



The Marmaton of Western Kansas and Eastern Colorado

**SIPES Luncheon
January 28, 2016**

Presentation by: Jim Milne, Geologist
Ancient Oceans Energy, Ltd.

Outline

- Where are the Marmaton Fields?
- Production Expectations
- Stratigraphy
- Lithology
- Porosity
- Oil Traps
- Field Examples
- Exploration Considerations

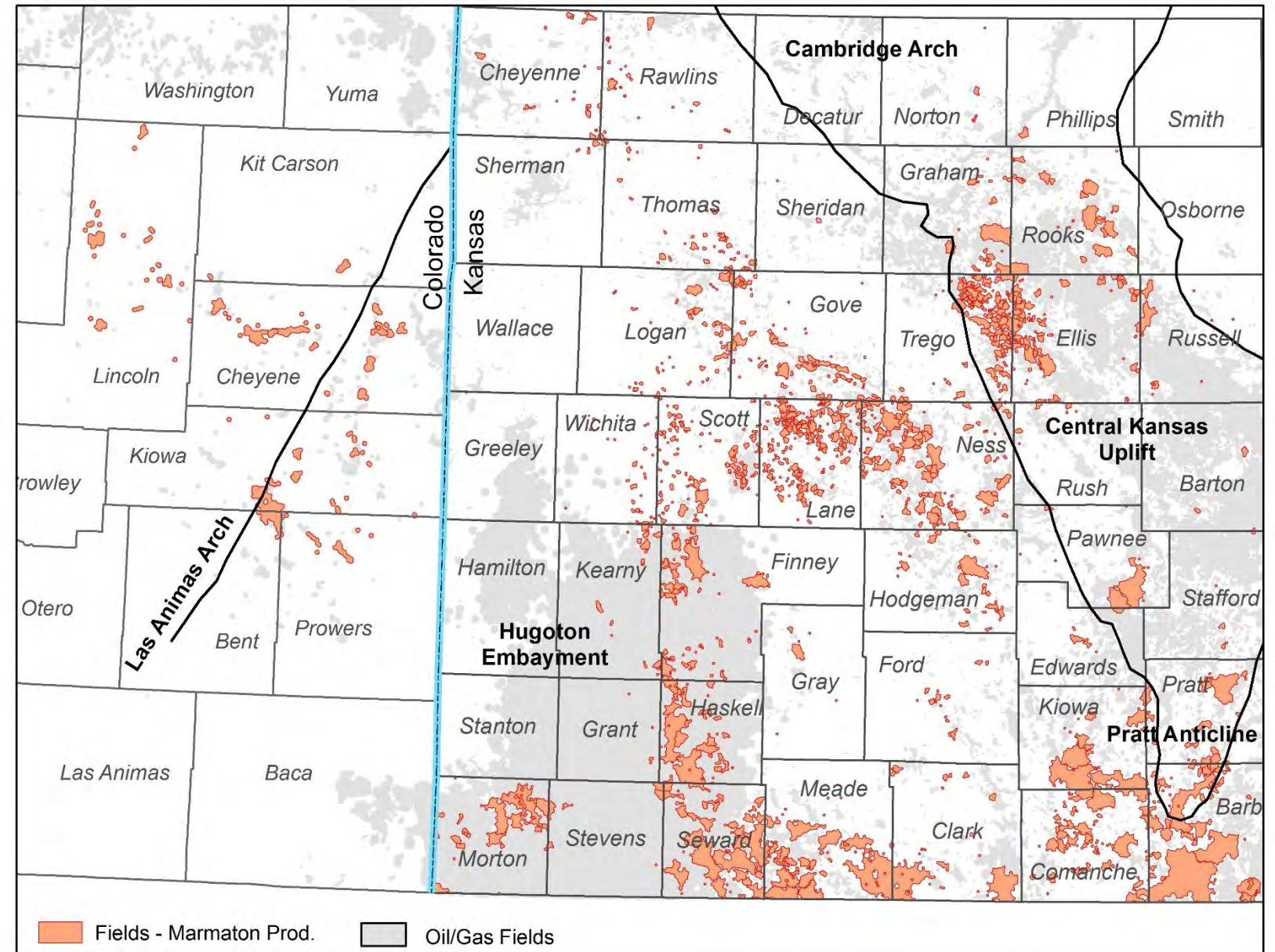


Where are the
Marmaton Fields ?



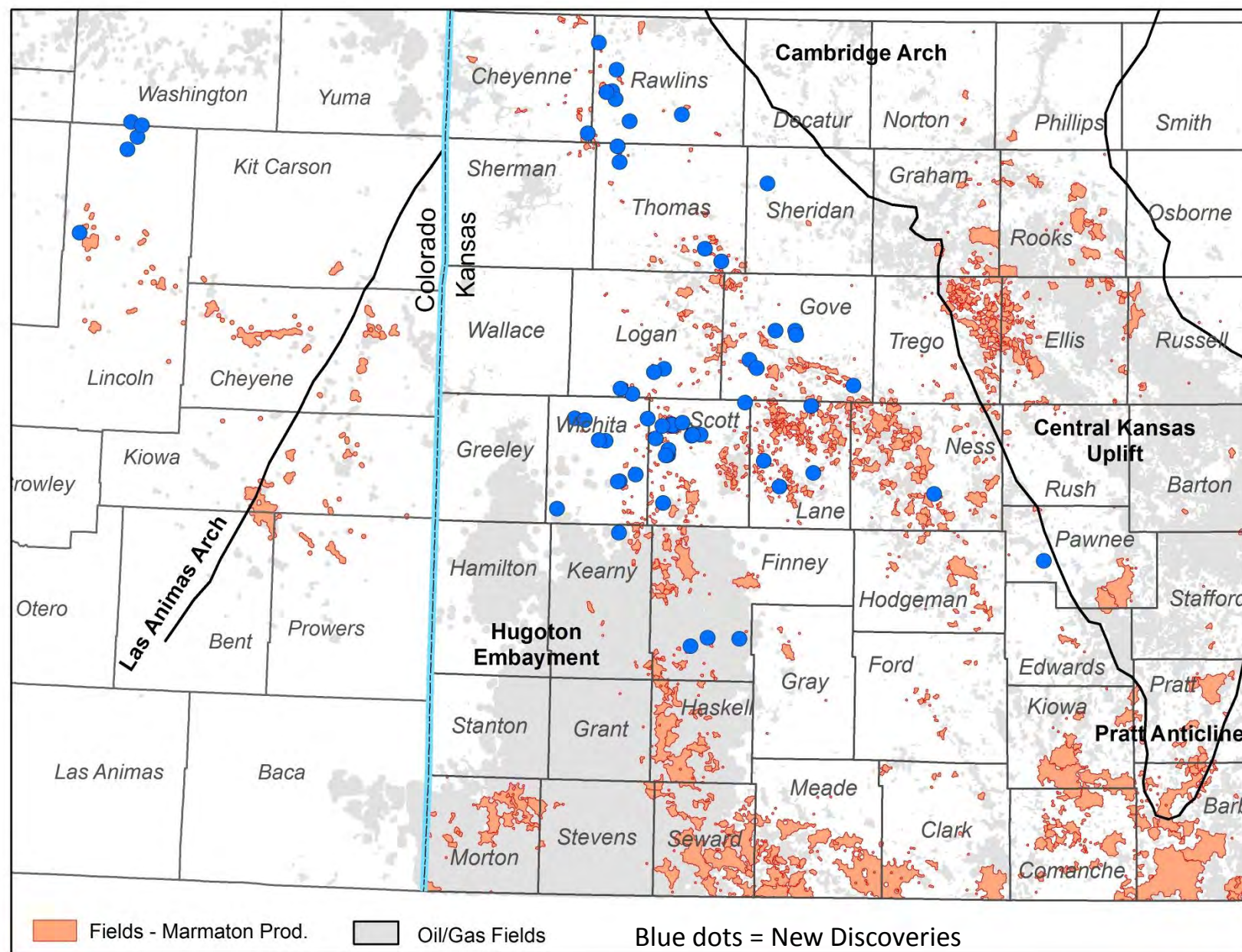
Fields with Marmaton Production

There are approximately 1164 fields in Western Kansas and 57 fields in Eastern Colorado with Marmaton production.



New Marmaton Discoveries

Since early 2014, there have been approximately 55 new Marmaton discoveries in Western Kansas and Eastern Colorado.



Production Expectations



Production Expectations

Western Kansas

Most productive Marmaton Field - Novinger Field (7.3 million BBLs).

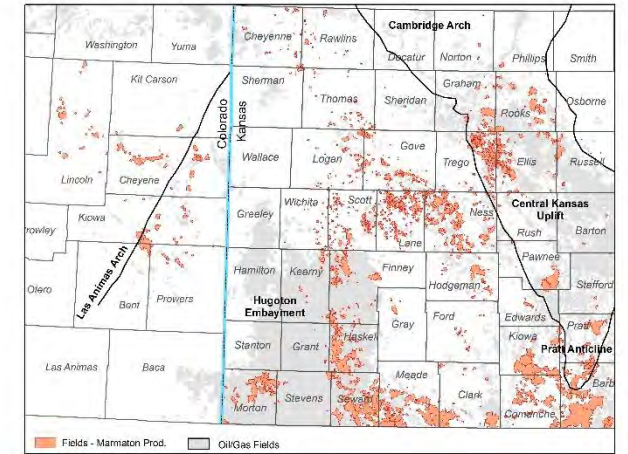
Marmaton Fields > 500,000 BBLs are rare.

Typical Marmaton Production ~ 250,000 BBLs per field.

Most Marmaton Fields are made up of between 1 to 6 wells; there are several 1 well fields.

Best Marmaton wells produce between 60,000 and 100,000 BBLs; a few have produced > 100,000 BBLs.

Commonly part of multipay fields; combined with other formations many of these fields > 1 million BBLs.



Eastern Colorado

Most productive Marmaton Field – Bledsoe Ranch Field (249,731 BBLs).

Marmaton Fields > 100,000 BBLs are rare.

Typical Marmaton Production ~ 40,000 – 70,000 BBLs per field.

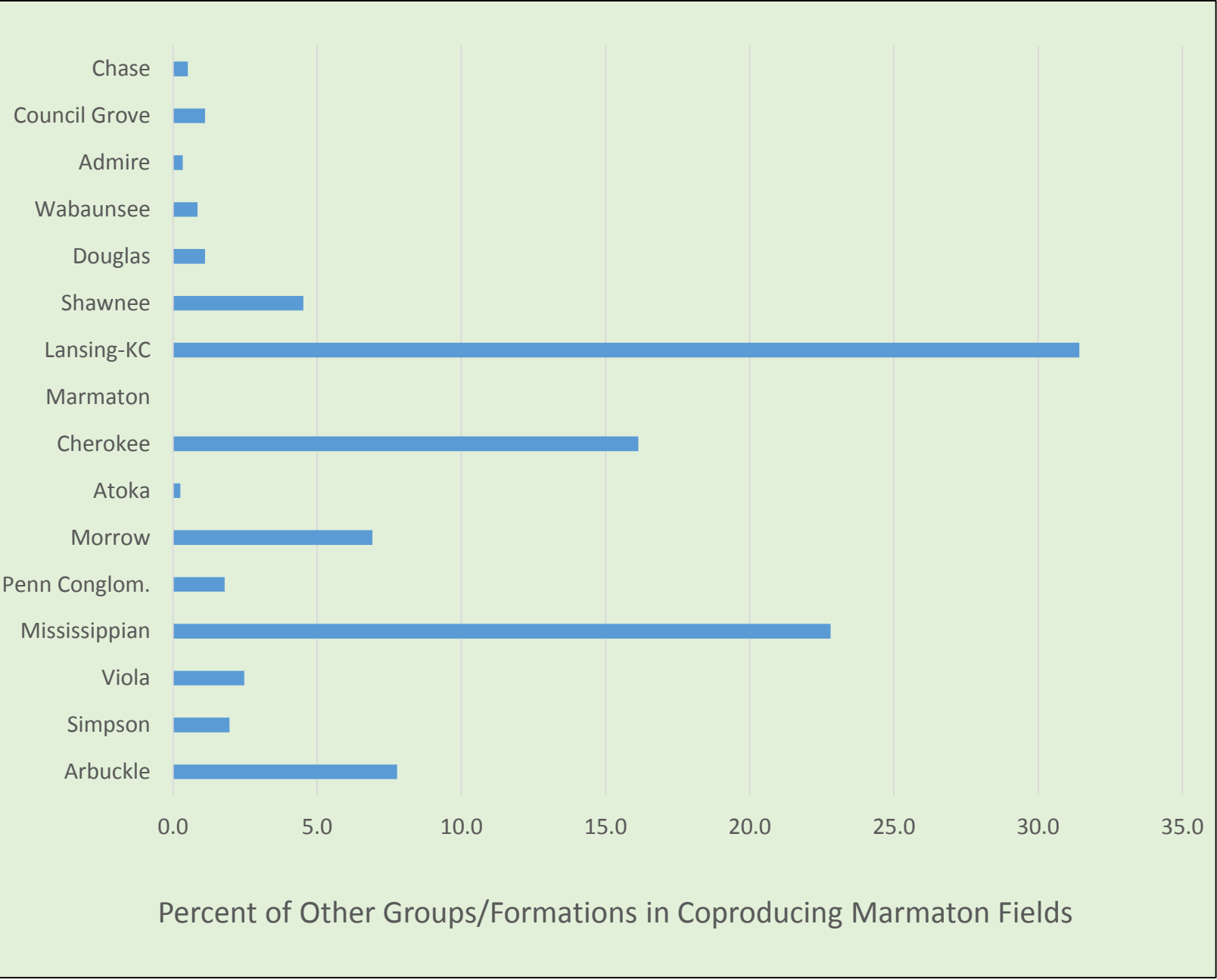
Most Marmaton Fields are 1 or 2 well fields, occasionally 4 or 5 well fields are observed.

Best Marmaton Wells produce on the order of 60,000 - 80,000 BBLs per well; a few have produced > 100,000 BBLs.

Commonly part of multipay fields; combined with other formations many of these fields > 1 million BBLs.

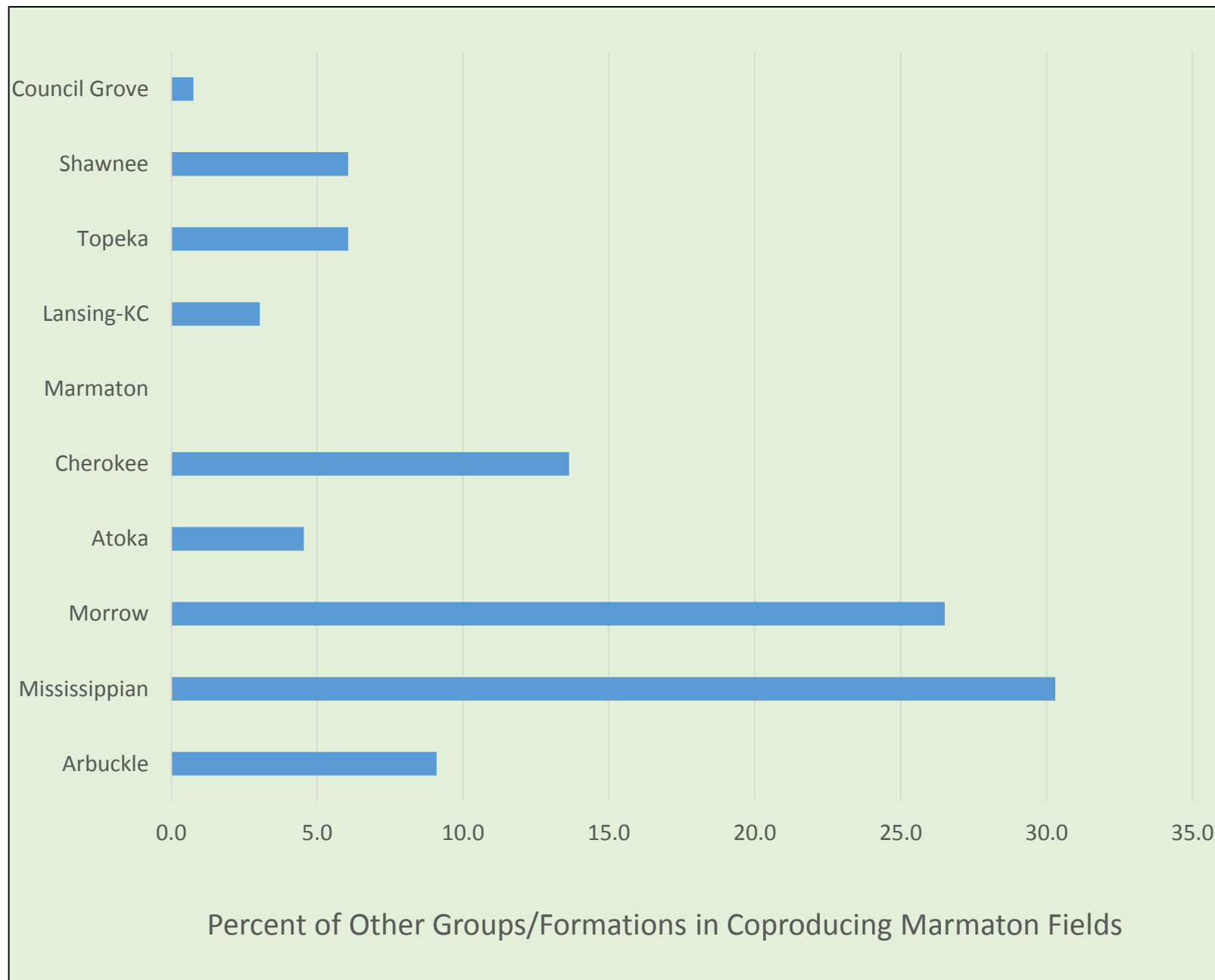
Marmaton Production with
Multiple Pay Zones in
Western Kansas

Approximately 66% of the Fields
that produce from the Marmaton
in Western Kansas, also produce
from Other Groups/Formations.



Marmaton Production with Multiple Pay Zones in Colorado

Approximately 85% of the Fields that produce from the Marmaton in Colorado, also produce from other Groups/Formations.



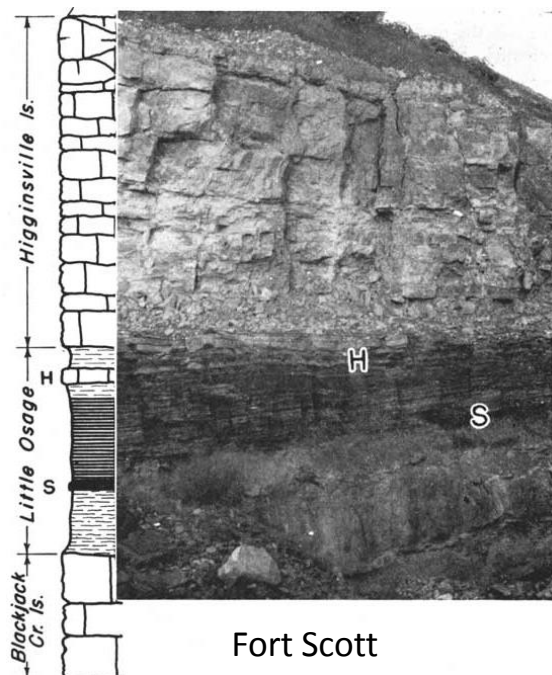
Stratigraphy

Stratigraphy of the Marmaton Group,
Pennsylvanian, in Kansas

By
JOHN MARK JEWETT

UNIVERSITY OF KANSAS PUBLICATIONS
STATE GEOLOGICAL SURVEY OF KANSAS
Bulletin 58

Marmaton Outcrop Southeastern Kansas



Fort Scott



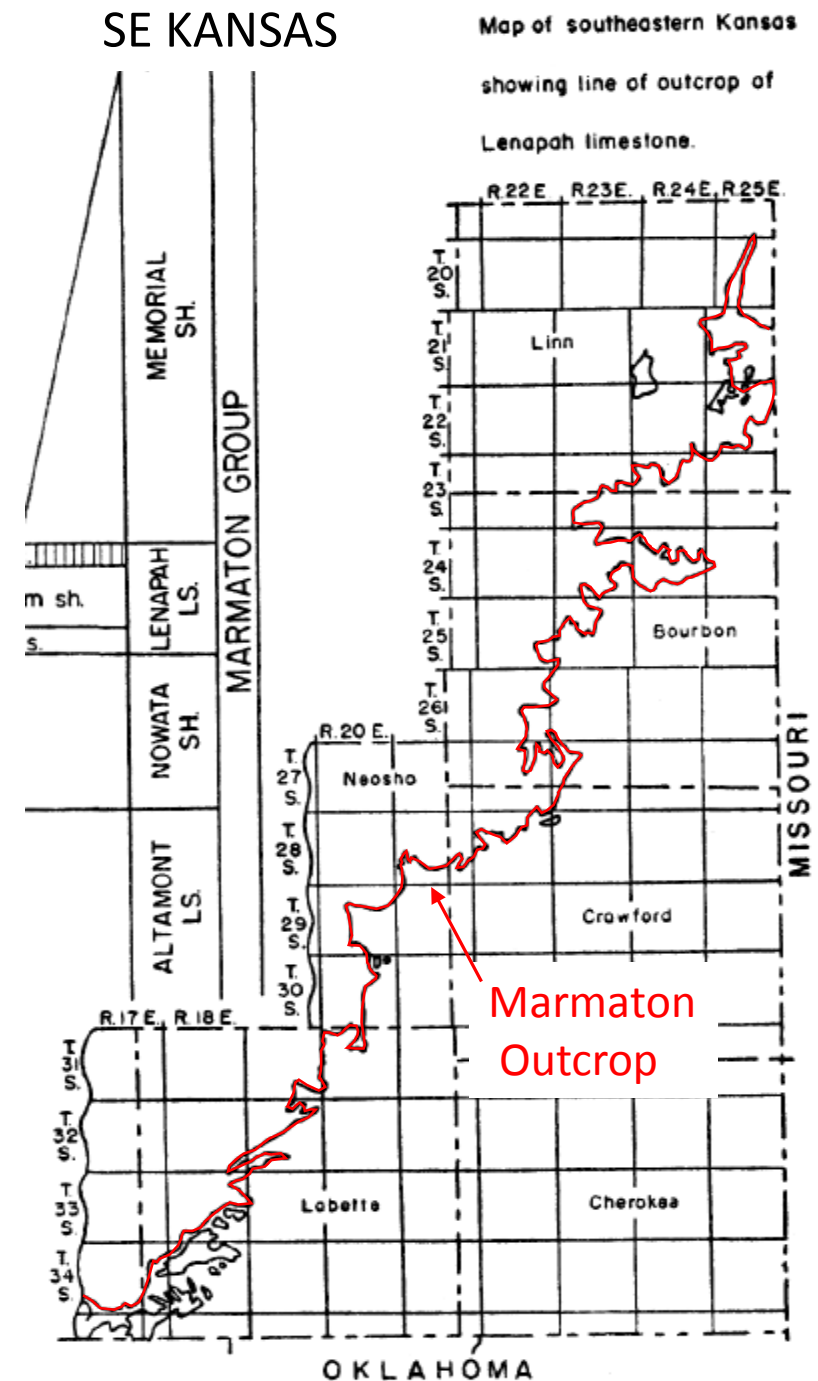
Pawnee



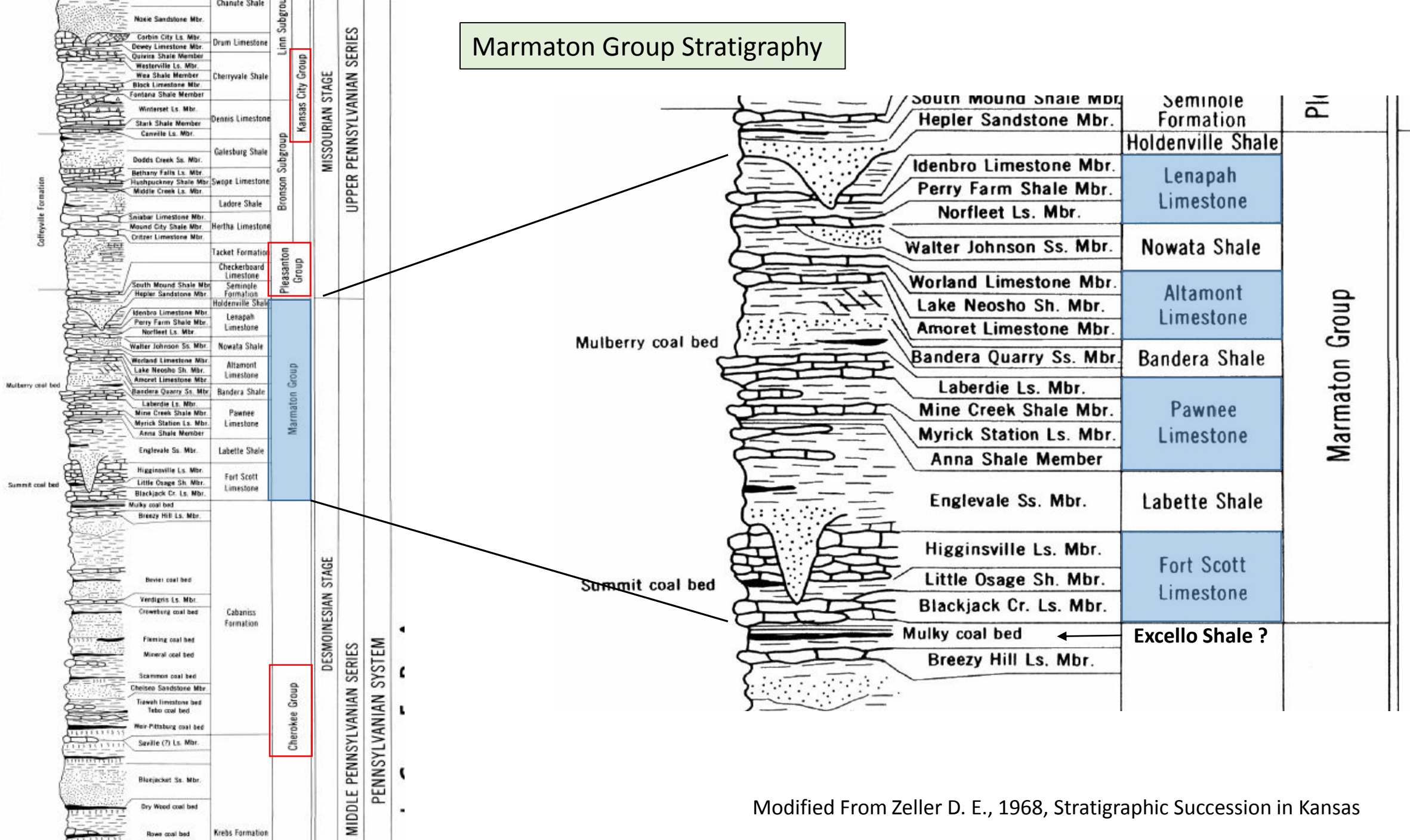
Altamont

From Jewett, 1941, Classification of the Marmaton Group, Pennsylvanian, In Kansas

SE KANSAS



Marmaton Group Stratigraphy



Modified From Zeller D. E., 1968, Stratigraphic Succession in Kansas

Osborn's Correlations

- Masters thesis under Jewett
- Made correlation from outcrop area to SW Kansas (A-A')
- Reported that the Lenapah LS was absent in SW Kansas

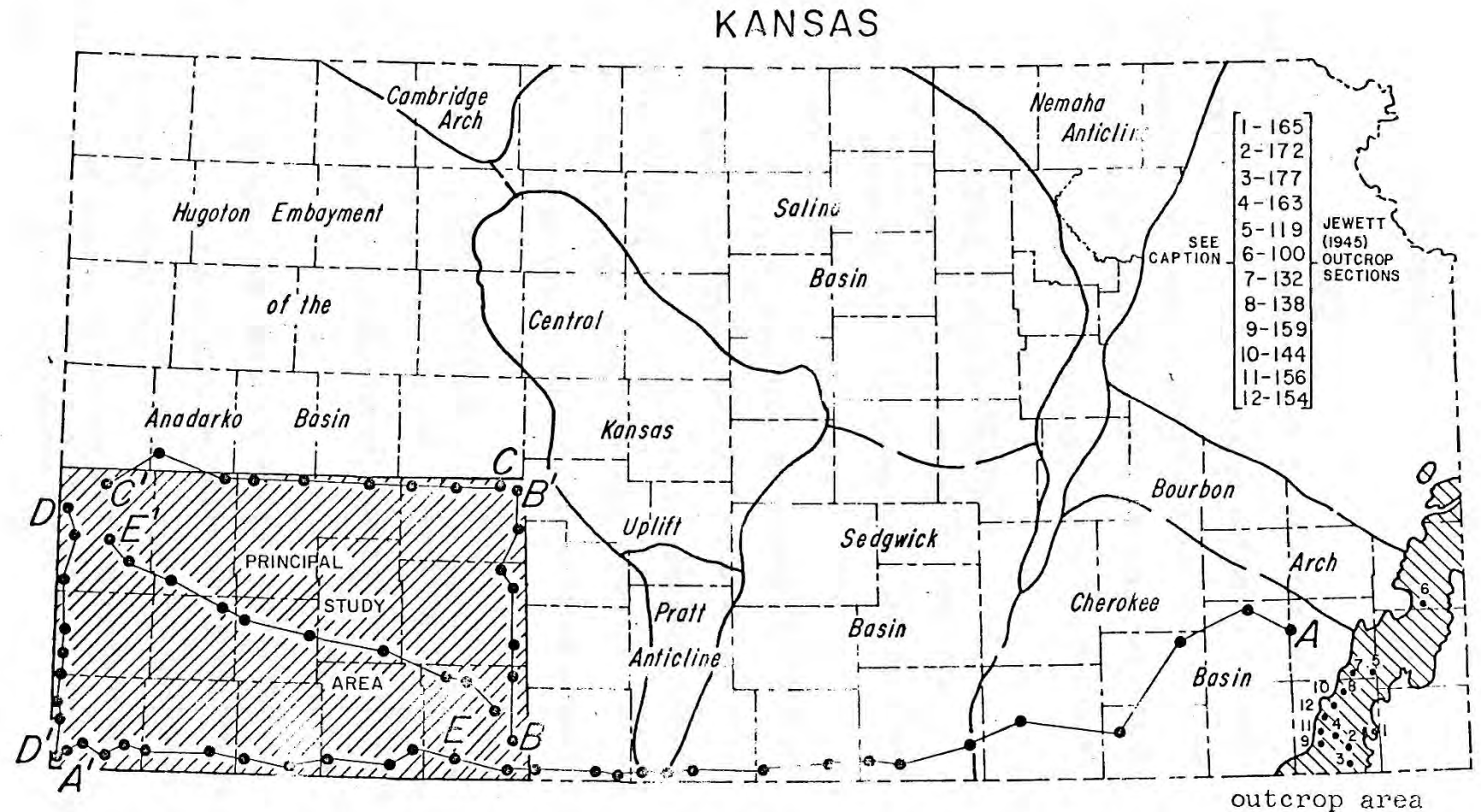


Fig. 1. Map showing location of: principal study area, service log cross sections, major Kansas post-Mississippian structures, and outcrop area of Marmaton Group with location of sections (1 through 12) as in composite section.

Marmaton Type Log-
Seward County, Kansas

Stoll 1-30 , SENE 30-32S-31W

Top of Marmaton

Altamont

Porosity in all 3 Limestone Zones

Perf: 5079-81
Produced 239,479 BO
and 315,941 mcf of gas
from the Marmaton (1988-2012).

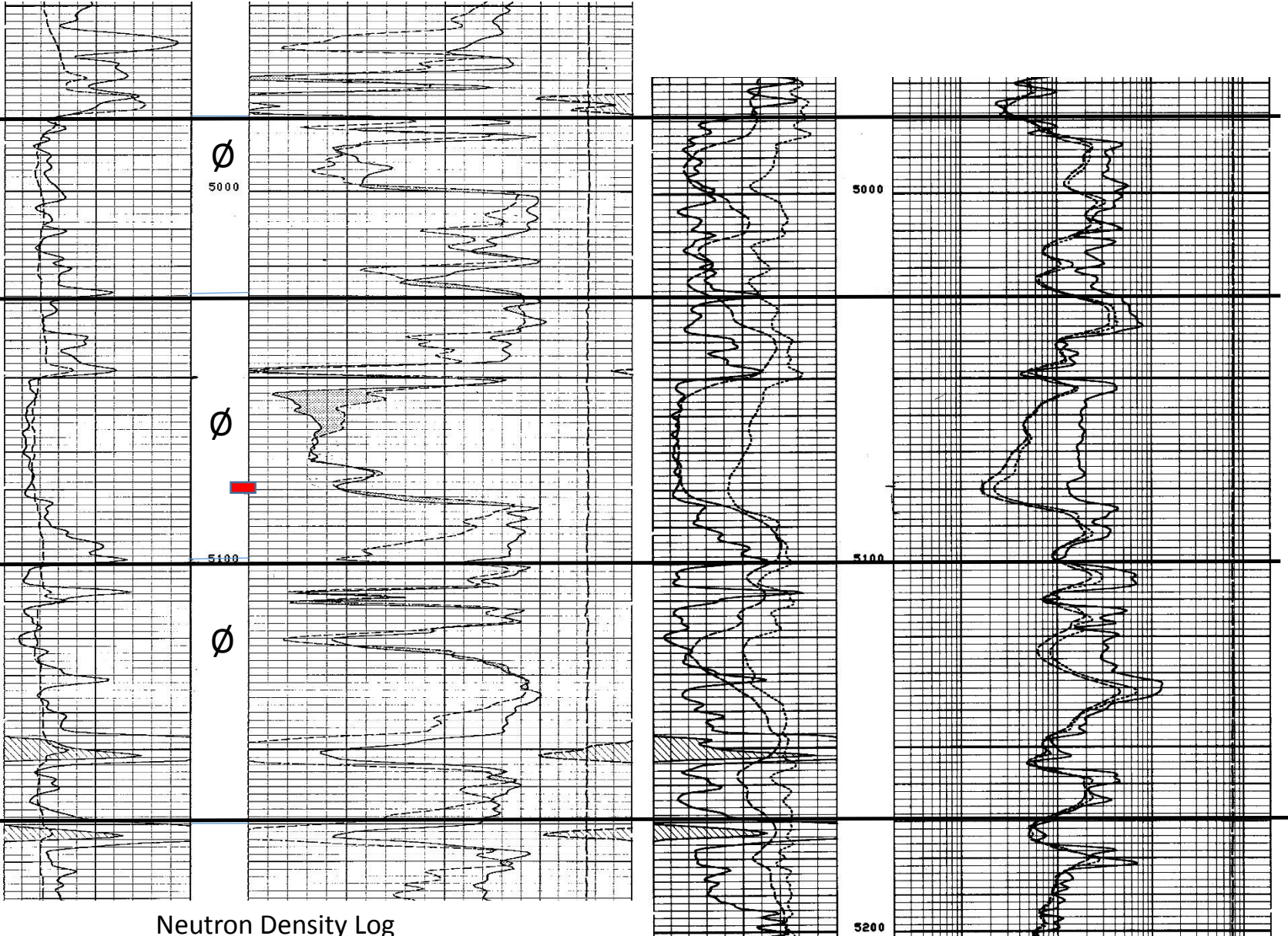
Pawnee

Local names such as
Novinger (Pawnee) and Beymer
(Pawnee?) Zones are also used.

Fort Scott

Base of Marmaton

Cherokee



Neutron Density Log

Dual Induction Log

Marmaton Type Log –
Cheyenne County, Colorado

Bledsoe Ranch 14-30, SWSW 30-12S-50W

Top of Marmaton

Altamont

Cored Top of Marmaton

Perf: 5600 -5603 (2006)
IP 35 BOPD, 6 BWPD

Local names such as the Torch
(Altamont?) are also used.

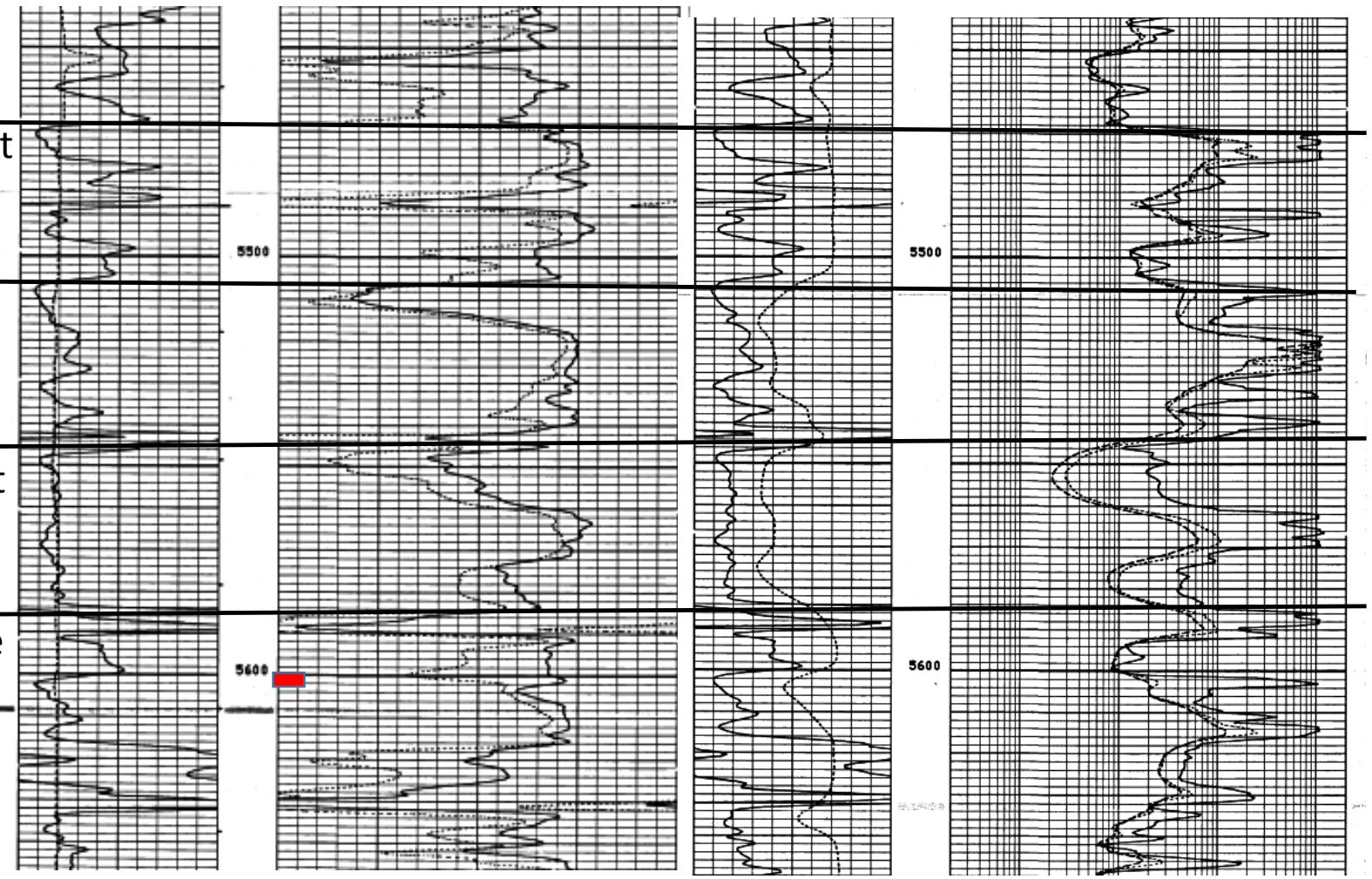
Pawnee

Fort Scott

Base of Marmaton

Cherokee

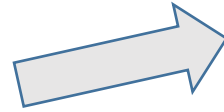
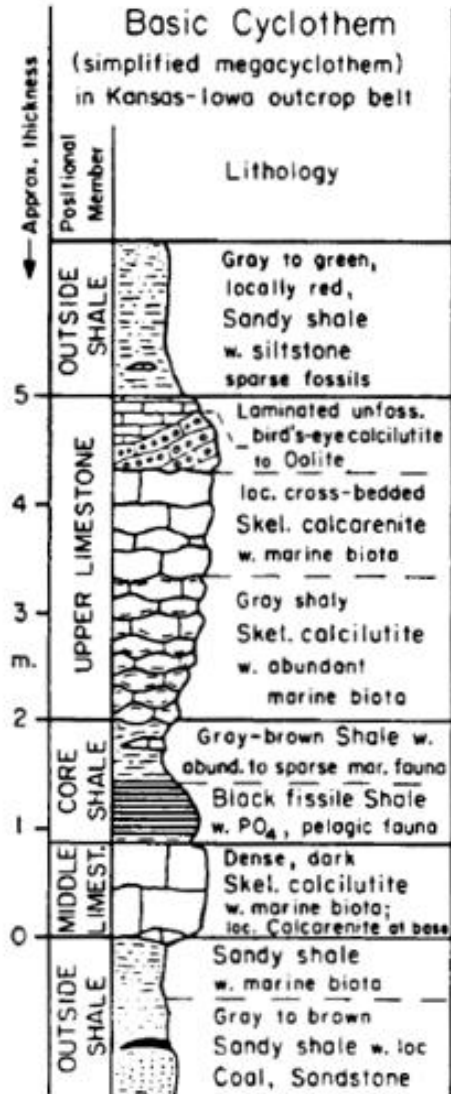
This shale is usually picked as
Top of Cherokee Shale in Kansas



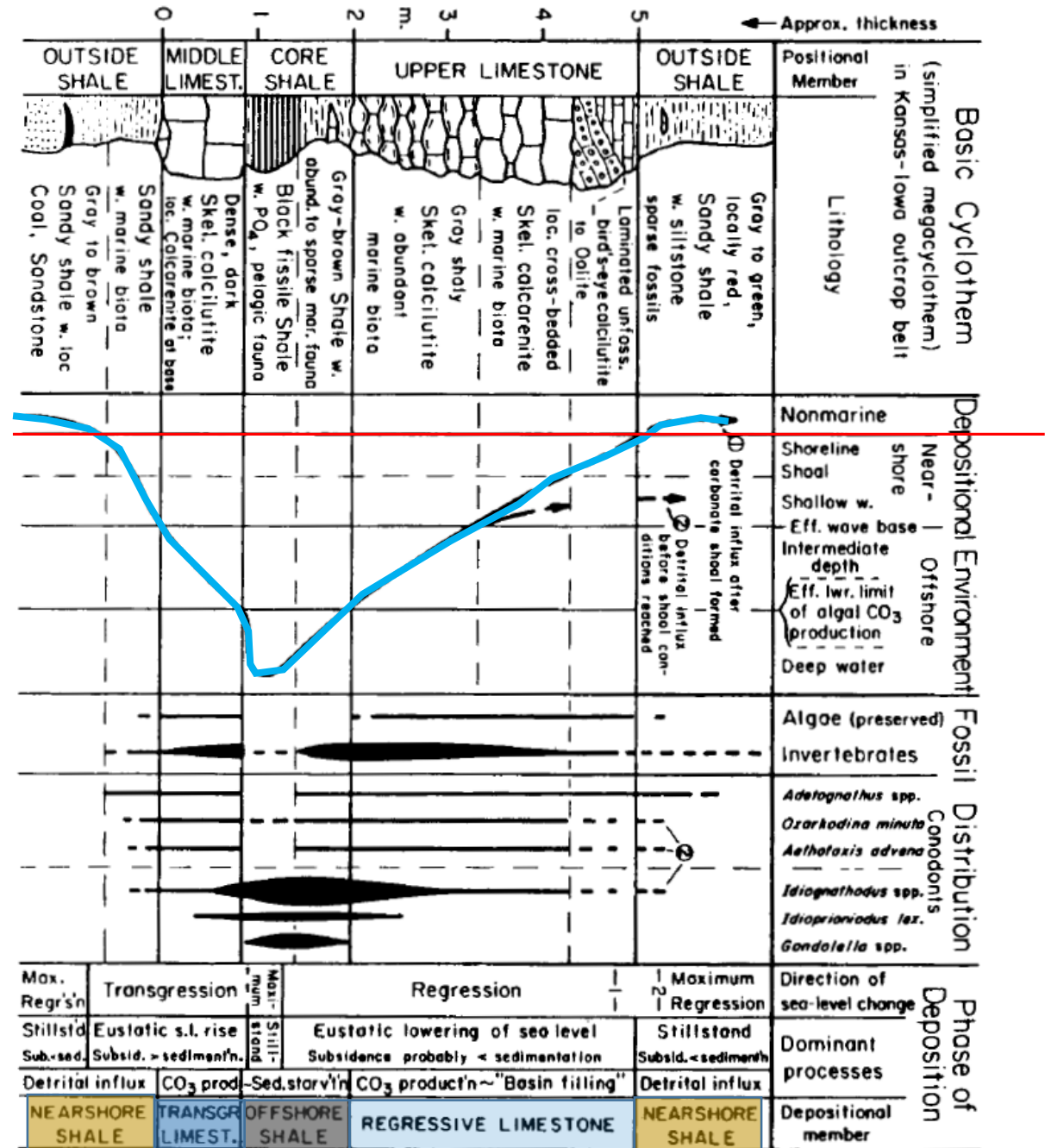
Neutron Density Log

Dual Induction Log

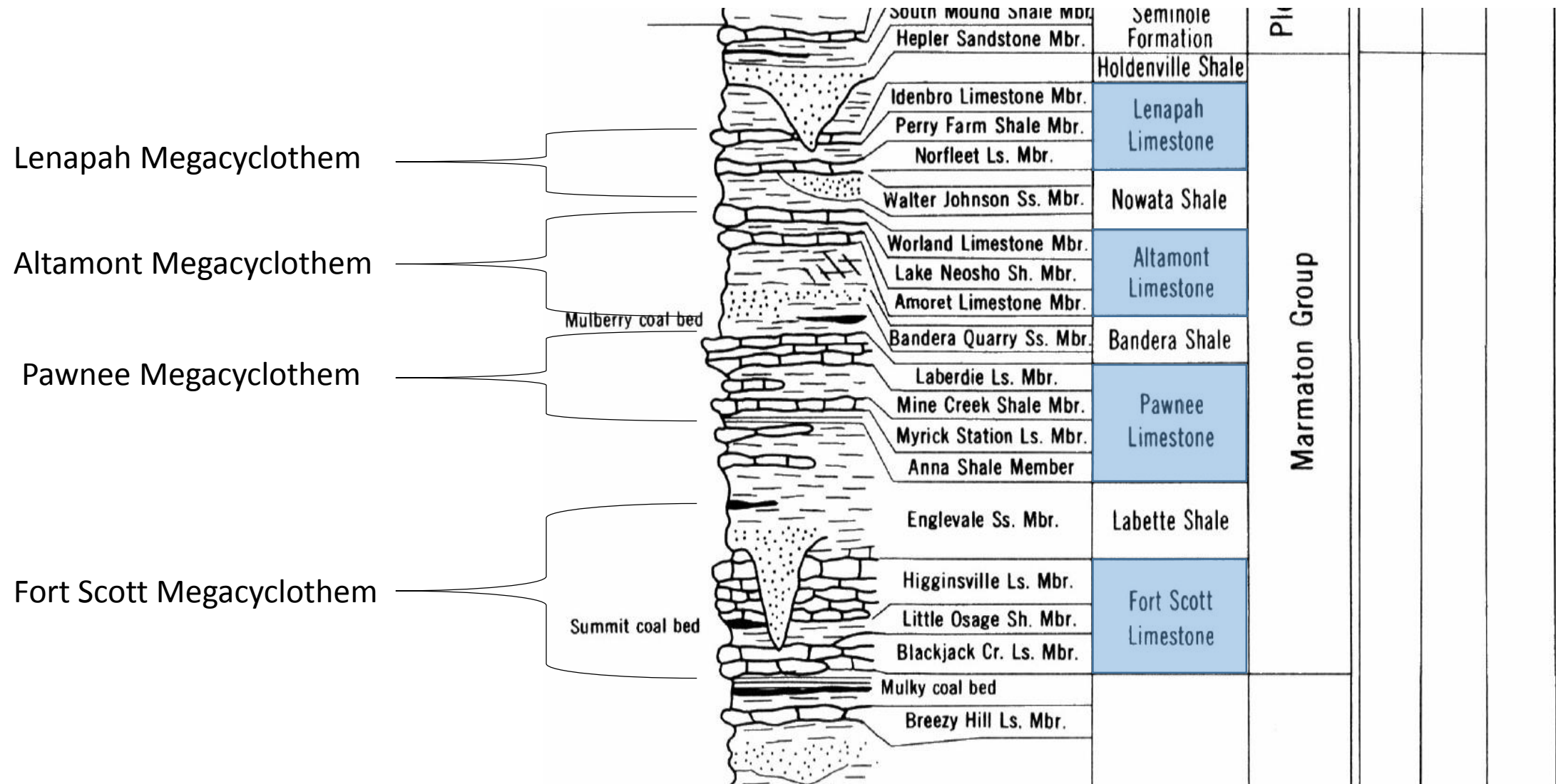
Basic Kansas Cyclothem



Water Depth



Kansas Marmaton Megacyclothems



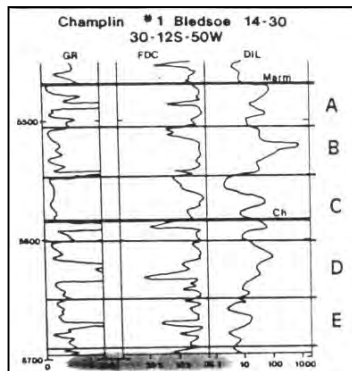
Daniels' Eastern Colorado Desmoinesian Cycles

Compared Log Signatures to Core Data in Eastern Colorado and identified 5 major cycles in the Marmaton + Cherokee which were designated A, B, C, D, and E.

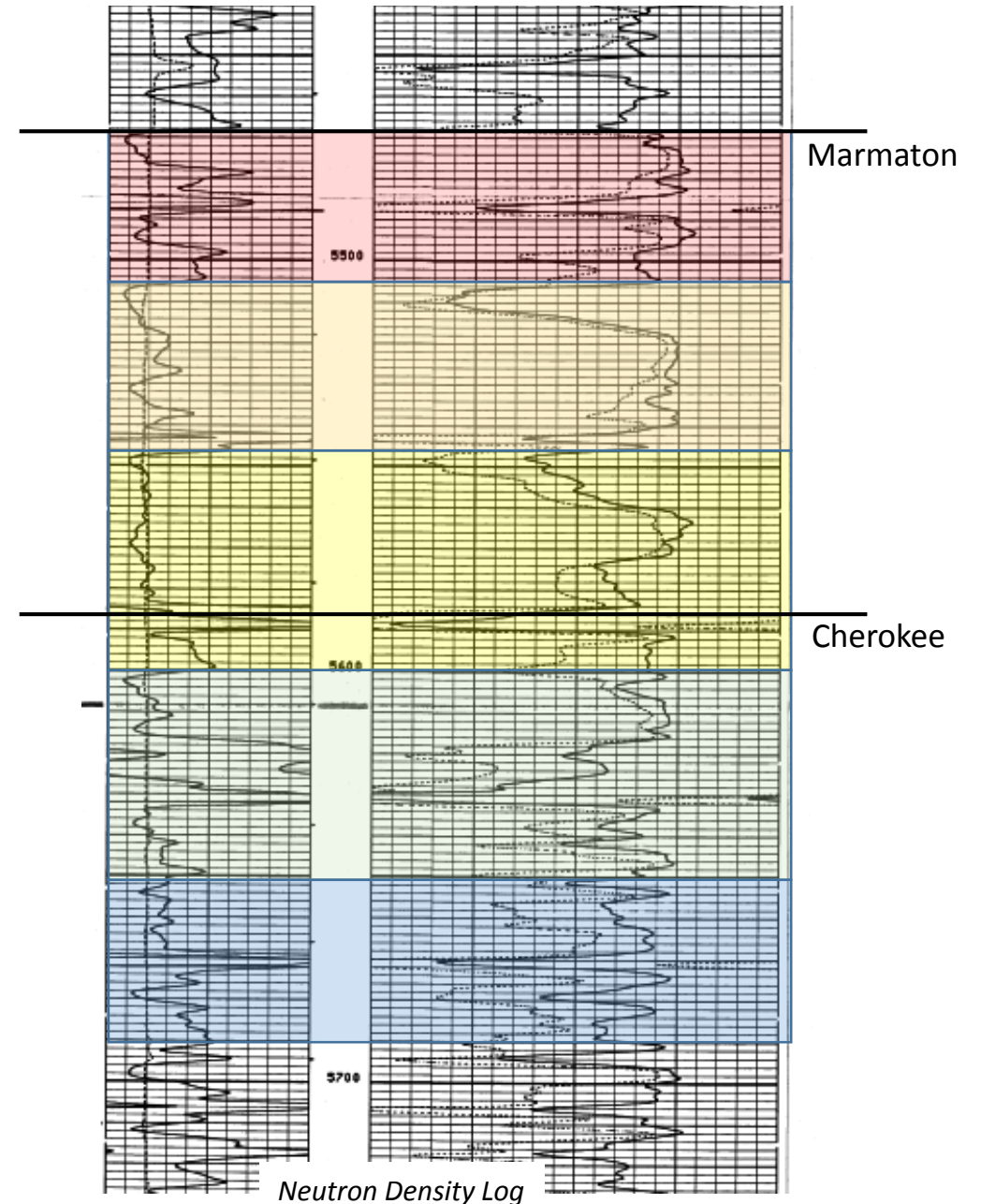
Used Heckel's terminology to describe depositional environment, rock type, and water depth:

Upper Limestone A Unit
Upper Limestone B Unit
Core Shale Unit
Middle Limestone Unit
Outside Shale Unit

The good reservoir rock is usually at the top of the cycle
In the Upper Limestone A Unit where local deposits of fossiliferous, oolitic lime grainstones were deposited in high energy shallow waters.

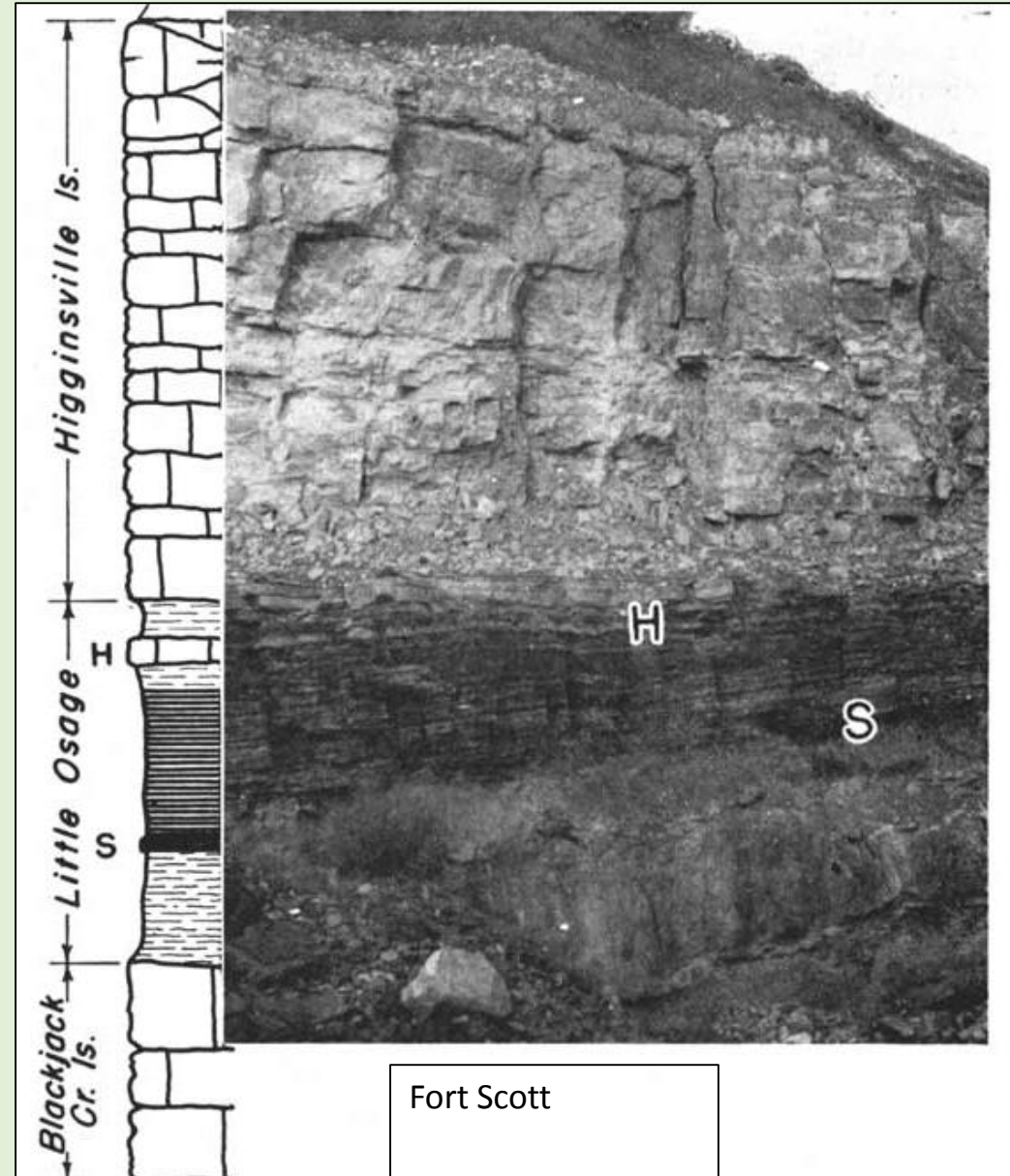


Bledsoe Ranch 14-30, SWSW 30-12S-50W



Source: Daniels, R., 1985, Pennsylvanian (Desmoinesian) stratigraphy and petroleum potential, southeast Colorado, Masters Thesis, Colorado School of Mines.

Lithology



Lithologic Descriptions

Altamont LS

Cream to buff or gray, dense to fine crystalline, fossiliferous limestone. At some locations, it is dolomitic, and occasionally oolitic.

Pawnee LS

Cream to light gray to buff, dense to fine crystalline limestone, described as a grainstone in some areas, oolitic, occasionally dolomitic.

Fort Scott LS

Cream to gray, mottled, cryptocrystalline, dense, slightly fossiliferous, slightly oolitic. Chaetetes fossil corals are observed in the Higginsville Member.



Porosity



Porosity Example- Cuttings Samples, Great Plains Field, Colorado

Intergranular oolitic and moldic porosity



Chaetetes coral framework porosity

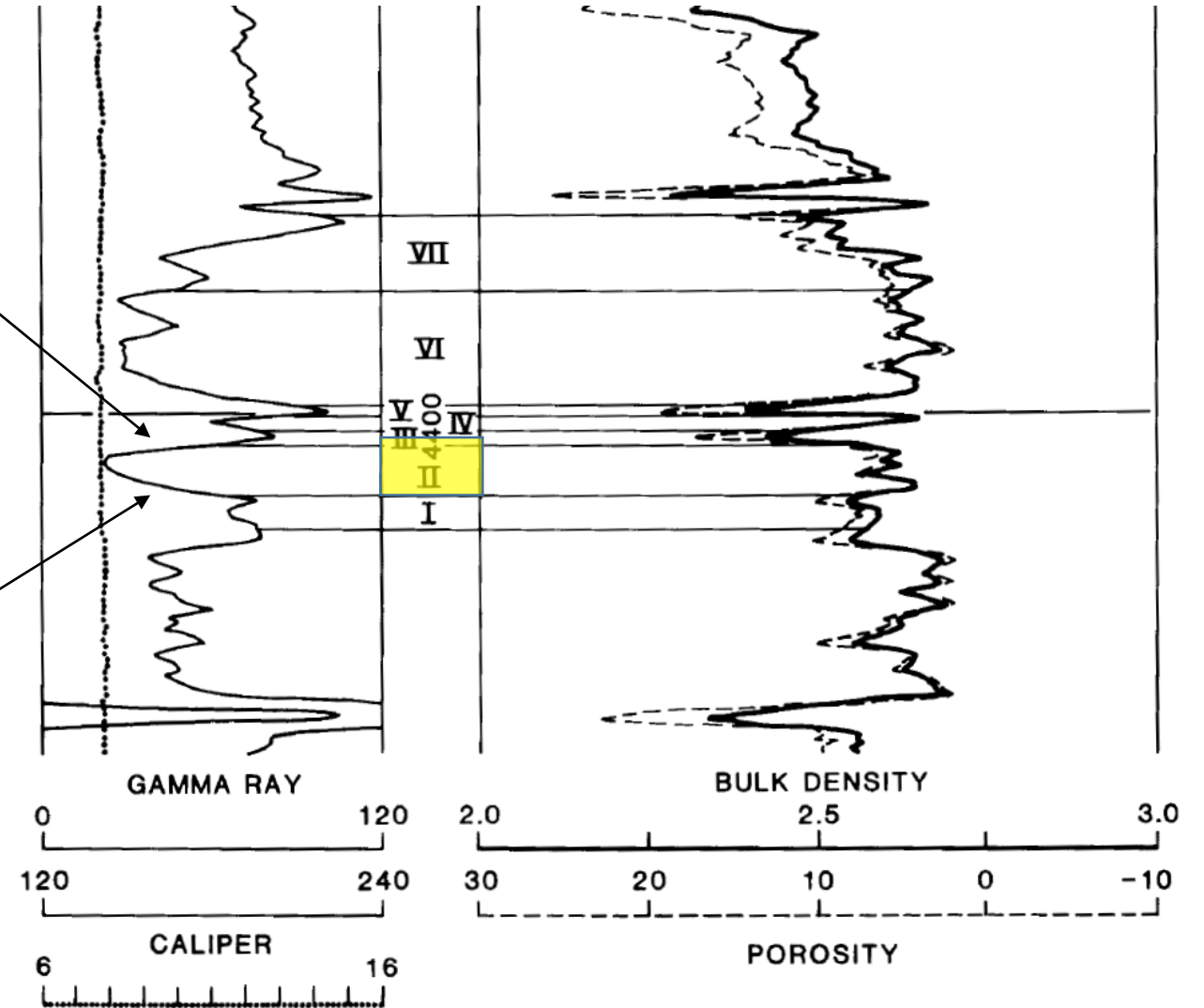
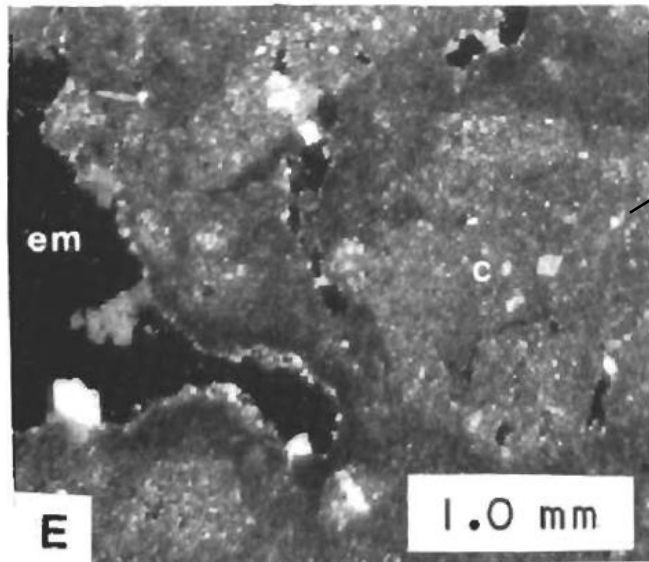
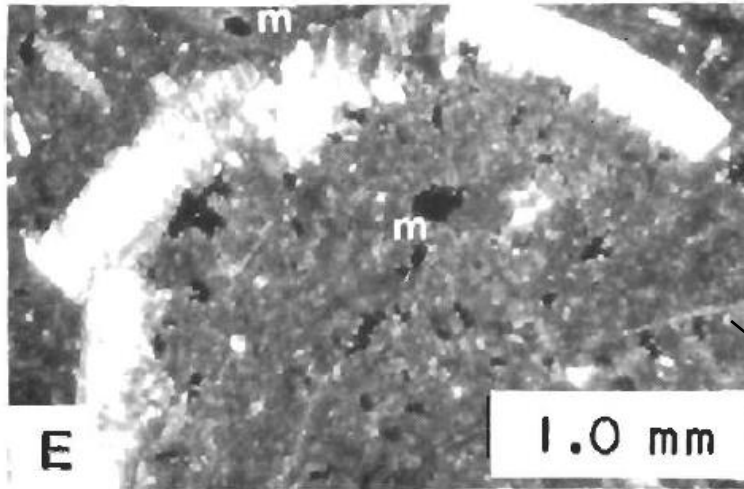


Porosity Examples –Howard Dirks No. 2 Core, Logan County, Kansas

Moldic Leached Bioclasts (m)

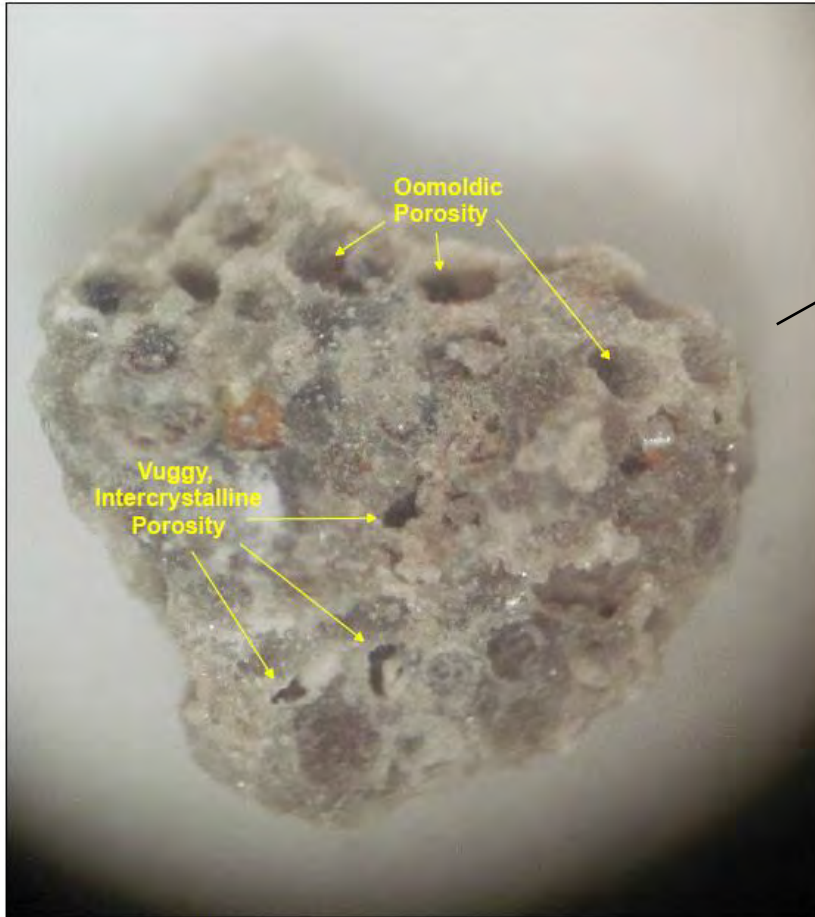
Altamont LS

Enlarged Moldic Porosity (em)



Porosity Example- Cuttings Sample, Western Kansas

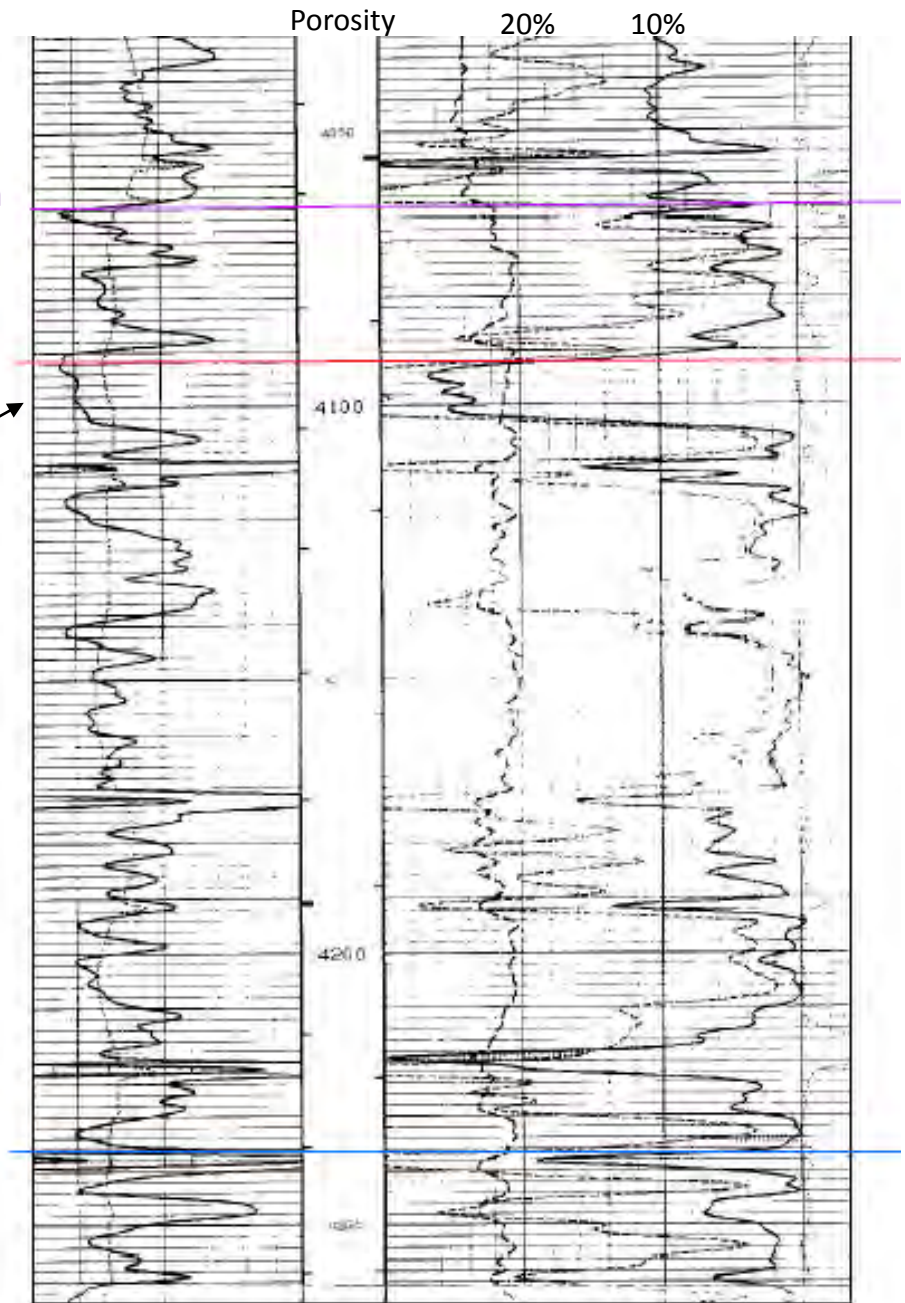
Altamont LS



Samples examined by J. Milne on October 18, 2010

Marmaton

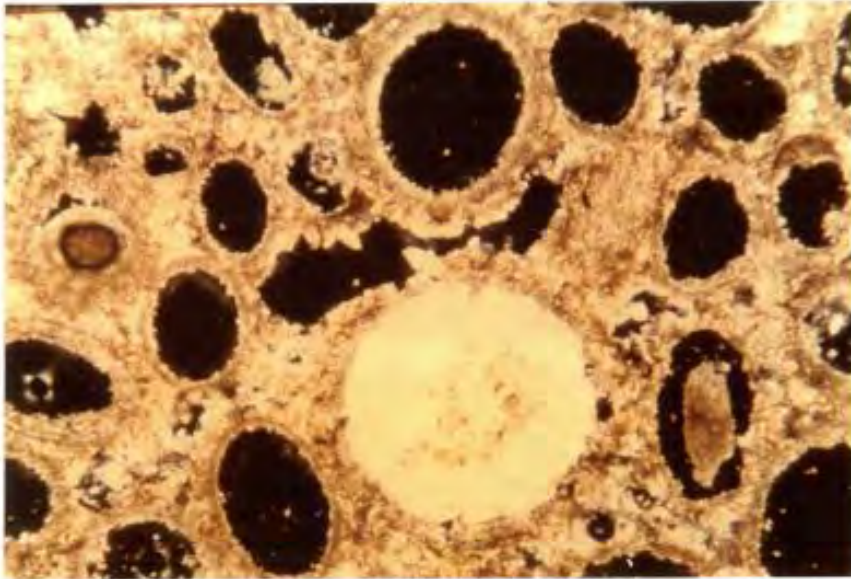
Cherokee



Neutron-Density Log

Porosity Example- Novinger No. 8 Core, Meade County, Kansas

Pawnee LS



Oolitic Grainstone with oomoldic porosity (black); Sparry calcite cement also exhibits intercrystalline porosity.



Electrical Survey - Microlog

Porosity Example- Wilkinson 2-18 Cuttings, Scott County, KS

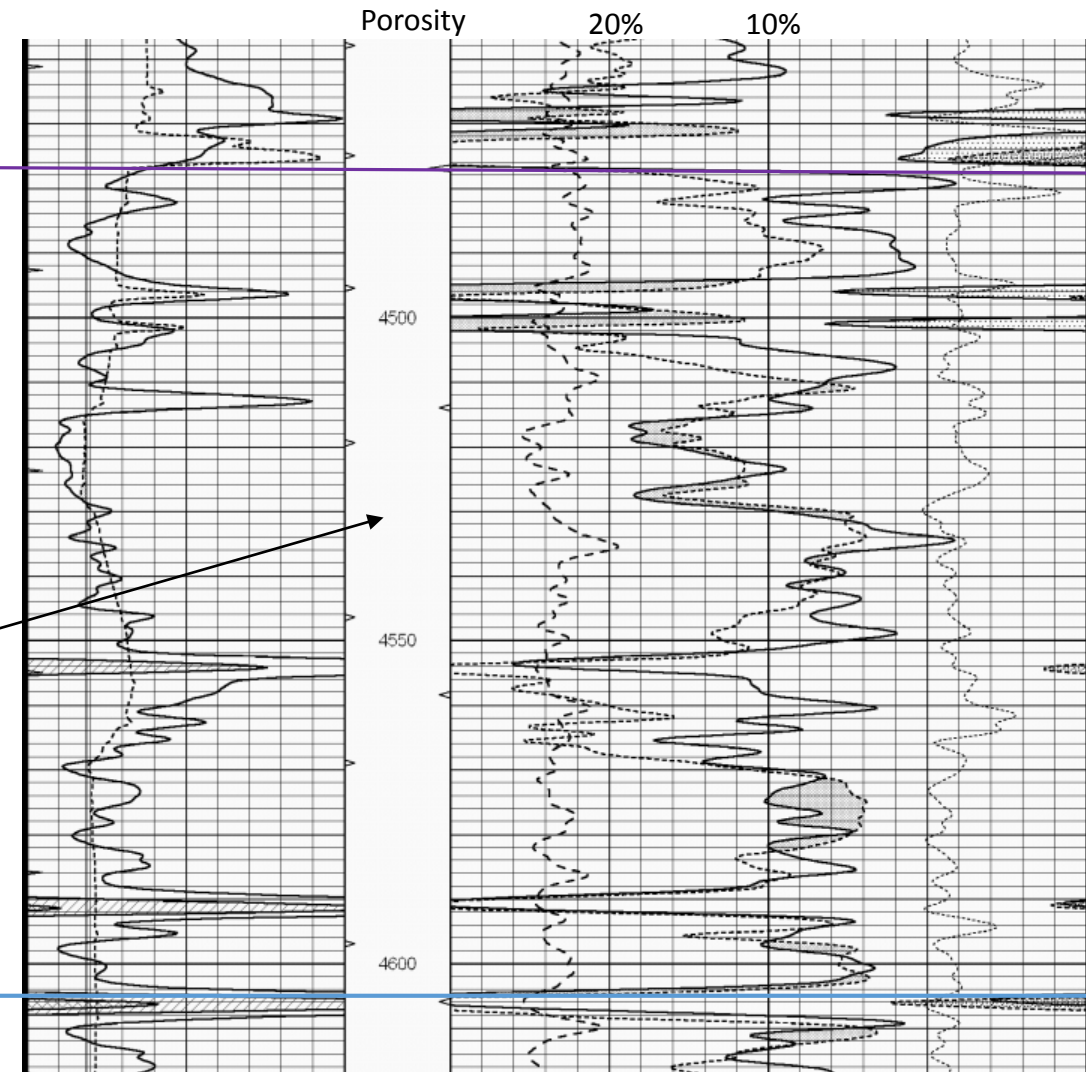
Intergranular, Pinpoint, and Vugular Porosity
(no mention of oomoldic).

Pawnee LS?

MARM C: Tr Grainstn, crm (brn-sat stn), p.srted grains:smll-md.sub-rdd to lg oblong, intr-bdd iso foss in fn-xln matrix,p intr-gran por, iso p ppts betwn grns, evn stn, full sat, FSFO (live-lt brn & flky dd oil),VSSG bbls in por.. Much Packstn,gran-sb gran, crm, arg, scat p-intr-gran por, iso p.pt-vug por, t tn-brn evn to mstly unevn stn, p-no fluor, gd swt odr, W/Depth Ls, crm, p intr-xln por, no stn, less por, diminished shows/odr. Tr's of Bryozoans, & lg xl growths.

Marmaton

Cherokee



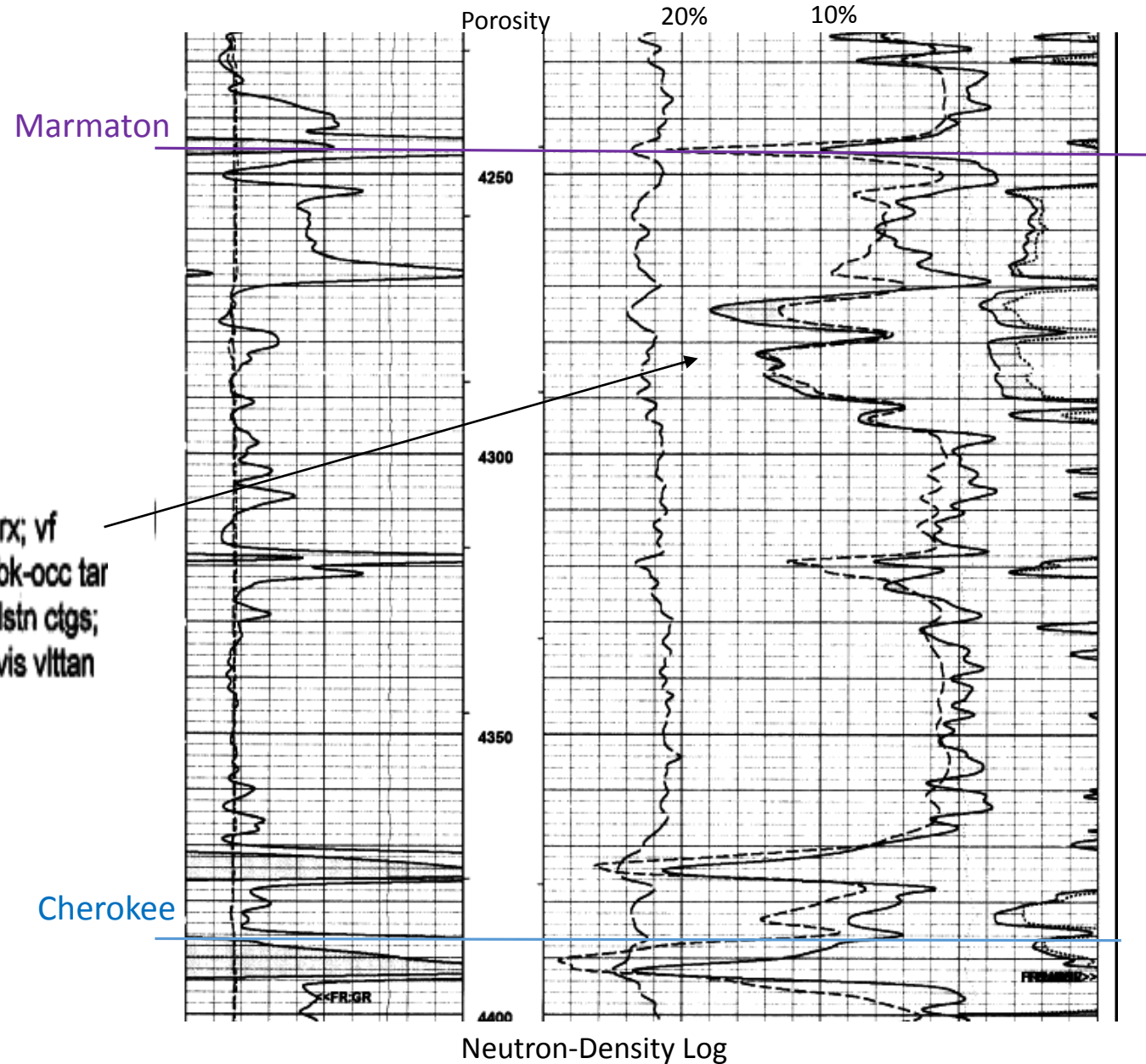
Neutron-Density Log

Porosity Example- Tradewinds 1-28, Cuttings, Kiowa County, Colorado

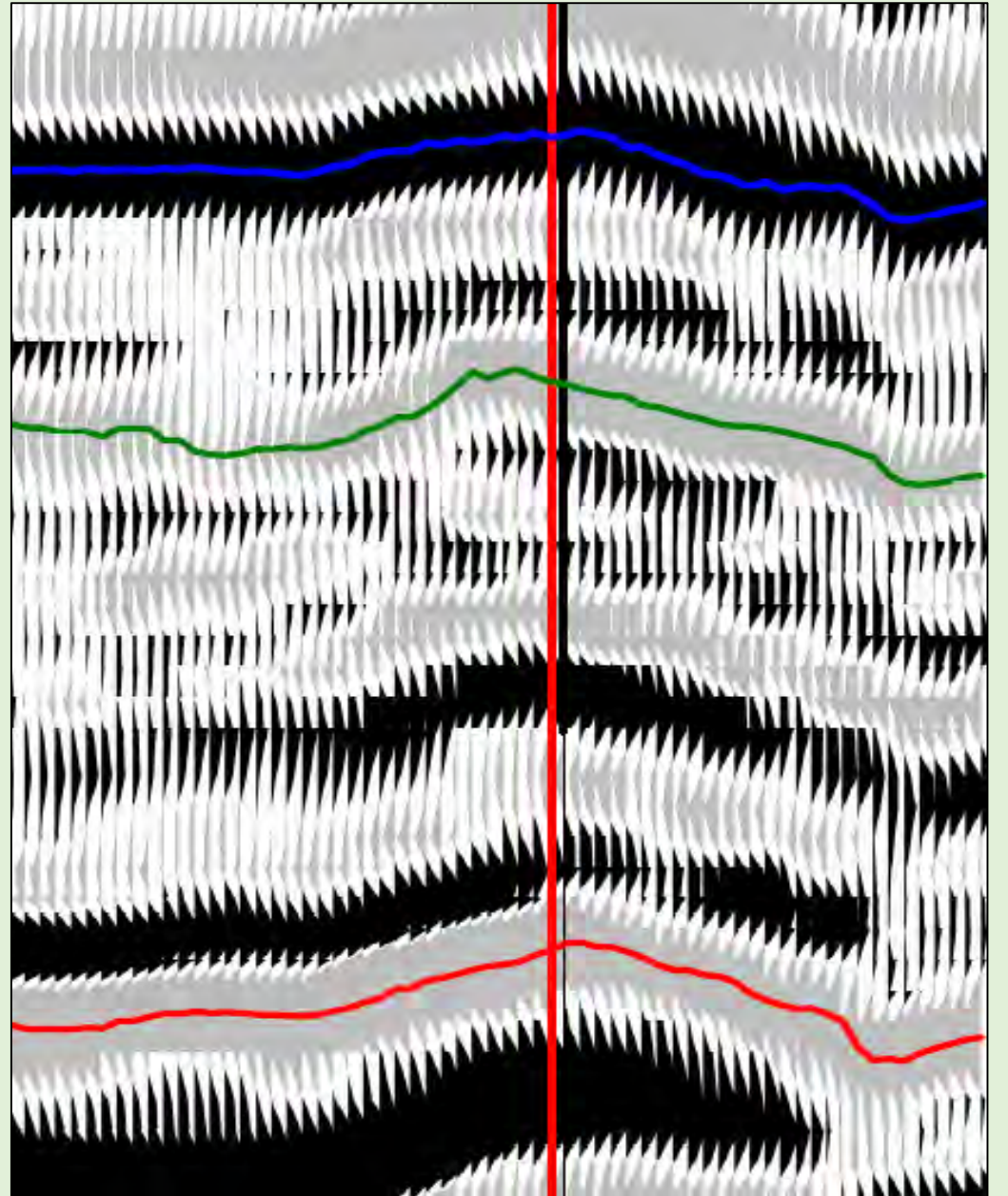
Interconnected Pinpoint Porosity and Fracture Porosity

Pawnee LS

LS crm-ltgy-tan gran-xfxl fri-firml vfos-ool w/occ calc infill & moc cln, chky & arg mtrx; vf dissemin pyr; por-fr-g (interconn pinpoint por-occ evid of frac por); oilstn-30% dkgrn-bk-occ tar oilstn, asph-occ live tan strm oil from crushed cuttings; flor-30% m-briyel esp on oilstn ctgs; cut-30% immed myel-mlky strm on oilstn ctgs-slow mlky diffuse on xline ctgs; res-vis vlttan res in dish from oil ring

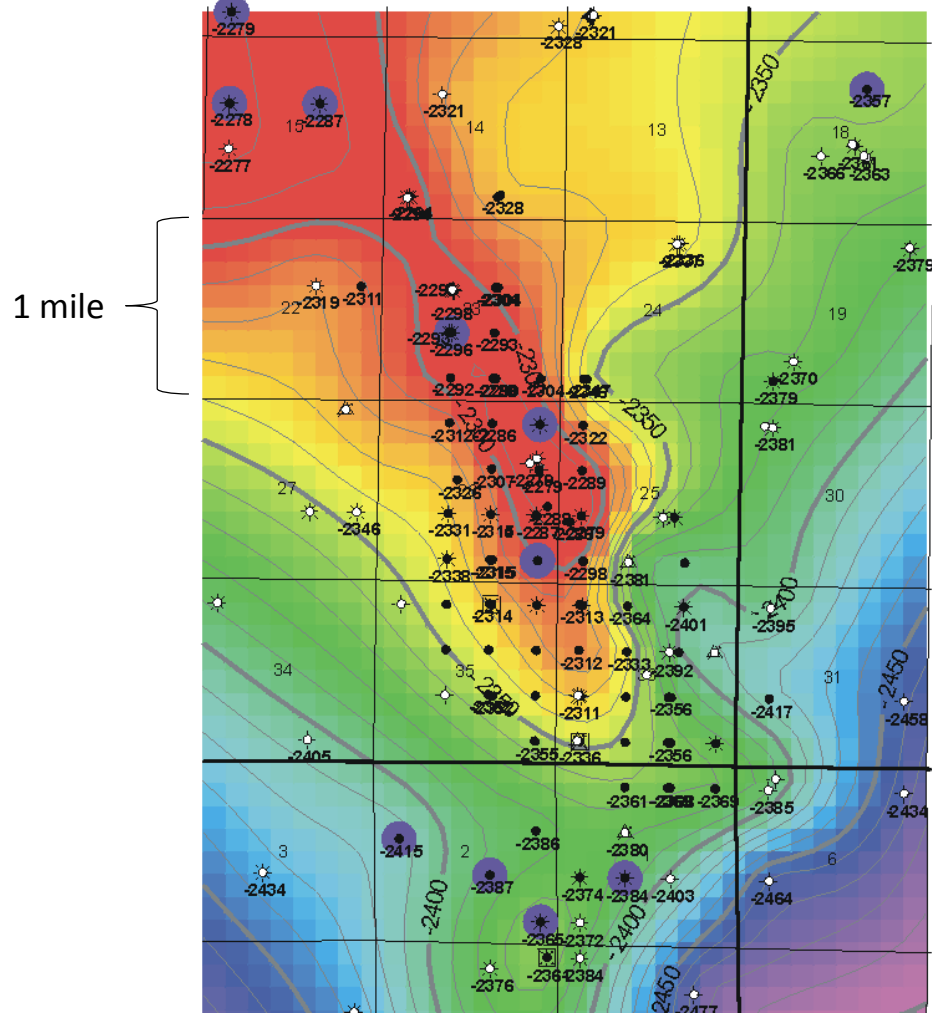


Oil Traps



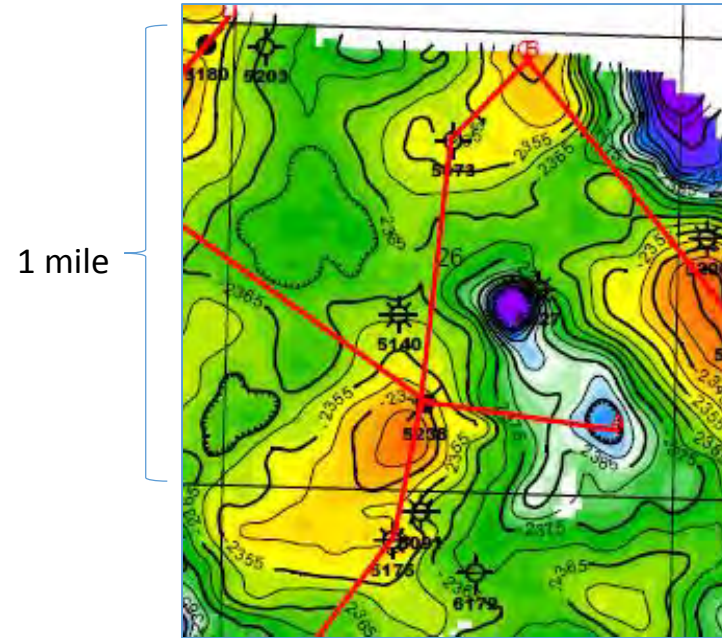
Traps – Structural

Large Structures

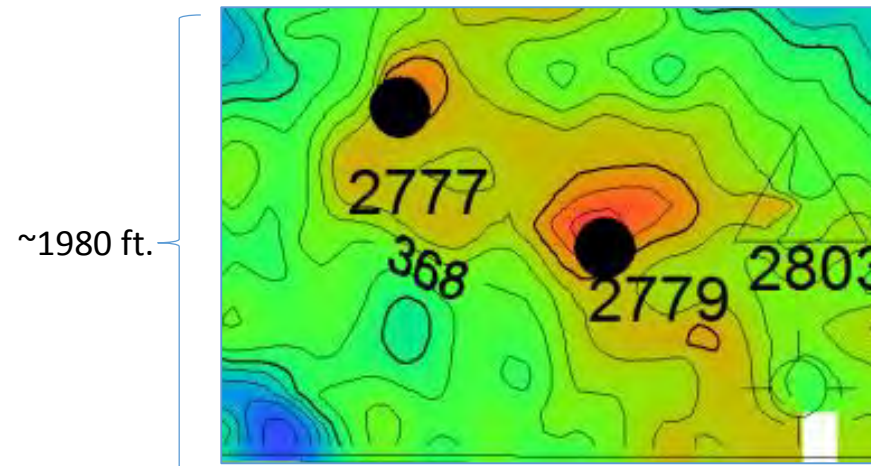


Structure Map - Top of Marmaton, Kismet Dome, Seward County, Kansas, Blue circles are Marmaton Wells.
(Source: KGS Digital Petroleum Atlas)

Small Structures

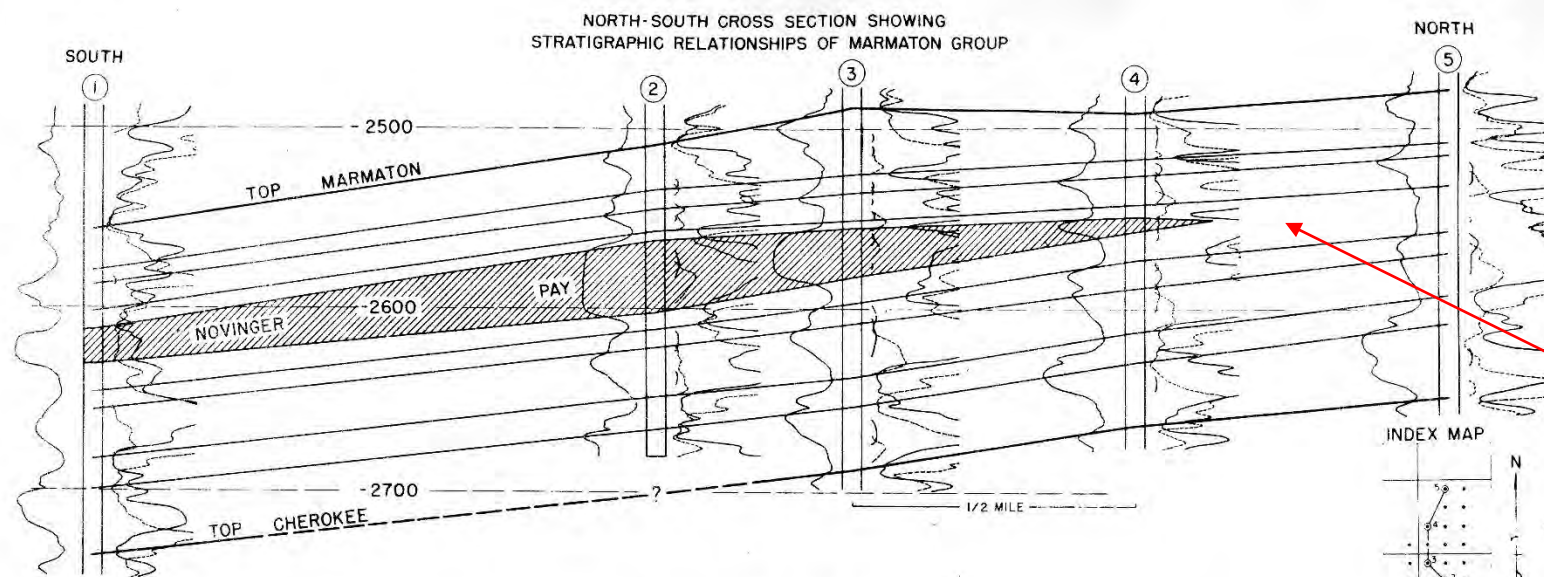


3-D Seismic Time Structure Map on the Pawnee, Western Kansas
The single well at intersection of red lines has produced 100,000+ BO from the Pawnee LS.
(Source: Ancient Oceans Energy, Ltd.)

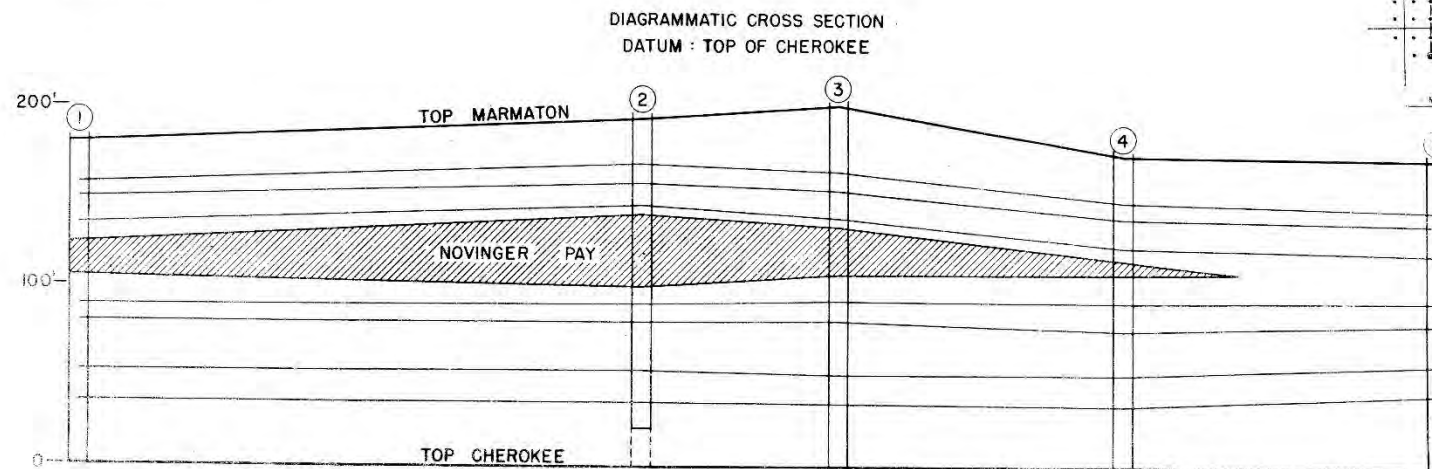


3-D Seismic Isochron Map –Anhydrite to Mississippian, Wesley Field, Ness County, Kansas. The 2 wells have produced 81,685 BO from the Altamont LS.
(Source: Trans Pacific Oil, Wichita, KS)

Traps – Stratigraphic



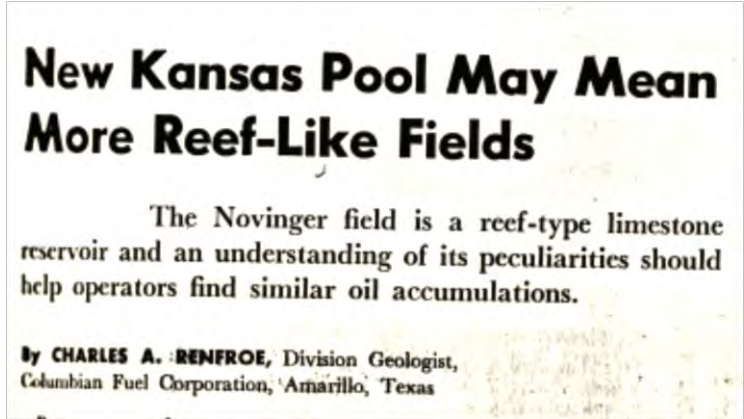
Porosity Zone “pinches out”
at updip location.



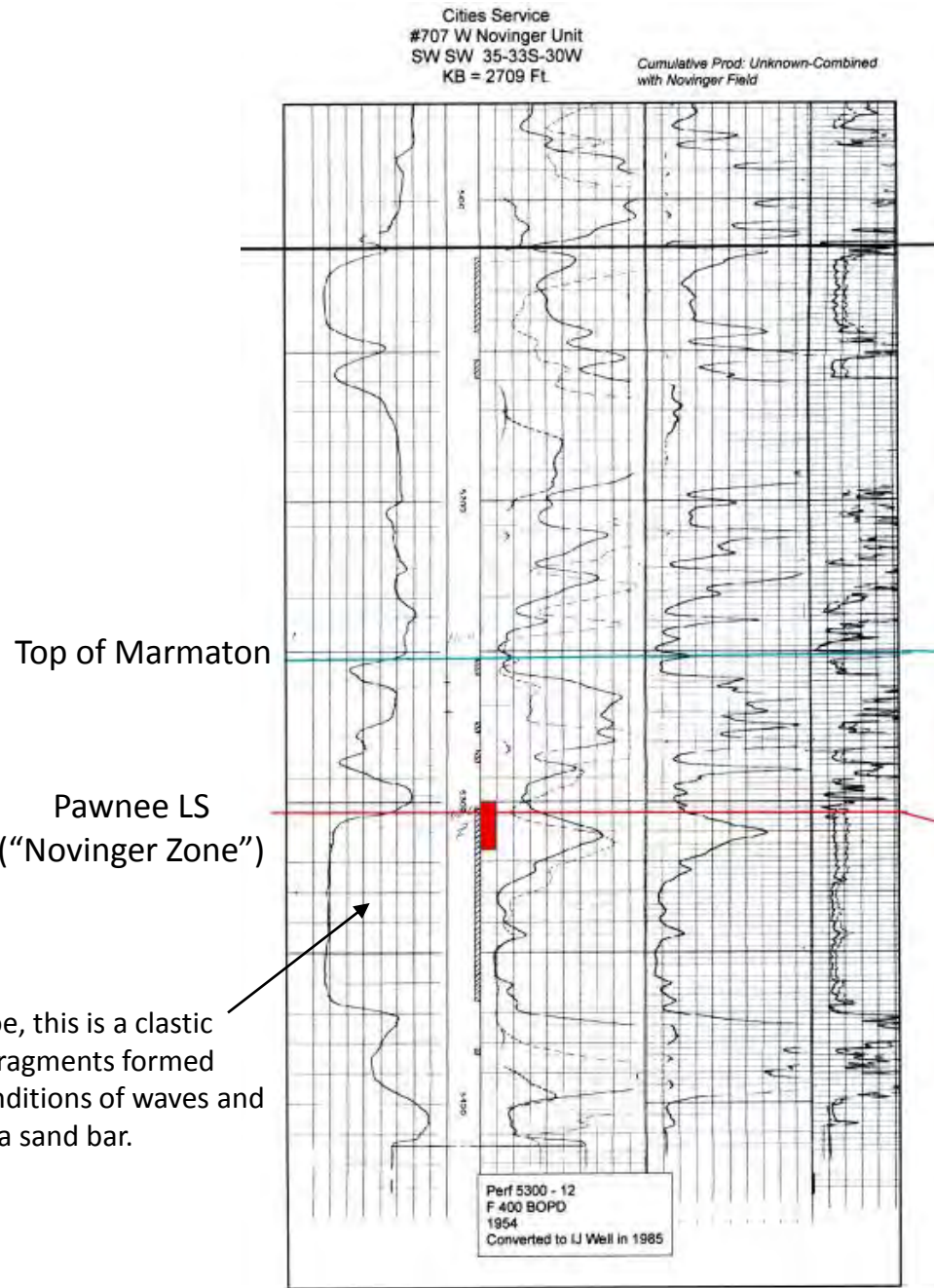
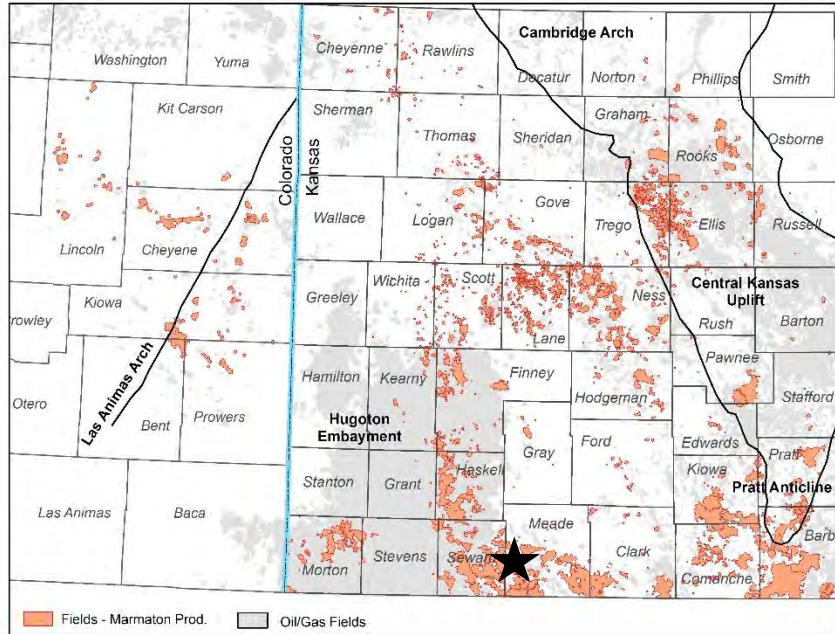
Novinger Field Meade County, Kansas



Novinger Field, Meade County, Kansas



From World Oil, Oct. 1954



Electrical Survey-Microlog

According to Renfro, this is a clastic deposit of organic fragments formed under turbulent conditions of waves and currents, similar to a sand bar.

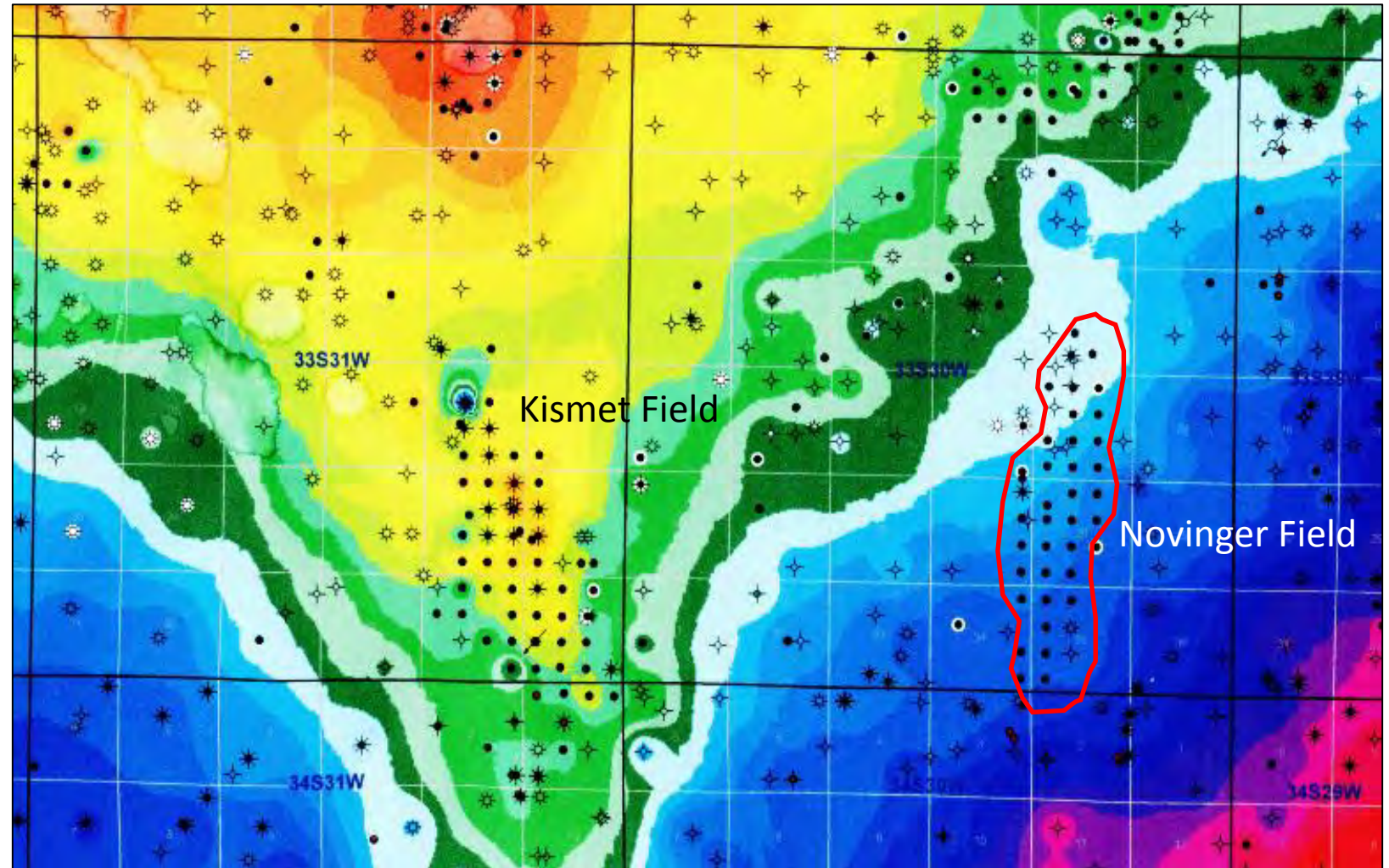
Novinger Field –continued...

Produced 7.3 Million BBLs of Oil from 34 wells.

Discovered in 1950, 2 years after the Kismet Field discovery.

Largest Continuous Marmaton Field in Western Kansas and Eastern Colorado.

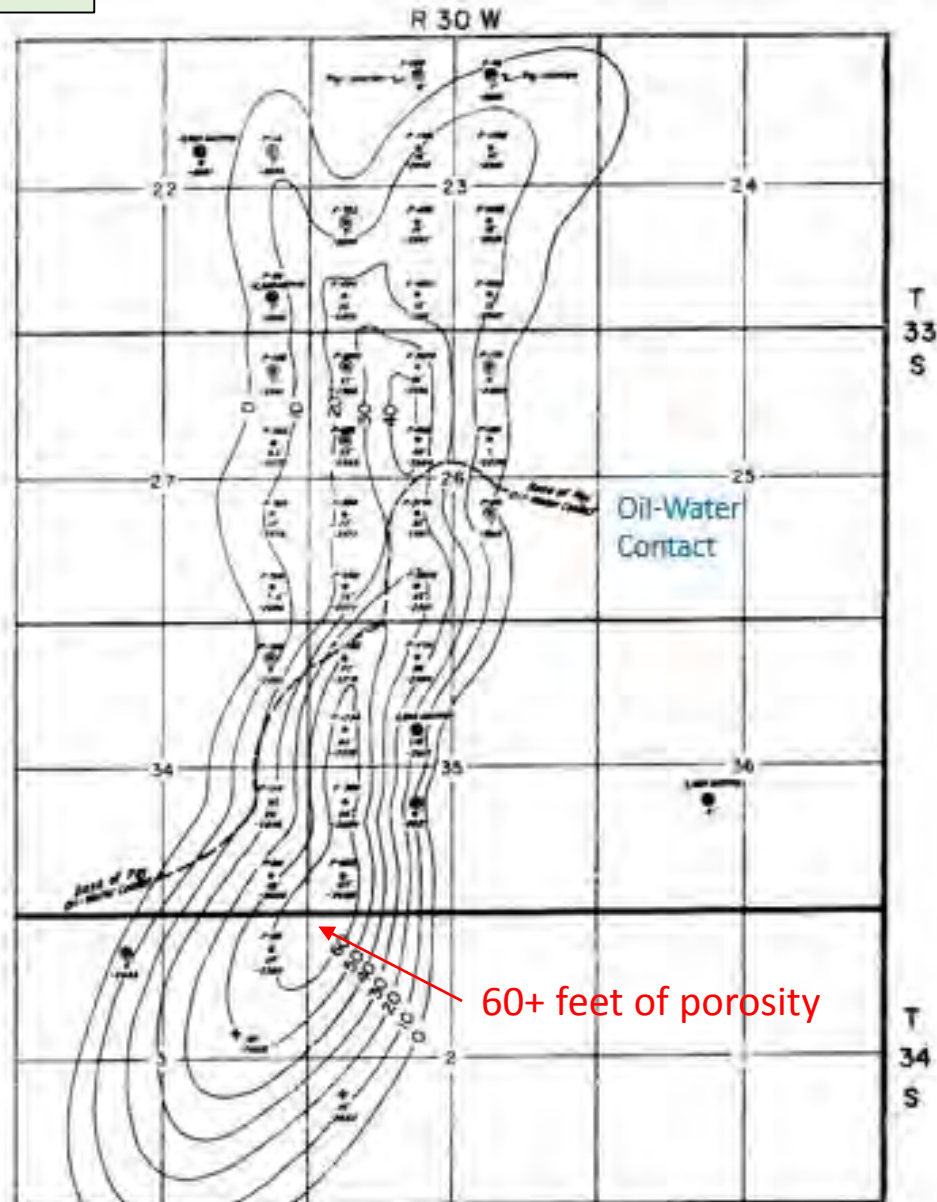
No obvious signs of significant structure on the Mississippian surface like that of the Kismet Dome.



Structure Map- Top of Mississippian Chester, Red and Yellow = Higher; Blue and Purple = Lower
Source: Ancient Oceans Energy, Ltd.

Novinger Field - continued

Isopach Map- Pawnee Porosity



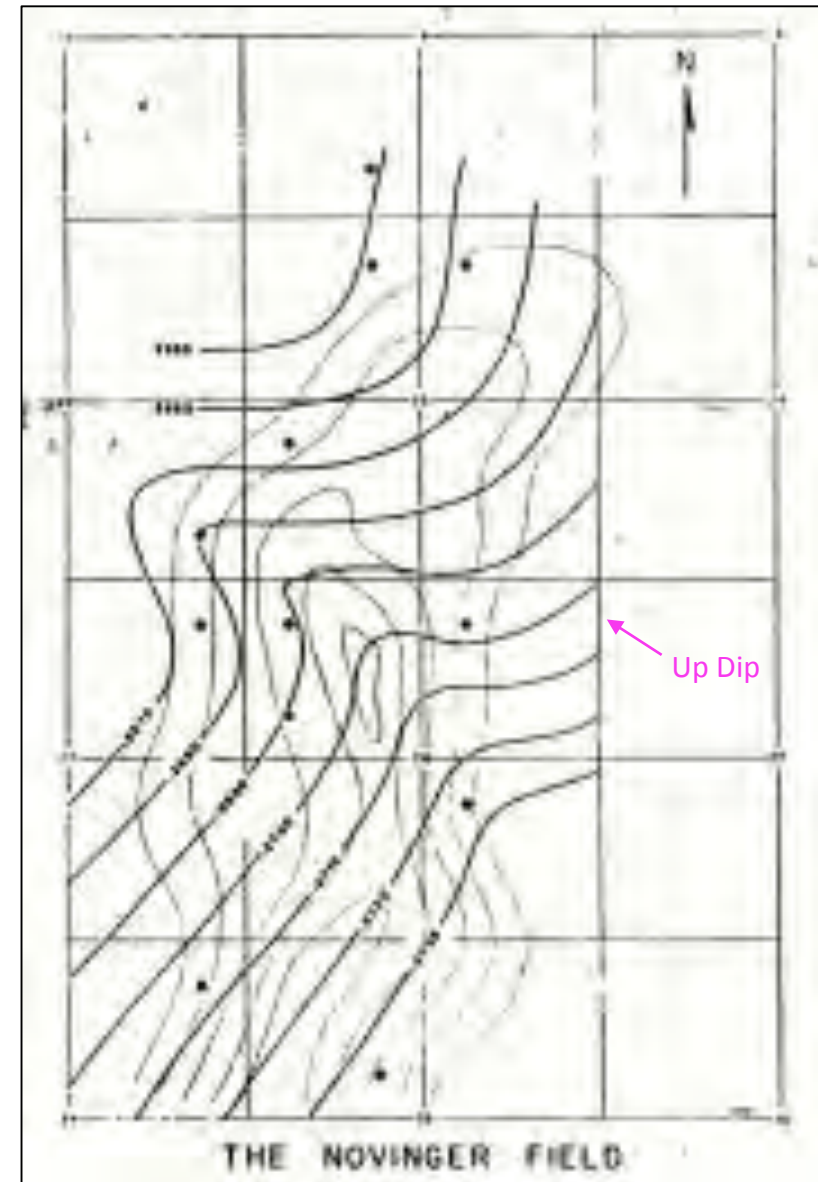
4 mile long deposit
of porous limestone.

No obvious indication
of deposit or structure
on the Cherokee surface.

Oil stratigraphically
trapped within up dip
half of the field.

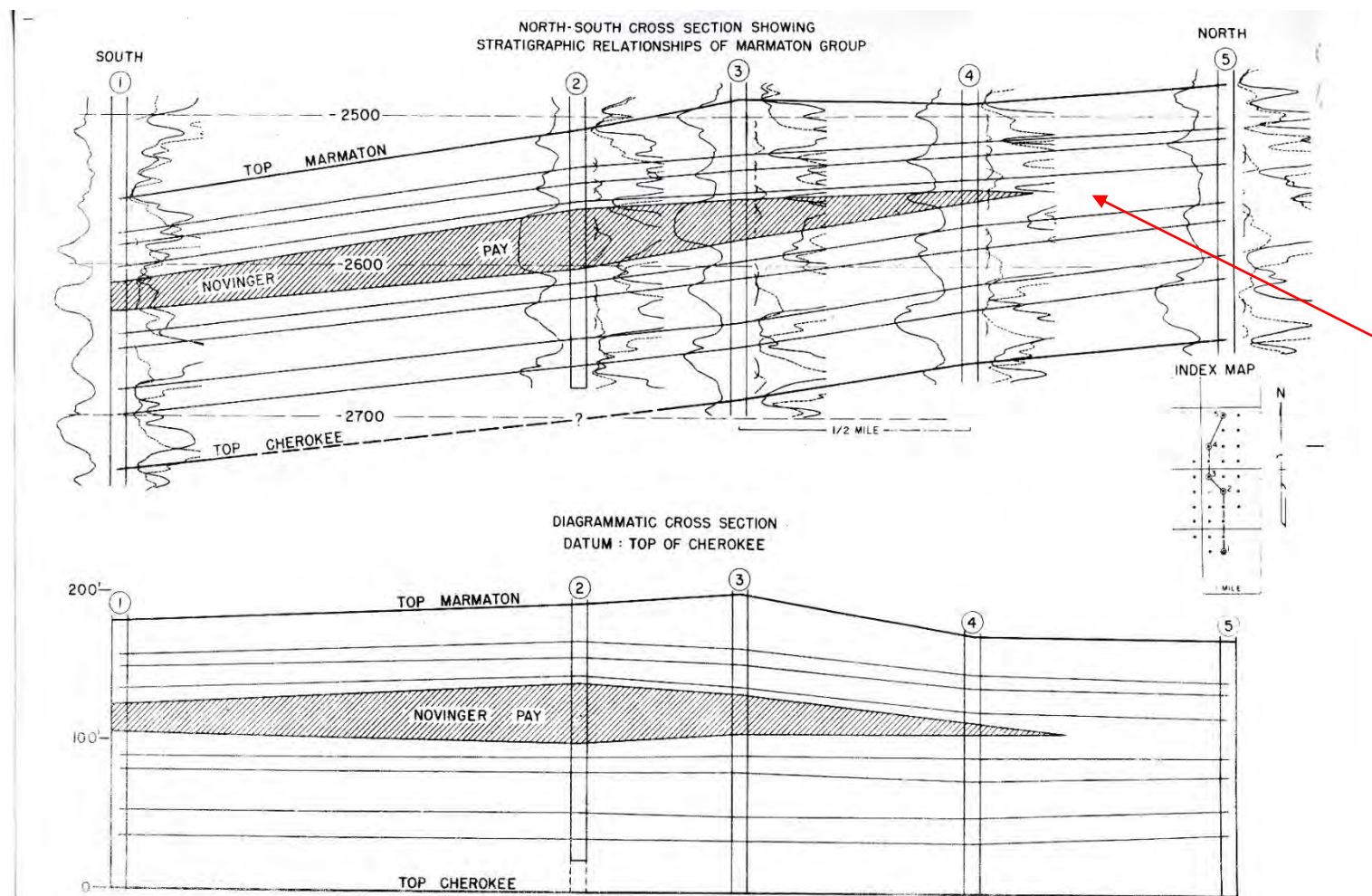
From Renfroe, 1959, Novinger Field,
Oil and Gas Fields of Kansas, Volume 2

Structure Map- Cherokee Shale



From Renfroe, 1954, World Oil, October 1954

Novinger Field- continued.

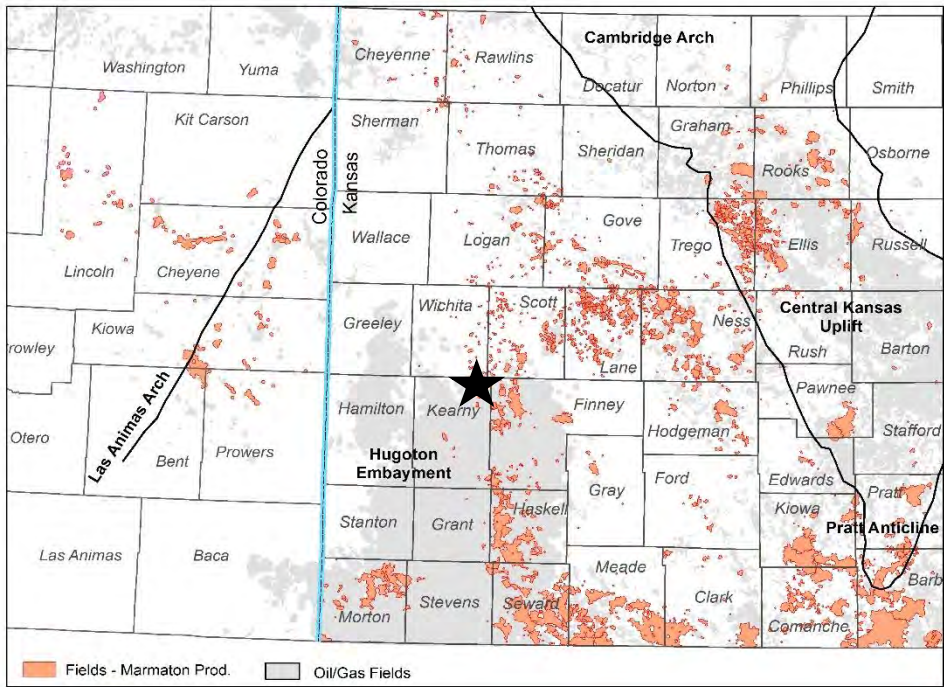


White Woman Field Wichita and Kearny Counties, Kansas

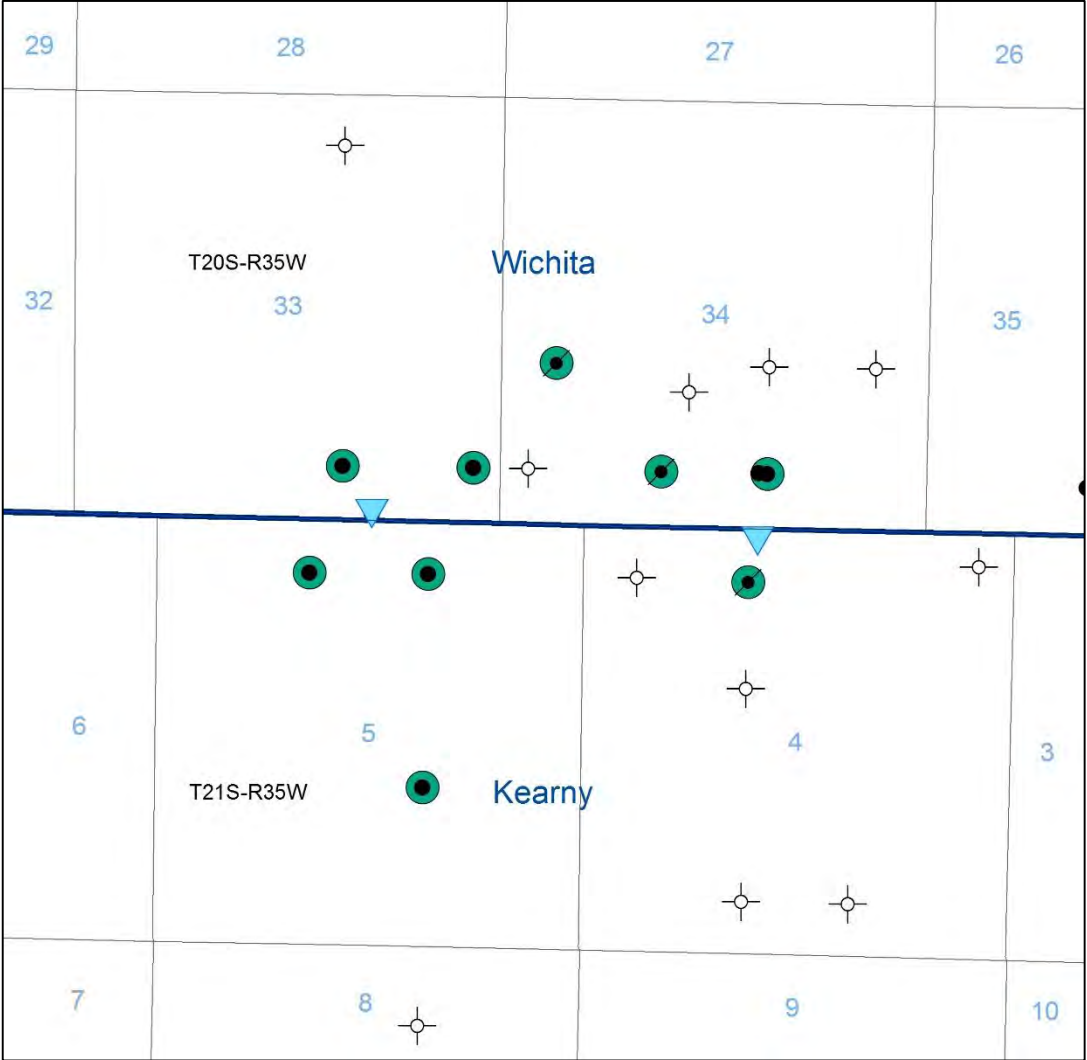


White Woman Field- Wichita and Kearny Counties, Kansas

Discovered in 1962, Developed in the 1980s
Produced 500,000+ BBLs of Oil from the Marmaton



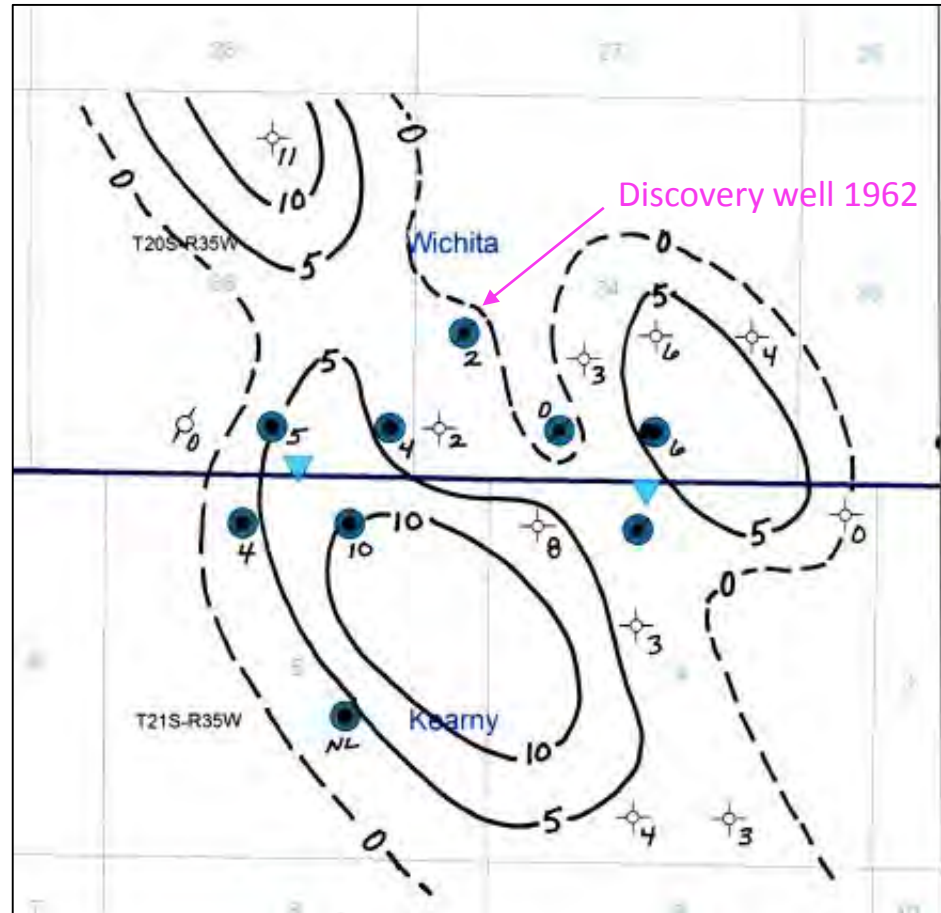
Green = Marmaton Oil Wells; Blue = Disposal Wells



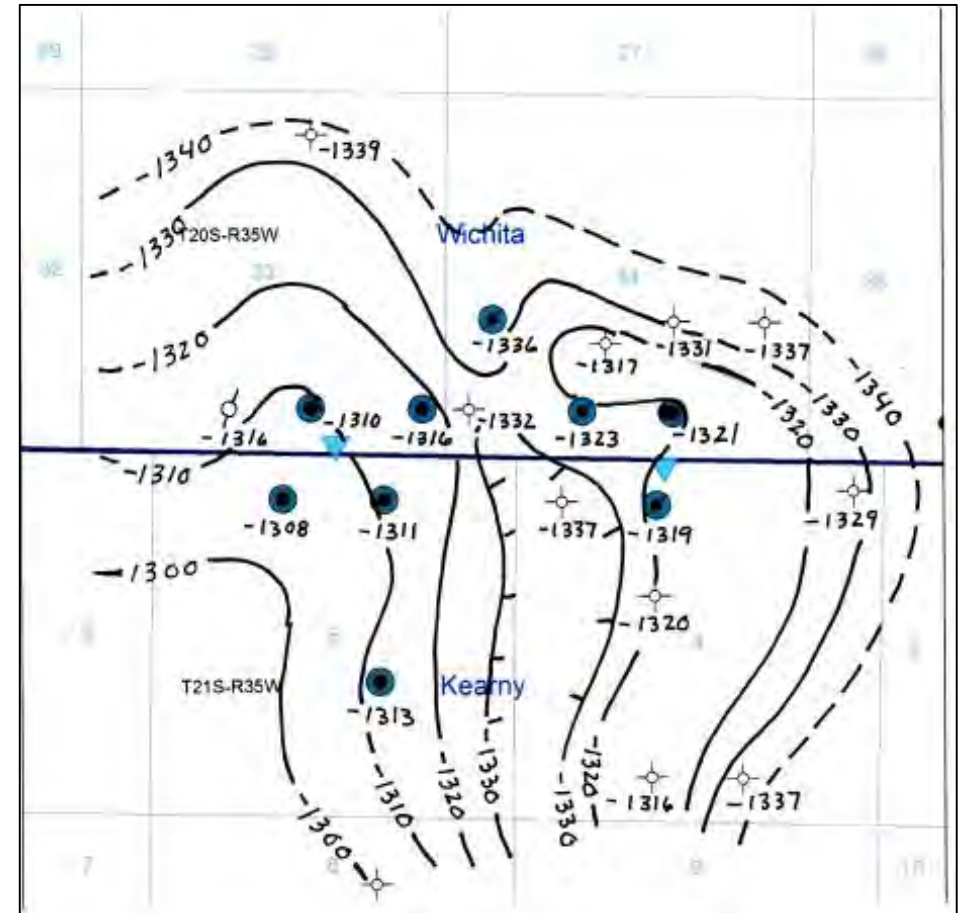
Ancient Oceans Energy, Ltd.

White Woman Field-continued...

Isopach Map- Feet of Porosity > 6% in the Altamont B Zone



Structure Map- Top of the Marmaton



Blue circles are Marmaton Producing Wells; all are completed in the Altamont B zone except for the well in the SESW of Sec. 34; this well is an Altamont A well.

Good Production on Structural Highs; Water-Wet in low areas.

Field discovered by mediocre well (4891 BBLs) in 1962, yet good offset wells in the SE/4 of Section 33 were not drilled until the early 1980's.

White Woman Field-continued.

High Oil Well (-1311)

Low Water Wet Well (-1339)

Description from the Alyce

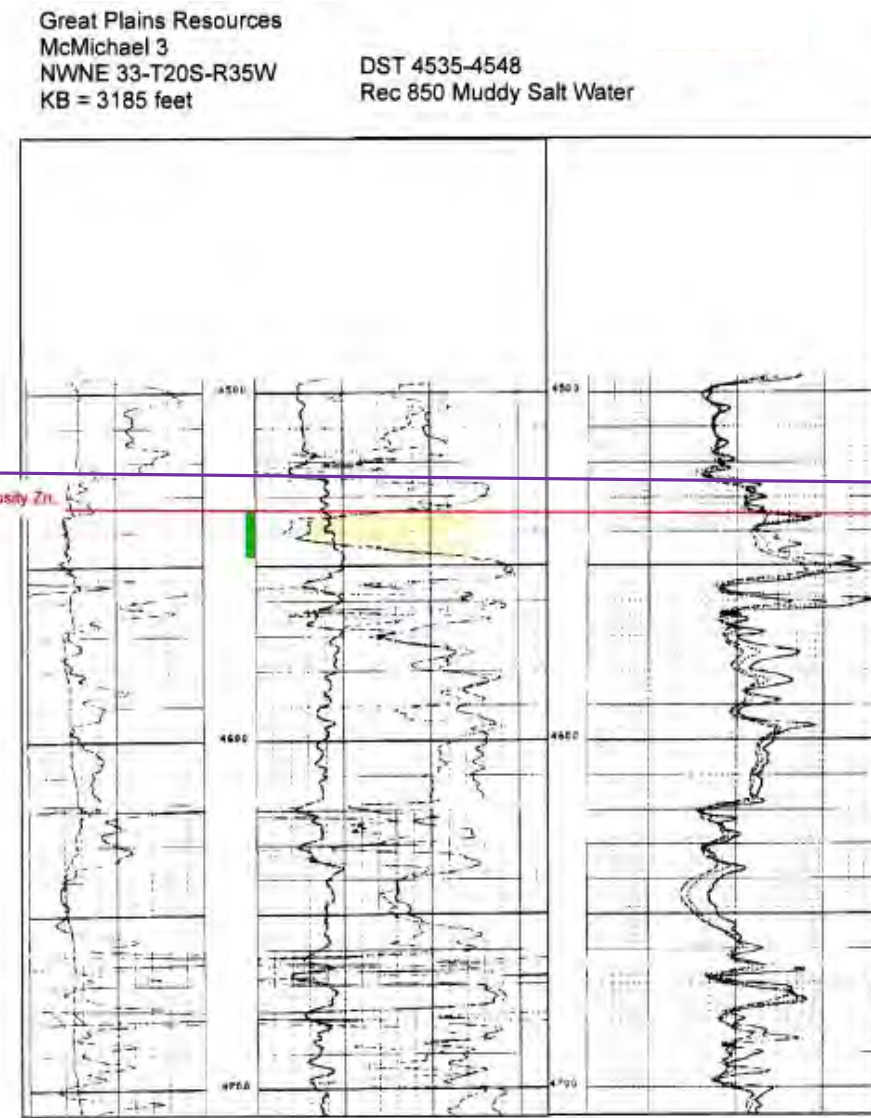
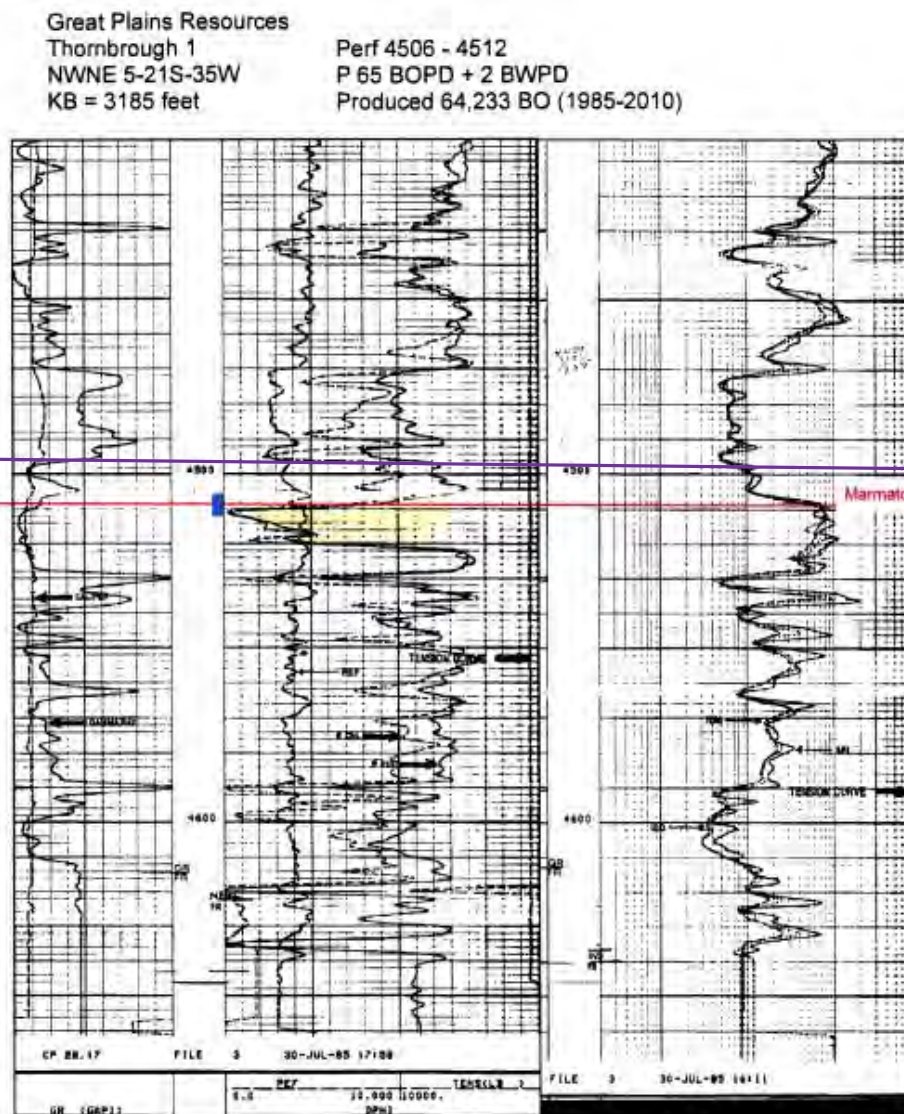
McMichael No. 1

(E2SESE 33-T20S-R35W):

Limestone: tan, fine crystalline, oolitic, sucrosic texture, bioclastic, some loose oolites, free oil, vugular and interoolitic porosity.

Marmaton

Altamont LS



Cowdery West Field Scott County, Kansas



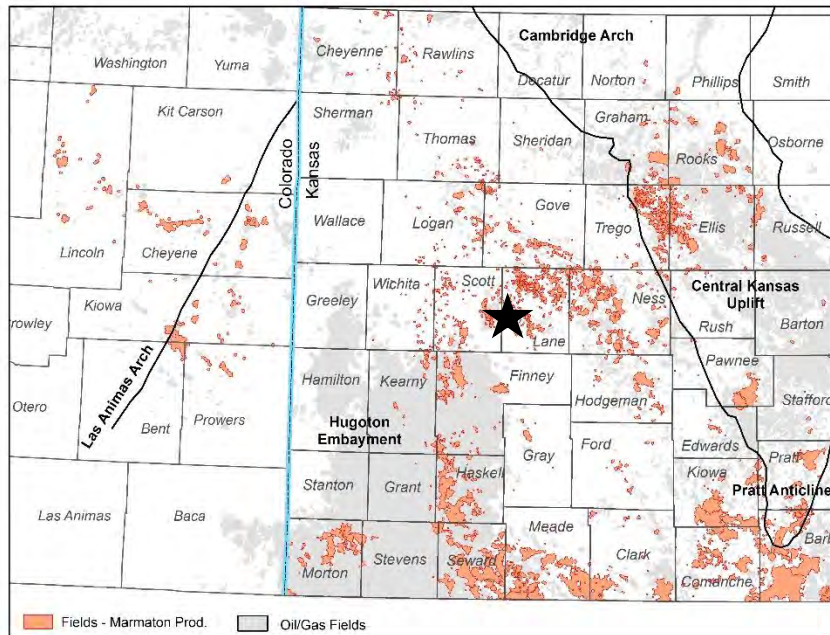
Cowdery West Field, Scott County, Kansas

Single Well Marmaton Field

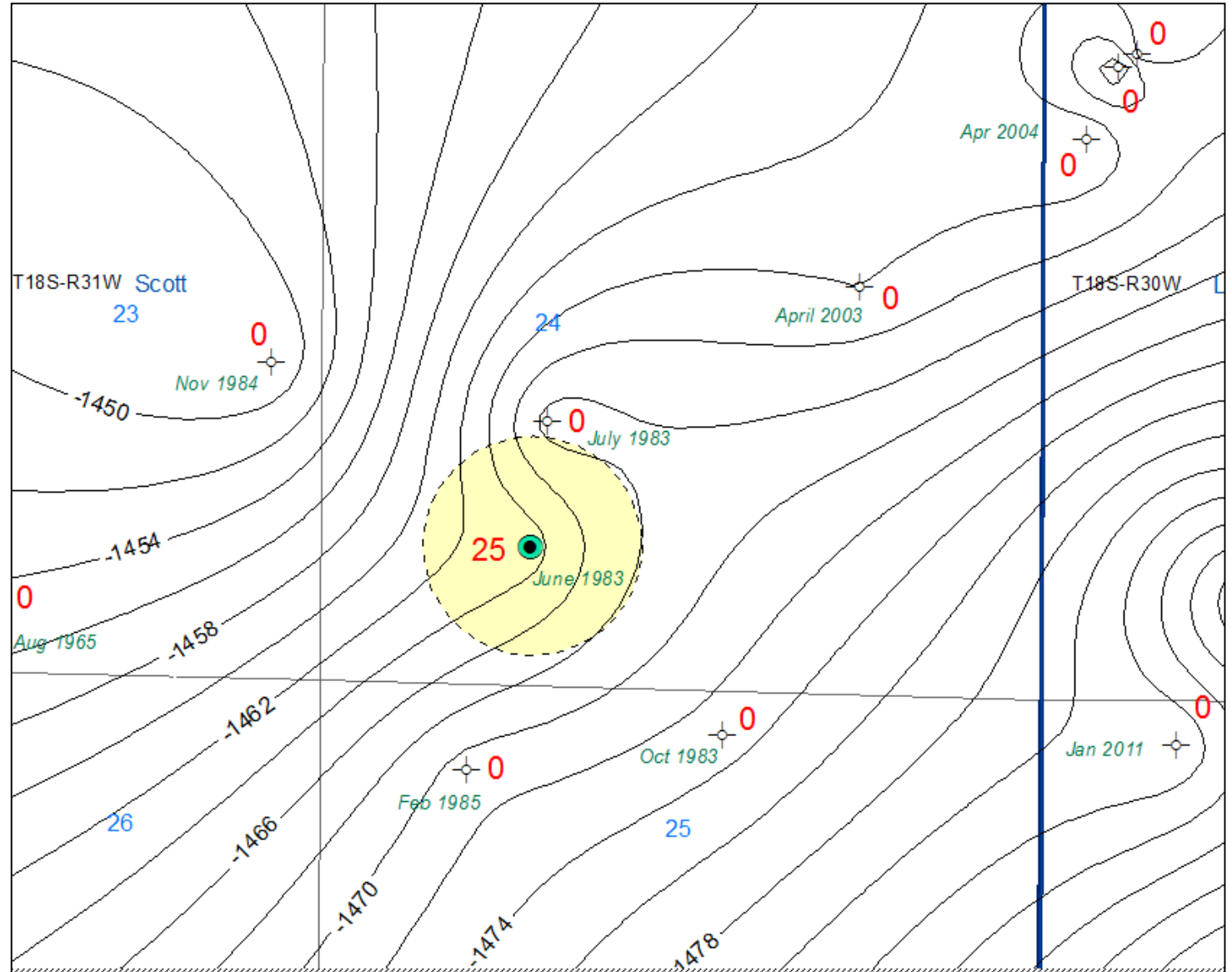
Snyder 1- SW/4 Sec 24-T18S-R31W

Produced 158,550 BBLs of oil since 1983.

Porosity zone not present
in offsets.



Structure Map- Base of the Altamont Pay Zone, Red numbers= feet of porosity > 6%



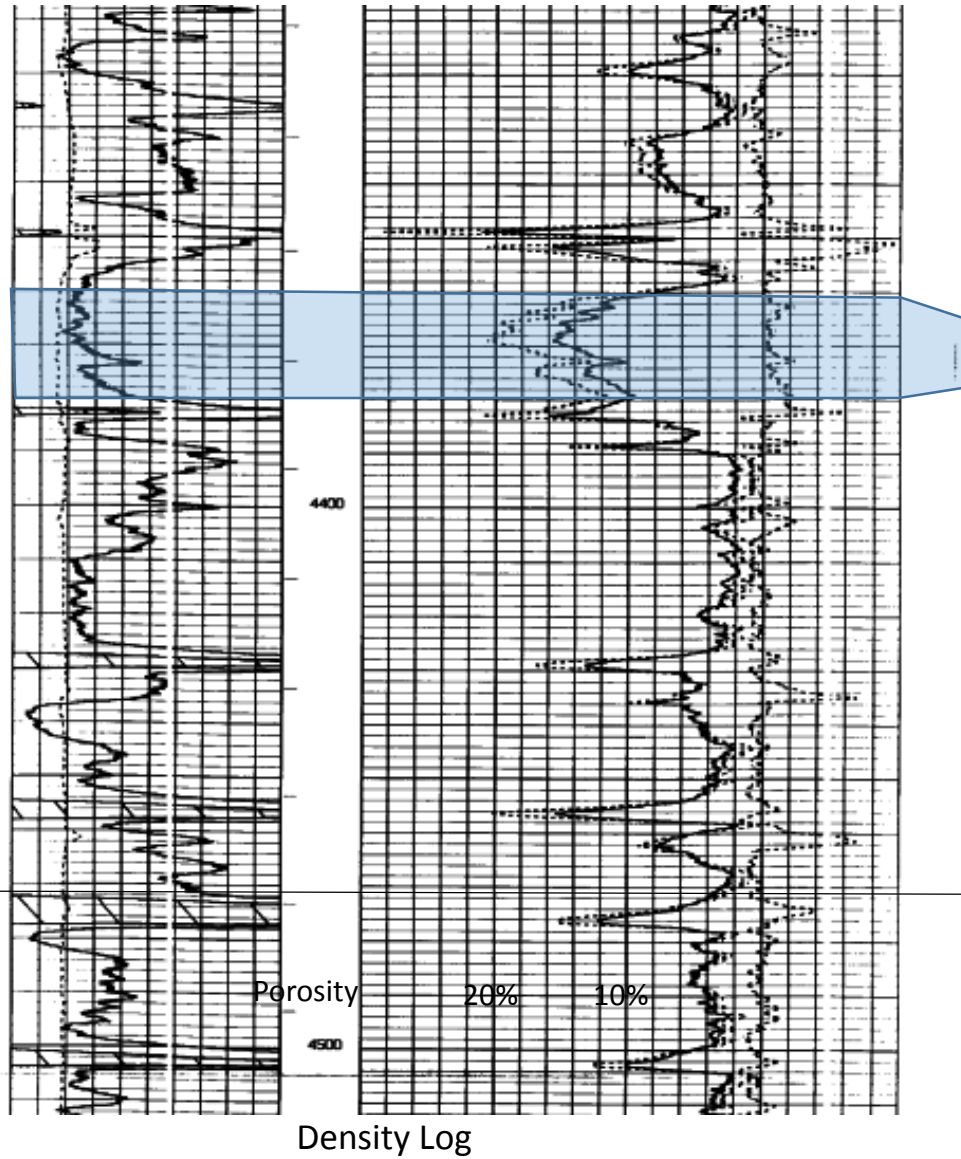
Source: Ancient Oceans Energy, Ltd.

Cowdery West Field continued.

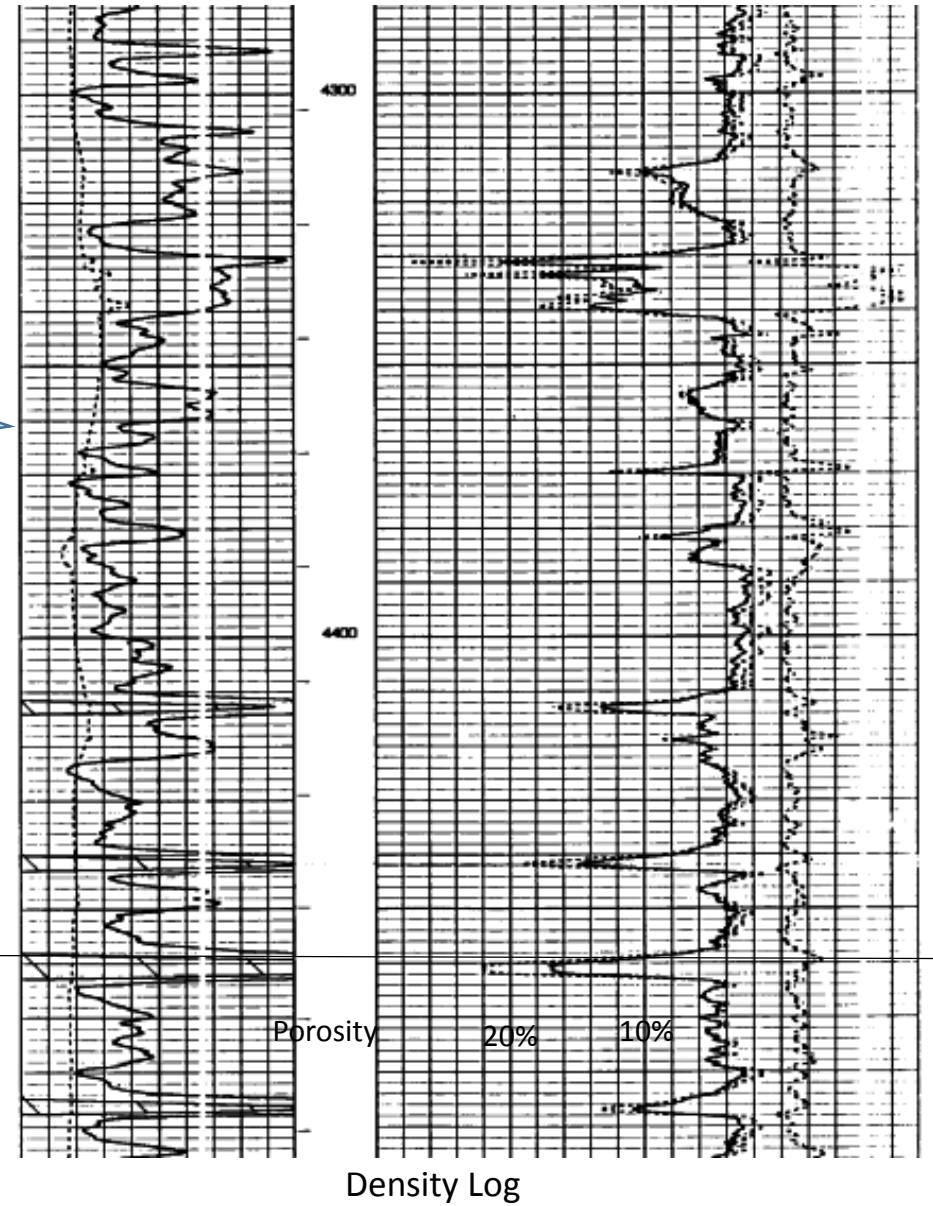
Snyder 1 NWSESW 24-18S-31W

Altamont B Pay Zn.
Perf: 4360-70
IP: 130 BOPD

Cherokee



Eitel 1-23 NENESE 23-18S-31W



Clifford Field

Lincoln County, Colorado

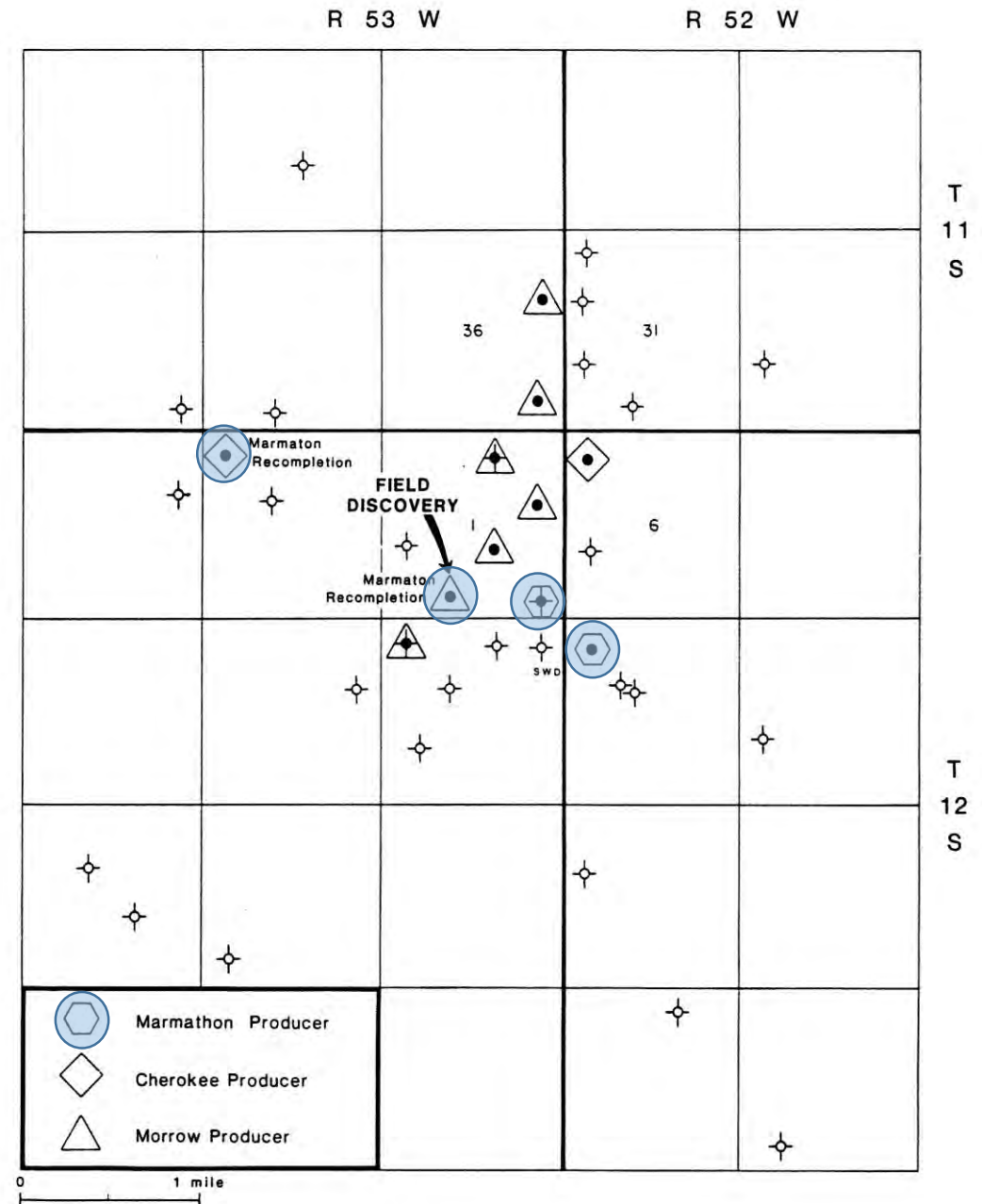
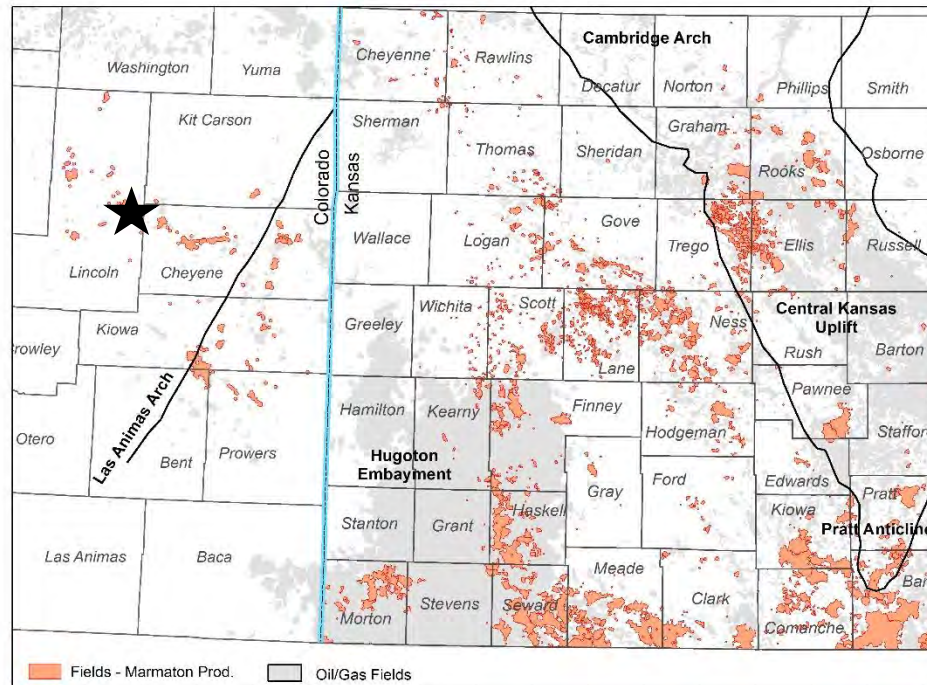


Clifford Field, Lincoln County, Colorado

2.4 Million BBL Oil Field; Produced 243,497 BBLs from 4 Marmaton Wells.

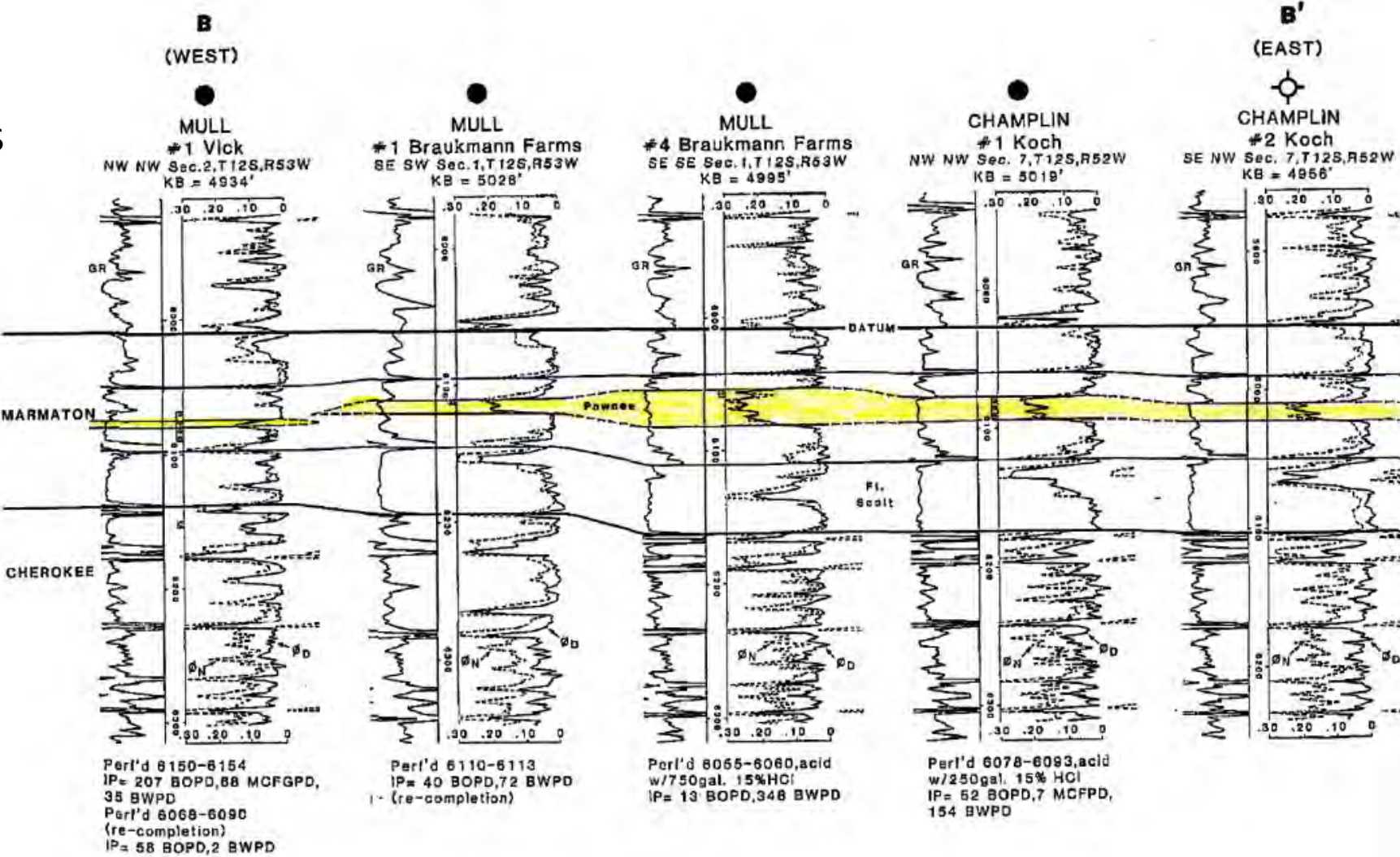
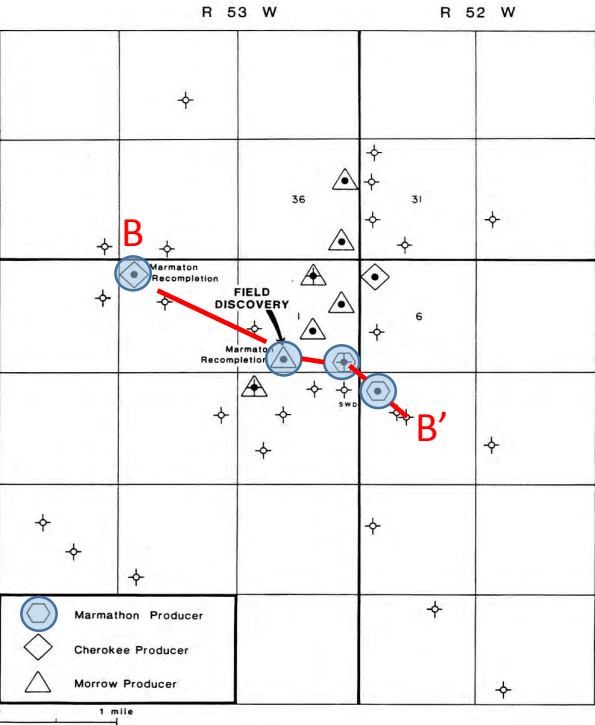
Most of the production is from the Morrow.

Discovered in 1982 by drilling a seismic anomaly (Thin Stone Corral to Morrow Isochron) in Section 1-T12S-R53W.



Clifford Field continued...

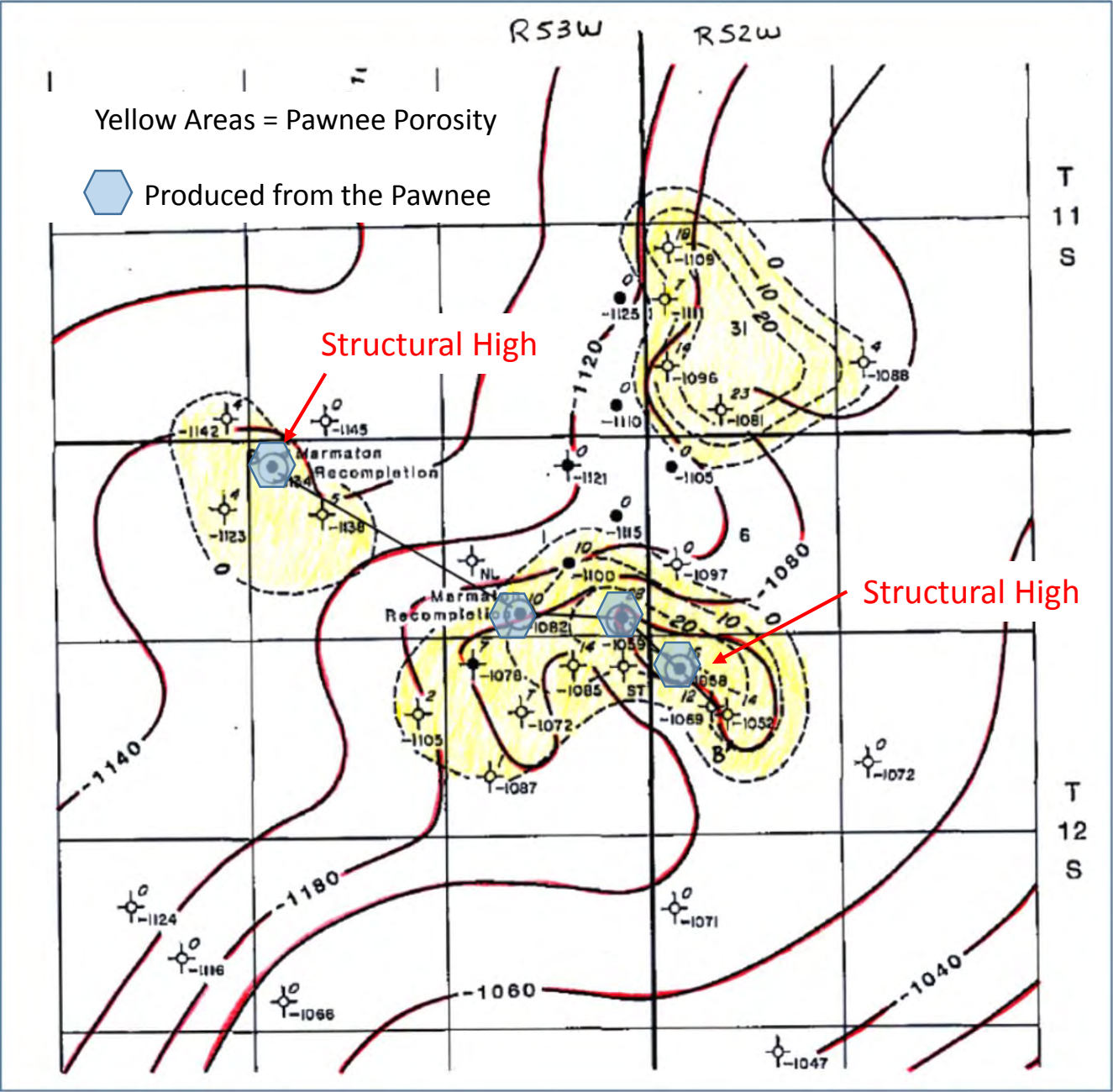
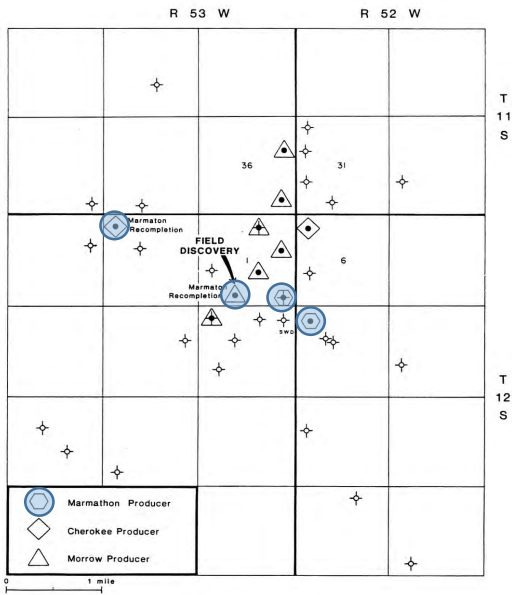
Porosity Zone developed in the Pawnee.
Described as a fossiliferous and oolitic LS in core.



Modified from Shannon, L., 1990, Clifford Field: a Fluvial Valley-Fill Reservoir, Lincoln County, Colorado, RMAG Morrow Sandstones

Clifford Field continued.

- Marmaton (Pawnee) Production on structural highs.
- Discontinuous porosity development.
- Several dry holes adjacent to Marmaton Production.



Great Plains Field Lincoln County, Colorado

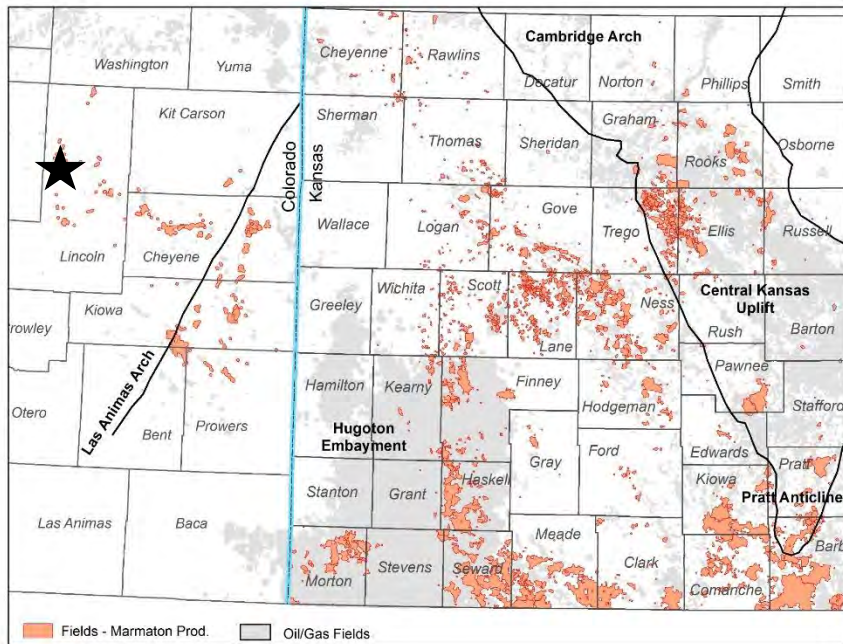


Great Plains Field, Lincoln County, Colorado

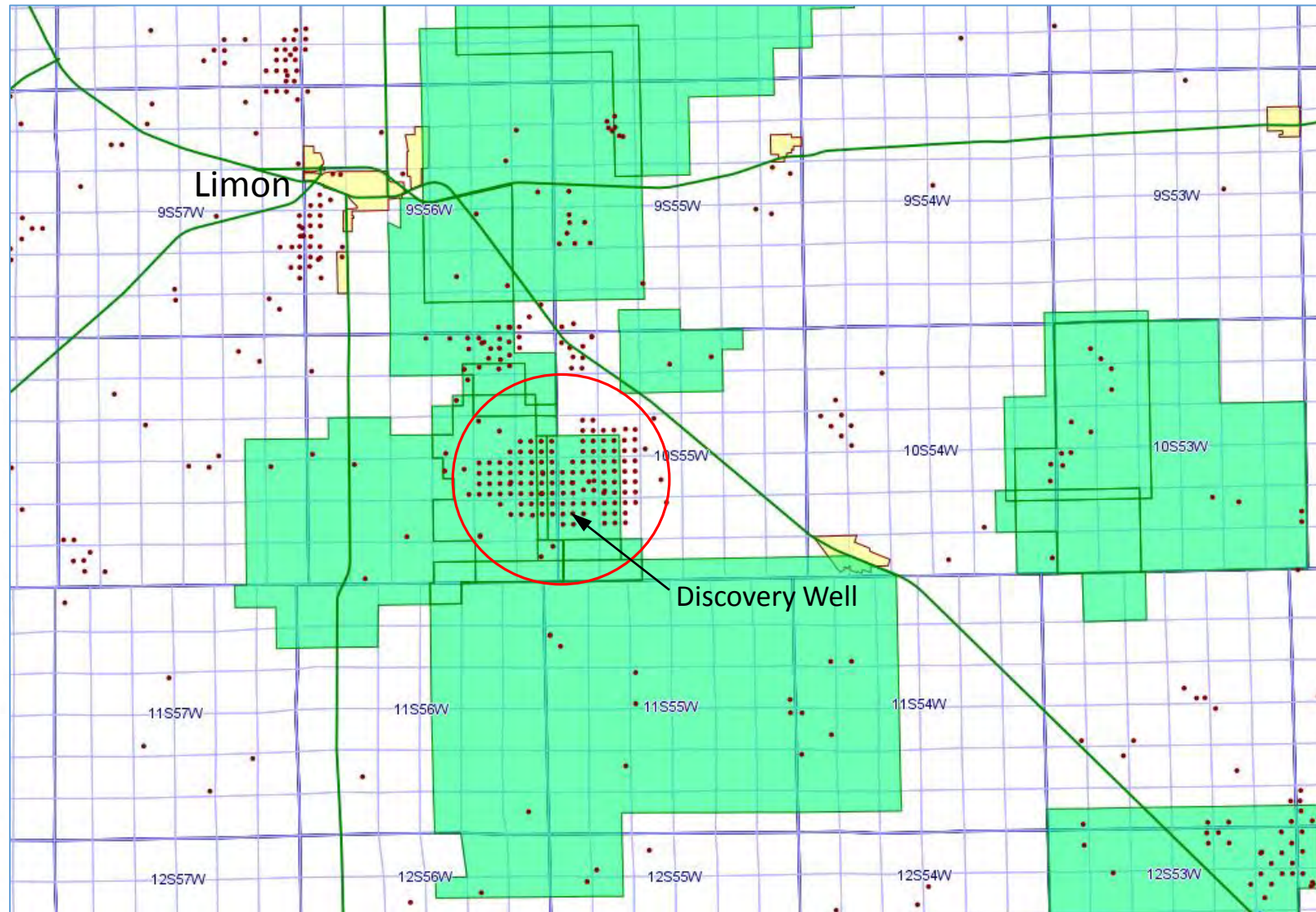
Produced > 1.7 Million BBLs from Lansing, Cherokee, Marmaton, Morrow, and Osage.

Discovered in 2007 by re-entry of Forristal Ranch State 22-30 which was abandoned as a dry hole in 1991. Subsequent drilling and a 3-D seismic survey revealed a large structure to the north.

Still developing Field today and limits of the field are to be determined.



Field Discovered in 2007, Multiple 3-D Seismic Surveys (Green) Followed

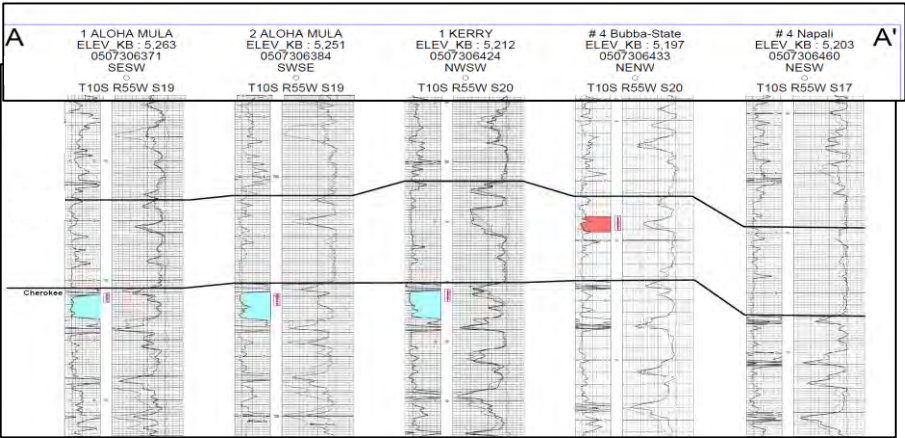


Great Plains Field continued...

Multiple Pay Zones: Lansing, Marmaton (Torch, Pawnee A, Pawnee B), Cherokee, Morrow, and Osage.

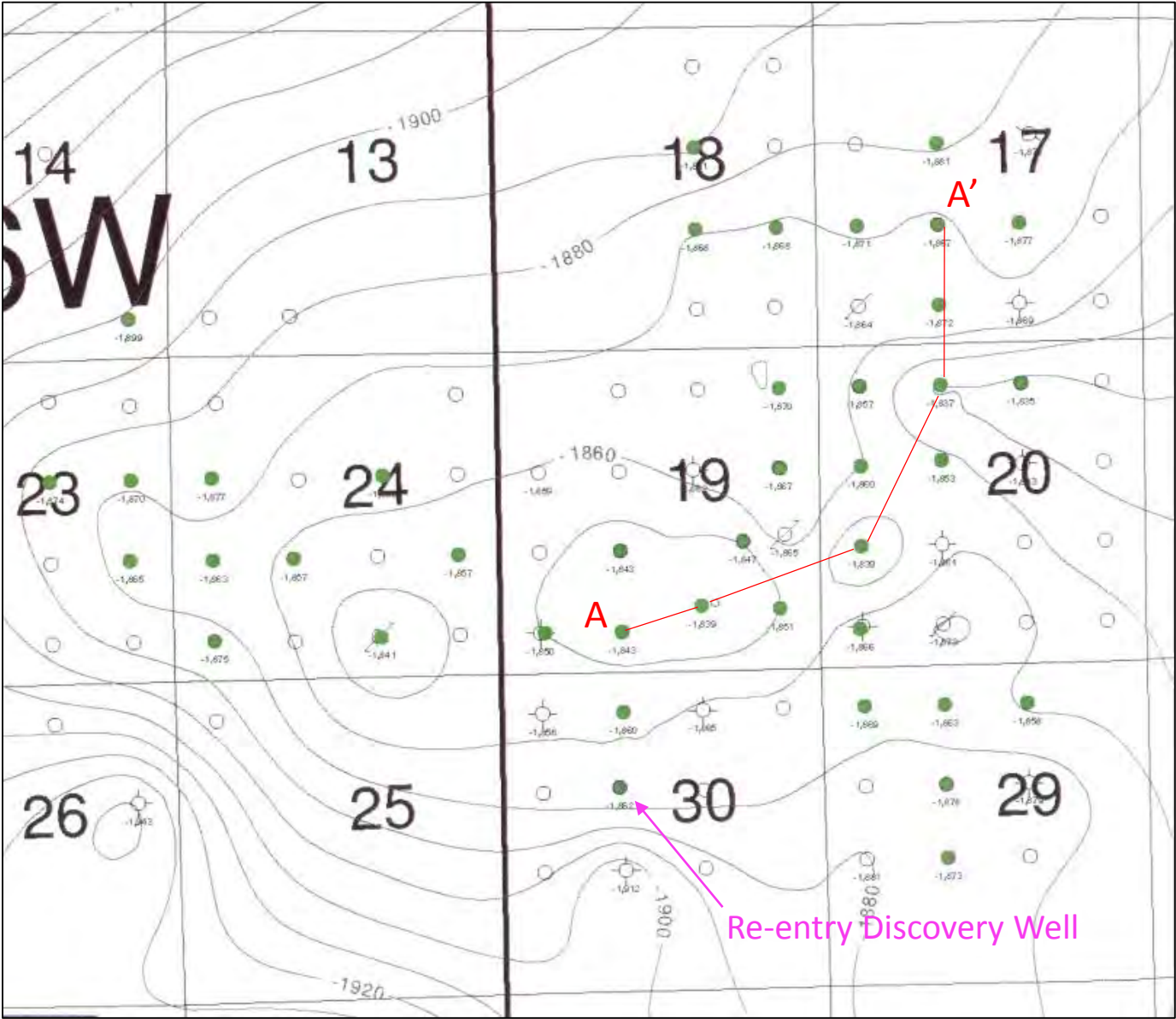
Large structure discovered by drilling and 3-D seismic in Sections 23, 24, 19, and 20. 3-D seismic also revealed some faulting in the field.

Additional development ongoing.



Cross Section by Sapp, S., 2013, Great Plains Field, RMAG Oil and Gas Fields of Colorado, 2014

Structure Map- Top of Cherokee Shale



Map Source: Wiepking-Fullerton Energy, LLC.

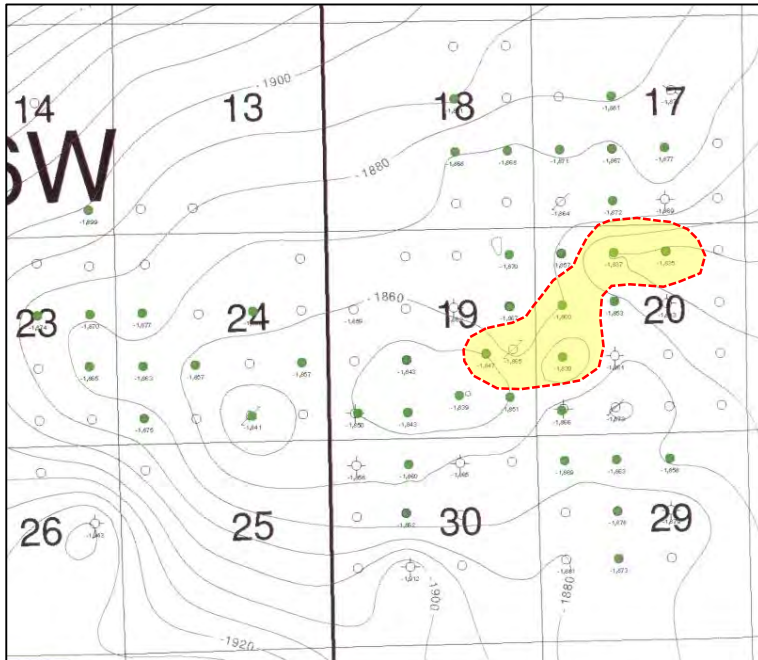
Great Plains Field continued...

Three Marmaton Zones produce on the structural high:

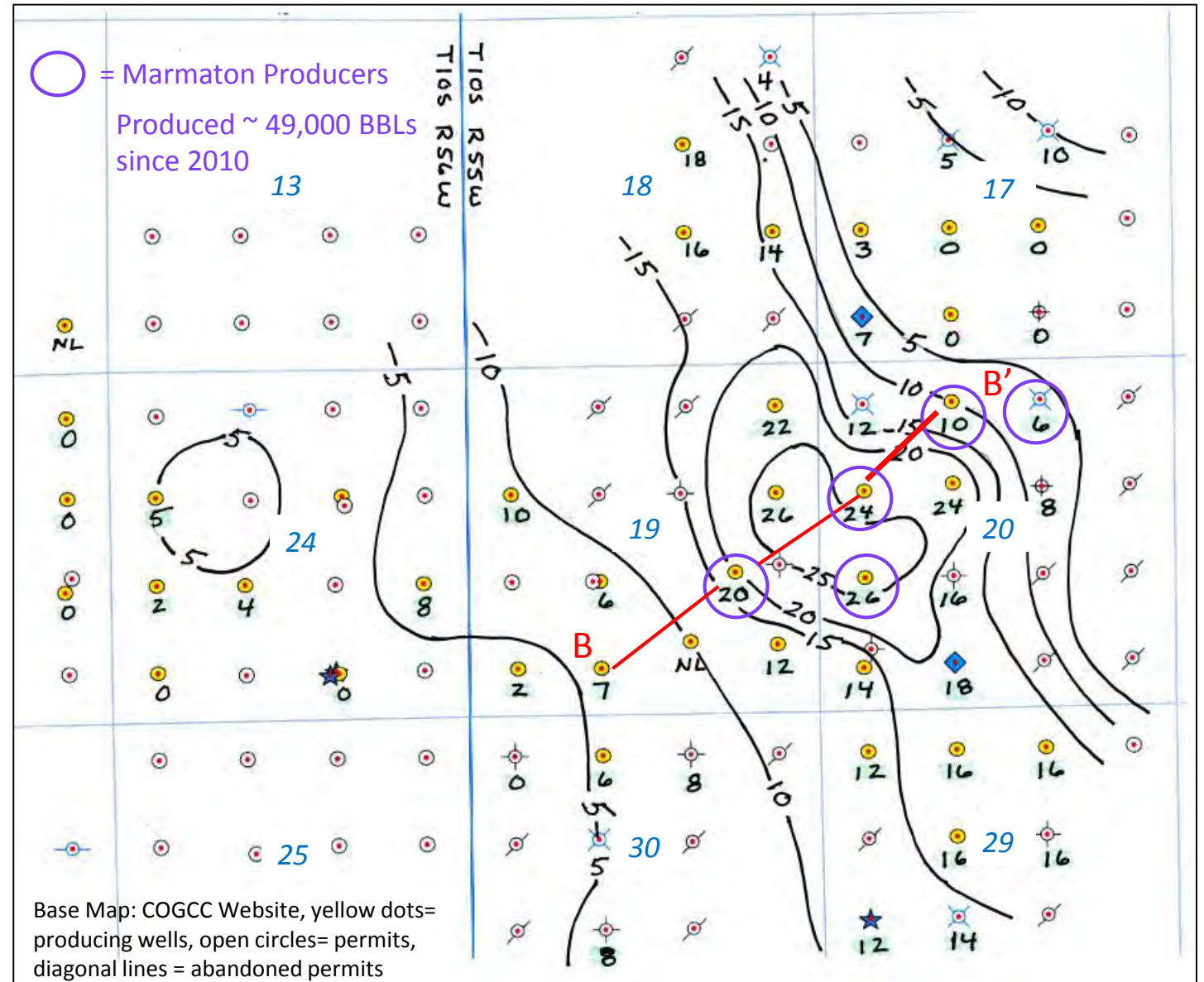
1. Torch
2. Pawnee A
3. Pawnee B

The Pawnee B is by far the thickest and most continuous deposit of porous limestone.

Marmaton production to date (yellow area below) seems to coincide with the structural high.



Isopach Map- Marmaton Pawnee B Zone (Feet of porosity > 6%)



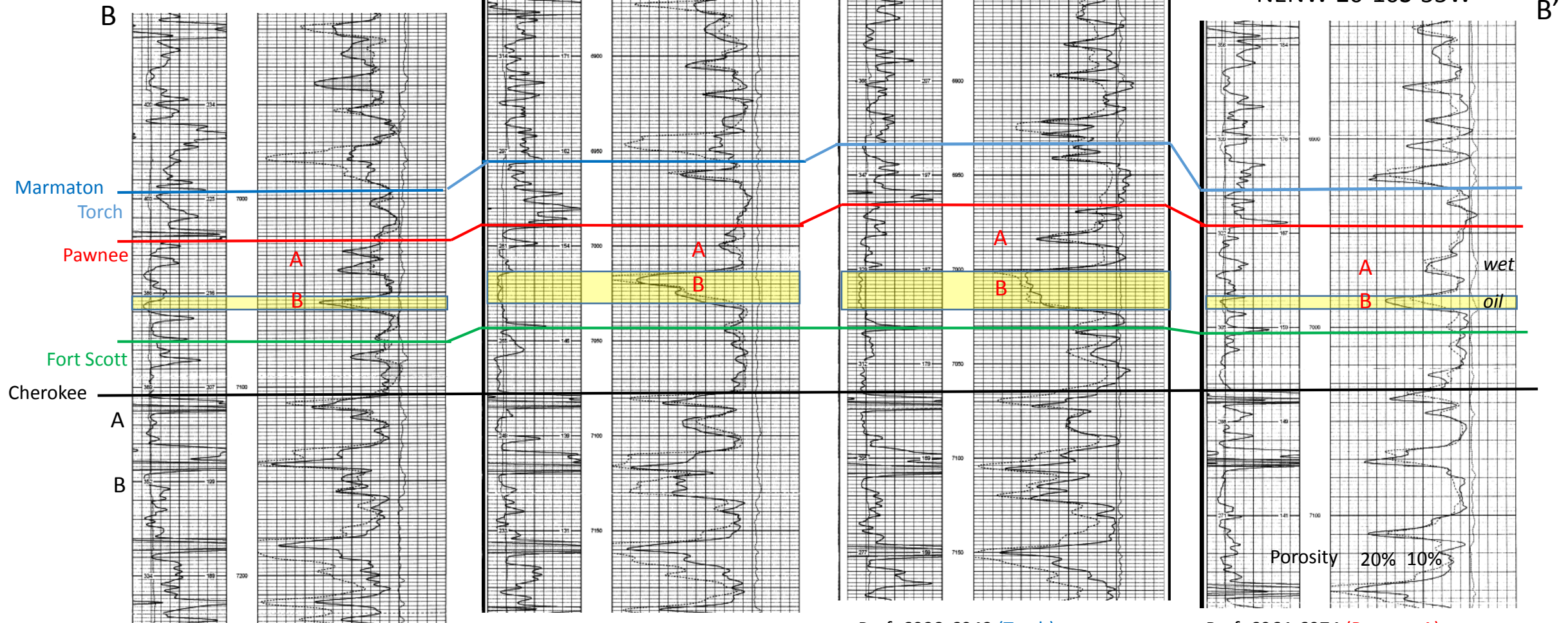
Great Plains Field continued.

Aloha Mula #1
SESW 19-10S-55W

Aloha Mula #9
NESE 19-10S-55W

Bubba State #2
SWNW 20-10S-55W

Bubba State #4
NENW 20-10S-55W



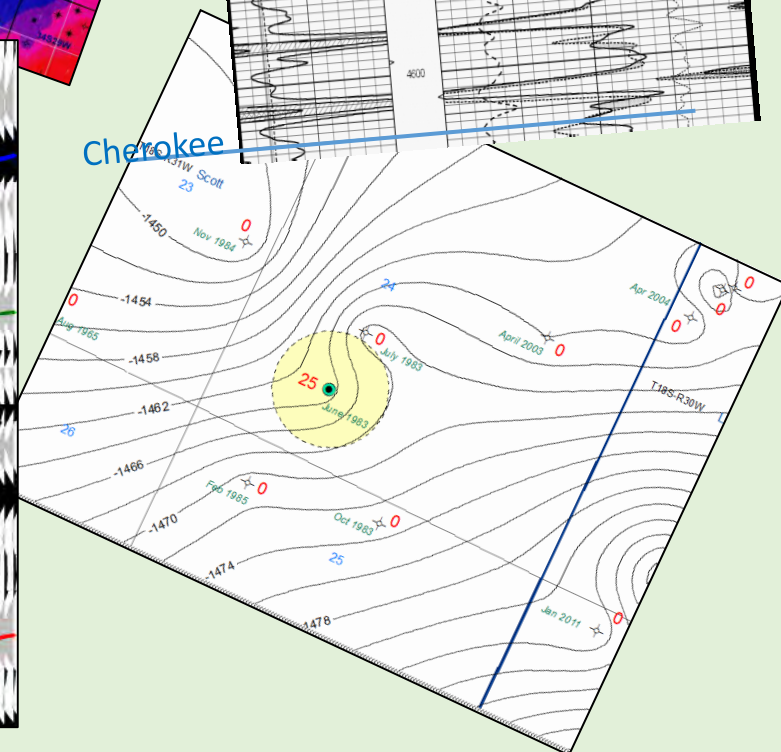
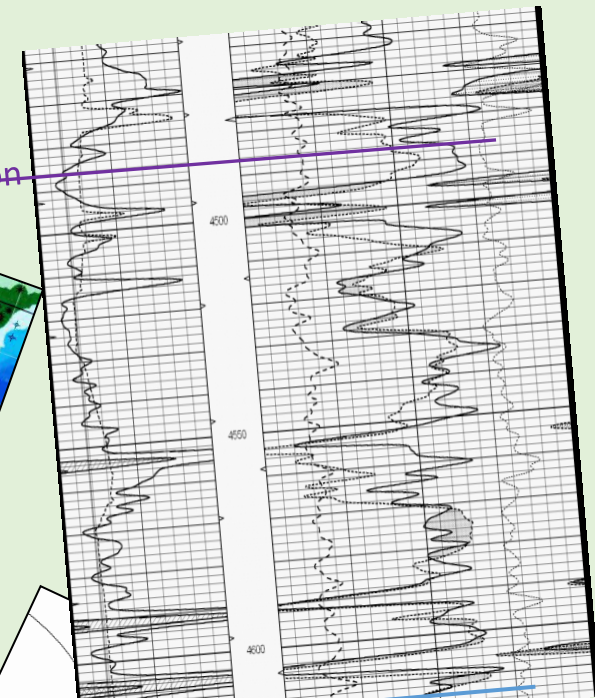
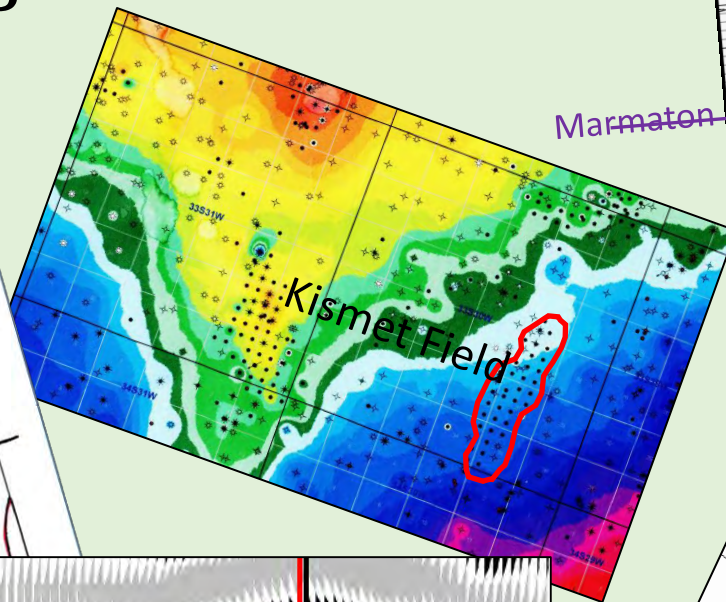
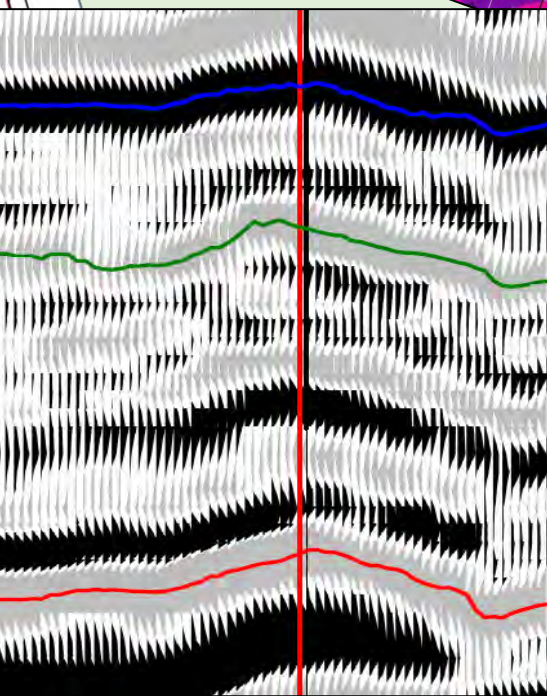
Perf: 7110-7118 (Cherokee A)
IP: 634 BOPD, 55 BWPD,
370 MCFGPD

Perf: 6954-6966 (Torch)
IP: 24 BOPD, 90 BWPD
Perf: 7014-7030 (Pawnee B)
IP: 12 BOPD, 105 BWPD, 21 MCFGPD

Perf: 6928-6942 (Torch)
IP: 162 BOPD, 81 MCFGPD

Perf: 6964-6974 (Pawnee A)
IP: 135 BWPD
Perf: 6980-6992 (Pawnee B)
IP: 114 BOPD, 171 BWPD

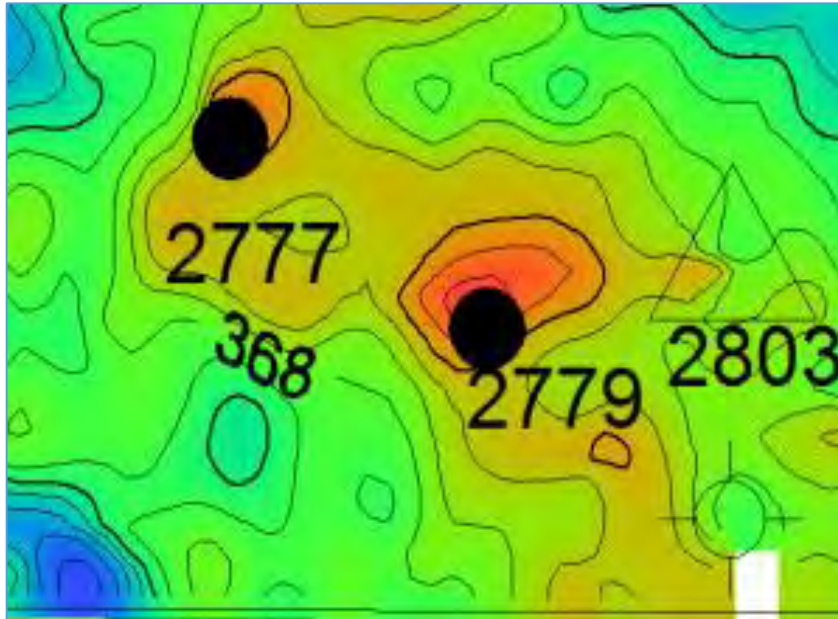
All logs are Neutron-Density Logs



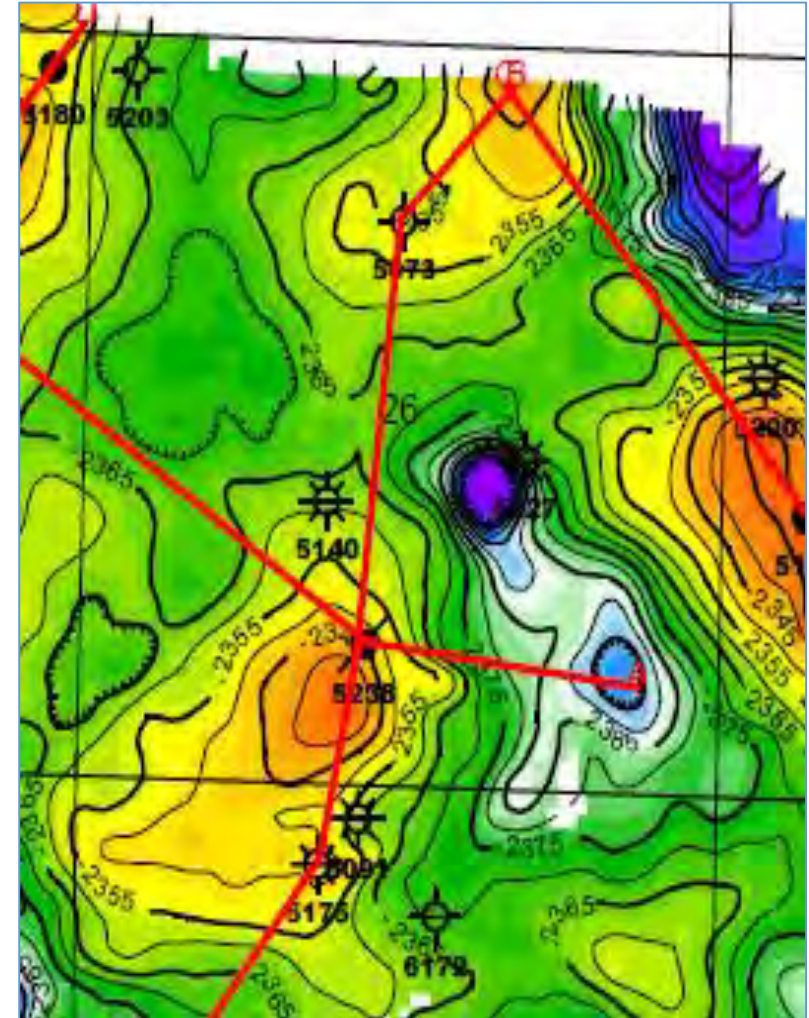
Exploration Considerations

1. Marmaton Fields are usually relatively small targets, with a few exceptions. 3-D Seismic is essential to help identify targets.

~1980 ft.



1 mile



Exploration Considerations continued...

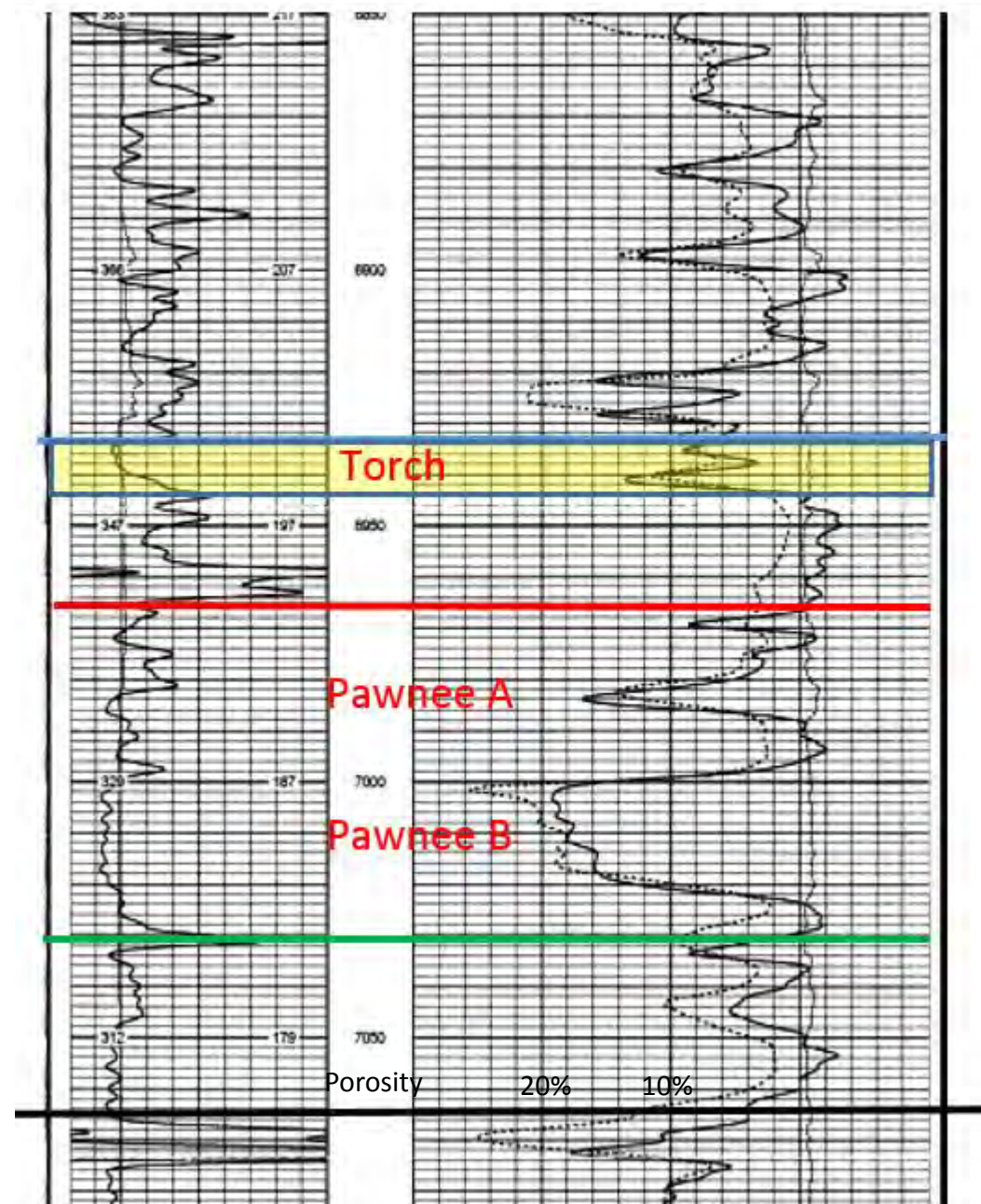
2. In many cases, Marmaton production has been discovered as a secondary target, or as a “surprise” while exploring for other groups/formations like the Lansing/KC, Cherokee, Morrow, and/or Mississippian.

Always map the Marmaton zones to see if an ideal drilling location can be selected that will test the primary target(s) and the Marmaton, if possible.

Also, watch the Marmaton closely during drilling for shows and consider DSTs.

The Bubba State #2 was a Cherokee test.
Marmaton Torch zone was a nice surprise in this well.
IP: 162 BOPD + 81 MCFGPD

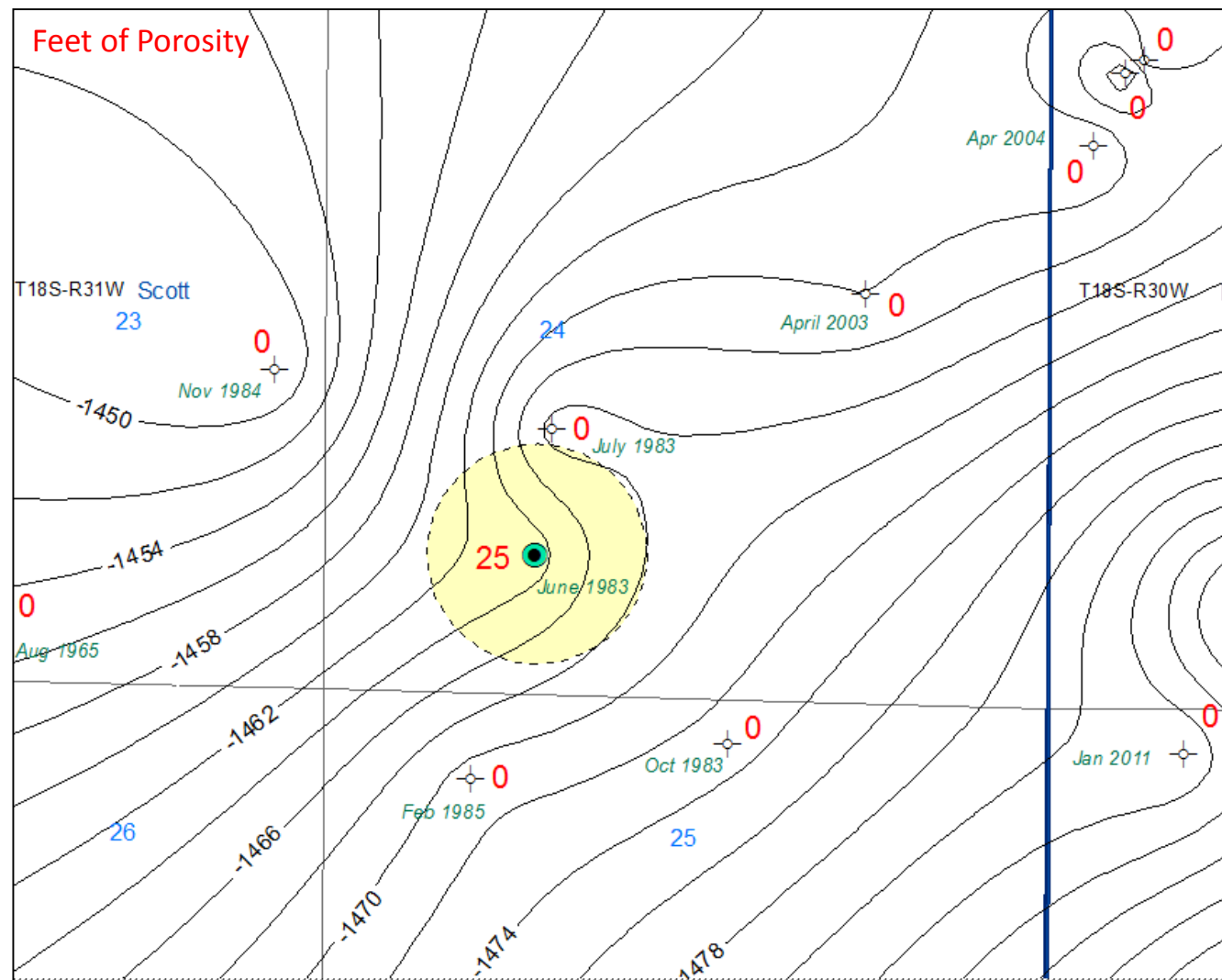
Bubba State #2 SWNW 20-10S-55W



Exploration Considerations continued...

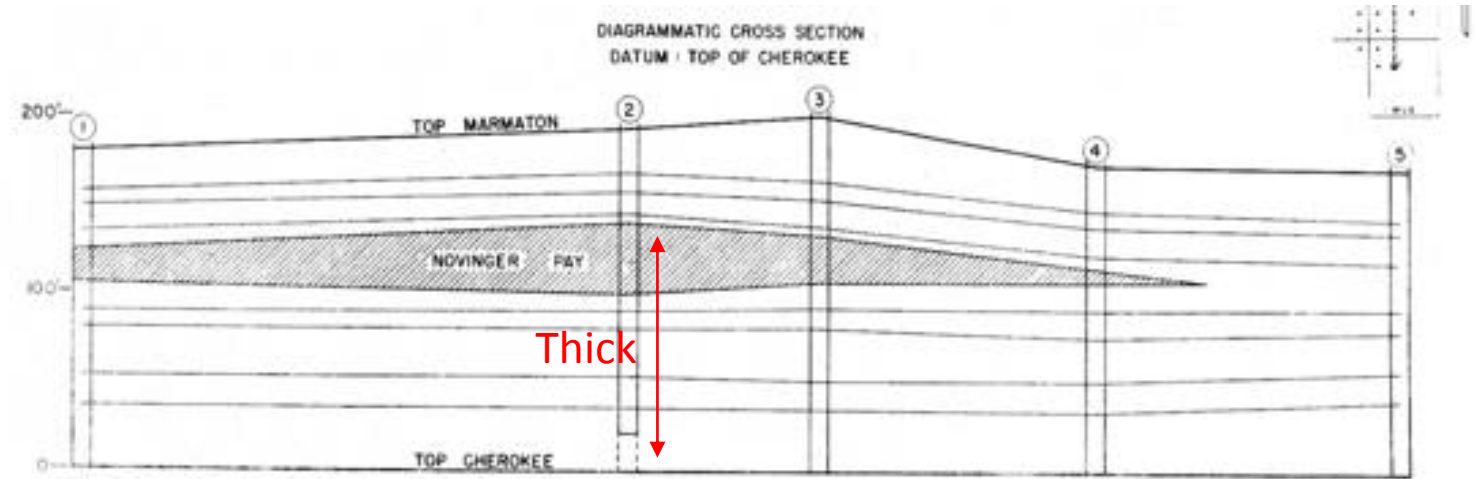
- Although good porosity zones in all 3 Marmaton Limestone intervals are widespread, predictions of the of porosity trends are difficult. There are many dry holes around good Marmaton producers that demonstrate this issue.

Cowdery West Field Example: There were five unsuccessful attempts to offset a good 158, 550 BBL Marmaton Well.

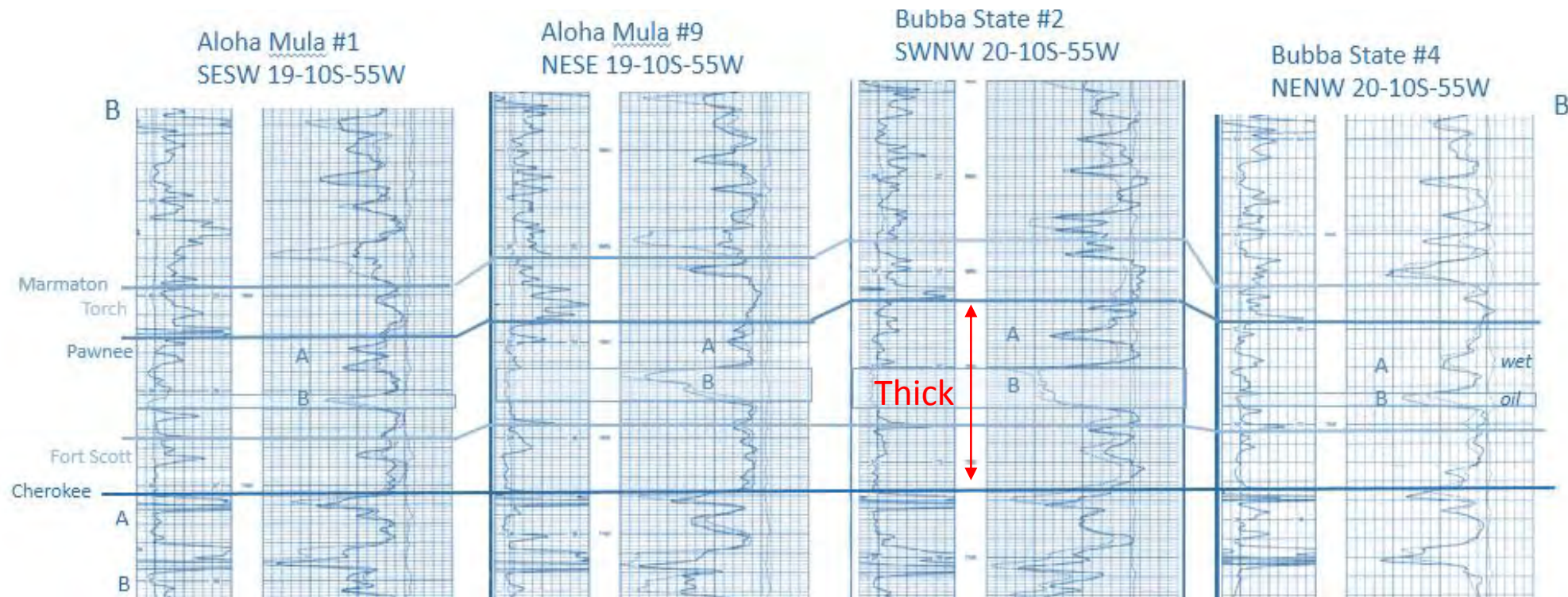


Exploration Considerations continued...

- Isopach maps of the individual cycles may reveal thick zones with deposits of high quality, oolitic grainstone reservoir rock.



Novinger Field Example

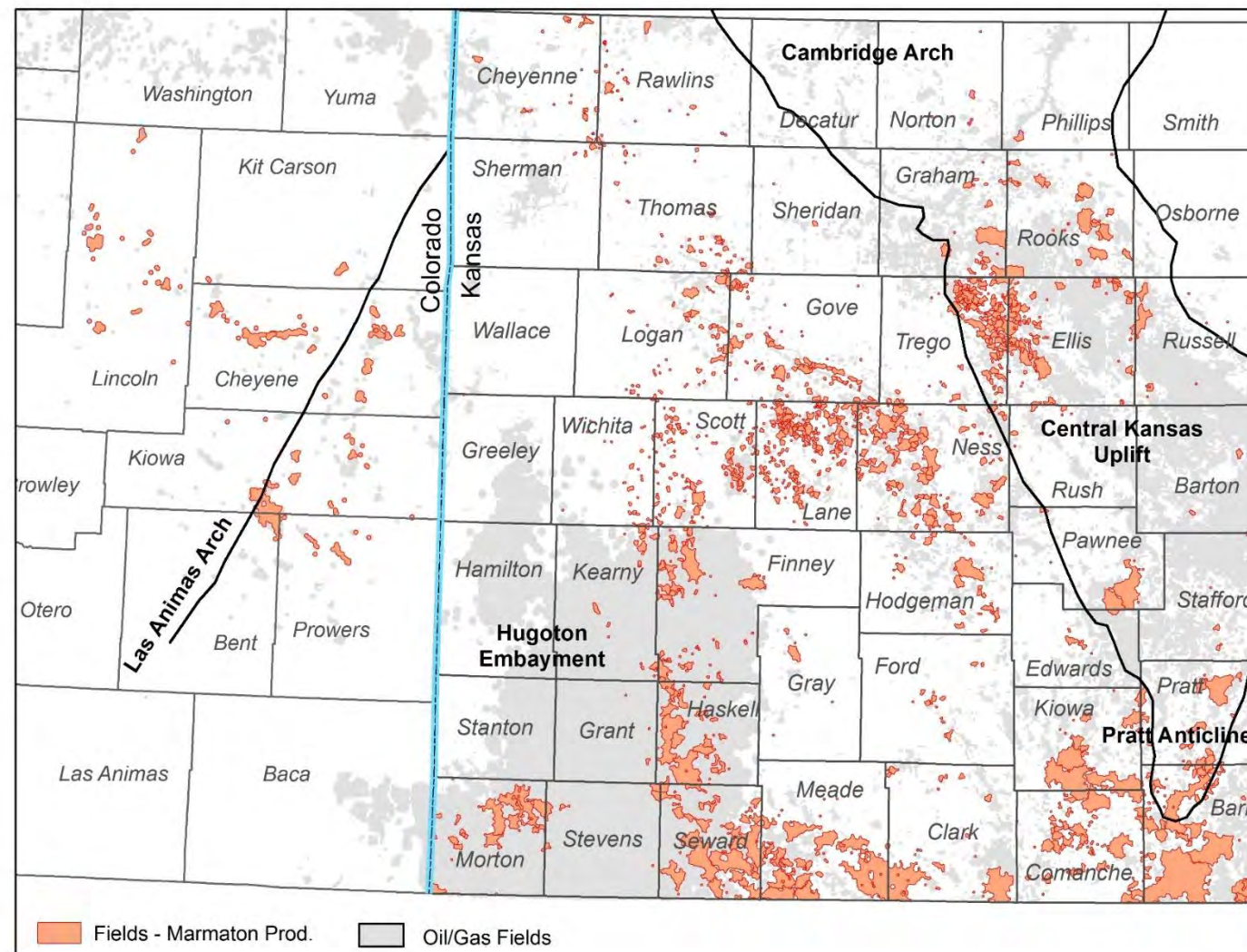


Great Plains Field Example

Exploration Considerations continued.

5. There is plenty of space between Marmaton Fields for the next half-million BBL White Woman Field.

An undiscovered 7-million BBL Novinger Field may also be waiting somewhere out there.



Thank You.



Jim Milne, Geologist, Ancient Oceans Energy, Ltd., milnej@comcast.net