STATE OF TENNESSEE
DEPARTMENT OF CONSERVATION AND COMMERCE

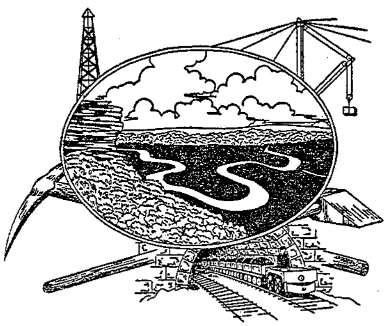
DIVISION OF GEOLOGY

REPORT OF INVESTIGATIONS No. 16

GEOLOGY OF THE DOVER AREA, STEWART COUNTY, TENNESSEE

By

MELVIN V. MARCHER



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GEOLOGY OF THE DOVER AREA, STEWART COUNTY, TENNESSEE

By

MELVIN V. MARCHER [1]

ABSTRACT

The Dover area includes about 300 square miles in Stewart County in the northwestern corner of the Highland Rim Plateau. Most of the area consists of heavily forested and thoroughly dissected hills. Formations that crop out within the area range in age from Devonian to Quaternary, but only rocks of Mississippian age were studied in detail.

The formations of Devonian age are Camden Chert, Pegram Limestone, and Chattanooga Shale. Outcrops of the Camden Chert and Pegram Limestone are limited to a small anticlinal fold in the southwestern part of the area. Chattanooga Shale is exposed on the crest and flanks of the anticline and on the upthrown side of the Piney Creek fault about 3 miles northeast of the anticline.

Formations of Mississippian age are the Maury Formation, New Providence Shale, Fort Payne Chert, and Warsaw, St. Louis, and Ste. Genevieve Limestones. The Maury Formation, which is exposed only near the east end of Scott Fitzhugh Bridge, consists of about 10 inches of mudstone containing abundant rounded phosphatic nodules. The New Providence Shale is a gray or greenish calcareous shale or mudstone as much as 69 feet thick. Outcrops of the New Providence are limited to the vicinity of the small anticline in the southwestern part of the area. The Fort Payne Chert is widely exposed in the western part of the area, where bluffs along Kentucky Lake provide sections as much as 150 feet thick. The thickness of the Fort Payne ranges from about 240 feet to possibly as much as 500 feet in the northern part of the area. The Fort Payne consists of bedded chert intercalated with highly siliceous and silty limestone or very rough platy and granular chert in a siliceous and silty limestone matrix. Locally the formation contains beds of cherty fossil-fragmental calcarenite. The Warsaw Limestone, which is at least 200 feet thick in the central part of the area, is a light-colored, medium- to coarse-grained, massive, fossil-fragmental calcarenite. Crossbedding commonly is well developed, particularly in the more massive beds. Minor rock types in the Warsaw are silty dolomitic limestone and coquinite. The St. Louis Limestone is similar to the Warsaw but is generally finer grained, darker colored, more argillaceous, and contains much more chert. Foraminiferal limestone and shaly limestone are prominent locally. The St. Louis is at least 250 feet thick in the northeastern part of the area. Only three isolated outcrops of Ste. Genevieve

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Limestone are known in the Dover area, and in each of these the rock is an oolite which contains irregular patches of medium- to coarse-grained calcarenite.

Rocks of Cretaceous age, which include the Tuscaloosa Gravel and the Coffee Sand, are limited largely to the northwestern part of the area, where they cap most of the higher ridges. The Tuscaloosa is as much as 30 feet thick and consists of unsorted chert gravel 1 inch to 8 inches in diameter in a sandy clay matrix. The Coffee is about 20 feet thick and is medium to coarse reddish sand which contains small blobs and stringers of white kaolinitic clay.

The Tertiary System is represented by a single formation, the Lafayette Gravel (of former usage), which consists of well-rounded, iron-stained particles of chert and quartz about 1 inch in diameter in a clayey sand matrix. The maximum thickness of the gravel is about 25 feet.

Alluvium of Quaternary age probably is as much as 75 feet thick along the Cumberland River, where it consists of unsorted gravel, sand, silt, and clay.

The Dover area lies on the southwest flank of the Tennessee lobe of the Illinois basin. Regional dip is northeast in the southern part of the area but progressively changes to east in the northwestern part. The central part of the area is traversed by a broad east-west trending syncline. Another syncline of lesser magnitude, also trending east-west, occupies the north-central part of the area. Most of the minor folds within the area appear to be closely related to faults. With the exception of the Hayes Fork Creek fault, which strikes about N. 70°W., the faults in the Dover area trend northeast. All faults are normal and most are downthrown on the north side. Displacements along the faults range from 100 to probably as much as 350 feet.

INTRODUCTION

Purpose and Scope of the Investigation

Most of the Western Highland Rim is underlain by dominantly calcareous rocks of Mississippian age, whose stratigraphy and structure play a major role in the occurrence and movement of ground water and the location of other mineral resources of the area. An effective appraisal of mineral deposits and ground-water conditions and the identification of areas suitable for development of these resources can be accomplished only through comprehensive geologic studies. In order to provide the basic geologic knowledge essential to such investigations, the Dover area, because of its more complete and well-exposed sequence of Mississippian rocks, was selected for detailed stratigraphic study as the first step in an appraisal of the water and mineral resources of the entire Highland Rim province in Tennessee. Although general information on the water and mineral resources of the area was collected during the course of field work, that information is not included in this report.

The objective of this study was principally to clarify the details of Mississippian stratigraphy in the northwestern part of the Highland Rim. Detailed geologic mapping was done only in parts of the area where bedrock exposures offered adequate control. This limited scope therefore precluded the overall detailed study required for precise geologic mapping in areas that are blanketed by residuum or where formation outcrops are sparse in dense forests. Under such conditions geologic contacts and structural features are shown on the basis of known formation thicknesses and stratigraphic and structural relationships in surrounding areas. The geologic map is considered to be sufficiently accurate for general purposes, however.

This investigation was made by the U. S. Geological Survey as a part of the program of geologic studies in cooperation with the Tennessee Division of Geology. Field work was done intermittently between 1956 and 1960 as a part of the overall geologic and hydrologic studies of the Highland Rim in cooperation with the Tennessee Division of Geology and Tennessee Division of Water Resources.

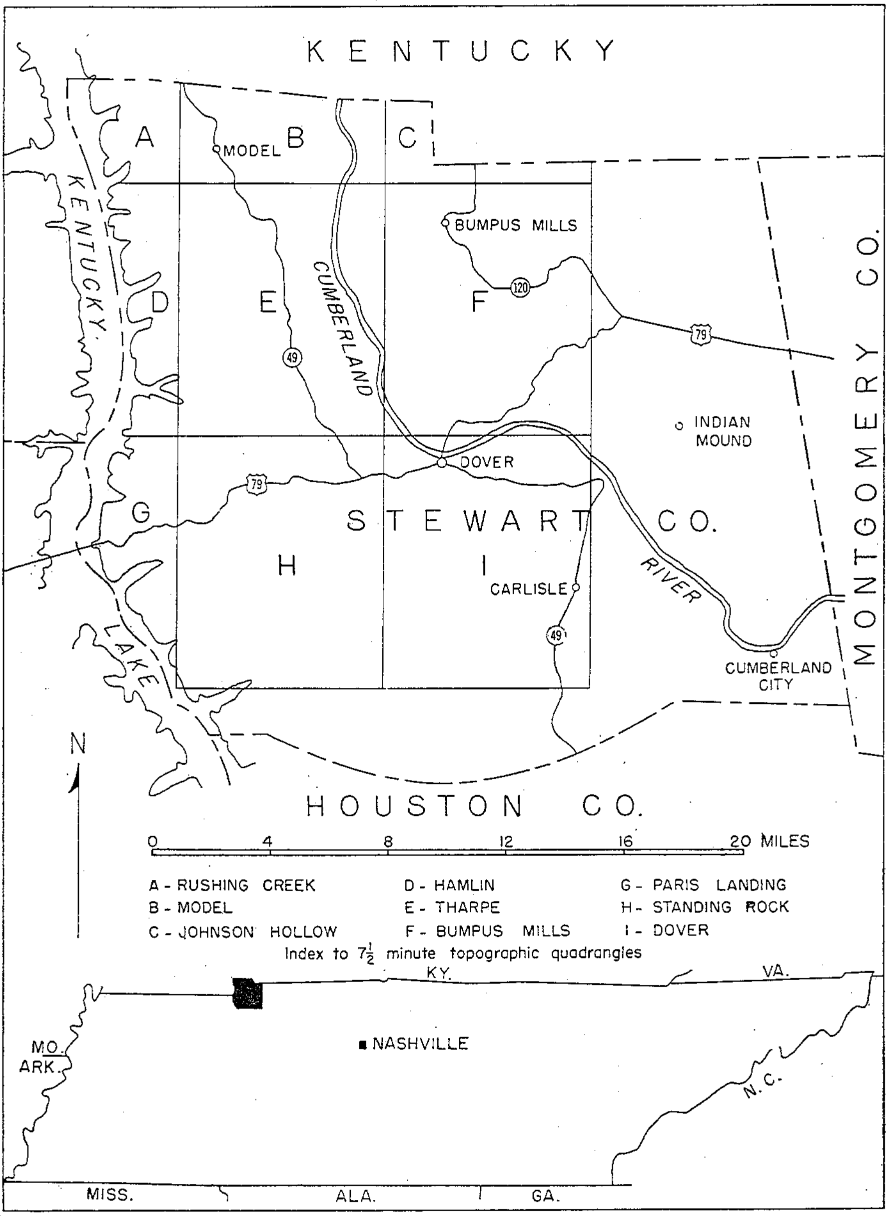


Figure 1. Index map showing location of the Dover area.

Location and General Features of the Area

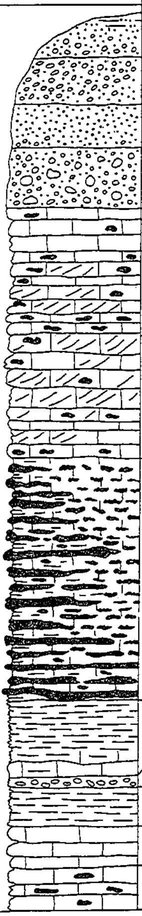
The Dover area, as described in this report, includes about 300 square miles in the western two-thirds of Stewart County in north-central Tennessee (fig. 1). It extends from latitude 36°22′30″S. to the Tennessee-Kentucky boundary on the north and from longitude 87°45′W. to Kentucky Lake (Tennessee River) on the west. The area includes all the Tharpe, Bumpus Mills, Standing Rock, and Dover 7½-minute quadrangles and parts of the Rushing Creek, Model, Johnson Hollow, Hamlin, and Paris Landing 7½-minute quadrangles (fig. 1).

The town of Dover (population 736 in 1960) is on the south bank of the Cumberland River, in the east-central part of this sparsely settled and densely forested area. It is the business center and seat of government for Stewart County; access to surrounding regions is via U. S. Highway 79 and State Highway 49 (fig. 1).

The Dover area is in the northwestern corner of the Highland Rim Plateau, where the local relief is as much as 250 feet and the maximum relief is slightly more than 450 feet. Tennessee Ridge (pl. 1), a continuous highland which crosses the area from northwest to southeast, forms the drainage divide between the Cumberland and Tennessee Rivers. Other narrow and sinuous ridges divide the area into a number of lesser drainage basins. The summits of these ridges generally are accordant and are remnants of the Highland Rim plain. The valley of the Cumberland River, trenched about 250 feet below the general level of the upland, trends northwesterly across the area.

Previous Investigations

The first significant study of rocks of Mississippian age in the Western Highland Rim was made by J. M. Safford in 1851. Detailed information on these rocks is given by Safford in his "Geology of Tennessee" (1869). From 1869 little work was done until the Columbia quadrangle, covering the east-central part of the Western Highland Rim, was studied by Hayes and Ulrich (1903). The geology of Wayne County and parts of adjacent counties in the southwestern part of the Rim was described by Drake (1914) and in more detail by Miser (1921). In 1914 the geology of Perry County and vicinity, in the west-central part of the Rim, was reported on by Wade. Jewell (1931) described the geology of Hardin County in the extreme southwestern corner of the Rim. Bassler's



AGE	THICKNESS	FORMATION	GENERAL DESCRIPTION
QUATERNARY	75′	Alluvium	Unsorted gravel, sand, silt, and clay.
TERTIARY	25′	Lafayette Gravel (of former usage)	Chert and quartz gravel, well rounded, iron-stained, crossbedded, in an iron-stained sand matrix.
CRETACEOUS	20′	Coffee Sand	Quartz sand, reddish, fine to medium, locally crossbedded, contains stringers of kaolinitic clay.
	30′	Tuscaloosa Gravel	Chert gravel, well rounded, unsorted, in a clayey sand matrix.
MISSISSIPPIAN	?	Ste. Genevieve Limestone	Limestone, yellowish-gray, medium-grained, oolitic.
	250′ ±	St. Louis Limestone	Limestone, pale- to dusky yellowish-brown, fine- to coarse-grained, fossil-fragmental, argillaceous, locally crossbedded and cherty.
	200′ +	Warsaw Limestone	Limestone, yellowish-gray, medium- to very coarse-grained, fossil fragmental, massive, crossbedded, locally cherty.
	445′	Fort Payne Chert	Bedded chert, brownish-black to dusky-brown, layers 6 to 10 inches thick, interbedded with highly siliceous, silty and shaly limestone; grades laterally into very rough and irregular platy or granular chert in an olive-gray silty, siliceous limestone matrix.
	69′	New Providence Shale	Clay shale, greenish-gray, sparsely glauconitic; phosphatic nodules and beds of crinoidal limestone are present locally.
	10″	Maury Formation	Mudstone, light olive-gray, abundant phosphatic nodules.
DEVONIAN	14′	Chattanooga Shale	Shale, brownish-black, fissile, carbonaceous.
	5′	Pegram Limestone	Limestone, gray, fine- to coarse-grained arenaceous, silty.
	14′	Camden Chert	Limestone, bluish-gray, fine- to medium-grained, argillaceous, cherty.

FIGURE 2. Composite geologic column of rocks cropping out in the Dover area.

study of the Central Basin in Tennessee (1932) included information on Mississippian rocks of the Highland Rim Plateau. General information was given by Burchard (1934) in a report on the iron ores of the region and by Piper (1932) and Theis (1936) in reports on the ground-water resources of central Tennessee.

ACKNOWLEDGMENTS

The writer is indebted to R. G. Stearns, Assistant State Geologist, Tennessee Division of Geology, for advice and assistance from the beginning of this investigation to a final critical reading of the manuscript. The writer also is grateful to J. M. Kellberg, Geologist, Tennessee Valley Authority, for corehole data from proposed steam plant sites. E. E. Russell, Mississippi State University, assisted in mapping Cretaceous rocks in the northwestern part of the area, and C. W. Wilson, Jr., Vanderbilt University, also provided helpful assistance and advice. The report was edited for publication by R. J. Floyd, Principal Geologist, Tennessee Division of Geology, and his efforts are gratefully acknowledged.

STRATIGRAPHY

Sedimentary rocks that crop out in the Dover area range in age from Devonian to Quaternary (fig. 2), but only rocks of Mississippian age were studied in detail. Considerable attention was given to the Tuscaloosa Gravel of Cretaceous age because of its importance in interpreting the geologic and physiographic history of the area.

Except for the New Providence Shale, each Mississippian formation in the Western Highland Rim contains distinctive and characteristic varieties of chert. Residual chert fragments left upon weathering of the enclosing limestone provide a basis for mapping contacts in areas where bedrock exposures are scarce or nonexistent. Some intermediate varieties of chert are difficult to identify with certainty, and mixing of chert types is common near formational boundaries. Slumping of the residuum also adds to the difficulty of mapping, but in most parts of the area residuum contacts can be corroborated by scattered bedrock outcrops.

In the area between Kentucky Lake and the Tennessee-Cumberland divide the map can be considered only a reasoned approximation. In this area, where outcrops are present only along the shore of the lake, deep weathering, slumping, and mixing of the residuum have obscured the geologic features.

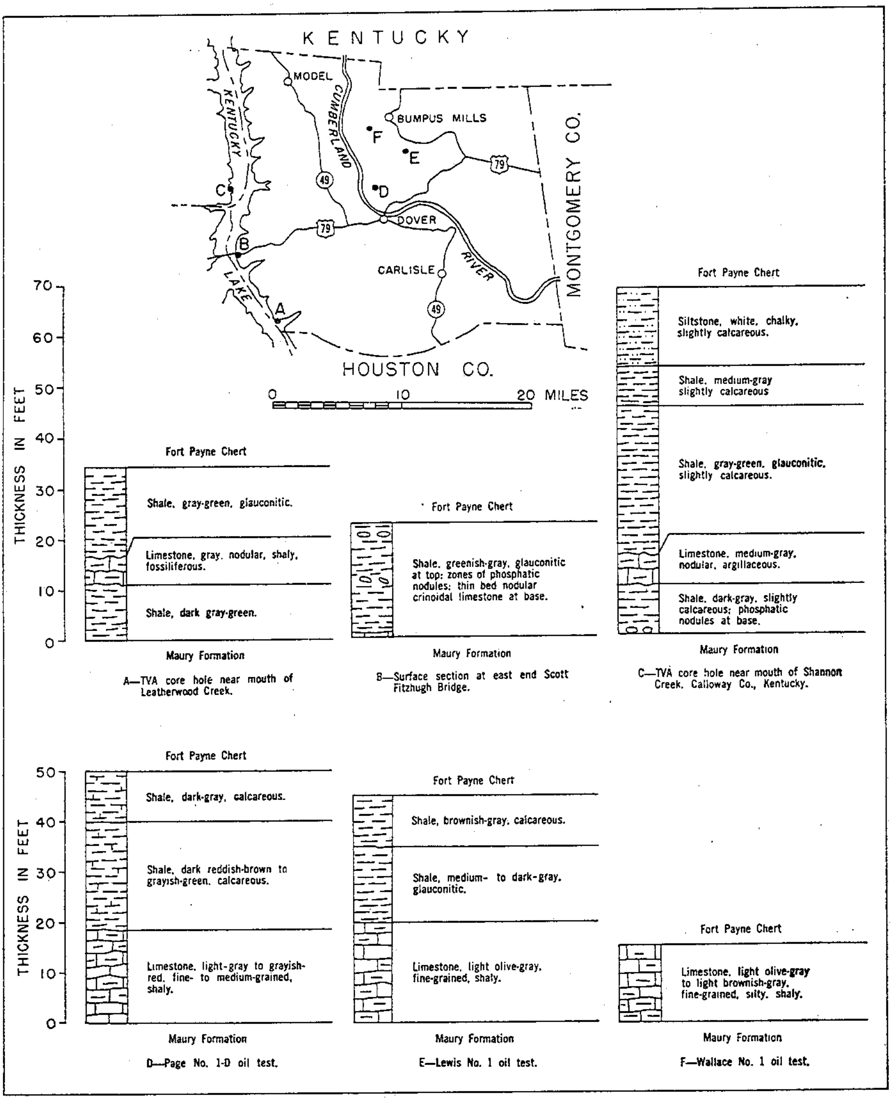


FIGURE 3. Representative sections of the New Providence Shale.

Devonian System

Rocks of Devonian age are exposed only along Kentucky Lake in the vicinity of Scott Fitzhugh Bridge (pl. 1), where they have been brought to the surface by upward folding of the rocks. The Camden Chert and the overlying Pegram Limestone here have been measured and described by Wilson (1949, p. 310-311, fig. 89). The Pegram Limestone is overlain by Chattanooga Shale. The Gassaway Member (Hass, 1956, p. 20) appears to be the only unit of the Chattanooga Shale in the area.

Mississippian System

Maury Formation

Definition.—Originally, the beds between the Chattanooga Shale and the Tullahoma Formation of Safford and Killebrew were called the Maury green shale (Safford and Killebrew, 1900, p. 104). These beds, now referred to as the Maury Formation (Hass, 1956, p. 23), include the strata overlying the Chattanooga Shale and underlying the New Providence Shale, or the Fort Payne Chert if the New Providence is absent.

Distribution and thickness.—The Maury Formation is known to crop out only on the south side of U. S. Highway 79 at the east end of Scott Fitzhugh Bridge, where it is about 10 inches thick. It may be present but covered on the crest and south flank of the anticline just south of Scott Fitzhugh Bridge and along the fault that cuts across South Fork Piney Creek (pl. 1). A core taken by the Tennessee Valley Authority from near the mouth of Shannon Creek, just west of Kentucky Lake in Calloway County, Kentucky (fig. 3), has a layer of phosphatic nodules at the base of the New Providence Shale which may represent the Maury Formation. Elsewhere within the area the formation may be in the subsurface, but is not recognizable in well cuttings because of its thinness and similarity to the overlying New Providence Shale.

Lithology.—At the east end of Scott Fitzhugh Bridge the Maury Formation is a light olive-gray to yellow-gray mudstone which contains many phosphatic nodules. Most of the nodules are somewhat flattened and have a maximum diameter of 3 or 4 inches. The weathered surface of the nodules, which are rather hard and tough, is usually yellowish-gray but the interior is much darker. Some nodules contain a few small cubes and irregular grains of pyrite. The rock is fairly well indurated and no bedding is discernible.

Stratigraphic relationships.—The contact of the Maury with the underlying Chattanooga Shale is sharp and probably represents an unconformity. At Scott Fitzhugh Bridge the basal bed of the overlying New Providence is limestone and the contact is distinct. Elsewhere in the Rim, where the limestone is higher in the section or is missing, the Maury Formation grades upward into the New Providence Shale and the two units appear to be conformable.

New Providence Shale

Definition.—The rocks between the Maury Formation and the St. Louis Limestone originally were included in the Tullahoma Formation of Safford and Killebrew (1900, p. 104). Bassler (1912, p. 212) discarded Tullahoma in favor of Fort Payne, the lower part of which he subdivided into the New Providence and Ridgetop Shales. Faunal and stratigraphic studies by Wilson and Spain (1936, p. 805-809), however, showed the Ridgetop to be a phase of the New Providence.

Distribution and thickness.—The New Providence Shale is in the subsurface throughout most, if not all, of Stewart County, but it crops out only along the flanks of the anticline south of Scott Fitzhugh Bridge and at the mouth of Mint Spring Hollow. On the north flank of the anticline the formation is 23 feet thick, but toward the north it thickens gradually and in a corehole drilled by the Tennessee Valley Authority near the mouth of Shannon Creek, just west of the map area, it is 69 feet thick (fig. 3). Because of its restricted area of outcrop and thinness, the New Providence is not shown separately on the geologic map but is included with the Fort Payne Chert.

Lithology.—At the outcrop around the edges of the Tennessee lobe of the Illinois basin, the New Providence is medium-gray to gray-green, calcareous clay shale, but farther out in the basin it is dark-gray silty shale or mudstone (fig. 3). Glauconite is scattered through the formation. A layer of nodules similar to those in the Maury Formation is near the top of the formation near Scott Fitzhugh Bridge. Cuttings from several oil test holes in the north-central part of the area show a layer of light olive-gray to medium-gray, fine-grained silty to shaly limestone, ranging from 5 to 20 feet in thickness, at or near the base of the formation (fig. 3). Near

Scott Fitzhugh Bridge this limestone is nodular, pale reddish-brown, highly silty, and contains an abundance of crinoid fragments.

Stratigraphic relationships.—The New Providence Shale generally is conformably underlain by the Maury Formation.

The marked lithologic difference between the New Providence and the overlying Fort Payne Chert near Scott Fitzhugh Bridge suggests the two formations are unconformable. Additional evidence of a local unconformity is a layer of greenish-black glauconitic and phosphatic shale which may be the residual product of weathering at the top of the formation. An electrical log of a corehole near the mouth of Shannon Creek just west of the map area shows an abrupt lithologic change between the New Providence and the Fort Payne, but the core does not reveal any other evidence of an unconformity. Electrical logs and cuttings from the Wallace No. 1 and the Lewis No. 1 oil tests in the north-central part of the area show that the Fort Payne becomes finer grained and less siliceous with depth, grading into the underlying New Providence.

Fort Payne Chert

Definition.—As previously stated, Bassler (1912, p. 212) renamed the Tullahoma Formation of Safford and Killebrew the Fort Payne Chert, which he restricted at the base by placing the lower shaly beds in the New Providence and Ridgetop Shales. Safford and Killebrew included some beds of the overlying Warsaw in the Fort Payne, but most workers (Hayes and Ulrich, 1903; Drake, 1914; Wade, 1914; and Jewell, 1931) excluded these beds, and the Fort Payne or Tullahoma as used by them corresponds approximately to its present definition. The upper boundary was defined by Bassler (1932, p. 153) to exclude all Warsaw beds.

Distribution.—The Fort Payne Chert is well exposed at the surface throughout the southwestern quarter of the Dover area, especially along Standing Rock and Leatherwood Creeks (pl. 1). Bluffs along the shores of Kentucky Lake provide very good sections, some as much as 150 feet thick (pl. 2). In the southeastern part of the area good outcrops are exposed along Cross Creek south of the Carlisle fault. The Fort Payne is not exposed east of the Cumberland River except in the bluffs along the Cumberland River between Dover and the Bumpus Mills fault and in the fault block just northwest of Bumpus Mills (pl. 1). Where not exposed the Fort Payne lies at varying depths below the surface and has been penetrated in several oil tests and water wells.

Thickness.—In the north-central part of the area, where the depositional basin was deepest and the formation is thickest, four oil test holes have penetrated the full thickness of the Fort Payne. A study of cuttings from the Lewis No. 1 oil-test well shows that the maximum thickness of the formation is 445 feet. A driller's log of the Moore No. 1 at Tobaccoport gives the thickness of the Fort Payne as 500 feet but this figure probably includes an unknown thickness of New Providence Shale. The thickness of the Fort Payne is 280 feet in the Page No. 1 well about 4 miles north of Dover. The Fort Payne is 234 feet thick at Shannon Creek, just west of the map area, and about 240 feet thick about 4 miles south of the southern boundary of the map. Away from the deeper parts of the basin in Stewart and Montgomery Counties, the average thickness over much of the Western Highland Rim is probably between 200 and 250 feet.

Lithology.—Superficially, the Fort Payne appears to be a monotonous sequence of bedded chert in the northern half of the Western Highland Rim. However, the lithologic characteristics of the rock are variable both laterally and vertically, and two lithofacies can be readily discriminated (Marcher, 1959, p. 1767). For descriptive purposes the lithofacies are herein informally referred to as "bedded" and "scraggy" chert, respectively.

In the map area the bedded chert lithofacies consists of layers of chert 4 inches to 1 foot thick intercalated with layers of highly siliceous limestone or siltstone of similar thickness (pl. 2). Chert makes up 25 to 50 percent of the rock. Small, irregularly shaped siliceous geodes occur locally in both the chert and the limestone, although they are more common in the latter. Megascopically, the limestone is uniformly fine grained except in a few local beds at the top of the formation, which are somewhat coarser grained. In thin section the rock is a microcrystalline mosaic of interlocking calcite and silica particles and, except for a very few grains, crystal boundaries are completely lacking. Although there is considerable range in particle size, recrystallization of the original silica-lime mud has produced a remarkably uniform overall texture. Most of the silica in the limestone is cryptocrystalline, but small amounts of fibrous silica and microcrystalline quartz also are present. Small euhedral grains of pyrite, some partly or completely altered to iron oxide, are sparse and tiny irregularly rounded masses of iron oxide are rather rare.

Upon exposure to weathering the soluble material is leached from the more calcareous layers first, leaving a pale yellowish-brown residue of the relatively insoluble silica. The chert beds are much more resistant to weathering and in many outcrops the limestone has been thoroughly leached to tripolitic material, whereas the chert is relatively unaltered. Where weathering has not been too severe the rock is sufficiently coherent to retain its original structure, and in some outcrops the weathered rock grades laterally into fresh rock with very little change in volume. Local variations in the degree of leaching, however, cause differential slumping and produce small-scale folds and faults. At many localities the chert is leached differentially along certain poorly defined lenslike layers, thus producing a semibanded effect in partly weathered specimens. No significant differences in mineral composition that would account for differential leaching were discerned, but slight differences in the degree of crystallization may be the cause.

The color of the limestone layers is dark, with dusky-brown, dusky yellowish-brown, and brownish-black hues being most common. The dark color is caused largely by an abundance of finely disseminated brown organic material. An analysis by the U. S. Bureau of Mines shows that even highly weathered Fort Payne may contain 1 or 2 percent of organic material. Much of the organic material occurs as very fine flakes embedded in the calcite and silica or as thin films along contacts between the particles. Concentration along grain contacts is probably the result of crystal growth during lithification.

Concentration of calcite and organic material along irregular, discontinuous, but closely-spaced planes give the rock a thinly laminated structure. Where the rock is exposed to weathering the calcite and some of the organic matter breaks down first, giving the rock a shaly or platy appearance.

Chert, which occurs as persistent beds or irregular nodules in the limestone, is nearly everywhere brownish black to olive black. Because of its dense and brittle character the chert fractures along irregular planes, producing angular pieces of all sizes. Under magnification the chert is very fine grained and fairly uniform in texture, much like the limestone. The silica is mostly cryptocrystalline, but small amounts of chalcedonic silica are present. Most of the chalcedonic silica occurs as irregularly-shaped spherulites randomly scattered through the rock. Brownish organic matter and finely disseminated iron oxides are abundant, much more so than in the limestone. Small carbonate rhombs are present but are rare. Small cubes and irregular masses of unaltered pyrite also occur, but most of them have been more or less oxidized.

Along the eastern shore of Kentucky Lake northward from the mouth of Panther Creek, the upper part of the Fort Payne contains beds of fine-grained to very coarse grained fossil-fragmental calcarenite. In texture and color these beds closely resemble some beds in the overlying Warsaw Limestone. Chert is abundant in these beds and is of two types—large, rounded or irregularly shaped masses of dense dark chert typical of the Fort Payne, and highly porous fossiliferous chert identical to that derived from the Warsaw Limestone. This type of chert, which is well developed in many places along the shores of Kentucky Lake, locally is crowded with well-preserved fossils, mainly brachiopods.

Except along the shores of the lake, outcrops of the calcarenite beds in the Fort Payne are extremely scarce, and thus their exact stratigraphic position is not certain. Furthermore, the presence in the Fort Payne of chert similar to that in the Warsaw Limestone makes it difficult to place the Fort Payne-Warsaw boundary with accuracy. In the vicinity of Panther Creek, in the southwestern part of the Tharpe quadrangle, however, these beds apparently are about 50 feet below the base of the Warsaw. Toward the north the beds seem to lower stratigraphically and in the vicinity of Rushing and Ginger Creeks appear to be about 100 feet below the base of the Warsaw.

The best exposures of the scraggy chert lithofacies are along Standing Rock and Leatherwood Creeks in the southwestern part of the area, along Bear Creek in the central part, and on Cross Creek south of Carlisle (pl. 1). The lateral gradation from the more typical bedded chert into the scraggy chert is shown best on the bluffs along the north side of North Fork Leatherwood Creek near its junction with East Fork Leatherwood Creek. This gradational relationship is shown well also on the west side of the Cumberland River just south of the mouth of Bear Creek valley, where the scraggy chert grades both laterally and downward into the bedded chert. Although the total thickness of the scraggy chert is not known, as much as 80 to 100 feet is exposed at several points along Standing Rock Creek.

On a fresh outcrop the scraggy chert generally is quite massive, but as the rock weathers the inherent platy structure is emphasized. Individual plates and nodules of chert are very irregular and discontinuous and have an exceedingly rough surface, hence the term "scraggy." Leaching of the scraggy chert beds removes the carbonate and leaves rough plates of yellowish-brown chert with a porous, spongy texture. Continued weathering removes much of the iron oxide that gives the chert its color and breaks the rock down into weakly coherent tripolitic material with a very pale orange to grayish-orange color.

On the north side of Standing Rock Creek, between Cole Hollow and Terrapin Run, the scraggy chert lithofacies is medium grained, but all other exposures in the Dover area exhibit a fine-grained texture. In thin section the rock consists of patches of chert and siliceous limestone interlocked together in an exceedingly intricate pattern. Chert, in the form of cryptocrystalline silica, makes up 75 percent or more of the rock. Only minor amounts of microcrystalline quartz are present. Except for carbonate rhombs, which locally are abundant in the chert patches, crystal outlines are not discernible. The patches of limestone form a mosaic of very fine recrystallized calcite and cryptocrystalline silica. Accessory minerals such as pyrite and iron oxide are rare or absent.

The light color of the scraggy chert contrasts sharply with that of the darker bedded chert. In general the chert patches are light to very light gray. The limestone patches are slightly darker, giving the rock a mottled appearance. The variation in color of the chert and limestone patches is largely due to the greater abundance of organic material in the limestone.

Stratigraphic relationships.—The Fort Payne and underlying New Providence Shale apparently are conformable, except for a local unconformity on the anticline south of Scott Fitzhugh Bridge. The Fort Payne-Warsaw contact is well exposed near the mouth of North Fork Leatherwood Creek, between Terrapin Run and Cole Hollow on Standing Rock Creek, along both North and South Cross Creeks, and in the bluff on the east side of the Cumberland River a short distance north of the mouth of Mossy Run Creek. At the latter two localities the lithologic change is fairly sharp at the contact, but there is no other evidence of unconformity. On both Standing Rock and Leatherwood Creeks the change from dark, fine-grained, siliceous, cherty limestone of the Fort Payne into the light-colored, medium-grained, noncherty limestone of the Warsaw is gradational, and the two units appear to be conformable. Electrical logs and cuttings from several oil tests also support this conclusion.

WARSAW LIMESTONE

Definition.—Safford (1869, p. 338-348; 1900, p. 143-145; and 1901, p. 11) apparently placed part of the Warsaw in the St. Louis, and part in the Fort Payne. Hayes and Ulrich (1903, p. 3) and Bassler (1912, p. 212) considered it to be part of the St. Louis, although they identified a Warsaw fauna in beds in the lower part. Later workers (Drake, 1914; Wade, 1914; and Miser, 1921) variously included it in either the Fort Payne or St. Louis. Jewell (1931, p. 44-45) described the Warsaw in Hardin County as a separate lithologic unit, but because of its extremely weathered condition he included it with the Fort Payne on his map. Bassler (1932, p. 156-157) was the first to define the Warsaw as a separate unit.

Distribution.—The Warsaw Limestone is well exposed along Cross, Long, and Lick Creeks in the southeastern part of the area, and along Dyers Creek and the Cumberland River in the east-central part (pl. 1). Several quarries on Hickman Creek about 2 miles west of Dover also provide unusually good sections. In much of the southwestern part of the area and northward along the shore of Kentucky Lake, the limestone has been leached away and the Warsaw is represented only by residual chert. The Warsaw generally is covered with St. Louis bedrock and residuum in the northern half of the area.

Thickness.—Of the several oil tests that have been drilled in the area only the Wallace No. 1 starts high enough in the section to penetrate the full thickness of the Warsaw, and in that well the Warsaw is 180 feet thick. In the bluffs along the Cumberland River northeast of Dover and along Hickman Creek west of Dover the Warsaw is at least 200 feet thick.

Lithology.—Medium- to coarse-grained calcarenite consisting of broken and abraded fossil fragments is the dominant lithology of the Warsaw (pl. 2). Subordinate lithologies include fine- to medium-grained calcarenite, dolomitic limestone, and coquinite similar to that described by Moore (1957, p. 119-120) from the Ozark region of Missouri. The medium- to coarse-grained calcarenite consists of sand and granule-sized organic fragments in a finer grained matrix. Crinoid fragments are the most abundant of the identifiable fossil fragments, but bryozoan fragments and pieces of brachiopod shells also are very common. Nearly all the larger grains are more or less abraded. Many large grains show varying degrees of corrosion around the edges, indicating that recrystallization has played an important role in lithification. The fine- to medium-grained matrix is a recrystallized mixture of unsorted fossil detritus and anhedral calcite particles of indeterminate origin. Sorting is essentially nonexistent and only rarely is there any orientation of particles parallel to bedding surfaces. In general, clear secondary calcite is not common, but in a few thin sections large, irregularly corroded organic fragments are surrounded by secondary calcite and appear to be "floating" in it. Many coarse particles, especially bryozoan fragments, are incrusted with microlaminated calcite probably of algal origin.

Beds of fine-grained highly silty and dolomitic limestone occur at or near the top of the formation in the bluffs on the north side of Cumberland River and at a number of other points in the area. In thin section, samples from these beds show a very fine, uniform texture and a complete lack of structure. Bryozoans, oriented parallel to the bedding, are abundant locally. Small siliceous geodes similar to those from some parts of the Fort Payne also are fairly common.

Apparently the environmental conditions controlling textures also influenced the color. In general the coarser calcarenites are medium-gray to pale yellowish-gray. The fine textured beds, including those that are dolomitic, are pale to dark yellowish-brown.

Locally, the upper half of the formation contains discontinuous and irregular beds that are finer grained, darker colored and much more cherty than typical Warsaw calcarenite. Such beds are well-exposed in the quarries on Hickman Creek about 2 miles west of Dover. Like the coarser parts of the formation, the fine-grained, dark-colored beds are made up mainly of broken fossil debris with a few coarse particles, such as crinoid ossicles, irregularly distributed through the rock. Orientation of the finely broken debris gives the rock an irregular, very finely laminated structure, which is emphasized by the concentration of insoluble organic and siliceous material along planes between the microlaminae and in microstylolitic zones.

Coquinite may occur anywhere in the formation but it is most common in the upper half. The coquinite from the Dover area consists primarily of bryozoan fragments and broken brachiopod shells with very little matrix. Orientation of the particles varies but a rudely laminated structure is apparent on etched surfaces. Most particles show little or no abrasion or corrosion but many are incrusted with threadlike algae.

Most, if not all, the chert in the Warsaw is of secondary origin and in part is the result of surface weathering. In its earliest stages of development the chert is no more than a thin crust on the surface of the limestone. As silicification at the interface between the limestone and incrusting chert continues, large masses of vesicular chert that retain the original texture of the rock are developed. In some fine-grained dark-colored limestone beds replacement of both fossil fragments and matrix has altered the texture to a fairly uniform mosaic of cryptocrystalline silica. Replacement of the calcite by silica is selective, with the matrix being replaced first, small fossil particles next, and large fossil particles last. In some places the matrix remains unchanged, whereas some of the large particles have been partly or completely replaced. Of the large fossil particles, bryozoan fragments seem to be least resistant to replacement and crinoid ossicles most resistant; brachiopod shells are intermediate. Although replacement by silica may almost completely destroy the original texture of the rock in the fine-grained limestone beds, delicate organic structures in the coquinite are reproduced faithfully in many places. For example, algal incrustations on some particles have been replaced completely without destroying or blurring the delicate laminae.

Silicification generally stops before the entire rock has been replaced, so that in unweathered but well-developed pieces of chert the matrix and some of the fossil material are partly or completely replaced. The large brachiopod fragments and most of the crinoid ossicles generally remain unaltered. Weathering removes whatever calcite may be left, producing the large blocks of highly porous, fossiliferous chert so characteristic of the Warsaw Limestone.

Few minerals other than calcite and, in partly weathered outcrops, quartz, have been observed in the limestone. Fine organic and clayey material is present in some of the darker and finer grained beds. Glauconite, pyrite, and iron oxide have been noted in a few thin sections. A few well-rounded sand-sized particles of quartz were noted in one thin section.

One of the most characteristic features of the Warsaw Limestone is the widespread crossbedding that is etched into relief on weathered outcrops. Typically, the bedding of the Warsaw is massive; beds 4 to 8 feet thick are common and even thicker beds occur locally. Locally, however, the bedding is very thin or even laminated, especially where the rock is medium or fine grained. Stylolites are most common in the fine- to medium-textured beds but they also occur in coarse-textured beds. Being unusually massive and homogeneous, the Warsaw is a cliff former. Because of its purity it is readily susceptible to solution, and solution openings from a fraction of an inch to several feet in diameter are common. Solution by ground water at the bedrock-residuum contact has produced an extremely irregular surface with pinnacles of rock extending up into the residuum. The fine-grained and dolomitic beds in the upper part of the formation weather to smooth and rounded surfaces.

Stratigraphic relationships.—The contact between the Warsaw Limestone and the Fort Payne Chert may be sharply defined or essentially gradational, but in either case apparently it is conformable and easy to identify. The contact with the overlying St. Louis Limestone is more difficult to pick accurately, especially where the Warsaw and St. Louis seem to be interbedded with one another, as in the bluffs along the Cumberland River. Wherever the relationship can be determined, the Warsaw and St. Louis seem to be conformable.

St. Louis Limestone

Definition.—In Tennessee the St. Louis Limestone was first referred to by that name in Safford's "Geology of Tennessee" (1869, p. 339). Safford and later authors (Hayes and Ulrich, 1903, p. 3; Bassler, 1912, p. 212; Drake, 1914; Wade, 1914, p. 172; Miser, 1921, p. 24-25) included all or part of the Warsaw in the St. Louis. Butts (1919, p. 25-26) and Bassler (1932, p. 157-158) described the St. Louis in the northern and western parts of the Highland Rim, respectively. As used in this report the St. Louis consists of dark-colored beds of varying lithology overlying the coarse-grained, light-colored, massive Warsaw Limestone and underlying the light-colored, highly oolitic Ste. Genevieve Limestone.

Distribution.—Residual chert fragments derived from weathering of St. Louis Limestone cap most of the hills in the area except in the southwestern corner, where all the St. Louis and most of the Warsaw have been removed by erosion (pl. 1). Bedrock is well exposed along Saline Creek and its tributaries, near the upper end of Dyers Creek, on Long Creek east of Dover, and on both sides of the Cumberland River north of the Bumpus Mills fault.

Thickness.—Throughout the area the upper part of the St. Louis is so deeply and thoroughly weathered that no determination as to the total thickness of the formation can be made. Only in a few places is as much as 50 to 75 feet exposed in any section. In the northern part of the area, St. Louis bedrock crops out low on the valley walls, and residuum derived from the St. Louis continues to the tops of the hills, which are as much as 250 feet above the valleys. These data indicate that the St. Louis is at least 250 feet thick.

Lithology.—The St. Louis is the most heterogeneous of the Mississippian formations exposed in the Dover area. Fine- to coarse-grained calcarenite is widespread and is distributed throughout the section. Foraminiferal limestone is prominent locally but seems to be restricted to the lower part of the formation. Dense, dark, cherty limestone and shaly limestone also occur locally in the lower part of the formation. Discontinuous outcrops of dolomitic and siliceous limestone are exposed at several places in the area and, although their stratigraphic position is not known certainly, they probably are close to the base of the formation.

Fine- to coarse-grained fossil-fragmental calcarenite is especially well-exposed along Saline Creek and in the bluffs on both sides of the Cumberland River (pl. 2). Broken and abraded crinoid and echinoid ossicles, bryozoan fragments, and brachiopod shells make up the bulk of the rock. Sorting is usually good but in some beds it is virtually nonexistent. Incrustation of fibrous algae is present on some of the fossil fragments. Most of the calcarenite beds contain sporadic and poorly developed ooliths, which locally make up a prominent part of the rock. The matrix generally is subordinate. Most of the matrix is of secondary origin because, in contrast to that in the Warsaw, it consists mostly of clear crystalline calcite, and edges of the fossil fragments are sharp and exhibit little or no corrosion as a result of recrystallization.

One of the most characteristic features of the St. Louis is its invariable dark color. Dusky brown, dusky yellowish-brown, dark yellowish-brown, and pale yellowish-brown are the predominating hues. Some beds near the base of the formation may be much lighter, either light olive-gray or even yellowish-gray.

The individual calcarenite beds are generally a foot or less in thickness, but in a few places they may be as much as 3 or 4 feet thick. Crossbedding in the calcarenite beds of the St. Louis is not as widespread nor as well developed as in the Warsaw Limestone.

Chert is not particularly abundant in the calcarenite, but where present it has originated in the same manner as that in the Warsaw. Some of the chert in the St. Louis is texturally identical to the vesicular variety from the Warsaw, but most is more dense, darker colored, and in smaller masses. Specimens of partly chertified calcarenite in thin section show that much of the original texture may be destroyed as the rock is replaced by silica. Except for minor amounts of microcrystalline, feathery quartz the silica is cryptocrystalline. In contrast to the Warsaw, in which the fine-grained recrystallized matrix is replaced first, the matrix of the St. Louis, consisting largely of clear crystalline calcite, is the last to be replaced.

Along the upper end of Dyers Creek and on several of the tributaries of Saline Creek, endothyroid foraminifera form as much as 25 percent of the rock. Except for the abundance of foraminifera, these beds are almost identical to the typical calcarenite. Organic detritus of various kinds comprises 25 to 50 percent of the rock and the remainer is clear crystalline calcite. Sorting is very good and most of the organic particles are well-rounded.

At several places in the Dover area, notably along Hayes Fork Creek, the lower part of the St. Louis is made up in part of beds of dense, dusky yellowish-brown, highly siliceous and cherty limestone. These beds also are well-exposed along Cub Creek and North Cross Creek in the Indian Mound quadrangle just east of the area. Thin sections of the dense limestone show an extreme range in particle size, although most of the rock is made up of fine-grained recrystallized calcite. Scattered fossil fragments, mainly echinoid and crinoid ossicles, "float" in the rock. Nearly all the fossil fragments show varying amounts of corrosion. Organic material is abundant and its concentration along very irregular and discontinuous planes gives the rocks a rudely laminated structure. Chert is a prominent component of the rock, occurring as very irregular masses that replace matrix and fragments indiscriminately, so that preservation of the original texture and structure is generally poor. Most of the chert is dense, brittle, and fractures into small angular pieces. In some places it has a semi-banded appearance, much like chert from some parts of the Fort

Payne. The banded and nonbanded varieties of chert differ from the Fort Payne Chert, however, in that both almost invariably are fossiliferous. Individual beds of the dense limestone seldom are more than a foot thick and generally are separated from adjacent beds by shale seams an inch or two thick. Along Cub Creek, where the shaly seams are best developed, they are locally crowded with colonial corals. Colonial corals also are abundant locally in the dark, dense beds and are but rarely found in any other type of rock. Various species of blastoids also are common in these beds.

Although thin shaly zones are rather common in the St. Louis, shaly limestone is prominent only along Saline Creek near the northern boundary of the area. Here 50 to 75 feet of dusky, yellowish-brown, shaly limestone is exposed. Clay, very fine silt, and brownish organic material all are abundant in the rock. Fossils, other than bryozoans, are rare. The bryozoans are oriented parallel to the bedding and nearly all have been replaced by calcite or silica.

Beds of fine-grained, pale yellowish-brown, dolomitic and siliceous limestone are poorly exposed at several places in the area. Thin sections show that the dolomitic beds are similar texturally to the dolomitic and siliceous beds in the upper part of the Warsaw. Small irregular patches of finely crystalline calcite are scattered through the rock. No chert as discrete masses has been observed in the dolomitic beds anywhere within the area. At a few places on Hayes Fork Creek these beds contain large numbers of fossils, especially brachiopods.

"Cannonballs" are the most distinctive variety of chert found in residuum from the St. Louis Limestone. The few "cannonballs" that have been found in place occur in fine- to medium-grained calcarenite. The "cannonballs" have a thin white tripolitic rind, but the interior generally is dusky yellowish-brown or nearly black. Most of the "cannonballs" are dense in texture and show no internal structure, although a few are concentrically layered. None show radiating internal structure.

Where the beds are sufficiently massive the St. Louis forms prominent cliffs, but the thinner beds crop out on more gently sloping hillsides as a series of rounded steps. In some places weathering of the coarser calcarenite beds has formed pinnacles similar to those of the Warsaw. A thin layer of punky siliceous material is formed by weathering of the surface where the rock contains much finely disseminated silica and silt. In beds containing abundant organic material, as in those of dense or shaly limestone, weathering bleaches the surface of the rock to a grayish-orange or very pale-orange color.

Stratigraphic relationships.—As far as is known the St. Louis Limestone overlies the Warsaw Limestone conformably. As the only three outcrops of Ste. Genevieve Limestone known in the area are remote from bedrock outcrops of the underlying St. Louis, the relationship of the two formations is not known.

STE. GENEVIEVE LIMESTONE

Definition.—The Ste. Genevieve, identified in the Dover area in only three outcrops, is here reported in the Western Highland Rim for the first time. The Ste. Genevieve crops out near Hopkinsville, Kentucky (Walker, 1956, p. 15), about 30 miles northeast of Dover and in the Clarksville area about 25 miles east of Dover. Outcrops lithologically identical to those in the Dover area are on the N. C. and St. L. Railroad west of Tennessee City in Humphreys County about 30 miles southeast of Dover. Here, the rock contains *Platycrinus penicillus* (R. G. Stearns, Vanderbilt University, oral communication, 1958), which is considered to be a reliable guide fossil of the Ste. Genevieve Limestone.

The Ste. Genevieve in the Dover, Clarksville, and Tennessee City areas consists of light-colored, highly oolitic, nonsilty limestone, and because of these very distinctive lithologic characteristics the outcrops in all three areas are confidently identified as Ste. Genevieve.

Because of its very limited extent the Ste. Genevieve is not shown on the geologic map (pl. 1) but is included with the St. Louis Limestone.

Distribution and thickness.—The three outcrops of Ste. Genevieve Limestone in the Dover area are: a single boulder about 8 feet in diameter, about 200 feet south of State Highway 120 and about 0.7 mile west of Big Rock; at the edge of the roadcut on State Highway 49, where it crosses the dividing ridge between Bear Creek and Brandon Spring Branch; and near the top and on the east side of the dividing ridge between the headwaters of Hayes Fork Creek and Dyers Creek. The last two exposures of the Ste. Genevieve have been preserved in downfaulted blocks. Oolitic chert, probably derived from the Ste. Genevieve, is scattered on some of the ridges in the vicinity of Big Rock, on ridges north of Indian Mound, and on the ridge between Hayes Fork Creek and Dyers Creek.

Because of its limited outcrop area the thickness of the Ste. Genevieve in the Dover area is unknown.

Lithology.—The St. Genevieve is primarily a yellowish-gray calcarenite consisting of ooliths set in a matrix of clear secondary calcite. Individual ooliths are well developed and because they have formed around nuclei of fossil fragments of all sizes and shapes they range from spheres to elongate weinerlike forms as much as 1.5 mm long. As the size of the nuclei varies greatly, so does the size of the ooliths.

On the dividing ridge between Hayes Fork Creek and Dyers Creek, the Ste. Genevieve is partly medium- to coarse-grained calcarenite with irregularly distributed patches of dense, sublithographic limestone.

Stratigraphic relationships.—Because of its restricted extent the relationship of the Ste. Genevieve Limestone to the underlying St. Louis Limestone is not known. Blocks of sandstone, possibly derived from the Bethel Sandstone, are on the downfaulted side of the Hayes Fork Creek fault between Hayes Fork Creek and Dyers Creek, but because the sandstone is not in place its relationship to the Ste. Genevieve is undetermined.

Cretaceous System

Tuscaloosa Gravel

Definition.—Discontinuous patches of gravel cap many of the higher ridges in the Western Highland Rim. These rocks were first studied and described by Safford (1869, p. 434-436), who referred to them as "ore-region gravel." Safford apparently included both terrace gravel and the Tuscaloosa Gravel in this unit. Although he stated that the "ore-region gravel" is younger than Cretaceous, he recognized that some of the gravel may be Cretaceous in age (1869, p. 434).

Although Tuscaloosa Gravel caps many ridges along the western side of the Columbia quadrangle, Hayes and Ulrich (1903, p. 3) did not differentiate it from the terrace gravel which also is common in some parts of that area. Instead, they correlated both terrace gravel and Tuscaloosa Gravel with similar deposits that extend around the margin of the Appalachian province from southern Illinois to New Jersey.

The true identity of the Tuscaloosa on the Western Highland Rim was recognized first by Miser (Drake, 1914, p. 107), who traced the overlying Eutaw Formation into Hardin County where the Eutaw contains typical fossils. Wade (1914) mapped the Tuscaloosa as far north as Perry County and later (1917, p. 102-106; 1920, p. 54) traced it farther north into Trigg County, Kentucky. Additional outliers of Tuscaloosa Gravel in Montgomery, Dickson, and Hickman Counties were mapped and described by Born (1935, p. 222-230). In western Kentucky the Tuscaloosa has been studied by Roberts (1927; 1929).

As discussed in this report the Tuscaloosa Gravel is a distinct lithologic unit that can be traced from Hardin County, where it is overlain by sand containing marine fossils, across the Western Highland Rim into western Kentucky, where it also is overlain by fossiliferous sands.

Distribution and thickness.—Tuscaloosa Gravel crops out in discontinuous remnants capping some of the higher ridges in the northern part of the Dover area (pl. 1). Good exposures are in gravel pits along U. S. Highway 79, State Highway 49, and along several secondary roads. Gravel deposits also are scattered on many of the ridges throughout the area, and the Tuscaloosa apparently once was much more widespread but has been dissected since Cretaceous time.

Although its full thickness is not exposed anywhere within the Dover area, the Tuscaloosa in some of the larger gravel pits is as much as 25 or 30 feet thick. The gravel probably is not more than 50 feet thick and in most parts of the area is about 10 to 15 feet thick.

Lithology.—The Tuscaloosa consists of well-rounded chert particles ranging in size from fine pea-gravel to large cobbles 10 inches or more in diameter. Although no size analyses were made for this study, the average size of individual particles probably is about 2 to 4 inches. Many of the chert fragments are readily identifiable as having been derived from the Fort Payne, Warsaw, and St. Louis formations. A characteristic and ubiquitous type of chert fragment was derived from the Camden Chert of Devonian age. This type of chert is nearly white in color, has a rather chalky texture, and contains patches of dark-colored chalcedonic or opaline quartz. Fossils, mostly brachiopods, which are very abundant in the Camden, are replaced by fibrous chalcedonic quartz in many specimens. The chalcedonic patches and replaced fossils are more resistant to weathering than the matrix and when weathered stand out in relief. Large, well-rounded cobbles of quartzitic sandstone in the northwestern corner of the area may have been derived from the Dutch Creek Sandstone of Devonian age or the Roubidoux Formation of Ordovician age. Pebbles of quartz, ironstone, limonite, and hematite do not occur in the Tuscaloosa in the Dover area, and over most of the Western Rim the Tuscaloosa is entirely devoid of these constituents. Limestone particles have not been observed in the Tuscaloosa anywhere in the Western Highland Rim.

The matrix of the gravel in most places is a sandy and clayey material which appears to have a high kaolin content, probably derived from the weathering of chert.

Silica, probably also derived from weathering of chert, is the main cement although in most places the gravel is only semi-indurated. The sand in the matrix and in local pods or stringers in the gravel consists mostly of chert, although some quartz may be present, especially in the upper part of the formation. Thin lenses and stringers of nearly white or gray kaolinitic clay also are present locally.

Most of the Tuscaloosa has a characteristic bleached appearance, but in a few parts of the area it is stained by iron and manganese. Locally the iron minerals, usually limonite, cement thin discontinuous layers of conglomerate.

Typically, the Tuscaloosa is massive and lacking in internal bedding. In a few outcrops, however, the materials are poorly crossbedded. Dip of the crossbeds generally is toward the east or northeast, but outside the area this trend locally is reversed.

Stratigraphic relationships.—A major unconformity separates the Tuscaloosa from the underlying residual material derived by weathering of the Fort Payne, Warsaw, and St. Louis formations. On the dividing ridge between the Cumberland River and Kentucky Lake in the northwestern part of the area, the Tuscaloosa is overlain by Coffee Sand. The contact between them is gradational.

Coffee Sand

Definition.—The sand overlying the Tuscaloosa Gravel in the Waynesboro quadrangle was first studied and mapped by Miser (Drake, 1914, p. 107), who identified it as Eutaw. Wade (1914) also identified similar sand in Stewart County as Eutaw. Studies now underway by E. E. Russell (Mississippi State University) for the Tennessee Division of Geology show, however, that the Eutaw is overlapped by the Coffee Sand in Hardin County about 80 miles south of the Dover area and that sands formerly called Eutaw farther north are actually Coffee. Furthermore, Russell has shown that the Coffee Sand is readily traceable from its type locality at Coffee Bluff in Hardin County northward to the Kentucky State Line (E. E. Russell, oral communication, 1960).

From its stratigraphic position and its lithologic similarity to the Coffee Sand on the west side of Kentucky Lake in Henry County, the sand overlying the Tuscaloosa Gravel in the Dover area is identified as Coffee. Locally, however, beds of coarse reddish sand, which are similar to those in the Coffee, overlie the Tuscaloosa. These sands differ in that they are highly silty and clayey and contain well-rounded quartz pebbles. E. E. Russell (oral communication, 1960) considers these sands to be terrace deposits.

Distribution and thickness.—The Coffee Sand largely is restricted to the northwestern corner of the Dover area. Sand, tentatively identified as Coffee, crops out sporadically along U. S. Highway 79 for about 2 miles eastward from the top of the hill overlooking Scott Fitzhugh Bridge. Because of its thinness and erratic distribution, the Coffee Sand is included with the Tuscaloosa and the Lafayette Gravel (of former usage) on the map (pl. 1). Because of its topographic position on the crests of ridges, it is impossible to determine the total thickness of the Coffee Sand. The maximum known thickness in the map area is about 20 feet near the Tennessee-Kentucky Line. In most places, however, no more than 5 or 10 feet of the formation is exposed.

Lithology.—Where exposed, the Coffee Sand consists of medium- to coarse-grained brownish or reddish sand. The color is due largely to a thin film of iron-stained clay on the surface of the sand grains. Most of the sand grains are well-rounded to subangular and sorting is generally good. Very fine heavy minerals, mostly ilmenite and magnetite, locally are quite abundant. A prominent characteristic of the Coffee is the presence of small blobs and stringers of white kaolinitic clay. Thin beds and boulders of iron-cemented sand are present locally but, in general, the Coffee Sand is unindurated. Bedding is indistinct although crossbedding is well developed in some localities. The dip of the crossbeds varies and no direction of dip seems to predominate.

The only fossils found thus far in the Coffee Sand within the Dover area are *Halymenites major* (E. E. Russell, oral communication, 1960). The same form is present on the west side of Kentucky Lake and just north of the map area in Trigg County, Kentucky.

Stratigraphic relationships.—As previously stated, the contact of the Coffee Sand with the Tuscaloosa Gravel is gradational and the two units probably are conformable. The Coffee Sand is overlain unconformably by Lafayette Gravel (of former usage) of Pliocene age.

Tertiary System

LAFAYETTE GRAVEL (OF FORMER USAGE)

The Lafayette Gravel is defined by Potter (1955, p. 3) as follows: " In this study the term *Lafayette* refers to a distinctive deposit found in the Central Lowland, Interior Low Plateau, Ozark Plateau province and the Mississippi embayment portion of the Coastal Plain Province, that consists primarily of insoluble components: chert, sandstone, quartz and quartzite pebbles, cobbles, and boulders associated with noncalcareous sands, silts, and clays, which in the aggregate are either stained or, less commonly, cemented by the oxides of iron and manganese." A complete discussion of this gravel, which has been the subject of much debate, is beyond the scope of this report. Potter's excellent paper on "The Petrology and Origin of the Lafayette Gravel" (1955) gives a complete and comprehensive discussion of the history and present status of the Lafayette.

Distribution and thickness.—The Lafayette Gravel (of former usage) is exposed in several road cuts for about 2 miles eastward from the east end of Scott Fitzhugh Bridge. It is also well-exposed on many of the ridges in the northwestern part of the area. Because of its thinness and erratic distribution it is included with the Tuscaloosa Gravel and Coffee Sand on the geologic map (pl. 1).

The maximum known thickness of about 25 feet of gravel is exposed along U. S. Highway 79 and north of Dry Fork Creek. Elsewhere the exposed thickness seldom exceeds 5 or 10 feet.

Lithology.—The detailed lithologic description of the Lafayette in western Kentucky and Tennessee given by Potter (1955, p. 5-35) also is applicable to the gravel in the Western Highland Rim. In general, the Lafayette Gravel (of former usage) consists of well-rounded chert, quartz, and quartzite pebbles and sand. Most of the particles are coated with a thin film of iron or manganese oxide and locally the iron may act as a cement. Rounded pebbles of limonite and hematite also are present in the gravel. The rounded pebbles of limonite and hematite, the abundance of quartz and quartzite fragments, the more common iron staining, and the characteristic "lima bean" shape of many of the pebbles serve to distinguish these rocks from the Tuscaloosa Gravel.

In relatively fresh exposures crossbedding generally is well displayed. The direction of dip of the crossbeds varies greatly but is usually toward the north or northwest.

A rather unusual feature, well shown in the gravel pit north of Dry Fork Creek, is the presence of clay dikes cutting through the gravel. Some of the clay seems to have filtered into fractures from above, but some dikes seem to have been intruded from below, as suggested by an upward branching of the dikes so that they have a dendritic pattern in vertical section.

The only fossil found is a poorly preserved fragment of wood. S. H. Mamay, Paleontology and Stratigraphy Branch, U. S. Geological Survey, states that although the specimen may be coniferous, it is not identifiable generically and is of no use in age determination.

Stratigraphic relationships.—In the pit north of Dry Fork Creek, along U. S. Highway 79, and on State Highway 49 at the Kentucky Line, the Lafayette Gravel (of former usage) unconformably overlies Coffee Sand. At other localities the gravel is underlain by Tuscaloosa Gravel or residuum derived from Mississippian formations and, except for soil and colluvium, is not overlain by younger rocks.

STRUCTURE

In order to depict the structural pattern of the Dover area the top of the Fort Payne Chert was used as the datum for the structure contours (pl. 1) and, although this horizon leaves much to be desired, it is the only one for which even partly adequate information is available. In the southwestern part of the area where the

Chattanooga Shale crops out along Kentucky Lake, elevations were projected upward from the top of that formation to the top of the Fort Payne. Where the Fort Payne is covered by younger strata, as it is over much of the area, elevations were projected downward from the top of the Warsaw. This method is subject to considerable error because it is based on a presumed thickness of the Warsaw or Fort Payne formations, which in most parts of the area can only be estimated. The possibility of error is further increased in the northwestern part of the area where contacts are based almost entirely on residual chert subject to slumping. Where elevations have been projected upward or downward minimum values for the thickness of either the Fort Payne or Warsaw formations have been used. This, in effect, minimizes structure and if thicknesses are greater than those used the contours would be moved upslope. In spite of these imperfections, which influence elevations only, the structure map reflects the general structural pattern of the area.

The Dover area lies on the southwest flank of the Tennessee lobe of the Illinois Basin (Wilson, 1949, p. 327). As shown by the structure contours on the geologic map (pl. 1) the beds in the southern part of the area dip northeast at the rate of about 50 feet per mile. The direction of dip progressively changes to east in the northwestern part of the area and becomes slightly steeper.

Major structural features in the area include a broad eastward-plunging syncline in the central part of the area and a number of high-angle normal faults. Most of the minor folds trend east-west. All of the faults trend northeast with the exception of the Hayes Fork Creek fault which trends northwest. Because all the faults strike perpendicularly or diagonally to the strike of the regional structure, they may be classified as transverse faults. Similarly, most of the folds in the area are transverse to the regional structure. Minor anticlines and synclines in the vicinity of faults probably are the result of folding during faulting.

Folds

The broad syncline that occupies the east-central part of the map (pl. 1) plunges eastward at an average rate of about 10 feet per mile. The syncline is bounded on the south by the Carlisle fault and on the north by the Bumpus Mills and Hayes Fork Creek faults. Near the margin of the syncline the rocks dip inward at the rate of 50 to 100 feet per mile. Toward the axis of the syncline the rate of dip decreases to less than 10 feet per mile. East of Dover, the general northern trend of the Cumberland River is offset to the southeast and the river follows the axis of the syncline for about 6 miles. However, there is some possibility that this offset in the trend of the river may be due to a fault that follows the axis of the syncline to near Dover and then cuts diagonally across the southeast flank of the syncline and dies out about 3 miles east of Scott Fitzhugh Bridge. Surface evidence is very meager and inconclusive and until subsurface data become available the existence of such a fault can only be conjectured.

Other folds in the area are of varying magnitude, and most of them are related to faults. One of the larger of these folds is the syncline in the north-central part of the area. Data to outline this syncline are rather meager and its actual size and shape may be somewhat different from that shown by the contours.

Along Kentucky Lake just south of Scott Fitzhugh Bridge the rocks have been folded gently upward to form a small anticline (pl. 1). This structure, whose axis trends about N.50°E., is about 2 miles wide and 3 or 4 miles long. Along the axis of the anticline where movement was greatest the rocks have been folded upward 50 or 60 feet, sufficient to expose Chattanooga Shale, Camden Chert, and Pegram Limestone in the bluff along Kentucky Lake.

Faults

Carlisle Fault

The Carlisle fault trends southwestward from beyond the eastern edge of the area at the community of Carlisle, for which it is named, and dies out gradually near the mouth of East Fork Leatherwood Creek (pl. 1). The fault is normal; the St. Louis Limestone, on the north side, is downdropped against the Fort Payne Chert. The maximum displacement probably is not less than 250 feet and may be as much as 350 feet. Near its western end the fault swings northwestward across the mouth of Largent Hollow, and apparently is joined by the Largent Hollow fault.

Largent Hollow Fault

The Largent Hollow fault trends about N.50°E. along Largent Hollow from near the mouth of East Fork Leatherwood Creek, crosses the ridge between Leatherwood and Standing Rock Creeks, and dies out a short distance north of Standing Rock Creek. This fault forms the northern boundary of the downdropped block at the western end of the Carlisle fault. Maximum displacement, which is at the southern end of the fault, is about 200 feet.

Near the junction of East and North Forks of Leatherwood Creek, the rocks are rather badly shattered and jumbled, suggesting that a small fault may cross between the Carlisle and Largent Hollow faults. If such a cross fault is present, its displacement cannot be great.

Bumpus Mills Fault

The Bumpus Mills fault begins near the town of Bumpus Mills and extends southwestward to near the head of Panther Creek (pl. 1). Like the other faults in the area, the Bumpus Mills fault is normal; the St. Louis Limestone is downdropped on the north side of the fault along most of its extent. Near Bumpus Mills a horst of Fort Payne Chert is separated from the St. Louis Limestone on both sides by nearly vertical faults with 200 to 300 feet of displacement. The Fort Payne horst is broken by two small cross faults of lesser displacement.

Southwest of Hayes Fork Creek geologic control along the Bumpus Mills fault varies from good to none and the fault trace is based partly on topographic lineation. Bedrock control is provided by outcrops on the east side of the Cumberland River near Bruton Spring Branch and along the dividing ridge between Bear Creek and Brandon Spring Branch.

Piney Creek Fault

The Piney Creek fault, which trends about N.50°E., may be an extension of the Bumpus Mills fault. However, in the area between State Highway 49 and the North Fork Piney Creek the rocks are so thoroughly weathered and slumped that the relationships are uncertain. Although the fault has not been mapped on the west side of Kentucky Lake, a southeast-facing topographic scarp, which follows the same trend as the fault, indicates that the fault may extend some distance beyond the lake.

The amount of displacement along the Piney Creek fault probably is not less than 100 feet.

Hayes Fork Creek Fault

The Hayes Fork Creek fault, from the creek of the same name, extends from Dyers Creek to near the Bumpus Mills fault south of

Bumpus Mills. The fault probably extends farther southeast to the edge of the Bumpus Mills quadrangle, where it may continue as the east-trending fault that follows North Cross Creek just east of the map area. Although there is a slight indication of topograpic lineation between these faults, the relationship is uncertain.

Control on the Hayes Fork Creek fault is provided by bedrock outcrops on a northwest-flowing tributary of Dyers Creek, on the ridge between Hayes Fork Creek and Dyers Creek, and at a number of points along Hayes Fork Creek. Additional control is provided by the Lewis No. 1 oil test near the upper end of Hayes Fork Creek. The maximum displacement along the Hayes Fork Creek fault probably is not more than 350 feet.

Prior Creek Fault

Control along the Prior Creek fault is provided by bedrock outcrops on either side of Prior Creek northeast of Model (pl. 1). Control at the west end of the fault is meager and the fault trace shown on the map is based largely on topographic lineation. Displacement along the fault is 150 feet or less.

The Prior Creek fault is paralleled on both sides by two other faults (pl. 1). The presence of the fault west of the Prior Creek fault is indicated by residual chert, identified as Fort Payne, lying adjacent to residuum derived from the St. Louis Limestone along State Highway 49.

Joints

Joints in the Dover area are well-developed and with a few local exceptions the major sets strike N.30°-40°E. and N.30°-40°W. Many of the streams apparently are controlled by joints because they trend in the same general direction. Striking variations in stream trend near the junction of Hayes Fork Creek and Saline Creek and near the mouth of Leatherwood Creek are the result of faulting.

GEOLOGIC HISTORY AND ENVIRONMENTS OF DEPOSITION

The first event of the Mississippian Period in the Dover area was the deposition of the Maury Formation. According to Hass (1956, p. 23-24) the Maury includes beds of Late Devonian, Kinderhook, and probably Osage age (Early Mississippian). He also considers that the bed of phosphatic nodules at the base of the formation represents a transgressive deposit, because in north-central Tennessee it contains conodonts similar to those in the Gassaway Member of the Chattanooga Shale of Devonian age, whereas farther south in west-central Tennessee it contains conodonts of Early Mississippian (Kinderhook) age. Apparently the Maury Formation represents initial deposition in the Early Mississippian sea as it advanced southward into the Tennessee lobe of the Illinois basin.

From its lithology and distribution the New Providence Shale is most logically interpreted as a near shore, relatively shallow-water phase of the Fort Payne Chert. Farther out in the basin, where the water was deep and tranquil, dark-colored, fine-grained, highly siliceous Fort Payne was deposited.

Fossils are extremely rare in typical Fort Payne Chert. This may be due in part to destruction during recrystallization. However, articulated crinoid stems, some several inches long, and bryozoan fragments occur locally. Transportation of such large and fragile forms may have been accomplished by floating. The unbroken condition of these fossils and the thinly laminated bedding of the limestone layers indicate quiet water free from scavengers. Local highs on the sea floor provided favorable sites for the growth and development of numerous marine organisms. As these organisms died their remains accumulated to form discontinuous beds of fossiliferous calcarenite such as those now exposed on the shores of Kentucky Lake.

Abrupt thickening of the Fort Payne Chert toward the north indicates considerable but probably slow subsidence of the depositional basin. Lack of comparable thickening of the Warsaw Limestone suggests that subsidence had diminished before Warsaw deposition began.

From its lithology, sedimentary structures, and related features the Warsaw is interpreted as having been deposited in an open shelf shoal environment. Shoaling of the water may have been accomplished in large part by filling of the basin, accompanied by gradual cessation of subsidence. Subsidence, however, continued at a sufficiently rapid rate to preserve unsorted fossil debris.

The environment in which the Warsaw was deposited was characterized by shallow, warm, turbulent water with an abundant and diverse fauna, Marine organisms, especially crinoids, bryozoans, echinoids, and brachiopods were extremely abundant because the rocks consist almost entirely of their fossil fragments. For such an abundance of life to flourish, the water must have been well supplied with food. Turbulent, well-aerated water is indicated by the broken and abraded condition of the particles, widespread crossbedding, and the generally light color of the rock. The extremely massive bedding suggests that periods of quiescence were widely spaced. Although chert is common most of it is epigenetic and is, in part, a result of surface weathering. The chert therefore does not provide any clue as to the original environment.

Shoal conditions like those in which the Warsaw Limestone was deposited were maintained during deposition of the St. Louis Limestone and, as a result, beds of fossil-fragmental calcarenite accumulated. However, the more variable character of the St. Louis and the general influx of silt and clayey material reflect increasing instability of the shelf and surrounding margins during St. Louis time. Environments favoring the development of ooliths and providing a favorable habitat for endothyroid foraminifera prevailed locally. The pale to dark yellowish-brown colors that are common in the calcarenites suggest that the water was neither as turbulent nor as well aerated as on the open shelf. In some places restriction of circulation was more pronounced, resulting in a reducing environment favoring the preservation of sapropelic material and the formation of pyrite. In most places, however, restriction was not sufficient to prohibit life. Colonial corals, such as *Dorldotia* and *Syringopora,* and various species of blastoids are more common in the dark silty beds. Restricted circulation and deeper, cooler water also favored the deposition of silica, which now occurs as irregular nodules and discontinuous beds of dark chert similar to that in the Fort Payne.

The St. Louis Limestone was deposited in environments ranging from relatively deep, quiet water to shallow, agitated water, and the different environments favored different faunas. Conditions generally were not as extreme during deposition of the St. Louis as they had been earlier.

On the Western Highland Rim the record of post-St. Louis deposition during Mississippian time is very meager. Three outcrops of Ste. Genevieve Limestone in Stewart County, a single outcrop in Humphreys County about 30 miles south of Dover, and the Ste. Genevieve Limestone in north-central Montgomery County indicate that the Ste. Genevieve was quite extensive at one time and perhaps covered the entire northwestern Highland Rim.

The lithologic characteristics of the Ste. Genevieve suggest that it was deposited in an open marine shelf or on barrier banks where a prolific fauna of bryozoans, brachiopods, corals and other marine organisms flourished. The purity of the limestone, the high degree of sorting, and the abundance of ooliths all show that the water was well-aerated, shallow, and turbulent.

Although rocks of Pennsylvanian age may have covered all or part of the Western Highland Rim at one time, there is no preserved record. Neither is there any record of Permian, Triassic, or Jurassic deposition. Presumably, then, the Rim was above sea level and was subject to weathering and erosion at least during much of the Mesozoic era, and by the end of Early Cretaceous time the rocks had been eroded to the surface whose remnants now form the Highland Rim Plain. The topography of the Dover area at that time perhaps was comparable to the well-developed karst topography of the area immediately to the east. Only a few isolated sinkholes remain of this former widespread karst plain.

The age of the Western Highland Rim Plain is indicated by the veneer of Tuscaloosa Gravel of Late Cretaceous age that caps many of the ridges and drapes down the valley sides. Most occurrences of the Tuscaloosa below the general level of the Rim Plateau are the result of mass-wasting and slumping. Locally, however, pockets of Tuscaloosa are found in place at altitudes that range from the summits of the ridges to the floors of the valleys. The position of some low-lying pockets may be due to faulting, but most of them are believed to have been deposited in sinkholes and solution channels in the soluble limestones that underlie the plateau, as was postulated by Miser (1921, p. 50-51) for similar deposits to the south in Wayne County, Tennessee. Some pockets of gravel are surrounded on all sides by residuum. These may have been deposited in caves or solution openings, and as the overlying bedrock weathered away, insoluble clay and chert collapsed upon and was mixed with the gravel.

All the available evidence indicates that the Tuscaloosa Gravel is nonmarine and that its source area lay to the west (Stearns and Marcher, 1959, p. 1679). That the source of the Tuscaloosa was a highland to the west is proven conclusively by the abundance of Camden Chert in every known outcrop in the Western Highland Rim. Detailed mapping by C. W. Wilson, Jr. (1949, p. 86) shows that the Camden is exposed only in the Western Valley of the Tennessee River. Identification of the Camden gravel in the Tuscaloosa is based on its very characteristic lithology and the presence of typical fossils.

In summary, the Tuscaloosa Gravel was deposited on the Highland Rim Plain by eastward-flowing streams. The source of the streams was a highland, the Pascola Arch (Grohskopf, 1955, p. 25), which lay in the area now occupied by the Upper Mississippi Embayment. As the Pascola Arch subsided, Coffee Sand was deposited in the Late Cretaceous sea that encroached upon parts of the Highland Rim Plain from the east. Although undoubted Coffee Sand is now present only on the southern and northern edges of the Western Highland Rim, it probably was much more extensive but has been removed by erosion.

Tensional stresses induced by subsidence of the Upper Mississippi Embayment resulted in high-angle normal faults, although some thrust faulting took place in the vicinity of Camden (Ross, 1946, p. 201-204). Some of the thrust faults in that area involved the Tuscaloosa Gravel but not the overlying Coffee Sand (R. G. Stearns, personal communication, May 1959). Just west of the Dover area in Calloway County, Kentucky, Tuscaloosa Gravel was faulted (J. M. Kellberg, oral communication, 1959) prior to the deposition of the overlying Coffee Sand. On State Highway 49 north of Model, Stewart County, both the Tuscaloosa Gravel and Coffee Sand have been faulted. Although most of the previously cited evidence is outside the Dover area, it proves that at least part of the faulting on the margin of the Western Highland Rim took place during Late Cretaceous time and suggests that some of the major faulting in the Dover area also may have taken place at that time.

No deposits that elsewhere lie between the Coffee Sand and the Lafayette Gravel (of former usage) have been found in the Dover area. Just east of the area, however, deposits of high-alumina clay, sand, and lignite, identified as Eocene (Wilcox) or at least post-Cretaceous and pre-Miocene in age, have been mapped by Wilson (1953, p. 755). Deposits of Eocene (Wilcox) age are not known elsewhere in the Western Highland Rim, but Wilson believes that the deposits in eastern Stewart County were continuous with the main mass of Wilcox in West Tennessee (1953, p. 763). If this is true, all or part of the Dover area was near or below sea-level during the early part of the Eocene.

According to Potter (1955, p. 117, 120) deposits of the Lafayette Gravel (of former usage) of Pliocene age in Kentucky and

Tennessee are the remnants of coalescing alluvial fans built by the ancestral Mississippi, Tennessee, Cumberland, and Ohio Rivers, and which overlapped onto the flanks of the Highland Rim. These deposits are restricted mostly to the western part of the area.

The presence of deposits of such widely different ages as Tuscaloosa, Coffee, Wilcox, and Lafayette (of former usage) suggests that the Western Highland Rim remained relatively low-lying from the time that the Highland Rim Plain was cut (pre-Tuscaloosa) until after deposition of the gravel of post-Pliocene or Pliocene age. The present cycle of dissection probably commenced during the latter part of Pliocene or early Pleistocene time.

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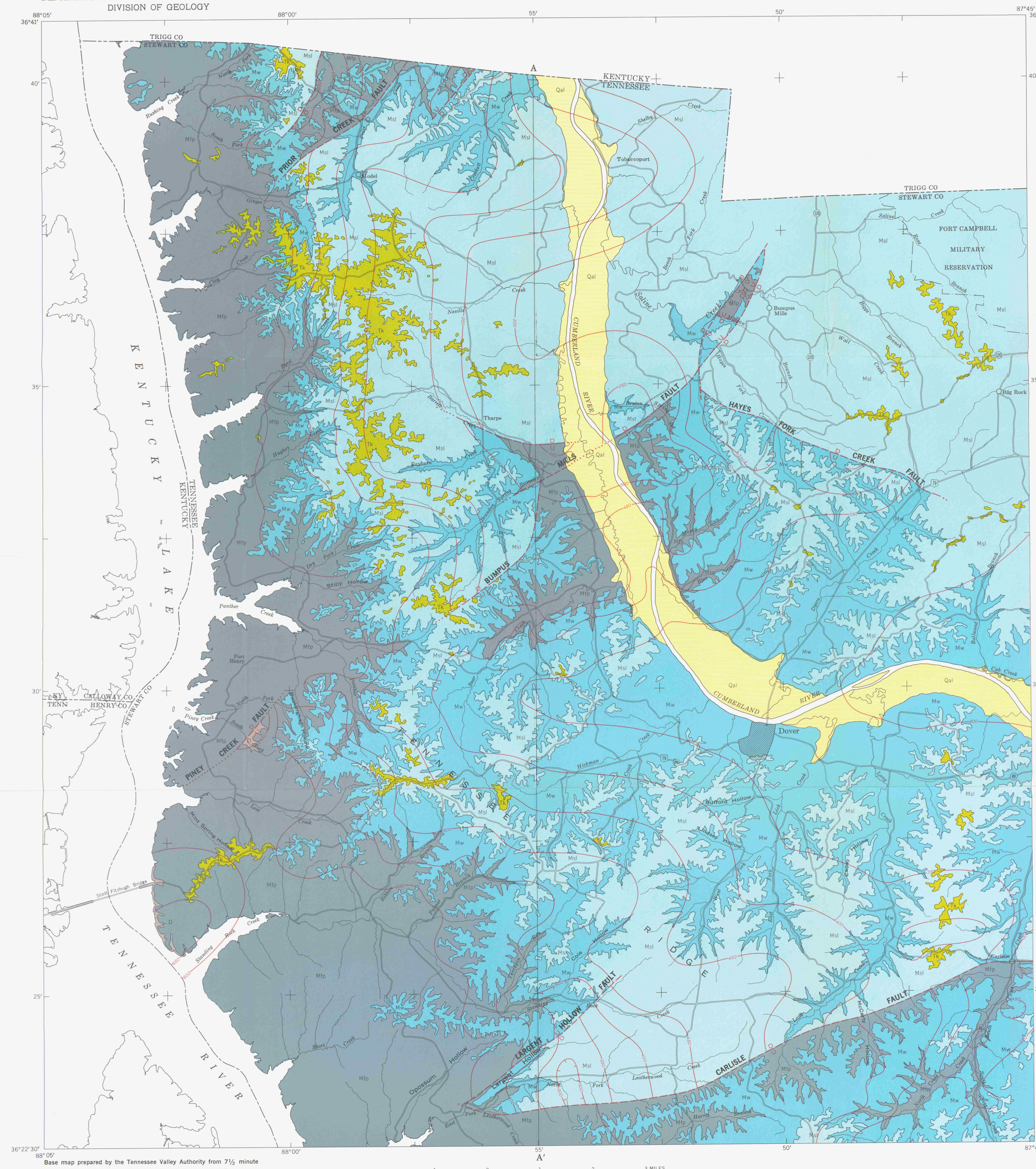
Tennessee Division of Geology
Report of Investigations No. 16
Plate 1

DOVER AREA
TENNESSEE

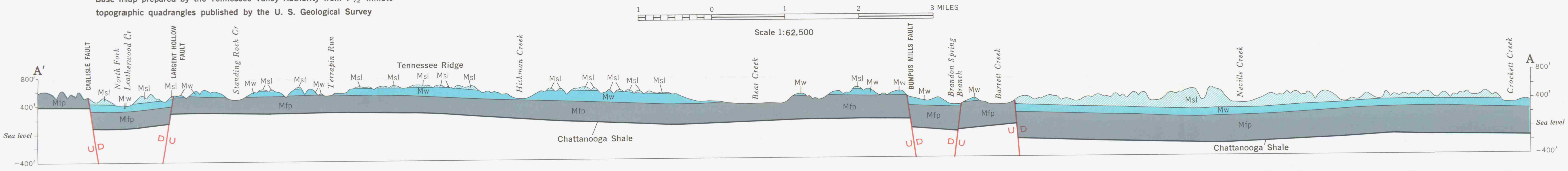
STATE OF TENNESSEE
DEPARTMENT OF CONSERVATION AND COMMERCE
DIVISION OF GEOLOGY

PREPARED IN COOPERATION WITH
THE UNITED STATES GEOLOGICAL SURVEY



Base map prepared by the Tennessee Valley Authority from 7½ minute topographic quadrangles published by the U. S. Geological Survey

Scale 1:62,500



QUATERNARY

Qal

Recent

Alluvium

Unsorted gravel, sand, silt, and clay.

TERTIARY-CRETACEOUS UNDIVIDED

Tk

TERTIARY — *Pliocene*

Lafayette Gravel (of former usage): Well-rounded, iron-stained chert and quartz gravel in an iron-stained sand matrix.

CRETACEOUS — *Upper Cretaceous*

Coffee Sand: Fine- to medium-grained, locally crossbedded

Tuscaloosa Gravel: Well-rounded, unsorted chert gravel in a clayey sand matrix.

MISSISSIPPIAN

Upper Mississippian

Msl

St. Louis Limestone (Includes Ste. Genevieve Limestone)

Ste. Genevieve Limestone: Yellowish-gray, medium-grained, oolitic limestone.

St. Louis Limestone: Yellowish-brown, fine- to coarse-grained, fossil-fragmental, cherty limestone.

Mw

Warsaw Limestone

Yellowish-gray, medium- to very coarse-grained, fossil-fragmental limestone.

MISSISSIPPIAN

Lower Mississippian

Mfp

Fort Payne Chert (Includes the Maury Formation and New Providence Shale)

Fort Payne Chert: Brown to black bedded chert intercalated with highly siliceous and silty limestone; grades laterally into very rough and irregular platy chert in a silty siliceous limestone matrix.

New Providence Shale: Greenish-gray sparsely glauconitic clay shale containing local beds of crinoidal limestone.

Maury Formation: Olive-gray mudstone containing abundant phosphatic nodules.

DEVONIAN UNDIVIDED

D

Upper Devonian

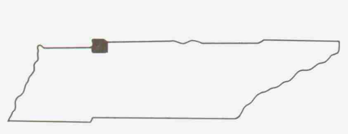
Chattanooga Shale: Brownish-black fissile shale.

Middle Devonian

Pegram Limestone: Gray, fine- to coarse-grained, silty limestone.

Camden Chert: Gray, fine- to medium-grained, argillaceous, cherty limestone.

APPROXIMATE MEAN DECLINATION, 1962



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Geologic contact

Structure contours drawn on top of the Fort Payne Chert.
Contour interval 50 feet.
Datum is mean sea level.

Fault
Dashed where inferred, dotted where concealed.
U, *upthrown side*; D, *downthrown side*

GEOLOGIC MAP OF THE DOVER AREA, STEWART COUNTY, TENNESSEE

By

Melvin V. Marcher, 1962

A—Section begins at creek level (elevation 400± feet) about 700 feet northeast of Standing Rock Church, Standing Rock Quadrange. Tennessee coordinates: 1,422,400E; 749,200N.

B—Section begins at river level (elevation 350± feet) about 2,000 feet north-northwest of Mossy Run, Bumpus Mills Quadrangle. Tennessee coordinates: 1,499,700E; 788,000N.

C—Section begins at road level (elevation 400± feet) about 400 feet southwest of Pearl Spring on Leatherwood Creek, Standing Rock Quadrangle. Tennessee coordinates: 1,429,000E; 733,300N.

D—Section begins about 20 feet above river level (elevation 350± feet) about 2,800 feet east-northeast of eastern tip of Dover Island, Bumpus Mills Quadrangle. Tennessee coordinates: 1,474,100E; 774,700N.

E—Section begins at creek level (elevation 420± feet) about 3.65 miles northeast of junction of U.S. Highway 79 and Bumpus Mills road, Bumpus Mills Quadrangle. Tennessee coordinates: 1,474,300E; 789,500N.

F—Section begins about 20 feet above creek level (elevation 370± feet) about 2,000 feet west confluence Saline Creek and Hayes Fork Creek, Bumpus Mills Quadrangle. Tennessee coordinates: 1,452,000E; 807,200N.

G—Section begins near base of hill (elevation 370± feet) about 1,000 feet north Bruton Spring Branch, Tharpe Quadrangle. Tennessee coordinates: 1,444,200E; 801,800N.

H—Section begins above creek level (elevation 460± feet) on Dyers Creek about 1.5 miles southwest of Big Rock, Bumpus Mills Quadrangle. Tennessee coordinates: 1,478,400E; 795,500N.

I—Section begins at creek level (elevation 380± feet) about 0.7 mile east of high school in Bumpus Mills, Bumpus Mills Quadrangle. Tennessee coordinates: 1,465,200E; 811,400N.

J—Section begins near base of hill (elevation 360± feet) about 1,000 feet south of Saline Creek and about 2,300 feet northwest of Shemwell Cemetery, Tharpe Quadrangle. Tennessee coordinates: 1,444,600E; 814,400N.

REPRESENTATIVE SECTIONS OF THE FORT PAYNE CHERT, WARSAW LIMESTONE, AND ST. LOUIS LIMESTONE