Upper Cretaceous Sequence Stratigraphy, U.S. Eastern Gulf Coastal Plain

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Four depositional sequences have been recognized and mapped in the Upper Cretaceous strata of the northeastern Gulf Coastal Plain of Alabama, Mississippi and Tennessee. These depositional sequences are the UZAGC-2.0, UZAGC-3.0, UZAGC-4.0 and UZAGC-5.0 sequences. Biostratigraphic calibration of these sequences is based primarily on planktonic foraminifera, ostracodes and calcareous nannoplankton (Mancini *et al*., 1996). The maximum flooding surfaces associated with these depositional sequences correlate well with transgressive peaks observed in Europe.

The base of the UZAGC-2.0 sequence is defined by the Mid-Cretaceous Unconformity (MCU), which is recognized throughout the northern Gulf of Mexico. The duration of the hiatus at the MCU is variable in the northern Gulf of Mexico. In some areas, such as the Main Pass area of the Outer Continental Shelf (OCS), the hiatus at the MCU ranges from Cenomanian to Maastrichtian in age. In the OCS, the UZAGC-2.0, UZAGC-3.0, UZAGC-4.0 and possibly part of the UZAGC-5.0 sequences are missing. In Mississippi and Alabama, the hiatus at the MCU is not well defined biostratigraphically, but appears to represent only a portion of the Cenomanian. In this area, the MCU occurs between the Dantzler Formation and the base of the Lower Tuscaloosa Formation. The age of the top of the Dantzler Formation is not precisely known because it is comprised of nonmarine sediments devoid of calcareous microfossils and occurs only in the subsurface. Regional correlations indicate that the Dantzler can be correlated with the Washita Group of Texas, and is thus assigned an Early Cenomanian Age. The Lower Tuscaloosa Formation is a predominantly sandstone unit also devoid of calcareous microfossils, but lithostratigraphically equivalent strata do occur at the surface. The age of the Lower Tuscaloosa is not known precisely because the palynomorph taxa are long ranging. Studies by Christopher (1982) indicate that the Lower Tuscaloosa equivalent strata are of Cenomanian Age. Lower Tuscaloosa equivalent strata in outcrop are the oldest post-Paleozoic strata to occur at the surface in the Mississippi-Alabama area. The “massive” sand represents the lowstand systems tract deposits of the UZAGC-2.0 sequence, whereas the upper portion of the Lower Tuscaloosa Formation is interpreted to represent the transgressive systems tract of this sequence.

The Marine Shale, or Middle Tuscaloosa Formation, is a regionally extensive shale unit that forms a distinctive marker bed useful for subsurface mapping. Although the Marine Shale proper only occurs in the subsurface, lithostratigraphically equivalent fine-grained, marginal marine sediments do occur at the surface. Planktonic foraminiferal biostratigraphy by Mancini *et al.* (1980) indicates that the base of the Marine Shale can be assigned to the *Rotalipora cushmani-greenhornensis* Taxon Range Zone of Middle to Late Cenomanian in age. Recent studies indicate that the bulk of the Marine Shale can be assigned to the *Helvetoglobotruncana helvetica* Taxon Range Zone of Turonian Age (Rosen, in press). The maximum flooding surface within the Marine Shale represents the transgressive peak of the UZAGC-2.0 depositional sequence.

The marine and marginal marine sandstones and shales of the Upper Tuscaloosa represent the highstand systems tract of the UZAGC-2.0 depositional sequence. In outcrop, these highstand deposits are represented by the cherty gravels of the Gordo Formation. The age of the Upper Tuscaloosa Formation is not known precisely, due to the lack of calcareous micro- and nannofossils. Regional correlations and constraint by supra- and subjacent strata indicate that the Upper Tuscaloosa Formation is probably Turonian in age. The unconformity at the top of the Upper Tuscaloosa Formation is difficult to recognize on the basis of subsurface information, but can be observed at the surface at the boundary between the Tuscaloosa Group and the Eutaw Formation. This unconformity represents the top of the UZAGC-2.0 depositional sequence.

The UZAGC-3.0 depositional sequence is the oldest post-Paleozoic sequence that is completely exposed at the surface in the Alabama-Mississippi area. The Eutaw Formation is the oldest stratigraphic unit in the UZAGC-3.0 sequence. The Eutaw changes character along strike. East of Montgomery, central Alabama, the Eutaw consists of a stacked series of biostromes dominated by the oyster *Flemingostrea cretacea* separated by sand units. These biostromes were deposited in a lagoon formed by barrier islands. The barrier islands were subsequently reworked, and are represented by a ravinement surface at the base of the Blufftown Formation. The oyster biostromes are of Santonian Age, as indicated by calcareous nannofossils (Charles C. Smith, written communication; see Puckett, 1995), and are biostratigraphically correlable with the Tombigbee Sand and lower Mooreville Chalk. West of Montgomery, the Eutaw is subdivided into a lower, unnamed member and an upper Tombigbee Sand Member. The lower member of the Eutaw in central Alabama consists of a lower tidal channel-barrier facies overlain by a shoreface to offshore facies (Tew, 1988) that possibly represent lowstand sand deposits. The Tombigbee Sand Member consists of massive, glauconitic sands that often contain abundant calcareous fossils. Calcareous microfossil biostratigraphy of the Tombigbee Sand Member demonstrates that the top of the unit is diachronous. The top of the Tombigbee Sand in central Alabama occurs in the lower portion of the planktonic foraminiferal *Dicarinella asymetrica*

Taxon Range Zone of mid-Santonian Age, whereas the top of the Tombigbee Sand in eastern Mississippi occurs at the top of the *D. asymetrica* zone. These observations indicate that the top of the Tombigbee Sand is approximately 1 million years older in central Alabama than in eastern Mississippi. This difference in age is probably related to differences in sediment supply along strike. In eastern Mississippi, siliciclastic sediment from the ancestral Tombigbee River caused the Tombigbee Sand Member to be relatively thick, and overrode the eustatic rise recorded in central Alabama.

Initially, marine tongues that extend into the nearshore units in both northern Mississippi (marly tongue of Mooreville Chalk, which occurs between the sands of the Tombigbee Sand Member of the Eutaw Formation and the sands of the Tupelo Tongue of the Coffee Sand) and in eastern Alabama (marly tongue of the Mooreville Chalk, which occurs between sandy marl tongues of the Blufftown Formation) were hypothesized to represent the transgressive peak of the UZAGC-3.0 depositional sequence. Microfossil biostratigraphy, however, indicates that the two tongues differ significantly in age. The Mooreville tongue in northern Mississippi occurs in the ostracode *Ascetoleberis plummeri* Interval Zone, which corresponds to the lower portion of the planktonic foraminiferal *Globotruncana ventricosa* Interval Zone of early Campanian age. Biostratigraphic correlations indicate that this marine tongue is close to the age of the maximum flooding surface of the UZAGC-3.0 depositional sequence, as approximated by a shift from increasing to decreasing planktonic:benthic foraminiferal ratios in eastern Mississippi and central Alabama. In eastern Alabama, the marly tongue of the Mooreville is at the top of the planktonic foraminiferal *Dicarinella asymetrica* Taxon Range Zone of latest Santonian age. Additional information, including subsurface wireline log signatures and surface reconnaissance, indicates the presence of a sequence or parasequence in eastern Alabama that is not manifested in western Alabama or northern Mississippi. This parasequence is referred to herein as the UZAGC-3.0-a sequence.

The boundary between the UZAGC-3.0 and UZAGC-4.0 depositional sequences has been referred to as a Type II sequence boundary by Mancini *et al*. (1996). No significant hiatus is observed in the offshore area of eastern Mississippi and western and central Alabama. In the offshore area, the boundary is recognized by a bed rich in baculites, belemnoids, pieces of wood, and, in central Alabama, fine sand. Highstand systems tracts, consisting primarily of marginal marine to nonmarine sands, are well developed in the nearshore areas of eastern Alabama and northern Mississippi. In eastern Alabama, these sands occur in the basal portion of the Cusseta Sand, whereas in northern Mississippi, the highstand sands are in the Tupelo Tongue of the Coffee Sand. Paleoecologic information from ostracodes indicates decreasing marine influence in a vertical section at the type locality of the Tupelo Tongue.

The UZAGC-4.0 depositional sequence consists of thin transgressive systems tract deposits in the lower or basal portions of the Demopolis Chalk, a maximum flooding surface in the middle Demopolis Chalk, which extends into the Cusseta Sand in eastern Alabama to the backwaters of the Chattahoochee River, early highstand systems tract deposits of the Bluffport Marl, and late highstand systems tract deposits of the Ripley Formation. In the offshore area, the transgressive deposits of this sequence are nearly identical to the highstand deposits of the previous sequence, as the boundary between these two sequences is nearly conformable. However, in the nearshore areas, the boundary between the UZAGC-3.0 and UZAGC-4.0 depositional sequences is recognized at a sharp contact between the sands of the previous highstand deposits and oyster-bearing sands of the basal Demopolis Chalk. These oyster-bearing sands pass quickly upsection into the chalk of the Demopolis.

The transgressive peak in the UZAGC-4.0 depositional sequence is observed as a marine tongue that extends much farther landward than any of the other Upper Cretaceous tongues, and reaches as far north as central Tennessee and eastward as far as as the Alabama-Georgia line. This marine tongue, known as the Coonewah bed, occurs slightly below the planktonic foraminiferal *Globotruncanita calcarata* Taxon Range Zone and within the calcareous nannoplankton CC 21 Interval Zone, both of late Campanian age. Planktonic foraminiferal data indicate that the early highstand deposits of this sequence are diachronous. For example, the Bluffport Marl Member of the Demopolis Chalk, which represents the early highstand deposits, are within the *G. calcarata* zone in northern Mississippi, but occur approximately 60 feet above the Bluffport in eastern Mississippi. This observation demonstrates the sluggish change in sea level that occurred during the late Campanian. The late highstand deposits of the Ripley Formation show decreasing marine influence upsection, and are capped by an erosional surface that marks the upper boundary of this depositional sequence.

The UZAGC-5.0 depositional sequence is the chonostratigraphically shortest depositional sequence in the Upper Cretaceous of the Gulf Coastal Plain. Biostratigraphic data from calcareous nannofossils indicate that one entire zone and parts of two other zones are missing between the youngest marine deposits of the UZAGC-4.0 sequence (later part of CC 23) and the oldest marine deposits of the UZAGC-5.0 sequence (early part of the CC 25) sequences. Between these marine strata are the marginal marine to nonmarine lowstand sands of the upper Ripley Formation. Outcrop observations and subsurface mapping have revealed incise-valley-fill deposits in which these lowstand sands occur. A transgressive surface occurs at the top of these sands in the uppermost Ripley Formation, which is immediately overlain by oyster-bearing sands very similar to those in the UZAGC-4.0 sequence. This oyster-bearing

sand is immediately overlain by the relative pure chalk of the Prairie Bluff Chalk. The maximum flooding surface in UZAGC-5.0 sequence is recognized as a thin bed of eroded and bored macrofossils. This phosphatic macrofossil bed occurs at the base of the *Racemiguembelina fructicosa* Interval Zone of mid-Maastrichtian age (Mancini *et al*., 1989). The highstand systems tract deposits in the UZAGC-5.0 depositional sequence occur in the *R. fructicosa* Zone. An unconformity at the K-T boundary marks the top of this depositional sequence. The hiatus at the K-T boundary is variable; some authors have claimed very little time is missing at the boundary near the type locality of the Prairie Bluff Chalk, whereas in other areas, such as west-central Alabama, the Prairie Bluff was completely eroded, and Paleogene strata directly overlie the Ripley Formation. A relative drop in sea level near the end of Maastrichtian deposition is indicated in central Alabama, where the sandy marl of the Providence Sand overlies the Prairie Bluff Chalk.

The Upper Cretaceous depositional sequences in the Gulf Coastal Plain record generally sluggish changes in sea level, particularly during the Santonian to Maastrichtian. The Earth system is generally considered to have been in a "Greenhouse" climate regime during this time interval. In contrast, recent evidence (Barrera and Savin, 1999) from oxygen isotope ratios of planktonic and benthic foraminifera indicates that a sharp cooling interval occurred during the later part of the *G. gansseri* Interval Zone. The rapid sea level drop in the Maastrichtian is possibly related to ice buildup on Antarctica (Barrera and Savin, 1999).

Two of the depositional sequences recognized in the Gulf Coastal Plain appear to correlate well with sequences observed in the Atlantic Coastal Plain. Sugarman *et al.* (1995) observed one sequence, the Marshalltown sequence, to occur in calcareous nannofossil zones CC20/21 to CC22b. This sequence corresponds to the UZAGC-4.0 depositional sequence in the Gulf Coast. The younger sequence, the Navesink sequence, occurs in CC25-26, which corresponds the UZAGC-5.0 depositional sequence in the Gulf Coast. The older sequences (Santonian-early Campanian) display more lateral variation in the ages of the component systems tracts than the youngest (UZAGC-5.0) sequence. This variation is attributed to the sluggish changes in sea level and concomitant manifestation of local phenomena.

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