ART. XXXVI.—*On the Geology of Florida*; by EUGENE A. SMITH, of the University of Alabama. With a Map.

DURING an excursion into Florida, made last summer for the purpose of collecting data for the Cotton Culture Report of the Tenth Census, I made incidentally some notes on the geological formations of that State, which, with the kind consent of the Superintendent, are now made public.

The literature of this subject is extremely meagre, and I propose first to give a concise account of the published observations of my predecessors in this field, so far as I have been able to consult them.

In this Journal, I, xxxv, pages 47 et seq., are found some "Cursory Remarks upon East Florida in 1838, by Maj. Henry Whiting, U. S. Army." This paper is chiefly descriptive of the topography, natural productions and climate of the country, yet it contains some observations upon the geology. The author states that the "rocks found *in situ* are all calcareous, though siliceous bowlders of small size are occasionally seen, and nodules of hornstone are here and there mingled with the limestone, which elicit sparks, and are sometimes used by the Indians for flints." "The coast, as far as Cape Florida, is alluvial, a seeming mass of comminuted shells, resting on a rocky formation, composed also of shells, more or less broken and abraded. From Cape Florida, the formation is mostly coralline, the Keys being of that character." "As high as Indian River Inlet, the beach is still formed of shells, mingled with some sand; while about Cape Canaveral the sand predominates, until shelly fragments almost disappear to the naked eye. Still it seems probable that the whole beach is of a calcareous character."

The author then describes the "coquina" rock quarries of St. Augustine, adding some conjectures as to the mode of formation of this singular rock, which he states is generally considered as of recent formation, and that causes are still operating to produce it. This conjecture, while apparently plausible, wants, in his opinion, the support of deeper investigation into the character and force of these causes.

He speaks of the shell formations of the Upper St. Johns, which are made up chiefly of a species of *Helix*—the soil at Volusia and Fort Mellon consists half of shells, generally perfect in shape but occasionally slightly broken or abraded.

"On Black Creek, west of the St. Johns, a porous, rotten limestone appears, and this is said to be characteristic of the rock formations throughout the western part of the peninsula. Hence the many 'surth-holes' which appear in these

regions, and the disappearance of streams for many miles beneath the surface of the earth, while others come forth in all their fullness at once."

He also speaks of the large limestone springs, frequently impregnated with sulphuretted hydrogen.

In volume i of the 2d series of this Journal, page 38, we find "Some Facts respecting the Geology of Tampa Bay, by John H. Allen, Lieut. of Artillery in U. S. Army."

This author describes a limestone occurring at Fort Brooke, at the head of Tampa Bay, as hard, white, with an earthy texture, and apparently formed of decomposed and comminuted shells; in some places it is soft and friable, very much resembling chalk. He states further, that he has noticed this rock at points more than one hundred and fifty miles distant from each other, and presenting the same lithological characters; it constitutes the bottom of the many ponds and lakes in the interior, and he has been informed that its white and jagged surface can be seen throughout the whole extent of the Everglades. He mentions fossils contained in the rock, univalves, bivalves and echini; and he ascribes the great fertility of some of the sandy soils of the territory to the loose marl disseminated through it.

According to the author, there is another rock probably dipping beneath the limestone—a dark bluish, siliceous rock, of a compact texture, somewhat vesicular, the vesicles containing minute crystals of quartz. This rock was noticed at the falls of Hillsboro River, nine miles from its mouth. Bowlders of it were also seen at several places in the interior. Large sulphur springs with clear pellucid water are mentioned as occurring in the vicinity of Hillsboro River and other streams flowing into Tampa Bay.

Near Tampa Bay are beds of marl which differ materially in their composition and organic contents; they evidently belong to different geological periods. One of the most ancient and interesting of these beds occurs two miles west of Fort Brooke, and it is well known as furnishing the beautiful fossils petrified with wine-colored chalcedony. Other beds of marl, apparently of much more recent origin, extend along the shore at Fort Brooke.

Farther south, near the mouth of the Manatee River, is an extensive bank of shells, ten feet or more in thickness, composed almost wholly of large unbroken univalves belonging principally to a species of *Pyrula*, without any admixture of earth. Although he observed many fragments of Indian pottery in these shell heaps, the immense quantity of the shells precludes the idea that they have been accumulated by the aborigines of the country. In this paper the author makes a

clear distinction between the marl beds near the shore and the more ancient marls, and limestones occurring farther inland, although he does not undertake to decide upon the geological age of either.

His remarks upon the distribution of the more ancient limestone in the interior, where it forms "the bottoms of the many ponds and lakes," are particularly interesting, in the light of my recent observations.

We come next to an important paper by T. A. Conrad: "Observations on the Geology of a part of East Florida, &c."* In this, the author describes certain Post-Pliocene deposits on the St. Johns River and at Tampa Bay, occurring ten or fifteen feet above high tide; proving a considerable elevation of the whole Florida peninsula in the Post-Pliocene period, a movement which clearly raised all the Florida Keys above water. The greater part of the paper is devoted to a description of the Keys, with notices of the shells occurring on them and in the neighboring waters. At Tampa Bay and southward along the shore, he notices the Post-Pliocene deposits, but calls attention also to an underlying limestone occurring at Fort Brooke and as far inland as the Falls of Hillsboro River. This limestone he refers to an upper division of the Eocene. The same rock occurs, he says, a few miles up the Manatee River. Closer examination of the casts and shells from Tampa, brings the author to the following conclusions, viz., that the Nummulite limestone of St. Stephens and of Clarke County, Ala., and the fossiliferous bluff at Claiborne, are to be classed as Lower Eocene, while the limestone of Savannah River, containing two recent shells, he proposes to call Upper Eocene, and very probably the prevalent limestone of Florida will be included in this division."† This rock, he states, extends throughout the peninsula, as far south as Tampa Bay; and both the eastern and western shores are covered with a Pleistocene formation of recent species of shells, and remains of mammalia. The elevation of East Florida above the sea level is so inconsiderable that all or nearly all of it must have been submerged at the time the Post Pliocene species were existing, and therefore its elevation was contemporaneous with that of the Keys, which line its eastern, western and southern shores."‡

We have here the first definite attempt at the determination of the age of the Florida limestone.

In volume ii of this Journal, 2d series, p. 399, Conrad gives "Descriptions of new species of Organic remains from the Upper Eocene Limestone of Tampa Bay." In this article he

* This Journal, II, ii, 36 et seq.

† In more recent papers by Conrad these views are slightly modified.

‡ In this connection, see table of altitudes appended to the present article, and Dr. Burnett's letter below.

describes *Bulimus Floridanus*, *Bulla petrosa*, *Nummulites Floridana*, *Cristellaria rotella*, *Venus penita*, *Venus Floridana*, *Nucula tellinula*, *Cytherea Floridana* and *Balanus humilis*.

In this Journal, 2d series, vol. x, p. 282, Professor J. W. Bailey notes the discovery by him of an Infusorial stratum, between the mouth of Hillsboro River and Ballast Point. He is doubtful about the geological position of this bed, but states that it is associated with strata containing fossils which appear to belong to the epoch of the Eocene Tertiary.

During the summer of 1850, Professor M. Tuomey, of the University of Alabama, paid a short visit to the coast of Florida, with the view of comparing the recent deposits there with the white limestone (St. Stephens, etc.,) of Alabama, and in this Journal, 2d series, vol. xi, pp 390 et seq., he published "A notice of the Geology of the Florida Keys, and of the Southern Coast of Florida." The author describes the limestone of the Keys—in which the fossils are all identical with the shells living in the surrounding waters—and points out the agency of the Mangrove tree in the formation of islands between the mainland and the Keys. At Tampa Bay he confirms the observation of Conrad respecting the Tertiary age of limestone there, which he says extends doubtless to Charlotte Harbor.

The limestone which underlies the Everglades he states to be similar in every respect to that at the mouth of the Miami River, which, in turn, is of the same age as the rocks examined at Key West and elsewhere inside the reef. He calls attention to the fact that an elevation of the Keys, of about ten to twenty feet, would form a ridge similar to that surrounding the Everglades, shutting out the sea from the space, at present between the reef and the mainland, thus producing a second "Everglade," differing from the present only in its greater comparative length.

In the same volume, p. 86, Professor J. W. Bailey publishes a notice of "Silicified Polythalamia in Florida," in which he speaks of large masses possessing all the mineralogical characters of flint, as occurring in the white Orbitulite limestone which is common throughout the portion of Florida between Tampa and Pilatka. The flint was collected about forty miles west of Pilatka, and upon examination of thin sections by the microscope, *Orbitulina*, *Nummulina*, *Rotalia*, *Textilaria*, etc., were recognized in numerous specimens.

In a letter to Professor Dana, Dr. W. I. Burnett (this Journal, II, vol. xvii, p. 407) calls attention to the circumstance that the peninsula of Florida is by no means so flat as is generally supposed, for surveys made by Gen. Barnard establish the fact that there is an elevated ridge in places 237½ feet

above low tide in the Atlantic, extending slopingly from north to south, and terminating at a line drawn from Cape Canaveral to Tampa Bay. At points only fifteen or twenty miles west of the St. Johns River, there are elevations at least of 100 to 150 feet. The author believes that all Florida is of comparatively recent age, except the elevated ridge spoken of above, but he does not express any opinion as to the age of this ridge. He endorses Professor Agassiz's conclusion respecting the recent origin of the Everglades.

In the winter of 1851, Professor Joseph LeConte, in company with Professor Agassiz, visited and examined the Keys and reefs of Florida, and the results of his observations are recorded in an article in this Journal, II, vol. xxiii, pp. 46 et seq., entitled, "On the Agency of the Gulf Stream in the Formation of the Peninsula and Keys of Florida." The author states that until the time referred to (1851), nothing definite was known concerning the geology of Florida, but it was supposed to consist of a southward prolongation of the Eocene of Georgia and Alabama, and its shell limestone to bear some general resemblance to the white limestone of these States. But the observations of Professor Tuomey in 1850, and the more full and careful observations of Professor Agassiz during the following winter, brought to light the remarkable fact, that the Keys and the larger portion of the peninsula of Florida are of recent origin, and as far as could be examined, the work of corals still living in the vicinity, and still engaged in the work of extension. He then goes on to give his well-known theory of the agency of the Gulf Stream in forming the submarine banks upon which the reef-building corals could grow.

The author states that the eastern coast of Florida, from Lake George as far north as St. Augustine, is of recent coral formation similar to that of the southern coast and Keys; and supposing the statements of Conrad and Tuomey concerning the Eocene age of the limestone near Tampa to be correct, though *still problematical* in his opinion, he thinks that all that portion of the peninsula lying south of a line connecting St. Augustine with Tampa Bay, is almost certainly of coral origin and formed by the growth of successive reefs.

In vol. ii, art. 8, of the Smithsonian Contributions, Professor J. W. Bailey publishes his microscopical observations made in South Carolina, Georgia and Florida. This I have not been able to consult. The monograph of Professor Agassiz, also, I have not been able to see.

The last Geological Map of the United States, by Professors Hitchcock and Blake, accompanying the publication of the Ninth Census, represents the whole of Florida as alluvial.

From the preceding notes, it will be seen that while many

valuable observations on Florida geology have been recorded, yet the subject is still enveloped in obscurity, partly because of the isolated character of the earlier observations, and partly because of the failure of the later observers to give due weight to the statements of those preceding them.

I give now some notes of my own recent observations:

In the lower part of Geneva County, Ala., the *Orbitoides* limestone of Vicksburg age, is exposed in many places, and passing thence southward into Jackson County, Fla., the same rock is found underlying the whole county from Campbellton to Marianna, and thence eastward to Chattahoochee, and north-eastward through Greenwood to the river. The Vicksburg formation in Mississippi, Alabama and Florida, is almost everywhere covered with superficial beds of pebbles and sand (Orange Sand or Stratified Drift), and of yellow or red loam (Hilgard's Yellow Loam). The sand is rarely absent, the pebbles are distributed in belts which follow more or less closely the valleys of the principal rivers; the loam, together with the great mass of *yellow* and *red* sand of Stratified Drift age, which it overlies, thins out rather abruptly along an irregular line, which in Alabama and Florida may be roughly drawn as follows: from the northern boundary of Escambia County, Ala., eastward and southward through the lower part of Covington, diagonally across Geneva, through the lower part of Henry County; whence it is deflected southeastward so as to include parts of Gadsden, Leon and Jefferson Counties in Florida, and thence eastward and northward through parts of Madison and Hamilton Counties into Georgia. North of this line the country is more or less hilly and broken, the mean level of the uplands being perhaps 250-300 feet above the main water-courses, while southward the country slopes away to the gulf in an almost unbroken plain, the inequalities of the surface being everywhere comparatively slight, with scarcely anything deserving the name of *hills*.* This sea-ward, or rather gulf-ward, slope is covered almost uniformly with sand, which has rarely the bright yellow and red colors of the Stratified Drift sand further north. The timber is almost as uniformly long-leaf pine, with sometimes an undergrowth of small oaks, but often only of wire-grass. Exceptions to this state of things are found in the so-called "hammocks," where the soil is of

* From Clinch and Chariton Counties in Georgia, through Baker, Bradford and Clay Counties in Florida and thence southward, runs the Trail Ridge, which is 210 feet above sea level, where crossed by the Fernandina and Cedar Key railroad. And further west there is a range of sand hills 120 feet above sea level, between Archer and Bronson stations; but in both cases the local inequalities of the surface are exceedingly small, so that even upon the summit of Trail Ridge it is difficult to realize that one is upon an elevated plain, and not in a low pine barren.

darker color from intermixture of marl or disintegrating limestone, and where varieties of oak and hickory replace partly or wholly the lonely pine.

In the hilly country above mentioned, rocks of Vicksburg age are exposed along the banks of streams, ravines, etc., and sometimes as outcrops upon level ground; but on the Gulf slope, these exposures are usually at the edges and bottoms of the large "boiling springs" or "blue springs" which are so numerous throughout this entire region, and so characteristic of the formation wherever it makes a level, flat country. Occasional outcrops through the sand covering are to be noticed, and some streams like the Suwannee River, flow in part of their courses through channels cut in this limestone.

Where the limestone is hidden completely over large areas by the prevailing sands, its presence below is indicated by the sink-holes, ponds and lakes, which more than any other single feature are characteristic of the Florida landscape.

These being all due to the same cause, viz., the formation of subterranean caverns and the sinking in of superincumbent strata, the same depression may at one time be a mere lime-sink, (or "prairie" as the larger sunken areas—destitute of trees and carpeted with a dense growth of "blanket" grass—are called) or subsequently, a pond or lake, by the collection of water in the depression. A good example in point is Payne's prairie near Gainesville, which for many years was a widely-known pasture ground, to which thousands of cattle were driven from long distances. A small creek flowed through this basin, disappearing near its northern edge into an underground channel. During the great storm of 1871 this outlet was closed, and the "prairie" has become a lake several miles wide and from fifteen to twenty feet deep. As a matter of course, these phenomena are not confined to any particular limestone, and the occurrence of a *Miocene* limestone forming the basin of Rock Spring in Orange County, is noted below; still, from specimens collected by me at points widely distant from each other, from the observations of others as quoted above, and from evidence derived from other sources, I am brought to the conclusion that almost the whole State of Florida, from the Perdido River on the west, eastward and southward, including the middle and western parts of the peninsula, certainly as far south as the latitude of Tampa Bay, and probably as far as the latitude of Charlotte Harbor, has for its underlying formation the white or *Orbitoides* limestone of Vicksburg age, the exceptions as yet known being the Post Pliocene or recent limestones forming the Keys and the immediate coasts along the western, southern and eastern shores, and isolated patches, if not a continuous belt of *Miocene* lime-

stone between the St. Johns River and the elevated table lands westward.

The following notes present proofs more or less conclusive of the statement above made :

1. *West Florida.*

The occurrence of Vicksburg limestone in Jackson County has already been noticed, and specimens of *Orbitoides Mantelli*, *Pecten Poulsoni*, and other characteristic fossils were collected *in situ* at several localities, e. g., a few miles southeast of Campbellton, at the Big Spring east of Marianna, etc., while the use of blocks of this stone in the construction of chimneys, through the eastern and northern portion of the county, attest its occurrence everywhere in those parts. In the region referred to, the limestone lies very near the surface, often outcropping over considerable areas, and to this circumstance is probably due the exceptional fertility of much of the soil of Jackson County.

Holmes Valley on the creek of same name in Washington County, another widely-known fertile tract of land, presents the same geological features as the portion of Jackson County just mentioned.

Westward, in Holmes, Walton, Santa Rosa and Escambia Counties, the surface is generally covered with sand, so that outcrops of rock are not numerous; but the great number of "boiling" springs, sink-holes, ponds and lakes, taken in connection with the distribution of the *Orbitoides* limestone in the adjacent counties of Alabama, make it almost certain that this rock underlies most of West Florida, down at least to the near vicinity of the Gulf coast.

2. *Middle and South Florida.*

In these portions of the State my observations have covered a larger extent of country and are correspondingly more conclusive as to their geological structure.

Near the village of Chattahoochee, the bluff of the Appalachian River is formed in part by the Vicksburg limestone, which has here a tolerably thick covering of Stratified Drift, consisting of reddish and yellow sands with some small pebbles. The greater part of Gadsden County, as far east at least as Quincy, is a high level plateau with thick beds of Stratified Drift and Yellow Loam as surface materials. For this reason exposures of the underlying rock are not numerous, except toward the river, along the lower parts of the water courses. Liberty County was not visited, but from information obtained at Mount Pleasant, I feel very well convinced that the Vicksburg limestone makes its appearance along the river as far south as Rock Bluff.

Leon, Jefferson and Madison Counties are similarly covered with thick beds of Stratified Drift and Yellow Loam, and near the Georgia line the country is somewhat hilly. Going southward from Tallahassee, however, one descends from the elevated country, two miles from the town, to the low, flat pine woods which slope away gently toward the Gulf. Here, the usual feature of the Gulf slope are observed, viz: limesinks, ponds, lakes, boiling springs, and outcrops of limestone. Specimens of this rock collected about six miles from St. Marks, in Wakulla County, were submitted to Mr. Angelo Heilprin, and by him pronounced to be of Vicksburg age, *Orbitoides Mantelli* being prominent among the fossils.

In many places near the coast in Wakulla County, a very finely pulverized white marl is mingled with the sand, imparting to it a great degree of fertility; this is the "Gulf Hammock" land of which much has been written. From enquiries, and from the observations of Conrad and others, I learn that these "Hammocks" exist all along the coast from Wakulla, through Taylor, Lafayette, Levy and Hillsboro Counties to Tampa Bay. This marl is also of Vicksburg age where I have examined it, and from descriptions which I have had from various sources, it seems almost certain that the marls of the Gulf Hammocks in the other counties named, are of the same geological age. In Jefferson, Madison and Hamilton Counties, the Vicksburg limestone underlies the Stratified Drift everywhere, as may be seen in its outcrops along the banks of streams. In Suwannee and Columbia Counties the Vicksburg is still the underlying rock, the surface covering being here light colored sands chiefly—the yellow and reddish sands and loams of the adjoining counties westward, being usually absent. Specimens of the limestone with characteristic fossils have been collected in the vicinity of Live Oak, and an earthy limestone, the counterpart of some of the Vicksburg limestone, in which, however, no fossils were observed, was noticed by me near Lake City and thence out near to the Suwannee shoals on the river of same name. I am informed that the rock at the shoals is highly fossiliferous. At the time of my visit it was hidden by high water.

The Suwannee River, which has its head waters partly in Okefinokee Swamp in Georgia flows through most of its course in Florida, between banks of Vicksburg limestone, and several large sulphur and limestone springs break out through crevices in the rock along the river.

A bed of what I suppose is *lignite* has been found lower down the river; the exact locality I could not learn; but a large quantity was raised some years ago, and experiments, with unfavorable results, made with it in Tallahassee, to test its fitness as a material for the manufacture of illuminating gas.

Okefinokee Swamp, in Georgia and Florida, as may be seen from a map, is upon the water-shed between the Suwannee and St. Mary's Rivers; this ridge is prolonged southward and eastward as Trail Ridge, through Baker, Bradford and Clay Counties, and the elevation (whether by that name or some other) is continued, according to my own observations and those of others, nearly to the Everglades. Although observations are as yet wanting, to prove that the Okefinokee swamp reposes upon a bed of Vicksburg limestone, yet the occurrence of that rock along its southwestern and southern edges in Florida, as above mentioned, makes it very probable that such will be found to be the case, especially when we consider the fact that farther south along this ridge and particularly along its western slope in Alachua, Marion and Sumter Counties, the *Orbitoides* limestone is everywhere the underlying formation, sometimes hidden by overlying sands, but often outcropping over extensive areas.

The enumeration of a few localities from which characteristic fossils have been collected, will make more definite this general assertion. *Orbitoides* limestone is the prevailing, and I might say the only, rock in the vicinity of Gainesville, many of the chimneys and pillars of the houses there are built of it. The limestone is often a mass of shells and in places *O. Mantelli*, forms it to the almost total exclusion of every other species.

Payne's Prairie, south of Gainesville, already mentioned above, occupies a depression or sink in this limestone.

The observations of Professor J. W. Bailey quoted above, show that the same formation extends at least to within forty miles of Pilatka. Between Gainesville and Ocala in Marion County, the chimneys of the farm-houses reveal the character of the underlying rock. At Ocala, it outcrops in numerous localities, *Orbitoides Mantelli*, here as at Gainesville, often forming the entire rock. Silver Spring, six miles east of Ocala, occupies a basin in the same limestone. This is one of the largest of the very numerous sulphur springs of the peninsula. Steamers from the Ocklawaha come up into the spring where they can easily turn. The waters of the spring as well as of the stream—twenty feet or more in width, fifteen in depth, and eight miles in length, from the spring to the river,—are beautifully clear, the jagged edges of the limestone banks, the numerous fish, and even objects lying upon the bottom, being distinctly visible from the deck of a steamer.

Specimens of limestone from Silver Spring were found by Mr. Heilprin, to be composed of *O. Mantelli* Morton and *O. supera* Con., to the exclusion of other forms except polyzoa.

About Ocala, southward and southwestward, is a belt of

"hammock" land, where an earthy, partly disintegrated limestone mingles with the surface soil. Reference to tables of elevations appended below, will show that this hammock land, is sixty feet higher than the sandy plain of Ocala. My own observations in the interior confirm the statement of Conrad with reference to the Gulf Coast near Tampa that the Tertiary limestone is certain to be the substratum of all the "hammock" land.*

From Sumter County I have no specimens of the limestone, but from statements made by the inhabitants, there seems to be little if any doubt that the rock which outcrops in the western and southern parts of the county toward Tampa, is Vicksburg limestone. It is described to me as being in part a mass of shells, in part earthy and disintegrated, in part flinty, all well known characters of this formation in Florida, and its use in the construction of chimneys in that part of the county, is at least *suggestive* of its age.

We have thus traced the Vicksburg limestone, by its *actual outcrops*, from Jackson County in West Florida, through Middle Florida, into South Florida below Ocala in Marion Co. The observations of Conrad, Tuomey and others, prove its occurrence at Tampa and probably at Charlotte Harbor. That it underlies also the other counties of West Florida, and part of those south of Sumter nearly to the Everglades† is open to very little doubt, still we must draw a sharp line of distinction between what has *actually been proven* by personal observation, and what is only *an inference* from the facts observed, however strongly the inference may be supported by the facts.

In Orange County between Sanford and Lake Apopka, there are several large sulphur springs of the kind already mentioned, affording streams navigable by small steamers. Three of these, Hoosier Spring, Clay Spring and Rock Spring, all within eight or ten miles of the village of Apopka, were visited by me. They all come up through fissures in limestone. At the first two, at the time of my visit, the limestone was so deep under water, by reason of recent heavy rain storms, that it could not be closely examined. At Rock Spring, however, there is a bluff of limestone some ten feet in height, and from this I was able to collect a number of fossils. They were submitted to Mr. Heilprin who determined among them the following species: *Pecten Madisonius*, *Venus alveata*, ‡*Cardita granulata*, ‡*Carditamera arata*, *Mytiloconcha incurva*; doubt-

* This Journal, II, vol. ii, p. 43.

† From the distribution of the Vicksburg limestone in the lower part of the peninsula, I am strongly inclined to believe that it will be found on further examination, to underlie a part, at least of the Everglades.

‡ Also Pliocene.

ful were also *Cardium sublineatum* and *Oliva litterata*. This would make the limestone of Miocene age, as Mr. Heilprin states his belief that no Vicksburg species are associated with the shells enumerated.

I do not know that Miocene limestone has been observed elsewhere in the state, but it seems probable that it will, upon examination, be found either in isolated patches, or forming a continuous belt between the Post Pliocene deposits toward the east, and the elevated country westward, which has as a substratum the Vicksburg limestone.

My observations along the St. Johns River from Sanford to Jacksonville have added nothing to what has already been recorded, although corroborating the statements quoted above in the introduction.

Summary of Observations.

From the foregoing pages it will be seen that the earlier observers, Major Whiting in 1838, and Lieutenant Allen in 1846, mention the occurrence in the peninsula of a limestone *older* than that forming the coasts and keys: the latter author making the statement that it underlies even the Everglades. In 1846 also, Conrad determined definitely the age of the older limestone occurring at Tampa Bay, and expressed the opinion that the prevailing limestone of the peninsula would be found to be of the same age. In 1850, Tuomey confirmed Conrad's statement concerning the age of the rock at Tampa.

Up to this time it appears, as LeConte states, that it was the general opinion that the Florida peninsula was substantially a prolongation southward of the Eocene limestone of Georgia; but the researches of Agassiz and LeConte in bringing more prominently into view the recent character of the coasts and keys, and of the extreme southern end of the peninsula, together with the extension of the theory of the latter author, regarding the successive additions to the end of the peninsula, by coral formations, threw a shade of doubt, to say the least, over the observations of Conrad and others, which we now know to have been correct. The result has been, that since 1856 or 1857, a general impression has prevailed, that with the exception of the problematical Tertiary limestone at Tampa, the whole of Florida was of comparatively recent origin, and so it is laid down in the latest geological map.

In what precedes, I believe that I have established, beyond doubt, the correctness of the older views concerning the geological structure of the greater part of the peninsula, which views, so far as the published records show, were based either upon casual statements or conjectures of authors, except in the case of Tampa and its vicinity.

So far as I know, this article contains also the first published record of observations upon the geology of any part of Middle or Western Florida, and the first account of the discovery of Miocene strata in the State. For these reasons it has seemed worth while to publish the foregoing notes.

Leaving out of consideration, for the present, the beds of stratified drift, it appears further, that along the Gulf coasts of Alabama, of West Florida and of the Peninsula, the Post-Pliocene strata are directly superimposed upon the Vicksburg limestone; the intervening beds, representing the Miocene and Pliocene, being, so far as we now know, absent from those localities.

On the other hand, we know that in one locality certainly, and presumably elsewhere along the Atlantic slope of the peninsula, a Miocene limestone overlies the Vicksburg.

While rocks of Pliocene age have not yet been recognized, it is reasonable to suppose that future explorations will reveal their existence along the eastern coast in a position similar to that occupied by beds of the same age in Georgia and South Carolina.

The facts with regard to the distribution of the rocks of Florida are presented in the following map.

Those points where the existence of the Vicksburg limestone has been determined beyond doubt, by fossils collected and identified, are indicated upon the map by a slightly darker shade. This formation was first recognized at Tampa and near the mouth of the Manatee River by Conrad; between Gainesville and Pilatka, by Professor J. W. Bailey; and at the other localities marked, by myself. The locality of the Miocene limestone was first observed by myself, and the Post-Pliocene age of the coasts and keys has been determined at many points by Conrad, Tuomey, Agassiz, LeConte and others.

Between the Post-Pliocene on the eastern coast and the Eocene of the interior, a space is left blank, as *undetermined*, except in one place, Rock Spring, where the Miocene limestone was noticed. In this area other occurrences of Miocene beds will probably be found.

Professor Tuomey states that the Vicksburg limestone is probably the country rock as far south as Charlotte Harbor.

Below that latitude, however, to the Everglades, the formation is a matter of conjecture, though laid down as probably of Vicksburg age.

In how far the construction of the map is justified by the facts observed, the reader has thus the opportunity of judging for himself.

which elevation was maintained without material interruption until the Champlain period. Proofs of this statement may be found in the universal occurrence of the Vicksburg limestone as the country rock throughout the entire State, except perhaps in the southern part of the peninsula.

3d. In this upward movement, the axis of elevation did not coincide in position with the present main dividing ridge (north and south) of the peninsula, but lay considerably to the westward, probably occupying approximately the position of the present western coast.*

In other words, during the Middle and Upper Tertiary periods the Florida peninsula was much broader than it is now, toward the west; and while the eastern coast had nearly its present position, the western lay probably one hundred, in places perhaps one hundred and fifty miles beyond its present place. West Florida was also affected by this movement, and remained above sea level during the same periods.

Reasons for this conclusion are found in the total absence along the Gulf shores of West Florida and the peninsula, of all strata between the Vicksburg limestone and the Post Pliocene; while the peculiar beds of the Grand Gulf group of Hilgard overlie the Vicksburg limestone, on the Gulf borders of Mississippi, Louisiana and Texas, and a marine Miocene limestone of the usual Atlantic coast character, overlies the same rock on the eastern side of the peninsula.

This conclusion, reached as is seen above from purely geological considerations, finds a support amounting almost to demonstration, in the position of the one hundred fathom line off the Florida coasts, as shown on the accompanying map. It will be seen there that the submerged portion of the peninsula (within one hundred fathoms) on the west, is as wide as the present land surface, while on the east it is only a narrow strip.

That sediments were deposited during the Middle and Upper Tertiary periods off the Gulf coasts of Florida as well as of the other States mentioned is of course self-evident, and their absence along the coast at Tampa and elsewhere can be explained only upon the supposition that the coast line at that time was west of its present position, and that the deposits then made off that old coast are now submerged beneath the waters of the Gulf.

It may be objected that the absence of these deposits on the western coast is *apparent* and not *real*: that they have simply escaped notice: but it seems hardly probable that two such

* This assumes approximate uniformity of slope on each side of the main line of elevation. Under any other supposition, the facts would apparently require an elevation of the peninsula after the Vicksburg period, much above its present height, and a depression during the Miocene period at least thirty feet below present level.

close observers as Conrad and Tuomey should have overlooked them if they occur at least from Tampa southward.

4th. After the Miocene (or possibly after the Pliocene) period, there was again an elevation* of Florida, as is shown by the presence of a Miocene limestone on the eastern slope of the peninsula, some distance (not less than thirty feet) above present sea level.

The absence along the Gulf coasts, of Miocene and later Tertiary deposits, either of marine (limestone), or of brackish or fresh-water (Grand Gulf) origin, has already been accounted for above.

5th. We have evidence in the distribution of the beds of the Champlain period (Stratified Drift or Orange Sand), that Florida and parts of adjacent States were during this time submerged sufficiently to allow the deposition over them of a mass of pebbles, sand and clay, varying in thickness from a few feet to two hundred. The conditions under which these beds were deposited have been ably discussed by Hilgard in this Journal, and in his Mississippi and Louisiana Reports.

Of these conditions, I shall speak of one only. From the peculiar mode of stratification of most of these beds, it is concluded with reason, that they were sediments from rapidly flowing, ever varying currents. In the northern part of the State, the beds of red and yellow loam lie directly upon the Stratified Drift. These beds of loam are devoid of stratified structure as well as of fossils, and were probably deposited from slowly running or nearly stagnant waters.

The direct superposition of the Loam upon the Stratified Drift throughout Florida, Alabama and the greater part of Mississippi and Louisiana, and the fact that there is, with the exception presently to be noted, rarely, if ever, any sharp line of demarcation between the two—the upper beds of the Drift passing by imperceptible gradations into the Loam—point strongly to a community of origin, and appear to indicate that the Loam is the last of the sediments made by the floods of the Drift. Along the Mississippi River, the two are separated by the Port Hudson and Loess deposits, both having more or less local characters; the Loess being distinctly a river bank—and the Port Hudson, a river or gulf swamp deposit.

We can imagine that after the great rush of waters which deposited most of the pebbles and other coarse materials of our Drift, there followed, over the larger part at least of the Gulf States, a gradual checking of the currents and consequent deposition of the finer Yellow Loam, while along the axis of the Mississippi, where, as Hilgard has shown, the extremes of oscillation were experienced, this gradual change,

* On this point, compare foot-note on page 306, above.

from swiftly flowing to nearly stagnant waters, might have been interrupted by such subordinated and local oscillations as would have caused the formation of deposits like the Port Hudson and the Loess.

6th. Following the submergence during the Champlain period, was a re-elevation, which brought up the peninsula with approximately its present configuration.*

Evidences on this point are to be found in the Post-Pliocene deposits described by Conrad, Tuomey and others, as bordering more or less uniformly, the eastern, southern and western shores, and forming the keys.

7th. In the height of these Post-Pliocene deposits above the present sea-level, Conrad and Tuomey see proofs of the elevation of the peninsula and keys (ten or fifteen feet) in still more recent times, while, on the other hand, Professors Agassiz and LeConte give a different explanation. To quote the words of the latter author: "Neither the mainland nor the Keys are anywhere higher than may be accounted for by the action of the waves, viz: from ten to fifteen feet."

8th. Since about one-fifth of the coast line of the Gulf of Mexico is formed by Florida, the present article would lack completeness if it did not take into account a theory or hypothesis which has been advanced in connection with the geological history of the Gulf region.

In view of the absence of marine formations of Middle and Upper Tertiary age along the Gulf coasts of Mississippi, Louisiana and Texas, and to account for the formation of the beds of the Grand Gulf group, without remains of marine life, which overlie the Eocene of those coasts, Professor Hilgard has been brought to the conclusion that during a part or the whole of the interval between the Vicksburg and Champlain periods, the Gulf was by some means isolated from the Atlantic, and thus converted into a fresh- or brackish-water basin, and he also further suggested that this was brought about by a land connection between Florida and Yucatan.

This hypothesis has been freely discussed in this Journal and elsewhere, and a further discussion of it would be to some extent foreign to this article, since the facts observed by me and recorded above, beyond proving that Florida during the Middle and later Tertiary periods, was part of the firm land of the continent, and was probably then nearly twice its present

* We can only speculate as to *when* and *how* the change from the broad peninsula of the Middle and later Tertiary periods, to the present narrow form took place. Two possibilities suggest themselves, viz: 1. At the beginning of the Champlain period, a more profound depression of the western as compared with the eastern half of the broad Tertiary peninsula; or 2. At the end of the period of submergence, the shifting of the main axis of elevation eastward, would have brought about this result.

width, have no direct bearing upon the hypothesis, and offer no solution of the main difficulty in the way of its acceptance, viz: the depth (7000 feet) of the straits between Yucatan and Cuba, and between Cuba and Florida (3000 feet).

And besides, so far as yet known, the Grand Gulf beds form no part of the *present* land surface of Florida, being now, as suggested in one of the conclusions above, probably submerged, if they ever formed a part of its Gulf coast deposits.

Appendix.

Lists of altitudes obtained from Maj. P. W. O. Kœrner, Engineer.

I. Transit Railroad.

Names.	Distances from Fernandina. Miles.	Altitude above low tide in Atlantic.
Fernandina,	0	0
Boggy River,	20	} 27 ft. highest elevation between these points. Back tide water.
Callahan,	27	
Dutton,	36	30 ft.
Baldwin,	47	45
Maxville,	56	47
Summit of Trail Ridge,	61	57 foot of Trail Ridge.
Western foot of Trail Ridge, 62½		210
Laughty,	66	180
Starke,	73	140
Sante Fe (Lake Outlet),	79	150
Waldo,	84	137
Hatchet Creek,	91	150
Gainesville (Court House),	95	(about 100)
Arredondo,	100 (?)	128
Archer,	107	70
Sand Hills (Summit),	- - -	70
Bronson,	127	120
Otter Creek,	134	27
(Gulf Hammock)		19
Rosewood,	144	10
Cedar Key,	154	0

II. Peninsular Railroad.

	Names.	Elevation above low tide in Atlantic.
Topographical Features near line of Road.	Sante Fe Lake,	137 ft.
	Pithlachooke Lake,	85
	Payne's Prairie,	68 Rim of Prairie about 100 ft. higher.
	Lochloosa Lake and Orange Lake,	52
	Silver Spring,	39
Stations.	Hawthorne,	150
	Lochloosa,	60
	Ocala (C. H. square),	100
	Ridge 1 m. s. of Ocala (Hammock),	160

The average elevation of the country between Ocala and Orange Lake is 80 ft.

University of Alabama, Dec. 15, 1880.