DEPARTMENT OF THE INTERIOR

BULLETIN

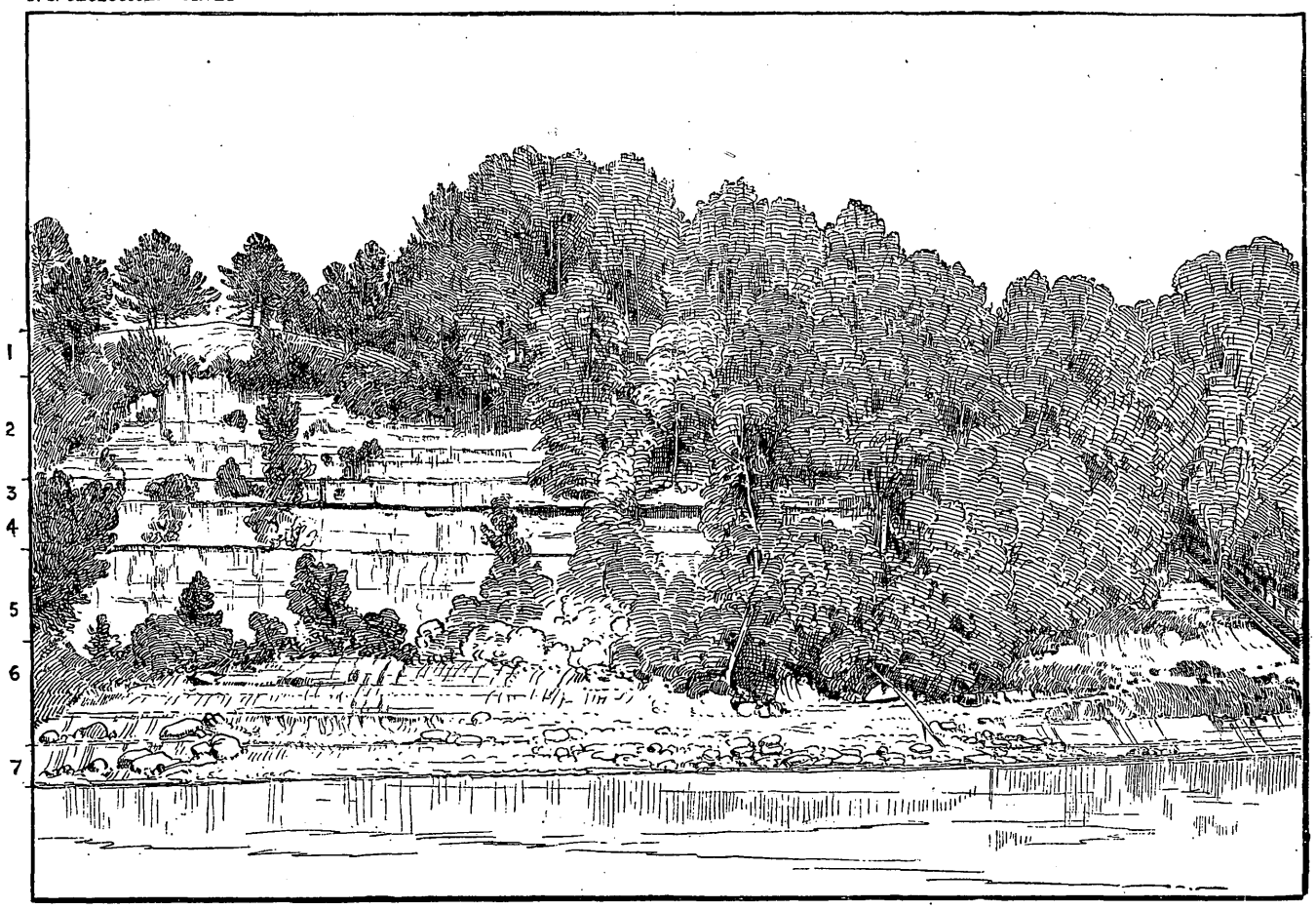
OF THE

UNITED STATES

GEOLOGICAL SURVEY

No. 43

WASHINGTON
GOVERNMENT PRINTING OFFICE
1887



1. Red loam with pebbles and sand. 2. White limestone. 3. *Scutella Lyelli* bed, with subjacent ferruginous sands. 4. Claiborne sand. 5. Calcareous clay etc. (*O. sellæformis*). 6. Calcareous sand. 7. Blue clay with greensand.

CLAIBORNE UPPER LANDING, ALABAMA RIVER.

UNITED STATES GEOLOGICAL SURVEY

J. W. POWELL, DIRECTOR

TERTIARY AND CRETACEOUS STRATA

OF THE

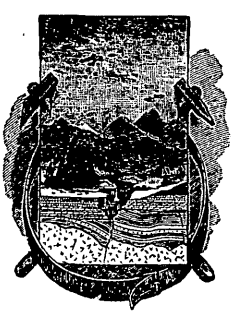
TUSCALOOSA, TOMBIGBEE, AND ALABAMA RIVERS

BY

EUGENE A. SMITH

AND

LAWRENCE C. JOHNSON



WASHINGTON

GOVERNMENT PRINTING OFFICE

1887

CONTENTS.

ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

GEOLOGICAL SURVEY OF ALABAMA,
Tuscaloosa, Ala., November 30, 1886.

SIR: I have the honor to transmit herewith a report on the observations of Mr. L. C. Johnson, of the U. S. Geological Survey, and myself on the Tertiary and Cretaceous strata exposed along the Tuscaloosa, Tombigbee, and Alabama Rivers in this State, made under instructions from you during the summer of 1883, together with my own subsequent observations.

Although the report is a preliminary one and further investigations in the same region are now in progress, recent publications have excited such interest in the Tertiary and Cretaceous formations in the Southern States as to justify immediate publication.

I have the honor to be, sir, with great respect, very truly yours,

EUGENE A. SMITH,
State Geologist of Alabama.

Hon. J. W. POWELL,
Director U. S. Geological Survey, Washington, D. C.

PREFACE.

During the summer of 1883 a trip was made by the authors, in a small steamer, down the Tuscaloosa (also called Black Warrior or Warrior) River, from Tuscaloosa to its confluence with the Tombigbee, down the latter stream to its confluence with the Alabama, down the Alabama and Mobile Rivers to the head of Mobile Bay, and thence up the last two rivers to Prairie Bluff. This route, the localities of the accompanying detailed sections, and other points mentioned in the text are indicated in the accompanying geologic map of Alabama forming Plate XI. The trip by steamer was made at the joint expense of the U. S. Geological Survey and the Geological Survey of Alabama.

The first draft of this bulletin was prepared with the data collected during this trip, there being added thereto information gathered by myself in 1872, 1880, 1881, 1882, and 1884 for the Geological Survey of Alabama and for the Tenth Census of the United States, and information obtained by Mr. L. C. Johnson in 1881, 1882, and 1883. The bulletin was not completed until I had gone over the whole ground again, in the summer of 1885, in company with Messrs. T. H. Aldrich and D. W. Langdon, of the Geological Survey of Alabama. Finally, the results of my investigations in the same region during the summer of 1886 have been in large part incorporated. Though it is believed that the accompanying sections of the Tertiary and Cretaceous strata of Alabama are much more nearly complete and more trustworthy than anything hitherto published, it should be said that the paleontologic material has not yet been fully examined, and that the Ripley, Eutaw, and Tuscaloosa formations require some further investigation. The present report must, therefore, be regarded as a preliminary one.

The photographic views from which some of the illustrations have been prepared were taken during the summer of 1885. It is greatly to be regretted that some of the photographic plates of important localities were spoiled by dampness before prints could be obtained from them.

The authors desire to express their indebtedness to Mr. W J McGee, of the U. S. Geological Survey, for assistance kindly given in the

preparation of the present report, and particularly for the discussion of the age of the Tuscaloosa formation and for the résumé of results.

Both authors co-operated in the field work and in the preliminary discussion of the observations; but the present writer is responsible for the arrangement of the matter of the report, the plates, and the maps. The manuscript, however, has received the approval of the associate author.

EUGENE A. SMITH.

TERTIARY AND CRETACEOUS STRATA OF THE TUSCALOOSA, TOMBIGBEE, AND ALABAMA RIVERS.

By E. A. Smith and L. C. Johnson.

INTRODUCTION.

In a memoir on the geological history of the Gulf of Mexico, published in 1871, Dr. E. W. Hilgard gives in descending order the following subdivisions of the Tertiary and Cretaceous in the Gulf States:[1]

			Feet.
Post-Eocene Tertiary	Grand Gulf group (brackish)		250
Eocene Tertiary	Vicksburg	Marine group	120
	Red Bluff		12
	Jackson		80
	Claiborne		60
	Buhrstone		150
	Lagrange	Lignitic group	450
	Flatwoods		
Cretaceous	Ripley group		350
	Rotten Limestone group		1,200
	Coffee (or Eutaw) group		300–400

Professor Angelo Heilprin,[2] using the publications of E. W. Hilgard, M. Tuomey, T. A. Conrad, C. S. Hale, C. Lyell, and A. Winchell, and manuscript notes furnished by the writer in 1873, has compiled the following section of the Eocene strata in Alabama:[3]

	Feet.
White Limestone (Jacksonian)	50
Claibornian	17
Buhrstone (Silicious Claiborne of Hilgard)	250
Wood's Bluff and Bashi (Eolignitic)	50?

Our observations compel us to modify slightly the nomenclature of these authors and to modify materially their estimates of the thickness of the formations.

We are led to revive Tuomey's term White Limestone,[3] and apply it to the Vicksburg, Red Bluff, and Jackson divisions of Hilgard, since

[1] Proc. Am. Assoc. Adv. Sci., Vol. XX, p. 222, 1871; also Am. Jour. Sci., 3d ser., Vol. II, p. 391 and map, 1871.

[2] Contrib. to the Ter. Geol. and Pal. of U. S., pp. 29, 30, 1884.

[3] First Bien. Rep. Geol. Ala., p. 154, 1850.

the collections recently made by Mr. T. H. Aldrich, but not yet described, show that there are very few fossils severally peculiar to any of these quasi-formations; and we are disposed to refer the several strata to the Upper Eocene. We are also led to divide the Claiborne of Hilgard into two formations, corresponding to his Calcareous Claiborne and Silicious Claiborne, respectively, and to restrict the term to the upper. We follow Tuomey[1] and others in denominating the lower formation the Buhrstone. Again, we are unable to discriminate the Lagrange and the Flatwoods of Hilgard; and we find the formation including these divisions to include also several beds containing marine fossils.[2]

The three Cretaceous formations are easily distinguishable along our rivers as distinctive rock masses; but in constructing our sections we have been constantly confronted with the difficulty of fixing their boundaries with precision, since they appear to shade into one another, lithologically at least, by almost imperceptible gradations. Thus we are not sure that any of the outcrops along either of the rivers show the contact of the Ripley beds with the upper part of the Rotten Limestone. The contact of the lowermost strata of the latter formation with the underlying sandy beds is clearly enough seen at several places, at Erie and Choctaw Bluff, Tuscaloosa River, and at House Bluff, Alabama River, &c.; but below the first 15 or 20 feet of these sands the strata for nearly 300 feet (and, indeed, to the base of the Tuscaloosa formation, perhaps 1,000 feet lower still) are exceedingly poor in fossil remains, except those of vegetable origin, and even these are almost indeterminable. Dr. Hilgard considers these fossiliferous sands (his Tombigbee Sand group) as more nearly allied to the Rotten Limestone than to the Eutaw group, and if we class them with the former then the line between the Rotten Limestone and the Eutaw groups will come somewhere within the first 20 feet or so below the base of the calcareous part of the Rotten Limestone. The limit between the Eutaw and the Tuscaloosa formation, in like manner, is ill defined. It may further be mentioned that we have not seen in Alabama any beds which we can identify as belonging to the Grand Gulf age.

Our estimates of thicknesses vary considerably from those of Hilgard, partly, at least, because his estimates do not represent the thick-

[1] First Bien. Rep. Geol. of Ala., p. 143, 1850.

[2] This formation has been denominated Eolignitic by Heilprin (Proc. Acad. Nat. Sci. Phila., p. 159, 1881); but the law of priority demands the retention of the name Lignitic, which was used in the same sense by Hilgard in 1860 or earlier. Once more, we feel compelled to restrict the name Eutaw to the glauconitic sands, laminated clays, micaceous sands, &c., beneath the Tombigbee sand and above the Big Log Shoals horizon. And, finally, for reasons stated fully on a subsequent page, we apply the name Tuscaloosa formation to the fossiliferous clays, purple clays and associated rocks exposed on the Tuscaloosa River from Tuscaloosa to White Bluff and at many localities between the Tuscaloosa and Alabama Rivers.

ness at any one locality, but the maxima in the Gulf States, and partly because our estimates are based on careful measurements of actual exposures of which only a part have hitherto been examined.

Since our route described two approximately parallel lines at right angles to the strike of the strata, we have generally been able to supply the breaks in continuity of exposures along one river by satisfactory exposures at corresponding stratigraphic horizons on the other, or at some points inland but contiguous to the water courses.

In the Tertiary formations at two horizons only have we been unable, by the combination of undoubtedly overlapping sections, to perfect our stratigraphic column. These breaks, which, upon an assumed uniform dip of 30 to 40 feet to the mile, cannot involve more than 50 feet each, probably much less, we have left blank. The black clays at the base of the Tertiary are exposed along the Tombigbee River from Black Bluff to Naheola, a distance which, with such a dip as that assumed, would correspond to a thickness of 260 feet.[1] These clays are much thinner on the Alabama River, and in the Bladen Springs boring, as we interpret it, the thickness is about 100 feet, which we have adopted in our section. The apparently much greater thickness indicated by the exposures along the Tombigbee is probably due to undulations in the strata.

Our estimate of the total thickness of the Tertiary formations, ranging from 1,630 to 1,700 feet, is considerably larger than any hitherto made. It is, however, a minimum, as may be seen from our plates giving the overlapping sections from which the stratigraphic column has been constructed. This estimate finds a strong corroboration in the records of borings made in Meridian, Miss., and at Bladen Springs, Ala. The former boring was commenced in the upper strata of the Lignitic, just beneath the Buhrstone, and it is certain that the Rotten Limestone of the Cretaceous was not reached at a depth of 980 feet. At Bladen Springs the surface rocks are the Hatchetigbee beds, immediately underlying the Buhrstone. In this boring the Rotten Limestone was reached at 1,220 feet and the boring terminated in that formation at a depth of 1,345 feet. Accordingly, while our estimates of the aggregate thickness of the Tertiary formations of the Alabama and Tuscaloosa Rivers doubtless include minor errors, we have, we believe, a nearly complete and generally accurate section of the strata exposed on these rivers.

In the case of the Cretaceous our observations have less completely covered the ground, and we have been forced in some instances to rely upon estimates based upon an assumed seaward dip of the strata of 40 feet to the mile. This rate of dip agrees with the average of our obser-

[1] A re-examination of the exposures of these black clays in the summer of 1886 has convinced me that no reliance can be placed upon the dip in estimating the thickness, for the clays undulate very considerably. One bed in the black clay, for instance, was traced down the river (across the strike) for several miles, with scarcely any change in its height above the water level.—E. A. S.

vations and is corroborated by the record of the boring for an artesian well at Livingston, in Sumter County. The thickness of Rotten Limestone penetrated in this boring is 930 to 950 feet, and the width of the belt in which this is the surface rock in this part is about twenty-four miles across the strike of the strata. In the Ripley division we have, we think, a nearly complete section from our observations. In the Rotten Limestone we have the record of the Livingston well. In the Eutaw formation we have to rely in some degree upon estimates, though we have at Eutaw, on the Tuscaloosa, and at House Bluff and at Cunningham Bluff, on the Alabama, as we believe, nearly if not quite the complete series.

The materials of the Tuscaloosa formation, clays and loose sands, make comparatively little show along the Tuscaloosa River. Our column of this formation is accordingly very imperfect, and the estimate of thickness is based altogether upon an assumed dip of the strata of 40 feet to the mile.

The following table exhibits, in condensed form, our subdivisions of the Tertiary and Cretaceous formations of Alabama as exposed along the Tuscaloosa, Tombigbee, and Alabama Rivers, together with the carefully estimated thickness of each:

				Feet.
Tertiary (Eocene).	Upper	White Limestone	Coral Limestone (Vicksburg?)	150
			Vicksburg (orbitoidal)	140
			Jackson	60
	Middle.	Claiborne		140–145
		Buhrstone		300
	Lower	Lignitic	Hatchetigbee	175
			Wood's Bluff	80–85
			Bell's Landing	140
			Nanafalia	200
			Matthews's Landing and Naheola	130–150
			Black Bluff	100
			Midway	25
Cretaceous		Ripley		250–275
		Rotten Limestone		1,000
		Eutaw		300
Cretaceous (?)		Tuscaloosa		(?) 1,000

Our investigations relate chiefly to the formations below the White Limestone, and more especially to those underlying the Buhrstone, of which, so far as we are aware, no connected account has hitherto been published.

Our itinerary notes have been assembled and digested and the various exposures of the two water ways are described together in the inverse order of antiquity. The leading phenomena are recapitulated in the description of the general section.

I.—TERTIARY STRATA.

§1. THE WHITE LIMESTONE.

As already stated, we include in this formation both the Vicksburg and the Jackson group of Conrad, Hilgard, and others, as well as the Red Bluff group of Hilgard, if it is developed in Alabama. The recent very extensive collections of Mr. T. H. Aldrich have shown that, with very few exceptions, the same shells are common to the Vicksburg and to the Jackson bed. Certain lithological and paleontological differences may easily be observed in the different parts of this formation, as set forth below, but these differences do not, in our opinion, justify us in dividing a formation which, in Alabama, so clearly presents itself as a unit. The term White Limestone has been used by Professors Tuomey and Winchell and by other geologists as representing both of the above groups, though most of the writers on Alabama Tertiary geology have called attention to certain differences existing between the upper and the lower parts of the formation as exhibited at the bluff at St. Stephens.

The term, moreover, is popularly used to designate this whole series of limestone rocks throughout the region in which it occurs. As above stated, it is in this sense that we also wish to use it, and we do not intend to confine the term, as does Heilprin, to the lower 60 feet, which corresponds to the Jackson division.

The thickness of the White Limestone in Alabama we believe to be not less than 350 feet, and our estimates are based upon the following facts: About half a mile from the Claiborne bluff, on the road to Perdue Hill, White Limestone filled with *Orbitoides Mantelli* Mort. occurs at least 200 feet above the base of the argillaceous White Limestone (Jackson) which immediately overlies the Claiborne fossiliferous sands. At this locality, therefore, we have undoubtedly 200 feet of limestones belonging to this division of the Tertiary. At Salt Mountain, 150 feet of a coral limestone overlies the uppermost of the beds with *Orbitoides Mantelli*, and this, added to the orbitoidal and argillaceous limestones seen at Claiborne, gives what we consider to be the minimum thickness of the White Limestone.

As regards the classification of the White Limestone in the Tertiary series, opinions vary. Conrad says:[1] "The Claiborne group I regard as newer Eocene, the Jackson as older Oligocene, and the Vicksburg group as newer Oligocene."

Heilprin[2] also puts the Vicksburg and the Jackson together as Oligocene, though elsewhere in the same volume he speaks of the Vicksburg alone as Oligocene and places the Jackson with the Eocene as its uppermost member.

[1] Geol. N. C., Vol. I, Appendix A, p. 25, 1875.

[2] Contrib. to the Tert. Geol. and Pal. of the U. S., p. 33.

The view of Conrad was at first adopted by us, but subsequently the study of extensive collections made by Mr. Aldrich at Jackson and Vicksburg, the finding by him of *Venericardia planicosta* in the uppermost beds of the White Limestone near Claiborne, and other circumstances have led us to think that there is no good reason for separating any part of our White Limestone from the Eocene, and we have no strata in Alabama which we regard as Oligocene.

It is to be remarked that nowhere in Alabama have any deposits yet been found comparable with the fossiliferous beds of Jackson and Vicksburg in Mississippi, as regards either the excellence of preservation or the number and variety of the fossils; for, with the exception of *Orbitoides Mantelli*, *Pecten perplanus* Mort., *Zeuglodon cetoides*, and a few others, fossils are comparatively rare in the Alabama White Limestone.

DIVISIONS OF THE WHITE LIMESTONE.

The few forms, however, which do occur here appear to be generally restricted to a definite horizon, and we recognize in every locality of its occurrence two divisions of the White Limestone, and in one place three divisions, each distinguished by peculiarities in its lithological characters and in its fossils.

The *uppermost division*, 150 feet in thickness, has as yet been observed in one locality only, viz, at Salt Mountain at the Middle Salt Works in Clarke County. The rock here, is a hard, white limestone, composed in great measure of masses of corals partly silicified. Near the base of this rock there occur great numbers of the spines and plates of echinoderms.

The *middle division* of the White Limestone has a thickness of at least 140 feet. Lithologically it varies considerably, being in part a hard, crystalline limestone weathering into rough, irregularly shaped pieces, which have suggested the name "horsebone" rock, popularly used to designate it. Another variety is a soft, sometimes pulverulent mass of nearly pure carbonate of lime, which is everywhere quarried for building purposes. When fresh, this rock may easily be cut with an ax or a saw, but it hardens on exposure to the air and lasts for many years in chimneys and pillars to houses. This part of the White Limestone contains as a characteristic fossil *Orbitoides Mantelli*, often in such numbers that the rock is little more than a mass of the disks of orbitoides packed in soft, white carbonate of lime. The orbitoides are most abundant in the upper two-thirds of this division, becoming less and less abundant below this.

The *lower division* of the White Limestone, about 60 feet in thickness, is in general terms a light colored, argillaceous limestone resembling the Rotten Limestone of the Cretaceous formation both in the character of the rock and in that of the soils to which it gives rise on disintegration. It is traversed by thin bands of tolerably pure, white limestone and by beds of slightly calcareous clay, the latter often impreg-

nated with gypsum. In places it is strongly glauconitic. This division contains a greater variety of fossils than either of the other two, though probably a smaller number. The fossils appear in general to be much more abundant in the upper half of the rock, where the more commonly occurring species are *Pecten perplanus* Mort., *Spondylus dumosus* Mort., *Ostrea cretacea* Mort., sharks' teeth, bones of *Zeuglodon cetoides*, and *Terebratula lachryma* Mort. This upper and most highly fossiliferous part holds calcareous clays which are strongly phosphatic and occasionally well filled with phosphatic or coprolitic nodules. The lower half of this division, while less fossiliferous than the preceding, has in nearly every locality examined a bed near its base at least three feet in thickness holding vast numbers of *Scutella Lyelli* Con. This, which we have called the Scutella bed, has often served us as a guide in the study of this formation in the field, since it overlies by a few feet only the Claiborne fossiliferous sands.[1]

This lower division of the White Limestone has usually been considered the equivalent of the Jackson, and the overlying orbitoidal rock (middle division) the equivalent of the Vicksburg group of Mississippi, and there seems to be no reason to doubt the correctness of the identification. The uppermost division has been observed or recognized only at one locality (Salt Mountain), but it will probably be found to belong to the Vicksburg group.

The following sections (see Plate XII, p. 143) exhibit the characters of two phases of the White Limestone as they are exposed along the two rivers, and a third phase seen in the lower part of Clarke County between the rivers.

(*a*) About six miles south of Jackson, in Clarke County, at the Central Salt Works, I obtained in the summer of 1885 a section of the uppermost of the White Limestone rocks which overlie the orbitoidal rock. These rocks, which are seen in actual contact with the orbitoidal limestone, form the summit of the White Limestone formation in Alabama, so far, at least, as our observation goes. At this locality, Salt Creek flows at the base of a hill rising 150 feet above the water level and composed of limestone in which the only recognizable fossils are spines and plates of echinoderms and great masses of corals. These corals make up a very considerable proportion of the hill. A few hundred yards from the base of the hill a thickness of about twenty feet of the orbitoidal rock, such as is used in the vicinity for building purposes, is exposed, and in such position as to show unmistakably that it underlies the coral rock of the hill just mentioned, which has the local name of Salt Mountain. (See Plate XII, Fig. 1, p. 143.)

[1] The rocks of the Claiborne group are distinguished from those of the White Limestone by the presence of glauconite in large proportion, and this Scutella bed is the first of the ferruginous beds of the Tertiary. We are undecided whether this Scutella bed should go with the White Limestone or with the Claiborne, since the fossil is found in both formations.

(*b*) The bluff at Saint Stephens on the Tombigbee River (Plate II), about one hundred feet in height, exhibits both of the commonly occurring phases of the White Limestone, viz, the middle and lowermost. (See Plate XII, Fig. 2, p. 143.) The uppermost 70 feet of this bluff consists of the soft White Limestone, which is extensively quarried for building chimneys. *Orbitoides Mantelli* occurs throughout this rock, but is particularly abundant in the uppermost 20 or 30 feet. Below the orbitoidal rock to the water's edge the limestone is rather argillaceous and holds in places great numbers of *Spondylus* (*Plagiostoma*) *dumosus* and other fossils which are usually considered characteristic of the Jackson group. In this part of the bluff, Mr. D. W. Langdon, jr., of the Alabama Geological Survey, in 1884 discovered phosphatic nodules and a phosphatic marl, a more detailed description of which will be found in a forthcoming Alabama State Geological Report. In this connection it may be proper to say that in the summer of 1885 we found that a phosphatic marl occurs in the lower or Jackson division of the White Limestone everywhere in Choctaw, Clarke, and Monroe Counties.

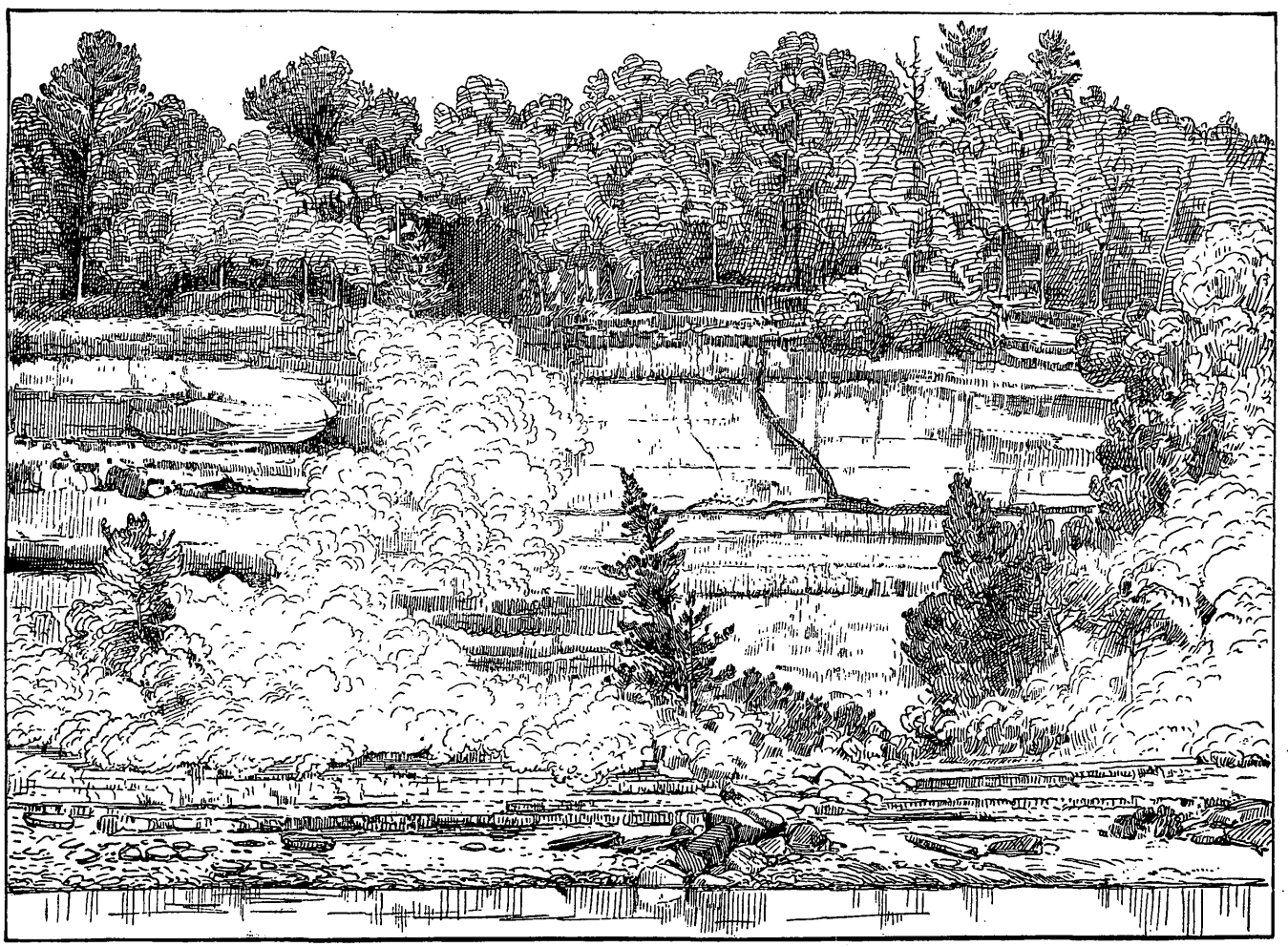
(*c*) About half a mile above Saint Stephens Bluff, and in plain sight of it, is Gopher or Baker's Hill, where the actual contact of the limestones of Saint Stephens Bluff with the ferruginous sands of the Claiborne formation may be clearly seen.

The following section of Baker's Hill should set forever at rest the question of the relative positions of the strata concerned (see Plate XII, Fig. 3, p. 143).

Section at Baker's Hill, Tombigbee River.

1. Orbitoidal limestone forming summit of the hill. This limestone is the same as that forming the upper part of the Saint Stephens Bluff, half a mile distant ..... 20 to 30 feet.
2. Argillaceous limestone with *Pecten perplanus* Mort. and *Pecten Poulsoni* Mort. in its upper part and with hard ledges in lower part ..... 55 to 60 feet.
   This rock is the same as that at the base of Saint Stephens Bluff, but only 15 to 20 feet of it are to be seen above water at the latter place.
3. Bed with *Scutella Lyelli* in great numbers, 1 foot seen, at other points ..... 3 feet.
4. Coarse grained, ferruginous sands, passing downwards into reddish, ferruginous sands, with the characteristic fossils of the Claiborne sands, viz, *Melongena alveata* Con., *Crepidula lirata* Con., *Infundibulum trochiformis* Con., *Corbula Murchisoni* Lea, *Turritella lineata* Lea, *Cytherea æquorea* Con., *Oliva Alabamensis* Con., *Turbinella pyruloides* Con., *Turbinolia Maclurei* Lea, *Voluta Defranckii* Lea, *Astarte sulcata* Lea, &c ..... 15 to 18 feet.
5. Bluish green, glauconitic sands and clayey sands containing a *Flabellum* similar to that found at Claiborne and at Coffeeville ..... 8 to 10 feet.
6. Hard ledge at water's edge at upper end of bluff ..... 1 foot.

(*d*) During the summer of 1885 many localities were visited in Choctaw and Clarke Counties where the White Limestone and the Claiborne sands are to be seen in contact, so that there can be no possible doubt as to their relative position, unless we assume that the strata have been overturned, and of this there is not a shadow of proof. Some of the localities were also visited by Professor Tuomey and by Prof. A.



ST. STEPHENS BLUFF, TOMBIGBEE RIVER.

Winchell, while some have not yet been referred to in any published document. These localities will be given below, under Claiborne group.

Professor Tuomey[1] says that the Buhrstone, after dipping below the surface in the upper part of Clarke County, emerges again at the Lower Salt Works, in the southern part of the county. Our visit to this place in 1883 confirmed this statement of Professor Tuomey, but there were many things observed in the distribution of the rocks in Clarke and Choctaw Counties which were difficult of explanation so long as we confined our attention to the banks of the rivers.

During several excursions by land through these counties previous to 1883 and again in the summer of 1885, the present writer was able to collect the data which prove that the basin in Clarke County, referred to by Professor Tuomey, is by no means a simple syncline, but includes several undulations, by which the Buhrstone rocks are again brought to the surface of the country at several points to the southward of the line where they first dip below it. It is by reason of these irregularities that the southernmost exposures of the Tertiary rocks along the rivers are not made by the uppermost rocks of the White Limestone series, but in the case of Choctaw Bluff, at least, by those of the Jackson or lower division of the White Limestone.

Section at Choctaw Bluff, Clarke County.

1. Drift, pebbles and sand, capped with red loam.....20 feet.
2. Bluish clay.....5 feet.
3. Greenish clay .....5 feet.
4. White argillaceous limestone or indurated marl, containing many large specimens of *Ostrea Georgiana, Scutella Lyelli, Pecten Poulsoni*, many tubes of *Aspergilium* or allied genus, and obscure casts of other fossils .....5 feet.

The bluish clay (No. 2) contained in many places lignitized or half lignitized stumps, while the underlying greenish clay contained no fossils.

At Gainestown, a few miles above Choctaw Bluff, there is another exposure of the White Limestone. The principal rock at this place is a heavy bedded, yellowish limestone with *Orbitoides Mantelli*. This rock has been quarried for building purposes, and several large blocks of it are to be seen on the river bank at Choctaw Bluff, whither they were carried during the war. The tubes of Aspergillum are also to be seen at several places near Gainestown, and some of the clays there hold a very considerable amount of gypsum crystals, as described by Mr. E. Q. Thornton,[2] who also says that the bones of Zeuglodon have been found a few miles from the Gainestown Landing. From these circumstances it appears that a part, at least, of the strata at Gainestown is of the Jackson horizon.

(*e*) From Marshall's Landing, some miles above Gainestown, up to Claiborne, the bluffs on both sides of the river give a very complete

[1] First Bien. Rep. Geol. Ala., p. 150, 1850.
[2] Second Bien. Rep. Geol. Ala., pp. 250 251, 1858.

and almost uninterrupted section, with none of the irregularities noticed on the Tombigbee, since all the strata show a gentle southerly dip.

At Marshall's Landing, the upper part of the bluff consists of the orbitoidal limestone, the lower part of the argillaceous limestone of Jackson age, and from this point up to the mouth of Cedar Creek the other beds of the Jackson series form the low bluffs of the river, from which a very good section has been made, as follows:

Section of White Limestone strata, Alabama River.

1. Orbitoidal White Limestone of the usual character.....10 feet.
2. White Limestone containing *Scutella Lyelli* in numbers.....10 feet.
   This is the base of the Vicksburg or Orbitoidal Limestone, which, as we have seen at Claiborne, has a thickness of 140 feet, and at Salt Mountain has 150 feet of a coral limestone above it.
3. Effervescent or calcareous, joint clay, in two beds, each 5 or 6 feet in thickness, separated by 3 feet of soft, earthy White Limestone; below this a harder ledge of limestone, and then about 8 feet of blue clay, passing into a blue, calcareous clay or marl, making in all.....about 24 feet.
4. Earthy white limestone, resembling the Rotten Limestone of the Cretaceous formation.....about 25 feet.
   (This limestone has at intervals of 3 or 4 feet, ledges of similar but harder material projecting slightly from the faces of the bluff. These ledges vary from one to three feet in thickness.
5. Scutella bed (*S. Lyelli*), consisting of 3 layers: (*a*) a limestone, with a few *Scutellas* (*S. Lyelli*), 1 foot; (*b*) a ferruginous sand filled with the same *Scutella*, 1 foot; (*c*) a white limestone bed similar to (*a*) and 1 foot thick.....3 feet.
   Beneath this is a bed of coarse grained, ferruginous sand, extending down to the water.....1 or 2 feet.
   This bed is seen at Rattlesnake Bluff, Claiborne.

These relations are shown in the section. (See Plate XII, Fig. 4, p. 143.)

(*f*) The upper part of the bluff at Claiborne is also composed of the argillaceous White Limestone of the Jackson age, and as we ascend the hill back of Claiborne, leading up to Perdue Hill (2 miles), the orbitoidal limestone appears in gullies and wherever the surface soil has been removed, up to an elevation of 90 or 100 feet above the top of the river bluff. This is precisely the position which the White Limestone occupies with reference to the Claiborne sands at Baker's Hill on the Tombigbee, as well as at other localities in Clarke County, referred to above. (See Plate XII, Fig. 5, p. 143.)

The White Limestone is the surface rock over a very considerable part of Choctaw, Washington, Clarke, Monroe, Conecuh, Covington, and Geneva Counties. Where the lower or more argillaceous portion of it forms the surface, it gives rise, upon disintegration, to a limy soil, very similar to that of the Rotten Limestone of the Cretaceous group, but the topography is much more broken, justifying the name of Lime Hills, which I have given to this region in the Report of the Geological Survey of Alabama for 1881–'82. These Lime Hills may be followed from Choctaw and Washington Counties, without a break, into

Mississippi, and there can be no doubt as to their identity with the Jackson prairies of Professor Hilgard.

It is in these Prairie Hills that the Zeuglodon bones are always found. Other commonly occurring fossils are *Pecten perplanus*, *Spondylus dumosus*, *Scutella Lyelli*, a species of Ostrea, and a Cassis similar to one occurring at Red Bluff in Mississippi.

§ 2. THE CLAIBORNE.

The beds which in Alabama intervene between the base of the White Limestone and the top of the Lignitic division, and which are at least 450 feet in thickness, may be divided into two groups, of very unequal thickness, which exhibit very marked differences in their lithological features and in the relative abundance and variety, though perhaps not in the specific characters, of their fossil contents.

The upper group, 140 to 150 feet in thickness, constituting the *Claiborne beds proper*, consists of ferruginous sands, calcareous sands, and calcareous clays, generally glauconitic. These beds are mostly loose and incoherent, crumbling easily and giving rise to no marked topographic features in the region which they immediately underlie. This whole group is distinguished by the abundance and the variety of its fossils. Near the top of the series is the bed of ferruginous sand which has furnished the greater part of the celebrated Claiborne fossils. The calcareous sands underlying for 60 feet the ferruginous Claiborne sand above named are clearly marked by the great numbers of the shells of *Ostrea sellæformis* which they contain. Below these beds are glauconitic sands and clays holding a great variety of well preserved shells.

The lower group, about 300 feet thick, consists of silicious and aluminous sandstones and indurated clays, with occasional glauconite beds; all, except a few thin beds with marine shells, containing very little lime and, by comparison with the preceding group, very few fossils. These rocks are mostly hard and resistant and form some of the highest and most rugged hills in the southern part of the State. To this series of rocks Professor Tuomey[1] has given the name *Buhrstone*, and has pointed out their identity with the Buhrstone rocks of South Carolina and Georgia.

Prof. E. W. Hilgard[2] placed these two together under the head of the Claiborne group, distinguishing the upper and lower divisions as the Calcareous and the Silicious Claiborne strata, respectively. From the section given in Hilgard's Report,[3] it seems that the middle part of what we have called the Claiborne series, containing the great numbers of *Ostrea sellæformis*, are the beds of the Calcareous division, best developed in that State. The Silicious Claiborne or Buhrstone strata are found in

[1] First Bien. Rep. Geol. Ala., p. 150, 1850.

[2] Rep. on Geol. and Agric. of Mississippi, pp. 108, 123, and 126, 1860.

[3] Rep. on Geol. and Agric. of Mississippi, pp. 126, 127, 1860.

great thickness in Mississippi and present practically the same features as in Alabama. The rugged Buhrstone hills of Clarke, Lauderdale, Newton, Kemper, Neshoba, and Leake Counties, in Mississippi, have their counterparts in Choctaw, Clarke, and Monroe Counties in Alabama.

The fossiliferous greensands mentioned by Professor Hilgard,[1] in connection with the Silicious Claiborne, were afterwards (1871) traced by the writer from Marion, in Mississippi, across the State to the Mississippi bottom in Holmes and Carroll Counties.

As already indicated above in our tabular presentation, we adopt here Professor Tuomey's division of these strata into Claiborne and Buhrstone.

The lithological and other characters of the Claiborne beds have been stated above in the most general terms. A few additional details will suffice to give a fair conception of the general features of the Claiborne formation. Near the top of the series we find a bed varying from 15 to 17 feet in thickness, which, at Claiborne, Gosport, Rattlesnake Bluff, and Baker's Bluff, is a reddish yellow, ferruginous sand, literally packed with the most beautifully preserved fossils. In many parts of Clarke and Monroe Counties, where this bed has undergone less change from exposure to the atmospheric agencies, these sands are mixed with a very considerable proportion of glauconite, and the color is a very decided dark green, instead of reddish yellow. This bed we have called the Claiborne Fossiliferous Sand. Below it are some 60 feet of calcareous clays and calcareous sands, the former making the upper 25 feet, characterized by a bluish color, shading into light gray below. The calcareous sands make up the lower 35 feet, and they are of a light yellowish color. The whole of this 60 feet of strata, except perhaps some 10 feet of blue clay near the top, is distinguished from all the other beds of the Claiborne formation by the great numbers of shells of *Ostrea sellæformis* Con. which it holds. These shells are found more abundantly in the hard, sandy ledges which occur at intervals of a few feet through the whole thickness of these beds. This part of the Claiborne formation, contrary to the experience of Professor Winchell,[2] we find to be the most widely distributed of any. We have identified it within two miles of Nicholson's Store in Choctaw County; at several localities on Souilpa Creek, in the same county; at Coffeeville; near Old Clarkesville; on Stave Creek; and near Lisbon Landing, in Clarke County; at Claiborne; near Monroeville; and at several places on Limestone Creek, in eastern Monroe County. It is described by Professor Hilgard[3] as occurring on Falling Creek, near Quitman, and on Suanlovey Creek, west of Enterprise, in Clarke County, in Mississippi, and it has been observed by Mr. Johnson in Wahtubba Cut, 5 miles

[1] Rep. on Geol. and Agric. of Mississippi, pp. 118, 119, 121, 122, 123, 124, 125, 1860.
[2] Proc. Am. Ass. Adv. Sci., Vol. X, Part II, p. 85, 1856.
[3] Rep. on Geol. and Agric. of Mississippi, pp. 126, 127, 1860.

southwest of Enterprise, Miss. We have not yet followed it further east than Evergreen, Conecuh County, though we have good reason for believing that it occurs near Elba, in Coffee County, and probably still further eastward. Below these *Ostrea sellæformis* beds we find at Claiborne and at Lisbon some 50 feet or more of sandy and clayey beds, in many cases strongly glauconitic, and holding a great number as well as a great variety of well preserved fossils.

Such are a few of the most obvious characters of the beds which we here wish to include in our Claiborne formation. The precise details of the structure and composition of these beds may be gathered from the sections which follow.

The rocks of the Claiborne formation proper occur at Claiborne, Gosport, and Rattlesnake Bluff, on the Alabama River, and at many other localities in that vicinity. They also occur on the Tombigbee River at Baker's Bluff (a short distance north of Saint Stephens) at Coffeeville and at very many points away from the rivers in Monroe, Clarke, Washington, and Choctaw Counties. We are at this time concerned only with the occurrences along the two rivers.

(*a*) The bluff at Claiborne affords one of the best exposures of the rocks of the Claiborne formation, as well as of part of the overlying Jackson strata, and we have therefore been at considerable pains to get a correct and detailed section of this celebrated bluff. It will be understood by every field geologist that no two observers will ever make the same grouping of the strata in a detailed section, and for this reason sections of the same bluff by different observers will often seem to be at variance with one another. The same bed, moreover, in different parts of a long bluff will often vary considerably in thickness and in other characteristics. Thus, along the road leading to the ferry at Claiborne, the ferruginous sands are less than ten feet in thickness and are overlaid with laminated clays holding leaf impressions, but these clays thin out rapidly going down the river and disappear altogether in less than a quarter of a mile from the ferry road. Our section, therefore, does not profess to be a section at one point only of the long Claiborne bluff, but we have examined and given the details of the different beds wherever they are most clearly exposed, from below the lower landing up to the ferry.

In this part of the State the Alabama River depression exhibits at least two well defined terraces; the upper one, from one hundred and seventy-five to two hundred feet above low water mark; the lower, from thirty to fifty feet above the same mark. The upper terrace is formed by the Tertiary rocks, which are, however, covered by thirty to forty feet of the sands and pebbles and loam of the drift. Upon this terrace, about a mile wide, the town of Claiborne stands. The second or lower terrace, in great measure above overflow, except in extremely high water, is formed of ancient river deposits to which the name "second bottom" has been given. Opposite Claiborne the second bottom is some three

miles wide, and the river pursues its winding course in a channel cut into these second bottom deposits, impinging first against one side of the bordering Tertiary bluffs, whence it is deflected across the wide second bottom to strike then the opposite border. At Claiborne the river flows at the base of the southern Tertiary border of its ancient plain; next it turns across this plain and strikes the northern Tertiary bluff at Gosport; it is then deflected to strike the southern margin again at Rattlesnake Bluff.

The feature of the Claiborne bluff which first attracts the eye of the observer from a distance is the existence of nearly horizontal parallel stripes or bands which mark the limits of the different materials that make up the bluff. These bands, which are pretty well brought out in the views, are marked off approximately in the second vertical column of Plate XIII, Fig. 3, p. 147, and, if we neglect the minor details, they may be described as follows:

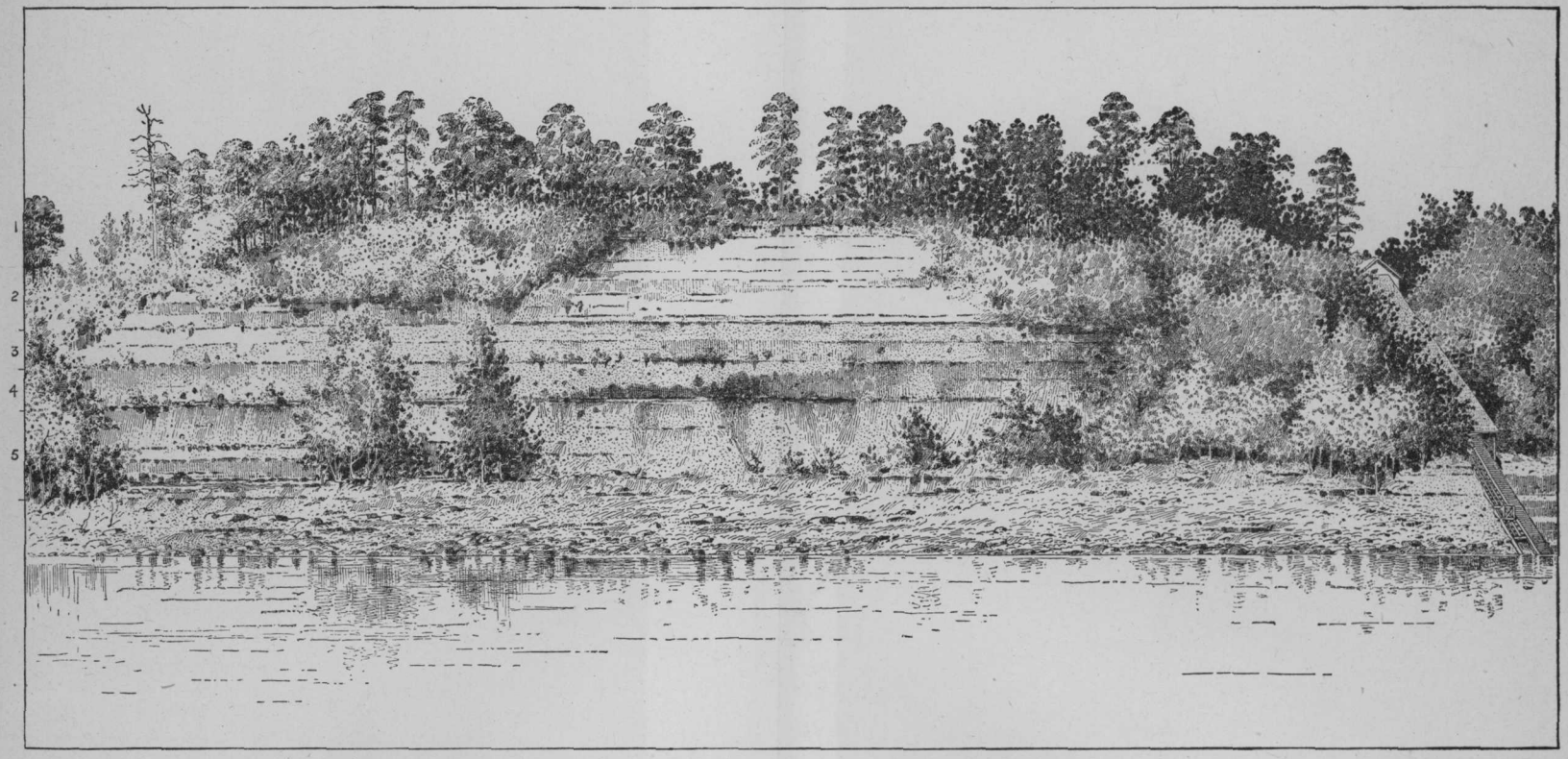
Section of the Claiborne Bluff, Alabama River.

1. A bed of very variable thickness, consisting of sand, pebbles, and red loam, which forms the surface over a great part of the State. The average thickness of this bed along the bluff may be put at ..... 35 to 40 feet.
2. A band of White Limestone containing glauconite grains, forming vertical faces usually striped by thin projecting ledges ..... about 45 feet.
3. A band showing two very distinct parts, viz, an upper part, a bed holding great numbers of *Scutella Lyelli*, 3 feet thick; and a lower part, 6 feet thick, of coarse, ferruginous sands which are indurated at the base and form a very marked projecting ledge ..... 9 feet.
4. A band of very uniform appearance of reddish yellow or buff color, consisting of a mass of shells embedded in red sand. This is the celebrated Claiborne sand. It weathers very smoothly and is less projecting than the ledges above and below it ..... 15 to 17 feet.
5. A band of light gray, calcareous clay with a few sandy stripes and indurated ledges ..... 25 to 28 feet.

All these beds make up the nearly vertical part of the bluff near and between the two landings. Below these to the river level the slope is almost entirely covered by the loose fragments rolled down from above, so that the underlying stratified rocks are discovered only where these loose materials have been removed. Between the upper landing and the ferry these lower strata of the bluff are more clearly exposed to view.

6. A band of light yellowish gray, calcareous sand, striped with a number of hard ledges of similar sandy material. This band is a very prominent part of the bluff, but is in many places, as above stated, much obscured by the fragments of the other beds which have rolled down from above ..... about 35 feet.
7. A band of dark, bluish green color, consisting of clayey sands and clays passing downwards into a greensand bed 6 to 8 feet thick, which appears, however, above water only above the upper landing ..... about 12 feet.

The upper part of this band, at the lower landing, appears only two or three feet above the low water mark, and it is consequently best seen farther up the river. Between the two landings these beds, where they



1. Drift. 2. White limestone. 3. *Scutella* bed etc. 4. Fossiliferous sands. 5. *Ostrea sellæformis* beds.

CLAIBORNE BETWEEN UPPER AND LOWER LANDINGS, ALABAMA RIVER.

are above water, are generally covered with débris. The second of the bands above named is the lower part of the Zeuglodon bearing bed of this part of the State, which has generally been considered as of Jackson age. The third band is also probably a part of the Jackson limestone, but we are not sure that some of it, especially the lower five or six feet, should not be placed with the Claiborne division. At any rate the line between the Claiborne and the Jackson falls somewhere in this band (Plate I, p. 3, and Plate III, p. 29).

Given more in detail, the section of the Claiborne bluff is as follows:

Detailed section of Claiborne Bluff, Alabama River. (*Plate XIII, Fig.* 3, *p.* 147.)

1. Drift deposits, consisting of sand, pebbles, and red loam of variable thickness.....35 to 40 feet.
2. Argillaceous, white limestone, with grains of glauconite, very few fossils..45 feet.
3. Scutella bed; light colored, calcareous materials, holding great numbers of *Scutella Lyelli* Con .....3 feet.
4. Coarse, ferruginous sand, with glauconite, fossiliferous, passing below into more calcareous material, which is indurated and projects from face of bluff....6 feet.
5. Ferruginous sand, holding vast numbers of comminuted as well as well preserved shells. Near the center of this there are, in places, thin bands of lignite, and along the ferry road the upper part of it is composed of laminated gray clays filled with leaf impressions. This is the source of the celebrated Claiborne fossils, and we shall call it the Claiborne Fossiliferous Sand. In many parts of Monroe and Clarke Counties, where this bed is more protected, the material in which the shells are embedded is seen to be a greensand, while at the Claiborne bluff and vicinity, and at a bluff just above Saint Stephens, it is completely oxidized into a red, ferruginous sand. Thickness about Claiborne.....15 to 17 feet.
6. Bluish green, glauconitic, sandy marl, with *Ostrea sellæformis*, usually somewhat indurated above, and forming a hard projecting ledge.....3 to 4 feet.
7. Calcareous clay or clayey marl, of gray color when dry, but blue when wet. It contains a few badly preserved chalky fossils, *Bulla* and small *Turritellas*. This bed becomes sandier below, as well as glauconitic and highly fossiliferous, the principal shells being *Ostrea sellæformis* and a few *Pectens*. The clayey and sandy parts, together.....about 18 feet.
8. Light gray, calcareous clay, similar to the upper part of the preceding bed, with hard sandy ledges at top and bottom.....7 feet.
9. Light yellowish gray, calcareous sands, with *Ostrea sellæformis* and *Pectens;* the lower half indurated and full of the molds or casts of univalve shells.....5 feet.
10. Light yellowish gray, calcareous sands like those which make the upper half of bed No. 9. This bed has several hard projecting ledges of the same sandy material and contains a number of fossils: *Ostrea sellæformis*, fragments of *Scutella Lyelli, Scalpellum Eocense* Myer, *Pecten Deshayesii* Lea, &c. The sandy parts of this bed are loose, crumbling easily between the fingers. There are thin beds of more clayey texture, one of which, about the center of the stratum, holds a number of irregularly shaped, concretionary masses of clay. Near the base are one or two indurated ledges of glauconitic sand and shells of *Ostrea sellæformis*..27 feet.
11. Layer of comminuted shells of *Ostrea sellæformis*, together with perfect shells of some other species embedded in glauconite or greensand.....3 feet.
12. Dark bluish black, sandy clay .....2 feet.
13. Bluish green, clayey sands with few fossils in the upper part, but becoming more clayey below and highly fossiliferous; *Venericardia planicosta, V. rotunda, Nucula magnifica, Arca rhomboidella, Ostrea sellæformis, Voluta Sayana, Turritella lineata, T. bellifera* Aldrich, besides species of *Natica, Corbula, Cytherea, Lucina,* &c. This bed averages 10 feet or more in thickness.

14. Dark green, sandy marl, glauconitic; grayish above, bluish below. This bed is sometimes badly weathered and of more brownish color. It holds a number of fossils, among which the most noticeable are a peculiar small form of *Venericardia planicosta* Lam. and large *Turritella Mortoni* Con. This bed, which is the lowest at Claiborne, may be seen between the upper landing and the ferry, and its exposure is from six to eight feet, according to the stage of the water.

(*b*) A few miles above Claiborne, near Lisbon Landing, we find the continuation of the Claiborne beds down to the top of the Buhrstone, and there is no doubt as to the geologic horizon of the Lisbon section, since the two lowermost beds of the Claiborne section appear at the top of the Lisbon bluff, the peculiar association of the shells making the identification easy and certain. In the following full section at Lisbon the bracketed numbers show the relations of the Lisbon beds to those of Claiborne, as indicated in Plate XIII.

Section at Lisbon Bluff, Alabama River.

1. Drift and loam ..... 20 feet.
2. [13] Brown, sandy clays, difficult to describe more closely, as they are badly weathered and contain very few fossils ..... 10 feet.
3. [14] Dark brown, sandy clays, badly weathered, highly fossiliferous, containing the same shells as beds Nos. 13 and 14 at Claiborne, viz, the peculiar small variety of *Venericardia planiscosta* Lam., large *Turritella Mortoni* Con., *Arca rhomboidella* Lea, *Lucina compressa* Lea, *Nucula magnifica* Con., *Turritella bellifera* (Aldrich), &c. This bed becomes more sandy below ..... 8 to 12 feet.
4. [15] Hard projecting sandy ledge ..... 8 inches.
5. [16] Calcareous, clayey sands, light yellow when wet, nearly white when dry, glauconitic, forming smooth vertical bluff ..... 6 to 8 feet.
6. [17] Coarse grained, sandy, glauconitic bed with comminuted shells and many finely preserved shells of uncommon occurrence ..... 3 feet.
7. [18] Light yellow, glauconitic sands capped with hard ledge ..... 15 feet.
8. [19] Blue, glauconitic sands, probably the same as No. 7 above, but less completely oxidized, lowest of Claiborne strata ..... 5 feet.
9. Bluish black clay, 8 feet actually seen, below which, to the water, 5 feet, all the strata are covered by fragments of the concretionary sandstone described below.

In the clay immediately below the glauconitic sands, No. 8, concretionary masses are formed, which resemble a tangled mass of roots or branches, exposed in high relief upon a plate or block of sandstone. These root-like concretions lie strewn upon the lower strata of the bluffs about Lisbon, and seem to be somewhat characteristic of this particular horizon, which we place at the very summit of the Buhrstone division, the Claiborne proper extending to and including No. 8 [19] of the above section.

The combined sections of the Claiborne Bluff and the Lisbon Bluff show the whole of the Claiborne formation, which, according to our division, extends from the White Limestone down to the top of the Buhrstone and includes about 140 feet of strata, of which 106 are to be seen in place at Claiborne, while the rest may be seen a few miles above Claiborne at Lisbon.

The fossiliferous sands (No. 5 of Claiborne section) have furnished the greater part of the beautiful Claiborne shells. The uppermost five

or six feet of this bed are made up chiefly of the shells of *Cytherea æquorea* Con., *Pectunculus Broderipii* Lea, and *Crassatella alta* Con., 90 per cent. of the shells belonging to the first named species. The two feet next below contain not only many of the Cythereas but great numbers of other shells also, the most prominent of which are *Turritella lineata* Lea, *Rostellaria velata* Con., *Crepidula lirata* Con., *Turbinella pyruloides* Con., *Voluta Defranckii* Lea, *Monoceros armigerus* Con., *Melongena alveata* Con., *Ancillaria subglobosa* Con., &c.[1]

The strata below the Claiborne sands are much less fossiliferous and more sandy, *Ostrea sellæformis* being by far the most abundant shell down to the black clay stratum near the base of the bluff. The greensand beds at the base of the Claiborne bluff and at the top of the Lisbon bluff contain many of the rarer forms. The marl bed No. 6 of the Lisbon section promises to yield a rich harvest of novelties.

The collocated sections on Plate XIII give the details of the preceding drawn to scale. For the sake of comparison we give on the same sheet the sections of Professor Tuomey[2] and of C. S. Hale.[3] Hale's No. 3 corresponds with our Nos. 14 and 15. His No. 4 and Tuomey's bed *b* are represented by our Nos. 12 and 13 and part perhaps of 11. Hale's beds 5 and 6 and Tuomey's *c* are our numbers 6 to 11, inclusive. The correspondence of the rest of the sections is easily seen.

Some of the more important exposures of the Claiborne beds elsewhere are the following:

(*c*) A few miles below Claiborne, at Gosport landing, there is substantially the same section as that at Claiborne.

(*d*) At Rattlesnake Bluff, below Gosport, there is the following section (see Plate XII, Fig. 4, p. 143):

Section at Rattlesnake Bluff, Alabama River.

1. Ferruginous sands, becoming more calcareous below and terminating with a hard ledge ..... 6 feet.
2. Claiborne fossiliferous sands ..... 10 to 12 feet.
3. Calcareous clay or hard clay marl, with an indurated ledge in the middle .... 6 feet.
4. Clay marl, with *Ostrea sellæformis*, with four or five hard, projecting ledges, about ..... 10 feet.
5. Greensand, indurated at top but softer below, extending down to the water, about ..... 2 feet.

(*e*) On the Tombigbee River, half a mile above Saint Stephens, there is a good exposure of the Claiborne sands, with some 10 to 12 feet of the next underlying beds, already given above in a section illustrating the White Limestone. (See Plate XII, Fig. 3, p. 143.)

[1] Aware of the fact that most of these shells have synonyms, we have in most cases given our authority for the names used by us, leaving the question of priority to be decided hereafter.

[2] First Bien. Rep. Geol. Ala., p. 153, 1850.

[3] Geology of South Alabama, Am. Jour. Sci., 2d ser., Vol. VI, p. 354, Nov., 1848.

(*f*) Still farther up the river, at Coffeeville landing, the *Ostrea sellæformis* beds of the Claiborne profile form the river bluff, as may be seen from the following:

Section at Coffeeville Landing, Tombigbee River. (*Plate XIII, Fig.* 4, *p.* 147.)

1. Light yellowish sands, with *Ostrea sellæformis*, partly indurated, forming sandy ledge ..... 3 feet.
2. Loose, yellowish, calcareous sands, with *Ostrea sellæformis*, indurated, sandy ledge at base ..... 6 feet.
3. Loose, yellowish gray, calcareous sands, highly fossiliferous, especially in lower part; *Ostrea sellæformis* the principal form; separated from next bed by sandy ledge ..... 10 feet.
4. Bluish, sandy clay or clayey sand, with *Ostrea sellæformis* and a flabellum; in two parts, separated by a hard ledge, the upper part 8 feet, the lower 3 or 4 feet, in all ..... 12 feet.
5. A bed of glauconitic sand filled with shell fragments and perfect shells: *Ostrea sellæformis* Con., *Crassatella alta* Con., a flabellum, *Venericardia rotunda* Lea, *Corbula Murchisoni* Lea, *Pecten Deshayesii* Lea, *Arca rhomboidella* Lea, *Nucula magnifica* Con., &c ..... 2 to 3 feet.
6. Dark bluish clays, nearly black, non-fossiliferous, breaking into cuboidal blocks ..... 2 feet.
7. Dark greenish, clayey sand, like that near the base of the Claiborne Bluff, about 5 feet showing above the water.

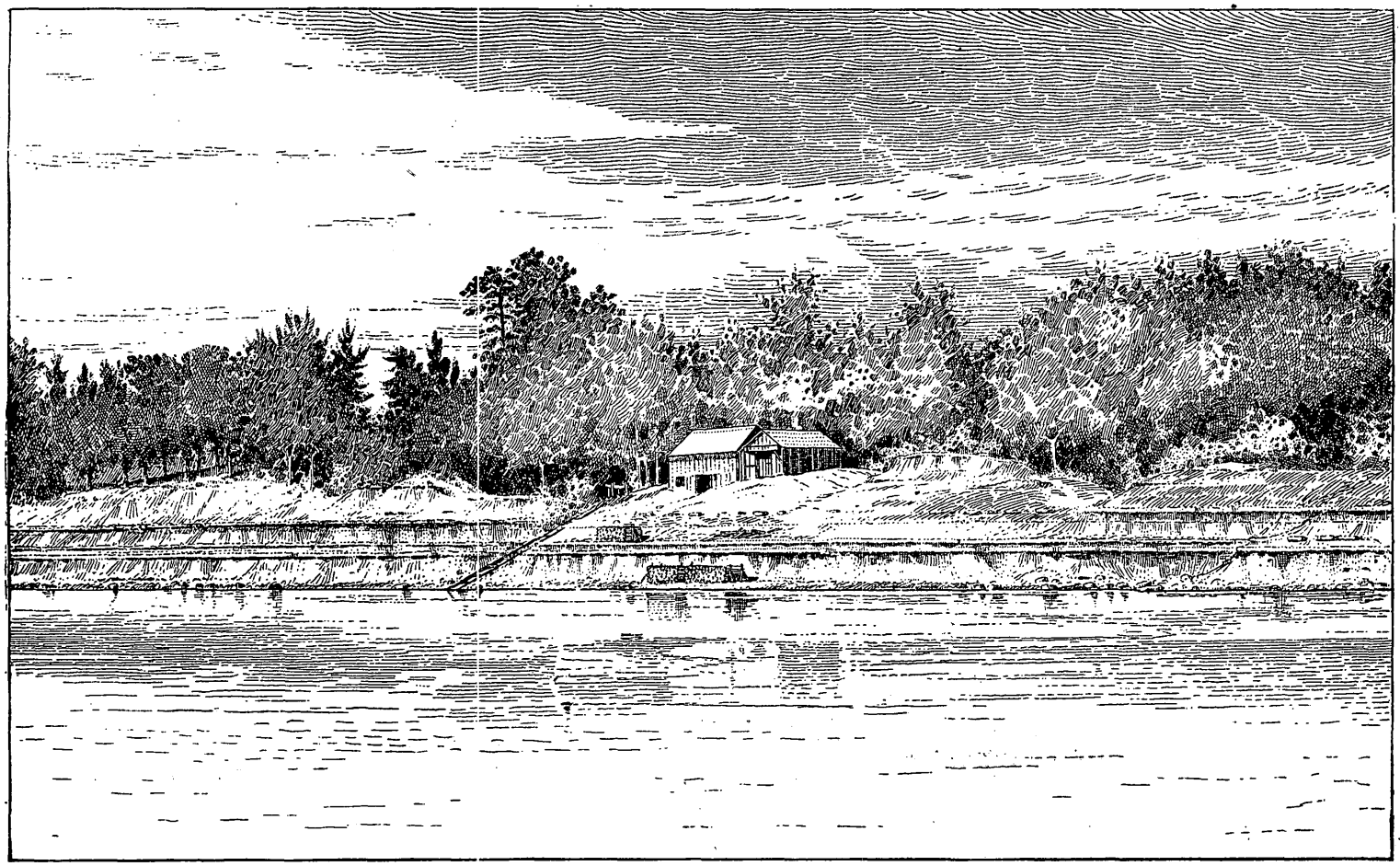
The accompanying view of Coffeeville Landing (Plate IV) shows well the general character of the lower Claiborne beds. The lowest wood piles rest upon the black clays, No. 6, equivalent to No. 12 of the Claiborne Bluff section. The main fossil bearing bed, No. 5, is immediately over this, between it and the first (lowest) of the projecting ledges seen in the plate.

Hale states[1] that his bed No. 4 occurs also at Coffeeville, with the same fossiliferous characters, and a comparison of the Claiborne Bluff section with the above shows very clearly the correspondence of the two. The bed No. 5 above is identical with No. 11 at Claiborne, except that it holds *Crassatella alta* and a few forms which we have not seen at the same horizon at Claiborne; but the underlying black clay (No. 6) is equivalent to No. 12, and the overlying bluish and yellowish, fossiliferous sands (Nos. 1–4) are identical with Nos. 9 and 10 of our Claiborne Bluff section. These relations are shown in the sections, Plates XII and XIII.

There are no other exposures of the Claiborne beds along the two rivers, but in Washington, Clarke, and Monroe Counties we have recently (summer of 1885) visited a number of localities where the Claiborne beds are to be seen often in contact with the overlying White Limestone.

(*g*) Thus, north of Bladen Springs, on descending the hill towards Souilpa Creek, yellowish sands, with *Ostrea sellæformis*, the counterpart of our Nos. 9 and 10, are passed over along the road, while above them, near the top of the hill, is a fossiliferous bed holding forms common both to the Claiborne sands and to the marls at the base of the Claiborne Bluff.

[1] Am. Jour. Sci., 2d ser., Vol. VI, Nov., 1848.



COFFEEVILLE LANDING, TOMBIGBEE RIVER.

(*h*) At the Barryton mill on Oaktuppah Creek, three miles northeast of the village of Barryton, there is a bed of greensand filled with broken and perfect shells of *Ostrea sellæformis*, identical with No. 11 of our Claiborne Bluff section, and above it, as at Claiborne, a series of bluish and yellowish sands, with *Ostrea sellæformis*.

(*i*) About two miles northward from this mill the Claiborne fossiliferous sands occur, and at Womack's Hill, still farther northward, the White Limestone caps the hill.

(*j*) The yellow sands, with *Ostrea sellæformis*, are also seen at a mill on the headwaters of Oaktuppah Creek, in the western part of Choctaw County, Sec. 8, T. 11 N., R. 4 W., and again within two miles of Nicholson's Store, on Billy's Creek, where they are exposed at the base of a hill capped with the White Limestone.

(*k*) Thirteen miles west of Bladen Springs, D. W. Langdon, jr., of the Geological Survey of Alabama, saw in 1884 an outcrop of greenish, argillaceous sand, weathering red and containing a number of shells peculiar to the Claiborne sands, such as *Crepidula lirata*, *Corbula Alabamensis* Lea, and others commonly found in the Claiborne sand but not peculiar to it. This bed also was beneath the White Limestone.

(*l*) In the northern part of Washington County I saw, in 1882, an outcrop of marl containing *Turritella Mortoni* Con., *Ostrea sellæformis* Con., *Voluta Sayana* Con., &c., on Dry Creek, Sec. 6, T. 8, R. 2 W.

(*m*) In Clarke County, near the site of Old Clarkesville, in Sec. 23, T. 9 N., R. 2 E., there is seen in the bed of a branch a greensand containing all the peculiar shells of the Claiborne fossiliferous sands, and on the hills above White Limestone containing bones of Zeuglodon.

(*n*) In Sec. 18, T. 9 N., R. 3 E., the same beds occur, and in the same relations to the White Limestone.

(*o*) On Stave Creek, in Secs. 8 and 9 of T. 7 N., R. 2 E., and in other localities in the immediate vicinity, the Claiborne sands, with all their easily recognizable and unmistakable shells, are at the water level in the creek banks, while the White Limestone outcrops on the hillsides hard by, with orbitoidal limestone on the summits.

(*p*) D. W. Langdon, in 1884, observed the Claiborne sands also nine and a half miles south of west of Grove Hill and fifteen miles east of Coffeeville, in both cases underlying the White Limestone. The locality on Stave Creek was visited by Prof. A. Winchell[1] and the localities near old Clarkesville were seen by Professor Tuomey[2] and by Professor Winchell[3] also.

(*q*) In Monroe County the yellow sands, with *Ostrea sellæformis*, occur in sections 25 and 34 of T. 7 N., R. 8 E., and in sections 19 and 30 of T. 7 N., R. 9 E., partly on the land of Mr. T. A. Rumbly.

[1] Proc. Am. Assoc. Adv. Sci., Vol. X, Part II, pp. 84, 85, 1856.

[2] First Bien. Rep. Geol. Alabama, p. 149.

[3] Proc. Am. Assoc. Adv. Sci., Vol. X, Part II, p. 86, 1856.

(*r*) In Sec. 2, T. 7 N., R. 7 E., occur the yellow sands, with *Ostrea sellæformis*, as at Rumbly's, and in Sec. 12, T. 7 N., R. 7 E., the Claiborne greensand, with all the characteristic shells, occurs in the branches of the creeks, while the White Limestone occupies the summits of the hills.

Our observations correct a statement of Professor Winchell[1] that the calcareous beds underlying the Claiborne sands are not seen elsewhere. These beds are now known to occur from the western part of Choctaw to the Sepulga River, in Conecuh County, and probably still farther eastward.[2]

Other occurrences of the Claiborne beds, observed in 1886, will be found described below in the chapter on undulations &c.

§3. THE BUHRSTONE.

The fossils of this subdivision, as has already been suggested by Dr. Hilgard, do not appear to differ essentially from those of the calcareous Claiborne strata above described, yet the lithological character is so entirely different as fully to justify the division here made.

The rocks of the Buhrstone formation in Alabama, as well as in Mississippi, consist of aluminous and silicious materials, partly glauconitic, and in places interstratified with thin beds of greensand. The chief varieties of these rocks, in the order of their relative abundance, are the following:

1. Gray, aluminous sandstone, often glauconitic, with numerous galls or concretions of pure whitish clay and traversed throughout with streaks of yellowish, hydrated oxide of iron. In this rock are occasionally found impressions of shells. In the upper part of the formation, upon the surfaces of this sandstone irregularly branching, cylindrical elevations of slightly harder texture, but apparently of similar composition, are sometimes seen. These ridges have in some cases the appearance of being organic remains (fucoidal), but are more probably concretionary. These are best seen at Lisbon Landing on the Alabama River, and west of Bladen Springs, in Choctaw County, and at other points along the southern line of this formation.

2. Indurated, white clay, forming a rock, which is, however, quite light and easily broken. This indurated clay has joint planes approximately at right angles to one another, the planes of separation being mostly stained red or yellow with hydrated ferric oxide. Fragments of this claystone worn into rounded pebbles are of common occurrence in most of the creeks and branches flowing through the Buhrstone hills, both in Alabama and in Mississippi. The claystones are often silicious.

3. Hard, coarse grained, glauconitic sandstone.

4. Hard, yellowish, silicious, or aluminous sandstone, streaked with a darker shade of yellow.

5. A white, silicious rock, almost a quartzite, varied by spots of leaden gray color. This rock has often furnished the material for Indian lance and arrow heads. It occurs near the base of the series, associated with a hard, silicious sandstone.

The prevailing color of the rocks of this formation is light gray, often nearly white, and, on account of their hardness and resistance to decay.

[1] Proc. Am. Assoc. Adv. Sci., Vol. X, Part II, page 86, 1856.

[2] D. W. Langdon, jr., has also traced these sandy *Ostrea sellæformis* beds into Mississippi, as far as Suanlovey Creek, near Garlandsville, in Newton County, a locality already recorded by Dr. Hilgard. See paper "On the Tertiaries of Mississippi and Alabama," in Am. Jour. Sci., 3d ser., Vol. XXXI, Mar., 1886. See, also, pp. 25–33 and foot-notes.

the country which they make is very broken and rugged. The high and often precipitous hills of the Buhrstone are usually called *mountains* in Clarke, Monroe, and Choctaw Counties, in this State, and in northeastern Clarke, Lauderdale, Newton, and Neshoba Counties, in Mississippi. The soil, where it is derived from these rocks, is, of course, poor, and mostly timbered with long leaf pine, and the country is generally very sparsely settled.

It is impossible as yet to give with absolute certainty the thickness of this division of the Tertiary. During the summer of 1885, I measured with the aneroid barometer at one locality, near McCarthy's Ferry, in Choctaw County, 270 feet of Buhrstone rocks, and, as this section did not include the uppermost beds of the formation, we are safe in placing 300 feet as the minimum thickness. I am strongly inclined to the opinion that the real thickness, in some cases, will rise to 400 feet. In the section we give the lower limit, 300 feet.

In general, the uppermost beds (fifteen to twenty feet) are composed of joint clays, which, when indurated, form tolerably firm rocks. Near the base of the formation similar clays or claystones are usually seen. In many places, there is a bed several feet in thickness of a hard, silicious, or flinty sandstone, almost a quartzite, just at the base of the Buhrstone. I have noticed this rock a few miles north of Bladen Springs, also near McCarthy's Ferry, and south of Pushmataha, in Choctaw County. In Choctaw and Clarke Counties it is not unusual to find spear or arrow heads made of this material, which is easily recognized. The great bulk of the Buhrstone, as already said above, consists of aluminous sandstones.

Inasmuch as we have not yet been able to point out any characteristic distinction, based upon organic remains, between the Buhrstone and the Lignitic, we have thought it best to draw the line between them upon lithologic grounds, and our justification in this course is found in the following considerations: In the strata which we have called Lignitic, the material, as compared with that of the Buhrstone, is more sandy and calcareous and at the same time more fossiliferous. The shells in many cases are decayed and the calcareous matter of the same often appears to have been leached out and diffused through the surrounding sands, occasionally cementing them together and forming calcareous sandstone. These sandstone beds always show a tendency to weather into rounded, bowlder-like masses, which project from the faces of the bluffs or, broken off, roll down, forming a talus. When broken open, these bowlders usually show a nucleus of thoroughly decayed shells or of ferruginous, lignitic matter.

A ledge of calcareous sandstone of this kind is found about twenty or thirty feet below the lowermost of the aluminous rocks, which we consider as characteristic of the Buhrstone, and similar calcareous sandstones weathering into bowlders occur at intervals throughout the underlying lignitic strata.

The aluminous rocks we assign to the Buhrstone, while the sandy rocks, with the intercalated beds of calcareous matter, we place with the Lignitic.

This division based upon lithologic characters can be consistently carried out in Alabama, at least in the region contiguous to the two rivers, since the indurated clays and aluminous sandstones of the Buhrstone are in general easily distinguished from any of the other strata of the Tertiary formation. None of the beds of the underlying Lignitic have even a remote resemblance to the Buhrstone rocks, except certain indurated clays which overlie the *Gryphæa thirsæ* beds in the Grampian Hills of Wilcox County and their prolongation into Butler County. Even in this case the distinction between the two can readily be discovered, as the indurated clays of the Lignitic are, in some of the beds, quite full of shell casts, principally Turritellas and Cythereas, and the material itself, upon close examination, does not so strongly resemble the Buhrstone as upon first sight appears. Then the circumstances that these lignitic claystones lie over 300 feet below the Buhrstone, are by no means so thick, and are in most, if not all, cases in immediate contact with the *Gryphæa thirsæ* beds greatly diminish the chance of any confusion between the two series.

On the Alabama River the uppermost of the Buhrstone beds are well exposed at Lisbon Landing, and the lowermost, a short distance above Hamilton's, whence they extend across Clarke County westward or northwestward to White Bluff and McCarthy's Ferry and thence in a northwesterly direction across Choctaw County, just south of Butler. On the eastern side of the Alabama River they appear in the hills south of Bell's Landing, and across Monroe County north of Kempsville and south of Turnbull, turning a little to the northward in the eastern part of the county. To the eastward they may be seen again near Ozark, in Dale County, and near Abbeville, in Henry County.

In general we have not attempted in the following sections to give the exact sequence of the different materials which form the Buhrstone beds. In most cases they are merely alternations of indurated clays, with aluminous sandstones of varying degrees of hardness. While in the extremes of pure clay and almost pure quartz the materials of this formation differ widely, the formation as a whole leaves upon the mind of the observer a lively impression of the uniformity in the lithological structure and general appearance of its constituent strata.

Although the best natural sections of the Buhrstone are perhaps to be found in the hills away from the rivers, we shall here describe only the exposures along the banks or in the immediate vicinity of the two water courses. The sections on the Alabama River are as follows:

(*a*) *Section at Lisbon Landing, Alabama River.* (*Plate XIV, Fig.* 1, *p.* 151.)

1. Yellowish, sandy marl, lowermost of the Claiborne beds..... 20 feet.
2. Bluish black clay, massive, jointed or breaking into cuboidal blocks, 8 feet seen, but to the water's edge.....about 15 to 20 feet.

Immediately beneath the sands which form the lowermost beds of the Claiborne formation in this section concretions are formed which resemble a mass of tangled and matted roots. Blocks of sandstone with these concretions cover all the lower part of the section at Lisbon and they seem to be more or less characteristic of the uppermost beds of the Buhrstone.

(*b*) At Hamilton's Landing, 6 miles above Lisbon, is an exposure of 75 to 80 feet of light colored, indurated clays or clayey sandstones with two or three indurated, projecting ledges, all characteristic Buhrstone rocks. (See Plate XIV, Fig. 2, p. 151.)

The positions of the outcrops of the Buhrstone rocks on the Tombigbee River present apparent anomalies which, at the time of our visit in 1883, we could not explain. The later observations, however, made by myself in 1885 have cleared up many of the obscurities, and the structure of the two counties of Clarke and Choctaw in its main features is pretty definitely made out. This will be set forth in detail in a forthcoming report of the Geological Survey of Alabama, while at this time we need only give the sections exposed on the river banks and in the immediate vicinity. As stated above, the regular line of outcrop of the Buhrstone rocks extends from near Hamilton's Landing, on the Alabama, across to the Tombigbee at White Bluff and McCarthy's Ferry. At both these localities we have very good sections of the lower beds of the formation.

(*c*) At White Bluff there is a clear exposure of these rocks in a cliff of about 115 feet. They are light colored, aluminous rocks, which, however, could not be closely examined because of the precipitous nature of the bluff. (See Plate XIV, Fig. 4, p. 151.)

(*d*) At McCarthy's Ferry the immediate bluff of the river is made of the clays which underlie the Buhrstone, but on the hills just back of the river we get a section of nearly 300 feet of Buhrstone rocks. (See Plate XIV, Fig. 3, p. 151.)

(*e*) Down the river from these localities the Buhrstone rocks dip beneath the surface, the overlying Claiborne beds forming the river banks, as at Coffeeville, &c., already mentioned, but just south of Coffeeville, at Hatchetigbee Bluff, the Buhrstone is again seen, and the lowermost beds at that, as shown in the section (see Plate XIV, Fig. 5, p. 151). The exposures at White Bluff and at the Hatchetigbee Bluff both show the contact of the light colored claystones with the underlying sandy clays &c. of the Lignitic, but at the former locality all except the uppermost 20 feet or so of the Lignitic are obscured by land slips and rubbish of all sorts. These sections will be given in detail under the next heading.

(*f*) Still farther down the Tombigbee River these rocks sink again below the surface, for at Saint Stephens, and just above, the Claiborne sands and the overlying White Limestone make the river bluffs, as before stated. At the Lower Salt Works, however, we have the Buhrstone

rising again to the surface, as described by Professor Tuomey.[1] During the summer of 1885 I ascertained that these rocks appear at the surface at an intermediate point, viz, near Jackson. The Lower Salt Works are situated near the center of T. 5 N., R. 2 E., and the rocks exposed along the road which ascends the hill just south of the works are as follows:

Section at the Lower Salt Works, Clarke County.

1. Orbitoidal limestone forming the upper part of the hill, thickness not determined.
2. Between the orbitoidal rock and the topmost bed of the continuous section below given there is a space in which the rocks are covered with soil, undetermined thickness.
3. Argillaceous White Limestone or clayey marl, with several indurated ledges of similar material.....about 18 to 20 feet.
4. Coarse grained, ferruginous sand, with harder ledge at base and above. This bed, as well as the harder portions, contains fossils, the most conspicuous of which are *Scutella Lyelli* and *Pecten perplanus*. This bed is strongly glauconitic near the base.....about 9 feet.
5. Greenish clay passing at bottom into a ledge of hard claystone, the first of the Buhrstone formation .....3 feet.
6. Aluminous sandstones or indurated claystones of the usual Buhrstone character to the base of the hill.....60 feet or more.

About half way down the hill there is a bed of greensand holding a good many fossils.

That which most strikes the observer in this section is the absence of the sands and marls of the Claiborne formation. The glauconitic sands with *Scutella Lyelli* and *Pecten perplanus*, supposed to be of Jackson age, immediately overlie the greenish clays of the Buhrstone, while at Claiborne the two are separated by at least 130 or 140 feet of other strata.

Professor Tuomey[1] called attention to the fact that the Buhrstone beds, after dipping beneath the surface in the upper part of Clarke County, appear again at the Lower Salt Works, the White Limestone and other calcareous strata occupying a basin in the Buhrstone formation. Our own observations on the river in 1883, and later in 1885 in the western part of Clarke County and in Choctaw County, have shown that the Buhrstone rocks appear at at least two intermediate points between the two limits observed by Professor Tuomey, viz, at Hatchetigbee and at Jackson.

§ 4. THE LIGNITIC.

All the strata lying between the Buhrstone and the Cretaceous, representing a thickness of 850 to 900 feet, have been classed by Dr. Hilgard under the two names of Lagrange (or Lignitic) and Flatwoods. Lately, Prof. Angelo Heilprin has proposed the name Eolignitic for both these divisions; but, since Dr. Hilgard had already used the name Lignitic in the same sense, that term has priority and must be retained.

[1] First Bien. Rep. Geol. Ala., p. 150, 1850.

The greater part of this subdivision is made up of laminated clays and laminated and cross bedded sands of a prevailing gray color, except immediately below the Buhrstone, where for 200 feet or more they are of dark brown, often purplish colors. With the above mentioned laminated clays and sands are interstratified several beds of lignite and several beds holding marine fossils and usually characterized by the presence of glauconite or greensand.

The lignite beds appear to be more numerous and thicker towards the west, and especially in Mississippi, while eastward of the Alabama River they become, as a rule, inconspicuous. Only one of these lignites, viz, that which appears at Coal Bluff, on the Alabama River, is of very considerable size, six or seven feet; they possess no very well marked characters by which they may be distinguished from one another; they are traced with difficulty across the country, since, being softer, they are more easily eroded than the associated rocks. On the other hand we have found the marine beds to retain their characteristic features to a remarkable degree: each has its peculiar association of fossils, most of them are also easily recognizable by lithologic and structural characters, and some of them may be followed with the greatest ease across at least three counties. These circumstances have led us to use the marine beds instead of the lignites for marking the different horizons of the Lignitic division, and provisionally we have thus used the seven following marls, each marking a well defined horizon and each presenting its easily recognized paleontologic character:

1. The Hatchetigbee marls.
2. The Wood's Bluff or Bashi marl.
3. The Bell's Landing series.
4. The Nanafalia or *Gryphæa thirsæ* marl.
5. The Matthews's Landing and Naheola marls.
6. The Black Bluff beds.
7. The Midway or Pine Barren beds.

Our account of the stratigraphy of the Lignitic division of the Alabama Tertiary will be more intelligible and more easily followed if we describe the strata in sections, each corresponding to and including one of the seven marl beds above enumerated.

(1) THE HATCHETIGBEE SERIES. (PLATE XV.)

In this we would include all the strata intervening between the base of the Buhrstone and the uppermost of the Wood's Bluff fossiliferous beds, aggregating about 170 to 175 feet, as may be seen by consulting the engraved sections of Plate XV, especially Fig. 1, p. 155.

By far the greater part of the beds here included are sandy clays or clayey sands of brownish gray colors, alternating with bands of dark brown or purple color, the whole forming a tolerably well marked and in most cases easily recognized group. Where these brown clays have been much exposed to the action of the atmosphere, and conse-

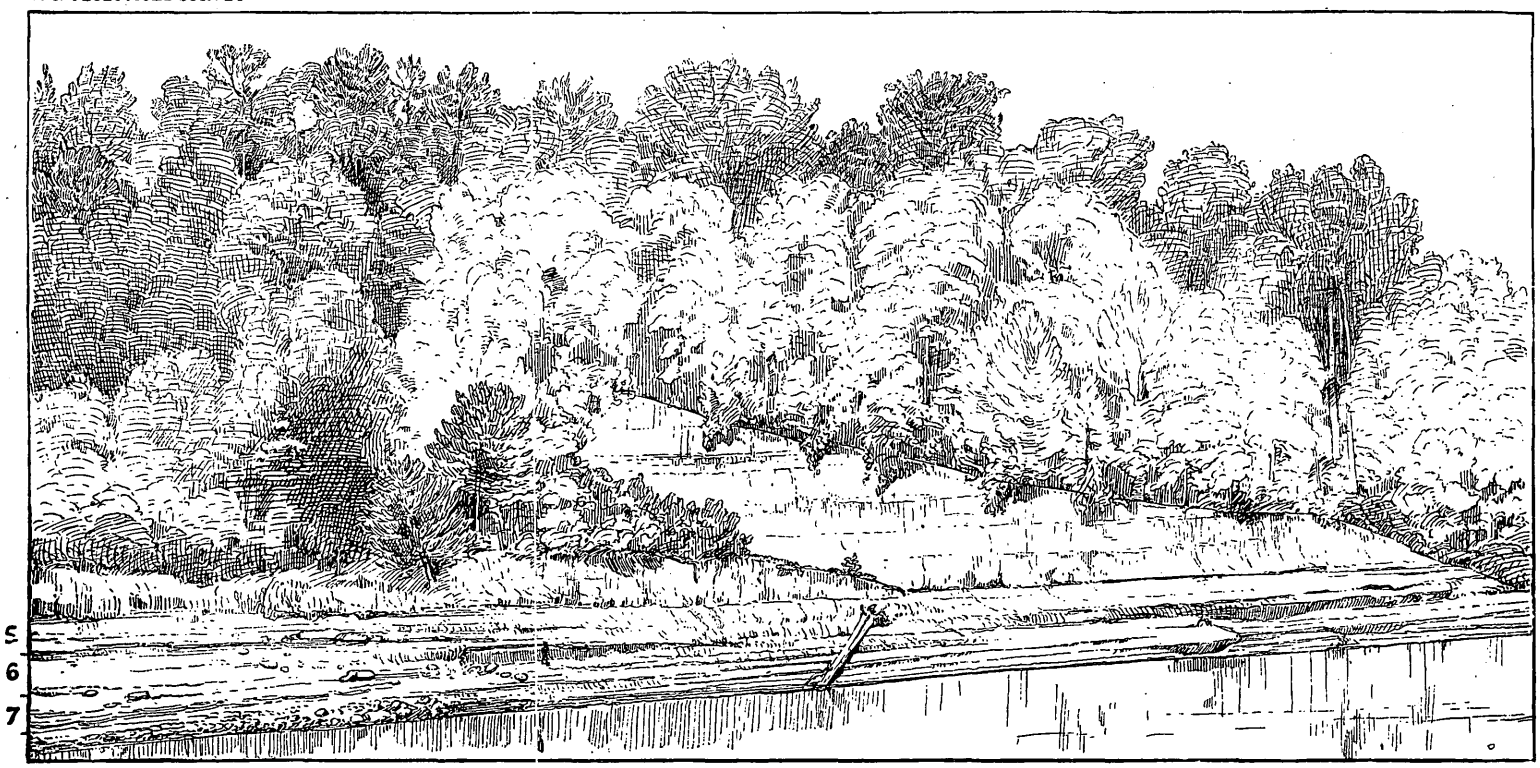
quently thoroughly leached, as occurs wherever they lie high up on the hills, they exhibit very much lighter and less characteristic colors. The best exposures of these beds are to be seen at the localities more particularly described below, and at one of them, White Bluff and vicinity, the whole series occurs in actual superposition, only about sixty-five feet of it being somewhat obscured by slides. The distinctively marine deposits of this series consist of three or four shell or marl beds, separated by non-fossiliferous sands and clays (Plate V).

(*a*) *Section at Hatchetigbee, Tombigbee River.* (*Plate XV, Fig.* 2, *p.* 155.)

1. Light colored, aluminous sandstones and indurated clays, forming a vertical escarpment back of the main bluff[1] ..... 20 to 30 feet.
   These light colored claystones we consider to be the lowermost of the Buhrstone formation, and all the underlying to be Lignitic.
2. Sandy clays of brown, yellowish, and reddish colors interstratified. These are dark blue when moist, but of lighter colors when dry ..... 15 to 20 feet.
3. Heavy bedded, dark brown clays, somewhat like No. 2, but of darker color when dry ..... 10 feet.
4. Yellowish, glauconitic marl ..... 2 to 3 feet.
   This bed shows a tendency to form at intervals hard concretionary ledges, which on weathering break off and roll down the bluff and are piled in great numbers at its base. Some of these bowlders have a nucleus of shells, which, however, are not usually very well preserved.
5. Purplish brown, sandy clays, in the middle of which is a projecting ledge of dark colored clays which are harder but break up into small prismatic fragments upon drying and on exposure to weather ..... 15 feet.
6. Yellowish gray sands, striped with thin streaks of brown, sandy clay. These sands form, at intervals along the bluff, indurated, concretionary, rounded masses ..... 5 to 6 feet.
7. Bluish brown, sandy, clay marl, containing many new forms of shells. The upper part more fossiliferous ..... 5 to 6 feet.
8. Laminated, grayish sands, interstratified with thin beds of brown or black, lignitic clay. These sands form rounded, concretionary masses, which project from face of bluff ..... 4 feet.
9. Heavy bedded, gray, sandy clays with streaks of brown clay ..... 8 feet.
10. Reddish, sandy marl, highly fossiliferous, forming concretionary bowlders. Remarkable for the great numbers of *Venericardia planicosta* Lam., but containing also many other forms, such as *Athleta Tuomeyi* Con., and *Fusus pagodiformis* Heilprin ..... 4 to 5 feet.
11. Dark gray to brown sandy clays to water ..... 15 feet.

Beds No. 8 and 9 above form very conspicuous parts of the bluff, as they are striped with dark brown, nearly black, bands of clay and resemble strongly a part of the section at McCarthy's Bluff described below.

[1] Between our joint visit in 1883 and my second in 1885 the appearance of the bluff was very materially changed by a landslide. In 1883 we saw about six feet below the marl bed No. 4 another of very similar character, which I have now reason to think was a mere repetition of No. 4, since I was unable to make out two such beds in 1885. I have, therefore, given only one in the section, though convinced of the existence of two at the time of our first visit.



5. Lower part of purplish brown, sandy clays. 6. Yellowish gray sands. 7. Bluish brown, sandy marl.
(The human figure stands upon the bed which we call the middle marl. References are to the sections on p. 40, and also to Fig. 2 of Plate XV.)

HATCHETIGBEE—UPPER END OF BLUFF, TOMBIGBEE RIVER.

(*b*) At White Bluff, on the Tombigbee, as above stated, there is another exposure of the contact between the Buhrstone and the underlying Lignitic, which, however, includes in continuous exposure only the uppermost 25 feet of the latter formation. From the top of White Bluff down to the river level the distance is 275 feet by barometric measurements made at several different times. Of this, the uppermost 140 feet are shown in a clear perpendicular bluff and consist of 115 feet of the light colored claystones of the Buhrstone formation and 25 feet of sandy clays of the Lignitic. The strata composing the rest of the slope of White Bluff are so much obscured by landslides that it is impossible to make them out satisfactorily, but the lowermost 70 feet of the beds which make this slope are well exposed on the banks of Witch Creek and at Davis's Bluff, near by. Between these two parts of the section there are some 65 feet of strata not seen here, which include the Hatchetigbee marls &c. In proof of this, I found on the slope, a few feet below bed No. 3 of the accompanying section, a fragment of hardened, glauconitic marl with a few badly preserved fossils. The marl resembled that described in No. 4 of the Hatchetigbee section above. The fossils were, however, too obscure to be identified.

All this is shown in the following section and in Plate XV, Fig. 1, p. 155:

Section at White Bluff and Davis's Bluff, Tombigbee River.

1. Aluminous sandstones and claystones, of light color, forming a vertical bluff, the details of which it is impossible to examine closely, Buhrstone rocks....115 feet.
2. Grayish, sandy clays, with a layer about 18 inches in thickness at its base, containing fragments of lignitized stems and twigs.....20 feet.
3. Sandy clays, with a layer at bottom about 8 inches thick, consisting of alternating layers (one-fourth of an inch in thickness) of lignite and sand.....5 feet.
4. Strata not seen, covered by landslides[1].....65 feet.
5. Gray, sandy clays, striped with brownish purple bands of clay, containing few if any fossils, except that about 12 feet above the water there occurs a thin bed with a few fossil shells, and some 12 feet above this a single specimen of *Athleta Tuomeyi* was found sticking in the clay[2].....70 feet.

White Bluff is in the southwestern part of Sec. 14, T. 11 N., R. 1 W., just below the mouth of Witch Creek.

(*c*) Above this, the river bends towards the west, and in the northwestern part of Sec. 6, T. 11 N., R. 1. W., at McCarthy's Ferry, the strata which make the lower part of the preceding section are again exposed, as may be seen from the following section:

Section at McCarthy's Ferry, Tombigbee River. (*Plate XV, Fig. 3, p. 155.*)

1. Sandy clays interlaminated with clays less sandy, all of light gray colors, but along the whole length of the bluff there are parallel bands of much darker clays, which make a very conspicuous marking.....50 to 55 feet.

[1] A fragment of glauconitic sandstone with fossils was picked up from the surface in this part of the section a few feet below the base of No. 3.

[2] These beds, as well as those included in No. 4, are covered by the débris of landslides at White Bluff, but they are well shown in the banks of Witch Creek, which washes the base of White Bluff, and at Davis's Bluff, half a mile above, where we get the lower 70 feet of the section (No. 5).

2. Laminated clays and sands, firm and compact at base, forming a projecting ledge which divides the bluff into two parts.....4 to 5 feet.
3. Pyritous, sandy clays, with two or three bands of darker color; the sands are indurated in places, forming bowlder-like masses.....20 to 25 feet.

The dark bands which mark the bluff and which look at a distance like lignite beds are found upon closer inspection to consist of thin layers of dark bluish gray clays interbedded with thin streaks of gray sand. The whole 75 feet of this section appear to be barren of fossils.

At the base of the bluff lie great numbers of fragments of the silicious and aluminous rocks which characterize the Buhrstone formation and which have rolled down from the hills that rise a short distance back of the immediate bluff of the river. These hills are composed entirely of the Buhrstone rocks for a vertical distance of 270 feet. (See Plate XIV, Fig. 3, p. 151.) This is the greatest thickness of Buhrstone rocks that has been measured in one section, except at one other place in the same range of hills.

Above McCarthy's Bluff I failed to find any outcrop of the Hatchetigbee marls, but a short distance northward, on the road to Mount Sterling, some 10 to 11 miles south of Butler, the road descends over 250 feet of Buhrstone rocks, below which I saw in 1885 an indurated greensand marl with fossils embedded in brown sandy clays. This is doubtless one of the Hatchetigbee marls.

The position of the McCarthy's Bluff beds with reference to the Buhrstone and to the Davis's Bluff beds is shown on the general section in Plate XIV, Fig. 3 (p. 151), and in Plate XV, Fig. 3 (p. 155).

Up the Tombigbee River from White Bluff and Davis's Bluff to Wood's Bluff, similar dark gray, sandy clays with darker bands are displayed in the river banks. The thickness of the strata between the Buhrstone and the top of the Wood's Bluff marl is about 175 feet, of which the lower 100 feet are well characterized by a prevailing dark brown or slightly purple color and by the absence of fossils, except an occasional band of lignitic clay or a sandier band with a few marine shells. The upper 75 feet are more fossiliferous and varied in appearance.

In these lower, dark, sandy clays there occur concretionary masses of silicious matter, sometimes almost a flint of approximately spherical shape, and made up of concentric layers or shells. These concentric shells are usually separated by a thin layer of pure quartz of fibrous texture, the fibers being perpendicular to the surfaces of the spheres. These concretions are very commonly looked upon as petrified turtles by the people of the vicinity. They vary from 6 inches to 4 or 5 feet in diameter. In other places the clayey sands themselves are cemented together into rounded concretions, with a nucleus of black lignitic matter.

Where the dark brown or purple, clayey sands above described occur at considerable elevations above the water and have been thoroughly leached and desiccated, they exhibit very much lighter colors. They are

seen under such condition on the hills back of Yellow Bluff, on the Alabama River, and in the country between the two rivers. It is only along the river bluffs and low places, where they are kept more or less moist, that the dark purple and brown shades are so characteristically displayed.

(2) THE WOOD'S BLUFF OR BASHI SERIES. (PLATES XV AND XVI.)

The first beds of marine fossils of any consequence below the series of brown and purple clays above mentioned occur at Wood's Bluff, on the Tombigbee, and just below Johnson's Island, on the Alabama River; also, on Bashi Creek and its tributaries in Clarke County, and at numerous other localities to be given below. We have given to these beds the name of the *Wood's Bluff* or *Bashi Marl.* They are from 15 to 20 feet in thickness, are highly fossiliferous, hold a very considerable percentage of greensand, and the marl has a tendency to become indurated by carbonate of lime into rounded, bowlder-like masses of glauconitic, fossiliferous limestone. These bowlders may be formed in any part of the beds, but are more commonly seen in the upper half, and when this is the case the loose greensand marl below is easily washed out, giving rise to the formation of caves, sometimes of considerable dimensions. Immediately below this marl, and usually within 25 feet of it, are at least four or five thin seams of lignite, varying from a few inches up to 18 inches in thickness.

All these characters render the Wood's Bluff marl easily recognized, and it has been traced by me from the western part of Choctaw across to the eastern part of Monroe County without any essential change in its quality. It has become one of our most important geologic landmarks.

Some 35 to 40 feet below the lowermost of the thin, lignitic beds immediately underlying the Wood's Bluff marl, and separated from it by yellowish, cross bedded sands, is another lignite, about two feet in thickness, at the base of which we wish to draw the line between the Wood's Bluff and the Bell's Landing series. As thus defined, the Wood's Bluff series includes the strata intervening between the purplish brown, sandy clays, above described, immediately overlying the Wood's Bluff marl, and the two feet of lignite. The thickness represented is about 80 feet. The most complete section of the whole series is at Yellow Bluff, on the Alabama River. (See Plate XVI, Fig. 1, p. 159.)

The best exposures of the marl bed are to be seen at Wood's Bluff, on the Tombigbee River, and on the tributaries of Bashi Creek in Clarke County, in the immediate vicinity of Wood's Bluff, although, as stated above, the marl may be readily traced across Choctaw, Clarke, and Monroe Counties, exhibiting at many places away from the rivers very fair sections. On the immediate banks of the Alabama River the marl does not make much show, though it may be seen below Johnson's wood yard.

We give here only three sections, showing the details of the marl bed and of the strata underlying down to the top of the next, or Bell's Landing, series.

(*a*) *Section at Wood's Bluff, Tombigbee River.* (*Plate XV, Fig.* 1, *p.* 155, *and Plate XVI, Fig.* 7, *p.* 159.)

Orange sand or stratified drift.....20 feet or more.

1. Dark brown or bluish black, laminated clays, breaking up into small fragments, 6 to 8 feet, at the upper end of the bluff, but rising to 10 feet or more farther down. These clays are identical with those at the base of the White Bluff section.....8 to 10 feet or more.
2. Dark bluish, sandy clay, turning red on exposed and weathered surfaces and capped with a hard ledge which may be easily traced down the river nearly to Davis's Bluff[1].....3 feet.
3. Bluish, laminated clay or sandy clay, very much like No. 2 in color and texture, but containing no fossils, or very few, and not appearing red at the surface, of variable thickness.....5 to 8 feet.
4. Bluish or greenish, sandy clay, somewhat indurated, of decidedly reddish color on the surface, highly fossiliferous, characterized by *Turritella lineata* Lea and *Dentalium microstriatum* Heilpr., but containing also *Ancillaria staminea* Con., a small Natica *Pyrula multangulata* Heilpr., *Corbula oniscus, Infundibulum trochiformis* Lea, a *Phorus*, and a small oyster. The lower part of this bed passes gradually into the greensand marl No. 5 and is the best collecting ground, as the material is less indurated and the shells are more easily removed.....3 to 4 feet.
5. Greensand marl to the water's edge.....10 to 12 feet.

The upper part of this marl is quite soft and friable, but just above the water's edge it becomes indurated and shows a disposition to form rounded, bowlder-like masses, quite hard and firm and resembling a limestone. That this indurated part is of the same nature as the softer greensand above and below it, is seen from the circumstance that the indurated bowlders are sometimes near the top, sometimes near the bottom of the greensand stratum. The accompanying view (Plate VI) shows well the large, bowlder-like masses of the indurated greensand, No. 5. Passing through the central part of this marl bed is a layer of *Ostrea compressirostra* Say, with very thick and ponderous shells.

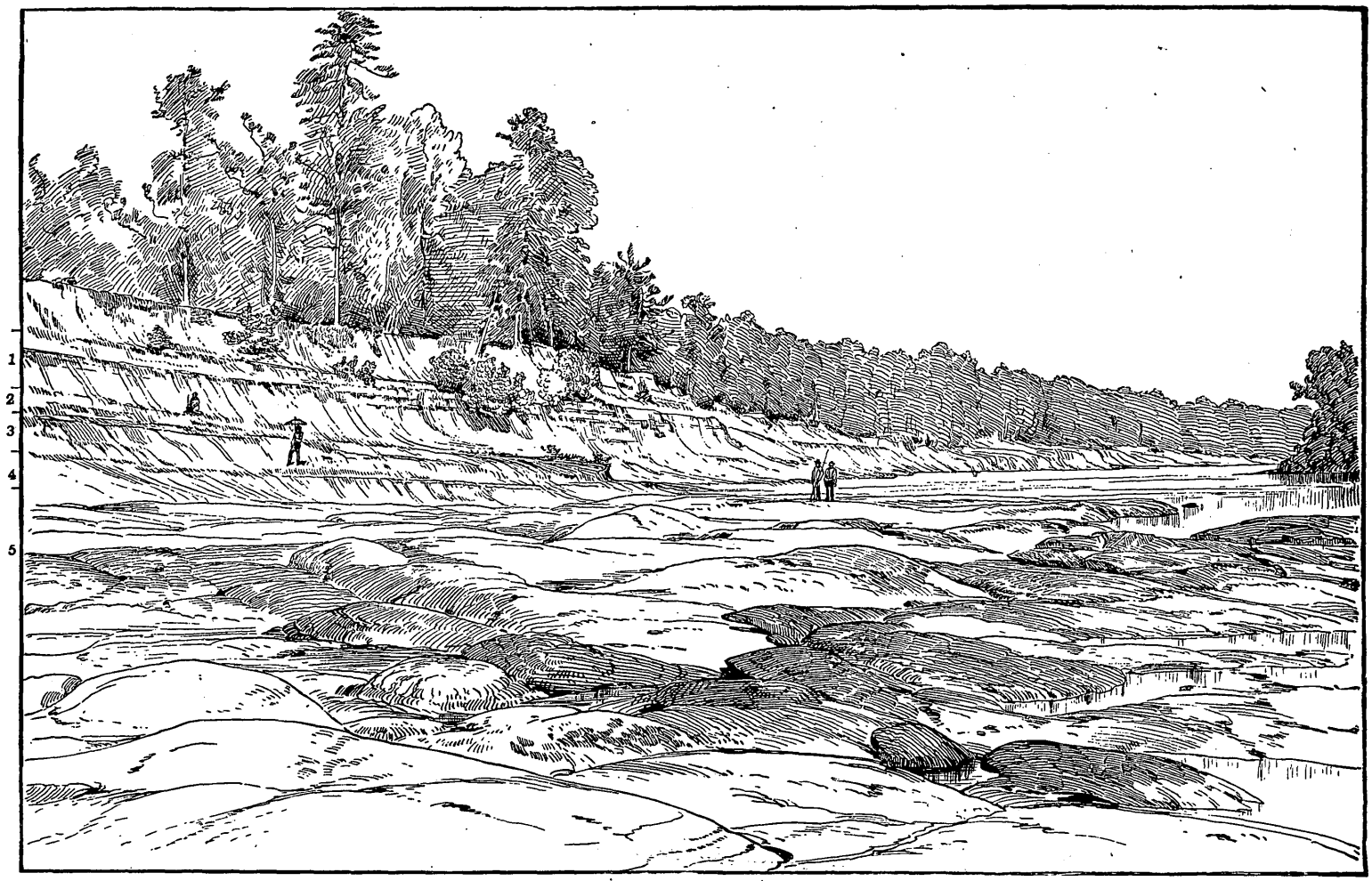
(*b*) About two miles from Wood's Bluff, on the banks of Bashi Creek, there is the following exposure (Plate XVI, Fig. 7, p. 159):

Section near Wood's Bluff.

1. Yellowish gray limestone or indurated marl, like that seen at the base of the Wood's Bluff section.....10 feet.
2. Greenish blue, fossiliferous sands[2].....8 feet.
3. Seam of lignitic clay, laminated and jointed.....6 inches.
4. Brown, laminated, joint clay, passing below into a greenish, non-fossiliferous sand.....4 feet

[1] This bed is highly fossiliferous, containing *Lævibuccinum striatum* Heilpr. (which appears to be confined to this particular horizon), *Athleta Tuomeyi* Con., *Fusus pagodiformis* Heilpr., *Venericardia planicosta* Lam., *Actæon pomilius*, Con., a small Natica, *Pleurotoma acuminata* Sow., sharks' teeth, *Ancillaria staminea* Con., a small Cytherea, &c.

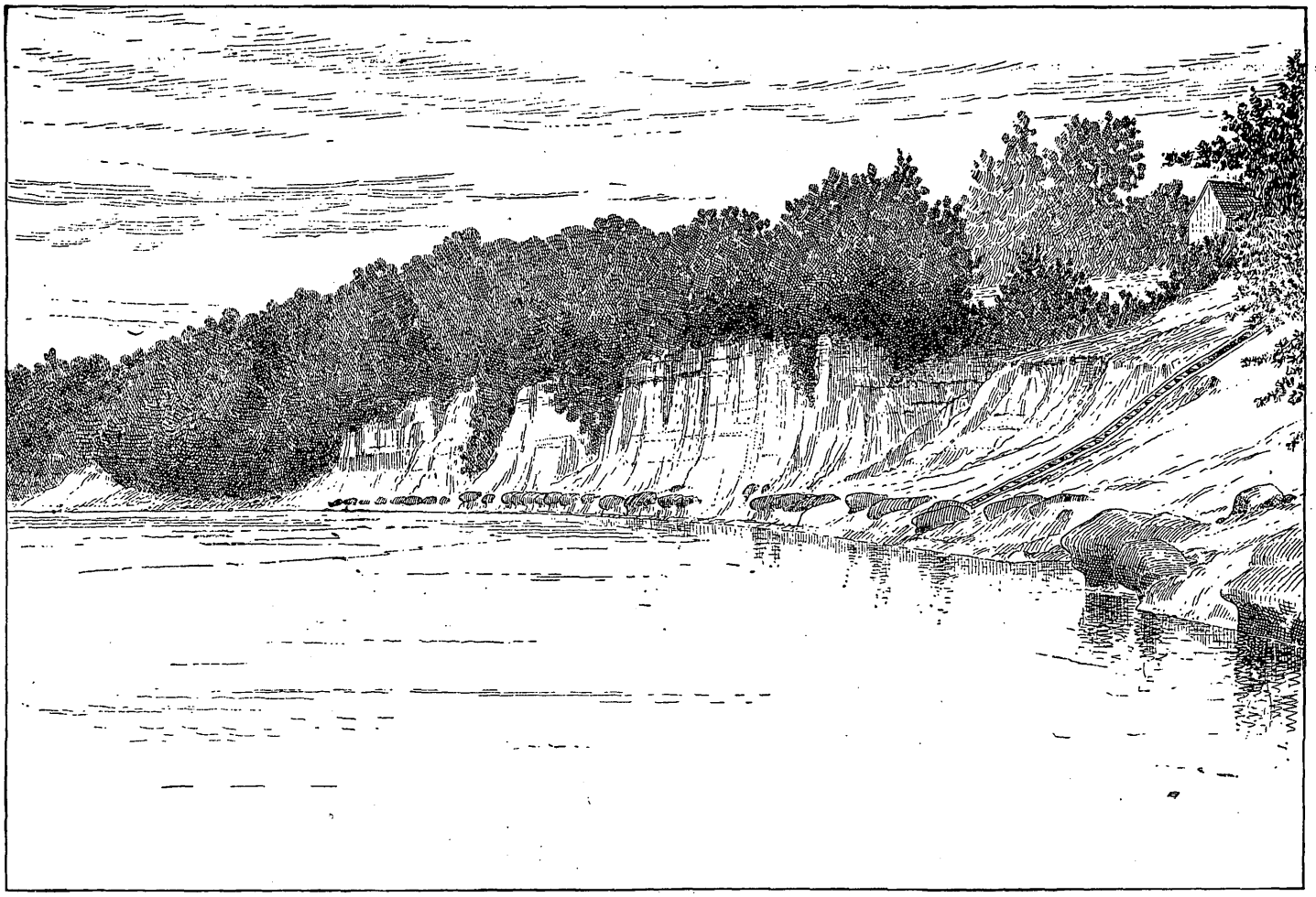
[2] These sands are frequently washed out from beneath the limestone or indurated marl, forming caves which are to be seen wherever the Wood's Bluff marl occurs.



1. Dark gray clays. 2. Bluish, sandy clay, fossiliferous. 3. Bluish, sandy clay, non-fossiliferous. 4. Greenish, sandy clay, highly fossiliferous. 5. Greensand marl.

(The figures refer to sections on p. 44, and also to the section given in Fig. 7 of Plate XVI.)

WOOD'S BLUFF, LOOKING DOWN THE TOMBIGBEE RIVER.



YELLOW BLUFF LANDING, ALABAMA RIVER.

5. Laminated, greenish gray clay, alternating with thin seams of dark purplish, lignitic clays, giving the exposure a beautiful and regularly striped appearance[1] ..... 5 feet.
6. Thin layer of lignite ..... about 12 inches.
7. Gray clay to the water's edge.

(*c*) The strata which intervene between the Wood's Bluff and the Bell's Landing series of marls, together with 130 feet of the beds overlying the former, are to be seen in a continuous section of 250 feet at Yellow Bluff and in the hill which lies just back of the bluff (Plate VII). Here all the strata between the two marl beds mentioned are exposed in actual and unmistakable contact at the river bluff, where there is an uninterrupted section of 120 feet. This is one of the most important sections we have, and it was obtained in the summer of 1885.

Section at Yellow Bluff, Alabama River. (*Plate XVI, Fig.* 1, *p.* 159.)

1. Laminated, gray, sandy clays of light color, variously interstratified with sands; in places there is a white or very light colored clay, and in other places cross-bedded sands, interlaminated with thin sheets of white clay; reddish sand abundant near the top of the section, which is one mile back from the river. Thickness by barometer ..... 130 feet.

   These beds are the same as those shown on the Tombigbee River below Wood's Bluff, at Davis's Bluff, and at White Bluff, and belong to the Hatchetigbee series; but, lying high up on the hills and exposed to sun and weather, they are uniformly much lighter in color than on the Tombigbee River, where they are near the water level. Below this we have a gentle slope, along which about fifty feet of beds are exposed (Nos. 2 to 4), and below that the perpendicular bluff of the river, some seventy feet (Nos. 5 to 10).
2. Greensand marl, with Wood's Bluff fossils (*summit of the Wood's Bluff series*), with indurated, rounded masses above, and loose marl below ..... about 6 feet.
3. Blue clay ..... 1 foot.
4. Gray, sandy clays with a slight tinge of purple, holding four or five thin seams of lignite, each one foot or less in thickness. The actual positions of these lignite beds are slightly obscured by landslides ..... 40 to 50 feet.
5. Reddish, cross bedded sands ..... 20 feet.
6. Lignitic clay and lignite (*base of Wood's Bluff series*) ..... 2 feet.
7. Reddish sands slightly laminated ..... 15 feet.
8. Laminated, sandy clays in perpendicular cliff ..... 20 to 25 feet.
9. Greensand marl in two parts separated by one foot of sandy clay without fossils. The upper part, one foot thick, holds chiefly *Ostrea compressirostra* and *Venericardia planicosta*, while the lower part, six feet thick, contains all the characteristic fossils of the Bell's Landing series, *Voluta Newcombiana*, large *Turritella Mortoni*, *Rostellaria trinodifera*, &c. This upper part shows strong tendency to harden into round, bowlder-like masses; in all ..... about 8 feet.

   This bed, No. 9, is very clearly marked in the accompanying view (Plate VII) by the line of bowlders near the water's edge. The lignite, No. 6, occurs near the top of the cliff, but does not show out in the picture.
10. Greenish, ferruginous sands interlaminated with thin sheets of clay, passing into a dark blue, sandy clay at the water level ..... 7 feet.

In this section the beds numbered 5 to 10, inclusive, are seen in the actual bluff of the river about half a mile or less below the steamboat

[1] The dark clays in this stratum appear to resist denudation better than the greenish clay, so that they project slightly from the face of the bluff.

landing. The beds numbered 2 to 4, inclusive, together with about forty feet of the lower strata of No. 1, are seen on the top of the bluff, along the road leading up the hill, and they directly overlie the beds exposed in the river bluff. Nos. 2 to 6, inclusive, represent the Wood's Bluff series.

From the sections represented on Plates XV and XVI it will be seen that the Wood's Bluff marl lies embedded in a great thickness of clays and clayey sands, a circumstance which has an important bearing upon its economic value. The disintegration of the clays produces heavy clay soils, which are thoroughly marled by the Wood's Bluff beds, and they form in consequence some of the most productive and lasting soils of the Tertiary group. We have as instances the heavy, calcareous, clay soils which occupy a broad belt north of Butler, in Choctaw County; the productive soils of parts of the Tallahatta and Bashi Creeks region; the clay hill soils of the eastern part of Clarke and the western part of Wilcox Counties, between Choctaw Corner and Lower Peach Tree; the celebrated Flat Creek lands of Monroe County, &c. Some descriptions of these soils, with analyses, were presented in the Report of the Geological Survey of Alabama for 1881–'82.

(3) THE BELL'S LANDING SERIES. (PLATE XVI, FIGS. 1 TO 6, P. 159.)

This series includes two important fossiliferous beds, separated by about twenty-five feet of gray, sandy clays. Between the lignite, which forms the base of the preceding division, and the upper marl of this series there are some forty feet of reddish sands and laminated, gray, sandy clays, and below the lower marl about sixty feet of sandy clays of the prevailing gray color, rather massive in the lower part. About fifty feet below the lower of the two marl beds, and ten feet above the base of this series, there is a third small greensand bed one foot or less in thickness containing fossils. The entire series comprises about one hundred and forty feet of strata, which, as a whole, are gray, sandy clays, becoming more and more massive toward the base, while they are more thinly laminated and more mixed with sands near the summit of the section. The strata which lie between the Wood's Bluff marl and the uppermost of this series are about sixty feet of sandy clays, containing several thin seams of lignite, all of which are exhibited in direct superposition at Yellow Bluff, and have been placed, as above shown, with the Wood's Bluff series. The upper marl bed, which is the Bell's Landing marl bed proper, is some ten feet thick, contains greensand, and indurates into bowlders, fine examples of which are to be seen at the base of the bluff at Bell's Landing. This marl is characterized above all others in the Tertiary of Alabama by containing gigantic specimens of shells which at other localities are of moderate size. The lower bed, known as the Gregg's Landing marl from its occurrence at the landing of that name, is four or five feet in thickness and is of clayey material. It has a peculiar group of fossils,

The fossil bearing beds of this series are best exposed along the banks of the Alabama River at Bell's Landing, Gregg's Landing, Peebles's Landing, Lower Peach Tree, and Yellow Bluff; and on the Tombigbee at Tuscahoma, Turner's Ferry, near the mouth of Shuquabowa Creek, and at Barney's Upper Landing. The exposures on the Alabama are much more satisfactory.

Unlike the Wood's Bluff marl, the marls of this series make comparatively little show inland from the rivers and exercise little, if any, influence upon either the soils or the topography of the country in which they come to the surface. I am not certain that either the Bell's Landing marl or the Gregg's Landing marl has been identified at any distance from the rivers, while the Wood's Bluff marl can be followed with ease from the Mississippi line as far eastward as we have been.

The following sections illustrate the occurrences of the Bell's Landing beds along the two rivers:

(*a*) *Section at Bell's Landing, Alabama River.* (*Plate XVI, Fig.* 2, *p.* 159.)

1. Yellowish red, cross bedded sands.....15 feet.
2. Lignite .....about 2 feet.
3. Laminated, sandy clays, with a few large, bowlder-like concretions.....10 feet.
4. Yellow, stratified sands alternating with gray, sandy clays.....15 feet.
5. Gray, sandy clays.....15 feet.
6. Greensand marl forming large concretionary bowlders and holding gigantic specimens of *Rostellaria trinodifera, Turbinella pyruloides* Con., *Fusus pagodiformis* Heilpr., *Voluta Newcombiana* Whitfield, &c. The bowlders cover all the lower part of the slope below the landing. The marl beds ..... about 6 to 10 feet.
7. Dark gray, laminated, sandy clays, black when wet, but light gray when dry..25 feet.
8. Bluish green, sandy clay marl .....1 to 2 feet.
9. Dark gray, sandy clay to water level .....4 feet.

Above Bell's Landing the strata of this series are exposed along the river as far as Yellow Bluff, and the most important localities are given below.

(*b*) *Section at Gregg's Landing, Alabama River.* (*Plate XVI, Fig.* 4, *p.* 159.)

1. Greensand marl with concretionary bowlders, the same as No. 6 at Bell's Landing.....5 feet.
2. Gray, sandy clays .....20 to 25 feet.
3. Dark gray or bluish, sandy clay or clayey sand containing well preserved fossils, many of which are peculiar, and some identical with those at Wood's Bluff, such as *Pyrula multangulata* Heilpr. and *Fusus subscalarinus* Heilpr. This bed has an indurated ledge of variable thickness at the base and is in all...about 4 to 5 feet.
4. Laminated, sandy clays to the water level.....about 10 feet.

This bluff extends at least one mile down the river from the landing, and along this whole distance there have been landslides, and the two marl beds have in consequence been thoroughly mixed up. In some places the upper marl has slid down and completely covered the lower; in other places the lower marl is in its proper position, but the upper has slipped down *below* it; sometimes the two are in direct contact, the upper above; but in all cases a careful inspection of the original bluff

a short distance back from this river slope will reveal the true relative position of the two beds. I am particular in calling attention to these circumstances because at many points these broken off parts of the bluff appear to be in place, and where the two beds, apparently in place, are thus brought into contact or their relative positions are reversed the commingling of the two sets of fossils would lead the incautious observer far astray.

The next exposure is about a mile below Lower Peach Tree, at Peebles's Landing.

(*c*) *Section at Peebles's Landing, Alabama River.* (*Plate XVI, Fig.* 3, *p.* 159.)

1. Yellow sands ..... 1 foot.
2. Lignite and lignitic clay ..... about 2 feet.
3. Reddish, laminated sands ..... 10 feet.
4. Dark gray clays and sands interstratified ..... 30 feet.
5. Greensand marl, No. 6 of Bell's Landing section ..... 8 feet.
6. Dark gray clays and sands variously interstratified ..... 25 feet.
7. Dark bluish gray, clay marl, Gregg's Landing ..... 2 feet.
8. Dark gray sandy clays extending to the foot of hill, 20 feet above the river level ..... about 14 feet.

The next locality is Lower Peach Tree, where we have a repetition of the above section, together with beds extending some 45 to 50 feet lower.

(*d*) *Section at Lower Peach Tree, Alabama River.* (*Plate XVI, Fig.* 5, *p.* 159.)

1. Sandy, laminated clays at the top of the bluff ..... about 10 feet.
2. Greensand marl containing the characteristic fossils of the upper bed at Bell's Landing ..... 8 to 10 feet.
3. Sandy, laminated clays, of gray color, but with some reddish layers ..... 20 to 25 feet.
4. Bluish, sandy, clay marl containing a number of peculiar fossils. To this bed we have given the name of *Gregg's Landing Marl*, as it is seen at Gregg's Landing better than elsewhere ..... 5 feet.
5. Sandy clays of prevailing gray color, varying in degree of sandiness and coarseness of lamination, without fossils so far as we could discover ..... 50 feet.
6. Coarse grained greensand marl, indurating into bowlders in places, containing some fossils, which are also in the bed No. 4, above ..... 1 foot.
7. Gray, sandy clays to water level ..... 10 feet.

The last exposure of the beds of this series up the Alabama River is seen at Yellow Bluff, the section of which has already been given (Plate XVI, Fig. 1).

The exposures at Lower Peach Tree and at Yellow Bluff, in part overlapping, give us a continuous section of some 250 feet, and the two, taken with the exposures at Wood's Bluff, Davis's Bluff, White Bluff, and Hatchetigbee, all of which overlap in some parts, afford a series which is without a break from the base of the Buhrstone down 390 to 400 feet. It would be impossible to find anything more satisfactory for making out the stratigraphy of this part of the Tertiary group.

On comparison of all these sections it will be seen that the Bell's Landing marl, at Bell's Landing, is about 30 feet above the river level; at Gregg's Landing, about 40 feet; at Peebles's Landing, about 60 feet;

at Lower Peach Tree, 85 feet or more; while at Yellow Bluff it is only about 7 feet above the river level. The beds rise with tolerably uniform inclination (40 feet to the mile) up to the Lower Peach Tree, and then sink rapidly, Lower Peach Tree being about on the summit of the anticlinal or roll. As a consequence of this undulation the beds involved are spread in a north and south direction over a much greater extent of surface than is usually the case where the average dip is uniformly southward some 30 or 40 feet to the mile. This roll in the strata may be traced from Choctaw County to Monroe County, but seems to be most pronounced in the lower part of Marengo County and the upper part of Clarke County. In the southern part of Wilcox County and the northern part of Monroe County the undulation involves in general a lower series of rocks, to be mentioned presently.

On the Tombigbee River the strata between the Wood's Bluff marl and the Bell's Landing marl at Tuscahoma are not well exposed, and it would have been impossible to get any clear understanding of the stratigraphy from the bluffs of that river alone. It is fortunate that the section, here so faulty, is so complete and satisfactory on the Alabama River.

The few localities where Tertiary strata make the banks of the river, from Wood's Bluff up to Tuscahoma, are given below.

Across a narrow neck of land from Wood's Bluff at Cade's Bend, the Wood's Bluff marl is again seen in the river bluff.

At the mouth of Bashi Creek, as above shown (see Plate XVI, Fig. 7, p. 159), the lower strata of the marl, as well as two of the underlying lignites, are exposed.

Two others of these lignites are seen a little higher up the river, at Pickens's Landing, where we have the following section:

(e) Section at Pickens's Landing, Tombigbee River.

1. Gray, laminated, sandy clays	10 feet.
2. Lignite	12 to 18 inches.
3. Bluish, clayey sands with yellowish division planes	6 to 8 feet.
4. Lignite	2 feet.
5. Gray, sandy clays to water level	1 to 2 feet.

The beds are undulating and in some places show a dip towards the northwest, but the general dip of the surrounding strata is southwest.

Above Pickens's Landing gray, sandy clays are shown in the river banks at Magnolia Landing and one or two other points; but these clays contain no fossils, so far as our observations went. The Pickens's Landing lignites are found in the hills about the headwaters of Horse Creek and elsewhere in the lower part of Marengo County.

At Tuscahoma we have the first considerable bluff above Wood's Bluff. In the section below given we include not only the strata actually appearing in the bluff at the landing, but also those which make the bank for half a mile or more down the river. This section, as will be seen, is about the equivalent of that at Yellow Bluff on the Alabama.

(*f*) *Section at Tuscahoma, Tombigbee River.* (*Plate XVI, Fig. 6, p. 159.*)

1. Indurated sands, with a line of bowlders at the base. This stratum is eight to ten feet thick at the warehouse, but down the river it thickens to twenty feet or more, and a second line of ferruginous, indurated bowlders appears about ten feet above the first. The strata above this upper string of bowlders are more distinctly laminated and interbedded with thin sheets of clay. This is most clearly shown about six to eight feet above the upper line of bowlders. Taken all together there are ..... about 30 feet.
2. Light bluish gray, sandy clays, which are somewhat striped with harder projecting seams ..... 35 to 40 feet.
3. Sandy marl, containing the Bell's Landing fossils, but in badly preserved condition ..... 2 feet.
4. Dark blue, massive clay ..... 3 to 4 feet.
5. Thin streak of greensand, with *Venericardia planicosta* and other Bell's Landing fossils to water level ..... 6 inches or more.

About half a mile below the landing there is a low bluff capped by the upper string of bowlders above mentioned, which form a little terrace forty or fifty feet wide, the farther limit of which is made by another low bluff of second bottom deposits.

The lignite which occurs about thirty-five to forty feet above the marl bed at Yellow Bluff and at Bell's Landing was not observed at Tuscahoma, those parts of the bluff where it would be looked for being badly weathered.

The massive clay, No. 4, which separates the two parts of the marl bed, is everywhere perforated by pholas, and in most of the perforations their shells are still to be found. Mr. T. H. Aldrich, who made this observation, also saw these shells in the clay which occurs below the lower marl bed at Bell's Landing.

The Tuscahoma (Bell's Landing) marl, with its accompanying beds, may be followed up the river without essential interruption to Barney's Upper Landing, as shown in the following sections (Plate XVI, Fig. 6, p. 159):

(*g*) *Section at Turner's Ferry, Tombigbee River.*

1. Indurated sands, No. 2 of the Tuscahoma section ..... 5 feet.
2. Marl with badly preserved shells ..... 3 to 4 feet.
3. Bluish clay, becoming sandy below ..... 3 to 4 feet or more.

From Turner's Ferry these beds rise, going up stream, and at the mouth of Shuquabowa Creek they give the following section:

(*h*) *Section at mouth of Shuquabowa Creek, Tombigbee River.*

1. Greensand marls ..... 3 to 4 feet.
2. Dark bluish black, massive clay ..... 2 feet.
3. Hard sands, passing into sandy clay below ..... 5 feet.
4. Light colored, nearly white, cross bedded sands, about 3 feet, with 3 to 4 feet below it of sands with clay partings, in all ..... 6 to 8 feet.

Above this place the strata sink towards the north, and at Barney's Upper Landing only three feet of the beds immediately below the marl are above the water, as seen below.

(i) *Section at Barney's Upper Landing, Tombigbee River.*

1. Laminated, sandy clays, striped with somewhat harder and more clayey seams, in all ..... 15 to 20 feet.
2. Sandy, fossiliferous bed, with greensand in the lower parts, more clayey above. The fossils in this bed are badly preserved, as was the case also at Tuscahoma, Turner's Ferry, &c., but are the characteristic Bell's Landing forms ..... 5 feet.
3. Dark bluish to gray clays to water level ..... 3 feet.

From Barney's Upper Landing to the mouth of Horse Creek no Tertiary strata appear on the river banks, but just above that point the river bank is formed by dark gray, clayey sands or sandy clays, which continue up to Williams's Gin, where they overlie the first of the beds containing *Gryphæa thirsæ* Gabb, and in consequence may be better classed with the next section.

(4) THE NANAFALIA SERIES, INCLUDING THE COAL BLUFF LIGNITE

The series of strata to which the Nanafalia marl has given the name, broadly considered, is susceptible of threefold division upon the basis of lithological and paleontological characters, viz:

First. Forty feet or more of indurated, gray clays and sandy clays, in part glauconitic and rather closely resembling some of the materials of the Buhrstone. Near the base of this first division there are hard, sandy clays filled with shell casts, chief among which are Turritellas and Cythereas.

Second. Seventy-five to eighty feet of yellow and reddish and whitish sands, alternating with greensand beds, highly fossiliferous. The characteristic shell in both the sands and the greensands is *Gryphæa thirsæ* Gabb. In the upper fifty or sixty feet of this division this shell is found either in thin greensand beds or sparingly distributed through the other sands. In the lower twenty feet there are thick greensand beds literally packed with these shells. The greater part of the exposure at Nanafalia Landing consists of greensand beds filled with *Gryphæa thirsæ* and other forms, the first named making perhaps 90 per cent. of the whole.

Third. Below the *Gryphæa thirsæ* beds follow some eighty feet or more of sandy clays and sands, variously interstratified, cross bedded sands passing near the base of the division into greensands which overlie a bed of lignite varying from four to seven feet in thickness.

It is easily possible to obtain overlapping sections which embrace the whole series of about two hundred feet; thus in the bluff at Gullette's Landing, on the Alabama River, nearly the whole of the two upper divisions are represented, while on Pursley Creek, a few miles eastward, the lower part of the second division and the whole of the third are shown in direct contact, the whole series being thus represented at two localities.

Between the heavy bedded, sandy clays exposed at the base of the Lower Peach Tree Bluff and those which are seen at the top of the bluff at Gullette's Landing there is a series of glauconitic clays and

clayey sands which have a tendency to harden into pretty firm rocks, having a striking resemblance to some of the materials of the Buhrstone formation, but which are readily distinguished from the latter by one familiar with both of them. These rocks are shown in the hills which rise immediately back of Gullette's Landing and Black's Bluff (Alabama River) to the height of two hundred and fifty to three hundred feet above the river level, and they are seen again in the Grampian Hills of Wilcox County. We have not as yet been able to connect the beds at Lower Peach Tree with those at Gullette's Landing by an overlapping section which includes a part of each, and there is therefore a little uncertainty as to the precise thickness of these beds, though none as to their quality. There is very little doubt that the lower beds of the Lower Peach Tree Bluff are exposed in the hills back of Gullette's Landing and Black's Bluff, but, as already said, this identity is not absolutely made out. The uncertainty, however, cannot concern more than twenty or thirty feet of strata, if so much. Still, it is much to be regretted that even this slight hiatus exists, since from the top of the White Limestone down to this point every foot of the strata has been exhibited in overlapping sections, so that there is not the slightest room for doubt as to their relative position or thickness, nor is there the slightest room for doubt as to relative position here, but only as to exact thickness.

Before giving the section at Gullette's Bluff Landing, some notes concerning the indurated clays and sands that immediately overlie the rocks at the last named locality, and which are seen in the Grampian Hills, will serve to bring out their peculiarities, especially the points of resemblance between them and certain of the materials of the Buhrstone.

About three miles south of Camden, in the Grampian Hills, we find the following:

(*a*) *Section in Grampian Hills, No.* 1.

1. Light-colored, argillaceous, sand rock, containing casts of *Cytherea, Turritella, Voluta*, &c. This passes below into a clayey stratum, which in turn is underlaid by a hard, sandy rock containing many shell casts, particularly of *Turritella Mortoni* Con. ..... 5 feet.
2. Gray, clayey beds, breaking into small angular bits ..... 5 feet.
3. Ledge of glauconitic, clay rock, sandier below and breaking by joints into large cuboidal blocks of tolerably hard sandstone, containing also a great number of shell casts ..... 2 feet.
4. Gray clays resembling those of the Buhrstone, but softer and crumbling more easily ..... 15 feet.
5. Glauconitic sands, indurated, filled with casts of *Gryphæa thirsæ* (*first of the Gryphæa thirsæ beds*) ..... 2 feet.
6. Greensand beds, with perfect shells of *Gryphæa thirsæ* ..... 7 to 8 feet.
7. Dark gray clays ..... 2 to 3 feet.
8. Yellowish, calcareous sands, with *Gryphæa thirsæ, Flabellum, Venericardia planicosta*, &c ..... 4 to 5 feet.
9. Bed of *Gryphæa* shells ..... 1 foot.
10. Yellowish, calcareous sands, with concretionary bowlders, containing *Gryphæa thirsæ* and casts of other shells ..... 6 to 8 feet.

Half a mile farther south, other beds overlying No. 1 of the above are seen, as shown below.

(*b*) *Section in Grampian Hills, No. 2.*

1. Whitish, sandy rock, indurated, containing shell casts.....1 foot.
2. Whitish clay rock.....1 foot.
3. Hard ledge of sandy rock, with casts of Turritella, Cytherea, &c.....2 feet.
4. Gray clays, indurated, and greatly resembling some of the Buhrstone clays, 10 to 15 feet.
5. Ledge of indurated glauconitic clay, the lower 12 or 18 inches of which are sandier and filled with shell casts, mostly of *Turritella Mortoni* Con., same as No. 1 of preceding section.....3 to 4 feet
6. Gray, crumbling clays, with indurated ledge of hard, glauconitic clay in center.....6 feet.
7. Hard ledge of glauconitic clay or sandstone breaking by joints into large cuboidal blocks.....4 feet or more.
8. Laminated gray clays resembling those of the Buhrstone, breaking up into small bits.....12 feet,
9. Glauconitic sands, indurated, containing casts of *Gryphæa thirsæ* in the upper part and perfect shells of the same in the lower part.....1 foot.
10. Greensand, with occasional shells of *Gryphæa thirsæ*.....5 feet.
11. Yellowish sand filled with shells of *Gryphæa thirsæ*.....1 foot.
12. Laminated, yellowish sands, with a few shells of *Gryphæa thirsæ*.....4 feet.

The relations between these two sections and the others which exhibit the same strata are more clearly seen in Plate XVII, Fig. 2, p. 163, which is a representation of the two preceding profiles combined.

The Grampian Hills extend westward to the river at the Lookout, which is a cliff reaching fully 275 feet above the river level. This cliff is half a mile or more above Gullette's Landing, and in its lower half the beds which make the bluff at Gullette's Landing are exposed by a landslide in a perpendicular section of nearly 150 feet. Above this a very steep, almost precipitous hill rises 125 feet higher. In this upper part of the hill the rocks are not clearly exposed, but they consist of gray, laminated clays, interstratified with heavy bedded, massive clays, such as are seen in the lower part of the Lower Peach Tree Bluff, with which they are probably, in part at least, identical. No fossils were discovered in these clays, which include in places indurated bowlders of calcareous sand. In the lower part of the hill, hard, glauconitic, sandy clays with shell casts are abundant and correspond in position, as well as in other respects, to those represented in the upper members of the two preceding sections.

At Gullette's Landing a cut has been made for the cotton slide and tramway down to the river level through the strata of the bluff, which are thus very clearly exposed almost as if in a vertical wall.

(*c*) *Section at Gullette's Landing, Alabama River.* (*Plate XVII, Fig.* 1, *p.* 163.)

1. Drift and loam.....10 feet.
2. Indurated, glauconitic clay, forming ledge.....3 feet.
3. Gray, sandy clays, thinly laminated and heavy bedded alternating.....12 feet.
4. Glauconitic sand, very green in places.....2 feet.
5. Gray and sandy clays, like No. 3.....20 feet.
6. Glauconitic. sandy ledge, fossiliferous (*the first of the Gryphæa thirsæ beds*)..3 feet.
7. Compact; yellowish sands holding *Gryphæa thirsæ*, and forming a vertical cliff, capped with an indurated ledge a foot in thickness.....13 feet.

8. Indurated sandy ledge.....2 feet.
9. White, cross bedded sands.....12 feet.
10. Bluish sands, forming a vertical cliff. These contain numbers of *Gryphæa thirsæ* and have an indurated ledge in the midst of the bed, and one at the bottom.....20 feet.
11. Bluish, clayey sands containing a few *Gryphæa*.....10 feet.
12. Sands containing *Gryphæa thirsæ*, traversed by several indurated projecting ledges; materials are of darker color and more clayey below to water level..20 feet.

At Black's Bluff, Alabama River, about a mile or less below Gullette's Landing, there is a similar section, which, however, is not so clearly exposed. Above the warehouse at this landing, the strata are the same as those at the top of the bluff at Gullette's Landing, but there have been many landslides, by which the relative thickness and positions of the beds here are obscured. Between these two places the river flows approximately along the strike of the strata, which, however, do not lie horizontal, but show one or two undulations with twenty or thirty feet wave height.

The actual contact of the strata of the Bell's Landing and the Nanafalia series fails to appear in the bluffs of the Tombigbee River also, as may be seen in what follows. From Barney's Upper Landing, described in the preceding section, up to the mouth of Horse Creek, no Tertiary beds appear in the river banks. Just above the mouth of this creek grayish, sandy clays occur similar to those which make up the lower 50 feet of the Lower Peach Tree Bluff, and these clays may be traced foot by foot up the river or northward to Williams's Gin, half a mile or so below Gay's Landing, where they are seen overlying the first of the beds holding *Gryphæa thirsæ*. A section of these strata is given below. (See Plate XVII, Fig. 4, p. 163.)

The grayish, sandy clays which overlie these Gryphæa beds are undoubtedly the same as those at Lower Peach Tree, but here also the exact thickness cannot be measured because of their failure to appear in the banks of the river. Still, unless in this short distance of less than a mile there is a fault or a very violent, decided change in the dip of the strata, the thickness of the beds not exposed on the river cannot be much more than fifty feet, if so much.

The strata exposed at Williams's Gin and along the river for half a mile up to Gay's Landing are as follows (see Plate XVII, Fig. 4, p. 163):

(*d*) *Section from Williams's Gin to Gay's Landing, Tombigbee River.*

1. Gray, sandy clays, thin bedded, reddish on joint planes, passing below into an indurated ledge of lighter color.....8 feet.

About 20 feet more of similar sandy clays appear in the banks of the river, between the mouth of Horse Creek and Williams's Gin, as above mentioned, making the whole thickness actually exposed on this river, between the top of the Gryphæa beds and the bottom of the Bell's Landing marl at Barney's Upper Landing, about thirty feet.[1]

[1] In bed No. 1 above I found a specimen of *Voluta Newcombiana* Whitfield, which heretofore was seen only in the Bell's Landing marl bed and which seemed to be characteristic of it.—E. A. S.

2. Indurated, glauconitic bed, with *Gryphæa thirsæ* ..... 2 feet.
3. Dark blue, nearly black, jointed clays, with thin, hard ledges ..... 6 feet.
4. Indurated, sandy, fossiliferous bed, with a few *Gryphæa* and other forms. 2 to 3 feet.
5. Bluish black clays, with ferruginous concretions at base ..... 3 feet.
6. Greensand bed, with *Gryphæa thirsæ* to water ..... 3 feet.

Above Gay's Landing there is a long stretch of several miles in which no Tertiary rocks show on the river banks; but at Lott's Ferry the Gryphæa beds make their appearance again and may be followed thence without material interruption to Eureka Landing and to Nanafalia, a distance in all of perhaps two miles.

These exposures exhibit the following details:

(*e*) *Section at Lott's Ferry, Tombigbee River.* (*Plate XVII, Fig.* 4, *p.* 163.)

1. Dark gray, nearly black, sandy clay, weathering light gray, containing a few fossils ..... 5 feet.
2. Indurated, sandy marl, containing *Gryphæa* in places. This bed varies, being in part a cross bedded sand devoid of fossils ..... 3 feet.
3. Dark, sandy clays, with a few very badly preserved fossils ..... 2 to 3 feet.
4. Glauconitic, sandy beds, with *Gryphæa thirsæ*. This bed is only a few feet thick at Lott's Ferry, but just above shows ..... 20 to 30 feet.

All the Tertiary beds about Lott's Ferry exhibit decided undulations. Bed No. 4 of the preceding section sinks entirely below the water and rises again 20 feet or more above it within the distance of a few hundred yards. All these beds probably overlie the section at Nanafalia below given.

At Eureka Landing there are some 20 to 25 feet of a glauconitic, sandy marl (probably the same as part of the upper bed at Nanafalia) filled with *Gryphæa thirsæ*, associated with very few other forms. This makes a tolerably firm rock, which appears in vertical bluffs, usually capped by hard ledges of the same material, and these ledges are mostly strongly phosphatic.[1]

At Nanafalia we have the lowermost of the Gryphæa beds, as shown in the following section:

(*f*) *Section at Nanafalia Landing, Tombigbee River.* (*Plate XVII, Fig.* 4, *p.* 163.)

1. Greensand marl, highly fossiliferous, containing chiefly *Gryphæa thirsæ* Gabb, but holding also *Turritella Mortoni* Con., *Flabellum*, and a few other fossils. This marl makes a tolerably firm rock, with a line of indurated, projecting bowlder-like masses 12 to 18 inches thick of nearly similar material along the whole length of the bluff and near the middle of the bed ..... about 20 feet.
2. Dark blue, almost black, laminated clay, devoid of fossils, but passing below gradually into a bluish marl ..... 3 to 4 feet.
3. Bluish greensand marl, with a few shells in the upper 3 or 4 feet, but more highly fossiliferous below. This bed contains a great variety of beautifully preserved and easily detached fossils. The fossils can be collected only during very low stages of the water ..... 8 to 10 feet.

[1] Specimens of the indurated ledges of the *Gryphæa thirsæ* beds from Nanafalia and Eureka Landing, collected in 1884 by Mr. Langdon, prove to be very decidedly phosphatic; one of the specimens analyzed quantitatively contained 6.7 per cent. of phosphoric acid.

The view (Plate VIII) shows clearly the greensand No. 1, with its line of indurated bowlders along the center. The large rocks in foreground are part of this indurated marl.

The Nanafalia marl, like that of Wood's Bluff, is one of our most important geological landmarks, both because of its tendency to form by induration tolerably firm and weather resisting rocks and because of the influence which it exerts upon the soils. If there were any doubt as to the agricultural value of either the Wood's Bluff or the Nanafalia marls, it would be dispelled by an inspection of the fertile, naturally marled soils produced where these beds come to the surface across the country.

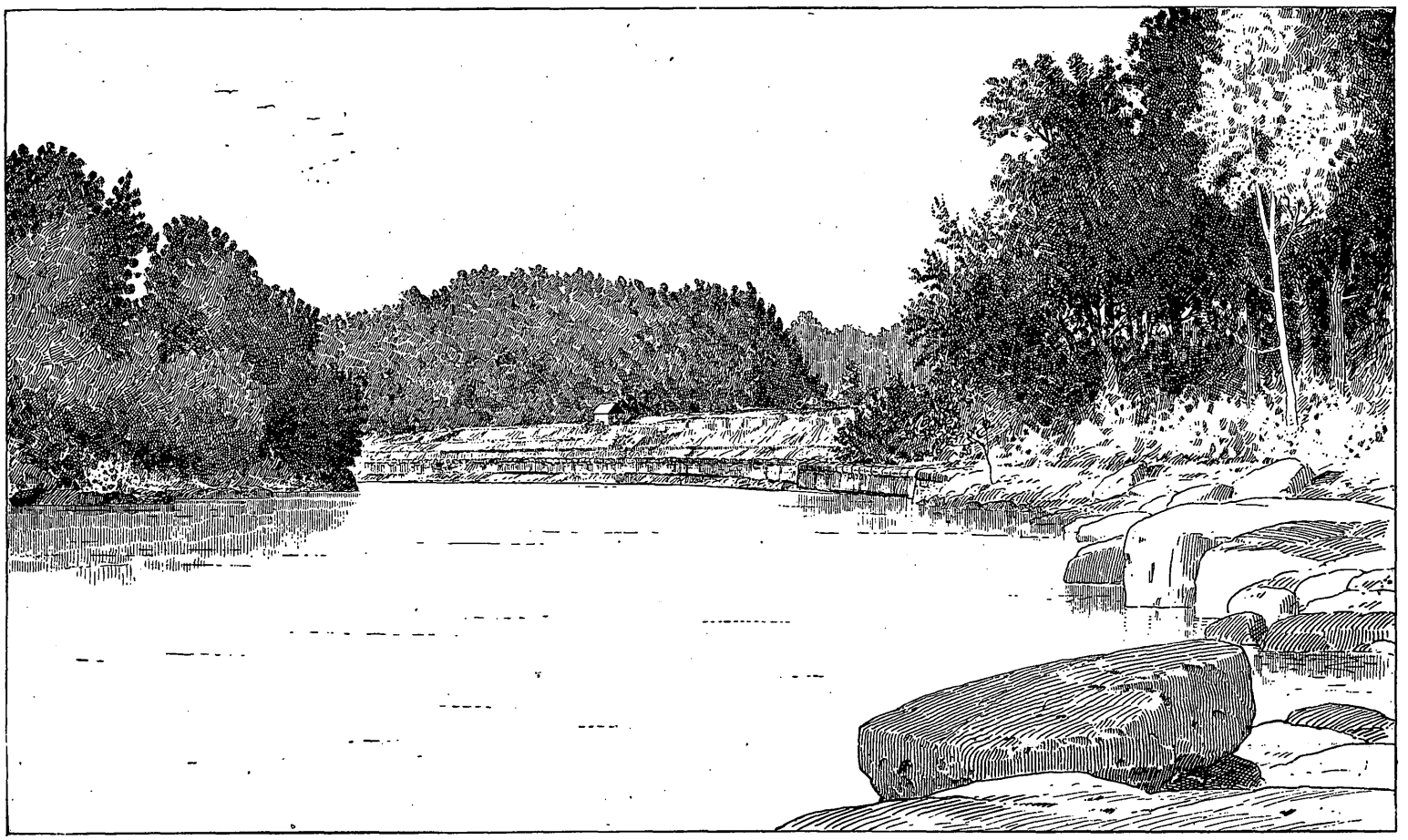
About 60 feet below the lowermost of the beds containing *Gryphæa thirsæ*, above described, there is an important bed of lignite, which shows a thickness of 4 feet at Coal Bluff, on the Alabama River, and of 7 feet at Landrum's Creek, in Marengo County, near Nanafalia Landing. This lignite appears also at many localities in Marengo and Wilcox Counties, e. g., near Shiloh, Magnolia, Hampden, &c., always in connection with the Gryphæa beds, the latter on the summits of the hills, the former 60 feet below in the branches; and, as the Gryphæa marl usually produces very characteristic limy soils, it is not difficult to trace it, as well as the lignite, across the country.

Between the Gryphæa beds and the lignite, the strata are chiefly sands, mostly glauconitic, alternating with sandy clays of grayish colors. The greensands when weathered appear as yellowish or ferruginous sands, and this is the prevailing color upon the hills, while some shade of green or blue characterizes them near the drainage level, where oxidation is less complete. None of these beds are seen on the immediate banks of the Tombigbee River, and only about 30 feet immediately overlying the lignite occur on the banks of the Alabama; but they may all be seen in direct superposition in the hills which border Pursley Creek on the south, where they are laid bare by the road leading from Black's Bluff to Camden.

This section is complete, as may be seen below.

(*g*) *Section on Pursley Creek, Wilcox County.* (*Plate XVII, Fig.* 3, *p.* 163)

1. Drift and loam and other beds, much weathered and not further particularized ..... 10 to 15 feet.
2. Dark colored, crumbling clays ..... 5 feet.
3. Sands containing *Gryphæa thirsæ* and a few other fossils ..... 5 feet.
4. Thin bedded sands and sandy clays, partly glauconitic, with a few obscure fossils ..... 15 to 20 feet.
5. Yellowish gray, cross bedded sands, with concretionary bowlders of the same material. These sands hold also at intervals lenticular sheets of gray clay. 25 to 30 feet.
6. Interstratified sands and clays, of grayish color with a shade of yellow, rather thin bedded ..... 10 to 15 feet.
7. Gray, sandy clays, exposed in the immediate banks of Pursley Creek below the bridge ..... 6 to 8 feet.
8. Lignitic clay, thickness not determined.



NANAFALIA LANDING, TOMBIGBEE RIVER.

Along the Alabama River no Tertiary strata are to be seen from near Gullette's Bluff to the mouth of Pursley Creek. Just above the last named point, however, there is a continuous exposure of these strata up to Coal Bluff, as shown in the following:

(*h*) *Section between mouth of Pursley Creek and Coal Bluff.* (*Plate XVII, Fig.* 1, *p.* 163.)

1. Greensand at mouth of Pursley Creek ..... 5 feet.
2. Sands, with an indurated ledge one foot thick at top ..... 3 feet.
3. Laminated, clayey sands, with a hard projecting ledge at top and one or two lower ones ..... 6 feet.
4. Indurated greensand, forming a ledge ..... 3 feet.
5. Greensand of softer texture, easily washed out by the waters and forming shallow caves below the preceding ..... 5 feet.
6. Greensand of firm texture, with a bed of brownish sand one foot thick at the base ..... 8 feet.
7. Lignite of Coal Bluff ..... 4 feet.
8. Firm, sandy clays appearing just above the Coal Bluff Landing ..... 10 feet.

These beds, as exposed on Landrum's Creek (Sec. 23, T. 14, R. 2 E.), are as follows:

(*i*) *Section on Landrum's Creek, Marengo County.* (*Plate XVII, Fig.* 4, *p.* 163.)

1. Bluish green, micaceous sands ..... 12 to 15 feet.
2. Lignite ..... 7 feet.
3. Dark gray, sandy clay ..... 2 feet.

The lignite here also is 60 feet, by barometric measurement, below the lowermost of the Gryphæa beds, which may be seen on all the hills in the vicinity, where they produce limy soils of great fertility. In most of these limy soils are embedded rounded or water worn fragments of indurated marl.

In many places in Marengo County and elsewhere the greensands overlying the lignite are thoroughly oxidized into a brown iron ore. This may be seen near Magnolia, near Hampden, and near Dumas's Store.

(5) THE NAHEOLA AND MATTHEWS'S LANDING SERIES.

The strata which make up this series are mostly gray sandy clays alternating with cross bedded sands, with a bed at the base of the section containing marine fossils, and consisting of glauconitic sands and dark gray, nearly black, sandy clays. The thickness of these strata varies from west to east, being 150 feet or more on the Tombigbee River, and not more than 125 or 130 at Oak Hill, in Wilcox County.

In 1883 we failed to establish the identity of the Naheola marl on the Tombigbee with that of Matthews's Landing on the Alabama, for the reason that at the former place the upper part of the marl is most conspicuous, and was the only part examined by us, while at Matthews's the bluff is made up of the black or dark gray sandy clays which form the lower part of the marl bed. In the summer of 1886 I made a re-examination of the exposures along the Tombigbee River, and found at

Naheola the black, clayey marl, identical both in material and in fossil contents with that at Matthews's.

On the Tombigbee River there are no Tertiary rocks exposed in the river bluffs between Nanafalia, which lies near the base of the preceding section, and the mouth of Beaver Creek, a distance of about four miles. With an assumed uniform dip of some 30 feet to the mile, this would indicate a thickness of about 120 feet of strata. But from the undulations seen at Lott's Ferry (below Nanafalia) and elsewhere along this river, it is known that the dip is not uniform, and the thickness of the missing beds is probably less than the estimated 120 feet.

From the mouth of Beaver Creek to Naheola there is an almost continuous exposure of Tertiary rocks along the river bank, embracing about 80 feet of strata, making, with the 120 feet estimated above, 200 feet intervening between the base of the Nanafalia marl and the top of the Naheola marl. Of these 200 feet we know from exposures on Landrum's Creek, in Marengo County, and on Pursley Creek, in Wilcox County, the uppermost 60 feet (viz, from the base of the Nanafalia marl down to the Coal Bluff lignite), while at Oak Hill (see below) we have a clear profile embracing at least 130 feet immediately overlying the Naheola marl. This would leave only about 10 feet of unknown beds at the top of our Naheola section, and it is altogether probable that the Pursley Creek and Oak Hill sections embrace the entire series.

The strata which make all the bluffs between the mouth of Beaver Creek and Naheola, as well as the upper part of the bluff at the last named place, consist, in descending order, of about 20 feet of coarse-grained micaceous sands, with projecting, indurated bowlders of sandstone (no fossils observed), with thin clay partings at intervals; below these, about 10 feet of strongly cross bedded sands, seen in the bluffs just below Tompkinsville, and underlying this to Naheola, laminated sandy clays traversed by layers of lighter colored, sandier, and indurated materials; no fossils observed. It is difficult to give a close estimate of the thickness of these last named beds, but it is not less than 50 or 60 feet, and may be 80.

The section (see Plate XVIII, Fig. 3, p. 167) represents the succession and quality of the beds along this stretch of the river.

The lowest of these gray sandy clays are seen at the top of the bluff at Naheola, a few miles above Tompkinsville, where they are underlaid by a marl, and black shaly clays at Naheola, as shown in the following section:

Section at Naheola, Tombigbee River, Sec. 31, *T.* 15, *R.* 1 *E.* (*Plate* XVIII, *Fig.* 3, *p.* 167.)

1. Laminated, gray, sandy clays, with two or three indurated ledges eight to ten inches thick, of lighter colored, sandier materials.....18 to 20 feet.
2. Ledge of greensand, oxidized into a brown iron ore of irregular thickness, 3 to 6 inches.

3. Black, shaly, sandy clay ..... 3 feet.
4. Ledge like No. 2, of irregular thickness ..... 6 inches.
5. Greensand marl, the upper part indurated, forming a kind of limestone. Both the indurated marl and the limonite, or oxidized greensand above it, hold fossils, prominent among which are an *Arca*, a *Venus*, *Pectunculus Broderipii* Lea, *Turritella Mortoni* Con., *Cardita alticosta* Con., and *Venericardia rotunda* Lea, *Rostellaria trinodifera*, &c. All the fossils are badly preserved. Thickness of bed ..... about 3 feet.[1]
6. Black, slaty clay like that occurring on the river above this point to Black Bluff ..... 10 to 15 feet.

Half a mile or so below Naheola, just below Marengo Shoot, the marl bed No. 5 occurs at the water level, and at Kemp's Landing, a short distance above Naheola, the marl, with its overlying ferruginous concretions, is again seen.

On the Alabama River the Tertiary beds, corresponding to those just described in the vicinity of Tompkinsville, occur between Coal Bluff and Clifton, a distance, by the river, of 10 or 12 miles. On this river there are many interruptions in the continuity of the Tertiary bluffs, so that it would be impossible, from the exposures along the river alone, to get any clear idea of the stratigraphy. All this, however, is made good, as will be seen above, in the sections obtained at Oak Hill and on Pine Barren Creek, in eastern Wilcox County.

The Tertiary beds make the bluffs of the Alabama River at a few localities mentioned below and exhibited in Plate XVIII, Fig. 2, p. 167.

At Burford's Landing, NW. ¼ of Sec. 5, T. 11, R. 7 E., and just above it in Sec. 32, T. 12, R. 7 E., there are low bluffs of laminated and cross bedded sands, alternating with thin seams of gray clay.

At Walnut Bluff, below the mouth of Turkey Creek, the banks are of light colored, yellowish, cross bedded sands, and above Turkey Creek a laminated, sandy clay like so much of the material occurring about Tompkinsville. These clays are devoid of fossils and continue up to Clifton, with very variable dip, the beds being sometimes horizontal, sometimes strongly inclined (nearly one foot in ten), but the average dip is much less, probably somewhere near one in two hundred. It thus becomes very difficult to sum up the thickness of these sandy clays, both because of variable dip and because the bluffs are not continuous.

At Clifton the bluff is 75 feet or more in height, the greater part of the slope being of drift sands, &c., while the Tertiary clays at the base of the hill are only about 10 feet in thickness.

[1] During the summer of 1886 this bed was more closely examined than in 1883, with the result of finding in its lower part a great number of the characteristic Matthews's Landing fossils. Wherever this bed has been exposed to the weather it crumbles down, liberating the shells exactly as at the last-named locality. In 1883 our attention was confined to the upper part of the Naheola bed, with its badly-preserved shells in a greensand matrix; and thus the identity of this bed with that at Matthews's Landing was not so clearly seen.

About one mile above Clifton, on the left bank of the river, there is a low bluff of black clays, which extends about a mile up the river. These clays have not been closely examined, but they appear quite similar to those better seen higher up, at the mouth of Dickson's Creek, where a bluish black, micaceous, sandy clay, holding many finely preserved fossils, forms the right bank of the river. This is the same bed as that which makes the top of the bluff at Matthews's Landing, a mile or two higher up the river, where we get the following good section of this important deposit:

(a) *Section at Matthews's Landing, Alabama River, northern part of Sec.* 12, *T.* 12, *R.* 6 *E.* (*Plate XVIII, Fig.* 2, *p.* 167.)

1. Bluish or greenish black, micaceous, clayey sand, with finely preserved fossils, very dark when wet, but becoming grayish blue on drying; crumbles upon exposed slopes, liberating the fossils, which lie in the crumbs thus produced. This is capped by an indurated, sandy, concretionary ledge.[1] The thickness of the marl deposit is ..... about 5 to 6 feet.
2. Gray sands with a slightly yellowish cast, showing a great tendency to indurate into lens-shaped bowlders, 1 to 2 feet thick and 3 to 4 feet wide. The sands are also fossiliferous, but much less so than the preceding; the fossils are difficult to get out because of the hardness of the material ..... 3 to 4 feet.
3. Bluish, micaceous, clayey sand, much like No. 1, but not holding all of its characteristic fossils. Where this stratum lies exposed to the sun and weather upon flat or nearly horizontal benches, it disintegrates, like No. 1, into crumbs, in which the liberated fossils lie loosely, but where it forms vertical bluffs, it is firm and compact and resembles black clay ..... 7 to 8 feet.

This lowermost bed is sandy above and clayey below, and the material of the whole bluff might be better described as a bluish black, sandy clay, divided into two parts by a bed of calcareous sand, which reaches up into the upper clay bed and down into the lower by gradual transition. The beds which compose this bluff are seen along the river for a mile or more, and are approximately horizontal in position, since the river in this part of its course runs in the direction of the strike of the beds.

The Matthews's Landing marl bed is seen eastward of the Alabama River at very many places in Wilcox County, and it holds usually a number of well-preserved fossils. Near Mr. Clarence Jones's, 7 miles east of Camden, on the Allenton road, there are a good many exposures of this marl bed in the gullies, and we get a very fair section of some 30 feet of the underlying rock. At Oak Hill and in Dale's Branch (see below) we have other good outcrops of the marl. The consideration of this fine section, which includes also the underlying beds down to the base of the Tertiary, we shall leave till after the description of the occurrences along the two rivers.

[1] This is probably one of the glauconitic, concretion-forming sands which are so characteristic of the marl of Naheola.

(6) THE BLACK BLUFF SERIES.

This section has been named from its most characteristic exposure at Black Bluff, on the Tombigbee River, in Sec. 12, T. 16, R. 1 W., in Sumter County, which is as follows:

(*a*) *Section at Black Bluff, Tombigbee River.* (*Plate XVIII, Fig.* 3, *p.* 167.)

1. Yellowish clay, which makes the basis of the Flatwoods, occupying top of bluff ..... about 20 to 25 feet.
2. Black, slaty clay, fossiliferous ..... 40 feet.
3. Brownish shale or clay to water level ..... 8 to 10 feet.

The black clay, No. 2, contains marine fossils, the most prominent among which are a little coral, an Arca, fragments of the shells of a large Nautilus, parts of crabs, &c.

The lower part of the bluff at this place is covered with singularly shaped concretionary masses of limonite. The surfaces of these concretions are marked off into rhomboidal plates, like the markings on an alligator skin. The shales or black clays are strongly calcareous, which accounts for the limy character of some of the soils derived from them in Marengo and Wilcox Counties.

In Sumter County a bed of lignite is found near the summit of the black clays, and just beneath the yellowish clays of the above section.

All the bluffs from Black Bluff down to Naheola, above described, are composed of a black clay in most respects similar to No. 2 of the above section.

The fossiliferous bed of Black Bluff may be seen at any of the exposures as far down the river as Griffin's Landing, 7 or 8 miles, nearly along the strike of the strata. Below Griffin's, down to Naheola, the black clay of the bluffs is quite hard and compact, breaking with conchoidal fracture and resembling very closely the black shale of the Devonian formation. No trace of a fossil could be detected in the black clay along this long stretch of the river. At Lewis's Lower Landing, Beckley's, Oakchia, Steiner's, Kemp's, and Naheola the clays are usually covered with the singular limonite concretions remarked upon at Black Bluff.

The distance across the strike of the rocks, from Black Bluff to Naheola, is about 7 or 8 miles, and through this distance the only Tertiary rocks which appear on the river banks are black clays. Upon the assumption that the dip of these rocks is uniformly about 30 feet to the mile, this would indicate a thickness of nearly 200 feet. But we have seen above that undulations are not rare in the Tertiary rocks, so that the actual thickness is probably very considerably less than 200 feet. The Bladen Springs boring (Plate XXI, column 4, p. 183), shows, according to our interpretation of it, only about 100 feet of black clays above the Rotten Limestone, and a part of this may belong to the Ripley group of the Cretaceous.

As to the equivalence of this black clay group, there is no doubt that it in part represents the Flatwoods group of Dr. Hilgard, because these Flatwoods, so well developed in Mississippi, extend down into Sumter County, in Alabama, and across it to the Tombigbee, and thence across Marengo to the Alabama, which they touch at Midway, a short distance below Prairie Bluff. So far as I am aware, they have not been identified in Wilcox County, although the fossiliferous stratum of the Black Bluff group is very characteristically developed across this county, as may be seen from the sections still to be given.

These Black Bluff clays in Sumter and Marengo Counties contain very little lime, and form Post-Oak Flatwoods with stiff clay soil, while east of the Alabama River they become more and more calcareous, and form the basis of the prairies in Wilcox County and eastward. Even in Marengo County the lower part of the Black Bluff clays is much more calcareous than the upper, and we find a narrow belt of black prairie land lying just north of the Post-Oak Flatwoods. This prairie soil merges by almost imperceptible gradations into the genuine Flatwoods.

7. THE MIDWAY SERIES.

Between Matthews's Landing, above described, and Midway there are no Tertiary rocks exposed along the banks of the Alabama River.

The bluff at Midway is half a mile or more in length, the dip of the strata quite variable, but very considerable, in places as much as one in thirty, and in some places the beds are nearly horizontal. At the lower end of the bluff appear black clays similar to those at Matthews's Landing or Black Bluff, a few feet only showing, and these apparently without fossils. These clays overlie about 10 feet of light colored argillaceous limestone, with projecting hard ledges. This limestone contains the large Nautilus (Enclimatoceras) which characterizes the lowermost Tertiary beds about Pine Barren Creek below mentioned, and it is no doubt identical with the Nautilus rock of eastern Wilcox.

This Nautilus rock has been recognized in that part of Wilcox County lying west of the Alabama River, and it has been traced thence across Marengo County to Moscow, on the Tombigbee River. Southward of the localities where it forms the surface appears always a strip of black prairie soils, derived from the disintegration of the calcareous clays (of Black Bluff group), which immediately overlie the Nautilus limestone, and southward still of this prairie belt lies the belt of Post-Oak Flatwoods, the soils of which come from the disintegration of the non-calcareous clays of the Black Bluff group. The Flatwoods belt, as has already been intimated, does not appear to extend beyond the Alabama River towards the east, while the prairie belt attains to greater and greater importance in that direction.

Midway is some 4 miles down the river from Prairie Bluff, where occurs the first outcrop of Cretaceous rocks on the Alabama.

Between these two points there are none but comparatively recent deposits along the river banks.

The position and character of the Tertiary rocks exposed at Midway may be seen on Plate XVIII, Fig. 2, p. 167.

THE OAK HILL AND PINE BARREN PROFILE.

This profile embraces the strata of the Naheola or Matthews's Landing, the Black Bluff, and the Midway sections above described, and gives us a continuous view of all the strata from just below the Coal Bluff lignite down to and including the uppermost beds of the Cretaceous. Our three lowest sections of the Lignitic might with propriety be classed together as the Oak Hill Pine Barren group.

About half a mile to three-quarters west of Oak Hill, in Sec. 16, T. 11, R. 10 E., in Wilcox County, the Allenton and Camden road descends a long hill, where at least 150 feet of the Tertiary strata are laid bare.

(*a*) *Section near Oak Hill, Wilcox County.* (*Plate XVIII, p.* 167.)

Red loam, pebbles, &c. of the Drift.

1. Cross bedded sands and thinly laminated clays, much decayed and difficult at times to distinguish from the overlying red loam ..... 25 feet.
2. Gray, cross bedded sands, alternating with thin laminæ of gray clay; general aspect of the whole, gray ..... 40 feet.
3. Bed of yellowish gray, cross bedded, and laminated sand ..... 18 inches.
4. Thinly bedded, gray clays, interstratified with thin ledges of cross bedded sands ..... 30 feet.
5. Sands 1 foot, clays 1 foot, sands 1 foot ..... 3 feet.
6. Gray clays, interstratified with cross bedded sands ..... 6 feet.
7. Gray, cross bedded sands with very little clay ..... 3 feet.
8. Gray clay breaking up into cuboidal blocks, interstratified with sandy ledges ..... 15 feet.
9. Black to gray micaceous sands, with the fossils of Matthews's Landing ..... 7 feet. This bed is darker at top and lighter colored at bottom. In Dale's Branch, close by, the same bed occurs with glauconite in part of it. It is quite possible that part of this bed may be identical with the Naheola marl. At other localities, near Oak Hill, this bed has a greater thickness, and the above may be taken as the lower limit. According to the observations of Mr. Johnson, in a well bored at W. W. McConnico's, the thickness goes even to 20 feet, thus approximating the thickness at Matthews's Landing.
10. Hard ledge of calcareous glauconitic sand ..... 1 foot.
11. Yellowish, calcareous sands, with white lime concretions and one or two harder ledges ..... 12 feet.
12. Glauconitic sands with indurated ledge at top ..... 10 feet.
13. Sandy shales, with indurated ledge ..... 5 feet.
14. Hard, yellowish, sandy limestone, with phosphatic nodules, appearing also in the Graveyard Hill section, No. 3 ..... 2 to 3 feet.

This bed is a very conspicuous feature in all this vicinity; it may be seen on the sides and summits of most of the low hills, where, breaking off in consequence of joint planes, it appears like a low stone wall running around the hills. From the locality above given to the Graveyard Hill this stratum can be followed with certainty, and appears as above stated in the accompanying section.

(*b*) *Section on Graveyard Hill.* (*Sec.* 5, *T.* 11, *R.* 10 *E.*)

1. Grayish white, calcareous sands, with small phosphatic nodules, characterized by an abundance of crustacean remains ..... 5 feet.
2. Whitish, calcareous sands, with several harder ledges which shale off in weathering ..... 20 feet.
3. Hard, yellowish, sandy limestone, containing small phosphatic nodules. This is the rock which forms the walls around all the low hills in the vicinity. 2 to 3 feet.
4. Yellowish, calcareous, clayey sand, with white lime concretions, becoming grayer in color and more clayey, and containing numerous fossils identical with those found at Black Bluff ..... 15 feet.
5. Black, calcareous clays, yellowish gray on weathered surfaces, also containing the Black Bluff fossils, but less abundantly than the preceding bed. 20 feet or more.

This black clay and the overlying bed yield the prairie soils of this section of Wilcox County. These soils are exceedingly fertile, as may be seen by the fine crops which grow upon them and by the immense height of the weeds which spring up by the roadsides.

Graveyard Hill, like all the others in the vicinity, slopes off into the prairie fields which border Prairie and Pine Barren Creeks. In the lower parts of these fields we come always upon a ledge of rocks, decribed below, which forms the continuation of the section above given. Below this rocky ledge occur sands and sandy shales, which undoubtedly belong to the Cretaceous formation.

The whole thickness of the clays, &c., which form the prairies here is about 30 to 35 feet, so that what follows is only the direct continuation of the preceding section.

(*c*) *Section from base of Graveyard Hill to Pine Barren Creek.*

Black clays, weathering yellow, basis of prairies, No. 5 of the preceding section.

6. Hard, grayish white limestone, characterized by great numbers of a large *Nautilus* (*Enclimatoceras Ulrichi*), and hence known as the Nautilus Rock.. about 10 feet.
7. Calcareous sands forming basis of the black, sandy prairies of this vicinity.. 6 feet.
8. Hard, yellowish white, crystalline lime rock, sandy in places and filled with red specks, highly fossiliferous, containing *Turritella* in great numbers; also *Carditas*, a *Rostellaria*, *Ostrea*, and two or three species of coral. This is one of the most persistent of the lower Tertiary rocks towards the east..... 8 feet.
9. Yellowish, micaceous sands, with Cretaceous fossils..... 55 feet.
10. Bluish gray, calcareous sands, with two very prominent ledges 4 feet apart, and two or three smaller ledges. Thickness to water level below Palmer's Mill ..... 15 feet.

These three sections are illustrated in Fig. 1 of Plate XVIII, p. 167.

It may be remembered that from the summit of the White Limestone down to the base of the Bell's Landing section of Lignitic, representing about 1,200 feet, our geological column is uninterrupted and is covered throughout by overlapping sections.

Below the Bell's Landing section occurs the first hiatus or break in this column, the first place where we have as yet been unable to connect two contiguous divisions by overlapping sections.

Immediately below the Coal Bluff lignite of the preceding section there is a second gap, the exact dimensions of which we have as yet not been able to ascertain. Making the highest estimate (based upon an assumed uniform dip of the strata of 30 feet to the mile), the thickness of the beds here concerned can hardly be more than 50 or 60 feet, for the missing beds should outcrop along the Tombigbee River between Nanafalia Landing and the mouth of Beaver Creek, a distance of 4 miles, corresponding to a thickness of 120 feet. We know, from exposures on Landrum's Creek and Pursley Creek, all the beds below the Nanafalia marl down to the lignite, 60 feet below, so that the missing beds would constitute the other half of this estimated 120 feet.

On the Alabama River, likewise, we see some ten feet of strata below the lignite, after which follows a barren stretch of river bank which shows no Tertiary beds at all for two or three miles.

In the Pine Barren profile, which gives so complete a view of the lower part of the Tertiary formation, the lignite is not seen in actual contact with the beds of this section, so that here, also, we have the gap unfilled. From the occurrence of the lignite, however, a short distance south of Oak Hill, which makes the summit of the Pine Barren section, the thickness of the beds involved in this gap is here also shown to be not very great, except upon the assumption of a very abrupt change in the dip of the strata, which is wholly unauthorized by any facts which have come under our observation.

Geologically below this gap, from the mouth of Beaver Creek, on the Tombigbee, to Black Bluff (up the river), there is an almost continuous exposure of Tertiary beds along the river banks, but there is difficulty in getting the exact thickness of the beds thus exposed.

On the Alabama River the exposures are much less continuous, and the thickness of the beds correspondingly more difficult to ascertain.

It is therefore fortunate that we have, in the Pine Barren region, a continuous section of 240 to 250 feet, embracing all the beds below the gap or hiatus named, down to the top of the Cretaceous formation.

This section is exposed at two localities, above given, viz: Along the Camden road, about half a mile west of Oak Hill, and at the Graveyard Hill in Sec. 8, T. 11, R. 10 E., the lower beds of Oak Hill appearing in the upper part of the Graveyard Hill. The lower portion of the section appears at the base of the latter hill and along the low grounds of Prairie Creek down to Palmer's mill on Pine Barren Creek. All the lower part of this section, up to the Dale Branch or Matthews's Landing marl, was very carefully worked out in 1883 by Mr. Johnson, and the section continued by estimates up to the Nanafalia beds, which appear at Eggville, in Sec. 22, T. 11, R. 10 E. To Mr. Johnson also belongs the whole credit of determining beyond doubt the exact limit between the Tertiary and Cretaceous rocks in eastern Wilcox.

He has shown that the Nautilus (Enclimatoceras) Rock, which had, up to 1883, been considered Cretaceous, overlies a crystalline limestone

holding *Turritellas*, *Carditas*, a *Rostellaria*, and other Tertiary species. The measured section from Chambers Creek across Pine Barren Creek up to the summit of the Graveyard Hill profile (see Plate XVIII, Fig. 1, p. 167) was also made by him.

In the summer of 1885 these localities were visited by the present writer, when the measured part of Mr. Johnson's section up to the Dale Branch or Matthews's Landing marl was fully verified and extended by the addition of some 125 feet of strata exposed along the Camden road, near Oak Hill, and in direct superposition over the Dale Branch marl. Notwithstanding the 125 feet thus transferred from "estimated" to the firm ground of "measured" strata, there still remains, as above stated, a gap not covered by overlapping sections between the top of the Oak Hill section and the Coal Bluff lignite.

It would be manifestly a serious omission on our part not to speak in this connection of the observations of Prof. Alexander Winchell, made in 1856 in eastern Wilcox County.[1]

This author recognized as Tertiary, and described in sufficient detail to render their identification easy, several of the beds included in our Pine Barren sections below given, notably No. 3 of the Graveyard Hill and the underlying marls containing Black Bluff fossils, and also the Turritella rock which lies at the base of our Tertiary section, and he rightly extends the line between the Tertiary and Cretaceous to a point eight and a half miles north of Allenton.

These rocks he, however, places in the Buhrstone, and above his Buff Sand, which he considers the lowermost of the Tertiary rocks. By comparing our Nanafalia sections and Professor Winchell's description, it will be seen that his Buff Sand overlies (at Black's Bluff on the Alabama River) the beds with *Gryphæa thirsæ*, which at that time was generally considered a Cretaceous species. These beds we now know are some 300 feet above the top of the Cretaceous.

Notwithstanding some mistakes in fixing the relative positions of rocks observed at widely distant localities, mistakes which were probably unavoidable without long-continued observations, we find recorded in this pioneer work of Professor Winchell a host of sagacious observations which have been fully confirmed by those who have since gone over the same ground.

In this part of the Tertiary the variations in the thickness of the beds and the quality of the material as we go from west to east are more striking than in the overlying strata. Thus, on the Tombigbee River, near the base of the Tertiary, there is a great thickness of black, sandy clays (80 feet or more in one place, Black Bluff), which extend down the river for many miles, to Naheola, while on the Alabama the only rocks seen of this kind are at and near Matthews's Landing, which is near the top of the series; and in the Pine Barren section in eastern

[1] Proceedings Am. Assoc. Adv. Sci., Part II, pp. 87–89, 1856.

Wilcox County, where all the strata are shown, the whole thickness, including the Matthews's Landing marl, is not greater than 75 feet.

On account of these differences it becomes impossible, without further comparison, to correlate some of the beds of the Tombigbee section with those exposed at Oak Hill and on Pine Barren Creek.

In the vicinity of Palmer's Mill (Smith's bridge), on Pine Barren Creek, in Wilcox County, we have the lowermost of the Tertiary beds in direct contact with the uppermost of the Cretaceous. At this place the beds of the two formations appear to be strictly conformable with each other. Here, also, the lower Tertiary beds have a very striking resemblance in lithological characters to some of the Cretaceous beds; but the fossils, as Mr. Johnson has shown, leave no room for doubt as to the age of the beds.

This resemblance is most pronounced in the case of the shaly sandy beds of Graveyard Hill, which might easily be mistaken for similar beds occurring at Canton Landing and back of Prairie Bluff. The latter are of Ripley age, while the Graveyard Hill rock overlies sandy clays holding Black Bluff fossils. So, also, the Nautilus rock might well pass for Cretaceous, except that it overlies a limestone holding Turritellas, Carditas, and other fossils which Mr. Johnson has identified as Tertiary. No one can fail to be impressed with the similarity in general aspect, if not in the organic contents, of the contiguous beds of the two formations.

THE BLADEN SPRINGS BORING.

In the years 1884 and 1885 a boring was made at Bladen Springs, in Choctaw County, in search of petroleum. The carefully kept record was obtained from Captain Trowbridge, who had charge of the boring.

The surface rocks at the place of boring are either the lowermost of the Buhrstone or, more probably, the uppermost of the Hatchetigbee, the loose surface materials hiding the Tertiary rocks at the locality. The boring penetrated through the underlying Tertiary rocks, through the Ripley, and 125 feet (as we interpret it) into the Rotten Limestone of the Cretaceous. We have inserted this record, drawn to scale, in its proper place in the general section (see Plate XXI, column 4, p. 183), where it will be seen the thickness revealed by the boring corresponds very well with that established by our measurements. It is, however, difficult to correlate with any certainty the beds penetrated by the boring with the strata of the general section, since an accurate determination of the lithological and other characters of the beds from the loose and mingled materials brought up by the auger is manifestly impossible; still, we have felt warranted in several instances in pointing out the probable equivalences. In the lower part of the boring, especially, we think that the black or dark blue clays and clayey sands of the Black Bluff and Ripley sections are unmistakably shown, as is also the Rotten Limestone, although in the boring there appear only 17 feet of sands at

base of the Ripley, while in some places, as at Prairie Bluff, the thickness is at least 60 feet.

In 1884, while the boring was still in progress, Mr. D. W. Langdon, jr., visited Bladen Springs, and, upon the authority of our much less perfect river section, predicted that the Rotten Limestone would be reached at 1,200 feet. In reality it was reached at 1,220 feet.

§5. SUMMARY OF THE LEADING FEATURES OF THE TERTIARY STRATA OF ALABAMA (PLATE XXI).

With a brief review of the distinguishing characteristics of the divisions of the Tertiary above made, we conclude this part of our subject.

The whole thickness of the strata of the Tertiary group of Alabama occurring in the vicinity of the two rivers is between 1,620 and 1,700 feet. This estimate is based upon actual measurement, except at one or two horizons, and even in these places we are able to give a close estimate of the thickness of the strata not measured.

We have adopted the following fourfold division of the Tertiary:

(1) The White Limestone,
(2) The Claiborne,
(3) The Buhrstone, and
(4) The Lignitic.

In all that follows, the strata are described in descending order.

(1) THE WHITE LIMESTONE.

This subdivision is calcareous throughout, but the lowermost 60 feet are more argillaceous than the rest. The minimum thickness is 350 feet, of which the uppermost 150 feet consist of a tolerably pure but somewhat silicious limestone, filled with coral masses. The next succeeding 140 feet or more are made up of a soft, white limestone, often quite pure and filled with *Orbitoides Mantelli*. The lowermost 50 feet are of impure, argillaceous limestone, which in disintegrating yields a black, calcareous soil similar to that derived from the Rotten Limestone of the Cretaceous. This lower portion of the White Limestone surpasses the others in the variety of its fossil contents.

(2) THE CLAIBORNE.

The thickness is 140 to 145 feet, the materials are sands and clays, which are generally calcareous and often glauconitic. Near the top of the subdivision is a bed of glauconitic sand 15 to 17 feet in thickness, filled with shells in a perfect state of preservation. The sandy clays forming the lower 50 feet are likewise filled with a great variety of shells in a good state of preservation. The intervening calcareous clays and calcareous sands are distinguished by the great numbers of shells of *Ostrea sellæformis* which they hold, as well as by the comparative rarity of other forms.

(3) THE BUHRSTONE.

The minimum thickness of this formation is 300 feet; the materials are almost altogether aluminous and silicious, consisting of aluminous sandstones, claystones, and quartzitic sandstones, with occasional thin beds of glauconitic sand. The few fossils which have been obtained from this division are mostly in the form of casts. They do not appear to differ specifically from those of the overlying division.

(4) THE LIGNITIC.

This is the most massive of the subdivisions of the Tertiary, having a thickness which can hardly be less than 900 feet. It also presents a greater variety in mineral composition, as well as in fossils, than the other divisions. In the most general terms, the Lignitic strata are cross bedded sands, thin bedded or laminated sands, laminated clays and clayey sands, and beds of lignite, as well as the lignitic matter which merely colors the sands and clays. With these are found interbedded, at several horizons, strata containing marine fossils. For the sake of greater convenience and clearness of description we present the Lignitic in seven sections, each of which is characterized by one or more beds of marine fossils included in it. These sections are as follows:

(*a*) *The Hatchetigbee section.*—This section is 175 feet in thickness, made up of sandy clays of prevailing brown or purplish color, containing three or four beds of marine fossils in the uppermost 75 feet, and of somewhat similar purplish brown, sandy clays nearly devoid of marine fossils in the lower 100 feet. All these brown, sandy clays become much lighter colored upon drying and exposure to the weather.

(*b*) *The Wood's Bluff or Bashi section.*—This is 80 to 85 feet in thickness. The uppermost 30 feet of the section consist of dark brown clays passing into a greensand, which holds a great variety of finely preserved marine shells. Below this greensand marl are gray, sandy clays, with four or five thin beds of lignite within the first 25 feet, succeeded by about 30 feet of cross bedded sands, with a two foot seam of lignite at the base.

(*c*) *The Bell's Landing section.*—This is 140 feet in thickness, and includes two important marine beds, and a third, quite small and apparently unimportant. These fossiliferous beds are interstratified with yellowish sands in the upper and rather heavy bedded, sandy clays in the lower part of the section. The upper marine bed, called the Bell's Landing marl, is about ten feet in thickness and has 40 feet of sandy strata above it. The middle bed is called the Gregg's Landing marl, and it is twenty to twenty-five feet below the preceding; it is about five feet in thickness. The lowermost of the fossiliferous beds of this section is only about one foot in thickness and lies about fifty

feet below the Gregg's Landing bed. It is highly glauconitic, but does not contain any great variety of fossils. The Bell's Landing marl is distinguished from all others in Alabama by the great size of the shells which it contains.

(*d*) *The Nanafalia and Coal Bluff section.*—The strata of this section are 200 feet in thickness and consist of about fifty feet of gray sandy clays at top, which show a tendency to indurate into tolerably firm rocks resembling very closely some of the strata of the Buhrstone. Below this, about eighty feet of sandy beds, often strongly glauconitic, characterized throughout by shells of a small oyster, *Gryphæa thirsæ*. Near the base of this sandy division there is a bed about twenty feet thick, literally packed with these shells. Below the *Gryphæa thirsæ* beds follow some seventy feet of cross bedded sands, glauconitic and apparently devoid of fossils, including, about ten feet from the base of the section, a bed of lignite which varies in thickness from four to seven feet.

(*e*) *The Naheola and Matthews's Landing section.*—It is difficult to give the precise thickness of this section, since it varies on the two rivers. We have placed it at one hundred and thirty to one hundred and fifty feet; the strata are gray, sandy clays in the main, alternating with cross bedded sand. The beds of dark, sandy, and glauconitic clay, containing marine fossils, lie at the base of the section. At Naheola on the Tombigbee the upper and more glauconitic part of the bed is most prominent, while at Matthews's Landing on the Alabama, the lower part of the bed, dark gray sandy clay forms the bluff.

(*f*) *The Black Bluff section.*—Here again we have difficulty in determining the exact thickness, since on the Tombigbee the strata of this section are spread over an extent of surface which would, with uniform dip, correspond to a thickness of over two hundred feet, while on the Alabama, and more particularly inland in the eastern part of Wilcox County, the thickness is not greater than thirty-five or forty feet. Since 80 feet of these beds are seen in superposition at one locality (Black Bluff), we think that the maximum thickness cannot be less than one hundred feet. The characteristic strata which compose nearly the whole of this section are black or very dark brown clays, which are in part fossiliferous.

(*g*) *The Midway or Pine Barren section.*—Thickness, 25 feet. The strata are: a white, argillaceous limestone holding a large nautilus, which is characteristic of the horizon, 10 feet; calcareous sands and a yellowish, crystalline limestone, with Turritellas, Carditas, and corals, the sands 6 feet, the limestone 8 or 9 feet. This section is best seen in eastern Wilcox County on Pine Barren Creek, but the upper or Nautilus rock occurs at Midway, on the Alabama River, and westward across Marengo County. No exposure was noticed on the Tombigbee, but it will probably be found a short distance below Moscow.

II. CRETACEOUS STRATA.

The Cretaceous formation in Alabama exhibits three well marked divisions, which, in descending order, are as follows:

First. A series of yellow sands, dark gray or bluish, sandy, micaceous clays, impure limestone, and sands again, in all between two and three hundred feet in thickness. This has been called the Ripley formation by Hilgard, and the name is retained for Alabama.

Second. An impure, argillaceous limestone of tolerably uniform composition and about one thousand feet in thickness, known as the Rotten Limestone.

Third. A series of laminated sands and sandy clays at least three hundred feet in thickness which has been named the Eutaw formation.

All these strata, especially the calcareous parts, are more or less perfectly exhibited in the bluffs of the two rivers.

It will be seen below that we have not as yet been able to construct the column of strata of this formation with as great a degree of completeness as has been done for the Tertiary, but this want of completeness is in the figures showing the thicknesses of the several strata rather than in the succession and quality of these beds.

§1. THE RIPLEY FORMATION.

The character of the uppermost beds of this formation immediately underlying the Tertiary was first clearly determined by Mr. Johnson in the Pine Barren section, in the eastern part of Wilcox County, already given above. These uppermost beds were afterwards traced by him westward to the Alabama River and eastward to Clayton and Eufaula. The relation of the Bridgeport horizon to the yellow sands was also first determined by him. In 1885 the strata connecting the Bridgeport section with the Prairie Bluff section were determined by Mr. Langdon and myself, and it is believed that we now have the complete section of the Ripley strata along the rivers, except that the actual contact with the Rotten Limestone of the sands forming the lower part of Prairie Bluff, has not come under observation. The uppermost beds of this formation were also examined in 1885 by Mr. Langdon and myself in Marengo County, south of Dayton, as described below.

The strata of the Ripley formation, according to the investigations above alluded to, are as follows:

First. Fifty-five feet of yellow sands, not recognized on the Tombigbee River, but constituting the upper part of the bluff at Bridgeport, on the Alabama River, and much better developed in the hills immediately back of the bluff. From here they may be traced across the country for a great distance eastward. Mr. Johnson has probably identified this sand at Clayton, in Barbour County, where it constitutes

the basis of the fields on the south side of Barbour Creek. In this sand on the road between Eufaula and Clayton were found decayed shells of a small oyster, and with them *Exogyra costata* Say in a pretty good state of preservation. The same oyster, without the Exogyra, was seen in the eastern part of Wilcox County, on Prairie Creek.

Second. About one hundred feet of bluish, micaceous, sandy clays, somewhat calcareous, marked at intervals of ten or fifteen feet throughout the whole thickness by the occurrence of indurated ledges, usually of rather sandier texture. These ledges appear occasionally as shaly sandstones of very little hardness, flaking off readily into sheets under the influence of the weather. Our observations in the Canton Bend and in the hills between Prairie Bluff and Rehoboth, and also westward towards Linden, in Marengo County, and eastward in Dallas and Wilcox Counties, have shown that these sandy clays, where they lie high above the drainage and well exposed to the action of the weather, lose altogether their bluish color and appear in all shades of yellowish gray. This difference in color, depending upon the degree of oxidation of certain constituents of the strata, especially the iron bearing materials, has not unfrequently been observed in the strata both of the Tertiary and of the Cretaceous groups. The most striking instance of this sort is to be seen at Prairie Bluff, where the sands forming the lower part of the bluff exhibit a dark blue, almost black color near the water's edge, while the same stratum is seen to be a white sand where it outcrops at the top of the bluff higher up the river.

Later observations in 1886 by Mr. Langdon and myself have shown clearly that the differences in these yellow sands and bluish micaceous sandy clays arise merely from different degrees of oxidation. In some of the outcrops observed by us, e. g., in Little Texas, Butler County, and in Lowndes County, bluish, micaceous sands, identical in appearance with those making the lower part of the Bridgeport Bluff, are seen along the banks of Cedar Creek directly underlying the Nautilus rock and Turritella limestone which lie at the base of the Tertiary. The same thing may likewise be seen in the upper part of Marengo County, where it has been found impossible to separate the yellow sands from the bluish, sandy clays.

Third. Calcareous beds some twenty feet in thickness, holding great numbers of Cretaceous fossils, some well preserved, others only in casts, which in every case appear to be very strongly phosphatic. One of the layers of this section is a sandy limestone containing a large percentage of phosphoric acid (see details below). These beds appear in a small bluff at the mouth of Tear Up Creek, above Bridgeport, which has been studied by Mr. Johnson; also in localities recently examined by Mr. Langdon and myself, viz, in the bluff at the old Canton landing; on Foster's Creek, in Gee's Bend; near Snow Hill, Wilcox County, and

Minter, Carlowville, and Richmond, in Dallas County; the four last named localities were also visited by Mr. Johnson in 1883.

Fourth. From sixty to one hundred feet of sand, with indurated bands of calcareous sand passing through it. These hard, projecting, sandy layers are usually filled with the shells of large *Exogyra costata* Say and *Gryphæa mutabilis* Mort. The thickness of these sandy beds, which apparently immediately overlie the Rotten Limestone, has not yet been accurately determined, but we see some fifty feet or more of them at Prairie Bluff.

Prof. A. Winchell[1] considers the rock at the base of Prairie Bluff as the topmost of the Rotten Limestone formation, and if this supposition be correct we have the complete section of the Ripley formation. We were, however, unable to satisfy ourselves of the identity of any of the rocks at Prairie Bluff with the Rotten Limestone, though we are convinced that the top of the latter formation does not lie far below the lowermost of the Prairie Bluff strata, since Rotten Limestone appears in the hills near the river a short distance above Prairie Bluff.

SECTIONS OF THE RIPLEY FORMATION.

In the subjoined sections and in the figures on Plate XIX we have given in detail the characters of the strata making up these subdivisions of the Ripley formation. These sections are given in descending order, that is, beginning with that one which shows the uppermost of the strata, and in the figures of Plate XIX the equivalence of the several sections is indicated as nearly as it can be made out. In most cases the equivalence is very clearly seen.

Near Palmer's Mill, on Pine Barren Creek, in the eastern part of Wilcox County, Mr. Johnson in 1883 obtained the following satisfactory section showing the actual contact of Tertiary and Cretaceous strata. The locality was also visited by myself in 1885, as mentioned above.

(*a*) *Pine Barren section.* (*Plate XVIII, Fig.* 1, *p.* 167, *and Plate XIX, Fig.* 1, *p.* 171.)

1. Hard, grayish white limestone, characterized by great numbers of a large *Nautilus* (*Enclimatoceras Ulrichi* White), and hence designated by us as the "Nautilus Rock"..... 10 feet.
2. Calcareous sands forming the basis of the sandy prairies of the vicinity..... 6 feet.
3. Hard, yellowish white, crystalline limestone, sandy in places and filled with red specks. Highly fossiliferous, a *Turritella*, closely related to *T. Mortoni*, being the chief fossil, along with a *Cardita*, two or three species of coral, and numerous oysters. This is one of the most persistent of the lower Tertiary rocks towards the eastern part of the State..... 8 feet.
4. Yellowish, micaceous sands, with Cretaceous fossils..... 55 feet.
5. Bluish gray, calcareous sands, with one or two very prominent hard ledges 4 feet apart, and two or three smaller ledges of similar character. Thickness seen at Palmer's Mill..... 15 feet.

[1] Proc. Am. Assoc. Adv. Sci., Vol. X, Part II, p. 91, 1856.

In this section the lowest Tertiary bed is No. 3 and the uppermost Cretaceous No. 4, as is very clearly shown by the included fossils of each, and as the two are in direct contact there can be no question of their relations.

Bridgeport.— On the way from Camden to Bridgeport the road descends a long clay hill, in which the clays of the Black Bluff horizon form the surface (see Pine Barren section, under the Tertiary, Plate XVIII). At the foot of the hill is the yellowish white, crystalline limestone, No. 3 of the preceding section, and below that yellow, micaceous sands to the landing. At the Bridgeport Landing these yellow sands form the upper part of the bluff, though their whole thickness is not seen in the immediate bluff of the river, but may be seen at the base of the hills immediately back of the river bluff.

The section at Bridgeport is as follows:

(*b*) *Section at Bridgeport Bluff, Alabama River.* (*Plate XIX, Fig.* 2, *p.* 171.)

1. Yellowish, clayey sands, probably reworked ..... 10 feet.
2. Coarse, yellow sands ..... 10 feet.
3. Laminated, gray clays ..... 1 foot.
4. Projecting ledge of sandy clay of dark gray color ..... 1 foot.
5. Dark gray, nearly black, sandy, and in some parts micaceous clays, in beds about 3 feet thick, separated by hard projecting ledges of sandier material and of lighter color and averaging 8 to 10 inches in thickness ..... 22 feet.
6. Projecting ledge of light colored, sandy material, forming a pretty firm sandstone. This ledge breaks off in cuboidal blocks, which roll down and cover the slope below it ..... 18 inches.
7. Dark gray clays ..... 3 feet.
8. Projecting sandy ledge ..... 1 foot.
9. Dark, sandy clays, with two or more harder ledges, down to the water level.. 10 feet.

The ledge No. 6 makes a very prominent mark along the face of the bluff, as it is more persistent, harder, and more rock-like than the others. No distinct and well defined fossils were found at this place in the micaceous clays, but in one or two of the harder ledges below No. 6 were found a few friable shells of Ostrea, one *Pecten quinquecostatus* Sow., and a few indistinct impressions of other forms, two of which, if Mr. Johnson is not mistaken as to their characteristics, he was enabled at Eufaula to identify as *Nautilus Dekayi* Mort. and *Placuna scabra* Mort.

Canton Landing.—A short distance below Bridgeport there is an exposure of Cretaceous rocks at the old Canton Landing and in the hill which comes down nearly to the river bluff at that place. This locality was examined by Mr. Langdon and myself in the summer of 1885. It presents the following:

(*c*) *Section at the old Canton Landing, Alabama River.* (*Plate XIX, Fig.* 3, *p.* 171.)

1. Yellowish gray, calcareous, clayey sands in beds 3 to 5 feet thick, separated by harder projecting ledges of somewhat sandier material averaging perhaps a foot in thickness ..... 100 feet.

   The hard ledges named have a tendency to flake off on weathering into sheets as wide as the hand. They often also break off into fragments which are of very

irregular shape and of rough surface. All these beds make up the hill, appearing at intervals through the overlying débris, but no continuous section is exposed. In some places the clayey sands lying immediately below one of the hard ledges have the bluish black color which characterizes the whole of the lower part of the Bridgeport bluff, with which there seems to be very little doubt that these are identical.

2. Yellowish, calcareous, sandy clays like the preceding, with a hard, sandier ledge above and below, making top of immediate bluff of the river..... 10 feet.
3. Bluish, micaceous clays, the counterpart of those at Bridgeport, with two or more indurated ledges..... 12 feet.
4. Light gray, calcareous sands, with an indurated ledge of nearly pure sandstone at the base. The upper part of this bed is disposed to form rough, indurated masses holding phosphatized shell casts and phosphatic nodules..... 6 feet.
5. Bluish gray, sandy clays, much more clayey than the preceding bed, about 5 feet in thickness, passing below into a more sandy bed 3 feet thick, containing numerous shell casts and nodules..... 8 feet.
6. Bluish, argillaceous limestone, containing great numbers of *Exogyra costata* Say, *Gryphæa mutabilis* Mort., and phosphatized shell casts..... 3 feet.
7. Bluish, calcareous sands containing many well preserved shells, prominent among which is a *Spondylus*; *Pecten quinquecostatus* Sow., together with phosphatized casts of *Nautilus Dekayi* Mort., turreted shells, &c. This bed goes down to water level..... 3 feet.

At this bluff there is a very distinctly defined fault, where some fifty yards of the face of the bluff have slipped down a distance of five or six feet. The lines of fault on each side of this piece are marked by broken fragments of the beds or so-called "fault rock" (see Fig. 1, p. 132).

In this section, beds Nos. 2 and 3 are entirely similar in mineral composition and appearance to part of the Bridgeport bluff, and the overlying beds are also similar in composition, though of much lighter yellowish color, which is in all probability due to their greater degree of exposure to the oxidizing action of the weather. This bluff is only a mile or so distant across the strike of the rocks from Bridgeport, and there seems to be no reason for doubting that the bluish, micaceous clays and sands of Bridgeport are identical with the yellowish, sandy clays with indurated ledges which form the upper members of the Canton section. The beds numbered from 4 down we consider the same as those appearing at the top of the bluff at Prairie Bluff, to be presently described.

Foster's Creek.—The beds above described at Canton landing continue across the bend lying to the east and known as Gee's Bend, where they may be seen in the banks of Foster's Creek, on John H. Pettway's land.

(*d*) *Section on Foster's Creek.* (*Plate XIX, Fig.* 4, *p.* 171.)

1. Yellowish, calcareous, clay soil supporting a vegetation almost exclusively of cedars.
2. Dark gray, sandy, micaceous clays like those at Bridgeport landing, in beds of 5 to 6 feet thickness, separated by harder ledges of lighter colored and sandier material..... 30 feet.

In the lower part of these beds were collected by myself some of the small Gryphæas, probably *Gryphæa vomer* Mort., first seen by us at Moscow, on the Tombigbee River.

3. Cream colored, impure limestone, glauconitic, holding some phosphatized shell casts ..... 5 feet.
4. Ledge of coarse grained, calcareous sandstone ..... 2 feet.
5. Bluish, clayey limestone, no fossils at the top, but filled in its lower parts with fossils which are in many instances only the phosphatized casts of the shell. Among the forms collected here we have identified the following: A *Spondylus*, same as that at Canton; *Gryphœa mutabilis* Mort., *Exogyra costata* Say, *Scaphites Conradi* Mort., *Nautilus Dekayi* Mort., &c ..... 20 feet.
6. Dark brown, crystalline, phosphatic limestone ..... 1 foot.
7. Yellowish white limestone down to water ..... 1 foot.

In another part of the same plantation, on what is called Livingston Hill, the phosphatic limestone and accompanying rocks may again be seen. From the geographical position of the beds represented in the above section, there is every reason to think that they underlie the visible portion of the bluff at Bridgeport. The identity of the lower 20 feet or so of this and of the Canton section is sufficiently clear.

Tear Up Creek.—A few miles above Bridgeport, at the mouth of Tear Up Creek, Mr. Johnson obtained in 1883 a good section of the beds underlying those of the Bridgeport bluff and was able to trace the connection between the two.

(*e*) *Section at the mouth of Tear Up Creek.* (*Plate XIX, Fig.* 5, *p.* 171.)

1. Ferruginous, sandy marl full of Cretaceous fossils ..... 3 feet.
2. Very firm, white limestone, no fossils seen ..... 6 feet.
3. Firm limestone, with a few fossils ..... 2 feet.
4. Sandy, calcareous beds, with fine *Ammonites* ..... 4 feet.
5. Sandy, indurated limestone forming a broad ledge ..... 1 to 2 feet.
6. Argillaceous limestone, with *Exogyra costata*, &c ..... 8 feet.

The fossils of this bluff are plainly Cretaceous and resemble the finest of those occurring at Prairie Bluff. There is good reason for thinking that most of the fine specimens of the old Tuomey collection labeled "Bridgeport" have come from this locality (L. C. J.). The dark, micaceous clays of Bridgeport are easily recognized in the bed of Tear Up Creek between its mouth and its source under McNeill Mountain, as shown in Plate XIX, Fig. 5. As has already been pointed out, they are seen also in the banks of Pine Barren Creek, at Palmer's Mill. The fossiliferous portion of this bluff is undoubtedly equivalent to the fossiliferous beds occurring on Foster's Creek and at Canton Landing, above described, as also to those at the top of the Prairie Bluff, given below.

During the summer of 1886 Mr. Langdon and myself went in a skiff from Bridgeport to Prairie Bluff and saw no Rotten Limestone in any of the river bluffs, all these exposures representing the Bridgeport and Prairie Bluff strata only.

The principal exposures are the following: From Bridgeport the bluff extends about a mile down the river, and then after a barren

stretch of two miles or more come the bluffs at the old Canton Landing described above, and below that the following:

(*f*) *Section four or five miles below the old Canton Landing, Alabama River.*

1. Sandstone ledge, fossiliferous, yellowish, and wearing into very irregular shapes, 1 to 1½ feet.
2. Highly fossiliferous, blue sand, becoming light gray below, containing *Ostrea larva, Exogyra costata, Turritella,* &c., very much resembling specimens from Eufaula..... 5 to 6 feet.

Two hundred yards down the river other underlying beds are to be seen, as follows:

3. Sandstone ledge..... 1 to 1½ feet.
4. Light colored sands, no fossils observed..... 20 feet.

At an old abandoned landing just above Mixon's we get a very good section, as follows:

(*g*) *Section near Mixon's.*

1. Yellow sands making top of the bluff back of the immediate river bank, at least 30 feet exposed, but apparently forming the whole slope of 60 feet..... 60 feet.
2. Blue, micaceous sands, with the same fossils as No. 2 of the preceding section, 6 to 8 feet.
3. Sandstone ledge..... 1 to 1½ feet.
4. Light colored sands..... 30 feet.
5. Hard sandstone ledge..... 1 foot.
6. Blue, micaceous, sandy clays (few fossils)..... 10 feet.

A mile or two above Prairie Bluff there is a high bluff very much resembling that at the former locality. The strata are undulating, at the lower end of the bluff dipping down stream at the rate of 1 foot in 10, at the upper end lying nearly horizontal. The beds here are as follows:

(*h*) *Section one mile above Prairie Bluff (Rocky Bluff), Alabama River.*

1. In the cliff just back of the immediate bluff of the river there are about 40 feet of strata, light colored, calcareous sands, with indurated bands, as at Prairie Bluff..... 40 feet.
2. Dark blue, sandy, micaceous clays, with a few fossils, chiefly Anomias..... 20 feet.
3. Hard, yellow, sandy ledge, the broken pieces of which cover the slope of No. 4. It dips below water at the lower end of the bluff..... 1 foot.
4. Grayish, fossiliferous sands, full of shells of *Pecten quinquecostatus*, which, however, are very friable..... 8 feet.
5. Hard, yellowish, sandy ledge like No. 3..... 1 foot.
6. Bluish gray, calcareous sands, with some fossils..... 10 feet.

In all these bluffs the indurated sandstone ledges are of very irregular thickness and lateral extent and are probably only local deposits in the regular strata or local indurations of the sands.

Prairie Bluff.—This locality has been visited by Professor Tuomey, Professor Winchell, and others.[1] We have very little to add to their descriptions, except to point out the probable equivalences of the beds

[1] Described in First Bien. Rep. Geol. Ala., 1850, and Proc. Am. Assoc. Adv. Sci., Vol. X, Part II, p. 90, 1856.

occurring here with those just described. The bluff shows the following:

(*i*) *Section at Prairie Bluff, Alabama River.* (*Plate XIX, Fig.* 6, *p.* 171.)

1. Bluish limestone containing *Exogyra costata, Gryphœa mutabilis*, and great numbers of shell casts, which are mostly phosphatized. This limestone has two hard ledges passing through it. Professor Winchell gives 6 feet as the thickness of this limestone, but we include with it some overlying fossiliferous, sandy beds and make the thickness[1] ..... 20 feet.

   Among the forms recognized in casts or otherwise from this stratum may be mentioned *Gryphœa convexa, Placuna scabra, Scaphites Conradi*, and *Nautilus Dekayi*. Besides these there are very many other turreted shells not fully identified. The association is the same as at Canton Landing, Foster's Creek, Tear Up Creek, &c.
2. Sandy beds, with bands of hardened sand passing through them; these harder ledges are usually fossiliferous, the commonest forms being *Exogyra costata* and *Gryphœa mutabilis*. These sands form all the lower part of the bluff..50 to 60 feet.

The upper sandy beds contain great numbers of *Ostrea falcata* Mort. The lower beds are of dark blue color, but they bleach out to nearly white sand where they come to the top of the bluff, a short distance up the river from the landing.

The dip of the strata at Prairie Bluff is very considerable, being as high as 300 to 350 feet to the mile. Between Prairie Bluff and Reho-both the hills are formed of the strata overlying the limestone No. 1 of the section. These are yellowish, micaceous sands, in beds 5 to 6 feet in thickness, separated by sandy ledges, and in all respects similar to the upper 100 feet of the section at the old Canton Landing. In structure and general appearance they are like the dark colored, sandy clays of Bridgeport, but the color is much lighter, due, as we believe, to the more complete oxidation of the materials. In these sands there are, in some localities, great numbers of irregular calcareous concretions. All the shell casts occurring in the upper calcareous part of Prairie Bluff,

[1] In the summer of 1886 Mr. Langdon gave this bluff a closer examination. He subdivides that part of No. 1, immediately above the sands, as follows:

1. Shaly, calcareous sands, yellowish gray on weathered surface; contains a seam of phosphatic greensand at the top, immediately underneath the warehouse..4 feet.
2. Pseudo-Rotten Limestone, i. e., calcareous clay.....3 feet.
3. Shell conglomerate.....3 to 4 feet.
4. Light colored sands &c., No. 2 of the section in the text above.

Mr. Langdon makes the additional important observation here that the very rapid dip down stream is confined to the sandy strata No. 4, and is not shared by Nos. 2 and 3, which half a mile below the warehouse are only about ten feet nearer water level than at the warehouse, while the uppermost indurated ledge in the sands No. 4 dips below the water within a distance of 200 yards, a descent of some 40 or 50 feet. This observation would show an unconformity between the calcareous and the sandy parts of the strata at Prairie Bluff.

Our discovery of the phosphatic greensand here fixes its position in the geological scale. The bed at Coatopa, in Sumter County, seems to have a similar position, but it appears now probable that there are at least two of these phosphatic greensands in the Ripley formation.

together with the calcareous sandstone which is included in the limestone, are very strongly phosphatic, as has been shown by the recent investigations of the Geological Survey of Alabama.

In the foregoing sections the calcareous and fossiliferous parts, about 20 feet in thickness, appearing at the mouth of Tear Up Creek, on Foster's Creek, at the base of the Canton Bluff, and at the top of Prairie Bluff are, we think, the same; for, though there seem to be slight differences in the succession of the different materials which constitute these beds, these differences are in many cases due to differences in the groupings. The general impression made upon the mind in inspecting them is that they are identical; they contain the same fossils and in the same state of preservation; they hold strata of sandy limestone, or, rather, of calcareous sandstone which is very highly phosphatic; in some instances, where analyses have been made, they hold from 10 to 15 per cent. of phosphoric acid. In all cases they are overlaid by micaceous, clayey sands, traversed by indurated bands of similar, but rather more sandy, material. These overlying beds differ sometimes conspicuously in color, which at Bridgeport, near the water level, is a dark blue, while on the hills back of the old Canton Landing and back of Prairie Bluff the color is a yellowish gray. This difference can be accounted for by differences in degree of oxidation, for where the color at the surface is yellow we have noticed that upon digging into the beds a few inches the dark color may be seen in most cases. In our minds there is no doubt of these equivalences. Prof. A. Winchell is of opinion that the lower beds of the Prairie Bluff section belong to the Rotten Limestone, but we were unable to discover anything there which we could identify with the Rotten Limestone. There is no doubt, however, for reasons above given, that the Rotten Limestone is not far below the lowest of the Prairie Bluff sands.

Moscow.—On the Tombigbee River we have seen only one locality where the strata of this division of the Cretaceous appear, and that is at Moscow, a mile or two above Black Bluff, already described.

(*j*) *Section exposed at Moscow and below, Tombigbee River.* (*Plate XIX, Fig. 7, p.* 171.).

1. Black, shaly clay, devoid of fossils, but containing a few rounded, concretionary masses like fucoids. This stratum appears below the Moscow Landing and in the principal stratum at the mouth of Sucarnochee River. Thin layers of calcite lie upon this clay, having been weathered out from between the layers of clay, in all.....6 to 8 feet.
2. Dark blue, shaly, argillaceous limestone, with thin, projecting ledges of harder material, 10 to 12 feet thick near Moscow, but down the river thickening up to.....20 or 30 feet.
3. Thin ledge made up almost entirely of the shells of the small Gryphæa (*Gryphæa vomer*), noticed also at Foster's Creek, in Gee's Bend.....8 to 12 inches.
4. Hard, white, argillaceous limestone, with *Exogyra costata*, *Gryphæa mutabilis*, &c.....10 feet.[1]

[1] Near the landing this bed is not less than 25 feet.—E. A. S.

This stratum is indurated near the top, forming a hard ledge which is highly fossiliferous, containing Exogyra, Gryphæa, *Nautilus Dekayi*, Baculites, and univalve shells in phosphatized casts. Many of these casts are covered with little lumps of reddish, phosphatic, clayey material, which has replaced the whole of the original matter of the shells. Casts of this kind have been noticed in the strata of this horizon all across the State to Barbour County and seem to be quite characteristic.

In this argillaceous limestone there is, near the top, a very irregular, hard ledge consisting in the main of comminuted shells embedded in a sandy matrix. This ledge is very variable in thickness, ranging from a mere line up to 10 feet, and is not conformable with the rest of the strata, but appears to form irregular concretionary or segregative masses in the limestone. It contains a considerable percentage of phosphoric acid. A similar phosphatic sandy bed appears at top of Prairie Bluff, at the base of the Canton Bluff, and in the bank of Foster's Creek, above described.

The dip of the strata at Moscow is very rapid down the stream, and at the same time irregular, being in places as much as 350 feet to the mile, in which respect it agrees with the dip at Prairie Bluff. It is to be remarked that the dip of the Tertiary beds nearest to these two sections, viz, Black Bluff on the Tombigbee and at Midway and at Matthews's Landing on the Alabama, is very much less, being only about thirty to thirty-five feet to the mile. The dip of the Ripley beds, indeed, especially near the top, seems to be considerably greater than that of the underlying Rotten Limestone and other Cretaceous strata.

In the summer of 1886 Mr. Langdon and myself made a more careful examination of the bluffs between Moscow and the cut off, just above the mouth of Sucarnochee Creek, a distance of a mile or two. We found the strata not only strongly undulating, but in six or eight places very distinctly faulted, with a displacement of perhaps ten feet maximum.

Good photographs were obtained of two of these faults, and diagrams were made of several others. A very careful measurement of the thicknesses of the several strata exposed here confirms the estimates above given in the Moscow section, except that the black clays may be a little thicker, and the white, argillaceous limestone, No. 4, is at least 25 feet thick at the landing. Our former measurement was made a short distance below, where only 10 feet of it were seen.

The pockets of cross bedded sandstone which are noted as occurring at irregular intervals in this limestone are of very limited extent and of varying thickness. In one or two instances they have been broken by the faults above noted. (See Plate X, p. 133.)

That which we find most difficult of explanation at Moscow is the passage from the undoubted Ripley limestone, which appears to be the same in horizon with the beds at the old Canton Landing, in Gee's Bend, at the mouth of Tear Up Creek, &c., to the black clays of the Black

Bluff section (Tertiary), without any show of the Bridgeport sandy clays and the Nautilus and the Turritella rocks. And as the black clays and the Cretaceous limestone are in actual contact, visible to the eye, we cannot explain the failure of these beds to appear here, by interruptions in the continuity of the river bluffs. It is possible that the black clays may be the representatives of the Bridgeport beds, but it is not probable, for the reason that they are lithologically identical with the clays of Black Bluff, which is hardly more than a mile distant.

For the sake of greater completeness, we give below a few sections obtained in the southern part of Dallas County where the Ripley beds are exposed. These localities have acquired a practical interest from the circumstance that they include a bed of phosphatic greensand which has been used with profit upon the soil as a fertilizer. In addition to this greensand bed, there is also a sandy, phosphatic limestone which may some day be utilized, since it holds a very considerable percentage of phosphoric acid.

Snow Hill to Minter.—The town of Snow Hill occupies the summit of a long ridge, at the southern end of which the Nautilus and the Turritella rocks of the lowermost Tertiary form the surface, while at the northern end of the ridge the underlying yellow sands are the surface materials. Descending this ridge towards the north, one passes over yellowish gray, micaceous sands, alternating with hard, sandy ledges which flake off under the action of the weather. These strata are the same as those exposed on the hillside near the old Canton Landing and on the hill north of Prairie Bluff. Near the residence of Mr. W. S. Purifoy, a mile or so from Snow Hill, we see some fifty or sixty feet of these sands and shales overlying a bed of phosphatic greensand three feet or more in thickness. The section here exposed is the following:

(*k*) *Section near W. S. Purifoy's, near Snow Hill.*

1. Yellowish, micaceous sands, in beds four or five feet thick, separated by ledges of sandier material, which flakes off in weathering.....50 to 60 feet.
2. Phosphatic greensand, holding concretions of white carbonate of lime and a good deal of soft, white lime.....4 feet.
   This greensand contains from 1.5 to 2 per cent of phosphoric acid. It lies very favorably at the foot of the hill, and at the level of the cultivated fields, and can be dug and spread upon the land with very little trouble or expense.
3. Hard, reddish or yellowish, phosphatic limestone, forming very irregular, concretionary masses.....1 foot.
4. Yellowish, calcareous clays containing great numbers of large *Exogyra costata*, *Gryphæa mutabilis*, &c.....20 feet.
5. Impure, argillaceous limestone, containing numbers of the shells above named, 10 to 15 feet.

This greensand has been tested practically by Mr. Purifoy, and with the most flattering results.

On Col. N. H. R. Dawson's place, adjoining Mr. Purifoy's on the north, the same beds are to be seen, together with some still lower. Below the greensand bed there are some sixty to seventy feet of calcareous, sandy

beds with hard ledges, and near the base of the series an impure limestone weathering into calcareous clays, in which are embedded great numbers of *Exogyra costata*, *Gryphæa mutabilis*, and phosphatized shell casts, prominent among which are *Nautilus Dekayi*, and *Scaphites Conradi*. This shell deposit lies about six feet above a bed of hard, silicious, phosphatic limestone or calcareous sandstone, which is the lowest of the strata here exposed.

Carlowville.—At Carlowville there is substantially the same section.

(*l*) *Section at Carlowville, Dallas County.*

1. A bed of phosphatic greensand holding much lime, in small concretions and in soft lumps easily crushed between the fingers.....4 feet or more.
2. A clayey, glauconitic limestone, which has been quarried for the purpose of building culverts on the railroad.....3 feet.
3. Yellowish, calcareous, sandy shales with hard sandy ledges. The color of this material, where wet and not exposed to the weather, is dark blue like that at Bridgeport .....60 feet.
   In the lower part of this there is an impure, argillaceous limestone which holds a great number of the two shells above named, together with casts (phosphatized) of others.
4. Hard, coarse grained, silicious limestone or calcareous sandstone .....2 feet.

Richmond.—A few miles southwest of Richmond, on the land of Dr. J. P. Keyser, we get a more complete section embracing beds which overlie the preceding, viz:

(*m*) *Section 3 miles southwest of Richmond, Dallas County.*

1. Sandy shales, hardening into a shaly sandstone, forming a conspicuous ledge along the hillsides. This is underlaid by about 20 feet of calcareous sandy clays, similar to those near old Canton Landing.....20 feet.
2. Calcareous, sandy ledge somewhat like the preceding, but perhaps more calcareous. This also overlies a series of calcareous shales, 35 feet or more.....40 feet.
3. Bed of phosphatic greensand, with lumps of soft white limestone and concretions of lime .....4 feet.
4. Impure, clayey, glauconitic limestone, making a shelf or ledge around the hill. sides.....3 to 5 feet.
5. Calcareous shales interstratified with beds of sandier material which form projecting ledges. These beds correspond in appearance to those forming the hill back of old Canton Landing, and where less exposed to the weather they still retain the dark blue color which is characteristic of them at Bridgeport. They hold the usual fossils in their lower strata, and in weathering give rise to the formation of a calcareous, clayey soil .....60 to 70 feet.
6. Hard, silicious limestone, coarse grained and phosphatic, appearing near the water level at base of the hills.....3 feet.

We have not yet given these localities the close examination which would enable us to say with certainty what their equivalents are; yet, from the position of the fossiliferous, impure limestone containing *Exogyra costata*, *Gryphæa mutabilis*, and the phosphatic shell casts above named, it seems quite probable that this greensand lies some 50 feet or more above the fossiliferous beds of old Canton Landing and of Prairie Bluff. I should also add that, below the phosphatic, silicious rock at

the base of the preceding sections, we have seen at other localities a yellow sand which is traversed by bands of silicious sandstone precisely as is the case at Prairie Bluff, so that we have very little doubt of the equivalence, although it is not certainly made out.[1]

These Upper Cretaceous rocks belonging to the Ripley formation have recently acquired a new interest from the circumstance that they are throughout the State very generally impregnated with phosphoric acid, often to such a degree as to render them available as materials for the manufacture of fertilizers. Thus the rock at Moscow and westward to Coatopa and Livingston and thence traced to Shuqualak, Miss., by Mr. Johnson, has been found to be phosphatic, and the same is true of the hard ledges of limestone rock occurring in the Canton bend, and thence eastward to Minter, and on to Fort Deposit, and thence to Chunnenugga Ridge and Union Springs. The occurrence and the characters of these phosphatic rocks will be more fully described at another place.

§ 2. THE ROTTEN LIMESTONE.

The next subdivision of the Cretaceous group, viz, the Rotten Limestone, extends for many miles along both the rivers, and, assuming a uniform dip of 25 to 30 feet to the mile, its thickness cannot be much less than 930 to 1,200 feet. The rock is of comparatively uniform composition, being a gray to bluish colored, argillaceous limestone, traversed at intervals by beds of purer limestone which is at the same time usually a little harder in texture. In some places the material is a dark bluish clay marl, in appearance not altogether unlike some of the blue or black clays at the base of the Tertiary group. The fossils of the Rotten Limestone are principally Exogyra, Gryphæa, and Ostrea, but in the upper and lower parts other forms become more abundant, forming transitions to the overlying and underlying subdivisions.

The best general view of the strata of the Rotten Limestone is afforded by the record of a boring for an artesian well at Livingston, Sumter County. The town is situated on the line of junction of the Rotten Limestone and Ripley formations, and the boring, therefore, passes through the whole of the former into the underlying Eutaw greensands. The boring was made from December, 1854, to March, 1857, and the record was carefully kept by Dr. R. D. Webb. The thickness of Rotten Limestone proper penetrated by this boring is 930 feet, the underlying sands and greensands belonging probably, for the most part, to the next division. The uppermost 20 feet are certainly in part drift and probably in part Ripley formation, though there are no fossils to decide the matter definitely.

[1] A bed of phosphatic greensand was discovered in 1886 by Mr. Langdon and myself at Prairie Bluff just overlying the limestone strata. Whether this is the same as the bed above described or a different one, we are not yet prepared to say.—E. A. S.

Section of the Rotten Limestone at Livingston, Sumter County. (*See Plate XXI, Column 4, p. 183.*)

	Materials.	Depth in feet.
1	Sandy loam, 1 foot	1
2	Coarse, dry sand, stratified, 12 feet	13
3	White quicksand (had to be curbed), 7 feet	20
4	Soft, rotten, blue limestone, thickly set with shells and containing iron	
5	pyrites, 180 feet	200
	White limestone, harder than the preceding, with very few if any shells	
	or pyrites, 50 feet	250
6	Hard, blue limestone, so hard that the auger cuts it with difficulty, clear	
	of shells and pyrites, 7 feet	257
7	Bluish white limestone, not so hard as the preceding, clear of shells and	
	pyrites, 68 feet	325
8	Very hard, white limestone, 55 feet	380
	At 330 feet, passed through a stratum of oyster shells from which a speci-	
	men very much resembling an egg was brought up.	
9	Light blue limestone, not so hard as No. 8, but harder than No. 4, 47 feet.	427
10	Bluish brown rock, filled with small shells. In this there was more sand	
	than in the blue or white varieties of rock, 58 feet	485
11	Hard, white rock, 105 feet	590
12	Soft, reddish brown rock, 2 feet	592
13	Soft rock of deep blue color, 20 feet	612
14	Brownish blue rock, moderately soft, 78 feet	690
15	Hard, gritty, bluish colored rock, so hard that it had to be drilled, 6 or 8	
	inches	690
16	Dark bluish colored rock, easily cut by auger, 10 feet	700
17	Soft, whitish limestone, with occasional slight change in hardness and	
	color, 250 feet	950
18	Hard sandstone, 6 feet	956
19	Sand, in which, at 964 feet, a small stream of water was reached, which	
	ran feebly from the top of the well, 10 feet	966
20	Sand rock, 1 foot	967
21	Coarse greensand, in which a larger stream of water was reached at 1,005	
	feet depth, 38 feet	1,005
22	Sandstone, 2 feet	1,007
23	Greensand, 25 feet	1,032
24	Sandstone, 2 feet	1,034
25	Coarse greensand, 18 feet	1,052
26	Flint rock (crystallized), 1 foot	1,053
27	Very fine greensand, 9 feet	1,062
	In this greensand the well was stopped at a depth of 1,062 feet.	

In the following notes are given the characters of the Rotten Limestone as shown in a few prominent bluffs along the rivers, without any attempt to fix absolutely their position in the vertical scale of the boring.

The great degree of uniformity in the lithological characters and fossil contents of the different parts of the Rotten Limestone makes it impossible as yet to give the precise place in the vertical section of its ex-

posures described below, with the exception of those which include the phosphatic greensands immediately below the limestone proper. We have, therefore, not attempted to represent the main body of the limestone except in the single plate illustrating the boring at Livingston; but in Plate XX we have given several figures illustrating the contact of the Rotten Limestone with the underlying, sandy beds.

EXPOSURES OF ROTTEN LIMESTONE.

About eight or nine miles above Moscow landing there is at Barton's Bluff an exposure of about sixty feet, consisting of dark bluish, clayey limestone, or perhaps better described a blue marl, with several harder ledges projecting from the face of the bluff. These ledges hold a good many fossils, the principal forms being *Ostrea falcata* in the upper ledges and large Gryphæa and Exogyra in the lower ones. These dark, clayey, limestone bluffs continue up the river to within nine miles of Demopolis. They are probably represented by No. 4 of the boring.

On the Alabama a similar material makes the bluff at Lexington Landing, and it holds also a large number of shells, especially those of Exogyra and other oysters.

At Demopolis the bluff is made of a very compact, light blue or gray limestone, which does not seem to be very highly fossiliferous. A similar limestone makes the bluffs for several miles down the river, nearly to Barton's Bluff, where, as already stated, it is more argillaceous and darker in color.

On the Alabama the counterpart of the Demopolis Bluff may be seen at Elm Bluff and at White Bluff.

The same rocks may also be seen on the Upper Tombigbee River (above the mouth of the Tuscaloosa) at Jones's Bluff, where the railroad bridge crosses the river.

Underlying the Demopolis limestone there is a stratum of undetermined thickness of a tolerably pure limestone of light yellow color, filled with concretionary lumps, cylinders, &c., of clay. When this clay washes out it leaves the limestone perforated in every direction, which circumstance is referred to in the name "bored rock." Below Arcola this bored rock is quite thick, and has bedding planes two or three feet apart, which cause the rock to break up into large cubical blocks.

At Arcola and at Hatch's Bluff, on the Tuscaloosa, the bored rock is near the top of the bluff, and underlying it is softer and crumbling Rotten Limestone of the usual character. The bored rock has sometimes been burned for lime, and its outcrop may be followed westward as far at least as Sherman, in Sumter County. It forms a rocky ridge wherever it comes to the surface.

The limestone underlying the bored rock for many feet is tolerably uniform in composition and resembles that of the Demopolis Bluff, except that it is, if anything, rather more argillaceous and less compact,

being rather a white, calcareous clay than a limestone. There is nothing of interest to record at any of the bluffs of the river from Hatch's Bluff up to Wolf's Bluff, just above Cowan's Landing.

Here come in the strata, still better exposed higher up at Erie and at Choctaw Bluff, which form the transition between the Rotten Limestone and the sands of the Eutaw formation, and which probably represent the Tombigbee Sand group of Dr. E. W. Hilgard, if this group has its counterpart on the Tuscaloosa River.

Characteristic fossils of this horizon appear to be certain reptilian bones, Mosasaurus, the curious Hippurites, teeth of sharks, and large palatal teeth (*Ptychodus Mortoni* and others).

The lowermost strata of the Rotten Limestone (calcareous clays) also contain many of these fossils, and in addition to those mentioned, shells of Inoceramus in great numbers and of great size. These shells are of fibrous texture, the thickness of the shell (half an inch or less) forming the length of the fibres. In consequence of this structure the shells are very fragile and it is impossible to take them out unbroken except by removing a block of the matrix rock with them.

In no localities have I seen them in greater numbers and of larger size than in the long bluff at Fairfield, on the Tombigbee River, in the southern part of Pickens County, and in the fields back of House Bluff, on the Alabama River, in Autauga County. In the former place they are perfectly preserved, and many of them are more than a foot in diameter.

Near House Bluff they are seen in the old fields, associated with Leiodon bones, sharks' teeth, and phosphatic greensands. In the weathering of rock they break into fragments which, though slightly separated, retain their relative position and preserve the outline of the shell. In many cases these fragments cover a space three feet in diameter, indicating the size of the shell as at least two feet in diameter.

These would probably form the first of the transition beds above mentioned.

On the Alabama River these beds make their appearance above the latitude of Selma at Cunningham's and House Bluffs. Inasmuch as their paleontologic relations have not yet been determined and as they are more closely related in lithologic character to the Eutaw, we have thought it best to combine them with the latter formation in our description. The first five sections in the next division exhibit the Rotten Limestone in connection with the next underlying beds.

§ 3. THE EUTAW FORMATION.

As noted above, the sandy, fossiliferous strata lying beneath the argillaceous and calcareous rocks whose lithologic character is so well defined by the name of Rotten Limestone are referred by us to the Eutaw formation. In striking contrast with the Rotten Limestone, this series of deposits consists of sands and clays with little or no calcareous

matter except in the uppermost 25 or 30 feet spoken of above as forming a transition between the Rotten Limestone proper and the sands of the undoubted Eutaw.

This upper member of the Eutaw formation consists at the summit of a bed 5 feet in thickness of indurated, calcareous sands, with numerous fossils and irregularly shaped nodules of nearly pure phosphate of lime, together with many highly phosphatized shell casts, and in addition the sand itself is very generally phosphatic. Below this bed there are 15 feet of sand with comparatively few fossils, except in a thin layer of compacted shells at the base and in two or three similar shell layers dividing the sand at different horizons. These shell beds are also usually phosphatic. Beneath the lowest comes a bed of greensand 6 to 8 feet in thickness, which is distinguished by its high percentage (5 per cent. and above) of phosphoric acid. These phosphatic and calcareous beds have been less closely examined on the Alabama River than on the Tombigbee, where they appear to be somewhat thicker.

The bulk of the lower and principal member of the Eutaw formation consists of cross bedded sands, with subordinate beds of pebbles and of thinly laminated clays with sandy partings in many alternations. The exact sequence of these beds is known only for about 80 or 90 feet below the phosphatic strata above mentioned. (See profile at the House Bluff, Alabama River, Pl. XX, Fig. 5, p. 175.)

The most striking peculiarities of the various beds of the lower member of the Eutaw formation are found in the abrupt changes which they undergo in both the vertical and horizontal directions. The dark gray, laminated clays with sandy partings seen at Finch's Ferry, Tuscaloosa River, may also be seen farther up the river at Semple's Bluff and at Brown's Bluff, and with nearly the same characters in all three localities. With this exception, however, I know of none of the Eutaw beds which preserve their characters with anything like uniformity for more than a few rods. Laminated clays pass into cross bedded sands or rather are replaced by them; cross bedded sands thin out abruptly, as if forming lenticular masses; the pebble beds thicken up and thin down rapidly within a few yards' distance; and indeed it is impossible to follow any of the beds with certainty from one end of a long bluff to the other, and it would be well nigh impossible to get two vertical sections of a bluff, 100 yards apart, which would exhibit the same sequence of materials. Two examples will illustrate my meaning. At Stave Bluff, Tuscaloosa River, half a mile long, we see at the upper end and near the center of the bluff a preponderance of laminated clays with thin intervening sheets of cross bedded sands, but at the lower end of the bluff the clays disappear or cease, not, however, by dipping below the water level, but abruptly, and they are replaced by thick beds of yellow sand which neither overlie nor underlie the clays, but are substituted for them on the same horizon. Again, at Merriwether's Landing, farther up the river, where the bluff is perhaps half a mile long, at the landing (upper

end of the bluff) we find the bluff made up of laminated clays with sand partings, the sand partings becoming thicker and thicker as we descend, and assuming within 10 feet of the water the character of cross bedded sands with thin clay sheets following some of the lines of false bedding. One hundred yards or less below the landing the whole bluff appears to be cross bedded sands with clay seams, including, about twenty feet above the water, a 10 foot bed of sand. These change again, not because of the dipping of the strata below the river level, but because of the replacement at the same horizon of one set of beds by another.

The great mass of the Eutaw formation seems to have been deposited in shallow water by ever varying currents.

The absence of all fossils except an occasional lignitized tree trunk and the lack of any persistent or easily identified beds of any kind make it impossible for us here to sum up the thickness as we have done in the Tertiary group, and we are therefore compelled to rely either upon width of outcrop across the country of the beds of this formation or upon the borings for artesian wells. The thickness of the beds of this formation, estimated from their outcrop along the banks of the Tuscaloosa River from Finch's Ferry to Big Log Shoals, on an assumed uniform dip of 40 feet to the mile, is about 200 feet; but this estimate is probably too small. Between Big Log Shoals and White's Bluff no Cretaceous rocks are exposed on the river, but they may be seen upon the neighboring hills, and recent observations of Mr. Langdon and myself indicate that this stretch of the river is almost entirely underlaid by the beds of the Eutaw formation; and if this is so their total thickness can hardly be less than 300 feet. This estimate is confirmed by the width of the outcrop of the Eutaw beds upon the hills on both sides of the Tuscaloosa River. On the eastern side, in Hale County, they are found from three miles south of Havana down to Greensborough, and on the western side, in Green County, from just south of Knoxville down to Eutaw, or in each case about 10 miles in a direct line across the strike. This with a uniform dip of 30 feet to the mile would correspond to a thickness of 300 feet, and with a dip of 40 feet per mile to 400 feet; 300 feet may therefore be given as the minimum thickness of these beds along the Tuscaloosa. A boring now in progress at Eutaw reached the purple clays of the Tuscaloosa formation at a depth of 400 feet; which indicates a thickness for the formation nearly the same as that estimated from the width of outcrop and dip. The corresponding portion of the course of the Alabama River—i. e., between Selma and Montgomery—is such that the lowermost members of this formation are not there exposed.

SECTIONS OF THE EUTAW FORMATION.

The following sections illustrate fairly well the lithologic and other peculiarities of the Eutaw formation, including the transitional beds, which may hereafter, upon paleontologic grounds, be classed with the Rotten Limestone.

(*a*) *Section of the bluff at Erie, Tuscaloosa River.* (*Plate XX, Fig.* 1, *p.* 175.)

1. Rotten Limestone of usual character ..... 30 feet.
2. Indurated ledge of calcareous sand, containing grains of glauconite, strongly phosphatic and in part filled with oyster shells ..... 5 to 8 feet.
3. Yellowish sands containing shells in the upper part, and thus forming a continuation of the preceding ..... 8 feet.
4. Projecting hard ledge filled with small bivalve shells, chiefly oysters, 8 to 12 inches.
5. Yellowish sands, with some glauconite, becoming more and more glauconitic as we descend ..... 5 to 6 feet.

   The lower part of this stratum, say one or two feet, is indurated, shells become more abundant, and there is thus a gradual transition into the next underlying bed. In these sands, which are hollowed out from beneath the preceding ledge, there are embedded some curious stalagmitic formations, of indurated calcareous sand, which stand up like small pillars. These are strongly phosphatic, and have much the appearance and composition of the ledge No. 4.
6. Indurated ledge of sand, greensand, and shells, mostly oysters, like that at Choctaw Bluff ..... 1 foot.
7. Greensand, cross bedded ..... 3 to 4 feet.
8. Laminated, blue clay, in several distinct layers, which project from the vertical faces formed by the greensand above and below it ..... 2 feet.
9. Greensand like No. 7, but with more glauconite to water's edge; contains much phosphoric acid ..... 1 foot.

Just above Erie there is a great southwestward bend in the river, by reason of which only the Rotten Limestone appears in the river banks, the greensands being all below the water level. This condition of things continues up to McAlpine's Ferry, where we have the following:

(*b*) *Section near McAlpine's Ferry, Tuscaloosa River.* (*Plate XX, Fig.* 2, *p.* 175.)

1. Rotten Limestone of variable thickness, with a covering of drift above it.
2. Calcareous sands, indurated and glauconitic, partly filled with shells, mostly oysters ..... 6 to 8 feet.
3. Sands ..... 8 to 10 feet.
4. Greensand to water's edge ..... 6 feet or more.

From Eastport, just above McAlpine's Ferry, up to Melton's Bluff the course of the river is nearly along the strike of the strata, and we have practically the same beds as those above described at Erie along this stretch of the river. The undulations which are usually observed along the outcropping edges of our Tertiary and Cretaceous strata may be seen here also.

(*c*) *Section at Melton's Bluff and Eastport, Tuscaloosa River.*

1. Cross bedded sands, grading off below into greensand ..... 10 feet.
2. Greensand, forming a bench or ledge 6 to 8 feet broad and 3 feet thick down to the water's edge.

Between Melton's Bluff and Choctaw Bluff another great southwestward bend in the river causes the greensands to disappear below the water level, to reappear near the last named bluff, where we get the following very interesting section, which, however, embraces practically the same beds with the Erie bluff, the two places being situated from each other in the direction of the strike of the strata.

(*d*) *Section at Choctaw Bluff, Greene County, Tuscaloosa River.* (*Plate XX, Fig. 3, p. 175.*)

1. Rotten Limestone of the usual appearance, with a cover of drift or second bottom deposits. The rock contains some fossils, Inocerami, and bones of reptiles, 20 feet or more.
2. Indurated, calcareous sands, with some glauconite, filled with shells, mostly *Exogyra*, forming a projecting ledge, which is a very prominent and persistent mark along the face of the bluff[1] ..... 6 to 7 feet.
3. Yellowish, cross bedded sands, shading off above into the fossiliferous ledge. These sands become more and more glauconitic and devoid of fossils below ..... 15 feet.
4. Indurated ledge of glauconitic sands and small oysters, slightly effervescent, phosphatic ..... 1 foot.
5. Highly glauconitic sands, strongly phosphatic. These sands show above the water at the upper end of the bluff 6 to 8 feet, but sink below the water at the lower end, making a dip of about 20 feet to the mile along this stretch of the river.

This section shows well the point of contact of the Rotten Limestone with the glauconitic beds below it. The beds immediately under the Rotten Limestone are coarse, calcareous sands, somewhat indurated and filled with the shells of Exogyra, No. 2 above. Both the Rotten Limestone and the ledge are filled with nodular masses of iron pyrites. One mile below this, at Stevens's Bluff, the sands are all below the water, and only the Rotten Limestone above it; the same is true of the banks at Hamlet's Shoals. These beds, as above intimated, have acquired a considerable interest from the fact that most of them are strongly impregnated with phosphoric acid. This seems to be particularly the case with the glauconitic sands, especially when they are indurated; and in many cases the induration seems to be due to the formation of phosphates. Wherever the beds immediately underlying the Rotten Limestone have been examined, from the Mississippi line eastward to Wetumpka, and even farther toward the Georgia line, they have been distinguished by containing very notable quantities of phosphate of lime, either impregnating the greensands in a general way or concentrated into irregularly shaped nodules of nearly pure phosphate of lime. These, should they ever be found in sufficient quantity, will be of great value as an article of export. The phosphatic greensands, without the least doubt, can be very profitably used as fertilizers where they are convenient to transportation. This subject, however, will be more specially treated in the report of the Geological Survey of Alabama.

At Finch's Ferry, near Eutaw, on the Tuscaloosa River, there is a bluff which varies from 50 to 75 feet in height, in which strata underlying the phosphatic sands of Choctaw Bluff are seen. The upper 25 to 40 feet of this bluff (according to locality) consist of yellowish, cross bedded sands, in which a few indistinct fossils have been found, and below this some 25 feet of alternating blue clays and cross bedded sands;

[1] This bed has been called "Concrete Sand" by Prof. A. Winchell, and the next below it, "Loose Sand" (Proceedings Am. Assoc. Adv. Sci., Vol. X, Part II, p. 92, 1856). He, however, limits the former name to the first 2 or 3 feet below the Rotten Limestone.

then, forming base of the bluff, about 20 feet of laminated, blue clays, with partings of sand. No fossils have yet been observed in these lower beds.

(e) *Section at Finch's Ferry, Tuscaloosa River.* (*Plate XX, Fig.* 4, *p.* 175.)

1. Yellowish, cross bedded sands, with indurated bands at intervals. This sand contains a few casts of shells, mostly oysters, and pieces of silicified wood..25 to 40 feet.
2. Laminated, blue clays, with partings of sand.....10 feet.
3. Alternations of cross bedded sands and blue, laminated clays.....5 feet.
4. Bluish, glauconitic sands .....10 feet.
5. Laminated, blue clays, the laminæ separated by thin sand partings.....20 feet.

The exact position of this section with reference to that at Choctaw Bluff is not certainly made out, but it is quite possible that some of the lowermost of the Choctaw Bluff beds may appear in the highest parts of the bluff at Finch's Ferry. At all events the two sections are very nearly conterminous.

On the Alabama River the same beds are seen at the Batte Smith Bluff, Cunningham's Bluff, and the House Bluff.

At the last-named locality we have perhaps the best section of the transition beds between the Rotten Limestone and the Eutaw formations to be seen in the State.

This bluff, gapped by ravines, forms the northern bank of the river for a mile or more at the top of one of those long bends made by the Alabama in this part of the State. Near the lower or western end of the bluff, where these gaps are close together, the sharp crested, interjacent ridges come out to the face of the bluff in cross section like the gable ends of a house, whence the name of the bluff.

The uppermost (i. e., most eastern) of these bluffs has about thirty feet of Rotten Limestone on top, and the washings from this have whitened all the underlying red and yellow sands, so that if not closely examined the white bluff would easily be mistaken for limestone throughout. The next bluff below separated from this by a narrow ravine only, and of nearly the same height, consists of yellow, cross bedded sands to the very top. The absence of the Rotten Limestone on top of this second bluff and its presence on top of the next succeeding or third bluff are due to undulations in the strata. The contrast between the first two bluffs is very striking. The uppermost bluff is probably the highest of the set and is about one hundred and fifty feet high, and the strata exposed in it are the following:

(f) *Section of the House Bluff.* (*Plate XX, Fig.* 5, *p.* 175.)

1. Rotten Limestone.....20 to 30 feet.
2. Greensand, with phosphatic nodules.....4 feet.
3. Conglomerate of shells embedded in loose sand.....1 foot.
4. Light colored sands, with irregular deposits of shells and a six inch layer of shells at bottom.....5 feet.
5. Sands 8 feet, with a layer of shells at bottom, 1 foot, in all.....9 feet.[1]

[1] Nos. 2 to 5, inclusive, constitute the "Concrete Sand" of Dr. Winchell.

6. Alternating beds of horizontally laminated and cross bedded sands, yellow (glauconitic); the separate beds from 1 to 2 feet thick. These beds are marked with numerous streaks deeply colored with iron ..... 40 to 50 feet.
7. Laminated clays (soapstone), devoid of fossils ..... 10 feet.
8. Blue, micaceous sands, no fossils ..... 15 feet.
9. Light colored sands, with large, bowlder-like concretions of concentric layers ..... 20 feet.
10. Alternations of the laminated clays and blue sands above described down to the water level.

The great irregularity in the stratification of the sands of this formation is well exhibited in the House Bluff, where hardly any two sections will show the same sequence of beds. The following section of this bluff was taken by me in the summer of 1886, and shows the stratification of the first quarter of a mile of the bluff rather than that of a single locality:

(f^1) *Section of the upper part of House Bluff.*

1. Rotten Limestone, including near the base a bed of phosphatic greensand four and a half feet in thickness ..... 30 feet.
2. Ledge of oyster shells embedded in sands, forming a hard ledge ..... 8 inches.
3. Whitish sands ..... 8 to 10 feet.
4. Ledge of shells like No. 2 ..... 8 to 11 inches.
5. Yellowish, cross bedded sands, indurating into rounded, bowlder-like masses of concentric structure. On the weathering and caving of the bluff, these bowlders break off and roll down to the water's edge and cover all the slope below them. The two hard ledges of shell conglomerate also break off in a similar way, and their fragments also cover the slope below ..... 50 to 60 feet.
6. Yellowish, cross bedded sands like the preceding, except that they are traversed by clay bands and partings of very irregular thickness and extent ..... 10 feet.
7. Compact sands, making a smooth, perpendicular face ..... 15 feet.
8. Cross bedded sands, the lower part containing gray clay partings, and in the lowermost 5 feet merging into bluish gray, laminated clays ..... 15 feet.
9. Blue sands to the water's edge ..... 5 feet.

The resemblance between this section and those of Choctaw Bluff and Finch's Ferry, Tuscaloosa River, is sufficiently strong to justify us in correlating them in a general way, though we cannot, of course, expect to find absolute identity in the individual beds.

The two ledges of shell conglomerate appear in the hills in many places westward of this bluff. Between the two Mulberry creeks, one and a half miles west of Statesville, they are nearly at the general level of the high table lands; and everywhere about seven or eight feet above the upper of these ledges, appears the bed of phosphatic greensand, so well known in the vicinity of Hamburg, in Perry County. These beds rise toward the north and appear in several places in Autauga County, high up on the hills. In the vicinity of the old Slaton place and the old Jim Brown place, the shell conglomerate and the greensands are exposed over a large territory.

All the bluffs of the Alabama River, from House Bluff up to Montgomery, show more or less of the House Bluff beds, according to the windings of the river. At Washington Ferry the banks are made of

the laminated gray clays with interbedded sands, which are seen near the base of House Bluff. About two hundred yards above the Washington Ferry there is a high red bluff showing the following:

(f^2) *Section of bluff near Washington Ferry, Autauga County.*

1. Drift and red loam ..... 10 to 15 feet
2. Cross bedded, yellow sands, stained deep red by the washings from No. 1.. 50 feet.
3. Laminated clays and sands ..... 50 feet.

No. 2 above corresponds with No. 5 of my House Bluff section, while No. 3 corresponds to the rest of the House Bluff.

The river bluff, just below the steamboat landing at Montgomery, shows the following:

(f^3) *Section at Montgomery.*

1. Drift (very closely resembling what we have called second bottom deposits), 15 to 20 feet.
2. Laminated, gray sands, with gray clay partings ..... 3 feet.
3. Gray clayey sands, with white and gray clay partings ..... 4 feet.
4. Rather compact, yellow sands with small, lens-shaped, spherical, and other irregularly shaped masses of pure, gray clay scattered through the mass of sands. These form the greater part of the perpendicular bluff to the river below the drift deposits, and extend to the water's edge ..... 25 to 30 feet.

Where the Rotten Limestone is seen at the summit of the bluff, as at Choctaw Bluff and at House Bluff, the geological horizon of the underlying beds of the section is at once determined. The uncertainty is felt only in regard to the exact relative position of the Finch's Ferry beds and those where the Rotten Limestone is absent.

Between Finch's Ferry and Big Log Shoals, a distance of four and a quarter miles or a little more, across the strike, which corresponds to a thickness of about one hundred and fifty feet of strata, the banks of the river are composed of laminated, bluish clays and cross bedded, glauconitic sands, in many alternations. Interbedded with these, at two or three points, are thin beds of pebbles, from eight to twelve inches thick, and thin layers of lignitic matter, consisting of lignitized stems, twigs, and other fragments, embedded in bluish sands. In addition to these, lignitized trunks of trees are not infrequently seen at many of the exposures. Occasionally, also, a silicified trunk is to be found lying upon the bluff, but whether derived from the Cretaceous or from the overlying drift deposits is still a matter of doubt.

It has as yet been impossible to ascertain the actual sequence of these different beds for the whole distance mentioned above, but the following detailed sections will probably cover nearly their entire thickness.

Immediately below the laminated clays which form the base of the exposure at Finch's Ferry, come alternations of similar laminated clays, with cross bedded sands many feet in thickness, which are to be seen at Semple's Bluff, just above the railroad bridge, and at Collins's wood yard, where about ten feet of thickness are to be seen.

Childs's Ferry.—At Childs's Ferry similar strata are exposed, the bluff being some thirty feet high. The lower part of this exposure consists, without doubt, of the same beds as those at the top of the bluff at Merriwether's Landing, given below:

(*g*) *Section at Merriwether's Landing, Tuscaloosa River.*

1. Laminated clays and sands; the sands are bluish green in color when freshly exposed, but become yellowish on weathering.....10 to 15 feet.
2. Sands .....7 to 8 feet.
3. Laminated sands and clays again to the water's edge.....20 feet or more.

Much of the blue clay in the lower part of this bluff breaks up on drying into small chips, which are covered with white efflorescence derived from the oxidation of iron pyrites, nodules of which are of common occurrence in the clay. Along the bluff are to be seen many trunks of trees, either lignitized or silicified.

The lowermost five or ten feet of the beds exposed at Merriwether's are seen again at the top of the bluff at Long Bend, where the following section is exposed:

(*h*) *Section at the head of Long Bend, Tuscaloosa River.*

1. Cross bedded sands forming top of bluff.....5 to 10 feet.
2. Laminated, blue clays.....2 to 3 feet.
3. Bed of quartz pebbles.....2 to 3 feet.
4. Laminated, blue clays again, containing galls or concretions of pure, light colored clay.....4 to 5 feet.
5. Coarse grained, yellowish sands, strongly cross bedded, running down to the water level.....5 feet or more.

Hickman's.—At Hickman's, below Big Log Shoals, the bluff is made up of laminated clays alternating with cross bedded sands in the most irregular manner. The thickness of these beds was not estimated, but their relative position is as follows:

(*i*) *Section at Hickman's, Tuscaloosa River.*

1. Cross bedded sands of yellowish color on exposed surfaces, probably 10 feet or more in thickness.
2. Laminated, blue clays, more or less sandy and containing lignitized tree trunks, which are, in general, pyritous. The laminated, blue strata in the upper part of this division are much more clayey than those in the lower part, and mark the bluff with parallel and approximately horizontal stripings, probably 5 to 10 feet.
3. Cross bedded sands again down to the water's edge.

At the head of Big Log Shoals we have another section of ten or twelve feet, as follows:

(*j*) *Section at the head of Big Log Shoals, Tuscaloosa River.*

1. Compact, blue, micaceous sands.....3 to 4 feet.
2. Laminated sands .....3 to 4 feet.
3. Lignitic stratum, consisting of lignitized twigs, stems, and other fragments, embedded in bluish sands.....1 foot.
4. Alternating layers of blue clay and bluish, micaceous sands, the latter including a bed of pebbles 8 to 10 inches in thickness.....4 to 5 feet.

This section represents the lowermost of the blue clays and cross bedded sands, which we have considered as belonging to the Eutaw formation of the Cretaceous group, leaving undetermined some seventy-five feet from this to White's Bluff. At the latter begins what we shall now call the Tuscaloosa formation.

III. OTHER MESOZOIC STRATA, PROBABLY CRETACEOUS.

§ 1. THE TUSCALOOSA FORMATION.

Underlying the strata last described, and forming all the country between White's Bluff and the city of Tuscaloosa, are beds whose age has not been certainly determined.

The most conspicuous rocks are purple and mottled clays interstratified with white, yellowish white, pink, and light purple, micaceous sands, and near the base of the formation dark gray, nearly black, thinly laminated clays, with sand partings. Typical sections of the mottled clays and white sands may be seen at Steele's Bluff and at White's Bluff on the Tuscaloosa River; and a beautiful section of the pink, micaceous sands is exposed in two large gullies below Havana, in Hale County, near the residence of Hon. A. M. Avery. The dark gray, laminated clays are well seen near and in the city of Tuscaloosa.

All the beds of this formation, being of loose clays and still less coherent sands, have suffered a great amount of denudation, and in consequence they form the banks of the river at only a few points.

(1) SUMMARY OF PREVIOUS OBSERVATIONS AND OPINIONS.

The peculiar formation above described appears to have been observed a third of a century ago by Prof. L. Harper, then State Geologist of Mississippi, and by Prof. Alexander Winchell.

In 1856 Professor Harper described three specimens of *Ceratites*, which he called *C. Americanus*,[1] found by him in 1853 in the bed of the Tuscaloosa (or Warrior) River near Erie, and pronounced by the elder Agassiz "closely allied to *Ceratites Syriacus* of L. v. Buch," from the Cretaceous rocks of the Caucasus. Professor Harper considered it "somewhat doubtful" whether this was a Cretaceous fossil, and suggested that it was washed out from the formation underlying the known Cretaceous beds of that section of Alabama. He adds: "What formation this is seems difficult to decide, it being devoid of fossils. It must, of course, be one of the older formations intermediate between the coal [Carboniferous] and the lime [Cretaceous], and I should not at all be astonished if a careful examination should give the result of its classification among the poikilitic rocks, to which this variegated clay bears great resemblance."[2] Subsequently, in his Report on the Geology of

[1] Proc. Acad. Nat. Sci. Phila., Vol. VIII, pp. 126-128.
[2] Ibid., p. 28.

Mississippi,[1] he speaks of the occurrence of a clay of greenish blue color with red streaks, penetrated by a boring for an artesian well at Columbus, Miss., and he looks upon the occurrence of this clay as an evidence that "there exists between the Cretaceous and the Carboniferous formations an intermediate one, perhaps the Permian;" and in the same connection he again mentions the occurrence of great beds of variegated clays below the greensand of the Cretaceous formation above the town of Eutaw, in Alabama, and repeats his suggestion that the three specimens of Ceratites were "most probably washed out of a formation underlying the Cretaceous formation." With respect to the age of the infracretaceous formation he adds: "The *Ceratites* being especially a fossil of the Triassic formation, it is possible that this formation underlies the Cretaceous."[2]

In 1856, also, Professor Winchell mentioned the beds of sand and clay which underlie the sands of Finch's Ferry, remarked upon the variegated and mottled colors of the clays and also of the red sandstone, and added that in Greene County many of the artesian wells which penetrate these beds furnish a constant supply of salt water (showing the occurrence of local deposits of salt), while the deeper borings brought up an abundance of quartzose pebbles; all of which he considers compatible with the supposition that these deposits are of Triassic age.[3] This supposition is still further strengthened by the occurrence of "remains of vegetables appearing like the stems and leaves of dicotyledonous plants, * * * some specimens of which appeared to me indistinctly allied to stems of *Equisetites*." Professor Winchell also remarks upon the great scarcity of any organic remains in all these beds, extending to the very suburbs of the city of Tuscaloosa, which, he says, "renders the determination of their age extremely doubtful;"[4] and he is evidently not fully convinced of the Triassic age of the beds, since in his table of principal strata,[5] he includes them in the Lower Cretaceous.

From these extracts it seems certain that both Harper and Winchell were aware of the existence of this formation as early as 1856, if not in 1853. No unmistakable reference to these strata has been found in Professor Tuomey's writings, though he must have known of the observations of the two gentlemen above named. It must be remembered, however, that at the time of his death Professor Tuomey had a large number of unpublished notes on the geology of Alabama, many of which have been lost. It is true that in 1850 Tuomey described certain "superficial beds of red loam," &c.,[6] and that as early as 1846 Lyell mentioned "great beds of gravel and sand" in the vicinity

[1] Prel. Rep. Geol. and Agric. Miss., p. 279, 1857.
[2] Ibid., p. 282.
[3] Proc. Am. Assoc. Adv. Sci., Vol. X, Part II, p. 92, 1856.
[4] Ibid., p. 93.
[5] Ibid., p. 84.
[6] First Rien. Rep. Geol. Ala., p. 164, 1850.

of Tuscaloosa;[1] but these great beds of gravel, sand, and loam which constitute so large a proportion of the surface material about Tuscaloosa are undoubtedly, as Professor Tuomey has said, of comparatively recent age, though possibly derived primarily from a Mesozoic formation. Certainly neither Lyell's nor Tuomey's description applies to the predominant beds of the Tuscaloosa formation, and it appears equally certain that, when their descriptions were written, neither of these authors had in view the laminated and mottled clays of the formation, which appear only here and there in comparatively insignificant exposures in a few of the gullies back of the city, the majority of these gullies exposing only post-Tertiary gravels and sands.

The age of the various Mesozoic deposits of Alabama was discussed at great length nearly thirty years ago by Hall, Meek, Conrad, Hayden, and others.

In 1855 Hall and Meek, referring to Tuomey's publications, classed the various Mesozoic strata of Alabama as Cretaceous.[2] Two years later Meek and Hayden, making use of the information published by Tuomey, Harper, and A. Winchell, together with additional matter privately communicated by the last named gentleman,[3] correlated the lower portion of the Alabama Mesozoic[4] with the lowest Cretaceous formation of New Jersey and Nebraska and the lower strata of Pyramid Mountain, New Mexico (regarded by Marcou as Jurassic and Triassic).[5] Among their conclusions are these:

7th. There is at the base of the Cretaceous system, at distantly separated localities in Nebraska, Kansas, Arkansas, Texas, New Mexico, Alabama, and New Jersey, if not indeed everywhere in North America where that system is well developed (at any rate east of the Rocky Mountains), a series of various colored clays and sandstones, and beds of sand, often of great thickness, in which organic remains, excepting leaves of apparently dicotyledonous plants, fossil wood, and obscure casts of shells, are very rarely found, but which everywhere preserves a uniformity of lithological and other characters, pointing unmistakably to a similarity of physical conditions during their deposition over immense areas.

8th. Although the weight of evidence thus far favors the conclusion that this lower series is of the age of the Lower Greensand, or Neocomian of the Old World, we yet want *positive* evidence that portions of it may not be older than any part of the Cretaceous system.[6]

---

[1] Quar. Jour. Geol. Soc., Vol. II, p. 280, 1846; Second Visit to North America, Vol. II, p. 79, 1855.

[2] Trans. Am. Acad., Vol. V, p. 380, 1855.

[3] Proc. Acad. Nat. Sci. Phila., Vol. IX, pp. 117–133, 1857.

[4] Described (Proc. Acad. Nat. Sci. Phila., Vol. IX, p. 126, 1857) as "beds of dark blue, soft shale or indurated clay, alternating with strata and seams of white and mottled clays, green and ferruginous sand, and dark, pyritiferous shale. No organic remains, but stems and leaves of apparently dicotyledonous plants and a few obscure casts of other fossils. *Ceratites Americana* of Harper, is, however, supposed to hold a position somewhere in this series."

[5] Pac. R. R. Rep., Vol. III, Résumé and Field Notes, p. 137, 1853–'54.

[6] Proc. Acad. Nat. Sci., Vol. IX, p. 133, 1857.

Later, in the same year, Hall[1] pointed out that Marcou's erroneous reference of the Pyramid Mountain beds to the Jurassic and Triassic was at least partly due to mistaken identification of certain fossils, and followed the former authors in definitively referring the several formations in question to the Cretaceous, of which the lower division is "represented by No. 1 of the Nebraska section, and including the various sandstones and shales or clays at the base of the formation in the Llano Estacado and other portions of New Mexico; and probably equivalent to the lower clay beds of New Jersey [and Alabama],[2] in which the only fossils yet known are of vegetable origin,"[3] while Conrad was of the opinion that the Cretaceous deposits of Alabama form a passage or intermediate stage between the Cretaceous strata of Texas" and those of New Jersey.[4] Subsequently Hilgard (who was unquestionably familiar with the suggestions of Harper and Winchell as to the pre-Cretaceous age of the clays and sands resting upon the Carboniferous strata in Alabama and Mississippi) united the beds immediately beneath the Tombigbee sands and the subjacent highly colored clays and sands, applied the name Eutaw group to the formation thus defined, and referred it to the Cretaceous.[5] In the following year Meek and Hayden re-expressed their convictions as to the age of the lowest Mesozoic beds of Alabama, correlated the beds subsequently described by J. S. Newberry[6] and B. F. Shumard[7] with the formation to which they had already referred these deposits, and applied to it the name Dakota group.[8] In 1869 Safford followed Hilgard in uniting the lowest Mesozoic beds of Western Tennessee with the immediately superjacent strata containing Cretaceous fossils; and to the formation thus defined he gave the name Coffee Sand.[9] The latest specific expression on the subject known is that of Meek, who, in 1876, with the entire information available before him up to the initiation of the investigations herein described, maintains his opinion that the beds of dark blue, soft shale or indurated clay &c. of Alabama, the plastic clays of New Jersey, and the yellow and brown sandstones and green shales of New Mexico, to which he added the Eutaw group of Mississippi, are Cretaceous and the equivalent of the Dakota formation of Dakota, Nebraska, and Colorado;[10] but Lesquereux has recently correlated the Dakota

[1] Am. Jour. Sci., 2d ser., Vol. XXIV, pp. 72–86, 1857; also Rep. U. S. and Mex. Bound. Surv., Vol. I, Pt. II, 1857.

[2] Am. Jour. Sci., 2d ser., Vol. XXIV, p. 75, 1857.

[3] Ibid., p. 83.

[4] Rep. U. S. and Mex. Bound. Surv., Vol. I, Pt. II, p. 141, 1857.

[5] Rep. Geol. and Agr. of Miss., p. 61, 1860.

[6] Rep. Expl. Exped. 1859 under Macomb, p. 52, 1876; Am. Jour. Sci., 2d ser., Vol. XXIX, p. 208, 1860.

[7] Trans. Acad. Sci. St. Louis, Vol. I, pp. 582–590, 1856–1860.

[8] Proc. Acad. Nat. Sci. Phila., Vol. XIII, pp. 419–421, 1861.

[9] Geol. of Tenn., p. 411, 1869.

[10] U. S. Geol. Surv. Terr., Vol. IX, pp. 38–42, 1876.

group of Meek and Hayden with the Cenomanian of Europe,[1] thereby increasing the probability that the formations subjacent to the Eutaw or other well defined portions of the Dakota group may belong to the Cretaceous.

Examination of their literature shows, however, that these geologists failed to discriminate the poorly fossiliferous beds denominated Eutaw in Mississippi and Alabama and Coffee Sand in Tennessee from the subjacent and apparently much older formations now in question; and, since their determination of the age of the entire series of strata rests on the evidence of the fossils from the admittedly Cretaceous Eutaw group, their opinion as to the age of the subjacent formations is of little value.

Although the poverty of the formation in organic remains precludes the possibility of determining its precise position in the geologic series, its relation to other Mesozoic formations of the eastern United States is suggested by its attitude, its lithologic character, and its stratigraphic position.

On comparing it with the Red Sandstone of New Jersey and Connecticut (generally regarded as Triassic, though W. M. Fontaine has recently pronounced certain bodies of it Rhætic < Lower Liassic[2]) marked differences are found to exist. Thus the deposits of the Tuscaloosa formation are seldom lithified, while those of the Red Sandstone are, in general, firm sandstones, conglomerates, and shales; the strata of the Tuscaloosa formation are little disturbed (having only a gentle inclination of thirty or forty feet per mile to the seaward), while the Red Sandstone is everywhere highly tilted, faulted, slickensided, and sometimes contorted; the former formation has never been affected by intrusives, while the latter is intersected by trap dikes and interbedded with trap sheets; vegetal matter in the formation exposed along the Tuscaloosa River is comparatively little altered, and often retains its woody texture, although it is usually converted into lignite, while the carbonaceous matter of the Red Sandstone on Deep and Dan Rivers and elsewhere has been converted into true coal. Both formations are alike unconformable to the subjacent and Paleozoic and Azoic formations; but while the former is sensibly conformable to known Cretaceous formations the latter is apparently separated from the adjacent (but nowhere contiguous) later Mesozoic deposits by one of the greatest unconformities of the American rock series; and finally, while only slight and uniform elevation appears to have occurred in the eastern part of the continent since the formation of the Alabama deposit, great changes in continental configuration have unquestionably taken place since the formation of the highly tilted Red Sandstone of New Jersey and the Connecticut Valley. Accordingly these formations could not

[1] Rep. U. S. Geol. Surv. Terr., Vol. VIII, pp. 92, 105, 1883.
[2] Mon. U. S. Geol. Surv., Vol. VI, pp. 96, 128, 1883.

legitimately be correlated without the strongest possible paleontologic evidence; and such evidence has not been found.

But on comparing the formation with the younger Mesozoic deposits of Eastern Virginia, Central Maryland, Northern Delaware, Southeastern Pennsylvania, and perhaps Central New Jersey and Southern New York—the Potomac formation of McGee—there is found to be so striking similarity in attitude, in composition, in degree of lithification, and in stratigraphic position that the description of the one in general terms will equally apply to the other; and this similarity will warrant provisional correlation of the formations.

The age of the Potomac formation has not, however, been satisfactorily determined, as the following history of opinion concerning it indicates:

It appears to have been first discriminated by R. C. Taylor[1] who, in 1835, spoke of it in one of its exposures as "The Secondary Horizontal Strata of Fredericksburg," and described half a dozen species of fossil plants from it, and, on the evidence of the plants, referred it to the "Oölitic group of Europe." Its probable equivalent was again separated from the fossiliferous Cretaceous deposits in New Jersey in 1840 by H. D. Rogers, who denominated it the "Potter's Clay formation," referred it to the "Upper Secondary series,"[2] (in contradistinction to the "Middle Secondary series," to which the Red Sandstone was relegated), and showed that it passes gradually upward into the greensand division of the Cretaceous. In the following year it was specifically designated the "Red Clay formation" in Delaware, and referred to the "Upper Secondary formation," on the ground of its resemblance to the "Secondary" formation of Europe;[3] and in the same year it was described in Virginia by W. B. Rogers, who denominated the formation the "Upper Secondary Sandstones and Conglomerates,"[4] in contradistinction to the "Middle Secondary Sandstone" &c. (comprised in the Rhætic of Fontaine). In 1842, he referred it to the Oölitic[5] and again in the same year (as a subsequent publication indicates) "to the upper part of the Jurassic series, corresponding probably to the Purbeck beds of British geologists."[6] The bases for these references appear to have been (1) the evidence of undescribed plant and animal remains, (2) the lithologic character of the deposits, and (3) the stratigraphic relations of the formation. In 1845, after examining this and associated formations in company with Conrad, Sir Charles Lyell[7] "arrived at the conclusion that the whole of the New Jersey series [of

[1] Trans. Geol. Soc. Pa., Vol. I, pp. 320–325, 1835.
[2] Geol. of N. J., Final Rep., pp. 177–179, 1840.
[3] Memoir Geol. Surv. Del., 1837–'38, pp. 14–16, 1841.
[4] Rep. Prog. Geol. Surv. Virg., p. 29, 1840.
[5] Reprint, Geol. of the Virginias, p. 542.
[6] Proc. Bos. Soc. Nat. His., Vol. XVIII, p. 104, 1875.
[7] Trav. in N. A., Vol. I, p. 63, 1845.

Cretaceous deposits] agrees in its chronological relations with the European White Chalk, or, to speak more precisely, with the formations ranging from the Gault to the Maestricht beds inclusive;" but his language in another publication suggests that his expression is designed to apply only to the fossiliferous formations overlying the plastic clays constituting the upper division of the Potomac formation.[1] Certainly, his conclusion rested in large part on his own observations of conformity and collections of shells from the fossiliferous formations. In 1867, as already mentioned, Meek and Hayden, after visiting the exposures and examining the collections of the State geologic survey and discussing the paleontologic, lithologic, and stratigraphic evidence then available, correlated the plastic clays forming the base of the newer Mesozoic of New Jersey—the "Potter's Clay" formation of H. D. Rogers—with the European Neocomian.[2] In 1860, Tyson recognized what appears to be the same formation in Maryland, denominated it "Formation No. 21,"[3] and, on the questionable evidence of a few imperfectly silicified casts of undetermined fossils, a new genus of Cycas, silicified and lignitized coniferous wood, a fragment of a rib of a whale, and "part of the teeth and bones of an herbiferous Saurian," referred it (including the "Iron Ore Clays") to the Cretaceous; but two years later, on the evidence of the cycad alone, concluded (with the expressed concurrence of L. Agassiz) that it ought to be placed "at least as low as the Oölitic period."[4] On assuming control of the geologic survey of New Jersey, Cook recognized and repeatedly described the formation constituting the base of the newer Mesozoic series. In 1865 he denominated it the "Fire and Potter's Clays" and definitively referred it to the Cretaceous,[5] though without explicit statement of the reasons for the reference. In the same year Leidy[6] adopted the taxonomy of Meek and Hayden, and described and referred to the Cretaceous a reptilian tooth (*Astrodon Johnstonii*) from the "Iron Ore Clays" of Maryland. In 1868, Cook substituted the name "Plastic Clays"[7] for the formation as developed in New Jersey, and correlated it with the Lower Greensand of Europe on paleontologic and stratigraphic grounds. During the same year, however, Conrad[8] referred the formation to the Triassic, on the evidence of two casts of lamellibranchs (called "Cretaceous species" in the title), and a few plant remains referred to the genus Cyclopteris, which he found within it; while Cope, who found within it in Western New Jersey "leaves of dicotyledonous trees, ctenoid fish scales,

[1] Quar. Jour. Geol. Soc., Vol. I, p. 60, 1845.
[2] Proc. Acad. Nat. Sci. Phila., Vol. IX, pp. 127–133, 1857.
[3] First Rep. Agr. Chem. Maryland, pp. 41–43, 1860.
[4] Sec. Rep. Agr. Chem. Maryland, p. 54, 1862.
[5] Ann. Rep. Geol. Surv. N. J., p. 24, 1864.
[6] Smithsonian Cont., Vol. XIV, Cret. Rep. U. S., pp. 2-4, 1865.
[7] Geol. of N. J., pp. 36, 241, 246–248, 1868.
[8] Am. Jour. Conc., Vol. IV, p. 279, 1868.

and numerous Unionidæ in a tolerably good state of preservation," correlated it with Meek and Hayden's "Earlier Cretaceous No. 1" (Dakota), although the six species of Unios and Anodontas contained within it have "some analogy with those of the Wealden, procured by Dr. Mantell in England."[1] In 1875 W. B. Rogers,[2] referring to Tyson's discovery of stumps of cycads in the formation, relegated it to the horizon of the Upper Jurassic rocks, and suggested that "we may find here a passage group analogous to the Wealden of British geology." In the next year, after an exhaustive review of its paleontologic and stratigraphic relations, Meek[3] referred the formation unquestioningly to the Cretaceous, and suggested that it represents a "part, if not the whole, of the Upper Greensand." In 1878 Cook retained the name "Plastic Clay" for the formation as developed in New Jersey, and, on the authority of Lesquereux and Gabb, who examined, respectively, the plant and animal remains found within it, again correlated it with the Lower Greensand of Europe.[4] Lesquereux remarks that the plant remains of the formation have, "so far as they are determinable, the characters of the flora of the Dakota group, or of the Lower Cretaceous of Nebraska and Kansas. This is Lower Cretaceous for this country, equivalent to a lower member of the Upper Cretaceous of Europe."[5] During the next year Fontaine described the formation as exhibited in the Fredericksburg and Petersburg belts, and, on the evidence of a moderately abundant flora, correlated the upper division of the strata of the former belt with the Wealden[6] and those of the lower part with the Upper Oölite,[7] and referred the whole of the Petersburg belt to the Wealden.[8] In 1880 (?) Dana[9] adopted the taxonomy of Meek and Hayden, and referred the Plastic Clay of Cook and the correlative deposits in Delaware, Maryland, and Virginia to the Cretaceous, to which he also ascribes the Alabama beds supposed to yield Harper's doubtful genus *Ceratites*.[10] In 1881 this formation was recognized in Pennsylvania by C. E. Hall[11] (though its existence there was long ago denied by H. D. Rogers),[12] who denominated it "Wealden Clay" and classed it as "a remnant of the lowest clay beds of the New Jersey Cretaceous (Wealden?)." In the same year Britton[13] denominated

[1] Proc. Acad. Nat. Sci. Phila., Vol. XX, p. 157, 1868.
[2] Proc. Boston Soc. Nat. His., Vol. XVIII, p. 105, 1875.
[3] Rep. U. S. Geol. Surv. Terr., Vol. IX, p. xliv, 1876.
[4] Rep. Clay Deposits of N. J., pp. 25–30, 1878.
[5] Ibid., pp. 27, 28.
[6] Am. Jour. Sci., 3d ser., Vol. XVII, p. 156.
[7] Ibid., p. 157.
[8] Ibid., p. 233.
[9] Man. of Geol., Dana, 3d ed., pp. 454–458.
[10] Ibid., p. 468.
[11] Sec. Geol. Surv. Pa., Rep. Prog., C[6], p. 19.
[12] Geol. Pa., Vol. I, p. 59, 1858. "Tertiary and Cretaceous strata border the State upon the SE. in New Jersey, but they do not cross the Delaware River into Pennsylvania."
[13] Ann. N. Y. Acad. Sci., Vol. II, p. 170, 1882.

the formation as represented on Staten Island the Cretaceous formation and remarked that it is "a direct continuation of the 'Plastic Clay' division of the Cretaceous, so named by the New Jersey geologists, and lie[s] at the base of the formation in Eastern North America." Newberry[1] also, during the same year, expressed the conviction that these strata are Cretaceous. In 1883 Fontaine[2] discriminated the older Mesozoic and the younger Mesozoic of Virginia, and remarked that "the younger Mesozoic strata have very little in common with" the older, but expressed no more definite opinion as to their age. In the same year Uhler[3] described the formation as developed in Maryland in a popular address, discussed its flora and fauna, denominated it the Wealden, and referred it to the upper part of the Jurassic. A year later Chester[4] applied the New Jersey name of Plastic Clay to the formation in Delaware and referred it to the "Lower Cretaceous (Wealden ?)," but upon what basis is not evident. In the same year appeared W. B. Rogers's posthumous geologic map of Virginia and West Virginia,[5] in which the formation is classed as "Upper Jurassic passing upward into base of Cretaceous." In the same year also McGee,[6] after assembling and adjudicating the entire available evidence as to the age of the formation, provisionally mapped it as Cretaceous.[7] One of the latest published expressions, and perhaps the most authoritative, is that of R. P. Whitfield, who describes five species of lamellibranchiate shells from this formation in New Jersey. Whitfield considers that "Mr. Conrad may have been mistaken" in regard to the casts of *Astarte* from the ash colored clays of this formation, referred by him to the Triassic, and expressed the "feeling" that the formation more probably represents the Jurassic than the Cretaceous.[8] In the same volume Cook applies the eminently suitable name Raritan Clays[9] to the formation as developed in New Jersey, and, on stratigraphic grounds, adheres to his opinion that the formation is a part of the Cretaceous. Still more recently Fontaine[10] has re-examined the various exposures of the formation in Virginia and made extensive collections of plant remains from them. He finds that while the general facies of the flora is Neocomian there is a notable commingling of Jurassic and even earlier forms. Accordingly the precise equivalence of the formation with any of the European or western American divisions cannot be established.

[1] Trans. N. Y. Acad. Sci., Vol. I, p. 57, 1881–'82.
[2] Mon. U. S. Geol. Surv., Vol. VI, p. 2, 1883.
[3] Johns Hopkins Univ. Cir., Vol. II, p. 53, 1883.
[4] Proc. Acad. Nat. Sci. Phila., pp. 250–2, 1884.
[5] Reprint Geol. of the Virgs., map, 1883–'84.
[6] Fifth Ann. Rep. U. S. Geol. Surv., Pl. II, 1883–'84.
[7] Fifth Ann. Rep. U. S. Geol. Survey, Pl. II, 1885.
[8] Mon. U. S. Geol. Surv., Vol. IX, pp. 22, 23, 1885.
[9] Ibid., p. x.
[10] Sixth Ann. Rep. U. S. Geol. Surv., pp. 85 and 86, 1884–'85.

2. OBSERVATIONS FROM 1833 TO 1886 OF OCCURRENCES ON THE TUSCALOOSA.

The recent work upon the basal Mesozoics in Alabama may be summarized as follows: In the spring of 1883 Mr. L. C. Johnson, while engaged in the work of the U. S. Geological Survey, observed the purple and mottled clays, briefly described above, in Dallas County, and on Big and Little Mulberry Creeks in Autauga County, and obtained from well borers many notes of their occurrence, and conjectured that they belonged to a formation anterior to the Cretaceous. I had seen the same clays in 1871 on the road between Tuscaloosa and Eutaw, without reaching any decision as to their age. In August, 1883, upon the joint excursion of which this paper is the record, we had the satisfaction of observing every outcrop of these beds along the Tuscaloosa River below Tuscaloosa, and in the autumn of 1884, at the joint expense of Mr. T. H. Aldrich and the Geological Survey of Alabama, Mr. D. W. Langdon, jr., undertook an excursion through Bibb County along the Cahaba River, for the purpose of studying this formation there.

In the summer of 1885 the writer had the opportunity of examining many exposures of these clays and sands in the interior of Tuscaloosa, Hale, Bibb, and Autauga Counties.

In the early part of 1886 we found in the city of Tuscaloosa a fine exposure of dark gray, laminated clays, full of leaf impressions, which promise to furnish the means of determining definitively the age of the formation.

Some leaf impressions collected by Mr. Langdon and the writer in Bibb County were submitted to Professor Leo Lesquereux. One of these was considered by him to be referable to the genus *Podozamites*, with affinities to *P. lanceolatus* and *P. distans* of the Trias or Rhætic, and with still closer affinities to *P. pulchellus* Heer, from the Jurassic of Spitzbergen. Professor Lesquereux remarks: "I have found some species of the genus in the Cretaceous, but none with leaves of the same form as yours. The *P. pulchellus* has, like your leaf, distinct, coarse, somewhat distant primary nerves, separated by thin, punctate ones."[1] This leaf impression, so far as it goes, appears thus to confirm the evidence afforded by the *Ceratites* of Professor Harper, and the leaf impressions of Professor Winchell in so far as these indicate a pre-Cretaceous age for the formation.

This evidence, unfortunately, is not decisive. The plant remains found by Professor Winchell were not determined even generically; while the specimens of *Ceratites* were not found in situ in the beds in question, but "on a sand bank in the middle of the river * * * [in the area of known Cretaceous rocks] among other evidently Cretaceous fossils,"[2]

[1] Six (Rep. U. S. Geol. Surv. Terr., Vol. VIII, pp. 27–30, 1883).
[2] Proc. Acad. Nat. Sci. Phila., Vol. VIII, p. 126, 1856.

and at least one of them has since been pronounced, by no less competent an authority than Meek, "to be a worn specimen of the old genus *Ammonites*."[1]

Some better specimens from the city of Tuscaloosa were determined recently by Professor Lesquereux. They all point to the Cretaceous age of these beds, although the evidence is not yet conclusive.

In view of the diversity of opinion indicated by the foregoing review and of the paucity of organic remains in the Potomac formation and correlative deposits on the Atlantic slope, and in view of our uncertainty as to the exact equivalence of the deposits exposed on the Tuscaloosa River, we are unwilling to express ourselves decidedly as to the age of the formation to which they belong, though we incline to the belief that it is Cretaceous.

Since the formation to which the purple clays and associated strata belong is clearly distinct from those already recognized and named in Alabama and since it cannot be co-ordinated with certainty with any other formation in this country, it seems desirable that it should receive a specific designation. We therefore propose for it the name Tuscaloosa formation, after the name of the city at which and the river along which its typical exposures occur.

The stratigraphic relations of the Tuscaloosa formation may be seen by reference to the general section (Plate XXI, p. 185). In constructing this part of the section we have assumed a uniform dip towards the southwest of about forty feet to the mile. The indicated thickness is, accordingly, only approximate.

Rock Bluff.—Between Big Log Shoals and White's Bluff no rocks are seen along the river banks, except at Rock Bluff, where a pebbly conglomerate with ferruginous cement forms a bluff and, lower down the river, a rocky reef. This rock is underlaid by a gray or bluish clay. The position of this stratum is about seventy-five feet below the lowest of the Eutaw beds as exposed at Big Log Shoals.

At *White's Bluff* we see the first of a series of purple and mottled clays with interstratified sands, which occur at intervals as high up the river as Mrs. Prince's Landing, near Carthage. At the lowest estimate, these clays and sands are 275 feet in thickness.

In detail, the sections exposed along the river, in geologically descending order, are as follows:

(*a*) *Section at White's Bluff, Greene County, Tuscaloosa River.*

1. Purple clay, mottled with irregular patches of gray clay, both purple and gray portions sandy ..... 10 feet.
2. Micaceous sands of light, nearly white color ..... 1 foot.
3. Light colored sands, with little or no mica ..... 14 feet.

[1] Rep. U. S. Geol. Surv. Terr., Vol. IX, p. 40, 1876.

A few miles higher up the river the same beds are again seen at *Steele's Bluff*, as follows:

(*b*) *Section at Steele's Bluff, Tuscaloosa River.*

1. Purple and mottled clays ..... 10 feet.
2. Light colored, often nearly white, coarse grained sands, holding a few small pebbles in places; the pebbles mostly of chert, not quartz..... 10 to 12 feet.

The sands in the above section are in places strongly cross bedded and on exposure to the atmosphere show a tendency to harden into a pretty firm sandstone, which is, however, quite friable and easily rubbed down between the fingers after the thin outside coating of harder material has been removed.

At *Battle's Landing* there is a thin bed of ferruginous sandstone, extremely hard and firm and very similar to the ferruginous rocks so often formed in the drift beds.

At *Williford's Landing* the purple clay shows from the water's edge about ten feet in thickness, and over it occur second bottom or river deposits. Between the two a great number of bold springs of very pure water break out. An artesian well, said to be 400 feet deep, was bored at this place thirty or forty years ago, but no record of the boring is now to be had. The water flows out at the top and is not salty. This is the farthest north of any of the artesian wells of Middle Alabama. The locality is Sec. 31, T. 24 N., R. 4 E., in the lower edge of Tuscaloosa County.

Just above Williford's Landing and at *Bealle's Landing* there are reefs of rock forming shoals at low water. These rocks are sandstones and conglomerates, with ferruginous cement, similar to that already noticed at Battle's Landing.

We see the last outcrop along the river of the purple mottled clays at *Mrs. Prince's Landing*,[1] where they are about six or eight feet above the water's edge.

Between Mrs. Prince's Landing and Tuscaloosa the immediate banks of the river are with few exceptions formed by the loose materials of the second bottom deposits. At one or two places, however, given below, appear exposures of more ancient rocks. With a uniform dip of the strata, the distance between Mrs. Prince's Landing and Tuscaloosa would represent a thickness of more than five hundred feet, only forty or fifty of which are at all exposed along the river.

Saunders's Ferry.—At or near Saunders's Ferry, just below the Twelve Mile Rock, there is a fine exposure made by a landslide. Here are seen about thirty to forty feet perpendicular of thin, laminated clays and sands of a dark gray color, containing no recognizable fossils, but many small fragments of lignitic matter. Very similar beds have also been noticed by myself on the road from Tuscaloosa to Carrollton.

[1] They may be seen, however, above Mrs. Prince's in many places, in the hills a few rods back from the immediate banks of the river. See section (*c*), next page.

At the time of my subsequent visit to this locality certain overlying strata omitted in 1883, because considered to be a part of the drift, were added, as well as some beds, nearer the water level, at that time hidden by alluvial deposits. The full section is as follows:

(c) *Section above Saunders's Ferry, Tuscaloosa River.*

1. Rather massive clays of greenish and purple colors, breaking with conchoidal fracture. On drying, these clays become hard and rock-like, resembling then, except in color, some of the claystones of the Buhrstone formation. These clays when wet soften and slide down the slopes, covering them completely in places. In this clay we find many rounded masses of ferruginous and silicious matter of oölitic structure. Thickness of the clays ..... 40 feet.
2. Laminated, sandy clays, gray, with sand partings ..... 5 feet.
   This bed is rather more coherent than the underlying and forms a slightly projecting or overhanging ledge.
3. Gray, cross bedded sands, with partings of clay along many of the planes of false bedding ..... 25 feet.
   This and the preceding might readily be considered together as one member, more clayey in the upper five feet and sandier below, and this is our grouping of 1883. In these beds we find a good deal of lignitic matter and some leaf impressions very well preserved.
4. Slope or bench forty to fifty feet wide, covered by red clay and sands, slidden down from No. 1 and washed out of Nos. 2 and 3 ..... 3 feet.
5. Gray or whitish, cross bedded sands, forming the immediate bank of the river. 15 feet.
6. Blue, micaceous sands to water level ..... 5 feet.

This section of 140 feet is undoubtedly of Tuscaloosa materials.

At *Venable's Landing* there is a sandstone bluff 15 to 20 feet high, formed of bluish, micaceous sands indurated into a tolerably firm rock in places. The bedding planes of this rock are strongly ferruginous and numbers of chalybeate springs break out from the sides of the bluff.

About five and a half miles below Tuscaloosa there are to be seen at the water's edge some rocks which consist of sandy clays somewhat indurated. These clays are interstratified with thin beds of lignitic matter, with black scales resembling graphite disseminated through it. The lignitic matter consists of indistinguishable impressions of leaves and stems, and occasionally throughout the mass are nodules of iron pyrites, and not unfrequently fragments of stems lignitized or converted into charcoal, coated externally with a thin shell of pyrite.

In the banks of the branch at the University of Alabama there is a very similar small remnant of the Tuscaloosa formation, mottled clays, embedded in the red loam. The same, mottled purple and gray, appear at several places along the road leading from the university to the city of Tuscaloosa and in the gullies back of the city toward the river. In many of these localities the clays have evidently been partly redistributed, drift fashion, but in one or two places we see the undisturbed beds, consisting of dark bluish gray, nearly black clay, in laminæ (half an inch thick), separated by partings of white sand, six or eight feet thick, with white and yellowish, strongly cross bedded sands underlying them. It

is difficult to determine the thickness of these sands, as they are so hidden by the débris from above, but it is not less than 20 feet.

In one of the gullies back of Tuscaloosa we get the following section:

(*d*) *Section in Tuscaloosa.*

1. Pebbles, sand, and red loam of the Drift, forming the plateau on which the city of Tuscaloosa stands ..... 15 feet.
2. Light gray, somewhat massive clays, mottled with yellow, but becoming laminated below ..... 3 feet.
3. Dark blue, nearly black, laminated clays, laminæ half an inch thick, separated by thin partings of white sand. The clay contains the leaf impressions which have been examined ..... 3 feet.
4. Yellowish gray, laminated clays, also containing a few leaf impressions, of rather variable thickness ..... 2 feet.
5. Strongly cross bedded, yellowish or nearly white, sharp sand, with a few streaks of clay irregularly distributed through it. Thickness uncertain, but not less than ..... 20 feet.

We cannot say what lies below the sands, since the strata of this formation about Tuscaloosa have suffered a great amount of denudation by erosion and their outcrops appear only here and there. The erosion hollows have been filled in with pebbles and sands of the Drift, often to the depth of 50 or 60 feet. These circumstances and the fact that the clays themselves have in places been broken up and redeposited in lumps among the drift pebbles have caused this formation to be overlooked or confounded with the Drift. The dark gray, laminated clays above mentioned contain many beautifully preserved leaf impressions, which are now being studied and which will probably fix definitely the age of the formation.

It will thus be seen that the exposures along the river give us an insight into the composition of only a very small proportion of the strata which underlie the purple clays.

3. OBSERVATIONS FROM 1883 TO 1885 OF OCCURRENCES AWAY FROM THE TUSCALOOSA.

The observations made since 1883 by each of us independently and by D. W. Langdon, jr., of the Geological Survey of Alabama, have confirmed our first conclusion as to the relative positions of the various strata of this formation, and at the same time have added to our knowledge of its component parts.

The observations of Mr. Johnson have extended over parts of Autauga and Dallas Counties, on the waters of Mulberry Creek, and, in 1884, to Tishomingo and Itawamba Counties, in Mississippi. Those of the writer and of Mr. Langdon have extended over parts of Tuscaloosa, Hale, Bibb, and Autauga Counties.

To these observations are added those of Prof. A. Winchell, who describes the formation under discussion in the following terms:[1]

[1] Proc. Am. Assoc. Adv. Sci., Vol. X, Part II, p. 93, 1856.

At about eight miles above Eutaw the shale becomes softer, the lamination disappears, and we have beds of light clay, mottled curiously with blue, red, and yellow, reminding one forcibly of the Keuper of the Germans. More than this, we find along the roadsides and the margins of ravines in the upper part of Greene County large masses of red and poikilitic sandstone, exceedingly compact, and used for underpinning buildings. Add to this that very many of the artesian wells in Greene County, which penetrate these beds, furnish a constant flow of salt water, showing the occurrence of local deposits of salts, while the deepest borings have brought up abundance of quartzose pebbles, and we have four well established facts compatible with the supposition of the Triassic age of these beds, without mentioning the occurrence of vegetable remains, some specimens of which appeared to me indistinctly allied to stems of *Equisetites*.

These beds continue without much change to the very suburbs of Tuscaloosa; and a very good section is seen at Foster's Ferry, within a few miles of town.

The almost total absence of organic remains from these shaly and poikilitic deposits renders the determination of their age extremely uncertain.

It seems probable that the red sandstone mentioned by Professor Winchell is the same as that occurring at Battle's Gin, on the river, and at Havana, presently to be described.

On going by land from Tuscaloosa to Eutaw, on the western side of the river, in 1886, we have been able to repeat the observations of Professor Winchell. Two miles west of Saunders's Ferry and about ten miles west of Tuscaloosa, the road passes by the edge of a great gully washed out of materials of the Tuscaloosa formation. This gully is of nearly 100 feet perpendicular depth, and the bottom slopes then very gradually down 40 or 50 feet more.

(*a*) *Section of gully* 10 *miles west of Tuscaloosa.*

1. Drift and red loam ..... 10 feet.
2. Sharp, yellowish, cross bedded sands, with strings of light yellow, chert pebbles, subangular and in many cases showing casts of encrinital buttons and bryozoans and other sub-Carboniferous fossils ..... 20 to 25 feet.
3. White and red, laminated clays of very irregular thickness, often discontinuous ..... 5 feet.
4. Firm, yellowish sands ..... 12 feet.
5. Bed of subangular, white and yellow chert pebbles, with sub-Carboniferous fossils ..... 2½ feet.
6. Red clay in irregular beds or pockets ..... about 3 to 4 feet.
7. Yellowish white sands, with thin streaks of pebbles ..... 8 feet.
8. Red clay and sand ..... 1 foot.
9. Strongly cross bedded, yellow sands, with thin, irregular sheets of clay following some of the lines of false bedding ..... 35 feet.

Below this, cross bedded sands with clay partings continue to the lowest part of the gully, probably 40 feet below the above section.

From this place down to Knoxville nearly every hill reveals the materials of this formation, consisting mainly of yellowish and reddish, cross bedded sands, with clays (red and purple) sparingly interspersed. The section of the gully above given might be taken as typical of the strata exposed over this entire distance.

In places the sands are cemented by iron into quite firm sandstones, which are quarried for rough work. The rock can be easily cut when

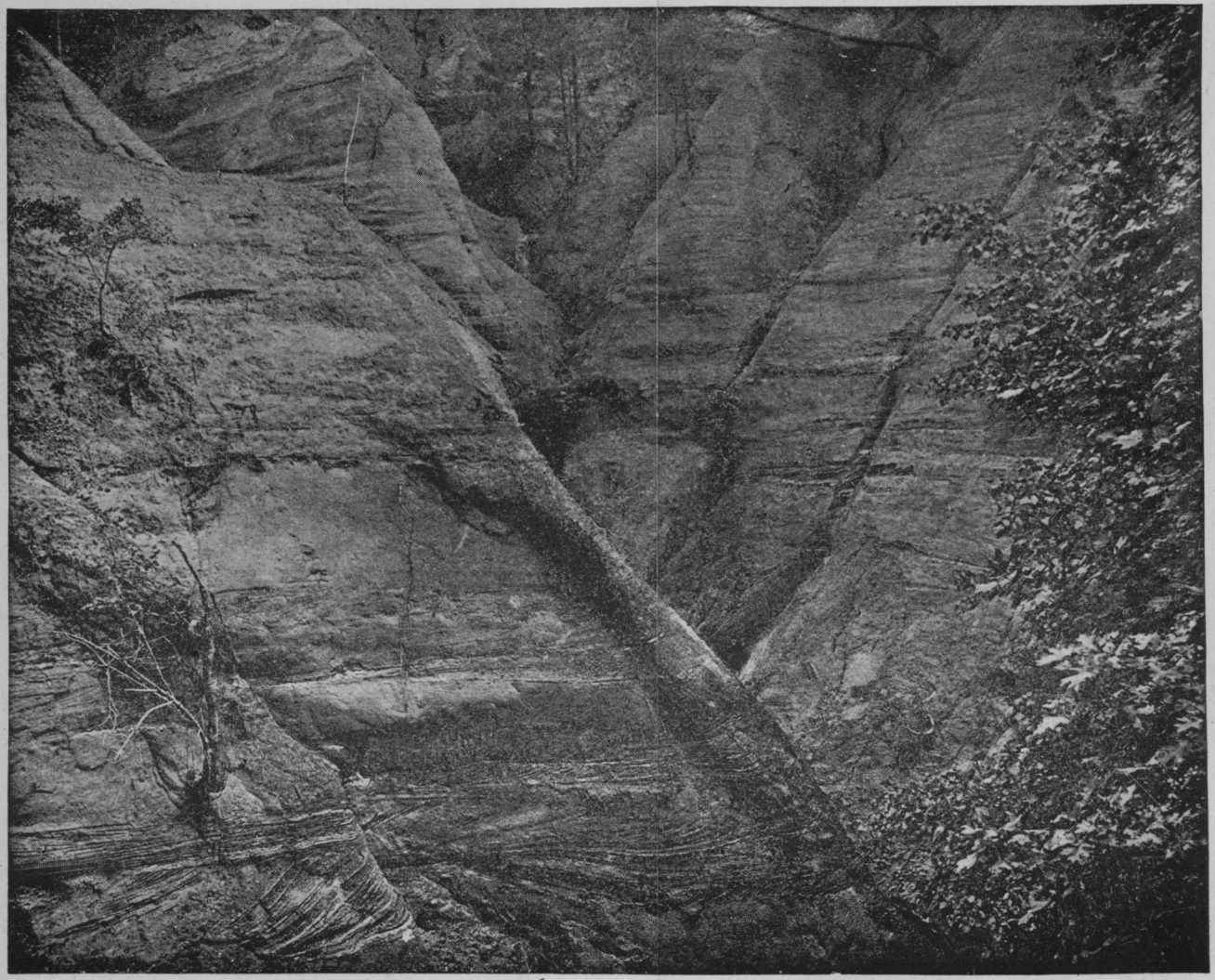
freshly dug, but it soon hardens on exposure. I am strongly inclined to believe that the red sandstones and conglomerates seen at Battle's Gin, above Williford's Landing, near Havana, &c., are bedded rocks of this formation; at any rate the constituent sands are of this age, while the induration into rocks by the ferruginous solutions may have occurred in comparatively recent times.

A short distance south of Knoxville we lose sight entirely of the red and purple clays which have been to us a characteristic of the Tuscaloosa formation, and begin to encounter the glauconitic, cross bedded sands, laminated clays, and other materials which we have classed with the Eutaw formation. If we assume a dip of 30 or 40 feet to the mile, estimating from the width of outcrop, there will be some 900 feet or more of the Tuscaloosa and 300 to 400 feet of the Eutaw formation. In both, these materials have been deposited under almost identical conditions, except that at the base and at the summit of the Tuscaloosa formation we find heavy beds, 40 feet or more in thickness, of massive clays of red, purple, and greenish colors, and also sparingly interspersed through the whole of the formation are thinner beds of similar clays. No beds of this character have been observed in what we have called the Eutaw formation, the only beds of which, other than sands, are thin, laminated, gray clays, with partings of sand.

The pebbles of the Tuscaloosa formation are, as a rule, subangular, of chert, and in many cases fossiliferous; those of the Eutaw, well rounded, of quartz, and non-fossiliferous, so far as our observations go. The cross bedding of the sands in the Tuscaloosa formation is much less pronounced than in the Eutaw, as if effected in less rapidly flowing waters. The two formations are further alike in the circumstance that their only fossils are leaf impressions and lignitized trunks, the marine fossils in the sands just below the Rotten Limestone characterizing the transition beds which have been named "Tombigbee Sand" by Dr. Hilgard.

One may well hesitate to separate very widely these two formations, whose strata were deposited continuously and under very similar conditions and contain the same character of fossil remains, until a thorough study of the leaf impressions and other fossils shall have established their positions in the geological scale. In our southern post-Tertiary Drift, our Eutaw, and our Tuscaloosa formations we have three groups of very similar strata, whose distinctive characters it is difficult, if not impossible, to describe in words, since there are cross bedded sands with interspersed sheets and beds of clay and pebbles in all three; yet in the field the differences are so easily recognized in the topography, the timber, in the color and other qualities of the soils, &c., that we are never long in doubt as to which formation we have under consideration.

A few miles south of the village of Havana on the Greensborough road begin the yellowish red, glauconitic, cross bedded sands of the Eutaw group, which extend down to Greensborough.



GULLY IN SANDS OF THE TUSCALOOSA FORMATION, NEAR HAVANA, HALE COUNTY.

Just north of the first appearance of these cross bedded, glauconitic sands, near the residence of Hon. A. M. Avery, there are several very deep gullies near the road where the upper beds of the Tuscaloosa formation are beautifully exposed (Plate IX). These beds are as follows:

(*b*) *Section two miles south of Havana, Hale County.*

1. Red surface loam, forming exceedingly fertile soil.....10 to 15 feet.
2. Yellow sands and pebbles, conformable in stratification with the underlying strata.....10 to 12 feet.
3. Purple and pink, micaceous, argillaceous sands, most beautifully cross bedded, 20 to 30 feet.

That these deposits lie very near the summit of the Tuscaloosa formation is evident from the fact that the cross bedded, glauconitic sands of the Eutaw formation occur at the surface only a very short distance to the southward. The red loam forming the uppermost of the section resembles in some degree the usual red loam of much of the southern part of the State, except that it is of much deeper color and apparently more fertile than most of these loams. It may be derived from the disintegration of the glauconitic sands of the Eutaw formation or from the uppermost of the Tuscaloosa formation. The pebble bed No. 2 resembles also in some degree the pebble beds of the Drift, but as it is entirely conformable in stratification with the underlying beds (a circumstance of rare occurrence in the Drift) I am inclined to consider this bed also as a part of the Tuscaloosa formation. The sands No. 3 differ from anything which occurs in the Drift, and I have seen the like only at one other place, viz, on Mulberry Creek, in Autauga County, near the residence of Hon. James W. Lapsley.

North of Havana the underlying beds of this formation are exposed in the following order: At Havana, and appearing at intervals for several miles northward, there is a thick bed of ferruginous conglomerate, best seen in a ravine back of the town of Havana, where it forms perpendicular bluffs ten to twelve feet in height at the top of the ravine. Large masses of the rock have split off from time to time and have rolled down into the gorge below.[1] It has been impossible thus far to determine whether to refer this conglomerate to the Drift or to the Tuscaloosa formation. Its great extent and its persistence seem to favor the supposition that it belongs to the older formation, yet it is in appearance quite similar to a conglomerate of very common occurrence in the

[1] Underneath the ledge of rock shallow caves have been washed out, and in these flourish several rare ferns, especially *Asplenium ebenoides* Schw., which was discovered here by Miss Julia Tutwiler and is interesting from the fact that it is known to occur elsewhere only along the banks of the Schuylkill River. Besides this fern, there are *Camptosorus rhizophyllus* or walking leaf, *Trichomanes radicans*, and *Aspedium marginale*. The appearance of this conglomerate and the ferns growing in the shallow caves beneath it recall very forcibly the Carboniferous conglomerate which forms the surface over so great a part of the counties of Marion and Winston.

Drift everywhere. I do not know, however, of any similar Drift formation approaching this in the thickness of the rock.[1]

On the south side of Big Sandy Creek we get again a very good section of the purple clays which form the lower members of the Tuscaloosa formation, as follows:

(c) *Section on Big Sandy Creek, Tuscaloosa County.*

1. Purple and mottled clays like those occurring at Steele's Bluff, on the Tuscaloosa River.....30 feet.
2. Light yellow sands, with pebbles, also similar to those seen at the above named locality and at White's Bluff .....10 to 15 feet.
3. Gray, laminated clay, inclosing a lignitized tree trunk, at base of hill...4 to 5 feet.

Farther along the road the thickness of the purple clays is seen to be at least 50 feet and they crop out along the hillsides for a good many miles. It is easy to recognize them even without close examination, for wherever they come to the surface in the roads it is necessary in wet weather to lay down a causeway, since the tenacity of the clay is so great that the road would otherwise be impassable.

About seven and a half miles from Tuscaloosa, where the Greensborough road crosses Little Sandy Creek, we get an exposure of what we suppose to be still lower members of the formation. This section was first examined in 1884 by Mr. Langdon. It is as follows:

(d) *Section on Little Sandy Creek, Tuscaloosa County.*

1. Micaceous, yellow sands, including a thin streak of gray, lignitic clay, with small pieces of lignitic matter.....10 inches.
2. Gray, laminated clays, highly micaceous.....6 feet.

Between the two branches of Sandy Creek the purple and mottled clays appear upon nearly every hillside. North of Little Sandy Creek we see no more of the strata of this formation along this road.

In November, 1884, D. W. Langdon, jr., made a study of this formation in Bibb County, and in 1885, in company with Mr. Langdon, I examined its outcrops in the western part of Autauga County and the adjoining parts of Dallas and in those parts of Bibb and Tuscaloosa Counties lying between the towns of Tuscaloosa and Randolph.

In the western part of Autauga County, near the post office, Vineton, there are several exposures of the upper beds of the Tuscaloosa formation, shown in the following sections:

(e) *Section near Col. J. W. Lapsley's, near Vineton, Autauga County, No. 1.*

1. Stratified clays of white, pink, and purple colors, interlaminated with thin sheets of yellow sands; the lower 8 feet of this bed have a larger proportion of sands.....10½ feet.
2. Gray, laminated clays, with partings of purple sands .....5 feet.
3. Yellowish white, laminated clays, with purple and other bright colors on the dividing planes, 5 feet showing; but the same beds appear to continue down the hill for at least 10 feet farther .....15 feet.

[1] A careful comparison of the pebbles should be made.

At another locality near Colonel Lapsley's, in a gully, we see the following section:

(*f*) *Section near Col. J. W. Lapsley's, No. 2.*

1. Yellowish sands, beautifully cross bedded ..... 4 feet.
2. White and pink clays, interbedded with yellow sands..... 10 feet.

Along the road leading from Colonel Lapsley's to the railroad station (Jones's switch), we get another section of the strata represented in the first section above, together with some underlying beds. In the upper part, these beds, being exposed along a road, are much stained, so that it is impossible to correlate them, foot by foot, with those exposed in Section 1, although they have about the same altitude and are distant from each other only about half a mile.

Below some 40 or 50 feet of red loam containing fragments and bowlders of ferruginous sandstone, such as characterizes the Drift formation we get the following section:

(*g*) *Section near Col. J. W. Lapsley's, No. 3.*

1. Purple clays, interbedded with reddish sands..... 6 feet.
2. Mottled (red and yellow), sandy clays, partly obscured by overlying drift, pebbles, and sands..... 12 feet.
3. Red sands, containing small, lenticular bits of yellow clay ..... 5 feet.
4. White and yellow laminated clays..... 6 to 8 feet.
5. Strata not seen ..... 10 to 15 feet.
6. Variegated, micaceous, and slightly argillaceous sands, strongly cross bedded; colors, bright and sharply defined, pink, dark purple, yellow, and red..5 to 6 feet.

The strata of bed No. 6 are identical in appearance and in composition with the variegated sands exposed in the gullies at Mr. Avery's, near Havana, in Hale County, above described. I did not notice here the yellow sands with pebbles immediately over the variegated sands, but they may have been in the division No. 5, here obscured by surface materials.

Across a small ravine from this section, the yellow sandy clays have been washed for yellow ocher, the beds occupying about the same position as Nos. 2, 3, and 4 of the preceding:

(*h*) *Section at the ocher beds, near Vineton.*

1. Yellowish red, cross bedded sands, inclosing thin streaks of purple clay ....6 feet.
2. Yellow, sandy clay, from which the ocher is obtained..... 16 feet.

The sand makes about 80 per cent. of the above bed, and the ocher is obtained from it by washing. The ocher is of excellent quality and of bright yellow color.

Nearly 100 feet below the lowest of the beds of Section 3 we see in the banks of Mulberry Creek, just below the iron bridge, the following section:

(*i*) *Section on Mulberry Creek, near Vineton, Autauga County.*

1. Mottled, purple clays, similar to those at Steele's Bluff, on Tuscaloosa River.5 feet.
2. Yellow, cross bedded sands ..... 3 feet.
3. Mottled clays, sandy below..... 5 feet.
4. Grayish white, micaceous sands, with irregular patches of red and yellow colors ..... 4 feet to water.

This whole section is identical in appearance with that seen at White's Bluff and at Steele's Bluff.

From Vineton up to Randolph very little can be seen of the strata of the Tuscaloosa formation until within three miles of the latter place, where the dark purplish gray clays, which seem to lie near the base of the formation, are encountered. These clays are undistinguishable from those above described between the two branches of Sandy Creek in Tuscaloosa County.

Between Randolph and Centreville we get several very good sections of the beds under consideration, as follows:

(*j*) *Section at Soap Hill, 7 miles east of Centreville, Bibb County.*

1. Purple, mottled clays at summit of hill ..... 5 feet.
2. Clayey sands in several ledges ..... 10 feet.
3. Cross bedded, yellowish and whitish sands, traversed at intervals by ledges of sandstone formed by the induration of the cross bedded sands ..... 30 feet.
   The thickest of the above sandstone ledges is about 3 feet.
4. Laminated, gray clays, with partings of sand ..... 10 feet.
5. Alternations of laminated, gray clays and cross bedded sands in beds of 12 to 18 inches thickness ..... 40 feet.
6. Yellowish, cross bedded sands, with clay partings ..... 20 feet.
7. Laminated, gray, sandy clays, containing a few leaf impressions, which are, however, not distinct enough as a rule to permit perfect identification .. 10 to 15 feet.
8. Grayish white sands ..... 8 feet.

In this section the first three members are best seen on the eastern slope of the hill and Nos. 7 and 8 in a gully on the eastern side of the hill. The intervening members are most clearly exposed on the western descent of the hill, nearly a mile from the first locality.

Between four and five miles east of Centreville a part of the preceding section is repeated.

(*k*) *Section 4 to 5 miles east of Centreville, Bibb County.*

1. Gray and reddish, sandy clays ..... 15 feet.
2. Ledge of sandstone showing cross bedding ..... 3 feet.
3. Whitish sands and clays ..... 4 feet.
4. Nearly white, cross bedded sands ..... 25 to 30 feet.

The hill in the eastern part of the town of Centreville contains a good deal of reddish, mottled clays, probably of this formation. These clays may be seen again about half way between Centreville and Scottsville, where they appear to overlie the strata of the Lower Silurian and Carboniferous formation. Between Scottsville and Tuscaloosa these beds are seen at several localities.

About twelve miles east of Tuscaloosa the grayish purple clays similar to those described between the two branches of Sandy Creek appear in many places along the slopes of hills where they are laid bare by the road.

(*l*) *Section 10 miles east of Tuscaloosa.*

1. Ferruginous sandstone in sheets ..... 6 to 8 inches.
2. Variegated, clayey sands holding small pieces of purple clay. The sands show chocolate, purple, red, and yellow colors ..... 6 to 8 feet.

3. Purple clays, with partings of sand; similar to the purple clays south of Tuscaloosa ..... 10 feet.
4. Ledge of ferruginous sandstone ..... 1 foot or more.
5. Laminated, gray and yellow, sandy clays or clayey sands, yellow at top and shading into gray at bottom ..... 6 to 8 feet.
6. Lignite, with pyrite nodules ..... 2 to 6 inches.
7. Dark gray, somewhat massive clays, becoming lighter below ..... 6 to 8 feet.
8. Strata obscured by washings from above ..... 20 feet.
9. Purple clays at base of hill ..... undetermined.

In some places near this, five feet of purple clays are seen overlying No. 1 of the section.

About nine miles east of Tuscaloosa about 30 to 40 feet thickness of purple clays is seen along a hillside. In these clays there are two ledges of ferruginous sandstone or, perhaps more properly speaking, of sandy iron ore. The clays are a mixture of purple and yellow and appear to form the lower strata of the hill for 20 or 30 feet below those above described. The iron ore which covers so much of the slope of this hill is somewhat sandy, occasionally quite pure and compact, giving a red streak. It differs very materially from the usual limonite of the valleys.

At the Box Spring, about five miles east of Tuscaloosa, the railroad cut exposes 6 to 8 feet of laminated, gray clays marked with purple streaks. Immediately above these is a very persistent ledge of ferruginous sandstone and over that 10 or 12 feet of drift and loam of recent date.

About four miles east of Tuscaloosa we see the summit of a rounded mass of the strata of this formation, consisting of 2 or 3 feet of purple, gray, and variegated, laminated clays, underlaid by about the same thickness of cross bedded sands. This exposure lies plainly unconformably embedded in the red loam of the Drift.

4. OBSERVATIONS IN MISSISSIPPI.

In 1884 Mr. Johnson, on his reconnaissance of Tishomingo and Itawamba Counties, in Mississippi, saw beds of lignite and tough, laminated clays which he, at the time, referred to a formation below the Eutaw (our Tuscaloosa). This lignite was traced by him the whole length of Reed's Creek (between the Tombigbee at Fulton and Bull Mountain Creek). At several localities, viz, at Maxey's Old Mill, Sec. 9, T. 10 S., R. 9 E., he collected many fine leaf impressions. The lignite here was two feet thick. At Reed's Mill and at Chaney's, Secs. 20 and 17, in T. 10 S., R. 9 E., many phytogene fossils were collected, and these localities were remarkable for the fine, jet-like appearance of the lignite. A jet of this kind was also found by Mr. Langdon in Centreville, Bibb County, Alabama. At Barnard's Bluff on the Tombigbee, the lignite appears again embedded in characteristic clays of the Tuscaloosa formation.

Mr. Johnson also calls attention to the gravel beds which occur in this part of Mississippi, and which, according to my observations, have their counterpart in Marion, Colbert, and Franklin Counties, Alabama.

The materials of these gravel beds are mostly cherty, subangular, and quite different from the usual quartz pebbles of the Drift. Associated with these are the so-called kaolin beds and the deposits of pulverulent silica. The pebbles as well as the silica are evidently derived for the most part, if not entirely, from the fossiliferous chert of the sub-Carboniferous formation of that region. Mr. Johnson expresses the opinion that these pebble beds of chert underlie the newer, stratified, glacial drift deposits without being a part of the same. Wherever the pebble beds occur in the Cretaceous or sub-Cretaceous clays of Tishomingo and Itawamba Counties, in Mississippi, there is a prevalence of these cherty characteristics. In this connection we may also refer to the fact that the pebbles seen in the Tuscaloosa sands at White's Bluff and at Steele's Bluff on the Tuscaloosa were of chert and not of quartz.

IV. SUMMARY OF THE LEADING FEATURES OF THE CRETACEOUS STRATA OF ALABAMA. (PLATE XXI.)

Under this heading, while making a distinction between the two, we include both the strata of undoubted Cretaceous age and those of as yet undetermined but probably Cretaceous age.

CRETACEOUS STRATA.

The whole thickness of unquestioned Cretaceous rocks in the western part of Alabama, according to our measurements and estimates, is between 1,550 and 1,575 feet, and the group has been divided into three formations, which are (1) the Ripley, (2) the Rotten Limestone, and (3) the Eutaw.

1. *The Ripley formation.*—We cannot give the absolute thickness of this formation, but it will in all probability fall between 250 and 275 feet. The strata are, first, 55 to 60 feet of yellow sands,[1] in some localities containing many Cretaceous shells, followed by 100 feet of dark gray, nearly black, micaceous, sandy clays or clayey sands, traversed by hard ledges of similar materials, and, along the two rivers at least, not prolific of fossil remains. Then 30 to 35 feet of bluish, argillaceous limestones, with great numbers of Cretaceous fossils, which are, however, mostly in the form of casts and generally phosphatic. Below this, again, a mass of sands (60 feet or more) of various colors, with indurated bands of sandstone running through it.

2. *The Rotten Limestone.*—In this we have the most massive of the calcareous formations of Alabama, outside of the Paleozoic. The thickness is about 1,000 feet, and there is surprising uniformity in the material, which is an impure, argillaceous limestone, merging in places into a calcareous clay. Where the clay predominates, we usually find the

[1] We have recently found conclusive evidence that the yellow sands are merely a modification produced by oxidation of the gray sandy clays next below.—E. A. S.

greatest abundance and variety of fossils. The strata of the Rotten Limestone form the bluffs along great stretches of both rivers.

3. *The Eutaw formation.*—This formation has a thickness of not less than 300 feet. At the base of the Rotten Limestone we find some 20 to 25 feet of calcareous sands and greensands, in part strongly phosphatic, containing a large number of fossils, many of which are in the form of phosphatized casts. This bed forms a transition between this and the next succeeding formation. We place it with the Eutaw formation for the sake of convenience, with the remark that an examination of the fossils may hereafter show that it is more closely related to the Rotten Limestone.

Below these phosphatic sands are yellowish, cross bedded sands, 40 to 50 feet, and laminated, blue clays alternating with glauconitic sands for 40 feet more. The rest of the strata, to the base of this division, consist of laminated and cross bedded sands and laminated clays in many alternations, interbedded at intervals with lignitic strata consisting of lignitized twigs and trunks of trees, but not, so far as yet known, of beds of lignite. With these are one or two thin beds of pebbles. As before stated, the exact thickness cannot be given.

STRATA OF UNDETERMINED AGE, PROBABLY CRETACEOUS.

The Tuscaloosa formation.—Below the lowermost of the undoubtedly Cretaceous beds is found a great thickness of clays and sands of as yet undetermined age. These appear at intervals along the banks of the Tuscaloosa or Warrior River from Big Log Shoals up to the city of Tuscaloosa. Assuming a uniform dip of some 40 feet to the mile, the thickness of this formation will be about 1,000 feet. We cannot as yet give the order of succession of the various strata, which are mottled, purple, and gray clays, yellowish and gray sands, pink and light purple sands, and thinly laminated, dark gray clays, which contain impressions of leaves in considerable numbers and sometimes in a state of preservation perfect as to form and markings.

V. UNDULATIONS AND FAULTS IN THE TERTIARY AND CRETACEOUS STRATA OF ALABAMA.

TERTIARY STRATA.

The average seaward dip of the Tertiary strata of Alabama is about twenty-five or thirty feet to the mile, but there is at many points a wide departure from this uniformity. Professor Tuomey appears to have been the first to direct attention to this circumstance. In speaking of the Buhrstone at the Lower Salt Works, in Clarke County, he remarks:

> We have here, then, an interesting example of the sinking of strata below the surface and of their rising again. The beds exposed at Baker's Bluff, and still higher on the river, as well as on Bashi Creek, after being depressed beneath Saint Stephens and a portion of Clarke County, make their appearance again at this locality, and probably still farther west.[1]

[1] First Bien. Rep. Geol. Ala., p. 150, 1850.

As intimated in another part of the present publication, these observations of Professor Tuomey were confirmed by us in 1883, and my subsequent investigations have further shown the existence of more than one well marked fold in the strata of this part of the State.

On another page we have said that the Buhrstone rocks which dip below the surface a short distance south of Wood's Bluff, in Clarke County, rise again at Hatchetigbee Bluff and at Jackson, and from this place an almost continuous outcrop of these rocks may be followed southward as far as the Lower Salt Works. These points appear to mark the summits of at least two distinct anticlines, and a third is marked by Lower Peach Tree, on the Alabama River, while the unequal surface distribution of the beds of the Lignitic formation, lying to the northward of the localities above named, leads one to suspect the existence of several other folds, notably one involving the black clays of the Black Bluff group along the Tombigbee River, another concerning the *Gryphæa thirsæ* beds in the central part of Marengo County and in the Grampian Hills region of Wilcox County.

We have determined approximately the limits of the Hatchetigbee anticlinal and of the Lower Peach Tree fold and its associated fault in the immediate vicinity of the Alabama River. We have also followed a line of uplift from near Jackson down to the Lower Salt Works in Clarke County. In what follows we give some details of the observations on which our knowledge of these undulations is based and we also append a few notes concerning the irregularities in the surface distribution of the Buhrstone and the underlying beds of the Lignitic in Monroe and Conecuh Counties.

(1) THE LOWER PEACH TREE ANTICLINE.

In ascending the Alabama River we find the Wood's Bluff marl at the water level at Johnson's wood yard, a few miles below Bell's Landing. At the latter locality a marl bed, which is about 115 to 120 feet below the Wood's Bluff marl, and which we have called the Bell's Landing marl, is some 25 or 30 feet above water level. Nine miles farther up the river, at Lower Peach Tree, this bed is 100 feet above water level, while at Yellow Bluff, several miles still farther up the river, it is seen within 10 feet of water level, and the Wood's Bluff marl appears about 115 or 120 feet above it on the hillside immediately back of the river bluff.

Above Yellow Bluff the river makes a bend towards the southeast, so that the Wood's Bluff marl is not seen again along its banks in this direction; at Bethel, however, a few miles west of Yellow Bluff, we see the Wood's Bluff marl and the *Gryphæa thirsæ* beds, which are separated by at least 250 and probably by over 300 feet of strata, coming to the surface within half a mile of each other and not more than 120 feet hypsometrically apart. This disposition of things appears to show that just north of Bethel there is either a very abrupt change in the angle

of dip of the strata or a stratigraphic break. I have examined the ground very carefully on several occasions, and have failed to see any evidence of high angle of dip, but, on the contrary, have obtained the clearest evidence of the existence of a fault of nearly 200 feet vertical displacement, traced from Bethel across the river to Black's Bluff, and it probably extends much farther in each direction from these limits. We shall call this the Bethel fault and give below some details of its occurrence.

The Lower Peach Tree fold.—The geographic limits of the Lower Peach Tree fold, so far as we have determined them, have been fixed by the following data: Across Choctaw County, the Wood's Bluff marl occupies a narrow strip of surface; at Wood's Bluff, on the Tombigbee, and at Cade's Bend, a mile or two above, it appears at the water level, showing a nearly horizontal position. This may be the beginning of the fold, which, beyond Choctaw Corner, eastward, broadens out till at the Alabama River it spreads over an expanse, north and south, of 10 miles or more. In the vicinity of the river, however, its occupation of the surface is not continuous, but the underlying beds of the Bell's Landing series come in and make the intervening country between its two exposures, the one south of Lower Peach Tree, the other in the vicinity of Bethel and Yellow Bluff. In its longer dimension, therefore, this fold appears to rise about the Tombigbee River near Wood's Bluff and to extend with constantly increasing elevation to the Alabama River, Lower Peach Tree occupying the summit of the roll, which has its widest cross section along the Alabama River. Eastward from this river, I have followed, with the exception noted below, a single outcrop only of the Wood's Bluff marl across Monroe County along the course of Flat Creek, and this is the continuation of the lower of the two outcrops of the bed above spoken of, as exhibited in Wilcox County west of the river and south of Lower Peach Tree, while, of the northern or Bethel outcrop, I have seen only one occurrence east of the river, viz, near Black's Bluff. This is no doubt in great measure due to the fact that there is on the eastern side of the river, opposite Yellow Bluff, a good deal of low country from which the older strata have been removed by denudation.

This fold involves, so far as concerns their surface outcrop, the Bell's Landing, the Wood's Bluff, and the Hatchetigbee series of the Lignitic, for the clays of the latter series are to be seen overlying the Wood's Bluff marl in the hills west of Yellow Bluff. I have not seen any evidence either of the broadening or of the duplication, by reason of this fold, of the outcrops of the Buhrstone rocks which immediately overlie the Hatchetigbee beds.

To summarize, we can trace this anticline in the direction of its axis from Wood's Bluff, on the Tombigbee River, across Clarke County, to the Alabama River, where it has its greatest elevation and its broadest cross section; beyond the river, eastward, we have traced it as far as

Black's Bluff. The northern limit of this fold, in the vicinity of Bethel, is a fault of at least 200 feet displacement, length not ascertained, already mentioned above.

The Bethel fault.—To obtain a clear idea of this fault it is necessary to recall the stratigraphic relations of the several subdivisions of the Lignitic which it involves. The Wood's Bluff marl, with its indurated limestone bowlders and its characteristic fossils, is our best landmark. Above this marl lie the sandy clays of the Hatchetigbee section, 175 feet in thickness. These latter beds are only slightly concerned in the fault. Below the Wood's Bluff marl we have about 120 feet of sandy clays and clayey sands, the upper 75 feet of which hold several beds of lignite, and then another marl bed, the Bell's Landing marl. Below this marl we have at Lower Peach Tree about 100 feet of gray sandy clays containing two marl beds (Gregg's Landing marl being the upper of the two). In these sections, therefore, we have over 400 feet of strata, the exact relations of which are clearly seen at Yellow Bluff and at Lower Peach Tree.

The Nanafalia section consists at top of 50 feet or more of gray, sandy clays, showing a great tendency to indurate into hard rocks, resembling the Buhrstone, to which, for convenience, I give the name *pseudo-Buhrstone.* Below the pseudo-Buhrstone are at least 80 feet of sandy strata, characterized by the presence of *Gryphæa thirsæ*, and below these still, about 70 feet of cross bedded, glauconitic sands, with a few obscure fossils in the upper part, and a bed of lignite, from four to seven feet in thickness, near the base. As we have already intimated several times, we have seen no exposures which exhibit both the Lower Peach Tree beds and the pseudo-Buhrstone, so that it has been thus far impossible to determine the dimensions of the gap between the base of the Bell's Landing (at Lower Peach Tree) and the summit of the Nanafalia section (at Gullette's Landing); and the Bethel fault, coming as it does exactly at this place in our geological scale, serves to complicate matters still more. In estimating the vertical displacement caused by the fault, there is always the unknown quantity embraced in this gap to be considered, and our estimates are to be taken as exclusive of this unknown quantity.

Following are given some details concerning the fault. At Bethel, SW. ¼ of Sec. 35, T. 12 N., R. 5 E., the Wood's Bluff marl occupies the summit of the hills, and about half a mile north we find the *Gryphæa thirsæ* beds. The Wood's Bluff marl may also be seen on most of the hills between Bethel and Yellow Bluff and at the latter place, and a line drawn from Bethel to Yellow Bluff will just about define the limit of the marl towards the east. As we descend towards the east from any of these hills, capped with the Wood's Bluff marl, we come directly, and usually within 50 feet vertical distance, upon the pseudo-Buhrstone, and 60 or 70 feet below that upon greensands holding *Gryphæa thirsæ.* Near Bethel towards the southeast then the fault brings

together, or rather within 50 feet of each other, the Wood's Bluff marl and the pseudo-Buhrstone, a displacement, taking no account of the gap between the Bell's Landing and Nanafalia sections, of more than 150 feet. At Yellow Bluff, as we have seen in foregoing pages, there are exposed all the strata from the Wood's Bluff down to the Bell's Landing marl. Up the river, within half a mile of the landing, this marl dips below the water level. Less than half a mile farther up the river, beds of *Gryphæa thirsæ* appear in the left bank. Here some of the beds overlying the Bell's Landing marl are brought together with *Gryphæa thirsæ* beds, a displacement, as before, of 175 feet or more. Again, across the river, on the plantation of Mr. James Tait, Sec. 24, T. 11 N., R. 6 E., near Black's Bluff, we find the Wood's Bluff marl forming the second bluff, about 100 yards from the river, while the lower beds of *Gryphæa thirsæ* marl, Nos. 10, 11, and 12 of the Gullette's Bluff section, make the immediate bank of the river. In this case the strata between Wood's Bluff and Bell's Landing marls (120 feet), those below the Bell's Landing marl at Lower Peach Tree (100 feet), the pseudo-Buhrstone (50 feet or more), and about 30 or 40 feet of the *Gryphæa thirsæ* beds have been engulfed, a displacement of not less than 300 feet, leaving out of account, as before, the gap mentioned. We have traced the fault from Bethel to Black's Bluff, a distance of 10 miles or more. Eastward from Black's Bluff, near where the Camden road crosses Gravel Creek, on Yankee Branch, a thick bed of lignite (4 feet or more) occurs immediately and to all appearances conformably below beds of *Gryphæa thirsæ*. The Coal Bluff lignite has above it some 60 feet or more of glauconitic sands, separating it from the *Gryphæa thirsæ* beds, so that this contact of two unusually widely separated beds (if this be the Coal Bluff lignite) could only be brought about by some kind of displacement. And lastly, at Black's Bluff we have a thick bed of lignite in contact with the *Gryphæa thirsæ* beds. From its close proximity to the Wood's Bluff marl (at the line of fault above described), one would be inclined to consider this as one of the lignites of the Wood's Bluff series but for its thickness. The certain identification of these lignites and their relations to the Bethel fault we have still to work out.

(2) THE HATCHETIGBEE ANTICLINE.

The axis of this fold, like that of the preceding, has a northwest-southeast direction. At the southeastern end and also at the northwestern it sinks gradually to the level of the undisturbed beds. It may be traced from near Nicholson's Store, in Choctaw County, across that county, through Bladen Springs, into the northeastern corner of Washington County at Hatchetigbee Bluff, and thence across the river for about ten or twelve miles into Clarke County. It is about twelve miles across in its widest part, i. e., from Coffeeville southwestward. It involves, so far as concerns their surface exposure, the following strata: The White Limestone, the Claiborne, the Buhrstone, and the Hatchetigbee beds, aggre-

gating, with the exclusion of the White Limestone, about 500 feet of strata. It appears to have exerted no influence upon the direction of the drainage.

In the following routes we obtain the data from which we have outlined this fold:

First. From Jackson to Coffeeville and thence northward to Wood's Bluff. On this road, 6 miles north of Jackson, the first well defined outcrop of Tertiary rocks is encountered. These rocks belong to the Buhrstone, but before reaching them the presence of the Claiborne beds at no great depth below the surface is very clearly revealed in the frequent occurrence of patches of the characteristic red, limy clays produced by the action of these beds upon the red loam. Beyond this the sands and clays of the underlying Hatchetigbee group are seen along the slope leading down to the crossing of Jackson's Creek. By turning eastward from this place the Claiborne sands, with their characteristic fossils, can be seen on Stave Creek, in Secs. 8 and 9 of T. 7 N., R. 2 E. This I take to be the southeastern limit of the anticline, for looking eastward and southeastward from this place we see nothing but the characteristic landscape of the Lime Hills region. Proceeding northward, the Buhrstone rocks are again encountered about eight miles from Coffeeville, and they extend thence to within five miles of that place. The limit of the anticline in another place, southeast of Coffeeville, is ascertained by going northeastward from Salitpa post office, which is on the Hatchetigbee formation in Sec. 31, T. 8 N., R. 1 E., towards Dead Level, in Clarke County. In this direction the Buhrstone is crossed between three and five miles from Salitpa post office. Coffeeville itself is upon the Claiborne, and going northward we pass first into the White Limestone, and at Turkey Creek, near the northern limit of T. 10 N., R. 2 W., into the Buhrstone, the Claiborne as usual making very little show upon the surface, except in the red, limy clays above noticed. The Buhrstone ridge just alluded to becomes very prominent at White Bluff, and from that place an uninterrupted view may be had of all the underlying strata down to the Wood's Bluff group. In this route, therefore, we pass over the anticline between Jackson and Coffeeville and over a syncline, with White Limestone as the uppermost formation, between Coffeeville and White Bluff, while by diverging eastward in two or three places the eastern limits of the anticline can be pretty accurately determined.

Second. On the western side of the river the anticline is equally well marked along the route from Saint Stephens, through Bladen Springs, to Butler, in Choctaw County. On this road the White Limestone may be seen to within nine miles south of Bladen Springs; then occurs a strip of pine lands, in which the underlying Claiborne formation is not often clearly seen. At one place, however, near the road in the northeast corner of Sec. 29 (corresponding to Sec. 27 in the ordinary

townships)[1] T. 8 N., R. 2 W., about a quarter of a mile west of the Tony Rail place, in the bluff over a spring, about six feet of the Claiborne sands are exposed. The upper part of this exposure is a mass of shells packed in a yellowish red sand, as at Claiborne; the lower part at the water level is a hard, greensand filled with shells, as at Pugh's Branch, in Clarke County. *Crassatella protexta* is here the commonest shell; but *Melongena alveata*, *Monoceros armigerus*, *Ancillaria subglobosa*, *A. scamba*, *A. staminea*, and other Claiborne forms are also abundant. This locality is about a quarter of a mile north of the last Lime Hill. Beyond this, towards Bladen Springs, the Buhrstone rocks are first seen at the bridge across Sinta Bogue in the northwest corner of Sec. 14, T. 8 N., R. 2 W., six miles from the springs, and they continue up to within two miles. About the central part of this outcrop, four miles from the springs, there is a marl bed several feet in thickness, containing great numbers of a shell closely allied to *Ostrea sellæformis*. This marl is found just below a hard ledge of claystone, and in the fields near by lie many fragments of rock filled with silicified Claiborne shells. The springs are upon the upper Hatchetigbee beds, for going northwards the Buhrstone is again met in the hills about two miles north of the springs, and outcrops along this road for about four miles. Beyond this Buhrstone belt we come upon the Claiborne sands on the hill just south of Souilpa Creek, and going down the hill we see the *Ostrea sellæformis* beds, and in the immediate bank of the creek the bed of comminuted shells in a matrix of greensand, precisely like that in the lower part of the Claiborne bluff and at Coffeeville landing. At Barryton Mill, about the northeast quarter of Sec. 13, T. 10 N., R. 3 W., about a mile east of the road we are now describing, this bed of comminuted shells, with numbers of large and perfect shells of *Ostrea sellæformis*, forms the bed and banks of the creek. To the westward also of this road the banks and channel of Oaktuppah Creek are formed of the lower Claiborne beds, which outcrop again on the hills some four miles north of the creek. The belt of Claiborne beds is crossed on this road from the southern banks of Souilpa Creek northward about seven or eight miles. This great width of outcrop is due to the fact that the beds form a shallow synclinal basin. This basin holds a narrow belt of White Limestone, which may be traced from Womack Hill, SE. ¼, Sec. 4, T. 10 N., R. 2 W., northwestward to the Mississippi line at Nicholson's Store. The outcrop of White Limestone at Womack Hill is about two miles long and one hundred or two hundred yards wide. Then northwestward in Mrs. Nix's field, Sec. 2, T. 10 N., R. 3 W., is another outcrop, about a mile long and two hundred yards wide. Still farther northwestward the White Limestone is next seen on the south side of Oaktuppah Creek, on Dr. Gilbert's old place and between that place and Mr. Troup Trice's. Then on the north side of Oaktuppah Creek, on Messrs. Seaborn Bonner's and Rigby's lands, Secs. 22, 23, 26, and 27,

[1] In this township the sections are numbered differently from the usual manner.

T. 10 N., R. 4 W., is a narrow tract, about two miles in width north and south; again, still farther westward, on Mr. James Bonner's land, N. W. ¼ of Sec. 15, T. 11 N., R. 4 W., is about a square mile of the White Limestone prairie. Beyond this the prairie belt widens out and merges into the great mass of prairies west of the end of the Hatchetigbee anticline. Returning to our Bladen Springs and Butler road, after crossing the syncline of Claiborne beds which holds the narrow belt of White Limestone, we come upon the Buhrstone rocks again some ten miles south of Butler, and these make the country to within five miles of that place, where they are succeeded by the Hatchetigbee beds, and at Butler by the Wood's Bluff beds.

Third. Along another route, approximately parallel to the two preceding, but in the western part of Choctaw County, we discover that our anticline has sunk beneath the surface, though still impressing itself upon the country by keeping the White Limestone as the surface rock over a distance north and south of more than twenty miles. A very similar state of things may be seen beyond the southeastern end of this fold in Clarke County, as below noted. The following details will serve to make this clear: Three miles south of Pushmataha the Wood's Bluff marl is seen on Rabbit Creek, and a mile or two farther south the first of the Buhrstone, which rock then makes the country southwestward as far as the SE. ¼ of Sec. 25, T. 12 N., R. 5 W., near Mr. Johnson Allen's. In this vicinity *Ostrea sellæformis* beds are found upon many of the high hills which show Buhrstone rocks at their bases. The line between the two formations may therefore be drawn here. Going still southward we find the *Ostrea sellæformis* or Claiborne beds at lower and lower levels, till on Billy's Creek, in Sec. 7, T. 11 N., R. 4 W., they are at the water level, and we get a first rate section extending nearly up to the White Limestone.

Section on Billy's Creek, Choctaw County.

1. Red, white, and yellow, laminated sands, with yellow clay partings.....15 feet.
2. Laminated, gray clays, with bits of leaves and indistinct leaf impressions, 12 to 15 feet.
3. Greenish yellow, calcareous, glauconitic sands; no fossils.....8 feet.
4. White, calcareous sands, with *Ostrea sellæformis*.....6 feet.
5. Hard, white ledge, with shell casts.....1 foot.
6. White, calcareous sands, with *Ostrea sellæformis*, passing below into coarse, yellow sands, and then to gray, calcareous sands, holding a few friable shells; hard ledges traverse these beds near the top; in all.....12 feet.
7. Highly fossiliferous, gray, calcareous sands, holding *Ostrea sellæformis* (small shells), *Ostcodes Wailesii*, *Turbinolia Maclurei*, *Nucula magnifica*, *Pecten Lyelli*, &c. These are alternating streaks of barren sands and fossiliferous sands.....20 feet.
8. Gray, laminated clays to base of bluff.....10 feet.

One of the beds of No. 7 is densely packed with the small form of *Ostrea sellæformis (divaricata)*, and this is the bed which crops out so frequently upon the hills to the northward of this locality. A comparison of the elevations of this bed in different places shows that it dips about 50 feet to the mile. South of Billy's Creek we enter upon the.

wide belt of prairie land (White Limestone) which extends to the northwestern corner of Washington County four or five miles below Isney. The line between Ranges 4 and 5 W. marks about the western limit of the Hatchetigbee anticline, for east of Push Cush Creek, about Sec. 17 or Sec. 18, T. 10 N., R. 4 W., the outcrops of the *Ostrea sellæformis* beds are seen.

The map will show that in the western part of Washington and Choctaw Counties and in adjoining parts of Mississippi the width (north and south) of the White Limestone belt is much greater than elsewhere, except in the eastern part of Clarke County. This is undoubtedly in great measure due to the influence of our Hatchetigbee fold; but there is also a very considerable increase in the thickness of the beds constituting the lower or Jackson division of the White Limestone in the western part of Alabama and in Mississippi, or perhaps it would be more correct to say that there is a very considerable increase in the thickness of the beds of gypseous clay of the formation in these localities. The "prairie" character of the soils of this formation is much more pronounced in Western Alabama and in Mississippi than elsewhere eastward.

Fourth. The limits of the anticline are also well defined along several roads leading out from Bladen Springs.

(*a*) On the road from Bladen Springs to Millry, in Washington County, the Buhrstone and Claiborne formations are crossed, and at a distance of seven or eight miles from the springs appears the first outcrop of White Limestone.

(*b*) On the lower road from the springs to Isney the first outcrop of Buhrstone is about one and a half miles and the last about five miles from the springs. A very conspicuous bed in these Buhrstone rocks is a greensand, several feet in thickness, of very bright, light green color, to be seen on almost every hillside from three to four and a half miles from the springs. In many places the upper part of this bed has been oxidized to deep red sand. From the five mile post west of the springs out to the lower line of Sec. 15, T. 9 N., R. 4 W., we cross diagonally the outcrop of the Claiborne beds, coming into White Limestone at the last named locality, where along a hillside Claiborne beds are seen, with White Limestone overlying them. Thence out to Isney (and beyond to Mississippi) the country is made by the White Limestone. A very good section of the Upper Claiborne beds was obtained in Sec. 13, T. 9 N., R. 4 W.

Section near Jordan's Mill.

1. Yellowish, clayey sands, with some Claiborne fossils in a soft, friable condition; lower part of this bed bluish ..... 25–30 feet
2. Projecting ledge of coarse grained greensand, with a large number of badly preserved Claiborne fossils ..... 4 feet.
3. Coarse grained greensand, with Claiborne fossils, compact and hard ..... 10 feet.

The upper half of No. 3 is coarser in grain and more fossiliferous than the lower, but the latter contains a number of the smaller forms. A

little northwest of this, in Sec. 2, T. 9 N., R. 4 W., at Shoemaker's Mill, this greensand bed is again seen, holding *Crassatella alta.* While in some respects these two outcrops resemble the Claiborne sands (main fossiliferous bed at Claiborne), there are differences observed which lead us to think that their position is below these sands. The limit between Claiborne and White Limestone is seen again about half a mile northeast of Fail's Store.

(*c*) Along the upper road from Isney to Bladen Springs the Buhrstone belt is entered at Powe's Store, about two miles northeast of Silas post office, and from this point on by the Turkey Creek bridge (about Sec. 10, T. 9 N., R. 2 W.) we cross only Buhrstone rocks. No Hatchetigbee beds are observed. From this circumstance it would seem that the outcrop of the last named beds, passing through Bladen Springs, does not extend northwest beyond the line running from Silas to Turkey Creek bridge, these two points being on opposite slopes of the anticline. In the piny woods northeast of Isney there are many outcrops of the *Ostrea sellæformis* beds, betrayed by the appearance of red, limy clay spots in the woods. Thus at Singeley & Peel's store, Sec. 11, T. 10 N., R. 5 W., the immediate surface is sandy and timbered with long leaf pine, but prairie spots (White Limestone) occur on the hillsides in all directions. Two and a half miles due east of this store, in the banks of Push Cush Creek, the *Ostrea sellæformis* beds are seen, as also at Mr. Marion Carroll's (Sec. 21, T. 10 N., R. 4 W.), and in the piny woods southeastward, eastward, and northeastward, for a good many miles.

(*d*) Again, going towards Bladen Landing, Sec. 3, T. 9 N., R. 2 W., the road is over Buhrstone all the way, after leaving the immediate vicinity of the springs.

(*e*) And lastly, going from the springs to Coffeeville, after leaving the Hatchetigbee clays of the springs, the road passes over Buhrstone to the river lowlands; it then follows the river for three miles (no rocks seen) to Coffeeville, where the Claiborne rocks are well exposed. At Coffeeville Landing these rocks have a very strong dip towards the east or northeast, and the White Limestone is encountered within a very short distance of the river bluff eastward. Thus, on the road from Coffeeville to Grove Hill, we see orbitoidal limestone at the level of the small water courses, within five miles of the former place, and at six miles from Coffeeville this rock forms the banks of Satilpa Creek. This marks about the lowest part of the depression, for a mile farther eastward limy clays containing ribs of Zeuglodon are noticed upon a hillside, at some considerable elevation above the level of Satilpa Creek. These lime hills continue thence to within a mile of Grove Hill, where the Tertiary rocks are concealed by the Drift deposits.

From these details it will be seen that this anticline has been tolerably well defined on all sides by our observations, and its representatives on the other map may be taken as fairly correct. In describing the

limits of this undulation we have made use of the Buhrstone rocks more than of other formations, for the reason that the Buhrstone, being in general hard and resistant to denudation, may almost always be seen along its line of outcrop. The Claiborne beds (sands and clays), on the other hand, as a rule, are likely to escape detection. It may, however, be of interest to give the following localities of the occurrence of the Claiborne along the two sides of the anticline.

The ferruginous sand bed, with the great mass of the Claiborne shells, we have seen less frequently than the lower or *Ostrea sellæformis* beds.

The former has been observed on the southern side of the anticlinal on Stave Creek, in the SW. ¼ of Sec. 8 and in the SE. ¼ of Sec. 9, T. 7 N., R. 2 E., in Clarke County; on the Tombigbee River, half a mile above Saint Stephens Bluff; also in Sec. 5, T. 8 N., R. 2 W., and in Sec. 29, T. 8 N., R. 2 W., in Washington County. Then in Sec. 13, T. 9 N., R. 4 W., and in Sec. 2, T. 9 N., R. 4 W. On the northern side of the anticline the ferruginous sand bed has not come under observation except on the southern bank of Souilpa Creek, about Sec. 13 or Sec. 25, T. 10 N., R. 3 W.

On the other hand, the lower or *Ostrea sellæformis* beds are to be seen along the whole outline of the anticlinal, and even where the beds do not come to actual outcrop their presence is just as certainly revealed by the occurrence of what are called "piny woods prairies"—that is, red, limy, clay spots in the piny woods. A great proportion of the country underlaid by the *Ostrea sellæformis* beds has a light, sandy soil and is timbered with long leaf pine, and the reaction of the calcareous sands upon the red loams, which occur in these sandy lands, produces the so-called prairie spots. I give a few of the localities of *Ostrea sellæformis* beds around the anticline, beginning at Coffeeville Landing, where there is a fine exposure. Thence northwestward they may be followed up Oaktuppah Creek, on both sides, and forming the bed of the creek in many places, out towards Nicholson's store. Thus, on both sides of Womack Hill, at Barryton Mill; on Surveyor's Creek, Sec. 36, T. 11 N., R. 3 W.; in the banks of Souilpa Creek, at the bridge, about Sec. 13 or Sec. 25, T. 10 N., R. 3 W.; two miles west of Barryton; in the bed of Oaktuppah Creek, about Sec. 28, T. 11 N., R. 3 W.; in Sec. 20, T. 11 N., R. 3 W., on Bogue Loosa; in many places northward as far as Lusk post office, SW. corner of Sec. 9, T. 11 N., R. 3 W.; in Sec. 25, T. 12 N., R. 5 W.; Secs. 6 and 7, T. 11 N., R. 4 W.; in Sec. 15, T. 11 N., R. 4 W.; many places near center and northern part of T. 10 N., R. 4 W.; and thence along the southern border of the anticline, i. e., about Sec. 7 or Sec. 8, T. 8 N., R. 2 W.; then across the river a few miles north of Jackson, &c. Indeed, with a little practice, the *Ostrea sellæformis* beds are about as easily followed as the Buhrstone. In Clarke County, also, as across the river in Choctaw County, in the syncline lying to the northeast of the Hatchetigbee anticlinal, the Claiborne ferruginous sands are in many places not far below the general level of the country,

and are exposed in the beds of the water courses. Examples of this are seen in the central part of Sec. 23, T. 9 N., R. 2 E., and in the SE. ¼ of Sec. 18, T. 9 N., R. 3 E.

It will be noticed that along the sides of this anticline, as well as where the Buhrstone first dips below the surface in the northern part of Clarke and Choctaw Counties, the rate of dip is much greater than the average of 30 feet to the mile; for the thickness of the Buhrstone is about three hundred feet, and its outcrop, with a dip of the strata of thirty feet to the mile, would be about ten miles broad, but in the instances cited above this outcrop will not average more than four miles in width. A part of this difference is undoubtedly due to the fact that the Buhrstone usually forms high hills, with a rather steep escarpment looking northward, but a part is also certainly due to the more rapid dip along these lines.

(3) OTHER BUHRSTONE DISPLACEMENTS.

A few words respecting the appearance of the Buhrstone rocks at localities farther south than the anticline just described may not be out of place here. A few miles south of Jackson, on the road to Gainestown, there is a hill which rises to a height of 300 feet above the adjacent water courses. Upon its summit there is a good outcrop of Buhrstone rocks, and in immediate contiguity with it Orbitoidal White Limestone, at the same level. This state of things may be seen also southward and northward of the locality named for at least a mile in each direction, and southward presumably as far as the Lower Salt Works (see below). The locality mentioned is about the corner of the four sections 14, 15, 22, 23, T. 6 N., R. 2 E.; and a mile north of it, in the Etheridge Old Fields, there is another occurrence of Buhrstone and White Limestone in actual contact apparently at the same level, for in both these cases, as we go eastward, we find the White Limestone making the country for many miles. In the same range of hills with the outcrops above mentioned (but eastward of the Buhrstone occurrences), there are places where the ravines have cut down into the *Ostrea sellæformis* beds of the Claiborne. The Tertiary strata lying westward of these localities have generally been removed by denudation, but in one place at least, we find Orbitoidal White Limestone lying to the *west* of the line of contact of Buhrstone and White Limestone, so that to all appearances we have here a narrow belt of Buhrstone (north and south) coming up right in the midst of the White Limestone, and with the latter in visible contact with it on its eastern side. When we go a few miles farther south, to what is called the Central Salt Works, in the northern part of Sec. 34 or the southern part of Sec. 27, T. 6 N., R. 2 E., we find the Orbitoidal White Limestone at the level of the water courses, but a mile east of the Salt Works, up Salt Creek, on ascending a hill we pass over what appear to be the Hatchetigbee strata. Of this I could not be perfectly sure, as no well defined fossils were obtained; but on

another branch of the creek, which flows from the north, heading nearly in the localities first mentioned, we find the Buhrstone making the lowermost forty or fifty feet of the hills in both sides of the branch, while the upper strata of the hills were White Limestone, apparently *conformably overlying the Buhrstone*, the strata of the latter at one place, where they were clearly shown in a low bluff, being approximately horizontal. This locality is near the upper edge of Sec. 35 or of Sec. 36 in T. 6 N., R. 2 E., or in the lower part of the section lying next towards the north. At Mr. F. Payne's spring, on the NW. ¼ of NE. ¼ of Sec. 11, T. 5 N., R. 2 E., the Buhrstone is found, while directly west, on the bank of the river, in Secs. 16, 17, 21, 28, and 29 the White Limestone appears. So, also, east of Mr. Payne's house there are lime sinks and outcrops of White Limestone in Secs. 12, 13, 24, &c. Though not actually seen, it would appear that here, also, we have the White Limestone lying directly upon the Buhrstone, the strata falling away rapidly westward so as to bring the former rock down to the river within two or three miles towards the west. A few miles below this, in Secs. 21 and 28, T. 5 N., R. 2 E., at the Lower Salt Works, we have the section already given, in which the White Limestone and the Buhrstone are shown in direct contact, the former apparently directly and conformably overlying the latter, just as appears to be the case at Mr. Payne's, at the Central Salt Works, and probably also at the first locality mentioned above (Secs. 14 and 15, T. 6 N., R. 2 E.).

I should be inclined to explain these anomalies on the supposition that a north and south fault has brought the Buhrstone and the White Limestone together, but for the fact that at most of the localities above mentioned the White Limestone may be seen directly, and to all appearance conformably, resting upon the Buhrstone. Whether by a fault or otherwise, all the Claiborne strata are wanting at all these localities, and my observations show also either that there is an anticlinal axis extending from Sec. 28 in T. 5 N., R. 2 E., a little east of north up to Sec. 14, T. 6 N., R. 2 E., which brings the Buhrstone above drainage along this line and for this distance, or that this elevation has been brought about by a fault. There are great difficulties in the way of making satisfactory observations in this part of the State, as thick beds of drift and loam (in some places, as at Mr. Payne's, 75 feet thick) cover the whole face of the country, except where they have been removed by the few streams; but I hope to have this fold or fault fully traced out in another season.

The sulphur spring at Jackson comes apparently through the Buhrstone out of the Hatchetigbee strata, as is the case at Bladen Springs, Tallahatta Springs, the Upper Salt Works, the Lower Salt Works, &c. The Jackson well, however, is in the low grounds of Bassett's Creek, and no Tertiary rocks show in the immediate vicinity, but the Buhrstone and the Hatchetigbee sands appear on a hill at no great distance towards the east.

As before stated, the White Limestone is the country rock through all the lower part of Clarke County, as far south at least as Choctaw Bluff and the Lower Salt Works; but away from the streams these Tertiary beds are hidden by drift, and their presence is revealed only by the numerous lime sinks which are of such frequent occurrence in the piny woods of this section. Below the Lower Salt Works the Tertiary rocks may be continuously followed down to Oven Bluff, a few miles distant, southward of which point they do not appear to come again to the surface. It is probable, however, from the occurrence of lime sinks, that the White Limestone underlies the surface at no great depth for many miles farther in this direction.

The uplift of the Lower Salt Works is felt across to the Alabama River, but not to the same degree as here, for at Gainestown and at Choctaw Bluff the lower measures of the White Limestone are at the water level.

It would not be correct to say that these undulations are not felt at all across the whole of Clarke County; for, although the underlying Claiborne and Buhrstone rocks are not, so far as we now know, lifted much above the general drainage level in the eastern part of the county after having once disappeared beneath the surface, the undulations have still been operative in keeping the White Limestone as the surface rock over an extent, north and south, of 30 miles. This is well illustrated along the meridian of Grove Hill, Clarke County, where we find the White Limestone as surface rock from about five miles north of that town down to Choctaw Bluff, and the thickness of the formation is not much over 300 feet. Moreover, at several localities we find the underlying Claiborne beds at no great depth below the general level of the country. Now, if we travel southward of this last outcrop of the White Limestone at Choctaw Bluff, through Monroe and Escambia Counties, and eastward also, in Covington, Coffee, and Geneva Counties, we find the country generally level piny woods, with a surface mantle of drift, in which, however, the frequent occurrence of depressions caused by lime sinks reveals the fact that the White Limestone is at no great distance from the surface at any place. And, still further, if we pass into Florida we find this rock again at the surface over the greater part of the peninsula, although, as recent discoveries of Mr. L. C. Johnson have shown, covered in many places by later deposits of Miocene age.

The elevation of the Florida peninsula was therefore subsequent to the deposition of the Miocene beds, and the undulations of the Alabama Tertiary may date back to the same epoch. That these disturbances antedate the elevation of the Terrace epoch is shown by the circumstance that the Drift (Champlain) deposits rest upon an eroded surface of the Tertiary (Eocene and Miocene) rocks.

(4) EASTERN EXTENSION OF THE BUHRSTONE.

By referring to the map it will be seen that the northern line of the Buhrstone outcrop, after crossing the Alabama River just below

Johnson's wood yard, turns sharply northeastward to a point nearly east of Bell's Landing and six or seven miles distant therefrom. Then it turns southward six miles, sweeps around eastward and northeastward just south of the lower prong of Flat Creek, running up as far north as Cokerville, near the line between Monroe and Conecuh Counties. Beyond Cokerville it again makes an abrupt turn southeastward and crosses the extreme southwestern corner of Butler County, beyond which point it has not been continuously followed. The two extreme northern points above noted, namely, that east of Bell's Landing and that at Cokerville, are upon dividing ridges, and this northward extension is no doubt in part due to this circumstance, but not altogether. The course of the two branches of Flat Creek has also much to do with this peculiar surface distribution of the strata. These two branches rise near Cokerville, in the northeastern part of Monroe County. The southern branch flows southward and westward, its channel being mostly in the Wood's Bluff strata, while the Hatchetigbee and Buhrstone form an escarpment on the southern border of the creek valley down to its confluence with the northern branch. The latter flows at first northward, then westward, and then southward to the point of confluence above noted. It thus flows out of the Wood's Bluff strata into the Bell's Landing, and even into the Nanafalia beds, coming back in its southward course into Wood's Bluff again, six or eight miles above the confluence.

Northward of the upper branch of Flat Creek we have a wide area of outcrop of the Nanafalia beds in the Grampian Hills of Wilcox County, in some places eight or ten miles in width.

Our observations have not given us the complete explanation of any of these irregularities, and this mere notice of them must suffice for the present.

CRETACEOUS STRATA.

The Rotten Limestone division of the Cretaceous in Alabama consists of about one thousand feet of calcareous strata of very great uniformity in lithologic character throughout, and, similarly, the strata of the Eutaw division are cross bedded sands and laminated clays, possessing no very well marked features in any part; and the same is true of the beds of the Tuscaloosa formation. While, therefore, we might expect to find disturbances in the strata of the Cretaceous group, such disturbances are not easily recognized in the two great subdivisions of this group, by reason of the uniformity in lithological composition above noted. In the upper or Ripley formation of the Cretaceous, on the other hand, alternations of sandy strata with calcareous and fossiliferous strata are easily identified, and disturbances in the stratification do not so easily escape detection.

While our observations in the Cretaceous territory have not been so extended as in the Tertiary, we are yet able to note a few instances of well marked irregularities in the Ripley formation of this group.

(1) CANTON LANDING, ALABAMA RIVER.

In the river bluff at this locality we have the following section of the Ripley strata:

Section at Canton Landing, Alabama River.

1. Surface beds covering first terrace of the river.....undetermined.
2. Light gray, calcareous sands, with an indurated ledge of nearly pure sandstone at base.....6 feet.
3. Bluish gray, sandy clays, passing downwards gradually into a more sandy bed containing numerous phosphatic casts and nodules (sandy bed 3 feet thick)..8 feet.
4. Bluish, argillaceous, calcareous beds, holding great numbers of *Exogyra costata*, *Gryphæa*, and casts.....3 feet.
5. Bluish, calcareous sands containing many fossils, chief among which a *Spondylus*, a *Nautilus*, and turreted shells, to water level.....3 feet.

In one place here a block about 50 yards long of the face of the bluff has been broken from the rest of the strata and settled down some six to eight feet, bringing the base of bed No. 2 of the section down to the top of No. 4 of the undisturbed strata.

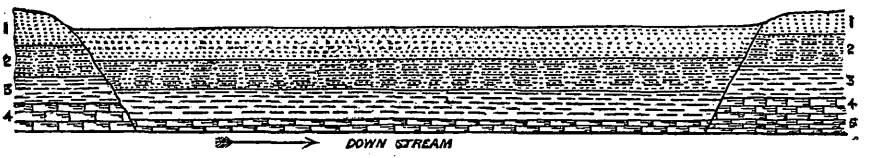


FIG. 1. Displacement at Canton Landing.

The figure gives an idea of this, and it is to be remarked further that the beds of the main bluff at the left of the break are lower than those at the right (with reference to the water level) by two or three feet.

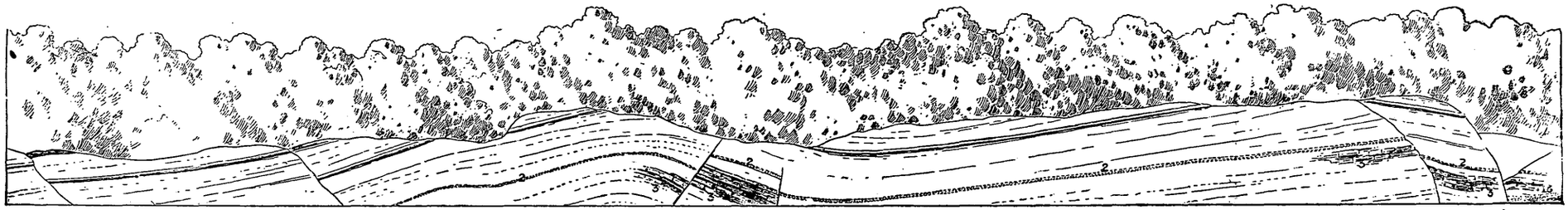
(2) PRAIRIE BLUFF, ALABAMA RIVER.

At this place, as noted above, we have at the top of the bluff some 15 or 20 feet of fossiliferous, calcareous beds, including part at least of those just given as occurring at Canton Landing, and below these to the river level some 60 feet of sandy strata traversed by bands of indurated sands containing numbers of large shells of Gryphæa and Exogyra. These sandy strata have a very rapid dip down stream (southward) of some 300 to 350 feet to the mile; while the calcareous beds at the top of the bluff, according to the recent observations of Mr. Langdon, show a much less decided dip, it being only about 30 or 40 feet to the mile. This may be and probably is due to the cross bedding on a large scale of the sandy strata.

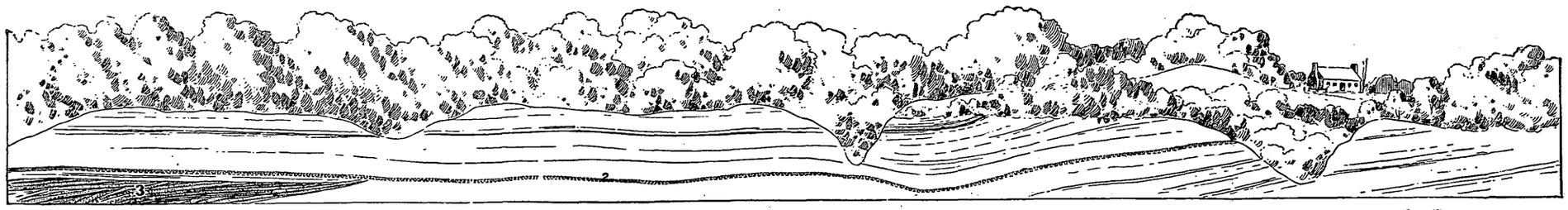
A mile or two above Prairie Bluff we have another exposure of these sandy strata, with similar rapid dip down stream. This dip, if uniformly continued down to Prairie Bluff, would bring these beds 300 to 400 feet below the visible portion of that bluff, while in all probability

1. Second bottom deposits, which overlie the black, shaly clays forming No. 1 of the section on p. 79.

(Black, shaly clays, No. 1 of the section on p. 79, are the uppermost beds in this diagram.) 2. Ledge of Gryphæa shells, No. 3 of the section on page 79. 3. Irregular pockets of cross-bedded sandstone embedded in the limestone No. 4 of the section on page 79. (No. 2 of the section on page 79 is included between 1 and 2 of this diagram.)



2. Thin ledge of Gryphæa shells, No. 3 of the section on page 79. 3. Irregular pockets of cross-bedded sandstones embedded in the limestone No. 4 of the section on page 79. (Several faults are shown in this part of the river bank.)



2. Ledge of Gryphæa shells, No. 3 of the section on page 79. 3. Irregular pockets of cross-bedded sandstone embedded in the limestone No. 4 of the section on page 79.

DIAGRAM SHOWING EXPOSURE OF RIPLEY STRATA ON RIGHT BANK OF TOMBIGBEE RIVER, FROM MOSCOW LANDING (MARKED BY THE HOUSE) DOWN THE RIVER.

the strata of the two bluffs are, in part at least, the same, and it is probable that between the two places these strata undulate very decidedly or are perhaps faulted.

(3) MOSCOW, TOMBIGBEE RIVER.

Some of the calcareous beds of the Ripley formation are exposed along the right bank of the river from Moscow a mile or two down stream. In these bluffs, which are continuous, about fifty feet in all of these strata may be seen, and there is no difficulty in following any particular stratum to its disappearance below the water level. The strata here exposed are the following:

Section near Moscow, Tombigbee River.

1. Black, shaly clay like that of Black Bluff, supposed to be Tertiary, but devoid of fossils ..... 10 to 15 feet.
2. Dark blue, argillaceous limestone, with thin, projecting ledges of harder material. One of these ledges, about 8 feet below the black clay, is very persistent, and easily followed from Moscow down to the cut off just above the mouth of Sucarnochee Creek ..... 20 to 30 feet.
3. Thin ledge of shells of a small *Gryphæa* ..... 1 to 1½ feet.
4. Hard, argillaceous, white limestone, resembling the Rotten Limestone, containing many Cretaceous shells, as *Exogyra costata*, *Gryphæa mutabilis*, &c., especially in the upper part, which is indurated ..... 25 feet.

Near the top of stratum No. 4 there are at several places along the river hard, sandy ledges of very irregular shape, and discontinuous. These sandstones contain comminuted shells embedded in a sandy matrix. The thin ledge of Gryphæa shells (No. 3) and an indurated ledge near the top of No. 2 are easily recognized, and they serve to identify the other beds.

In going from Moscow down to the cut off we see that the above described strata are not only undulating but at seven or eight places distinctly faulted.

The accompanying diagram of the right bank of the river, carefully sketched from nature, shows very clearly the character of these disturbances and renders any further description in words superfluous (Plate X).

VI. RÉSUMÉ.

THE FORMATIONS.

The general section forming Plate XXI is so arranged as to exhibit in the two inner columns, by conventions and descriptive text, the structure and character of the formations exposed along the rivers traversed and our conceptions of their relations. The portions of the sections in which the conventions are introduced are constructed from observations recorded in the foregoing pages and the portions left blank represent those parts of our ideal section in which exposures do not occur along either river. In the two outer columns are exhibited in similar

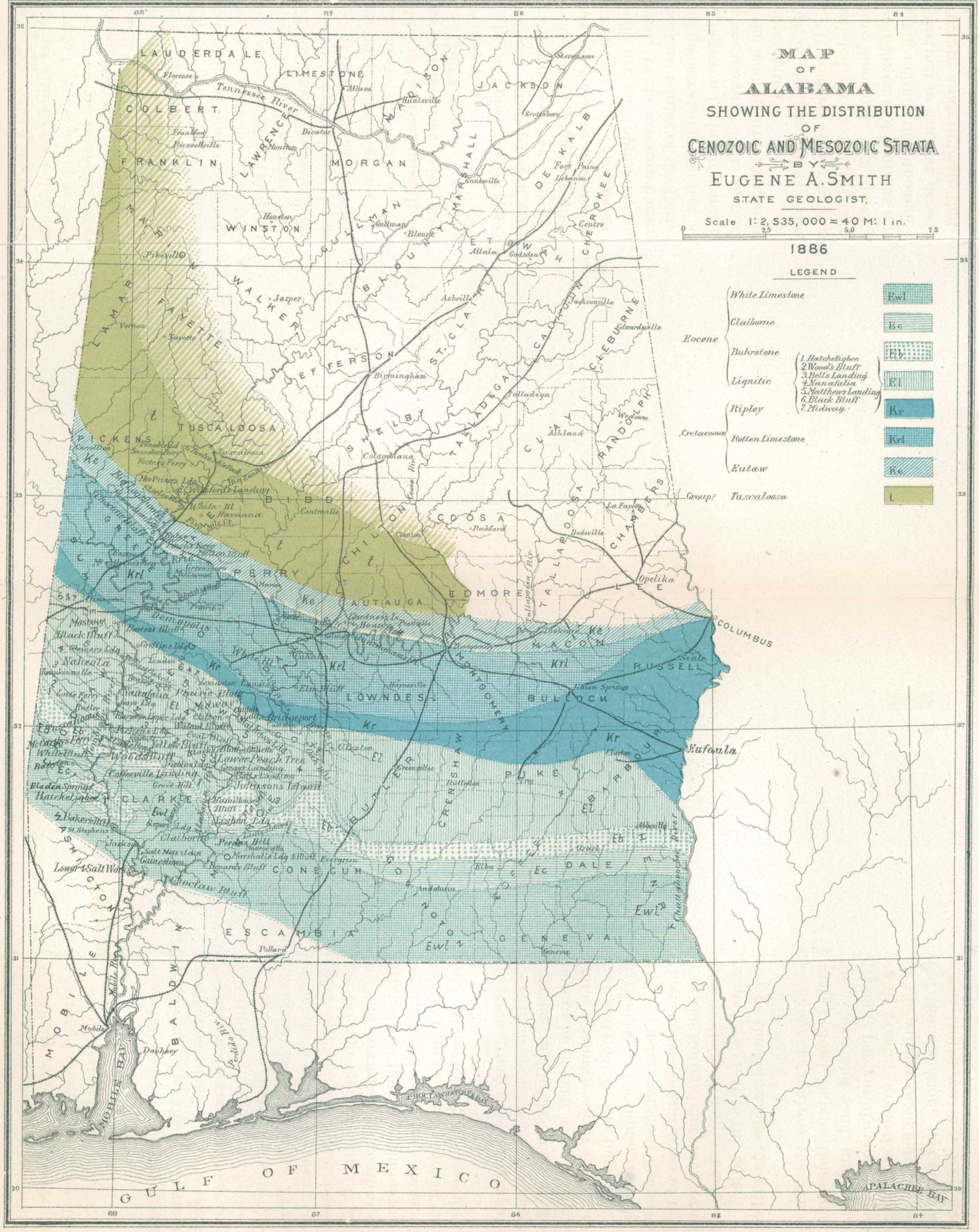
manner those portions of the formations not actually seen along either river, which are either exposed in the immediate vicinity of the rivers so clearly as to leave no doubt as to their stratigraphic relations or else disclosed by artesian borings. These two columns, therefore, serve either to fill out the missing parts of the river sections or to confirm the measurements made elsewhere.

By reference to the text and to the general section it will be seen that in the Tertiary group we have been able to fill up the blanks thus occurring along the rivers by direct measurement of the exposures seen in the vicinity of the rivers, except in two places, viz, just below the Bell's Landing section and below the Coal Bluff section of the Lignitic. The stratigraphic column of the Tertiary formation, therefore, with the two exceptions noted, is constructed from actual measurements. From the known thickness of the several divisions which we have made in the Tertiary and their extent upon the surface, we find, from careful observations made at many points, that the average general dip of the Tertiary strata is about 30 feet to the mile towards the southwest. There are, however, undulations and variations in the dip, culminating in the vicinity of the Tombigbee River, where the disturbances are more conspicuous than anywhere else in the post-Appalachian clastics of the Atlantic and Gulf slopes, so far as known. These have been described in the preceding pages.

Similarly in the upper part of the Cretaceous group the stratigraphic column has been constructed in great part from actual measurements; but in the lower part of the known Cretaceous and in the whole of the Tuscaloosa formation, where our observations have been less numerous and satisfactory, we have assumed a uniform southwesterly dip of 40 feet to the mile, and the thicknesses thus assigned to the imperfectly exposed beds are only approximations, though, as we think, close approximations. In the artesian boring at Livingston, which is upon the extreme southern border of the Rotten Limestone, the thickness of this rock actually penetrated is 930 feet, and as the Rotten Limestone forms the surface between Livingston and Eutaw, a distance across the strike of 24 miles, the average dip is seen to be about 40 feet to the mile.

Some of the leading structural features of the formations described may be recapitulated.

The newest of the formations exposed along our route is the White Limestone. It consists chiefly of regularly bedded, impure limestone, with intercalated layers of marl, calcareous clay and sand, and some ledges of pure limestone. Its upper portion is perceptibly more calcareous than the lower and contains a notably greater proportion of deep sea fossils; but neither the lithologic nor the paleontologic features are sufficiently distinct to warrant division of the formation. Its position and its structure alike indicate that it was laid down in a deep and probably deepening sea.


MAP
OF
ALABAMA
SHOWING THE DISTRIBUTION
OF
CENOZOIC AND MESOZOIC STRATA
BY
EUGENE A. SMITH
STATE GEOLOGIST.
Scale 1: 2,535,000 = 40 M: 1 in.
0 2.5 5.0 7.5
1886
LEGEND
Eocene
White Limestone
Claiborne
Buhrstone
Lignitic
1. Hatchetigbee
2. Woods Bluff
3. Bells Landing
4. Nanafalia
5. Matthews Landing
6. Black Bluff
7. Midway
Cretaceous
Ripley
Rotten Limestone
Eutaw
Group?
Tuscaloosa
Ewl
Ec
Eb
El
Kr
Krl
Ke
t
LAUDERDALE
LIMESTONE
COLBERT
FRANKLIN
MORGAN
MADISON
JACKSON
DE KALB
CHEROKEE
MARSHALL
LAWRENCE
WINSTON
BLOUNT
ETOWAH
CALHOUN
CLEBURNE
WALKER
JEFFERSON
ST. CLAIR
TALLADEGA
CLAY
RANDOLPH
MARION
LAMAR
FAYETTE
TUSCALOOSA
PICKENS
GREENE
HALE
BIBB
SHELBY
CHILTON
COOSA
TALLAPOOSA
CHAMBERS
PERRY
AUTAUGA
ELMORE
LEE
MACON
COLUMBUS
RUSSELL
MONTGOMERY
LOWNDES
BULLOCK
BUTLER
CRENSHAW
PIKE
BARBOUR
CLARKE
CONECUH
COVINGTON
DALE
HENRY
HOUSTON
ESCAMBIA
GENEVA
BALDWIN
MOBILE
Florence
Tennessee River
Decatur
Huntsville
Russellville
Jasper
Birmingham
Talladega
Columbiana
Centreville
Montgomery
Eufaula
Abbeville
Andalusia
Elba
Geneva
Pollard
Mobile
Mobile Bay
Dauphin
Choctawhatchee Bay
GULF OF MEXICO
Apalachee Bay

The Claiborne formation is made up of tolerably uniformly bedded, calcareous, and generally glauconitic sands and clays, containing rather shallow water, but not littoral, fossils mingled with deep sea organisms. There is no conformity or clearly marked line of demarkation between the Jackson beds of the White Limestone and the upper calcareous beds of the Claiborne, the one grading imperceptibly into the other, both lithologically and paleontologically.

The Buhrstone deposits are sands and clays variously interstratified, generally lithified by silicious cement. Some of the clays are remarkably pure and fine grained. The fauna is meager, but of facies identical with that of the Claiborne.

The Lignitic formation comprises three well marked divisions defined by color, which is here an index of constitution. The upper one-fourth consists of irregularly bedded, dark, silicious, and lignitiferous clays and heterogeneous sands, approaching the basal portion of the Buhrstone formation in composition and structure, interstratified with discontinuous beds of lignite and continuous layers of clay and sand containing marine fossils. The medial three-fifths of the formation is made up of rather more regularly stratified clays and sands of light color, frequently cross bedded, containing occasional beds of lignite and of marine sands yielding littoral fossils, one of which (the *Gryphæa thirsæ* bed) is 50 to 60 feet in thickness. The basal deposits are irregularly bedded, dark, or even black, calcareous, shaly or slaty clays, with few fossils or definite beds of lignite, though considerable quantities of carbonaceous matter are disseminated throughout its mass.

At the base of the Lignitic there is a rapid change in the character of both rocks and fossils, the lowermost 15 or 20 feet of the formation being limestone, at first argillaceous, then quite pure, and even crystalli This crystalline limestone rests with apparent conformity upon the yellow sands which make the summit of the Cretaceous group.

The materials of the Ripley formation are generally fine and uniformly bedded, particularly toward the summit, are predominantly arenaceous at top and bottom, though notably calcareous, particularly in the middle layers, and are often richly phosphatic. The formation is characterized by littoral or offshore, but not strictly pelagic, fossils.

The Rotten Limestone consists of uniformly bedded and tolerably homogeneous, argillaceous, or rarely pure limestones and clay marls, with occasional intercalations of clay and sand, sometimes glauconitic. Its abundant fauna is pelagic rather than littoral.

The transition beds between this and the Eutaw formation — the Tombigbee sand of Hilgard — are predominantly arenaceous and glauconitic, and speak of shallower waters than those of the Rotten Limestone.

The Eutaw deposits, like those of the Ripley, are usually fine and uniformly bedded, though they are more arenaceous than those of the latter formation. They consist of alternations of sand and clay, the former often cross bedded and glauconitic, and the latter lignitiferous,

together with occasional lignitized tree trunks and intercalated beds of lignitic matter or pebbles. The rare fossils have a littoral aspect.

No unconformity has been found between the Eutaw and Tuscaloosa formations, and the similarity in lithologic character and attitude of the two is so close that search for discordance is unpromising.

The Tuscaloosa formation consists of a great series of irregularly or obscurely bedded, quartzitic and micaceous sands, often cross stratified; heterogeneous clays, sometimes carbonaceous or lignitiferous; lenticular pebble beds (the pebbles very commonly of chert); and discontinuous lignitic layers. With the exception of the lignite and leaf impressions, it has yielded no fossils.

The coarse sands and laminated clays forming the base of the Tuscaloosa formation repose unconformably upon the eroded surface of the Carboniferous and other Paleozoic rocks.

THE GENESIS OF THE FORMATIONS.

A preliminary report on a limited region is scarcely the place for recording a chapter in the evolution of the continent; but we are convinced that, by reason of the poverty in organic remains of many of the formations, the paucity of our knowledge of the geographic distribution and local variation of their faunas and floras, and the unity and simplicity of the terrestrial oscillations to which they are referable, the Cenozoic and Mesozoic formations of the Gulf and Atlantic slopes must eventually be correlated physically rather than paleontologically; and we at the same time emphasize this conviction and contribute toward the chief end of geologic science—the co-ordination of terrestrial phenomena—by setting forth in terms of written language what we conceive to be the history recorded in the Cenozoic and Mesozoic rocks of Alabama.

At an undetermined epoch in the Mesozoic, the southern extremity of the Appalachians, together with the Piedmont region on the east and the Cumberland Plateau on the west, was submerged; and the uneven surface sculptured by subaërial erosion formed an irregular shore line diversified by a multitude of estuaries and a highly inclined and unequal sea bottom. Within the estuaries and upon the uneven sea bottom the strong currents, high tides, and violent waves of a deep sea coast washed here and there, assorted rudely, and finally deposited the coarse detritus brought down by numerous streams of high declivity—the upper reaches of river courses shortened by submergence and steepened by tilting; the strong currents, the constant shifting of the littoral deposits, and the variable salinity of the estuarine and shoreward waters (depending upon the seasonal and non-periodic variability in stage of the affluents) were inimical to organic existence; but leaves, logs, and other vegetal matters were occasionally swept into the sea by the rivers. The downward movement during this epoch was

interrupted and, about the middle of the epoch, perhaps reversed; but in general it went on progressively. With continued deposition a submarine terrace analogous to those now fringing the Atlantic and Gulf coasts was apparently developed; and, with the growth of the terrace and consequent shallowing of the offshore waters, there was evidently a diminution in strength of currents and violence of waves, accompanied by a diminution in heterogeneity and coarseness of sediments. The deposits produced by these agencies are those of the Tuscaloosa formation.

During the epoch immediately succeeding that of the deposition of the Tuscaloosa formation, so far as our present knowledge indicates, there occurred a diminution in the rate or perhaps a cessation of the downward continental movement; but there were continued growth of the submarine terrace, shoaling of the sea by reason of sedimentation, and some recession of the shore line. The shoal water deposits of this epoch constitute the Eutaw formation.

The Rotten Limestone epoch was apparently inaugurated by a comparatively sudden renewal of the continental depression and rapid deepening of the sea. The sands of the Tombigbee were distributed by the advancing waves of the encroaching sea, and in the deep waters of the succeeding episode the abundantly fossiliferous limestones and marls of the later Cretaceous were laid down. During this epoch the waves of the Cretaceous probably lapped upon the Appalachians higher and farther inland than the Tuscaloosa shore line.

The succeeding epoch was marked by a reversal in terrestrial movement, progressively increasing coarseness and heterogeneity of sediments, rapid retreat of the shore line down the gentle slope of the adolescent submarine terrace, diminution in salinity commensurate with the relatively great (though absolutely constant) influx of fresh waters, some commingling of terrestrial plant débris with the sediments, and diminution in abundance of marine organisms. The deposits of the epoch constitute the Ripley formation and indefinitely mark the closing stages of the Cretaceous period.

The Tertiary was introduced by a continuation of the Ripley elevation sufficient to produce shoaling of the ocean over the then broad submarine terrace, diminished salinity of the littoral waters and consequent destruction of marine organisms, and extension of the terrestrial flora and commingling of its remains with the littoral deposits. There is thus a paleontologic but not (in the portions of the formations that have resisted erosion) a physical break in the sequence of events and in the continuity of strata. The altitude of the land with respect to the sea was generally persistent throughout the Lignitic epoch, but depression apparently went on pari passu with sedimentation, and there were occasional oscillations and consequent incursions of the sea upon the land—notably those represented by the Wood's Bluff and *Gryphœa thirsœ* beds—and excursions of the terrestrial flora upon the coastal marshes.

The Lignitic formation is the analogue of the Tuscaloosa; but by reason of the less acclivity and the less inequality of the sea bottom and the greater regularity of the shores the waves and currents were less violent, and in consequence the deposits are more homogeneous. The approximate horizontality and the shallowness of the sea bottom are attested by the great geographic extent of beds referable to slight changes in depth of the littoral waters.

From the initiation of the Tuscaloosa epoch to the close of the Lignitic, the offshore sediments appear to have been pushed progressively farther and farther into the sea, and the depression accompanying the sedimentation appears to have been uniform throughout the area over which the deposits are now exposed; but the Lignitic epoch was apparently terminated by a depression (perhaps due to its own weight) of the margin of the subaqueous shelf thus formed, and a consequent increase in depth of the off shore waters and in violence of waves and currents. These conditions induced increased heterogeneity and coarseness of deposits, the invasion of a deep sea fauna, and the entombment of its remains in littoral deposits. The formation thus developed we denominate the Buhrstone. The shore probably retreated rapidly and far inland during the Buhrstone epoch, particularly in its earlier episodes.

The Buhrstone epoch waned with the cessation of the seaward tilting; and, with the consequent reconstruction of a submarine terrace and some concomitant depression, there was introduced a slight physical change in the character of the deposits, without paleontologic break, marking the introduction of the Claiborne. Throughout, the Claiborne epoch depression proceeded somewhat more rapidly than sedimentation, and with increasing depth of waters went increasing homogeneity and fineness of deposits.

The continuation of the Claiborne depression was accompanied by gradual modification in physical character of the deposits and by differentiation of fauna, culminating in the latter part of the White Limestone epoch, when the Tertiary sea reached a depth approaching and perhaps equaling the maximum attained during the Cretaceous.

During the Claiborne and the White Limestone epochs the distribution of sediments was apparently such as again to bring the sea bottom to approximate horizontality; and, with what appears to have been a sudden re-elevation of the land, conditions similar to those under which the Lignitic formation was laid down were once more introduced, and the shoal water strata of the Grand Gulf formation—the homologue of the Lignitic—were laid down upon the seaward margin of the White Limestone.

Thus, our preliminary observations suggest the movements and in some cases the positions of the Cenozoic and Mesozoic shore lines, and enable us to say that the breaks in stratigraphic and paleontologic continuity in these formations are apparent rather than real and are due to simple and readily determinate continental movements.

PLATES XII-XXI,

WITH EXPLANATIONS.

PLATE XII.

SECTIONS OF THE WHITE LIMESTONE ALONG THE TOMBIGBEE AND ALABAMA RIVERS, IN PART SHOWING THE RELATIVE POSITIONS OF THE WHITE LIMESTONE AND THE CLAIBORNE BEDS.

FIG. 1. *Section of Salt Mountain, Clarke County.*

1. White Limestone, forming Salt Mountain. This limestone consists in great measure of masses of partially silicified corals. In the lower strata compact, crystalline limestone occurs, which holds plates and spines of echinoderms....150 feet.
2. Orbitoidal White Limestone quarried for building purposes .....20 feet.

FIG. 2. *Saint Stephens Bluff, Tombigbee River.*

1. Soft White Limestone, with *Orbitoides Mantelli.* The upper half contains this fossil in great abundance, the lower part more sparingly. The lithological character of the whole 70 feet is quite uniform. The top of Saint Stephens Bluff is here represented as equivalent to the top of the orbitoidal limestone at Salt Mountain, giving the *minimum* thickness of this rock. There may be, however, a greater thickness of this rock than here shown .....70 feet.
2. Indurated bed of *Spondylus dumosus*.....3 feet.
3. Light yellowish white marl or argillaceous limestone, containing nodules of phosphate of lime. The marl itself is strongly phosphatic .....27 feet.

FIG. 3. *Section at Baker's Hill, continuation of Saint Stephens Bluff, showing relative positions of the White Limestone and the Claiborne sands, Tombigbee River.*

1. Orbitoidal White Limestone forming summit of hill, passing into the argillaceous limestone below (line between the two here rather arbitrarily drawn)....25 feet.
2. Argillaceous, glauconitic limestone, with *Pecten perplanus, Pecten Poulsoni,* &c. This is the same rock as that at base of Saint Stephens Bluff, half a mile distant and in plain sight. The strata are covered at intervals by débris.
3. Bed with *Scutella Lyelli,* 1 foot seen; at other points.....3 feet.
4. Coarse, ferruginous sands passing downwards to reddish sand, holding the usual Claiborne fossils of unmistakable character.....15 to 18 feet.
5. Bluish green, glauconitic, and clayey sands, containing the *Flabellum* found at Coffeeville .....8 to 10 feet.

FIG. 4. *Strata exposed in continuous bluffs between Marshall's Landing and Rattlesnake Bluff, just below Claiborne, showing relative positions of the White Limestone and the Claiborne sands, Alabama River.*

1. Orbitoidal White Limestone of the usual character .....10 feet.
2. White Limestone, containing great numbers of *Scutella Lyelli* and other echinoderms .....10 feet.
3. Calcareous clay in two beds of five feet each, separated by three feet of soft, earthy White Limestone. Below this, a ledge of hard limestone three feet and eight feet of blue clay with fucoids, becoming more calcareous below, in all..... about 24 feet.

4. Ledge of hard, white limestone, followed by twenty feet or more of argillaceous, soft, white limestone, with thin projecting ledges of purer limestone at intervals. Resembles the Rotten Limestone of Cretaceous formation .....about 25 feet.
5. Bed of *Scutella Lyelli*, in three layers, the middle one ferruginous.....3 feet.
6. Coarse, ferruginous sand, calcareous below, hard ledge at bottom.....6 feet.
7. Claiborne ferruginous, fossiliferous sands, the counterpart of those at Claiborne Bluff .....10 to 12 feet.
8. Calcareous, sandy clay, with hard ledge in middle .....6 feet.
9. Sandy, clay marl, with *Ostrea sellæformis;* four or five hard ledges passing into greensand below.....12 feet.

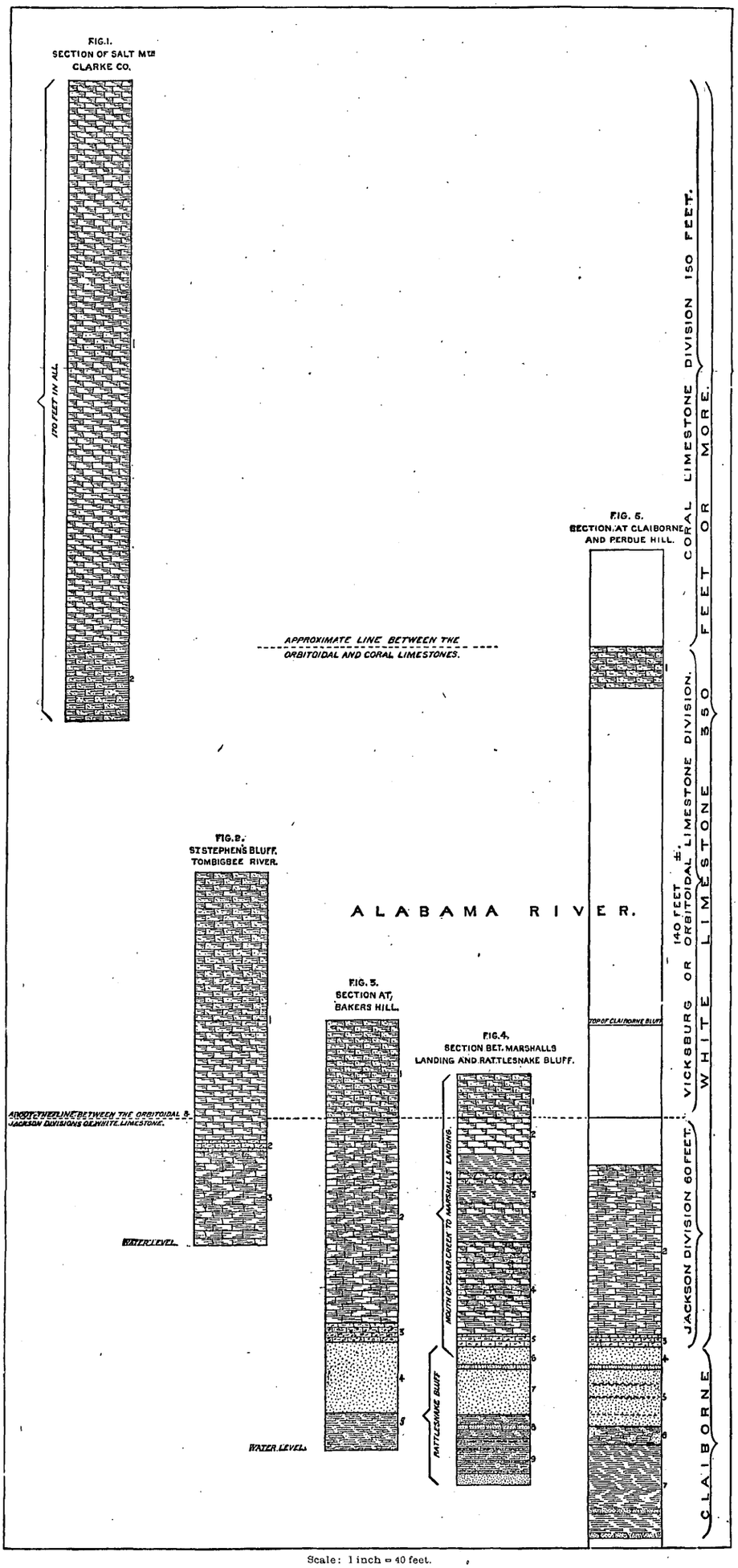
FIG. 5. *Section of upper part of bluff at Claiborne and of part of hill back of bluff, along the road to Perdue Hill, Alabama River.*

Hill back of river bluff.

1. White Limestone filled with *Orbitoides Mantelli,* occurring on road to Perdue Hill, 100 feet or more above top of bluff at Claiborne Landing. Tertiary strata covered by Drift along road leading from Perdue Hill up to Claiborne..90 to 100 feet. Tertiary strata covered by Drift, at top of river bluff .....38 to 40 feet.

Upper part of bluff.

2. White or bright colored, argillaceous limestone with glauconite grains.....45 feet.
3. Indurated ledge of *Scutella Lyelli*.....3 feet.
4. Coarse, ferruginous sand, calcareous below, indurated at base .....6 feet.
5. Claiborne fossiliferous sands, ferruginous. Lignitic in places above..15 to 17 feet.
6. Bluish green, glauconitic, sandy marl, with *Ostrea sellæformis*, part indurated..4 feet.
7. Calcareous, bluish gray clay, few badly preserved fossils, passing below into a greenish, glauconitic marl containing great numbers of young *Ostrea sellæformis* and a few *Pectens*, together about 18 feet; below this, light gray, calcareous clay, similar to top of preceding hard, sandy ledge at top and bottom, 7 feet; in all.....25 feet.



Scale: 1 inch = 40 feet.

SECTIONS OF THE WHITE LIMESTONE ON ALABAMA AND TOMBIGBEE RIVERS.

PLATE XIII.

ILLUSTRATING THE CLAIBORNE STRATA AS EXPOSED ALONG THE ALABAMA AND TOMBIGBEE RIVERS.

FIG. 1. *Section by C. S. Hale.*

No. 8. White Limestone, thickness not given by Hale.
No. 7. Yellow, quartzose sand, highly fossiliferous; seam of earthy lignite near the middle.....15 feet.
No. 6. Clay bed, with shells of full grown *Ostrea sellæformis*.....20 feet.
No. 5. Marly, arenaceous beds, with same shells as are common in the other beds; thickness not given by Hale.
No. 4. Argillaceous, muddy deposits. Fossils mostly oyster, except *Venericardia planicosta, Arca,* and *Turritella;* occurs also at Coffeeville.....15 to 20 feet.
No. 3. Only a few feet at Claiborne; greensand running gradually into No. 4.

FIG. 2. *Section by Professor Tuomey.*

g. Red loam, sand, and pebbles.....30 feet.
f. White and mottled clay.....8 feet.
e. Limestone, with a small percentage of greensand.....54 feet.
d. Sandy, fossiliferous bed.....15 feet.
c. Whitish limestone, with bed on top containing *Ostrea sellæformis* and *Scutella Lyelli.* This bed passes below into a bluish marl with shells.....62 feet.
b. Bed of clay, with limestone seam on top. This bed is more calcareous below and contains fossils that, as a group, are peculiar.....15 to 18 feet.

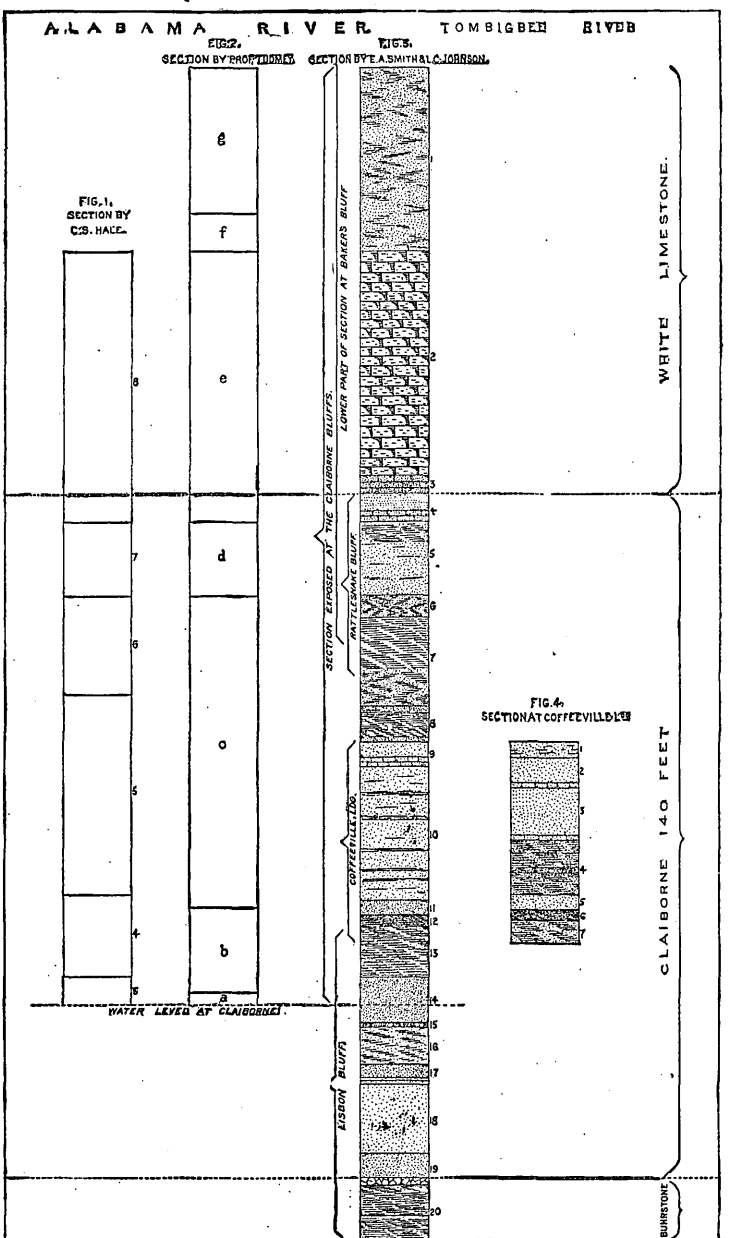
FIG. 3. *Section by E. A. Smith and L. C. Johnson.*

1. Red loam, sand, and pebbles.....35 to 40 feet.
2. Argillaceous limestone, with greensand grains.....45 feet.
3. Indurated ledge, with *Scutella Lyelli*.....3 feet.
4. Coarse, ferruginous sand, calcareous below; indurated ledge at base.....6 feet.
5. Claiborne fossiliferous sands; ferruginous sands, with shells; laminated lignitic clays, with leaf impressions, and thin seams of lignite in places in upper part.....15 to 17 feet.
6. Bluish green, glauconitic sandy marl, containing *Ostrea sellæformis,* in part indurated.....3 to 4 feet.
7. Calcareous, bluish gray clay, with a few badly preserved fossils, passing downward into a greenish, glauconitic, sandy marl, containing great numbers of young shells of *Ostrea sellæformis* and a few *Pectens,* the two together, clay and sand.....about 18 feet.
8. Light gray, calcareous clay, similar to the preceding, with hard, sandy ledges at top and bottom, in all.....about 7 feet.
9. Light yellowish gray, calcareous sands, with *Pectens* and *Ostrea sellæformis,* the lower half indurated, containing casts of univalve shells.....about 5 feet.

10. Light yellowish gray, calcareous sands, with thin beds of more clayey texture and with five or six hard, sandy ledges at intervals; the sand is, in places, loose and crumbling, and quite fossiliferous, with *Ostrea sellæformis*, *Pecten Deshayesii*, fragment of *Scutella Lyelli*, &c., lower 8 feet a bluish, clayey sand. about 27 feet.
11. Bed of greensand, with perfect shells and fragments of *Ostrea sellæformis* &c..... about 3 feet.
12. Dark blue, nearly black, sandy clay.....2 feet.
13. Bluish green, clayey sands, few fossils above, but highly fossiliferous below and rather more clayey, *Venericardia planicosta*, *Nucula magnifica*, *Ostrea sellæformis*, *Arca rhombodella*, *Voluta Sayana*, *Turritella Mortoni*, *T. bellifera*, &c....10 feet.
14. Dark grayish blue greensand, peculiar small form of *Venericardia planicosta*, large *Turritella Mortoni*, &c., 6 feet at Claiborne, but 10 feet at Lisbon.
15. Hard, sandy ledge..... 8 inches.
16. Calcareous, clayey sands, lighter yellowish to white color.....8 feet.
17. Coarse, ferruginous sands, with numerous fossils.....3 feet.
18. Light yellow sands, capped with a hard ledge, forming perpendicular bluff. 15 feet.
19. Blue, glauconitic sands, probably a modification of 18.....5 feet.
20. Bluish black clay; top of Buhrstone contains curious concretions of sandy clay, like interlacing roots.

FIG. 4. *Section at Coffeeville Landing, Tombigbee River.*

1. Light yellowish sands, partly indurated, with *Ostrea sellæformis*, &c.....3 feet.
2. Loose, yellowish, calcareous sands, with *Ostrea sellæformis*. Indurated sand ledge at base..... 6 feet.
3. Loose, yellowish gray, calcareous sands, highly fossiliferous below, *Ostrea sellæformis* the chief form, separated from next by hard, sandy ledge.....10 feet.
4. Bluish, clayey sand, with *Ostrea sellæformis* and *Flabellum*, in two parts, separated by hard ledge: upper part, 8 feet; lower, 3 feet, in all .....12 feet.
5. Glauconitic sands, filled with comminuted and perfect shells of *Ostrea sellæformis*, &c.....3 feet.
6. Dark bluish black, non-fossiliferous, sandy clays .....2 feet.
7. Dark bluish green, clayey sand to water level.....5 feet.



Scale: 1 inch = 40 feet.

SECTIONS OF THE CLAIBORNE STRATA ALABAMA AND TOMBIGBEE RIVERS.

PLATE XIV.

SECTIONS OF THE BUHRSTONE STRATA WITH THE ADJACENT STRATA OF THE CLAIBORNE AND LIGNITIC.

FIG. 1. *Section at Lisbon, Alabama River.*

1. Light yellow sands, with glauconite, capped with hard ledge, lower 5 feet of bluish color, base of Claiborne rocks.....20 feet.
2. Bluish black jointed clay, sandy concretions in upper part .....15 feet.

FIG. 2. *Section at Hamilton's Landing, Alabama River.*

1. Light gray, indurated clays and aluminous sandstones, with one or two indurated ledges, forming the whole of the bluff at Hamilton's Landing.....75 feet.

FIG. 3. *Section exposed along road leading up hill west of McCarthy's Ferry, Tombigbee River.*

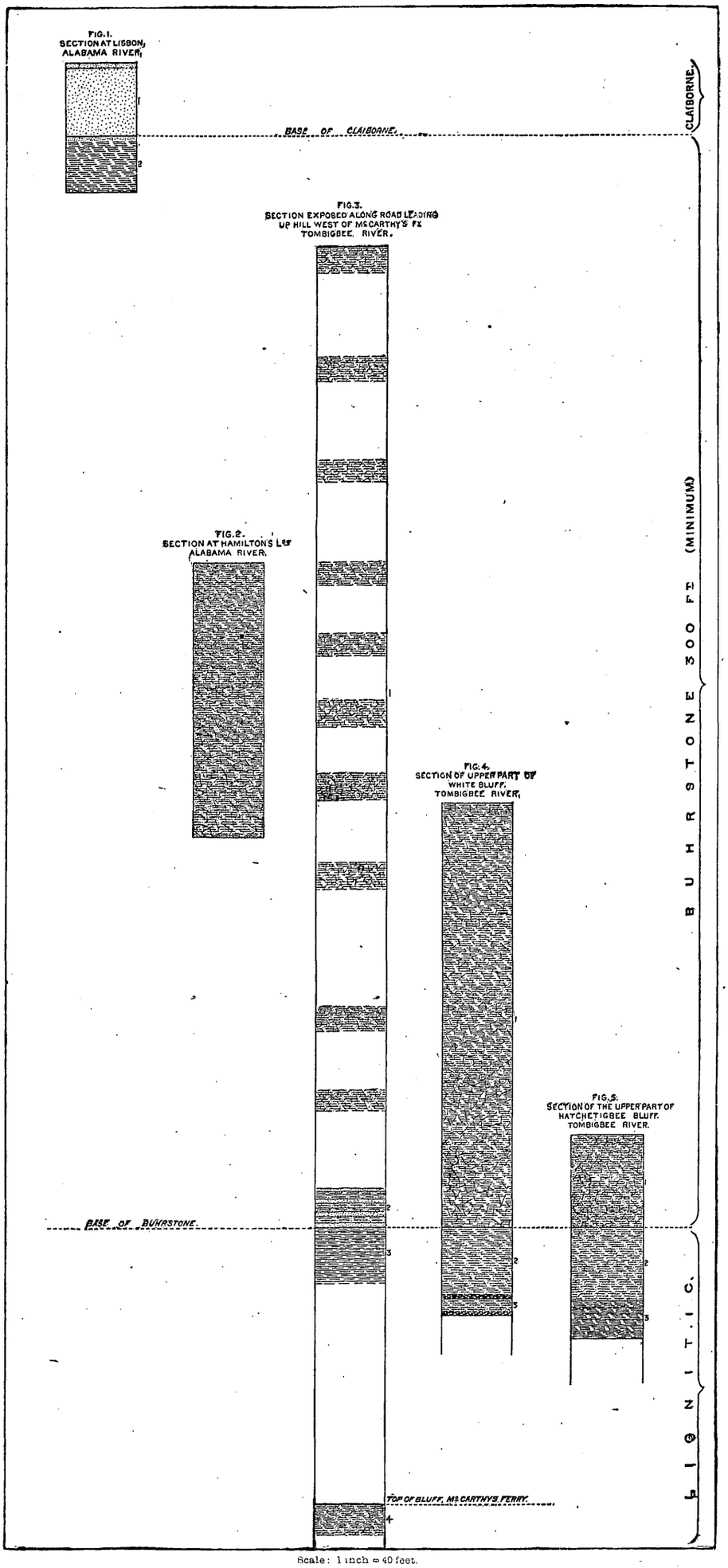
1. Top of hill west of McCarthy's Ferry, in Choctaw County. On the road down to the ferry 250 to 270 feet of Buhrstone rocks are passed over. These consist of indurated clays, claystones, and aluminous sandstones; the relative positions and order of succession of the different beds not intended to be represented in figures. These rocks appear at the surface at short intervals all the way..exposed 270 feet.
2. Ledge of silicious sandstone or quartzite, interstratified with indurated clays.
3. Laminated clays, reddish and yellowish, just below Buhrstone rocks on road down the hill; strata exposed just back of bluff of river.
4. Sandy clays &c. (Continuation, see Fig. 3, Plate XV.)

FIG. 4. *Section of upper part of White Bluff, below Wood's Bluff, Tombigbee River.*

1 Aluminous sandstones and indurated clays with jointed structure, forming a clear, perpendicular bluff.....115 feet.
2. Grayish, sandy clays, with a layer 18 inches thick at base, containing lignitized stems and twigs.....20 feet.
3. Sandy clays, lignitic layer at base.....5 feet.

FIG. 5. *Section of the upper part of Hatchetigbee Bluff, Tombigbee River.*

1. Light colored, aluminous sandstone and indurated clays.....20 to 30 feet.
2. Sandy clays, brown, yellow, and red, interstratified, bluish when wet, but lighter when dry .....20 feet.
3. Heavy bedded, brownish clays, darker than the preceding.....10 feet.



Scale: 1 inch = 40 feet.

SECTIONS OF THE BUHRSTONE STRATA, WITH ADJACENT STRATA OF THE CLAIBORNE AND LIGNITIC.

PLATE XV.

ILLUSTRATING THE HATCHETIGBEE SECTION OF THE LIGNITIC, BUT INCLUDING ALSO A PORTION OF THE LOWER PART OF THE BUHRSTONE AND THE UPPER PART OF THE WOOD'S BLUFF SECTION.

FIG. 1. *Section of White Bluff, Davis's Bluff, and Wood's Bluff, Tombigbee River.*

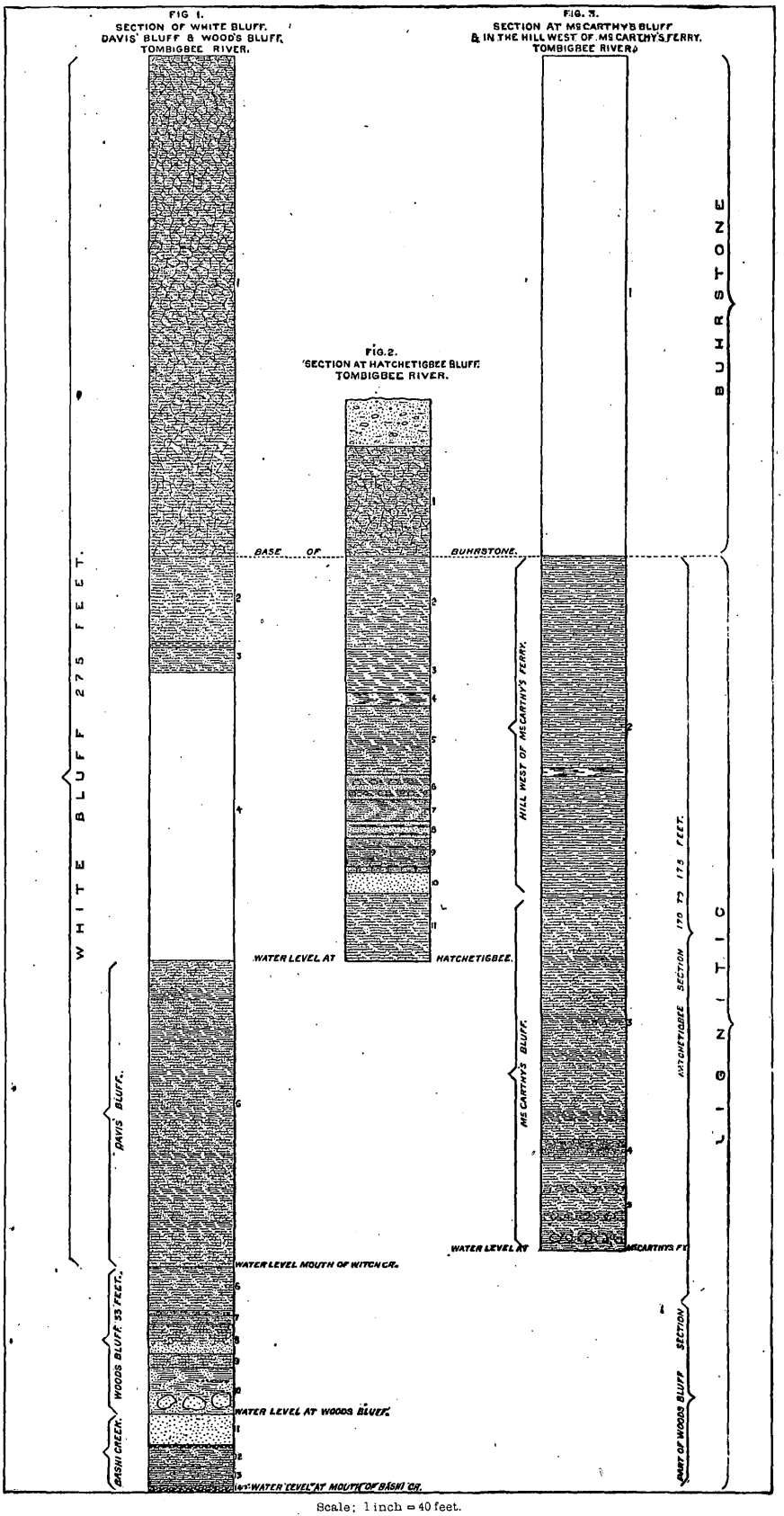
1. Buhrstone rocks, chiefly aluminous sandstones and indurated clays, with jointed structure and prevailing light gray colors, forming a perpendicular cliff. 115 feet.
2. Grayish, sandy clays, with a layer 18 inches thick at base, containing lignitic stems and twigs ..... 20 feet.
3. Sandy clays, with lignitic layer at base ..... 5 feet.
4. Strata obscured by landslides ..... 65 feet.
5. Dark gray, sandy clays, striped with brownish purple bands of clay containing very few fossils, except in a thin band of marl 12 feet above the water and one 24 feet above the water, all exposed in Davis's Bluff. ..... 70 feet.
6. Dark gray to brown, sandy clays, between Wood's Bluff and Davis's Bluff.. 10 feet.
7. Bluish, sandy, fossiliferous clay, red on surface, hard ledge at top ..... 3 feet.
8. Bluish, sandy clay, like No. 7, but not fossiliferous, passing into greensand below ..... 7 feet.
9. Fossiliferous, clayey greensand ..... 3 feet.
10. Greensand marl, with stratum of ponderous oyster shells, highly fossiliferous; tends to form rounded bowlders ..... 10 feet.
11. Fossiliferous greensand, loose and easily washed out, forming caves under the bowlders ..... 8 feet.
12. Thin band of lignite over greenish, non-fossiliferous, clayey sands ..... 5 feet.
13. Laminated, gray, sandy clays ..... 3 to 4 feet.
14. Lignite ..... 8 feet or more.

FIG. 2. *Section at Hatchetigbee Bluff, Tombigbee River.*

1. Drift and surface materials, light colored, aluminous sandstones and indurated clays, Buhrstone rocks ..... 20 to 30 feet.
2. Sandy clays of brown, yellow, and red colors, interstratified, blue when moist, lighter color when dry ..... 15 to 20 feet.
3. Heavy bedded, brownish clays of darker color than No. 2 ..... 10 feet.
4. Yellowish, glauconitic marl ..... 3 feet.
5. Purplish brown, sandy clays, with band of hard, dark colored clays in middle, projecting ..... 15 feet.
6. Yellowish gray sands, striped with brown clays, forming bowlders at intervals ..... 6 feet.
7. Blue clay marl, sandy, many new forms ..... 5 feet.
8. Grayish sands striped with brown clay bands, bowlders ..... 4 feet.
9. Heavy bedded, gray, sandy clays, with brown clay stripes, indurated at base. 8 feet.
10. Reddish, fossiliferous sand, *Venericardia planicosta* abundant ..... 5 feet.
11. Dark gray to brown, sandy clays, to water's edge ..... 15 feet.

FIG. 3. *Section at McCarthy's Ferry, Tombigbee River.*

1. Buhrstone rocks exposed along road leading up the hill from McCarthy's Ferry. See Fig. 3, Pl. XIV.
2. Laminated clays, reddish and yellowish, containing an indurated greensand marl with Hatchetigbee fossils, exposed in hill above the bluff and intervening between the strata seen in the river bluff and the aluminous rocks of the Buhrstone seen higher up the hill.
3. Sandy clays interstratified with clays less sandy, light gray, along the whole length of the bluff. There are parallel bands of much darker brown clays... 55 feet.
4. Laminated clays and sands, firm and compact at base, and forming projecting ledge..... 5 feet.
5. Pyritous sandy clays, with two or three bands of darker color, indurated in places, forming bowlders ..... 20 feet.



Scale: 1 inch = 40 feet.

HATCHETIGBEE SECTION OF THE LIGNITIC, WITH PARTS OF THE BUHRSTONE AND WOOD'S BLUFF.

PLATE XVI.

ILLUSTRATING THE WOOD'S BLUFF OR BASHI AND BELL'S LANDING SECTIONS OF THE LIGNITIC, AND INCLUDING THE LOWER BEDS OF THE HATCHETIGBEE SECTION.

FIG. 1. *Section at Yellow Bluff, Alabama River.*

1. Gray, sandy clays, with cross bedded sands. Forty feet seen in one exposure in river bank and 90 feet more seen on the hills within 1 mile of the river. Only the lower 40 feet occurring at river are here shown.....40 feet.
2. Greensand marl, Wood's Bluff fossils .....6 feet or more.
3. Blue clay .....1 foot.
4. Gray, sandy clays of slightly purple tinge, containing four or five thin seams of lignite .....40 feet.
5. Reddish, cross bedded sand .....20 feet.
6. Lignitic clay and lignite.....2 feet.
7. Reddish sands, slightly laminated.....15 feet.
8. Gray, sandy clays, laminated, forming perpendicular cliff .....25 feet.
9. Greensand marl, indurating into bowlders, Bell's Landing fossils.....8 feet.
10. Greenish, ferruginous sands interlaminated with thin sheets of clay to water level.....7 feet.

FIG. 2. *Section at Bell's Landing, Alabama River.*

1. Yellowish, cross bedded sands .....15 feet.
2. Lignite .....2 feet.
3. Laminated, sandy clays, with a few large, bowlder like concretions.....10 feet.
4. Yellow, stratified sands, alternating with gray, sandy clays.....15 feet.
5. Gray, sandy clays, laminated .....15 feet.
6. Greensand marl, forming bowlders, gigantic shells.....6 to 10 feet.
7. Dark gray, laminated, sandy clays.....25 feet.
8. Sandy, clay marl .....1 to 2 feet.
9. Dark gray, sandy clay to water level.....4 feet.

FIG. 3. *Section at Peebles's Landing, Alabama River.*

1. Yellowish sands .....1 to 2 feet.
2. Lignite and lignitic clay.....2 feet.
3. Reddish sands, laminated.....10 feet.
4. Gray clays and sands, variously interstratified.....about 30 feet.
5. Greensand marl, forming bowlders, Bell's Landing fossils .....8 feet.
6. Dark gray, sandy, laminated clays .....25 feet.
7. Strata covered by second bottom deposits, down to water level.....20 feet.

FIG. 4. *Section at Gregg's Landing, Alabama River.*

1. Greensand marl, forming bowlders, Bell's Landing fossils.....8 to 10 feet.
2. Gray, sandy, laminated clays .....20 to 25 feet.
3. Sandy clay marl, fossiliferous.....4 to 5 feet.
4. Laminated, sandy clays to water level.....10 feet.

FIG. 5. *Section at Lower Peach Tree Landing, Alabama River.*

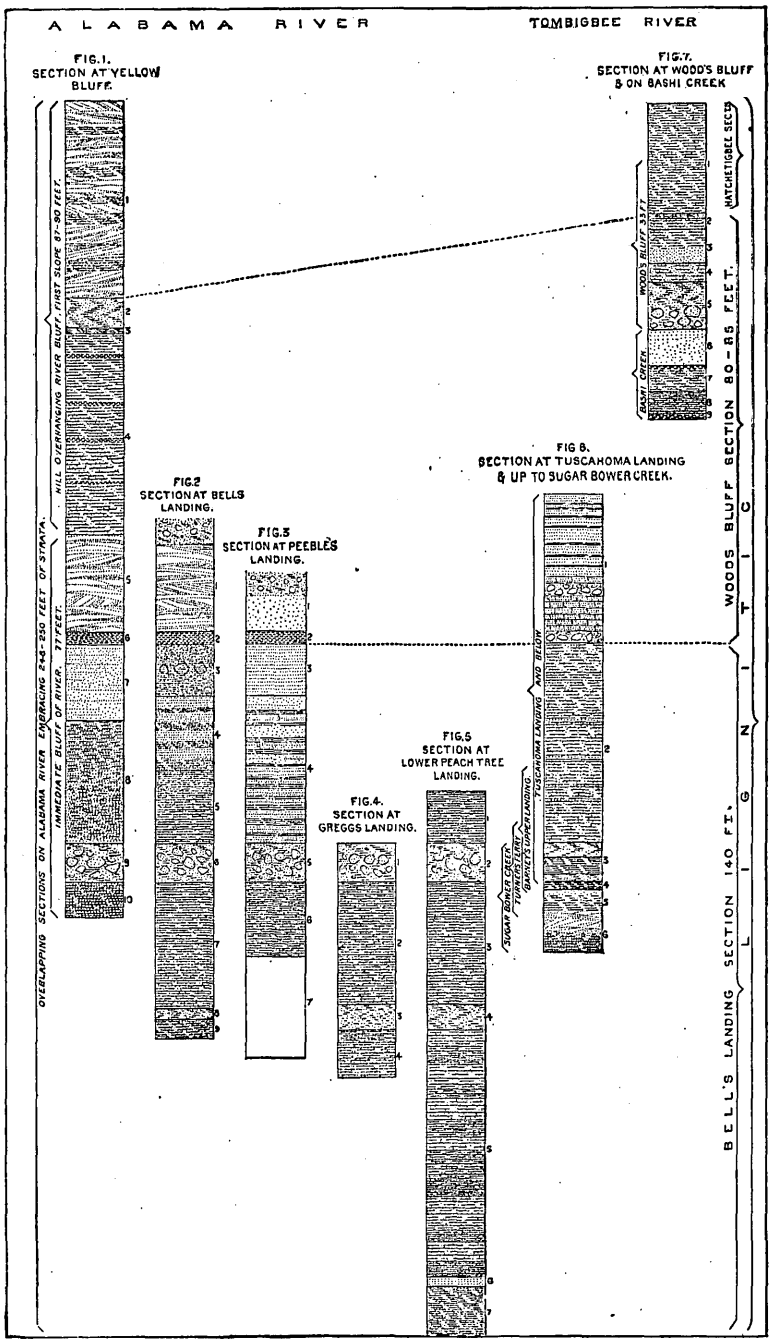
1. Sandy, laminated clays, top of bluff ..... 10 feet.
2. Greensand marl, forming bowlders, Bell's Landing fossils..... 8 to 10 feet.
3. Laminated, sandy clays of gray color but with reddish layers ..... 20 to 25 feet.
4. Bluish, sandy clay marl, Gregg's Landing fossils..... 4 to 5 feet.
5. Sandy clays of prevailing gray color, varying in degree of sandiness and coarseness of lamination. No fossils observed ..... 50 feet.
6. Fossiliferous greensand..... 1 foot.
7. Gray, sandy clays to water level..... 10 feet.

FIG. 6. *Section at Tuscahoma Landing and up to Shuquabowa Creek, Tombigbee River.*

1. Laminated sands, interstratified with clayey sheets, upper part; lower part, indurated sands with two lines of ferruginous, bowlderlike concretions, one at base, the other ten feet above..... 30 feet.
2. Light bluish gray, sandy clays, striped with somewhat harder projecting bands or ledges..... 35 to 40 feet.
3. Greensand marl, Bell's Landing fossils; three feet blue clay in middle..6 to 7 feet.
4. Bluish black, massive clay..... 2 feet.
5. Sands passing into sandy clays below ..... 5 feet.
6. Lighter colored, cross bedded sands above, with sands and clay interstratified below..... 8 feet.

FIG. 7. *Section at Wood's Bluff and Bashi Creek, Tombigbee River.*

1. Dark gray to brown and purple, sandy clays, lower beds of Hatchetigbee section.
2. Bluish, sandy, fossiliferous clay, red on surface, hard ledge on top ..... 3 feet.
3. Bluish, sandy clay (like 2), but not fossiliferous, passing into greensand below. 7 feet.
4. Fossiliferous, clayey greensand..... 3 feet.
5. Greensand marl, main bed, with a stratum of ponderous oyster shells; highly fossiliferous sands forming bowlders..... 10 feet.
6. Fossiliferous greensand, loose and easily washed out, forming caves below the bowlders ..... 8 feet.
7. Thin bands of lignite over greenish, non-fossiliferous, clayey sands..... 5 feet.
8. Laminated, gray, sandy clays..... 3 to 4 feet.
9. Lignite ..... 1 foot.



Scale. 1 inch = 40 feet.

WOOD'S BLUFF OR BASHI SECTION AND BELL'S LANDING SECTION OF THE LIGNITIC.

PLATE XVII.

ILLUSTRATING THE NANAFALIA AND COAL BLUFF SECTIONS OF THE LIGNITIC.

FIG. 1. *Sections at Gullette's Bluff and Coal Bluff, Alabama River.*

Gullette's Bluff.

1. Red loam, sand, &c., of Drift, at the top of the bluff.....10 feet.
2. Indurated, glauconitic clay.....3 feet.
3. Gray, sandy clays, alternately thinly laminated and heavy bedded or massive.....12 feet.
4. Very green, glauconitic sand.....2 feet.
5. Gray, sandy clays, similar to No. 3 above.....20 feet.
6. Fossiliferous, glauconitic sand, first of *Gryphæa thirsæ* beds.....3 feet.
7. Compact, yellowish sands with *Gryphæa thirsæ*, capped by hard ledge, forming vertical cliff.....13 feet.
8. Indurated sands.....2 feet.
9. White, cross bedded sands.....12 feet.
10. Bluish sands in a vertical cliff; contains *Gryphæa thirsæ;* indurated ledge in middle and at bottom of the bed.....20 feet.
11. Bluish, clayey sands, with *Gryphæa*.....10 feet.
12. Sands with *Gryphæa thirsæ*, traversed by several indurated ledges down to water level; darker colored and more clayey below.....20 feet.

Between mouth of Pursley Creek and Coal Bluff.

13. Greensand, mouth of Pursley Creek.....5 feet.
14. Sands capped with indurated ledge.....3 feet.
15. Clayey sands; indurated sandy ledges at top and in the midst.....6 feet.
16. Indurated greensand.....3 feet.
17. Softer greensand, out of which caves are washed.....5 feet.
18. Greensand of firmer texture, with 1 foot of brownish sand at bottom.....8 feet.
19. Lignite of Coal Bluff.....4 feet.
20. Firm, gray, sandy clays appearing just above Coal Bluff Landing.....10 feet.

FIG. 2. *Section in Grampian Hills, 2 to 3 miles south of Camden, Wilcox County.*

1. Light colored sand and clayey rocks 2 feet, and 2 feet sandstone with shell casts.....4 feet.
2. Gray clays, indurated, closely resembling Buhrstone.....10 to 15 feet.
3. Light colored, sandy clay rock, full of shell casts, chiefly *Turritella*.....5 feet.
4. Gray crumbling clays, weathering into small bits.....5 to 6 feet.
5. Hard, glauconitic, sandy clay with shell casts breaking into cuboidal blocks..3 feet.
6. Gray, indurated clays, glauconitic in places, and like some of the Buhrstone clays.....12 to 15 feet.
7. Greensand, with casts of *Gryphæa thirsæ*.....2 feet.
8. Greensand, in places converted into a yellowish sand, holding the *Gryphæa thirsæ*.....10 feet.

9. Yellow sands, with *Gryphæa* ..... 5 feet.
10. Bed of *Gryphæa* shells ..... 1 foot.
11. Yellow sands, with *Gryphæa*, and forming bowlders, 6 to 8 feet; in all..12 to 14 feet.

FIG. 3. *Section on Pursley Creek, Wilcox County, Camden and Black's Bluff road.*

1. Red loam, sand, &c., of Drift.
2. Dark colored, crumbling sandy clays ..... 5 feet.
3. Sands, with *Gryphæa thirsæ* and a few other fossils ..... 5 to 7 feet.
4. Thin bedded sands and sandy clays ..... 15 feet.
5. Yellowish gray, cross bedded sands, with indurated bowlders of same materials; these sands hold also thin, lenticular sheets of gray clay ..... 25 feet.
6. Interstratified sands and clays of grayish color, with shades of yellow, rather thin-bedded ..... 15 feet.
7. Gray, sandy clays in banks of Pursley Creek ..... 6 feet.
8. Lignite or lignitic clay, bed of Pursley Creek.

FIG. 4. *Strata exposed on Tombigbee River from mouth of Horse Creek up to Nanafalia; also section on Landrum's Creek.*

Mouth of Horse Creek to Gay's Landing.

1. Gray, sandy clays, forming banks of river between mouth of Horse Creek and Williams's Gin, and directly overlying the bed at the last named place. 20 feet.
2. Gray, sandy clays, thin bedded, and in joint planes, passing below into a hard, sandy ledge ..... 8 feet.
3. Indurated greensand, with *Gryphæa thirsæ* ..... 2 feet.
4. Dark blue black clays, with thin, firm ledges ..... 6 feet.
5. Indurated sands, with *Gryphæa thirsæ* ..... 2 feet.
6. Bluish black, sandy clays ..... 3 feet.
7. Greensand, with *Gryphæa thirsæ*, passing below into gray, sandy clay. 5 feet or more.

Lott's Ferry.

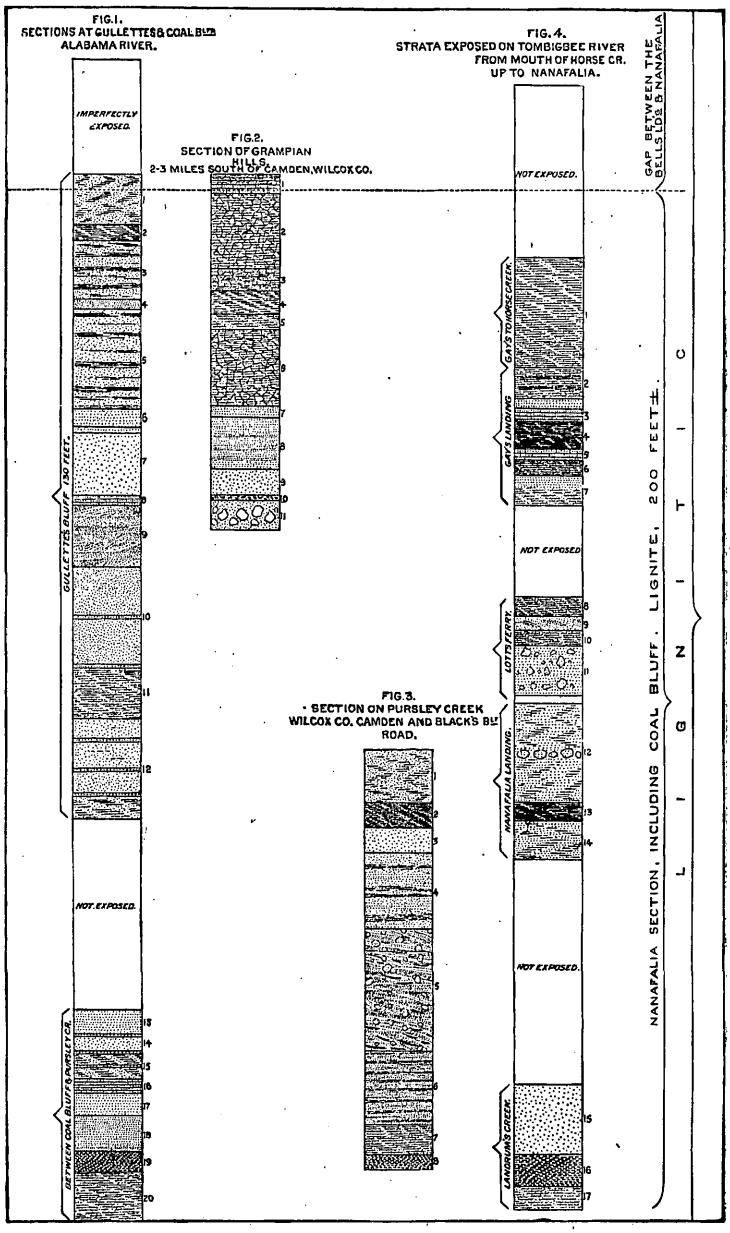
8. Black, sandy clay, fossiliferous ..... 4 feet.
9. Sands, with *Gryphæa thirsæ*, cross bedded in places ..... 3 feet.
10. Dark gray, sandy clay, with few fossils ..... 3 feet.
11. Greensand, with *Gryphæa thirsæ*, forming hard bowlders in places ..... 10 feet.

Nanafalia Landing.

12. Greensand marl, highly fossiliferous, with *Gryphæa thirsæ* and other forms; line of indurated, projecting bowlders along central part of bed ..... 20 feet.
13. Dark blue, almost black, laminated clay, devoid of fossils ..... 3 to 4 feet.
14. Bluish greensand marl, highly fossiliferous below, *Gryphæa thirsæ* and other forms ..... 8 to 10 feet

Landrum's Creek.

15. Bluish, micaceous sands overlying lignite on Landrum's Creek, near Nanafalia Bluff ..... 15 feet.
16. Lignite exposed on Landrum's Creek ..... 7 feet.
17. Gray, sandy clays ..... 5 feet.



Scale: 1 inch = 40 feet.

NANAFALIA AND COAL BLUFF SECTION OF THE LIGNITIC.

PLATE XVIII.

ILLUSTRATING THE OAK HILL, PINE BARREN SERIES, WHICH INCLUDES THE NAHEOLA AND MATTHEWS'S LANDING, BLACK BLUFF. AND THE MIDWAY SECTIONS OF THE LIGNITIC.

FIG. 1. *Section at Oak Hill and on Pine Barren Creek.*

1. Cross bedded sands and thinly laminated clays, much weathered and with difficulty distinguished from the red loam &c. of the Drift.....25 feet.
2. Gray, cross bedded sands, with thin laminæ of dark gray clay. These beds are much the same as the preceding, but are much less weathered.....40 feet.
3. Cross bedded and laminated sands, yellowish.....1½ feet.
4. Thin bedded, gray, laminated clays, interstratified with thin ledges of cross bedded sands.....30 feet.
5. Sands 1 foot, clays 1 foot, sands 1 foot .....3 feet.
6. Gray clays interstratified with cross bedded sands .....6 feet.
7. Gray, cross bedded sands.....3 feet.
8. Gray clay, breaking up into cuboidal blocks, and interstratified with sandy ledges.....15 feet.
9. Black to gray, micaceous sands, with the fossils of Matthews's Landing, dark at top, lighter and glauconitic below .....7 feet.
10. Glauconitic sandy ledge, calcareous.....1 foot.
11. Yellowish, calcareous sands, with phosphatic and white lime concretions; crustacean remains in upper 5 feet; several hard, shaly ledges.....12 feet.
12. Glauconitic, sandy shales, with indurated ledge at top .....10 feet.
13. Sandy, shaly beds, with indurated ledges .....6 feet.
14. Hard, yellowish, sandy limestone, phosphatic.....3 feet.
15. Yellowish, calcareous, clayey sands, with white lime concretions, grayer and more clayey below; Black Bluff fossils abundant.....15 feet.
16. Black, calcareous clays, gray on weathered surfaces; Black Bluff fossils, especially in upper part. This forms basis of the prairie soils.....20 feet.
17. Hard, grayish white limestone, used for chimneys, &c., containing a large *Nautilus* .....10 feet.
18. Calcareous sands forming basis of the sandy prairies.....6 feet.
19. Hard, yellow, crystalline limestone, with Ostrea, *Turritella Mortoni*, and *Venericardia planicosta* .....8 feet.
20. Yellow, micaceous sands, with Ripley fossils—seen on road above Palmer's Mill .....55 feet.
21. Bluish gray, calcareous sands, with projecting sandy ledges, on Pine Barren Creek.....15 feet.

FIG. 2. *Section on the Alabama River.*

Coal Bluff.

1. Bluish greensand over lignite.
2. Coal Bluff lignite.....4 feet.
3. Compact, clayey sand underlying lignite.

Burford's Landing.

4. Gray, cross bedded sands alternating with laminæ of gray clay, Burford's Landing ..... 10 feet.

Walnut Bluff.

5. Light yellowish, cross bedded sands, Walnut Bluff.

Turkey Creek to Clifton.

6. Gray or bluish, sandy clays, forming river banks from mouth of Turkey Creek to Clifton, of variable dip and hence of undetermined thickness.
7. Dark, gray sandy clays at Clifton and above, nearly to mouth of Dickson's Creek. The beginning of the Matthews's Landing beds ..... 10 feet.

Matthews's Landing.

8. Bluish black, micaceous sands, highly fossiliferous ..... 5 to 6 feet.
9. Yellowish gray, calcareous sands, indurating into bowlders ..... 4 feet.
10. Bluish black, micaceous sands, fossiliferous, compact and clayey below. 7 to 8 feet.

Midway.

11. Black, calcareous clay overlying the Nautilus Rock ..... 5 feet.
12. Gray, argillaceous limestone, with numerous large *Enclimatoceras Ulrichi*.. 10 feet.

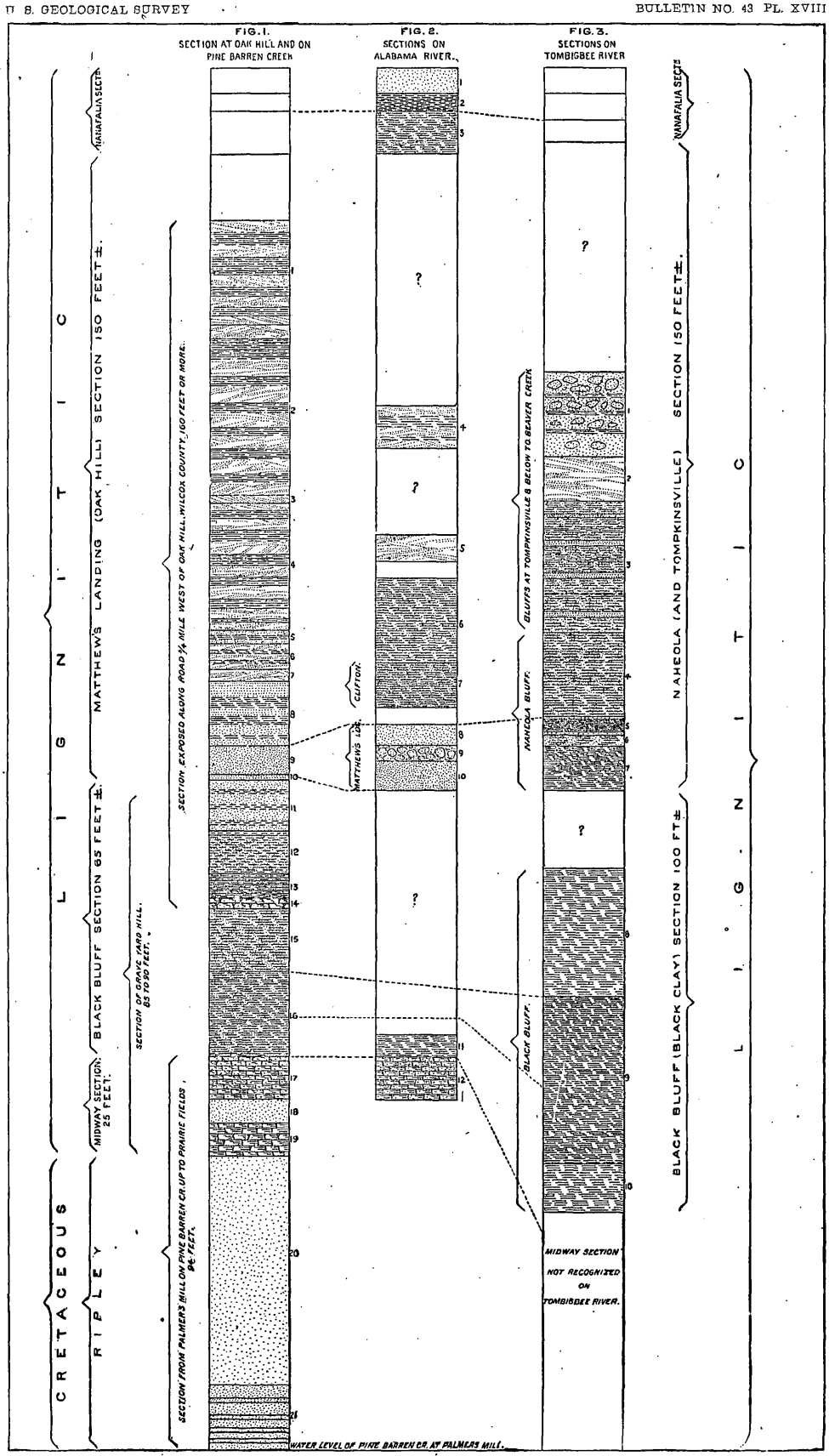
FIG. 3. *Sections on the Tombigbee River.*

Mouth of Beaver Creek to Naheola.

1. Coarse grained, micaceous sands, with projecting bowlders of indurated sand or sandstones, no fossils, thin clay partings at intervals, seen just below Tompkinsville ..... 20 feet.
2. Cross bedded sands, just below Tompkinsville ..... 10 feet.
3. Gray, sandy clays, alternating with ledges of indurated sand and thin clay partings, Tompkinsville Bluff, no fossils ..... 30 feet.
4. Gray, sandy clays, with ledges of sandier texture and lighter color ..... 20 feet.
5. Black, sandy clay, with indurated ledge of greensand above, in all ..... 3 feet.
6. Greensand marl, capped with hard ledge, ferruginous ..... 3 feet.
7. Black, slaty clay, recurring at all the bluffs above this to Black Bluff ..... 10 feet.

Black Bluff.

8. Yellowish clay at top of bluff. This clay is the basis of the Flatwoods ..... 30 feet.
9. Black, slaty clay, strongly calcareous, fossiliferous (Black Bluff fossils) ... 40 feet. The lower part of this division is covered with singularly shaped concretions of limonite.
10. Brownish, shaly clay to the water level ..... 10 feet.



Scale: 1 inch = 40 feet.

OAK HILL, PINE BARREN SERIES OF THE LIGNITIC, INCLUDING THE NAHEOLA AND MATTHEWS'S LANDING, THE BLACK BLUFF, AND THE MIDWAY SECTIONS.

PLATE XIX.

ILLUSTRATING THE RIPLEY FORMATION OF THE CRETACEOUS GROUP, ALABAMA AND TOMBIGBEE RIVERS.

FIG. 1. *Palmer's Mill, on Pine Barren Creek.*

1. Hard, yellow, crystalline limestone, with *Ostrea*, corals, *Turritella Mortoni, Venericardia planicosta*, &c ..... 8 feet.
2. Yellow, micaceous sands, with Ripley fossils, seen on road above Palmer's Mill ..... 55 feet.
3. Bluish gray, calcareous sands, with several projecting sandy ledges, to level of Pine Barren Creek ..... 15 feet.

FIG. 2. *Bridgeport Landing, Alabama River.*

1. Yellow, crystalline limestone, seen in Camden-Bridgeport road.
2. Yellowish, micaceous sands, forming basis of the hills back of the Bridgeport Bluff.
3. Yellow, clayey sands, top of bluff at Bridgeport Landing ..... 10 feet.
4. Coarse, yellow sands ..... 10 feet.
5. Laminated, gray clays ..... 1 foot.
6. Ledge of dark gray, sandy clay ..... 1 foot.
7. Dark gray, nearly black, sandy, micaceous clays, with hard, projecting, sandy ledges at intervals of 3 to 4 feet ..... 22 feet.
8. Projecting, sandy ledge ..... 1½ feet.
9. Dark gray, sandy clays ..... 3 feet.
10. Sandy ledge ..... 1 foot.
11. Dark gray, sandy clays, with two hard, sandy ledges, to water level ..... 10 feet.

FIG. 3. *Canton Landing, Alabama River.*

1. Yellow sands, forming basis of the fertile soils of the Canton Bend.
2. Yellowish gray, micaceous, and calcareous sands, in beds averaging 3 to 5 feet in thickness and separated by hard, sandy ledges, which shale off on weathering; these beds appear at intervals on hillside immediately back of the river bluff, being in part covered by débris ..... 100 feet.
   In places the clayey sands have a dark blue color.
3. Yellow, calcareous, sandy clays, like the preceding, with hard ledges above and below; top of river bluff ..... 10 feet.
4. Bluish, micaceous, sandy clays, the counterpart of those at Bridgeport, with two projecting, sandy ledges ..... 12 feet.
5. Light gray, calcareous sands, holding indurated, irregular masses, phosphatized shell casts, &c.; sandstone ledge at base ..... 6 feet.
6. Bluish gray, sandy clay, 5 feet thick, underlaid by more sandy bed, with phosphatized shell casts, nodules, &c ..... 8 feet.
7. Bluish, argillaceous limestone, with *Exogyra, Gryphæa*, and phosphatic casts. 3 feet.
8. Calcareous sands, with variety of fossils ..... 3 feet.

FIG. 4. *Foster's Creek, in Gee's Bend, Alabama River.*

1. Yellowish, calcareous, sandy clay soil, with growth of red cedars.
2. Dark gray, micaceous, sandy clays, like those of Bridg eport, with hard, sandier ledges of lighter color at intervals of 5 to 6 feet. The lowermost of these beds contain the small Moscow *Gryphæa* ..... 30 feet.

3. Impure limestone, glauconitic, with phosphatized shell casts &c. .....5 feet.
4. Coarse, calcareous sandstone ledge .....2 feet.
5. Bluish, sandy, argillaceous limestone, no fossils at top, but filled in its lower and middle parts with shells and phosphatized shell casts. The materials of this bed vary from argillaceous limestone to calcareous sands.....20 feet.
6. Brown, phosphatic limestone .....1 foot.
7. Argillaceous sandstone.....1 foot.

FIG. 5. *Section on Tear Up Creek, Wilcox County, Alabama River.*

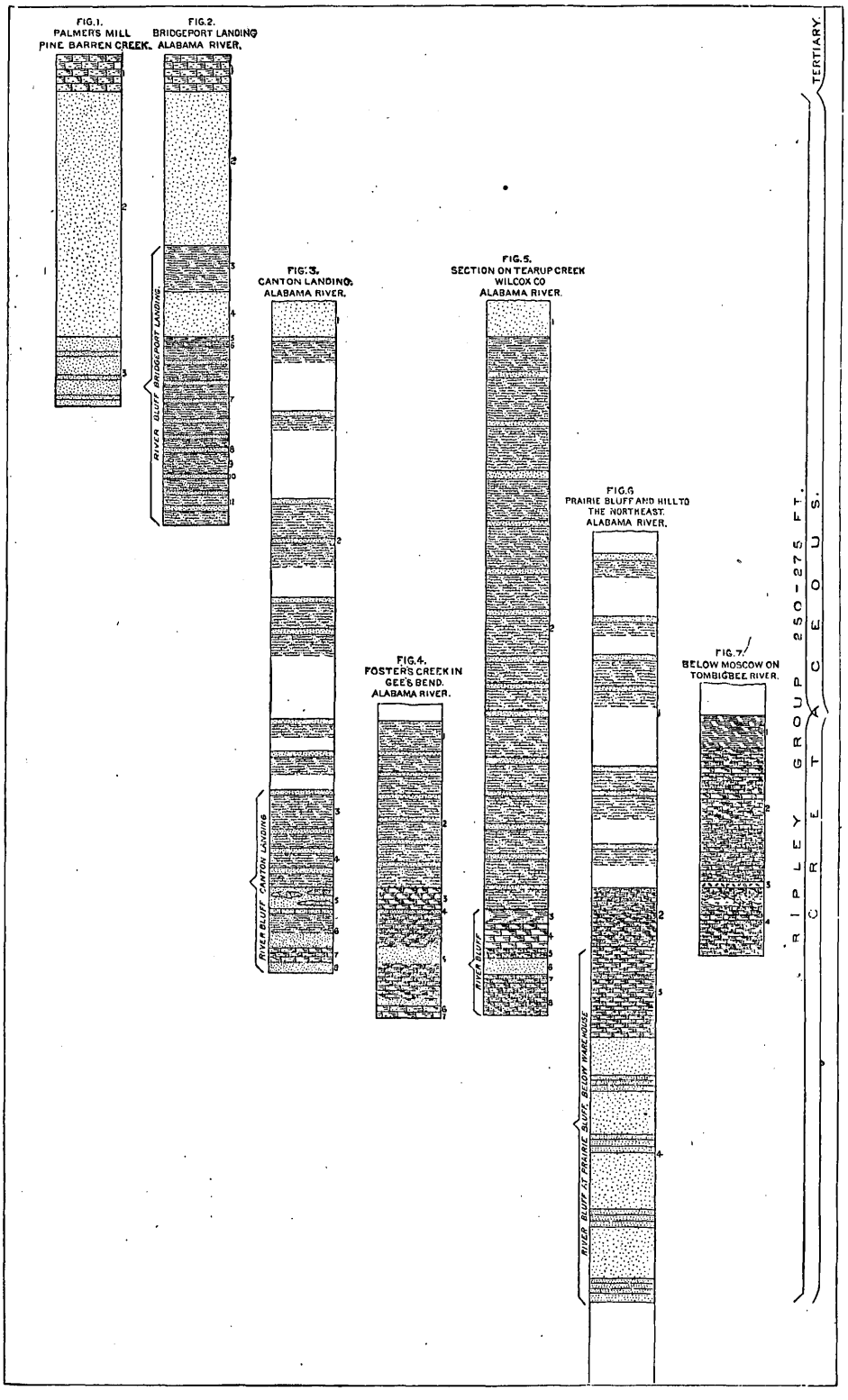
1. Yellow sands at base of McNeill's Mountain.
2. Dark bluish gray, sandy, micaceous clays, with hard, projecting ledges at intervals of 3 or 4 feet. These beds are exposed in channel of Tear Up Creek between the river and the foot of McNeill's Mountain, distance about 1 mile. The thickness not measured, but here placed equal to that noticed at Canton Landing ....100 feet.
3. Ferruginous, sandy marl, full of Ripley fossils.....3 feet.
4. Firm white limestone; no fossils observed.....6 feet.
5. White limestone, with a few fossils.....2 feet.
6. Sandy, calcareous beds, with fine fossils .....4 feet.
7. Sandy, indurated limestone ledge .....1 to 2 feet.
8. Calcareous limestone, with *Exogyra costata* &c .....8 feet.

FIG. 6. *Prairie Bluff and hill to the northeast, Alabama River.*

1. Yellowish, calcareous, and micaceous sands, with hard, sandy ledges at intervals of 4 or 5 feet, forming the hill northeast of Prairie Bluff towards Rehoboth. In some places, where less exposed to weathering, the color of the sandy clays is dark bluish, like those of Bridgeport. The strata of this hill are in appearance identical with those above the river bluff at the old Canton Landing, not a continuous section.....75 to 100 feet, perhaps more.
2. Impure limestone, holding phosphatized shell casts &c., outcropping on the bluff north of warehouse; extended thickness.....12 to 15 feet.
3. Bluish limestone, with shell casts and *Exogyra costata*, *Gryphæa mutabilis*, &c., forming top of bluff below warehouse; two hard ledges in it .....20 feet.
4. Sands, traversed by indurated bands of calcareous sand, holding *Exogyra costata* and *Gryphæa mutabilis* chiefly. The sands are white above and dark blue near water level, but the blue sands become white where they crop out up the river near the top of the bluff. Sands contain great numbers of *Ostrea falcata*.....50 to 60 feet.

FIG. 7. *Below Moscow, on the Tombigbee River.*

1. Black, shaly clay, devoid of fossils, joints filled with calcite, at mouth of Sucarnochie Creek .....6 to 8 feet.
2. Dark blue, shaly, argillaceous limestone and thin, projecting, harder ledges..30 feet.
3. Ledges of small *Gryphæa* shells .....1 foot.
4. Hard, impure limestones, with *Exogyra costata* and *Gryphæa mutabilis;* irregular, concretionary, sandy ledge above, with comminuted shells, below which a projecting ledge, with many phosphatized shell casts.....15 feet.



Scale 1 inch = 40 feet.

RIPLEY GROUP OF THE CRETACEOUS FORMATION.

PLATE XX.

ILLUSTRATING THE PHOSPHATIC GREENSANDS (TOMBIGBEE SAND) AT BASE OF THE ROTTEN LIMESTONE, TOGETHER WITH THE UPPER STRATA OF THE EUTAW FORMATION OF THE CRETACEOUS GROUP.

FIG. 1. *Bluff at Erie, Tuscaloosa River.*

1. Rotten Limestone of the usual character.....30 feet.
2. Indurated ledge, calcareous sand, glauconitic and phosphatic, containing oyster shells.....7feet.
3. Yellowish sands, containing shells in upper part.....8 feet.
4. Ledge of shells.....1 foot.
5. Yellowish, glauconitic sands; more glauconitic below.....5 feet.
6. Sandy ledge, with shells.....1 foot.
7. Greensand, cross bedded.....4 feet.
8. Laminated, blue clay, projecting.....2 feet.
9. Phosphatic greensand.....1 foot.

FIG. 2. *McAlpine's Ferry, Tuscaloosa River.*

1. Rotten Limestone of variable thickness, with covering of Drift.
2. Calcareous sands, indurated, containing shells, mostly oysters.....6 to 8 feet.
3. Sands.....8 to 10 feet.
4. Greensand to water level.....6 feet or more.

FIG. 3. *Choctaw Bluff, Tuscaloosa River.*

1. Rotten Limestone, with Inocerami and reptilian bones, covering of Drift..20 feet.
2. Indurated calcareous sands, full of shells, glauconitic; upper part = the "Concrete Sand" of Winchell.....6 to 7 feet.
3. Yellowish, cross bedded sands, containing oyster shells in upper part, more glauconitic and devoid of fossils below.....15 feet.
4. Glauconitic sands and small oyster shells.....1 foot.
5. Phosphatic greensand.....6 to 8 feet.

FIG. 4. *Section at Finch's Ferry, Tuscaloosa River.*

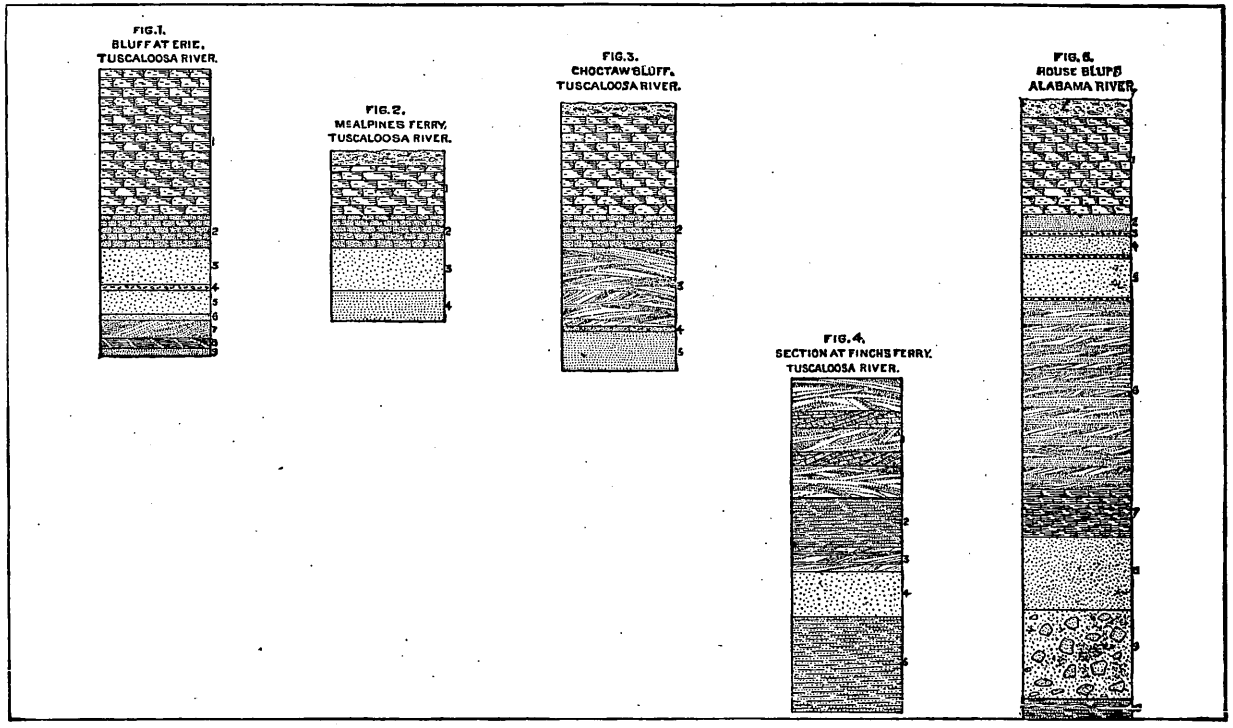
1. Yellowish, cross bedded sands, with indurated bands at intervals; contains a few casts of shells, mostly oysters, and pieces of silicified wood.....25 feet.
2. Laminated, blue clays, with sand between the laminæ.....10 feet.
3. Alternations of cross bedded sand and blue, laminated clay.....5 feet.
4. Bluish, glauconitic sands.....10 feet.
5. Laminated, blue clays, the laminæ separated by sand.....20 feet.

FIG. 5. *House Bluff, Alabama River.*

1. Rotten Limestone.....20 feet.
2. Greensand, with phosphatic nodules.....4 feet.
3. Bed of shells in sand.....1 foot.

4. Light colored sands, with irregular deposits of shells and shell bed at base. 5 feet.
5. Sands, with layer of shells at base ..... 9 feet.
6. Alternating beds of horizontally laminated and cross bedded sands, yellow (glauconitic), the separate beds from 1 to 2 feet thick, marked with streaks deeply colored by iron ..... 40 feet.
7. Laminated clays (soapstone), devoid of fossils ..... 10 feet.
8. Blue, micaceous sands, no fossils observed ..... 15 feet.
9. Light colored sands, with large, bowlder-like concretion ..... 20 feet.
10. Alternations of laminated clays and blue sands to water level.

(326)



Scale: 1 inch = 40 feet.

PHOSPHATIC GREENSANDS AT THE BASE OF THE ROTTEN LIMESTONE.

PLATE XXI.

GENERAL SECTION OF TERTIARY AND CRETACEOUS STRATA OF ALABAMA, AS EXPOSED ALONG THE ALABAMA, TOMBIGBEE, AND TUSCALOOSA RIVERS.

COLUMN 1. *Exposures inland near Alabama River.* (*Supplementary to Alabama River section.*)

Hills back of Yellow Bluff.

1. Gray, sandy clays, alternating with cross bedded sands, seen in hill back of Yellow Bluff; barometric measurement.....90 feet.
2. Gray, sandy clays, alternating with cross bedded sands, like the preceding; seen in hill at top of Yellow Bluff.....40 feet.
3. Greensand marl, Wood's Bluff.....6 to 15 feet.
4. Gray, sandy clays of purple tinge, including four or five thin seams of lignite. Top of Yellow Bluff.....40 feet.

Grampian Hills.

5. Gray, sandy clays, indurated, in part glauconitic, and filled with shell casts, chiefly of Turritella, in part closely resembling Buhrstone clays.....47 to 50 feet.
6. Glauconitic sands, with *Gryphæa thirsæ*, several indurated bands.....25 feet.

On Pursley Creek.

7. Glauconitic sands, with *Gryphæa thirsæ*, clayey above.....12 feet.
8. Laminated sand and sandy clays.....15 feet.
9. Yellowish gray, cross bedded sands, indurating, with bowlders, inclosing lenticular sheets of clay.....25 feet.
10. Gray sands and clays, interstratified, glauconitic; lignite at base; seen in Pursley Creek.....20 feet.

Oak Hill, Graveyard Hill, and Pine Barren Creek.

11. Gray, sandy clays, cross bedded sands, and thin, laminated clays in many alternations.....108 feet.
12. Gray clay, breaking into cuboidal blocks, 15 feet, passing into black clay marl, Matthews's Landing.....23 feet.
13. Yellowish, calcareous sands and sandy shales, with hard ledges and 3 feet hard, yellowish, phosphatic, sandy limestone at base.....31 feet.
14. Yellow, calcareous clays, passing below into black, all holding Black Bluff fossils.....35 feet.
15. Argillaceous white limestone; Nautilus Rock 10 feet, with 6 feet calcareous sands below.....16 feet.
16. Crystalline limestone and Turritella Rock.....8 to 9 feet.
17. Yellowish, micaceous sand, with Ripley fossils.....55 feet.
18. Bluish gray, calcareous sands, hard, projecting layers.....15 feet.

Near Vinton, Autauga County.

19. Thinly laminated, white and pink and purple clays, with small percentage of pink, purple, and yellow sand.....30 feet.
20. Purple and mottled clays 12 feet, red sands 5 feet, and white and yellow, laminated clays 8 feet.....25 feet.
21. Variegated pink and micaceous sands.....6 feet.
22. Mottled, yellow and purple, sandy clays and sands, on the banks of Mulberry Creek.....20 feet.

Soap Hill, Bibb County.

23. Clayey sands in several ledges.....10 feet.
24. Cross bedded, yellowish white sands, indurating into sandstones at intervals.....30 feet.

25. Laminated, gray clay, with partings of sand 10 feet, overlying 40 feet of laminated clays and cross bedded sands ..... 50 feet.
26. Laminated, gray, sandy clays, with leaf impressions, sand at base ..... 20 feet.

Near Tuscaloosa.

27. Variegated, purple sands, sheet of ferruginous sandstone on top ..... 8 feet.
28. Purple clay, with partings of sand ..... 10 feet.
29. Gray, yellow sands and clays, ferruginous ledge on top ..... 8 feet.
30. Thin bed of lignite in clays, over gray mass. Not seen ..... about 20 feet.
31. Purple clays, with two ledges of sandy iron ore ..... 40 to 50 feet.

COLUMN 2. *Section exposed on Alabama River.*

Marshall's Landing to Lisbon.

1. *Vicksburg.* White Limestone, with *Orbitoides Mantelli*, hill back of Claiborne, also back from river, from Marshall's Landing to Gainestown.. at least 140 feet.
2. *Jackson.* Argillaceous White Limestone, with bones of *Zeuglodon Cetoides*, phosphatic nodules, and marls, from Claiborne to Marshall's Landing ..... 60 feet.
3. Scutella bed, followed by coarse, ferruginous sands, of which 17 feet is highly fossiliferous; hard, sandy ledge at base ..... 30 feet.
4. Calcareous clay, alternating with greensand containing *Ostrea sellæformis*. 25 feet.
5. Light gray, calcareous sands, traversed by hard, sandy ledges, clayey in part, *Ostrea sellæformis*, characteristic greensand, and shells at base ..... 35 feet.
6. Blue clay, passing into greensand, upper half with few fossils, lower half highly fossiliferous ..... 22 feet.
7. Calcareous, clayey sands ..... 9 feet.
8. Coarse ferruginous marl 3 feet, followed by 20 feet of light yellow sands, few fossils ..... 23 feet.
9. Bluish, jointed clay ..... 12 feet.

Hamilton's Landing.

10. Light colored, aluminous sandstones, claystones, and silicious sandstones.. 75 feet.

Yellow Bluff, Bell's Landing, and Lower Peach Tree.

11. Reddish, cross bedded sands, 2 feet lignite at base ..... 22 feet.
12. Laminated, sandy clays, gray color ..... 15 feet.
13. Yellow sands, passing below into gray, laminated, sandy clays ..... 25 feet.
14. Greensand marl, Bell's Landing ..... 10 feet.
15. Gray, laminated, sandy clays 22 to 25 feet, passing into clay marl, Gregg's Landing, 5 feet ..... 30 feet.
16. Sandy clays of prevailing gray color, varying in degree of sandiness and coarseness of lamination, 1 foot greensand marl at base ..... 50 feet.
17. Gray, sandy clays ..... 10 feet.

Gullette's Landing.

18. Gray, sandy clays, alternately thin, laminated, and heavy bedded; indurated by glauconitic clay on top and greensand bed in middle ..... 37 feet.
19. Glauconitic sands, with *Gryphæa thirsæ*, indurated ledges passing through beds ..... 18 feet.
20. White, cross bedded sands ..... 12 feet.
21. Bluish, clayey, glauconitic sands, with *Gryphæa thirsæ*, several hard ledges. 50 feet.

Pursley Creek to Coal Bluff.

22. Glauconitic, clayey sands of varying degree of hardness, bed of lignite 4 feet (Coal Bluff) at base ..... 35 feet.
23. Gray, sandy clays ..... 10 feet.

Burford's Landing.

24. Gray clay, cross bedded sands, Burford's Landing ..... 10 feet.

Walnut Bluff to Clifton.

25. Gray, sandy clays, forming river banks from Walnut Bluff to Clifton...35 (?) feet.

Matthews's Landing.

26. Black, sandy clay marl, micaceous, Matthews's Landing.....20 feet.

Midway to Prairie Bluff.

27. Black clay, Midway.....5 feet.
28. Argillaceous White Limestone (Nautilus Rock).....10 feet.
29. Crystalline limestone (*Turritella*) back of Bridgeport.
30. Yellowish, micaceous sand (Ripley fossils) at Bridgeport and hills back of landing.....55 feet.
31. Dark bluish gray, sandy, micaceous clays, weathering into yellowish shales, with indurated, sandy, projecting ledges at intervals of 5 to 10 feet throughout whole thickness, exposed at Bridgport, Tear Up Creek, Canton Landing, and hills back of Prairie Bluff, and in Gee's Bend.....100 feet.
32. Bluish, argillaceous limestone, with phosphatized shell casts &c., Ripley formation.....30 to 35 feet.
33. Sands of various colors, dark blue, gray to white, traversed by indurated bands of calcareous sands with Cretaceous shells.....60 feet.

Rotten Limestone, Bridgeport to House Bluff.

34. Highly argillaceous limestone, with ledges holding many shells (*Ostrea, Gryphæa, Exogyra*).....1,000 feet.

House Bluff.

35. Hard, calcareous sands, with fossils strongly phosphatic in part.....20 feet.
36. Alternating layers of horizontally laminated and cross bedded, yellowish (glauconitic) sands.....40 feet.
37. Laminated, blue clays.....10 feet.
38. Blue, micaceous sands.....15 feet.
39. Light colored, micaceous sands.....20 feet.
40. Laminated clays and blue sands, thickness not determined.

COLUMN 3. *Section exposed on the Tombigbee (including the Tuscaloosa) River.*

St. Stephens and Baker's Bluff.

1. *Vicksburg.* White Limestone, with *Orbitoides Mantelli*, forms upper 70 feet of Saint Stephens Bluff, upper part of Baker's Hill, and greater part of river bluffs, down to Oven Bluff.....140 feet.
2. *Jackson.* Argillaceous White Limestone lower part of Saint Stephens and Baker's Bluffs.....60 feet.
3. Scutella bed, underlaid by coarse greensand and Claiborne fossiliferous sands.....15 feet.

Coffeeville Landing.

4. Yellowish gray, calcareous sands, with *Ostrea sellæformis*, clayey in part, traversed by hard, sandy ledges, greensand, with comminuted shells at base.....35 feet.
5. Bluish clay.....7 feet.

Hatchetigbee to mouth of Bashi Creek.

6. Aluminous sandstones, claystones, &c., of jointed structure, forming at White Bluff a perpendicular cliff.....115 feet.
7. Brown clays, sandy, non-fossiliferous, 30 feet, followed by 3 feet marl and 15 feet purplish brown, sandy clays; then 28 feet of sands, striped with brown clays and inclosing two beds with marine shells; in all.....75 to 76 feet.
8. Dark gray, sandy clays, striped with brown or purple, sandy clays. Very few fossils exposed at Davis's Bluff, White's Bluff, and McCarthy's Bluff...100 feet.

9. Clayey marl, passing into a greensand marl 18 feet thick ..... 31 feet.
10. Gray, clayey sands, with four or more thin seams of lignite ..... 25 feet.

Tuscahoma to Shuquabowa Creek.

11. Laminated sands and indurated sands, with bowlders ..... 30 feet.
12. Gray, sandy clays, striped with somewhat harder, projecting ledges .. 35 to 40 feet.
13. Greensand marl (Bell's Landing) ..... 7 feet.
14. Sandy, laminated clays ..... 15 feet.

Horse Creek to Gay's Landing.

15. Gray, sandy clays, rather thin bedded; hard, sandy ledge at base ..... 28 feet.
16. Glauconitic sands and clays, with *Gryphæa thirsæ* ..... 18 feet.

Lott's Ferry to Nanafalia.

17. Glauconitic sands, with *Gryphæa thirsæ*, at Lott's Ferry, Eureka Landing, and Nanafalia Landing ..... 35 feet.
18. Black clay, passing into greensand marl, with *Gryphæa thirsæ* ..... 18 feet.

Landrum's Creek.

19. Black, micaceous, glauconitic sands ..... 15 feet.
20. Lignite 7 feet and 5 feet gray clay below ..... 12 feet.

Tompkinsville to Naheola.

21. Gray, sandy clays, cross bedded sands and laminated clays in many alternations ..... 80 feet.
22. Greensand marl (Naheola), with black clay below ..... 20 feet.

Naheola to Black Bluff.

23. Between Naheola and Black Bluff, black clays ..... thickness unknown.
24. Yellowish clays 30 feet, underlaid by 50 feet of black in dark brown, slaty, fossiliferous clays, Black Bluff fossils ..... 80 feet.

Moscow.

25. Dark blue or black, sandy clays, with indurated bands, calcareous below, passing into an argillaceous limestone 16 to 18 feet, with phosphatized shell casts ..... 55 feet.

Rotten Limestone, Moscow to Choctaw Bluff.

26. Argillaceous limestone, with hard ledges, holding many shells (*Ostrea*, *Exogyra*, *Gryphæa*) ..... 1,000 feet.

Choctaw Bluff to Big Log Shoals.

27. Hard, calcareous sands, highly fossiliferous, 6 to 8 feet; thin, yellow, cross bedded sands, 15 feet; and below this a phosphatic greensand, 8 to 10 feet .. about 25 feet.
28. Cross bedded, glauconitic sands, with thin clay partings, yellowish color prevailing ..... 40 feet.
29. Dark gray, laminated, sandy clays, alternating with bluish sands ... 15 to 20 feet.
30. Laminated sands and clays, alternating with cross bedded sands ..... 40 (?) feet.
31. Compact, micaceous sands, cross-bedded sands, laminated clays, in many alternations, including two small beds of pebbles and thin bed of lignitic matter ..... 60 (?) feet.

White's Bluff.

32. Purple and mottled clays, 10 feet, with 15 feet of yellow, micaceous sands below ..... 25 feet.

Steele's Bluff.

33. Purple and mottled clays, 10 feet, with 10 feet light yellow, coarse, cross bedded pebbly (chert) sands ..... 20 feet.

Williford's.

34. Purple and mottled clays ..... 10 feet.

Mrs. Prince's.

35. Purple and mottled clays.....10 feet.

Saunders's Ferry to Tuscaloosa.

36. Dark gray, laminated clays, sandy partings, 25 feet, and gray sands, indurated, 15 feet, at Venable's and near Saunders's Ferry.....40 feet.
37. Sandy clays, with leaf impressions, black scales like graphite, fragments of lignitized stems.

COLUMN 4. *Exposures inland near Tombigbee and Tuscaloosa Rivers. (Supplementary to the Tombigbee River section.)*

Salt Mountain.

1. White Limestone, in part crystalline, filled with masses of coral.....150 feet.
2. Orbitoidal White Limestone.....20 feet.

Hills west of McCarthy's Ferry.

3. Aluminous sands, indurated clays or claystones, silicious sandstones, &c., forming hills west of McCarthy's Ferry, in Choctaw County, 270 feet in one exposure, with 15 feet laminated clays at base; in all.....285 feet.

Bladen Springs boring.

4. Loose surface materials, varying slightly in color and texture.....80 feet.
5. Alternations of blue and sandy marl (clay), with indurated blue ledge 5 feet thick at base.....81 feet.
6. Soft, clayey marl.....23 feet.
7. Greensand, with shells, 3 feet, followed by 22 feet alternating hard and soft beds, the latter fossiliferous, water bearing.....25 feet.
8. Marls or blue clays.....46 feet.
9. Brown and blue marls (clays) in many alternations (lignitic ?).....21 feet.
10. Blue marls or clays, with 2 feet of greensand at base.....61 feet.
11. Lignite, 5 feet, followed by 19 feet of brown, tough marl (clay).....24 feet.
12. Blue, sandy marl, with many varieties of shells; *Venericardia planicosta* recognized.....23 feet.
13. Blue, sandy marl (clay).....58 feet.
14. Brown marl (clay) 5 feet, with 32 feet blue marl below.....37 feet.
15. Greensand marl, 9 feet, followed by 37 feet of blue marl (clay). At 500 feet water was struck, which flowed 10 feet above surface.....46 feet.
16. Brown clay marl, 19 feet, followed by 15 feet blue clay, with greensand, containing shells.....34 feet.
17. Brown marl, resembling soapstone; contains shells; stream of water near bottom which flowed 30 feet above surface.....50 feet.
18. Gray, sandy marl, with shells.....15 feet.
19. Gray, sandy marl, with shells; more clayey than preceding.....64 feet.
20. Very tough, blue marl (clay), at base of which a thin layer of white sand and then a thin layer of greensand.....71 feet.
21. Brown marl (clay) 5 feet, followed by alternating beds of clay and sand, mostly sand (*first salt water*).....20 feet.
22. Alternations of gray and brown sand, with marl (clay).....26 feet.
23. Tough, blue marl, clay (*big vein of salt water*).....13 feet.
24. Sand and clay alternating.....14 feet.
25. A kind of white limestone (?) containing mica, passing below into 3 feet blue, sandy marl, containing shells.....28 feet.
26. Blue marl (clay) 14 feet, followed by 14 feet of blue marl and sand, numerous shells.....28 feet.
27. Marl, 12 feet, with streaks of sand, followed by brown sand and blue marl, 12 feet.....24 feet.

28. Greenish rock, chalky above, hard below ..... 11 feet.
29. Sandstone 4 feet, followed by 25 feet quicksand, of white, blue, and gray colors (*strong stream of salt water*) ..... 29 feet.
30. Marls or clays, mostly of grayish or light brown colors, with several ledges of extremely hard rock, e. g., one 2 feet thick at 966 feet, one 1 foot thick at 971 feet, one 3 inches thick at 978 feet, one 1 foot thick at 1,009 feet ..... 137 feet.
31. Tough black clay, 2 feet, followed by 99 feet of dark blue clay, some of it quite hard and firm; some very soft and sticky ..... 99 feet.
32. Snuff colored clay, soft and sticky ..... 13 feet.
33. Gray sand and shells 12 feet, followed by 5 feet soft, sandy clay ..... 17 feet.
34. Hard ledge 4 inches at top, below which 125 feet of moderately hard, grayish or blue rock, with scarcely any change in color or texture, to bottom of boring; no shells observed; Rotten Limestone ..... probably 125 feet.

Livingston artesian well boring.

35. Soft, blue, argillaceous Rotten Limestone, thickly set with shells and containing iron pyrites ..... 180 feet.
36. Hard, white limestone, with few shells ..... 50 feet.
37. Hard, blue limestone 7 feet, followed by 68 feet of pure, bluish white limestone, with few if any shells ..... 75 feet.
38. Very hard, white limestone, stratum of oyster shells near top ..... 55 feet.
39. Light blue limestone, not so hard as preceding ..... 47 feet.
40. Bluish brown limestone, filled with small shells, rather sandy ..... 58 feet.
41. Hard, white limestone ..... 105 feet.
42. Soft, blue limestone, 2 feet brown rock at top ..... 22 feet.
43. Rather soft, brownish blue limestone ..... 78 feet.
44. Very soft, blue limestone, hard ledge at top ..... 11 feet.
45. White limestone, moderately soft, with occasional slight changes in color and hardness ..... 250 feet.
46. Hard sandstone 6 feet, 10 feet sand, water bearing, and 1 foot sandstone ... 17 feet.
47. Coarse greensand 38 feet, sandstone 2 feet, greensand 25 feet, sandstone 2 feet, and greensand again 18 feet, water bearing at 1,005 feet ..... 85 feet.
48. Fine greensand, flint layer on top ..... 10 feet.

Strata of Tuscaloosa formation.

Near Havana.

49. Yellow sand and pebbles 10 feet, overlying 30 feet of variegated, pink and purple, micaceous, cross bedded sands, near Havana ..... 40 feet.

Big Sandy Creek.

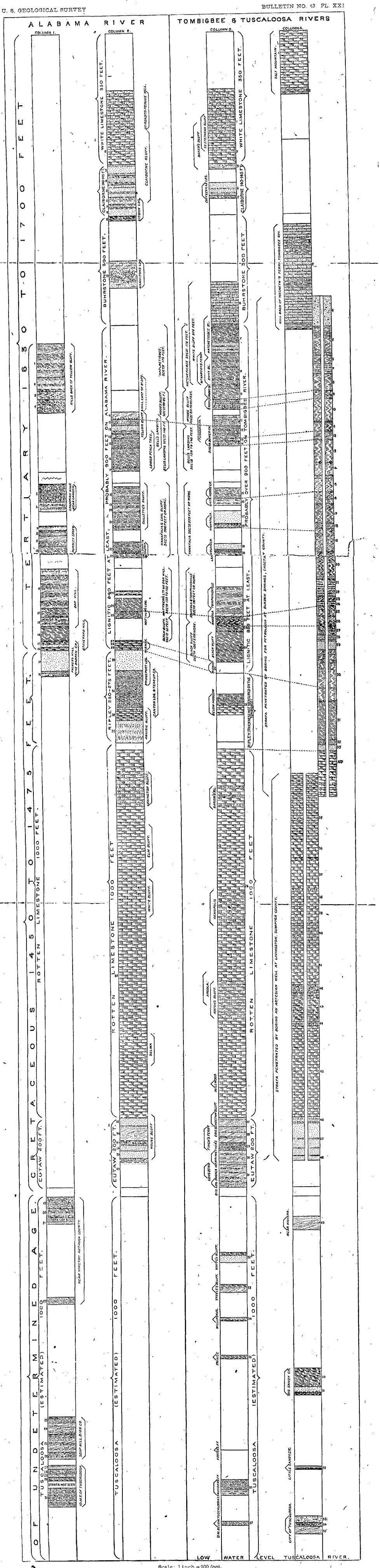
50. Purple and mottled clays seen along road leading up hill from Big Sandy Creek ..... 50 feet.
51. Light yellow sands and pebbles 15 feet, with 8 feet dark gray, laminated clay, with lignitized trunk, Big Sandy Creek ..... 23 feet.

Little Sandy Creek.

52. Yellow, micaceous sands, overlying dark gray, micaceous, laminated clays .. 8 feet.
53. (Belongs to a recent formation.)

Tuscaloosa City.

54. Dark gray, laminated clays, with leaf impressions ..... 8 feet.
55. Light colored, sharp, cross bedded sands ..... 20 feet.



Scale: 1 inch = 200 feet.

GENERAL SECTION OF TERTIARY AND CRETACEOUS STRATA OF ALABAMA, AS EXPOSED ALONG THE ALABAMA, TOMBIGBEE, AND TUSCALOOSA RIVERS.

INDEX.