ART. III.—*Observations on the Tertiary and Grand Gulf of Mississippi*; by OTTO MEYER, Ph.D.

I HAVE spent some time recently in Mississippi, mainly for the purpose of determining the relative positions of the Marine Tertiary and the Grand Gulf formations in the State. Through part of my journey, that is, from Jackson to Terry and from Pelahatchee to Brandon, I had the company of Mr. T. H. Aldrich, and I am greatly indebted to him for calling my attention to the places in Mississippi which might yield me information.

The natural valleys which probably give the best information about the stratification in Mississippi are those of Pearl River and the Chickasawhay at their lowest water level. At the time of my visit, however, the water was too high for such an exploration, and the only means for determining the contact of the Grand Gulf and Tertiary seemed to be systematic examination of the railroads near the frontier of the two formations.

1. Along the railroad south of Vicksburg, the Vicksburgian, covered by Loess, can be traced along for about a mile; then the Loess seems to cover everything.

2. The railroad from Jackson to Natchez has a narrow gauge, and between Jackson and Raymond shows no deep cuts. In Raymond a clayey sand is to be seen.

3. On the railroad from Jackson to New Orleans we find Tertiary limestone alternating with softer strata one mile north of Byram station, all containing *Orbitoides* and *Pecten*. In Byram occurs marl with Vicksburgian fossils. Five and a half miles south of it, that is, half a mile north of Terry, on the creek at the iron railroad bridge, the first sure outcrop of Grand Gulf is found.

The following profile of the Grand Gulf strata north of Terry was taken by Mr. Aldrich and myself:

(c) Light sandy clay	10 feet
(b) Sandstone, hard above, softer below, containing small nodules of green clay or corresponding cavities.....	7 feet
(a) Green sandy clays	5 feet to water's edge

Three and a half miles south of Terry, a deep cut about 1,400 feet long, shows a remarkable exposure of Grand Gulf strata. They are laminated sandy clays and clayey sands. The fine lamination of the clays is made very conspicuous wherever water runs over them. Laminæ of iron concretions also make the stratification more conspicuous. The northern two-thirds of the cut shows a very strong northern dip, abruptly turning over southward in the remaining third with an equally strong dip. The height of the cut at the anticlinal is twenty-

five feet, twenty feet of it composed of these clays. Taking the dip into consideration the total thickness shown is about forty feet. Small pieces of lignite are disseminated through the layer, but no fossils were found by Mr. Aldrich and myself. Not only the general dip of the strata in this cut, as mentioned, changes suddenly, but besides this, the *stratification shows cross-bedding*.^{*} Between this cut and Terry ledges of white Grand Gulf sandstone, several feet thick, crop out at different places.

In recapitulation we have Vicksburgian strata occurring in Byram station and Grand Gulf strata occurring about five miles south of it, but the contact of the two formations cannot be observed along the railroad.

4. On the railroad from Meridian to New Orleans the Marine Tertiary reaches at least as far as Heidelberg, Jasper County, for there is blue limestone, from which I collected *Orbitoides* and *Pecten Poulsoni* in an abandoned quarry about one mile and a half southeast of this town. Walking along the railroad we meet a clay of a light greenish blue color at a point four miles south of Heidelberg. At a point eleven miles south of this town (south of Erata, Jones County) the railroad cuts about ten feet of gray sandy clays and white sands without fossils.

5. In Pelahatchee on the Vicksburg & Meridian Railroad we find Marine Tertiary clays with *Pecten calvatus*? Mort., *Scalaria* sp., teeth of sharks and *Miliobates*, vertebra of fish and clayey concretions containing casts of shells, especially of *Protocardia*. Three miles west of it we meet the first cut of Grand Gulf strata—laminated clays—but the contact of the two formations cannot be observed here.

6. Walking farther west from the just mentioned cut of the Grand Gulf clays toward Brandon, we meet another exposure of these laminated clays a mile distant. They have a thickness of more than twenty feet and *show a very strong westward dip*. Another mile farther on, the same strata, of about equal thickness, are nearly horizontal. Another exposure is met about one mile and a half still farther west. It consists of laminated clays of about eighteen feet thickness, containing impressions of leaves. Sometimes the beds are more sandy, and in a few places they show cross-bedding. These clays are here enclosed in two lignitic streaks. The lower streak consists of almost pure lignite. Below this lower lignitic streak there are seen gray clayey sands without visible stratification. These sands at this point were not examined as to whether they contain fossils or not. The dip in this exposure, which consists of two connecting cuts, is west. The next cut is about a mile

* Discordante Parallelstructur.

farther west. It contains the same laminated clays with cross-bedding and at the bottom the gray clayey sands of the preceding cut are seen. They were here examined and found to contain extremely friable casts of small bivalves, apparently marine. Near the top of the laminated clays there is a streak of kaolin.—*This whole material of about twenty feet thickness is overlaid by a strip of limestone containing Pecten Poulsoni, Orbitoides, etc.* A dip in this cut is not apparent. Going farther toward Brandon no sure Grand Gulf strata were seen, but outcrops of limestone occur at two or three points at the same height with, or somewhat higher than the railroad track. Approaching Brandon and about half a mile from the station marine strata of about fifteen feet thickness are seen. They consist of sands overlaid and underlaid by ledges of limestone, all the beds containing *Pecten Poulsoni* and *Orbitoides*. The sands are sometimes clayey and at one place there are among them stratified clays of a few feet thickness which are not laminated, and contain on the planes of stratification shells and shell detritus. At Brandon station the limestone and patches of the sands are seen; and going west of the station hard limestone ledges, alternating with softer material, containing *Pecten* and *Orbitoides* occur as far as two miles west from Brandon.

The relation of the heights of all the above-mentioned cuts is as follows: The railroad track rises from the point two miles west of Brandon toward Brandon, continues to rise to the point where the contact of the Grand Gulf and marine limestone can be seen (about four miles east of Brandon); continues farther to rise for some distance in the Grand Gulf region and then falls down toward Pelahatchee.

Recapitulating these observations: Between Pelahatchee and Brandon the railroad cuts through, for a length of five miles, a belt of Grand Gulf strata, which are situated at a higher level than the marine strata west of it and which are either nearly horizontal or strongly dipping west. The Marine Tertiary of Brandon rises toward these Grand Gulf strata, and at the point where the two formations meet the marine limestone has a thickness of only two feet and overlies the Grand Gulf clays.

Those geologists who object to the conclusion from this that the Grand Gulf is older than the Marine Tertiary have the choice between two hypotheses. They can either consider this whole region of laminated clays, lignite, etc., with this peculiar dip, as not belonging to the Grand Gulf formation, or they can consider all these exposures as Grand Gulf with the only exception of that one where the orbitoidic limestone is seen on the top. After a careful examination of this region I am unable to share in either of these hypotheses.

7. In Newton, Newton County, at the Vicksburg & Meridian Railroad, laminated clays dipping east, apparently belonging to the Grand Gulf formation, may be seen. Three miles east of Newton there is a vertical railroad cut two hundred feet long and about fifty feet high affording the following profile :

(c) Clayey green sands of varying quality, sometimes with hard ledge-like nodules, numerous well preserved fossils; nearly-----	40 feet
(b) Reddish sand, somewhat lignitic-----	4 feet
(a) <i>Laminated clays, cross-bedded</i> with pockets of sand. They either alternate with or are overlaid by lignitic sandy clays or clayey sands, scarcely stratified, <i>with numerous lignitized plants and roots erect in natural position</i> -----	10 feet

The stratum "c" is seen on the surface 1,000 feet west from the cut on the railroad track, and therefore the dip must be west. I collected in this stratum "c," in less than a day, 105 species of fossils. The position of the lignitized plants in the stratum "a" shows that they grew on the spot, apparently in very shallow water (swamp?).

The above is the account of my efforts at eight different points to find the contact of the Grand Gulf beds and the Tertiary. The following observations are less directly connected with this question.

Greensands south of Enterprise.

The same clayey greensands, mentioned above, from Newton (stratum "c") occur in cuts of the railroad between Meridian and New Orleans, four miles south of Enterprise near Wautubbee, and are here underlaid by white, micaceous, cross-bedded sands, which attain a thickness of at least twenty feet and sometimes contain clays. These greensands are here very variable in thickness and in petrographic and paleontological qualities. Sometimes they are clayey, sometimes stratified, hardened and lignitic. At one point occurs the same ledge-like nodules as in Newton, containing *Ostrea sellceformis* C. I collected here 110 species, agreeing mostly, although not entirely, with those in Newton, among them two species of Cephalopods. The description of this Wautubbee-Newton fauna will appear in the Journal of the Cincinnati Society of Natural History for July, 1886. If I am not mistaken the same bed occurs at the tunnel west of Meridian and I think it is identical with a greensand bed which can be seen on the Chickasawhay at the bridge in Enterprise, underlying my bed "b"* (Claiborne profile). If this is so, the bed ranges stratigraphi-

* See this Journal, xxx, pp. 69, 70, 71, 1885.

cally immediately below the Claiborne profile and the paleontological evidence points to the same result and shows it to be parallel with the strata in Lisbon, Ala. After this position is determined it will be of interest in regard to the age of the Jacksonian to notice that the following species of this fauna occur in Jackson and are not known from the Claiborne sand: *Arca aspera* C., *Leda multilineata* C., *Pecten scintillatus* C., *Mitra pactilis* C. var. *dumosa* C., *Distortrix septemdentata* Gabb, *Solarium bellastratum* C., *Flabellum Wailesii* C.; and the following species are known only from the Vicksburgian: *Corbula engonata* C., *Chama Mississippiensis* C., *Caricella reticulata* Aldr.

Profile of the strata in Jackson.

The profile of the strata near Jackson, taken by Mr. Aldrich and myself at various points, is as follows:

- (f) Clay; blue below, lighter above, containing a large number of small bivalves, *Kelliella*?, *Corbula*, *Leda* and crab-claws. The shells are either very thin and soft or entirely dissolved, leaving only a few impressions 20-25 feet
- (e) Glauconitic marl, varying in distinctness, containing Pecten, various Bryozoa and corals, concretion-like Madrepora (nigger-heads), all in abundance, and in addition to them some Jacksonian fossils, about 2 feet
- (d) Jacksonian shell marl. Yellowish; or yellowish above and blue below. At one point this subdivision of this stratum is marked by a layer of *Rostellaria* in great quantity 10-15 feet
- (c) Dark lignitic clay, without fossils at some points, but at others containing pockets of green sand full of Jacksonian fossils, bivalves numerous about 5 feet
- (b) Earthy lignite 20 inches
- (a) Gray sandy micaceous clay —————

It will be seen that this profile differs from a profile given by Mr. D. W. Langdon* in that he puts strata "e" and "f" together. About a mile south of Jackson clays occur, which may be or may not be identical with the clays in "f." Mr. Langdon observes clays on the river south of Jackson only a few feet above the water, but not far from the river clays are to be found at heights of more than fifty feet above the river level. I have little doubt that the lignitic, non-fossiliferous stratum with very strong dip between Jackson and Byram will be found on examination underlying the Jacksonian as well as the Vicksburgian.

* This Journal, xxxi, p. 202, 1886.

The Jacksonian stratum "d" occurs at Moody's Branch at a higher level than southeast from there at the bridge over the Pearl River. This would indicate a southern dip. On the other hand, following Moody's Branch toward its mouth in a southeastern direction the older strata dip up stream. Stratum "e" is seen at the uppermost part of the creek two feet above the water; a few hundred yards below, its surface is five feet above the water, and farther below, the whole stratum is about four feet above the water. Supposing a difference in the water level of four feet even, which must be a maximum there, there is yet a northern dip for these strata at this creek.

Grand Gulf formation in Grand Gulf.

The material of the Grand Gulf formation in Grand Gulf is quite variable. Cross-bedded sands pass over and alternate with friable as well as hard sandstones of the same structure and even regular quartzites occur. The clays have different degrees of induration. I did not notice here the laminated clays found in Terry. It may be that these laminated clays occupy the highest horizon of the Grand Gulf formation, above the sandstones which form the top of the strata in Grand Gulf—if the "Grand Gulf formation" is one single formation.

The sandstones enclose silicified trees. Although making a careful search I was unable to detect any shells as such in these strata, but some of the indurated clays, besides traces of lignitized plants, *contain impressions of fresh-water bivalves*, and these cannot be said to be very rare. The most distinct ones which I was able to collect are two casts of *Unio*, each showing both valves. I procured in all casts of at least three species of *Unio*.

Resumé.

1. After studying the literature as well as the field, I do not know any place where Grand Gulf strata can be seen in actual superposition over the Marine Tertiary.

2. There are two places where strata which cannot be distinguished from unquestioned Grand Gulf can be seen actually overlaid by Marine Tertiary. In one of the cases, moreover, there is internal evidence that these strata were dry land or nearly dry land before the Marine Tertiary was deposited upon them.

3. The Grand Gulf formation, at least for its main part, is not a marine formation; it contains fresh-water shells.

4. A thick and extended marine greensand formation with a numerous fauna is found in Eastern Mississippi. It is parallel to the strata immediately below the Claiborne profile. Its fauna is Claibornian, but approaches the Jacksonian.