[PS]Reservoir Characterization of the Upper Cretaceous Woodbine Group in Northeast East Texas Field, Texas*

Merve Dokur[1] and Tucker F. Hentz[2]

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[1]Department of Geological Sciences, Jackson School of Geosciences, The University of Texas at Austin, TX (mervedokur86@gmail.com)
[2]Bureau of Economic Geology, Jackson School of Geosciences, The University of Texas at Austin (tucker.hentz@beg.utexas.edu)

Abstract

East Texas field, a giant U.S. oil field, produced 5.42 billion stock-tank barrels from discovery in 1930 through mid- 2007. The lower part of the siliciclastic Upper Cretaceous Woodbine Group is reservoir rock, and almost all production comes from the upper unit, the operator-termed Main sand. The field could produce 70 million stock-tank barrels (MMSTB) using current strategies, whereas 410 MMSTB of remaining reserves from the Stringer zone (lower unit), along with bypassed pay in both units and unswept oil, is possible. These favorable statistics have increased interest in reservoir characterization of the Woodbine, especially the Stringer zone. This study delineates sandstone geometry and interprets reservoir facies and heterogeneity of the Stringer zone and Main sand in northeast East Texas field. Additional objectives are to define key chronostratigraphic surfaces, such as flooding surfaces and unconformities, and to establish a realistic depositional model for the reservoir succession. To achieve these objectives, well log analysis, core description, and net-sandstone mapping of the Stringer zone and Main sand were conducted. According to sequence-stratigraphic and depositional-system analysis, the Woodbine Group is divided into two genetically unrelated units: (1) the highstand deltaic Stringer zone and (2) the lowstand incised-valley-fill Main sand. Principal reservoir units are Stringer 1 and Stringer 2 sands within the Stringer zone and the Main sand. Stringer 2, best developed in the southwest study area, is the most promising reservoir unit for new production. Well deepening and water flooding in this more continuous and thicker sand are proposed to increase production in East Texas Field.

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THE UNIVERSITY OF TEXAS AT AUSTIN
JACKSON SCHOOL OF GEOSCIENCES

DGS UT-Austin

BUREAU OF ECONOMIC GEOLOGY

ABSTRACT

East Texas field, a giant U.S. oilfield, produced 5.42 billion stock-tank barrels from discovery in 1930 through mid-2007. The lower part of the siliciclastic Upper Cretaceous Woodbine Group is reservoir rock, and almost all production comes from the upper unit, the operator-termed *Main sand*. The field could produce 70 million stock-tank barrels (MMSTB) using current strategies, whereas 410 MMSTB of remaining reserves from the Stringer zone (lower unit), along with bypassed pay in both units and unswept oil, is possible. These favorable statistics have increased interest in reservoir characterization of the Woodbine, especially the Stringer zone. This study delineates sandstone geometry and interprets reservoir facies and heterogeneity of the Stringer zone and Main sand in northeast East Texas field. Additional objectives are to define key chronostratigraphic surfaces, such as flooding surfaces and unconformities, and to establish a realistic depositional model for the reservoir succession. To achieve these objectives, well log analysis, core description, and gross-sandstone mapping of the Stringer zone and Main sand were conducted. According to sequence-stratigraphic and depositional-system analysis, the Woodbine Group is divided into two genetically unrelated units: (1) the highstand deltaic Stringer zone and (2) the lowstand incised-valley-fill Main sand. Principal reservoir units are Stringer 1 and Stringer 2 sands within the Stringer zone and the Main sand. Stringer 2, best developed in the southwest study area, is the most promising reservoir unit for new production. Well deepening and waterflooding in this more continuous and thicker sand are proposed to increase production in East Texas field.

INTRODUCTION

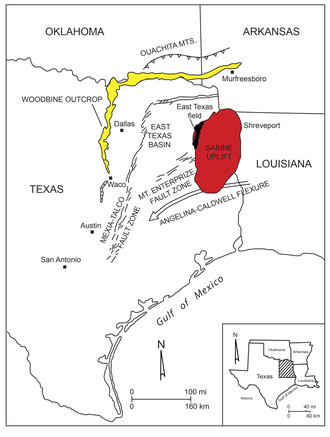


Figure 1: Principal structural elements around and within the East Texas Basin (modified from Calavan, 1985).

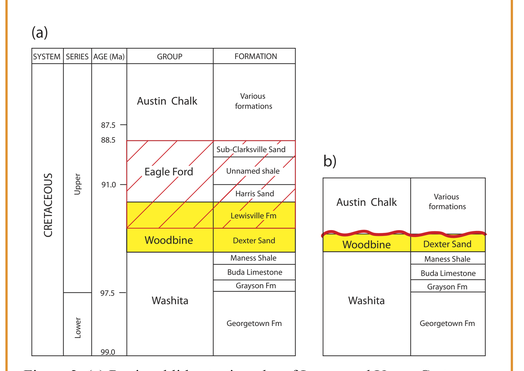


Figure 2: (a) Regional lithostratigraphy of Lower and Upper Cretaceous units of the East Texas Basin (Salvador and Muneton, 1991). (b) Austin Chalk directly overlies strata of the Woodbine Group in East Texas field because the entire Eagle Ford Group and all of the upper and most of the lower Woodbine Group were eroded owing to contemporaneous rise of the Sabine Uplift (Halbouty and Halbouty, 1982; Ambrose et al., 2009).

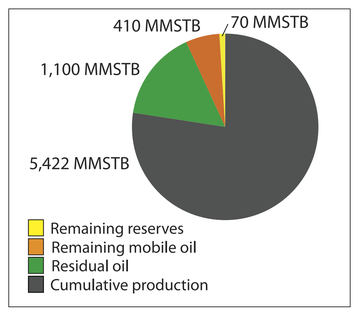


Figure 3: Distribution of cumulative oil production, residual oil, remaining mobile oil, and remaining reserves in East Texas field (Wang, 2010). Almost all production from East Texas field has been from the Main sand (upper Woodbine Group). On the other hand, recent evaluations indicate that remaining reserves are in bypassed pay in the Main sand, deeper pay in the Stringer sand (lower Woodbine Group), and poorly swept oil (Wang, 2010).

STUDY AREA

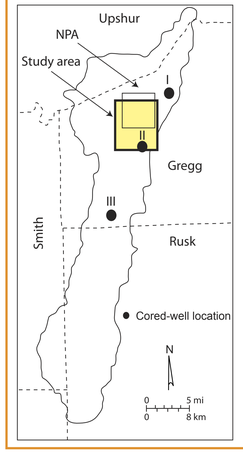


Figure 4: Location of the study area in East Texas field (NPA: north pilot area of Ambrose et al., 2009; Hentz, 2010). Map also identifies location of cored wells (I: Cities Service No. B2 Killingsworth, II: Arco No. B142 King, and III: Shell No. 55 Watson) used in this investigation.

OBJECTIVES

- To delineate sandstone-body geometry and interpret reservoir facies and reservoir heterogeneity in the Stringer sand and the Main sand reservoir facies.
- To define and interpret prominent chronostratigraphic surfaces.
- To establish a realistic depositional model for the reservoir succession.

DATA AND METHODS

- 500 well logs (GR, SP, and resistivity)
- 3 cores
- Well log analysis
- Core description
- Gross-sandstone mapping

SEQUENCE-STRATIGRAPHIC FRAMEWORK

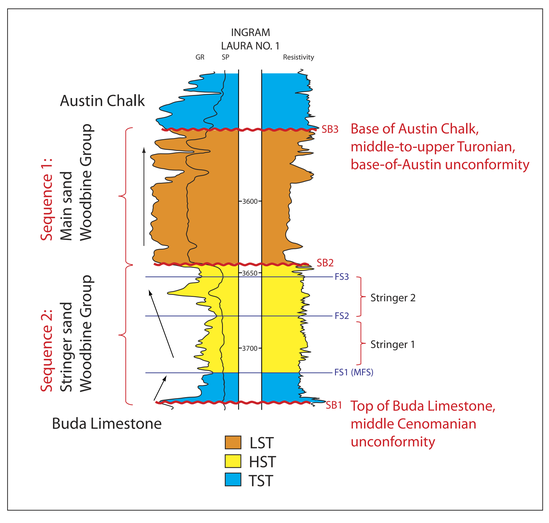


Figure 5: Type log showing system tracts (TST: transgressive system tract, HST: highstand system tract, and LST: lowstand system tract) and significant chronostratigraphic surfaces (FS: flooding surface, MFS: maximum flooding surface, and SB: sequence boundary) in fourth-order squences dividing the Woodbine Group in the study area. Arrows show general grain-size trends of depositional units.

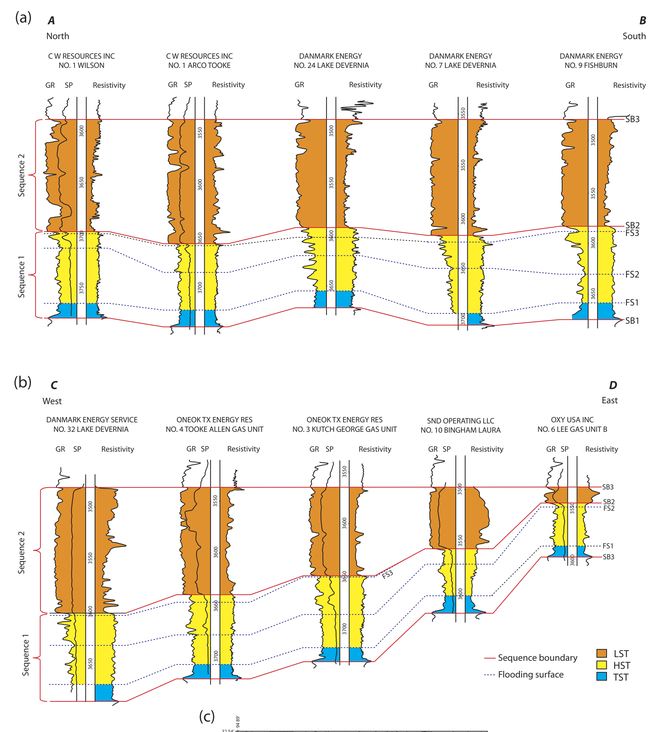
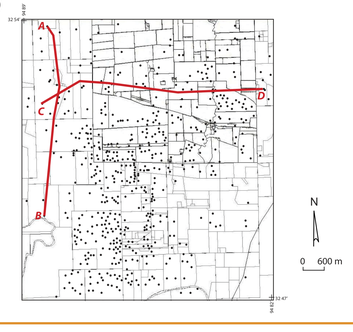


Figure 6: (a) North-south sequence-stratigraphic cross section A-B along the depositional dip of the Woodbine Group indicates only minimal thickness changes where depth of incision by the incised valley varies. (b) West-east sequence-stratigraphic cross section C-D along the depositional strike of the Woodbine Group exhibits a gradual eastward (structural updip) decrease in thickness of the overall Woodbine section because of progressive updip truncation of the interval below the base-of-Austin unconformity. Sequence 1 also diminishes in thickness toward the east edge of the field from about 110 ft (30 m) to about 20 ft (6 m). On the other hand, Sequence 2 decreases only slightly in thickness updip. However, flooding surface FS3 is truncated at the base of incision of the overlying incised-valley fill. (c) Base map shows location of control wells used in the study and lines of representative cross sections.



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DEPOSITIONAL SYSTEMS

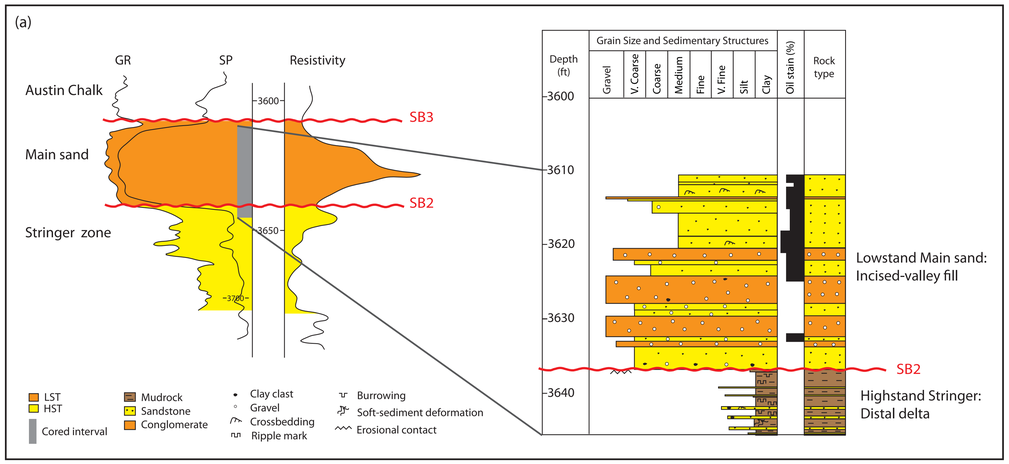

Figure 7: (a) Log image and core description of highstand deltaic Stringer zone and lowstand incised-valley-fill Main sand in Cities Service No. B2 Killingsworth well. An erosional contact at 3,637 ft (1,109 m) between the Main sand and the Stringer zone occurs. The typical observation for this surface is an abrupt change in grain size from mudstone or siltstone to very coarse sandstone or gravel. (b) Channel-fill deposits, conglomerate bed at 3,430 ft (1,046 m). (c) Base of channel-fill deposits have an erosional contact with distal-delta-front siltstone beds at 3,437 ft (1,048 m). (d) Burrowed distal-delta-front deposits composing interbedded mudrock with thin (~ 4–5 cm) very fine grained sandstone bed and burrow fills at 3,638 ft.

CONCLUSION

- The Woodbine Group in the north part of East Texas field comprises two fourth-order sequences (Sequences 1 and Sequences 2), consisting of transgressive, highstand, and lowstand systems tracts.
- The lower part of the Woodbine Group, the Stringer zone, is defined as a highstand deltaic unit that contains promising reservoir-sandstone bodies (Stringer 1 and Stringer 2) that represent distributary-channel fills, crevasse-splay deposits, and delta-front facies.
- Reservoir heterogeneity is relatively high in the Stringer sand owing to the existence of narrow distributaries.
- The upper part of the Stringer sand, Stringer 2, has thicker and relatively well connected sandstone bodies.
- The southwest part of the study area contains well-developed, thicker reservoir Stringer sand.
- Although the Main sand has better reservoir properties, such as well-developed lateral and vertical continuity of stacked fluvial sandstone bodies and high porosity and permeability values, it is suggested that the Stringer sand also has the potential to be a prospective reservoir unit.
- Production in East Texas field can be increased by application of proper field strategies, such as well deepening and waterflooding, with polymer gel flooding in the southwest part of the field, where the Stringer sand is thicker.
- The Stringer zone should be considered as another Woodbine reservoir in East Texas field. Therefore, future studies should include detailed regional mapping of the Stringer zone to develop a better understanding about depositional trends and remaining oil in East Texas field.

RESERVOIR FACIES

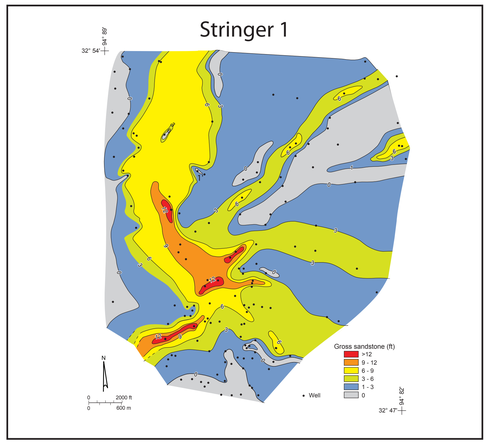

Figure 8: Gross-sandstone map of the Stringer 1 reservoir unit indicates a dominant channel trend characterized by highest gross-sandstone values (9–>12 ft [2.7–>3.6 m]) that extends from north to south parallel to primary depositional dip in the west part of the study area. Ancillary feeder channels extending from the east and northeast to the main channel contain gross-sandstone thickness of <9 ft (<2.7 m). Gross-sandstone values are generally highest at the junction of the main channel and the feeder systems. Stringer 1 is composed of highstand distal-deltaic deposits after they accumulated directly above the maximum flooding surface (FS1) at the top of the transgressive systems tract composing the lower part of the Maness Shale (SB1–FS1).

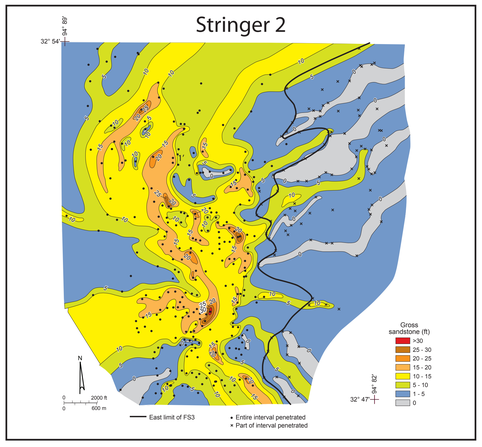

Figure 9: Gross-sandstone map of the Stringer 2 reservoir unit showing the east limit of FS3. A main channel in the west and central parts of the study area extends from the north to northeast and bifurcates toward the south in the south part of the study area. Secondary sandstone trends extend into the main trend from the east and northeast. Within the Main sandstone trend, dip-elongated sandstone bodies with thicknesses ranging from 15 ft (4.6 m) to 30 ft (9.1 m) exist. However, unlike Stringer 1, many wells in the east third of the study area do not contain a complete Stringer 2 succession because FS3 is truncated by the base-of-Austin unconformity in that region. The Stringer 2 zone records more proximal deltaic facies and consists of sandstone bodies that are thicker than the distal deltaic facies of Stringer 1.

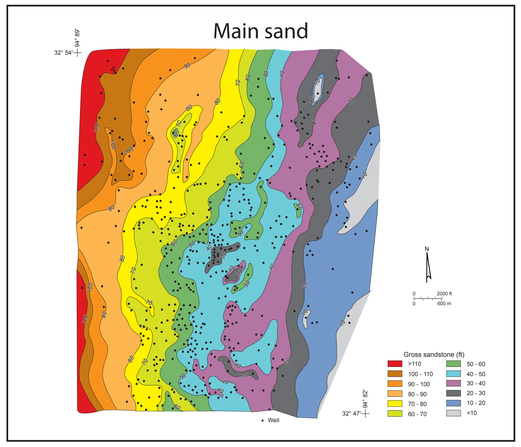

Figure 10: Gross-sandstone map of the Main sand reservoir unit between the base of the Main sand and the base of the Austin Chalk. The map exhibits a gradual decrease in thickness from 110 ft (34 m) to 10 ft (3 m) from west to east of the study area, except for a few regions in central and south parts of the area. This eastward decrease in thickness is a result of eastwardly increasing truncation of the Main sand by the overlying base-of-Austin unconformity.

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Turkish Petroleum Corporation

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