Sequence Stratigraphy of the Smackover Formation in the North-Central U.S. Gulf Coast

Ezat Heydari[1] and Lawrence R. Baria[2]

[1]Department of Physics, Atmospheric Sciences, and Geoscience, Jackson State University, P.O. Box 17660, Jackson, MS 39217

[2]Jura-Search Inc., P.O. Box 320426, Flowood, MS 39232

EXTENDED ABSTRACT

Investigations by Sarg (1988), Mancini *et al.* (1990), and Moore and Druckman (1991) have increased our knowledge of the sequence stratigraphy of the Smackover Formation. Despite these contributions, this aspect of the Upper Jurassic Smackover Formation remains poorly understood. Here, we present a conceptual model on the sequence stratigraphy of this prolific oil and gas producing unit in order to understand better the temporal and spatial relationships among lithofacies within the Smackover Formation and between its underlying and overlying units (the Norphlet Formation and the Buckner Anhydrite, respectively). Our study of cores, logs, and seismic lines suggests three sequences in the Smackover Formation in the north-central U.S. Gulf Coast. In ascending order they are named the Smackover "C," the Smackover "B," and the Smackover "A" sequences.

The Norphlet Formation forms the lowstand system tract (LST) of the roughly 600 ft (183 m) thick "C" sequence. The lithofacies succession following the Norphlet Formation includes (from bottom to top) laminated lime mudstone, thin-bedded lime mudstone, bioturbated lime mudstone, wackestone – packstone, and ooid grainstone (the Reynolds Oolite) (Fig. 1A). This succession of lithofacies indicates that the Smackover portion of the "C" sequence was deposited on a ramp (Fig. 1B). We did not recognize any deepening-upward lithofacies assemblage. Therefore, it appears that the rapid sea-level rise that initiated the deposition of the Smackover Formation portion of the "C" sequence may not have left behind a recognizable transgressive system tract (TST) deposit. The "C" sequence can be interpreted as a beach-to-basin prograding highstand systems tract (HST) to possibly a forced regression systems tract (FRST) (Fig. 2A). The modern analog for the "C" sequence is the ramp system of the Persian Gulf (Fig. 1C). A shelf margin had developed by the end of the "C" sequence deposition (Fig. 2A).

Caliche and silcrete deposits indicate that the "C" sequence was exposed to meteoric processes during a relative sea-level fall (Heydari and Moore, 1994). In addition, turbidites were deposited in the basin forming the LST of the overlying "B" sequence. A rapid sea-level rise occurred, but again, there is little or no evidence of TST sedimentation during the "B" sequence deposition. The lithofacies succession that was deposited (from bottom to top) includes peloid wackestone – packstone, peloid-oncoid grainstone, peloid-oncoid-ooid grainstone, and an ooid grainstone (Fig. 3A). The wackestone-to-grainstone succession of the "B" sequence that includes up to 400 ft (122 m) of grainstone is interpreted as steeply-dipping marine sand belts that formed parallel to the shelf margin

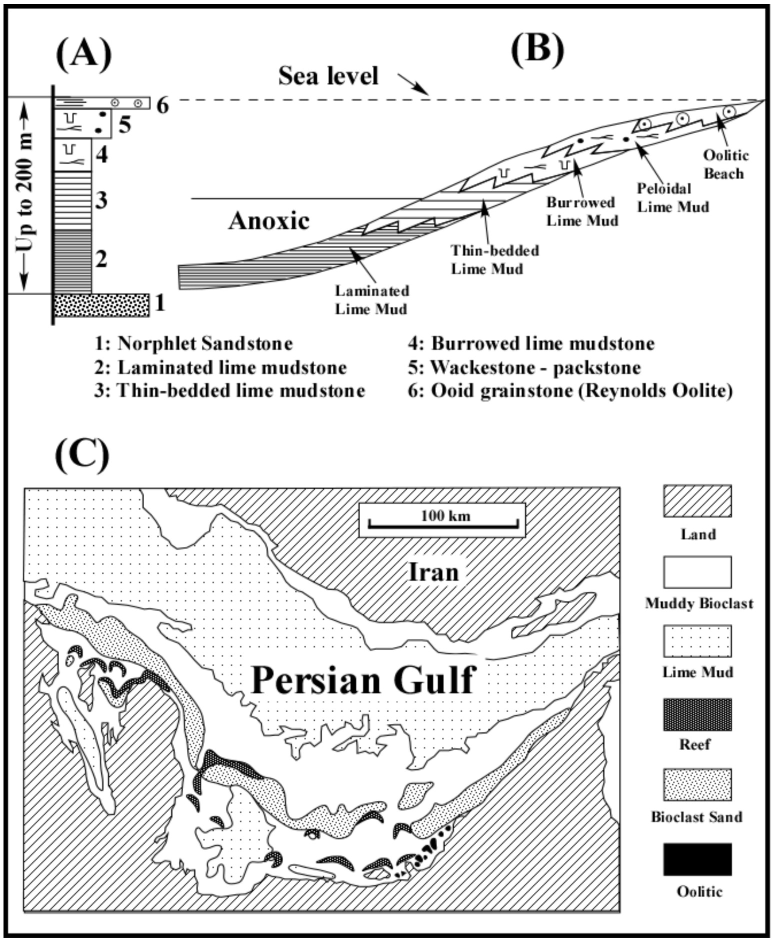

Figure 1. (A) Schematic stratigraphic column shows lithofacies succession of the Smackover "C" sequence as seen in cores. (B) A profile shows beach-to-basin lithofacies of a typical ramp. Progradation of the ramp produced the succession of lithofacies seen in Smackover "C" cycle as shown in A. (C) Map shows general sedimentological patterns of the Persian Gulf area (modified after Wilson and Jordan, 1983), considered to be a possible modern analog for the Smackover "C" sequence deposition (modified after Heydari and Baria, 2005).

(Fig. 3B). Progradation of these ooid shoals during the HST deposition formed the bulk of "B" sequence strata (Fig. 2B). The modern analog to the "B" sequence is the marine sand belt system of the Bahamas (Fig. 3C).

A relative sea-level fall exposed grainstones of the "B" sequence to subaerial processes (Heydari, 2003). Delivery of sand to the self margin adjacent to major rivers deposited turbidites in the basin forming the LST deposits of the overlying "A" sequence. Isolated shoals of the "A" sequence are approximately 70 ft (21 m) thick and formed along the shelf margin. They include skeletal packstone at the base which grades upward to ooid-oncoid grainstone, and finally into ooid grainstone (Tye and Moore, 1986).

A relative sea-level fall at the end of "A" sequence deposition exposed the Smackover platform to meteoric processes. The overlying Buckner sequence was deposited as a blanket of evaporites covering nearly the entire Smackover platform during a relative sea-level rise (Fig. 2C). Therefore, the Smackover and Buckner formations are not time equivalent according this model as applied to the north-central U.S. Gulf Coast.

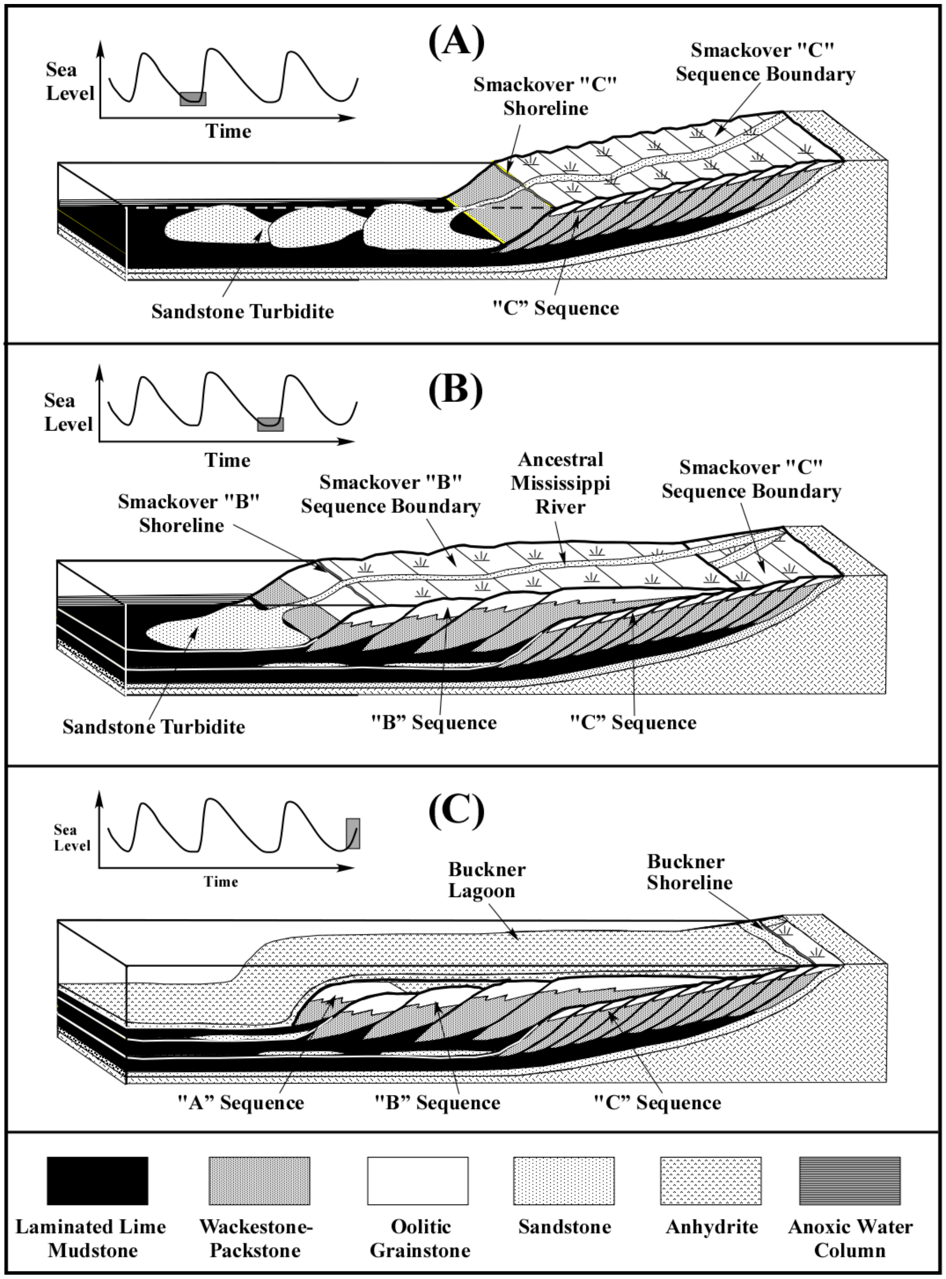

Figure 2. (A) Schematic diagram shows the end of Smackover "C" deposition and the LST phase of the "B" sequence. The "C" sequence was exposed to meteoric processes. A river system may have extended to the shelf margin delivering sandstones to the basin forming the LST turbidites of the "B" sequence. (B) Schematic diagram shows termination of Smackover "B" sequence and deposition of LST of the Smackover "A" sequence. The "B" sequence was deposited as shelf-margin parallel marine sand belts. It was exposed to meteoric processes. It is possible that a river system may have extended to the shelf margin delivering sandstones to the basin forming the LST turbidites of the "A" sequence. (C) Schematic diagram illustrates deposition of the Buckner Anhydrite as a blanket over the Smackover platform during the sea-level rise (from Heydari and Baria, 2005; reprinted with permission of the Gulf Coast Association of Geological Societies).

This conceptual model is supported by a north-south seismic line across northern Louisiana and southern Arkansas which shows prograding marine sand belts of the "B" sequence as sigmoidal features (Fig. 4). The proposed model can be summarized by hypothetic shelf-to-basin stratigraphic columns (Fig. 5). Only the "C" sequence is present in the landward portion of the Smackover platform. The "C" sequence and part of the "B" sequence occur in the middle part of the platform. Farther basinward, the 400-foot thick grainstones belong to the "B" sequence. The patchy "A" sequence is present in the southernmost part of the platform. In this model, basinward thickening of the Smackover Formation is caused by stacking of three sequences (Fig. 5).

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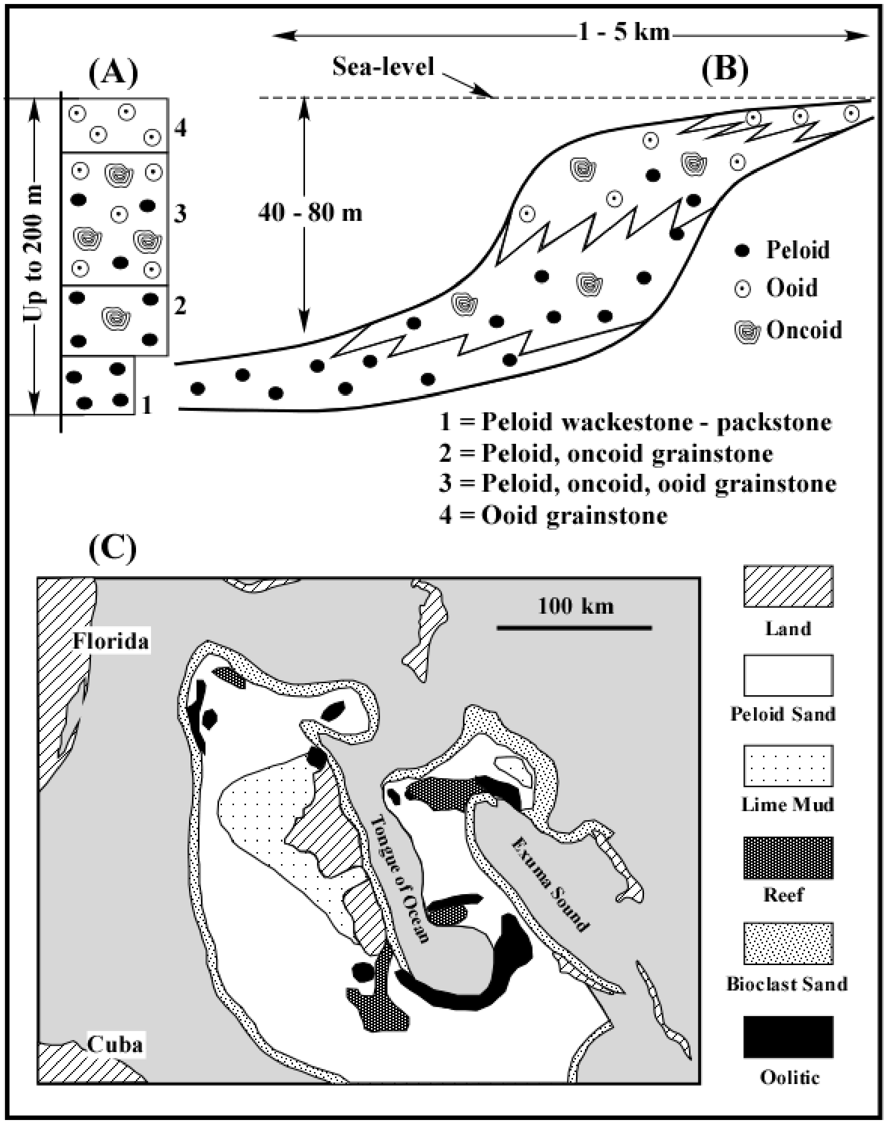

Figure 3. (A) Schematic stratigraphic column shows lithofacies succession of the Smackover "B" sequence as seen in cores. (B) Schematic profile of one Smackover "B" shoal interpreted to be shelf-margin parallel marine sand belt. Progradation of this shoal resulted in the succession of lithofacies seen in Smackover "B" and shown in A. (C) Map shows general sedimentological pattern of the Bahamas (modified after Wilson and Jordan, 1983). Ooid shoals occur along the shelf margin. Some shoal are perpendicular to the shelf margin (tidal bar belts) and others are parallel (marine sand belt). The shelf margin parallel marine sand shoals of the Bahamas are considered to be modern analog for the deposition of Smackover "B" shoals (from Heydari and Baria, 2005; reprinted with permission of the Gulf Coast Association of Geological Societies).

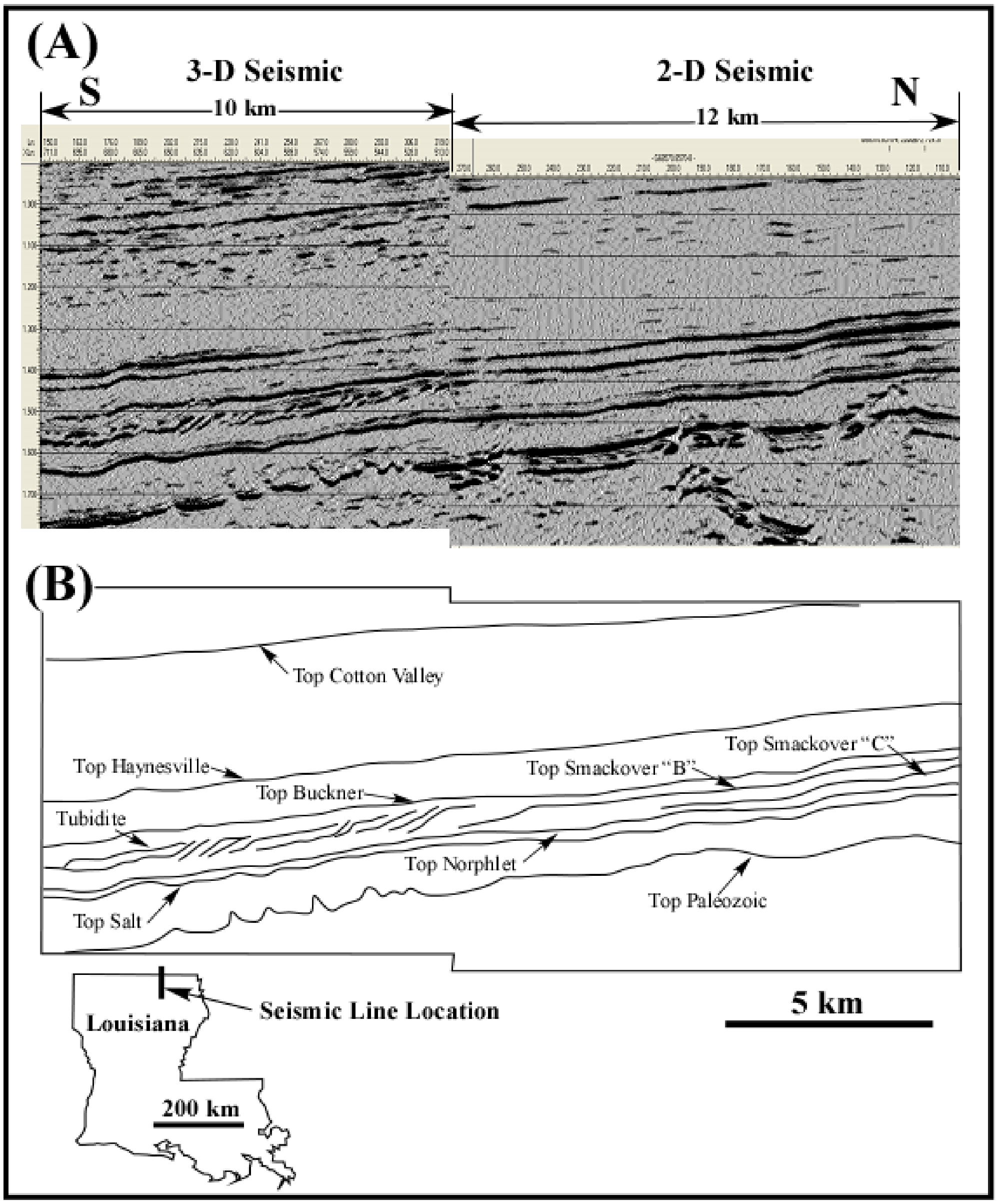

Figure 4. (A) North-south, dip-oriented seismic line from northern Louisiana and southern Arkansas. (B) Interpretation of the above seismic line. Note the prograding shelf edge marine sand belts of the Smackover "B" sequence.

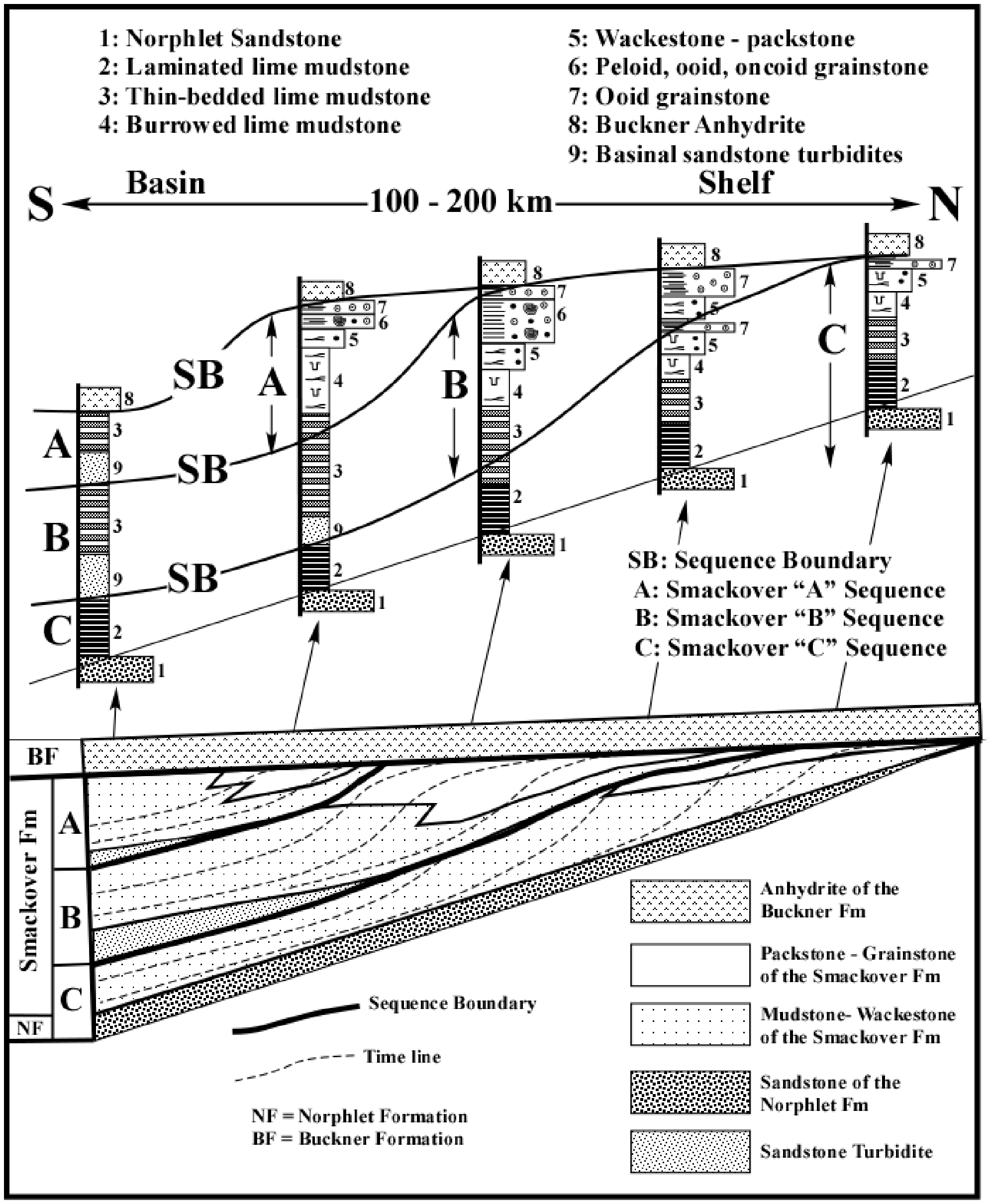

Figure 5. (A) Conceptual sequence stratigraphic model of the Smackover Formation in north-central U.S. Gulf Coast. (B) Schematic diagram depicts a north-south cross section of the Smackover Formation illustrating the three Smackover sequences.