Age and Correlation of the Chattanooga Shale and the Maury Formation

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By WILBERT H. HASS

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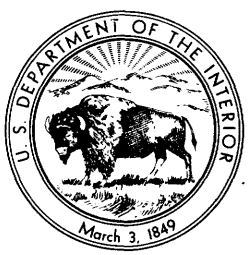
A contribution to the Devonian and Mississippian black-shale problem, based on conodont studies



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CONTENTS

ILLUSTRATIONS

[Pl. 1, in pocket; pls. 2–5 follow index]

TABLES

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By WILBERT H. HASS

ABSTRACT

The Chattanooga shale and the overlying Maury formation of central Tennessee and adjacent States belong to the Devonian and Mississippian black-shale sequence. This sequence occurs throughout much of the interior of the United States and a part of Canada.

The Chattanooga shale is herein considered to be of Late Devonian age though the oldest beds of the formation could be of late Middle Devonian age. The Maury formation is herein considered to be of Mississippian (Kinderhook and possibly Osage) age with one exception—in a part of north-central Tennessee the basal bed of the Maury is classified as very late Devonian. The age designations, faunal zonations, and correlations of the paper are based, for the most part, on a study of the conodonts in 325 collections from 65 measured sections; conodonts in 186 collections from 27 of the measured sections are mentioned by number.

The Chattanooga shale has three members: the Hardin sandstone, the Dowelltown, and the Gassaway (youngest). The Hardin sandstone member grades into the overlying Dowelltown member. It is a local thickening of the basal sandstone bed of the Chattanooga shale, and is restricted to the vicinity of Wayne, Perry, Lawrence, and Hardin Counties, Tenn., and to the adjoining part of Alabama. The Hardin consists chiefly of siliceous fine-grained sand and silt, and is as much as 16 feet thick. It is herein classified as early Late Devonian though some part of the member could be late Middle Devonian.

The basal sandstone bed of the Chattanooga shale commonly ranges in thickness from a featheredge to about 0.5 foot, though, as stated above, to the southwest of the Nashville Basin, it is thicker and is there called the Hardin sandstone member. This basal sandstone is a transgressive deposit, for in some areas it is a part of the Dowelltown member and elsewhere, where the Dowelltown is absent, it is a part of the Gassaway member. Along the Eastern Highland Rim where it is a part of the Dowelltown member, the basal sandstone contains early Late Devonian conodonts like those in the lowermost part of the New Albany shale of Indiana and the "conodont bed" of the Genundewa limestone lentil of the Geneseo shale of New York; but where the older beds of the Chattanooga shale are missing, as, for example, near the crest of the Cincinnati anticline, and in south-central Tennessee and north-central Alabama, the basal sandstone contains younger Late Devonian conodonts.

Good sections of the Chattanooga shale are exposed along the Eastern Highland Rim of central Tennessee from southern Jackson County south into Coffee and Bedford Counties. Throughout much of that area the formation is between 25 and 35 feet thick and its subdivisions—the Gassaway and the Dowelltown members—are well developed. In the above-mentioned area of the Eastern Highland Rim, the Dowelltown is between 10 and 17.5 feet thick and consists of two persistent lithologic units: a lower one which is predominantly black shale, and an upper one which is primarily a grayish mudstone, near the top of which occurs a bentonite bed, about 0.1 foot thick. This bentonite bed is probably present throughout at least 4,000 square miles of east-central Tennessee. Along the outcrop, northward from southern Jackson County—except in the Flynn Creek structure—the Dowelltown is probably less than 10 feet thick. Also, it wedges out southward in the Sequatchie Valley of eastern Tennessee and has not been recognized in south-central Tennessee or in north-central Alabama. On the west flank of the Cincinnati anticline the Dowelltown is commonly a sandy black shale, and is as much as 17 feet thick. At Olive Hill, Hardin County, where its relationships to the Hardin sandstone member are evident, the Dowelltown is 31.8 feet thick. The Dowelltown is assigned by the writer to the Upper Devonian Finger Lakes, Chemung, and basal Cassadaga stages of Cooper (Cooper and others, 1942); however, its basal beds may belong to the uppermost part of the Middle Devonian.

The Gassaway member is chiefly a thin-bedded, grayish-black shale, though along a part of the Eastern Highland Rim, it can be subdivided into two black-shale units and an intervening thin zone consisting of gray mudstone and black shale. The member is between 12 and 21 feet thick along the Eastern Highland Rim but is thinner in south-central Tennessee and north-central Alabama. It is absent throughout most of Lawrence County, Tenn. and parts of the adjacent counties; on the other hand, it is at least 46.4 feet thick in south-central Kentucky. Phosphatic nodules occur in the youngest beds of the Gassaway member. These nodule-bearing beds range in thickness from a featheredge in DeKalb County, Tenn., to more than 8 feet in the vicinity of Somerset, Pulaski County, Ky.

The Gassaway member contains two distinct conodont faunas. The older fauna ranges throughout most of the Gassaway interval and its widespread occurrence indicates that during some part of Gassaway time, deposition of sediments took place throughout most of the central Tennessee area. Beds having this older fauna are correlated with the lower part of the Ohio shale of Ohio and Kentucky; the Antrim shale as exposed in the Paxton shale pit west of Alpena, Mich.; the major part of the middle division of the New Albany shale of Indiana; a faunal zone of the middle division of the Arkansas novaculite of Arkansas and Oklahoma; a faunal zone of the Woodford chert of Oklahoma; and a faunal zone that ranges throughout most of the Chattanooga shale of northeastern Oklahoma. All these formations or parts of formations are classified as Late Devonian.

The Chattanooga shale and the Maury formation probably are separated by an unconformity throughout much of south-central Tennessee and north-central Alabama for, there, the youngest beds of the Gassaway member have not been recognized. These youngest beds have phosphatic nodules and conodonts like those in the upper part of the Upper Devonian

Ohio shale of Ohio and Kentucky, and in that part of the Sanderson formation of Campbell (1946) which, at the type locality of the Sanderson, near New Albany, Ind. contains phosphatic nodules and directly underlies Campbell's Falling Run member of his Sanderson formation. The present writer classifies the Falling Run member as early Mississippian (Kinderhook) and the underlying beds of the type Sanderson as Late Devonian.

The Maury formation is a well-defined lithologic unit wherever it underlies the Fort Payne chert but its top is indefinite wherever it underlies beds identified in the literature as the Ridgetop shale and the New Providence shale. The formation is generally 1.5 to 3.0 feet thick and consists for the most part of grayish-yellow, green, and greenish-gray, glauconitic mudstones. Phosphatic nodules are commonly scattered throughout the Maury and at many localities also occur as a course or bed at or near the base of the formation. In a part of north-central Tennessee this nodule bed contains Late Devonian conodonts like those in the youngest beds of the Gassaway member of the Chattanooga shale, but elsewhere in central Tennessee, it contains early Mississippian (Kinderhook) conodonts. The phosphatic-nodule bed at the base of the New Providence shale of south-central Kentucky has a similar Mississippian conodont fauna and, therefore, the writer considers the Maury formation to be the biostratigraphic equivalent of the lower part of the New Providence shale.

There are several distinct conodont faunas in the Maury formation. In a part of north-central Tennessee, a thin grayish-black shale occurs just above the aforementioned basal phosphatic-nodule bed that contains Late Devonian conodonts. This black shale has an early Mississippian conodont fauna; but the conodonts that seem to range throughout most of the Maury formation are like those in the Sunbury shale of Ohio and Kentucky; the uppermost part of the New Albany shale of Indiana; the Bushberg sandstone member of the Sulphur Springs formation and the Hannibal shale, both of Missouri; beds near the top of the middle division of the Arkansas novaculite of Arkansas and Oklahoma; a faunal zone of the Woodford chert of Oklahoma; and a faunal zone of the Chattanooga shale of northeastern Oklahoma. All these formations or parts of formations are classified as Mississippian (Kinderhook). At some localities the Maury formation contains conodonts of late Kinderhook age and probably others of early Osage age.

INTRODUCTION

Because the Chattanooga shale of central Tennessee is a potential source of oil, uranium, and other materials, members of the United States Geological Survey have been investigating that formation. This report on the age and correlation of the Chattanooga shale and the Maury formation is a part of that study.

The Chattanooga shale, which, when first delimited by Hayes (1891, 1892, 1894a, 1894b, 1894c, 1894d, 1895), included the beds herein called the Maury formation, is a part of the Devonian and Mississippian black-shale sequence. This sequence is present throughout much of the interior of the United States and a part of Canada. It varies in age from place to place and is known by many different names; usually, the oldest beds are considered to be of late Middle Devonian age and the youngest, of early Mississippian age. Numerous papers have been written on the age and correlation of these beds but much of the record is incorrect because it is based on inadequate data, for the black shales do not contain—except at a few widely spaced localities—the fossils commonly used in stratigraphic paleontology. Instead, the recognizable fauna and flora consist chiefly of inarticulate brachiopods, a few arthropods, fish remains, conodonts, and plant fragments and spores. Of these, conodonts are the best fossils on which to base an age determination or correlation. In central Tennessee the black shales unconformably overlie beds of Ordovician, Silurian, and Devonian ages and underlie beds of Mississippian age.

This report is based on a study of conodonts in 325 collections from 65 measured sections. However, in order to avoid a great duplication of data, only 186 of these collections from 27 of the measured sections are mentioned by number in the report. The stratigraphic position of each collection has been referred either to the Chattanooga shale–Maury formation contact or to the Chattanooga shale–New Providence shale contact. Conodonts in most of the 186 collections are listed either in table 7 or in table 8; and the localities from which the collections came are indicated in plate 1. Locality data are given on pages 26 to 38, and information pertaining to individual collections is listed on pages 38 to 43. Some of the conodonts considered significant in determining the age and correlation of the Chattanooga shale and the Maury formation are illustrated in plates 2–4, and their stratigraphic range in the Chattanooga shale of the Eastern Highland Rim of central Tennessee is recorded in figure 1. All specimens illustrated in this paper have been deposited in the United States National Museum. Locality numbers are the same as those used by L. C. Conant and V. E. Swanson in a paper they are now preparing on the Chattanooga shale.

Many conodonts that belong chiefly to the bladelike and barlike genera have been disregarded because the species of these genera are not easily differentiated. Molds of conodonts are common in the black shales, and rubber replicas were made of many such specimens as an aid to their identification.

The stratigraphic classification used in this paper was agreed upon during a field conference held May 4 to 7, 1952, in central Tennessee between P. E. Cloud, Jr., J. S. Williams, L. C. Conant, V. E. Swanson, and the writer. The classification follows:

Mississippian:

Maury formation: throughout much of the area the basal bed of the Maury contains many phosphatic nodules. This nodule bed is classified as early Mississippian except in a part of north-central Tennessee where it is probably of very late Devonian age.

Upper Devonian:
  Chattanooga shale:
    Gassaway member
    Dowelltown member
    Hardin sandstone member

Field work was begun in June 1944 when A. L. Slaughter, S. E. Clabaugh, and the writer did reconnaissance work on the Devonian and Mississippian black shales of the eastern United States. Outcrops in central Tennessee—at Horseshoe Bend on the Caney Fork in White County (locality 88) and in the Flynn Creek area of Jackson County (locality 54)—were measured and sampled, and it was partly through these investigations that the potentialities of the black shales in a part of the Eastern Highland Rim of Tennessee as a source of uranium became evident. During June 1947 the writer collected conodonts from some of the sections in central Tennessee and south-central Kentucky that Campbell (1946) listed in his paper on the New Albany shale; also, in June 1947, the writer (Hass, 1948) discovered a thin bed of bentonite in the upper part of the Dowelltown member of the Chattanooga shale. The type area of the Chattanooga shale was first studied by the writer (Hass, 1947b) during the summer of 1947.

In November 1947 the United States Geological Survey placed a party in central Tennessee for the purpose of investigating the Chattanooga shale for the Raw Materials Division of the Atomic Energy Commission. L. C. Conant was in charge of the investigation, and the writer, who was with the party intermittently, was responsible for the paleontologic and some of stratigraphic phases of the work. V. E. Swanson joined the party in June 1949 and worked mostly in the area between the Western Highland Rim of central Tennessee and the Tennessee River. He worked also in northwest Georgia, north Alabama, and northeast Mississippi. The following field men assisted in the measurement and interpretation of sections: R. C. Robeck, 1947–49; R. E. Smith, 1947–48; Andrew Brown, 1947–49; and W. A. Heck, 1948. Most of the collections were prepared in 1948 and 1949 by L. A. Shirley, W. M. Hisey, and Alford Rarick, all of whom were geology students at the University of Alabama.

PREVIOUS WORK

The literature on the age and correlation of the black-shale sequence of central Tennessee and nearby States contains many conflicting opinions. Witness, for example, some of the ideas that have been held:

Safford (1851) regarded the "Black or bituminous slate" of central Tennessee as one of his five major stratigraphic units. He assigned it to the Devonian but several years later he (1856, p. 148, 149) placed the "Black slate" in the Carboniferous as the lowest division of that system. Even so, Safford (1856, p. 158) mentioned in a footnote that the age of the "Black slate" is in doubt.

In his "Geology of Tennessee" Safford (1869, p. 150, 151) regarded the black shale as of Devonian age. He (1869, p. 330, 331) stated that to the west of the Cumberland tableland the "Black shale group" or "Black shale formation" consists of three parts, which from top to bottom are:

1. A thin bed of argillaceous, fetid, concretionary bodies commonly called "kidneys".
2. Black shale.
3. A dark-gray sandstone which is bituminous, fetid, and commonly fined grained. This sandstone was reported to range in thickness from a few inches to 15 feet and to form conspicuous ledges in Wayne, Hardin, and southwest Lewis Counties, Tenn.

The divisions of Safford's "Black shale group" have been recognized by subsequent workers, but, as indicated on the following pages, these divisions have been treated in various ways.

Killebrew and Safford (1874, p. 28, 39) briefly mentioned the "Black shale" of Tennessee. They assigned it to the Devonian "Hamilton period." And Smith (1878, p. 10, 11; 1890, p. 154, 155) who worked in Alabama considered the "Black shale" of that State to be of Devonian age.

The name "Chattanooga black shale" was proposed by Hayes (1891, p. 142, 143) as a substitute for Smith's (1878, p. 10, 11; 1890, p. 154, 155) and Safford's (1869, p. 330) nongeographic term "Black shale." It included the beds between the Rockwood formation of Silurian age and the Fort Payne chert of Carboniferous age. Hayes' (1892, 1894a, 1894b, 1894c, 1894d, 1895) "Chattanooga black shale" consists of two units: a lower black shale and an upper gray one which commonly contains a layer of round concretions. He placed the formation in the Devonian and designated the outcrop at the north end of Cameron Hill in Chattanooga, Tenn., as the type locality.

Safford and Killebrew (1900, p. 104) proposed a classification of the black-shale sequence that differed from previous ones. They used several new stratigraphic names:

Carboniferous:
  Mississippian or Subcarboniferous:
    Maury green shale (ball or kidney phosphate)
Devonian:
    Black shale (Chattanooga shale)
    Swan Creek phosphate
    Hardin sandstone

The Maury green shale of Safford and Killebrew (1900, p. 104, 141–143) is the top division of Safford's (1869) "Black shale group", and the gray-shale unit of Hayes' (1892, 1894a, 1894b, 1894c, 1894d, 1895) "Chattanooga black shale." The Maury was described as ranging from a few inches to 5 feet in thickness, as containing concretions of calcium phosphate, and as including the beds between the Tullahoma formation and the underlying "Black shale (Chattanooga shale)." It was named for Maury County. Safford and Killebrew (1900, p. 104, 138, 139) proposed the name "Swan Creek phosphate" for a phosphatic bed which they stated ranges from 10 to 50 inches in thickness in Lewis and Hickman Counties, Tenn., and from 1 to 10 inches, in the adjacent area. In the present paper the name "Swan Creek phosphate" is not used. The bed so identified by Safford and Killebrew is the basal sandstone of the Gassaway member. The Hardin sandstone of Safford and Killebrew (1900, p. 104, 137) is the lower division of Safford's (1869) "Black shale group."

Hayes and Ulrich's (1903) Chattanooga shale—which they also refer to as the "Chattanooga formation"—is the "Chattanooga black shale" of Hayes (1891). As so defined, their Chattanooga shale includes Safford and Killebrew's (1900) Maury green shale, Black shale (Chattanooga shale), Swan Creek phosphate, and Hardin sandstone. Hayes and Ulrich (1903, explanation of correlation table) classified the Chattanooga shale as Devonian, stating that it "seems to represent the whole of, and perhaps more than, the upper Devonian deposits of Pennsylvania and New York."

Ulrich (1905, p. 24, 25) suggested that the Devonian black shale should be called the Ohio shale because that name had priority over other geographic names including Chattanooga shale and New Albany shale. Also, he divided the Mississippian into two divisions of undesignated rank: the Tennessean, which included Chester and Meramec rocks, and the Waverlyan, which included Osage and Kinderhook rocks.

Grabau (1906, p. 612, 613) regarded the "Black shale" of the southern United States as

> a basal deposit—a residual soil of an ancient peneplain, very fine and very carbonaceous, and the result in many places of the solution of calcareous strata. [He believed that] this soil was worked over by the transgressing Mississippian sea, which rearranged it, washed it from the higher points, and collected it in greater thickness in the depressions of the old peneplain. As the water deepened, deposition of calcareous shales or of limestones followed, the transition being a perfect one—sometimes gradual, sometimes abrupt.

Grabau held that the name Ohio shale—of Late Devonian age—could not be used for the transgressive "Black shale" of the southern United States. He suggested that the name "Chattanooga shale" might be used if it were "dissociated from the idea of any definite age relations."

In 1911 Ulrich proposed a new classification of the Paleozoic. In this classification Mississippian rocks were assigned either to the Tennessean system, which included those of Meramec and Chester ages, or to the Waverlyan system, which included those of Kinderhook and Osage ages. Ulrich refused to accept such stratigraphic concepts as facies faunas and lithofacies; moreover he was of the opinion that the geologic systems should be delimited by widespread pronounced unconformities. Because of these views, Ulrich proposed that a new series—the Chattanoogan—be inserted into the Waverlyan system below the Kinderhookian. The general time scale of the Waverlyan according to Ulrich (1911, pl. 29) and the formations in middle Tennessee assigned to that system follow:

General time scale	*Middle Tennessee formations*	
Waverlyan:		
Osagian:		
Keokuk	Tullahoma of Hayes and Ulrich	Fort Payne chert
Late Burlington		
Early Burlington		
Fern Glen		New Providence shale
Kinderhookian:		
Chouteau		
Hannibal		
Glen Park		
Louisiana		Ridgetop shale
Chattanoogan:		
Sunbury	Chattanooga	Maury shale
Berea		Black shale
Bedford		
Cleveland		Hardin sandstone

By 1911 Ulrich's (1911, p. 426) studies had led him to believe that much of the black-shale sequence of the interior of the United States is post-Devonian, for, with the exception of "the lower part of the 'New Albany shale,' which is probably of Devonian age," he knew of no deposits of unquestionable Late Devonian age in Kentucky, Tennessee, Arkansas, or Oklahoma.

In 1911 Bassler (1911, p. 214) also considered the Chattanooga shale and its thin basal sandstone—identified as the Hardin sandstone member—as the first post-Devonian deposit of central Tennessee. The basal sandstone was reported to contain reworked silicified fossils of Ordovician, Silurian, and Devonian ages in addition to many specimens of fish teeth and conodonts that Bassler thought are like those that Newberry (1875) had found in the Cleveland shale of Ohio. A similar conodont fauna was believed (Bassler, 1911, p. 214) to be present in the black-shale portion of the Chattanooga shale.

Bassler believed that two Tennessee formations of Waverlyan age had been deposited in a number of closely spaced embayments. He (Bassler, 1911, p.

216) proposed the name "Ridgetop shale" for the older formation and designated the outcrops along the Louisville and Nashville Railroad between Bakers in Davidson County and Ridgetop in Robertson County as the type locality. The Ridgetop shale according to Bassler (1911, p. 223) is early Kinderhookian.

The New Providence shale is the other Waverlyan formation that Bassler believed was deposited in a number of embayments. He (1911, p. 218–220, 223) was of the opinion that the formation is early Osagian and regarded the exposures at Whites Creek Springs (Crocker Springs), Davidson County, Tenn., as the most "important Waverlyan section of Tennessee."

Kindle (1912b) believed that it is possible to have different contemporaneous faunas and distinct lithofacies represented in the rocks of the same basin of deposition; and instead of accepting the idea that the Chattanooga shale is Mississippian because it is separated from the underlying rocks by a widespread unconformity, Kindle placed most of the black-shale sequence of the eastern United States in the Devonian. According to Kindle (1912a, p. 136) the hiatus at the base of the Chattanooga shale represents the early Genesee, the late Hamilton, or both.

Kindle (1912a, p. 130–135) believed that so far as the Chattanooga shale is concerned, Bassler's (1911) paper on "The Waverlyan period of Tennessee" can be reduced to the following three propositions:

1. The Chattanooga shale of central Tennessee is distinct from the black shales designated as the Chattanooga shale in the U. S. Geological Survey folios of eastern Tennessee. Kindle rejected this proposition; he regarded the black shales of central and eastern Tennessee as correlatives and as Devonian in age. His opinion was based on his finding identical conodont faunas in the shales of the two areas.

2. The Chattanooga shale is a correlative of the Cleveland shale of Ohio. Kindle did not take issue with this proposition, but stated that, in his opinion, the Chattanooga shale is probably a correlative not only of the Cleveland shale of Ohio but also "of much of the remainder of the Ohio shale as well."

3. The Cleveland shale of Ohio is of Waverlyan age. Kindle disagreed with this proposition. According to Kindle, the evidence, submitted by Newberry and restated by Bassler, in support of a Waverlyan age for the Cleveland shale is incorrect. That age designation was based in part on the reported presence of Carboniferous fishes in the Cleveland shale; but, according to Kindle, such fishes have not been found by subsequent workers. Instead, Kindle claimed some of the Cleveland fishes are similar to those present in rocks of accepted Devonian age. As for the conodont fauna of the Cleveland shale, which Bassler claimed is also in the Chattanooga shale of central Tennessee, Kindle stated that the recorded evidence indicated a Devonian age.

Ulrich (1912, p. 157, 162, 164) regarded diastrophism as the ultimate basis for the division of the geologic column into systems. He clarified his stand on the time-stratigraphic limits of the Chattanoogan series, stating that the Cleveland shale, as previously delimited by him, consists of the Cleveland shale, Olmsted shale, and Huron shale of other authors—that is, the Chattanoogan series embraces the formations from the base of the Huron shale to the top of the Sunbury shale. These formations and their correlatives in Tennessee, according to Ulrich, are given below.

General time scale	*Ohio section*	*Tennessee section*
Waverlyan:		
Osagian		
Kinderhookian		
Chattanoogan:		
Sunbury	Sunbury shale	Sunbury shale equivalent
Berea	Berea sandstone	
Bedford	Bedford shale	?
Cleveland	Cleveland shale	
Olmsted	Olmsted shale	
Huron	Huron shale	Cleveland shale equivalent
Devonian:		
Neodevonian:		
Chemung	Chagrin formation	
Portage	(? break)	
Genesee	? Genesee shale	

Chattanooga shale

Ulrich (1912, p. 158) did not believe that the Cleveland-Olmsted-Huron sequence could be a black lithofacies which grades eastward into the gray, Upper Devonian, Chagrin shale—a view held at least in part by many geologists, including Prosser (1912, p. 515–518), Kindle (1912b), Kindle (*in* Prosser, 1912, p. 518), and G. A. Cooper (Cooper and others, 1942, p. 1764). Instead, Ulrich (1912, p. 159, 166) held that the Cleveland-Olmsted-Huron sequence wedges out eastward on top of the Chagrin shale which in turn wedges out westward. The wedging out in different directions of these two rock sequences was due, in Ulrich's

opinion (1912, p. 159), to a tilting of the North American Continent; this tilting permitted the sea to invade the Continent from the north-middle-Atlantic area in the Late Devonian and from the Gulf of Mexico in Chattanoogan time. Ulrich (1912, p. 158) believed that there is a close and undeniable similarity in the conodont and fish faunas of the Cleveland shale and the Huron shale—faunas which, he claimed, are quite unlike those "in the supposed intervening Chagrin shale." However, his opinion regarding the close similarity of the conodont faunas of the Cleveland shale and the Huron shale is open to question. The writer (Hass, 1947a) has studied the conodont faunas of these two shales and has found them to be dissimilar.

According to Ulrich (1912, p. 170, 171)

> In Tennessee, more particularly in the west middle part of the state, a . . . [time] break is indicated by the Maury shale, a thin glauconite bed often filled with phosphatized concretions, that probably represents surficial decomposition and subsequent recementation. This layer was referred to the top of the Chattanooga by Hayes and Ulrich [1903], which is correct if we consider chiefly the origin of its material. But if the date of its recementation and the fact that its top includes both reworked and transported material is brought into the foreground, the layer becomes debatable ground. On the latter grounds, I [Ulrich] take it, Safford [and Killebrew, [1900], and more recently Bassler [1911], have classified the Maury shale as post-Chattanoogan.

Ulrich did not favor this classification. On practical grounds he preferred to place the Maury green shale of Safford and Killebrew (1900) in the Chattanooga shale, instead of regarding it as the recemented basal deposit of the immediately overlying formation. Otherwise, he claimed, the age of the Maury, even in the same general area, would differ from outcrop to outcrop. For example, where directly overlain by the Ridgetop shale, the recemented Maury would be of early Kinderhook age; where directly overlain by the New Providence shale, it would be of early Osage age; and where directly overlain by the Fort Payne chert, it would be of late Osage age.

To Ulrich (1912, p. 162) the term "Chattanooga shale" as used by many of his contemporaries refers to the entire black-shale sequence present "between the middle Devonian and the first limy or sandy beds of the Mississippian." In Ulrich's opinion, the following two distinct groups of black shales are present within this interval:

1. A younger group of Waverlyan age, which includes the Chattanooga shale of the middle Tennessee area.
2. An older group of Devonian age, of which the Genesee segment is the most important.

Although Ulrich (1912, p. 164, 166, 167) believed that representatives of both groups are probably in Kentucky, he was of the opinion that only the upper part of the younger group (Cleveland shale and Sunbury shale equivalents) is in central Tennessee. The Hardin sandstone was considered to be the transgressive basal bed of the Chattanooga shale.

Drake (1914), in his paper on the economic geology of the Waynesboro quadrangle in Tennessee considered the Chattanooga shale and the Hardin sandstone member to be of Late Devonian age. He referred to the Maury green shale of Safford and Killebrew (1900) as the Maury glauconitic member of the Ridgetop shale and believed it rested unconformably upon either the Chattanooga shale or the Hardin sandstone member.

In 1915, Ulrich (1915, p. 96–99) stated that his "Chattanoogan is approximately contemporaneous with the Kinderhookian series." The presence of a widespread unconformity beneath the Chattanooga shale was cited as evidence for placing that formation in the Mississippian. Also, he regarded the Ridgetop shale of Tennessee as of late Kinderhook age—rather than early, as previously held—and stated that inasmuch as the Ridgetop grades into the underlying Chattanooga shale, the latter formation is inferred to be "at least in part, of early Mississippian age."

Shaw and Mather (1919, p. 48–51) reported on the Chattanooga shale in Allen County, Ky. In their paper, the shale was classified as Devonian. They published a paleontological report by Ulrich, who stated that the fossils from an upper horizon of the Chattanooga shale indicate an early Mississippian (Berea "grit" and Sunbury shale) age, and those from a lower horizon indicate a possible "late Devonian but more probably [a] very early Mississippian (Cleveland shale) age." Ulrich identified *Lingula* cf. *L. subspatulata* [probably = *Barroisella campbelli* Cooper], *?Pseudobornia*, *"Sporangites huronensis"* [*Tasmanites huronensis* (Dawson)], and conodonts in a collection from the lower part of the Chattanooga shale; and *Lingula melie*, *Orbiculoidea newberryi*, and conodonts in collections from the upper part of the shale. He also reported on some fossils that were collected by Wallace Lee and Mather from a thin conglomeratic sandstone at an exposure on "Bledsoe Creek, 2 or 3 miles north of Bransford," Sumner County, Tenn. (See Mather, 1920, p. 19, 20.) This sandstone is Campbell's (1946) Bransford sandstone member of his Gassaway formation. Ulrich recognized some fish bones and teeth, including a *Cladodus* tooth, and two species of *Lingula* in the collection from the sandstone in addition to conodonts which he stated are like those "commonly found in the Cleveland shale in Ohio, in the lower and middle parts of the Chattanooga shale in the Appalachian region, and in the phosphatic basal deposit of the same formation in central Tennessee." He suggested that the sandstone might represent a part of the Berea sandstone of Ohio.

Shaw and Mather's report on Allen County, Ky., was followed by Mather's (1920) paper on an adjoining area in Sumner County, Tenn. In Mather's paper the Chattanooga shale was officially classified by the United States Geological Survey and the State Geological Survey of Tennessee as Devonian or Carboniferous; but Mather (1920, p. 19) personally considered the Chattanooga shale of northern Tennessee and southern Kentucky to be of early Mississippian age. He stated that the black-shale sequence consists of two divisions or formations: "the lower of these formations may be of Devonian age, but the upper, in the writer's [Mather's] opinion, must be considered Mississippian."

Miser (1921, p. 16, 23, 24) classified the Chattanooga shale as Devonian or Carboniferous. He considered the Hardin sandstone to be a member of the Chattanooga shale and placed the Maury glauconitic member of the Ridgetop shale in the Carboniferous.

Swartz (1924, p. 24) proposed the name "Glendale shale" for "a thin, hard, gray shale crowded with *Lingula melie*" that overlies the Chattanooga shale and underlies the Fort Payne chert in the vicinity of Chattanooga, Tenn. The Glendale shale of Swartz is considered herein to be the upper division of Hayes' (1891, 1892, 1894a, 1894b, 1984c, 1894d, 1895) "Chattanooga black shale," and the Maury green shale of Safford and Killebrew (1900). Swartz, however, was of the opinion that his Glendale shale consists of beds which, prior to his work, had been included in the Fort Payne chert. He correlated his Glendale with the lower part of the Cuyahoga shale of Ohio; this correlation was based on the presence in both formations of numerous phosphatic brachiopods, identified as *Lingula melie*. He (1924, p. 24–26) regarded an exposure near Apison, Tenn., as important for determining the age and correlatives of the Chattanooga shale. His section is given below:

Ft. Payne chert.	Feet	Inches
Hard gray shale, full of concretions, becoming much darker towards the base. From 4 to 6 inches above the base are found *Lingula melie* abundant	2	11
Black shale	2	10½
Light to somewhat dark gray clay shale, containing, about 6 inches above the base, *Lingula irvinensis*, *Orbiculoidea ovata* var. *transversa* n. var., *Schuchertella* sp., *Rhipidomella* sp., *Chonetes acutiliratus* Girty, and a poorly preserved rhynchonelliform brachiopod	1	10
Black shale	10	8
Very argillaceous sandstone		4
Rockwood formation: gray, greenish, and buff arenaceous shale and argillaceous sandstone.		

Swartz's (1924, p. 25, 26) remarks on the Apison section follow:

> The fossiliferous gray shale of the above section furnishes the key to the situation. *Chonetes acutiliratus* Girty (in manuscript) was originally described from the Bedford shale of Ohio. The *Rhipidomella* sp. is very similar to if not identical with a form from the Bedford shale of Ohio also being described by Girty. *Lingula irvinensis* was originally described from the Bedford-Berea shale of Indian Fields, Kentucky. Both the fossils and lithology serve to identify it with the Bedford-Berea wedge traced to east central Kentucky by Morse and Foerste in 1909. This correlation is further strengthened by its position between two black shales.
>
> Swartz also wrote that the black shale immediately overlying the above-mentioned gray fossiliferous shale contains [the] abundant and characteristic *Lingula melie*. This fact, together with its position above a gray shale containing a Bedford-Berea fauna, and below a second gray shale which appears to represent the lower part of the Cuyahoga shale of Ohio, makes highly probable its correlation with the Sunbury shale of Ohio. The stratigraphic succession would also appear to demand the correlation of the lower black shale with the Cleveland shale of the Ohio section.

Swartz (1924, p. 26) also investigated the type locality of the Chattanooga shale at the north end of Cameron Hill in Chattanooga, Tenn. His section is given below:

Ft. Payne chert.	Feet	Inches
Glendale shale: hard gray shale with some concretions toward the base	2	4
Black shale		⅜
Mottled brown and gray shale		0–9
Black shale	8	0
Concealed.		

He (Swartz, 1924, p. 26) commented that

> Although no fossils were found in it, it is thought that the mottled shale probably represents the Bedford-Berea interval. In that event the overlying ⅜ inch black shale is all that is left of the Sunbury shale of the Apison section. The main mass of the shale at the type locality is thus of Cleveland age.

As for the Maury shale of central and western Tennessee, Swartz (1924, p. 28, 29) stated that it is separated from the Chattanooga shale by "a marked unconformity" and that it is older in central Tennessee where, at Eulie, Sumner County [sic] it contains fossils of Hamburg öolite age, than in western Tennessee where, at Linden, Perry County, it contains "in addition to Ridgetop forms, a number of species hitherto known only from the basal Ft. Payne chert."

Ulrich and Bassler (1926) published a descriptive paper on the conodont faunas of two formations: the Rhinestreet shale (=Attica shale of Chadwick, 1923) at Shaletown, Erie County, N. Y., and the basal sandstone of the Chattanooga shale at Mount Pleasant, Maury County, Tenn. (vicinity of locality 154 of present paper), which they considered to be the Hardin sandstone. The paleontologic data published by Ulrich and Bassler are intended to support their opinion that two groups of beds are involved in the black-shale

problem: an older group of Devonian age and a younger one, which includes the Chattanooga shale, of early Mississippian age. Among the conodonts Ulrich and Bassler (1926) described from the basal sandstone at Mount Pleasant, Tenn., the following are regarded by the present writer to be characteristic of the Upper Devonian Gassaway member of the Chattanooga shale (fig. 1):

Names used in present paper	*Names used by Ulrich and Bassler, 1926*
Ancyrognathus bifurcata (Ulrich and Bassler)	*Palmatolepis bifurcata* Ulrich and Bassler
Palmatolepis glabra Ulrich and Bassler	*Palmatolepis glaber* Ulrich and Bassler
Palmatolepis perlobata Ulrich and Bassler	*Palmatolepis perlobata* Ulrich and Bassler *Palmatolepis extralobata* Ulrich and Bassler *Palmatolepis peculiaris* Ulrich and Bassler
Polylophodonta confluens (Ulrich and Bassler)	*Polygnathus confluens* Ulrich and Bassler

Ulrich and Bassler's Rhinestreet shale (=Attica shale of Chadwick, 1923) conodont fauna includes *Prioniodus alatus* Hinde. This species is in the lowermost beds of the Upper Devonian Dowelltown member of the Chattanooga shale.

In Butts' (1926) paper, the Chattanooga shale of Alabama was officially classified by the United States Geological Survey and the Geological Survey of Alabama as Devonian or Carboniferous. Butts (1926, p. 161), however, classified the Chattanooga shale of southwestern Tennessee and Alabama as Mississippian and correlated it with the Sunbury shale of Ohio; however, the explanation of plate 48 of his paper states that the black-shale fossils illustrated on that plate occur in the Cleveland shale as well as in the Sunbury shale. Butts' conodonts were collected at Quicks Mill, about 4 miles west of New Market, Madison County, Ala. (locality 127 of present paper). Among those he illustrated are *Ancyrognathus bifurcata* (Ulrich and Bassler), *Palmatodella delicatula* Bassler, and *Polylophodonta confluens* (Ulrich and Bassler). These conodonts have not been found by the present writer in either the Cleveland member of the Ohio shale (formerly Cleveland shale) or the Sunbury shale, but they have been found by him in the Huron member of the Ohio shale. The conodonts illustrated by Butts (1926) were later described and figured by Holmes (1928).

Swartz (1927) reported on the black-shale sequence of eastern Tennessee and the adjacent part of Virginia. He considered his Chattanooga shale of that area—which corresponds to the upper black-shale unit of Campbell's (1894) "Chattanooga black shale" and to the Big Stone Gap shale of Stose (1923)—to be partly of Devonian and partly of Mississippian age and divided it into an upper and a lower black shale and a middle gray shale. Swartz proposed the following names for his divisions:

Big Stone Gap member (youngest)
Olinger member
Cumberland Gap member (oldest)

Swartz also held (1927, p. 494, 499) that the name Big Stone Gap shale of Stose (1923) must be abandoned, because it refers to beds considered by Swartz to be the exact equivalent of the Chattanooga shale of the type area. However, believing that Stose's name should be preserved, Swartz (1927, p. 494) proposed that it be redefined so as to apply only to the upper member of Swartz's Chattanooga shale. According to Swartz (1927, p. 498) a well-marked unconformity separates his Big Stone Gap member from his Olinger member throughout southeastern Tennessee; he (1927, p. 497) also stated that his "Olinger member was deposited concomitantly with the upper part of the Cumberland Gap member."

In discussing the sections he published in 1924, Swartz (1927) stated that all three members of his Chattanooga shale are at the type locality of the formation on Cameron Hill as well as at the locality near Apison. His assignment of the beds at these two localities follows:

Type locality of Chattanooga shale, north end of Cameron Hill, Chattanooga, Hamilton County, Tenn.

[Swartz, 1927, p. 486, modified by present writer]

Chattanooga shale:	*Feet*	*Inches*
Big Stone Gap member:		
Black shale	0	⅜
Unconformity.		
Olinger member:		
Gray clay shale		0–9
Cumberland Gap member:		
Black shale	8	0

Section near Apison, approximately 16 miles east of Chattanooga, Hamilton County, Tenn.

[Swartz, 1927, p. 485, modified by present writer]

Chattanooga shale:	*Feet*	*Inches*
Big Stone Gap member:		
Black shale with *Lingula melie*	2	10½
Unconformity.		
Olinger member:		
Gray clay shale with *Lingula irvinensis, Rhipidomella* sp., and abundant *Chonetes acutiliratus*?	1	10
Cumberland Gap member:		
Black shale	10	8

Holmes (1928) described a conodont fauna from the Chattanooga shale at Quicks Mill, Madison County, Ala. (locality 127 of present paper). She regarded the Chattanooga shale as of Mississippian age. Among

the conodonts she described, the writer of this paper regards the following species as characteristic of the Upper Devonian Gassaway member of the Chattanooga shale (fig. 1):

Names used in present paper	*Names used by Holmes, 1928*
Palmatolepis glabra Ulrich and Bassler	*Palmatolepis elongata* Holmes
Palmatolepis perlobata Ulrich and Bassler	*Palmatolepis perlobata* Ulrich and Bassler
Polylophodonta confluens Ulrich and Bassler	*Polygnathus gyratilineata* Holmes *Polygnathus pergyrata* Holmes *Polygnathus trilobata* Holmes *Polygnathus concentrica* Ulrich and Bassler *Polygnathus rhomboidea* Ulrich and Bassler
Ancyrognathus bifurcata (Ulrich and Bassler)	*Palmatolepis inequalis* Holmes
Palmatodella delicatula Bassler	*Palmatodella delicatula* Ulrich and Bassler

Morse (1928) named the black-shale sequence of northeast Mississippi the Whetstone Branch shale. This formation was described as consisting chiefly of black shale together with some sandy shales and a few sandstones. Morse (1928, p. 36) found *Lingula* sp., *Tentaculites* sp., and other fossils in the shale and concluded that

> because of the fossils, and especially because of its unconformable relation to other beds of more definite age, the Whetstone Branch formation is referred to the Devonian. It belongs, therefore, to the lower and greater part of the Chattanooga shale of the type locality.

Swartz later (1929) reported more fully on the Chattanooga shale of northeastern Tennessee and the adjacent part of Virginia, and (1929, p. 447, 448) concluded [1] that

> *the Chattanooga shale in Tennessee and Virginia, with the possible exception of the lower part of the Cumberland Gap member, is Mississippian throughout.*
>
> This is especially true in the type area about Chattanooga where the Cumberland Gap member, which there comprises almost the entire Chattanooga shale, is represented by its upper part only, the part which intertongues with the Mississippian Olinger member.

Savage (1930) identified the black-shale sequence of Kentucky with the New Albany shale. He (1930, p. 16–21) listed some of the fossils in the black shales and stated that these fossils indicate a Late Devonian (Tully and Genesee) age.

Pohl (1930a, p. 62) considered some of the black shales of northern Tennessee to be of Genesee age, but stated that "because of the unestablished relations of the Genesee equivalent in Tennessee the name Trousdale shale is here tentatively proposed for" these shales. Later, he (1930b, p. 152) suggested a correlation of the Trousdale with the "Genesee-Portage black shales of the northeastern Devonian." Pohl (1930b, p. 151) also stated that the term "Chattanooga shale" cannot be used to refer to the entire black-shale sequence because the type Chattanooga shale, according to Swartz, is Mississippian. He, therefore, proposed to restrict the name "Chattanooga shale" to deposits of "post-Devonian–pre-Osage" age.

Pohl's (1930b) classification of the black-shale sequence of central Tennessee follows:

Mississippian:
- Kinderhookian:
  - Chattanooga shale (widespread occurrence):
    - Upper black shale; a correlative of the Sunbury shale of Ohio and Kentucky.
    - Widespread unconformity representing the Berea sandstone and Bedford shale interval of Ohio and Kentucky.
    - Lower black shale; a correlative of the Cleveland shale of Ohio and Kentucky.

Upper Devonian:
- Trousdale shale (local occurrence): a correlative of Genesee and Portage rocks of the northeastern States.

Morse (1930) published a second paper on the black shale of northeast Mississippi. Previously he (1928) had named this shale, the Whetstone Branch shale, had correlated it with a part of the Chattanooga shale, and had classified it as Devonian. Morse's conclusions were based partly on fossils—which include *Tentaculites*—and partly on the supposed presence of an important widespread unconformity at the top of the Whetstone Branch shale. Morse (1928) named the overlying formation the Carmack limestone and considered it to be of Mississippian age. He (1930, p. 72) stated that the basal foot of his Carmack limestone consists "of long flat shalelike pebbles in a dark matrix of oolitic and green sand texture. Some of the larger rounded masses may be concretions instead of pebbles, and some of them give the test for phosphate." This description suggests that the basal bed of the Carmack limestone of Morse is the upper division of Safford's (1869) black-shale sequence, the upper unit of Hayes' (1891, 1892, 1894a, 1894b, 1894c, 1894d, 1895) "Chattanooga black shale," and the Maury green shale of Safford and Killebrew (1900).

Jewell (1931, p. 22, 37), because of his work in Hardin County, Tenn., considered the "Chattanooga formation" to be of Mississippian age and to consist of the Maury glauconitic member at the top, a Black shale member, and the Hardin sandstone member at the base. He (1931, p. 38) held that the Chattanooga is set off by unconformities from the adjacent formations and regarded the break at the base of the Chattanooga

[1] The italics are Swartz's.

as more important than the one at the top. Jewell (1931, p. 41) placed the Maury glauconitic member in the "Chattanooga formation" instead of in the overlying Ridgetop shale because to him the Maury seems to be absent throughout most of Hardin County. Jewell argued that if the Maury were the basal bed of the Ridgetop shale, its geographic distribution should conform closely with that of the Ridgetop shale.

As a result of their work in south-central Kentucky, Savage and Sutton (1931) considered the black-shale sequence of that State to be chiefly of Late Devonian age, though partly of early Mississippian (Kinderhook) age. In their opinion the Upper Devonian portion is widespread in its occurrence; it contains beds of Tully and Genesee ages and, in addition, may include younger Devonian beds. They stated that in south-central Kentucky the Mississippian portion of the black-shale sequence—which contains megafossils—is restricted in its occurrence and lies unconformably upon the Devonian black shales.

In 1932, in keeping with the philosophical concepts expressed in his 1911 paper, Bassler stated (1932, p. 7) "that many of the important formations [in central Tennessee] are restricted to small areas and . . . thin out along the old shore lines instead of passing laterally into different rock types holding distinct fossils." In the same paper (1932, p. 136 passim) he also classified the Chattanooga shale and the Hardin sandstone member in the areas he mapped as lowermost Mississippian and placed both stratigraphic units in the "Chattanooga group." He (1932, p. 143) believed that the "Maury green shale" represents the introductory stage of whatever formation directly overlies it—that is, at some localities, as at Bakers Station, Davidson County (Bassler, 1932, p. 140), the Maury is in the basal Ridgetop shale and is of Kinderhook age; at other localities, as at Whites Creek Springs (Crocker Springs), Davidson County (1932, p. 147), it is in the basal New Providence shale and is of early Osage age; and at still other localities (1932, p. 179), it is in the basal Fort Payne chert and is of late Osage age. Bassler further mentioned (1932, p. 133) that "in northern Tennessee the lower part of the Black shale is separated from the upper by a well-marked unconformity and, moreover, contains Devonian fossils. This Devonian part of the shale does not apparently extend southward over the Nashville Dome to any great distance." On figure 4 of Bassler's (1932) paper, this Devonian black shale is called the "Chattanooga shale (lower)" in order to distinguish it from his Mississippian or "Chattanooga shale (upper)" black shale. Also on figure 4, Bassler shows the Hardin sandstone as a transgressive sandstone that is partly of Devonian age and partly of early Mississippian age.

According to Wilson and Spain (1936) the Ridgetop shale is not a valid stratigraphic unit; in their opinion, it is merely a phase of the New Providence shale and is of early Osage (Fern Glen) age. Their opinion was based on field and faunal studies. Wilson and Spain classified the "Maury shale" as a member of the Chattanooga shale.

Klepser (1937, p. 187) thought that "the Chattanooga and Maury formations are merely facies developments or shore phases of the New Providence, Fort Payne, and possibly Warsaw formations. They become increasingly younger toward the south." Stockdale's (1939, p. 54, 55) opinions are similar to those of Klepser (1937).

"Because of the established facies relationships of the Devonian of New York and Pennsylvania," Cooper (Cooper and others, 1942, p. 1736) regarded "much of the black shale of Ohio, Indiana, Kentucky, Illinois, and Michigan" as Devonian; but he was undecided as to how some of the black shale of the southern States should be classified and, therefore, on the correlation chart that accompanies the paper, he placed most of the Chattanooga shale and the Hardin sandstone of west Tennessee in the Devonian or Mississippian. He regarded the Trousdale shale of Pohl as late Middle Devonian and correlated it with the Geneseo shale of New York.

Guy Campbell (1946) has published a comprehensive paper on the stratigraphy of the Devonian and Mississippian black shales of the eastern interior of the United States. His (1946, p. 881 passim) classification for central Tennessee follows:

Maury shale:
  Mississippian (Osage): Considered to be the basal bed of the Fort Payne chert and the New Providence shale.
Chattanooga shale:
  Mississippian (Kinderhook):
    Westmoreland shale
    Eulie shale
    Gassaway formation:
      Bransford sandstone member
  Upper Devonian:
    Dowelltown formation:
      Hardin sandstone member
  Middle Devonian:
    Trousdale formation

Campbell named all the above-listed divisions of the Chattanooga shale with the exception of the Trousdale and the Hardin sandstone. Campbell's Trousdale formation is the Trousdale shale of Pohl. Pohl (1930b) considered his formation to be of Late Devonian (Genesee-Portage) age, but Campbell, as did Cooper (Cooper and others, 1942, chart 4), preferred to assign the formation to the late Middle Devonian. In the present report the name "Trousdale formation"

or "Trousdale shale" is not used; beds so identified by Campbell, Pohl, and Cooper are placed in the Upper Devonian Dowelltown member of the Chattanooga shale.

The type localities of Campbell's (1946, p. 886) Dowelltown and Gassaway formations are located along the Eastern Highland Rim of central Tennessee: the Dowelltown is in DeKalb County, the Gassaway in Cannon County. Campbell placed his Dowelltown formation in the Upper Devonian and his Gassaway formation in the lower Mississippian. In the present report the Dowelltown and the Gassaway are both classified as Upper Devonian and are considered to be members of the Chattanooga shale rather than distinct formations.

Campbell stated (1946, p. 883) that to the

> east of the Central Basin, in DeKalb County and adjacent territory, the Dowelltown shows deposition under normal conditions for the formation and consists of a lower and an upper member, each with a lower bed of fissile black shale and an upper bed with interbedded layers of gray and black shale. The two members are delimited by *Barroisella* n. sp. and *Spathiocaris*, which occur in the lower member but not in the upper. This is in harmony with the characters of the Blackiston [formation] in Indiana.

The Hardin sandstone according to Campbell (1946, p. 881, 892) is the basal sandstone member of his Dowelltown formation.

Campbell (1946, p. 881, 884) correlated his Gassaway formation with his Sanderson formation, stating that its "only change in character from the Sanderson of Kentucky and Indiana is in the addition of a layer of sandstone at the base." The Bransford sandstone member of Campbell is at the base of his Gassaway formation throughout the northwestern part of the Nashville Basin. At its type locality on Bledsoe Creek, 3.6 miles north of Bransford, Sumner County, Tenn., the Bransford sandstone is as much as 0.25 foot thick and consists of very-light-gray to dark-gray iron-oxide-stained unsorted rounded grains of quartz sand together with bone fragments, teeth, conodonts, and iron sulfide grains and nodules. The Bransford sandstone, according to Campbell (1946, p. 884), occurs "at the level of the marked faunal break between the Blackiston and Sanderson [formations] in Indiana and at the level of the lithic break between the Olmsted and Cleveland [shales] in Ohio." In Shaw and Mather (1919) and Mather (1920), Ulrich said that this sandstone might correlate with the Berea sandstone of Ohio; and Pohl (1930b) believed that it occurs at the level of an unconformity which corresponds to the Berea sandstone and Bedford shale interval of Ohio. The name "Bransford sandstone" is not used in the present paper; the bed so designated by Campbell is not named.

Campbell's Eulie shale and Westmoreland shale are thin beds that crop out in the vicinity of eastern Sumner County, Tenn. The Eulie shale is a gray to greenish-gray mudstone that contains phosphatic nodules. Campbell held that this shale is of early Mississippian age, but the present writer classifies it as very late Devonian. The Westmoreland shale is a grayish-black shale which locally contains phosphatic nodules. Campbell, as does the writer, classified this bed as early Mississipian. The names "Eulie shale" and "Westmoreland shale" are not used herein; the beds so named by Campbell are placed in the Maury formation and are not named.

The writer, in an abstract entitled *The Chattanooga shale type area* (1947b, p. 1189), stated that the Chattanooga shale in the vicinity of Chattanooga, Tenn., consists of an upper and a lower black shale and a middle gray shale. He wrote:

> At the Apison locality [locality 228, see p. 36], the upper black shale member contains lower Mississippian conodonts and is correlated with the Sunbury shale of Ohio. The lower black shale member . . . contains conodonts that correlate it with the Huron shale of Ohio, a formation that the U. S. Geological Survey classifies as Upper Devonian. The middle gray shale member contains Huron conodonts, but its age is equivocal as J. H. Swartz has reported macrofossils from it which he considered to be of early Mississippian age. . . . The presence of Huron conodonts in the lower black shale member of the Chattanooga disproves the thesis, held by some workers, that, as a unit, the Chattanooga shale is younger than the black shale sequence of the North-Central States.

Herein, the above-mentioned upper black shale is placed in the Maury formation and the middle gray shale and the lower black shale in the Upper Devonian Gassaway member of the Chattanooga shale.

Stockdale (1948, p. 265, 266) regarded the Chattanooga shale as a time-transgressing unit that resulted from the deposition of near-shore sediments in a southward advancing sea. He published the above quotation from Hass (1947b) and argued against the stratigraphic usefulness of conodonts, suggesting in the form of a question that they are facies fossils that "might have remained unchanged throughout a considerable span of time and might now be found as a fossil assemblage coextensive with the given lithologic, time-transgressing unit."

According to Weller and others (1948, chart 5, column 86) the Chattanooga shale of central Tennessee consists of two parts. Rocks of the lower part are of Late Devonian age and rocks of the upper part are partly of Mississippian or Devonian (Fabius group of their Kinderhookian series) age and partly of Mississippian (Easley group of their Kinderhookian series) age. The authors (1948, p. 105) commented on the

TABLE 1.—*Standard section of the Chattanooga shale*

System	Series	Formation		Informal field names		Thickness (feet)	Description
MISSISSIPPIAN		Fort Payne chert					Limestone, light-gray; numerous cherty beds
		Maury formation				2.3	Mudstone, light- to medium-bluish-gray. Phosphatic nodules throughout interval; nodules in basal 0.4 ft embedded in olive-gray sandy matrix and classified as Upper Devonian
DEVONIAN	Upper Devonian	Chattanooga shale	Gassaway member	Upper black shale	Top black shale	6.9	Shale, grayish-black, carbonaceous, tough; iron sulfides common as grains, nodules, and lenses. Phosphatic nodules present in topmost 0.45 ft. They are embedded in black shale and separated from underlying beds of unit by a 0.04 ft thick olive-gray sandstone
					Upper gray beds	2.3	Shale, grayish-black, carbonaceous, tough; interbedded with thin gray mudstone beds. A finely laminated bed, 0.13 ft thick, at base
					Middle black shale	7.5	Shale, grayish-black, carbonaceous, tough
			Dowelltown member	Middle gray beds		9.2	Mudstone; consists of alternating, thin, greenish-gray, grayish-olive, and grayish-brown beds together with a few thin grayish-black shale beds. A bentonite bed, 0.09 ft thick, is present 0.82 - 0.91 ft below top
				Lower black shale		6.2	Shale, grayish-black, carbonaceous, tough. A basal sandstone, as much as 0.2 ft thick, may be present; it is grayish black, poorly sorted, and consists chiefly of rounded grains of quartz sand
ORDOVICIAN							Limestone, gray

widespread occurrence of an unconformity at the base of the black-shale sequence; stating that

> if diastrophism is accepted as the ultimate basis for the subdivision of geologic time, and if plants and animals are believed to have altered in response to the resulting physical changes, a good case can be made for accepting this unconformity as the [Devonian and Mississippian] systemic boundary.

It is evident from the above resumé that the age and correlation of the Chattanooga shale have been controversial subjects for many years. Ellison (1946, p. 102) summarized the status of the problem as follows:

> there exist three present-day interpretations of the age of the Chattanooga and its equivalents. The paleobotanists, some conodont workers, and the United States Geological Survey geologists have much evidence that these formations are in the greater part Devonian in age. A number of workers, including some petroleum geologists and a few State Geological Survey men, prefer to remain neutral and classify the Chattanooga problem as Mississippian-Devonian. Many petroleum geologists, some conodont workers, and a number of State Geological Survey men believe that these beds are definitely Mississippian in age.

CHATTANOOGA SHALE

Hayes (1891, p. 142, 143) proposed the name "Chattanooga black shale" as a substitute for Smith's (1878, 1890) and Safford's (1869) nongeographic term "Black shale." The first reference to the Chattanooga shale is brief. It appears as part of the descriptive matter of a geologic column and indicates that the "Chattanooga black shale" is of Devonian age, that it is overlain by the Fort Payne chert of Carboniferous age and underlain by the Rockwood formation of Silurian age, and that it is as much as 35 feet thick. Hayes' (1892, 1894a, 1894b, 1894c, 1894d, 1895) "Chattanooga black shale" consists of two lithologic units: an upper gray shale, 3 to 4 feet thick, which commonly contains a layer of concretions; and a lower black shale. Outcrops at the north end of Cameron Hill in Chattanooga, Tenn., were designated the type locality. The best exposure at the type locality is pictured in plate 5. Swartz (1924, p. 24) named the upper gray-shale unit of Hayes' "Chattanooga black shale" the Glendale shale. Swartz, however, was of the opinion that the beds he identified as Glendale were, prior to his work, a part of the Fort Payne chert. The name "Glendale shale" is not used herein; beds so named by Swartz are called the Maury formation.

STANDARD SECTION OF THE CHATTANOOGA SHALE

The best exposures of the Chattanooga shale in central Tennessee are situated along the Eastern Highland Rim from Jackson County southward to Coffee and Bedford Counties. Throughout much of that area the Chattanooga shale is between 25 and 35 feet thick and at most localities consists of the lithologic divisions given in table 1. Because the type section of Campbell's Dowelltown formation and the type section of his Gassaway formation—both herein reduced to the rank of members of the Chattanooga shale—are not exceptional exposures, and because the type locality of the Chattanooga shale on Cameron Hill in Chattanooga, Tenn., is a poor exposure (see pl. 5), a standard section for the Chattanooga shale has been proposed by L. C. Conant, V. E. Swanson, and the writer. This section is a cut on Tennessee Highway 26, at the east approach to the bridge over Caney Fork, 7.1 miles east of the courthouse at Smithville, DeKalb County, Tenn. The standard section is locality 76. (See table 1 for description.)

The type locality of Campbell's Dowelltown formation (1946, p. 886) is given as "one and one half miles east of Dowelltown, DeKalb County, Tennessee." No section was found at that distance east of the community of Dowelltown, but there is an exposure, 3.1 miles east of Dowelltown, on the portion of Tennessee Highway 26 that was abandoned as the main highway in 1953. This exposure is taken to be Campbell's type locality. The section given below was measured after the Chattanooga shale and the Maury formation interval had been completely exposed. The section is locality 95.

Section 3.1 miles east of Dowelltown, Tenn.

[See locality 95, pl. 1]

		Feet
Mississippian:		
Fort Payne chert.		
Maury formation (in part):		
	Mudstone, yellowish-brown to bluish-gray, iron-oxide-stained, laminated; a few phosphatic nodules present	3.0
	Mudstone, olive-gray, laminated	.6
	Shale, grayish-black, tough; with course of phosphatic nodules at top	.2
	Mudstone, iron-oxide-stained	.1
	Course of phosphatic nodules	.1
	Mudstone, greenish-gray, laminated, iron-oxide-stained	.2
Devonian:		
Maury formation (in part):		
	Course of large phosphatic nodules embedded in iron-oxide-stained mudstone	.3

Section 3.1 miles east of Dowelltown, Tenn.—Continued

	Feet
Devonian—Continued	
Chattanooga shale:	
Gassaway member:	
Upper black shale:	
Top black shale:	
Shale, grayish-black, carbonaceous, tough; bedding undulating	0.3
Course of phosphatic nodules embedded in grayish-black shale	.2
Shale, grayish-black, carbonaceous, tough; iron sulfides present as grains and nodules	.2
Course of phosphatic nodules embedded in grayish-black shale	.1
Shale, grayish-black, carbonaceous, laminated, tough; iron sulfides present as nodules, grains, and paper-thin layers	5.8
Upper gray beds:	
Shale, grayish-black, carbonaceous, tough, with iron sulfides present as nodules, grains, and paper-thin layers; alternating with thin beds of grayish-olive to greenish-gray mudstone. The laminated bed, commonly present at the base of this unit, was not recognized	2.2
Middle black shale:	
Shale, grayish-black, carbonaceous, tough, with iron sulfides present as nodules, grains, and paper-thin layers	4.2
Dowelltown member:	
Middle gray beds:	
Mudstone, alternating thin greenish-gray, grayish-olive, olive-gray, and grayish-brown beds together with a few thin grayish-black shale beds. A very light-gray iron-oxide-stained bentonite bed, 0.07 ft thick, present 0.53 to 0.60 ft below top	7.9
Lower black shale:	
Shale, grayish-black, carbonaceous, tough; iron sulfides present as nodules, grains, and paper-thin layers; a few thin grayish-olive to greenish-gray siltstone beds	5.1
Total	30.5
Ordovician.	

The thicknesses recorded above differ from Campbell's (1946, p. 886) measurements. However, his description of the section is sufficiently detailed for one to determine that the limits of his type Dowelltown formation are as indicated in table 2. Thus, with reference to the lithologic divisions of the Chattanooga shale used in the present paper, Campbell's type Dowelltown includes the beds from the base of the lower black shale to the top of the upper gray beds. Also, the beds Campbell assigned to his Gassaway formation belong to the top black shale, and those he identified as the Maury shale and "New Providence(?) soft blue shale" belong to the Maury formation.

The type locality of Campbell's (1946, p. 886) Gassaway formation is "on [Tennessee] Highway 53, 5 miles south of Gassaway, Cannon County, Tennessee." There are two exposures on Highway 53 within 0.4 mile of each other, one on the north side of a hill and the other on the south side of the same hill. Although it is not certain which outcrop is the type section of the Gassaway, the northern one is so taken because the upper black shale is better exposed there. The section given below is a composite one; the lower black shale and the middle gray beds were trenched and measured at the southern exposure, the upper black shale and the Maury formation at the northern outcrop. This is locality 100.

Section 5 miles south of Gassaway, Tenn.

[See locality 100, pl. 1]

	Feet
Mississippian:	
Fort Payne chert.	
Maury formation:	
Mudstone, bluish-green, laminated; phosphatic nodules present, but not common. Topmost 0.6 ft contains glauconite	2.2
Mudstone, greenish-gray; iron sulfide nodule course present 0.15–0.19 ft below top	.3
Mudstone, bluish-green; phosphatic nodules present, especially at top	.8
Mudstone, greenish-gray, laminated	.4
Shale, grayish-black, carbonaceous	.35
Sandstone, iron-oxide-stained	.15
Devonian:	
Chattanooga shale:	
Gassaway member:	
Upper black shale:	
Top black shale:	
Shale, grayish-black, carbonaceous, very well laminated, tough; iron sulfides present as grains and nodules. Weathered outcrop is distinctly banded. No phosphatic nodules in upper part of this unit	5.6

Section 5 miles south of Gassaway, Tenn.—Continued

	Feet
Devonian—Continued	
Chattanooga shale—Continued	
Gassaway member—Continued	
Upper black shale—Continued	
Upper gray beds:	
Shale, grayish-black, carbonaceous, tough, alternating with thin beds of grayish-olive to greenish-gray mudstone; iron sulfides present as grains and nodules. A laminated bed, 0.25 ft thick, consisting of alternating paper-thin layers of grayish-black shale and iron-oxide-stained fine to very fine sand at base	2. 3
Middle black shale:	
Shale, grayish-black, carbonaceous, tough, with iron sulfides present as nodules, grains, and paper-thin layers	6. 2
Dowelltown member:	
Middle gray beds:	
Mudstone, alternating thin greenish-gray, grayish-olive, olive-gray, and grayish-brown beds together with a few thin grayish-black shale beds. The thin bentonite bed commonly present near the top of this interval was not recognized	8. 5
Lower black shale:	
Shale, grayish-black, carbonaceous, tough; iron sulfides present as nodules, grains, and paper-thin layers. Few thin grayish-olive to greenish-gray mudstone beds	6. 35
Sandstone, consisting chiefly of rounded quartz grains and conodonts; iron oxide stained	. 05
Total	33. 20
Ordovician.	

Campbell's (1946, p. 886) measurements differ from the thicknesses recorded above, but his description of the section indicates that he regarded the limits of his Dowelltown formation, at the type locality of his Gassaway formation, to be as shown in table 2. Thus, with reference to the lithologic divisions of the Chattanooga shale used in the present paper, the Dowelltown of Campbell is the lower black shale and the middle gray beds; and the type Gassaway formation is the upper black shale. The Maury formation includes beds that Campbell identified as Maury shale and Fort Payne chert.

The above discussion is summarized in table 2, which shows that the basal beds of Campbell's type Gassaway formation are the exact correlatives of the topmost beds of his type Dowelltown formation. Therefore, Campbell's Dowelltown formation has been amended so as to consist only of the lower black shale and middle gray beds. The stratigraphic limits of Campbell's Gassaway formation are not changed; they correspond to those of the upper black shale. Table 2 also indicates that Campbell's formations are herein treated as members of the Chattanooga shale.

HARDIN SANDSTONE MEMBER

The Hardin sandstone member underlies the Dowelltown member. It is a part of the widespread basal sandstone of the Chattanooga shale and is restricted to the vicinity of Wayne, Perry, Lawrence, and Hardin Counties, Tenn. and the adjoining part of Alabama. It is as much as 16 feet thick and consists chiefly of siliceous fine-grained sand and silt. The Hardin sandstone member is well exposed along a secondary road by a stone church, 0.15 mile south of United States Highway 64 at Olive Hill, Hardin County, Tenn. where it grades into the overlying beds of the Dowelltown member. The section at Olive Hill is locality 239.

Although conodonts have not been found in the Hardin sandstone member, the writer did collect a few specimens of *Palmatolepis unicornis* Miller and Youngquist (pl. 4, figs. 7, 8) from the overlying Dowelltown member at Olive Hill, Hardin County (locality 239). These specimens came from 8.5 to 17.5 feet below the top of the Chattanooga shale and, as indicated in figure 1, they belong to a species which does not range above the Dowelltown member along the Eastern Highland Rim of central Tennessee.

Because *Palmatolepis unicornis* is present in the overlying beds and because the Hardin sandstone member grades into the Dowelltown member, the writer suggests that the Hardin is of early Late Devonian age, though it is possible that some part of the member could be slightly older. The Hardin is probably about the same age as the basal sandstone of the Dowelltown member of the Eastern Highland Rim area and the basal part of the Dowelltown member of north-central Tennessee.

Ulrich and Bassler (1926) considered the Hardin sandstone member to be a widespread basal deposit of Mississippian age. They described some conodonts collected from a thin sandstone at an exposure west of Mount Pleasant, Tenn., and identified the bed from which their fossils came as the Hardin sandstone. As

TABLE 2.—*Comparison of stratigraphic limits of Campbell's type sections of his Dowelltown and Gassaway formations and the amended section adopted for this report*

<table>
<tr><th colspan="4">This report</th><th colspan="3">Guy Campbell, 1946</th></tr>
<tr><th colspan="2">Formation</th><th colspan="2">Informal names</th><th colspan="2">Type locality of Dowelltown formation</th><th>Type locality of Gassaway formation</th></tr>
<tr><td colspan="2">Fort Payne chert</td><td colspan="2" rowspan="2"></td><td colspan="2">Fort Payne chert</td><td rowspan="2">Fort Payne chert</td></tr>
<tr><td colspan="2">Maury formation</td><td colspan="2">New Providence(?)shale</td></tr>
<tr><td colspan="4"></td><td colspan="2">Maury shale</td><td>Maury shale</td></tr>
<tr><td rowspan="3">Chattanooga shale</td><td rowspan="2">Gassaway member</td><td rowspan="3">Upper black shale</td><td>Top black shale</td><td colspan="2">Gassaway formation</td><td rowspan="2">Gassaway formation</td></tr>
<tr><td>Upper gray beds</td><td rowspan="2">Dowelltown formation</td><td rowspan="2">Upper Dowelltown member</td></tr>
<tr><td>Dowelltown member</td><td>Middle black shale</td></tr>
<tr><td></td><td></td><td colspan="2">Middle gray beds</td><td rowspan="2">Lower Dowelltown member</td><td rowspan="2">Dowelltown formation</td><td>Upper Dowelltown member</td></tr>
<tr><td></td><td></td><td colspan="2">Lower black shale</td><td>Lower Dowelltown member</td></tr>
</table>

stated above on page 8, Ulrich and Bassler's (1926) fauna includes *Ancyrogathus bifurcata, Palmatolepis glabra, Palmatolepis perlobata,* and *Polylophodonta confluens.* Along the Eastern Highland Rim of central Tennessee, these species, as a group, are a part of the lower fauna of the Upper Devonian Gassaway member. (See fig. 1.) It is the writer's opinion, therefore, that the thin sandstone bed from which Ulrich and Bassler's (1926) conodont fauna came is neither the same age as the Hardin sandstone member of the present report nor of early Mississippian age.

DOWELLTOWN MEMBER

The Dowelltown member is well developed along the Eastern Highland Rim of central Tennessee—from southern Jackson County to the vicinity of Manchester in Coffee County. In that area, it is between 10 and 17.5 feet thick and consists of a lower grayish-black shale unit and an upper predominantly gray mudstone unit. The lower black shale unit is as much as 10.6 feet thick—except in the Flynn Creek structure where, within a mile of locality 54, it is probably on the order of 150 feet thick. The upper division of the Dowelltown member is called the middle gray beds. This unit is as much as 9.7 feet thick and consists chiefly of gray mudstone together with a few thin layers of grayish-black shale. Individual beds commonly range between 0.01 and 0.3 foot in thickness. Where weathered, many of these beds are yellowish or brownish, but some are greenish.

In central Tennessee, during Dowelltown time, the basins of deposition appear to have been partly delimited by the Cincinnati anticline and a slightly elevated area in south-central Tennessee and the adjacent

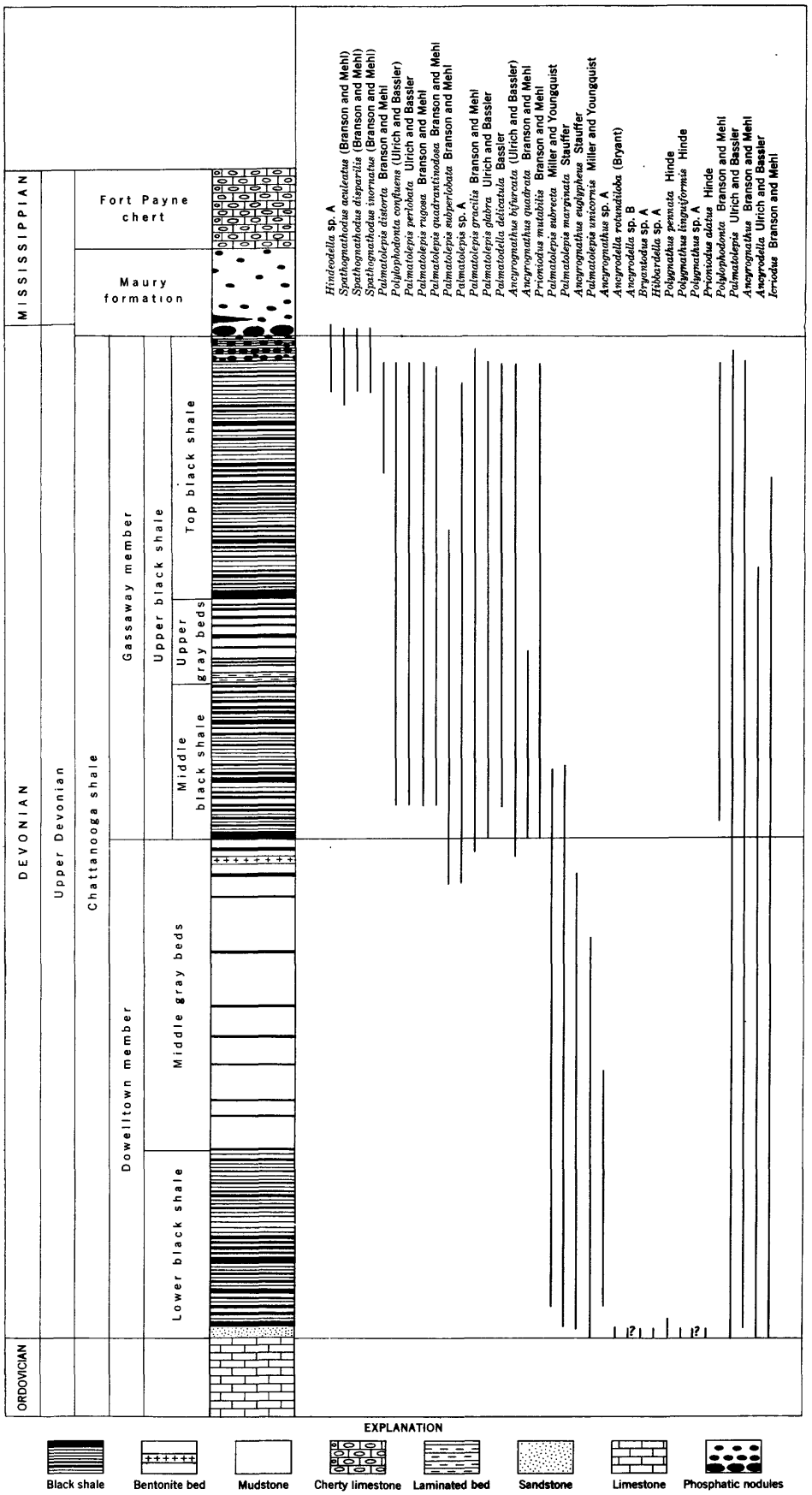

FIGURE 1.—Range of significant conodont genera and species in the Chattanooga shale of the Eastern Highland Rim, in Tennessee.

part of Alabama. Also, the axis of the Cincinnati anticline seems to have trended southwestward from eastern Macon County, Tenn., into central Maury County, where it merged with the aforementioned elevated area of south-central Tennessee. The writer believes this to have been the case because the Dowelltown member wedges out toward these structurally higher areas. These areas seem also to have effectively prevented the eastward transport of coarse arenaceous material, for to the west of them the Dowelltown is commonly sandy from bottom to top, whereas to the east the member is sandy only at the base. A basal sandstone is present at many localities. This sandstone commonly ranges from a featheredge to several tenths of a foot in thickness, though to the southwest of the Nashville Basin, it is thicker and there is called the Hardin sandstone member; it contains fish remains, conodonts, and reworked fossils. The color of the basal sandstone is light to dark gray where freshly exposed, and light to dark brown where weathered.

A bentonite bed (Hass, 1948), which averages 0.1 foot in thickness, is present within a foot or two of the top of the Dowelltown member throughout at least 4,000 square miles of east-central Tennessee. This bed has been recognized along the Eastern Highland Rim from the vicinity of the Flynn Creek structure in Jackson County (locality 54) to the vicinity of Shelbyville in Bedford County. It has also been seen on the west side of the Nashville Basin in southeast Williamson County (locality 185), in the Sequatchie Valley of eastern Tennessee (localities 215 and 220), near Dayton in Rhea County, and in cuttings from wells drilled in the area east of the Nashville Basin.

This bentonite bed is an excellent datum. Its widespread occurrence supports the writer's opinions on the age and correlation of the Chattanooga shale as based on conodonts and disproves the thesis suggested by Grabau (1906) and later adopted by Klepser (1937) and by Stockdale (1939, 1948) that the black-shale sequence of the southern United States is a time-transgressing unit that resulted from the deposition of near-shore sediments in a southward advancing sea. Along the Eastern Highland Rim of central Tennessee where the Chattanooga shale is best developed, the stratigraphic ranges of distinctive conodont genera and species have been found to be constant with reference to the bentonite bed (see figure 1); were it otherwise, there would be reason for believing that conodonts are of no use to the stratigraphic paleontologist.

Conodonts are abundant in the basal sandstone of the Dowelltown member. Where the Chattanooga shale is well developed—as in the vicinity of the standard section (locality 76)—the basal sandstone contains conodonts like those in Pohl's (1930a, 1930b) Trousdale shale of north-central Tennessee, Campbell's (1946) Blocher formation of Indiana, and the "conodont bed" of the Genundewa limestone lentil of the Geneseo shale of New York. The distribution of the easily recognized conodont species of the basal sandstone along the Eastern Highland Rim and of the Trousdale shale of Pohl is given in table 3. The species listed in table 3, however, represent only a small part of the conodont fauna, as most of the specimens in this sandstone are indeterminable fragments.

TABLE 3.—*Distribution of easily recognized conodont species of the basal sandstone of the Dowelltown member where the Chattanooga shale section is essentially complete, and of the Trousdale shale of Pohl*

	No. of figure on pl. 4	1	2	3
Ancyrodella rotundiloba (Bryant)	21	------	x	x
Bryantodus sp. A	23	x	------	------
Hibbardella sp. A	22	------	------	x
Palmatolepis unicornis Miller and Youngquist	7, 8	x	------	------
Polygnathus linguiformis Hinde	16, 17	x	x	x
pennata Hinde	2, 3	x	x	x
Prioniodus alatus Hinde	24	x	x	x

1. Trousdale shale of Pohl (1930a, 1930b). Included in Dowelltown member of Chattanooga shale in present report. Writer's collections.
2. Blocher formation of Campbell (1946); species illustrated by Huddle (1934) as part of lower conodont fauna of New Albany shale of Indiana.
3. "Conodont bed" of Genundewa limestone lentil of the Geneseo shale of New York. Writer's collections; some species illustrated by Hinde (1879), Bryant (1921), and Branson and Mehl (1933).

In addition to the stratigraphic distribution given in table 3, specimens identified as *Bryantodus* sp. A in this report are similar to some of the bryantodids in the "conodont bed" of the Genundewa limestone lentil of the Geneseo shale of New York; to some of the bryantodids described from the Rhinestreet shale (=Attica shale of Chadwick, 1923) of New York by Ulrich and Bassler (1926); as well as to other bryantodids described from the lower part of the Attica shale of Chadwick (1923) by Youngquist, Hibbard, and Reimann (1948). Also, some of the specimens listed herein as *Palmatolepis unicornis* Miller and Youngquist resemble *Palmatolepis punctata* (Hinde) from the "Genesee shale" of New York and the Rhinestreet shale (=Attica shale of Chadwick, 1923). *Prioniodus alatus* Hinde is in the Rhinestreet shale (=Attica shale of Chadwick, 1923), and *Polygnathus linguiformis* Hinde occurs in some Middle Devonian limestones of Ohio. *Hibbardella* sp. A (pl. 4, fig. 22) is known only through fragmentary material. It has a short tongue-like posterior bar which supports one or two minute denticles.

Polygnathus sp. A (pl. 4, fig. 19) which has rostral ridges adjacent to the blade, and *Ancyrodella* sp. B (pl. 4, fig. 20) which has a posteriorly trending secondary carina on the outer platform are both shown in figure 1 as doubtfully in the basal sandstone of the Dowelltown member along the Eastern Highland Rim

of central Tennessee. Both species have been found in the beds that Pohl named the Trousdale shale. Herein these beds are placed in the Dowelltown member and they are probably the same age as the basal sandstone of the Dowelltown member of the Eastern Highland Rim area. *Ancyrodella* sp. B is also in the basal sandstone of the Dowelltown at locality 220 in southeastern Tennessee and locality 204 near Nashville. The writer has not differentiated the species of *Icriodus* (pl. 4, figs. 4–6) that occur in the Chattanooga shale. However, the stratigraphic range of *Icriodus* is recorded on figure 1 because the writer considers this genus to be an index of the Middle and Upper Devonian.

Although no recognizable unreworked megafossils have been found in the basal sandstone of the Chattanooga shale along the Eastern Highland Rim, such fossils are known to occur in association with some of the conodonts listed in table 3 in Pohl's Trousdale shale of north-central Tennessee and in Campbell's Blocher formation of Indiana. The writer, as well as Campbell (1946, p. 883), has collected *Schizobolus* sp. from Pohl's Trousdale shale. This brachiopod, which, according to Cooper (Cooper and others, 1942, p. 1761 and chart 4), ranges from near the top of the Middle Devonian into the lower part of the Upper Devonian, is an important element of the Geneseo fauna. The Blocher formation of Campbell is the same part of the New Albany shale from which Huddle's (1934) lower conodont fauna came. According to Campbell (1946, p. 841) "*Chonetes lepidus* Hall, *Leiorhynchus quadricostatum* Hall, and *Styliolina fissurella intermittens* Hall are common to abundant at many localities" in the lower bed of the Blocher and *Leiorhynchus*, *Styliolina*, and *Tentaculites gracilistriatus* Hall are abundant in the next higher bed of the formation. Also *Schizobolus concentricus* Vanuxem is in the basal foot of Campbell's Blocher at a few localities.

Campbell (1946) classified his Blocher formation and Pohl's Trousdale shale as Middle Devonian, but some of the earlier workers classified these same stratigraphic units as Upper Devonian. Kindle (1899, p. 111), for example, stated that the fauna of the New Albany shale seems to be an equivalent of the fauna of the Genesee shale of New York; later, he (1900, p. 569) concluded that the formation seems to be a correlative of both the Genesee and the Portage of New York. Huddle (1934, p. 17) placed the lower part of the New Albany shale (Campbell's Blocher formation) in the Genesee. As for the Trousdale shale, Pohl (1930b) considered his formation to be of Genesee-Portage age. Cooper (Cooper and others, 1942, chart 4), however, classified the lower part of the New Albany shale (Blocher formation of Campbell), the Trousdale shale of Pohl, the Geneseo shale in New York, and other black shales throughout the interior of the United States as late Middle Devonian.

At the present time, the United States Geological Survey classifies the Genundewa limestone as a lentil of the Geneseo shale which, in turn, is the basal formation of the Genesee group. Because the Federal Survey classifies the Genesee group as early Late Devonian, and because Pohl's Trousdale shale and the basal sandstone of the Chattanooga shale—where that formation is best developed—contain conodonts like those in the Genundewa limestone lentil and the younger beds of the New York section, the writer of this report classifies the basal beds of the Dowelltown member as early Late Devonian.

An early Late Devonian age designation applies to the basal sandstone only where the Chattanooga shale section is as complete as it is along the Eastern Highland Rim. Elsewhere in central Tennessee the age of this sandstone is younger; for example, at locality 154, near Mount Pleasant in Maury County, the basal sandstone contains *Ancyrognathus bifurcata*, *Palmatolepis glabra*, *Palmatolepis perlobata*, and *Polylophodonta confluens;* and at locality 126a, near Fayetteville in Lincoln County, the basal sandstone contains, among others, *Ancyrognathus bifurcata*, *Palmatolepis distorta*, *Palmatolepis glabra*, *Palmatolepis perlobata*, *Palmatolepis quadrantinodosa*, *Palmatolepis subperlobata*, *Palmatolepis* sp. A, and *Polylophodonta confluens*. The stratigraphic ranges of these species in the Chattanooga shale of the Eastern Highland Rim area indicate that the basal sandstone at localities 154 and 126a is a part of the Gassaway member. (See fig. 1.)

Along the Eastern Highland Rim in the vicinity of the standard section, beds of the Dowelltown member above the basal sandstone contain several distinctive conodont species. With the exception of *Polygnathus pennata* (pl. 4, figs. 2, 3)—which ranges upward for several feet above the basal sandstone—and *Palmatolepis unicornis* (pl. 4, figs. 7, 8)—which ranges throughout most of the Dowelltown interval—the species in the basal sandstone of the Eastern Highland Rim area have not been recognized in collections from the overlying beds of the Chattanooga shale. *Palmatolepis subrecta* Miller and Youngquist (pl. 4, figs. 9–15) is another easily recognized conodont species of the Dowelltown; it ranges from the lower beds of the lower black shale into the basal beds of the overlying Gassaway member. *P. subrecta*, according to the writer (Hass, 1951, p. 2536), was described by Miller and Youngquist (1947) from material collected at the type locality of the Sweetland Creek shale near Muscatine, Iowa, and it, or a very closely related species, is also present in the basal beds of the Dunkirk shale of New York; *P. subrecta* may also be conspecific with *Palmatolepis flabelliformis* described by Stauffer from the Olentangy shale. The official classification of the United States Geological Survey places the Olentangy shale and the Dunkirk shale in the Upper Devonian

but it places the Sweetland Creek shale in the Devonian or Mississippian. It is quite possible, however, that the Sweetland Creek shale contains beds of several different ages and it is the writer's opinion that those beds at the type locality of the Sweetland Creek shale, from which Miller and Youngquist (1947, pp. 501–17) obtained their conodonts, are Upper Devonian. Miller and Youngquist (1947, p. 502) have suggested that the Grassy Creek shale of Missouri may be approximately contemporaneous with the Sweetland Creek shale of Iowa. Be this as it may, the present writer regards the beds from which Miller and Youngquist's conodont fauna came as being older than the beds from which Branson and Mehl (1934a) obtained their Grassy Creek conodont fauna.

The writer (Hass, 1951, p. 2534–2536) has collected *Palmatolepis subrecta* from the Arkansas novaculite at Caddo Gap, Montgomery County, Ark., where the species is in a faunal zone approximately 184 feet below the top of the middle division. This portion of the middle division of the Arkansas novaculite is classified as Upper Devonian.

Ancyrognathus sp. A (pl. 4, fig. 1), distinguished by narrow upturned platforms, and *Ancyrodella* sp. A (pl. 4, fig. 18), a rather generalized form, are represented in the collections by only a few specimens. The occurrence of these two species is recorded in order to help establish the stratigraphic range of *Ancyrognathus* and *Ancyrodella*. The writer is of the opinion that *Ancyrognathus* is an index of the Upper Devonian and that *Ancyrodella* ranges from the Middle Devonian into the Upper Devonian; however, some stratigraphers believe that these two genera—as well as *Icriodus*, *Palmatolepis*, and *Polylophodonta*—range naturally into the lower beds of the Mississippian. As indicated on figure 1, along the Eastern Highland Rim of central Tennessee, the stratigraphic range of all 5 above-mentioned genera is restricted to the Devonian.

Palmatolepis marginata Stauffer (pl. 4, figs. 25, 26) ranges from near the base of the Dowelltown member into the basal beds of the Gassaway. This species was first described from the Olentangy shale of Ohio and has since been recognized in a faunal zone of the middle division of the Arkansas novaculite, where it is associated with *Palmatolepis subrecta*. *Ancyrognathus euglypheus* (pl. 4, fig. 27), which is characterized by the abrupt heightening of the distal end of the blade, appears to be restricted to the Dowelltown member. This species is in the Olentangy shale of Ohio and a faunal zone of the Woodford chert of Oklahoma.

Recently the writer made serial collections of conodont material from the Upper Devonian succession of western New York and found that the highest stratigraphic appearance of any of the above-mentioned conodonts of the Dowelltown member is in the Dunkirk shale member of the Perrysburg formation. The Dunkirk is classified by Cooper (Cooper and others, 1942) as basal Cassadaga stage. The writer is of the opinion, therefore, that the Dowelltown member of the Chattanooga shale correlates in a general way with Copper's Finger Lakes, Chemung, and basal Cassadaga stages of the Upper Devonian. The basal beds of the Dowelltown member, however, could be upper Middle Devonian.

As indicated in table 2, the Dowelltown member of the Chattanooga shale is the lower member of Campbell's type Dowelltown formation. Campbell (1946, p. 881, 883) correlated the lower member of his Dowelltown formation with the lower member of his Blackiston formation of Indiana. This correlation appears to have been based chiefly on the belief that *Barroisella* and *Spathiocaris* are restricted to the lower member of each formation. Because of the stratigraphic position of the beds involved, the writer considers this correlation to be essentially correct. However, the reported occurrence (Campbell, 1946, p. 844, 845) in the lower member of Campbell's Blackiston formation of *Ancyrognathus bifurcata*, *Palmatodella delicatula*, *Palmatolepis glabra*, *Palmatolepis perlobata*, and *Palmatolepis subperlobata* indicates that, based on conodonts, a part of this lower member is a correlative of the upper member of Campbell's Dowelltown formation (Gassaway member of Chattanooga shale of present report) instead of the lower member of his Dowelltown formation (Dowelltown member of present report).

GASSAWAY MEMBER

Along much of the Eastern Highland Rim, as well as in north-central Tennessee, in the vicinity of Nashville, and in south-eastern Tennessee, the Gassaway member is between 12 and 21 feet thick. It is commonly less than 6 feet thick along the west and south margins of the Nashville Basin, and is even absent throughout most of Lawrence County, Tenn. and parts of adjacent counties. On the other hand, the Gassaway is as much as 46.4 feet thick in the vicinity of Somerset, Pulaski County, Ky. Throughout a large part of the Eastern Highland Rim the Gassaway member consists of two black-shale units and an intervening zone of alternating thin beds of gray mudstone and black shale. These three units are called informally the middle black shale (lowermost unit), the upper gray beds, and the top black shale (topmost unit); combined, they are the upper black shale. Phosphatic nodules occur in the very youngest beds of the Gassaway member; these nodules are commonly scattered throughout the shale, though at some places they also form one or more courses. At most localities the phosphatic nodules in the Gassaway member are smaller than those in the basal bed of the overlying Maury formation.

The Gassaway member contains two conodont faunas whose stratigraphic ranges overlap slightly. As indicated in figure 1, the species of the older fauna range,

TABLE 4.—*Distribution of significant conodont species present in the lower fauna of the Gassaway member*

	No. on—		1	2	3	4	5	6
	Pl.	Fig.						
Ancyrognathus bifurcata (Ulrich and Bassler)	3	25, 26	x	x	x	x	x	x
Palmatodella delicatula Bassler	------	--------	x	x	x	x	x	x
Palmatolepis distorta Branson and Mehl	2	1	x	----	x	----	----	----
glabra Ulrich and Bassler	3	15–17	x	x	x	x	x	x
perlobata Ulrich and Bassler	3	19–21	x	x	x	x	x	x
rugosa Branson and Mehl	------	--------	x	----	----	----	----	----
subperlobata Branson and Mehl	3	4–9	x	----	----	----	----	x
Polylophodonta confluens (Ulrich and Bassler)	3	10	x	----	x	----	----	x

1. Lower part of the Ohio shale of Ohio and Kentucky. Writer's collections; Hass (1947a).
2. Antrim shale; exposure in Paxton shale pit near Alpena, Alpena County, Mich. Writer's collections.
3. Blackiston formation of Campbell (1946); species illustrated by Huddle (1934) as part of middle conodont fauna of New Albany shale of Indiana.
4. Faunal zone, 46.5 to 140 feet below top of middle division of Arkansas novaculite, Caddo Gap, Montgomery County, Ark. Writer's collections; Hass (1951).
5. Faunal zone of Woodford chert of Oklahoma. Writer's collections.
6. Faunal zone of Chattanooga shale of northeast Oklahoma. Writer's collections.

as a unit, throughout most of the Gassaway member, whereas those of the younger fauna range throughout only the very topmost beds of the member. In north-central Tennessee the younger fauna is also found in the phosphatic-nodule bed at the base of the Maury formation. The older or lower conodont fauna of the Gassaway member includes the species given in table 4.

The species listed in table 4 make possible a correlation of all but the youngest beds of the Gassaway member with the lower part of the Ohio shale of Ohio and Kentucky; the Antrim shale as exposed in the Paxton shale pit west of Alpena, Mich.; the major portion of the middle division of the New Albany shale (most of Campbell's Blackiston formation) of Indiana; a faunal zone of the middle division of the Arkansas novaculite of Arkansas and Oklahoma which, at Caddo Gap, Montgomery County, Ark., is 46.5 to 140 feet below the top of the middle division; a faunal zone of the Woodford chert of Oklahoma; and a faunal zone that ranges throughout most of the Chattanooga shale of northeastern Oklahoma. The formations or parts of formations mentioned above are placed in the Upper Devonian series. Recently, the writer found conodonts similar to those listed in table 4 in the Gowanda shale member of the Perrysburg formation of western New York. The Gowanda shale member is placed in Cooper's (Cooper and others, 1942) Cassadaga stage of the Upper Devonian.

Other species in this fauna—which, in the writer's opinion, indicate a Late Devonian age—are *Ancyrognathus quadrata* Branson and Mehl, *Palmatolepis gracilis* Branson and Mehl, *Palmatolepis quadrantinodosa* Branson and Mehl (pl. 3, fig. 11), *Palmatolepis* sp. A (pl. 3, figs. 1–3, 13)—a species with distinctly noded platforms anterior to the azygous node—and *Prioniodus mutabilis* Branson and Mehl. The thalli of *Foerstia*—a small sargassoid alga of probable fucoidal affinity (J. M. Schopf, February 1953, oral communication)—have been found associated only with conodonts like those in the lower fauna of the Gassaway member. Good specimens of this plant have been collected by the writer from the Gassaway member of the Chattanooga shale in Kentucky and Tennessee (localities 14, 225, 228); from the Chattanooga shale of southwestern Virginia (Little Stone Gap), and northeastern Oklahoma (Spavinaw Dam section); and from the lower part of the Ohio shale of Ohio (The Narrows, near Columbus; and from a core at the limestone mine at Barberton, between 1,429 and 1,527 feet below the surface). The information now on hand indicates that *Foerstia* is restricted stratigraphically to rocks of Late Devonian age that contain conodonts like those in the lower faunal zone of the Gassaway member.

The widespread occurrence of the older fauna of the Gassaway member indicates that during some part of Gassaway time, the sea in which the Chattanooga shale was deposited covered most, if not all, of central Tennessee and the adjoining parts of Kentucky, Alabama, Georgia and Mississippi.

Swartz (1924, 1927, 1929; see also p. 7–9 and 25, 26 of the present paper) subdivided the Chattanooga shale into the Big Stone Gap member (youngest), the Olinger member, and the Cumberland Gap member. He believed that the Olinger member interfingers with the Cumberland Gap member and that, with the possible exception of the lowest beds of the Cumberland Gap member, the Chattanooga shale of Tennessee and southwestern Virginia is definitely of Mississippian age. However, some of Swartz's conclusions are herein considered to be invalid, as they are based in part on Swartz's interpretation of a megafauna collected near Apison, Tenn. (locality 228). Swartz believed that this fauna consists of Mississippian fossils and correlated the 2-foot-thick bed in which the fauna occurs with the Bedford shale and Berea sandstone wedge of Ohio and Kentucky and with the Olinger member of his Chattanooga shale of eastern Tennessee and southwestern Virginia. Swartz's fossils were not available for study and comparison with the writer's poorly preserved specimens from the same bed. G. A. Cooper, of the United States National Museum, who examined the writer's collection stated (July 1947, oral communication) that, with the exception of an *Orbiculoidea* sp., the preservation of the fossils is such that even generic determinations are not justified. In 1947 the writer (Hass, 1947b) stated that the age of the above-mentioned fossiliferous bed is equivocal, but he now believes that this bed, as well as the underlying black shale, belongs in the Upper Devonian, Gassaway member. The writer's opinion is based on the fact that all of the

species given below occur in the aforementioned black shale, and that the first three listed also occur in the 2-foot-thick bed from which Swartz's fossils came.

Foerstia sp. (a sargassoid alga of probable fucoidal affinity).
Palmatolepis distorta Branson and Mehl (pl. 2, fig. 1).
Palmatolepis glabra Ulrich and Bassler (pl. 3, figs. 15–17).
Ancyrognathus bifurcata (Ulrich and Bassler) (pl. 3, figs. 25, 26).
Palmatodella delicatula Bassler.
Palmatolepis perlobata Ulrich and Bassler (pl. 3, figs. 19–21).
Palmatolepis rugosa Branson and Mehl.
Polylophodonta confluens (Ulrich and Bassler) (pl. 3, fig. 10).

As delimited by the writer, the Chattanooga shale at its type locality (locality 226) is the Cumberland Gap member of Swartz's section (see p. 8). The immediately overlying beds, which Swartz assigned to his Olinger member and his Big Stone Gap member, are herein placed in the Maury formation. Identifiable conodonts were found in the type Chattanooga at only one place, about 350 feet south of the north end of Cameron Hill; there, molds of *Palmatolepis perlobata* (pl. 3, figs. 19–21), *Palmatolepis* sp. B (pl. 3, fig. 18)—which is based on a single specimen whose outer platform resembles that of *Palmatolepis rugosa* Branson and Mehl—*Hindeodella* sp., and other barlike conodonts, were collected from the upper foot of the shale. The occurrence of *Palmatolepis perlobata* in the topmost foot of the Chattanooga shale indicates that at its type locality the shale is Devonian and assignable, at least in part, to the Gassaway member.

Sedimentation appears to have been continuous in the vicinity of the standard section (locality 76) during late Dowelltown and early Gassaway time. Were it otherwise, the bentonite bed which is within a foot or two of the top of the Dowelltown member would probably not be present today throughout more than 4,000 square miles of east-central Tennessee. Under such conditions, mixing of conodont faunas does not seem probable and therefore on figure 1 *Ancyrognathus bifurcata*, *Palmatolepis gracilis*, *Palmatolepis subperlobata*, and *Palmatolepis* sp. A are indicated as ranging down into the topmost beds of the Dowelltown member and *Palmatolepis marginata* and *Palmatolepis subrecta* as ranging up into the basal beds of the Gassaway member.

However, sedimentation was not continuous during late Dowelltown and early Gassaway time throughout all of central Tennessee. For example, the topmost beds of the Dowelltown member are missing from the section in the vicinity of the type locality of Campbell's Gassaway formation (locality 100). Also, a thin sandstone bed is at the base of the Gassaway member along the northwest rim of the Nashville Basin (for example, at localities 204, 205 and 206). This sandstone is Campbell's Bransford sandstone member of his Gassaway formation. The conodont fauna of this sandstone contains reworked specimens, for in addition to those that are characteristic of the lower fauna of the Gassaway member along the Eastern Highland Rim, it also contains numerous representatives of species which, along the Eastern Highland Rim, are restricted to the Dowelltown member. (See figure 1. Also see table 8, locality 204, collections 328, 335; and locality 206, collection 451.) At Bransford (locality 206) this sandstone unconformably overlies the Dowelltown member of the Chattanooga shale.

The main area of deposition during latest Gassaway time was in north-central Tennessee and the adjacent part of Kentucky. The strata resulting from this deposition commonly contain phosphatic nodules which, in addition to being scattered throughout the interval, are locally concentrated into one or more courses. These beds have not been recognized along the Eastern Highland Rim very much farther south than the standard section (locality 76) in DeKalb County; nor have they been recognized in south-central Tennessee and the adjacent part of Alabama. Northward from the vicinity of the standard section to Somerset, Pulaski County, Ky. (locality 6), however, this interval gradually increases in thickness from a featheredge to 8 feet. A thin bed containing phosphatic nodules has been observed at the top of the Gassaway member at a few exposures in the Sequatchie Valley, including locality 220 near Dunlap, where it is one foot thick, and locality 215 in Bledsoe County, where it is 2.2 feet thick; also, the nodule bed is in the top of the Gassaway member along United States Highway 64, 1.8 miles west of Olive Hill, Hardin County, where it is 0.1 foot thick; and at Bakers Station, Davidson County, (locality 204), where it is 0.7 foot thick. The nodule bed is more than 2 feet thick in Macon County, Tenn. and about 6 feet thick in Clay County, Tenn.

The topmost beds of the Gassaway member have a small, distinctive set of conodonts. As indicated in figure 1, these conodonts, though characteristic of that portion of the Gassaway which contains phosphatic nodules, range into slightly older beds where they are associated with conodonts that range throughout the older portions of the Gassaway member. In a part of north-central Tennessee the conodonts that characterize the topmost beds of the Gassaway are also in the very oldest beds of the Maury formation. The species in question are:

Hindeodella sp. A (pl. 3, figs. 27, 28); this species has a long downward-trending anterior bar.
Spathognathodus aculeatus (Branson and Mehl).
Spathognathodus inornatus (Branson and Mehl) (pl. 3, figs. 22–24).
Spathognathodus disparilis (Branson and Mehl).

The Chattanooga shale and the Maury formation are evidently separated by an unconformity throughout much of south-central Tennessee and north-central Alabama for in that area the youngest beds of the Gassaway member—those characterized by phosphatic nodules and the conodonts listed above—have not been recognized. Instead, the beds directly beneath the Maury formation contain the conodonts of the lower fauna of the Gassaway member. Some of the conodonts of the lower fauna have also been found as reworked material in the basal 0.05 foot of the Maury formation.

The conodont fauna of the youngest beds of the Gassaway is like that in the upper part of the Ohio shale of Ohio and Kentucky, as well as in that part of Campbell's (1946) Sanderson formation which, at the type locality of the Sanderson, near New Albany, Ind., directly underlies Campbell's Falling Run member of the Sanderson and contains phosphatic nodules. The Falling Run member is considered by the writer to be of early Mississippian age but he regards the immediately underlying beds of the Sanderson at the type locality of that formation to be of Late Devonian age and to be a correlative of the upper part of the Ohio shale of Ohio and Kentucky. The oldest beds of the type Sanderson, however, contain the same conodont fauna as the underlying Blackiston formation of Campbell (1946); the writer correlates these beds with the lower part of the Ohio shale.

MAURY FORMATION

Safford and Killebrew (1900, p. 104, 141–143) proposed the name "Maury green shale" for the beds between the "Black shale (Chattanooga shale)" and their Tullahoma formation. They considered the Maury to be of early Carboniferous age and described it as consisting of green or greenish shale with embedded concretions of calcium phosphate. Some stratigraphers have classified the Maury as the topmost member of the Chattanooga shale; others have considered it to be a distinct formation; and still others have regarded it as the basal bed of the immediately overlying formation.

STANDARD SECTION OF THE MAURY FORMATION

The Maury formation of the present paper is the "Maury green shale" of Safford and Killebrew, who designated Maury County, Tenn., as the type locality. L. C. Conant, V. E. Swanson, and the writer failed to find an adequate exposure of the formation in Maury County and therefore selected an exposure near Cross Key in Williamson County as the standard section (locality 185). This is given below.

Section along south side of road near top of west slope of Pull Tight Hill, 13.5 miles southeast of Franklin and 1.2 miles east of Cross Key, Williamson County, Tenn.

[Measurements of Chattanooga shale by V. E. Swanson]

	Feet
Mississippian:	
Fort Payne chert: Limestone, gray, cherty.	
Maury formation: Mudstone, grayish-yellow, green, greenish-gray; lowermost 0.3 ft dark gray to greenish black. Phosphatic nodules throughout interval as well as in a course, 0.3–0.6 ft thick, 0.3–0.9 ft above base	1.5
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough; phosphatic nodules throughout interval	1.6
Shale, grayish-black, carbonaceous, tough	2.1
Siltstone, dark-gray	.1
Shale, grayish-black, carbonaceous, tough	1.6
Dowelltown member:	
Mudstone	.45
Bentonite	.05
Mudstone	.2
Sandstone	.2
Mudstone and interbedded thin grayish-black carbonaceous shale	4.3
Shale, grayish-black, carbonaceous, tough	7.0
Covered	1.0
Total	20.10
Ordovician.	

The lithologic characteristics, the stratigraphic position, and the fauna of the Glendale shale of Swartz (1924) are similar to those of the Maury formation of central Tennessee, and it is the writer's opinion that these names refer to the same lithologic unit. The name "Maury formation" is used in the present report in preference to Glendale shale because Maury is an older and better known name.

AGE AND CHARACTERISTICS

The Maury formation is an easily recognized unit wherever it is overlain by the Fort Payne chert, but its top is indefinite wherever it is overlain by either the Ridgetop shale or the New Providence shale. The Maury consists chiefly of grayish-yellow, green, and greenish-gray mudstone. Grayish-black shale is present at some localities. Phosphatic nodules are generally scattered throughout the formation and at many outcrops are also concentrated into a course at or very near the base. Generally, the formation is between 1.5 and 3.0 feet thick, though at one locality (228) it is more than 7 feet thick. The Maury is chiefly of Kinderhook age; however, the youngest beds of the formation are probably of Osage age and the oldest

beds in a part of north-central Tennessee are probably of very late Devonian age. The formation contains several distinct conodont faunas.

At many places along the north and west margins of the Nashville Basin of Tennessee, the Maury formation appears to grade into the overlying formation. At some localities (for example, Bakers Station, locality 204) the overlying formation has been identified in the literature as the Ridgetop shale—a formation classified as Kinderhook by the United States Geological Survey—but at other nearby outcrops (for example, Whites Creek Springs or Crocker Springs, locality 203) the overlying strata have been identified as the New Providence shale—a formation classified as Osage by the United States Geological Survey. Wilson and Spain (1936) have a different opinion, they regard the Ridgetop shale as a phase of the New Providence shale and as Osage in age. Be this as it may, the writer of the present report restricted his investigations to 1 or 2 feet of beds, directly on top of the Chattanooga shale, that contain for the most part phosphatic nodules, glauconite, and conodonts of Kinderhook age. The writer has not concerned himself with the problems of the age, nomenclature, or stratigraphy of the beds commonly called Ridgetop shale and New Providence shale, except to note that the basal beds of the New Providence in south-central Kentucky are of Kinderhook age and are the biostratigraphic equivalent of the Maury formation of Tennessee.

The course of phosphatic nodules at the base of the Maury formation may be a transgressive deposit, because in a part of north-central Tennessee the nodule bed contains conodonts like those in the youngest beds of the underlying Gassaway member of the Chattanooga shale, whereas in west-central Tennessee, and south-central Kentucky—where the nodules occur at the base of the New Providence shale—the bed contains conodonts of early Mississippian (Kinderhook) age. On the other hand, there could be two distinct phosphatic-nodule beds, as no correlative of the Bedford shale and Berea sandstone of Ohio has been definitely recognized in central Tennessee. Some stratigraphers might prefer to place the thin phosphatic-nodule bed of north-central Tennessee—that contains conodonts like those in the youngest beds of the Gassaway member—in the Chattanooga shale, and to regard the Maury formation as entirely of Mississippian age. (See descriptions of sections at localities 39, 60, 74, 75, 76, 78, 91, 92, 95, 206, and 207.) However, from the viewpoint of the field man who is concerned with delimiting easily recognized mappable units, the aforementioned phosphatic-nodule bed is a good base for the Maury formation of central Tennessee, and for that reason, L. C. Conant's party placed the nodule bed in the Maury formation. It is the writer's opinion that if a correlative of the Bedford shale and Berea sandstone interval of Ohio is present in central Tennessee, it is probably the grayish-black shale that Campbell called the Westmoreland shale.

The conodonts in the phosphatic-nodule bed that indicate a very Late Devonian age are *Hindeodella* sp. A (pl. 3, figs. 27, 28), *Spathognathodus aculeatus* (Branson and Mehl), *Spathognathodus disparilis* (Branson and Mehl), and *Spathognathodus inornatus* (Branson and Mehl) (pl. 3, figs. 22–24). The last-named species, however, ranges into younger beds, as it has been recognized in collections from the Bedford shale of Ohio and the Louisiana limestone of Missouri; both formations are Mississippian. In these two formations, however, *Spathognathodus inornatus* is associated with conodonts unlike those in the nodule bed of north-central Tennessee.

Conodonts in the phosphatic-nodule bed of the Maury formation that indicate a Mississippian (Kinderhook) age are listed in table 5. These conodonts have been recognized in many collections in west-central Tennessee including those from localities 203 and 204 in Davidson County; 163, 165, 168, and 250 in Hickman County; 249 in Perry County; and 134 in Marshall County. The same conodonts are also in the phosphatic-nodule bed at the base of the New Providence shale in south-central Kentucky, for example, at locality 6, in Pulaski County; 11 in Russell County; and 14 in Cumberland County.

At several localities in north-central Tennessee, a grayish-black shale overlies the aforementioned phosphatic-nodule bed that contains Upper Devonian conodonts. This shale is 0.2 foot thick at locality 92 in DeKalb County; 0.5 foot thick at locality 207 in Sumner County, where it has been designated the type of the Westmoreland shale by Campbell (1946, p. 885); and 1.0 foot thick at locality 206, also in Sumner County. The shale is 0.35 foot thick at locality 100 in Cannon County. The following species have been recognized in one or more collections from this shale:

Gnathodus sp. B.
Polygnathus communis Branson and Mehl (pl. 2, figs. 2–5).
Spathognathodus aciedentatus (E. R. Branson) (pl. 2, fig. 26).
Spathognathodus sp. A (pl. 2, fig. 19).
Hindeodella sp. A (pl. 3, figs. 27, 28).

The first three species listed above are characteristic of the Mississippian and range into the overlying beds of the Maury formation. The remaining two have not been recognized in younger beds. One of these, *Hindeodella* sp. A, ranges down into the topmost beds of the Gassaway member of the Chattanooga shale. The other, *Spathognathodus* sp. A, is represented in the writer's collections by only one specimen; this species

TABLE 5.—*Distribution of significant conodont species present in the major part of the Maury formation*

	No. of figure on pl. 2	1	2	3	4	5	6	7	8	9	10
Dinodus fragosus (E. R. Branson)	---	---	---	x	---	x	x	---	---	---	---
Elictognathus bialata (Branson and Mehl)	---	---	x	x	---	x	x	---	---	---	---
lacerata (Branson and Mehl)	21, 22	x	x	x	x	x	x	x	x	---	x
Pinacognathus profunda (Branson and Mehl)	17	---	x	---	---	---	x	---	---	---	---
Polygnathus allocota (Cooper)	18	---	---	---	---	---	x	---	---	---	---
longipostica Branson and Mehl	28	---	x	x	---	---	x	---	---	---	---
Pseudopolygnathus prima Branson and Mehl	24	x	x	x	---	---	x	---	x	x	x
Siphonodella duplicata (Branson and Mehl)	6–11	x	x	x	---	x	---	---	---	x	x
duplicata (Branson and Mehl) var. A	13, 23	---	---	---	x	---	x	---	x	---	x
lobata (Branson and Mehl)	25	---	x	---	---	---	x	---	---	---	---
quadruplicata (Branson and Mehl)	29	x	x	---	---	x	x	x	x	---	x
serplicata (Branson and Mehl)	30	---	x	---	---	x	x	---	---	---	---
Spathognathodus aciedentatus (E. R. Branson)	26	x	x	x	---	x	x	---	---	x	---
Polygnathus communis Branson and Mehl	2–5	x	x	x	x	x	x	---	x	x	---
inornata E. R. Branson	14, 15	---	x	x	x	---	x	x	---	x	x

1. Sunbury shale of Ohio (Hass, 1947a).
2. Bushberg sandstone member of the Sulphur Springs formation of Missouri (Branson and Mehl, 1934b).
3. Hannibal shale of Missouri (E. R. Branson, 1934).
4. Chouteau limestone of Missouri (Branson and Mehl, 1938).
5. Upper faunal zone of New Albany shale of Indiana (Huddle, 1934).
6. Pre-Welden shale interval of Oklahoma (Cooper, 1939).
7. Middle division of Arkansas novaculite, Caddo Gap, Ark., 18.8–19.5 ft below top of middle division (Hass, 1951).
8. Middle division of Arkansas novaculite, Caddo Gap, Ark., 20.0–20.2 ft below top of middle division (Hass, 1951).
9. Middle division of Arkansas novaculite, Caddo Gap, Ark., 28.0–28.5 ft below top of middle division (Hass, 1951).
10. Faunal zone in Chattanooga shale of northeastern Oklahoma. Writer's collections.

has a spinelike denticle on the inner lip of the pulp cavity, and in that feature, resembles a distinctive spathognathodid of the Bedford shale of Ohio. Unfortunately, a good rubber replica of the spinelike denticle—which is approximately as high as the blade—could not be made. (See pl. 2, fig. 19.) A single specimen of *Polygnathus communis* Branson and Mehl has been found in the prepared material of collection 172 from the topmost 0.3 foot of the Gassaway member at locality 207. Because this is the only known occurrence of the species in rocks of Late Devonian age, the writer prefers to regard the presence of *P. communis* in collection 172 as having resulted either through a stratigraphic leak or through a mixing of collections. The latter is a likely possibility, as lithologically, at locality 207, chips from the topmost beds of the Gassaway member and those from the grayish-black shale of the Maury formation are indistinguishable.

The conodont species that appear to range throughout a large part of the Maury formation are listed in table 5. The name *Siphonodella duplicata* (Branson and Mehl) refers to specimens which, like the types of the species, have transverse ridges on the oral surface of both platforms, and the name *Siphonodella duplicata* (Branson and Mehl) var. A is used for specimens that differ from the types by having nodes rather than transverse ridges on the oral surface of the inner platform. Most of the species listed in table 5 belong to one of the following genera: *Dinodus*, *Elictognathus*, *Pinacognathus*, *Pseudopolygnathus*, and *Siphonodella*. It is the writer's opinion that these genera as well as *Gnathodus* are index fossils of the post-Devonian. The conodonts listed in table 5 make it possible to correlate part of the Maury with the Sunbury shale of Ohio; the uppermost part of the New Albany shale of Indiana; the Bushberg sandstone member of the Sulphur Springs formation and the Hannibal shale, both of Missouri; beds near the top of the middle division of the Arkansas novaculite of Arkansas and Oklahoma; a faunal zone of the Chattanooga shale of northeastern Oklahoma; and a faunal zone in the lower part of C. L. Cooper's (1939) pre-Welden shale of Oklahoma. All these formations or parts of formations are classified as Mississippian.

The writer believes that the Maury formation is a biostratigraphic equivalent of the basal portion of the New Providence shale of south-central Kentucky; that is, the New Providence shale contains beds of Kinderhook age. This opinion is held because identical species of Kinderhook conodonts are present in the basal beds of the New Providence shale in south-central Kentucky—including the exposures at localities 6, 11, and 14—and in the Maury formation—including exposures at locality 204, the type locality of the Ridgetop shale, and at locality 203, the local standard section of the New Providence shale.

A few specimens of *Siphonodella* sp. A (pl. 2, fig. 12) have been collected from the Maury formation at locality 205 in Sumner County, Tenn., and from the phosphatic-nodule bed at the base of the New Providence shale at locality 6 in Pulaski County, Ky. This species has an outer platform whose oral surface is nearly smooth; it has not been recognized in any of the formations listed in table 5, but it has been observed by the writer in collections from the Mississippian Chappel limestone of Texas.

A single specimen of *Spathognathodus* sp. B (pl. 2, fig. 27) has been found in the Maury formation at locality 205 in Sumner County, Tenn. This specimen resembles *Spathognathodus aciedentatus*, but differs in that the lateral expansions of its pulp cavity are more asymmetric.

A few of the conodont species listed in table 5 have been found in the Maury formation at locality 226, the type locality of the Chattanooga shale, and at locality 228, an exposure near Apison, Tenn. Conodonts collected at the type locality of the Chattanooga shale include *Polygnathus communis* Branson and Mehl (pl. 2, figs. 2–5) and *Siphonodella duplicata* (Branson and Mehl) (pl. 2, figs. 6–11). These fossils came from an interval of small phosphatic nodules and olive-gray to dark-gray shale that is 0.4 to 0.45 foot above the Chattanooga shale and Maury formation

contact. Swartz placed this bed in the Chattanooga shale and identified it as his Big Stone Gap member. (See p. 7–9 for a review of Swartz's papers.) However, for the reasons given on page below, the present writer prefers to place the above-mentioned bed in the Maury formation. The thin gray mudstone bed at the type locality of the Chattanooga shale, which Swartz identified as his Olinger member of the Chattanooga shale, is also placed in the Maury formation because its lithologic character more closely resembles that of the Maury formation than that of the underlying grayish-black Chattanooga shale, which at locality 226 is deformed and slickensided.

The Maury formation at locality 228 consists of two lithologic units: a greenish-gray mudstone, 3 feet thick, and an underlying grayish-black shale, which, because the shale is slightly deformed, varies in thickness from 3.8 to 4.7 feet along the face of the outcrop. Both units contain numerous phosphatic nodules. No conodonts were collected from the greenish-gray mudstone, but the following species have been found in the underlying grayish-black shale:

Elictognathus lacerata (Branson and Mehl) (pl. 2, figs. 21, 22).
Pseudopolygnathus prima Branson and Mehl (pl. 2, fig. 24).
Siphonodella duplicata (Branson and Mehl) (pl. 2, figs. 6–11).
Siphonodella duplicata (Branson and Mehl) var. A (pl. 2, figs. 13, 23).
Palmatolepis distorta Branson and Mehl (pl. 2, fig. 1).

These conodonts, with the exception of *Palmatolepis distorta*, are characteristic of the lower Mississippian (Kinderhook) and are like those in the Maury formation of the central Tennessee area. *Palmatolepis distorta* must have been reworked into the Maury formation for elsewhere in Tennessee it is a typical fossil of the lower faunal zone of the Gassaway member of the Chattanooga shale. (See figure 1.)

Locality 228 is the only one at which a thick black shale of Mississippian age was recognized. Swartz, like the writer, correlated this shale with the Sunbury shale of Ohio and Kentucky. However, Swartz—who worked in eastern Tennessee and southwestern Virginia, where the black-shale sequence contains beds of both Devonian and Mississippian ages—preferred to place the above-mentioned black shale of Mississippian age in the Chattanooga shale and identified it as the Big Stone Gap member; whereas, the present writer—who worked in central Tennessee, where the Chattanooga shale is definitely of Devonian age—prefers to place this shale, as well as the beds mentioned above, in the Maury formation. This stratigraphic assignment is made because the beds in question either contain conodonts like those in the Maury formation of central Tennessee or have a lithology similar to that formation. Moreover, the Maury, as delimited in the present paper, lies unconformably on the Chattanooga shale throughout much of southeastern Tennessee with the youngest beds of the Gassaway member missing from the section. These beds are discussed on pages 21–23.

In addition to conodonts that indicate an early Kinderhook age, the Maury formation at some localities contains still younger conodonts. These fossils include *Gnathodus punctatus* (Cooper) (pl. 2, fig. 20) and *Bactrognathus* sp. *Gnathodus punctatus* is represented in the writer's collections by a single specimen which came from locality 134 near Cornersville, Marshall County, Tenn., where it is associated with *Gnathodus* sp. A (pl. 2, fig. 16), a gnathodid that resembles *Gnathodus delicatus* Branson and Mehl from the Chouteau limestone of Missouri. *Gnathodus punctatus* is also in a faunal zone of the Chappel limestone of Texas; in both C. L. Cooper's Welden limestone and the topmost bed of Cooper's (1939) pre-Welden shale of Oklahoma; and in beds between 11.5 and 19.5 feet below the top of the middle division of the Arkansas novaculite at Caddo Gap, Montgomery County, Ark. (See Hass, 1951). The Chappel limestone, the Welden limestone, and the above mentioned beds of the middle division of the Arkansas novaculite are all classified as of late Kinderhook (Chouteau) age. *Bactrognathus* sp. has been found in collections from the Maury formation at the following localities: 89 and 95 in DeKalb County, 249 in Perry County, and 250 in Hickman County. The genus *Bactrognathus* ranges from the upper Kinderhook into the lower Osage. Collection 15003 from the top 3.6 feet of the Maury formation at locality 95 in DeKalb County, Tenn., and collection 350 from 0.5 to 0.8 foot above the base of the New Providence shale at locality 6 in Pulaski County, Ky., each contain a few specimens of an elongate pseudopolygnathid which in this paper is listed as *Pseudopolygnathus* sp. These specimens resemble *Pseudopolygnathus striata* Mehl and Thomas from the Fern Glen limestone of Missouri.

A few specimens of *Taphrognathus* have been found in the Maury formation at localities 165 and 250 in Hickman County, Tenn. This genus has not been recorded in the literature as ranging into rocks older than those of Keokuk age. It cannot be determined from the material at hand whether these specimens occur naturally in the Maury formation or whether they are there as the result of a stratigraphic leak.

MEASURED SECTIONS

The locality numbers used in this paper are the same as those that will be used in a report on the Chattanooga shale and related rocks of central Tennessee and nearby areas which L. C. Conant and V. E. Swanson are preparing. (See pl. 1.)

LOCALITY 6.—*In cut and on hillside below Oil Center Road, just east of the crossing over Big Clifty Creek, 5.4 miles west of Somerset, Pulaski County, Ky.*

	Feet
Mississippian:	
New Providence shale:	
The basal part of this formation is considered to be the biostratigraphic equivalent of the Maury formation of Tennessee. It is a dark-gray glauconitic mudstone. A course of phosphatic nodules is situated 0.3–0.45 ft above base.	
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough; phosphatic nodules scattered throughout	8.0
Shale, grayish-black, carbonaceous, tough; iron sulfides present as grains, nodules, and thin seams. No fossils obtained from basal 4.5 ft; this part may belong to Dowelltown member	38.4
Dowelltown member:	
Sandstone, consisting chiefly of rounded grains of quartz sand, calcareous bond	.4
Shale, grayish-black, carbonaceous, tough	.2
Sandstone, consisting chiefly of rounded grains of quartz sand, calcareous bond	.4
Total	47.4
Boyle limestone.	

LOCALITY 11.—*Cut on State Highway 35, 1.5 miles south-southeast of Rowena and just north of the county line, Russell County, Ky.*

	Feet
Mississippian:	
New Providence shale:	
The basal part of this formation is considered to be the biostratigraphic equivalent of the Maury formation of Tennessee. It is a light-gray siltstone with a concentration of large phosphatic nodules in the basal 0.4 ft.	
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough. Phosphatic nodules scattered throughout, some as much as 0.6 ft long. Iron sulfides present as grains and nodules	4.6
Shale, grayish-black, carbonaceous, tough. Iron sulfides present as grains, nodules, and thin seams	25.8
Mudstone, various shades of gray and greenish-gray, laminated, weathers hackly; interbedded with thin grayish-black carbonaceous shale. Iron sulfides present as grains and nodules. Basal 0.02 ft sandy	4.9
Total	35.3
Ordovician.	

LOCALITY 14.—*Cut on State Highway 90, 1.25 miles west of Burkesville, Cumberland County, Ky.*

	Feet
Mississippian:	
New Providence shale:	
The basal part of this formation is considered to be the biostratigraphic equivalent of the Maury formation of Tennessee. It is a greenish-gray mudstone with a concentration of large phosphatic nodules in the basal 0.6 ft.	
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough; phosphatic nodules throughout	4.1
Shale, grayish-black, carbonaceous, tough	13.5
Mudstone, dark-gray, alternating with thin beds of grayish-black carbonaceous shale	1.3
Mudstone, dark-gray	1.9
Sandstone, consisting chiefly of rounded grains of quartz sand	.1
Total	20.9
Ordovician.	

LOCALITY 39.—*Cut on State Highway 56, 1.7 miles south of Gainesboro, Jackson County, Tenn.*

	Feet
Mississippian:	
Fort Payne chert:	
Basal beds include a coarse textured, lenticular, biohermal mass. Pelmatozoan columnals abundant, megafossils present. Basal beds somewhat cherty.	
Maury formation (in part):	
Mudstone, dusky-green to dusky-yellow	0.07
Mudstone, yellowish-gray to olive-gray; phosphatic nodules scattered throughout	1.43
Devonian:	
Maury formation (in part):	
Persistent course of phosphatic nodules, 0.5 ft thick, embedded in grayish-blue-green to dusky-blue-green glauconitic mudstone which is underlain by dark-gray to olive-gray crossbedded siltstone	1.0
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough. Phosphatic nodules throughout interval and concentrated in two courses; the main course located approximately 1 ft below top; the other, approximately 3.2 ft below top. Iron sulfides present as grains and nodules	4.7
Shale, grayish-black, carbonaceous, tough; iron sulfides present as grains, nodules, and paper-thin layers	6.5
Shale, grayish-black, carbonaceous, tough; alternating with thin beds of greenish-gray mudstone. Iron sulfides present as grains	3.8

LOCALITY 39—Continued

	Feet
Devonian—Continued	
Chattanooga shale—Continued	
Dowelltown member:	
Mudstone, greenish-gray, banded; alternating with thin beds of grayish-black carbonaceous shale and sandy beds. Iron sulfides present as grains, nodules, and thin seams	5. 9
Total	23. 40
Ordovician.	

LOCALITY 54.—*Cut on road leading northwest from State Highway 56 into the Flynn Creek structure, 1.2 miles from Highway 56 and 6.5 miles (airline) south-southeast of the courthouse at Gainesboro, Jackson County, Tenn.*

[Chattanooga shale measurements made by W. A. Heck, March 1, 1948]

	Feet
Mississippian:	
Fort Payne chert:	
Limestone, cherty.	
New Providence shale:	
Mudstones, bluish-green and greenish-gray. Thin siliceous layers, iron sulfide grains, and pelmatozoan columnals present. A course of siliceous geodes up to 0.1 ft in diameter at base	7. 2
Maury formation:	
Mudstone, greenish and brownish, glauconitic	. 4
Mudstone, yellowish-gray to olive-gray, laminated. Iron sulfides present as grains. Phosphatic nodules scattered throughout	1. 8
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough. Phosphatic nodules scattered throughout interval. Iron sulfides present as grains and nodules	2. 5
Shale, grayish-black, carbonaceous, tough. Iron sulfides present as grains	9. 3
Shale, grayish-black, carbonaceous, tough, with iron sulfides present as grains; alternating with thin beds of grayish-olive to greenish-gray mudstones. A laminated bed, 0.1 ft thick, present at base	1. 4
Shale, grayish-black, carbonaceous, tough. Iron sulfides present as grains	2. 3
Dowelltown member:	
Mudstone; alternating thin greenish-gray, grayish-olive, olive-gray, and grayish-brown beds together with a few thin grayish-black-shale beds. A light-gray iron-oxide-stained bentonite bed, 0.1 ft thick, present 0.4–0.5 ft below top	3. 4
Shale, grayish-black, carbonaceous, tough; iron sulfides present as grains	6. 2

LOCALITY 54—Continued

	Feet
Devonian—Continued	
Chattanooga shale—Continued	
Dowelltown member—Continued	
Sandstone, iron-oxide-stained, consisting chiefly of rounded quartz grains. Lower surface uneven. Thickness ranges from 0.25–0.5 ft; average	0. 4
Total	34. 9
Ordovician.	

LOCALITY 60.—*Cut on United States Highway 70N, 0.8 mile west of Chestnut Mound, Smith County, Tenn.*

	Feet
Mississippian:	
Fort Payne chert:	
Limestone, blocky, interbedded with chert.	
Maury formation (in part):	
Mudstone, grayish-green, laminated	3. 1
Devonian:	
Maury formation (in part):	
Course of large phosphatic nodules embedded in dark-gray shale and mudstone	1. 2
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough. Phosphatic nodules scattered throughout. Iron sulfides present as grains and nodules	3. 4
Shale, grayish-black, carbonaceous, tough, laminated; iron sulfides present as grains, nodules, and thin layers	7. 3
Shale, grayish-black, carbonaceous, tough; interbedded with thin beds of gray mudstone. A laminated bed, which ranges from 0.3–0.13 ft in thickness, present at the base	3. 0
Shale, grayish-black, carbonaceous, tough	2. 1
Dowelltown member:	
Mudstone; alternating thin greenish-gray, grayish-olive, olive-gray, and grayish-brown beds, together with a few thin grayish-black shale beds. A medium-dark-gray bentonite bed (very light gray and iron oxide stained where weathered), 0.1 ft thick, present 1.3–1.4 ft below top	5. 3
Shale, grayish-black, carbonaceous, tough; interbedded with thin gray mudstone beds	2. 3
Mudstone, gray; interbedded with a few thin grayish-black carbonaceous shale beds	3. 8
Sandstone, iron-oxide-stained, consisting chiefly of rounded grains of quartz sand	. 1
Total	31. 6
Ordovician.	

LOCALITY 74.—*Face of Taylor Creek Falls (Fanchers Mill), about 10 miles (airline) northwest of Sparta, White County, Tenn.*

[Modified from notes of Ralph Smith, dated May 19, 1948]

	Feet
Mississippian:	
Fort Payne chert.	
Maury formation (in part):	
Mudstone, grayish-green	1. 6
Devonian:	
Maury formation (in part):	
Course of large phosphatic nodules embedded in grayish-black, carbonaceous shale. Iron sulfides present as grains and nodules	. 9
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough; scattered phosphatic nodules	1. 7
Shale, grayish-black, carbonaceous, tough	7. 4
Shale, grayish-black, carbonaceous; interbedded thin beds of gray mudstone	3. 1
Shale, grayish-black, carbonaceous. A laminated bed, 0.15 ft thick, present 1.25–1.40 ft below top	8. 4
Dowelltown member:	
Mudstone; alternating thin greenish-gray, grayish-olive, olive-gray, and grayish-brown beds, together with few thin grayish-black shale beds. A bentonite bed, 0.12 ft thick, present 0.93–1.05 ft below top	9. 4
Shale, grayish-black, carbonaceous, tough	6. 7
Total	39. 2
Ordovician.	

LOCALITY 75.—*Cut on abandoned farm road, 0.5 mile northwest of point on State Highway 26 where descent starts to the east end of the Sligo Bridge over the Caney Fork, and 5.8 miles (airline) east of the courthouse at Smithville, DeKalb County, Tenn.*

	Feet
Mississippian:	
Fort Payne chert.	
Maury formation (in part):	
Mudstone, grayish-green	2. 1
Devonian:	
Maury formation (in part):	
Course of large phosphatic nodules	. 3
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough	7. 7
Shale, grayish-black, carbonaceous, with some interbedded gray mudstones. A laminated bed, 0.2 ft thick, consisting of alternating paper-thin layers of black shale and gray fine to very fine sandstone at base	1. 9
Shale, grayish-black, carbonaceous, tough	7. 7
Dowelltown member:	
Mudstone; alternating thin greenish-gray, grayish-olive, olive-gray, and grayish-brown beds, together with a few thin grayish-black shale beds. A bentonite bed, 0.11 ft thick, present 0.67–0.78 ft below top	9. 3

LOCALITY 75—Continued

	Feet
Devonian—Continued	
Chattanooga shale—Continued	
Dowelltown member—Continued	
Shale, grayish-black, carbonaceous, tough	6. 9
Sandstone, brownish to grayish-black, poorly sorted, consisting chiefly of rounded grains of quartz sand	. 2
Total	36. 1
Ordovician.	

LOCALITY 76.—*Cut on State Highway 26, at east approach to the Sligo Bridge over the Caney Fork, 5.9 miles (airline) or 7.1 miles by road east of the courthouse at Smithville, DeKalb County, Tenn. Standard section of the Chattanooga shale, described on page 12.*

LOCALITY 78.—*Cut on that portion of State Highway 26 abandoned in 1948, approximately 0.6 mile southeast of the eastern approach to Sligo Bridge over the Caney Fork on the present State Highway 26, and 5.9 miles (airline) east of the courthouse at Smithville, DeKalb County, Tenn.*

	Feet
Mississippian:	
Fort Payne chert.	
Maury formation (in part):	
Mudstone, olive-gray, laminated, slightly glauconitic	2. 1
Devonian:	
Maury formation (in part):	
Course of large phosphatic nodules	. 3
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough	7. 0
Shale, grayish-black, carbonaceous, tough, interbedded with thin beds of gray mudstone. A laminated bed, 0.25 ft thick, consisting of alternating, paper-thin layers of black shale and gray very fine grained sand at base	3. 3
Shale, grayish-black, carbonaceous, tough	8. 4
Dowelltown member:	
Mudstone; alternating thin greenish-gray, grayish-olive, olive-gray, and grayish-brown beds, together with a few thin grayish-black shale beds. A bentonite bed, 0.11 ft thick, present 0.69–0.80 ft below top	9. 7
Shale, grayish-black, carbonaceous, tough	4. 5
Sandstone, grayish-black, consisting chiefly of rounded grains of quartz sand	. 2
Total	35. 5
Ordovician.	

LOCALITY 88.—*Horseshoe Bend; along the right bank of the Caney Fork, 4.8 miles (airline) west-northwest of United States Highway 70S at the community of Walling, White County, Tenn.*

[This locality is now below the normal pool level of a reservoir]

Mississippian:	
Fort Payne chert:	
Limestone, gray, bedded, cherty, with siliceous geodes. Uneven contact with underlying beds.	

LOCALITY 88—Continued

	Feet
Devonian:	
Chattanooga shale:	
Gassaway member:	
Upper black shale:	
Mudstone, greenish-gray to olive-gray	0.7
Mudstone, greenish-gray to olive-gray, indurated, blocky; iron sulfides present as grains and nodules	1.0
Shale, grayish-black, carbonaceous, tough; iron sulfides present as grains and nodules	13.7
Dowelltown member:	
Middle gray beds:	
Mudstone; alternating thin greenish-gray, grayish-olive, olive-gray, and grayish-brown beds, together with a few thin grayish-black shale beds. A medium-dark-gray bentonite bed, 0.1 ft thick, present 1.22–1.32 ft below top	5.5
Lower black shale:	
Shale, grayish-black, carbonaceous, tough; iron sulfides present as grains	10.6
Total	31.5
Ordovician.	

Locality 88 is now below the normal pool level of a reservoir. The Maury formation was not recognized at this locality. The mudstone beds just beneath the Fort Payne chert contain numerous conodonts like those that characterize the lower faunal zone of the Gassaway member of the Chattanooga shale and include *Ancyrognathus bifurcata*, *Palmatolepis glabra*, *Palmatolepis perlobata*, *Palmatolepis subperlobata*, and *Polylophodonta confluens*. The Maury formation could have been cut out of the section through faulting as elsewhere, within a mile or two of locality 88, the Chattanooga shale and Maury formation interval has been greatly contorted and ranges from 3 to 6 feet in thickness.

LOCALITY 89.—*Face of waterfall on Pine Creek, 4.4 miles (airline) west of confluence with Caney Fork and 3.3 miles (airline) southeast of the courthouse at Smithville, DeKalb County, Tenn.*

	Feet
Mississippian:	
Fort Payne chert:	
Limestone, blocky, interbedded with chert.	
Maury formation:	
Mudstone, grayish-green, laminated	1.6
Mudstone, medium-gray to olive-gray, laminated	.3

LOCALITY 89—Continued

	Feet
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough	5.0
Shale, grayish-black, carbonaceous, tough; interbedded with thin beds of gray mudstone. A laminated bed, 0.19 ft thick, consisting of paper-thin layers of black shale and gray very fine grained sand at base	2.3
Shale, grayish-black, carbonaceous, tough	7.7
Dowelltown member:	
Mudstone: alternating thin grayish-green, grayish-olive, olive-gray, and grayish-brown beds, together with a few thin grayish-black shale beds. A bentonite bed, 0.08 ft thick, 0.60–0.68 ft below top	9.3
Shale, grayish-black, carbonaceous, tough. Basal contact under water. Measured	6.7
Total exposed	32.9
Ordovician.	

LOCALITY 91.—*Cut on farm road, one mile north of State Highway 26 and 3.4 miles northeast of the courthouse at Smithville, DeKalb County, Tenn.*

	Feet
Mississippian:	
Fort Payne chert.	
Maury formation (in part):	
Mudstone, grayish-green, laminated	2.1
Devonian:	
Maury formation (in part):	
Course of phosphatic nodules embedded in gray mudstone	.1
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough	7.0
Shale, grayish-black, carbonaceous; interbedded with thin gray mudstones. A laminated bed, consisting of alternating paper-thin layers of black shale and gray very fine grained sand at base	2.4
Shale, grayish-black, carbonaceous, tough	7.6
Dowelltown member:	
Mudstone; alternating thin greenish-gray, grayish-olive, olive-gray, and grayish-brown beds, together with few thin grayish-black shale beds. A bentonite bed, 0.1 ft thick, 0.6–0.7 ft below top	9.3
Shale, grayish-black, carbonaceous, tough	5.9
Sandstone, iron-oxide-stained, consisting chiefly of rounded grains of quartz sand	.1
Total	34.5
Ordovician.	

LOCALITY 92.—*Cut on the Holmes Creek road, 1.6 miles north of the courthouse at Smithville, DeKalb County, Tenn.*

Mississippian:
Fort Payne chert:
Covered, float only.
Maury formation (in part):

	Feet
Covered interval.	
Mudstone, grayish-green, laminated	1.0
Shale, grayish-black, carbonaceous, tough	.2
Mudstone, gray	.4

Devonian:
Maury formation (in part):

Course of phophatic nodules embedded in gray mudstone	.5

Chattanooga shale:
Gassaway member:

Shale, grayish-black, carbonaceous, tough; scattered phosphatic nodules	.2
Shale, grayish-black, carbonaceous, tough	6.7
Shale, grayish-black, carbonaceous, tough; interbedded with thin beds of gray mudstone. A laminated bed, 0.2 ft thick, consisting of alternating paper-thin layers of black shale and gray very fine grained sand at base	2.0
Shale, grayish-black, carbonaceous, tough	6.2

Dowelltown member:

Mudstone; alternating thin grayish-green, grayish-olive, olive-gray, and grayish-brown beds, together with a few thin grayish-black shale beds. A bentonite bed, 0.12 ft thick, present 0.50–0.62 ft below the top	9.0
Shale, grayish-black, carbonaceous, tough	6.1
Total	32.3

Ordovician.

LOCALITY 95.—*Cut on that portion of State Highway 26 abandoned as the main highway in 1953, 3.1 miles east of Dowelltown, DeKalb County, Tenn. Regarded as the type locality of Campbell's Dowelltown formation. This section is described on pages 13, 14.*

LOCALITY 100.—*Cut on State Highway 53, about 5 miles by road south of Gassaway, Cannon County, Tenn. Type locality of Campbell's Gassaway formation. This section is described on pages 14, 15.*

LOCALITY 107.—*Deep cut on United States Highway 41, 1 mile northwest of Noah and 10.1 miles northwest of Manchester, Coffee County, Tenn.*

Mississippian:
Fort Payne chert.
Maury formation:

	Feet
Mudstone, light-greenish-gray to grayish-yellow-green, laminated, iron-oxide-stained	0.9

LOCALITY 107—Continued

Devonian:
Chattanooga shale:
Gassaway member:

	Feet
Shale, grayish-black, carbonaceous, tough	0.2
Mudstone, gray, iron-oxide-stained	.2
Shale, grayish-black, carbonaceous, tough; iron sulfides present as grains and nodules. Interval contains a few mudstone beds 0.01–0.08 ft thick	5.1
Shale, grayish-black, carbonaceous, tough, alternating with thin beds of grayish-olive to greenish-gray siltstone; iron sulfides present as grains and nodules. A laminated bed, 0.4 ft thick, consisting of alternating, paper-thin layers of grayish-black shale and iron-oxide-stained very fine grained sand at base	1.2
Shale, grayish-black, carbonaceous, tough	5.8

Dowelltown member:

Mudstone; alternating thin greenish-gray, grayish-olive, olive-gray, and grayish-brown beds, together with a few thin grayish-black shale beds. A bentonite bed, 0.05 ft thick, present 1.16–1.21 ft below top	9.4
Shale, grayish-black, carbonaceous, tough; a few thin gray mudstone beds. Iron sulfides present as grains and nodules	7.5
Sandstone, medium-light-gray to grayish-black, calcareous. Consists chiefly of rounded quartz grains and iron sulfide grains and stringers. Top 0.45 ft of interval contains thin layers of grayish-black, carbonaceous shale	.6
Total	30.8

Ordovician.

LOCALITY 126a.—*In gully about 100 feet south of United States Highway 241, 4 miles south of the courthouse at Fayetteville, Lincoln County, Tenn.*

Mississippian:
Fort Payne chert.
Maury formation:

	Feet
Mudstone, light-greenish-gray to pale-greenish-yellow where freshly exposed, and yellowish-orange where weathered. Basal 0.5 ft greenish gray, indurated	1.5

Devonian:
Chattanooga shale:
Gassaway member:

Shale, grayish-black, carbonaceous, tough; iron sulfides present as grains, nodules, and paper-thin layers. The shale beds, which may be as much as 0.1 ft thick, are separated by reddish-brown silty beds as much as 0.02 ft thick	5.2

LOCALITY 126a—Continued

	Feet
Devonian—Continued	
Chattanooga shale—Continued	
Gassaway member—Continued	
Sandstone; light olive gray where freshly exposed, but yellowish brown and moderate brown where weathered; somewhat friable, consists chiefly of rounded grains of quartz sand. Iron sulfides common in top 0.1 ft	0. 7
Total	7. 4
Ordovician.	

LOCALITY 127.—*Quicks Mill on Flint River, about 4 miles west of New Market, Madison County, Ala. Section measured along mill race, approximately 0.2 mile upstream from Quicks Mill.*

[Holmes (1928) conodont fauna came from vicinity of this locality]

	Feet
Mississippian:	
Fort Payne chert:	
Limestone, yellowish-gray.	
Maury formation:	
Course of large phosphatic nodules embedded in gray siltstone	0. 3
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale, dark-gray to grayish-black, carbonaceous, tough; iron sulfides present as grains	5. 0
Total	5. 3
Water level of mill race.	

LOCALITY 134.—*Cut on south side of State Highway 129, 0.9 mile west of junction with United States Highway 31A in Cornersville, Marshall County, Tenn.*

	Feet
Mississippian:	
Fort Payne chert.	
Maury formation:	
Mudstone, light-greenish-gray, iron-oxide-stained, with few phosphatic nodules in basal 0.2 ft	1. 3
Devonian:	
Chattanooga shale:	
Gassaway member:	
Mudstone, pale-olive	1. 6
Shale, dark-gray, carbonaceous, silty	1. 0
Claystone, light-green and orange-brown, laminated	. 4
Shale, grayish-black, carbonaceous, tough; with persistent sandy bed, 0.6 ft thick, at base	3. 4
Shale, grayish-black, with paper-thin silty seams; iron sulfides are present as grains and nodules	1. 0
Total	8. 7
Ordovician.	

LOCALITY 154.—*Cut on road to Hampshire, 3.8 miles west of United States Highway 43 at Mount Pleasant, Maury County, Tenn.*

[Ulrich and Bassler's (1926) "Hardin sandstone" conodont fauna came from this vicinity. See Bassler (1932, p. 141) for his description of section]

	Feet
Mississippian:	
Ridgetop shale:	
Mudstone, laminated, light-bluish-gray to greenish-gray. Approximately	13. 0
Maury formation:	
Mudstone, greenish-gray and yellowish-brown, glauconitic, phosphatic grains common; course of phosphatic nodules in basal 0.2 ft	. 8
Devonian:	
Chattanooga shale:	
Sandstone, several shades of brown, indurate, poorly sorted. Consists chiefly of quartz sand together with phosphatic grains, glauconite, bones and conodonts	. 6
Total	14. 4
Ordovician.	

LOCALITY 163.—*Cut on State Highway 50, 3 miles southwest of the main intersection at Coble, Hickman County, Tenn.*

	Feet
Mississippian:	
Maury formation:	
Mudstone, light-olive-gray, glauconitic; few phosphatic nodules	0. 2
Course of large phosphatic nodules embedded in light-olive-gray mudstone; glauconitic	. 3
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough	1. 0
Total	1. 5
Covered.	

LOCALITY 165.—*Cut on State Highways 43 and 100; 2 miles northeast of Centerville, Hickman County, Tenn.*

	Feet
Mississippian:	
Fort Payne chert:	
Limestone, cherty; basal foot weathered reddish-brown and dusky red.	
Maury formation:	
Course of large phosphatic nodules embedded in a glauconitic grayish-olive mudstone	0. 6
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough	3. 6
Sandstone, consisting chiefly of rounded grains of quartz sand. Upper 0.25 ft bluish-gray to olive gray; lower 0.35 ft iron oxide stained	. 6
Total	4. 8
Silurian.	

LOCALITY 168.—*Cut on State Highway 50, about 3.5 miles southeast of Centerville, Hickman County, Tenn.*

Mississippian:
Fort Payne chert.
Maury formation:

	Feet
Course of large phosphatic nodules embedded in dusky-yellow-green to grayish-olive, glauconitic mudstone	0. 7

Devonian:
Chattanooga shale:
Gassaway member:

Shale, grayish-black carbonaceous, tough	4. 2
Sandstone, bluish-gray to olive-gray, unsorted; consisting of quartz grains, phosphatic pellets, bone fragments, conodonts, and iron sulfide grains, nodules, and lenses	. 7
Total	5. 6

Silurian.

LOCALITY 185.—*Standard section of the Maury formation. South side of a road 13.5 miles (airline) southeast of Franklin and 1.2 miles east of the road junction at Cross Key, Williamson County, Tenn. This section is described on page 23.*

LOCALITY 203.—*Local standard section of the New Providence shale. Cited in literature as Whites Creek Springs, but locally known as Crocker Springs, about 10.5 miles (airline) north of State Capitol in Nashville and 1.3 miles north of community of Mount Hermer, Davidson County, Tenn.*

[The following description is from L. C. Conant's notes of April 29, 1952]

Mississippian:
New Providence shale.
Maury formation:

	Feet
Top indefinite. Greenish-gray, glauconitic mudstone. Phosphatic nodules numerous and as much as 0.75 ft long. Interval poorly exposed; approximate thickness	1. 0

Devonian:
Chattanooga shale:
Gassaway member:

Shale, grayish-black, massive. Probable duplication of beds through faulting	24. 0

Dowelltown member(?):

Shale, grayish-black, hackly in top 2 ft. Remainder of interval mostly concealed	5. 0
Covered. Estimated thickness	1. 0–2. 0
Shale, grayish-black, massive; exposed in creek bed. Base not exposed. Approximate thickness of exposed beds	3. 0
Total	34. 0–35. 0

LOCALITY 204.—*Type locality of the Ridgetop shale, in cuts along the tracks of the Louisville and Nashville Railroad at Bakers Station, Davidson County, Tenn. From community of Ridgetop go south 3 miles on United States Highway 41 to road junction, turn west onto secondary road, go 0.7 mile to cuts along railroad tracks. The Gassaway member was measured in a cut at Bakers Station crossing, the Dowelltown member in a cut 1,560 ft south of the Bakers Station crossing.*

Mississippian:
Ridgetop shale (only basal beds described):

	Feet
Limestone, cherty, fossiliferous	1. 3
Mudstone, gray, laminated	1. 5

Maury formation:

Mudstone, glauconitic	. 3
Mudstone, gray	. 7
Course of large phosphatic nodules embedded in gray mudstone	. 6
Mudstone, gray and dark-brown, laminated	. 3

Devonian:
Chattanooga shale:
Gassaway member:

Shale, grayish-black, carbonaceous, tough; phosphatic nodules throughout	. 7
Shale, grayish-black, carbonaceous, tough; iron sulfides present as grains and nodules. A persistent re-entrant zone, 0.3 ft thick, present 2.0–2.3 ft above base	10. 5
Shale, grayish-black, carbonaceous, tough; numerous iron sulfide grains and nodules	1. 0
Sandstone (Bransford sandstone of Campbell, 1946),[1] yellowish-gray, iron-oxide-stained; unsorted, consisting chiefly of rounded quartz grains, bone fragments, teeth, and conodonts	. 4

Dowelltown member:

Shale, dark-gray to grayish-black, carbonaceous, tough	. 5
Mudstone, dark-gray, hackly, iron sulfides present as grains and thin seams	3. 1
Sandstone, medium-light-gray, iron-oxide-stained, friable; ranges in thickness from 0.02–0.13 ft; average	. 1
Shale, grayish-black to dark-gray, carbonaceous, laminated	. 35
Mudstone, sandy, laminated. Upper half consists of alternating paper-thin layers of dark-gray shale and light-gray mudstone; lower half consists chiefly of quartz sand	. 15
Shale, grayish-black, carbonaceous, tough; interbedded thin gray beds and lenses of mudstone and sandstone. Iron sulfides present as grains and nodules	11. 7
Sandstone, dark-gray to medium-dark-gray, unsorted; consists chiefly of rounded grains of quartz sand	1. 0
Total	34. 20

Silurian.

[1] Section carried 1,560 ft south of Bakers Station crossing on this sandstone.

LOCALITY 205.—*Cut on State Highway 109, 5.5 miles north of Gallatin, Sumner County, Tenn.*

	Feet
Mississippian:	
New Providence shale (basal portion):	
Chert, porous, weathered, iron-oxide-stained	2.0
Siltstone, indurated, laminated, greenish-gray to pale-olive; basal 0.15 ft contains glauconite and phosphatic nodules	9.5
Maury formation:	
Mudstone, plastic, dusky-yellow to greenish-gray, glauconitic. Contact with overlying New Providence shale indefinite	.9
Mudstone, grayish-green, glauconitic	.3
Course of large phosphatic nodules embedded in dark-gray siltstone. Largest nodule observed measured 2.5 by 0.1 by 0.3 ft	.2
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough; no phosphatic nodules recognized in topmost portion of interval. Lower portion disturbed	16.0
Sandstone (Bransford sandstone of Campbell, 1946), very light gray to dark-gray, iron-oxide-stained, poorly sorted, indurated; consists chiefly of rounded grains of quartz sand. Lenticular, ranges from featheredge to 0.2 ft in thickness, average	.1
Dowelltown member:	
Shale, grayish-black, with sandy lenses; beds of interval disturbed. Base not exposed; estimated thickness	15.0
Total	44.0
Covered.	

LOCALITY 206.—*Type locality of Campbell's Bransford sandstone member of his Gassaway formation. In west bank of Bledsoe Creek which parallels United States Highway 31E, 3.6 miles north of intersection with State Highway 10A at Bransford, Sumner County, Tenn.*

	Feet
Mississippian:	
New Providence shale:	
Limestone interbedded with mudstone. Unit greenish gray and light bluish gray, crinoidal. Grades into overlying cherty limestones.	
Maury formation (in part):	
Covered, probably Maury formation, estimated thickness	1.0
Shale (Westmoreland shale of Campbell, 1946), grayish-black to black, carbonaceous, tough; iron sulfides present as grains and nodules	1.0

LOCALITY 206—Continued

	Feet
Devonian:	
Maury formation (in part):	
Mudstone (upper part of Eulie shale of Campbell, 1946), yellowish-gray to pale-olive-gray, indurated	0.2
Course of large phosphatic nodules (lower part of Eulie shale of Campbell)	.3
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough; iron sulfides present as grains and nodules. Phosphatic nodules common, may be as much as 1 ft in length	.5
Shale, grayish-black, carbonaceous, tough; iron sulfides present as grains, nodules, and seams. A few very thin beds of gray mudstone	15.5
Sandstone (Type Bransford sandstone of Campbell, 1946), very light gray to dark-gray, iron-oxide-stained; poorly sorted, indurated; consists chiefly of rounded grains of quartz sand, bone fragments, fish teeth, conodonts, and iron sulfide grains and nodules. Base uneven. As much as 0.25 ft thick; average	.2
Dowelltown member:	
Shale, grayish-black, carbonaceous, tough; a few thin beds of gray mudstone present. Rocks of interval weather to small chips and dip about 8° NW	15.0
Shale (Trousdale shale of Pohl, 1930a), grayish-black, carbonaceous; interbedded with medium-gray to dark-gray calcareous sandstones that consist chiefly of rounded grains of quartz sand. Iron sulfides present as grains and nodules	2.0
Total	35.7
Silurian.	

LOCALITY 207.—*Type locality of Campbell's Westmoreland shale; 200 yards north of Garretts Creek Church and 5.6 miles by road north of Westmoreland, Sumner County, Tenn.*

	Feet
Mississippian:	
New Providence shale:	
Limestone, crinoidal, light-gray; interbedded with thin greenish-gray calcareous silty beds.	
Maury formation (in part):	
Covered	0.2
Mudstone, light-gray	.2
Shale (type Westmoreland shale of Campbell, 1946), grayish-black, carbonaceous; a few phosphatic nodules, as much as 0.3 ft long, throughout interval. Iron sulfides present as grains	.5

LOCALITY 207—Continued

Devonian:
Maury formation (in part):

	Feet
Mudstone (upper part of Eulie shale of Campbell, 1946), olive-gray, medium-gray, and greenish-gray	0.4
Course of large phosphatic nodules (lower part of Eulie shale of Campbell, 1946)	.2

Chattanooga shale:
Gassaway member:

Shale, grayish-black, carbonaceous, tough; iron sulfides present as grains. Few phosphatic nodules embedded in top 0.1 ft. Basal contact covered. Measured	6.0
Total	7.5

Covered, creek level.

LOCALITY 215.—*Road cut and hillside, 2 miles east of road junction near Cedar Ridge, northeast corner of Melvine quadrangle, Bledsoe County, Tenn.*

Mississippian:
Fort Payne chert:
Limestone, cherty.
Maury formation:

	Feet
Mudstone; predominantly yellow green, friable. Indurated and dark gray at base. Phosphatic nodules throughout interval	1.5

Devonian:
Chattanooga shale:
Gassaway member:

Shale, grayish-black, carbonaceous; phosphatic nodules present	.4
Mudstone, light-gray	.2
Shale, grayish-black, carbonaceous; phosphatic nodules present	1.6
Shale, grayish-black, carbonaceous, somewhat disturbed. Iron sulfides present as grains	10.7

Dowelltown member:

Mudstone: alternating thin greenish-gray, grayish-olive, olive-gray, and grayish-brown beds, together with a few thin grayish-black shale beds. A light-gray bentonite bed, 0.14 ft thick, present 0.43–0.57 ft below top. This interval is poorly exposed and somewhat disturbed	7.4
Shale, grayish-black, disturbed	2.5
Sandstone, consists chiefly of rounded grains of quartz sand	.2
Total	24.5

Silurian.

LOCALITY 220.—*West slope of Walden Ridge. Cut along State Highway 8, 1 mile southeast of junction with State Highway 28, near Dunlap, Sequatchie County, Tenn.*

Mississippian:
Fort Payne chert:

	Feet
Limestone, cherty, blocky; basal 0.25 ft weathered.	

LOCALITY 220—Continued

Mississippian—Continued
Maury formation:

	Feet
Mudstone, plastic, grayish-green to dusky-green; phosphatic nodules abundant	0.1
Mudstone, indurated, dusky-yellow-green; phosphatic nodules abundant; calcareous-siliceous geodes in top 0.4 ft	1.1
Mudstone, indurated, greenish-gray to dark-greenish-gray; phosphatic nodules in top 0.5 ft	1.7

Devonian:
Chattanooga shale:
Gassaway member:

Shale, grayish-black, tough. Numerous phosphatic nodules throughout interval, also concentrated in a persistent course 0.9–1.0 ft below top. Iron sulfides present as grains and nodules	1.0
Shale, grayish-black, tough, very thinly bedded. Iron sulfides common as grains, nodules, and paper-thin layers	4.2
Shale, grayish-black, somewhat disturbed. Iron sulfides present as grains and nodules	7.4

Dowelltown member:

Bentonite bed, 0.04–0.15 ft thick	.15
Shale, grayish-black, alternating with thin beds of light- to medium-gray mudstone	.95
Sandstone, indurated; light gray where freshly exposed and dark rusty brown where weathered. Thickness varies from 0.3–0.6 ft; average	.5
Total	17.10

Silurian.

LOCALITY 225.—*Type locality of the Glendale shale of Swartz (1924). Hillside exposure along railroad tracks, just southwest of junction of State Highway 27 (not United States Highway 27) and State Highway 8, North Chattanooga, Hamilton County, Tenn.*

Mississippian:
Fort Payne chert:

	Feet
Limestone, cherty, blocky; basal 0.25 ft weathered.	

Maury formation (Glendale shale of Swartz):

Mudstone, plastic, grayish-green to dusky-green; phosphatic nodules and calcareous-siliceous geodes common	0.2
Mudstone. Top 0.25 ft somewhat plastic, predominantly grayish yellow green to dusky yellow green; phosphatic nodules and calcareous-siliceous geodes abundant. Bottom 0.85 ft indurated, dusky yellow green; phosphatic nodules present but not abundant	1.1
Mudstone, indurated, laminated, greenish-gray to dark-greenish-gray; phosphatic nodules scarce	.7
Mudstone, indurated, olive-gray	.1
Course of phosphatic nodules in olive-gray silty matrix	.2

LOCALITY 225—Continued

	Feet
Mississippian—Continued	
Maury formation—Continued	
Mudstone, less indurated than middle portion of formation, olive-gray, with few phosphatic nodules in basal 0.1 ft and a concentration of conodonts in paper-thin layer at very base	0.5
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale, carbonaceous, grayish-black, tough. Exposed	2.3
Total	5.1
Covered.	

LOCALITY 226.—*Type locality of the Chattanooga shale. Hillside exposure at the north end of Cameron Hill, Chattanooga, Hamilton County, Tenn.*

[See pl. 5]

	Feet
Mississippian:	
Fort Payne chert:	
Limestone, cherty, blocky; basal beds locally weathered to a porous, somewhat friable, reddish-brown rock.	
Maury formation:	
Mudstone, plastic, grayish-green to dusky-green; phosphatic nodules and calcareous-siliceous geodes common	0.2
Mudstone. Top 0.25 ft somewhat plastic, predominately greenish gray to light olive brown; bottom 0.35 ft indurated, dusky yellowish green. Phosphatic nodules throughout	.6
Mudstone, indurated, pale-olive and grayish-olive. Phosphatic nodules scarce	1.2
Course of small phosphatic nodules embedded in olive-gray to dark-gray shale	.05
Mudstone, indurated, olive-gray	.4
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale, carbonaceous, grayish-black, incompetent, fractured; slickensided surfaces common; iron sulfides present as stringers, paper-thin layers, nodules, and clusters of pyrite crystals	7.0
Total	9.45
Silurian.	

LOCALITY 228.—*Cut along tracks of Southern Railroad, immediately south of the Ooltewah–Apison road crossing. About 1 mile east of Collegedale and 2 miles west of Apison, Hamilton County, Tenn.*

	Feet
Mississippian:	
Fort Payne chert:	
Limestone, cherty, blocky; basal beds locally weathered to a porous, somewhat friable, reddish-brown rock.	

LOCALITY 228—Continued

	Feet
Mississippian—Continued	
Maury formation:	
Mudstone, plastic, dusky-green to dusky-yellow-green; phosphatic nodules common and as much as 0.5 ft long	0.25
Mudstone, indurated, dark-greenish-gray; phosphatic nodules common, irregularly shaped, as much as 0.2 ft long	2.25
Mudstone, indurated, olive-black to olive-gray; phosphatic nodules present, as much as 0.2 ft long	.5
Shale, carbonaceous, dark-gray to grayish-black, incompetent; phosphatic nodules abundant, as much as 0.1 ft long; iron sulfides present as grains and nodules. Thickness varies from 3.8–4.7 ft; average	4.2
Sandstone, indurated, brownish-black; composed chiefly of rounded grains of quartz sand cemented with iron sulfides	.2
Devonian:	
Chattanooga shale:	
Gassaway member:	
Mudstone, indurated, olive-gray to olive-black	.2
Claystone; pale olive to grayish olive where freshly exposed and dark yellowish orange where weathered	1.3
Mudstone, grayish-olive. Poorly preserved megafossils	.3
Mudstone, indurated, olive-gray, sandy	.2
Shale, carbonaceous, grayish-black; rounded grains of quartz sand common; iron sulfides present as grains and paper-thin layers	1.5
Mudstone, olive-gray; thickness varies from 0.02–0.17 ft; average	.1
Shale, carbonaceous, grayish-black; rounded grains of quartz sand	1.0
Mudstone, olive-gray. Thickness varies from 0.02–0.33 ft; average	.2
Shale, carbonaceous, grayish-black; rounded grains of quartz sand	5.6
Mudstone, indurated, olive-gray, interbedded with grayish-black shale; numerous rounded grains of quartz sand; also irregularly shaped, very light gray to greenish-gray granules and pebbles of siltstone. Thickness varies from 2.5–3.0 ft; average	2.7
Sandstone, indurated, blocky; dark gray where freshly exposed and moderate brown where weathered	.2
Total	20.70
Silurian.	

Through faulting, some of the beds in the lower part of the Chattanooga shale at locality 228 appear to have been duplicated. The stratigraphic thickness of the shale is probably about 10 feet.

LOCALITY 235.—*Type locality of Whetstone Branch shale of Morse (1928), Whetstone Branch, Tishomingo County, Miss. From junction of State Highways 25 and 72 in Iuka go north on Highway 25 for 3.5 miles; turn north onto well-traveled secondary road; go 3.5 miles to road fork, continue north; go 3.1 miles to road fork, continue north; go 0.8 mile and immediately after crossing tributary of Whetstone Branch, turn onto dirt road that parallels Whetstone Branch; go 0.5 mile. The best outcrop is along the north bank of Whetstone Branch, about 300 feet from its confluence with the Tennessee River.*

	Feet
Mississippian:	
Carmack limestone of Morse:	
Limestone, bluish-gray.	
Maury formation:	
Course of large phosphatic nodules embedded in glauconitic mudstone. (Basal bed of Morse's Carmack limestone)	0.5
Devonian:	
Chattanooga shale (Whetstone Branch shale of Morse)	
Gassaway member:	
Mudstone, gray, indurated, siliceous; numerous grains and stringers of iron sulfide	.1
Mudstone, gray, indurated; numerous conodonts in basal 0.1 ft	.5
Shale, grayish-black, carbonaceous, tough; iron sulfides present as grains, nodules, and lenses	.8
Sandstone, grayish-black, lenticular, calcareous, crossbedded; iron sulfides present as grains and nodules. The sandstone beds are 0.3–0.4 ft thick and are separated by thinner undulating beds of grayish-black carbonaceous shale	1.2
Dowelltown member:	
Sandstone and shale similar to that above. The topmost 1 or 2 ft of interval may belong to the Gassaway member. Exposed	9.5
Total exposed	12.6

Bed of Whetstone Branch.

LOCALITY 239.—*In gutter and bed of secondary road by stone church, 0.15 mile south of United States Highway 64 at Olive Hill, Hardin County, Tenn.* [The description and thickness of the lithologic units given below are after V. E. Swanson's notes of July 1, 1949. The present writer is responsible for assigning beds to the Gassaway and Dowelltown members of the Chattanooga shale]

	Feet
Mississippian:	
Ridgetop shale.	
Maury formation:	
Total thickness not determinable, top not exposed. Sandstone unit at base, 0.5 ft thick, contains abundant glauconite, abundant phosphatic nodules, some marcasite nodules, and siliceous geodes. Conformable with Chattanooga shale. Approximately	1.0

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LOCALITY 239—Continued

	Feet
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale; weathered to chocolate-brown clay-like material	0.9
Covered	3.3
Shale, grayish-black, finely laminated	.4
Dowelltown member:	
Covered	1.5
Siltstone, light-gray to light-buff; somewhat ferruginous	3.4
Sandstone, buff, medium-grained; very friable on weathered surfaces	.6
Shale, dark-gray to grayish-black; thin marcasite lenses	2.7
Sandstone, light-gray to yellowish-gray, fine grained, individual beds as much as 0.3 ft thick	1.7
Shale, gray to chocolate-brown (probably weathered grayish-black shale)	1.2
Sandstone, probably gray where unweathered. Surface iron oxide stained. Small marcasite nodules present	.3
Shale and some siltstone. Dominantly grayish-black shale which weathers light gray to tan. Shale grades into thin siltstone beds which commonly are dark gray and have black lamellae	7.5
Shale and sandstone beds, alternating; each bed approximately 0.4 ft thick. The shale beds are grayish black and the sandstone beds have grayish-black lamellae. Marcasite present	4.1
Sandstone, buff to gray, fine-grained	.3
Sandstone and siltstone; gray sandstone interbedded with grayish-black siltstones. Thin zones appear to be crossbedded, slightly calcareous; marcasite nodules present. Surface with iron oxide stain	5.8
Covered	1.0
Sandstone, gray to buff, very fine grained	.2
Siltstone, gray to dark-gray	.6
Hardin sandstone member:	
Sandstone, buff to gray, fine-grained, massive to poorly bedded. Top 2.7 ft well exposed; additional 10 ft poorly exposed. Base covered	12.7
Total	49.2

Covered.

LOCALITY 249.—*Vicinity of city pumphouse, along small stream valley, west of State Highway 100, 0.2 mile northeast of courthouse at Linden, Perry County, Tenn. Additional exposures along Highway 100, 0.25 mile from courthouse.*

	Feet
Mississippian:	
Maury formation:	
Course of large phosphatic nodules embedded in fine-grained, glauconitic, light-olive-gray, iron-oxide-stained sandstone. Thickness varies from 0.15 – 0.9 ft	0.9

LOCALITY 249—Continued

	Feet
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale, dark-gray to grayish-black, carbonaceous, tough	5.2
Sandstone, brownish-gray, interbedded with dark-gray shale	.5
Dowelltown member:	
Shale, dark-gray to grayish-black, carbonaceous, tough	1.0
Hardin sandstone member:	
Sandstone, fine-grained	2.5
Total	10.1
Quall limestone.	

LOCALITY 250.—*Exposure to east of the entrance to the Hayes and Elkins limestone mine; 100 ft north of State Highway 100, 0.5 mile west of the intersection at Pleasantville, Hickman County, Tenn.*

	Feet
Mississippian:	
Fort Payne chert(?):	
Limestone, bluish; grading into basal silty limestone.	
Maury formation:	
Mudstone, olive-gray, laminated	2.0
Mudstone, glauconitic	.5
Course of large phosphatic nodules embedded in glauconitic mudstone	.2

LOCALITY 250—Continued

	Feet
Mississippian—Continued	
Maury formation—Continued	
Mudstone, glauconitic	0.2
Devonian:	
Chattanooga shale:	
Gassaway member:	
Shale, grayish-black, carbonaceous, tough; *Palmatolepis glabra* Ulrich and Bassler present at very base of interval	1.5
Sandstone, grayish-black; consisting chiefly of rounded quartz grains	.3
Total	4.7
Silurian.	

CONODONT COLLECTIONS

Listed below are data pertaining to the conodont collections mentioned by number in the text. Almost all the collections were prepared in 1948 and 1949, at which time each was given the number listed in the first, or left-hand, column of table 6. Subsequently, each collection was given the permanent number listed in column 2 of the table. In this column the letter "C" affixed to a collection number indicates that the number is from the "Carboniferous" catalog, and the letters "SD," that the number is from the "Silurian and Devonian" catalog.

TABLE 6.—*Conodont collections from the Chattanooga shale, Maury formation, and New Providence shale*

[Stratigraphic position given with reference to top of Chattanooga shale, base of Maury formation, or base of New Providence shale. All collections made by W. H. Hass]

Collection				Locality	
No.	U. S. G. S. No.	Date	Stratigraphic position	No. on pl. 1	Description
3	15500-C	Nov. 14, 1947	Maury formation: 0.3–0.5 ft above base	78	Cut on that portion of State Highway 26 abandoned in 1948; approximately 0.6 mile southeast of eastern approach to Sligo Bridge over the Caney Fork on present State Highway 26 and 5.9 miles (airline) east of the courthouse at Smithville, DeKalb County, Tenn.
5	3650-SD	Nov. 14, 1947	Chattanooga shale, Gassaway member: 1.3–1.7 ft below top.	78	Same as collection 3.
7	3651-SD	Nov. 19, 1947	Chattanooga shale, Dowelltown member: 27.0–29.0 ft below top.	92	Cut on the Holmes Creek road, 1.6 miles north of the courthouse at Smithville, DeKalb County, Tenn.
9	3652-SD	Nov. 19, 1947	Chattanooga shale, Dowelltown member: basal 1.5 ft or 28.7–30.2 ft below top.	92	Same as collection 7.
11	3653-SD	Nov. 19, 1947	Chattanooga shale, Dowelltown member: 20.0–20.3 ft below top.	92	Same as collection 7.
15	15501-C	Dec. 18, 1947	Manry formation: basal 0.05 ft	89	Face of waterfall on Pine Creek, 4.4 miles (airline) west of confluence with Caney Fork and 3.3 miles (airline) southeast of the courthouse at Smithville, DeKalb County, Tenn.
17	15502-C	Nov. 29, 1947	Maury formation: 0.9–1.1 ft above base	92	Same as collection 7.
18	3654-SD	Nov. 14, 1947	Chattanooga shale, Gassaway member: 3.5–4.0 ft below top.	78	Same as collection 3.
19	3655-SD	Nov. 19, 1947	Chattanooga shale, Gassaway member: 9.4–10.5 ft below top.	92	Same as collection 7.
21	3656-SD	Nov. 13, 1947	Chattanooga shale, Gassaway member: 12.0–12.6 ft below top.	78	Same as collection 3.
22	15503-C	Jan. 22, 1948	Maury formation: 0.15–0.5 ft above base	100	Type locality of Campbell's Gassaway formation. Cut on State Highway 53, about 5 miles by road south of Gassaway, Cannon County, Tenn. There are two exposures within 0.4 mile of each other: one on the north slope of a hill, the other on the south slope. All collections mentioned in this report from this locality are from the outcrop on the north slope.
23	3657-SD	Nov. 20, 1947	Chattanooga shale, Gassaway member: 1.1–1.6 ft below top.	92	Same as collection 7.
24	3799-SD	Nov. 12, 1947	Chattanooga shale, Dowelltown member: 20.0–20.7 ft below top.	78	Same as collection 3.

TABLE 6.—*Conodont collections from the Chattanooga shale, Maury formation, and New Providence shale*—Continued

[Stratigraphic position given with reference to top of Chattanooga shale, base of Maury formation, or base of New Providence shale. All collections made by W. H. Hass]

Collection				Locality	
No.	U. S. G. S. No.	Date	Stratigraphic position	No. on pl. 1	Description
26	3658-SD	Jan. 8, 1948	Chattanooga shale, Gassaway member: 11.87–11.9 ft below top.	95	Regarded as the type locality of Campbell's Dowelltown formation. Cut on that portion of State Highway 26 abandoned as the main highway in 1953, 3.1 miles east of Dowelltown, DeKalb County, Tenn.
27	3659-SD	Jan. 15, 1948	Chattanooga shale, Gassaway member: 4.5–4.9 ft below top.	95	Same as collection 26.
28	3660-SD	Jan. 22, 1948	Chattanooga shale, Gassaway member: 8.5–9.3 ft below top.	100	Same as collection 22.
29	3661-SD	Jan. 19, 1948	Chattanooga shale, Dowelltown member: 14.5–14.8 ft below top.	95	Same as collection 26.
30	3662-SD	Jan. 19, 1948	Chattanooga shale, Dowelltown member: 21.5–22.5 ft below top.	95	Same as collection 26.
31	3663-SD	Jan. 22, 1948	Chattanooga shale, Gassaway member: top 0.4 ft.	100	Same as collection 22.
32	3664-SD	Jan. 15, 1948	Chattanooga shale, Gassaway member: 9.5–9.7 ft below top.	95	Same as collection 26.
33	3665-SD	Jan. 15, 1948	Chattanooga shale, Gassaway member: 2.3–3.6 ft below top.	95	Same as collection 26.
34	3666-SD	Jan. 15, 1948	Chattanooga shale, Gassaway member: 6.2–6.5 ft below top.	95	Same as collection 26.
35	3667-SD	Jan. 22, 1948	Chattanooga shale, Gassaway member: 2.3–2.7 ft below top.	100	Same as collection 22.
40	3668-SD	Jan. 15, 1948	Chattanooga shale. Gassaway member: top 0.8 ft.	95	Same as collection 26.
42	3669-SD	Jan. 24, 1948	Chattanooga shale, Dowelltown member: 24.5–25.4 ft below top.	95	Same as collection 26.
43	3670-SD	Jan. 22, 1948	Chattanooga shale, Gassaway member: 12.8–13.5 ft below top.	100	Same as collection 22.
44	3671-SD	Jan. 22, 1948	Chattanooga shale, Gassaway member: 2.0–2.3 ft below top.	100	Same as collection 22.
46	3672-SD	Nov. 20, 1947	Chattanooga shale, Dowelltown member: basal 0.1 ft or 32.2–32.3 ft below top.	91	Cut on farm road, 1 mile north of State Highway 26 and 3.4 miles northeast of the courthouse at Smithville, DeKalb County, Tenn.
47	3673-SD	Nov. 12, 1947	Chattanooga shale, Dowelltown member: basal 0.2 ft or 32.9–33.1 ft below top.	78	Same as collection 3.
48	3674-SD	Nov. 29, 1947	Chattanooga shale, Dowelltown member: basal 0.2 ft or 33.5–33.7 ft below top.	75	Cut on abandoned farm road, 0.5 mile northwest of point on State Highway 26 where descent starts to the east end of the Sligo Bridge over the Caney Fork, and 5.8 miles (airline) east of the courthouse at Smithville, DeKalb County, Tenn.
49	15504-C	Jan. 2, 1948	Maury formation: 0.5–0.9 ft above base	89	Same as collection 15.
50	15505-C	Jan. 2, 1948	Maury formation: top 0.1 ft or 1.8–1.9 ft above base.	89	Same as collection 15.
51	15506-C	Jan. 22, 1948	Maury formation: 0.5–1.7 ft above base	100	Same as collection 22.
55	15507-C	June 26, 1947	Maury formation: 3.8–4.1 ft above base	228	Cut along tracks of the Southern Railroad, immediately south of the Ooltewah-Apison road crossing. About 1 mile east of Collegedale and 2 miles west of Apison, Hamilton County, Tenn.
64	3675-SD	June 28, 1947	Chattanooga shale, Gassaway member: 7.0–8.0 ft below top.	228	Same as collection 55.
65	3676-SD	June 27, 1947	Chattanooga shale, Gassaway member: 3.6–4.6 ft below top.	228	Same as collection 55.
66	3677-SD	June 26, 1947	Chattanooga shale, Gassaway member: top 0.2 ft.	228	Same as collection 55.
67	3678-SD	June 28, 1947	Chattanooga shale, Gassaway member: 0.2–1.4 ft above base or 11.9–13.1 ft below top.	228	Same as collection 55.
68	3679-SD	June 27, 1947	Chattanooga shale, Gassaway member: 2.0–2.7 ft below top.	228	Same as collection 55.
69	3680-SD	July 1, 1947	Chattanooga shale, Gassaway member: top 1.0 ft.	226	Type locality of the Chattanooga shale. Hillside exposure, about 350 ft south of the north end of Cameron Hill, Chattanooga, Hamilton County, Tenn.
71	3681-SD	June 24, 1947	Chattanooga shale, Gassaway member: top 2.3 ft.	225	Type locality of Swartz's Glendale shale. Hillside exposure along railroad tracks, just southwest of junction of State Highway 27 (not United States Highway 27) and State Highway 8, North Chattanooga, Hamilton County, Tenn.
72	3682-SD	June 24, 1947	Chattanooga shale, Gassaway member: top 0.9 ft.	225	Same as collection 71.
73	15508-C	June 26, 1947	Maury formation: 4.2–4.4 ft above base	228	Same as collection 55.
74	15509-C	June 23, 1947	Maury formation: 0.4–0.45 ft above base	226	Type locality of the Chattanooga shale. Hillside exposure at the north end of Cameron Hill, Chattanooga, Hamilton County, Tenn.
76	3683-SD	June 28, 1947	Chattanooga shale, Gassaway member: 8.7–9.5 ft below top.	228	Same as collection 55.
77	3684-SD	June 24, 1947	Chattanooga shale, Gassaway member: top 0.9 ft.	225	Same as collection 71.
82	3685-SD	June 26, 1948	Chattanooga shale, Gassaway member: 4.7–5.2 ft below top.	126a	In gully about 100 ft south of United States Highway 241, 4 miles south of the courthouse at Fayetteville, Lincoln County, Tenn.
83	3686-SD	May 20, 1948	Chattanooga shale, Gassaway member: 4.1–4.5 ft below top.	207	Type locality of Campbell's Westmoreland shale, 200 yards north of Garretts Creek Church and 5.6 miles by road north of Westmoreland, Sumner County, Tenn.

TABLE 6.—*Conodont collections from the Chattanooga shale, Maury formation, and New Providence shale*—Continued

[Stratigraphic position given with reference to top of Chattanooga shale, base of Maury formation, or base of New Providence shale. All collections made by W. H. Hass]

Collection				Locality	
No.	U. S. G. S. No.	Date	Stratigraphic position	No. on pl. 1	Description
84	3687-SD	May 19, 1948	Maury formation: basal 0.5 ft	74	Face of Taylor Creek Falls (Fanchers Mill), about 10 miles (airline) northwest of Sparta, White County, Tenn.
85	3688-SD	June 22, 1948	Chattanooga shale, Dowelltown member: 12.9–13.2 ft below top.	107	Deep cut on United States Highway 41, 1 mile northwest of Noah and 10.1 miles northwest of Manchester, Coffee County, Tenn.
86	3689-SD	May 31, 1948	Chattanooga shale, Gassaway member: 10.7–11.2 ft below top.	6	In cut and on hillside below the Oil Center Road, just east of the crossing over Big Clifty Creek, 5.4 miles west of Somerset, Pulaski County, Ky.
95	3690-SD	May 20, 1948	Chattanooga shale, Gassaway member: 0.3–0.7 ft below top.	60	Cut on United States Highway 70N, 0.8 mile west of Chestnut Mound, Smith County, Tenn.
100	3691-SD	May 20, 1948	Chattanooga shale, Gassaway member: top 0.2 ft	207	Same as collection 83.
102	3692-SD	May 22, 1948	Chattanooga shale, Dowelltown member: 18.5–19.0 ft below top.	107	Same as collection 85.
103	3693-SD	June 22, 1948	Chattanooga shale, Dowelltown member: 22.2–22.7 ft below top.	107	Same as collection 85.
104	3694-SD	June 23, 1948	Chattanooga shale, Gassaway member: top 0.6 ft	107	Same as collection 85.
106	3695-SD	May 20, 1948	Chattanooga shale, Gassaway member: 13.6–13.9 ft below top.	60	Same as collection 95.
107	3696-SD	May 26, 1948	Chattanooga shale, Dowelltown member: 0.1–0.3 ft above base or 21.7–21.9 ft below top.	39	Cut on State Highway 56, 1.7 miles south of Gainesboro, Jackson County, Tenn.
110	3697-SD	June 2, 1948	Chattanooga shale, Gassaway member: 19.6–21.0 ft below top.	11	Cut on State Highway 35, 1.5 miles south-southeast of Rowena and just north of the county line, Russell County, Ky.
111	3698-SD	June 2, 1948	Chattanooga shale, Gassaway member: 10.6–11.6 ft below top.	11	Same as collection 110.
112	3699-SD	June 2, 1948	Chattanooga shale, Gassaway member: 30.0–30.4 ft below top.	11	Same as collection 110.
113	15510-C	May 20, 1948	Maury formation: 0.6–1.1 ft above base. This is from Campbell's type Westmoreland shale.	207	Same as collection 83.
115	3700-SD	June 2, 1948	Chattanooga shale, Gassaway member: 19.6–21.0 ft below top.	11	Same as collection 110.
116	3701-SD	June 2, 1948	Chattanooga shale, Gassaway member: basal 0.1 ft or 35.2–35.3 ft below top.	11	Same as collection 110.
119	3702-SD	May 26, 1948	Chattanooga shale, Gassaway member: 4.9–5.2 ft below top.	39	Same as collection 107.
120	3703-SD	May 17, 1948	Chattanooga shale, Dowelltown member: basal 0.6 ft or 31.5–32.1 ft below top.	76	Standard section of the Chattanooga shale. Cut on State Highway 26, at the east approach to the Sligo Bridge over the Caney Fork, 5.9 miles (airline) or 7.1 miles by road east of the courthouse at Smithville, DeKalb County, Tenn.
123	3704-SD	May 31, 1948	Chattanooga shale, Gassaway member: 12.4–13.1 ft below top.	6	Same as collection 86.
126	3705-SD	May 26, 1948	Chattanooga shale, Gassaway member: top 0.8 ft.	39	Same as collection 107.
129	3706-SD	June 28, 1948	Chattanooga shale, Gassaway member: 8.9–9.9 ft below top.	220	West slope of Walden Ridge. Cut on State Highway 8, 1 mile southeast of junction with State Highway 28, Sequatchie County, Tenn.
130	3707-SD	May 31, 1948	Chattanooga shale, Gassaway member: 14.3–14.7 ft below top.	6	Same as collection 86.
131	3708-SD	June 27, 1948	Chattanooga shale, Gassaway member: top 0.5 ft	126a	Same as collection 82.
133	3709-SD	May 20, 1948	Chattanooga shale, Gassaway member: 6.7–7.0 ft below top.	60	Same as collection 95.
137	15511-C	June 14, 1948	Maury formation: 0.6–0.66 ft above base. This is from basal 0.06 ft of Campbell's type Westmoreland shale.	207	Same as collection 83.
138	3710-SD	June 16, 1947	Chattanooga shale, Gassaway member: 0.6–1.0 ft below top.	206	Type locality of Campbell's Bransford sandstone member of his Gassaway formation. In west bank of Bledsoe Creek which parallels United States Highway 31E, 3.6 miles north of intersection with State Highway 10A at Bransford, Sumner County, Tenn.
143	3711-SD	June 23, 1948	Chattanooga shale, Gassaway member: 11.5–12.5 ft below top.	107	Same as collection 85.
144	3712-SD	June 16, 1947	Chattanooga shale, Gassaway member: 1.5–2.0 ft below top.	206	Same as collection 138.
145	3713-SD	June 29, 1948	Chattanooga shale, Gassaway member: 1.5–2.1 ft below top.	220	Same as collection 129.
146	3714-SD	June 16, 1947	Chattanooga shale, Gassaway member: 12.5–12.9 ft below top.	206	Same as collection 138.
149	3715-SD	May 26, 1948	Chattanooga shale, Gassaway member: 4.4–4.6 ft below top.	39	Same as collection 107.
150	3716-SD	June 28, 1948	Chattanooga shale, Gassaway member: 4.4–5.2 ft below top.	220	Same as collection 129.
151	3717-SD	June 22, 1948	Chattanooga shale, Dowelltown member: 27.7–28.4 ft below top.	107	Same as collection 85.
153	3718-SD	June 17, 1947	Chattanooga shale, Gassaway member: 6.0–6.5 ft below top.	206	Same as collection 138.

TABLE 6.—*Conodont collections from the Chattanooga shale, Maury formation, and New Providence shale*—Continued

[Stratigraphic position given with reference to top of Chattanooga shale, base of Maury formation, or base of New Providence shale. All collections made by W. H. Hass]

Collection				Locality	
No.	U. S. G. S. No.	Date	Stratigraphic position	No. on pl. 1	Description
154	3719-SD	June 16, 1947	Chattanooga shale, Gassaway member: 10.5–10.8 ft below top.	206	Same as collection 138.
155	3720-SD	June 17, 1947	Chattanooga shale, Dowelltown member: 20.6–22.1 ft below top.	206	Same as collection 138.
157	3721-SD	June 19, 1947	Chattanooga shale, Gassaway member: 13.7–14.1 ft below top.	100	Same as collection 22.
158	15512-C	June 16, 1947	Maury formation: 0.5–1.5 ft above base. This is from Campbell's Westmoreland shale.	206	Same as collection 138.
159	3722-SD	June 18, 1947	Chattanooga shale, Gassaway member: 8.6–8.8 ft below top.	95	Same as collection 26.
160	3723-SD	June 18, 1947	Chattanooga shale, Dowelltown member: 14.1–14.5 ft below top.	95	Same as collection 26.
161	3724-SD	May 17, 1948	Chattanooga shale, Dowelltown member: 20.1–20.2 ft below top.	76	Same as collection 120.
162	3725-SD	June 23, 1948	Chattanooga shale, Gassaway member: 0.4–1.4 ft below top.	107	Same as collection 85.
165	15513-C	June 14, 1947	Maury formation: 0.6–1.1 ft above base. This is from Campbell's type Westmoreland shale.	207	Same as collection 83.
167	3726-SD	June 18, 1947	Chattanooga shale, Gassaway member: 0.8–1.1 ft below top.	95	Same as collection 26.
169	3727-SD	June 17, 1947	Chattanooga shale, Dowelltown member: 31.2–33.2 ft below top. This is from Pohl's Trousdale shale.	206	Same as collection 138.
172	3728-SD	June 14, 1947	Chattanooga shale, Gassaway member: top 0.3 ft.	207	Same as collection 83.
173	3729-SD	June 18, 1947	Chattanooga shale, Gassaway member: 11.4–12.2 ft below top.	95	Same as collection 26.
175	3730-SD	Mar. 9, 1948	Chattanooga shale, Gassaway member: top 0.9 ft.	220	Same as collection 129.
176	3731-SD	Mar. 2, 1948	Chattanooga shale, Gassaway member: 14.3–14.4 ft below top.	206	Same as collection 138.
179	3732-SD	May 26, 1948	Chattanooga shale, Gassaway member: top 0.8 ft.	39	Same as collection 107.
180	3733-SD	May 26, 1948	Chattanooga shale, Gassaway member: 2.3–3.1 ft below top.	39	Same as collection 107.
181	3734-SD	June 19, 1947	Chattanooga shale, Gassaway member: 8.0–8.5 ft below top.	100	Same as collection 22.
182	3735-SD	June 18, 1947	Chattanooga shale, Dowelltown member: 20.9–21.9 ft below top.	95	Same as collection 26.
184	3736-SD	May 31, 1948	Chattanooga shale, Gassaway member: 9.6–9.9 ft below top.	6	Same as collection 86.
185	3737-SD	June 18, 1947	Chattanooga shale, Gassaway member: 10.4–11.4 ft below top.	95	Same as collection 26.
186	3738-SD	June 18, 1947	Chattanooga shale, Dowelltown member: 14.5–14.8 ft below top.	95	Same as collection 26.
189	3739-SD	Jan. 19, 1948	Chattanooga shale, Dowelltown member: 18.0–18.3 ft below top.	95	Same as collection 26.
191	3740-SD	May 19, 1948	Chattanooga shale, Gassaway member: 4.0–4.3 ft below top.	74	Same as collection 84.
192	3741-SD	June 10, 1948	Chattanooga shale, Gassaway member: 9.07–9.1 ft below top.	206	Same as collection 138.
193	3742-SD	June 10, 1948	Chattanooga shale, Gassaway member: 7.4–7.6 ft below top.	206	Same as collection 138.
195	3743-SD	May 26, 1948	Chattanooga shale, Gassaway member: 5.4–5.8 ft below top.	39	Same as collection 107.
199	3744-SD	June 2, 1948	Chattanooga shale, Gassaway member: 31.3–31.9 ft below top.	11	Same as collection 110.
200	3745-SD	May 31, 1948	Chattanooga shale, Gassaway member: 8.6–9.0 ft below top.	6	Same as collection 86.
201	3746-SD	May 31, 1948	Chattanooga shale, Gassaway member: 4.3–4.6 ft below top.	6	Same as collection 86.
202	3747-SD	May 26, 1948	Chattanooga shale, Dowelltown member: 16.4–17.0 ft below top.	39	Same as collection 107.
207	3748-SD	June 2, 1948	Chattanooga shale, Gassaway member: 19.6–21.0 ft below top.	11	Same as collection 110.
208	3749-SD	May 26, 1948	Chattanooga shale, Gassaway member: 10.7–11.0 ft below top.	39	Same as collection 107.
211	3750-SD	June 3, 1948	Chattanooga shale, Gassaway member: 4.2–4.6 ft below top.	11	Same as collection 110.

TABLE 6.—*Conodont collections from the Chattanooga shale, Maury formation, and New Providence shale*—Continued

[Stratigraphic position given with reference to top of Chattanooga shale, base of Maury formation, or base of New Providence shale. All collections made by W. H. Hass

Collection				Locality	
No.	U. S. G. S. No.	Date	Stratigraphic position	No. on pl. 1	Description
213	3751-SD	June 14, 1948	Chattanooga shale, Gassaway member: top 0.7 ft.	204	Type locality of the Ridgetop shale, cuts along the tracks of the Louisville and Nashville Railroad at Bakers Station, Davidson County, Tenn. From community of Ridgetop go south for 3 miles on United States Highway 41 to road junction; turn west onto secondary road, go 0.7 mile to cuts along railroad tracks. The Gassaway member was measured in a cut at Bakers Station crossing, the Dowelltown member in a cut 1,560 ft south of Bakers Station crossing.
214	3752-SD	June 10, 1948	Chattanooga shale, Dowelltown member: 18.7–19.2 ft below top.	206	Same as collection 138.
216	3753-SD	June 10, 1948	Chattanooga shale, Dowelltown member: 27.5–27.8 ft below top.	206	Same as collection 138.
218	3754-SD	June 10, 1948	Chattanooga shale, Dowelltown member: 18.7–19.2 ft below top.	206	Same as collection 138.
220	3755-SD	June 14, 1948	Chattanooga shale, Gassaway member: 12.1–12.2 ft below top.	204	Same as collection 213.
224	3756-SD	June 14, 1948	Chattanooga shale, Gassaway member: 4.4–4.7 ft below top.	204	Same as collection 213.
225	3757-SD	June 1, 1948	Chattanooga shale, Gassaway member: 34.4–34.9 ft below top.	6	Same as collection 86.
227	3758-SD	June 3, 1948	Chattanooga shale, Gassaway member: 7.2–8.1 ft below top.	11	Same as collection 110.
228	3759-SD	June 1, 1948	Chattanooga shale, Gassaway member: 39.4–39.7 ft below top.	6	Same as collection 86.
229	3760-SD	June 1, 1948	Chattanooga shale, Gassaway member: 34.4–34.9 ft below top.	6	Same as collection 86.
230	3761-SD	June 3, 1948	Chattanooga shale, Gassaway member: top 0.4 ft.	11	Same as collection 110.
231	3762-SD	June 1, 1948	Chattanooga shale, Gassaway member: 41.3–41.6 ft below top.	6	Same as collection 86.
232	3763-SD	May 29, 1948	Chattanooga shale, Gassaway member: 1.4–1.7 ft below top.	6	Same as collection 86.
236	3764-SD	Jan. 15, 1948	Chattanooga shale, Gassaway member: 6.2–6.5 ft below top.	95	Same as collection 26.
237	3765-SD	Jan. 22, 1948	Chattanooga shale, Gassaway member: top 0.4 ft.	100	Same as collection 22.
238	3766-SD	Jan. 22, 1948	Chattanooga shale, Gassaway member: 12.8–13.5 ft below top.	100	Same as collection 22.
239	3767-SD	Jan. 15, 1948	Chattanooga shale, Gassaway member: 4.5–4.9 ft below top.	95	Same as collection 26.
240	3768-SD	Jan. 19, 1948	Chattanooga shale, Dowelltown member: 21.5–22.5 ft below top.	95	Same as collection 26.
241	3769-SD	Jan. 15, 1948	Chattanooga shale, Gassaway member: 9.5–9.7 ft below top.	95	Same as collection 26.
242	3770-SD	Jan. 22, 1948	Chattanooga shale, Gassaway member: 2.3–2.7 ft below top.	100	Same as collection 22.
243	3771-SD	Jan. 22, 1948	Chattanooga shale, Gassaway member: 8.5–9.3 ft below top.	100	Same as collection 22.
244	15514-C	Jan. 22, 1948	Maury formation: 0.15–0.5 ft above base	100	Same as collection 22.
245	3772-SD	Jan. 22, 1948	Chattanooga shale, Gassaway member: top 0.4 ft.	100	Same as collection 22.
328	3773-SD	June 14, 1948	Chattanooga shale, Gassaway member: 12.2–12.6 ft below top.	204	Same as collection 213.
329	3774-SD	June 14, 1948	Chattanooga shale, Dowelltown member: 19.0–19.5 ft below top.	204	Same as collection 213.
331	3775-SD	May 26, 1948	Maury formation: basal 1.0 ft	39	Same as collection 107.
332	3776-SD	May 26, 1948	Chattanooga shale, Dowelltown member: 20.3–20.5 ft below top.	39	Same as collection 107.
334	15515-C	June 12, 1948	Maury formation: 0.3–0.9 ft above base	204	Same as collection 213.
335	3777-SD	June 24, 1948	Chattanooga shale, Gassaway member: 12.2–12.6 ft below top.	204	Same as collection 213.
336	3778-SD	June 24, 1948	Chattanooga shale, Dowelltown member: 19.0–19.5 ft below top.	204	Same as collection 213.
337	15516-C	June 11, 1948	Maury formation: 1.2–1.4 ft above base	205	Cut on State Highway 109, 5.5 miles north of Gallatin, Sumner County Tenn.
344	3779-SD	May 26, 1948	Chattanooga shale, Dowelltown member: 19.6–19.7 ft below top.	39	Same as collection 107.

TABLE 6.—*Conodont collections from the Chattanooga shale, Maury formation, and New Providence shale*—Continued

[Stratigraphic position given with reference to top of Chattanooga shale, base of Maury formation, or base of New Providence shale. All collections made by W. H. Hass

Collection				Locality	
No.	U. S. G. S. No.	Date	Stratigraphic position	No. on pl. 1	Description
345	15517-C	May 26, 1948	Maury formation: 1.0–2.5 ft above base	39	Same as collection 107.
348	15518-C	May 29, 1948	New Providence shale: basal 0.5 ft	6	Same as collection 86.
349	15519-C	May 29, 1948	New Providence shale: basal 0.5 ft	6	Same as collection 86.
350	15520-C	May 29, 1948	New Providence shale: 0.5–0.8 ft above base	6	Same as collection 86.
352	3780-SD	June 1, 1948	Chattanooga shale, Dowelltown member: 47.0–47.4 ft below top.	6	Same as collection 86.
353	15521-C	June 3, 1948	New Providence shale: basal 0.3 ft	11	Same as collection 110.
354	15522-C	June 11, 1948	Maury formation: 0.5–1.2 ft above base	205	Same as collection 337.
355	15523-C	June 11, 1948	Maury formation: 0.2–0.5 ft above base	205	Same as collection 337.
357	3781-SD	June 14, 1948	Chattanooga shale, Dowelltown member: basal 1.0 ft or 28.5–29.5 ft below top.	204	Same as collection 213.
391	3782-SD	Nov. 14, 1947	Maury formation: basal 0.5 ft	92	Same as collection 7.
392	3783-SD	Nov. 14, 1947	Maury formation: basal 0.3 ft	78	Same as collection 3.
400	15524-C	Mar. 11, 1948	Maury formation: 0.2–0.3 ft above base	228	Same as collection 55.
421	3784-SD	June 14, 1947	Maury formation: basal 0.6 ft. This is from Campbell's Eulie shale.	207	Same as collection 83.
423	3785-SD	June 16, 1947	Maury formation: basal 0.1 ft. This is from Campbell's Eulie shale.	206	Same as collection 138.
426	3786-SD	June 18, 1947	Maury formation: basal 0.3 ft	95	Same as collection 26.
428	15525-C	June 19, 1947	Maury formation: 1.7–2.0 ft above base	100	Same as collection 22.
433	3787-SD	Nov. 11, 1947	Chattanooga shale, Dowelltown member: basal 0.2 ft or 29.8–30.0 ft below top.	107	Same as collection 85.
451	3788-SD	Mar. 2, 1948	Chattanooga shale, Gassaway member: 16.0–16.2 ft below top. This is from Campbell's type Bransford sandstone member of his Gassaway formation.	206	Same as collection 138.
460	3789-SD	Mar. 11, 1948	Chattanooga shale, Gassaway member: 1.5–1.8 ft below top.	228	Same as collection 55.
461	15526-C	Mar. 11, 1948	Maury formation: basal 0.05 ft	225	Same as collection 71.
462	15527-C	Mar. 11, 1948	Maury formation: 1.1–2.0 ft above base	225	Same as collection 71.
472	15528-C	June 27, 1948	Maury formation: entire formation, 1.5 ft thick	126a	Same as collection 82.
473	3790-SD	June 27, 1948	Chattanooga shale, Gassaway member: basal 0.7 ft or 5.2–5.9 ft below top.	126a	Same as collection 82.
474	3791-SD	June 28, 1948	Chattanooga shale, Dowelltown member: basal 0.5 ft or 13.7–14.2 ft below top.	220	Same as collection 129.
591	3792-SD	July 5, 1949	Chattanooga shale, Gassaway member: basal 0.3 ft or 4.6–4.9 ft below top.	168	Cut on State Highway 50, about 3.5 miles southeast of Centerville, Hickman County, Tenn.
647	15529-C	Sept. 1, 1949	Maury formation: entire formation, 1.3 ft thick	134	Cut on south side of State Highway 129, 0.9 mile west of junction with United States Highway 31A in Cornersville, Marshall County, Tenn.
652	3793-SD	Sept. 2, 1949	Chattanooga shale, Gassaway member: top 1.0 ft.	185	Standard section of the Maury formation. South side of a road 13.5 miles (airline) southeast of Franklin and 1.2 miles east of the road junction at Cross Key, Williamson County, Tenn.
653	3794-SD	Sept. 2, 1949	Chattanooga shale, Gassaway member: 1.0–1.6 ft below top.	185	Same as collection 652.
654	3795-SD	Sept. 2, 1949	Chattanooga shale, Gassaway member: 3.7–3.8 ft below top.	185	Same as collection 652.
655	3796-SD	Sept. 2, 1949	Chattanooga shale, Gassaway member: 2.4–2.5 ft below top.	185	Same as collection 652.
656	3797-SD	Sept. 2, 1949	Chattanooga shale, Dowelltown member: 7.0–7.5 ft below top.	185	Same as collection 652.
657	3798-SD	Sept. 2, 1949	Chattanooga shale, Dowelltown member: 7.8–8.8 ft below top.	185	Same as collection 652.
11113	11113-C	Mar. 2, 1948	Chattanooga shale, Dowelltown member: basal 2 ft or 31.2–33.2 ft below top. This is from Pohl's Trousdale shale.	206	Same as collection 138.
15000	15000-C	June 25, 1950	Maury formation: basal 0.3 ft. This is from Campbell's Eulie shale.	206	Same as collection 138.
15001	15001-C	June 12, 1950	Maury formation: basal 0.7 ft	168	Same as collection 591.
15002	15002-C	June 12, 1950	Maury formation: 1.0–1.5 ft above base	39	Same as collection 107.
15003	15003-C	June 17, 1950	Maury formation: 0.9–4.5 ft above base	95	Same as collection 26.
15004	15004-C	June 14, 1948	Maury formation: basal 0.3 ft	75	Same as collection 48.

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INDEX

PLATES 2–5

PLATE 2

[Figures are 30 times natural size]

FIGURE 1. *Palmatolepis distorta* Branson and Mehl.
Oral view. Rubber replica, collection 400, USNM 123466.

2–5. *Polygnathus communis* Branson and Mehl.
Oral views. 2, Collection 74, USNM 123467; 3, rubber replica, collection 113, USNM 123468; 4, collection 355, USNM 123469; 5, collection 355, USNM 123470.

6–11. *Siphonodella duplicata* (Branson and Mehl).
Oral views. 6, Rubber replica, collection 400, USNM 123471; 7, rubber replica, collection 55, USNM 123472; 8, collection 74, USNM 123473; 9, collection 355, USNM 123474; 10, collection 355, USNM 123475; 11, collection 355, USNM 123476.

12. *Siphonodella* sp. A.
Oral view. Collection 355, USNM 123477.

13, 23. *Siphonodella duplicata* (Branson and Mehl) var. A.
Oral views. 13, Rubber replica, collection 55, USNM 123478; 23, rubber replica, collection 73, USNM 123479.

14, 15. *Polygnathus inornata* E. R. Branson.
Oral views. 14, Collection 354, USNM 123480; 15, collection 355, USNM 123481.

16. *Gnathodus* sp. A.
Oral view. Collection 647, USNM 123482.

17. *Pinacognathus profunda* (Branson and Mehl).
Lateral view. Inner side, collection 355, USNM 123483.

18. *Polygnathus allocota* (Cooper).
Lateral view. Collection 355, USNM 123484.

19. *Spathognathodus* sp. A.
Lateral view. Rubber replica, collection 113, USNM 123485.

20. *Gnathodus punctatus* (Cooper).
Oral view. Collection 647, USNM 123486.

21, 22. *Elictognathus lacerata* (Branson and Mehl).
Lateral views. 21, Inner side, collection 355, USNM 123487; 22, outer side, collection 355, USNM 123488.

24. *Pseudopolygnathus prima* Branson and Mehl.
Oral view. Collection 355, USNM 123489.

25. *Siphonodella lobata* (Branson and Mehl).
Oral view. Collection 355, USNM 123490.

26. *Spathognathodus aciedentatus* (E. R. Branson).
Lateral view. Collection 355, USNM 123491.

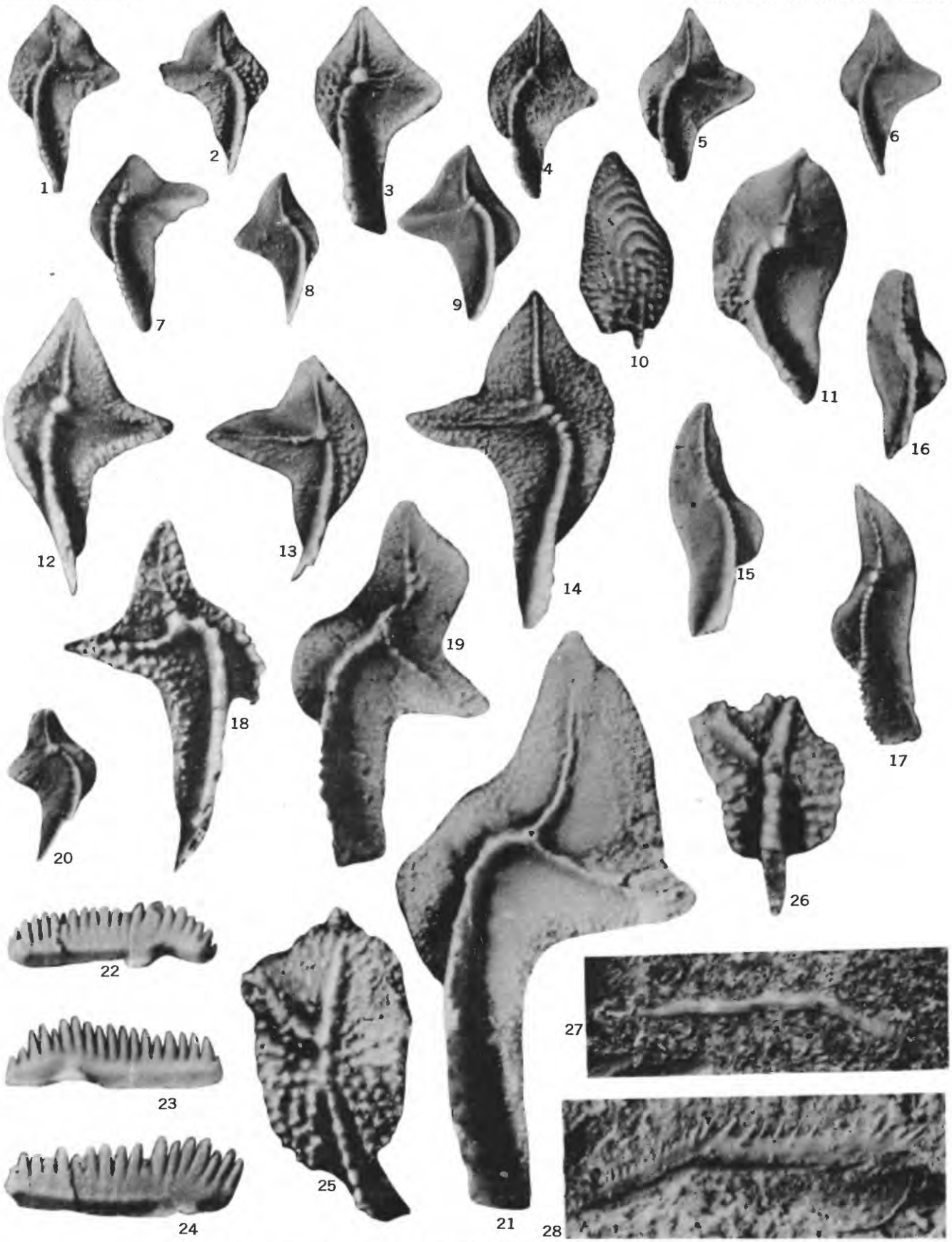
27. *Spathognathodus* sp. B.
Oral view. Collection 355, USNM 123492.

28. *Polygnathus longipostica* Branson and Mehl.
Oral view. Collection 355, USNM 123493.

29. *Siphonodella quadruplicata* (Branson and Mehl).
Oral view. Collection 355, USNM 123494.

30. *Siphonodella sexplicata* (Branson and Mehl).
Oral view. Collection 355, USNM 123495.

CONODONTS FROM MAURY FORMATION



CONODONTS FROM GASSAWAY MEMBER OF CHATTANOOGA SHALE

PLATE 3

[Figures are 30 times natural size]

Figures 1–3, 13. *Palmatolepis* sp. A.
Oral views. 1, Rubber replica, collection 28, USNM 123496; 2, rubber replica, collection 28, USNM 123497; 3, collection 157, USNM 123498; 13, rubber replica, collection 243, USNM 123499.

4–9. *Palmatolepis subperlobata* Branson and Mehl.
Oral views. 4, Rubber replica, collection 157, USNM 123500; 5, rubber replica, collection 157, USNM 123501; 6, rubber replica, collection 157, USNM 123502; 7, rubber replica, collection 243, USNM 123503; 8, rubber replica, collection 43, USNM 123504; 9, rubber replica, collection 43, USNM 123505.

10. *Polylophodonta confluens* (Ulrich and Bassler).
Oral view. Rubber replica, collection 243, USNM 123506.

11. *Palmatolepis quadrantinodosa* Branson and Mehl.
Oral view. Rubber replica, collection 181, USNM 123507.

12, 14. *Palmatolepis subrecta* Miller and Youngquist.
Oral views. 12, collection 157, USNM 123508; 14, rubber replica, collection 157, USNM 123509.

15–17. *Palmatolepis glabra* Ulrich and Bassler.
Oral views. 15, Rubber replica, collection 28, USNM 123510; 16, rubber replica, collection 28, USNM 123511; 17, rubber replica, collection 243, USNM 123512.

18. *Palmatolepis* sp. B.
Oral view. Rubber replica, collection 69, USNM 123513.

19–21. *Palmatolepis perlobata* Ulrich and Bassler.
Oral views. 19, Rubber replica, collection 181, USNM 123514; 20, rubber replica, collection 69, USNM 123515; 21, rubber replica, collection 31, USNM 123516.

22–24. *Spathognathodus inornatus* (Branson and Mehl).
Lateral views. 22, Inner side, collection 167, USNM 123517; 23, inner side, collection 201, USNM 123518; 24, outer side, collection 180, USNM 123519.

25, 26. *Ancyrognathus bifurcata* (Ulrich and Bassler).
Oral views. 25, Rubber replica, collection 28, USNM 123520; 26, collection 242, USNM 123521.

27, 28. *Hindeodella* sp. A.
Lateral views. 27, Inner side, collection 167, USNM 123522; 28, inner side, collection 167, USNM 123523.

PLATE 4

[Figures are 30 times natural size

Figure 1. *Ancyrognathus* sp. A.
Oral view. Rubber replica, collection 182, USNM 123524.

2, 3. *Polygnathus pennata* Hinde.
2, Aboral view, collection 169, USNM 123525; 3, oral view, collection 11113, USNM 123526.

4. *Icriodus* sp.
Oral view. Rubber replica, collection 240, USNM 123527.

5. *Icriodus* sp.
Lateral view. Rubber replica, collection 42, USNM 123528.

6. *Icriodus* sp.
Oral view. Collection 11113, USNM 123529.

7, 8. *Palmatolepis unicornis* Miller and Youngquist.
Oral views. 7, Collection 7, USNM 123530; 8, rubber replica, collection 7, USNM 123531.

9–15. *Palmatolepis subrecta* Miller and Youngquist.
Oral views. 9, rubber replica, collection 186, USNM 123532; 10, rubber replica, collection 186, USNM 123533; 11, rubber replica, collection 186, USNM 123534; 12, rubber replica, collection 186, USNM 123535; 13, rubber replica, collection 186, USNM 123536; 14, rubber replica, collection 186, USNM 123537; 15, rubber replica, collection 182, USNM 123538.

16, 17. *Polygnathus linguiformis* Hinde.
Oral views. 16, collection 357, USNM 123539; 17, collection 169, USNM 123540.

18. *Ancyrodella* sp. A.
Oral view. Rubber replica, collection 240, USNM 123541.

19. *Polygnathus* sp. A.
Oral view. Collection 169, USNM 123542.

20. *Ancyrodella* sp. B.
Oral view. Collection 474, USNM 123543.

21. *Ancyrodella rotundiloba* (Bryant).
Oral view. Collection 46, USNM 123544.

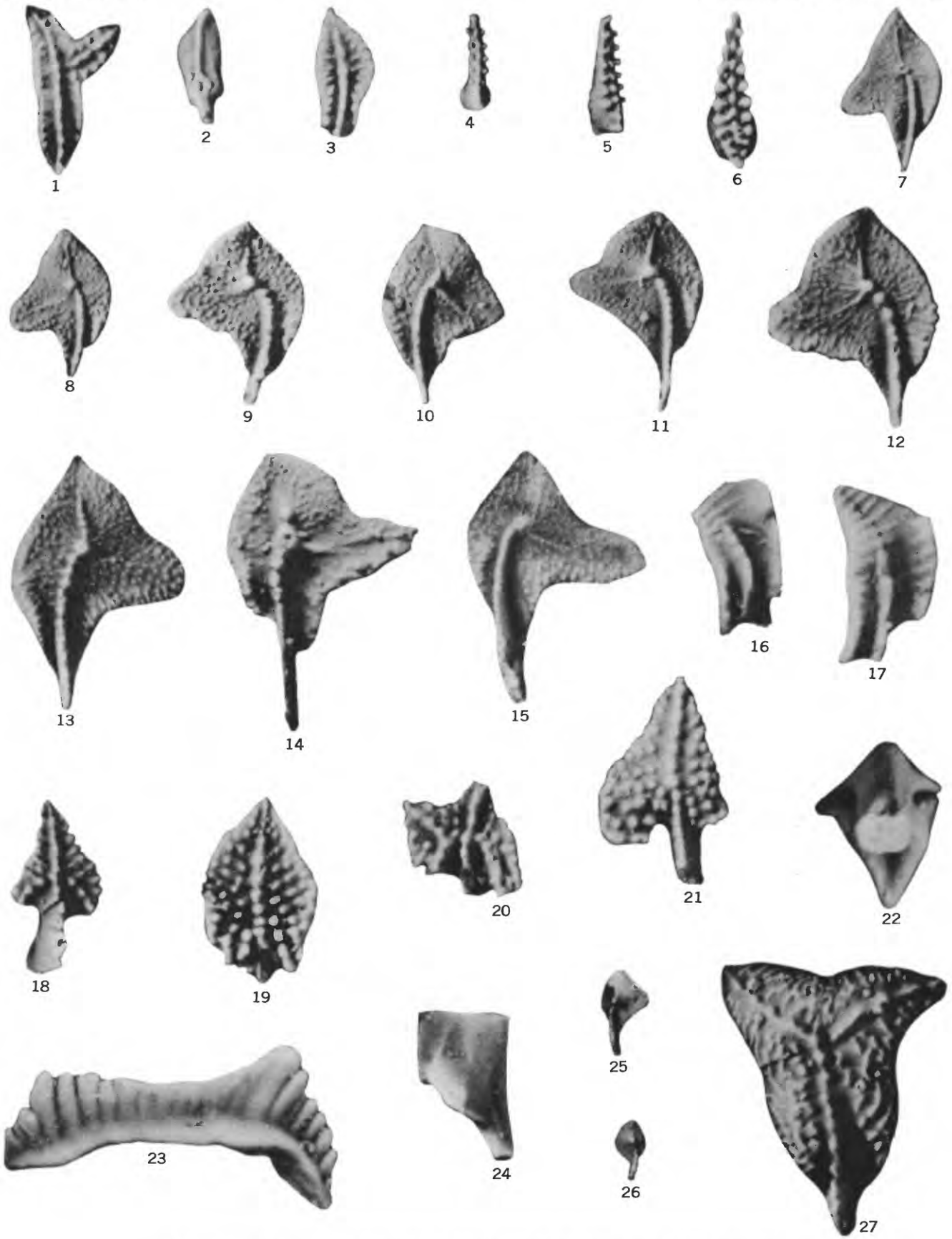
22. *Hibbardella* sp. A.
Oral view. Collection 48, USNM 123545.

23. *Bryantodus* sp. A.
Lateral view. Collection 11113, USNM 123546.

24. *Prioniodus alatus* Hinde.
Lateral view. Inner side, collection 46, USNM 123547.

25, 26. *Palmatolepis marginata* Stauffer.
Oral views. 25, Rubber replica, collection 240, USNM 123548; 26, rubber replica, collection 240, USNM 123549.

27. *Ancyrognathus euglypheus* Stauffer.
Oral view. Rubber replica, collection 42, USNM 123550.



CONODONTS FROM DOWELLTOWN MEMBER OF CHATTANOOGA SHALE

TYPE SECTION OF THE CHATTANOOGA SHALE, CAMERON HILL, CHATTANOOGA, TENNESSEE