	BASIN	Paradox
	SUB-BASIN	
5b,5a	FIELD	Lisbon
5b,5a	RESERVOIR	Redwall Limestone, Madison
5b,8,5a	GEOLOGIC AGE	Mississippian
5b	AAPG STRATIGRAPHIC AGE CODE	330
5b,5a	RESERVOIR LITHOLOGY	Limestone and dolomite; dolomite
5b,8	TRAPPING MECHANISM	Faulted anticline; fault truncated anticline
5b,5a,13	DISCOVERY YEAR	1960
5b,5a,13	PROVED ACREAGE	5120, 5760, ±3420
5b,5a	REGULAR WELL SPACING (acres/well)	Does not apply, unit status; 80
5b,5a,13	RESERVOIR DEPTH	7570, 8500, 8261
	RESERVOIR THICKNESS	
5b,5a	NET PAY	225, 394 ft.
5b,5a	GROSS	328-534; 500 (log)
	NET/GROSS RATIO	
	POROSITY	
5a	TYPE	IG, V
5b,5a	FRACTION	.055, .10
	PERMEABILITY	
5b	RANGE	.01 to 1100 md
5b,5a	AVERAGE	22, 3 md
	HORIZONTAL	
	VERTICAL	
5b	OTHER INFORMATION	Other reservoirs include the McCracken Sandstone and Paradox Salt.
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
5b,5a	TOTAL NUMBER OF WELLS	19 (11P, 2SI, 1P&A, 5DH); 14P (1961)
5b	PRODUCTION 1976 oil (cum)	39,307 mbbls
5b	PRODUCTION 1977 oil (cum)	40,225 mbbls oil; 310,920.6 mmcf gas
	PRODUCTION 1978 oil (cum)	
	PRODUCTION 1979 oil (cum)	
5b	PRODUCTION 1-1-77 to 1-1-78	948.4 mbbls oil; 25,165.8 mmcf gas
5b	SECONDARY RECOVERY RECORDS?	yes
5b	WATER ANALYSIS RECORDS?	yes
	OTHER DATA	
5b,5a	STRUCTURE CONTOUR?	yes
5b,5a	LOGS?	yes
	STRUCTURE SECTION?	
5b,5a	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Lisbon
5b, 5a	RESERVOIR:	Redwall Lm.; Madison
5b,5a, 13	PROD. ACRES:	5120, 5760, ±3420
5b, 13	AVG. THICKNESS (FT.):	225, 70
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
5b	WATER SATURATION (S_W):	.39
	OIL SATURATION (S_O):	
5b,5a	PRIMARY DRIVE MECHANISM: expanding gas	cap & grav.drain.; ~~sol. gas~~ & water
5b,8,5a	PRIMARY GAS CAP?:	yes
11	TEMPERATURE (°F):	171
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
5b	RESERVOIR PRESSURE INITIAL (psi):	2982
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
5b,5a, 13	STOCK TANK OIL GRAVITY (°API):	54, 52-71, 44
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL	
5b	ESTIMATED PRIMARY OIL:	25,710.5 mbbls;250,000mmc
5b	Estimated Ultimated Oil:	42,850 mbbls

OTHER INFORMATION:

5b Secondary recovery is controlled gas injection.

5b Water salinity 70,000 to 100,000 ppm.

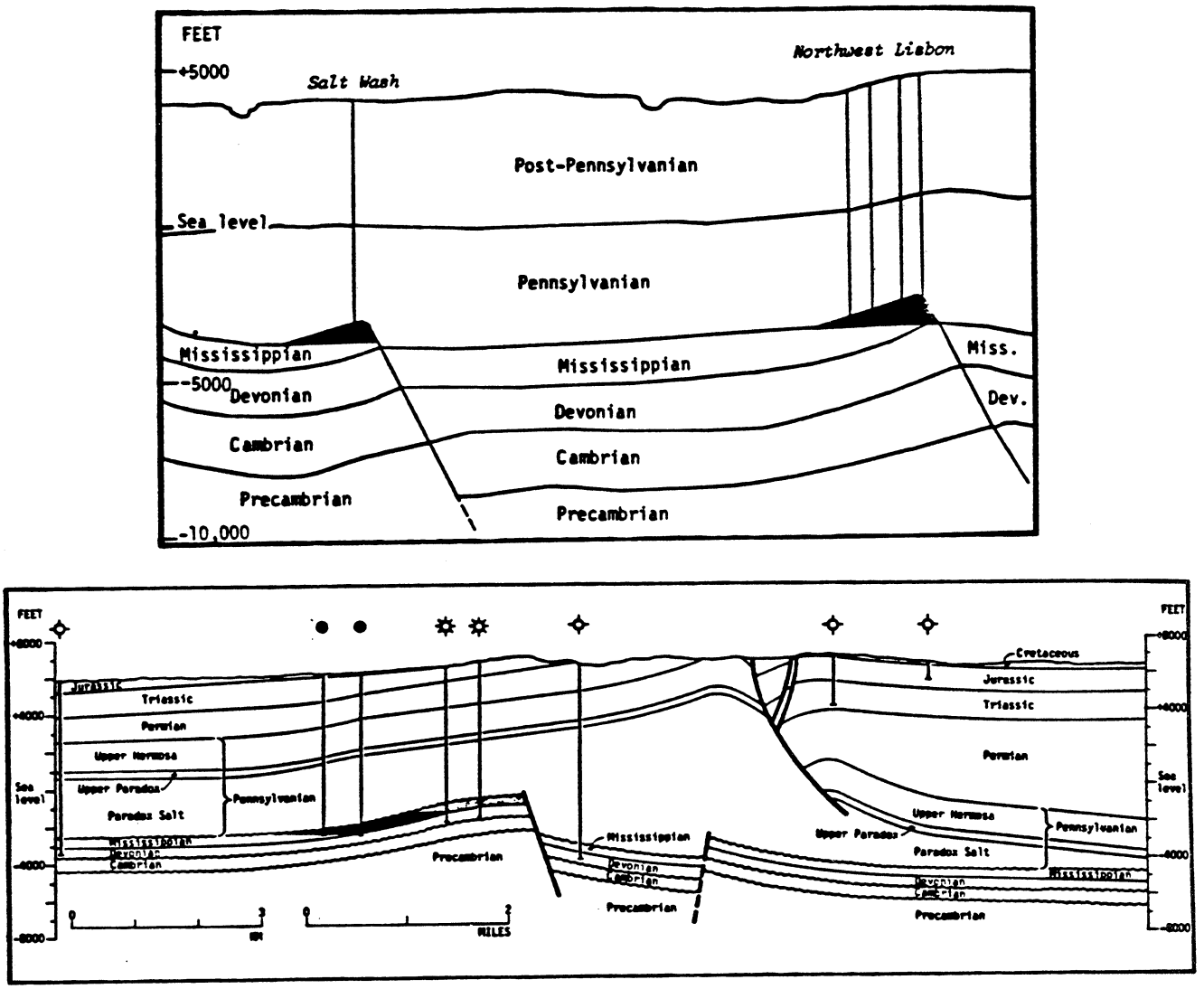


FIGURE 36.9 Salt anticline traps, northern Paradox basin, Utah. Upper: northwest-southeast (close to strike) hypothetical section through Salt Wash and Northwest Lisbon fields. Approximate distance between two fields is 60 miles (100 km). *Courtesy Pan American Petroleum Corporation (1961, p. 1), subsidiary of Standard Oil Company (Indiana).* Lower: southwest-northeast cross section, Northwest Lisbon field, showing four Mississippian oil and condensate gas wells. Gas and condensate pay zone stippled. *Courtesy John M. Parker (1968, Figure 5, p. 1378–1379).*

To the west of San Rafael swell, in the Castle Valley and especially on the Wasatch Plateau, hunting for flammable gas has been more successful (Figure 36.2). This district contains one very large field, Clear Creek, and several smaller gas fields. Castle Valley–Wasatch Plateau is an area of extensive outcrops of Tertiary and Cretaceous rocks. The column, including underlying lower Mesozoic and Paleozoic sediments, has a total thickness of about 19,000 feet. "It is a structurally complex area of numerous north-trending horsts and grabens that generally cut older structures" (Gere et al., 1964, p. 58).

The *Clear Creek* gas field (Anon., 1961; Walton, 1955), discovered in 1951, had produced over 100 billion cubic feet by the end of 1962. The reservoirs are sandstones in the Ferron Member of the Upper Cretaceous Mancos Shale. These sandstones are low in interpore permeability; both gas storage capacity and movement are greatly enhanced by the presence of natural fractures. Accumulation is in the higher parts of the Clear Creek anticline, a major upfold in the north-central part of the Wasatch Plateau. This anticline is segmented by horst and graben faults. Trapping is in the fault slices, especially the horsts, on the anticlinal crest.

KAIPAROWITS BASIN AND SOUTHWESTERN UTAH.

FROM: LANDES, K.S., 1970, PETROLEUM GEOLOGY OF THE UNITED STATES, John Wiley and Sons, New York, New York, page 444 Source B

LISBON

(Oil)

T. 30 S., R. 24 E., SLPM

San Juan County, Utah

By: Charles R. Clark
Union Oil Company of California

GEOLOGY

Regional Setting: Central portion, Paradox Fold and Fault Province

Surface Formations: Triassic-Jurassic, Wingate Sandstone

Exploration Method Leading to Discovery: Seismic and subsurface geology

Type of Trap: Faulted anticline

Producing Formation: Devonian, McCracken Sandstone Member of Elbert Formation; Mississippian, Redwall Limestone

Gross Thickness and Lithology of Reservoir Rocks: Redwall Limestone, 328 to 534 feet, limestone and dolomite; McCracken Sandstone Member, 113 feet, sandstone

Geometry of Reservoir Rock: Redwall Limestone, shallow marine shelf carbonate; McCracken Sandstone Member, transgressive shoreline sandstone

Other Significant Shows: None (clastic breaks in Pennsylvanian, Paradox Formation salt have yielded some oil)

Oldest Stratigraphic Horizon Penetrated: Pre-Cambrian

DISCOVERY WELL

Name: The Pure Oil Company No. 1 NW Lisbon USA

Location: NE NW (563 ' FNL and 2050 ' FWL) sec. 10, T. 30 S., R. 24 E.

Elevation (KB): 6,589 feet

Date of Completion: January 5, 1960

Total Depth: 8,440 feet

Production Casing: 7" at 8,440 with 2,000 sacks of cement (two stages)

Perforations: 7,567 to 7,970 feet (Redwall); 8,261 to 8,293 feet, 8,310 to 8,348 feet (McCracken)

Stimulation: HyFlo, acid, sand-oil fracture

Initial Potential: Flow 179 BOD, 4,376 MCFGD (Redwall); flow 586 BOD (McCracken)

Bottom Hole Pressure: 2,788 psi at 7,773 feet (Redwall); 2,713 psi at 8,271 feet (McCracken)

DRILLING AND COMPLETION PRACTICES

Drill and set 13 3/8" conductor at 30 to 73 feet as warranted by surface conditions. Drill and set 9 5/8" to 10¾" surface casing at 700 to 1,200 feet. Drill to approximate top of Paradox Formation salt and convert fresh water mud to natural brine or salt base mud. Drill to total depth, set 5½" or 7" production casing and cement with volume sufficient to cover complete Paradox salt section. Selectively perforate, stimulate (15 percent HCl used in Redwall), and if warranted, place on production.

RESERVOIR DATA (Redwall Limestone)

Productive Area:
Proved (as determined geologically): 5,120 acres
Unproved: 0 acres
Approved Spacing: Does not apply, unit status
No. of Producing Wells: 11 (10 shut-in)
No. of Abandoned Wells: 2 temporarily abandoned, 1 plugged and abandoned
No. of Dry Holes: 5 (outside the Unit Area, effectively outline the accumulation)

Average Net Pay: 225 feet

Porosity: 5.5 percent (average, highly variable from 1 to 21 percent)

Permeability: 22 millidarcies (highly variable from 0.01 to 1,100 millidarcies)

Water Saturation: 39 percent

Initial Field Pressure: 2,982 psia at -2,400 feet

Type of Drive: Expanding gas cap and gravity drainage

Gas Characteristics and Analysis: Sour, specific gravity 0.97, CO_2 21 percent, H_2S 1.2 percent, Btu 740

Oil Characteristics and Analysis: Sour, 54° API gravity, yellow to red

Associated Water Characteristics and Analysis: Salt water 70,000 to 100,000 ppm total dissolved solids

Original Gas, Oil, and Water Contact Datums: Gas-oil -1,800 feet, oil-water -2,570 feet

Estimated Primary Recovery: 25,710,500 BO (30 percent), 250,000,000 MCFG (70 percent)

Type of Secondary Recovery: Controlled pressure decline (crestal gas injection)

Estimated Ultimate Recovery: 42,850,000 BO (47 percent), 250,000,000 MCFG (70 percent)

Present Daily Average Production: 2,667 BOD, 55,662 MCFGD, 4,566 BWD (49,170 MCFGD injected back into reservoir)

Market Outlets: Ute Pipeline (company owned); gas injected back into Redwall Limestone

RESERVOIR DATA (McCracken Sandstone Member)

Productive Area:
Proved (as determined geologically): 1,050 acres
Unproved: 0 acres
Approved Spacing: None established, state spacing in effect
No. of Producing Wells: 1
No. of Abandoned Wells: 3 (temporarily abandoned)
No. of Dry Holes: 7 (penetrated McCracken during field development; McCracken not necessarily primary objective of all wells)

Average Net Pay: 25 feet

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 5b.

Porosity: 8 percent

Permeability: 2.6 millidarcies

Water Saturation: 43 percent

Initial Field Pressure: 2,713 psi at 8,271 feet

Type of Drive: Solution gas

Gas Characteristics and Analysis: Sweet 1,300 Btu

Oil Characteristics and Analysis: 43° to 50° API gravity, red, waxy

Associated Water Characteristics and Analysis: 70,000 to 100,000 ppm total dissolved solids

Original Gas, Oil, and Water Contact Datums: Oil-water -2,300 feet

Estimated Primary Recovery: 1,375,800 BO (20 percent)

Type of Secondary Recovery: None

Estimated Ultimate Recovery: 1,375,800 BO (20 percent)

Present Daily Average Production: 26 BO

Market Outlets: Oil, Ute Pipeline (company owned); gas, used on lease

FIELD COMMENTARY

The Mississippian is generally considered to have been deposited on a broad, shallow, partially restricted, low energy, marine shelf dipping gently to the northwest. Following deposition, the uppermost part of the Mississippian section was severely eroded and an undetermined amount of section lost. A karst topography was developed and in present day sections, solution cavities and fractures, filled with overlying Pennsylvanian, Molas Formation are easily identified. The contact of the karst surface and the overlying Pennsylvanian, Molas regolith clearly mark the unconformity at the top of the Mississippian. A general three-fold division of the Redwall Limestone is used in the Lisbon field; upper non-permeable limestone, porous middle dolomite, and lower non-permeable dolomite. The major productive portion is the middle dolomite which exhibits intercrystalline vuggy fracture and pinpoint porosity.

The surface structure in this part of the Paradox Basin is controlled by five major salt folds which are post-Mississippian in age and are related to salt flowage. Lisbon field is located on the southwest flank of the Lisbon Valley-Dolores salt anticline, however, field production is interpreted to be related to old structure which is related to basement. The crest of the Mississippian structure is located approximately four miles west of the crest of the Lisbon Valley salt anticline thus indicating the disparity of pre- and post-Mississippian structures. The Mississippian accumulation at Lisbon is controlled by a fault on the northeast side of the structure exhibiting a throw of approximately 1,200 to 1,600 feet. The remaining limits of production are controlled by an oil-water contact. From the highest structural well (C-93, SE¼ section 3) to the interpreted oil water contact, an oil column of 1,800 feet can be calculated for the structure.

The Mississippian reservoir fluid, by research done to date, is believed to be unique to the Lisbon field area. The fluid is a high, 54° API gravity crude which necessitated the early construction of an oil stabilization plant in order to transport the crude with a minimum of shrinkage. Thus Lisbon at the present time seems to fall into the category of one of a kind (like many of the Rocky Mountain fields). A second Lisbon is clearly a worthy exploratory goal.

I would like to thank the following persons for their help in preparing this report: Rox Green, drafting; John Roe, engineering; and Norman Ross, production records.

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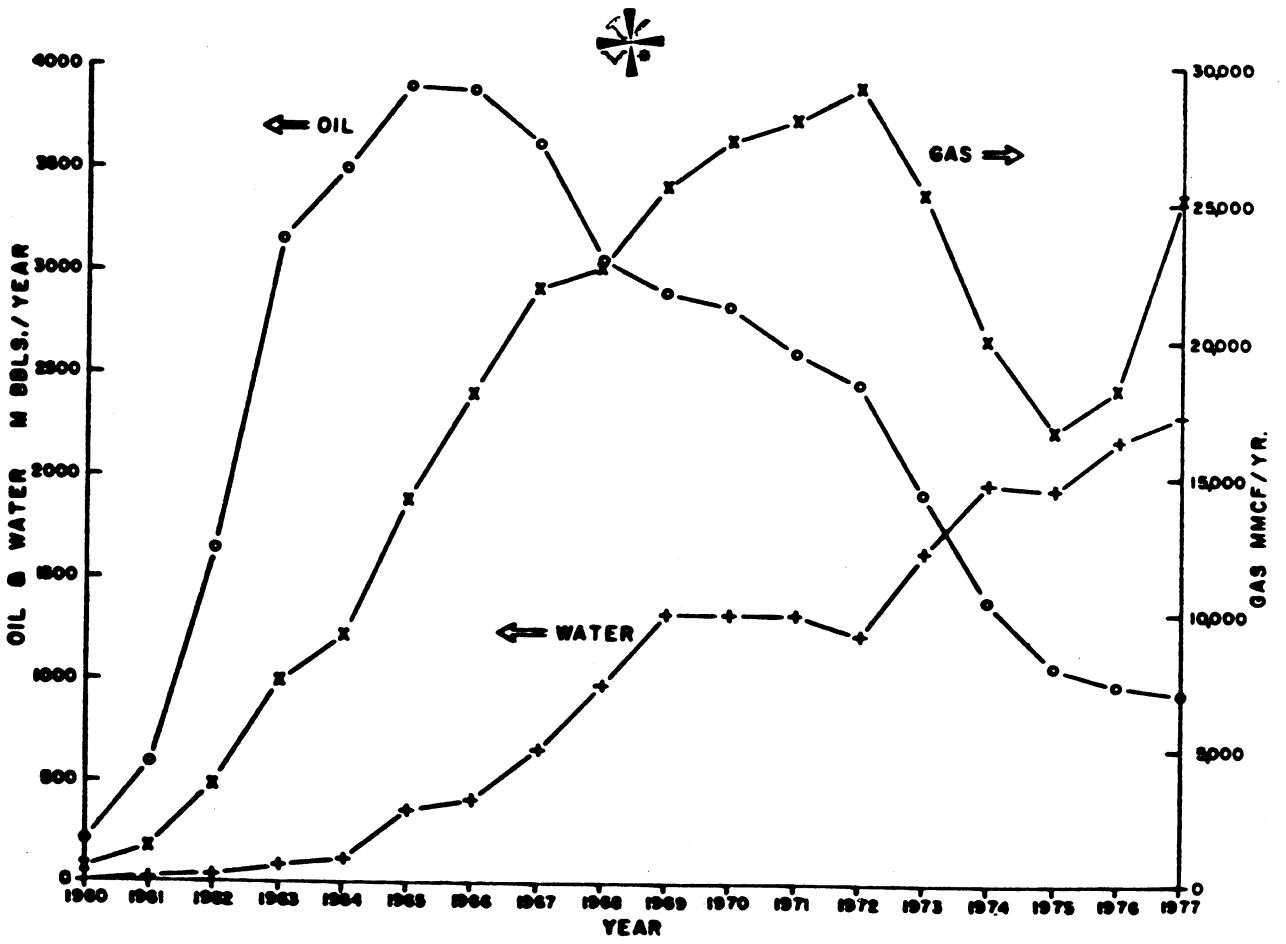
Navajo people in front of water tank for the Gypsy Oil Co. No. 1 Tocito wildcat, 1924. Amos Guthrie, landman for Gypsy, in cap on right. (Photo compliments of C. W. Spencer)

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

LISBON

LISBON PRODUCTION

YEAR	TYPE	NO. OF WELLS AT YEARS END PROD	NO. OF WELLS AT YEARS END S.I./ABD.	OIL IN BBLS. ANNUAL	GAS IN MCF CUMULATIVE
1960	Oil	8		209,307	209,307
	Gas			425,321	425,321
1961	Oil	15		531,574	740,881
	Gas			1,195,407	1,620,728
1962	Oil	23		1,353,452	2,094,333
	Gas			3,507,478	5,128,206
1963	Oil	21	2	3,152,901	5,247,234
	Gas			7,351,427	12,479,633
1964	Oil	22		3,505,285	8,752,519
	Gas			9,002,684	21,482,317
1965	Oil	25		3,905,106	12,657,625
	Gas			14,004,423	35,485,740
1966	Oil	23		3,873,184	16,530,809
	Gas			17,846,766	53,332,506
1967	Oil	22		3,611,631	20,142,440
	Gas			21,639,837	74,972,343
1968	Oil	21		3,039,458	23,181,898
	Gas			22,505,272	97,477,615
1969	Oil	21		2,885,850	26,067,748
	Gas			25,600,770	122,878,385
1970	Oil	21		2,816,696	28,884,444
	Gas			27,098,754	149,977,139
1971	Oil	22		2,593,748	31,478,192
	Gas			27,801,228	177,778,367
1972	Oil	21		2,451,836	33,930,028
	Gas			28,940,363	206,718,730
1973	Oil	21		1,923,880	35,853,908
	Gas			24,985,804	231,704,534
1974	Oil	11	9/0	1,391,481	37,245,389
	Gas			19,763,891	251,468,425
1975	Oil	11	10/1	1,067,563	38,312,952
	Gas			16,386,986	267,855,411
1976	Oil	11	10/1	944,008	39,306,960
	Gas			17,899,379	285,754,790
1977	Oil	11	10/1	948,356	40,255,316
	Gas			25,165,773	310,920,563



From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

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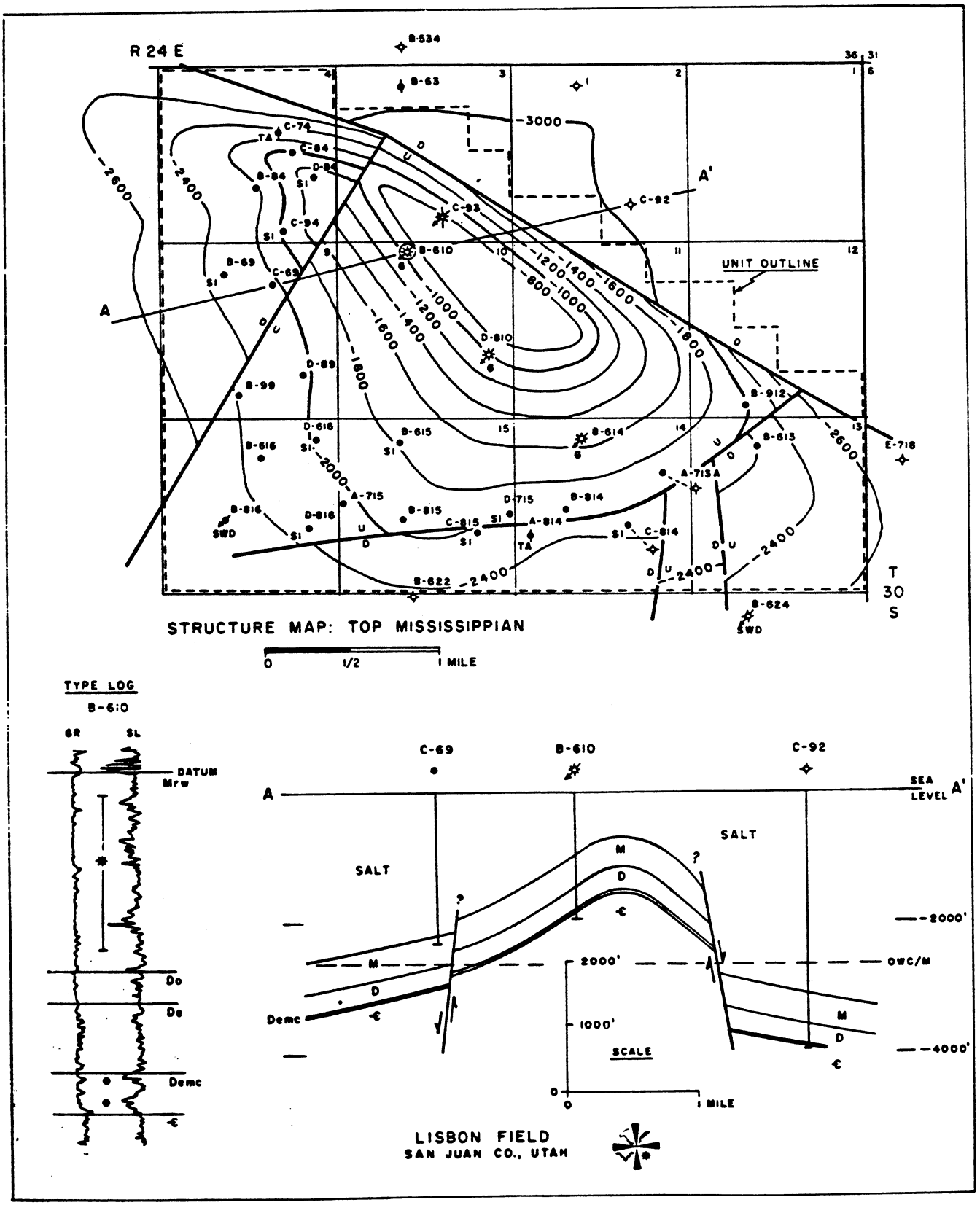


Oil and Gas Fields of the Four Corners Area]

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

LISBON FIELD

San Juan County, Utah

The Lisbon field is on the northwest end of the Lisbon Valley – Dolores anticlinal trend, one of the major salt folds in the Salt Anticline Province of the Paradox Basin. Production has been established in the Pennsylvanian salt, the Mississippian carbonates and basal Devonian clastics. The field is in Twp. 30 South, Rge. 24 East, San Juan County, Utah, about 27 miles southeast of Moab.

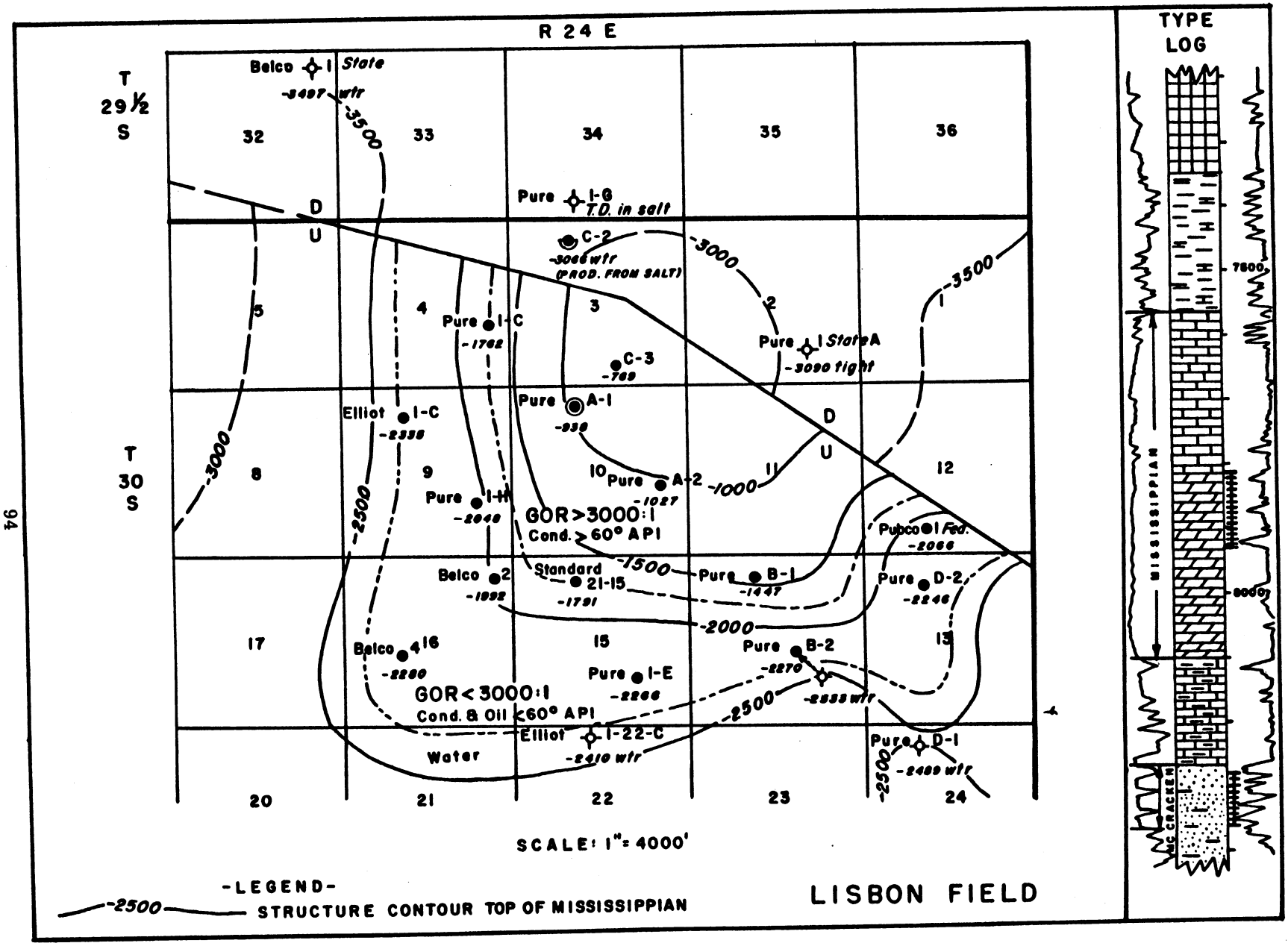
Pure Oil Company drilled the discovery well, Lisbon A-1, in the NW¼ Sec. 10, Twp. 30 South, Rge. 24 East. The well was completed in January, 1960, for a flow of 587 BOPD from the McCracken sandstone member of the Devonian Elbert formation at a depth of 8350 feet. The McCracken has been subsequently shut in and the well recompleted in the Mississippian for 187 BOPD and 4376 MCFGPD. Pure's discovery well is located on the southwest flank of the Lisbon Valley surface anticline.

The Lisbon Valley anticline is a surface structure with an indicated 4000 feet of closure against a prominent normal fault which bounds this feature to the northeast. The first test of this surface structure was drilled by Union Oil in 1929. This well, the No. 1 State (NW¼ Sec. 16, Twp. 30 South, Rge. 25 East) was abandoned in the salt at a depth of 6640 feet. Superior Oil has drilled potash tests in recent years near the crest of the surface structure. The Pure Oil discovery well is low on the southwest flank, about 3000 feet below the surface crest. Development drilling in the Lisbon field by Pure Oil, Pubco, Elliot Production and Standard Oil of California has outlined a pre-salt structural configuration quite different from the surface structure. The pre-salt structure contains about 1800 feet of closure against a normal fault with about 2000 feet of throw. This subsurface closure parallels the surface trend but is located about four miles to the west. Published information suggests that as much as 10,000 feet of salt may underlie the crest of the Lisbon Valley surface structure while only about 3000 feet of salt is present at the Lisbon field.

The reservoirs of the Lisbon field include the salt of the Pennsylvanian Paradox formation, the carbonates of the Mississippian and the basal McCracken sandstone of the Devonian Elbert formation. The oil from the salt section probably comes from fractured shales interlaced with the salt. Vugular dolomites and, to a lesser extent, limestones with intergranular porosity are the Mississippian pays.

There is a gas cap in the Lisbon field. Updip from the –1775 foot structural contour on the top of the Mississippian, the gas-oil ratio reportedly increases to as much as 37,500 to 1 while downdip from this structural position the ratios are generally less than 3000 to 1. The oil-water contact must lie about –2400 referred to a datum at the top of the Mississippian.

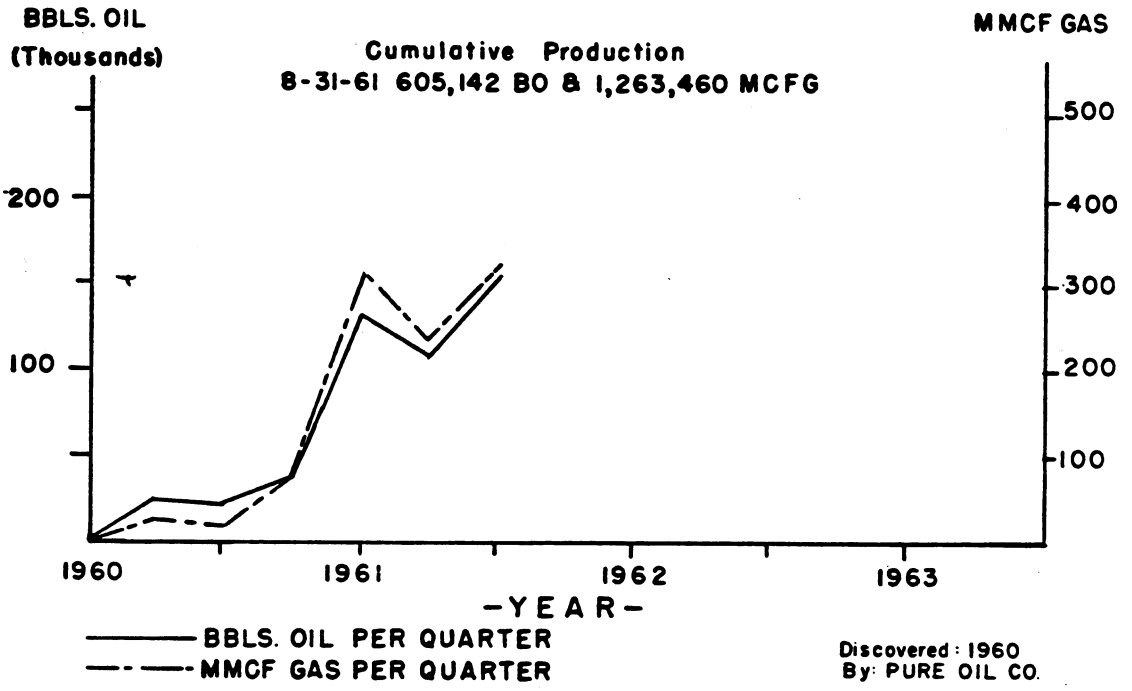
From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.



From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

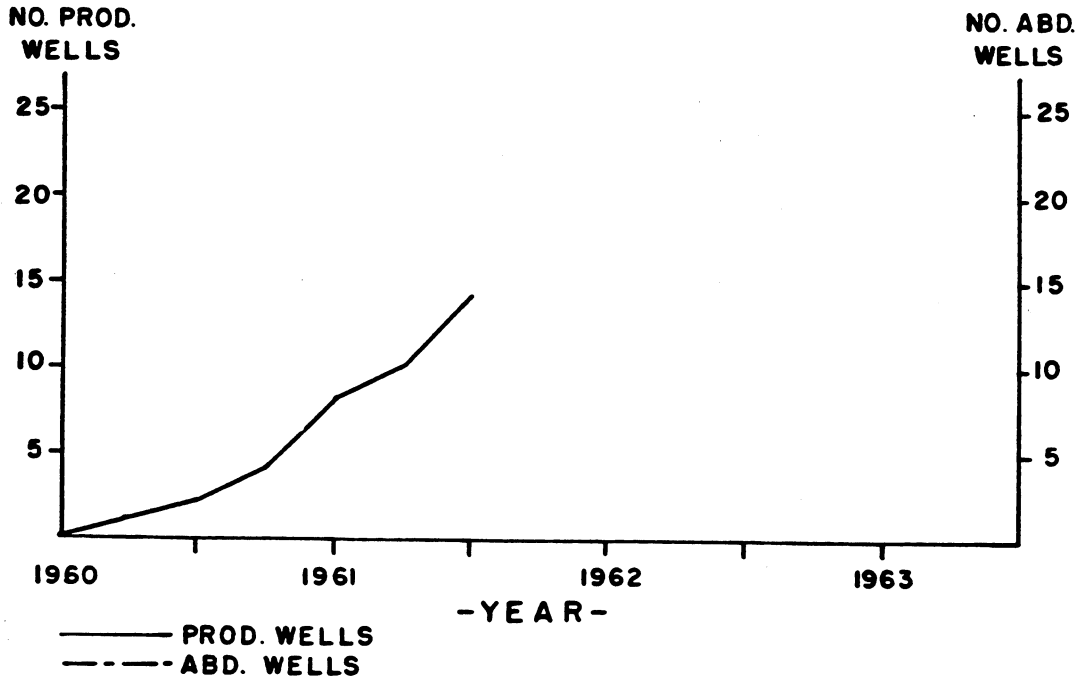
LISBON FIELD

HYDROCARBON PRODUCTION



Discovered: 1960
By: PURE OIL CO.

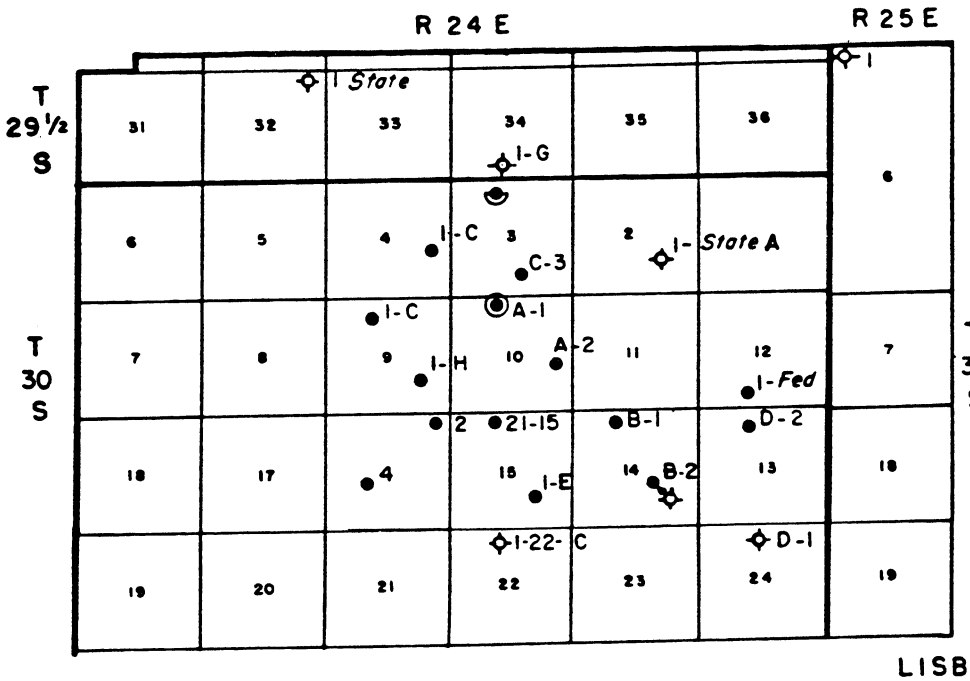
DEVELOPMENT DRILLING



From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

PARADOX BASIN
T 29½, 30S - R24, 25E

LISBON FIELD
SAN JUAN COUNTY



LISBON FIELD
LOCATION MAP
SCALE: 1" = 8000'

PRODUCTION CHARACTERISTICS

RESERVOIR

FORMATION NAME	AGE	LITH	AVE DEPTH	NET PAY	INIT. PRESS.	CURR. PRESS.	TYPE DRIVE	% POROS.	PERM. MD
Madison	Miss	Dolomite	8500	394			Solution Gas & Wtr	10% est.	3md est
McCracken	Dev.	Sandstone	8500	97			Water	9% est.	
Paradox salt	Penn.	Shale	6100	37			Gas		

FLUIDS

FORMATION NAME	GRAVITY	POUR POINT	SULFUR CONTENT	GOR	BTU/FT³	METHANE	ETHANE	WATER SALINITY	OTHER FLUIDS
Madison	52-71° API			1271·1 to 37,500·1	835 to 1207	42 %	8 %		22% CO_2 1.1% He
Mc Cracken	41 1° API			484·1					
Paradox salt	46 5 API			1252·1					

ECONOMICS

FORMATION NAME	PROD WELLS	PROD 1-1-60–1-1-61	CUMULAT PROD 1-1-61	$ / BBL WELL HEAD	$ / MCF WELL HEAD	ULT. RES.	PROVEN ACREAGE	TOTAL WELLS	SPACING
Madison	14	210,645 BO 426 MMCFG	210,645 BO 426 MMCFG	$2.14	13.5¢	26 million BO	5760± acres	15	80 acre
McCracken	3(dual)	(Included	w/Miss. production)			257 billion CFG			
Paradox salt	1	(Included	w/Miss. production)						

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

Utah - Long Canyon
Paradox - Cane Creek zone
Paradox Basin

DATA SOURCE CODE		
5b	STATE	Utah
5b	COUNTY	Grand
	REGULATORY DISTRICT	
5b	BASIN	Paradox
	SUB-BASIN	
5b	FIELD	Long Canyon
5b	RESERVOIR	Cane Creek zone, Paradox Fm.
5b	GEOLOGIC AGE	Pennsylvanian
5b	AAPG STRATIGRAPHIC AGE CODE	320
5b	RESERVOIR LITHOLOGY	Shale, dolomite and anhydrite
5b	TRAPPING MECHANISM	Structural, stratigraphic
5b	DISCOVERY YEAR	1962
	PROVED ACREAGE	
	REGULAR WELL SPACING (acres/well)	
5b	RESERVOIR DEPTH	7050
	RESERVOIR THICKNESS	
5b	NET PAY	25
5b	GROSS	70
	NET/GROSS RATIO	
	POROSITY	
5b	TYPE	Fracture
	FRACTION	
	PERMEABILITY	
	RANGE	
	AVERAGE	
	HORIZONTAL	
	VERTICAL	
	OTHER INFORMATION	
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
5b	TOTAL NUMBER OF WELLS	1P, 1A, 1DH
5b	PRODUCTION 1976 oil (cum)	714 mbbls
5b	PRODUCTION 1977 oil (cum)	738 mbbls oil; 817 mmcf gas
	PRODUCTION 1978 oil (cum)	
	PRODUCTION 1979 oil (cum)	
5b	PRODUCTION 1-1-77 to 1-1-78	23.6 mbbls oil; 21.9 mmcf gas
	SECONDARY RECOVERY RECORDS?	
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
	STRUCTURE CONTOUR?	
5b	LOGS?	yes
	STRUCTURE SECTION?	
5b	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Long Canyon
5b	RESERVOIR:	Cane Creek
	PROD. ACRES:	
5b	AVG. THICKNESS (FT.):	25
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
5b	PRIMARY DRIVE MECHANISM:	solution gas
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	161
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
5b	RESERVOIR PRESSURE INITIAL (psi):	5000
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
5b	STOCK TANK OIL GRAVITY (°API):	40
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

OTHER INFORMATION:

LONG CANYON

(Oil)

T. 26 S., R. 20 E., SLPM
Grand County, Utah

By: Kenneth T. Smith
Husky Oil Company

GEOLOGY

Regional Setting: Lisbon-Big Flat trend (hinge), Paradox Basin

Surface Formations: Triassic, Wingate Sandstone and Jurassic, Kayenta Formation

Exploration Method Leading to Discovery: Surface and subsurface geology

Type of Trap: Structural-stratigraphic

Producing Formation: Pennsylvanian, Cane Creek Zone, Paradox Formation, Hermosa Group

Gross Thickness and Lithology of Reservoir Rocks: 70 feet of thin interbeds (vertically fractured) of shale, dolomite, and anhydrite

Geometry of Reservoir Rock: Fractured reservoir; no matrix porosity or permeability

Other Significant Shows: Other zones in Pennsylvanian, Paradox Formation salt; inert gas in Mississippian

Oldest Stratigraphic Horizon Penetrated: Cambrian, in No. 1 Long Canyon well

DISCOVERY WELL

Name: Southern Natural Gas Co. No. 1 Long Canyon Unit

Location: SE NW sec. 9, T. 26 S., R. 20 E.

Elevation (KB): 5,794 feet

Date of Completion: August 30, 1962

Total Depth: 8,134 feet (plugged back to 7,393 feet)

Production Casing: 7 5/8" at 7,505 feet with 760 sacks of cement

Perforations: 7,050 to 7,075 feet

Stimulation: 1,500 gallons acid

Initial Potential: 660 BOD (flowing 6/64" choke)

Bottom Hole Pressure: Approximately 5,000 psi (overpressured)

DRILLING AND COMPLETION PRACTICES

Surface Casing: 13 3/8" at 300 feet (into Chinle Formation shale)

Intermediate Casing: 9 5/8" at top of salt

Production Casing: 7" at total depth; cement entirely across salt section

Drilling: Air or mud to top of salt; natural brine (or salt-gel mud) to total depth

RESERVOIR DATA

Productive Area:
Proved: Unknown
Unproved: Unknown
Approved Spacing: None

No. of Producing Wells: 1
No. of Abandoned Wells: 1 (December 1965)
No. of Dry Holes: 1

Average Net Pay: 25 feet

Porosity: Unknown

Permeability: Unknown

Water Saturation: Unknown

Initial Field Pressure: Estimated at 5,000 psi (overpressured)

Type of Drive: Solution gas

Gas Characteristics and Analysis: Good methane gas, no H_2S; Btu 1,200 plus

Oil Characteristics and Analysis: 40° API gravity, pour point 25° F, trace sulfur, specific gravity 0.823

Associated Water Characteristics and Analysis: Unknown

Original Gas, Oil, and Water Contact Datums: Not known

Estimated Primary Recovery: Unknown

Type of Secondary Recovery: Unknown

Estimated Ultimate Recovery: Unknown

Present Daily Average Production: 65 BOD, 60 MCFGD, 5 BWD

Market Outlets: Oil trucked to Salt Lake City, or to Ute Pipeline at Lisbon field; gas is flared

FIELD COMMENTARY

The Southern Natural Gas Company No. 1 Long Canyon well is significant in that it is the only example of a genuinely successful completion in one of the fractured clastic intervals within the Paradox Formation salt (Pennsylvanian). This single well (through 1977) has produced almost 738,000 barrels of high gravity oil from the "Cane Creek zone," which separates salt no. 21 from salt no. 22. The Cane Creek is the most persistent of these clastic zones, and usually the thickest, throughout the Paradox Basin. Elsewhere, the Cane Creek produced some oil at Bartlett Flat, Grand County, Utah, before abandonment due to mechanical problems. At Wilson Canyon, San Juan County, Utah, a Cane Creek completion is still producing, but the cumulative is not significant.

The Paradox salt interval is overpressured, and fluids have been recovered from pure halite zones, as well as from the clastic breaks between salt bodies. While drilling at 6,010 feet in pure salt, the No. 1 Long Canyon well flowed salt water (supersaturated brine), requiring 18 lb. mud to kill the flow; a gradient of 0.94 psi. Several high mud-gas readings were noted while drilling through the salt, including the Cane Creek Zone.

In drilling to the top of the Cambrian before completing in the Cane Creek, a drill-stem test in the Mississippian carbonates recovered 5,000 MCFD of inert gas (105 Btu) with a trace of oil. Oil shows were also noted in the Devonian, but salt water was recovered on a drill-stem test.

The Long Canyon No. 2 well, about one-half mile southeast of the discovery, was also drilled to the Mississippian. Shortly

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after penetrating the top of the Mississippian, the well blew out (after losing returns), flowing inert gas. Flow rates were not gauged. Efforts to drill ahead were unsuccessful, and the well was plugged back to the Cane Creek. Completion attempts in the Cane Creek through casing failed, even though coring revealed fractures with fluorescence. The well was then completed in another fractured shale break about 600 feet above the Cane Creek, between salts no. 18 and no. 19. After producing 26,700 barrels of oil, the No. 2 well was abandoned in 1965.

As the Cane Creek zone is nothing more than thinly-bedded evaporitic cyclothems, it is a difficult reservoir unit to handle. Because fracturing is required to provide porosity and permeability, logs are of no value. Mud logging is more desirable than coring, and open-hole drill-stem tests are the only conclusive tool for proving reservoir parameters before running production casing. It is preferable to drill into the Cane Creek slightly underbalanced. Excessive mud weights, upon initial penetration, appear to inflict irreparable damage for reasons not fully understood. Cementing, completing, and completion fluid chemistry also appear to require a delicate touch. As the reservoir is overpressured, maintaining considerable backpressure while producing also seems to be critical to maintaining commercially productive rates and to insure longevity of production. Long Canyon field certainly points toward the unevaluated potential for additional new reserves from the Cane Creek Zone throughout the Paradox Basin.

REFERENCES

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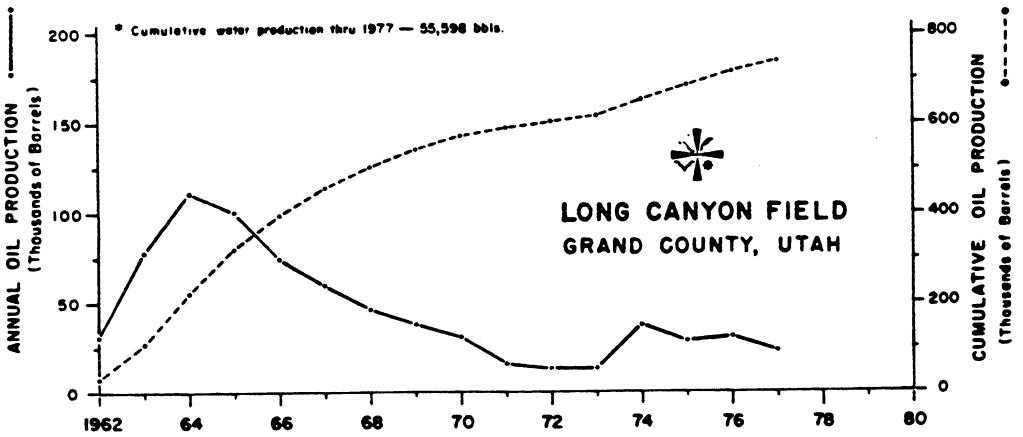
Personal files.

Stowe, C. (compiler), 1972, Oil and gas production in Utah to 1970: Utah Geological and Mineralogical Survey, Bulletin 94, 179 p.

Utah State production records.

Kenneth T. Smith
3-1-78

NO. OF WELLS @ YR. END				PRODUCTION OIL IN BARRELS GAS IN MCF	
YEAR	TYPE	PROD.	SI/ABN	ANNUAL	CUMULATIVE
1962	Oil	1		31,140	31,140
	Gas				-
1963	Oil	2		78,727	109,867
	Gas			59,483	59,483
1964	Oil	2		110,857	220,724
	Gas			176,830	236,313
1965	Oil	1	1	100,965	321,689
	Gas			153,168	389,481
1966	Oil	1	1	74,746	396,435
	Gas			108,954	498,435
1967	Oil	1	1	60,270	457,458
	Gas			60,003	558,438
1968	Oil	1	1	46,766	504,224
	Gas			43,072	601,510
1969	Oil	1	1	38,444	542,668
	Gas			35,405	636,915
1970	Oil	1	1	31,010	573,678
	Gas			28,587	665,502
1971	Oil	1	1	15,970	589,648
	Gas			14,707	680,209
1972	Oil	1	1	13,580	603,228
	Gas			12,510	692,719
1973	Oil	1	1	13,255	616,483
	Gas			12,206	704,925
1974	Oil	1	1	37,628	654,111
	Gas			34,656	739,581
1975	Oil	1	1	29,100	683,211
	Gas			26,801	766,382
1976	Oil	1	1	31,150	714,361
	Gas			28,690	795,072
*1977	Oil	1	1	23,588	737,949
	Gas			21,928	817,000



Oil and Gas Fields of the Four Corners Area]

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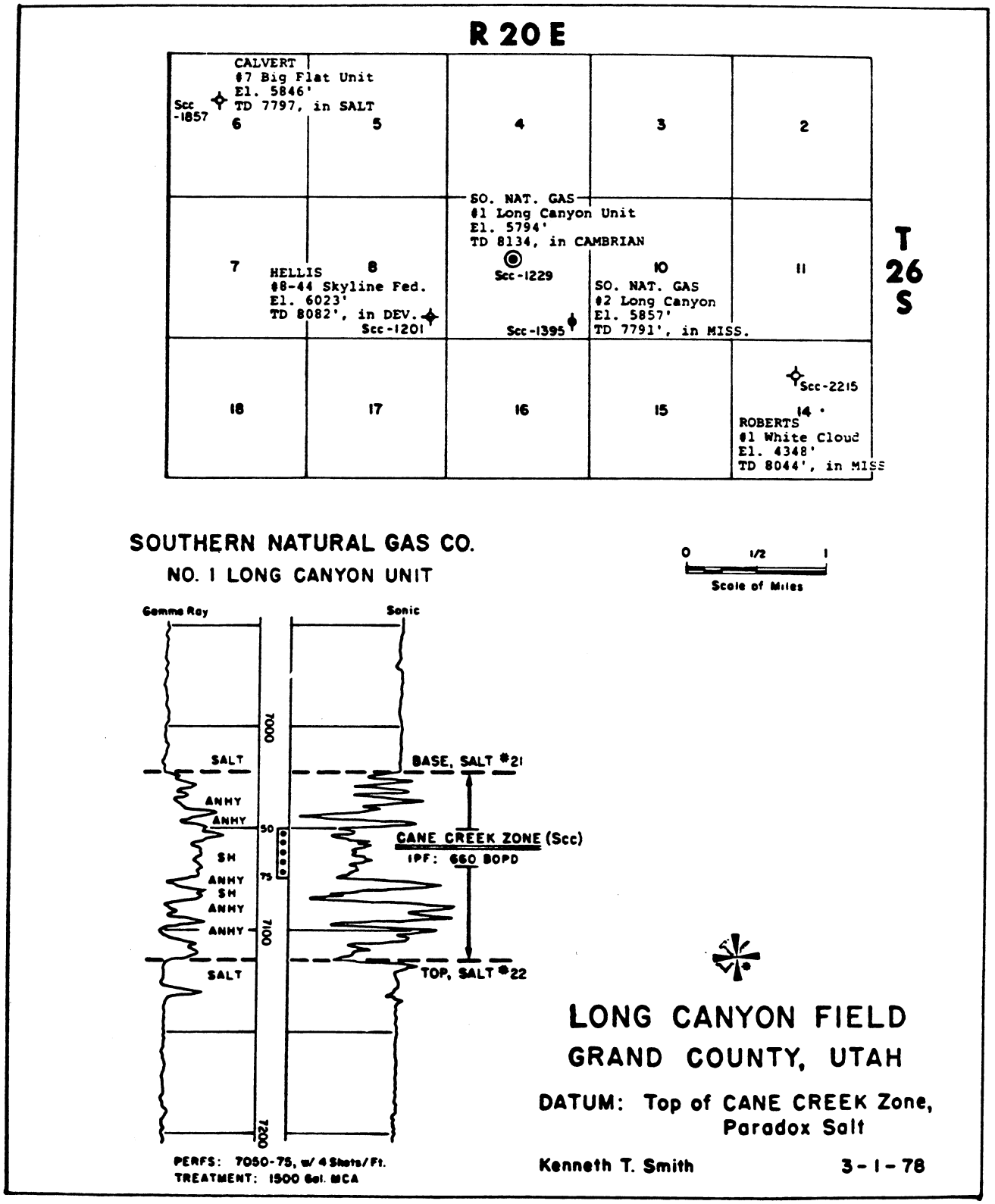

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Colorado - Marble Wash
Paradox - Ismay
Paradox Basin

DATA SOURCE CODE		
	STATE	Colorado
6d	COUNTY	Montezume
	REGULATORY DISTRICT	
6d	BASIN	Paradox
	SUB-BASIN	
6d	FIELD	Marble Wash
6d	RESERVOIR	Ismay zone of Paradox
6d	GEOLOGIC AGE	Pennsylvanian
1	AAPG STRATIGRAPHIC AGE CODE	320
6d	RESERVOIR LITHOLOGY	200 ft. of interbedded carbonate, shales, anhydrite
6d	TRAPPING MECHANISM	Stratigraphic - thin discontinuous algal buildup
6d	DISCOVERY YEAR	11-1958
6d	PROVED ACREAGE	400
6d	REGULAR WELL SPACING (acres/well)	80
6d	RESERVOIR DEPTH	5760
	RESERVOIR THICKNESS	
6d	NET PAY	10-20 ft.
6d	GROSS	200 ft.
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
6d	FRACTION	.10
	PERMEABILITY	
	RANGE	
6d	AVERAGE	2.0 md
	HORIZONTAL	
	VERTICAL	
	OTHER INFORMATION	
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
6d	TOTAL NUMBER OF WELLS	10 (4P, 0A, 6DH)
	PRODUCTION 1976 oil (cum)	
6d	PRODUCTION 1977 oil (cum)	645.8 mbbls; 1,112.9 mmcf gas
	PRODUCTION 1978 oil (cum)	
6f	PRODUCTION 1979 oil (cum)	687 mbbls; 1205.6 mmcf gas
6d	PRODUCTION PRESENT	68 BOD
6d	SECONDARY RECOVERY RECORDS?	none
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
6d	STRUCTURE CONTOUR?	yes
6d	LOGS?	yes
	STRUCTURE SECTION?	
6d	ENGINEERING REPORTS?	production
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Marble Wash
	RESERVOIR:	Ismay
	PROD. ACRES:	400
	AVG. THICKNESS (FT.):	10-20
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
6d	WATER SATURATION (S_w):	ND
	OIL SATURATION (S_o):	
6d	PRIMARY DRIVE MECHANISM:	solution gas
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	145
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
6d	RESERVOIR PRESSURE INITIAL (psi):	2250
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
6d	GAS OIL RATIO LATEST (GOR) (cf/bbl):	2200:1
6d	STOCK TANK OIL GRAVITY (°API):	41.5
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL	
6d	ESTIMATED PRIMARY OIL	250-300 mbbls
6d	Estimated Primary Recovery Factor:	15 - 20%

OTHER INFORMATION:

6d Water analysis: total solid - 234,685 ppm
NaCl - 237,398 ppm(?)
resistivity at 68°F - .051 ohm

MARBLE WASH

(Oil)

T. 33½ N., R. 20 W., NMPM

Montezuma County, Colorado

By: Harold H. Brown
Consultant

GEOLOGY

Regional Setting: Southwestern shelf, Paradox Basin

Surface Formations: Cretaceous, Dakota Sandstone and Jurassic, Morrison Formation

Exploration Method Leading to Discovery: Stratigraphic drilling

Type of Trap: Algal buildup

Producing Formation: Pennsylvanian, Ismay Zone of Paradox Formation

Gross Thickness and Lithology of Reservoir Rocks: 200 feet of interbedded carbonates, shales and anhydrite

Geometry of Reservoir Rock: Thin, discontinuous algal buildups

Other Significant Shows: None

Oldest Stratigraphic Horizon Penetrated: Pennsylvanian, Akah Zone of Paradox Formation

DISCOVERY WELL

Name: The California Company No. 2 Calco-Superior Ute Tribal (present operator, Merrion and Bayless)

Location: NE NE (660' FNL and 660' FEL) sec. 15, T. 33½ N., R. 20 W.

Elevation (KB): 5,098 feet

Date of Completion: November 3, 1958

Total Depth: 6,055 feet

Production Casing: 5½" at 6,052 feet with 792 sacks of cement

Perforations: 5,761 to 5,766 feet; 5,770 to 5,781 feet; 5,785 to 5,814 feet; 5,818 to 5,838 feet; 5,846 to 5,852 feet

Stimulation: Wash with mud acid, various amounts depending upon operator

Initial Potential: Pump 38 BOD and 24 BWD

Bottom Hole Pressure: Drill-stem test shut-in pressure 2,250 psi

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, 1978, Four Corners Geological Society, Source 6d.

RESERVOIR DATA

Productive Area:
Proved (as determined geologically): 400 acres
Unproved: Unknown
Approved Spacing: 80 acres
No. of Producing Wells: 4
No. of Abandoned Wells: 0
No. of Dry Holes: 6 (within 80 acre spacing of producing wells)

Average Net Pay: 10 to 20 feet

Porosity: 10 percent

Permeability: 2.0 millidarcies

Water Saturation: Unknown

Initial Field Pressure: Drill-stem test shut-in pressure 2,250 psi

Type of Drive: Solution gas

Gas Characteristics and Analysis: Unknown

Oil Characteristics and Analysis: 41.5° API gravity, initial solution gas-oil ratio 2,200:1

Associated Water Characteristics and Analysis: Total solids 234,685 ppm, NaCl equivalent 237,398 ppm, resistivity at 68°F .051 ohm

Original Gas, Oil, and Water Contact Datums: Not mappable

Estimated Primary Recovery: 250,000 to 300,000 BO from best wells (estimate), 15 to 20 percent (estimate)

Type of Secondary Recovery: None

Estimated Ultimate Recovery: Same as primary recovery

Present Daily Average Production: 68 BOD

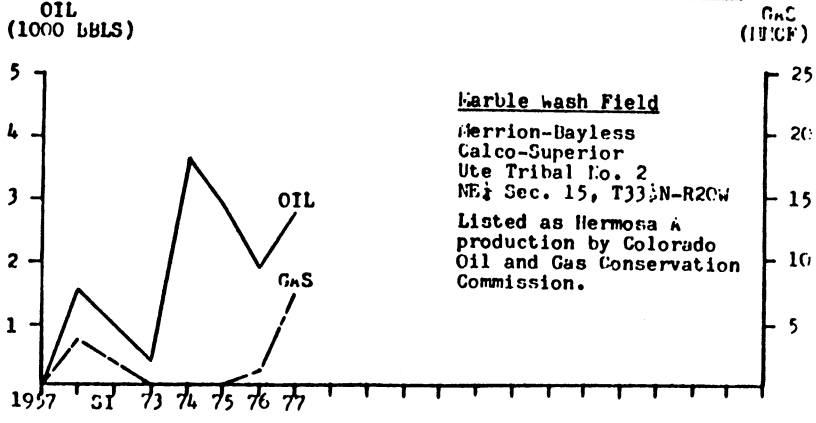
Market Outlets: Trucked to Aneth loading station, San Juan Co., Utah

REFERENCES

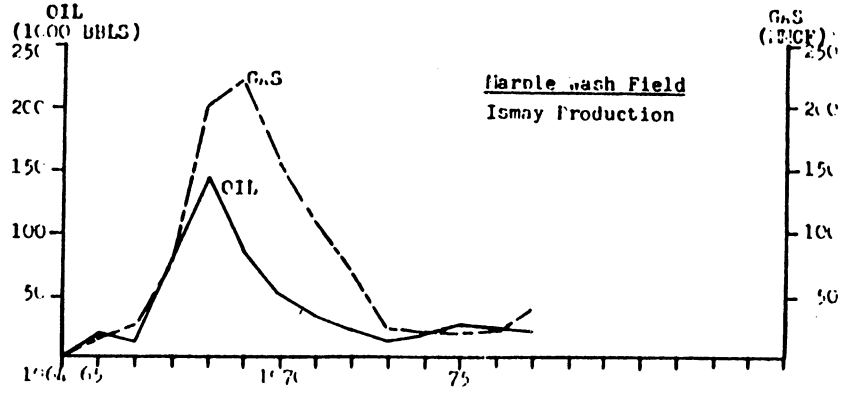
Irwin, Dennis C., 1963, Producing carbonate reservoirs in the Four Corners area, *in* Shelf carbonates of the Paradox Basin, Fourth Field Conference: Four Corners Geological Society, p. 144-148.

Mercurio, R. N., 1961, Marble Wash Field, Oil and gas field volume, Colorado-Nebraska: Rocky Mountain Association of Geologists, p. 174-175.

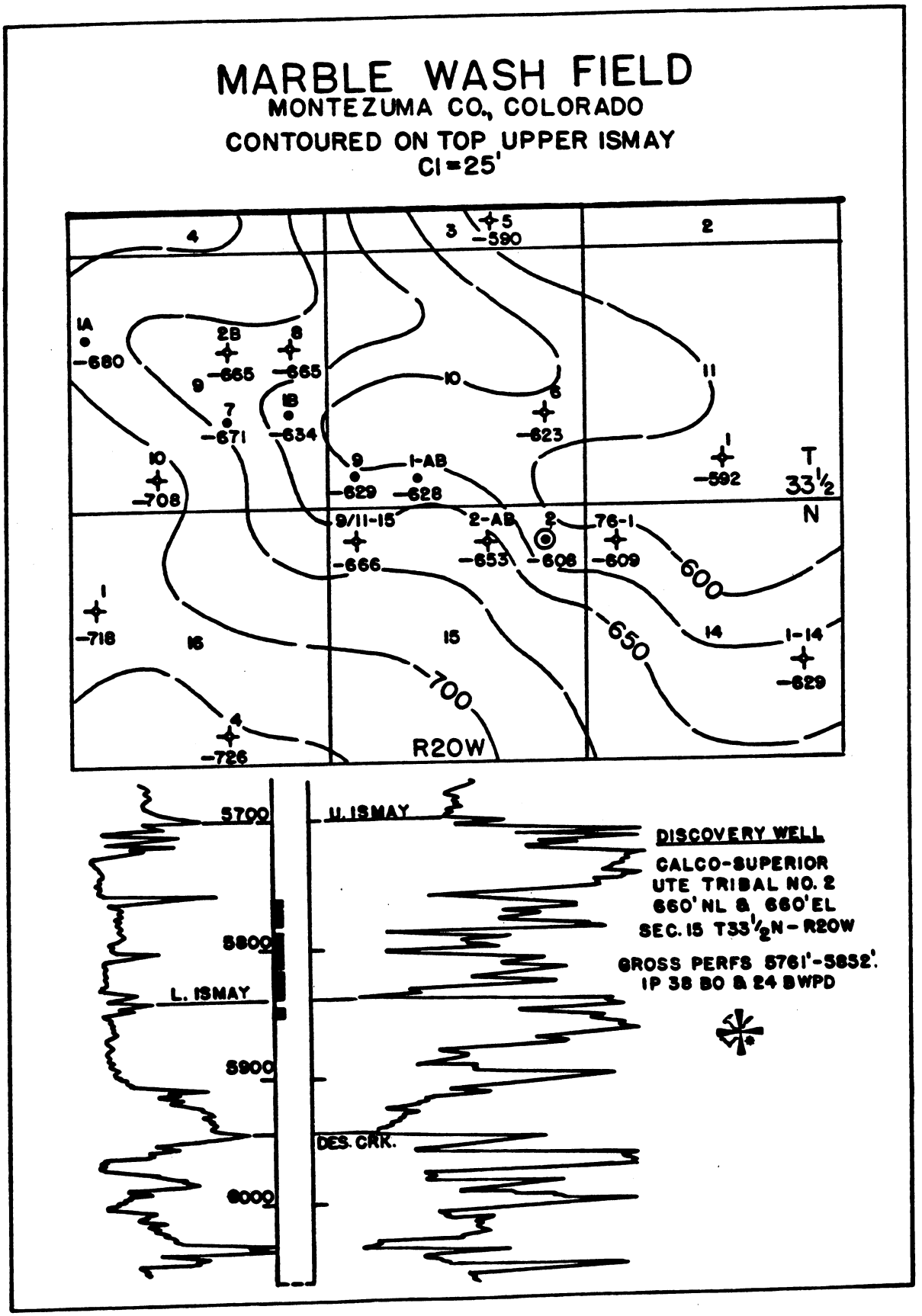
NUMBER OF WELLS AT YEARS END				- PRODUCTION - OIL IN BARRELS GAS IN MCF	
YEAR	TYPE	PROD.	S.I./ABN.	ANNUAL	CUMULATIVE
1958	Oil	1		1494	1494
	Gas			3332	3332
1959-1972	O		1 Shut In 14 Yrs.		
	G				
1973	O	1		3252	1955
	G			0	3332
1974	O	1		3624	5579
	G			0	3332
1975	O	1		2978	8557
	G			0	3332
1976	O	1		1924	10,481
	G			1520	4852
1977	O	1		2800	13,281
	G			7080	11,932



NUMBER OF WELLS AT YEARS END				- PRODUCTION - OIL IN BARRELS GAS IN MCF	
YEAR	TYPE	PROD.	S.I./ABN	ANNUAL	CUMULATIVE
1965	OIL	1		22,780	56,189
	GAS			29,403	57,666
1966	O	1		15,702	65,891
	G			27,106	84,752
1967	O	5		66,302	152,693
	G			81,781	166,533
1968	O	5		148,384	301,077
	G			203,889	370,422
1969	O	4	1 SI	62,849	363,926
	G			220,995	591,417
1970	O	4	1	55,688	419,614
	G			165,297	765,714
1971	O	4	1	38,858	488,772
	G			116,281	882,995
1972	O	4	1	30,632	519,404
	G			78,917	957,213
1973	O	3	2 SI	21,318	540,722
	G			30,301	988,214
1974	O	3	2	24,779	565,501
	G			29,980	1,018,194
1975	O	3	2	28,322	593,823
	G			23,403	1,041,597
1976	O	3	2	27,130	620,953
	G			25,324	1,066,921
1977	O	3	2	24,845	645,798
	G			46,011	1,112,932



From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, 1978, Four Corners Geological Society, Source 6d.



From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, 1978. Four Corners Geological Society, Source 6d.

Utah - McElmo Mesa
Ismay
Paradox Basin

DATA SOURCE CODE		
	STATE	Utah
5b	COUNTY	San Juan
	REGULATORY DISTRICT	
5b	BASIN	Paradox Basin
	SUB-BASIN	
5b	FIELD	McElmo Mesa
5b	RESERVOIR	Ismay zone
5b	GEOLOGIC AGE	Pennsylvanian
5b	AAPG STRATIGRAPHIC AGE CODE	325
5b	RESERVOIR LITHOLOGY	Light to medium gray, fossiliferous in part, some anhydrite infilling interbedded limestone and dolomite.
5b	TRAPPING MECHANISM	Stratigraphic
5b	DISCOVERY YEAR	1964
5b	PROVED ACREAGE	2240
5b	REGULAR WELL SPACING (acres/well)	80
5b	RESERVOIR DEPTH	5540
	RESERVOIR THICKNESS	
5b	NET PAY	29
5b	GROSS	150
	NET/GROSS RATIO	
	POROSITY	
5b	TYPE	V
5b	FRACTION	.06 - .13
	PERMEABILITY	
	RANGE	
	AVERAGE	
	HORIZONTAL	
	VERTICAL	
	OTHER INFORMATION	
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
5b	TOTAL NUMBER OF WELLS	5P, 7Aban., 1SI, 8DH
5b	PRODUCTION 1976 oil (cum)	2094 mbbls
5b	PRODUCTION 1977 oil (cum)	2118 mbbls; 2519 mmcf
	PRODUCTION 1978 oil (cum)	
	PRODUCTION 1979 oil (cum)	
5b	PRODUCTION 1-1-77 to 1-1-78	24.3 mbbls oil; 39.2 mmcf gas
	SECONDARY RECOVERY RECORDS?	
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
5b	STRUCTURE CONTOUR?	yes
5b	LOGS?	yes
5b	STRUCTURE SECTION?	yes
5b	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	McElmo Mesa
5b	RESERVOIR:	Ismay zone
5b	PROD. ACRES:	2240
5b	AVG. THICKNESS (FT.):	29
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
5b	WATER SATURATION (S_W):	.15-1.00; .37 avg.
	OIL SATURATION (S_O):	
5b	PRIMARY DRIVE MECHANISM:	water drive
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	142
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
5b	RESERVOIR PRESSURE INITIAL (psi):	2176
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
	STOCK TANK OIL GRAVITY (°API):	
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

OTHER INFORMATION:

McELMO MESA

(Oil)

T. 40-41 S., R. 26 E., SLPM

San Juan County, Utah

By: Edward G. Mickel
Grace Petroleum

GEOLOGY

Regional Setting: Southwest shelf of Paradox Basin

Surface Formations: Jurassic, Morrison Formation; Cretaceous, Dakota Sandstone

Exploration Method Leading to Discovery: Subsurface geology

Type of Trap: Stratigraphic

Producing Formation: Pennsylvanian, lower Ismay Zone of Paradox Formation

Gross Thickness and Lithology of Reservoir Rocks: 150 feet of interbedded limestone and dolomite, light to medium gray, fossiliferous in part, vuggy porosity, some anhydrite in-filling

Geometry of Reservoir: Lenticular

Other Significant Shows: Unknown

Oldest Stratigraphic Horizon Penetrated: Pennsylvanian, Paradox Formation evaporites

Plugged and Abandoned: Temporarily abandoned in 1972, plugged and abandoned 1973

DISCOVERY WELL

Name: Zoller and Danneberg Kimbark Exploration No. 1 South Ismay

Location: NE NE (660' FNL and 660' FEL) sec. 5, T. 41 S., R. 26 E.

Elevation (KB): 4,799 feet

Date of Completion: November 16, 1964

Total Depth: 5,553 feet

Production Casing: 5½" at 5,553 feet with 100 sacks of cement

Perforations: 5,540 to 5,545 feet with 4 holes per foot

Stimulation: Acidized

Initial Potential: Flow 270 BOD, 47 BWD

Bottom Hole Pressure: 2,176 psig (drill-stem test)

DRILLING AND COMPLETION PRACTICES

Approximately 150 feet of 13 3/8" surface casing is set. After drilling out, mud weight is increased as required. The Glenn Canyon Group is water-bearing in some parts of the field; water flows have been controlled with moderate mud weight. Lost circulation can be a problem in the Glenn Canyon Group. If it is necessary to control the water flows and/or lost circulation zones with casing, a string of 8 5/8" is run at depths of approximately 1,450 feet. If no serious water flows or lost circulation zones are encountered, the well is completed with 5½" casing. The lower Ismay Zone is perforated and then stimulated with acid.

RESERVOIR DATA

Productive Area:
Proved: 2,240 acres
Unproved: None
Approved Spacing: 80 acres
No. of Producing Wells: 5
No. of Abandoned Wells: 7
No. of Shut-In Wells: 1
No. of Dry Holes: 8

Average Net Pay: 29 feet (includes upper, middle and lower log porosity)

Porosity: 6 to 13 percent (average 9 percent for productive interval)

Permeability: Not available

Water Saturation: 15 to 100 percent (average 37 percent for productive interval); productive interval is underlain by water in many of the wells with a transition interval of 4 to 20 feet

Initial Field Pressure: 2,176 psig (drill-stem test, Zoller and Danneberg No. 1 South Ismay)

Type of Drive: Water

Gas Characteristics and Analysis: (in molecular percent) methane 60.5, ethane 19.0, propane 10.7, normal butane 3.5, iso-butane 1.7, argon trace, helium trace, normal pentane .95, iso-pentane .95, hexanes plus .8, nitrogen 1.8, CO_2 .1

Oil Characteristics and Analysis: Not available

Associated Water Characteristics and Analysis: Not available

Original Gas, Oil, and Water Contact Datums: Unknown

Estimated Primary Recovery: Unknown

Type of Secondary Recovery: None

Estimated Ultimate Recovery: Unknown

Present Daily Average Production: 15 to 20 BOD, approximately 200 BWD

Market Outlets: Not available

FIELD COMMENTARY

The McElmo Mesa field is located in the Aneth Area one mile west of the Utah-Colorado state line and 2 miles south of Cache field, which also produces from the Ismay Zone. The discovery well was drilled in 1964 by Zoller and Danneberg; Kimbark Exploration was the operator. Texaco and Monsanto, between 1965 and 1967, drilled 12 wells of which 5 are still producing. Each company operated their own leases. The Ismay Zone is the producing interval. Hydrocarbons are entrapped in the lower part of the Ismay in lenticular porosity zones. Porosity logs of wells drilled in the field indicated primary porosity, but several wells that were drilled were dry holes because of secondary anhydrite filling in these porous zones. A small structural closure has been mapped on the B zone. The highest well is the Monsanto No. 3 South Ismay, which is still the best producer in the field. The structural high

on the Desert Creek Zone is between the Monsanto No. 3 South Ismay well and the Texaco No. 7 well. The following are Ismay gross thicknesses for the field; gross porosities for the Ismay are shown on the accompanying map:

Well	Thickness (feet)
Kimbark No. 2 Hogan, sec. 31	142
Monsanto A-4 NAV, sec. 31	156
Pan American NAV-Tribal-AA, sec. 31	150
Kimbark No. 2, sec. 32	157
Texaco 3-NAV "U" NCT, sec. 32	159
Texaco 5-NAV-Tribal-AC, sec. 33	150
Pan American No. 2, NAV-M, sec. 6	160
Monsanto A-1 NAV, sec. 5	150
Monsanto 6-South Ismay, sec. 5	147
Monsanto 4-South Ismay, sec. 5	158
Zoller and Danneberg 1-South Ismay, sec. 5	148
Monsanto A-3 NAV, sec. 5	138
Monsanto 2-NAV A, sec. 5	151
Monsanto 5-South Ismay, sec. 5	151
Monsanto 3-South Ismay, sec. 5	152
Texaco 6-NAV-Tribal-AC, sec. 4	160
Texaco 7-NAV-Tribal-AC, sec. 4	156
Texaco 9-NAV-Tribal-AC, sec. 4	156
Texaco 8-NAV-Tribal-AC, sec. 4	149
Texaco 8x-NAV-Tribal-AC, sec. 4	139
Texaco 11-NAV-Tribal-AC, sec. 4	161
Texaco 12-NAV-Tribal-AC, sec. 4	164
Monsanto 1-NAV-9, sec. 9	171
Kimbark 1-Shadscale-NAV, sec. 9	160
Kimbark 1-Mail Trail Mesa, sec. 8	128

The field is now fairly well depleted making 3,900 BO, 5,877 MCFG, and 40,235 BW per month (Feb. 1978).

REFERENCES

Geomap, Denver, Colorado.

Grace Petroleum Company files.

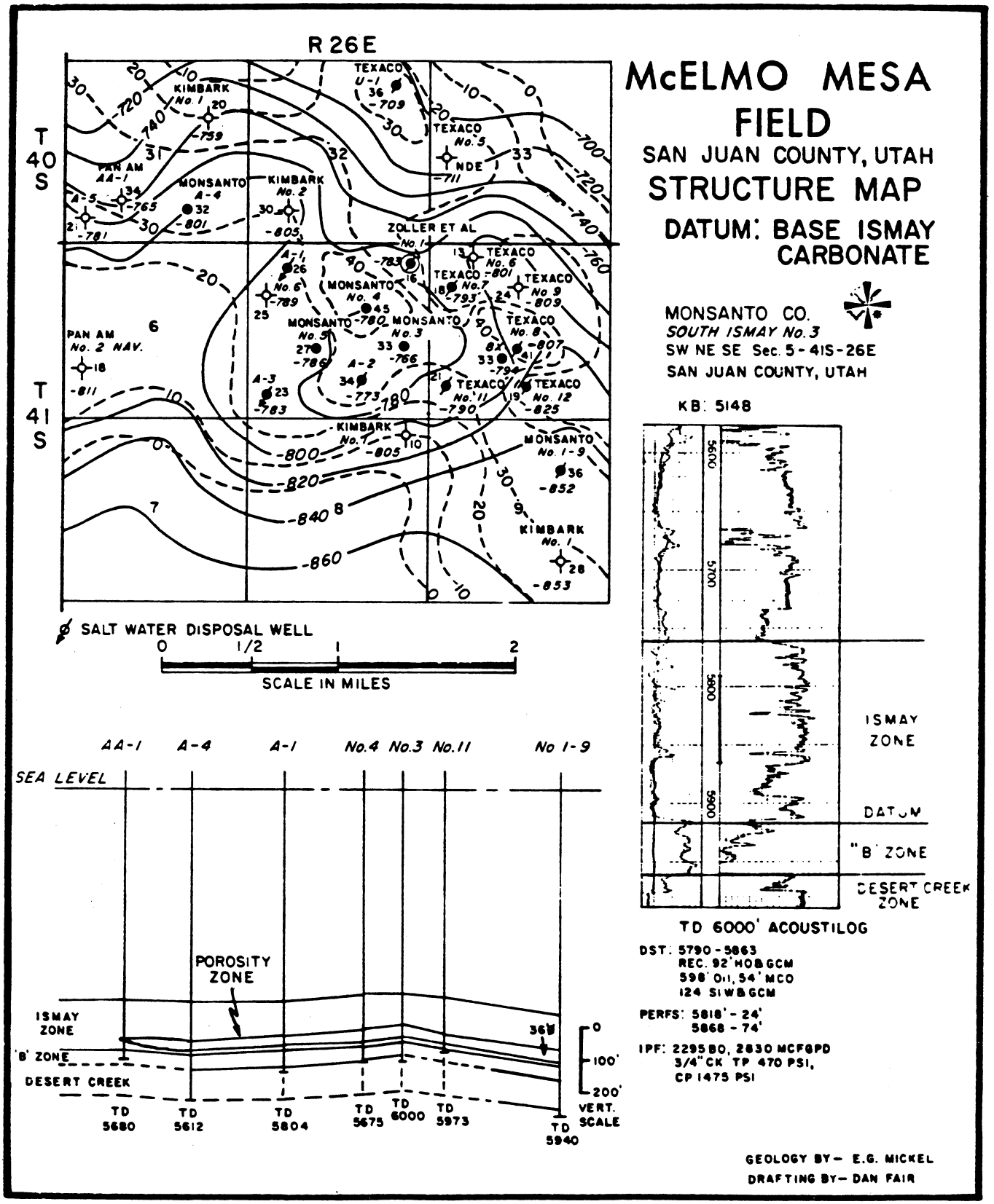
State of Utah production records.

Stowe, C. (compiler), 1972, McElmo Mesa Field, San Juan County, *in* Oil and Gas Production in Utah to 1970: Utah Geological and Mineralogical Survey, Bulletin 94, p. 73.

NO. OF WELLS @ YR. END				PRODUCTION OIL IN BARRELS GAS IN MCF		WATER	
YEAR	TYPE	PROD.	SI/ABN	ANNUAL	CUMULATIVE	ANNUAL	CUM.
1964	Oil	2		33,820	33,820	40,079	40,079
	Gas			20,745	20,745		
1965	Oil	1		23,276	57,096	29,616	69,695
	Gas			13,966	34,711		
1966*	Oil	10		716,712	773,808	174,927	244,622
	Gas			820,507	855,218		
1967	Oil	13		656,291	1,430,099	342,370	586,992
	Gas			699,733	1,554,951		
1968	Oil	11	2 (SI)	266,607	1,696,706	416,269	1,003,661
	Gas			301,299	1,856,180		
1969	Oil	9	2 (SI)	138,241	1,834,947	346,816	1,350,077
	Gas			196,379	2,052,559		
1970	Oil	8	1 (SI)	81,790	1,916,737	331,827	1,681,904
	Gas			119,221	2,251,780		
1971	Oil	5	3 (SI)	48,168	1,964,905	241,523	1,923,427
	Gas			71,080	2,322,860		
1972**	Oil	5	6 (ABN)	34,813	1,999,718	265,906	2,189,333
	Gas		3 (SI)	46,647	2,369,507		
1973	Oil	5	7 (ABN)	22,130	2,021,848	164,333	2,353,666
	Gas		2 (SI)	25,321	2,394,828		
1974	Oil	5	2 (SI)	18,632	2,040,480	229,947	2,583,613
	Gas			22,918	2,417,746		
1975	Oil	5	1 (SI)	28,433	2,068,913	301,824	2,885,437
	Gas		1 (ABN)	28,099	2,445,845		
1976	Oil	5	1 (SI)	24,918	2,093,831	306,194	3,191,531
	Gas			34,105	2,479,950		
1977	Oil	5	1 (SI)	24,319	2,118,150	314,061	3,505,592
	Gas			39,270	2,519,220		

* Includes: 768 bo, 14,592 bw, for Monsanto Co. Navajo 1-9, undesignated in 1966.

** The Monsanto A-1 and A-3 converted to salt water disposal well.



From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

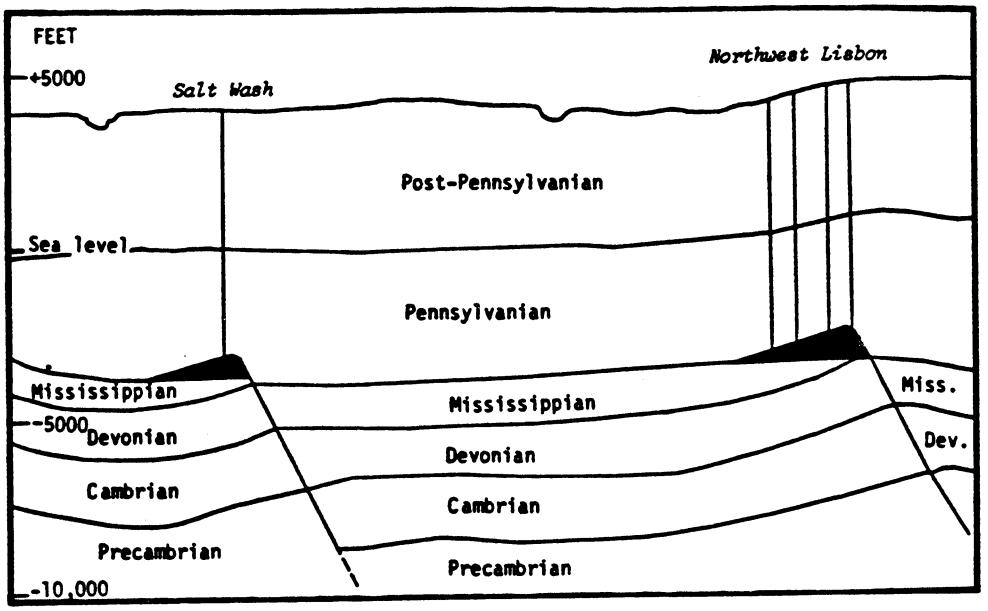
Utah - Salt Wash
Leadville Lime - Mississippian
Paradox Basin

DATA SOURCE CODE		
	STATE	Utah
5b	COUNTY	Grand County
	REGULATORY DISTRICT	
5b	BASIN	North Paradox Basin
	SUB-BASIN	
5b	FIELD	Salt Wash
5b	RESERVOIR	Leadville Limestone
5b	GEOLOGIC AGE	Mississippian
5b	AAPG STRATIGRAPHIC AGE CODE	330
5b	RESERVOIR LITHOLOGY	Dolomite
5b	TRAPPING MECHANISM	Structural dome
5b	DISCOVERY YEAR	1961
5b	PROVED ACREAGE	920
5b	REGULAR WELL SPACING (acres/well)	160
5b	RESERVOIR DEPTH	8693
	RESERVOIR THICKNESS	
5b	NET PAY	28
5b	GROSS	100
	NET/GROSS RATIO	
	POROSITY	
5b	TYPE	IC, V
5b	FRACTION	.078
	PERMEABILITY	
	RANGE	
	AVERAGE	
	HORIZONTAL	
	VERTICAL	
	OTHER INFORMATION	
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
5b	TOTAL NUMBER OF WELLS	1P, 7A, 1DH
	PRODUCTION 1976 oil (cum)	
5b	PRODUCTION 1977 oil (cum)	1182 mbbls oil; 11,616.5 mmcf gas
	PRODUCTION 1978 oil (cum)	
	PRODUCTION 1979 oil (cum)	
5b	PRODUCTION 1-1-78 to 1-1-79	9.4 mbbls oil; 58.4 mmcf gas
	SECONDARY RECOVERY RECORDS?	
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
5b	STRUCTURE CONTOUR?	yes
5b	LOGS?	yes
	STRUCTURE SECTION?	
5b	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Salt Wash
5b	RESERVOIR:	Leadville Limestone
5b	PROD. ACRES:	920
5b	AVG. THICKNESS (FT.):	10-27
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
5b	WATER SATURATION (S_W):	.25
	OIL SATURATION (S_O):	
5b	PRIMARY DRIVE MECHANISM:	gas cap & encroaching H_2O
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	183
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
5b	RESERVOIR PRESSURE INITIAL (psi):	4075
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
5b	STOCK TANK OIL GRAVITY (°API):	50.1
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

OTHER INFORMATION:



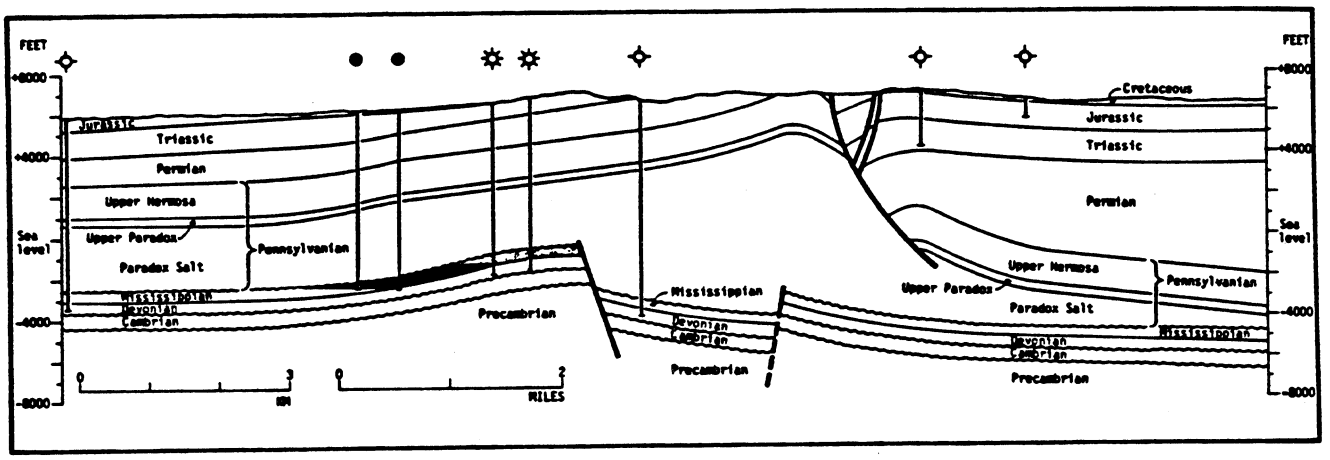


FIGURE 36.9 Salt anticline traps, northern Paradox basin, Utah. Upper: northwest-southeast (close to strike) hypothetical section through Salt Wash and Northwest Lisbon fields. Approximate distance between two fields is 60 miles (100 km). *Courtesy Pan American Petroleum Corporation (1961, p. 1), subsidiary of Standard Oil Company (Indiana).* Lower: southwest-northeast cross section, Northwest Lisbon field, showing four Mississippian oil and condensate gas wells. Gas and condensate pay zone stippled. *Courtesy John M. Parker (1968, Figure 5, p. 1378–1379).*

To the west of San Rafael swell, in the Castle Valley and especially on the Wasatch Plateau, hunting for flammable gas has been more successful (Figure 36.2). This district contains one very large field, Clear Creek, and several smaller gas fields. Castle Valley–Wasatch Plateau is an area of extensive outcrops of Tertiary and Cretaceous rocks. The column, including underlying lower Mesozoic and Paleozoic sediments, has a total thickness of about 19,000 feet. "It is a structurally complex area of numerous north-trending horsts and grabens that generally cut older structures" (Gere et al., 1964, p. 58).

The *Clear Creek* gas field (Anon., 1961; Walton, 1955), discovered in 1951, had produced over 100 billion cubic feet by the end of 1962. The reservoirs are sandstones in the Ferron Member of the Upper Cretaceous Mancos Shale. These sandstones are low in interpore permeability; both gas storage capacity and movement are greatly enhanced by the presence of natural fractures. Accumulation is in the higher parts of the Clear Creek anticline, a major upfold in the north-central part of the Wasatch Plateau. This anticline is segmented by horst and graben faults. Trapping is in the fault slices, especially the horsts, on the anticlinal crest.

KAIPAROWITS BASIN AND SOUTHWESTERN UTAH.

FROM: LANDES, K.S., 1970, PETROLEUM GEOLOGY OF THE UNITED STATES, John Wiley and Sons, New York, New York, page 444 Source 8

SALT WASH

(Oil)

T. 23 S., R. 17 E., SLPM

Grand County, Utah

By: J. A. Norton
Consolidated Oil and Gas Co.

GEOLOGY

Regional Setting: North Paradox Basin

Surface Formations: Jurassic, Morrison Formation

Exploration-Method Leading to Discovery: Seismic

Type of Trap: Structural

Producing Formation: Mississippian, Leadville Limestone

Gross Thickness and Lithology of Reservoir Rocks: 100 feet, vertically fractured dolomite with intercrystalline and vuggy porosity

Geometry of Reservoir Rock: 5 to 10 foot stringers of porosity; maximum net pay 28 feet

Other Significant Shows: None

Oldest Stratigraphic Horizon Penetrated: Cambrian, Lynch Dolomite

DISCOVERY WELL

Name: Pan American No. 1 Salt Wash

Location: NW SW (660' FWL and 1980' FSL) sec. 15, T. 23 S., R. 17 E.

Elevation (KB): 4,292 feet

Date of Completion: May, 1961 (plugged and abandoned September, 1964)

Total Depth: 9,523 feet

Production Casing: 5½" at 8,898 feet with 250 sacks of cement

Perforations: 8,693 feet to 8,707 feet, with 4 shots per foot

Stimulation: Acidize with 500 gallons

Initial Potential: Flow 115 BOD, 9 BWD

Bottom Hole Pressure: 3,875 psi (bottom-hole shut-in pressure from drill-stem test)

DRILLING AND COMPLETION PRACTICES

In the discovery well 13 3/8" surface casing was set at 934 feet with 975 sacks of cement, 9 5/8" intermediate casing was set just above the Paradox Formation salt at 5,075 feet and 5½" production casing was set at 8,898 feet with 250 sacks of cement. The lower Leadville was perforated between 8,734 to 8,750 feet and acidized with 1,500 gallons of hydrochloric acid. Swabbing of this interval resulted in the recovery of salt water. The interval between 8,693 to 8,707 feet was perforated and acidized with 500 gallons of hydrochloric acid for completion.

RESERVOIR DATA

Productive Area:
Proved (as determined geologically): 920 acres
Unproved: 0 acres
Approved Spacing: 160 acres

No. of Producing Wells: 1
No. of Abandoned Wells: 7
No. of Dry Holes: 1

Average Net Pay: 10 to 27 feet

Porosity: 7.8 percent

Permeability: Unknown

Water Saturation: 25 percent

Initial Field Pressure: 4,075 psi

Type of Drive: Gas cap and encroaching water

Gas Characteristics and Analysis: Changes with production; specific gravity .968; methane 43 percent, nitrogen 56 to 80 percent, helium 1.2 percent

Oil Characteristics and Analysis: 50.1° API gravity; specific gravity 0.779; formation volume factor 1.25; pour point 40°F; color NPA3; viscosity 100°F 32 seconds, 77°F 34 seconds; sulfur .23 percent, nitrogen .002 percent

Associated Water Characteristics and Analysis: Total dissolved solids 183,150 ppm; Cl 110,027 ppm, SO_4 1,574 ppm, Na 59.630 ppm, Ca 7,520 ppm, K 2,400 ppm

Original Gas, Oil, and Water Contact Datums: Gas-oil -4,387 feet, oil-water -4,420 feet

Estimated Primary Recovery: 1,250,000 BO

Type of Secondary Recovery: None

Estimated Ultimate Recovery: 1,250,000 BO

Present Daily Average Production: 34 BOD (September, 1978)

Market Outlets: Unknown

FIELD COMMENTARY

The Salt Wash field is located on a structure, and was discovered using seismic exploration techniques. The field produces from the Mississippian, Leadville Limestone. There is no Pennsylvanian algal mound production in the field. The discovery well, the Pan American (Amoco) No. 1 Salt Wash, was drilled in April, 1961. This is also the deepest well in the field and tested the Cambrian at a total depth of 9,523 feet. There have been a total of 8 wells drilled to the Leadville.

The producing zone of the Leadville is crystalline dolomite with varying intercrystalline and vuggy porosity and permeability development which occurs approximately 250 feet into the Leadville below a dense limestone. Vertical fracturing has been observed in cores throughout the producing formation and the pay zone thickness varies from 10 to 27 feet.

From its discovery, the field has been plagued by high water production that is aggravated by the pronounced vertical fracturing of the reservoir rock. The disposal of this corrosive water results in high operating costs. The most menacing operational problem in the field is casing collapse in the Paradox Formation salt interval above the Leadville Limestone. Casing collapse has resulted in the abandonment of 4 wells in the Salt Wash field. Presently only one well is producing, the Consolidated Government Smoot No. 3. The CF&I

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

No. 42-16 well and the CF&I No. 22-16 well have produced 691,771 BO and 5,300 MCFG; the No. 22-16 well produced almost 45 percent of the field's reserves before its casing collapsed. In 1978 the field was sold by Consolidated Oil and Gas to Richard Smoot of Salt Lake City.

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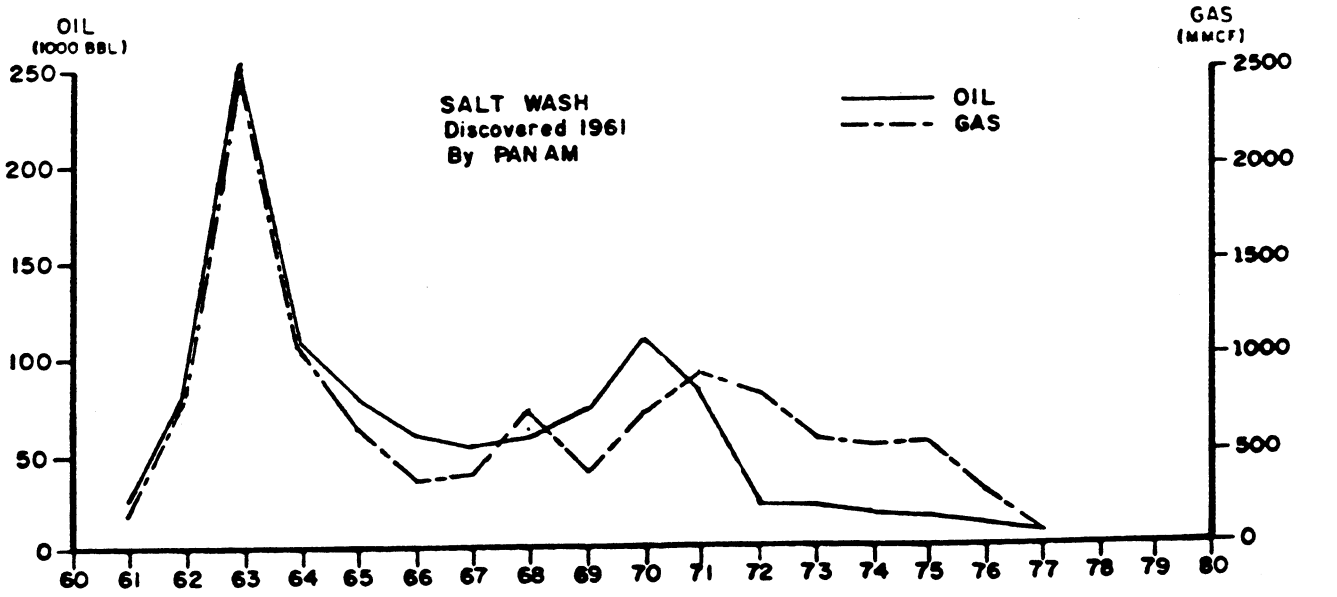
Company files.
International Association of Oil Scouts, International Oil Development Year Books.
Petroleum Information production records.

NUMBER OF WELLS AT YEARS END				- PRODUCTION - OIL IN BARRELS GAS IN MCF	
YEAR	TYPE	PROD	S I /ABN	ANNUAL	CUMULATIVE
1961	Oil	1	-	26,213	26,213
	Gas	1	-	352,721	352,271
1962	Oil	3	-	79,468	105,681
	Gas	-	-	713,461	1,065,732
1963	Oil	7	-	252,212	360,893
	Gas	-	-	2,507,824	3,573,556
1964	Oil	5	2	113,575	474,468
	Gas	-	-	1,090,816	4,664,272
1965	Oil	4	3	77,379	551,847
	Gas	-	-	611,386	5,275,658
1966	Oil	3	4	61,671	613,518
	Gas	-	-	351,643	5,627,401
1967	Oil	3	4	52,664	666,182
	Gas	-	-	400,543	6,027,944
1968	Oil	2	5	58,744	724,926
	Gas	-	-	734,516	6,762,460
1969	Oil	3	5	72,007	796,933
	Gas	-	-	414,637	7,177,097
1970	Oil	3	5	108,543	908,969
	Gas	-	-	720,073	7,678,790
1971	Oil	3	5	82,856	991,825
	Gas	-	-	913,815	8,592,605
1972	Oil	2	6	44,309	1,036,134
	Gas	-	-	806,691	9,399,296
1973	Oil	2	6	43,855	1,079,838
	Gas	-	-	577,296	9,958,532
1974	Oil	2	6	34,762	1,114,600
	Gas	-	-	545,180	10,503,717
1975	Oil	2	6	32,987	1,147,587
	Gas	-	-	565,615	11,069,327
1976	Oil	1	7	22,228	1,169,815
	Gas	-	-	298,493	11,427,820
1977	Oil	1	7	12,266	1,182,081
	Gas	-	-	188,717	11,616,537
1978	Oil	1	7	9,391	1,191,472
	Gas	-	-	58,362	11,674,899

Thru Sept. 1978



From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 5b.

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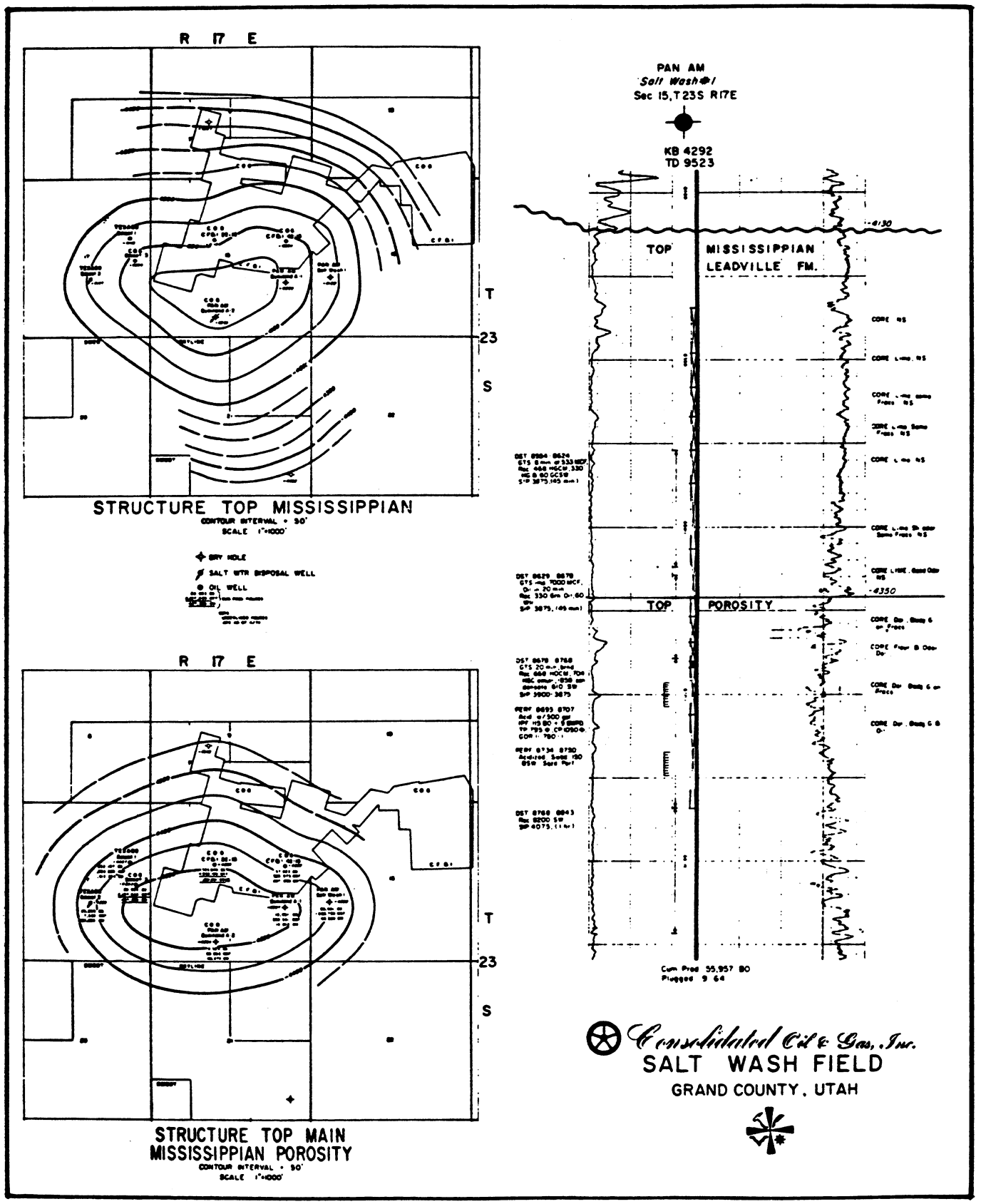

Oil and Gas Fields of the Four Corners Area]

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

New Mexico - Tocito Dome
Paradox - Hermosa
Paradox Basin

DATA SOURCE CODE		
7c	STATE	New Mexico
7c	COUNTY	San Juan
	REGULATORY DISTRICT	
7c	BASIN	Paradox
7c	SUB-BASIN	Four Corners Platform
7c	FIELD	Tocito Dome
7c	RESERVOIR	Hermosa Fm. (zone "D")
	GEOLOGIC AGE	Pennsylvanian
	AAPG STRATIGRAPHIC AGE CODE	
7c	RESERVOIR LITHOLOGY	Fossilferous, calcareous boundstone, packstone, and grainstone with interbeds of varicolored claystone and siltstone and occasional streaks of nodular phosphate.
7c	TRAPPING MECHANISM	Structural stratigraphic
8,7c	DISCOVERY YEAR	1963
7c, 13	PROVED ACREAGE	6380, 2600
	REGULAR WELL SPACING (acres/well)	
8, 13	RESERVOIR DEPTH	6300, 6940
	RESERVOIR THICKNESS	
7c	NET PAY	17 ft.
7c	GROSS	100 to 120 ft.
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
7c	FRACTION	.086
	PERMEABILITY	
	RANGE	
7c	AVERAGE	94 md
	HORIZONTAL	
	VERTICAL	
	OTHER INFORMATION	
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
13,7c	TOTAL NUMBER OF WELLS	60; 76 (41P, 11A, 13DH, 11SI)
7c	PRODUCTION 1976 oil (cum)	11,197
7c	PRODUCTION 1977 oil (cum)	11,461
	PRODUCTION 1978 oil (cum)	
7a	PRODUCTION 1979 oil (cum)	12,012
	PRODUCTION 1-1-79 to 1-1-80	
	SECONDARY RECOVERY RECORDS?	
7c	WATER ANALYSIS RECORDS?	yes
	OTHER DATA	
7c	STRUCTURE CONTOUR?	yes
7c	LOGS?	yes
7c	STRUCTURE SECTION?	yes
7c	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Tocito Dome
7c	RESERVOIR:	Hermosa
7c	PROD. ACRES:	6380
7c	AVG. THICKNESS (FT.):	171
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
7c	WATER SATURATION (S_W):	.20 to .30
	OIL SATURATION (S_O):	
7c	PRIMARY DRIVE MECHANISM:	Comb. of water, soln. gas, gravity drain.
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	160
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
7c	RESERVOIR PRESSURE INITIAL (psi):	3217
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
7c	STOCK TANK OIL GRAVITY (°API):	44 to 47
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	
7c	Estimated Primary Recovery:	15,000,000 BO and 28,000,000 MCFG
	OTHER INFORMATION:	

WATER ANALYSIS RECORD

FIELD: Tocito Dome RESERVOIR: Hermosa TOTAL NO. PROJECTS:
DATA SOURCE: selected produced water analyses

TOTAL SOLIDS (ppm):	142,240	89,270
NA	35,889	26,237
Ca	15,438	6,660
Mg	1,812	900
Fe		Present
SO_4	500	1,148
Cl	88,000	54,000
CO_2		
HCO_3		317
OH		
H_2S		
K	535	169
RESISTIVITY:	.074 @ 68°F	.01 @ 68°F
SPECIFIC GRAVITY:		
OTHER WATER QUALITY DATA:	pH 6.6	pH 6.8

TOCITO DOME PENNSYLVANIAN "D"

(Oil)

T. 26 N., R. 18 W., NMPM
San Juan County, New Mexico

By: Charles W. Spencer
U.S. Geological Survey

GEOLOGY

Regional Setting: Southern edge of the Four Corners Platform, just west of the west edge of the San Juan Basin; on the south-central edge of the Pennsylvanian Paradox depositional basin

Surface Formations: Upper Cretaceous, Gallup sandstone, Tocito Sandstone, and Mancos Shale

Exploration Method Leading to Discovery: Surface geology, lithologic study, electric-log analysis

Type of Trap: Structural and stratigraphic

Producing Formation: Pennsylvanian, Paradox Member of Hermosa Formation, zone "D" of subsurface usage; correlates with Barker Creek Substage of Baars, Parker, and Chronic (1967) of Des Moinesian age

Gross Thickness and Lithology of Reservoir Rocks: Approximately 100 to 120 feet of fossiliferous, calcareous boundstone, packstone, and grainstone with interbeds of varicolored claystone and siltstone and occasional streaks of nodular phosphate

Geometry of Reservoir Rock: Limestone bioherms with common *Chaetetes* coral and *Ivanovia* algal plates; porous intervals locally discontinuous

Oldest Stratigraphic Horizon Penetrated: Precambrian, granite

DISCOVERY WELL

Name: Pan American (Amoco) No. 1 Navajo Tribal "N"

Location: SW SW (790' FSL and 790' FWL) sec. 17, T. 26 N., R. 18 W., NMPM

Elevation (KB): 5,851 feet

Date of Completion: April 21, 1963 (as a shut-in gas well)

Total Depth: Initial 6,654 feet; later deepened to 6,694 feet

Production Casing: 5½" casing at 6,654 feet with 600 sacks of cement

Perforations: 6,338 to 6,355 feet and 6,392 to 6,410 feet with 4 shots per foot

Stimulation: 6,392 to 6,410 feet with 1,500 gallons of acid; 6,338 to 6,355 feet with 3,000 gallons of acid

Initial Potential: 5,077 MCFGD

DRILLING AND COMPLETION PRACTICES

Most wells set 13 3/8" surface casing to 90 or 100 feet with 100 to 200 sacks of cement; 9 5/8" intermediate casing set to 1,500 to 1,700 feet with 500 to 700 sacks of cement; 4½" to 7" production string to 6,400 to 6,600 feet with 500 to 1,700 sacks of cement; wells treated with 1,000 to 3,000 gallons of acid.

RESERVOIR DATA

Productive Area:
Proved (as determined geologically): 6,380 acres
Approved Proration Units: 160 acres (oil); 320 acres (gas)
No. of Producing Wells: 41 (in 1977)
No. of Abandoned Wells: 11
No. of Dry Holes: 13
No. of Shut-in Wells: 11

Average Net Pay: 17 feet (3 percent porosity cut off)

Average Porosity: 8.6 percent

Permeability: Variable, approximate average 94 millidarcies

Water Saturation: 20 to 30 percent

Initial Field Pressure: 3,217 psi

Type of Drive: Combinations of water, solution gas, and gravity drainage

Oil API Gravity: 44° to 47° API gravity, reservoir volume factor, 1.766

Gas Characteristics and Analysis: Btu 1,000+; sweet; Amoco No. 3 Navajo "N" SW¼SE¼, sec. 17, T. 26 N., R. 18 W. gas composition in molecular percent: methane 79.9, ethane 7.4, propane 2.3, butanes 0.7, pentanes trace, hexanes plus 0.2, nitrogen 7.9, oxyen 0.3, argon 0.1, helium 0.51, carbon dioxide 0.8, calculated gross Btu 1,030 (analyzed by U.S. Bureau of Mines, sample collected December 17, 1964)

Associated Water Characteristics and Analysis: Total dissolved solids vary from more than 142,000 mg/l on east side of field to about 89,000 mg/l in the northwest part of the Tocito producing area; selected produced water analyses in mg/l are as follows:

Amoco No. 26 Navajo "U" SW¼NE¼SE¼, sec. 22, T. 26 N., R. 18 W. (depth 6,257 to 6,276 feet): Na 35,889; K 535; Ca 15,438; Mg 1,812; SO_4 500; Cl 88,000; CO_3 134; resistivity 0.074 ohm at 68°F; pH 6.6; total dissolved solids 142,240

Amoco No. 2 Navajo "P" NW¼SE¼, sec. 7, T. 26 N., R. 18 W. (depth 6,398 to 6,402 feet): Na 26,237; K 169; Ca 6,660; Mg 900; Fe present; SO_4 1,148; Cl 54,000; HCO_3 317; resistivity 0.1 ohm at 68°F; pH 6.8; total dissolved solids 89,270

Original Gas, Oil, and Water Contact Datums: Gas-oil contact approximately 511 feet; oil-water contact variable

Estimated Primary Recovery: Author's estimate, approximately 15,000,000 BO and 28,000,000 MCFG

Type of Secondary Recovery: Reinject produced water; pilot gas injection project terminated February 1, 1977

Present Daily Average Production: 722 BOD and 2,720 MCFGD (1977 average)

Market Outlets: Gas: El Paso Natural Gas Co.; oil: Four Corners Pipeline Co. and Giant Refinery

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 7c.

[Four Corners Geological Society

SOURCES OF DATA

Amoco Production Company, engineering data.
New Mexico Oil and Gas Engineering Committee, Annual Reports.
Personal files of Curtis J. Little, Consultant.
Petroleum Information Inc. Well History Control System.
Records of the New Mexico Oil Conservation Commission.

FIELD COMMENTARY

The Tocito Dome field is located on the Navajo Indian Reservation about 20 miles south of Shiprock, New Mexico. Tocito Dome is a northwest-trending complex anticline situated on the southern edge of the Four Corners Platform. The producing interval comprises generally fossiliferous limestones in the Pennsylvanian, Paradox Barker Creek Substage of Baars, Parker, and Chronic (1967). The New Mexico Oil Conservation Commission has designated the producing pool as "Tocito Dome Penn D (Associated)." The reservoir carbonates were deposited on the south-central edge of the Paradox sea, adjacent to the Defiance paleopositive feature that is situated west and southwest of the field.

The structure is well expressed on the surface. It is interpreted that the east flank of the structure is bounded by a high-angle normal (?) fault. The Sinclair No. 1 Navajo Tribal 149 well, located in the NE¼NE¼, sec. 23, T. 26 N., R. 18 W., is approximately 2,000 feet structurally low, on the top of the Barker Creek, to the nearest oil wells only ¾ mile to the west. The actual amount of displacement is not known by me, but the throw is less than 2,000 feet owing to probable east dip on each side of the fault. There are relatively steep eastward dips (O'Sullivan and Beikman, 1963) in Upper Cretaceous, Mesaverde Group rocks cropping out at the location of the Sinclair No. 1 Navajo Tribal 149 dry hole. It is interpreted that these steep eastward dips along the Hogback Monocline represent drape over the fault shown cutting the top of the Barker Creek on the Tocito structure map. The fault probably dies out in the relatively plastic shales within the Upper Cretaceous, Mancos Shale. The Hogback Monocline marks the west edge of the San Juan Basin. A road log prepared by O'Sullivan, Beaumont, and Knapp (1957, p. 194) notes that Tocito Dome has almost 300 feet of surface closure and about 17,000 acres are within the lowest closing contour.

The surface mapping of Tocito Dome began at least in the early 1920's and possibly earlier. In 1923, Virgil B. Cole was assigned the task of mapping all the significant surface structures in the San Juan Basin by the Gypsy Oil Company (V. B. Cole, oral commun., 1978). In the summer of 1923, he was joined by A. I. Levorsen and they mapped the Tocito Dome structure. In February 1924, the Gypsy Oil Company, a subsidiary of Gulf Oil, drilled the first wildcat on the structure in NW¼NE¼SW¼, sec. 17, T. 26 N., R. 18 W. It was drilled to a depth of 3,022 feet in the Triassic, Chinle Formation. The well flowed water from the Cretaceous, Dakota Sandstone and was subsequently sold to the Navajo Tribe as a water well. The well site is remarkably close to the subsurface crest as mapped on strata on the top of the Barker Creek Substage. In April 1926, Continental Oil Company (Conoco) drilled a wildcat 2,678 feet from the south line and 1,325 feet from the west line of sec. 8, T. 26 N., R. 18 W. This well was designated the No. 1 Navajo Tract A, and was drilled to a total depth of 1,430 feet. This shallow test well was also reportedly sold to the Navajos as a water well.

In 1937, Ben F. Baldwin, while employed by Stanolind, located some old plane table sheets of the Tocito structure prepared for Midwest Refining in November 1922, by H. T. Morley and Harrison Schmitt (B. F. Baldwin, oral commun., 1978). Baldwin relocated the 1922 mapping monuments in the field and confirmed the earlier plane table work. In January 1943, Continental Oil Company (Conoco), Stanolind (Amoco), and Standard Oil of Texas commenced drilling the No. 1 Navajo Tribal well in NW¼SW¼ sec. 17, T. 26 N., R. 18 W. This wildcat was drilled to a total depth of 6920 feet after running a drill-stem test in Mississippian rocks from 6,659 to 6,700 feet. This test recovered helium-bearing gas at the rate of 458 MCFGD. Acording to data furnished by B. J. Moore, U.S. Bureau of Mines (written commun., 1978), the gas contained 6.93 percent helium. The U.S. Bureau of Mines took over the testing of the well at total depth and 7" casing was run to 6,648 feet. After acidizing with 2,000 gallons of HCl on April 26, 1943, the well flowed 2,600,000 MCFGD gas containing 7.1 percent helium and a considerable amount of salt water from open hole 6,648 to 6,701 feet. Water shut-off was never accomplished and the well was abandoned on March 24, 1944.

In 1963, the development of the Tocito oil and gas pool was initiated with the discovery of flammable gas in the Barker Creek carbonates. The initial hydrocarbon discovery well was the Pan American (Amoco) No. 1 Navajo "N" in SW¼ SW¼, sec. 17, T. 26 N., R. 18 W., which was drilled to 6,694 feet in Mississippian limestone. This wildcat was drilled as a south offset to the Continental No. 1 Navajo helium discovery. Pan American restudied the cuttings from the Pennsylvanian in the Continental test and reanalyzed the logs (W. T. Smith, oral commun., 1978). This work encouraged them to redrill the structure. The helium potential was at least a minor consideration because the No. 1 Navajo "N" was perforated in the Mississippian from 6,634 to 6,651 feet and after acidizing the perforations and open-hole from 6,654 to 6,694 feet, the well yielded a flow of 150 MCFGD of nonflammable gas. The U.S. Bureau of Mines (1976, p. 281) analyzed a sample of this gas, which was collected March 21, 1963. It contained 90.0 percent nitrogen and 6.56 percent helium. The rest of the gas was a mixture of carbon dioxide and flammable gases. Subsequently, Amoco completed the discovery well in what was reported as the "Pennsylvanian Hermosa" (Formation) from gross perforations between 6,338 to 6,410 feet for 5,077 MCFGD of flammable gas. The well was completed April 21, 1963, and at the date of this writing is producing oil with the gas.

On May 3, 1964, Texaco completed the No. 1 Navajo "AL" in SE¼NE¼, sec. 28, T. 26 N., R. 18 W., flowing 430 BOD and 1,238 MCFGD from the Barker Creek. This second discovery well was located on a low-relief closure in the southeast part of the Tocito Dome structure. Subsequent drilling has shown these two discoveries to be within the same oil and gas pool.

The development of the Tocito Dome field has gone through two phases. There was an initial flurry of drilling activity after Amoco and Texaco drilled their discovery wells and infill drilling joined the two areas. The drilling activity decreased in the late 1960's, probably because both operators felt they had identified the oil-water contact for their part of the field. Texaco apparently reanalyzed the production and in September 1973, drilled their No. 3 Navajo "AR" (NE¼ NE¼, sec. 27, T. 26 N., R. 18 W.) as a ¾ mile east step-out, about 200 feet downdip from existing production. The well came in flowing for an initial potential of 800 BOD. This well initiated the second phase of drilling activity and explains the large hump in the production chart between 1973 and 1976.

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 7c.

Since the Texaco step-out, oil has been found over 400 feet downdip from the Amoco No. 11 Navajo "U" dry hole in the SE¼NE¼, sec. 21, T. 26 N., R. 18 W. (see cross-section A-A'), which flowed water and gas on a drill-stem test.

An analysis of initial potentials in the field shows a wide variety of ratios of gas, oil, and water (see cross-section A-A'). This variation suggests that atypical reservoir conditions exist in this field and in the Tocito North Penn (gas) field located in sec. 9 and 10, T. 26 N., R. 18 W. I have had conversations with geologists and engineers familiar with the field and they have suggested several theories to account for the atypical reservoir performance. The most popular of these theories are 1) that small faults separate reservoirs or 2) that gravity drainage is taking place; however, some workers have indicated the reservoirs may be discontinuous and isolated. Detailed log analysis of porous zones, study of reservoir pressures from available drill-stem tests, and analysis of fluid recoveries suggest to me that the field is producing from a series of displacement pressure traps (DPTs) or, in other words, partial barriers. This type of trap is discussed in some detail in an excellent paper by Schowalter (1976). Under DPT conditions, oil and gas are generated deeper in a basin and move updip by buoyancy until they encounter a stratigraphic trap. The hydrocarbons then spread out along the barrier and accumulate until the displacement pressure of the updip rock is exceeded. When it is exceeded, approximately one-half of the hydrocarbon column leaks updip (Showalter, 1976, p. 38) until another trap is encountered along the migration route.

Descriptions of cores and samples given in proprietary lithologic logs by American Stratigraphic Company indicate that most of the shales (or claystones) of Barker Creek age are organically lean. The shales are commonly described as red, brown, purple, gray-green, and green in color. These colors are not typical of the sapropelic dolomites and shales generally acknowledged as the hydrocarbon source beds deeper in the Pennsylvanian, Paradox depositional basin. Consequently, it is interpreted that most of the Barker Creek oil and gas at Tocito was generated deeper in the basin and moved south and west updip into the area of the present structure.

The pronounced surface structure seen in rocks of Late Cretaceous age is the result of Laramide folding. Therefore, it is likely that some oil and gas adjustment also took place during and after the Laramide orogeny. The DPTs at Tocito would have enhanced trapping capability if a downdip hydrodynamic flow of reservoir water existed. According to F. A. F. Berry (oral commun., 1978) the potentiometric surface in the Barker Creek reservoir is relatively flat (static) in the immediate Tocito area. The predevelopment static conditions calculated by Berry may be in part due to the fault barrier east of the field. Also, the reservoir porosity decreases generally away from the producing area.

If the DPT concept is valid, there are some significant implications in regard to the ultimate recovery from this field. If, in fact, there are multiple DPTs, then some selective experimental infill drilling might be undertaken. Such additional development could possibly recover additional oil. The field oil production is prorated on 160-acre units but the development oil wells are legally located on spacing ranging from 160-acre spacing to what is effectively 40-acre spacing. If economic and engineering studies justify some infill drilling, I would think that prudent drill-stem testing of new wells, in conjunction with bottomhole pressure surveys in existing wells, would help operators predict the limits of individual pressures pods. Such work might demonstrate the need for off-pattern well locations to improve recovery.

There are some broader exploration implications relative to the DPT concept. Other Pennsylvanian fields in the Four Corners area may contain oil and gas downdip from presently producing fields where the oil-water contact has been thought to be "established." Defining paleotilt directions in the manner suggested by Spencer (1975) may be helpful to define which direction would be most favorable for encountering DPTs. For example, a paleotilt analysis of the thickness of sediments above strata of Barker Creek age in the Tocito area show that the oil in the field migrated into the present structure from the north and east. Therefore, the north-to-east flank of the structure was the most logical area to explore for additional production from DPTs in downdip structural positions.

ACKNOWLEDGEMENTS

The author would like to express sincere appreciation to Amoco Production Company and Margaret Tezak for furnishing reservoir and analytical data, and control points from which the structural map was prepared. Curtis J. Little, very generously, made his personal files on Tocito available. Without this assistance the paper could not have been prepared.

Historical data relative to the early exploration of Tocito and the work leading to the drilling of the discovery well were furnished by Virgil B. Cole, Ben F. Baldwin, and William T. Smith.

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From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 7c.

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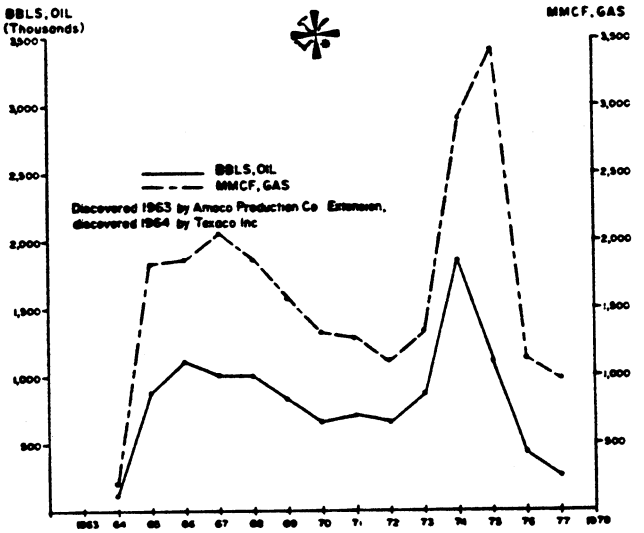
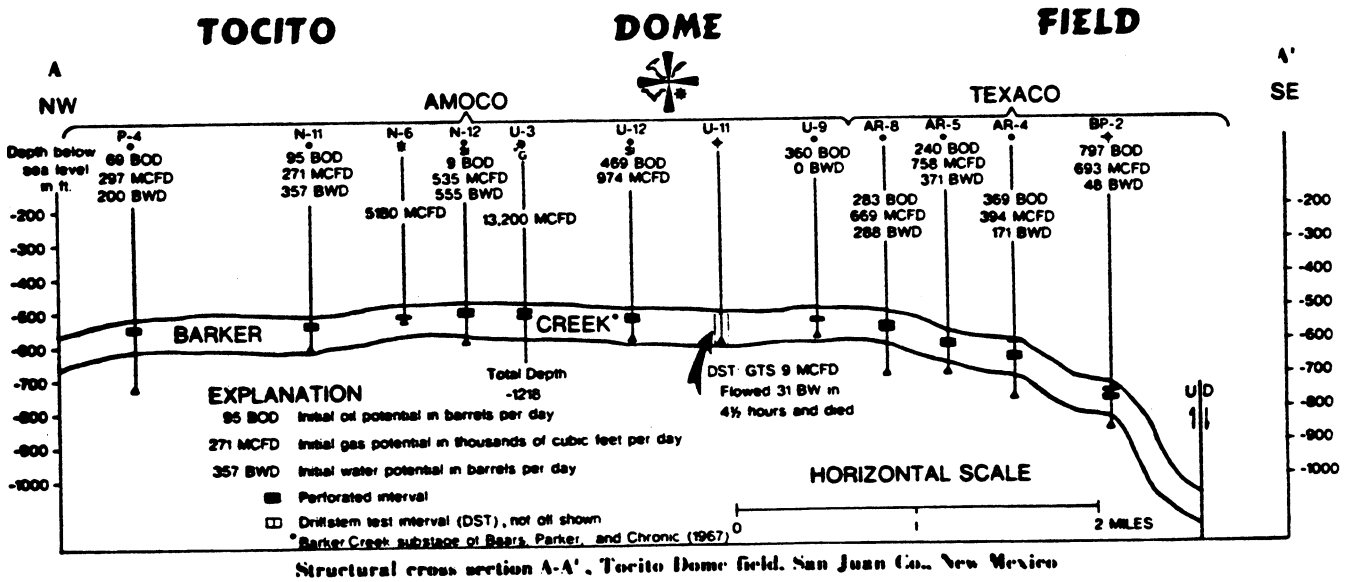
TOCITO DOME PENNSYLVANIAN "D"

NO. OF WELLS @ YR. END				PRODUCTION OIL IN BARRELS GAS IN MCF	
YEAR	TYPE	PROD.[1]	SI/ABD.[1]	ANNUAL	CUMULATIVE[2]
1963	Oil	None			
	Gas	None			
1964	Oil	8		115,357	115,357
	Gas			205,097	205,097
1965	Oil	14		868,939	984,296
	Gas			1,821,577	2,026,674
1966	Oil	15		1,103,760	2,086,794
	Gas			1,852,135	3,878,809
1967	Oil	17		1,004,656	3,091,450
	Gas			2,058,103	5,936,912
1968	Oil	19		1,004,700	4,096,150
	Gas			1,859,287	7,796,199
1969	Oil	15		826,435	4,922,585
	Gas			1,575,276	9,371,475
1970	Oil	20		652,340	5,574,925
	Gas			1,318,181	10,689,656
1971	Oil	17		705,443	6,280,368
	Gas			1,293,903	11,983,559
1972	Oil	20		657,646	6,938,014
	Gas			1,164,640	13,148,199
1973	Oil	30		869,035	7,807,049
	Gas			1,321,734	14,469,933
1974	Oil	44		1,851,147	9,658,196
	Gas			2,906,504	17,376,437
1975	Oil	51		1,105,172	10,763,368
	Gas			3,418,094	20,794,531
1976	Oil	44		434,004	11,197,372
	Gas			1,187,717	21,982,248
1977	Oil	41	22	263,316	11,460,688
	Gas			992,625	22,974,873

1/ All wells shown as oil wells even though some dominantly produce gas. Shut in and abandoned wells only shown for 1977.

2/ Annual figures do not exactly total to equal cumulative due to later adjustments to production.

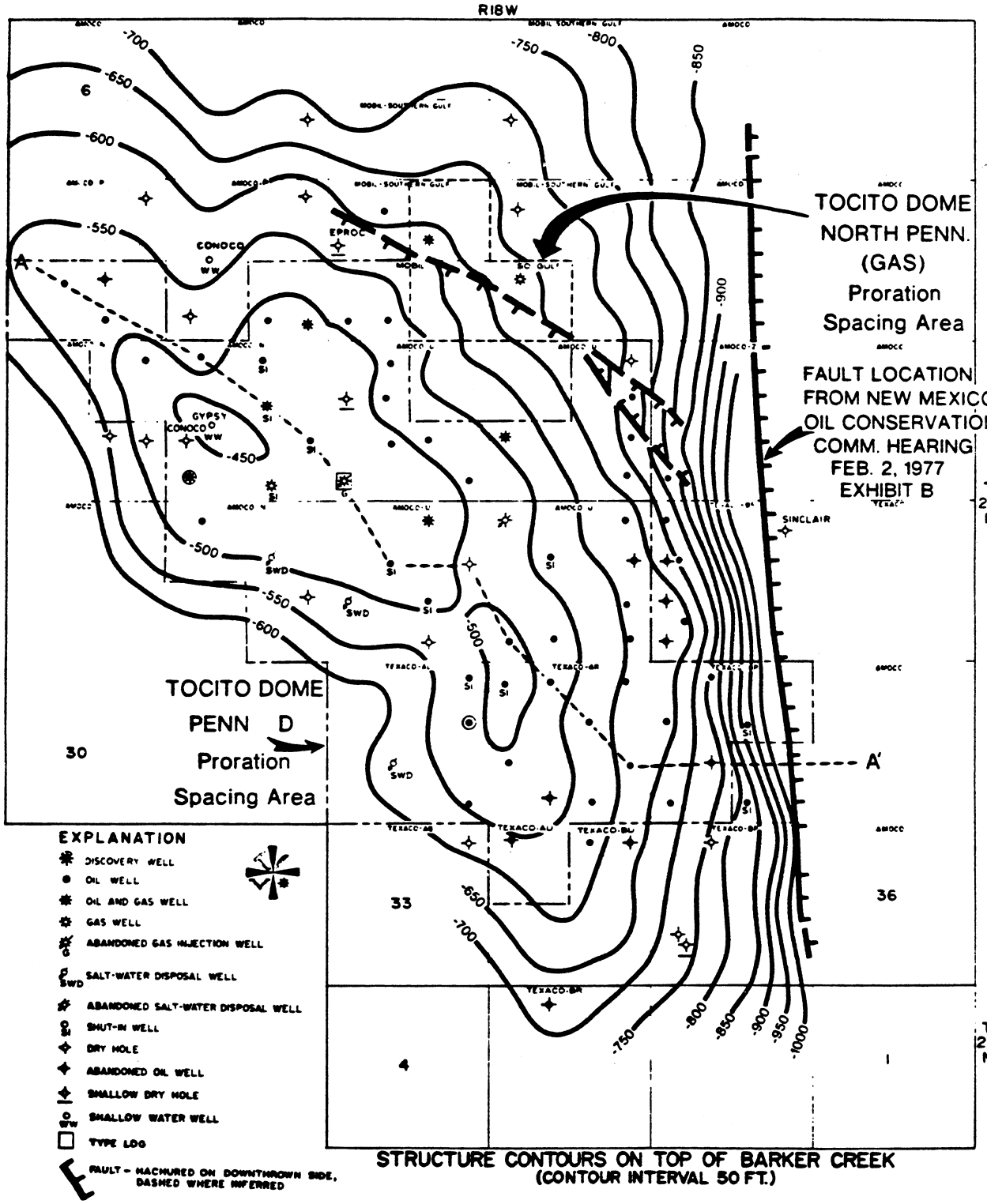




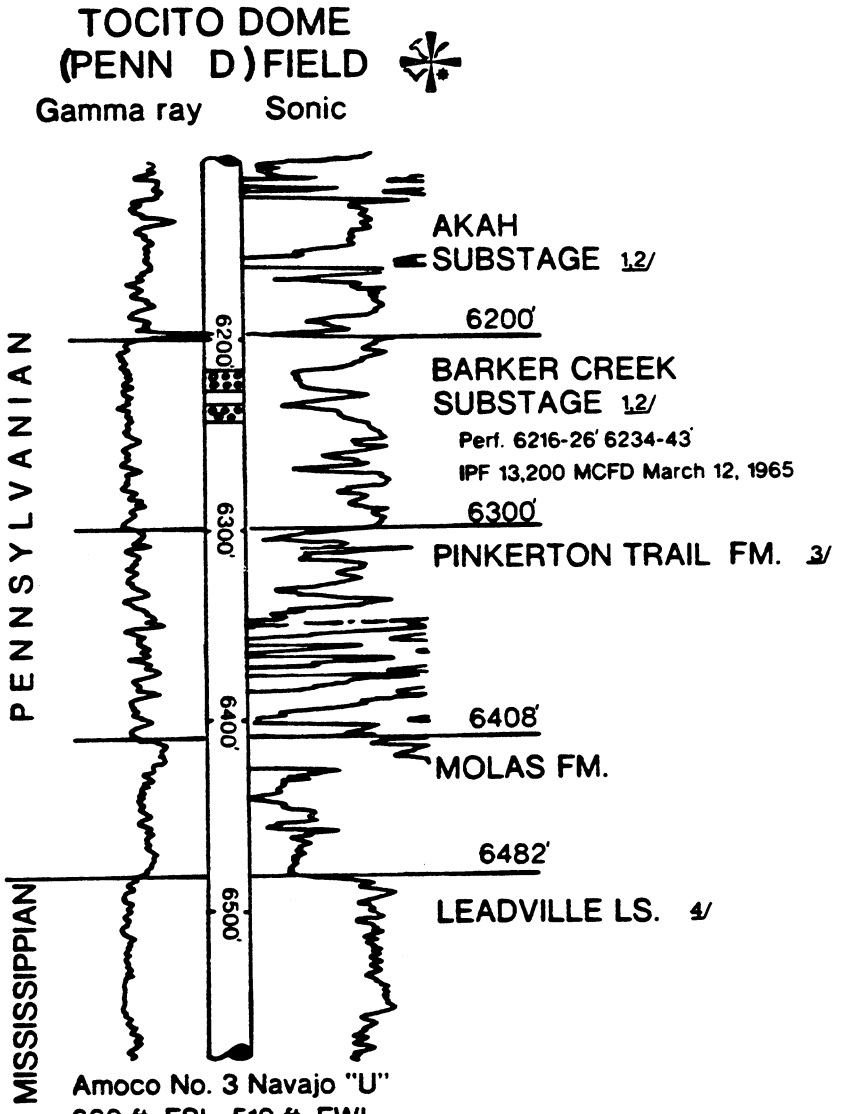
Structural cross section A-A', Tocito Dome field, San Juan Co., New Mexico

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 7c.

TOCITO DOME PENNSYLVANIAN "D"



From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 7c.



Amoco No. 3 Navajo "U"
660 ft. FSL, 510 ft. FWL
sec. 16, T. 26 N., R. 18 W.
San Juan Co., New Mexico
Elev. 5720 ft. KB
Total Depth 6940 ft.

1/ Operator terminology and log top
2/ Baars, Parker, and Chronic (1967)
3/ Wengerd and Strickland (1954)
4/ Called Redwall Limestone by many authors

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 7c.

Utah - Tohonalda
Paradox - Akah
Paradox Basin

DATA SOURCE CODE		
5a	STATE----------	Utah
	COUNTY----------	San Juan
	REGULATORY DISTRICT----------	
5a	BASIN----------	Paradox
	SUB-BASIN----------	
5a	FIELD----------	Tohonadla
5a	RESERVOIR----------	Paradox Fm., Akah zone
5a,1,5b	GEOLOGIC AGE----------	Pennsylvanian - Des Moines
1	AAPG STRATIGRAPHIC AGE CODE----------	325
5a,1,5b	RESERVOIR LITHOLOGY----------	Limestone, dolomite
5a,5b	TRAPPING MECHANISM----------	Stratigraphic; structural and stratigraphic specifically anticline nose.
8a, 1	DISCOVERY YEAR----------	1957
5a,5b	PROVED ACREAGE----------	2120, 1200
5a,5b	REGULAR WELL SPACING (acres/well)-----	80
5a	RESERVOIR DEPTH----------	5800
	RESERVOIR THICKNESS	
5a	NET PAY----------	25
	GROSS----------	
	NET/GROSS RATIO----------	
	POROSITY	
5a,1,5b	TYPE----------	V, IG, IG, IG
5b	FRACTION----------	.096
	PERMEABILITY	
5a	RANGE----------	2-20
	AVERAGE----------	
	HORIZONTAL----------	
	VERTICAL----------	
5a	OTHER INFORMATION----------	Other Paradox carbonate reservoirs include the Desert Creek and Ismay zones
	PRODUCTION STATISTICS - FIELD (oil in mbbls, gas in mmcf)	
5b	TOTAL NUMBER OF WELLS----------	5P, 5A, 4DH (combined Ismay, Desert
5b	PRODUCTION 1976 oil (cum)----------	1688 mbbls Creek & Akah)
5b	PRODUCTION 1977 oil (cum)----------	1725 mbbls
5b	PRODUCTION 1978 oil (cum)----------	1752 mbbls; 829.4 mmcf gas
	PRODUCTION 1979 oil (cum)----------	
	PRODUCTION 1-1-79 to 1-1-80----------	
	SECONDARY RECOVERY RECORDS?----------	
	WATER ANALYSIS RECORDS?----------	
	OTHER DATA	
5a,5b	STRUCTURE CONTOUR?----------	yes
5a	LOGS?----------	yes
	STRUCTURE SECTION?----------	
5a,5b	ENGINEERING REPORTS?----------	yes
	CORE DESCRIPTIONS?----------	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Tohonadla
5a, 5b	RESERVOIR:	Akah
5a, 5b	PROD. ACRES:	2120, 1200
5a	AVG. THICKNESS (FT.):	25
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
5b	WATER SATURATION (S_W):	.302
	OIL SATURATION (S_O):	
5a, 5b	PRIMARY DRIVE MECHANISM:	gas solution
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	145
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
5a, 5b	RESERVOIR PRESSURE INITIAL (psi):	2140
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
5a, 5b	STOCK TANK OIL GRAVITY (°API):	35 - 40
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

OTHER INFORMATION:

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

TOHONADLA FIELD

San Juan County, Utah

Gregory K. Elias

The Tohonadla Field is located in southeastern Utah within the areal limits of the Pennsylvanian Paradox Sedimentary Basin and the Tertiary Blanding Structural Basin. Locally the Field is situated 11 miles west of the "Greater Aneth" Oil Field. Oil and gas production occurs in the Tohonadla Field from reservoir beds of Pennsylvanian age occurring sporadically along an axial fold. The Field should be regarded as a Stratigraphic Trap even though some structural closure is present.

Three different producing horizons are found in the Field. Vugular limestones and dolomites are found in the Akah zone of the Paradox fm., oomoldic limestones occur in the Desert Creek zone of the Paradox fm., and vugular algal limestones comprise the main reservoir in the Ismay zone of the Honaker Trail fm.

The Akah zone reservoir resulted from primary intergranular porosity found in reworked lime muds (intraclasts) which was subsequently altered by dolomitization. These beds correlate with penesaline and saline sediments lying to the north and northeast, and are interpreted to have been deposited in relatively shallow, agitated waters.

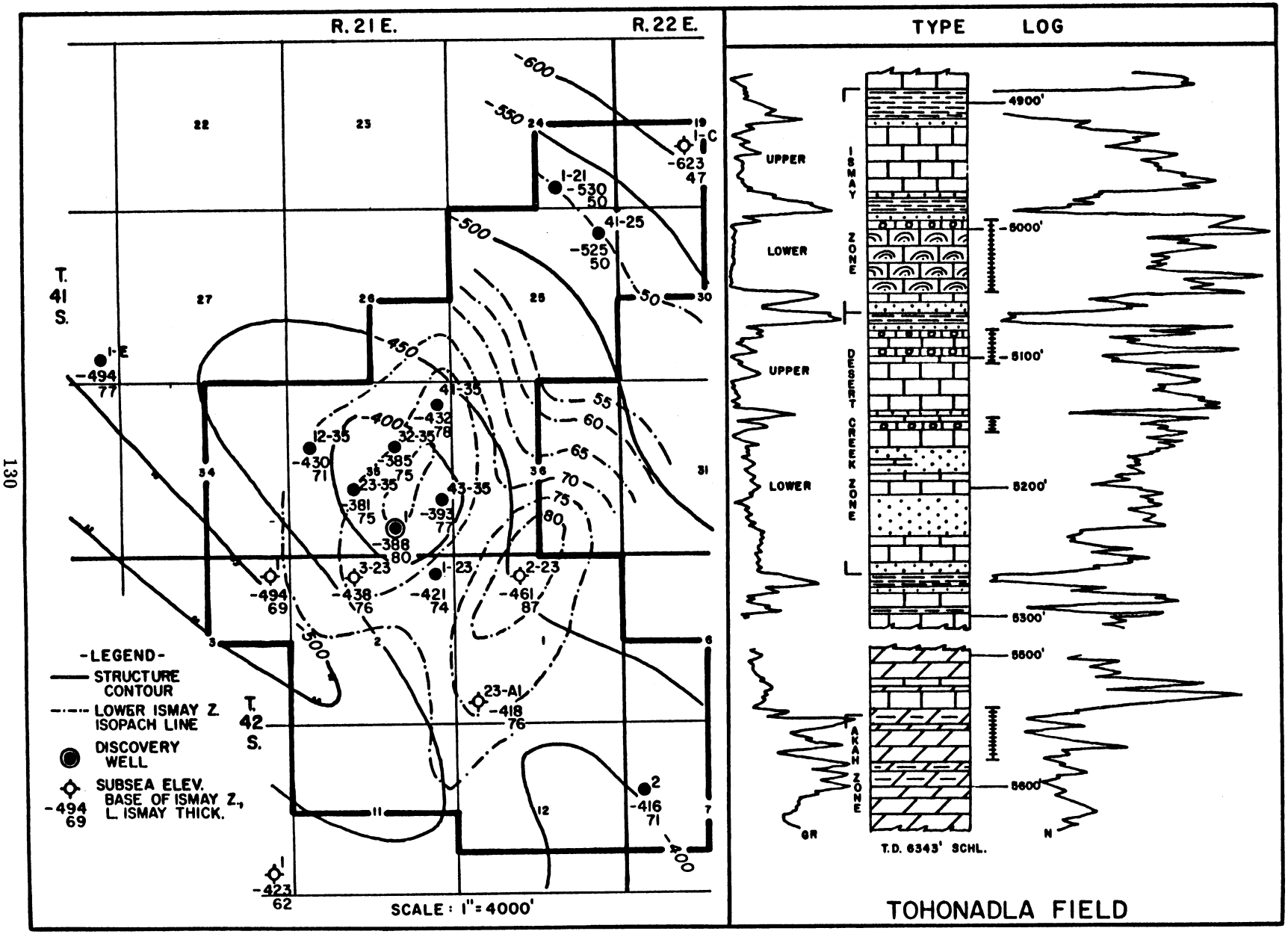
The oomoldic limestones of the Desert Creek zone resulted from the leaching and recrystallization of a pelletal-oolitic limestone. Very little to no primary intergranular porosity is found. Instead there occurs a sparry calcite framework with a "honeycombed" void network. The spheroid holes have no intercommunication other than the porosity and permeability of the cement which filled the original intergranular porosity. The spheroids which were dissolved away are larger (½-1 mm.) than the associated non-leached pellets and oolites, and are thought to be a type of algae by some geologists in the area. In the Tohonadla Field area, these pelleted-oolitic zones grade into penesaline dolomites and anhydrites to the north and east.

The prolific lower Ismay zone reservoir consists of calcareous, green algal remains (*Ivanovia* sp.) and associated clastic limestones (intraclasts, invertebrate fossil remains, pellets, and oolites). The porosity is primary intergranular void space, somewhat altered by recrystallization and subsequent mineral filling. Very little replacement such as dolomitization is seen. The algae is believed to have grown and accumulated in place, with little to no lateral movement after death. The algal patches are likened to the modern *Halimeda* growths in the Bahama Islands. The algal remains are flat and always occur in parallel pairs, suggesting that the original leaf was hollow. They are quite often curled and near vertical (best porosity) within the thickest section, and horizontally layered (poorer porosity) at the peripheres of the buildup. These algal accumulations are the "reefs" so often referred to in the southern Paradox Basin.

In the Tohonadla Field area, the regional linear trend of the algae appears to be northwest-southeast. However, as elsewhere in the Paradox Basin, the *individual* algal "pods" trend northeast-southwest. The geologic map illustrates this relationship by a simple isopach map. The reader is cautioned that thickness alone will not necessarily show trend in sparse control areas. Lithology must be used to reconstruct paleotopography and the physio-chemical forces which influenced algal growth. Subsequent mineralization occasionally fills the primary void space eliminating the potential reservoir within a buildup.

The geologic map also shows the relatively minor northwest-southeast trending fold on which the Tohonadla Field is situated. Though some closure is noted, favorable reservoir beds influence the producing area. Probable source beds are the many black, organic shales lying above and below each carbonate cycle.

The exploratory wildcat in Tohonadla resulted from extensive geophysical, stratigraphic, and surface mapping programs initiated by Shell in the late 1940's. Initial wildcat drilling in the Paradox Basin concentrated upon the determination of structural anomalies on the edges of the Pennsylvanian "evaporite pan" where reefs, as well as other carbonate reservoirs were likely to be encountered. Today, emphasis has swung to the search for stratigraphic traps. However, we still see the need for some structural assistance such as a nosing or terracing in order to obtain a commercial accumulation. Structurally low wells in Fields and in wildcat areas usually have strong water shows when porosity is tested.

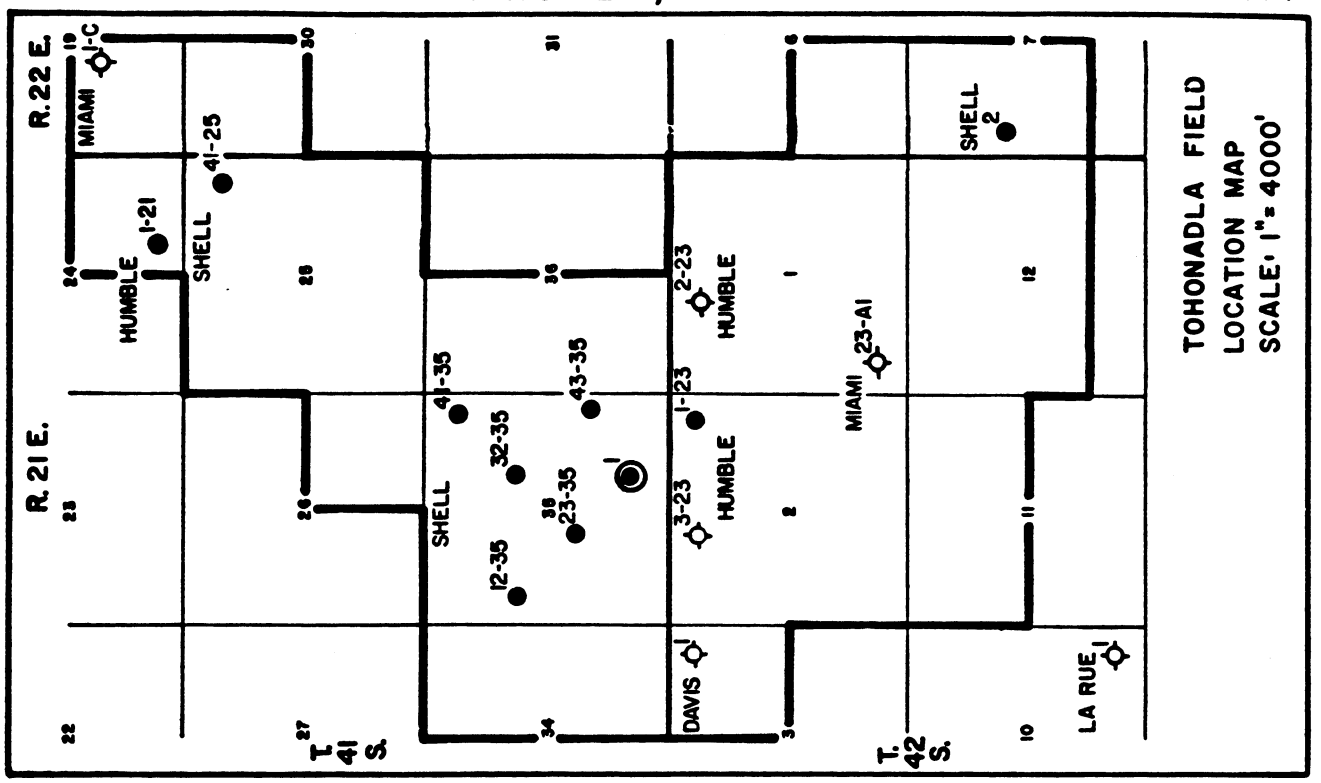


From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

PARADOX BASIN
T. 41 & 42 S., R. 21 & 22 E.

TOHONADLA FIELD
SAN JUAN COUNTY



PRODUCTION CHARACTERISTICS

RESERVOIR

FORMATION NAME	AGE	LITH.	AVE. DEPTH	NET PAY	INIT. PRESS.	CURR. PRESS.	TYPE DRIVE	% POROS.	PERM. MD.
HONAKER TRAIL FM.									
ISMAY ZONE	PENN.	ALGAL LS.	5100'	25' AVE.	1895 PSI	800 PSI	GAS-SOL.	9% AVE.	2 – 50
PARADOX FM.									
DESERT CREEK ZONE	PENN.	OOMOLDIC LS.	5300'	15' AVE.	1960 PSI		GAS-SOL.	11% AVE.	2 – 20
AKAH ZONE	PENN.	LS – DOL.	5800'	25' AVE.	2140 PSI		GAS-SOL.?		2 – 20

FLUIDS

FORMATION NAME	GRAVITY	POUR POINT	SULFUR CONTENT	GOR	BTU / FT^3	METHANE	ETHANE	WATER SALINITY	OTHER FLUIDS
HONAKER TRAIL FM.									
ISMAY ZONE	37-40° API	25° F.		600-830				82,000 PPM	
PARADOX FM.									
DESERT CREEK ZONE	39.7° API			600-1268					
AKAH ZONE	38-40° API								

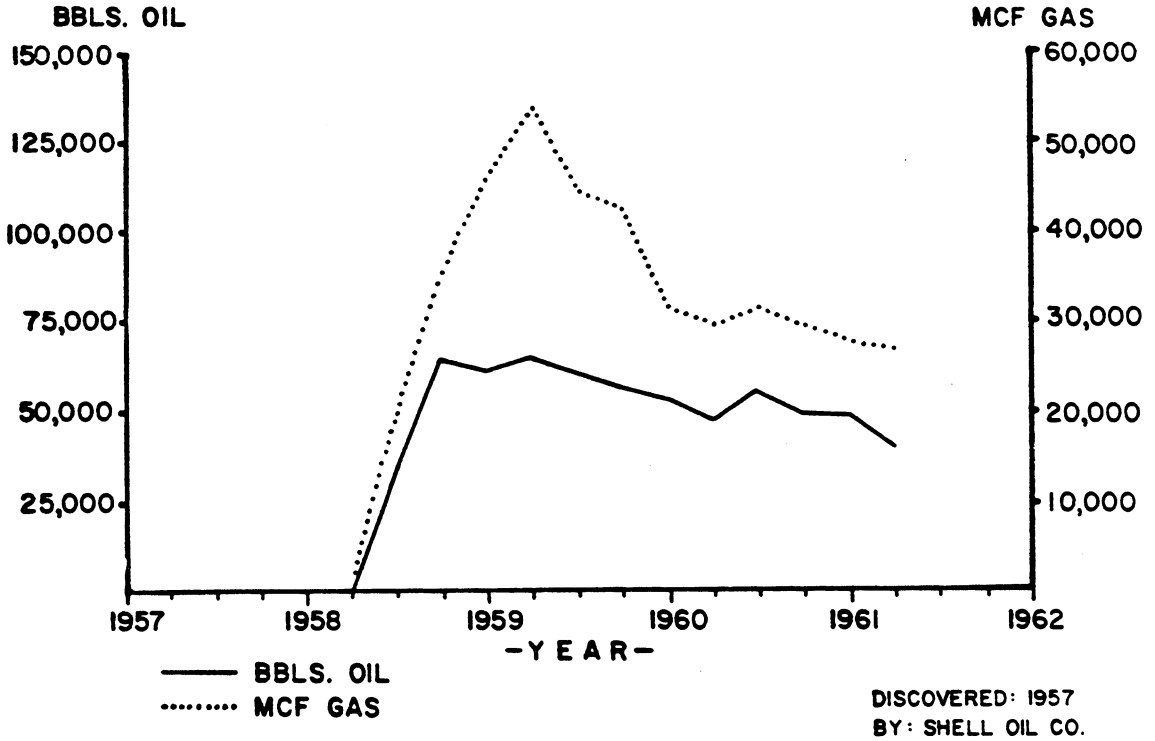
ECONOMICS

FORMATION NAME	PROD. WELLS	PROD. 1-1-60-1-1-61	CUMULAT. PROD. 1-1-61	$ / BBL. WELL HEAD	$ / MCF. WELL HEAD	ULT. RES.	PROVEN ACREAGE	TOTAL WELLS	SPACING
HONAKER TRAIL – PARADOX FMS. UNDIF.	10	202,658 BO 119,561 MCF	600,794 BO 394,789 MCF	$ 2.78 / 40° API	GAS FLARED		2120 ACRES	15	80 ACRES

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

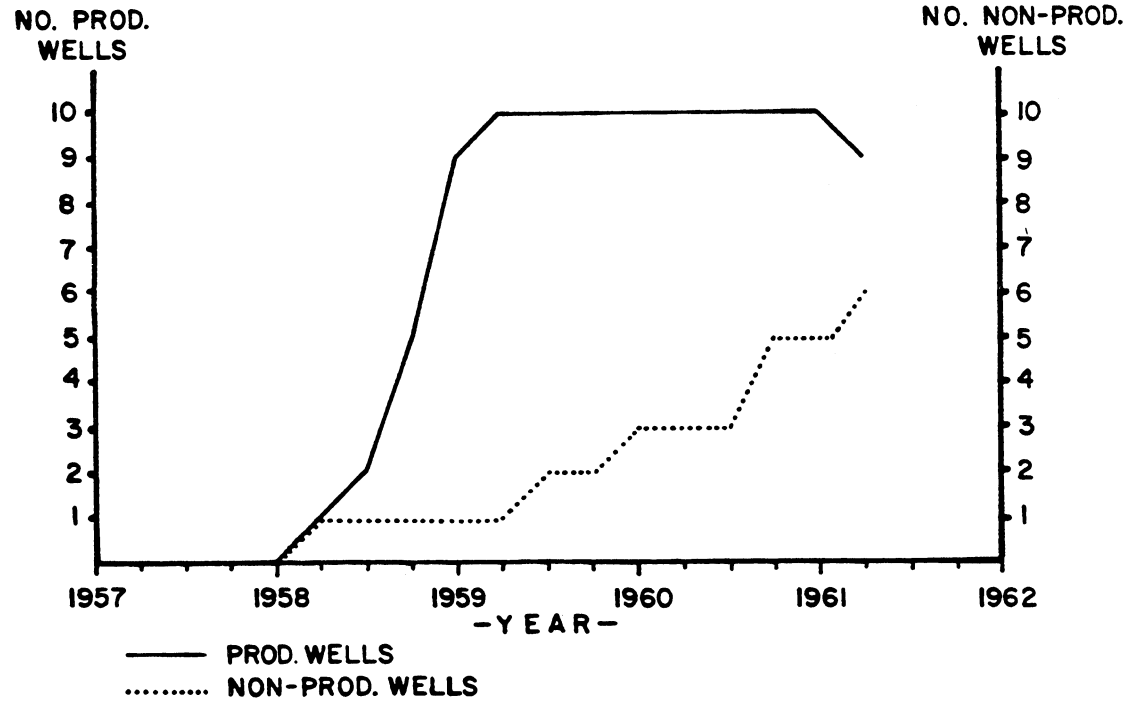
TOHONADLA FIELD

HYDROCARBON PRODUCTION



DISCOVERED: 1957
BY: SHELL OIL CO.

DEVELOPMENT DRILLING



From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

TOHONADLA

(Oil)

T. 41-42 S., R. 21 E., SLPM

San Juan County, Utah

By: J. A. Norton
Consolidated Oil and Gas Co.

GEOLOGY

Regional Setting: Southwest Paradox Basin

Surface Formations: Jurassic, Bluff Sandstone and Morrison Formation

Exploration Method Leading to Discovery: Seismic and subsurface geology

Type of Trap: Mostly stratigraphic with some structural closure

Producing Formation: Pennsylvanian, Ismay, Desert Creek and Akah Members of the Paradox Formation

Gross Thickness and Lithology of Reservoir Rocks: Ismay, vuggy algal limestone and dolomite; Akah, limestone with intergranular (intraclastic) porosity, Desert Creek, oomoldic limestone

Geometry of Reservoir Rock: Ismay, algal mound; Akah and Desert Creek, sheetlike

Other Significant Shows: Not available

Oldest Stratigraphic Horizon Penetrated: Devonian, Elbert Formation

DISCOVERY WELL

Name: Shell Oil Company No. 1 Tohonadla

Location: SW SE, sec. 35, T. 41 S., R. 21 E.

Elevation (KB): 4,678 feet

Date of Completion: June 13, 1957

Total Depth: 6,345 feet

Production Casing: 5½" at 5,714 feet with 250 sacks of cement

Perforations: 4,990 feet to 5,050 feet

Stimulation: Acidize perforations with 2,500 gallons

Initial Potential: Flow 1,450 BOD, 1,200 MCFGD (48/64" choke)

Bottom Hole Pressure: 4,995 to 5,050 psi (drill-stem test); bottom-hole shut-in pressure, 1,910 psi

DRILLING AND COMPLETION PRACTICES

In the discovery well 8 5/8" casing was set at 1,000 feet with 100 sacks of cement and 5½" production casing was set at 5,714 feet with 250 sacks of cement. The interval between 4,990 to 5,050 feet was perforated and treated with 2,500 gallons of hydrochloric acid for completion.

RESERVOIR DATA

Productive Area:
Proved (as determined geologically): 1,200 acres
Unproved: 0 acres
Approved Spacing: 80 acres
No. of Producing Wells: 5
No. of Abandoned Wells: 5
No. of Dry Holes: 4

Average Net Pay: 25 feet (Bluff zone of Ismay Member)

Porosity: Ismay (Bluff zone) 6.5 percent; Desert Creek 5 percent (average); Akah 9.6 percent

Permeability: Ismay (Bluff zone) .01 to 50 millidarcies (average 10 to 15 millidarcies); Desert Creek, mostly less than .01 millidarcy; Akah, not available

Water Saturation: Ismay (Bluff zone) 25.4 percent; Desert Creek 23.2 percent; Akah 30.2 percent

Initial Field Pressure: Ismay (Bluff zone) 1,895 psi, Desert Creek 1,960 psi, Akah 2,140 psi

Type of Drive: Solution gas

Gas Characteristics and Analysis: Not available

Oil Characteristics and Analysis: Ismay (Bluff zone) 30° to 37° API gravity; Desert Creek 40° API gravity; Akah 35° to 40° API gravity

Associated Water Characteristics and Analysis: Ismay (Bluff zone) 82,000 ppm

Original Gas, Oil, and Water Contact Datums: Not available

Estimated Primary Recovery: 1,878,000 BO

Type of Secondary Recovery: None

Estimated Ultimate Recovery: 1,878,000 BO

Present Daily Average Production: 95 BO (September, 1978)

Market Outlets: Shell Oil Company

FIELD COMMENTARY

The Tohonadla field, located in the Paradox Basin, about 20 miles southwest of the Aneth field, is centered in sec. 35, T. 41 S., R. 21 E. The discovery well, Tohonadla No. 1, was completed in June, 1957, in the Pennsylvanian, Ismay Member of the Paradox Formation (Bluff zone) with an initial potential of 1,450 BOD and 1,200 MCFGD. Ultimately, ten wells were completed in the field, with initial production ranging from 84 BOD and 41 MCFGD to 2,150 BOD. Within the field boundary, there are four productive zones: Ismay (Bluff zone); the Desert Creek; the Lower Desert Creek, and the Akah. All four zones are within the Pennsylvanian, Paradox Formation.

The most prolific productive zone is the Bluff (Ismay) in which eight of the wells were initially completed. The Bluff reservoir is a northeast trending algal mound composed of *Ivanovia* sp. algae mixed with pellets, oolites, and invertebrate fossil remains. The porosity is primarily vuggy. In wells with good mound development, core porosities range from 2 to 15 percent and permeabilities range from .01 to 50 millidarcies, with an average of about 10 to 15 millidarcies.

The Desert Creek and Lower Desert Creek zones are a pelletal-oolitic deposit that grades into an evaporitic facies to the north and east. The sparry calcite cemented pellets and oolites were leached to give the limestone oomoldic porosity. Core data from the Navajo Tract No. 23-2 well indicate the

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 5b.

TOHONADLA

porosity to be in the 1 to 10 percent range with an average of about 5 percent. Permeabilities are quite low with the major portion of the cored interval having less than .01 millidarcy. The porosity of the Akah zone is intergranular and intercrystalline resulting from reworked lime muds and dolomitization. No core data was available for the Akah; however, an average porosity of 9.6 percent was calculated from logs.

The wells initially completed in the Bluff (Ismay) declined rapidly due to depletion of the reservoir. These wells were then completed, usually from 1 to 3 years after initial completion, in the Akah and Desert Creek zones and production commingled with the Bluff. These wells were owned and operated by Shell and Exxon at the time, and the production at the time of recompletion for only one well is available: Consolidated Oil and Gas Navajo Tract 23-1 was producing 5 to 8 BOD.

REFERENCES

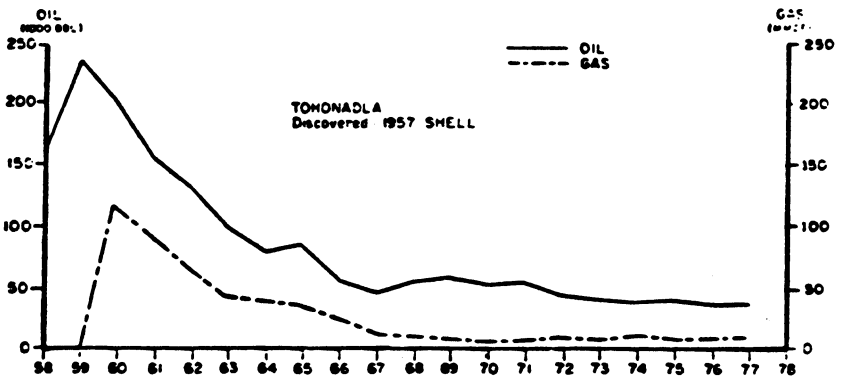
Company files.

Elias, G. K., 1961, Tohonadla Field, in Oil and gas fields of Utah: a Symposium: Intermountain Association of Petroleum Geologists. (no page numbers; field papers are arranged alphabetically).

International Association of Oil Scouts; International Oil Development Year Book.

Petroleum Information production reports.

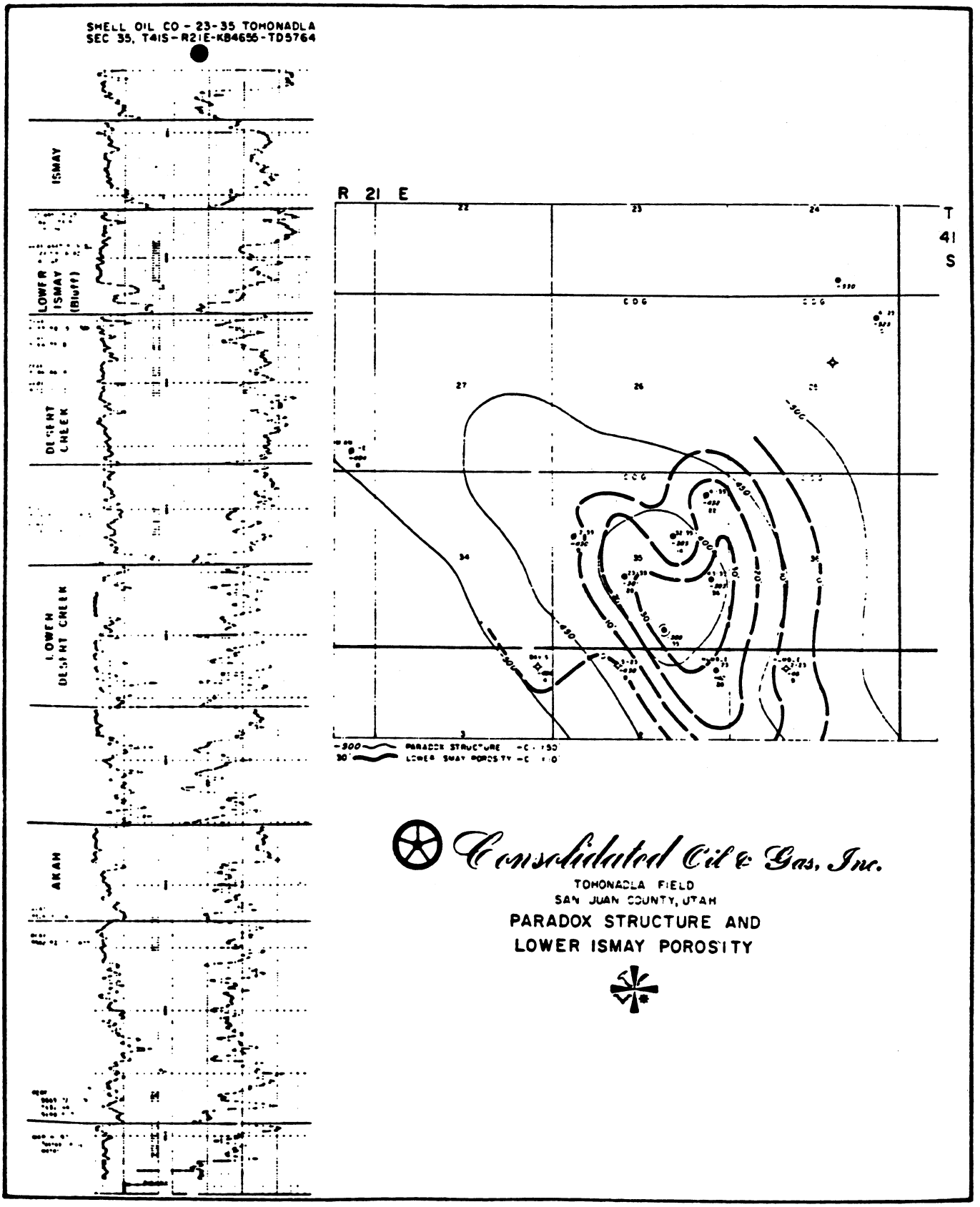
NUMBER OF WELLS AT YEARS END				OIL IN BARRELS GAS IN MCF	
YEAR					
1956	Oil	20	0		19[illegible]
	Gas	-	-	0	0
1959	Oil	23	0	[illegible]	39[illegible]
	Gas	-	-	[illegible]	[illegible]
1960	Oil	9	1	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1961	Oil	9	1	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1962	Oil	-	-	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1963	Oil	5	2	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1964	Oil	8	1	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1965	Oil	8	2	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1966	Oil	7	3	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1967	Oil	9	4	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1968	Oil	8	4	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1969	Oil	-	3	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1970	Oil	6	4	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1971	Oil	6	4	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1972	Oil	5	5	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1973	Oil	5	5	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1974	Oil	5	5	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1975	Oil	5	5	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1976	Oil	5	5	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1977	Oil	5	5	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]
1978	Oil	5	5	[illegible]	[illegible]
	Gas	-	-	[illegible]	[illegible]



[Four Corners Geological Society]

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 5b.

TOHONADLA



Utah - Tohonadla
Paradox - Desert Creek
Paradox Basin

DATA SOURCE CODE		
5a	STATE	Utah
	COUNTY	San Juan
	REGULATORY DISTRICT	
5a,1	BASIN	Paradox
	SUB-BASIN	
5a,1	FIELD	Tohonadla
5a,1	RESERVOIR	Paradox Fm. - Desert Creek zone
5a,1	GEOLOGIC AGE	Pennsylvanian - Des Moines
5a	AAPG STRATIGRAPHIC AGE CODE	325
5a,1	RESERVOIR LITHOLOGY	Oomoldic limestone; limestone
5h,5a,1	TRAPPING MECHANISM	Stratigraphic; structural and stratigraphic, specifically anticline nose
1	DISCOVERY YEAR	1957
5a,5b	PROVED ACREAGE	2120, 1200
5a,5b	REGULAR WELL SPACING (acres/well)	80
5a,1	RESERVOIR DEPTH	5200, 5400
	RESERVOIR THICKNESS	
5a,5b	NET PAY	15
5a	GROSS	200 ft. (log)
	NET/GROSS RATIO	
	POROSITY	
5a,1	TYPE	V, "honeycombed" void network, IG-P
5a,1,5b	FRACTION	.11, .08, .05
	PERMEABILITY	
5a	RANGE	2-20
1	AVERAGE	2
	HORIZONTAL	
	VERTICAL	
	OTHER INFORMATION	Other reservoirs include the Akah and Ismay zones
	PRODUCTION STATISTICS - FIELD (oil in mbbls, gas in mmcf)	
5b	TOTAL NUMBER OF WELLS	5P 5A, 4DH (combined Ismay, Desert
5b	PRODUCTION 1976 oil (cum)	1688 mbbls Creek & Akah)
5b	PRODUCTION 1977 oil (cum)	1725 mbbls
5b	PRODUCTION 1978 oil (cum)	1752 mbbls oil; 829.4 mmcf gas
	PRODUCTION 1979 oil (cum)	
	PRODUCTION 1-1-79 to 1-1-80	
	SECONDARY RECOVERY RECORDS?	
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
5a,5b	STRUCTURE CONTOUR?	yes
5a,5b	LOGS?	yes
	STRUCTURE SECTION?	
5a,5b	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Tohonadla
5a,1	RESERVOIR:	Desert Creek
5a	PROD. ACRES:	2120
5a,1	AVG. THICKNESS (FT.):	15, 41
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
5b	WATER SATURATION (S_W):	.23
	OIL SATURATION (S_O):	
5a, 1	PRIMARY DRIVE MECHANISM:	gas solution
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	138
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
5a	RESERVOIR PRESSURE INITIAL (psi):	1960
	RESERVOIR PRESSURE LATEST (psi):	
5a	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	600 - 1260
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
5a,1, 5b	STOCK TANK OIL GRAVITY (°API):	39.7, 41, 40
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

OTHER INFORMATION:

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

TOHONADLA FIELD

San Juan County, Utah

Gregory K. Elias

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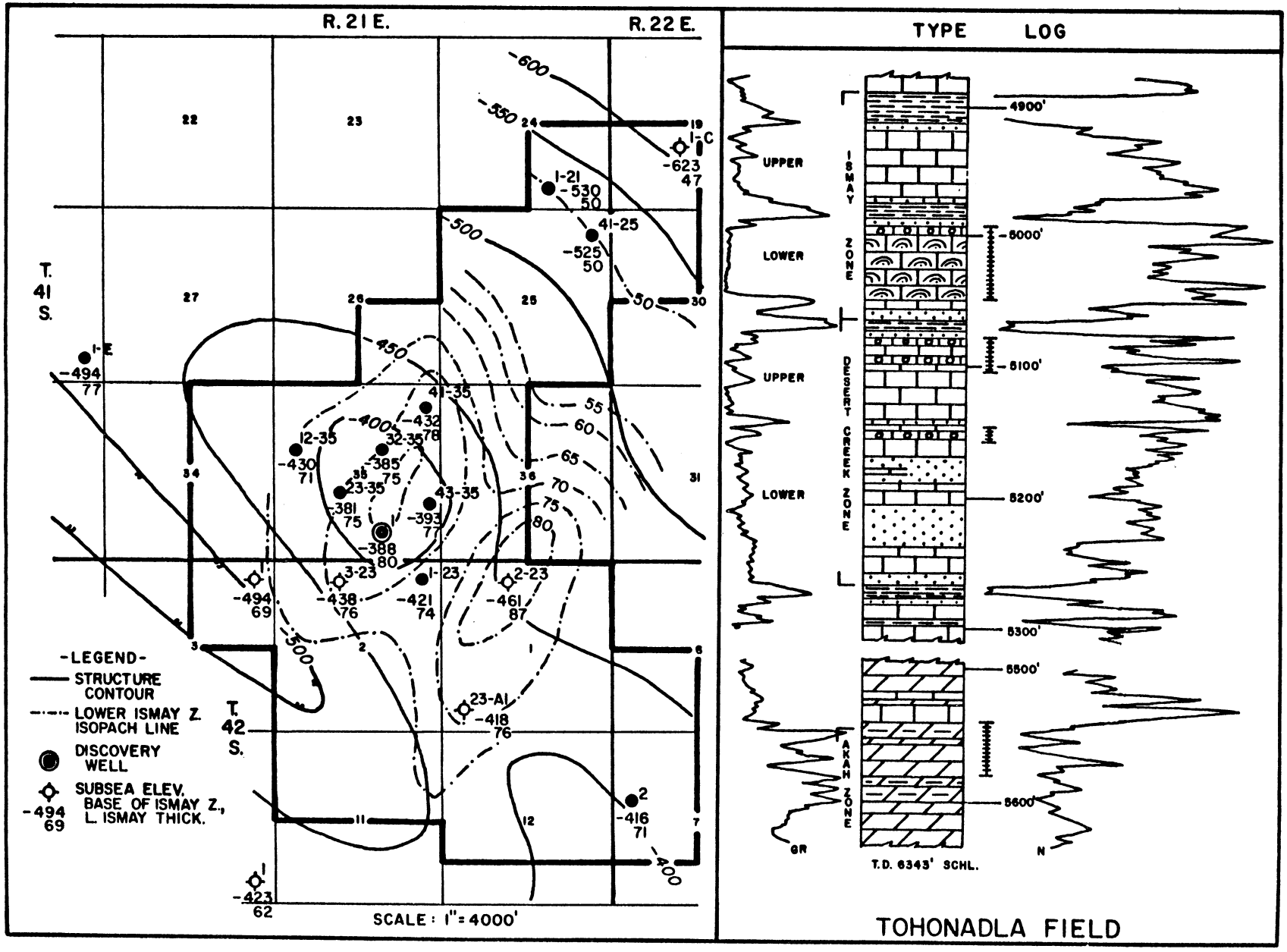

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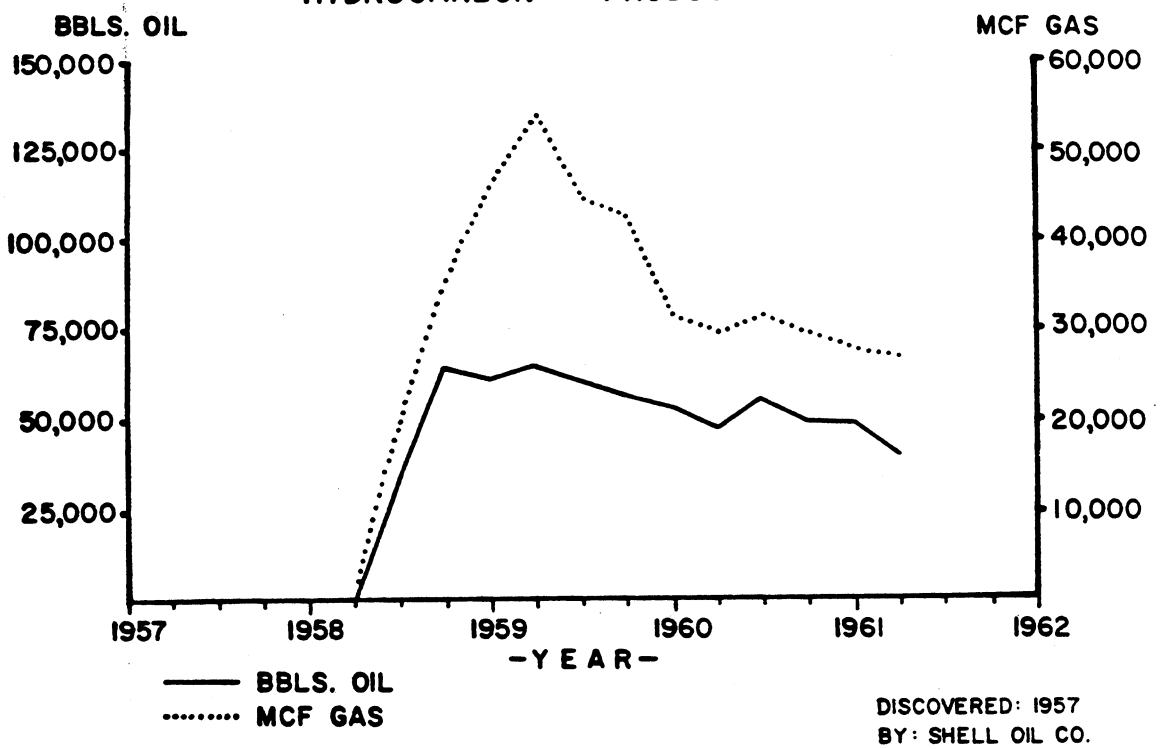
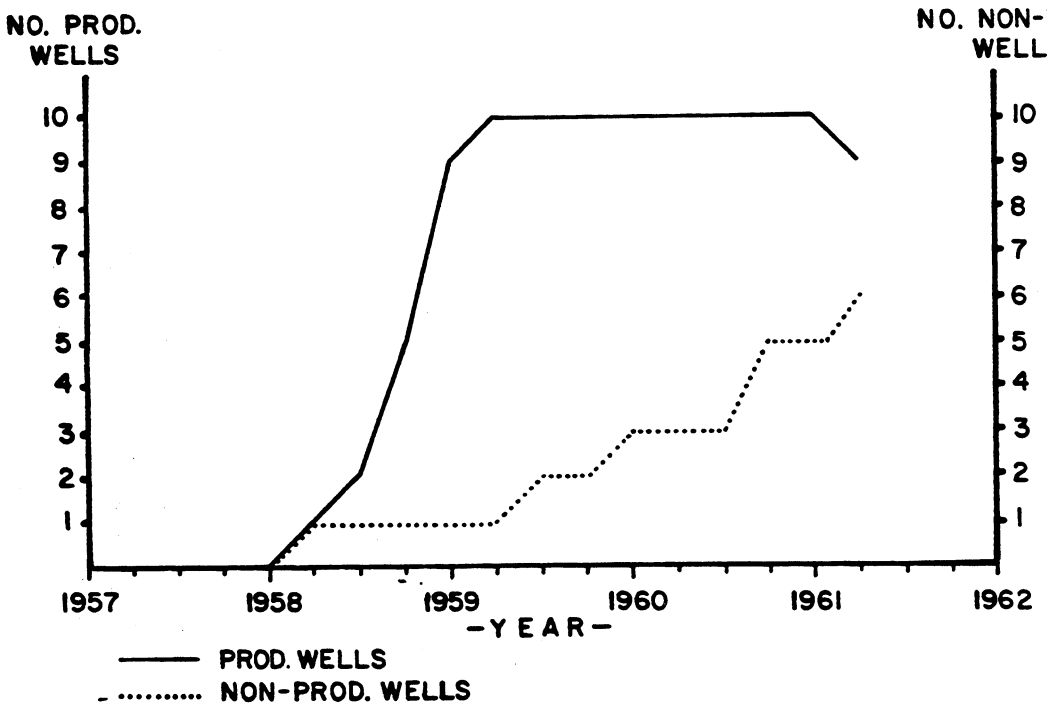
TOHONADLA FIELD

HYDROCARBON PRODUCTION



DISCOVERED: 1957
BY: SHELL OIL CO.

DEVELOPMENT DRILLING



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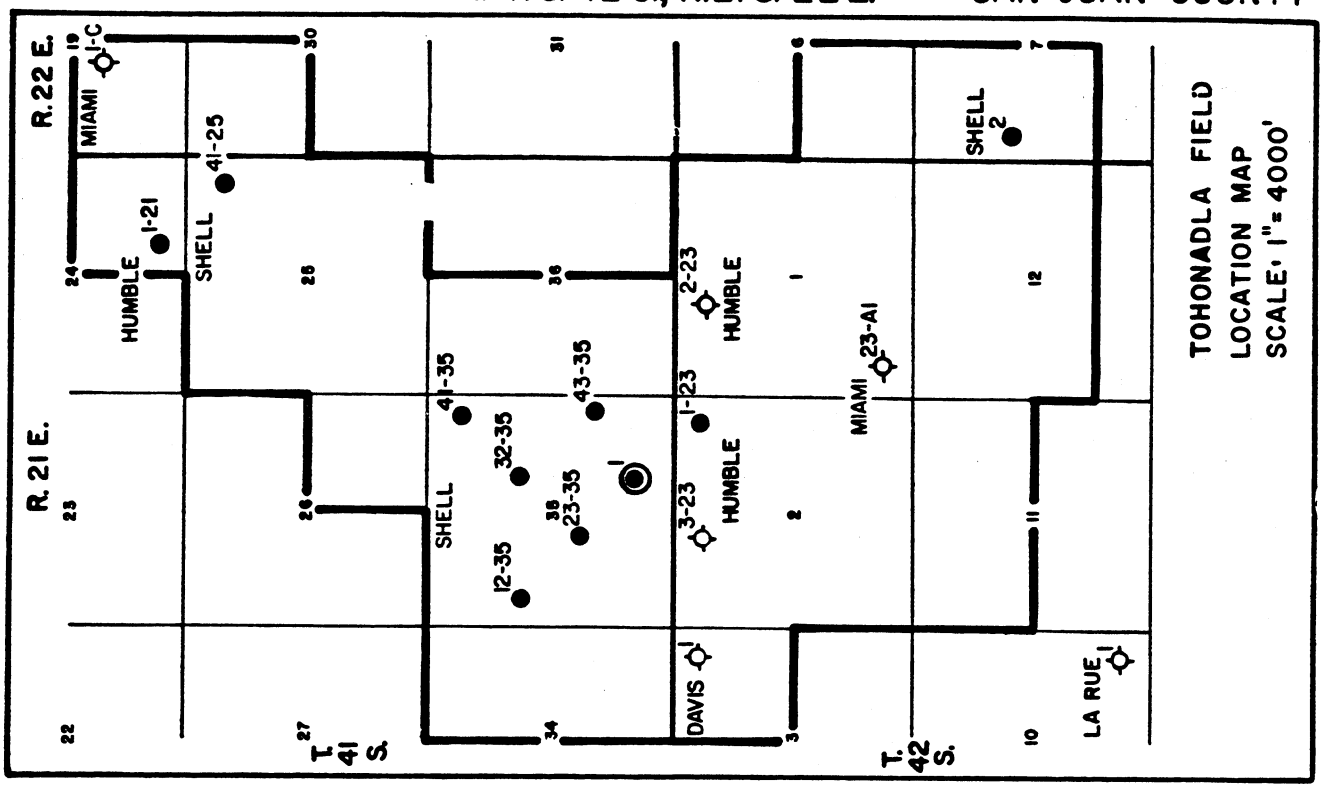
PARADOX BASIN
T. 41 & 42 S., R. 21 & 22 E.

TOHONADLA FIELD
SAN JUAN COUNTY



PRODUCTION CHARACTERISTICS

RESERVOIR

FORMATION NAME	AGE	LITH.	AVE. DEPTH	NET PAY	INIT. PRESS.	CURR. PRESS.	TYPE DRIVE	% POROS.	PERM. MD.
HONAKER TRAIL FM.									
ISMAY ZONE	PENN.	ALGAL LS.	5100'	25' AVE.	1895 PSI	800 PSI	GAS-SOL.	9% AVE.	2-50
PARADOX FM.									
DESERT CREEK ZONE	PENN.	DOMOLDIC LS.	5300'	15' AVE.	1960 PSI		GAS-SOL.	11% AVE.	2-20
AKAH ZONE	PENN.	LS-DOL.	5800'	25' AVE.	2140 PSI		GAS-SOL.?		2-20

FLUIDS

FORMATION NAME	GRAVITY	POUR POINT	SULFUR CONTENT	GOR	BTU/FT^3	METHANE	ETHANE	WATER SALINITY	OTHER FLUIDS
HONAKER TRAIL FM.									
ISMAY ZONE	37-40° API	25° F.		600-830				82,000 PPM	
PARADOX FM.									
DESERT CREEK ZONE	39.7° API			600-1268					
AKAH ZONE	35-40° API								

ECONOMICS

FORMATION NAME	PROD. WELLS	PROD. 1-1-60-1-1-61	CUMULAT. PROD. 1-1-61	$ / BBL. WELL HEAD	$ / MCF. WELL HEAD	ULT. RES.	PROVEN ACREAGE	TOTAL WELLS	SPACING
HONAKER TRAIL - PARADOX FMS. UNDIF.	10	202,658 BO 119,561 MCF	600,794 BO 394,789 MCF	$ 2.75 / 40° API	GAS FLARED		2120 ACRES	15	80 ACRES

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

TOHONADLA

(Oil)

T. 41-42 S., R. 21 E., SLPM

San Juan County, Utah

By: J. A. Norton
Consolidated Oil and Gas Co.

GEOLOGY

Regional Setting: Southwest Paradox Basin

Surface Formations: Jurassic, Bluff Sandstone and Morrison Formation

Exploration Method Leading to Discovery: Seismic and subsurface geology

Type of Trap: Mostly stratigraphic with some structural closure

Producing Formation: Pennsylvanian, Ismay, Desert Creek and Akah Members of the Paradox Formation

Gross Thickness and Lithology of Reservoir Rocks: Ismay, vuggy algal limestone and dolomite; Akah, limestone with intergranular (intraclastic) porosity, Desert Creek, oomoldic limestone

Geometry of Reservoir Rock: Ismay, algal mound; Akah and Desert Creek, sheetlike

Other Significant Shows: Not available

Oldest Stratigraphic Horizon Penetrated: Devonian, Elbert Formation

DISCOVERY WELL

Name: Shell Oil Company No. 1 Tohonadla

Location: SW SE, sec. 35, T. 41 S., R. 21 E.

Elevation (KB): 4,678 feet

Date of Completion: June 13, 1957

Total Depth: 6,345 feet

Production Casing: 5½" at 5,714 feet with 250 sacks of cement

Perforations: 4,990 feet to 5,050 feet

Stimulation: Acidize perforations with 2,500 gallons

Initial Potential: Flow 1,450 BOD, 1,200 MCFGD (48/64" choke)

Bottom Hole Pressure: 4,995 to 5,050 psi (drill-stem test); bottom-hole shut-in pressure, 1,910 psi

DRILLING AND COMPLETION PRACTICES

In the discovery well 8 5/8" casing was set at 1,000 feet with 100 sacks of cement and 5½" production casing was set at 5,714 feet with 250 sacks of cement. The interval between 4,990 to 5,050 feet was perforated and treated with 2,500 gallons of hydrochloric acid for completion.

RESERVOIR DATA

Productive Area:
Proved (as determined geologically): 1,200 acres
Unproved: 0 acres
Approved Spacing: 80 acres
No. of Producing Wells: 5
No. of Abandoned Wells: 5
No. of Dry Holes: 4

Average Net Pay: 25 feet (Bluff zone of Ismay Member)

Porosity: Ismay (Bluff zone) 6.5 percent; Desert Creek 5 percent (average); Akah 9.6 percent

Permeability: Ismay (Bluff zone) .01 to 50 millidarcies (average 10 to 15 millidarcies); Desert Creek, mostly less than .01 millidarcy; Akah, not available

Water Saturation: Ismay (Bluff zone) 25.4 percent; Desert Creek 23.2 percent; Akah 30.2 percent

Initial Field Pressure: Ismay (Bluff zone) 1,895 psi, Desert Creek 1,960 psi, Akah 2,140 psi

Type of Drive: Solution gas

Gas Characteristics and Analysis: Not available

Oil Characteristics and Analysis: Ismay (Bluff zone) 30° to 37° API gravity; Desert Creek 40° API gravity; Akah 35° to 40° API gravity

Associated Water Characteristics and Analysis: Ismay (Bluff zone) 82,000 ppm

Original Gas, Oil, and Water Contact Datums: Not available

Estimated Primary Recovery: 1,878,000 BO

Type of Secondary Recovery: None

Estimated Ultimate Recovery: 1,878,000 BO

Present Daily Average Production: 95 BO (September, 1978)

Market Outlets: Shell Oil Company

FIELD COMMENTARY

The Tohonadla field, located in the Paradox Basin, about 20 miles southwest of the Aneth field, is centered in sec. 35, T. 41 S., R. 21 E. The discovery well, Tohonadla No. 1, was completed in June, 1957, in the Pennsylvanian, Ismay Member of the Paradox Formation (Bluff zone) with an initial potential of 1,450 BOD and 1,200 MCFGD. Ultimately, ten wells were completed in the field, with initial production ranging from 84 BOD and 41 MCFGD to 2,150 BOD. Within the field boundary, there are four productive zones: Ismay (Bluff zone); the Desert Creek; the Lower Desert Creek, and the Akah. All four zones are within the Pennsylvanian, Paradox Formation.

The most prolific productive zone is the Bluff (Ismay) in which eight of the wells were initially completed. The Bluff reservoir is a northeast trending algal mound composed of *Ivanovia* sp. algae mixed with pellets, oolites, and invertebrate fossil remains. The porosity is primarily vuggy. In wells with good mound development, core porosities range from 2 to 15 percent and permeabilities range from .01 to 50 millidarcies, with an average of about 10 to 15 millidarcies.

The Desert Creek and Lower Desert Creek zones are a pelletal-oolitic deposit that grades into an evaporitic facies to the north and east. The sparry calcite cemented pellets and oolites were leached to give the limestone oomoldic porosity. Core data from the Navajo Tract No. 23-2 well indicate the

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 5b.

TOHONADLA

porosity to be in the 1 to 10 percent range with an average of about 5 percent. Permeabilities are quite low with the major portion of the cored interval having less than .01 millidarcy. The porosity of the Akah zone is intergranular and intercrystalline resulting from reworked lime muds and dolomitization. No core-data was available for the Akah; however, an average porosity of 9.6 percent was calculated from logs.

The wells initially completed in the Bluff (Ismay) declined rapidly due to depletion of the reservoir. These wells were then completed, usually from 1 to 3 years after initial completion, in the Akah and Desert Creek zones and production commingled with the Bluff. These wells were owned and operated by Shell and Exxon at the time, and the production at the time of recompletion for only one well is available: Consolidated Oil and Gas Navajo Tract 23-1 was producing 5 to 8 BOD.

REFERENCES

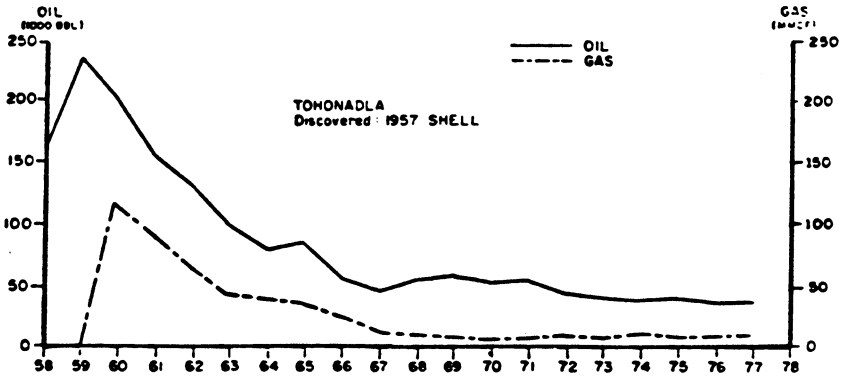
Company files.

Elias, G. K., 1961, Tohonadla Field, in Oil and gas fields of Utah, a Symposium: Intermountain Association of Petroleum Geologists. (no page numbers; field papers are arranged alphabetically).

International Association of Oil Scouts; International Oil Development Year Book.

Petroleum Information production reports.

	NUMBER OF WELLS AT YEARS END			- PRODUCTION - OIL IN BARRELS GAS IN MCF	
YEAR	TYPE	PROD	SI ABN	ANNUAL	CUMULATIVE
1958	Oil	10	0	162,020	162,020
	Gas	-	-	0	0
1959	Oil	10	0	236,980	398,000
	Gas	-	-	173	173
1960	Oil	9	1	202,667	600,792
	Gas	-	-	113,561	113,734
1961	Oil	9	1	155,718	756,510
	Gas	-	-	92,166	205,900
1962	Oil	10	-	133,249	889,759
	Gas	-	-	65,676	271,576
1963	Oil	8	2	99,283	989,042
	Gas	-	-	46,631	318,207
1964	Oil	8	2	81,425	1,070,467
	Gas	-	-	56,725	374,932
1965	Oil	8	2	84,325	1,154,792
	Gas	-	-	39,393	414,325
1966	Oil	7	3	59,631	1,214,423
	Gas	-	-	28,500	442,825
1967	Oil	6	4	49,554	1,263,977
	Gas	-	-	11,978	454,803
1968	Oil	6	4	55,956	1,319,933
	Gas	-	-	9,369	464,172
1969	Oil	7	3	58,761	1,378,694
	Gas	-	-	9,786	473,958
1970	Oil	6	4	52,002	1,430,696
	Gas	-	-	8,356	482,314
1971	Oil	6	4	54,061	1,484,757
	Gas	-	-	8,607	490,921
1972	Oil	5	5	45,855	1,530,612
	Gas	-	-	8,955	499,876
1973	Oil	5	5	42,957	1,573,569
	Gas	-	-	8,306	508,182
1974	Oil	5	5	40,278	1,613,847
	Gas	-	-	8,405	516,587
1975	Oil	5	5	40,343	1,654,190
	Gas	-	-	8,252	524,839
1976	Oil	5	5	38,675	1,692,865
	Gas	-	-	7,924	532,763
1977	Oil	5	5	37,256	1,730,121
	Gas	-	-	7,528	540,291
1978	Oil	5	5	27,053	1,757,174 Thru Sept. 1978
	Gas	-	-	5,442	545,733



[Four Corners Geological Society

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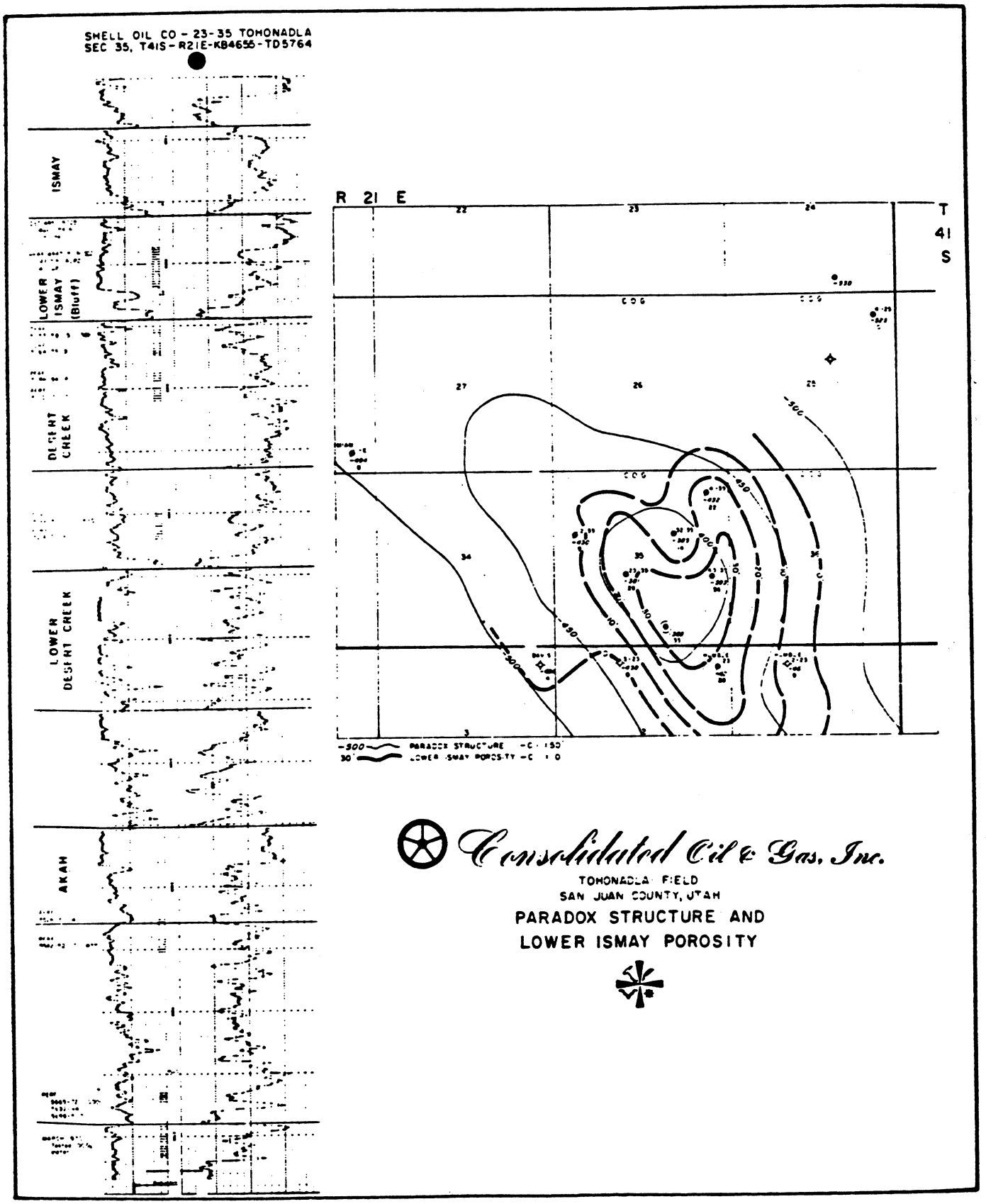
TOHONADLA



Utah - Tohonadla
Honaker Trail - Ismay
Paradox Basin

DATA SOURCE CODE		
5a	STATE	Utah
	COUNTY	San Juan
	REGULATORY DISTRICT	
5a	BASIN	Paradox
	SUB-BASIN	
5a	FIELD	Tohonadla
5a,5b	RESERVOIR	Honaker Trail Fm., Ismay zone
5a,5b	GEOLOGIC AGE	Pennsylvanian
1	AAPG STRATIGRAPHIC AGE CODE	325
5a,1,5b	RESERVOIR LITHOLOGY	Algal limestone; limestone;vuggy algal limestone and dolomite
5a,1,5b	TRAPPING MECHANISM	Stratigraphic; stratigraphic and structural specifically anticline nose; stratigraphic and structural.
1,5b	DISCOVERY YEAR	1957
5a,5b	PROVED ACREAGE	2120, 1200
5a,5b	REGULAR WELL SPACING (acres/well)	80
5a,1	RESERVOIR DEPTH	5100, 5168
	RESERVOIR THICKNESS	
5a,5b	NET PAY	25
5a	GROSS	200 ft. (log)
	NET/GROSS RATIO	
	POROSITY	
5a,1,5b	TYPE	IG, IG, Vuggy
5a,1,5b	FRACTION	.09, .06, .02-.15
	PERMEABILITY	
5a,5b	RANGE	2-50; .01-50
1,5b	AVERAGE	25, 10-15
	HORIZONTAL	
	VERTICAL	
5a	OTHER INFORMATION	Other carbonate reservoirs include the Akah, Desert Creek zones of the Paradox
	PRODUCTION STATISTICS - FIELD (oil in mbbls, gas in mmcf)	
5b	TOTAL NUMBER OF WELLS	5P, 5A, 4DH (combined Ismay, Desert
5b	PRODUCTION 1976 oil (cum)	1687 mbbls Creek & Akah)
5b	PRODUCTION 1977 oil (cum)	1725 mbbls
5b	PRODUCTION 1978 oil (cum)	1752 mbbls (12/1/78)
	PRODUCTION 1979 oil (cum)	
	PRODUCTION 1-1-79 to 1-1-80	
	SECONDARY RECOVERY RECORDS?	
5b,5a	WATER ANALYSIS RECORDS?	yes
	OTHER DATA	
5b,5a	STRUCTURE CONTOUR?	yes
5b,5a	LOGS?	yes
	STRUCTURE SECTION?	
5b,5a	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Tohonadla
5a,5b	RESERVOIR:	Ismay
5a,5b	PROD. ACRES:	2120, 1200
5a	AVG. THICKNESS (FT.):	25
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
5b	WATER SATURATION (S_W):	.254
	OIL SATURATION (S_O):	
5b,5a,1	PRIMARY DRIVE MECHANISM:	gas solution
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	136
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
5a,5b	RESERVOIR PRESSURE INITIAL (psi):	1895
5a	RESERVOIR PRESSURE LATEST (psi):	800 (1962)
5a	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	600 - 830
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
5a,1,5b	STOCK TANK OIL GRAVITY (°API):	37-40, 41, 30-37
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL	
5b	ESTIMATED PRIMARY OIL	1878 mbbls

OTHER INFORMATION:

5a,5b Water salinity: 82,000 ppm

5a Reference: Elias, G. K., 1961: Tohonadla Field in a Symposium of the Oil and Gas Fields of Utah, International Association of Petroleum Geologists.

TOHONADLA FIELD
San Juan County, Utah
Gregory K. Elias

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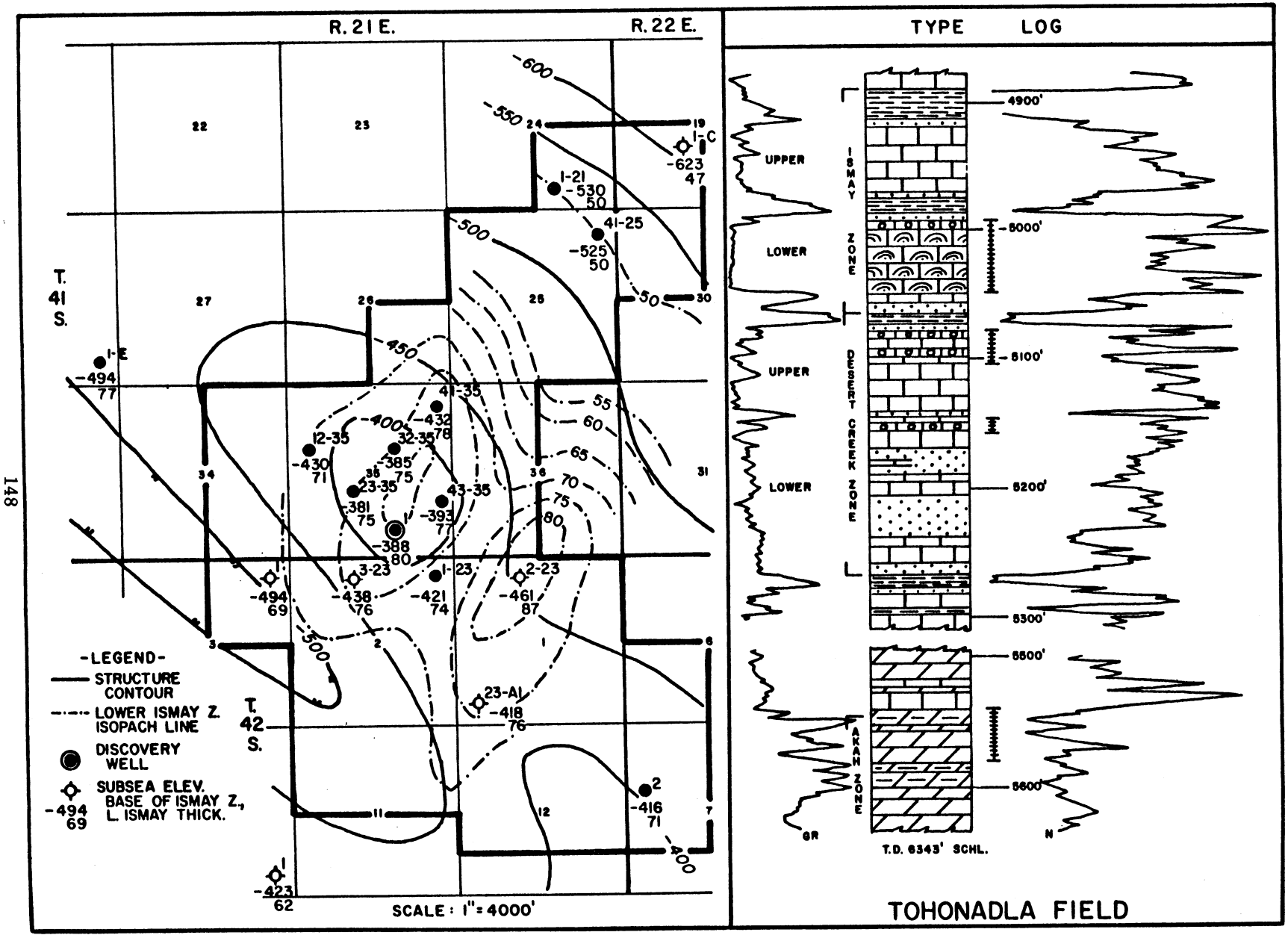

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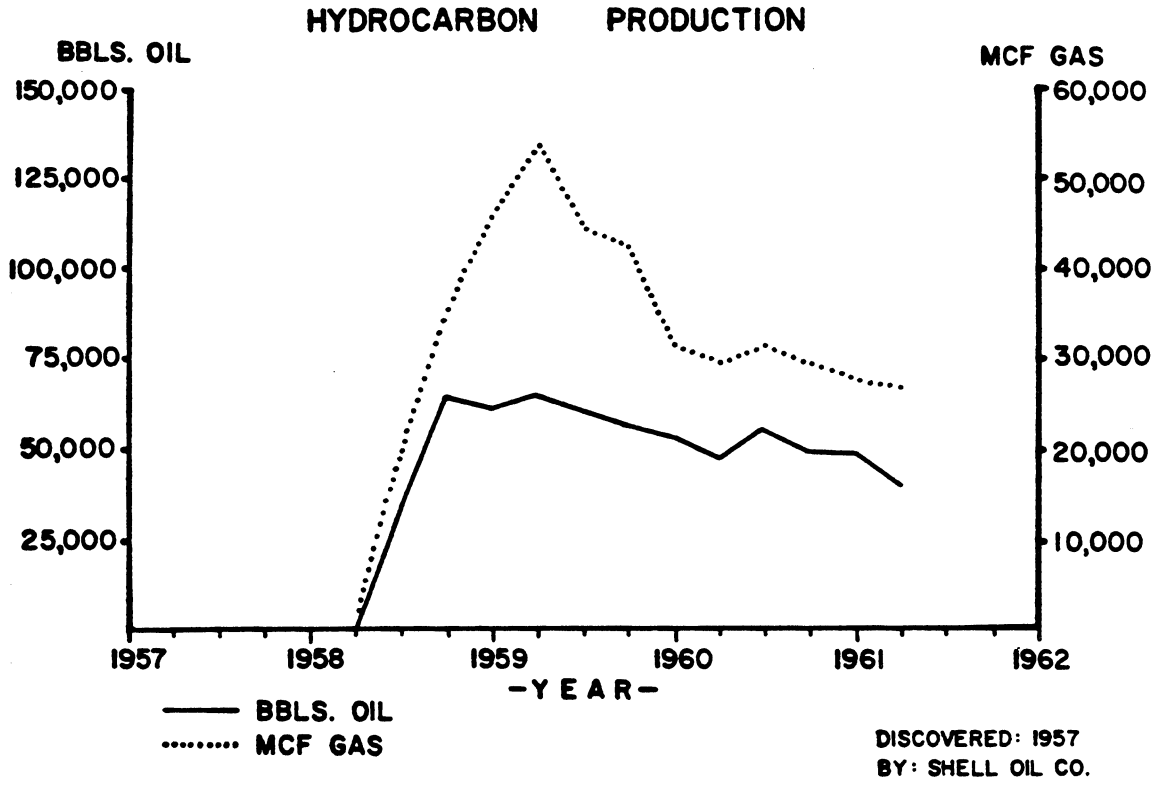
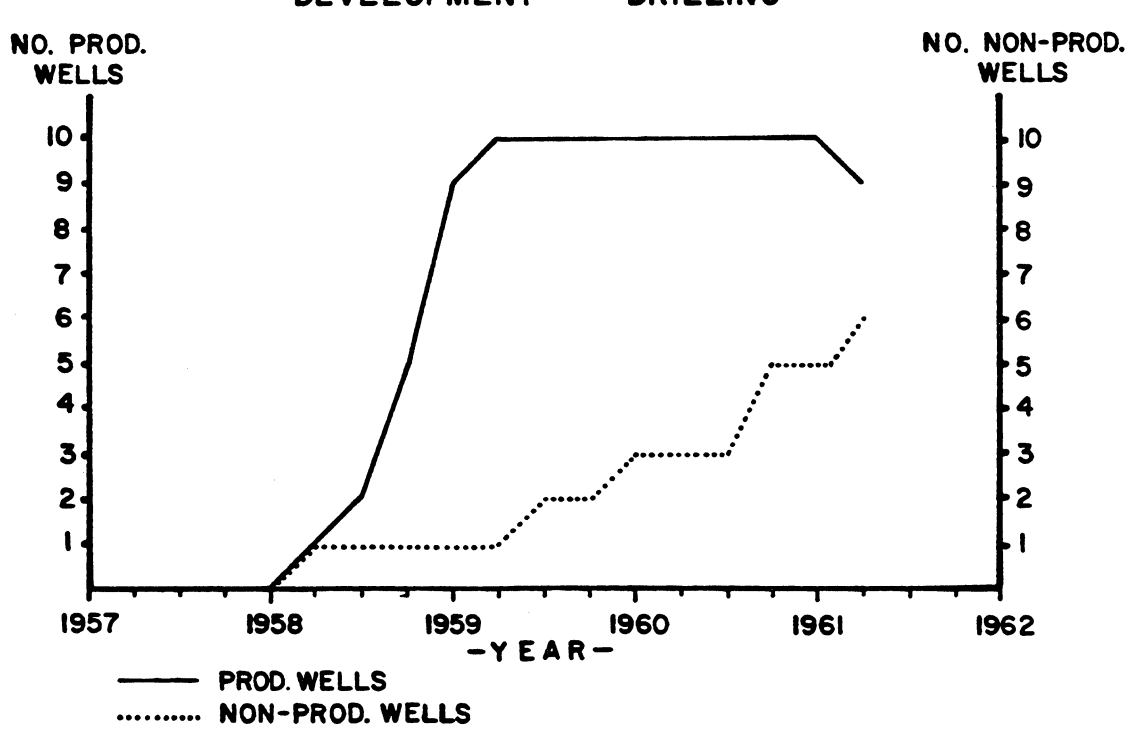
TOHONADLA FIELD





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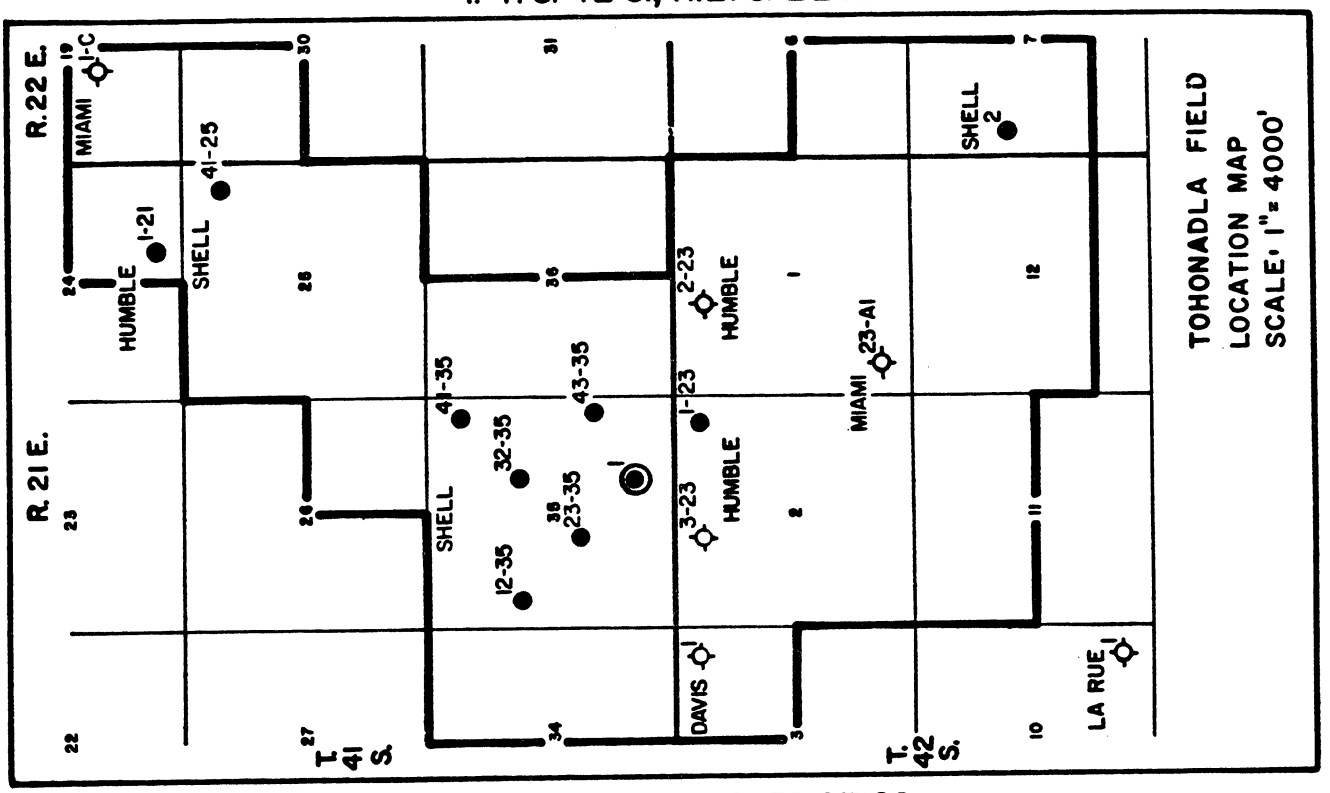
PARADOX BASIN
T. 41 & 42 S., R. 21 & 22 E.

TOHONADLA FIELD
SAN JUAN COUNTY



PRODUCTION CHARACTERISTICS

RESERVOIR

FORMATION NAME	AGE	LITH.	AVE. DEPTH	NET PAY	INIT. PRESS.	CURR. PRESS.	TYPE DRIVE	% POROS.	PERM. MD.
HONAKER TRAIL FM. ISMAY ZONE	PENN.	ALGAL LS.	5100'	25' AVE.	1895 PSI	800 PSI	GAS-SOL.	9% AVE.	2-50
PARADOX FM. DESERT CREEK ZONE	PENN.	OOMOLDIC LS.	5300'	15' AVE.	1960 PSI		GAS-SOL.	11% AVE.	2-20
AKAH ZONE	PENN.	LS-DOL.	5800'	25' AVE.	2140 PSI		GAS-SOL.?		2-20

FLUIDS

FORMATION NAME	GRAVITY	POUR POINT	SULFUR CONTENT	GOR	BTU/FT³	METHANE	ETHANE	WATER SALINITY	OTHER FLUIDS
HONAKER TRAIL FM. ISMAY ZONE	37-40° API	25° F.		600-830				82,000 PPM	
PARADOX FM. DESERT CREEK ZONE	39.7° API			600-1268					
AKAH ZONE	35-40° API								

ECONOMICS

FORMATION NAME	PROD. WELLS	PROD. 1-1-60-1-1-61	CUMULAT. PROD. 1-1-61	$/BBL WELL HEAD	$/MCF WELL HEAD	ULT. RES.	PROVEN ACREAGE	TOTAL WELLS	SPACING
HONAKER TRAIL - PARADOX FMS. UNDIF.	10	202,858 BO 119,561 MCF	600,794 BO 394,789 MCF	$ 2.75 / 40° API	GAS FLARED		2120 ACRES	15	80 ACRES

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREAS, Four Corners Geological Society, 1978, Source 5b.

TOHONADLA

(Oil)

T. 41-42 S., R. 21 E., SLPM

San Juan County, Utah

By: J. A. Norton
Consolidated Oil and Gas Co.

GEOLOGY

Regional Setting: Southwest Paradox Basin

Surface Formations: Jurassic, Bluff Sandstone and Morrison Formation

Exploration Method Leading to Discovery: Seismic and subsurface geology

Type of Trap: Mostly stratigraphic with some structural closure

Producing Formation: Pennsylvanian, Ismay, Desert Creek and Akah Members of the Paradox Formation

Gross Thickness and Lithology of Reservoir Rocks: Ismay, vuggy algal limestone and dolomite; Akah, limestone with intergranular (intraclastic) porosity, Desert Creek, oomoldic limestone

Geometry of Reservoir Rock: Ismay, algal mound; Akah and Desert Creek, sheetlike

Other Significant Shows: Not available

Oldest Stratigraphic Horizon Penetrated: Devonian, Elbert Formation

DISCOVERY WELL

Name: Shell Oil Company No. 1 Tohonadla

Location: SW SE, sec. 35, T. 41 S., R. 21 E.

Elevation (KB): 4,678 feet

Date of Completion: June 13, 1957

Total Depth: 6,345 feet

Production Casing: 5½" at 5,714 feet with 250 sacks of cement

Perforations: 4,990 feet to 5,050 feet

Stimulation: Acidize perforations with 2,500 gallons

Initial Potential: Flow 1,450 BOD, 1,200 MCFGD (48/64" choke)

Bottom Hole Pressure: 4,995 to 5,050 psi (drill-stem test); bottom-hole shut-in pressure, 1,910 psi

DRILLING AND COMPLETION PRACTICES

In the discovery well 8 5/8" casing was set at 1,000 feet with 100 sacks of cement and 5½" production casing was set at 5,714 feet with 250 sacks of cement. The interval between 4,990 to 5,050 feet was perforated and treated with 2,500 gallons of hydrochloric acid for completion.

RESERVOIR DATA

Productive Area:
Proved (as determined geologically): 1,200 acres
Unproved: 0 acres
Approved Spacing: 80 acres
No. of Producing Wells: 5
No. of Abandoned Wells: 5
No. of Dry Holes: 4

Average Net Pay: 25 feet (Bluff zone of Ismay Member)

Porosity: Ismay (Bluff zone) 6.5 percent; Desert Creek 5 percent (average); Akah 9.6 percent

Permeability: Ismay (Bluff zone) .01 to 50 millidarcies (average 10 to 15 millidarcies); Desert Creek, mostly less than .01 millidarcy; Akah, not available

Water Saturation: Ismay (Bluff zone) 25.4 percent; Desert Creek 23.2 percent; Akah 30.2 percent

Initial Field Pressure: Ismay (Bluff zone) 1,895 psi, Desert Creek 1,960 psi, Akah 2,140 psi

Type of Drive: Solution gas

Gas Characteristics and Analysis: Not available

Oil Characteristics and Analysis: Ismay (Bluff zone) 30° to 37° API gravity; Desert Creek 40° API gravity; Akah 35° to 40° API gravity

Associated Water Characteristics and Analysis: Ismay (Bluff zone) 82,000 ppm

Original Gas, Oil, and Water Contact Datums: Not available

Estimated Primary Recovery: 1,878,000 BO

Type of Secondary Recovery: None

Estimated Ultimate Recovery: 1,878,000 BO

Present Daily Average Production: 95 BO (September, 1978)

Market Outlets: Shell Oil Company

FIELD COMMENTARY

The Tohonadla field, located in the Paradox Basin, about 20 miles southwest of the Aneth field, is centered in sec. 35, T. 41 S., R. 21 E. The discovery well, Tohonadla No. 1, was completed in June, 1957, in the Pennsylvanian, Ismay Member of the Paradox Formation (Bluff zone) with an initial potential of 1,450 BOD and 1,200 MCFGD. Ultimately, ten wells were completed in the field, with initial production ranging from 84 BOD and 41 MCFGD to 2,150 BOD. Within the field boundary, there are four productive zones: Ismay (Bluff zone); the Desert Creek; the Lower Desert Creek, and the Akah. All four zones are within the Pennsylvanian, Paradox Formation.

The most prolific productive zone is the Bluff (Ismay) in which eight of the wells were initially completed. The Bluff reservoir is a northeast trending algal mound composed of *Ivanovia* sp. algae mixed with pellets, oolites, and invertebrate fossil remains. The porosity is primarily vuggy. In wells with good mound development, core porosities range from 2 to 15 percent and permeabilities range from .01 to 50 millidarcies, with an average of about 10 to 15 millidarcies.

The Desert Creek and Lower Desert Creek zones are a pelletal-oolitic deposit that grades into an evaporitic facies to the north and east. The sparry calcite cemented pellets and oolites were leached to give the limestone oomoldic porosity. Core data from the Navajo Tract No. 23-2 well indicate the

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, Four Corners Geological Society, 1978, Source 5b.

TOHONADLA

porosity to be in the 1 to 10 percent range with an average of about 5 percent. Permeabilities are quite low with the major portion of the cored interval having less than .01 millidarcy. The porosity of the Akah zone is intergranular and intercrystalline resulting from reworked lime muds and dolomitization. No core data was available for the Akah; however, an average porosity of 9.6 percent was calculated from logs.

The wells initially completed in the Bluff (Ismay) declined rapidly due to depletion of the reservoir. These wells were then completed, usually from 1 to 3 years after initial completion, in the Akah and Desert Creek zones and production commingled with the Bluff. These wells were owned and operated by Shell and Exxon at the time, and the production at the time of recompletion for only one well is available: Consolidated Oil and Gas Navajo Tract 23-1 was producing 5 to 8 BOD.

REFERENCES

Company files.

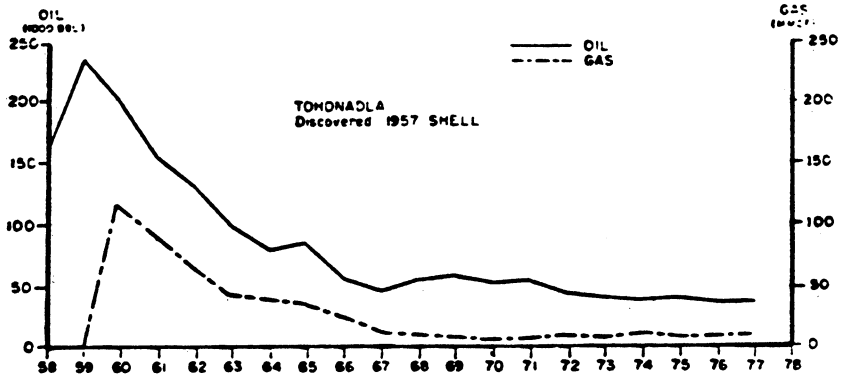
Elias, G. K., 1961, Tohonadla Field, in Oil and gas fields of Utah: a Symposium: Intermountain Association of Petroleum Geologists. (no page numbers; field papers are arranged alphabetically).

International Association of Oil Scouts; International Oil Development Year Book.

Petroleum Information production reports.

NUMBER OF WELLS AT YEARS END				- EOY - OIL IN BARRELS GAS IN MCF	
YEAR	FUEL	ACTIVE	S. INJ.	ANNUAL	CUMULATIVE
1956	Oil	14	0	[illegible]	18,[illegible]
	Gas	-	-	0	0
1959	Oil	23	0	[illegible]	394,[illegible]
	Gas	-	-	[illegible]	[illegible]
1960	Oil	9	1	2[illegible]	8,[illegible]
	Gas	-	-	[illegible]	3[illegible]
1961	Oil	9	1	[illegible]	9[illegible]
	Gas	-	-	9[illegible]	[illegible]
1962	Oil	-	-	13[illegible]	6[illegible]
	Gas	-	-	6[illegible]	55[illegible]
1963	Oil	5	2	4[illegible]	4[illegible]
	Gas	-	-	[illegible]	6[illegible]
1964	Oil	8	-	8[illegible]	1,0[illegible]
	Gas	-	-	56[illegible]	4[illegible]
1965	Oil	8	2	8[illegible]	1,[illegible]
	Gas	-	-	39,3[illegible]	69[illegible]
1966	Oil	7	3	59,6[illegible]	1,[illegible]
	Gas	-	-	26,[illegible]	3[illegible]
1967	Oil	9	4	49,8[illegible]	1,[illegible]
	Gas	-	-	12,9[illegible]	[illegible]
1968	Oil	8	-	55,8[illegible]	1,[illegible]
	Gas	-	-	9,[illegible]	[illegible]
1969	Oil	7	3	58,[illegible]	1,[illegible]
	Gas	-	-	9,[illegible]	[illegible]
1970	Oil	6	4	52,[illegible]	1,[illegible]
	Gas	-	-	8,3[illegible]	[illegible]
1971	Oil	6	4	5[illegible]	1,[illegible]
	Gas	-	-	8,[illegible]	[illegible]
1972	Oil	5	5	[illegible]	1,[illegible]
	Gas	-	-	8,[illegible]	[illegible]
1973	Oil	5	5	[illegible]	1,[illegible]
	Gas	-	-	8,[illegible]	[illegible]
1974	Oil	5	5	40,[illegible]	1,[illegible]
	Gas	-	-	8,[illegible]	[illegible]
1975	Oil	5	5	40,[illegible]	1,[illegible]
	Gas	-	-	8,25[illegible]	[illegible]
1976	Oil	5	5	36,0[illegible]	1,0[illegible]
	Gas	-	-	7,9[illegible]	[illegible]
1977	Oil	5	5	37,[illegible]	1,7[illegible]
	Gas	-	-	7,5[illegible]	[illegible]
1978	Oil	5	5	2[illegible]	1,[illegible]
	Gas	-	-	5,[illegible]	[illegible]

Thru Sept. 1978



[Four Corners Geological Society

Colorado - Towaoc
Ismay - Paradox
Paradox Basin

DATA SOURCE CODE		
	STATE	Colorado
6d	COUNTY	Montezuma
	REGULATORY DISTRICT	
6d	BASIN	Paradox
	SUB-BASIN	
6d	FIELD	Towaoc
6d	RESERVOIR	Ismay
6d	GEOLOGIC AGE	Pennsylvanian
1	AAPG STRATIGRAPHIC AGE CODE	320
6d	RESERVOIR LITHOLOGY	35 to 45 feet of microsucrosic dolomite and calcareous grainstone, packstone and boundstone with interbedded argillaceous limestone anc calcareous siltstone.
6d	TRAPPING MECHANISM	Combination structural and stratigraphic.
6d	DISCOVERY YEAR	2-1959
6d	PROVED ACREAGE	160 + 120 unproved
6d	REGULAR WELL SPACING (acres/well)	80
6d	RESERVOIR DEPTH	5820
	RESERVOIR THICKNESS	
6d	NET PAY	16 ft.
6d	GROSS	180 - 200 ft.
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
6d	FRACTION	.05 - .22 (avg. of .10)
	PERMEABILITY	
	RANGE	
6d	AVERAGE	25 md
	HORIZONTAL	
	VERTICAL	
	OTHER INFORMATION	
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
6d	TOTAL NUMBER OF WELLS	5 (1P, 1A, 3DH)
	PRODUCTION 1976 oil (cum)	
6d	PRODUCTION 1977 oil (cum)	396.3 mbbls oil; 278.3 mmcf gas
	PRODUCTION 1978 oil (cum)	
6f	PRODUCTION 1979 oil (cum)	409 mbbls; 290.7 mmcf gas
6d	PRODUCTION PRESENT	18 BOD
	SECONDARY RECOVERY RECORDS?	
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
6d	STRUCTURE CONTOUR?	yes
6d	LOGS?	yes
	STRUCTURE SECTION?	
6d	ENGINEERING REPORTS?	production
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Towaoc
6d	RESERVOIR:	Ismay
6d	PROD. ACRES:	380
6d	AVG. THICKNESS (FT.):	16
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
6d	WATER SATURATION (S_W):	.44 con. & 35-80 log
	OIL SATURATION (S_O):	
6d	PRIMARY DRIVE MECHANISM:	water & solution gas
6d	PRIMARY GAS CAP?:	no
11	TEMPERATURE (°F):	146
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
6d	RESERVOIR PRESSURE INITIAL (psi):	2290
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
6d	GAS OIL RATIO LATEST (GOR) (cf/bbl):	754
6d	STOCK TANK OIL GRAVITY (°API):	41.8
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL:	
6d	ESTIMATED PRIMARY OIL:	80 BO per cu.ft.
	Estimated Ultimate Oil:	430 mbbls; 305 mmcf gas
	OTHER INFORMATION:	

TOWAOC

(Oil)

T. 33½ N., R. 20 W., NMPM
Montezuma County, Colorado

By: C. W. Spencer
U.S. Geological Survey

GEOLOGY

Regional Setting: Southeast edge of the Blanding structural basin, adjacent to the Four Corners platform; southern shelf of Pennsylvanian, Paradox depositional basin

Surface Formations: Cretaceous, Dakota Sandstone and Burro Canyon Formation and Quaternary eolian deposits

Exploration Method Leading to Discovery: Seismic

Type of Trap: Combination structural and stratigraphic

Producing Reservoir: Pennsylvanian, Ismay Substage of the Paradox Formation (Baars, Parker, and Chronic, 1967) of Des Moinesian age

Gross Thickness of Ismay Rocks: 180 to 200 feet

Lithology of Reservoir Rocks: 35 to 45 feet of microsucrosic dolomite and calcareous grainstone, packstone, and boundstone with interbedded argillaceous limestone and calcareous siltstone

Geometry of Reservoir Rock: Lenticular

Other Significant Shows: None

Oldest Stratigraphic Horizon Penetrated: Pennsylvanian, Desert Creek Substage of Paradox Formation (Baars, Parker and Chronic 1967)

DISCOVERY WELL

Name: The Texas Company (Texaco) No. 1 Ute Mountain Tribe

Location: SW NE (1980' FNL and 1980' FEL), sec. 21, T. 33½ N., R. 20 W.

Elevation (KB): 5,046 feet

Date of Completion: February 25, 1959 (plugged and abandoned April 23, 1971)

Total Depth: 5,885 feet

Production Casing: 5½" to 5,860 feet with 275 sacks of cement

Perforations: Initial 5,850 to 5,855 feet with 4 shots per foot. Workover on December 6, 1962: perforations 5,817 to 5,820 feet, 5,831 to 5,835 feet, 5,838 to 5,844 feet with 2 shots per foot, reacidized all perforations

Stimulation: Initial perforations acidized with 500 gallons (15 percent) HCl

Initial Potential: Flowed 1,236 BOD and 932 MCFGD, recompleted December 6, 1962, pump 81 BOD and 5 BWD from gross perforations in the interval 5,817 to 5,855 feet

Bottom Hole Pressure: Approximately 2,290 psi

DRILLING AND COMPLETION PRACTICES

Surface casing 13 3/8" to 103 feet with 200 sacks of cement; intermediate casing 9 5/8" to 1,480 feet with 1,300 sacks of cement; production string 5½" to 5,860 feet with 275 sacks of cement; acidized perforations with 500 gallons HCl (15 percent) acid.

RESERVOIR DATA

Productive Area:
Proved: 160 acres
Unproved: 120 acres. (The fairly flat decline rate shown on the production chart suggests the remaining producing well is draining a large area or that oil is leaking from a structurally lower displacement-pressure trap. [See Tocito Penn D, Associated field paper, elsewhere in this publication.] In other words, pressure drawdown, due to production, could lower the pore-throat entry pressure in a partial barrier and allow oil to slowly leak updip.)
Approved Spacing: 80 acres
No. of Producing Wells: 1
No. of Abandoned Wells: 1
No. of Dry Holes: 3

Average Net Pay: 16 feet

Porosity: 5 to 22 percent, average 10 percent

Permeability: Average 25 millidarcies

Water Saturation: 44 percent (core analysis), 35 to 80 percent (log analysis)

Type of Drive: Water and solution gas

Gas Characteristics and Analysis: Btu 1,607; gas is sweet. Texaco No. 1 Ute gas composition in molecular percent: methane 56.4, ethane 18.4, propane 12.9, normal butane 4.7, iso-butane 2.2, pentanes 2.5, hexanes plus 0.5, nitrogen 1.7, oxygen trace, hydrogen 0.1, carbon dioxide 0.1, helium 0.02. Sampled October 23, 1962. Analysis by U.S. Bureau of Mines.

Original Gas-Oil Ratio: 754 cubic feet per barrel

Oil Characteristics and Analysis: 41.8° API gravity

Original Gas, Oil, and Water Contact Datums: No gas cap, oil-water variable but approximately -820 feet

Estimated Primary Recovery: 88 BO per acre foot

Type of Secondary Recovery: None

Estimated Ultimate Recovery: 430,000 BO and 305,000 MCFG primary if no additional drilling. (Ultimate recovery from the remaining producing well will depend on the economic limit, which is controlled in part by future oil prices and other economic factors.)

Daily Average Production in 1977: 18 BOD

Market Outlets: The Permian Corporation

SOURCES OF DATA

Colorado Oil and Gas Conservation Comm. Oil and Gas Statistics.
U.S. Bureau of Mines, 1976, Analyses of Natural gases, 1917-74: Nat. Tech. Inf. Service PB-251-202, 889 p.
U.S. Geological Survey well report files.

FIELD COMMENTARY

The Towaoc field is located on the Ute Mountain Indian Reservation about 27 miles southwest of Cortez, Colorado

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, 1978. [Four Corners Geological Society
Four Corners Geological Society, Source 6d.

and only one mile east of the Colorado-Utah border. Geologically, the field is on the southeast edge of the Blanding structural basin and southern shelf of the Pennsylvanian, Paradox depositional basin.

Towaoc field produces oil and gas from porous limestone and dolomite beds of the Paradox Formation in the upper part of the Ismay Substage of Baars, Parker, and Chronic (1967). The Ismay is of Pennsylvanian (Des Moinesian) age and the trap is interpreted to be similar to other Paradox carbonate-mound producing trends, where porosity pinches out across plunging anticlinal noses. The Towaoc nose is interpreted to plunge to the southwest. The discovery well was probably located on a seismically-mapped structure; therefore, there may be a local structural closure in the area of the Towaoc field. Structural closure on rocks at the top of the Ismay (see structural map) is not apparent, however, using present well control.

The Towaoc field is the southernmost of a series of producing pools in southwest Colorado starting with Flodine Park on the northwest (T. 35 N., R. 20 W.) and including Cache (T. 34 N., R. 20 W.), and Marble Wash (T. 33½ N., R. 20 W.) fields. These fields are along a general trend of strata comprising carbonate mounds with porous reservoirs on the west changing to tight carbonates and/or evaporites east and northeastward (Elias, 1963; Choquette and Traut, 1963). Structural cross section A-A′ shows the change from porous Ismay reservoir rocks on the west and southwest to rocks with only slight porosity to the east. The Calco-Superior No. 3 Ute (cross section A-A′) was extensively cored. The core from 5,666 to 5,700 feet (core depth adjusted to sonic log) is described as dominantly anhydrite. The anhydrite is interpreted to be slightly younger than the main body of porous zones shown in the log of the Texaco No. 1 Ute. The anhydrite was probably deposited in a submarine topographic low, east and northeast of the mound buildups, during a period of lower sea level.

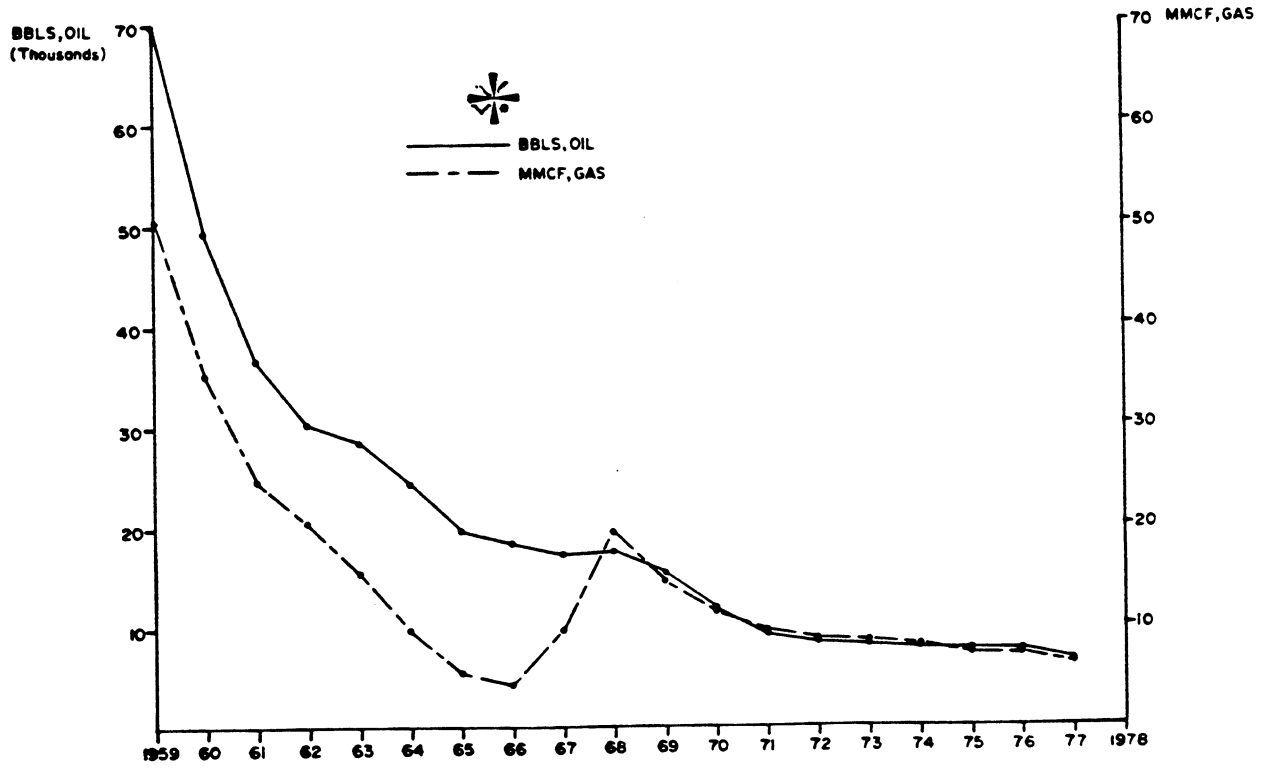
The Texas Company No. 1 Ute discovery well swabbed water from the open-hole at a depth of 5,860 to 5,885 feet. It was subsequently completed, initially, in a 5 foot zone from 5,850 to 5,855 feet. It is significant that this zone has a measured induction-log resistivity of less than 4 ohms (see type log). No adequate sample logs are available on the Towaoc wells; however, based on the low resistivity coupled with good porosity, I interpret the zone from 5,850 to 5,855 feet in the No. 1 Ute to be a microsucrosic dolomite. Porous reservoirs, comprising silt-size dolomite, typically have low resistivities which are difficult to calculate using logs. The abnormally low resistivity is, in part, due to high irreducible water saturations. Generally the permeability of such reservoirs is low, but a reservoir that had an initial flowing potential of 1,236 barrels of oil per day from a 5 foot interval is certainly not a low-permeability rock. M. O. Glerup (oral comm., 1978) believes the initial 5 feet of perforations may have been communicated behind casing to overlying porous zones. These overlying porous limestones were later perforated in 1962 when the well was worked over. Glerup's interpretation seems consistent with the low initial potential (81 BOD, 5 BWD) of the combined porosity zones after recompletion.

REFERENCES

Baars, D. L., Parker, J. W., and Chronic, John, 1967, Revised stratigraphic nomenclature of the Pennsylvanian System Paradox basin: American Association of Petroleum Geologists Bulletin v. 51, no. 3, p. 393-403.

Choquette, P. W. and Traut, J. D., 1963, Pennsylvanian carbonate reservoirs, Ismay field, Utah and Colorado, *in* Symposium on shelf carbonates of the Paradox Basin: Four Corners Geological Society 4th Field Conference Guidebook, p. 157-184.

Elias, G. K., 1963, Habitat of Pennsylvanian algal bioherms, Four Corners area, *in* Symposium on shelf carbonates of the Paradox Basin: Four Corners Geological Society 4th Field Conference Guidebook, p. 185-203.



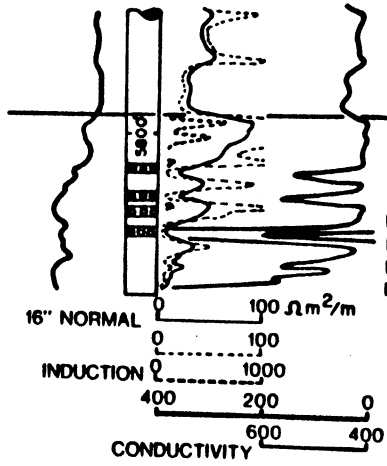
Oil and Gas Fields of the Four Corners Area]

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, 1978, Four Corners Geological Society, Source 6d.

NO. OF WELLS @ YR. END				PRODUCTION OIL IN BARRELS GAS IN MCF	
YEAR	TYPE	PROD.	SI/ABN	ANNUAL	CUMULATIVE
1959	Oil	2		69,988	69,988
	Gas			50,798	50,798
1960	Oil	2		49,465	119,453
	Gas			35,189	85,987
1961	Oil	2		36,883	156,336
	Gas			24,867	110,854
1962	Oil	2		31,127	187,463
	Gas			20,757	131,611
1963	Oil	2		28,736	216,199
	Gas			15,396	147,007
1964	Oil	2		24,265	240,464
	Gas			9,981	156,988
1965	Oil	2		19,942	260,406
	Gas			5,309	162,297
1966	Oil	2		18,266	278,672
	Gas			4,288	166,585
1967	Oil	2		17,223	295,895
	Gas			9,961	176,546
1968	Oil	2		17,727	313,622
	Gas			19,798	196,344
1969	Oil	2		15,293	328,915
	Gas			14,474	210,818
1970	Oil	1	1	11,967	340,882
	Gas			11,746	222,564
1971	Oil	1	1	9,122	350,004
	Gas			9,304	231,868
1972	Oil	1	1	8,404	358,408
	Gas			8,570	240,438
1973	Oil	1	1	8,265	366,673
	Gas			8,375	248,813
1974	Oil	1	1	8,015	374,688
	Gas			8,062	256,875
1975	Oil	1	1	7,625	382,313
	Gas			7,564	264,439
1976	Oil	1	1	7,320	389,633
	Gas			7,254	271,693
1977	Oil	1	1	6,624	396,257
	Gas			6,576	273,269

TOWAOC FIELD

PENNSYLVANIAN



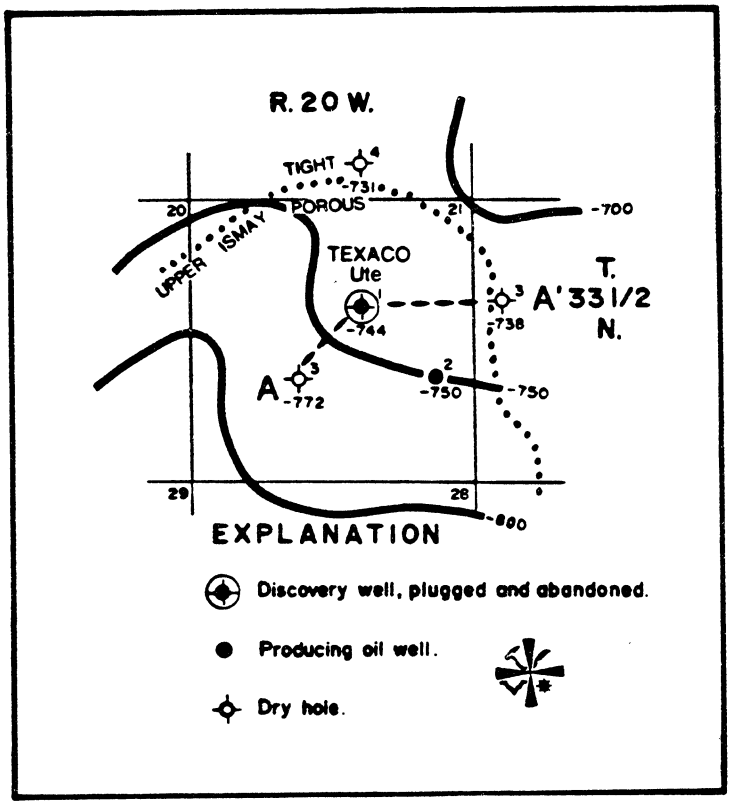
ISMAY SUBSTAGE 1/

Rework perf. 5817-20', 5831-35', 5838-44' IPP 81 BOD & 5 BWD December 6, 1962
Initial perf. 5850-55 ft. IPF 1236 BOD & 932 MCFD February 25, 1959

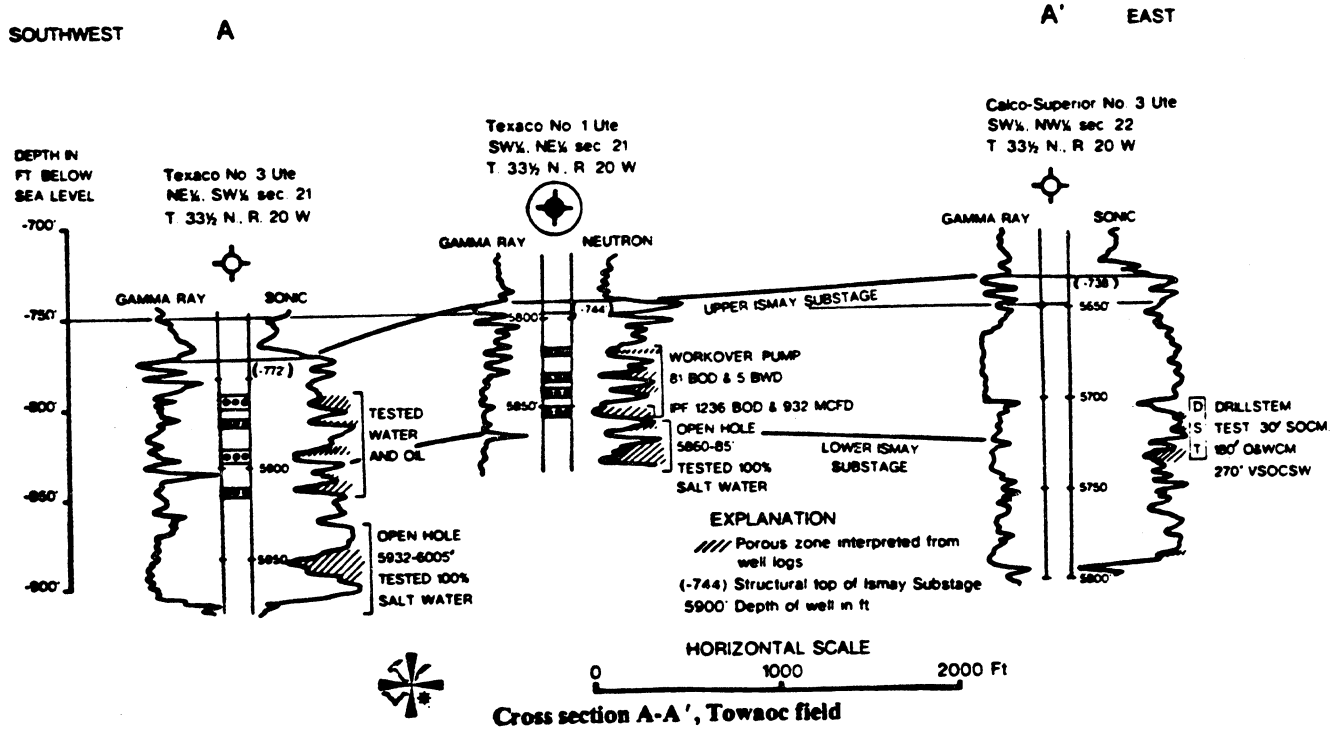
Texaco No. 1 Ute Mtn. Tribe
1980 ft FNL , 1980 ft FEL
sec. 21, T. 33 1/2 N., R. 20 W.
Montezuma Co., Colorado
Total Depth 5885 ft

1/ Terminology from Baars, Parker, and Chronic (1967)

TOWAOC



Structure map of Towaoc field contoured on top of rocks of Ismay Substage (C.I. 50 ft)



Cross section A-A', Towaoc field

Oil and Gas Fields of the Four Corners Area]

From: OIL AND GAS FIELDS OF THE FOUR CORNERS AREA, 1978, Four Corners Geological Society, Source 6d.

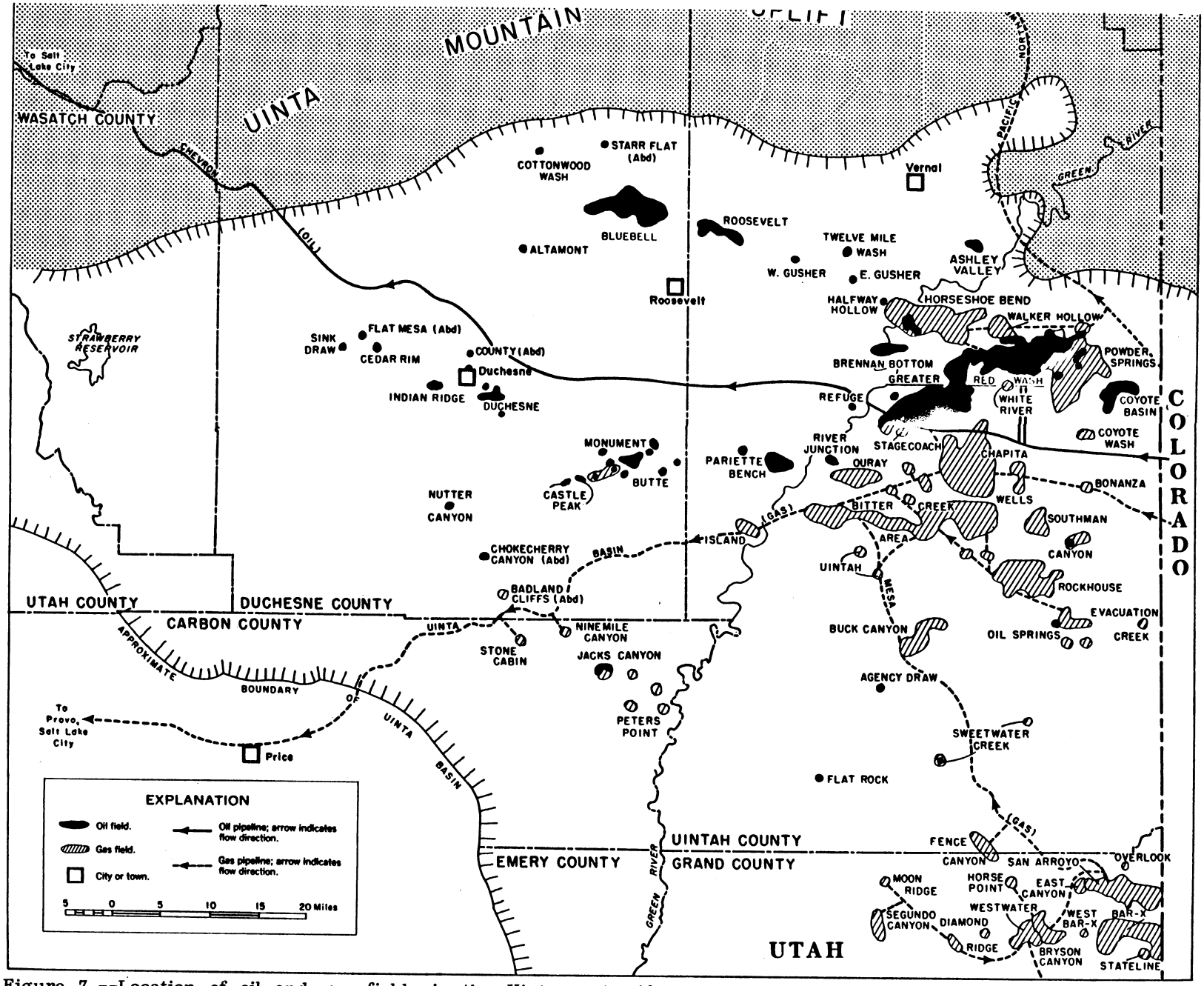


Figure 7.--Location of oil and gas fields in the Uinta basin (from Rocky Mountain Association of Geologists, 1972, Geologic Atlas of the Rocky Mountain Region).

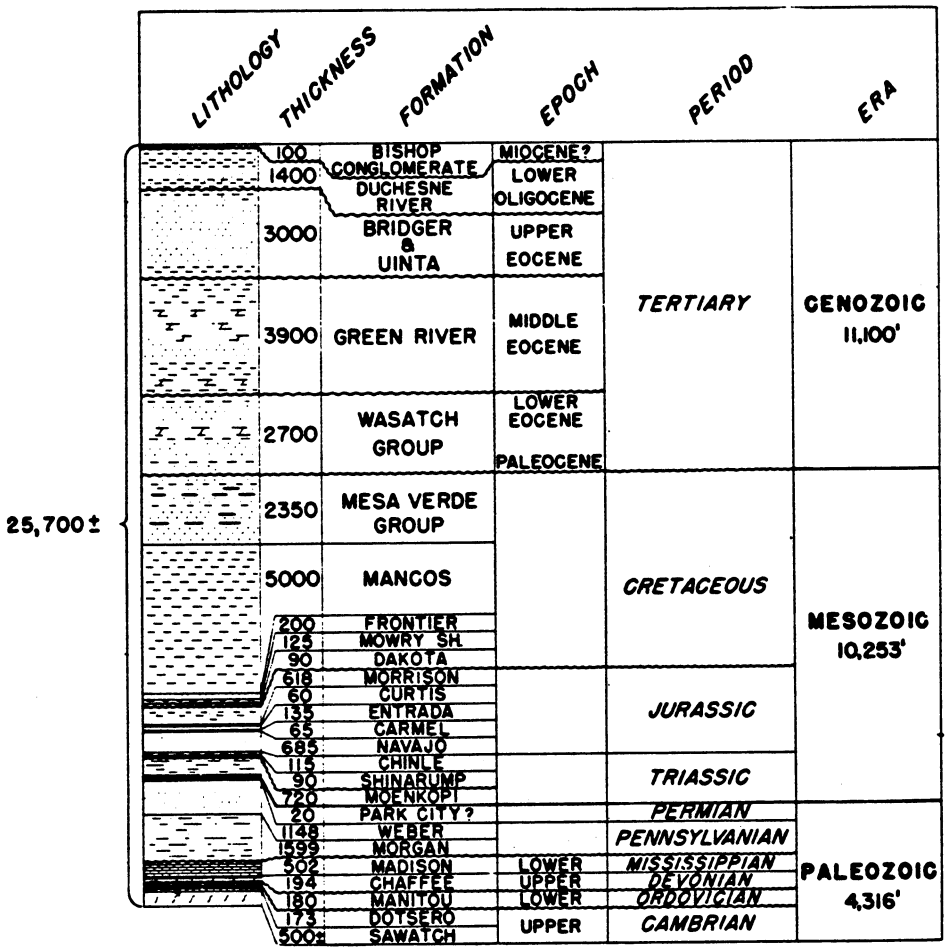


Figure 8.--Geologic section of the Uinta basin (from L. F. Wells, 1958, Petroleum occurrence in the Uinta basin, in AAPG, Habitat of Oil, A Symposium).

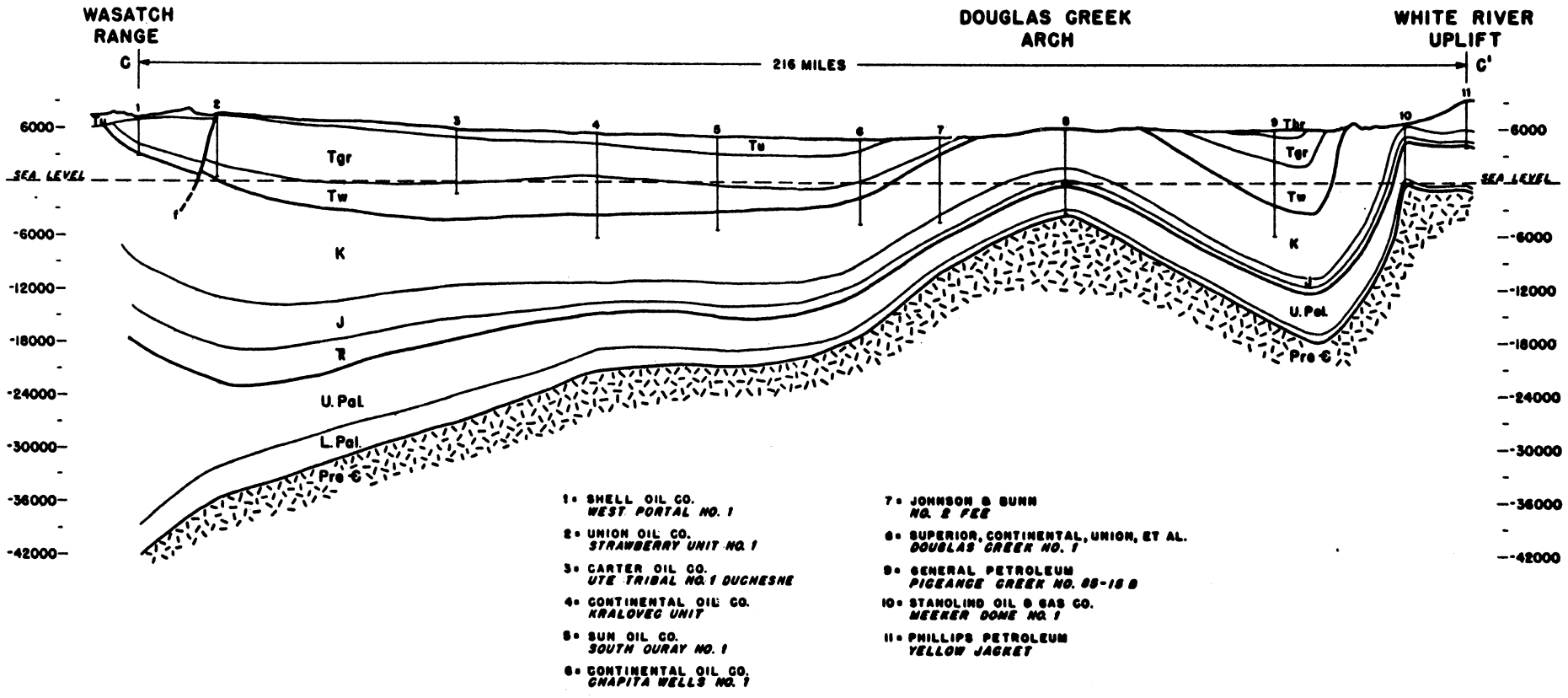


Figure 9.--West-east diagrammatic cross section of the Uinta basin (from L. F. Wells, 1958, Petroleum occurrence in the Uinta basin, in AAPG, Habitat of Oil, A Symposium).

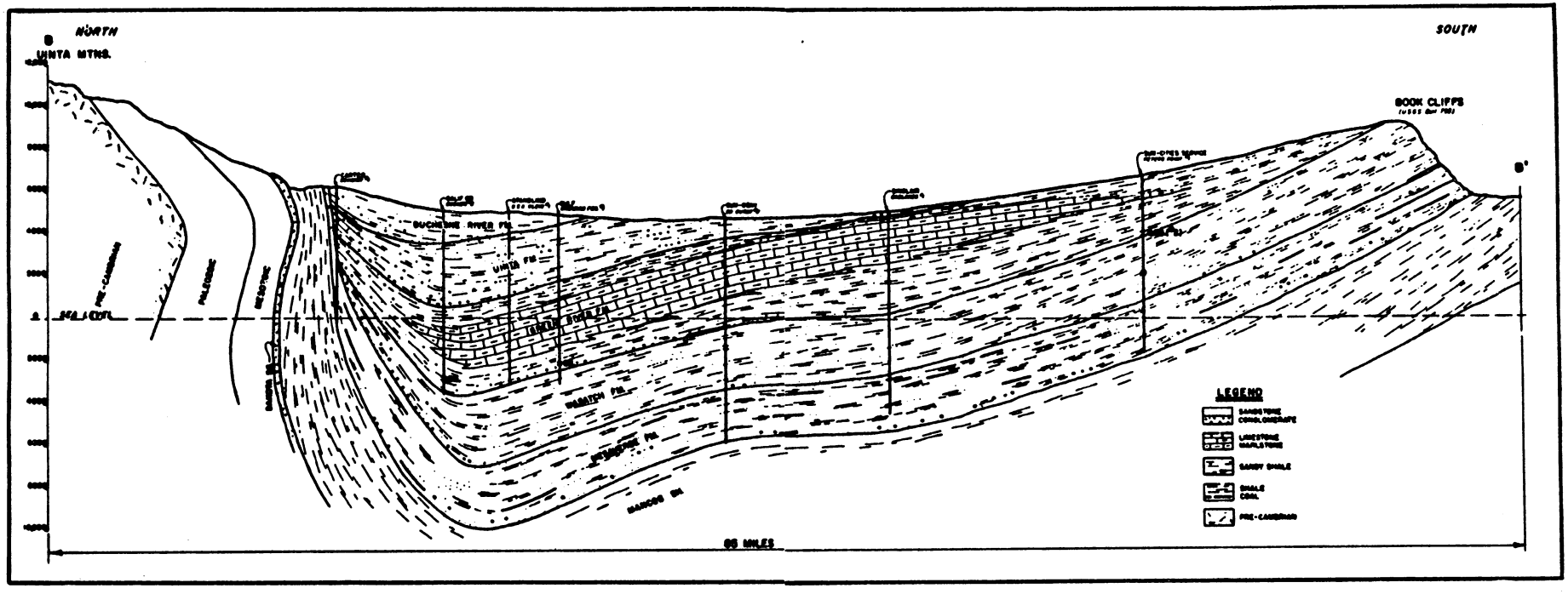


Figure 10.--North-south diagrammatic structural cross section of the Uinta basin (from L. F. Wells, 1958, Petroleum occurrence in the Uinta basin, in AAPG, Habitat of Oil, A Symposium).

TABLE 3

GEOLOGIC SUMMARY CHART, OIL AND GAS PRODUCTION
UINTA BASIN, UTAH-COLORADO*

Field Name	*Producing Formation*	*Age*	*Type of Structure*	*Number of Wells*	*Type of Reservoir*[1]	*Gravity A.P.I.*	*Producing Depth (feet)*	*Daily Production*[2]	*Recoverable Reserves*
Asbury Creek	Dakota	Cretaceous	Seismograph anomaly	1	ss.	Gas	2,914	3–5,000 MCF	396,000 MCF
Ashley Valley	Weber and Phosphoria	Pennsylvanian Permian	Faulted anticline	30	ss.	32°	4,200	2,700 bbls.	26,000,000 bbls.
Bar "X"	Entrada	Jurassic	Anticlinal	4	ss.	Gas	3,900	3,600 MCF	Shut in.
Brennan Bottoms	Green River-Wasatch	Eocene	Stratigraphic	1	ss. & ost. ls. (inter. por.)	40°	6,870– 7,275	102 bbls.	—
Chapita Wells	Wasatch	Eocene	Stratigraphic	2	ss.	Gas	5,052– 5,084	4,618 MCF	New discovery.
Clear Creek	Ferron	Cretaceous	Faulted anticline	13	frac. ss.	Gas	5,600	35,000 MCF	972,000,000 MCF
Douglas Creek	Dakota	Cretaceous	Anticlinal	7	ss.	Gas	5,600	2,000–6,000 MCF	Shut in.
Duchesne	Green River	Eocene	Fault closure	2	frac. ss. & dolo.	42°	7,486– 7,596	538–1,400 bbls.	2,400,000 bbls.
Duchesne County Pool	Green River	Eocene	Stratigraphic	1	frac. ss.	29°	4,520– 5,165	90–239 bbls.	—
Elk Springs	Weber	Pennsylvanian	Anticlinal	3	ss.	31°	6,100	110 bbls.	500,000 bbls.
Flat Mesa	Green River	Eocene	Stratigraphic	1	frac. dolo. & ss.	41°	8,850– 8,857	273 bbls.	—
Garmesa	Dakota and Entrada	Cretaceous Jurassic	Anticlinal	1	ss.	Gas	3,511	6–800 MCF	—
Maudlin Gulch	Morrison	Jurassic	Anticlinal	8	ss., cong.	34°	6,100	550 bbls.	8,000,000 bbls.
Peters' Point	Green River-Wasatch	Eocene	Combination anticlinal nose and stratigraphic	5	lent. ss.	Gas	Various zones 2,700– 4,650	650–2,600 MCF 72 bbls.	Shut in.
Piceance Creek	Green River	Tertiary	Anticlinal	15	ss.	Gas	3,000	2–13,000 MCF	Shut in.
Rangely	Mancos	Cretaceous	Anticlinal	50	frac. sh., cal. cav.	52°	300– 1,400	350–1,350 bbls.	6,500,000 bbls.
Rangely	Shinarump	Triassic	Anticlinal	1	ss., cong.	39°	5,200	30–200 bbls.	100,000 bbls.
Rangely	Weber	Pennsylvanian	Anticlinal	478	ss., qtzite.	35°	5,800	60–62,000 bbls.	345,000,000 bbls.
Red Wash-Walker Hollow	Green River	Eocene	Anticlinal nose	38	lent. ss.	29°–34°	5,160– 5,805	5–339 bbls. 1,200–3,400 MCF	5,500,000 bbls. 29,000,000 MCF
Roosevelt	Green River	Eocene	Anticlinal nose	3	frac. ls., ss.	32°	9,200–10,000	82–1,633 bbls.	6,400,000 bbls.
Twin Buttes	Morrison	Jurassic	Anticlinal and stratigraphic	2	ss.	Gas	6,438	8,100 MCF	95,800 MCF
White River	Wasatch	Tertiary	Anticlinal	8	ss.	Gas	3,904	2–15,000 MCF	Shut in.
Wilson Creek	Morrison-Entrada	Jurassic	Anticlinal	38	ss.	50°	6,400– 6,600	7,800 bbls.	54,000,000 bbls.

[1] ss.—sandstone; ls.—limestone; dolo.—dolomite; sh.—shale; ost. ls.—ostracodal limestone; int. por.—interstitial porosity; frac. ss.—fractured sandstone; cong.—conglomerate; lent. ss.—lenticular sandstone; qtzite.—quartzite.
[2] MCF—thousand cubic feet of gas; bbls.—barrels of oil.

*From L. F. Wells, 1958, Petroleum occurrence in the Uinta basin, in AAPG, Habitat of Oil, A Symposium.

Utah - Ashley Valley
Phosphoria
Uinta Basin

DATA SOURCE CODE		
	STATE	Utah
5a	COUNTY	Uintah
	REGULATORY DISTRICT	
5a	BASIN	Uinta Basin
	SUB-BASIN	
5a	FIELD	Ashley Valley
5a	RESERVOIR	Phosphoria
5a	GEOLOGIC AGE	Permian
5a	AAPG STRATIGRAPHIC AGE CODE	310
5a	RESERVOIR LITHOLOGY	Vuggy dolomite
5a	TRAPPING MECHANISM	Faulted anticline
13,8	DISCOVERY YEAR	1925, oil in 1948
5a	PROVED ACREAGE	780
5a	REGULAR WELL SPACING (acres/well)	40
5a,13	RESERVOIR DEPTH	4100, 4314
	RESERVOIR THICKNESS	
13	NET PAY	14 avg.
	GROSS	
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
	FRACTION	
	PERMEABILITY	
	RANGE	
	AVERAGE	
	HORIZONTAL	
	VERTICAL	
	OTHER INFORMATION	
	PRODUCTION STATISTICS (oil in mbbls, gas in mmcf)	
	TOTAL NUMBER OF WELLS	
5a	PRODUCTION 1961 oil (cum)	10,791.3
14	PRODUCTION 1969 oil (cum)	18,831.5
	PRODUCTION 1978 oil (cum)	
	PRODUCTION 1979 oil (cum)	
	PRODUCTION 1-1-79 to 1-1-80	
	SECONDARY RECOVERY RECORDS?	
	WATER ANALYSIS RECORDS?	no
	OTHER DATA	
5a	STRUCTURE CONTOUR?	yes
5a	LOGS?	yes
	STRUCTURE SECTION?	
5a	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Ashley Valley
5a	RESERVOIR:	Phosphoria
5a	PROD. ACRES:	780
13	AVG. THICKNESS (FT.):	14
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
5a	PRIMARY DRIVE MECHANISM:	water
5a	PRIMARY GAS CAP?:	no
11	TEMPERATURE (°F):	132
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
5a	RESERVOIR PRESSURE INITIAL (psi):	2125
5a	RESERVOIR PRESSURE LATEST (psi):	2085
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
5a, 12a	STOCK TANK OIL GRAVITY (°API):	31.8 - 32, 32
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	
12a	Ultimate Recovery:	26,000 mbbls
5a	In. Oil in Place	40,000 mbbls
	OTHER INFORMATION:	

12a L. F. Wells, 1958, Petroleum Occurrence in the Uinta Basin, in AAPG Habitat of Oil, A Symposium.

ASHLEY VALLEY OIL FIELD
Uintah County, Utah

V. E. Peterson

Gas in commercial quantities was first discovered in the Frontier and Morrison sands in this field in the spring of 1925 and served as a source of gas for Vernal and the Ashley Valley until abandonment during the second World War. Though shows of oil had been observed in the Morrison and Entrada sections of the field, it was not until the drilling of the Equity Oil Company No. 1 Ashley Valley into the Weber sandstone that oil in commercial quantities was produced. This discovery well, drilled in the fall of 1948, is recognized as opening the first commercial oil field in the State of Utah.

The structure on which the Ashley Valley Oil Field is located is a northwest-southeast trending anticline which is situated on the west-plunging Blue Mountain uplift. Closure on the field appears to be a combination of anticlinal and fault closure approximately 300 feet. The anticline is cut by numerous normal faults, the largest recognized displacement of which is approximately 150 feet. Only one period of faulting has been recognized in the field, and this is known to involve the youngest consolidated beds exposed.

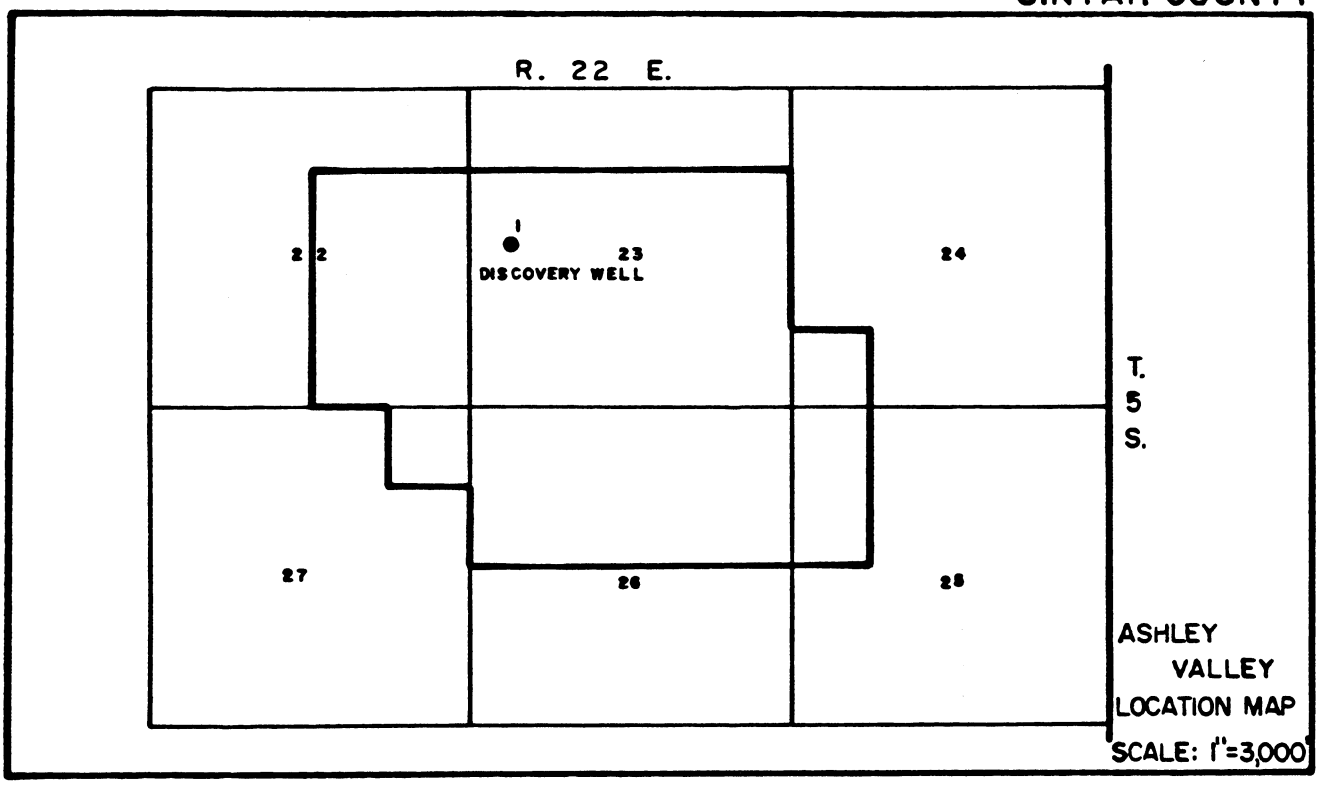
Stratigraphically, all of the wells drilled in the field begin in the lower part of the Mancos section. The deepest penetration of the section to date is in the Hollandsworth Drilling Co. No. 1-B Government, a dry hole on the south flank of the field which penetrated beds of Mississippian age.

Production of oil in the fields is primarily from the Weber sandstone, though some wells are producing from the overlying Phosphoria formation. It appears from the production history of the field that the two formations form a common resrvoir and at the present time a number of the wells within the field are producing from both sections. Before being produced, the oil-water contact for the Weber and Phosphoria sections was believed to be between 600 and 620 feet above sea level. Initially, all of the wells in the field flowed and were essentially free of water. No gas cap was present in the field and the oil produced is nearly gas-free. Within a year after discovery, most of the wells drilled in the field were making some water with the oil. The water-oil ratio has increased throughout the productive history of the field until at the present time the field average is eleven barrels of water for each barrel of oil produced. In a period since late 1959, high volume down-hole pumps have been installed in many of the wells in the field, accounting for a material increase in the production of oil.

As of January 1st, 1961, a total of 10,791,369 barrels of oil had been produced from the Phosphoria and Weber sections in the field. It has been estimated that the total initial oil in place in the combined reservoirs was 40,000,000 barrels. Estimated ultimate recovery from the field ranges between 18,000,000 and 22,000,000 barrels of oil.

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

ASHLEY VALLEY FIELD
UINTAH COUNTY



PRODUCTION CHARACTERISTICS

RESERVOIR

FORMATION NAME	AGE	LITH.	AVE. DEPTH	NET PAY	INIT. PRESS.	CURR. PRESS.	TYPE DRIVE	% POROS.	PERM. CMD
PHOSPHORIA WEBER	PERMIAN PERM-PENN	VUGGY DOL SANDSTONE	4,100'		2,125	2,085	WATER		

FLUIDS

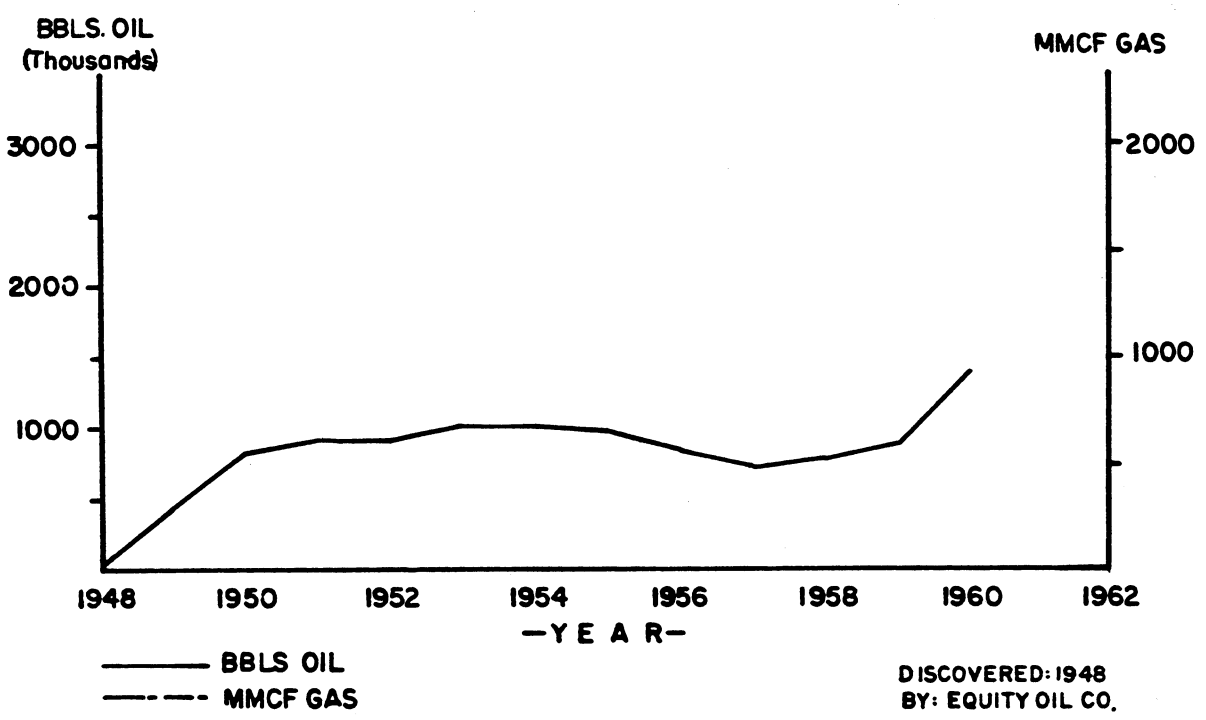
FORMATION NAME	GRAVITY	POUR POINT	SULFUR CONTENT	GOR	BTU/FT.^{3}	METHANE	ETHANE	WATER SALINITY	OTHER FLUIDS
PHOS-WEBER	31.8 - 32								

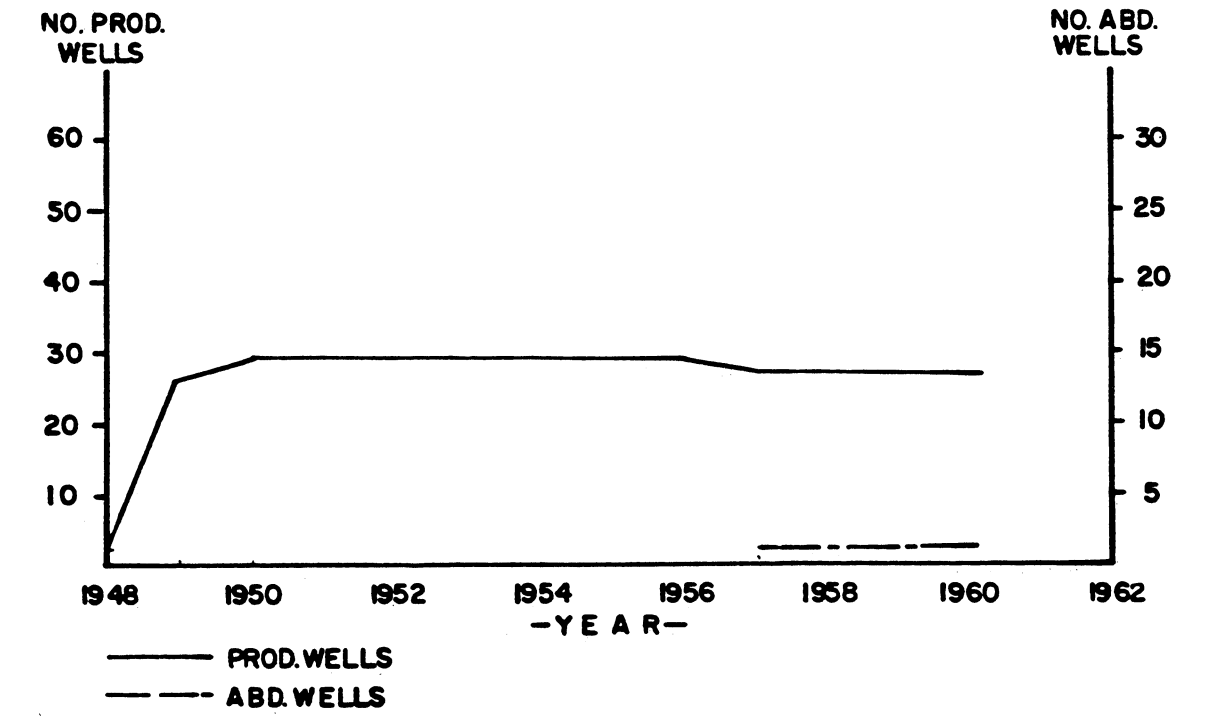
ECONOMICS

FORMATION NAME	PROD. WELLS	PROD. 1-1-60 - 1-1-61	CUMULAT. PROD. 1-1-61	$ / BBL. WELL HEAD	$ / MCF WELL HEAD	ULT. RES.	PROVEN ACREAGE	TOTAL WELLS	SPACING
PHOS - WEBER	29	1,388,218	10,791,388				780	29	40

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

ASHLEY VALLEY FIELD





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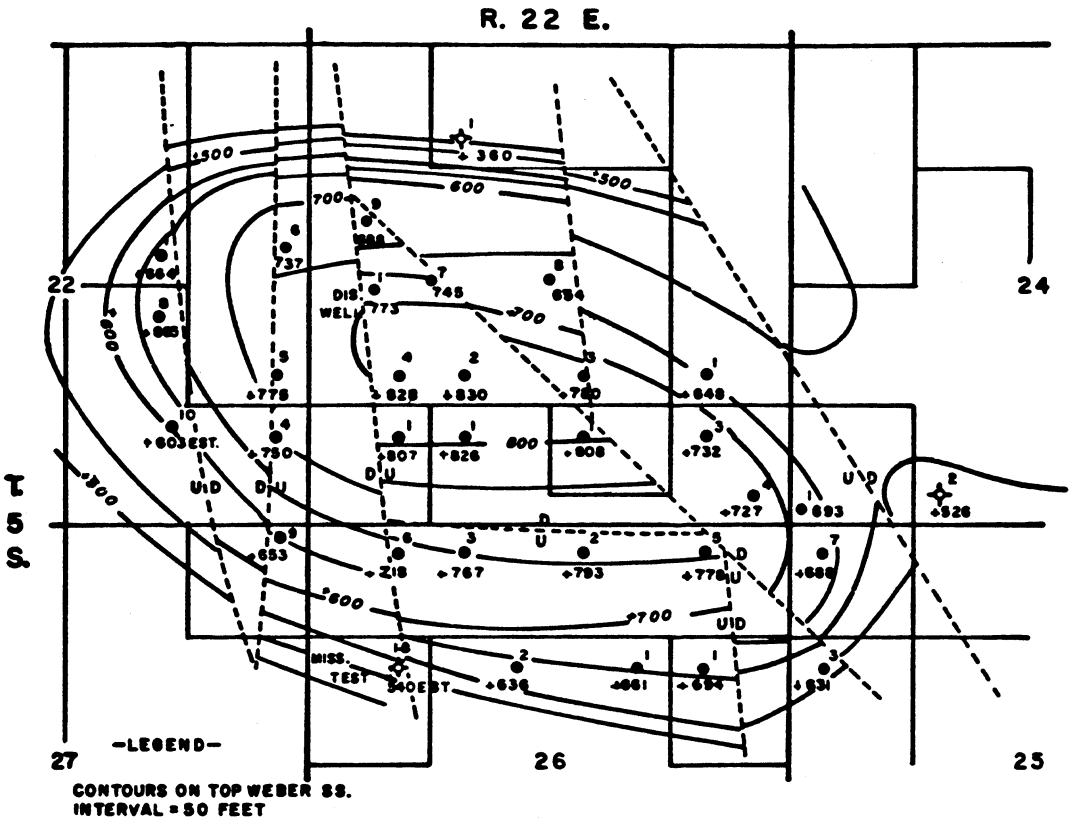
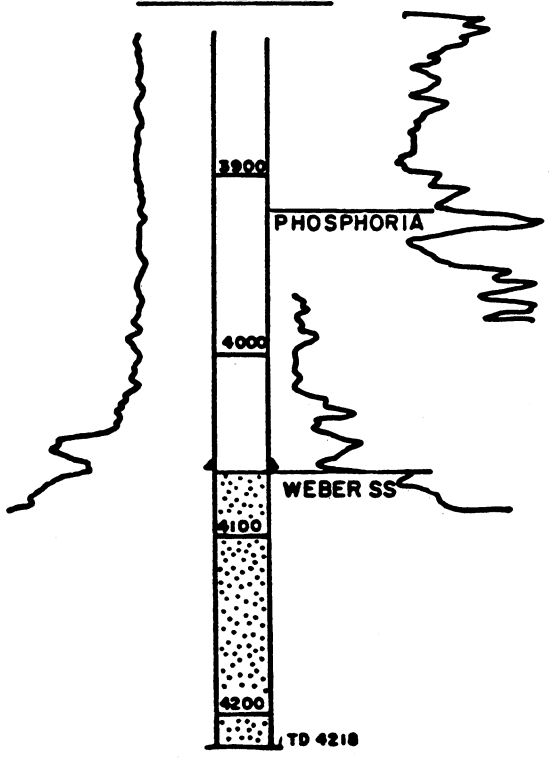


WEBER POOL MAP

TYPICAL LOG



ASHLEY VALLEY FIELD

From: A SYMPOSIUM OF THE OIL AND GAS FIELDS OF UTAH, Intermountain Association of Petroleum Geologists, 1961, Source 5a.

EASTERN UTAH OVERTHRUST FIELDS

Utah -Pineview
Twin Creek - Jurassic
Eastern Utah Overthrust

DATA SOURCE CODE		
5c	STATE----------	Utah
	COUNTY----------	Summit
	REGULATORY DISTRICT----------	
5c	BASIN----------	Eastern Utah Overthrust Belt
	SUB-BASIN----------	
5c	FIELD----------	Pineview
5c	RESERVOIR----------	Twin Creek
5c	GEOLOGIC AGE----------	Jurassic
5c	AAPG STRATIGRAPHIC AGE CODE----------	220
5c	RESERVOIR LITHOLOGY----------	Argillaceous limestone, reservoir discontinuous across structure.
5c	TRAPPING MECHANISM----------	Structural-fracture
5c	DISCOVERY YEAR----------	1975
5c	PROVED ACREAGE----------	1600
5c	REGULAR WELL SPACING (acres/well)-----	80
5c	RESERVOIR DEPTH----------	9850 (top of perforation)
	RESERVOIR THICKNESS	
5c	NET PAY----------	16-100
5c	GROSS----------	500 ft. (oil column)
	NET/GROSS RATIO----------	
	POROSITY	
5c	TYPE----------	Fractured
5c	FRACTION----------	.03
	PERMEABILITY	
	RANGE----------	
5c	AVERAGE----------	30 md
	HORIZONTAL----------	
	VERTICAL----------	
5c	OTHER INFORMATION----------	Other reservoirs include the Upper Cretaceous, Stump, and Nugget
	PRODUCTION STATISTICS - FIELD (oil in mbbls, gas in mmcf)	
5c	TOTAL NUMBER OF WELLS----------	20P, 2A, 2SI
	PRODUCTION 1976 oil (cum)----------	
	PRODUCTION 1977 oil (cum)----------	
5c	PRODUCTION 1978 oil (cum)----------	3,535.6 mbbls (12/1/78)
	PRODUCTION 1979 oil (cum)----------	
	PRODUCTION 1-1-79 to 1-1-80----------	
	SECONDARY RECOVERY RECORDS?----------	
5c	WATER ANALYSIS RECORDS?----------	yes
	OTHER DATA	
5c	STRUCTURE CONTOUR?----------	yes
5c	LOGS?----------	yes
	STRUCTURE SECTION?----------	
	ENGINEERING REPORTS?----------	
	CORE DESCRIPTIONS?----------	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Pineview
5c	RESERVOIR:	Twin Creek
5c	PROD. ACRES:	1600
5c	AVG. THICKNESS (FT.):	16-100
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
5c	PRIMARY DRIVE MECHANISM:	water
	PRIMARY GAS CAP?:	
11	TEMPERATURE (^oF):	218
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
	RESERVOIR PRESSURE INITIAL (psi):	4000
	RESERVOIR PRESSURE LATEST (psi):	3900 (1978)
5c	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	1000:1
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
5c	STOCK TANK OIL GRAVITY (^oAPI):	46
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

	OTHER INFORMATION:
5c	Water resistivity: .30 @ 68^oF

Theron R. Blazzard
American Quasar Petroleum Company of New Mexico
Denver, Colorado
January 1979

Pineview

T2N R7E
Summit County, Utah
Upper Cretaceous, Stump, Twin Creek, Nugget

DISCOVERY WELL

Name: American Quasar, 1 Newton Sheep Co.
Location: NWNESE 4-2N-7E
Date of Completion: January 21, 1975
Initial Potential: 540 BOPD, 270 MCFGPD, 226 BWPD
Nugget
Total Depth: 14,500 Elevation: 6555KB
Casing: 13-7/8 at 1708 w/1630 sx, 9-5/8 at 10,989 w/3650 sx
Perforations: 9928-9931 w/4 shots/ft, 9931-9936 w/2 shots/ft
Treatment: None
Pressures: FTP 1000-16/64 ck

GENERAL FIELD DATA

Regional Setting: Eastern Utah Overthrust Belt
Other Formations with Shows: None
Exploration Method Leading to Discovery: Subsurface, seismic, surface
Trap Type: Structural, fracture
Surface Formations: Wasatch-Tertiary, Echo Canyon, Frontier, Aspen, Bear River-Cretaceous
Oldest Formation Penetrated: Woodside-Triassic
Well: NWSW 3-2N-7E
Spacing Order: 80 acres (Nugget and Twin Creek)
Logging Practice: DLL, SonL-GR, FDC-CNL, HDT
Completion Practice: Set casing through, selectively perforate
Productive Area: 1600 acres
Number of Producing Wells: 18 on 80 acre spacing, 2 on 40 acre spacing
Number of Abandoned Producers: 2, 4 suspended (Nugget-3, Cretaceous-1)
Number of Dry Holes: 0
Number of Shut-in Wells: 2 (34-1, 31-3)
Market for Production: Amoco Pipeline Co. (pipeline)
Major Operators: American Quasar Petroleum Co., Champlin Petroleum Co.
Number of Disposal Wells: 1
Number of Pressure Maintenance/Injection Wells: 0

RESERVOIR DATA

Formation: Upper Cretaceous
Lithology: Sandstone
Discovery Date: November 12, 1978
Location: SESE 4-2N-7E
Initial Potential: 360 BOPD, 504 MCFGPD, FTP 270 15/16 ck
Perforations: 2784-2832, 2862-2882 w/4 shots/ft
Treatment: None
Porosity: 6% Permeability: Unknown, fractured sand
Average Pay Thickness: 21-48 feet
Oil/Gas Column: Unknown
Gas/Oil/Water Contact: Unknown
Gas Oil Ratio: 1125:1
Initial Pressure: BHP 1237
Present Pressure: Unknown (1979)
Drive Mechanism: Water
Rw and/or Salinity: Unknown
Character of oil: Gravity-48.4°API
Continuity of Reservoir: Unknown
Cumulative Production: 15,794 BO, 11,301 MCF, 3637 BW 12/31/78
STBO or MCF/AC FT: Unknown
Secondary: Unknown
Estimated Ultimate Primary: Unknown

RESERVOIR DATA

Formation: Stump-Jurassic
Lithology: Sandstone
Discovery Date: October 20, 1978
Location: NWNESE 4-2N-7E
Initial Potential: 1266 BO, 6 BW, 702 MCF 40/64 ck
Perforations: 5997-6012 w/2 shots/ft
Treatment: None
Porosity: 13% Permeability: 30 md
Average Pay Thickness: 40 feet
Oil Column: Unknown
Oil/Water Contact: Unknown
Gas Oil Ratio: 550:1
Initial Pressure: BHP 2400
Present Pressure: BHP 2400 (1979)
Drive Mechanism: Water
Rw and/or Salinity: Rw = .32 at 68°F
Character of oil: Gravity-46°API, pour point 5°F
Continuity of Reservoir: Faulted into several blocks, other production unknown
Cumulative Production: 24,824 BO 12/1/78
STBO/AC FT: 400
Secondary: Unknown
Estimated Ultimate Primary: Unknown

DISCUSSION

This well is a recompletion in the Stump after the Nugget went to water.

RESERVOIR DATA

Formation: Twin Creek-Jurassic
Litholgoy: Limestone, argillaceous
Discovery Date: September 23, 1975
Location: NWNW 3-2N-7E
Initial Potential: 576 BOPD 420 MCF
Perforations: 9850-9866 w/4 shots/ft
Treatment: None
Porosity: 3% Permeability: 30 md (est) fractured
Average Pay Thickness: 16-100 feet
Oil Column: 500± feet
Oil/Water Contact: -3413 feet
Gas Oil Ratio: 1000:1
Initial Pressure: BHP 4000
Present Pressure: BHP 3900 (1978)
Drive Mechanism: Water
Rw and/or Salinity: Rw = .30 at 68°F (produced)
Character of oil: Gravity-46°API
Continuity of Reservoir: Discontinuous across structure
Cumulative Production: 3,535,646 BO 12/1/78
STBO/AC FT: 100 (est)
Secondary: Unknown
Estimated Ultimate Primary: Unknown

DISCUSSION

Some Twin Creek wells are given a medium acid fracture to initiate production.

(Continued)

From: WYOMING OIL AND GAS FIELDS-A SYMPOSIUM-GREATER GREEN RIVER BASIN, Wyoming Geological Association, 1979, Source 5c.

Pineview

From: WYOMING OIL AND GAS FIELDS-A SYMPOSIUM-GREATER GREEN RIVER BASIN, Wyoming Geological Association, 1979, Source 5c.

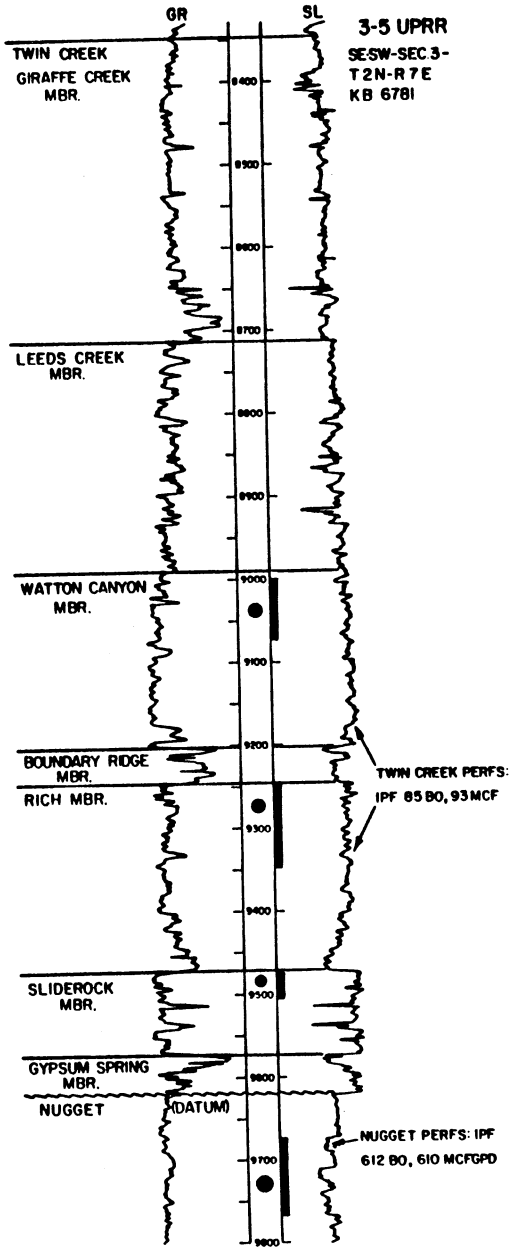
RESERVOIR DATA

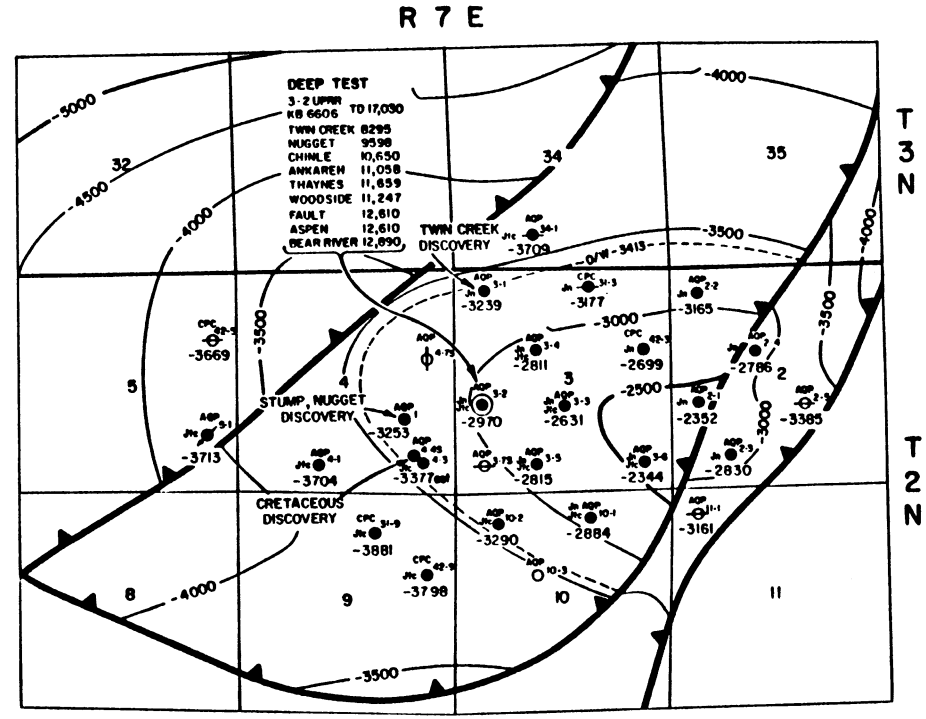
Formation: Nugget-Jurassic
Lithology: Sandstone
Porosity: 10% Permeability: 3 md
Average Pay Thickness: 160 feet
Oil Column: 1069 feet
Oil/Water Contact: -3413
Gas Oil Ratio: 1000:1
Initial Pressure: BHP 4170
Present Pressure: BHP 3900 (1978)
Drive Mechanism: Water
Rw and/or Salinity: Rw = .30 at 68°F (produced)
Character of oil: Gravity-46°API
Continuity of Reservoir: Continuous sand with variable porosity in top half
Cumulative Production: 6,479,003 BO 12/1/78
STBO/AC FT: 300
Secondary: Unknown
Estimated Ultimate Primary: Unknown

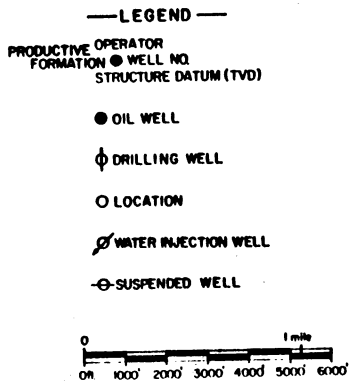
DISCUSSION

Some Nugget wells require sand fracture.

REFERENCES







W. G. A.

PINEVIEW

SUMMIT COUNTY, UTAH

DATUM – NUGGET

CONTOUR INTERVAL -500'

From: WYOMING OIL AND GAS FIELDS-A SYMPOSIUM-GREATER GREEN RIVER BASIN, Wyoming Geological Association, 1979, Source 5c.

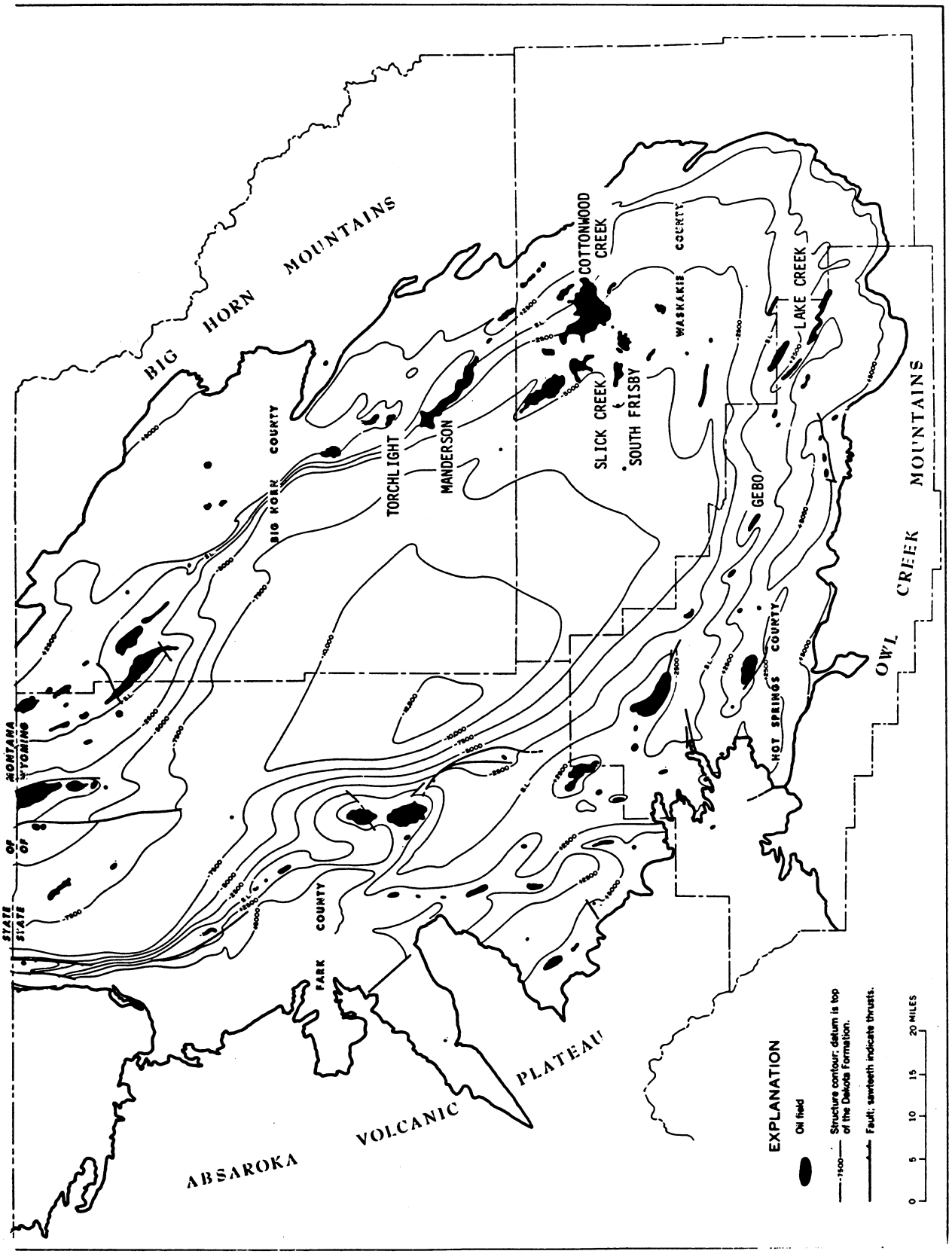


Figure 11.--Location of fields in the Big Horn basin (adapted from Geologic Atlas of the Rocky Mountain Region).

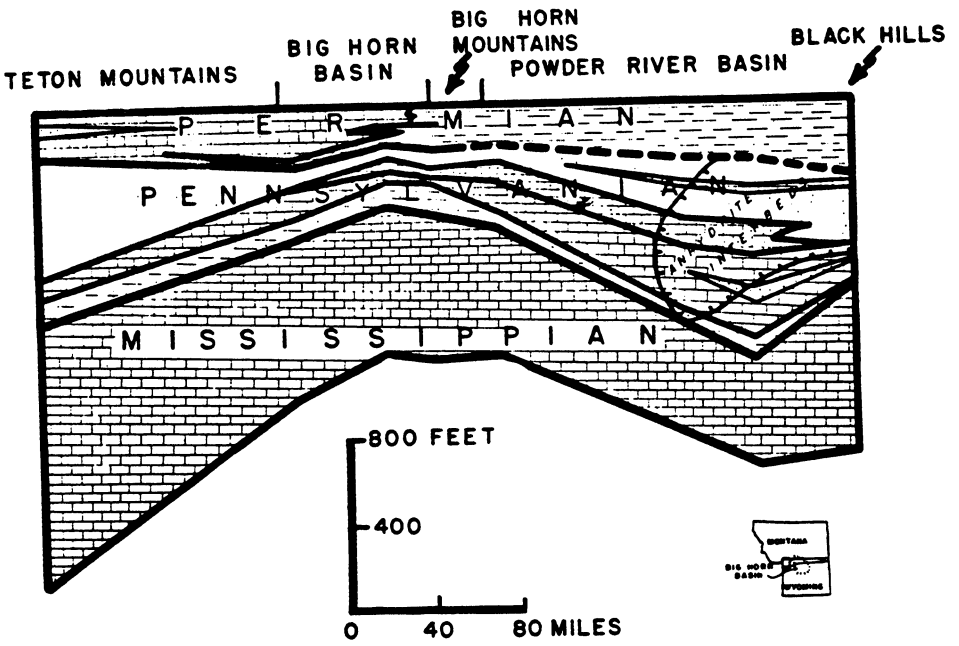


Figure 12a.--Digrammatic stratigraphic cross section of Big Horn and Powder River basins.
Datum is top of Permian.

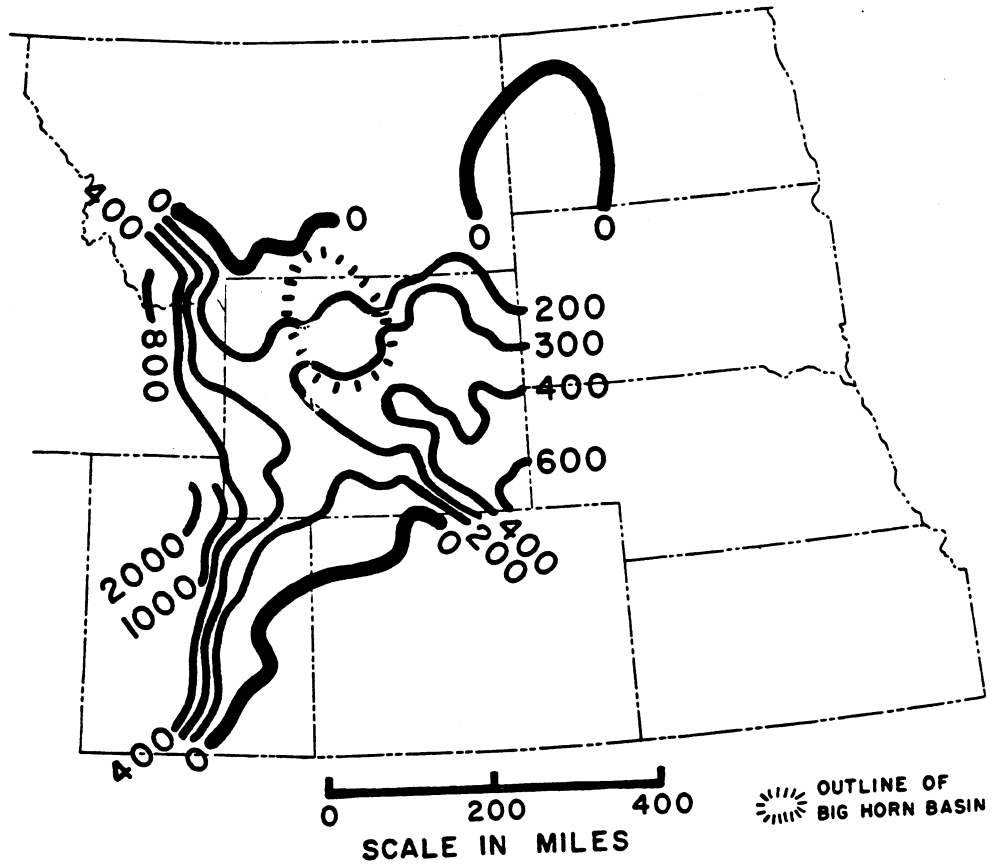


Figure 12b.--Isopach map of Phosphoria formation and equivalents (Permian) in western interior of the United States.

(From J. F. Partridge, Jr., 1958, Oil occurrence in Permian, Pennsylvanian, and Mississippian rocks, Big Horn basin, Wyoming, in AAPG, Habitat of Oil, A Symposium.)

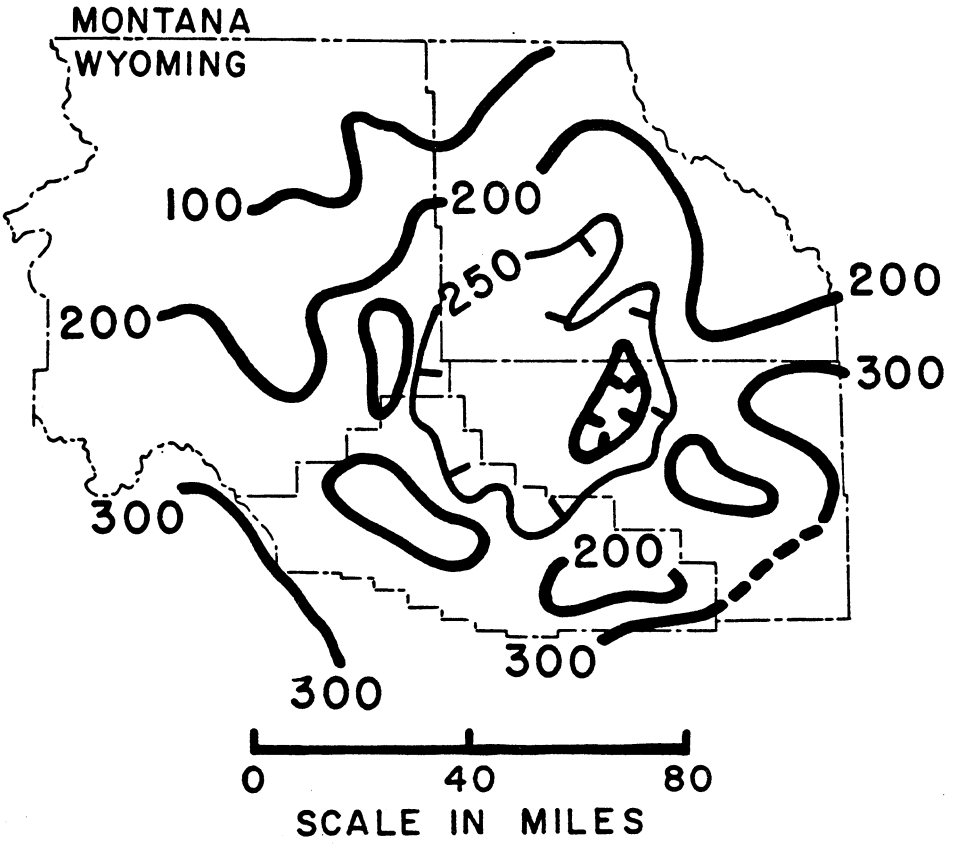


Figure 13a.--Isopach map of the Phosphoria formation in Big Horn basin.

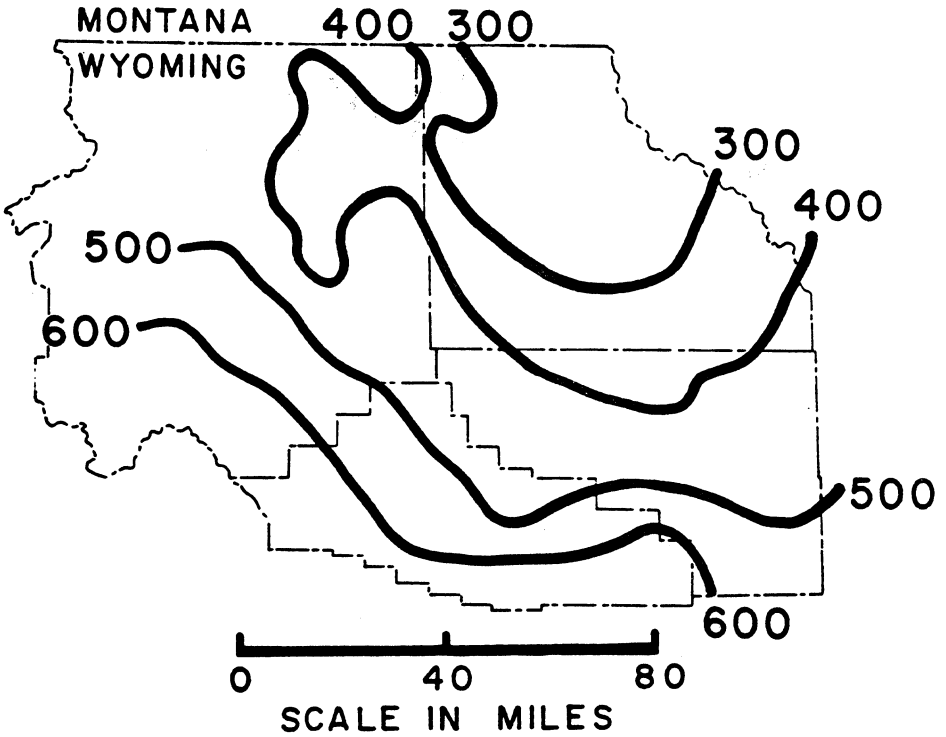


Figure 13b.--Isopach map of Pennsylvanian in Big Horn basin.

(From J. F. Partridge, Jr., 1958, Oil occurrence in Permian, Pennsylvanian and Mississippian rocks, Big Horn basin, Wyoming, in AAPG, Habitat of Oil, A Symposium.)

Wyoming - Cottonwood Creek
Phosphoria
Big Horn

DATA SOURCE CODE		
	STATE	Wyoming
8,9	COUNTY	Washakie
	REGULATORY DISTRICT	
8,9	BASIN	Big Horn
	SUB-BASIN	
8,9	FIELD	Cottonwood Creek
8	RESERVOIR	Phosphoria
8	GEOLOGIC AGE	Permian
	AAPG STRATIGRAPHIC AGE CODE	
8,9	RESERVOIR LITHOLOGY	Dolomite, tan to light gray; fine to microcrystaline dolomite - oolitic, fossiliferous, fractured, stylolic and vuggy porosity.
8,2c,9	TRAPPING MECHANISM	Stratigraphic; stratigraphic trap on a structural nose; stratigrapic trap on a structural nose.
2b,9,8,2c	DISCOVERY YEAR	1953
2c,9,12	PROVED ACREAGE	32,979; 5000 ; 14,200
9	REGULAR WELL SPACING (acres/well)	160
2c,9,2b	RESERVOIR DEPTH	7270; 5000-8400; 7270
	ELEVATION	4500 - 4800 ft.
	RESERVOIR THICKNESS	
2c, 9	NET PAY	53; 3-75
9	GROSS	30 - 95
	NET/GROSS RATIO	
	POROSITY	
8	TYPE	V, F
9	FRACTION	Variable, >.03
	PERMEABILITY	
	RANGE	
9	AVERAGE	Variable, >1 md
	HORIZONTAL	
	VERTICAL	
2c	OTHER INFORMATION	Other reservoir - Madison
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2d	TOTAL NUMBER OF WELLS	63P
	PRODUCTION 1976 oil (cum)	
	PRODUCTION 1977 oil (cum)	
	PRODUCTION 1978 oil (cum)	
2d	PRODUCTION 1979 oil (cum)	43,239.7 mbbls oil; 39,392.6 mmcf gas
2d	PRODUCTION 1-1-79 to 1-1-80	612.8 mbbls oil; 60 mmcf gas
2d	SECONDARY RECOVERY RECORDS?	yes
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
9	STRUCTURE CONTOUR?	yes
9	LOGS?	yes
9	STRUCTURE SECTION?	yes
12	ENGINEERING REPORTS?	yes
	CORE DESCRIPTIONS?	
2c	CRUDE ANALYSIS?	yes

RESERVOIR DATA

DATA SOURCE CODE		
2c	FIELD:	Cottonwood Creek
2c, 9, 12	RESERVOIR:	Phosphoria
	PROD. ACRES:	32,979; 5000;14,200
	AVG. THICKNESS (FT.):	
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
9	PRIMARY DRIVE MECHANISM:	solution gas
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	190
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
9,2c	RESERVOIR PRESSURE INITIAL (psi):	3331; 3330
	RESERVOIR PRESSURE LATEST (psi):	
2c, 2	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	450; 452
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
2c, 9	STOCK TANK OIL GRAVITY (°API):	28.6, 30.2
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
11	MINIMUM MISCIBILITY PRESSURE (MMP):	2387
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	
14	ESTIMATED ULTIMATE RECOVERY:	50,000 mbbls oil

2d **OTHER INFORMATION:**

Secondary recovery records: waterflood - 17 active injection wells, 29 inactive wells in Phosphoria & Madison, began 1961 by Amoco Production Company.

9 Reference: Pedry, John J., 1957: AAPG Bull. Vol. 41, No. 5, May, pp.823-838.

12 Reference: Dickey, Parke A., 1979: Petroleum Development Geology, Published by PPC Books, Tulsa, Oklahoma.

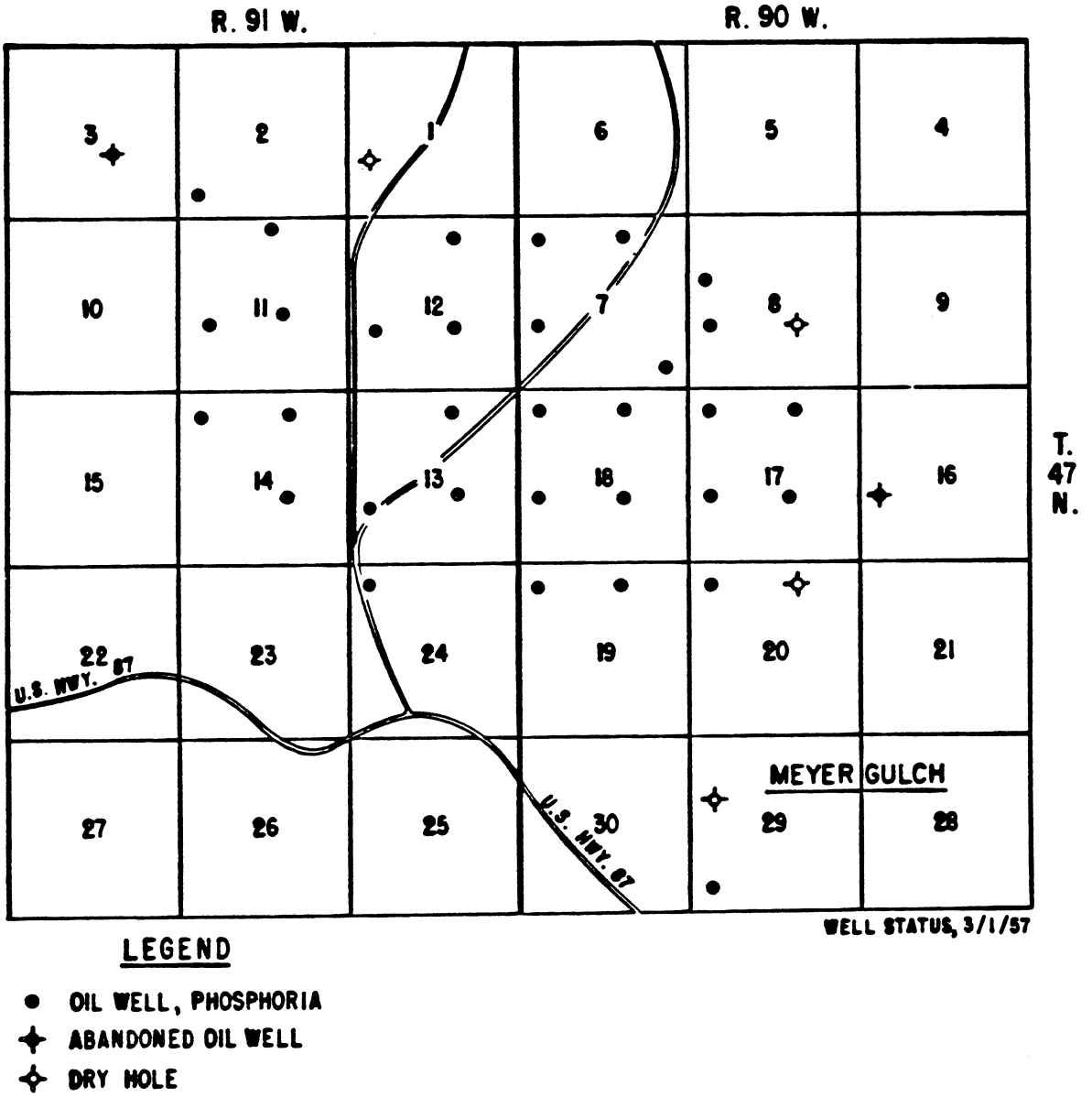


FIGURE 51.—Map of Cottonwood Creek Field, Washakie County, Wyo.
(Adapted from Federal Geological Survey map.)

Leo, 1,419. Analyses of oil and water from the Leo sand are given on page 364 and in table 9 (p. 294), respectively.

At least 13 wells have been drilled in the Cow Gulch area; 3 were oil wells and 10 were plugged and abandoned. Two of the plugged and abandoned wells were drilled on the north high of the anticline in secs. 10 and 15, T. 37 N., R. 62 W.

In December 1956 the oil wells were shut in. Production for 1956 was 1,520 barrels of oil; cumulative production to the end of 1956 was 12,712 barrels of oil. The oil was trucked to a refinery at Lusk, Wyo.

CROOKS GAP

The Crooks Gap oilfield (fig. 52) is in secs. 18 and 19, T. 28 N., R. 92 W., and secs. 12 and 13, T. 28 N., R. 93 W., Fremont County. Crooks Gap is a sharply folded, asymmetrical anticline separated by a narrow syncline from the Spring Creek anticline to the north. The axes of these anticlines, which are nearly paral-

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

TABLE 12.—*Crude-oil analyses*—Continued

REPORT OF CRUDE PETROLEUM ANALYSIS

U. S. Geol. Survey ~~[illegible]~~ Casper Laboratory
Sample 47-01

IDENTIFICATION

Casley field
Embar lime - Permian
4,100 - 4,134 feet

Wyoming
Hot Springs County
NE¼NE¼ sec. 3,
T. 43 N., R. 93 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.912 A. P. I. gravity 23.7° Pour point, °F. below 5
Sulfur, percent, 2.02 Color, black
Saybolt Universal viscosity at 100 °F., 126 sec.; at 70 °F., 332 sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, 638 mm. Hg
First drop, 90 °C. (194 °F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Sum, percent	Sp. Gr. 60/60° F.	°A.P.I. 60° F.	C.I.	Refractive index, n_D at 20° C.	Specific dispersion	S.U. vis. 100° F.	Cloud test, °F.
1	80	176			0						
2	75	167									
3	100	212	0.5	0.5	.712	67.2	20				
4	125	257	1.7	2.2	.736	60.8	22				
5	150	302	2.3	4.5	.744	58.7	18				
6	175	347	2.3	6.8	.754	56.2	16				
7	200	392	3.6	10.4	.777	50.6	20				
8	225	437	4.6	15.0	.801	45.2	26				
9	250	482	3.7	18.7	.819	41.3	29				
10	275	527	10.8	29.5	.843	36.3	36				

Stage 2—Distillation continued at 40 mm. Hg

11	200	392	0	29.5	0						
12	225	437	4.3	33.8	.880	29.3	44			49	30
13	250	482	8.4	42.2	.890	27.5	46			63	45
14	275	527	6.5	48.7	.905	24.9	49			93	55
15	300	572	8.8	57.5	.920	22.3	54			154	75
Residuum			38.6	96.1	.998	10.3					

Carbon residue of residuum, 11.8 percent; carbon residue of crude, 5.0 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A.P.I.	Viscosity
Light gasoline	0.5	0.712	67.2	
Total gasoline and naphtha	10.4	0.755	55.9	
Kerosine distillate	8.3	.809	43.4	
Gas oil	13.9	.851	34.8	
Nonviscous lubricating distillate	13.8	.881-.907	29.1-24.5	50-100
Medium lubricating distillate	11.1	.907-.928	24.5-21.0	100-200
Viscous lubricating distillate				Above 200
Residuum	38.6	998	10.3	
Distillation loss	3.9			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample RC-36-148

IDENTIFICATION

Cottonwood Creek field
Phosphoria limestone - Permian
7,270 - 7,323 feet

Wyoming
Washakie County
SW¼SW¼ sec. 2,
T. 47 N., R. 91 W.

GENERAL CHARACTERISTICS

Gravity, specific, 0.884 Gravity, ° API, 28.6° Pour point, °F., below 5
Sulfur, percent, 2.52 Color, brownish black
Viscosity, Saybolt Universal at 100°F., 63 sec. at 77°F., 78 sec. Nitrogen, percent, 0.190

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 82 °F.

Fraction No.	Cut temp. °F.	Percent	Sum, percent	Sp. Gr. 60/60° F.	°API, 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, °F.
1	122	1.3	1.3	0.696	84.2					
2	167	1.5	2.8	.663	81.9	4.2	1.37690	124.0		
3	212	2.4	5.2	.700	70.6	12	1.39546	131.2		
4	257	3.2	8.4	.732	61.8	18	1.40906	136.2		
5	302	3.9	12.3	.758	55.2	23	1.42418	143.3		
6	347	4.1	16.4	.779	50.1	26	1.43551	146.8		
7	392	3.8	20.2	.793	46.9	26	1.44303	144.4		
8	437	3.8	24.0	.809	43.4	28	1.44966	143.7		
9	482	4.7	28.7	.823	40.4	30	1.45733	144.0		
10	527	6.0	34.7	.841	36.8	33	1.46630	150.5		

Stage 2—Distillation continued at 40 mm. Hg

11	200	6.7	41.4	0.867	31.7	42			41	below 5
12	437	6.7	48.1	.880	29.3	44			49	20
13	482	7.8	55.9	.900	25.7	50			70	30
14	527	5.5	61.4	.922	22.0	58			130	70
15	572	7.5	68.9	.932	20.3	59			260	85
Residuum		28.9	97.8	.999	10.1					

Carbon residue, Conradson: Residuum, 13.9 percent; crude, 4.5 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	5.2	0.678	77.2	
Total gasoline and naphtha	20.2	.744	58.7	
Kerosine distillate	8.5	.817	41.7	
Gas oil	16.3	.859	33.2	
Nonviscous lubricating distillate	10.3	.881-.912	29.1-23.7	50-100
Medium lubricating distillate	6.8	.912-.927	23.7-21.1	100-200
Viscous lubricating distillate	6.8	.927-.938	21.1-19.4	Above 200
Residuum	28.9	.999	10.1	
Distillation loss	2.2			

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Source 9.

COTTONWOOD CREEK FIELD, WASHAKIE COUNTY, WYOMING, CARBONATE STRATIGRAPHIC TRAP[1]

JOHN J. PEDRY[2]
Casper, Wyoming

ABSTRACT

The Cottonwood Creek field is perhaps the first major discovery in Wyoming drilled specifically as a stratigraphic trap prospect. At present, the field is 4 miles long and 2½ miles wide, with 5,000 acres proved productive by 28 Phosphoria wells. The southern and western limits of the field have not yet been defined.

During deposition of the Phosphoria, west-central Wyoming was the site of a large arcuate embayment on a shallow platform that sloped westward into the Cordilleran miogeosyncline. Throughout most of Phosphoria time the eastern margin of marine deposition fluctuated within the area of the present Bighorn basin. The Cottonwood Creek field is near the eastern edge of the final marine transgression of the Phosphoria sea. The facies change from marine dolomite to red shale and anhydrite provides the trap for oil accumulation. Development of porosity in the dolomite at Cottonwood Creek may be due to a reef.

The producing zone is oölitic, fossiliferous, stylolitic, fractured dolomite with pin-point to coarse vuggy porosity. The thickness of dolomite in the producing wells ranges from 30 to 95 feet; the net porous dolomite varies from a few feet to 74 feet.

The Cottonwood Creek field is believed to be a volumetric reservoir with solution gas drive as the producing mechanism. The oil is 30.2° A.P.I. gravity with 2.7 per cent sulphur. The production for all oil wells in the field is 10,000 barrels of oil per day.

INTRODUCTION

The Cottonwood Creek field is on the east side of the Bighorn basin in Washakie County approximately 15 miles east of Worland, Wyoming, in T. 47 N., R. 90 and 91 W. (Fig. 1).

The Cottonwood Creek field is perhaps the first major discovery in Wyoming drilled specifically as a stratigraphic trap prospect. The discovery well was drilled by the Stanolind Oil and Gas Company in June, 1953, on a structural nose near a dolomite-to-shale facies change, with the objective of finding porosity in the upper Phosphoria dolomite. Although the first well drilled on the prospect was a marginal producer and the subsequent drilling of two more dry holes appeared to condemn the prospect, the development of a new idea and the decision to "drill one more" led to the drilling of the fourth well. The Unit No. 4 well was completed in September, 1955, flowing initially 956 barrels of oil per day. Active field development followed completion of this well.

The Cottonwood Creek field, still being developed, is 4 miles long and 2½ miles wide, with approximately 5,000 acres proved productive. The field, developed on 160-acre spacing, has 28 Phosphoria producers ranging in depth from 5,000 to 8,400 feet. The location and size of Cottonwood Creek field in relation to other Phosphoria fields in the Bighorn basin are shown in Figure 2.

[1] Read before the Rocky Mountain Section of the Association at Salt Lake City, Utah, February 27, 1957. Manuscript received, February 4, 1957. Published by permission of Stanolind Oil and Gas Company.

[2] Geologist, Pan American Petroleum Corporation. Grateful acknowledgment is extended to Myron D. Hubley and T. C. Woodward for their helpful suggestions and criticism given during writing of the manuscript.

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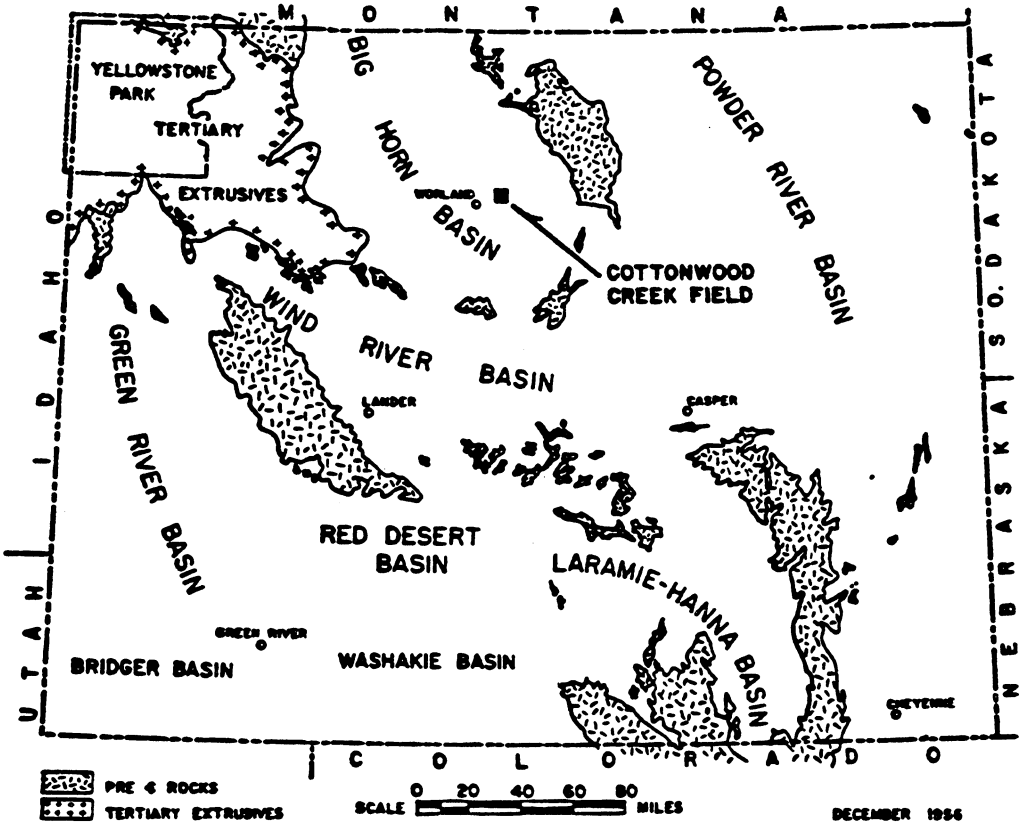

FIG. 1.—Index map of Wyoming showing location of Cottonwood Creek field on east flank of Bighorn basin.

STRATIGRAPHY OF COTTONWOOD CREEK AREA

POST-DINWOODY ROCKS

Rocks of Upper Cretaceous age and overlapping Tertiary are exposed on the west-plunging nose of the Cottonwood Creek field. Outcropping Cretaceous strata within the field include the Cody shale at the eastern end, followed by Mesaverde, Meeteetse, and Lance; overlapping Tertiary Willwood formation crops out in the western part of the field. From the surface down, a normal sequence of rocks is penetrated (Fig. 3); no showings of oil or gas are encountered in any formation above the Dinwoody.

TRIASSIC DINWOODY

The Dinwoody is green or red dolomitic shale, 55–70 feet thick, which unconformably overlies the Phosphoria. The Dinwoody is normally red in the general Cottonwood-Manderson area, but, where the underlying Phosphoria is productive, the Dinwoody is light green to gray. Where the Phosphoria has a poor pro-

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Source 9.

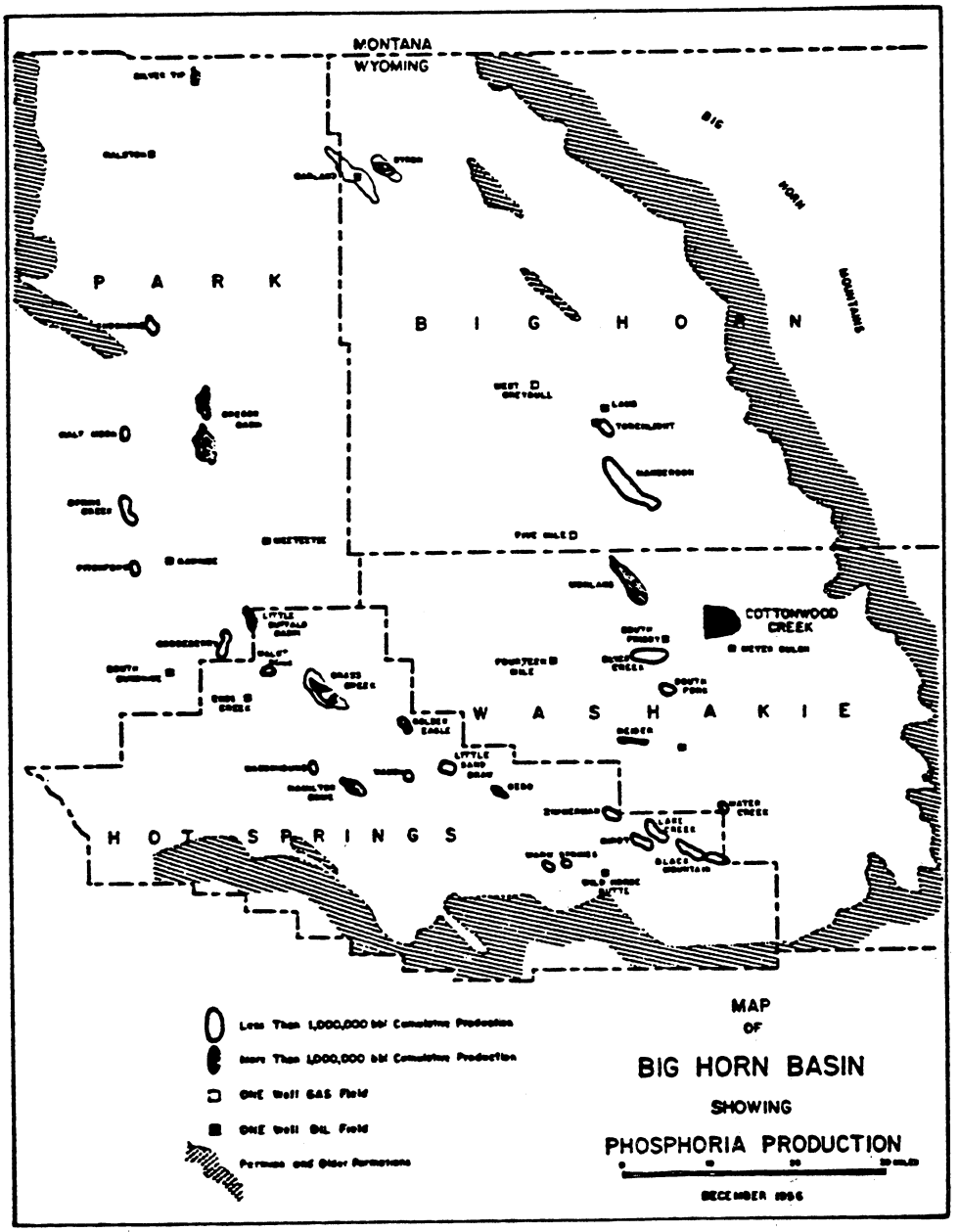

FIG. 2.—Map of Bighorn basin showing fields producing from Phosphoria. Relative location, size, and production history of fields are shown.

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Source 9.

STRATIGRAPHIC SECTION

COTTONWOOD CREEK UNIT NO.4

SEC. 7 - T. 47 N. - R. 90 W.

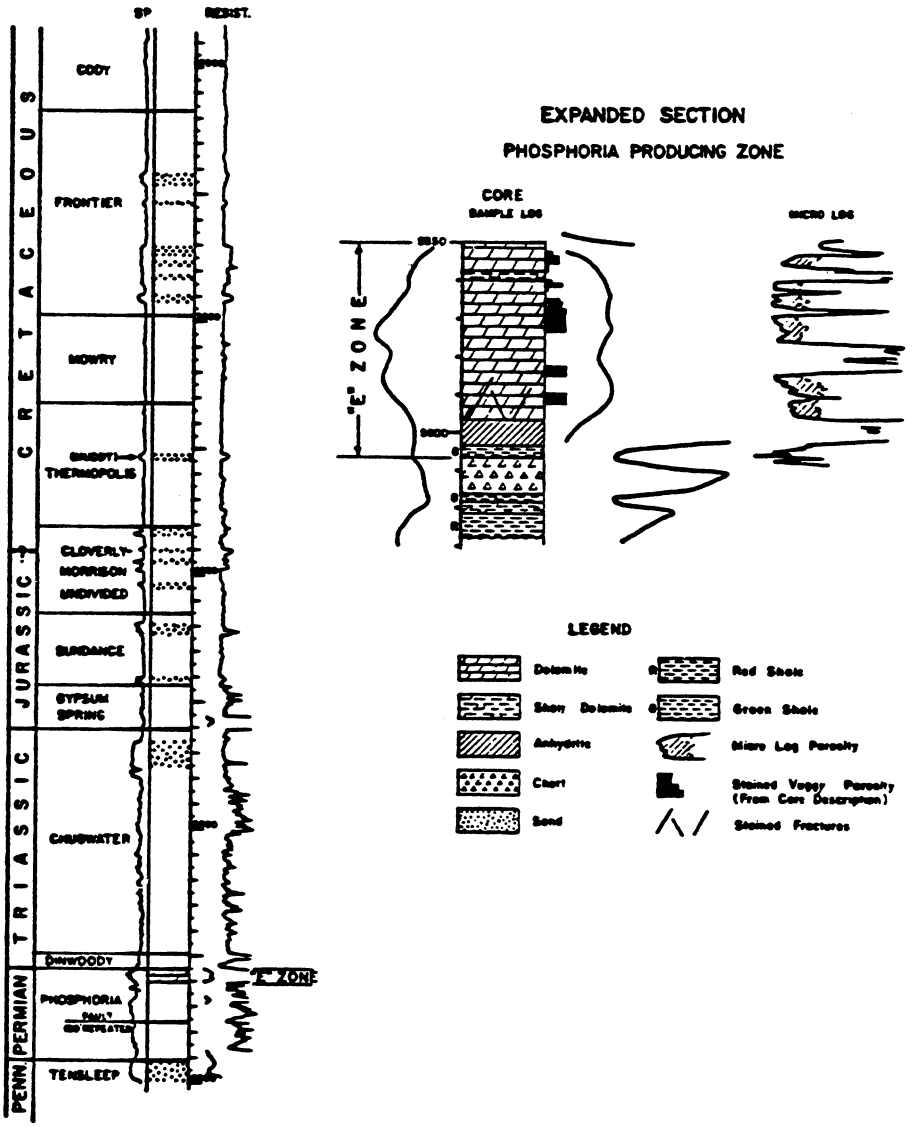

FIG. 3.—Stratigraphic section and electric log of Unit No. 4 well showing rock subdivisions and sand development. Expanded section of "E" zone at right shows lithologic character and porous zones.

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Source 9.

ductive section, only the lower part of the Dinwoody is green. Harris (1955) suggested that in the Manderson area the characteristic green color may be the result of reduction by hydrogen sulphide gas emanations from the Phosphoria "limestone." However, evidence obtained in the Cottonwood Creek area indicates that the green Dinwoody shale may be restricted to those areas where the underlying Phosphoria is productive.

PERMIAN PHOSPHORIA

The Phosphoria in the Unit No. 4 well is 260 feet thick. No break-down into correlative units has been made, but for purposes of discussion, the rocks above

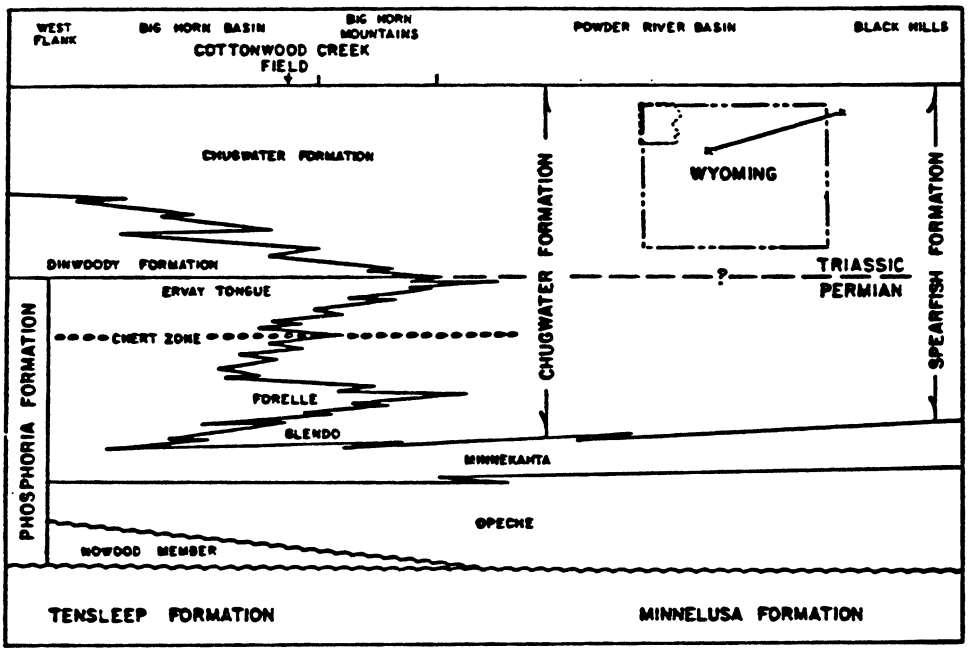
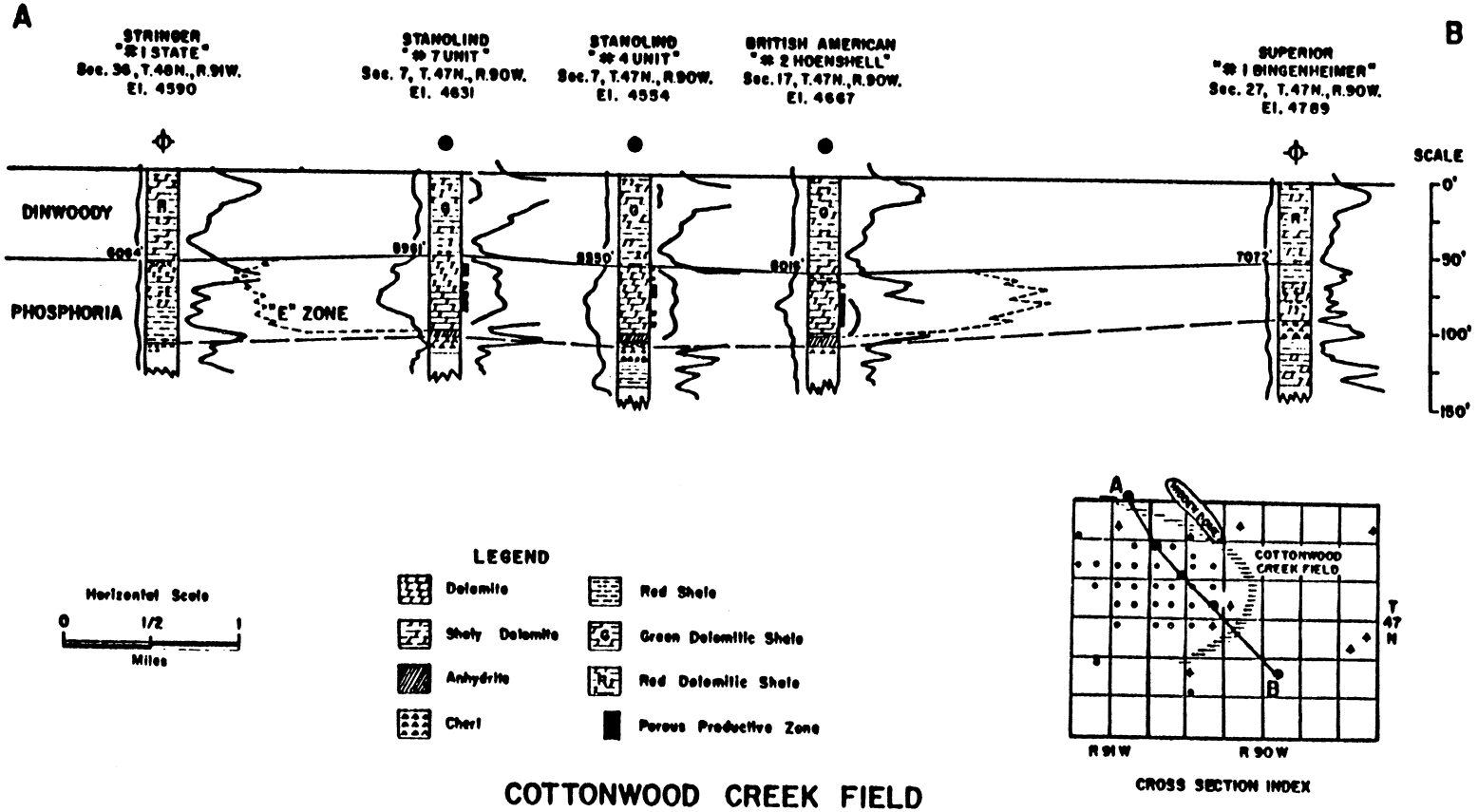


FIG. 4.—West-east correlation of Phosphoria formation (after McCue, 1953).

a 10-foot chert bed are referred to as the "E" zone. The "E" zone is roughly equivalent to the Ervay tongue as used by McCue (1953). The relationship of the Ervay tongue to the rest of the Phosphoria and to the eastward facies change is shown in Figure 4.

Lateral changes only within the "E" zone are considered in this paper. Cross sections through the field (Figs. 5, 6) show the lithologic change from dolomite in the productive part of the field to red shale and anhydrite in the dry holes on the north, east, and southeast edges of the field. The dolomite in the "E" zone is tan to light gray, oölitic, fossiliferous, fractured, stylolitic, and has vuggy porosity.



COTTONWOOD CREEK FIELD
N.W.—S.E. CROSS SECTION

FIG. 5.—Subsurface lithologic cross section showing "E" zone facies change from productive dolomite within field to red shale and anhydrite on north and southeast edges. Datum plane is top of Dinwoody.

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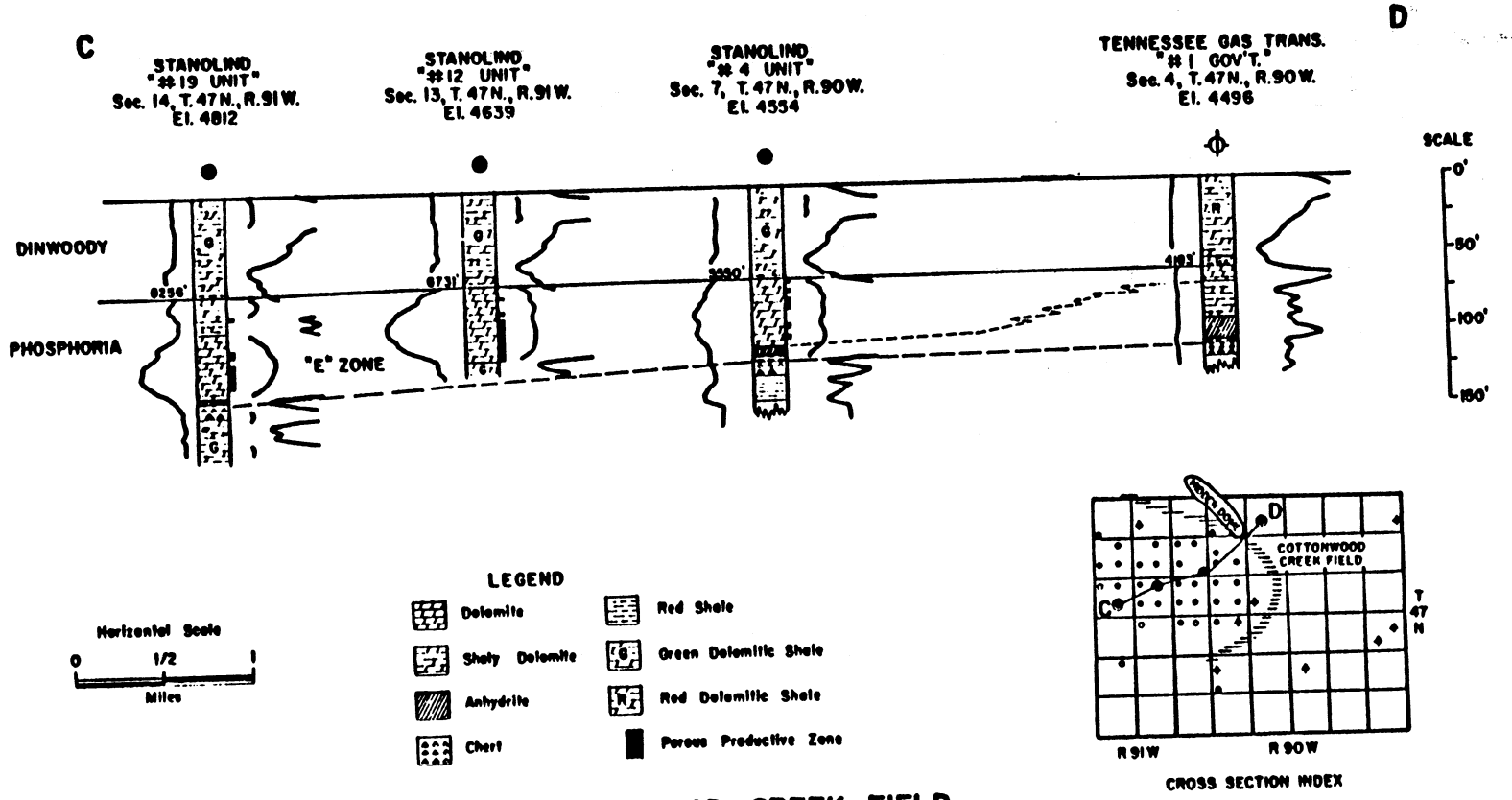
Source 9.



COTTONWOOD CREEK FIELD

S.W.–N.E. CROSS SECTION

FIG. 6.—Subsurface lithologic cross section showing eastward facies change within "E" zone. Datum plane is top of Dinwoody.

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Source 9.

The rocks from the chert down to the Tensleep are mostly red shale, anhydrite, and thin dolomite stringers.

Missing in the Cottonwood Creek area is the basal Phosphoria dolomite unit, the Nowood member of McCue (1953). The Nowood member has an erratic distribution and variable thickness in the southeast part of the Bighorn basin. Late early Permian warping and truncation are believed to have removed this unit in the vicinity of the Cottonwood Creek field.

A diagrammatic cross section (Fig. 7) shows generalized producing zones in Phosphoria fields west of Cottonwood Creek in the Bighorn basin. At the Worland and Slick Creek fields, the upper dolomite unit is approximately 100 feet thick. Porous productive zones are present throughout this unit and are not

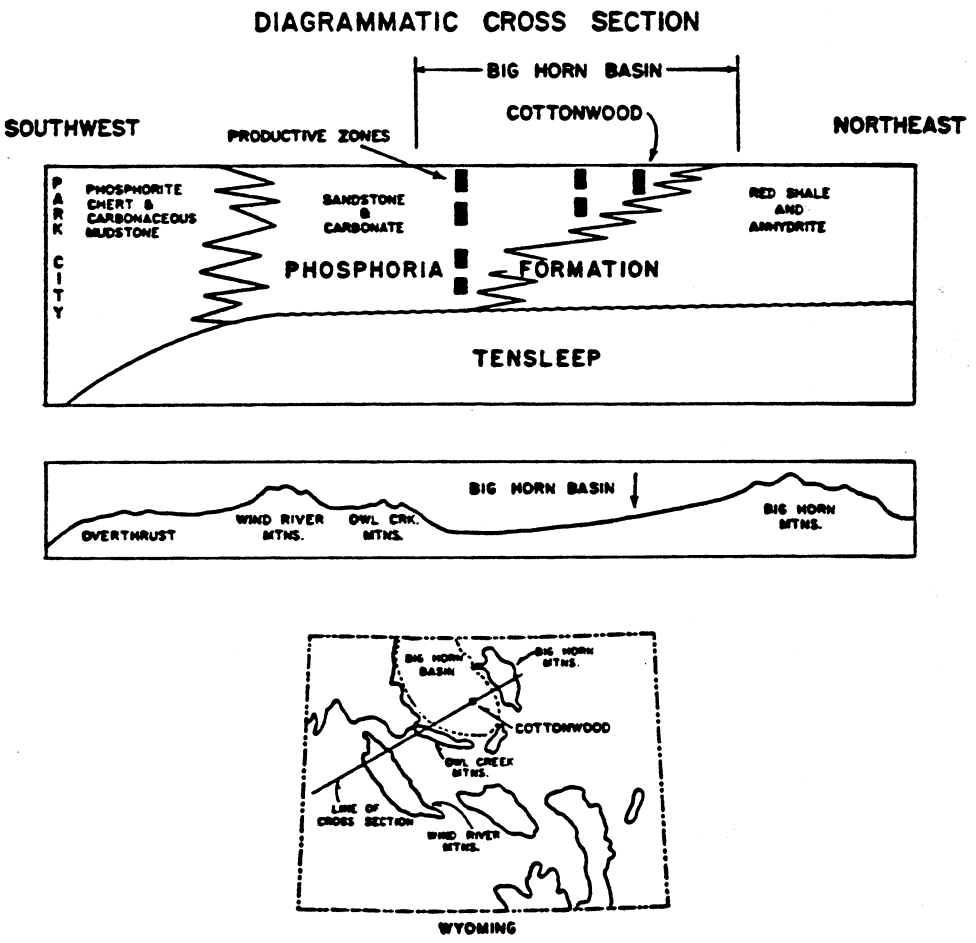

FIG. 7.—Diagrammatic cross section showing generalized facies relationships and producing zones in Phosphoria.

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Source 9.

restricted to any definite interval within the fields. As the dolomite thickens westward, production is developed from different zones throughout the whole section.

PENNSYLVANIAN TENSLEEP

A regional unconformity exists between the Phosphoria and the Tensleep in the Bighorn basin. The Tensleep is composed of white and pink fine- to medium-grained, sub-rounded, porous sandstone with some zones of tight dolomite, shale, or anhydrite. The Tensleep is productive at Hidden Dome on the northeast edge of Cottonwood Creek field and showings of oil in the Tensleep have been reported in many wells in the general area.

REGIONAL PERMIAN SEDIMENTATION

During deposition of the Phosphoria, west-central Wyoming was the site of a large arcuate embayment on a shallow platform that sloped westward into the Cordilleran miogeosyncline paralleling the western edge of Wyoming (Fig. 8).

The Bighorn basin area was emergent during late Pennsylvanian and probably much of early Permian time. With emergence came erosion and truncation of the Tensleep sandstone with redeposition on the southeast as part of the Casper formation (Agatston, 1954). The initial eastward advance of the Permian sea covered all of western and possibly much of eastern Wyoming and deposited a basal dolomite unit named the Nowood member by McCue (1953). Subsequent uplift resulted in truncation of part of the Nowood and underlying Tensleep. Continued fluctuations of the sea resulted in the deposition of siltstone, anhydrite, and red shale in eastern Wyoming, and phosphorite, chert, and carbonaceous mudstone in western Wyoming. Meanwhile the intermediate area was receiving deposits of both carbonate and sandstone.

Throughout most of Phosphoria time, the eastern margin of marine deposition fluctuated within the area of the present Bighorn basin as evidenced by the thick dolomite section on the west side of the basin and the presence of red shale, anhydrite, and thin shaly dolomites on the east side (Figs. 4, 7). The "E" zone was deposited during the final eastward transgression of the Phosphoria sea.

In addition to its lateral facies change across the Bighorn basin, the Phosphoria formation also varies greatly in thickness. As shown by Agatston (1954), the variation in thickness of the Phosphoria is due mainly to the unconformity at the top of the Tensleep. However, local variations in thickness of the "E" zone dolomite are the result of differences in sedimentary environment in the nearshore marine sea. The configuration and slope of the shoreline and the amount and character of material being supplied from near-by sources resulted in lithologic changes parallel with, as well as normal to, the shoreline. It is believed that the Cottonwood Creek field is located near the eastern edge of this marine transgression in an area that was favorable to the formation of reefs.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 41, NO. 5 (MAY, 1957), PP. 823-838, 12 FIGS

Source 9.

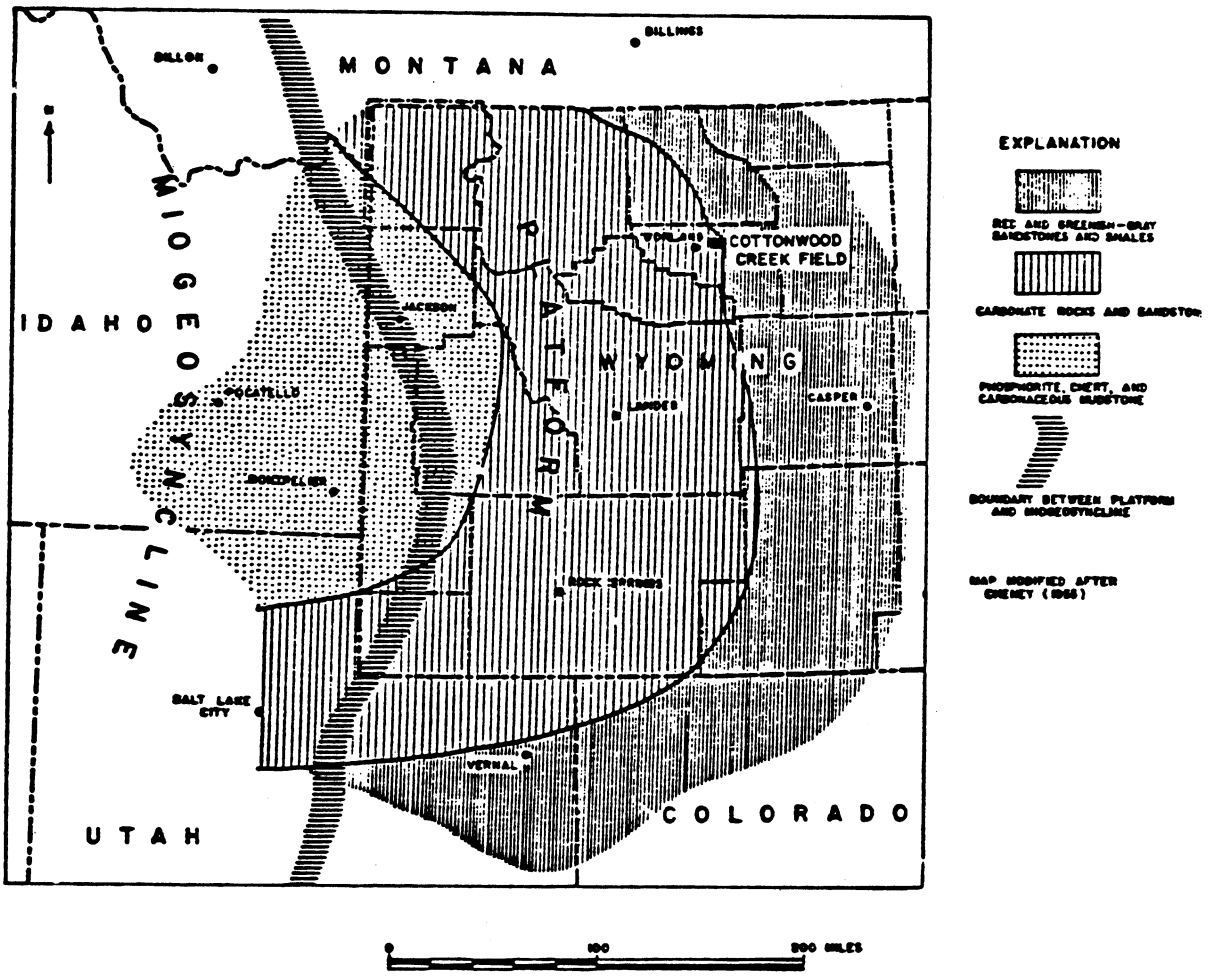

FIG. 8.—Map showing boundary between platform and miogeosyncline, and dominant lithologic character of Phosphoria formation and its correlative parts in parts of Idaho, Wyoming, Utah, and Colorado.

HISTORY OF DISCOVERY

Although the west-to-east facies change along the east side of the Bighorn basin has been generally recognized by geologists, the drilling of Phosphoria tests wells has been restricted to anticlines and faulted noses. Of the many Phosphoria fields in the basin, most are closely associated with structural closure, although it is now believed that some may be partly or wholly stratigraphically controlled. At Manderson (Fig. 9) the Phosphoria discovery well in Sec. 20, T. 50 N., R. 92 W., was drilled on a structural high, but after additional field development it was suspected that accumulation was due in part to the updip facies change from porous dolomite to red shale.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 41, NO. 5 (MAY, 1957), PP. 823-838, 12 FIGS

Source 9.

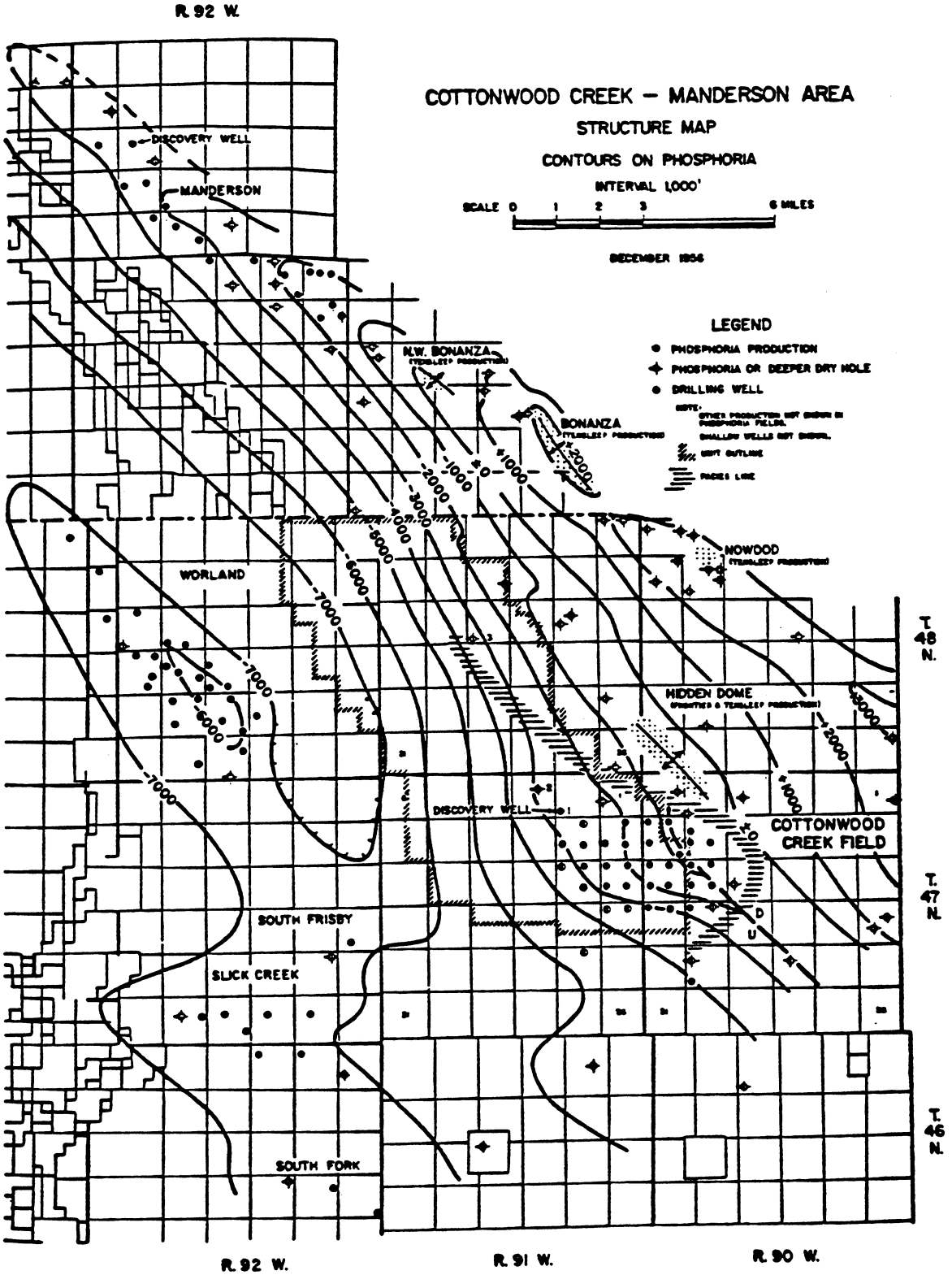

FIG. 9.—Map showing structural relationship of Cottonwood Creek field to other Phosphoria production. Facies line shows dolomite re-entrant at Cottonwood.

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Source 9.

After acquiring leases along a belt downdip from the postulated facies change, the Stanolind Oil and Gas Company formed a federal unit, and in 1953, drilled the discovery well in Sec. 2, T. 47 N., R. 91 W. (Fig. 9). A total dolomite section of 59 feet was obtained by coring. The dolomite was dense with scattered pin-point vugs and stained fractures, the only exception being a 6-foot stained vuggy porous zone near the top and a 4-foot porous zone near the bottom. Analysis of cores showed an average porosity of 3 per cent, and a permeability of less than one millidarcy for the porous intervals. Thirty feet of mud was recovered on a drill-stem test, but after extensive acid and fracture treatment, the well was put on pump for 150 barrels of oil per day.

The Unit No. 2 well, a 160-acre northwest offset, and located 309 feet structurally lower, recovered 50 feet of dolomite with oil stain and vuggy development similar to the Unit No. 1, with the exception that most of the vugs were filled with anhydrite. No oil in commercial quantity was obtained, following very extensive acid and fracture treatments, and the test was abandoned.

The Unit No. 3, located approximately 4 miles northwest in Sec. 16, T. 48 N., R. 91 W., penetrated a thin "E" zone section of shaly dolomite, chert, and red shale, indicating that the well had been drilled on the east side of the facies line.

Stratigraphic studies of the Phosphoria on the east side of the Bighorn basin showed that the development of porosity within the "E" zone was erratic, and no ready answer could be advanced to explain porosity development or predict where it could be found. The porous dolomite contained faint fossil outlines, vugs that appeared to be fossil casts, and in general gave an impression that the rock was a reef or some form of organic accumulation.

Subsurface studies in the Hidden Dome area showed the presence of a possible eastward re-entrant of the dolomite facies just south of Hidden Dome field. Meanwhile, pressure decline in the Unit No. 1 well was relatively small indicating that the thin porous zones in the well were near the wedge edge of a much better reservoir.

The drilling of the Unit No. 4 well in the SE. $\frac{1}{4}$ of Sec. 7, T. 47 N., R. 90 W. (Fig. 10), revealed the presence of an eastward dolomite re-entrant and a better developed producing section than had been found in the Unit No. 1 well. The Unit No. 4 well with 27 feet of porous dolomite flowed at the rate of 956 barrels of oil per day on initial production tests.

CHARACTER OF PRODUCING SECTION

Thickness of the "E" zone dolomite in the producing wells at the Cottonwood Creek field ranges from 30 to 95 feet and the net porous dolomite varies from a few feet to maximum of 74 feet. The dolomite in the "E" zone is tan to light gray, fine to micro-crystalline, oölitic, fossiliferous, fractured, stylolitic, with pin-point to coarse vuggy porosity (Figs. 11, 12). In some zones, the vugs appear to be the result of secondary leaching of primary fossil voids. Most of the vugs are lined with crystalline anhydrite, dolomite, or calcite; others are entirely anhydrite

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 41, NO. 5 (MAY, 1957), PP. 823-838, 12 FIGS

Source 9.

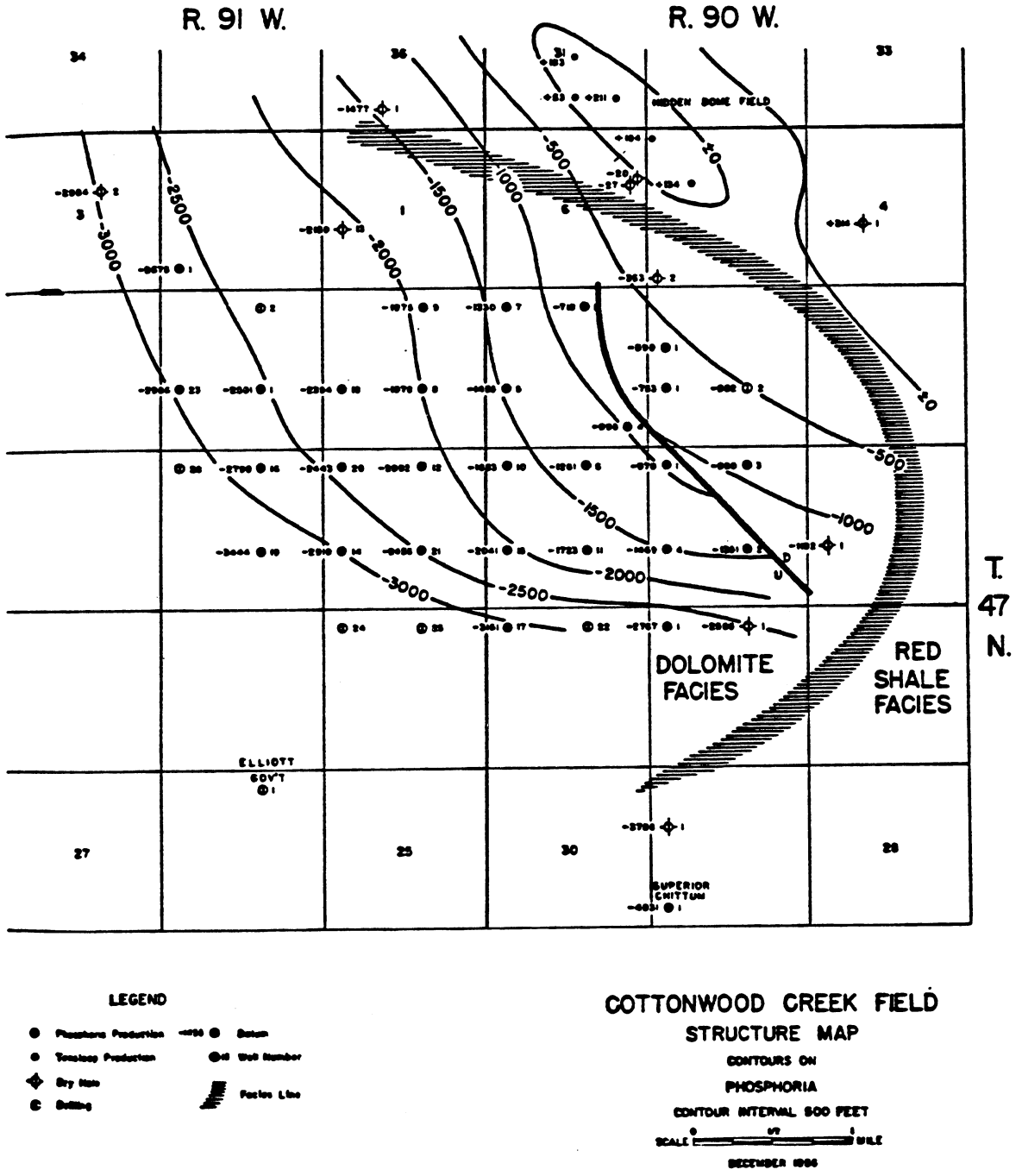

FIG. 10.—Phosphoria structure map of Cottonwood Creek field.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 41, NO. 5 (MAY, 1957), PP. 823-838, 12 FIGS
Source 9.

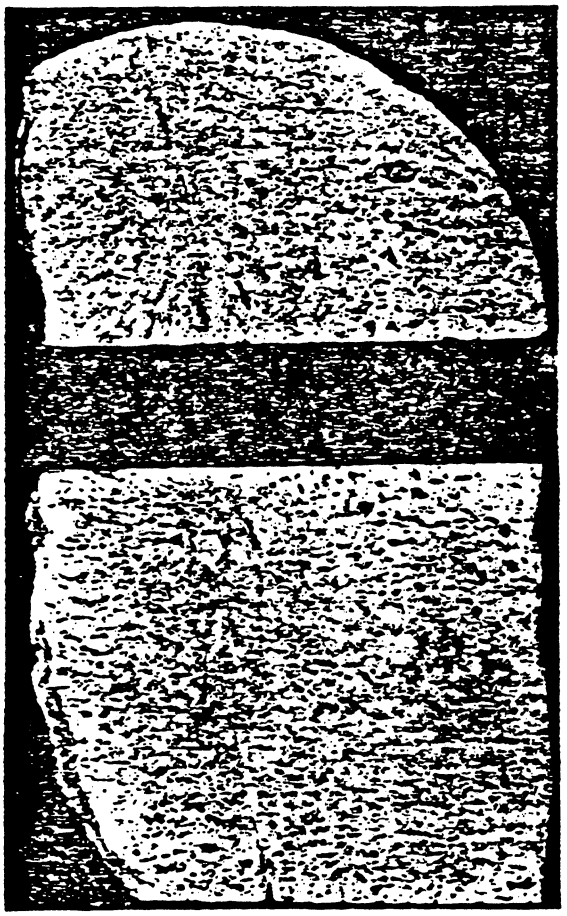

FIG. 11.—Polished core section of "E" zone dolomite (top and front views, natural size). Example of good productive vuggy dolomite. Light-colored area along fracture in upper part of front view is anhydrite. Small light-colored circular spots in lower left corner of front view are oölites. Dark areas in both views are open vugs. Small gray areas in lower part of front view are anhydrite-filled vugs. Unit 19; depth 8,303 feet; dip 10°–15°.

filled. Some of the rock is composed almost entirely of fossil debris with primary fossil void porosity. Carbonate pellets or oölites are present throughout the producing section but in general they are more commonly associated with zones of better vuggy development. Concentric rings were noted in only a few of the larger pellets. Stylolites are found throughout the section but are more numerous in the porous zones. Thin, 1–6-inch streaks of green shale have been noted in many of the less porous intervals. Stained vertical and diagonal fractures are present throughout much of the section.

Although some of the evidence presented seems to support the idea that a reef exists at Cottonwood Creek, the writer feels that additional detailed study

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Source 9.

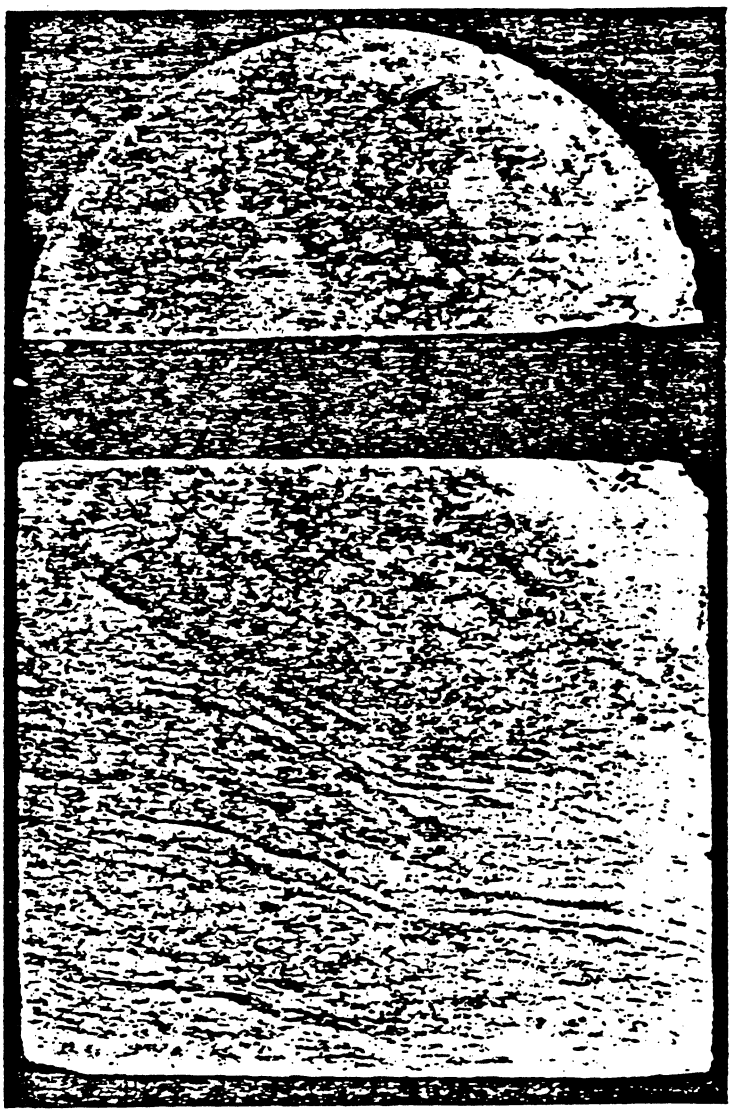

FIG. 12.—Polished core section of "E" zone dolomite (top and front views, natural size). Example of less porous zone showing scattered pin-point and larger vugs, stylolites, and hair-line fractures. Well developed bedding plane stylolite is present in upper right corner of front view and right side of top view. Some dark lines in lower part of front view are poorly developed stylolites. Light-colored hairline fractures shown in top view are believed to be result of differential pressures created in rock during solution along stylolitic planes. Dark area is oil stain. Unit 19; depth 8,288 feet; dip 10°–15°.

is necessary to definitely establish the presence of a reef. Therefore, the intention is to present a brief chronological picture of the exploratory thinking involved in the discovery of the field.

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Source 9.

RESERVOIR DATA

The Cottonwood Creek field is believed to be a volumetric reservoir with solution gas drive as the producing mechanism. The original bottom-hole pressure at minus 1,450 feet datum was 3,331 psia with a gas-oil ratio of approximately 452 cubic feet per barrel of oil. Initial bottom-hole pressures on new wells fall on the pressure decline trend of older wells, thereby indicating that all wells are producing from the same common source of supply. The oil has an API gravity of 30.2° with 2.7 per cent sulphur. The production for all wells in the field is approximately 10,000 barrels of oil per day at the present time, or an average production of 357 barrels of oil per day per well. Drilling has established a productive oil column of 2,854 feet (Fig. 10).

DRILLING AND COMPLETION PROCEDURE

Drilling depth through the pay zone in the field ranges from 5,000 feet for wells on the east end of the field to 8,500 feet for currently drilling wells on the west edge. Rig time to drill and complete averages 30 days on the shallower wells, and 50 days on the deeper wells. At least 200 feet of surface casing is normally set and 5½-inch oil string is cemented through the pay section and selectively perforated opposite the porous zones.

Flowing wells are obtained following acidization with 2,000–5,000 gallons of 15 per cent hydrochloric acid.

PRODUCTION DATA

Cumulative oil production in the Cottonwood Creek field on January 1, 1956, totaled 130,886 barrels. Cumulative oil production on January 1, 1957, totaled 1,881,210 barrels. Field production for the month of December, 1956, was 316,215 barrels.

CONCLUSIONS

The intensified search for stratigraphic traps brings with it the need for some changes in exploratory methods and thinking. A regional reconstruction of environmental conditions during sedimentation is required to localize possible areas of interest. Proper evaluation of those localized areas for the existence of oil or gas accumulation usually requires the drilling of more than one well. Continuous subsurface studies before, during, and after drilling are vital in the search for stratigraphic traps.

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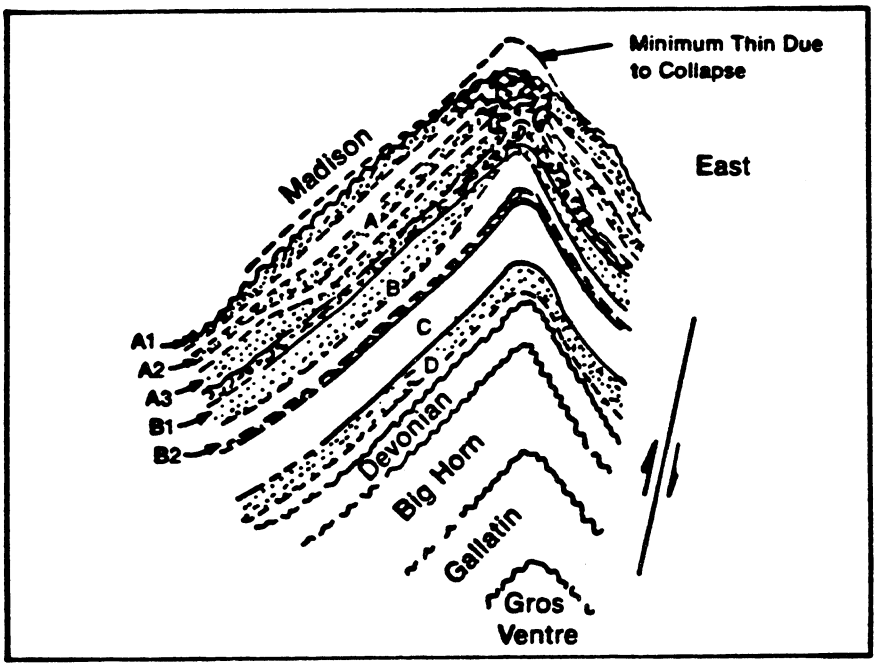


Fig. 15–19 Cross-section of Elk Basin field, showing four different zones in Madison reservoir *(From Wayhan and McCaleb, 1968 Copyright Society of Petroleum Engineers)*

that water was being pumped into portions of the reservoir where there was no outlet. The peripheral water wells on the west flank had accomplished nothing because the B and D zones already had a good natural water drive. The injected water was not entering the A zone because of its poor lateral permeability.

Cottonwood Creek. The Cottonwood Creek field in Wyoming was discovered in 1953 and was developed with 80 producing wells on 14,200 acres (McCaleb and Willingham, 1967). It is on the west flank of an anticline, and trapping is stratigraphic against an up-dip facies change in the Permian Phosphoria formation. Up-structure gas injection was started in 1958, and the gas almost immediately appeared in the producing wells, Figure 15–20. Water was injected in up-structure wells in 1959 and in mid-structure wells in 1962. This water also broke through quickly, Figure 15–21.

Review of the geology showed that three main lithologic types of rock composed the reservoir. Area I has good pay thickness and good

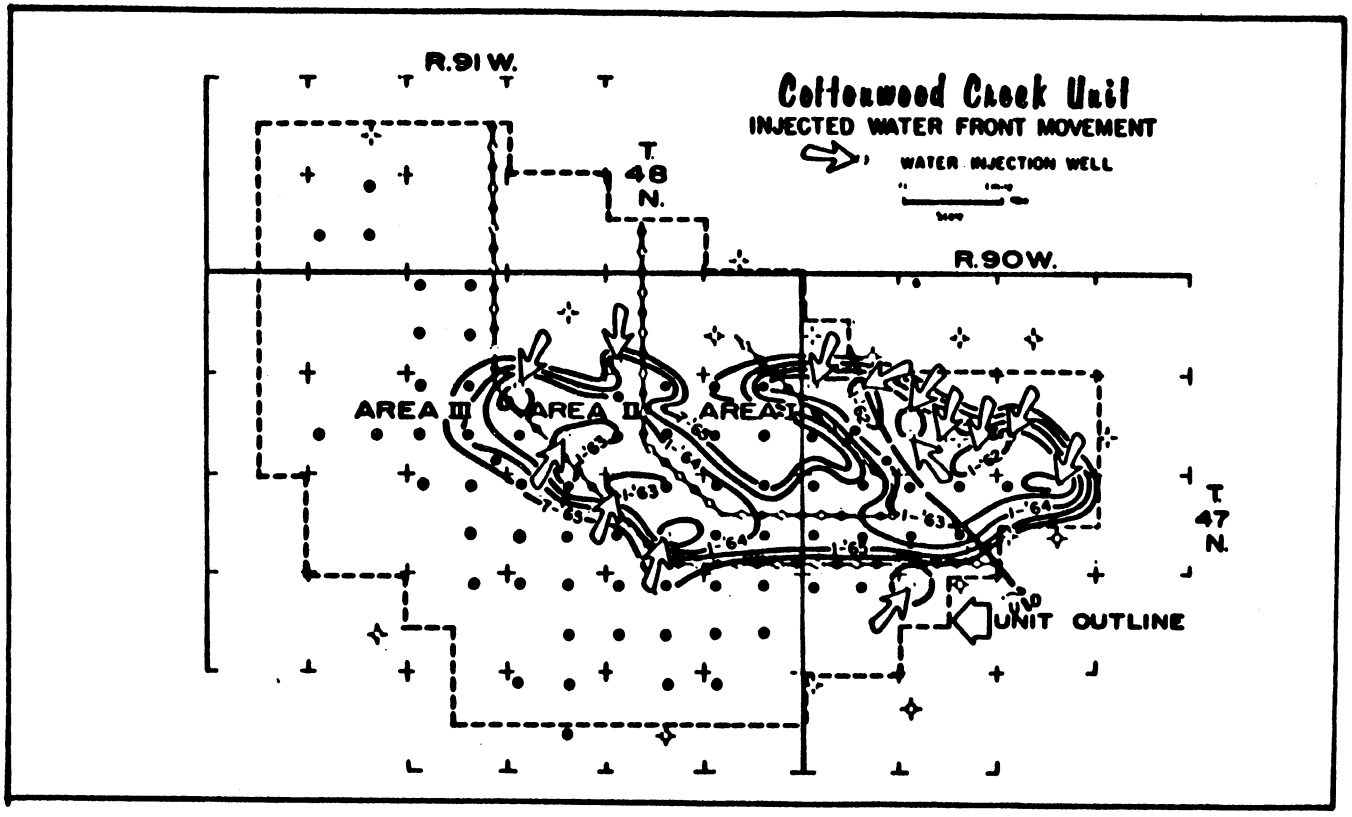


Fig. 15-21 Map showing movement of injected water in upstructure wells (NE) and downstructure wells (SW) *(From Willingham and McCaleb, 1968, Copyright Society of Petroleum Engineers)*

From: PETROLEUM DEVELOPMENT GEOLOGY, 1979, by Parke A. Dickey, Source 12.

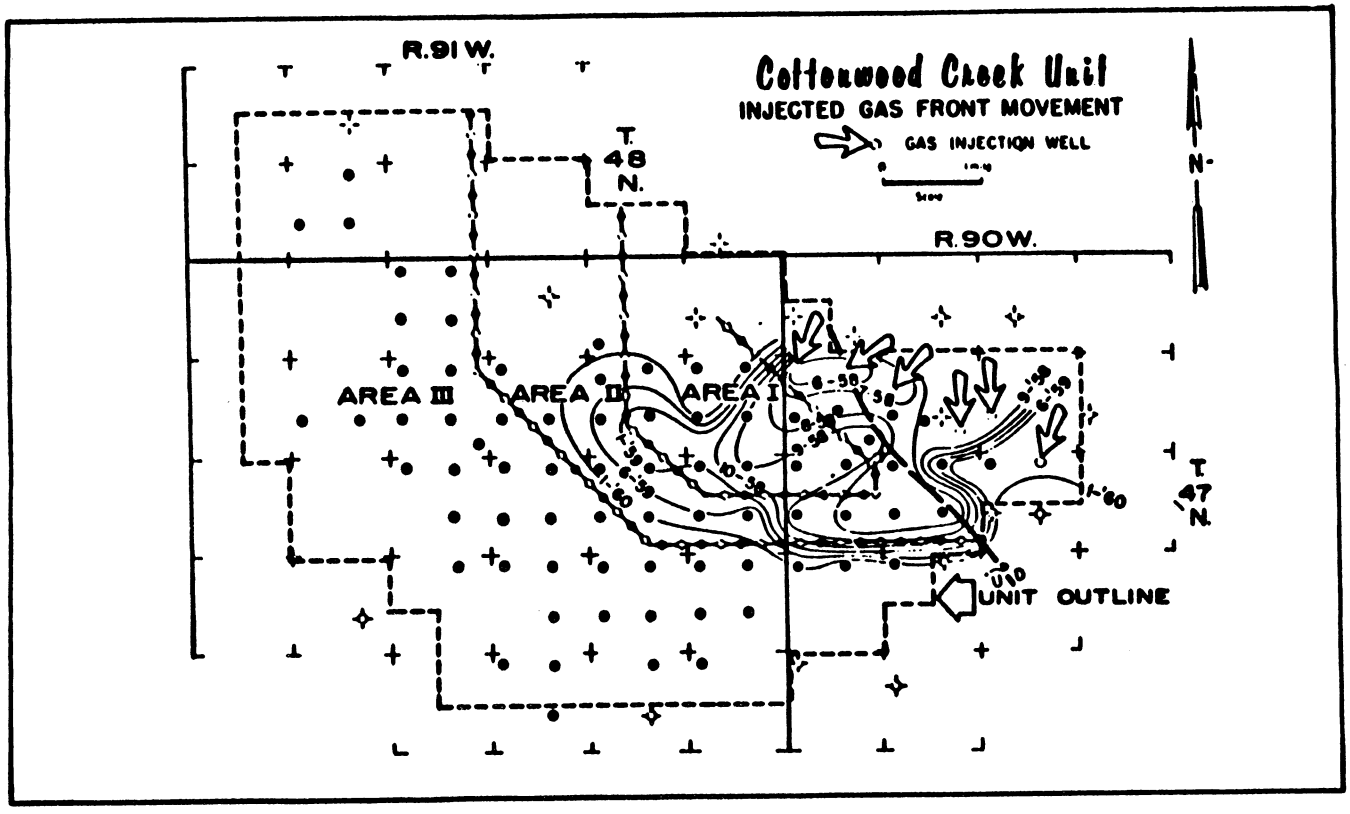


Fig. 15-20 Map showing irregular movement of gas from upstructure wells, Cottonwood Creek, Wyoming *(From Willingham and McCaleb, 1968, Copyright Society of Petroleum Engineers)*

From: PETROLEUM DEVELOPMENT GEOLOGY, 1979, by Parke A. Dickey, Source 12.

porosity. Oil can be obtained here by water flooding. Area II, has similar good porosity, but it is extensively fractured. Here the initial production rates were the highest in the field, but when water was injected, it simply went through the fractures. When water injection was stopped in 1966, the water injection wells back-flowed 100 percent water at first. After a few months, eight former injection wells were producing 1,050 bbl/d of oil and 2,900 water.

Area III is relatively unfractured, fine-grained dolomite with low porosity and permeability. Rapid breakthrough of water did not occur, and water-flooding appears to be successful.

Burbank, Oklahoma. The Burbank field in Osage County, Oklahoma, is a large stratigraphic trap discovered in 1920. By 1950 it had produced 221,000,000 bbl (35×10^6 cu m) from the Pennsylvanian Burbank sand at a depth of about 3,000 ft (1,000 m). It had operated under dissolved gas drive and it was estimated that it had produced only 25 percent of the original oil in place. A pilot flood was started in 1950 consisting of nine injection wells and four producing wells on a 5-spot pattern. Water was injected into the pilot flood at pressures equal to or less than hydrostatic (less than 0.433 psi per ft). Production increased from 37 to 1,000 bbl/d by January, 1951. Elated by their success the operators began work immediately on a thousand-acre extension.

However, right from the beginning, one well (127–6) produced with a high water-oil ratio. Uranine dye was injected into the nearest injection well, and it was detected in wells to the NE and SW in a few days, indicating that open fractures existed. As development proceeded the water production problems grew worse. In spite of a good water supply the intake rate declined as a result of plugging. Pressures were increased gradually to 600 psi, and at 300 psi surface pressure the rate of injection increased sharply. It was supposed that the plugging problem was solved, but actually what happened was that the fractures were opened, Figure 15–22.

Cores of the Burbank sand showed vertical fractures, probably joints. There were several cases of lost circulation in the shale immediately above the sand. Wells in the Stanley Stringer, a separate reservoir at the same horizon but a mile to the east started to produce large amounts of water. The water also travelled westward to the Little Chief pool. The water never travelled north or south.

Evidence from the behavior of the wells and the tracer tests suggested that the fractures were oriented east-west, and belonged to a joint system. The joints are very well developed in the hard limestones and sandstones at their surface outcrop and they are visible both on the ground and from the air as seen in Figure 15–23. The average direction of

From: PETROLEUM DEVELOPMENT GEOLOGY, 1979, by Parke A. Dickey, Source 12.

Wyoming - Frisby, South
Phosphoria
Big Horn

DATA SOURCE CODE		
	STATE	Wyoming
2c	COUNTY	Washakie
	REGULATORY DISTRICT	
	BASIN	Big Horn
	SUB-BASIN	
2c	FIELD	South Frisby
2c	RESERVOIR	Phosphoria limestone
2c	GEOLOGIC AGE	Permian
	AAPG STRATIGRAPHIC AGE CODE	
2c	RESERVOIR LITHOLOGY	Limestone
2c	TRAPPING MECHANISM	Dome
2c,2b	DISCOVERY YEAR	1949
11	PROVED ACREAGE	640
	REGULAR WELL SPACING (acres/well)	
2c,2b	RESERVOIR DEPTH	10,580; 10,575
	RESERVOIR THICKNESS	
2c	NET PAY	85
	GROSS	
	NET/GROSS RATIO	
	POROSITY	
2c	TYPE	"tight"
	FRACTION	
	PERMEABILITY	
	RANGE	
	AVERAGE	
	HORIZONTAL	
	VERTICAL	
	OTHER INFORMATION	
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2d	TOTAL NUMBER OF WELLS	15P
	PRODUCTION 1976 oil (cum)	
	PRODUCTION 1977 oil (cum)	
	PRODUCTION 1978 oil (cum)	
2d	PRODUCTION 1979 oil (cum)	1,356.9 mbbls oil; 740.1 mmcf gas
2d	PRODUCTION 1-1-79 to 1-1-80	250.9 mbbls oil; 74.1 mmcf gas
	SECONDARY RECOVERY RECORDS?	no
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
2c	STRUCTURE CONTOUR?	no (field map with Slick Creek field)
	LOGS?	no
	STRUCTURE SECTION?	no
	ENGINEERING REPORTS?	no
	CORE DESCRIPTIONS?	no
2c	CRUDE ANALYSIS?	yes

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	South Frisby
2c	RESERVOIR:	Phosphoria
11	PROD. ACRES:	640
2c	AVG. THICKNESS (FT.):	85
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
	PRIMARY DRIVE MECHANISM:	
	PRIMARY GAS CAP?:	
11	TEMPERATURE (^oF):	228
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
	RESERVOIR PRESSURE INITIAL (psi):	
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
2c	STOCK TANK OIL GRAVITY (^oAPI):	30 - 32.1
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	
	OTHER INFORMATION:	

TABLE 12.—*Crude-oil analyses*—Continued

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..Laramie.. Laboratory
Sample ..PC-50-737..

IDENTIFICATION

South Frisby field
Phosphoria limestone - Permian
10,580 - 10,665 feet

Wyoming
Washakie County
SE¼SW¼ sec. 24,
T. 47 N., R. 92 W.

GENERAL CHARACTERISTICS

Gravity, specific, ..0.869.. Gravity, ° API, ..32.1°.. Pour point, ° F., ..below 5..
Sulfur, percent, ..1.82.. Color, ..brownish black..
Viscosity, Saybolt Universal at ..100° F.. 46 seconds Nitrogen, percent, ..0.14..

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, ..760.. mm. Hg
First drop, ..77.. ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	122	1.5	1.5	0.650	86.2					
2	167	2.3	3.8	.665	81.3	5.1	1.37337	123.8		
3	312	3.6	7.4	.706	68.9	15	1.39380	125.6		
4	387	4.4	11.8	.737	60.5	20	1.41024	136.2		
5	392	5.5	17.3	.764	53.7	26	1.42579	145.9		
6	447	5.2	22.5	.786	48.5	29	1.43737	149.4		
7	392	4.7	27.2	.800	45.4	30	1.44442	147.0		
8	437	4.5	31.7	.813	42.5	30	1.44993	142.5		
9	482	5.4	37.1	.827	39.6	31	1.45692	145.7		
10	527	6.6	43.7	.844	36.1	35	1.46646	151.8		

STAGE 2—Distillation continued at 40 mm. Hg

11	392	2.1	45.8	0.867	31.7	42			41	5
12	437	8.2	54.0	.875	30.2	42			45	20
13	482	6.5	60.5	.891	27.3	46			57	40
14	527	5.3	65.8	.911	23.8	52			84	55
15	572	6.1	71.9	.921	22.1	54			150	75
Residuum		26.5	98.4	.985	12.1					

Carbon residue, Conradson: Residuum, 11.5 percent; crude, 3.5 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	7.4	0.682	76.0	
Total gasoline and naphtha	27.2	.748	57.7	
Kerosine distillate	4.5	.813	42.5	
Gas oil	21.5	.853	34.4	
Nonviscous lubricating distillate	11.3	.882-.914	28.9-23.3	80-100
Medium lubricating distillate	7.4	.914-.926	23.3-21.3	100-200
Viscous lubricating distillate	.0			Above 200
Residuum	26.5	.985	12.1	
Distillation loss	1.6			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..Laramie.. Laboratory
Sample ..PC-50-633..

IDENTIFICATION

Spence Dome field
Madison limestone - Mississippian
434 - 470 feet

Wyoming
Big Horn County
S½S½ sec. 4,
T. 54 N., R. 94 W.

GENERAL CHARACTERISTICS

Gravity, specific, ..0.943.. Gravity, ° API, ..18.5°.. Pour point, ° F., ..below 5..
Sulfur, percent, ..3.13.. Color, ..brownish black..
Viscosity, Saybolt Universal at 100° F., 580 sec. at 130° F., 280 sec. Nitrogen, percent, ..0.30..

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, ..760.. mm. Hg
First drop, ..162.. ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	122									
2	167									
3	312	3.9	3.9	0.745	58.4	33	1.41383	129.4		
4	387	.7	4.6							
5	392	.5	5.1	.782	49.4		1.43243	132.3		
6	447	.0	5.1							
7	392	1.8	6.9	.798	45.8	29	1.44032	133.0		
8	437	3.1	10.0	.815	42.1	31	1.44891	132.7		
9	482	4.7	14.7	.834	38.2	35	1.45852	140.1		
10	527	7.1	21.8	.854	34.2	40	1.47025	147.8		

STAGE 2—Distillation continued at 40 mm. Hg

11	392	.8	22.6	0.874	30.4	45			42	below 5
12	437	5.3	27.9	.884	28.6	46			47	below 5
13	482	6.8	34.7	.896	26.4	48			59	20
14	527	6.0	40.7	.911	23.8	52			88	35
15	572	8.3	49.0	.932	20.3	59			175	50
Residuum		48.9	97.9	1.015	7.9					

Carbon residue, Conradson: Residuum, 17.8 percent; crude, 9.4 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	3.9	0.745	58.4	
Total gasoline and naphtha	6.9	.765	53.5	
Kerosine distillate	3.1	.815	42.1	
Gas oil	16.7	.856	33.8	
Nonviscous lubricating distillate	12.0	.887-.914	28.0-23.3	80-100
Medium lubricating distillate	8.1	.914-.939	23.3-19.2	100-200
Viscous lubricating distillate	2.2	.939-.945	19.2-18.2	Above 200
Residuum	48.9	1.015	7.9	
Distillation loss	2.1			

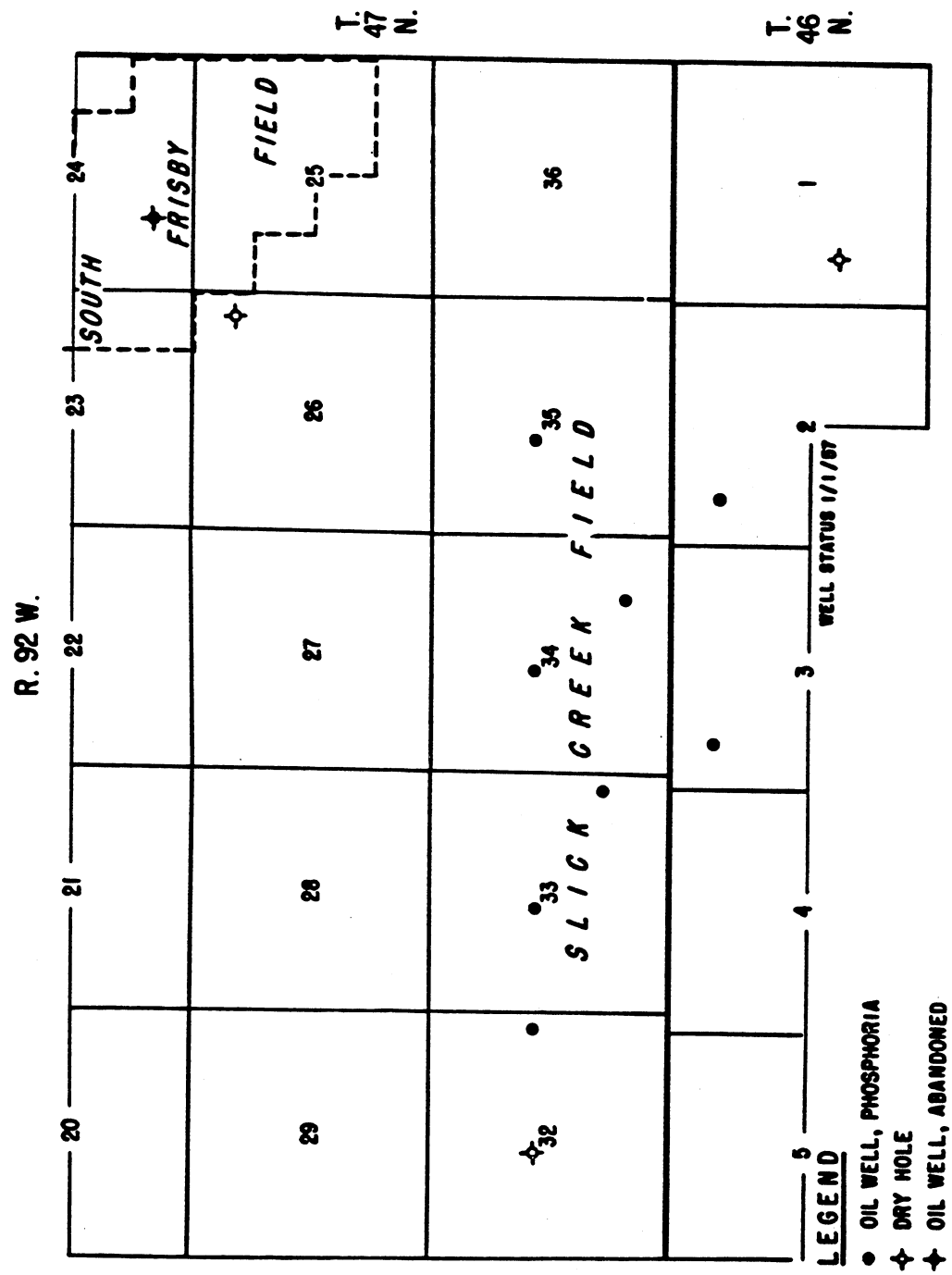


Figure 150.—Map of Slick Creek and South Frisby Fields, Washakie County, Wyo.

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

Wyoming - Gebo
Phosphoria - Embar
Big Horn Basin

DATA SOURCE CODE		
	STATE	Wyoming
2c	COUNTY	Hot Springs
	REGULATORY DISTRICT	
	BASIN	Big Horn
	SUB-BASIN	
2c	FIELD	Gebo
2c	RESERVOIR	Phosphoria - Embar
2c	GEOLOGIC AGE	Permian
	AAPG STRATIGRAPHIC AGE CODE	
2c	RESERVOIR LITHOLOGY	Limestone
2c	TRAPPING MECHANISM	Anticline
2c,2b	DISCOVERY YEAR	1943
11	PROVED ACREAGE	1280-2560 (from 2c structure contour map)
	REGULAR WELL SPACING (acres/well)	
2b	RESERVOIR DEPTH	4700
	RESERVOIR THICKNESS	
2c	NET PAY	30
2c	GROSS	276
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
	FRACTION	
	PERMEABILITY	
	RANGE	
	AVERAGE	
	HORIZONTAL	
	VERTICAL	
2c	OTHER INFORMATION	Other production from Tensleep
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2d	TOTAL NUMBER OF WELLS	51P
	PRODUCTION 1976 oil (cum)	
	PRODUCTION 1977 oil (cum)	
	PRODUCTION 1978 oil (cum)	
2d	PRODUCTION 1979 oil (cum)	24,645.0 mbbls oil; 825.5 mmcf gas
2d	PRODUCTION 1-1-79 to 1-1-80	559.2 mbbls oil; 18.6 mmcf gas
	SECONDARY RECOVERY RECORDS?	
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
2c	STRUCTURE CONTOUR?	yes
	LOGS?	
	STRUCTURE SECTION?	
	ENGINEERING REPORTS?	
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
2c	FIELD:	Gebo
	RESERVOIR:	Phosphoria
11	PROD. ACRES:	1280-2560
2c	AVG. THICKNESS (FT.):	30
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
	PRIMARY DRIVE MECHANISM:	
	PRIMARY GAS CAP?:	
2c	TEMPERATURE (°F):	140
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
2c	RESERVOIR PRESSURE INITIAL (psi):	2223
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
2c	STOCK TANK OIL GRAVITY (°API):	28.4 - 29.5
2c	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	65 sec. SU
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	
14	ESTIMATED ULTIMATE RECOVERY:	25,000 mbbls
	OTHER INFORMATION:	

Water Analysis: Gebo-Embar (in parts per million)

Na & K	3,897
Ca	380
Mg	71
SO4	5,720
Cl	1,980
CO_3	-0-
HCO_3	1,185
Total solids	12,631
Primary salinity	87.24%
Secondary salinity	2.78%
Secondary alkalinity	9.98%

TABLE 12.—*Crude-oil analyses*—Continued

CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-50-627

IDENTIFICATION

Garland, South field
Frontier sandstone - Upper Cretaceous
3,225 - 3,285 feet

Wyoming
Big Horn County
C lot 43-C sec. 15,
T. 55 N., R. 97 W.

GENERAL CHARACTERISTICS

Gravity, specific, 0.783 Gravity, ° API, 49.2° Pour point, ° F., below 5
Sulfur, percent, 0.04 Color, NPA 4
Viscosity, Saybolt Universal at 100° F., less than 32 sec. Nitrogen, percent, 0.005

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Grade 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 77 ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	122	2.8	2.8	0.645	87.9		1.37275	129.7		
2	167	5.1	7.9	.674	78.4	9.4	1.37845	124.1		
3	312	12.9	20.8	.725	63.7	24	1.40101	126.8		
4	367	17.4	38.2	.753	56.4	28	1.41632	134.4		
5	392	11.4	49.6	.776	50.9	31	1.43018	144.5		
6	347	8.7	58.3	.791	47.4	32	1.43926	149.2		
7	392	6.4	64.7	.803	44.7	31	1.44564	147.2		
8	437	4.6	69.3	.814	42.3	31	1.45078	146.6		
9	482	4.6	73.9	.826	39.8	31	1.45787	149.9		
10	527	5.2	79.1	.838	37.4	32	1.46532	156.3		

Grade 2—Distillation continued at 40 mm. Hg

11	302	3.5	82.6	0.851	34.8	34				38	15
12	347	3.8	86.4	.853	34.4	31				43	35
13	392	3.1	89.5	.859	33.2	31				51	55
14	437	2.2	91.7	.871	31.0	33				65	75
15	473	2.8	94.5	.880	29.3	35				100	90
Residuum		4.4	98.9	.913	23.5						

Carbon residue, Conradson: Residuum, 1.2 percent; crude, .1 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	20.8	0.702	70.1	
Total gasoline and naphtha	64.7	.751	56.9	
Kerosine distillate	4.6	.814	42.3	
Gas oil	18.1	.842	36.6	
Nonviscous lubricating distillate	5.7	.858-.880	33.4-29.3	50-100
Medium lubricating distillate	1.4	.880-.885	29.3-28.4	100-200
Viscous lubricating distillate	0			Above 200
Residuum	4.4	.913	23.5	
Distillation loss	1.1			

CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-50-702

IDENTIFICATION

Gebo field
Phosphoria limestone - Permian
4,558 - 4,598 feet

Wyoming
Hot Springs County
NW¼SE¼ sec. 23,
T. 44 N., R. 95 W.

GENERAL CHARACTERISTICS

Gravity, specific, 0.885 Gravity, ° API, 28.4° Pour point, ° F., 5
Sulfur, percent, 1.83 Color, brownish black
Viscosity, Saybolt Universal at 100° F., 65 sec. at 77° F., 84 sec. Nitrogen, percent, 0.20

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Grade 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 90 ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	122	0.5	0.5							
2	167	1.6	2.1	0.672	79.1		1.37802	126.2		
3	312	2.4	4.5	.675	78.1	0.0	1.39534	133.7		
4	357	1.9	6.4	.731	62.1	18	1.40688	128.4		
5	392	2.0	8.4	.748	57.7	18	1.41547	130.7		
6	347	3.8	12.2	.767	53.0	20	1.42585	135.8		
7	392	3.7	15.9	.786	48.5	23	1.43602	137.5		
8	437	4.9	20.8	.804	44.5	26	1.44514	138.5		
9	482	5.3	26.1	.820	41.1	28	1.45386	142.2		
10	527	7.3	33.4	.838	37.4	32	1.46445	152.5		

Grade 2—Distillation continued at 40 mm. Hg

11	302	1.8	35.2	0.870	31.1	43				40	5
12	347	7.8	43.0	.868	31.5	38				44	20
13	392	7.5	50.5	.880	29.3	41				55	35
14	437	6.8	57.3	.899	25.9	47				80	60
15	473	7.4	64.7	.914	23.3	51				140	75
Residuum		34.6	99.3	.980	12.9						

Carbon residue, Conradson: Residuum, 11.0 percent; crude, 4.2 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	4.5	0.674	78.4	
Total gasoline and naphtha	15.9	.738	60.2	
Kerosine distillate	10.2	.812	42.8	
Gas oil	17.3	.857	33.6	
Nonviscous lubricating distillate	12.9	.875-.904	30.2-25.0	50-100
Medium lubricating distillate	8.4	.904-.922	25.0-22.0	100-200
Viscous lubricating distillate	0			Above 200
Residuum	34.6	.980	12.9	
Distillation loss	.7			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

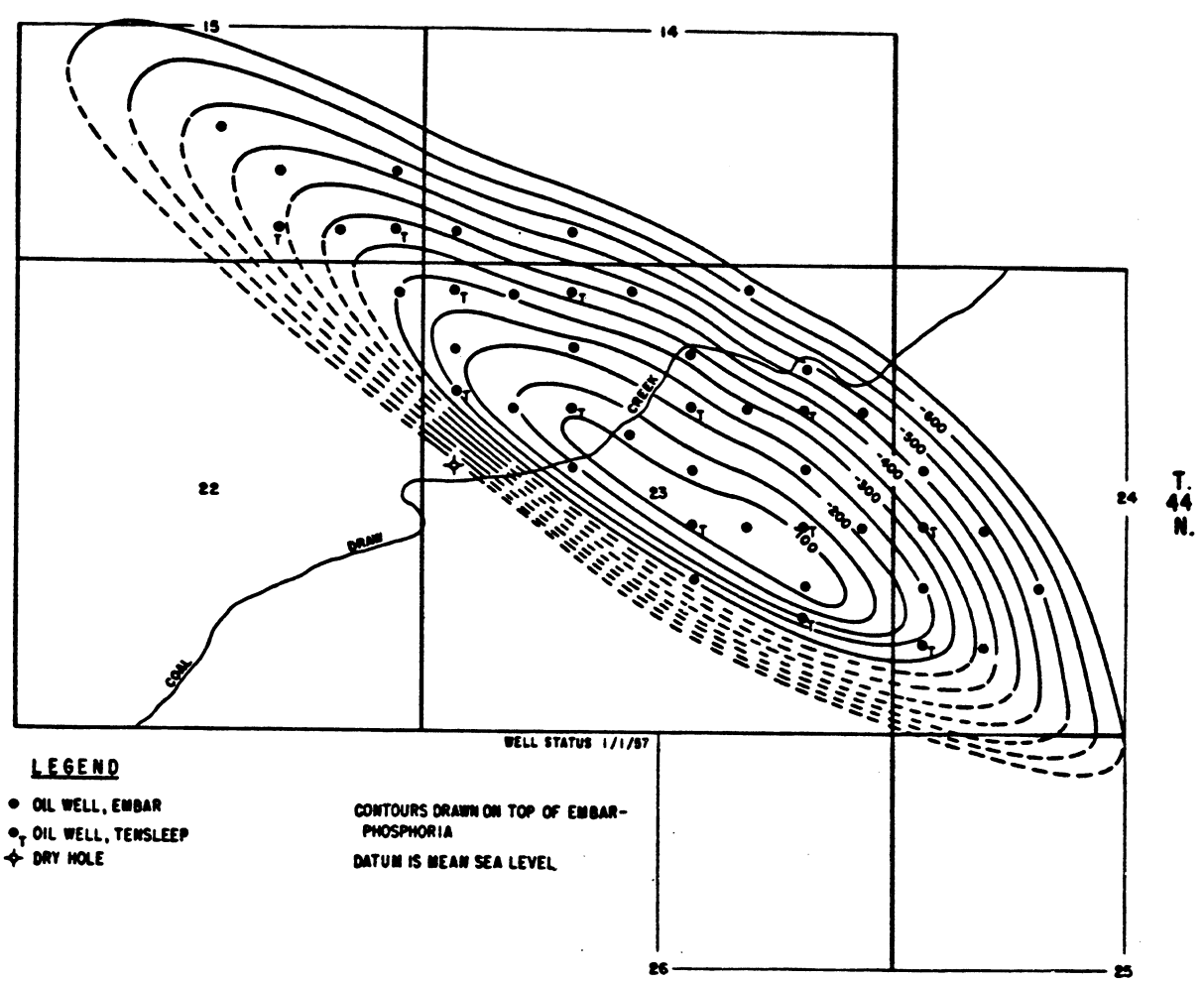


FIGURE 69.—Structure-Contour Map of Gebo Field, Hot Springs County, Wyo.

sandstone. The daily production was 1,700 barrels of oil and 6,800 barrels of water from the Embar and 1,334 barrels of oil and 2,178 barrels of water from the Tensleep. In 1956, 1,340,560 barrels of oil was produced at the Gebo field, which brought the cumulative oil production to 7,999,513 barrels. Analyses of oil from the Embar and Tensleep, gas from the Tensleep, and water from the Curtis, Embar, and Tensleep are given on pages 384 and 385 and in tables 8 and 9 (pp. 288 and 294, respectively).

The oil from the field is piped to Kirby, Wyo., where the line joins the Elk Basin-Casper pipeline. The field was unitized on September 1, 1943.

GLENROCK

The Glenrock oilfield (fig. 70) is in secs. 4 and 5, T. 33 N., R. 75 W., and secs. 32 and 33, T. 34 N., R. 75 W., Converse County. The field is about 4 miles east of the northeast tip of the Big Muddy oil field. Data collected during the drilling of wells indicated that the structure is a stratigraphic trap. The Muddy sand is shown to be very lenticular. An example of this lenticularity was apparent in the first two wells drilled in the field; the first well was completed in the Muddy sand, but the same sand was missing in the second well, about 1,320 feet to the southeast. If faulting is present in the structure, it has not been reported. The average elevation of the field is 4,975 feet.

The discovery well was completed in December 1949 in the SW¼NE¼SE¼ sec. 32, in the Muddy sand between 7,202 and 7,206 feet. When placed on production in March 1950 the well produced 400 barrels of 40.2° API gravity oil a day. The second well in the field

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

Wyoming - Lake Creek
Phosphoria
Big Horn Basin

DATA SOURCE CODE		
	STATE	Wyoming
2c	COUNTY	Hot Springs
	REGULATORY DISTRICT	
	BASIN	Big Horn
	SUB-BASIN	
2c	FIELD	Lake Creek
2c	RESERVOIR	Phosphoria - Embar
2c	GEOLOGIC AGE	Limestone
	AAPG STRATIGRAPHIC AGE CODE	
2c	RESERVOIR LITHOLOGY	Limestone
2c	TRAPPING MECHANISM	Anticline
2c	DISCOVERY YEAR	1925
11	PROVED ACREAGE	1280-2560 (from 2c structure contour)
	REGULAR WELL SPACING (acres/well)	
2c	RESERVOIR DEPTH	3253 Phosphoria; 3690 Embar
	RESERVOIR THICKNESS	
2c	NET PAY	44 total
2c	GROSS	213 ft.
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
	FRACTION	
	PERMEABILITY	
	RANGE	
	AVERAGE	
	HORIZONTAL	
	VERTICAL	
2c	OTHER INFORMATION	Other production from Tensleep
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2d	TOTAL NUMBER OF WELLS	25P
	PRODUCTION 1976 oil (cum)	
	PRODUCTION 1977 oil (cum)	
	PRODUCTION 1978 oil (cum)	
2d	PRODUCTION 1979 oil (cum)	8576.2 mbbls oil; 165.1 mmcf gas
2d	PRODUCTION 1-1-79 to 1-1-80	118.9 mbbls oil; 0 gas
	SECONDARY RECOVERY RECORDS?	
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
2c	STRUCTURE CONTOUR?	yes (Frontier)
	LOGS?	
	STRUCTURE SECTION?	
	ENGINEERING REPORTS?	
	CORE DESCRIPTIONS?	
2c	CRUDE ANALYSIS?	yes

RESERVOIR DATA

DATA SOURCE CODE		
2c	FIELD:	Lake Creek
2c	RESERVOIR:	Phosphoria
11	PROD. ACRES:	1280 - 2560
2c	AVG. THICKNESS (FT.):	44
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
	PRIMARY DRIVE MECHANISM:	
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	125
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
	RESERVOIR PRESSURE INITIAL (psi):	
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
2c	STOCK TANK OIL GRAVITY (°API):	24 - 32.6
2c	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	44 sec SU
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

OTHER INFORMATION:

12 Water Analysis: Lake Creek-Phosphoria

Na & K	6,329
Ca	1,122
Mg	320
SO4	6,991
Cl	2,799
CO_3	-0-
HCO_3	8,126
Total solids	21,557
Primary salinity	62.74%
Secondary salinity	--
Primary alkalinity	14.24%
Secondary alkalinity	23.02%

TABLE 12.—*Crude-oil analyses*—Continued

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ....Laramie.... Laboratory
Sample ....PC-50-705....

IDENTIFICATION

Lake Creek field
Ember limestone - Permian
3,690 - 3,720 feet

Wyoming
Hot Springs County
SNE¼NW¼ sec. 34,
T. 43 N., R. 91 W.

GENERAL CHARACTERISTICS

Gravity, specific, ...0.903.... Gravity, ° API, ...25.2°.... Pour point, ° F., ...below 5....
Sulfur, percent, ...2.87.... Color, ...brownish black....
Viscosity, Saybolt Universal at 100° F. ..97 sec. at 127° F. ..155 sec. Nitrogen, percent, ...0.25....

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, ...760.... mm. Hg
First drop, ...84..... ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	122	0.9	0.9	0.655	84.5		1.36959	118.5		
2	167	1.5	2.4	.672	79.1	8.4	1.37755	122.0		
3	212	1.4	3.8	.702	70.1	13	1.39184	124.2		
4	257	2.8	6.6	.725	63.7	15	1.40479	129.2		
5	302	4.0	10.6	.756	55.7	22	1.41989	139.8		
6	347	3.9	14.5	.780	49.9	26	1.43334	143.7		
7	392	3.9	18.4	.801	45.1	30	1.44381	145.2		
8	437	4.8	23.2	.818	41.5	33	1.45212	143.8		
9	482	4.7	27.9	.833	38.4	34	1.45969	148.9		
10	527	7.6	35.5	.851	34.8	38	1.46999	166.0		

STAGE 2—Distillation continued at 40 mm. Hg

11	302	1.3	36.8	0.873	30.6	45				42	10
12	347	4.9	41.7	.882	28.9	45				46	25
13	392	6.9	48.6	.896	26.4	48				56	40
14	437	6.0	54.6	.912	23.6	53				84	55
15	482	6.4	61.0	.931	20.5	59				160	70
Residuum		38.3	99.3	1.005	9.3						

Carbon residue, Conradson: Residuum, 14.4 percent; crude, 6.1 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	3.8	0.679	76.9	
Total gasoline and naphtha	18.4	.750	57.2	
Kerosine distillate	4.8	.818	41.5	
Gas oil	10.4	.856	33.8	
Nonviscous lubricating distillate	11.3	.888-.916	27.8-23.0	80-100
Medium lubricating distillate	8.1	.916-.941	23.0-18.9	100-200
Viscous lubricating distillate	.0			Above 200
Residuum	38.3	1.005	9.3	
Distillation loss	.7			

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ....Laramie.... Laboratory
Sample ....PC-56-140....

IDENTIFICATION

Lake Creek field
Tensleep sandstone - Pennsylvanian
3,484 - 3,513 feet

Wyoming
Hot Springs County
SW¼SW¼ sec. 27,
T. 43 N., R. 91 W.

GENERAL CHARACTERISTICS

Gravity, specific, ...0.876.... Gravity, ° API, ...30.0°.... Pour point, ° F., ...below 5....
Sulfur, percent, ...2.02.... Color, ...brownish black....
Viscosity, Saybolt Universal at 100° F. ..48 sec. Nitrogen, percent, ...0.116....

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, ...760.... mm. Hg
First drop, ...133.... ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	122									
2	167	1.8	1.8	0.677	77.5		1.38126	126.8		
3	212	4.2	6.0	.703	69.8	13	1.39556	126.6		
4	257	.6	6.6	.722	64.5	13	1.40408	130.3		
5	302	3.9	10.5	.739	60.0	14	1.41207	133.9		
6	347	6.1	16.6	.759	54.9	16	1.42279	132.1		
7	392	4.8	21.4	.779	50.1	20	1.43257	132.6		
8	437	5.8	27.2	.797	46.0	23	1.44124	134.0		
9	482	7.9	35.1	.816	41.9	26	1.45174	134.8		
10	527	8.4	43.5	.839	37.2	32	1.46381	145.0		

STAGE 2—Distillation continued at 40 mm. Hg

11	302	3.7	47.2	0.868	31.5	42				42	below 5
12	347	8.7	55.9	.883	28.8	46				49	25
13	392	6.5	62.4	.907	24.5	54				68	42
14	437	7.0	69.4	.934	20.0	63				115	65
15	482	4.1	73.5	.947	17.9	66				240	85
Residuum		24.1	97.6	1.007	9.0						

Carbon residue, Conradson: Residuum, 14.5 percent; crude, 4.0 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	6.0	0.695	72.1	
Total gasoline and naphtha	21.4	.741	59.5	
Kerosine distillate	13.7	.808	43.6	
Gas oil	16.9	.856	33.8	
Nonviscous lubricating distillate	11.7	.884-.925	28.6-21.5	80-100
Medium lubricating distillate	6.0	.925-.943	21.5-18.6	100-200
Viscous lubricating distillate	3.8	.943-.952	18.6-17.1	Above 200
Residuum	24.1	1.007	9.0	
Distillation loss	2.4			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

TABLE 12.—*Crude-oil analyses*—Continued

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..Laramie.. Laboratory
Sample ..PC-50-703..

IDENTIFICATION

Lake Creek, Northwest field
Phosphoria limestone - Permian
3,253 - 3,367 feet

Wyoming
Hot Springs County
NE lot 2, sec. 14,
T. 43 N., R. 93 W.

GENERAL CHARACTERISTICS

Gravity, specific, 0.862 Gravity, ° API, 32.6° Pour point, ° F., below 5
Sulfur, percent, 2.27 Color, brownish black
Viscosity, Saybolt Universal at 100°F. 44 sec. Nitrogen, percent, 0.16

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 77 ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	122	3.2	3.2	0.639	89.9		1.36352	123.0		
2	167	3.0	6.2	.664	81.6	4.6	1.37340	121.7		
3	212	4.4	10.6	.701	70.3	12	1.39310	128.7		
4	257	5.2	15.8	.734	61.3	19	1.40838	136.1		
5	302	5.9	21.7	.764	53.7	26	1.42090	145.3		
6	347	5.4	27.1	.789	48.7	29	1.43766	153.3		
7	392	4.8	31.9	.803	44.7	31	1.44619	151.8		
8	437	4.6	36.5	.817	41.7	32	1.45253	149.1		
9	482	4.9	41.4	.831	38.8	33	1.45921	149.2		
10	527	5.9	47.3	.847	35.6	36	1.46836	156.7		

Stage 2—Distillation continued at 40 mm. Hg

11	302	2.8	50.1	0.872	30.8	44			40	below 5
12	347	6.1	56.2	.892	28.9	45			44	20
13	392	6.2	62.4	.900	25.7	50			56	40
14	437	4.8	67.2	.922	22.0	58			85	60
15	572	5.6	72.8	.935	19.8	61			162	75
Residuum		25.3	98.1	1.003	9.6					

Carbon residue, Conradson: Residuum, 13.4 percent; crude, 3.9 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	10.6	0.672	79.1	
Total gasoline and naphtha	31.9	.738	60.2	
Kerosine distillate	4.6	.817	41.7	
Gas oil	19.8	.860	33.0	
Nonviscous lubricating distillate	9.5	.891-.924	27.3-21.6	80-100
Medium lubricating distillate	6.5	.924-.940	21.6-19.0	100-200
Viscous lubricating distillate	.5	.940-.942	19.0-18.7	Above 200
Residuum	25.3	1.003	9.6	
Distillation loss	1.9			

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..Laramie.. Laboratory
Sample ..PC-50-704..

IDENTIFICATION

Lake Creek, Northwest field
Tensleep sandstone - Pennsylvanian
3,587 - 3,796 feet

Wyoming
Hot Springs County
SE Tract 45 sec. 14,
T. 43 N., R. 92 W.

GENERAL CHARACTERISTICS

Gravity, specific, 0.873 Gravity, ° API, 30.6° Pour point, ° F., below 5
Sulfur, percent, 2.20 Color, brownish black
Viscosity, Saybolt Universal at 100°F. 45 sec. Nitrogen, percent, 0.14

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 102 ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	122	0.8	0.8	0.642	88.9		1.36487	113.2		
2	167	2.2	3.0	.656	83.5	1.8	1.37111	121.7		
3	212	3.9	6.9	.688	74.2	6.1	1.38490	120.6		
4	257	5.0	11.9	.716	66.1	10	1.39897	122.9		
5	302	6.1	18.0	.744	58.7	16	1.41337	129.9		
6	347	5.9	23.9	.770	52.3	22	1.42759	136.7		
7	392	5.6	29.5	.793	46.9	26	1.43940	141.4		
8	437	5.6	35.1	.812	42.8	30	1.44881	142.9		
9	482	6.2	41.3	.829	39.2	32	1.45773	143.0		
10	527	7.1	48.4	.850	35.0	38	1.46912	134.1		

Stage 2—Distillation continued at 40 mm. Hg

11	302	2.8	51.2	0.877	29.8	46			41	below 5
12	347	6.8	58.0	.889	27.7	48			46	20
13	392	6.3	64.3	.913	23.5	56			59	35
14	437	5.6	69.9	.930	20.6	61			89	55
15	572	6.2	76.1	.949	17.6	67			185	70
Residuum		23.9	100.0	1.017	7.6					

Carbon residue, Conradson: Residuum, 14.7 percent; crude, 4.1 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	6.9	0.673	78.7	
Total gasoline and naphtha	29.5	.737	60.5	
Kerosine distillate	5.6	.812	42.8	
Gas oil	21.5	.857	33.6	
Nonviscous lubricating distillate	11.1	.896-.929	26.4-20.8	80-100
Medium lubricating distillate	6.2	.929-.932	20.8-17.1	100-200
Viscous lubricating distillate	2.2	.932-.939	17.1-16.0	Above 200
Residuum	23.9	1.017	7.6	
Distillation loss	.0			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

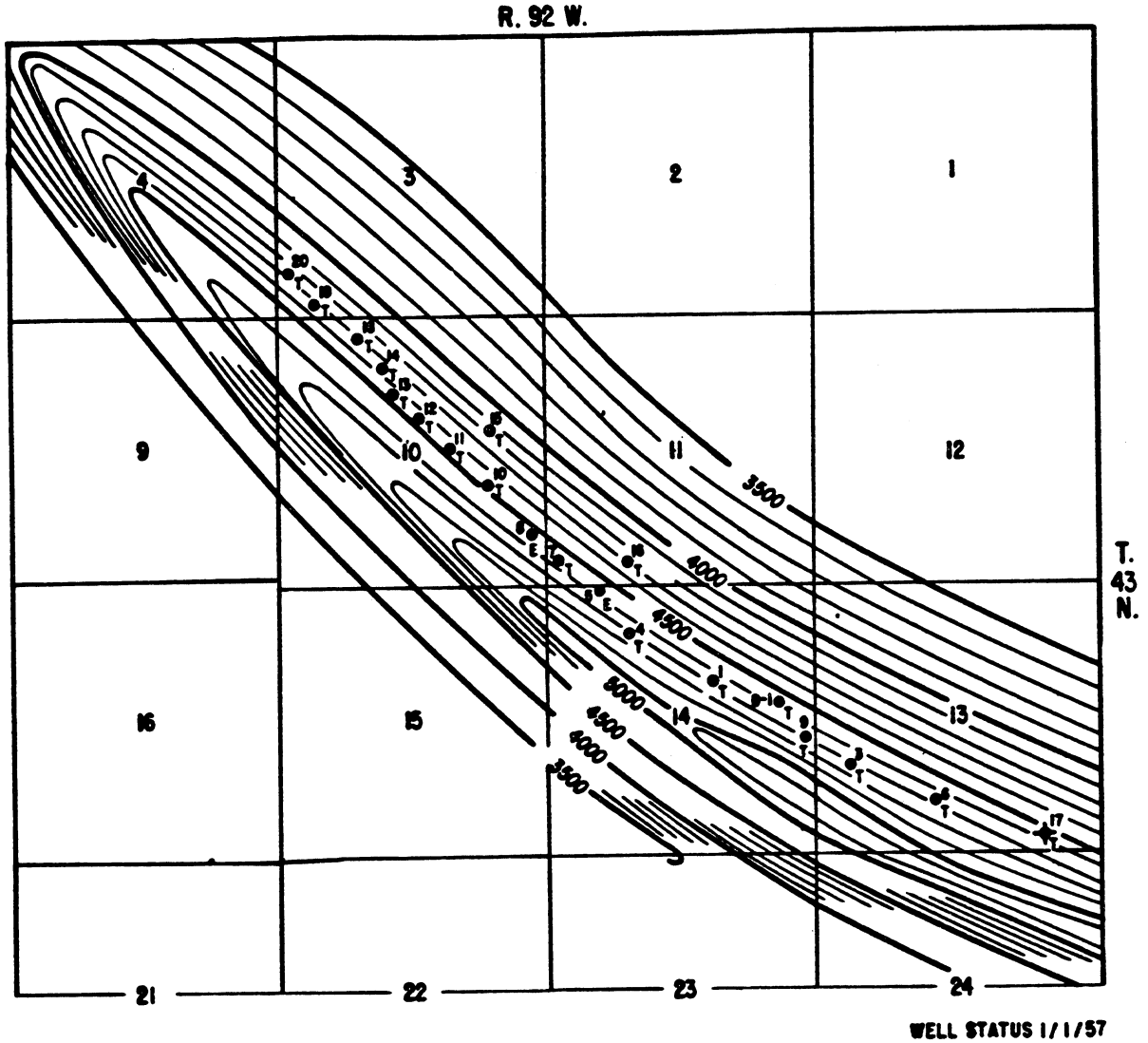


FIGURE 94.—Structure-Contour Map of Lake Creek Unit Oilfield, Hot Springs and Washakie Counties, Wyo.

in secs. 4, 10, 11, 13, and 14, T. 43 N., R. 92 W., Hot Springs County. The field is on the long, narrow Lake Creek anticline. Murphy Dome and Black Mountain parallel the structure to the east, and Kirby Creek and Zimmerman Butte are almost on echelon to the west. Although the structure has at least 800 feet of independent closure, it is thought that the oil did not accumulate as a result of this closure. The Frontier is exposed on the surface at an average elevation of 4,765 feet.

Oil-saturated zones in both the Embar and Tensleep formations were found in a well drilled in the NE¼ sec. 14 in May 1949. The well was not placed on production until November 1949 because previously there was no market for the oil. Initial daily production of the discovery well by pumping was 578

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

Wyoming - Manderson
Phosphoria
Big Horn

DATA SOURCE CODE		
	STATE	Wyoming
2c	COUNTY	Big Horn
	REGULATORY DISTRICT	
	BASIN	Big Horn
	SUB-BASIN	
2c	FIELD	Manderson
2c	RESERVOIR	Phosphoria Limestone
2c	GEOLOGIC AGE	Permian
	AAPG STRATIGRAPHIC AGE CODE	
	RESERVOIR LITHOLOGY	Limestone
2c, 8	TRAPPING MECHANISM	Updip facies changes from porous dolomite to red shale in anticlinal plunging nose.
2c,2b	DISCOVERY YEAR	1950; 1951
2c	PROVED ACREAGE	7106
	REGULAR WELL SPACING (acres/well)	
2c,2b	RESERVOIR DEPTH	7220; 7150
	RESERVOIR THICKNESS	
2c	NET PAY	45 ft.
2c	GROSS	217 ft.
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
	FRACTION	
	PERMEABILITY	
	RANGE	
	AVERAGE	
	HORIZONTAL	
	VERTICAL	
	OTHER INFORMATION	Other production from Tensleep, Morrison and Muddy
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2c	TOTAL NUMBER OF WELLS	26P
	PRODUCTION 1976 oil (cum)	
	PRODUCTION 1977 oil (cum)	
	PRODUCTION 1978 oil (cum)	
2c	PRODUCTION 1979 oil (cum)	3547.7 mbbls oil; 75,211.5 mmcf gas
2c	PRODUCTION 1-1-79 to 1-1-80	45.5 mbbls oil; 773.3 mmcf gas
	SECONDARY RECOVERY RECORDS?	
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
8	STRUCTURE CONTOUR?	yes
	LOGS?	
	STRUCTURE SECTION?	
	ENGINEERING REPORTS?	
	CORE DESCRIPTIONS?	
2c	CRUDE ANALYSIS?	yes

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Manderson
2c	RESERVOIR:	Phosphoria
2c	PROD. ACRES:	7106
2c	AVG. THICKNESS (FT.):	45
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
	PRIMARY DRIVE MECHANISM:	
	PRIMARY GAS CAP?:	
11	TEMPERATURE (^oF):	178
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
	RESERVOIR PRESSURE INITIAL (psi):	
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
2c	STOCK TANK OIL GRAVITY (^oAPI):	33.4 - 36.9
2c	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	38 sec SU
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

OTHER INFORMATION:

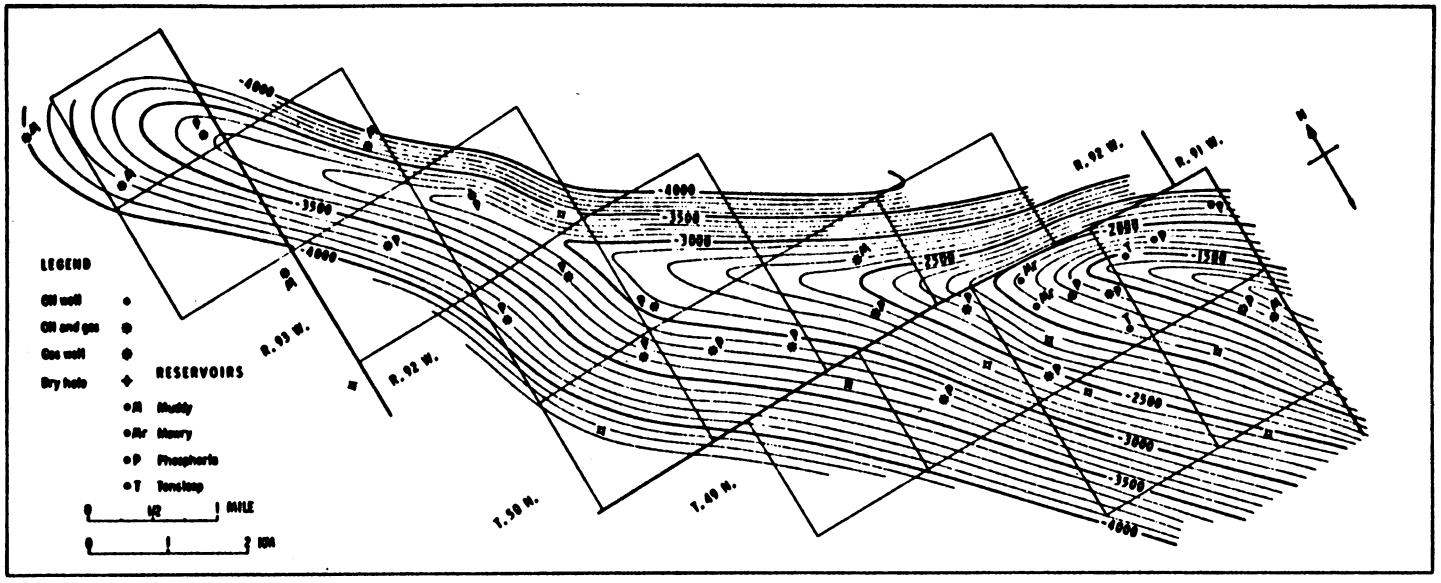


Figure 34.9 **Manderson field, Big Horn County, Wyoming. Structure contour map based on top of Phosphoria. Interval, 100 feet.** ***Courtesy Wyoming Geological Association (1957).***

From: LANDES, K. S., 1970, PETROLEUM GEOLOGY OF THE UNITED STATES, John Wiley and Sons, New York, New York, page 409, Source 8.

TABLE 12.—*Crude-oil analyses*—Continued

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..Laramie.. Laboratory
Sample ..PC-56-337..

IDENTIFICATION

Henderson field
Muddy sandstone - L. Cretaceous
6,019 - 6,057 feet

Wyoming
Big Horn County
SW¼SW¼ sec. 12,
T. 50 N., R. 93 W.

GENERAL CHARACTERISTICS

Gravity, specific, ..0.771.. Gravity, ° API, ..52.0°.. Pour point, ° F., ..below 5..
Sulfur, percent, ..0.03.. Color, ..NPA 2..
Viscosity, Saybolt Universal at ..100° F., ..32 sec.. Nitrogen, percent, ..0.000..

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, ..760.. mm. Hg
First drop, ..127.. ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	122									
2	167	1.9	1.9	0.676	77.8		1.38011	136.2		
3	212	5.1	6.6	.720	65.0	21	1.40242	136.9		
4	257	22.4	29.0	.752	56.7	27	1.41978	146.7		
5	302	25.8	54.8	.772	51.8	29	1.43155	153.8		
6	347	20.1	74.9	.782	49.5	27	1.43754	153.3		
7	392	13.8	88.7	.786	48.5	23	1.43934	146.2		
8	437	8.7	97.4	.794	46.7	21	1.44264	141.3		
9	482									
10	527									

STAGE 2—Distillation continued at 40 mm. Hg

11	302									
12	437									
13	482									
14	527									
15	572									
Residuum		2.8	100.2	0.815	42.1					

Carbon residue, Conradson: Residuum, ..0.. percent; crude, ..0.. percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	6.6	0.710	67.8	
Total gasoline and naphtha	88.7	.768	52.7	
Kerosine distillate	8.7	.794	46.7	
Gas oil				
Nonviscous lubricating distillate				50-100
Medium lubricating distillate				100-200
Viscous lubricating distillate				Above 200
Residuum	2.8	.815	42.1	
Distillation loss	.0			

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..Laramie.. Laboratory
Sample ..PC-56-330..

IDENTIFICATION

Henderson field
Phosphoria limestone - Permian
6,910 - 7,001 feet

Wyoming
Big Horn County
SW¼SW¼ sec. 28,
T. 50 N., R. 92 W.

GENERAL CHARACTERISTICS

Gravity, specific, ..0.858.. Gravity, ° API, ..33.4°.. Pour point, ° F., ..below 5..
Sulfur, percent, ..1.74.. Color, ..brownish green..
Viscosity, Saybolt Universal at ..100° F., ..38 sec.. Nitrogen, percent, ..0.053..

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, ..760.. mm. Hg
First drop, ..79.. ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	122	0.9	0.9	0.665	81.3					
2	167	2.4	3.3	.673	78.8	8.9	1.38116	129.7		
3	212	3.7	6.0	.711	67.5	17	1.39810	132.7		
4	257	5.4	11.4	.742	59.2	23	1.41471	138.8		
5	302	6.8	18.2	.769	52.5	28	1.42990	154.1		
6	347	6.5	24.7	.787	48.3	30	1.44035	154.3		
7	392	5.8	30.5	.801	45.2	30	1.44691	150.1		
8	437	4.9	35.4	.814	42.3	31	1.45261	146.4		
9	482	5.9	41.3	.827	39.6	31	1.45862	147.7		
10	527	6.9	48.2	.843	36.4	34	1.46778	155.0		

STAGE 2—Distillation continued at 40 mm. Hg

11	302	10.2	58.4	0.871	31.0	44			41	below 5
12	437	5.8	64.2	.889	27.7	48			52	25
13	482	5.2	69.4	.904	25.0	52			69	45
14	527	4.9	74.3	.921	22.1	57			105	70
15	572	6.2	80.5	.934	20.0	60			200	80
Residuum		18.2	98.7	.977	13.3					

Carbon residue, Conradson: Residuum, ..7.2.. percent; crude, ..1.5.. percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	6.0	0.689	73.9	
Total gasoline and naphtha	30.5	.758	55.2	
Kerosine distillate	4.9	.814	42.3	
Gas oil	24.6	.853	34.4	
Nonviscous lubricating distillate	11.3	.886-.919	28.2-22.5	50-100
Medium lubricating distillate	6.1	.919-.934	22.5-20.0	100-200
Viscous lubricating distillate	3.1	.934-.941	20.0-18.9	Above 200
Residuum	18.2	.977	13.3	
Distillation loss	1.3			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

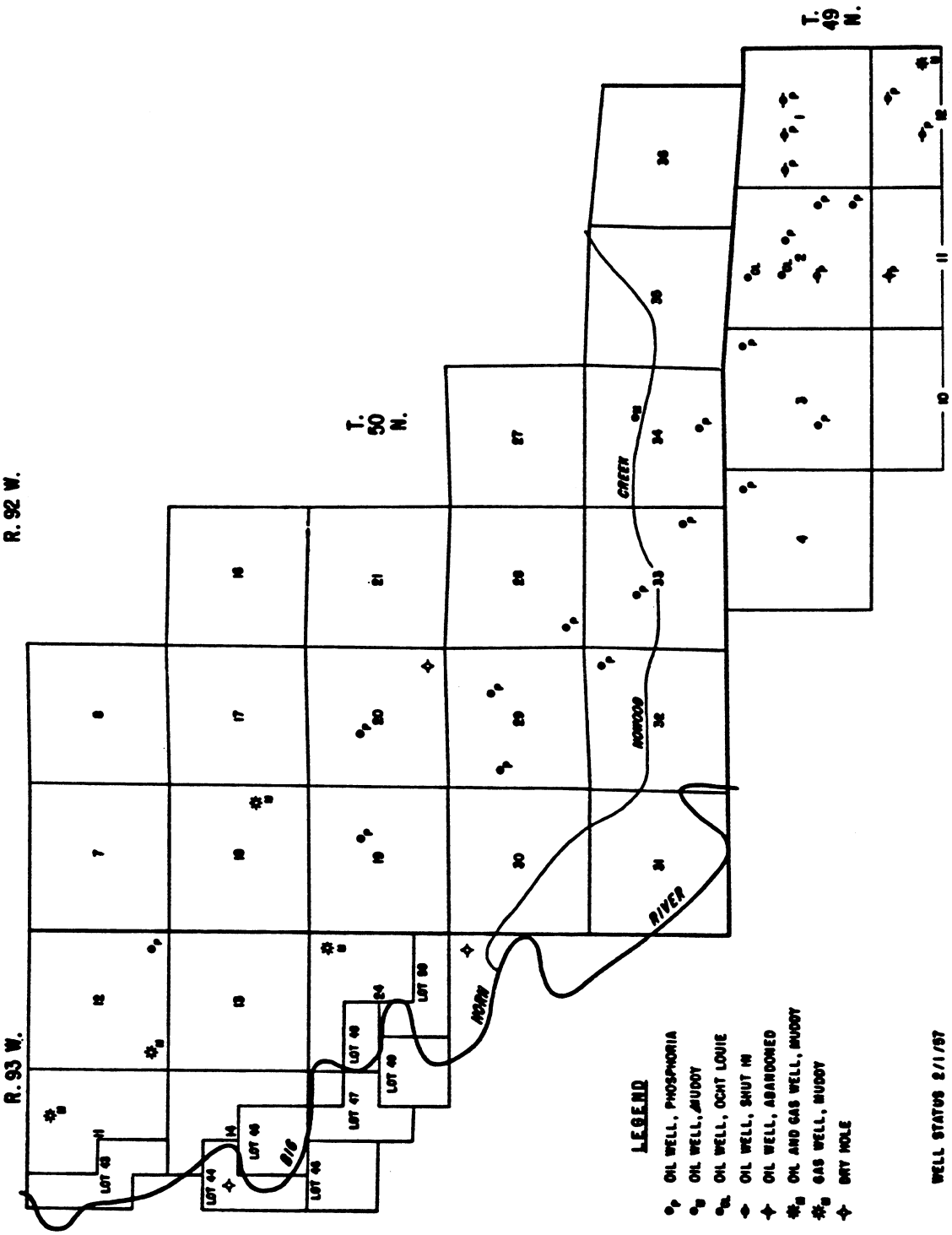


FIGURE 107.—Map of Manderson Field, Big Horn County, Wyo.
(Adapted from Federal Geological Survey map.)

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

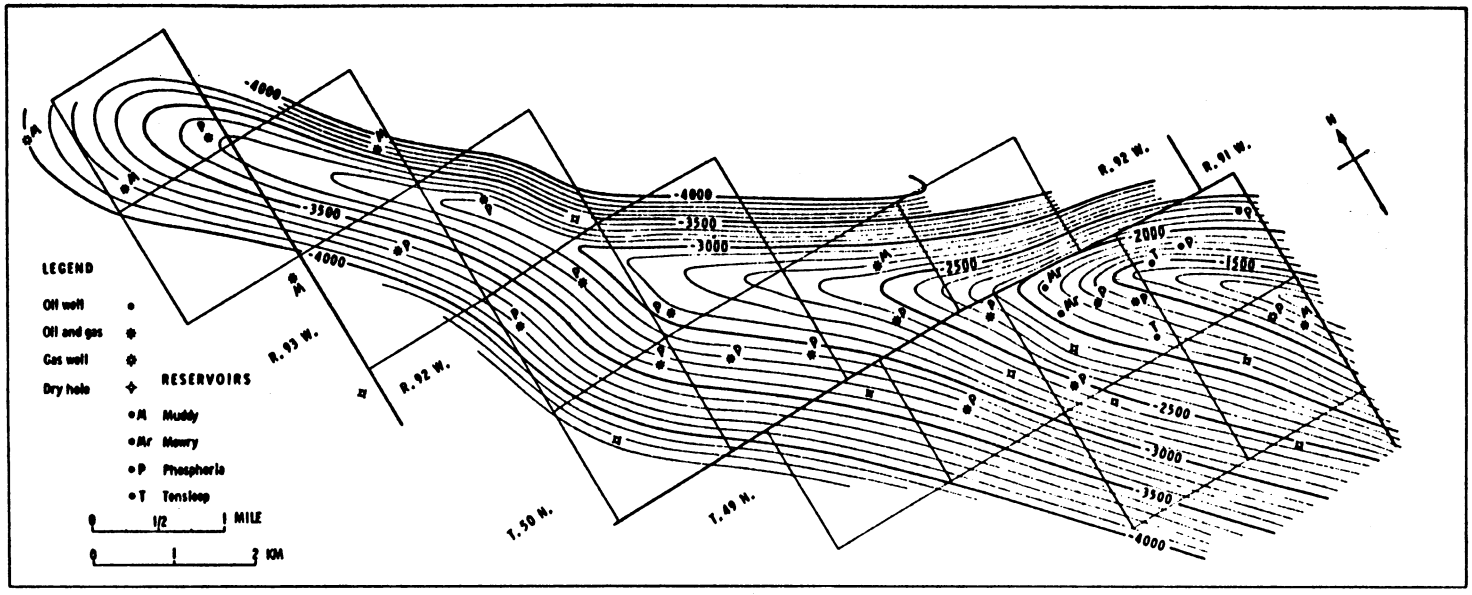


FIGURE 34.9 Manderson field, Big Horn County, Wyoming. Structure contour map based on top of Phosphoria. Interval, 100 feet. *Courtesy Wyoming Geological Association (1957).*

From: Landes, Kenneth K., Petroleum Geology of the United States, Source 8.

Wyoming - Slick Creek
Phosphoria
Big Horn

DATA SOURCE CODE		
	STATE	Wyoming
2c	COUNTY	Washakie
	REGULATORY DISTRICT	
	BASIN	Big Horn
	SUB-BASIN	
2c	FIELD	Slick Creek
2c	RESERVOIR	Phosphoria limestone
2b	GEOLOGIC AGE	Permian
	AAPG STRATIGRAPHIC AGE CODE	
8	RESERVOIR LITHOLOGY	Limestone
2c	TRAPPING MECHANISM	Anticline
2c, 2b	DISCOVERY YEAR	1950
11	PROVED ACREAGE	1920
	REGULAR WELL SPACING (acres/well)	
2c, 2b	RESERVOIR DEPTH	10,460; 10,400
	RESERVOIR THICKNESS	
2c	NET PAY	26
2c	GROSS	94
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
2c	FRACTION	.09
	PERMEABILITY	
	RANGE	
2c	AVERAGE	8 md
	HORIZONTAL	
	VERTICAL	
	OTHER INFORMATION	
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2d	TOTAL NUMBER OF WELLS	24P
	PRODUCTION 1976 oil (cum)	
	PRODUCTION 1977 oil (cum)	
	PRODUCTION 1978 oil (cum)	
2d	PRODUCTION 1979 oil (cum)	4722.1 mbbls oil; 6592.4 mmcf gas
2d	PRODUCTION 1-1-79 to 1-1-80	257.2 mbbls oil; 134.6 mmcf gas
2d	SECONDARY RECOVERY RECORDS?	yes
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
	STRUCTURE CONTOUR?	
	LOGS?	
	STRUCTURE SECTION?	
	ENGINEERING REPORTS?	
	CORE DESCRIPTIONS?	
2c	CRUDE ANALYSIS?	yes

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Slick Creek
2c	RESERVOIR:	Phosphoria
11	PROD. ACRES:	1920
2c	AVG. THICKNESS (FT.):	26
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
	PRIMARY DRIVE MECHANISM:	
	PRIMARY GAS CAP?:	
11	TEMPERATURE (^oF):	226
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
	RESERVOIR PRESSURE INITIAL (psi):	
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
2c	STOCK TANK OIL GRAVITY (^oAPI):	33.2
2c	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	43 sec SU
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

2d OTHER INFORMATION:

Secondary recovery: water injection 2 wells in Phosphoria since 1969 by Tenneco Oil Co.

TABLE 12.—*Crude-oil analyses*—Continued

CRUDE PETROLEUM ANALYSIS

Bureau of Mines .....Laramie..... Laboratory
Sample .....PC-50-742.....

IDENTIFICATION

Slick Creek field
Phosphoria limestone - Permian
10,460 - 10,731 feet

Wyoming
Washakie County
SE¼SE¼NE¼ sec. 32,
T. 47 N., R. 92 W.

GENERAL CHARACTERISTICS

Gravity, specific, ...0.859..... Gravity, ° API, ...33.2°..... Pour point, ° F., ...below 5.....
Sulfur, percent, ...2.00..... Color, ...brownish black.....
Viscosity, Saybolt Universal at 100°F., ...43 sec.; ..... Nitrogen, percent, ...0.11.....

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, ...760..... mm. Hg
First drop, ...73..... ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1.....	122	2.4	2.4	0.644	88.2		1.36742	128.1		
2.....	167	2.9	5.3	.664	81.6	4.6	1.37318	115.3		
3.....	212	4.2	9.5	.706	68.9	15	1.39440	127.1		
4.....	257	4.7	14.2	.742	59.2	23	1.41307	139.0		
5.....	302	5.6	19.8	.770	52.3	28	1.42952	150.3		
6.....	347	5.3	25.1	.791	47.4	32	1.44091	154.1		
7.....	392	4.6	29.7	.803	44.7	31	1.44669	151.2		
8.....	437	4.5	34.2	.815	42.1	31	1.45125	146.4		
9.....	482	5.0	39.2	.828	39.4	32	1.45746	145.6		
10.....	527	6.4	45.6	.844	36.1	35	1.46654	152.4		

Stage 2—Distillation continued at 40 mm. Hg

11.....	302	3.3	48.9	0.867	31.7	42			40	15
12.....	437	5.9	54.8	.876	30.0	42			45	30
13.....	482	7.0	61.8	.892	27.1	46			56	45
14.....	527	5.3	67.1	.912	23.6	53			81	60
15.....	572	6.0	73.1	.922	22.0	55			145	80
Residuum.....		24.7	97.8	.988	11.7					

Carbon residue, Conradson: Residuum, 12.1 percent; crude, 3.4 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	9.5	0.678	77.2	
Total gasoline and naphtha	29.7	.745	58.4	
Kerosine distillate	4.5	.815	42.1	
Gas oil	20.6	.854	34.2	
Nonviscous lubricating distillate	11.3	.884-.915	28.6-23.1	50-100
Medium lubricating distillate	7.0	.915-.928	23.1-21.0	100-200
Viscous lubricating distillate	.0			Above 200
Residuum	24.7	.988	11.7	
Distillation loss	2.2			

CRUDE PETROLEUM ANALYSIS

Bureau of Mines .....Laramie..... Laboratory
Sample .....PC-50-724.....

IDENTIFICATION

South Fork field
Phosphoria limestone - Permian
10,285 - 10,360 feet

Wyoming
Washakie County
SE¼NE¼ sec. 23,
T. 46 N., R. 92 W.

GENERAL CHARACTERISTICS

Gravity, specific, ...0.887..... Gravity, ° API, ...28.0°..... Pour point, ° F., ...below 5.....
Sulfur, percent, ...1.84..... Color, ...black.....
Viscosity, Saybolt Universal at 100°F., 77 sec.; at 77°F., 110 sec. Nitrogen, percent, ...0.19.....

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, ...760..... mm. Hg
First drop, ...86..... ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1.....	122									
2.....	167	1.4	1.4	0.659	83.2					
3.....	212	1.6	3.0	.688	74.2	9.1	1.38532	121.6		
4.....	257	2.4	5.4	.721	64.8	13	1.40080	126.1		
5.....	302	2.9	8.3	.746	58.2	17	1.41483	129.8		
6.....	347	3.3	11.6	.770	52.3	22	1.42682	133.2		
7.....	392	3.8	15.4	.790	47.6	25	1.43698	136.8		
8.....	437	4.0	19.4	.807	45.2	27	1.44592	136.6		
9.....	482	4.9	24.3	.822	40.6	29	1.45419	141.7		
10.....	527	6.6	30.9	.840	37.0	33	1.46445	150.7		

Stage 2—Distillation continued at 40 mm. Hg

11.....	302	3.9	34.8	0.860	33.0	38			41	below 5
12.....	437	7.3	42.1	.868	31.5	38			46	20
13.....	482	7.3	49.4	.887	28.0	44			60	45
14.....	527	6.4	55.8	.902	25.4	48			90	60
15.....	572	6.8	62.6	.913	23.5	50			165	80
Residuum.....		35.4	98.0	.993	11.0					

Carbon residue, Conradson: Residuum, 16.5 percent; crude, 6.5 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	3.0	0.674	78.4	
Total gasoline and naphtha	15.4	.744	58.7	
Kerosine distillate	8.9	.815	42.1	
Gas oil	16.0	.855	34.0	
Nonviscous lubricating distillate	13.2	.873-.903	30.6-25.2	50-100
Medium lubricating distillate	8.5	.903-.918	25.2-22.6	100-200
Viscous lubricating distillate	.6	.918-.919	22.6-22.5	Above 200
Residuum	35.4	.993	11.0	
Distillation loss	2.0			

From: WYOMING OIL AND GAS FIELDS, GREATER GREEN RIVER BASIN, 1979 SYMPOSIUM, Wyoming Geological Association, Source 2a.

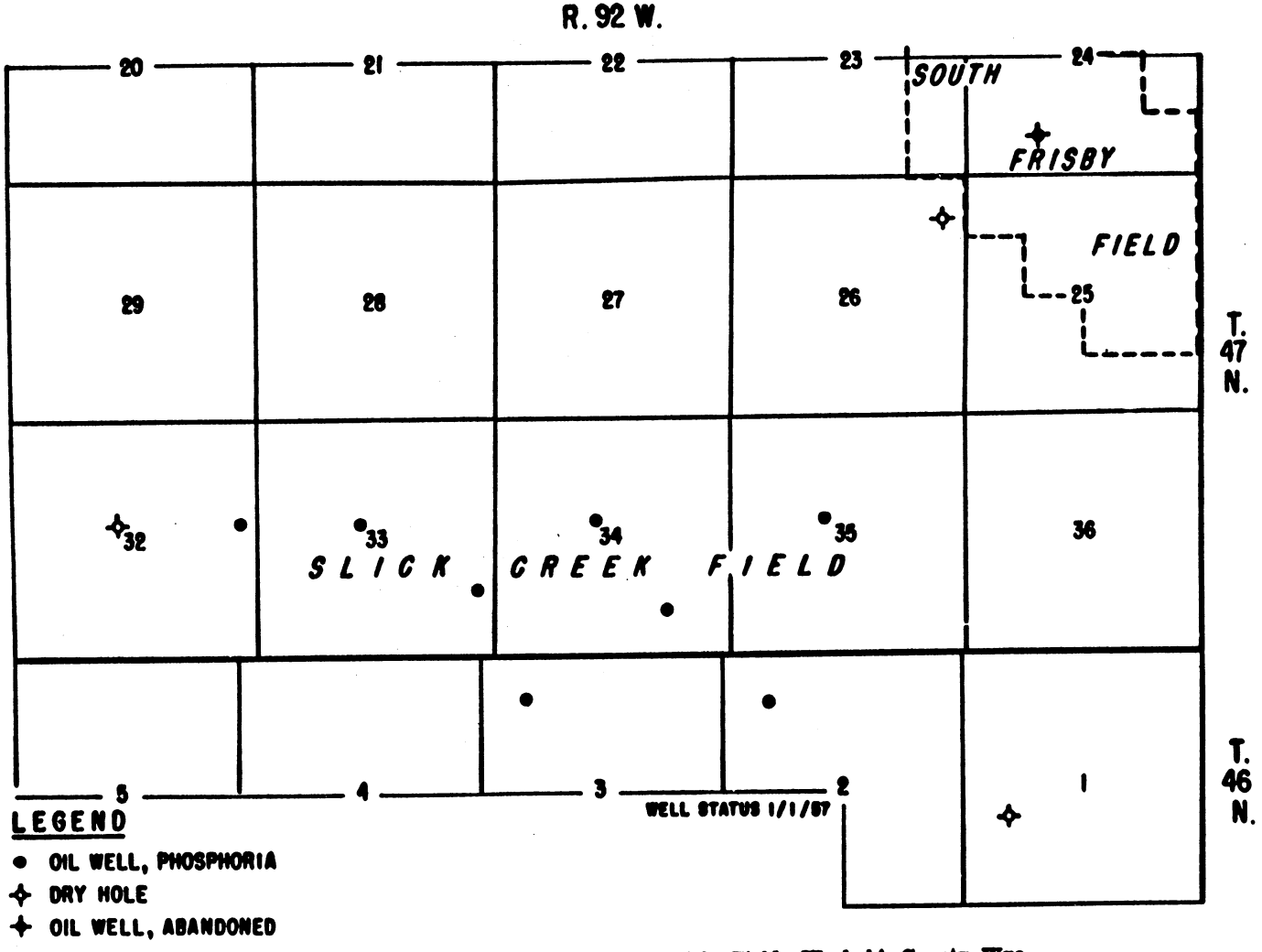


FIGURE 150.—Map of Slick Creek and South Frisby Fields, Washakie County, Wyo.

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

Wyoming - Torchlight
Phosphoria
Big Horn Basin

DATA SOURCE CODE		
	STATE	Wyoming
2c	COUNTY	Big Horn
	REGULATORY DISTRICT	
	BASIN	Big Horn
	SUB-BASIN	
2c	FIELD	Torchlight
2c	RESERVOIR	Phosphoria limestone
2c	GEOLOGIC AGE	Permian
	AAPG STRATIGRAPHIC AGE CODE	
2c	RESERVOIR LITHOLOGY	Limestone
2c	TRAPPING MECHANISM	Elliptical dome
2c,2b	DISCOVERY YEAR	1904 field; 1013
11	PROVED ACREAGE	1280
	REGULAR WELL SPACING (acres/well)	
2b	RESERVOIR DEPTH	2750
	RESERVOIR THICKNESS	
2c	NET PAY	36 ft.
2c	GROSS	230 ft.
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
	FRACTION	
	PERMEABILITY	
	RANGE	
	AVERAGE	
	HORIZONTAL	
	VERTICAL	
2c	OTHER INFORMATION	Other reservoirs include Mowry Sand zones, Madison, Tensleep, Kimball
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2d	TOTAL NUMBER OF WELLS	32P
	PRODUCTION 1976 oil (cum)	
	PRODUCTION 1977 oil (cum)	
	PRODUCTION 1978 oil (cum)	
2d	PRODUCTION 1979 oil (cum)	14,177.5 mbbls oil; 3,888.5 mmcf gas
2d	PRODUCTION 1-1-79 to 1-1-80	255.3 mbbls oil; 32.6 mmcf gas
	SECONDARY RECOVERY RECORDS?	
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
2c	STRUCTURE CONTOUR?	yes (Greybull Sand)
	LOGS?	
	STRUCTURE SECTION?	
	ENGINEERING REPORTS?	
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Torchlight
2c	RESERVOIR:	Phosphoria Limestone
11	PROD. ACRES:	1280-3200
2c	AVG. THICKNESS (FT.):	36
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
	PRIMARY DRIVE MECHANISM:	
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	110
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
	RESERVOIR PRESSURE INITIAL (psi):	
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
2c	STOCK TANK OIL GRAVITY (°API):	31.3
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	
14	ESTIMATED ULTIMATE RECOVERY:	20,000 mbbls; 6,700 mmcf
	OTHER INFORMATION:	

TABLE 12.—*Crude-oil analyses*—Continued

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..... Laramie ..... Laboratory
Sample ..... PC-50-726 .....

IDENTIFICATION

Torchlight field
Madison limestone - Mississippian
3,550 - 3,655 feet

Wyoming
Big Horn County
SW¼SE¼NW¼ sec. 24,
T. 51 N., R. 93 W.

GENERAL CHARACTERISTICS

Gravity, specific, ...0.931..... Gravity, ° API, ...20.5°..... Pour point, ° F., ...below 5.....
Sulfur, percent, ...2.72..... Color, ...brownish black.....
Viscosity, Saybolt Universal at 100°F...400 sec. at 130°F...190 sec. Nitrogen, percent, ...0.22.....

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, ...760..... mm. Hg
First drop, ...156..... ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	150									
2	167									
3	213	0.7	0.7	0.703	69.8	13	1.39250	123.2		
4	257	.8	1.5	.719	65.3	12	1.40289	123.1		
5	302	1.0	2.5	.735	61.0	12	1.40927	124.8		
6	347	1.6	4.1	.755	55.9	14	1.41937	125.8		
7	392	1.9	6.0	.775	51.1	18	1.42876	128.0		
8	437	3.1	9.1	.795	46.5	22	1.43839	127.6		
9	482	4.3	13.4	.813	42.6	25	1.44729	129.8		
10	527	6.2	19.6	.830	39.0	28	1.45630	132.7		
Stage 2—Distillation continued at 40 mm. Hg										
11	572	9.4	29.0	0.855	34.0	36			41	below 5
12	617	7.6	32.6	.868	31.5	38			48	15
13	662	7.5	40.1	.885	28.4	43			64	35
14	707	7.0	47.1	.903	25.2	49			99	50
15	752	8.2	55.3	.924	21.6	55			200	70
Residuum		44.6	99.9	1.022	7.0					

Carbon residue, Conradson: Residuum, 19.4 percent; crude, 9.2 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	0.7	0.703	69.8	
Total gasoline and naphtha	6.0	.747	57.9	
Kerosine distillate	7.4	.800	44.3	
Gas oil	16.2	.849	35.2	
Nonviscous lubricating distillate	14.1	.870-.903	31.1-25.2	80-100
Medium lubricating distillate	7.5	.903-.924	25.2-21.6	100-200
Viscous lubricating distillate	4.1	.924-.935	21.6-19.8	Above 200
Residuum	44.6	1.022	7.0	
Distillation loss	.1			

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..... Laramie ..... Laboratory
Sample ..... PC-50-710 .....

IDENTIFICATION

Wagonhound field
Ember limestone - Permian
4,278 - 4,302 feet

Wyoming
Hot Springs County
NE¼SE¼ sec. 6,
T. 44 N., R. 98 W.

GENERAL CHARACTERISTICS

Gravity, specific, ...0.898..... Gravity, ° API, ...26.1°..... Pour point, ° F., ...below 5.....
Sulfur, percent, ...1.53..... Color, ...brownish black.....
Viscosity, Saybolt Universal at 100°F...100 sec. at 130°F...67 sec. Nitrogen, percent, ...0.21.....

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, ...760..... mm. Hg
First drop, ...81..... ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	122	0.4	0.4							
2	167	.6	1.0	0.698	71.2		1.38996	130.5		
3	213	1.3	2.3	.684	75.4	4.2	1.38257	121.0		
4	257	2.1	4.4	.716	66.1	10	1.39828	124.7		
5	302	2.9	7.3	.743	58.9	16	1.41301	127.6		
6	347	3.2	10.5	.767	53.0	20	1.42602	133.4		
7	392	3.4	13.9	.789	47.8	24	1.43731	135.7		
8	437	4.6	18.5	.807	43.8	27	1.44757	139.2		
9	482	5.3	23.8	.827	39.6	31	1.45717	142.4		
10	527	7.0	30.8	.843	36.4	34	1.46672	150.8		
Stage 2—Distillation continued at 40 mm. Hg										
11	572	2.1	32.9	0.863	32.5	40			47	below 5
12	617	7.1	40.0	.873	30.6	41			50	10
13	662	7.0	47.0	.889	27.7	45			62	30
14	707	6.8	53.8	.904	25.0	49			98	50
15	752	6.9	60.7	.921	22.1	54			190	75
Residuum		38.4	99.1	.990	11.4					

Carbon residue, Conradson: Residuum, 13.7 percent; crude, 5.8 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	2.3	0.690	73.6	
Total gasoline and naphtha	13.9	.747	57.9	
Kerosine distillate	4.6	.807	43.8	
Gas oil	17.9	.846	35.8	
Nonviscous lubricating distillate	14.2	.873-.904	30.6-25.0	80-100
Medium lubricating distillate	7.3	.904-.923	25.0-21.8	100-200
Viscous lubricating distillate	2.8	.923-.930	21.8-20.7	Above 200
Residuum	38.4	.990	11.4	
Distillation loss	.9			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

TABLE 12.—*Crude-oil analyses*—Continued

CRUDE PETROLEUM ANALYSIS

Bureau of Mines .....Laramie..... Laboratory
Sample .....PC-56-344.....

IDENTIFICATION

Torchlight field, Wyoming
Phosphoria limestone - Permian, Big Horn County
3,148 - 3,184 feet, SE¼SW¼ sec. 14, T. 51 N., R. 23 W.

GENERAL CHARACTERISTICS

Gravity, specific, ...0.869..... Gravity, ° API, ...31.3°..... Pour point, ° F., ...below 5.....
Sulfur, percent, ...1.99..... Color, ...greenish black.....
Viscosity, Saybolt Universal at ...100° F...42 seconds..... Nitrogen, percent, ...0.083.....

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, ...760..... mm. Hg
First drop, ...122..... ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis., 100° F.	Cloud test, ° F.
1	122									
2	167	1.1	1.1	0.661	82.6		1.38691	127.1		
3	212	2.5	3.6	.706	68.9	15	1.39684	130.8		
4	257	4.5	8.1	.737	60.5	20	1.41213	140.0		
5	302	6.9	15.0	.765	53.5	26	1.42773	150.7		
6	347	6.0	21.0	.786	48.5	29	1.43973	152.2		
7	392	5.7	26.7	.799	45.6	29	1.44641	151.9		
8	437	5.4	32.1	.813	42.6	30	1.45218	149.8		
9	482	5.7	37.8	.826	39.8	31	1.45803	148.4		
10	527	8.0	45.8	.845	36.0	35	1.46741	153.3		

STAGE 2—Distillation continued at 40 mm. Hg

11	392	6.5	52.3	0.869	31.3	43			39	below 5
12	437	8.1	60.4	.881	29.1	45			46	15
13	482	6.4	66.8	.903	25.2	52			64	40
14	527	6.1	72.9	.914	23.3	54			87	60
15	572	6.8	79.7	.938	19.4	62			220	85
Residuum		20.0	99.7	.995	10.7					

Carbon residue, Conradson: Residuum, 14.0 percent; crude, 3.2 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	3.6	0.692	73.0	
Total gasoline and naphtha	26.7	.762	54.2	
Kerosine distillate	5.4	.813	42.6	
Gas oil	25.9	.855	34.0	
Nonviscous lubricating distillate	12.4	.886-.916	28.2-23.0	80-100
Medium lubricating distillate	4.9	.916-.934	23.0-20.0	100-200
Viscous lubricating distillate	4.4	.934-.950	20.0-17.5	Above 200
Residuum	20.0	.995	10.7	
Distillation loss	.3			

CRUDE PETROLEUM ANALYSIS

Bureau of Mines .....Laramie..... Laboratory
Sample .....PC-50-725.....

IDENTIFICATION

Torchlight field, Wyoming
Tensleep sandstone - Pennsylvanian, Big Horn County
3,176 - 3,220 feet, NE¼SE¼NW¼ sec. 24, T. 51 N., R. 93 W.

GENERAL CHARACTERISTICS

Gravity, specific, ...0.850..... Gravity, ° API; .....35.0°..... Pour point, ° F., ...below 5.....
Sulfur, percent, ...1.83..... Color, ...brownish green.....
Viscosity, Saybolt Universal at ...100° F...39 seconds..... Nitrogen, percent, ...0.055.....

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, ...760..... mm. Hg
First drop, ...102..... ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis., 100° F.	Cloud test, ° F.
1	122	0.7	0.7							
2	167	2.6	3.3	0.655	84.5		1.36915	120.1		
3	212	4.0	7.3	.690	73.6	7.1	1.38639	122.3		
4	257	5.3	12.6	.717	65.9	11	1.39963	123.1		
5	302	5.9	18.5	.740	59.7	14	1.41331	128.9		
6	347	5.9	24.4	.764	53.7	19	1.42490	134.1		
7	392	5.5	29.9	.785	48.8	23	1.43594	137.8		
8	437	5.5	35.4	.803	44.7	25	1.44509	139.8		
9	482	5.9	41.3	.820	41.1	28	1.45375	143.4		
10	527	7.7	49.0	.838	37.4	32	1.46370	150.2		

STAGE 2—Distillation continued at 40 mm. Hg

11	392	4.2	53.2	0.863	32.5	40			39	below 5
12	437	7.0	60.2	.875	30.2	42			44	20
13	482	6.8	67.0	.893	27.0	47			56	35
14	527	6.2	73.2	.909	24.2	51			81	60
15	572	5.5	78.7	.925	21.5	56			145	75
Residuum		20.2	98.9	.975	13.6					

Carbon residue, Conradson: Residuum, 7.0 percent; crude, 1.6 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	7.3	0.674	78.4	
Total gasoline and naphtha	29.9	.733	61.5	
Kerosine distillate	11.4	.812	42.8	
Gas oil	18.7	.858	33.4	
Nonviscous lubricating distillate	11.8	.884-.914	28.6-23.3	80-100
Medium lubricating distillate	6.9	.914-.933	23.3-20.2	100-200
Viscous lubricating distillate	.0			Above 200
Residuum	20.2	.975	13.6	
Distillation loss	1.1			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

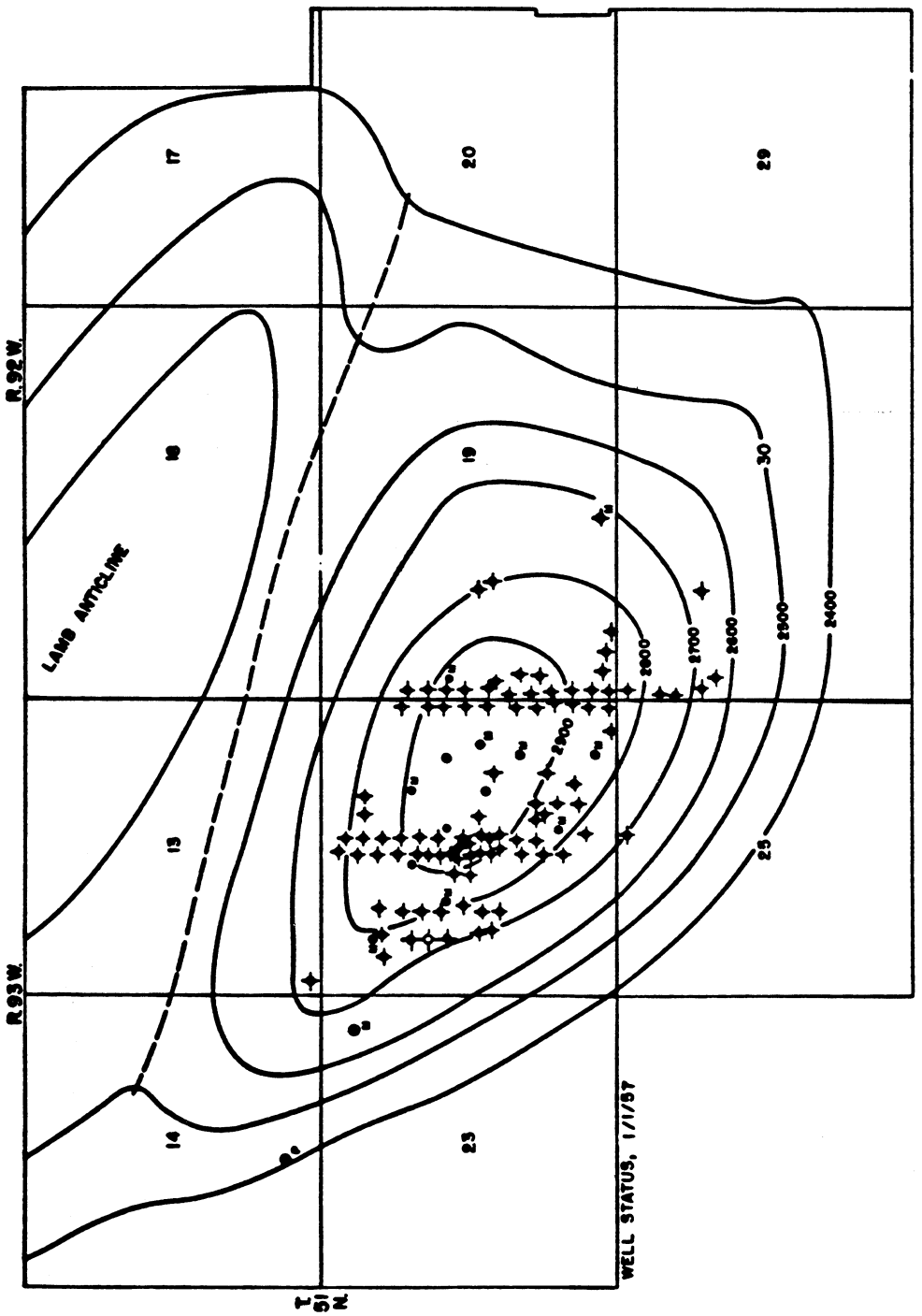


FIGURE 163.—Structure-Contour Map of Torchlight Dome, Big Horn County, Wyo.

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

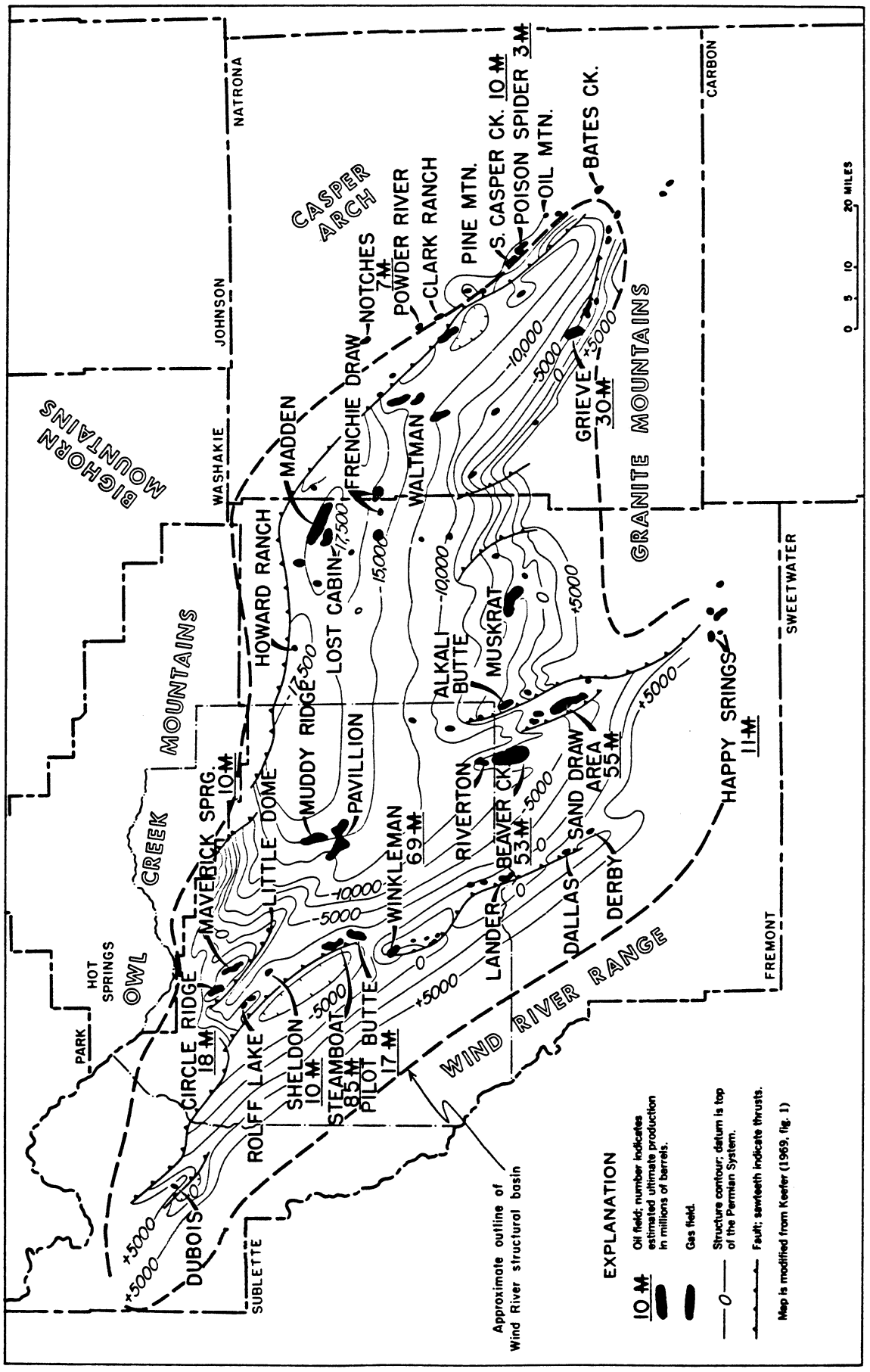


Figure 14.--Location of oil and gas fields in the Wind River basin (from Rocky Mountain Association of Geologists, 1972, Geologic Atlas of the Rocky Mountain Region).

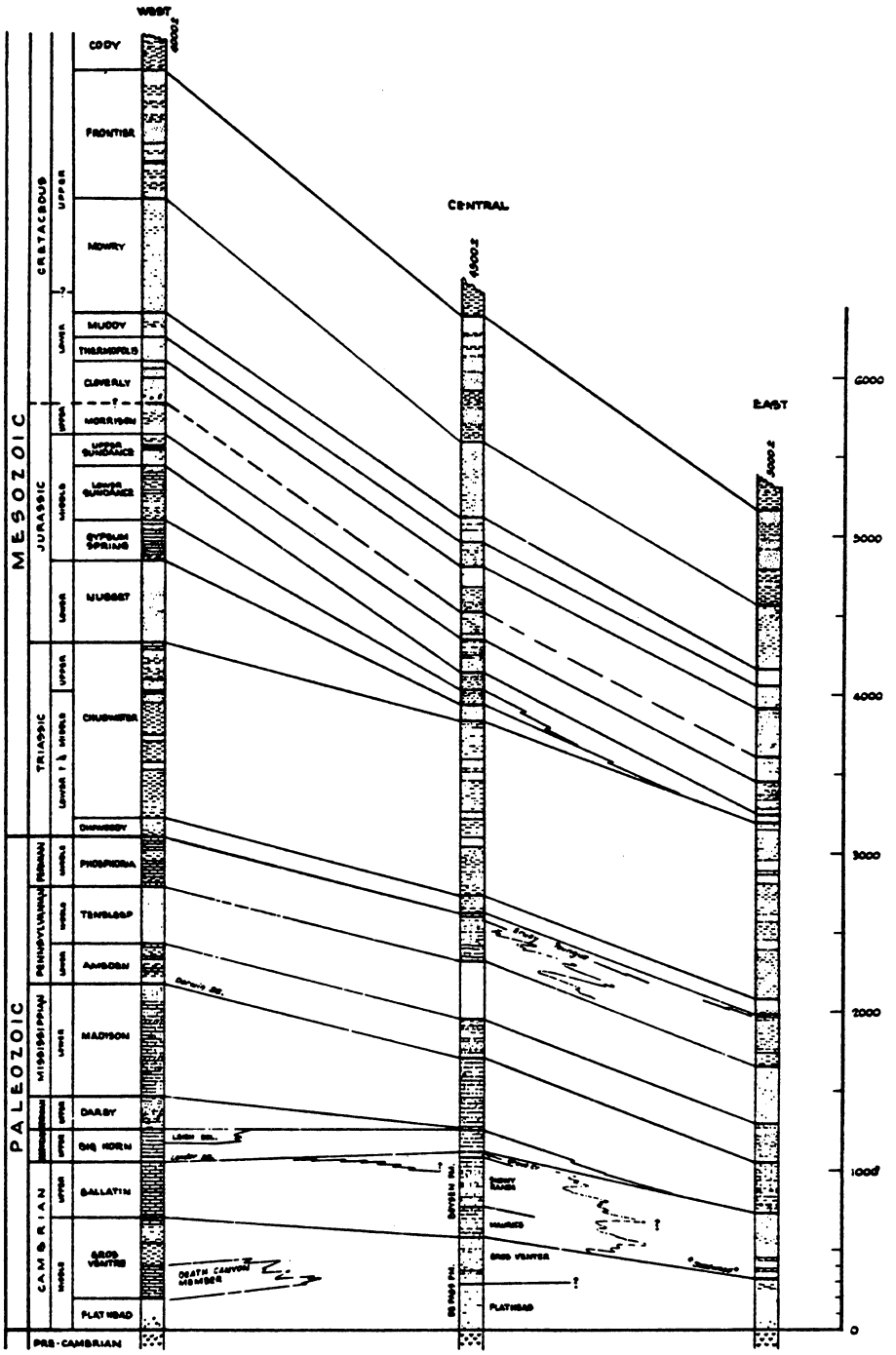


Figure 15.--Correlation of Paleozoic and some Mesozoic rocks in a general east-west direction, Wind River basin, Wyoming. Vertical scale in feet. (From R. M. Thompson, 1958, Geology and oil and gas possibilities of the Wind River basin, in AAPG, Habitat of Oil, A Symposium.)

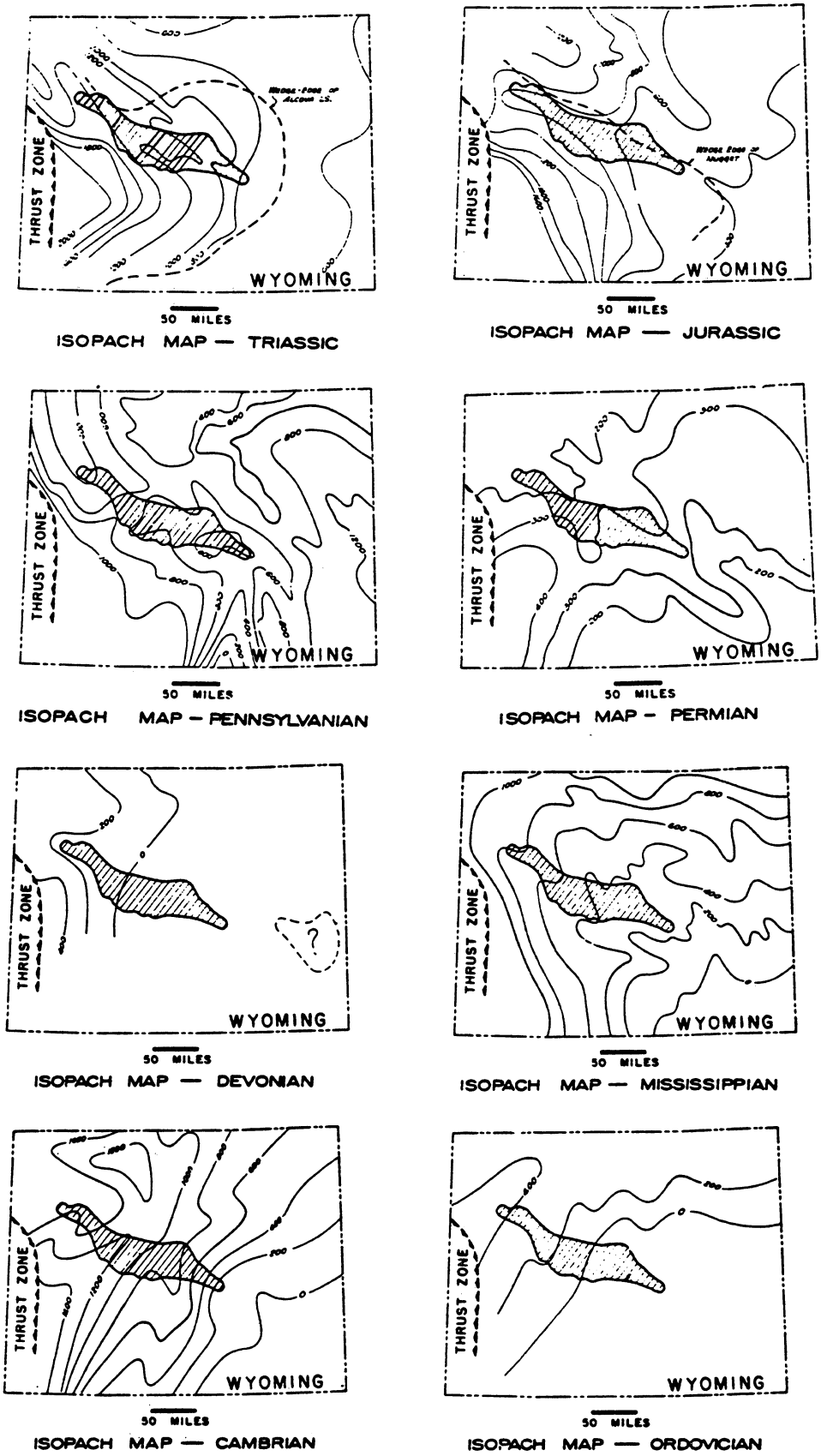


Figure 16.--Isopach maps of the Wind River basin. (From R. M. Thompson, 1958, Geology and oil and gas possibilities of the Wind River basin, in AAPG, Habitat of Oil, A Symposium.)

TABLE I. OIL PRODUCTION AND RESERVE DATA—WIND RIVER BASIN—THROUGH 1954

FIELD	PRODUCTIVE FORMATION	NO. OF PROD. WELLS	CUMULATIVE OIL PRODUCTION	GRAVITY OF OIL	APPROX. DEPTH OF PROD. FM.	ESTIMATED CLOSURE	THICKNESS OF OIL ZONE	EFFECTIVE THICKNESS	RESERVOIR CONTROL	RECOVERY METHOD	EST. TOTAL PROVEN RESERVES	YEAR OF DISCOVERY
Alkali Butte	Shannon ?	4	10,617	34								1928
	Muddy & Lakota											
Beaver Creek	Cody	29	800,000 est.	45	3,700	800	125	25	Vol.	Flow	8,700,000	1951
	Tensleep		2,023,867 est.	39	10,500	1300	400	70	Vol.	Flow		1949
	Madison											
Big Sand Draw	Tensleep	18	18,178,062	32.2	7,300	2500	400	350	Hyd.	Flow	15,000,000	1944
Circle Ridge	Embar-Tensleep	108	5,855,251	23.7	180-1300	1800	300	224	Hyd.	Pump	8,500,000	1923
	Madison	2	55,000 est.	23.8	1600-1670	?	65	65	Hyd.	Pump	700,000	1946
Dallas Derby	Embar-Tensleep	44	5,793,307	22	1,000	250	85	85	Hyd.	Pump	2,400,000	1883
Dubois	Phosphoria	1	13,763	21	2,060	?	83	50	Hyd.	Pump	10,000	1946
Grieve	Muddy	2										
Lander-Hudson	Phosphoria-Tensleep	37	5,134,284	22	1,790	1300	65	65	Hyd.	Pump	5,000,000	1909
Maverick Springs	Embar	44	4,066,441	22	1100-1700	1000	30	15	Hyd.	Pump	1,500,000	1918
	Tensleep	2		22	1,800	1000	100	62	Hyd.	Pump		1953
Pilot Butte	Cody	41	5,714,654	37	800	?	?	?	Hyd.	Pump	14,235,000	1916
	Muddy			45	3,575	?	16	11	Hyd.	Pump		1949
	Embar			25	5,760	275	80	28	Hyd.	Pump		1944
	Tensleep			26	6,200	275	240	150	Hyd.	Pump		1942
Plunkett	Mowry	16	17,842	41	500' ±	?	?	?	Hyd.	Pump	?	1909
Poison Spider, West	Mesa Verde	1	300,016 est.	45	9,288	800	60	30	Hyd.	Pump	129,000	1948
	Frontier	1	306,000 est.	46	14,199	800	117	117	Hyd.	Pump	359,000	1948
	Morrison	1	12,000 est.	42.7	15,922	?	38	28	Hyd.	Pump	9,500	1948
Riverton	Phosphoria	3	898,484	56	11,250	400	417	100	Vol.	Flow	1,812,000	1949
	Tensleep	2		46	11,585	400	2	?	Vol.	Flow		1949
Sage Creek	Phosphoria	3	7,331	21					Hyd.	Pump	?	
Sand Draw, North	Tensleep	1	47,874	40.4	10,737	?	650	18	Hyd.	Pump	75,000	1953
Sheldon	Embar	2	544,069 est.	36	6,545	500	115	85	Hyd.	Pump	369,000	1945
	Tensleep	1	15,000 est.	34	6,800	500	445	?	Hyd.	Pump	37,000	
Sheldon, NW	Curtis	3			3,400				Hyd.	Pump		1954
Steamboat Butte	Lakota	39	26,962,403	38-45	4150-4500	150	33-65	20-38	Hyd.	Pump	81,000,000	1944
	Nugget			26	5,125	200	132	70	Hyd.	Pump		1943
	Embar			31	6,700	315	58	34	Hyd.	Pump		1948
	Tensleep			29	7,066	315	307	200	Hyd.	Pump		1944
Winkleman	Phosphoria	9	7,418,722	25	2,920	700	117	75	Vol.	Pump	16,000,000	1948
	Tensleep	10		28	3,250	750	275	165	Vol.	Pump		1944
		TOTALS	64,194,987								154,835,500*	

NOTE: Where necessary to estimate production by formations the cumulative totals are correct.
* This represents about 12% of the total reserves in Wyoming.

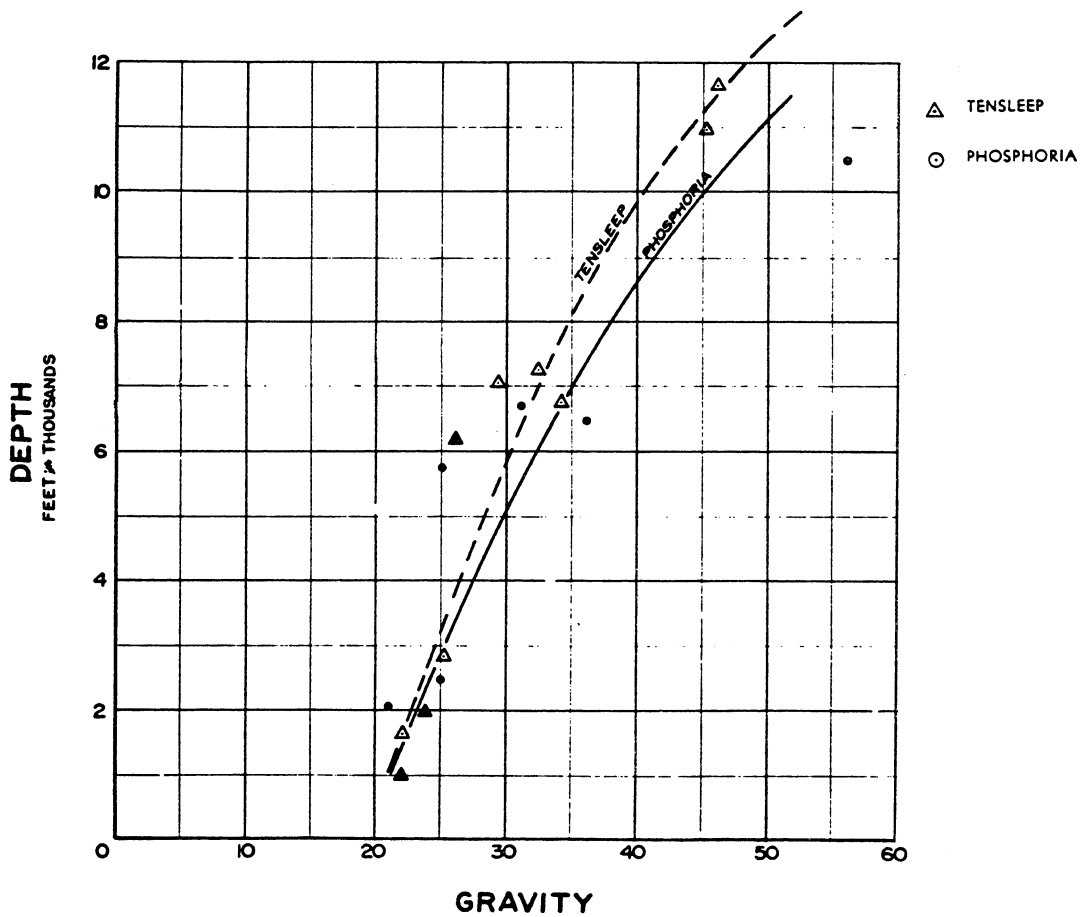


Figure 17.--Production data and depth-gravity relationships of Phosphoria oils. (From R. M. Thompson, 1958, Geology and oil and gas possibilities of the Wind River basin, in AAPG, Habitat of Oil, A Symposium.)

Wyoming - Big Sand Draw
Phosphoria
Wind River Basin

DATA SOURCE CODE		
	STATE	Wyoming
2c	COUNTY	Fremont
	REGULATORY DISTRICT	
	BASIN	Wind River
	SUB-BASIN	
2c	FIELD	Big Sand Draw
2c	RESERVOIR	Phosphoria
2c	GEOLOGIC AGE	Permian
	AAPG STRATIGRAPHIC AGE CODE	
2c	RESERVOIR LITHOLOGY	Limestone
2c	TRAPPING MECHANISM	Anticline faulted
2c, 2b	DISCOVERY YEAR	1918 field, 1948 fm., 1918
11	PROVED ACREAGE	3200 - 4480 (from 2c structure contour)
	REGULAR WELL SPACING (acres/well)	
2c, 2b	RESERVOIR DEPTH	7095; 6850
	RESERVOIR THICKNESS	
2c	NET PAY	50
2c	GROSS	365
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
	FRACTION	
	PERMEABILITY	
	RANGE	
	AVERAGE	
	HORIZONTAL	
	VERTICAL	
2c	OTHER INFORMATION	Other reservoirs include the Tensleep
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2d	TOTAL NUMBER OF WELLS	36P
	PRODUCTION 1976 oil (cum)	
	PRODUCTION 1977 oil (cum)	
	PRODUCTION 1978 oil (cum)	
2d	PRODUCTION 1979 oil (cum)	53,147.5 mbbls oil; 139,516.9 mmcf gas
22	PRODUCTION 1-1-79 to 1-1-80	965.7 mbbls oil; 1,154.3 mmcf gas
	SECONDARY RECOVERY RECORDS?	no
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
2c	STRUCTURE CONTOUR?	yes
	LOGS?	
	STRUCTURE SECTION?	
	ENGINEERING REPORTS?	
	CORE DESCRIPTIONS?	
2c	CRUDE ANALYSIS?	yes

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Big Sand Draw
2c	RESERVOIR:	Phosphoria
11	PROD. ACRES:	3200 - 4480
2c	AVG. THICKNESS (FT.):	50
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
	PRIMARY DRIVE MECHANISM:	
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	182
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
	RESERVOIR PRESSURE INITIAL (psi):	
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
2c	STOCK TANK OIL GRAVITY (°API):	62.1
2c	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	32 sec. SU
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

	OTHER INFORMATION:

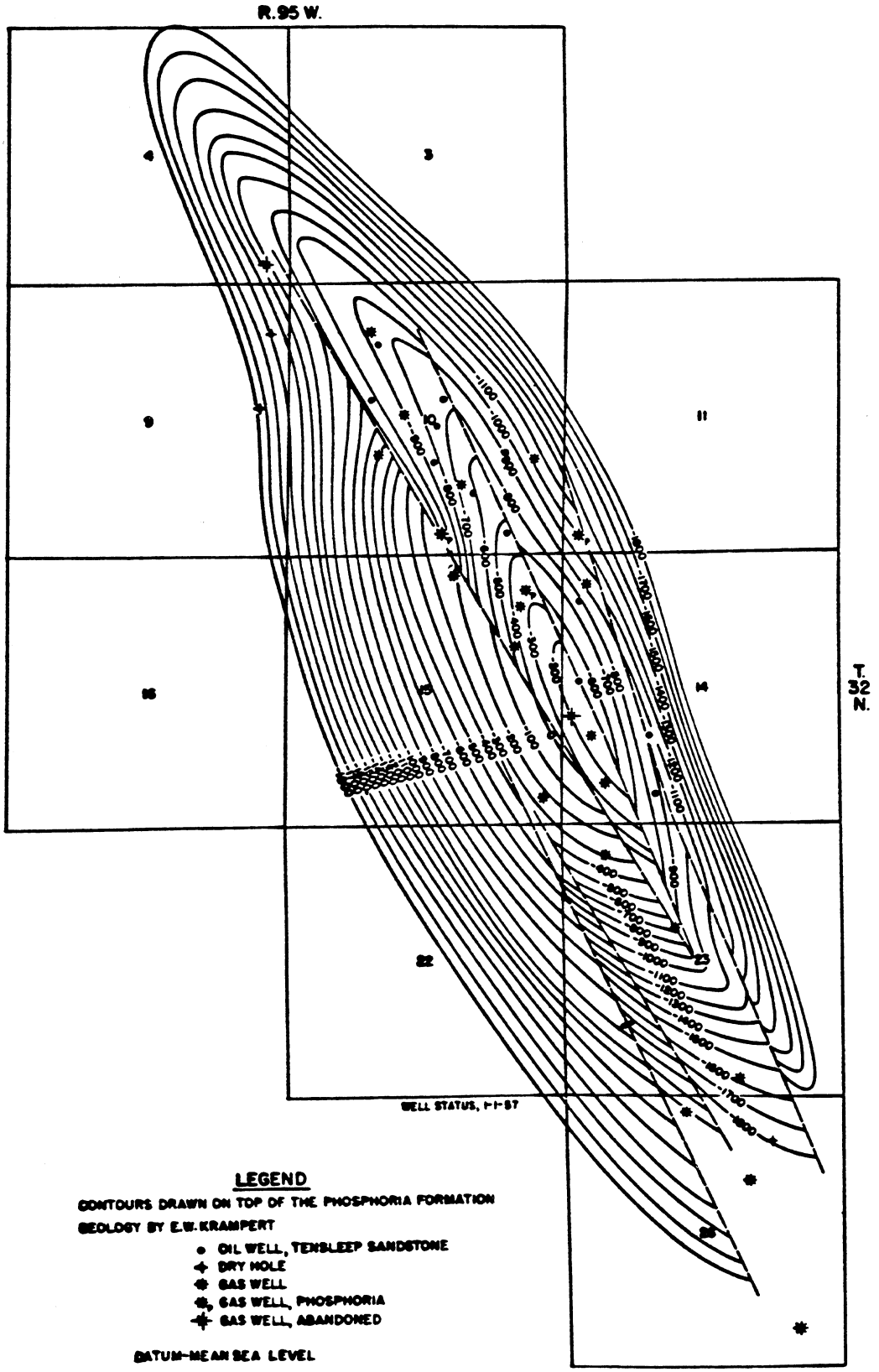


FIGURE 21.—Structure-Contour Map of Big Sand Draw Field, Fremont County, Wyo.

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

TABLE 12.—*Crude-oil analyses*—Continued

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..Laramie.. Laboratory
Sample ..PC-56-339..

IDENTIFICATION

Polecat, Big — Field
Tensleep sandstone - Pennsylvanian
9,525 - 9,537 feet

Wyoming
Park — County
SE¼SW¼ sec. 16,
T. 57 N., R. 98 W.

GENERAL CHARACTERISTICS

Gravity, specific, ..0.896.. Gravity, ° API, ..26.4°.. Pour point, ° F., ..below 5..
Sulfur, percent, ..2.56.. Color, ..brownish black..
Viscosity, Saybolt Universal at 100° F., 89 sec.; at 77° F., 92 sec. Nitrogen, percent, ..0.180..

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, ..760.. mm. Hg
First drop, ..64.. ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index n_D at 20° C.	Specific dispersion	S. U. vis. at 100° F.	Cloud test, ° F.
1	150	0.9	0.9	0.654	84.9					
2	167	1.9	2.8	.658	83.6	1.8	1.37202	128.6		
3	219	2.4	5.2	.697	71.5	10	1.39190	126.0		
4	257	3.2	8.4	.725	63.7	15	1.40491	130.8		
5	300	4.2	12.6	.749	57.4	18	1.41780	135.9		
6	347	3.7	16.3	.777	50.6	25	1.43257	142.0		
7	398	3.3	19.6	.796	46.3	28	1.44331	143.9		
8	437	4.2	23.8	.813	42.6	30	1.45157	144.3		
9	488	4.3	28.1	.828	39.4	32	1.45996	145.9		
10	527	6.0	34.1	.848	35.4	37	1.46925	155.2		
Stage 2—Distillation continued at 40 mm. Hg										
11	300	7.5	41.6	0.873	30.6	45			42	below 5
12	437	6.9	48.5	.893	27.0	50			54	20
13	488	6.0	54.5	.913	23.5	56			84	45
14	527	5.5	60.0	.935	19.8	64			160	65
15	572	7.1	67.1	.946	18.1	66			380	80
Residuum		30.6	97.7	1.019	7.4					

Carbon residue, Conradson: Residuum, 20.7 percent; crude, 7.2 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	5.2	0.675	78.1	
Total gasoline and naphtha	19.6	.739	60.0	
Kerosine distillate	4.2	.813	42.6	
Gas oil	18.8	.859	34.0	
Nonviscous lubricating distillate	10.1	.886-.917	28.2-22.8	80-100
Medium lubricating distillate	5.7	.917-.937	22.8-19.2	100-200
Viscous lubricating distillate	8.7	.937-.953	19.2-17.0	Above 200
Residuum	30.6	1.019	7.4	
Distillation loss	2.3			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..Laramie.. Laboratory
Sample ..PC-49-78..

IDENTIFICATION

Big Sand Draw — Gold
Phosphoria limestone - Permian
6,850 - 7,257 feet

Wyoming
Fremont — County
NE¼NE¼ sec. 19,
T. 32 N., R. 95 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.731 A. P. I. gravity 62.1 ° Pour point, ° F. ..below 5..
Sulfur, percent, ..0.32.. less than Color, ..less than NPA 1..
Saybolt Universal viscosity at 100° F., ..32.. sec.; at ____ ° F., ____ sec. Nitrogen, percent 0.000

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, ..760.. mm. Hg
First drop, ..25.. ° C. (..77.. ° F.)

Fraction No.	Cut at ° F.	Percent	Sum, Percent	Sp. gr. 60/60° F.	° A.P.I. at 60° F.	a.s.	Saybolt vis. at 100° F.	S.U. vis. at 100° F.	Cloud test, ° F.
1	80	11.4	11.4	0.640	89.6				
2	98	10.4	21.8	.663	81.9	4.2			
3	160	16.2	38.0	.702	70.1	13	56.4		
4	198	14.6	52.6	.733	61.5	18	51.2		
5	250	14.0	66.6	.755	55.9	21	48.8		
6	295	10.1	76.7	.773	51.5	23	49.6		
7	350	6.7	83.4	.783	49.2	22	55.0		
8	400	4.5	87.9	.795	46.5	22	61.2		
9	450	3.8	91.7	.803	44.7	20	66.4		
10	515	3.4	95.1	.816	41.9	22	69.8		
Stage 2—Distillation continued at 40 mm. Hg.									
11	350								
12	400								
13	450								
14	515								
15	550								
Residuum		2.7	97.8	.860	33.0			44	

Carbon residue of residuum, 0.0 percent; carbon residue of crude, 0.0 percent.
*Column holdup

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A.P.I.	Viscosity
Light gasoline	38.0	0.673	78.7	
Total gasoline and naphtha	83.4	0.718	65.6	
Kerosine distillate	11.7	.804	44.5	
Gas oil	2.7	.860	33.0	
Nonviscous lubricating distillate				80-100
Medium lubricating distillate				100-200
Viscous lubricating distillate				Above 200
Residuum	Included in gas oil			
Distillation loss	2.2			

Wyoming - Beaver Creek
Madison
Wind River Basin

DATA SOURCE CODE		
8	STATE	Wyoming
	COUNTY	Fremont
	REGULATORY DISTRICT	
	BASIN	Wind River
	SUB-BASIN	
8	FIELD	Beaver Creek
8	RESERVOIR	Madison
2c, 8	GEOLOGIC AGE	Mississippian
	AAPG STRATIGRAPHIC AGE CODE	
8	RESERVOIR LITHOLOGY	Dolomite
8, 2c	TRAPPING MECHANISM	Anticline
2c,8,2b	DISCOVERY YEAR	1938 field, 1954 Fm, 1938, 1938
11	PROVED ACREAGE	1280 - 3200 (from 2c structure contour)
	REGULAR WELL SPACING (acres/well)	
8,2c,2b	RESERVOIR DEPTH	11,000; 11,204; 11,200
	RESERVOIR THICKNESS	
11	NET PAY	(25)
	GROSS	
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
	FRACTION	
	PERMEABILITY	
	RANGE	
	AVERAGE	
	HORIZONTAL	
	VERTICAL	
8	OTHER INFORMATION	Other reservoirs are the Mesaverde Sand, the Tensleep Sand, Lakota Sand, and Muddy Sand.
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2d	TOTAL NUMBER OF WELLS	44P
	PRODUCTION 1976 oil (cum)	
	PRODUCTION 1977 oil (cum)	
	PRODUCTION 1978 oil (cum)	
2d	PRODUCTION 1979 oil (cum)	48,200.8 mbbls oil; 471,605.4 mmcf gas
2d	PRODUCTION 1-1-79 to 1-1-80	425.3 mbbls oil; 12,708.4 mmcf gas
2d	SECONDARY RECOVERY RECORDS?	yes
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
2c	STRUCTURE CONTOUR?	yes (Lakota Sand)
	LOGS?	
2c	STRUCTURE SECTION?	yes
	ENGINEERING REPORTS?	
	CORE DESCRIPTIONS?	
2c	CRUDE ANALYSIS?	yes

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Beaver Creek
8	RESERVOIR:	Madison
11	PROD. ACRES:	1280 - 3200
	AVG. THICKNESS (FT.):	
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
	PRIMARY DRIVE MECHANISM:	
	PRIMARY GAS CAP?:	
11	TEMPERATURE (^oF):	246
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
	RESERVOIR PRESSURE INITIAL (psi):	
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
2c	STOCK TANK OIL GRAVITY (^oAPI):	42
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

2d **OTHER INFORMATION:**

Secondary recovery: waterflood - 6 injection wells in Madison by Amoco Production Company

2c Water Analysis: Beaver Creek-Madison

Na & K	346
Cl	115
Mg	26
SO4	561
Cl	165
CO_3	-0-
HOC_3	403
ts	1,411
Primary salinity	65.64%
Secondary salinity	5.54%
Primary alkalinity	---
Secondary alkalinity	28.82

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-49-90

IDENTIFICATION

Beaver Creek field
Frontier sandstone - Upper Cretaceous
7,059 - 8,108 feet

Wyoming
Fremont County
NW¼SW¼ sec. 11,
T. 33 N., R. 96 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.747 A. P. I. gravity 57.9 ° Pour point, ° F. below 5
Sulfur, percent, less than 0.10 Color, less than NPA 1
Saybolt Universal viscosity at 100° F., less than 32 sec.; at ____° F., ____ sec. Nitrogen, percent 0.00

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 28 ° C. (82 ° F.)

Fraction No.	Cut at ° C.	Cut at ° F.	Percent	Sum. Percent	Sp. Gr. 60/60° F.	° A. P. I. 60° F.	C. I.	Aniline Point ° C.	S. U. Visc. 100° F.	Cloud Test ° F.
1	50	122	9.7	9.7	0.639	89.9				
2	75	167	4.4	14.1	.674	78.4	8.9	55.0		
3	100	212	19.3	33.4	.720	65.0	21	50.5		
4	125	257	20.0	53.4	.749	57.4	26	45.2		
5	150	302	13.2	66.6	.766	53.2	27	46.1		
6	175	347	8.4	75.0	.780	49.9	26	50.1		
7	200	392	5.9	80.9	.788	48.1	24	56.9		
8	225	437	4.7	85.6	.799	45.6	24	62.2		
9	250	482	3.8	89.4	.812	42.8	24	66.3		
10	275	527	3.0	92.4	.827	39.6	27	69.6		

STAGE 2—Distillation continued at 40 mm. Hg

Fraction No.	Cut at ° C.	Cut at ° F.	Percent	Sum. Percent	Sp. Gr. 60/60° F.	° A. P. I. 60° F.	C. I.	Aniline Point ° C.	S. U. Visc. 100° F.	Cloud Test ° F.
11	200	392	1.9	94.3	0.833	38.4		73.6	38	10
12	225	437								
13	250	482								
14	275	527								
15	300	572								
Residuum*			2.4	96.7	.853	34.4		82.4	46	45

Carbon residue of residuum, 0.0 percent; carbon residue of crude, 0.0 percent.
*Column holdup

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	° A. P. I.	Viscosity
Light gasoline	33.4	0.692	72.1	
Total gasoline and naphtha	80.9	0.735	61.0	
Kerosine distillate	8.5	.805	44.3	
Gas oil	7.3	.837	37.6	
Nonviscous lubricating distillate				50-100
Medium lubricating distillate				100-200
Viscous lubricating distillate				Above 200
Residuum	included in gas oil			
Distillation loss	3.3			

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-49-91

IDENTIFICATION

Beaver Creek field
Muddy sandstone - Lower Cretaceous
8,440 - 8,470 feet

Wyoming
Fremont County
SW¼SE¼ sec. 34,
T. 34 N., R. 96 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.761 A. P. I. gravity 54.4 ° Pour point, ° F. below 5
Sulfur, percent, less than 0.10 Color, NPA 1
Saybolt Universal viscosity at 100 ° F., 32 sec.; at ____° F., ____ sec. Nitrogen, percent 0.00

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 30 ° C. (86 ° F.)

Fraction No.	Cut at ° C.	Cut at ° F.	Percent	Sum. Percent	Sp. Gr. 60/60° F.	° A. P. I. 60° F.	C. I.	Aniline Point ° C.	S. U. Visc. 100° F.	Cloud Test ° F.
1	50	122	0.9	0.9	0.644	88.2				
2	75	167	4.9	5.8	.680	76.6	12	58.0		
3	100	212	20.2	26.0	.729	62.6	26	45.3		
4	125	257	32.8	58.8	.760	54.7	31	37.6		
5	150	302	17.7	76.5	.781	49.7	34	35.5		
6	175	347	9.3	85.8	.789	47.8	31	42.7		
7	200	392	5.5	91.3	.794	46.7	27	52.7		
8	225	437	3.3	94.6	.805	44.3	26	59.6		
9	250	482	1.3	95.9	.815	42.1		62.2		
10	275	527								

STAGE 2—Distillation continued at 40 mm. Hg

Fraction No.	Cut at ° C.	Cut at ° F.	Percent	Sum. Percent	Sp. Gr. 60/60° F.	° A. P. I. 60° F.	C. I.	Aniline Point ° C.	S. U. Visc. 100° F.	Cloud Test ° F.
11	200	392			0.					
12	225	437								
13	250	482								
14	275	527								
15	300	572								
Residuum*			2.5	98.4	.840	36.9		68.4	35	10

Carbon residue of residuum, 0.0 percent; carbon residue of crude, 0.0 percent.
*Column holdup

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	° A. P. I.	Viscosity
Light gasoline	26.0	0.717	65.8	
Total gasoline and naphtha	91.3	0.757	55.4	
Kerosine distillate	4.6	.808	43.6	
Gas oil	2.5	.840	36.9	
Nonviscous lubricating distillate				50-100
Medium lubricating distillate				100-200
Viscous lubricating distillate				Above 200
Residuum	included in gas oil			
Distillation loss	1.6			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

TABLE 12.—*Crude-oil analyses*—Continued

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..Laramie.. Laboratory
Sample ..PC-33-353..

IDENTIFICATION

Baxter Basin, North field
Nugget sandstone - Triassic
4,082 - 4,084 feet

Wyoming
Sweetwater County
SE¼NW¼ sec. 11,
T. 19 N., R. 104 W.

GENERAL CHARACTERISTICS

Gravity, specific, ...0.723..... Gravity, ° API, ...61.2°..... Pour point, ° F., ...below 5.....
Sulfur, percent, ...0.06.....
Viscosity, Saybolt Universal at 100° F., ...less than 32 sec..... Color, ...less than NPA 1.....
Nitrogen, percent, ...0.000.....

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Grade 1—Distillation at atmospheric pressure, ...760..... mm. Hg
First drop, ...75..... ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	150	4.0	4.0	0.642	88.9		1.36188	123.2		
2	167	14.7	18.5	.671	79.4	8.0	1.37529	121.5		
3	218	23.0	42.5	.711	67.5	17	1.39456	124.1		
4	287	19.4	61.9	.740	59.7	22	1.40930	125.7		
5	368	16.7	78.6	.762	54.2	25	1.42157	134.5		
6	547	10.5	89.1	.784	49.0	28	1.43410	140.3		
7	568	5.0	94.1	.799	45.6	29	1.44203	143.1		
8	627	2.0	96.1	.806	44.1	27	1.44619	140.6		
9	668									
10	697									

Grade 2—Distillation continued at 40 mm. Hg

11	368									
12	427									
13	468									
14	527									
15	578									
Residuum		3.0	99.1	0.834	38.2					

Carbon residue, Conradson: Residuum, ..2 .. percent; crude, ...0.. percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	42.9	0.689	73.9	
Total gasoline and naphtha	94.1	.729	62.6	
Kerosine distillate	2.0	.806	44.1	
Gas oil				
Nonviscous lubricating distillate				80-100
Medium lubricating distillate				100-200
Viscous lubricating distillate				Above 200
Residuum	3.0	.834	38.2	
Distillation loss	.9			

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..Laramie.. Laboratory
Sample ..PC-21-149..

IDENTIFICATION

Beaver Creek field
Mesaverde sand - Upper Cretaceous
3,632 - 3,785 feet

Wyoming
Fremont County
NW¼SW¼ sec. 10,
T. 33 N., R. 96 W.

GENERAL CHARACTERISTICS

Gravity, specific, ...0.856..... Gravity, ° API, ...33.8°..... Pour point, ° F., ...below 5.....
Sulfur, percent, ...0.20.....
Viscosity, Saybolt Universal at 100° F., ...48..sec..... Color, ...brownish green.....
Nitrogen, percent, ...0.117.....

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Grade 1—Distillation at atmospheric pressure, ...760..... mm. Hg
First drop, ...172..... ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	150									
2	167									
3	218	2.1	2.1	0.715	66.4		1.39720	124.1		
4	287	5.4	7.5	.740	59.7	22	1.40856	125.2		
5	368	5.8	13.3	.758	55.2	23	1.41902	130.5		
6	547	5.7	19.0	.775	51.1	24	1.42830	131.8		
7	568	5.4	24.4	.791	47.4	25	1.43684	134.6		
8	627	5.5	29.9	.805	44.3	26	1.44470	136.5		
9	668	6.2	36.1	.818	41.5	27	1.45199	139.6		
10	697	7.5	43.6	.830	39.0	28	1.45921	143.6		

Grade 2—Distillation continued at 40 mm. Hg

11	368	2.0	45.6	0.845	36.0	31			39	15
12	427	7.3	52.9	.849	35.2	29			43	35
13	468	6.6	59.5	.860	33.0	31			53	50
14	527	5.8	65.3	.879	29.5	37			73	70
15	578	7.0	72.3	.892	27.1	40			125	85
Residuum		26.8	99.1	.959	16.7					

Carbon residue, Conradson: Residuum, ...5.6 percent; crude, ..1.7. percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	2.1	0.715	66.4	
Total gasoline and naphtha	24.4	.762	54.2	
Kerosine distillate	11.7	.812	42.8	
Gas oil	10.1	.842	36.6	
Nonviscous lubricating distillate	11.6	.856-.866	33.8-28.2	80-100
Medium lubricating distillate	6.5	.866-.899	28.2-25.9	100-200
Viscous lubricating distillate	.0			Above 200
Residuum	26.8	.959	16.7	
Distillation loss	.9			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

well was plugged and abandoned in 1956. The oil from the field was transported by truck.

The Bearcat unit, approved December 30, 1954, consisted of 12,608 acres.

BEAVER CREEK

The Beaver Creek field (fig. 13) is a gently folded anticline in secs. 21, 28, and 34, T. 34 N., R. 96 W., and secs. 3, 4, 9, 10, 11, 14, and 15, T. 33 N., R. 96 W., Fremont County. The field is 20 miles east of Lander and 14 miles southeast of Riverton. It lies between the Riverton Dome and Big Sand Draw fields The east side of the structure has the steepest dip. Based on the Lakota sandstone the subsurface closure is over 1,200 feet. Several east-west trending faults having a maximum vertical displacement of 160 feet cut the fold at the south end of the field. The field rests along the Beaver Creek drainage in a broad valley, which is floored by strata of the Wind River formation and has a surface elevation of 5,250 to 5,400 feet above sea level.

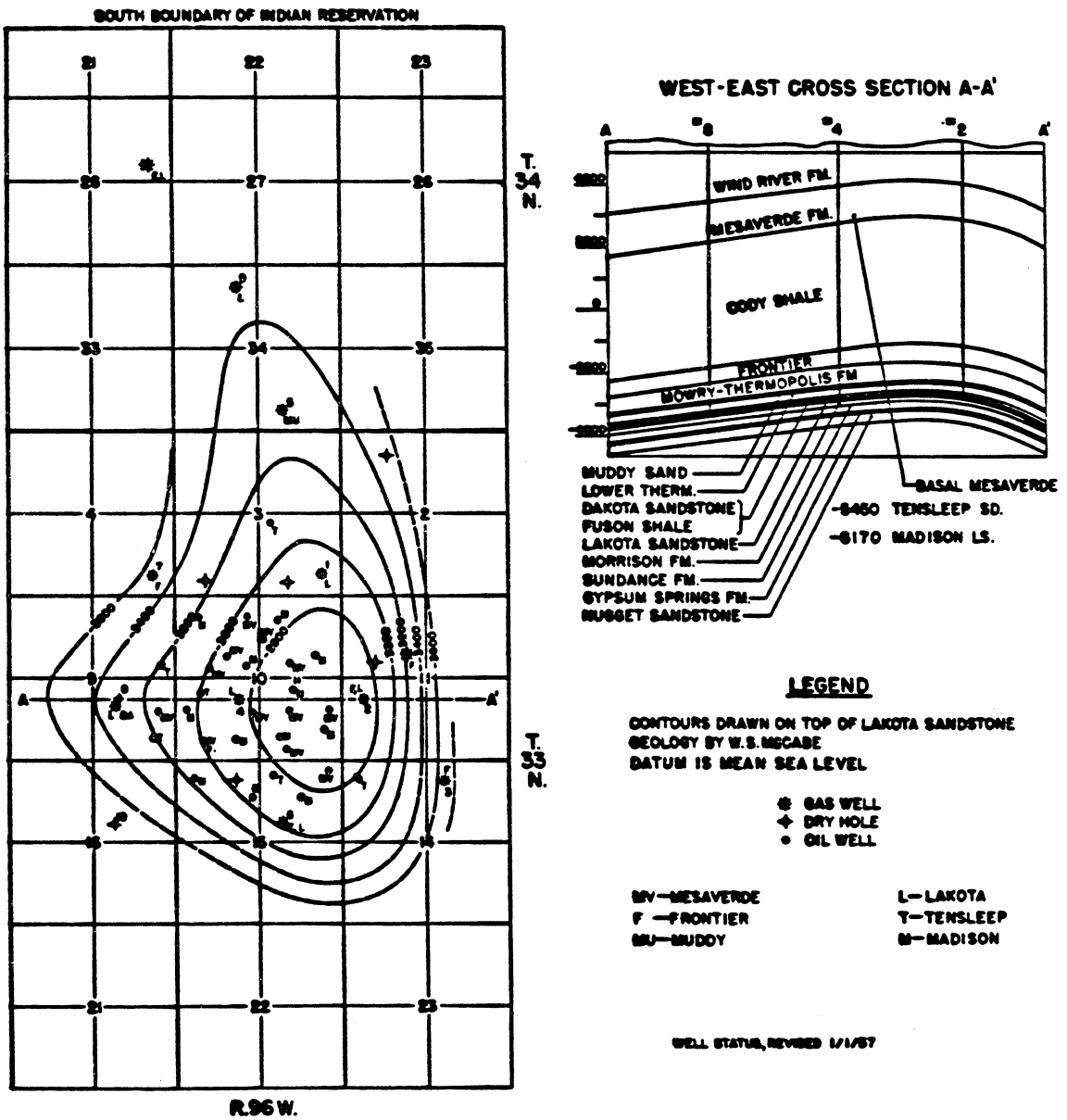


FIGURE 13.—Structure-Contour Map of Beaver Creek Field, Fremont County, Wyo.

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

TABLE 12.—*Crude-oil analyses*—Continued

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-49-89

IDENTIFICATION

Beaver Creek field
Lakota sandstone - Lower Cretaceous
8,738 - 8,790 feet

Wyoming
Fremont County
SW¼SE¼ sec. 34,
T. 34 N., R. 96 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.792 A. P. I. gravity 46.7 ° Pour point, ° F. below 5
Sulfur, percent, less than 0.10 less than Color, less than NPA 1
Saybolt Universal viscosity at 100° F., 32 sec.; at ° F., sec. Nitrogen, percent 0.00

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 28 ° C. (82 ° F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Cum. Percent	Sp. Gr.	°A. P. I.	n_D^20	Aniline point °C.	Aniline point °F.	Pour point °F.
1	80	176	2.1	2.1	0.649	87.9				
2	95	203	5.0	7.1	673	78.7	8.9			
3	150	302	14.6	21.7	716	66.1	19	53.1		
4	175	347	19.2	41.6	740	59.7	22	50.8		
5	190	374	16.9	58.5	756	55.7	22	51.9		
6	215	419	12.5	71.0	769	52.5	21	55.9		
7	230	446	8.1	79.1	779	50.1	20	62.2		
8	255	491	6.5	85.6	789	47.8	19	67.8		
9	280	536	4.9	90.5	800	45.4	19	72.0		
10	275	527	3.4	93.9	815	42.1	21	75.4		

STAGE 2—Distillation continued at 40 mm. Hg

11	200	392	2.0	95.9	0.822	40.6		78.2	35	5
12	225	437								
13	250	482								
14	275	527								
15	300	572								
Residuum . . .			2.7	98.6	835	38.0		84.2	42	30

Carbon residue of residuum, 0.0 percent; carbon residue of crude, 0.0 percent.
*Column holdup

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A. P. I.	Viscosity
Light gasoline	21.7	0.699	70.9	
Total gasoline and naphtha	29.1	0.741	59.5	
Kerosine distillate	14.8	.799	45.6	
Gas oil	4.7	.829	39.2	
Nonviscous lubricating distillate				50-100
Medium lubricating distillate				100-200
Viscous lubricating distillate				Above 200
Residuum	Included in gas oil			
Distillation loss	1.4			

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-49-93

IDENTIFICATION

Beaver Creek field
Tensleep sandstone - Pennsylvanian
10,442 - 10,903 feet

Wyoming
Fremont County
NE¼NW¼SE¼ sec. 10,
T. 33 N., R. 96 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.809 A. P. I. gravity 44.3 ° Pour point, ° F. below 5
Sulfur, percent, 0.08 Color, brownish green
Saybolt Universal viscosity at 100° F., 32 sec.; at ° F., sec. Nitrogen, percent 0.01

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 28 ° C. (82 ° F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Cum. Percent	Sp. Gr.	°A. P. I.	n_D^20	Aniline point °C.	Aniline point °F.	Pour point °F.
1	80	176	3.3	3.3	0.644	88.2				
2	95	203	3.5	6.8	662	82.2	3.7			
3	150	302	5.5	12.3	703	69.8	13	57.3		
4	175	347	7.4	19.7	734	61.3	19	52.8		
5	190	374	7.7	27.4	758	55.2	23	49.4		
6	215	419	8.0	35.4	775	51.1	24	49.0		
7	230	446	6.7	42.1	789	47.8	24	52.8		
8	255	491	6.0	48.1	799	45.6	24	59.1		
9	280	536	6.9	55.0	817	41.7	27	64.7		
10	275	527	6.7	61.7	830	39.0	28	68.3		

STAGE 2—Distillation continued at 40 mm. Hg

11	200	392	5.7	67.4	0.854	34.2	34	72.2	39	5
12	225	437	7.3	74.7	868	31.5	38	76.4	45	30
13	250	482	5.1	79.8	888	27.8	45	79.3	58	50
14	275	527	3.0	82.8	898	26.1	46	82.2	78	70
15	300	572	5.7	88.5	906	24.7	47	89.4	125	90
Residuum . . .			7.5	96.0	962	15.6				

Carbon residue of residuum, 7.3 percent; carbon residue of crude, 0.7 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A. P. I.	Viscosity
Light gasoline	12.3	0.676	77.8	
Total gasoline and naphtha	42.1	0.738	60.2	
Kerosine distillate	12.9	.809	43.4	
Gas oil	18.5	.850	35.0	
Nonviscous lubricating distillate	9.8	.874-.902	30.4-25.4	50-100
Medium lubricating distillate	5.2	.902-.912	25.4-23.6	100-200
Viscous lubricating distillate	0			Above 200
Residuum	7.5	962	15.6	
Distillation loss	4.0			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

Wyoming - Circle Ridge
Phosphoria
Wind River Basin

DATA SOURCE CODE		
	STATE----------	Wyoming
2c	COUNTY----------	Fremont
	REGULATORY DISTRICT----------	
	BASIN----------	Wind River
	SUB-BASIN----------	
2c	FIELD----------	Circle Ridge
2c	RESERVOIR----------	Phosphoria
2c	GEOLOGIC AGE----------	Permian
	AAPG STRATIGRAPHIC AGE CODE----------	
2c	RESERVOIR LITHOLOGY----------	Limestone
2c	TRAPPING MECHANISM----------	Overturned faulted anticline
2c, 2b	DISCOVERY YEAR----------	1923 (fm.)
11	PROVED ACREAGE----------	3200
	REGULAR WELL SPACING (acres/well)-----	
2b	RESERVOIR DEPTH----------	950
	RESERVOIR THICKNESS	
	NET PAY----------	
2c	GROSS----------	280'
	NET/GROSS RATIO----------	
	POROSITY	
	TYPE----------	
	FRACTION----------	
	PERMEABILITY	
	RANGE----------	
	AVERAGE----------	
	HORIZONTAL----------	
	VERTICAL----------	
2c	OTHER INFORMATION----------	Other production from Tensleep and Madison limestone
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2d	TOTAL NUMBER OF WELLS----------	160P
	PRODUCTION 1976 oil (cum)----------	
	PRODUCTION 1977 oil (cum)----------	
	PRODUCTION 1978 oil (cum)----------	
2d	PRODUCTION 1979 oil (cum)----------	20,888.2 mbbls oil; 0 gas
2d	PRODUCTION 1-1-79 to 1-1-80----------	903.1 mbbls oil; 0 gas
	SECONDARY RECOVERY RECORDS?----------	
	WATER ANALYSIS RECORDS?----------	
	OTHER DATA	
2c	STRUCTURE CONTOUR?----------	yes
	LOGS?----------	
8	STRUCTURE SECTION?----------	yes
	ENGINEERING REPORTS?----------	
	CORE DESCRIPTIONS?----------	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Circle Ridge
	RESERVOIR:	Phosphoria
11	PROD. ACRES:	3200
	AVG. THICKNESS (FT.):	
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
2c	PRIMARY DRIVE MECHANISM:	water drive
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	72
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
	RESERVOIR PRESSURE INITIAL (psi):	
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
2a	STOCK TANK OIL GRAVITY (°API):	24
2c	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	160 sec SU
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

OTHER INFORMATION:

FIGURE 34.10 Air photo mosaic, with photograph numbers superimposed. Circle Ridge oil field, northern Fremont County. Southeast flank of anticline is faulted (Figure 34.11), limiting production in that direction. Beautiful example of differential erosion, with Chugwater (Triassic) sandstones making the rim-rocks and older Phosphoria carbonate rocks the central depression. *U. S. Department of Agriculture photos CCK-7N-32, 34-35 and 19N-144, 146.*

From: LANDES, K. S., 1970, PETROLEUM GEOLOGY OF THE UNITED STATES, John Wiley and Sons, New York, New York, page 411, Source 8.

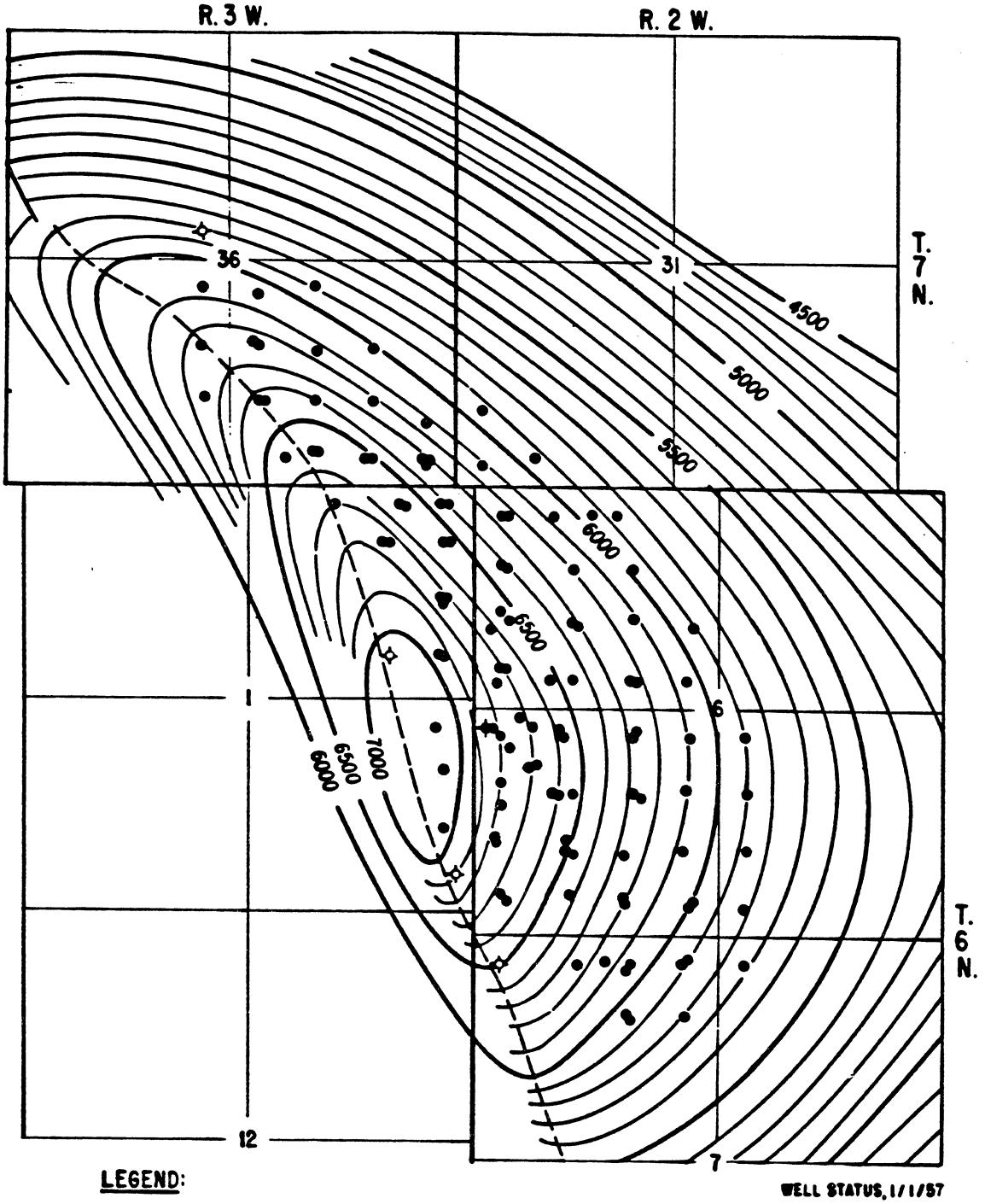


FIGURE 87.—Structure-Contour Map of Circle Ridge Dome Field, Fremont County, Wyo.
(Adapted from Federal Geological Survey map.)

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

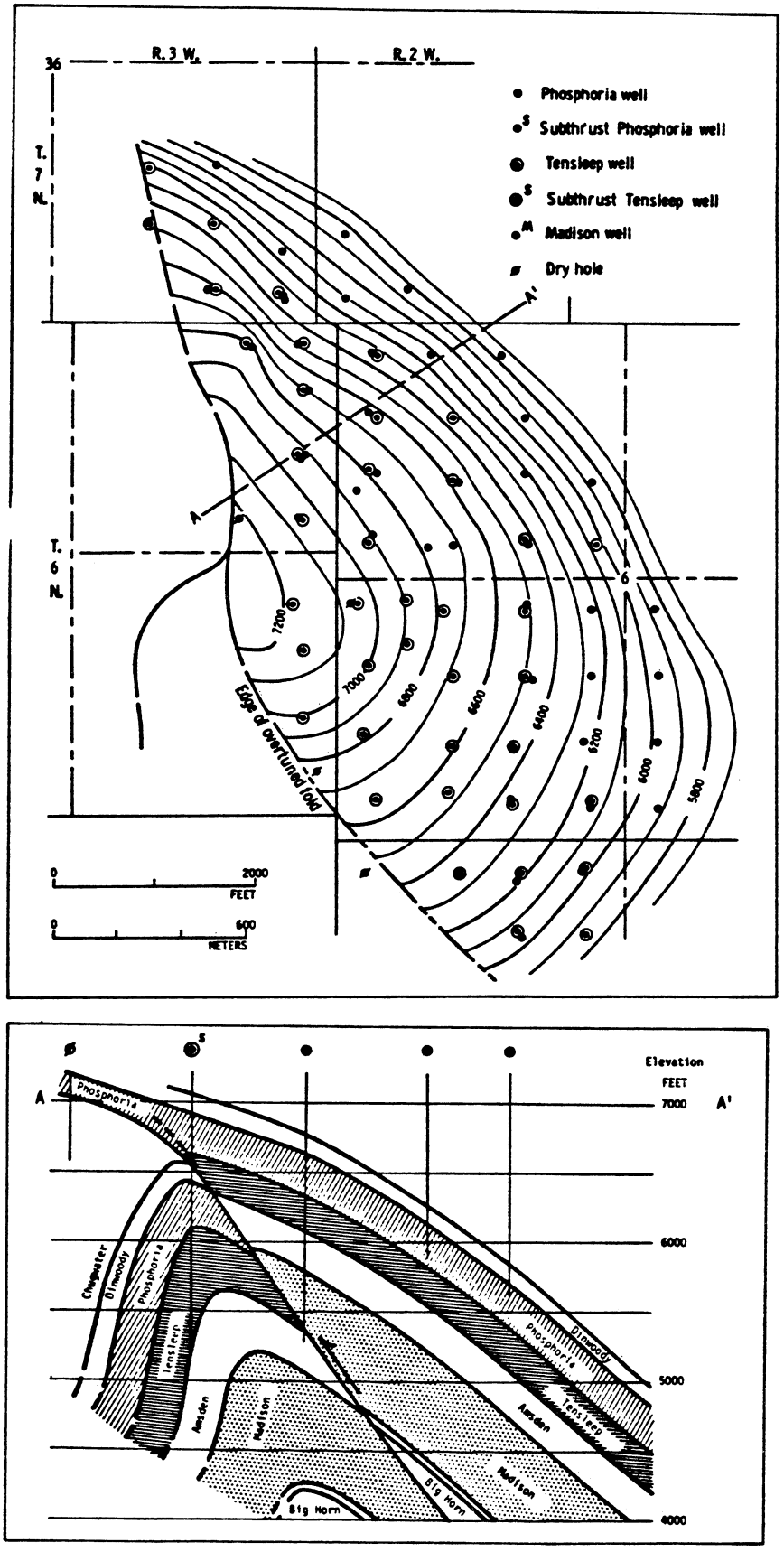


FIGURE 34.11 Upper: Circle Ridge field, Fremont County. Subsurface structure contour map based on top of the Permian Phosphoria Formation. Contour interval, 100 feet. Lower: Cross section along line *A-A'* in illustration above, showing thrust fault, and production on both the thrust sheet and on the subthrust block. *Both illustrations courtesy Lewis E. Beebe (1953) and the Oil and Gas Journal.*

From: LANDES, K. S., 1970, PETROLEUM GEOLOGY OF THE UNITED STATES, John Wiley and Sons, New York, New York, page 412, Source 8.

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..Laramie.. Laboratory
Sample ..PC-49-246..

IDENTIFICATION

Church Buttes field — Wyoming
Dakota sandstone - Lower Cretaceous — Uinta and Sweetwater County
12,800 - 13,000 feet — T. 16 and 17 N., R. 112 W.

GENERAL CHARACTERISTICS

Gravity, specific, ..0.788.. Gravity, ° API, ..48.8°.. Pour point, ° F., ..10..
Sulfur, percent, ..0.02..
Viscosity, Saybolt Universal at 100° F., ..below 32.. sec.. Color, ..NPA 1..
Nitrogen, percent, ..0.000..

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, ..760.. mm. Hg
First drop, ..77.. ° F.

Fraction No.	Cut at, ° F.	Percent	Sum, percent	Sp. gr. or sp. gr. °/60° F.	° API, at 60° F.	C. I.	Refractive index n_D at 20° C.	Specific dispersion	S. U. vis. at 100° F.	Cloud test, ° F.
1	150	3.1	3.1	0.641	89.3		1.36934	128.5		
2	167	4.6	7.7	.680	76.6	12	1.38844	109.0		
3	212	13.0	20.7	.731	62.1	27	1.41186	140.2		
4	257	18.7	39.4	.767	53.0	35	1.42859	156.8		
5	302	11.1	50.5	.785	48.8	36	1.44043	166.4		
6	347	7.6	58.1	.791	47.4	32	1.44429	159.5		
7	392	5.8	63.9	.796	46.3	28	1.44475	151.7		
8	437	5.5	69.4	.810	43.2	29	1.45070	149.3		
9	482	5.4	74.8	.826	39.8	31	1.45939	156.5		
10	527	5.8	80.6	.838	37.4	32	1.46646	157.1		
Stage 2—Distillation continued at 40 mm. Hg										
11	392	1.4	82.0	0.854	34.2	36			40	20
12	437	4.7	86.7	.855	34.0	32			43	40
13	482	3.5	90.2	.861	32.8	32			51	60
14	527	2.6	92.8	.863	32.5	30			63	80
15	572	3.3	96.1	.864	32.3	27			86	95
Residuum		2.4	98.5	.886	27.9					

Carbon residue, Conradson: Residuum, ...0 percent; crude, ...0.. percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	20.7	0.706	68.9	
Total gasoline and naphtha	63.9	.756	55.7	
Kerosine distillate	5.5	.810	43.2	
Gas oil	10.4	.842	36.6	
Nonviscous lubricating distillate	8.3	.860-.865	33.0-32.1	80-100
Medium lubricating distillate	0			100-200
Viscous lubricating distillate	0			Above 200
Residuum	2.4	.889	27.9	
Distillation loss	1.5			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..Bartlesville.. Laboratory
Sample ..288..

IDENTIFICATION

Circle Ridge field — Wyoming
Ember formation - Permian — Fremont County
230 feet — SE¼ sec. 1, T. 6 N., R. 3 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.912 A. P. I. gravity 23.7 ° Pour point, ° F.
Sulfur, percent, 2.84 Color, brownish black
Saybolt Universal viscosity at 100 ° F., 160 sec.; at ° F., sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, 745 mm. Hg
First drop, 96 ° C. (205 ° F.)

Fraction No.	Cut at, °C.	Cut at, ° F.	Percent	Sum, Percent	Sp. Gr. 60/60° F.	° A. P. I. 60° F.	C. I.	Aniline temp. °C.	S. U. vis. 100° F.	Cloud test, ° F.
1	80	176			0.					
2	75	167								
3	100	212	0.2	0.2						
4	125	257	1.5	1.7	.717	65.9				
5	150	302	2.9	4.6	.736	60.2	13			
6	175	347	3.3	7.9	.761	54.4	17			
7	200	392	3.1	11.0	.783	49.2	22			
8	225	437	3.9	14.9	.800	45.4	24			
9	250	482	5.6	20.5	.819	41.3	28			
10	275	527	6.9	27.4	.841	36.8	33			
Stage 2—Distillation continued at 40 mm. Hg										
11	200	392	3.4	30.8	0.871	31.0	44		62	
12	225	437	6.6	37.4	.877	29.9	43		56	20
13	250	482	6.9	44.3	.895	26.6	48		66	45
14	275	527	6.1	50.4	.914	23.3	54		99	60
15	300	572	7.9	58.3	.925	21.5	56		180	70
Residuum			38.7	97.0	1.004	9.4				

Carbon residue of residuum, 15.1 percent; carbon residue of crude, 5.8 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	° A. P. I.	Viscosity
Light gasoline	0			
Total gasoline and naphtha	11.0	0.754	56.2	
Kerosine distillate	9.2	.811	43.0	
Gas oil	11.6	.871	31.0	
Nonviscous lubricating distillate	13.4	.874-.914	30.4-23.3	80-100
Medium lubricating distillate	8.3	.914-.927	23.3-21.1	100-200
Viscous lubricating distillate	2.5	.927-.931	21.1-20.5	Above 200
Residuum	38.7	1.004	9.4	
Distillation loss	5.0			

Wyoming - Circle Ridge
Madison
Wind River Basin

DATA SOURCE CODE		
	STATE	Wyoming
2c	COUNTY	Fremont
	REGULATORY DISTRICT	
	BASIN	Wind River
	SUB-BASIN	
2c	FIELD	Circle Ridge
2c	RESERVOIR	Madison
2c	GEOLOGIC AGE	Mississippian
	AAPG STRATIGRAPHIC AGE CODE	
2c	RESERVOIR LITHOLOGY	Limestone
2c, 8	TRAPPING MECHANISM	Overturned faulted anticline
2c,2b	DISCOVERY YEAR	1946 fm.; 1923
11	PROVED ACREAGE	3200 (from 2c structure contour)
	REGULAR WELL SPACING (acres/well)	
2b,2c	RESERVOIR DEPTH	1700; 1170-1525
	RESERVOIR THICKNESS	
2c	NET PAY	25 ft.
2c	GROSS	355
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
	FRACTION	
	PERMEABILITY	
	RANGE	
	AVERAGE	
	HORIZONTAL	
	VERTICAL	
2c	OTHER INFORMATION	Other production from Tensleep and Phosphoria
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2d	TOTAL NUMBER OF WELLS	160P
	PRODUCTION 1976 oil (cum)	
	PRODUCTION 1977 oil (cum)	
	PRODUCTION 1978 oil (cum)	
2d	PRODUCTION 1979 oil (cum)	20,888.2 mbbls oil; 0 gas
2d	PRODUCTION 1-1-79 to 1-1-80	903.1 mbbls oil; 0 gas
	SECONDARY RECOVERY RECORDS?	
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
2c	STRUCTURE CONTOUR?	yes (Phosphoria top)
	LOGS?	
	STRUCTURE SECTION?	
	ENGINEERING REPORTS?	
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Circle Ridge
	RESERVOIR:	Madison
11	PROD. ACRES:	2560 - 3200
~~2c~~	AVG. THICKNESS (FT.):	25
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
	PRIMARY DRIVE MECHANISM:	
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	97
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
	RESERVOIR PRESSURE INITIAL (psi):	
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
2c	STOCK TANK OIL GRAVITY (°API):	23.2
2c	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	150 sec. SU
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

OTHER INFORMATION:

2c Water Analysis: Circle Ridge-Madison

Na & K	287
Ca	166
Mg	101
SO4	437
Cl	70
CO_3	--
HCO_3	1,098
ts	1,715

Primary salinity 38.06%
Secondary salinity ---
Primary alkalinity 4.88%
Secondary alkalinity 57.06%

TABLE 12.—*Crude-oil analyses*—Continued

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample 431 - S

IDENTIFICATION

Circle Ridge field
Tensleep sandstone - Pennsylvanian
680 feet

Wyoming
Fremont County
SE¼SE¼NE¼ sec. 1,
T. 6 N., R. 3 W. (W.I.M.)

GENERAL CHARACTERISTICS

Specific gravity, 0.909 A. P. I. gravity 24.2 ° Pour point, ° F.
Sulfur, percent, 2.73 Color, brownish black
Saybolt Universal viscosity at 100° F., 160 sec.; at ° F., sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Sample 1—Distillation at atmospheric pressure, 581 mm. Hg
First drop, 75 ° C. (167 ° F.)

Fraction No.	Cut temp. ° C.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° A.P.I. 60° F.	C. I.	Refractive index, n, at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	80	176			0						
2	90	194									
3	100	212	1.6	1.6	.690	73.6	3.8				
4	125	257	2.4	4.0	.722	64.5	10				
5	150	302	3.2	7.2	.745	58.4	14				
6	175	347	4.2	11.4	.766	53.2	17				
7	200	392	3.7	15.1	.792	47.2	24				
8	225	437	4.6	19.7	.811	43.0	27				
9	250	482	5.8	25.5	.828	39.4	30				
10	275	527	7.0	32.5	.849	35.2	35				

Sample 2—Distillation continued at 40 mm. Hg

11	200	392	2.8	35.3	0.865	32.1	38			43	10
12	225	437	7.0	42.3	.878	29.7	42			52	25
13	250	482	7.5	49.8	.898	26.1	48			75	45
14	275	527	6.9	56.7	.921	22.1	55			130	65
15	300	572	11.0	67.7	.933	20.2	58			260	75
Residuum			32.0	99.7	.982	12.6					

Carbon residue of residuum, 19.3 percent; carbon residue of crude, 6.7 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° A.P.I.	Viscosity
Light gasoline	1.6	0.690	73.6	
Total gasoline and naphtha	12.1	0.759	56.4	
Kerosine distillate	4.6	.811	43.0	
Gas oil	10.3	.848	35.4	
Nonviscous lubricating distillate	11.9	.876-.909	30.0-24.2	80-100
Medium lubricating distillate	8.6	.909-.927	24.2-21.1	100-200
Viscous lubricating distillate	9.8	.927-.941	21.1-18.9	Above 200
Residuum	32.0	.982	12.6	
Distillation loss	3.3			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-54-210

IDENTIFICATION

Circle Ridge field
Madison limestone - Mississippian
1,170 - 1,525 feet

Wyoming
Fremont County
SW¼SW¼ sec. 6,
T. 6 N., R. 2 W., W.R.M.

GENERAL CHARACTERISTICS

Gravity, specific, 0.912 Gravity, ° API, 23.7° Pour point, ° F., below 5
Sulfur, percent, 2.67 Color, brownish black
Viscosity, Saybolt Universal at 100° F., 190 sec.; at 130° F., 89 sec. Nitrogen, percent, 0.22

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Sample 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 216 ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index, n, at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	250									
2	300									
3	350									
4	400	1.5	1.5	0.719	65.3					
5	450	2.3	3.8	.727	63.1	8.0	1.41929	123.0		
6	500	2.5	6.3	.748	57.7	11	1.43444	122.7		
7	550	3.2	9.5	.772	51.8	16	1.44959	124.9		
8	600	4.3	13.8	.797	46.0	23	1.45825	130.3		
9	650	5.2	19.0	.817	41.7	27	1.47082	144.4		
10	700	7.4	26.4	.837	37.6	32	1.48320	177.3		

Sample 2—Distillation continued at 40 mm. Hg

11	350	3.0	29.4	0.868	31.5	42			43	below 5
12	400	6.7	36.1	.875	30.2	44			46	15
13	450	6.6	42.7	.891	27.3	46			61	30
14	500	6.3	49.0	.907	24.5	50			92	50
15	550	7.8	56.8	.923	21.8	55			180	65
Residuum		40.1	96.9	1.004	9.4					

Carbon residue, Conradson: Residuum, 14.7 percent; crude, 6.3 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline				
Total gasoline and naphtha	9.5	0.746	58.2	
Kerosine distillate	9.5	.808	43.6	
Gas oil	14.8	.854	34.2	
Nonviscous lubricating distillate	12.6	.877-.908	29.9-24.3	80-100
Medium lubricating distillate	8.1	.908-.927	24.3-21.1	100-200
Viscous lubricating distillate	2.3	.927-.931	21.1-20.3	Above 200
Residuum	40.1	1.004	9.4	
Distillation loss	3.1			

Wyoming - Steamboat Butte
Phosphoria
Wind River Basin

DATA SOURCE CODE		
	STATE----------	Wyoming
2c	COUNTY----------	Fremont
	REGULATORY DISTRICT----------	
	BASIN----------	Wind River
	SUB-BASIN----------	
2c	FIELD----------	Steamboat Butte
2c	RESERVOIR----------	Phosphoria limestone
2c	GEOLOGIC AGE----------	Permian
	AAPG STRATIGRAPHIC AGE CODE----------	
2c	RESERVOIR LITHOLOGY----------	Limestone
2c	TRAPPING MECHANISM----------	Anticlinal fold (faulted)
2c, 2b	DISCOVERY YEAR----------	1943
11	PROVED ACREAGE----------	1920
	REGULAR WELL SPACING (acres/well)-----	
2c,2b	RESERVOIR DEPTH----------	6484, 6730
	RESERVOIR THICKNESS	
2c	NET PAY----------	60
	GROSS----------	
	NET/GROSS RATIO----------	
	POROSITY	
	TYPE----------	
	FRACTION----------	
	PERMEABILITY	
	RANGE----------	
	AVERAGE----------	
	HORIZONTAL----------	
	VERTICAL----------	
	OTHER INFORMATION----------	
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2d	TOTAL NUMBER OF WELLS----------	50P
	PRODUCTION 1976 oil (cum)----------	
	PRODUCTION 1977 oil (cum)----------	
	PRODUCTION 1978 oil (cum)----------	
2d	PRODUCTION 1979 oil (cum)----------	78,659 mbbls oil; 10,152.4 mmcf gas
2d	PRODUCTION 1-1-79 to 1-1-80----------	837.5 mbbls oil; 228 mmcf gas
2d	SECONDARY RECOVERY RECORDS?----------	yes
	WATER ANALYSIS RECORDS?----------	
	OTHER DATA	
2c	STRUCTURE CONTOUR?----------	Yes (Tensleep sand)
	LOGS?----------	no
	STRUCTURE SECTION?----------	
	ENGINEERING REPORTS?----------	
	CORE DESCRIPTIONS?----------	
2c	CRUDE ANALYSIS?----------	yes

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Steamboat Butte
2c	RESERVOIR:	Phosphoria
11	PROD. ACRES:	1920
2c	AVG. THICKNESS (FT.):	60
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
	PRIMARY DRIVE MECHANISM:	
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	178
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
	RESERVOIR PRESSURE INITIAL (psi):	
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
	STOCK TANK OIL GRAVITY (°API):	31.1
2c	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	51 sec SU
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

2d OTHER INFORMATION:

Secondary recovery: waterflood - Gulf Oil has 6 injection wells in Tensleep, 6 injection wells in Phosphoria; National Cooperative Refinery has 11 injection wells in the Minnelusa.

S10267-O-60—33

TABLE 12.—*Crude-oil analyses*—Continued

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample 431 - S

IDENTIFICATION

Steamboat Butte Gold
Sundance sandstone - Jurassic
5,092 - 5,272 feet

Wyoming
Fremont County
NW¼NW¼ sec. 5,
T. 3 N., R. 1 W., (W.R.I.M.)

GENERAL CHARACTERISTICS

Specific gravity, 0.826 A. P. I. gravity 28.2 ° Pour point, ° F.
Sulfur, percent, 2.41 Color, brownish black
Saybolt Universal viscosity at 100 ° F., 77 sec.; at ° F., sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 587 mm. Hg
First drop, 32 ° C. (90 ° F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Cum. Percent	Sp. Gr. 60/60° F.	°A. P. I. 60° F.	c.c.	Aniline point °C.	R.I. 20° C.	Flash °F.
1	80	176	2.0	2.0	0.690	86.2				
2	75	167	1.7	3.7	677	77.5	7.5			
3	100	212	3.3	7.0	712	67.2	14			
4	125	257	3.5	10.5	738	60.2	18			
5	150	302	4.3	14.8	761	54.4	21			
6	175	347	3.7	18.5	782	49.5	25			
7	200	392	4.1	22.6	801	45.1	28			
8	225	437	4.4	27.0	818	41.5	30			
9	250	482	4.9	31.9	833	38.4	32			
10	275	527	7.1	39.0	852	34.6	37			

STAGE 2—Distillation continued at 40 mm. Hg

11	200	392	2.4	41.4	0.870	31.1	41		42	10
12	225	437	5.4	46.8	878	29.7	42		49	25
13	250	482	5.4	52.2	891	27.3	44		64	45
14	275	527	8.1	60.3	913	23.5	51		110	65
15	300	572	7.5	67.8	925	21.5	54		195	85
Residuum			31.3	99.1	991	11.3				

Carbon residue of residuum, 18.2 percent; carbon residue of crude, 6.4 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A. P. I.	Viscosity
Light gasoline	7.0	0.686	74.8	
Total gasoline and naphtha	22.6	0.745	58.4	
Kerosine distillate	4.4	818	41.5	
Gas oil	17.4	853	34.4	
Nonviscous lubricating distillate	10.4	879-.909	29.5-24.2	80-100
Medium lubricating distillate	9.9	909-.926	24.2-21.3	100-200
Viscous lubricating distillate	3.1	926-.930	21.3-20.6	Above 200
Residuum	31.3	991	11.3	
Distillation loss	.9			

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-49-119

IDENTIFICATION

Steamboat Butte Gold
Phosphoria limestone - Permian
6,732 - 6,792 feet

Wyoming
Fremont County
NW¼SE¼ sec. 9,
T. 3 N., R. 1 W. (W.R.I.M.)

GENERAL CHARACTERISTICS

Specific gravity, 0.870 A. P. I. gravity 31.1 ° Pour point, ° F. below 5
Sulfur, percent, 1.69 Color, black
Saybolt Universal viscosity at 100 ° F., 51 sec.; at 77 ° F., 64 sec. Nitrogen, percent 0.16

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 28 ° C. (82 ° F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Cum. Percent	Sp. Gr. 60/60° F.	°A. P. I. 60° F.	c.c.	Aniline point °C.	R.I. 20° C.	Flash °F.
1	80	176	0.5	0.5	0					
2	75	167	1.3	1.8	661	82.6				
3	100	212	1.8	3.6	675	78.1			59.2	
4	125	257	3.1	6.7	723	64.2	14		58.1	
5	150	302	4.8	11.5	749	57.4	18		56.9	
6	175	347	3.9	15.4	771	52.0	22		55.2	
7	200	392	4.4	19.8	790	47.6	25		55.3	
8	225	437	4.5	24.3	801	45.1	24		57.9	
9	250	482	4.6	28.9	816	41.9	26		61.6	
10	275	527	6.7	35.6	835	38.0	31		63.3	

STAGE 2—Distillation continued at 40 mm. Hg

11	200	392	5.1	40.7	0.862	32.6	39	64.7	40	below 5
12	225	437	6.8	47.5	871	31.0	40	68.0	45	20
13	250	482	5.9	53.4	885	28.4	43	70.9	57	40
14	275	527	5.8	59.2	900	25.7	47	73.1	82	60
15	300	572	8.0	67.2	916	23.0	52	77.1	170	85
Residuum			28.6	95.8	991	11.3				

Carbon residue of residuum, 14.1 percent; carbon residue of crude, 4.6 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A. P. I.	Viscosity
Light gasoline	3.6	0.668	80.3	
Total gasoline and naphtha	19.8	0.744	58.7	
Kerosine distillate	9.1	809	43.4	
Gas oil	17.7	855	34.0	
Nonviscous lubricating distillate	11.0	876-.903	30.0-25.2	80-100
Medium lubricating distillate	8.1	903-.922	25.2-22.0	100-200
Viscous lubricating distillate	1.5	922-.926	22.0-21.3	Above 200
Residuum	28.6	991	11.3	
Distillation loss	4.2			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

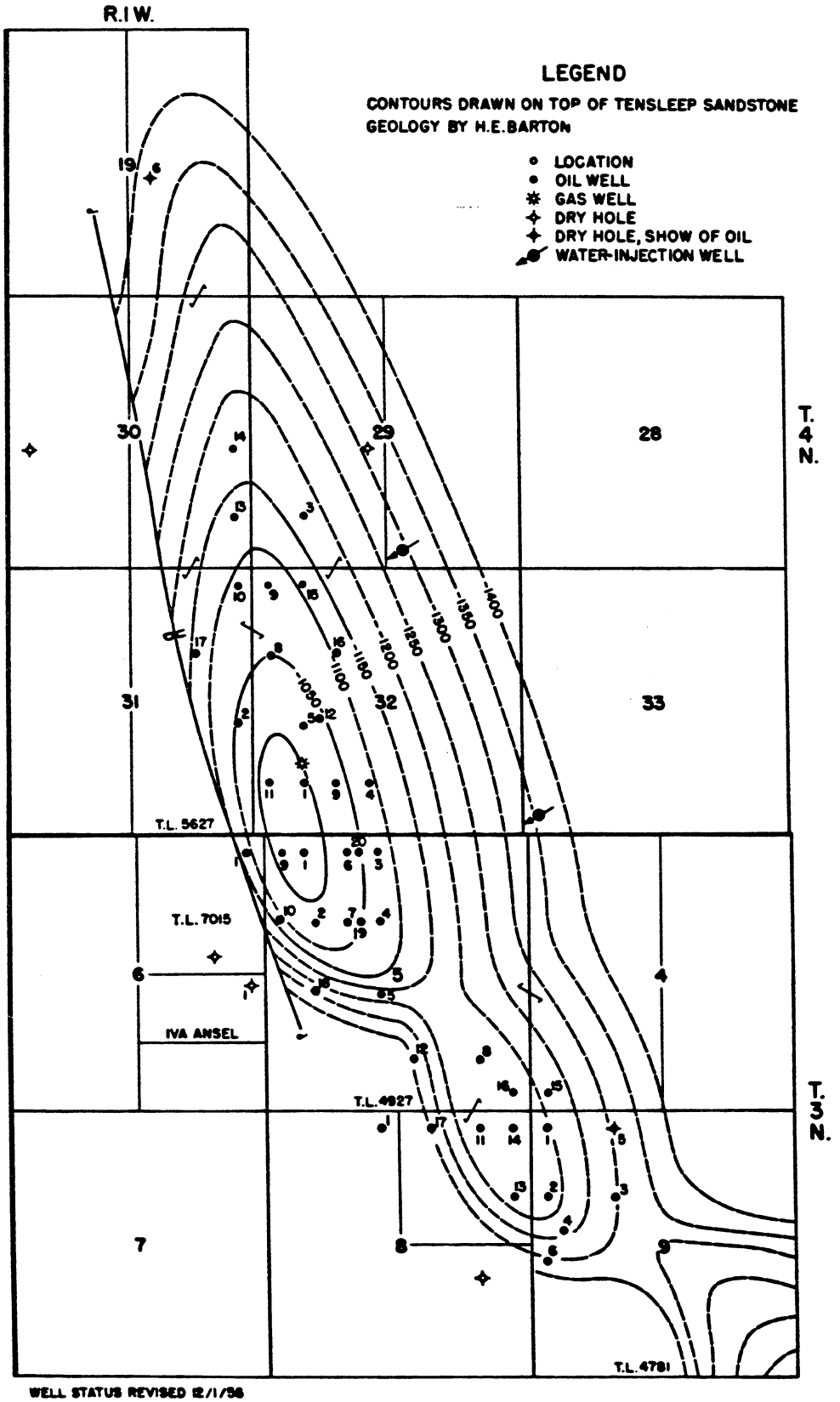


FIGURE 154.—Structure-Contour Map of Steamboat Butte Field, Fremont County, Wyo.

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

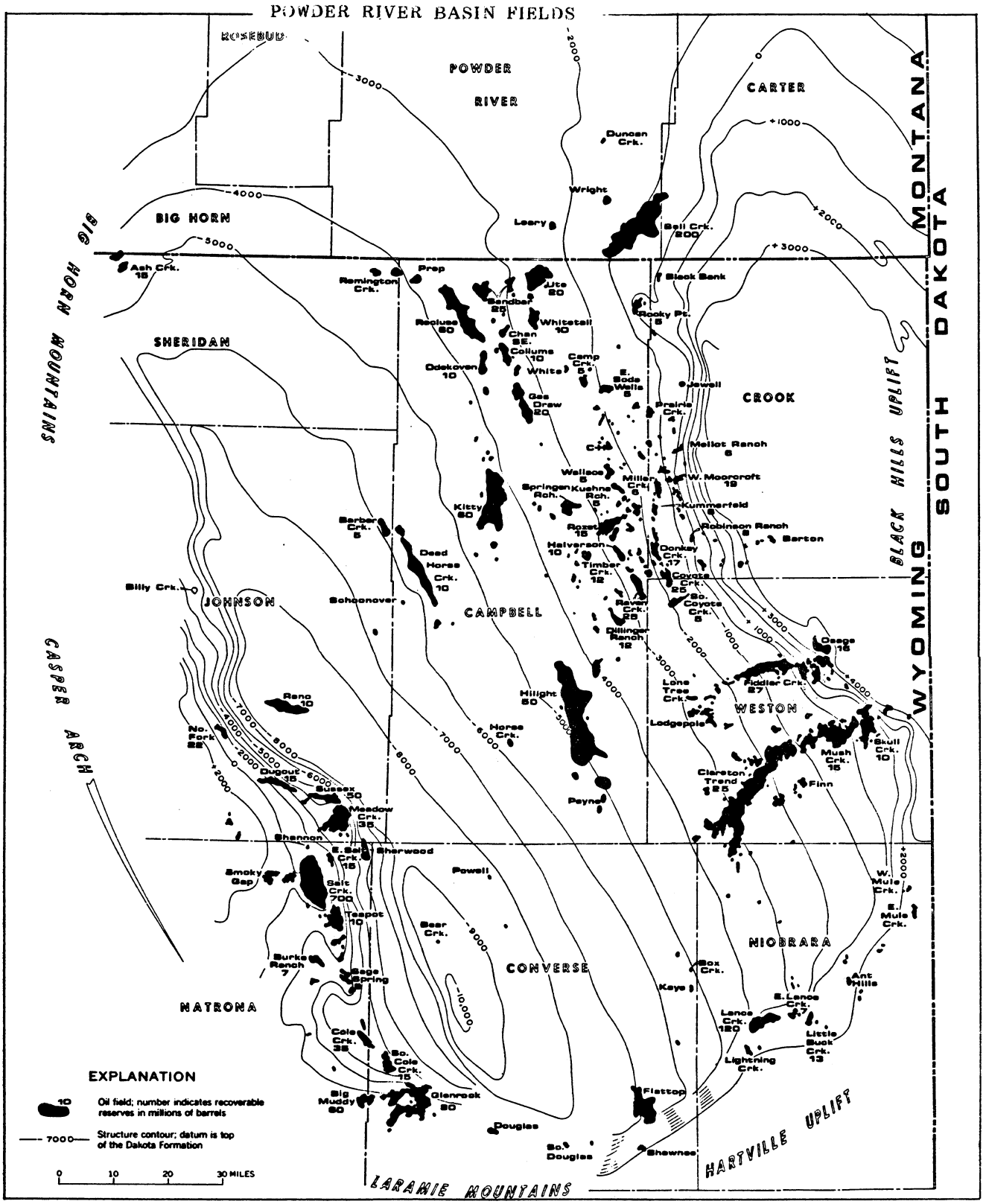
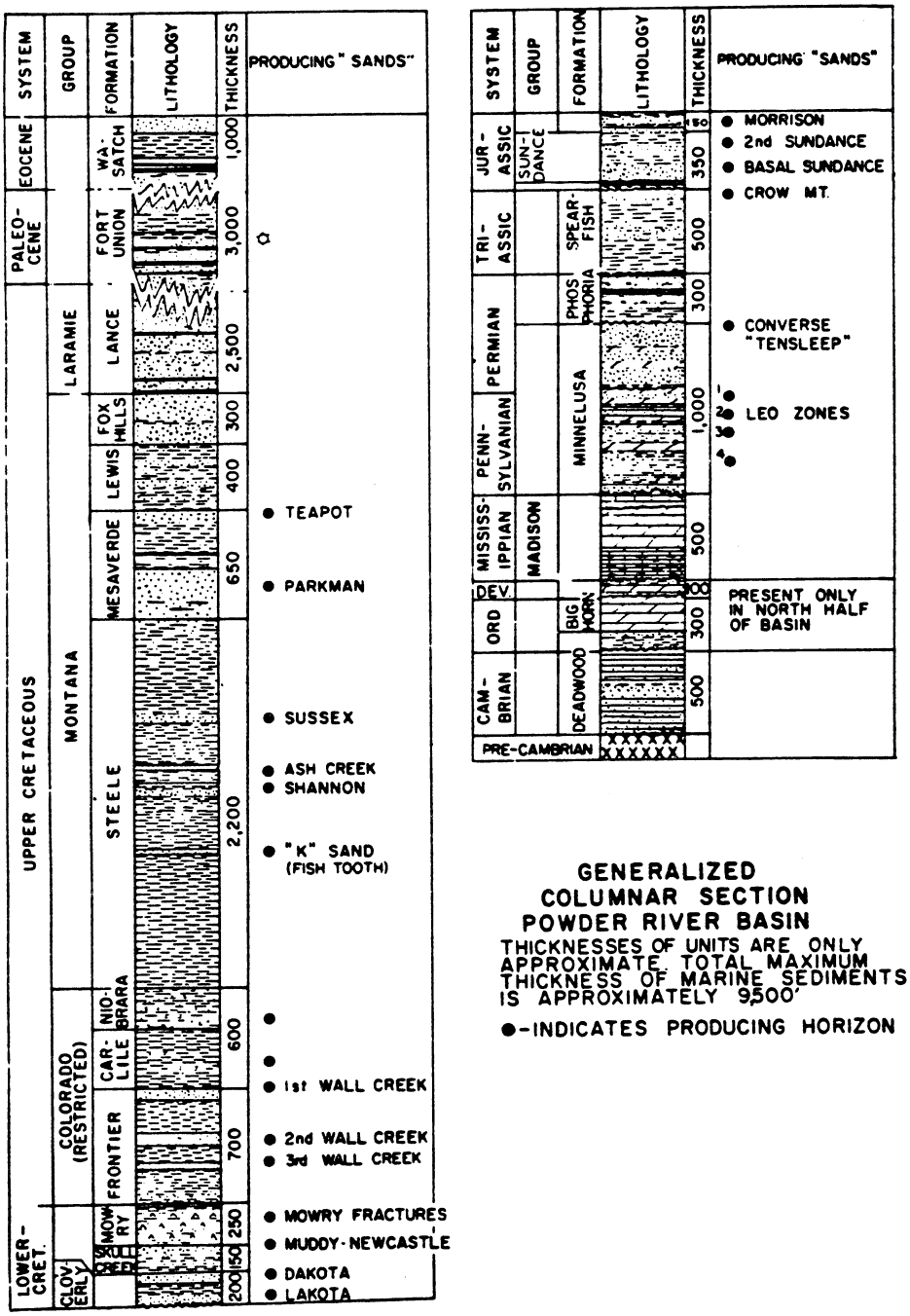


Figure 18.--Location of oil fields in the Powder river basin (from Rocky Mountain Association of Geologists, 1972, Geologic Atlas of the Rocky Mountain Region).



GENERALIZED
COLUMNAR SECTION
POWDER RIVER BASIN

THICKNESSES OF UNITS ARE ONLY APPROXIMATE. TOTAL MAXIMUM THICKNESS OF MARINE SEDIMENTS IS APPROXIMATELY 9,500'

●-INDICATES PRODUCING HORIZON

Figure 19.--Generalized columnar section, Powder River basin. (From B. F. Curtis and others, 1958, Patterns of oil occurrence in the Powder River basin, in AAPG, Habitat of Oil, A Symposium.)

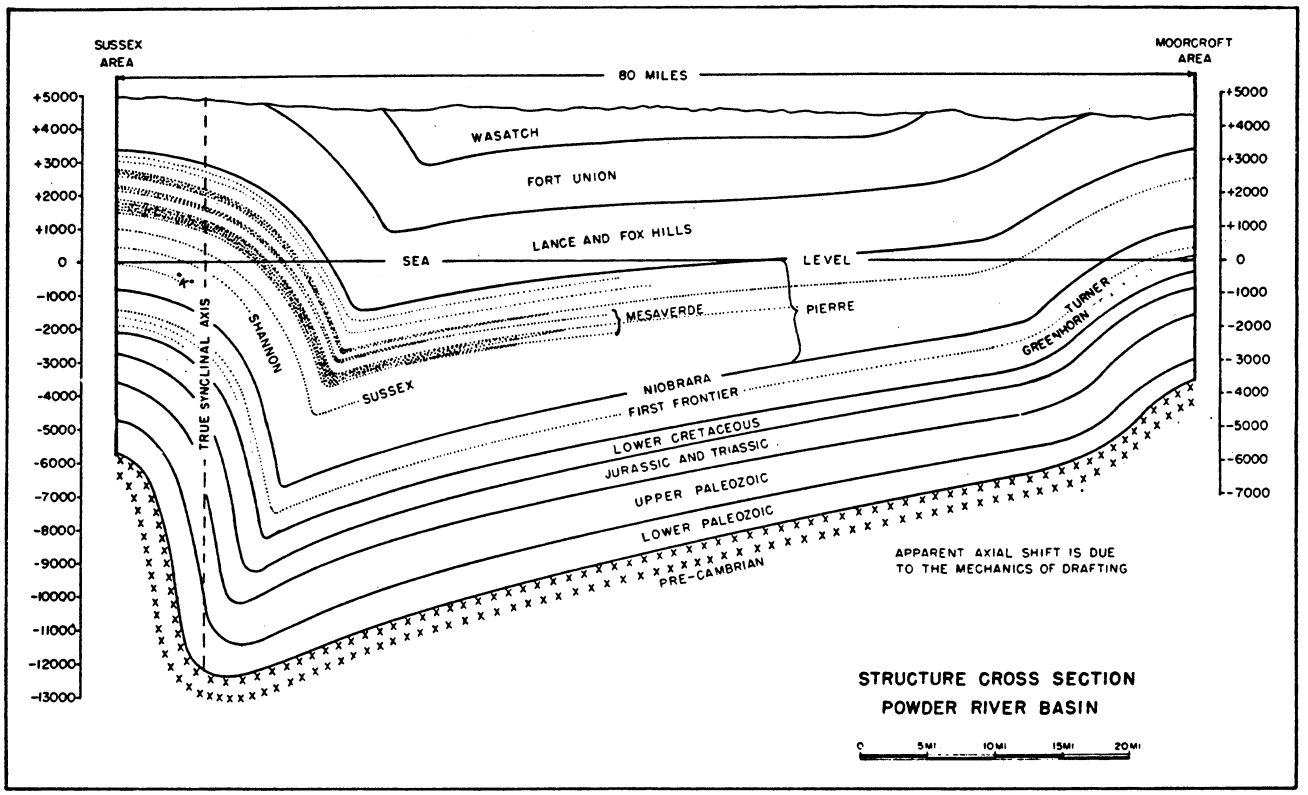


TABLE III. RELATIONS BETWEEN POWDER RIVER BASIN CRUDE OILS AND THEIR ENVIRONMENT OF DEPOSITION

Era	*Controlling Depositional Environment*	*Character of Sediments*	*Composition of Crude Oil*
Mesozoic	Moderate tectonic activity with rising highlands, subsiding shallow basins, and rapidly oscillating shorelines. Wide variations in rates of subsidence and clastic deposition.	Dark-gray and black shale interfingering or interbedded with discontinuous sandstones, subordinate red sandstones, red shale and limestone.	Cretaceous oils have a paraffin-naphthene base, high gasoline content, very low sulfur and asphaltene content and high (40°) A.P.I gravity. Jurassic oils are similar but have higher average sulfur and asphaltene content and slightly lower A.P.I. gravity. Triassic oils are very similar to Mississippian oils.
Paleozoic	Quiet, stable conditions during early periods. Moderate tectonic activity during Permo-Pennsylvanian. Broad, shallow, epicontinental seas during early periods. Intracratonic basining during Permo-Pennsylvanian. Gentle warping resulted in numerous unconformities.	Thick beds of limestone, dolomite, and sheet sandstone. Subordinate red and black shale and dolomite-evaporite facies.	Permian oils have aromatic-naphthene base, low gasoline content, very high sulfur content (2.0%), high residue and high asphaltene content. Low (28°) A.P.I. gravity. Pennsylvanian oils have aromatic-naphthene base, low gasoline content, high sulfur content (1.0%), high asphaltene content and medium (31°) A.P.I. gravity. Mississippian oils are low gravity (20°), very high sulfur content (2.5%–3.0%), high asphaltene content and an aromatic-naphthene base.

Figure 20.--Structure cross section and crude oil-deposition environment relations, Powder River basin. (From B. F. Curtis and others, 1958, Patterns of oil occurrence in the Powder River basin, in AAPG, Habitat of Oil, A Symposium.)

Wyoming - Mule Creek
Mule Creek Dolomite
Power River Basin

DATA SOURCE CODE		
	STATE	Wyoming
2c	COUNTY	Niobrara
	REGULATORY DISTRICT	
	BASIN	Powder River
	SUB-BASIN	
2c	FIELD	Mule Creek
2c	RESERVOIR	Mule Creek Dolomite
2c	GEOLOGIC AGE	Mississippian
	AAPG STRATIGRAPHIC AGE CODE	
2c	RESERVOIR LITHOLOGY	Dolomite
2c	TRAPPING MECHANISM	Elongate dome
2c	DISCOVERY YEAR	1919 field - 1920 fm.
2c	PROVED ACREAGE	40 acres (?); 320
	REGULAR WELL SPACING (acres/well)	
2c	RESERVOIR DEPTH	2712
	RESERVOIR THICKNESS	
2c	NET PAY	10 ft.
	GROSS	
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
	FRACTION	
	PERMEABILITY	
	RANGE	
	AVERAGE	
	HORIZONTAL	
	VERTICAL	
2d	OTHER INFORMATION	Other production from Lakota Sand, Minnelusa
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2d	TOTAL NUMBER OF WELLS	29P
	PRODUCTION 1976 oil (cum)	
	PRODUCTION 1977 oil (cum)	
	PRODUCTION 1978 oil (cum)	
2d	PRODUCTION 1979 oil (cum)	3356.6 mbbls oil; 87.3 mmcf gas
2d	PRODUCTION 1-1-79 to 1-1-80	41.9 mbbls oil; 0 gas
2d	SECONDARY RECOVERY RECORDS?	yes
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
	STRUCTURE CONTOUR?	
	LOGS?	
	STRUCTURE SECTION?	
	ENGINEERING REPORTS?	
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Mule Creek
2c	RESERVOIR:	Mule Creek Dolomite
	PROD. ACRES:	
2c	AVG. THICKNESS (FT.):	10 ft.
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
	PRIMARY DRIVE MECHANISM:	
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	114
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
	RESERVOIR PRESSURE INITIAL (psi):	
	RESERVOIR PRESSURE LATEST (psi):	
	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
2c	STOCK TANK OIL GRAVITY (°API):	32.7
2c	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	43 sec SU
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	

2d OTHER INFORMATION:

Secondary recovery: 2 water injection wells into Lakota Sand by Damson Oil Corp.

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..... Laramie ..... Laboratory
Sample ..... PC-57-158 .....

IDENTIFICATION

Mule Creek, West field
Mule Creek dolomite - Mississippian
2,712 - 2,722 feet

Wyoming
Niobrara County
NE¼NE¼ sec. 2,
T. 39 N., R. 61 W.

GENERAL CHARACTERISTICS

Gravity, specific, ...0.862..... Gravity, ° API, ...32.7°.....
Sulfur, percent, ...0.95.....
Viscosity, Saybolt Universal at ..100°F...43..sec.s.....
Pour point, ° F., ...below 5.....
Color, ...greenish black.....
Nitrogen, percent, ...0.156.....

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, ...760..... mm. Hg
First drop, ...75..... ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	122	2.1	2.1	0.650	86.2					
2	167	2.8	4.9	.665	81.3	5.1	1.37461	126.9		
3	212	4.4	9.3	.706	68.9	15	1.39407	128.3		
4	257	4.7	14.0	.732	61.8	18	1.40700	126.4		
5	302	5.2	19.2	.752	56.7	20	1.41925	131.6		
6	347	5.8	25.0	.774	51.3	23	1.42001	137.9		
7	392	5.4	30.4	.795	46.5	27	1.44147	143.5		
8	437	4.7	35.1	.812	42.8	30	1.45125	146.9		
9	482	6.5	41.6	.828	39.4	32	1.46012	151.7		
10	527	6.6	48.2	.847	35.6	36	1.47195	154.8		

Stage 2—Distillation continued at 40 mm. Hg

11	302	6.7	54.9	0.870	31.1	43	1.48421	164.7	41	below 5
12	437	6.8	61.7	.885	28.4	46	1.49328	173.4	53	10
13	482	4.1	65.8	.904	25.0	52	1.50307	184.9	77	20
14	527	4.6	70.4	.916	23.0	55	1.51067	205.7	125	40
15	572	5.9	76.3	.938	19.4	62			330	60
Residuum		21.9	98.2	1.012	8.3					

Carbon residue, Conradson: Residuum, 18.2 percent; crude, ...4.7 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	9.3	0.681	76.3	
Total gasoline and naphtha	30.4	.739	60.0	
Kerosine distillate	4.7	.812	42.8	
Gas oil	21.5	.851	34.8	
Nonviscous lubricating distillate	8.7	.882-.908	28.9-24.3	80-100
Medium lubricating distillate	4.7	.908-.924	24.3-21.6	100-200
Viscous lubricating distillate	6.3	.924-.951	21.6-17.3	Above 200
Residuum	21.9	1.012	8.3	
Distillation loss	1.8			

CRUDE PETROLEUM ANALYSIS

Bureau of Mines ..... Laramie ..... Laboratory
Sample ..... PC-50-719 .....

IDENTIFICATION

Murphy Dome field
Tensleep sandstone - Pennsylvanian
4,390 - 4,440 feet

Wyoming
Hot Springs County
SE¼SE¼ sec. 6,
T. 43 N., R. 91 W.

GENERAL CHARACTERISTICS

Gravity, specific, ...0.855..... Gravity, ° API, ...34.0°.....
Sulfur, percent, ...1.70.....
Viscosity, Saybolt Universal at ..100°F...43..sec.s.....
Pour point, ° F., ...below 5.....
Color, ...greenish black.....
Nitrogen, percent, ...0.11.....

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, ...760..... mm. Hg
First drop, ...86..... ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	122	0.9	0.9	0.649	86.5		1.38372	131.4		
2	167	2.6	3.5	.657	83.9	1.3	1.37075	124.5		
3	212	4.0	7.5	.692	73.0	8.0	1.38686	125.8		
4	257	5.4	12.9	.719	65.3	12	1.40009	129.1		
5	302	5.6	18.5	.742	59.2	15	1.41228	130.5		
6	347	5.6	24.1	.766	53.2	20	1.42501	135.9		
7	392	5.2	29.3	.787	48.3	23	1.43627	140.0		
8	437	5.5	34.8	.805	44.3	26	1.44528	141.3		
9	482	5.8	40.6	.820	41.1	28	1.45325	145.3		
10	527	6.9	47.5	.837	37.6	32	1.46250	152.2		

Stage 2—Distillation continued at 40 mm. Hg

11	302	5.5	53.0	0.861	32.8	39			39	15
12	437	6.7	59.7	.872	30.8	40			45	30
13	482	6.2	65.9	.892	27.1	46			56	45
14	527	5.2	71.1	.913	23.5	53			81	60
15	572	6.1	77.2	.923	21.8	55			140	75
Residuum		22.6	99.8	.991	11.3					

Carbon residue, Conradson: Residuum, 10.8 percent; crude, ...2.8 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	7.5	0.675	78.1	
Total gasoline and naphtha	29.3	.733	61.5	
Kerosine distillate	11.3	.813	42.5	
Gas oil	18.8	.857	33.6	
Nonviscous lubricating distillate	10.8	.881-.916	29.1-23.0	80-100
Medium lubricating distillate	7.0	.916-.928	23.0-21.0	100-200
Viscous lubricating distillate	.0			Above 200
Residuum	22.6	.991	11.3	
Distillation loss	.2			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

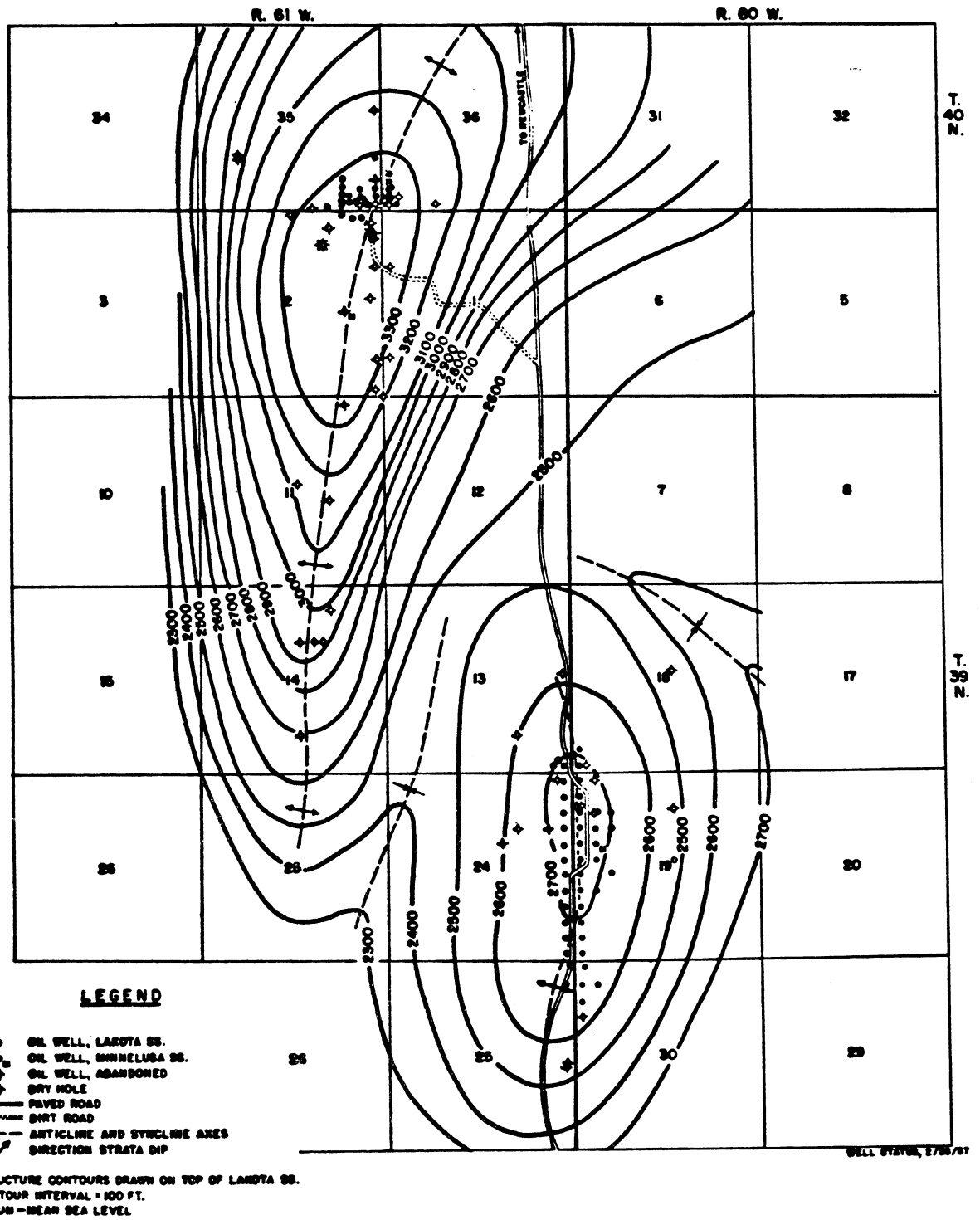


Figure 113.—Structure-Contour Map of Mule Creek and West Mule Creek Fields, Niobrara County, Wyo.
(Adapted from Bureau of Mines Bulletin 418.)

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

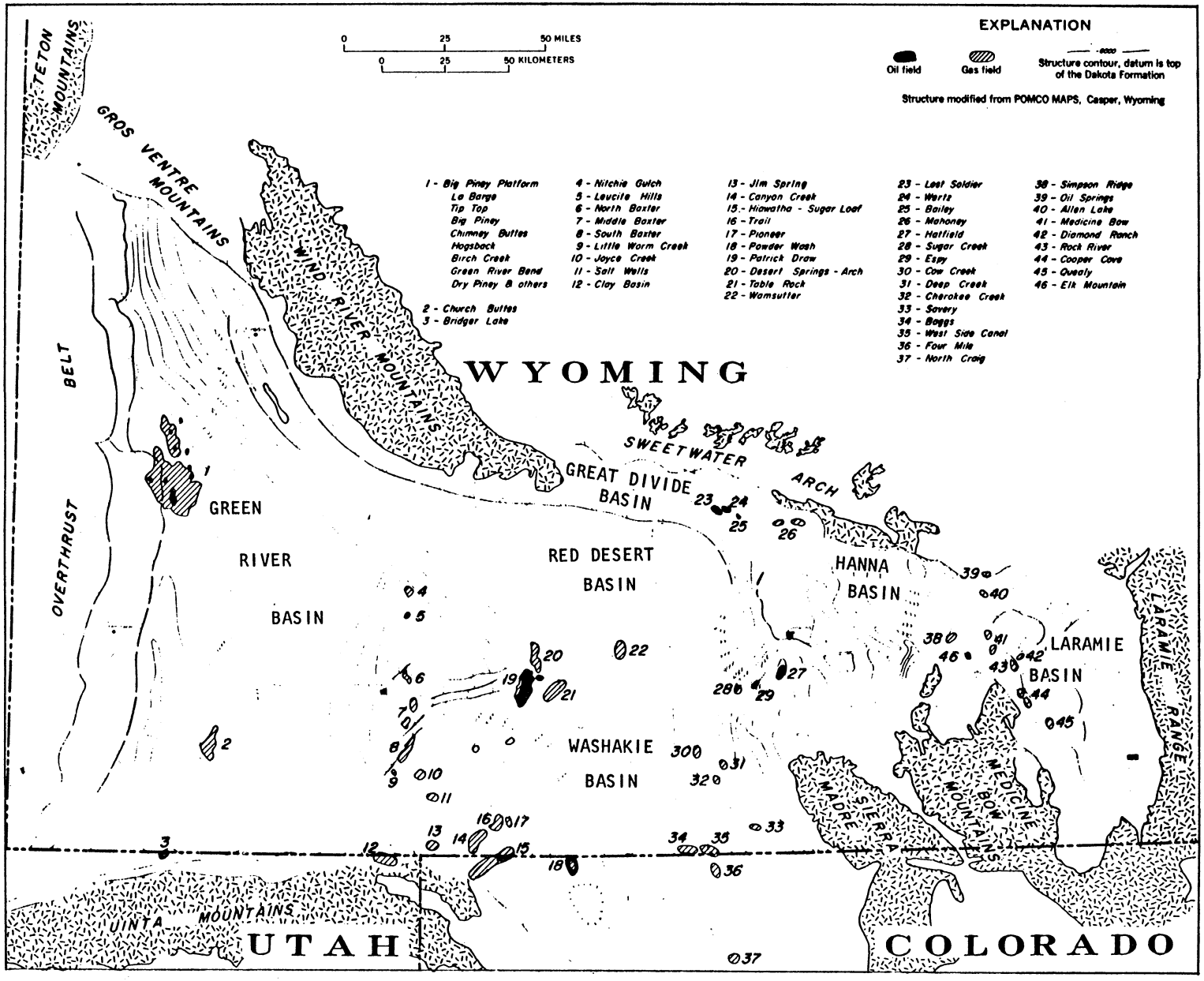


Figure 21.--Location of fields in the Red Desert and Great Divide basins (from Rocky Mountain Association of Geologists, 1972, Geologic Atlas of the Rocky Mountain Region).

Wyoming - Lost Soldier
Madison
Great Divide Basin

DATA SOURCE CODE		
	STATE	Wyoming
2a	COUNTY	Sweetwater
	REGULATORY DISTRICT	
2a	BASIN	Great Divide Basin
	SUB-BASIN	
2a	FIELD	Lost Soldier
2a	RESERVOIR	Madison
2a	GEOLOGIC AGE	Mississippian
	AAPG STRATIGRAPHIC AGE CODE	
2a	RESERVOIR LITHOLOGY	Limestone
2a, 2c	TRAPPING MECHANISM	Asymmetrical anticline
2a,2c,2b	DISCOVERY YEAR	1948; 1916 field - 1948 fm.; 1916
2a	PROVED ACREAGE	1320
2a	REGULAR WELL SPACING (acres/well)	10
2a,2c,2b	RESERVOIR DEPTH	4950; 5398; 5700
	RESERVOIR THICKNESS	
	NET PAY	
2a	GROSS	188, 300
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
2a	FRACTION	.13
	PERMEABILITY	
	RANGE	
2a	AVERAGE	20 md
	HORIZONTAL	
	VERTICAL	
2d	OTHER INFORMATION	Other production from Cretaceous, Pennsylvanian & Cambrian
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2d	TOTAL NUMBER OF WELLS	52P (18 Madison)
	PRODUCTION 1976 oil (cum)	
	PRODUCTION 1977 oil (cum)	
	PRODUCTION 1978 oil (cum)	
2d	PRODUCTION 1979 oil (cum)	73,412.6 mmcf gas; 181,554 mbbls oil
2d	PRODUCTION 1-1-79 to 1-1-80	495.3 mmcf gas; 5,192.3 mbbls oil
2d	SECONDARY RECOVERY RECORDS?	yes
2a	WATER ANALYSIS RECORDS?	no (pilot waterflood attempted & abandoned)
	OTHER DATA	
2a	STRUCTURE CONTOUR?	no (on Tensleep)
2a	LOGS?	yes
	STRUCTURE SECTION?	
	ENGINEERING REPORTS?	
	CORE DESCRIPTIONS?	

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Lost Soldier
2a	RESERVOIR:	Madison
2a	PROD. ACRES:	1320
2a	AVG. THICKNESS (FT.):	188
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
	OIL SATURATION (S_O):	
2a	PRIMARY DRIVE MECHANISM:	water
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	161
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
2a	RESERVOIR PRESSURE INITIAL (psi):	2350
	RESERVOIR PRESSURE LATEST (psi):	
2a	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	137.1
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
2a,2c	STOCK TANK OIL GRAVITY (°API):	35.6
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	
2a	Estimated Ultimate Recovery:	30,000 mbbls

2d OTHER INFORMATION:

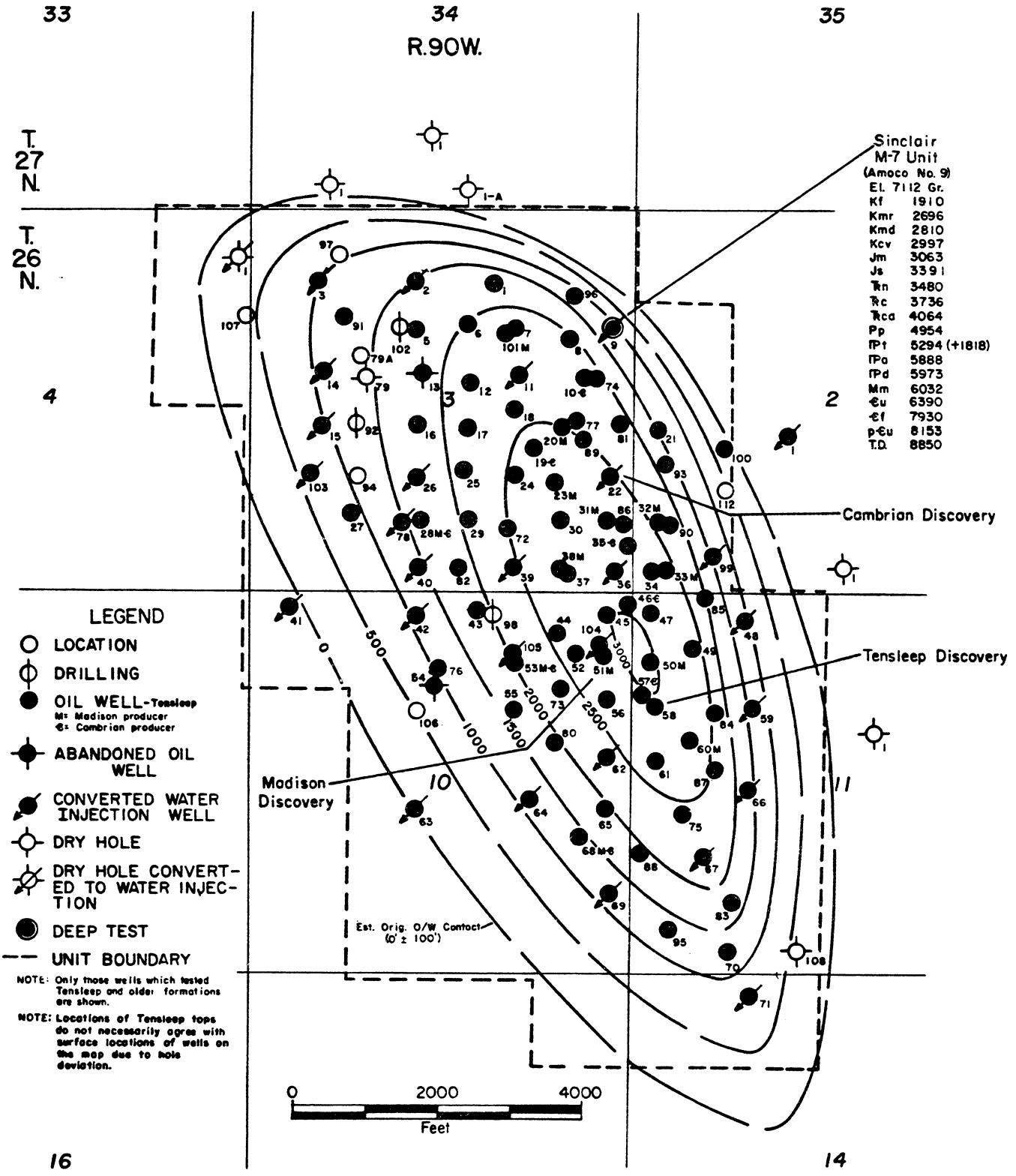
Secondary recovery: waterflood - with 4 active injection wells since 1961 by Amoco Production Company.

2d Water analysis: NaCl 13,000 ppm

2c Water Analysis: Lost Soldier-Madison (ppm)

Na & K	2,816
Ca	396
Mg	71
SO4	1,998
Cl	3,215
CO_3	--
HCO_3	969
ts	8,973

Primary salinity 82.72%
Secondary salinity 6.56%
Primary alkalinity ---
Secondary alkalinity 10.72%



From: WYOMING OIL AND GAS FIELDS, GREATER GREEN RIVER BASIN, 1979 SYMPOSIUM, Wyoming Geological Association, Source 2a.

W.G.A.

LOST SOLDIER

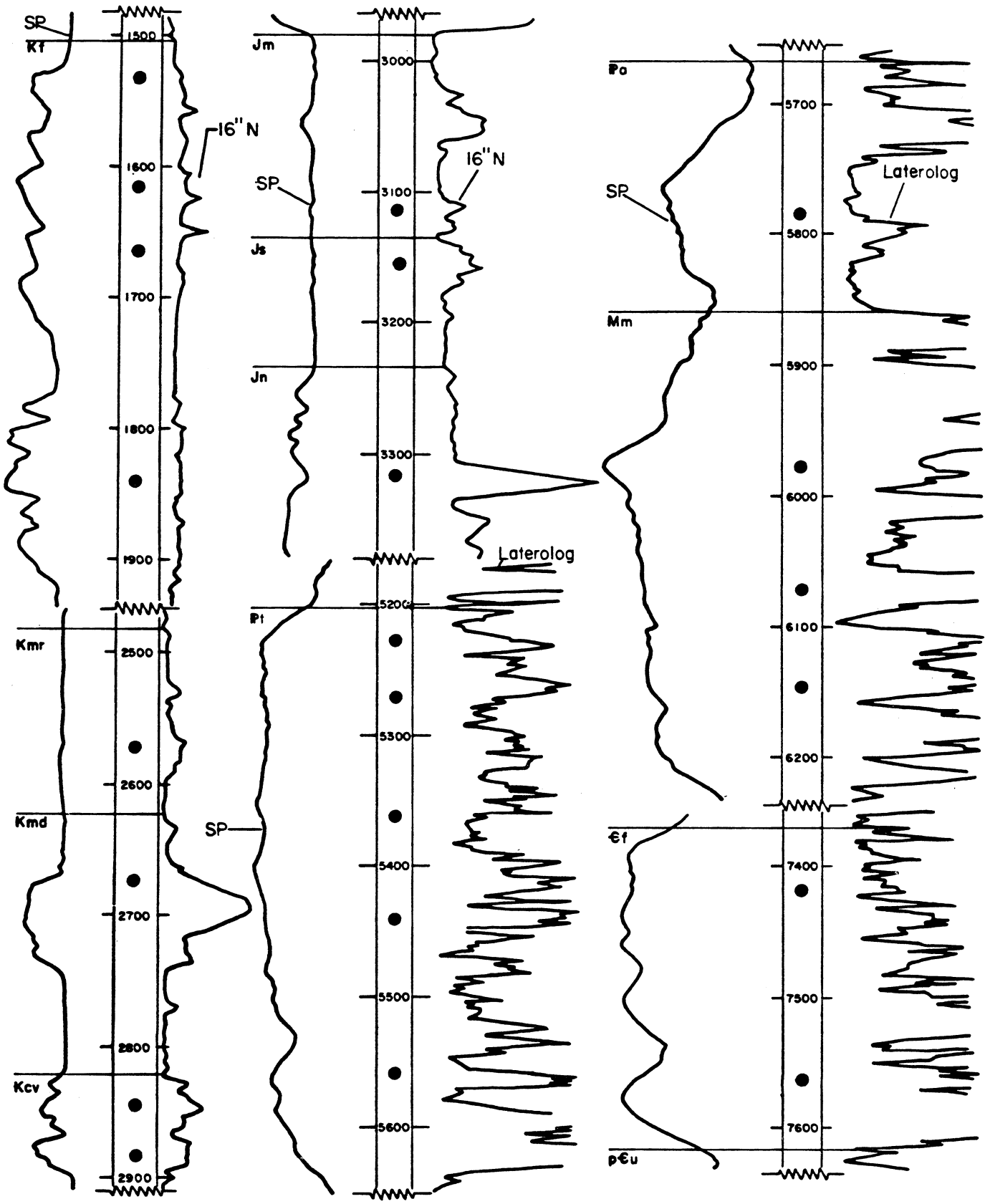
SWEETWATER COUNTY, WYOMING

DATUM-TOP TENSLEEP SANDSTONE

Contour Interval: 500'

MAY, 1978

Type Log for Lost Soldier Field



Typical producing zones depicted for both past and present production. Jurassic section taken from NE SW NE 3-26N-90W (well no. 7), remaining section taken from NW SW 2-26N-90W (well no. 21).

From: WYOMING OIL AND GAS FIELDS, GREATER GREEN RIVER BASIN, 1979 SYMPOSIUM, Wyoming Geological Association, Source 2a.

Alan J. VerPloeg and Robert Spatz, Jr.
Wyoming Geological Survey
Laramie, Wyoming
May 15, 1978

Lost Soldier

T26N R90W
Sweetwater County, Wyoming
Frontier, Mowry, Muddy, Dakota, Lakota, Morrison Sundance, Nugget, Tensleep, Madison, Flathead*

*Current producing horizons include the Tensleep, Madison, and Flathead

DISCOVERY WELL

Name: Bair Oil Company, Lost Soldier 1
Location: NW 11 - 26N - 90W
Date of Completion: June 29, 1916
Initial Potential: F200 BOPD Frontier
Total Depth: 770
Casing: NA
Perforations: 265-340 (gross)
Treatment: NA
Pressures: NA

GENERAL FIELD DATA

Regional Setting: Northeast Rim Great Divide Basin
Other Formations with Shows: Darwin Formation - Pennsylvanian
Exploration Method Leading to Discovery: Surface geology
Trap Type: Structural: asymmetrical anticline trending N 25° W
Surface Formations: Cody Shale - Cretaceous
Oldest Formation Penetrated: Precambrian
Well: Sinclair M-7 Unit (Amoco #9)
Spacing Order: Approximate spacing of 10 acres, excluded from Commission Rule 302
Logging Practice: DLL, FDC-CNL, SONL
Completion Practice: Run 7 casing to TD; perf 250 feet
Productive Area: Approximately 1320 acres
Number of Producing Wells: 51 (Tensleep), 18 (Madison and Cambrian)
Number of Abandoned Producers: 2
Number of Dry Holes: 10
Number of Shut-in Wells: 2 temporarily
Market for Production: by pipeline to refinery at Sinclair
Major Operators: Amoco Production Company
Number of Disposal Wells: 0
Number of Pressure Maintenance/Injection Wells: 29 water (Tensleep)

RESERVOIR DATA

Formation: Frontier-Cretaceous Lithology: Sandstone
Porosity: 15% (1st) 17% (2nd)
Permeability: 17 md (1st), 28 md (2nd)
Average Pay Thickness: 114 feet (Combined)
Oil/Gas Column: 300
Gas/Oil/Water Contact: +6300
Gas Oil Ratio: Unknown
Initial Pressure: Unknown
Present Pressure: Unknown
Drive Mechanism: Probably solution drive w/limited water drive
Rw and/or Salinity: Unknown
Character of oil or gas: 30.6°API, pour point - 50°F, sulphur - .14%, 988 BTU
Continuity of Reservoir: Uncertain
Cumulative Production: 2,077,000 BO
STBO/AC FT: 108
Secondary: None
Estimated Ultimate Primary: 2,077,000 BO

DISCUSSION

A pilot waterflood has been attempted and was abandoned. It recovered 2,268 BO

RESERVOIR DATA

Formation: Mowry Shale - Cretaceous
Lithology: Shale
Discovery Date: May, 1920
Location: SESWNW 11-26N-90W
Initial Potential: F 500 BOPD
Perforations: 1376-1445 (open hole)
Porosity: Fracture Permeability: Fracture
Average Pay Thickness: Unknown
Oil/Gas Column: Unknown
Gas/Oil/Water Contact: Unknown
Gas Oil Ratio: Unknown
Initial Pressure: Unknown
Present Pressure: Unknown
Drive Mechanism: Unknown
Rw and/or Salinity: Unknown
Character of oil: Gravity: 36° ? API
Continuity of Reservoir: Limited to fracture development
Cumulative Production: Unknown (probably included in Frontier cumulative)
STBO or MCF/AC FT: Not determined
Secondary: None
Estimated Ultimate Primary: Not determined

RESERVOIR DATA

Formation: Muddy-Creta Lithology: Sandstone
Lithology: Sandstone
Discovery Date: Sept. 5, 1919
Location: NWSWNW 11-26N-90W
Initial Potential: F 1500 BOPD
Perforations: 1376-1445 (open hole)
Porosity: 17.9% Permeability: 288 md
Average Pay Thickness: 45 feet
Oil/Gas Column: 950 feet
Gas/Oil/Water Contact: +4550
Gas Oil Ratio: Unknown
Initial Pressure: Unknown
Present Pressure: Unknown
Drive Mechanism: Solution drive, gravity drainage and limited water influx
Rw and/or Salinity: Unknown
Character of oil or gas: 31.1° API, sulphur content - .1%, 678 BTU
Continuity of Reservoir: limited by oil-water contact and erosional discontinuity
Cumulative Production: 13,048,000 BO*
STBO/AC FT: 341*
Secondary: No plans at this time
Estimated Ultimate Primary: 13,048,000 BO*

DISCUSSION

*Included commingled production from Cloverly and Morrison.

From: WYOMING OIL AND GAS FIELDS, GREATER GREEN RIVER BASIN, 1979 SYMPOSIUM, Wyoming Geological Association, Source 2a.

Lost Soldier

RESERVOIR DATA

Formation: Cloverly-Cretaceous
Lithology: Sandstone
Discovery Date: June 4, 1922
Location: SWSESE 3-26N-90W
Initial Potential: F 2400 BOPD
Perforations: 1895-1950 (open hole)
Porosity: 17.1%
Permeability: NA but estimated less than Muddy
Average Pay Thickness: 40 feet
Oil/Gas Column: 800 feet
Gas/Oil/Water Contact: +4550
Gas Oil Ratio: Unknown
Initial Pressure: Unknown
Present Pressure: Unknown
Drive Mechanism: Solution drive, gravity drainage and limited water influx
Rw and/or Salinity: Unknown
Character of oil or gas: 28.6°API, pour point - 55°F, sulphur - .15%, 979 BTU
Continuity of Reservoir: Limited by oil-water contact
Cumulative Production: 13,048,000 BO*
STBOAC FT: 341*
Secondary: No plans at this time
Estimated Ultimate Primary: 13,048,000 BO*

DISCUSSION

*Includes commingled production from Muddy and Morrison.

RESERVOIR DATA

Formation: Morrison-Jurassic
Lithology: Sandstone
Discovery Date: September, 1924
Location: SWSWNW 11 - 26N - 90W
Initial Potential: F 310 BOPD
Perforations: 1985-2040 (Open hole)
Porosity: 13.5% Permeability: NA
Average Pay Thickness: 20 feet
Oil/Gas Column:
Gas/Oil/Water Contact:
Gas Oil Ratio: Unknown
Initial Pressure: Unknown
Present Pressure: Unknown
Drive Mechanism: Solution drive
Rw and/or Salinity: Unknown
Character of oil or gas: 28.7°API, pour point - 75°F, sulphur - .11%
Continuity of Reservoir: Limited by permeability pinchout
Cumulative Production: 13,048,000 BO*
STBO/AC FT: 341*
Secondary: No plans at this time
Estimated Ultimate Primary: 13,048,000 BO*

DISCUSSION

*Includes commingled production from Muddy and Cloerly.

RESERVOIR DATA

Formation: Sundance (Nugget?) - Jurassic
Lithology: Sandstone
Discovery Date: 1926 Location: SWNW 11 - 26N - 90W
Initial Potential: F 200 BOPD Perforations: 2015-2040
Porosity: 19.7% Permeability: 263 md
Average Pay Thickness: 103 feet
Oil/Gas Column: 400 feet
Gas/Oil/Water Contact: +4650
Gas Oil Ratio: Original GOR estimated 50:1
Initial Pressure: 850 at +5050
Present Pressure: Unknown
Drive Mechanism: Water drive
Rw and/or Salinity: 1,200 ppm NaCl equivalent
Character of oil or gas: 28.9° API, pour point 65°F, sulphur - .17%
Continuity of Reservoir: Limited by water contact, good internal continuity
Cumulative Production: 10,400,000 BO
STBO/AC FT: 658
Secondary: Probably none - primary recovery 57% OIP
Estimated Ultimate Primary: 10,400,000 BO

RESERVOIR DATA

Formation: Tensleep-Pennsylvanian
Lithology: Sandstone
Discovery Date: June, 1930
Location: NWSWNW 11-26N-90W
Initial Potential: F 1800 BOPD Perforations: 3942-3962
Porosity: 12% Permeability: 60 md
Average Pay Thickness: 250 feet
Oil/Gas Column: 3100 feet
Gas/Oil/Water Contact: Original 0 to +100 feet
Gas Oil Ratio: Original 136:1
Initial Pressure: 2520 at +1650
Present Pressure: Approximately 1000 psi at +1650
Drive Mechanism: (1)
Rw and/or Salinity: 8000 ppm NaCl equivalent
Character of oil or gas: 35.4° API, pour point below 5°F, sulphur 1.18%
Continuity of Reservoir: (2)
Cumulative Production: 76,743,000 BO 12/31/77
STBO/AC FT: 232
Secondary: Probably equal to primary
Estimated Ultimate Primary: 55,000,000 BO

DISCUSSION

(1) Primary mechanisms a combination of solution drive, gravity drainage and limited water influx.
(2) Limited externally by water table, internally by numerous dense dolomitic interbeds of highly variable extent.

From: WYOMING OIL AND GAS FIELDS, GREATER GREEN RIVER BASIN, 1979 SYMPOSIUM, Wyoming Geological Association, Source 2a.

Lost Soldier

RESERVOIR DATA

Formation: Madison-Mississippian
Lithology: Limestone
Discovery Date: January 10, 1948
Location: SWNENE 10-26N-90W
Initial Potential: F 1045 BOPD
Perforations: 4950-5030
Porosity: 13% Permeability: 20 md (est.)
Average Pay Thickness: 188 feet
Oil/Gas Column: 1700 feet
Gas/Oil/Water Contact: +700
Gas Oil Ratio: Original 137:1
Initial Pressure: 2350 at +2200
Present Pressure: Unknown
Drive Mechanism: Water drive - primary, water injection - secondary
Rw and/or Salinity: 13,000 ppm NaCl equivalent
Character of oil or gas: 35.6° API, pour point - below 5°F, sulphur 1.22%
Continuity of Reservoir: Limited externally by water table, internally by variable zones of porosity development
Cumulative Production: 32,406,000 BO 12/31/77
STBO/AC FT: 182
Secondary: Possibly 60% of primary
Estimated Ultimate Primary: 30,000,000 BO

RESERVOIR DATA

Formation: Flathead-Cambrian
Lithology: Sandstone
Discovery Date: June 3, 1948
Location: SENESE 3-26N-90W
Initial Potential: F 720 BOPD Perforations: 5985-6026
Porosity: 12% Permeability: 20md (est)
Average Pay Thickness: 90 feet
Oil/Gas Column: 1000 feet
Gas/Oil/Water Contact: +300
Gas Oil Ratio: Original 130:1
Initial Pressure: 2623 at +1000
Present Pressure: Unknown
Drive Mechanism: Solution gas and limited water influx - primary; water injection - secondary.
Rw and/or Salinity: 13,000 ppm NaCl equivalent
Character of oil or gas: 35.2° API, pour point below 5°F, sulphur 1.23%
Continuity of Reservoir: Limited by water table
Cumulative Production: 17,422,000 BO (12/31/77)
STBO/AC FT: 280
Secondary: About 30% of primary
Estimted Ultimate Primary: 15,000,000 BO

DISCUSSION

The author wishes to thank Amoco Production Company and specifically, D. L. Garthwaite for their assistance in supplying reservoir data, current status, etc. for Lost Soldier Field.

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From: WYOMING OIL AND GAS FIELDS, GREATER GREEN RIVER BASIN, 1979 SYMPOSIUM, Wyoming Geological Association, Source 2a.

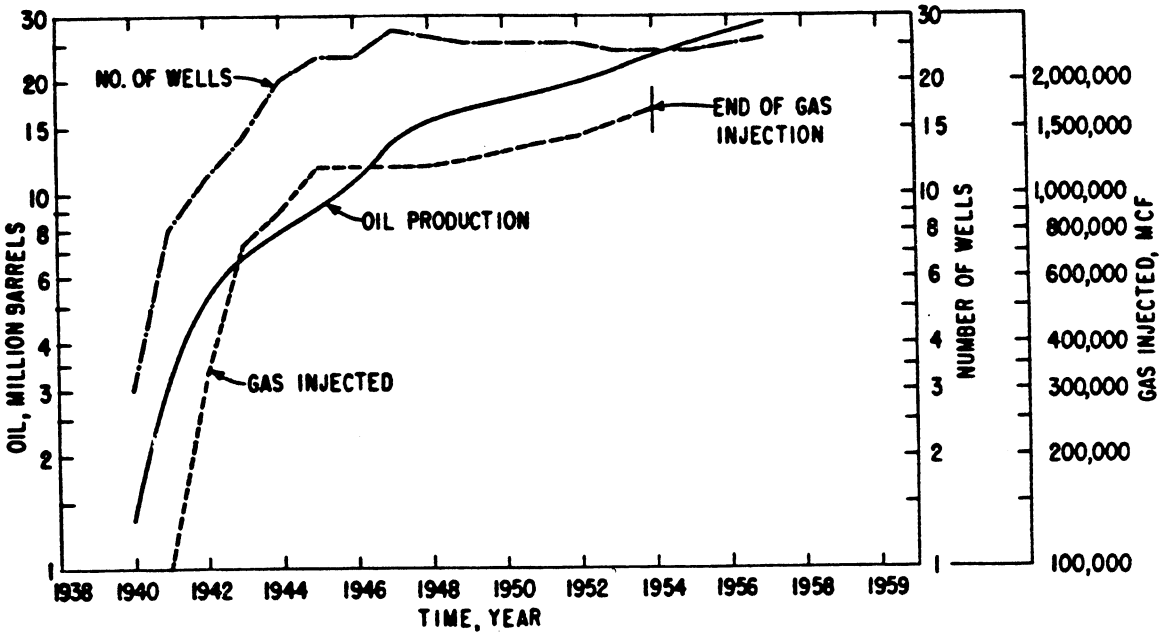

FIGURE 106.—Cumulative Oil Production and Gas Injected, Tensleep Reservoir, Lost Soldier Field, Sweetwater County, Wyo.

Sundance. The open-flow volume of the wells in the Sundance sand ranged from 2 to 20 million cubic feet of gas daily, and depth to the sand ranged from 2,646 to 2,990 feet; the sand averaged 100 feet in thickness. In 1930 a well was drilled in the SE¼NW¼ sec. 34 into the Tensleep sandstone at 4,670 to 4,685 feet; it produced 65 barrels a day of 32° API gravity black oil. The well was operated only to determine its productive capacity. The Embar formation was logged at 4,317 to 4,600 feet and the Tensleep from 4,600 to 4,760 feet.

Around 1939 the demand for crude increased. Since that time 11 additional Tensleep wells have been drilled. In 1944 a well in the NW¼NE¼ sec. 34 was drilled into the Cambrian at a total depth of 5,366 feet, and water was found in the Madison formation. The following formations and their depth, in feet, were logged in this well: Frontier, 934; Dakota, 2,104; Lakota, 2,248; Alcova, 3,225; Tensleep, 4,312; Madison, 5,000; and Cambrian, 5,345.

The Tensleep sand at Mahoney Dome is unusually hard and tight. To stimulate production the Tensleep sandstone interval has been shot with as much as 600 quarts of nitroglycerin in some wells.

By December 1957 all gas wells had been abandoned. Nine wells completed in the Tensleep sandstone were yielding 245 barrels of oil and 565 barrels of water each day.

Analyses of oil from the Tensleep and water from the Frontier, Sundance, Tensleep, and Madison formations are given on page 429 and in table 9 (p. 296), respectively. Analyses of gas from the Dakota and Sundance formations are included in table 8 (p. 289).

In 1956 the field produced 98,429 barrels of oil and 55.7 million cubic feet of gas. The cumulative production through 1956 was 3,371,709 barrels of oil and 50,683 million cubic feet of gas. Gas production began in 1922, when a line was laid to Sinclair, Wyo. Until the fall of 1937 gas was transported to Casper, Wyo., through the 89-mile Wertz-Mahoney-Casper pipeline system. The produced oil is pumped into the pipeline system serving the area and may be pumped either to Sinclair or Casper, Wyo.

The West Ferris gas and oil field (fig. 63), known also as East Mahoney and sometimes included in Mahoney Dome field, is in the southwest corner of T. 26 N., R. 87 W., and the southeast corner of T. 26 N., R. 88 W., Carbon County. It is situated on an elliptical dome, which has about 400 feet of closure independent of Mahoney dome to the west and Middle Ferris structure to the east, and a total closure of about 1,500 feet. The Niobrara formation, obscured by soil and sand dunes, covers the structure at an elevation range of 6,920 to 7,075 feet.

The discovery well in the SE¼SW¼ sec. 29 was completed in 1923 in the Dakota sand

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

TABLE 12.—*Crude-oil analyses*—Continued

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-50-90

IDENTIFICATION

Lost Soldier field
Lakota sandstone - Lower Cretaceous
1,914 - 1,950 feet

Wyoming
Sweetwater County
sec. 3,
T. 26 N., R. 90 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.884 A. P. I. gravity 28.6 ° Pour point, ° F. 55
Sulfur, percent, 0.15 Color, greenish black
Saybolt Universal viscosity at 100 ° F., 90 sec.; at 77 ° F., 192 sec. Nitrogen, percent 0.075

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 85 ° C. (185 ° F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Sum. Percent	Sp. Gr. 60/60° F.	°A. P. I. 60° F.	C. I.	Aniline Point, °C.	S. U. Vis. 100° F.	Cond. Vis. °F.
1	50	122			0.					
2	75	167								
3	100	212	0.5	0.5	.738	60.2				
4	125	257	1.1	1.6	.761	54.4	32	50.6		
5	150	302	1.6	3.2	.780	49.9	33	51.3		
6	175	347	2.6	5.8	.809	43.4	40	50.8		
7	200	392	2.8	8.6	.833	38.4	45	48.9		
8	225	437	3.7	12.3	.849	35.2	47	50.2		
9	250	482	5.3	17.6	.857	33.6	46	55.8		
10	275	527	8.4	26.0	.859	33.2	42	64.2		
STAGE 2—Distillation continued at 40 mm. Hg										
11	200	392	2.7	28.7	0.860	33.0	38	72.0	41	30
12	225	437	9.9	38.6	.860	33.0	35	77.6	45	45
13	250	482	12.8	51.4	.864	32.3	33	83.8	55	60
14	275	527	9.6	61.0	.878	29.7	37	89.1	78	80
15	300	572	8.3	69.3	.888	27.8	38	93.6	120	95
Residuum			30.7	100.0	.943	18.5		too dark		

Carbon residue of residuum, 5.0 percent; carbon residue of crude, 1.6 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A. P. I.	Viscosity
Light gasoline	0.5	0.738	60.2	
Total gasoline and naphtha	5.8	0.786	48.5	
Kerosine distillate	0			
Gas oil	33.6	.856	33.8	
Nonviscous lubricating distillate	21.4	.862-.883	32.6-28.7	60-100
Medium lubricating distillate	8.5	.883-.892	28.7-27.1	100-200
Viscous lubricating distillate	0			Above 200
Residuum	30.7	.943	18.5	
Distillation loss	0			

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample 371 - 30

IDENTIFICATION

Lost Soldier field
Morrison formation - Jurassic
1,950 - 1,954 feet

Wyoming
Sweetwater County
NE¼ sec. 10,
T. 26 N., R. 90 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.883 A. P. I. gravity 28.7 ° Pour point, ° F. 75
Sulfur, percent, 0.11 Color, brownish green
Saybolt Universal viscosity at 100 ° F., 99 sec.; at ° F., sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 589 mm. Hg
First drop, 89 ° C. (192 ° F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Sum. Percent	Sp. Gr. 60/60° F.	°A. P. I. 60° F.	C. I.	Aniline Point, °C.	S. U. Vis. 100° F.	Cond. Vis. °F.
1	50	122			0.					
2	75	167								
3	100	212	0.6	0.6	.760	54.7				
4	125	257	.7	1.3	.773	51.5	34			
5	150	302	1.6	2.9	.781	49.7	31			
6	175	347	1.8	4.7	.806	44.1	36			
7	200	392	2.7	7.4	.830	39.0	41			
8	225	437	4.6	12.0	.849	35.2	45			
9	250	482	5.5	17.5	.857	33.6	44			
10	275	527	8.8	26.3	.858	33.4	40			
STAGE 2—Distillation continued at 40 mm. Hg										
11	200	392	3.8	30.1	0. 858	33.4			43	30
12	225	437	13.0	43.1	.860	33.0	33		48	45
13	250	482	11.6	54.7	.868	31.5	34		61	65
14	275	527	8.4	63.1	.877	29.8	35		116	80
15	300	572	9.1	72.2	.896	26.4	41		185	95
Residuum			27.8	100.0	.951	17.3				

Carbon residue of residuum, 6.5 percent; carbon residue of crude, 2.0 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A. P. I.	Viscosity
Light gasoline	0.6	0.760	54.7	
Total gasoline and naphtha	4.7	0.787	48.3	
Kerosine distillate	0			
Gas oil	33.8	.855	34.0	
Nonviscous lubricating distillate	17.5	.861-.874	32.8-30.4	60-100
Medium lubricating distillate	13.6	.874-.900	30.4-25.7	100-200
Viscous lubricating distillate	2.6	.900-.906	25.7-24.7	Above 200
Residuum	27.8	.951	17.3	
Distillation loss	0			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

TABLE 12.—*Crude-oil analyses*—Continued

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-48-25

IDENTIFICATION

Lost Soldier field
Madison limestone - Mississippian
4,794 - 5,410 feet

Wyoming
Sweetwater County
SW¼ sec. 11,
T. 26 N., R. 90 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.847 A. P. I. gravity 35.6 ° Pour point, ° F. below 5
Sulfur, percent, 1.22 Color, brownish black
Saybolt Universal viscosity at 100 ° F., 42 sec.; at ° F., sec. Nitrogen, percent 0.082

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 31 ° C. (88 ° F.)

Fraction No.	Cut temp. ° C.	Cut temp. ° F.	Percent	Sum, Percent	Sp. Gr. 60/60° F.	° A. P. I. 60° F.	C. I.	Aniline point ° C.	S. U. vis. 100° F.	Cloud test, ° F.
1	50	122	1.8	1.8	0.658	83.5				
2	75	167	2.8	4.6	659	83.2	2.3			
3	100	212	3.5	8.1	695	72.1	9.4			
4	125	257	4.3	12.4	722	64.5	13			
5	150	302	5.5	17.9	747	57.9	18			
6	175	347	5.5	23.4	770	52.3	22			
7	200	392	5.2	28.6	786	48.5	23			
8	225	437	4.7	33.3	800	45.4	24	61.5		
9	250	482	5.7	39.0	817	41.7	27	65.0		
10	275	527	7.4	46.4	836	37.8	31	66.2		
STAGE 2—Distillation continued at 40 mm. Hg										
11	200	392	3.0	49.4	0.865	32.1	41	69.4	41	10
12	225	437	6.5	55.9	870	31.1	39		45	25
13	250	482	6.0	61.9	884	28.6	43		56	40
14	275	527	7.4	69.3	908	24.3	51		89	60
15	300	572	4.3	73.6	918	22.6	53		170	80
Residuum			24.1	97.7	976	13.5				

Carbon residue of residuum, 10.9 percent; carbon residue of crude, 3.0 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	° A. P. I.	Viscosity
Light gasoline	8.1	0.674	78.4	
Total gasoline and naphtha	28.6	0.734	61.3	
Kerosine distillate	10.4	.802	43.4	
Gas oil	15.9	.853	34.4	
Nonviscous lubricating distillate	11.5	.875-.909	30.2-24.2	80-100
Medium lubricating distillate	7.2	.909-.922	24.2-22.0	100-200
Viscous lubricating distillate	0			Above 200
Residuum	24.1	976	13.5	
Distillation loss	2.3			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-50-87

IDENTIFICATION

Lost Soldier field
Cambrian sandstone
6,348 - 7,323 feet

Wyoming
Sweetwater County
SW¼ sec. 3,
T. 26 N., R. 90 W.

GENERAL CHARACTERISTICS

Gravity, specific, 0.849 Gravity, ° API, 35.2° Pour point, ° F., below 5
Sulfur, percent, 1.23 Color, black
Viscosity, Saybolt Universal at 100°F. 41 sec. Nitrogen, percent, 0.084

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 75 ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. Gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	122	2.0	2.0	0.652	85.5		1.36751	100.0		
2	167	2.7	4.7	.659	83.2	2.3	1.37070	120.6		
3	212	3.7	8.4	.696	71.8	10	1.38898	126.6		
4	257	4.9	13.3	.725	63.7	15	1.40403	128.8		
5	302	5.3	18.6	.750	57.2	19	1.41751	135.7		
6	347	5.6	24.2	.771	52.0	22	1.42944	139.9		
7	392	4.9	29.1	.789	47.8	24	1.43822	141.1		
8	437	5.2	34.3	.803	44.7	25	1.44537	141.5		
9	482	5.5	39.8	.820	41.1	28	1.45419	142.2		
10	527	7.3	47.1	.839	37.2	32	1.46524	152.5		
STAGE 2—Distillation continued at 40 mm. Hg										
11	392	3.7	50.8	0.863	32.5	40			41	5
12	437	6.5	57.3	.872	30.8	40			47	25
13	482	6.5	63.8	.891	27.3	46			61	45
14	527	5.3	69.1	.904	25.0	49			93	65
15	572	6.0	75.1	.915	23.1	51			180	80
Residuum		23.5	98.6	.978	13.2					

Carbon residue, Conradson: Residuum, 11.4 percent; crude, 3.1 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	8.4	0.674	78.4	
Total gasoline and naphtha	29.1	.734	61.3	
Kerosine distillate	10.7	.812	42.8	
Gas oil	15.5	.854	34.2	
Nonviscous lubricating distillate	11.4	.875-.905	30.2-24.9	80-100
Medium lubricating distillate	6.7	.905-.917	24.9-22.8	100-200
Viscous lubricating distillate	1.7	.917-.921	22.8-22.1	Above 200
Residuum	23.5	.978	13.2	
Distillation loss	1.4			

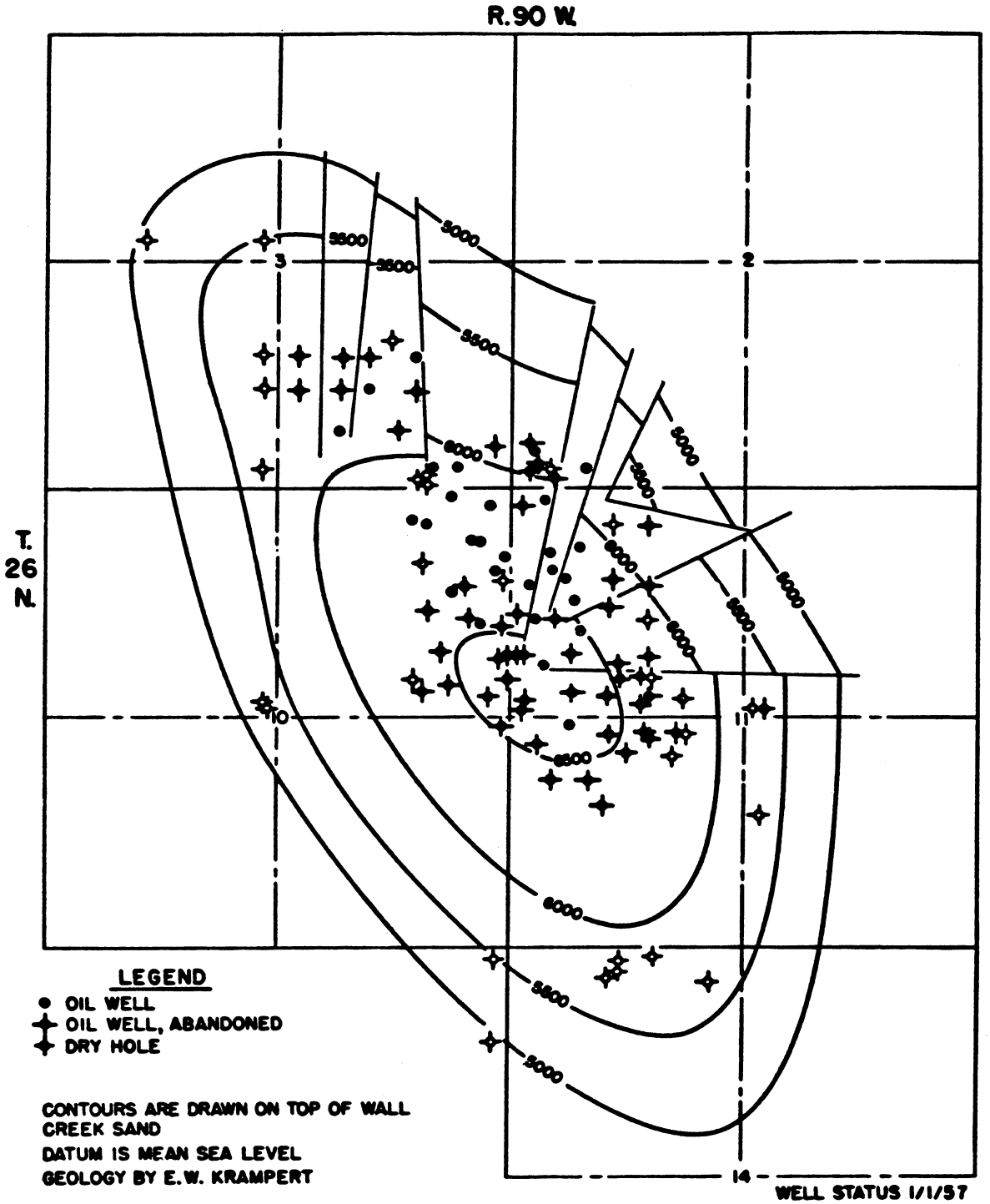

FIGURE 104.—Structure-Contour Map of Lost Soldier Field, Sweetwater County, Wyo.
(Adapted from Bureau of Mines Bulletin 418.)

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

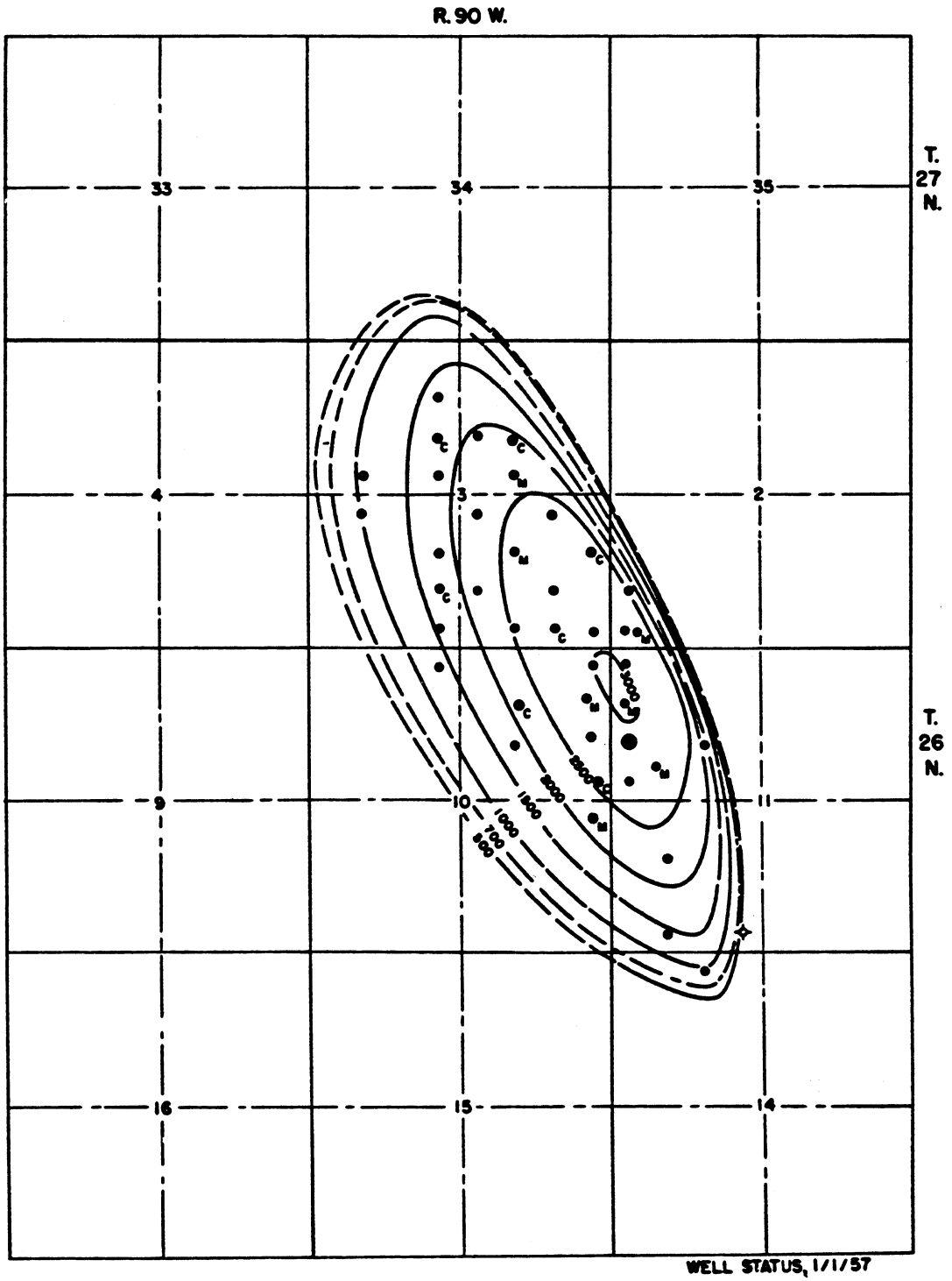

FIGURE 105.—Structure-Contour Map of Lost Soldier Field, Sweetwater County, Wyo.
(Adapted from Federal Geological Survey map.)

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

Wyoming - Wertz
Madison
Red Desert Basin

DATA SOURCE CODE		
	STATE	Wyoming
2a	COUNTY	Carbon and Sweetwater
	REGULATORY DISTRICT	
2a	BASIN	Northeast Red Desert Basin
	SUB-BASIN	
2a	FIELD	Wertz
2a	RESERVOIR	Madison
2a	GEOLOGIC AGE	Mississippian
	AAPG STRATIGRAPHIC AGE CODE	
2a	RESERVOIR LITHOLOGY	Dolomite, limey; continuous reservoir
2a,2c	TRAPPING MECHANISM	Anticline, faulted
2a,2c,2b	DISCOVERY YEAR	1948, 1920 field, 1948 fm., 1920
2a	PROVED ACREAGE	648
2a	REGULAR WELL SPACING (acres/well)	10
2a, 2b	RESERVOIR DEPTH	6820, 6500
	RESERVOIR THICKNESS	
2a	NET PAY	260
	GROSS	
	NET/GROSS RATIO	
	POROSITY	
	TYPE	
2a	FRACTION	.117
	PERMEABILITY	
	RANGE	
2a	AVERAGE	<15 md
	HORIZONTAL	
	VERTICAL	
2d	OTHER INFORMATION	Other reservoirs Cretaceous, Jurassic, Pennsylvania, Cambrian sands
	PRODUCTION STATISTICS - FIELD TOTALS (oil in mbbls, gas in mmcf)	
2d	TOTAL NUMBER OF WELLS	39P
	PRODUCTION 1976 oil (cum)	
	PRODUCTION 1977 oil (cum)	
2a	PRODUCTION 1978 oil (cum)	7,444.6 mbbls oil; 204.2 mmcf (Madison only)
2d	PRODUCTION 1979 oil (cum)	77,262 mbbls oil; 22,300 mmcf gas
2d	PRODUCTION 1-1-79 to 1-1-80	1,785.8 mbbls oil; 819 mmcf gas
2d	SECONDARY RECOVERY RECORDS?	yes
	WATER ANALYSIS RECORDS?	
	OTHER DATA	
2a	STRUCTURE CONTOUR?	yes
2a	LOGS?	yes
	STRUCTURE SECTION?	
	ENGINEERING REPORTS?	
	CORE DESCRIPTIONS?	
2c	CRUDE ANALYSIS?	yes

RESERVOIR DATA

DATA SOURCE CODE		
	FIELD:	Wertz
2a	RESERVOIR:	Madison
2a	PROD. ACRES:	648
2a	AVG. THICKNESS (FT.):	260
	FORMATION VOLUME FACTOR INITIAL (FVF/INT):	
	FORMATION VOLUME FACTOR LATEST (FVF):	
	WATER SATURATION (S_W):	
2a	OIL SATURATION (S_O):	water
2a	PRIMARY DRIVE MECHANISM:	mappable gas cap
	PRIMARY GAS CAP?:	
11	TEMPERATURE (°F):	179
	SATURATION PRESSURE/BUBBLE POINT PRESSURE (psi)	
2a	RESERVOIR PRESSURE INITIAL (psi):	2657
	RESERVOIR PRESSURE LATEST (psi):	
2a	GAS OIL RATIO INITIAL (GOR/INT) (cf/bbl):	25:1
	GAS OIL RATIO LATEST (GOR) (cf/bbl):	
2a,2c	STOCK TANK OIL GRAVITY (°API):	35.6
	OIL VISCOSITIES (μ_{oi}/μ_{ob}):	
	MINIMUM MISCIBILITY PRESSURE (MMP):	
	ESTIMATED ORIGINAL OIL IN PLACE FOR ___SRPs:	
	ESTIMATED PRIMARY OIL RECOVERED FOR ___SRPs:	
2a	Estimated Ultimated Recovery:	15,000 mbbls
2d	OTHER INFORMATION:	

Secondary recovery: waterflood in Madison (1 well) since 1954
Amoco Production Co.

Albert E. Allen, Jr.
Casper College - Consultant Kirkwood Oil & Gas Co.
Casper, Wyoming
August, 1978

DISCOVERY WELL

Name: Producers and Refiners Corp., #1
Location: NENESW 7-26N-89W
Date of Completion: September 23, 1921
Initial Potential: F 42 MMCFGPD Muddy; F15-25 BOPD Mowry
Total Depth: 3445 Elevation: 6723Gr
Casing: 15½ at 40, 10 at 1200, 8 at 1755, 6-5/8 at 2677, 5-3/16 at 3403
Perforations: Open hole 3403-3445 (pay 3427-3435) Flowed from Mowry between 6-5/8 and 5-3/16 casing.
Treatment: None, natural
Pressures: None reported

GENERAL FIELD DATA

Regional Setting: Northeast Red Desert Basin, South Flank Granite Mtns.
Other Formations with Shows: Nugget-Jurassic, Chugwater-Triassic, Phosphoria-Permian
Exploration Method Leading to Discovery: Surface geology
Trap Type: Anticline
Surface Formations: Cody (Steele) - Cretaceous
Oldest Formation Penetrated: Precambrian
Well: NWSESE 1-26N-90W
Spacing Order: 10 acres
Logging Practice: Recent; DLL, SonL-GR, FDC-CNL, CDM
Completion Practice: Recent; run casing to total depth, selectively perforate, acidize or frac
Productive area: 1200 acres
Number of Producing Wells: Total 41; Lakota-1, Tensleep-33, Darwin-3, Madison-4
Number of Abandoned Producers: Unknown; recently Madison-1
Number of Dry Holes: Unknown
Number of Shut-in Wells: Total-3, Lakota-2, Tensleep1
Market for Production: Unknown
Major Operators: Sinclair, Amoco
Number of Disposal Wells: 8
Number of Pressure Maintenance/Injection Wells: Water-7; gas-1

Wertz

T26N R89-90W
Carbon and Sweetwater Counties, Wyoming
Frontier, Mowry, Muddy, Cloverly, Sundance, Tensleep, Amsden, Flathead

RESERVOIR DATA

Formation: Frontier-Cretaceous
Lithology: Sandstone, fine gr, argil
Discovery Date: 1925 Location: NWNWNW 7-26N-89W
Initial Potential: F 7,000 MCFGPD
Perforations: 2160-2265
Porosity: 11%
Permeability: less than 15 md estimate
Area: 80 acres
Average Pay Thickness: 30 feet
Oil/Gas Column: 800 feet estimate
Gas/Oil/Water Contact: Unknown
Gas Oil Ratio: Dry gas
Initial Pressure: SIWHP 850
Present Pressure: Depleted
Drive Mechanism: Water, gas expansion
Rw and/or Salinity: Unknown
Character of gas: BTU-967, methane-94.87%, ethane-0.21%, propane-0.15%, N-3.77%, CO_2-1.0%
Continuity of Reservoir: Poor
Cumulative Production: 1,000 MMCFG+
STBO or MCF/AC FT: Not determined
Secondary: None
Estimted Ultimate Primary: 1,000 MMCFG+

DISCUSSION

A total of 35 gas wells were completed in the Frontier, however, two wells produced approximately 700 MMCFG. The cumulative is only approximate and represents only the estimated gas processed between 1922 and late 1937. A water flood project was instituted in 1972 but failed.

RESERVOIR DATA

Formation: Mowry-Cretaceous
Lithology: Sandstone
Porosity: Unknown Permeability: Fractured
Average Pay Thickness: Unknown
Area: 40 acres
Oil/Gas Column: Unknown
Gas/Oil/Water Contact: Unknown
Gas Oil Ratio: Unknown
Initial Pressure: Unknown
Present Pressure: Depleted
Drive Mechanism: Probably solution gas
Rw and/or Salinity: Unknown
Character of oil or gas: Gravity - 40° API
Continuity of Reservoir: Limited by fracture development
Cumulative Production: 8967 BO (1 well, 1920-1924)
Abandoned: 1924
STBO or MCF/AC FT: Not determined
Secondary: None
Estimated Ultimate Primary: Not determined

(Continued)

From: WYOMING OIL AND GAS FIELDS, GREATER GREEN RIVER BASIN, 1979 SYMPOSIUM, Wyoming Geological Association, Source 2a.

Wertz

RESERVOIR DATA

Formation: Muddy-Cretaceous
Lithology: Sandstone
Porosity: 15%
Permeability: 1.0 - 0.5 md (empirical)
Average Pay Thickness: 28 feet
Area: 500 acres ±
Oil/Gas Column: Unknown 600 feet ±
Gas/Oil/Water Contact: Unknown
Gas Oil Ratio: Unknown; probably dry gas
Initial Pressure: SIWHP 1800
Present Pressure: Depleted
Drive Mechanism: Gas expansion
Rw and/or Salinity: Rw = 1.3 at 68°F (comparable to Dakota water)
Character of oil or gas: BTU-1053, methane-84.88%, ethane-2.6%, propane-1.92%, higher fractions-2.63%, N-5.49%, O_2-2.48%
Continuity of Reservoir: Continuous with variable thickness
Cumulative Production: 34 BCF+estimate (1920-1937)*
STBO or MCF/AC FT: Not determined
Secondary: None
Estimated Ultimate Primary: Not determined

DISCUSSION

*It is estimated that 34 BCFG was produced until the Wertz gas field was shut-in in 1937. From 1937 until the present time the gas production is unknown. A pressure maintenance program was initiated in 1941 which used casinghead gas from the deeper reservoirs and make-up gas from the shallow zones to supplement the natural water drive in the Tensleep. An unknown amount of gas may have been produced from the Muddy for injection purposes. The gas character may be for the "Cloverly."

In the past the Muddy has often been incorrectly referred to as "Dakota" in the Wertz Field and environs.

RESERVOIR DATA

Formation: Dakota-Lakota (Cloverly) - Cretaceous
Lithology: Sandstone, cherty, cgltc
Discovery Date: January 10, 1928
Location: 7-26N-89W
Initial Potential: F 6,000 MCFGPD
Perforations: Open hole, 3549-3610
Porosity: 18% Permeability: 200 md
Average Pay Thickness: 36 feet
Area: 300 acres
Oil/Gas Column: 150 feet ±
Gas/Oil/Water Contact: Unknown
Gas Ol Ratio: Unknown
Initial Pressure: SIWHP 1340
Present Pressure: Depleted
Drive Mechanism: Gas expansion; water
Rw and/or Salinity: Rw = 1.3 at 68°F
Character of oil or gas: Oil - gravity - 31°API, gas; BTU-1053, methane-84.88%, ethane-2.6%, propane-1.92%, higher fractions-2.63%, N-5.49%, O_2-2.48%*
Continuity of Reservoir: Continuous in field area
Cumulative Production: 24 BCFG+ (1928-1937) 3 wells 2-SI 31,006 BO, 112,210 MCF 8/1/78
STBO or MCF/AC FT: Not determined
Secondary: None
Estimated Ultimate Primary: Not determined

DISCUSSION

*Available references do not allow differentiation between the Muddy and Cloverly gas character.

RESERVOIR DATA

Formation: Sundance-Jurassic
Lithology: Sandstone, f to m. gr, calc, glau
Discovery Date: August 6, 1929
Location: NWNW 7-26N-89W
Initial Potential: F 57,000 MCFGPD
Perforations: Open hole, 4100-4150
Porosity: 14% Permeability: Unknown
Average Pay Thickness: 50 feet
Area: 100 acres
Oil/Gas Column: Unknown
Gas/Oil/Water Contact: Unknown
Gas Oil Ratio: Unknown; probably dry gas
Initial Pressure: SIWHP 1520
Present Pressure: Depleted
Drive Mechanism: Gas expansion
Rw and/or Salinity: Rw = 1.45 at 68°F (DST)
Character of gas: BTU-1092, methane-87.07%, ethane-2.29%, propane-2.25%, higher fractions-3.04%, N-1.6%, CO_2-3.75%
Continuity of Reservoir: Continuous in field
Cumulative Production: 2.6 BCF
STBO or MCF/AC FT: Not determined
Secondary: None
Estimated Ultimate Primary: Not determined

RESERVOIR DATA

Formation: Darwin (Amsden) - Pennsylvanian
Lithology: Sandstone, m gr., w srtd
Discovery Date: February 28, 1948
Location: E/½SESE 1-26N-90W
Initial Potential: F 595 BOPD
Perforations: 6480-6590
Treatment: SF w/15,000 gals gelled water, 3000# sand, 600# 12/20 glass beads, 3000#?
Porosity: 15% Permeability: 25md+
Average Pay Thickness: 100 feet
Oil/Gas Column: 1150 feet
Gas/Oil/Water Contact: +200 NE and SE, Sea level SW and NW
Gas Oil Ratio: 43:1 (production)
Initial Pressure: SIP 2630
Present Pressure: SIP 1100
Drive Mechanism: Water drive
Rw and/or Salinity: Unknown
Character of oil or gas: Oil; gravity-35°API, S-1.25%, N-0.80%, pour point-below 5°, gas; BTU-673, methane-18.52%, ethane-10.03%, propane-8.67%, higher fractions-8.16%, N-22.27%, CO_2-40.49%
Continuity of Reservoir: Blanket sandstone, highly fractured, good communication
Cumulative Production: 3,018,206 BO 131,119 MCFG ? BW 9/1/78
STBO or MCF/AC FT: 150
Secondary: 2,000,000 BO 150,000 MCFG
Estimated Ultimate Recovery; 5,000,000 BO 250,000 MCFG

(Continued)

From: WYOMING OIL AND GAS FIELDS, GREATER GREEN RIVER BASIN, 1979 SYMPOSIUM, Wyoming Geological Association, Source 2a.

Wertz

RESERVOIR DATA
Formation: Tensleep-Pennsylvanian
Lithology: Sandstone, calcareous
Discovery Date: December 22, 1936
Location: SWSENW 7-26N-89W
Initial Potential: F 1780 BOPD
Perforations: Open hole 5863-5886 three zones separately.
Treatment: None, natural; recent completions SF w/11,000 gals, 6750# 20/40 sand, 13,500# 10/40 sand
Porosity: 6-14% Permeability: 70 md
Area: 1200 acres
Average Pay Thickness: 250 feet
Oil/Gas Column: 1,150 feet
Gas/Oil/Water Contact: -100
Gas Oil Ratio: 344:1 (pronounced gas cap)
Initial Pressure: 2640
Present Pressure: 1100
Drive Mechanism: Water drive
Rw and/or Salinity: Rw = 0.42 at 148°F, 0.90 at 68°F
Character of oil or gas: Oil; gravity-33.6°API, S-1.32%, N-0.056%, pour point-below 5°, gas; BTU-683, methane-26.8%, ethane-6.35%, propane-5.35%, higher fractions-4.3%, N-4.09%, CO_2-52%, H_2S-1.11%
Continuity of Reservoir: Continuous thick sandstones; total interval with three important sandstones.
Cumulative Production: 61,764,537 BO 21,244,651 MCFG ? BW 9/1/78
STBO or MCF/AC FT: 350
Secondary: 20,000,000 BO
Estimated Ultimate Recoverable: 120,000,000 BO, 8 BCFG

DISCUSSION
In 1939 the discovery was deepened to 6161 and produced 8350 BOPD.

RESERVOIR DATA
Formation: Madison-Mississippian
Lithology: Dolomite, limey
Discovery Date: April 24, 1948
Location: SESWNE 1-26N-90W
Initial Potential: 1,145 BOPD
Perforations: 6790-6950 w/unknown shots/ft
Treatment: Acidized w/100 gals; recent completions are variable
Porosity: 11.7%
Permeability: less than 15 md in dolomite zones
Area: 648 acres
Average Pay Thickness: 260 feet
Oil/Gas Column: 1700 feet
Gas/Oil/Water Contact: +700 (originally at -200) tilt to southwest
Gas Oil Ratio: 25:1 mappable gas cap
Initial Pressure: SIP 2657
Present Pressure: Unknown
Drive Mechanism: Water
Rw and/or Salinity: Rw = 0.60 at 68°F
Character of oil or gas: Oil; gravity-35.6°API, S-1.17%, N-0.085%, pour point-below 5°, gas; BTU-959, methane-25.95%, ethane-10.03%, propane 8.67%, high fractions-8.16%, N-28.7%, $CO_2$18.49%
Continuity of Reservoir: Continuous
Cumulative Production: 7,444,615 BO 204,248 MCFG ? BW 9/1/78
STBO or MCFT/AC FT: 92 (630BO/AF in place)
Secondary: 3,000,000 BO 100,000 MCFG
Estimated Ultimate Recoverable: 15,000,000 BO 500,000 MCFG

DISCUSSION
Madison behaves as common reservoir with Darwin

RESERVOIR DATA
Formation: Flathead-Cambrian
Lithology: Sandstone, white, fine to coarse, well sorted
Discovery Date: October 1948
Location: N½SESE 1-26N-90W
Initial Potential: P 277 BOPD
Perforations: Open hole, 5964-6142, 7535-7630
Treatment: Shot with 155 qts nitroglycerine
Porosity: 12.3% Permeability: 18.7 md
Area: 803 acres
Average Pay Thickness: 110 feet
Oil/Gas Column: Originally 2020 feet; now 600 feet
Gas/Oil/Water Contact: -318 with no water
Gas Oil Ratio: 43:1 (production)
Initial Pressure: 2623
Present Pressure: Unknown
Drive Mechanism: Solution gas, water drive
Rw and/or Salinity: Rw = .75 at 68°F
Character of oil or gas: Oil; gravity-33.6°API, pour point-less than 5°, S-1.39%, N-0.071%
Continuity of Reservoir: Blanket sandstone with good communication
Cumulative Production: 3,018,206 BO 131,119 MCFG ? BW 8/1/78
STBO or MCF/AC FT: 112 (679 BO/AF in place)
Secondary: 1,000,000 BO 50,000 MCFG
Estimated Ultimate Recoverable: 5,000,000 BO 180,000 MCF

DISCUSSION

REFERENCES
Biggs, P. and Espach, R. H., 1960 Petroleum & Natural Gas Fields in Wyoming, Bull. 582, Bureau of Mines, p. 277-280.
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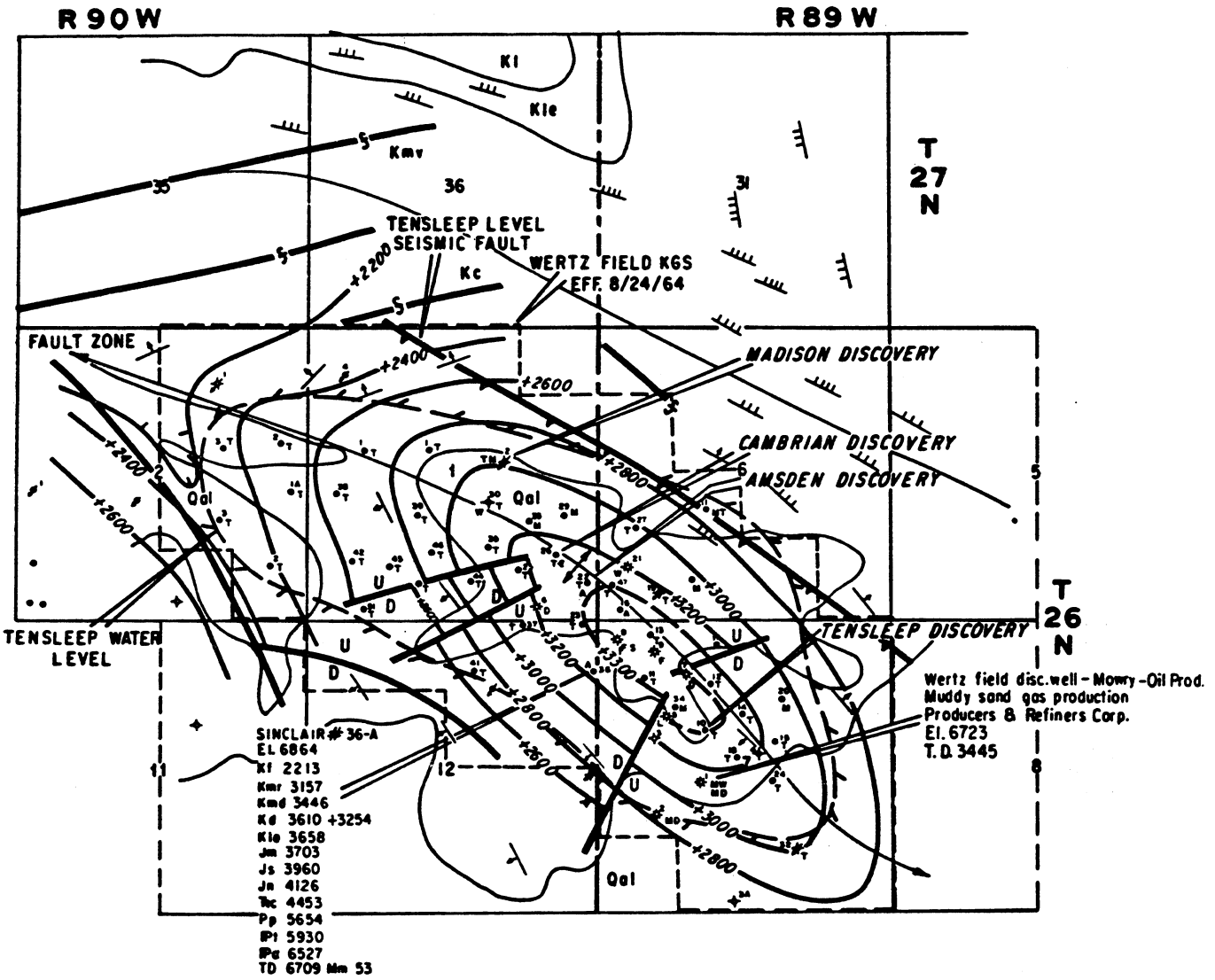
Wyoming Oil and Gas Commission Hearing Files.

From: WYOMING OIL AND GAS FIELDS, GREATER GREEN RIVER BASIN, 1979 SYMPOSIUM, Wyoming Geological Association, Source 2a.



SURFACE DATA BASED ON PHOTOGEOLOGY

FORMATION LEGEND

Qal	QUATERNARY GRAVELS
Kl	LANCE FM. (UPPER CRETACEOUS)
Kle	LEWIS SH.
Kmv	MESAVERDE FM.
Kc	CODY FM.

STRIKE & DIP LEGEND

- 10° to 25°
- 25° to 45°
- Amount of Dip cannot be estimated on Photographs
- SURFACE TRACE OF AXIS

PRODUCING LEGEND

F	FRONTIER FM. (UPPER CRETACEOUS)
MW	MOWRY SH. (LOWER CRETACEOUS)
MD	MUDDY FM.
D	DAKOTA FM.
L	LAKOTA FM.
S	SUNDANCE FM. (JURASSIC)
T	TENSLEEP SS. (PENNSYLVANIAN)
A	AMSDEN FM. (DARWIN SS.)
M	MADISON LS. (MISSISSIPPIAN)
C	CAMBRIAN SS.
	OIL WELL ABANDONED
	GAS WELL ABANDONED
	DRY HOLE
	WATER INJECTION WELL
W	WATER SOURCE WELL

From: WYOMING OIL AND GAS FIELDS, GREATER GREEN RIVER BASIN, 1979 SYMPOSIUM, Wyoming Geological Association, Source 2a.

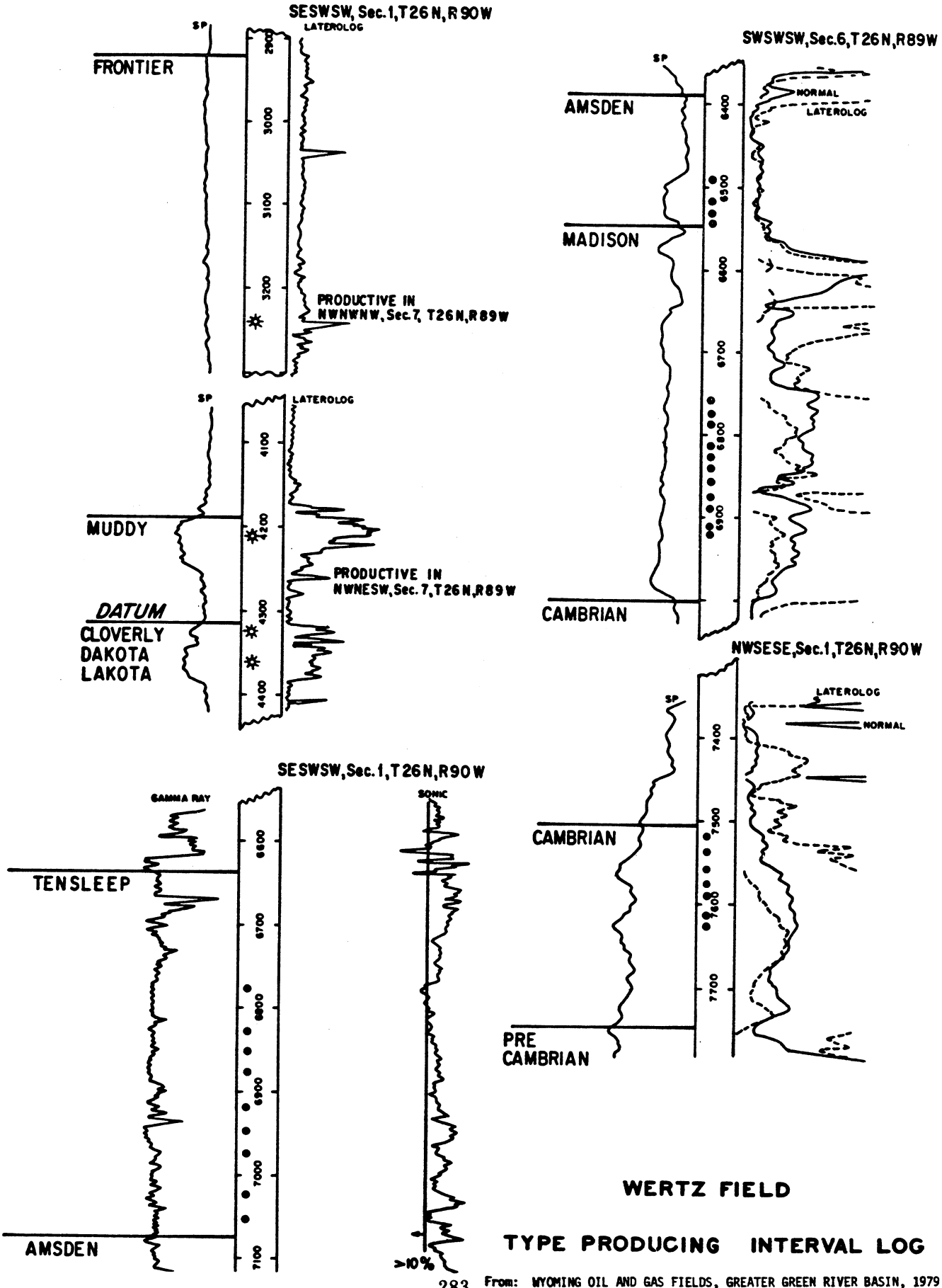
W.G.A.

WERTZ

CARBON COUNTY, WYOMING

DATUM-DAKOTA

CONTOUR INTERVAL-200'



WERTZ FIELD

TYPE PRODUCING INTERVAL LOG

From: WYOMING OIL AND GAS FIELDS, GREATER GREEN RIVER BASIN, 1979 SYMPOSIUM, Wyoming Geological Association, Source 2a.

TABLE 12.—*Crude-oil analyses*—Continued

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-50-80

IDENTIFICATION

Hartz field
Tensleep sandstone - Pennsylvanian
9,999 - 6,200 feet

Wyoming
Carbon County
SE¼SW¼ sec. 6,
T. 26 N., R. 89 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.857 A. P. I. gravity 33.6 ° Pour point, ° F. below 5
Sulfur, percent, 1.32 Color, greenish black
Saybolt Universal viscosity at 100 ° F., 43 sec.; at ° F., sec. Nitrogen, percent 0.056

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 34 ° C. (93 ° F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Sum. Percent	Sp. Gr. 60/60° F.	°A.P.I. 60° F.	c.c.	Aniline point °C.	R.V. 100° F.	Cloud test °F.
1	50	122	1.0	1.0	0.660	82.9				
2	75	167	2.7	3.7	.669	81.3	9.1			
3	100	212	3.9	7.6	.701	70.3	12	60.3		
4	125	257	4.9	12.5	.728	62.9	16	58.4		
5	150	302	5.3	17.8	.752	56.7	20	56.2		
6	175	347	5.7	23.5	.774	51.3	23	55.4		
7	200	392	5.0	28.5	.790	47.6	25	58.2		
8	225	437	5.1	33.6	.805	44.3	26	62.8		
9	250	482	5.7	39.3	.821	40.8	29	65.6		
10	275	527	7.3	46.6	.841	36.7	33	67.0		
STAGE 2—Distillation continued at 40 mm. Hg										
11	200	392	2.7	49.3	0.866	31.9	41	69.8	41	15
12	225	437	7.6	56.9	.873	30.6	41	72.2	46	30
13	250	482	6.8	63.7	.888	27.8	45	74.8	59	45
14	275	527	5.2	68.9	.908	24.3	51	77.2	90	65
15	300	572	6.4	75.3	.928	21.0	57	82.2	170	80
Residuum			24.3	99.6	.976	13.5		too dark		

Carbon residue of residuum, 10.1 percent; carbon residue of crude, 2.8 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A.P.I.	Viscosity
Light gasoline	7.6	0.683	75.7	
Total gasoline and naphtha	28.5	0.740	59.7	
Kerosine distillate	10.8	.813	42.5	
Gas oil	16.1	.857	33.6	
Nonviscous lubricating distillate	11.6	.877-.911	29.8-23.8	50-100
Medium lubricating distillate	7.3	.911-.936	23.8-19.7	100-200
Viscous lubricating distillate	1.0	.936-.939	19.7-19.2	Above 200
Residuum	24.3	.976	13.5	
Distillation loss	.4			

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-48-27

IDENTIFICATION

Hartz field
Amsden sandstone - Pennsylvanian
6,494 - 6,587 feet

Wyoming
Sweetwater County
SE¼SE¼ sec. 1,
T. 26 N., R. 90 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.850 A. P. I. gravity 35.0 ° Pour point, ° F. below 5
Sulfur, percent, 1.25 Color, brownish black
Saybolt Universal viscosity at 100 ° F., 44 sec.; at ° F., sec. Nitrogen, percent 0.080

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 30 ° C. (86 ° F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Sum. Percent	Sp. Gr. 60/60° F.	°A.P.I. 60° F.	c.c.	Aniline point °C.	R.V. 100° F.	Cloud test °F.
1	50	122	1.4	1.4	0.652	86.5				
2	75	167	2.5	3.9	.655	84.5	0.4			
3	100	212	3.4	7.3	.690	73.6	7.1			
4	125	257	4.7	12.0	.720	65.0	12			
5	150	302	5.3	17.3	.745	58.4	17			
6	175	347	5.8	23.1	.768	52.7	21			
7	200	392	5.1	28.2	.787	48.3	23			
8	225	437	5.3	33.5	.802	44.9	25	61.6		
9	250	482	6.8	40.3	.821	40.8	29	65.4		
10	275	527	6.8	47.1	.842	36.5	34	66.6		
STAGE 2—Distillation continued at 40 mm. Hg										
11	200	392	2.1	49.2	0.866	31.9	41	68.4	40	10
12	225	437	7.1	56.3	.871	31.0	40		46	25
13	250	482	6.5	62.8	.887	28.0	44		58	45
14	275	527	5.2	68.0	.904	25.0	49		85	60
15	300	572	7.2	75.2	.915	23.1	51		160	80
Residuum			23.2	98.4	.973	13.9				

Carbon residue of residuum, 9.8 percent; carbon residue of crude, 2.6 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A.P.I.	Viscosity
Light gasoline	7.3	0671	78.4	
Total gasoline and naphtha	28.2	0734	61.3	
Kerosine distillate	12.1	813	42.5	
Gas oil	14.8	857	33.6	
Nonviscous lubricating distillate	11.5	877-.906	29.8-24.7	50-100
Medium lubricating distillate	8.3	906-.921	24.7-22.1	100-200
Viscous lubricating distillate	.3	921-.921	22.1-22.1	Above 200
Residuum	23.2	973	13.9	
Distillation loss	1.6			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-50-79

IDENTIFICATION

Wertz field
Madison limestone - Mississippian
6,670 - 7,017 feet

Wyoming
Carbon County
SE¼SW¼ sec. 6,
T. 26 N., R. 89 W.

GENERAL CHARACTERISTICS

Gravity, specific, 0.847 Gravity, ° API, 35.6° Pour point, ° F., below 5
Sulfur, percent, 1.17 Color, greenish black
Viscosity, Saybolt Universal at 100° F., 41 sec., Nitrogen, percent, 0.085

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 81 ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. vis. 100° F.	Cloud test, ° F.
1	152	2.4	2.4	0.637	90.6		1.36163	127.0		
2	167	4.7	7.1	.672	79.1	8.4	1.37585	122.9		
3	219	2.9	10.0	.710	67.8	17	1.39570	124.4		
4	257	3.4	13.4	.730	62.3	17	1.40616	130.9		
5	298	5.1	18.5	.751	56.9	19	1.41769	136.0		
6	347	5.4	23.9	.772	51.8	23	1.42944	139.6		
7	398	5.0	28.9	.789	47.8	24	1.43856	141.7		
8	457	4.6	33.5	.804	44.5	26	1.44592	139.9		
9	488	5.9	39.4	.820	41.1	28	1.45490	147.7		
10	527	6.7	46.1	.842	36.6	34	1.46699	156.1		

Stage 2—Distillation continued at 40 mm. Hg

11	398	4.9	51.0	0.866	31.9	41			41	5
12	437	6.2	57.2	.874	30.4	41			48	20
13	488	6.1	63.3	.894	26.8	47			63	45
14	527	5.7	69.0	.909	24.2	51			96	65
15	572	5.9	74.9	.919	22.5	53			190	80
Residuum		22.3	97.2	.975	13.6					

Carbon residue, Conradson: Residuum, 9.8 percent; crude, 2.3 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	10.0	0.675	78.1	
Total gasoline and naphtha	28.9	.733	61.5	
Kerosine distillate	10.5	.813	42.6	
Gas oil	15.4	.857	33.6	
Nonviscous lubricating distillate	11.6	.876-.909	30.0-24.2	50-100
Medium lubricating distillate	6.2	.909-.920	24.2-22.3	100-200
Viscous lubricating distillate	2.3	.920-.924	22.3-21.6	Above 200
Residuum	22.3	.975	13.6	
Distillation loss	2.8			

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines Laramie Laboratory
Sample PC-50-77

IDENTIFICATION

Wertz field
Cambrian sandstone
7,150 - 7,630 feet

Wyoming
Sweetwater County
NW¼SE¼ sec. 1,
T. 26 N., R. 90 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.857 A. P. I. gravity 33.6 ° Pour point, ° F. below 5
Sulfur, percent, 1.39 Color, brownish black
Saybolt Universal viscosity at 100 ° F., 42 sec.; at ° F., sec. Nitrogen, percent 0.071

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, 760 mm. Hg
First drop, 35 ° C. (95 ° F.)

Fraction No.	Cut at ° C.	Cut at ° F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° A. P. I. 60° F.	C. I.	Aniline temp. ° C.	S. U. vis. 100° F.	Cloud test, ° F.
1	80	176	1.0	1.0	0.631	92.7				
2	75	167	2.3	3.3	.661	82.6	3.2			
3	100	212	3.6	6.9	.696	71.8	10	61.1		
4	125	257	4.4	11.3	.724	63.9	14	59.2		
5	150	302	5.3	16.6	.749	57.4	18	57.2		
6	175	347	5.5	22.1	.771	52.0	22	55.6		
7	200	392	5.2	27.3	.788	48.1	24	58.1		
8	225	437	5.3	32.6	.803	44.7	25	62.3		
9	250	482	6.0	38.6	.821	40.8	29	65.9		
10	275	527	7.5	46.1	.843	36.3	34	67.2		

Stage 2—Distillation continued at 40 mm. Hg

11	200	392	3.3	49.4	0.867	31.7	42	70.5	42	15
12	225	437	8.8	58.2	.875	30.2	42	73.0	48	25
13	250	482	5.6	63.8	.892	27.1	46	75.6	65	50
14	275	527	5.9	69.7	.908	24.3	51	79.0	100	65
15	300	572	6.7	76.4	.921	22.1	54	83.4	200	85
Residuum			22.5	98.9	.981	12.7		too dark		

Carbon residue of residuum, 11.3 percent; carbon residue of crude, 2.9 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	° A. P. I.	Viscosity
Light gasoline	6.9	0.675	78.1	
Total gasoline and naphtha	27.1	0.738	60.2	
Kerosine distillate	11.3	.813	42.5	
Gas oil	16.2	.858	33.4	
Nonviscous lubricating distillate	11.9	.877-.902	29.8-25.4	50-100
Medium lubricating distillate	6.3	.902-.922	25.4-22.0	100-200
Viscous lubricating distillate	3.4	.922-.933	22.0-20.2	Above 200
Residuum	22.5	.981	12.7	
Distillation loss	1.1			

PETROLEUM AND NATURAL GAS FIELDS IN WYOMING

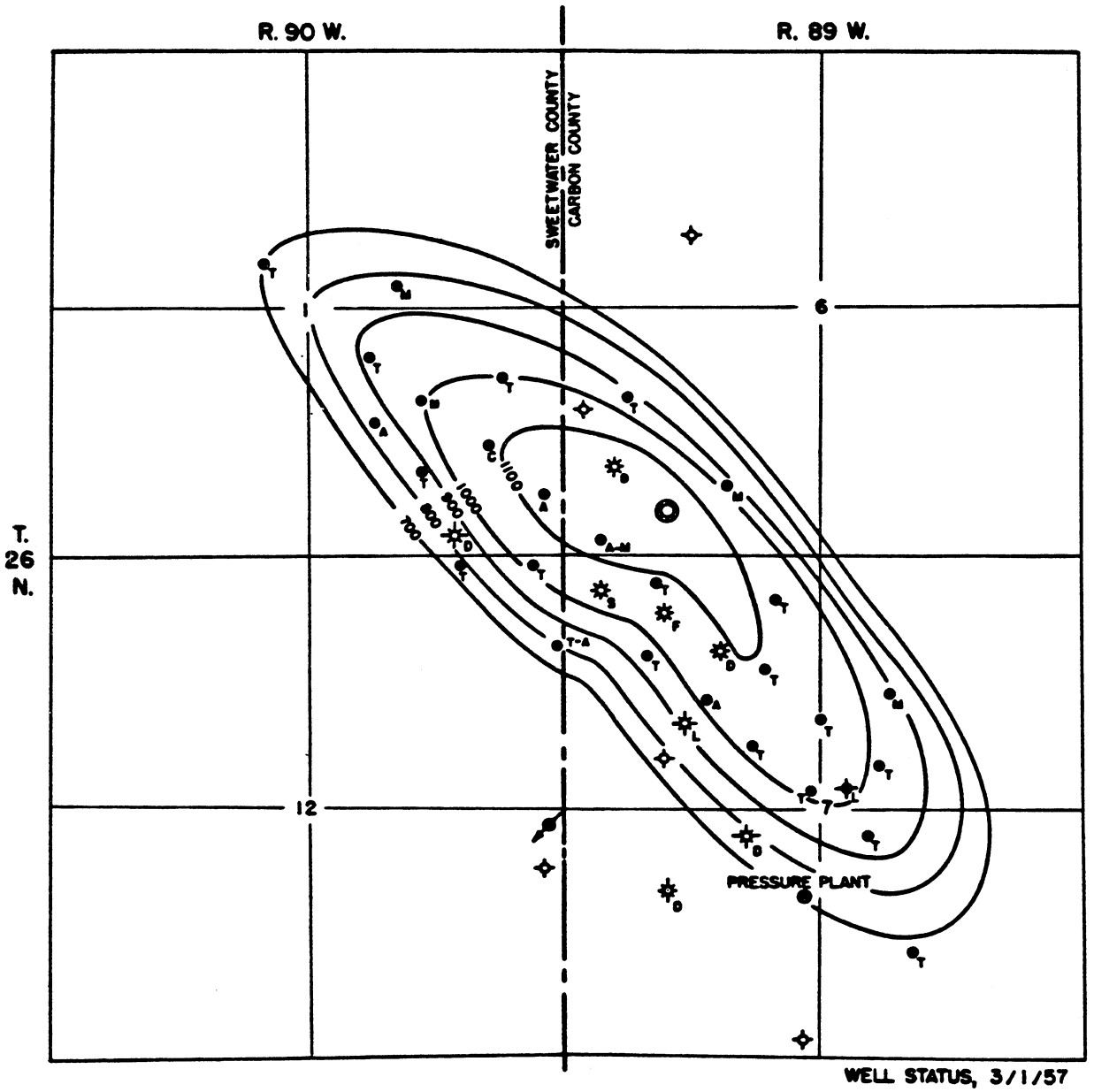


FIGURE 168.—Structure-Contour Map of Wertz Field, Sweetwater and Carbon Counties, Wyo.
(Adapted from Federal Geological Survey map.)

From: PETROLEUM AND NATURAL GAS FIELDS IN WYOMING, Bulletin 582, Bureau of Mines, by Paul Biggs and Ralph H. Espach, Source 2c.

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