Interpretation of Depositional Environments of Upper Seven Rivers Formation from Core and Well Logs Grayburg Jackson Pool, Eddy County, New Mexico

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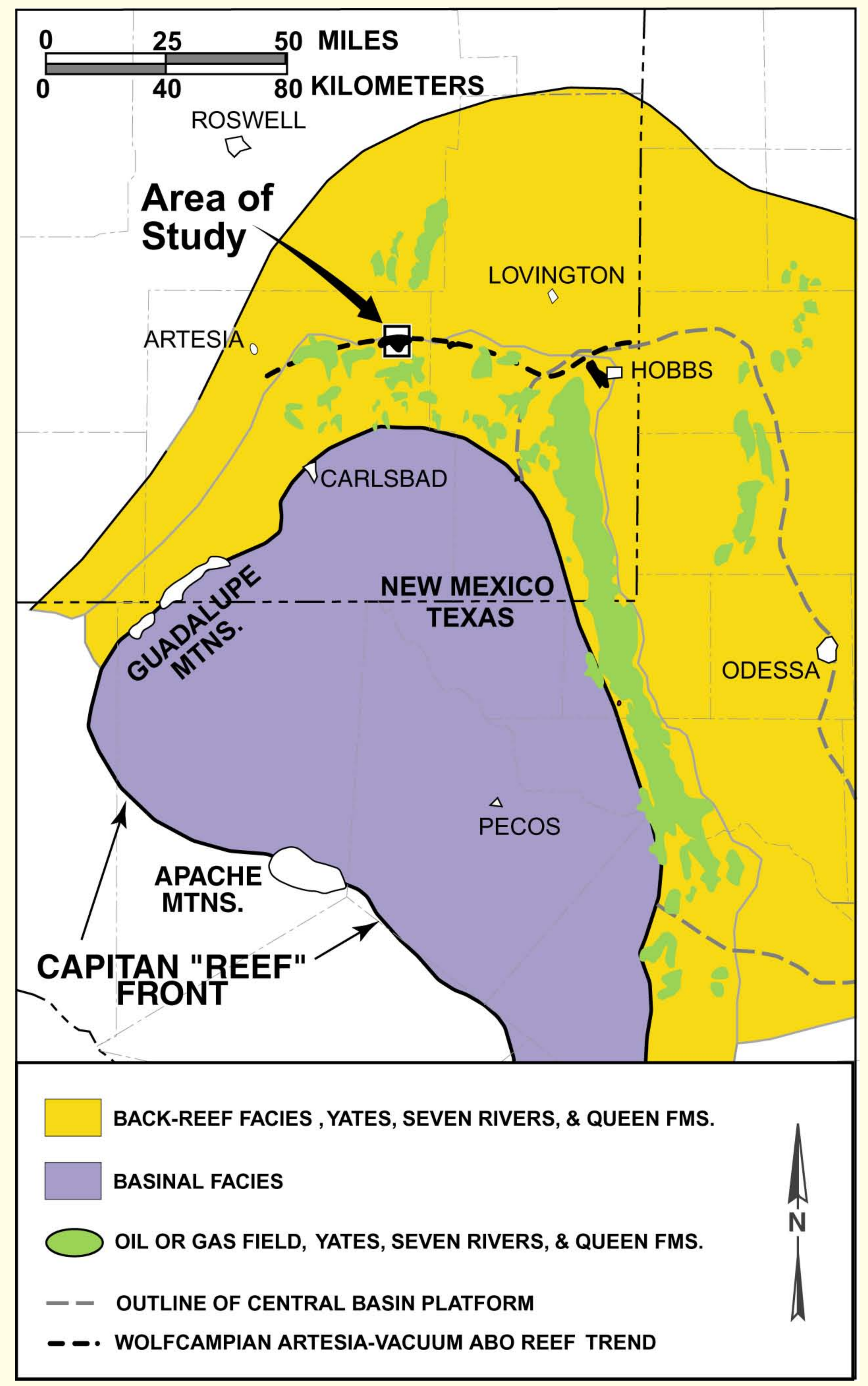
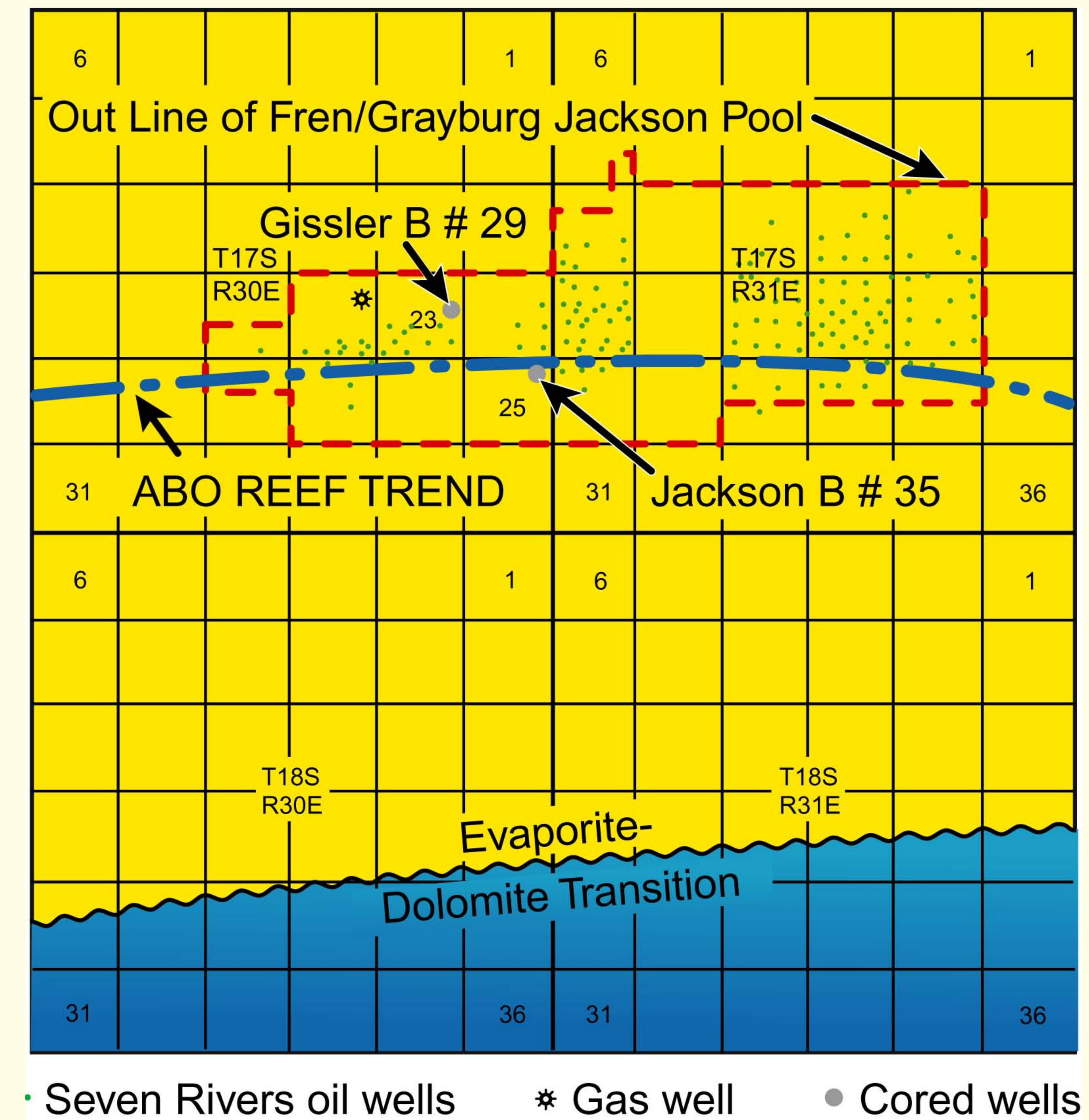
Abstract: The Seven Rivers Formation is a potential oil and gas reservoir in many fields across the northern shelf of the Delaware Basin. The largest Seven Rivers reservoir, Grayburg Jackson Pool (formerly Fren Pool), has yielded more than 5.4 mmbo and 1.6 bcf of associated gas. Grayburg Jackson and other fields that overlie the Artesia-Vacuum Abo reef trend mark the northernmost significant Seven Rivers production where porous dolomite stringers pinch out landward into bedded anhydrite. Two wells were cored and thin sectioned to study these thin (<4 feet) dolomite reservoir beds. The cores demonstrate that the upper Seven Rivers is comprised of massive to bedded nodular anhydrite (majority), non-reservoir, algally laminated, fenestral, dolomitized boundstone/mudstone; and dolomitized grainstone/packstone reservoir rocks. Petrography reveals complete dolomitization of carbonate units, abundant anhydrite cements in the laminated facies, and excellent porosity preservation in the higher energy facies. These lithofacies represent depositional environments that range from supratial sabkha to intertidal mud flat and tidal channel. The grainstone/packstone facies are the primary contributors to production having porosity ranging from 10 to 28.5% and permeabilities ranging from 0.1 to 35 md. Well log-derived pore volume mapping demonstrates that the higher energy facies are related to shore-perpendicular porosity zones suggestive of tidal channels.

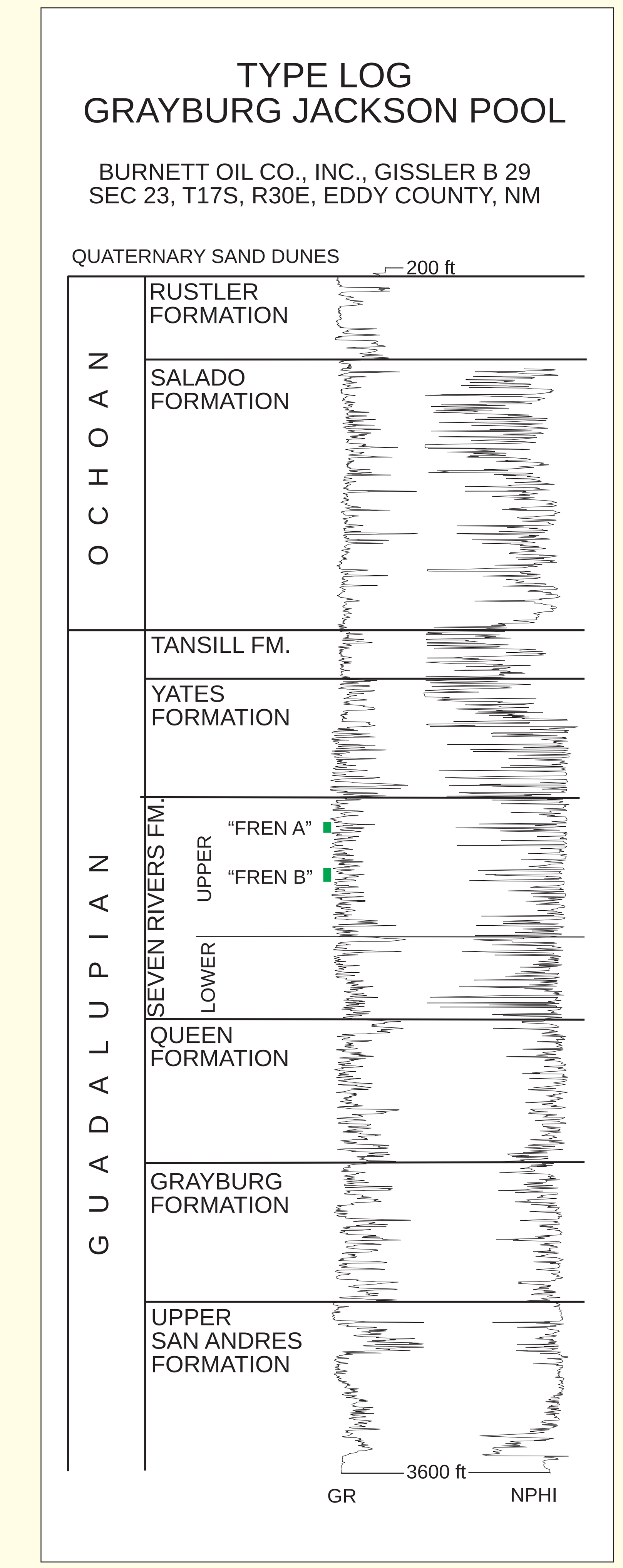


Map showing Upper Guadalupian (Queen-Seven Rivers-Yates) production and depositional facies of west Texas and southeastern New Mexico. Grayburg Jackson Pool (study area) is one of several similar fields overlying the crest of the Wolfcampian Artesia-Vacuum Abo reef trend (after Ward et al., 1986)

Geologic Framework

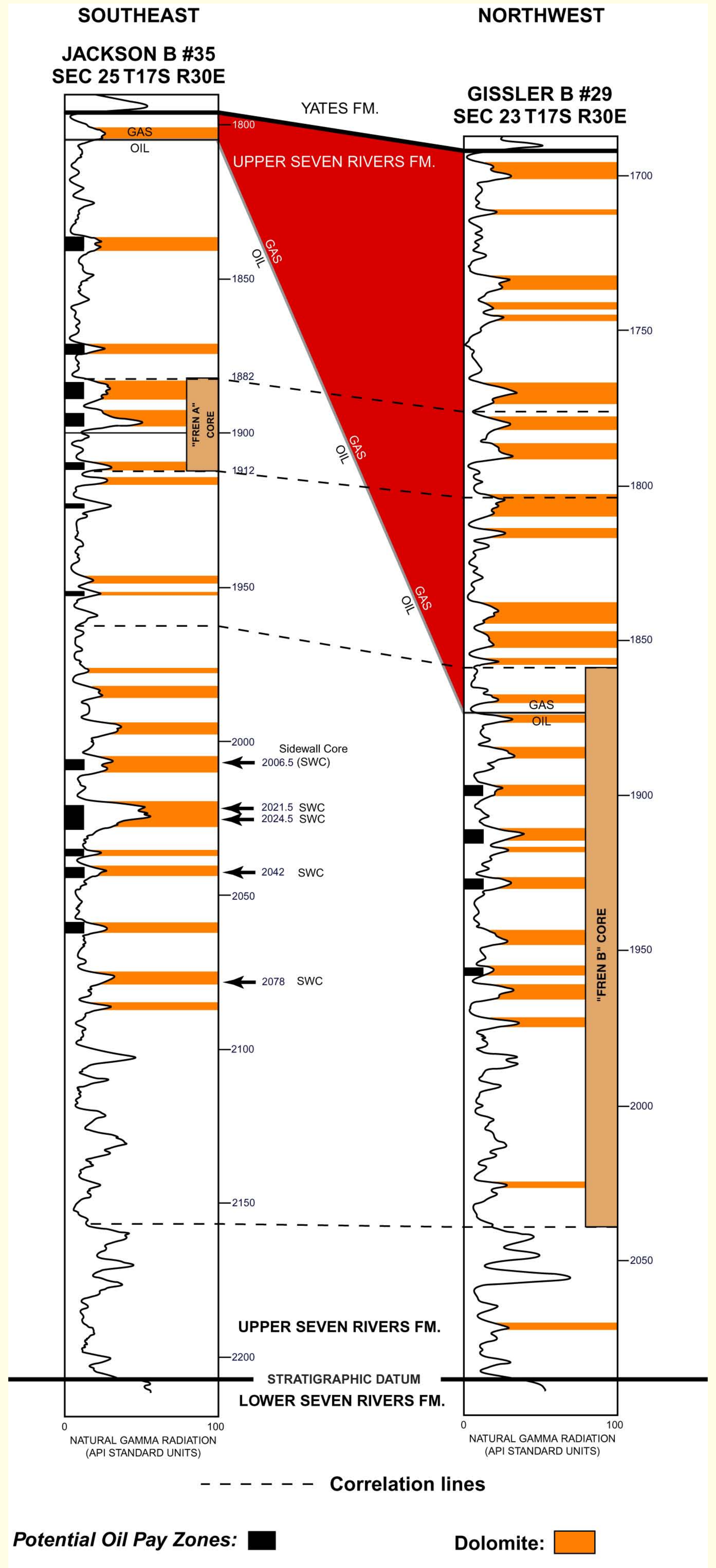


Map of Seven Rivers production in Grayburg Jackson Pool showing outline of abolished Fren Seven Rivers Pool (Seven Rivers oil and gas wells denoted) and two cored wells of interest. Also shown are the axis of Artesia-Vacuum Abo reef trend and the approximate location of the Seven Rivers evaporite-carbonate transition after Sheldon (1954).



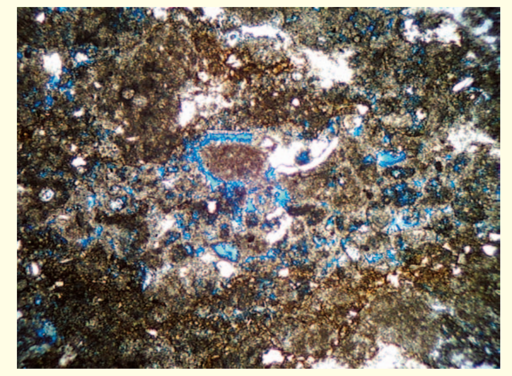
Type log demonstrating lithostratigraphic nomenclature for Grayburg Jackson Pool. Informal Seven Rivers Formation reservoir zones "Fren A" and Fren B" are noted. GR = gamma ray; NPHI = neutron porosity.

Well Log and Core Correlation

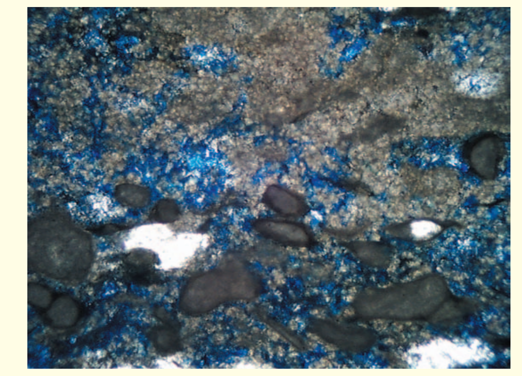


Stratigraphic cross-section showing correlation between the Jackson B 35 and Gissler B 29 wells. Stratigraphic datum = top of lower Seven Rivers Formation. "Potential oil pay zones" are based on log and core characteristics (ie. neutron log porosity > 10%; core fluorescence). Present gas/oil contact elevation is approximately 1830 feet above sea level.

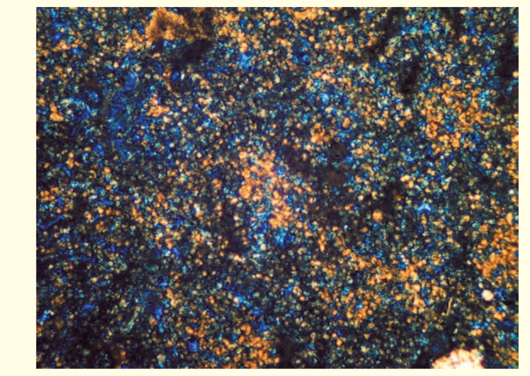
Petrography



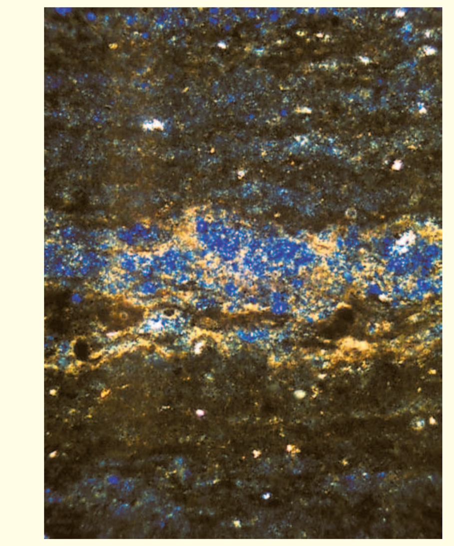
Peloidal bioclastic packstone. Secondary porosity in this view is both interparticle and moldic. Jackson B #35, 1895.9 feet depth,



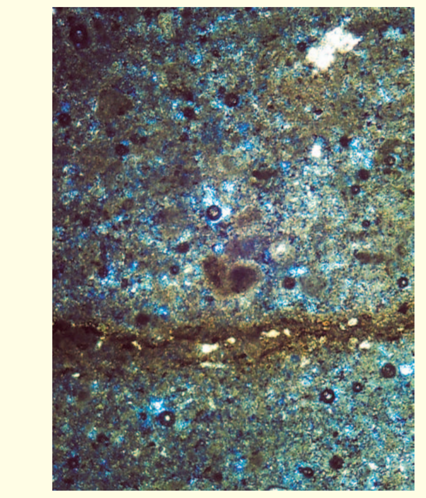
Intraclastic packstone/grainstone. Secondary porosity is both interparticle and intercrystalline; Gissler B 29, 1897.3 feet depth, LA = 2.54 mm



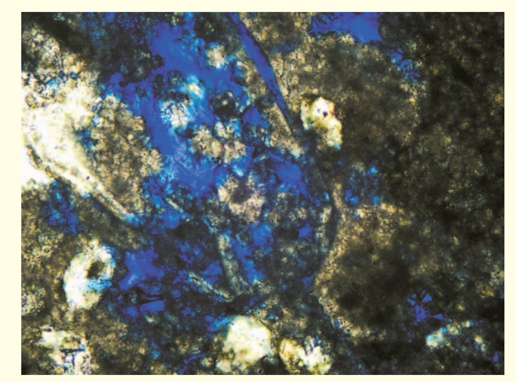
Dolomitized grainstone demonstrating secondary intercrystalline porosity. Jackson B #35, sidewall core at 2042 feet depth, LA = 2.2 mm.



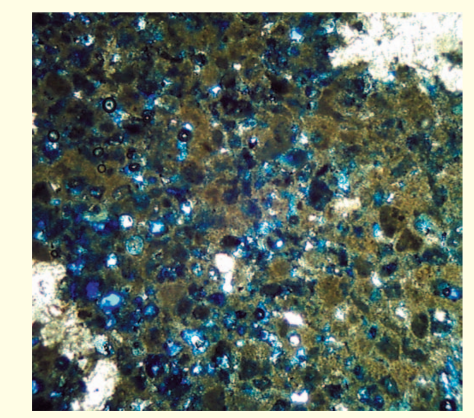
Dolomitized algally laminated boundstone. Porosity is highest adjacent to wispy pressure solution seams; possibly due to a thin horizon of leached bioclastic material. Jackson B #35, 1884.9', LA = 2.54 mm.



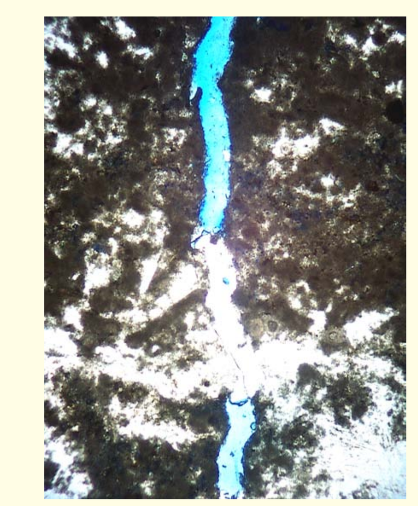
Sandy oolitic (?), bioclastic peloidal packstone. Porosity in this v. finely crystalline dolomite is intercrystalline and interparticle. Note the wispy pressure solution seam. Gissler B #29, 1911.4 feet depth, LA = 2.2 mm.



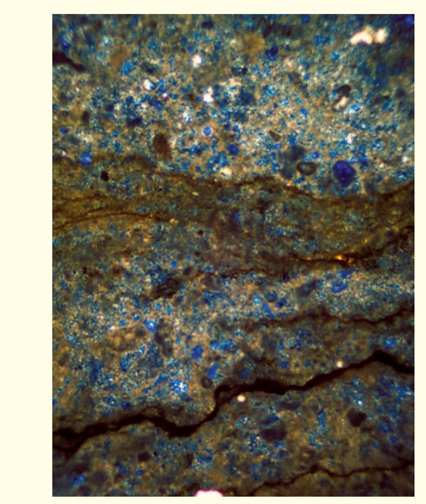
Peloidal bioclastic packstone. This close-up view is of the secondary moldic and intercrystalline porosity. Jackson B #35, 1895.9 feet depth, LA = 0.38 mm.



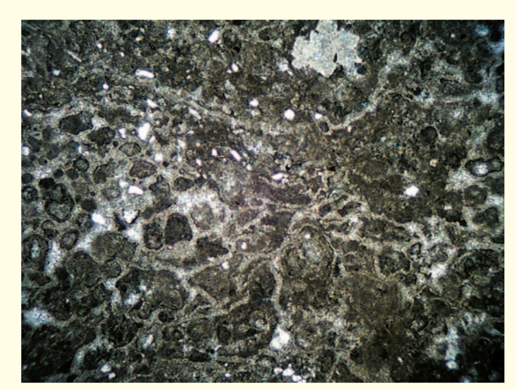
Dolomitized bioclastic peloidal packstone. Note abundant intercrystalline and inter-particle porosity in this section. Replacement anhydrite plugs some porosity. Gissler B #29, 1899.1', LA = 2.54 mm



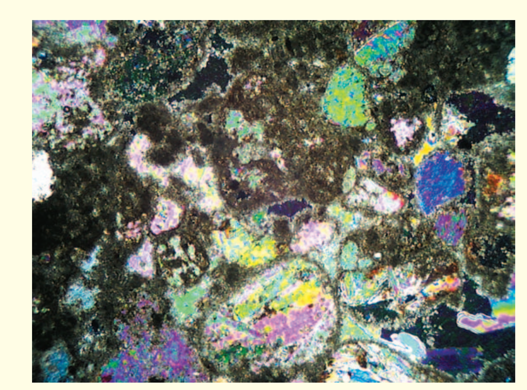
Bioclastic peloidal boundstone. Fracture porosity is open adjacent to dolomite, but closed adjacent to anhydrite. Gissler B #29, 1915.9 feet depth, LA = 2.54 mm.



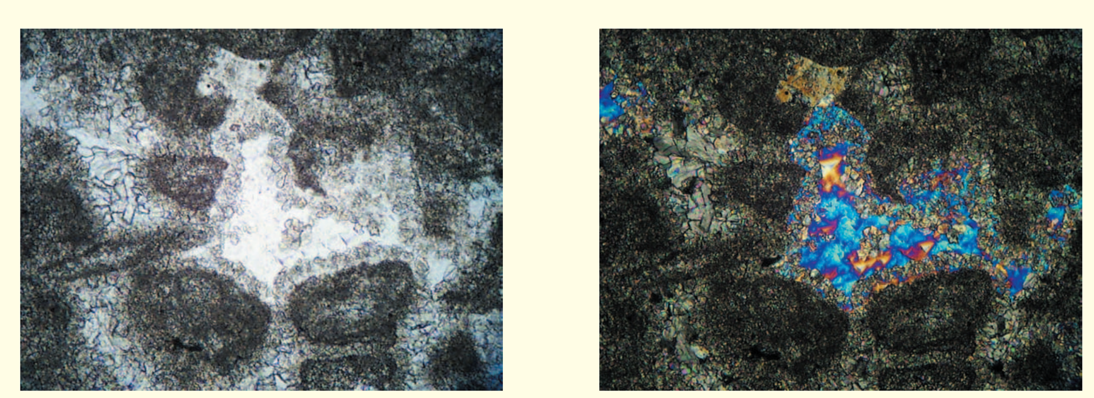
Bioclastic peloidal dolomitized packstone. Note how wispy pressure solution fabrics dirupt porosity distribution. Jackson B #35, sidewall core at 2078 feet depth, LA = 2.2 mm



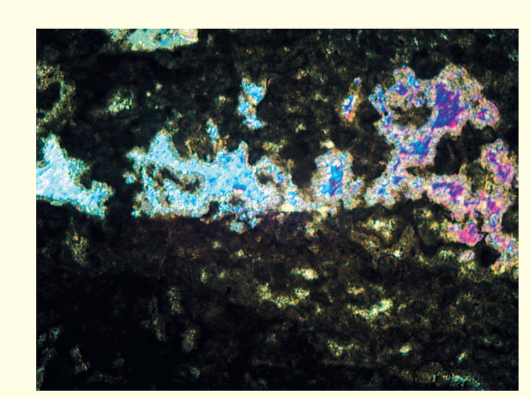
Sandy pisolitic bioclastic grapestone grainstone. Compaction has destroyed much of the interparticle porosity in this section. Gissler B #29,, 1922.4 feet depth, LA = 2.2 mm.



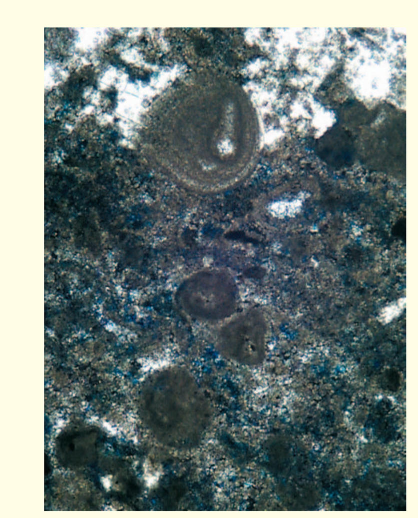
Dolomitized grapestone grainstone. Note micritic envelopes that have been filled by anhydrite. Jackson B #35, 1895.8, LA = 2.54 mm.



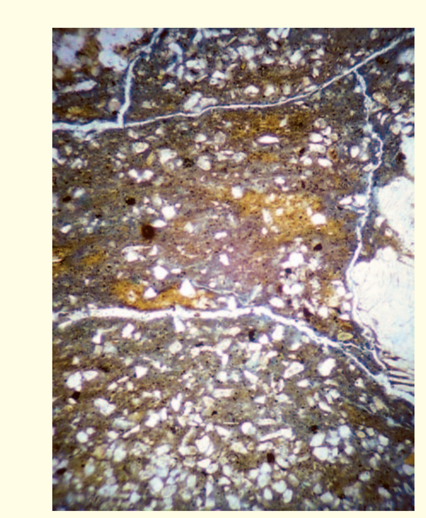
Anhydrite filled relict porosity in pisolitic bioclastic grapestone grainstone. The original isopachous cements fringing the pore have been dolomitized along with the rest of the carbonates in this section. Left - plane light; Right - crossed polarizers. Gissler B #29, 1911.4 feet depth, LA = 0.38 mm



Anhydrite filling fenestral porosity in algal laminated mudstone/boundstone facies. Gissler B #29, 1944.7 feet, LA = 2.54 mm.

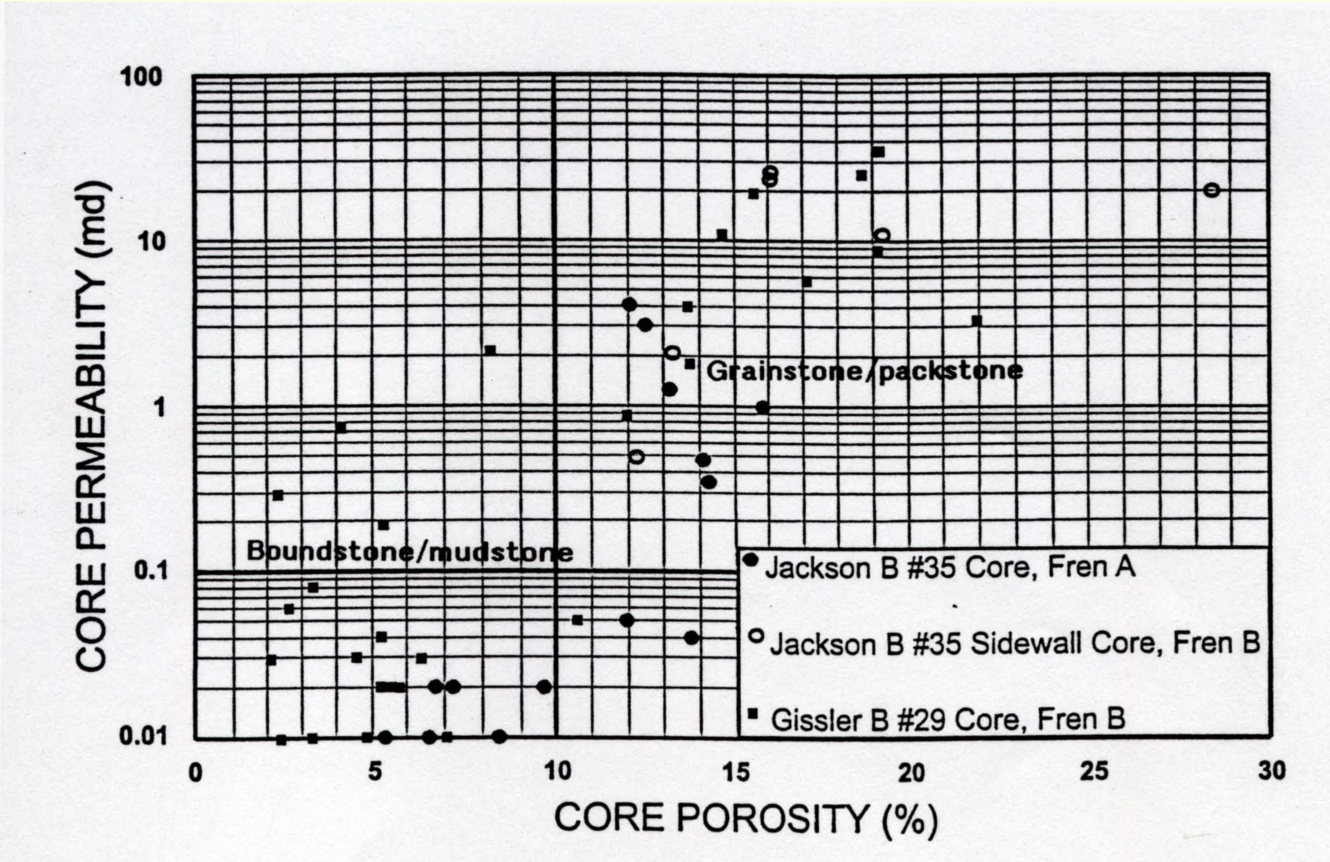


Dolomitized bioclastic oolitic or pisolitic packstone. Gissler B #29, 1857.1 feet depth, LA = 1.85 mm.



Sandy shale and nodular anhydrite. A sabkha deposit. Jackson B #35, sidewall core at 2021.5 feet depth, LA = 2.54 mm.

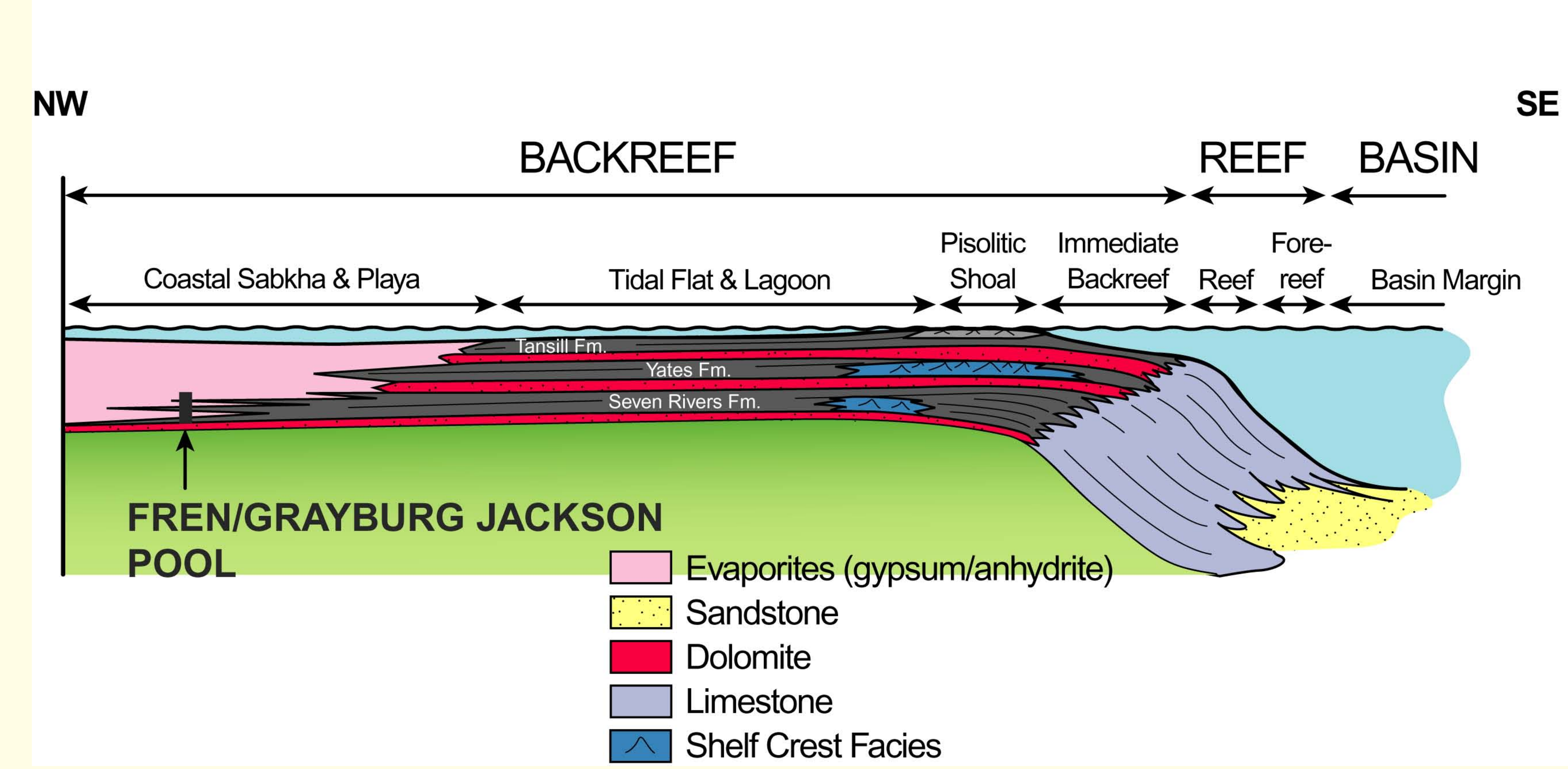
Core Porosity and Permeability



Plot of porosity vs. permeability for dolomite core plugs and sidewall cores from Jackson B #35 and Gissler B #29 wells. Only samples with permeability equal or greater than 0.01 md are included. Due to low permeability, "pay" porosity threshold is approximately 10%.

Depositional Environments

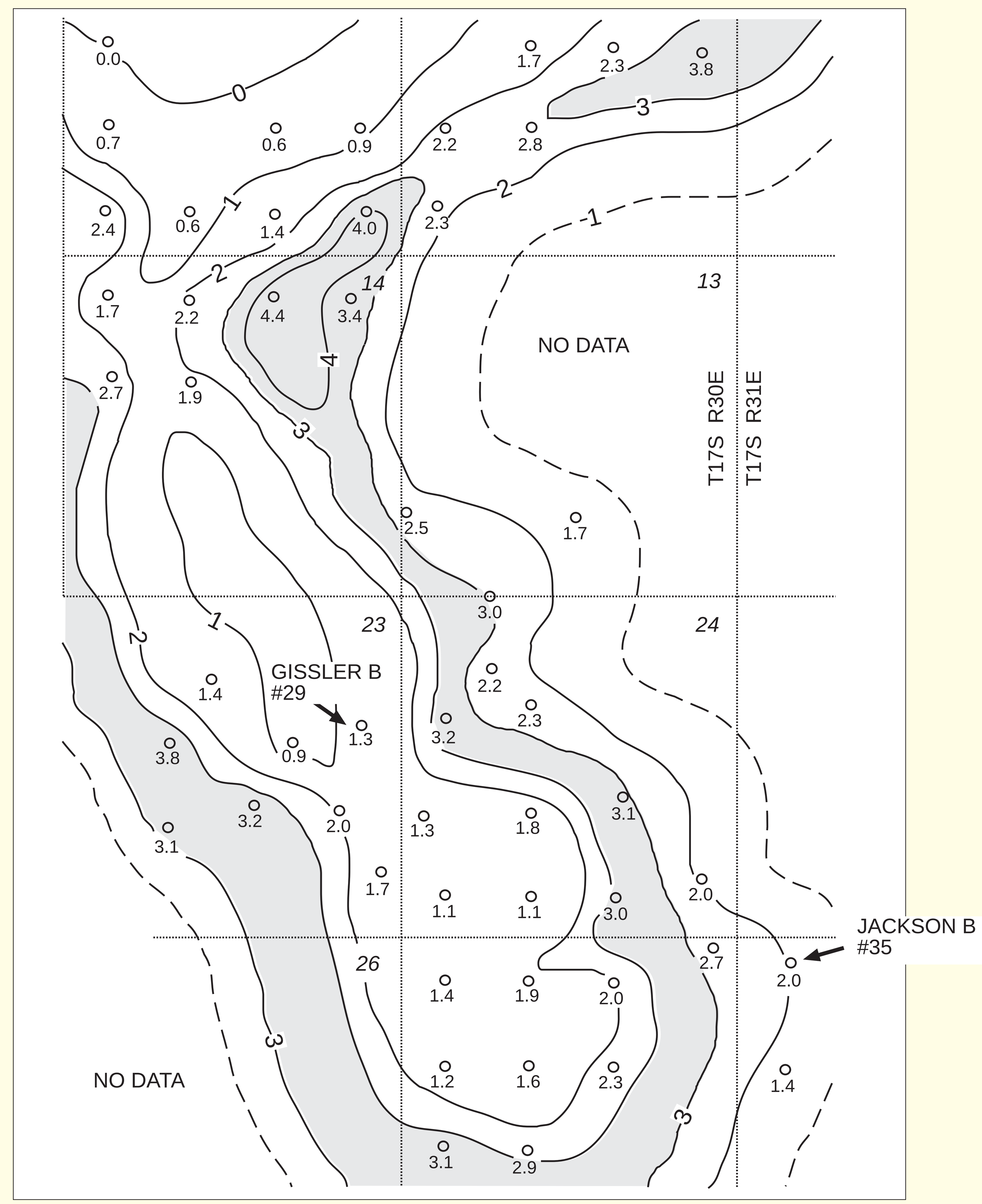
Schematic cross-section showing regional depositional relationships of Upper Permian strata along the western margin of the Delaware Basin and the general location of the Fren/Grayburg Jackson Seven Rivers Pool (modified from Esteban and Pray, 1983). The predominance of thick units of massive to nodular chicken-wire anhydrite interbedded with algally laminated carbonates indicates that evaporative, supratidal, coastal sabkha conditions dominated this area. Thin porous tidal channel carbonate units represent intermittent episodes of higher stands of base level such that intertidal depositional conditions shifted temporarily landward.



Porosity Volume Map: Depositional Environment Implications

Isopach of upper Seven Rivers dolomite "net porosity volume" (porosity x feet of thickness). Pore volumes were estimated from gamma ray/neutron logs of various vintages (1950's to 1990's). A conservative method of estimating pore volume was utilized that ignored porosity less than 4% and tended to focus on the probable grainstone/packstone higher-energy facies.

The shaded area is maximum pore volume (phi x ft >3). Although this is a "net pore volume" map for the entire upper Seven Rivers, the map illustrates distinct shore-perpendicular (northwest-oriented) linear trends interpreted to be indicative of tidal channels. This would suggest that the depositional environment for porous units was probably intertidal.



Conclusions

1) Upper Seven Rivers Formation carbonates span a range of depositional environments from tidal channels to intertidal algal mats. The evaporites are interpreted to be supratidal sabkha deposits.

2) The pinchout of dolomite units into sabkha sulfate evaporites, combined with drape over the underlying Artesia-Vacuum Abo reef provided excellent stratigraphic and structural conditions for trapping petroleum.

3) Shoreline-perpendicular packstone/grainstone tidal channel facies were extensively dolomitized creating secondary porosity that may have been preserved by early oil migration or by later dissolution of gypsum/anhydrite.

4) Although porosity is potentially as high as 30% in the tidal channel facies, permeabilities are relatively low and the thin porous units are preferentially oriented, making the Seven Rivers a challenging reservoir for effective secondary recovery.

Acknowledgments

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Reference

Brister, B. S., and Ulmer-Scholle, D., 2000, Interpretation of depositional environments of upper Seven Rivers Formation from core and well logs, Grayburg Jackson Pool, Eddy County, New Mexico *in* West Texas Geological Society Publication #00-109, p. 65-72.