sandstone with a southwest-northeast sand body orientation; Facies B, a low permeability, rippled, 0 to 25 ft (8 m) thick, glauconitic sand also oriented in a southwest-northwest direction, and Facies C, a high-angle (20° to 30°) cross-bedded, permeable, producing sand oriented in a northwest-southeast direction ranging from 0 to 18 ft (5 m) thick.

Facies A sands may represent the remains of a thin progradational beach sequence ending in production of a thin shale. Facies B sands are interpreted as the erosional remnants of a "drowned" barrier-bar system with successive parallel bars, each 1 to 3 mi (2 to 5 km) wide, up to 20 mi (32 km) long and oriented southwest-northeast. The bars are incised by tidal channel-tidal delta deposits, approximately 0.25 mi (0.4 km) wide and 1 to 4 mi (1.6 to 6 km) long, oriented northwest-southeast. Between the barriers are sandy shales, shales, and limestones, representing back-barrier deposits, with very thin (< 5 ft, 1.5 m) facies B sands. No evidence of permeable facies C sands are recorded between bars. The sequence is analogous to modern barrier bar-tidal inlet sequences proposed by Kumar and Sanders for the Fire Island area of New York.

Oil producing tidal channel-tidal delta sands show evidence of migration to the north based on (1) a wedge-shaped isopach thickening to the north across the width of the channel, (2) a slight bowing to the northeast in reaction to longshore currents, and (3) isolated fossil-hash lime bodies paralleling the long direction of the channels to the north, representing fill in deposits of the last position of the channel that was inundated by a transgressive sea.

## GULF COAST ASSOCIATION OF GEOLOGICAL SOCIETIES and GULF COAST SECTION SEPM

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### Burial Diagenesis and Reservoir Development in North Haynesville (Smackover) Field, Louisiana

Smackover carbonates were deposited on a regional ramp which was locally affected by salt-generated paleotopography and basement structures. The paleobathymetry at North Haynesville field was a salt-generated high on which oolite grainstones accumulated. These shoals consisted of tide-dominated sand waves that were flanked by algal-rich grainstones and packstones which, in turn, were surrounded by open marine, peloidal wackestones.

The sand shoals were lithified primarily in the marine phreatic environment, but as they had accumulated significant depositional relief, they became exposed during minor regressions. Consequently, the shoals were affected by early meteoric phreatic diagenesis. Blocky calcite cements and inversion of metastable allochems marked this diagenetic episode.

Subsequent burial diagenetic history can be charted from early to late by the sequential appearance (in order) of the following characteristics: microstylolites, dolomitization, macrostylolites, poikilotopic calcite cements, baroque dolomite cements, and late leaching.

Whole-rock trace element analyses indicate that magnesium, iron, and manganese correlate strongly with dolomitized horizons; strontium correlates with algal-encrusted grains; and aluminum correlates with tight, argillaceous micrites. To an extent, the algal-encrusted grains are also correlated with late, dissolution-enhanced intergranular porosity.

The North Haynesville reservoir is both selective and nonselective for certain depositional microfacies. Selection is for those sand shoals that had the highest primary porosity and permeability and that were affected by dissolution enhancement in the subsurface. However, the same late dissolution processes affected both micrite and allochems in the nonfacies-selective sectors of the reservoir.

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### Smackover Platform Sand Bodies: A Bahamas Model

Stave Creek field, a potential multimillion-barrel Smackover oil field in Clarke County, Alabama, owes much of its prolific production to an extensive, 100 ft (30 m) thick buildup of porous ooid and peloid grainstones.

Seismic profiles and residual gravity maps indicate the field is located on the edge of a large, Jurassic, northeast tilted block of approximately 12 $mi^2$ (31 $km^2$). The block, which formed a shallow platform for Late Jurassic deposition, is bounded on the west by an older component of the Jackson fault, and slopes eastward into the present graben complex of the Gilbertown and West Bend faults. This location placed the platform in a position between the mouth of the Manila embayment and the eastern edge of the Mississippi interior salt basin. Tidal fluctuation between basins and the open marine conditions to the west had a strong influence on sedimentation across the platform.

Cores from the area indicate a pronounced westward trend in increased carbonate grain stability and sediment winnowing. Smackover sediments from the deeper east side of the platform are composed primarily of peloidal lime mudstones and wackestones. Those of the central platform are peloidal and onchoidal wackestones and packstones. Those of the western edge form a high-energy facies of well-sorted ooid and onchoidal grainstones, e.g., the Stave Creek field reservoir.

A modern analog to the deposition on this Jurassic platform is found along the margins of the Great Bahama Bank, and specifically the north Andros-Joulters Cays area.

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### Depositional History and Petroleum Potential of Middle and Upper Ordovician of Alabama Appalachians

Middle and Upper Ordovician deposits occupy a significant position in the Paleozoic sequence in the southern Appalachians, since they represent a transition from passive margin carbonate to active margin clastic deposition. In the Alabama Valley and Ridge these Middle and Upper Ordovician deposits are exposed in two northeast-southwest trending outcrop belts separated by the Helena fault. Units west of the fault are essentially autochthonous, while those east of the Helena have been displaced some distance to the west by late Paleozoic thrusting.

Middle Ordovician units show a transition from shallow-water deposits in the west to deeper water basinal deposits in the east. West of the Helena fault the Middle Ordovician is represented by peritidal to shallow subtidal lithologic characteristics of the Chickamauga Limestone. East of the Helena these shallow-water deposits are replaced by deeper water carbonates of the Lenoir and Little Oak Limestones and graptolitic shales of the Athens Formation. As this deep-water basin filled during the late Middle Ordovician, tectonic uplift generated clastic sediments which prograded into the basin from the east. Red-green mudrocks of the Greensport Formation were deposited in shallow-shelf to tidal-flat environments and were in turn overlain by quartz arenites of the Colvin Mountain Sandstone, deposited as part of a shallow-barrier system.

With continued uplift during the Late Ordovician, additional clastics prograded westward over the filled basin. Early Late Ordovician shallow-shelf to tidal-flat mudrocks of the Sequatchie Formation grade westward into shallow-water carbonates of the Inman and Leipers Formations. With continued input, Sequatchie clastics prograded westward and overrode the westerly carbonates. A relative sea-level rise during the late Late Ordovician was accompanied by deposition of open-marine shelf, bioclastic limestones of the Fernvale facies of the Sequatchie throughout much of the western Valley and Ridge.

The petroleum potential of the Middle and Upper Ordovician sequence in the Alabama Appalachians appears to range from marginal to moderate. West of the Helena fault the Chickamauga Limestone appears to have the best potential, though both source rock and reservoir potential are limited. Source rock potential is better east of the Helena, particularly in the Athens Formation, but reservoir potential is limited again. The existence of significant reservoirs in this area appears dependent upon the development of fracture porosity associated with Appalachian structures.

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Biostratigraphy of Tallahatta Formation (Eocene) in Eastern Gulf Coastal Plain and Revised Age for Claiborne Stage

Five continuous core holes drilled downdip of the outcrop belt of the Tallahatta Formation from western Georgia to western Alabama yielded calcareous inner neritic sand and clay containing calcareous nannofossils and foraminifers. The occurrence of these biostratigraphically useful groups in the subsurface Tallahatta allows the reliable dating of the entire formation; this has been difficult in the past because of the dominance in the outcrop belt of heavily leached, noncalcareous coarse clastics and sparsely fossiliferous siliceous clay and silt.

Fossiliferous sand at the base of the Tallahatta generally overlies carbonaceous clay of the Hatchetigbee Formation. These lowest Tallahatta strata contain calcareous nannofossils diagnostic of Zone NP12 of Martini; overlying these strata are beds placed in Zone NP13. The uppermost Tallahatta beds in the core holes and in the Little Stave Creek outcrop section in western Alabama are assigned to Zone NP14; no positive evidence for strata belonging to Zone NP15 was found. Erosion surfaces separate the sediments belonging to each of the three calcareous nannofossil zones. On the basis of foraminiferal assemblages, the strata belonging to Zone NP12 and the lower part of Zone NP13 are interpreted as probably representing shallow-marine deposits; sediments in the upper part of Zone NP13 and Zone NP14 were probably deposited in somewhat deeper inner-shelf environments.

Zones NP12 and NP13 are normally placed in the lower Eocene of the intercontinental correlation charts, whereas Zone NP14 has been considered entirely early Eocene, entirely middle Eocene, or straddling the boundary. Most of the Tallahatta Formation, including those strata considered to represent the basal Meridian Sand Member, is therefore of early Eocene age. As the Tallahatta is the lowest formation of the Claiborne Group, the base of the Claibornian Stage is thus placed within the early Eocene, and the Sabinian-Claibornian Stage boundary in Alabama and Georgia does not correspond to the early middle Eocene boundary.

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Reworked *Hantkenina* Specimens at Little Stave Creek, Alabama

The Eocene-Oligocene boundary in Mississippi and Alabama has been traditionally placed between the Shubuta Member of the Yazoo Formation and the overlying Red Bluff Formation (or its carbonate facies equivalent, the Bumpnose Limestone). Consequently, the presence of Eocene planktonic foraminifers in the Red Bluff and Bumpnose has long been attributed to reworking. To test the validity of this hypothesis, samples were collected on both sides of the boundary from the upper "Shubuta" and Bumpnose units at Little Stave Creek, Alabama, and they were examined for both calcareous nannofossil and planktonic foraminiferal content. The calcareous nannofossil assemblage, preserved in the matrix from inside hand-picked specimens of *Hantkenina* from both units, was demonstrably older than the calcareous nannofossil assemblage from the surrounding sediment. Thus, at least some of the *Hantkenina* specimens in both the "Shubuta" and Bumpnose are indeed reworked, which not only confirms the original hypothesis regarding reworking within the Red Bluff and Bumpnose, but also indicates that the last occurrence of *Hantkenina*, the "Shubuta"-Bumpnose contact, and the Eocene-Oligocene boundary in the U.S. Gulf Coast may not be equivalent.

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Smackover-Norphlet Stratigraphy, South Wiggins Arch, Mississippi and Alabama

Mesozoic rocks of the Gulf were deposited on a wide coastal plain which was punctuated transversely by major positive and negative warpings. Two of the positive elements (Sabine and Monroe uplifts) underlie giant hydrocarbon accumulations. The Wiggins arch is notable because, although the flanks are productive, the crestal area is barren. This condition has led to a paucity of well control, especially deep well control. Only three wells on the arch have penetrated the entire sedimentary sequence (20,000 ft, 6,100 m) and reached basement rock (2 granite, 1 metamorphic) dated at 300 ± m.y. These three wells are reported to have a normal stratigraphic sequence except that the Jurassic Haynesville Formation lies on the basement, and the Buckner, Smackover, Norphlet, and Louann are missing. Careful analysis of these wells indicates the lower part of the reported "Haynesville" is time-correlative with the Smackover. Thus, the Smackover is not missing, but is represented by a Haynesville-like facies deposited on a block of granitic basement. This block must have been barely emergent and led to a complex set of cays during Smackover deposition. Careful analysis of seismic records indicates the proposed cays are surrounded by areas of very different reflective character. These reflections may indicate the presence of high-energy Smackover carbonate and Norphlet sand that is missing from the wells.

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Re-evaluation of Lower Tuscaloosa and Dantzler Formations (middle Cretaceous) with Emphasis on Depositional Environments and Time-Stratigraphic Relationships

The lower Tuscaloosa and Dantzler formations of east-central Louisiana and southeastern Mississippi are excellent examples of fluvial-deltaic sediments deposited in a semiarid climate. This deltaic deposition was subsequently slowly transgressed by the sea, and deposition of the middle marine Tuscaloosa occurred.

The Lower Cretaceous Dantzler sediments were deposited in a downdip stranded (dry) basin (Perry basin) contemporaneous with uplift and erosion of the land to the north. Sedimentation continued in this manner throughout deposition of the lower Tuscaloosa. By this means the basins were filled with sediment, and deltas were built seaward of the older Edwards shelf edge. As the sea continued to transgress during deposition of the middle Tuscaloosa, all fluvial-deltaic deposition was restricted to the far updip areas. The result of this marine transgression and sediment deposition has been a tripartite relationship of depositional environments. Observations from electric logs, cores, and cuttings indicate a typical depositional sequence consists of a basal braided channel complex overlain by meander-belt point bars and topped by overlapping, shallow-marine, nearshore bars. Facies and depositional interpretations indicate that the lower Tuscaloosa and Dantzler are facies equivalents of one another and, as such, form a time-transgressive unit which spans the Upper-Lower Cretaceous boundary.

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Carboniferous Terrigenous Clastic Facies, Hydrocarbon Producing Zones, and Sandstone Provenance, Northern Shelf of Black Warrior Basin

Deltaic and barrier-bar depositional systems from the Chester and Pottsville Groups of the Black Warrior basin produce natural gas and minor oil from 11 Mississippian sandstone reservoirs and four Pennsylvanian clastic units. Within the Chester, four major genetic sequences containing cratonic delta systems have been mapped. These include, in ascending stratigraphic position, the lobate, river-dominated Lewis system, the wave-dominated Evans and Hartselle systems, the river-dominated, elongate, and lobate deltas of the Muldon complex (Rea, Abernathy, Sanders, and Carter), and the hybrid Gilmer system.

Chester deltas prograded southeastward onto the stable northern shelf from a cratonic source area, most likely the Ozark uplift. Net sandstone isolith maps for discrete genetic units demonstrate a northwest-to-