

see (TN) are reported in this study. These data have been used to assign each of the following nannoplankton-bearing formations and members to Martini's 1971 internationally recognized calcareous nannoplankton zones.

Formations and Members	Zones
Paynes Hammock Formation (MS)	NP 24
Chickasawhay Limestone (AL)	NP 24
Bucatanma Formation (AL)	NP 22
Byram Formation (MS)	NP 22
Glendon Limestone (MS)	NP 22
(AL)	NP 22
Marianna Limestone (MS)	NP 21, 22
(AL)	NP 21
Mint Spring Formation (MS)	NP 22
Forest Hill Formation (MS)	NP 21
Red Bluff Formation (AL)	NP 21
Bumpnose Limestone (AL)	NP 21
Crystal River Formation (AL)	NP 19/20
Yazoo Formation	
Shubuta Clay Member (MS)	NP 19/20, 20, 21
(AL)	NP 19/20, 20, 21
Pachuta Marl Member (MS)	NP 19/20
(AL)	NP 19/20
Cocoa Sand Member (AL)	NP 17, 18, 19
North Twistwood Creek Clay Member (AL)	NP 17
Moody Branch Formation (MS)	NP 17
(AL)	NP 17
Gosport Sand (AL)	NP 17
Cook Mountain Formation	
Potterchitto Member (MS)	NP 16
Lisbon Formation	
"Upper" (AL)	NP 16, 17
"Middle" (AL)	NP 16
"Lower" (AL)	NP 15
Tallahatta Formation (AL)	NP 14, 15
Hatchetigbee Formation	
Bashi Marl Member (AL)	NP 9, 10
Tusahoma Sand	
Bells Landing Marl Member (AL)	NP 9
Nanafalia Formation	
" <i>Ostrea thirsae</i> " beds (AL)	NP 7, 8
Salt Mountain Limestone (AL)	NP 7
Naheola Formation	
Coal Bluff Marl Member (AL)	NP 5
Porters Creek Formation (AL)	NP 3/4
Matthews Landing Marl Member (AL)	NP 3/4
Clayton Formation (TN)	NP 2, 3/4
McBryde Limestone Member (AL)	NP 3/4, 4
Pine Barren Member (AL)	NP 1, 2

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#### Basement Model for Panhandle of Florida

Core samples from deep boreholes in panhandle Florida form the basis of a basement model involving at least eight separate fault blocks and basins, each with a distinct depositional history. The dominant structures are a northwest-trending fault and a large, northeast-trending Triassic graben which encompasses several secondary fault blocks and forms the Southwest Georgia Embayment (Apalachicola Embayment). This graben as well as associated perpendicular (northwest-southeast) faults were formed in response to tensional forces related to the Mesozoic separation of North American and South American landmasses and the consequent formation of the Gulf of Mexico. Granitic basement blocks, perhaps early Cambrian in age, experienced differential subsidence and changing relationships with various sedimentary source terranes. Thus, the separate basins accommodated different combinations of Triassic Eagle Mills red beds and Jurassic deposits ranging from the Louann Salt to the Cotton Valley sandstones and shales.

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#### Red Bluff, Marion County, Mississippi: A Citronelle Braided-Stream Deposit

Red Bluff is an erosional escarpment located on the western margin of the Pearl River flood plain in northwestern Marion County, Mississippi. The bluff shows approximately 30 m (100 ft) of relief and is composed of alternating units of red-to-yellow sand and sandy gravel. The sand grains are composed primarily of quartz, with small amounts of heavy minerals and feldspar. The gravel is composed of varying percentages of chert,

flint, jasper, rip-up clasts, quartz, and tripoli, including a small fraction of silicified Paleozoic fossils.

Grain-size analysis of the sediment and investigation of the sedimentary structures suggest a braided-fluvial environment of deposition. Particle sizes in the medium sand to pebble range predominate in all units; very little silt and clay is present. The largest "particles" present are boulder-size rip-up clasts. The most conspicuous sedimentary structures at Red Bluff are graded bedding, low-angle to medium-angle cross-bedding, and well-developed paleochannels.

A statistical comparison (discriminant analysis) of the seven most abundant heavy minerals of Red Bluff, with the same suite of heavy minerals found at the type section of the Citronelle Formation (Pliocene-Pleistocene), and outcrops of a known Miocene coarse clastic unit indicates a correlation of Red Bluff to the Citronelle Formation. These heavy minerals are kyanite, staurolite, rutile, tourmaline, zircon, black opaques (primarily ilmenite and magnetite), and white opaques (primarily leucoxene).

The suite of heavy minerals present at Red Bluff belongs to the east Gulf province. This metamorphic assemblage of heavy minerals implies the source area of the sediments at Red Bluff to be the southern Appalachians. The silicified pebble-size Devonian-Mississippian fossils were derived most likely from formations flanking the southern Appalachians in northern Alabama.

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#### Sedimentary Regimes of Upper Midway and Lower Wilcox Lignite in Alabama

Paleoenvironments favorable for lignite deposition existed in sedimentary regimes of the Naheola Formation (upper Midway Group) and in Midway-Wilcox transition sediments apparently assignable to the Nanafalia Formation (Wilcox Group). In addition, lignite horizons are recognized in the Tusahoma Sand (Wilcox Group). Lignite of potential economic significance occurs within the Naheola Formation west of Butler County and within the Nanafalia Formation east of Butler County. Lignite horizons in the Naheola Formation west of Butler County probably are not stratigraphically or time equivalent to lignite horizons east of Butler County. Depositional environments of the Naheola west of Butler County were favorable for development of lignite deposits with extensive lateral continuity, whereas lignite depositional environments east of Butler County apparently favored variability in thickness and lateral continuity. Estuarine and back-barrier coastal marsh environments are suggested for the lignite.

Carbonaceous silt and clay in varying proportions are commonly associated with lignite in the Naheola Formation. Lithologic associations of lignite related to the Nanafalia Formation include quartzarenite, carbonaceous silt and clay, oyster beds, and limestone of the Clayton Formation (Midway Group).

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#### Diagenetic History of Cotton Valley Limestone at Teague Townsite Field, Freestone County, Texas

The Cotton Valley lime was deposited during a regressive phase of the Late Jurassic, in a shallow sea with an extensive platform. Mild salt tectonism has modified depositional and diagenetic environments through time. The Cotton Valley lime is composed of thick, massive oolitic, finely crystalline, micritic limestones which rim the west flank of the East Texas basin. The Cotton Valley lime at Teague Townsite field represents deposition within a shallow sublittoral marine sandbar environment and its associated laterally equivalent facies. Included within the sequence are as many as nine local shoaling upward cycles. Petrographically observed diagenetic features include products of neomorphism, compaction and pressure-solution, cementation, leaching, and replacement intergranular porosity was occluded early by rim and pore-filling cements. Intragranular porosity was produced as a result of early meteoric leaching, a feature abundant in porous zones, and occasionally accompanied by equant cement. Compaction is expressed mainly as pressure-solution features and stylolitization. It is inferred that early mineralogic stabilization and meteoric cementation armored grains in porous intervals against burial

effects. Hydrothermal baroque dolomite is most abundant in porous intervals, and occurs as void-filling cement precipitated in interparticle porosity, fracture porosity, along stylolites, and also as a replacement mineral after anhydrite. During diagenetic dissolution and reprecipitation events, certain elements substitute for  $\text{Ca}^{2+}$  in the  $\text{CaCO}_3$  lattice, in proportion to the composition of the diagenetic fluids. The behavior of substituting cations in this study is largely indicative of diagenesis by subsurface fluids. It also implies that much of the observed diagenetic alteration occurred in a closed diagenetic system. During diagenesis the isotopic content of a carbonate will re-equilibrate with that of surrounding pore fluids. The depletion of  $\text{O}^{18}$  implies precipitation at elevated temperatures or from subsurface fluids, while  $\text{C}^{13}$  consistency reflects original carbon composition. Values from this study coincide with those for other Jurassic carbonates and late dolomites. Petrography and geochemistry indicate that diagenesis occurred in the marine phreatic, mixed phreatic, meteoric phreatic, and subsurface diagenetic environments.

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#### Regional Variability of Washover Deposits on South Texas Coast

Overwash processes play an important role in determining the stratigraphy of microtidal barrier islands. Along the microtidal coast of south Texas, regional variability in barrier island geometry produces a spectrum of washover types. South Padre Island is a low profile, transgressive feature with a discontinuous to nonexistent foredune ridge. It displays sheet overwash, coalescing washover terraces, and washover fans fed by large hurricane channels. North Padre and Mustang Islands are high-profile barrier islands with continuous foredune ridges, and thus only small, discrete interdune washovers occur. The relict tidal inlets between Mustang and Padre Islands are the sites of the largest washovers in the system, termed reactivated tidal deltas. This last type, although relatively rare in modern washover deposits, is probably similar in mode of origin to the large lobate back barrier features found on many high profile barriers on the Texas coast.

Internal structures of the washovers were studied by trenching, box coring, and vibracoring. The dominant stratification type is plane beds with extensive heavy mineral laminae. Washover margins display some landward dipping foreset bedding. Hurricane channels show cut and fill structures with shell lags, plane beds, and some trough cross-beds. Directional features indicate that the washovers are formed by storm surge flood, and modified by surge ebb. This is supported by the existence of separate flanking ebb channels on some washovers, as well as current velocity simulations for the storm surge of Hurricane Allen, which show that flood currents are both stronger and longer lived than the ebb.

In the ancient record, low profile barriers should be relatively thin deposits consisting of numerous coalescing washovers. Thicker sand bodies corresponding to high profile barriers should be found along strike. Since back-barrier facies have a higher preservation potential than other barrier environments, such a deposit might be dominated by reactivated tidal deltas.

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#### Coal Stratigraphy of Deeper Part of Black Warrior Basin in Alabama

The Warrior coal field of Alabama is stratigraphically in the upper part of the Lower Pennsylvanian Pottsville Formation and structurally in the eastern part of the Black Warrior foreland basin. In the Warrior coal field, the Pottsville Formation has been divided into a lower non-coal-productive sandstone-rich sequence and an upper coal-productive sequence that contains less sandstone. The productive coal beds extend southwestward from the mining area down dip into the deeper part of the Black Warrior structural basin. Because the deep part of the basin is beyond the limits of conventional coal exploration, study of the stratigraphy of coal beds must rely on data from petroleum wells. For example, the density log as run in petroleum wells is sensitive to the presence of coal beds more than a few inches thick, but evidently does not provide a reliable measure of the thickness of individual coal beds. Relative abundance of coal can be stated in terms of numbers of beds, but because of the limitations of the available data, thicknesses of coals presently are not accu-

rately determined. Distribution of coal beds in the Black Warrior basin reflects controls by depositional environments from delta plain to barrier islands; the various depositional environments shifted across the Black Warrior basin through time.

The lower sandstone-rich coal-poor part of the Pottsville has been interpreted as barrier sediments in the mining area. To the southwest in the deeper Black Warrior basin, coal beds are more numerous within the sandstone-dominated sequence. The area of most numerous coals, trends northwestward parallel with the trend of the barrier islands, and evidently is in a back-barrier location.

The coal-productive upper Pottsville is informally divided into "coal groups" (in ascending order, Black Creek, Mary Lee, Pratt, Cobb, Gwin, Utley, and Brookwood), each of which includes several coal beds. The Black Creek, Mary Lee, and Utley coal groups are associated with northeast-trending delta-distributary sandstones. The areas of most numerous coals also trend northeastward and are laterally adjacent to relatively thick distributary sandstones, suggesting coal accumulation in backswamp environments. The most numerous coals in the Pratt coal group are in an area that trends northwestward parallel with and southwest of a northwest-trending linear sandstone, suggesting coal accumulation in a back-barrier environment. Equivalents of the Cobb, Gwin, and Brookwood coal groups contain little coal in the deep part of the Black Warrior basin.

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#### Problematical Petrophysical Characteristics of Smackover at Bayou Middle Fork Field, Claiborne Parish, Louisiana

Values of irreducible water saturation calculated from conventional electric and porosity logs at Bayou Middle Fork field are commonly greater than 60%. Mercury injection curves reveal that the true water saturation averages about 40%. Scanning electron micrographs show oolitic grains that have been recrystallized and have rough irregular surfaces as well as intercrystalline porosity within the particles. Water adheres to these grain surfaces and occupies some of the intercrystalline porosity in productive zones, causing the calculated water saturations to read too high. Application of the Archie equation, the Guillolette et al technique, and the Rocky Mountain technique provides a different suite of water saturations.

Archie water saturations average about 75% when density-neutron porosity values are used. Density-neutron porosity values tend to read about 2 porosity units low when compared with core porosity values throughout the field. When core corrected porosity is used, the Archie saturation averages about 60%.

The Guillolette et al technique employs a variable textural parameter "w" which is dependent on porosity and permeability. Mean water saturation with this method averages about 49%, which is in better agreement with the mercury injection data.

The Rocky Mountain ratio yields water saturations that are too high until the porosity balance technique is applied. Since  $R_i$  is assumed to read too low due to the excess immobile water, the Rocky Mountain derived porosities are too low. When  $R_i$  is increased to balance the porosity the water saturation averages about 43%, using  $Z = .025$ . When the Rocky Mountain  $R_i$  is used in the Archie equation, water saturations more consistent with the mercury injection data result. In addition the difference between the observed  $R_i$  and the Rocky Mountain derived  $R_{ia}$  can be plotted as a function of porosity.

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#### Early Mesozoic Tectonics of Northern Gulf of Mexico Coastal Plain

Major events in the early Mesozoic development of the northern Gulf Coast region are related to corresponding stages in the opening of the central North Atlantic Ocean from its southern end, as interpreted from three prominent lineaments on aeromagnetic maps of the southeastern United States and its offshore region. The Brunswick magnetic anomaly, which marks the edge of continental crust in the Carolina trough, comes ashore in southern Georgia and follows the subsurface belt of Triassic rocks into southwestern Alabama. This belt continues into eastern Texas, occupying a rift system along which North America was then drawing away from South America.