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State Geologist
on
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REPORT ON THE PHOSPHATES OF ALABAMA.

Early in May of the current year the Montgomery Daily Advertiser published a letter from Dr. E. A. Smith, State Geologist, to Gov. E. A. O'Neal, telling of the existence and discovery of phosphates at or near Hamburg, in Perry county Alabama. This official announcement to the world of the existence of phosphates was received by the farmers all over our state with wild delight. Our state agricultural economy consumes annually many thousands of tons of Commercial Fertilizers. The phosphates either raw or treated with sulphuric acid, constitute the chief bulk and cost of nearly every manipulated fertilizer. The presence of large beds of phosphates convenient to our water courses and railroads, meant numerous manufactories of fertilizers and cheap goods at an early day. The subject was one full of interest to every Alabamian, and particularly to those, to whom by law the fostering care of the agricultural interests of the state had been committed. No time was to be lost in fully investigating this subject. Accordingly at the request of Judge Betts, our Commissioner of Agriculture, a visit was made at once to Hamburg Ala., by the writer and his assistant, Mr. W. LeRoy Broun, Jr., in order to examine these deposits and obtain specimens for analysis. Upon arrival at Hamburg we made hasty but unsatisfactory examinations of the deposits. Having pressing collegiate duties which recalled me, I left Mr. Broun to make more extensive examinations and to collect further specimens for analyses. I append extracts from his written report.

"Upon arriving at Hamburg we found already in the field Mr. D. W. Langdon, assistant to State Geologist. With him the investigations were made.

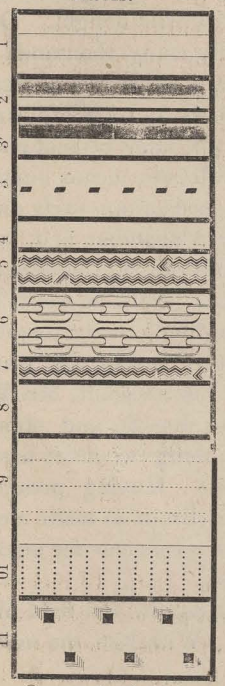
As stated by Dr. Eug. A. Smith the geological occurrence of this formation is in the Eutaw group of the lower cretaceous. The green sand marl with the phosphate-bearing rock immediately underlies the rotten limestone formation, and on the northern border of this lime belt or commonly "black belt," where the rotten limestone gives out there is exposed to the surface green sand marl with the underlying phosphatic deposit.

A limited investigation was made by Mr. Langdon and myself as

to the extent of the occurrence of these beds; as far as this investigation was made they were found to outcrop here and there over some of the fields of Mr. Spencer and also to the S. E. on the places of Messrs A. F. and A. J. Davis. From the places of Messrs Davis to the banks of Cahaba river, the geological formation was well developed.

Below is given a section of the formation in this locality, which is similar to that occurring on lands of Mr. Spencer, near Hamburg.

Geological Section near Cahaba River on Places of Messrs. Davis.



1 Rotten limestone increasing in depth to the South.

2 Green sand marl 0 to 6 ft.

3' Cream colored rock, soft, bearing Phosphoric Acid and some nodules.

3 Gray limestone bearing Phosphatic Nodules 1½ ft.

4 Hard indurated ledge 1 to 1½ ft.

5 Yellow micaceous sand, upper part shelly, 10 to 20 ft.

6 Ferrugenious sand 10 to 20 ft.

7 Hard indurated ledge 1 to 1½ ft.

8 Yellow sand, upper part shelly, 10 ft.

9 Blue laminated clay ½ to 10 ft.

10 Ferrugineous sand 30 to 40 ft.

11 Green sand, composing bed of Cahaba River, 4 ft.

Our principal investigations were carried on in Mr. Spencer's fields. The surface soils were made up mostly of greensand marl. Occasionally this has been washed off or removed and the soft gray limestone rock containing the phosphatic nodules was exposed. This rock decomposes by atmospheric agencies, liberating brown and cream colored phosphatic nodules, these, by their higher specific gravity remain, while the lighter gray matrix is washed away. Accordingly in parts of the field the soil is covered

by these nodules. They vary in size, from a pea to an egg and larger. Their shape is varied but in all cases the edges are rounded, some retaining the original spiral form.

By the aid of a few qualitative reagents we found phosphoric acid in considerable quantities both in the gray matrix which contained the nodules and the overlying greensand. In fact, its presence was proven in all the formations from 2 to lower part of 5. (See section above) Following the instructions of Dr. Smith, Mr. Langdon had dug in different parts of the field lying to the S. E. of Mr. Spencer's house, four pits. With the first greensand marl existed for a depth of four feet, with the remaining three, parts of the field were selected where this marl was almost or entirely absent. From two of these pits samples of the rock bearing phosphatic nodules were taken and their dimensions ascertained; they were then broken into small pieces from which were taken all the nodules, these were collected and weighed. Below I give a statement of the results with the calculated amount per acre.

	Depth from Surface at which Sample was taken.	Thickness of Green sand Marl	Thickness of Phosphate Rock.	Size of Sample taken for getting nodules.	Wt. of Nodules Extracted.	Yield per Acre.	Average.
Pit I	5 ft 8 in.	4 ft	2 ft	¼ Sq ft x 1 ¼ in	5½ ozs	574.8 tons	
Pit II	9½ "		2 ft	1 Sq ft x 3 "	1½ lbs	261.4 "	
Pit II	18 "		2 ft	12 in x 12 in x 1 in	6 ozs	208 "	377.92
Pit II	25 "		2 ft	6 in x 6 in x 2 in	4 ozs	261.4 "	tons
Pit II	33 "		2 ft	6 in x 6 in x 2 in	12 ozs	784 "	
Pir III			2 ft				
Pit IV			2 ft				

From the above, the samples taken 9½ inches to 18 inches from the surface apparently yield a small amount per acre, the cause of this is that the position selected for pit II was one where no overlying green sand marl existed, the rock itself was only covered by a thin stratum of earth, disintegration had taken place, but no washing away of the disintegrated particles, consequently the upper part occupied a larger space than when in the compact condition and in proportion the yield for any given amount was less.

The sample taken from 23 inches from the surface was unusually poor in phosphatic nodules."

As a further contribution to this interesting subject, I insert a most valuable paper from Dr. E. A. Smith, our State Geol-

ogist, containing an account of the geological relations of the phosphates of Alabama and an explanation of the probable origin of all phosphates. This paper also contains a number of analyses made in the Laboratory of the University of Ala. I regret that we were unable to fill the blanks with the analyses made in the State Laboratory, but the printer was ready before our work; they will however, be found in the tables at the end of this bulletin.

REPORT ON THE PHOSPHATES OF ALABAMA

BY

E. A. SMITH PH. D., STATE GEOLOGIST.

The distribution of the phosphate deposits of this state will be made clearer by referring to the account of Cretaceous formation of Alabama, given in the lately published report of the State Geological Survey, 1881-2, pages 237, and 266-267, &c.

This formation is made up of three parts. The lowermost of these, called the Eutaw group, about 150 feet in thickness, consists of alternating beds of clay and sand, the latter often containing much of the mineral called "glauconite" or greensand, which is essentially a compound of silica, iron, and potasium. Upon exposure to the atmosphere the greensand beds assume a yellowish brown or reddish color, due to the oxidation of the iron.

Overlying the Eutaw group is an impure argillaceous limestone interstratified with clays, called the "Rotten Limestone.". This limestone, which has a thickness of 1000 feet and more, shows a remarkable degree of uniformity in its composition, except at its base and summit, where there are gradual transitions into the underlying and overlying groups. It is in these transition beds that the phosphates occur, and to these we shall direct special attention.

Next above the Rotten Limestone lie the beds of the Ripley group, consisting of hard, sandy, crystalline limestone, underlaid by calcareous clays, and bluish micaceous marls. The alternation of harder and softer strata, gives character to the topography of the country in which these rocks occur, and which is known as the "hill prairie" region.

The prairie hills are usually very steep and abrupt, and the depressions between them are filled in with the sandy loams of the drift, usually more or less mingled with the washings of the calcareous clays which alternate with the hard limestone ledges of the

llsides. The soils resulting from these mixtures are stiff, marly, and in many cases extremely fertile.

Towards the eastern part of the state, the blue micaceous marls of this formation become more prevalent, and are well known in the Cowikee and Bear Creek lands of Russell and Barbour counties.

All these strata have a gentle slope or dip towards the south or southwest, by reason of which they outcrop, or appear at the surface, in parallel belts across the state from east to west, the lowest beds coming to the surface furthest northward, while the newer ones appear in successions as we go southward. As a further consequence of this dip of the strata, any one of these beds, while appearing at the surface only in a comparatively narrow belt, passes beneath the newer beds and may be found at a depth below the surface, constantly increasing as we go southward. The bearing of this fact upon the future mining of phosphates is obvious.

As before stated, the phosphatic deposits of our Cretaceous region occur in two positions, viz., at the base, and at the summit, of the Rotten Limestone; in both cases in transition beds between this and under or overlying rocks. In the special description of these occurrences it will be best to consider them separately.

1. THE EUTAW, HAMBURG, SELMA BELT.

Mr. J. W. Spencer appears to have been the first to suspect the true character of the phosphatic nodules which are so abundant about the old town of Hamburg in Perry county. After analyses made by Dr. C. U. Shepard of Charleston, S. C., and in the laboratory of the Alabama Geological Survey at Tuscaloosa, had placed beyond doubt the composition of these nodules, the locality was visited and closely examined by a number of persons, but particularly by Mr. D. W. Langdon, Jr., of the Geological Survey, and Mr. W. LeRoy Broun Jr., Assistant Chemist of the A. & M. College.

The following section of the strata at Hamburg, given in descending order, will show the mode of occurrence and general character of the phosphatic materials at that place.

1. Base of the Rotton Limestone. The beds here included, contain very little phosphoric acid.

2. Greensand, averaging about five feet in thickness, and strongly impregnated with phosphoric acid. The lowermost strata of this greensand contain a few phosphatic nodules, which however become much more abundant in the next succeeding stratum.

3. Sandy calcareous stratum, matrix of the nodules, five to six feet in thickness. Where this bed outcrops in the fields the surface of the ground is covered with the phosphatic nodules, which are concretionary masses of nearly pure phosphate of lime, of exceedingly irregular shapes, and from sizes varying from small pebbles no larger than a pea, to pieces two or more inches in diameter. The nodules vary also in color, from light gray to dark brown, and they may easily be recognized by the peculiar odor which they emit when rubbed together or broken. This odor is described by some as "fishy", by others as "bituminous" or "naphthous," as it resembles to some degree the odor of crude petroleum. Along with these phosphatic nodules are also great numbers of casts or moulds of fossils, usually somewhat worn, and badly preserved, and consisting of fragments of Ammonites, Baculites, Nautili, and other well known Cretaceous forms. These casts have themselves, in most cases, been more or less phosphatized, and in some instances have almost entirely lost their organic shape and structure, and are then difficult to distinguish from the nodules. Besides these there are great numbers of the teeth of sharps, and bones of saurians.

The nodules are found as above stated, in small numbers in the lower beds of the greensand, but more abundantly in the next underlying stratum, mainly through about two to two and a half feet of its thickness. In quantity, according to the estimates of Messrs Langdon and Broun, these nodules would average some two to eight hundred tons to the acre. The nodules compare favorably in composition with those of South Carolina as may be seen from the analyses given below.

4. Hard ledge of calcareous sand, six to eight inches in thickness, and holding a considerable quantity of phosphoric acid as shown by the subjoined analyses,

5. Loose sandy beds, micaceous, with numbers of shark's teeth and in the upper part just beneath the hard ledge No. 4, filled with the shells of small oysters. This division is about thirty feet thick, and holds some phosphoric acid as may be seen from the analyses. It passes below into a greensand.

The following analyses will show the composition, (or rather the contents of phosphoric acid), in the various materials occurring at Hamburg.

1.--The Greensands from Spencer's Field, Hamburg, Alabama.

	Phosph Acid	Bone Phosph	Analyst.
1. Greensand	11.41	24.88	W. I. Herzberg. Univ. of Ala.
2. "	10.16	22.15	" " " "
3. "	10.19	22.21	T. D. Stallings, " "
4. "	11.51	24.99	D. J. Spotswood, " "
5. "	11.20	24.42	John Daniel, " "
6. "	9.00	19.62	" " " "
7. "	11.78	25.78	C. R. Westcott, " "
8. "	9.31	20.29	" " " "
9. "	11.33	24.70	" " " "
10. "	5.16	11.26	" " " "
11. "	9.97	21.78	" " " "
12. "	8.12	17.70	Eugene A. Smith, Univ. of Ala.
13. "	7.6	16.59	Dr. Chas. Gibson, Chicago.

2.--The Nodules and Phosphatic Casts of Fossils from Spencer's Field, Hamburg, Ala.

	Phosph Acid	Bone Phosph	Analyst
1 Nodule	22.02	48.00	W. I. Herzberg, Univ. of Ala.
2 Phosphatized shell	19.80	43.16	" " " "
3 Surface Nodules	38.00	82.84	John Daniel " "
4 Surface Nodules	35.5	77.39	" " " "
5 Surface Nodules. Sample 1 lb...	25.66	55.88	Chas Gibson, Chicago.

For further analyses see table at back.

3.--Matrix of the Nodules from Spencer's Pit No. 2, Hamburg, Alabama.

	Phosph Acid	Bone Phosph	Analyst.
1. Matrix of Nodules	5.12	11.16	E M. Harris, Univ. of Ala.
2. " " "	4.2	9.16	John Daniel, " " "
3. " " "	4.65	10.14	L. L. Dean, " " "
4. " " "	8.00	17.44	" " " "
5. Blue Matrix of Nodules	2.2	4.80	Chas. Gibson, Chicago.
6. White " " "	3.6	7.85	" " "

For further analyses see table at back.

4.--Indurated Ledge.

	Phosph Acid	Bone Phosph	Analyst
Indurated Ledge	1.16	2.53	State Laboratory, Auburn, Ala.

5.--Sands Below the Indurated Ledge from 1 to 2 feet at Spencer's, Hamburg, Ala.

	Phosph Acid	Bone Phosph	Analyst.
1. Sands	6.5	14.17	R. H. Stickney, Univ. of Ala.
2. Sands	3.8	8.28	" " " " "

The analyses made at State Laboratory were not completed in time to be inserted in their proper places. At the back of this Bulletin will be found a table of all those made here, together with those furnished by State Geologist. W. C. S.

From Hamburg, Mr. Langdon has traced the outcrop of the nodule bearing stratum eastward to the Dallas county line, and westward to the vicinity of Greensboro; while Mr. John Daniel of the University, has followed this line of outcrop continuously from Perry county eastward to within a few miles of Selma, thus demonstrating the fact that these phosphates occur without interruption from

Greensboro to Selma; and without material change in the character of the phosphates and their mode of occurrence.

Beyond these points the same beds have been discovered at Choctaw Bluff, (Warrior River), at Eutaw, Pleasant ridge and Pickensville, in the one direction, and at Mulberry, and other places in western Autauga, at Prattville, Wetumpka, Tuskegee, and Society Hill, in the other direction, thus forming a belt which stretches practically entirely across the state. Of the quality of the phosphates found at these points, the following analyses give sufficient evidence; of the quantity, and commercial value of the same we can be sure only after long continued and careful examination.

Pickensville, Pickens County.

1. Fossil casts and nodules, collected by Mr. Walton Harrison. See table No. 207.

Pleasant Ridge, Greene County.

1. Nodules and casts from Turkey Creek Hills, R. K. Horton, collector. See table No. 177

SELMA, SUMMERFIELD AND VICINITY, DALLAS COUNTY.

1. Greensand, 8ft in thickness, J. R. Barker's mill, John Daniel, Collector. See table number 162.
2. Nodules from near Valley Creek church, 3m S. E. of Summerfield, from stratum overlying the greensand, John Daniel Collector. See table number 163.
3. Greensand from near Selma, Jos. Hardie, Collector. See table number 164.
4. Fossil casts and nodules, near Selma, J. H. Robbins Collector. See table number 165.
5. Fossil casts and nodules, 3m from Selma, Kernan's Place. See table number 166.
6. Nodules from near Selma (Sampled) Jno. Daniel Collector.
7. Nodules from near Selma (Sampled) Jno. Daniel Collector.
8. Nodules from near Selma (Sampled) Jno. Daniel Collector.
9. Nodules from near Selma (Sampled) Jno. Daniel Collector.
10. Matrix of nodules, near Selma (Sampled) Jno. Daniel Collector.
11. Matrix of nodules, near Selma, John Daniel Collector.

Mr. Leonidas Howard, of Mulberry, has devoted a good deal of time to the examination of the phosphate deposits of western Autauga, and from his collection, we learn that besides the nodules, a portion of the limestone beds, and the greensands are phosphatic.

The analyses below show the character of the several materials sent by him for examination.

	Phosph Acid	Bone Phosph	Analyst.
	26.1	56.90	John Daniel, Univ. of Ala.
	25.8	56.24	John Daniel, Univ. of Ala.
	36.0	78.48	John Daniel, Univ. of Ala.
	38.0	82.84	John Daniel, Univ. of Ala.
	5.05	10.11	John Daniel, Univ. of Ala.
	3.98	8.67	John Daniel, Univ. of Ala.

MARION AND VICINITY, PERRY COUNTY.

1. Fossil casts, A. T. Moore Collector. See table number 187.
2. Light colored greensand marl, M. W. Oliver. See table number 188.
3. Dark Bluish greensand marl, M. W. Oliver. See table number 189.
4. Greensand, Carlos Reese's, 2m S. E. of Marion. See table number 190.
5. Fossil casts. Dr. W. W. Wilkerson's, 4 M. S. of Marion. See table number 191.
6. Greensand, E. N. Driver, Scott's Station. See table number 192.

GREENSBORO AND NEWBERNE, HALE COUNTY.

	Phosph Acid	Bone Phosph	Analyst.
1. From Cocke's mill, 6m from Greensboro, D. W. Langdon, Collector,	4.30	9.38	Chas. Gibson, Chicago.
2. Nodules and fossil casts, from Mrs. Jemison's 6m N. E. of Newberne, D. W. Langdon, Collector,	See table number 183.		
3. Fossil casts. Chas. W. Turpins, near Newberne, D. W. Langdon, Collector,	See table number 184.		
4. Fossil casts. J. B. Reid's, near Greensboro, D. W. Langdon Collector.	See table number 179.		

CHOCTAW BLUFF, WARRIOR RIVER, GREENE COUNTY.

	Phosph Acid	Bone Phosph	Analyst.
1. Greensand from just below Rotten Limestone, Eug. A. Smith, Collector,	5.03	10.96	W. I. Herzberg Univ. of Ala.

See table numbers 212 &c.

EUTAW, GREENE COUNTY.

At this place, nodules are found embedded in greensand, and in a whitish calcareous sandy matrix, seen in railroad cut under the bridge, in the well at fair grounds, in Mr. Kirksey's field, and on the western side of the town at Mr. C. S. Brag's.

With the nodules are also as usual, phosphatic casts of fossils, sharks teeth, &c.

	Phosph Acid	Bone Phosph	Analyst.
1. Greensand, from well in fair ground, E. A. Smith Collector	7.80	17.01	W. I. Herzberg Univ. of Ala.
2. Phosphate Sand, C. S. Brag's near Eutaw, E. A. Smith, Collector	9. 11	26.24	T. D. Stallings. " " "

3. Greensand near Hotel, E. A. Smith, Collector. See table number 180½.
4. Indurated greensand, N. E. fair ground, E. A. Smith, Collector. See table number 180.
5. Nodules and casts E. of fair ground, E. A. Smith Collector. See table number 181.

NEAR MULBERRY, AUTAUGA COUNTY.

2. Hard siliceous limestone, collected by Leonidas Howard. See table number 155.
3. Hard siliceous limestone with shell casts, collected by Leonidas Howard. See table number 155½
4. Argillaceous limestone, with greensand and phosphate grains, collected by Leonidas Howard. See table nnmber 156.
5. Argillaceous limestone, upper part of No. 4 more greensand, collected by Leonidas Howard. See table number 157.
6. Greensand, 10 inches thick collected by Leonidas Howard See table number 158.
9. Greensand marl from a well, collected by Leonidas Howard. See table number 159.
11. Main greensand bed, 1 ft thick, collected by Leonidas Howard. See table number 160.
12. Calcareous sinter, phosphates, collected by Leonidas Howard. See table number 161.

DAY'S BEND, AUTAUGA COUNTY.

1. White Phosphate marl, W. A. Gunter, collector. See table number 185.
2. Phosphatic casts and nodules W. A. Gunter collector. See table number 186.

PRATTVILLE, AUTAUGA COUNTY.

	Phosph Acid	Bone Phosph	Analyst.
1. Nodules near Prattville, collected by Dr. S. P. Smith	28.14	61.34	E. M, Harris, Univ. of Ala.
1½. Nodules near Prattville, collected by Dr. S. P. Smith	32.0	69.76	E. M. Harris, Univ, of Ala.

WETUMPKA, ELMORE COUNTY

1. Greensand marl, John Enslen, Collector. See table number 175.
2. White Phosphate marl, John Enslen Collector. See table number 176.

FORT DEPOSIT, LOWNDES COUNTY TO UNION SPRINGS, BULLOCK COUNTY.

	Phospn Acid	Bone Phosph	Analyst.
1. Hard Crystalline Siliceous limestone, 2m North of Fort Deposit, E. A. Smith Collector	13.55		Eug. A. Smith.
2. Siliceous limestone. Strata, Crenshaw county, E. A. Smith, Collector	6,22		" " "

3. Siliceous limestone. Olustee Creek, Pike county. T. M. L. Moore, Collector. See table number 211.

From these analyses and from the above notes it will be seen that the nodules from the various localities will compare very favorably with those from South Carolina, and are rich enough in phosphates to be shipped to any part of the world. They have, however, as yet, not been found in sufficient quantity in any place to be of great commercial value, but it must be remembered that Hamburg is the only place which has been examined with any degree of thoroughness.

In the greensand on the other hand, we have a material which cannot fail to be of great importance to the agricultural interests of the state, since it occurs in a bed of three to four feet in thickness, from Eutaw to Wetumpka, and probably across the entire state, and holds on an average nearly 10 per cent of phosphoric acid, equivalent to nearly twenty-two per cent of bone phosphate. In addition to the phosphoric acid, it holds 5 per cent. or more of potash, another important element of plant-food.

Experiments on a large scale to determine the practical and commercial value of this substance, are now in progress at the manufactory of the North-Western Fertilizer Company in Chicago, under the direction of Dr. Charles Gibson the chemist of the establishment, who has visited several of the localities named above, and who has made some of the analyses above given.

2. THE LIVINGSTON, FORT DEPOSIT, UNION SPRINGS BELT.

Soon after the discovery of phosphates at some of the localities above given, north of the prairies, a systematic examination for phosphoric acid was made of the specimens in the cabinet of the Geological Survey at the University of Alabama, and it was soon discovered that the limestones and other rocks of the Ripley group immediately overlying the Rotten Limestone, were all more or less phosphatic.

These rocks outcrop in a belt which extends across the state east and west, along the southern border of the prairie region, just as the first named phosphate belt appears as a border along the northern edge of the prairies.

The localities are of course very numerous, and as some of the rocks, especially the hard crystalline and sandy limestones appear to contain uniformly a high per centage of phosphoric acid, the aggregate amount of this substance is very great.

In this belt the phosphoric acid is found impregnating the lime

stones and marl rocks of the formation, and in addition is found in nodular or concretionary masses of tolerably pure phosphate of lime, and the casts or moulds of the fossils which are quite abundant in many localities, are all strongly phosphatised, having about the same composition as the nodules themselves. It is interesting to note in this connection, that wherever the original substance of the shell is present in any of these fossil remains, as is the case with the exogyras, and gryphoeas, of the oyster family, co-abundant throughout the prairie region, there is scarcely a trace of phosphor ic acid. The uppermost beds of the Rotten Limestone itself also appear to be very generally phosphatic, as may be seen from the analyses of this rock from various localities in the vicinity of Liv ingston in Sumter county.

Thes specimens were all taken from the surface on the slopes of the hills, generally on the South-east slopes, and usually seem to be only the crumbling or disintegrating part of the Rotten Limestone, and yet when the compact rock immediately underlying these phosphatic fragments is examined, it usually shows a very small proportion of phosphoric acid. In all cases the fossil casts are phosphatic.

Livingston and Vicinity.

1. Near R. R. bridge in N. E. part of the town of Livingston.....See table No. 199
2. Siliceous rock at negro graveyard 2½ M. S. E. of Livingston...Phosphoric Acid...7.30, Bone Phosphate...15.91....Analyst. Eug. A Smith.
3. Argillaceous lime rock. same locality..... ....See table No. 200
4. From hill 3¼ M. from Livingston on Jones' Bluff road..... " " " 201
5. Siliceous-Argillaceous lime rock 4½ M. from Livingston..... " " " 202
6. Phosphatic nodules 3¾ M. North of Livingston on Gainesville road.. " " " 203
7. Phosphatic rock6 M S. E. of Livingston, on Black Bluff road..... " " " 204
8. Fossil casts from same locality as 7..... " " " 205
9. White argillaceous limestone from Col. J. J. Lee's, 4 M. S. E. of Livingston..... " " " 206

These specimens were, with the exception of No. 4, all collected by the writer, (E. A. S.), in company with Dr. R. D. Webb, of Livingston, whose knowledge of the geological and topographical features of Sumter county is extensive as well as accurate. Many years ago, Dr. Webb made analyses of some of these materials, and in the newspapers called attention to the comparatively large percentage of phosphoric acid which they contained.

The other localities from which specimens have been obtained. have not been examined particularly with reference to the occurrence of phosphates, and we can, at present, do little more than give the analyses of the phosphatic material from the several localities. reserving for a future occasion the description of their stratigraphical relations.

The siliceous and glauconitic limestones appear to be everywhere several feet in thickness, (four to five), as do also the marls.

Coatopa, Sumter County.

1. Shell casts and nodules, John Wiatt's land. Eug. A. Smith, collector. See table No 193
2. Clayey marl from Wiatt's " " " " " " " " 194
3. Argillaceous limestone with greensand, Wiatt's, " " " " " " " 195

Moscow and Vicinity, Sumter County.

1. Siliceous rock from river bluff just below Moscow, Eug. A. Smith col. See table No 196
2. Shell casts " " " " " " " " " " " " 197
3. Greensand Marl (Dr. Kelly), a few M. N. of Moscow, Dr. Kelly, " " " " 198

Richmond, Dallas County.

1. Siliceous limestone sent by Dr. Keyser.....See table No. 167
2. Glauconitic " " " J. Z. Hearst..... " " " 208
3. Siliceous " " " " " " " " " 209
4. " " " " " " " " " 210

Minter Station, Dallas County.

1. Glauconitic limestone sent by H. M. Smith.....See table No. 168
2. Siliceous " " " Col. N. H. R. Dawson..... " " " 170
3. Phosphatic shell casts " " " " " " " " " 169

Tuskegee and Union Springs.

See table No's 225 &c.

Flora, Bullock County.

1. Dark colored clay marl sent by Dr. C. B. Leitner.....See table No. 171
2. Yellow clay marl sent by Dr. C. B. Leitner..... " " " 172
3. Dark colored clay marl sent by Dr. C. B. Leitner..... " " " 173
4. Dark Gray clay marl sent by Dr. C. B. Leitner..... " " " 174

Other Occurrences of Phosphates.

In addition to the two well defined belts of phosphates above described, phosphatic casts of fossils and phosphatic nodules have been found overlying the Rotten Limestone itself, in two localities, viz: at Boligee in Greene, and between Newberne and Uniontown, seven miles from the former place in Hale county. These occurrences appear to be similar to some of those about Livingston where the upper beds of the Rotten Limestone seem to be pretty generally phosphatic.

It may be that phosphatic strata are to be found at intervals through the whole thickness of this rock, being more abundant, however, at the base and summit.

The subjoined analyses show the composition of the nodules and casts overlying the Rotten Limestone and at a distance from both northern and southern borders.

1. Nodules and casts 7 M. S. of Newberne on Uniontown road, collected by D. W. Langdon, Jr.....See table No. 182
2. Fossil casts from Boligee, Greene co., collected by Chester Harding.. " " " 178

The phosphates above described in geological position, mode of occurrence, aud character of the material, resemble the phosphates of

Cambridgeshire, England. These are found at several horizons in the formations immediately underlying the Chalk, viz. the Upper Greensand, the Gault, and the Neocomian, or Lower Greensand: the phosphate or "coprolite" beds appear always to mark horizons of unconformity, i. e. they seem to have been deposited upon the eroded surfaces of previously existing strata; they consist of casts of shells, bones, etc., mineralized by phosphate, and of shapeless masses of phosphate of lime ; they are irregularly distributed through the matrix along with pebbles and other rolled masses; and many of the phosphatized casts are of fossils which belong to earlier formations than those of which they now form a part. (See T. G. Bonney, Cambridgeshire Geology; and W. Keeping, (The Fossils of Upware, etc.)

So our Alabama phosphates occur at several horizons in the Cretaceous Formation; and they occur at planes of unconformity. This is particularly noticeable in the case of the phosphates at the base of the Rotten Limestone. In western Alabama, along the Tombigbee River, from 800 to 1000 feet of Lower Cretaceous, and probably also of Jura-Trias beds underly the Rotten Limestone, the northern outcrop of which is at least thirty miles from the Coal Measures at Tuscaloosa, while eastward, these underlying beds seem to thin out so that at Wetumpka, the phosphate bearing beds almost lap over upon the Metamorphic rocks.

The fossil casts are worn into most irregular shapes, and are associated with the bones of saurians, and the teeth of sharks. These phosphates are mingled with rolled or water-worn fragments of other rocks, especially is this the case in the southern phosphate belt. At Fort Deposit, or just south of it, is a ridge which owes its existence to the hard crystalline limestone of the Ripley group; the foot of this, and the plain north of it for several miles, are strewn with rounded and water-worn fragments of this siliceous limestone.

The specimen from Fort Deposit of which an analysis is given above, was one of these rounded and water-worn fragments.

The same thing may be noticed at Strata, and probably at very many other similar localities. Speaking of the Chunnenuggee Ridge at Union Springs, Prof. Toumey says, "The north side of the ridge presents the appearance of an ancient sea-beach, waterworn, detached masses of limestone and calcareous sandstone, embedded in sand, and presenting the appearance of having been washed for ages by the ocean waves." (2nd. Report on the Geology of Alabama, p, 136.)

It is thus seen that in all these respects, the Alabama phosphate

beds resemble those of England, and it is quite probable that many of the phosphatic shell casts, are "derived" fossils, that is they have been washed out of the beds of which they originally formed a part, and redeposited in the beds where they are now found. To decide this question, a thorough study of our Cretaceous fossils will be needed.

In South Carolina a very similar state of things exists, only the phosphate beds are of Tertiary, or later, instead of Cretaceous age.

The explanation of the origin and mode of formation of the phosphatic deposits now most generally accepted, is that originally presented by Prof. Holmes of Charleston, which is thus well summarized by Dr. C. U. Shepard, Jr., "Accumulations of decomposed animal detritus and exuviae were acted on by carbonic acid water, which dissolved out the phosphates and transported them into calcareous earth, where they were precipitated and fixed by carbonate of lime. This process was continued till the carbonate of lime was transformed into a rich phosphate of lime. The mass, originally soft and loose, hardened gradually, but under the wear and roll of water it was broken up and rounded into the phosphatic pebbles now found."

Prof. T. G. Bonney, (Geology of Cambridgeshire,) has given the following account of this process; "With regard to the mode of formation of these phosphatic casts, nodules, etc., we have to consider not only the probable source of the phosphate, but also the mode in which it has been concentrated into these "coprolites." Phosphate of lime in the form of the mineral Apatite is present in granite, gneiss, slate, talc, and chlorite schists, and several kinds of lava. .... It is also present in the waters of numerous mineral springs...., It has been detected in the waters of several rivers, and is probably present in all, as well as in the sea, though of course in small quantities. Again, phosphates (chiefly of lime) are present in marine and other plants. In short, the various investigations that have been made show that it is almost universally present in organic and not unfrequently in inorganic bodies."

Next it has been shown by numerous experiments that phosphate of lime is soluble in carbonated water, and further, that phosphate of lime present in an organism, (plant or animal) is much more soluble than that in a mineral.

"Again, phosphate of lime dissolved in carbonated water is precipitated by ammonia, which is a result of decomposition of organic

bodies." "It appears, then, to me that the best explanation of these phosphatic nodules is to consider them formed by what, for want of a better name, we may call concretionary action. The excreta, softer tissues, and smaller bones of the Vertebrata, the bodies of numerous Invertebrata, many of which have left no other trace behind, the various marine plants which probably would flourish abundantly in a shallow sea, to say nothing of any apatite which might be present in the detritus wherein they were entombed, would furnish a considerable supply of phosphates; in fact, caeteris paribus, a shallow sea appears to me more likely to be rich in phosphates than a deep one. The phosphates of the more perishable parts of the abovenamed organisms would be dissolved in the water permeating the mud of the sea-bottom, which would also be supplied with carbonic acid from decomposition, and so the mud be saturated with a weak solution of phosphate of lime. Now, if at a certain point in the mud there were an excess of phosphate of lime, and especially if ammonia were being involved at that point, the phosphate in the neighboring solution might be preciptated; and probably (for it seems to have often happened with other minerals) all the phosphates of the surrounding mass would be precipitated about this nucleus. I regard, then, these nodules as the result of a process which took place during a part of the Gault period, and was continued during the Greensand epoch; which began shortly after the death of the organism, and lasted for a long time; and I explain their abundance, as I have already said, by considering the seam as the riddlings of a considerable deposit. It is note-worthy how often a bed of phosphate nodules comes just above a more or less marked stratigraphical break. It appears to me, therefore, that the process of formation of these nodules is... very analogous to that of flint; both, in many cases, proceeding from the mineralization of sponges."

It may not unfairly be asked, why, seeing that weak solutions of phosphate of lime must be almost always present in sea-water, are not phosphate nodules generally present in rocks. The answer to this is that phosphate nodules are far from rare, and that the difficulty is exactly of the same kind as exists in the formation of flint.

"It may be that local circumstances, as indicated above, have been favorable to slightly concentrating the phosphatic element in the sea-water; but without availing ourselves of this possibility we may fairly answer that the process of deposition from weak solutions, one of which we are very ignorant, is probably a complex process which

requires several independent conditions to be fulfilled, so that it is but rarely that all are satisfied."

I have spoken above of the circumstance that casts of fossils are generally phosphatized, while those fossils, especially those of the oyster family, which retain their original shells, show scarcely a trace of phosphoric acid.

The purer limestones also are usually very slightly if at all phosphatic. This circumstance is accounted for by Mr. Keeping, (Fossils of Upware) on the supposition that the purer carbonate of lime was uncongenial to the phosphatic matter which was taken up more readily by the more argillaceous mud, which formed the impure limestones and which filled the cavities of the shells and produced the casts and moulds of which we have spoken.

The lessons to be learned from a careful study of the mode of occurrence of our phosphates, and of the conditions under which they have probably been accumulated are obvious. We see that the formation of phosphatic deposits is not confined to any one geological period, but will follow whenever certain conditions, (some of which have been given above) are fulfilled. The association of phosphatic deposits with breaks or interruptions in the conformability of the strata, and the connection between the two, are also not without their practical bearings." E. A. Smith. Ph. D.

State Geologist, University of Alabama.

After returning from Hamburg, at the request of Judge Betts our Commissioner of Agriculture, and with the approval of Dr. Smith, State Geologist, Mr. LeRoy Broun, Jr., was sent to search for phosphates in the Eastean part of the state. At this time the upper phosphate deposits had been traced from near Montgomery, Ala., westwart to the Mississippi line. We were curious to know whether the same geological formation in the Eastern part of the state also abounded in phosphates. Accordingly Mr. Broun was sent to Tuskegee with instructions to follow the Northern limit of the rotten limestone belt Eastward to Georgia, examine closely for phosphatic deposits, take samples and forward to state laboratory for analyses. His work was very satisfactorily performed and the evidence clearly established of the continuation of the phosphate deposits through this part of the state, but so deeply covered by the drift, as to be of practically little value save locally where the creeks have cut through the drift into the beds of greensand, which

are found everywhere in the state, overlying the rock bearing the phosphate.

Analyses of the samples sent from this section of the state may be found in the table at the back, No. 225.

I append the report of Mr. Broun.

On May 19th, soon after returning from Perry county in the Western part of the state, I left, by your request for Tuskegee, in Macon county to follow up and trace from there east as far as the state border these natural phosphate deposits. The tracing of this bed in these counties (Macon and Russell) was attended with difficulties from the overlying clay and sand drift, which exist almost everywhere to the depth of fourteen to fifteen feet.

The first trace of this formation was recognized on the place of Mr. T. L. Nobles T. 17 R. 23 S. 36. Here a few feet from his house is a well dug four years ago. The debris taken from the well was allowed to accumulate, and from this mass greensand marl was taken in abundance. It will be remembered that this greensand marl immediately overlies the phosphate beariug rock in the Western part of the state. As far as could be gathered, the greensand marl in this section is immediately underlying the clay drift, which exists here to the extent of some twenty feet. Following this indication S. E. and E. the next and most decided evidence of the presence of this phosphatic bed was found to exist on the place and in the neighborhood of Mr. Frank Howard T. 16 R. 23 S. 22. Here, on the banks of Little Charlie creek occurs an outcrop of greensand marl, an attempt was made to pass through this to the underlying phosphate bed, but for lack of proper tools I failed to do so. In this community the drift formation as in other localities covers every thing and recourse to the examination of wells had to be made.

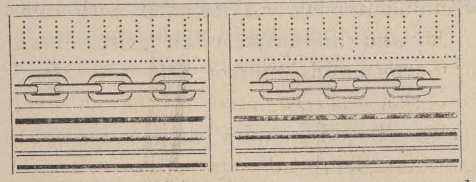
These for a circuit of one mile and a half, as far as examination was made, were dug by first passing through drift clay of 8-10 feet underlying which was encountered greensand marl of 6-12 feet.

At the well of Mr. W. W. Dubose one mile east of Mr. Howard's* in a small amount of debris taken from it and lying near was found samples of the phosphate rock sought for; in one case a phosphatic

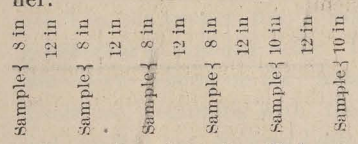
*I wish to acknowledge the courtesy shown me by Mr. Frank Howard and his son, both of whom accompanied me while in his community and rendered much assistance in the investigation which could not have been obtained otherwise. I also wish to acknowledge his assistance given in making out a map of the north border of the lime belt in this part of the state, which from his knowledge of the country he was so able to do.

nodule encased in the gray matrix rock was found; others would have been sought for and obtained but the larger part of the earth had been scattered over the adjoining fields.

From the locality of Mr. Howard's this green sand marl formation extends almost due east, on the place of Mr. J. M. Comer four miles S. E. of Tuskegee T. 16 R. 24 E½ S Q., a well giving a good example of the formations as dug through, exists. This was entered and samples taken; I give a cut of the formations with the manner in which the samples were taken.



In the green sand marl samples were taken in the following manner:

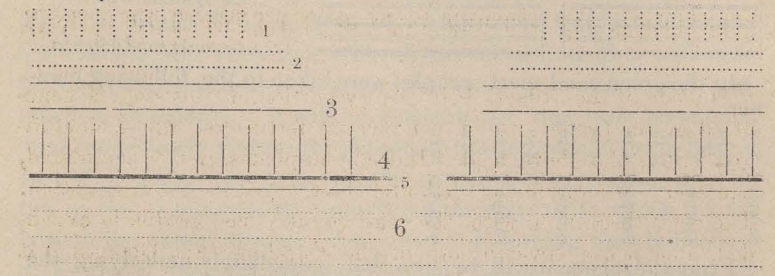


From the above it will be seen that immediately underlying the green sand marl is a sandy formation. This differs from that of Perry county, since this phosphate nodule bearing rock comes next in order to the green sand marl. I am confident from finding the samples spoken of near the well of Mr. W. W. Dubose that this phosphate rock still underlies this formation. To prove this I have had no opportunity, since generally water is gotten in this sandy strata preventing any further observations.

Following the above traces of marl almost due east, samples were gotten near Smith's store, though no where going east was it found outcropping on the surface. The belt extends to within one and a half miles south of Society Hill and about one mile of Marvyn. From this point going east the formation changes to one of blue clay interstratified with small amounts of pyrite, this clay when dug out of the well is hard, though it soon crumbles from the oxidation of the pyrite, This formation was followed for some twelve miles; feeling confident that the green sand marl and with it the phosphates beds had given out near Marvyn, I proceeded immediately to the Chattahoochee river, at the mouth of Uchee creek.

Here at the head of Uchee shoals the banks of the river are made up of blue laminated clay overlayed by drift, Underlying this laminated clay and composing the bed of the river is a bluish green massive clay containing sand, probably green sand.

I wish also to report the occurrence of phosphatic limestone rock in the eastern part of the state overlying the rotten limestone formation. This exists as far west as Cubehatchee creek and Union Springs, the extent of western and southern examination. A series of hills and ridges having a general parallel direction, their trend being N W and S E. Below is a section of two of these adjoining ridges near Cubehatchee creek, all others from Cubehatchee east by Cotton Valley and Warrior Stand are either in part or an entire repetition of this section.



1 Hard Sand 3 ft
2 Hard limestone ledge 8 in.
3 Hard Sand 2 ft
4 Hard limestone ledge 10 in.
5 Hard Yellow Sand 6 in
6 Sand interstratified with white chalky looking subst. 4 ft.

Upon the Cotton Valley road leading out from Tuskegee an outcrop of this upper cretaceous formation is exposed some eight miles from Tuskegee. Samples of this together with some of the same formation on the Calebee Creek, to the left of the road, were taken, May 20th, and sent for analyses, they coming under suspicion from the peculiar vaporous odor given off when rubbed. This formation, I think, extends almost to the State border, but I can not speak definitely of their extent farther than Warrior Stand. Since sending you these samples for analyses, in which you found phosphoric acid to exist, an announcement has been made by Dr. Smith of a similar occurrence of phosphoric limestone in the upper cretaceous of the western part of the State, and from his knowledge of the geology of the State he predicted the occurrence in the eastern part.

From the above report of investigations undertaken by myself at your request, it will be seen that in the eastern part of the State the

phosphatic deposits of the lower cretaceous on the northern border of the lime belt can be of little or no economic value. The green sand marl outcropping on Little Charlie Creek, together with its occurrence in other parts where the drift is of little depth, can probably prove of local value, as in fact has already been tested by some of the energetic farmers along the line of its occurrence, with stated good results. With regard to the phosphatic limestone of upper cretaceous (overlying rotten limestone formation), this, when burnt and ground, will, if containing enough phosphoric acid, be of benefit, especially to what is known as the sandy lands, bordering in this locality, those containing lime.

AGRICULTURAL AND ECONOMIC VALUE OF THESE PHOSPHATIC DEPOSITS.

Outside of the "black belt", every portion of this state is benefitted by the proper use of commercial fertilizers, whose chief ingredient is phosphoric acid. Indeed phosphates, raw or acidulated, are every where, on the Atlantic coast, used in growing cotton. Their use, beginning with the coast country has gradually expanded, until it has covered both of the Carolinas and Georgia. It has invaded Alabama, and to-day the "black belt" is the only region of this state which does not annually consume many hundreds of tons. This rapid growth of the use of phosphates, demonstrates beyond doubt the needs of our worn soils for phosphoric acid. They have not been used to any extent on our "black belt" and whether this non-use has been due to the superior fertility of the soils, which enables the farmers yet to produce good crops of cotton without any manure, or whether phosphates are not beneficial to these soils, is an open question, which has not yet been satisfactorily decided. A series of experiments, soon to be instituted in this belt, by the Experiment Station will, we hope, throw some light upon this subject. We feel confident that phosphates will pay upon the red and gray lands, found here and there, interspersed among the prairies proper.

Again a number of special experiments have demonstrated the superiority of acidulated phosphates over the raw phosphates, on many of our soils, for immediate results. Hence acid phosphates have occupied our markets almost to the exclusion of raw bones and phosphates. The latter, when very finely ground by the "Duc

process" are called "floats" and have been very successfully used in connection with kainite, (ash element), as a fertilizer for peas and clover, and upon certain classes of swamp and meadow lands, where the organic acids were present in such quantities as to effect solution.

They can also be used advantageously in connection with organic nitrogenious manures, upon all classes of soils where permanent improvement of the land is desired rather than immediate results.

With these preliminary remarks, we can point out a few of the uses to which our Alabama phosphates may be adapted—reserving further comments until a large number of experiments in the field, now contemplated, shall have been consummated—for be it always remembered, that only by co-operation of laboratory and field tests, can any great question in Agriculture be decided.

PHOSPHATIC CASTS AND NODULES.

These are rich in phosphoric acid, containing enough to justify their manufacture in acid phosphates. Their average content of phosphoric acid is fully up to the Charleston phosphates and like the latter contain only a small amount of this ingredient in combination with iron and allumna An average of a number of analyses, shows less than two per cent. of these ingredients present, and therefore an acid phosphate properly made from them has very little tendency to "reversion". I append results of several experiments made in the laboratory, with a view of determining the value of these nodules for the manufacture of acid phosphates. 1st A large quantity of ground nodules which contained by analysis, a little over 26 per cent. of phosphoric acid was treated with sulphuric acid, properly "dried", ground, and analysed and found to contain a little over 11 per cent. of soluble phosphoric acid.

This experiment demonstrated that an acid phosphate of good grade could be made out of these nodules. Accordingly experiments were instituted based upon the known composition of the nodules to determine their economical value for manufacture into acid phosphates—in other words to determine the amount of sulphuric acid necessary to render the phosphoric acid soluble. These nodules, beside the phosphates present, contain a small quantity of carbonate of lime (limestone). When sulphuric acid is added, it first attacks the limestone and converts that into gypsum (land plaster) before it acts upon the phosphates. Accordingly an amount of acid must be added sufficient to convert both the limestone into gypsum and the insoluble phosphates into the acid or soluble phos-

phates. We took a large quantity of nodules, No. 89 and No. 90 and subjected them to treatment with acid.

I give analyses of these nodules before treatment with acid.

No. 89 Phosph. Acid 26.137 per cent.
" 90 " " 24.167 per cent.

Five hundred pounds of each, or at this rate, finely ground, were taken for each experiment.

EXPERIMENT 1st.—NO. 134,

500lbs. finely ground nodules, No. 89.
200 " Sulphuric Acid Sp. Gr. 1.82.
100 " Water.

EXPERIMENT 2nd—NO. 135.

500lbs finely ground nodules, No 90.
200 " Sulphuric Acid Sp Gr, 1.82.
50 " Water.

EXPERIMENT NO 3—NO 134½

500lbs finely ground nodules, No 89.
300 " Sulphuric Acid Sp Gr, 1.82.
150 " Water.

EXPERIMENT NO 4—NO 135½.

500 lbs finely ground nodules, No 90.
300 " Sulphuric Acid Sp Gr, 1.81.
200 " Water.

The above were prepared by first mixing the water with the finely ground phosphates, and then the acid, stirring vigorously and letting the mixture stand several days. It was then ground and analyzed. Before giving the results of analysis it would be well to show the chemical changes which take place. The sulphuric acid used in the above experiments had a specific gravity of 1.82 and therefore contains 90 per cent. of pure sulphuric acid. The oil of vitriol of commerce, or the sulphuric acid usually used in the manufacture of acid phosphates is known as 66° acid and contains 75 per cent. of anhydrous sulphuric acid. The complete analysis of No 89, might be put as follows:

Insoluble matter	1.09.
Bone Phosphate	57.05.
Carbonate of Lime	41.86.

As the above is used for the purpose of illustration, the amounts of phosphates of Iron and Alumina, Carbonate of Magnesia and organic matter are omitted, and all calculated as Carbonate of Lime.

The insoluble matter is not acted upon by the acid. A pound of Carbonate of Lime requires 1.066 lb and a pound of Bone phosphate of Lime requires 0.688 lb of sulphuric acid (66°) to render them soluble. Every pound of Carbonate of Lime, when treated with acid loses 0.44 lb of Carbonic acid which escapes as a gas. Now applying these facts to our ground phosphates we will find that—

	Sulphuric Acid. (66°)	Gas Liberated.
57.05 lbs Phos Lime requires	39.25 lbs	
41.86 " Carb " "	44.62 "	18.42 lbs
1.09 " Sand &c. "		
100 lbs ground phosphate requires	83.87 lbs.	

There is required beside the above about 13½ lbs of water to be added to the mixture and then we will have as a result—

1 lb Sand

72 lbs Hydrated Sulphate of Lime (plaster) from Carbonate of Lime,

63 lbs " " " " from the Phos Lime,

43 lbs Super or Acid Phosphate of Lime, and 18.42 lbs of Carbonic acid which will escape as a gas, leaving 179 lbs of what is usually termed acid phosphate and containing over 14 per cent. soluble phosphoric acid. The above fully illustrates the changes which take place in the treatment of phosphates with acid. The example taken does not fairly represent our nodules, since the amount of carbonate of lime is in excess of what actually exists.

Analysis of above experiments gave the following:

	Sol Phos Acid,	Tot Phos Acid.
No 134	8.60	16.52
" 135	7.07	15.94
" 134½	13.88	14.08
" 135½	12.04	12.20.

In No 135½ a slight excess of water was used which was easily remedied by evaporation. The above fully shows that a first class acid phosphate can be made from the average nodules found in Alabama.

The next question of importance, is whether the quantity of these nodules is sufficient to supply without difficulty, manufactories of acid phosphates. This question is of vital importance since many manufactories have indicated their willingness to remove their

works to Alabama, as soon as they can have positive assurance of the existence of phosphates of such quality and in such quantities as may meet their requirements. We cannot positively answer these questions. Examinations in the field have been too limited to justify a categorical reply. Only the nodules can be used for the manufacture of acid phosphates. These are found on the surface of the ground along the shore line, where the matrix rock comes to the surface, entirely across the state. In many places they can be raked up in considerable quantities, and if in every neighborhood a local agent were appointed, to purchase these nodules, we are satisfied a large quantity in the aggregate could be accumulated. If the same energy were used in securing these nodules, as is exhibited by the "bone pickers" of other countries, we are quite certain a number of factories could be supplied. Again, a demand for these nodules, would soon cause many farmers and planters along this border, to make full examination of their lands, and perhaps discover extensive beds, which may reasonably be supposed to exist.

Another method of obtaining these nodules has been suggested. The matrix rock containing these nodules consists largely of carbonate of lime—enough it is believed to reduce the rock to powder, (except the phosphatic nodules) by burning and slaking. After slaking, the lime could be passed through seives which would stop the nodules, The lime could possibly be utilized as a cheap fertilizer since it would still contain a goodly amount of phosphates and thus reduced, it is thought would be available to plants. Kainit might be added, when potash was required. The nodules after such treatment are said to be better and easily ground. The above plan of utilizing such rock, was first suggested by Sir John Bennett Lawes to Dr. Chas. W. Dabney and others of North Carolina. We hope to be able to conduct at an early day experiments of this kind, and give results in a future bulletin.

GREEN SANDS.

While the phosphatic nodules and casts are of great interest to the manufacturer, the phosphatic green sands are particularly interesting to the farmer. Forming extensive beds running from Mississippi to Georgia, and containing goodly quantities of phosphoric acid and potash, they are abundant, accessible and desirable as a fertilizer, and the day is not far distant when they will be used

locally in large quantities. They are especially adapted to sandy and gray lands, and will doubtless prove beneficial to most of the red lands of our State. As they vary greatly in quality, only those containing the largest percentages of phosphoric acid and potash should be transported to a distance. It is to be hoped that our railroads will give such cheap transportation for this fertilizer as to place it within the reach of every farmer in the State. How best to use these green sands is a question which can best be answered by experiments. It must be pulverized before use, which on a small scale can be done by hand, on a large scale by machinery. Perhaps the plan of burning suggested on page 27 may be applicable here, since these sands contain 20 to 60 per cent carbonate of lime.

These sands can be used in large quantities without fear of injury to the land, but it is best always that they are applied either upon soils rich in humus or in connection with vegetable matter. Composted with stable manure and cotton seed, and the mixture covered with a thin layer of gypsum or thick layer of rich earth, and permitted to remain for several months, is perhaps the best way to utilize them. In making such a compost large quantities of greensand must be used. I would recommend the following proportions:

100 Bushels Stable Manure,
100 " Cotton Seed,
100 " Green Sand, put up in the way and manner described for making composts in a former bulletin. This compost should remain up much longer than one prepared with acid phosphate—in fact, the longer the better—even twelve months would not be too long, provided the compost had been properly made and under shelter.

These sands could be properly used alone as a manure for peas, clover, and other legumunous crops. When the best sands are selected, their constitution closely approximates the "ash element" now sold as a specific for peas, &c.

Leaves, stalks, pine straw, and other course vegetable matter can easily be reduced by composting with greensand and the resulting mixture will be found an excellent manure, provided it is applied in large quantities.

Locally, these sands must prove of incalculable benefit and it is hoped that our farmers, living near them, will give them a fair trial and report their results.

The yellow sands found underlying the phosphate beds, may be used locally in preference to the greensands on account of the ease with which they are pulverized. They are not so rich in phosphoric acid, and do not contain notable quantities of potash. They are of secondary consideration from an Agricultural standpoint besides the inexhaustable beds of green sand marl just overlying the phosphate beds.

Experiments in the laboratory and the field will be extensively made during the coming year to further test the value of these phosphatic deposits, results of which will be published in a bulletin from this Department.

Laboratory A. & M. College
Auburn, Ala.

WM. C. STUBBS,
State Chemist.

TABLE OF ANALYSES.

I give below a table of all analyses made in the laboratory of the University of Alabama, and in the State laboratory at the Agricultural and Mechanical College.

Those from the State laboratory are entered below by the numbers in the order in which they were made. I have taken the liberty of assigning numbers to those made at the University in order to place them here.

Analyses Made at the University of Alabama.

No 1 Greensand from Spencer's field, Hamburg, Perry County.
2 " " " " " " "
3 " " " " " " "
4 " " " " " " "
5 " " " " " " "
6 " " " " " " "
7 " " " " " " "
8 " " " " " " "
9 " " " " " " "
10 " " " " " " "
11 " " " " " " "
12 " " " " " " "
13 " " " " " " "
14 Nodules " " " " " "
15 Phosphorized shell from Spencer's field, Hamburg, Perry County.
16 Surface Nodules " " " " " "
17 " " " " " " " "
18 " " " " " " " "
19 Matrix of Nodules " " " " " "
20 " " " " " " " "
21 Matrix of Nodules from Spencer's pit No 2, Hamburg, Perry County.
22 " " " " " "
23 Blue Matrix of Nodules from Spencer's pit No 2, Hamburg, Perry County. ‡
24 White Matrix of Nodules from Spencer's pit No 5, Hamburg, Perry County. ‡
25 Sands below indurated ledge from one to two feet at Spencer's, Hamburg.
26 " " " " " " " "
27 Nodules from near Selma, Ala.
28 " " "
No 29 Nodules from near Selma, Ala.
No 30 Nodules from near Selma, Ala.
No 31 Matrix of Nodules from near Selma, Ala.
No 32 Matrix of Nodules from near Selma, Ala.
No 33 Nodules near Prattville, Ala.
No 34 Nodules near Prattville, Ala.
No 35 Green sand from well in fair grounds, Eataw, Ala.
No 36 Phosphatic sand, C S. Bray's, near Eutaw, Ala.
No 37 Green sand from just below rotten limestone, Choctaw Bluff, Warrior River, Green County, Ala.
No 38 From Coke's Mill, six miles from Greensboro, Ala. [From Dr. Charles Gibson's analysis.]
No 39. Hard crystaline siliceous limestone two miles north of Fort Deposit, Lowndes County, Ala.
No. 40 Siliceous limestone strata, Crnshaw County, Ala.

‡Analyses made by Dr. Charles Gibson, Chicago.

Analyses Made at State Laboratory, Agricultural and Mechanical College of Ala.

No 84 Phosphatic nodules from Davis's place, Cahaba River, Perry County, Ala.
No 85 Phosphate lime rock containing nodules, Davis' place, Cahaba River Perry County, Ala.
No 88 Yellow sand under green sand, Davis's place, Cahaba River. Perry County Ala
No 89 Nodules, Spencers's place, Hamburg, Perry County, Ala.
No 90 Black Nodules, Spencer's place, Hamburg, Perry County, Ala.
No 91 White nodules, Spencer's place, Hamburg, Perry County Ala.
No 92 Mixed nodules, Spencer's place, Hamburg, Perry County, Ala.
No 113 Matrix rock containing phosphatic nodules from pit 1, in field southeast from Spencer's, near Hamburg, Perry County, Ala.
No 114 Matrix rock from pit 3, bearing phosphatic nodules, from southeast field of Spencer's, near Hamburg, Perry County, Ala.
No 115 Matrix rock free from nodules, from pit 1.
No 116 Nodules taken from rock 115, same as before,
No 117 Matrix rock bearing nodules, six feet below surface, pit 3, Spencer's, Hamburg, Perry County Ala.
No 118 Nodule Matrix, pit 1, five feet nine inches below surface. Spencer's, Hamburg, Perry County Ala.
No 119 Cream colored rock overlying matrix nodules rock, Spencer's place, Hamburg, Perry County, Alabama.
No 120 Matrix phosphate rock 29 inches below surface same as former Pit II dug about 300 yards N W of Pit I, position selected so as to avoid overlying green sand marl.
No 121 Matrix rock free from nodules [the rock decomposed) Pit II 9½ inches from surface same place.
No 122 Matrix rock with nodules 24 in from surface—Pit II—same as before.
No 123 Green sand soil 7 ft above nodule bearing rock in Spencer's field S E (weathered)
No 124 Green sand soil same as before 6 ft above nodule rock (weathered)
No 125 Green sand soil same as before 4 ft above phosphate rock (weathered)
No 126 Green sand soil 1 ft above nodule bearing rock same as before (weathered)
No 127 Phosphate rock from M W Oliver, Marion Alabama.
No 136 Phosphatic nodules from near Eutaw. (A W S Anderson)
No 137 White nodules found in green sand Spencer's, Hamburg, Perry County, Ala.
No 138 Bone fossil from Barker's mill, Dallas County, near Cahaba River, Jos. Hardie, Selma, Alabama.
No 140 This and the following eight represent a section from Spencer's house to King's mill, 1st 3 ft
No 141 On hill, Spencer's, 3 ft below No 140.
No 142 Sample 2 ft beneath ledge rock 3 ft below No 141
No 143 Sample greenish sand 3 ft below No 142 going down hill to King's mill.
No 144 Sample micaceous sand 3 ft below 143 going down hill to King's mill.
No 145 Samples greenish micaceous 3 ft below 142
No 146 Samples sand 3 ft below 145 towards King's mill
No 147 Samples ferruginous sand above 2nd layer shell rock beneath King's mill.
No 148 Lowest formation at King's mill.
No 149 Green sand 1st 12 inches of Pit I. This and next 3 constitute the green sand section of Pit I in field S by W on road to Cahaba 50 ft from road and 400 yards from the house of Mr. Spencer, the owner of the land. The field generally covered by green sand with here and there the underlying shell rock exposed. Field in cultivation about 50 years.
No 150 Green sand 9 inches next to 149
No 151 Green sand 7 inches next to 150
No 152 Green sand 20 inches next to 151
No 153 Phosphatic nodules—Marion (Judge Bailey)
No 154 Indurated ledge underlying phosphatic rock, Spencer's, Hamburg, Alabama
No 155 Hard siliceous limestone—Western Autauga—Leon Howard.
No 155½ Siliceous limestone—Western Autauga.
No 156 Argillaceous limestone with green sand and phosphatic grains—Western Autauga—Leon Howard
No 157 Upper part of 156—Western Autauga—Leon Howard
No 158 Green sand ten inches thick—Western Autauga—Leon Howard
No 159 Green sand marl from a well—Western Autauga—Leon Howard
No 160 Green sand bed three feet thick—Western Autauga—Leon Howard
No 161 Calcareous sinter phosphate—Western Autauga—Leon Howard
No 162 Green sand eight feet thick—I J Barker's mill near Summerfield. Dallas County Ala
No 163 Nodules from stratum overlying green sand near Valley Creek Church, three miles southeast Summerfield, Dallas County Ala
No 164 Green sand near Selma, Dallas County Ala—Joseph Hardie
No 165 Fossils casts and nodules near Selma—I H Robins
No 166 Fossils casts and nodules from Kernan's plantation three miles from Selma
No 167 Siliceous limestone, (Ripley group) Richmond, Dallas County, Ala—George W Keiser
No 168 Glauconitic limestone, (Ripley) Minter Station, Dallas County Ala—A M Smith

No 169 Phosphatic shell casts, Minter Station, Dallas County Ala—Col N H R Dawson
No 170 Siliceous limestone. Minter Station, Dallas County—Col N H R Dawson
No 171 Dark Clay marl Flora, Bullock County Ala—Dr Leitner
No 172 Yellowish clay marl, Flora, Bullock County Ala—Dr Leitner
No 173 Dark colored clay marl, Flora, Bullock County Ala—Dr Leitner
No 174 Dark gray marl, Flora, Bullock County Ala—Dr Leitner
No 175 Phosphatic green sand, Wetumpka, Elmore County
No 176 Phosphatic white marl, Wetumpka, Elmore County
No 177 Nodules and casts, Turkey Creek Hills, Pleasant Ridge, Greene County
No 178 Shell casts overlying rotten limestone, Boligee, Greene County
No 179 Fossil casts from J B Reid's, near Greensboro
No 180 Indurated green sand, Northeast of fair grounds, Eutaw, Ala
No 181 Nodules and casts from field northeast of fair grounds, Eutaw, Ala
No 182 Nodules and casts overlying rotten limestone, seven miles south of Newberne on Uniontown road.
No 183 Fossil casts and nodules from Mrs Jemison's, five miles Northeast of Newberne, Hale County
No 184 Fossil casts from Charles W Turpin, S 29 T 19 R 6 E, near Newberne
No 185 White phosphatic marl, Day's Bend, Alabama River, Autauga
No 186 Phosphatic shell casts and nodules, Day's Bend, Ala. River, Autauga county.
No 187 Fossil casts Marion, Alabama, Perry county.
No 188 Light colored calcareous rock with green sand grains, M W Oliver, Marion.
No 189 Dark bluish greensand marl—Marion, Alabama.
No 190 Greensand from Carlos Reese, 2 m S E of Marion.
No 191 Fossil casts from Dr W W Wilkerson's 4 m S of Marion, Alabama.
No 192 Greensand from E N Driver's, Scott's station, Perry county, Alabama.
No 193 Shell casts and nodules, Coatopa, Sumter county, John Wiatt's.
No 194 Clayey marl from John Wiatt's, Coatopa, Sumter county.
No 195 White argillaceous limestone with greensand grains, John Wiatt's, Coatopa
No 196 Siliceous rock from river bluff just below landing, Moscow, Sumter Co., Ala.
No 197 Shell casts &c., from river bluff just below landing, Moscow, Sumter county.
No 198 Light colored marl with greensand grains a few m N of Moscow, Sumter Co.
No 199 Near railroad bridge, Livingston, Sumter County, northeast part of town
No 200 Argillaceous lime rock near negro cemetery, two and a half miles southeast of Livingston
No 201 Argillaceous and siliceous lime rock near Mrs Eskridge's, four and a half miles north of Livingston, on Gainesville road
No 202 Argillaceous limestone from hill beyond Cedar Creek, three and one-fourth miles from Livingston on Jones's Bluff
No 203 White phosphate concretions, three and three-fourth miles north of Livingston on Gainesville road
No 204 Light colored argillaceous limestone, six miles southeast of Livingston, on Black Bluff Road
No 205 Fossil casts, six miles southeast of Livingston, on Black Bluff Road
No 206 White argillaceous limestone, Col J J Lee's place four miles southeast of Livingston Coatopa Road
No 207 Phosphatic nodules and casts, Pickensville, Ala
No 208 Glauconitic limestone, Richmond, Dallas County Ala
No 209 Siliceous limestone, Richmond, Dallas County Ala
No 210 Siliceous limestone, Richmoud, Dallas County Ala
No 211 Shell conglomerate siliceous-calcareous—Olustee Creek Ala
No 212 Green sand from well of T L Nobles T 16, R 25, S 5, Macon County, twenty feet green sand underlying eighteen feet drift.
No 213 Green sand from Charlie Creek—Mr F Howard's, five miles west of Tuskegee
No 214 Green sand from Charlie Creek at border of Calebee swamp
No 215 Green sand from debris of well dug four years ago, T 16, R 25, S 10, near Tuskegee
No 216 Green shell marl from debris of well T 16 R 27, S, 1, Andrew Smith's place near Uchee
No 217 Green sand from well of J. M. Comer T 16 R 24 E ½ S 2, near Tuskegee, taken from beginning of strata 8 inches down.
No 218 Same as 217 Taken one and two-third feet from beginning of strata, eight inches down
No 219 Same as 217 Taken three and one-third feet from beginning of strata Extent eight inches
No 220 Same as 217 Taken five feet from surface Extent eight inches
No 221 Same as 217 Taken seven and one-sixth feet below surface Eight inches
No 222 Same as 217 Taken eight feet below surface Extent eight inches
No 223 Sand ferruginous immediately underlying green sand in J M Comer's well, T 16, R 24, S 2 Eight inches deep
No 224 Sand underlying 223 in same well Two and a half feet to edge of water in well
No 225 Upper cretaceous limestone on road from Tuskegee on Cotton Valley road, 9 ms from Tuskegee on Mr. McBride's place Rock outcrops on a hill one-half mile to left of road of Calebee Creek

No 226 Upper cretaceous limestone, same as 225 but from another ledge
No 227 Same as 226 only two hundred yards nearer Tuskeegee
No 228 Rock from near well on J P Morris's place, T 17, R 28, S 36 Society Hill
No 229 Phosphatic limestone rock in bluffs Cubehatchee Creek, near residence of Mr. Johnson Upper cretaceous formation
No 230 Sample greenish loam underlying blue laminated clay in bluffs on Chattahoochee River at Uchee Shoals
No 231 Sample of blue clay from bluffs on the Chattahoochee River at Uchee Shoals

Number	Insoluble Matter	Phosph Acid	Bone Phosph	Lime
1		11.41	24.88	
2		10.16	22.15	
3		10.19	22.21	
4		11.51	24.99	
5		11.20	24.42	
6		9.00	19.62	
7		11.78	25.78	
8		9.31	20.29	
9		11.33	24.70	
10		5.16	11.26	
11		9.97	21.78	
12		8.12	17.70	
13		7.6	16.59	
14		22.02	48.00	
15		19.80	43.16	
16		38.00	82.84	
17		35.5	77.39	
18		25.66	55.88	
19		5.12	11.16	
20		4.2	9.16	
21		4.65	10.14	
22		8.00	17.44	
23		2.2	4.80	
24		3.6	7.85	
25		6.5	14.17	
26		3.8	8.28	
27		26 1	56 90	
28		25 8	56 24	
29		36 6	78 48	
30		38 0	82 84	
31		5 05	10 11	
32		3 98	8 67	
33		28 14	61 34	
34		32 0	69 76	
35		7 80	17 01	
36		9 11	26 24	
37		5 03	10 96	
38		4 30	9 38	
39		13 55	29 58	
40		6 22	13 57	
84	20 50	19 41	42 37	40 20
85	54 30	1 83	3 99	25 22
88	94 34			1 95
89	1 09	26 13	57 04	
90	2 50	24 16	52 03	
91	21 94	20 07	43 81	
92	9 79	19 97	43 59	49 36
113	30 28	2 58	5 63	30 06
114	32 50	3 85	8 40	29 61
115	40 61	2 45	5 34	27 07
116	22 07	14 02	30 60	39 03
117	53 74	2 79	6 09	17 20
118	33 81	2 26	4 93	27 85
119	35 17	2 20	4 80	24 10
120	47 13	1 46	3 18	24 41
121	27 82	95	2 09	41 00
122	31 55	3 58	7 81	32 07
123	41 42	67	1 46	29 62
124	41 11	85	1 85	17 68
125	48 81	4 35	9 56	9 13
126	28 62	66	1 44	24 80
127	7 61	11 05	24 12	
136	26 99	16 48	35 97	34 51
137	3 91	3 85	8 40	49 83
138	39 71	14 93	32 59	18 40
140	31 53	3 38	7 37	26 73
141	56 65	69	1 50	21 20
142	92 3	.332	.724	9 47
143	91 89	.291	63	2 85
144	95 55	44	96	.72
145	96 27	.115	25	.75
146	92 14	39	85	.687

Number	Insoluble Matter	Phosph Acid	Bone Phosph	Lime
147	91 40	.425	92	.792
148	90 42	.251	54	50
149	42 66	1 61	3 51	16 18
150	54 52	2 79	6 09	13 86
151	31 95	2 15	4 65	9 44
152		3 38	7 37	8 40
153	25 94	26 74	58 37	33 55
154	53 77	1 16	2 53	23 33
155	57 17	78	1 70	
155½	49 05	4 86	10 61	26 55
156		1 69	3 69	14 89
157		2 20	4 80	7 99
158		2 49	5 43	8 38
159		6 67	14 56	7 57
160		2 63	5 74	
161	1 97	2 10	4 52	
162		3 60	7 85	9 70
163	2 67	25 59	55 85	
164		5 22	11 39	
165	6 49	24 85	54 25	31 57
166	50 68	12 88	28 11	22 20
167	39 47	8 69	18 97	29 31
168	17 38	.740	1 62	
169	10 72	16 90	36 89	
170	42 44	1 45	3 12	
171	87 25	53	1 16	1 15
172	67 25	81	1 76	12 02
173	77 48	76	1 66	8 20
174	77 02	66	1 44	12 32
175	66 15	1 52	3 31	4 33
176	41 36	1 11	2 42	32 11
177	5 9.	25 14	54 88	
178	2 98	22 76	49 68	
179	16 22	23 20	50 64	39 34
180	39 87	3 24	7 07	
180½		66	1 44	
181	9 44	21 55	47 00	41 72
182	3 59	20 68	45 14	
183	10 85	23 10	50 43	
184	7 73	26 54	57 94	
185	43 79	4 10	8 95	
186	49 52	20 77	45 34	
187	7 91	27 74	60 55	
188		2 98	6 50	
189		2 57	5 61	
190	37 70	3 78	8 25	
191	12 55	14 23	31 06	
192		2 36	5 15	
193	9 38	14 56	31 78	
194	51 25	2 24	4 89	
195	25 74	5 01	10 93	
196	57 00	28	1 26	
197	25 52	1 55	3 38	
198		2 52	5 50	
199	11 90	20	43	
200	25 30	56	1 22	
201	33 16	41	86	
202	39 52	50	1 09	
203	8 48	1 10	2 40	
204	15 02	64	1 39	
205	11 65	9 9.	21 65	
206	13 50	2 58	5 62	
207	4 21	22 40	48 90	
208	15 73	2 62	5 72	
209	34 95	3 21	7 00	
210	40 .6	5 94	12 96	
211	41 56	1 14	2 49	
212	80 9	45	98	
213	74 9	31	67	
214	66 71	77	1 68	
215	75 67	58	1 28	
216	74 46	59	1 28	

Number	Insoluble Matter	Phosph Acid	Bone Phosph	Lime
217	71 35	1 29	2 81	
218	73 15	67	1 46	
219	75 8	57	1 24	
220		48	1 04	
221	82 27	42	91	
222	83 89	33	72	
223	82 25	70	1 52	
224	93 65	36	78	
225	25 34	47	1 02	
226	45 99	29	63	
227		37	80	
228	10 77	5 33	11 65	
229		51	1 11	
230	71 00	96	2 09	
231	77 26	2.	45	