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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

ON SOME POST-EOCENE AND OTHER FORMATIONS OF THE GULF REGION OF THE UNITED STATES.

IN 1871 Dr. Eugene W. Hilgard, formerly state geologist of Mississippi, read before the American Association for the Advancement of Science a paper 'On the Geology of the Gulf of Mexico.' This paper was supplemented in 1881 by another, 'On the Later Tertiaries of the Gulf of Mexico,' in which account was taken of the geological investigations made in the interval.

In both these papers that problematical formation, the Grand Gulf, held the chief place of interest, and the hypothesis of a temporary and partial isolation of the gulf from the Atlantic Ocean was urged as being necessary to account for its phenomena.

On the present occasion, I purpose to speak of some additions to our knowledge of the geology of the gulf coastal plain, since 1881, and especially of the post-Eocene formations; and if in this summary I shall be thought to dwell too much on Alabama, I shall urge in explanation that the opportunities for the study of these formations in Alabama are, perhaps, better and more favorable than in the other states,

and I might add that my personal acquaintance with these formations in Alabama is much larger than in the other states concerned.

CRETACEOUS.

In the Cretaceous, the principal advance seems to have been the discovery or discrimination of a lower division, represented in Texas, the Indian Territory and Arkansas by the Comanche series, and in the Gulf states east of the Mississippi, by the Tuscaloosa formation.

The Comanche includes in ascending order, three groups, the Trinity, the Fredericksburg and the Washita. By means of its flora the Tuscaloosa formation has been correlated with the Raritan formation of New Jersey, which is placed at the top of the Lower Cretaceous (Potomac group) of that region. A somewhat similar unstudied flora occurs in the Cheyenne sandstone of southern Kansas, which is certainly in the upper portion of the Comanche series and probably within the Washita group. The Tuscaloosa, therefore, seems to be about on the horizon of the Washita group and may represent it in whole or in part.[1]

The Tuscaloosa strata were well and fully described by Hilgard in his 'Geology of Mississippi,' but both by himself and by Tuomey, of Alabama, were included in their Eutaw formation, as its lowest member; but subsequent study in Alabama, especially of the plant remains of the formation, led to the separation of these beds from the other Eutaw strata and the establishment of their equivalencies as above indicated.

It has also been recently shown that very much of the Rotten Limestone division of the Cretaceous is largely composed of foraminiferal shells and is, therefore, of the nature of chalk, and in Alabama the name Selma chalk has been given to it.

It may further be noted as a matter of interest that the suitability of the purer beds of this chalk as material for the manufacture of Portland cement has been amply demonstrated by the success of the Demopolis (Alabama) cement plant.

TERTIARY AND LATER FORMATIONS.

These I prefer to consider together, for the reason that the precise line between the Tertiary and post-Tertiary can hardly be said to be definitely fixed as yet.

Since 1881 much geological work has been done in the Tertiary formations of Alabama, especially in the beds below the Lower Claiborne or Buhrstone (the Northern Lignitic of Hilgard), and their stratigraphic relations along the Tombigbee, Alabama and Chattahoochee rivers have been carefully worked out, and described in Bulletin 43 of the United States Geological Survey, and more fully in the Report on the Coastal Plain of Alabama, published in 1894, by the Geological Survey of Alabama.

While in Mississippi in these lower beds the lignitic character is more pronounced, in Alabama the marine facies is better developed, and the existence of a number of beds with well-preserved marine shells has made possible a greater degree of differentiation than could be obtained in the adjoining states; though several of these marine deposits of the Alabama Lignitic have been traced into Mississippi on the one hand, and into Georgia on the other.

In 1880, while acting as special agent of the tenth census, the present speaker showed that the Vicksburg limestone was the underlying formation of the Florida peninsula down nearly to the Everglades, and that this limestone at a number of points was overlain by another limestone or marl containing Miocene shells.[2]

The Miocene localities then observed were, however, mostly on the Atlantic side of the peninsula, to which region our in-

[1] T. W. Stanton, letter of November 1, 1905.

[2] Vol. VI., Quarto Reports, Tenth Census.

vestigations were mainly confined.

Little or nothing was done in continuation of these observations until 1887, when Daniel W. Langdon, of the Alabama Geological Survey, discovered on the Chattahoochee River a series of marine Tertiary beds of Miocene age directly overlying the Vicksburg limestone, which, before that time, had been considered the uppermost of the marine Tertiary formations of the Gulf coast.[3] By this capital discovery interest in the later Tertiary formations of this region, especially in Florida, was greatly stimulated, in part because of the great number and beautiful state of preservation of the fossil shells, and the geologists, paleontologists and shell collectors of the U. S. Geological Survey were soon abroad in the land, with the result that other occurrences of Miocene strata were speedily made known, especially east of the Chattahoochee River, at Coe's Mill and other localities down the western side of the peninsula where the exposures are more numerous and continuous.

West of the Chattahoochee also, on Chipola River not far from Alum Bluff, on Shoal River in Walton County, and even as far westward as Oak Grove on Yellow River in Santa Rosa County a few miles below the Alabama line, beds with Miocene shells in an almost perfect state of preservation were quickly added to the list of desirable collecting grounds.

North of Oak Grove and on the banks of the Conecuh River near Roberts in Escambia County, Alabama, some poorly preserved but still identifiable shell casts of Miocene forms were found by Mr. L. C. Johnson, of the Alabama Geological Survey, in beds which were very close above the Vicksburg limestone and consequently near the horizon of the lower Chattahoochee. The westernmost occurrence of the post-Eocene marine Tertiaries was also discovered by Mr. Johnson near Merrill in Greene County, Mississippi, at the confluence of Leaf and Chickasawhay rivers, which make the Pascagoula. Here in the banks of Chickasawhay is a bed made up almost exclusively of the shells of a small *gnathodon* or *rangia,* along with some large but very badly preserved oysters (*O. Virginica*).

Inasmuch as this was in territory mapped by Hilgard as Grand Gulf, and as the strata of the latter formation, containing lignitized and silicified trunks of trees, formed the upper two thirds of the bluff at the place, the gnathodon bed was considered as *a part* of the Grand Gulf, and the name Pascagoula was given to it. Provisionally, at least, the horizon was determined to be Miocene and equivalent to the uppermost of the Alum Bluff beds, but the subsequent determination by Mr. Dall of the oyster above mentioned, as *O. Virginica,* would make the horizon Pliocene, since *O. Virginica* is not known in strata older than the Pliocene.

It may be here remarked that this shell-bearing bed is not a part of the Grand Gulf, since in a deep well bored in Mobile, Ala., in 1894–5, it was penetrated at the depth of 700 feet, while the Grand Gulf there is at the surface.

But the Chattahoochee River section still held the first place, as alone showing clearly and unmistakably the order and succession of most of these beds; for, from Chattahoochee Landing down to Alum Bluff, as first demonstrated by Langdon and since verified by numerous geologists, there is a practically unbroken series of marine strata exposed along the banks and bluffs of the river.

At several points, and especially in the upper part of the Chattahoochee series, there are beds with well-preserved shells which have been studied and described

[3] Report on the Coastal Plain of Alabama, Montgomery, Alabama, 1894.

mainly by Professor Dall, who has classed them as Oligocene and Miocene.

Their thickness, as estimated by Messrs. Pumpelly and Dall, is 200 feet, but the well borings in Mobile have since shown that a greater thickness must probably be allowed.

It will be remembered by those who have kept pace with the progress of gulf coast geology that up to 1881, when the last paper of Hilgard's above referred to was written, the Grand Gulf, a non-marine formation, had always been observed to be, along its northern border, in contact with the Vicksburg limestone, and to occupy the surface of the coastal plain (of Mississippi, at least), thence southward to within ten miles of the gulf shores.

No other Tertiary formation younger than the Vicksburg had then been observed *underlying* it, or indeed outcropping at all in this coastal plain, and none *overlying* it older than the Stratified Drift or Orange Sand (since called Lafayette), and its position in the geological column seemed thus to be definitely fixed, leading Hilgard to the conclusion that 'its rocks alone represented on the northern border of the gulf, the entire time and space intervening between the Vicksburg epoch of the Eocene and the Stratified Drift.'

This view was generally accepted by the geologists of the gulf coastal plain, since similar relations between Vicksburg and the Grand Gulf beds had been observed and described at various points from Texas to the Perdido River.

At this time (1881) the Grand Gulf beds had been identified in Alabama through Washington and Baldwin counties to the Perdido River, the boundary between Alabama and western Florida; and in Georgia the siliceous strata of the wire-grass region, since designated Altamaha grit, were correlated by Drs. Loughridge and Hilgard with the Grand Gulf of Mississippi and Alabama;[4] but neither in Alabama, nor in Florida, nor in Georgia, had the superficial distribution of these beds been at all fully mapped; only detached occurrences had been noticed. West of the Mississippi River, also, the Grand Gulf had been identified and partially mapped through Louisiana and Texas.

The discovery by Langdon of the marine Miocene beds of the Chattahoochee occupying a part at least of the position hitherto thought to be monopolized by the Grand Gulf, naturally necessitated some modification of Hilgard's view, and this necessity was emphasized by the subsequent discoveries mentioned of beds with marine and estuarine shells of Miocene and Pliocene age at other localities in Mississippi, Alabama and Florida, in territory known to be occupied, superficially at least, by unquestioned and unmistakable Grand Gulf strata.

At first, as we have seen, the supposition was put forward that the Pascagoula bed was an estuarine deposit *in* the Grand Gulf and a part of that formation, then, considering the conditions at Roberts in Escambia County, Ala., where typical Grand Gulf sandstones and clays (from the relative positions of their surface outcrops) *appeared* to lie between the Vicksburg limestone and the beds with the Miocene shells, the Miocene age of the Grand Gulf, and the fact of the gradual replacement, coming eastward, of its non-marine beds by marine equivalents, were thought to have been established; and finally, in the Chattahoochee River section, it was thought that we had proof of the complete replacement of non-marine by marine strata.

At that time the presence of Grand Gulf beds of the characteristic *non-marine* type, overlying, and neither interstratified with nor replacing, the *marine* Miocene beds of

[4] Tenth Census Report, Vol. V.

the Chattahoochee series, had not been demonstrated as has since been done by many observations, and in reaching the above-mentioned erroneous conclusions regarding the Miocene age and equivalents of the Grand Gulf, we were dominated by the idea suggested by its relations to the Vicksburg limestone, which it almost everywhere immediately overlies, that it must, therefore, be the immediate successor of this limestone in the geological sequence.

It seems almost impossible to eradicate this belief, notwithstanding its absolute disproof by the records of the Mobile well alone.

Other equally incontestable, though perhaps not quite so obvious, proofs of the true position of the Grand Gulf in the geological column have been obtained by the field investigations in Mississippi, Alabama, Florida and Georgia during the years 1900–1904. As long ago as 1860, Dr. Hilgard, that most sagacious of southern geologists, described and mapped correctly the Grand Gulf as covering all the lower part of Mississippi from the Vicksburg outcrop down to within ten miles of the gulf, and with no formation overlying it older than the Stratified Drift or Lafayette. In Alabama, west Florida and Georgia a similar condition of things exists, as will be evident from the following instances:

1. From Healing Springs in Washington County, Ala., down through Mobile County to within a few miles of the gulf, the surface formation is everywhere the Grand Gulf with its usual capping of Lafayette.

2. A little further east in Alabama, beginning in Clarke County and coming southward through Baldwin to Perdido Bay, we find again nothing at the surface save Grand Gulf with its Lafayette capping. At Montrose on the eastern shore of Mobile Bay and a little below the latitude of Mobile, these Grand Gulf clays and sands of the most characteristic type make the Red Bluff, seventy-five feet in height, with the usual thin capping (fifteen or twenty feet) of Lafayette red loam and pebbles. Continuing on down to the southern end of the county we find the same materials making a bluff, twenty-five or thirty feet in height, washed by the waters of Perdido Bay, *i. e.*, the Gulf of Mexico. So here in Alabama, the Grand Gulf most certainly overlies *everything* except the Lafayette and more recent strata.

3. Again along the L. & N. R. R. we have followed the same combination, Grand Gulf with Lafayette capping, from above Evergreen down to Pensacola, where they form a bluff some thirty to forty feet in height overlooking the Bay of Pensacola.

4. Again in Escambia County, Ala., starting north of the Conecuh River near Roberts, we find the Grand Gulf overlying and in contact, first with the Vicksburg limestone, then with the Miocene clayey sands which there directly overlie the Vicksburg; then, coming southward into Florida, the same formation with its capping of Lafayette occupies the surface down to the latitude of Oak Grove and beyond; the Oak Grove bed with its beautiful Miocene fossils cropping out in the bank of the river, the Grand Gulf on the uplands one hundred feet above.

5. Eastward of Escambia County the northern limit of the Grand Gulf laps over formations still older than the Vicksburg, and we see it in Covington County near Andalusia, overlying the Claiborne and the Buhrstone; and in Barbour County and the adjoining (Quitman) county in Georgia, opposite Eufaula, it overlies the Ripley beds of the Cretaceous. Thence, its landward border takes a northeasterly direction, and indurated beds identical with those of the type locality in Mississippi (here called Altamaha Grit) begin to make

a small percentage (not more than one one hundredth of one per cent. according to Dr. Harper) of the rocks of the series, eastward of Flint River.

From this northern border it may be traced southward to the southern limit of the state, and beyond, at least to Chattahoochee in Florida, where it occupies as usual, the summit of the plateau with only the red loam and pebbles of the Lafayette over it; and along the road leading down from this plateau to the Old Chattahoochee Landing, it may be seen resting directly upon the Miocene limestone first identified as such by Langdon as above mentioned.

While our recent observations have not extended any further south along the Chattahoochee than this point, we have good reason for the belief that the same Grand Gulf and Lafayette mantle occupies the summit of Alum Bluff itself.

Keeping in mind the fact that the Grand Gulf mottled clays overlie directly the Miocene limestone at Chattahoochee Landing, let us consider what the deep borings at Mobile, at Alabama Port, Mobile County, and at Bon Secours Bay in Baldwin County, reveal. In all these wells, with the Grand Gulf capped with the Lafayette forming the surface, the Gnathodon bed of the Pascagoula Pliocene is penetrated at the depth of 700 to 800 feet; and below that, to the depth of 1,600 feet, follows a succession of beds with well preserved and easily identifiable shells, characteristic of the several horizons of the Chattahoochee (Miocene) River section. The borings end in these beds before reaching the top of the Vicksburg.

The most remarkable thing in connection with these later Tertiary strata and that which has caused so much perplexity among the geologists is the rarity of their outcrops at the surface west of the Chattahoochee River. There are several known exposures in west Florida already noticed, *i. e.*, on Chipola River, Shoal River and at Oak Grove; only one locality has as yet been noticed in Alabama, *i. e.*, on Conecuh River near Roberts in Escambia County; only one in Mississippi, viz., that of the gnathodon bed near Merrill on Chickasawhay River. We hear of none in Louisiana, and none in Texas; yet in the latter state the deep borings at Galveston and Beaumont, after passing through 458 feet of recent and Pleistocene strata, and 1,035 feet of beds of doubtful age, penetrate at least 650 feet of beds referred to the *Upper Tertiary,* and 917 feet of beds containing characteristic shells of *Miocene* age.[5] We know the reason of this in Alabama, for the surface of the country here in which they should outcrop is covered by an undetermined thickness of the beds of the Grand Gulf and Lafayette. Probably the same explanation would apply to the other states.

From the facts detailed above, the conclusion seems unavoidable that the Grand Gulf, lies *above* any Tertiary formation as yet described in the Gulf states; it being, on the testimony of the Mobile wells, at least 700 feet above the Pascagoula beds which from the *O. Virginica* which they contain, must be assigned to the Pliocene. The additional fact that no formation older than the Lafayette has yet been observed overlying it, betokens its comparatively recent age.

The only escape from the conclusion thus forced upon us seems to be the assumption that Wailes, Hilgard, Hopkins, Loughridge, Hill, Kennedy, Dumble and the other geologists who have made this region a study, have been mistaken in their identifications of the Grand Gulf, and have confounded it with something else.

Let us, therefore, look at it from another point of view. The usual place as-

[5] Gilbert D. Harris, Fourth Annual Report, Geological Survey of Texas, 1892, pp. 91–95.

signed to the Grand Gulf is between the Vicksburg and the Chattahoochee limestones; or between the members of the Chattahoochee River series; or else as being equivalent to the whole of the above series.

We ought, if this assignment be correct, to find it somewhere or other *underlying* some of the Post-Vicksburg Tertiary rocks. It has never yet, so far as the records show, been seen in these relations.

That it does not come in between the Vicksburg and Chattahoochee is amply proven by the observations of Professors Pumpelly, Foerste, McCallie, Burns, Dall and others who have described the contact of these formations in southwestern Georgia and in Florida, with no sign of anything that could possibly be referred to the Grand Gulf coming in between them.

Characteristic Grand Gulf beds were observed by Mr. S. W. McCallie and myself in 1904, on Withlacoochee River in Lowndes County, Ga., near the Florida line, overlying limestones holding Miocene corals referred to the Chattahoochee horizon, this limestone in its turn resting on the Vicksburg; and I can personally bear witness to the fact that the Grand Gulf overlies the Miocene limestone at old Chattahoochee Landing, and along the road from Chattahoochee town to River Junction. From Chattahoochee Landing down to Alum Bluff, the succession of Marine Tertiary beds along the river is unbroken; in the words of Professor Dall, 'While the series is not complete in any single section, taken collectively there is no gap outstanding between the beds, and, humanly speaking, no room for misapprehension as to their position and age.'[6] Certainly no Grand Gulf beds form any part of this Chattahoochee River section, which ranges from upper Oligocene, according to the latest decision of Professor Dall, up to the Chesapeake Miocene of the Alum Bluff exposure; but they do *overlie* in turn each member of this series.

But we have also seen above that eastward of Escambia County, Ala., the Grand Gulf beds are to be found overlying strata *older* than the Vicksburg, *e. g.*, the Claiborne, the Buhrstone, the Lignitic, the Clayton and even the Ripley of the Cretaceous. It has not occurred to any one to assign to the Grand Gulf an age older than that first referred to, because of its resting directly upon any of these sub-Vicksburg formations.

By way of parenthesis I might here say that this transgression of the Grand Gulf over the older formations in the eastern part of Alabama, finds a kind of parallel on the St. Stephens limestone. We have recently identified isolated patches of this limestone so far out of its usual position as to be directly in contact with the Nanafalia beds of the Lignitic and upon the very verge of the Clayton. This is the case, for instance, at Rutledge and Luverne in Crenshaw County and at Brundidge in Pike County, Ala. Between these outlying patches and the regular outcrop of the St. Stephens is the usual succession of the outcrops of the other Lignitic and Claiborne beds, with none of the Vicksburg remnants, as yet detected, overlying them.

We may sum up the evidence above presented, in the two following statements: (1) No one has yet seen or recorded the Grand Gulf actually in place *beneath* any Tertiary formation, Eocene, Oligocene, Miocene or Pliocene. (2) On the other hand, it has been observed *overlying*, and in direct contact with, every one of these Tertiaries, to say nothing of the Ripley of the Cretaceous.

It has been inferred that it passes below all the Tertiaries above the Vicksburg, simply because of the usual position of its northern boundary, ignoring what Hilgard

[6] *Bulletin Geol. Soc. Amer.*, Vol. 5, p. 162.

long ago emphasized, that, apart from local steep dips in any direction, its strata could nowhere be shown to have anything else than approximately horizontal position, on an average; and ignoring the still more convincing circumstance that, with a thickness of only 200 to 300 feet, it spreads over an area in the state of Mississippi, of at least 120 miles from north to south. If it had the usual observed dips of the other Tertiary formations in that state, the Grand Gulf would lie between 3,000 and 4,000 feet *below* the surface at points near the Gulf where it is certainly known to be *at* the surface.

MATERIALS.

The materials of the Grand Gulf are essentially clays and sandstones, the latter generally aluminous and soft, and of white, gray and yellowish-gray tints; the sand being very sharp. Beds of loose sand are unusual; but the clays are oftentimes quite meager, though the sand contained in them (as is the case in the sandstones) is usually quite fine.

To this description by Hilgard it might be added that the sandstones and the massive clays, which are often indurated into a mudstone grading into a sandstone, are frequently mottled with irregular red splotches, in this particular, as well as in others, resembling some of the material of the Tuscaloosa formation of the Cretaceous.

Stratified clays in thin layers are also common in Alabama, and these nearly always have a pink color. Pebbles of small size, one fourth to one half inch in diameter, are not uncommon in thin irregular bodies, generally at the base of sandy beds. Much stress has been laid on the occurrence of the sandstones and other indurated strata as being only in the presumably lowermost (because most northerly) beds of the formation; but this is a mistake, since one of the most conspicuous examples of this occurrence is at Fort Adams on the Mississippi River, in the southwestern corner of Mississippi, at the Louisiana line. In Alabama they occur down to the Florida line, and in the Altamaha Grit region of Georgia—as shown by McCallie, Harper, Burns and others—these indurated beds, in every respect identical with those of the type locality in Mississippi, have been observed sporadically in eighteen counties and in every part of this region, down nearly to the Florida line in southwestern Georgia, and to within twenty-five or thirty miles of the Atlantic coast on Ocmulgee River. According to the estimate above referred to of Dr. Harper, who has devoted several years to the study of this region, these *rock outcrops* do not constitute more than one one hundredth of one per cent. of the area of the formation.

The marks on the map before you will show this clearly enough, and ought to dispose of the statement so often made that the indurated parts of the Grand Gulf are older than the rest—or that they represent a different form from the less consolidated parts. One might as reasonably hold that the indurated crusts so often seen in the Lafayette constitute a distinct formation worthy of a distinct name. In general, however, the statement of Hilgard holds good, that 'there is a gradual increase in clayeyness and a decrease of hardness, until in the seaward portions of the formation we find chiefly stiff blue or green and more or less massy clays,'[7] and I might add for Alabama, laminated clays and coarse sands.

Lignite and gypsum are characteristic of the materials both in Alabama and in Mississippi, and in both states the wood is often silicified. The lignitic facies is, however, more common in Mississippi. The lignitic matters generally occur in rather limited lenses in the other strata. Some

[7] *Am. Jour. Sci.*, Vol. XXII., p. 59.

of the trunks of trees have been observed one half silicified, the other half lignitized.

TOPOGRAPHY.

The topographical features of the country covered by the Grand Gulf strata are quite characteristic. Near the northern border where the Vicksburg limestone is not far below the surface, lime sinks and deep ponds are common, and the surface of the country is often uneven, occasionally rugged; but going southward one finds the surface becoming gradually smoother until it assumes the character of 'flatwoods.' But these flatwoods are not necessarily low lands, since in Baldwin and Mobile and in the adjoining county of Florida (Escambia) the land, where not lowered by stream erosion, is from 150 to 300 feet above tide. One of the most characteristic features of this flat land is the frequent occurrence of shallow depressions which are hardly ever more than four or five feet deep, in which water may collect in shallow ponds a few yards to forty or fifty in diameter. These are lined with a shrubby growth of haw bushes, gum or cypress, or sometimes of herbaceous plants only. Other depressions, frequently of larger size than those above mentioned, may be free of water, thus giving rise to the *sarracenia* flats and to *savannahs,* covered with high grass and supporting a sparse growth of stunted long leaf pine. Along with the prevailing grass are many bright-colored flowers peculiar to the region, and the impression is made upon the traveler that he is in a well-kept park. Lower lying lands timbered with long leaf and Cuban pine are known as 'pine meadows,' in which the shallow ponds are not so frequent, but where the surface is gently undulating and mostly clothed with a growth of tall grass and flowers, like the savannahs.

It is not easy to account for these shallow depressions; they are certainly not due to any underlying limestone near the surface, nor is there, so far as we are aware, any sufficient amount of soluble matters in the soils to give rise to them. The only explanation as yet suggested is that they are due to the uneven surface of the underlying clayey beds of the formation, which are reached almost everywhere in wells at shallow depth.

THICKNESS.

The thickness of the formation is very difficult to estimate. Dr. Hilgard long ago observed that 'the position of the Grand Gulf strata could rarely be shown to be otherwise than nearly or quite horizontal on an average,' and during a recent trip by Mr. Aldrich and myself in a skiff, from Bucatunna to Merrill in Mississippi, a distance of fifty miles in direct line north and south, we could discover no sensible dip in the strata. Dr. Hilgard puts the thickness at 250 feet, stating that in the absence of deep borings in the gulf territory this can be best observed on the northern edge of the formation, where it forms high ridges, from which there is an abrupt descent northward into the level prairie country of the Vicksburg territory. The deep borings since made in the gulf territory have not settled the question, for it is not as yet possible to draw sharply the line between the Grand Gulf and other strata there penetrated. In Baldwin county, where these beds come down to salt water at Montrose on the eastern shore of Mobile Bay, the bluff itself is some 70 or 75 feet high, and the level plateau, a mile or two back from the bay, can not be less than 150 feet. This is about the height of the Spring Hill plateau at Mobile, and at the foot of that ridge is the boring in which the Pascagoula bed is struck at about 700 feet. For the first 180 feet of this boring the material can not well be distinguished from Grand

Gulf. This, with the 150 feet of the hill, would make the thickness something over 300 feet.

From its structure and distribution it is difficult to avoid the conclusion that the Grand Gulf is a sort of blanket or mantle formation spread over part of the Vicksburg; in places over parts of older formations; and over all the Miocene and later Tertiaries, with practically no general southward dip more rapid than the descent of the general land surface. In this it resembles the next overlying formation of our coastal plain, viz., the Lafayette, or Orange Sand of Dr. Hilgard. The latter, however, overlies a far greater number of formations, including the entire coastal plain series and even part of the Paleozoics and Crystalline schists. The Lafayette is also composed of siliceous materials, but my experience in Alabama is that the clays are comparatively rare. The prevailing material is a red sandy loam with beds of rounded, water-worn pebbles in irregular bodies at the base. Very often the red loam passes into a sandier phase of lighter color—generally yellowish—before the pebbles are reached. The thickness can rarely be shown to be more than twenty or twenty-five feet at any one place, unless the materials are filling erosion hollows in the underlying formations. A characteristic feature in Alabama is the almost total absence of evenly stratified beds of any kind; the red loam at the surface seldom shows any lines of stratification; the sands and pebbles almost invariably exhibit cross-stratification or false-bedding, due to deposition from swiftly flowing currents; laminated clays I have not seen at all in this formation in Alabama. In this we have a very marked distinction of the Lafayette from either the Tuscaloosa or the Grand Gulf, with both of which it has some features in common.

GENESIS.

To account for many of the phenomena of the Grand Gulf formation Dr. Hilgard has from the first insisted that foremost among the conditions of its accumulation was exclusion of the sea,[8] or at least such obstruction of the communication across the still submerged peninsula of Florida as to render the influx from the interior of the continent predominant over the original supply of sea-water. Later, in 1881, after soundings in the Gulf of Mexico had revealed the topography of the gulf bottom, and the existence of a submerged shelf of 100 to 130 miles width along the coast, he suggested that even an elevation of 450 feet (which seems to be proven for the Mississippi embayment) would convert the whole gulf border into a region of shallows out to the 100-fathom line, in which the waters would be kept permanently freshened by the continental drainage. It may be remarked in this connection that such an elevation would also raise a portion of the present sea bottom into dry land, and would not help to explain the accumulation of Grand Gulf strata far inland of the present coast, unless we assume that this uplifting of the submerged shelf was accompanied by a downward warping of a belt farther inland. Nor would it help in the explanation of the occurrence of this formation on the Atlantic side of the Georgia watershed, and through South Carolina.

In the Tuscaloosa or Potomac formation of the Cretaceous we have an almost parallel case. In their component materials and in their mode of accumulation the two formations show striking similarities; in both are only vegetable remains, or those of land and fresh-water origin; both must have been accumulated in sounds, partially, at least, cut off from the sea, and the difficulties in suggesting the precise nature and

[8] *Am. Jour. Sci.*, Vol. II., December, 1871.

origin of the barrier by which this exclusion of the sea was effected, are as great in the one case as in the other, but in neither greater than the difficulties met in accounting for the other great fresh-water formation of the coastal plain—the Lafayette.

In the case of this Lafayette formation, two explanations of its origin have been offered, viz.:

(1) That it was deposited along the borders of the Gulf and Atlantic during a period of depression, when the shore line was at the landward margin of the formation, and that the deposit was, therefore, a marine or estuarine one.

To this the structure of the formation, its position upon a deeply eroded surface, and the entire absence of fossil remains appear to be well-nigh insuperable objections.

(2) That the materials were drifted down the channels of ancient streams, in places coincident in position with the modern streams, and were thus of the nature of alluvial fans. All this would naturally happen during a period of elevation rather than of depression. In Alabama, the Lafayette does not seem to be confined to well-marked channels such as Dr. Hilgard finds in Mississippi, but it appears to have been spread over the whole face of the coastal plain of the Gulf as well as of the Atlantic, reminding one of a coalescence of alluvial fans on a large scale, as they spread out upon the plain, much after the fashion of the ice of the Piedmont type of glacier as displayed by the Malaspina. This view of the genesis of the formation would account for many of the phenomena, and certainly for the absolute lack of all trace of fossils.

In the nature of their materials; beds of sand often intricately false-bedded and of bright colors; beautifully laminated and gaily colored clays; great beds of massive clays of every variety, white, gray, reddish, purple and variously mottled; in their structure and in the general impression which they make upon the observer in the field, the two formations, Potomac and Grand Gulf, are astonishingly alike, so that in the absence of fossils it would be impossible to distinguish the one from the other if both occurred in the same area. On the other hand, the Lafayette has a character of its own, different from either, and so well marked that the observer with any reasonable degree of experience will scarcely ever remain long in doubt as to its identity or be likely to confound it with anything else, even though it holds no fossils to guide him.

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ANTHROPOLOGY AT THE SOUTH AFRICAN MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, 1905.

ONLY a few communications were brought by the over-sea members, and they all had a bearing upon South African anthropology. The president's address presented a brief summary of our knowledge of South African anthropology and pointed out lines for future inquiry, with an urgent appeal for immediate and more thorough investigation in the field. Mr. Henry Balfour gave an account (illustrated by lantern slides) of certain musical instruments of South Africa, dealing more especially with the musical-bow group of instruments. Mr. E. S. Hartland read an elaborate paper on the totemism of the Bantu, in which he pointed out that the totemism of the Bantu had been of a type similar to that of the Australians and North American Indians, but that everywhere it has fallen into decay and become more or less replaced by ancestor worship, and concomitantly father-right has replaced mother-right. Professor F. von Luschan gave an abundantly illus-