
Albian Cyclic Shelf Tidal Bar Complexes, Upper Glen Rose “D” Formation, Alabama Ferry Field, East Texas

Laura Zahm

Bureau of Economic Geology, The University of Texas at Austin
University Station, Box X Austin, Texas 78713-8924

EXTENDED ABSTRACT

Alabama Ferry Field, in Leon and Houston counties, Texas, provides an opportunity to characterize a Lower Cretaceous mixed carbonate-siliciclastic system using core and log data. The facies are represented by two end members in reservoir quality. The main reservoir facies are well-sorted, ooid grainstones to mixed-skeletal ooid grainstones with moldic porosity. The non-reservoir facies are organic-rich, siliciclastic mudstones. The contact between these facies is commonly very sharp. Where transitional facies are present, they represent a small proportion of the overall rock volume. In addition, the cyclicity and stratigraphic variability cause differential fracture development within some facies related to rock strength and pore-type.

The primary focus of this study is to develop a 3D stratigraphic framework. Results include detailed information on the 3D distribution of the grainstone bodies, how the depositional system changed from cycle to cycle. A secondary focus is to gain a better understanding of the genesis of this depositional system. The grainstone distribution and depositional changes resulting in significant accumulations of organic-rich black shales will be discussed and placed in a context to maximize reservoir production.

Introduction and Geologic Setting

Alabama Ferry Field, discovered in 1984, has been described in previous studies (Bruno et al., 1991; Fitchen et al., 1997; Lucia, 2002). The predominantly limestone reservoir occurs within the “D” interval of the Upper Glen Rose Formation approximately 50 miles behind the Stuart City Margin to the NW (Fig. 1). The area of interest in this study is a small region of the southwestern corner of the Alabama Ferry Field with 100 wells developed in an irregular 160 acre spacing pattern. The larger area encompassing all of Alabama Ferry is 40,000 acres with an estimate of in place total reserves of 100 million barrels of oil (Bruno et al., 1991).

Facies Descriptions

The reservoir facies observed in the 7 cores (totaling 360 feet) within the study area are:

(1) Ooid grainstones. The ooids are generally well-sorted but lack any bedding or stratification with rare skeletal fragments. The grainstone shoals show little evidence of

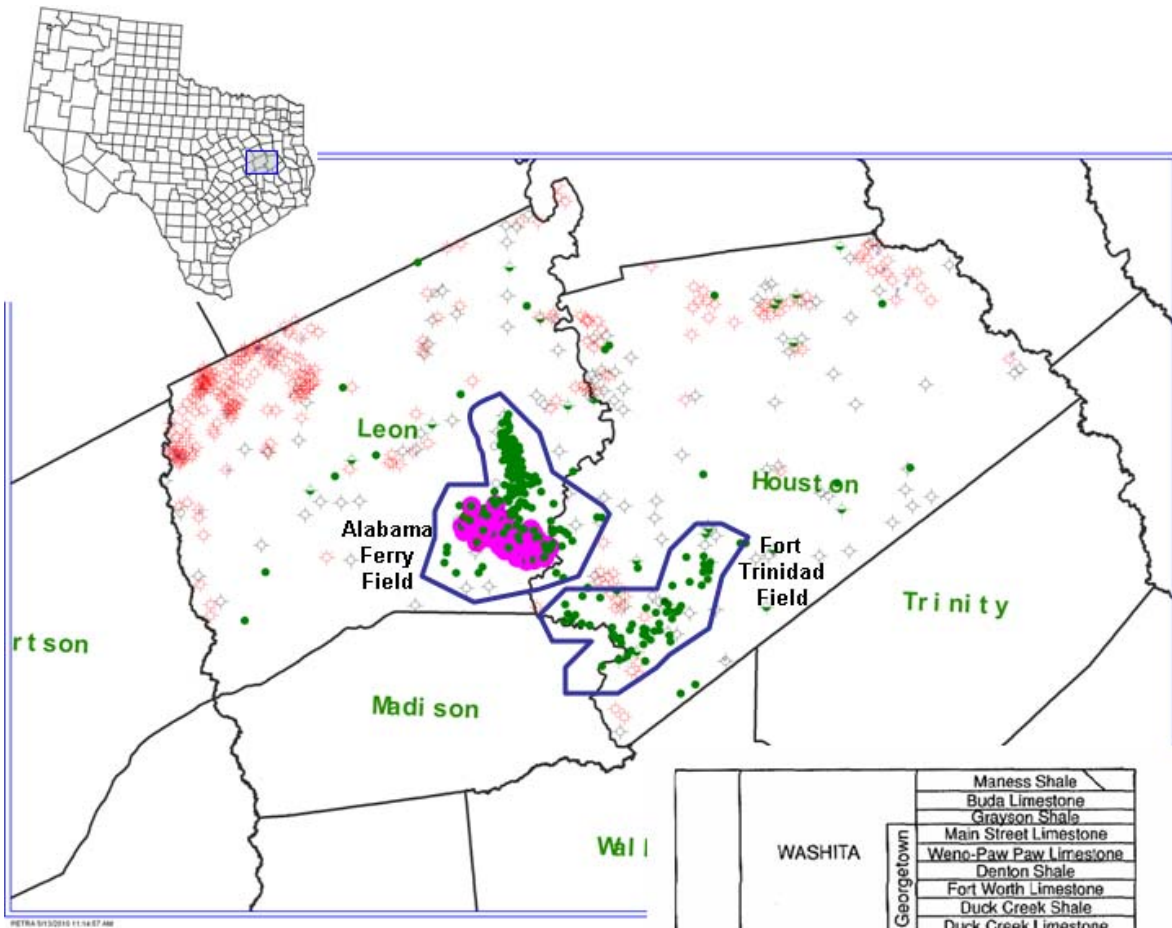
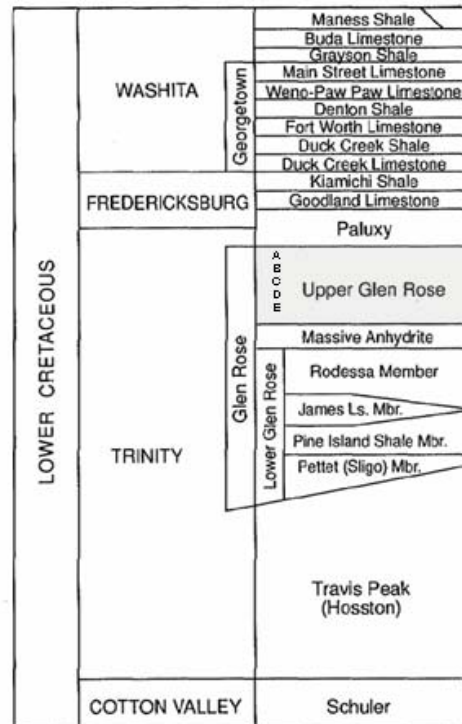


Figure 1. Basemap and stratigraphic column for the Alabama Ferry and Fort Trinidad fields in East Texas. The base map illustrates the outline of the Fort Trinidad and Alabama Ferry proper with wells from this study highlighted in pink. The stratigraphy of the East Texas Basin for the Lower Cretaceous is shown with the Upper Glen Rose highlighted in gray (adapted from Bruno et al., 1991; Fitchen, 1997). The Alabama Ferry Field produces from the Upper Glen Rose “D” interval.



exposure and lack meniscus cements. The lateral continuity, lack of stratification, and absence of early cementation indicate the shoals themselves have been re-worked. In the shallowing-upward succession at Alabama Ferry Field (Fig. 2), the ooid grainstones represent the shallowest depositional setting. The ooid grainstones can be the best reservoir facies where dissolution occurred creating connected-moldic porosity (Fitchen, 1994). However, these grainstones can also have low porosity and permeabilities where they have been diagenetically altered with pore-filling calcite cement.

(2) Ooid-pelecypod-echinoderm grain-dominated packstone. This facies has a transitional contact with the overlying ooid shoals and a sharp basal contact. It is generally poorly-sorted with pore-filling and calcite spar rims around the grains. The pelecypods in this facies are thin-walled and usually occur as large fragments indicating very little transport of abrasion. This facies has lower porosity and permeability measurements relative to the grainstone shoals.

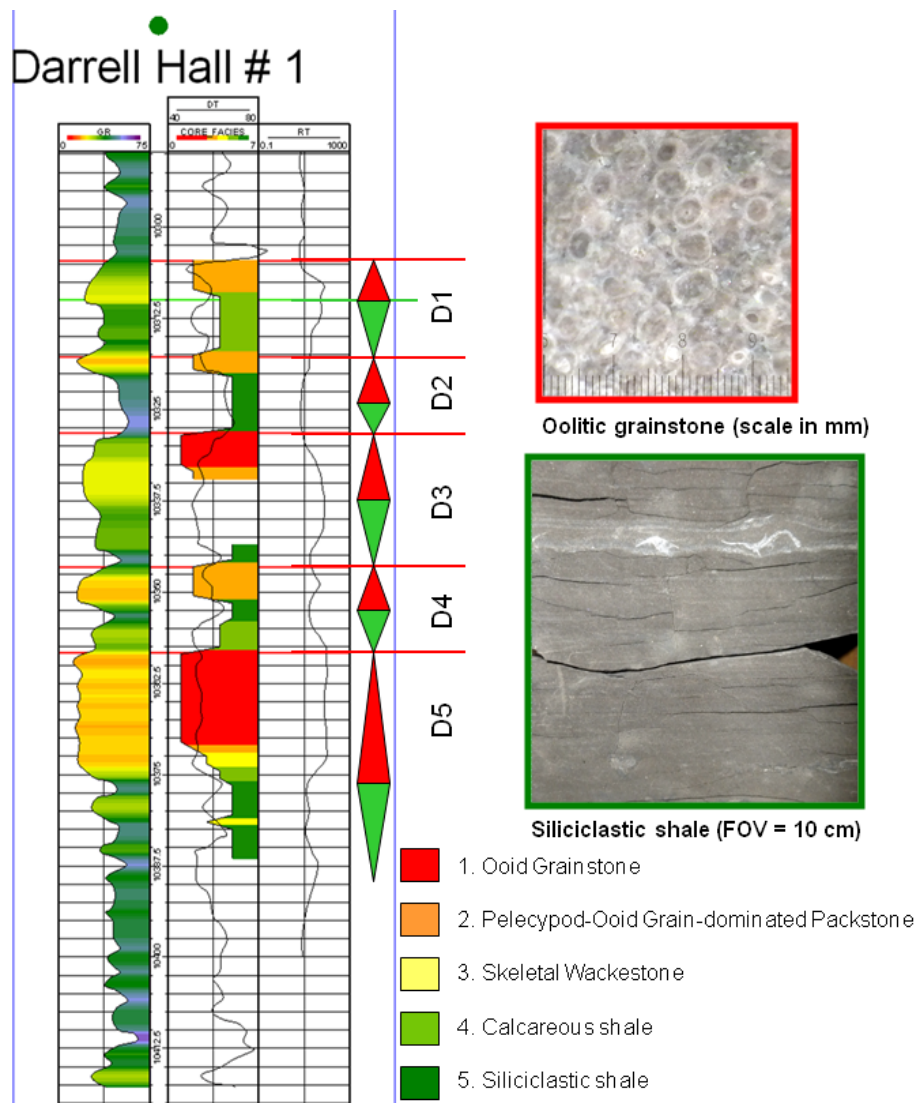


Figure 2. Darrell Hall # 1 well log and core description illustrating the vertical facies patterns, facies log character, cycle stacking patterns, and field wide correlations (designated as D1-D5 cycles).

(3) Organic-rich skeletal oolitic mud-dominated packstone to wackestone. This facies represents the thin bedded (where present at all) transition between the organic-rich shales and the more open marine, carbonate-dominated, oolitic and skeletal grain-dominated facies (Fig. 2). This facies has varying degrees of bioturbation and ooids are a rare component. It is poorly sorted and with the increase in mud-content a paired increase in organic matter occurs.

(4) Organic-rich shales. Initial core examination it was difficult to discern the difference between the calcareous and siliciclastic organic-rich fine grained facies. x-ray diffraction (XRD), x-ray fluorescence (XRF), and total organic carbon (TOC) analyses identified the different mineral components of these intercalated shales (Fig. 3). The four analyses were done on the J. P. Sullivan #1 well. Figure 3A illustrates the two shallower samples are the siliciclastic shales and the two deeper samples are the carbonate-rich shales. The carbonate shale sample from 10,239.4 feet had a TOC value of close to 2 by weight percent (Fig. 3B), so vitrinite reflectance analyses on this sample were done (Fig. 3C).

- (a) Calcareous shales. The organic-rich, carbonaceous shales have a lower degree of bioturbation. Based on the limited core material a few consistent trends seem to emerge. At Alabama Ferry Field, the calcareous shales have a lower TOC than the siliciclastic beds. The calcareous shales are slightly more fissile and can be thicker beds which may indicate a slightly higher sedimentation rate.
- (b) Siliciclastic shales. The siliciclastic shales are also organic-rich, dark grey to black in color, and relatively well cemented. The shales with greater than 50 percent siliciclastics are less fissile than the shales that have greater than 50 percent carbonate.

Depositional Setting and Sequence Stratigraphic Framework

Facies stacking patterns developed in the Glen Rose “D” are unique when compared to other shallow-water carbonates of similar age around the Cretaceous Comanche Platform. During transgression to maximum flooding in the East Texas Basin, bottom waters must have been partly anoxic to preserve the significant thickness of organic-rich shales observed in cores (Arthur et al., 1990; Fitchen 1994). There is an ongoing debate within the Aptian-Albian worldwide geology as to the genesis of the relatively thick accumulations of organic-rich shales. Is the shale accumulation related to an increase in surface water productivity and therefore higher sedimentation rates occur or does the ocean become stratified without cool, oxygenated bottom waters driving circulation resulting in anoxic bottom waters and a greater amount of preserved organics being deposited (e.g., Arthur et al., 1990)? At Alabama Ferry Field, a stark contrast exists between the two end-members of facies deposited. The shales (both siliclastic and carbonaceous) are deposited on the later rise to maximum flooding where the anoxic bottom waters are brought up onto the ramp margin to preserve the organic-rich sediments. As sea level falls, the circulation and wave energy increase setting up well-oxygenated waters where shallow-water carbonates can occur. The ooid grainstones are then deposited in the highstand and re-worked into sheet-like deposits as sea level falls.

Examining these relationships in a cross section illustrates that at Alabama Ferry Field an overall shallowing-upward succession occurs with progradation in the northwestern direction (Fig. 4). The stratigraphic framework is delineated into five cycles with the oldest high-frequency cycle identified as D5 and the youngest cycle identified as D1. The top of cycle D1 is the top of the Glen Rose “D” interval. The relative proportion of clean carbonates in within each cycle and the down dip changes inside a cycle indicate a subtle shift in grainstone thickness indicating progradation of these grainstone shoals to the northwest (Fig. 5). A better understanding of this progradation and shift-

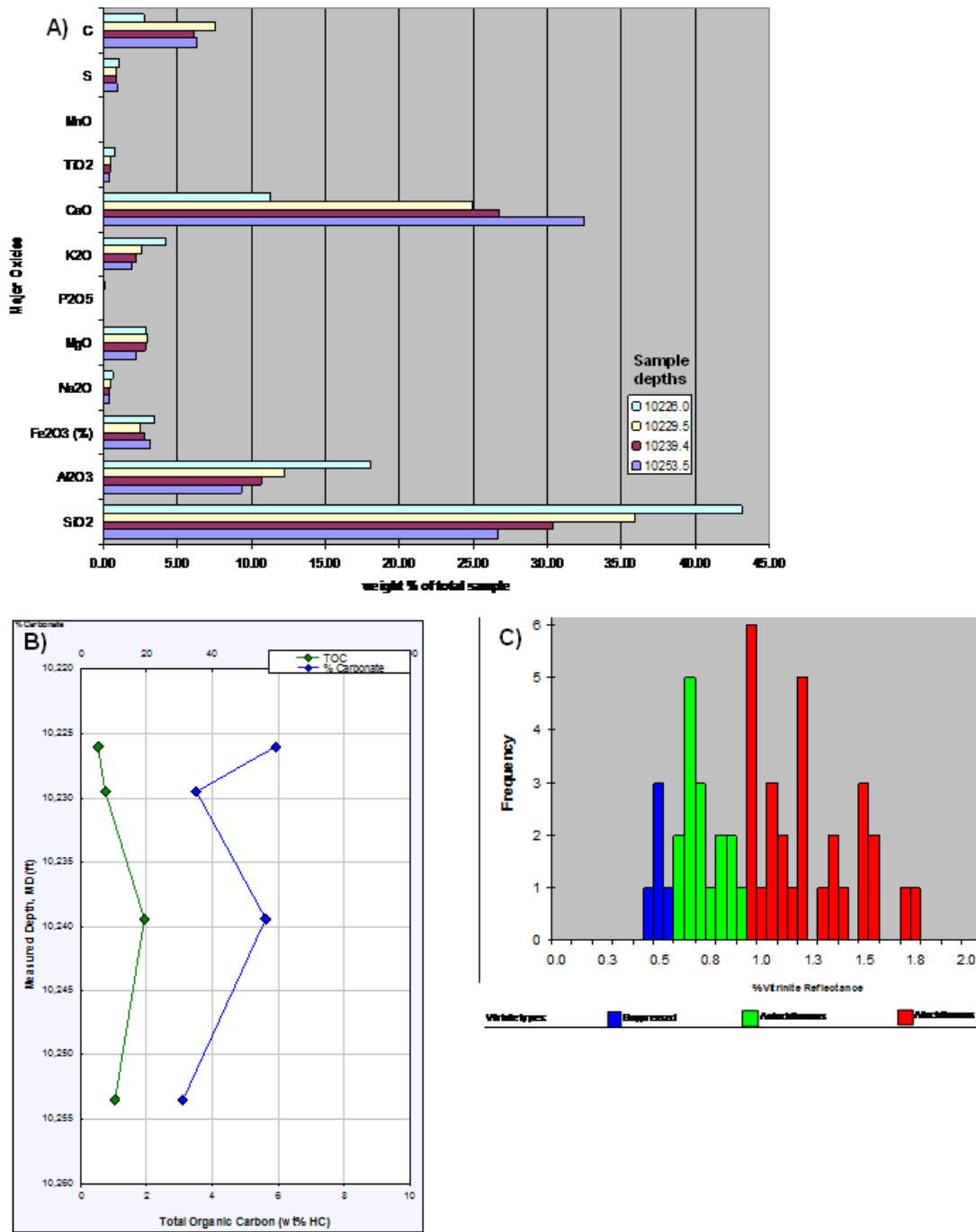


Figure 3. XRF, TOC, and vitrinite reflectance measurements from the Joseph P. Sullivan Estate #1-A well. (A) The XRF analyses show that the organic-rich shale intervals in cycles D3 and D4 are more carbonate rich. (B) The TOC analyses on the four samples illustrates the highest TOC measurements were found in the sample from 10,239.4 feet, so vitrinite reflectance analyses were done. (C) The vitrinite reflectance analyses are shown in the histogram which indicates that the majority of organic matter is allochthonous but authochthonous matter is well within the oil window between 0.7 and 0.9% Ro (vitrinite reflectance).

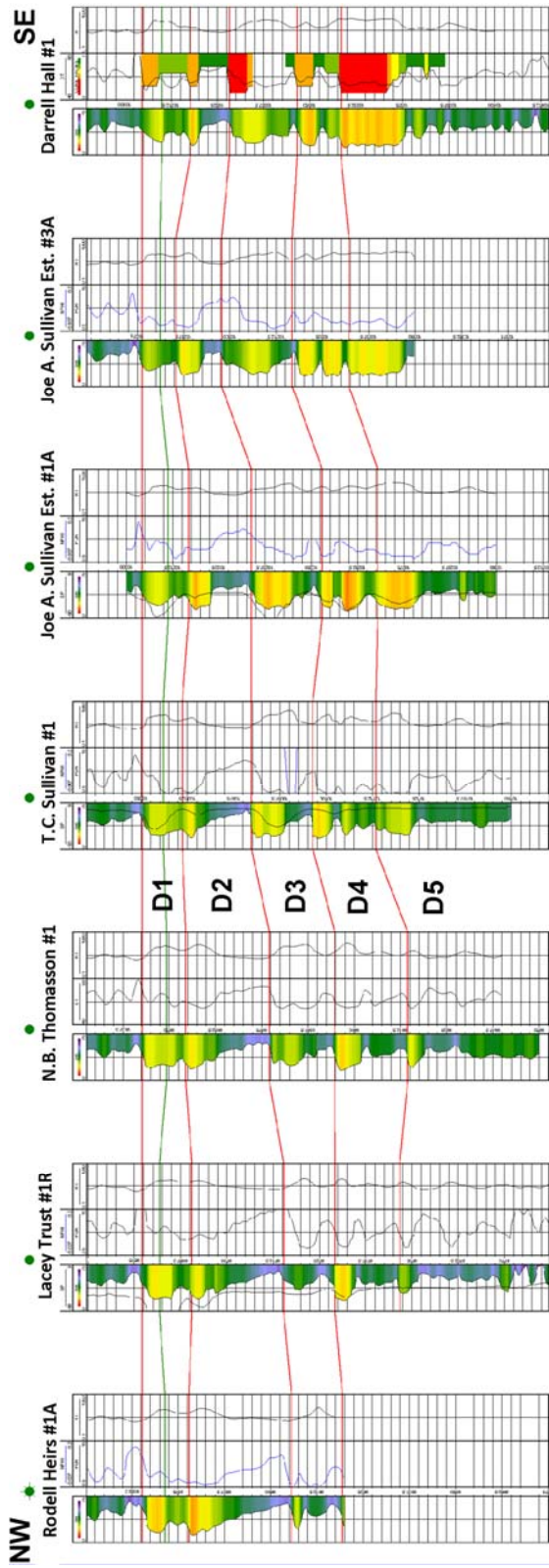
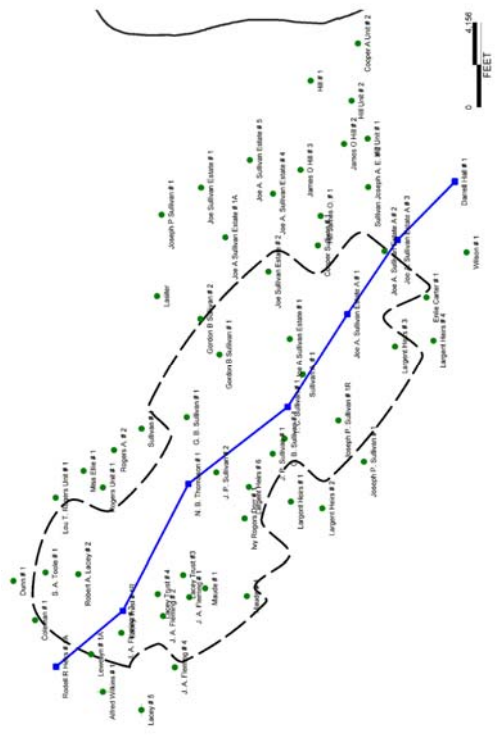


Figure 4. Southeast-northwest stratigraphic dip cross section through Alabama Ferry Field. High-frequency cycle boundaries for D5 through D1 are highlighted in red with the maximum flooding surface for D1 shown in green. The log to facies calibration from the Darrell Hall well on the far right indicate good correlation between the clean gamma ray (shaded on the first log track in orange and yellows) and ooid grainstone shoals (shown in the second log track in the red shading). By examining the gamma signature along a dip cross section the grainstone shoals seem to prograde to the northwest.



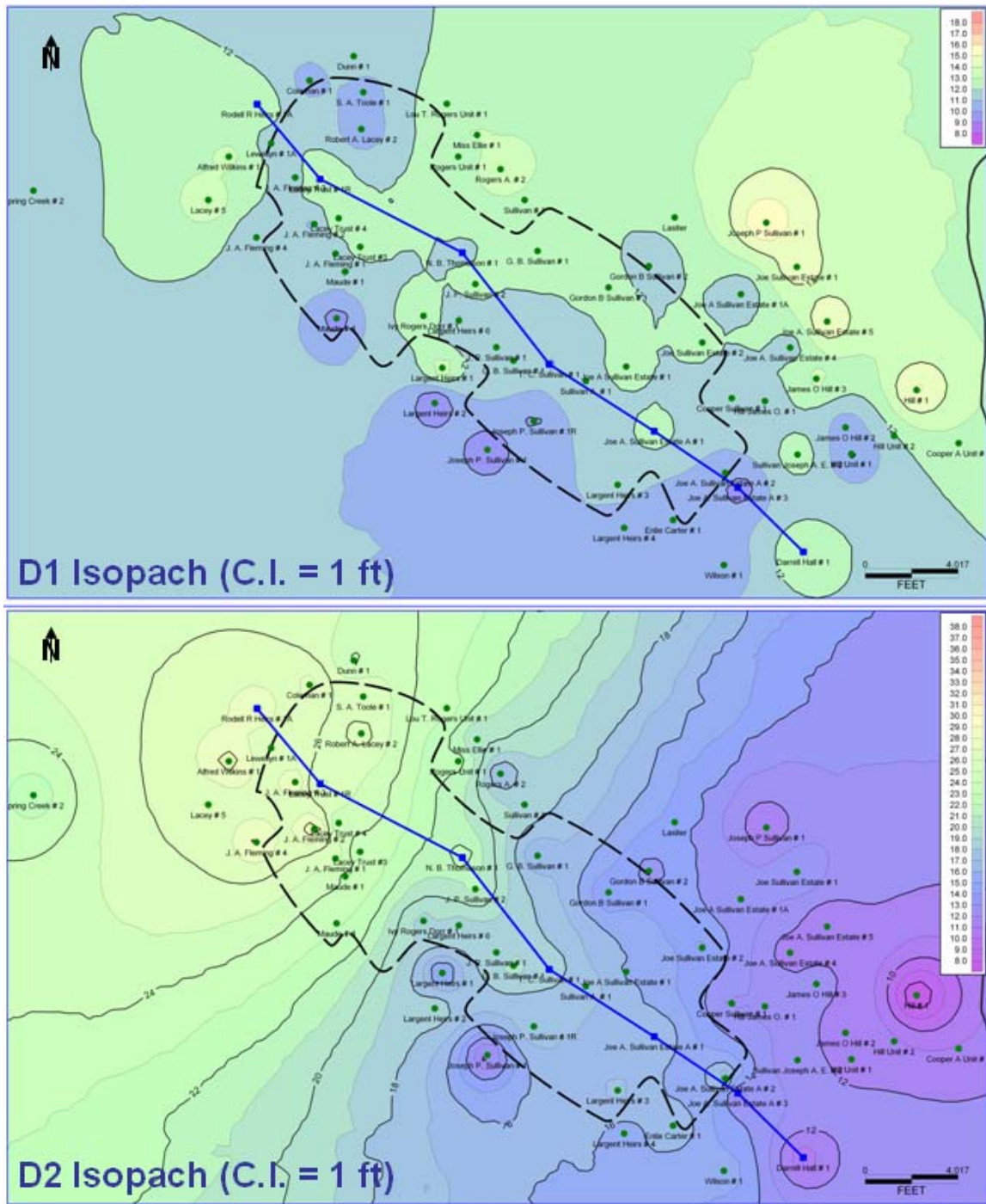


Figure 5. Isopach maps of the D1 and D2 cycles. The shallowing upward succession in the Glen Rose "D" appears to fill accommodation. During D2 deposition, the shoals thicken into the East Texas Basin to the northwest. D2 isopach shows that the system has not quite filled all accommodation and there is still some progradation. The depositional pattern changes in the next younger cycle, the D1, which is much thinner overall. The subtle thickness changes shown in the isopach do not show an basinward progradation and are likely attributed to erosion at the end of D1 time.

ing thickness of the ooid grainstone shoals needs further investigation in a larger regional area.

Conclusions

Ultimately, it is important to place the sedimentologic and stratigraphic interpretations presented here in a context of reservoir quality to maximize production (Lucia, 2002). The wireline-log measurements available for this study were of poor quality and did not lend themselves to detailed petrophysical analyses. The best reservoir facies is within the ooid grainstones where porosity values range from six to ten percent. Permeability is higher where inter-connected moldic porosity is developed. TOC analyses of shales indicate that there is sufficient organic matter in the carbonate-rich shale facies to be an active source rock. Therefore the best production in the Glenn Rose “D” interval at Alabama Ferry Field will be in the higher porosity ooid grainstones that are underlain by a significant thickness of organic rich shales.

ACKNOWLEDGMENTS

The author would like to acknowledge Brian Jarvie for running the TOC and vitrinite reflectance analyses, Henry Francis for completing the XRD analyses, and Necip Guven for the XRF analyses. The paper was greatly improved with editing assistance and technical discussions with Bill Fitchen, Chris Zahm, Bob Loucks, and Ursula Hammes.

REFERENCES CITED

- Arthur, M. A., H. C. Jenkyns, H. J. Brumsack, and S. O. Schlanger, 1990, Stratigraphy, geochemistry, and paleoceanography of organic carbon-rich Cretaceous sequences, *in* R. N. Ginsburg and B. Beaudoin, eds., *Cretaceous resources, events and rhythms*: Kluwer Academic Publishers, p. 75-119.
- Bruno, L., D. L. Roy, G. S. Grinsfelder, and A. J. Lomando, 1991, Alabama Ferry Field, U.S.A.—East Texas Basin, Texas, *in* N. H. Foster and E. A. Beaumont, eds., *Stratigraphic traps II: American Association of Petroleum Geologists, Treatise of Petroleum Geology, Atlas of Oil and Gas Fields*, Tulsa, Oklahoma, p. 1-27.
- Fitchen, W. M., D. G. Bebout, and D. R. Prezbindowski, 1997, Production from Cretaceous high-permeability carbonate grainstones—Alabama Ferry North Unit, Leon County, Texas, *in* R. P. Major, ed., *Oil and gas on Texas state lands: An assessment of the resource and characterization of type reservoirs*: Texas Bureau of Economic Geology Report of Investigations 241, p. 117-126.
- Fitchen, W. M., D. G. Bebout, and C. Hoffman, 1994, Recognition, correlation, and hierarchical stacking patterns of cycles in the Ferry Lake–Upper Glen Rose, East Texas Basin: Implications for grainstone reservoir distribution: *Gulf Coast Association of Geological Societies Transactions*, v. 44, p. 760.
- Lucia, F. J., 2002, Estimating permeability from porosity in Alabama Ferry Field: The rock-fabric approach: *Gulf Coast Association of Geological Societies Transactions*, v. 52, p. 673-680.