Extending Facies Interpretations by Integrating Core, Image-Log, and Wireline-Log Data in the Upper Cretaceous Olmos Formation of South Texas

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ABSTRACT

The Olmos Formation is composed of shelf, shoreface, and delta-system sandstones and associated mudstones. Facies architecture has distinct lateral and vertical variations. Cores are essential for documenting specific facies, and such cores are rare. Hydrodynamic and biological features down to several inches are, however, apparent and recognizable on image logs calibrated to core. When calibrated image logs are used, facies can readily be interpreted from the image logs resulting in a broader base for facies interpretations, because of the greater availability of image logs. In conjunction with wireline logs, facies can be reasonably predicted, extending facies, depositional systems, systems tract and sequence stratigraphic interpretations over a much larger area. The shelf strata in cores are extensively bioturbated, corresponding to the Cruziana ichnofacies (Asterosoma, Schaubcylindrichnus, Zoophycus, Bergaueria, Scolicia, Thalassinoides, Chondrites and Diplocraterion). The bioturbated strata appear as nonlaminated sandstone on the image log. The shoreface strata in core exhibit cross-bedding and Ophiomorpha and Macaronichnus trace fossils correspond to the Skolithos ichnofacies. Cross-bedding and burrowing are identifiable on image logs. The deltaic system is characterized by channel and salt-marsh subenvironments, and the salt-marsh related facies comprise beds of carbonaceous shale laminae to thin beds of coal, and very fine-grained, mud-rich, bioturbated sandstone and dark-gray bioturbated (Psilonichnus) sandy mudstone with common root traces. Channel related facies comprise fine- to medium-grained, cross-bedded sandstone, containing up to 50% rock fragments with common shale clasts and minor amounts of detrital coal. The channel-related sandstone is well laminated. These two subenvironments compose a wave-dominated, deltaic depositional system, and the related facies can be identified on image logs.

INTRODUCTION

The goal of the current study was to analyze the facies and depositional systems of the Olmos Formation in the study area. Data for the study comprised whole core, wireline logs, and image logs from Gold River North Field, Webb County, Texas (Fig. 1).

The lower Maastrichtian Olmos Formation of southwest Texas (Fig. 2) has been an active exploration target since the 1920s. Tyler and Ambrose (1986) provided a regional study of the Olmos depositional systems and oil
Figure 1. Location map of Gold River North Field, Webb County, Texas, showing cored wells: Huber #224 Briscoe E and Crimson #132 Briscoe E. Satellite image from Google Earth; used by permission; downloaded on February 26, 2007.
Figure 2. Stratigraphic column of the Upper Cretaceous (modified from Mahmoud, 2004) including chronostratigraphy and lithostratigraphy of the study area (Rio Grande) and central Texas. Note that the vertical stripes signify lacunas (hiatus in deposition).

and gas plays. They also mentioned the previous work that had been performed on the Olmos as of the date of publication of their study. Finley (1986) included an overview of the Olmos and its low permeability characteristics. Subsequently, Dennis (1987) discussed the depositional environments of A. W. P. Olmos Field in McMullen County, Texas. Barrow et al. (1992, 1997) discussed the lithology and petrophysical properties of the muddy-sandstone facies in the Olmos in an area just south of the current study area. Scott (2000) and Eguiliz de Antuñano et al. (2003) discussed the coalbed methane potential of the Olmos. Mahmoud (2004), who conducted an integrated (well, outcrop, and seismic data) study of the palynology and sequence stratigraphy of the Olmos, concluded that the age of the Olmos corresponds to the late early Maastrichtian (Fig. 2).

The paleogeography of the region during early Maastrichtian deposition of the Olmos is shown in Figure 3. Note the Alisitos Magmatic Arc of western Mexico that was shedding coarse volcaniclastic sediments eastward partly culminating in the Olmos Fan and Olmos Delta depositional systems. Also noteworthy is the uplift and crustal shortening occurring between the magmatic arc and the Olmos Delta. Both features influenced deposition of the Olmos sands.
METHODS

A major part of the study involved analysis of conventional whole cores from two wells, the Crimson #132 Briscoe E and the Huber #224 Briscoe E (Fig. 1). The cores of the Crimson #132 Briscoe E well consist of two segments, each approximately 120 ft long encompassing core depths of 4590 to 4711 ft and 4848 to 4972.5 ft (Fig. 4), respectively. The core of the Huber #224 Briscoe E consists of two 60-ft segments encompassing core depths from 4160 to 4280 ft (Fig. 4).

The study also had access to image logs from over eighty wells (including the cored wells) in Gold River North. The intent of the study was to correlate the facies seen in core with the corresponding facies on a cored well’s image log (Fig. 5) and then interpret facies from image logs of the uncored wells. The available whole cores were successfully integrated with the image logs. However, the extended phase of the study using the image logs of wells without core did not occur because the field was sold before the study was finished.

DISCUSSION

Facies

Five major facies were identified in the cores, three of which are detailed in Figure 5. One facies (facies 1) comprises bioturbated strata of light gray, fine-grained sandstone that include *Ophiomorpha* and other ichnofossils (e.g., *Asterosoma*, *Schaubcylinrichmus*, *Zoophycus*, *Bergaueria*, *Scolicia*, *Thalassinoides*, *Chondrites*, *Macaronichnus*, and *Diplocraterion*). The facies commonly includes scattered oyster shells, with a few 1- to 3-ft-thick beds containing abundant and concentrated oyster shells.
Figure 4. Stratigraphic cross section of cored wells #224 Briscoe E and #132 Briscoe E (see Figure 1 for well locations). The datum “Top Olmos MFS” is present throughout the field area and is interpreted as a maximum flooding surface, but no core or seismic data are available to corroborate this interpretation. The cored intervals are indicated by the sections highlighted in yellow. SB2 may be a true sequence boundary, a basinward shift in base level. SB1, SB3 and SB4 are now interpreted as autocyclic facies changes, and are not true sequence boundaries.

A second facies (facies 2) comprises laminated and cross-laminated light gray, fine-grained sandstone, commonly with dispersed, fine-grained organic fragments. Note also the presence of thin, sandy, clay-rich beds at core depth 4946 ft composed of 70% clay (46% mixed layer clay, 9% illite, 8% kaolinite, and 7% chlorite), 9% quartz, and 15% feldspar. These beds show up as high-gamma-ray spikes on wireline logs.

A third facies (facies 3) comprises light-yellowish-gray, medium- to coarse-grained sandstone, with some clay drapes, mud clasts, and dispersed woody organic fragments and detrital coal throughout. Note the basal mud-clast conglomerate with clasts up to 1 inch in diameter at a core depth of 4944.5 ft in Figure 5A. The mud clasts are also identifiable in Figure 5C at log depth 4945 ft.

A fourth facies (facies 4) consists of light-gray to reddish-brown, medium- to fine-grained, laminated to crossbedded sandstone that sometimes includes root traces in and near bed tops, especially when overlain by the fifth facies (facies 5), dark-gray, laminated mudstone with isolated shell lags and interbedded black, carbonaceous mudstone, with laminae of bedded coal. *Psilonichnus* (i.e., crab burrows) is commonly present.
Figure 5. Comparison of facies between core and image logs of #132 Briscoe E well, core #2. (A) Uncompressed core photograph from 4943 to 4949 ft (core depths). (B) Photograph of core from 4937 to 4949 ft (core depths). Photograph compressed to the same scale as image log. (C) Image log of core from 4940 to 4950.5 ft (wireline log depths). Note the easily discernable mud clasts and *Ophiomorpha* burrows in image C and the equivalent facies in images A and B.
Depositional Environments

Facies 1 corresponds to a marine (shoreface swale and shelf) depositional environment, an example of which is shown in Figure 5A and 5B at core depths of 4947.5 to 4949 ft. Note also the distinct corresponding facies on the image log in Figure 5C at log depths 4948.5 to 4951 ft.

Facies 2 was also deposited in a shoreface depositional environment but in a somewhat higher energy setting (e.g., a shoreface ridge or bar). An example of this facies is in Figure 5A and 5B at core depths 4944.5 to 4947.5 ft. The sandy clay-rich beds are interpreted as altered volcanic ash-fall deposits.

Given its relatively coarser grain size, the depositional environment for facies 3 is interpreted as either a distributary mouth bar or a fluvial channel. The presence of mud clasts and woody fragments suggests that the channel was actively eroding nearby muddy salt marsh deposits because this type of clast does not generally travel far from its provenance without disaggregating.

Facies 4 and 5 were both deposited in a nonmarine environment and probably compose a facies tract. Facies 4 was deposited in beach ridges and facies 5 in adjacent salt marshes with occasional crevasse splays. The carbonaceous shale and laminae of bedded coal suggest an organic-rich, nonmarine depositional environment. The crab burrows and root traces in muddy sandstone beds associated with facies 4 also indicate a non-marine environment.

The regional setting of the Olmos shown in Figure 3 (Goldhammer, 1999) suggests that distant volcanism and possibly incipient tectonism related to the Laramide Orogeny were important influences on Olmos deposition. The provenance of the clastic grains was the Alisitos Magmatic Arc via a large intervening alluvial plain. Scattered sandy clay-rich beds with high gamma-ray signatures probably indicate volcanic-ash falls. Therefore, the eustatic signal in the stratigraphy of the Olmos may have been mostly overwhelmed by tectonism. Figure 4 includes stratigraphic markers SB1, SB3, and SB4. Initially these were considered to be high-order sequence boundaries. However, difficulty in correlating them and an unclear areal extent argue that these may actually be autocyclic facies boundaries. Conversely, the much broader regional extent of the SB2 surface and the juxtaposition (in core #1 of well #132 Briscoe E) of fluvial sandstone above middle to lower shoreface sandstone suggest that it may be a sequence boundary, albeit one that tectonism could have augmented.

SUMMARY AND CONCLUSIONS

Facies identified in the #132 Briscoe E and #224 Briscoe E cores indicate deposition in both marine and nonmarine depositional systems. Given the presence of exceptionally well-preserved *Cruziana* ichnofacies, the marine facies were deposited in a shallow, normal-marine depositional system below fair-weather wavebase. Highly burrowed beds alternating with nonbioturbated beds were deposited in swales and ridges, respectively, in lower to middle shoreface environments. The presence of coal laminae, carbonaceous mudstone, dispersed woody and detrital coal fragments (in sandstone), clay clasts and root traces, and *Psilonichnus* trace fossils typifies nonmarine facies in the cores. The nonmarine depositional environments include fluvial channels and channel-mouth bars, levees, crevasse splays, and salt marshes. All the nonmarine depositional environments indicate a wave-dominated deltaic depositional system that periodically prograded over the shoreface depositional system and was alternately transgressed by the shoreface depositional system by autocyclic delta-lobe switching and abandonment. The regional setting of the Olmos suggests that tectonism played an important role in its deposition.

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