

# **San Andres on the Northwest Shelf: Things You May Not Know\***

**Bob Trentham<sup>1</sup>**

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See similar article [Search and Discovery Article #51259 \(2016\)](#)

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## **Abstract**

Residual Oil Zones (ROZs) in the San Andres have gone from a “one off” a decade ago to established, economically producible reservoirs today. The science of ROZs have been documented over the past decade with DOE and RPSEA supported projects. There are now a variety of different methodologies used to produce oil from ROZs: co-mingled and separate “brownfield” ROZ and Main Pay CO<sub>2</sub> floods, CO<sub>2</sub> EOR ROZ floods peripheral to existing fields, “greenfield” CO<sub>2</sub> EOR ROZ floods without an associated main pay. Recently, horizontal depressuring (DUROZ) projects where horizontal wells target uneconomic classic vertical pay zones and ROZs together, have been developed on the Northwest Shelf and northern Central Basin Platform.

Despite the fact that there is now a decade of research into ROZs, and close to 20 projects producing oil for the ROZ, we need to step back and evaluate the relationship between ROZ targets and the complex depositional and diagenetic history of the San Andres to avoid the pitfalls associated with developing any new play. Assuming that the environment of deposition and diagenetic overprint are the same will lead you down that same garden path. Ditto for the fluid's properties in the ROZ.

## **Selected References**

Broadhead, R.F., 2004, Petroleum Geology of the Tucumcari Basin - Overview and Recent Exploratory Activity: New Mexico Geology, v. 26/3, p. 90-94.

Budding, A. J., 1980, Geology and Oil Characteristics of Tar Sands near Santa Rosa, New Mexico: New Mexico Geology, v. 2/1, p. 4-5.

Dutton, S.P., E.M. Kim, R.F. Broadhead, W.D. Raatz, C.L. Breton, S.C. Ruppel, and C. Kerans, 2005, Play Analysis and Leading-Edge Oil-Reservoir Development Methods in the Permian Basin: Increased Recovery Through Advanced Technologies: American Association of Petroleum Geologists Bulletin, v. 89/5, p. 553-576.

Dutton, S.P., E.M. Kim, R.F. Broadhead, C.L. Breton, W.D. Raatz, S.C. Ruppel, and C. Kerans, 2005, Play Analysis and Digital Portfolio of Major Oil Reservoirs in the Permian Basin: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 271, 287 p.

Dutton, S.P., E.M. Kim, R.F. Broadhead, C.L. Breton, S.C. Ruppel, W.D. Raatz, and C. Kerans, 2004, Play Analysis and Digital Portfolio of Major Oil Reservoirs in the Permian Basin: Application and Transfer of Advanced Geological and Engineering Technologies for Incremental Production Opportunities: The University of Texas at Austin, Bureau of Economic Geology, and New Mexico Institute of Mining and Technology, New Mexico Bureau of Geology and Mineral Resources, final report prepared for U.S. Department of Energy, under contract no. DE-FC2602NT15131, 408 p.

Kerans, C., 2006, San Andres Formation: Outcrop to Subsurface Stratigraphic Framework. Bureau of Economic Geology, PGGSP Annual Meeting, Austin, TX.

Koperna, G.J., and V.A. Kuuskraa, 2006, Assessing Technical and Economic Recovery of Oil Resources in Residual Oil Zones: prepared by Advanced Resources International (ARI), prepared for US Department of Energy, 107 p.

Martin, F.D., 1983, Steamflood Pilot in the O'Connell Ranch Field: New Mexico Energy Research and Development Institute, Report NMERDI 269-3302, 70 p.

McKallip, C., Jr., 1984, Newkirk Field - The geology of a Shallow Steamflood Project in Guadalupe County, New Mexico: Unpublished M.S. Thesis, New Mexico Institute of Mining and Technology, 89 p.

New Mexico Geologic Highway Map, Compiled by Maureen E. Wilks, 2005, New Mexico Geological Society and New Mexico Bureau of Geology and Mineral Resources, scale 1:1,000,000.

Pitt, W.D., and G.L. Scott, 1981, Porosity Zones in the Lower Part of the San Andres Formation, East-Central New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 179, 19 p.

Scott, G.L., and C.C. Joy, 1983, Recovering Heavy Oil in the Santa Rosa Sandstone (abs.), Conference on Improved Production of Oil and Gas in New Mexico: New Mexico Petroleum Recovery Research Center, pages not numbered.

Trentham, R.C., L.S. Melzer, V. Kuuskraa, and G. Koperna, 2015, Case Studies of the ROZ CO<sub>2</sub> Flood and the Combined ROZ/MPZ CO<sub>2</sub> Flood at the Goldsmith Landreth Unit, Ector County, Texas. Using "Next Generation" CO<sub>2</sub> EOR Technologies to Optimize the Residual Oil Zone CO<sub>2</sub> Flood: DOE DE-FE0005889, 231 p.

Trentham, R.C., L.S. Melzer, D.B. Vance, V. Kuuskraa, and R. Petrusak, 2015, Identifying and Developing Technology for Enabling Small Producers to Pursue the Residual Oil Zone (ROZ) Fairways in the Permian Basin San Andres: Research Partnership to Secure Energy for America (RPSEA) 10123.17.FINAL, Final Report, 504 p.

Trentham, R.C., L.S. Melzer, and D. Vance, 2012, Commercial Exploitation and the Origin of Residual Oil Zones: Developing a Case History in the Permian Basin of New Mexico and West Texas: Research Partnership to Secure Energy for America (RPSEA) 08123-19 final report, 157 p.



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2017 SW AAPG

Bob Trentham

## ***Residual Oil Zone Studies and Technical Reports***

- Assessing Technical and Economic Recovery of Oil Resources in Residual Oil Zones. ARI, Melzer, DOE Report, 2006. [NETL Website](#)
- Commercial Exploitation and the Origin of Residual Oil Zones: Developing a Case History in the Permian Basin of New Mexico and West Texas UTPB, Melzer, Arcadis. RPSEA 08123-19 final report, 2012. [NETL Website](#).
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- Identifying and developing technology for enabling small producers to pursue the residual oil zone (ROZ) fairways in the Permian Basin San Andres. UTPB, Melzer, Arcadis, ARI. RPSEA 10123.17 Final Report, Dec 2015. [NETL Website](#).

# Things we think we know...or should.

- Horizontal San Andres play is not the carbonate equivalent to shales
- Evidence points to likely success in Huff-n-Puff projects after horizontal depressuring: using CO<sub>2</sub> or Ethane thru Pentane?
- Movement on deep faults cause flexures in the San Andres:
  - Those flexures **can** result in **transmissive** fractures
  - Those fractures are a pathway for migration/sweep for oil/water/frac fluids
  - Those fractures, when healed, can alternatively be **lateral seals** to fluids and fracs.
  - The TDS in MNW is a critical element in the efficiency of sweep. Focused in fractures?
- Higher GOR's are critical to the success of a horizontal San Andres.
- Drawing pressure down to below bubble point is essential in horizontal Depressuring.
- Going up? Going Down? Which way does the frac go?
- 2017 is an Exciting Year - ongoing case histories - open holes, smaller or no fracs?
- Are all ROZ CO2 projects going to FLOOD the same?
- **The Northwest Shelf is not monolithic.**
- And by extension, neither is the Central Basin Platform.

# We'll concentrate on the Northwest Shelf today.

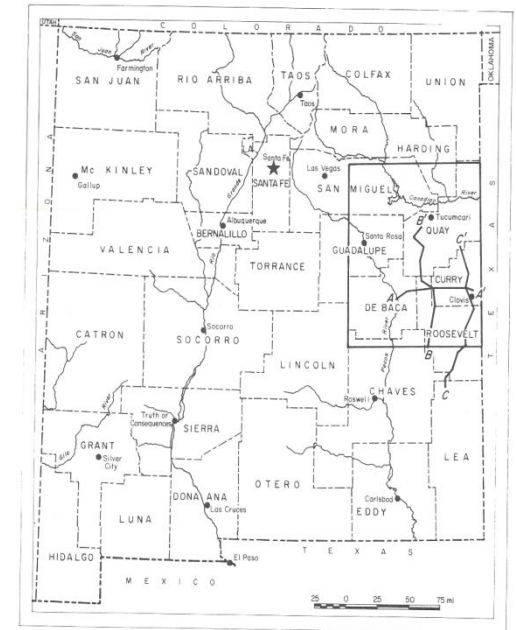
- The Northwest Shelf is not monolithic:
- There are exit pathways for San Andres oil to migrate out of the basin to the north.
- Correlations and facies distribution indicate the Maximum Flood was during the "P4". This makes it equivalent to the Cutoff Formation, the "G-1", and the McKnight Shale.
- Hot Water? Was the Slaughter Levelland Trend swept by Mother Natures "Hot Tea Flood"?
- What happening to the Limestone in 14S?

There are exit pathways for San Andres oil to migrate out of the basin to the north.

**Porosity zones  
in lower part of San Andres Formation,  
east-central New Mexico**

by William D. Pitt and George L. Scott

1981



INDEX MAP SHOWING LOCATION OF STUDY AREA.



## Oil Shows North of the Matador Arch

The most important oil show in the region north of the Matador Arch is represented by the Santa Rosa Tar Pit, 6 miles north of Santa Rosa and I-40, in T9N, R21E.

The asphalt pit has an estimated 90 MMBO (Broadhead, 2004 quoting Budding, 1980). The oil has been typed and is believed to have migrated from the San Andres during post Triassic time.

Newkirk oil field in NE Guadalupe County contains heavy oil at depths of 400–800 ft; (Broadhead, 2004 quoting Martin 1983; McKallip 1984). Estimated resources are 62 million bbls of oil in place (Broadhead, 2004, quoting Scott and Joy, 1983).

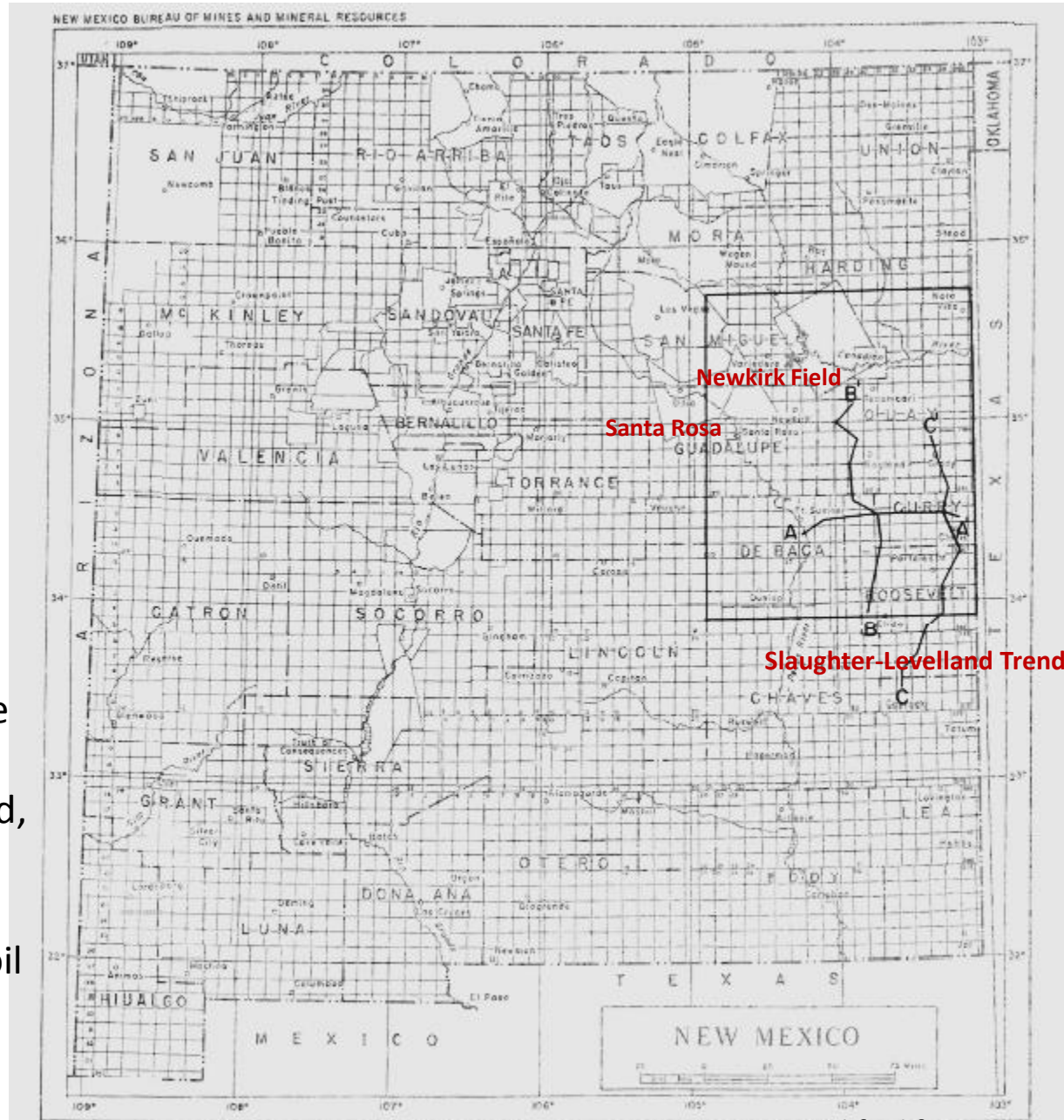
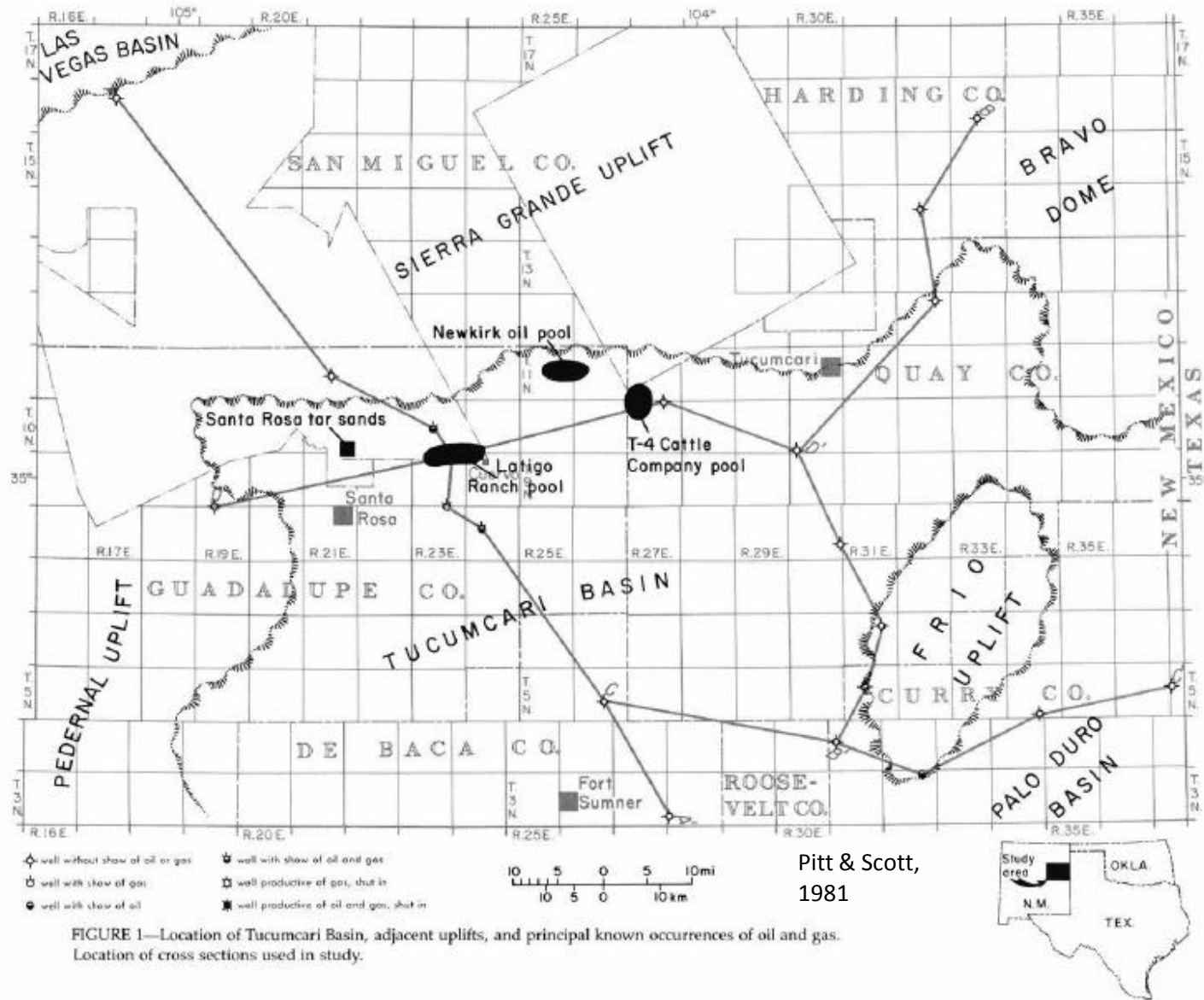


FIGURE 1—INDEX MAP SHOWING LOCATION OF STUDY AREA.

Modified from  
Pitt & Scott, 1981



The northern limit of correlation of the lower San Andres P-3, P-4, and P5 is coincident with the northern margin of the Tucumcari Basin. What exploration there has been in the Tucumcari has “Bombed-Thru” the San Andres looking for Penn clastics.

We'll look at  
P-3, P-4, & P-5

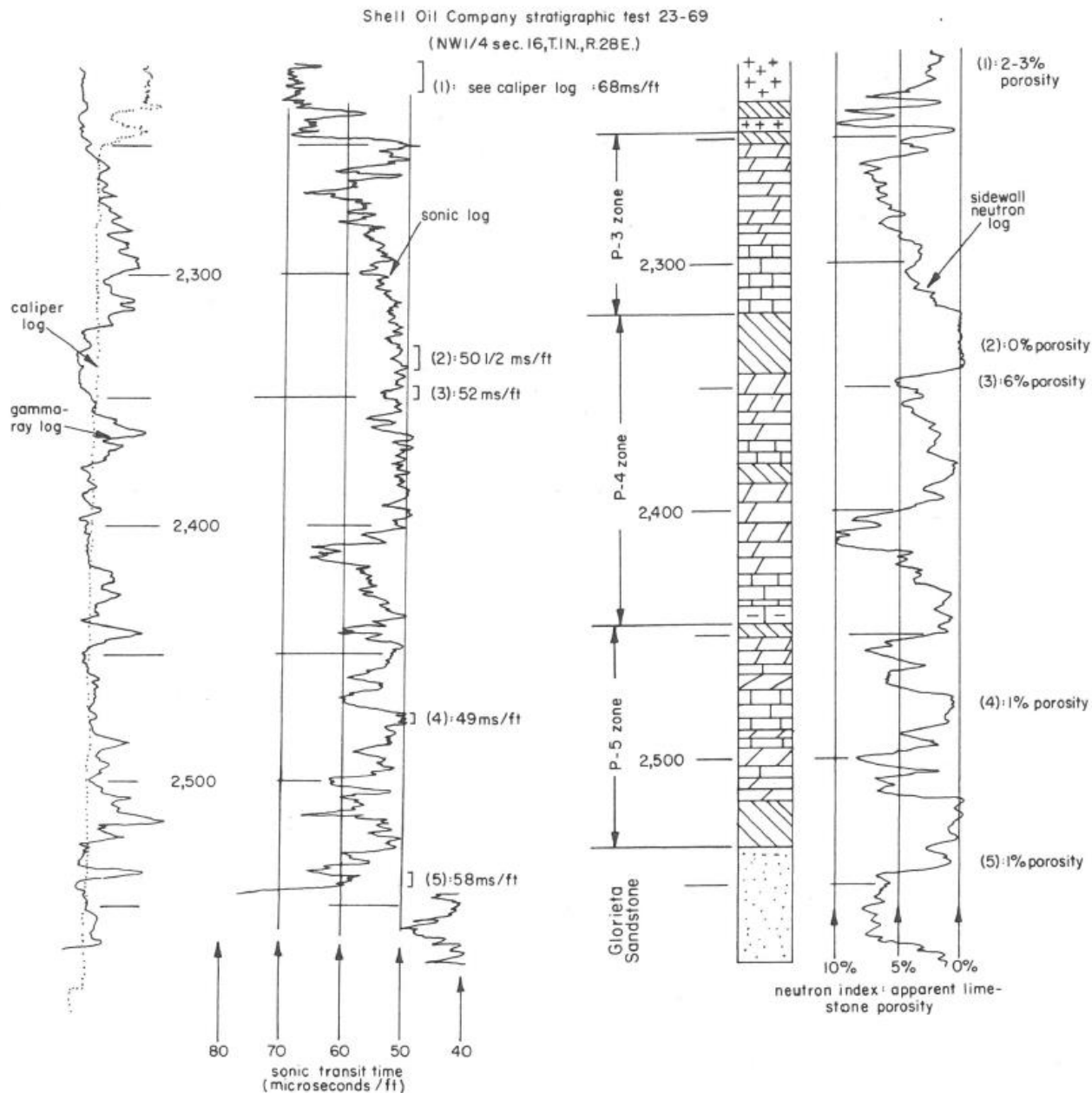
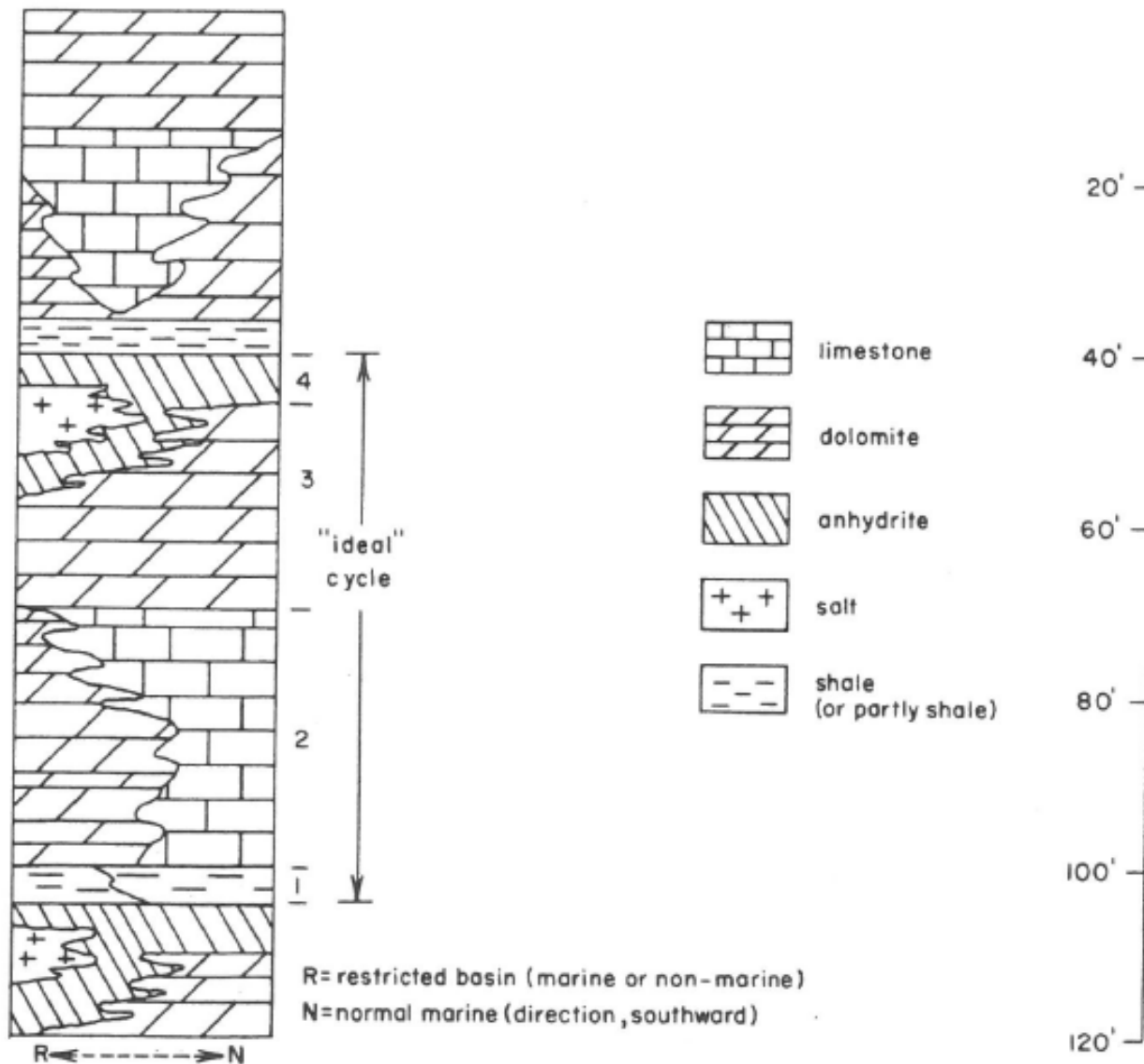


FIGURE 3—LOWER SAN ANDRES FORMATION LOG INTERVALS, showing intervals of cross-plot lithologic determinations.



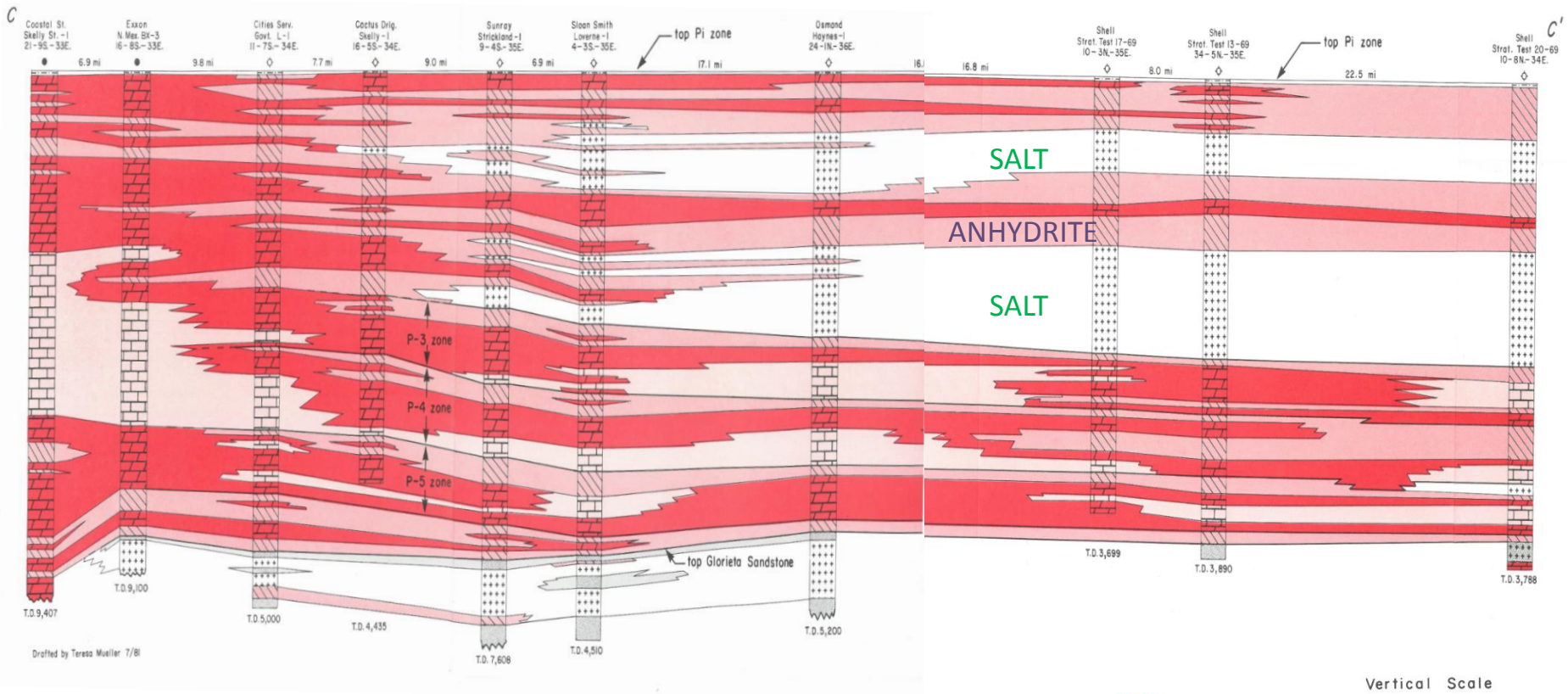
P-3, P-4, and P-5 are typically not productive and are LIMESTONE to the south and LIMESTONE and DOLOMITE to the north.

FIGURE 5—TYPICAL LITHOLOGIC SEQUENCE OF LOWER SAN ANDRES DEPOSITIONAL CYCLES.



South

North

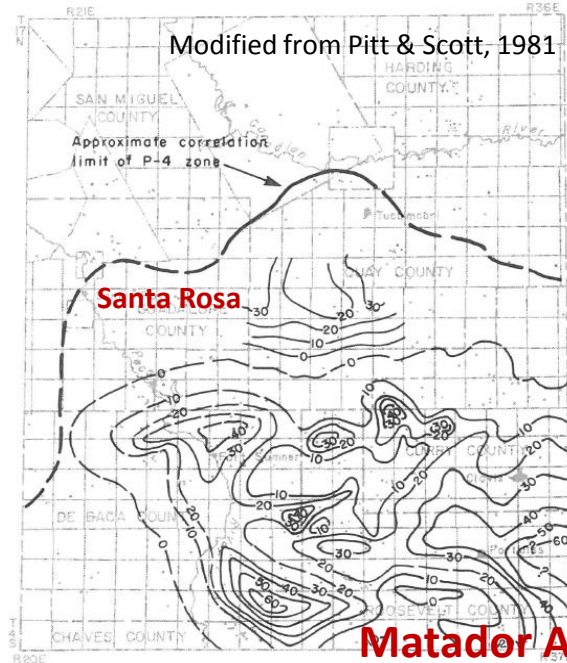


The cross sections show limestone as far north as TWN 8N.

P-1 and P-2 are EVAPORITIC to the North.

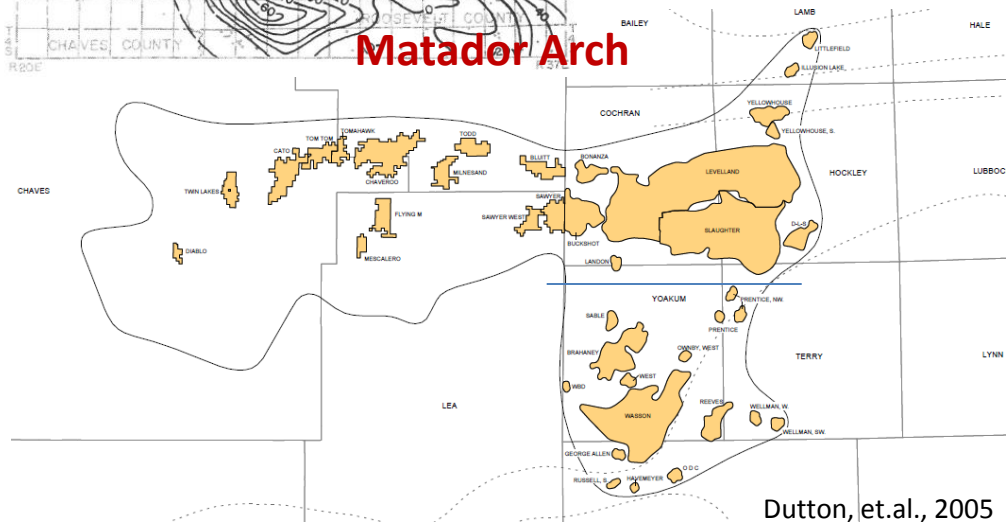
Where P-1 & P-2 are evaporitic, P-3, P-4, & P-5 are Limestones and Dolomites.

# Comparison of northern extent of P4 porosity and production from the Slaughter-Levelland trend (P1 and P2)



Greater than 10% porosity in P-4.

P4 is proposed to have been the “Maximum Flood” for the lower San Andres.





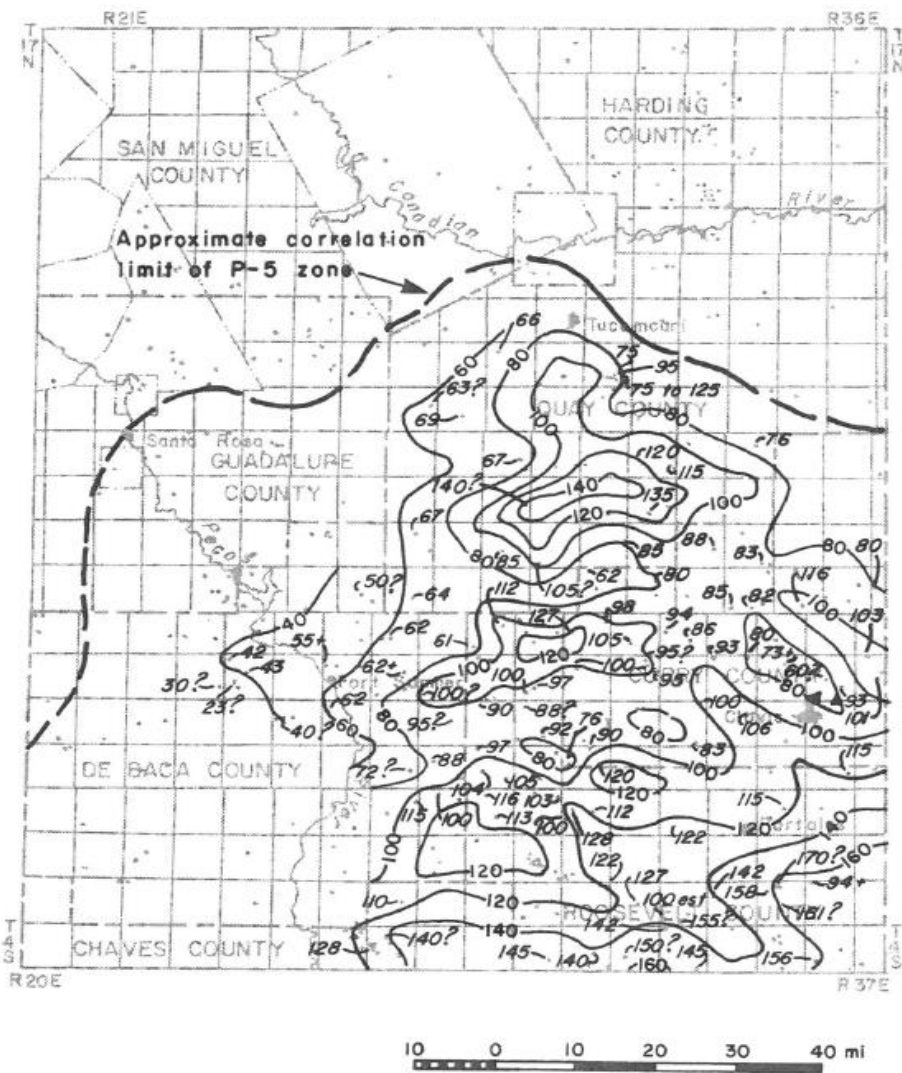


FIGURE 15—ISOPACH MAP OF P-5 ZONE; contour interval equals 20 ft, depths of well measurements shown in feet.

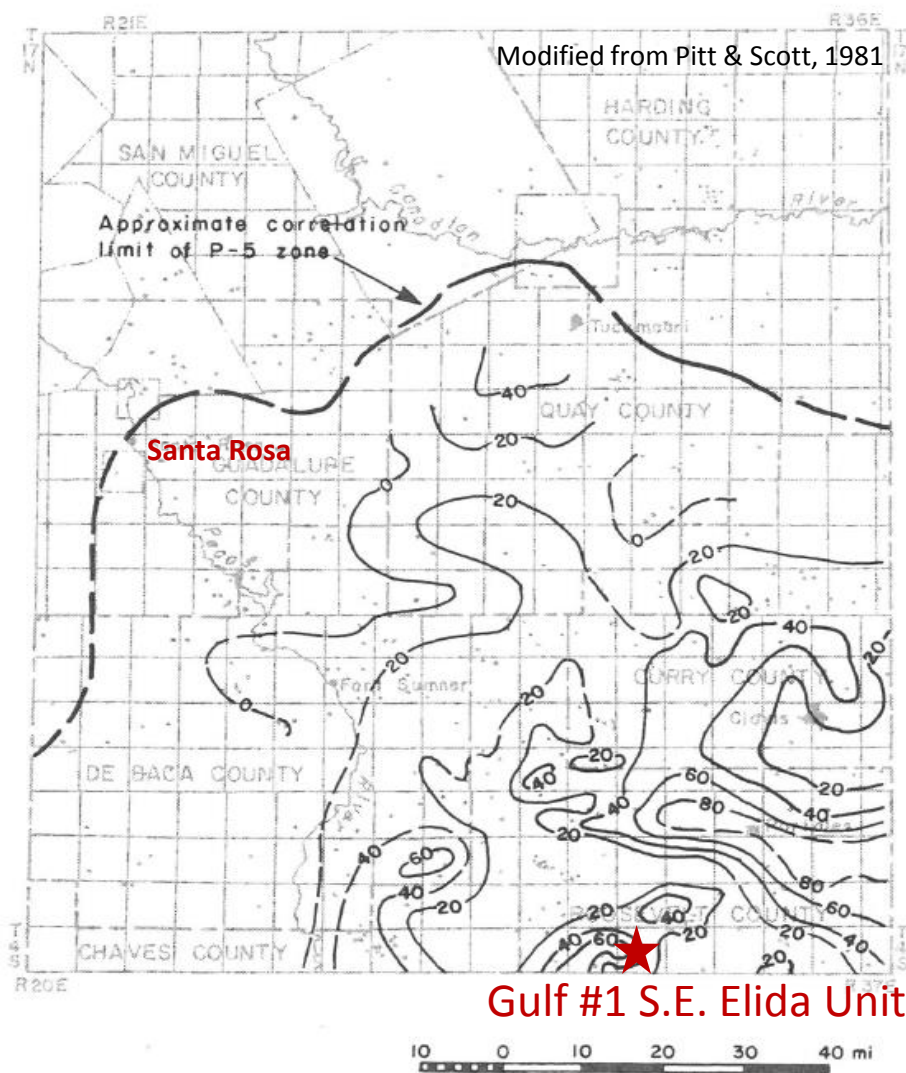


FIGURE 17—THICKNESS IN FEET OF P-5 ZONE WITH 10+ PERCENT POROSITY; contour interval equals 20 ft.

The **Gulf #1 N. E. Elida Unit**, is in sec 1, 4 S, 32 E in Roosevelt County. Oil was seen on the pits, and it was expected that this would be a new field discovery, cores were taken and DST's run but it was determined that there was insufficient cause to set pipe and attempt to complete.



FIGURE 11—Isopach map of P-4 zone; contour interval equals 20 ft, depths of well measurements shown in feet.

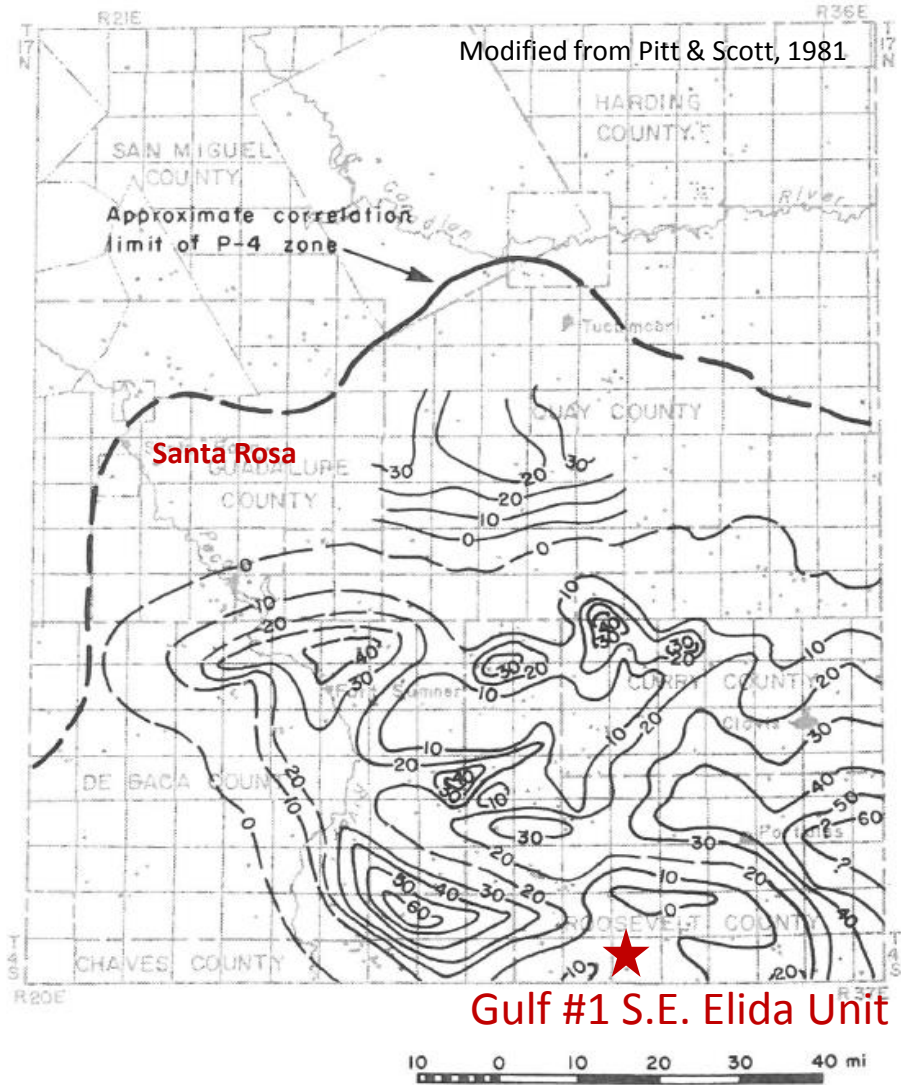


FIGURE 13—Thickness in feet of P-4 zone with 10+ percent porosity; contour interval equals 10 ft.

Although there is a greater thickness of P-5 further north, the Thickness of >10% is found in P-4 in the Tucumcari Basin.



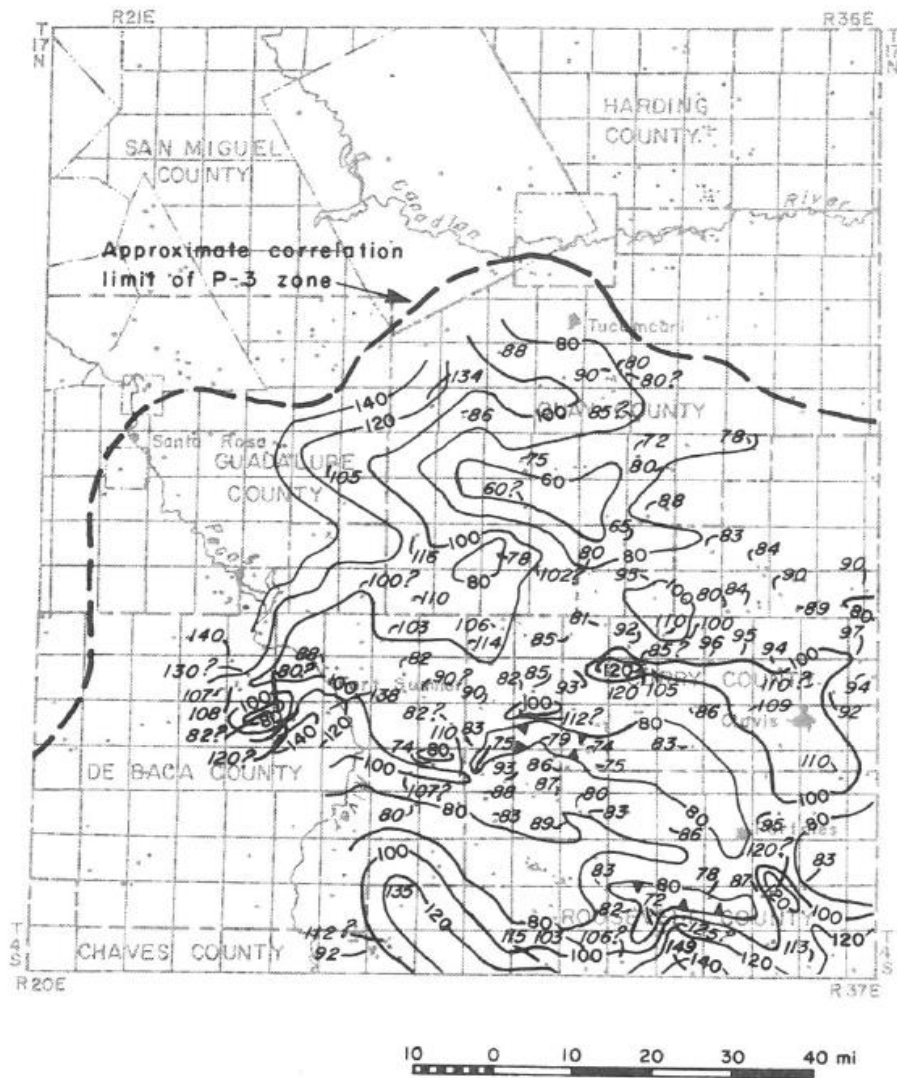


FIGURE 6—ISOPACH MAP OF P-3 ZONE; contour interval equals 20 ft, depths of well measurements shown in feet.

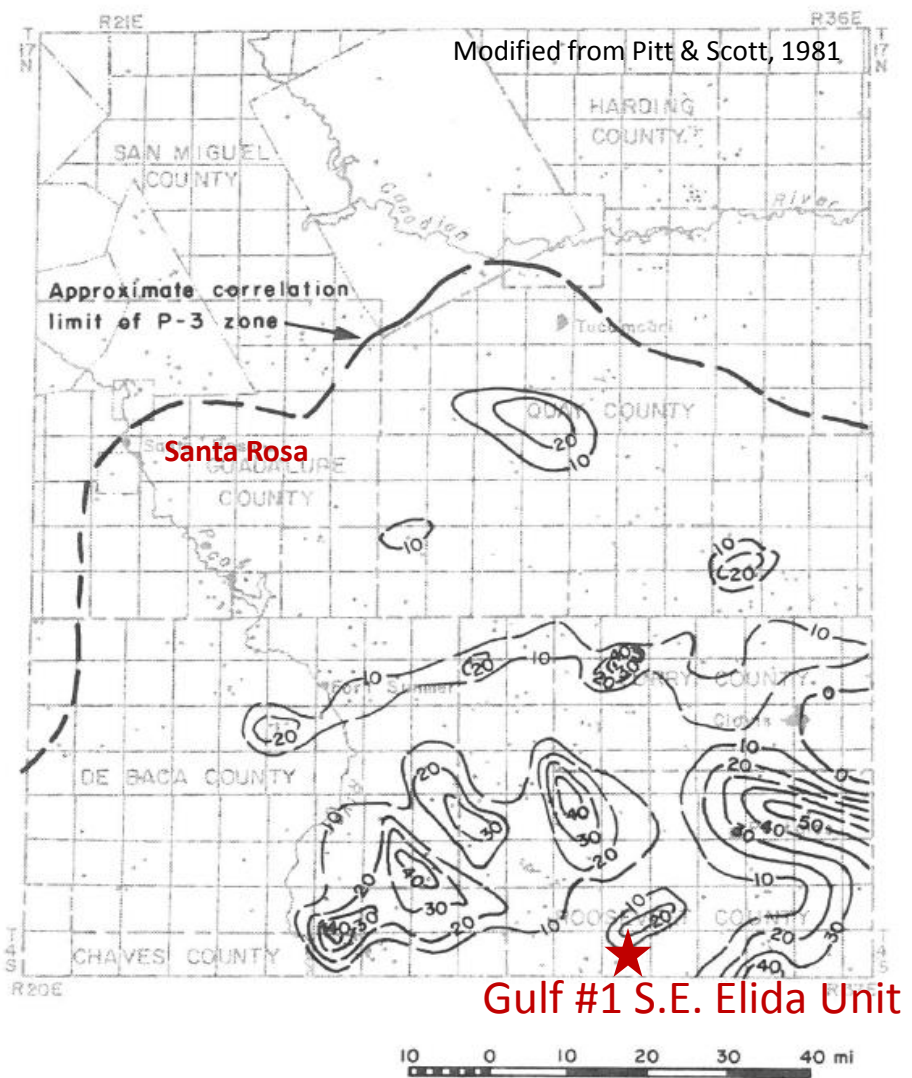


FIGURE 8—THICKNESS IN FEET OF P-3 ZONE WITH 10+ PERCENT POROSITY; contour interval equals 10 ft.

P-3 is significantly thinner in the Tucumcari Basin and is evidence of the “turnaround” and initiation of the highstand.

Our work extended these correlations to TWN 15 S and west to the Sacramento Mountains to tie into the San Andres outcrops.

Sacramento Mtns  
Measured Section,  
Elliott, 1988

COG #1 Bagley 16 St  
11 33 16 025-36903

Phillips 1 Johnson St  
10 33 26 025-27707

Yates 1 BLF Abby St  
09 33 10 025-38951

Yates #1 Boomerang  
08 33 26 005-29036

Sabre #11 Roberts  
07 33 09 041-20416

Yates #1 ZE Cleary Fed  
07-29-24 041-62150

BHP #1 Coll  
06 33 10 041-20725

Ensearch #1 Harvey  
05 33 06 041-20558

Pi Marker

P-1

P-2

P-3

P-4

P-5

Four  
Mile  
Draw

Bonney  
Canyon

Rio Bonito

Yellow  
house

Yellowhouse

Yellowhouse

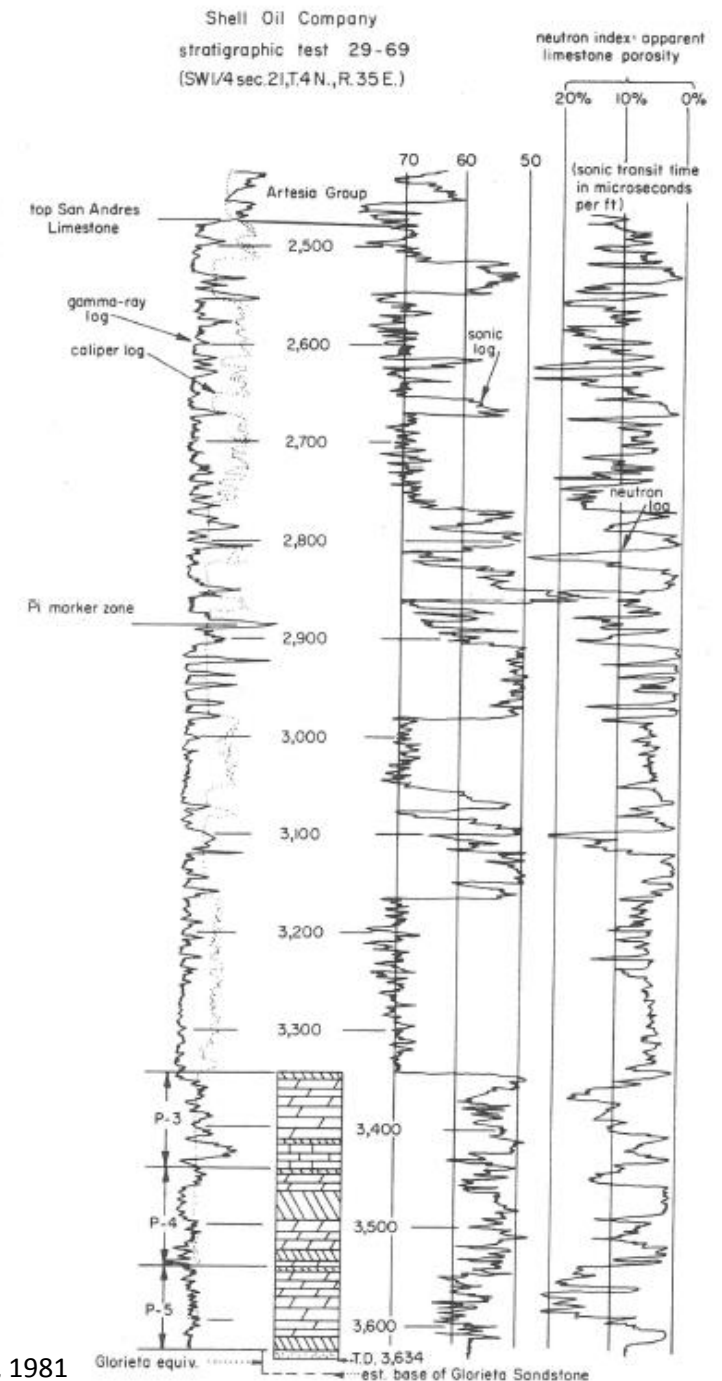
Yellow  
house

Yellowhouse

Yellowhouse

Yellow  
house

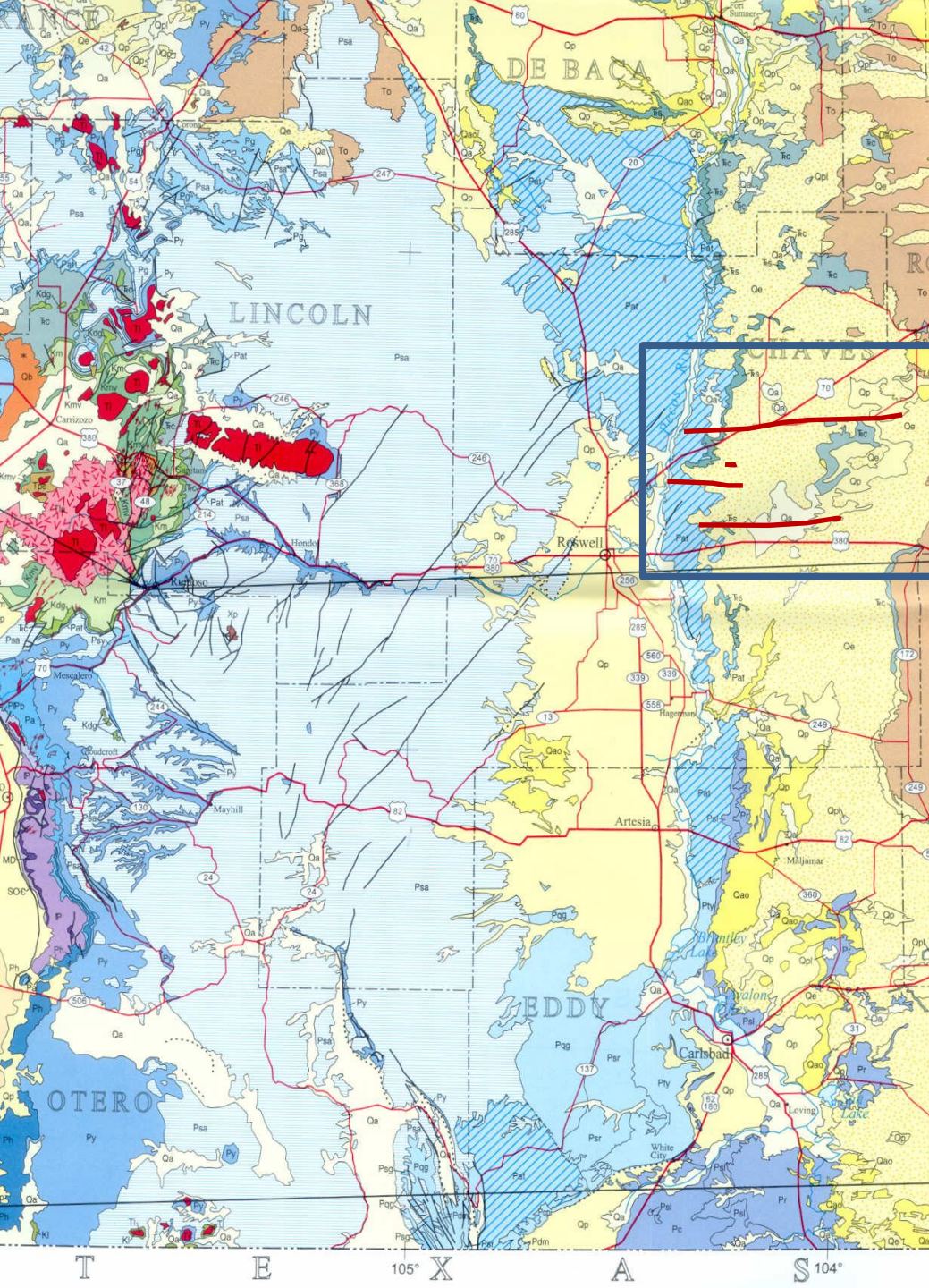
- Based on the extent of deep water limestone in the P-4, and assuming therefore, that the P4 is the maximum flood, can we also assume that the P4 is equivalent to the El Centro Member of the Cutoff Formation and the McKnight Shale on the Central Basin Platform?
- To quote Willis Terrell (2011, WTGS): “The El Centro Member of the Cutoff is a good time marker being only slightly younger than the world standard base of the Guadalupian Series”.



	Guad Mts.	Downdip Northwest Shelf	Updip Northwest Shelf NM TX		Delaware Basin	Central Basin Platform	Eastern Shelf, NE Midland Basin
	Guad. 10	Grayburg 1 Premier Sand	Evaporites		U. Cherry Cnyn	L. Grayburg	L. Grayburg
Upper San Andres Composite Seq. CS10	Guad. 9	Upper S A Lovington Sand	Evaporites		L. Cherry Cnyn	U. San Andres Lovington Sand	
	Guad. 8	Upper S A	P1-3	Slaughter 1-3		U. San Andres	U. San Andres Cedar Lake, Welch
	Guad. 7				Brushy Canyon		
	Guad. 6						
	Guad. 5						
Lower San Andres Composite Seq. CS9	Guad. 4	Upper S A2	P4	Slaughter 4	U. Bone Spring or Cut Off	San Andres	San Andres
	Guad. 3	Upper S A 1	P5	Slaughter 5		San Andres	
	Guad. 2	Middle S A2	P6			McKnight Shale	
	Guad. 1	Middle S A 1	P7			Holt	Lower San Andres Howard Glasscock, Iatar, Ddiamond M
	Leonardian 8	Lower S A 2	P8				
	Leonardian 7	Lower S A 1	P8		Pipeline Sh		
	Leonardian 6	Glorieta	Glorieta		Bone Spring	Glorieta	San Angelo

	Proposed Correlation				
Guadalupean 8					
	Brushy Canyon Bypass Surface		Pi Marker		
Guadalupean 3-4			P-0		
Guadalupean 3-4			P-1		
Guadalupean 3-4			P-2		
Guadalupean 2		McKnight	P-3		Williams Ranch?
Guadalupean 1	Maximum Flood	McKnight Shale	P-4	Cutoff	El Centro?
Leonardian 8		Holt	P-5		Shumard?
Leonardian 7		Holt	P-6		
Leonardian 6	Glorieta	Glorieta	Glorieta		





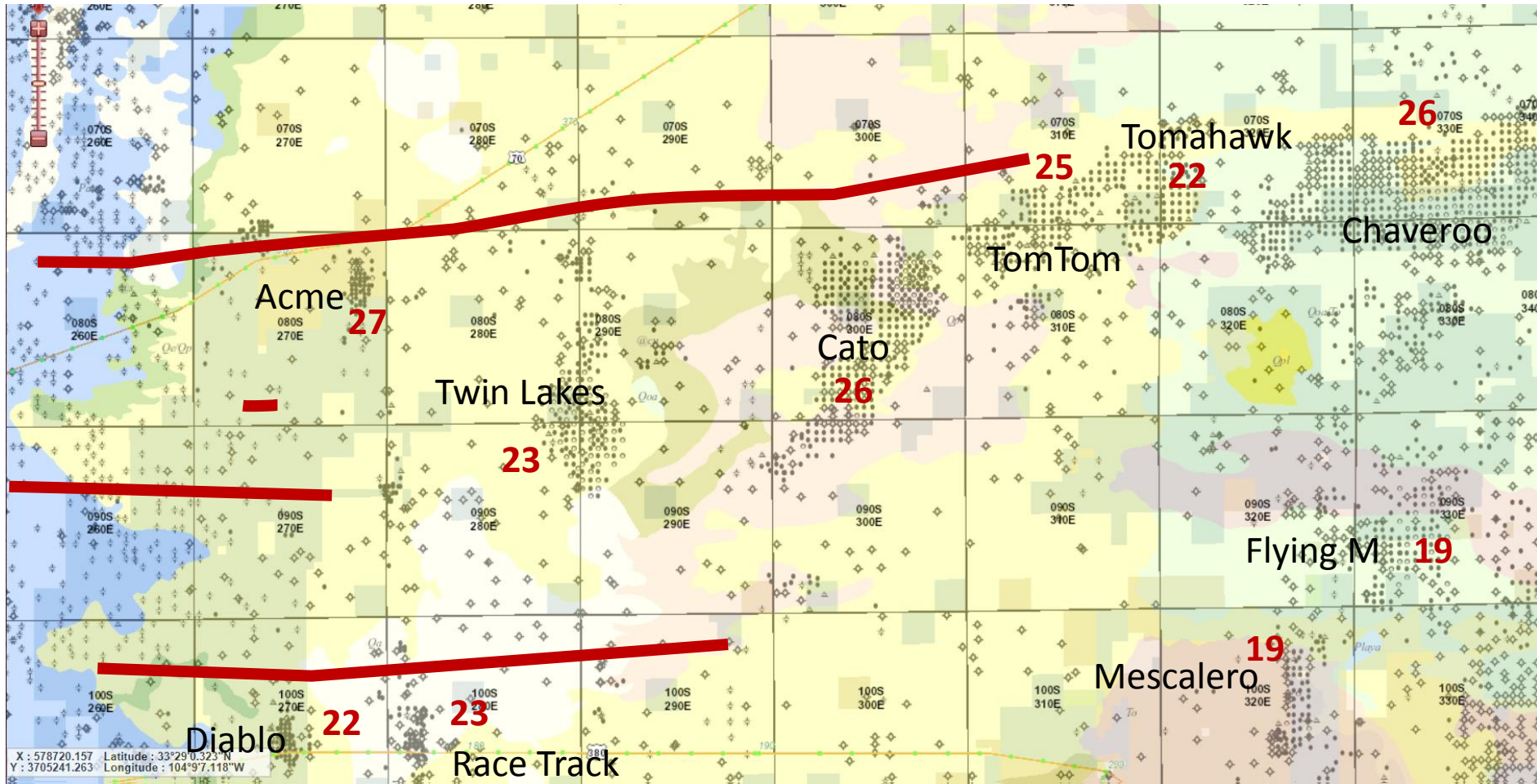
San Andres outcrop  
(light Blue) is the  
present day extent of  
the recharge area for  
the meteoric water  
that sustains the  
tilted oil water  
contacts in San  
Andres reservoirs.  
Railroad Mountain  
Dikes in blue box.



The dikes in the region (including Railroad Mountain and Jones Camp) lie on the WNW trending **Capitan Lineament**. The Capitan lineament extends from the Matador arch in west Texas, westward to Socorro, NM. The period was late Tertiary (30 to 26.5 Ma) during which mafic alkalic dikes and granite plutons were emplaced along the Capitan lineament and minor granites were intruded into the Sierra Blanca complex. This later period is associated with the early stages of Rio Grande rifting. Constantopoulos, 2017 pers. Comm.



# Evidence of “ Railroad Tracks” flushing along the Slaughter Levelland Trend? Low API gravity oils in the San Andres fields.



There are other theories as to why the API gravities in this trend are so low (Ramondetta, 1980...but the “Hot Tea” flood certainly needs to be evaluated.

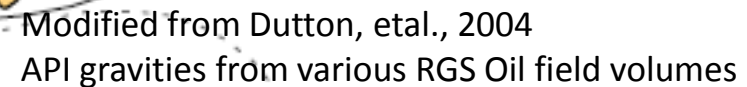
Anybody have Water Chemistry we can have?

Geologic map of New Mexico, NE of Roswell.

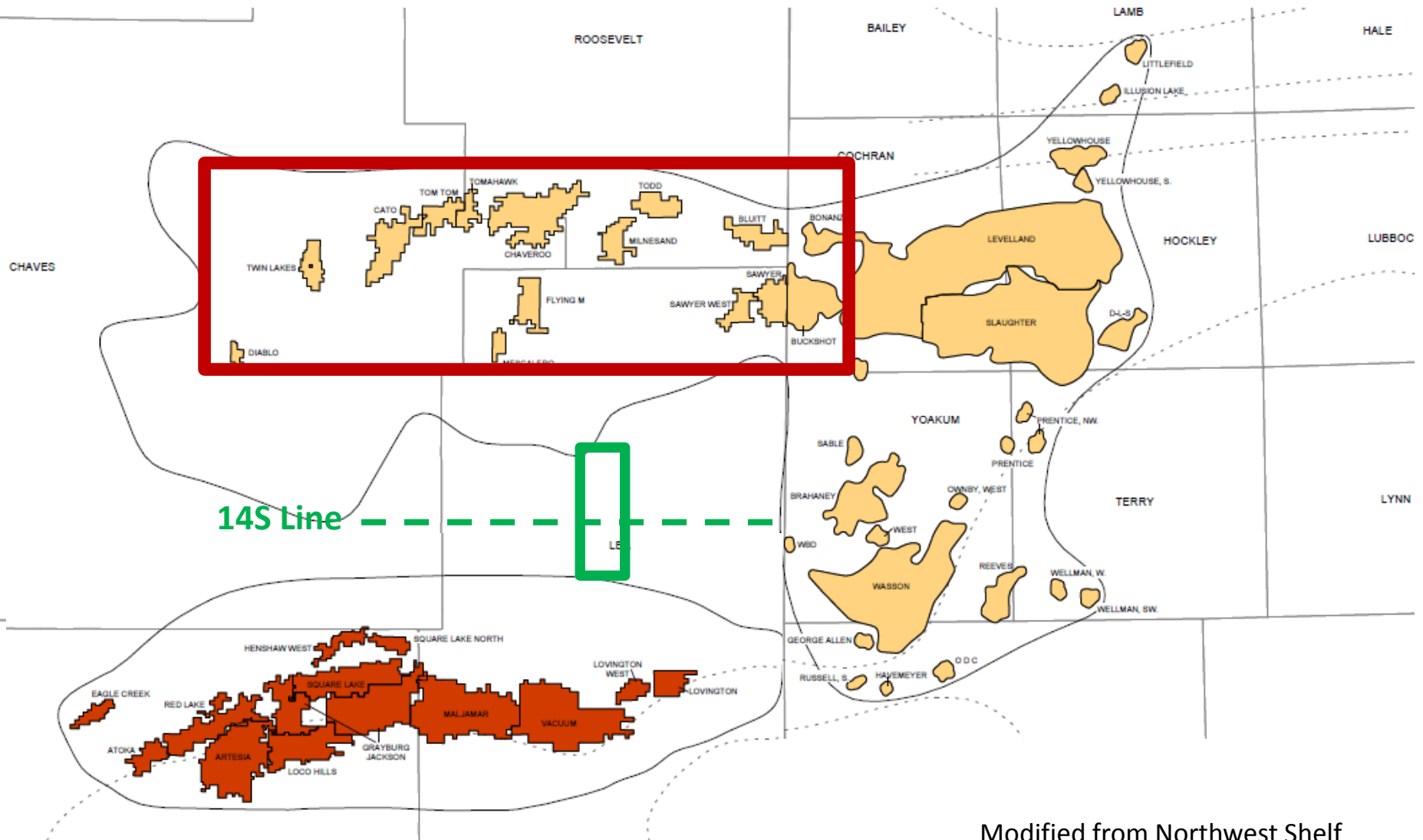
Location of 4 “Railroad” dikes with oil, gas, and minerals NM State Land Office Base



Map of the Fort Worth area showing the number of police officers per precinct. The map includes precincts such as Cato, Tom Tom, Tomahawk, Todd, Milnesand, Bluff, Bonanza, Chaveroo, Flying M, Mescalero, Sawyer West, Sawyer, and Buckshot. The number of officers per precinct is indicated by a red number next to the precinct name.



# The TWN 14S line. What is going on?



Modified from Northwest Shelf  
San Andres fields. Dutton, 2004

Between the north side of TWN 13S and the south side of TWN 15S, The +/- 500' of Limestone in the P3, P4 and P5 is reduced to 0'. What's going on?

Will this impact the success of Horizontal San Andres wells?

15 34 34 30-025-25324  
Sabine 1 Eidson

15 34 09 30-025-27832  
Mapco 3 Morton Solid

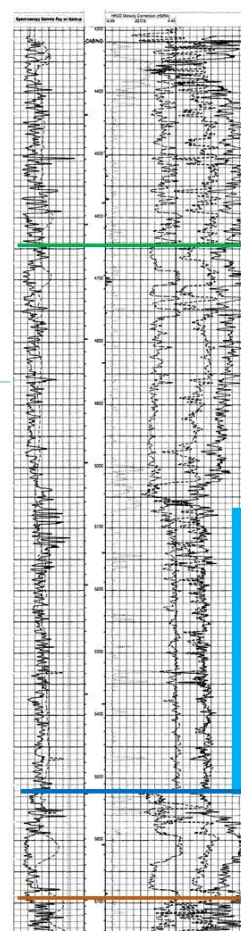
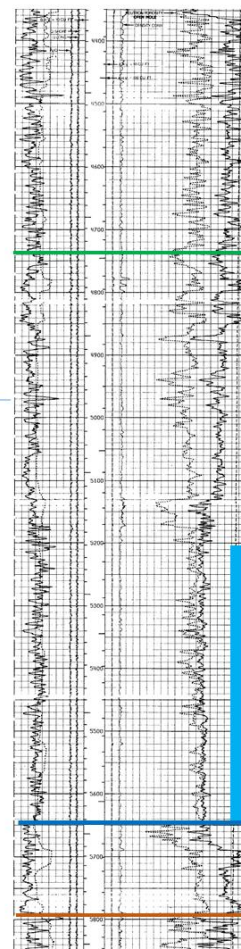
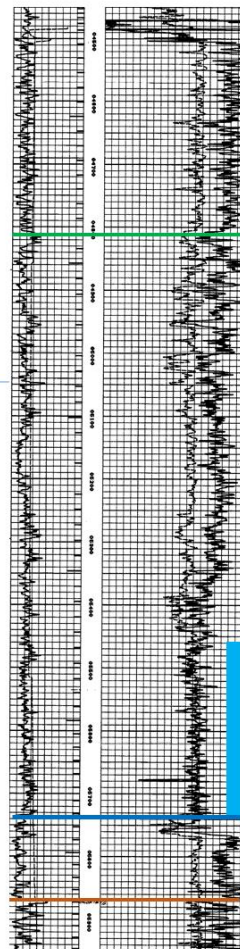
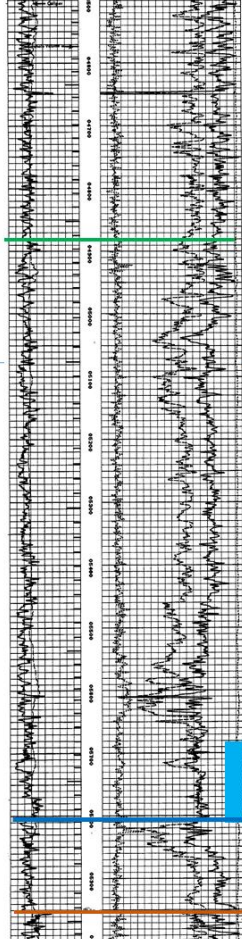
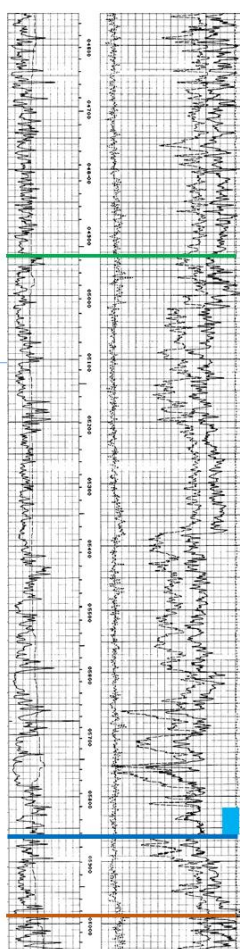
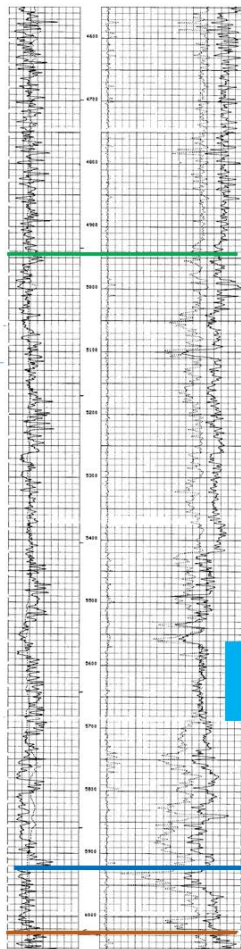
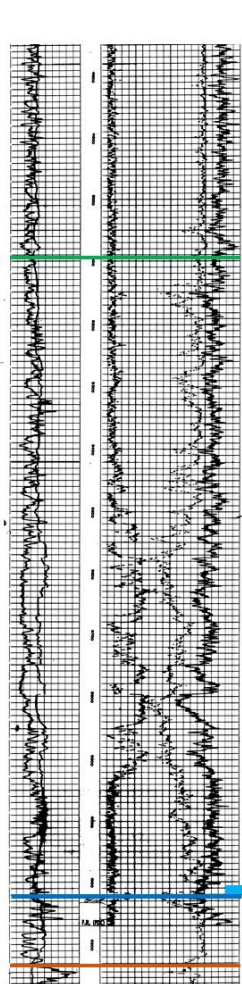
14 34 23 30-025-29426  
Manzano 1 Manzano St

14 34 22 30-025-28091  
Clements 1 MGF NM

14 34 02 30-025-27209  
Dorchester 1 Saunders St

13 34 26 30-025-30224  
Terra 1 Morgan

13 34 01 30-025-01868  
Yates 1 AZU St

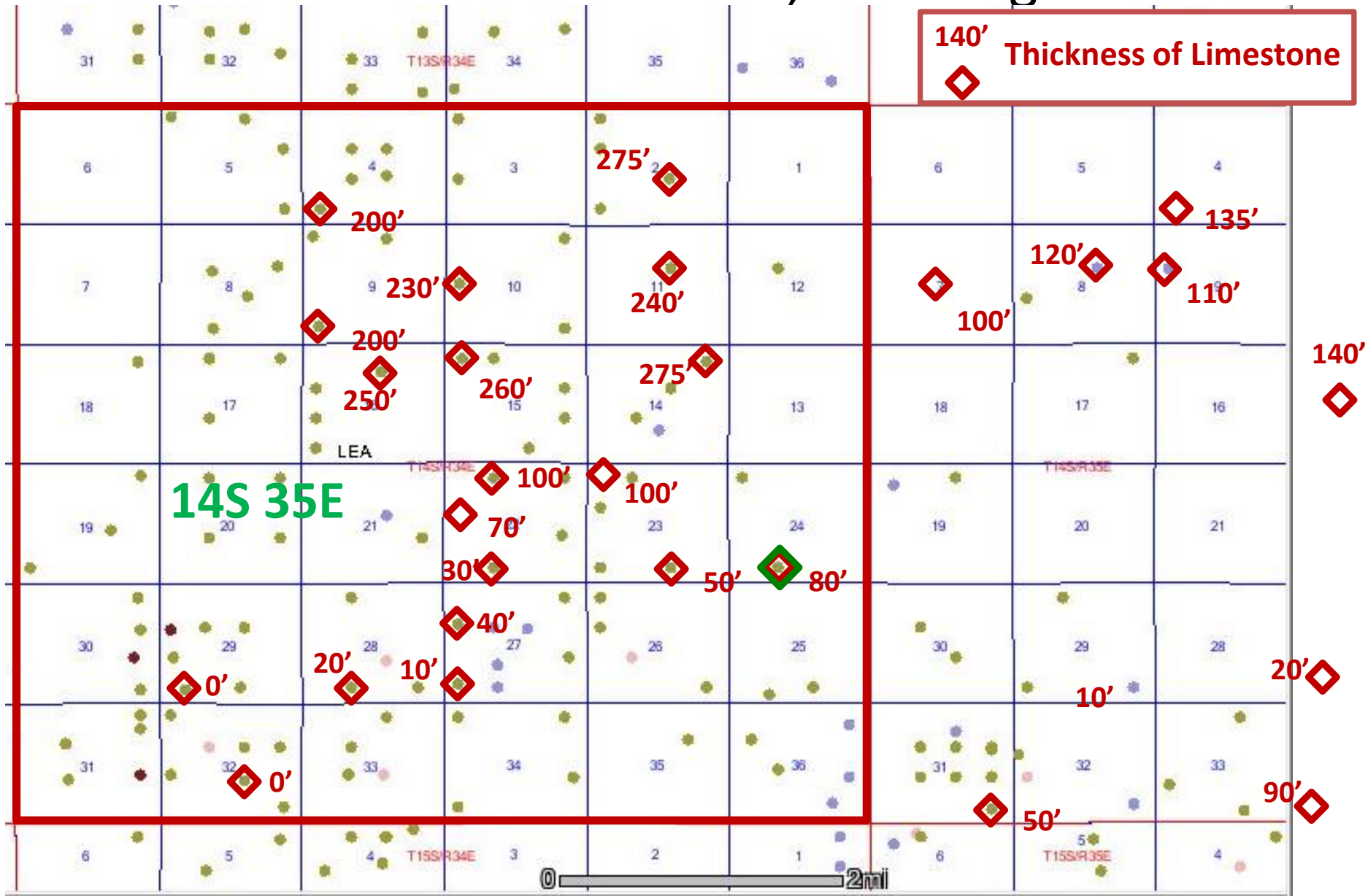


Beginning to get dolomitic Lime

Limestone interval



Where did all the limestone go? The reduction of Limestone is not smooth, but is significant.



# Things we think we know...or should.

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# Appreciation

- Thanks to:
- Steve Melzer, Melzer CO<sub>2</sub>nsulting
- David Vance, Arcadis
- KinderMorgan
- Chevron
- And all others who engaged in necessary conversations about ROZ's.

# References

- Broadhead, Ronald, F., 2004 Petroleum geology of the Tucumcari Basin—overview and recent exploratory activity, New Mexico Geology, vol 26, #3.
- Dutton, S. P., E. M. Kim, R. F. Broadhead, C. L. Breton, W. D. Raatz, S. C. Ruppel, and C. Kerans, 2004, Play analysis and digital portfolio of major oil reservoirs in the Permian basin: Application and transfer of advanced geological and engineering technologies for incremental production opportunities: final report prepared for the U.S. Department of Energy. DE-FC26-02NT15131, 408 p.
- Kerans, Charles, 2006, Bureau of Economic Geology, PGGSP Annual Meeting, Austin, TX
- New Mexico Geologic Highway Map, Compiled by Maureen E. Wilks, 2005. NMBG&MR and NMGS.
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# Thanks!



# Questions?