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DAVID WHITE, CHIEF GEOLOGIST

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THE AGE OF THE OCALA LIMESTONE.

By CHARLES WYTHE COOKE.

INTRODUCTION.

In 1881 Eugene A. Smith [1] announced the presence, underlying large areas in both western and peninsular Florida, of limestone which he correlated with the Vicksburg limestone of Mississippi and Alabama and designated by the term Vicksburg limestone. Among the localities he mentioned specifically are Marianna, in Jackson County, and Ocala, in Marion County.

In the following year Heilprin [2] described a species of Nummulites from fragments of rock found by Willcox in Hernando County, on the west coast of Florida, and two years later Willcox discovered the nummulitic limestone in place not far away. Heilprin believed the rock to be the equivalent, in part, of the "Nummulitic" of Europe and, on account of the association of the Nummulites with *Orbitoides ephippium*, considered it to be of Oligocene age.

At the meeting of the American Association for the Advancement of Science in 1887 Johnson [3] said that the rocks mentioned by Heilprin "may be remnants of the Nummulitic limestone, which is really a stratum overlying the Vicksburg rocks" near Levyville and is apparently conformable with the "Vicksburg stage" but evidently not identical with it.

The term Ocala appears to have been first formally used by Dall, who described the formation under the heading "Nummulitic beds, Ocala limestone (Oligocene of Heilprin)." He says: [4]

> Among the rocks which until recently were not discriminated from the Orbitoides limestone and which appear in central Florida directly and conformably to overlie the latter, though no one has described their contact, is a yellowish friable rock containing many Foraminifera, conspicuous among which are two species of Nummulites, *N. willcoxii* and *N. floridana* Hp. This rock was first brought to notice by Mr. Joseph Willcox, and to Prof. Heilprin we owe a description of it which discriminates between it and the Vicksburg or Orbitoides rock. The rock was early recognized as Eocene, though not discriminated from the earlier beds. It is best displayed at Ocala, Fla., where it forms the country rock and has been quarried to a depth of 20 feet without coming to the bottom of the beds.

Besides Ocala, Dall mentions several localities where the same nummulitic rock is said to have been found by Willcox and Johnson.

At this time little was known of the fauna of the Ocala limestone, but Dall [5] remarks that "vertebrate remains belonging to the cetacean genus Zeuglodon or possibly to Squalodon were discovered by Mr. Willcox in the Nummulitic rock of the Ocala quarry, thus adding another indication of the close faunal relations of the Nummulitic with the preceding post-Claiborne beds." He adds:

> There is little doubt of the correctness of Prof. Heilprin's contention that these rocks are the analogue of the so-called Oligocene of the West Indies and of northern Europe. But, while this may be admitted, the propriety of regarding the group or series as constituting a distinct epoch, equivalent to or analogous in value to the Eocene, Miocene, or Pliocene epochs, which would be inferentially granted by adopting for them the term Oligocene, is a very different matter and in Florida receives no justification from the paleontological evidence.

Four years later, however, a more thorough study of the faunas led to the recognition of the correlation of the "Old Miocene," including the Vicksburg limestone, with the Oligocene of European geologists. The Oligocene was then accepted by Dall [6] as a separate epoch of the North American Tertiary, a view maintained in his subsequent publications.

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[1] Smith, E. A., On the geology of Florida: Am. Jour. Sci., 3d ser., vol 21, pp. 292-309, 1881.

[2] Heilprin, Angelo, On the occurrence of nummulitic deposits in Florida: Philadelphia Acad. Nat. Sci. Proc., vol. 34, pp. 189-193, 1883.

[3] Johnson, L. C., The structure of Florida: Am. Jour. Sci., 3d ser., vol. 36, p. 232, 1887.

[4] Dall, W. H., Correlation papers—Neocene: U. S. Geol. Survey Bull. 84, pp. 103-104, 1892.

[5] Idem, p. 105.

[6] Guppy, R. J. L., and Dall, W. H., Descriptions of Tertiary fossils from the Antillean region: U. S. Nat. Mus. Proc., vol. 19, No. 1110, pp. 303-304, 1896.

In 1903 appeared the concluding volume of Dall's monumental work on the Tertiary fauna of Florida,[1] in which is incorporated a brief account of the Ocala limestone, together with a list of 59 species of mollusks and foraminifers. The formation is supposed to overlie conformably the "Peninsular" limestone, which is believed to represent a higher horizon than the typical Vicksburg limestone.

The next report on the geology of Florida embodying the results of additional field work appeared in 1909 and was written by Matson and Clapp,[2] who employed the term Vicksburg group to include both the Ocala and "Peninsular" limestones of Dall as well as the limestone of western Florida, to which they gave the definite formation name Marianna limestone. The Marianna, which they considered the stratigraphic equivalent of the upper part of the bluff at Vicksburg, Miss., they believed to represent a horizon below the "Peninsular" limestone, but they were in doubt as to the stratigraphic relations of the two. They stated that the Ocala limestone conformably overlies the "Peninsular" limestone. The geologic conclusions of Matson and Clapp were republished with little change in 1913.[3]

The most recent contribution to the geology of Florida appeared in January, 1915, from Dall's pen.[4] Although presenting no new information in regard to the Ocala limestone, he gives an account of the geologic exploration of the region and repeats his former summary of the Ocala fauna.

The accompanying correlation table shows the present state of knowledge of the sequence of Eocene and lower Oligocene formations in Mississippi, Alabama, and Florida. For purposes of comparison the sequence for Florida as published by Matson in 1913 is given in a column parallel to the one presenting the changes proposed in this paper.

Correlation table of the Eocene and lower Oligocene formations of Mississippi, Alabama, and Florida.

<table>
<tr><th rowspan="2"></th><th colspan="2" rowspan="2">Mississippi.</th><th rowspan="2">Alabama.</th><th colspan="4">Florida.</th></tr>
<tr><th colspan="3">Matson, 1913.</th><th>This paper.</th></tr>
<tr><td rowspan="3">Oligocene.</td><td rowspan="3">Vicksburg limestone.</td><td>Upper bed at Vicksburg.[5]</td><td rowspan="3">St. Stephens limestone.[6]</td><td rowspan="3">Vicksburg group.</td><td>Ocala limestone.
"Peninsular" limestone.
Marianna limestone.</td><td rowspan="3">Exact correlations doubtful.</td><td rowspan="3">Marianna limestone.</td></tr>
<tr><td>Lower bed at Vicksburg.</td><td>(Buried.)</td></tr>
<tr><td>Red Bluff clay member.</td><td>(Buried.)</td></tr>
<tr><td rowspan="5">Eocene.</td><td colspan="2" rowspan="2">Jackson formation.</td><td rowspan="2"></td><td colspan="2" rowspan="2">(Buried.)</td><td>Ocala limestone.</td></tr>
<tr><td>(Buried.)</td></tr>
<tr><td colspan="2">Claiborne group.</td><td>Claiborne group.</td><td colspan="2">(Buried.)</td><td>(Buried.)</td></tr>
<tr><td colspan="2">Wilcox group.</td><td>Wilcox group.</td><td colspan="2">(Buried.)</td><td>(Buried.)</td></tr>
<tr><td colspan="2">Midway group.</td><td>Midway group.</td><td colspan="2">(Buried.)</td><td>(Buried.)</td></tr>
</table>

[1] Wagner Inst. Trans., vol. 3, pt. 6, 1903.

[2] Matson, G. C., and Clapp, F. G., Preliminary report on the geology of Florida: Florida Geol. Survey Second Ann. Rept., 1909.

[3] Matson, G. C., and Sanford, Samuel, Geology and ground waters of Florida: U. S. Geol. Survey Water-Supply Paper 319, 1913.

[4] Dall, W. H., Fauna of the *Orthaulax pugnax* zone: U. S. Nat. Mus. Bull. 90, 1915.

[5] Distinctive names have not been applied to the different beds at Vicksburg.

[6] Vaughan's statement that the Vicksburg and Jackson formations can be discriminated in Alabama (U. S. Geol. Survey Prof. Paper 71, pp 738, 739, 1912) has been fully confirmed by my own unpublished studies, which show that the St. Stephens limestone is susceptible of division into several lithologic and faunal units.

RELATIONS OF THE MARIANNA LIMESTONE TO THE OCALA LIMESTONE.

During a recent investigation of the stratigraphy and paleontology of the St. Stephens limestone of Alabama I discovered a startling similarity between the fauna of the beds which are considered to represent the upper part of the Jackson formation (the "Zeuglodon bed" of Mississippi and western Alabama) and that of the Ocala limestone of Florida. It became apparent not only that many species of the Ocala are present in the Jacksonian deposits of Alabama but that they are restricted to that horizon and are not present in the overlying Vicksburgian members of the St. Stephens limestone. This conclusion is the more surprising in view of the fact that the Ocala limestone has been correlated with the very top of the Vicksburg limestone and, if present at all in Alabama, should overlie the Vicksburgian "chimney rock" of the St. Stephens limestone.

As the work progressed, more and more species of mollusks and echinoids were found to be common to the two faunas, and in 1913 a portion of the jaw of *Basilosaurus cetoides* [1] (the Zeuglodon), which had hitherto been thought to be exclusively of Jackson age, was obtained at the type locality of the Ocala limestone.

The obscurity in regard to this similarity of faunas was illuminated by the discovery at Marianna, Fla., of soft nummultic limestone containing an abundance of *Amusium ocalanum* and lying unmistakably beneath the Marianna limestone, which is the equivalent of the lower Vicksburgian "chimney rock" of Alabama and carries the exclusively Vicksburgian *Pecten poulsoni*,[2] as well as many Orbitoides. The section at Marianna is as follows:

Section on the west bank of Chipola River at the wagon bridge one-half mile east of Marianna, Fla.

	Feet.
Marianna limestone:	
5. Alternating hard and softer beds of light-colored limestone, very hard and compact in places, locally semicrystalline. The lower portion contains a considerable amount of glauconite. The upper portion has been quarried for building stone and contains Orbitoides, *Pecten poulsoni* (var.?), *Clypeaster rogersi*, and casts of other fossils. The floor of the bridge is 9 feet above the base of this bed	33
Ocala limestone:	
4. Concealed	3
3. Hard creamy-white semicrystalline limestone, apparently a more indurated phase of bed No. 1. Contains Orbitoides (stellately marked species), Arca, Glycymeris, *Amusium ocalanum*, Plicatula (Ocala species), Venericardia	1⅓
2. Concealed	4
1. Soft cream-colored porous limestone or marl, composed largely of Foraminifera loosely packed together. Contains Nummulites, Orbitoides (stellately marked species), Bryozoa, *Amusium ocalanum*, Cardium. Extends beneath water in the river	5

The intervals concealed at the bridge are exposed near the mouth of a cavern about 200 yards below the bridge, where the following supplementary section was observed:

Section 200 yards below the wagon bridge east of Marianna, Fla.

Marianna limestone:	Feet.
5. White limestone, the same as bed No. 5 of the section at the bridge	33
Ocala limestone:	
4. Soft cream-colored limestone with several species of Orbitoides and some Bryozoa	1
3. Hard semicrystalline pinkish limestone with large Orbitoides, Flabellum, and *Amusium ocalanum*	6½
2. Soft granular cream-colored limestone much like No. 1 of section at bridge but with fewer Foraminifera. Contains Orbitoides (stellately marked species), Flabellum, Bryozoa, *Terebratulina lachryma*?, Natica, Arca, *Pecten indecisus*, *Amusium ocalanum*, and Plicatula (Ocala species)	3
1. Concealed to water level in Chipola River	3

[1] Identified by J. W. Gidley.

[2] Erroneous statements regarding the stratigraphic range of *Pecten poulsoni* and of *Pecten perplanus* have from time to time appeared in the literature. Contrary to the general opinion, the two species cited do not occur together. *Pecten poulsoni* is exclusively Vicksburgian, whereas *Pecten perplanus* is restricted to deposits older than the Red Bluff clay member and is probably confined to the Jackson formation, though it may range down into the upper Claiborne. As these two pectens have a narrow stratigraphic range and a wide areal distribution and flourished in great abundance under very dissimilar conditions of sedimentation, they form exceptionally good index fossils. Moreover, they may readily be distinguished from each other and are not likely to be confused with other species.

Bed No. 5 of these sections is the Marianna limestone, the lower portion of which is the stratigraphic equivalent of the Red Bluff clay member of the Vicksburg limestone of Mississippi and western Alabama. Beds 1 to 4, inclusive, belong to the Ocala limestone, as is shown by the included fossils.

The lower bed of the Marianna limestone forms a hard projecting ledge which in several places in the vicinity serves as the roof to small caverns excavated in the softer Ocala limestone. I could detect no evidence of unconformity between the two formations.

The same nummulitic limestone crops out along Flint River in the vicinity of Bainbridge, Ga., where it is almost identical in lithologic appearance and fossil content with the exposure at Marianna. In 1900 the identity of the rock near Bainbridge with the Ocala limestone was recognized by Vaughan,[1] and 11 years later his notes on the geology of this region were incorporated in a report by Veatch and Stephenson.[2] My own observations, made during a two-weeks' stay at Bainbridge, have confirmed in every respect Vaughan's account of the stratigraphic relations of the rocks exposed along Flint River.

The lowest rock exposed in the vicinity of Bainbridge is a white to yellow, partly consolidated foraminiferal limestone like that of the lower bed at Marianna. It is separated by a well-marked erosional unconformity from the overlying series of irregularly bedded sands and variegated clays with chert blocks carrying corals and mollusks of earliest Chattahoochee age.

At Red Bluff,[3] 7 miles above Bainbridge, the following fossils were obtained from the Ocala limestone:[4]

Orbitoides papyracea (Boubée).
Orbitoides n. sp. (stellately marked form).
Nummulites willcoxi Heilprin.
Echinolampas sp.
Cassidulus sp.
Clypeaster sp.
Pecten suwaneensis Dall.
Pecten indecisus Dall.
Amusium ocalanum Dall.

From the Ocala limestone at a bend in the river near the old factory three-fourths of a mile north of the Atlantic Coast Line Railway station at Bainbridge, the following species have been recently collected:

Orbitoides sp.
Nummulites sp.
Bryozoa, many species.
Ostrea sp.
Oligopygus haldermani Conrad.
Agassizia conradi (Bouvé).
Eupatagus sp.
Pecten perplanus Morton.
Amusium ocalanum Dall.

REVIEW OF DALL'S LIST OF SPECIES FROM THE OCALA LIMESTONE.

In order to find out whether the fossils which are known to occur at the type locality of the Ocala limestone justify the reference of the formation to the high stratigraphic position which is assigned to it in all accounts of the geology of Florida, I have undertaken a critical analysis of the Mollusca enumerated in 1903 by Dall[5] in his list of species from the Ocala limestone. Dall's summary of the list is as follows:

> The total is about 59 species, of which about 25 appear to be peculiar, 15 are inherited from the Vicksburgian, and 11 persist as far as the silex beds of Tampa. Two Ocala species are present in the Eocene, four as far up as the Chipola, one reaches the Miocene, and one survives to the present day.

Inspection of the list brings to light the fact that among "those also known from Vicksburg" are mentioned *Papillina dumosa, Cassis globosa, Cyprædia fenestralis, Pinna quadrata,*

[1] Vaughan, T. W., A tertiary coral reef near Bainbridge, Ga.: Science, new ser., vol. 12, p. 873, 1900.

[2] Veatch, Otto, and Stephenson, L. W., Preliminary report on the geology of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 26, pp. 321–322, 329–333, 1911.

[3] Not to be confused with the type locality of the Red Bluff clay member of the Vicksburg limestone, which is on Chickasawhay River, Wayne County, Miss.

[4] Veatch, Otto, and Stephenson, L. W., op. cit., p. 320.

[5] Dall, W. H., Tertiary fauna of Florida: Wagner Inst. Trans., vol. 3, pt. 6, pp. 1557, 1558, 1903.

Pecten perplanus, *Pecten indecisus*, *Amusium ocalanum*, and *Plicatula densata*, none of which have ever been found at Vicksburg. It is evident that Dall intended to imply the "Vicksburg or Peninsular limestone" rather than the specific locality Vicksburg, Miss.

Species from Ocala.—By excluding the Foraminifera, which require study by a specialist on that group, and eliminating those species which are not credited to Ocala, the number is reduced to 32 mollusks, of which three (*Serpulorbis granifera*, *Turritella gatunensis*, and *Pecten centrotus*) appear to have been referred to Ocala by mistake. The abbreviated list is given below.

Those marked O are from Ocala; M, from Martin station. Those also known from Vicksburg are marked V, while those followed by S are also known from the silex beds of Tampa. An asterisk denotes the survival of the species to the recent fauna.

Aturia (near alabamensis Morton), O.
Helix (Cepolis?) sp., O.
Scaphander grandis Aldrich, O; also Jacksonian.
Eucymba ocalana Dall, O; also Eocene.
Caricella sp., O.
Lyria musicina Heilprin, O, S.
Turbinella polygonata Heilprin, O, S; also Chipola?
Mitra like millingtoni Conrad, O, V?
Fusus (Papillina) dumosus Conrad, O, V.
Cassis globosa Dall, O, V.
Transovula multicarinata Dall, O, M.
Cypræa heilprini Dall, O, S; also Tampa limestone.
Cyprædia fenestralis Conrad, O, V.
Rimella smithii Dall, O, M.
Cerithium ocalanum Dall, O, M.
Cerithium sp., O.
Turritella var. martinensis Dall, M, O.
*Xenophora conchyliophora Conrad, O, S, V.
Amauropsis ocalana Dall, O.
Leda multilineata Conrad, O, M, V.
Pinna quadrata Dall, O, V?
Pecten (Æquipecten) perplanus Morton, O, V.
Pecten sp., O.
Amusium ocalanum Dall, O, M, V, S.
Plicatula densata Conrad, O, M, V, S.
Crassatellites sp., M, O.
Diplodonta sp., M. O.
Cardium sp., O.
Fistulana ocalana Dall, O.

Of the 29 species in this list, seven are not named specifically and seven others appear to be peculiar to the Ocala limestone. The peculiar species are *Ovula multicarinata*, *Rimella smithii*, *Cerithium ocalanum*, *Turritella martinensis*, *Amauropsis ocalana*, *Pinna quadrata*, and *Fistulana ocalana*. Two species, *Eucymba ocalana* and *Cassis globosa*, are apparently elsewhere restricted to the Claiborne group. Seven, *Aturia alabamensis*, *Scaphander grandis*, *Mitra millingtoni*, *Papillina dumosa*, *Cypræa fenestralis*, *Pecten perplanus*, and *Amusium ocalanum*, are restricted to the Jackson or have their closest affinities in that formation. Four, *Lyria musicina*, *Turbinella polygonata*, *Cypræa heilprini*, and *Plicatula densata*, have not been found in beds older than the "silex beds" of the Tampa formation. One, *Xenophora conchyliophora*, is supposed to range from the Cretaceous to the Recent, and one, *Leda multilineata*, occurs in the Claiborne group of Mississippi and Georgia, is very abundant at Jackson, Miss., and is doubtfully reported from Vicksburg.

Presenting the preceding statement in tabular form, we have:

Generic name only	7
Peculiar to Ocala	7
Peculiar to the Claiborne	2
Peculiar to the Jackson	7
"Silex beds" of Tampa formation or later	4
Cretaceous to Recent	1
Claiborne to Vicksburg	1
	29

An examination of the specimens on which the determinations of the four species from the "silex beds" were based showed that all were identified from poor material and that the correctness of the identifications appears doubtful. Two of them apparently occur also in the Castle Hayne limestone at Wilmington, N. C., which is of Jackson age.

The summary may now be restated as follows:

Undetermined and peculiar species	14
Known to occur in the Jackson or earlier	13
Supposed to occur also in the Vicksburg	2
Post-Vicksburg (2 doubtful)	3
	32
Counted twice	3
	29

The foregoing analysis shows that the molluscan fauna of the Ocala limestone at the type locality is decidedly Jacksonian in its affinities. The testimony of the mollusks is amply corroborated by that of the vertebrates, echinoids, and bryozoans,[1] and the foraminifers, which are now being studied, apparently point to the same conclusion.

Species from Martin.—Those species in Dall's list which are not from Ocala come, with one exception, from Martin, Fla. In addition to some species of undoubted Ocala age, the fossils listed from Martin include three Vicksburg species, *Drillia servata*, *Fusus mississippiensis*, and *Pitaria astartiformis*, and four "silex beds" species, *Conus planiceps*, *Latirus floridanus*, *Serpulorbis granifera*, and *Ostrea mauricensis*. These Vicksburg and "silex beds" species are represented in the collection by siliceous pseudomorphs which may have come from a different horizon; the oyster certainly did not come from the Ocala limestone but is probably from the Alum Bluff ("Hawthorn") formation, which overlies the Ocala limestone at many localities in peninsular Florida. Until further investigations have been made these doubtful species had better be eliminated from lists of the Ocala fauna.

RELATION OF THE "PENINSULAR" LIMESTONE TO THE OCALA LIMESTONE.

Regarding the relation of the "Peninsular" to the Ocala limestone, it may be said that the name "Peninsular" is a general term, without type locality, applied to the "Orbitoidal limestone which forms the mass of the Floridian plateau and which has been * * * generally called the Vicksburg limestone" but which "may really form a different [higher] horizon altogether from the typical Vicksburgian and be intermediate between the latter and the nummulitic Ocala limestone."[2] "The two are distinguishable only by their contained fauna, the nummulites, a great profusion of other Foraminifera, and a certain number of mollusks being characteristic of the Ocala limestone."[3]

The presence of nummulites in the Ocala limestone appears to have been the chief reason for the separation of that formation from the "Peninsular" limestone and the presence or absence of nummulites to have been the essential criterion for distinguishing between the two formations. Inasmuch as nummulites are known to occur at several different horizons, the mere presence of the genus, when not specifically determined, can have very little bearing on the correlation of the strata containing it, and its apparent absence from strata whose fauna has been insufficiently explored seems scarcely sufficient cause for discriminating between formations which in other respects appear identical. Whether the "Peninsular" limestone or any part of it can be distinguished from the Ocala remains to be ascertained. It is certain that at many localities in north-central Florida, which are cited in the following section of this paper, the two appear to be identical. It is quite possible, however, as Dall has suggested, that more than one horizon may be represented in the "Peninsular" limestone, and I have seen places where the fauna has a different aspect from that of the Ocala. However, the discrimination of these beds must await further investigation.

[1] Since the above was written the study of the typical Ocala bryozoan fauna of north-central Florida has been completed by F. Canu and R. S. Bassler, who have identified accurately the same fauna in the vicinity of Bainbridge and at Rich Hill, Crawford County, Ga. Dr. Bassler authorizes the statement that this assemblage of Bryozoa shows a marked resemblance to upper Jacksonian faunas, especially those of the "Zeuglodon bed" of Alabama, the Castle Hayne limestone of North Carolina, and the corresponding strata at Eutaw Springs, S. C. The result of these studies shows that the Bryozoa of the Ocala limestone are quite distinct from typical Vicksburgian faunas and can be correlated only with faunas of upper Jacksonian age.

[2] Dall, W. H., Tertiary fauna of Florida: Wagner Inst. Trans., vol. 3, pt. 6, p. 1554, 1903.

[3] Idem, p. 1556.

LOCAL DETAILS OF THE OCALA LIMESTONE.

It may not be out of place here to anticipate a more comprehensive report by the insertion of a few notes on the Ocala limestone at the type locality and at other places in north-central Florida.

Ocala and vicinity.—At plant No. 1 of the Florida Lime Co., on the southwest edge of Ocala, the fresh face of the quarry exposed, at the time of my visit in 1913, 40 feet of white limestone, for the most part amorphous, soft, and porous, but containing scattered lumps of cherty limestone. Fossils are very abundant, especially Orbitoides and *Amusium ocalanum*. I collected also *Oligopygus haldermani*, *Laganum floridanum?*, Laganum sp., Mitra aff. *M. millingtoni*, *Cerithium ocalanum*, Turritella aff. *T. mississippiensis*, *Ovula multicarinata*, Fissuridea, *Pecten suwaneensis*, Cardium sp., Tellina n. sp., and many others. All are preserved only as casts except the sea urchins and the pectens. The rock contains many cavities which are filled with sand, clay, and fragments of small bones. On the southern face of the most recent working is a mass of sand and clay resembling fuller's earth which has evidently fallen to its present position by the collapse of a cavern roof. The clay resembles that of the Alum Bluff formation.

The quarry of the Oakhurst Lime Co. (plant No. 2, Florida Lime Co.) is south of the tracks of the Atlantic Coast Line Railway about 2 miles southeast of Ocala. The rock exposed consists of 52 feet of light cream-colored, very homogeneous limestone resembling the "chimney rock" of Alabama. The basal 9 feet is below the floor of the quarry but is visible in a small cavern. The overburden consists of 1 or 2 feet of dark sandy loam containing much vegetable matter. Several crevices and solution cavities, all except the cavern mentioned filled with sandy clay and humus, extend to the floor of the pit. They contain fragments of bones of living species of animals. The rock is exceedingly fossiliferous, containing several species of Orbitoides and other Foraminifera, several echinoids, and mollusks. Mr. G. C. Fraser, one of the proprietors, presented to me several large bones of *Basilosaurus cetoides*[1] which had been blasted from the rock. I obtained also Flabellum, *Oligopygus haldermani*, Conus, Cypræa cf. *C. fenestralis*, *Papillina dumosa*, Solarium, Spondylus, *Pecten suwaneensis*, *P. perplanus*, *Amusium ocalanum*, Cardium, Crassatellites, and other forms. This quarry contains very little chert, which is confined mostly, if not entirely, to residual blocks embedded in the clay of the cavity fillings.

A quarry in the Ocala limestone 1½ miles east of Ocala and 100 yards north of the Silver Springs road shows about 30 feet of massive porous white limestone with Orbitoides, *Amusium ocalanum*, and other species. The upper portion is cherty, and there are some thin vertical bands of chert filling crevices. The overburden consists of 2 or 3 feet of soil.

Zuber.—At plant No. 3 of the Florida Lime Co., at Zuber post office, 6½ miles north of Ocala, the quarry is 35 feet deep, exposing 33 feet of soft white porous limestone overlain by 2 feet of brown sandy soil. The limestone is remarkably homogeneous and free from impurities. Fossils are very abundant, the following being represented: Orbitoides, Flabellum, *Oligopygus haldermani*, *O. wetherbyi*, Laganum, 2 sp., *Agassizia conradii*, Polygyra, Conus, *Ovula multicarinata*, Xenophora, Ostrea, *Pecten perplanus*, Pecten sp., *Amusium ocalanum*, Spondylus, Cardium, and Tellina.

Martin.—About one-eighth of a mile southeast of Martin station, 9 miles north of Ocala, a small quarry exposes about 15 feet of soft white porous limestone, highly fossiliferous in places, with very abundant Foraminifera, *Oligopygus wetherbyi?*, and *Amusium ocalanum*. The upper portion of the rock is much weathered. In one place near the top is a mass of light-green siliceous clay or fuller's earth, and on the surface above are fragments of sandstone intermingled with limestone and chert. I was unable to determine whether the clay had been deposited in a hollow in the surface of the limestone or whether it had fallen to its present position by the collapse of a cavern roof. The latter supposition is the more probable.

[1] Identified by J. W. Gidley.

Newberry and vicinity.—In the vicinity of Newberry the Ocala limestone is well exposed in many phosphate mines of the "hard rock" type. The upper surface of the Ocala is very irregular, with high pinnacles projecting above the general level of the rock. In the process of mining, the ore, which in most places immediately overlies the limestone, is stripped off, leaving the uneven surface of the Ocala exposed to view. A photograph showing this feature may be found in Sellards's report on the Florida phosphate deposits.[1] The Ocala limestone in this region is soft, white, porous, and apparently very pure. It is very fossiliferous and in places is composed almost entirely of Foraminifera.

At plant No. 6 of the Cummer Lumber Co., 1¼ miles south of Newberry, the following fossils were collected: Orbitoides, Lunulites, Agassizia?, *Amblypygus merrilli?*, Laganum, Olivula, Rimella cf. *R. smithii*, *Pecten suwaneensis*, Spondylus, Plicatula, and Cardium.

At plant No. 10, 1 mile northwest of Newberry, I obtained Orbitoides, *Pecten suwaneensis*, *P. perplanus*, Spondylus, Plicatula, Crassatellites, and casts of other fossils. Scattered among the phosphate rock and on top of the limestone are many lumps of chert that contain *Cassidulus gouldii* and are apparently residual from a younger formation. Similar chert with the same species of Cassidulus was found near the top of the pit in plant No. 11.

At the Franklyn phosphate mine, 1½ miles northwest of Newberry, the limestone contains Orbitoides, Bryozoa, *Oligopygus haldermani*, *Laganum floridanum*, Ostrea, *Amusium ocalanum*, *Pecten suwaneensis*, *P. perplanus*, Plicatula, and Crassatellites?.

Clark station.—At Clark station on the Atlantic Coast Line Railway, 5 miles south of High Springs, there are many abandoned phosphate pits. The Ocala limestone is exposed in the bottoms of the pits and in places reaches the surface. The top of the limestone, as laid bare by the workings, contains high pinnacles separated by narrow channels from which the phosphatic ore has been extracted. The limestone is soft and white, as at the other mines visited. It contains Orbitoides, *Oligopygus haldermani*, and *Pecten perplanus*.

Fort White.—At the Fort White phosphate mine, now abandoned, a quarter of a mile northwest of Fort White, Orbitoides, Bryozoa, *Oligopygus haldermani?*, *Pecten perplanus*, *Amusium ocalanum*, and Cardium occur in the Ocala limestone. Lying loose in the quarry is an enormous bowlder of light-colored silicified limestone containing *Cassidulus gouldii*, Cylichna?, Glycymeris cf. *G. lameyi*, and Modiolus cf. *M. grammatus*. The bowlder is of post-Ocala age.

SECTIONS IN MISSISSIPPI AND ALABAMA.

In order that the stratigraphic equivalents of the Ocala limestone in its western extension may be available for comparison, several sections from Mississippi and western Alabama are given below.

Jackson, Miss.—The following generalized section of the Jackson formation in the vicinity of Jackson, Miss., was published by Hilgard.[2]

Section of Jackson strata at Moody's Branch and McNutt Hills.

	Feet.
Yellowish-white marl, more or less sandy, sometimes indurate and forming a soft rock; gives rise to "bald prairies" in the McNutt Hills. Contains bones of Zeuglodon, vertebræ and teeth of fish, Echinus!, Scutella, Hemiaster?, and casts of univalves and bivalves of the Jackson group	30–45
Yellowish-white clayey marl, with few fossils—*Pecten nuperus*, Pinna, Ostrea	6–10
Coarse yellow sand, somewhat clayey, with "Jackson fossils" in a fine state of preservation	8
Blue sand with Jackson fossils, mostly detritus	2
Blue sandy clay, fetid, somewhat micaceous; its upper portion filled with oddly shaped ferruginо-siliceous concretions. No fossils	10
Earthy lignite	1
Gray laminated clay, interstratified with sand, with traces of stems and leaves	10

[1] Sellards, E. H., A preliminary paper on the Florida phosphate deposits: Florida Geol. Survey Third Ann. Rept., pl. 2, fig. 1, 1910.
[2] Hilgard, E. W., Agriculture and geology of Mississippi, p. 131, 1860.

Willow Branch, Ala.—An instructive section showing nearly the entire Jackson formation and much of the Claiborne group is exposed in the valley of Willow Branch, Choctaw County, Ala., about 4 miles from Silas on the road to Fail.

Section at Willow Branch, Ala.

	Feet.
Post-Vicksburg:	
13. Red sand to top of hill; about	50
Jackson formation:	
12. Drab calcareous clay with white calcareous concretions	25
11. Yellowish marl with *Pecten perplanus* and *Periarchus pileus-sinensis?*. Indurated in lower portion	11
10. Fine-grained yellow sand	21
9. Argillaceous yellow sandy marl with shells; grades into the underlying bed	9
8. Greenish-yellow clay with shells, forming a gentle slope; about	50
Claiborne group:	
7. Hard gray indurated marl with small grains of glauconite and a few fragmentary shells	1½
NOTE.—The measurements of the beds above No. 7 were made on the south side of the valley; of those below, on the north side.	
6. Reddish-brown ferruginous glauconitic sand containing casts of mollusks, with a 1-foot shell bed at bottom	7
5. Dark-gray to black sandy clay with shells	3½
4. Laminated gray sand and clay with *Oreodaphne inequilateralis* and *Mespilodaphne columbiana* [1]	7
3. Dark-green to black glauconitic sand loaded with Claiborne shells	2
2. Dark-green to black, somewhat sandy clay. Weathers with fissile parting resembling "coal blossom"	5
1. Reddish-brown ferruginous sand to stream bed (1 or 2 feet concealed at bottom)	10

Most of the fossils in the following list were collected by W. C. Mansfield from bed No. 9 of the section, but some came from bed No. 8.

Endopachys shaleri Vaughan.
Scala sp.
Turritella sp.
Natica sp.
Dentalium sp.
Nucula spheniopsis Conrad.
Leda mater Meyer?
Ostrea trigonalis Conrad?
Pecten aff. P. membranosus Morton.
Pecten (Pseudamusium) scintillatus Conrad.
Pteria limula (Conrad).
Corbula alabamiensis Lea?
Corbula wailesiana Harris?
Tellina aff. T. vicksburgensis Conrad.
Spisula sp.
Lucina sp.
Phacoides (Miltha) claibornensis (Conrad) var.?
Venericardia planicosta Lamarck.

The evidence afforded by these fossils is scarcely sufficient in itself to determine positively whether the beds from which they came are of Claiborne or of Jackson age, but as the beds lie above the horizon of the sand bed of the Claiborne and resemble more closely the Jackson in lithologic appearance, they are tentatively referred to the Jackson formation.

There can be no question as to the Claiborne age of the fossils in the following list, collected by W. C. Mansfield from beds Nos. 3 to 6 of the section:

Turbinolia pharetra Lea.
Endopachys maclurii (Lea).
Cylichna sp.
Ringicula sp.
Pleurotoma sp.
Olivula staminea (Conrad).
Marginella sp.
Ptychosalpinx altilis (Conrad).
Mazzalina inaurata Conrad.
Pseudoliva vetusta (Conrad).
Plejona petrosa (Conrad).
Fusus bellus Conrad, var.
Calyptraphorus velatus (Conrad).
Turritella, 2 sp.
Eulima sp.
Natica sp.
Teinostoma subrotunda Meyer.
Solariella lineata (Lea).
Crepidula lirata Conrad.
Dentalium sp.
Nucula sp.
Leda media (Lea).
Trinacria cunea (Conrad).
Corbula, 2 sp.
Lucina sp.
Myrtæa curta (Conrad).
Phacoides alveatus (Conrad).
Venericardia parva Lea.
Venericardia planicosta Lamarck.
Crassatellites protexta (Conrad), var.?
Meretrix, 2 sp.

[1] Identified by E. W. Berry.

Cullomburg, Ala.—The relation of the "Zeuglodon bed" to the Red Bluff clay member of the Vicksburg limestone is well shown on the road from Millry to Bladon Springs, Ala., 3 or 4 miles from Millry and about 3½ miles southeast of Cullomburg. The section extends from a small branch southward along the road.

Section 3½ miles southeast of Cullomburg, Ala.

	Feet.
8. Concealed to top of hill; about	50
Red Bluff clay member of Vicksburg limestone:	
7. Very plastic gray clay with crystals of gypsum. Contains *Pleurotoma plutonica*?, *P. congesta*, *Busycon spiniger*, *B. nodulatum*, *Phos macilentus*, *Ostrea vicksburgensis*, Pecten aff. *P. poulsoni*, *Spondylus dumosus*, *Corbula perdubia*	22
6. Green-gray or buff glauconitic marl, consisting of grains of green glauconite the size of bird shot, in a white calcareous clay matrix. In the upper portion are several discontinuous ledges, and at the top is a more persistent ledge. Contains *Balanophyllia caulifera*, *Ostrea vicksburgensis*, *Pecten cocoanus*, Pecten aff. *P. poulsoni*, *Spondylus dumosus*, Corbula sp., and *Astarte triangulata*. The Ostrea and Spondylus weather out of the lower 2 feet in great abundance but are difficult to see in the unweathered material	9
Jackson formation:	
5. Stiff calcareous clay, yellow or buff on weathered surface, bluish green on damp, fresh surface. Contains small irregular concretions. Merges into the overlying bed	8
4. "Zeuglodon bed," buff argillaceous marl, merging into the overlying bed. Forms a gentle slope. Contains Flabellum, *Schizaster armiger*, *Ostrea falco*, *O. trigonalis*, Gryphæostrea, Pinna, *Modiolus cretaceus*, *Pecten perplanus*, *Terebratulina lachryma*	9
3. Gray to yellow, very calcareous, argillaceous marl with some hard ledges. Forms steep slope. *Pecten perplanus*, *Ostrea trigonalis*, and Bryozoa abundant; other fossils represented by casts	6
2. Yellow calcareous sand with poorly preserved shells and casts of Leda. Some calcareous concretions at base	18
1. Steel-gray sandy calcareous clay; about	3

It is believed that beds 2 to 5 inclusive are the equivalent of beds 9 to 12 of the section at Willow Branch.

Cocoa, Ala.—Near the site of Cocoa post office, which was located on the road from Gilbertown to Melvin, Choctaw County, Ala., about 2¼ miles east of Melvin, the "Zeuglodon bed," No. 3 of the Cullomburg section, is very fossiliferous. The following section was measured at the place where the large Zeuglodon skeleton in the National Museum was obtained:

Section half a mile southwest of Cocoa, Ala.

	Feet.
4. Concealed. Exposures elsewhere in the vicinity show that above No. 3 is yellowish-brown argillaceous marl with *Spondylus dumosus* and *Ostrea vicksburgensis*, overlain by gray to yellow clay with crystals of gypsum and many Red Bluff fossils.	
3. Drab clay with irregular calcareous concretions in lower portion. Thickness seen, about	10
2. "Zeuglodon bed," gray or drab sandy and argillaceous marl with harder ledges and irregular calcareous concretions; very argillaceous in the upper part; about	11
1. Fine yellow sand with soft white calcareous lumps and large irregular lumps of hard yellow sandy marl. Grades upward into bed No. 2. Thickness seen	6

From bed No. 2 the following fossils were collected:

Flabellum sp.
Lunulites distans Lonsdale.
Many other Bryozoa.
Terebratulina lachryma (Morton).
Aturia alabamensis (Morton).
Scala ranellina Dall.
Turritella alveata Conrad.
Ostrea trigonalis Conrad.
Ostrea vicksburgensis Conrad (perhaps derived from higher bed).
Ostrea falco Dall.
Gryphæostrea sp.
Pecten perplanus Morton.
Pecten n. sp.?
Panopea oblongata Conrad?
Protocardia sp.
Schizaster armiger Clark.
Shark teeth.
Fish vertebræ.
Coprolites.

In addition to the species enumerated in the list, the old collections in the National Museum contain from this locality *Cypræa fenestralis* Conrad?, *Crassatellites flexura* (Conrad), *Leda multilineata* Conrad, and *Venericardia planicosta* Lamarck.

Those species which the "Zeuglodon bed" has in common with the Ocala limestone, or which have near relatives in the Ocala, are the following:

Flabellum (perhaps not the same species; the genus is rare in the Vicksburgian beds).	Cypræa fenestralis.
Terebratulina lachryma (doubtfully at Marianna).	Leda multilineata.
Aturia alabamensis.	Pecten perplanus.
	Basilosaurus cetoides.

That more species do not appear to be common to the two may be attributed partly to ecologic and geographic causes (Cocoa is more than 400 miles from Ocala) and partly to the unexplored state of the fauna.

From the hillsides near by the following Red Bluff fossils were collected:

Balanophyllia caulifera var. multigranosa Vaughan.	Eulima sp.?
Conus protractus Meyer.	Turritella sp.
Pleurotoma congesta Conrad.	Lunatia sp.
Pleurotoma plutonica Casey.	Solarium hargeri Meyer.
Pleurotoma tantula Conrad.	Dentalium sp.
Pleurotoma (Drillia) caseyi Aldrich.	Glycymeris intercostata (Gabb).
Pleurotoma (Gemmula) amica Casey.	Ostrea vicksburgensis Conrad.
Pleurotoma (Gemmula) sp.	Pecten aff. P. poulsoni Morton.
Cancellaria mississippiensis Conrad var.	Spondylus dumosus Morton.
Mitra lintoidea Aldrich.	Corbula engonata Conrad.
Latirus protractus (Conrad).	Corbula perdubia Gregorio.
Busycon nodulatum (Conrad).	Astarte triangulata Meyer.
Triton conradianus Aldrich.	Myrtæa curta (Conrad)?
Phos macilentus Casey.	Cardium sp.
Murex mississippiensis Conrad.	

Toward the east the Red Bluff member thins, becomes calcareous, and merges into the Marianna limestone. The underlying beds also become more calcareous and can scarcely be distinguished from those of the Vicksburg group except by their fossils. In general, however, the lower beds are less pure and in many places contain a considerable amount of glauconite.

CONCLUSIONS.

It has been shown that the Ocala limestone is the equivalent in age of the upper part of the Jackson formation as defined in Alabama and Mississippi and that it underlies Vicksburgian limestone in western Florida. As the relations are conformable, the Ocala must represent at least the upper portion of the Jackson formation, but whether the lower portion of the Jackson in peninsular Florida is different from the Ocala, either lithologically or faunally, is at present unknown.

The "Peninsular" limestone is in large part identical with the Ocala, but further investigations are required to determine what other formations may be included in the "Peninsular."

The Vicksburg group is represented in western Florida by the Marianna limestone; although it may be present in peninsular Florida, it is of much less areal extent than has hitherto been supposed.

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