[PS]Depositional Lithofacies and Diagenetic Overprints of Pennsylvanian Lower Cisco Shelf Margin Carbonates, Wolf Flat Field, Motley County, Texas, USA*

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Abstract

The Wolf Flat field produces from Pennsylvanian aged shelf margin carbonates that were subaerial exposed to fresh water diagenesis during the late Pennsylvanian. About 400 feet of cores from five wells were studied to understand the reservoir's lithofacies and diagenesis relationship to porosity.

Eight lithofacies types were identified in the reservoir section that is overlain by black phosphatic-glauconitic prodelta shale. The lithofacies are: Crinoid peloid wackestone; bryozoan crinoid and bryozoan sponge mud rich packstone; phylloid /phylloid skeletal/ phylloid crinoid mud rich packstone; phylloid fusulinid / fusulinid phylloid/ fusulinid/ fusulinid crinoid mud rich and grain rich packstone; skeletal wackestone/mud rich packstone; peloid skeletal mud rich and grain rich packstone; peloid crinoid skeletal grainstone and oolitic/oolitic skeletal/oolitic pisolitic grainstone.

Although the fossil assemblage of the lithofacies in the wells vary significantly, the wackestone and mud rich packstone lithofacies generally constitute the bases of shoaling upward cycles that are capped by grain rich packstones or grainstones. The crinoid peloid wackestone and skeletal wackestone lithofacies are mound facies at the bottom of two different cycles in two different wells. Together the lithofacies represent a long-term regressive cycle marked by progressive upward reduction in accommodation space, cycle thinning and increasing proportion of shallow subtidal facies.

Long-term regression resulted in subaerial exposure of the reservoir lithofacies followed by fresh water diagenesis. Freshwater diagenesis was typified by karst features, owing to intense leaching with associated cave structures and collapse breccias. Other diagenetic overprints include replacement dolomites, fractures, stylolites, pyrite, calcite cement, anhydrite cement, saddle dolomite and sediment infill.

Most of the primary intergranular/intragranular porosity related to depositional lithofacies was occluded by spar calcite cements. New porosity types; cavernous, vuggy, moldic, fracture and breccia porosities; were also partially occluded by calcite and anhydrite cements as well as

saddle dolomite and sediment infill. Although fresh water diagenesis and ensuing karstification created abundant cavernous/vuggy and breccia porosity in the mud rich lithofacies, most of the new porosity were occluded by cements and sediment infill. Replacement dolomitization of the crinoid peloid wackestone and skeletal wackestone mounds created significant vuggy porosity in the mud rich lithofacies. Most of the cycle capping grainstone and grain rich packstone lithofacies have high porosity irrespective of whether they were dolomitized or not. The only exceptions to this are the grainstones and grain rich packstones below the exposure surface, where the transgressive phosphatic prodelta shale overlies the reservoir. Fresh water diagenesis on these grain-rich lithofacies occluded primary intergranular/intragranular porosity with spar calcite cement; the secondary breccia porosity that developed from subaerial exposure was also occluded by percolating prodelta shales.

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DEPOSITIONAL LITHOFACIES AND DIAGENETIC OVERPRINTS OF PENNSYLVANIAN LOWER CISCO SHELF MARGIN CARBONATES, WOLF FLAT FIELD, MOTLEY COUNTY, TEXAS.

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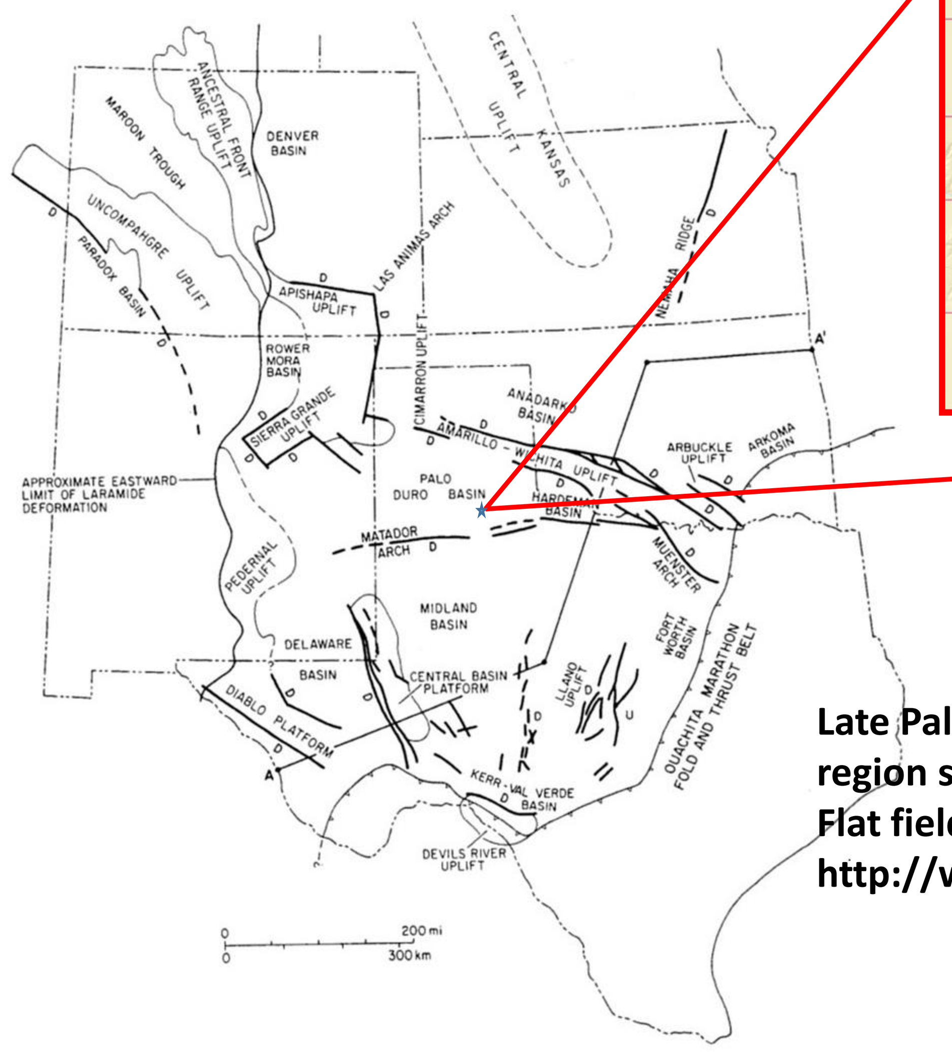
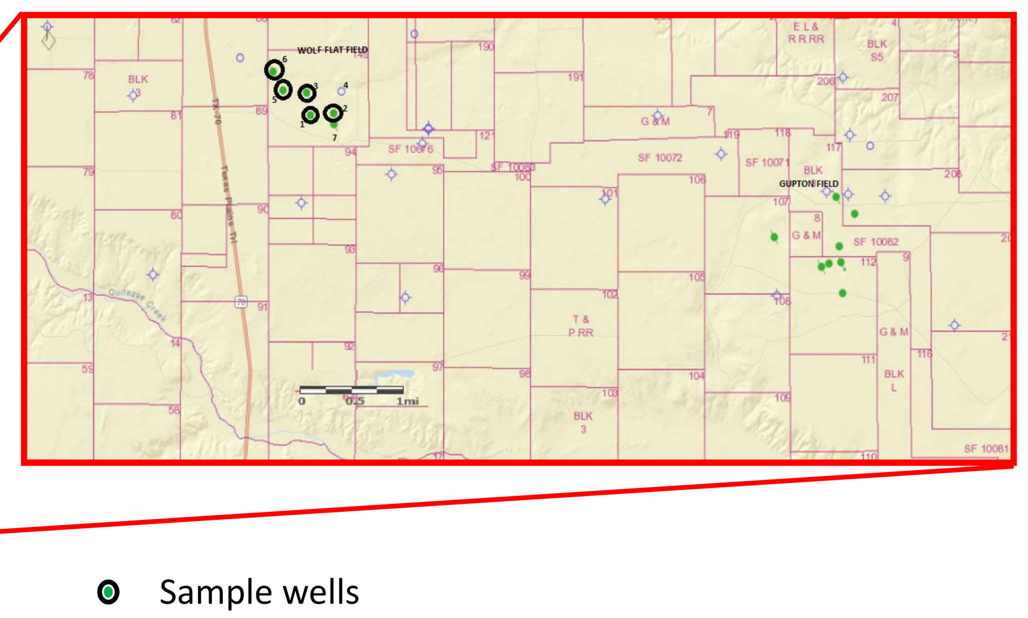
ABSTRACT

The Wolf Flat field produces from Pennsylvanian aged shelf margin carbonates that were subaerial exposed to fresh water diagenesis during the late Pennsylvanian. About 400 feet of cores from five wells were studied to understand the reservoir's lithofacies and diagenesis relationship to porosity. Eight lithofacies types were identified in the reservoir section which is overlain by black phosphatic-glauconitic prodelta shale. The lithofacies are: Crinoid peloid wackestone; bryozoan crinoid and bryozoan sponge mud rich packstone; phylloid /phylloid skeletal/ phylloid crinoid mud rich packstone; phylloid fusulinid / fusulinid phylloid/ fusulinid/ fusulinid crinoid mud rich and grain rich packstone; skeletal wackestone/mud rich packstone; peloid skeletal mud rich and grain rich packstone; peloid crinoid skeletal grainstone and oolitic/oolitic skeletal/oolitic pisolitic grainstone Although the fossil assemblage of the lithofacies in the wells vary significantly, the wackestone and mud rich packstone lithofacies generally constitute the bases of shoaling upward cycles that are capped by grain rich packstones or grainstones. The crinoid peloid wackestone and skeletal wackestone lithofacies are mound facies at the bottom of two different cycles in two different wells. The reservoir lithofacies represent a long term regressive cycle marked by progressive upward reduction in accommodation space, cycle thinning and increasing proportion of shallow subtidal facies. Long term regression resulted in subaerial exposure of the reservoir lithofacies followed by fresh water diagenesis. Freshwater diagenesis was typified by karst features, owing to intense leaching with associated cave structures and collapse breccias. Other diagenetic overprints include replacement dolomites, fractures, stylolites, pyrite, calcite cement, anhydrite cement, saddle dolomite and sediment infill. Most of the original intergranular/intragranular porosity related to depositional lithofacies were occluded by spar calcite cements. New porosity types; cavernous, vuggy, moldic, fracture and breccia porosities; were also partially occluded by calcite and anhydrite cements as well as saddle dolomite and sediment infill. Although fresh water diagenesis and ensuing karstification created abundant cavernous/vuggy and breccia porosity in the mud rich lithofacies, most of the new porosity are occluded by cements and sediment infill. Replacement dolomitization of the crinoid peloid wackestone and skeletal wackestone mounds created significant vuggy porosity in the mud rich lithofacies. Most of the cycle capping grainstone and grain rich packstone lithofacies have high porosity irrespective of whether they have experienced replacement dolomitization or not. The only exception to this are the grainstones and grain rich packstones below the exposure surface with overlying transgressive phosphatic prodelta shale. Fresh water diagenesis on these grain rich lithofacies occluded primary intergranular/intragranular porosity with spar calcite cement, the breccia porosity that developed from subaerial exposure was also occluded by percolating prodelta shales.

Introduction





Late Paleozoic basins and uplifts of Southern Midcontinent region showing the location the Palo Duro basin and the Wolf Flat field. (Dutton,Goldstein, and Ruppel, 1982; http://wwwgisp.rrc.state.tx.us/GISViewer2).

Wolf Flat Field History

- It was discovered October 18, 1987 by Chevron USA Inc.
- It is on a 640 acre lease that is Section 149, Block S5 of the D&P RR Co. Survey, Motley county, Texas.
- Reservoir is Pennsylvanian aged Lower Cisco shelf margin carbonates that underwent subaerial exposure and fresh water diagenesis.
- 5 wells, Mullin 1-5, were drilled on the structural top of the late Pennsylvanian shale above the reservoir.
- Mullin 4 was a dry hole while the other 4 wells were productive.
- 2 other productive wells, Mullin 6 and 7, were drilled by later lease owners, Pennzoil.
- Total oil production as at 2013 is about 1.3 million BBL.
- The reservoir is water driven.
- Total production is solely primary production.

Statement of Work

Depositional lithofacies and diagenesis relationship to reservoir porosity was studied using about 400 feet of slabbed core and corresponding gamma ray and neutron/density logs from 5 producing wells in the Wolf Flat field. The results provide a subsurface porosity trend for the field.

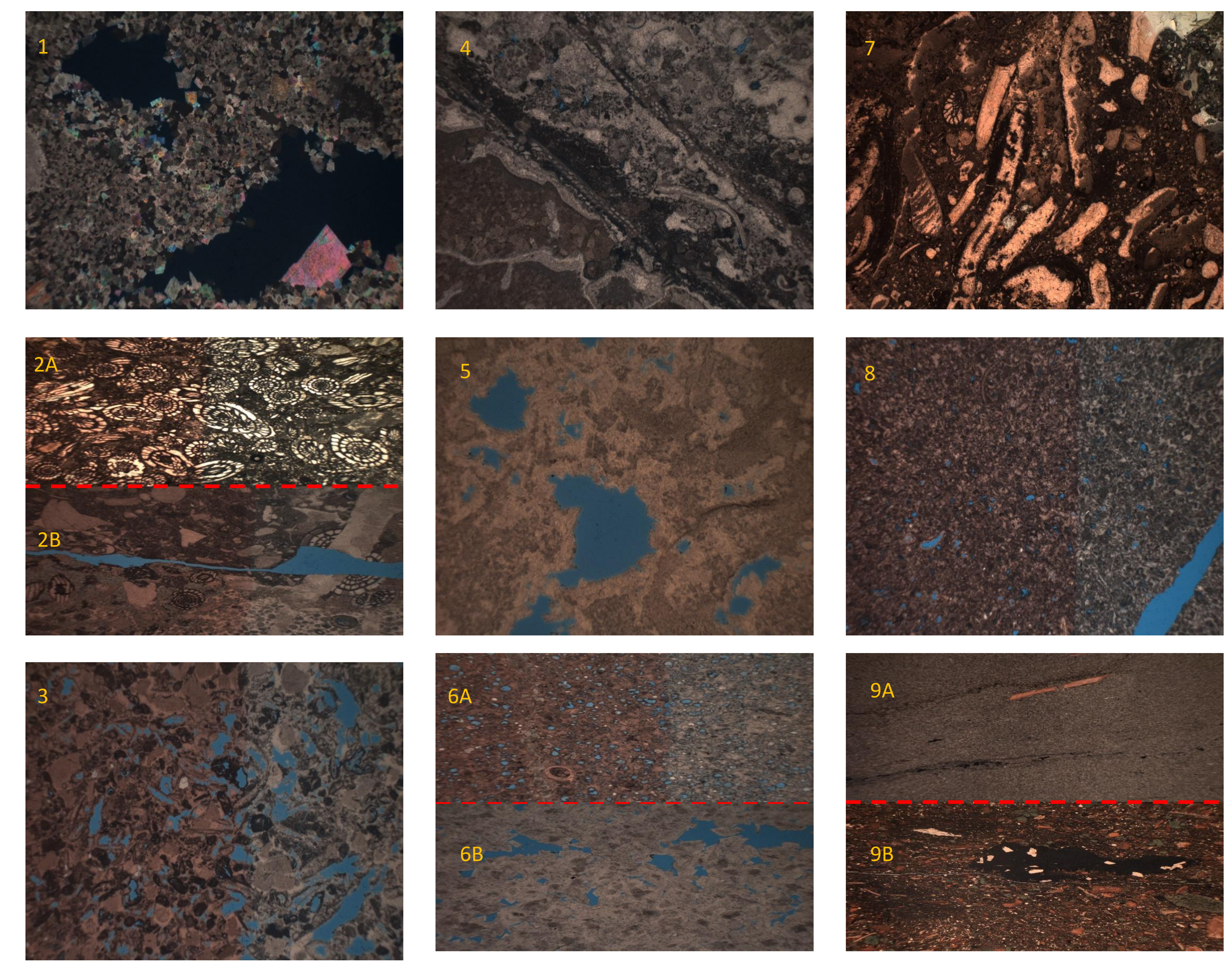
Discussion

- Eight depositional lithofacies were identified in the reservoir section of Wolf Flat field namely: Crinoid peloid wackestone; bryozoan crinoid and bryozoan sponge mud rich packstone; phylloid /phylloid skeletal/ phylloid crinoid mud rich packstone; phylloid fusulinid / fusulinid phylloid/ fusulinid/ fusulinid crinoid mud rich and grain rich packstone; skeletal wackestone/mud rich packstone; peloid skeletal mud rich and grain rich packstone; peloid crinoid skeletal grainstone and oolitic/oolitic skeletal/oolitic pisolitic grainstone.
- The mud rich wackestone and packstones make up the bases of shoaling upward cycles that are capped by grain rich packstones and grainstones. Together, the cycles represent long term regression typified by upward thining of cycles and increasing proportion of shallow subtidal facies.
- The reservoir was subaerially exposed and karsted due to fresh water diagenesis. Karstification resulted in the occlusion of most of the original primary depositional porosity by calcite cements and created abundant moldic porosity in the grain rich lithofacies by leaching carbonate grains. Although, karstification also created abundant breccia and cavernous porosity in the mud rich facies, most of the created secondary porosity were destroyed by abundant cave sediment and calcite cave cements. Other significant porosity types on the reservoir facies are: tiny fracture network originating from the collapse cave structures; and abundant vuggy porosity created by the replacement dolomitization of parts of the grain rich, oolitic grainstone lithofacies, and the mud rich skeletal wackestone and crinoid peloid wackestone mound. Most of the fracture porosity are occluded by calcite cement and saddle dolomite. Diagenetic anhydrite are suspected to have migrated in solutions from updip anhydrite rich environments via some of these fractures and have precipitated anhydrite in a dissolution pipe and few vuggy porosity. Saddle dolomite also occlude some moldic and vuggy porosity. Their presence suggest that the reservoir also experienced burial diagenesis possibly due to the thick overlying transgressive shale which will also account for the abundant stylolite on the reservoir lithofacies
- Overlying the reservoir facies is a black transgressive Phosphatic-glauconitic prodelta shale with thin beds – thick laminae of mud rich-grain rich packstone. This prodelta shale eventually grades into basinal shale due to the late Pennsylvanian marine transgression. Few tiny quartz grains were observed in the packstone confirming the clastic source of the prodelta shale which did not take on the "Alizarin red s" stain on thinsection. Traces of pyrite were observed on the slabbed core suggesting that the oxygenated conditions that allowed the glauconitic-skeletal grain rich packstone to be deposited within the shale alternated with anoxic conditions before the prodelta shale translated into basinal shales.

Conclusion

Eight depositional lithofacies were identified in the Pennsylvanian Lower Cisco reservoir of the Wolf Flat field. The lithofacies present a long-term regressive cycle that was subaerially exposed and diagenetically altered in the late Pennsylvanian. Fresh water diagenesis created, modified and destroyed the reservoir porosity. The grain rich lithofacies have abundant moldic porosity due to intense leaching. They also developed abundant vuggy porosity from replacement dolomitization. Although leaching created abundant cavernous and breccia in the mud rich lithofacies, porosity gain was only observed in the dolomitized crinoid peloid wackestone and skeletal wackestone with vuggy porosity. The initial porosity gain were occluded by abundant cave cements and sediment infill. Diagenetic anhydrite cement and saddle dolomite (from burial diagenesis) also occlude fracture, moldic and vuggy porosity in the reservoir.

Results



1. Dolomitized crinoid peloid wackestone with abundant vuggy porosity. Diagenetic anhydrite crystal can be seen here in a vuggy porosity on the thinsection.

2A. Fusulinid mud rich packstone with abundant fusulinid grains.

2B. Fusulinid crinoid mud rich packstone with fracture porosity.

3. Leached peloid crinoid skeletal grainstone. With abundant moldic porosity.

4. Bryozoan crinoid mud rich packstone with fenestrate bryozoan.

5. Dolomitized skeletal wackestone with abundant vuggy porosity.

6A. Leached oolitic skeletal grainstone with abundant moldic porosity..

6B. Dolomitized oolitic grainstone with abundant vuggy porosity.

7. Phylloid mud rich packstone. The phylloid algae grains have abundant borings but are not in growth position suggesting that they have been eroded from a nearby mound and redeposited in the current location.

8. Leached peloid skeletal grain rich packstone with abundant moldic porosity and a fracture porosity.

9A. Prodelta shale with a brachiopod fragment. Unlike the brachiopod, the shale was not stained by Alizarin red S solution used to identify calcite on thinsection.

9B. A thin glauconitic skeletal grain rich packstone limestone within the shale has dead oil with tiny quartz grains...

Longest dimension of thin section photograph is 14.5mm

Acknowledgements

- AAPG Southwest Section.
- Dr. Robert Trentham and Dr. Emily Stoudt, University of the Permian Basin, Odessa, Texas.

References

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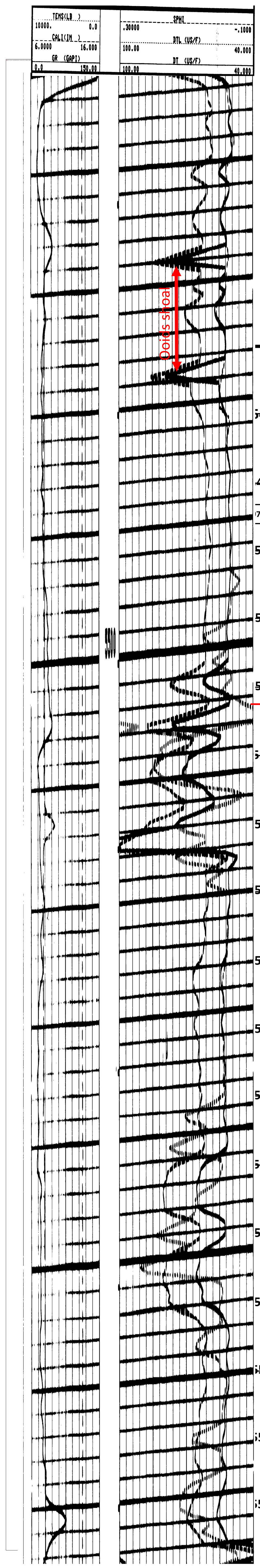
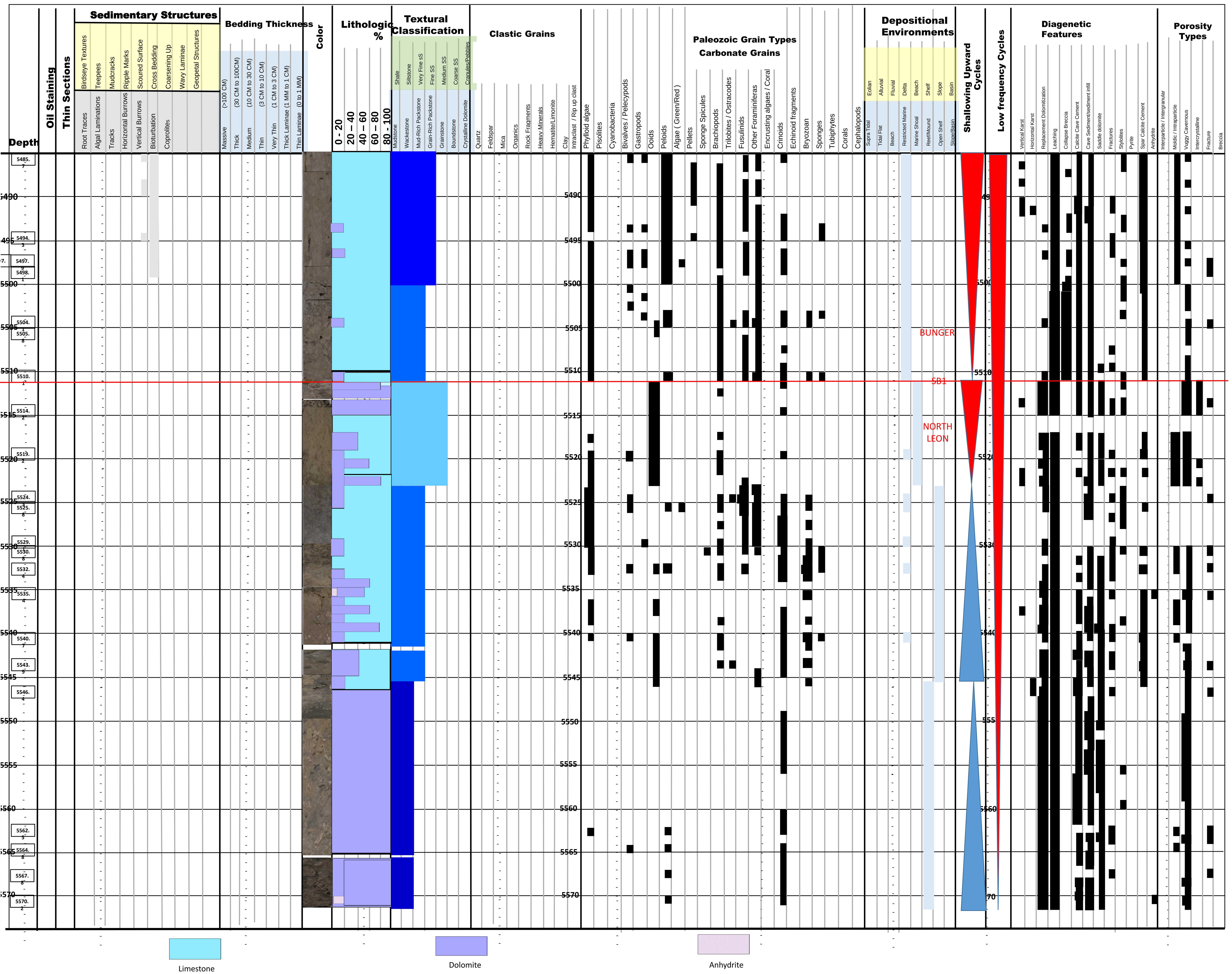
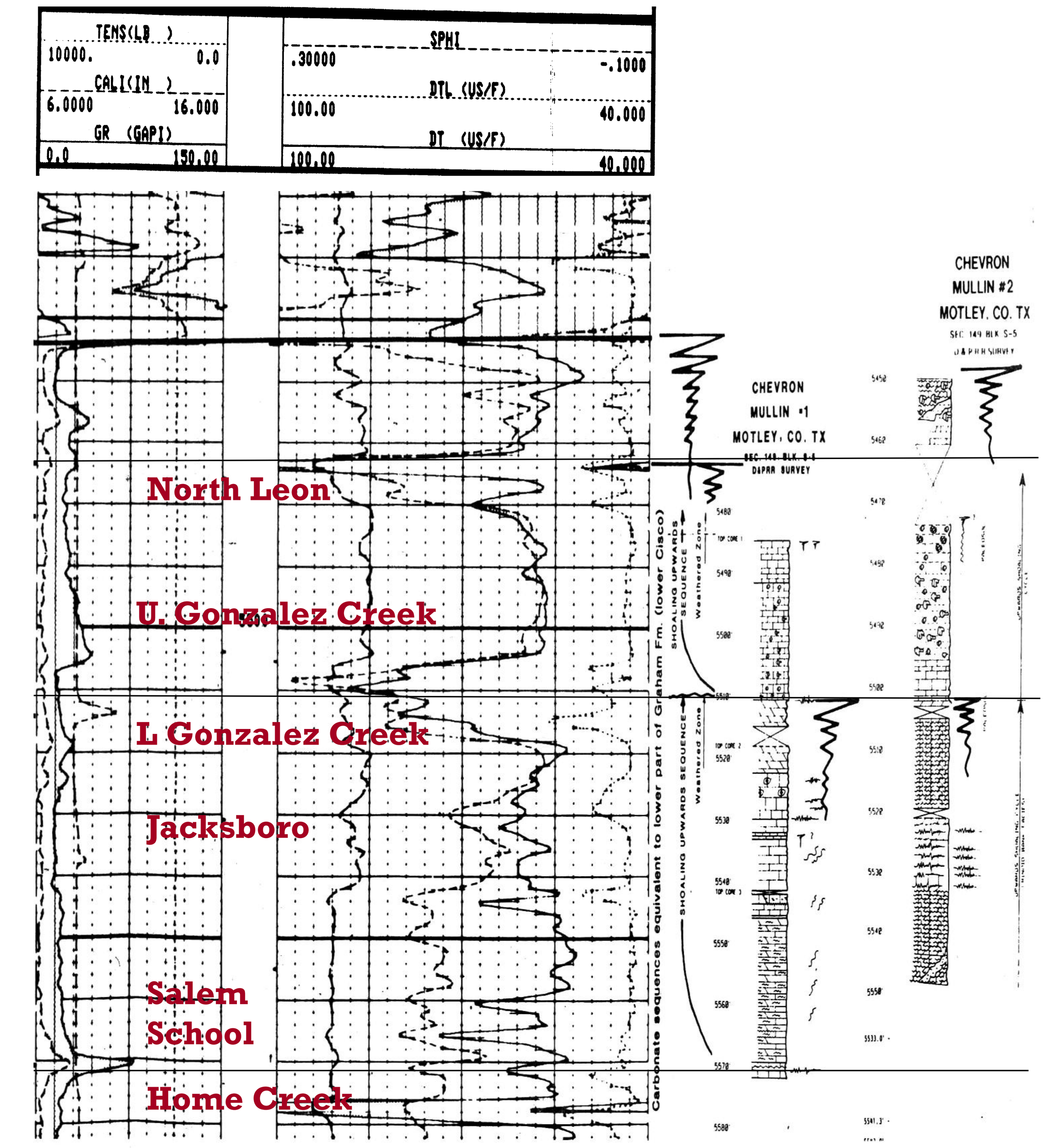
Well or Measured Section: Mullin 1 Location D& P RR.Co Blk S5 Section 149 Survey, Motley Co, TX.

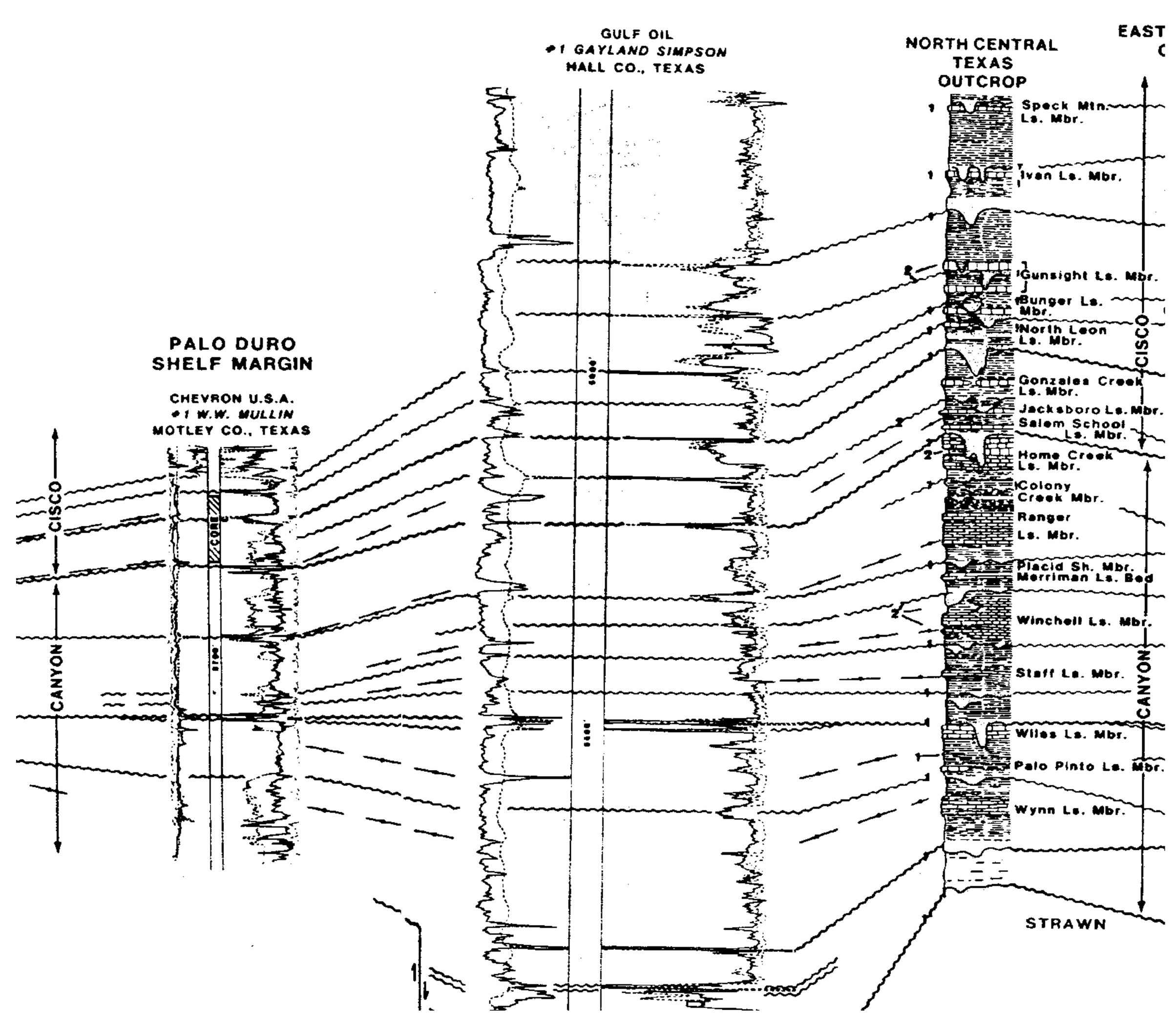
Formation(s) Lower Cisco Depth or Outcrop interval 5485 - 5571







Biostratigraphic analysis (C. A. Ross, 1988) of the cores determined that the Wolf Flat productive interval is Lower Cisco. There are a number of cycles present with in the interval.



C. A. Ross, 1988, determined that the interval correlated with the classic North Texas section and also correlated to productive intervals in the Horseshoe Atoll and Central Basin Platform.