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DISTRIBUTION OF URANIUM IN THE FLORIDA PHOSPHATE FIELD

by
J. B. Cathcart

August 1949

Trace Elements Investigations Report 85

AEC RESEARCH AND DEVELOPMENT REPORT

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DISTRIBUTION OF URANIUM IN THE FLORIDA PHOSPHATE FIELD

by

J. B. Cathcart

ABSTRACT

Land-pebble phosphate, hard-rock phosphate, and river-pebble phosphate are the three types of phosphatic rock found in Florida. This report is concerned primarily with the land-pebble deposits, the only type which contains a significant amount of uranium. The most productive part of the land-pebble district is in Polk and Hillsborough Counties, in the west-central part of the Florida peninsula.

Phosphate occurs in both the Hawthorn formation of lower middle Miocene age and the Bone Valley formation of Pliocene age. The phosphate in the Bone Valley is generally of higher grade, probably as the result of mechanical reworking and further precipitation during submergence in Pliocene time. In a few places, leached parts of the Hawthorn formation are also of minable grade. Pleistocene terrace deposits and beach sands unconformably overlie the Bone Valley.

In Polk and Hillsborough Counties, the high-grade part of the land-pebble phosphate district, uranium occurs principally in the Bone Valley formation and is concentrated in the upper part of the formation, which has been leached by ground water. The maximum tenor found to date is 0.1 percent uranium. The basal member of the Bone Valley has a maximum grade of .02 percent uranium, and averages about .01

percent uranium. Fresh, unweathered Hawthorn formation has little or no uranium, but leached Hawthorn, rich in P_2O_5, contains a maximum of 0.01 percent uranium. The Pleistocene sands have no uranium except where they contain reworked phosphatic material from the Bone Valley formation.

South of the high-grade district, in Manatee and Hardee Counties, the Bone Valley, Hawthorn, and Pleistocene formations contain only very minor amounts of uranium.

The uranium in the land-pebble deposits was probably syngenetic in origin. Subsequent leaching of soluble material has resulted in residual enrichment of uranium. The uranium seems to be associated with the phosphate mineral.

INTRODUCTION

Three types of phosphate deposits are found in Florida: land-pebble, hard-rock, and river-pebble. The land-pebble deposits contain a small percentage of uranium associated with the phosphate-bearing mineral and with certain phosphatic clays, whereas the other deposits contain little or no uranium. This report is concerned largely with the land-pebble deposits, and only brief mention will be made of the other two types.

The land-pebble phosphate deposits of Florida occupy a shield-shaped area of about 2,800 square miles in Polk, Hillsborough, Hardee, Manatee, Sarasota, DeSoto, and Highland Counties, Florida (fig. 1).

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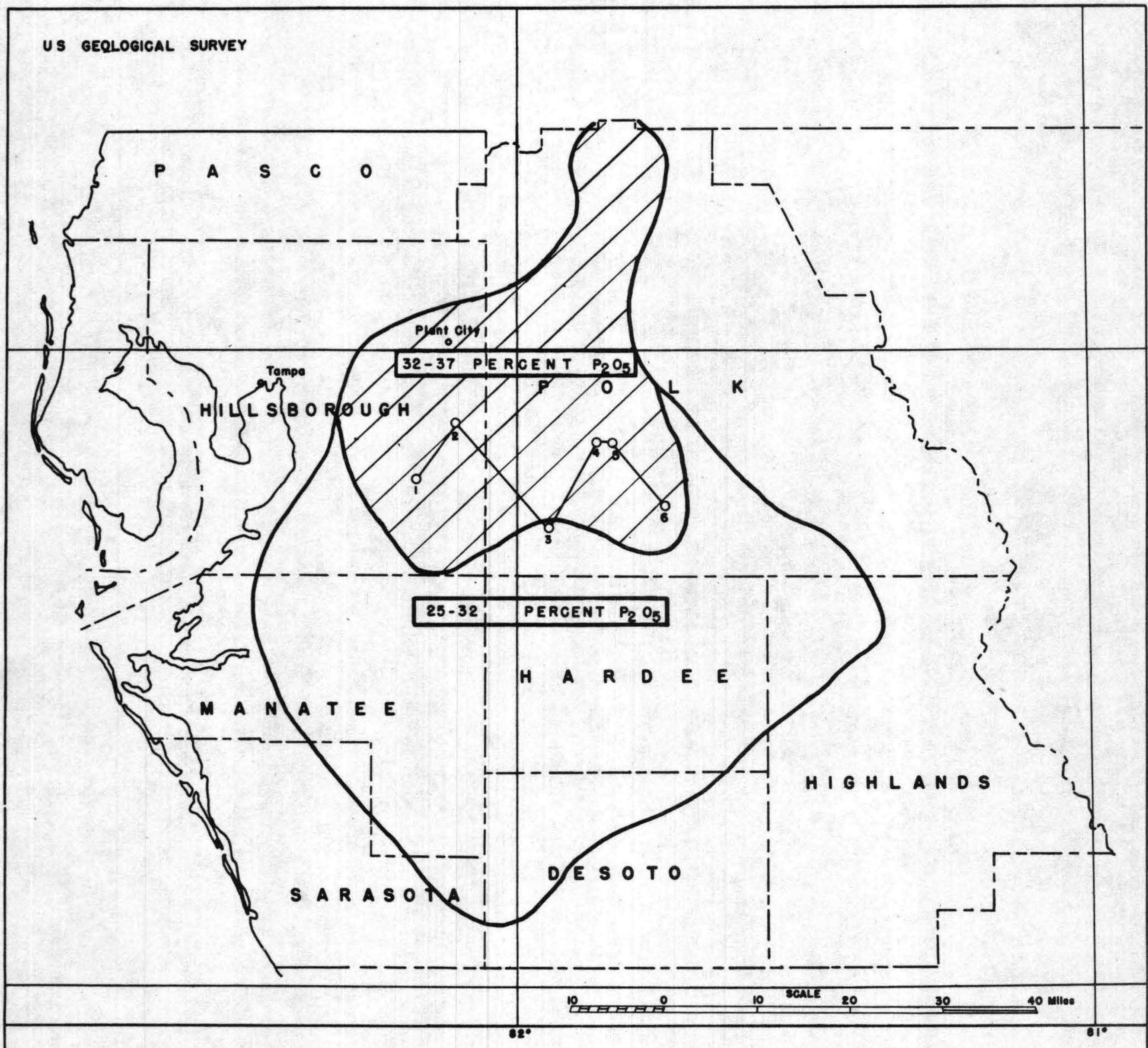

EXPLANATION

1. Boyette (AAC Co.) Sec. 14, T31S, R23E
2. Eleanor (Coronet) Sec. 16, T30S, R22E
3. South Pierce (AAC) Sec. 6, T32S, R24E
4. Noralyn (IMC Corp) Sec. 25, T30S, R24E
5. Borrow Pits Sec. 20 + 29, T30S, R25E
6. Varn (Swift + Co.) Sec. 30, T31S, R26E

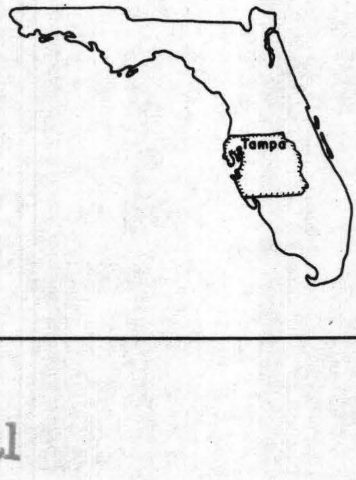

FIGURE 1. INDEX MAP OF LAND-PEBBLE PHOSPHATE FIELD, FLORIDA.

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Present mining operations are confined to the northern part of the field, centered in Polk and Hillsborough Counties. Phosphate deposits in the southern part of the field are too low grade to be mined at present.

GENERAL GEOLOGY OF THE LAND-PEBBLE PHOSPHATE DISTRICT

The land-pebble phosphate deposits of Florida are in the west-central part of the Florida peninsula, which is a part of the Gulf Coastal Plain, and which is underlain by thin, nearly flat-lying formations that dip south.

The oldest formation exposed in the land-pebble phosphate district is the Hawthorn formation of lower middle Miocene age. The Hawthorn is unconformably overlain by the Bone Valley formation, which is generally regarded as Pliocene. Unconformably overlying the Bone Valley formation are the sands of the Pleistocene terraces. These in turn are overlain by a very thin veneer of Recent sediments.

STRATIGRAPHY

Miocene rocks

The oldest rocks exposed in west-central Florida have been divided into the lower Miocene Tampa limestone; the middle Miocene Hawthorn formation and equivalent Alum Bluff group, and the upper Miocene Duplin formation.

The Tampa limestone is known only from deep-well records in the land-pebble phosphate area, where it underlies the Hawthorn formation. It crops out to the west in the vicinity of the city of Tampa.

Hawthorn formation

The Hawthorn formation consists of interbedded impure limestone, marl, and clastic sediments and contains phosphate nodules in varying amounts.

In the northern part of the district the Hawthorn formation consists of interbedded yellowish to grayish phosphatic marl and yellow or buff-colored limestone with well-preserved shell molds. In the southern part of the district clastic beds of an unknown thickness overlie the limestone.

The thickness of the Hawthorn formation cannot be accurately estimated because its base is not exposed in southern Florida. The estimates of its thickness that have been made are based on a few deep-well logs. These data indicate a range in thickness from a feather edge to almost 600 feet.

Pliocene rocks

Bone Valley formation

The Bone Valley formation consists of a lower zone composed largely of coarse materials with only subordinate amounts of fine sand and clay and an upper zone made up largely of gray silty or sandy clay.

In the northern part of the district, the lower zone of the Bone Valley lies unconformably on the Hawthorn formation and ranges from less than one foot to more than 50 feet in thickness. It is composed of sand, sandy clay, green silty clay, and coarse gravel. This member of the Bone Valley formation contains variable quantities of phosphate nodules that range from clay-size particles to boulders, some of which are more than one foot in diameter. The larger phosphate nodules are phosphatized limestone, and many contain molds of Hawthorn fossils.

The upper zone of the Bone Valley is a leached, partly indurated sand and clay and ranges in thickness from less than one foot to about 16 feet. Phosphate nodules have been removed by downward percolating ground water, leaving molds of the pebbles and a very light, highly porous rock.

The leached zone is extremely irregular and patchy and grades laterally into sands and clays which show no visible evidence of leaching.

In the southern part of the area, the division of the Bone Valley into a lower and an upper zone has not been observed. The Bone Valley, where it overlies the clastic higher part of the Hawthorn, is a fairly well-sorted sand with little clay and no cobbles and contains only medium-sized phosphate nodules. These range from 1/32 to 1/2 inch in diameter. The P_2O_5 content of the Bone Valley is appreciably lower in the southern part of the district than it is in the north.

STRATIGRAPHIC SECTIONS

The index map (fig. 1) shows the location of the sections chosen to show the general characteristics of the Bone Valley formation. It should be noted (fig. 2) that the upper or leached zone cannot be recognized with certainty in the South Pierce section in the southern part of the district. The phosphate content of this section is small, and there is little or no uranium in the "matrix" and none in the Hawthorn or in the "overburden."

The stratigraphic sections (fig. 2) show the variations that occur within the land-pebble district. The correlations shown on the chart are generalized, as detailed sections are possible only in the mines, which are several miles apart, and variations, both vertical and horizontal, are extreme. Thin beds can rarely be traced through the length of a single mine cut, a maximum of 2,000 feet.

The stratigraphic sections (fig. 2) show most of the variations that exist in the land-pebble field. "Matrix", the term used for the economic or minable part of the phosphate deposit, occupies a somewhat different stratigraphic position in the various mines. From section to section its stratigraphic position differs in detail dependent upon the phosphate content and other economic factors; it is not a stratigraphic unit but an economic unit.

ORIGIN AND MODE OF OCCURRENCE

In order to understand the distribution of the uranium in the Florida field, it may be well to outline the present ideas on the origin of the phosphate deposits.

The phosphate in the Hawthorn formation is believed to have been deposited directly from sea water in an environment where considerable amounts of lime and clastic materials were being deposited, at a rate which quickly buried the phosphate nodules.

A long period of erosion followed the deposition and uplift of the Hawthorn formation. This resulted in development of an irregular Karst topography and a residual product of varying thickness from which the lime was leached. The less soluble phosphate nodules were thus concentrated and may have been enriched. With transgression of the sea during the lower Pliocene, deposition of the Bone Valley formation began, and phosphatic material was reworked and deposited.

During Bone Valley time (all of the lower Pliocene, and perhaps all of the Pliocene) only very minor amounts of material other than phosphate were deposited. The Bone Valley is a very thin formation, no more than 75 feet thick, but represents a fairly long period of geologic time. Thus, the phosphate nodules were exposed to sea water for a much longer time than were the nodules in the Hawthorn formation.

The phosphate deposits in the Bone Valley formation are thickest over low areas on the post-Hawthorn erosion surface. Over basement ridges, the phosphate is either very thin or absent, indicating that some of the basement highs may have been islands in the Bone Valley sea.

Phosphate in the Bone Valley may have been formed by one or a combination of the following:

1. Reworking, concentrating, and enriching the phosphate nodules leached from the Hawthorn.
2. Phosphatizing unweathered lumps of Hawthorn limestone. This mechanism is particularly important as fine-grained phosphate and coarse-grained phosphate are present only in the northern part of the area, where the bedrock is limestone. In the southern part of the area, where the bedrock is clastic, only reworking was important, and the deposits are much lower in grade and tonnage.

3. Deposition of the original phosphate nodules from the Bone Valley sea.
4. An additional possible source of phosphate is from the rivers draining the hardrock area to the north.

DISTRIBUTION OF URANIUM

Regional

Significant amounts of uranium are found only in the marine Bone Valley formation in the land-pebble district. River-pebble phosphate, derived largely from the Hawthorn formation, contains little or no uranium, and phosphate of the hard-rock district, also continental in origin, contains only very small amounts of uranium.

Stratigraphic distribution in the land-pebble district

The Hawthorn formation, although marine and phosphatic, contains very little uranium where fresh. Leached parts of the Hawthorn, where classed as "matrix", contain a maximum of .01 percent uranium, which is nearly as much as the average content of the Bone Valley.

The removal of the more soluble lime by leaching apparently caused a residual concentration of the uranium in the leached Hawthorn.

The lower zone of the Bone Valley (which makes up the greatest part of the "matrix") has a maximum tenor of .02 percent uranium and probably averages 0.01 percent uranium. In general, there is a rough correspondence between the P_2O_5 content and the uranium content. This generality holds on a regional, rather than on a local, scale.

In the northern high-grade part of the district, in Polk and Hillsborough Counties, the concentrations of both P_2O_5 and U are appreciably greater than in the southern low-grade part of the district.

A typical analysis of low-grade phosphate rock is as follows:

Constituents	Percent
P_2O_5	28.85
CaO	40.36
Fe_2O_3	1.60
Al_2O_3	1.79
SiO_2	17.45
CO_2	2.61
F	3.25
H_2O	3.45
Total	99.36

Analysis by International Minerals and Chemical Corporation.

Some thin beds of restricted lateral extent in the lower zone contain appreciably more uranium than other beds. In all samples examined, those beds that contain the highest percentage of phosphate nodules of the greatest percentage of P_2O_5 contain the highest percentage of uranium. The green silty clay beds, common in the "matrix," contain little or no uranium and practically no phosphate.

The upper or leached zone of the Bone Valley contains the greatest concentration of uranium in the district. The grade ranges from 0.01 to 0.1 percent uranium and averages about 0.035 percent. Within the leached zone, vertical and horizontal variations are extreme. The best exposure of the leached zone in the district is in the borrow pits, sections 20 and 29, T. 30 S., R. 25 E., Polk County (figs. 4 and 3). The horizontal and vertical variations in grade in the leached zone are illustrated in figure 4. In samples of very restricted vertical extent (see fig. 2 Boyette and Borrow Pit leached zone analyses) the grade of the uranium increases to a maximum at the base, whereas the top, which is usually the most thoroughly leached part, contains very little uranium.

The leached rock is a dead-white sandy clay, with no visible phosphate nodules. Abundant evidence of leaching is furnished by molds of former nodules, and the rock is thin, very porous, and light in weight. The leached zone ranges in thickness from a feather edge to over 16 feet but probably averages only two feet in thickness. The leached zone has been recognized over an area of about 140 square miles but is extremely irregular in occurrence, and only one-eighth or less of this area is underlain by this zone.

Greenish silty clays, common in the "matrix," contain little or no uranium, whereas uraniferous clays elsewhere in the section are of the same type as the leached-zone clay, i.e., a dead-white, kaolin-type clay. It is possible that the green "matrix" clays have acted as barriers to downward circulating ground waters, producing a perched water table. The concentration of uranium above the green clays is distinctly greater than at other places in the section. In a long

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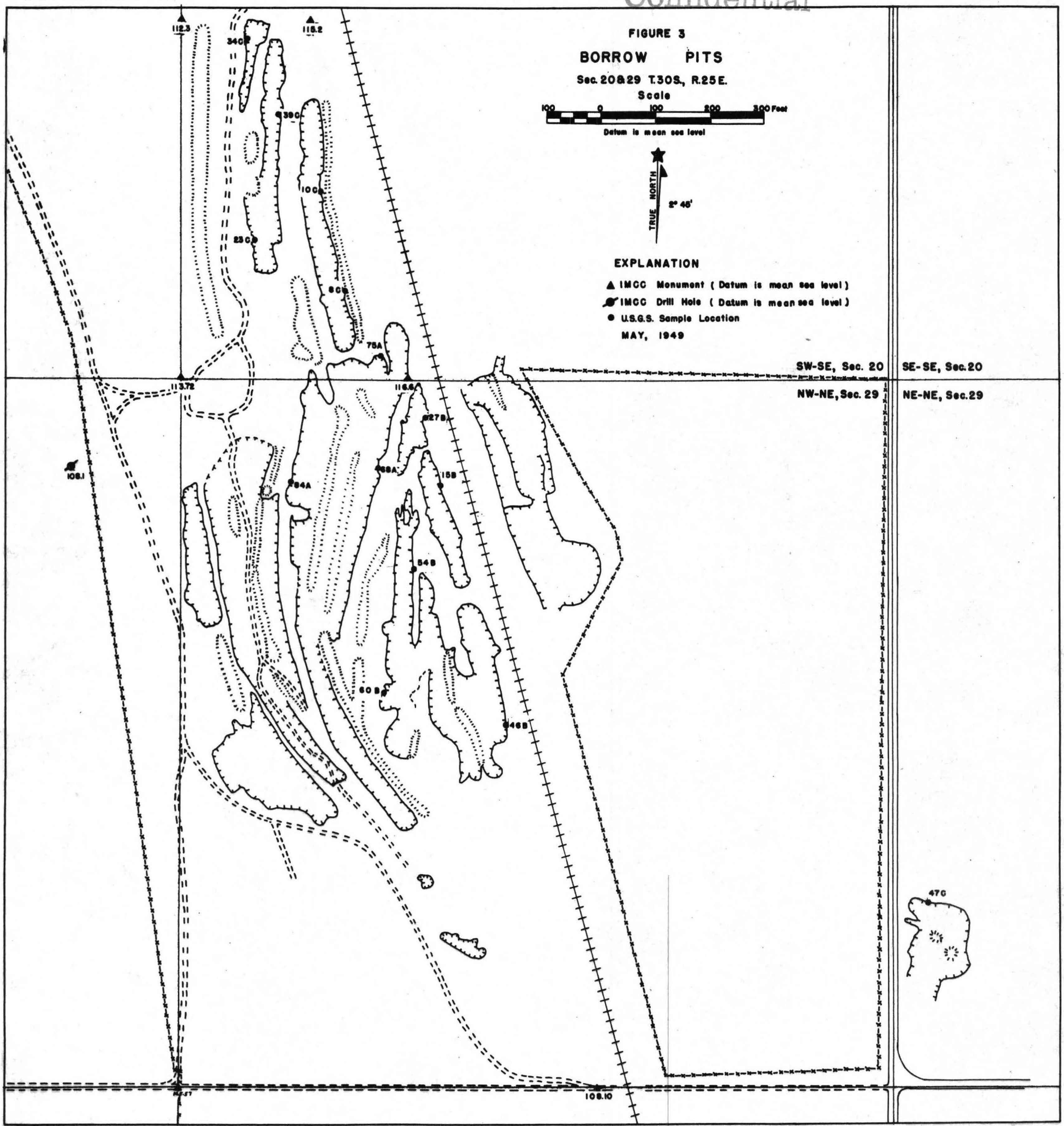

No uranium is known in the sands of the Pleistocene terraces (the overburden), except in one place at the Eleanor mine where a thin bed of reworked phosphate from the Bone Valley contains some uranium.

CONCLUSIONS

Uranium in central Florida is found in significant amounts only in the marine phosphate, or land-pebble, deposits. Two types of rock in the land-pebble phosphate district contain uranium in small amounts. First and highest in content of uranium is the white, kaolin-type, phosphatic clay found in the upper leached zone of the Bone Valley formation. The phosphate nodules have been leached, leaving a highly porous, usually very light-weight rock composed of quartz grains, in a cement of dead-white kaolinitic (?) clay. The mineral torbernite has recently been identified as an uranium-bearing mineral in this zone, and wavellite is present in fairly large amounts. Second in importance is the rock composed of sand, clay, and abundant phosphate nodules, which is termed "matrix." The uranium is present in the clay fraction (slime) and also in the phosphate nodules, as has been proved by analyses of samples from which everything but the phosphate nodules has been removed. In this case, it is possible that the uranium takes the place of the calcium in the phosphate mineral. 1/

1/ McKelvey, V. E., and Nelson, J. M., Characteristics of marine uranium-bearing sedimentary rocks: U. S. Geol. Survey, report in preparation.

ACKNOWLEDGMENTS

The writer is indebted to all of the companies currently mining phosphate in the land-pebble area: American Agricultural Chemical Company; American Cyanamid Company; Coronet Phosphate Company; Davison Chemical Corporation; International Minerals and Chemical Corporation; Virginia-Carolina Corporation; and Swift and Company. Without their complete cooperation, the work would have been seriously hampered if not impossible.

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