Sequence Stratigraphy, Depositional Systems, and Ground-Water Supply

David T. Dockery III, Mississippi Department of Environmental Quality

Ground-water supplies in the state's Tertiary, Late Cretaceous, and even Paleozoic aquifers are not all evenly distributed. Many (and some of the most prolific) are concentrated in valley-fill deposits created during times of low sea level and in the channels of fluvial and deltaic systems that formed during sea-level lowstands and sea-level highstand-regressive intervals. Examples of such linear and lenticular water-supply sands include: (1) valley-fill sands in the Tuscaloosa Formation, (2) valley-fill sands in the basal Clayton Formation, (3) valley-fill sands in the Coal Bluff Member of the Naheola Formation (lower Wilcox aquifer), (4) valley fill sands in the Gravel Creek Sand Member of the Nanafalia Formation (lower Wilcox aquifer), (5) valley-fill sands in the basal Tuscahoma Formation (middle Wilcox aquifer), (6) highstand-regressive channel sands in the lower Hatchetigbee Formation (upper Wilcox aquifer), (7) valley-fill sands in the Meridian Sand (upper Wilcox aquifer), (8) highstand-regressive channel sands in the Kosciusko Formation (Sparta Aquifer), (9) highstand-regressive channel sands in the Cockfield Formation, (10) valley-fill sands in the Forest Hill Formation, (10) valley-fill sands in the Waynesboro Sand, (11) valley fill sands in the basal Catahoula Formation, (12) valley-fill sands in the Citronelle Formation and other high-level terrace deposits, and (13) valley-fill sands in the Mississippi River Alluvium (Alluvial aquifer).

There are two major drainage systems responsible for most of the valley-fill and fluvial/deltaic-channel deposits, which serve as aquifers for ground-water supplies in Mississippi. The first is an ancient drainage basin with an Appalachian source, which is often referred to as the ancestral Tennessee River. This ancient river system is responsible for valley-fill gravels and sands of the Tuscaloosa Formation in northeastern Mississippi and for the vein-quartz and heavy minerals in the state's Tertiary and Quaternary gravels and sands. The second drainage basin drained a portion of the North American mid-continent and is referred to as the ancestral Mississippi River. This river system has been credited for fluvial sands as old as the Late Jurassic sandstones in the Smackover Formation in west-central Mississippi. It is certainly responsible for those Late Cretaceous and Tertiary formations that thicken along the axis of the Mississippi Embayment as well as the Pliocene gravels of the Citronelle Formation in west-central Mississippi and the perched Early Pleistocene pre-loess gravel deposits below the loess along the eastern Mississippi River valley wall, extending from Tennessee to Louisiana.

Key words: Ground Water, Hydrology, Water Quantity, Water Supply

Ground-Water Supplies in Lowstand Valley-Fill Sands

The following are selected examples of low-stand-valley-fill-sand aquifers in Mississippi. In each case, the greatest quantity of ground water can be obtained along the axis of the ancient stream channel.

Tuscaloosa Formation.

When the U. S. Army Corps of Engineers made borings in preparation for the divide cut on the Tennessee-Tombigbee Waterway they encountered east-to-west-trending paleovalleys in the eroded Paleozoic basement containing more that 300 feet of Tuscaloosa sand and gravel. At other sites, the Tuscaloosa was absent over Paleozoic highs. Thick occurrences of the Tuscaloosa Formation should provide an excellent ground-water source for central Tishomingo County, Mississippi. Merrill (1988, p. 76, figure 74) gave an isopach map for thickness of the Tuscaloosa Formation in Tishomingo County and a cross section across paleovalleys (Figure 1).

Coal Bluff Member of the Naheola Formation.

Beach and nearshore sands of the Coal Bluff Member of the Naheola Formation stretch along an ancient shoreline from the type locality in Wilcox County, Alabama, where the member contains marine fossils and overlies lignite-bearing clays of the Oak Hill Member of the Naheola Formation, through Kemper (Figures 2) and Noxubee (Figure 3-5) counties northward to Union County (Figure 6) and the Tennessee state line. These sands rest on the weathered and eroded upper surface of the Oak Hill Member, which in places has weathered to a regolith of bauxite and kaolinitic clay. The sands of the Coal Bluff Member and those of the overlying Gravel Creek Member of the Nanafalia Formation (Figure 7), which channel into lignitic, kaolinitic, and bauxitic strata of the upper Coal Bluff Member, comprise the lower Wilcox aquifer.

Tuscahoma Formation.

The lower Tuscahoma Formation contains a fluvial sand interval above the lignite-bearing clays and sands of the Grampian Hills Member of the Nanafalia Formation. The lower Tuscahoma sand interval is called the Middle Wilcox aquifer. There is an east-to-west-trending channel at the base of the lower Tuscahoma sand that was exposed in the Red Hills Lignite Mine in Choctaw County, Mississippi. Water seepage from this channel sand has been a problem at the mine, but such channels could be an important ground-water resource (figures 8-9). Figure 10 shows a lignite-filled oxbow-lake channel in the upper Tuscahoma Formation in a roadcut on Interstate 20 east of Meridian.

Lower Hatchetigbee Sand and Meridian Sand.

The lower sand of the Hatchetigbee Formation of the upper Wilcox Group and the Meridian Sand of the lower Claiborne Group are placed together within the Upper Wilcox aquifer. Though the fluvial lower Hatchetigbee sand is part of a regressive highstand sequence at the top of the Wilcox Group and the Meridian Sand is the lowstand beach sand of the transgressive lower Claiborne Group, these sands are separated at times by only a thin, clay-rich, floodplain section of the upper Hatchetigbee Formation (Figure 11) and both may be strongly cross bedded. Figures 11-13 show the cross bedded lower Hatchetigbee sand at the excavation site of the Super Wal-Mart in Meridian. Excavations in the old Colvert sand pit in Meridian, to the west of the Super Wal-Mart site, exposed massive channel sands of the lower Hatchetigbee Formation, containing large clasts of bedded silt and clay eroded into the channel from levee deposits (figures 14 and 15). Figures 16-19 show the cross bedded Meridian Sand in a sand pit on Mt. Barton in Meridian. Figure 20 shows Ophiomorph burrows, the borrows of nearshore callianassid shrimp, in a road cut in the Meridian Sand on Highway 16 near Philadelphia, Mississippi.

Waynesboro Sand.

Hendy (1948, p. 29) named the Waynesboro Sand as a cross-bedded fluvial channel sand of early Bucatunna age. He stated that: "A fairly large stream in the general vicinity of the present Chickasawhay River eroded a surface well down into the Marianna in an area centering approximately two miles west of the common corner of Twps. 9 and 10 N., Rgs. 6 and 7 W [Wayne County, Mississippi]." Hendy (1948) gave a measured section of the Waynesboro Sand in Stop 10 of the Mississippi Geological Society Sixth Field Trip Guide Book. Johnson (1982) recognized the Waynesboro Sand as a lentil of the Bucatunna Formation and illustrated the laminated and cross bedded strata of this lentil at Hendy's Stop 10 locality. He also included three cross sections, a net sand isopach for the Waynesboro Sand in Wayne County, and a isopach map of the interval between the base of the Glendon Formation and the top of the Bucatunna clay. The greater thicknesses of the latter map tracked the depth of the erosional surface above the Glendon and Marianna limestone sections. Johnson noted the thickest Waynesboro Sand section, approximately 100 feet of sand resting on the lower ledges of the Glendon Limestone, to occur beneath the Town of Waynesboro where it served as a good source of water for small-capacity wells.

Though both Hendy and Johnson placed the deposition of the Waynesboro Sand as contemporaneous with the typical marine/lagoonal Bucatunna Clay, it is more likely a valley-fill lowstand deposit associated with the drastic 29 Ma sea level fall on the "Cenozoic Cycle Chart" of Vail and Mitchum (1979) discussed below. Dockery in MacNeil and Dockery (1984, p. 22-23) stated that: "Fresh water flowing through the Waynesboro fluvial system flushed through the underlying Glendon bedrock to produce vuggy limestones, collapsed rubble zones, and other karst features." Figure 21 illustrates a Waynesboro channel sand cutting into leached Glendon Limestone at a quarry of the Wayne County Lime Company north of Waynesboro, where the Glendon contains large masses of sparry calcite, a rarity in the state.

Ground-Water Supplies in Highstand Regressive Fluvial and Deltaic Sands

Both the Kosciusko and Cockfield formations of central and northwestern Mississippi contain highstand regressive fluvial and deltaic sands, which are important aquifers in the Delta region and across central Mississippi. In northwest Hinds County both formations contain upper and lower aquifer sands, and in both cases the lower sand has the better water supply. The Kosciusko sands in the subsurface are referred to as the Sparta aquifer.

A study of confining beds (aquitards) bounding the Cockfield Formation and the net sand thicknesses within the formation showed the presence of channel systems associated with ancient rivers and delta distributaries (Dockery 1976). Such channel sands produce the greatest ground-water supply within the formation. A sea-level rise in the late Middle Eocene Cook Mountain Formation established a limestone bank and shelf across southern Mississippi and a clay-rich shelf across west-central Mississippi, which now function as an aquitard between aquifer sands in the Kosciusko and Cockfield formations. Deltas, followed by river systems, prograded southward above the underlying Cook Mountain marine shelf, as the shelf filled with sediments and the ocean retreated. A second sea-level rise flooded the deltas and produced a second limestone shelf across areas of southern Mississippi. The final progradation of Cockfield deltas covered the second limestone shelf with a thick clay and sand sequence and covered the offshore Cook Mountain carbonate bank with a layer of clastic marine mud. The stratigraphic sequence produced by prograding deltas, in ascending order, include: (1) prodelta clays, (2) delta-front sands, (3) distributary-mouth-bar sands, and (4) delta plain clays and lignites. While delta-front sands may produce a tabular, wide-spread sand unit, distributary-mouth-bar sands are lenticular, linear, thicker, and thus have the potential to produce a greater water supply.

Figure 22 shows facies of the Cook Mountain and Cockfield formations across their outcrop belts in central Mississippi. Figures 23-25 show the Archusa Marl Member of the Cook Mountain Formation at Dobys Bluff on the Chickasawhay River near Quitman, Mississippi. This is the best exposure of the Cook Mountain limestone shelf, which underlies much of southern Mississippi as shown in Figure 26. North-to-south and northwest-to-southeast cross sections across the limestone shelf and bank (figures 27-28) show the updip and downdip deltaic and marine facies of the overlying Cockfield Formation.

Figure 29 shows the formation of a second Cook Mountain limestone shelf and marine reworking of delta sands in the Cockfield Formation. In one area, the second marine shelf and reworked delta sands merge together.

Figure 30 shows an exposure in Clarke County of the Cockfield delta-front sands overlain by delta plain deposits, including a lignitic-clay-filled channel. These sediments are part of a second deltaic progradation in the Cockfield Formation, which is illustrated in the net-sands map of Figure 31. Updip fluvial facies, as seen in the west-to-east cross section of Figure 32, are characterized by thick linear channel sand trends, containing an abundant groundwater supply. Figure 33 contains a north-south cross section down a fluvial and delta-distributary sand trend and a northeast-to-southwest cross section across delta-sand trends. Figure 34 follows a delta sand trend from northwestern Madison County till the trend ends in southeastern Jasper County. A recent (September 21, 2009) water-well geophysical log made along this trend in Rankin County at an elevation of 600 feet above sea level in the ACL Water Association #3 Firetower well in Section 36, T. 5 N., R. 4 E. showed 75 feet of clay-rich delta-plain deposits in the upper Cockfield Formation followed by a continuous 195-foot-thick channel sand at the base of the formation. Below this was 85 feet of the Cook Mountain marine clay and sand. The Kosciusko Formation below contained the following, in ascending order: (1) 130 feet of clay-rich delta-plain deposits, (2) continuous channel sand that was 190 feet thick, (3) 40 feet of clay-rich sediments, and (4) 130-foot-thick basal sand. At this site, the driller had a choice of three aquifer sands to screen for a water well; it is usually the lower sand of the Kosciusko Formation that provides the most abundant water supply of the three sands.

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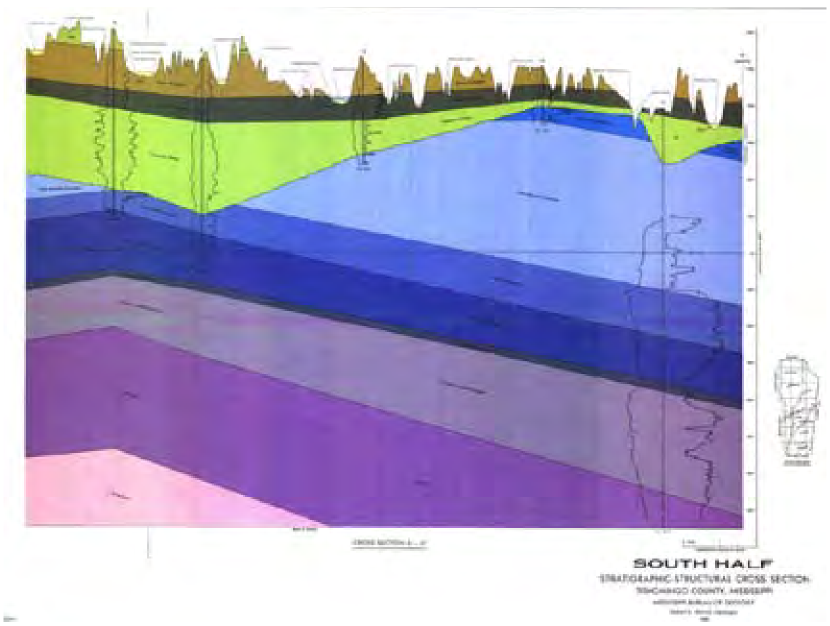

Figure 1. South half of a north-south cross section through Tishomingo County, Mississippi, by Bob Merrill (1988), showing the thickening of the Tuscaloosa Formation (green) within a valley cut into the Paleozoic bedrock.

Figure 2. Ernest Russell (left) and Tom Gibson (right) at USGS sample site 16.1 in the Oak Hill Member just below sands of the Coal Bluff Member in the SW/4, SW/4, Section 23, T. 11 N., R. 16 E., Kemper County. Picture (Kodachrome slide 404-2) taken on May 9, 1990.

Figure 3. Contact of clay and lignite (just below contact) of the Oak Hill Member with sands of the overlying Coal Bluff Member at the Delta Brick clay pit in the SE/4, NW/4, Section 7, T. 13 N., R. 155 E., Noxubee County. Picture (Kodachrome slide 223-7) taken on May 10, 1990.

Figure 4. Tom Gibson taking a clay sample below the lignite seam at the top of the Oak Hill Member and below the sands of the overlying Coal Bluff Member. Picture (Kodachrome slide 223-6) taken on May 10, 1990.

Figure 5. George Puckett (left) and David Thompson at sand pit in the Coal Bluff Member with cross-bedded, white, very loose sands, containing quartzite pebbles in Section 15, T. 13 N., R. 15 E., Noxubee County. Picture (Kodachrome slide 231-11) taken on October 7, 1992.

Figure 6. David Dockery standing on a quartzite ledge protruding from the sands of the Coal Bluff Member in a sand pit on the south side of Highway 30 in the NW/4, SW/4, Section 9, T. 7 S., R. 1 E., Union County. Picture (Kodachrome slide 399-11) taken in June of 1973.

Figure 7. Lignite seam (site of USGS sample 21) and brick clay in the Coal Bluff Member (Naheola Formation) below channel sand in the Gravel Creek Sand Member (Nanafalia Formation) in the Delta Brick pit in the NE/4, SE/4, Section 28, T. 12 N., R. 15 E., Kemper County. Picture (Kodachrome slide 404-18) taken on May 10, 2990.

Figure 8. A channel sand in the lower Tuscahoma Formation at the Red Hills Lignite Mine underlies the J seam and, at right, cuts out the I and H2 seams. The G and F seams can be seen bending beneath the channel sand where they intersect the ramp ascending from the quarry floor. Picture (slide 393-38) taken on November 10, 2004.

Figure 9. Lignite seams bend beneath a fluvial channel sand (upper right) in the middle Tuscahoma Formation, which cuts out the I and H2 lignite seams. The red cable carries 60,000 volts to power the dragline. Picture (color negative 531-16) taken on November 11, 2004.

Figure 10. Channel lignite in the Tuscahoma Formation on south side of Interstate 20 in the SW/4, SE/4, Section 23, T. 7 N., R. 17 E., Lauderdale County. Picture (slide 131-14) taken in September of 1976.

Figure 11. Ken Davis holding survey rod on a channel sand in the lower Hatchetigbe Formation at the construction side of a Super Wal-Mart in Meridian, Mississippi. Here the channel sand is about 30 feet thick and comprises the excavation floor and two benches in the high wall. Picture (slide 341-14) taken on October 13, 2000.

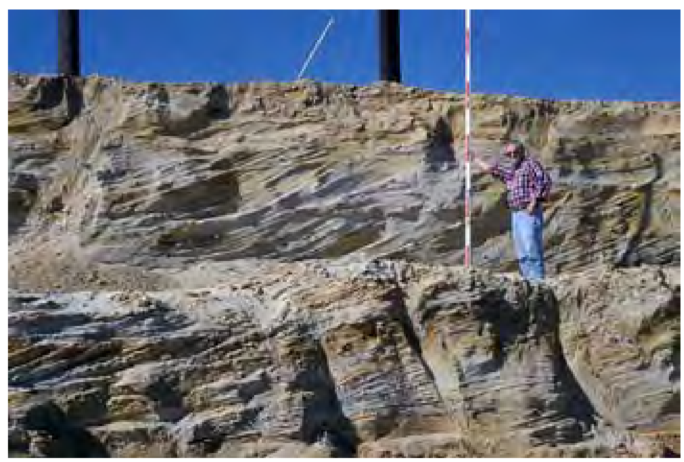

Figure 12. Ken Davis holding survey rod on a bench cut into the cross-bedded channel sands of the lower Hatchetigbee Formation at the construction site of the Super Wal-Mart (power pole site) in Meridian (view is to the west). Picture (slide 341-5) taken on October 13, 2000.

Figure 13. Ken Davis holding survey rod beside cross-bedded channel sand in the lower Hatchetigbee Formation at the Super Wal-Mart construction (at power pole site) in Meridian, Mississippi (view is to the west). Cross-bed laminae indicate that stream flow was from north to south. Picture (slide 340-15) taken on October 13, 2000.

Figure 14. From left to right, Ernest Mancini, Jan Handronbol, and Bill Berggren at the Covert pit in Meridian. Mancini is looking at boulder-size clay clasts in the channel sands of the lower Hatchetigbee Formation. Picture (Kodachrome slide 225-8) was taken on October 27, 1991.

Figure 15. Tom Gibson examining large clay clasts embedded in the channel sands of the lower Hatchetigbee Formation at the Covert sand pit west of 31st Street and south of I-20 in Meridian, Mississippi. Picture (Kodachrome slide 222-10) taken on May 8, 1990.

Figure 16. Contact of the cross-bedded Meridian Sand and the overlying, more-massive Tallahatta Formation at Mt. Barton south of Interstate 20 in Meridian, Mississippi. Picture (slide 136-20) taken on March 21, 1981, during a GSA field trip.

Figure 17. Crossbed sets in the upper Meridian sand at Mt. Barton in Meridian, Mississippi. Picture (Kodachrome slide 237-14) taken on June 5, 1993, during a GSA field trip.

Figure 18. Bill Berggren (far left) looking at the Meridian-Tallahatta contact as pointed to by Nick Tew (second from left) at Mt. Barton in Meridian, Mississippi. Picture (Kodachrome slide 224-20) taken on October 27, 1991.

Figure 19. Bill Berggren just above the Meridian-Tallahatta contact on the slope of Mt. Barton, an outlier of the Tallahatta cuesta with a view of Meridian to the north. Picture (slide 203-2) taken on August 16, 1988.

Figure 20. *Ophiomorpha*, trace fossils of callianassid shrimp burrows, in the Meridian Sand in a road cut on Highway 16 west of Philadelphia, Mississippi. Picture (slide 368-12) taken on September 4, 2003.

Figure 21. Hammer marks the base of a channel in the Waynesboro Sand cut into the leached zone of the Glendon Limestone in a test pit at the agricultural lime quarry in Wayne County. Picture (Kodachrome slide 140-15) taken on February 11, 1984.

Figure 23. The contact of the Dobys Bluff Tongue of the Kosciusko Formation (gray at bottom) and the Archusa Marl (white limestone on top) at Dobys Bluff on the Chickasawhay River below Quitman in Clarke County (MGS locality 26). Picture (slide 314-11) taken by Linda Ivany.

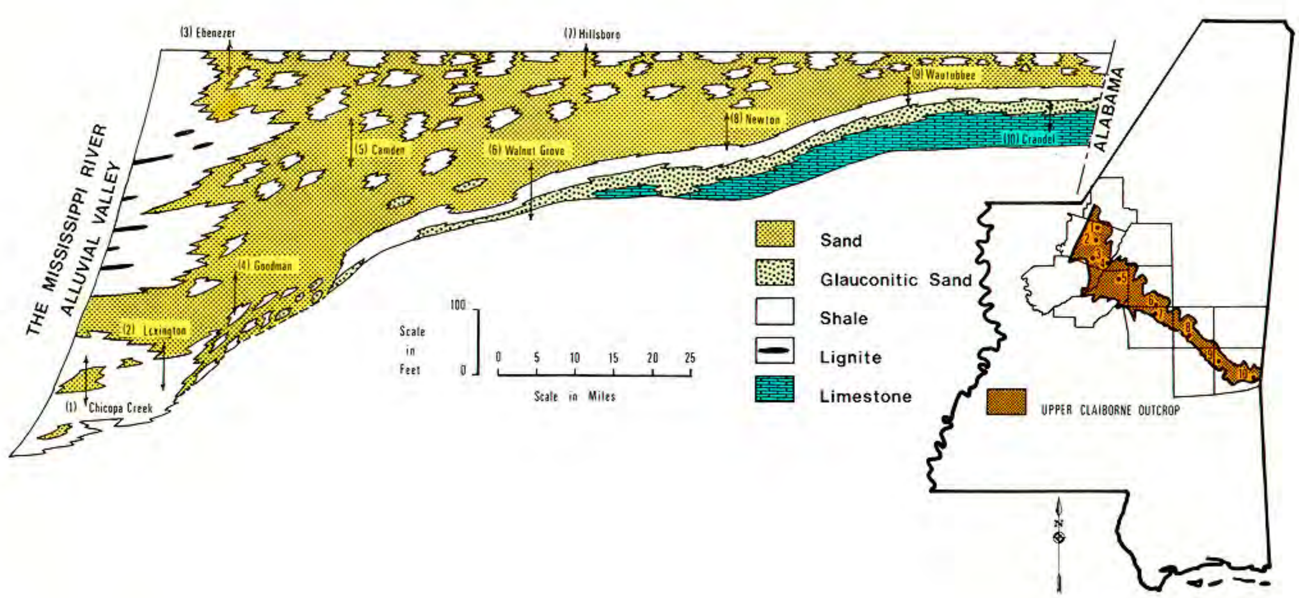

Figure 22. Facies of the Cook Mountain and Cockfield formation along their outcrop belt. Marine carbonates and clastics of the Cook Mountain Formation grade north and west into the laminated shales of the Gordon Creek Shale Member (after Thomas, 1946).

Figure 24. David Williamson standing on the bank of the Chickasawhay River at Dobys Bluff (MGS locality 26), where the Archusa Marl forms a vertical wall. Picture (slide 132-28) on August 26, 1976.

Figure 25. David Williamson points at contact of the Dobys Bluff Tongue of the Kosciusko Formation (below) and the Archusa Marl Member of the Cook Mountain Formation (above) at Dobys Bluff on the Chickasawhay River (MGS 26). Picture (slide 119-2) taken in June of 1974.

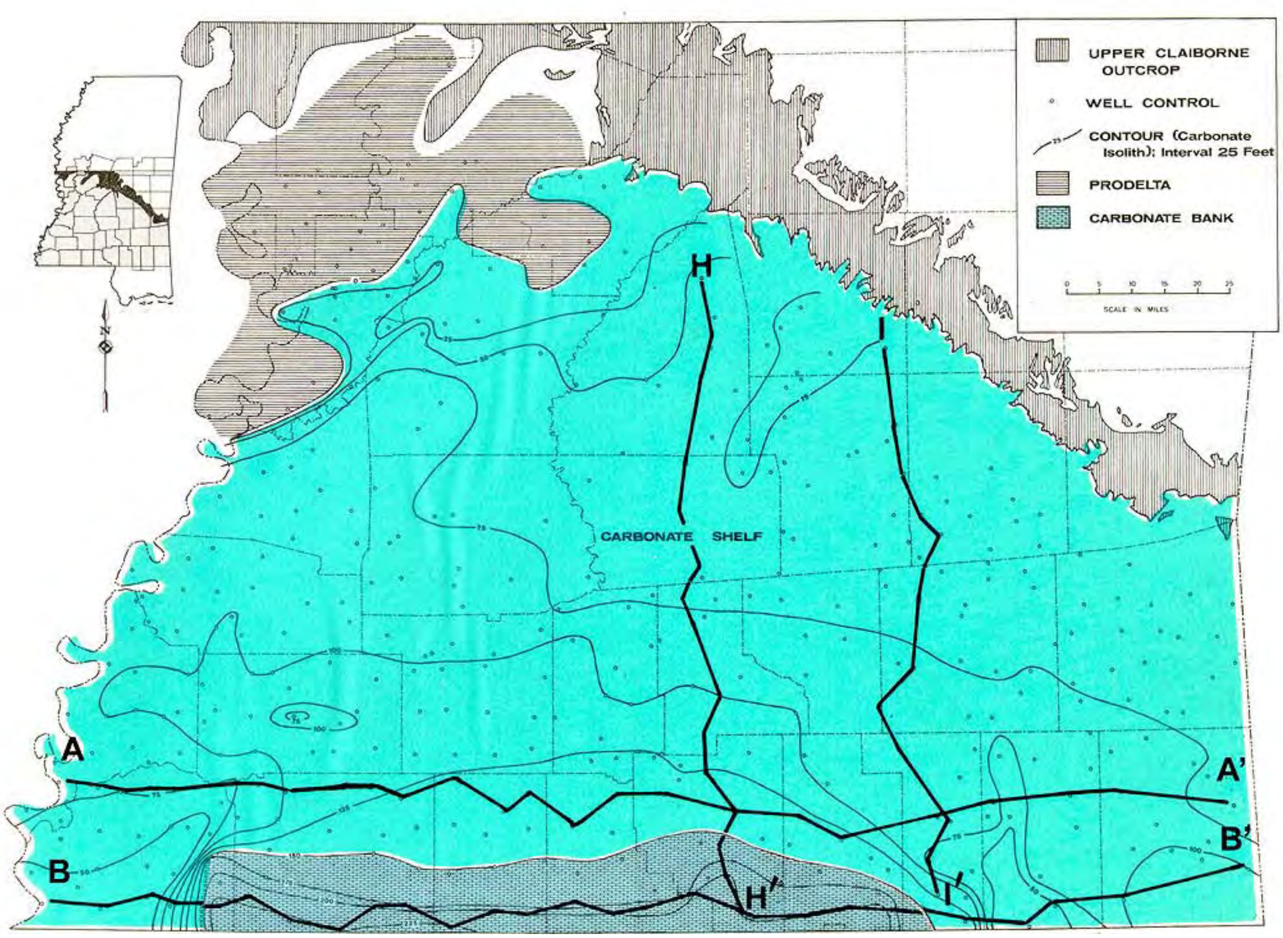

Figure 26. Carbonate isolith map of the Cook Mountains limestone in south-central Mississippi and location map for east-west cross sections A-A' and B-B' and north-south cross sections H-H' and I-I'. B-B' follows depositional strike across a carbonated bank, while H-H' is a dip section extending across the carbonate shelf to the carbonate bank (from Dockery, 1976).

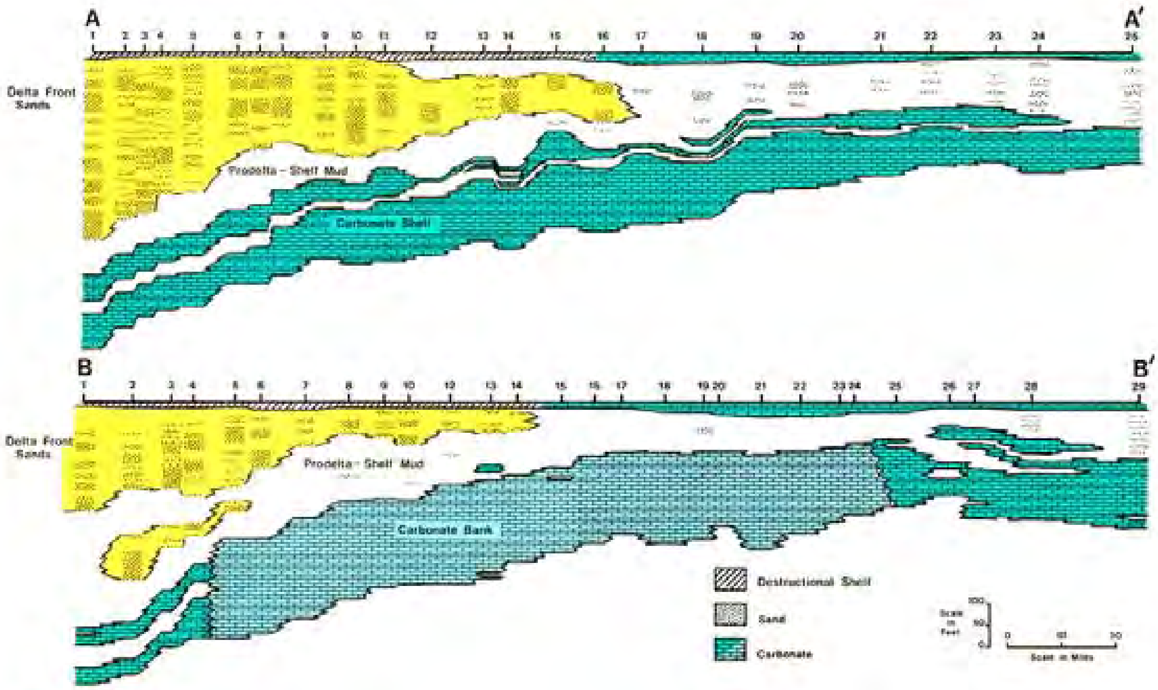

Figure 27. East-west cross sections A-A' and B-B'; A-A' shows the lower and upper carbonate shelf units of the Cook Mountain Limestone, while B-B' extends across a carbonate bank south of the carbonate shelf (from Dockery, 1976).

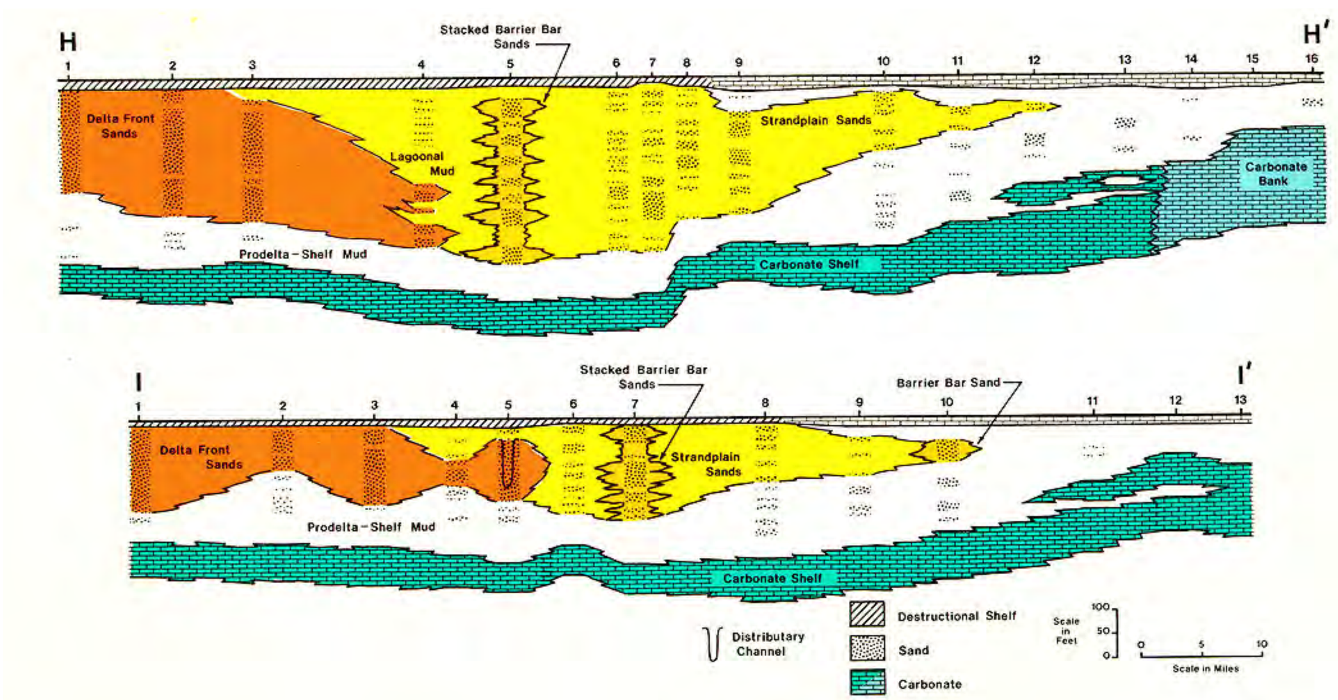

Figure 28. North-south cross section H-H' and I-I', showing updip delta-front sand facies and downdip barrier-bar facies of the Cockfield Formation (from Dockery, 1976).

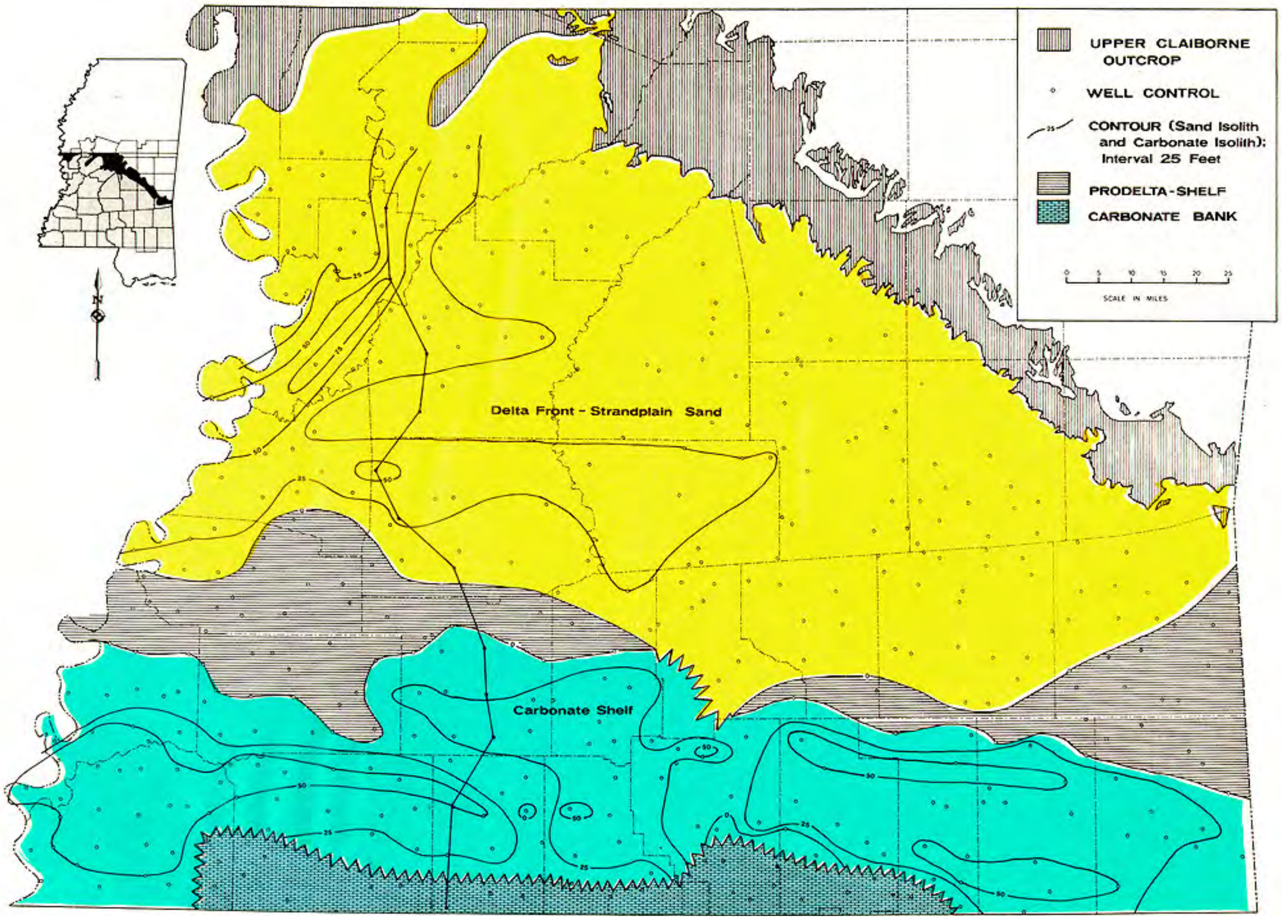

Figure 29. Net sand isolith map for the lower sand sequence of the cockfield Formation and carbonate isolith map for the upper shelf carbonate unit of the Cook Mountain Formation. The lower sand sequence and the upper carbonate unit are separated by marine shales except in Jefferson Davis county where they merge.

Figure 30. Michael Bograd walking toward exposure of the lower delta-front sands and overlying delta-plain sands and lignitic clays of Cockfield Formation at MGS locality 56 in Clarke County. Picture (slide 119-7) taken in June of 1974.

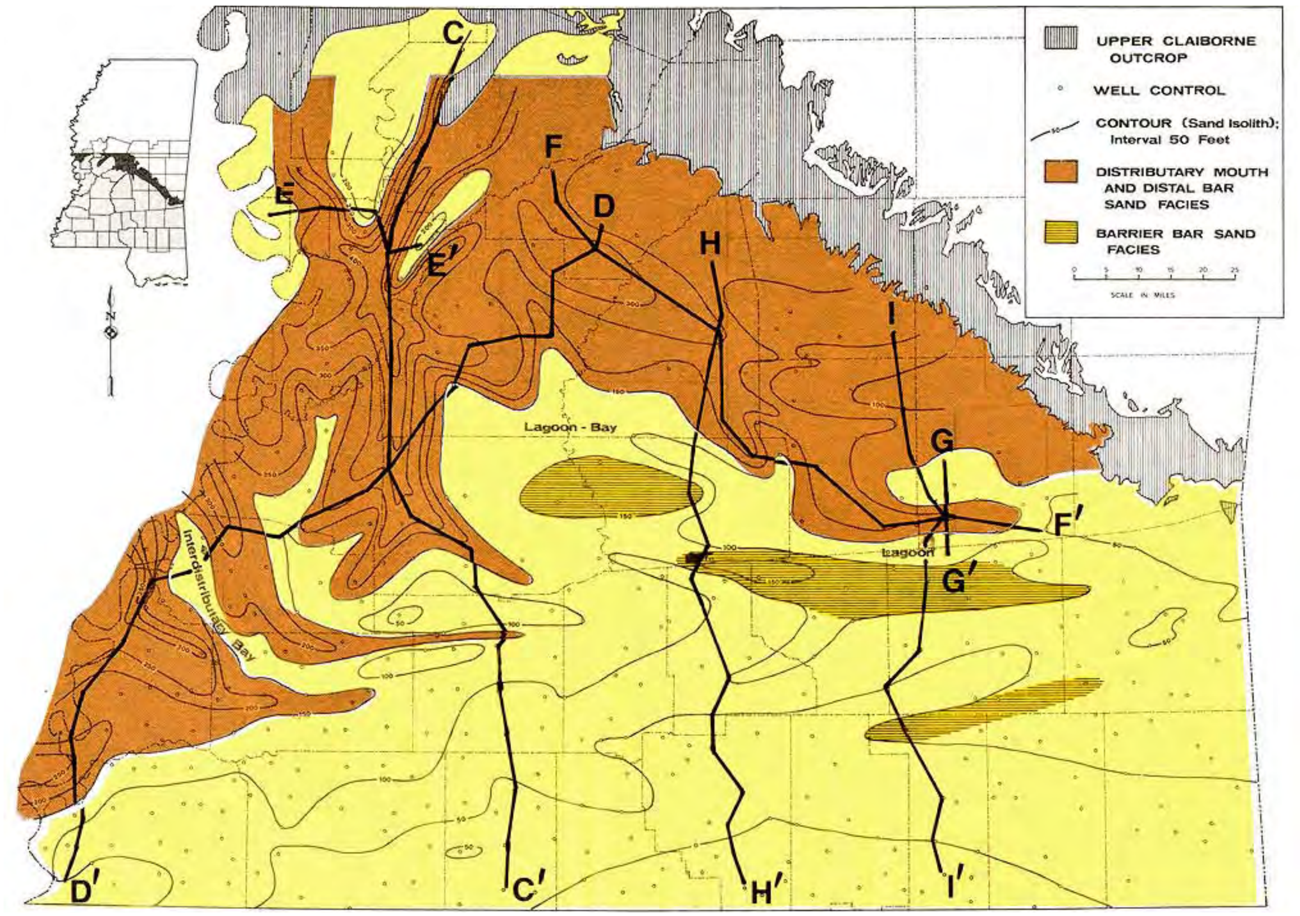

Figure 31. Net sand isolith map, showing delta distributary-mouth-bar-sand trends in the Cockfield Formation of south-central Mississippi and location map from cross section C-C' through I-I'. Delta-front sands occur in the north and west, while barrier-bar sands are present in the southeast (from Dockery, 1976).

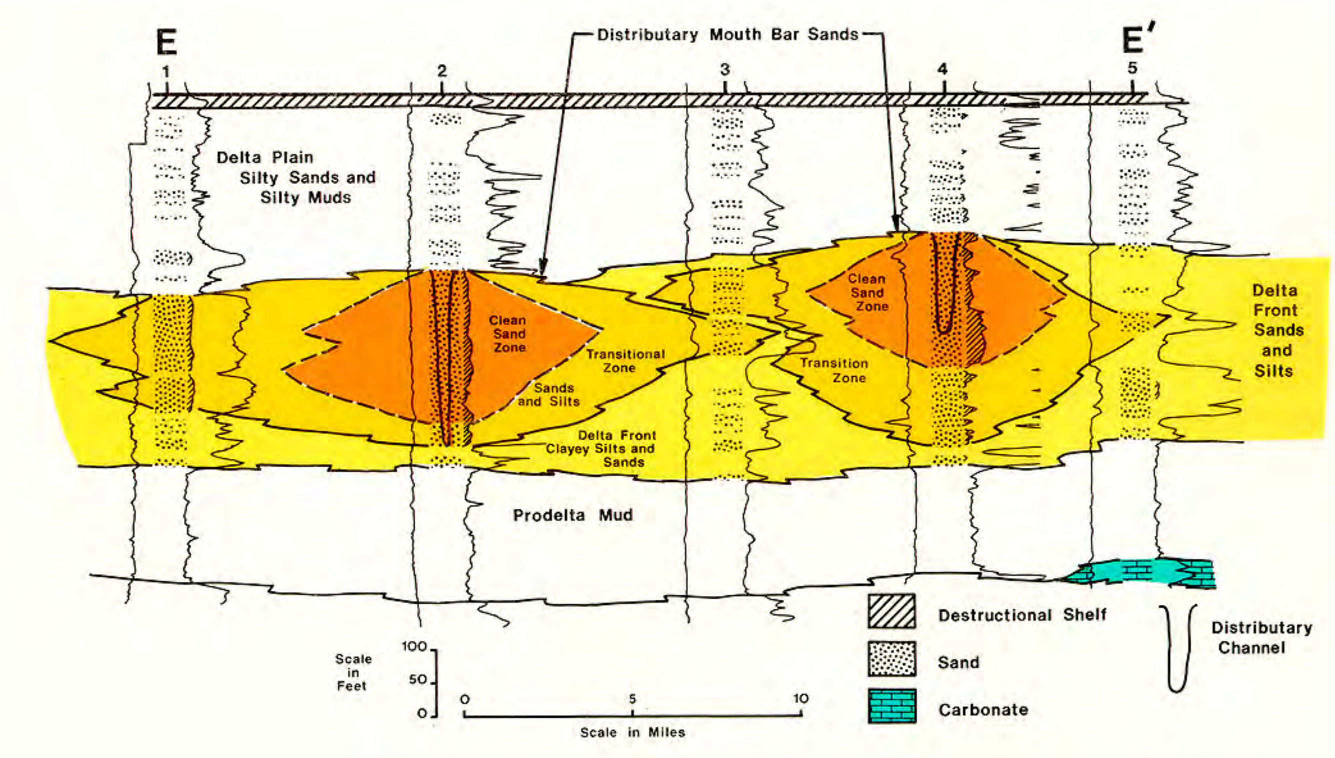

Figure 32. East-west cross section E-E' along depositional strike and across lenticular distributary-mouth-bar sands of the Cockfield Formation in Warren and Yazoo counties, Mississippi (from Dockery, 1976).

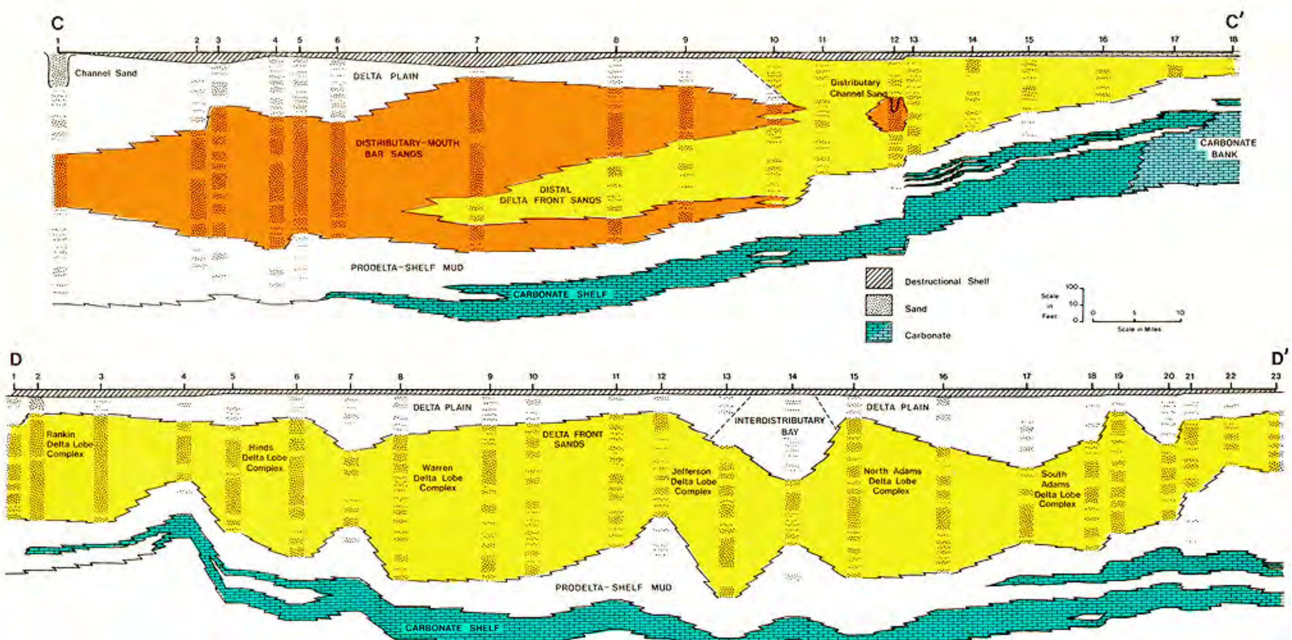

Figure 33. North-south cross section C-C' along the deposition slope of a major delta distributary-mouth-bar-sand trend, extending from Yazoo to Wilkinson County and cross section D-D' along deposition strike and across major delta-sand lobes in the Cockfield Formation (from Dockery, 1976).

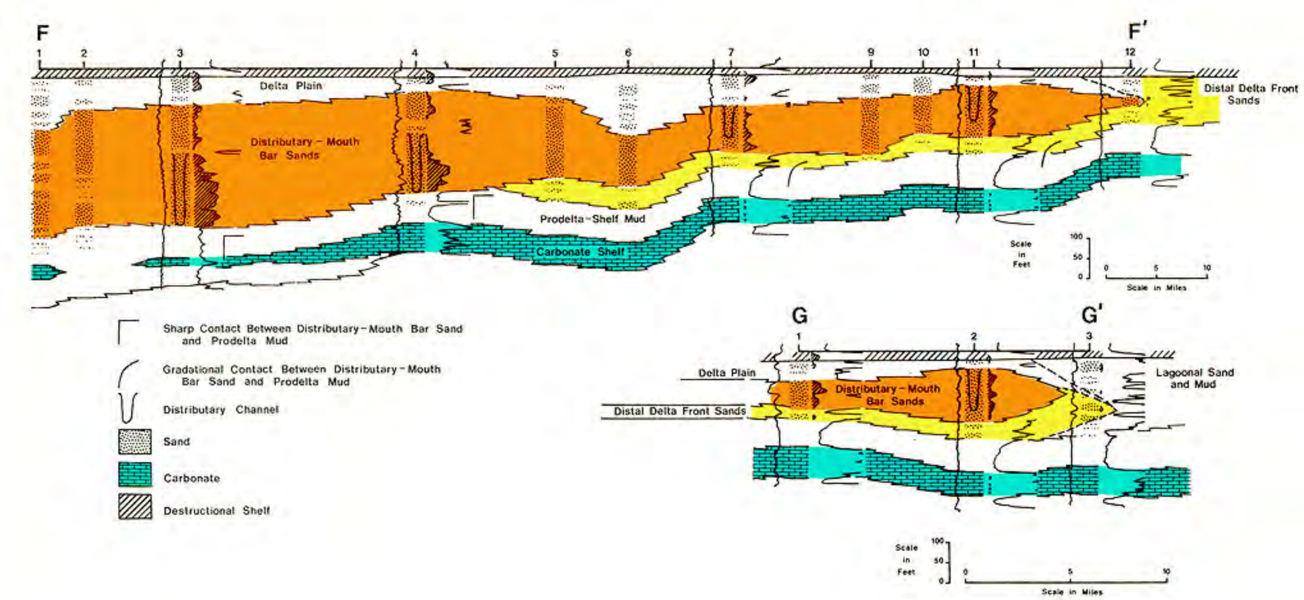

Figure 34. Cross section F-F' follow a distributary-mouth-bar-sand trend in the Cockfield Formation along the depositional slope, while G-G' cuts across the trend in a view that shows the sand to be lenticular (from Dockery, 1976).