

## AN ELEPHANT BATTERY IN INDIA.

THE elephants represented in these engravings (which are from sketches by Mrs. Brackenbury, of Trimulgherry, Deccan, India) belong to the Heavy Battery, Secunderabad, Deccan. In the first sketch they are being washed at a trough in their barracks, where they also drink. They much enjoy the operation, lying down in any position to suit the convenience of their attendant. He rubs their hides with a piece of stone, and, should it slip out of his hand, they politely pick it up with their trunks and restore it to him. They also use their trunks to dash water over themselves, and can hit off any part of their bodies with great exactitude. These are all female elephants, as they are more tractable than males.

In the second sketch the elephants are formed up in row, waiting for their breakfast. Every elephant has five bundles of straw, each containing two pounds of raw rice, laid in front of her; and they are not allowed to take it up for themselves, as they usually spill some of the rice. When the word "feed" is given, each animal raises its trunk. The mahout then picks up a bundle and puts it into the animal's mouth. After the feed they march back in line to the stables, where they remain for the rest of the day, with some sugar cane and coarse grass as a second course.—*London Graphic*.

## THE LADY CRICKETERS.

THE cricket season of this summer is enlivened by a social novelty which may in some degree be illustrative of the disputed notion that women can, may, and will do everything quite as well as men. If they can play lawn tennis, it was argued, why not cricket? This experiment is being tried, for the first time with a full field, not by lady amateurs, but in the public performances of a professional company, numbering some five-and-twenty fair experts in batting and bowling, organized last winter by Mr. Michel, and privately trained, for some time, on a covered ground spread with coconut matting, before the season allowed them to prove their skill on the grassy turf. Having received careful instruction from Matthews and other players of repute, they seem to understand the game, and are resolved to do all they know. Their costume is effective and workmanlike—a loose skirt of white flannel, with a sailor collar, opening in front to show a jersey on which are embroidered the letters "O. E. L. C.," and a short skirt of the same material terminating just below the knees; stockings and sash in accordance with the colors of their side, and a white cap with a similar bow above the peak. The feet are encased in ordinary lace-up cricketing boots. The rival teams are known as "Reds" and "Blues," the players having their pretty costumes of white flannel trimmed with the representative color of their side. The "Blues," captained by Miss Stanley, usually play against Miss Violet Westbrook and the "Reds."—*Illustrated London News*.

## THE NEWLY DISCOVERED PHOSPHATE BEDS OF FLORIDA.\*

By Dr. ALBERT R. LEDOUX.

THE discovery of widely distributed beds of phosphates in western Florida has of late produced a local excitement and activity similar to the "gold fever" of a newly opened mining region. Prospectors are everywhere, boring into the soil; capitalists from the North are seeking favorable openings from point to point; the local press is wildly excited; and the native "cracker" occupants are suddenly aroused by a rise of value in their barren little holdings, that turns their heads with undreamed of wealth. One poor man, at least, has become actually insane at realizing \$300 for an option on his land, when probably he had never before seen such a thing as a twenty dollar note.

As regards phosphate deposits in general, we may first glance at the two extremes of their occurrence. In the oldest rocks of the continent—the Archæan of Canada—we have the crystalline phosphate of lime (apatite) in large amount; while at the present time there are still forming extensive deposits of bird manure (guano) on many islands like the Chinchas, etc. Between these extremes of age and of condition, there is every possible intermediate grade. On rocky islands like those off the arid coast of Peru, where rain is slight and rare, only fermentation occurs, and the phosphoric acid is largely soluble, and combined mechanically with organic salts, urates, and oxalates. But when formed within the rain belt, and constantly subject to its influence, the soluble compounds, including ammonia and phosphoric acid, are leached out. When this has occurred on limestone or coral islands, a third type of material is produced by the action of these leached out compounds on the carbonate of lime, altering it to phosphate, as on Aruba and Sombrero. If there is much iron or alumina present, the less desirable phosphates of those bases may be similarly formed.

As to the rate at which bird guano is accumulated—which is the main source of the tropical phosphate beds of recent geological time—the following very definite evidence is of interest. I was personally acquainted with an intelligent captain who was sent to a coral island in the South Pacific for a cargo of guano. The island was uninhabited, and the birds were there in countless swarms. The same captain had been there twenty years before and the place had been unvisited since that time. On this former trip, his men had built a hut of coral rock, after clearing off a space for it, and covered it with a piece of sail, as a shelter during their stay. On leaving, they took away the sail and left the "hypathral" hut with its board flooring. On returning after twenty years, the fresh deposit had accumulated within the hut to a depth of twenty inches—showing a rate of about one inch per annum—while the underlying coral limestone was altered to phosphate for several feet, gradually passing into carbonate in going down.

At some points, especially in caverns (as e. g. in Cuba), bat guano accumulates to a degree sufficient to become valuable in commerce. This material is easily recognized by containing quantities of undigested horny wings, and other hard parts, of insects. Seal guano is also known on some coasts. All these are geologically modern.

In the Mesozoic era, abroad, we find the remarkable

"coprolite beds," formed in a similar manner by the great marine reptiles of the Jurassic time. These deposits have yielded thousands of tons per year, in Suffolk and Cambridgeshire, and are extensively and regularly worked like mines in many parts of the Continent from Spain to Russia.

In our own country we have, besides the Laurentian apatite before referred to, a series of phosphatic marls extending along the seaboard region from New Jersey to Florida, and belonging to the early and middle Tertiary. The most important are the beds of the Ashley and Cooper river region in South Carolina, which are different from any others previously known. They were discovered in 1867, just after the war, and have been a priceless boon to the State and to the country, aiding greatly in restoring the waste and desolation wrought by the war, both by fertilizing the sandy lands of the whole Southern coast region and by furnishing a most important and profitable industry in mining, preparing, and shipping the material. Their use is extending over the entire United States, and the demand seems almost unlimited.

The "phosphate rock" had been observed, and to some extent recognized in its character, years before. But much of the land underneath which it lies is extremely barren, and perhaps for this reason the material was not considered of any especial value. I have myself analyzed soils that contain phosphoric acid up to six per cent., but so lacking in other elements of plant food as to be wholly barren. Upon such lands it was that Ravenel discovered the method of producing an abundant yield by planting green crops and then "plowing under"—thus furnishing the organic material necessary to act on the insoluble phosphates.

These beds are a wonderful repository of fossil remains. They consist largely of the so-called "nodules" of phosphate rock, varying in size from a few millimeters to large masses; and intermingling with these, but not included in them, are quantities of bones and teeth of vertebrate animals—sharks of great size, manatee, horse, elephant, etc.—representing various periods from the Eocene to the Pliocene Tertiary. The nodules contain casts of fossil shells, but none of these vertebrate remains. The question of the manner in which these beds originated is one of great geological interest; but this is not the time for its discussion.

During the past year (1889) it is reported that the amount taken out by the several companies operating in South Carolina was over 423,000 tons, and the dividends paid more than \$400,000—that is, nearly one dollar per ton. About one-half of this output was exported to points on the coast—to Baltimore, Philadelphia, Richmond, and New York, in the order named—about one-third sent abroad, and the rest manufactured into fertilizers at Charleston, or to a small extent sent into the interior for treatment.

The material is divided into "land rock" and "river rock"—the former light colored and dry, the latter dark and needing to be kiln dried before shipment. The first is dug from the ground by pitting and trenching; the second is dredged from the rivers that cut through the strata of the region—the nodules and fossils, in a rolled and waterworn condition, accumulating in the beds of the streams. So great is the demand that during the year past the price of both kinds has steadily risen, averaging about \$6 per ton at the beginning of 1889 and approaching \$7 at its close.

Outside of this Ashley-Cooper region in South Carolina, the phosphate beds have not been discovered in paying quantities, save at a few points in North Carolina. In some of the southern counties of that State the yield may perhaps become valuable in years to come, when the South Carolina beds begin to be exhausted.

After these preliminary references to other phosphatic deposits, especially those near Charleston, I proceed to describe the newly opened Florida beds, which form the proper subject of this paper. These are of two kinds, one closely resembling those of Carolina, both in character and occurrence, and the other entirely different.

In southern and western Florida we find a rather low region, nowhere exceeding 260 feet of elevation above tide. In crossing the State from Fernandina to Cedar Keys, following the railway survey in a direction N.E. to S.W., we pass over an alternation of valleys and ridges—the latter sandy, and known as "pine lands," the former swampy, and called "hammock lands." The elevations vary greatly along this line of section, from 20 feet to over 200; the average, in Marion County, being about 80 feet above mean low water.

Little attention has heretofore been paid to the geology of Florida, as it was not supposed that valuable deposits of any kind existed there. Up to 1881, the best summary of what was known or published upon the subject was that compiled by Prof. Eugene A. Smith of Alabama.\* After collecting and comparing the facts and views given by a number of geologists who have written more or less upon portions of the State, Prof. Smith goes on to say: "From specimens collected by me at points widely distant from each other, from the observations of others as quoted above, and from the evidence derived from other sources, I am brought to the conclusion that almost the whole State of Florida, from the Perdido River on the west, eastward and southward, including the middle and western parts of the peninsula, certainly as far south as the latitude of Charlotte Harbor, has for its underlying formation the white or Orbitoides limestone of Vicksburg age, the exceptions as yet known being the Post-Pliocene or recent limestones forming the Keys and the immediate coast along the western, southern, and eastern shores, and isolated patches, if not a continuous belt, of Miocene limestone between the St. John's River and the elevated table lands westward. In many places near the coast in Wakulla County a very fine pulverized marl is mingled with the sand, imparting to it a great degree of fertility; this is the 'Gulf Hammock' land of which much has been written. From inquiries and from the observations of Conrad and others, I learn that these hammocks exist all along the coast from Wakulla through Taylor, Lafayette, Levy, and Hillsboro Counties to Tampa Bay. This marl is also of Vicksburg age where I have examined it, and from descriptions which I have had from various sources it seems almost certain that the marls of the Gulf Hammocks in the other counties named are of the same geological age.

"About Ocala, southward and southwestward, is a belt of 'hammock' land, where an earthy, partly disintegrated limestone mingles with the surface soil. Reference to tables of elevations will show that this hammock land is 60 feet higher than the sandy plain of Ocala. My own observations in the interior confirm the statement of Conrad, with reference to the Gulf coast near Tampa, that the Tertiary limestone is certain to be the substratum of all the 'hammock' land. At Rock Spring, however, there is a bluff of limestone some 10 feet in height, and from this I was able to collect a number of fossils. They were submitted to Mr. Heilprin, who determined among them the following species: *Pecten madisonius*, *Venus alveata*, *Cardita granulata*, *Carditamera arata*, *Mytiloconcha incurva*; doubtful were also *Cardium sublineatum* and *Oliva litterata*. This would make the limestone of Miocene age, as Mr. Heilprin states his belief that no Vicksburg species are associated with the shells enumerated. I do not know that Miocene limestone has been observed elsewhere in the State, but it seems probable that it will, upon examination, be found either in isolated patches or forming a continuous belt between the Post-Pliocene deposits toward the east and the elevated country westward, which has a substratum of the Vicksburg limestone."

After the above observations Prof. Smith summarizes as follows (which I condense):

"(1st) The Vicksburg limestone is the oldest rock in Florida, and therefore the State was still submerged until near the end of the Eocene period. (2d) After the deposition of the Vicksburg limestone (upper Eocene), Florida was elevated to its present level above the sea. (3d and 4th) After the Miocene submergence there was another elevation of Florida, followed (5th and 6th) by a submergence during the Champlain period, and then an emergence which brought about the present topography and elevations, substantially."

We may limit our discussions of the new phosphate beds to the western counties, though rearrangement and restatement may at any time be rendered necessary by further discoveries. But for the present we will consider only the region of the Gulf counties south of Wakulla and north of Tampa. There appears to be a concentration also toward a central area, indicated by a circle of some 15 miles radius around the town of Hernando, in Citrus County. The Withlacoochee River crosses this circle from S. E. to N. W., and within its limits are the towns of Dunellen on the north and Floral City on the south. Of course, wherever such a line is drawn, I am compelled to exclude some good localities that lie beyond it, and to incur the wrath of speculators and boomers elsewhere. But this statement merely indicates the center of the region, while there are important deposits over an extensive area of the State beyond this limit.

The first kind of phosphate beds above mentioned—similar to those near Charleston, in appearance, composition, and occurrence—have long been known, but have attracted little attention. Some years ago the occurrence of nodules and fossil bones in the outlets of creeks on the west coast had been reported by officers of the United States Coast Survey. Fine specimens of them are in the Smithsonian Institution at Washington, and they were also exhibited at the Sub-Tropical Exposition at Jacksonville. More than ten years since, attempts were made to work these deposits at several points. The process is simple, and at the works of the De Soto Mining Company, at Peace River, is substantially as follows: A centrifugal dredge is anchored in the river, and the sand and pebbles taken from the bottom discharged into a revolving screen. The sand washes through, and the pebbles, which are entirely phosphate nodules, are delivered into barges and taken to the works to be dried and shipped. The company's storage capacity here is 1,500 tons. The material seems to be redeposited by the river almost as fast as removed. This is probably due simply to a constant washing away of the fine sand, whereby the nodules are continually re-exposed. As compared with the Carolina phosphates, however, the small size of the nodules, and the consequently higher cost of working, seemed to preclude the idea of any very formidable rivalry on the part of these Florida deposits.

Until within a few months these were the only kind of phosphate beds known in Florida, and were not considered of great importance; but in the fall of 1889 an entirely different material, but of great promise as a fertilizer, was discovered.

An orange grower near Ocala, possessed of more curiosity than others around him, sent to a chemist for analysis a specimen of a white subsoil material occurring in his grove. It was familiar to every one in the region, but was supposed to be only limestone, for it had been found in all the wells in the neighborhood. The chemist reported that it was 80 per cent phosphate of lime. The secret got out, and then the excitement began. It may be said now, in all seriousness, that there is more danger that too much phosphate has been discovered than too little, and that a reaction will take place which may maintain values below the cost of Florida production for a while. Yet the world will take it all, and there is really to-day a scarcity in the market.

In the area described at the beginning of my remarks, covering Citrus, Marion, and Hernando Counties, it seems that almost anywhere a pit or auger will reveal phosphate. In no opening that I visited in this section did I find it wholly absent. The very soil in some of the hammock lands is impregnated with it, as in South Carolina, while the ground around old wells and cisterns reveals its presence.

Outside of this region, as already said, both north, south, and west, there are undoubtedly large deposits whose extent and grade are as yet undetermined. They lie in lenticular beds upon the limestone—or lime carbonate, as it might better be termed, as it is rarely hard enough to be called a rock—and are covered by the sandy soil and clay subsoil, rarely cropping out at the surface. A valuable indication to me of their existence beneath the surface was an examination of the ant hills and gopher holes upon the tract. The earth thrown up by the former was interspersed with small whitish grains. These were found to be phosphate, and on digging or boring in the vicinity the deposit would be disclosed. A handful of sand from an ant hill, submitted to analysis, showed the presence of about five per cent. of phosphate. The material occurs at various depths below the surface, from two feet to ten or twelve. In sinking a pit, it is sometimes diffi-

\* Read before the Academy of Sciences, New York.

\* *Amer. Journal of Science*, vol. xxi.

cult to tell where the clay ends and the phosphate begins; they shade into each other, at times gradually; at other times the clay is entirely absent, the sand being the only thing between the surface and the valuable mineral. When wet they are dark or light yellow, but usually a dazzling white when dry. The thickness of the beds is very variable, and there is nothing to indicate it on the surface; it may be a few inches, or it may be 10, 12 or 16 feet of solid phosphate. A surface indication that is considered of value by some experts is the presence of masses of flint or silicious rock protruding from the soil, which seem to have segregated when the influences were at work which changed the carbonate of lime into phosphate, as has undoubtedly been the case. The area of some of the phosphate beds is sometimes also defined by curious boulders and masses of a hard phosphate rock, white or yellowish white, which has withstood weathering remarkably, and which is quite rich in phosphate.

As said, the phosphate proper varies in color from a dazzling white (when dried) to cream color. Professor W. P. Frost, of Savannah, to whose publication I am indebted for a description of the Dunellen field, which I did not visit, states in regard to the quantity: "I myself saw an auger bored sixteen feet into this stuff without going through it. It remained of the same consistence throughout—perfectly smooth and free from grit. It was a solid bank of phosphate sixteen feet thick to my certain knowledge, how much thicker I do not know, but the natives, who are ignorant men, not knowing the value of the material, testified that they had seen wells dug sixty feet through this material to reach water-bearing strata." Professor Frost, in

culty which will be experienced on all low grounds, from water, many of this class will be comparatively difficult to work. But on the pine ridges which constitute the greater area in Citrus County, this difficulty will not be encountered, especially because it seems necessary to go through the compact phosphate material to strike water, and above this point, I believe, only surface water will have to be contended with.

Among these pine ridges in the vicinity of Floral City are many localities which have been carefully examined by others, and from which I procured specimens containing from sixty to eighty-five per cent. of bone phosphate, the latter being a pure white article from the bottom of a well, which it was stated, and I have no reason to doubt the statement, was at that time thirteen feet deep in solid phosphate.

Near Floral City were two properties (among many) controlled by Mr. Collin M. Hawkins, of Raleigh, N. C. In company with Dr. H. B. Battle, the North Carolina State chemist, I examined these with considerable care, and the result will serve as a type of other lands in the vicinity. The tracts were rolling and consisted together of about 100 acres of sandy pine land, having some fifteen or twenty acres in productive orange groves. They had been developed by pits sunk at irregular distances in a zigzag manner across the field, being distant respectively from each other 138 yards, 226 yards, 93 yards, 84 yards, 60 yards, and 126 yards. They had all gone down until the phosphate was exposed, or until the owner of the land became discouraged at his supposed inability to find it. I may say here that with the eye alone the most experienced chemist, unless his experience has been obtained in

detached masses, if thrown on one side in digging and the sand on the other, will nearly equal the latter in bulk.

An analysis of the Peace River phosphate obtained by river dredging, in samples submitted to me, and which are shown here, gave in the coarser particles 58.42 per cent. of bone phosphate, and in the finer 60.38 per cent. In the samples from the Hawkins property spoken of, the percentage of oxide of iron and alumina varied from 5 per cent. as a minimum up to 10 per cent. as a maximum. In a sample from the hammock land, the maximum (15½ per cent.) of oxide of iron and alumina was found. The presence of iron and alumina, so dreaded by many of our American fertilizer manufacturers, was detected very early in the examination of these Florida beds, and yet in practical working it was found that in spite of these elements the other difficulties usual in such cases were not encountered, and the rock dried out fairly well and did not "revert" after treatment.

Professor Frost, above quoted, called attention to this fact, and says: "I can only account for these injurious constituents not acting in their usual way by supposing that the presence of lime counteracts their presence." I venture with some hesitation, in the absence of any thorough investigation, to say that from preliminary tests I think another explanation possible. Besides the phosphate of lime, there is in all the samples a certain amount of carbonate rock, in the rich specimens very little more than in the South Carolina, and also a good deal of sand or matter insoluble in dilute hydrochloric acid. An examination of this latter shows the presence of considerable clay. As all of



LADY CRICKETERS, LONDON.

speaking of the area at Dunellen, estimates that over 3,000 (out of 13,000) acres are underlaid with the mineral, which occurs in ridges and pockets, running by his analyses from fifty to sixty-five per cent. and averaging between fifty-five and sixty per cent. Much of this new phosphate has reached the more Northern mills, and is being experimented with—several tons having been shipped to Atlanta and elsewhere.

It is the policy of those who are securing land—and everybody in Florida seems to be of this class—not to prospect too much or commence shipments until they have gotten all that could be obtained. Dr. C. U. Shepherd, of Charleston, the leading expert on phosphates in this country, has established a laboratory at Ocala, and with guides, tents, and horses is swinging round my imaginary circle, with headquarters near Floral City when I was there.

In what was said above, I have depended largely on reliable information, especially as to the more southern and northern sections of the phosphate area. My own observation was made in the area lying between the Withlacoochee River and two large lakes upon which are situated the towns of Thompkinsville and Floral City. At the orange grove of Dr. Hawkins, a mile southeast of Rutland Post Office, on the river, the surface boulders showed the existence of phosphate, and it was apparent in the cistern which was being enlarged. On the adjoining plantation, in the midst of an orange grove, several pits have been sunk, revealing the presence of phosphate in numerous nodules or masses in the sand, but not in place; these masses nevertheless being so numerous as to make up, I should say, fully one-third of the material excavated below a depth of three or four feet. The masses were of a yellow color and quite hard. These deposits were in high hammock lands near the river, but, owing to the diffi-

Florida, and that within sixty days, is utterly at a loss, and his judgment no better than that of the average "cracker." I could not tell by the eye the difference between the carbonate of lime and the white phosphate, nor between the calcareous clay and the cream colored phosphate, and was much surprised at finding large percentages of phosphate in samples from pits which I had set down in my memoranda as not affording any promise. A sample from pit No. 2, marked by Dr. Battle as a poor specimen (in which I concurred) showed by analysis over 61 per cent. of bone phosphate. The samples from the seven pits above indicated yielded respectively about 61, 58, 62, 69 (another "poor specimen"), 50, 32, and 41 per cent.

There had been other pits on this property, just over the line, opened by previous prospectors before the property came under the control of Mr. Hawkins, which had been carefully filled up before they left. These were not reopened during my stay, but specimens picked up on the surface showed 64.85 per cent. of bone phosphate, 67.59 per cent. and 64.59 per cent. In one pit, situated upon a rise of ground, and which did not strike the phosphate until some 12 feet below the surface, an auger was run down to a depth of between two and three feet, and the boring yielded 50 per cent. of bone phosphate; as the auger had no handle, we could not go deeper.

The examination of these properties showed, first, the probable presence of phosphate underlying nearly the whole area, and, second, a considerable variation in the percentage at different depths. The deeper one goes into the material, the freer it is from clay and sand, and the purer. Unlike the samples from the hammock land that I have alluded to, these pits were quite uniform and solid; but even in some of the hammock properties I am told that, in prospecting, the

phosphate is readily soluble in dilute acid, while the clay and silica are not, I am led to believe that perhaps the phosphoric acid is practically all combined with lime, and not with iron and alumina, and that this fact may have been overlooked by chemists, who have simply determined the total amount of phosphoric acid, silica, alumina, and iron, regardless of their combination.

The nodules in the hammock district, which I analyzed, may compensate for their not being a continuous body by being of very high grade. The specimens gathered showed respectively 74.32 per cent. and 71.69 per cent. of bone phosphate.

In closing, I desire to call attention to the fact that in the present stage of developments there is yet great uncertainty; that I have personally examined but one part of the field, and that somewhat superficially, but believe that the facts here stated, which have been obtained with considerable pains from reliable sources, will prove sufficiently correct to give a fair view of the situation; and that the phosphate trade may regard it as settled that there is an enormous quantity of high grade material accessible with comparative ease in Florida, and that the center of production must undoubtedly leave Charleston in the near future. While there is much wild speculation and reckless investment, there is also a magnificent opportunity for intelligent expenditure of money for well chosen property, and great fortunes are to be made in the State, which but yesterday attracted little attention except for its climate and its fruit. For investigators to go down at this late day is, perhaps, useless; but with the co-operation of those who have been in Florida from the beginning of the excitement, and have intelligently tested and secured the best lands, there is a splendid field for Northern capital.