PETROLOGY OF CRETACEOUS TO QUATERNARY GRAVELS FROM THE WESTERN VALLEY OF THE TENNESSEE RIVER

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ABSTRACT—Textural and compositional data from gravels in the Western Valley of the Tennessee River show that Cretaceous gravels can be distinguished from Pliocene-Quaternary gravels. Cretaceous gravels are coarse grained, angular, and dominated by white (Camden) chert. All of the younger gravels are dominated by honey-colored (Ft. Payne) chert. The Pliocene "Lafayette" gravels of Henry County were coarser and contained more cobbles and less white (Camden) chert than Tennessee River terraces in Hardin and McNairy Counties, suggesting that the two were deposited in different drainage basins.

A petrologic study was conducted on fluvial Cretaceous to Quaternary gravels in the Western Valley of the Tennessee River (Fig. 1). The goal was to determine the temporal and spatial relationship between deposits in order to help delineate paleo-drainage patterns in West Tennessee. The Tennessee River makes a sharp turn south of Pickwick, Tennessee, and changes from a westward flowing stream to northward flowing stream, an anomalous direction in the Mississippi Embayment-Gulf Coast. Therefore, evidence for the Tertiary-Quaternary course of the Tennessee River would be significant.

Gravel deposits studied include the following: 1) The Cretaceous Tuscaloosa gravels of the Western Highland Rim; 2) The Pliocene (?) "Lafayette" gravels (Potter, 1955) or Continental deposits (Olive, 1980) of Henry County in Northwest Tennessee; and 3) Tennessee River Terraces, of undetermined age, that underlie Hardin, McNairy and Southern Decatur counties in Southwest Tennessee (Fig. 1).

Both the "Lafayette" and the Tennessee terraces are labeled Qft on the state geologic map (Miller, et al., 1966). However, a gap of approximately 100 miles exists between the outcrops of the Lafayette in Henry County and the terraces in Southern Decatur County, so the Lafayette and Tennessee terraces may or may not be related.

METHODS

Field Description—The Tuscaloosa outcrops in eastern Hardin and in Wayne Counties (Fig. 1) and in remnants scattered across the Western Highland Rim where much of it has been removed by erosion. Marcher and Stearns (1962) divide the Tuscaloosa into a quartzose eastern facies, found in central Tennessee, and a cherty western facies. This cherty western facies outcrops along the western sections of the Western Highland Rim and is the subject of this paper. It is dominated by white chert, probably derived from the Devonian Camden chert, which outcrops northwest of the main Tuscaloosa outcrop areas (Fig. 1). The Tuscaloosa gravels are thought to be derived from the Pascola Arch area, and transported southeastward by streams. It is considered to be coalescing valley fill deposit (Marcher and Stearns, 1962). Bedding is massive with minor crossbedding. Some iron staining is present, but few if any pebbles are iron coated. The outcrops often have a "bleached" look due to the white chert.

The younger gravels are massive to weakly crossbedded, and lenticular. Pebbles are iron coated, and in some cases, lenses and beds are cemented by iron to form conglomerates. Scoured surfaces and channels are present. Some gravels are imbricated and a few are graded. Sand lenses are common, and are highly crossbedded with both trough and tabular crossbeds present. Contacts between sands and gravels are sharp. Most pebbles are honey-colored chert derived from the Ft. Payne formation of the Western Highland Rim with secondary amounts (4–15%) of crystalline quartz, igneous, metamorphic, sandstone, and limestone rock fragments probably derived from the crystalline Appalachians or Valley and Ridge Providences. Some limestones may be locally derived from the Western Highland Rim. Appalachian components may have been recycled through Pennsylvanian and Tertiary-Cretaceous rocks (Potter, 1955; Olive, 1980).

The "Lafayette" gravels, extensively studied by Potter (1955), form deposits in Northwest Tennessee, the Jackson Purchase area of Western Kentucky and in Southern Illinois. Potter (1955) considers them to be the remains of a series of coalescing alluvial fan deposits from the ancestral Tennessee, Cumberland, and Mississippi Rivers. Olive (1980) designated these as "Continental deposits" that formed one large Pliocene fan from the Tennessee River, part of which has been reworked into a second Pleistocene fan.

Tennessee River terrace gravels are located in Hardin, McNairy, and southern Decatur counties in Southwestern Tennessee. Several terraces have been described at different elevations (Russell and Parks, 1975; Self, 1997, 2000). Each terrace consists of a basal gravel that grades upward into a sand (Russell and Parks, 1975; Russell 1979). Age has not been determined. These terraces are found just north of the abrupt change in the course of the Tennessee River from west to north and are therefore critically located for interpreting the paleo-geography of West Tennessee.

Laboratory Studies—Twenty-five gravel samples, 21 from

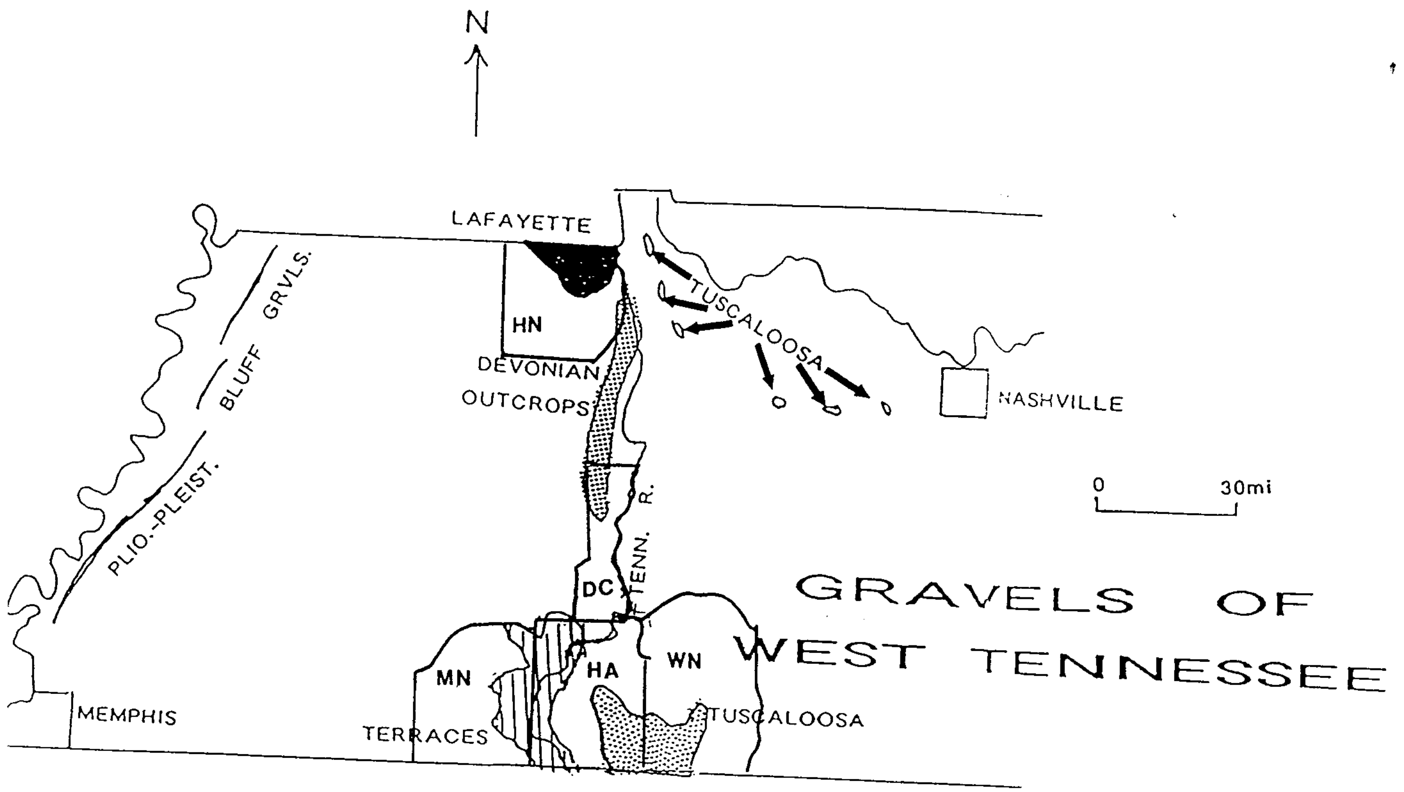

FIG. 1. Map indicating the location and source of West Tennessee gravels from Decatur County (DC), Hardin County (HA), Henry County (HN), McNairy County (MN), and Wayne County (WN).

the terraces and 2 each from the "Lafayette" and the Tuscaloosa, were sieved using standard techniques (Folk, 1968). Measurements were made in Phi (ϕ) units:

$$\phi \text{ size} = -\log_2 \text{mm}$$

where mm is the diameter of the grain in millimeters. Both ϕ units and their millimeter equivalents are reported in this study.

Textural parameters were calculated using standard techniques developed by Folk (1968) for the gravel fraction. These are: 1) Mean grain size which is the best measure of average grain size, and indicates overall distance of transport and/or stream energy and competence; 2) Inclusive graphic standard deviation which measures the degree of sorting in the deposit and indicates the rate of sedimentation, amount of reworking and distance of transport; 3) Inclusive graphic skewness which indicates and excess of coarse (−) or fine (+) grains in a deposit relative to a normal distribution. Lag deposits may have a negative skewness and winnowed deposits a positive skewness; Percent gravel by weight was determined to ascertain overall energy of deposition and the rate in which stream competency is lost during deposition; 5) Percent of gravel coarser than −4.60 (25 mm) in order to determine the maximum sized grains the stream could carry and the distance of transport.

The percentages of chert, crystalline quartz, and quartzite, and rock fragments were calculated. A ratio of honey-colored to white chert for the −2.0 ϕ (4 mm) and −1.0 ϕ (2 mm) were determined. Comparisons of honey-colored and white chert are important because the honey-colored chert matches chert from the nearby Mississippian Ft. Payne bedrock in the Western Highland Rim whereas the white chert matches the Devonian Camden found both in bedrock in the Western Tennessee Valley north of the terraces and in the Tuscaloosa gravels in the nearby Western Highland Rim. Chert is generally coarser and more angular than

TABLE 1. Average textural and compositional values in west Tennessee gravel.

Unit	Tuscaloosa	"Lafayette"	Tennessee River Terraces
Mean Grain Size	−4.46 ϕ (24 mm)	−4.02 ϕ (16 mm)	−3.64 ϕ (12.5 mm)
Stand Dev.	1.09 ϕ (0.47 m)	1.09 ϕ (0.47 m)	1.06 ϕ (0.47 m)
Honey:White Chert			
−2.0 ϕ (4 mm)	2:98	62:38[1]	78:22
−1.0 ϕ (2 mm)	3:97	81:19	62:38

[1] Contained one anomaly high white chert content in one sample.

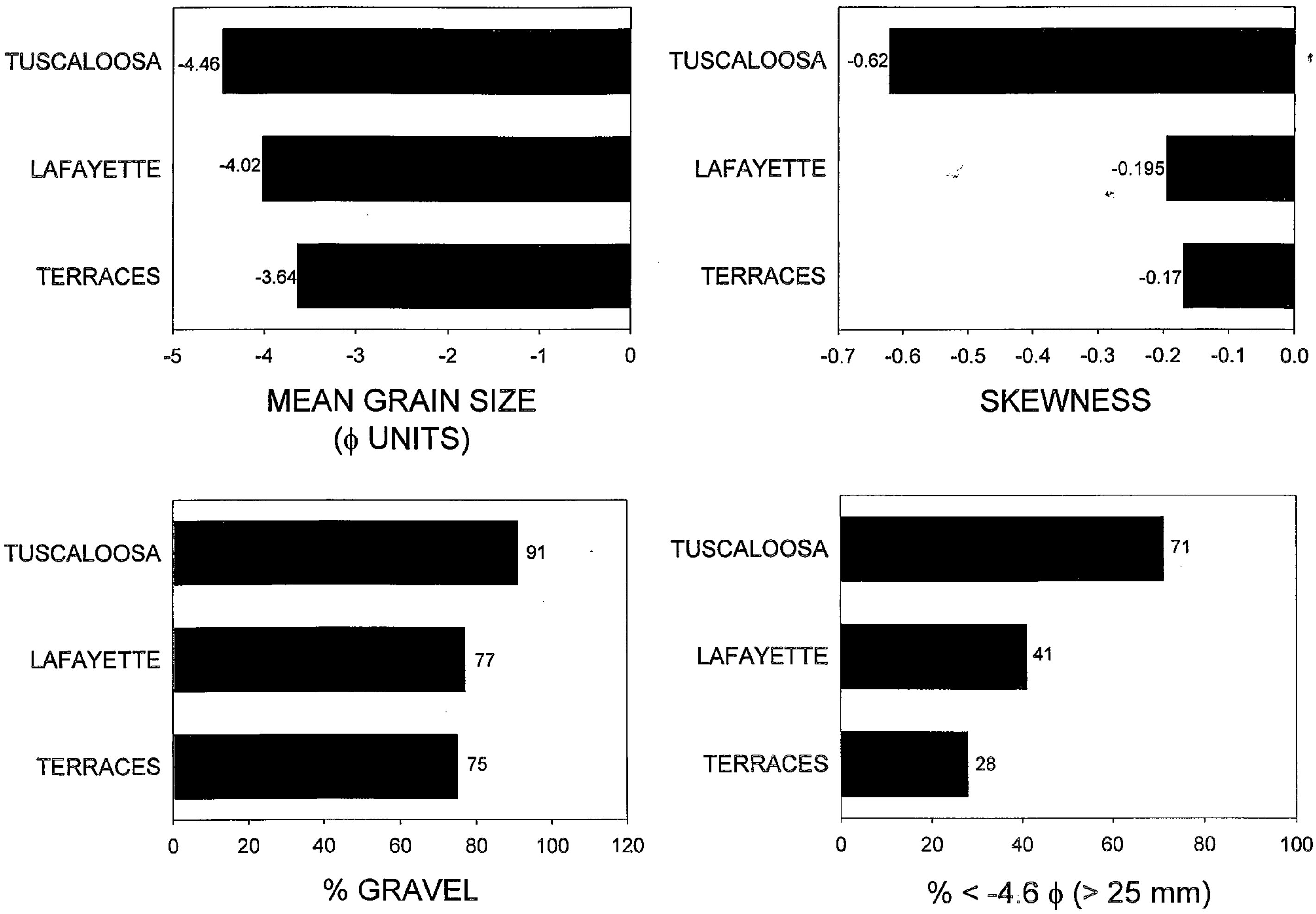

FIG. 2. Comparison of textural data obtained from Cretaceous Tuscaloosa, Pliocene "Lafayette", and Tennessee River Terrace gravels in Tennessee. ϕ size = —$\log_2$ mm.

quartz, and quartz and quartzite are thought to be derived from the Appalachians.

RESULTS

Laboratory results are reported in Table 1 and Fig. 2 and 3. All gravels have mean grain sizes in the medium pebble range ($-3.0\ \phi$ to $-4.5\ \phi$; 8.0–2.45 mm) are moderately to poorly sorted (standard deviation = $0.9\ \phi$ to $1.3\ \phi$; 0.5–0.42 mm), negatively skewed (-0.040 to -0.62) and are dominated by chert (74–87%). Chert is generally coarser and more angular than quartz.

The data suggest rapid deposition from high competence streams with relative short distance of transport for the coarser chert and longer transport for the finer quartz. The deposits are lag deposits and finer components (sand, silt, etc.) have been moved further downstream. These characteristics are consistent with stream/alluvial fan depositional environments for the "Lafayette" and terrace gravels as proposed by Potter (1955), Olive (1980) and Self (1996, 2000).

Tuscaloosa gravels are easily distinguished from the younger gravels by their coarse grain size ($-4.46\ \phi$; 24 mm) greater angularity and the overwhelming dominance of white chert. (Table 1, Fig. 2). The data confirms Marcher and Stearns' (1962) conclusion that the Tuscaloosa was derived from the Pascola Arch, to the northwest of the study area in Southeast Missouri and Northwest Tennessee. The Tuscaloosa gravels contain very little Appalachian derived material. The white chert in the younger gravels is thought to be recycled through the Tuscaloosa.

Although the "Lafayette" and terrace gravels appear similar to each other, the "Lafayette" is coarser, contains higher percentage of gravels coarser than $-4.6\ \phi$ (25 mm) and has higher honey-colored to white chert ratios than gravel in the terraces. Large angular sandstone boulders, some over six feet in diameter, and slabs of soft burrowed clay are found in the "Lafayette" (Self and Gibson, 1993; Gibson and Self, 1993). The latter suggests very short distance of transport, and input from immediately adjacent sources.

The Tennessee terrace deposits contain greater amounts of white chert indicating greater contributions from recycled Tuscaloosa of the Highland Rim than the "Lafayette".

DISCUSSION

The Tuscaloosa provided recycled white chert for the terraces gravels and lesser amounts for the "Lafayette". Camden bedrock crops out in the Tennessee River Valley between the "Lafayette" and the terraces and would most likely contribute sig-

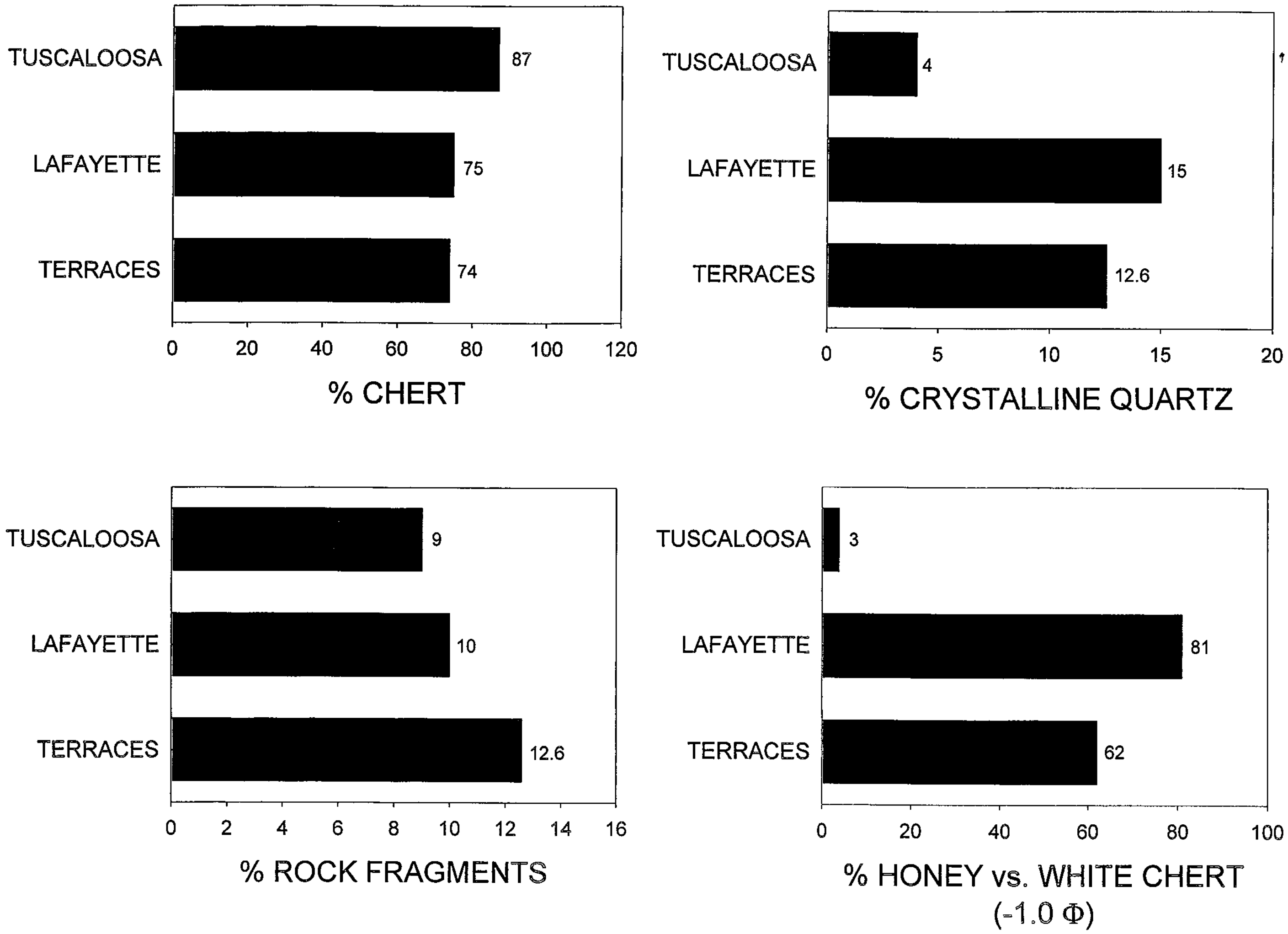

FIG. 3. Comparison of compositional data obtained from Cretaceous Tuscaloosa, Pliocene "Lafayette", and Tennessee River Terrace gravels in Tennessee.

nificant amounts of white chert to the "Lafayette" if the "Lafayette" drainage system extended south of Henry County, or if the Tennessee River flowed northward into Henry County. The coarse nature of the "Lafayette" as well as the presence of boulders and clay clasts suggests shorter transport and possibly a smaller basin. This leads the author to believe the "Lafayette" and the Tennessee River terraces were deposited in separate drainage basins.

Although the age of the terrace gravels is uncertain, it appears that the "Lafayette" gravels in Henry County were deposited before the Tennessee River assumed its present course. This is consistent with several authors (Brown, 1967; Kay, 1974; Isphording, 1983; Self, 1996) who have suggested that the ancestral Tennessee River flowed southward or westward from the Pickwick area.

CONCLUSIONS

Conclusions derived from this study include the following: 1) White Camden chert was originally derived from the Devonian Camden formation to the northwest of the terraces and was recycled through the Tuscaloosa formation of the Highland Rim into younger gravel deposits; 2) Textural data is consistent with an alluvial fan/braided stream deposit for the "Lafayette" and terraces gravels; 3) The Tuscaloosa contributed more white chert to the terraces than to the "Lafayette"; 4) The Lafayette was deposited in a drainage basin that did not extend south of its present outcrop area and was not connected to the Tennessee River system; and 5) The Lafayette was deposited from the Tennessee River assumed its present course.

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