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RESULTS OF GEOLOGIC DRILLING, 1953, LAND-PEBBLE PHOSPHATE DISTRICT, FLORIDA*

By

James B. Cathcart and Lawrence J. McGreevy

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RESULTS OF GEOLOGIC DRILLING, 1953, LAND-PEBBLE PHOSPHATE DISTRICT, FLORIDA

By James B. Cathcart and Lawrence J. McGreevy

ABSTRACT

A program of core drilling to delimit the uranium and phosphate-bearing strata (the aluminum and calcium phosphate zones) of the land-pebble phosphate district, and to study the stratigraphic relations of the Bone Valley formation was carried out in the fall of 1953.

A series of cross sections, an isometric block diagram, and a series of tables summarize the lithologic, stratigraphic, analytical, and economic data derived from the drilling.

The Bone Valley formation of Pliocene(?) age was deposited by a transgressing sea. In most of the district, the Bone Valley overlies limestone or dolomite of the Hawthorn formation (middle Miocene); but in the northern part of the district in northern Polk County, where the Hawthorn thins to an erosional feather edge, the Bone Valley overlies the Tampa formation (early Miocene), and farther to the north, in Pasco County, clayey sands of the upper Bone Valley overlie the Suwannee limestone (Oligocene). To the east and south, however, the Bone Valley overlies a micaceous, phosphatic, clayey sand, containing fossils of late middle Miocene age. This material in turn overlies the limestone or dolomite of the Hawthorn formation. The material is thought to be an unnamed member of the upper part of the Hawthorn.

In the northernmost line of holes drilled, material lithologically similar to the Bone Valley overlies a sandy clay containing angular white phosphate particles, material very similar to the hardrock phosphate.

It is thought that this material may represent the Alachua(?) formation. It appears, therefore, that the Bone Valley is in part equivalent to the Alachua(?) formation, but that a part of the Bone Valley formation may be somewhat younger than the Alachua(?). Three holes in the northeast penetrated the Ocala limestone (Eocene). Indications are that this limestone may occupy an upthrown fault block.

Since the deposition of the Bone Valley, weathering altered the formation, changing fluorapatite to wavellite and crandallite (pseudowavellite), and forming the aluminum phosphate zone.

In the northwest part of the land-pebble district, the aluminum phosphate zone extends beyond the limits of the calcium phosphate zone. To the east and south, the calcium phosphate zone extends beyond the limits of the aluminum phosphate zone. In the northern part of the area where the phosphate deposition was thinnest, the entire Bone Valley formation may have been leached, while to the south, where the formation was thicker, only the top part of the formation was leached, and both zones are present. Still farther to the south, in Hardee and Manatee Counties, the Bone Valley formation may not have been exposed to subaerial weathering, and the aluminum phosphate zone was not formed. The present limit of the aluminum phosphate zone is the result of a combination of erosion after the zone was formed, and the possibility that to the east and south, phosphatic sediments were not exposed to weathering in the Pliocene. The aluminum phosphate zone and the calcium phosphate zone both cut across stratigraphy. This is clearly shown in some of the lines where, for example, aluminum phosphate minerals have formed in the Bone Valley, the Hawthorn, and the Tampa formations. The calcium phosphate zone may be entirely within the Bone Valley formation, entirely within the Hawthorn formation, or most commonly, it includes the bottom part of the Bone Valley, and the weathered top of the Hawthorn formation.

The phosphate deposits of the land-pebble district are thus complex--partly residual, partly marine reworked, and partly phosphatized clay.

INTRODUCTION

The land-pebble phosphate district is located in west-central peninsular Florida between 27°00' and 28°15' North latitude and 81°45' and 82°15' West longitude. The district is divided on the basis of phosphate content and tonnage into a northern, high-grade part in Polk and Hillsborough Counties, and a southern, lower-grade part in Hardee and Manatee Counties (fig. 1).

A program of core drilling to delimit the uranium- and phosphate-bearing strata of the Bone Valley formation and to study the stratigraphic relations of the Bone Valley formation was undertaken by the U. S. Geological Survey, on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission. A spoke-like pattern of lines of drill hole sites was laid out; the first site in each line was selected within the limits of the land-pebble phosphate district. Drilling permits from the land-owners were obtained under the direction of Emerson C. Willey of the Geological Survey. A sampler followed the drilling in the field, checked core recovery, and collected chip samples from the core at one foot intervals. A total of 115 holes aggregating 7,112 feet were drilled from May 26 to October 21, 1953, using a truck-mounted rotary drill.

Heavy drilling mud was used to prevent caving and contamination during coring. Average core recovery was 74 percent; losses were noted and are shown on the cross-sections. Holes with low recovery were redrilled to recover enough sample for analytical purposes. All holes were cased with 1-1/2-inch (inside diameter) cast-iron pipe, and gamma-ray logs were made. Casing was necessary to prevent caving prior to gamma-ray logging.

Samples corresponding to the high-peak areas on the gamma-ray logs were split from most cores for analysis. These samples represent, at least in part, the aluminum phosphate zone. Where visual inspection showed abundant phosphate grains, a sample was also taken that represented the calcium-phosphate zone or "matrix." The sample was weighed and then washed over a 14-mesh screen, and the oversize retained, dried, and weighed. The undersize was screened on 35- and 150-mesh screens. The material retained on the 35-mesh screen was dried and weighed. If phosphate minerals were present in the -35+150 mesh material, it was treated in a laboratory flotation cell to separate the quartz sand and phosphate minerals. The material passing the 150-mesh screen (the slime fraction) was dried, weighed, and retained. Weight percents of sample fractions were computed from the dry weights. Equivalent uranium and, where necessary, chemical uranium were determined for all sample splits. The samples highest in uranium content were analyzed for P_2O_5, CaO, F, and Al_2O_3.

The drill holes were logged by the following geologists: D. C. Alverson, W. J. Carr, J. B. Cathcart, K. B. Ketner, L. J. McGreevy, and R. G. Petersen of the U. S. Geological Survey. Samples of the fossiliferous material were examined by F. Stearns MacNeil of the U. S. Geological Survey, and all fossil determinations and age assignments from fossils were made by him.

Studies of the limestone cores from lines 1 through 4 were made by W. J. Carr and D. C. Alverson (1955). The writers have used their age assignments for non-fossiliferous limestones in those lines. A. M. Coleman and Charlotte Axsell assisted the writers in the preparation of the tables and illustrations. All analytical work was done by the U. S. Geological Survey Laboratory, Washington, D. C. Radioactivity analyses were made by J. Goode and B. McCall under the direction of F. Flanagan. Chemical analyses were made by J. Smith, W. Tucker, J. Budinsky, L. Jenkins, E. Campbell, I. Barlow, R. Smith, S. Betbee, R. Moore, A. Sweeney, T. Murphy, J. Waving, and G. Daniels under direction of I. May.

All of the factual data obtained during the drilling are presented in tables 1-39. The even-numbered tables show all the mechanical and chemical analyses for all samples. The odd-numbered tables give tonnage and grade computations for the aluminum-phosphate and calcium-phosphate zones.

A series of cross-sections, one for each line of drill holes, summarize the lithologic, stratigraphic, and economic data. Lithologic correlations were made from geologists' logs of the core, plus the authors' examination of the core chips with the binocular microscope. The authors' stratigraphic correlations are based on lithology, except for the few fossiliferous beds. The fossil lists and age identifications are given in the text.

The delineation of the aluminum-phosphate and the calcium-phosphate zones as shown on figures 2-19, was made with the use of the chemical analyses of the samples, and for the aluminum-phosphate zone, from the high peaks on the gamma-ray logs.

GENERAL GEOLOGY

The land-pebble phosphate district is a part of the Gulf Coastal Plain and is underlain by thin, nearly flat-lying formations, that dip very gently to the south and southeast. King (1951) has pointed out that the geology of peninsular Florida differs from that of the remainder of the coastal plain in that Florida was a positive, relatively stable area during a large part of Mesozoic and Cenozoic time and, because of its distance from the main part of the North American continent, it received relatively small amounts of land-derived sediment.

Phosphate deposits in the land-pebble district are part of the Bone Valley formation of probable Pliocene age and/or phosphate-bearing sandy clays of the Hawthorn formation. The Bone Valley formation was deposited on the eroded surface of the underlying phosphatic Hawthorn formation of middle Miocene age, and in the northern part of the district, where the Hawthorn formation thins to an erosional feather edge, on the Tampa formation of early Miocene age. On the fringes of the district (to the north, west, and east), drilling penetrated rocks of the Suwannee limestone of Oligocene age and the Ocala limestone of Eocene age, and on the northern edges of the district, clayey sands, possibly equivalent to the Bone Valley formation, rest on the Suwannee limestone.

The Bone Valley formation was deposited by a transgressing sea that reworked and partly sorted the residual mantle formed on the Hawthorn at the close of the Miocene. Since its deposition, the upper part of the Bone Valley has been deeply weathered. Much of the phosphate in this upper zone has been removed, and some of the phosphate combined with alumina from clay minerals to form aluminum-phosphate minerals. The Bone Valley deposits are thus complex--partly residual, partly marine reworked, and partly phosphatized clay.

The district is covered by a blanket of loose, quartz sand of probable Pleistocene age. Wind-blown sand, swamp deposits, and bars and flood plains of streams are probably Recent.

STRATIGRAPHY

Details of the stratigraphy and local stratigraphic relations, are shown on figures 2-19. Stratigraphic relations and the geographic distribution of the formations based on geological drilling is shown on figure 20.

Eocene series

Ocala limestone

The Ocala limestone was named by Dall and Harris (1892, p. 103), for the city of Ocala in Marion County. Cooke (1915, p. 117) believed the Ocala was of late Eocene age. Vernon (1951, p. 111-113) divided the Ocala into the Ocala limestone (restricted) at the top and the Moodys Branch formation at the base. The Moodys Branch formation is divided by him into a lower, Inglis member and an upper, Williston member. Because only a few, short cores of the Ocala were obtained in the present study, it was not possible to sub-divide the Ocala, and the term is used in this report as synonymous with the Jackson group (Cooke, 1945, p. 53).

The Ocala is a white, cream to yellow, very pure limestone, in places containing over 99 percent calcium carbonate. It varies in thickness from about 50 to almost 400 feet. Fossiliferous Ocala limestone was identified from the following locations:

Line 15, hole 5, (SW$\frac{1}{4}$ of SW$\frac{1}{4}$ sec. 3, T. 27 S., R. 26 E.)

Amusium ocalanum.

Line 16, hole 1a (SW$\frac{1}{4}$ of SW$\frac{1}{4}$ sec. 21, T. 26 S., R. 25 E.)

Chlamys sp., cf. C. spillmani.
Tubulostum sp.
Lepidocyclina ocalana.

Line 16, hole 2, (NW$\frac{1}{4}$ of NW$\frac{1}{4}$ sec. 21, T. 26 S., R. 25 E.)

Lepidocyclina sp. cf. L. pseudomarginata

The altitude of the Ocala limestone in these holes is about the same as the altitude of the Hawthorn formation in adjacent holes (See figs. 16 and 17.) Calcareous clays, assigned to the Hawthorn, overlie the Ocala limestone at these drill holes. This indicates that a part of the Hawthorn formation, the Tampa limestone and the Suwannee limestone may have been cut out. Thus, the Ocala limestone here may occupy an upthrown fault block (fig. 20). If this is a fault block, the age of the faulting is probably pre-Bone Valley, because sediments assigned to the Pliocene(?) are apparently not affected by the faulting.

Oligocene series

Suwannee limestone

The name Suwannee limestone was proposed by Cooke and Mansfield (1936, p. 71) for limestone exposed along the banks of the Suwannee river. Cooke (1945, p. 88) says the Suwannee is the equivalent of the Chickasawhay limestone of late Oligocene age. MacNeil (1947) indicates that the Suwannee limestone is the equivalent of the Byram and the Chickasawhay formations combined and thus includes rocks of middle and upper Oligocene age.

The Suwannee limestone is a yellow or cream limestone. It is commonly soft and granular. Small solution holes, filled with green clay, probably residual from the limestone, are abundant. In places, the lime has been leached from the surface of the limestone, leaving a mass of flint. Chemical analyses (Mossom, 1925) show that the Suwannee contains between 91 and 98 percent calcium carbonate.

The Suwannee limestone lies unconformably on the Ocala and is unconformably overlain by the Tampa limestone of early Miocene age or by younger rocks. The thickness of the Suwannee limestone in the land-pebble district is about 130 feet (MacNeil, personal communication, 1956).

Fossiliferous Suwannee limestone was identified from the following localities:

Line 1, hole 4, (SW$\frac{1}{4}$ of NE$\frac{1}{4}$ sec. 19, T. 27 S., R. 22 E.)

Phacoides (Miltha) sp. aff. P. chipolanus
Turritella n. sp. (?)
Turritella sp. aff. T. bowenae
Kuphus incrassatus

Line 2, hole 4, (NE$\frac{1}{4}$ of SW$\frac{1}{4}$ sec. 6, T. 28 S., R. 21 E.)

Sorites sp.
Peneroplis sp.
Chlamys sp. cf. C. brooksvillensis
Kuphus incrassatus

Line 17, hole 5, (SW$\frac{1}{4}$ of SW$\frac{1}{4}$ sec. 8, T. 26 S., R. 23 E.)

Turritella halensis
Glycymeris suwannensis
Divaricella sp.
Pitar sp.
Corbula sp.
Myrtaea sp. cf. M. taylorensis
Chlamys sp. cf. C. brooksvillensis
Orthaulax hernandensis
Amauropsis sp. (?)
Chione sp.
Pitar sp. cf. P. heilprini
Anatina sp.
Venus sp.

Line 17, hole 6, (NW$\frac{1}{4}$ of NW$\frac{1}{4}$ sec. 1, T. 26 S., R. 22 E.)

Tritiaria n. sp. (?)
Venus sp.
Barnea sp.
Coskinolina floridana

Line 17, hole 9, (NW¼ of SE¼ sec. 13, T. 25 S., R. 21 E.)

Peneroplis sp.
Asterigina subacula floridensis

Line 17, hole 10, (SW¼ of NE¼ sec. 11, T. 25 S., R. 21 E.)

Peneroplis sp.
Sorites sp.
Asterigina subacula floridensis

Line 17, hole 11, (NW¼ of SE¼ sec. 22, T. 24 S., R. 21 E.)

Sorites sp.

In addition to the fossiliferous limestones, material at the bottom of hole 5, line 1; hole 3, line 2; and holes 3 and 8, line 17, was tentatively assigned to the Suwannee. All of the drill holes that penetrated Suwannee limestone are at the northern end of the mapped area (fig. 1). In this part of the area, the Hawthorn and Tampa formations, which normally overlie the Suwannee, are thinning. None of the holes in the south, east, or west penetrated the Suwannee limestone, indicating a general thickening of the younger formations to the south.

Miocene series

Tampa limestone

The name "Tampa formation" was first used by Johnson (1888, p. 235); Cooke and Mossom (1929, p. 78-93) changed the name to "Tampa limestone." Both Cooke (1945) and MacNeil (1947) put the Tampa limestone in the Early Miocene.

The Tampa limestone is much more variable in composition than either the Suwannee or Ocala. It is a white to cream, sandy and clayey limestone, and contains abundant chert fragments and very few phosphate nodules. The limestone is interbedded with beds of clay and sandy clay and is often covered with a residual mantle of greenish calcareous clay, containing chert and limestone fragments and sparse phosphate nodules.

The Tampa limestone lies unconformably on the Suwannee limestone, but the relations between the Tampa and the overlying formations are uncertain. Cooke (1945, p. 115) indicates that in the northern part of Florida, near the Georgia state line, the contact between Tampa limestone and Hawthorn formation is gradational and conformable. Recent work in the land-pebble district by Carr and Alverson (1953, p. 182) indicates that the contact between the Tampa and the Hawthorn is marked by an erosional interval.

According to Mansfield (1937, p. 14) the Tampa limestone is about 65 feet thick near Tampa.

Fossiliferous Tampa limestone was identified from the following localities:

Line 1, hole 3, (NE$\frac{1}{4}$ of SE$\frac{1}{4}$ sec. 31, T. 27 S., R. 22 E.)

Helisoma sp.

Line 2, hole 3, (SE$\frac{1}{4}$ of SE$\frac{1}{4}$ sec. 8, T. 28 S., R. 21 E.)
molds and casts in siliceous bed at top of calcareous clay.

Helisoma sp.

Line 3, hole 2, (SE$\frac{1}{4}$ of SE$\frac{1}{4}$ sec. 35, T. 28 S., R. 20 E.)
fossils in limestone fragments in green clay.

Trigonocardia sp.
Camerina sp.
Sorites sp.

Line 4, hole 1, (SW$\frac{1}{4}$ of SW$\frac{1}{4}$ sec. 4, T. 30 S., R. 20 E.)

Murex sp. cf. *M. trophonoformis*
Arca irregularis
Cardium sp. cf. *C. anclotensis*
Anomalocardia penita

Line 4, hole 3, (NW$\frac{1}{4}$ of SE$\frac{1}{4}$ sec. 13, T. 30 S., R. 19 E.)

Sorites sp.

Line 14, hole 7, (NW¼ of SE¼ sec. 15, T. 28 S., R. 26 E.)

Turritella tampae
Turritella hillsboroensis
Amauropsis sp.
Arcopsis sp.
Chlamys crocus
Phacoides sp.

Line 14, hole 8, (NW¼ of SE¼ sec. 14, T. 28 S., R. 26 E.)

Venus sp.
Sorites sp.
Camerina sp.
Peneroplis sp.

Line 17, hole 4, (NE¼ of SW¼ sec. 27, T. 26 S., R. 23 E.)

Terebra sp.
Knefastia sp. cf. K. brooksvillensis
Olivella sp. cf. O. posti
Turritella atacta
Anadara latidentata
Chlamys sp.
Cardium delphicum
Callocardia sp.
Pitar sp.
Venus sp.
Corbula sp.
Architectonica, n. sp. (?)

Line 17, hole 9, (NW¼ of SE¼ sec. 13, T. 25 S., R. 21 E.)

Glycymeris sp.

In addition to the fossiliferous localities, limestone or clastics lithologically similar to the Tampa were cored at holes 1, 2, and 4 of line 1; hole 4 of line 2; holes 1, 3, 4, and 5 of line 3; hole 4 of line 14; and holes 3, 5, 6, 7, 8, and 10 of line 17. All of the drill holes that intersected limestones or clastics of the Tampa are in the northern half of the area mapped, but, in the northernmost holes of lines 1 and 17, the Tampa was missing, and the formation thins to the north. Because the formation extends further to the north than does the overlying Hawthorn, the thinning may be in part, at least, erosional.

Hawthorn formation

The Hawthorn formation was named for the town of Hawthorn, Alachua County, by Dall and Harris (1892, p. 107). The Hawthorn was called Middle Miocene by Cooke (1945) and MacNeill (1947). In the land-pebble district the Hawthorn formation consists of interbedded limestones or dolomites, sands, sandy clays, and greenish-blue or gray clays, all of which contain abundant phosphate nodules. Where exposed in the mining pits of the land-pebble district, the Hawthorn formation is a soft buff to yellow, sandy, clayey, phosphate-bearing dolomite. In studying cuttings from a deep well Berman (1953) found an abrupt change at 80 feet from dolomite to limestone. It is believed that the upper dolomitic zone may be a replacement of the limestone.

A thin, discontinuous deposit of soft, water-saturated plastic sandy calcareous clay (called bedclay by the phosphate companies) overlies the dolomite of the Hawthorn formation in most of the pits in the district. This clay is gradational with the material below and probably was derived from the hard dolomite beneath by leaching.

No limestone of the Hawthorn formation was found in the drill holes in the northern fringe of the district. (See figs. 2, 3, 18, and 19.) The formation in this area is very thin and pinches out to the north. In the southern part of the area, the drill holes penetrated sandy clays, clays, and sands of the Hawthorn formation, but many bottomed in limestone or dolomite of the Hawthorn. (See figs. 8, 9, 10, and 11.) The Hawthorn formation is unconformably overlain by the Bone Valley formation of Pliocene(?) age or by sands of the Pleistocene. The Hawthorn ranges in thickness from a feather edge to the north of the district to a maximum of several hundred feet to the south.

Fossiliferous Hawthorn was identified from the following localities:

Line 4, hole 2, (SW¼ of SW¼ sec. 18, T. 30 S., R. 20 E.)

Ostrea sp.

Line 10, hole 8, (SW¼ of SW¼ sec. 15, T. 34 S., R. 25 E.)

Anadara sp.
Chione sp.

Line 11, hole 1, (NW¼ of NW¼ sec. 1, T. 34 S., R. 25 E.)
(upper Hawthorn age)

Cancellaria sp.
Semicassis (?)
Glycymeris sp.
Anadara sp.
Plicatula sp.
Phacoides sp.
Venericardia sp.
Cardium sp.
Dosinia sp.
Venus sp.

Line 11, hole 5, (NE¼ of SE¼ sec. 35, T. 33 S., R. 26 E.)

Glycymeris sp.
Phacoides sp.

Line 11, hole 6, (NE¼ of SE¼ sec. 31, T. 33 S., R. 27 E.)

Chlamys sp.
Venericardia sp.
Chione sp.
Venus sp.

Line 12, hole 1, (sec. 36, T. 31 S., R. 25 E.)
(Hawthorn (?))

Anadara sp.

Line 12, hole 6, (NW¼ of NE¼ sec. 31, T. 31 S., R. 27 E.)
(fossils are in a limestone gravel)

Chlamys sp.

Line 12, hole 8, (NE¼ of SW¼ sec. 33, T. 31 S., R. 27 E.)
(Hawthorn(?))

Turritella sp.
Chlamys sp.
Pecten sp.

Line 13, hole 1, (SW¼ of SW¼ sec. 17, T. 30 S., R. 26 E.)
(Hawthorn (?))

Chlamys sp.
Venericardia sp.
Phacoides sp.

Line 13, hole 2, (NW¼ of SE¼ sec. 17, T. 30. S., R. 26 E.)

Anadara sp.
Chione chipolana

Line 13, hole 5, (NW¼ of SE¼ sec. 13, T. 30 S., R. 26 E.)

Cardium (*Trachycardium*) sp.
Chlamys sp. (probably *sayanus*)
Tellina sp.

Limestones and clastics, lithologically similar to the Hawthorn formation, were cut by all drill holes except for holes 4 and 5 of line 1, and holes 4 through 11 of line 17. (See figs. 2 and 18.) The approximate northern limit of the Hawthorn formation is shown on figure 20. The thinning and pinch out of the Hawthorn to the north is shown on figures 2 and 18. In addition, figure 4 indicates a thinning of the Hawthorn to the west. The northern thinning of the Hawthorn is believed to be erosional; outliers of the formation are shown on the geologic map of Florida (Cooke, 1945), to the north of the area mapped. The thickening of the formation to the south is shown from logs of deep wells.

Hawthorn(?) formation, unnamed member

Fossils, identified as late middle Miocene or early late Miocene in age_/ were found in two areas. On the eastern fringe of the district in eastern Polk County the easternmost drill holes in lines 12 and 15 (figs. 13 and 16) penetrated a bed of micaceous clayey sand, olive-green, fine to very fine-grained, with abundant shell fragments, and minor black phosphate grains. Lithologically similar material was identified in lines 11, 13, and 14 (figs. 12, 14, and 15) and is tentatively correlated with the late middle Miocene. The fossiliferous material in hole 8 of line 12 (fig. 13) overlies fossiliferous limestone of the Hawthorn formation, and in hole 6 of line 15 (fig. 16), the fossiliferous material overlies limestone that is lithologically similar to the Hawthorn.

_/MacNeil, F. S., written communication, 1956. MacNeil says further: "I think I would prefer to see this zone labeled Middle Miocene(?). Inasmuch as the Middle Miocene is called the Hawthorn formation in peninsular Florida it might be called Hawthorn(?) formation, unnamed member."

To the south, at the north end of DeSoto County, in line 10, hole 14 (fig. 11) fossils identified as late Miocene(?) were found in a white to cream, sandy and clayey limestone with a trace of black phosphate nodules. This fossiliferous bed overlies a non-fossiliferous limestone that is lithologically similar to the Hawthorn. According to Bergendahl (in preparation) most of the upper Miocene is sand, containing variable amounts of clay. This sand from its description is similar to the sand in the east and was penetrated in holes 12, 13, 15, and 16 at the south end of line 10.

The clayey sand beds lie to the east of a subsurface ridge that is parallel to and east of the Peace River. The land-pebble phosphate district as an economic unit does not extend to the east of this ridge, (fig. 1) although subeconomic phosphate beds overlie the middle Miocene(?) beds east of the ridge.

The total thickness of the middle Miocene(?) beds is unknown. In line 12, hole 8, (fig. 13) a tan sand, containing abundant coarse phosphate, overlies the olive-green clay sand with late Miocene fossils. This material is tentatively put into the Bone Valley; and, if this correlation is correct, the middle Miocene(?) beds are only 10 feet thick in this drill hole from a depth of 59.8 feet (the base of the phosphorite bed) to 70.1 feet (the top of the fossiliferous Hawthorn). In line 15, hole 6, (fig. 16) the fossiliferous middle Miocene(?) beds are overlain by a tan sand with coarse phosphate nodules, also tentatively put into the Bone Valley, and are underlain by non-fossiliferous limestone, lithologically identified with the Hawthorn. The middle Miocene(?) beds extend from a depth of 74.4 to 86.0 feet, a thickness of only 11.6 feet. This may represent the approximate shoreline of the late middle Miocene sea, and the formation thickens to the east and south as shown on the cross-sections, figures 11 through 16. In hole 16, line 10, (fig. 11) the olive-green sand tentatively correlated with the middle Miocene(?) extends from a depth of 28.0 to 84.0 feet, a thickness of 56 feet.

Fossils identified are as follows:

Line 10, Hole 14, (N½ of SE½ sec. 21, T. 36 S., R. 25 E.)

Ostrea sp. aff. *O. puelchana*
Chlamys sp.
Cardita sp.
Cardium sp.
Venus ?
Spisula ?

The oyster (*O.* sp. aff. *O. puelchana*) is unlike anything in the Hawthorn, and this assemblage is tentatively put into the Upper Miocene.

Line 12, hole 8, (NE¼ of NW¼ sec. 33, T. 31 S., R. 27 E.)

Anadara sp.
Chlamys sp.
Anomia sp.
Phacoides sp.
Dosinia sp.
Mulinia orthria

Mulinia orthria is known only in the Shoal River. (This is a high middle Miocene assemblage).

Line 15, hole 6, (NE¼ of NW¼ sec. 7, T. 27 S., R. 27 E.)

Olivella sayana
Cancellaria sp. cf. *C tabulata*
Turritella sp. cf. *T. alumensis*
Crepidula sp.
Anadara sp. of *A. idonea harveyensis*
Chlamys (*Plagioctenium*) *eboreus* subsp. *watsonensis*
Pecten (*Pecten*) sp.
Venus sp.
Spisula (*Hemimactra*) *delumbis*

Pliocene(?) series

Alachua(?) formation

The name Alachua was applied by Dall and Harris (1892, p. 127) to the bone-bearing beds found in sinks in Alachua County.

Cooke, (1945, p. 199) puts the Alachua in the middle Pliocene. Vernon (1951, p. 183) suggests that the Alachua formation ranges in age from lower Miocene to the Pleistocene and represents the terrestrial equivalent of the entire marine Miocene of Florida. Fossils found in the Alachua include bones of Miocene and Pliocene animals, which Simpson (1930, p. 176) regarded as the indigenous fauna, and bones of Pleistocene animals.

The formation is a blue, gray, or green sandy clay, which weathers to a yellow or red. The sand fraction is medium to coarse, and the formation also contains white, angular fragments of phosphate.

Sediments assigned to the Alachua(?) formation were cored only in holes 8 through 11 of line 17 (fig. 18). The sediments are non-fossiliferous, coarse sandy clays containing angular white phosphate fragments, They overlie rocks assigned to the Tampa in holes 8 through 10 and Suwannee limestone in hole 11. Coarse quartz grains are not found in the Tampa, Suwannee, or Ocala limestones, but are characteristic of the Hawthorn. It is likely, therefore, that the sediments assigned to the Alachua were derived largely from the Hawthorn, if they are not a residuum of the Hawthorn. The angular phosphate fragments are probably phosphatized Ocala or Suwannee limestone. The fragments are present throughout the Alachua(?) and may indicate some reworking. The Alachua(?)

is overlain at hole 10 of line 17 by a sandy clay with phosphate nodules, similar lithologically to the lower part of the Bone Valley. In holes 8, 9, and 11 of line 17, the Alachua(?) is overlain by clayey sands lithologically similar to the upper Bone Valley. It seems likely, therefore, that these sediments assigned to the Alachua(?) are at least in part equivalent to the Bone Valley but may also be somewhat older.

Bone Valley formation

The Bone Valley gravel was named by Matson and Clapp (1909, p. 138-141), from a railroad stop west of Bartow, Fla. They divided the Bone Valley gravel into lower beds rich in phosphate nodules and an upper, non-economic unit containing only traces of phosphate. Cooke (1945, p. 203) suggested a change in name to Bone Valley formation, as gravel makes up only a small part of the material.

The Bone Valley formation is generally regarded as Pliocene in age on the basis of land vertebrates (Simpson, 1929), although it may be latest Miocene. Brodkorb (1955, p. 38-39), says: "The avifauna, therefore, must be of late Miocene to middle Pliocene age, and the agreement is closest to other avifaunas recorded from the early or middle parts of the Pliocene." Bergendahl (in preparation) shows an interfingering of "undifferentiated phosphate," in part equivalent to the Bone Valley formation, with a sand containing marine invertebrates which may be very late Miocene in age. At present, this discrepancy in age assignment has not been resolved.

The Bone Valley formation consists of a lower zone composed of phosphate nodules, sand and clay and an upper zone composed predominantly of clayey sand with minor amounts of phosphate nodules.

The lower zone, which ranges in thickness from a feather edge to more than 30 feet at hole 1, line 8 (fig. 9), is composed of interbedded, lens-like beds of sand, clay, and clayey sand. All of the beds contain phosphate particles, and individual beds may vary from almost barren clay or sand to those which are almost entirely phosphate nodules. The upper part of the Bone Valley formation ranges from a slightly clayey sand to a sandy clay and generally contains a few phosphate nodules. The contact between the lower and upper zones of the Bone Valley formation is gradational over a vertical distance of a few inches. The upper part ranges in thickness from a feather edge to about 68 feet at hole 6, line 12 (fig. 13). Toward the fringes of the district (line 1, fig. 2) the phosphate beds of the lower Bone Valley are not present, and the Pliocene(?) is represented by clayey sands. These beds are lithologically similar to the upper part of the formation.

The lower, phosphorite unit of the Bone Valley formation is present almost throughout the area. The limits of the calcium phosphate zone, shown on figure 1, also represent, at least roughly, the limits of the lower unit of the Bone Valley formation. The lower unit is not present, except as small patches north of Polk and Hillsborough Counties. The limits of the formation to the south are not known; the southernmost drill holes contained material lithologically similar to the Bone Valley.

The upper clayey sand unit of the Bone Valley formation is present throughout the area mapped. The distinctive lithology, a medium to fine quartz sand, lightly bound with white clay, was noted in every drill hole.

Pleistocene series

Terrace sands

The loose sands overlying the Bone Valley are probably Pleistocene in age. No fossils were found in any of the drill cores, but a few horse teeth of Pleistocene age have been found in the loose surficial sands in the land-pebble district. The sands are nearly pure quartz, with only traces of clay, heavy minerals, and as much as 0.5 percent P_2O_5. They are generally white in color but locally are stained gray with organic material, or light brown or tan with iron. Wind-blown sand, swamp deposits, and bars and flood plain deposits of streams are considered Recent in age.

MINERALOGY

The mineralogy of the land-pebble phosphate district has been described by Altschuler and others (1955). For the purposes of this report, the mineralogy will be described only briefly.

Berman (1953) points out that the deeper, unaltered Hawthorn limestone in a deep drill hole contains calcite, quartz, minor apatite, and the clay minerals, either kaolinite or montmorillonite. The Hawthorn formation consists of dolomite, attapulgite, quartz and apatite closer to the surface; the "matrix" of the Bone Valley formation is quartz, montmorillonite, and apatite; and the overburden is quartz with minor montmorillonite. This section is typical of those areas where aluminum-phosphate minerals were not formed.

X-ray spectrometer analyses of a series of vertical channel samples, each sample representing a very limited vertical interval, were made by L. V. Blade of the Geological Survey in 1952. All of the sections were taken from the surface to the base of the pit at mines in the district. The following are generalizations from several sections which are believed typical of areas that were leached and where aluminum-phosphate minerals were formed.

The loose surface sand contains only quartz, except near the contact with the clayey sand of the upper Bone Valley, where minor kaolinite was detected. The clayey sand of the upper Bone Valley, whether obviously leached or not, contains kaolinite, wavellite, crandallite, and possibly a minor amount of montmorillonite. Quartz is ubiquitous. The same minerals are present at the top of the lower Bone Valley, but at the upper contact or slightly above it, montmorillonite is the most abundant clay mineral, apatite is abundant and commonly crandallite is more abundant than wavellite. In the lower Bone Valley ("matrix") apatite and montmorillonite are the most abundant minerals; kaolinite and aluminum-phosphate minerals are minor constituents. The residual Hawthorne (bedclay) contains calcite and dolomite in addition to apatite and montmorillonite.

CHEMISTRY

Table 1 was made from the analytical and screen data from the drilling. Only samples which were clearly in one of the stratigraphic intervals shown were used. Many of the samples taken included more

Table 1.--Comparison of screen size distribution and chemical analyses. Averages of samples from different stratigraphic intervals.

Mesh size	Weight percent retained on screen					Aluminum phosphate zone (Bone Valley)
	Hawthorn limestone	Calcium phosphate zone				
		Hawthorn clastics	Middle Miocene (?)	Bone Valley (lower)		
				Dark phosphate	Light phosphate	
+ 14 (pebble)	19.3	5.1	8.3	11.2	8.3	1.6
-14 + 35 (feed)	10.7	13.0	18.0	14.7	14.3	17.0
-35 + 150 "	1/					66.5
-35 + 150 (concentrate)	10.1	10.5	10.6	6.2	6.8	
-35 + 150 (tall)	25.5	45.1	49.6	54.5	44.0	
-150 (slime)	34.4	26.2	13.5	13.4	26.4	14.9
Percent P_2O_5						
Pebble	17.9	22.1	25.6	27.0	31.8	11.2
Concentrate	22.9	30.1	30.0	31.5	34.1	none
Slime						12.4
Percent U						
Pebble	0.007	0.009	0.014	0.013	0.016	0.008
Concentrate	0.006	0.008	0.011	0.010	0.012	none
Slime						0.020
CaO/P_2O_5 ratio						
Pebble	3.15	1.62	1.69	1.47	1.32	0.61
Concentrate	2.67	1.47	1.37	1.39	1.38	none
Slime						0.49
F/P_2O_5 ratio						
Pebble	0.119	0.114	0.114	0.114	0.108	0.079
Concentrate	0.115	0.110	0.112	0.114	0.110	none
Slime						0.052

1/ The -35 + 150 mesh feed fraction was separated, by flotation into a concentrate and sand tailings fraction. No concentrate was present in the samples from the aluminum phosphate zone of the Bone Valley formation.

than a single stratigraphic interval. For example, in many of the drill holes, a single sample of the calcium phosphate zone was taken; the sample may include phosphate of both Bone Valley and Hawthorn.

The weight distribution shows that samples of the limestone of the Hawthorn contain the highest percentages of pebble, and the analyses show that the pebble fraction is low in phosphate, and from the calcium/phosphate ratio, contain excess calcium. Probably the pebble sample contains abundant particles of slightly phosphatized limestone, as well as the coarser particles of calcium phosphate. The limestone also contains the highest percentage of slime, and the lowest percentage of quartz sand (the tails fraction) of any of the samples.

Hawthorn clastics, however, have much less pebble, slightly less slime, much more sand, and about the same amount of concentrate as the limestone.

The phosphate of the unnamed member of the Hawthorn (?) formation differs from the Hawthorn principally in the amount of the slime fraction, which is only half of that in the Hawthorn. The pebble fraction is higher, the concentrate about the same, and the sand fraction is increased slightly.

Phosphorite of the Bone Valley has been divided into those deposits characterized by black phosphate nodules and those characterized by lighter colored nodules (white, tan and gray). The darker material contains a high pebble percentage and a lower concentrate fraction than the middle Miocene(?) or the lighter material of the Bone Valley. Also, the slime fraction of the darker material is low, half as much as in the lighter material.

The aluminum phosphate zone is characterized by a very minor pebble fraction, high sand, with no concentrate, and medium slime.

Several generalizations about the phosphate content of the nodules in the different stratigraphic units can be made: First, the pebble fraction always has less phosphate than the concentrate fraction; second, the phosphate content of the aluminum phosphate zone is only about half that of the calcium phosphate zone; and third, the phosphate content of the nodules is highest in the Bone Valley, and gets progressively lower in the middle Miocene(?), Hawthorn clastics, and is lowest in the Hawthorn limestone.

The uranium content also varies in a more or less regular manner and follows the variations in phosphate content. In general, the uranium content of the phosphate nodules is greater in the coarser fraction, is higher in the calcium phosphate zone of the Bone Valley and middle Miocene(?) than in the Hawthorn clastics, and the limestone of the Hawthorn contains the least amount of uranium. It is also notable that the highest average uranium content is found in the slime fraction of the aluminum phosphate zone.

The calcium/phosphate ratio is lowest in the aluminum phosphate zone, increases regularly through the Bone Valley, middle Miocene(?) and Hawthorn clastics, and is greatest in the Hawthorn limestone. This change in ratio corresponds to a change in mineralogy--from aluminum phosphate to calcium phosphate to calcium phosphate plus calcite. It is also interesting to note that the ratio is generally higher in the pebble fraction than in the concentrate fraction. The calcium/phosphate ratio in fluorapatite (Palache, and others, 1951) is slightly more than 1.3, and only those samples highest in phosphate, (the pebble fraction of the light phosphate of the Bone Valley, the concentrate fractions of the Bone Valley and middle Miocene(?) approach this theoretical ratio. All of the other samples contain an excess of calcium.

The fluorine/phosphate ratio is less than 0.1 only in the samples of the aluminum phosphate zone, is about the same for all of the samples of the calcium phosphate zone, and is slightly higher in the samples from the Hawthorn limestone. Fluorapatite has a theoretical ratio slightly in excess of 0.10. The pebble fraction of the light phosphate of the Bone Valley formation approaches this theoretical ratio most closely; it is also these samples that are closest to the theoretical calcium/phosphate ratio for fluorapatite.

WEATHERING

Intense weathering has altered the rocks in the land-pebble district, apparently several times. Lack of fossils and the similarity of the rock types make it difficult to separate the different weathering cycles. The unconformable relations between the Bone Valley and the Hawthorn formations cannot be demonstrated from the drilling, but these relationships have been noted in mining pits where basal phosphorite conglomerates of the Bone Valley rest directly on the irregular, eroded surface of limestone or dolomite of the Hawthorn formation. It seems likely that a period of weathering followed the deposition of the Hawthorn. This weathering dissolved the calcium carbonate, leaving behind a residuum enriched in phosphate particles. The transgressing sea of the Bone Valley reworked this residuum and deposited the Bone Valley formation on the irregular karst topography of the Hawthorn. It has been noted that the limestone of the Hawthorn has been dolomitized close to the surface. That this dolomitization took place after the deposition of the Bone Valley formation is indicated by the fact that the phosphate particles of the Bone Valley, many of which are phosphatized limestone, contain no magnesium; complete analyses show that phosphate particles average less than 0.1 percent MgO, whereas the Hawthorn "limestone" may contain 20 percent MgO or more. Weathered sections of the Hawthorn (the thicker sections of calcareous bedclay) are close to and apparently related to the present land surface. Deeper beds in the Hawthorn are fresh, unweathered rocks. Therefore, it is believed that the residuum formed on the Hawthorn surface prior to the deposition of the Bone Valley formation may have been entirely reworked into the Bone Valley.

The intense weathering that formed the aluminum phosphate or leached zone took place after the deposition of the Bone Valley. This zone of alteration underlies and is older than the surficial soil profile, a ground-water podzol, typified by the acid Leon soil, (Fowler, 1927, p. 11). Figure 7 illustrates the typical soil profile--loose light gray surficial sand, overlying a dark-brown to black iron-cemented and organic sand. Below this layer the sands are loose and stained brown with iron.

The alteration is generally confined to the upper part of the Bone Valley formation and to the top of the lower part, although there is some aluminum phosphate as low in the stratigraphic section as the Hawthorn formation, (line 1, fig. 2); and even the Tampa (line 17, fig. 18).

The alteration changed calcium phosphate minerals to aluminum phosphate minerals, and the dominant clay mineral from montmorillonite to kaolinite. It is possible that in addition this period of weathering also altered the limestone of the Hawthorn to a dolomite and, by continued leaching, changed the limestone to calcareous clay.

The formation of the surficial soil profile is the last episode of the weathering and presumably occurred during one or more of the Pleistocene withdrawals of the sea.

ECONOMIC GEOLOGY

Two zones of economic significance are shown on the cross-sections (fig. 2-19). These zones are the calcium-phosphate zone or "matrix," and the aluminum-phosphate or "leached" zone. Neither term is used in a stratigraphic sense; both units cut across the stratigraphy. (See fig. 11, holes 11, 12, 13.)

Calcium-phosphate zone

The calcium-phosphate zone is that part of the stratigraphic section, which is characterized by nodules or particles of carbonate-fluorapatite (Altschuler and Cisney, 1952). This zone is nearly synonymous with the "matrix," which is that part of the section which can be mined profitably under existing economic conditions. The calcium-phosphate zone may be entirely within the lower zone of the Bone Valley formation, or it may be entirely the residual Hawthorn (the calcareous "bedclay") or a combination of the two.

Many of the drill holes bottomed in formations older than the Hawthorn. In many of the holes, sections of core from the Hawthorn contained phosphate nodules. These sections of phosphate-bearing Hawthorn are not included in the calcium-phosphate zone when they are separated from the lower phosphatic unit of the Bone Valley formation by barren clays or sandy clays. The phosphate-bearing calcareous clay of the Hawthorn formation is considered a part of the calcium-phosphate zone only when it immediately underlies the Bone Valley formation and is close enough to the surface to be mined. The calcium-phosphate zone as used in this report is not synonymous with "matrix" because some of the factors necessary for deciding whether a given drill hole contains economic phosphate could not be computed. Factors that must be considered in separating economic from non-economic phosphate are: (1) thickness of waste material (overburden) above the zone (computed in cubic yards of material removed to recover one ton of product), (2) amount of recoverable phosphate (computed in tons per acre), (3) amount of waste material in the phosphatic zone (computed in cubic yards of matrix per ton of product), (4) P_2O_5 content of the phosphate particles (computed as percent bone phosphate of lime-BPL), (5) thickness of the zone in feet, and (6) total combined iron and alumina in percent. If any of these factors are above the maximum allowable limit or below a given minimum limit, the deposit is probably not minable. Because each active company in the district has slightly different standards for each factor, the figures given in table 2 are approximate.

Table 2.--Economic factors, calcium-phosphate zone

	Maximum	Minimum
Cubic yards overburden per ton of recoverable product	15-20	
Cubic yards matrix per ton of recoverable product	5-7	
Thickness (in feet) of matrix bed		3.0
Tons per acre foot of recoverable product		400
Percent B.P.L.[1] (percent P_2O_5 x 2.185)		66.0
Percent combined iron and alumina (I&A)	5.0	

[1] B.P.L. =bone phosphate of lime.

These factors are not absolute. For example, a deposit containing only 66 percent BPL phosphate must have a smaller factor of cubic yards per ton and a greater factor of tons of product per acre than a deposit containing 75 percent BPL. In addition, a single drill hole might contain some factors that were not economic; but, if located in an area containing better than average material, it would be mined if the average of the larger area was economic. To block out a deposit 16 holes per 40 acres are drilled, or one hole in each two and one-half acre block. The area of a standard drill hole is about one-millionth of the area of the 2-1/2 acre block. Thus, the accuracy of tonnage and grade estimates for this drilling is extremely low, and tonnage and grade figures are not projected but are given only in tons per acre, or cubic yards per acre.

Aluminum-phosphate zone

The aluminum phosphate zone is that part of the section that has been strongly altered by acid ground waters. The zone is characterized by the presence of aluminum phosphate minerals, kaolinite, and generally by the highest uranium content as indicated by the high peaks on the gamma-ray logs. The alteration is generally confined to the upper part of the Bone Valley formation and the top of the lower part, although aluminum phosphate minerals were developed as low as the Hawthorn (fig. 2) or the Tampa (fig. 18). The zone can be identified by some or all of the following features: vesicular-like texture, secondary cements, white color, low specific gravity, and indurated or friable character.

Factors concerned in the economics of the aluminum-phosphate zone are more uncertain than those for the calcium-phosphate zone because so little is known as to the possible processes that may be used to recover the various materials in the zone. For example, any one or combination of three products, phosphate, alumina and uranium might be obtained from this zone. For purposes of this report, it is assumed that phosphate and uranium will be recovered, and that alumina will not be a product. The lines of possible economic correlation on the cross-sections are drawn on this assumption. If alumina should be recovered as a third product, some of the upper clayey sands that have been excluded from the aluminum-phosphate zone on the cross-sections may become economic. However, because these clayey sands are low in uranium, they were not analyzed for phosphate or alumina. Therefore, it is not possible to say whether they contain enough alumina or phosphate to be economic.

If the above assumptions are correct, the factors that affect the economics of the aluminum-phosphate zone are: (1) thickness of the waste material above the zone, (2) thickness of the zone, (3) phosphate and uranium content of the zone in percent, (4) CaO and Al_2O_3 content of the zone in percent, and (5) whether economic calcium-phosphate zone underlies the aluminum-phosphate zone. At present, all mining of the zone must be integrated with the mining plans of the active companies for the phosphate matrix. As indicated on figure 1, fringe areas to the west and northwest of the central part of the land-pebble district are underlain by aluminum-phosphate zone, which is not underlain by matrix.

An absolute figure for excessive overburden thickness cannot be given. However, because the digging depth of the largest draglines is about 70 feet, more than about 50 feet of waste material overlying the zone would be excessive.

The cutoff value of contained P_2O_5 has been arbitrarily placed at 5 percent, principally because large areas contain aluminum-phosphate zone with more than 5 percent P_2O_5, and other large areas are underlain by clayey sands which contain less than 5 percent P_2O_5.

A lower limit of 0.005 percent uranium has been chosen because most of the samples which were above this value had high contents of uranium in the slime fraction (in which the aluminum-phosphate minerals are concentrated). The uranium content of the slime fraction tends to be greater than 0.010 percent in samples where the head assays range from 0.005 to 0.010 percent U. Conversely, in samples where the head assay is less than 0.005 percent uranium, the slime fractions tend to be less than 0.005 percent.

Little is known about the effect of high or low CaO content, but processing costs possibly could rise with high calcium.

If the final product is to be a fertilizer, a high alumina content could be somewhat less desirable than a lower content, but it is not possible to evaluate the effect of varying alumina content.

General relations

The index map, figure one, shows the location of the drill holes, the limits of the calcium phosphate zone, and the limits of the aluminum phosphate zone. The limits of the phosphate zones are based only on the

115 drill holes shown. Figure 1 shows that to the northwest the aluminum phosphate zone extends beyond the limits of the calcium phosphate zone (see lines 1, 2, 3, 4, 17, and 18), and that the aluminum phosphate zone apparently extends farther to the south, in Hardee and Manatee Counties than was previously known. This extension is based on lines 9 and 10, and because of limited data it is possible that only patches of aluminum phosphate zone are present in this area. East and south the calcium phosphate zone extends beyond the limits of the aluminum phosphate zone. The **difference** in position of the two lines may be explained by the facts that 1) in the northwest phosphate deposits were thinnest, the entire calcium phosphate zone apparently was leached, so that only remnants of it remain, and 2) where the Bone Valley formation was thicker to the south, only the top part of the formation was leached, and hence both zones are still present. Still farther to the south, in Hardee and Manatee Counties, the formation may not have been exposed to subaerial weathering, and no aluminum phosphate zone was formed. (See discussion of lines 7, 8, and particularly, 9.) The limit of the aluminum phosphate zone on the east coincides approximately with the present topographic ridge to the east of the Peace River. The land east of the ridge, which is lower in elevation than the land to the west, also probably was not exposed to subaerial weathering. The present limit is the result of a combination of two factors: (1) erosion after the zone was formed, and (2) the possibility that somewhere to the east the phosphatic sediments were not exposed to weathering.

SUGGESTIONS FOR EXPLORATION

The area east of R. 26 E., even though there may be some leached material present, is deeply buried by barren sands of the overburden and is not a good area for exploration. The most promising areas for exploration, based on the results of this drilling program, are first, the area to the northwest in Hillsborough and Pasco Counties, where the aluminum phosphate zone is not underlain by economic matrix, and second, the area to the south, in Hardee and Manatee Counties, where extensive deposits may be present. This latter area has not been extensively explored by the private companies because of the low grade of the phosphate nodules in the matrix. It is most probable that the area is not entirely underlain by aluminum phosphate zone, but in some localities, particularly adjacent to the Peace River, aluminum phosphate zone material may be present. Results of scattered drilling west of the Peace River, in Hardee and Manatee Counties, indicate that patches of the aluminum phosphate zone are present. This area should be explored further if it becomes necessary to outline reserves of the aluminum phosphate zone more fully. The remainder of the district, in Polk and Hillsborough Counties, probably has been well-enough explored by private companies at least for preliminary estimates of tonnage and grade.

DISCUSSION AND EXPLORATION OF FIGURES

General

Table 3 is a summary of the lithologic characteristics used in stratigraphic correlation. The table shows, for example, that the clastics of the Hawthorn formation are loose sands, clayey sands, calcareous clays, or green or blue sandy or silty clays; all contain phosphate particles, low in P_2O_5 content. The clastics of the Hawthorn contain more phosphate particles and fewer chert fragments than the Tampa clastics. The criteria as shown on the table are not invariable but are in general characteristic of the formations. For example, chert fragments do not always occur in the clastics of the Tampa formation, and occasional chert fragments or silicified fossil fragments are found in the Hawthorn formation. However, chert fragments in a calcareous clay overlying fossiliferous Suwannee limestone (fig. 2) were considered enough evidence to classify this material as Tampa.

Line 1, figure 2

Stratigraphy

Suwannee.--Fossils from the bottom of hole 4 were identified as Oligocene in age. Hole 5 was bottomed in a very hard bed, probably siliceous limestone, that is correlated with the Suwannee limestone of hole 4.

Tampa.-- Fossils from the bottom of hole 3 were identified as early Miocene in age. In addition, the sandy calcareous clay from sample 13 (table 4) contained no phosphate particles and is included in the Tampa. The limestones in holes 1 and 2 are lithologically identical with that in

TABLE 3 — SUMMARY OF LITHOLOGIC CRITERIA USED IN STRATIGRAPHIC CORRELATION

FORMATION	Loose quartz sand	Clayey sand	Organic material	Iron staining "hardpan"	Aluminum Phosphate	Calcium Phosphate Nodules: High P_2O_5	Calcium Phosphate Nodules: Low P_2O_5	Calcium Phosphate Nodules: Tonnage	Chert fragments	Clay shades of green or blue sandy, silty	Clay calcareous	Limestone: Very pure	Limestone: Slight impurities	Limestone: Moderate impurities	Limestone: Abundant impurities	Limestone: Silicified
TERRACE SANDS	X		X	X												
UPPER BONE VALLEY		X		X	A	X		TR								
LOWER BONE VALLEY	X	X			TR	X		A								
HAWTHORN CLASTICS	X	X			TR		X	X		X	X					
HAWTHORN LIMESONE							X	X							X	
TAMPA CLASTICS							X	TR	X	X	X					
TAMPA LIMESTONE							X	TR	X					X		
SUWANNEE LIMESTONE													X			X
OCALA LIMESTONE												X				

A = abundant; X = present; TR = trace amounts

hole 3; they are correlated on this basis. In holes 1, 2, and 4, the calcareous clay above the limestones contains chert fragments, limestone fragments, and very sparse phosphate nodules; this material is tentatively called Tampa.

Hawthorn.--Greenish silty clays, calcareous clays and sands, all of which contain phosphate nodules, overlie the sandy clays of the Tampa formation in holes 1, 2, and 3. These materials are tentatively correlated with the Hawthorn formation. The contact between the Hawthorn and the Bone Valley is marked in holes 1, 2, and 3 by a green silty clay underlain by a bed of quartz sand containing amber phosphate nodules. The Hawthorn formation pinches out to the north; apparently it is not represented in holes 4 and 5.

Bone Valley.--Slightly clayey sands overlie the greenish clay of the Hawthorn formation in holes 1 and 3, the calcareous clay of the Tampa formation in hole 4, and the hard material on which hole 5 was bottomed. Phosphate sand is between the clayey sand and the green clay of the Hawthorn formation in hole 2. The clayey sand and the phosphate sand are believed to be Pliocene in age and equivalent to the Bone Valley formation.

Terrace sands.--White, loose, quartz sands overlie the iron-stained clayey sands in each drill hole. These surficial sands are lithologically alike and are believed to be of Pleistocene age.

Economic geology

The calcium phosphate zone was cut only by hole 2, where it is thin, low grade, low in tonnage (table 4), and not economic. Small amounts of phosphate nodules, low in P_2O_5 content were found in samples of the Hawthorn formation from holes 1 and 3; because of excessive depth, low tonnage, and low grade, these samples are not included in the calcium phosphate zone.

The aluminum phosphate zone was penetrated by holes 1, 2, 3, and 4; tonnages and uranium contents are given in table 5. The thick section of clayey sand in hole 5 probably contains some aluminum phosphate minerals, but the content is too low for the sand to be an economic source of phosphate and uranium.

All of the analytical data and results of screen-size analysis are shown in table 4.

Line 2, figure 3

Stratigraphy

Suwannee.--Fossils from the limestone of hole 4 were identified as Oligocene in age. The hard material at the bottom of hole 3 is tentatively correlated with the Suwannee because fossils of early Miocene age were found above the hard material. The Suwannee was probably not intersected in drill holes 1 and 2.

Tampa.--Casts and molds of fossils identified as lower Miocene in age were found in a thin bed of siliceous material cut by hole 3. Although it is possible these fossils are reworked, the lithology of the material in which they are found is similar to the lithology of the core from hole 4 that overlies the Suwannee.

Hawthorn.--The greenish silty clays, sandy clays, and clayey sands, all of which contain phosphate grains, are lithologically similar to the Hawthorn. These materials overlie material lithologically like the Tampa in holes 1, 3, and 4. The Hawthorn is thickest at hole 1 and is a little thinner to the northwest.

Bone Valley.--The Bone Valley formation is thickest at hole 1, and thins to the northwest to hole 4, except that at hole 2, in the sink hole, the formation thickens, and the base was not reached. The calcium phosphate zone is present at holes 2 and 3, is absent at hole 4, and may be present at hole 1, in the section of core that was not recovered.

White, gray or brown (iron-stained) clayey sands form the upper part of the Bone Valley formation at holes 1, 2, and 3. At hole 4 the entire Pliocene(?) is clayey sand, lithologically similar to the clayey sand of holes 1, 2, and 3.

Terrace sands.--The base of the Pleistocene(?) at hole 1 is put at the base of the highly organic sand. The great thickening of the section at hole 2 is due to the filling of a sink hole. The base of the Pleistocene(?) at holes 3 and 4 is the contact of the loose, surficial sands with the clayey sands of the upper part of the Pliocene(?).

Economic geology

Although the calcium phosphate zone is present at holes 1, 2, 3, and 4, no economic material is present. Samples 21 and 22 (tables 6 and 7) from hole 1 contain calcium phosphate nodules, but they are low in grade, low in tonnage, and are covered by too great a thickness of barren material (overburden) to be economic; therefore, this material is not considered a part of the calcium phosphate zone.

The aluminum phosphate zone, a part of the clayey sand of the upper part of the Pliocene(?) Bone Valley formation or its equivalents, varies in its position in the section. It forms the bottom part of the clayey sands at holes 1 and 2, the upper part the clayey sand at hole 3, and at hole 4 the entire zone of clayey sand is possibly aluminum phosphate zone. The highest gamma-ray peak (2700 counts per minute--cpm) in the aluminum phosphate zone is in hole 1. In hole 2 the high peak is greater than 1800 cpm, in hole 3 it is less than 1800 cpm, and in hole 4, the high peak barely reaches 900 cpm. Thus, there seems to be a decrease to the northwest and toward the fringe of the district in the concentration of uranium.

Line 3, figure 4

Stratigraphy

Tampa.-- Early Miocene fossils were found in limestone fragments in sandy clay in the bottom of hole 2. Lithologically similar material from holes 1, 3, 4, and 5 is considered a part of the Tampa. No fossils were found in the limestone cores from holes 1, 3, 4, and 5, but these limestones are lithologically like the Tampa limestone and are tentatively correlated with the Tampa.

Hawthorn.--Greenish sandy clays and clays, in part containing nodules of calcium phosphate are tentatively correlated with the Hawthorn. The contact of the Hawthorn with the underlying Tampa at hole 2 is the base of these phosphate bearing clays, with the somewhat different sandy clays which contain fossils. The Hawthorn formation thins to the west.

Bone Valley.--The Bone Valley formation at hole 1 consists of an upper zone of clayey sand, with traces of soft white phosphate nodules, and a lower phosphorite zone. The lower zone contains abundant coarse phosphate. At holes 2, 3, 4, and 5, the lower zone is not present, and the Bone Valley is represented by white or tan clayey sand, probably containing some aluminum phosphate minerals. The clayey sand is lithologically similar in all holes.

The top of the Bone Valley at hole 3 is marked by a gray clay bed. This clay is not like any other clay in the cross-section.

Terrace sands.--Loose, gray, tan or white quartz sands overlie the clayey sands of the upper Bone Valley(?) in all drill holes. These sands are tentatively classed as Pleistocene.

Economic geology

The calcium phosphate zone was penetrated only by hole 1, where it is thin, but very high in BPL content. (See tables 8 and 9.) The analyzed material from hole 4, (sample 35) is high enough in BPL content to be a part of the calcium phosphate zone, but tonnages are very low; therefore, it is not included in the calcium phosphate zone. The phosphate bearing material from hole 3 was not analyzed; visual inspection of the core indicated that only uneconomic amounts of phosphate were present.

The aluminum phosphate zone, at holes 1 and 2, at the top of the section of clayey sand, was delineated by analysis and by the high radioactivity shown on the gamma-ray logs. The clayey sands of holes 3, 4, and 5, analyzed only from hole 4, are too low in uranium content and probably in phosphate content to be economic, although aluminum phosphate minerals are probably present. The material, therefore, is not included in the aluminum phosphate zone.

Line 4, figure 5

Stratigraphy

Tampa.--Fossils from the limestone cores at the bottom of holes 1 and 3 were identified as early Miocene in age. A zone of iron-stained and cemented, laminated sandy clays at hole 1 occurs above the limestone. The lithology of this material does not resemble anything in the Hawthorn and is very tentatively correlated with the Tampa.

Hawthorn.--The limestone at the bottom of hole 2 contained fossils identified as probably middle Miocene. The greenish sandy clay above the Tampa at hole 1, plus the phosphate-bearing sandy clay of sample 41 are tentatively correlated with the Hawthorn. The phosphate-bearing calcareous clay from hole 1 together with the calcareous clay above it are put into the Hawthorn.

Bone Valley.--Lower Bone Valley was penetrated by holes 1, 2, and 3, At hole 1, the contact of the Bone Valley with the Hawthorn is at the top of the sandy clay of sample 41, which contains lower P_2O_5 content nodules than the clayey sand of sample 40 (table 10). The lower unit of the Bone Valley rests on Hawthorn limestone at hole 2. The contact between the units is sharp; the phosphorite above the contact is bedded and non-calcareous. At hole 3, the lower unit of the Bone Valley rests on greenish calcareous sandy clay of the Hawthorn. The upper clayey sand of the Bone Valley is present at holes 1 and 2, but is absent at hole 3, where highly carbonaceous sands rest directly on the lower unit of the Bone Valley.

Terrace sands.--The loose, slightly iron-stained and highly organic sands at the surface are tentatively correlated with the Pleistocene.

Economic geology

Possibly economic calcium phosphate zone was penetrated by all drill holes in this line (table II). The calcium phosphate zone at holes 1 and 3 is made up of the lower unit of the Bone Valley formation and the phosphate-bearing beds of the Hawthorn formation. However, the entire calcium phosphate zone at hole 2 represented by the lower unit of the Bone Valley formation.

Possibly economic aluminum phosphate zone material was penetrated only in hole 1, where it is delimited by the gamma-ray log. Hole 2 penetrated upper Bone Valley clayey sand, probably containing some aluminum phosphate minerals. This material is not considered a part of the aluminum phosphate zone because the gamma-ray log was not above background in the interval represented by the clayey sand. Clayey sand of the upper part of the Bone Valley formation was not penetrated by hole 3. Tonnages and grades for the possibly economic parts of the cores are given in table 11.

Line 5, figure 6

Stratigraphy

Hawthorn.--Phosphate-bearing sandy, clayey limestone at the bottom of holes 3 and 4 is correlated with the Hawthorn. Although no limestone was recovered in holes 1 and 2, the holes were bottomed on hard material which is assumed to be limestone of the Hawthorn. Calcareous, sandy, phosphatic clays overlying the limestone at hole 3, and similar clays in holes 1 and 2 are tentatively correlated with the Hawthorn.

Bone Valley.--The lower zone of the Bone Valley formation was penetrated in holes 1, 2, and 3. The contact with the underlying Hawthorn is put at the top of the calcareous clays. Clayey sands of the upper part of the Bone Valley formation are present in all drill holes. The contact of the upper unit with the lower unit is placed at the appearance of calcium phosphate nodules.

Terrace sands.--Loose quartz sands, tentatively assigned to the Pleistocene were cut by each drill hole. The contact with the upper Bone Valley formation is placed at the base of the iron-stained loose sand.

Economic geology

The calcium phosphate zone is present at holes 1, 2, and 3 (tables 12 and 13). At holes 2 and 3 the zone includes phosphate deposits of both the lower Bone Valley and the Hawthorn formation. The basal calcareous clay at hole 1 was excluded from the calcium phosphate zone because of probable very low tonnages. The analyzed material from hole 4, although it is not too different in phosphate content from the material in other drill holes, is excluded from the calcium phosphate zone because it is in a limestone which would be very difficult to mine and process.

The aluminum phosphate zone is present at holes 2 and 4. The zone was delimited by the use of the gamma-ray logs. The material of sample 42, hole 1 contains aluminum phosphate minerals but was excluded from the aluminum phosphate zone because the computed head analysis would be too low in phosphate and uranium contact. (See tables 12 and 13.)

Line 6, figure 7

Stratigraphy

Hawthorn.--Limestone was penetrated only by hole 3. The limestone contains abundant phosphate particles, sand, and clay and is therefore considered to be a part of the Hawthorn formation. The remaining holes in this line bottomed on a hard material from which no core was recovered. This material is tentatively considered to be limestone of the Hawthorn formation. The calcareous, sandy, phosphate bearing clays at the bottom of each hole are considered to be Hawthorn. Except at hole 5, the phosphate particles in these calcareous clays contain very low amounts of P_2O_5.

Bone Valley.--The lower phosphorite zone of the Bone Valley is present at holes 1, 2, and 3, but is absent from holes 4 and 5. The contact of the Bone Valley with the Hawthorn in these holes is placed at the top of the calcareous clay. In addition, the phosphate particles of the Bone Valley contain much higher amounts of P_2O_5 than the phosphate particles in the calcareous clay of the Hawthorn (table 14). The upper clayey sand of the Bone Valley formation is present at all drill holes. This unit contains trace amounts of apparently unleached phosphate particles at holes 3 and 4. The material is leached at holes 1 and 2 where aluminum phosphate minerals are present.

Terrace sands.--The loose surficial sands show evidence of a typical Leon soil profile. At holes 2, 3, 4, and 5, the loose, white surficial sands are underlain by iron-stained and organic sands, which are underlain by brown and tan loose sands. The contact of the Pleistocene(?)

with the Bone Valley formation is placed at the top of the clayey sands where the iron-staining becomes insignificant. At hole 5 the contact is placed in the middle of the section of core that was not recovered, at the point where there is a slight rise in the gamma-ray log. This rise probably coincides with an increase in clay content.

Economic geology

The calcium phosphate zone was penetrated by holes 1, 2, and 3, where it is entirely within the lower unit of the Bone Valley formation. Analyzed material below the calcium phosphate zone, in the Hawthorn formation contains too little P_2O_5 to be economic; this material is therefore not considered a part of the calcium phosphate zone. (See tables 14 and 15.) Phosphate-bearing calcareous clay of the Hawthorn formation in holes 4 and 5 is excluded from the calcium phosphate zone because of excessive thicknesses of overburden and too little tonnage of phosphate.

The aluminum phosphate zone is present at holes 1, 2, and possibly at hole 3. The top contact in each of these holes is placed at the rise in the gamma-ray log; the basal contact, at the appearance of calcium phosphate particles. At hole 3, the material called aluminum phosphate zone because of the rise in the gamma-ray log contains phosphate nodules, and may be calcium phosphate zone.

Line 7, figure 8

Stratigraphy

Hawthorn.--Limestone core was recovered only from hole 4; all other holes bottomed in hard material, presumed to be limestone of the Hawthorn. Sandy, clayey, phosphate-bearing, calcareous clays at the bottom of all holes are tentatively correlated with the Hawthorn.

Bone Valley.--The lower, phosphorite zone of the Bone Valley formation was penetrated by all drill holes. The contact of the Bone Valley with the Hawthorn is the top of the calcareous clays. P_2O_5 contents of the phosphate nodules are higher above this contact than below it. (See table 16.) The upper clayey sands of the Bone Valley formation were also penetrated by all drill holes in this line.

Terrace sands.--Loose, white, surficial sand is underlain by iron-stained, cemented, and highly organic sand, which is in turn underlain by brown, loose sand. These sands probably form a soil profile, and are tentatively assigned to the Pleistocene. The contact of the Pleistocene(?) with the underlying Bone Valley is at the top of the clayey sand. This contact generally coincides with a rise in the radioactivity, as shown by the gamma-ray logs.

Economic geology

The calcium phosphate zone was penetrated by all drill holes; however, stratigraphically this zone is made up of Bone Valley, Hawthorn, or both, in this section. The zone is composed of both Hawthorn and Bone Valley at holes 1, 2, 3, and 4. The entire calcium phosphate zone at hole 5 is represented by the lower unit of the Bone Valley formation. (See tables 16 and 17.)

The aluminum phosphate zone is present only at holes 1, 2, and 3 where it is delimited by the high peaks on the gamma-ray logs. The high peak at hole 4 is apparently entirely within the calcium phosphate zone, and radioactivity as shown by the gamma-ray log at hole 5 is only about twice background; too low for the clayey sand to be considered possibly economic.

Line 8, figure 9

Stratigraphy

Hawthorn.--Although no limestone cores were recovered from any of the drill holes, each hole bottomed on hard material, presumed to be limestone, probably of the Hawthorn formation. The greenish, calcareous, sandy clays and clayey sands at the bottom of holes 1, 2, and 4, are tentatively correlated with the Hawthorn, because of their high phosphate content, color, and general appearance. At hole 3, phosphorite of the Bone Valley(?) formation rests directly on the hard material.

Bone Valley.--The lower, phosphorite zone of the Bone Valley is present at all drill holes. The material consists of quartz sand, and coarse black phosphate particles, with only a small amount of clay. The screen analyses in table 18 show that the clay content of the Bone Valley is less than the clay content of material correlated with the Hawthorn. The upper clayey sands of the Bone Valley formation were penetrated by holes 1 and 3, and are absent at holes 2 and 4. The upper contact of the lower unit of the Bone Valley is put at the rise in the gamma-ray log.

Terrace sands.-- Loose quartz sands at the surface, iron-stained or cemented sands, and highly organic sandy clays are all tentatively correlated with the Pleistocene. Organic sands are close to the surface at holes 1 and 4, but at holes 2 and 3, a very highly organic sandy clay is at the base of the Pleistocene(?).

Economic geology

The calcium phosphate zone was penetrated by all drill holes. The coarse fraction (pebble) is invariably too low in P_2O_5 content to be economic, but the concentrate fraction is, in most of the samples, high enough in phosphate content to be considered economic. Material from both the Bone Valley and Hawthorn has been included in the calcium phosphate zone, except at hole 3, where a thin gravel probably representing the base of the Bone Valley rests on hard material that was not recovered. Tables 18 and 19 show that generally, the phosphate particles in the Hawthorn are somewhat lower in P_2O_5 content than are the particles in the Bone Valley.

The aluminum phosphate zone is not present in this cross-section. Clayey sands of the upper Bone Valley(?) are present only at holes 1 and 3, and gamma-ray logs indicate these clayey sands contain no abnormal radioactivity. At holes 2 and 4, sands of the Pleistocene(?) rest on the lower, phosphorite zone of the Bone Valley.

Line 9, figure 10

Stratigraphy

Hawthorn.--Limestone, lithologically similar to the Hawthorn, was recovered only from hole 12; the remaining holes in this line bottomed on hard material which is presumed to be limestone of the Hawthorn formation. Greenish, calcareous, clayey sands, containing phosphate nodules, were cored in each drill hole and vary in thickness from less than 2.0 feet in holes 1, 2, and 6, to a maximum of about 30 feet in hole 9. These calcareous sands are tentatively correlated with the Hawthorn. Phosphate nodules in the calcareous sands contain lower amounts of P_2O_5 than the phosphate nodules in the non-calcareous sands above them. (See table 20.)

Bone Valley.-- The lower, phosphorite unit of the Bone Valley formation was penetrated by each drill hole. The unit is a quartz sand, with a high percentage of dominantly black phosphate nodules. The upper clayey sand unit of the Bone Valley formation was also present at each drill hole, except for hole 6, where loose, white sands overlie the lower unit. At the south end of the line, in holes 10, 11, and 12, the upper unit contains traces of fresh appearing, black phosphate nodules; these nodules are not present in the upper zone in holes 1-9. This may indicated that the clayey sand in the south and of this cross-section was not leached.

Terrace sands.--Loose, white quartz sands, iron-stained in holes 2, 3, 8, 9, 10, 11, and 12, are tentatively correlated with the Pleistocene.

Economic geology

The calcium phosphate zone was penetrated by each drill hole in line 9. The zone ranges in thickness from about 8 feet at hole 11, to 41 feet at hole 9, and includes phosphate from both the Bone Valley and Hawthorn formations. (See tables 20 and 21.) Phosphate from the Bone Valley was penetrated by every hole, but the calcareous clayey sands of the Hawthorn were not included in the calcium phosphate zone in holes 2, 7, 8, and 10, because of the low content of P_2O_5 in the phosphate nodules. Tables 20 and 21 show the variation in phosphate content of the nodules in the Bone Valley and Hawthorn, and in addition show that the Hawthorn contains a higher percentage of concentrate fraction than does the Bone Valley. The ratio of pebble to concentrate fraction in the Bone Valley formation is always more than one; while in the Hawthorn the ratio is lower, and in most cases is less than one. In general, the phosphate content of the nodules is highest at the north end of the section, decreases to the south, to hole 11, where there is a rise in phosphate content. The reasons for this variation are not immediately apparent.

The aluminum phosphate zone is present at holes 1 through 9, except for hole 6, where no clayey sand is present, and loose sands of the Pleistocene(?) are in contact with the lower unit of the Bone Valley formation. This may represent an old stream channel, where the clayey sand of the upper Bone Valley was removed by erosion. At holes 10, 11, and 12, the upper clayey sand unit of the Bone Valley contains small to trace amounts of apparently unleached phosphate nodules; no aluminum phosphate minerals are present in the clayey sands. In the area of these holes, the Bone Valley formation apparently was not subjected to weathering. No samples of the aluminum phosphate zone were analyzed, the zone is delimited entirely by the gamma-ray logs; the upper contact is placed at the sharp rise in radioactivity (fig. 10). The lower contact of the zone is put at the point where phosphate nodules become abundant and high in P_2O_5 content, as shown by analyses. (See tables 20 and 21.) The zone is thickest at hole 1, gradually decreases in thickness to hole 6, and then increases again in hole 7. The zone is more or less constant in thickness from hole 7 through hole 9, and is absent from holes 10 through 12.

Line 10, figure 11

Stratigraphy

Hawthorn.--The limestone cored at most drill holes but containing identifiable fossils only at hole 8, is classed as Hawthorn because of its high phosphate content and abundant sand and clay impurities. The light green calcareous clayey sand or sandy clay containing a high percentage of fine-grained typically amber or black phosphate nodules is tentatively correlated with the Hawthorn. The calcareous sandy clay is present at holes 1 through 12, but is absent at holes 13-16, where the only material assigned to the Hawthorn is the basal limestone.

Hawthorn(?), unnamed member.--Fossils from limestone in hole 14 were classed as late Miocene(?). (See fossil list, page 28.) A dark olive green to gray calcareous clayey micaceous sand in holes 12, 13, 15, and 16, is lithologically similar to fossiliferous middle Miocene(?) sand in line 12, hole 6 and line 15, hole 6. Thus this sand is tentatively correlated with the middle Miocene(?). This sand is not lithologically like any other material in line 10. The material also contains shell fragments, which were not identifiable.

Bone Valley.--The lower phosphate-bearing unit was penetrated by drill holes 1-14. It is a clayey sand, non-calcareous and typically contains white or gray phosphate particles which tend to be coarser in size than the amber phosphate material of the Hawthorn. The upper clayey sand unit of the Bone Valley was penetrated by all drill holes. It thickens somewhat on the topographic highs (see holes 3 and 6, fig. 11) and is somewhat thicker in the southern part of the section. The material is white and slightly clayey and the quartz sand fraction tends to be somewhat coarser than the material below or above it. The color of the clay in the unit tends to become darker toward the south.

Terrace sands.--Loose quartz sands tentatively correlated with the Pleistocene were penetrated by each drill hole. Organic material below the loose sand was also, and rather arbitrarily placed in the Pleistocene, as was done in other lines of drill holes.

Economic geology

The calcium phosphate zone was penetrated by drill holes 1 through 14. (See tables 22 and 23.) The zone is made up of both Bone Valley and Hawthorn in roughly equal amounts at holes 1 through 10. However, at hole 11, the calcareous clay of the Hawthorn makes up the entire calcium phosphate zone; at hole 12, only the top part of the calcareous clay contains enough phosphate of high enough grade to be possibly economic; at holes 13 and 14, the entire calcium phosphate zone is within the Bone Valley formation; and at holes 15 and 16, where the lower zone of the Bone Valley formation, and calcareous clays of the Hawthorn formation were not penetrated, the phosphate-bearing material is assigned to the Hawthorn(?), unnamed member, and it is much too low in tonnage and percent BPL to be economic. This cross-section (fig. 11) is a good example of the crossing of stratigraphic lines by the calcium phosphate zone, particularly between holes 12 and 13.

The aluminum phosphate zone was present at all holes in this line, except for holes 13 and 15, where the clayey sand, as shown by the gamma-ray logs, was not abnormally radioactive. Samples of the aluminum phosphate zone were taken from a few of the cores, but in general, the zone is delimited, at the top, by the rise in the gamma-ray log, and at the base, by the contact with the calcium phosphate zone.

Line 11, figure 12

Stratigraphy

Hawthorn.--Fossils from limestone cores at the bottom of holes 1, 5, and 6 were identified as middle Miocene in age. Limestone cored in the other holes is lithologically similar to the fossiliferous material and is correlated with the Hawthorn. Greenish, calcareous sandy clays containing phosphate nodules overlie the limestone at holes 1, 2, 7, and 8, and are tentatively correlated with the Hawthorn. The contact of the Hawthorn with the Bone Valley formation is put at the top of the calcareous clays at holes 1 and 2, and at the top of the limestone at holes 3, 4, and 5.

Hawthorn(?), unnamed member.--Dark olive calcareous sandy clays containing black phosphate nodules and mica flakes are lithologically similar to the fossiliferous middle Miocene(?) in lines 12 and 15, and are tentatively correlated with the upper Hawthorn(?). This material is present at holes 6, 7, and 8.

Bone Valley.-- The lower, phosphorite unit of the Bone Valley formation is present at holes 2, 3, 4, and 5. The lower unit overlies calcareous clay of the Hawthorn at holes 1, 2, and 3, and limestone of the Hawthorn at holes 4 and 5. The lower unit is absent at holes 1, 6, 7, and 8.

The upper unit of the Bone Valley formation was penetrated by all drill holes. It is thinnest at hole 1, thickens markedly at hole 2, and remains thick in the other holes of this line. The lower part of the upper unit contains traces of phosphate nodules at holes 3, 5, 6, 7, and 8. The contact of the lower unit with the upper unit of the Bone Valley formation is put at the point below which the phosphate content rises sharply.

Terrace sands.--Loose surficial iron-stained quartz sands, containing organic material, are tentatively correlated with the Pleistocene. These sands are present at all drill holes.

Economic geology

The calcium phosphate zone is absent from holes 1 and 8; in the remaining holes it represents different stratigraphic intervals. For example, at holes 2, 4, and 5, the calcium phosphate zone is the lower unit of the Bone Valley formation; at hole 3 it is both Bone Valley and Hawthorn; and at holes 6 and 7 it is the lower part of the unnamed member of the Hawthorn(?).

The zone is economic in holes 2 and 3, but because of low grade, is questionably economic in holes 4 and 5. The zone is covered by thick overburden at holes 6 and 7, and is also very low grade, particularly in the pebble fraction (tables 24 and 25). For these reasons, the zone is probably not economic at holes 6 and 7.

The aluminum phosphate zone is present at holes 2, 3, and 4, but is thin, and is high in the section of clayey sands of the upper unit of the Bone Valley formation. It is, therefore, probably not economic in these holes. The zone was delimited by the use of the gamma-ray logs in all of these holes. The analyzed samples (table 24) are too low in uranium content to be economic. The phosphate content of the slime (D) fraction of samples 49, 52, and 54 is high, indicating the presence of aluminum phosphate minerals. It is possible that the thick sections of clayey sands in these drill holes could be economic for alumina, phosphate and uranium, if the three product process is used.

Line 12, figure 13

Stratigraphy

Hawthorn.--Fossils, identified as middle Miocene in age, were identified from limestone cores at holes 1 and 8, and from a conglomerate at hole 6. Limestones cored at holes 2 and 3 are lithologically similar to the Hawthorn, and holes 4 and 6 bottomed on hard material which is presumed to be limestone of the Hawthorn. Green, calcareous, sandy clays, containing abundant phosphate were intersected by holes 1, 2, 3, and 4, and are tentatively correlated with the Hawthorn. The contact of the Hawthorn with the lower unit of the Bone Valley at holes 1, 2, 3, and 4 is placed at the top of the calcareous clay. The contact of the Hawthorn with the unnamed upper member of the Hawthorn(?) is located on fossil evidence at the top of the limestone at hole 8; at hole 6, it is put at the contact of the fossiliferous conglomerate of the Hawthorn with the olive green calcareous clayey sand.

Hawthorn(?), unnamed member.--Fossils, identified as middle Miocene(?) in age were found at hole 8 in an olive green slightly calcareous clayey sand, containing flakes of mica, and low grade black phosphate nodules. Lithologically similar material overlies the conglomerate at hole 6; this material is tentatively correlated with the middle Miocene(?). At hole 8, the upper contact of the fossiliferous material is put at the contact of this material with a phosphate and quartz sand which is in sharp contact with the calcareous clayey sand beneath. Holes 1, 2, 3, and 4 did not intersect any material lithologically like the fossiliferous middle Miocene(?). It is believed that this material was not deposited on or to the west ridge on which hole 4 was drilled.

Bone valley.--The lower, phosphate unit of the Bone Valley formation was penetrated at holes 1, 2, 3, 4, and 8 where it is a sand or clayey sand containing abundant white phosphate nodules. The nodules are somewhat coarser than those in the underlying Hawthorn. The lower unit apparently was not deposited at the location of hole 6. The upper clayey sand unit of the Bone Valley formation was penetrated by all holes. The unit thickens markedly to the east to the location of hole 6, then thins somewhat at hole 8. The upper contact of the clayey sand unit of the Bone Valley formation is placed at the base of the iron-stained loose sand of the Pleistocene(?) at holes 2, 3, and 6, and at the base of the loose sand at holes 1, 4, and 8.

Terrace sands.--Holes 1, 2, 6, and 8 penetrated only loose, or slightly iron-stained quartz sands of probable Pleistocene age. At holes 3 and 4, however, the section is somewhat different. At these holes the section of core represented by samples 70 and 73 contained lumps and fragments of aluminum phosphate cemented sand and fragments of calcium phosphate. (See sample 73 A, table 26.) At both holes, this material is underlain by thick sections of loose quartz sand. The material in these samples appears to be reworked; it is therefore correlated with the Pleistocene, rather than the Bone Valley. At hole 4, from a depth of 14.5 to 28.6 feet, a red and white mottled clayey sand was cored. This material is lithologically unlike anything else in the cross-section and is higher than the collar elevations of the other drill holes. The material is lithologically similar to material called Citronelle by Cooke (1945, p. 230). It is correlated with the Pleistocene(?) in this cross-section because of its elevation and position and because it is underlain by loose sand, and the possible reworked aluminum phosphate zone material of sample 73.

Economic geology

The calcium phosphate zone was penetrated by holes 1, 2, 3, and 4, and consists of both Bone Valley and Hawthorn phosphorites. The phosphate nodules in cores from these holes are high in P_2O_5 content (tables 26 and 27) and contain more concentrate than pebble. The calcium phosphate zone is probably economic at holes 1, 2, and 3 but because of its depth is probably not economic at hole 4. Calcium phosphate nodules are present at holes 6 and 8, but are too deep, and too low in tonnage and grade to be possibly economic; they are not considered a part of the calcium phosphate zone.

The aluminum phosphate zone was penetrated at holes 1, 2, and 3 where it includes the entire upper clayey sand unit of the Bone Valley formation. Cores from holes 1 and 2 were sampled; the analytical data are given in table 26. No sample was taken of the aluminum phosphate zone at hole 3; the zone is delimited by the sharp radioactivity peak shown by the gamma-ray log. (See fig. 13.) Although thick clayey sands of the upper Bone Valley were penetrated at holes 4, 6, and 8, the material was not above background radioactivity as indicated by the gamma-ray logs. This material is not considered a part of the aluminum phosphate zone. At holes 3 and 4, an upper zone of possibly reworked aluminum phosphate material was penetrated. This material was analyzed; analytical results are shown in tables 26 and 27. The material represented by sample 70 contains very high phosphate and uranium in the slime fraction. It is possibly economic. The material of sample 73, while lithologically similar is not as high grade; it is of questionable economic importance.

Line 13, figure 14

Stratigraphy

Hawthorn.--The impure limestone cores from the bottom of holes 1, 2, and 5 contained fossils identified as middle Miocene in age. The remainder of the drill holes bottomed in lithologically similar limestone, tentatively correlated with the Hawthorn. Calcareous clays at holes 1 and 2 are tentatively assigned to the Hawthorn.

Hawthorn(?), unnamed member.--Dark olive-gray calcareous, micaceous clayey sands and sandy clays, containing black phosphate particles, overlie Hawthorn limestone at holes 3 to 8. These dark sands are lithologically like material in hole 6 of line 12, which contained fossils of middle Miocene(?) age. They are therefore tentatively assigned to the unnamed member of the Hawthorn(?) formation.

Bone Valley.--The lower phosphorite zone of the Bone Valley was penetrated only at holes 1 and 2; it is apparently absent from the locations of holes 3 to 8. The bottom contact of the Bone Valley at holes 1 and 2 is placed at the top of the calcareous clay of the Hawthorn. The upper clayey sand unit of the Bone Valley is divided into a lower fine-grained clayey sand and an upper coarser clayey sand. The clay fraction is very minor and is white. The contact of the upper unit of the Bone Valley with the middle Miocene(?) is placed at the top of the dark, olive, micaceous phosphate-bearing sand at holes 3 to 8.

Terrace deposits.--Loose surficial quartz sands are tentatively correlated with the Pleistocene. In addition, a red and white mottled clayey sand at holes 1 and 5, lithologically similar to the clayey sand of hole 4, line 12, is considered a part of the Pleistocene(?). (See discussion of line 12, page 87.)

Economic geology

The calcium phosphate zone was penetrated by all drill holes in this line, except for hole 8. The zone includes both Hawthorn and Bone Valley at holes 1 and 2 (tables 28 and 29). At holes 3 to 7, the calcium phosphate zone is a part of the unnamed member of the Hawthorn(?).

The zone is probably not economic at holes 3 through 7 because of excessive thickness of overburden, but it is high in P_2O_5 and in tonnage. At hole 8, the zone contains too little phosphate of too low grade to be economic; thus it is not considered a part of the calcium phosphate zone at this location.

The aluminum phosphate zone, at holes 1 and 2 is a part of the Bone Valley formation; at holes 3 and 4, it is a part of the unnamed upper member of the Hawthorn(?). The zone is not present at holes 5 through 8. The zone was delimited by the high radioactivity of the gamma-ray logs at holes 1 and 2; at holes 3 and 4, a sample representing the high peak section of the gamma-ray log was split out from the core and analyzed.

Line 14, figure 15

Stratigraphy

Tampa.--Cores at the bottom of holes 7 and 8 contained fossils of early Miocene age. Non-fossiliferous limestone cores at the bottom of holes 3 and 4 were similar in lithology to the fossiliferous material; this limestone is tentatively correlated with the Tampa.

Hawthorn.--Limestone cored at holes 1 and 2 is impure (sandy, clayey, and containing phosphate nodules); it is lithologically similar to the Hawthorn. Greenish, calcareous sandy clays with abundant phosphate nodules at holes 1, 2, 4, 7, and 8 are tentatively correlated with the Hawthorn.

Hawthorn(?), unnamed member.--Olive green, calcareous, phosphate-bearing, micaceous clayey sand and sandy clay at the location of holes 3 to 8 are lithologically similar to the material of hole 6, line 15, and are tentatively correlated with the middle Miocene(?). The material is lower in elevation than the limestone of hole 2, and forms an eastward thickening wedge of lithologically distinct material.

The upper contact of this material is placed at the base of the slightly clayey sands of the upper Bone Valley(?), at a distinct lithologic break.

Bone Valley.--The lower, phosphorite zone of the Bone Valley is present only at hole 1. The contact of this unit with the underlying Hawthorn is placed at the top of the greenish calcareous clay.

The upper clayey sand unit of the Bone Valley formation is present at all locations in this line. The unit consists of an upper, coarse sand, with minor white clay, and a lower fine to very fine grained sand, with minor white clay.

Terrace sands.--Loose, iron-stained or cemented, and white quartz sands at the surface at each drill hole location are tentatively correlated with the Pleistocene. The basal contact of the terrace sands is placed at the bottom of the iron-staining, and at the point where the sand becomes slightly clayey. At hole 8, the bottom half of the terrace sands is the red and white mottled slightly clayey sand lithologically similar to material in line 12 (fig. 13). It is arbitrarily placed at the base of the Pleistocene.

Economic geology

The calcium phosphate zone was penetrated by holes 1 and 2. At hole 1, the zone consists of both Hawthorn and Bone Valley phosphorite; at hole 2, the zone is entirely within the Hawthorn (tables 30 and 31). Phosphate above the limestone at hole 3 is correlated with the middle Miocene(?). It is not put into the calcium phosphate zone because of low P_2O_5 content (table 30), low tonnage, and excessive depth of overburden. Phosphate at holes 4, 7, and 8, is not put into the calcium phosphate zone because of excessive overburden thickness. The phosphorite was so deep and contained so few phosphate nodules at these holes that it was not sampled.

The aluminum phosphate zone is present only at hole 1. Analysis of sample 94 showed the slime (D) fraction to be high in phosphate and uranium and low in calcium (table 30). The material represented by sample 97 at hole 2 is possibly aluminum phosphate zone, but the analysis is probably too low in phosphate and uranium for the material to be economic. Gamma-ray logs indicated no abnormal radioactivity at holes 3 and 4. At holes 7 and 8, the high peak of the gamma-ray log is probably aluminum phosphate material, but the excessive depth of overburden makes it unlikely that this material is economic. Sample 3, at hole 8, was taken of this high count material. The sample analyses indicate the material is calcium phosphate, with too low phosphate content to be economic (table 30).

Line 15, figure 16

Stratigraphy

Ocala.--Fossils from limestone cored at the bottom of hole 5 were identified as Eocene. Although no other fossiliferous limestone was cored in this line, the limestones at the bottom of the other drill holes are lithologically similar to the Hawthorn. If this is true, both the Tampa and the Suwannee are not present, and it is possible that the location of hole 5 represents an upthrown fault block. Because there is no indication of faulting above the Ocala, the faulting, if present, is at least pre-Bone Valley in age.

Hawthorn.--Sandy, clayey, phosphate-bearing limestone at holes 1, 2, 4, and 6 is tentatively correlated with the Hawthorn. Calcareous, phosphate-bearing, sandy clays above the limestone in holes 1, 2, 3, 4, and 5 are also tentatively correlated with the Hawthorn. The contact of the Hawthorn with the overlying Bone Valley is placed at the top of the calcareous clays.

Hawthorn(?), unnamed member.--Fossils from the bottom of a section of core of olive-gray, micaceous, calcareous clayey sand, containing black phosphate nodules, were identified as late middle Miocene in age. This material is lithologically distinctive and is present only at hole 8. It is overlain by a loose sand with brown and black phosphate nodules, correlated with the Bone Valley. At the bottom of drill hole 8, the unnamed member of the Hawthorn(?) rests on limestone correlated with the Hawthorn.

Bone Valley.-- The lower phosphorite unit of the Bone Valley formation was penetrated by all drill holes. The unit is a clayey sand, with brown, tan, gray and white phosphate nodules. The unit rests on calcareous clay of the Hawthorn in all drill holes except number 8, where it rests on the olive micaceous clayey sand member of the Hawthorn(?).

The upper clayey sand unit of the Bone Valley consists of a medium to coarse grained slightly clayey sand. The clay fraction is white.

Terrace deposits.--Loose white, to slightly iron-stained sands at the surface at each drill hole location are correlated with the Pleistocene. In addition, a mottled red and white slightly clayey sand was penetrated at holes 3, 4, and 5. This material is lithologically distinct and like the material in line 12. At hole 3, it is high in the section, at holes 4 and 5, it forms the basal part of the Pleistocene(?). The base of the Pleistocene at hole 2 is put at the base of the sand with some phosphate particles. The phosphate in this section of core consists of fine-grained, angular fragments. It appears to be broken particles of phosphate nodules and is thought to be reworked.

Economic geology

The calcium phosphate zone was penetrated by all drill holes except for number 6. The zone is entirely within the Bone Valley at holes 1, 2, 3, and 4, but consists of both Hawthorn and Bone Valley at hole 5. At hole 6, the phosphate is deep, low in P_2O_5 content, and low in tonnage; this material is not included in the calcium phosphate zone.

The phosphate at holes 3 and 4 is covered by a thick section of barren material (overburden) and is probably not economic for that reason (tables 32 and 33).

The aluminum phosphate zone is present at holes 1, 2, 3, and 4. At these holes the top contact of the aluminum phosphate zone is taken at the mid-point of the sharp rise in radioactivity as shown by the gamma-ray logs (fig. 16). The zone is uniformly thin and is covered by thick barren quartz sand; it is probably not economic in this section.

Line 16, figure 17

Stratigraphy

Ocala.--Fossils from limestone at the bottom of holes 1 and 1a were identified as Eocene in age. As mentioned in the discussion of line 17, the Ocala limestone here may be in an upthrown fault block.

Hawthorn.--Limestones cored at the bottom of holes 1 and 3 are lithologically similar to the Hawthorn. In addition, calcareous sandy, phosphate-bearing clays above the limestone at all holes except 4 are tentatively correlated with the Hawthorn. At hole 4 a thick section of greenish silty and sandy clays, phosphate bearing at the botton and about the middle of the section, is tentatively correlated with the Hawthorn. This material may be equivalent to the Alachua(?) and may represent a channel or sink-hole filling of reworked Hawthorn. The material is somewhat similar to the Hawthorn but is also similar to material in line 17 that is correlated with the Alachua(?).

Bone Valley.--The lower phosphate unit of the Bone Valley formation is apparently not present in this section. The upper unit is divided into a lower zone of slightly clayey fine-grained sand and an upper zone of clayey coarse-grained sand. The clay fraction of the upper Bone Valley is white.

Terrace sands.--Loose, quartz sands, stained with iron, and containing organic material at holes 1a and 2, are correlated with the Pleistocene. At hole 1, the middle part of the terrace deposits consists of red and white mottled slightly clayey sand; and at hole 4 the bottom half of the terrace sands is composed of this material. The red and white mottled material is lithologically distinctive; it is arbitrarily placed in the Pleistocene(?). (See discussion, line 12.)

Economic geology

The calcium phosphate zone was penetrated at holes 1a, 2, and 5, and is entirely within the Hawthorn formation. It is absent at the location of the remainder of the holes in this line. (See tables 34 and 35.)

The aluminum phosphate zone is present at holes 1, 1a, 2, 3, and 5. The zone is very thin and questionably economic. Except at hole 5, where it is within the Hawthorn, the zone is the basal part of the Bone Valley.

Line 17, figure 18

Stratigraphy

Suwannee.--Fossils from limestone at the bottom of holes 5, 6, 9, 10, and 11 were identified as Oligocene in age. Lithologically similar limestone was cored at holes 3 and 8.

Tampa.-- Greenish, sandy, calcareous clays, containing chert fragments and nodules, contain fossils identified as early Miocene at holes 4 and 9. Lithologically similar clays at holes 3, 5, 6, 7, 8, and 10 are tentatively correlated with the Tampa. Impure limestone cored at hole 2 is tentatively correlated with the Tampa. At hole 3, the Tampa is overlain by calcareous phosphate sandy clay of the Hawthorn. At holes 4, 5, 6, and 7 the Tampa is overlain by slightly clayey sands of the upper Bone Valley, and at holes 8, 9, and 10 the Tampa is overlain by sandy clays of the Alachua(?).

Hawthorn.--Calcareous, sandy, phosphate-bearing clays at holes 1, 2, and 3 are tentatively correlated with the Hawthorn. At holes 1 and 2, the calcareous clays are overlain by green clays or sandy clays, also assigned to the Hawthorn. The Hawthorn is overlain at holes 1 and 2 by white clayey sands of the upper Bone Valley, and at hole 3, by phosphorite of the lower Bone Valley. The Hawthorn is absent at holes 4 through 11, although the material assigned to the Alachua(?) at holes 8 through 11 may be a residuum of the Hawthorn.

Alachua(?).--Coarse to medium grained sandy clays, green to blue to shades of red and yellow and containing fragments of angular white phosphate, were penetrated at holes 8 through 11. This material is lithologically distinct. The material overlies clastics assigned to the Tampa at holes 8, 9, and 10, and limestone of Oligocene age at hole 11. It is overlain by clayey sand of the upper Bone Valley at holes 8, 9, and 11, and by phosphorite of the lower Bone Valley at hole 10. From its position in the section, and distinctive lithology, this material is tentatively correlated with the Alachua(?) formation, although it is possible that the material is equivalent to the lower part of the Bone Valley.

Bone Valley.-- The lower phosphorite zone of the Bone Valley, was intersected only at holes 3 and possibly 10. The zone is absent in the remaining drill holes. At hole 3, the lower unit overlies calcareous clay of the Hawthorn; at hole 10 the material overlies sandy clays of the Alachua(?) formation. In both cases the contact is distinct.

The upper clayey sand unit of the Bone Valley formation was intersected at all drill holes. The unit is distinctive lithologically, consisting of medium to fine sand with minor amounts of white clay. The unit apparently contains aluminum phosphate minerals, as indicated by the rise in the gamma-ray logs, at most drill hole locations.

Terrace sands.--A thin blanket of loose quartz sands, stained with iron at some locations, was penetrated at each drill hole location. The loose sands thicken at hole 10, at the ridge, and the thickening may be due to the increased elevation at this locality.

Economic geology

The calcium phosphate zone was penetrated at holes 1, 2, 3, and 10; it is absent at the remaining locations. At holes 1 and 2, the zone is entirely within the Hawthorn formation, while at holes 3 and

10, it is entirely within the Bone Valley formation. Analyses of the samples from holes 2, 3, and 10 indicate the zone is probably economic. (See tables 36 and 37.)

The aluminum phosphate zone was penetrated at all drill holes. The zone is delimited by the high peak of radioactivity as indicated by the gamma-ray logs. The zone was not sampled in this line. Line 17 is an excellent example of the nature of the aluminum phosphate zone, and the way the zone crosses stratigraphic lines. At holes 4, 5, 7, 10, and 11, the entire upper unit of the Bone Valley formation is aluminum phosphate zone. At holes 3, 8, and 9, only the basal part of the upper Bone Valley is aluminum phosphate zone. At holes 1 and 2 the basal part of the upper Bone Valley plus the top part of the Hawthorn make up the aluminum phosphate zone, and at hole 6, the aluminum phosphate zone is within the Tampa formation. Although the zone varies in radiation intensity, it is marked in every drill hole by a peak of radiation intensity. (See figure 18.)

Line 18, figure 19

Stratigraphy

Hawthorn.--Limestone cored at the bottom of hole 1 is impure, sandy, clayey, and phosphate-bearing; it is correlated with the Hawthorn. Calcareous clays overlying the limestone at hole 1 are also lithologically similar to the Hawthorn. Green slightly sandy clays at the bottom of hole 4 are tentatively correlated with the Hawthorn. The contact of the

Hawthorn with the Bone Valley at hole 1 is placed at the top of the calcareous, phosphatic clay. At hole 2, the Hawthorn-Bone Valley contact is placed at the base of the white slightly clayey sands of the upper Bone Valley.

Bone Valley.--The lower phosphorite of the Bone Valley was penetrated at hole 1. The upper slightly clayey sand of the Bone Valley was penetrated at holes 1 and 4. At hole 4, the upper clayey sands of the Bone Valley rest directly on green sandy clay of the Hawthorn.

Terrace sands.--Loose, slightly iron-stained quartz sands, that contain organic material, are correlated with the Pleistocene. They are present at both locations in this line.

Economic geology

The calcium phosphate zone was intersected only at hole 1, where it consists of the lower phosphorite zone of the Bone Valley plus the top of the calcareous clay of the Hawthorn. No phosphorite is present at hole 4. (See tables 38 and 39.)

The aluminum phosphate zone was intersected by both drill holes of line 18. At hole 1, the zone is the lower part of the clayey sand of the upper Bone Valley, while at hole 4 the aluminum phosphate zone is entirely within the Hawthorn. The zone was not sampled and was delimited entirely by use of the gamma-ray logs.

TONNAGE CALCULATIONS

Aluminum-phosphate zone

Tonnages were calculated by a modification of the method used in the district for calculating the matrix tonnages. The method is based on the thickness of the deposit and the weight per cubic foot of rock in place.

A bed one foot thick contains 1,613 cubic yards per acre.

(1) 43,560 (sq. ft./acre) x 1 (thickness in feet) = 43,560 cu. ft./ acre foot.

(2) $\frac{43{,}560 \text{ (cu. ft./acre foot)}}{27 \text{ (cu. ft./ cu. yd.)}} = 1613.33$ cubic yards per acre-foot,

and, rounding,

(3) 1,600 x thickness (in feet) = cubic yards per acre.

Cubic yards per acre is shown on all of the tables because the weight per cubic foot of aluminum-phosphate zone material varies between wide limits. This figure may be changed to tons per acre by using a factor of 90 pounds per cubic foot, the approximate average weight of a cubic foot of aluminum-phosphate zone material. This is equivalent to 2,430 pounds per cubic yard; 1,088 long tons per cubic yard, or 1.215 short tons per cubic yard.

Calcium-phosphate zone (Matrix)

The tonnage calculations used in this report are based on the thickness of the phosphate bed, its percentage of contained pebble or concentrate, and the specific gravity of the deposit. The phosphate companies use the weight of a cubic foot of matrix instead of the specific gravity. For much of the area, this weight is about 125 pounds. Thus, the tonnage calculations are as follows:

(4) $\frac{\text{Square feet per acre (43,560) x 125}}{\text{long ton (2240 pounds)}} = 2430.8$, or

(5) 2430 = constant. 2430 x thickness (feet) x percentage of pebble, (or concentrate) = tons of pebble (or concentrate) per acre.

No correction was made for the variation in weight per cubic foot. However, this variation is small; computation shows that a change of 1 pound in weight of a cubic foot of matrix changes the total tonnage 1/5 ton per foot of matrix for one percent of pebble, or concentrate.

Long tons are used in this report to conform with general practice in the phosphate field. Long tons can be converted to short tons (2000 pounds) by multiplying the given tonnage figure by 1.12.

(6) $\frac{2240}{2000} = 1.12$

Grade is shown in percent BPL (bone phosphate of lime) the conversion factor is:

(7) P_2O_5 percent x 2.185 = BPL percent.

Table 4-- Analytical and screen data, samples from holes in line 1

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1-1	9.1-10.8	+14 mesh (A)	12.7	2/					0.005
		-14+35 mesh (B)	14.0						0.005
		-35+150 mesh (C)	58.5						0.002
		-150 mesh (D)	14.8	18.5	3.74	1.34	26.5	0.021	0.018
1-2	10.8-18.8	(A)	0.4						0.005
		(B)	9.4					a	a 3/
		(C)	70.0						a
		(D)	20.1	18.5	4.12	1.61	30.4	0.032	0.028
1-3	18.8-19.4	(B)	13.2						0.005
		(C)	53.0						0.002
		(D)	33.8	7.2	9.70	0.85	14.6	0.013	0.011
1-4	24.5-26.2	(A)	1.4	27.0	38.10	2.96		0.014	0.016
		(B)	1.4						0.006
		(D)	97.2					0.001	0.002
1-5	26.2-32.9	(D)	99.1						0.001
1-6	34.1-37.2	(A)	1.0	7.8	12.30	0.83			0.005
		(B)	1.6						0.004
		(C)	67.4						0.001
		(D)	30.0					0.001	0.002
1-7	39.6-41.7	(A)	2.4	15.1	23.60	1.70			0.005
		(B)	3.9						0.002
		(C)	50.8						0.001
		(D)	43.0					0.002	0.002

Table 4--Analytical and screen data, samples from holes in line 1--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
2-8	5.0-9.1	+14 mesh (A)	0.8						0.001
		-14+35 mesh (B)	8.1						a
		-35+150 mesh (C)	72.9						a
		-150 mesh (D)	18.2					0.002	0.002
2-9	9.1-12.1	(A)	1.8	18.7	29.6	2.40		0.012	0.013
		(B)	12.4						0.003
		(C)	54.8						0.002
		(D)	31.0	7.3	10.6	0.83	12.8	0.004	0.005
3-10	7.1-20.5	(A)	0.4						0.005
		(B)	2.6						a
		(C)	70.3						a
		(D)	26.7					0.003	0.003
3-11	20.5-22.0	(A)	29.6	16.4	0.84	0.96		0.020	0.018
		(B)	5.8						0.005
		(C)	47.1						0.002
		(D)	17.5	12.2	0.11	1.44	28.5	0.021	0.018
3-12	29.5-37.6	(A)	3.2	18.5	0.10	1.40			0.009
		(B)	14.8						0.002
		(C)	55.3						a
		(D)	26.7	9.2	0.03	0.61	25.0	0.012	0.012
3-13	52.4-78.5	(A)	1.4						0.001
		(B)	4.4						a
		(C)	74.1						a
		(D)	20.1	0.55	0.50	0.35	14.9	0.002	0.002
4-14	5.0-15.0	(B)	4.8						a
		(C)	60.7						a
		(D)	34.5					0.006	0.004

Table 4--Analytical and screen data, samples from holes in line 1--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
4-15	15.0-19.4	+14 mesh (A)							
		-14+35 mesh (B)	9.1						a
		-35+150 mesh (C)	61.8						a
		-150 mesh (D)	29.1	9.0	2.93	0.21	29.4	0.006	0.006
5-16	5.0-20.9	(B)	2.1						a
		(C)	69.7						a
		(D)	28.1					0.001	a
5-17	20.9-57.4	(B)	4.3						a
		(C)	77.8						a
		(D)	17.9					0.002	0.001

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.
3/ "a" equals less than 0.001.

All samples are from lot 2545.

Table 5.—Tonnage computations, line 1

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone			Calcium-Phosphate Zone	
		Cu. yds. per acre	Percent U 1/	C.P.M. 2/	Tons per acre	Percent BPL
1	9.1-19.3	16,300	0.007			
2 2	7.0-9.1 9.1-12.1	3,200		800	P-130 3/	40.5
3	20.5-22.0	2,400	0.011			
4	5.0-19.4	23,000	0.003			
5	Blank Hole					

1/ Head assay calculated from analyses of individual fractions.
2/ Counts per minute computed from gamma-ray log. See fig. 2.
3/ P = pebble fraction (+14 mesh). No concentrate.

Table 6--Analytical and screen data, samples from holes in line 2.

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1-18	13.5-23.1	+14 mesh (A)	0.4	2/					0.005
		-14+35 mesh (B)	11.5						a 3/
		-35+150 mesh (C)	70.2						a
		-150 mesh (D)	17.9	6.9	1.30	0.25	31.0	0.011	0.008
1-19	23.2-32.9	(A)	4.2	18.5	1.00	0.86		0.018	0.017
		(B)	16.5						0.003
		(C)	52.7						0.002
		(D)	26.6	14.4	2.30	0.77	32.0	0.031	0.036
1-20	42.7-57.9	(A)	1.2						0.003
		(B)	1.2						0.003
		(C)	42.9						0.004
		(D)	54.8					0.003	0.003
1-21	57.9-60.5	(A)	0.1	18.4	25.7	1.96		0.010	0.011
		(B)	0.1						0.007
		(C)	9.9						0.005
		(D)	89.9					0.006	0.005
1-22	67.7-75.9	(A)	6.2	27.6	36.2	2.82		0.019	0.020
		(B)	6.8						0.009
		(C)	60.1						0.001
		(D)	26.9					0.003	0.002
3-23	10.9-12.9	(B)	33.8						a
		(C)	53.8						a
		(D)	12.4					0.006	0.006

Table 6--Analytical and screen data, samples from holes in line 2--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
3-24	14.0-15.6	+14 mesh (A)	0.1	12.1	5.6	0.56		0.024	0.026
		-14+35 mesh (B)	5.8						0.004
		-35+150 mesh (C)	75.6					0.001	0.001
		-150 mesh (D)	18.6	7.3	2.8	0.33	32.0	0.022	0.020
3-25	15.7-20.1	(A)	0.4	16.0	8.1	0.83		0.022	0.021
		(B)	3.7	2/					0.003
		(C)	49.5						0.001
		(D)	46.4	9.6	4.4	0.63	24.4	0.022	0.019
3-26	20.1-33.9	(A)	0.5						0.008
		(B)	4.4						0.003
		(C)	64.5						a
		(D)	30.6					0.006	0.007
3-27	36.0-43.0	(A)	11.0						a
		(B)	3.4						0.002
		(C)	48.0						a
		(D)	37.5					0.001	0.001
4-28	6.6-16.7	(B)	19.3						a
		(C)	69.2						a
		(D)	11.5					0.002	0.003
4-29	16.7-21.9	(A)	0.1	14.3	10.3	0.84		0.009	0.010
		(B)	9.7						a
		(C)	58.4						a
		(D)	31.8					0.004	0.003

Table 6--Analytical and screen data, samples from holes in line 2--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
4-30	22.6-26.4	+14 mesh (A)	2.2						0.004
		-14+35 mesh (B)	13.7						0.001
		-35+150 mesh (C)	50.2						a
		-150 mesh (D)	33.7					0.005	0.005

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.
3/ "a" equals less than 0.001.

All samples are from Lot 2545.

Table 7.--Tonnage computations, line 2

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone			Calcium-Phosphate Zone	
		Cu. yds. per acre	Percent U 1/	C.P.M. 2/	Tons per acre	Percent BPL
1	23.1-34.1	17,600	0.010			
1	34.1-42.1				3/	
2	131.0-137.4	10,200			1100	
2	137.4-150.4				4/	
3	12.8-20.0	11,500	0.010			
3	31.0-33.9				5/	
4	17.9-21.9	6,400	0.003			

1/ Head assay calculated from analyses of individual fractions.
2/ Counts per minute computed from gamma-ray log. See fig. 3.
3/ Possible calcium-phosphate zone. Top contact taken from gamma-ray log. Bottom contact at base of lost core.
4/ Possible calcium-phosphate zone. Not sampled, but coarse phosphate pebble present. Tonnage is low.
5/ Base of sample 26. Samples show phosphate nodules. Not analyzed for P_2O_5. Possible calcium-phosphate zone. Tonnage is low.

Table 8--Analytical and screen data, samples from holes in line 3

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	[1] Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1-31	14.9-16.1	+14 mesh (A)	19.2	36.1	49.6	4.07	[2]	0.010	0.012
		-14+35 mesh (B)	17.1	31.2	42.3	3.36		0.010	0.010
		-35+150 mesh (C)							
		-150 mesh (D)	43.0	18.5	27.8	2.07	12.4	0.005	0.006
		-35+150 conc (E)	7.9	36.5	49.0	3.85		0.012	0.013
		-35+150 tail (F)	12.9						0.004
1-32	28.4-43.5	(A)	3.2	30.9	42.6	3.43			0.006
		(B)	16.3						0.001
		(C)	44.5						0.001
		(D)	36.0					0.001	0.002
1-33	43.6-59.9	(A)	0.9						0.002
		(B)	2.4						0.002
		(C)	40.2						0.001
		(D)	56.5					0.001	0.002
2-36	5.0-13.1	(A)	6.9						0.008
		(B)	29.8						a [3]
		(C)	49.3						a
		(D)	13.9	7.2	1.5	0.26	27.5	0.006	0.006
2-37	13.1-18.1	(A)	7.4	16.1	0.4	1.04			0.006
		(B)	24.2						0.002
		(D)	40.6	10.7	0.7	0.69	23.3	0.008	0.007
		(E)	2.0					0.005	0.006
		(F)	25.7						0.001

Table 8--Analytical and screen data, samples from holes in line 3--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
4-34	6.9-14.0	+14 mesh (A)	1.8						0.004
		-14+35 mesh (B)	12.9						a
		-35+150 mesh (C)	64.0						a
		-150 mesh (D)	21.3					0.006	0.006
4-35	21.8-22.9	(A)	0.1	32.5	41.9	3.39	2/		0.005
		(B)	6.0						0.002
		(C)	43.0						a 3/
		(D)	50.0					0.002	0.002

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.
3/ "a" equals less than 0.001.

All samples are from Lot 2545.

Table 9.--Tonnage computations, line 3

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone			Calcium-Phosphate Zone	
		Cu. yds. per acre	Percent U 1/	C.P.M. 2/	Tons per acre	Percent BPL
1	7.0-12.0	8,000		1500		
1	14.9-16.1				P-562 3/ C-231	78.7 79.6
2	10.3-18.1	12,500	0.005			

Holes 3, 4, and 5 had no aluminum-phosphate or calcium-phosphate.

1/ Head assay calculated from analyses of individual fractions.
2/ Counts per minute computed from gamma-ray log. See fig. 4.
3/ P = pebble fraction (+14 mesh); C = concentrate fraction (-35+150 mesh).

Table 10--Analytical and screen data, samples from holes in line 4

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1-40	19.2-35.9	+14 mesh (A)	2.9	35.1	46.2	3.79	2/		0.013
		-14+35 mesh (B)	8.1						0.004
		-35+150 mesh (C)	60.3						0.002
		-150 mesh (D)	28.6					0.007	0.005
1-41	35.9-39.9	(A)	2.1	30.7	41.9	3.29			0.006
		(B)	3.6						0.003
		(C)	59.3						0.002
		(D)	35.0					0.002	0.003
2-38	17.6-24.5	(A)	1.6	29.1	44.9	3.50			0.012
		(B)	4.7						0.004
		(C)	47.0						0.003
		(D)	46.8					0.002	0.002
3-39	28.6-45.4	(A)	3.7	30.2	45.2	3.21			a 3/
		(B)	8.0						0.002
		(C)	51.1						0.001
		(D)	37.2					0.001	a

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.
3/ "a" equals less than 0.001.

All samples are from Lot 2545.

Table 11.--Tonnage computations, line 4

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone			Calcium-Phosphate Zone	
		Cu. yds. per acre	Percent U	C.P.M. 1/	Tons per acre	Percent BPL
1	10.5-19.2	13,900		1000		
1	19.2-35.9				P-1168 2/	76.5
1	35.9-39.9				P-187	67.1
2	17.6-24.5				P-270	63.5
3	21.2-28.6				3/	
3	28.6-45.4				P-1530	66.0

1/ Counts per minute computed from gamma-ray log. See fig. 5.
2/ P = pebble fraction (+14 mesh). No concentrate.
3/ Possible calcium-phosphate zone. Not sampled.

Table 12--Analytical and screen data, samples from holes in line 5

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	Weight Percent 1/	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1-42	49.2-56.1	+14 mesh (A)	0.4	5.7	3.5	0.2	2/		0.006
		-14+35 mesh (B)	44.1						0.001
		-35+150 mesh (C)	50.3						a 3/
		-150 mesh (D)	5.2	10.3	6.2	0.4	21.2	0.012	0.006
1-43	56.1-71.9	(A)	7.7						a
		(B)	17.9						0.004
		(C)	60.4						0.002
		(D)	14.0					0.004	0.002
2-44	28.1-34.6	(A)	2.7						0.014
		(B)	14.3						0.008
		(C)	55.1						0.004
		(D)	27.9	5.1	8.9	0.8	16.2	0.005	0.004
2-45	34.6-48.9	(A)	2.1	18.6	39.5	2.6			0.008
		(B)	7.5						0.006
		(D)	52.3					0.001	a
		-35+150 conc (E)	6.8						0.008
		-35+150 tail (F)	31.3	30.4	43.4	3.5			0.009
3-46	22.5-32.8	(A)	2.7	16.4	24.7	1.9			0.006
		(B)	15.2						0.006
		(D)	38.4					0.003	0.002
		(E)	15.0	30.6	45.0	3.6			0.008
		(F)	28.7						0.003

Table 12--Analytical and screen data, samples from holes in line 5--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
4-47	21.4-26.2	+14 mesh (A)	12.5	23.7	39.9	2.8		0.017	0.016
		-14+35 mesh (B)	9.1	24.4	37.7	2.9			0.015
		-35+150 mesh (C)							
		-150 mesh (D)	55.5	8.2	24.6	1.2	3.7	0.011	0.004
		-35+150 conc (E)	5.3	30.8	45.2	3.6			0.016
		-35+150 tail (F)	17.6						0.006

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.
3/ "a" equals less than 0.001.

All samples are from Lot 2545.

Table 13.—Tonnage computations, line 5

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone: Cu. yds. per acre	Percent U	C.P.M. 1/	Calcium-Phosphate Zone: Tons per acre	Percent BPL
1	56.1-71.9				P-2990	Not analyzed
2	28.1-29.9	2880		1000		
2	29.9-34.6				2/	
2	34.6-48.9				P-714 3/	40.6
					C-2280	66.4
3	22.5-32.8				P-655	35.8
					C-3600	66.9
4	21.4-23.2	2880		1500	4/	

1/ Counts per minute computed from gamma-ray logs. See fig. 6.
2/ Possible calcium-phosphate zone, analyzed cut both aluminum-phosphate and calcium-phosphate zones.
3/ P = pebble fraction (+14 mesh); C = concentrate fraction (-35+150 mesh).
4/ Some phosphate present in limestone. Not calcium-phosphate zone.

Table 14--Analytical and screen data, samples from holes in line 6

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1-48	27.2-37.6	+14 mesh (A)	0.1	2/					0.005
		-14+35 mesh (B)	1.2						0.004
		-35+150 mesh (C)	72.3						0.002
		-150 mesh (D)	27.5					0.003	0.005
1-49	37.6-44.6	(A)	6.0	31.8	46.1	3.8			0.008
		(B)	12.5						0.005
		(C)	56.2						0.002
		(D)	25.4					0.002	0.001
1-50	44.6-54.4	(A)	1.5	25.5	38.7	3.0		0.009	0.008
		(B)	13.3						0.003
		(C)	16.8						0.002
		(D)	68.6					0.002	0.001
1-51	54.4-59.1	(A)	0.5	18.5	38.3	2.4			0.008
		(B)	4.8						0.004
		(D)	90.0					0.001	a 3/
		-35-150 conc (E)	1.2	25.5	40.7	3.1			0.006
		-35-150 tail (F)	3.6						0.001
2-52	27.1-32.0	(A)	4.4	33.3	47.5	4.1		0.016	0.018
		(B)	8.5						0.007
		(C)	35.5						0.002
		(D)	51.5					0.002	0.003
2-53	32.0-48.6	(A)	1.7	18.3	36.2	2.3			0.008
		(B)	6.4						0.002
		(C)	55.4						0.001
		(D)	36.6					0.001	0.002

Table 14--Analytical and screen data, samples from holes in line 6--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
3-54	67.2-68.8	+14 mesh (A)	11.3	40.0	45.2	3.6		0.016	0.016
		-14+35 mesh (B)	14.5						0.008
		-150 mesh (D)	30.7					0.003	0.004
		-35+150 conc (E)	4.4						0.011
		-35+150 tail (F)	39.1						0.000
3-55	68.8-71.9	(A)	24.0	8.7	33.4	1.1	2/		0.004
		(B)	13.8						a
		(D)	35.9					a	a 3/
		(E)	3.0	18.4	39.7	1.9			0.004
		(F)	23.3						a
5-56	46.3-48.6	(A)	5.0	15.8	37.6	1.7			0.007
		(B)	10.0					0.006	0.007
		(D)	35.0					0.001	0.001
		(E)	19.5	33.8	43.8	3.2			0.009
		(F)	30.5						0.003

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.
3/ "a" equals less than 0.001.

All samples are from lot 2545.

Table 15.--Tonnage computations, line 6

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone: Cu. yds. per acre	Aluminum-Phosphate Zone: Percent U 1/	Aluminum-Phosphate Zone: C.P.M. 2/	Calcium-Phosphate Zone: Tons per acre	Calcium-Phosphate Zone: Percent BPL
1	22.6-37.6	24,000	0.003			
1	37.6-44.6				P-1020 No concentrate	69.5
2	21.0-27.1	9,760		900		
2	27.1-32.0				P-530 No concentrate	72.6
3	62.9-67.2	6,880		800		
3	67.2-68.8				P-440 3/ C-170	87.3 69.1
4	77.2-81.2				4/	
5	46.3-48.6				P-340 C-940	34.5 73.8 5/

1/ Head assay calculated from analyses of individual fractions.
2/ Counts per minute computed from gamma-ray logs. See fig. 7.
3/ P = pebble fraction (+14 mesh); C = concentrate fraction (-35+150 mesh).
4/ Possibly calcium-phosphate zone. Not analyzed, overburden too thick, tonnage too low to be economic.
5/ Possibly calcium-phosphate zone. Overburden too thick, strata too thin to be economic.

Table 16--Analytical and screen data, samples from holes in line 7

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1-57	30.6-36.1	+14 mesh (A)	4.1	32.4	38.5	3.3	2/	0.034	0.036
		-14+35 mesh (B)	10.3	11.1	8.8	1.1			0.012
		-35+150 mesh (C)	77.4						0.003
		-150 mesh (D)	8.2					0.044	0.045
1-58	36.1-45.5	(A)	5.4	32.8	47.0	3.8			0.015
		(B)	7.0					0.005	0.005
		(D)	11.6					0.002	0.002
		-35+150 conc (E)	13.0	32.5	46.1	3.5			0.008
		-35+150 tail (F)	63.0						a 3/
1-59	45.8-55.8	(A)	1.3						0.010
		(B)	11.3						0.005
		(D)	31.4					a	0.001
		(E)	12.3						0.007
		(F)	43.7						a
2-60	20.3-28.1	(A)	6.5	30.8	44.7	3.8			0.014
		(B)	13.7						0.006
		(D)	15.5	13.2	12.6	1.5	16.3	0.006	0.006
		(E)	7.0	34.1	37.9	3.3			0.011
		(F)	57.4						0.001
2-61	28.1-34.4	(A)	1.4	31.6	46.4	3.8			0.012
		(B)	6.9						0.005
		(D)	43.1					0.001	0.002
		(E)	1.9	38.4	43.0	3.5			0.010
		(F)	46.7						0.002
2-62	34.4-45.9	(A)	3.8	31.1	45.2	3.6			0.012
		(B)	6.7						0.004
		(D)	24.9					0.002	0.001
		(E)	7.8	31.6	45.5	3.6			0.007
		(F)	56.9						a

Table 16--Analytical and screen data, samples from holes in line 7--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
2-63	45.9-63.1	+14 mesh (A)	1.4	18.6	39.2	2.7			0.009
		-14+35 mesh (B)	5.2					0.001	0.001
		-150 mesh (D)	42.1					0.001	0.001
		-35+150 conc (E)	6.7	31.2	39.4	2.8			0.006
		-35+150 tail (F)	44.6						a
3-64	39.8-51.5	(A)	1.7	27.5	41.7	3.2			0.011
		(B)	6.6						0.006
		(D)	34.6						0.002
		(E)	6.9	29.6	44.1	3.3		0.006	0.008
		(F)	50.2						0.001
4-65	39.9-56.0	(A)	4.5	26.5	38.7	3.0			0.012
		(B)	14.0						0.006
		(D)	23.8					0.003	0.003
		(E)	9.8	31.9	47.2	3.6			0.008
		(F)	47.9						a
4-66	56.0-65.9	(A)	0.5	24.5	38.3	2.7			0.007
		(B)	6.4						0.005
		(D)	47.0					a	a
		(E)	8.8	30.7	47.1	3.4			0.007
		(F)	37.3						0.001

Table 16--Analytical and screen data, samples from holes in line 7--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	Weight Percent 1/	Analytical Data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
5-67	41.4-73.0	+14 mesh (A)	1.9	27.9	43.1	3.2			0.010
		-14+35 mesh (B)	6.7						0.004
		-150 mesh (D)	14.6					0.002	0.002
		-35+150 conc (E)	5.4	31.9	46.6	3.6			0.007
		-35+150 tail (F)	71.4						a

1/ Weight retained on screen.
2/ Blanks indicate no analysis.
3/ "a" equals less than 0.001.

All samples are from Lot 2545.

Table 17.—Tonnage computations, line 7

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone: Cu. yds. per acre	Percent U 1/	C.P.M. 2/	Calcium-Phosphate Zone: Tons per acre	Percent BPL
1	28.1-33.9	9,120	0.008			
1	33.9-48.5 3/				P-1770 4/	71.0
					C-3200	71.0
1	48.5-55.8 5/				P-300	
					C-2980	Not assayed
2	15.5-23.0	12,000		1500		
2	23.0-45.9 6/				P-1840	68.0
					C-3020	70.0
2	45.9-63.1 5/				P-610	40.5
					C-2850	68.1
3	39.8-51.5 7/				P-500	60.0
					C-2020	64.6
4	39.9-65.9 8/				P-1870	57.0
					C-5960	68.0
5	58.8-78.8 9/					

1/ Head assay calculated from analyses of individual fractions.
2/ Counts per minute computed from gamma-ray logs. See fig. 8.
3/ Top part of calcium-phosphate zone - Bone Valley formation.
4/ P = pebble fraction (+14 mesh); C = concentrate fraction (-35+150 mesh).
5/ Bottom part of calcium-phosphate zone - Hawthorn formation.
6/ Top part of calcium-phosphate zone - Bone Valley formation. Weighted average bottom part of sample 60, and all of samples 61 and 62.
7/ Bottom of calcium-phosphate zone - Sample 64.
8/ All of calcium-phosphate zone. Weighted average of samples 65 and 66.
9/ No tonnages computed, sample included both upper and lower zone of Bone Valley formation.

Table 18--Analytical and screen data, samples from holes in line 8

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	Weight Percent [1]	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1-68	51.0-83.0	+14 mesh (A)	10.4	16.8	37.5	1.9	[2]		0.007
		-14+35 mesh (B)	32.7					0.005	0.006
		-150 mesh (D)	11.9					0.004	0.003
		-35+150 conc (E)	11.7	31.9	46.2	3.7			0.010
		-35+150 tail (F)	33.3						a [3]
1-69	83.0-94.0	(A)	1.3	18.4	38.1	2.2			0.009
		(B)	7.1						0.004
		(D)	45.0					0.001	a
		(E)	6.1	27.1	40.1	2.8			0.008
		(F)	40.5					a	a
2-70	39.2-52.4	(A)	9.0	18.6	30.6	2.3			0.010
		(B)	18.0						0.002
		(D)	20.0					0.003	0.003
		(E)	4.0	31.5	44.0	3.5			0.010
		(F)	49.0						a
2-71	57.5-77.8	(A)	3.0	13.5	22.3	1.5			0.004
		(B)	3.0						0.002
		(D)	29.0					0.002	0.002
		(E)	6.0	28.5	42.3	3.4			0.006
		(F)	59.0						0.001
2-72	77.8-83.5	(B)	1.8						0.002
		(D)	58.9						0.002
		(E)	2.5	28.7	42.5	3.1			0.007
		(F)	37.0						0.001

Table 18--Analytical and screen data, samples from holes in line 8--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
2-73	83.5-87.5	+14 mesh (A)	8.5	13.3	30.7	1.5			0.005
		-14+35 mesh (B)	18.0						0.002
		-150 mesh (D)	6.5					0.001	0.002
		-35+150 conc (E)	6.2	28.9	45.4	3.2			0.005
		-35+150 tail (F)	60.8						a
3-74	60.0-62.4	(A)	51.0	13.8	32.8	1.6	2/		0.008
		(B)	2.0						0.006
		(D)	2.0					0.005	0.004
		(E)	3.7	26.8	42.1	3.2			0.011
		(F)	41.3						0.002
4-75	45.5-50.3	(A)	14.8	25.6	36.2	2.9		0.013	0.014
		(B)	10.2						0.005
		(D)	14.4	7.4	11.0	0.9	12.1	0.007	0.009
		(E)	5.2	30.0	43.4	3.4			0.010
		(F)	55.4						0.001
4-76	56.1-63.4	(A)	8.6	22.9	40.2	2.7			0.012
		(B)	6.6						0.005
		(D)	15.2					0.001	0.002
		(E)	7.9	30.0	45.1	3.4		0.009	0.010
		(F)	61.6						0.001

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.
3/ "a" equals less than 0.001.

All samples are from Lot 2545.

Table 19.--Tonnage computations, line 8

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone			Calcium-Phosphate Zone	
		Cu. yds. per acre	Percent U	C.P.M.	Tons per acre	Percent BPL
1	51.0-83.0 1/				P-8076 2/ C-9087	36.7 69.6
1	83.0-94.0 3/				P-347 C-1630	40.3 59.2
2	39.2-52.4 1/				P-2840 C-1260	40.6 68.9
2	52.4-87.5 3/4/				P-2636 C-6379	29.4 62.4
3	57.5-62.4 5/				P-6075 C-450	30.2 58.6
4	45.5-50.3 1/				P-1800 C-630	56.0 65.6
4	50.3-56.1				Not analyzed	
4	56.1-63.4 3/				P-1570 C-1440	50.8 65.6

No aluminum-phosphate zone present in this line of drill holes.

1/ Top sample of calcium-phosphate zone - Bone Valley formation.
2/ P = pebble fraction (+14 mesh); C = concentrate fraction (-35+150 mesh).
3/ Bottom sample of calcium-phosphate zone - Hawthorn formation.
4/ Weighted average of samples 71, 72, and 73.
5/ Total calcium-phosphate zone - Bone Valley formation.

Table 20--Analytical and screen data, samples from holes in line 9

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent) P_2O_5	CaO	F	Al_2O_3	U	eU
1-78	26.6-35.4	+14 mesh (A)	7.6	31.2	44.7	3.6	2/	0.019	0.019
		-14+35 mesh (B)	18.5						0.008
		-150 mesh (D)	2.3					0.007	0.008
		-35+150 conc (E)	2.8	31.6	44.3	3.6			0.013
		-35+150 tail (F)	68.9						a 3/
1-79	35.4-43.3	(A)	4.8	22.4	41.4	2.5			0.014
		(B)	14.1	14.8	24.6	1.6		0.019	0.020
		(D)	38.6					0.003	0.002
		(E)	10.9	30.5	46.8	3.4			0.011
		(F)	31.6						0.001
2-80	38.7-48.6	(A)	26.2	32.7	46.9	3.6		0.013	0.015
		(B)	12.5	17.1	25.3	1.9			0.007
		(D)	11.6	18.6	28.9	2.2	7.6	0.006	0.007
		(E)	6.0	33.1	47.4	3.7			0.013
		(F)	43.7						a
2-81	48.6-50.2	(A)	13.8	24.6	43.1	2.8			0.011
		(B)	13.8	18.6	34.0	2.4			0.009
		(D)	21.8					0.001	0.002
		(E)	15.7	29.6	44.2	3.2		0.010	0.010
		(F)	34.9						0.001
3-82	23.6-38.9	(A)	19.6	31.6	45.7	3.7			0.014
		(B)	13.0						0.008
		(D)	9.8	12.7	17.7	1.3	12.5	0.006	0.007
		(E)	9.8	26.7	36.4	3.8			0.010
		(F)	46.8						a

Table 20--Analytical and screen data, samples from holes in line 9--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
3-83	42.6-53.0	+14 mesh (A)	12.1	29.6	43.7	3.1			0.010
		-14+35 mesh (B)	23.9						0.006
		-150 mesh (D)	24.5					0.001	0.002
		-35+150 conc (E)	8.8	31.5	44.8	3.5			0.009
		-35+150 tail (F)	30.7						a
3-84	53.0-59.3	(A)	5.8	28.0	42.4	3.1	2/		0.012
		(B)	12.5						0.006
		(D)	28.0						0.001
		(E)	8.6	30.8	44.6	3.4			0.007
		(F)	45.1						0.001
5-85	17.7-28.7	(A)	15.9	28.7	40.6	2.7			0.014
		(B)	11.9						0.007
		(D)	32.1					0.003	0.005
		(E)	2.8	32.5	46.5	3.7			0.012
		(F)	37.3						a 3/
5-86	28.7-51.4	(A)	3.5	27.0	42.7	3.1			0.010
		(B)	19.4						0.005
		(D)	23.8						0.002
		(E)	10.7	32.7	47.1	3.7		0.006	0.008
		(F)	42.6						0.001
5-87	51.4-57.4	(A)	8.1	24.1	41.5	2.8			0.009
		(B)	22.9						0.005
		(D)	16.4					0.003	0.003
		(E)	10.5	30.4	54.5	3.5			0.009
		(F)	42.1						0.001

Table 20--Analytical and screen data, samples from holes in line 9--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
6-77	31.4-39.3	+14 mesh (A)	11.5	22.4	40.7	2.7			0.011
		-14+35 mesh (B)	14.2						0.004
		-150 mesh (D)	10.6	6.0	23.5	0.8	6.3		0.004
		-35+150 conc (E)	5.1	28.2	41.2	3.4			0.010
		-35+150 tail (F)	58.5						a
7-88	22.0-39.0	(A)	6.2	27.6	38.6	2.8			0.013
		(B)	21.9						0.004
		(D)	11.7					0.007	0.007
		(E)	3.1	32.3	45.1	3.6			0.013
		(F)	57.1						a
8-89	35.6-49.0	(A)	7.0	27.9	39.8	3.2			0.013
		(B)	25.4						0.005
		(D)	3.4					0.003	0.004
		(E)	9.8	33.7	47.2	3.9			0.010
		(F)	53.4						a
8-90	49.0-66.2	(A)	3.4	27.1	39.9	3.2		0.009	0.009
		(B)	9.1						0.005
		(D)	8.0					0.003	0.002
		(E)	13.9	31.0	45.9	3.6			0.008
		(F)	65.6						a
8-91	66.2-72.3	(A)	2.9	15.7	34.8	2.0			0.006
		(B)	3.8						0.004
		(D)	30.2					a	a
		(E)	9.1					0.006	0.006
		(F)	54.0						a
9-92	34.8-51.2	(A)	2.2	26.5	39.5	2.9			0.013
		(B)	20.2						0.001
		(C)	65.9						a
		(D)	11.7					0.003	0.004

Table 20--Analytical and screen data, samples from holes in line 9--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
9-93	51.2-62.0	+14 mesh (A)	3.6	24.8	39.2	2.8			0.012
		-14+35 mesh (B)	14.7						0.005
		-35+150 mesh (C)	63.8						0.001
		-150 mesh (D)	17.9					0.001	0.001
9-94	62.0-75.3	(A)	0.3	24.7	40.1	2.8		0.006	0.008
		(B)	9.1						a
		(D)	9.7					0.001	0.002
		-35+150 conc (E)	3.2	29.6	43.7	3.4			0.010
		-35+150 tail (F)	77.7						a
9-95	75.3-81.3	(A)	42.0	18.7	40.0	2.4			0.010
		(B)	13.4						0.005
		(D)	6.4					0.003	0.003
		(E)	7.2	28.8	44.7	3.2		0.008	0.010
		(F)	31.0						a
10-96	37.3-55.2	(A)	0.1	19.1	33.3	2.5			0.006
		(B)	1.0						0.001
		(D)	36.8					0.001	0.002
		(E)	2.5	28.7	38.9	3.1			0.007
		(F)	59.6						a
10-97	55.2-75.2	(A)	5.5	28.6	39.0	3.1			0.013
		(B)	15.1						0.003
		(D)	8.7					0.004	0.004
		(E)	3.5	27.2	42.3	3.1			0.010
		(F)	67.2						0.001

Table 20--Analytical and screen data, samples from holes in line 9--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	Weight Percent 1/	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
10-98	75.2-77.2	+14 mesh (A)	8.2	22.8	37.9	2.5			0.007
		-14+35 mesh (B)	17.5						0.005
		-150 mesh (D)	9.3					a	a
		-35+150 conc (E)	14.3	27.9	41.2	2.9			0.007
		-35+150 tail (F)	50.6						a
11-99	45.8-50.6	(A)	13.2	29.5	42.8	3.3		0.015	0.014
		(B)	14.1						0.007
		(D)	2.3					0.004	0.005
		(E)	8.4	34.5	46.7	3.5			0.008
		(F)	62.0						0.002
11-100	50.6-53.7	(A)	0.1	23.7	39.4	2.5			0.008
		(B)	3.9						0.002
		(D)	26.3					a	a
		(E)	8.2	33.9	44.9	3.2		0.005	0.005
		(F)	61.5						0.001
12-1	52.0-60.9	(A)	3.8	28.7	40.9	3.5		0.016	0.018
		(B)	19.9						0.002
		(D)	8.7						0.004
		(E)	3.3	29.3	40.9	3.7			0.006
		(F)	64.3						a
12-2	62.4-72.4	(A)	7.9	28.1	43.2	3.3			0.015
		(B)	14.0						0.006
		(D)	18.5						0.003
		(E)	8.8	31.1	45.0	3.7			0.008
		(F)	50.8						0.001

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.
3/ "a" equals less than 0.001.

Samples 78-100 are from Lot 2545. Samples 1 & 2 are from Lot 2546.

Table 21.—Tonnage computations, line 9

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone: Cu. yds. per acre	Percent U	C.P.M. 1/	Calcium-Phosphate Zone: Tons per acre	Percent BPL
1	8.3-26.6	29,200		1000		
1	26.6-35.4 2/				P-1650 3/	68.1
					C-630	69.0
1	35.4-43.3 4/				P-928	48.9
					C-2120	66.0
2	32.2-39.7	12,000		1500		
2	39.7-48.6 2/				P-5720	71.4
					C-1310	72.4
2	48.6-50.3 4/				P-500	53.7
					C-580	64.6
3	15.4-23.6	13,200		1300		
3	23.6-38.9 2/				P-7350	69.0
					C-3700	60.4
3	42.6-59.3 4/				P-4950	64.0
					C-4250	67.0
5	16.0-17.7	2,720		1500		
5	17.7-28.7 2/				P-4250	62.6
					C-750	71.0
5	28.7-57.4 4/				P-3120	58.0
					C-7530	69.0
6	27.0-31.4				Not sampled	
6	31.4-39.3 5/				P-2240	49.0
					C-1190	61.6
7	14.0-19.7	9,100		1000		
7	19.7-39.0 2/				P-2560	60.4
					C-1490	70.5
8	29.7-35.6	9,450		1500		
8	35.6-66.2 2/				P-3690	60.0
					C-8900	69.0

Table 21.--Tonnage computations, line 9--Cont.

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone			Calcium-Phosphate Zone	
		Cu. yds. per acre	Percent U	C.P.M. 1/	Tons per acre	Percent BPL
9	27.0-34.8	1,250		1000		
9	34.8-51.2 2/				P-880	57.9
9	51.2-75.3 4/				P-3180	54.0
					C-980	64.6
10	55.2-75.2 2/				P-2680	62.5
					C-1700	59.4
11	45.8-50.6 2/				P-1600	64.5
					C-1020	75.4
11	50.6-53.7 4/				P-70	51.7
					C-590	74.0
12	52.0-72.4 5/				P-3040	61.0
					C-3160	67.0

1/ Counts per minute computed from gamma-ray logs. See fig. 10.
2/ Upper part of calcium-phosphate zone - Bone Valley formation.
3/ P = pebble fraction (+14 mesh); C = concentrate fraction (-35+150 mesh).
4/ Lower part of calcium-phosphate zone - Hawthorn formation.
5/ One sample of calcium-phosphate zone - Bone Valley and Hawthorn formations.

Table 22--Analytical and screen data, samples from holes in line 10

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	Weight Percent [1]	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1-101	5.3-12.6	+14 mesh (A)	0.6	28.0	39.2	3.2	2/		0.012
		-14+35 mesh (B)	13.2						0.005
		-150 mesh (D)	38.0					0.009	0.010
		-35+150 conc (E)	13.0	34.6	47.9	3.8			0.012
		-35+150 tail (F)	35.4						0.002
1-102	12.6-18.9	(A)	2.8	29.7	44.3	3.1			0.009
		(B)	26.5						0.005
		(D)	20.3					0.004	0.004
		(E)	24.4	32.4	47.7	3.6			0.007
		(F)	25.0						0.001
2-105	9.6-17.1	(A)	9.2	31.6	45.2	3.8		0.016	0.017
		(B)	10.8						0.009
		(D)	21.8	17.3	25.4	2.0	7.8	0.010	0.011
		(E)	24.0	33.7	49.7	4.0		0.008	0.010
		(F)	34.4						0.001
3-3	27.5-37.0	(A)	6.2	30.2	44.7	3.5		0.014	0.016
		(B)	14.2						0.006
		(D)	28.0						0.004
		(E)	13.5	31.3	47.2	3.4			0.010
		(F)	38.3						a 3/
4-4	17.4-26.6	(A)	13.0	30.9	45.9	3.6		0.016	0.022
		(B)	15.0					0.009	0.008
		(D)	24.7	15.9	26.4	2.0	6.0	0.014	0.013
		(E)	11.0	31.1	47.1	3.7			0.014
		(F)	36.2						a

Table 22--Analytical and screen data, samples from holes in line 10--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
5-5	22.4-26.0	+14 mesh (A)	2.9	30.3	41.6	3.3			0.009
		-14+35 mesh (B)	9.2						0.004
		-35+150 mesh (C)	65.1						0.002
		-150 mesh (D)	22.8	12.8	12.4	1.2	17.3		0.005
5-6	31.2-34.8	(A)	12.8	29.0	43.8	3.4			0.010
		(B)	14.8					0.007	0.007
		(D)	34.2						0.003
		-35+150 conc (E)	16.0	29.7	44.7	3.6			0.004
		-35+150 tail (F)	22.3						0.002
6-7	35.0-39.8	(A)	0.1	10.6	9.5	1.1			0.003
		(B)	7.4						0.001
		-35+150 mesh (C)	83.3						a
		(D)	9.3	25.6	0.7	1.1	32.0	0.050	0.029
6-8	41.7-56.1	(A)	1.9	29.9	44.1	3.6			0.013
		(B)	11.9					0.002	0.002
		(D)	36.1						0.004
		(E)	9.5	32.1	45.9	3.7			0.010
		(F)	40.6						a
6-9	56.1-60.9	(A)	1.0	24.7	40.1	2.9			0.010
		(B)	16.4						0.004
		(D)	43.3						0.001
		(E)	9.6	30.1	45.8	3.5			0.007
		(F)	29.7					0.001	0.002
7-10	7.0-22.0	(A)	0.2	10.6	10.3	1.0			0.012
		(B)	14.5						0.003
		(C)	67.7						0.002
		(D)	17.7	13.5	10.7	1.2	20.7	0.022	0.018

Table 22- Analytical and screen data, samples from holes in line 10--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
7-11	22.0-28.1	+14 mesh (A)	5.8	30.3	41.5	2.2		0.040	0.030
		-14+35 mesh (B)	4.4	18.0	26.2	2.1		0.021	0.020
		-35+150 mesh (C)	63.5						0.004
		-150 mesh (D)	26.2	12.9	16.6	1.6	15.3	0.017	0.015
7-12	33.1-43.2	(A)	7.6	22.5	38.8	2.7			0.008
		(B)	6.0					0.005	0.006
		(D)	34.4						0.002
		-35+150 cone (E)	12.6	30.8	46.5	3.5			0.007
		-35+150 tail (F)	39.4						0.001
8-13	18.0-22.9	(A)	3.3	13.0	0.3	1.4			0.004
		(B)	11.3						0.001
		(C)	64.6						0.001
		(D)	20.8	16.9	0.8	1.8	27.7	0.015	0.013
8-14	22.9-36.3	(A)	5.9	31.5	42.2	3.4		0.010	0.010
		(B)	11.7					0.003	0.004
		(D)	21.1	15.7	18.4	1.8	12.8	0.011	0.011
		(E)	20.3	34.2	46.8	3.7			0.008
		(F)	41.0						
8-15	36.3-37.2	(A)	27.3	8.7	30.1	1.2			0.004
		(B)	12.1						0.005
		(D)	24.2						0.003
		(E)	17.4	27.6	43.7	3.2			0.007
		(F)	19.0					0.001	0.001
9-16	14.8-20.6	(A)	5.6	30.6	44.3	3.6			0.009
		(B)	11.5	18.5	29.6	2.4			0.006
		(D)	38.3						0.002
		(E)	10.9	31.5	47.6	3.7			0.008
		(F)	33.7						0.001

Table 22--Analytical and screen data, samples from holes in line 10--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
9-17	20.6-23.6	+14 mesh (A)	1.6	28.6	42.1	3.1			0.011
		-14+35 mesh (B)	7.8						0.005
		-150 mesh (D)	23.6					0.002	0.001
		-35+150 conc (E)	22.3	32.0	48.2	3.7			0.007
		-35+150 tail (F)	44.7						a
10-18	8.0-17.1	(A)	0.4	7.6	6.3	0.7			0.008
		(B)	14.1						a
		-35+150 mesh (C)	65.4						0.001
		(D)	20.1	12.6	5.1	0.7	29.3	0.026	0.027
10-19	17.1-25.1	(A)	0.2	31.7	42.1	3.1			0.009
		(B)	5.9						0.003
		(C)	63.9						0.002
		(D)	30.0	8.5	8.9	1.1	17.5	0.004	0.005
10-20	25.1-36.9	(A)	5.4	30.8	43.1	3.0			0.009
		(B)	16.9						0.007
		(D)	21.8					0.001	0.002
		(E)	10.8	31.3	45.1	3.2			0.008
		(F)	45.1						a
10-21	36.9-46.5	(A)	1.3	25.8	39.8	3.0			0.008
		(B)	4.7						0.004
		(D)	30.1						0.001
		(E)	10.1	28.4	43.2	3.4			0.008
		(F)	52.8						a
10-22	52.4-57.4	(A)	8.7	15.5	32.7	2.0			0.006
		(B)	10.9						0.005
		(D)	32.0						0.002
		(E)	14.8	28.3	45.1	3.5			0.007
		(F)	33.6						a

Table 22--Analytical and screen data, samples from holes in line 10--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
11-23	20.3-22.0	+14 mesh (A)	0.1	23.7	36.9	2.8			0.010
		-14+35 mesh (B)	7.8					0.001	a
		-35+150 mesh (C)	85.6						a
		-150 mesh (D)	6.5						a
11-24	22.0-26.3	(A)	2.8	29.0	39.1	3.7		0.016	0.016
		(B)	19.7						0.005
		(C)	57.8						0.002
		(D)	19.7	7.3	8.6	1.1	19.3	0.008	0.009
11-25	28.2-38.1	(A)	5.8	29.0	42.7	3.5			0.010
		(B)	14.0						0.004
		(D)	16.6					0.001	0.002
		-35+150 conc (E)	12.1	30.6	43.5	3.3			0.008
		-35+150 tail (F)	51.5						a
11-26	38.1-39.1	(A)	12.5	18.5	36.4	2.4			0.008
		(B)	17.5						0.006
		(D)	27.5						a
		(E)	12.2	28.5	43.1	3.3			0.006
		(F)	30.3						0.001
12-27	19.8-22.1	(A)	0.8	13.1	17.3	1.7		0.017	0.019
		(B)	19.5					a	a
		(C)	71.6						a
		(D)	8.1	3.0	1.9	0.3	25.2	0.008	0.006
12-28	22.1-31.5	(A)	8.5	27.5	41.0	3.1		0.015	0.016
		(B)	17.3						0.004
		(D)	7.9						0.005
		(E)	11.0	26.7	39.3	3.4			0.009
		(F)	55.3						a

Table 22--Analytical and screen data, samples from holes in line 10--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
12-29	31.5-34.2	+14 mesh (A)	4.6	29.2	43.3	3.2			0.010
		-14+35 mesh (B)	17.9					0.001	0.002
		-150 mesh (D)	26.5						0.002
		-35+150 conc (E)	9.6	30.8	44.3	3.5			0.008
		-35+150 tail (F)	41.4						a
12-30	34.2-38.5	(A)	8.3	27.2	42.7	3.1			0.011
		(B)	29.5						0.004
		(D)	12.4						0.002
		(E)	13.6	25.8	39.1	3.0			0.006
		(F)	36.2					0.001	a
12-31	38.5-43.1	(A)	12.5	26.0	28.6	3.0			0.001
		(B)	36.4						0.005
		(D)	23.3						0.001
		(E)	6.1	30.4	31.3	3.0			0.007
		(F)	21.7						0.001
13-32	27.7-38.0	(A)	7.7	29.0	28.2	3.3		0.016	0.017
		(B)	50.7						0.005
		(D)	2.5	9.1	11.6	0.7		0.013	0.013
		(E)	7.1	32.1	30.7	3.6			0.011
		(F)	32.0						0.001
13-33	38.0-39.6	(A)	9.9	27.9	28.6	3.2			0.012
		(B)	3.6						0.006
		(D)	18.0						0.003
		(E)	8.4	28.0	27.1	2.8			0.008
		(F)	60.1						0.001

Table 22--Analytical and screen data, samples from holes in line 10--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
13-34	39.6-54.3	+14 mesh (A)	9.2	29.5	29.9	3.3			0.012
		-14+35 mesh (B)	16.0					0.003	0.004
		-150 mesh (D)	5.7						0.003
		-35+150 conc (E)	16.4	29.2	28.0	3.1			0.007
		-35+150 tail (F)	52.7						a
13-35	54.3-55.5	(A)	17.9	19.7	26.0	2.1			0.010
		(B)	10.7						0.004
		(D)	39.3						0.001
		(E)	8.0	26.5	27.6	2.7			0.007
		(F)	24.1					0.001	a
14-36	23.3-25.0	(A)	1.0	8.9	7.2	0.7			0.012
		(B)	18.0						0.002
		-35+150 mesh (C)	63.0						a
		(D)	18.0	4.5	2.9	0.3			0.013
14-37	25.0-29.1	(A)	2.9	30.0	29.5	3.0		0.018	0.017
		(B)	8.5						0.006
		(D)	32.2	15.5	16.7	1.1			0.006
		(E)	3.4	30.0	31.1	3.4			0.013
		(F)	53.0						0.001
14-38	29.1-34.0	(A)	42.3	3.6	35.0	0.4			0.002
		(B)	5.7						0.002
		(D)	42.3						0.002
		(E)	2.6	9.2	49.2	1.1			0.004
		(F)	7.1						a

Table 22--Analytical and screen data, samples from holes in line 10--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
14-39	35.0-37.0	+14 mesh (A)	46.0	3.8	30.9	0.4			0.002
		-14+35 mesh (B)	15.8						0.002
		-150 mesh (D)	11.8						0.001
		-35+150 conc (E)	13.8	3.8	33.3	0.4			0.001
		-35+150 tail (F)	12.6						a
15-40	40.2-49.7	(A)	2.5	24.2	35.2	2.6			0.012
		(B)	17.0						0.004
		(D)	3.5						0.003
		(E)	2.1	27.7	41.0	3.2			0.009
		(F)	74.9						a
15-41	51.3-54.1	(A)	27.5	19.4	39.2	2.3			0.011
		(B)	7.7					0.007	0.007
		(D)	28.6						0.001
		(E)	7.5	24.9	43.1	2.9			0.009
		(F)	28.7						a
16-42	10.2-13.1	(A)	0.1	9.4	10.3	0.9			0.010
		(B)	16.5						0.003
		-35+150 mesh (C)	76.7						0.002
		(D)	6.6	7.6	4.2	0.3		0.048	0.027
16-43	20.7-32.3	(A)	0.2	21.0	33.9	2.5		0.010	0.009
		(B)	5.6						a
		(C)	79.7						a
		(D)	14.5	1.5	3.7	0.2			0.003
16-44	78.4-84.1	(A)	2.8	10.3	41.4	1.2			0.007
		(B)	3.1						0.003
		(D)	19.1						0.002
		(E)	5.8	26.2	43.4	3.2			0.011
		(F)	69.2						0.001

1/Weight percent retained on screen.
2/Blanks indicate no analysis.
3/"a" equals less than 0.001.
All samples are from Lot 2546.

Table 23.—Tonnage computations, line 10

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone: Cu. yds. per acre	Percent U 1/	C.P.M. 2/	Calcium-Phosphate Zone: Tons per acre	Percent BPL
1	2.0-5.3	5,300-		2800		
1	5.3-12.6 3/				P-100 4/	61.1
					C-2200	75.6
1	12.6-18.9 5/				P-400	65.0
					C-3560	71.0
2	1.5-8.2	10,700		1000		
2	8.2-9.6 3/				6/	
2	9.6-17.1 5/				P-1780	69.0
					C-4670	73.6
3	9.0-27.5	29,600		1800		
3	27.5-37.0 7/				P-1430	66.0
					C-3100	68.4
4	9.0-17.4	13,400		1100		
4	7.4-26.6 7/				P-2840	67.5
					C-2400	68.0
5	3.0-22.4	31,200		1000		
5	22.4-26.0 3/				P-250	66.2
					No concentrate	
5	26.0-31.2				Not sampled	
5	31.2-34.8 5/				P-1090	63.5
					C-1360	65.0
6	35.0-39.8	7,600		1500		
6	39.8-41.7	Not recovered, probably clayey sand - (Aluminum phosphate(?))				
6	41.7-56.1 7/				P-640	65.4
					C-3060	70.0
6	56.1-60.9 5/				P-108	54.0
					C-970	65.7

Table 23.—Tonnage computations, line 10—Cont.

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone: Cu. yds. per acre	Percent U 1/	C.P.M. 2/	Calcium-Phosphate Zone: Tons per acre	Percent BPL
7	7.0-22.0	24,000	0.006			
7	22.0-28.1 3/				P-850	66.2
					No concentrate	
7	28.1-33.1				Not sampled	
7	33.1-43.2 5/				P-1845	49.1
					C-3060	67.2
8	18.0-22.9	7,840	0.004			
8	22.9-36.3 7/				P-1940	68.8
					C-6640	74.7
8	36.3-37.2 8/				P-660	19.0
					C-420	60.4
9	14.0-14.8	No economic		500		
9	14.8-20.6				P-826	66.9
					C-1580	68.8
9	20.6-23.6				P-120	68.5
					C-1670	70.0
10	8.0-17.1	14,500	0.005			
10	17.1-25.1 3/				P-390	69.0
					No concentrate	
10	25.1-36.9 5/				P-1570	67.2
					C-3140	68.4
10	36.9-46.5 5/				P-350	56.4
					C-2320	62.0
10	46.5-52.4				Not sampled	
10	52.4-57.4 5/				P-1050	33.9
					C-1800	61.8

Table 23.--Tonnage computations, line 10--Cont.

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone: Cu. yds. per acre	Percent U 1/	C.P.M. 2/	Calcium-Phosphate Zone: Tons per acre	Percent BPL
11	20.3-22.0	2,720	0.001			
11	22.0-26.3 3/				P-300	63.5
					No concentrate	
11	26.3-28.2 3/				No recovery	
11	28.2-38.1 5/				P-1410	63.3
					C-2940	66.9
11	38.1-39.1 5/				P-290	40.5
					C-280	62.4
12	19.8-22.1	3,680	0.002			
12	22.1-31.5 9/				P-1960	60.0
					C-2540	58.3
12	31.5-34.2 5/				P-330	63.7
					C-700	67.2
12	34.2-43.2 5/10/				P-2170	58.0
					C-1990	60.0
13	27.7-38.0 3/				P-1870	63.5
					C-1730	70.2
13	38.0-54.3 11/				P-3700	63.6
					C-6260	63.4
13	54.3-55.5 8/				P-430	43.1
					C-200	58.0
14	19.9-25.0	8,160		800		
14	25.0-29.1 3/				P-290	65.6
					C-330	65.6
14	29.1-37.0 12/				Not computed	8.0-20.0
15	40.2-49.7					
16	10.2-13.1	4,640	0.005			

1/ Head assay calculated from analyses of individual fractions.
2/ Counts per minute computed from gamma-ray logs. See fig. 11.
3/ Top sample of calcium-phosphate zone - Bone Valley formation.
4/ P = pebble fraction (+14 mesh); C = concentrate fraction (-35+150 mesh).
5/ Bottom sample of calcium-phosphate zone - Hawthorn formation.
6/ Sample not assayed.
7/ One sample includes both Hawthorn and Bone Valley formations.
8/ Hawthorn limestone samples. Not calcium-phosphate zone.
9/ Sample includes Bone Valley and late middle Miocene (?). Not economic.
10/ Weighted average of samples 30 and 31.
11/ Hawthorn (?) unnamed member, weighted average of samples 33 and 34. Not economic.
12/ Hawthorn (?) unnamed member, and Hawthorn. Not economic.

Table 24--Analytical and screen data, samples from holes in line 11

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	Weight Percent 1/	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1-45	13.3-16.9	+14 mesh (A)	51.4	5.2	32.1	0.7	2/		0.008
		-14+35 mesh (B)	14.0					0.005	0.006
		-150 mesh (D)	11.2						0.002
		-35+150 conc (E)	3.3	4.4	33.5	0.6			0.004
		-35+150 tail (F)	20.1						0.003
2-46	18.6-32.0	(A)	0.9	8.9	3.3	0.4			0.003
		(B)	19.0						a 3/
		-35+150 mesh (C)	70.5						a
		(D)	9.5	4.5	4.6	0.3		0.016	0.018
2-47	32.0-39.3	(A)	0.3	13.8	11.8	0.7			0.008
		(B)	10.5					0.001	a
		(C)	79.0						a
		(D)	10.1	9.2	4.5	0.4			0.010
2-48	39.3-41.9	(A)	16.6	30.4	44.3	3.4			0.014
		(B)	23.2						0.006
		(D)	3.9	6.9	8.9	0.4			0.006
		(E)	4.5	32.6	47.5	3.7			0.013
		(F)	51.8						a
3-49	8.9-21.4	(A)	0.2	13.0	11.9	1.1			0.006
		(B)	1.6					0.001	a
		(C)	73.0						a
		(D)	25.2	11.5	9.6	0.6			0.006
3-50	39.8-51.5	(A)	12.5	29.5	44.4	3.5		0.019	0.020
		(B)	18.0						0.007
		(D)	9.5	11.9	16.1	1.1			0.006
		(E)	5.4	3.7	5.6	0.5			0.001
		(F)	54.6	30.7	46.6	3.7			0.009

Table 24--Analytical and screen data, samples from holes in line 11--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	[1] Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
3-51	51.5-53.9	+14 mesh (A)	14.0	24.8	41.7	3.2			0.001
		-14+35 mesh (B)	14.0						0.004
		-150 mesh (D)	4.0						0.001
		-35+150 conc (E)	3.4	26.3	41.6	3.3			0.007
		-35+150 tail (F)	64.6						a
4-52	13.0-23.2	(A)	0.1	13.7	15.4	1.5			0.006
		(B)	8.0						a
		-35+150 mesh (C)	50.8						a
		(D)	41.1	10.1	5.4	0.4			0.008
4-53	50.4-56.5	(A)	14.9	17.1	42.9	3.0			0.014
		(B)	24.0						0.006
		(D)	26.4						0.002
		(E)	2.9	31.0	48.1	3.7			0.010
		(F)	31.8						0.002
5-54	5.2-17.4	(A)	1.7						0.002
		(B)	8.8						a
		(C)	67.4						a
		(D)	22.1	7.3	0.9	0.3			0.005
5-55	36.0-48.9	(A)	1.9	26.3	39.1	3.3			0.013
		(B)	27.2						0.002
		(D)	6.7						0.003
		(E)	3.2	31.3	43.0	3.5			0.008
		(F)	61.0						a
6-56	12.9-19.8	(A)	0.1					0.004	0.005
		(B)	4.4						a
		(C)	72.5						a
		(D)	23.0						0.002

Table 24--Analytical and screen data, samples from holes in line 11--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
6-57	66.6-70.2	+14 mesh (A)	1.2	16.9	36.1	2.0			0.010
		-14+35 mesh (B)	56.5						0.002
		-150 mesh (D)	13.5						0.002
		-35+150 conc (E)	4.9	31.3	46.4	3.4			0.012
		-35+150 tail (F)	23.9						a
7-58	34.9-49.9	(A)	2.3	25.5	41.0	3.0		0.012	0.014
		(B)	42.9						0.001
		(D)	4.4					0.002	0.004
		(E)	3.0	31.3	47.4	3.3			0.012
		(F)	47.4						a
7-59	49.9-56.1	(A)	16.0	27.6	37.3	1.9			0.012
		(B)	13.7						0.004
		(D)	13.7					0.002	0.003
		(E)	3.4						
		(F)	53.2						0.002
8-60	20.9-27.0	(A)	22.4						0.004
		(B)	21.0						a
		-35+150 mesh (C)	50.4						a
		(D)	6.2	15.8	0.5	0.1		0.005	0.005
8-61	65.6-70.2	(A)	0.2						a
		(B)	23.0						0.002
		(C)	71.2						0.002
		(D)	5.6	5.0	5.1	0.3		0.006	0.006
8-62	70.2-77.0	(A)	2.9	27.9	40.7	3.0			0.006
		(B)	17.2					0.001	0.002
		(D)	23.3						0.002
		(E)	3.4	27.8	42.6	3.0			0.011
		(F)	53.2						a

Table 24--Analytical and screen data, samples from holes in line 11--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	Weight Percent 1/	Analytical data (in percent					
				P_2O_5	CaO	F	Al_2O_3	U	eU
8-63	77.0-78.1	+14 mesh (A)	7.1	9.3	35.1	1.1			0.006
		-14+35 mesh (B)	11.2						0.004
		-150 mesh (D)	59.2						0.001
		-35+150 conc (E)	13.5	8.6	36.3	1.1			0.003
		-35+150 tail (F)	9.0						a

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.
3/ "a" equals less than 0.001.

All samples are from Lot 2546.

Table 25.--Tonnage computations, line 11

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone: Cu. yds. per acre	Aluminum-Phosphate Zone: Percent U	Aluminum-Phosphate Zone: C.P.M. 1/	Calcium-Phosphate Zone: Tons per acre	Calcium-Phosphate Zone: Percent BPL
1	Blank Hole					
2 2	22.5-28.0 2/ 39.3-41.8 3/	8,800		1000	P-1010 4/ C-270	66.5 71.2
3 3	21.3-24.4 2/5/ 39.7-51.4 6/	4,960			P-3490 C-1510	64.6 67.3
4 4	13.0-15.1 2/ 47.5-51.8 3/	3,360		1000	7/	
5	36.0-48.8 3/				P-600 C-1000	57.4 68.4
6	66.5-71.9 8/				P-140 C-630	37.0 68.5
7	34.8-54.0 8/				P-2200 C-1390	57.0 68.0
8	Blank Hole					

1/ Counts per minute computed from gamma-ray logs. See fig. 12.
2/ Interval between aluminum-phosphate zone and calcium-phosphate zone is clayey sand, not economic.
3/ Upper part of calcium-phosphate zone, Bone Valley formation.
4/ P = pebble fraction (+14 mesh); C = concentrate fraction (-35+150 mesh).
5/ Aluminum-phosphate zone based on lithology - No analysis on gamma-ray data available.
6/ One sample of calcium-phosphate zone, Bone Valley and Hawthorn formations.
7/ Not computed - sample analysis includes 4.4 feet limestone beneath calcium-phosphate zone.
8/ Calcium-phosphate zone in middle Miocene (?) unnamed member. Sample 58 and part of 59 used to compute tonnage and grade.

Table 26--Analytical and screen data, samples from holes in line 12

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1-64	6.0-11.0	+14 mesh (A)	9.3	14.4	2.9	0.3	2/	0.010	0.011
		-14+35 mesh (B)	9.3						0.005
		-150 mesh (D)	36.2	22.4	6.3	0.8		0.023	0.026
		-35+150 conc (E)	0.9	17.5	13.3	0.9		0.015	0.017
		-35+150 tail (F)	44.1						0.002
1-65	11.0-19.0	(A)	3.2	33.6	45.6	3.2			0.012
		(B)	14.0						0.007
		(D)	25.0	23.6	21.4	1.4		0.014	0.014
		(E)	8.1	35.2	50.7	3.8			0.012
		(F)	49.8						0.004
1-66	22.1-28.0	(A)	7.3	34.8	50.6	4.0		0.016	0.016
		(B)	8.3						0.011
		(D)	28.3					0.009	0.011
		(E)	24.8	37.5	52.0	4.3		0.016	0.016
		(F)	31.3						0.005
2-67	8.5-17.2	(A)	1.2						0.005
		(B)	30.4						a 3/
		-35+150 mesh (C)	49.4						0.001
		(D)	19.0	10.9	6.5	0.5		0.017	0.019
2-68	17.2-26.5	(A)	2.6	33.4	48.1	4.0		0.014	0.015
		(B)	15.8						0.008
		(D)	32.7					0.004	0.005
		(E)	19.4	32.6	48.6	3.6			0.010
		(F)	29.5						0.001

Table 26--Analytical and screen data, samples from holes in line 12--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	Weight Percent [1]	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
2-69	26.5-31.0	+14 mesh (A)	2.7	26.2	43.8	3.2			0.008
		-14+35 mesh (B)	6.4					0.004	0.005
		-150 mesh (D)	57.1						0.001
		-35+150 conc (E)	13.1	29.6	48.0	3.1			0.007
		-35+150 tail (F)	20.7						0.002
3-70	8.1-12.6	(A)	6.5						0.006
		(B)	29.2						0.001
		-35+150 mesh (C)	55.5						0.001
		-150 mesh (D)	8.7	22.7	4.2	0.5		0.030	0.031
3-71	35.4-40.6	(A)	5.1	32.6	46.5	3.1		0.034	0.036
		(B)	16.5					0.016	0.017
		(D)	32.9	17.3	23.1	1.3		0.031	0.032
		(E)	10.0	33.1	48.3	3.4		0.024	0.025
		(F)	35.5						0.002
3-72	40.7-43.1	(A)	0.1	25.8	43.4	3.1			0.013
		(B)	2.9						0.008
		(D)	60.7						0.002
		(E)	14.5	30.1	47.9	3.6			0.011
		(F)	21.8					0.002	0.004
4-73	42.0-47.1	(A)	0.1	18.8	27.7	2.1			0.012
		(B)	9.5						a
		(C)	75.6						a
		(D)	14.8						a
4-74	91.3-97.0	(A)	7.1	33.8	45.2	3.6		0.013	0.014
		(B)	15.7						0.009
		(D)	18.7	16.9	23.8	1.5		0.008	0.010
		(E)	11.7	35.6	50.7	3.9		0.010	0.012
		(F)	46.8						0.004

Table 26--Analytical and screen data, samples from holes in line 12--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
4-75	97.0-99.1	+14 mesh (A)	1.2	32.0	46.3	3.6		0.020	0.022
		-14+35 mesh (B)	12.0	19.3	28.9	2.3			0.012
		-150 mesh (D)	36.0					0.006	0.005
		-35+150 conc (E)	21.2	34.1	51.0	3.7		0.019	0.021
		-35+150 tail (F)	29.6						0.006
6-76	101.4-103.5	(A)	52.1	23.7	42.2	3.1			0.009
		(B)	9.4						0.006
		(D)	19.8	8.9	30.0	1.1		0.018	0.020
		(E)	3.6	28.9	45.6	3.2			0.009
		(F)	15.1						0.007
8-78	50.9-59.9	(A)	8.6	26.7	40.6	3.4		0.014	0.016
		(B)	14.4						0.002
		-35+150 mesh (C)	57.1						a
		(D)	19.8					0.001	0.003

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.
3/ "a" equals less than 0.001.

All samples are from Lot 2546.

Table 27.—Tonnage computations, line 12

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone: Cu. yds. per acre	Aluminum-Phosphate Zone: Percent U 1/	Aluminum-Phosphate Zone: C.P.M. 2/	Calcium-Phosphate Zone: Tons per acre	Calcium-Phosphate Zone: Percent BPL
1	6.0-11.0	8,000	0.012			
1	11.0-19.0 3/				P-620 4/	73.5
					C-1570	77.0
1	19.0-22.1				Not sampled	
1	22.1-28.0 5/				P-1060	76.0
					C-3620	82.0
2	8.5-17.2	13,900	0.004			
2	17.2-26.5 6/				P-566	73.0
					C-4240	71.2
3	8.1-12.6 7/	7,200	0.005			
3	12.7-30.5				Barren loose sand.	
3	30.5-35.4	7,850		2500		
3	35.4-40.6 6/				P-600	71.2
					C-1200	72.2
4	42.0-47.1	8,160		800		
4	47.1-91.3				Barren beds.	
4	91.3-97.0 3/				P-950	73.9
					C-1564	77.6
4	97.0-99.1 5/				P-60	70.0
					C-1030	74.5
6	Blank Hole (Phosphate too deep)					
7	Blank Hole (Low grade, low tonnage)					

1/ Head assay calculated from analyses of individual fractions.
2/ Counts per minute computed from gamma-ray log. See fig. 13.
3/ Upper part of calcium-phosphate zone. Bone Valley.
4/ P = pebble fraction (+14 mesh); C = concentrate fraction (-35+150 mesh).
5/ Lower part of calcium-phosphate zone. Hawthorn.
6/ One sample of calcium-phosphate zone - both Bone Valley and Hawthorn.
7/ Upper, possibly reworked aluminum-phosphate material.

Table 28--Analytical and screen data, samples from holes in line 13

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	Weight Percent 1/	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1-79	62.9-74.6	+14 mesh (A)	5.2	33.5	48.8	3.9	2/		0.010
		-14+35 mesh (B)	14.7						0.006
		-150 mesh (D)	17.4					0.004	0.004
		-35+150 conc (E)	24.5	34.4	48.3	3.8			0.004
		-35+150 tail (F)	38.2					a	a 3/
2-80	37.4-46.0	(A)	12.1	30.9	46.5	3.6			0.015
		(B)	12.5					0.010	0.012
		(D)	44.6						0.007
		(E)	13.5	32.9	47.5	3.8		0.009	0.011
		(F)	17.3						0.001
2-81	46.0-50.8	(A)	3.8	24.0	42.3	2.9			0.010
		(B)	9.4						0.007
		(D)	51.1						0.002
		(E)	13.6	29.9	46.7	3.5			0.007
		(F)	22.1					0.001	0.002
3-82	75.8-81.2	(A)	18.6	31.2	46.3	3.6		0.017	0.020
		(B)	8.7					0.014	0.016
		(D)	18.6	22.4	32.2	2.2		0.019	0.021
		(E)	24.6	33.5	48.0	3.9			0.012
		(F)	29.5						0.004
3-83	81.6-85.8	(A)	13.2	31.2	46.7	3.6		0.013	0.015
		(B)	11.8	27.2	40.3	2.9			0.010
		(D)	49.3					0.004	0.004
		(E)	13.7	32.2	47.2	3.4		0.015	0.017
		(F)	12.0						0.007

Table 28--Analytical and screen data, samples from holes in line 13--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
3-84	72.3-75.8	+14 mesh (A)	0.7						0.006
		-14+35 mesh (B)	4.8						0.006
		-35+150 mesh (C)	83.4						0.002
		-150 mesh (D)	11.1	3.9	1.4	0.3		0.014	0.015
4-85	66.3-70.0	(A)	0.1						0.002
		(B)	1.0						0.001
		(C)	74.4						0.002
		(D)	24.5					0.001	0.003
4-87	70.0-75.0	(A)	0.5					0.014	0.016
		(B)	11.8						0.008
		(C)	59.3						0.004
		(D)	28.4	5.0	4.2	0.4		0.021	0.024
4-77	75.0-81.5	(A)	11.9	29.6	43.7	3.8			0.007
		(B)	12.2						0.005
		(D)	5.0	17.9	26.0	2.0		0.008	0.010
		-35+150 conc (E)	27.1	29.8	42.3	3.6			0.006
		-35+150 tail (F)	43.8						0.001
4-86	91.1-94.3	(A)	36.2	31.7	46.7	3.5			0.011
		(B)	14.5	22.0	33.9	2.8			a
		(D)	11.6	19.6	34.6	1.9		0.012	0.010
		(E)	3.7	31.2	48.9	4.0			0.013
		(F)	34.0					0.006	0.007
5-88	80.9-85.9	(A)	9.2	27.1	41.2	3.2			0.012
		(B)	10.7	21.3	31.3	2.3			0.012
		(D)	17.5					0.004	0.005
		(E)	0.9	30.9	46.6	3.4		0.014	0.017
		(F)	61.7					0.001	0.003

Table 28--Analytical and screen data, samples from holes in line 13--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	Weight Percent [1]	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
6-90	67.4-71.6	+14 mesh (A)	13.9	29.5	45.5	3.5		0.024	0.026
		-14+35 mesh (B)	17.7	23.4	35.4	2.8		0.018	0.018
		-150 mesh (D)	30.4	15.2	23.1	1.3		0.016	0.015
		-35+150 conc (E)	11.3	32.1	47.4	3.7		0.015	0.018
		-35+150 tail (F)	26.7						0.007
6-91	72.4-81.5	(A)	13.1	29.8	44.9	3.4		0.013	0.015
		(B)	16.2						0.009
		(D)	27.5	7.4	24.1	0.8		0.009	0.007
		(E)	13.5	29.4	44.4	3.3			0.008
		(F)	29.7						0.001
7-89	76.9-78.9	(A)	13.2	30.4	43.3	3.5		0.017	0.019
		(B)	13.2	12.8	23.3	1.6			0.008
		(D)	13.2					0.009	0.011
		(E)	10.4	33.6	47.8	3.9			0.012
		(F)	50.0						0.004
8-92	69.1-75.6	(A)	0.1						0.006
		(B)	0.5					0.003	0.004
		-35+150 mesh (C)	80.0						0.002
		(D)	19.4						0.002
8-93	76.0-83.2	(A)	5.6	24.8	33.8	2.6		0.015	0.017
		(B)	4.4	20.8	30.4	2.5			0.012
		(C)	68.2						0.003
		(D)	21.8					0.002	0.004

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.
3/ "a" equals less than 0.001.

All samples are from Lot 2546

Table 29.--Tonnage computations, line 13

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone: Cu. yds. per acre	Aluminum-Phosphate Zone: Percent U 1/	Aluminum-Phosphate Zone: C.P.M. 2/	Calcium-Phosphate Zone: Tons per acre	Calcium-Phosphate Zone: Percent BPL
1	57.0-62.9	9,500-		1000		
1	62.9-74.6 3/				P-1500 4/ C-6850	73.2 75.2
2	29.2-32.5	5,280		1700		
2	32.5-37.4				Not sampled - calcium-phosphate zone	
2	37.4-46.0 5/				P-2500 C-2780	67.5 71.9
3	72.3-75.8 6/	5,600	0.004			
3	75.8-81.2 7/				P-2480 C-3290	68.2 73.2
4	70.0-75.0 6/	8,000	0.006			
4	75.0-81.5 7/				P-1880 C-4280	64.7 65.1
5	80.9-85.9 7/				P-890 C-90	59.2 67.5
6	67.4-79.5 8/				P-4000 C-3500	64.5 67.8
7	76.9-80.7 9/				P-1250 C-1000	66.5 73.5
8	Blank Hole					

1/ Head assay calculated from analyses of individual fractions.
2/ Counts per minute computed from gamma-ray log. See fig. 14.
3/ Total calcium-phosphate zone, Bone Valley and Hawthorn formations.
4/ P = pebble fraction (+14 mesh); C = concentrate fraction (-35+150 mesh).
5/ Bottom of calcium-phosphate zone. Hawthorn formation.
6/ Aluminum-phosphate zone. Middle Miocene(?) unnamed member.
7/ Calcium-phosphate zone. Middle Miocene(?).
8/ Calcium-phosphate zone. Middle Miocene(?). Weighted average of samples 90 and 91.
9/ Calcium-phosphate zone. Middle Miocene(?). Includes 2.0' of core not recovered.

Table 30--Analytical and screen data, samples from holes in line 14

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent) P2O5	CaO	F	Al2O3	U	eU
1-94	35.1-40.8	+14 mesh (A)	0.4	2/					0.001
		-14+35 mesh (B)	8.9						a 3/
		-35+150 mesh (C)	85.5						a
		-150 mesh (D)	5.2	16.8	8.2	0.8		0.021	0.022
1-95	40.8-44.0	(A)	6.4	28.3	41.7	3.3		0.015	0.016
		(B)	9.8	24.0	35.3	1.9			0.011
		(D)	10.9						0.002
		-35+150 conc (E)	20.3	34.3	48.5	3.7			0.012
		-35+150 tail (F)	52.6						0.003
1-96	44.0-49.5	(A)	7.6	20.8	29.4	2.3			0.009
		(B)	5.6	26.8	38.7	3.1			0.012
		(D)	27.7					0.002	0.003
		(E)	24.4	34.3	49.5	3.9			0.013
		(F)	34.7						0.002
2-97	40.5-43.6	(A)	0.4	14.4	18.3	1.4			0.010
		(B)	15.6						0.001
		(C)	69.2						a
		(D)	14.8	4.4	5.1	0.3		0.018	0.018
2-98	43.6-49.3	(A)	14.6	33.9	48.3	3.5		0.018	0.018
		(B)	11.1	26.0	39.3	2.9			0.014
		(D)	21.8	17.1	25.1	1.5		0.011	0.010
		(E)	13.2	33.5	50.0	3.8			0.009
		(F)	39.3						0.003

Table 30--Analytical and screen data, samples from holes in line 14--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
3-99	65.6-73.4	+14 mesh (A)	5.8	26.8	42.6	3.3		0.020	0.022
		-14+35 mesh (B)	6.4						0.008
		-150 mesh (D)	17.5					0.003	0.004
		-35+150 conc (E)	2.3	27.2	32.8	3.3			0.012
		-35+150 tail (F)	68.0						0.002
3-100	73.4-75.6	(A)	13.4	26.5	43.8	3.3		0.016	0.016
		(B)	11.3	16.9	28.7	2.1			0.010
		(D)	30.3						0.008
		(E)	7.8	21.5	51.1	2.7			0.008
		(F)	37.2						
4-4	58.0-75.0	(A)	0.2						0.002
		(B)	22.3						a
		-35+150 mesh (C)	53.9						0.001
		(D)	23.6						0.002
8-3	98.0-101.0	(A)	2.3						0.005
		(B)	14.1						0.003
		(C)	73.5						0.002
		(D)	10.2	2.5	1.7	0.2		0.047	0.046

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.
3/ "a" equals less than 0.001.

Samples 94 through 100 are from Lot 2546; samples 3 & 4 are from Lot 2547.

Table 31.—Tonnage computations, line 14

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone			Calcium-Phosphate Zone	
		Cu. yds. per acre	Percent U	C.P.M. 1/	Tons per acre	Percent BPL
1	38.0-40.8	4,480		1400		
1	40.8-49.5 2/				P-1550 3/ C-4990	51.7 75.0
2	43.6-49.3 4/				P-2130 C-1920	74.1 73.2

Holes 3, 4, 7, and 8 intersected no aluminum phosphate or calcium phosphate.

1/ Counts per minute computed from gamma-ray logs. See fig. 15.
2/ One sample of calcium-phosphate zone, Bone Valley and Hawthorn formations.
3/ P = pebble fraction (+14 mesh); C = concentrate fraction (-35+150 mesh).
4/ Lower part of calcium-phosphate zone, Hawthorn formation.

Table 32--Analytical and screen data, samples from holes in line 15

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1-1	16.9-25.9	+14 mesh (A)	0.1	2/					0.004
		-14+35 mesh (B)	5.0						a 3/
		-35+150 mesh (C)	84.3						0.001
		-150 mesh (D)	10.6	4.0	1.0	0.3			0.006
2-2	41.9-45.9	(A)	13.4	27.7	41.6	3.6		0.015	0.016
		(B)	16.4						0.009
		(D)	11.9						0.006
		-35+150 conc (E)	4.5	31.6	46.6	3.9		0.015	0.015
		-35+150 tail (F)	53.8					0.001	0.001
3-5	57.9-59.9	(A)	20.7	35.8	48.4	3.9		0.026	0.028
		(B)	8.6	22.3	31.9	2.5		0.018	0.018
		(D)	41.3	16.3	22.8	1.3			0.012
		(E)	3.3	34.5	46.7	3.8		0.026	0.027
		(F)	26.1						0.005
4-6	64.8-68.8	(A)	9.4	32.5	46.2	3.7		0.014	0.015
		(B)	12.0						0.012
		(D)	27.3	11.8	17.3	1.0		0.016	0.017
		(E)	10.0	33.9	48.0	3.8		0.015	0.018
		(F)	41.3					0.002	0.002
5-7	55.5-66.5	(A)	8.1	31.1	43.5	3.4		0.015	0.017
		(B)	7.6	22.5	33.1	2.7			0.011
		(D)	26.5						0.009
		(E)	10.7	30.5	44.0	3.5		0.014	0.016
		(F)	47.1						a

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.
3/ "a" equals less than 0.001.
All samples are from lot 2547.

Table 33.--Tonnage computations, line 15

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone			Calcium-Phosphate Zone	
		Cu. yds. per acre	Percent U	C.P.M. 1/	Tons per acre	Percent BPL
1 1	21.0-24.5 24.5-29.0	5,600		1100	Possible calcium-phosphate zone. Sample not analyzed.	
2 2	35.0-40.0 41.9-45.9	8,000		600	P-1300 2/ C-440	60.3 69.0
3 3	54.0-56.5 56.5-59.9	4,000		1800	P-1760 C-280	78.4 75.4
4 4	60.0-64.8 64.8-68.8	7,680		2000+	P-920 C-970	71.0 74.1
5	55.5-66.5				P-2160 C-2860	68.0 67.6
6	Blank Hole					

1/ Counts per minute computed from gamma-ray logs. See fig. 16.
2/ P = pebble fraction (+14 mesh); C = concentrate (-35+150 mesh).

Table 34--Analytical and screen data, samples from holes in line 16

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1a-19	58.5-71.5	+14 mesh (A)	7.4	24.4	35.9	2.8	2/	0.011	0.013
		-14+35 mesh (B)	6.1						0.012
		-150 mesh (D)	22.6						0.008
		-35+150 conc (E)	5.4	32.2	47.2	3.8		0.016	0.016
		-35+150 tail (F)	58.5						0.001
2-15	50.6-56.4	(A)	3.8	18.3	26.5	2.1		0.015	0.017
		(B)	6.1					0.012	0.014
		-35+150 mesh (C)	50.7					0.002	0.003
		(D)	39.3	7.0	10.3	0.6		0.013	0.015
3-16	35.5-37.4	(A)	5.3	26.7	39.7	3.1			0.010
		(B)	9.3	14.0	21.1	1.5			0.014
		(C)	70.5						0.001
		(D)	14.7						0.007
5-20	39.2-42.4	(A)	5.2	26.8	41.4	3.2		0.017	0.018
		(B)	10.4	20.8	31.4	2.5			0.014
		(D)	18.3						0.008
		(E)	5.3	32.0	47.3	3.6		0.017	0.023
		(F)	60.8						0.001

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.

All samples are from Lot 2547.

Table 35.--Tonnage computations, line 16

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone Cu. yds. per acre	Percent U	C.P.M. 1/	Calcium-Phosphate Zone Tons per acre	Percent BPL
1	78.0-82.0	6,400		1100		
1	56.0-58.5	4,000		900		
1	58.5-71.5 2/				P-2340 3/ C-1700	53.4 70.5
2	47.3-52.4	8,160		1400		
3	32.8-35.5	4,320		900		
4	Blank Hole					
5	36.5-39.2	4,320		1300		
5	39.2-42.4 2/				P-379 C-380	58.5 70.3

1/ Counts per minute computed from gamma-ray logs. See fig. 17.
2/ Lower part of calcium-phosphate zone - Hawthorn formation.
3/ P = pebble fraction (+14 mesh); C = concentrate fraction (-35+150 mesh).

Table 36--Analytical and screen data, samples from holes in line 17

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	[1] Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
2-12	34.0-36.0	+14 mesh (A)	0.0	[2]					
		-14+35 mesh (B)	0.0						
		-35+150 mesh (C)	0.0						
		-150 mesh (D)	100.0	7.5	10.7	0.6			0.011
2-13	36.0-39.0	(A)	0.1					0.006	0.008
		(B)	14.3						0.002
		(C)	60.2						0.002
		(D)	25.4						0.004
2-14	43.0-52.0	(A)	3.6	29.0	45.3	3.1		0.026	0.027
		(B)	11.4					0.014	0.016
		(D)	25.3						0.006
		-35+150 conc (E)	13.5	31.3	47.3	3.4		0.017	0.020
		-35+150 tail (F)	46.2						0.001
3-8	23.0-29.0	(A)	7.1	35.1	33.0	3.4			0.020
		(B)	12.3	18.7	24.2	1.9			0.014
		(D)	35.8					0.011	0.012
		(E)	5.4					0.017	0.020
		(F)	39.4						0.002
9-11	53.0-62.0	(A)	0.3						0.008
		(B)	1.7						0.005
		(C)	41.5						0.001
		(D)	56.5	6.5	10.3	0.7			0.007
10-9	79.0-82.5	(A)	3.9						0.006
		(B)	5.3						0.004
		(D)	59.0						0.005
		(E)	2.0						0.006
		(F)	29.8						0.002

Table 36--Analytical and screen data, samples from holes in line 17--Continued

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
10-10	82.5-87.0	+14 mesh (A)	7.8	33.3	36.5	3.7	2/		0.009
		-14+35 mesh (B)	8.9					0.007	0.009
		-150 mesh (D)	56.7						0.006
		-35+150 conc (E)	6.1	34.0	40.4	3.8			0.010
		-35+150 tail (F)	20.5						0.003

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.

All samples are from Lot 2547.

Table 37.—Tonnage computations, line 17

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone: Cu. yds. per acre	Percent U 1/	C.P.M. 2/	Calcium-Phosphate Zone: Tons per acre	Percent BPL
1	17.3-25.0	12,320		1000		
1	25.0-39.3				Possible calcium-phosphate zone. Not analyzed.	
2	29.5-39.0	15,200	0.007			
2	39.0-43.0				Not sampled	
2	43.0-52.0				P-790 3/	63.5
					C-2960	68.3
3	20.0-23.0	4,800		3500		
3	23.0-29.0				P-1000	35.1
					C-780	Not analyzed
4	7.4-15.8	13,400		1100		
5	1.5-6.0	7,200		1100		
6	9.0-12.0	4,800		900		
7	4.0-10.5	10,400		800		
8	53.5-64.5	17,600		1200		
9	15.5-25.5	16,000		1100		
10	72.5-78.0	8,800		1100		
10	79.0-87.0				P-1180	72± 4/
					C-840	74±
11	4.0-11.3	11,680		800		

1/ Head assay calculated from analyses of individual fractions.
2/ Counts per minute computed from gamma-ray logs. See fig. 18.
3/ P = pebble fraction (+14 mesh); C = concentrate fraction (-35+150 mesh).
4/ Grades estimated. Sample analyzed included only a part of the calcium-phosphate zone.

Table 38--Analytical and screen data, samples from holes in line 18

Hole No. & Sample No.	Sample Interval (in feet)	Screen Size	1/ Weight Percent	Analytical data (in percent)					
				P_2O_5	CaO	F	Al_2O_3	U	eU
1-17	23.0-31.0	+14 mesh (A)	11.6	36.8	48.8	3.7	2/	0.015	0.016
		-14+35 mesh (B)	10.4						0.007
		-150 mesh (D)	35.1	23.5	32.4	1.8			0.010
		-35+150 conc (E)	10.6	36.5	50.0	3.9		0.015	0.018
		-35+150 tail (F)	32.3						0.003
1-18	31.0-36.1	(A)	7.1	35.7	48.4	3.7		0.015	0.018
		(B)	11.3	25.1	34.8	2.4			0.013
		(D)	49.6						0.006
		(E)	7.7	35.2	49.5	3.7		0.016	0.018
		(F)	24.3						0.001

1/ Weight percent retained on screen.
2/ Blanks indicate no analysis.

Both samples are from Lot 2547.

Table 39.--Tonnage computations, line 18

Hole No.	Depth Interval (in feet below the surface)	Aluminum-Phosphate Zone			Calcium-Phospate Zone	
		Cu. yds. per acre	Percent U	C.P.M. 1/	Tons per acre	Percent BPL
1	20.0-23.0	4,800		1300		
1	23.0-31.0 2/				P-2260 3/ C-2050	80.4 79.6
1	31.0-36.1 4/				P-860 C-930	78.0 76.9
4	38.5-55.0	26,400		1000		

1/ Counts per minute computed from gamma-ray logs. See fig. 19.
2/ Upper part calcium-phosphate zone - Bone Valley formation.
3/ P = pebble fraction (+14 mesh); C = concentrate fraction (-35+150 mesh).
4/ Lower part calcium-phosphate zone - Hawthorn formation.

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