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PHOSPHATE INVESTIGATION IN FLORIDA
1934 AND 1935

BY

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Investigation made by the Geological Survey under grants from the Federal Emergency Administration of Public Works

Contributions to economic geology, 1938-39
(Pages 267-345)

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PHOSPHATE INVESTIGATION IN FLORIDA, 1934 AND 1935

By P. V. Roundy [1]

ABSTRACT

Of the lands in Florida originally placed in the phosphate reserves, 66,796 acres remained under Government control on January 1, 1934. Only a small part of this area had been definitely classified. Under two grants made by the Federal Emergency Administration of Public Works, data were obtained for classifying about 3,500 acres in 15 townships in Polk, Marion, and Citrus Counties. Most of the tested tracts were in the land-pebble phosphate area, and methods of prospecting were developed that permitted the fine phosphate formerly discarded in both prospecting and mining to be saved and its amount estimated. This fine material is now being saved at some of the operating phosphate plants by flotation or other processes. The prospecting showed many areas where this fine material contained two or more times as much phosphate (calculated as tricalcium phosphate) as the pebble. The location and estimated phosphate content of each prospected tract are given.

INTRODUCTION

The mining of rock phosphate is one of the large industries of Florida. Since 1892 the value of the annual output of the phosphate at mines has exceeded a million dollars. In 1913, before the World War, the phosphate output at the mines was 2,545,276 long tons, valued at $9,563,084, an average of $3.76 a ton. In 1920 production reached 3,369,384 long tons, valued at $19,464,362, an all-time high for the State. Fluctuations in annual production and value followed until in 1932 the low point of 1,469,976 long tons, valued at $4,779,612, was reached. Since that time the industry has advanced again, and in 1939, the latest year for which figures are available, Florida's production was 2,678,784 long tons, valued at $7,893,457, or $2.95 a ton at the mines.

The following table shows the annual tonnage and value of phosphate sold or used in Florida each year from 1888, when the Florida industry began.

[1] Mr. Roundy died without having had opportunity to review the final draft of his report.—Ed.

TABLE 1.—*Phosphate sold or used in Florida, 1888–1939* [1]

Year	Long tons	Value	Year	Long tons	Value
1888	3,000	$21,000	1914	2,138,891	$7,354,744
1889	4,100	28,000	1915	1,358,611	3,762,239
1890	46,501	338,190	1916	1,515,845	4,170,165
1891	112,482	703,013	1917	2,022,599	5,464,493
1892	287,343	1,418,418	1918	2,067,230	6,090,106
1893	438,804	1,979,056	1919	1,660,200	7,797,929
1894	527,653	1,666,813	1920	3,369,384	19,464,362
1895	568,061	2,112,902	1921	1,780,028	10,431,642
1896	495,199	1,547,353	1922	2,058,593	8,347,522
1897	552,342	1,493,515	1923	2,547,653	9,059,427
1898	600,894	1,847,796	1924	2,432,581	8,017,476
1899	726,420	2,804,061	1925	2,929,964	8,789,070
1900	706,243	2,983,312	1926	2,708,207	8,683,508
1901	751,996	3,159,473	1927	2,637,420	8,646,162
1902	785,430	2,564,197	1928	2,883,446	9,424,022
1903	860,336	2,986,824	1929	3,088,298	9,901,074
1904	1,072,951	3,974,304	1930	3,248,071	10,790,305
1905	1,194,106	4,251,845	1931	2,061,466	7,202,086
1906	1,304,505	5,585,578	1932	1,469,976	4,779,612
1907	1,357,365	6,577,757	1933	2,136,123	6,417,110
1908	1,692,102	8,484,539	1934	2,369,334	8,076,317
1909	1,779,702	8,541,301	1935	2,422,804	8,377,609
1910	2,067,507	8,647,774	1936	2,624,900	8,528,523
1911	2,436,248	9,473,638	1937	2,996,820	9,142,985
1912	2,406,899	9,461,297	1938	2,707,335	8,773,680
1913	2,545,276	9,563,084	1939	2,678,784	7,893,457

[1] Mineral Resources of the United States, chapters on phosphate, U. S. Geol. Survey through 1923 and U. S. Bur. Mines, 1924-31; U. S. Bur. Mines Minerals Yearbook 1932-39.

Unpatented Government lands in Florida that were believed to contain phosphate rock were first withdrawn for examination and classification and segregated in phosphate reserves by Presidential order on July 2, 1910. Thereafter other withdrawals and restorations were made until on January 1, 1934, the reserves aggregated 66,796 acres, of which only a small part had been definitely classified as phosphate land. The reserved land is in scattered parcels widely distributed over several counties. For administrative purposes and for final disposal of any of the numerous parcels, mineral classification and restoration of the land are necessary. As the presence of phosphate rock cannot be determined by surface observation, drilling is necessary to obtain the definite evidence required for classification purposes.

In 1934 the Federal Emergency Administration of Public Works made a grant of funds to the Geological Survey for the prospecting and classification of certain public lands in the Florida phosphate reserves. In 1935 a similar grant was made for continuing the work.

The field work under these grants was done under the direct supervision of the writer. The General Land Office cooperated in the location of the selected 40-acre tracts, the field locations being made by transitman Hugh B. Crawford. A crew of men and a practical phosphate prospector, J. H. Wingate, of Zephyrhills, Fla., with his equipment, were employed under regulations of the Federal Emergency

Administration of Public Works, and a camp was maintained near the work.

This prospecting work fitted well the requirements for Public Works projects in general; it could not be done on any considerable scale under the Survey's usual appropriations; it gave employment to unemployed labor; and it may be expected ultimately to repay to the Government in royalties more than the cost of the exploration. The prospecting under the first grant was started March 24, 1934, and continued to September 15; that under the second grant was started February 5, 1935, and completed June 28. The unit area of land is usually considered a 40-acre tract. Some single isolated tracts and groups of adjacent tracts were tested by hand drilling.

The object of the investigation was to obtain data on which to base a decision whether the phosphate rock present in any given tract was sufficient in quantity or of suitable quality to justify the Government in retaining the mineral rights in that tract. Although standard methods were used in prospecting the lands, this work was not carried so far as is both customary and necessary in commercial practice, because no problem of early utilization of the land was involved, and under existing law the burden of proving up a commercial deposit is laid on the prospective lessee.

In all, 107 wells were drilled, averaging 61 feet in depth, the deepest 109½ feet. As methods of recovery now include flotation and other means of saving fine materials formerly wasted, the Geological Survey party saved also the finer parts of the deposits, the so-called matrix (see page 278), and made estimates of its phosphate content along with those for the phosphate pebble or hard phosphate rock. From this work data were obtained for classifying about 3,500 acres.

So many people gave valuable information, cooperation, and assistance that it is not possible to name them all here, but special mention should be made of E. A. Pierce and Charles N. Becker, of the Southern Phosphate Corporation; Herman Gunter, State geologist; E. M. L'Engle, State director, National Reemployment Service; J. H. Pratt and R. P. Thornton, of Tampa; A. A. McLeod and Hugh Wear, of Bartow; and W. L. Akin, of Dunnellon. To these and many others the writer expresses thanks.

The phosphate reserves in Florida extend from the northern part of the State southward nearly to the area near Fort Myer, but with the limited funds available prospecting was done only in Polk, Citrus, and Marion Counties, and this paper will be confined to these counties.

Plate 55, a map of the central part of Florida, shows the location of the 83 tracts in Polk County and the 6 tracts in Marion and Citrus Counties prospected in 1934 and 1935.

GEOLOGY

The geology of Florida is well described by Cooke and Mossom.[3] In this paper it is intended to discuss only the geology of the formations encountered in the present investigation. Parts of two areas were drilled in which both the geologic formations and the phosphate deposits differ in origin and character. All of the phosphate in Polk County is a part of the so-called land-pebble phosphate area, whereas the wells drilled in Marion and Citrus Counties are in a part of the so-called hard-rock phosphate area. The geology of these two areas will be presented separately.

LAND-PEBBLE AREA

The geology of the land-pebble area appears, by the wells drilled in 1934 and 1935, to be relatively simple, though not clear in all details. Table 2 shows the correlation of the deposits in Polk County with those described by Cooke and Mossom and with the prospector's divisions. Table 3 (p. 276) shows the relation of these deposits in the land-pebble area to those in the hard-rock area.

The deposits will be described under the divisions used by the prospector, beginning with the lowest.

HARD BEDROCK

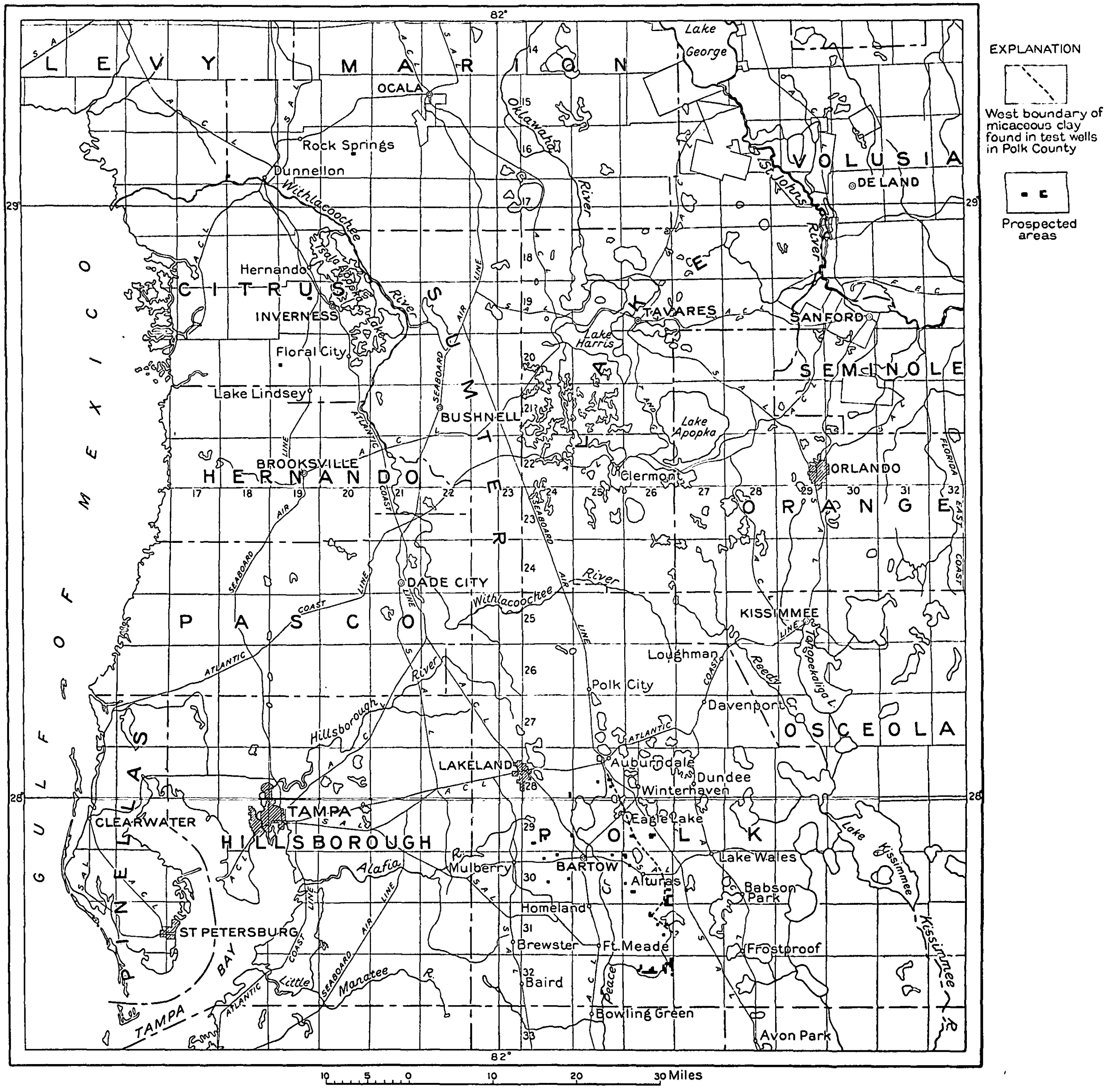
In the drilling in Polk County the hard limestones beneath the phosphate deposits were not penetrated more than an inch or two in most places, as all the pebble phosphate of known workable quality in this general region occurs above the hard limestone beds.

The hard bedrock reached in some of the wells may have been a limestone bed of the Tampa limestone, which, though without surface exposures in Polk County, is said probably to underlie all upper Miocene or younger rocks in the county. However, the hard bedrock reached in most of the wells drilled is thought to have been some bed in the Hawthorn formation. As the erosion and solution of the Hawthorn was probably uneven and irregular, wells even in the same or adjacent 40-acre tracts may have reached different beds of the Hawthorn formation, classed in the well logs as "top of hard bedrock."

SOFT BEDROCK

The material classed as soft bedrock in drilling lies below the phosphate deposits. It usually contains a very small amount of phosphate and always a considerable amount of carbonate of lime, as a powder, in clay, or as soft plastic lime. It ranges from a very soft clay deposit, easily penetrated by the auger, to a tough, harder deposit, in places with thin limestone beds, for which a hard-rock drill was required. It contains more or less sand but not as distinct beds of pure sand.

[3] Cooke, C. W., and Mossom, Stuart, Florida Geol. Survey 20th Ann. Rept., pp. 29–228, 1929.



MAP OF CENTRAL FLORIDA, SHOWING LOCATION OF TRACTS TESTED IN POLK, MARION, AND CITRUS COUNTIES.

TABLE 2.—*Correlation of deposits in land-pebble area with prospector's divisions*

[Thicknesses are those obtained from test wells]

Prospector's divisions		Lithologic character	Formation	Series	System
Over-burden (3½ to 98 feet).	0 to 27 feet.	Wind-blown sand, soil, sand, silt, muck, sandy clay, and peat.		Recent.	Quaternary.
		Sand, hardpan.		Recent or Pleistocene.	
	0 to 67 feet.	Sand, sandy clay, clay.	Citronelle (?) formation.	Pliocene.	Tertiary.
	0 to 19 feet.	Black to dark greenish-gray clay with very fine mica flakes.	Probably marginal phase of Bone Valley gravel.		
Phosphate deposits (0 to 28½ feet).	Phosphate beds (0 to 24⅙ feet).	Phosphate pebbles in sand, sandy clay, or clay matrix, with or without some barren beds.	Bone Valley gravel.		
	Bed clay (0 to 9½ feet).	Soft clay with or without phosphate pebbles and with or without sand.			
Barren beds (0 to 19½ feet).		Sand, sandy clay, or clay without phosphate or with only a few scattered minute phosphate pebbles. Occur between lowest important phosphate deposit and top of soft or hard bedrock.	Probably lower part of Bone Valley gravel. (May contain some material in bottom equivalent to soft bedrock.)		
Soft bedrock (0 to 11 feet).		Soft clay with strong lime reaction. Locally some sand but not as distinct sand beds. Usually shows slight amount of phosphate on chemical test.	Hawthorn formation. (In a few wells the limestone may be Tampa limestone.)	Miocene (lower).	
Hard bedrock.		Hard limestone.			

The writer thinks that in some wells the soft bedrock may be the softer beds of the Hawthorn formation, practically unchanged, whereas in other wells it may be limy beds, originally hard but later softened by the leaching of some of the contained lime. In still other wells the soft bedrock may represent both types of material. Except for leaching and settling, the soft bedrock has apparently not been disturbed or reworked since the deposition of the Hawthorn formation.

BARREN BEDS

Many beds of clay and either sandy clay or sand lie between the lowest beds containing phosphate pebbles and the bedrock. They appear to contain no phosphate, and are called barren beds, as are similar beds intercalated with those that contain pebbles. These beds are rejected by the prospector if no phosphate pebbles are found below them when soft bedrock or hard bedrock is reached. The writer believes that they represent any or all of the following: (1) The equivalent of the lower part of the phosphate beds, (2) the bed clay, or (3) the soft bedrock not otherwise recognized as such in the field.

The barren beds at many places contain considerable powdered phosphate, and in one sample the top 1½ feet contained 24.8 percent of phosphate calculated as tricalcium phosphate, which shows clearly that this part of the barren beds should be classed as the lower part of the phosphate deposits, probably as bed clay. The bottom part of the barren beds in the well from which this sample was taken was evidently a part of the soft bedrock, and the middle part may have belonged either to the phosphate deposits or to the soft bedrock.

PHOSPHATE DEPOSITS

The phosphate deposits are the part of the section that is considered valuable and is saved by the prospectors as a source of phosphate. This part is divided by them into the phosphate beds and the bed clay.

Bed clay.—The bed clay, which forms the lower part of the phosphate deposits, is composed mainly of clay, sandy clay, or sand with a little clay and usually shows a lime-carbonate reaction with acid. One marked character of the bed clay, used as a means of recognition by the drillers, is the tendency of the contained pebbles to peel clean when the clay, as recovered from the well, is broken in the hand. In the main phosphate beds the matrix adheres to the pebbles more closely. In character and number the pebbles in the bed clay vary, as they do in the beds above. However, in the bed clay the basal part is usually an aggregation of the larger and more abundant pebbles, suggesting a basal deposit just above an unconformity. The bed clay may be absent or may range in thickness from a few inches to as much as 9½ feet or more. In some wells it may have been present but not recognized. Usually the phosphate pebbles in this clay are darker in color than in the main phosphate beds. The phosphate content of the bed clay varies from practically nothing to 20 percent or more. In a few wells the bed clay was richer in pebbles than the beds above.

Phosphate beds.—The phosphate beds, or main part of the phosphate deposits, usually contain the richest phosphate pebble. In the wells drilled in Polk County under the writer's direction the phosphate beds ranged in thickness from 24 feet 2 inches to the vanishing point. The well that had the thickest phosphate bed also had 4 feet 4 inches of phosphate-bearing bed clay, making a total thickness of 28½ feet for the phosphate deposits at that place. The phosphate beds consist of sand, sandy clay, or clay, with or without pebbles, and some beds of pebbles with very little clay. The boundary between these beds and the overburden is determined only by the abundance of the included pebbles and is therefore economic rather than geologic; however, in many of the wells drilled it proved to be both.

The phosphate beds, together with the bed clay, belong to the Bone Valley gravel, of lower Pliocene age. The details of the lithology and phosphate content of these beds are set forth under the heading "Phosphate" (pp. 277–278).

OVERBURDEN

The wells in Polk County that penetrated phosphate deposits showed an overburden that ranged in thickness from 3½ to 98 feet.

Components of overburden.—This overburden consisted of sand, sandy clay, clay, hardpan, silt, muck, soil or sandy soil, and peat. Peat was found in only one well, where it was 15 feet thick and very dark brown, almost black. Muck or silt was noted in about one-fifth of the wells, but only at or near the top. Its greatest thickness recorded was 10½ feet.

Hardpan was present in about one-third of the wells. It consisted of sand cemented by an iron compound and varied in color from dark brown to deep brownish black. The average thickness of the hardpan beds was about 2 feet, and only a few of the wells had more than one bed. The depth of the beds below the surface ranged from 3 to 26½ feet. A few wells showed some very thin layers of hardpan, an inch or less in thickness, called "hardpan crusts" by the prospector, and the depth of these crusts below the surface corresponded with that of the hardpan. In areas where hardpan was present the tall pine trees had noticeably flat tops, but in areas where there was no hardpan pines that seemed to be the same variety had more pointed tops. Wells drilled in lakes or swamps encountered no hardpan.

The greatest part of the overburden was composed of sand and sandy clay with some beds of clay. The sand consisted of quartz grains of different sizes, mostly in beds, each bed having grains of rather uniform size. The sand beds differed in compactness and color. In some the sand was so loosely packed that it would flow upward into the casing unless the bottom of the casing was kept well below the depth at which the sand pump was used. These beds of quicksand might be present in any part of the overburden from the very bottom nearly to the top. In some wells no quicksand was found. Some beds of sand were packed so hard that the auger would not penetrate them, yet when loosened with the drill and brought to the surface they did not appear to be cemented in any way. However, in some of the wells small pieces composed of cemented sand grains were found in the beds of loose sand. These pieces were called sandrock by the prospector, but they seldom caused trouble in the use of the auger. All the sand grains in the overburden were white or glassy quartz, usually coated with a colored film, which could be removed by hard scrubbing in water. The sand beds ranged in color from white through many shades of yellow, brown, and gray to black, with reddish tints here and there.

Different amounts of sandy clay are present in many parts of the overburden. The term "sandy clay" as used by the prospectors indicates a mixture of clay in relatively small amounts with sand, and the change from a sandy clay to a clay, as the terms were used in the drilling, appears to depend more upon the size of the sand grains than upon the actual percentage of clay present. All the clays recorded in the overburden in Polk County, except those found at the very bottom in some of the wells, probably contained 10 percent or more of quartz sand. The clays and sandy clays had colors similar to those of the sand beds, and, in addition, some beds were slightly bluish.

The dark mica-bearing clay at the base of the overburden (see table 2) appeared to be the only true clay found in the overburden in Polk County. It is a tough fine-grained clay, with considerable carbonaceous matter and practically no quartz sand. The mica is present in extremely fine flakes, noticeable to the naked eye mainly by their reflection of light. Under a lens they appear very thin. This clay is dark grayish or black and locally greenish. In the test wells it ranges in thickness from 2 to 19 feet. Some of it from different places gave a slight phosphatic reaction when tested chemically, the reaction being stronger in material nearer the bottom, where fine grains of phosphate appeared here and there. Beds of phosphate were present below this clay in more than two-thirds of the wells in which it was found. The distribution of this clay in Polk County, so far as known from the available test wells, is shown on the map, (pl. 55) by a line drawn generally southward from a point 2 miles south of Auburndale to the vicinity of Lake Buffum, representing a length of about 20 miles. Twenty test wells drilled east of this line all showed the dark micaceous clay, but this clay was not found in any of the wells drilled west or southwest of the line.

Age of overburden.—The geologic age of the overburden is not definitely known. No fossils were found in it in any of the wells drilled. The soil, muck, and silt at the top are considered Recent. The 15 feet of peat found in one well is evidently also Recent. The material at the very surface described as peat should perhaps be called vegetation, for a part of it is composed of living swamp plants, and the change downward is gradual. It contains little silt or clay. This well was drilled about 300 feet from the north margin of a swamp that received very little wash from flooding rains in its northern part.

The sands just below the soil or muck in the wells where the overburden is thick are probably reworked material from the underlying deposits, but whether the reworking was done in Recent or Pleistocene time was not determined. The rather uniform depth of the hardpan in relation to the probable position of the water table and its absence under swamps and lakes suggest that the cementation of sands into hardpan occurred in Quaternary time.

The dark micaceous clay in the lowest part of the overburden, found only in the eastern part of the area drilled, is believed to be part of the Pliocene Bone Valley gravel, deposited where the water was relatively free from currents and possibly protected by vegetation, while coarser material was being laid down elsewhere. As the lower limit of the overburden is where phosphate pebbles become abundant, it is probable that, where the dark clay is absent, an undetermined part of the basal portion of the overburden may represent the upper part of the Bone Valley gravel. In the wells where the overburden is relatively thin the Quaternary deposits lie directly upon the Bone Valley gravel. In the other wells the intervening sands and sandy clays of varying thickness evidently belong to another formation, regarded as the Citronelle (?) formation, of later Pliocene age. These sands and clays are not accompanied by gravel beds such as those found in the Citronelle formation at its type locality, but this difference is consistent because at the time the Citronelle formation was deposited, the nearby area in Polk and other counties lacked a source of gravel. It is possible, however, that these beds may belong to an unnamed formation of Pleistocene age.

The similarity of the materials, their unconsolidated condition, and the lack of gravel or pebbles in the overburden make it practically impossible to determine, merely by the records of drilled wells, the presence or location of the unconformities that probably are present.

HARD-ROCK AREA

The hard-rock area in those parts of Marion and Citrus Counties where wells were drilled contains four sets of deposits that affect phosphate explorations. At the top lies such Recent material as soil, silt, and wind-blown sand, and below are the Alachua formation, the Suwannee limestone (present only in a small area), and the Ocala limestone. Table 3 shows the correlation of the phosphate beds in the land-pebble area of Polk County with the hard-rock phosphate deposits of Marion and Citrus Counties.

TABLE 3.—*Correlation of the deposits in the land-pebble area of Polk County and the hard-rock phosphate area of Marion and Citrus Counties*

System	Series		Land-pebble phosphate area of Polk County	Hard-rock phosphate area of Marion and Citrus Counties
Quaternary.	Recent and Pleistocene (?).	Recent and Pleistocene (?).	Quaternary deposits (relatively thin deposits of windblown sand, soil, muck, silt, or stream deposits).	Quaternary deposits (relatively thin deposits of windblown sand, soil, muck, silt, or stream deposits).
Tertiary.	Pliocene.	Pleistocene (?) and Pliocene.	Citronelle (?) formation (sand, sandy clay, and clay with some sand).	Alachua formation (sand, sandy clay, and clay with hard-rock phosphate deposits in its lower part; may be equivalent in age to all of the Citronelle (?) and the Bone Valley combined).
		Lower Pliocene.	Bone Valley gravel (phosphate-bearing deposits with dark clays above them in western part of county and probably some sand above them in other parts of the region).	
	Miocene.	Upper and middle Miocene.	Absent where phosphate beds are present.	Absent.
		Lower Miocene.	Hawthorn formation (chiefly phosphatic limestone with clayey and sandy beds, the usual bed-rock of the land-pebble phosphate).	
			Tampa limestone (limestone, locally cherty, and some clay; covered in phosphate area but probably present).	
	Oligocene.	Middle Oligocene.	Suwannee limestone (pure limestone, formerly included in the Tampa; covered if present).	Suwannee limestone (probably occurs under phosphate only in southern part of Citrus County).
		Lower Oligocene.	Covered if present.	Absent.
	Eocene.	Upper Eocene.	Ocala limestone (probably present but covered).	Ocala limestone (a rather pure limestone, the bedrock of the hard-rock phosphate deposits).

The Alachua formation consists of sand, sandy clay, clay, and irregular deposits of phosphate in its lower part. According to Cooke and Mossom:[3]

The Alachua differs from most other formations in Florida in that the greater part of it seems not to have been laid down under water. It appears to be the residual product of the Hawthorn formation. Rain water, seeping downward, leached out the lime in the Hawthorn, deeply etched the underlying Ocala limestone, and ran off through the caverns in the Ocala. Much of the disseminated phosphate in the Hawthorn was also dissolved by the percolating carbonated waters, carried to lower levels, and redeposited as hard-rock phosphate in plates, sheets, and other forms. The sand in the Hawthorn formation, loosened by the removal of the cementing lime and containing many voids once occupied by phosphate nodules, settled under its own weight into more compact form and was further disturbed from time to time by the collapse of caverns in the underlying rock.

[3] Cooke, C. W., and Mossom, Stuart, op. cit., p. 175.

These processes of solution and settling have been going on ever since the Hawthorn formation emerged from the sea. They appear to have been especially active in the Pliocene, for many animals that are commonly referred to that epoch became trapped in sink holes or mired in the mud of ponds and left their bones in the Alachua formation. The fauna found in the Alachua may be mixed, for the entombment of animals in the Alachua was probably not restricted to Pliocene time. The dominant element of the fauna, however, is like that of the Bone Valley gravel and is regarded as of the same age.

The sands and sandy clays found to predominate in the wells drilled in the hard-rock area were much more brilliantly colored than in the land-pebble area. Clays were present, and in contrast to those in the overburden in Polk County, many of them contained practically no quartz sand. The deposits of hard-rock phosphate occur in the lower part of the Alachua formation. This formation, as shown by the wells drilled, is more than 100 feet thick.

Recently Cooke and Mansfield[4] have divided the beds, chiefly limestones, previously known as the Tampa limestone, into two formations—the Tampa limestone above and the Suwannee limestone below. The Tampa of the original area in the vicinity of Tampa and in most of Hillsborough County is of Miocene age. The northward extension of the limestone into Hernando County and the southern part of Citrus County, however, is now considered to be Oligocene and, like the material farther north, is named the Suwannee limestone. It is tentatively correlated with the Flint River formation of Georgia and with the Chickasawhay member of the Bryam marl of Mississippi. The limestone reached beneath the hard-rock phosphate in sec. 20, T. 20 S., R. 19 E., in the southern part of Citrus County, is considered Suwannee. In all other wells drilled in the hard-rock area the Ocala was the only limestone found beneath the phosphate.

The Ocala limestone is probably the most widespread formation in Florida. It underlies all or most of the State and is remarkably pure.

PHOSPHATE

LAND-PEBBLE AREA

The phosphate deposits of the land-pebble area consist of pebbles of different kinds mixed with sand and clay. As recovered from the well they are here called crude phosphate. The pebbles consist of all parts of the crude phosphate which are retained on a steel screen with slots half an inch long and 1/32 inch wide. All the material washed through this screen is called the matrix. The age and thickness of these deposits are mentioned under "Geology" (pp. 272–273).

Matrix is a term often used in the phosphate industry to designate the entire mixture here called crude. However, in this report it is restricted to the material in which the pebbles are embedded, because

[4] Cooke, C. W., and Mansfield, W. C., Suwannee limestone of Florida: Geol. Soc. America Proc., 1935, p. 71, 1936.

the introduction of flotation and other processes of recovery in the phosphate-mining industry demands a definite term.

Pebbles.—The pebbles have a minimum diameter of 1/32 inch, and the average pebble is probably less than half an inch in diameter. However, large pebbles are found, some so large they have to be broken before they can be recovered from the deposit through the 4½-inch casing. Pebbles 1½ inches in length are not uncommon.

Pebbles consisting mainly of phosphate calculated as tricalcium phosphate are associated with pebbles of flint, chert, limestone, quartz, fragments of calcareous fossils, iron pyrites, and ironstone.

The phosphate-bearing pebbles vary in composition, shape, size, and color. No attempt was made to determine the composition of the individual pebbles. Some appeared to be composed of rather pure phosphate; others contained iron, alumina, carbon, silica, and other constituents. Some pebbles contained varying amounts of quartz grains and small clay balls as inclusions. There were also many phosphatic fish remains, especially shark teeth. The pebbles, except the shark teeth, ranged through many different shapes, from well-rounded to angular, and their surface from smoothly polished to rough and irregular. The shark teeth, however, retained their original shape, and many of them did not appear to be water-worn. Pebbles with smooth rounded surfaces and flattened sides usually predominated; their colors ranged from a very light gray (almost white) through shades of gray, yellow, brown, red, blue, and green to jet black. As a rule dark pebbles are more abundant in the lower part of the phosphate-bearing section, but they are present and at many places abundant in other parts of the section. The calcareous fossils noted were mainly water-worn fragments of invertebrates that evidently were reworked from a previously existing formation. Silicified wood was relatively scarce, but some of the largest pebbles found were remnants of it. Quartz usually occurred either as coarse sand or as flat water-worn pebbles, generally oval and with rounded margins. Limestone pebbles, present mainly in the lower part of the phosphate beds, were, as a rule, irregularly subangular, rarely well rounded. Chert and flint pebbles were of different sizes and shapes but not very abundant. Among the rarer pebbles were small ironstone nodules and small pebbles of iron pyrites showing considerable oxidation.

Matrix.—The components of the matrix are similar to those of the pebbles described above but occur in different proportions and in the form of grains or powdered material. Relatively pure clay is also commonly present. Many minute shark teeth were noted. Ordinarily quartz as fine sand predominated.

HARD-ROCK AREA

The phosphate in the hard-rock area occurs mainly as boulders of rather high-grade phosphate. These are of different sizes, some weighing several tons. Their distribution is very irregular. In some places they are segregated in large masses in an area of several acres, with adjacent areas barren. Elsewhere they may occur in long, irregular-shaped areas, connected or nearly connected and covering many acres. In one square 40-acre tract containing a valuable commercial deposit the phosphate was so irregularly distributed that prospect wells drilled in the centers of each of three of the constituent 10-acre lots of the tract failed to show any phosphate. Flint boulders, pebbles of flint, phosphate, and other materials with powdered phosphate may occur with or near the phosphate boulders.

ORIGIN OF FLORIDA PHOSPHATE

Much has been written about the origin of the two types of phosphate deposits in the area covered by this report—the hard-rock in Marion and Citrus Counties and the land-pebble in Polk County—but any extended discussion of that subject is beyond the scope of this paper.

Briefly, the hard-rock phosphate is contained in the Alachua formation, which in most parts of the area rests on the Ocala limestone, a rather pure granular limestone of Eocene age. The Alachua formation is a residual accumulation of material derived mostly from the Hawthorn formation. The uneven floor on which it rests, like the deposit itself, is in large part a product of solution that has produced deep and wide crevices and irregular depressions in which the residual material of the Alachua has accumulated. In some places the accumulations are large enough to fill and overspread adjoining depressions, producing deposits many acres in extent and of varying thickness. Elsewhere they are smaller and more localized. The details of accumulation involve solution not only of the country rock (Hawthorn formation) but also of the contained phosphate, which apparently has undergone repeated solution and redeposition at successively lower levels. This process gives rise to the large individual boulders, the cemented masses of broken and more or less platy phosphate and the coatings of phosphate on other phosphatic objects, so frequently observed. The method of accumulation just described, as will be further shown, has a very direct bearing on the methods and cost of prospecting and exploiting the deposits.

The land-pebble phosphate is part of the Bone Valley gravel, of Pliocene age. It is thought to be contemporaneous with the Alachua formation, but instead of accumulating on the land as a residual

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deposit it was laid down in a shallow sea infested by sharks, as attested by the great number of shark teeth now found in it. Other forms of marine life were also present, but their remains are less abundant. Phosphatic pebbles, doubtless derived from the Hawthorn formation and its residual accumulations, together with sand and clay, were built into a bedded formation (see pl. 57) under conditions of irregular deposition; however, the floor on which the deposit lies and the thickness and distribution of the deposit are relatively regular as compared with the hard rock. These features have greatly facilitated the exploration and exploitation of these deposits.

A selected list of references is given below for those who wish to follow the subject further.

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Sellards E. H., A preliminary paper on the phosphate: Florida Geol. Survey 3d Ann. Rept., pp. 30-32, 37-38, 1910.

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Sellards, E. H., Origin, mining, and preparation of phosphate rock: Am. Inst. Min. Eng. Trans., vol. 50, pp. 904-912, 1915.

Sellards, E. H., Florida phosphate deposits: 14th Internat. Geol. Cong. Compte Rendu, fasc. 1, pp. 297-30, 1927. Pan-Am. Geologist, vol. 49, pp. 183-194, 1928.

Wyatt, Francis, Notes on Florida phosphate beds: Eng. and Min. Jour., vol. 50, pp. 218-220, 1890.

LOCATION OF TRACTS AND SELECTION OF WELL SITES

All but four of the tracts tested were located and marked with corner posts or stakes by Hugh B. Crawford, transitman, of the United States General Land Office. Well sites were selected and located as needed within the tracts.

The usual method of prospecting in the land-pebble phosphate area is to drill 16 wells to each 40 acres where phosphate is present. This permits an estimate of contained tonnage close enough to use in buying or leasing the land. However, for public-land classification, the Government needs only enough information to justify it in retaining the title to the mineral rights within the given tract. Under the law the burden of finding whether a deposit is really of commercial value is laid on the prospector, who becomes also a prospective lessee of the property. The Government's interest is not confined to the early exploitation of the deposit but extends far into the future. Deposits too poor or too unfavorably situated for early exploitation may deserve consideration for future generations and for times when present commercial conditions and requirements may be greatly changed. Thus fewer wells are needed for public-land classification than for commercial prospecting. Usually one to four wells properly spaced give sufficient information for classification of a 40-acre tract in the land-pebble area, especially where the trend of the deposits in the adjacent areas is known. In the hard-rock phosphate area, however, where the distribution of the phosphate deposits is markedly irregular, more wells are needed to test 40 acres.

DRILLING METHODS

LAND-PEBBLE AREA

The drilling in the land-pebble area was done with a modified Iwan Bros. type of post-hole auger about 4 inches in diameter and 1 foot long, shown in plate 59, *B*. The top of the auger was threaded to receive the end of a standard ¾-inch black iron pipe, which formed the auger stem. A short handle was screwed on the top section of the auger stem, as shown in plate 58, *A*.

The casing used consisted of 4½-inch extra heavy steel pipe with an inside diameter of about 4¼ inches. It weighed about 17 pounds to the foot. The sections of the casing had an inside thread on the upper end and an outside thread on the lower end, so that two pieces when screwed together formed a smooth joint, both inside and outside. The threads were cut square, about five to the inch. (See pl. 56, *A*.) The bottom section of the casing, called the "gun," had only the upper end threaded and notches cut into the bottom, which left that end with large sawlike teeth. The ends of these teeth were bent slightly outward so that the section of material forced into the casing as it was lowered was 5 inches in original diameter.

An auger hole was first bored to a depth of 4 to 6 feet if the nature of the ground permitted. Next the gun, or toothed lower section of casing, was inserted and a wooden clamp attached to the casing, as shown in plate 56, *B*. This served both as a platform for the drillers and as a means of twisting the casing back and forth to force it downward. (See pl. 58, *C*.)

Material too hard or too tough to be penetrated by the auger was broken up or loosened by a churn-type drill bit, which was screwed on the auger stem instead of the auger. The loosened material was later removed from the well with the auger. Where quicksand or soft wet material that could not be brought up with the auger was encountered, a sand pump was used. This was a steel pipe 3¼ inches in outside diameter and 42 inches long, with a large flapper valve in the bottom, and a fixed steel bail at the top. The sand pump with attached rope about to be lowered into the casing is shown in plate 59, *C*.

A lean pole (pl. 58, *A*) or tripod (pl. 56, *B*) was used to guide or support the auger stem. When the stem was over 30 feet long, it was usually unscrewed into sections about 25 feet long as the auger was being pulled. Where the strata of the overburden were firm, the auger was kept slightly ahead of the bottom of the casing; but where the strata were soft or mobile or when the phosphate beds were reached the casing was kept well ahead of the auger to prevent caving or the entrance of more material than that contained in the original 5-inch core. The drill and sand pump were used as needed, but when the phosphate deposits were reached the sand pump was always used to clean out the loose overburden mixed with water before recovery of the phosphate was attempted.

The phosphate was removed from the auger and saved in large bags as shown in plate 59, *B*. The part of the phosphate mixed with water by the movement of the auger was recovered by the sand pump. The mixture was poured into bags placed in holes dug in the ground. This allowed the excess water to drain out slowly so as to carry but little powdered matrix with it. The phosphate samples were divided, as the drilling progressed, wherever the character of either the pebbles or the matrix changed. The drilling was continued to hard bedrock, which was always well tested with the drill. The total weight of the crude samples obtained from a single well ranged from a few pounds to more than 500 pounds.

When the well was completed the casing was removed from the ground by looping a log chain around it and over the end of a long log lever, as shown in plate 59, *A*. Some men bore down on the end of the lever while others loosened the casing by alternately pushing and pulling on the ends of the casing clamp. Wells were drilled under different surface conditions, such as open country (pl. 58, *C*), improved property, thick-grown swamps, lakes (pl. 58, *B*), impounded rivers (pl. 58, *A*), and wooded areas.

The deepest well drilled in the pebble area was 109½ feet deep and is thought to be the deepest well ever drilled in the land-pebble field with a 4½-inch casing and man power alone.

HARD-ROCK AREA

The usual method of drilling in the hard-rock area employs a heavy 2-inch casing with standard couplings and a fishtail bit screwed on a ¾-inch pipe. The bit has holes in the sides directed upward and inward and a ball check valve, so that the drilled rock is forced into the drill stem and retained as a sample. A driving block is also used to force the casing downward. Considerable trouble is experienced in recovering casing. In the work here described a combination of the methods of the land-pebble and the hard-rock areas was used.

The wells were started with the auger and 4½-inch casing and continued to the top of the hard phosphate rock. The 2-inch casing was then inserted inside the 4½-inch casing, and drilling with the equipment just described was begun. The 2-inch casing was re-threaded in the same manner as the 4½-inch casing, and the regular pipe couplings were eliminated, thus making the casing smooth outside as well as inside. This allowed the casing to penetrate the strata more easily, so that often the mere twisting of the casing was sufficient. This method gave clear and definite information as to the character and depth of the material passed through. If any phosphate, as pebbles, soft phosphate rock, or powdered phosphate, occurred above the hard rock, definite information as to its presence and amount was obtained. The rate of drilling by man power was increased. The time required for pulling casing was reduced, and casing losses were practically eliminated. However, if a power-drilling outfit was available, or if the overburden was very thin, the old established method would probably be preferable.

DETERMINATION OF PHOSPHATE CONTENT

LAND-PEBBLE AREA

The samples of crude phosphate, obtained from the wells as explained in the preceding section on drilling, were allowed to stand until the surplus water in the samples from the sand pump had drained off. Then the samples were weighed as "crude weight." The crude material was then washed over a steel screen with slots half an inch long and 1/32 inch wide. All material passing through the screen was saved, boiled dry, and weighed as "dry matrix," and the pebbles retained by the screen were dried over a fire and weighed as "dry pebble." The difference between the crude weight and the sum of the weights of dry pebble and dry matrix represented the moisture loss, which averaged about 33 percent of the crude weight. The drying was intended to remove only the uncombined water and not to calcine the material. The dry pebbles and dry matrix were also each computed as a percentage of the crude.

Former prospecting in this area has concerned itself mainly with the pebbles, and the matrix has seldom been saved. Now that flotation and other processes of concentration and recovery have been adapted to phosphate mining, it is important to determine the amount of fine phosphate in the crude. The work here reported was probably the first general prospecting in Polk County where the entire matrix was systematically recovered and tested, though in commercial practice a $\frac{3}{64}$-inch screen is now used in addition to a $\frac{1}{32}$-inch screen in order to catch finer material.

The samples of dry pebble and dry matrix were each reduced by quartering, crushing, and pulping. Representative samples were sent to the Geological Survey laboratory in Washington, and the percentages of soluble aluminum and iron oxides, of phosphoric pentoxid, and of equivalent tricalcium phosphate were determined.

Two general methods are used in the Florida land-pebble area for computing the tonnage of pebble per acre from data obtained by prospecting. They are the Pratt and the Mead methods.

The Mead method is based upon the weight of pebble in the core obtained from a well, it being assumed that this core has a perfectly uniform diameter, and upon the relation of the area of cross section of this core to an acre. The determined thickness of the phosphate deposit, the total amount of matrix, and the weight of a cubic foot of crude are not direct factors in this method. However, a variation of as little as an eighth of an inch in the diameter of the core obtained, which may be caused by the spreading or bending in of the teeth on the bottom of the casing, may cause an error of several hundred tons to the acre in the estimate. Likewise a small loss or a gain in the sample caused by flowage of material into the casing, if the casing was not driven sufficiently ahead of the auger, may cause a large difference in the estimate.

The Pratt method is based upon the thickness of the phosphate bed, its percentage of contained pebble, and the specific gravity of the deposit. This method, with minor variations of details, is the more widely used. The size of the hole drilled is not a factor in this method, and minor variations of the size of core obtained do not ordinarily affect the final calculations appreciably. In the prospecting here described the Pratt method was used exclusively. In practice, the weight of a cubic foot of crude is used instead of the specific gravity. For much of the Polk County deposits this weight is 125 pounds. Thus:

$$\frac{\text{Square feet per acre (43,560)}\times 125}{\text{long ton (2,240 pounds)}}=2{,}430.8 \text{ or (omitting the 0.8)}$$

$= 2{,}430 =$ constant. $2{,}430\times$thickness (feet)$\times$percentage of pebble $=$ tons of pebble per acre.

As the weight of crude per cubic foot actually varies from place to place, correction must be applied to each result obtained. This is easily done, for computation shows that a change of 1 pound in weight of a cubic foot of crude changes the total tonnage ⅕ ton per foot of crude for 1 percent of pebble.

For example, a 15-foot bed of crude weighing 125 pounds per cubic foot and containing 12 percent of pebble indicates 2,430×0.12×15, or 4,374 tons of pebble per acre. However, if the crude weighed only 121 pounds, 4 pounds less than standard, the correction is (−4)×⅕ ×15×12, or −144 tons. The amount of pebble would then be 4,374 −144, or 4,230 tons per acre. Ordinarily the bottom sample weighed slightly less than the top sample.

In general practice the thickness of the deposit is taken to the nearest half foot. In the present work it was recorded to the nearest inch, and this figure was used. By the method used to estimate tonnage, a variation of 3 inches in thickness of a deposit gives a variation of 60 tons per acre for 10 percent pebble content, or 243 tons per acre for 40 percent pebble. The tonnage of matrix was computed separately for each well in the same manner as the pebble content, and the sum of phosphate in pebble and in matrix was taken as the total tonnage of tricalcium phosphate per acre for a given tract.

Estimating tonnage per acre from a single well involves very large extrapolation from available data. Actual knowledge is confined to the area of the hole from which the samples were taken, and the ratio of this area to an acre is about 1:300,000. However, a deposit in a given area is generally so uniform that in commercial practice 16 holes ordinarily suffice for 40 acres. As already explained, the Government's needs can be met by using fewer holes.

HARD-ROCK AREA

No definite method of computing the amount of phosphate rock from the data obtained by hard-rock drilling appears to have been devised. One driller in Citrus County who has probably done more prospecting in the Florida hard-rock area during the last quarter of a century than any other man stated that he had no mathematical method. From long years of prospecting he was able to judge from seeing the coarse pieces of rock screened from the drill-stem sample the percentage of hard-rock phosphate present. His estimates, he said, usually came within a few percent of the actual amount mined. The method here employed was as follows: A hose was attached to the top of the drill stem, to catch in tubs the fine material forced with the water from the well as the drilling progressed. This fine material, with the material retained in the drill stem, constituted the phosphate samples. These samples were dried, pulped, and analyzed in the same way as the pebble phosphate, and the percentage of P_2O_5 and equivalent tricalcium phosphate, usually called B. P. L. (bone phosphate of lime), was determined. The constant 2,430 derived in the land-pebble area in determining the tonnage was also used. This constant is probably rather low—too low if solid phosphate alone is considered. However, in the 11 wells drilled in the hard-rock area those that showed phosphate had nonphosphatic beds between the phosphate layers. Therefore, the constant 2,430 is here considered fair but conservative. This constant 2,430 times the percentage of B. P. L. times the thickness in feet represented by the sample gave the contents in tons per acre of B. P. L. for the part of the section from which the sample came. The total tonnage of the different samples obtained from a well was therefore the total tonnage per acre of B.P.L. shown by that well. It did not indicate the total tons of rock phosphate per acre, nor the true grade, for the original samples contained beds of lime carbonate and of clay.

Where thin bands of clay lay between thin bands of phosphate rock, it seemed probable that much of the hard rock would be pushed aside by the drill and a corresponding amount of the clay forced into the drill pipe. This of course would reduce the average grade of the sample recovered.

As the phosphate deposits are unevenly distributed, an accurate test of an area in the hard-rock phosphate region requires many wells. In commercial practice about 16 wells are required to test an acre properly. However, the law requires a prospecting lessee to do his own prospecting; hence the Government's purpose was served if the presence of phosphate was indicated by one or more good showings in a given 40-acre tract, to afford a basis for classification of the land.

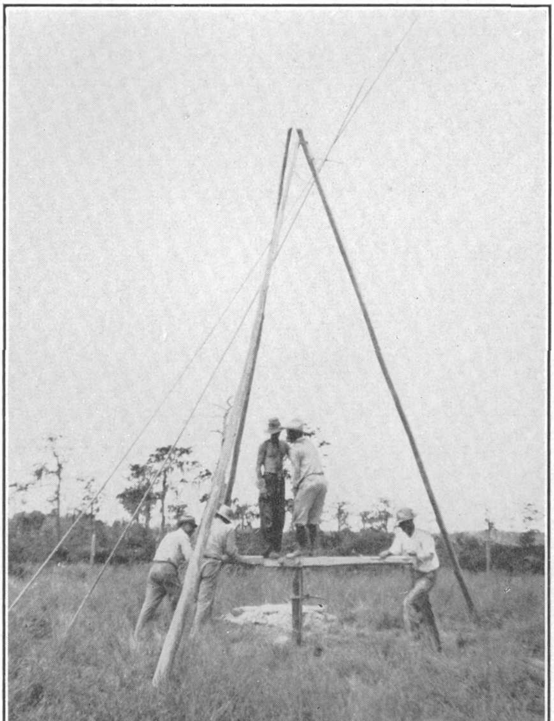
PHOSPHATE IN TESTED TRACTS

LAND-PEBBLE FIELD

The information obtained in prospecting the respective tracts is summarized by townships, and the location of both townships and prospected tracts is shown in plate 55. The figures for average overburden and phosphate content obtained for a given tract are based on data from just a few wells and may differ considerably from actual average conditions throughout the tract. The tracts usually contain 40 or some multiple of 40 acres. The quantity of phosphate pebbles to the acre is given for each tract in long tons. Similar figures are given separately for the phosphate (B. P. L.) content of the pebbles and the matrix for each tract, and for each tract as a whole.

If the estimate of the pebble content for a unit is less than 1,000 tons to the acre, all estimates for that unit are taken to the nearest 50 tons, whereas for units having 1,000 tons or more of pebble to the

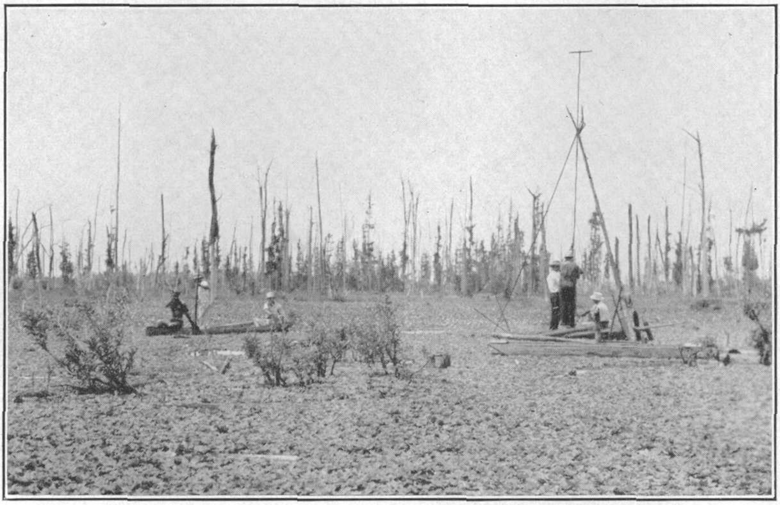
A. 4½-INCH WELL CASING, SHOWING COARSENESS AND ARRANGEMENT OF THREADS.



B. WELL IN T. 30 S., R. 26 E., SHOWING TRIPOD TYPE OF AUGER-STEM REST, METHOD OF SINKING CASING, AND MEN USING SAND PUMP.

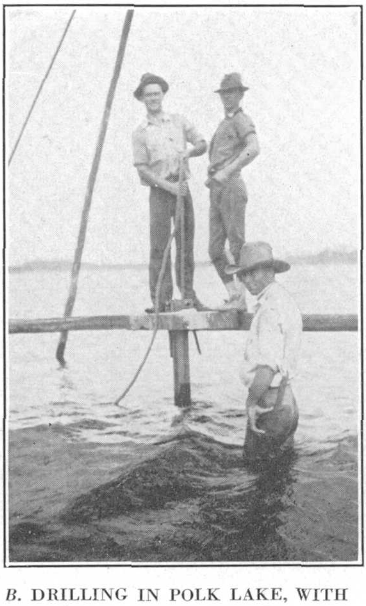
SECTION OF OVERBURDEN, PEBBLE PHOSPHATE, AND BEDROCK OF MARL, AT HOPEWELL MINE, NEAR PLANT CITY.

Photograph by G. R. Mansfield, 1923.



A. WELL DRILLED ABOUT 4 MILES WEST OF DUNNELLON IN AREA FLOODED BY THE WITHLACOOCHEE RIVER.

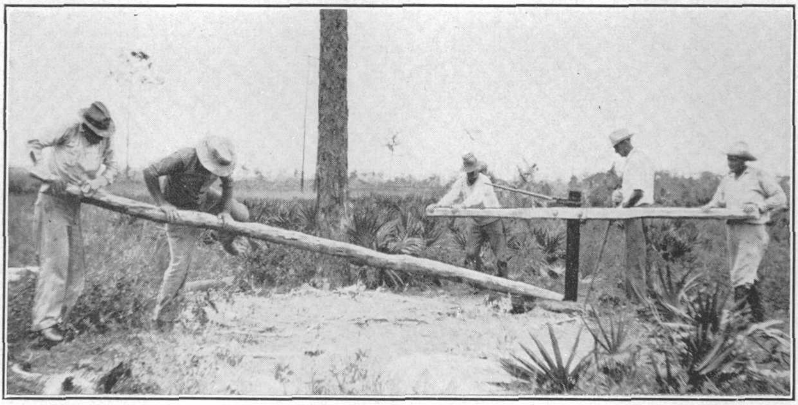
Note drilling platform on crossed-log crib and lean pole used for an auger-stem rest. This well was drilled more than 103 feet below the surface of the water.



B. DRILLING IN POLK LAKE, WITH SAND PUMP IN USE.

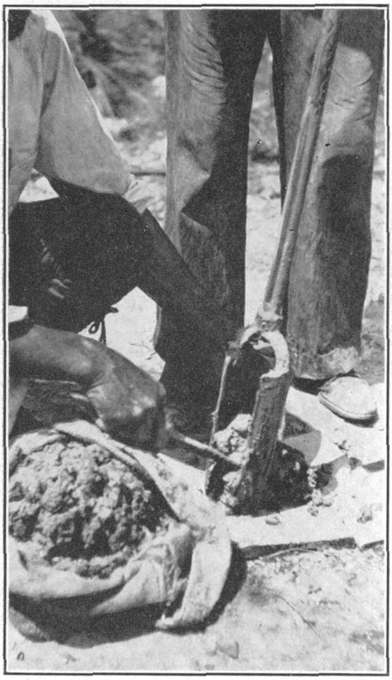
C. DRILLING OPERATIONS IN LAND-PEBBLE AREA.

Note lean pole. Some of the men sink the casing by revolving it while the others drill. Casing clamp serves as platform.



A. PULLING CASING BY MEANS OF LOG LEVER AND CHAIN LOOPED AROUND CASING AND OVER END OF LEVER.

Some of the men bear down on the lever while others alternately pull and push ends of casing clamp. The casing in this well weighs about three-fourths of a ton.



B. AUGER AND PHOSPHATE SAMPLE.

C. SAND PUMP READY TO BE LOWERED INTO WELL.

acre the estimates are indicated to the nearest 100 tons. This difference, together with the variation in acreage of the so-called "40-acre tracts," has for some tracts caused a seeming disagreement in the total B.P.L. content in the tract and the average total B.P.L. content to the acre.

T. 28 S., R. 24 E., POLK COUNTY

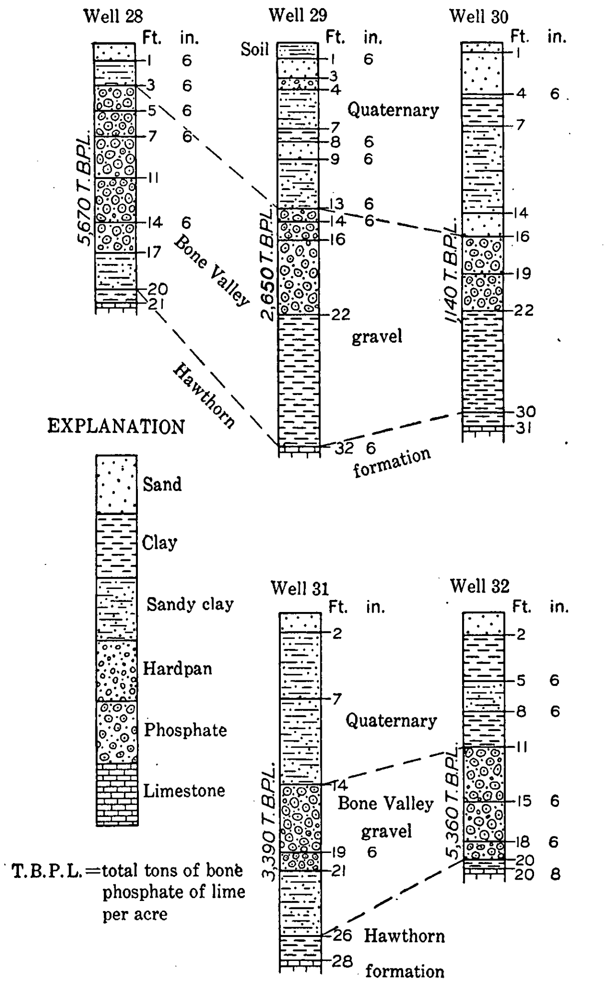
Location and character.—The three 40-acre tracts prospected in T. 28 S., R. 24 E., comprise the W½NE¼ and the NW¼SE¼ sec. 36. (See pl. 55 and fig. 36.) They are near Lake Hancock, and a swamp extends into them from the north end of the lake. An area in the northwest corner of the northern tract is cultivated and has a house on it. The western part of the southern tract is cleared and is now used for grazing cattle, as is a part of the southwestern part of the center tract. Pine trees grow on some of the drier areas within the tracts. Cypress is abundant. Other trees and much brush grow in and around the swamp.

Phosphate content.—The three tracts cover 120.97 acres, but for the purpose of estimating phosphate content each is considered as 40 acres. Five test wells were sunk in these tracts, located as shown in figure 36.

The data derived from prospecting in this township and from subsequent laboratory work are given in table 4.

The W½NE¼ sec. 36 is considered as a single 80-acre tract and was tested by wells 28, 31, and 32. On the basis of the results from these three wells, using arithmetical averages, the 80 acres is estimated to contain about 2,070 tons of pebble containing 1,160 tons of B. P. L. and 12,670 tons of matrix containing 3,650 tons of B. P. L. per acre, a total of 4,810 tons of B. P. L. per acre. This gives a total of 165,600 tons of pebble containing 92,800 tons of B. P. L. and 1,013,600 tons of matrix containing 292,000 tons of B. P. L., a grand total content of B. P. L. for the 80 acres of 384,800 tons.

The NW¼SE¼ sec. 36 was tested by wells 29 and 30. On the basis of the results from these wells the 40 acres is similarly estimated to contain about 680 tons of pebble containing 430 tons of B. P. L. and 10,450 tons of matrix containing 1,470 tons of B. P. L. per acre, a total of 1,900 tons of B. P. L. per acre. The total content of the 40-acre tract is 27,200 tons of pebble containing 17,200 tons of B. P. L. plus 418,000 tons of matrix containing 58,800 tons of B. P. L., a grand total B. P. L. content of 76,000 tons.



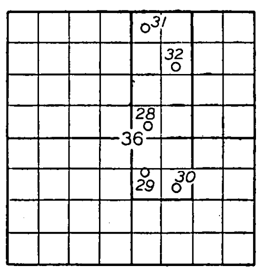


Diagram showing location of test wells in sec. 36, T. 28 S., R. 24 E.

FIGURE 36.—Logs of test wells 28 to 32, sec. 36, T. 28 S., R. 24 E.

TABLE 4.—*Phosphate data from T. 28 S., R. 24 E.*

Well No.	Overburden (feet)	Phosphate: Sample	Phosphate: Thickness (feet)	Crude weight (pounds)	Pebble dry weight (pounds)	Matrix dry weight (pounds)	Pebble (percent)	Matrix (percent)	$(Al, Fe)_2O_3$[1]: Pebble (percent)	$(Al, Fe)_2O_3$[1]: Matrix (percent)	$Ca_3P_2O_8$ (B. P. L.)[1]: Pebble (percent)	$Ca_3P_2O_8$ (B. P. L.)[1]: Matrix (percent)	Estimated quantity (tons per acre): Pebble	Estimated quantity (tons per acre): Matrix	Estimated content of B. P. L. (tons per acre): Pebble	Estimated content of B. P. L. (tons per acre): Matrix	Estimated content of B. P. L. (tons per acre): Total
28	3½	Top	7½	126½	16	69	12.6	54.5	1.76	8.34	48.05	33.55	2,300	9,900	1,100	3,320	4,420
		Bottom	6	34½	3	44	3.2	46.6	5.48	5.52	41.23	15.24	500	6,800	210	1,040	1,250
		Total	13½	161	19	113							2,800	16,700	1,310	4,360	5,670
29	13½	Top	1	29	3	18	10.3	62.0	1.71	4.29	65.37	16.62	250	1,500	160	250	410
		Bottom	7½	95	3	63	3.2	66.3	3.54	4.14	65.74	15.33	600	12,100	390	1,850	2,240
		Total	8½	124	6	81							850	13,600	550	2,100	2,650
30	16	Top	3	51	3	34	5,9	66.7	3.84	2.58	60.19	11.86	400	4,900	240	580	820
		Bottom	3	41	1	13¾	2.4	33.5	8.34	4.26	34.53	10.05	200	2,400	70	250	320
		Total	6	92	4	47¾							600	7,300	310	830	1,140
31	14	Top	5½	66	4	40	6.1	60.6	3.69	5.94	62.81	27.58	800	8,100	500	2,240	2,740
		Bottom	1½	49	6	25	12.2	51.0	2.82	4.50	64.45	37.32	400	1,200	250	400	650
		Total	7	115	10	65							1,200	9,300	750	2,640	3,390
32	11	Top	4½	87	9	46	10.3	52.8	2.58	3.66	67.62	34.40	1,100	5,800	760	1,990	2,750
		Middle	3	32	3¼	20	10.2	62.5	4.17	3.03	58.33	31.89	700	4,600	410	1,460	1,870
		Bottom	1½	33	4	14½	12.1	44.0	2.58	4.17	63.31	30.47	400	1,600	230	490	740
		Total	9	152	16¼	70½							2,200	12,000	1,400	3,940	5,360

[1] Analyst, J. G. Fairchild.

The tonnage estimates just given are tabulated for convenience below, with the figures rounded off:

TABLE 5.—*Tonnage estimates of phosphate for T. 28 S., R. 24 E.*

Unit	Area (acres)	Total B. P. L. (tons)	Average overburden (feet)	Average phosphate content (long tons per acre)			
				Pebble	B. P. L.		
					In pebble	In matrix	Total
W½NE¼ sec. 36	80	385,000	9¼	2,100	1,200	3,600	4,800
NW¼SE¼ sec. 36	40	76,000	12	700	450	1,450	1,900

The northern unit of 80 acres shows pebble with an average grade of 56 percent and soluble iron and aluminum oxides 2.8 percent. The southern unit of 40 acres not only contains less phosphate per acre, but the pebble is of lower grade—51½ percent B. P. L. and 3 percent soluble iron and aluminum oxides.

Each unit has about three times as much B. P. L. in the matrix as in the pebble. The resulting total recoverable phosphate, if flotation or some comparable process were used, would probably be of very high grade.

As the phosphate is so shallow, it is thought that many of the deeper parts of the swamps will contain less phosphate than the amount indicated by the drilling, and therefore the estimates, especially for the southern unit, are probably slightly too large.

T. 29 S., R. 24 E., POLK COUNTY

Location and character.—The location of the lands prospected and test wells drilled in T. 29 S., R. 24 E., is shown in plate 55 and figures 37 and 38.

The tract in sec. 25 is rather low land traversed by a small creek. Young pine trees and water oak grow on it, together with abundant brush and briers. Some parts are swampy. The area in sec. 28 is rather level and open except that a small stream that runs southward near the eastern edge has made a deep cut in the southern part and the brush is thick there. Many pine trees grow along the southern part of this tract. The 80 acres in sec. 32 is relatively open, with growths of palmetto and scrub oak and a few scattered pines.

Phosphate content.—Eight wells were drilled on these tracts, and the records of some other wells drilled in the township were made available to the writer from a private source. The data obtained from the eight wells mentioned and from the subsequent laboratory tests are summarized in table 6.

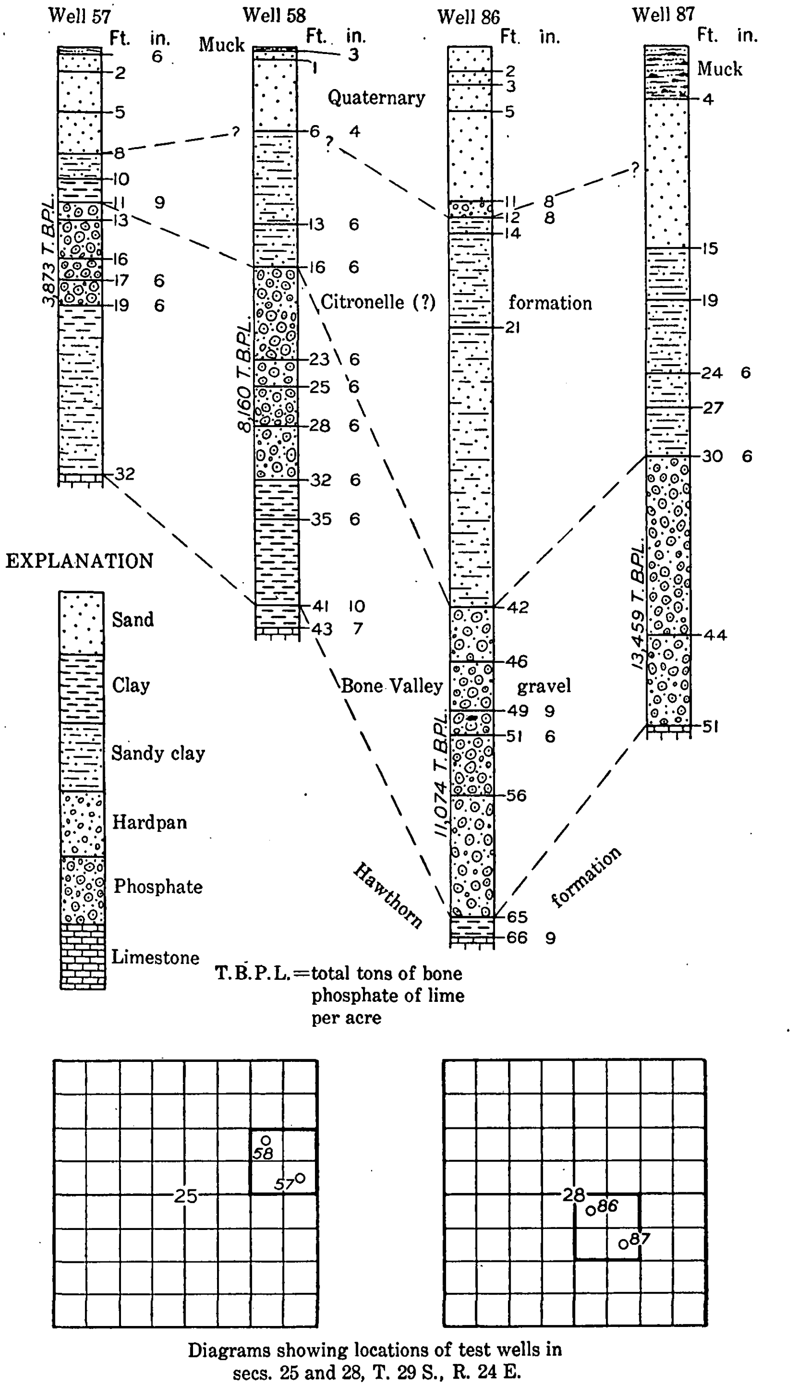


FIGURE 37.—Logs of test wells 57, 58, 86, and 87, secs. 25 and 28, T. 29 S., R. 24 E.

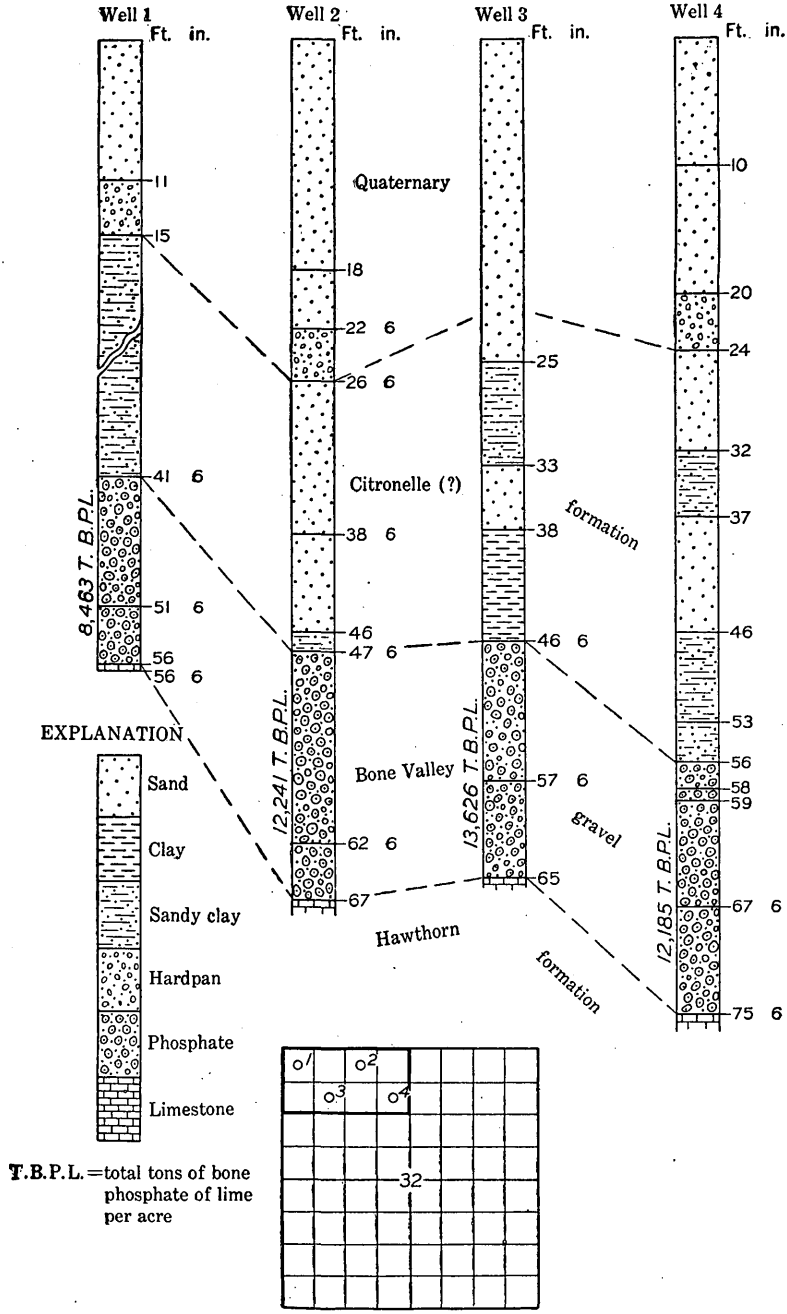


Diagram showing location of test wells in sec. 32, T. 29 S., R. 24 E.

FIGURE 38.—Logs of test wells 1 to 4, sec. 32, T. 29 S., R. 24 E.

TABLE 6.—*Phosphate data from T. 29 S., R. 24 E.*

[For wells 1-4 no samples of matrix were saved. For these wells the percent and quantity of matrix as given in the table are estimates. Analysts: Wells 57, 58, 86, and 87, R. E. Stevens; wells 1-4, J. G. Fairchild.]

Well No.	Over-burden (feet)	Phosphate		Crude weight (pounds)	Pebbles dry weight (pounds)	Matrix dry weight (pounds)	Pebble (percent)	Matrix (percent)	$(Al, Fe)_2O_3$		$Ca_3P_2O_8$		Estimated quantity (tons per acre)		Estimated content of B. P. L. (tons per acre)		
		Sample	Thick-ness (feet)						Pebble (percent)	Matrix (percent)	Pebble (percent)	Matrix (percent)	Pebble	Matrix	Pebble	Matrix	Total
57	11¾	Top	5¾	132	13	76	9.8	57.6	1.06	5.11	73.22	28.07	1,313	7,717	961	2,166	3,127
		Bottom	2	36	3¼	15½	9.0	43.1	1.28	.33	67.22	23.10	419	2,009	282	464	746
		Total	7¾	168	16¼	91½							1,732	9,726	1,243	2,630	3,873
58	16½	Top	12	183	24	104	13.1	56.8	1.19	.10	72.02	28.10	3,726	16,154	2,683	4,539	7,222
		Bottom	4	53½	¾	32½	1.4	60.7	.79	.18	65.93	14.76	133	5,755	88	850	938
		Total	16	236½	24¾	136½							3,859	21,909	2,771	5,389	8,160
86	42	Top	9½	124	4	59	3.2	47.6	3.57	4.90	70.81	9.33	739	10,989	523	1,024	1,547
		Bottom	13½	239	58	151½	24.3	63.3	1.87	5.04	64.73	21.03	7,972	20,767	5,160	4,367	9,527
		Total	23	363	62	210½							8,711	31,756	5,683	5,391	11,074
87	30½	Top	13½	226	65	104	28.8	46.0	1.40	3.67	67.51	20.33	9,448	15,090	6,378	3,068	9,446
		Bottom	7	97¼	26	31½	26.7	32.4	3.73	9.57	57.99	25.03	4,542	5,512	2,633	1,380	4,013
		Total	20½	323¼	91	135½							13,990	20,602	9,011	4,448	13,459
1	41½	Top	10	195½	43		22.0	48.4	2.54		67.24		5,300	11,600	3,565	2,320	5,885
		Bottom	4½	74½	17		22.8	44.2	5.13		64.73		2,500	4,800	1,618	960	2,578
		Total	14½	270	60								7,800	16,400	5,183	3,280	8,463
2	47½	Top	15	342	66½		19.4	50.6	1.30		70.37		7,100	18,400	4,996	3,680	8,676
		Bottom	4½	73	31		42.5	27.5	4.39		64.45		4,600	3,000	2,965	600	3,565
		Total	19½	415	97½								11,700	21,400	7,961	4,280	12,241
3	46½	Top	11	147	50½	56	34.3	38.1	2.53		67.28	23.98	9,200	10,200	6,190	2,446	8,636
		Bottom	7½	122½	43¾		35.7	21.3	4.87		64.77		6,500	3,900	4,210	780	4,990
		Total	18½	269½	94¼								15,700	14,100	10,400	3,226	13,626
4	56	Top	11½	259	55		21.2	48.8	1.82		70.17		5,900	13,600	4,140	2,720	6,860
		Bottom	8	120	33¾	35½	28.1	29.5	5.47		64.54	31.14	5,500	5,700	3,550	1,775	5,325
		Total	19½	379	88¾								11,400	19,300	7,690	4,495	12,185

In table 7 the data presented in table 6 are summarized with respect to the different areas prospected. Arithmetical averages are used, and the results are rounded off to the nearest hundred tons. For example, the N½NW¼ sec. 32 was tested by wells 1 to 4. The estimated quantity of B. P. L. in pebble, as derived from the sampling data for well 1, is 7,800 tons per acre. Similarly, the figures for wells 2, 3, and 4 are respectively 11,700, 15,700, and 11,400 tons. These added and averaged give 11,650 rounded to 11,600 tons, as shown in the table.

TABLE 7.—*Tonnage estimates of phosphate in T. 29 S., R. 24 E.*

Unit	Area (acres)	Total B. P. L. (tons)	Average over-burden (feet)	Average phosphate content (long tons per acre)			
				Pebble	B. P. L.		
					In pebble	In matrix	Total
N½NW¼ sec. 32	80	928,000	48	11,600	7,800	3,800	11,600
NW¼SE¼ sec. 28	40	488,000	36	11,400	7,300	4,900	12,200
SE¼NE¼ sec. 25	40	240,000	14	2,800	2,000	4,000	6,000

Sec. 32.—About 59 percent of the pebble in the 80-acre unit in sec. 32 is in the upper part of the phosphate beds. It ranges from 67 to 70 percent of B. P. L. and has a reasonably low content of soluble iron and aluminum oxides. The 41 percent of pebble in the lower part of the phosphate beds averages about 64½ percent of B. P. L. but contains about 5 percent of soluble iron and aluminum oxides. The B. P. L. in the matrix will raise the grade of the total phosphate present.

Sec. 28.—The average grade of the pebble in the 40-acre unit in sec. 28 is about 64 percent of B. P. L., with only about 2.16 percent of soluble iron and aluminum oxides. The large amount of B. P. L. in the matrix will improve the grade of the recoverable phosphate, but as the matrix contains a fairly large amount of iron oxide and alumina, the total amount of these constituents will also be increased.

Sec. 25.—The average grade of the pebble in the 40-acre unit in sec. 25 is about 71.84 percent of B. P. L., with less than 1.5 percent of soluble iron oxide and alumina. The matrix also shows a very small percentage of soluble iron oxide and alumina.

T. 30 S., R. 24 E., POLK COUNTY

Location.—The four 40-acre tracts explored in T. 30 S., R. 24 E., comprise the SW¼NW¼ sec. 2, the SW¼SE¼ sec. 4, the NW¼SW¼ sec. 22, and the NW¼NE¼ sec. 24. The location of these tracts is given on plate 55 and in figures 39 to 41, which also show the location of the test wells drilled.

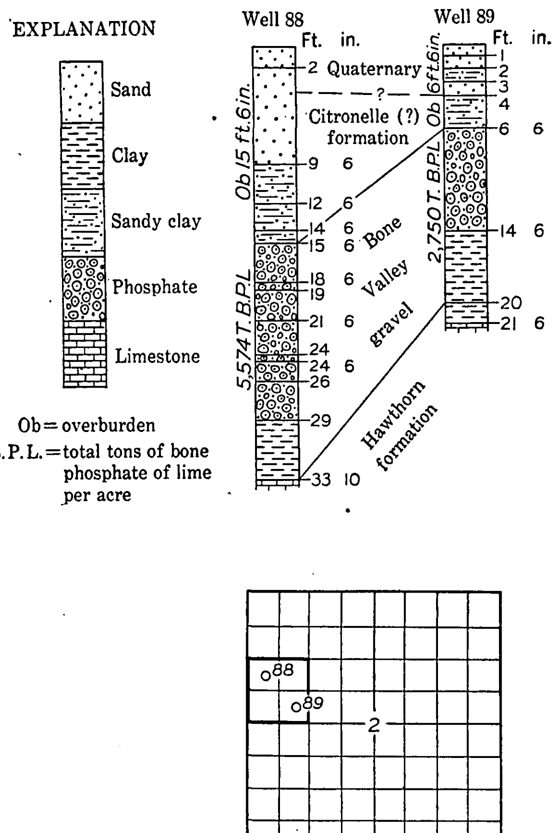


Diagram showing location of test wells in sec. 2, T. 30 S., R. 24 E.

FIGURE 39.—Logs of test wells 88 and 89, sec. 2, T. 30 S., R. 24 E.

Phosphate content.—Eight wells were drilled in T. 30 S., R. 24 E., and the records of some other nearby wells were available from a private source. The data from the Government wells, including laboratory tests of the samples, are summarized in table 8.

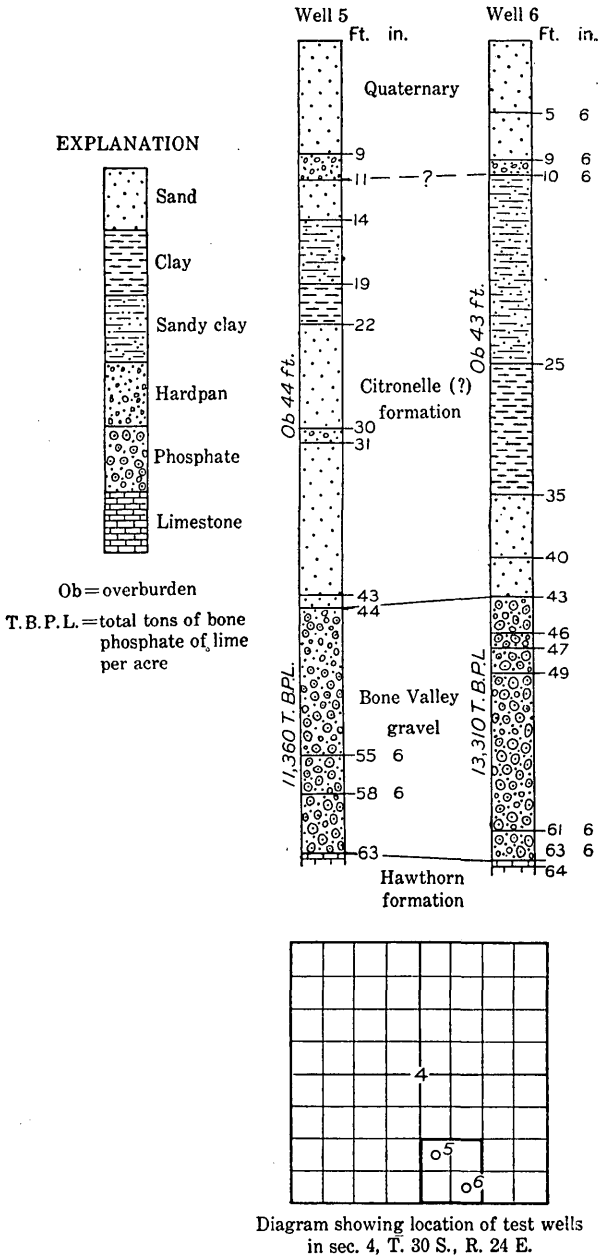
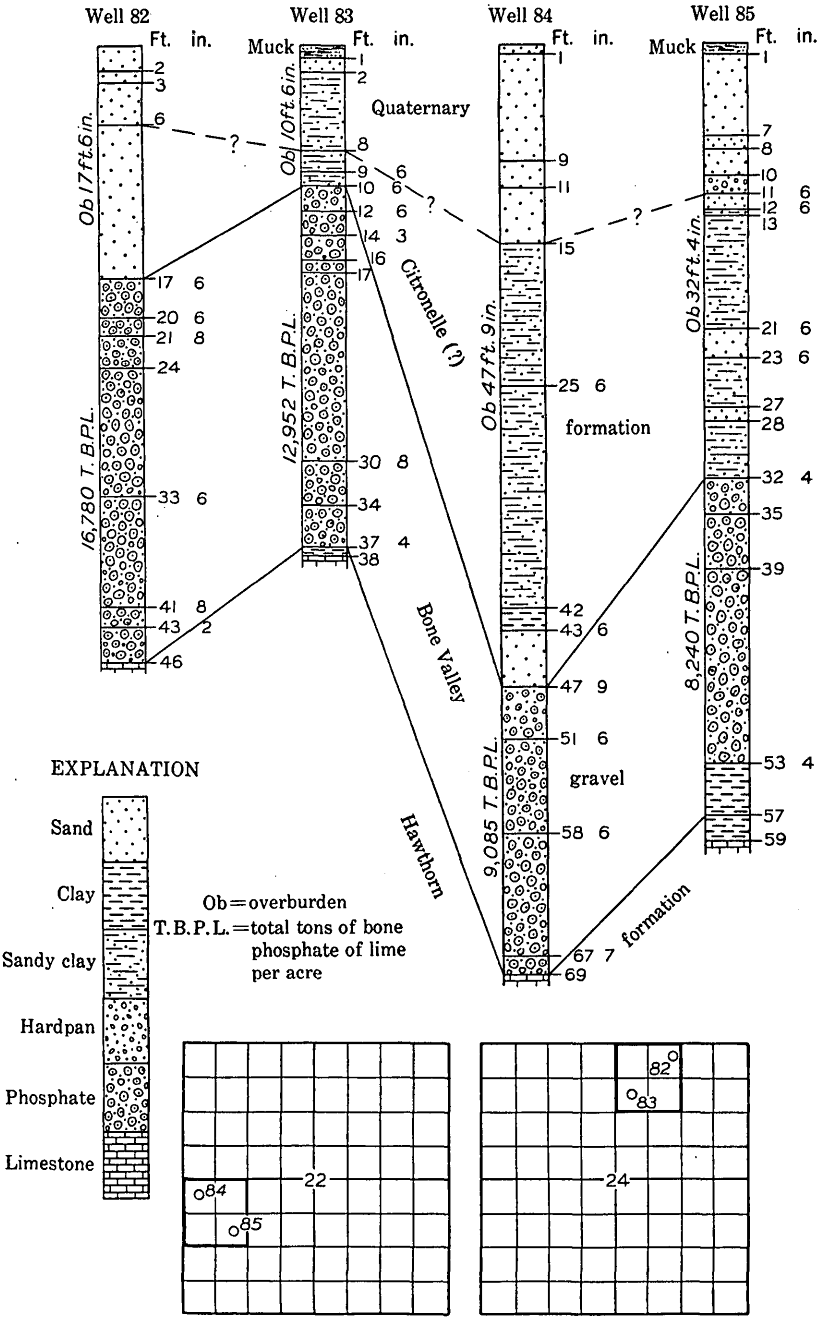


FIGURE 40.—Logs of test wells 5 and 6, sec. 4, T. 30 S., R. 24 E.



Diagrams showing locations of test wells in secs. 22 and 24, T. 30 S., R. 24 E.

FIGURE 41.—Logs of test wells 82 to 85, secs. 22 and 24, T. 30 S., R. 24 E.

TABLE 8.—*Phosphate data from T. 30 S., R. 24 E.*

Well No.	Overburden (feet)	Phosphate		Crude weight (pounds)	Pebble, dry weight (pounds)	Matrix dry weight (pounds)	Pebble (percent)	Matrix (percent)	$(Al, Fe)_2O_3$[1]		$Ca_3P_2O_8$[1]		Estimated phosphate (tons per acre)		Estimated B. P. L. (tons per acre)		
		Sample	Thickness (feet)						Pebble (percent)	Matrix (percent)	Pebble (percent)	Matrix (percent)	Pebble	Matrix	Pebble	Matrix	Total
88	15½	All	13½	208	6	133¾	2.9	64.3	4.5	3.77	60.08	23.72	951	21,094	571	5,003	5,574
89	6½	All	8	140	3	75½	2.1	53.9	6.18	3.75	58.88	23.96	408	10,478	240	2,510	2,750
5	44	Top	11½	205	62		30.0	[2] 40	1.78		66.17		8,400	11,100	5,550	[1] 2,200	7,750
		Middle	3	50	16		32.0	[2] 38	3.72		61.37		2,300	2,700	1,410	[1] 500	1,910
		Bottom	4½	50	8		16.0	[2] 41	3.92		47.09		1,700	4,500	800	[1] 900	1,700
		Total	19	305	86								12,400	18,300	7,760	3,600	11,360
6	43	Top	18½	274	84		30.6	[1] 39.4	2.44		63.51		13,800	17,700	8,760	3,500	12,260
		Bottom	2	26	6½		25	[2] 32	5.36		62.70		1,200	1,600	750	300	1,050
		Total	20½	300	90½								15,000	19,300	9,510	3,800	13,310
84	47¾	Top	3¾	104	20	55½	19.2	53.4	2.07	2.70	69.36	10.85	1,750	4,866	1,214	527	1,741
		Upper Middle	6¾	108	3	67	2.8	62.0	5.70	2.67	61.61	7.38	459	10,170	283	750	1,033
		Lower Middle	9⅓	195½	53½	71	27.4	36.3	2.47	3.84	63.99	17.73	6,214	8,233	3,976	1.460	5,436
		Bottom	1 5/12	40	9	16	22.5	40.0	5.04	3.90	55.76	32.17	775	1,377	432	443	875
		Total	21¼	447½	85½	209½							9,198	24,646	5,905	3,180	9,085
85	32⅓	Top	2⅔	84½	13¼	42½	15.7	50.3	1.20	8.00	75.26	27.34	1,017	3,259	765	891	1,656
		Middle	4	42½	¾	25	1.8	58.8	4.27	2.27	68.21	10.22	175	5,715	119	584	703
		Bottom	14⅓	239	52	107½	21.7	45.0	2.20	5.30	66.02	36.49	7,558	15,674	4,990	891	5,881
		Total	21	366	66	175							8,750	24,648	5,874	2,366	8,240
82	17½	Top	16	265	13½	175¼	5.1	66.1	6.87	8.14	64.62	32.04	1,983	25,700	1,282	8,234	9,516
		Middle	8⅙	160	13¼	104	8.3	65.0	1.57	3.27	69.60	35.58	1,646	12,900	1,146	4,589	5,735
		Bottom	4⅓	74½	8½	30½	11.4	40.9	.63	2.73	28.24	27.67	1,200	4,307	339	1,190	1,529
		Total	28½	499½	35¼	309¾							4,829	42,907	2,767	14,013	16,780
83	10½	Top	6½	140	9¾	51	7	36.4	5.07	1.87	65.85	16.71	1,106	5,750	728	960	1,688
		Middle	13⅔	312	10¾	223	3.4	71.5	1.87	2.27	72.12	33.20	1,129	23,745	814	7,783	8,597
		Bottom	6⅔	90	5¼	36	5.8	40.0	3.03	6.12	62.55	32.08	939	6,480	589	2,078	2,667
		Total	26⅚	542	25¼	310							3,174	35,975	2,131	10,821	12,952

[1] Analyses of samples from wells 82, 83, 84, 85, 88, and 89 made by J. J. Fahey; from wells 5 and 6 by J. G. Fairchild.
[2] Estimated.

In table 9 the data presented in table 8 are summarized with respect to the different areas prospected. Arithmetical averages are used, and the results are rounded off to the nearest 50 for tonnages below 1,000 or 100 for tonnages above 1,000. For example, the 40-acre tract in the SW¼NW¼ sec. 2 was tested by wells 88 and 89. The estimated tonnage of pebble per acre as derived from the sampling data for well 88 is 951, and similarly the figure for well 89 is 408. The average is 680 and is recorded in the table as 700.

TABLE 9.—*Tonnage estimates of phosphate in T. 30 S., R. 24 E.*

Unit	Area (acres)	Total B. P. L. (tons)	Average over-burden (feet)	Average phosphate content (long tons per acre)			
				Pebble	B. P. L.		
					In pebble	In matrix	Total
SW¼NW¼ sec. 2	40	166,000	11	700	400	3,750	4,150
SW¼SE¼ sec. 4	40	484,000	36	13,700	8,600	3,500	12,100
NW¼SW¼ sec. 22	40	356,000	40	9,800	6,100	2,800	8,900
NW¼NE¼ sec. 24	40	596,000	14	4,000	2,500	12,400	14,900

Sec. 2.—The 40-acre unit in sec. 2 is relatively open, level, and used as a pasture. It has a small amount of low-grade pebble, carrying about 60 percent of B. P. L., which contains about 5 percent of soluble iron and aluminum oxides. However, the matrix contains about nine times as much B. P. L. as the pebble and has much less soluble iron and aluminum oxides. This fact, together with the thin overburden, should make this tract very valuable.

Sec. 4.—The 40-acre unit in sec. 4 is nearly level, with scrub oak and palmetto as undergrowth and a few pine trees. It has a large amount of pebble which contains about 2.5 percent of soluble iron oxide and alumina. The pebble averages about 63 percent of B. P. L., which would be increased by not mining the bottom part of the phosphate beds. As this unit was the second one tested in this investigation, the method of efficiently saving and testing the matrix had not been well developed; hence the samples of it obtained on this tract were not sufficient for an adequate estimate of the phosphate content of the matrix. Accordingly, the B. P. L. in these five samples was only roughly estimated. It is probable that when mined, the B. P. L. in the matrix will raise the total phosphate content both in grade and amount.

The adjoining NE¼SE¼ sec. 4, locally called the "Smith 40," was prospected in 1924 by a Geological Survey party under J. T. Pardee.[5] Mr. Pardee states that this tract contains 400,000 tons of pebble phosphate similar in grade to the general run of phosphate deposits in the

[5] Pardee, J. T., unpublished report in files of Geological Survey.

pebble field. The overburden as shown in the four wells drilled in the tract ranged from 32½ to 38 feet.

Sec. 22.—The 40-acre unit in sec. 22 is mainly an open palmetto area with thick small gallberry brush in the southeast corner and scrub brush along the west side. Nearly a third of its B. P. L. content is in the matrix, which will probably raise the grade of the total minable phosphate above that of the pebble, which is nearly 66 percent. The total percentage of the soluble iron oxide and alumina is reasonably low.

In the figures given for well 85 those for the weights of the top and middle samples are out of proportion. It is supposed that the drillers inadvertently put part of the middle sample into the bag with the top sample. By combining the top and middle samples a correction may be made that adds slightly to the total amount of pebble and reduces the matrix accordingly.

Sec. 24.—The 40-acre unit in sec. 24 is wooded with pine and other trees in the eastern part; the remainder is a thickly grown swamp. The overburden is 14 feet thick. The grade of the pebble is near 63 percent B. P. L., but as there is nearly five times as much B. P. L. in the matrix, the total B. P. L. of the phosphate mined in this unit should be very high if flotation or some comparable process is employed in its recovery.

T. 28 S., R. 25 E., POLK COUNTY

Location and character.—The four 40-acre tracts in T. 28 S., R. 25 E., comprise the SE¼SE¼ sec. 21, the N½SW¼ sec. 23, and the SE¼NW¼ sec. 26. The location of these areas is shown on plate 55 and in figures 42 and 43.

The land in sec. 21 has poor sandy soil and is used for pasturage. In the northern part of the section a small area is covered with young pines, a few oak trees, and much brush. The land in the eastern and southern portions of the 80-acre tract in sec. 23 is part of a large swamp. The vegetation in the swampy portion is mainly pine and bay, but palmetto and grasses grow in the open areas. A narrow strip along the east side of the prospected land in sec. 26, wider at the north, is in open country, but the rest of the land is part of a large swamp in which grow bay and pine.

Phosphate content.—Six wells were drilled in T. 28 S., R. 25 E. The data obtained from these wells and from the laboratory tests made on the samples collected from them are summarized in table 10.

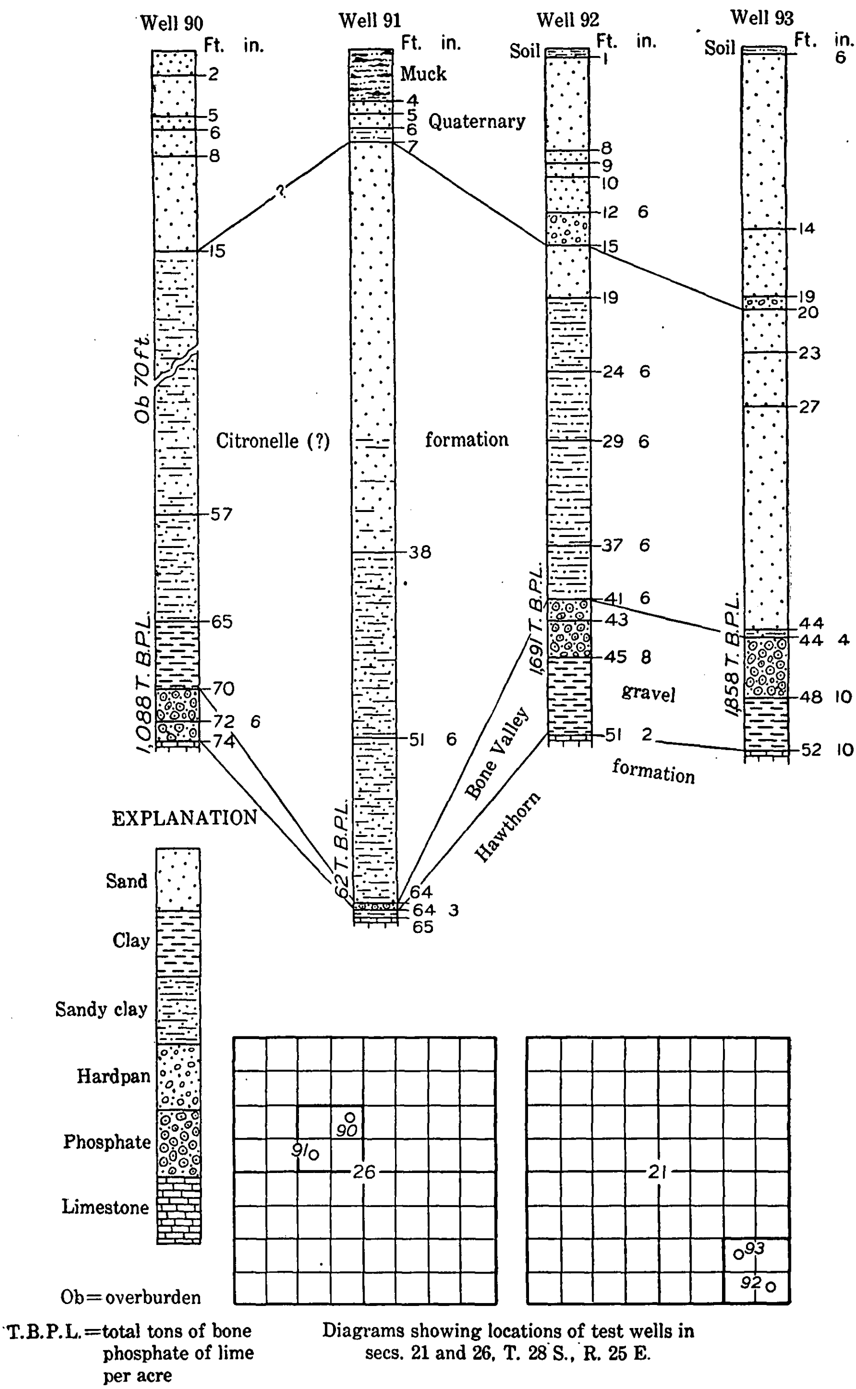


FIGURE 42.—Logs of test wells 90 to 93, secs. 21 and 26, T. 28 S., R. 25 E.

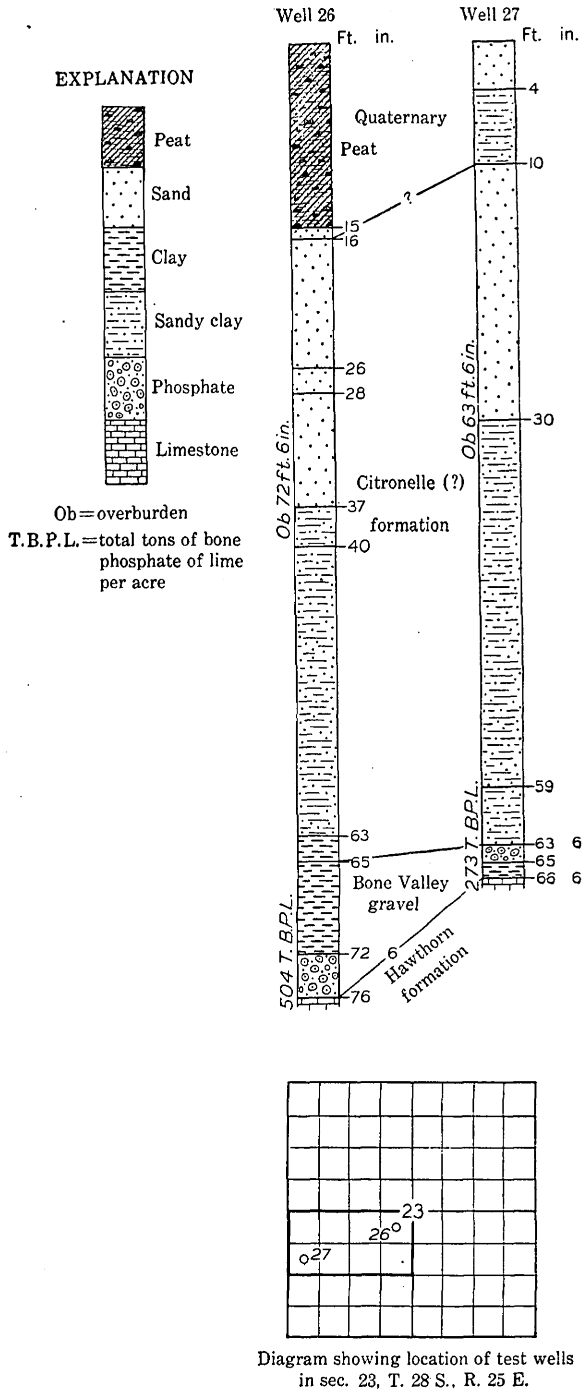


Diagram showing location of test wells in sec. 23, T. 28 S., R. 25 E.

FIGURE 43.—Logs of wells 26 and 27, sec. 23, T. 28 S., R. 25 E.

TABLE 10.—*Phosphate data from T. 28 S., R. 25 E.*

Well No.	Over-burden (*feet*)	Phosphate		Crude weight (pounds)	Pebble, dry weight (pounds)	Matrix, dry weight (pounds)	Pebble (percent)	Matrix (percent)
		Sample	Thickness (feet)					
92	41½	All	4⅕	94	8¾	54¼	9.3	57.7
93	44⅓	All	4½	110	14	63½	12.7	57.7
26	72½	All	3½	105	5¼	60	5	57
27	63½	All	1½	15	½	10¾	3.3	71.7
90	70	All	4	65	3¼	33½	5	51.5
91	64	All	¼	4	3/16	2¾	4.7	68.8

Well No.	$(Al, Fe)_2O_3$ [1]		$Ca_3P_2O_8$ [1]		Estimated phosphate (long tons per acre)		Estimated B. P. L. (long tons per acre)		
	Pebble (percent)	Matrix (percent)	Pebble (percent)	Matrix (percent)	Pebble	Matrix	Pebble	Matrix	Total
92	1.13	1.67	70.96	17.56	942	5,842	668	1,023	1,691
93	1.6	.5	70.26	13.98	1,389	6,309	976	882	1,858
26	3.06	1.4	51.02	5.33	400	4,900	204	300	504
27	3.21	2.13	52.74	8.6	100	2,613	53	220	273
90	1.8	1.9	61.7	15.75	486	5,006	300	788	1,088
91	1.83	2.17	53.44	11.29	29	418	15	47	62

[1] Analyst for wells 26 and 27, J. G. Fairchild; for wells 90 to 93, J. J. Fahey.

In table 11 the data presented in table 10 are summarized with respect to the different areas prospected. Arithmetical averages are used, and the results are rounded off to the nearest 50 for tonnages below 1,000 or 100 for tonnages above 1,000. For example, the 40-acre tract in the SE¼SE¼ sec. 21, was tested by wells 92 and 93. The estimated tonnage of B. P. L. per acre as derived from the sampling data is 1,691 for well 92 and 1,858 for well 93. The average is 1,774 and is recorded as 1,800. The total B. P. L. for the tract is 40 times the average (1,800) or 72,000.

TABLE 11.—*Tonnage estimates of phosphate in T. 28 S., R. 25 E.*

Unit	Area (acres)	Total B. P. L. (tons)	Average over-burden (feet)	Average phosphate content (long tons per acre)			
				Pebble	B. P. L.		
					In pebble	In matrix	Total
SE¼SE¼, sec. 21	40	72,000	43	1,200	800	1,000	1,800
N½SW¼, sec. 23	80	32,000	68	250	150	250	400
SE¼NW¼, sec. 26	40	22,000	67	250	150	400	550

Sec. 21.—The 40-acre unit in sec. 21 has a good grade of pebble (70.5 percent of B. P. L.), with only 1.5 percent of soluble iron oxide and alumina. The matrix, too, contains only 1 percent of soluble iron oxide and alumina. The overburden, which is 43 feet thick, is

probably too thick for mining while phosphate at shallower depths is available. However, this tract will probably have future value.

Sec. 23.—The 80-acre unit in sec. 23 has an actual area of about 81 acres. It contains but small amounts of phosphate in both pebble and matrix. The thickness of the phosphate bed averages about 2½ feet. The pebble itself averages only 51.36 percent of B. P. L., and the soluble iron oxide and alumina about 3 percent. The overburden averages 68 feet.

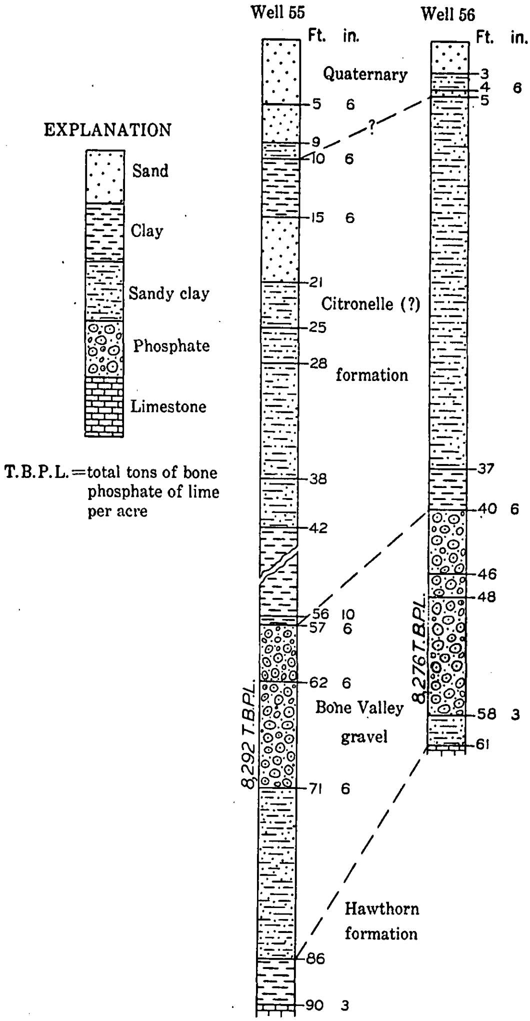
Sec. 26.—More than three-quarters of the 40-acre unit in sec. 26 lies in a swamp. One well drilled on the dry part cut phosphate beds 4 feet thick, but the other well drilled in the diagonally opposite corner of the tract, well out in the swamp, found only 3 inches of phosphate. The average overburden is 67 feet. The pebble contains about 61.2 percent of B. P. L. with only 1.5 percent of soluble iron oxide and alumina.

T. 30 S., R. 25 E., POLK COUNTY

Location and character.—The prospected land in T. 30 S., R. 25 E., is in the SE¼NE¼ sec. 2, as shown on plate 55 and in figure 44, which also gives the location of the two test wells.

On March 2, 1935, when work in this area was in progress, only 3.7 acres of it was above water. The rest was covered by Polk Lake.

Phosphate content.—Two wells, one of them well out in the lake itself (see pl. 58, *B*), were drilled in this tract. The data obtained from the wells and the results of laboratory tests on the samples are given in table 12.



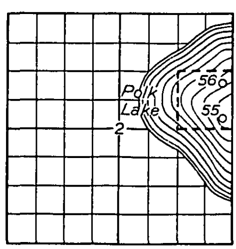


Diagram showing location of test wells in sec. 2, T. 30 S., R. 25 E.

FIGURE 44.—Logs of test wells 55 and 56, sec. 2, T. 30 S., R. 25 E.

TABLE 12.—*Phosphate data from T. 30 S., R. 25 E.*

Well No.	Overburden (feet)	Phosphate		Crude, weight (pounds)	Pebbles, dry weight (pounds)	Matrix, dry weight (pounds)	Pebble (percent)	Matrix (percent)	$(Al, Fe)_2O_3$[1]		$Ca_3P_2O_8$[1]		Estimated phosphate (long tons per acre)		Estimated B. P. L. (long tons per acre)		
		Sample	Thickness (feet)						Pebble (percent)	Matrix (percent)	Pebble (percent)	Matrix (percent)	Pebble	Matrix	Pebble	Matrix	Total
55	57½	Top	5	93	11	66¼	11.8	71.2	4.84	0.67	67.99	12.82	1,434	8,651	964	1,109	2,073
		Bottom	9	83	17	39½	20.5	47.6	3.20	1.97	69.38	32.39	4,483	10,410	3,110	3,371	6,481
		Total	14	176	28	105¾							5,917	19,061	4,074	4,480	8,554
56	40½	Top	5½	87½	9½	49½	10.9	56.5	.29	.36	72.9	22.02	1,457	7,553	1,062	1,663	2,725
		Bottom	12¼	128½	30	52	23.3	40.5	.63	.23	68.3	8.78	6,936	12,083	4,737	1,061	5,798
		Total	17¾	216	39½	101½							8,393	19,636	5,799	2,724	8,523

[1] Analyst, R. E. Stevens.

The calculations presented in the above table are, as customarily in the region, based on 125 pounds as the weight of a cubic foot of phosphate, whereas the actual weight was 121 pounds. As thus corrected the figures in the last five columns of the table would read as follows:

TABLE 13.—*Correction for table 12 based on weight of cubic foot of phosphate as 121 pounds*

Well No.	Sample	Thickness (feet)	Estimated phosphate (long tons per acre)		Estimated B. P. L. (long tons per acre)		
			Pebble	Matrix	Pebble	Matrix	Total
55	Top	5	1,386	8,436	942	1,082	2,024
	Bottom	9	4,336	10,067	3,008	3,260	6,268
	Total	14	5,722	18,503	3,950	4,342	8,292
56	Top	5½	1,409	7,304	1,027	1,636	2,663
	Bottom	12¼	6,708	11,686	4,586	1,027	5,613
	Total	17¾	8,117	18,990	5,613	2,663	8,276
	Average		6,920	18,746	4,782	3,502	8,284

The figures in table 13 are of interest in showing the order of magnitude of the corrections that follow when the figure 121 is substituted for 125 in the formula for determination of phosphate content given on page 284.

The data presented in tables 12 and 13 are summarized in table 14, arithmetical averages being used and the results rounded off to the nearest 100.

TABLE 14.—*Tonnage estimates of phosphate in T. 30 S., R. 25 E.*

Unit	Area (acres)	Total B. P. L. (tons)	Average overburden (feet)	Average phosphate content (long tons per acre)			
				Pebble	B. P. L.		
					In pebble	In matrix	Tota
SE¼NE¼ sec. 2	40	332,000	49	6,900	4,800	3,500	8,300

The pebble found in these wells ranges from 68 to 72.9 percent and averages 69 percent of B. P. L. The average soluble iron oxide and alumina in the pebble is 1.8 percent and is lower than that in the matrix. The lake is shallow and would not hinder mining.

T. 32 S., R. 25 E., POLK COUNTY

Location and character.—The two 40-acre tracts prospected in T. 32 S., R. 25 E., form the W½NW¼ sec. 27, as shown on plate 55 and in figure 45, which also shows the location of test wells 51 to

54. The entire 80 acres is rough river land forming part of the bed of the Peace River, and during the rainy season it is all under water. Near the east edge it has many large cabbage palms, together with some cypress and pine. The undergrowth is thick, and large palmettos are numerous.

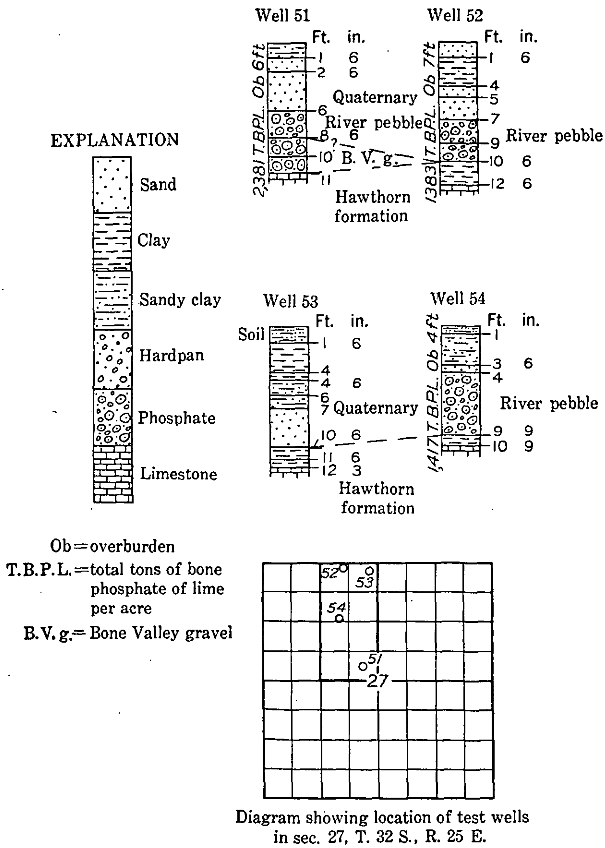


FIGURE 45.—Logs of test wells 51 to 54, sec. 27, T. 32 S., R. 25 E.

Phosphate content.—Four wells were drilled in the 80-acre tract. Phosphate was found in three of these at an average depth of 5½ feet. The data obtained from the wells and the results of laboratory tests on the samples are given in table 15.

TABLE 15.—*Phosphate data from T. 32 S., R. 25 E.*

Well No.	Over-burden (feet)	Phosphate		Crude, weight (pounds)	Pebbles, dry weight (pounds)	Matrix, dry weight (pounds)	Pebble (percent)	Matrix (percent)	$(Al_2\ Fe)_2O_3$[1]		$Ca_3P_2O_8$[1]		Estimated phosphate (long tons per acre)		Estimated B. P. L. (long tons per acre)		
		Sample	Thick-ness (feet)						Pebble (percent)	Matrix (percent)	Pebble (percent)	Matrix (percent)	Pebble	Matrix	Pebble	Matrix	Total
51	6	Top	2⅓	42	6	28½	14.3	67.8	0.26	0.30	57.85	9.35	869	4,119	503	385	888
		Middle	1½	26½	1¾	16¾	6.6	63.2	.13	.21	61.15	33.45	241	2,304	147	771	918
		Bottom	1⅓	25½	2¼	12¼	8.8	43	.44	.37	48.50	28.11	285	1,555	138	437	575
		Total	5⅓	94	10	57½							1,395	7,978	788	1,593	2,381
52	7	Top	2	20	2½	11½	12.5	57.5	.33	.03	6.44	22.39	608	2,795	39	625	664
		Bottom	1½	20	1¾	11¾	8.8	58.7	.26	2.07	56.21	25.19	321	2,140	180	539	719
		Total	3½	40	4¼	23¼							929	4,935	219	1,164	1,383
[2] 53																	
54	4	All	5¾	72½	6½	54¼	9	74.8	.17	.27	54.6	7.54	1,206	10,060	658	759	1,417

[1] Analyst, R. E. Stevens.
[2] No phosphate was found in well 53.

The data presented in the table may be summarized as follows. Arithmetical averages are used, and the results are rounded to the nearest 50 or 100. Area, 80 acres; total B. P. L. 104,000 long tons; average over-burden, 5⅔ feet; average phosphate content of the pebble, 900 long tons per acre; average B. P. L. per acre, 400 tons in pebble, 900 tons in matrix, total 1,300 tons. The average grade of pebble contains 47.46 percent of B. P. L. and 0.24 percent of iron and aluminum oxides.

Here and there in the Peace River small banks or bars contain phosphate pebbles, together with quartz pebbles, lime, and much sand. The amount of phosphate in the river bed is small. The river bed now occupies about 10 acres. If this area were deducted from the total of 80 acres in preparing the estimate for the total B. P. L. in the entire tract, that figure would be about 91,000 tons instead of 104,000

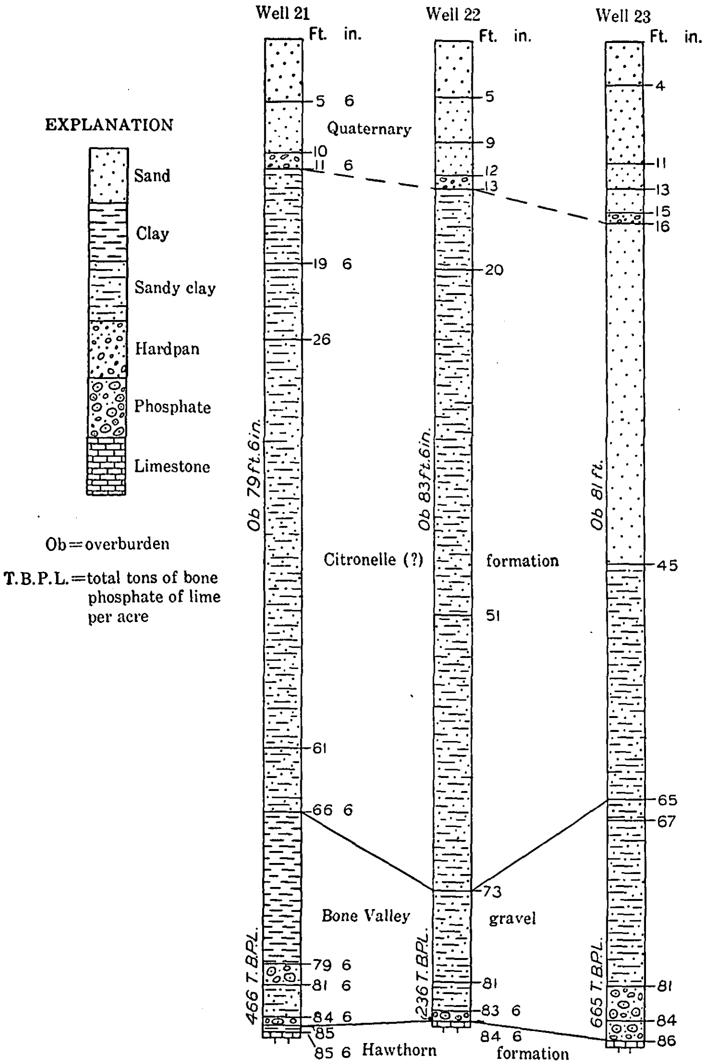
The Peace River is thought to have wandered over all the area of the 80-acre tract during Quaternary time and has reworked all or nearly all of the phosphate pebble. The bed of the river is lower than the top of the Hawthorn formation except in well 52, where the hard bedrock is about level with the exposure of the Hawthorn in the river, west of the well.

T. 29 S., R. 26 E., POLK COUNTY

Location and character.—The lands prospected in T. 29 S., R. 26 E., comprise seven 40-acre tracts in secs. 27, 29, and 30, as shown on plate 55 and in figures 46 and 47, which also show the location of test wells 21 to 25.

The 80-acre tract in secs. 29 and 30 has a small swampy area in its southwest corner. The rest is level, is fenced, and has five buildings used as a dairy. The tract of 200 acres in sec. 27 is nearly level and much of it is covered with pure white sand. A bay swamp lies near the center of sec. 27, and in the NW¼NE¼ of the section some soft, wet black silt is covered with swamp grass. Much stunted palmetto and some grass grow on the part of the land that is not swampy. This tract forms part of a large cattle pasture.

Phosphate content.—Three wells, Nos. 21 to 23, were drilled in the 200-acre tract and two wells, Nos. 24 and 25, in the 80-acre tract. The data obtained from these wells and from laboratory tests on the samples are given in table 16.



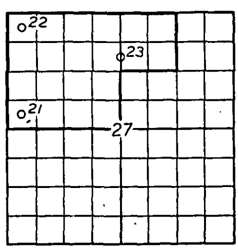


Diagram showing location of test wells in sec. 27, T. 29 S., R. 26 E.

FIGURE 46.—Logs of test wells 21 to 23, sec. 27, T. 29 S., R. 26 E.

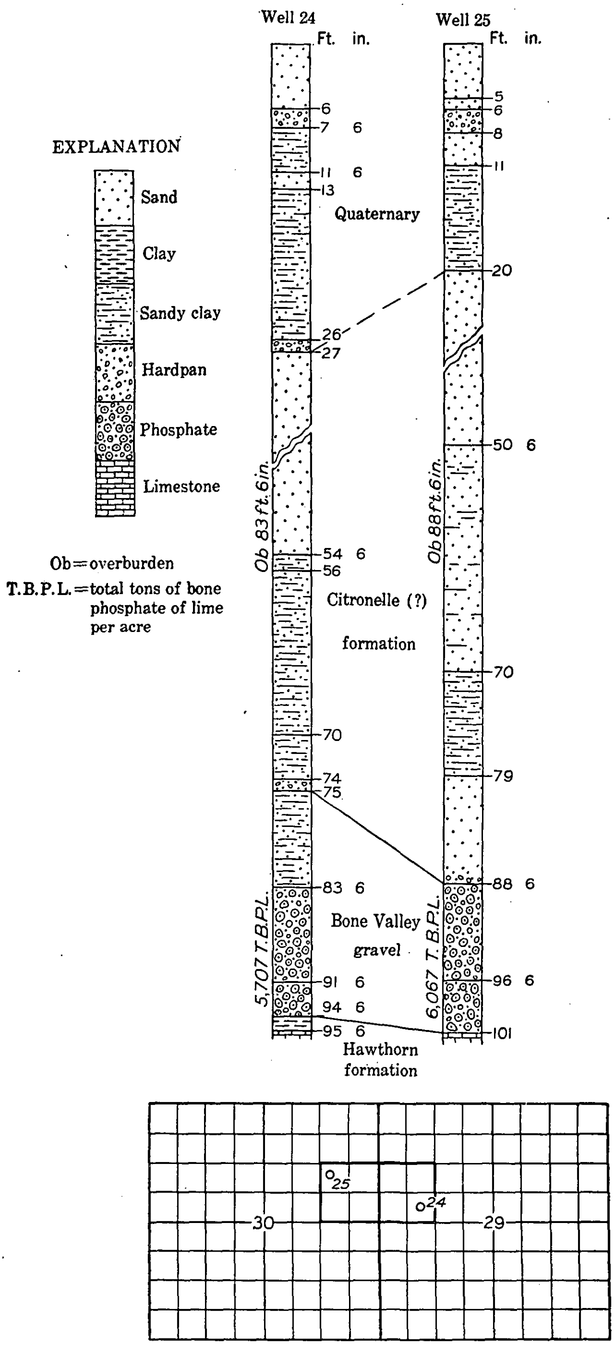


Diagram showing location of test wells in secs. 29 and 30, T. 29 S., R. 26 E.

FIGURE 47.—Logs of test wells 24 and 25, secs. 29 and 30, T. 29 S., R. 26 E.

TABLE 16.—*Phosphate data from T. 29 S., R. 26 E.*

Well No.	Overburden (feet)	Phosphate		Crude weight (pounds)	Pebbles dry weight (pounds)	Matrix dry weight (pounds)	Pebble (percent)	Matrix (percent)	$(Al, Fe)_2O_3$ [1]		$Ca_3P_2O_8$ [1]		Estimated phosphate (long tons per acre)		Estimated B. P. L. (long tons per acre)		
		Sample	Thickness (feet)						Pebble (percent)	Matrix (percent)	Pebble (percent)	Matrix (percent)	Pebble	Matrix	Pebble	Matrix	Total
21	79½	Top	2	14	½	10½	3.6	75.	4.6	1.54	53.18	6.75	200	3,700	106	200	306
		Barren	2½														
		Bottom	1.	20½	1	13	4.9	63.3	2.4		59.62		100	1,500	60	100	160
		Total	3	34½	1½	23½							300	5,200	166	300	466
22	83½	All	1	10	¼	5	2.5	50.	2.92	4.50	60.85	19.50	60	1,200	36	200	236
23	81	Top	3	25	¼	16	1.	61.5	3.44	2.68	61.98	5.35	70	4,500	43	200	243
		Bottom	2	44	2	27	4.5	61.3	2.44	1.88	60.80	11.51	200	3,000	122	300	422
		Total	5	69	2¼	43							270	7,500	165	500	665
24	83½	Top	8	140	17½	80	12.5	57.1	2.48	3.5	64.6	27.21	2,400	11,100	1,550	3,000	4,550
		Bottom	3	43	6	12½	13.9	29.1	1.76	4.16	55.73	29.31	1,000	2,100	557	600	1,157
		Total	11	183	23½	92½							3,400	13,200	2,107	3,600	5,707
25	88½	Top	8	184	15½	104	8.4	56.8	2.84	3.99	61.61	34.48	1,600	11,000	985	3,800	4,785
		Bottom	4½	34	1	18	2.9	52.9	1.92	2.34	60.65	18.52	300	5,800	182	1,100	1,282
		Total	12½	218	16½	122							1,900	16,800	1,167	4,900	6,067

[1] Analyst, J. G. Fairchild.

The data presented in table 16 are summarized for convenience below. The two tracts are considered separately. Arithmetical averages are used, and the figures are rounded to the nearest 50 or 100.

TABLE 17.—*Tonnage estimates of phosphate in T. 29 S., R. 26 E.*

Unit	Area (acres)	Total B. P. L. (tons)	Average over-burden (feet)	Average phosphate content (long tons per acre)			
				Pebble	B. P. L.		
					In pebble	In matrix	Total
NW¼ and NW¼NE¼ sec. 27	200	90,000	81	200	100	350	450
SW¼NW¼ sec. 29 and SE¼NE¼ sec. 30	80	472,000	86	2,700	1,600	4,300	5,900

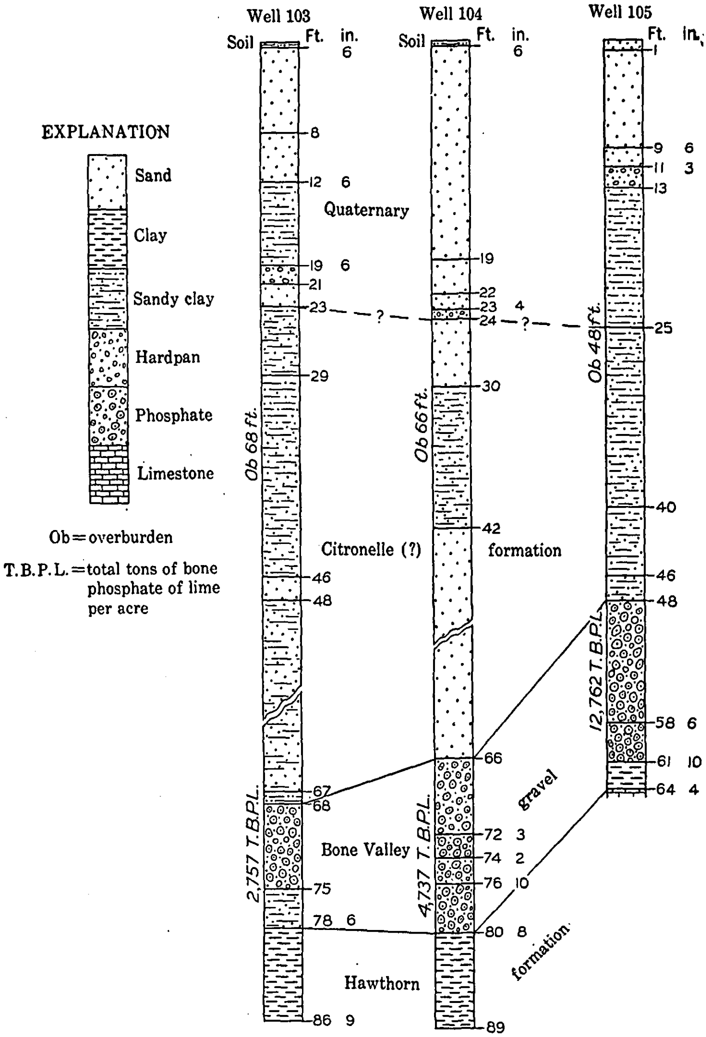
Sec. 27.—The three wells drilled in the 200-acre unit in sec. 27 were well distributed and showed so even a thin bed of low-grade phosphate with a thick overburden that it was decided unnecessary to drill other wells. The average thickness of the phosphate bed was 3 feet. The pebble contained 58.33 percent of B. P. L. and 3¼ percent of soluble iron oxide and alumina.

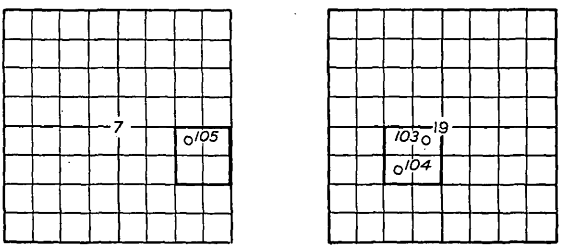
Secs. 29 and 30.—The two wells drilled in the 80-acre unit in secs. 29 and 30 showed much more phosphate but a thicker overburden (86 feet). The pebble contained 61.80 percent of B. P. L. and 2.42 percent of soluble iron oxide and alumina.

T. 30 S., R. 26 E., POLK COUNTY

Location.—The land prospected in T. 30 S., R. 26 E., comprised in all 680 acres, distributed as follows: sec. 6, 120 acres; secs. 7 and 19, 40 acres each; secs. 25 and 29, 80 acres each; sec. 36, 320 acres. The location of these tracts is shown on plate 55. Plates 60 and 62 and figures 48–50 show the sites and logs of the test wells.

Phosphate content.—The data obtained from the wells drilled in T. 30 S., R. 26 E., and the results of laboratory work on the samples are presented in table 18.





Diagrams showing locations of test wells in secs. 7 and 19, T. 30 S., R. 26 E.

FIGURE 48.—Logs of test wells 103 to 105, secs. 7 and 19, T. 30 S., R. 26 E.

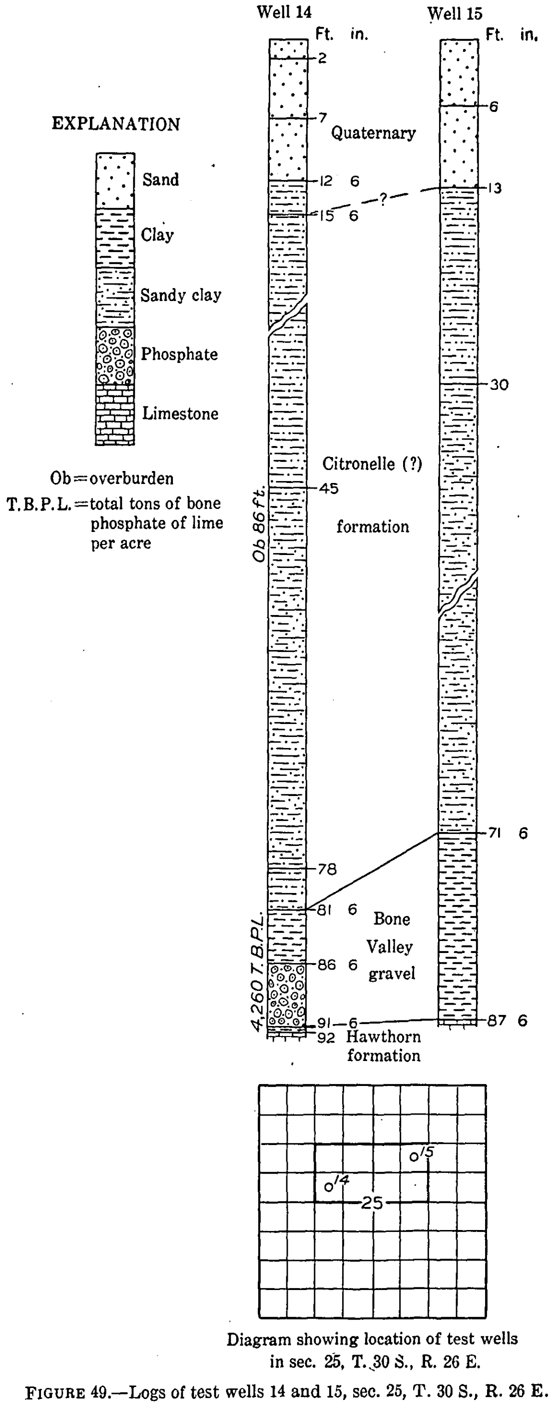


FIGURE 49.—Logs of test wells 14 and 15, sec. 25, T. 30 S., R. 26 E.

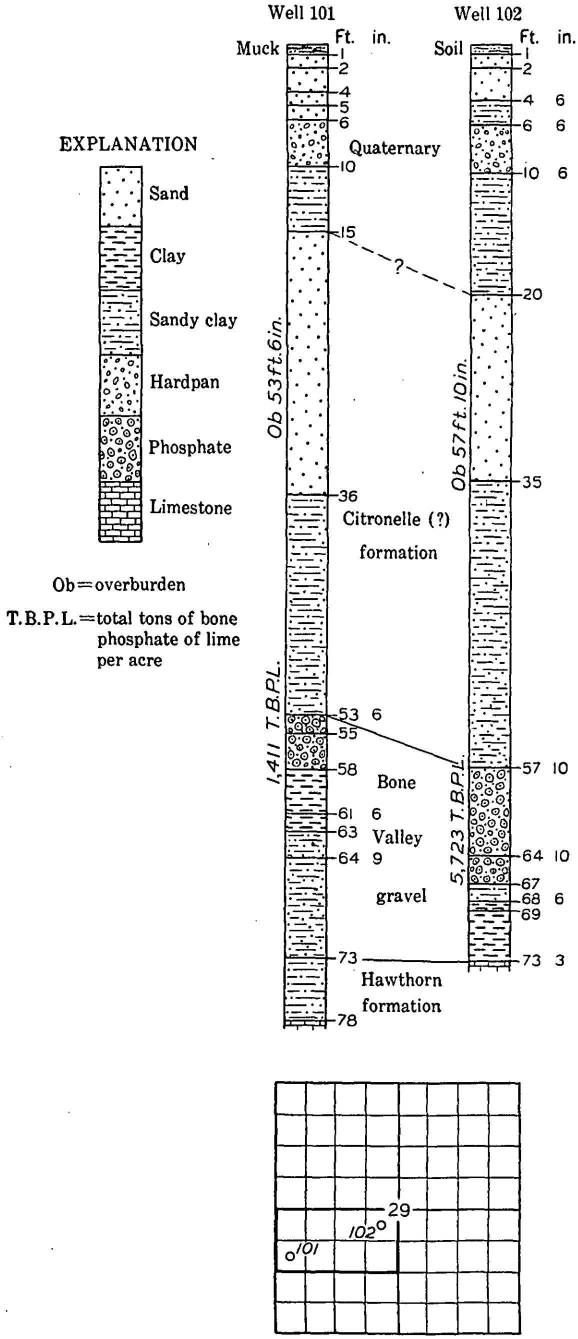


Diagram showing location of test wells in sec. 29, T. 30 S., R. 26 E.

FIGURE 50.—Logs of test wells 101 and 102, sec. 29, T. 30 S., R. 26 E.

TABLE 18.—*Phosphate data from T. 30 S., R. 26 E.*

Well No.	Overburden (feet)	Phosphate: Sample	Phosphate: Thickness (feet)	Crude weight (pounds)	Pebble dry weight (pounds)	Matrix dry weight (pounds)	Pebble (percent)	Matrix (percent)	$(Al, Fe)_2O_3$[1] Pebble (percent)	$(Al, Fe)_2O_3$[1] Matrix (percent)	$Ca_3P_2O_8$[1] Pebble (percent)	$Ca_3P_2O_8$[1] Matrix (percent)	Estimated phosphate (long tons per acre) Pebble	Estimated phosphate (long tons per acre) Matrix	Estimated B. P. L. (long tons per acre) Pebble	Estimated B. P. L. (long tons per acre) Matrix	Estimated B. P. L. (long tons per acre) Total
[2]7																	
[3]8																	
9	92½	All	1	10¾	¾	6¼	6.9	58.7	3.44	5	39.31	16.71	200	1,400	78	238	316
10	83	do	5½	79	16	(4)	20	[5]45	3.16		58.64		2,700	[5]6,000	1,583	[5]900	2,483
11	83	do	1	28	5½	(4)	19.6	[5]45	2.68		58.64		500	[5]1,100	293	[5]165	458
12	98	Top	10	251	25	150	10	59.7	3.26	1.42	62.85	14.46	2,400	14,500	1,508	2,097	3,605
		Bottom	1	13	3	6	23.1	46.1	2.7	4.18	63.14	30.25	600	1,100	380	338	718
		Total	11	264	28	156							3,000	15,600	1,888	2,435	4,323
[6]13																	
14	86	All	5½	69	22	31½	31.9	45.6	2.44	3.68	61.85	26.21	4,300	6,100	2,660	1,600	4,260
[6]15																	
16	54	All	5	107	17½	(4)	16.3	[5]43.7	1.46		69.58		2,000	[5]5,300	1,390	[5]1,060	2,450
17	44½	Top	5½	121½	15	56	12.3	46	1.5	2.28	71.96	42.60	1,600	6,100	1,151	2,598	3,749
		Middle	3	29	1	15¼	3.4	54.3	1.32	8.28	61.19	31.62	250	4,000	153	1,260	1,413
		Bottom	1	9	1½	4¾	16.7	52.7	2.8	7.06	43.02	20.14	400	1,300	172	260	432
		Total	9½	159½	17½	76							2,250	11,400	1,476	4,118	5,594
18	57½	All	5	101	15	(4)	14.9	[5]45	1.12		69.58		1,800	[5]5,500	1,252	[5]1,100	2,352
19	56½	Top	2	38	8	(4)	21	[5]39	1.08		71.73		1,000	[5]1,900	716	[5]380	1,096
		Middle	6	97	17½	(4)	18	[5]42	1.64		70.02		2,600	6,100	1,820	1,222	3,042
		Bottom	2	37½	2½	(4)	6	[5]54	1.42		56.30		300	[5]2,600	169	[5]520	689
		Total	10	172½	28								3,900	10,600	2,705	2,122	4,827
20	53½	Top	1½	59	9	35	15.3	59.3	1.24	1.72	69.01	25.07	600	2,100	414	526	940
		Middle	2	47½	5½	29	11.6	61	1.30	2	67.81	26.8	600	3,000	407	804	1,211
		Bottom	1½	37½	3¼	20¼	8.7	54	1.30	2.62	67.07	26.89	300	2,000	201	600	801
		Total	5	144	17¾	84¼							1,500	7,100	1,022	1,930	2,952
101	53½	All	4½	99	15	64	15.2	64.6	1.4	.47	63.25	5.11	1,662	7,064	1,051	360	1,411

102	57⅚	Top	7	232	24½	161¼	10.6	69.5	1.2	1.17	63.99	23.91	1,803	11,822	1,154	2,826	3,980
		Bottom	2⅙	31	6½	16	20.9	51.6	1.3	1.9	68.71	36.32	1,100	2,717	756	987	1,743
		Total	9⅙	263	31	177¼							2,903	14,539	1,910	3,813	5,723
103	68	All	7	122	6	85¾	4.9	70.3	4	1.93	61.24	18.8	834	11,958	510	2,247	2,757
104	66	Top	6¼	162	18½	110¼	11.4	68.2	1.03	1	62.81	7.71	1,731	10,358	1,087	799	1,886
		Middle	4⅙	81	9	46½	11.1	57.4	3.1	1.63	63.88	15.55	1,124	5,812	718	903	1,621
		Bottom	4¼	55	1½	36	2.7	65.5	2.47	2.17	64.78	15.51	279	6,764	181	1,049	1,230
		Total	14⅔	198	29	192¾							3,134	22,934	1,986	2,751	4,737
105	48	All	13⅚	150	39½	60	26.3	40	1.47	2.3	69.93	48.94	8,841	13,446	6,182	6,580	12,762

[1] Analyst, J. G. Fairchild, wells 9 to 20; J. J. Fahey, wells 101 to 105.
[2] Total depth 80 feet without reaching phosphate.
[3] Abandoned at 43 feet without reaching phosphate.
[4] Not collected.
[5] Estimated.
[6] No phosphate.

The different 40-acre tracts prospected in T. 30 S., R. 26 E., were divided into seven units, for which the phosphate data in table 18 are summarized below. Arithmetical averages are used and the figures rounded. Thus the 5 wells (16 to 20) in sec. 6 average 3,635 long tons in total B. P. L. content per acre. Rounding this to 3,700 and multiplying by 132, the number of acres, gives 488,400 rounded to 488,000.

TABLE 19.—*Tonnage estimates of phosphate in T. 30 S., R. 26 E.*

Unit	Area (acres)	Total B. P. L. (tons)	Average over-burden (feet)	Average phosphate content (long tons per acre)			
				Pebble	B. P. L.		
					In pebble	In matrix	Total
S½NW¼ and NE¼SW¼ sec. 6	132	488,400	53	2,300	1,600	2,100	3,700
NE¼SE¼ sec. 7	40	512,000	48	8,800	6,200	6,600	12,800
NE¼SW¼ sec. 19	40	148,000	67	2,000	1,200	2,500	3,700
SW¼NE¼ and SE¼NW¼ sec. 25	80	168,000	86	2,150	1,300	800	2,100
N½SW¼ sec. 29	80	288,000	55½	2,300	1,500	2,100	3,600
N½NE¼ and E½NW¼ sec. 36	160	64,000	88	350	200−	200	400−
SW¼, sec. 36	160	288,000	88	1,600	900+	900−	1,800

Sec. 6.—The three tracts forming the unit in sec. 6 are oversize and contain nearly 132 acres. The land is slightly rolling. Parts of it are cultivated, and parts are wooded with pine, scrub oak, and palmetto. Five wells drilled on this unit disclosed some of the highest-grade pebble found in this investigation, the best containing 71.96 percent of B. P. L. and 1.5 percent of soluble iron oxide and alumina. A few of the lowest beds of phosphate in some wells had low-grade pebble, but the average grade for the entire unit was 68.56 percent of B. P. L. and 1.44 percent of soluble iron oxide and alumina. The matrix also contained a large amount of B. P. L., and thus the total phosphate minable will be of good grade. (See pl. 60.)

Sec. 7.—The 40 acres in sec. 7 is open pasture land and was tested by one well, which indicated so large a tonnage of phosphate that it appeared unnecessary to drill others for purposes of land classification. The pebble contained 69.93 percent of B. P. L. and 1.47 percent of soluble iron oxide and alumina. The overburden was 48 feet. (See fig. 48.)

Sec. 19.—The unit of 40 acres in sec. 19 had an orange grove in the northwest corner, and the remainder contained pine trees and brush. Two wells were drilled on the tract. The average overburden was 67 feet and the grade of the pebble averaged 62.94 percent of B. P. L. with 2.33 percent of soluble iron oxide and alumina. The matrix contained twice as much B. P. L. as the pebble and even less soluble iron oxide and alumina. Thus the grade of the total minable phosphate should be good. (See fig. 48.)

Sec. 25.—The 80-acre unit in sec. 25 was mostly swamp and pasture land. Two wells were drilled on it, but one of them was barren. The average phosphate content for the unit given in the above table is therefore only half of the actual content found in the one well that showed phosphate. The hard bedrock in the barren well came at about the depth of the phosphate in the other well. The overburden is 86 feet thick, and the grade of the pebble is 61.85 percent of B. P. L. with 2.44 percent of soluble iron oxide and alumina. The amount of B. P. L. in the matrix is small and could not be expected to raise the grade of the phosphate deposit as a whole. (See fig. 49.)

Sec. 29. The 80 acres in sec. 29 is mostly pasture land but includes two small swamps. Two wells rather far apart were drilled on it. (See fig. 50.) The average overburden was 55½ feet. The average grade of the pebble was 64.85 percent of B. P. L. with 1.30 percent of soluble iron oxide and alumina. As the matrix contained more B. P. L. than the pebble, the total minable phosphate should be of much higher grade.

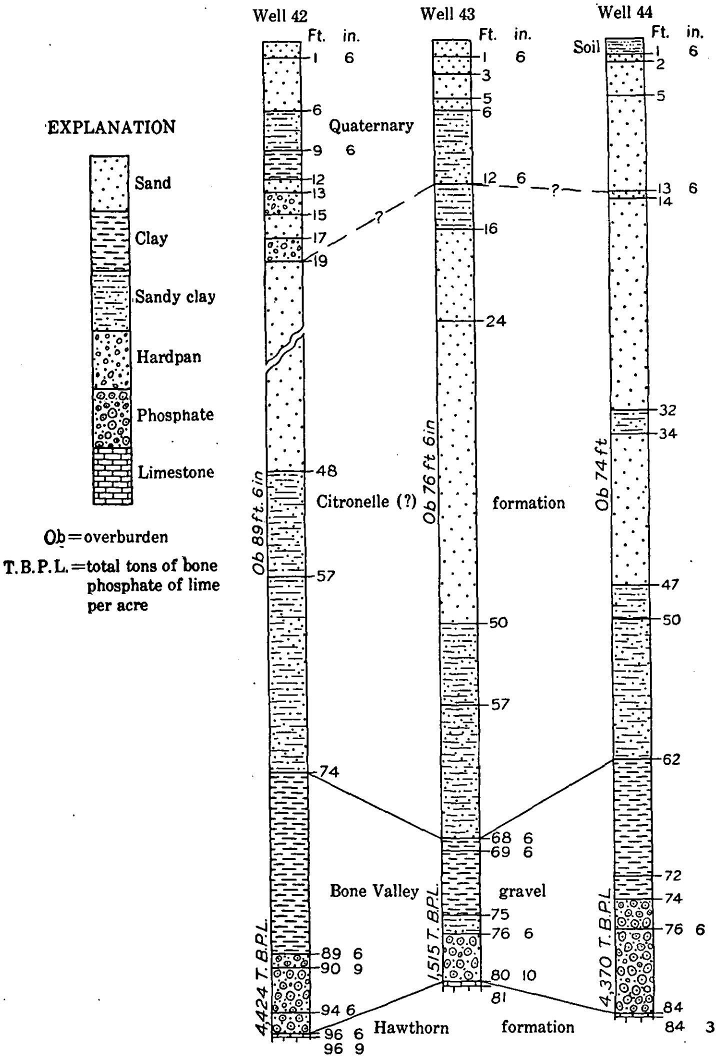
Sec. 36.—Sec. 36 is generally rolling land containing many swampy areas. The soil is sandy except in and near the swamps. About half the section is open grassy land. The rest is occupied by swamps and land covered with pines, scrub oak, and brush. Four wells were were drilled on the unit of 160 acres in the northern part of this section. (See pl. 62.) One of these was on the line between this unit and the SW¼ of the section. The overburden averaged nearly 88 feet. The amounts of pebble per acre and of B. P. L. in the matrix were both small. The grade of the pebble is low, 53.17 percent of B. P. L. The estimates for the northern part of sec. 36 are probably rather high.

Four wells were also drilled in the SW¼ sec. 36. (See pl. 62.) The overburden averaged 88 feet, and the pebble 60.7 percent of B. P. L. with 3.11 percent of soluble iron oxide and alumina. The average total B. P. L. content is estimated at 1,800 tons per acre, which is probably too low. However, if the 80 acres in the S½SW¼ sec. 36 is considered alone, a total B. P. L. content of 3,400 tons per acre is obtained. The adjacent area to the south contains a larger amount of phosphate.

T. 31 S., R., 26 E., POLK COUNTY

Location.—The location of nine 40-acre tracts prospected in T. 31 S., R. 26 E., is shown on plate 55 and in figures 51 to 53, which also show the location and logs of the test wells bored.

Phosphate content.—The data obtained from wells drilled in T. 31 S., R. 26 E., and from laboratory work on the samples are presented in table 20.



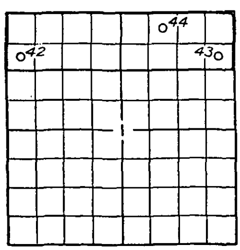


Diagram showing location of test wells in sec. 1, T. 31 S., R. 26 E.

FIGURE 51.—Logs of test wells 42 to 44, sec. 1, T. 31 S., R. 26 E.

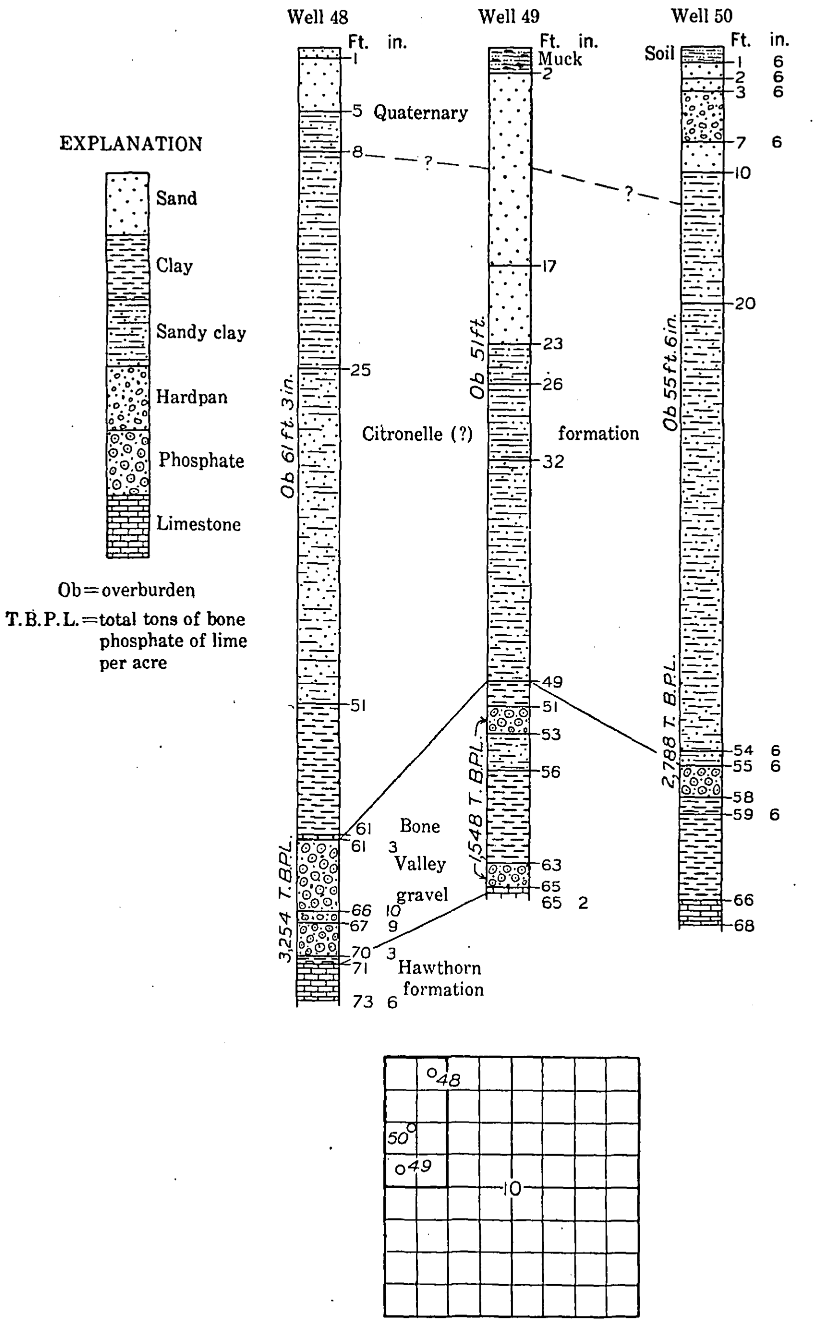
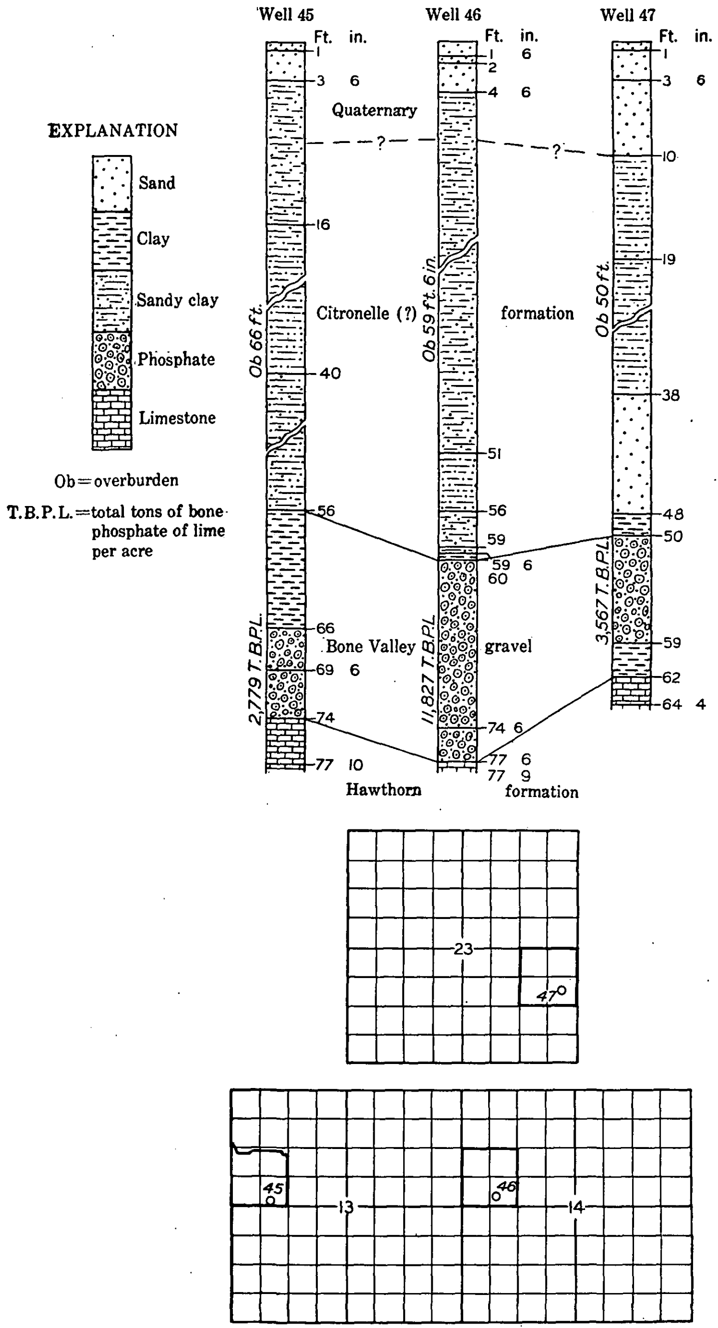


Diagram showing location of test wells in sec. 10, T. 31 S., R. 26 E.

FIGURE 52.—Logs of test wells 48 to 50, sec. 10, T. 31 S., R. 26 E.



Diagrams showing locations of test wells in secs. 13, 14, and 23, T. 31 S., R. 26 E.

FIGURE 53.—Logs of test wells 45 to 47, secs. 13, 14, and 23, T. 31 S., R. 26 E.

TABLE 20.—*Phosphate data from T. 31 S., R. 26 E.*

Well No.	Overburden (feet)	Phosphate		Crude weight (pounds)	Pebble dry weight (pounds)	Matrix dry weight (pounds)	Pebble (percent)	Matrix (percent)	$(Al, Fe)_2O_3$[1]		$Ca_3P_2O_8$[1]		Estimated phosphate (long tons per acre)		Estimated B. P. L. (long tons per acre)		
		Sample	Thickness (feet)						Pebble (percent)	Matrix (percent)	Pebble (percent)	Matrix (percent)	Pebble	Matrix	Pebble	Matrix	Total
42	89½	All	7	227½	25	141	11.	62.	0.03	Trace	65.	30.42	1,871	10,546	1,216	3,208	4,424
43	76½	All	4⅓	86½	10¾	42	12.4	48.6	1.26	Trace	57.57	14.9	1,306	5,118	752	763	1,515
44	74	Top	2½	52	8½	26	16.3	50.	.51	0.16	49.08	15.54	990	3,037	486	472	958
		Bottom	7½	57	10¼	27½	18.	48.2	2.29	5.74	50.97	19.81	3,281	8,784	1,672	1,740	3,412
		Total	10	109	18¾	53½							4,271	11,821	2,158	2,212	4,370
45	66	Top	3½	50½	5¼	18	10.4	35.6	2.23	.12	60.8	27.81	885	3,028	538	862	1,400
		Bottom	4½	47	3¾	23½	8.	50.	.8	.73	61.43	31.53	875	5,468	537	842	1,379
		Total	8	97½	9	41½							1,760	8,496	1,075	1,704	2,779
46	59½	Top	15	188	34	103	18.1	54.8	.47	.82	45.6	38.58	6,597	19,975	3,008	7,706	10,714
		Bottom	3	37¼	2¼	15	6.	40.3	.55	.20	54.78	29.7	437	2,938	240	873	1,113
		Total	18	225¼	36¼	118							7,034	22,913	3,248	8,579	11,827
47	50	All	9	119½	8¼	62½	6.9	52.3	.44	.42	73.2	21.53	1,509	11,438	1,105	2,462	3,567
48	61¼	Top	5 7/12	113¼	7	68	6.2	60.	2.28	.13	54.82	14.55	841	8,137	461	1,184	1,645
		Bottom	3 5/12	66	7¼	29½	11	44.7	1.55	.23	64.82	27.41	913	3,711	592	1,017	1,609
		Total	9	179¼	14¼	97½							1,754	11,848	1,053	2,201	3,254
		Soft Bedrock							2.17		20.38						
49	51	Top	2	32	5¾	13¼	18	41.4	.4	.1	61.21	15.4	875	2,012	536	310	846
		Bottom	2	24	1½	14	6.3	58.3	.48	.47	44.7	19.93	306	2,833	137	565	702
		Total	4	56	7¼	27¼							1,181	4,845	673	875	1,548
50	55½	All	2½	59	4¾	35½	8.1	60.2	.4	.2	61.65	15.88	492	3,657	303	581	884
		Soft Bedrock	5						.43	.39	24.83	11.75	0	8,000±	0	1,904	1,904
													492	11,657±	303	2,485	2,788

[1] Analyst, R. E. Stevens.

The nine 40-acre tracts prospected in T. 31 S., R. 26 E., have been arranged for convenience in five units. The prospecting data given in table 20 have been summarized for these units according to the method used in the division of T. 28 S., R. 24 E., as follows:

TABLE 21.—*Tonnage estimates of phosphate in T. 31 S., R. 26 E.*

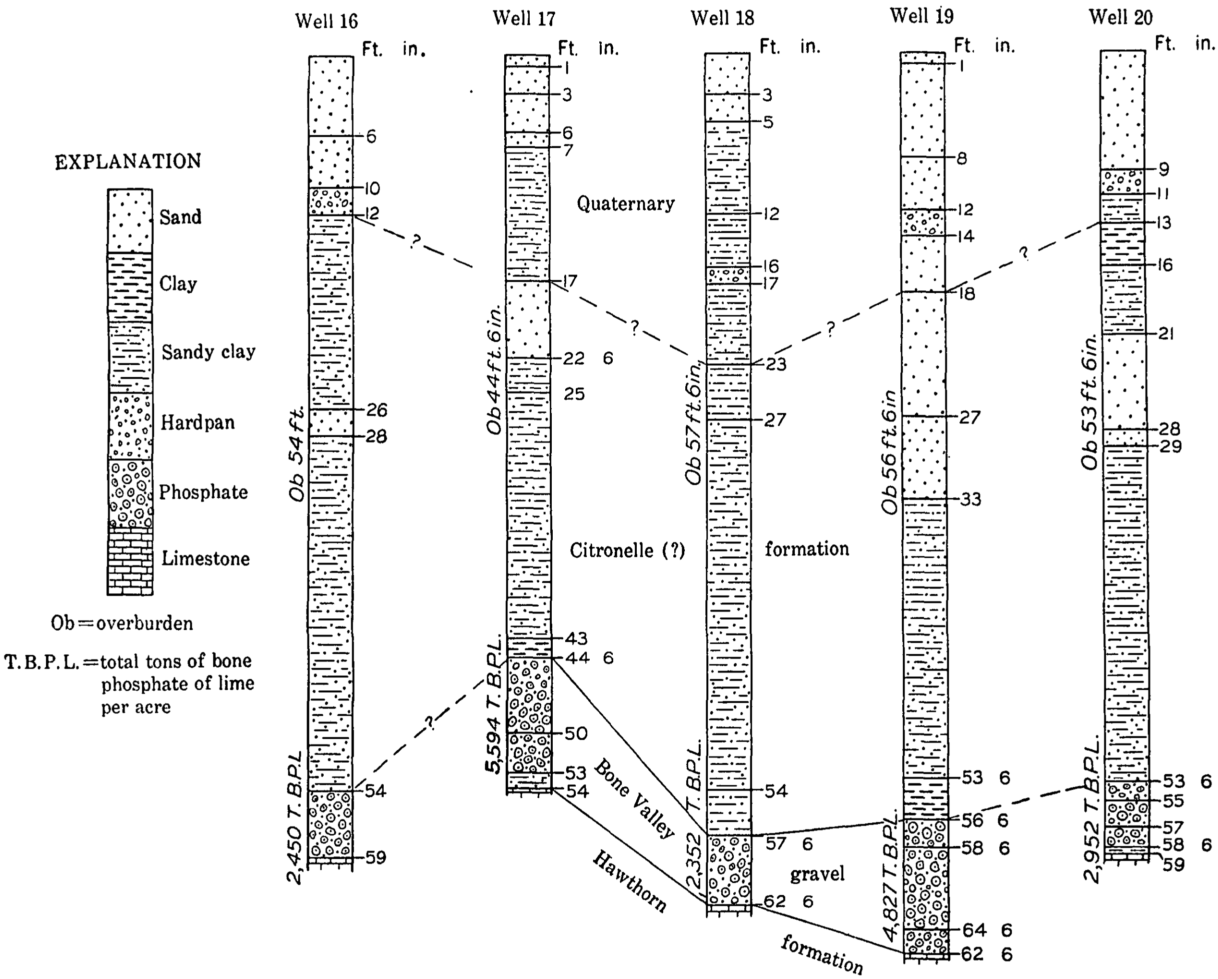
Unit	Area (acres)	Total B.P.L. (tons)	Average over-burden (feet)	Average phosphate content (long tons per acre)			
				Pebble	B.P.L.		
					In pebble	In matrix	Total
N½N½ sec. 1	172	602,000	80	2,500	1,400	2,100	3,500
W½NW¼ sec 10	80	208,000	56	1,100	700	1,900	2,600
SW¼NW¼ sec. 13	16	44,800	66	1,800	1,100	1,700	2,800
SW¼NW¼ sec. 14	40	472,000	59	7,000	3,200	8,600	11,800
NE¼SE¼ sec. 23	40	144,000	50	1,500	1,100	2,500	3,600

Sec. 1.—Three wells were drilled on the unit of 172 acres in sec. 1 and two more just north of it in sec. 36, T. 30 S., R. 26 E., as already described. The overburden is thick, averaging 80 feet. As the total B. P. L. content is only 3,500 tons per acre, the area could not be mined profitably now, but at some time in the future, when more accessible deposits are exhausted, this one may become minable. The pebble averages 55.41 percent of B. P. L. and the soluble iron oxide and alumina 1.27 percent. The matrix contains 1½ times as much B. P. L. as the pebble. Thus the total minable phosphate should be of higher grade.

Sec. 10.—Three wells were drilled on the unit of 80 acres in sec. 10. The average overburden was 56 feet. The pebble contained an average of 59.27 percent of B. P. L. with less than 1.5 percent of soluble iron oxide and alumina. The matrix contains more than 2½ times as much B. P. L. as the pebble; therefore the grade of the total minable phosphate may be greatly increased if an efficient recovery process is used.

Sec. 13.—The unit in sec. 13 has approximately 16 acres, the rest of the 40 acres being covered by Lake Buffum. The depth of overburden in the one well drilled was 66 feet. The pebbles average 61.12 percent of B. P. L. and the soluble iron oxide and alumina 1.51 percent.

Sec. 14.—The 40-acre tract in sec. 14 was tested by one well in which the overburden was 59 feet thick and the phosphate beds 18 feet. The grade of pebble averages only a little over 46 percent of B. P. L. The soluble iron oxide and alumina in pebble and matrix amount to less than 1 per cent in each but contain 2⅔ times as much B. P. L. as the pebble. Thus the grade of the total minable phosphate should be much higher than that of the pebble alone.



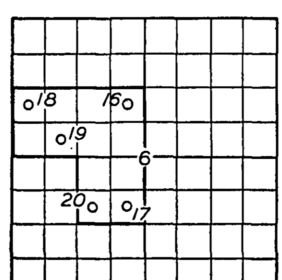
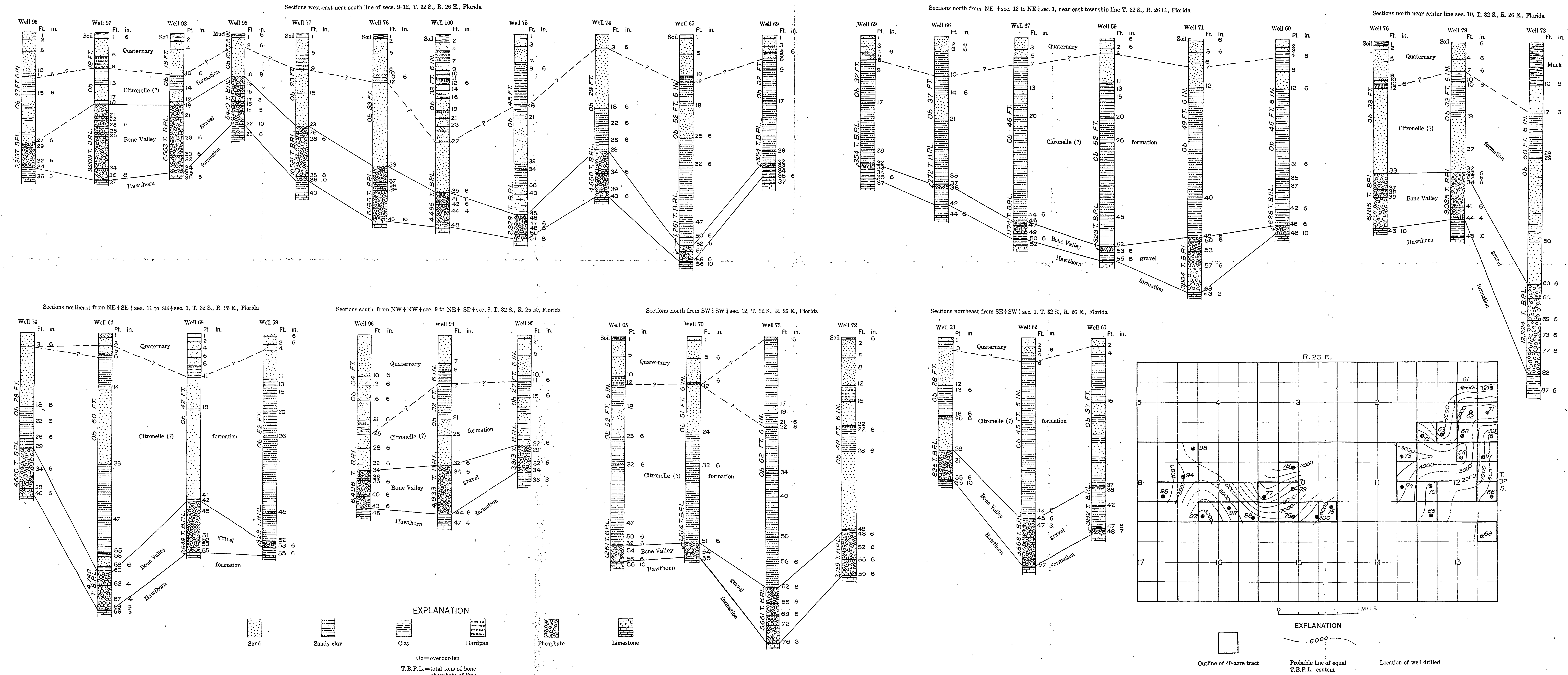
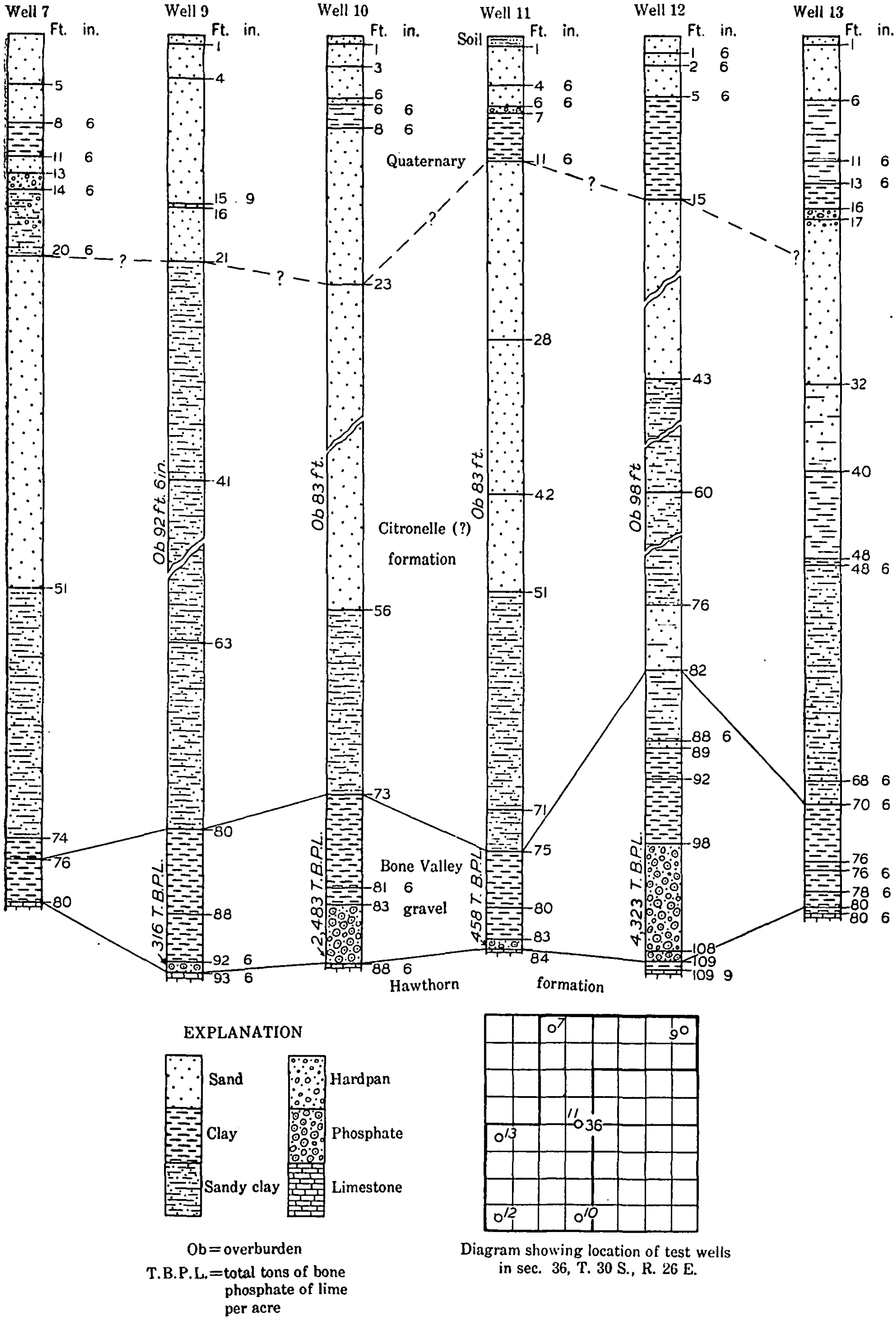


Diagram showing location of test wells in sec. 6, T. 30 S., R. 26 E.

LOGS OF TEST WELLS 16 TO 20, SEC. 6, T. 30 S., R. 26 E.



LOGS OF TEST WELLS IN T. 32 S., R. 26 E., SHOWING VARIATIONS IN THICKNESS AND DEPTH OF PHOSPHATE, AND DIAGRAM SHOWING LOCATION OF WELLS AND PROBABLE LINES OF EQUAL PHOSPHATE CONTENT, EXPRESSED IN TONS PER ACRE OF TRICALCIUM PHOSPHATE.



LOGS OF TEST WELLS 7 AND 9 TO 13, SEC. 36, T. 30 S., R. 26 E.

Sec. 23.—The 40-acre unit in sec. 23 is rather open, level land with a few scattered pines in the eastern part. There is a house in the northwestern part, and some of the land is cultivated. The tract was tested by one well, which showed an overburden of 50 feet. The pebble contained 73.20 percent of B. P. L. with only 0.44 percent of soluble iron oxide and alumina. The matrix also had less than 0.5 percent of soluble iron oxide and alumina and was very rich in B. P. L. Therefore, the total minable phosphate should be of very high grade.

T. 32 S., R. 26 E., POLK COUNTY

Location.—The location of the 40-acre tracts prospected in T. 32 S., R. 26 E., is shown on plate 55 and on the inset map on plate 61, which also shows the location of the different test wells drilled by the Geological Survey party in this township, together with lines of equal phosphate content expressed in tons per acre of tricalcium phosphate.

Phosphate content.—The data obtained from wells drilled in T. 32 S., R. 26 E., and the results of laboratory tests on the samples are given in table 22.

TABLE 22.—*Phosphate data from T. 32 S., R. 26 E.*

Well No.	Over-burden (feet)	Phosphate		Crude weight (pounds)	Pebble, dry weight (pounds)	Matrix, dry weight (pounds)	Pebble (percent)	Matrix (percent)	$(Al, Fe)_2O_3$ [1]		$Ca_3P_2O_8$ [1]		Estimated phosphate (long tons per acre)		Estimated B. P. L. (long tons per acre)		
		Sample	Thick-ness (feet)						Pebble (percent)	Matrix (percent)	Pebble (percent)	Matrix (percent)	Pebble	Matrix	Pebble	Matrix	Total
59	52	All	1½	11½	¼	7¾	2.2	67.4	.64	0.06	52.57	11.43	80	2,457	42	281	323
60	46½	All	2⅓	57	8	37½	14.0	65.8	2.61	1.61	42.0	7.91	794	3,731	333	295	628
61	37	Top	1	7	¼	4½	3.6	64.3	1.84	3.48	60.2	5.88	88	1,563	53	92	145
		Bottom	1 1/12	28	2¾	16¼	9.8	58	1.77	.2	36.3	9.38	258	1,526	94	143	237
		Total	2 1/12	35	3	20¾							346	3,089	147	235	382
62	45½	All	11½	274½	25	187	9.	68	2.33	.37	44.09	13.44	2,515	19,003	1,109	2,554	3,663
63	28	All	5½	73	2	55	2.7	75.3	1.66	.6	43.28	6.66	361	10,064	156	670	826
64	60	Top	3⅓	65½	23	20	35.1	30.5	1.77	2.09	63.63	23.88	2,843	2,470	1,809	590	2,399
		Bottom	6	90	19	37½	21.1	41.7	2.14	.44	43.32	16.71	3,076	6,080	1,333	1,016	2,349
		Total	9⅓	155½	42	57½							5,919	8,550	3,142	1,606	4,748
65	52½	All	4	128½	7	85	5.4	66.2	.36	.12	68.04	14.05	525	6,435	357	904	1,261
66	37	All	1	14	¼	6½	1.8	46.4	2.87	.29	59.57	21.8	44	1,127	26	246	272
67	46	All	3	108	25¼	55½	23.4	51.4	1.83	1.02	46.55	10.15	1,706	3,747	794	380	1,174
68	42	Top	9	187	12¾	133	6.8	71.1	1.61	1.37	40.38	7.43	1,487	15,550	600	1,155	1,755
		Bottom	4	62½	10¼	37¼	16.4	59.6	.96	.57	66.55	12.65	1,594	5,793	1,061	733	1,794
		Total	13	249½	23	170¼							3,081	21,343	1,661	1,888	3,549
69	32	All	1	12	¾	9	6.3	75	.43	2.41	48.2	15.4	153	1,823	73	281	354
70	51½	Top	2½	39½	9	22	22.8	55.7	2.03	2.7	61.97	14.96	1,385	3,384	858	506	1,364
		Bottom	1	4	2¼	(?)	(?)	(?)	1.12		50.24		300		150		150
		Total	3½	43½	11¼								1,685	3,384	1,008	506	1,514
71	49½	All	13½	380	52¼	256	13.7	67.4	.43	.36	42.64	8.54	4,494	22,110	1,916	1,888	3,804

72	48½	Top	4	88	14½	50	16.5	56.8	2.67	1.77	70.45	14.40	1,604	5,521	1,130	795	1,925
		Middle	3	76	9	42	11.8	55.3	2.54	2.15	51.22	12.32	860	4,031	432	497	929
		Bottom	4	68	3	39¾	4.4	58.5	2.77	2.8	56.96	11.62	428	5,686	244	661	905
		Total	11	232	26½	131¾							2,892	15,238	1,806	1,953	3,759
73	62½	Top	9½	180	30¼	108	16.8	60	1.7	.63	52.43	17.35	3,878	13,851	2,033	2,403	4,436
		Bottom	4½	53½	4¾	23¾	8.9	44.4	1.57	.94	48.4	15.54	973	4,855	471	754	1,225
		Total	14	233½	35	131¾							4,851	18,706	2,504	3,157	5,661
74	29	Top	5½	102	14½	51	14.2	50.0	3.2	1.8	69.82	14.92	1,898	6,683	1,322	997	2,319
		Bottom	6	133	3¼	81½	2.4	61.3	3.65	.6	59.98	23.73	350	8,938	210	2,121	2,331
		Total	11½	235	17¾	132½							2,248	15,621	1,532	3,118	4,650
75	45	Top	5	90	11	55	12.2	61.2	2.92	4.96	68.28	11.71	1,482	7,436	1,012	871	1,383
		Bottom	1⅔	68	1¾	42	2.6	61.8	3.5	2.11	54.75	15.54	105	2,503	57	389	446
		Total	6⅔	158	12¾	97							1,587	9,939	1,069	1,260	2,329
76	33	Top	4	115	24½	64½	21.3	56.1	1.03	.27	64.79	8.17	2,070	5,453	1,341	446	1,787
		Middle	2	51	6¼	28	12.3	55	4.47	6.34	57.29	18.52	598	2,673	343	495	838
		Bottom	7⅚	74	7	44	9.5	59.5	3.74	1.57	36.08	25.68	1,808	11,325	652	2,908	3,560
		Total	13⅚	240	37¾	136½							4,476	19,451	2,336	3,849	6,185
77	25	Top	2	35½	3½	20½	9.9	57.7	5.3	3.57	53.77	14.89	481	2,804	259	418	677
		Bottom	11⅚	207	28¼	119	13.6	57.5	2.3	2.33	67.66	43.96	3,911	16,534	2,646	7,268	9,914
		Total	13⅚	242½	31¾	139½							4,392	19,338	2,905	7,686	10,591
78	60½	Top	13	183	16	110	8.7	60	3.2	3.	64.62	31.17	2,748	18,954	1,776	5,908	7,684
		Bottom	9½	94½	5½	50¾	5.8	63.7	3.5	2.27	68.03	34.92	1,339	12,397	911	4,329	5,240
		Total	22½	277½	21½	160¾							4,087	31,351	2,687	10,237	12,924
79	32½	Top	9	203½	24½	119½	12	58.8	1.8	1.47	69.69	38.48	2,624	12,860	1,829	4,949	6,778
		Bottom	2⅚	68¼	9¾	37	14.3	54.2	3.03	2.77	70.06	42.02	984	3,732	689	1,568	2,257
		Total	11⅚	271¾	34¼	156½							3,608	16,592	2,518	6,517	9,035
94	32½	All	12¼	142	5¾	71¾	4.1	50.5	1.16	2.31	63.11	27.69	1,220	15,033	770	4,163	4,933
95	27½	All	6½	115	5½	66½	4.8	57.7	1.3	1.7	68.08	30.69	758	9,114	516	2,797	3,313
96	34	All	9½	135	10	76	7.4	56.3	1.2	2.43	69.45	40.86	1,708	12,997	1,186	5,310	6,496

[1] Analysts, R E. Stevens, wells 59-75; J. J. Fahey, wells 76-100.

TABLE 22.—*Phosphate data from T. 32 S., R. 26 E.*—Continued

Well No.	Over-burden (feet)	Phosphate		Crude weight (pounds)	Pebble, dry weight (pounds)	Matrix, dry weight (pounds)	Pebble (percent)	Matrix (percent)	$(Al, Fe)_2O_3$		$Ca_3P_2O_8$		Estimated phosphate (long tons per acre)		Estimated B. P. L. (long tons per acre)		
		Sample	Thick-ness (feet)						Pebble (percent)	Matrix (percent)	Pebble (percent)	Matrix (percent)	Pebble	Matrix	Pebble	Matrix	Total
97	18	Top	5½	79	11½	36½	14.6	46.2	1.17	2.43	63.10	28.41	1,951	6,175	1,231	1,754	2,985
		Bottom	13½	137	8½	70	6.2	51.1	1	2.1	67.92	33.07	2,034	16,763	1,381	5,543	6,924
		Total	19	216	20	106½							3,985	22,938	2,612	7,297	9,909
98	18	Top	8½	190	12	148	6.3	77.9	1.37	1.27	45.89	7.47	1,301	16,090	597	1,202	1,799
		Middle	7½	116	26½	50	22.8	43	1.17	1.9	63.62	20.86	4,155	7,837	2,643	1,635	4,278
		Bottom	1	26	3	11¼	11.5	43.3	1.6	2.1	61.94	29.77	280	1,052	173	313	486
		Total	17	332	41½	209¼							5,736	24,979	3,413	3,150	6,563
99	10⅔	Top	7⅓	105	16½	46	15.7	43.8	1.27	1.83	63.55	21.86	2,798	7,805	1,778	1,706	3,484
		Bottom	4⅚	96	13	31	13.5	32.3	2.27	3.9	63.25	25.64	1,586	3,641	1,003	933	1,936
		Total	12⅙	201	29½	77							4,384	11,446	2,781	2,639	5,420
100	39⅙	Top	4⅚	73	13	31	17.8	42.5	4.47	4.17	69.78	23.02	2,091	4,992	1,459	1,598	3,057
		Bottom	3⅔	43	4½	21	10.5	48.8	3.87	3.83	55.12	21.23	936	4,348	516	923	1,439
		Total	8½	116	17½	52							3,027	9,340	1,975	2,521	4,496

Notes on a few of the wells are given below.

63. Although the thickness of the phosphate bed is 7½ feet, the part from 29 to 31 feet appeared to be barren quartz sand and was discarded by the prospector; the sample saved represented only 5½ feet of phosphate beds. Therefore, in determining the phosphate content, the figure 5½ feet was used instead of 7½.

70. The bottom sample, 54 to 55 feet, appeared to be barren for the first 8 inches. The bottom 4 inches, however, was a layer of large subangular pebbles with practically no fine material. Tonnage as figured on this sample is unreasonably large and therefore was reduced to 300 tons of pebble per acre.

75. The phosphate samples were collected as three parts—top, middle, and bottom. However, a check of weights indicates that some of the sample material of the middle part had inadvertently been placed with that from the top part. It was therefore necessary to combine the two upper samples and consider them as a single new top sample.

94. The weights of the two samples of crude collected are out of proportion to the thickness of the parts of the section from which they are recorded as taken. It was necessary, therefore, to combine them as a single sample. This has involved a recomputation of the analyses, which were made on the original two samples. The computed new figures are given in the table under $(Al,Fe)_2O_3$ and $Ca_3P_2O_8$.

In table 23 the data presented in table 22 are summarized with respect to the different areas prospected. In all 28 wells were drilled in T. 32 S., R. 26 E., on 31 40-acre tracts. For convenience these were divided into nine units. Arithmetical averages were used, and the results generally rounded to the nearest 100. For example, the 80-acre tract in the W½ NW¼ sec. 9 was tested by wells 94 and 96. The estimated tonnage of B. P. L. per acre as derived from the sampling data for well 94 is 4,933 and that for well 96 is 6,496. The average is 5,714 and is rounded as 5,700. The total estimated tonnage of B. P. L. for the unit is 80 times the average and is recorded as 456,000.

TABLE 23.—*Tonnage estimates of phosphate in T. 32 S., R. 26 E.*

Unit	Area (acres)	Total B. P. L. (tons)	Average overburden (feet)	Average phosphate contents (long tons per acre)			
				Pebble	B. P. L.		
					In pebble	In matrix	Total
S½NE¼, SE¼, and S½SW¼ sec. 1	320	672,000	43	1,800	900	1,200	2,100
NE¼SE¼ sec. 8	40	148,000	30	900	600	3,100	3,700
W½NW¼ sec. 9	80	456,000	33	1,500	1,000	4,700	5,700
S½SE¼ and SE¼SW¼ sec. 9	120	876,000	18	4,700	2,900	4,400	7,300
S½SE¼, SW¼, and SE¼NW¼ sec. 10	280	2,128,000	39	3,500	2,300	5,300	7,600
E½NE¼ and NE¼SE¼, sec. 11	120	564,000	46	3,300	1,900	2,800	4,700
W½SW¼ sec. 12	80	144,000	52	1,200	800±	1,000±	1,800
N½NE¼, SE¼NE¼, and NE¼SE¼ sec. 12	160	240,000	48	1,800	900±	600±	1,500
NE¼NE¼ sec. 13	40	14,000	32	150	75	275	350

As the 31 tracts in this township were rather close together, it was possible to construct a map (inset, pl. 61) showing the lines of probable equal phosphate content expressed in tons per acre of contained

B. P. L. The details of the respective wells are given on plate 61, which also shows the thickness of the phosphate and the depth and character of the overburden.

Sec. 1.—Sec. 1 is crossed by Bow Legs Creek and Boggy Branch. Along these streams the growth of small trees and brush is abundant. Some large trees are present. Most of the remaining area is rather level, open land with palmetto, grass, and a few scattered trees. The area tested is used mainly for pasturage. The eight 40-acre tracts in sec.1 were taken as a single unit, and tested with 8 wells. As shown on inset map, plate 61, over two-thirds of the total B. P. L. content of the unit is contained in half of the acreage. The average grade of the pebble is rather low, 49.22 percent of B. P. L. The soluble iron oxide and alumina in both the pebble and matrix is low, about 1.5 percent. However, as the amount of B. P. L. in the matrix exceeds the amount in the pebble, the total minable phosphate is of much better grade. If some of the lower beds are left unmined, the average grade of pebble in the others will be improved. The total B. P. L. in the unit of 320 acres is estimated roundly as 672,000 long tons, distributed in the individual tracts approximately as follows:

SE¼NE¼ sec. 1, 50,000 tons, of which about 76 percent is in the southern 20 acres.

SW¼NE¼, 46,000 tons, of which about 77 percent is in the southern 20 acres.

NW¼SE¼, 121,000 tons.

NE¼SE¼, 124,000 tons.

SW¼SE¼, 127,000 tons.

SE¼SE¼, 50,000 tons, the greater part of which probably lies close to the northern and western edges of the 40 acres.

SE¼SW¼, about 55,000 tons. The interpretation of the phosphate contained in this tract is probably the most uncertain of all.

SW¼SW¼, 99,000 tons; contains the highest-grade pebble found in the entire unit.

Sec. 8.—The 40-acre unit in sec. 8 is rather open grassy land and is used as pasture. It was tested by two wells, one in the SW¼ quarter of the tract and the other in sec. 9, adjacent to the NE¼. The amount of pebble in this unit is rather low. The average grade is about 67 percent B. P. L. and about 1.2 percent soluble iron oxide and alumina. The matrix contains over five times as much B. P. L. as the pebble. The total minable phosphate of the tract should therefore be of higher grade.

Sec. 9.—For convenience the tracts in section 9 were divided into two units, 80 acres in the northwestern part and 120 acres in the southern part. The 80 acres in the northwestern part is nearly level ground covered with brush and trees. The southern tract of 120 acres is mainly open pasture land with a small stream flowing southward across its eastern part and a swampy area covering a small part of the southwest corner. Parts of the tract have been cultivated.

Two wells were drilled in the northwestern part of sec. 9. The overburden averaged 33 feet, and the phosphate content averaged 5,700 tons of B. P. L. per acre. The average grade of the pebble was about 67 percent of B. P. L. and 1.2 percent of soluble iron oxide and alumina. About four-fifths of the total B. P. L. is in the matrix, and the grade of the total minable phosphate should therefore be rather high.

Three wells drilled in the southern part of sec. 9 showed phosphate averaging 7,300 tons of B. P. L. per acre beneath an overburden averaging only 18 feet. The average grade of the pebble was 62½ percent of B. P. L. and 1.33 percent of soluble iron oxide and alumina. The matrix contained about 1½ times as much B. P. L. as the pebble, thus considerably increasing the grade of the total minable phosphate.

Sec. 10.—Six wells were drilled in the 280-acre unit in sec. 10 and one near it in the southeast corner of sec. 9. The surface rights of most or all of the area have passed into private hands, but the mineral rights still belong to the Government. Two houses with outbuildings are located near the central part of the section. The B. P. L. averages 7,600 tons per acre, a total of 2,128,000 tons for the 280 acres. In the 120 acres comprising the SE¼NW¼ and the N½SW¼ sec. 10 the total estimated B. P. L. is 1,264,000 tons, an average of 10,533 tons per acre. The pebble in this 120 acres is of 67 percent grade, and its content of soluble iron oxide and alumina is 2.7 percent. The grade of pebble in the entire 280 acres is 63½ percent of B. P. L. and 2.3 percent of soluble iron oxide and alumina. The matrix in the entire unit contains over twice as much B. P. L. as the pebble, and thereby the grade of the total minable phosphate is greatly improved. The average overburden for the unit is about 39 feet.

Sec. 11.—A part of the prospected area in sec. 11 has been cultivated, part is covered by small trees and brush, and part adjacent to Bow Legs Creek is swampy. Two wells were drilled in the 120-acre unit of this section. A well drilled in the southwest corner of sec. 1 and two wells on the western edge of sec. 12 also furnished data. The average overburden was 46 feet. The average B. P. L. content of the unit was approximately 4,700 tons to the acre, about three-fifths of which came from the matrix. The grade of the pebble alone is about 58 percent of B. P. L. and averages slightly less than 3 percent of soluble iron oxide and alumina. As the larger amount of B. P. L. is in the matrix, its inclusion in the total of minable phosphate should raise the grade considerably.

Sec. 12.—Six 40-acre tracts in sec. 12 were tested by 5 wells. Two wells in sec. 1 and one in sec. 11 furnished additional data. The tracts were divided for convenience into two units, one of 160 acres in the eastern part and the other of 80 acres in the western part.

The 160-acre tract in the northwestern part of sec. 12 is relatively open land used for pasture. It contains about 240,000 tons of B. P. L. three-fifths of which is in the pebble. Over half of the phosphate is concentrated in one-fourth of the area, the NW¼NE¼ of the section. (See pl. 61.) The pebble in the entire 160 acres averages 51.65 percent of B. P. L. and 1.9 percent of soluble iron oxide and alumina. The average overburden is 48 feet, and the average B. P. L. content 1,500 tons per acre. For the individual 40-acre tracts the total B. P. L. content is as follows: NW¼NE¼, 150,000 tons; NE¼NE¼, 34,000 tons; SE¼NE¼, 36,000 tons; NE¼SE¼, 20,000 tons.

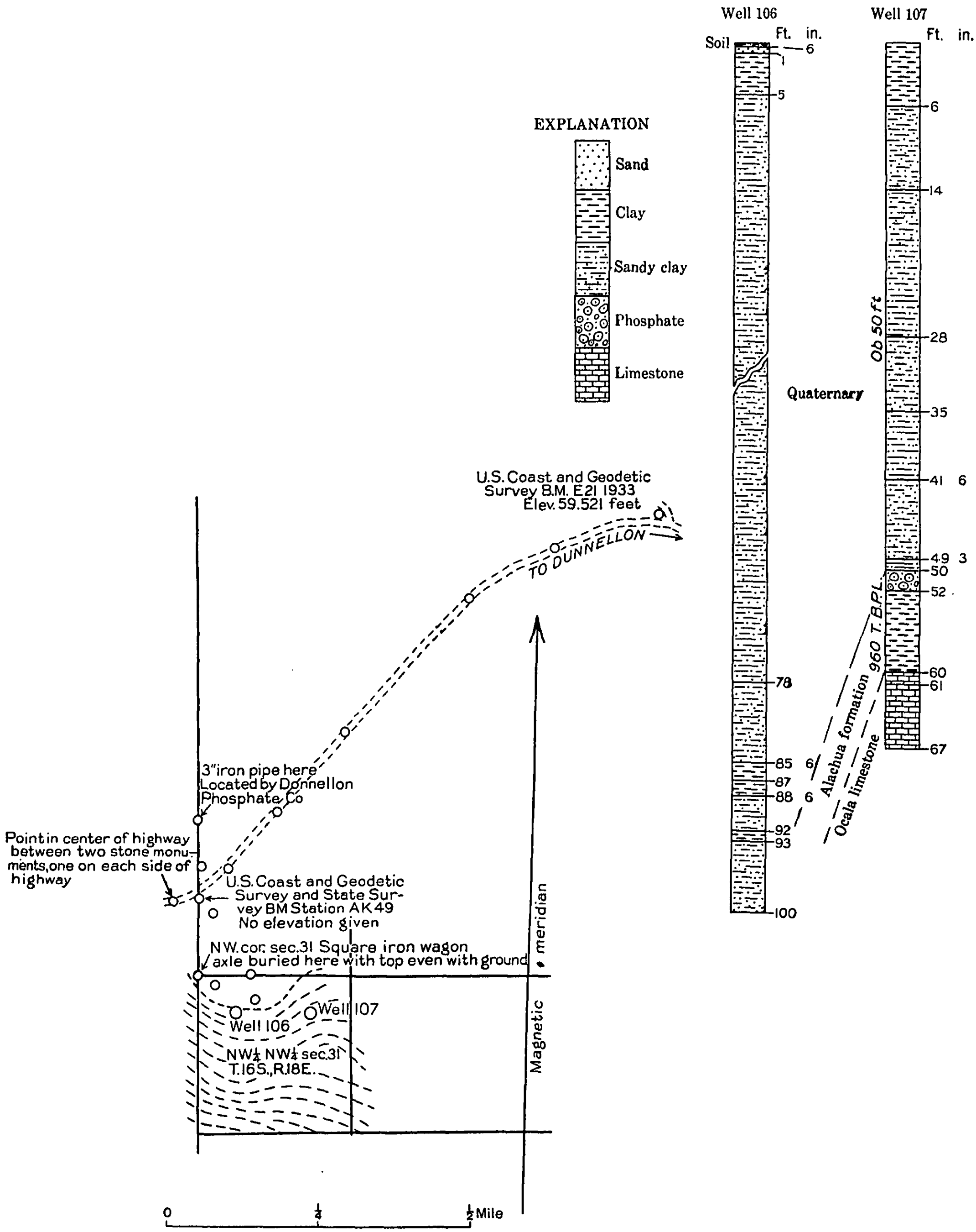
The 80-acre tract in the southwestern part of sec. 12 is partly open land, partly swampy, and partly scrub-timber land, where most of the large trees have been cut. The area is used as pasture. The tract contains about 143,600 tons of B. P. L., four-ninths of which is in the pebble. In reaching the estimate the data furnished by wells 65 and 70 have been supplemented by the use of the map. (See pl. 61.) The grade of the pebble averages about 62.5 percent of B. P. L. and 2 percent of soluble iron oxide and alumina. The average overburden is 52 feet. The amount of B. P. L. in the matrix exceeds that in the pebble, whereas the soluble iron oxide and alumina is less. Therefore the total minable phosphate will be of much higher grade than the pebble alone.

Sec 13.—The 40-acre unit in sec. 13 was tested by one well drilled in the center of the southwest 10 acres. Only 1 foot of phosphate was found. It indicated a phosphate deposit containing 150 tons of pebble per acre of 48.2 percent grade, having less than 2 percent of soluble iron oxide and alumina. As this result accords with the trend and character of the phosphate deposits as determined by drilling in secs. 1 and 12, it was deemed unnecessary to drill other wells on this unit. Taking into consideration these other wells, the average total B. P. L. content of this unit would be about 350 tons per acre. (See inset map, pl. 61.) The overburden would probably average about 32 feet.

T. 30 S., R. 27 E., POLK COUNTY

Location.—The location of the prospected land in sec. 29, T. 30 S., R. 27 E., is shown on plate 55 and in figure 54, which also shows the logs of test wells 80 and 81.

Character.—Lot 3 was originally all of the SW¼NE¼ sec. 29 except a part covered by one of the Twin Lakes. However, Twin Lakes have been partly drained, thus adding a large area of lake bed to the former land area. As this accession has not been subdivided, the acreage added to lot 3 has not been determined but is probably enough to



LOGS OF TEST WELLS 106 AND 107, SEC. 31, T. 16 S., R. 18 E.

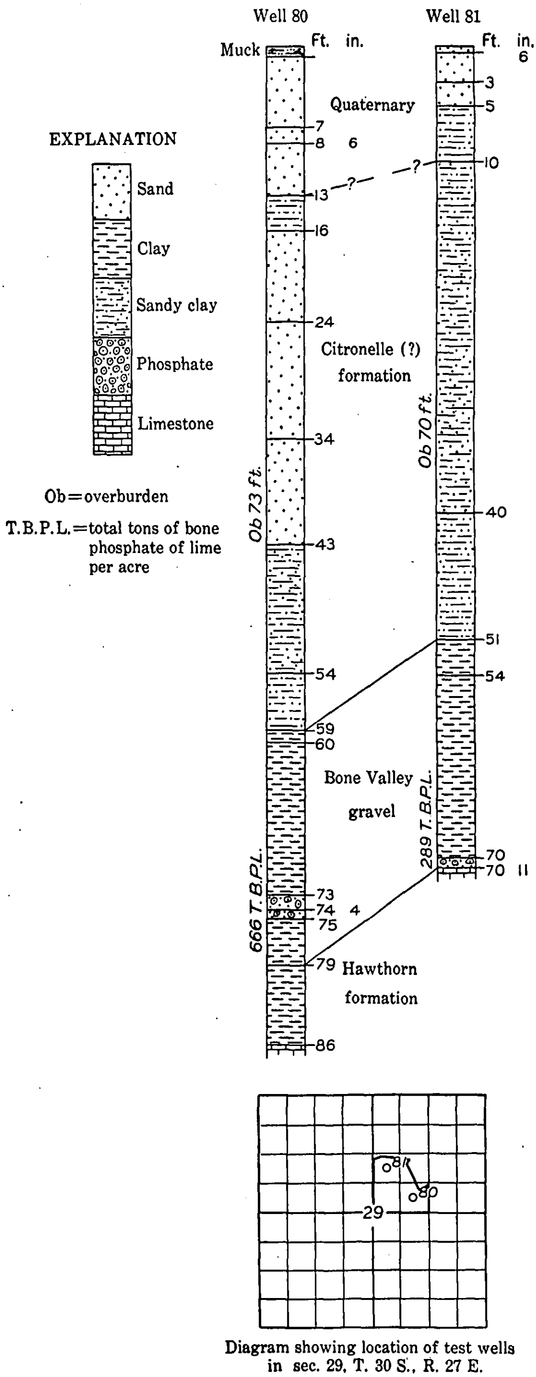


FIGURE 54.—Logs of test wells 80 and 81, sec. 29, T. 30 S., R. 27 E.

enlarge it to a total of 40 acres or more. The wells were drilled at the centers of the northwest and southeast approximately 10-acre lots comprised in the original limits of lot 3.

Phosphate data.—The data derived from sampling wells 80 and 81, together with the results of the chemical analyses of the samples, are presented in table 24.

TABLE 24.—*Phosphate data from T. 30 S., R. 27 E.*

Well No.	Overburden (feet)	Phosphate		Crude, weight (pounds)	Pebble, dry weight (pounds)	Matrix, dry weight (pounds)	Pebble (percent)	Matrix (percent)
		Sample	Thickness (feet)					
80	73	All	2	25	5	9	20.0	36.0
81	70	do	1½	10½	1½	4½	14.3	42.8

Well No.	$(Al, (Fe)_2O_3)$ [1]		$Ca_3P_2O_8$ [1]		Estimated phosphate (long tons per acre)		Estimated B. P. L. (long tons per acre)		
	Pebble (percent)	Matrix (percent)	Pebble (percent)	Matrix (percent)	Pebble	Matrix	Pebble	Matrix	Total
80	1.6	2.5	27.39	22.84	972	1,750	266	400	666
81	3.33	2.87	52.9	12.62	319	953	169	120	289

[1] Analyst, J. J. Fahey.

The average thickness of the phosphate deposits as shown by the two wells is 1½ feet and the average overburden 71 feet. The average amount of pebble is 650 tons per acre. Its grade is low, 33.27 percent of B. P. L., with 2 percent of soluble iron oxide and alumina. The B. P. L. in the matrix is 250 tons per acre, and the total B. P. L. in both pebble and matrix is only 475 tons per acre.

HARD-ROCK FIELD

The large number of wells required to determine accurately the probable tonnage of phosphate in a small area in the hard-rock field made it impossible with the funds available to obtain sufficient data for a wholly satisfactory classification of the lands. The main effort was therefore to find out if any hard-rock phosphate was present and if so to give an estimate in tons of B. P. L. per acre of the quantity near each well. Though the estimate applies only to the small area, perhaps less than an acre, immediately surrounding the well it affords a useful clue in the problem of classifying hard-rock phosphate lands.

T. 16 S., R. 18 E., MARION COUNTY

Location.—The prospected land in T. 16 S., R. 18 E., comprised a single 40-acre tract, the NW¼NW¼ sec. 31. Its location is shown on plates 55 and 63. Plate 63 shows also the location and logs of test wells 106 and 107.

Character.—About three-fourths of this tract is covered by water backed up by the power dam on the Withlacoochee River. Each of the wells was drilled in the water-covered area, the one shown in plate 58, *A*, was nearer to the shore.

Phosphate data.—In well 107, at depths of 28 to 50 feet, no signs of phosphate were visible, but a chemical test yielded a faint trace of phosphate. In the interval between 50 and 52 feet minute phosphate grains were noted in the matrix that was notably phosphatic. A sample of the 2-foot bed contained 10.27 percent of soluble iron oxide and alumina and 24.61 percent of B. P. L. From 52 feet to the bottom of the well, 67½ feet, 8 feet of limy clay and 7½ feet of limestone was penetrated. The sensitive ammonium molybdate test failed to show a trace of phosphate in the material recovered below 52 feet. These lower beds probably were part of the Ocala limestone.

Well 106 was drilled to a depth of 100 feet below ground or 103 feet and 7 inches below the top of the water. The only phosphate shown by the ammonium molybdate test was a slight trace at 93 feet.

It is doubtful if the very small amount of phosphate found in well 107 could justify mining.

T. 19 S., R. 19 E., CITRUS COUNTY

Location.—Two adjacent 40-acre tracts, forming the N½NE¼ sec. 14, T. 19 S., R. 19 E., were tested by two wells. The location of these tracts is shown in plate 55 and in figure 55, which also gives the logs of the test wells.

Character.—The area is rolling land timbered in the eastern part with pine, having a dense growth of oak underbrush. The western part has been cleared and has little undergrowth. The soil in the eastern part is mostly white sand with some clay; in the western part it is a sandy clay.

Phosphate data.—Well 37 showed phosphate from 84½ feet down to 96 feet. Five samples were collected from the drill stem and from the tub, which caught the overflow from the drill stem. The results of tests on these samples are given in table 25.

TABLE 25.—*Phosphate data from T. 19 S., R. 19 E., Citrus County*

Well No.	Sample	(Al, Fe)$_2$O$_3$ [1] (percent)	Ca$_3$P$_2$O$_8$ [1] (percent)	B. P. L. (long tons per acre)
37 I	Part of drill-stem sample from 84½ to 89 feet	0.70	53.20	5,817
II	Part of drill-stem sample from 89 to 91½ feet	.53	50.97	3,096
III	Sample in two parts (coarse and fine), represents 10 feet of material from 84½ to 94½ feet, including rest of I and II, together with all other material in drill stem and collecting tub from indicated interval:			
	Coarse	.32	40.15	6,975
	Fine	2.64	24.9	
IV	Drill stem and overflow material from 94½ to 97½ feet	.77	10.65	776

[1] Analyst, R. E. Stevens.

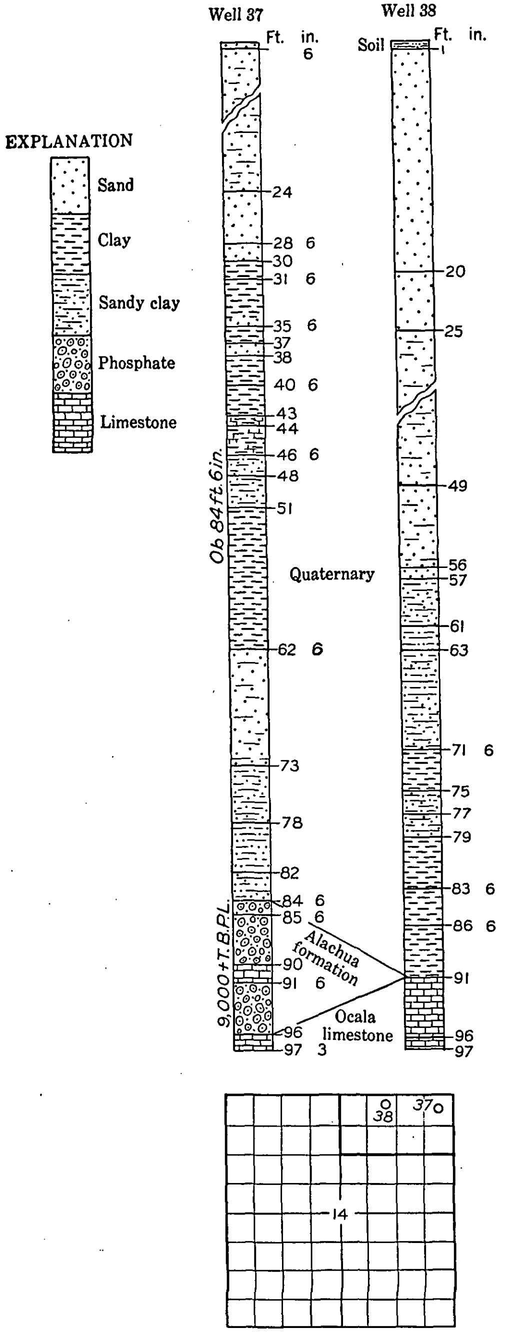


Diagram showing location of test wells in sec. 14, T. 19 S., R. 19 E.

FIGURE 55.—Logs of test wells 37 and 38, sec. 14, T. 19 S., R. 19 E.

As the samples overlap, the total B. P. L. content can be obtained by adding the figures for samples I, II, 0.3 of III, and IV, which gives 11,781 long tons per acre; or, by simply adding the figures for III and IV, which gives 7,751 tons per acre. It is thought that the actual amount present would be much nearer the higher than the lower figure and that 9,000 to 10,000 tons would be a fair estimate. The run-of-mine sample, III, shows about 7,000 tons per acre averaging about 33 percent B. P. L.

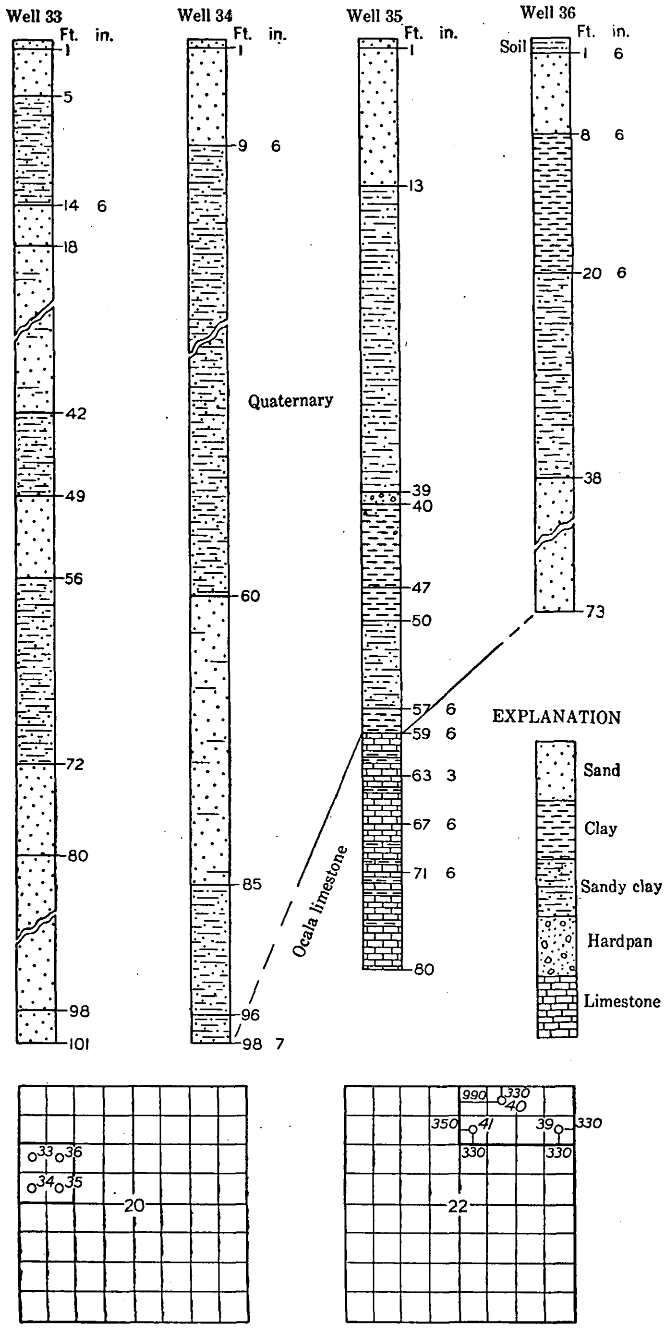
The lower part of the sample from 94½ to 96 feet contained much limestone, the basal part of which and the limestone from 96 to 97¼ feet appeared to be Ocala.

Well 38 was drilled about a quarter of a mile farther west and on top of a rise 15 feet or more above well 37. It showed only a trace of phosphate at 90 feet and reached the top of the Ocala limestone at about the same depth as in well 37. It would therefore appear that the well was on the side or top of a ridge of Ocala limestone, a poor location for finding hard-rock phosphate. The tests are considered sufficient to justify retention by the Government of the mineral rights of these two tracts.

T. 20 S., R. 19 E., CITRUS COUNTY

Location.—One 40-acre tract was tested in T. 20 S., R. 19 E., namely the SW¼NW¼ sec. 20, in which four wells were drilled. The location of the area is shown on plate 55 and in figure 56, which also shows the location of the test wells.

Character.—The land surface is rolling. The timber is scrub oak and scattering young pine. The tract is nearly free from undergrowth, and the soil is sandy clay.



Diagrams showing locations of test wells in sec. 20, T. 20 S., R. 19 E., and sec. 22, T. 16 S., R. 20 E.

FIGURE 56.—Logs of test wells 33 to 36, sec. 20, T. 20 S., R. 19 E.

Phosphate data.—Wells 33, 34, and 36 failed to reach the Ocala limestone and showed no phosphate. Well 35, however, penetrated phosphate at 59½ feet. Results of sampling this well and analyses of the samples obtained are summarized in table 26.

TABLE 26.—*Phosphate data from T. 20 S., R. 19 E., Citrus County*

Well No.	Depth (feet)	Thickness (feet)	Weight, dry (pounds)	$(Al,Fe)_2O_3$ [1] (percent)	$Ca_3P_2O_8$ [1] (percent)	Analyses recombined [2]		Estimated B. P. L. (Long tons per acre)
						$(Al,Fe)_2O_3$ (percent)	$Ca_3P_2O_8$ (percent)	
35 I	59½–63½	4	5¼			0.16	4.27	415
II	63½–67½	4	3¾			.43	.8	78
III	67½–71½	4	1¼			.31	2.49	242
IV	71½–80	8½	4			1.06	1.88	388
								1,123
I A [2]				0.24	8.96			
B				.13	2.71			
II A				.43	.59			
B				.43	.87			
III A				.25	2.29			
B				.33	2.56			
IV A				1.06	1.88			

[1] Analyst, R. E. Stevens.
[2] The samples marked A and B are coarse and fine products obtained by sifting the original samples. These fractional samples were used in making the original analyses. The analyses given in columns 7 and 8 have been obtained by recombining the original analyses in proportion to the relative amounts of course and fine material present in the original samples.

Wells 33 and 34 did not reach bedrock but were drilled to depths of 101 and 99 feet, respectively. Well 35 was drilled to 80 feet and found phosphate between 59½ and 78¼ feet. Much of the phosphate deposit contained limestone and clay. The basal limestone was probably the Suwannee, a limestone which occurs in the southern part of Citrus County and in northern Hernando County. On the basis of the B. P. L. estimated for well 35, the tract would contain about 1,100 tons per acre. Well 36 was abandoned at 73 feet because of casing trouble and lack of time. It did not reach phosphate or limestone.

The showing of phosphate in well 35 and the fact that the distribution of hard-rock phosphate is known to be very irregular make it possible that this tract may contain a relatively large amount of phosphate. However, the grade indicated by the analyses is very low. The overburden is 60 feet or more thick, another disadvantageous feature.

T. 16 S., R. 20 E., MARION COUNTY

Location.—Two adjacent 40-acre tracts, forming the N½NE¼ sec. 22, T. 16 S., R. 20 E., were tested by wells 39 to 41. The location of these tracts is shown on plate 55 and in figure 56.

Character.—The land is rolling and covered with scrub oak and scattered pines. The soil is mainly quartz sand with very slight amounts of clay and vegetable matter. No swamps or ponds were present even during the rainy season.

Phosphate data.—Three wells encountered limestone beds at depths ranging from 48 feet on the east to 12 feet on the west. They penetrated from 9 to 15 feet into the limestone. A few thin clay beds were present in the upper part of this rock, but the lower beds contained abundant Foraminifera and appeared to be of Ocala age. Numerous samples taken from the wells were tested by the ammonium molybdate method. A sample from a depth of 51 feet in well 39 yielded a faint reaction for phosphate. Otherwise no phosphate was found. On the basis of these tests the two 40-acre tracts would seem to be barren of phosphate. However, the occurrence of hard-rock phosphate is so irregular that the presence of phosphate in some parts of the area, though improbable, is not precluded by the tests made.

GENERAL SUMMARY OF PROSPECTING DATA

Table 27 gives a summary of the prospecting data given in the preceding pages.

TABLE 27.—*Summary of prospecting data for Polk, Marion, and Citrus Counties*

Location	Area (acres)	Number of wells	Total B. P. L. (long tons)	Average overburden (feet)	Average phosphate content (long tons per acre)				Grade of pebble (percent)	Iron and alumina (percent)
					Pebble	B. P. L.				
						In pebble	In matrix	Total		
POLK COUNTY										
T. 28 S., R. 24 E.:										
W½NE¼ sec. 36	80	3	384,000	9¼	2,100	1,200	3,600	4,800	56	2.8
NW¼SE¼ sec. 36	40	2	76,000	12	750	450	1,450	1,900	51.5	3
T. 29 S., R. 24 E.:										
SE¼NE¼ sec. 25	40	2	240,000	14	2,800	2,000	4,000	6,000	71.2	1.5
NW¼SE¼ sec. 28	40	2	488,000	36	11,400	7,300	4,900	12,200	64	2.2
N½NW¼ sec. 32	80	4	928,000	48	11,600	7,800	3,800	11,600	67.2	5
T. 30 S., R. 24 E.:										
SW¼NW¼ sec. 2	40	2	166,000	11	700	400	3,750	4,150	60	.5
SW¼SE¼ sec. 4	40	2	484,000	36	13,700	8,600	3,500	12,100	63	2.5
NW¼SW¼ sec. 22	40	2	356,000	40	9,800	6,100	2,800	8,900	66	------
NW¼NE¼ sec. 24	40	2	596,000	14	4,000	2,500	12,400	14,900	63	------
T. 28 S., R. 25 E.:										
SE¼SE¼ sec. 21	40	2	72,000	43	1,200	800	1,000	1,800	70.5	1.5
N½SW¼ sec. 23	80	2	32,000	68	250	150	250	400	51.4	3
SE¼NW¼ sec. 26	40	2	22,000	67	250	150	400	550	61.2	1.5
T. 30 S., R. 25 E.:										
SE¼NE¼ sec. 2	40	2	332,000	49	6,900	4,800	3,500	8,300	68.7	1.8
T. 32 S., R. 25 E.:										
W½SW¼ sec. 27	80	4	104,000	5½	900	400	900	1,300	47.5	.24
T. 29 S. R. 26 E.:										
NW¼ and NW¼NE¼ sec. 27	200	3	90,000	81	200	100	350	450	58.3	3.2
SW¼NW¼ sec. 29; SE¼NE¼ sec. 30	80	2	472,000	86	2,700	1,600	4,300	5,900	61.8	2.4
T. 30 S., R. 26 E.:										
S½NW¼ and NE¼SW¼ sec. 6	132	2	488,400	53	2,300	1,600	2,100	3,700	68.5	1.4
NE¼SE¼ sec. 7	40	1	512,000	48	8,800	6,200	6,600	12,800	69.9	1.5
NE¼SW¼ sec. 19	40	2	148,000	67	2,000	1,200	2,500	3,700	62.9	2.3

Table 27.—*Summary of prospecting data for Polk, Marion, and Citrus Counties*—Continued

Location	Area (acres)	Number of wells	Total B. P. L. (long tons)	Average overburden (feet)	Average phosphate content (long tons per acre)				Grade of pebble (percent)	Iron and alumina (percent)
					Pebble	B. P. L.				
						In pebble	In matrix	Total		
POLK COUNTY—con.										
T. 30 S., R. 26 E.—Continued.										
SW¼NE¼ and SE¼NW¼ sec. 25	80	2	168,000	86	2,150	1,300	800	2,100	61.8	2.4
N½SW¼ sec. 29	80	2	288,000	55½	2,300	1,500	2,100	3,600	64.8	1.3
N½NE¼ and E½NW¼ sec. 36	160	4	64,000	88	350	200	200	400	53.2	------
SW¼ sec. 36	160	4	288,000	88	1,600	900	900	1,800	60.7	3.1
T. 31 S., R. 26 E.:										
N½N½ sec. 1	172	3	602,000	80	2,500	1,400	2,100	3,500	55.4	1.3
W½NW¼ sec. 10	80	3	208,000	56	1,100	700	1,900	2,600	59.3	1.5
SW¼NW¼ sec. 13	16	1	44,800	66	1,800	1,100	1,700	2,800	61.1	1.5
SW¼NW¼ sec. 14	40	1	472,000	59	7,000	3,200	8,600	11,800	46	1
NE¼SE¼ sec. 23	40	1	144,000	50	1,500	1,100	2,500	3,600	73.2	0.4
T. 32 S., R. 26 E.:										
S½NE¼, SE¼, and S½SW¼ sec. 1	320	8	672,000	43	1,800	900	1,200	2,100	49.2	1.5
NE¼SE¼ sec. 8	40	2	148,000	30	900	600	3,100	3,700	67	1.2
W½NW¼ sec. 9	80	2	456,000	33	1,500	1,000	4,700	5,700	67	1.2
S½SE¼ and SE¼SW¼ sec. 9	120	3	876,000	18	4,700	2,900	4,400	7,300	62.5	1.3
S½SE¼, SW¼, and SE¼NW¼ sec. 10	280	6	2,128,000	39	3,500	2,300	5,300	7,600	63.5	2.3
E½NE¼ and NE¼ SE¼ sec. 11	120	2	564,000	46	3,300	1,900	2,800	4,700	58	3
W½SW¼ sec. 12	80	2	144,000	52	1,200	800	1,000	1,800	62.5	2
N½NE¼, SE¼NE¼, and NE¼SE¼ sec. 12	160	3	240,000	48	1,800	900	600	1,500	51.6	1.9
NE¼NE¼ sec. 13	40	1	14,000	32	150	75	275	350	48.2	2
T. 30 S., R 27 E.:										
SW¼NW¼ sec. 29	40	2	----------	71	650	225	250	475	33.3	2
MARION COUNTY										
T. 16 S., R. 18 E.:										
NW¼NW¼ sec. 31	40	2	----------	52	--------	--------	--------	-------	24.6	10.3
T. 16 S., R. 20 E.:										
N½NE¼ sec. 22	80	3								
CITRUS COUNTY										
T. 19 S., R. 19 E.:										
N½NE¼ sec. 14	80	2	----------	84½	--------	--------	--------	7,000	33	2
T. 20 S., R. 19 E.:										
SW¼NW¼ sec. 20	40	4	----------	60	--------	--------	--------	1,100	--------	------

As already pointed out the estimates given in this report are not comparable to those prepared for commercial purposes, but as summarized in table 27 they bring out some significant facts.

In phosphate mining today in the Florida field, attention is concentrated on material that contains 70 percent or more B. P. L. (bone phosphate of lime) and less than 3 percent of iron and alumina (abbreviated to I. and A.). High-grade rock of this kind has been much in demand for the manufacture of superphosphates by the acidulation process. However, operations of the Tennessee Valley Authority and others have shown that by the use of electric furnace methods material of much lower grade can be successfully utilized, and it is thought that by this and other possible methods material even as low as 40 percent in B. P. L. content may eventually be used.

In table 28, therefore, the results are grouped according to the grade of the phosphate pebble recovered. The results listed are all for the pebble field in Polk County. None of the wells drilled in the hard-rock field yielded material of grade as high as 40 percent B. P. L., but as the distribution of phosphate in the hard-rock field is known to be highly irregular the results obtained would probably justify in most of the tested areas retention of mineral rights by the Government.

TABLE 28.—*General results of Government prospecting in Polk County, Fla., 1934–35*

Grade of pebble (percent B. P. L.)	Area examined			Depth of overburden (feet)	Average B. P. L. (long tons per acre)			Total B. P. L. in area shown (long tons)	
	Acres	Part of total (percent)	With I. and A > 3 percent (percent)		Pebble	Matrix	Total	Pebble only	Pebble and matrix
70	120	4	0	14–50	1,300	2,500	3,800	156,000	456,000
60–70	1,588	48	6.5	11–86	2,517	3,483	6,000	3,997,000	9,528,000
50–60	1,092	33	10.8	9–88	775	1,295	2,070	846,000	2,260,000
40–50	480	14	0	5–59	940	1,690	2,630	451,000	1,262,000
0–40	40	1							
	3,320	100						5,450,000	13,506,000

The most significant of the results shown in table 28 is probably the remarkable increase in total phosphate content per acre and in the different acreage groups when the phosphate contained in the matrix is taken into account. The next feature of great importance is the fact that 99 percent of the area tested in Polk County contains phosphate of at least 40 percent B. P. L. content, 85 percent of it contains material of 50 percent grade or better, and 52 percent of it is material containing 60 percent or more of B. P. L.

The tracts tested were not selected in accordance with any particular arrangement, but they were fairly well scattered through the pebble phosphate field and may perhaps be considered representative of the field as a whole.

The areas tested therefore afford an example of how greatly an estimate based only on rock of 70 percent or better grade may be expanded if lower grades are taken into account. The bearing of this example on the life of the Florida pebble field is obvious.

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