Project Report No. 4
South Georgia Minerals Program

Georgia
State Division Of Conservation
Department of Mines, Mining and Geology

A. S. Furcron, Director

PHOSPHORITE EXPLORATION IN PORTIONS OF LOWNDES, ECHOLS, CLINCH AND CHARLTON COUNTIES, GEORGIA

By
Norman K. Olson
Industrial Development Department
Southern Railway System

October 1966

Prepared through the cooperation of
Southern Railway System, Washington, D.C.

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CONTENTS

CONTENTS (Continued)

TABLES

ILLUSTRATIONS

Plates

(All plates in pocket)

Figures

ABSTRACT

During Spring 1965 Southern Railway and the Georgia Department of Mines, Mining and Geology undertook a joint phosphorite exploration program. Known occurrences in North Florida guided the investigation into extreme South Georgia -- Lowndes, Echols, Clinch and Charlton Counties.

Over 3000 samples were collected from more than 160 drill holes. Prepared sample cuts for microscopic description are deposited with the State of Georgia for public use.

Phosphorite of low commercial grade, that is, 9 percent P_2O_5 or higher, occurs almost entirely in the western portion of the study area. It is found in transparent quartz sands. These zones commonly have 25 to 35 feet of overburden, and the phosphorite thickness generally ranges from 20 to 40 feet.

Structural control has influenced the accumulation of phosphorite in the four-county area in a broad sense. The two major structural features are the Withlacoochee Anticline to the west, and the Southeast Georgia Embayment to the northeast. Localization of much phosphorite in the western portion, however, is apparently in sinkholes and solution channels produced in the underlying Suwannee Limestone of Oligocene age.

Drilling and chemical results are given in various tables, driller's logs, geologic cross-sections, and thickness distribution maps.

PHOSPHORITE EXPLORATION IN PORTIONS OF LOWNDES, ECHOLS, CLINCH AND CHARLTON COUNTIES, GEORGIA

INTRODUCTION

A sharp increase in world-wide demand for phosphate compounds, particularly agricultural fertilizers (Piombino, 1964), has stimulated new interest for geological exploration by many chemical, petroleum and mining firms. Increasing attention to the mining potential of phosphate rock in the South Georgia-North Florida area provided the impetus for this investigation.

Occidental Corporation of Florida, a subsidiary of Occidental Petroleum Corporation, was the first company in the general area to initiate construction of a washer plant to produce phosphate concentrate. That plant was begun near Purvis Still in Hamilton County, Florida, in October, 1964, followed by construction of additional units of an agricultural chemicals complex in late Summer 1965.

Companies interested in the Georgia portion of the phosphate rock area began expressing their interest to the Department of Mines, Mining and Geology, State of Georgia, and to the Industrial Development Department of the Southern Railway System, as well as other agencies offering geological services.

In Spring 1965, the Industrial Development Department of the Southern Railway, through the cooperation of the Department of Mines, Mining and Geology, began a reconnaissance drilling program for phosphorite in parts of Lowndes, Echols, Clinch and Charlton Counties, Georgia. Holes were drilled at one-mile intervals on railroad and county road rights-of-way and on private land.

All drilling and chemical results have been furnished to the State of Georgia, and the samples, prepared for microscopic study, remain with the State for public use.

ACKNOWLEDGMENTS

The writer expresses thanks to Dr. A. S. Furcron, Director of the Department of Mines, Mining and Geology, State of Georgia. He provided the outlet for publication of the report.

Preparation of cuttings samples for microscope description, and their storage, was made possible through the joint cooperation of Dr. Furcron and John E. Husted and the staff of the Mineral Engineering Branch, Georgia Institute of Technology.

Thanks are due to J. Roger Landrum, Chemist, Department of Mines, for performing the more detailed chemical analyses.

The writer is particularly grateful to the following U. S. Geological Survey personnel:

> Dr. S. M. Herrick assisted with determining the series boundaries on the drill holes shown in the cross-sections (Plate II). His long experience in subsurface work proved invaluable in this respect.
>
> James B. Cathcart, Denver, and Robert C. Vorhis, Atlanta, reviewed the manuscript. Mr. Cathcart spent two days on drilling location with the writer and furnished assistance based upon wide experience in the phosphate minerals. He also provided X-ray diffraction data on the clay minerals.
>
> Charles W. Sever, geophysicist, formerly with the U. S. Geological Survey, Tifton, Georgia, furnished valuable field assistance and provided helpful comments on the general subsurface geology of the area.

Dr. H. K. Brooks, Department of Geology, University of Florida, provided beneficial comments. His studies in the areas bordering the Alapaha and Suwannee Rivers indicate late Miocene and Pliocene ages for some of the phosphorite.

Gail F. Moulton, Jr., project geologist for the Kerr-McGee Corporation, Gainesville, Florida, furnished information on the Pliocene horse tooth locality near Lake City, Florida.

Thanks are also due R. Fred Phillips of Southern Railway for typing the rough draft and Mrs. Joyce E. Fowler of Georgia Institute of Technology for typing the final manuscript, and Jack Bradley and John Hines of the Georgia State Highway Department for drafting the maps and cross-sections.

FMC Corporation, Pocatello, Idaho, kindly furnished comparative chemical results on drilling versus coring.

Many local citizens over the four-county area were most helpful. Of special note was the assistance given by E. K. Avriett, Jr., pharmacist, Homerville, Georgia.

PURPOSE AND SCOPE OF INVESTIGATION

The main objective in this study was to obtain generalized facts on the occurrence and distribution of phosphorite in the four-county area. The reconnaissance program was initiated with the idea of assisting those companies interested in phosphate exploration in the Georgia-Florida area.

The investigation was conducted to get preliminary data. No attempt was made to gather metallurgical laboratory analyses because only a limited amount of coring was done. Therefore, no tonnage estimate of recoverable concentrate are given. What is intended, however, is to give the reader an over-all conception of the distribution of phosphorite and its relations to the stratigraphy, structure, and geomorphology of the area.

DEFINITIONS

Some terms used in this report are of standard geologic usage, and others are identified with the phosphate industry. Definitions are taken from Altschuler and others (1964), and Howell (1960).

Apatite:	The principal mineral of phosphorites is a carbonate-containing variety of fluorapatite, called collophane or francolite, composed mainly of tri-calcium phosphate, $Ca_3(PO_4)_2$.
Attapulgite:	A group of clay minerals, hydrous magnesium aluminum silicates, characterized by a distinctive rod-like shape. Synonymous with palygorskite.
BPL:	Bone phosphate of lime ($Ca_3(PO_4)_2$). Equals percent P_2O_5 x 2.185.
Clastic:	A textural term applied to rocks derived from pre-existing rocks. The commonest clastics are sandstones and shales.
Concentrate:	Fine phosphate product, -1 mm + 0.1 mm in size. Separated from quartz by flotation.
Coquina:	Soft porous limestone composed of broken shells, corals and other organic debris.
Core hole:	Boring by diamond drill or other machine that is made for the purpose of obtaining a core sample, that is, a section of the rock penetrated.
Drill hole:	Hole sunk by means of drilling tools. In this investigation toothed rock bits were employed producing cuttings and clay aggregates which were pumped to the surface.
Isopach:	A line on a map drawn through points of equal thickness of a designated unit.
Kaolinite:	A common clay mineral. Two-layer hydrous aluminum silicate having the general formula $Al_2(Si_2O_5)(OH_4)$.
Karst topography:	A limestone plateau marked by sinks interspersed with abrupt ridges and irregular protuberant rocks; usually underlain by caverns and underground streams.
Lithofacies:	The rock record of any sedimentary environment, including both physical and organic characters.

Lithology: The physical character of a rock, generally as determined megascopically or with the aid of a low-power magnifier.

Marl: A calcareous clay or intimate mixture of clay and particles or calcite or dolomite, usually fragments of shells.

Matrix: That part of the calcium phosphate zone from which phosphate particles can be economically recovered. Equal to "ore."

Montmorillonite: A group of clay minerals, hydrous aluminum silicates, characterized by swelling in water due to introduction of inter-layer water in the direction of the C-axis. Ca and Na cations subject to ion exchange.

Overburden: All rock overlying the matrix.

P_2O_5: Phosphorus pentoxide. Chemist's expressions for percent phosphate content.

Pebble: Coarse phosphate product, +1 mm in size.

Pellet: General term for rounded, oviform sedimentary apatite particles, commonly sand to granule in size.

Phosphorite: Rock name, called phosphate rock in the land-pebble district. Used in this report to denote a rock or specimen containing substantial amounts of sedimentary apatite.

Slime: -0.1 mm material. Includes clay minerals, quartz, and phosphate minerals (apatite, crandallite, and wavellite).

Strand line: The line or level at which a body of standing water, e.g. the sea, meets the land.

Strath: Valley deeply filled with alluvial deposits, particularly glacial outwash, not now occupied by a stream.

FIELD AND LABORATORY PROCEDURES

Drilling, coring and sampling

All drilling and coring were done by Tyson and Dean Water Well Company of Moultrie, Georgia. Samples of cuttings were taken at five-foot intervals under the direction of the driller, L. L. Dean, by stopping drilling and pumping out all of the cuttings for the interval. Because of the reconnaissance nature of the drilling, only 26 cores were taken. A total of 161 holes were drilled in Lowndes, Echols, Clinch, Charlton, and Lanier Counties (Plate I). Holes were drilled to 90 feet where phosphate was present, but were stopped at 75 feet where barren. Thirteen holes, spaced about 5 miles apart, were drilled for structural and stratigraphic reasons to depths of as much as 300 feet (Plate I). Drilling and sample data for all holes are summarized in Basic Data 1.

Recent geologic field investigations in South Georgia by the Mineral Engineering Branch, Georgia Institute of Technology, have developed all basic data from core holes. By contrast this reconnaissance study employed very little coring, and nearly all samples are drill cuttings rather than an *in situ* section of the formation. Core holes and drill holes can be compared as to terminology under Definitions. It is readily apparent that some clay minerals are not recovered in the drilling process because of the drilling fluid used. Advantages and disadvantages of both methods are discussed under Future Prospecting, located in the final section.

Electric and gamma-ray logs

Electric logs were obtained to supplement the sample log information (Plate IV). Gamma-ray logs were run to detect the phosphorite zones. The phosphate particles themselves contain a small amount of uranium and their radioactivity can be detected by the gamma-ray instrument. A WIDCO portable model Y/PRG combination electric and gamma-ray logging instrument was mounted on the back of a pickup truck and operated from the vehicle's 12-volt battery. A probe at the end of a thin steel cable was carefully lowered by use of a hand crank into the completed hole. Pens on the chart paper were carefully "zeroed out" and set at the total depth. In the case of the electric logs, spontaneous potential was recorded on the left channel and resistivity on the right, both simultaneously. Electric and gamma-ray probes were interchangeable, and gamma-ray readings were recorded on the left channel only.

Operational difficulties with the gamma-ray probe itself caused less than half the holes to have gamma-ray logs. Therefore, one aid to determining the position and thickness of the phosphorite was greatly reduced.

Altitudes

Very few topographic quadrangle maps are available for the four-county area. Therefore, it was essential to establish vertical control for the drawing of any cross-sections. Altitudes above mean sea level of selected drill holes were determined to the nearest foot, using a Zeiss surveyor's level. Level circuits were run from and closed on established U. S. Coast and Geodetic Survey bench marks. Surveys were performed by Thomas M. Lowe and Associates, Atlanta.

Chemical analyses

A National Bureau of Standards chemical analysis (Table 1) is included to provide the reader with basic information as to the composition of Standard Sample 120a.

Table 1. Provisional certificate of analysis

by

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

(July 1961)

Standard Sample 120a

Phosphate rock
(Florida)

	Percent
P_2O_5	34.4
Fe_2O_3	1.00
Al_2O_3	.94
CaO	50.3
MgO	.26
F	3.92
MnO	.02
Na_2O	.41
K_2O	.10
TiO_2	.12
CO_2	3.18

Values are based on a sample dried for two hours at 110° C. A value for silica is not included at present due to poor agreement by different methods and analysts.*

*SiO_2-----3.60%

Determination by J. R. Landrum, Chemist, Georgia Department of Mines, Mining and Geology.

In the Basic Data 1, P_2O_5 determinations for selected drill holes are listed. Southern Testing and Research Laboratories, Wilson, North Carolina, performed the analyses. Approximately one pound of raw sample was submitted for P_2O_5 analysis only. The sample as received was split, oven-dried, and treated with nitric-hydrochloric acid mixture. No washing was performed, other than that originally received by the sample in the slurry as it came from the subsurface.

Considering present plant techniques, the writer arbitrarily selected all zones in holes having 9 percent P_2O_5 (19.7 percent BPL) or greater, as having commercial possibilities. Percent BPL, or bone phosphate of lime, is used as a standard in the fertilizer industry, and is equal to percent P_2O_5 x 2.185.

In addition to the P_2O_5 determinations, four holes -- E45, E46, E54 and E69 -- were selected for additional information. Wet chemical analyses were calculated for the phosphorite interval using washed samples retained on a standard 200-mesh sieve (Table 2).

A comparison of washed and unwashed samples from holes E34, E45 and E46 is shown in Table 3. Results of P_2O_5 content in unwashed samples are from Southern Testing and Research Laboratories; those from washed samples were furnished by the Department of Mines, Mining and Geology. The results are slightly erratic. Hole E45, for example, shows a general decrease in P_2O_5 upon removal of slimes of more than three percent. On the other hand, E46, located about one mile north of E45 (Plate I), showed nearly opposite results. Removal of slimes in these samples produced a general increase in P_2O_5 of more than four percent. With most of the samples there seems to be a relatively small percentage of P_2O_5 within the finer material.

Table 2. Chemical analyses of washed, plus-200-mesh samples

Hole (Plate I)	Phosphorite interval (feet)	P_2O_5 (percent)	CaO (percent)	$Fe_2O_3 + Al_2O_3$ (percent)	SiO_2 (percent)
E45	25-30	12.51	17.90	2.06	61.21
	30-35	11.13	17.70	2.41	64.32
	35-40	9.94	14.70	1.56	70.91
	40-45	11.82	18.20	3.22	60.71
	45-50	11.77	18.00	1.75	64.97
	50-55	13.20	20.20	2.63	59.11
	55-60	8.07	11.50	1.64	75.57
	60-65	8.39	12.00	5.55	67.80
E46	30-35	6.20	8.90	2.08	80.63
	35-40	5.08	7.70	1.87	83.88
	40-45	8.42	14.00	2.30	69.10
	45-50	11.06	16.00	1.94	64.88
	50-55	12.25	18.20	1.61	62.77
	55-60	13.29	21.40	1.95	57.07
	60-65	11.83	17.80	2.84	61.54
	65-70	12.51	21.00	2.83	54.01
	70-75	10.57	23.10	1.83	44.44
	75-80	5.67	21.00	2.79	46.46
E54	20-25	1.48	1.88	3.71	84.82
	25-30	1.47	2.05	2.12	91.11
	30-35	1.85	2.65	1.00	93.12
	35-40	6.17	9.10	1.89	79.56
	40-45	6.42	9.90	1.39	79.36
	45-50	6.61	9.80	1.37	78.68
	50-55	9.90	15.10	1.78	67.12
	55-60	11.61	17.80	2.48	61.46
	60-65	11.80	18.80	2.09	59.60
	65-70	8.06	16.60	1.03	60.71
	70-75	4.88	10.70	1.63	71.86
E69	40-45	5.84	7.55	7.02	69.39
	45-50	9.27	13.48	6.92	60.52
	50-55	7.87	11.60	5.98	66.44
	55-60	5.66	10.50	4.25	69.07
	60-65	3.69	13.88	2.18	59.06
	65-70	3.42	15.55	2.70	53.10

Note: Determinations by J. R. Landrum, Georgia Department of Mines, Mining and Geology.

Table 3. Comparison of percent P_2O_5 content in unwashed samples and washed phosphorite samples retained on a 200-mesh sieve

Hole	Depth interval	Southern Testing unwashed	Georgia Department of Mines washed	Percent difference from unwashed
E34*	70-75	9.15	12.61	+3.46
	75-80	7.60	10.03	+2.73
E45	25-30	11.50	12.51	+1.01
	30-35	11.43	11.13	-0.30
	35-40	11.25	9.94	-1.31
	40-45	13.25	11.82	-1.43
	45-50	14.63	11.77	-2.86
	50-55	16.53	13.20	-3.33
	55-60	7.60	8.07	+0.47
	60-65	8.75	8.39	-0.36
E46	30-35	6.80	6.20	-0.60
	35-40	5.92	5.08	-0.84
	40-45	9.15	8.42	-0.73
	45-50	9.50	11.06	+1.56
	50-55	10.60	12.25	+1.65
	55-60	10.09	13.29	+3.20
	60-65	12.70	11.83	-1.87
	65-70	8.25	12.51	+4.26
	70-75	6.50	10.57	+4.07
	75-80	3.04	5.67	+2.63

*Comparison made only on highest P_2O_5 values within phosphate interval 45-85 feet in E34.

The validity of obtaining drill cuttings versus cores was checked by FMC Corporation. Several holes were cored by FMC from top to bottom, some being offset less than 100 feet from a Southern Railway drill hole. The results of one comparison (Table 4) indicate less than two percent average variation between P_2O_5 values for the same intervals in cored and drilled holes. Southern Railway drill hole E3 showed an average 6.7 percent P_2O_5 for the upper half, compared to 5.3 percent for the same interval in FMC-2. The lower half of E3, with an average 5.9 percent P_2O_5, compared closely to the 5.8 percent for FMC-2. These averages indicate a slight increase in P_2O_5 as a result of obtaining drill cuttings rather than cores. Formational differences might account for the variation between the two holes. But it indicates more likely the probable absence of significant phosphate content in the slimes.

Table 4. Comparison of core and cuttings analyses

Southern Railway Drill Hole E3

Depth (feet)	P_2O_5 (percent)	Interval	Interval
35			
	6.5		
40			
	No assay		
45			
	No assay		
50			
	2.8	35' @ 6.7%	
55			
	8.6		
60			
	9.9		
65			
	6.0		70' @ 6.30%
70			
	5.6		
75			
	5.4		
80			
	5.4		
85			
	5.5	35' @ 5.9%	
90			
	8.3		
95			
	6.8		
100			
	4.7		
105			

FMC Corporation Core Hole FMC-2

Depth (feet)	P_2O_5 (percent)	Interval	Interval
36			
	7.88		
38.5			
	8.75		
41			
	1.80		
44			
	1.25		
46.5			
	1.60		
49			
	2.13	35' @ 5.30%	
53.5			
	3.12		
56.5			
	11.88		
59.0			
	Lost		
60.0			
	8.88		
63			
	9.50		
66			
	2.43		68.5' @ 5.58%
68.5			
	4.40		
71			
	6.18		
73			
	5.57		
75.5			
	7.38		
77.5			
	4.00		
80			
81	Lost		
	5.57		
84			
	Lost		
85.5		33.5' @ 5.80%	
	5.60		
89			
	5.28		
92			
93	Lost		
	5.57		
96			
	8.25		
99			
	5.13		
101			
	5.41		
104.5			

Note: FMC-2 data furnished through courtesy of FMC Corporation, Pocatello, Idaho.

GENERAL GEOLOGY

The four-county area of investigation is located in extreme South Georgia along the Georgia-Florida state line (Figure 1). The area lies entirely within the Atlantic Coastal Plain and contains surface rock units ranging from approximately middle Miocene through middle Pleistocene in age.

Pleistocene marine terrace materials blanket nearly the entire project area, but in most drill holes do not exceed ten feet in thickness. The occurrence of definite Pliocene age sediments in the study area has not been proven, mainly due to lack of any diagnostic fossils. In fact, the nearest known Pliocene material is located in the Occidental Corporation phosphate mine in Hamilton County, Florida (Plate I). The Hawthorn Formation of middle Miocene age is exposed in eastern Lowndes and western Echols Counties. Exposures along the Alapaha River at the Georgia-Florida state line may be older than the Hawthorn.

The composition and distribution of the Miocene sediments in the study area are related to two main structural features. They are the Withlacoochee Anticline (Veatch and Stephenson, 1911, pp. 62-65) and the Southeast Georgia Embayment (Toulmin, 1955). From subsurface data the writer calculated for the Embayment an average regional dip of about ten feet per mile to the northeast. Sand- and silt-sized clastics were deposited on the east flank of the Withlacoochee Anticline (Plate V) in western Echols County. Increasing amounts of clay minerals were deposited to the northeast and east.

Nearly all the streams in the four-county area flow into the Suwannee River which, in turn, flows into the Gulf of Mexico. The Alapaha River is the main tributary of the Suwannee. In southern Charlton County where the

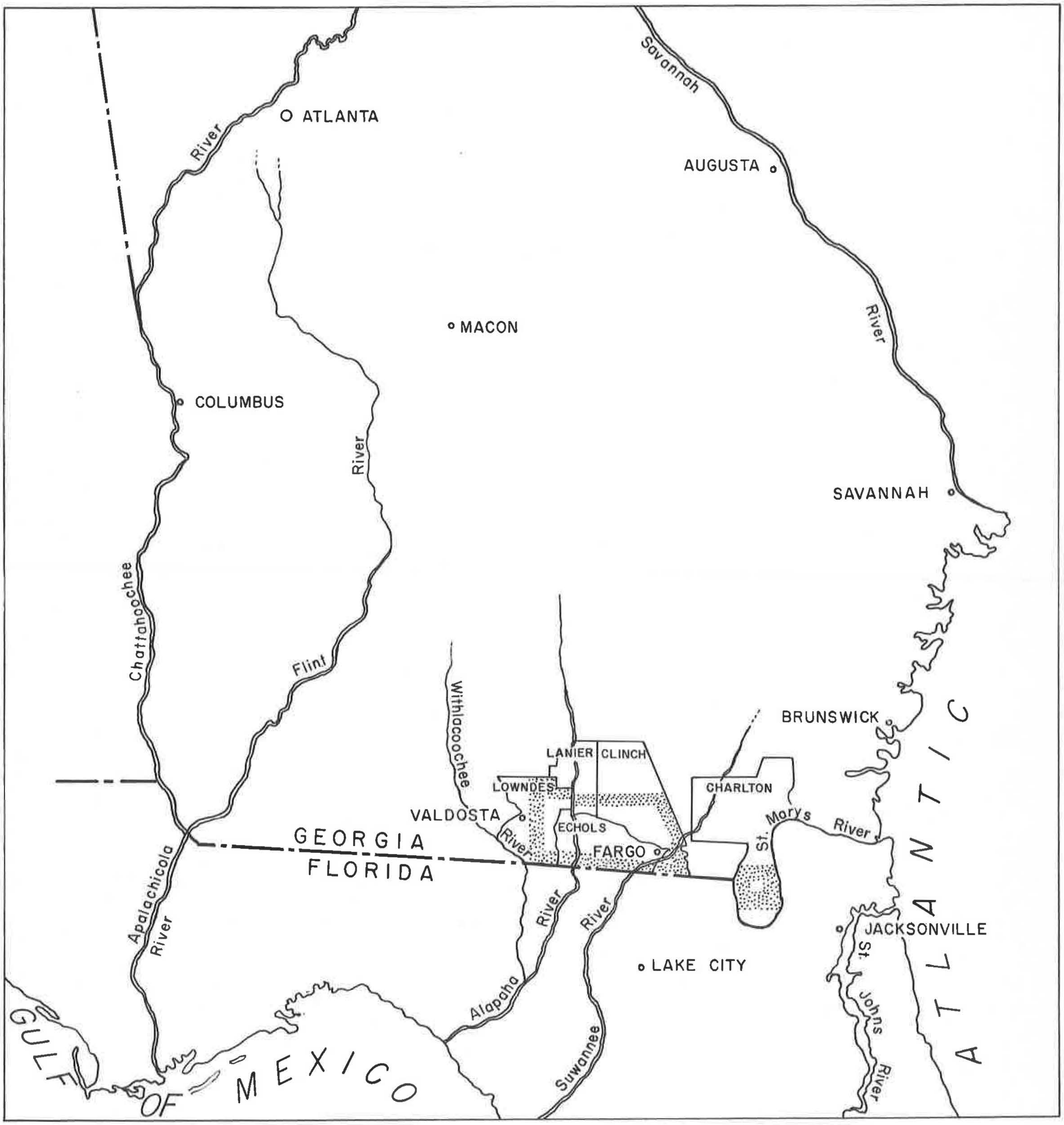

FIGURE I. SOUTH GEORGIA AND NORTH FLORIDA SHOWING AREA OF INVESTIGATION.

drainage is controlled by the presence of Trail Ridge, streams flow toward the St. Mary's River. Tributaries to these major streams show a rectangular pattern, and even the Suwannee River shows a remarkable gross pattern of intersecting rectangular segments (Plate V).

STRATIGRAPHY

General statement

Lithologic units encountered in drill holes in the four-county area belong to the Oligocene, Miocene, Pliocene(?) and Pleistocene Series (Plate II). Phosphorite is found in varying amounts within nearly the entire Miocene sequence. Some near-surface, loosely consolidated, reworked sediments covering most of the area are thought to be post-Miocene by the writer. Pleistocene marine sands are thickest in Charlton County.

The earliest geologic map of the Georgia Coastal Plain was produced by McCallie (1908). Various ages and names have been assigned since then to the formations exposed in the four-county project area. They are summarized from each of the authors' maps in Table 5.

Veatch and Stephenson (1911), however, made the first subdivision of the Tertiary and Quaternary age sediments. They mapped most of the Lowndes-Echols-Clinch county area nearest the Florida line as Alum Bluff Formation (approximately late Oligocene age). They extended these exposures northward on their map along nearly all the stream valleys. The remainder of the three-county area was mapped as "Altamaha (Lafayette?) Formation (Pliocene?)." Charlton County is shown almost entirely as Pleistocene age material.

The present State Geologic Map of Georgia (Cooke, in Stose and others, 1939) shows a large portion of the Coastal Plain as Hawthorn Formation. In Georgia no subdivision of the middle Miocene has been applied. Phosphatic material is found throughout the project area in those portions mapped as Hawthorn. A definite need exists for detailed work in stratigraphy, sedimentology and clay mineralogy of the broad area in Georgia covered by this

Table 5. Summary of mapped formations in project area

System	Series	McCallie (1908)	Veatch and Stephenson (1911)	Vaughan and others, in Stephenson and Veatch (1914)	Shearer (1917)	Cooke (1943)	MacNeil (1947)	MacNeil (1950)
Quaternary	Pleistocene							
			Okefenokee and Satilla Fms.	Satilla and Okefenokee Fms.	(Not mapped)		Marine features (Qmf) Older terraced surfaces (QP)	Wicomico Shore Line (100') Okefenokee Shore Line (150')
						Sunderland Fm. (170') Coharie Fm. (215')		High terrace
		Undifferentiated Oligocene, Miocene and Pliocene		Undifferentiated Oligocene to Pleistocene inclusive				
Tertiary	Pliocene		Altamaha (Lafayette?) Fm.					
	Miocene		Alum Bluff Fm.	Alum Bluff Fm.	Alum Bluff Fm.	Hawthorn Fm.	Duplin Marl and Hawthorn Fm. (Mhd)	
			Chattahoochee Fm.	Chattahoochee Fm.	Chattahoochee Ls.		Chipola Fm. and Tampa Ls. (Mtc)	
	Oligocene	Vicksburg-				Suwannee Ls.		
	Eocene	Jackson Fm.						

formation. Clay minerals investigations by Professor C. E. Weaver, Department of Earth Science, Georgia Institute of Technology (oral communication, 1966), should provide valuable clues to an understanding of the geologic events during Miocene time. Additional important subsurface exploration is in progress by the Mineral Engineering Branch, Georgia Institute of Technology. Their project is under contract from the State Department of Mines, Mining and Geology (Professor J. E. Husted, oral communication, 1965).

A total of 13 holes, ranging in depth from about 120 to 300 feet, were drilled in four parallel alignments for stratigraphic and structural information (Plate I). A comparison of general lithology can be made from the driller's logs listed in Basic Data 2.

Lower Miocene

The aim in this study, for purposes of the Geologic cross-sections (Plate II), was to establish both surface and subsurface control on the phosphorite interval. Altitudes on selected holes easily provided the former, but a persistent "marker bed" was needed for the subsurface.

The goal of each stratigraphic test was to obtain samples from the lower Miocene rocks. Fossils are scarce and so in this study the writer used a widely distributed dolomitic limestone. It is distinctive in its combination of being pale yellowish-brown, sucrosic, and hard; and in certain areas it is pitted (e.g., E6, CL2, CL3, CL6). Herrick (1961) and Applin and Applin (1964) also reported this lithology, at comparable depths, and in nearly all cases both authors placed it in the lower portion of the Miocene (Table 6). "Brown limestone" is also reported in the driller's logs for stratigraphic holes L14, E39, CL15, and LA1, but these have not been closely studied for comparison with the others.

Table 6. Summary of Tertiary subsurface data in Georgia from other reports

Author	County: Well	Approximate altitude	Stratigraphic interval and thickness		Phosphatic interval	Yellowish-brown, sucrosic, dolomitic limestone; lower Miocene(?)-Tampa(?)	Total depth
Modified from Herrick (1961)	Charlton: GGS 93	120	Pliocene to Recent Miocene undivided	0-82 = 82 82-270 = 188	39-50; 60-270	220-236	270 (In Miocene undivided)
	Charlton: GGS 185	75	In Pliocene to Recent Miocene undivided No samples	90-100 = 10 100-455 = 355+ 455-517 = 72	115-258; 278-430	286-307	554 (In upper Eocene Ocala Limestone)
	Charlton: GGS 453	80	Pliocene to Recent Miocene undivided Upper Eocene	0-120 = 120 120-520 = 400 520-650 = 130	120-310; 340-380; 395-470; 500-520	340-380	650 (In upper Eocene Ocala Limestone)
	Clinch: GGS 86	187	In Pliocene to Recent Miocene undivided	10-100 = 90 100-180 = 80	40-160	Not reported	180 (In Miocene undivided)
	Clinch: GGS 124	187	In Miocene undivided Oligocene undivided	248-445 = 197 445-520 = 75	274-325; 350-360	370-445	1,507 (In middle Eocene Claiborne Group)
	Echols: GGS 189	175	No samples In Miocene undivided Oligocene undivided	0-170 = 170 170-245 = 75 245-440 = 195	170-210	210-220	4,100+ (In Tuscaloosa Formation)
	Lowndes: GGS 15	236	Pliocene to Recent Miocene undivided Oligocene undivided	0-70 = 70 70-228 = 158 228-375 = 147	75-130	205-228	425 (In upper Eocene Ocala Limestone)

Note: All units of measurement are in feet; altitudes in feet above mean sea level.

(Continued)

Table 6 (Continued). Summary of Tertiary subsurface data in Georgia from other reports

Author	County: Well	Approximate altitude	Stratigraphic interval and thickness		Phosphatic interval	Yellowish-brown, sucrosic, dolomitic limestone; lower Miocene(?)-Tampa(?)	Total depth
Modified from Herrick (1961)	Lowndes: GGS 27	250	In Pliocene to Recent Miocene undivided Oligocene undivided	10-60 = 50 60-180 = 120 180-380 = 200	60-100	140-180	400 (In upper Eocene Ocala Limestone)
	Lowndes: GGS 40	Not listed	Pliocene to Recent Miocene undivided	0-40 = 40 40-200 = 160	40-100	Not reported	200 (In Miocene undi-vided)
	Lowndes: GGS 42	Not listed	Pliocene to Recent Miocene undivided Oligocene undivided	0-40 = 40 40-160 = 120 160-220 = 60	40-140	Not reported	220 (In Oligocene undivided)
	Lowndes: GGS 47	Not listed	In Pliocene to Recent Miocene undivided	10-20 = 10 20-220 = 200	20-100	120-220	220 (In Oligocene undivided)
	Lowndes: GGS 78	251	Pliocene to Recent Miocene undivided In Oligocene undivided	0-60 = 60 60-180 = 120 180-278 = 98	60-80; 100-140	Not reported	278 (In Oligocene undivided)
	Lowndes: GGS 79	250	Pliocene to Recent Miocene undivided In Oligocene undivided	0-40 = 40 40-180 = 140 180-200 = 20	50-90; 120-180	180-200	200 (In Oligocene undivided)
	Lowndes: GGS 173	230	Pliocene to Recent Miocene undivided Oligocene undivided	0-90 = 90 90-195 = 105 195-370 = 175	90-110	190-205	818 (In middle Eocene Claiborne Group)
	Lowndes: GGS 179	145	Pliocene to Recent Miocene(?) undivided No samples In Oligocene undivided	0-60 = 60 60-75 = 15 75-95 = 20 95-208 = 113	No phosphate	Not reported	208 (In Oligocene undivided)

(Continued)

Table 6 (Continued). Summary of Tertiary subsurface data in Georgia from other reports

Author	County: Well	Approximate altitude	Stratigraphic interval and thickness		Phosphatic interval	Yellowish-brown, sucrosic, dolomitic limestone; lower Miocene(?)-Tampa(?)	Total depth
Modified from Herrick (1961)	Lowndes: GGS 182	202	Pliocene to Recent Miocene undivided Oligocene undivided	0-45 = 45 45-175 = 130 175-248 = 73	55-70; 95-115	150-160; 175-200 (Gradational contact with Oligocene?)	248 (In Oligocene undivided)
	Lowndes: GGS 198	Not listed	No samples In Miocene undivided Oligocene undivided	0-176 = 176 176-207 = 31 207-361 = 154	No samples	192-207	361 (In Oligocene undivided)
	Lowndes: GGS 356	Not listed	Pliocene to Recent Miocene undivided	0-55 = 55 55-150 = 95	60-100	140-150+?	150 (In Miocene undivided)
	Lowndes: GGS 404	Not listed	Pliocene to Recent Miocene undivided Oligocene undivided	0-52 = 52 52-180 = 128 180-316 = 136	60-107	150-160	316 (In Oligocene undivided)
	Lowndes: GGS 412	250	Pliocene to Recent Miocene undivided Oligocene undivided	0-70 = 70 70-236 = 166 236-363 = 127	70-118; 123-175	207-226	500 (In upper Eocene Ocala Limestone)
	Lowndes: GGS 500	250	Pliocene to Recent Miocene undivided Oligocene undivided	0-50 = 50 50-180 = 130 180-375 = 195	50-100	170-180	400 (In upper Eocene Ocala Limestone)
	Lowndes: GGS 511	Not listed	Pliocene to Recent Miocene undivided No samples In Oligocene undivided	0-70 = 70 70-210 = 140 210-220 = 10 220-375 = 155	70-80	190-210; 210-220 (No samples)	400 (In upper Eocene Ocala Limestone)

(Continued)

Table 6 (Concluded). Summary of Tertiary subsurface data in Georgia from other reports

Author	County: Well	Approximate altitude	Stratigraphic interval and thickness		Phosphatic interval	Yellowish-brown, sucrosic, dolomitic limestone; lower Miocene(?)-Tampa(?)	Total depth
Modified from Applin and Applin (1964)	Charlton: GGS 185	75	No samples	0-90 = 90	115-125; 138-416	Absent (may be present at 416-430)	554 (In upper Eocene Ocala Limestone)
			In Miocene undivided	90-416 = 326			
			Oligocene absent				
			No samples	416-430 = 14	No samples: 0-90, 128-138; 149-158; 215-225, 317-327; 416-430		
			Upper Eocene	430-554 = 124			
	Lowndes: GGS 182	202	Miocene undivided	5-165 = 160	Absent	165-190 (Four faunal types present)	248 (In upper Oligocene Suwannee Limestone)
			Lower Miocene (Tampa Limestone)	165-190 = 25			
			Upper Oligocene	190-205 = 15			
			No samples	205-248 = 43			

The dolomitic limestone unit is probably the equivalent of the Tampa Formation, but only in part. The top of the lower Miocene, then, may well be above the dolomitic limestone, but further evidence, based in part on paleontology and sedimentology, is needed. Herrick and Vorhis (1963, p. 66) commented on a carbonate rock unit overlying the dolomitic limestone as follows: "The age of the phosphate-bearing limestone at the base of the Miocene in southeastern Georgia and adjacent parts of South Carolina is uncertain." The authors feel there is a possibility of its being late Oligocene.

Subsurface descriptions by Herrick (1961) and Applin and Applin (1964) on the lower Miocene were checked by the writer and are summarized for the area as a part of Table 6.

Middle Miocene(?) "Hawthorn" Formation

Cooke (1944) extended the name "Hawthorn" Formation into Georgia from already established localities in Florida. Prior to Cooke's work, the accepted geologic map (Veatch and Stephenson, 1911) showed most of the project area as Altamaha (Lafayette?) Formation of Pliocene(?) age. The sedimentary sequence was possibly already in its first stage of controversy.

Dall (1892) applied the name "Hawthorne beds" to several Miocene exposures, earlier described in part by L. C. Johnson, in the vicinity of Hawthorne, Florida. Puri and Vernon (1964, p. 145) pointed out that there is no valid type locality for the Hawthorn Formation. They considered the sections at Devil's Mill Hopper (Alachua County) and Brooks Sink (Bradford County) as being "closest to the type area and should form the basis of later correlation." A minor point is that the town of Hawthorne (Alachua County) now uses the original spelling that Dall applied when he first proposed the rock unit name.

Puri (1953, p. 38) in his study of the Florida panhandle, divided the entire Miocene sequence into three stages -- Tampa, Alum Bluff and Choctawhatchee -- from oldest to youngest. The Alum Bluff, bounded by unconformities, is further subdivided into four lithofacies -- Hawthorn, Chipola, Oak Grove and Shoal River. The Chipola is considered the downdip, or marine, equivalent of the nonmarine Hawthorn. According to Keroher and others (1966, p. 779), the preferred usage is Chipola Formation (of the Alum Bluff Group), and it is considered lower Miocene in age.

In later studies of North Florida, Espenshade and Spencer (1963) described the upper portion of the Hawthorn as terrestrial, the lower part as marine.

Age

Druid Wilson, Miocene specialist for the Paleontology and Stratigraphy Branch, U. S. Geological Survey (personal communication, 1966), has evidence for a possible early Miocene age for the Hawthorn and Chipola Formations.

Lithology

The Hawthorn Formation everywhere at the surface consists of weathered sandy clays and clayey sands. They are mottled in various hues of red, purple, yellow and brown because of varying amounts and types of iron oxide left by the ground water, the principal agent during decomposition. Within the four-county area the total thickness of the Hawthorn can best be generalized from the stratigraphic test holes (Plate I). The thickness ranges from 100 feet to more than 275 feet. Lithologic descriptions are given in Basic Data 2. An isopach map prepared by Toulmin (1952, p. 1173) shows the total thickness of the Miocene sediments increasing from about 150 feet in Lowndes County to about 350 feet in Charlton County.

Clay minerals (-200 mesh fraction) from a few cores in eastern Echols and southern Clinch Counties were identified by X-ray diffraction (J. B. Cathcart, written communication, 1965). Montmorillonite was found to be predominant in CL38 but minor in E34 (Plate I). South of Fargo minor amounts of attapulgite and mixed-layer attapulgite and montmorillonite were found in CL36 and CL37. Near the surface and in outcrops the montmorillonite has been altered to kaolinite. Dolomite was reported as significant in E34, CL36 and CL37. Quartz was present in all samples checked, but apatite was absent except for a trace in CL36 and CL38.

Quartz sand is almost universally found within the carbonate sequences as well as the predominantly clay intervals. The quartz grains are clear, generally subangular to subrounded, and are mostly medium-grained ($\frac{1}{2}$-$\frac{1}{4}$ mm) to coarse-grained (1-$\frac{1}{2}$ mm). The sand grains are well sorted, typical of a beach sand. When found in the limestone and dolomite layers, these grains are generally abundant and notably coarse-grained. The pitted surface of the drill cuttings is most likely due to removal of the quartz.

Limestone and dolomitic limestone are common within the lower portion of the Hawthorn. Much of the limestone is very friable, and when wetted is quite pasty in texture and appearance. Dolomitic limestone, within the lower part of the Hawthorn is typically harder. Interlaminated silty limestone and clear quartz grains were noted in CL2 between 145 and 170 feet (note description in Basic Data 2). Thin, apparently discontinuous, layers less than one foot thick are found beginning in the middle portion.

Chert was noted in at least 17 drill holes, and in all but two of them the first influx of chert in the cuttings occurred before any limestone was encountered. The thickness of these layers varied from a few inches to about two feet.

Distribution

The Hawthorn Formation is exposed within the four-county area only in southeastern and western Lowndes County, and in the western one-third of Echols County. However, it was encountered in the subsurface in all drill holes except most of those drilled in Charlton County. In Figure 2, a generalized section (D-D') shows the distribution of the predominant lithology from eastern Lowndes County to the Okefenokee Swamp.

Quartz sand with minor amounts of clay is common in western Echols County and a few parts of eastern Lowndes County. East of Haylow (Plate I and Figure 2), the quartz sand content diminishes and does not increase eastward until its irregular presence east of Headlight in holes CL5 and CL15.

Distribution of individual species of clay minerals is beyond the scope of this report, but some cursory observations can be made in addition to the few X-ray determinations. In the western portion of the study area (Figure 2), kaolinite (at or near the surface) and montmorillonite appear to be dominant. In the eastern portion, these same minerals are present with the addition of mixed-layer montmorillonite and attapulgite. In E1 and CL3 green, non-plastic clay, with gross properties similar to those of known attapulgite, was noted below 225 feet.

Limestone layers were encountered in portions of southwestern Echols and southeastern Lowndes Counties at depths of 45 to 50 feet. Thin limestone beds can be seen exposed during the dry season of the year along the Alapaha River west of Statenville. In the eastern portion of the project area, the uppermost limestone layers occur between 60 and 80 feet below the surface. Massive limestone was encountered in the eastern portion in the deeper stratigraphic test holes at variable depths from 75 to 155 feet.

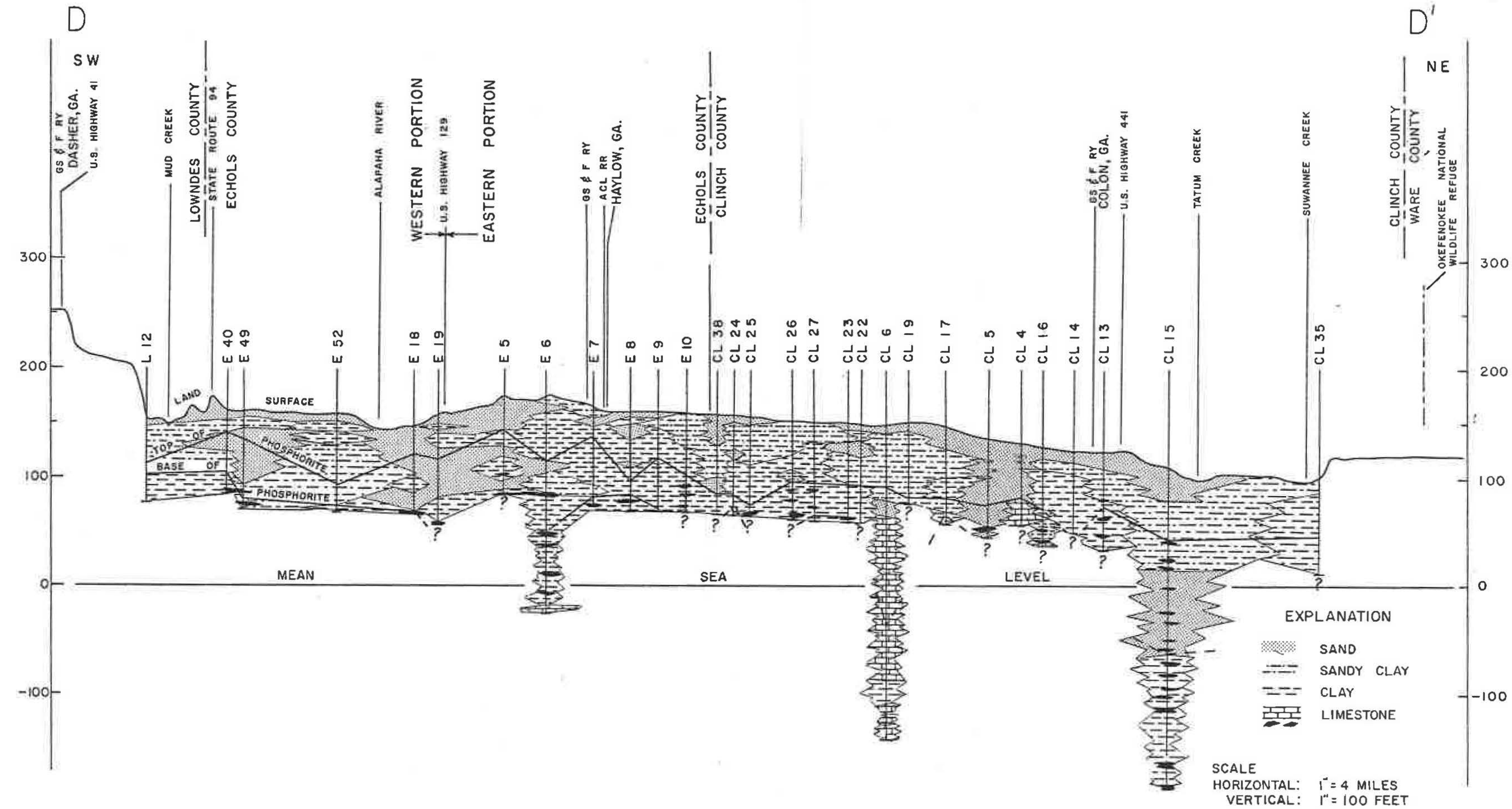

FIGURE 2. DIAGRAMMATIC SECTION D – D' SHOWING RELATIONSHIPS OF PHOSPHORITE AND ASSOCIATED LITHOLOGY BETWEEN WESTERN AND EASTERN PORTIONS OF PROJECT AREA.

Upper Miocene

The presence of late Miocene age material has been determined more successfully from vertebrate rather than invertebrate fossil remains. Late Miocene fossils which are nearest to the Georgia state line were reported by Olsen (1963) and Yon (1965). They discovered fossil mammal teeth near Ashville, in northeastern Jefferson County, Florida, about three miles south of the Georgia-Florida state line. Approximately 30 horse teeth (Merychippus sp.) and one rhinoceras molar (Diceratherium sp.) were identified by Olsen as late Miocene in age. Yon (1965, p. 169) has related that "they are important because they represent the only known late Miocene vertebrate locality in Florida."

Post-Miocene

Unconsolidated Pleistocene quartz sand is distributed over nearly the entire project area (Cooke, 1943). The clear quartz grains are a typically well sorted beach sand, and contain accessory amounts of feldspar and kaolin near the surface. In Lowndes, Echols and Clinch Counties, the material is of a fairly uniform thickness, averaging 10 feet. In Charlton County this sand occupies probably the upper 40 feet; sediments in the lower portion of the holes conform to the descriptions given by Herrick (1965, p. 7) as Pliocene(?) age material. The top of the Miocene in this area northwest of St. George is apparently 100 feet or more beneath land surface.

STRUCTURE

General statement

Two structural elements, the Withlacoochee Anticline and the Southeast Georgia Embayment are noted within the four-county area. A minor anticlinal fold with a north-south axial trace may be present at Statenville (Plate V). Relationship of the positive structural features to the Ocala uplift is discussed. A detailed structural analysis is considered beyond the scope of this report, but future work combining careful stratigraphic correlation and geophysical work is considered highly desirable.

Veatch suspected structural deformation in the southern Georgia Coastal Plain (Veatch and Stephenson, 1911, pp. 62-65). He was the first to record his observations of the interrelationship of geologic structure to present-day stream patterns and selected altitudes in this area. "There is also physiographic and geologic evidence of a low fold or arch ... in the area drained by Ocklockonee, Withlacoochee and Alapaha Rivers, and extending along the Florida line from Decatur to Echols Counties and northward to Crisp and Wilcox Counties." Veatch named this feature the Withlacoochee Anticline for the river which forms the western boundary of Lowndes County and flows southward along the middle of the fold (Plate V).

Pressler (1947, p. 1853) designated an anticline with a southeastward plunge which he called the Central Georgia uplift. He located the axial trace on his map to the east of the Withlacoochee Anticline. Pressler related, from north to south, the Central Georgia uplift and Ocala uplift to the eastern rim islands of the Bahama group. The latter he termed the Bahama uplift.

The major negative feature in southeast Georgia has been known by various names. Pressler (1947) used the term Okefenokee Embayment for a part of the area, and stated that it "is probably a part of a more pronounced downwarped area or embayment at the north." Toulmin (1955, p. 209) named the structure the Southeast Georgia Embayment. Herrick and Vorhis (1963, p. 55) proposed the name Atlantic Embayment of Georgia, based upon the similarity of its fossils to the present Atlantic Ocean assemblage. The writer prefers Southeast Georgia Embayment which not only includes the entire structural feature but also is a slightly shorter term.

Formations throughout the project area have a very low dip, generally to the east and northeast, and all at considerably less than one-half degree. Apparent dips ranging from 4.0 to 11.9 feet per mile to the northeast were calculated for the lower portion of the Miocene in eastern Echols and southern Clinch Counties. This range is slightly greater than the generalized dip given for the top of the Oligocene (Herrick and Vorhis, 1963, p. 56). The top of the widely distributed yellowish-brown, sucrosic, dolomitic limestone unit was used as a datum (Table 6). The writer recognizes that this limestone could well be a lithofacies of one or more time-rock units to the west. In fact, it is almost certain that this area, in particular, is not one of simple, stratiform lithologies. Such dips are therefore subject to revision with more detailed work.

Withlacoochee Anticline

As surface indicators of a geologic structure, anomalous stream patterns are certainly not conclusive, but structure does influence the geomorphology of an area. Therefore, Veatch was employing a geologic tool that is still useful today. In addition, Herrick and Vorhis (1963, p. 12) show a positive area, coinciding with the Withlacoochee Anticline, on their structure contour map of the top of the Oligocene rocks. In this investigation the absence of phosphorite in northeastern Lowndes County (Plate I -- holes L6, L7, L13, and L14) is also significant. Circulation of drilling fluid was lost in L13 and at a depth of 155 feet or an altitude of 70 feet. This altitude compares favorably as being the top of the Oligocene when placed upon the structure contour map of Herrick and Vorhis. In addition, Herrick (oral communication, 1966) identified the top of the Oligocene in drill hole E45 at a depth of 100 feet (Plate II).

A chronological sequence of structure contour maps by Herrick and Vorhis (1963) shows the following changes:

(1) By the end of middle Eocene time (p. 26), there was a southwest plunging syncline, with an east flank passing through northwestern Lowndes and eastern Brooks Counties.

(2) By the end of late Eocene time (p. 20), the axial trace of the middle Eocene syncline is shown as merely a "sag," or slightly depressed feature. The present-day course of the Withlacoochee River is located in this "sag."

(3) At the end of late Oligocene time (p. 12) the area included within Veatch's Withlacoochee Anticline was positive, except for a breached area in southern Brooks County. A convergence of two "zero line" contours is at about the northern terminus as noted by Veatch (1911, p. 63).

Southeast Georgia Embayment

This negative feature persisted the longest, and has remained consistently the largest, of any structural feature known in the Georgia Coastal Plain. Herrick and Vorhis (1963, p. 55) reported that on the basis of available evidence the Embayment "appears to have originated in middle Eocene time and continued as a depositional basin intermittently through Miocene time." The general dip of the sedimentary units to the east and northeast in Lowndes, Echols and Clinch Counties is because of the Southeast Georgia Embayment, the axis of which is northeast of the project area (Plate V).

Minor fold

At the west city limits of Statenville (Echols County), and southward along the Alapaha River, phosphorite is not only exposed, but partially eroded. It is also exposed in the banks of the Withlacoochee River on the western Lowndes County line south of Clyattville. Phosphorite is also exposed in those areas where meanders of the Suwannee River have become incised. If, indeed, the Withlacoochee River is flowing parallel to the axial trace of an anticline, then it is quite possible that the Alapaha River is doing likewise along an associated minor fold. Southward dips of 10 to 12 degrees can be recorded on thin-bedded limestone units at low water mark along the Alapaha River. These, however, are not true dips. The limestones crop out below the phosphorite, and the entire sequence is massively cross-bedded. Accurate structural data from these exposures are very difficult to obtain.

Preparation of a detailed structure map will help determine whether the Alapaha River is truly structurally controlled, or whether geomorphic processes have produced apparent relief in the phosphorite beds. An additional possibility is that all or part of the Alapaha River phosphorite is Pliocene, representing beds at or near the western limit of deposition.

Relations to Ocala uplift

In counties adjoining the project area, structural data from Georgia of Herrick and Vorhis (1963) may be compared with that of two Florida investigators.

Meyer (1963, p. 23) presented somewhat generalized cross-sections for Columbia County. This county adjoins southeastern Echols County and most of Clinch County. Meyer also showed on a structure map (Figure 9, p. 28) the top of beds of late Eocene age. A comparison with the similar map of Herrick and Vorhis (1963, p. 20) shows the waning influence of the Ocala uplift from Lake City northward. This is probably the reason for the reduction in slope of the southwest portion of the Southeast Georgia Embayment. Meyer also stated (p. 22) that for central Columbia County, "The thickening of beds of Miocene age northward suggests that uplift and contemporaneous deposition took place during post-Eocene time."

Vernon (1951, Plate 2) showed on his structure map the configuration of the Inglis Member, Moodys Branch Formation (Lower Jackson Group). No similar data for Georgia exist, but some structural trends can be projected into Georgia from Vernon's map and cross-sections (Figure 13, p. 54). For example, the Withlacoochee Anticline appears to be the northward extension of the main axial trace of the Ocala uplift. Another comparison shows structural highs west of Lake City and White Springs (Columbia County) and just west of High Springs (Alachua County) -- shown in Sections A-A' and B-B' (Figure 13) and depicted on the structure map (Plate 2). This northward-plunging minor fold from the Ocala uplift can be projected directly into the Statenville area. The axial trace, roughly parallel to the Alapaha River, becomes that of the minor fold previously noted by the writer.

GEOMORPHOLOGY

General statement

The four-county area studied lies within the Coastal Terraces physiographic division of Georgia (Cooke, 1925, p. 17). Altitudes range from greater than 225 feet in eastern Lowndes County to about 100 feet in southeastern Clinch County. The latter area, on the southwest edge of the Okefenokee Swamp, may be considered local base level. Within the study area, karst topography prevails in southeastern Lowndes and southwestern Echols Counties. Most of the entire project area is poorly drained, and generally of very low relief. Dominant physical features which provide clues to the occurrence of phosphorite in the South Georgia-North Florida area are sinkholes produced by solution of the underlying Suwannee Limestone of Oligocene age. Brief discussions are presented also concerning subsurface cavities and unusual thicknesses of phosphorite, stream patterns, and the influence of Trail Ridge in Charlton County.

Relations of karst topography to phosphorite occurrence

A careful inspection of the Valdosta sheet (USGS, 1:250,000), from which Plate I is taken, reveals an interesting pattern of lakes. The Georgia Southern and Florida Railway between Valdosta and Lake City forms a dividing line between a well-developed karst topography, containing abundant lakes, to the southwest; and a sharply decreased number of lakes and sinkholes to the northeast (C. W. Sever, oral communication, 1965).

The significant commercial phosphate discoveries so far have been made along a linear trend which parallels the northeast side of the railroad from south of Jasper, Florida, southward into Union and Bradford Counties.

Northward into Georgia, however, the pattern of lakes ends almost abruptly about five miles north of Valdosta. The rather discontinuous occurrences of commercial phosphorite take an apparent northward trend at about the intersection of the Alapaha River and the Georgia-Florida state line.

Subsurface cavities and unusual phosphorite thicknesses

Northeast of the Georgia Southern and Florida Railway more solution cavities were encountered but in the subsurface. In western Echols and eastern Lowndes Counties, the phosphorite was deposited upon the eroded surface of the Suwannee Limestone. There is little or no evidence of any lower Miocene or Tampa Formation equivalent present in this part of the study area.

Circulation of drilling fluid was lost in six drill holes, and only one (CL2) was located in the eastern portion of the project area. Excessive localized accumulations of phosphorite, interpreted as possible fillings in solution cavities and channels, were concentrated in the same western Echols-eastern Lowndes county area. Significantly, the phosphorite in holes adjacent to those mentioned was less than one-third as thick, or else a nearby hole was barren. Table 7 lists drill holes in which lost circulation occurred, and also those in which unusual thicknesses of phosphorite were found.

Stream patterns

Many observers have already noted the peculiar course of the Suwannee River. It heads in Okefenokee Swamp, flows generally S45W to a point a few miles south of the Georgia-Florida state line. Here its course changes rather abruptly to about S35E for approximately 12 miles, and then returns

Table 7. Solution cavities and probable cavity fillings encountered in drill holes

Drill hole		Depth of lost circulation (feet)	Anomalous thickness of phosphorite (feet)
	L10		45
L13		155	
	E18		52
	E32		65*
	E33		62
	E37		57
	E41		80*
E44		118	
	E46		55
	E49		55
	E54		50
E59		75	
E73		71	
E74		56	
	E77		42*
CL2		302	

*Indicates thickness greater than that shown.

to a southwesterly direction. Lineaments drawn for the Suwannee and its tributaries on the USGS Valdosta sheet (1:250,000) show a pronounced rectangular drainage (Plate V).

Over the crest of the Ocala uplift, the fault traces shown by Vernon in west-central Florida have a bearing of N45W (Vernon, 1951, Plate 2). Portions of the Suwannee and its tributaries in South Georgia and extreme North Florida, which divert a general southwesterly flow, have a bearing of approximately N35W. These same diversions change to about N55W farther south.

It is a well-known fact that joints, sinkholes and solution channels are commonly related in certain types of limestones. Limestone brought nearer to the surface by the Ocala uplift has become (1) fractured, and (2) dissolved. The map pattern of the Suwannee and its tributaries has been controlled quite likely by structural activity related to the Ocala uplift, and also by formation of joints (Plate V).

Other investigations

Professor H. K. Brooks (oral communication, 1966) has recently constructed a topographic relief model at the University of Florida of a portion of the North Florida-South Georgia area. The horizontal scale is approximately 1:125,000. The model reveals clearly the incised meanders of the Suwannee River and associated straths, or valleys deeply filled with alluvial deposits. Brooks has determined that the better phosphorite deposits are in areas near the Suwannee River associated with these straths. He has hypothesized an opposite former direction of flow for the Suwannee, based upon his studies. His evidence indicates that the topography of the region is very old, and that it has been little modified since early Pliocene time.

Influence of Trail Ridge

In Charlton County 12 holes were drilled to depths of 75 and 90 feet (Plate I). Driller's logs (Basic Data 2) compare favorably with lithologic sequences for the area shown by Herrick (1965, pp. 4-5). For example, the top of the coquina zone, near the bottom of drill holes CH3 and CH4, was encountered at about the same altitude as noted by Herrick as Pliocene(?) in his Section B-B'. Therefore, many of the other so-called "barren holes" in Charlton County (Plate I) are probably entirely within post-Miocene sediments.

Calver and Vernon (1949) stated that the high sand ridge, which includes Trail Ridge and the central highlands to the south, was originally a Pleistocene barrier island or similar feature. Trail Ridge, however, is now only a remnant of part of a delta plain and coastal geomorphologic complex, according to the authors.

PHOSPHORITE

General statement

Hard, concretionary phosphate in Georgia was first reported by J. W. Spencer, the third State Geologist, to the Governor in 1890. Commercial mining at the locality, three miles west of Boston (Thomas County), began in 1891 (Spencer, 1891, p. 82). McCallie later published a phosphate report on the entire South Georgia area in 1896. McCallie (1896, p. 94) concluded that other economic deposits were not likely in this area. Veatch and Stephenson (1911, p. 346) noted deposits of phosphate sand along the lower courses of the Suwannee and Alapaha Rivers and indicated that these deposits might someday be a source of low grade material. Mansfield (1942) and Espenshade and Spencer (1963) showed phosphate in Hamilton County, Florida, just south of the Georgia state line.

Phosphate particles are present in the Hawthorn Formation of middle Miocene age over a large area of South Georgia. Professor H. K. Brooks (oral communication, 1966) has pointed out that the phosphorite at Statenville is late Miocene, or possibly even Pliocene, in age. He has collected Pliocene land vertebrate remains from various localities in North Florida. Brooks previously had correlated on the basis of distinctive sedimentology and topographic relations, the phosphorite in the Occidental Corporation mine from the then known Pliocene (Plate I). This has recently been confirmed by the Neohipparion tooth collected by Professor David Webb, University of Florida. G. F. Moulton, Jr. (oral communication, 1965) located another Pliocene horse tooth from within a phosphorite core at 35 feet below land surface, two miles due north of Lulu, Florida (Plate I).

Beds of possibly economic phosphorite, that is, containing more than nine percent P_2O_5, in unwashed samples, are common in western Echols and eastern Lowndes Counties. Similar beds are uncommon or absent in the remainder of the four-county area. As a matter of convenience, U. S. Highway 129, north-south through Statenville (Plate I), will be a boundary separating the western and eastern portions of the four-county area. By this designation, phosphorite in these two parts will be contrasted (Figure 2).

Western portion

Gray and yellowish-brown phosphate deposits of marginal commercial grade occur within clear quartz sand intervals. Percentages of P_2O_5 are listed under Basic Data 1 and on the cross-sections (Plate II). Although many of the drill holes contain some economic phosphorite, there is one striking linear arrangement of such holes about four miles west of Statenville (Plate I). From north to south, they are holes E54, E46, E45, E62, and E69 (see Basic Data 1 for analyses). The nearest holes to all sides of this somewhat arcuate alignment contain phosphorite in reduced thickness, and in nearly all cases the phosphate particles are non-commercial.

Rapid changes in thickness of the phosphorite in the eastern Lowndes-western Echols area are shown in Plate II. Pebbles of quartz and phosphate within the same zones are abraded and sub-rounded. Some holes display two distinct zones of phosphorite. An upper zone is associated with relatively unconsolidated quartz sand with minor amounts of clay minerals. A lower zone is characterized by finer grained phosphate particles embedded in sandy clay or dolomitic limestone. It is possible that in these holes both Miocene and Pliocene phosphate particles are present.

Pebble-sized phosphate particles, retained on a 20-mesh screen, are typical of the western portion but are still uncommon. Where present, they are generally no more than 5 to 10 percent by volume in a sample, and ordinarily less than 5 percent. These pebble zones are commonly associated with coarse-grained quartz sand and pebbles which are rounded and translucent. In some cases, the phosphate pebbles have inner cores of pitted phosphatic limestone and merely an outer rim of concentrated phosphatic material. In other instances a broken phosphate pebble reveals small clear quartz grains. Both types contain impurities which lower the P_2O_5 content considerably. A discussion of weathering and secondary zonation of the phosphate pebbles and finer clastics has been presented by several authors for the west-central Florida district. A recent one, given by Altschuler and others (1964, pp. 34-36), may be applied to the South Georgia area as well.

Fine feed material, that is, passing a 35-mesh and retained on a 200-mesh screen, is the prevalent size grade in the western portion. The average concentration of these particles in the samples is about 10 to 15 percent by volume.

The volume of slimes (-200 mesh) varies widely in the samples, from 5 to more than 90 percent. An approximate weighted average, for the western portion, however, is about 20 percent based upon clay data from tests made by the Mineral Engineering Branch, Georgia Institute of Technology, for Project Report No. 2 (Husted and others, pp. 25-29). East of Statenville the clay minerals increase in volume and total thickness. The writer made no quantitative determinations of relative volume of slimes to the coarser fractions.

Phosphorite overburden ranges in thickness from zero, in exposures along the Alapaha River south of Statenville, to 70 feet in drill holes L5, L8, and L9, all located within six miles east of Valdosta (Plate III). Thickness of the phosphorite itself is quite variable, and ranges from zero, in stratigraphic test holes L6, L13, and L14 -- all north and east of Valdosta -- to more than 80 feet in E41 near the Echols-Lowndes county line just south of State Route 94 (Plate IV). An average range of thickness for the phosphorite in this portion is 20 to 40 feet.

As already mentioned, clear quartz sand is the predominant associated lithology in the zones containing commercial phosphate. In other holes there appears to be a direct relationship between increasing amounts of clay, identified as montmorillonite in several drill holes (Cathcart, written communication, 1965), and the lower grade phosphate. These phosphate pellets are generally black instead of gray or brown. Some phosphate particles are embedded in limestone, but the volume concentration within a given sample is minor.

The grain size and lateral distribution of the phosphate and its associated clastic material indicates deposition in an agitated, probably near-shore environment. On a sub-regional scale, the commercial phosphate deposits in South Georgia and North Florida are oriented northwest-southeast in a linear pattern which closely coincides with the alignment of the Georgia Southern and Florida Railway. It is quite possible this linear feature represents a middle Miocene (and possibly later) strand line upon which the coarse-grained quartz sand and phosphate were deposited. The quartz particles in the area of investigation are of nearly uniform size, representing a typical well-sorted beach sand. Along the Alapaha River in the vicinity of Statenville, phosphorite exposures contain shark teeth and poorly preserved marine shell fragments which further attest to the marine environment.

These clastics accumulated along the gently dipping east flank of the Withlacoochee Anticline (Veatch and Stephenson, 1911, p. 63), and a postulated parallel flexure to the east (Plate V). Phosphorite in this western portion was deposited upon a limestone surface which probably already contained many solution cavities and channels. Intertidal wave action, followed by active ground-water movement, was apparently the final agency to act upon the material.

Eastern portion

Fine-grained black phosphate particles are embedded in bluish-green, plastic, sandy clays throughout most of this portion of the project area (Figure 2). Very few drill holes were found containing economic phosphorite zones east and northeast of Statenville. The concentration of phosphate particles is notably lower than in the western portion; of the holes selected for P_2O_5 analyses on the basis of adequate concentration, only E2 and CL8 in the vicinity of Fargo (Plate I) showed zones of commercial phosphate (analyses in Basic Data 1).

Practically no pebble-sized phosphate (+20 mesh) was encountered in the holes of the eastern portion. A minor amount of pebble was noted, however, in thin zones below 100 feet in some of the stratigraphic test holes. Fine feed material is the dominant size grade. The higher concentrations of phosphate particles are confined primarily to the layers of sandy clay and loosely consolidated sandstone. The average concentration of phosphate within a given sample is about 10 percent by volume.

In drill holes showing phosphorite, the overburden thickens from 25 feet in drill holes E2 and CL3 west of Fargo, and in E7 and E15 west of Haylow, to 80 feet in CL25 south of Thelma (Plate III). It is quite certain that many of the 90-foot drill holes which were barren in the eastern portion would have encountered phosphorite had they been drilled deeper. The phosphorite ranges in thickness from zero (note symbols for the barren holes on Plate I) to 137 feet in CL2 northwest of Headlight, and 145 feet in E1 west of Fargo (Plate IV).

The phosphate and its associated sediments were deposited in a marine shelf environment that underwent several pulsations of relative subsidence and uplift. The controlling structural feature was the Southeast Georgia Embayment (Plate V) which had its axis to the northeast. In the early stages of phosphorite development there was alternate deposition of limestone and minor amounts of marl, with claystone and variable amounts of silt and sand. During the later stages, the phosphate particles were deposited more commonly with silty and sandy claystone and also some sandstone. In this later sequence limestone and phosphatic limestone were deposited in lenses or thin layers.

Figure 2 summarizes the relationships of overburden and phosphorite between the western and eastern portions of the four-county area. Section D-D' shows the progressive decline in altitude of the top of the phosphorite from west to east. The upper contact in the western portion is between 100 and 150 feet above sea level, and in the extreme eastern portion it is between 50 and 75 feet. Throughout the project area, information gained from conventional phosphate drill holes and deeper stratigraphic test holes shows a marked thickening of both overburden and phosphorite from southwest to northeast. The result can be described generally as a downward-tilted wedge of phosphorite.

Relationships among color, grade and mineralogy

Comments from geologists, mining engineers and others range from doubtful to certain when one discusses the relationship of percent P_2O_5 to color of the phosphate. Several observations which can be made are as follows:

(1) Colors of the phosphate particles are black, brown, yellowish-brown, various shades of gray, and white or nearly white. Particles are not necessarily segregated within the formation on the basis of color, for more than one color may be associated within the same depth interval.

(2) Lighter tints are uncommon in the subsurface but common to abundant in the phosphorite exposures. Some light colored material, however, was found in this study at a depth greater than 100 feet in relatively thin layers associated with clear, coarse-grained quartz sand.

(3) Almost without exception the phosphate embedded in clay minerals is black; that associated with coarse-grained to pebbly quartz sand is nearly always pale gray to white or light yellowish-brown. Intermediate colors are associated with variable mixtures of clay-, silt-, and sand-sized "host" material.

(4) P_2O_5 determinations presented herein (Basic Data 1) show definitely higher percentage values for zones containing lighter colored phosphate.

From the foregoing a logical deduction is that the phosphate particles undergo successive stages of enrichment, and a color change from black to white occurs, reaching maximum development in the more permeable zones of coarse-grained quartz sand and pebbles. In these latter intervals chemical weathering and leaching processes are most easily effected. Conversely, clay-rich zones severely inhibit vertical and lateral movement of water.

Hand-sorted samples of phosphate pebble material (+20 mesh) were collected by E. C. Pendery of Continental Oil Company from various drilling locations in South Georgia and North Florida. They were analyzed by J. B. Cathcart of the U. S. Geological Survey for both P_2O_5 and uranium content. Table 8 shows increases in percent P_2O_5 and U from black to white. Determinations by X-ray diffractometer on core samples from Echols and Clinch Counties show the phosphate mineral to be a carbonate fluorapatite as in the west-central Florida district (J. B. Cathcart, written communication, 1965).

The soft, dull, white phosphate particles near land surface are leached and contain wavellite and crandallite, according to Cathcart. These are the aluminum and calcium aluminum phosphate minerals, respectively. Altschuler and others (1964, p. 21) have summarized these mineralogic relationships in a diagrammatic cross-section.

According to Altschuler and others (1958), the precise chemical formula for carbonate fluorapatite is uncertain but a provisional one is as follows:

$$Ca_{10}(PO_4, CO_3)_6 F_{2-3}$$

In the formula carbonate ions substitute for phosphate ions, and the excess fluorine, according to the authors, serves to balance the charge difference when $(CO_3)^{-2}$ replaces $(PO_4)^{-3}$.

Table 8. P_2O_5 - U relationships to color of phosphate pebbles

Color of phosphate pebble (+20 mesh)	P_2O_5 content (percent)	U content (percent)
Black	26.0	0.006
Brown	32.7	0.009
White	34.1	0.009
Composite*	29.1	0.009

*Composite of pebble from Lowndes, Echols and Clinch Counties, Georgia.

In conclusion, the writer considers the use of color of phosphate particles as an approximate field indication of quality and no more. Pale gray, light yellowish-brown or white matrix is probably an indication of potentially commercial material. A metallurgical laboratory analysis offers the best positive results. On the other hand, dark gray to black particles in a concentration greater than 10 to 15 percent by volume should not be ignored.

SUMMARY AND CONCLUSIONS

Geologic and chemical data gained from drilling over 160 holes in Lowndes, Echols, Clinch and Charlton Counties showed presence of phosphorite in minable quantities about five miles west of Statenville (Echols County). Geologic information is of a reconnaissance nature only, being based upon drill holes spaced uniformly about a mile apart and drilled to depths of 75 and 90 feet. Chemical analyses were made on unwashed bulk samples from five-foot intervals, and in most cases consisted of a P_2O_5 determination only. Electric logs, plus some gamma-ray logs, provided an added tool for evaluating thickness and position of the phosphorite and associated lithology.

The phosphorite within the project area is found in the Hawthorn Formation of middle Miocene age. The upper portion of the Hawthorn consists mostly of varicolored sandy clay; from preliminary data, montmorillonite is the dominant clay mineral in the upper portion. The lower portion, below 70 feet, has mostly limestone and dolomitic limestone, generally with abundant quartz grains, and also clay and sandy clay; preliminary determinations show the dominant clay minerals to be mixed layer montmorillonite-attapulgite and dolomite. The thickness of the Hawthorn ranges from about 100 feet in western Echols County to more than 275 feet in southeastern Clinch County.

Distribution of the phosphorite appears to be primarily controlled by past structural activity in the South Georgia-North Florida area. The Withlacoochee Anticline and the Southeast Georgia Embayment are the dominant structural features. The positive features within the four-county area are quite likely a result of the Ocala uplift.

Karst topography, with its characteristic sinkholes and lakes, is well developed southwest of the Georgia Southern and Florida Railway between Valdosta and Lake City, Florida (Plate I). Northeast of the railroad there is a sharp reduction in the number of sinkholes. In eastern Lowndes and western Echols Counties, however, the foregoing features are still present in the subsurface as solution cavities. Some abnormal thicknesses of phosphorite in this same area (Plate IV) are attributed to cavity fillings. Core holes which are offset a short distance from such drill holes would provide a check for possible sloughing of drill cuttings.

The phosphorite thickens from about 20 to 40 feet in eastern Lowndes and western Echols Counties to more than 130 feet in southeastern Clinch County. Phosphate particles are associated with clear quartz sand in the former area and with bluish-green clay and sandy clay in the latter area.

Pebble-sized (+20 mesh) phosphate is more common to the western portion of the study area, but yet amounted to only 5 to 10 percent by volume in the samples; "pebble" is rare in the eastern portion. Concentrate (-20 +200 mesh) is the most common source of the phosphate in the project area. This material is of sand size, and is oviform. The slime fraction (-200 mesh) carries some P_2O_5 (Table 3), but preliminary tests indicate the amount is not significant. The volume of clay within the samples, also based on preliminary data and from Project Report No. 2 (Husted and others, 1966, pp. 25-29), shows an approximate range of 15 to 30 percent.

Future prospecting

Results of this reconnaissance survey have produced some suggestions for future prospecting in South Georgia. They are as follows:

(1) Take sufficient time to assemble and evaluate all published and open-file geologic information. This will include mainly subsurface data which are confined mainly to water wells and oil and gas tests. It also includes information from Federal, State, and private construction projects.

(2) For reconnaissance work a few advantages of drilling over coring are as follows:

(a) Drilling can be as much as three times faster, thereby enabling the exploration crew to cover much more territory in a given allotted time.

(b) Storage problems are reduced.

(c) Exploration costs are reduced in terms of time, labor, and contract coring prices.

(d) Comparison of P_2O_5 determinations between drill cuttings and cores in more than one hole indicates less than two percent deviation (Table 4).

(3) Disadvantages of drilling are found where contamination from unconsolidated zones occurs; where clay minerals are washed out of the original sample; and where lithologic changes, unconformities, diastems and macrofauna are needed for correlation. The geologist on location should be alert to the possibilities of even minor caving or enlarging of less consolidated sections of the hole during drilling operations.

Pump pressure should be kept as nearly constant as possible. Discharge should be sufficient only to get returns of larger particles within the sample in order to prevent excessive flushing action.

(4) Electric and gamma-ray logs are useful additional data to supplement the sample logs. Portable units are available on a rental or contract basis from several companies.

(5) Geologic structure is responsible in a somewhat broad sense for concentrating the South Georgia phosphorites. But in prospecting, one should understand that in the four-county project area, particularly the western part, localized concentration occurs in a modified sense. Examples of the latter are solution cavities and channels in the underlying limestone.

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BASIC DATA

BASIC DATA 1. Summary of drilling and analytical data.

[Altitude of selected drill holes is given to the nearest foot above mean sea level. ND = not determined. Leader (--) = no data. P_2O_5 determinations by Southern Testing and Research Laboratories, Wilson, North Carolina, unless noted otherwise.]

LOWNDES COUNTY

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
L1	---	90	90	0	----	Electric log
L2	---	75	45	45-72	ND	Electric log
L3	---	75	40	40-73	ND	Electric log
L4	---	90	55	55-60	4.60	Electric log
				60-65	4.25	
				65-70	4.30	
				70-75	4.30	
				75-80	5.92	
L5	---	90	70	70-75	3.83	Electric log; white phosphate particles present
				75-80	4.93	
				80-85	5.68	
				85-90	6.31	
L6	---	180	180	0	----	Stratigraphic-structural test hole; electric log
L7	---	75	75	0	----	Electric log

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
L8	---	90	70	70-75	6.88	Electric log
				75-80	7.80	
				80-85	5.92	
				85-90	5.13	
L9	---	90	70	70-90	ND	Electric log; minor phosphate in interval
L10	164	142	35	35-60	ND	Stratigraphic-structural test hole; electric log; cross-section
				60-65	6.50	
				65-70	9.90	
				70-75	5.25	
				75-80	1.93	
L11	128	75	10	10-15	7.00	Electric log; cross section
				15-20	9.63	
				20-35	ND	
L12	---	75	40	40-50	ND	Electric log; minor phosphate in interval
L13	---	155	155	0	----	Stratigraphic-structural test hole; lost circulation at 155 feet; electric log
L14	---	135	135	0	----	Stratigraphic-structural test hole; electric log

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
L15	158	75	35	35-40; 45-65	ND	Electric and gamma-ray logs; cross-section
L16	---	75	30	30-45	ND	Electric and gamma-ray logs
L17	159	75	35	35-70	ND	Electric and gamma-ray logs; cross-section
L18	165	75	35	35-70	ND	Electric and gamma-ray logs; cross-section

BASIC DATA 1. Summary of drilling and analytical data.

[Altitude of selected drill holes is given to the nearest foot above mean sea level. ND = not determined. Leader(--) = no data. P_2O_5 determinations by Southern Testing and Research Laboratories, Wilson, North Carolina, unless noted otherwise.]

ECHOLS COUNTY

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
E1	124	280	30	30-175	ND	Stratigraphic-structural test hole; cored interval = 60-63 feet; no logs
E2	---	225	25	25-30	1.88	Stratigraphic-structural test hole; hole caved; no logs
				30-35	6.42	
				35-40	5.62	
				40-45	5.37	
				45-50	5.68	
				50-55	5.57	
				55-60	5.75	
				60-65	ND	
				65-70	4.00	
				70-75	2.63	
				75-80	3.72	
				80-85	4.25	
				85-90	3.83	
				90-95	9.90	
				95-100	2.88	
				100-105	3.92	
				105-110	5.18	
				110-115	3.83	
				115-118	3.04	

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
E3	---	105	30	30-105	ND	Gamma-ray log
E4	---	90	35	35-70	ND	Cored interval = 40-44 feet; no logs
E5	---	90	30	30-90	ND	Electric log
E6	---	200	60	60-125	ND	Electric log
E7	---	90	25	25-80	ND	Electric log
E8	158*	90	62	62-75	ND	Electric log
E9	158*	90	40	40-88	ND	Electric log
E10	158*	90	55	55-90	ND	Electric log
E11	---	90	55	55-90	ND	Electric log
E12	---	90	60	60-90	ND	Electric log
E13	---	90	50	50-90	ND	Electric log
E14	169	72	40	40-90	ND	Cored interval = 70-72 feet; electric log
E15	170	90	25	25-30	0.45	Cored interval = 45-49 feet; electric log
				30-35	1.13	
				35-40	2.25	
				40-45	2.43	
				45-50	1.91	

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
E15 (Cont.)	170	90	25	50-55	2.77	
				55-60	2.30	
				60-65	2.38	
				65-70	2.06	
				70-75	1.88	
				75-90	ND	
E16	157	60	60	0	----	Hole caved; no logs
E17	147	90	25	25-50	ND	Electric log
E18	147	80	25	25-30	0.97	Electric log
				30-35	1.91	
				35-40	2.06	
				40-45	3.30	
				45-50	2.77	
				50-55	2.67	
				55-60	2.35	
				60-65	2.35	
				65-70	2.67	
				70-75	3.14	
				75-77	ND	
E19	160	100	40	40-45	0.33	Electric log
				45-50	0.78	
				50-55	0.33	
				55-60	0.29	
				60-65	0.88	
				65-70	0.78	
				70-100	ND	

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
E20	---	90	35	35-75; 85-90	ND	Electric log
E21	141	75	20	20-25	0.22	Electric log
				25-30	0.25	
				30-35	0.45	
				35-40	0.70	
				40-45	1.47	
				45-50	1.63	
				50-55	1.29	
				55-60	1.93	
E22	127	60	20	20-25	0.70	Cored interval = 20-22, 30-32 feet; no logs
				25-30	1.38	
				30-35	0.75	
				35-40	0.80	
				40-45	1.00	
				45-50	1.38	
				50-55	0.84	
				55-60	0.80	
E23	152	75	45	45-50	2.25	No logs; cross-section
				50-55	6.00	
				55-60	6.25	
				60-70	ND	
E24	151	90	15	15-60	ND	Electric log; cross-section
				60-65	3.09	
				65-70	5.75	
				70-75	10.13	
				75-80	7.25	

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
E25	---	55	50	50-55	ND	No logs
E26	165	90	45	45-80	ND	Cored interval = 55-60 feet; electric log; cross-section
E27	---	55	25	25-30 30-35 35-40 40-45 45-50	0.63 0.75 2.95 3.46 3.75	Cored interval = 30-35 feet; electric log
E28	170*	105	61	61-65 65-70 70-75 75-80 80-85 85-90	5.87 3.72 2.56 7.60 8.00 10.75	Electric log
E29	---	90	60	60-90	ND	Cored interval = 60-61 feet; electric log
E30	170*	90	45	45-60; 88-90	ND	Electric log
E31	170*	90	36	36-45; 60-77; 85-90	ND	Electric log
E32	---	105	40	40-105	ND	Electric log

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
E33	---	100	30	30-92	ND	Electric log
E34	---	90	45	45-50	2.35	Cored interval = 45-50 feet; electric log
				50-55	3.62	
				55-60	2.09	
				60-65	4.00	
				65-70	3.92	
				70-75	9.15	
				75-80	7.60	
				80-85	4.06	
E35	165	90	48	48-50	ND	Electric log; cross-section
				50-55	8.25	
				55-60	6.50	
				60-65	8.63	
				65-70	10.60	
				70-90	ND	
E36	165	90	40	40-90	ND	Cored interval = 45-47 feet; electric log; cross-section
E37	170	90	20	20-30	ND	Electric log; cross-section
				30-35	2.20	
				35-40	4.25	
				40-45	2.88	
				45-50	3.42	
				50-80	ND	
				80-86	7.88	

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
E38	---	90	35	35-40	ND	Electric log; cross-section
				40-45	1.15	
				45-50	2.06	
				50-55	2.77	
				55-57	3.67	
				57-82	----	
				82-90	ND	
E39	159	146	35	35-60	ND	Stratigraphic-structural test hole; electric log; cross-section
E40	160	75	20	20-25	4.60	Electric log
				25-30	4.50	
				30-35	7.50	
				35-40	8.88	
				40-45	4.90	
				45-50	5.21	
				50-55	6.62	
E41	147	90	10	10-15	1.15	Electric log
				15-20	6.25	
				20-25	7.18	
				25-30	5.00	
				30-35	5.75	
				35-40	6.88	
				40-45	7.08	
				45-50	6.72	
				50-55	6.62	

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
E41 (Cont.)	147	90	10	55-60	4.72	
				60-65	6.25	
				65-70	5.92	
				70-75	4.34	
				75-80	4.93	
				80-85	5.25	
				85-90	5.25	
E42	161	75	45	45-56	ND	Electric log; cross-section
E43	144	90	50	50-55	4.60	Electric log
				55-60	10.00	
				60-65	7.00	
				65-70	8.13	
				70-75	7.18	
				75-80	8.38	
E44	---	118	50	50-57; 84-100	ND	Stratigraphic-structural test hole; lost circulation at 118 feet
E45	147	105	25	25-30	11.50	Electric log; cross-section; additional P_2O_5 determinations in Table 2
				30-35	11.43	
				35-40	11.25	
				40-45	13.25	
				45-50	14.63	
				50-55	16.53	
				55-60	7.60	
				60-65	8.75	

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
E46	153	90	25	25-30	ND	Cored interval = 35-40 feet; electric log; cross-section; additional P_2O_5 determinations in Table 2
				30-35	6.80	
				35-40	5.92	
				40-45	9.15	
				45-50	9.50	
				50-55	10.60	
				55-60	10.09	
				60-65	12.70	
				65-70	8.25	
				70-75	6.50	
				75-80	3.04	
E47	156	90	20	20-25	1.80	Electric log; cross-section; no phosphate particles observed 50-60 feet
				25-30	2.43	
				30-35	2.17	
				35-40	2.50	
				40-45	4.00	
				45-50	4.12	
				50-55	ND	
				55-60	ND	
				60-65	6.07	
				65-70	9.75	
E48	160	90	15	15-20	0.45	Electric log; cross-section
				20-25	1.18	
				25-30	1.75	
				30-35	1.93	
				35-40	4.38	
				40-45	4.45	
				45-50	7.88	
				50-55	9.30	
				55-60	7.38	

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
E49	162	90	25	25-45 45-50 50-55 55-60 60-65 65-70 70-75 75-80	ND 2.17 3.62 4.34 3.04 3.67 6.25 4.50	No logs; cross-section
E50	162	90	45	45-50 50-55 55-60 60-65	2.38 4.50 7.38 8.69	Electric log; cross-section
E51	---	75	30	30-68	ND	Electric log
E52	---	90	65	65-85	ND	Electric log
E53	---	90	55	55-70; 75-85	ND	No logs
E54	150**	75	25	25-30 30-35 35-40 40-45 45-50 50-55 55-60 60-65 65-70 70-75	1.47 1.85 6.17 6.42 6.61 9.90 11.61 11.80 8.06 4.88	Electric log; P_2O_5 determination made on washed sample by J.R. Landrum, Georgia Department of Mines, Mining and Geology

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
E55	---	75	40	40-75	ND	No logs; very little phosphate
E56	---	90	35	35-40	4.34	Electric log; no phosphate observed from 50-70 feet and 75-80 feet
				40-45	6.62	
				45-50	6.07	
				50-70	ND	
				70-75	4.03	
				75-80	ND	
				80-85	6.25	
				85-90	9.30	
E57	---	45	25	25-45	----	Caved hole; no logs; minor phosphate
E58	---	75	30	30-40	ND	Electric log
E59	---	75	75	0	----	Lost circulation at 75 feet
E60	---	75	25	25-30	ND	No logs
E61	---	90	40	40-45	4.88	Electric log
				45-50	7.08	
E62	---	90	35	35-40	8.19	Electric log; no phosphate observed from 45-55 feet
				40-45	7.25	
				45-55	ND	
				55-60	10.60	
				60-65	9.63	

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
E63	---	75	42	42-47	ND	Cored interval = 45-50 feet; electric log
E64	---	75	17	17-35	ND	Electric log; minor phosphate
E65	---	75	30	35-40 40-45 45-50 50-55	2.60 3.34 8.13 5.25	Electric log
E66	---	75	38	38-45	ND	Electric log; very little phosphate
E67	---	75	40	40-57	ND	Electric log; very little phosphate
E68	---	75	35	35-40 40-45 45-50 50-55	1.85 3.67 4.00 3.83	Electric log
E69	---	75	40	40-45 45-50 50-55 55-60 60-65 65-70	5.84 9.27 7.87 5.66 3.69 3.42	Electric log; P_2O_5 determination made on washed sample by J.R. Landrum, Georgia Department of Mines, Mining and Geology

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
E70	---	75	20	20-25	4.25	Cored interval = 30-32 feet; electric log
				25-30	5.57	
				30-35	5.90	
				35-40	4.75	
				40-45	6.07	
				45-50	5.32	
				50-55	3.56	
E71	---	75	20	20-42	ND	Electric log
E72	---	75	18	18-20	ND	Cored interval = 15-25 feet; electric log
				20-25	3.62	
				25-30	4.72	
				30-35	3.00	
				35-40	3.92	
				40-45	4.36	
				45-50	3.62	
				50-55	3.48	
				55-60	3.72	
E73	---	71	46	46-70	ND	Lost circulation at 71 feet
E74	---	62	28	28-30	ND	Lost circulation at 62 feet
				30-35	3.75	
				35-40	3.67	
				40-45	4.38	
				45-50	2.88	
				50-55	4.25	

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
E75	---	160	20	20-58	ND	Stratigraphic-structural test hole; electric log
E76	---	75	20	20-35	ND	Electric log; very little phosphate
E77	---	80	18	15-20	0.63	Electric log; no phosphate observed from 25-45 feet
				20-25	1.18	
				25-45	ND	
				45-50	5.32	
				50-55	5.41	
				55-60	3.83	
				60-65	4.50	
				65-70	4.45	
				70-75	7.60	

*Scaled or estimated from Georgia Southern and Florida Railway profile, Valdosta to Fargo, or from U.S. Coast and Geodetic Survey Line 2.

**Estimated from Valdosta sheet (USGS 1:250,000).

BASIC DATA 1. Summary of drilling and analytical data.

[Altitude of selected drill holes is given to the nearest foot above mean sea level. ND = not determined. Leader (--) = no data. P_2O_5 determinations by Southern Testing and Research Laboratories, Wilson, North Carolina, unless noted otherwise.]

CLINCH COUNTY

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
CL1	150	95	75	75-95	ND	Cored intervals = 45-55 feet and 90-95 feet; electric and gamma-ray logs; minor phosphate from 75-85 feet
CL2	151	302	65	65-110; 125-217	ND	Stratigraphic-structural test hole; lost circulation at 302 feet; caved hole at 235 feet; electric log; very little phosphate 195-217 feet
CL3	129	300	25	25-170	ND	Stratigraphic-structural test hole; cored interval = 60-61 feet; gamma-ray log
CL4	133	75	50	50-75	ND	No logs
CL5	135	90	60	60-90	ND	No logs; minor phosphate

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
CL6	147	289	55	55-185	ND	Stratigraphic-structural test hole; very little phosphate 55-70 feet
CL7	---	90	40	40-90	ND	No logs
CL8	116	75	45	45-50 50-55 55-60	4.45 10.38 10.38	No logs
CL9	---	75	65	65-75	ND	No logs; very little phosphate
CL10	---	75	55	55-75	ND	No logs; minor phosphate
CL11	124*	75	45	45-55	ND	Cored interval = 55-58 feet; no logs
CL12	127*	75	70	70-75	ND	No logs; minor phosphate
CL13	125*	90	50	50-90	ND	No logs; minor phosphate
CL14	---	75	75	0	----	No logs
CL15	---	295	65	65-70 70-75 75-80	0.60 0.73 1.07	Stratigraphic-structural test hole; electric log

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
CL15 (Cont.)	---	295	65	80-85	1.67	
				85-90	2.06	
				90-95	2.47	
				95-100	4.18	
				100-105	4.00	
				105-110	3.67	
				110-115	4.34	
				115-120	4.30	
				120-125	3.25	
				125-130	3.62	
				130-135	3.19	
				135-140	7.38	
				140-145	8.63	
				145-150	5.92	
				150-155	6.72	
				155-160	4.18	
				165-170	4.34	
CL16	---	90	55	55-90	ND	Gamma-ray log
CL17	---	90	65	65-80	ND	Gamma-ray log
CL18	145*	75	60	60-75	ND	No logs; minor phosphate
CL19	146*	75	70	70-75	ND	No logs; minor phosphate
CI20	---	90	40	40-90	ND	Gamma-ray log
CI21	150*	90	55	55-90	ND	Gamma-ray log

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
CL22	---	90	55	55-90	ND	Gamma-ray log
CL23	---	90	55	55-84	ND	Gamma-ray log
CL24	158*	90	70	70-82	ND	Gamma-ray log
CL25	---	90	80	80-90	ND	Gamma-ray log
CL26	---	90	55	55-90	ND	Cored interval = 60-63 feet; gamma-ray log
CL27	---	90	55	55-85	ND	Gamma-ray log
CL28	116	90	35	35-40	2.17	Gamma-ray log
				40-45	1.56	
				45-50	1.43	
				50-55	1.06	
				55-60	0.70	
				60-65	0.84	
				65-70	1.70	
CL29	121	90	30	30-35	1.25	Gamma-ray log
				35-40	1.25	
				40-45	0.93	
				45-50	1.00	
				50-55	1.13	
				55-60	3.19	
				60-90	ND	
CL30	127*	90	40	40-60	ND	Gamma-ray log; minor phosphate

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
CL31	127*	90	40	40-45 45-50 50-90	2.30 2.25 ND	Gamma-ray log
CL32	---	90	45	45-90	ND	Cored interval = 60-65 feet; minor phosphate
CL33	128*	90	34	34-44	ND	Gamma-ray log
CL34	113	90	40	40-90	ND	Cored interval = 45-50 feet; gamma-ray log
CL35	125	90	55	55-90	ND	Gamma-ray log
CL36	---	90	30	30-90	ND	Cored interval = 45-48 feet; gamma-ray log
CL37	114	90	40	40-90	ND	Cored interval = 55-60 feet; gamma-ray log
CL38	154*	90	70	70-90	ND	Cored interval = 40-45 feet; caved hole at 25 feet; no logs
CL39	---	90	70	70-90	ND	Electric log
CL40	---	90	90	0	----	Electric log
CL41	---	90	75	75-90	ND	Electric log

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
CL42	---	75	75	0	----	Electric log
CL43	---	90	70	70-90	ND	Electric log; minor phosphate
CL44	---	75	75	0	----	Electric log
CL45	---	75	75	0	----	Electric log
CL46	---	75	60	60-70	ND	Electric log; minor phosphate
CL47	---	90	75	75-90	ND	Electric log
CL48	---	90	60	60-90	ND	Electric log
CL49	---	75	75	0	----	Electric log
CL50	---	90	70	70-90	ND	Electric log
CL51	---	90	60	60-90	ND	Electric log
CL52	---	75	70	70-75	ND	Electric log; minor phosphate
CL53	---	75	75	0	----	Electric log

*Scaled from Georgia Southern and Florida Railway profile, Valdosta to Fargo; and from U.S. Coast and Geodetic Survey Line 2.

BASIC DATA 1. Summary of drilling and analytical data.

[Altitude of selected drill holes is given to the nearest foot above mean sea level. ND = not determined. Leader (--) = no data. P_2O_5 determinations by Southern Testing and Research Laboratories, Wilson, North Carolina, unless noted otherwise.]

CHARLTON COUNTY

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
CH1	170*	75	75	0	----	Electric log
CH2	160*	75	75	0	----	Electric log
CH3	119*	90	80	80-90	ND	Electric log; minor phosphate
CH4	125*	75	75	0	----	Electric log
CH5	120*	75	65	65-75	ND	Electric log; minor phosphate
CH6	118*	75	75	0	----	Electric log
CH7	120*	75	75	0	----	Electric log
CH8	152*	75	75	0	----	Electric log
CH9	130*	75	75	0	----	Electric log
CH10	145*	75	75	0	----	Electric log

BASIC DATA 1 (Continued)

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
CH11	95*	75	75	0	----	Electric log
CH12	135*	75	75	0	----	Electric log

*Estimated from Moniac quadrangle (USGS 1:62,500; contour interval 10 feet).

BASIC DATA 1. Summary of drilling and analytical data.

[Altitude of selected drill holes is given to the nearest foot above mean sea level. ND = not determined. Leader (--) = no data. P_2O_5 determinations by Southern Testing and Research Laboratories, Wilson, North Carolina, unless noted otherwise.]

LANIER COUNTY

Hole (Plate I)	Altitude (feet)	Total depth (feet)	Overburden (feet)	Phosphorite interval (feet)	P_2O_5 (percent)	Remarks
LA1	---	177	38	38-45	ND	Stratigraphic-structural test hole; lost circulation at 177 feet; electric log

BASIC DATA 2. Driller's logs.

[All depths in feet. Symbols (L1) indicate hole numbers.]

LOWNDES COUNTY

L1

0-60	Sand; sandy clay
60-72	Clay, white
72-85	Clay, blue, soft; fossils
85-90	Clay, hard

NO PHOSPHORITE

L2

0-25	Sand; sandy clay
25-40	Clay
40-41	Chert
41-75	Clay; chert layers

PHOSPHORITE 45-72

L3

0-15	Clay, sandy
15-38	Clay, white
38-73	Clay, blue
73-75	Chert; clay; limestone

PHOSPHORITE 40-73

L4

0-5	Sand
5-25	Clay, sandy
25-75	Clay
75-80	Clay; chert layers
80-90	Clay

PHOSPHORITE 55-80

L5

0-20	Sand; sandy clay
20-45	Clay
45-90	Sand; sandy clay

PHOSPHORITE 70-90

L6

0-30	Sand; sandy clay
30-40	Clay, white
40-50	Sand; sandy clay
50-82	Clay, sandy
82-92	Clay, blue, hard
92-94	Chert
94-102	Clay
102-180	Clay; limestone layers

NO PHOSPHORITE

L7

0-20	Sand; sandy clay
20-32	Clay
32-60	Sand; clay, white, soft
60-75	Clay

NO PHOSPHORITE

L8

0-8	Clay, sandy
8-20	Clay, white
20-40	Sand; clay, white, soft
40-70	Clay
70-90	Clay, blue, sandy

PHOSPHORITE 70-90

L9

0-5	Sand
5-55	Clay, sandy
55-90	Clay

PHOSPHORITE 70-90

BASIC DATA 2 (Continued)

L10*

0-5	Sand, fine- to coarse-grained, arkosic
5-20	Clay, pale brownish-gray, very sandy
20-25	Sand, fine- to coarse-grained; some clay as above
25-30	As above; some clay, pale yellowish-brown, sandy
30-35	Sand; clay, mottled, very sandy; some argillaceous, limonitic sand
35-40	Clay, dark brownish-green, blocky, becoming pale green at depth
50-60	Clay, pale green to white, blocky, cherty
60-70	Sand as above
70-80	Clay as above
80-95	Sandstone, pale yellowish-green, fine-grained, interbedded with clays; some limestone
95-105	As above but becoming dolomitic
105-125	Clay, pale green, sandy; minor amount fine-grained sandstone and white to pale green sandy limestone
125-130	Clay, pale bluish-green, blocky
130-135	Clay as above; some chert
135-142	Limestone, dolomitic, sandy

PHOSPHORITE 35-80

L11*

0-10	Sand, clayey
10-20	Sand
20-30	Limestone, very sandy and clayey
30-55	Claystone, pale bluish-gray, very sandy, friable; influx limestone, yellowish-brown, dolomitic, sucrosic, pitted, hard; minor amount pale yellow crystalline limestone
55-75	Claystone, pale greenish-gray, siliceous, very sandy; minor amount pale yellow limestone as above

PHOSPHORITE 10-35

L12

0-40	Sand; sandy clay
40-50	Clay, sandy
50-75	Clay

PHOSPHORITE 40-50

BASIC DATA 2 (Continued)

L13

0-5	Sand
5-80	Clay, white, yellow
80-100	Clay, light blue; rock layers
100-104	Chert
104-112	Clay; rock layers
112-120	Rock
120-155	Clay; rock layers (LOST CIRCULATION in limestone cavity at 155)

NO PHOSPHORITE

L14

0-4	Sand
4-72	Clay, sandy
72-80	Rock, brown; clay layers
80-95	Clay
95-100	Limestone
100-128	Clay, white; limestone, soft
128-135	Limestone, brown

NO PHOSPHORITE

L15*

0-5	Sand, quartz, pale gray, coarse-grained
5-15	Claystone, mottled reddish-brown, yellowish-brown and gray, very sandy
15-25	Claystone, medium brown and pale gray; sandstone, quartz, pale gray, clayey
25-35	Sand as above; minor claystone as above
35-50	Sand as above
50-65	Claystone, bluish-gray with black specks, sandy; sharp decrease in phosphorite
65-75	Sand, quartz, very pale greenish-gray, calcareous, very clayey, with soft limy nodules; minor claystone as above

PHOSPHORITE 35-40; 45-65

L16

0-4	Sand
4-30	Clay, sandy
30-45	Sand
45-49	Rock
49-75	Clay

PHOSPHORITE 30-45

BASIC DATA 2 (Continued)

L17*

0-20	Sand, quartz, varicolored, clayey; minor claystone
20-25	Claystone, medium brown; sandstone as above
25-35	Sand, quartz, light gray, conglomeratic, arkosic
35-50	Sand, quartz, pale yellowish-brown, clayey
50-65	Sand as above; claystone, medium brown; minor amount limestone, pale yellowish-brown, dolomitic, with clear quartz grains
65-75	Sand as above, very clayey; sharp decrease in phosphorite 65-70

PHOSPHORITE 35-70

L18*

0-5	Sand, fine- to medium-grained, arkosic
5-10	Clay, dark brown, very sandy
10-15	Clay, light brownish-green to dark brown, blocky, sandy, lignitic
15-25	Sand; minor amount clay as above
25-30	Clay, dark brownish-green, blocky, sandy
30-70	Sand; minor amount clay as above
70-75	Clay, dark green, blocky, sandy

PHOSPHORITE 35-70

*Cross-section. Samples checked and some descriptions modified by the writer.

BASIC DATA 2. Driller's logs.

[All depths in feet. Symbols (E1) indicate hole numbers.]

ECHOLS COUNTY

E1*

0-25	Claystone, varicolored, sandy
25-30	Claystone, grayish-green, sandy
30-40	Claystone, slightly calcareous
40-60	Sandstone, quartz, slightly calcareous
60-75	Sandstone, quartz; claystone, grayish-green
75-95	Sandstone, quartz; minor limestone
95-115	Claystone, grayish-green
115-130	Sandstone, quartz; claystone, grayish-green; trace limestone
130-185	Limestone, pale yellowish-brown, sandy; minor quartz sand grains
185-225	Limestone; shale, pale green, siliceous; trace of chert
225-235	Limestone, white and pale yellowish-brown, calcite grains; claystone, pale yellowish-green, "fuller's earth" type
235-255	Limestone
255-280	Limestone as above; trace limestone, light gray with black specks, sandy

CORE 60-63
PHOSPHORITE 30-175

E2 (RERUN)

0-30	Sand
30-50	Clay, hard
50-75	Clay; limestone layers
75-108	Clay; limestone layers
108-112	Rock
112-118	Limestone, soft
118-125	Rock
125-141	Clay
141-148	Limestone, white
148-155	Clay
155-175	Clay; limestone layers
175-180	Limestone, sandy
180-225	Clay; limestone layers

PHOSPHORITE 25-118

BASIC DATA 2 (Continued)

E3

0-5	Sand
5-15	Clay
15-40	Clay, white
40-70	Clay
70-74	Limestone
74-105	Clay; limestone layers

PHOSPHORITE 30-105

E4

0-5	Sand
5-20	Clay, sandy
20-55	Clay
55-70	Clay, blue
70-90	Clay; limestone layers

CORE 40-44
PHOSPHORITE 35-70

E5

0-30	Sand
30-40	Clay, sandy
40-45	Clay
45-55	Sand
55-70	Clay, dark blue
70-71	Limestone
71-75	Clay
75-85	Sand
85-90	Clay; minor limestone

PHOSPHORITE 30-90

E6

0-8	Clay
8-15	Sand
15-40	Clay, yellow
40-44	Clay, gray
44-60	Clay, blue
60-70	Sand
70-90	Clay, blue, sandy
90-92	Limestone
92-125	Clay
125-140	Limestone, sandy; interbedded clay

E6 (Continued)

140-195	Clay; limestone layers
195-200	Limestone, brown

PHOSPHORITE 60-125

E7

0-10	Clay, sandy
10-18	Sand
18-30	Clay, white
30-55	Clay, blue
55-70	Clay
70-80	Clay, sandy
80-88	Clay
88-90	Limestone

PHOSPHORITE 25-80

E8

0-4	Sand
4-10	Clay
10-25	Sand
25-45	Clay, white
45-50	Sand
50-62	Clay, white
62-75	Clay
75-88	Clay, hard; limestone layers
88-90	Clay; chert layers

PHOSPHORITE 62-75

E9

0-5	Sand
5-12	Clay, sandy
12-25	Clay, yellow and white
25-40	Clay, blue
40-45	Clay, sandy
45-70	Clay
70-88	Clay, gray
88-90	Clay

PHOSPHORITE 40-88

BASIC DATA 2 (Continued)

E10

0-8	Clay, yellow and white, sandy
8-30	Clay, blue, sandy
30-50	Clay, blue
50-65	Clay, white and brown
65-68	Rock
68-74	Clay
74-76	Rock layers
76-90	Clay, rock layers

PHOSPHORITE 55-90

E11

0-6	Clay, sandy
6-20	Sand
20-55	Clay, sandy
55-90	Clay

PHOSPHORITE 55-90

E12

0-15	Clay, sandy
15-20	Sand
20-50	Clay, sandy
50-60	Clay
60-90	Clay, gray

MINOR PHOSPHORITE 60-90

E13

0-12	Clay, sandy
12-16	Sand
16-20	Clay, red and white
20-25	Clay, white
25-42	Clay, light green
42-46	Clay, white
46-47	Rock layers
47-50	Clay, light green
50-90	Clay

MINOR PHOSPHORITE 50-90

E14

0-5	Sand
5-10	Clay, sandy
10-20	Sand
20-40	Clay, sandy
40-90	Clay

CORE 70-72
PHOSPHORITE 40-90

E15

0-15	Sand
15-25	Clay, sandy
25-46	Clay, sandy
46-60	Sand
60-70	Clay, sandy
70-80	Sand
80-90	Clay, sandy

CORE 45-49
PHOSPHORITE 25-90

E16

0-5	Sand
5-10	Clay, sandy
10-16	Sand
16-18	Clay
18-60	Sand
	HOLE CAVED

NO PHOSPHORITE

E17

0-20	Sand
20-50	Sand
50-72	Clay, sandy
72-74	Limestone
74-90	Clay; limestone layers

PHOSPHORITE 25-50

BASIC DATA 2 (Continued)

E18

0-45	Sand
45-60	Clay, blue
60-77	Sand
77-80	Limestone

PHOSPHORITE 25-77

E19

0-5	Sand
5-12	Clay
12-15	Sand
15-30	Clay, white
30-40	Sand
40-75	Sand
75-100	Clay; limestone at 100 feet

PHOSPHORITE 40-75

E20

0-5	Sand
5-12	Clay
12-20	Sand
20-35	Clay, white, soft
35-55	Clay, blue
55-75	Clay, gray
75-85	Clay, blue
85-90	Sand

PHOSPHORITE 35-75; 85-90

E21

0-5	Sand
5-13	Clay
13-60	Sand
60-72	Clay
72-75	Rock

PHOSPHORITE 20-60

E22

0-40	Sand
40-60	Sand; clay layers; sandstone at 60 feet

CORE 30-32
PHOSPHORITE 20-60

E23**

0-28	Sand
28-45	Clay
45-58	Sand
58-70	Clay
70-75	Limestone

PHOSPHORITE 45-70

E24**

0-5	Sand, arkosic
5-15	Sand; minor amount mottled clay
15-20	Clay, brown, sandy
20-60	Clay, greenish-gray with brown streaks
60-80	Clay, sandy, soft
80-90	Clay; rock layers

PHOSPHORITE 30-80

E25

0-20	Sand
20-50	Clay, sandy
50-55	Sandstone

MINOR PHOSPHORITE 50-55

E26**

0-15	Sand, fine- to coarse-grained, arkosic
15-20	Clay, mottled, sandy
20-45	Sand; some clay as above
45-65	Clay, dark brown, sandy

BASIC DATA 2 (Continued)

E26**(Continued)

65-80	Clay, white
80-81	Chert layer
81-90	Clay; limestone layer

CORE 55-60
PHOSPHORITE 45-80

E27

0-15	Clay
15-30	Sand
30-40	Clay, sandy, soft
40-45	Clay, hard
45-48	Chert
48-53	Clay, rock layers
53-55	Chert

CORE 30-35
PHOSPHORITE 25-50

E28

0-16	Clay
16-18	Sand
18-25	Clay
25-40	Sand
40-60	Clay, blue
60-61	Chert
61-68	Sand
68-70	Chert
70-73	Clay
73-76	Chert
76-91	Clay, sandy
91-105	Clay

PHOSPHORITE 61-91

E29

0-5	Sand
5-13	Clay
13-25	Sand
25-40	Clay, sandy
40-60	Clay, blue
60-90	Clay, gray; rock layers

CORE 60-61
PHOSPHORITE 60-90

E30

0-45	Sand; sandy clay
45-60	Clay, sandy
60-78	Clay, blue
78-82	Chert
82-88	Clay
88-90	Clay, sandy

MINOR PHOSPHORITE 45-60; 88-90

E31

0-12	Clay, sandy
12-15	Sand
15-17	Clay
17-30	Sand
30-36	Clay, white
36-45	Clay, gray
45-60	Clay, blue
60-77	Clay, gray
77-82	Clay, blue
82-85	Chert
85-90	Clay; chert layers

PHOSPHORITE 36-45; 60-77; 85-90

E32

0-5	Sand
5-10	Clay
10-25	Sand
25-30	Clay
30-40	Sand; sandy clay
40-76	Clay, blue
76-78	Chert
78-100	Clay, green
100-105	Chert layers; clay

PHOSPHORITE 40-105

E33

0-5	Sand
5-15	Clay
15-30	Sand; clay
30-35	Clay
35-60	Clay, blue

BASIC DATA 2 (Continued)

E33 (Continued)

60-75	Clay
75-92	Clay, sandy
92-100	Clay; limestone layers

PHOSPHORITE 30-92

E34

0-5	Sand
5-12	Clay
12-45	Sand; sandy clay
45-50	Clay
50-55	Sand
55-60	Clay, hard
60-85	Clay, sandy
85-90	Limestone; chert

PHOSPHORITE 45-85

E35**

0-48	Sand; sandy clay
48-70	Clay, blue, sandy
70-90	Clay; limestone layers

PHOSPHORITE 48-70

E36**

0-5	Sand, fine- to coarse-grained, arkosic
5-30	Clay, mottled, very sandy
30-70	As above, with brown clay at top
70-90	Clay, sandy; chert and limestone layers

CORE 45-47
PHOSPHORITE 40-90

E37**

0-10	Sand, fine- to coarse-grained
10-20	Sand as above; clay, pale green, blocky, sandy
20-30	Clay, dark brown, blocky, sandy

E37** (Continued)

30-50	Sand
50-71	Clay, sandy
71-80	Clay, blue
80-86	Sand
86-90	Clay; limestone

PHOSPHORITE 20-71; 80-86

E38**

0-5	Sand
5-35	Sand; minor amount mottled clay
35-40	Sand as above; minor amount pale brown to gray clay
40-45	Clay, blue
45-57	Sand
57-90	Clay

PHOSPHORITE 35-57; 82-90

E39

0-5	Sand
5-20	Clay
20-35	Sand
35-60	Clay, blue
60-70	Clay, light blue
70-124	Clay; limestone layers
124-128	Limestone, sandy
128-132	Limestone, white, soft
132-144	Limestone, soft and hard
144-146	Limestone, brown, hard

PHOSPHORITE 35-60

E40

0-5	Sand
5-20	Clay
20-55	Sand; sandy clay
55-75	Clay; chert; limestone layers

PHOSPHORITE 20-55

BASIC DATA 2 (Continued)

E41

0-35	Sand
35-40	Clay
40-90	Clay; rock layers

PHOSPHORITE 10-90

E42**

0-5	Sand
5-20	Clay, sandy
20-45	Sand
45-56	Clay, blue, sandy
56-71	Limestone, sandy; clay layers
71-75	Clay

PHOSPHORITE 45-56

E43

0-4	Sand
4-15	Clay
15-55	Sand
55-60	Clay, sandy
60-80	Sand
80-90	Clay; limestone

PHOSPHORITE 50-80

E44

0-4	Sand
4-15	Clay
15-50	Sand
50-57	Clay, blue, sandy
57-59	Clay, hard
59-65	Clay; limestone layers
65-84	Clay, blue
84-100	Clay
100-116	Limestone, white
116-118	(Cavity) LOST CIRCULATION

PHOSPHORITE 50-57; 84-100

E45**

0-20	Sand, fine- to coarse-grained, arkosic
20-30	Clay, sandy
30-65	Sand
65-80	Clay
80-95	Clay, hard
95-102	Clay, soft
102-105	Limestone, white

PHOSPHORITE 25-65; 95-102

E46**

0-5	Sand, arkosic
5-20	Sand, arkosic; minor amount mottled clay
20-25	As above, with pale to dark brownish-green blocky clay
25-50	Clay, sandy
50-63	Sand
63-70	Clay; limestone layers
70-80	Clay
80-85	Clay
85-88	Limestone
88-90	Clay

PHOSPHORITE 25-80

E47**

0-5	Sand
5-10	Sand; minor amount mottled clay
10-25	Clay, dark brownish-green, sandy
25-50	Sand
50-60	Clay
60-70	Clay; sand layers
70-90	Clay; limestone layers

PHOSPHORITE 20-50; 60-70

BASIC DATA 2 (Continued)

E48**

0-4	Sand
4-15	Clay
15-57	Sand
57-65	Clay
65-75	Clay; sand layers
75-90	Clay

PHOSPHORITE 15-57; 65-75

E49**

0-5	Sand; sandy clay, reddish brown
5-17	Clay
17-68	Sand
68-90	Clay, sandy; limestone layers

PHOSPHORITE 25-80

E50**

0-10	Sand
10-16	Clay
16-62	Sand
62-80	Clay; limestone layers
80-90	Clay

PHOSPHORITE 45-65

E51

0-6	Sand
6-14	Clay
14-22	Sand
22-30	Clay
30-68	Clay, sandy
68-75	Clay

PHOSPHORITE 30-68

E52

0-4	Sand
4-14	Clay
14-17	Sand
17-28	Clay

E52 (Continued)

28-45	Clay, sandy
45-85	Clay, blue, sandy
85-90	Clay

PHOSPHORITE 65-85

E53

0-5	Sand
5-20	Clay
20-70	Clay, sandy
70-75	Clay
75-85	Clay, sandy
85-90	Clay

PHOSPHORITE 55-70; 75-85

E54**

0-10	Sand, fine- to coarse-grained, arkosic
10-28	Clay, mottled
28-55	Sand; clay, sandy
55-65	Clay
65-75	Clay; limestone layers

PHOSPHORITE 25-75

E55

0-5	Sand
5-20	Clay
20-75	Clay, sandy

PHOSPHORITE 40-75

E56

0-5	Clay
5-25	Sand
25-35	Clay, sandy
35-40	Clay
40-45	Clay; limestone layers
45-50	Sand
50-70	Clay
70-75	Sand
75-80	Clay, blue
80-90	Clay, sandy

PHOSPHORITE 35-50; 70-75; 80-90

BASIC DATA 2 (Continued)

E57

0-5	Sand
5-15	Clay
15-45	Sand; clay, sandy
	HOLE CAVED

PHOSPHORITE 25-45

E58

0-5	Sand
5-20	Clay
20-40	Clay, blue
40-44	Rock
44-75	Clay; rock layers

PHOSPHORITE 30-40

E59

0-10	Sand
10-16	Rock
16-65	Clay; rock layers
65-73	Limestone
73-75	Limestone, soft
	LOST CIRCULATION

NO PHOSPHORITE

E60

0-16	Sand
16-25	Clay
25-30	Clay, sandy
30-35	Limestone
35-75	Clay; limestone layers

PHOSPHORITE 25-30

E61

0-4	Sand
4-14	Clay
14-25	Sand; clay
25-40	Clay, blue, sandy
40-50	Sand; clay, sandy
50-90	Clay

PHOSPHORITE 40-50

E62

0-4	Sand
4-14	Clay
14-25	Clay, white, sandy
25-32	Clay, white
32-35	Clay, blue
35-45	Sand
45-50	Clay, blue
50-55	Clay, gray, hard
55-62	Sand
62-90	Clay; rock layers

PHOSPHORITE 35-45; 55-62

E63

0-3	Sand
3-30	Clay
30-36	Sand
36-42	Clay
42-47	Clay, sandy
47-60	Clay, white
60-75	Clay, blue

CORE 45-50
PHOSPHORITE 42-47

E64

0-4	Sand
4-17	Clay
17-35	Sand
35-40	Sand; rock layers
40-44	Clay, blue
44-47	Limestone
47-75	Clay; limestone layers

PHOSPHORITE 17-35

E65

0-3	Sand
3-28	Clay, sandy
28-35	Clay, blue, sandy
35-55	Clay, sandy
55-66	Clay, sandy
66-75	Clay, hard

PHOSPHORITE 35-55

BASIC DATA 2 (Continued)

E66

0-3	Sand
3-32	Sand; sandy clay
32-38	Clay
38-45	Clay, sandy
45-70	Clay; rock layers
70-75	Clay, blue

PHOSPHORITE 38-45

E67

0-3	Sand
3-14	Clay
14-30	Sand
30-40	Clay, blue, sandy
40-57	Clay, green
57-60	Limestone
60-75	Clay

PHOSPHORITE 40-57

E68

0-3	Sand
3-10	Clay
10-29	Sand
29-52	Clay, blue, sandy
52-60	Limestone, sandy
60-75	Clay; limestone layers

PHOSPHORITE 35-52

E69

0-4	Sand
4-30	Clay
30-40	Sand
40-55	Clay, sandy
55-75	Clay; limestone layers

PHOSPHORITE 40-55

E70

0-2	Sand
2-12	Clay
12-20	Sand

E70 (Continued)

20-25	Clay, blue, sandy
25-30	Sand
30-35	Clay
35-55	Clay; rock layers
55-65	Rock
65-75	Clay; rock layers

CORE 30-32
PHOSPHORITE 20-55

E71

0-4	Sand
4-12	Clay
12-20	Sand
20-25	Clay
25-32	Clay, blue, sandy
32-42	Clay, white and brown
42-55	Limestone
55-75	Clay; limestone layers

PHOSPHORITE 20-42

E72

0-3	Sand
3-18	Clay
18-35	Clay, sandy
35-58	Sand; rock layers
58-65	Clay; rock layers
65-67	Rock
67-75	Clay

CORE 15-25
PHOSPHORITE 18-58

E73

0-3	Sand
3-12	Clay
12-46	Sand
46-52	Clay, sandy
52-55	Clay
55-70	Rock
70-71	(Cavity) LOST CIRCULATION

PHOSPHORITE 46-70

BASIC DATA 2 (Continued)

E74

0-28	Sand; sandy clay
28-50	Clay, blue, sandy
50-56	Limestone
56-62	(Cavity) LOST CIRCULATION

PHOSPHORITE 28-50

E75

0-38	Sand
38-50	Sand; rock layers
50-58	Clay
58-66	Clay; limestone layers
66-72	Limestone
72-85	Limestone, white, soft
85-100	Clay, blue; limestone layers
100-120	Clay, blue; minor limestone
120-127	Clay; limestone layers
127-135	Limestone, sandy; clay
135-144	Limestone, sandy
144-148	Clay
148-160	Limestone, hard and soft

PHOSPHORITE 20-58

E76

0-16	Sand
16-20	Clay, blue
20-35	Clay; limestone layers
35-48	Clay
48-53	Clay; limestone layers
53-75	Limestone; minor clay

PHOSPHORITE 20-35

E77

0-5	Sand
5-18	Clay
18-25	Sand
25-41	Sand; clay, blue
41-45	Clay
45-65	Sand
65-80	Limestone

PHOSPHORITE 18-25; 45-80

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*Samples checked and some descriptions modified by the writer.

**Cross-section. Samples checked and some descriptions modified by the writer.

BASIC DATA 2. Driller's logs.

[All depths in feet. Symbols (CL1) indicate hole numbers.]

CLINCH COUNTY

CL1*

0-15	Sandstone, quartz, mottled brown, red, yellow and gray, coarse-grained, clayey
15-45	No samples
45-50	Sandstone, quartz, pale yellowish-brown, very coarse-grained, very friable, scattered feldspar grains
50-55	Sandstone, quartz, pale yellowish-gray, fine-grained, very friable; black fine-grained particles displaying metallic luster (heavy minerals?)
55-70	Sandstone as at 45 feet; black fine-grained particles as above
70-80	Claystone, pale greenish-gray, silty; sandstone, quartz, coarse-grained, clayey, very friable
80-90	Sandstone as above; minor amount claystone as above and limestone, pale yellow
90-95	Sandstone, quartz, medium gray, fine-grained; minor amount inter-bedded claystone as at 70 feet

CORE 45-55; 90-95
PHOSPHORITE 75-95 (Minor phosphorite 75-85)

CL2*

0-20	Sandstone, quartz, mottled brown, red, yellow, gray, very clayey, quartz grains very coarse-grained, becoming conglomeratic at 15 feet
20-30	Sandstone, quartz, mottled pale yellowish-brown and gray; less clayey feldspar fragments common
30-43	Sandstone as in uppermost unit
43-55	Claystone, medium gray, silty; sandstone, quartz, pale yellowish-brown, clayey
55-65	Sandstone, quartz, pale yellowish-brown, friable; shale, pale greenish-gray, mottled with black specks, siliceous
65-75	Sandstone as above.
75-100	Limestone, pale yellow, very silty with quartz grains common, medium hard
100-115	Marl, medium gray, with abundant clear quartz grains, very friable
115-125	Siltstone, light gray with black specks, slightly calcareous, bentonitic
125-145	Limestone, pale yellow, very silty, with abundant clear quartz grains, very friable
145-170	Sandstone, quartz, very coarse-grained, unconsolidated clear grains, decreasing grain size at 165 feet; minor limestone, pale yellow, silty, with laminae of clear quartz grains -- no phosphorite in the limestone

BASIC DATA 2 (Continued)

CL2* (Continued)

170-175	Limestone, pale yellow, as at 125-145
175-190	Sandstone and limestone as at 145-170
190-195	Limestone, pale yellow, very silty, with clear quartz grains common, very friable; sharp decrease in phosphorite
195-217	Limestone as above, with yellowish-brown iron oxide stain common on quartz sand aggregates and individual grains -- decrease in iron oxide stain at 200 feet
217-225	Shale, pale greenish-gray, with black specks, siliceous; limestone, pale yellow, silty, friable
225-245	Limestone as above; minor amount shale as above
245-250	Shale as above, clayey; minor amount limestone as above
250-277	Shale as above; clear quartz grains common
277-290	Limestone, pale yellow, dolomitic
290-294	Limestone, white, vuggy
294-302	Limestone, dolomitic, light yellowish-brown, finely crystalline, pitted; limestone, pale yellowish-white, very finely crystalline, dense

PHOSPHORITE 65-110; 125-217 (Minor phosphorite 195-217)

CL3*

0-10	Sand, quartz, brown, unconsolidated
10-20	Sand, quartz, yellowish-brown; clay, grayish-green
15-20	Sand as above; clay absent
20-25	Sand, quartz, pale yellowish-brown, unconsolidated
25-35	Limestone, pale yellow, finely crystalline with abundant quartz grains
35-65	Sandstone, light gray, calcareous
65-85	Sandstone as above; siltstone, gray, calcareous, clayey, with quartz grains
85-95	Sand (no consolidation), quartz, pale gray; sharp increase in phosphorite
95-115	Sandstone, quartz, pale gray, calcareous, clayey
115-140	Sandstone as above; interlayered green silty claystone
140-155	Claystone, bentonitic; sandstone as above
155-170	Limestone, gray, phosphatic, quartz grains
170-200	Limestone, grayish-white, silty
200-220	Limestone as above; minor amount chert, light gray
220-240	Limestone, grayish-white, silty, abundant quartz grains; minor amount pale green sandy claystone
240-255	Claystone, green, minor amount quartz grains
255-260	Limestone, grayish-white, silty, abundant quartz grains (cavings?)
260-275	Claystone as above

BASIC DATA 2 (Continued)

CL3* (Continued)

275-290 Claystone as above; minor amount light gray chert
290-297 Limestone, grayish-white, silty, abundant quartz grains
297-300 Limestone, dolomitic, pale yellowish-brown, vuggy, hard, quartz grains

CORE 60-61
PHOSPHORITE 25-170

CL4*

0-10 Sand, quartz, pale reddish-brown, coarse-grained
10-25 Sandstone, quartz, reddish-brown and yellowish-brown, interlayered greenish-gray claystone
25-30 Sand, quartz, yellowish-brown, very coarse-grained
30-40 Sand as above, white feldspar grains common
40-50 Sandstone, quartz, yellowish-gray, fine- to medium-grained, friable
50-60 Limestone, pale yellowish-brown, silty, friable, abundant quartz grains
60-75 Limestone as above, minor amount grayish-green siltstone

PHOSPHORITE 50-75

CL5*

0-5 Sand, quartz, pale yellowish-brown, very coarse-grained, unconsolidated
5-15 Sandstone, quartz, pale orange, coarse-grained, friable
15-30 Sandstone as above; claystone, pale greenish-gray, scattered clear quartz grains
30-40 Sandstone, quartz, pale yellowish-gray, calcareous, friable; claystone as above
40-65 Sandstone, quartz, pale yellowish-brown, fine-grained, very friable, abundant silt-sized particles, displaying metallic luster (heavy minerals?)
65-70 Siltstone, medium gray, slightly calcareous; minor amount sandstone as above
70-80 Sandstone, quartz, pale yellowish-gray, calcareous, friable
80-85 Limestone, pale yellow, abundant quartz grains; minor sandstone as above
85-90 Sandstone as at 70 feet

MINOR PHOSPHORITE 60-90

BASIC DATA 2 (Continued)

CL6*

0-55	Sand, quartz, mottled red, yellow, brown and gray, clayey, quartz grains very coarse-grained -- increase white feldspar at 30 feet
55-70	Sand, quartz, medium gray, yellowish-brown iron oxide staining, coarse-grained, clayey
70-85	Sand as above; siltstone, pale greenish-gray, slightly calcareous, containing clear quartz grains; minor influx limestone, pale yellow, sandy
85-95	Limestone, pale yellow, sandy; siltstone, pale greenish-gray, marly, containing clear quartz grains
95-115	Marl, yellowish-brown, clear quartz grains; interbedded with limestone, pale yellowish-brown containing abundant quartz grains -- some clastic limestone fragments (all containing phosphate) bounded by laminae of pure, fine, silty, pale orange limestone
115-180	Limestone, pale yellowish-gray, silty, friable, clear subrounded fine-grained quartz grains
180-190	Limestone as above; minor influx limestone, pale yellowish-brown, very finely crystalline, hard, pitted; chert, gray
190-210	Limestone as above; increase in chert, gray
210-230	Limestone, pale yellowish-gray, silty and clayey, friable, clear quartz grains; minor amount chert, probably cavings
230-235	Limestone as above; shale, pale greenish-gray, mottled with black specks, siliceous
235-255	Shale as above
255-260	Limestone, pale yellowish-gray, silty and clayey, friable, abundant clear quartz grains and pale orange phosphate (?) pellets
260-282	Limestone as above; interlayered shale, pale greenish-gray, mottled with black specks, siliceous; orange pellets absent
282-285	Limestone, dolomitic, pale yellowish-brown, abundant quartz grains, scattered dark green translucent grains, moderately hard
285-289	Limestone, dolomitic, pale yellowish-brown, very finely crystalline, pitted, quartz grains absent

PHOSPHORITE 55-185 (Very little phosphorite 55-70)

CL7

0-5	Sand
5-15	Clay, blue, sandy
15-40	Clay, white
40-90	Clay, blue

PHOSPHORITE 40-90

CL8

0-5	Sand
5-20	Clay
20-25	Sand

CL8 (Continued)

25-45	Clay
45-60	Sand
60-75	Clay, blue

PHOSPHORITE 45-60

CL9

0-35	Clay, sandy
35-38	Rock
38-75	Clay

MINOR PHOSPHORITE 65-75

BASIC DATA 2 (Continued)

CL10

0-20	Clay, white and red
20-25	Clay, sandy
25-55	Clay, white
55-75	Clay, blue

MINOR PHOSPHORITE 55-75

CL11

0-20	Sand; sandy clay
20-45	Clay, sandy
45-55	Clay, white
55-75	Clay, blue, sandy

CORE 55-58
PHOSPHORITE 45-55

CL12

0-20	Sand; sandy clay, white
20-42	Clay, blue, sandy
42-43	Rock
43-75	Clay; limestone layers

MINOR PHOSPHORITE 70-75

CL13

0-15	Sand
15-40	Clay, blue and white, sandy
40-75	Clay, blue; limestone layers
75-90	Clay, white; limestone layers

MINOR PHOSPHORITE 50-90

CL14

0-10	Sand
10-20	Clay, white, sandy
20-30	Clay, red and green
30-75	Clay, blue

NO PHOSPHORITE

CL15

0-30	Sand
30-60	Sand; sandy clay
60-96	Clay, sandy; limestone layers
96-98	Rock
98-170	Sand; limestone layers
170-190	Clay; limestone layers
190-196	Limestone, white, sandy
196-210	Clay; limestone layers
210-220	Clay
220-225	Limestone
225-235	Clay
235-257	Clay; rock layers
257-270	Clay, hard
270-275	Limestone, sandy
275-291	Clay
291-295	Limestone, brown

PHOSPHORITE 65-170

CL16

0-20	Sand; clay, white, sandy
20-42	Clay, brown and white
42-55	Clay, blue
55-70	Clay, blue, sandy; limestone layers
70-90	Clay, white, sandy; limestone layers

PHOSPHORITE 55-90

CL17

0-20	Sand
20-45	Clay, white, sandy
45-65	Clay, blue
65-80	Clay, white, sandy
80-90	Clay, light blue

PHOSPHORITE 65-80

BASIC DATA 2 (Continued)

CL18

0-60	Sand; sandy clay
60-75	Clay, blue, sandy

PHOSPHORITE 60-75

CL19

0-75	Sand; sandy clay

MINOR PHOSPHORITE 70-75

CL20

0-30	Sand
30-40	Clay, blue, sandy
40-60	Clay
60-80	Sand; sandy clay
80-90	Clay, sandy

PHOSPHORITE 40-90

CL21

0-30	Sand
30-55	Clay, white and brown
55-90	Clay, dark blue

PHOSPHORITE 55-90

CL22

0-5	Sand
5-15	Clay
15-30	Sand
30-55	Clay, light blue, sandy
55-75	Clay, dark blue
75-85	Clay, white
85-90	Clay, dark blue

PHOSPHORITE 55-90

CL23

0-5	Sand
5-8	Clay, red
8-15	Clay, sandy
15-25	Sand

CL23 (Continued)

25-55	Clay, sandy
55-84	Clay, blue
84-86	Limestone
86-90	Clay

PHOSPHORITE 55-84

CL24

0-5	Sand
5-30	Clay, sandy
30-40	Sand
40-45	Clay, light blue
45-55	Clay, white
55-70	Clay
70-82	Clay
82-85	Limestone
85-90	Clay; limestone layers

PHOSPHORITE 70-82

CL25

0-5	Sand
5-45	Sand; sandy clay
45-55	Clay, white, soft
55-70	Clay, blue, soft
70-80	Clay, black
80-90	Clay, black; limestone layers

PHOSPHORITE 80-90

CL26

0-30	Sand; sandy clay
30-45	Clay, white, soft
45-55	Clay, white, sandy
55-90	Clay, blue and white; limestone layers

CORE 60-63
PHOSPHORITE 55-90

BASIC DATA 2 (Continued)

CL27

0-18	Sand; sandy clay
18-30	Clay, white
30-55	Clay, light blue, soft
55-85	Clay, blue; limestone layers
85-90	Clay, white

PHOSPHORITE 55-85

CL28

0-3	Sand
3-12	Clay, sandy
12-30	Clay, light green
30-35	Rock layers
35-70	Clay
70-90	Rock layers

PHOSPHORITE 35-70

CL29

0-5	Sand
5-20	Clay, sandy
20-30	Clay, light green
30-40	Clay, white
40-70	Clay, blue
70-90	Clay, white

PHOSPHORITE 30-90

CL30

0-20	Sand; sandy clay
20-40	Clay, green and white, hard layers
40-60	Clay, blue and white
60-70	Clay, blue
70-90	Clay; limestone layers

MINOR PHOSPHORITE 40-60

CL31

0-12	Sand
12-40	Clay, blue; rock layers
40-65	Clay, blue and white
65-70	Clay
70-90	Clay, white

PHOSPHORITE 40-90

CL32

0-10	Sand
10-45	Clay; rock layers
45-60	Clay, white; rock layers
60-90	Clay; limestone layers

CORE 60-65
PHOSPHORITE 45-90

CL33

0-30	Sand; sandy clay
30-34	Rock
34-44	Clay
44-55	Clay, hard
55-75	Clay
75-90	Clay, dark blue

PHOSPHORITE 34-44

CL34

0-10	Sand
10-20	Clay, sandy, hard
20-65	Clay
65-90	Clay, white and blue

PHOSPHORITE 40-90

BASIC DATA 2 (Continued)

CL35

0-5	Sand; sandy clay
5-15	Clay, sandy, hard
15-30	Clay, white and red
30-55	Clay
55-70	Clay, white
70-90	Clay

PHOSPHORITE 55-90

CL36

0-15	Sand; sandy clay
15-30	Clay, light green
30-40	Clay
40-90	Clay; limestone layers

CORE 45-48
PHOSPHORITE 30-90

CL37

0-12	Sand; sandy clay
12-20	Clay
20-45	Shells
45-60	Clay
60-63	Clay, hard; limestone layers
63-90	Clay; limestone layers

CORE 55-60
PHOSPHORITE 40-90

CL38

0-25	Sand
25-55	Sand; sandy clay
55-70	Sand
70-90	Clay HOLE CAVED at 25 feet NO LOGS

PHOSPHORITE 70-90

CL39

0-5	Sand
5-10	Clay
10-33	Sand; sandy clay
33-70	Clay, blue
70-75	Clay, sandy
75-90	Clay

PHOSPHORITE 70-90

CL40

0-5	Sand
5-10	Clay
10-70	Sand; sandy clay
70-90	Clay, sandy

NO PHOSPHORITE

CL41

0-5	Sand
5-10	Clay
10-25	Sand
25-60	Clay, sandy
60-75	Clay, white, soft
75-90	Clay, blue

PHOSPHORITE 75-90

CL42

0-5	Sand
5-10	Clay, sandy
10-75	Sand; sandy clay

NO PHOSPHORITE

CL43

0-5	Sand
5-50	Sand; sandy clay
50-70	Clay, sandy
70-90	Clay, blue

MINOR PHOSPHORITE 70-90

BASIC DATA 2 (Continued)

CL44

0-5 Sand
5-47 Clay, sandy
47-75 Clay, blue

NO PHOSPHORITE

CL45

0-40 Sand; sandy clay
40-75 Clay, blue

NO PHOSPHORITE

CL46

0-5 Sand
5-30 Clay, sandy
30-40 Clay, white
40-75 Clay, blue

MINOR PHOSPHORITE 60-70

CL47

0-40 Sand; sandy clay
40-75 Clay, blue
75-90 Clay, blue; limestone layers

PHOSPHORITE 75-90

CL48

0-2 Sand
2-32 Sand; sandy clay
32-80 Clay, blue
80-90 Clay, blue and white

PHOSPHORITE 60-90

CL49

0-40 Sand; sandy clay
40-75 Clay, blue

NO PHOSPHORITE

CL50

0-40 Sand; sandy clay
40-70 Clay, blue
70-90 Clay, blue and white

PHOSPHORITE 70-90

CL51

0-55 Sand; sandy clay
55-60 Clay, blue
60-75 Sand; clay
75-90 Clay; limestone layers

PHOSPHORITE 60-90

CL52

0-35 Sand; clay
35-75 Clay, blue; sand layers

MINOR PHOSPHORITE 70-75

CL53

0-35 Sand; sandy clay
35-75 Clay, blue

NO PHOSPHORITE

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*Samples checked and some descriptions modified by the writer.

BASIC DATA 2. Driller's logs.

[All depths in feet. Symbols (CH1) indicate hole numbers.]

CHARLTON COUNTY

CH1

0-5	Sand
5-30	Sand, black
30-60	Sand, brown
60-75	Clay, sandy

NO PHOSPHORITE

CH2

0-50	Sand
50-75	Clay, sandy

NO PHOSPHORITE

CH3

0-40	Sand
40-55	Clay, blue, sandy
55-57	Rock
57-65	Clay, blue
65-90	Limestone; shells

PHOSPHORITE 80-90

CH4

0-40	Clay, sandy
40-75	Shells; clay

NO PHOSPHORITE

CH5

0-75	Sand; sandy clay

PHOSPHORITE 65-75

CH6

0-50	Clay, sandy
50-53	Rock
53-57	Clay
57-60	Rock
60-62	Clay
62-70	Rock
70-75	Clay

NO PHOSPHORITE

CH7

0-38	Sand
38-43	Clay, blue
43-71	Clay; limestone layers
71-75	Clay

NO PHOSPHORITE

CH8

0-75	Clay, sandy

NO PHOSPHORITE

CH9

0-75	Sand; sandy clay, black, brown

NO PHOSPHORITE

CH10

0-65	Sand
65-75	Clay, sandy

NO PHOSPHORITE

BASIC DATA 2 (Continued)

CH11

0-50	Sand
50-70	Clay, sandy
70-75	Clay, blue

NO PHOSPHORITE

CH12

0-65	Sand
65-75	Clay, sandy

NO PHOSPHORITE

BASIC DATA 2. Driller's logs.

[All depths in feet. Symbols (LA1) indicate hole numbers.]

LANIER COUNTY

LA1

0-22	Sand
22-38	Clay
38-45	Clay; rock layers
45-60	Clay; chert layers
60-95	Clay; limestone layers
95-105	Clay; thick limestone layers
105-115	Clay
115-120	Limestone, brown, sandy
120-150	Clay
150-160	Sand; rock layers
160-173	Sand
173-177	Limestone, white and brown
	LOST CIRCULATION

PHOSPHORITE 38-45

PLATE I

Scale 1:250,000

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

5 0 5 10 15 Nautical Miles

BASE FROM USGS VALDOSTA SHEET

CONTOUR INTERVAL 50 FEET
WITH SUPPLEMENTARY CONTOURS AT 25 FOOT INTERVALS

TRANSVERSE MERCATOR PROJECTION

EXPLANATION

- ● PHOSPHORITE TEST HOLE
- ▲ STRATIGRAPHIC-STRUCTURAL TEST HOLE
- ✕ NO PHOSPHORITE PRESENT
- PV PLIOCENE VERTEBRATE REMAINS

PHOSPHORITE DRILLHOLE LOCATIONS IN LOWNDES, ECHOLS, CLINCH, AND CHARLTON COUNTIES, GEORGIA

PREPARED BY THE SOUTHERN RAILWAY SYSTEM IN COOPERATION WITH THE DEPARTMENT OF MINES, MINING AND GEOLOGY

CROSS-SECTIONS SHOWING PHOSPHORITE AND ASSOCIATED SEDIMENTARY UNITS

IN A PORTION OF

EASTERN LOWNDES AND WESTERN ECHOLS COUNTIES, GEORGIA

EXPLANATION

- SAND AND SANDSTONE
- CLAY, SANDY AND CLAYSTONE
- PHOSPHORITE
- LIMESTONE

E 38 HOLE NUMBER
(165) ALTITUDE (Feet Above MSL)
8.06 PERCENT P_2O_5

SCALE

HORIZONTAL 1" = 1000'
VERTICAL 1" = 50'

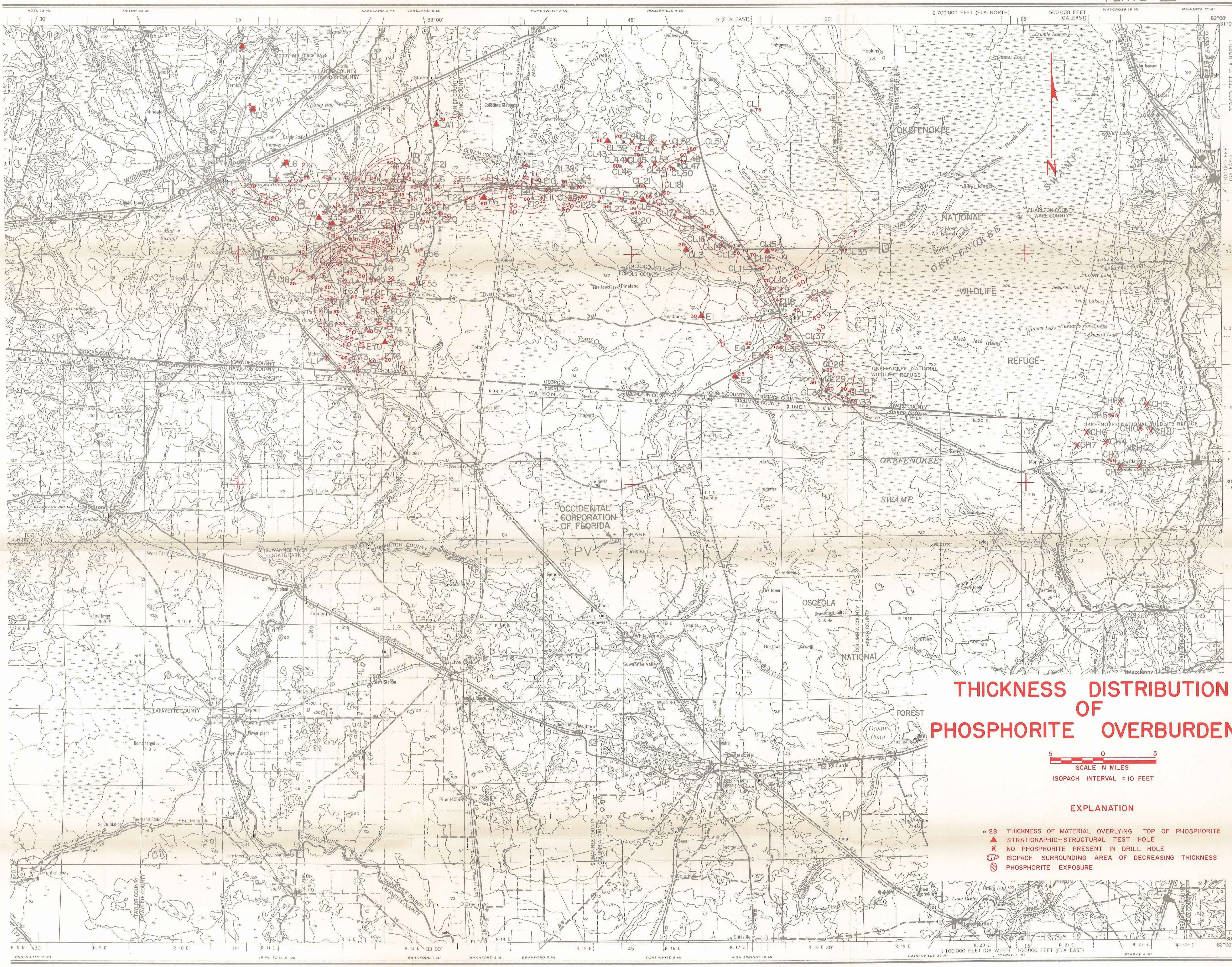
ELECTRIC AND GAMMA-RAY LOGS

SPONTANEOUS POTENTIAL [LEFT CHANNEL (1)]
RESISTIVITY [RIGHT CHANNEL (2)]
GAMMA-RAY LOG [LEFT CHANNEL (3)]

NOTE: EACH MEASUREMENT GIVEN BELOW IS SHOWN AS PER UNIT OF GRAPHIC SCALE

(1) MILLIVOLTS
(2) OHMS
(3) MILLIROENTGENS PER HOUR

PLATE III



BASE FROM USGS VALDOSTA SHEET

Scale 1:250,000

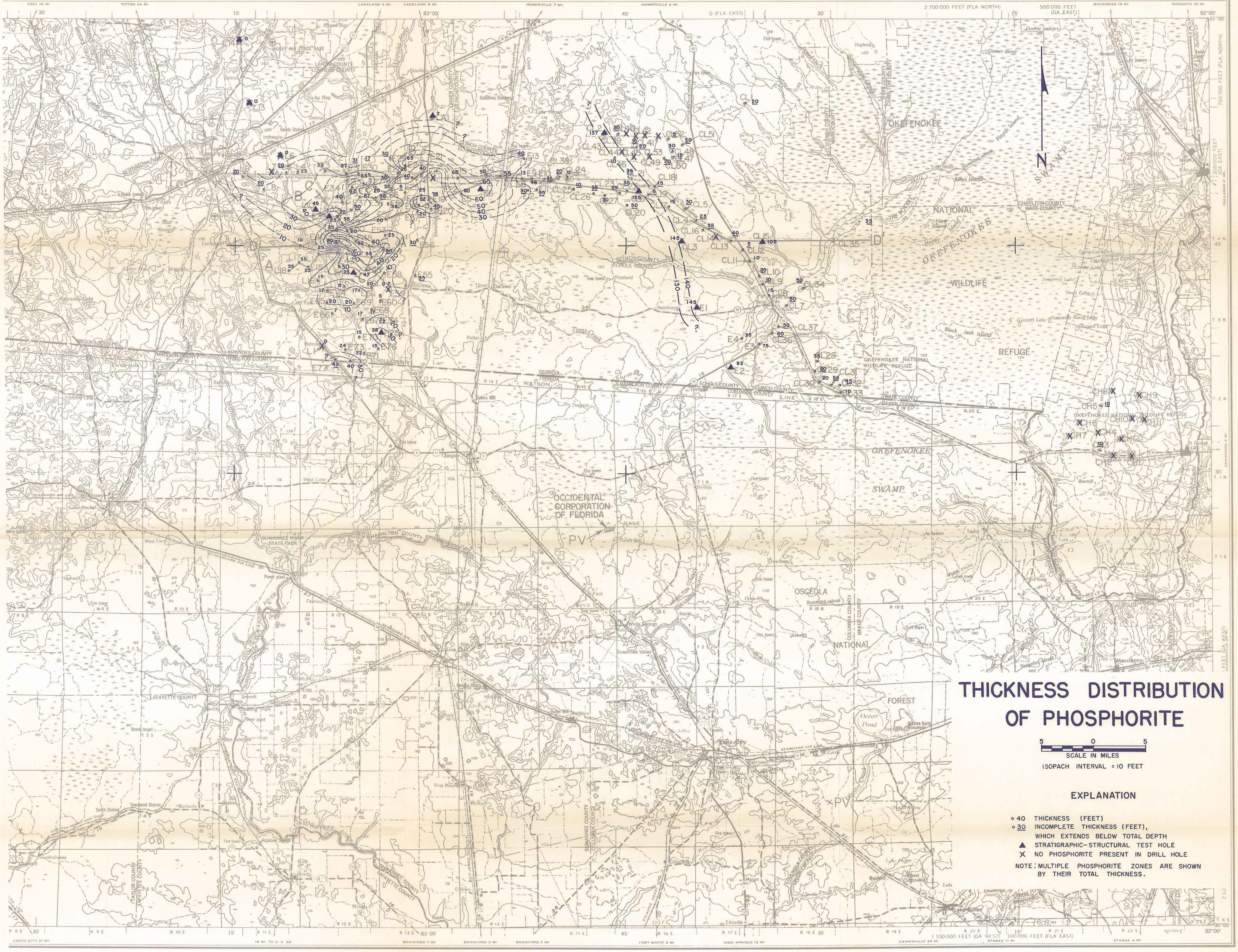
CONTOUR INTERVAL 50 FEET
WITH SUPPLEMENTARY CONTOURS AT 25 FOOT INTERVALS
TRANSVERSE MERCATOR PROJECTION

EXPLANATION

- PHOSPHORITE TEST HOLE
- STRATIGRAPHIC-STRUCTURAL TEST HOLE
- NO PHOSPHORITE PRESENT
- PV PLIOCENE VERTEBRATE REMAINS

PHOSPHORITE DRILLHOLE LOCATIONS IN
LOWNDES, ECHOLS, CLINCH, AND CHARLTON COUNTIES, GEORGIA

PREPARED BY THE SOUTHERN RAILWAY SYSTEM IN COOPERATION WITH THE
DEPARTMENT OF MINES, MINING AND GEOLOGY



BASE FROM USGS VALDOSTA SHEET

Scale 1:250,000

CONTOUR INTERVAL 50 FEET
WITH SUPPLEMENTARY CONTOURS AT 25 FOOT INTERVALS
TRANSVERSE MERCATOR PROJECTION

EXPLANATION

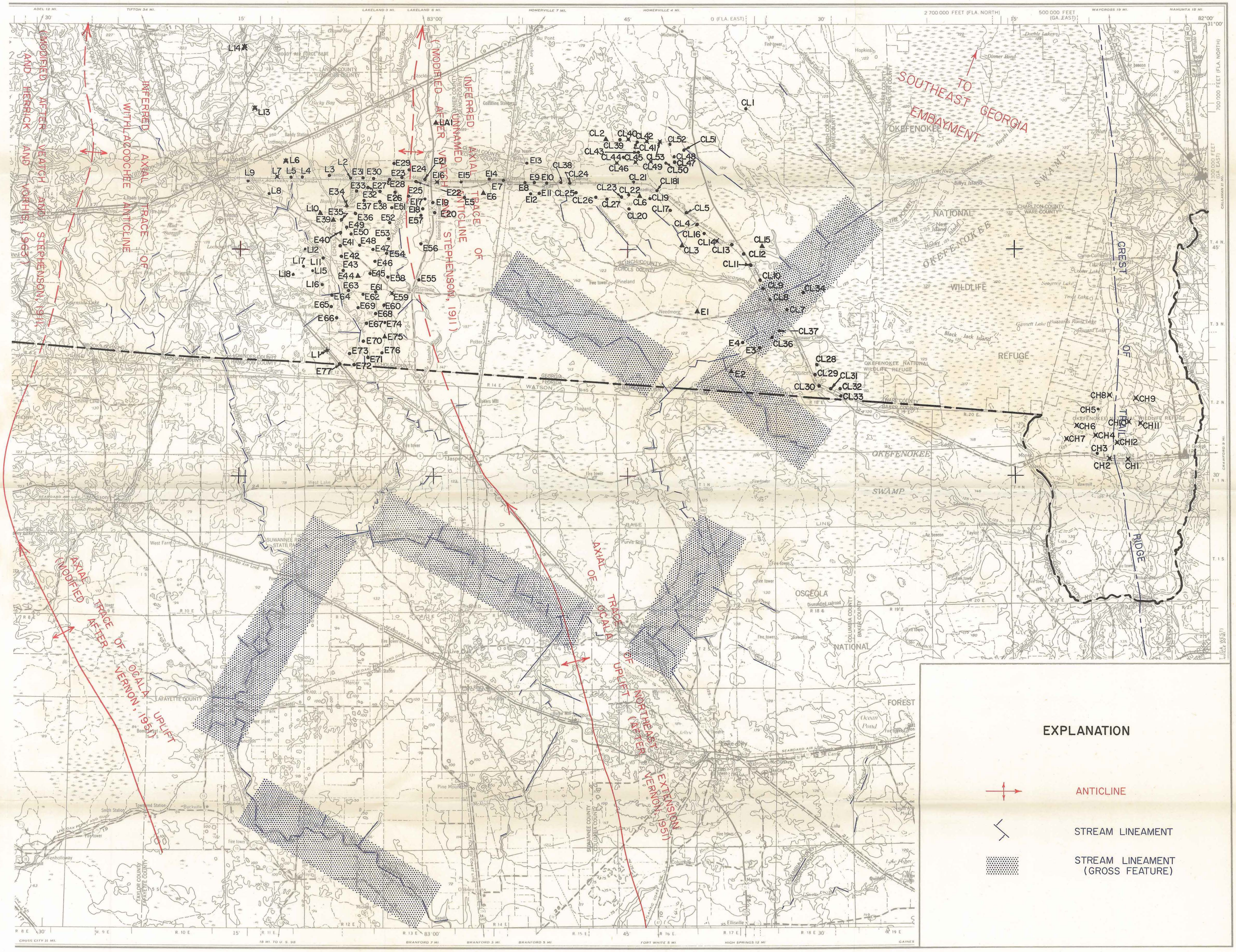
- PHOSPHORITE TEST HOLE
- ▲ STRATIGRAPHIC-STRUCTURAL TEST HOLE
- NO PHOSPHORITE PRESENT
- PV PLIOCENE VERTEBRATE REMAINS

PHOSPHORITE DRILLHOLE LOCATIONS IN
LOWNDES, ECHOLS, CLINCH, AND CHARLTON COUNTIES, GEORGIA

PREPARED BY THE SOUTHERN RAILWAY SYSTEM IN COOPERATION WITH THE
DEPARTMENT OF MINES, MINING AND GEOLOGY

MAJOR STRUCTURAL AND GEOMORPHIC ELEMENTS IN A PORTION OF THE GEORGIA-FLORIDA AREA

PLATE V



Base from USGS map

Scale 1:250,000

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

5 0 5 10 15 Nautical Miles

CONTOUR INTERVAL 50 FEET
WITH SUPPLEMENTARY CONTOURS AT 25 FOOT INTERVALS

TRANSVERSE MERCATOR PROJECTION