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LITHOSTRATIGRAPHY AND THICKNESS TRENDS OF THE TUSCALOOSA GROUP IN TISHOMINGO COUNTY, MISSISSIPPI

Robert K. Merrill
Mississippi Bureau of Geology

INTRODUCTION

The Tuscaloosa Group comprises the oldest (or basal) stratigraphic interval contained in the Upper Cretaceous coastal plain sediments of northeastern Mississippi. The Tuscaloosa was named for strata exposed along the banks of the Black Warrior River near the town of Tuscaloosa, Alabama, and assigned formational status in Smith and Johnson (1887). The Tuscaloosa was assigned group status and divided into the Cottondale, Eoline, Coker, and Gordo formations in Conant and Monroe (1945) and Monroe et al. (1946). Lower Tuscaloosa strata (Cottondale and Eoline formations) contain marine sediments, and overlying lithologies comprising the Coker and Gordo formations are primarily of continental origin (Monroe et al., 1946). The Gordo is the only formation in the Tuscaloosa Group that contains large thicknesses of gravel (Monroe et al., 1946).

Tishomingo County is located in the northeastern corner of Mississippi (Figure 1), and contains the northern limit of laterally continuous Tuscaloosa occurrences. Here the Tuscaloosa is characterized by isolated bodies of gravel, sand, and clay strata preserved in paleovalleys. Portions of the Tuscaloosa Group exposed in Tishomingo County are lithologically (not time-stratigraphically) equivalent to the Gordo Formation described elsewhere in the Mississippi-Alabama-Tennessee area. Lithologies previously included in the Gordo Formation of Tennessee, northeastern Mississippi, and northwestern Alabama are diachronous (Russell et al., 1983). Upper Cretaceous strata above the Paleozoic sedimentary rocks and below the Eutaw Group are therefore described in the present report as the Tuscaloosa Group (undifferentiated).

LITHOLOGY, THICKNESS, AND EXTENT

Marcher and Stearns (1962) divided Tuscaloosa lithologies exposed in Tennessee into western and eastern lithofacies. The western facies (typical Tuscaloosa) consists primarily of poorly sorted chert gravel and chert sand, with minor amounts of quartz sand in the matrix; the eastern facies is characterized by the appearance of quartz and quartzite pebbles in the gravel fraction and large proportions of quartz sand in the matrix. Poorly sorted chert gravels of the western facies grade eastward into, and interfinger with, the well-sorted chert and quartz-bearing (vein quartz and quartzite) gravels characteristic of the eastern Tuscaloosa facies in Tennessee

Figure 1. Location of study area.

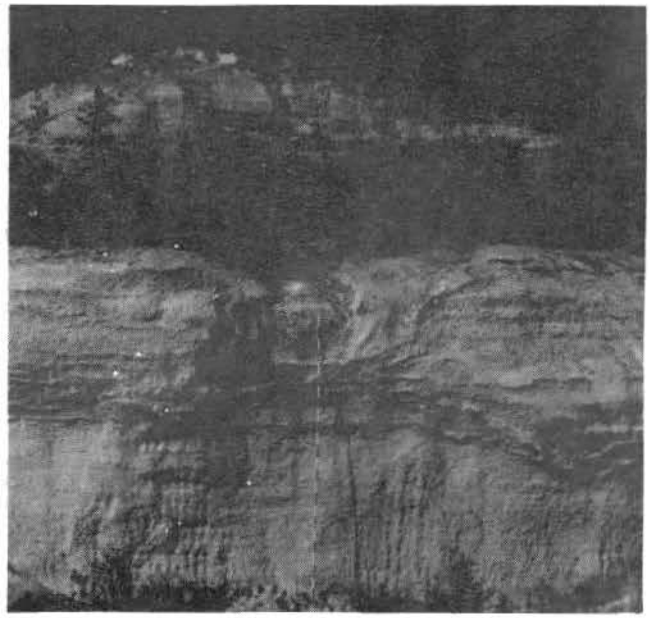

Figure 2. The irregular boundary between the eastern (lower) and western facies of Tuscaloosa gravels. Thinly bedded marine sands and silty clays of the overlying McShan Formation occur above the terraced area 4 feet above the top of the pole. Pole is 25 feet high, scale in feet. Location: NE/4, NE/4, SW/4, Sec. 17, T.7S., R.10E.

(Marcher and Stearns, 1962). Portions of the Tuscaloosa sequence exposed in Tishomingo County consist primarily of chert gravels in a matrix of chert sand and silty, kaolinitic, micaceous clay (western facies or typical Tuscaloosa).

Exposures of Tuscaloosa gravels in Tishomingo County that contain quartzite and quartz pebbles in addition to chert, and a matrix composed primarily of quartz sand (Gordo Formation lithologic equivalent), are limited to areas located along the eastern county boundary south of U.S. Route 72, and areas of low elevation within Red Bud and Rock Creek valleys. This (eastern) lithofacies occurs at a stratigraphically lower position than overlying (younger) quartz-free (western lithofacies) gravels characteristic of the great majority of Tuscaloosa exposures in Tishomingo County. The boundary between these Tuscaloosa facies extends northeastward into Alabama. Russell et al. (1983) determined that this boundary occurs along a northeast - southwest trending line extending north of Margerum, Alabama. An exposure of the contact of the eastern (quartz-bearing) and overlapping western (quartz-free) Tuscaloosa lithofacies in southern Tishomingo County is shown in Figure 2. The eastern Tuscaloosa facies occupies the lower 15 feet of this exposure, and occurs as well-sorted chert and rare quartzite pebbles in a matrix composed primarily of quartz sand; the overlying western facies consists of 16.5 feet of chert gravel in a matrix of silty kaolinitic clay with thin irregular layers of iron oxide cement. Thinly interbedded glauconitic sands and clays of the unconformably overlying McShan Formation occupy the uppermost portions of the exposure.

The western lithofacies occupies the great majority (over 90%) of Tuscaloosa exposures in Tishomingo County, and is composed primarily of well-rounded chert pebbles and cobbles in a matrix of chert sand and/or kaolinitic, silty, micaceous clay. Figure 3 illustrates the outcrop appearance of typical Tuscaloosa (western lithofacies) exposures. All pebbles and cobbles contained in Tuscaloosa gravels are very well rounded and have smooth outer surfaces. Gravels of the eastern facies are typically well sorted and generally have a light brown patina. Gravels of the western (typical) Tuscaloosa facies commonly have a bleached appearance in outcrop imparted by kaolinitic matrix clays which coat outer surfaces of pebbles, preserving the original coloration of the parent chert material from which the gravels were derived. Lenses and beds of silty, kaolinitic clays occupy uppermost Tuscaloosa intervals exposed in eastern Tishomingo County and western Colbert County, Alabama (Figure 4). Tuscaloosa strata locally contain carbonaceous clays and carbonized wood fragments.

The differing Tuscaloosa lithologies occur as a result of differing source areas and modes of transport. Prior to and dur-

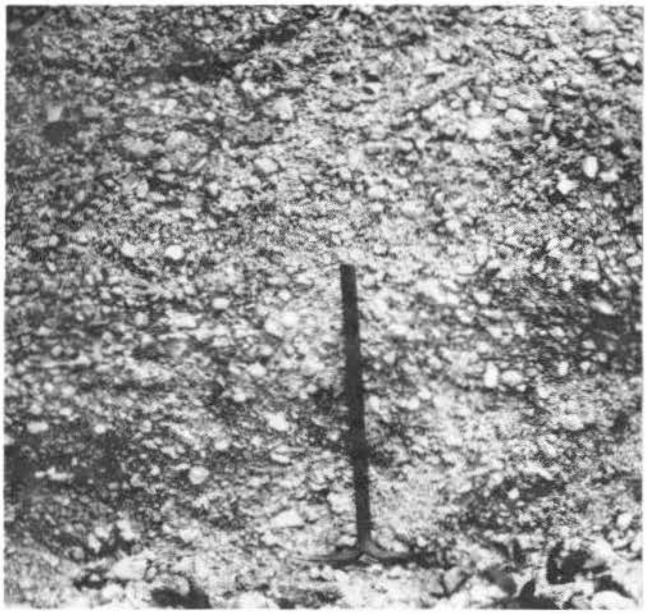

Figure 3. Outcrop appearance of typical (western lithofacies) Tuscaloosa gravels in Tishomingo County. Pickax is 26 inches in length. Location: SW/4, SW/4, NW/4, Sec. 15, T.3S., R.11E.

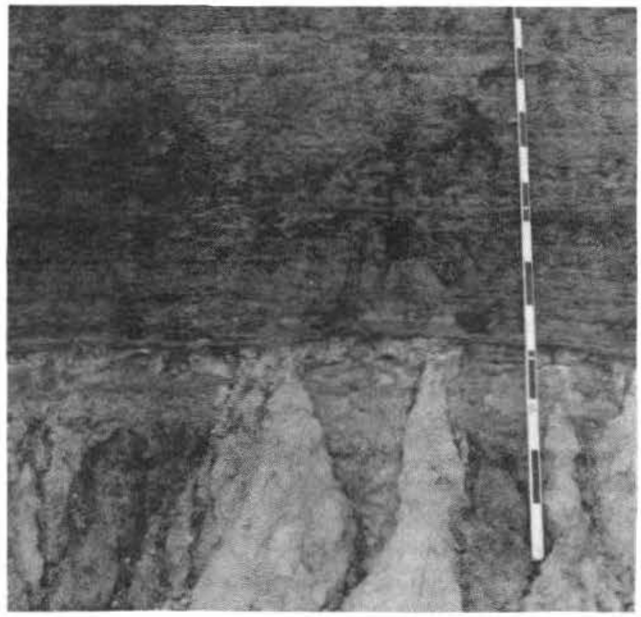

Figure 4. Silty clays of the Tuscaloosa Group (western facies) unconformably overlain by thinly interbedded and interlaminated silty clays and fine-grained marine sands of the McShan Formation. Scale in feet. Location: SE/4, SE/4, NW/4, Sec. 33, T.3S., R.15W.

ing Tuscaloosa deposition, the Pascola Arch extended across areas presently occupied by the Mississippi Embayment (Stearns and Marcher, 1962). Western Tuscaloosa lithofacies sediments exposed in Tennessee consist primarily of Devonian and Mississippian age cherts with occasional sandstone pebbles. These clastics were derived both locally (Fort Payne chert) and from bedrock comprising the Pascola Arch, which contributed Devonian age (Camden) chert; sandstone pebbles and frosted quartz sand were probably derived from Cambrian or Ordovician rocks exposed on the Pascola Arch (Marcher and Stearns, 1962). Possible source areas of quartz-bearing (vein quartz and quartzite) gravels of the eastern Tuscaloosa lithofacies of Tennessee include Pennsylvanian bedrock in the Appalachian Plateau to the east, the southern Illinois Basin to the north, and the Black Warrior Basin to the south; the distribution and exotic lithologies of the eastern facies indicate that longshore currents may have transported and winnowed these sediments (Marcher and Stearns, 1962).

Russell (1987) described two major Late Cretaceous stream systems that transported Tuscaloosa gravels into northeastern Mississippi: a system of southeast flowing streams that contributed chert gravel from chert-bearing formations exposed along the Pascola Arch in western Tennessee and northern Mississippi, and a southwest flowing system that crossed northern Alabama and contributed quartzite pebbles and quartz sand in addition to chert.

The Tuscaloosa Group occurs at the surface of Tishomingo County as a north-south trending belt of exposures about 7 miles in width. Strike trends generally north-south with local variations of about $\pm 20°$, and dip is generally westward at about 30 feet per mile; local variations in dip range between the horizontal and about 40 feet per mile. Figure 5 illustrates the distribution of the Tuscaloosa Group at the surface of Tishomingo County and local variations in strike of the upper Tuscaloosa surface in central and southern portions of the county.

The Tuscaloosa Group continues westward in the subsurface of Alcorn and Prentiss counties. Parks et al. (1960) reported a thickness of 87 feet in the shallow subsurface of Prentiss County.

The northwestern limit of continuous Tuscaloosa occurrences in northern Mississippi extends southwestward from northern Tishomingo County, crossing southeastern portions of Alcorn County and northwestern portions of Prentiss County (Boswell, 1978; Wasson and Tharpe, 1975). The northward limit of continuous occurrence of Tuscaloosa strata in Tishomingo County is shown in Figures 5 and 7. Isolated or locally occurring intervals of Tuscaloosa strata may occur northwest of the limit of continuous occurrence as these fluvial sediments fill local depressions or paleovalleys developed on the Paleozoic sedimentary rock surface. Strata comprising the Eutaw Group directly overlie Paleozoic sedimentary rocks where the Tuscaloosa Group is absent beyond the northern and western limit of Tuscaloosa occurrences, and where the Tuscaloosa thins locally over Paleozoic ridges.

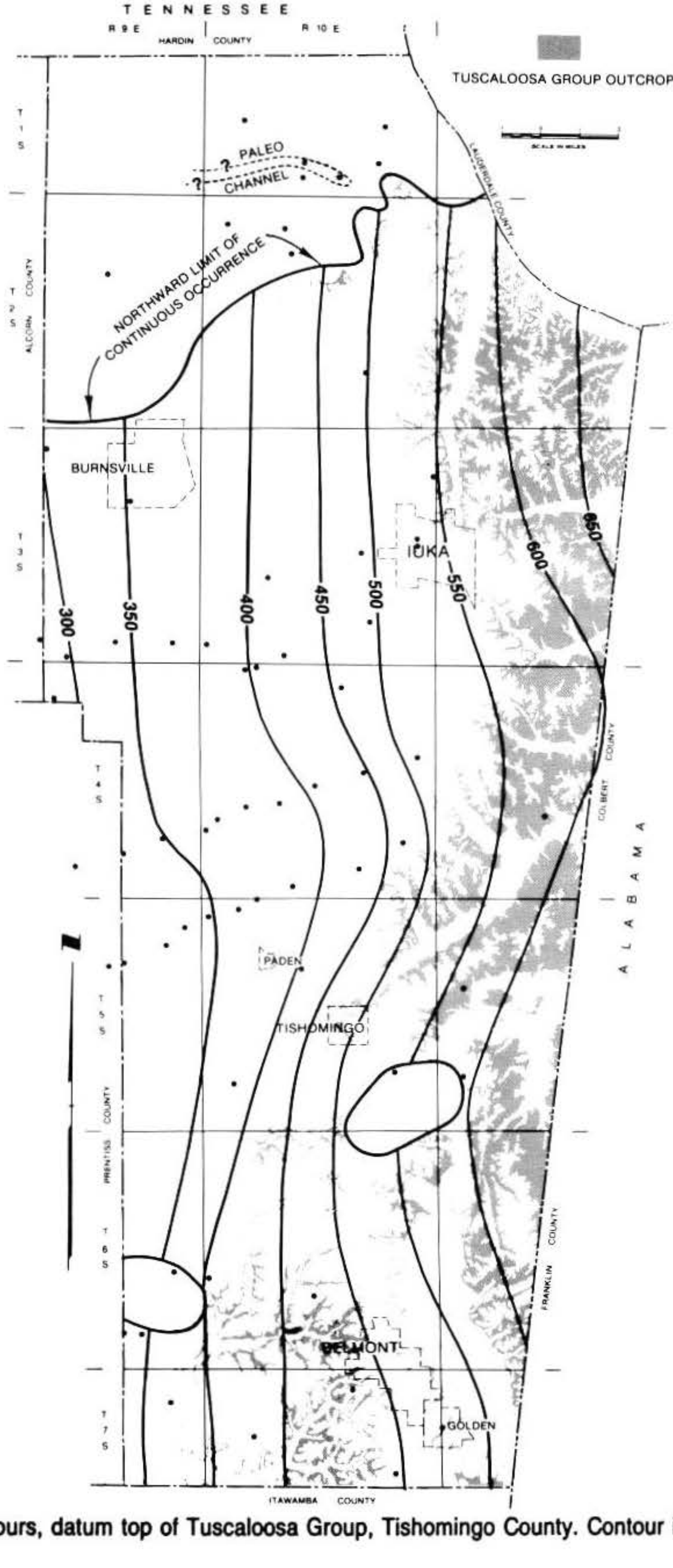

Figure 5. Structure contours, datum top of Tuscaloosa Group, Tishomingo County. Contour interval is 50 feet.

The arcuate Tuscaloosa outcrop belt continues southward from eastern Tishomingo County through eastern portions of Itawamba, Monroe, and Lowndes counties in Mississippi, and eastward across Alabama into Georgia. Surface and shallow subsurface thicknesses of Tuscaloosa strata in Mississippi are highly variable. Known thicknesses of the Tuscaloosa Group vary between 0 and 418 feet in Tishomingo County. The unit attains a maximum thickness of 200 feet in Itawamba County (Vestal and Knollman, 1947) and 600 feet in Monroe County (Vestal and McCutcheon, 1943). Eastward in neighboring areas of Alabama, the unit attains a maximum thickness of 170 feet in Lauderdale County (Harris, Peace, and Harris, 1963) and 100+ feet in Colbert County (Harris, Moore, and West, 1963). The Tuscaloosa Group was mapped over large areas of Franklin County, Alabama, although the thickness of the unit is not specified in Peace (1963).

The maximum Tuscaloosa thickness encountered in Tishomingo County was in Test Hole ME3-1 (NW/4, SE/4, NE/4, Sec. 13, T.4S., R.10E.) drilled by the U.S. Army Corps of Engineers in cooperation with the U.S. Geological Survey during ground-water investigations regarding the Tennessee-Tombigbee Waterway. This test hole encountered 418 feet of chert gravel, sand, and silty kaolinitic matrix clays underlain by more than 60 feet of residual clays developed in situ on Paleozoic strata prior to Tuscaloosa deposition. Residual clays developed on the uppermost Paleozoic (Mississippian) sedimentary rock surface were described at the surface of Tishomingo County and named the Little Bear Residuum by Mellen (1937). These clays are white in color, and are primarily composed of the mineral kaolinite. These residual clays were reworked and incorporated as matrix material as Tuscaloosa fluvial systems transgressed the region in Late Cretaceous time.

PALEOVALLEYS

The distribution of the Paleozoic sedimentary rocks at the surface and the contoured top of the Paleozoics in the subsurface of Tishomingo County are illustrated in Figure 6. Variations in thickness occur as thick sequences of Tuscaloosa strata preserved in paleovalleys thin laterally over paleoridges exposed locally at the surface and occurring in the shallow subsurface of Tishomingo County. Figure 6 illustrates the local relief developed on the Paleozoic sedimentary rock surface prior to and during deposition by Tuscaloosa fluvial systems, and Figure 7 shows the resulting thickness distribution of Tuscaloosa strata underlying Tishomingo County. The Paleozoic rocks are overlain by unconsolidated nearshore marine sands and clays of the Eutaw Group in areas of zero Tuscaloosa thickness shown in Figure 7. The county-wide distribution of all geologic units at the surface of Tishomingo County is illustrated on Plate 1 of Merrill et al. (1988).

Two prominent westward opening depressions on the Paleozoic floor are located in central and northern Tishomingo County. The centrally located depression or paleovalley contains the maximum Tuscaloosa thickness observed in the county. The northern paleovalley is much narrower and occurs in the county's northernmost township (Figures 6 and 7). Tuscaloosa fluvial sediments overlie limestone and chert strata comprising the Iowa Group (Fort Payne and Tuscumbia formations) in deepest portions of the centrally located paleovalley system. Figure 8 illustrates the stratigraphic relationships produced as a result of truncation of Paleozoic strata by the erosional surface at the base of the Tuscaloosa Group. The Paleozoic floor rises southward from the centrally located paleovalley and Tuscaloosa thicknesses decrease to zero along portions of the northeast-southwest trending paleoridge underlying portions of southern Tishomingo County (Figures 6 and 7).

The Hartselle Formation is the youngest Paleozoic unit preserved at the base of the Tuscaloosa Group in Tishomingo County (Figure 8). This sandstone caps portions of the paleoridge in southern Tishomingo County. The sandstone-capped ridge is an erosional remnant that extends southwestward from exposures of the Hartselle Formation along portions of the Bear Creek drainage system located in T.5S., R.10 and 11E. Intermittent exposures of the Hartselle sandstone occur along portions of Rock Creek and McDougal Branch and continue southwestward to the vicinity of Bay Springs Dam on Mackeys Creek in T.6S., R.10E. These occurrences are indicated as shaded areas in Figure 6. Tuscaloosa strata thicken southward of this ridge as fluvial gravels, sands and clays fill local valleys developed on the Paleozoic floor near the Itawamba County Line (Figures 7 and 8). Test wells utilized in the construction of Figure 8 are listed on Table 1.

The northern paleovalley is indicated by surface exposures and test well data in T.1S., R.10E. (Figures 6 and 7). A portion of this buried paleovalley crosses the line of section shown in Figure 8, adjacent to well 3. The Fort Payne Formation is directly overlain by the Eutaw Formation in areas of northernmost Tishomingo County where the paleovalley is absent (Figure 7). Pleistocene fluvial terrace deposits locally overlie the Fort Payne Formation where the Eutaw is absent in exposures located along the shores of the Yellow Creek and Tennessee River embayments of Pickwick Lake.

The thick sequence of Tuscaloosa strata preserved in central Tishomingo County is restricted to areas bounded to the north and south by Paleozoic highs. This local constriction opens westward where the Paleozoic floor dips to the southwest toward the axis of the Mississippi Embayment. A regional structural contour map on the top of the Paleozoic rocks by Mellen (1947) shows the central paleovalley as a local westward-opening depression in central Tishomingo County.

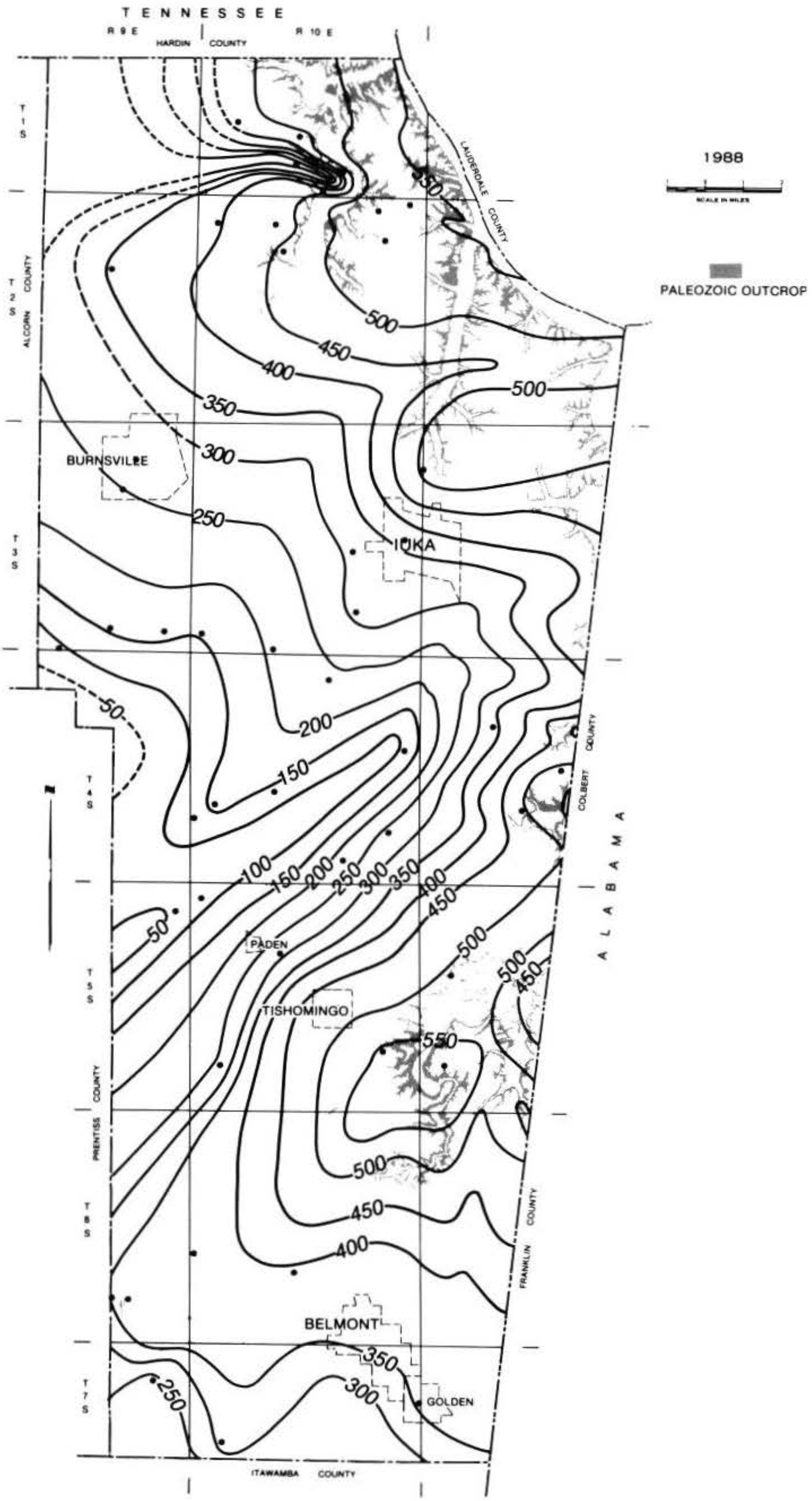

Figure 6. Contour map on the Paleozoic floor underlying Tishomingo County. Contour interval is 50 feet, datum mean sea level.

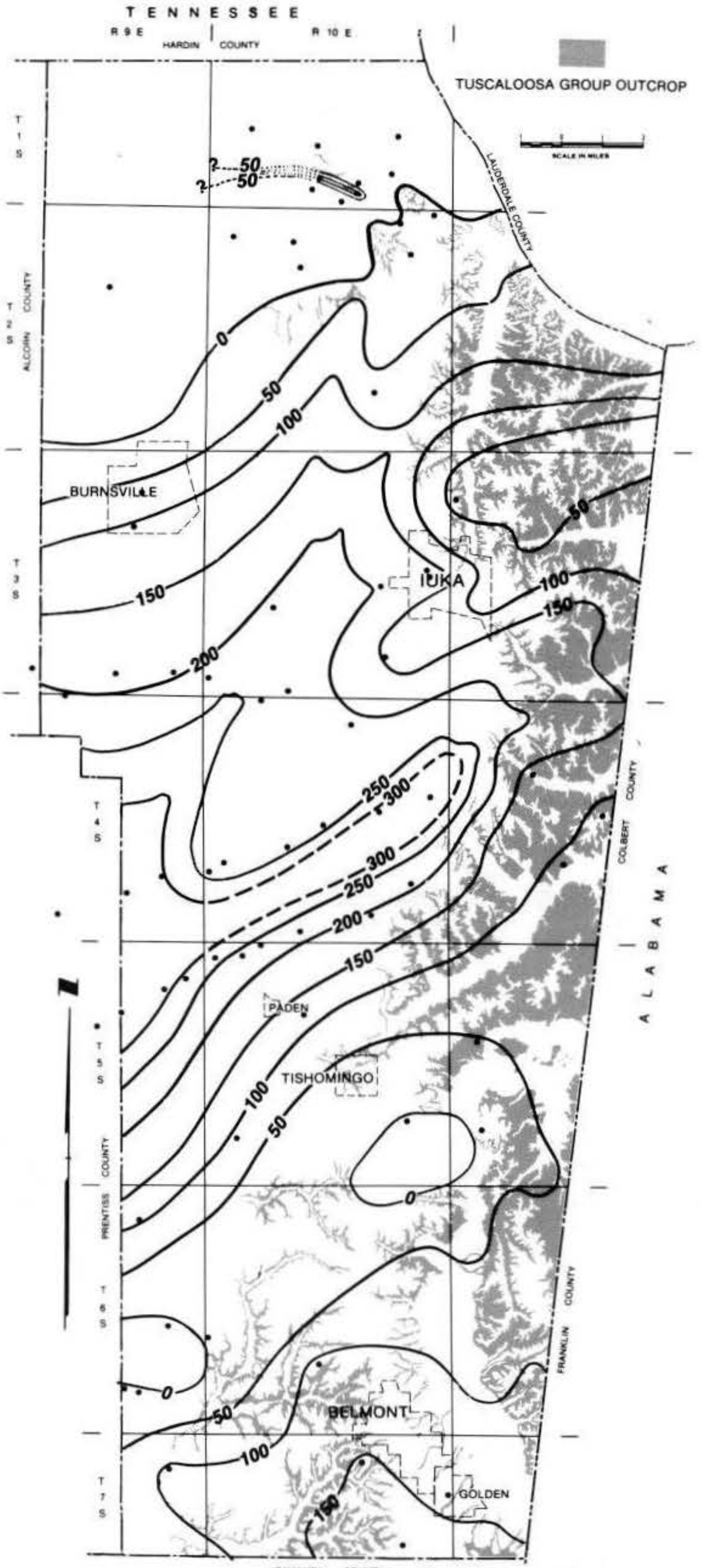

Figure 7. Isopach map of the Tuscaloosa Group in Tishomingo County. Tuscaloosa outcrop is shown as the shaded area. Contour interval is 50 feet.

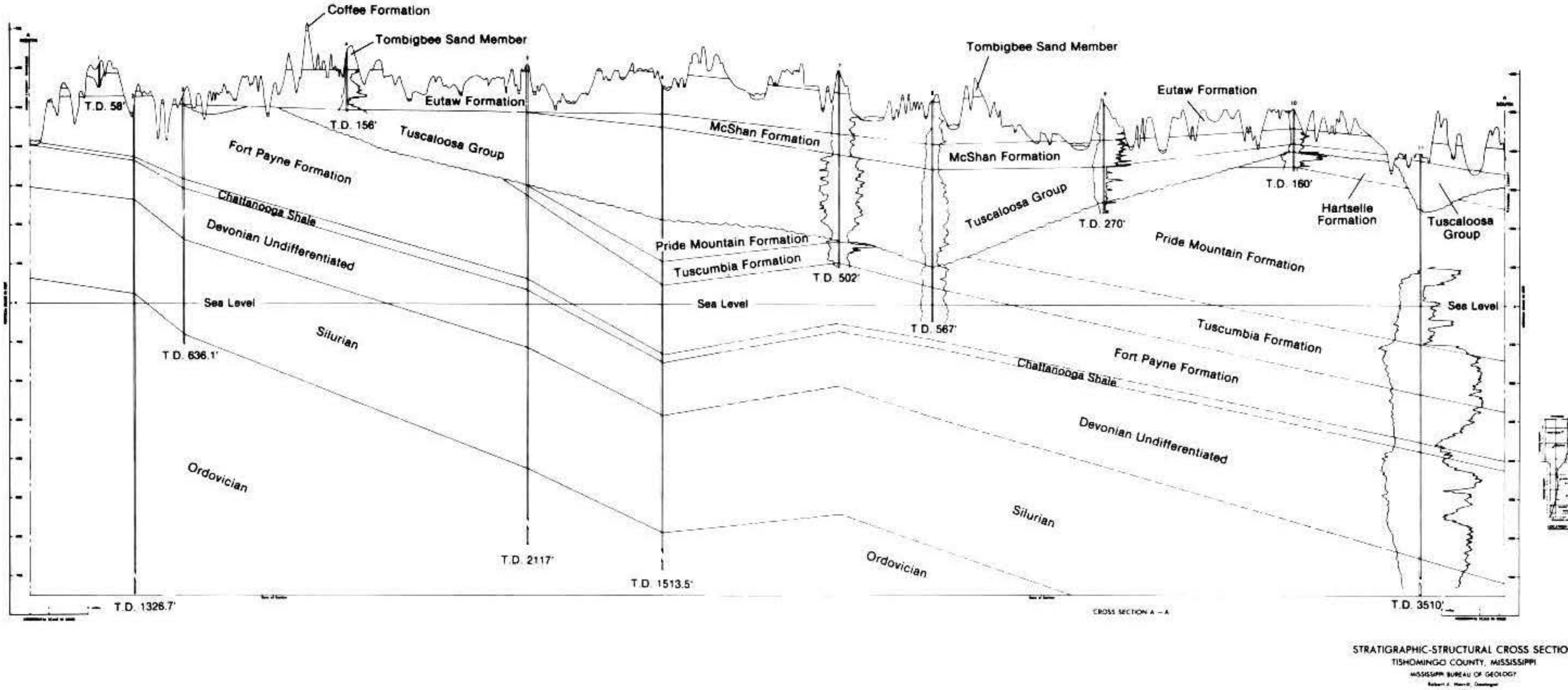

Figure 8. Cross section through Tishomingo County.

Table 1. List of wells utilized in the construction of Figure 8.

Number	Operator	Well	Location
1	Mississippi Bureau of Geology	Test Hole AP-6	NW/4, NW/4, NE/4, Sec. 16, T1S-R10E
2	Tennessee Valley Authority	Core Hole 51-C-3	NE/4, NE/4, NW/4, Sec. 35, T1S-R10E
3	Tennessee Valley Authority	Core Hole A	NE/4, SW/4, NE/4, Sec. 2, T2S-R10E
4	Mississippi Bureau of Geology	Test Hole AP-5	SW/4, SW/4, NW/4, Sec. 26, T2S-R10E
5	Levan and Akers	No. 1 J. D. Whitaker	Cent. NW/4, NW/4, Sec. 23, T3S-R10E
6	J. B. Levan et al.	No. 1 J.M. Russell	SW/4, NW/4, SE/4, Sec. 3, T4S-R10E
7	U.S. Army Corps of Engineers- U.S. Geological Survey	Hydrologic Site 24-A	SE/4, SE/4, SW/4, Sec. 19, T4S-R10E
8	U.S. Army Corps of Engineers- U.S. Geological Survey	Hydrologic Site 32	NW/4, SE/4, NW/4, Sec. 6, T5S-R10E
9	Mississippi Bureau of Geology	Test Hole AP-7	NW/4, SE/4, SE/4, Sec. 30, T5S-R10E
10	Mississippi Bureau of Geology	Test Hole AP-9	NW/4, SW/4, SW/4, Sec. 19, T6S-R10E
11	Cities Service Oil Co.	No. 1 Allen	SE/4, SW/4, SW/4, Sec. 1, T7S-R9E

The Tishomingo County paleovalleys were produced as a result of downcutting by Tuscaloosa fluvial processes along lines of weakness offered by fractures, formational contacts, or less resistant strata that occupied fluvial pathways during Late Cretaceous time. The axis of the centrally located paleovalley (Figure 6) trends N. 38° E., and is parallel to one of the dominant directions of fracture that extends throughout the Paleozoic sequence exposed in Tishomingo County. Stereonet projections of prominent directions of fracture in the Fort Payne Formation measured in exposures along the shoreline of the Yellow Creek embayment result in two dominant trends of N. 54° W. ± 5° and N. 38° E. ± 5° (Johnson, 1975). Similar directions of fracture occur county-wide in Paleozoic rock exposures, and vary within about 5 degrees locally in any given formation (Merrill et al., 1988). A more recent example of structural control of stream course by this fracture system is Horseshoe Bend in Bear Creek where the legs of the bend parallel the two prominent fracture directions (see shaded areas in southwestern portions of T.5S., R.11E. in Figure 6).

The axis of the northern paleovalley located in northernmost Tishomingo County trends approximately N. 65° W. in the upper (easternmost) reaches, although this trend can only be generally established with existing subsurface data. This axis is within 11° of the mean for the N. 54° W. ± 5° fracture trend. Other Tuscaloosa-filled paleovalleys adjacent to Tishomingo County are likely to follow one of the two dominant fracture trends. Thus the thick sequence of Tuscaloosa strata preserved in Tishomingo County's centrally located paleovalley probably extends southwestward in the subsurface of eastern Prentiss County. Here the local relief on the Paleozoic floor probably decreases toward the Tuscaloosa pinchout. The Eutaw Formation contains gravel in basal portions, but lithologies observed in exposures and well samples imply a much less energetic depositional environment than that indicated by the much coarser channel lag gravels contained in the Tuscaloosa Group; thus local relief due to channelization of the Paleozoic floor probably diminishes where Eutaw strata directly overlie Paleozoic rocks in the subsurface of northern Mississippi.

Thick accumulations of Tuscaloosa strata occur eastward in the subsurface and at the surface of Alabama and southward in the subsurface of Mississippi. The northeast-southwest trending paleoridge that crosses southern Tishomingo County (Figure 6) is a local feature when considered on a regional scale. This feature probably occurred as one of several extensions of a paleodrainage divide during deposition of Tuscaloosa fluvial sediments. The Tuscaloosa Group is absent along portions of this paleodrainage divide, and thickness increases rapidly away from areas of zero thickness shown in Figure 7. The paleoridge enters eastern Prentiss County in T.6S., R.9E. (Figure 6) and the Tuscaloosa is locally absent in that area at the county line.

IMPLICATIONS FOR WATER SUPPLY

The Tuscaloosa Group is an important aquifer in northeastern Mississippi (Boswell, 1978). Therefore it is possible that the Tuscaloosa-filled paleovalleys in Tishomingo County and adjoining areas may prove to be an important water resource for industrial development in the region. Major thicknesses of the Tuscaloosa aquifer system in Tishomingo County occur as shown in Figure 7. Extreme variations in thickness of Tuscaloosa strata, as well as the local absence of the unit (Figure 7), defy any generalized or "broad brush" description of the unit in northeastern Mississippi and adjoining areas of Alabama and Tennessee. The Tuscaloosa is variable in both lithology and thickness, and detailed studies of the unit are necessary to characterize the formation as a water resource in a given region.

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LANDSLIDES IN COASTAL PLAIN SOILS OF MISSISSIPPI

D. E. Pettry and R. E. Switzer
Department of Agronomy

Donald M. Keady
Department of Geology and Geography
Mississippi State University

ABSTRACT

Soil mass movements (landslides) occur in particular soils and parent materials in the Mississippi Gulf Coastal Plain region. Two landslide areas in central Mississippi were studied. Sideslopes ranged from 12-50%, with Maben soils (Ultic Hapludalfs) on the sideslopes and Providence soils (Typic Fragiudults) on the ridges. Both sites had deep well-drained soils with well-developed yellowish-red argillic horizons of silt loam and clay loam texture, C horizons that had reduced gleyed colors and increased mica content above the slippage surface. Both sites showed a large decrease in silt and clay from the slippage contact to the underlying sand. Kaolinite dominated the upper horizons and smectite the lower horizons. Examination of the slippage horizon and adjacent layers at a third site confirmed the findings at the previous sites. Landslides occur when the soil develops cracks or planes of weakness perpendicular to the slope direction near the crest. The soil separates and moves downslope under saturated conditions. We propose that desiccation surface cracks between trees may serve as the precursor of the planes of weakness that result in slope failure.

INTRODUCTION

Landslides in soils and unconsolidated sediments of the Gulf Coastal Plain region have received little attention and research documentation is lacking. Soil mass movement occurs in particular soils and parent materials in this region and may cause considerable localized economic damage. The impact of mass movement on timber, roads and structures may be severe in affected areas.

Landslides, the downslope mass movements of soil and underlying parent materials, may be classified according to their type of movement. Sharpe (1938) categorized landslides into four groups according to the type of movement: (1) slow flowage; (2) rapid flowage; (3) sliding; (4) subsidence. Previous studies in other regions have attributed mass movement to wetting and drying of expandable clays in combination with gravitational forces (Ciolkosz et al., 1979). Increases in gravitational forces due to slope gradients accompanied by decreased soil shearing strength due to saturation are generally the major causes of slides. Other soil, geological, environmental and climatic factors may be involved.

Landslide-prone soils have been identified in Pennsylvania and determined to have high clay contents, high coefficient of linear extensibility and slickensides (Ciolkosz et al., 1979). Lanyon and Hall (1983) developed a method to predict potentially unstable landscapes in Ohio using landscape morphology parameters and related process calculations.

This study was prompted by observations of numerous landslides in specific soil areas following intensive precipitation in winter and spring seasons. The objectives were to characterize the morphological, physical, chemical and mineralogical parameters of soils involved in mass movement in Winston and Choctaw counties.

METHODS AND MATERIALS

Study Area

Three landslide areas were investigated in the Noxubee Hills region of southeastern Choctaw County and northwestern Winston County. The topography was steep with sideslopes ranging from 12 to 50% with narrow ridges and drainageways. The ridges trended in a general northwestern to southeasterly direction. Sideslope lengths ranged from 45 to 90 meters. The area was densely vegetated with mixed hardwoods and pine. Dominant soils were mapped in the Maben-Providence association (USDA, 1986). Maben soils (fine, mixed, thermic Ultic Hapludalfs) were located on the sideslopes and Providence soils (fine-silty, mixed, thermic Typic Fragiudults) occurred on the narrow ridges. The Maben soils are well-drained and they formed in stratified loamy material and shaly clay. Providence soils are moderately well-drained and have dense fragipans in the subsoil. They formed in a thin mantle of silty material and underlying loamy materials. The study area was located in the lower part of the Wilcox Group (the Ackerman Formation as mapped by Vestal, 1943; Mellen, 1939). The formation was described as containing silty, laminated clay with plant remains, silty lignitic clay and laminated silt or silty clay and a basal cross-bedded sand.

Figure 1.

Figure 2.

Field Methods

Soils were examined via soil bucket auger (7.5 cm diameter) to depths of 3.5 m in positional transects. Freshly exposed faces of displaced landslide plates were described and sampled using standard methods (USDA, 1951).

Laboratory Methods

Soil samples were air-dried and sieved to remove coarse fragments (> 2mm). Particle size distribution was determined by the hydrometer method (Day, 1965) and sieving. Organic matter was determined by wet combustion (Walkley and Black, 1934). Extractable acidity was determined by the barium chloride-triethanolamine method (Peech, 1965). Exchangeable aluminum was determined following the procedure of Yuan (1959). Exchangeable cations were extracted with 1 M NH_4OAC and determined by atomic absorption spectrophotometry. Soil pH was determined in a 1:1 soil:distilled water suspension after 30 minutes equilibration.

Liquid limit (LL), plastic limit (PL) and plasticity index (PI) of selected samples were determined by standard methods

Figure 3.

(ASTM, 1968). Clay fractions were separated by centrifugal sedimentation. They were analyzed by x-ray diffraction with a Norelco Geiger counter spectrophotometer using CuK-alpha radiation and a Ni filter. Mineral type and content were estimated from basal spacings and x-ray peak intensity.

RESULTS

Landscape

The sideslopes had visual signs of past mass movement as evidenced by displaced soil masses of ellipsoidal shape which created an unusual hummocky microrelief (Figure 1). Recent landslides were readily recognized by the exposed displaced soil plate or "wedge" and disrupted trees (Figure 2). Older slides had partially "healed" by revegetation leaving raised topographical features with trees exhibiting curved trunks indicating downslope movement with new growth after displacement (Figure 3). Examination of older slide masses revealed cracks or planes of weakness between the displaced masses and adjacent undisturbed soils. Soil horizonation and other morphological features of the adjacent soil masses did not join. The cracks tended to be mask-

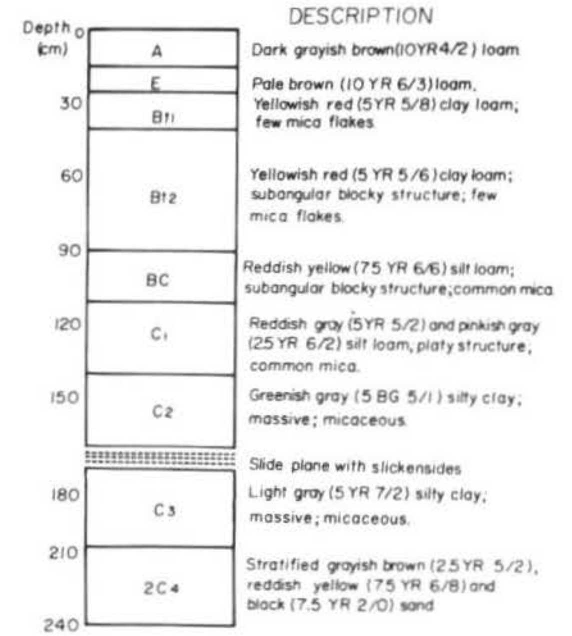

Figure 4. Soil profile of Choctaw County landslide site.

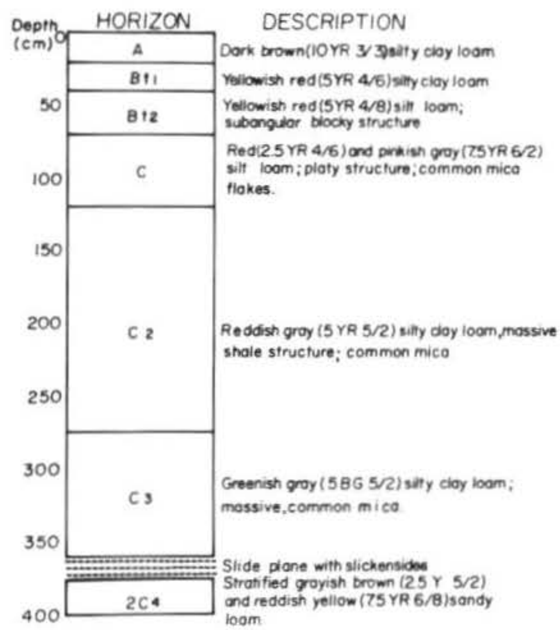

Figure 5. Soil profile of Winston County landslide site.

ed by surface vegetative detritus. Displaced soil plates ranged from 6 to 40 m length and 2 to 7 m width, with vertical thicknesses of about 2 to 6 m. Many trees with heights of 13 m and greater on displaced soil plates had survived downslope movement intact, while others were uprooted. Some soil mass movement resulted in the soil being inverted

Table 1. Physical properties of fresh landslide faces in the Noxubee Hills Region of Choctaw and Winston Counties.

Depth	Horizon	Sand (2-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<.002 mm)	Textural Class
cm		-------------------	%	-------------------	
			Choctaw County		
0-15	A	51.1	38.6	10.3	loam
15-25	E	43.2	49.2	7.6	loam
25-40	Bt1	28.2	43.1	28.7	clay loam
40-90	Bt2	27.6	38.2	34.2	clay loam
90-110	BC	27.6	57.1	15.3	silt loam
110-140	C1	3.8	46.7	49.5	silty clay
140-170	C2	0.2	53.1	46.7	silty clay
170-205	C3	87.2	10.3	2.5	sand
205-240	2C4	53.1	39.2	7.7	sandy loam
			Winston County		
0-15	A	18.1	57.2	24.7	silty clay loam
15-39	Bt1	9.2	61.5	29.3	silty clay loam
39-70	Bt2	1.7	72.6	25.7	silt loam
70-150	C1	6.7	67.8	25.5	silt loam
150-275	C2	2.7	68.7	28.6	silty clay loam
275-360	C3	19.7	52.5	27.8	silty clay loam
360-450	2C4	67.2	29.7	3.1	sandy loam

with surface horizons on the bottom and subsoils at the surface. The displaced ellipsoidal soil plates occurred from just below the ridge crest to drains at the bottom of the slopes. In places, soil plates had moved across drains forming a natural barrier to drainage.

Soils

The landslide masses were comprised of deep, well-drained soils with well-developed yellowish-red argillic horizons (Bt) of silt loam and clay loam textures. Surface textures were loam at the Choctaw County slide and silty clay loam at the Winston County site (Figures 4 and 5 respectively). The soils had medium to rapid surface runoff and moderately slow permeability. The deeper subsoil (C) horizons of both sites had reduced, gleyed colors indicating restricted air and water movement. Muscovite mica content increased in the C horizon above the slippage surface at both sites. The Choctaw County site had micaceous silty clay overlying sand at the slippage contact. Clay contents were 46.7% in the silty clay horizon and 2.5% in the underlying sand (Table 1). The slippage zone at the Winston County site had silty clay loam texture with 27.8% clay overlying a sandy loam horizon with 3.1% clay. Large decreases in silt contents also occurred at the failure zones, decreasing from 53.1 to 10.3% at the Choctaw site and from 52.5 to 29.7% at the Winston County site.

Soils at both sites had high base saturation levels in comparison to the highly leached soils of the area. Base saturation at the Choctaw County site decreased between depths of 90 to 170 cm before increasing, which suggests a more highly weathered seepage zone (Table 2). Lower pH and Ca/Mg levels and higher extractable acidity and aluminum in the Choctaw site suggest greater weathering under the extremely acid conditions. These data suggest weathering of the alumino-phyllosilicate clays with subsequent release of Al and Mg to the cation exchange sites. The presence of higher exchangeable K than typically occurs in soils of the area suggests weathering of muscovite mica with subsequent release of K to the cation exchange sites. The low exchangeable Na levels are similar to adjacent soils of the area. Organic matter contents decreased with increasing depth.

Clay fractions of both sites had similar mineralogical suites. The upper sola were dominantly kaolinite > hydroxy-interlayer vermiculite > illite > smectite > quartz. The deeper horizons, including the slippage surface, had clay fractions dominated with smectite > kaolinite > illite > quartz. The silty clay and silty clay loam horizons of

Table 2. Chemical characteristics of fresh landslide faces in the Noxubee Hill Region of Choctaw and Winston Counties.

Depth	Horizon	pH	Exchangeable cations Ca	Mg	K	Na	H	Al*	Total**	Base saturation	Organic matter
cm			cmol kg-1							%	%
					Choctaw County						
0- 15	A	5.1	2.31	0.90	0.21	0.06	4.11	0.06	7.59	45.8	2.5
15-25	E	4.5	0.08	0.44	0.08	0.05	2.75	0.99	3.40	19.1	0.5
25-40	Bt1	4.6	2.22	6.67	0.43	0.06	12.04	3.14	21.42	43.8	0.3
40-90	Bt2	4.6	1.93	6.74	0.47	0.07	11.95	5.17	21.16	43.5	0.3
90-110	BC	4.5	0.13	2.66	0.25	0.07	11.90	3.95	15.01	20.7	0.3
110-140	C1	4.3	0.09	6.15	0.37	0.10	21.32	12.14	28.03	23.9	0.5
140-170	C2	4.2	0.03	3.73	0.39	0.08	17.30	9.97	21.53	19.6	0.4
170-205	C3	4.6	0.04	0.51	0.03	0.06	1.30	0.68	1.94	32.9	0.1
205-240	2C4	4.5	1.33	3.39	0.11	0.09	7.04	2.27	11.96	41.1	0.1
					Winston County						
0-15	A	5.2	11.20	9.07	0.62	0.04	5.99	1.10	26.92	77.7	4.2
15-39	Bt1	4.7	10.86	11.08	0.53	0.04	11.06	3.17	33.57	83.3	0.7
39-70	Bt2	4.6	10.73	11.28	0.54	0.08	11.65	3.43	34.28	67.0	0.4
70-150	C1	4.9	11.83	12.92	0.60	0.07	9.10	1.35	34.52	66.0	0.2
150-275	C2	4.9	12.18	13.69	0.56	0.07	6.94	1.20	33.44	73.6	0.2
275-360	C3	4.9	11.79	13.32	0.51	0.08	7.80	0.89	33.50	79.2	0.1
360-450	2C4	5.5	8.25	8.79	0.22	0.04	3.13	0.33	20.43	76.7	0.1

*Not included in summation of exchangeable cations

**Summation of exchangeable cations

the slippage zone had smectite contents > 50%. The increased smectite clay contents of the lower horizons were accompanied by increased muscovite mica in the sand and silt fractions.

Examination of the slippage horizon and adjacent layers of a second landslide in Winston County indicated a close similarity to the other two slides. The slippage layer was light gray silty clay overlying a reddish-yellow sandy loam (Table 3). The gray color is depictive of reduced conditions. The clayey layer had base saturation levels above 35% with extremely acid pH and high exchangeable Al values (Table 4). Higher organic matter contents in the slippage layer were due to lignite fragments in the silty clay. The layer had a very low bulk density and high plasticity index which reflect the high smectite clay content. The low saturated hydraulic conductivity values and high water-holding capacities at different tensions also are due to the high smectite clay content. Higher muscovite mica content was associated with the increased smectite. The adjacent layers contained less smectite and greater kaolinite levels. The high exchangeable Al and Mg levels suggest weathering of the smectite clay in the slippage layer.

DISCUSSION

Landslides in the Noxubee Hills region of Choctaw and Winston counties occurred primarily on slopes exceeding 25% at elevations of 135 to 170 m above sea level. Soil mass movement occurred when the soil regolith developed cracks or planes of weakness perpendicular to the slope direction near the slope crest. The soil plates separated along the plane of weakness and moved downslope under saturated conditions. Although prominent slickensides occurred at the base of the displaced soil plates in the micaceous, clayey slippage zone, none were evident in the upper loamy soil sola. The absence of soil slickensides indicates insufficient shrinking-swelling in the upper soil horizons to develop the plane of weakness for subsequent separation. Soils exhibiting pronounced slickensides (Vertisols) typically contain 50% clay or greater dominated by expansive smectite. However, loamy soils commonly have desiccation surface cracks during extreme dry periods which subsequently close upon wetting, but they do not have slickensides.

The landslides had several common characteristics, including the following: slopes greater than 25%; heavily

Table 3. Particle size distribution and Munsell color of slippage plate and adjacent strata of recently exposed landslide in Winston County.

Strata	Depth	Sand (2-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)	Textural class	Munsell color
	m	--------	%	--------		
above slide zone	1.4-2.1	13.4	47.7	38.9	loam	reddish-yellow (7.5YR 6/6)
slide zone	2.1-2.4	4.7	47.2	48.1	silty clay	light gray (5Y 7/2)
below slide zone	2.4-4.0	51.0	40.9	8.1	sandy loam	reddish-yellow (7.5YR 6/8)

Table 4. Chemical characteristics of slippage plate and adjacent strata of recently exposed landslide plate in Winston County.

Strata	Depth	pH	Exchangeable cations Ca	Mg	K	Na	H	Al*	Total**	Base saturation	Organic matter
	m		--------			cmol kg-1			--------	%	%
above slide zone	1.4-2.1	5.0	1.76	4.49	0.30	0.12	11.40	5.60	18.07	36.9	0.3
slide zone	2.1-2.4	4.3	3.78	12.18	0.49	0.17	23.30	12.05	39.92	41.6	0.9
below slide zone	2.4-4.0	4.9	5.21	9.41	0.26	0.14	9.45	3.78	24.47	61.4	0.2

* Not included in sumation of exchangeable cations.

** Summation of exchangeable cations.

Table 5. Physical properties of slippage plate and adjacent strata of recently exposed landslide plate in Winston County.

Strata	Depth	Bulk density	Hydraulic conductivity	Liquid limit	Plasticity index	Water retention Mpa ⅓	1	3	6	15
	m	g/cm^3	in/hr	%		--------		%		--------
above slide zone	1.4-2.1	1.36	0.72	43.9	15.7	26.7	26.0	25.0	23.7	22.9
slide zone	2.1-2.4	1.11	0.20	63.6	30.2	50.8	49.9	48.4	46.7	45.2
below slide zone	2.4-4.0	1.40	2.73	39.6	9.6	25.6	24.0	22.5	21.1	19.8

vegetated with mature trees; upper sola containing less clay and smectite with greater hydraulic conductivity and structural aggregation than underlying micaceous, smectitic silty clay layers which rested on massive, bedded sandy strata. Prolonged wet periods which saturate the upper soil horizons (upper 2 m) add a large proportionate weight increase of 35 to 50% of the total soil mass. The increased weight per unit area is a factor in the slide process. Percolating water entry in developed cracks results in saturation of the underlying smectite clay to the liquid limit and it provides lubrication for the mica flakes, resulting in slope failure.

The surface vegetation of mature trees must also be considered causal factors in the slope failure. Mature trees present a large weight component which may range from 2,500 to 5,000 lbs per tree (Clark et al., 1985) and it is extended vertically to create a fulcrum effect on the regolith. Wind action on the trees could enhance the fulcrum effect and also create vibrational energies that could affect the soil mass. Trees may also play a role in creating the plane of weakness or initial surface crack. Field observations of the landslides showed that the surface cracks developed between trees rather than directly under them. The tree root adhesion to soil particles may prevent crack development at the tree trunk-soil contact. We propose that desiccation surface cracks between trees may be the precursor of the plane of weakness that ultimately results in slope failure. Surface cracks 2 cm wide have been observed in Maben soils at soil moisture contents of 16% and less. Loss of soil water due to dry weather and plant root removal may cause soil contraction (Russell, 1977) which results in these surface cracks. The underlying clayey strata which are buffered by 2 m of soil would probably not dry sufficiently to develop cracks that could ultimately extend to the surface. Reduced, gleyed colors in the clayey strata indicate it remains wet. Slickensides were present in the clayey strata at the slippage contact with the underlying sandy layer and they had an orientation parallel to the slope gradient.

The dominance of smectite clay in the subsoil is presumed to be inherited. Low pH levels and high levels of exchangeable Mg and Al suggest the material is weathering in the strongly acid environment. The progressive weathering may tend to increase water retention of the material and affect its stability.

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BULLETIN ON UPPER CRETACEOUS GASTROPODS IN PROGRESS AT MISSISSIPPI BUREAU OF GEOLOGY

David T. Dockery III
Mississippi Bureau of Geology

The northeastern Mississippi and southwestern Tennessee region of the North American Gulf Coastal Plain is noted world-wide for its diverse and well preserved Upper Cretaceous molluscan faunas. These faunas are well documented in Wade (1926) and Sohl (1960, 1964a, 1964b). They are best preserved in three horizons, which in ascending order are the Coffee Formation of Upper Campanian age and the Coon Creek Tongue of the Ripley Formation and Owl Creek Formation of Maastrichtian age. Of these horizons, the Coffee Formation fauna is the least well known.

Excavations within the last fifteen years in northern Lee County, Mississippi, have exposed a very fossiliferous interval of the Coffee Formation that has added considerable information about the formation's molluscan fauna. This fauna is both diverse and well preserved. Some shells show color patterns, and small species, larval shells, and protoconchs show microscopic sculpture. When completely published, the Coffee molluscan fauna of Lee County will prove to be perhaps the most diverse upper Campanian fauna in the world. This fauna will be of interest both to paleontologists and to those working with living mollusks as several Recent genera have their first occurrence in the Coffee Formation. It will also be useful in future work in biostratigraphy, the correlation and mapping of rock units of similar age based on the fossils they contain. Many of the Coffee Formation's molluscan species are small enough to be present in well cuttings and may prove to be useful guide fossils for the upper Campanian interval.

The Mississippi Bureau of Geology is in the later phase of work on a portion of the Coffee Formation's molluscan fauna. This work includes two orders of gastropods, the Archaeogastropoda and Mesogastropoda. Over 80 species from these orders have been illustrated in a series of 30 plates. Of these species, about one half are new. These plates include numerous scanning electron microscope (SEM) photographs that illustrate small specimens and protoconchs in great detail. The SEM photography for this project was done by E. E. Russell at Mississippi State University and Marcos Montes at the Materials Science and Engineering Division of the Institute for Technology Development. Some of the Coffee Formation gastropods are figured below.

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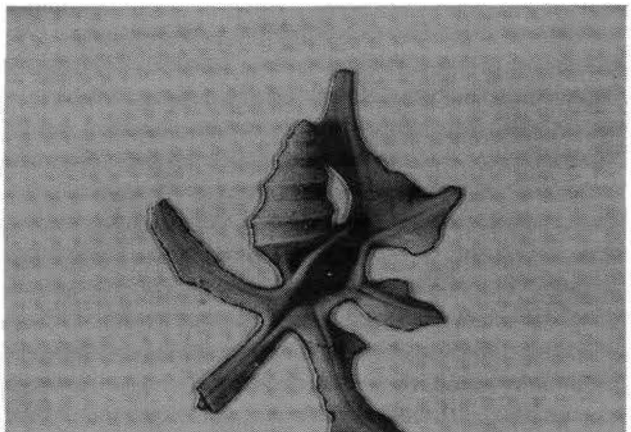

Figure 1. *Pterocerella* new species (Mesogastropoda: Aporrhaidae, x2). *Pterocerella* has a flaring outer lip that is divided into six digits, each with a narrow median channel. The specimen illustrated is perhaps the most complete and best preserved one known for this genus.

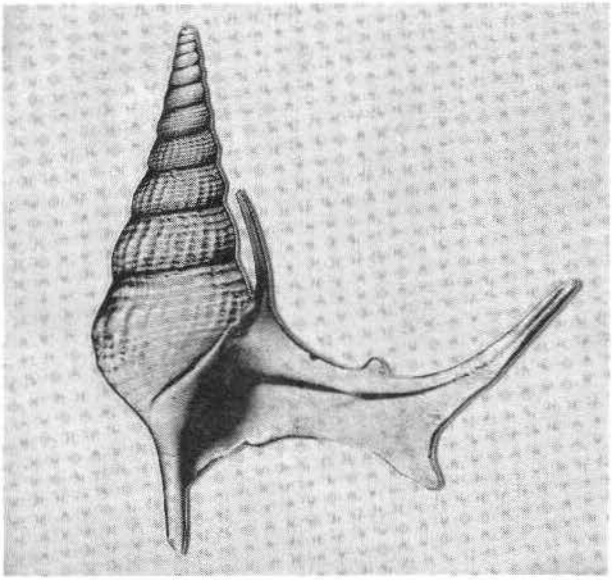

Figure 2. *Anchura* new species (Mesogastropoda: Aporrhaidae, x2). *Anchura* is a high-spired member of the Aporrhaidae with a prominent anterior (basal) spine and projecting outer lip. This lip bifurcates into an anterior (basal) digit and a rostrate posterior (upper) digit, the latter of which has a median channel. The outer lip of the new species illustrated also has a proximal digit that points toward the shell's apex.

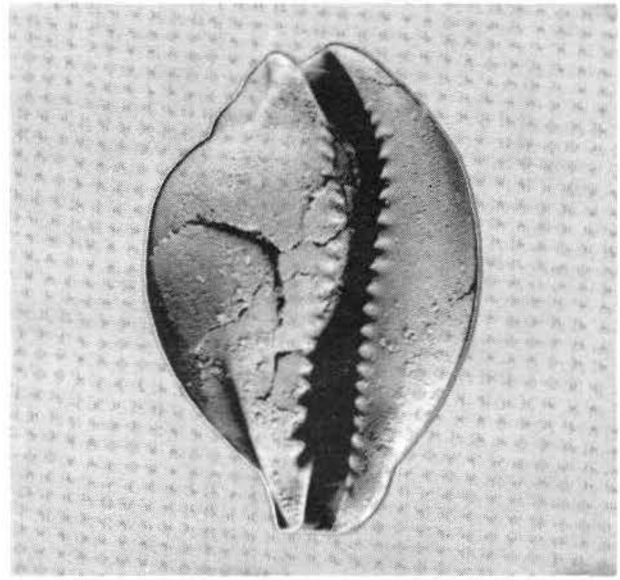

Figure 3. *Bernaya* (s.l.) new species (Mesogastropoda: Cypraeidae, x4). The specimen illustrated is the first Cretaceous cypraeid reported from the upper reaches of the Mississippi Embayment and probably the only Mesozoic cypraeid with the original shell material preserved. Luc Dolin recommended the generic placement for this species.

NEW PUBLICATION BY THE BUREAU OF GEOLOGY

TISHOMINGO COUNTY GEOLOGY AND MINERAL RESOURCES

The Bureau of Geology announces the publication of Bulletin 127, "Tishomingo County Geology and Mineral Resources," by Robert K. Merrill and others.

This publication describes the stratigraphy, water resources, and economic geology of Mississippi's northeasternmost county. Tishomingo County is unique in Mississippi in that it contains the only exposures of Paleozoic rocks, which are much older than the rocks elsewhere in Mississippi. The report brings our 60-year-old stratigraphic terminology for these rocks into line with regional usage. The introductory pages summarize Tishomingo County's geography, history, physiography, topography, drainage, and the geology of two scenic state parks. Then follow descriptions of the geologic units found at the surface in the county and sections on structural geology and economic geology. Other reports in the bulletin are "Mineralogy and Petrography of Selected Tishomingo County Formations" by Dr. Delbert E. Gann and "Water Resources of Tishomingo County" by Stephen P. Jennings.

Bulletin 127 may be purchased from the Bureau of Geology at 2525 North West Street, Jackson, for $12.00 per copy. Mail orders will be accepted when accompanied by payment ($12.00, plus $1.50 postage and handling).

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Editors: Michael B. E. Bograd and David Dockery

A HISTORY OF THE STATE GEOLOGICAL SURVEYS

The Association of American State Geologists has published a 500 page volume entitled "The State Geological Surveys - A History." Edited by retired Pennsylvania State Geologist Arthur A. Socolow, the hard-covered book contains the history, organization, and functions of each of the 50 State Geological Surveys in individual chapters prepared by the respective Surveys. Michael Bograd of the Bureau of Geology contributed the chapter on Mississippi.

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