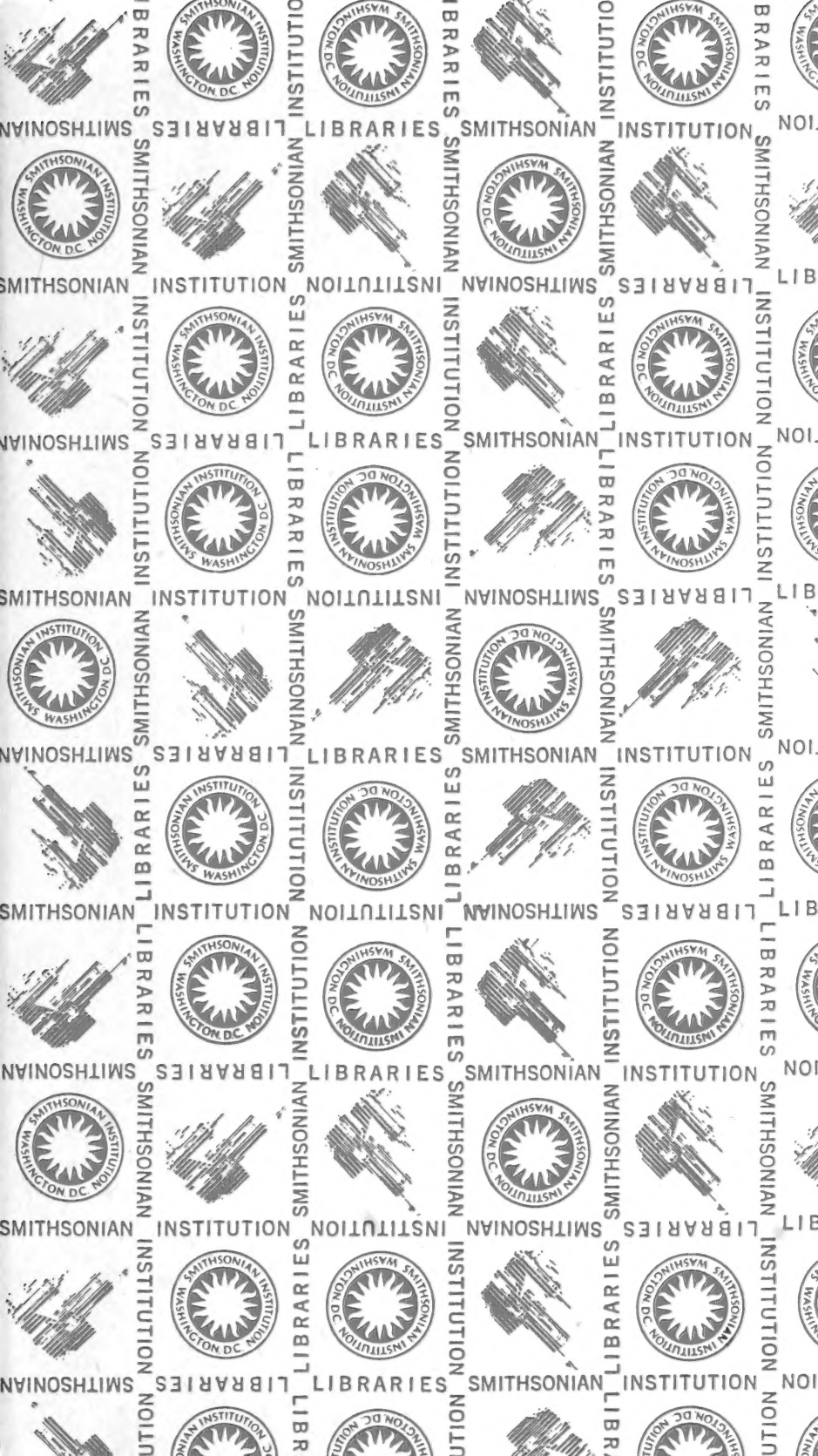


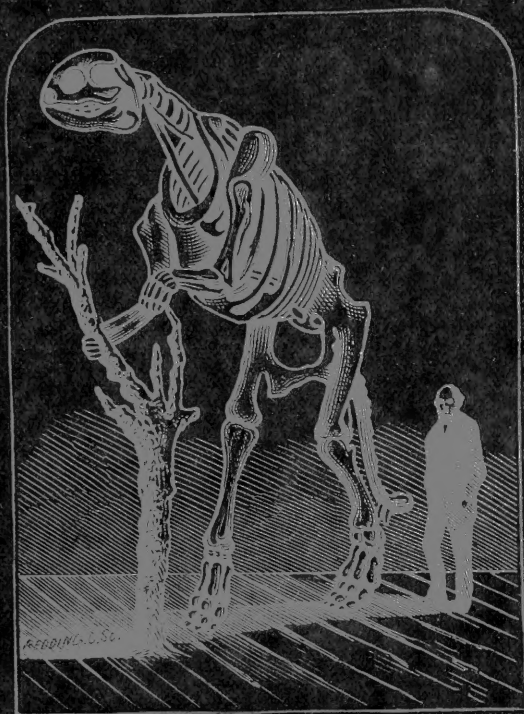
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THE PHOSPHATE ROCKS
OF
SOUTH CAROLINA;
THEIR HISTORY AND DEVELOPMENT.



Hadrosaurus Foulki.—LEIDY.
Skeleton of a Fossil Lizard eighteen feet in Length.

PUBLISHED BY HOLMES' BOOK HOUSE,
CHARLESTON, SO. CA.
1870.



SPECIMEN OF
PHOSPHATE ROCK



One fourth Natural Size.

*With Compliments
of the Author*

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Moll.

PHOSPHATE ROCKS OF SOUTH CAROLINA

AND THE

“GREAT CAROLINA MARL BED,”

WITH FIVE COLORED ILLUSTRATIONS.

A POPULAR AND SCIENTIFIC VIEW OF THEIR ORIGIN,
GEOLOGICAL POSITION AND AGE;

ALSO

THEIR CHEMICAL CHARACTER AND AGRICULTURAL
VALUE;

TOGETHER WITH

A HISTORY OF THEIR DISCOVERY AND DEVELOPMENT.

BY

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LATE PROFESSOR OF GEOLOGY AND PALÆONTOLOGY IN THE
COLLEGE OF CHARLESTON.

LECTURER ON GEOLOGY AND ZOOLOGY,

CHARLESTON LYCEUM.


“I lay it down as true that experimental philosophy is the only sure method of investigating the laws of Nature. We can only at best collate facts, and then draw deductions which we call reasoning, but without these facts, obtained from experiment, our knowledge is futile.”—J. B. MILLER.

CHARLESTON, S. C.:

PUBLISHED BY HOLMES' BOOK HOUSE.

1870.

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DEDICATION

TO THE PEOPLE OF SOUTH CAROLINA,

(MY NATIVE STATE,)

AND TO THE MEMORY OF

PROFESSOR MICHAEL TUOMEY AND OF DR. THOS. L. BURDEN ;

TO

JAMES T. WELSMAN, ESQ., OF CHARLESTON, S. C.,

AND

GEORGE T. LEWIS AND FREDK. KLETT, ESQS.,

OF PHILADELPHIA, PA.,

This little work, one of the results of thirty years' observations and labor
in the Geological fields of the Ashley,

IS RESPECTFULLY DEDICATED.

The first were my revered friends and co-laborers; and the last are
entitled to the honor and distinction of having at once recognized the
value of the great discovery of the Phosphate Rocks, and of having lib-
erally furnished the means to develop these long hidden treasures PREPARED
OF OLD by the GREAT MASTER BUILDER, and laid up in store for the
APPOINTED TIME, when the waste places of the earth should be replenished

SCIENTIFIC TERMS AND POPULAR NAMES.

To comprehend fully the scientific terms used in our descriptions, and the popular names of the objects of which we treat, is of the first importance, in order that there may be no confusion of names, and that the reader may clearly understand the subject before him. The common or popular name which a writer in this State may give in his description of a specimen or object in Natural History, would be readily understood in his own County or neighborhood; but in an adjoining County or State the object may be known by a very different name, and the people be misled by the description. For example: an intelligent traveller on a visit to Sullivan's Island, enquired the name of a venomous looking reptile, which he saw running along the rail of a fence, and he was told that it was a "Salamander." Passing through Georgia a few weeks after, he was invited by a planter to visit his fields, where the laborers were engaged in clearing and burning the pines preparatory to the next year's crop. During the walk he observed that several animals had just been caught escaping from the burning heaps of wood, and which, though resembling the well known forms of the tortoise or terrapin, were yet dissimilar from any he had ever seen. The farmer told him they were called Salamanders or Gophers. Soon after, visiting an orange grove in

Florida, he saw, in a clearing near by, a number of negroes with clubs killing what looked like rats, escaping from the burning brush, and on enquiring what sort of rats they were, he was politely informed that they were not rats, but "Salamanders."

Here we find a lizard, a tortoise and a rat called in three different States by the same name—*Salamander*; whereas, this name is given by scientific men to a little lizard-like animal, that in its general form and characteristics seems intermediate between the frog and the lizard; and, like the former, is amphibious in its habits. They are abundant in the up-country of South Carolina, and may be found in their nests under stones in wet places, often with many eggs around them.

The story of the ancients that the Salamander is able to endure fire is altogether fabulous; yet no doubt it has caused the name Salamander to be given to the Carolina Lizard, because of the fiery red bag apparently suspended under the throat, and from which it is said to "spit" a red fluid that will instantly quench the flames of a burning rail. The Gopher and the ground rat are also thus called, because in escaping from their burrows under ground, directly over which are the burning piles, they appear to endure the hot coals without injury. It is admitted it is always better to employ plain English names when they serve the purpose in view, but when each county, or each popular writer, gives the same name to a totally different object, it tends only to confusion. Let us then adhere to the scientific name, when one

has been given, and make it universal ; for derived, as it usually is, from languages common to all scientific men, when once adopted, there can no longer be any misconceptions.

NAMES GIVEN TO THE PHOSPHATE-ROCKS.

Writers have called these rocks by different names ; this has occurred even in the writings of scientific men, who should have at once fixed upon one name, and brought it into general use.

They have been called Marl-rocks, Marl-stone, Bone-phosphates, Phosphate-rocks, Coprolites, Conglomerates, and sometimes Bone-rocks. These names have been so used by writers of late that one is sometimes at a loss to know which of all the mineral products of the region is meant.

That there may hereafter be no mistake as to the name, we have adopted that of PHOSPHATE-ROCKS, as the best and most comprehensive. For, though by the terms Bone-phosphates, Marl-rocks, or Marl-stones, they might very properly be called, we think the name Phosphate-rocks, is more in accordance with popular usage, and conveys also a better idea of their true character.

And here it may be remarked, that these rocks are not Conglomerates, Coprolites, or Bones, and that the teeth and bones which are found mingled with the Phosphate-rocks in their beds, should not be called

Phosphate-rocks, but fossil *teeth* and fossil *bones*; and that, too, notwithstanding their richness (when thus associated) in Phosphate of Lime.

When we speak of MARL, we mean simply "that compound of earthy mixtures of which *Carbonate of Lime*, in any form, constitutes either the sole or the chief value as a manure, and which is in such large proportion as to be an important value, and the mass soft enough to be excavated and broken down by ordinary digging utensils."

GREEN SAND often contains no Carbonate of Lime; is not generally rich in calcareous matter, and therefore should be called GREEN-SAND MARL. MARLSTONE is calcareous, of a stony hardness, and not capable of being *dug*, because not of an earthy texture; cannot be pulverized enough by ordinary implements to be used as a manure, but requires for such purpose to be burnt to lime. It is truly a LIMESTONE, and should be so called.

CLAY is a soapy, non-calcareous, earthy material, but there are some forms or varieties that are improperly though popularly termed Marl.

COPROLITES are the undigested fecal remains of animals, fossilized; of stony hardness; often petrified, and sometimes, though not often, phosphatic when taken from Tertiary or modern rocks.

CONGLOMERATES are strictly commingled fragments of many kinds of rocks, or they may be termed loose materials of a rocky character cemented together in masses. The conglomerates of the Ashley Beds are made up of Phosphate-rocks, Marls, Pebbles, Gravel,

etc., etc., cemented together by oxide of iron, or lime. They often contain Pebbles of water-worn quartz.

BONES. The bones which are found in such numbers *intermingled* with the Phosphate-rocks, are not *rocks* in any sense of the term, nor are the PHOSPHATE-ROCKS bones. Many believe the Phosphate-rocks to be masses of true bone fossilized; but this is a mistake; *they never were bones at any time*, but were originally Calcareous rocks. This is evidenced by the shells, corals and corallines of which they are composed; and by the general character of the "mother bed" from which they were taken to be redeposited in basins, where by a chemical process (hereafter described) they were converted from a Carbonate of Lime-rock or Marl, into a Phosphate of Lime-rock, containing very little Carbonate of Lime.

EARLIEST NOTICE OF THE PHOSPHATE ROCKS.

This seems to be the proper place to introduce a short article which appeared in the August number, for this year, (1870,) of THE RURAL CAROLINIAN, under the above heading. The author signs himself P. H. M., and refers the reader to a notice of Phosphate rocks published by Judge John Drayton (1802) in his "VIEW OF SOUTH CAROLINA," page 40, and he gives extracts which I quote in part, as follows. In alluding to the regular Phosphates, he says: "Teeth

of unusual size have been found in this State (South Carolina) as far south as Stono Swamp. Bones and teeth of large dimensions were in 1795 dug out of Biggin Swamp, at the head of the west branch of Cooper River, two miles above Biggin Bridge. This was effected by Colonel John C. Sens, engineer to a company for opening a canal between Santee and Cooper Rivers. He found them eight or nine feet under ground; among them were grinders bearing all the marks of a carnivorous animal; others were of a different and much larger texture, apparently belonging to a graminivorous animal. There was also a large tusk three or four feet long, which Colonel Sens is of opinion resembled that of an elephant."

The writer, P. H. M., goes on to remark: "By these extracts it will be seen that the Phosphates were known to exist even seventy-five years ago, but the knowledge of their great use and value was wanting."

It is here intimated that fossil teeth, shells and bones are Phosphate-rocks. Like others, he fails to distinguish rocks from bones, and supposes the animal remains spoken of by Judge Drayton to be the same as the Phosphate-rocks of the present day; whereas these are rocks and the others bones.

And now a word as to the theory of Bernadin de St. Pierre, applied or quoted by Judge Drayton, regarding the origin of these teeth and bones of which he speaks, these last, be it observed, *are not* Phosphate-rocks.

Supposing it (the origin) "to have arisen from the

fusion of ice at either pole," he says: "Then it was that all the plans of Nature were reversed; complete islands of floating ice, loaded with white bears ran aground among the palm trees of the Torrid Zone, and the elephants of Africa were tossed amidst the fir groves of Siberia, where their larger bones are still found to this day." This theory might have been properly accepted by Judge Drayton and his contemporaries, for at that day but little was known of such things; but there is no excuse for a writer in a monthly journal, published in this the "Telegraphic age," who repeats these "old time stories." These bones have nothing to do with Phosphate-rocks, for just such teeth and bones are found throughout the salt-licks of Kentucky, the swamps of New York, Virginia, North Carolina, Alabama and Florida, and in very many parts of England; also, on the Continents of Europe, Asia and Africa, and in places too where there is no Phosphate-rock.

And finally, the same author, as if to settle the whole matter and put aside all doubts as to the discovery at that early time of the Phosphate-rocks, writes thus: "By reference, however, to the VIEW OF SOUTH CAROLINA, by JUDGE JOHN DRAYTON, page 40, there will be seen *drawings* of six different shapes of Phosphatic rocks."

Satisfied as soon as we read it that this was the greatest error of all, we immediately procured the book from the Charleston Library, and after carefully searching the whole volume, especially the plate at page 40, we found no drawings of *rocks* nor of anything like

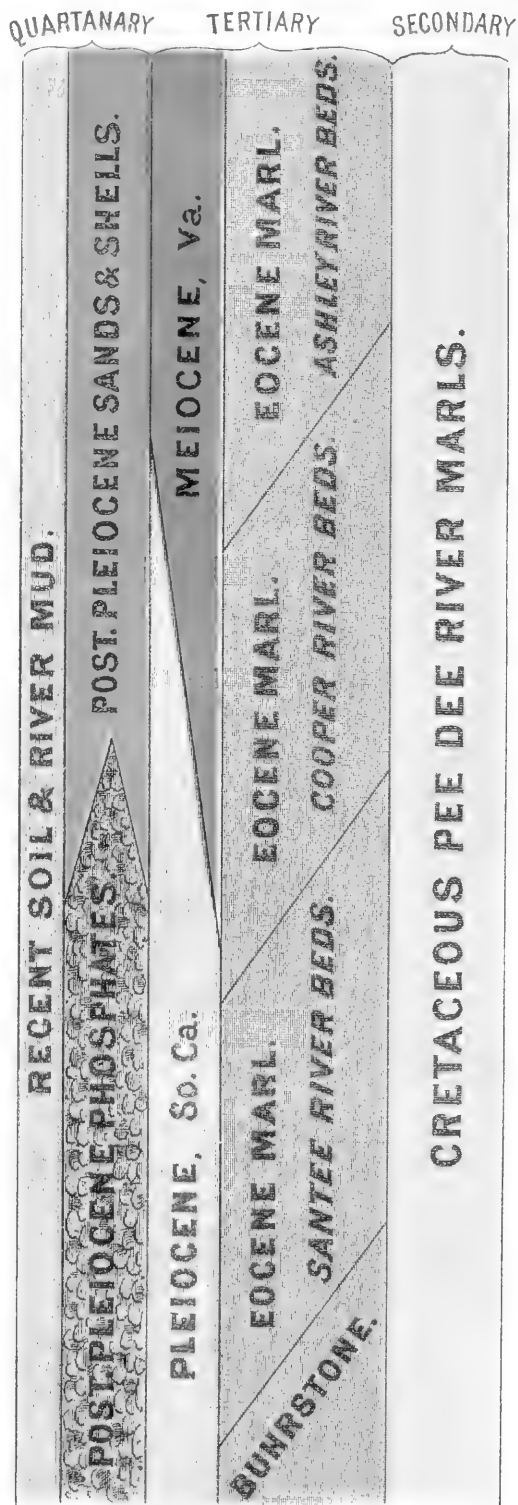
rocks; nor can the word *rock* be found in the description of these plates by Judge Drayton. In fact, the Judge accurately describes the six figures referred to, and calls them by their proper names—BONES AND TEETH! And these bones and teeth the writer, notwithstanding, calls Phosphate Rocks! Besides, there is not a *carnivorous* tooth figured in the plate; all belong to *herbivorous* animals, as the Mammoth and the Mastodon. The teeth and bones of carnivorous animals, the Shark, Whale, Seal, Phocodons, Squalodons and Porpoise, so common in the Phosphate basins, and characteristic of the mother bed, are *imbedded* (and not merely *intermingled*) in the Phosphate rocks; whereas the teeth and bones of land animals are only *intermingled* with these nodulous masses. The remains of the first named animals belong to marine formations, as do the phosphatic nodules. The last named are from lacustrine or lake and river deposits.



ORDER IN WHICH
 The GEOLOGICAL FORMATION of the
 SECONDARY.

TERTIARY & RECENT PERIODS OCCUR ON THE ATLANTIC COAST.

OF
 SOUTHERN STATES.



GEOLOGICAL HISTORY AND ORDER OF SUCCESSION OF THE FOSSILIFEROUS BEDS OF THE CHARLESTON BASIN.

CULTIVATED SOIL AND SUBSOILS.	{ PRESENT AGE. (Man and the animals which are living, his contemporaries.)	} Quaternary or Fourth Period.
SANDS AND SHELLS.—PHOSPHATE ROCKS AND CLAYS.	{ RECENT OR POST PLEIOCENE AGE. (Period of the advent of man upon this Continent.)	
SANDS AND BEDS OF LOOSE MATERIAL, containing fossil shells, etc.	{ PLEIOCENE AGE. (So-called because most of its fossil shells belong to species now living.)	
SANDS AND CLAYS, containing fossil shells, teeth and bones. (None in South Carolina of this meiocene age.)	{ MEIOCENE OR MIDDLE TERTIARY AGE. (Extensively exposed in Virginia and other States north of South Carolina, having a smaller number of fossils belonging to recent species.)	} Tertiary or Third Period.
SANDS AND MARLS.—Very rich in Carbonate of Lime, and extensively developed in this State. It was called by Mr. Ruffin the "GREAT CAROLINIAN MARL BED." The upper layers or Ashley Marl is known as the "FISH BED" of the Charleston Basin.	{ EOCENE AGE OR OLDEST TERTIARY. (Dawn of the creation of recent animals. No species found fossil in the Carolina Beds are now living.)	
SANDS, CLAYS AND MARLS, poor in Carbonate of Lime, though rich in fossil shells.	{ CRETACEOUS OR CHALK AGE. (Its fossil shells and bones correspond to those of the chalk beds of Europe. There is no TRUE CHALK in America.)	} Secondary Period.

As seen in the foregoing table of the fossiliferous beds exposed in South Carolina, the Cretaceous formation, which belongs to the Chalk age of Europe, is the lowest. It is exposed on the banks of the Pee Dee River. In boring the Artesian Well, in Charleston, it was reached at about eight hundred feet below the surface, and in the place where it properly belongs in the sequence, directly under the Eocene Marl Bed. On the Pee Dee it occurs in alternate layers of soft Marl and hard Limestone rock; its color is a dark blueish gray, though sometimes the limestone is yellowish. Cretaceous Marls are poor, they rarely contain more than thirty to forty per cent. of Carbonate of Lime. The Limestones of this age, however, are rich, varying from sixty to seventy-five per cent. In the annexed Plate, No. I, it is represented as the lowest stratum.

Second, in the ascending order, comes the Eocene, or oldest bed of the Tertiary Division. It is extensively developed in South Carolina, especially on the Ashley and Cooper Rivers, and therefore called by Mr. Ruffin "The Great Carolinian Marl Bed," and now known to be one of the thickest and richest deposits of MARL in the world; containing from fifty-five to ninety-five per cent. of Carbonate of Lime. It has been bored to the depth of seven hundred feet in the Artesian Well of Charleston, and though all the strata to that depth are homogenous, yet they vary in texture, according to the character of the animal remains of which they are composed.

The Marl proper is covered with thin layers of

sand and blue clay, containing casts of shells beautifully preserved; and also great numbers of fossil, sharks' teeth and cetacean bones; it was called, in 1839, the FISH BED OF THE CHARLESTON BASIN. From the "proceedings" of the American Association for the Advancement of Science, at a meeting held at Charleston, March, 1850, we make the following extracts.*

"Of the remains of marine vertebrata, it has been pronounced by Professor Agassiz to be the greatest cemetery he every saw. I have myself collected from it many thousand specimens of the teeth of Squalidæ, (sharks,) and am confident thirty thousand of such specimens have been taken from it within the last six years. Prior to the visit of Professor Agassiz a few specimens only of the remains of QUADRUPEDS had been found upon the Ashley. This was owing to the fact that collectors of these fossils were searching in the MARL and not in the overlying beds. These fossils (land quadrupeds) were at first supposed to belong to the Marl, (like the fish teeth,) but subsequent investigations show that they do not, and I will now proceed to point out their true position in the sequence. Between the Post-Pleiocene and the Marl we have two or three strata, containing fossils, which make them exceedingly interesting to the geologist, and which are not found in the Eocene Marl Bed below.

"The first of these is a thin, irregular stratum of loose gravelly sand, which lies immediately upon the

Observations on the Geology of Ashley River, by F. S. Holmes.

Marl, and which seldom exceeds eight inches in thickness.* From the number of fish teeth and bones found in this sand, Professor Tuomey called it the "*Ashley fish-bed.*" Above, and in a manner mixed with it, is another of irregular and partly rolled fragments of what is commonly called *Marl-rock*—the interstices between each being filled with blue mud. These rocks contain the same forms of fossils as are found in the Marl below; but the lime which they must have contained has been extracted, leaving a silicious mass much water-worn and boulder-like in appearance, and emitting a fetid odor when broken. The Marl of the Ashley contains about 70 per cent. of Carbonate of Lime—these only a small quantity, say 2 or 3 per cent.

"That they belong to and were broken off the Marl bed below, there can be no doubt, but at what period they were washed up and deposited where we now find them, is still undetermined. They extend over many miles of the surrounding country; increase in size towards the northwest, and decrease in the opposite course, southwest, where we find them under the City of Charleston.

"For the most part, they are enveloped, as I said, in a matrix of blue mud or clay, though often a peaty substance (marsh roots?) takes the place of the clay, and again the clay and peat are missing, and they are found in the sand.

"Next in the order of super-position are the red

* In boring the Artesian Well in Charleston, this stratum was reached at about sixty feet below the surface, and from it a supply of good water was obtained; the water rises within four feet of the surface.

clay, yellow sands, and alluvium of the country; the Post-Pleiocene, like the Miocene in other parts of the State, is only found in patches; its geological position is under the red clay.

"In the strata of sand, marl-rock, blue mud and peat, just described, we find the following fossils: Bones and teeth of Mastodon, Megatherium, Dinotherium, Elephant, Deer, Horse, Cow, Hog, Muskrat, etc., etc., mixed up with the remains of marine animals; but in the Marl not a single fragment of a Mammalian has yet been discovered, except cetacean. If ever a specimen has been taken from the Marl, it was near its surface—perhaps from some hole or depression so shallow as to escape the notice of the finder, and there can be no doubt that in this manner several naturalists have been deceived in supposing these fossils to have come out of the true Eocene Marl.

"I am convinced they belong to a more recent formation, and we must await further investigation ere we attempt a determination of the ages of these beds."

The Eocene Marl is soft and easily dug; its color is a greenish yellow; and it is composed mainly of microscopic shells and infusorial cases. These shells belong to a group called by naturalists POLYTHALAMIA, which means shells with many chambers or apartments, like the AMMONITE and the NAUTILUS. Comparatively, these shells are of *gigantic* size. The late Professor Bailey, of West Point, in a letter to Professor J. Lawrence Smith, remarks: "You can

inform the good people of Charleston that their *city is built upon a bed of animalcules several hundred feet in thickness*, every cubic inch of which is filled with myriads of perfectly preserved microscopic shells. These shells, however, do not, like those beneath Richmond and Petersburg, etc., belong to the silicious infusoriæ, but are all derived from those minute calcareous shelled creatures called by Professor Ehrenburg Polythalamia. You are aware that Ehrenburg proved *chalk* to be chiefly made up of such shells, and you doubtless will be delighted to learn that the Tertiary beds, beneath your city, are filled with more numerous and more perfect specimens of these beautiful forms, than I have ever seen in chalk or marl from any other locality. These forms are destined to be of great value in geology, and when the precise position of the formation beneath Charleston shall be fixed, *and the forms belonging to each bed determined*, we shall then have so perfect a guide to the geology of a large portion of our Southern country, that by a mere glance through the microscope at portions of strata, scarcely enough to be seen by the naked eye, their characteristic fossils may be seen, and their true position in the series determined. It will be a great labor, however, to give the subject all the development it needs."

There are comparatively few oyster or hard shells, or corals found in the Eocene Marl. The Ashley Bed is about two hundred and sixty feet thick, as ascertained from the Charleston Artesian Well borings, and rests upon the Cooper River Marl Beds, which,

though of the same geological age, (Eocene,) were deposited first, and hence are the oldest and also the firmest of the two, composed as they are of a greater number of hard shelled mollusca, like the clam and oyster; it is also of a lighter color.

These MARLS of the Cooper and Ashley Beds, abound in remains of cartilaginous fish, especially of the shark family, though they also contain numerous bones and teeth of Cetaceans, or whale-like animals, many of which were larger or as large as the whales found in the seas of the present time. From the number of their bones and teeth exhumed or washed out by the waves of the ocean they must have existed in large "shoals," and, together with the enormous sharks of that age, animals rivaling the whale in size, must have constituted a vast marine army of ravenous "flesh eaters" and capacious "scavengers" of the Eocene Ocean. Its geological position is seen in Plate I.

Underlying the Cooper River beds, as seen in the same Plate I, are the Santee-marls; these are also of the Eocene day or period, but unlike the superimposed or later deposits of the Ashley and Cooper, they are composed principally of hard shells and corals or corallines, though the corals are not of the "Reef-building order" of corals. It is very white when dried, and was called by Professor Tuomey the "Coralline Bed of the Charleston Basin." In two or three places are found interstratified with these Santee beds, layers of soft pulverulent Green-sand Marl, containing only about 25 per cent. of Carbonate of

Lime, while the coralline beds have 94 per cent. of this substance. Green-sand Marls are valuable as a mineral fertilizer on account of and in proportion to the amount of Potash they contain.

It is somewhat remarkable that the large deposits of Green-sand Marls in New Jersey are in beds of the Cretaceous age, whereas the Green-sand of South Carolina is obtained from what Mr. Ruffin, Professor Tuomey, and Dr. R. W. Gibbes call the Eocene Beds; and it must be acknowledged that we also have "followed in their footsteps," and have called this Carolina Marl Formation a middle age.

Many years ago we obtained fossils from these beds which could not be distinguished from similar forms collected in the New Jersey sands or Green-sand Marl of the Cretaceous formation; when this discovery was forwarded to our friend and colleague, the answer received was: "Be careful! from your short experience you cannot pronounce positively." Now that twenty-six years have passed by, and with hammer still in hand, we humbly submit to the geologists of America, that as the so-called Eocene of the Charleston Basin does not contain a single species—yet discovered—of recent or living animals, but several known forms of Cretaceous Mollusca, that it should belong to an intermediate period, a Sub-Eocene or Super-Cretaceous. If we mistake not, Sir Charles Lyell called it Cretaceous in 1842.

The Santee Marls are noted also by all writers on these subjects, from the time of Judge Drayton, in 1802, for a remarkable deposit containing *gigantic*

oyster shells, which are of two very well defined and remarkable species: the long and the globular. The long species are sometimes found twenty-three inches in length, only two and a half inches wide, and about three inches thick at the hinge. They resemble in outline the "Raccoon Oyster" of the Southern coast, now living in its bays and harbors. The other species weigh five or six pounds, (each shell.) They are generally "as wide as they are long, and as thick as they are broad." In a word, they are globular and very ponderous.

This remarkable shell bed extends from the Santee to the Savannah Rivers; the strike of the outcrop of the bed is parallel with the coast line.

THE BUHRSTONE OR SILICIFIED-SHELL FORMATION OF THE EOCENE AGE.

Referring again to Plate I, the reader will see in the left-hand corner of the lowest division of the diagram, the name of a formation called "Buhrstone," which is the exposed, upturned, elevated edge or outcrop of the Santee Beds. It is clearly exposed on the farm of Mr. Caraduc, near Aiken. This "Buhrstone" is a "living witness" of the remarkable and diverse changes which the same "rock" undergoes when subjected to the effects of different geological agents, as exhibited in itself and in the Phosphate rocks; both originally of the same geological formation, viz., the Eocene.

The "Buhrstone" takes its name from a similar rock formation, of the same age, extensively quarried in France. It is formed into millstones and then exported to all parts of the world. Most of the stones now used in our Rice mills for grinding rice are French Buhrstones. In the beds exposed at Aiken, alluded to above, we find the same fossil shells and corals as are contained in the Santee Marls exposed in the low country; but what is most remarkable, and almost marvellous to the general reader, the rock is not like the Santee Marl, calcareous; that is to say, a *lime-rock*, but the shells and corals or corallines, have been converted into a flint or silicified mass, each shell, coral or fossil preserving its original shape and size and retaining every wrinkle, indentation or other characteristic of the original. This change caused by a chemical agent, has converted a mass of lime rock, or Calcareous Marl into a *Buhrstone* or silicious indurated Marl rock, and is analogous to the conversion of the rocks of the "Upper" Ashley Marl, of the same age, (Eocene,) formed under the same conditions as were those of the Santee Marls, but subjected ultimately to the effects of two distinct and independent geological agents, thereby producing two distinct kinds of rocks, one a flint-like rock, (*Buhrstone*,) whose silex (or flint) was derived from the surrounding sand hills of that region, (Aiken,) the other (a Phosphate-rock) whose Phosphoric essence was derived from animal matter under the influence of which its chemical character was changed.

MEIOCENE FORMATION.

Next in the order of superposition is the Meiocene or Middle formation of the Tertiary Period. The Marls and rocks of this age have not been found, as yet, in South Carolina. The beds supposed by Mr. Ruffin to belong to this age, proved, upon careful examination by Professor Tuomey, to be Pleiocene, according to Sir Charles Lyell's classification. (See Tuomey and Holmes' Pleiocene Fossils of South Carolina, p. ix.) The Meiocene is found in Virginia and Maryland; but the Carolina Beds are younger and belong to the Pleiocene age.

THE PLEIOCENE FORMATION.

According to Professor Tuomey the beds of this age "are generally made up of loose materials, such as sand, clay, gravel and marl; rarely indurated." * * "Seldom thick or continuous, being for the most part found in detached patches of limited extent."

A beautiful and instructive example of the Pleiocene, with a band of carbonaceous matter of Post-Pleiocene age resting upon it, may be seen at the plantation of the late George Henry Smith, Esq., on Goose Creek, twelve miles from Charleston; and is indeed well worthy of a visit from those interested. It is the only locality where the Eocene or Great Carolinian Marl Bed, the Pleiocene, and the Post-Pleiocene are found in position, regularly superimposed.

The Miocene is represented, in Plate I, as being parallel with the Pleiocene, that is to say of the same age; geographical position may have caused the zoological difference. Formerly these beds were supposed to be Miocene, but Professor Tuomey and the writer carefully studied them, and discovered that they are younger and contain a greater number—forty-two per cent.—of recent or living species than the Miocene of Virginia, which contains only thirteen per cent. (See Tuomey and Holmes' Fossils of South Carolina, p. viii.)

THE AGE OF THE PHOSPHATE-ROCK—
BASINS OF THE ASHLEY AND OF PRE-
HISTORIC MAN.

Next in the geological series, as seen in the diagram, Plate I, are the beds of this exceedingly interesting age; the period in which (as indicated by the fossils collected) man first made his appearance on this Continent. To our mind the Post-Pleiocene is the connecting link between the *Anti-Historic* or *Tertiary*, and the *Historic* or *Recent age*; and may be properly designated the age of PRE-HISTORIC MAN.

Formerly, and before these beds had been carefully studied, they were supposed to belong to the Tertiary, and therefore considered (and in the tables of classification, placed) uppermost in the division according to Lyell's arrangement, being the youngest. But

since the discovery of human bones and works of art in 1844, in beds of this age, in the Ashley Basin; and of similar discoveries (1854) in the lake dwellings of Switzerland, and also in the Somme Valley in France, they must now be referred to a more recent date, the Quaternary period. Its sands, rocks and fossils are replete with interest to the practical man when he sees and comprehends their meaning, and they fascinate beyond description the scientific observer who after long years of study realizes in the rocks and fossils of this period the charming revelations of geology, and at once comprehends their "sweet influences."

Referring again to Plate I, the reader will observe that we have divided these beds into two formations; first, the Post-Pleiocene sands and shells; and second, the Phosphate-rock deposits.

The shells from these beds appear, when taken from the sands, as fresh and perfect as those picked up on the sea beaches of our coast, and nearly all of them are of the same species.

RECENT OR HISTORICAL AGE—PRESENT TIME.

To complete the geological series, as represented in the table, p. 13, and in Plate I, we find that after the Post-Pleiocene beds comes the Recent or Historical period in which were, and are, now being deposited the mould of the forests, and the washing of

the hills, forming the soils of our cultivated fields, the mud banks of our bays and harbors, and periodically spreading over our rice fields its rich and fertilizing sediment, brought down suspended in the waters of the Rivers. It is the HISTORICAL AGE, the age of mind, when man writes in "Time's Record" the passing events of the day. It is, emphatically, the *telegraphic age*, when he writes with a pen dipped in the electric fluid, and transmits his messages by the "sub-marine railway," a simple wire resting on the coral beds of the Ocean. It is, also, the age of PHOSPHATES AND FERTILIZERS, of more value to mankind than the mines of Golconda or the golden sands of California.

Geologically, the rocks of this period are called *Recent*, and are placed in the table under the Quarternary, the fourth and last Division, the top-most layers in the Diagram, Plate I. To it belong the soils we cultivate, the sands and clays of our fields and forests, the garden loam in which do grow flowers, and roses, and fruits, thus causing all animated nature to realize the munificent hand of the Great Creator, Our Father, who liberally dispenses his "good things" to the Butterfly and the worm as freely as to the sons of men, both to the great and the small, for they are all the work of His hands!

This fourth and last formation, is the crowning crust of the earth; in the geological series the "top-most stone;" formed especially for man's immediate use; always receiving the rains and dews of Heaven, the more abundantly to minister to man's wants and

to those of the creatures prepared on the earth and in the seas, and in the air for his support, pleasure and happiness. The Worm, the Bee, Ant, Spider and Butterfly, are all ministering angels!

ORIGIN OF THE PHOSPHATE-ROCKS,
AND FORMATION OF THE
PHOSPHATE-ROCK BASINS.

If the reader has followed us in the attempt to make plain the order of superposition, and the prominent characteristics of the geological formations as described in the foregoing pages, he is now prepared to go with us also into a consideration and examination of the origin of these rocks, and their remarkable position, as seen in the Charleston Basin.

And first, we should always bear in mind this important *fact*: that though these Basins were formed in the Post-Pleiocene age, the *rocks* deposited in them do not actually belong to that age, but in fact, to the Eocene an older formation. It has been ascertained beyond doubt, that frequently, rocks or fragments of rocks of older formations and therefore of greater age are found in newer deposits of a comparatively recent date. Quartz-pebbles, and fragments of water-worn crystalline rocks are often seen imbedded in modern clays and sands. The Phosphate-rocks of these basins, like the Quartz-pebbles, just named,

have been derived from an older formation, viz : the Eocene Marl, or the "Great Carolinian Bed of Marl," which is the foundation of the whole sea-board country of South Carolina, and as represented in Plate I, is composed of the Santee, Cooper and Ashley River Marls, which in the aggregate are seven hundred feet thick, and extend from North Carolina into Georgia. Before the low country of South Carolina was raised above the level of the Ocean, the waves of the Atlantic beat upon the granitic hills of Edgefield, Lexington and Richland.

The shallow water of the coast with its submarine formation of undulating sand-banks was then, as now, resting upon this surface of the great Marl formation, of Eocene age; both were below the level of the Ocean, (see Plate II,) exposed to the degrading influence of its waves, and bored by Mollusca and other marine animals, as represented in the diagram.

Examine this Plate II; it speaks for itself. The Eocene Marl is here represented as we have found it, with its surface washed into deep cavities and holes, bored by the animals just named and honey-combed to the depth of five or six feet. This is its condition off Charleston harbor at the present time; and wherever the surface of the bed inland has been uncovered, it is found irregular and broken, and the Phosphate-rocks show this plainly. From the coarsely honey-combed surface of this mother-bed, fragments were being continually broken off by the waves, rolled over the sand-beds, which wore off their angular edges, and finally deposited them in extensive masses in

FORMATION OF THE PHOSPHATE BASIN
 WITH THE DEPOSIT OF SALT
 THE ROCKS DERIVED FROM THE GREAT CAROLINIAN MARL BED
E O C E N E .

ANCIENT OCEAN LEVEL.



the great hollows or basins below the Ocean-level, as represented in Plate II.

We apprehend it did not require a very long time, nor much friction to reduce these comparatively soft lumps of Marl rock to the rounded or nodular forms they now have. Every gale drove them further and further upon the submarine beach, until at last, they were deposited in the lagoons or basins formed within the sand-reach of the coast as represented in Plate II.

Professor Ansted, describing the Phosphate beds near Cambridge, England, writes—and we quote him in corroboration of our own views on this subject: "Many years ago a discovery of Phosphate of Lime was made in the so-called Crag beds of Suffolk, and afterwards in the Green-sands of many parts of the southeast of England." (This corresponds with the Eocene or Green-sand of South Carolina.) "The former contain beds consisting of nodules of exceedingly hard material, which, when ground, are soluble in sulphuric acid, and then form a most valuable manure. The proportion of Phosphate of Lime in these nodules varies from 50 to 60 per cent." Now observe the analogy between the English and the Carolina Beds as regards origin. Professor Ansted continues: "The Crag nodules are found in the newer TERTIARY GRAVELS, but the nodules themselves are believed to have been washed out of older rocks also of TERTIARY AGE." It was, undoubtedly, so with the South Carolina Phosphate-rocks.

The next great change was the upheaval of the whole seaboard country by some geological agency,

and the elevation of the coast above the level of the Ocean. When the sand hills and the submarine lagoons were raised, the basins contained sea or salt water, and must have been so many small salt lakes along the sea-coast, having their bottoms covered or paved with a thin layer of the nodular fragments of Marl rock. As the evaporation of the salt water progressed, what was left became day after day a stronger brine, until at last a deposit of salt ultimately formed as a crust upon the pavement of Marl rocks. And here we must remind the reader, that these nodular fragments of Eocene rocks are composed (like the mother rock from which they had been broken off) entirely of the dead shells of marine animals, which age after age were deposited at the bottom of the Ocean or Eocene sea, and finally became an immense bed or formation of Marl, enclosing throughout its great depth not only the *Polythalamous* shells, corals and corallines, but the teeth and bones of sharks, and other fish, and of whale-like and alligator-like animals; such alone as live in the sea; but no remains of any land animal *have ever yet been found in it*. We say it without any fear of contradiction, and challenge proof of a single specimen being obtained from, or *imbedded* in the nodules, (Phosphate-rocks,) or from the Marl bed itself *the mother rock*. All the remains of land animals obtained in such vast numbers are *mingled* with, and not *imbedded in*, the nodules found in the Phosphate basins; and this mingling of bones and teeth occurred in the POST-PLIOCENE AGE after the elevation of the basins above the ocean level.

It was in this Post-Pleiocene age, the period when the American Elephant, or Mammoth, the Mastodon, Rhinoceros, Megathereum, Hadrosaurus, and other gigantic quadrupeds roamed the Carolina forests, and repaired periodically to these Salt-lakes or Lagoons, or as they are called in Kentucky, "*Salt-licks*;" and during a series of indefinite ages, engaged as they were first sipping brine, then licking salt, and depositing their fecal remains, and ultimately their bones and teeth, in fact their dead bodies, in these great open "*cravols*" or pens, thus preparing, as ordained beforehand by the Great Master-Builder of our Earth, a storehouse of rich material for Man's use. They converted the rocks, prepared of old at the bottom of the Ocean, into the basis of a most wonderful fertilizing substance, a substance which was to become by the labor and sweat of Man's brow, a renovator of his worn-out soils, causing it to yield in overflowing measures bread and meat, for the use of the sons and daughters of men; and not for their use only, but to give food in great abundance to the animals who are Man's companions in the present age; to the Ant, the Bee, and the Butterfly, animated links in the Chain of Creation, by which the whole fabric itself is sustained. God never intended that it should *be thus used* before the *appointed time*, ordained of old by Him who formed and fashioned these rocks.

HOW THE NODULES WERE CONVERTED
INTO PHOSPHATE-ROCKS.

At this stage of the history of the origin of the Phosphate-rocks, the reader naturally expects, and it seems to us also the proper place to explain the manner in which these masses of Lime Rock or Carbonate of Lime have been changed into Phosphate-rocks, or Phosphate of Lime, and to give all the evidence in support of the hypothesis which science can bring to bear on the subject.

In a former chapter, p. 21, we have endeavored to show that the outcrop or exposed edges of the upturned Santee beds which are seen near Aiken in this State, were originally Marl rocks, rich in Carbonate of Lime, and undoubtedly belonged to those beds, but have lost their Carbonate of Lime, and have been changed into a mass of flint rock or "Buhrstone."

We now propose to explain how this change occurred, and then to point out the analogy existing between the rocks of the lowest bed of the Eocene Marl changing from a lime rock into a flint rock, having no lime; and the rocks of the youngest beds of the same Eocene age changing into a Phosphate-rock, and retaining but a small portion of Carbonate of Lime. How, in fact, a Marl or Lime rock may be converted into flint, under certain chemical influences, and into Phosphate-rock under other influences of a very different nature.

The Santee Marl, where it outcrops near Aiken and along the strike of the bed in Orangeburg and

Lexington, is only exposed when the overlying or superimposed sands are removed by the winds, rains, or other denuding geological agents; and whenever thus exposed they are found to be "BUHRSTONE" or "MILLSTONE-ROCK," or beds of "SILICIOUS SHELLS." The Marl beds are sometimes interstratified with clay, and then the *shells only* are *silicified*, and the clay retains all its normal characteristics.

When the shells are imbedded in a mass of shelly matter, like that of the Santee Marls, and have been covered by beds of sand, and been subjected to the chemical influence of these sands, the whole mass is converted into a "Buhrstone," having not a particle of its original lime remaining. But the reader will ask, How is this accomplished; give us the process in detail? Well, we will try and explain it.

The silica is obtained from the sand beds above. "Hot water will dissolve silica largely, with the help of an alkali," (remarks Professor Tuomey,) "and as these beds overlap the igneous rocks, it is not a wild supposition that the waters of the Tertiary sea may have been at one time heated, and thus facilitated the solution of the silica."

Besides, it cannot be denied, that before the upheaval of the coast beds, the waters of the Atlantic, (the warm waters of the Gulf Stream,) passed over the Eocene beds. Thus we see how the silica was furnished from the sand hills. "But the removal of the lime, of which the shells are mainly composed, must first take place before the silica could be substituted, and this also is easily understood. Nothing

more is necessary, indeed, than the percolation of water holding in solution carbonic acid."

"Water thus charged would leave only such portions as were insoluble, namely, the silicious matter and alumina, precisely what is left in the beds just mentioned."

"But it is rather more difficult to account for the complete replacement of substances by other matter. When wood is enclosed in beds of clay it is generally converted into lignite, but when found imbedded in sand, the wood is replaced by silica and assumes the form and character of silicified wood." In like manner shells associated with sands or sandy strata in Tertiary ages invariably become silicified.

"To those who have not examined the matter closely," continues Professor Tuomey, (see Geol. of S. C., p. 148,) "it may appear that the lime of the shells was, first, *dissolved out*, and their hollow moulds filled by infiltration of silica held in solution. A little reflection, however, would satisfy any one that this is not the process; for it would be obviously impossible in loose sand for any such perfect moulds to exist, for the moment the lime was removed, the sand would pour into the hollows left. Besides, the internal cast of the shell would fall down, there being nothing to support it, and the mould be spoiled. We are then obliged to suppose that the process went on slowly, and that the lime was replaced by silica, *particle by particle*; that is, that when an atom of lime was removed, one of silica took its place, and this was continued until all the lime was removed and its place

taken by the silica; for in no other way can we account for the preservation of the most minute striæ on the shells together with every spine, process or other characteristic mark."

In confirmation of the above, Professor Tuomey found in Orangeburg District a fossil containing *fluid silica*. He says: "At first it resembled thin transparent jelly, but on exposure to the air it changed color, becoming milky, and, finally, became hard, and presented the appearance of Pearl-stone." Thus we can readily understand how a shell composed mostly of lime, will, under certain conditions, become flint, retaining its form and prominent characteristics.

WHAT ARE FOSSILS AND PETRIFACTIONS.

[From the Boston Journal of Chemistry.]

"Every one who has read even an elementary manual of geology knows that the remains of plants and animals are found in the crust of the earth more or less petrified, or converted into stony matter. They are commonly known as *fossils*, a term which etymologically means nothing more than *dug up*. To the men of old time and even to the earlier geologists, their occurrence was a riddle and few considered them as other than mere accidents or *lusus naturæ*; but to the geologist of our day they are pictures in the great stone-book of the earth's history, illustrating the life that peopled the lands and waters in pre-

Adamite epochs, and indirectly the geographical conditions under which they flourished and became extinct.

“A distinction is sometimes made between *fossils* and *sub-fossils*, as they are called. The latter are usually of more recent origin, and are only partially altered in texture; the former as a rule, date back to earlier epochs and the conversion into stone is complete. In the one case, the more volatile substances have been driven off from the plant, and the softer and more perishable tissues have disappeared from the animal, while mineral ingredients have been absorbed, to a greater or less extent in place of the organic matter lost. In the other case the vegetable, if not converted into coal, has been thoroughly changed by a slow process into stone, merely retaining its original organic form; and animal remains have undergone a similar metamorphosis, and are recognizable only through their forms and textures, which are unaltered.

“What is the nature of this marvellous transformation from the organic to the inorganic state? It is not the result of a *combination*, or *chemical union* of earthy matter with organic matter, but rather a gradual *replacement* of the latter by the former. Particle by particle the organic matter disappears, and particle by particle the mineral matter takes its place; and so delicately is the substitution effected that scarcely a cell or a fibre is ever broken or displaced! The nature of the petrification will depend, not so much upon the composition of the plant or animal,

(though this will have its bearing on the result,) as upon that of the mineral solutions which percolate the earth, the fossils being calcareous, silicious, ferruginous, and the like, according as the water contains lime, flint, or iron, etc. In all cases, the process seems to be essentially the same; a gradual decay and dissipation of the organic atoms, and a gradual substitution, through permeation, of the mineral or inorganic.

"In many cases the fossil itself is petrified anew, so to speak; that is, the mineral matter which was at first deposited, is gradually dissolved out, and a new substance takes its place; or no new matter may be substituted, and merely the hollow mould be left to prove that the organism was once there. Thus a shell or a coral which consist of organized carbonate of lime may be converted into the sparry mineral carbonate; and this may be dissolved and washed away, leaving a hollow mould marked with every ridge and line of the vanished organism; or this mould may be filled up again with silicious matter, so that the shell or coral seems to have been transmuted into flint, without losing the most delicate line traced on its original surface. The perfection with which the finest lineaments are thus preserved, after every particle of matter in the fossil has been twice changed, is almost incredible.

"Of course all plants and animals are not preserved alike, nor are the same organisms always found in the same state of preservation. Those that have partially decayed in the air before being imbedded in the earth

will be less perfect than those that were buried by some sudden convulsion before decay begun. The harder parts of plants, as roots, stems, and nuts, are more likely to be preserved than the soft and succulent portions.

“The shells, bones, teeth and scales of animals will be found when all the fleshy parts have perished; and the larger and harder bones of a skeleton may be the only ones that escape destruction.”

Something quite analogous to the change of the outcrop of the Santee Beds has taken place with the exposed portions of the Ashley Marls, which have been torn from their mother-bed, and redeposited as explained, page 27, and exemplified in Plate II.

The important agents in the latter case being not only water-holding Carbonic Acid in solution, whereby the lime was dissolved *particle by particle*, but the fecal matter from the animals named, would furnish the Phosphoric Acid to supply that portion of the lime dissolved out of the mass, and thus convert these nodules into a Phosphate-rock.

Additional evidence may be afforded by the fact, that the bones of land animals, as found intermingled with the nodules or Phosphate-rocks, when recently taken from the living animal, contain about 51 or 52 per cent. of Phosphate of Lime, but when associated as they must have been for centuries with the materials of the Phosphate-rock Basins, they necessarily *imbibed* an additional amount of this essence, and now yield upon analysis *ninety-two per cent.* of Phosphate of Lime! And where did this additional amount of

Phosphate of Lime come from? It follows, therefore, that if these *bones* had contributed to furnish the Phosphoric Acid to the rocks, (as some suppose,) they would have been deprived of all they possessed; and, therefore, it seems very plain, that from the fecal matter (dung and urine) deposited by *land quadrupeds* during a series of ages, dissolved by rain, and its juices carried down to be imbibed by the Marl nodules, atom after atom as the Carbonate of Lime was dissolved out of the rock, has been derived the chemical agent which converted the Eocene Marl nodules into Phosphate-rocks. To the bones which are buried with them was imparted also the additional amount of Phosphoric Acid they are now found to contain, in excess of that they possessed when in a recent or living state, and not as has been suggested, *from the excrement of birds*.

This theory regarding the conversion of the Carbonate of Lime rocks into Phosphate of Lime, was submitted by us in October, 1867, (just after reading Ansted's Lectures on Practical Geology, alluded to in this work as having been received from England the day of the discovery of the great value of the Phosphate-rocks,) to Professor Joseph Leidy, Professor Samuel H. Dickson, and several other scientific gentlemen of Philadelphia, and obtained their ready concurrence.* Sometime in the beginning of 1869, or late in 1868, Dr. F. Peyre Porcher, of Charleston, the distinguished author of "Resources of our Fields and

* George T. Lewis, Esq., Frederick Klett, Esq., and Mr. Williams, Chemist.

Forests," suggested to us *the same thing*, viz: the imbibition of the juices from fecal matter, deposited by land quadrupeds, above the nodular rocks.

Bird guanos invariably contain bird-bones and small fish-bones; and frequently entire skeletons of birds partly fossilized, are found in Peruvian Guanos. The Sombrero, and other West Indian and Caribbean varieties, are undoubtedly accumulations of the excrement of birds.

No bones of birds have been discovered in the Phosphate-rock Basins, and but two or three uncharacteristic fragments, *supposed* to belong to birds, have been found in the clay beds of this age; we feel warranted therefore in asserting that this is not the result of bird excrements.

The English beds of Phosphate-rocks, lately discovered, resembled in almost every particular those of the Ashley Basin.

Professor Ansted describes them as "containing numerous fossil remains of animals," and they correspond in a remarkable degree in geological position, being "*all along the outcrop* of the Green-sand beds on the south coast of England," the Carolina Phosphate-rocks, are also "*all along*" the outcrop of the Eocene Marl, the Green-sand bearing bed of South Carolina.

The amount of Phosphate of Lime and Carbonate of Lime is much the same in both, that is from 55 to 60 per cent. of the former, and 5 to 10 per cent. of the latter. The nodules are about the same size and form, both in the English and American beds; both are deposited in basins and the strata are not continuous.

THE FISH-BED OF THE ASHLEY.

The idea prevails that the "Fish-bed" of the Ashley Basin alluded to in Professor Tuomey's Geological Report, is the Phosphate-rock stratum with its associated teeth and bones. This is an error into which many have been led. In Professor Tuomey's Report, p. 165, he writes: "The most remarkable feature in the Fauna of the period of the deposition of these beds was the vast number of cartilaginous fishes. It would seem as if about the *close of the Eocene period* these voracious monsters, conscious of their approaching end, had congregated here to die, and it is no exaggeration to say that more than a bushel of fishes' teeth have been collected at Ashley Ferry within the last few years. I have visited the locality several times and never without finding a large number of specimens. As the *Marl* is washed away by the river and tides, the fossils are left exposed at low water, and in this way the locality appears almost inexhaustible and well deserves the name of the "Fish-bed of the Charleston Basin."

The surface or upper Marl beds are here alluded to, that is to say the *Ashley-Marl and Sands*, and not the overlying Phosphate-rock bed.

The "Fish-bed" of the Ashley had been thus named by us before Mr. Tuomey had visited South Carolina. In the above he only expresses his approval of the name given it.

At that time Professor Agassiz had not been on the Ashley.

A CHAPTER ON THE ASHLEY MARLS.

We have said that the Ashley Marl and Sands compose the Fish-bed of the Charleston Basin, because from them the varieties of Sharks' teeth were obtained, that are now taken from the Phosphate Beds. The Marl proper, contains but a small percentage of Phosphate of Lime, it is larger near the surface than at greater depths, and it is reasonable therefore, to infer, that the juices from the upper beds of Phosphate-rocks, being in excess, passed through the intervening sand and clays, percolated the soft Marl below, and was absorbed by its upper layers; hence we find such Marls as are or have been covered by Phosphate-rocks, *phosphatic* for a few feet below the surface, whilst others not thus covered contain only a small amount of this substance, and which was derived from marine animals imbedded in this great Eocene formation, deposited at the bottom of the Ocean.

COMPARISON OF MARLS, HAVING PHOSPHATE-ROCKS OVERLYING THEM AND MARLS THAT ARE WITHOUT SUCH COVERING.

These analyses are by Professor Shepard, Senr.
 Nos. 1 and 2 are overlaid by Phosphate-rock.
 Nos. 3 and 4 are not so overlaid.

	CARBONATE OF LIME.	PHOSPHATE OF LIME.	CARBONATE OF MAGNESIA.
1 Ashley Marl, (Clement's).....	Per cent. 58.00	Per cent. 8.80	Per cent. trace.
2 " " (Hanckel's).....	44.40	7.00	9.58
Total.....	92.40	15.80	9.58
3 Pon Pon Marl.....	58.56	2.47	2.12
4 Dixon's Marl.....	63.50	2.00	7.00
	112.06	4.47	9.12
Marls Nos. 1 and 2 (covered) average	46.20	7.90	4.79
" Nos. 3 and 4 (uncovered) "	56.03	2.23	4.56

It follows therefore, as indicated by the above table, that Marls *associated* or *covered* by *Phosphate-rocks* as Nos. 1 and 2, are comparatively rich in Phosphate of Lime, (say 7.90 per cent.) but poor in carbonate of Lime, (46.20.) Whereas those not so associated or covered, as Nos. 3 and 4, are poor in Phosphate of Lime (2.23,) but rich in Carbonate of Lime (56.03.) The Carbonate of Magnesia being nearly the same in both.

COMPARISON OF THE MARLS OF THE SANTEE, COOPER, AND ASHLEY RIVERS, AND OF THE SANTEE GREEN-SAND MARL.

As is seen by the following table, the Santee and Cooper Marls contain a larger percentage of Carbonate of Lime, (except when containing Green-sand,) than the phosphatic Marls of the Ashley Beds, they are therefore much better for lime burning than the latter. These analyses are taken from Ruffin's Report:

	Per cent		Per cent
Santee Marl, H. W. Ravenel,	95	Ashley Marl, Brisbane,	64
“ P. Porter,	86	“ O’Neale’s,	76
“ Fred’k Porcher,	92	“ Drayton Hall,	63
“ Wm. Cain,	87	“ Ashley Ferry,	50
“ Lenud’s Ferry,	93	“ Magnolia,	75
“ Eutaw,	94	“ Greer’s,	52
“ Vance’s Ferry,	86	“ Pringle’s,	75
“ Felder’s,	94	“ Clement’s,	52
Cooper River, Steep Bluff,	80	“ Marysville,	62
“ Point Comfort,	79	“ Ramsay,	67
“ Dr. Huger’s,	95	“ Oak Forest,	36
“ Moss Grove,	80	“ Indian Fields,	50
Average,	88.5-12	Average,	60.2-12

The GREEN-SAND MARLS average 30 per cent. of Carbonate of Lime, and 22 per cent. Green-sand.

Marl from Charleston Harbor, near Fort Sumter, taken forty-five feet below the surface of the water, after removing all the barnacles and recent shells adhering, contained 81½ per cent. of Carbonate of Lime. Under the City of Charleston, at the depth of 274 feet it was 79 per cent.

The time is not far distant when the Ashley Marl will be extensively quarried, and as much sought after by the planter and farmer as the Phosphates are at the present day. It will be used preparatory to a top dressing of Superphosphates.

ON THE USE OF RAW OR GROUND PHOSPHATE-ROCK AS A FERTILIZER.

Since the discovery of the Phosphate-rock Basins, a number of companies have been organized for Mining, Grinding, and Manufacturing the raw material into Fertilizers or Superphosphates, by subjecting the finely pulverized rock to the action of Sulphuric Acid, thereby rendering it more soluble in water and more easily assimilated by the plant; the raw material being held by chemists as *insoluble* in its original or present state. The Superphosphates, or prepared rocks, are costly, they require a large outlay of capital in machinery and buildings for their manipulation, and hence other companies have been formed with the design of simply grinding the rock into a fine powder and placing it upon the market in that condition; leaving it to the agriculturist to select as he pleases the *raw* or the *cooked* (super) *Phosphates*, knowing that the raw material though greatly cheaper (?) is slow in its effects, but will gradually afford a supply of food to the crops, its fertilizing prop-

erties extending through several years. Whereas the cooked or manipulated rock, (the Superphosphate, fertilizer,) is nearly exhausted the first crop, its action is immediate.

There is little doubt that an application of the raw-ground-phosphate, to the poor and almost worn out lands everywhere to be met with, still under cultivation, will be to a great extent beneficial, as none of these lands contain a particle of lime in any form, and possibly the native acid in the soil will gradually *cook* a sufficient quantity annually to aid and support the crop; or, in other words, gradually convert, in Nature's laboratory, the *raw* Phosphate into the *Super*-phosphate of commerce.

And of this, our Marl experiments in 1844 prove in a measure the reasonableness of the inference. The upper layers of the Marl of the Ashley, applied to cotton and corn, produced greater effects than Marl obtained from the depth of ten or twelve feet below; and we can only account for this difference from the fact afterwards ascertained, (but not at the time even suspected,) that the upper layers contained more Phosphate of Lime than the lower, the "drippings" of the Phosphate Basins above having been *imbibed* by the top layers of Marl underlying them. Hence as it was a *raw, uncooked* Phosphate of Lime, similar (and, as we confidently believe, even greater,) results must attend the application of the ground Phosphates, which contain from fifty to sixty per cent. of Phosphate of Lime.

MINERAL MANURES.

"There is one department," remarks Professor Tuomey, "in which chemistry has fully redeemed its pledge to agriculture—the analysis of the products of the soil and manures. Plants analyze soils most accurately, and whatever of organic matters they contain must be found in the soil. And if we continue to abstract these matters, by repeated cropping, and without making any return, sterility must be the result.

"Knowing, then, the composition of each crop, we know what is removed from the soil; and knowing also the composition of the manures within reach, we know what to apply. This is absolute knowledge, and must constitute the basis of every enlightened system of agriculture.

"When after a succession of crops, and consequent abstraction of a large amount of its salts, the soil begins to exhibit signs of exhaustion, application is made to the chemist to determine what is the matter, or to find out if some little ingredient is not wanting that may be supplied without any trouble or expense. Supposing that this wanting ingredient be discovered, how is it to be procured? Lime is almost the only substance that we, in this country, can afford to apply in an isolated state. The course to be pursued is obvious: We must study the composition of the failing crop, and add such manures as we know, by their composition, to contain the greatest number or quantity of the elements of the crop, trusting that

although not absolutely wanting, the others will not be lost. This, and the development, by proper means, of such substances as may already exist in the soil, are the only rational remedies."

We are, fortunately, in possession of a vast amount of information relating to the chemical composition of cultivated plants, and it will be interesting to present here the analyses of some of those that constitute our principal crops.

Analyses of the various Guanos, Fertilizers, Marls, Limes, etc., etc., are also here introduced for the benefit of the agriculturist.

Analysis of Santee Cotton Wool, by Prof. Shepard, under the direction of the Black Oak Agricultural Society:

Carbonate of Potassa, (with possible traces of Soda,)	44.19
Phosphate of Lime, (with traces of Magnesia,)	25.44
Carbonate of Lime,	8.87
Carbonate of Magnesia,	6.85
Silica,	4.12
Alumina, (probably accidental,)	1.40
Sulphate of Potassa,	2.70
Chloride of Potassium,	} and loss, 6.43
Chloride of Magnesium,	
Sulphate of Lime,	
Phosphate of Potassa,	
Oxide of Lime, (in minute traces,)	
	100.00

And the "Great Carolina Marl Bed." 49

Cotton Seed, by Professor Shepard.

Phosphate of Lime, with traces of Magnesia,	61.64
Phosphate of Potassa, with traces of Soda,	31.51
Sulphate of Potassa,	2.55
Silica,	1.74
Carbonate of Lime,	.41
Carbonate of Magnesia,	.26
Chloride of Potassium,	.25
Carbonate of Potassa,	} and loss, . 1.64
Sulphate of Lime,	
Sulphate of Magnesia,	
Alumina and Oxides of Iron and	
Manganese, in traces,	
	100.00

Cotton Stalk, by Professor J. Lawrence Smith, in 1,000 parts, (leaves, empty pods and stalk.)

Lime,	303.
Potash,	243.
Phosphoric Acid,	91.
Magnesia,	58.
Oxide of Iron,	4.
Sulphuric Acid,	13.
Chlorine,	8.
Carbonic Acid,	270.
Sand,	5.

Sea Island Cotton, by Dr. Ure.

Carbonate of Potash,	44.8
Muriate of Potash,	9.9
Sulphate of Potash,	9.3
Phosphate of Lime,	9.0
Carbonate of Lime,	10.6
Phosphate of Magnesia,	8.4
Peroxide of Iron,	3.0
Alumina, a trace, and loss,	5.0
	100.0

“Although there is a considerable difference in the proportions of the ingredients present in the two varieties of cotton, as exhibited by these analyses, they both show the presence of all the leading and important salts.” (Tuomey.)

—

Indian Corn, by Prof. Shepard. 100 parts of the grain left nearly 1 per cent of ash, composed of—

Silica,	38.45
Potassa, (with traces of Soda,)	19.51
Phosphate of Lime,	17.17
Phosphate of Magnesia,	13.83
Phosphate of Potassa,	2.24
Carbonate of Lime,	2.50
Carbonate of Magnesia,	2.16
Sulphate of Lime, . . . . .	.79
Silica mechanically present,	1.70
Alumina,	traces
Loss,	1.65
	100.00

ANALYSIS OF PHOSPHATE-ROCKS.

From Marysville Works, Ashley River, Charleston Mining and Manufacturing Companies Mines, cargo ex "Bailey, by G. A. Liebig."

BALTIMORE, September 24th, 1870.

Moisture determined at 100° C.,	. . . . .	6.225
Phosphoric Acid,	. . . . .	28.874

Which is equal to 63.034 Bone Phosphate of Lime.
 Rendered perfectly kiln dry, it will contain of Calc.
 Bone Phosphate of Lime 67.219.

From Sardy's Mines, Fraser's Plantation Ashepoo; by Professor Shepard, Jr. Analysis No. 6 combining the Acids with Lime—

Bone Phosphate of Lime,	. . . . .	65.14
Carbonate of Lime.	. . . . .	12.50
Sulphate of Lime,	. . . . .	5.59

Rocks from the Oak Point Mines, analyzed by Professor Shepard, yielded—

Bone Phosphate of Lime,	. . . . .	58.66
Carbonate of Lime,	. . . . .	6.90

Analyses of GUANOS, Pacific and Peruvian.

NOTE.—These analyses show that the Peruvian Guano contains 23.48-100 per cent. and the Pacific contains 83 per cent. of Phosphate of Lime.

*Analysis of Peruvian Guano, by Dr. Thos. Anderson,
Chemist to the Highland Agricultural Society of Scot-
land.*

Water,	13.73
Organic Matter and Ammoniacal Salts,	53.16
Phosphates,	23.48
Lime,	—
Sulphuric Acid,	—
Alkaline Salts,	7.97
Sand,	1.66
	<hr/>
	100.00

*Analysis of Baker's Island (Pacific) Guano, by L. D.
Gale, M. D., Chemical Examiner of Patents in the
United States Patent Office, Washington, D. C.*

Organic Compounds, yielding Ammonia, &c.,	9.940
Combined Water,	2.500
Carbonic Acid from Organic Compounds of Lime,	600
Bone Phosphate of Lime, and Bone Phos- phate of Magnesia, containing Phosphoric Acid 38.67,	83.266
Sulphate of Soda,	1.263
Common Salt,	1,615
Loss,	816
	<hr/>
	100.000

NAVASSA GUANO.

Contains about 49 per cent. Phosphate of Lime, and 12 per cent. Phosphate of Alumina and Iron.

Analysis of Swan's Island Guano—Cargo of "G. T. Ward:"

BALTIMORE, June 11, 1866.

Water and Organic Matter,	20.81
Phosphoric Acid,	28.34
Lime,	23.88
Sand and Insoluble Matter,	15.00
Indifferent Matter,	11.97

The Phosphoric Acid present is equal to 61.87 of bone Phosphate of Lime.

(Signed) G. A. LIEBIG.

Composition of Recent Oyster Shells, (Kane.)

Animal Membrane,	0.5
Carbonate of Lime,	98.5
Phosphate of Lime,	1.0
	<hr/>
	100.00

Ashley Marls, (Clement's,) Professor Shepard.

Silica,	28.00
Carbonate of Lime, (with traces of Magnesia,)	58.00
Phosphate of Lime (with traces of per oxide of iron,)	8.80
Alumina,	0.80
Water,	4.00
Loss, . . . . .	.40
	<hr/>
	100.00

Ashepoo Marl—Professor Shepard.

Silica,	34.41
Carbonate of Lime,	58.56
Carbonate of Magnesia,	2.12
Phosphate of Magnesia, (with traces of per oxide of iron,)	2.47
Alumina,	0.40
Water,	4.00
	<hr/>
	101.96

Analysis of Clean Crushed Bone.

Water,	10.40
Nitrogenized Organic Matter,	30.98
Alkaline Salts,	1.10
Phosphates,	49.32
Carbonate of Lime,	6.52
Silica,	1.68
	<hr/>
	100.00

Analysis of ordinary bones, with such admixture of dirt as will frequently be found where they have been gathered in small lots after being exposed to contact with the ground—a fair average after grinding :

Moisture,	10.50
Organic Matter Nitrogenized,	30.14
Alkaline Salts,	1.96
Phosphates,	40.28
Carbonate of Lime,	5.32
Sand,	11.80
	<hr/>
	100.00

Quantities of the Several Fertilizers to be Applied per Acre.

About three hundred pounds of Peruvian Guano per acre is the average used for market gardening, and general crops.

Of Peruvian Guano, and the best manufactured Superphosphates, the average application, when no other manure is used, is about four hundred pounds—varying with the crop and character of the soil which is to receive it. We give here the directions for applying Concentrated Fertilizers, which will serve as a general guide for the others :

For wheat or rye in drills, 300 pounds per acre ; broadcast, 400 to 450 pounds.

For cotton, in drills, 300 pounds ; broadcast, 400.

For oats, broadcast, 350 pounds ; drills, 250.

For corn, 400 pounds.

For tobacco, 350 to 400 pounds.

For potatoes, 400 to 450 pounds.

WHEN AND HOW THE ROCK WAS FIRST
FOUND.

Sometime in November, 1837, in an old rice field about a mile from the west bank of the Ashley in St. Andrew's Parish, we found a number of rolled or water-worn nodules, of a rocky material filled with the impressions or casts of marine shells. These nodules or "rocks" were scattered over the surface of the land, and in some places had been gathered into heaps, so that they could not materially interfere with the cultivation of the field.

At that time we were students of Geology and Palæontology, and the interesting and beautifully preserved forms of shells, teeth and bones mingled with the rocks filled with the casts of shells, corals and corallines, attracted our attention, and in a very short time enriched our cabinet with thousands of remarkable specimens. These, during a term of six years, we studied carefully and labelled as best we could. The appointment of Mr. Ruffin, in 1842, to make a survey (geological and agricultural) of the State, as ordered by the Legislature was generally understood to be mainly for the purpose of introducing the use of Marl and Lime as fertilizers; Marl having been successfully and extensively used by the farmers of Virginia, and the results obtained having been found to surpass their most favorable anticipations.

Mr. Ruffin immediately called the attention of the planters to the importance of searching diligently everywhere for Marl-beds and other sources from whence calcareous earths or lime could be obtained.

Shortly after his arrival among us, we had the satisfaction of pointing out the exposures of Marl on the Ashley, and of submitting for his examination specimens of the nodular rocks scattered over the fields just alluded to. As these rocks contained little Carbonate of Lime, (the material, of all others, then most eagerly sought after,) the nodules were thrown aside and considered useless as a fertilizing substance.

Mr. Ruffin also intimated, that as the "GREAT CAROLINIAN MARL BED" was extensively exposed on the river banks near by, was easy of access and readily dug with ordinary implements, he thought it well worth transporting in carts and wagons, four or five miles; especially as it was so much richer in Carbonate of Lime than the Marls of Virginia, which were often carted to a greater distance; the former having from 50 to 80 per cent., the latter only averaging about 40 per cent.

At that time, Marl and everything resembling Marl, was carefully scrutinized and analyzed by Professors Shepard, J. Lawrence Smith and Wm. Hume, and some of the results published.

DISCOVERY OF THE ROCKS IN SITU, AND
OF THE MARL BENEATH IT.

From a prize report, made to the State Agricultural Society of South Carolina, November, 1844, of successful experiments in Marling cotton and corn lands, and for which their premium was awarded, we extract the following, which forms a part of the history of Phosphate-rocks:

“In a low part of an old field, (December 9th, 1843,) we attempted to bore with an auger below the surface to ascertain the nature of the earth beneath, and with the hope of finding Marl. We did not penetrate two feet before the auger was thrown aside and the spade and pick resorted to. On removing the soil above the rocks, they were seen in a regular stratum about one foot thick imbedded in clay, and seemed to be identically the same as those found scattered on the surface of an adjoining field; all of them bearing the impressions of shells, and having similar cavities and holes filled with clay. Continuing our excavation, the yellow Marl was reached at about five feet from the surface. As the water sprung rapidly we had to abandon the work, but with the satisfaction of knowing that the Marl underlaid the stratum of rock and was to be had on our own farm, and in the midst of our cultivated fields, thereby enabling us to save carting one mile from the river bank.

“On the 22d of February following, (1844,) another attempt was made to find the Marl, and it was dis-

covered near an old causeway on the edge of the high land under the marsh. The following is a tabular arrangement of the strata taken from above the Marl which lies four feet six inches below the surface of the marsh mud:

	FEET.	INCHES.
1st. Marsh Mud, filled with roots,	1	0
2d. White Sand and a few pebbles,	0	3
3d. Marl Rocks, (Phosphate-rocks,)	1	3
4th. Dark sand, lumps of blue clay and pebbles,	1	0
5th. Blue and Gray Sand, with a quantity of finely divided shelly matter, (Post-Pleiocene shells,) with casts in soft Marl and fish bones and teeth,	1	0
Total,	4	6
6th. Yellowish Marl containing 61 per cent. of Carbonate of Lime,	2	0

“ At this depth the color changes with a green tint, and the Marl increases in strength to 71 per cent. of Carbonate of Lime, and continues thus seven feet deeper. The surface of the Marl Bed was found to be very much broken and irregular, having deep holes in it filled with blue mud and sand. Arrangements were immediately made to dig and marl lands extensively for the next crop, and a pit opened twenty feet wide and forty feet long.”

DISCOVERY OF STONE ARROW HEADS
AND A STONE HATCHET IN BEDS OF
POST-PLEIOCENE AGE.

It was on the 23d or 24th day of February, 1844, whilst engaged in the removal of the upper beds covering the Marl, and preparing for opening the large pit just alluded to, the laborers discovered among the rocks several stone arrow heads and one stone hatchet;* they were found directly under the roots of a large oak, which was cut down and its roots removed to make way for our marling operations. The tree stood just within the margin of the high land skirting the marsh; the pit as laid out, encroached upon the high land side about ten feet, and the depth of soil was about three feet above the rocky stratum.

The late Dr. Thomas L. Burden, an accomplished gentleman and scholar, and a true lover of nature, more especially of the departments of Botany and Palæontology, accompanied us almost daily collecting fossils in the neighborhood. We had during our explorations discovered upon one or two occasions a few arrow heads and spear heads, (for such we took them to be,) in "out of the way" places, and differing so greatly in their general characteristics from those found commonly scattered all over this Continent, that we examined and studied them again and again with deep interest, and were continually comparing them

* These Specimens are still in our Cabinet.

with the well known similar forms obtained from the Indian mounds of America, and attributed to the handiwork of its aborigines. But when found *under the oak* at the Marl pit, *among the "Marl rocks,"* as they were then termed, (and very properly too, for they are indeed Marl rocks derived from the mother-bed of Eocene Marl,) every precaution was immediately taken to satisfy ourselves fully as to the possibility of their being of the same age as the "mound," arrow heads and hatchets, but washed into a "gully" in after ages, and now found mixed with the Marl rocks; (Phosphate-rocks,) and therefore accidental occupants of the place.

After a careful study of everything connected with their discovery, the place and stratum in which they were found, and their remarkable forms, we were satisfied that they belonged to and were deposited in the same geological age to which the bones and teeth of the Mastodon, Elephant, Rhinoceros, Horse, and other land animals belong, and which are found associated with them in the same matrix or mother-bed of clay, which is of the Post-Pleiocene period, and which we have since designated as the PRE-HISTORIC AGE OF MAN.

Alas, for young students and their beautiful theories! Professor Tuomey, about this time, visited the locality, examined the specimens and everything connected with their discovery and exhumation, together with all the surrounding strata, and advised against their publication, as it was *possible* for them to have fallen into a hole at the foot of the tree, or the bur-

rows of some animal; and, should no more of such relics hereafter be found, our reputation as observers in the geological field would be affected. It was good advice and we took it. Though we certainly "were convinced against our will."

Night after night we studied and talked over these arrow heads and this stone hatchet.

HUMAN BONES DISCOVERED.

Not very long after finding the above named relics of human workmanship, and while engaged in our usual visits to the Ashley Bed, a bone was found projecting from the bluff, immediately in contact with the surface of the stony stratum (the Phosphate-rocks); we pulled it out, and behold a human bone! Without hesitation it was condemned as an "*accidental occupant*" of quarters to which it had no right—geologically—and so we threw it into the river. Alas! we have lived to regret our temerity and rashness. A year after, a lower jaw bone with teeth was taken from the same bed, and we now have it in the Cabinet.* Subsequent events and discoveries show, conclusively, that the first discovered human bone was "in place," and that the beds of the Post-Pleiocene, not only on the Ashley, but in France

* Professor Kerr and Dr. Pratt, in 1867, discovered other human bones, (parts of a femur and tibia,) in the same bed, and from the same locality. These are also in our Cabinet in Charleston.

Switzerland, and other European countries, contain human bones associated with the remains of extinct animals and relics of human workmanship, proving most conclusively that the Carolina specimens were found "in place," and as the European discoveries were made in 1854 and ours in 1844, to South Carolina should be awarded the honor of the first discovery, and the determination of the Palæontological age of the Post-Pleiocene Beds. It "stamps" it, as the PRE-HISTORIC AGE OF MAN, the connecting link between the Tertiary and the Recent age, the true Quarternary period in its geological history.

COPROLITES (?) IN A POCKET.

Whilst engaged manufacturing Saltpetre at Ashley Ferry, on the west bank of the River, during the late Confederate War, the lime or calcareous earth necessary in such operations, was obtained by sinking pits into the Eocene Marl-bed.

Upon the removal of four or five feet of the upper layers, the workmen discovered in one part of a pit a number of oddly shaped nodules, resembling somewhat the Marl stones (Phosphate-rocks) found in the stratum above the Marl, but more cylindrical in form and *not perforated*, and having their exterior polished as though each individual specimen had received a coat of varnish; they appeared to have been deposited in a large cavern or "pocket" in the Marl bed.

The quantity taken from this pocket was estimated at several wagon loads.

We supposed them to be Coprolites, or the fossilized excrements of some of those large Aquatic Mammalia of that age, whose bones are found in great numbers in the Marl, and also mixed with the Phosphate-rocks in the basins. The Zeuglodons, Squalodons and Phocodons, swarmed in the waters of that period, and they had as associates huge Crocodiles or Alligator-like creatures, which roamed the submarine forests like an army of Locusts seeking their prey.

The amount of Phosphate of Lime found by Dr. Pratt, in his analysis of these supposed Coprolites, is small compared with that of the Phosphate-rocks, being only 15 per cent. But it is not surprising, as the Marl must have extracted a large portion of their phosphoric essence.

This completes the history of the Marls and the Phosphate-rocks up to the close of the Confederate War in 1865, and which for four years excluded all Europe, their doings and their publications, from Confederate eyes; and it was not until 1867, when we had recovered sufficiently from the effects of the war to import a few books from England, was ascertained what had been done during the interval by scientific men in that country.

Early in the month of August, 1867, the 9th or 10th day, our friend Dr. N. A. Pratt, with whom we had been intimately associated during the war, brought us a small fragment of rock and enquired if we knew it. We replied yes; as well as we know

our children; we have been familiar with it since 1839, have a large collection of specimens at the College of Charleston, and would be glad to submit them to him for examination. To this the Doctor readily assented, and we repaired immediately to the College.

On examination, (there were fifty or sixty specimens in the closet,) he said: "I think you are mistaken, *these* are not the same kind of rock as that in in my hand." We rejoined, there is no doubt on our mind about it, but feel *confident they are the same*, and suggested that a quantity should be ground up finely, so as to obtain a fair sample for analysis. Dr. Pratt took, accordingly, several pounds, enquiring at the same time as to its chemical composition; we replied: Professor Tuomey made a crude analysis of it some years ago, his notes of the result were burnt with our library; but we well remember that the amount of Phosphate of Lime, 16 per cent., was considered too small, and the Carbonate of Lime, Iron and Sand, too great to admit of its being used advantageously for Agricultural purposes.

At that time patent fertilizers and fashionable superphosphates were unknown; in fact, Guanos in this country had been used but a short time, hence the anxiety of scientific men to develop the great masses of Marls which were found on the banks of rivers in South Carolina.

We well remember relating, too, an incident which occurred some years ago regarding these rocks. A

gentleman of Saint Andrew's* had a large quantity of the rocks pounded at considerable expense, intending to use it as a fertilizer, but Mr. Ruffin, and the party who accompanied him on the visit, dissuaded the old gentleman from using it by saying it would produce no beneficial effect. This was in the year 1843.

After selecting the specimens intended for analysis, the Doctor remarked "that the small specimen which he possessed was obtained from the neighborhood of Charleston," but did not name the locality, or from whom he had received it, nor did we ask him. He also remarked "it contains a much larger quantity of Phosphate of Lime than is known from published accounts of the Ashley rocks, by Shepard or Tuomey, and that it was valuable as a fertilizer if all the Ashley rocks were of the same quality; though if found in quantity, as we had represented, he was fearful the average percentage of Phosphate of Lime would not be so great, as our specimens indicated a greater amount of silex iron and lime than was found in that in his possession."

The day after this interview Dr. Pratt informed me that the analysis, though not completed, indicated to his surprise even greater results than he had obtained from *his specimen*, and that it was reduced to a certainty that the Ashley Ferry rocks were undoubtedly much richer in Phosphate of Lime. When the analysis was completed it was ascertained to con-

* The late Jno. S. Brisbane, Esq.

tain nearly SIXTY PER CENT. OF PHOSPHATE OF LIME. Dr. Pratt then said: "The question with me now is, *the extent of the formation*, and this must be looked into at once." Again we rejoined, "This is well known, and though we cannot take you up to the Ashley, to-day, because of engagements at the College, we will send Mr. Jonathan Lucas with you to-morrow, and you can then see and judge for yourself; for he knows the stratum and its outcrop, having been with us during the war, whilst engaged manufacturing saltpetre." At the same time we also told the Doctor that the extent of this deposit was marked upon a map which was still in our possession, and it should be looked for. The map was afterwards found and submitted to him for examination.

The necessary arrangements being made, Dr. Pratt left the next day with Mr. Lucas for Ashley Ferry, saw the rock *in situ*, and admitted "it surpassed his anticipation." On the very day the Doctor and Mr. Lucas were visiting the Ashley, we received Ansted's book from London, on the Geology of the Cambridge Beds of Phosphates, giving in detail the analysis of a rock similar to that of the Ashley, and discovered sometime during our Confederate War. His description of the Cambridge rock corresponds in almost every particular with that of the Ashley Beds, and in a most remarkable manner corroborated our statement made years ago, viz: that Charleston was located geologically, on the same formation as that of the great City of London.*

*Holmes' Notes, Geology of Charleston, 1849.

On the Doctor's return from the Ashley (with Mr. Lucas) we had the pleasure of placing the book in his hands, and directing his attention to the article. Several persons were present at the time, and all expressed their surprise.

The thickness of the beds described, the formation of strata and the percentage of Phosphate of Lime, were almost exactly those of the Ashley Beds; and it was remarked, that if the war had not occurred, which cut us off from all English publications, the value of the Ashley Beds would have been known to Carolinians in 1864. The Hon. C. G. Memminger, was the first person to whom we applied for aid to develop this additional source of wealth. At first he did not seem to appreciate its value, but when we exhibited our own publications, extending through many years, and also the work of Professor Ansted, of England, which had been received only the day before, he said, on taking leave of us: "*That book of Ansted's is of the first importance in enabling you (Dr. Pratt and the writer) to establish the worth of your discovery; be careful of it.*"

That book did ultimately convince many of the value of this discovery, and aided us greatly in obtaining the necessary means to develop the Phosphate deposits of South Carolina.

For several months after the discovery, we were engaged in making explorations and arranging future work, and had lost sight of or had forgotten to enquire concerning the specimen first analyzed by Dr. Pratt; and it was not until sometime in the early part

of 1868, we were informed by a friend, Dr. F. Peyre Porcher, that Dr. Ravenel had given the specimen to Dr. Pratt, and afterwards by Dr. Pratt himself when we told him of it, and that Dr. St. Julien Ravenel had been enquiring if we possessed a series of specimens of the several geological formations found in the Ashley Beds. And here it may be proper to state, that it was the first time since the war that Dr. Ravenel had conversed with us about Marls or geological specimens. Dr. Pratt said the specimen was given to him by Dr. Ravenel, who had analyzed it and found 15 per cent. of Phosphate of Lime. Professor Tuomey, as before stated, found 16 per cent. years ago in these rocks. Dr. Pratt analyzed the specimen obtained from Dr. Ravenel, and found 34 per cent., and afterwards those placed in his hands by us at the College, and found nearly 60 per cent. in them!

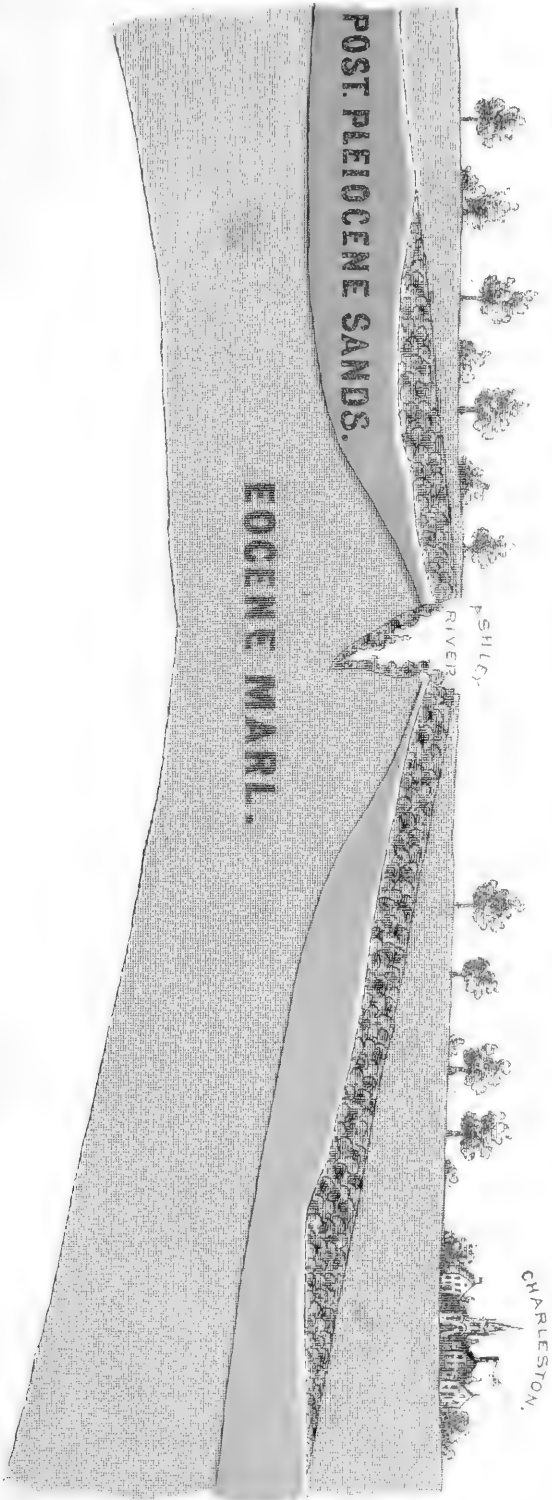
To continue the history: After SIX WEEKS OF UNAVAILING EXERTIONS, in obtaining means to develop these treasures of the Ashley River, and to convince the good people of Charleston of the value of the discovery, we were obliged to resort to Northern cities for aid. Mr. James T. Welsman, of Charleston, one of the few who fully appreciated the discovery, furnished the necessary funds. Geo. T. Lewis and Fredk. Klett, Esqs., two gentlemen of Philadelphia, immediately took the matter in hand, rewarded us both for our discovery, and furnished the capital for the first Phosphate Mining Association,—“The Charleston, South Carolina, Mining and Manufacturing Company.” The Phosphate-rocks have be-

come a staple article of commerce. Large ships and steamers are daily seeking cargoes from the Ashley, Stono, Wando, Ashepoo and other rivers; and the State is now reaping a great harvest. Over six millions of dollars have already been invested by Northern capitalists in mining and manufacturing the Rocks into rich fertilizers; and many persons who in 1867 were unbelievers, have now *their thousands invested in it*. The foregoing is a simple and true history of the discovery and development of the Phosphate-rocks of South Carolina.

THICKNESS OF THE STRATUM WITH YIELD PER ACRE.

Fifteen or eighteen inches may be considered the average thickness of the stratum of the Phosphate-rocks; though there are many places where it has been found three feet thick. Here and there a pocket occurs, extending several feet, and to as great a depth. It is safe, therefore, in making estimates of the yield per acre to take the lowest, that of fifteen inches. Should the stratum be uniform six hundred tons may be safely calculated upon as the yield; though there are many "diggings" now returning eight hundred and a thousand tons per acre. No estimate can be made for River deposits; in some places the rock is found in great heaps, accumulated by the force of currents, and then again, a few yards off, the river-bottom is laid bare from the same cause.

UPHEAVAL OF THE SEA COAST
OF
SOUTH CAROLINA & FORMATION OF ASHLEY RIVER.



60 FEET

SECTION
SHOWING RELATIVE POSITION

OF
EOCENE MARL, POST PLEIOGENE SANDS SHELLS PHOSPHATE DEPOSITS MARSH
LANDS.
ASHLEY BASIN.



As you approach the edges of the Phosphate-rock basins the stratum thins out. The outlines of these basins are as irregular as those of the ponds and lakes of the present period. The upheaval of the coast of South Carolina was very gradual, not sudden. The Ashley Basin was lifted and rent near its centre; and thus a channel for the river was made, as seen in Plate III. The stratum underlies the City of Charleston, and is reached at the depth of sixty feet.

Plate IV is an illustration of the relative position of the Eocene Marl; sands and clays, with imbedded shells of the Post-Pleiocene period, the strata of Phosphate-rocks in situ, under the marsh, and also as covered by the sedimentary formation of river mud. The shells in beds are found sometimes above the Phosphate-rock stratum.

WHY THE VALUE OF THESE BEDS WAS NOT DISCOVERED THIRTY YEARS AGO.

How often have we heard this question, and perhaps we will hear it again and again! There is but one answer, and that was given in our description of the Phosphate Beds of South Carolina, before the American National Academy of Science at Washington, as follows:

A few years ago the lands in Western Pennsylvania were selling at "sheriffs' prices;" the forests had all or nearly all been cut down and consumed, and every source from whence fuel could be obtained exhausted.

Coal was imported from England and other States, and the farmers were "pulling up stakes," emigrating West, and selling their farms to immigrants. Just then the immense beds of coal, whose outcroppings had been trodden under foot for eighty or ninety years as so much useless stuff, and therefore called "Stone Coal," was discovered to be of some value; in a short time scientific men pointed out the mode of using it, and *Stone Coal*, or what is now known as *Anthracite*, is consumed at \$10 per ton, and those lands in the Coal Fields of the Pennsylvania Basin are worth as many dollars as they brought cents a few years ago, and now millions of tons are annually exported.

Why were these Coal Fields not utilized fifty or eighty years ago?

Again, the Eastern Whalemens after a cruise of one or two years have of late been returning with a fourth or a half cargo of oil, reporting the whales as almost *extinct*. Sperm oil advanced to an unheard of price. Down goes the rod of the Geologist, and up comes the Petroleum! The Pennsylvania Petroleum Wells yield more *oil* in one month than the whale fisheries did in a year! Why was Petroleum not discovered fifty years ago?

The granitic soils of New England had also of late years become so poor they did not yield vegetable "stuff" enough for the support of its quota of grasshoppers, and her energetic sons were daily emigrating South and West for richer lands.

Again the joyful news is heard of the discovery of whole islands of guanos in the Pacific, and immedi-

ately those poor soils advance in price from \$5 per acre to \$100!

How is it these Guano Islands were not known one hundred years ago?

We apprehend that for the same wise purpose the great *Architect* of this world had stored up these things for man's use in the future, so, too, He has seen proper not to reveal their use or worth until they were required to minister to man's happiness and comfort.

The Carolina Marl and Phosphate Beds abound with overwhelming evidence of the foreknowledge and providence of God, preparing as He did, and at a time indefinitely remote, these vast stores to be brought forth for man's use when most needed.

WHAT HAS BEEN DONE TOWARDS THE DEVELOPMENT OF THE SOUTH CAROLINA PHOSPHATE BEDS.

The following list comprises the organized companies engaged in mining and in manufacturing this material into fertilizers:

CHARLESTON, SOUTH CAROLINA, MINING AND MANUFACTURING COMPANY, the pioneer in developing the Phosphate-rocks. Jesse E. Smith, Esq., of Philadelphia, is President.

Wando Mining and Manufacturing Company, John R. Dukes, Esq.

Etiwan Sulphuric Acid and Superphosphate Company, Hon. C. G. Memminger.

Oak Point Mines, Geo. S. Scott and D. U. Jennings, Esqs., Proprietors.

Marine and River Phosphate Mining and Manufacturing Company, G. W. Williams, Esq.

Carolina Fertilizer Manufacturing Company, G. W. Williams & Co., Agents.

Chicora Mining and Manufacturing Company, A. D. Estill, Esq.

Atlantic Phosphate Company, F. J. Porcher, Esq.

Stono Phosphate Company, Jas. S. Gibbes, Esq.

Farmers' Fertilizing Company, W. G. Whilden, Esq.

Palmetto Mining Company, T. D. Eason, Esq.

Pacific Guano Company, J. N. Robson, Esq., Agent.

Wappoo Mills and Ashepoo Mines, Jno. B. Sardy, Esq.

There are also several minor companies and private parties engaged in mining these rocks.

THE CHARLESTON, SO. CA., MINING AND MANUFACTURING COMPANY.

The Charleston, S. C., Mining and Manufacturing Company was the pioneer in developing this great and most valuable discovery, and was organized in 1867; Professor F. S. Holmes, of Charleston, as President; Doctor N. A. Pratt, of Georgia, Chemist and Superintendent of Works; and Mr. Arthur H. Locke, of Charleston, Secretary. The principal office was in Charleston, but as most of the directors resided in Philadelphia a branch office and agency was located there also.

Many difficulties had to be surmounted; it was a new and untried field; thousands of dollars were expended before the proper mode of working "THE DIGGINGS" could be known. Laborers were scarce, and the negro, unaccustomed to such work, accomplished very little towards a day's task. The best time for mining was during the summer or dry season of the year, when the white laborer could not withstand the chills and fevers of the season; in a word, difficulties and oppositions arose every day and in every form. Where the Company expected to keep employed one thousand laborers, thirty could not be placed. The thing could not be done in a day; time was required to develop and work out the problem. And perhaps it was well; for had very great quantities of the raw material been suddenly put upon the market, a substance new and untried, no one can tell what would have been the result. Time was required for the manufacturers of fertilizers to test the new material. But now that they have done so at the North, East, South and West; in England, Scotland, Ireland, Germany, France and Spain, the demand for the raw material has increased twenty fold.

The Charleston Mining and Manufacturing Company has expended large sums in purchasing lands; and these lands are now valued at millions. One hundred and fifty thousand dollars have been paid within the past year for buildings, wharves, mills, machinery, railroads and locomotives, besides making two dividends to the stockholders. The capital of this Company is \$800,000, to be increased, if desira-

ble, to ONE MILLION. The following is an analysis made by one of the first chemists of the age, G. A. Liebig, Esq.:

BALTIMORE, September 24, 1870.

Result of analysis of a sample of South Carolina Phosphates, (averaged from one keg crude, which was found at my office,) marked ex "Bailey," for Messrs. Wm. M. Ellicott & Sons:

Moisture determined at 100° C.	. . . . .	6.225
Phosphoric Acid,	. . . . .	28.874
which is equal to 63.034 BONE PHOSPHATE OF LIME.		
Rendered perfectly kiln dry it will contain of Calc.		
BONE PHOSPHATE OF LIME 67.219.		

(Signed)

G. A. LIEBIG.

In December, 1867, sixteen barrels of the rock were collected and shipped to Philadelphia by the writer for general distribution, and the first parcel of Superphosphates was manufactured by Messrs. Potts & Klett of that city.

The first cargo, one hundred tons, was shipped, per schooner Renshaw, on the 14th April, 1868, to Baltimore, Md., by John R. Dukes, Esq., the enterprising President of the Wando Company of Charleston; and who also manufactured the first Superphosphate from this rock in Charleston. The Charleston Mining and Manufacturing Company shipped to Philadelphia three hundred tons, per schooner Anna Barton, on the 18th, four days later.

Phosphate lands in the neighborhood of Charleston, which before the discovery were held at two dol-

lars per acre, immediately advanced to twenty, and have been going up steadily ever since. One plantation, belonging to a widow, valued formerly at six thousand dollars, was bought by the Charleston Mining and Manufacturing Company for forty-five thousand, and is now valued at \$500,000. Sales have been lately made to other parties at \$1.000 per acre. The Company owns about ten thousand acres of the best quality Phosphate-rock lands carefully selected by competent persons. It has a mining lease also of about twelve thousand acres, for which they are to pay a royalty of one-tenth of the rock mined.

On the resignation of Professor Holmes as President, and Dr. Pratt as Chemist and Superintendent, the office of the Company was removed to Philadelphia, where most of the Directors and Stockholders reside.

Jesse E. Smith, Esq., of Philadelphia, is now President and the largest stockholder. Colonel Joseph A. Yates, of Charleston, is the Superintendent of the Company's Works on the Ashley.

ARRIVAL OF THE FIRST CARGO IN PHILADELPHIA.

The arrival of the first cargo in Philadelphia caused no little excitement in mercantile circles, especially among manufacturers of fashionable fertilizers, and in a very short time after the chemists of that city, New York and Baltimore had pronounced it a true Bone

Phosphate-rock, the *Phosphate fever* became "EPI-
DEMIC" in those cities.

There were many persons who believed these rocks to be *true bone*, and the wild reports circulating confirmed them in this idea.

The teeth of sharks and other animals obtained from the rocks were magnified in size to a marvellous degree; some of the sharks were reported, on *the best authority*, to have been two hundred feet long! and the teeth represented to be one foot long, and to weigh ten pounds each! The cargo was said to be *all bones*.

For the satisfaction of those who have never seen the fossils from these rocks, we can say, that out of forty thousand specimens of sharks' teeth taken from the Ashley Basin, and examined by us, the largest specimen was six and a half inches long, about four and a half wide, and weighed two pounds. And, again we repeat, *the rocks are not bones!*

THE WANDO MINING AND MANUFACTURING COMPANY.

The Wando Mining and Manufacturing Company was first organized by Mr. John R. Dukes, the President of the Company.

From information received through Col. L. M. Hatch, before the war, the rock on Ashley River was brought to the notice of Dr. St. J. Ravenel, then Chemist of the Company, who, in 1867, analyzed it, and found 10 to 15 per cent. Phosphate of Lime; and

from a specimen obtained from Dr. Ravenel, in 1867, resulted, through the analysis of Dr. N. A. Pratt, the information of the high percentage of Phosphate it contains. See remarks p. 69.

The Company own its mines on Ashley River, from which they dug and shipped the first *cargo* of rock that was sent from Charleston, and have been the pioneers *here* in the *manufacture* of this material into a fertilizer.

They have mined a large amount of crude rock, a portion of which has been sold to other Companies and the balance manipulated, in this City, into a fertilizer, which has given a reputation to these deposits, and caused in a great degree the present excitement in Phosphatic enterprises. The present capital of the Company is \$300,000.

John R. Dukes, President; T. D. Dotterer, Superintendent.

THE ETIWAN SULPHURIC ACID AND SUPERPHOSPHATE COMPANY.

This Company was organized at Charleston, in the year 1868, for the purpose of manufacturing at home the highest grade of fertilizers from the Native Bone Phosphates lately discovered in such abundance in South Carolina. To effect this object it was necessary to manufacture on a large scale Sulphuric Acid, which is the proper chemical solvent of these Bone Phosphates. This Company therefore immediately erected large Sulphuric Acid Chambers, which they

have lately extended to a capacity of 180,000 cubic feet; and they are now one of the largest manufacturers of Sulphuric Acid in the United States—in fact the last chamber which they have erected exceeds in size any other in the United States. The whole product of these chambers they use to reduce the Insoluble Phosphate Rock, into the condition of Soluble Superphosphate, capable of being taken up by growing plants.

The location of the Works of this Company is remarkably fortunate. They occupy the Old Ship Yard on Town Creek, about three miles above the City of Charleston, where the old frigate John Adams was built; and have a secure dock and deep navigation to it for any vessel that can come to Charleston. They have also railroad communication from their Works to all points, and can therefore receive and deliver with economy and despatch.

The principle upon which this Company is founded is, that it will prepare and furnish Guanos of the highest possible grade of fertilizers. They guarantee as high a percentage of Soluble Phosphate of Lime as twenty per cent., with a sufficient quantity of Ammonia and Potash to ensure a good fertilizer. Their Works and their Guanos are called Etiwan, after the Indian name of Cooper River, into which Town Creek empties. Besides the prepared fertilizers they offer to Manufacturers or Planters who may prefer to manipulate their own manures, the Phosphates reduced to the condition of Dissolved Bone by the full application of Sulphuric Acid; and thus they enable parties

at the same time to transport the acid in the most convenient form, and to apply to their compost any grade of Soluble Phosphate which may be desired.

The Grinding Works of the Company are also on the most extensive scale, and enable them to offer for sale the Phosphates simply ground to powder; before any application of acid to make them soluble. In this form Bone Phosphate is extensively used in Maryland; and the same facilities at much lower rates can be had from this Company by any who desire mere ground Bone.

THE OAK POINT MINES.

The Oak Point Mines are on Wimbee Creek, a branch of the Ashepoo River, and about eighteen miles from St. Helena bar, convenient for vessels drawing 22 feet. The mines are owned by private parties. Mr. Geo. S. Scott, of New York, and Mr. D. U. Jennings, are the proprietors.

The last named gentleman superintends the works.

THE MARINE AND RIVER PHOSPHATE MINING AND MANUFACTURING COM- PANY OF SOUTH CAROLINA.

Capital, \$500,000. Office No. 5, Hayne street.

Officers, Geo. W. Williams, President; Jas. H. Taylor, Treasurer; C. C. Coe, Superintendent.

By Act of the Legislature of the State of South

Carolina, passed March 1st, 1870, this Company has the sole right to excavate those phosphatic deposits which underlie the navigable waters of the State. Before commencing active operations, the Company employed Professor Charles U. Shepard, Jr., of the Medical College of South Carolina, to ascertain the quality and quantity of the rock which lay at their disposition. In his report he alludes to the *alleged* superiority of land deposits over the marine, and, after citing his own analysis in support of his opinion, writes: "These comparisons may serve to show that, given a good or poor deposit, the mere exposure to water, for even great length of time, does not affect it materially. There are very poor marine and river deposits, but one would *not* have to search *very far or in vain*, I am sorry to say, for *corresponding* land beds. There are very rich land deposits, *but as rich marine*. No large deposit is entirely uniform in character, but the difference between one deposit and another has little to do with the present physical geography."

Having command of vast and practically inexhaustible beds, the Company has decided to work only those of the highest grade. At present, operations are carried on in the Wando, Stono, Edisto, Beaufort, Bull River, and other points, concerning whose quality Professor Shepard has given the following opinions. Of the Wando, he writes: "Carefully cleaned the rock will analyze 58 to 62 per cent. Bone Phosphate of Lime." Of the Stono deposit: "I have subjected several samples to the chemical analysis, and am happy to state that the *rock is of high grade*."

When washed free of the adhering sand, I do not doubt they will reach 59 to 60 per cent. Bone Phosphate of Lime. An analysis of phosphatic rock, obtained from Beaufort River, off Beaufort, afforded: Phosphoric Acid, 25.90 per cent., equivalent to Bone Phosphate of Lime, 56.54 per cent. Properly cleaned, I do not doubt that this deposit would afford 57 to 59 per cent. Phosphate of Lime."

Concerning the deposit in the Edisto River, Prof. Shepard further states: The quality is excellent, as may be seen by the following analysis: .

Phosphoric Acid,	28.94 per cent.
Bone Phosphate of Lime equivalent,	63.18 per cent.

The phosphatic rock is dug by powerful dredging machines, and washed by Leiby's Patent Washer, which furnishes a clean rock. In Bull River the deposit is gathered, partially, by hand, at low stages of the tide. With the facilities at the command of the Company it can furnish two thousand tons of rock per week. The great resources and appliances of the Company for excavating, washing, crushing and grinding rock enable them to offer their *high grade* Phosphate at the lowest rates. The Phosphate is furnished either crushed to a uniform size, suitable for manufacturers, or ground to a fine powder. Each consignment is sampled and analyzed by Prof. Shepard.

The Mills of the Company are situated on the Cooper River (Robb's Mills) and at Oak Point, Bull River, with a capacity for grinding to a fine powder one hundred tons per day.

CAROLINA FERTILIZER.

The Phosphate used in the manufacture of the Carolina Fertilizer, sold by Geo. W. Williams & Co., is taken from a deposit at the Eight-Mile Pump, on the Northeastern Railroad. The land is owned by Mr. Masseau, leased to Mr. Moses, and worked by Mr. W. L. Bradley, who has a capital of \$500,000 employed in the business of digging Phosphates and manufacturing Fertilizers. The sales of the Carolina Fertilizer this year being, as compared to those of last, as thirty is to two, and steadily increasing.

THE CHICORA MINES.

The Chicora Company own mines on Filbean Creek, near the centre of the Ashley Basin, in one of the most favorable localities.

The mill is worked by a powerful engine, driving two sets of stones; runs the washers, crushers and grinders, which reduces the rock to an impalpable powder.

The process pursued by this Company is, first, washing, then kiln-drying, crushing and grinding. Seventy thousand dollars have been invested by this Company in Phosphate, Mining and Works. Only the raw, powdered material is prepared for market.

ATLANTIC PHOSPHATE COMPANY.

The Atlantic Phosphate Company is located also on the Ashley; has a large capital of \$200,000, and is now engaged in erecting extensive works for the manufacture of Superphosphates. They will be ready to supply consumers for the next crop.

STONO PHOSPHATE COMPANY.

The Stock of the Stono Phosphate Company is owned mainly by merchants and planters in the interior of South Carolina and the adjoining States; it has also a large capital of \$350,000, and expects to prepare a first-class fertilizer. Their work-mills are now being erected on the banks of the Ashley.

Our esteemed friend and late colleague, Professor Lewis R. Gibbes, eminent for his scientific attainments, is the Chemist of this Company, and is well known and appreciated throughout the country.

Messrs. J. D. Aiken & Co., are the business managers.

FARMERS' FERTILIZER COMPANY OF SOUTH CAROLINA.

This Company has in the course of erection mills and machinery, at their location on the Ashley River, outside of the city limits, and propose to erect Acid Chambers during the spring of 1871.

The capacity of the proposed mills will be about 15,000 tons of Manipulated Fertilizer per annum. The capital of the Company will be \$150,000. They have under their control lands for mining purposes which indicate a yield of 1,000 tons per acre, the stratum varying in thickness from 18 to 36 inches.

They will manipulate for the next cotton crop. The Company is composed, to a great extent, of planters residing in this and the adjoining States.

THE PALMETTO MINING AND MANUFACTURING COMPANY,

The Palmetto Mining and Manufacturing Company own about one thousand acres of Phosphate lands, situate on Ashley River; employ about one hundred operatives, and expect to wash fifteen thousand tons of Rock annually. Their works are now in course of erection, and have already dug twenty-five hundred tons of Phosphate-rocks. T. D. Eason, Esq., is the President.


PACIFIC GUANO COMPANY.

The Pacific Guano Company own extensive mills just out of the city limits of Charleston. Capital, \$1,000,000. Dr. St. Julien Ravenel is the chemist and scientific advisor, and Mr. J. N. Robson, the business agent. The Ashley Phosphate-rock is used in the manufacture of their fertilizer, known as Soluble Pacific Guano.

J. B. SARDY'S WORKS.

The Wappoo Mills, opposite the City of Charleston, have been lately purchased by this enterprising gentleman, and converted into Phosphate-rock Mills. Mr. Sardy obtains the rock from his mines on the Ashepoo River; he is an old and experienced manipulator of fertilizers, having offices in Savannah, Ga., and New York.

Messrs. Geo. A. Trenholm & Son are his business agents in Charleston.

 Information regarding Phosphate-rocks, and the Phosphate business, can be obtained at Professor Holmes' office, in the rear of Holmes' Book House, Charleston.

ANATOMY OF THE HUMAN BODY

BY

WALTER DEWEY

OF THE UNIVERSITY OF CHICAGO

AND

OF THE UNIVERSITY OF TORONTO

NEW YORK

1911

CHARLESTON, SOUTH CAROLINA,

MINING

AND

MANUFACTURING COMPANY,

OFFICE 132 WALNUT STREET,

PHILADELPHIA, PA.

JESSE E. SMITH, President.

J. H. KIMBALL, Vice-President.

W. E. SIMPSON, Secretary.

JOS. A. YATES, Superintendent.

DIRECTORS:

Prof. F. S. HOLMES.

Dr. N. A. PRATT.

T. J. SUMNER.

S. F. FISHER.

J. E. SMITH.

Dr. GEORGE FOX.

GEO. T. LEWIS

This Company is now prepared to receive and execute promptly Orders from Manufacturers for their high grade Bone Phosphates.

GREATLY INCREASED CROPS

BY THE USE OF

The Best and Most Reliable Home-Made Fertilizer,

“THE WANDO.”

MANUFACTURED BY THE

WANDO MINING & MANUFACTURING COMPANY,



At their Works in Charleston, S. C.

WM. C. DUKES & CO.,

GENERAL AGENTS,

No. 1 South Atlantic Wharf.

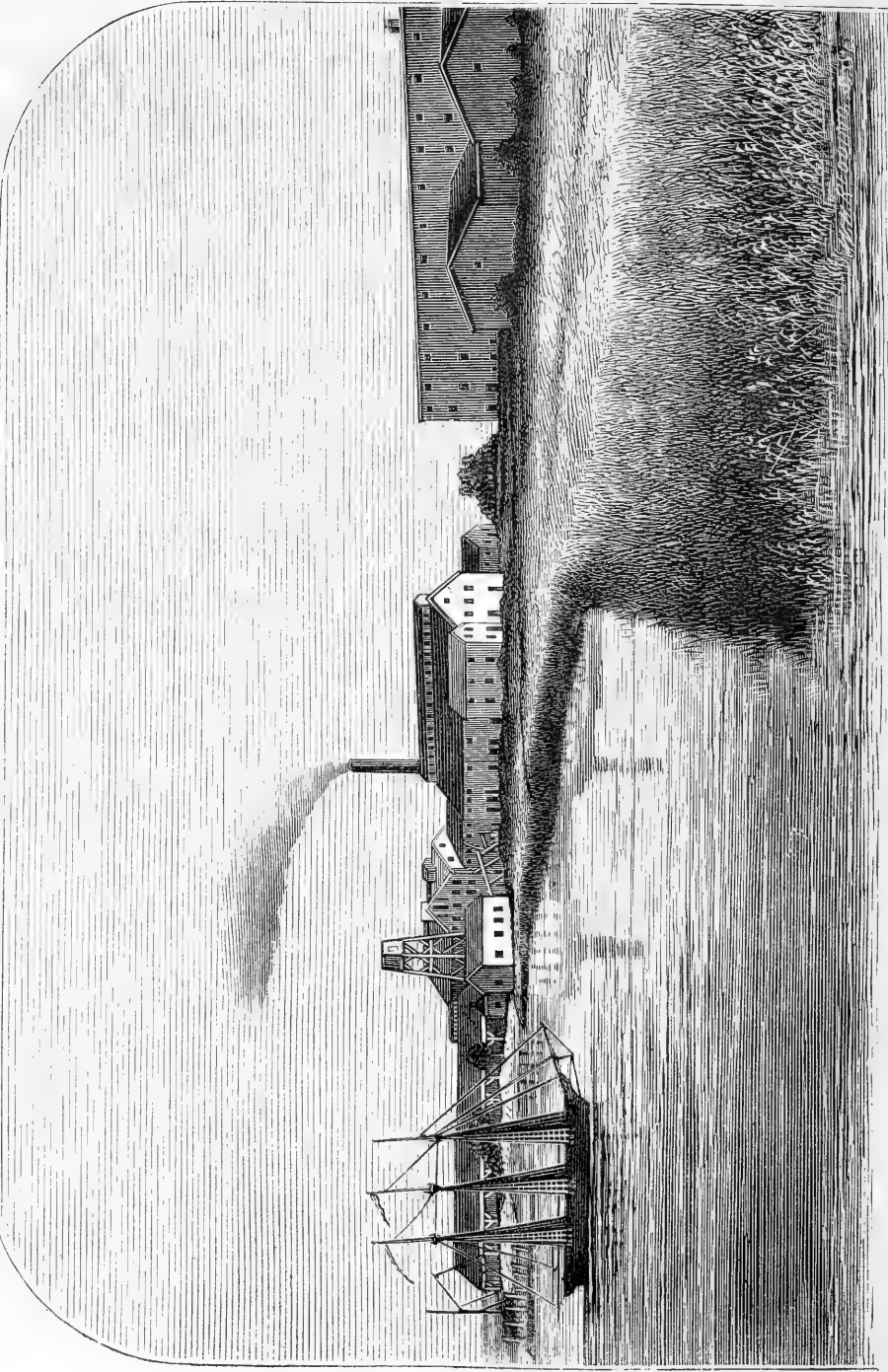
THE UNIVERSITY OF CHICAGO
DEPARTMENT OF THE HISTORY OF ARTS
AND ARCHITECTURE

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AND ARCHITECTURE



Etivau Works of the Sulphuric Acid and Superphosphate Company, Charleston, S. C.

ETIWAN GUANOS,

SOLUBLE MANURES,

AND

SULPHURIC ACID,

MANUFACTURED AT THE

ETIWAN WORKS,

CHARLESTON, S. C.,

BY THE

SULPHURIC ACID & SUPERPHOSPHATE COMPANY.

Prof. N. A. PRATT,

Chemist.

C. G. MEMMINGER,

President.

W. W. MEMMINGER, M. D.,

Assistant Chemist.

The now well-known *ETIWAN GUANO* is manufactured from the Native Bone Phosphates of South Carolina. These Phosphates in their natural state are Insoluble, and require to be ground to powder, and made Soluble by Sulphuric Acid. This Company have now in operation the largest Sulphuric Acid Chambers at the South, and are, therefore, able to manufacture at the lowest rates, the highest grade of Fertilizer; it being clear that the greater the proportion of Soluble Phosphate which any Fertilizer contains, the less the quantity required per acre. In order to make the Fertilizer complete, Ammonia and Potash in sufficient quantities are added. With these views the Company manufacture and offer for sale

ETIWAN GUANOS,

Warranted to contain from 15 to 20 *PER CENT. OF DISSOLVED BONE PHOSPHATE OF LIME*, and from 2 to 2½ per cent. of *AMMONIA*, with a sufficient addition of *PERUVIAN GUANO* and *POTASH*, to adapt it to all crops.

DISSOLVED BONE,

Of high grade, suitable for Manufacturers or for Planters, being in itself an excellent Fertilizer, and specially adapted for compost. As large quantities of Sulphuric Acid are used to dissolve the Phosphate, this will be found a cheap and convenient way to transport that material. The grade furnished will be from 18 to 20 per cent. Dissolved Bone Phosphate. Still higher grades will be furnished to order at an additional price per centage.

GROUND BONE,

At much lower rates, consisting simply of the Native Bone Phosphates ground to powder.

WM. C. BEE & CO.,

Agents, No. 14 Adger's Wharf.

N. B.—The percentage of Dissolved Bone Phosphate of Lime, and Ammonia in all the Etiwans, is ascertained at the Works, by their Chemist, before delivery. Should any purchaser be dissatisfied, he may return average samples of any purchase, within thirty (30) days after delivery, and they will be analyzed anew, and any deficiency in the percentage guaranteed will be made good to him by the Company.

SARDY'S SUPERPHOSPHATE WORKS

Wappoo Mills, Ashley River,

NEAR SAVANNAH RAILROAD DEPOT,

CHARLESTON, S. C.

These Works are now in full operation, manufacturing Sardy's well known

FERTILIZERS,
SOLUBLE PHOSPHO PERUVIAN GUANO,
AMMONIATED SOLUBLE PACIFIC GUANO,
Bone Phosphate, Soluble Ammoniated.

N. B.—Compounded with No. 1 Peruvian Guano and animal matter, in proportions, specially adapted to the Southern climate and soil, and to the production and support of the Cotton plant and cereals.

All these Fertilizers have been extensively and successfully used by prominent planters in the South for many years, and are pronounced the most reliable and profitable.

GROUND BONE PHOSPHATE,
ASHEPOO MINES,

(Considered by Professor SHEPARD the best in the State.)

J. B. SARDY offers for sale the above article, RENDERED SOLUBLE, in packages, at \$37.50 per ton of 2,000 lbs., or without acid, at \$20 per ton. These works are under the inspection of

Prof. SHEPARD, State Inspector of Fertilizers,
 and all packages will bear his stamp.

Gen. Agents, G. A. TRENHOLM & SON.
Agents, GRAESER & SMITH.

J. B. SARDY.

N. B.—Circulars and pamphlets may be had on application as above.

OAK POINT MINES,

Bull River, So. Ca.

GEO. S. SCOTT & D. U. JENNINGS,
P
ROPRIETORS.

These Mines are situated on KEAN'S NECK, at the confluence of North and South Wimbee Creeks.

The landing is about eighteen miles from St. Helena Bar. Large vessels drawing twenty-two feet of water can approach within two miles of the mines.

Analyses, by competent chemists in this country and Europe show, that the Rock from these mines is in quality *UNSURPASSED BY ANY YET SENT TO MARKET*. It has found, and continues to find, ready sale in England, *where 60 per cent. of Bone Phosphate is demanded as a standard*.

The Mines are worked under the supervision of Mr. D. U. JENNINGS, whose office is *No. 12 Broad Street, Charleston, S. C.*, where specimens and analyses may be seen and further information obtained.

THE
MARINE & RIVER
PHOSPHATE MINING
AND
Manufacturing Company
OF
SOUTH CAROLINA.

CAPITAL, - - \$500,000.

Office No. 5 Hayne Street,
CHARLESTON, S. C.

OFFICERS.

GEO. W. WILLIAMS, PRESIDENT.

JAS. H. TAYLOR, TREASURER.

C. C. COE, SUPERINTENDENT.

This Company is now prepared to deliver Phosphate Rock of HIGH GRADE, in any quantities, crude, crushed or ground to powder.



The "CAROLINA FERTILIZER" is made from the Phosphates of South Carolina, and is pronounced by various Chemists one of the best Manures known, only inferior to Peruvian Guano in its Fertilizing Properties. These Phosphates are fully described in this volume, and possess qualities of the greatest value to the agriculturist.

We annex the analysis of Professor Shepard:

LABORATORY OF THE MEDICAL COLLEGE OF SOUTH CAROLINA.

Analysis of a sample of CAROLINA FERTILIZER, personally inspected.

Moisture expelled at 212° F.....	16.70		
Organic Matter, with some water of combination expelled at low red heat.....	16.50		
Fixed Ingredients.....	66.80		
Ammonia.....	2.60		
Phosphoric Acid—Soluble.....	6.96	Equivalent to 11.27	Soluble Phosphate of Lime
Insoluble.....	6.17	Equivalent to 13.48	Insoluble (bone).
	13.13		24.75 Phosphate of Lime.
Sulphuric Acid.....	11.01	Equivalent to 23.65	Sulphate of Lime.
Sulphate of Potash.....		80	
Sulphate of Soda.....		3.50	
Sand.....		11.06	

On the strength of these results I am glad to certify to the superiority of the CAROLINA FERTILIZER.
examined. C. U. SHEPARD, Jr.

GEO. W. WILLIAMS & CO., Factors, Charleston, S. C.

CHICORA

MINING & MANUFACTURING COMPANY

The mines of this Company are situated a few miles from Charleston, S. C., directly in the Ashley Basin, furnishing Phosphate Rocks of the highest grade.

The Mills are now in full operation, and the Company prepared to furnish

PULVERIZED RAW PHOSPHATES,

such as is described in this book by Prof. HOLMES.

A. D. ESTILL,

President and Superintendent.

THOS. L. WITSELL,

Secretary and Treasurer.

DIRECTORS.

JOHN H. HOLMES.

R. SIEGLING.

J. S. MURDOCH.

T. A. JEFFORDS.

All business communications should be addressed to THOS. L. WITSELL, Secretary and Treasurer, 46 East Bay, Charleston, South Carolina.

THE ATLANTIC PHOSPHATE COMPANY

OF

CHARLESTON, S. C.,

Was organized at a meeting of Stockholders, held on the 25th May, 1870, and the following officers elected:

F. J. PORCHER, PRESIDENT.

F. J. PELZER, TREASURER.

WM. LEBBY,

W. P. HALL,

L. D. DESAUSSURE,

B. G. PINCKNEY,

} DIRECTORS.

The object of this Company is to manipulate the Phosphates of this State at their works on the Ashley River, about one mile above the city limits.

PELZER, RODGERS & CO.

GENERAL AGENTS,

BROWN & CO.'S WHARF,

CHARLESTON, S. C.

THE STONO PHOSPHATE COMPANY,

Of Charleston, South Carolina,

Is now erecting extensive works on Ashley River, and will furnish a first-class fertilizer for the next year's crop. It expects also to engage largely in foreign shipments of Phosphate Rocks.

The services of Professor L. R. Gibbes, the distinguished Chemist of the College of Charleston, has been secured; he will have charge of the chemical department, thereby insuring to consumers a genuine fertilizer of high grade.

BOARD OF DIRECTORS.

JAMES S. GIBBES, CHAIRMAN.
HENRY GOURDIN.
GEORGE S. CAMERON.
ROBERT MURE.
CHAS. H. SIMONTON.
J. D. AIKEN.
A. J. WHITE.
B. F. HUGER, JR.
HON. JAS. CHESTNUT, Camden, S. C.
R. N. HEMPHILL, Chester.
A. B. SPRINGS, York.
ADAM JOHNSTON, Augusta, Ga.
GEO. W. SCOTT, Tallahassee, Florida.

All business communications must be addressed to

J. D. AIKEN & CO.,
CENTRAL WHARF,
CHARLESTON, S. C.

FARMERS' FERTILIZER COMPANY

OF SOUTH CAROLINA.

WILLIAM G. WHILDEN, *President.*

A. H. MAZYCK, *Treasurer.*

HENRY T. PEAKE, *Superintendent.*

HUTSON LEE, *Clerk.*

DIRECTORS.

William G. Whilden, of Charleston.	Dr. G. Mason Strong, of Charlotte, N. C.
Col. John B. Palmer, of Columbia.	Archibald Cameron, of Charleston.
C. L. Burekmyer, of Charleston.	T. B. Jeter, of Union.
George H. McMaster, of Fairfield.	A. Lengnick, of Charleston.
B. D. Lazarus, of Charleston.	George Wm. Cooper, of Sumter.
William Beattie, of Greenville.	E. M. Gilbert, of Charleston.
Andrew P. Caldwell, of Charleston.	Major James Pagan, of Chester.
Col. D. Wyatt Aiken, of Abbeville.	John Hanckel, of Charleston.
Richard M. Butler, of Charleston.	

CHARLESTON, S. C.

Will furnish to consumers their Fertilizers, which are equal to any manipulated from the Carolina Phosphates. The other ingredients used in the manipulations are such as have been thoroughly tested, practically and scientifically, as requisite in agriculture, and we guarantee the high grade of our Fertilizers. A large number of the Stockholders of this Company being farmers and planters, it is our interest to offer only a first-class article.

Our Fertilizers can be obtained from our Agents in this and the adjoining States, at Factory prices, with freight and expenses added, or from the works of the Company, on the South Carolina and North-Eastern Railroads, near the city, or by addressing the President at the office of the Company, 29 Hayne Street, orders will receive prompt attention.

PALMETTO MINING
AND
MANUFACTURING COMPANY
OF
SOUTH CAROLINA.

Mines and Factory situated on Ashley River.

THOS. D. EASON, PRESIDENT.

C. R. HOLMES, TREASURER.

DIRECTORS.

CHAS. H. WEST. T. D. EASON.

ROBT. Q. PINCKNEY. JNO. S. FAIRLY.

C. R. HOLMES.

Will furnish in quantities, to suit purchasers, the Pure Ashley River Phosphate Rock and the Ground Bone Phosphate, which we guarantee to be fully up to standard.

Planters will be supplied on reasonable terms with the Ground Bone Phosphate, which is highly recommended as a basis for a compost.

THURSTON & HOLMES, Agents,
ADGER'S NORTH WHARF,
CHARLESTON, S. C.

NOTICE TO PLANTERS.**SOLUBLE PACIFIC GUANO.**

The highly satisfactory and remarkable effects of this Guano in producing very largely increased crops of Cotton, Corn, and other staple crops, has attracted the general attention of Planters and Farmers.

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Dr. Raverel is conversant with the composition and qualities of the Guano, as well as with the character, policy and unusual resources of the PACIFIC GUANO COMPANY, and will communicate full information on these points to planters who may call on him, or address him by letter, at Charleston, S. C.

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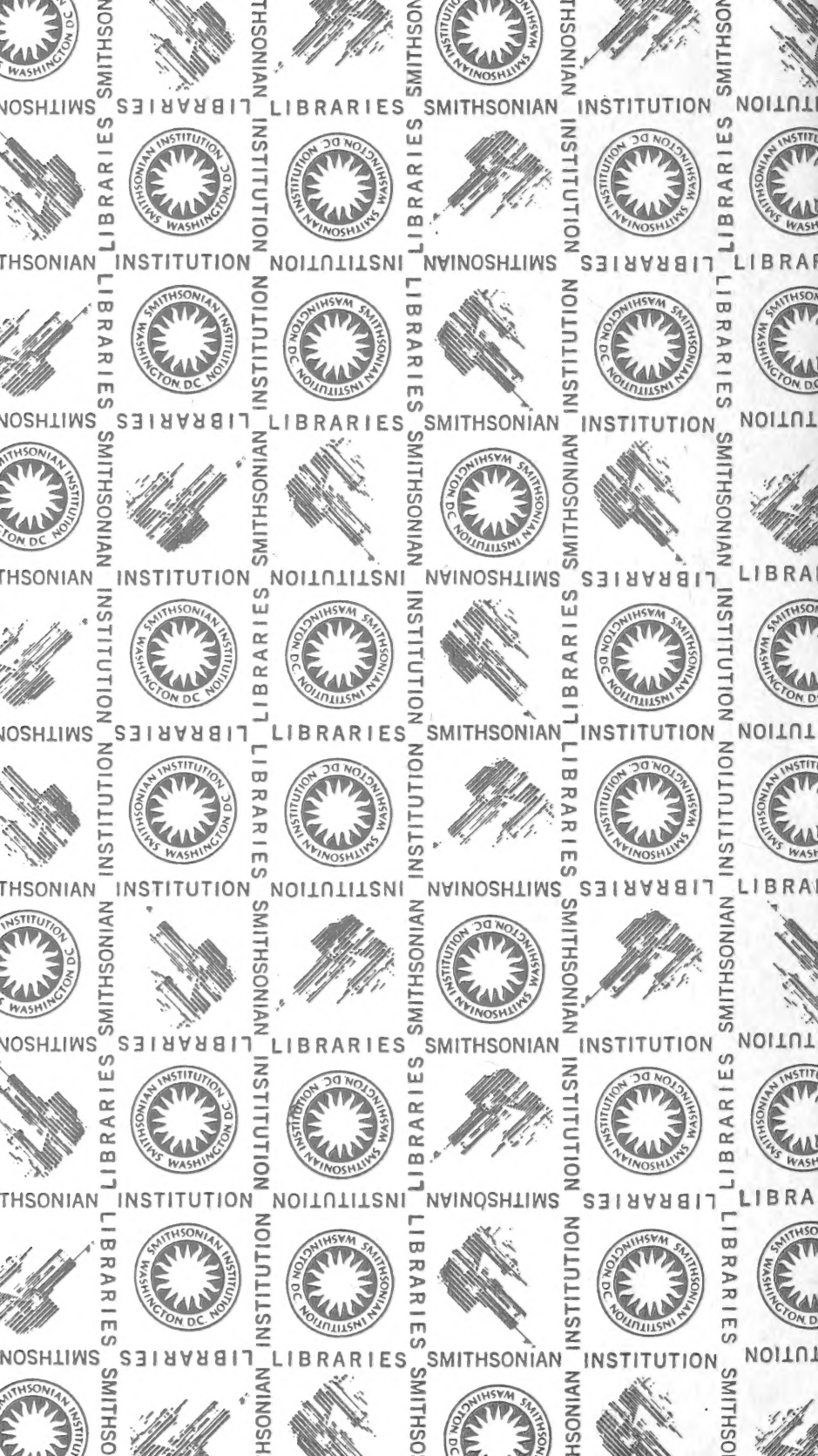
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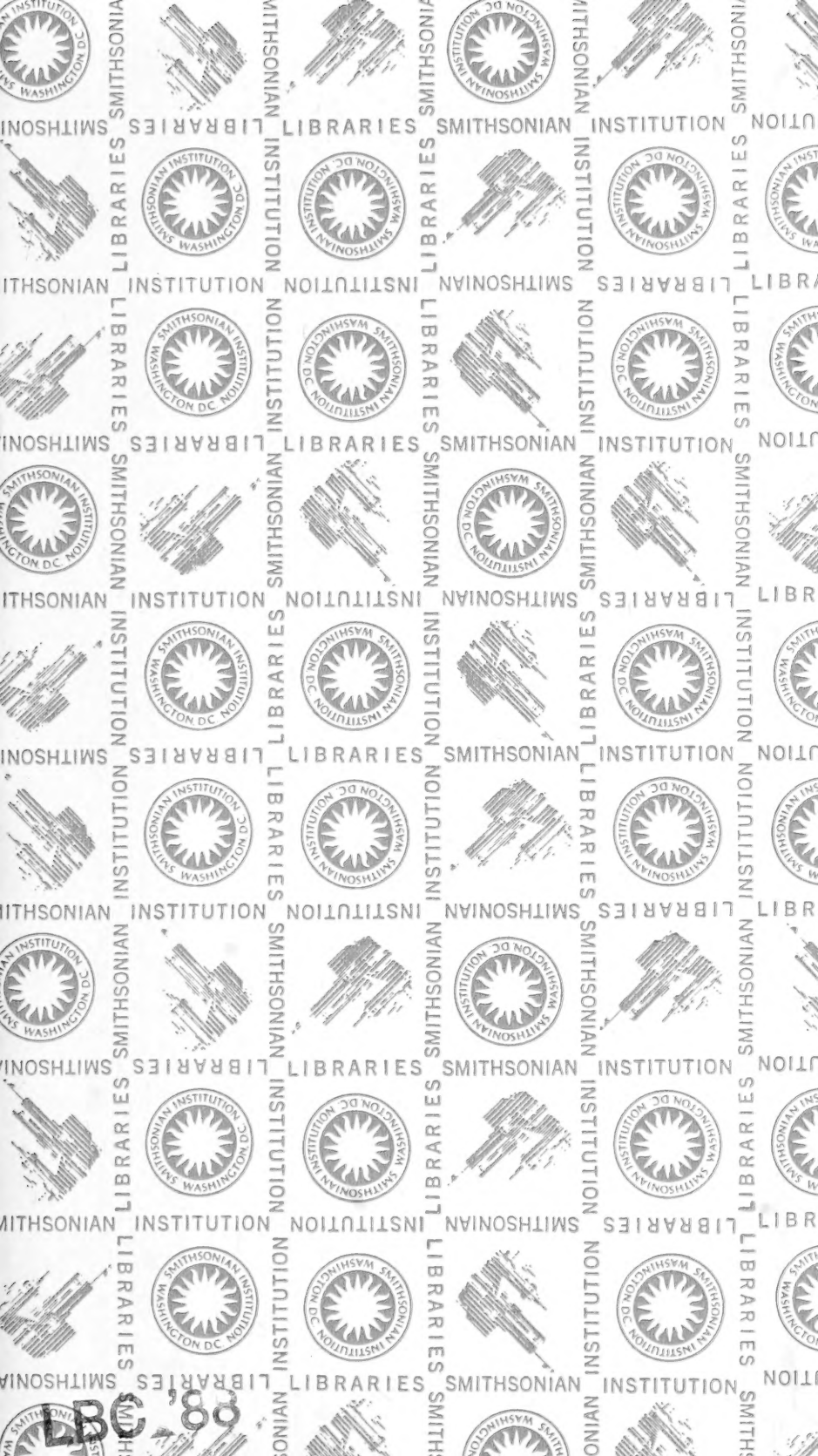
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