Project Report No. 5

South Georgia Minerals Program

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

A. S. Furcron, Director

By

Mineral Engineering Branch, Engineering Experiment Station
Georgia Institute of Technology, and
Georgia Department of Mines, Mining, and Geology

February 1967

This program is being carried out under contract as
Project A-880 of the Georgia Institute of Technology,
Atlanta, Georgia

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DEDICATION

ALEXANDER MARSH PETERSON
August 27, 1926 - August 27, 1966

The best we can ask in life is to be given the faith and the strength to lead a purposeful life, to bring happiness to others, and to do the right thing as we see it. Alexander Marsh (Alex) Peterson so lived.

His devotion to his work was exceeded only by his devotion to his family. His technical skill, his enthusiasm, his untiring efforts, and his outstanding personality gained for him the immediate respect and affection of all with whom he came in contact.

Alex joined the staff of Georgia Tech on November 22, 1965, as a Research Scientist. During the nine months with the South Georgia Minerals Program conducted by the Georgia Department of Mines, Mining, and Geology and the Georgia Institute of Technology, his contributions were invaluable; and his sound counsel and guidance, both as a scientist and as a person, have been missed by all.

In recognition thereof, Project Report No. 5 is dedicated to the memory of Alexander Marsh Peterson.

FOREWORD

As noted in prior Project Reports, it is desired again to express sincere appreciation to the County Commissioners, the State Highway Department, to many industrial representatives, and to the many other agencies and individuals whose interest, comments, and cooperation have been of inestimable value to the progress of this program.

Consistent with the desire to make the findings of this program available as soon as possible, Project Report Nos. 2 and 3 were published without certain non-critical data which were not available at that time. The data presented permitted calculation of "Economic Factors," but these were not presented until a better cross-section of industry practice was obtained. Accordingly, this Project Report No. 5 includes appendices to complete the data for Report No. 2 and Report No. 3 and to present a summary of "Economic Factors" and, uniquely, "Figures of Merit" which should be of interest to industry and to landowners in obtaining a summarized evaluation of the potential industrial utilization of the deposits.

Reproductions of the electric and gamma-ray logs are included under each county. Prior reports stated that the logs were available for study at the Department of Mines, Mining, and Geology. It is planned to append reproductions of logs from previously reported counties in a forthcoming report.

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SOUTH GEORGIA MINERALS PROGRAM

INTRODUCTION

This program to investigate the economic potential of mineral resources in the broad area of South Georgia - roughly 25,000 square miles - was initiated on July 1, 1965, under an appropriation by the General Assembly of Georgia to the Georgia Department of Mines, Mining, and Geology.

Consistent with the objectives of the program and the intent of the General Assembly, all information is published and released to the public as soon as feasible. Four Project Reports have been issued:

Project Report No. 1, January 1966, presented in general terms the background, purpose, scope, and procedures of the drilling program to be carried out, under contract, by Georgia Tech.

Project Report No. 2, May 1966, presented information on deposits in Echols County, Georgia. A number of samples from drilling operations by the Southern Railway System were analyzed and reported along with the data obtained by Georgia Tech. Several areas of probable industrial interest in Echols County were outlined.

Project Report No. 3, August 1966, presented data from core samples obtained by drilling in Brooks, Camden, Clinch, Lanier, Lowndes, Thomas, and Ware Counties. Data were included from one hole drilled in Effingham County at the start of the drilling program; and these data will be repeated with other data being obtained from this county in a future report. A "find" of high quality phosphates in southwestern Lanier

County was detailed in Project Report No. 3 and initiated high interest and activity by many of the phosphate companies in the United States and Canada. In fact, some of the data were questioned as being almost "too good to be true" but have been checked and confirmed by industry and project personnel.

Project Report No. 4, November 1966, was prepared by Mr. Norman K. Olson, Industrial Development Department, Southern Railway System, and presents results from 161 holes in Echols (77), Charlton (12), Clinch (53), Lanier (1), and Lowndes (18) Counties. This investigation was a cooperative effort of the Southern Railway System and the Department of Mines, Mining, and Geology. It is shown that phosphorites are present throughout the study area and that "minable quantities" exist in an area about 5 miles west of Statenville, Echols County. Hence, the results in this report more clearly delineate a specific area of interest to industry within the generalized area of probable interest depicted in Project Report No. 2.

This report - Project Report No. 5 - presents information gained from core drilling in Atkinson, Ben Hill, Berrien, Coffee, Cook, and Irwin Counties. These areas and drilling sites were selected to evaluate the northern trend and extent of the phosphorite deposits of interest. It also includes some data to complete information in Project Report Nos. 2 and 3 and results from calculating "economic factors" on a number of matrices which indicated promise of interest to industry and landowners.

Figure 1 is an outline map of counties in the Coastal Plain, showing the location of holes drilled to data.

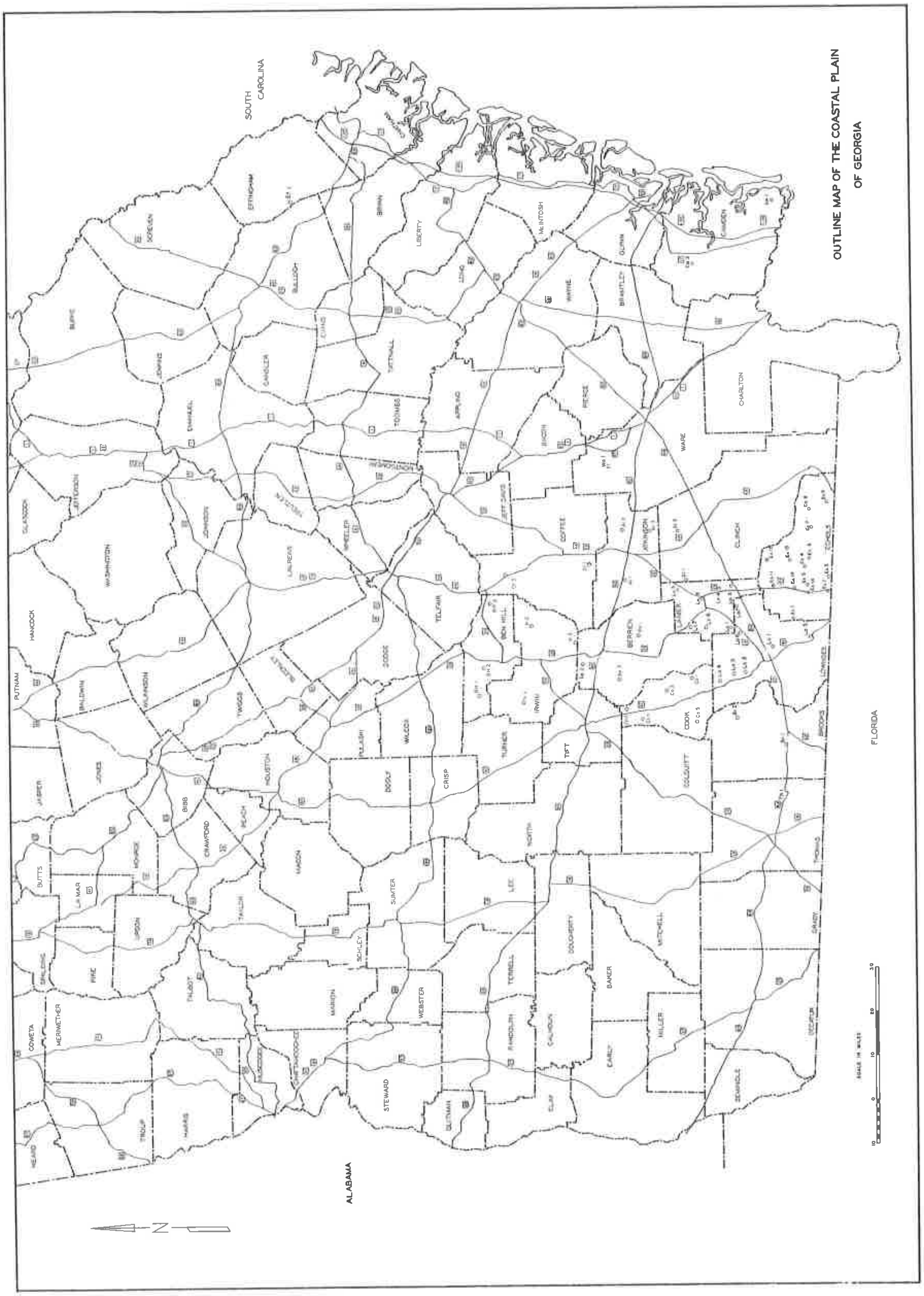


Figure 1. Index Map of Program Area

OBJECTIVE AND SCOPE

The objective of the South Georgia Minerals program is, simply, to determine the existence, preliminary quality-quantity data, and approximate location of mineral deposits with potential for establishing new, or expanded, mineral industries in the state.

The scope of this report, Project Report No. 5, embraces three parts:

First, presentation of data obtained from core drilling in six counties: Atkinson, Ben Hill, Berrien, Coffee, Cook, and Irwin.

Second, presentation of certain data which were not included in prior reports either through unavailability, or of questionable validity, at the time of publication.

Third, presentation of calculated Economic Factors and unique Figures of Merit which permit a simple and rapid evaluation of potential interest. The last two "parts" are included as appendices.

SUMMARY

Matrices from western Atkinson County (At-1) and central Berrien County (Be-1, Be-3) were the only ones with sufficient BPL content to warrant flotation procedures and calculation of Economic Factors and Figures of Merit. The phosphorite layers were roughly similar to those of northern Lanier County as regards amount, quality, and amenability to beneficiation. They occurred at greater depths below the surface than those in Lanier County, and thus have lower immediate economic interest.

When the data are reviewed in the light of geographic location, it appears that higher BPL content matrices, and closer to the surface, run in a broad band northward from the western third of Lanier County. East from western Atkinson and west from Berrien County (Cook County) the amount of BPL in matrices drops. Northward from Berrien County, through Irwin and Ben Hill Counties, the phosphorites are of lower BPL content, at greater depths below the surface, and appear to have low economic interest at this time.

Calculated so-called Economic Factors and unique Figures of Merit are presented in Appendix III for all holes to date on which adequate information was available. Individual companies apply different orders-of-priority and somewhat different levels of the several factors to determine the degree of interest in further exploration or mining. Hence, an average level of the range as reported in the literature was taken. If a different level is chosen, the Economic Factors and Figures of Merit can be adjusted by a simple ratio.

A significantly improved procedure for preparing samples for chemical analyses was developed. Fusion with lithium metaborate in inexpensive graphite crucibles gave more complete solution of the samples than had

been experienced with the usual caustic fusion in platinum crucibles. The results, particularly as regards Al_2O_3, were higher than obtained by the caustic fusion procedure. This must be remembered when current results are compared with results obtained by the older, but "approved," method.

A modified double-ball check valve for core barrels was designed and gave better performance and longer life.

PROCEDURE

Overall Program Procedure

The project procedure as noted in prior reports (Project Report Nos. 1, 2, and 3), and as illustrated in Figure 2, has not undergone any basic change. Core drilling to obtain in situ samples of deposits which are analyzed and processed by normal industrial techniques provides results which are immediately applicable to the calculation of economic factors for evaluation of the potential commercial utilization of the deposits.

Locations of core drilling operations are selected through consideration of data available from prior investigations - both as published in the literature and through consultation with authorities - through field reconnaissance by project personnel, and through data obtained from previously drilled holes. As reported in Project Report Nos. 2 and 3, phosphorite areas of interest had been found in Echols County and northward into Lanier County. The area covered in this report was selected to determine the potential northward limit of interest and to determine if the deposits trended eastward or westward from western Echols and Lanier Counties.

Drilling throughout was terminated at about 100 feet as this represents the maximum depth considered feasible at this time for strip mining. In other areas drilling may be carried out to greater depths for geologic control data. Cores of 2 7/8 in. diameter were obtained; with bits, core barrels and drilling muds varied to meet changing sedimentary conditions. Core recovery generally was relatively high, except in unconsolidated water-saturated layers.

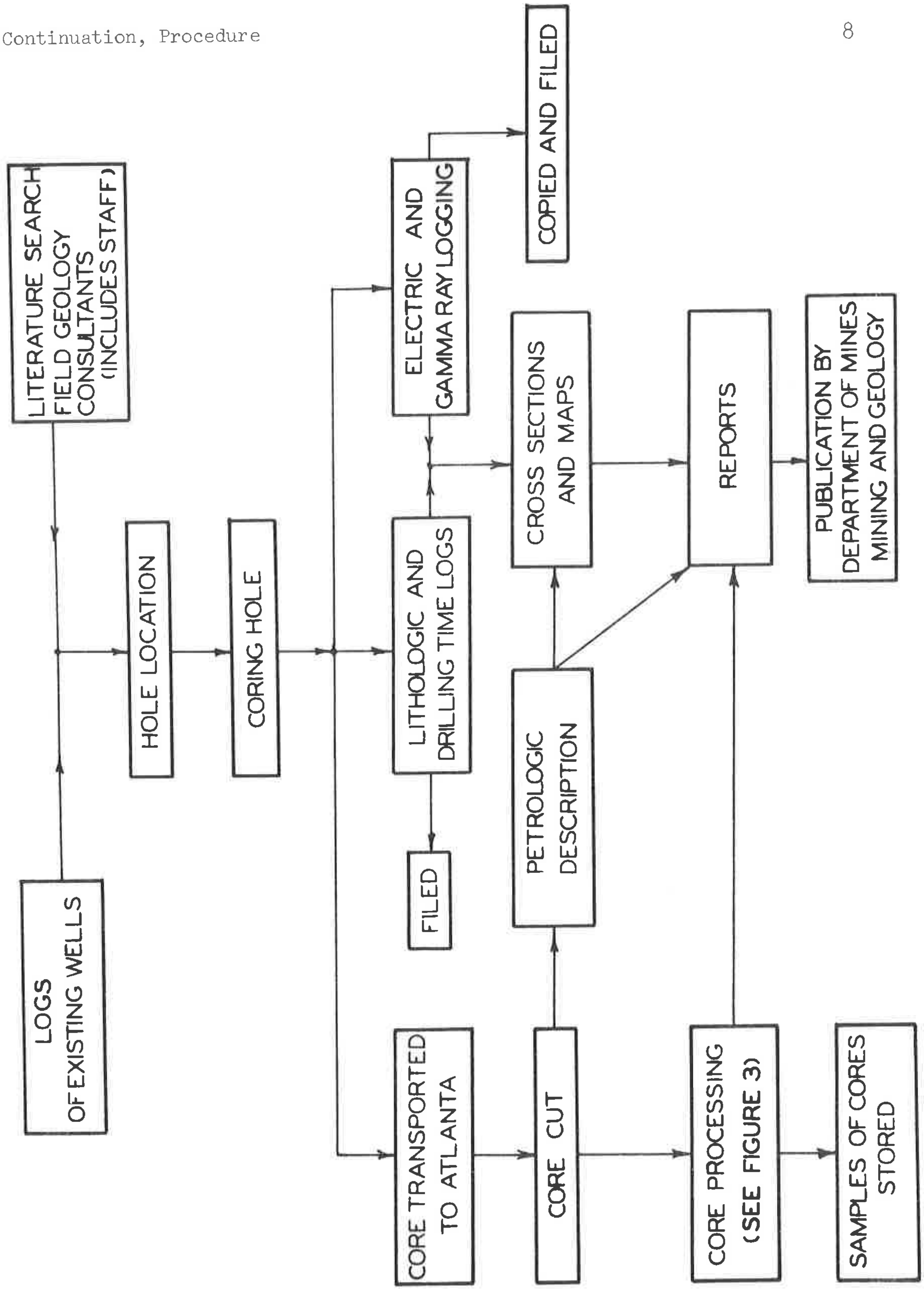


Figure 2. Flow Chart of Project Procedure.

Observations of the cores and recorded in the field, and checked at the laboratory, result in lithologic logs (geologic descriptions) of the cores. The cores were wrapped in plastic to retain moisture, placed in core boxes labeled to show layer depths, and trucked to the Georgia Tech laboratories.

Three instrumental "logs" were obtained,on many of the holes, upon completion of drilling. Earth resistivity and induced potential, called electric logs, provide an indication of sand, shale, and porosity of the earth throughout the depth of the hole. The gamma-ray log records the radiation emission of the earth and permits estimation of layers containing phosphorites and/or certain heavy minerals.

At the laboratory, with a 1-inch pipe, perpendicular to the longitudinal axis of the core, the cores are "plugged" to obtain a one-inch diameter sample through the center of the core, usually at one-foot intervals; five "plugs" in order were combined to form a representative sample of the five-foot layer. Based upon the lithologic logs and visual observation of a change of core composition, "plugs" were combined only from within the distinct layer, irrespective of five-foot intervals.

The combined representative samples were then analyzed for Bone Phosphate of Lime (BPL) content. Layers (matrices) containing over about nine percent of BPL were then processed to determine phosphate recovery and product quality when beneficiated in accordance with normal industrial practice.

Weight recoveries and chemical analyses were performed on the pebbles: +4, -4+8, -8+16 mesh sizes; on the -16+150 mesh flotation feed; and on the flotation step products: -16+35, -35+150, and concentrates. Some industrial companies obtain the -16+35 mesh fraction by "tabling" with the -35+150 mesh material serving as the flotation feed. Results shown in the tables for the -150 mesh material (slimes) were calculated by difference, not analyzed.

It should be noted that emphasis was on phosphorite, for fertilizers, deposits. Care was taken not to overlook deposits of clays, sand, and heavy minerals of industrial interest.

Upon completion of analyses, samples and cores were stored for possible future examination.

Core Processing

Figure 3 is a flow chart of the steps and analyses carried out in processing matrices of interest: cores containing over nine percent BPL.

Chemical Analyses

Sample Preparation

Analyses were carried out on portions quartered from larger amounts of cuts from the matrix and from the separate products from screen analysis and beneficiation procedures. The material for analysis was dried in an oven for two hours at 110° C; hence, all results were on a dry weight basis. To date, grinding of the samples for fusion-solution has been carried out either by an electric mortar grinder with an alumina mortar and pestle or by hand in a porcelain mortar and pestle. An automated grinder to produce samples rapidly in the desired size range has been on order for a couple of months and receipt is expected during early November.

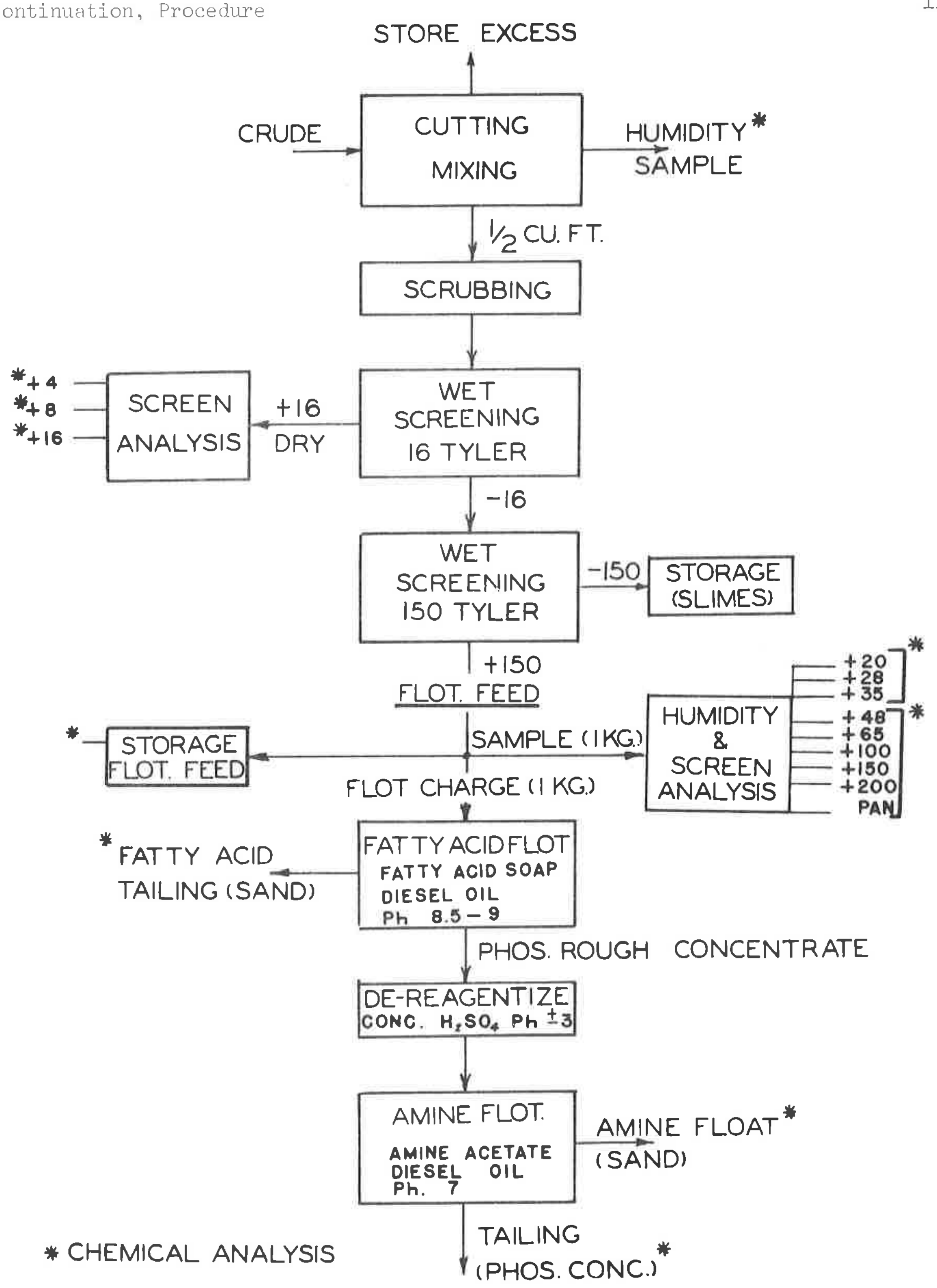


Figure 3. Flow Chart of Core Processing.

Methods of Analysis

Difficulties had been experienced in obtaining duplicate results of desired accuracy particularly in determining aluminum. In fact, aluminum contents were not reported in Project Report No. 3. Research showed two major causes of the difficulties. One was in the caustic fusion of samples for atomic absorption or wet chemical analyses. It was also found that the amount of component in a sample to be analyzed, concentration in a solution for precipitation, and time and temperature during precipitation were variables needing control.

Small variations in surface characteristics of pellets for x-ray fluorescent analyses were found to affect results. Accordingly, this technique was not used during this Project Report No. 5 period. With the receipt of an automated grinder-sizer and an automated hydraulic dwell press, uniform pellets should be obtained and use of the x-ray fluorescent technique resumed.

With the procedures outlined below, reliable results were obtained and "gaps" in previous Project Reports were filled in. See Appendix II. It should be noted that the sensitivity of analyses to minor variations in details of procedures suggests that results should be reported to only the first decimal.

Several of the analyses reported in Project Report No. 3 were "questioned" and led to re-analysis and the research mentioned above. New samples of the questioned results were taken and analyzed. No significant corrections to previously reported results were found necessary. For example, new samples of the reported high quality beneficiated products from Lanier County cores gave BPL results within about one percent of prior results.

1. Acid Insoluble Residue (AI). Acid insoluble residues were determined by a method adapted from the method for sand and insoluble silicates given on page 30 of "Methods Used and Adopted by the Association of Florida Phosphate Chemists (1960)." Thirty milliliters of concentrated nitric acid and ten milliliters of concentrated hydrochloric acid were used to digest one gram portions of the sample until evolution of red fumes ceased and the solution became clear. The solution was diluted to 100 milliliters with distilled water and filtered through a Whatman No. 40 paper. The filtrate and washings were diluted to 250 milliliters in a Class A volumetric flask and reserved for phosphorus analysis. The filter paper and residue were ignited to constant weight at 800° C in a muffle furnace. The percent acid insoluble (AI) was calculated from:

$$\text{percent acid insoluble} = \frac{\text{weight of ignited residue x 100}}{\text{weight of dry sample}}$$

2. Bone Phosphate of Lime (BPL). Wet phosphate determinations were made on all matrix samples by a modification of the "Phosphoric Acid (P_2O_5) Tricalcium Phosphate or Bone Phosphate of Lime (BPL)" method described on pp 27-30 of the manual referenced above in paragraph 1. The alkali used was S_o-S-270 Sodium Hydroxide N/2 (Fisher Scientific Company) tested against primary standard grade potassium acid phthalate as each container was opened. Nitric acid, N/2, was prepared using the standardized potassium hydroxide solution as a secondary standard. Agreement among duplicate samples was within two percent for samples containing less than 20 percent BPL.

On matrix and processed sample cuts containing more than 10 percent BPL, the volumetric method set forth in "Official Methods of Analysis of the Association of Official Agricultural Chemists," (AOAC), eighth edition, 1955, paragraph 2, 14b, pp 9-10, was followed in precipitating ammonium phosphomolybdate. This procedure required careful adjustment of acidity and dilution prior to precipitation. The resulting precipitate was more easily washed and filtered without loss than had been obtained with these higher phosphate content samples when using the Florida chemists' method described above. A reproducibility of within one percent on duplicate samples was obtained.

Slight differences found in results between aliquot portions of the same sample precipitated overnight at room temperature or precipitated for 20 minutes at 50° C were arithmetically adjusted by results from National Bureau of Standards Sample 120a aliquots precipitated and titrated among the groups of "unknown" samples. Calculations, for a typical 25 milliliter aliquot portion, were performed by:

$$\text{percent } P_2O_5 = \frac{0.500}{0.324} \times \frac{1}{\text{weight of sample}} \times (\text{ml NaOH} - \text{ml } HNO_3)\ *$$

$$\text{percent BPL} = 2.185 \times \text{percent } P_2O_5$$

3. Lime (CaO). Determinations were carried out on an atomic absorption spectrophotometer, Perkin Elmer Model 303, operated with a

*The terms "ml NaOH" and "ml HNO_3" refer to the number of milliliters of 0.5000 N sodium hydroxide required to dissolve the precipitated and washed ammonium phosphomolybdate and the number of milliliters of 0.5000 N nitric acid required to neutralize the excess caustic, respectively, using phenolphthalein as indicator.

nitrous oxide acetylene flame. Samples were prepared by fusion with purified lithium metaborate, dissolving the melt in four percent nitric acid, and diluting the sample to a suitable working concentration with a four percent nitric acid solution containing one-half percent lithium metaborate. A standard curve was derived from similarly treated National Bureau of Standard samples. The assortment included phosphate rock, feldspars, bauxite, and limestone.

4. Iron Oxide (Fe_2O_3). Iron oxide analyses were performed by the atomic absorption spectrophotometer using an air-acetylene flame. Samples were prepared by fusion with purified lithium metaborate and dilution with distilled water to working concentration.

5. Aluminum Oxide (Al_2O_3). Determinations were carried out on the atomic absorption spectrophotometer using a nitrous oxide-acetylene flame. Samples were prepared by fusion with purified lithium metaborate and dilution with distilled water to working concentration as required. Standard curves for iron oxide and aluminum oxide analyses were prepared by similar treatment of several different National Bureau of Standards samples chosen to represent differing types of natural rock.

Fusion with lithium metaborate constitutes a significant advance in the preparation of samples. It permits the use of inexpensive graphite cricibles instead of platinum. Complete solution of the sample is obtained. The prior procedure, using caustic fusion in platinum, apparently did not give complete solution of some of the aluminum silicates. In some cases, the caustic fusion was followed by an acid fusion step to try to overcome this difficulty. It should be noted that due to a more complete solution of the sample with the revised procedure, Al_2O_3 content is higher. This fact should be considered in comparing results obtained by the new technique with those obtained by others using the caustic fusion technique.

RESULTS

Data are presented under the individual counties listed in alphabetical order.

A drill site location map, lithologic log, and BPL content (by chemical analyses) for sample intervals are given for each hole. Figure 4 presents the "legend" for the lithologic description of the cores. "WS" in tables denotes "wash samples" when necessitated by inability to recover satisfactory cores for that interval.

Only phosphorite layers from Atkinson No. 1, Berrien No. 1, and Berrien No. 3 were found to contain sufficient phosphorites to process through the flotation procedure.

Absence, or but small amounts at depth, of phosphorites in eastern Atkinson and in Coffee, Irwin, and Ben Hill Counties indicated a low priority from the phosphate viewpoint, for further reconnaissance in these areas. It is, of course, possible that deposits in the form of lenses or stringers are present but other areas obviously should have higher priority for investigation at this time.

A revised procedure for preparing samples for chemical analyses was developed and constitutes a significant advance in chemical analysis of "rock phosphate (see Procedure).

A modified double-ball check valve for core barrels was constructed and found to perform better and have longer life (see Appendix IV).

Electric and gamma-ray logs have been recorded on practically all holes drilled, and it has been stated in prior reports that these log charts are available for review at the State Department of Mines, Mining, and Geology. Interpretation and correlation of data from the charts is quite difficult

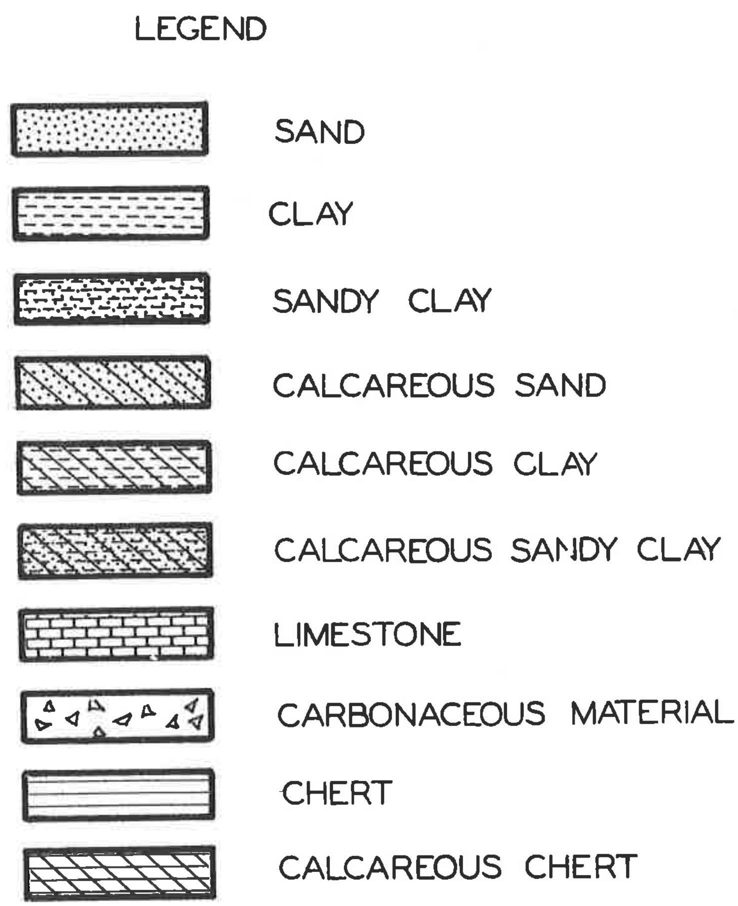


Figure 4. Legend for Lithologic Logs

due largely to the complex nature of the sedimentary layers encountered. Difficulties are enhanced near the surface layers through spurious electrical currents at the surface making it infeasible to record an accurate base line.

It was recognized that many geologists, skilled in interpreting these logs, would find it impracticable to come to Atlanta to study the charts. Accordingly, the available logs for the counties of this report have been reproduced, somewhat reduced in size from the originals, and are enclosed.

ATKINSON COUNTY

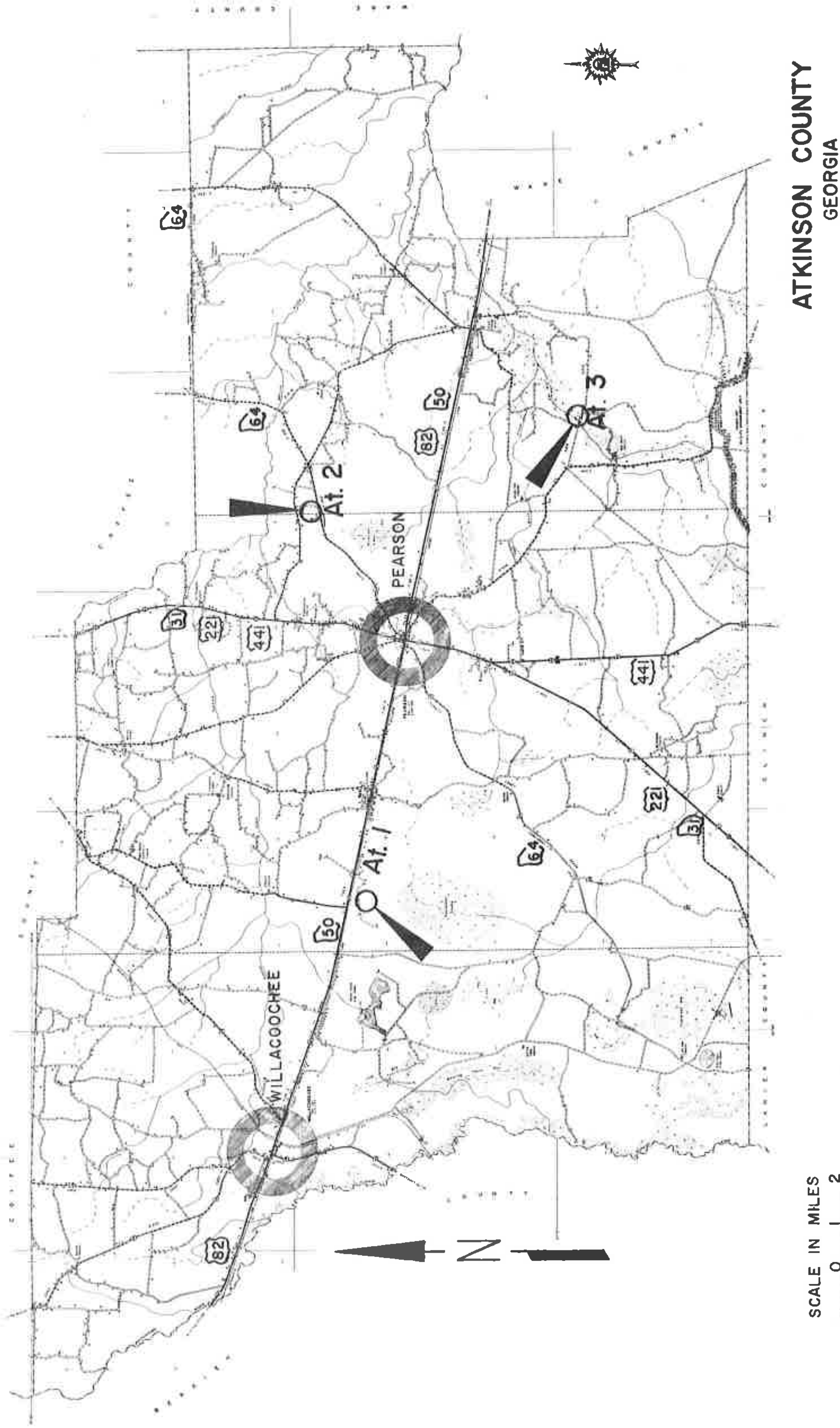


Figure AT-1. Location of Holes - Atkinson County

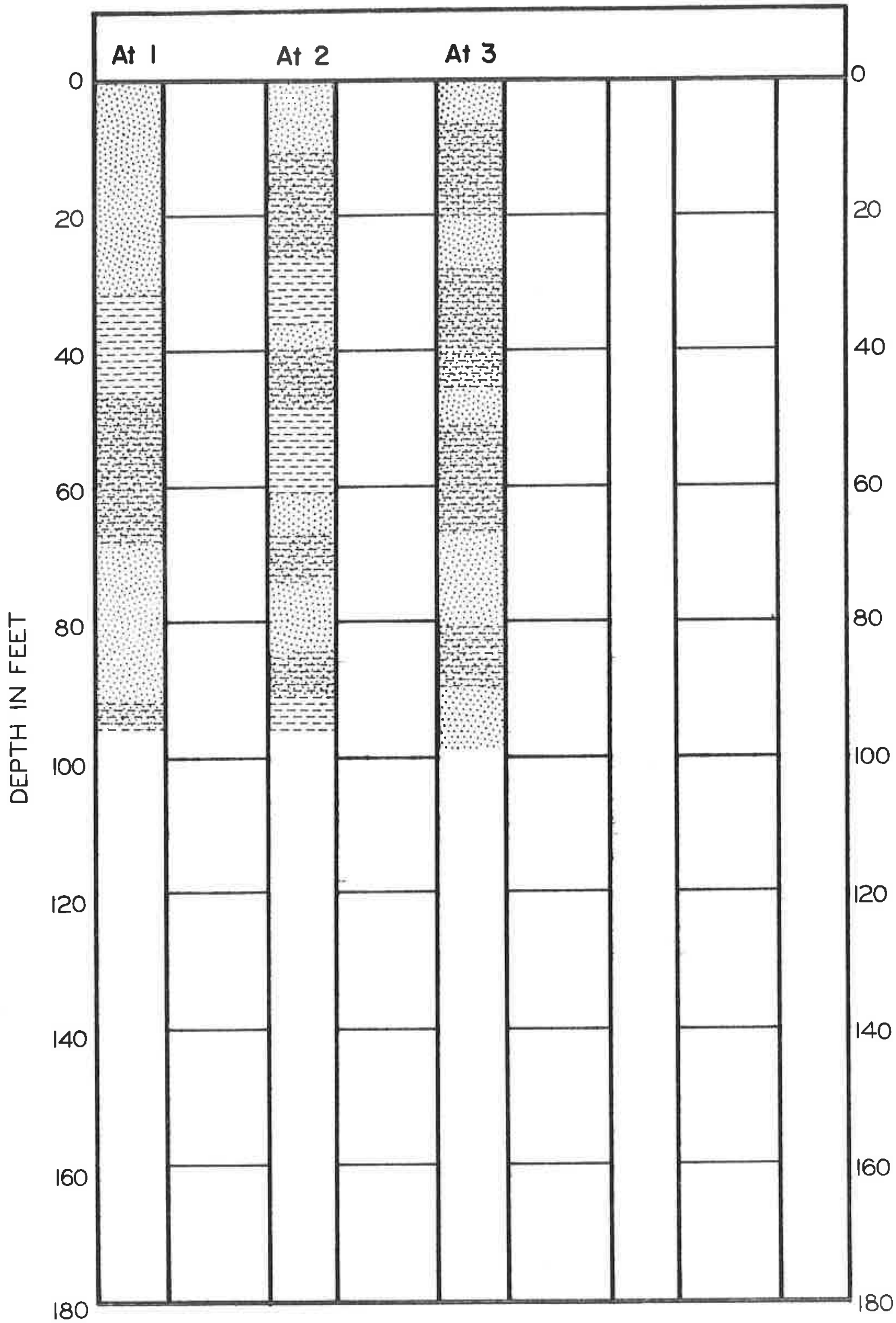


Figure AT-2. Lithologic Logs - Atkinson County

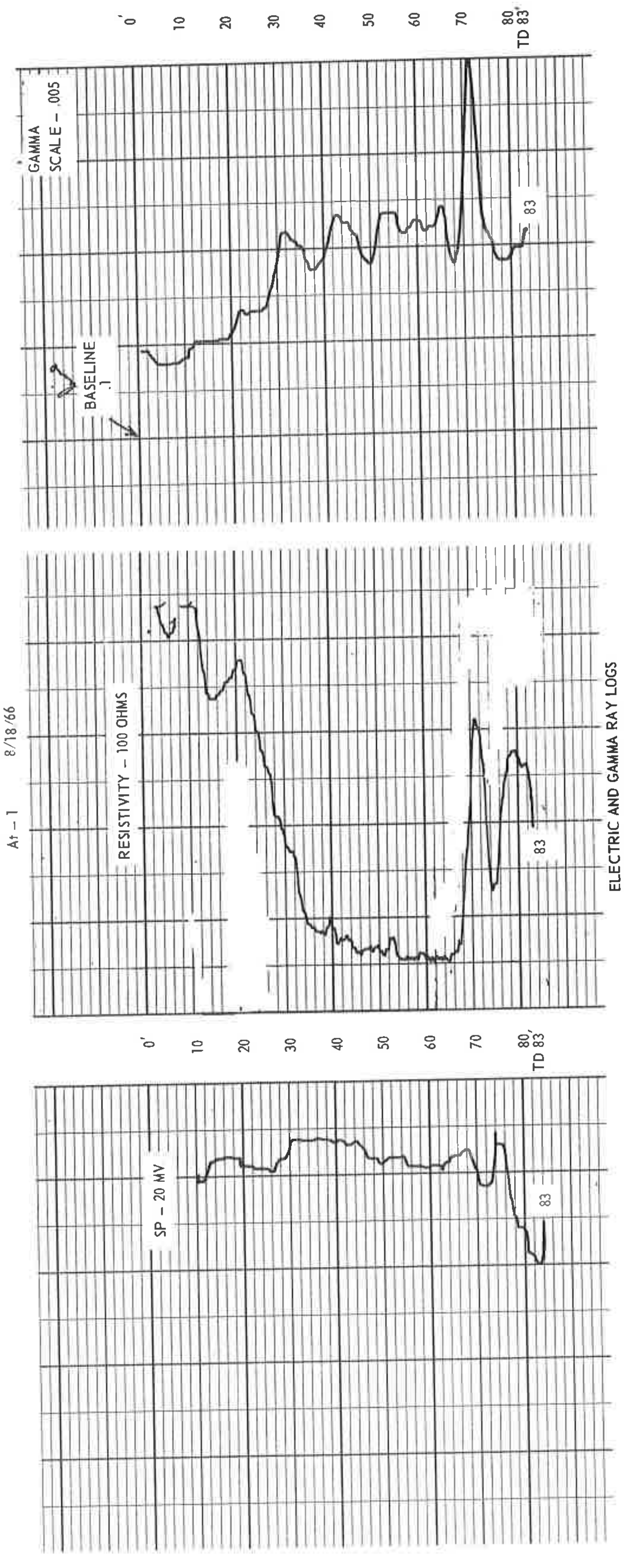


Figure AT-3. Electric and Gamma-Ray Logs - Atkinson County
Hole At-1

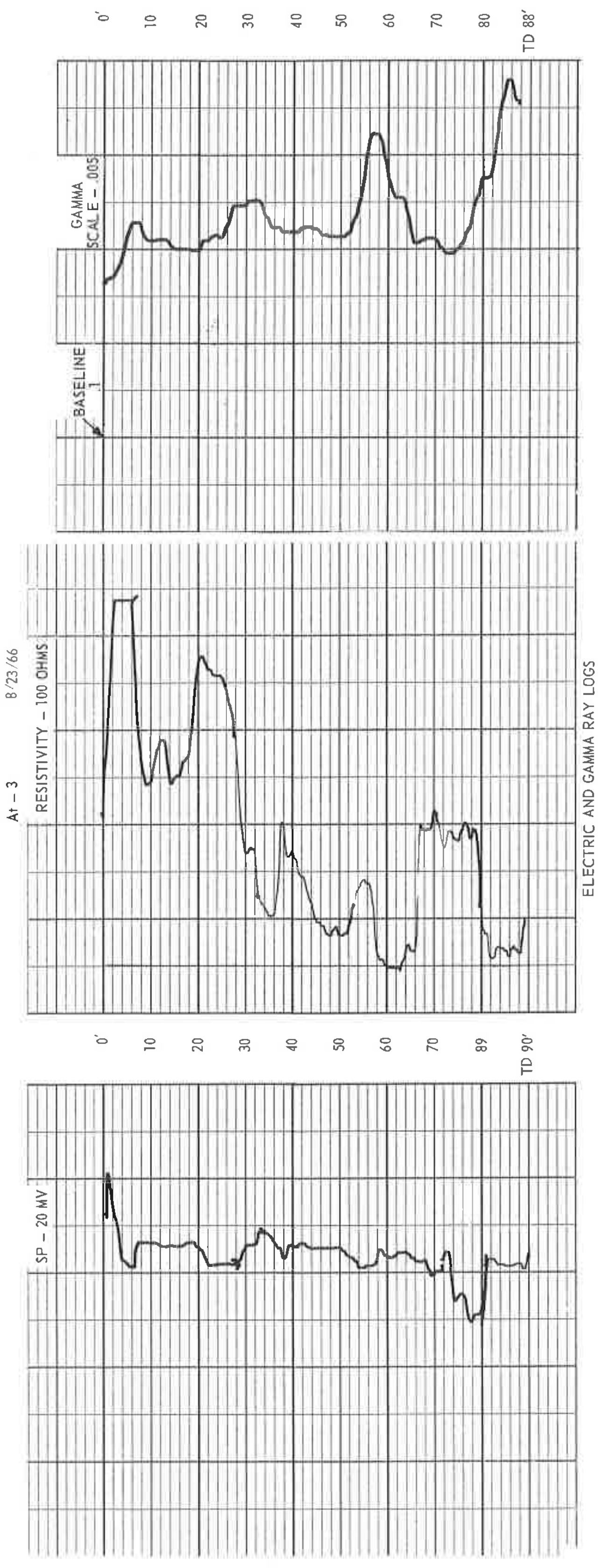


Figure AT-3. Electric and Gamma-Ray Logs - Atkinson County
Hole At-3

TABLE AT-I

BPL DETERMINATIONS ON CORES

Atkinson County

Hole No.	Surface Elevation (Sea Level) Feet	Depth, Feet	Core Recovery		BPL %
			Feet	%	
At-1	248	0-10	10 W.S.	W.S.	0.0
		10-12	2	100	0.0
		12-15	1.5	50	0.0
		15-18	1.5	50	0.0
		18-20	2	100	0.0
		20-23	2.2	90	0.0
		23-25	2	100	0.0
		25-30	5	100	0.0
		30-35	5	100	0.0
		35-45	7	70	0.0
		45-55	6	60	0.0
		55-65	4	40	0.0
		65-75	7	70	0.0
		75-81	5	83	0.6
		81-85	3.5	85	2.8
		85-91	5.5	90	14.7
		91-95	3.5	87	2.0
At-2	218	0-10	10	100	
		10-15	4	80	
		15-20	2.5	50	
		20-30	10	100	
		30-40	10	100	
		40-50	10	100	
		50-53	3	100	
		53-58	5	100	0.5
		58-63	5	100	0.0
		63-68	5	100	0.7
		68-73	5	100	0.5
		73-78	5	100	0.5
		78-80	2	100	0.7
		80-84	4	100	3.6
		84-88	4	100	2.5
		88-90	2	100	3.3
		90-95	5	100	4.4
At-3	194	0-68	68	100	0.0
		68-78	7	70	0.0
		78-88	10	100	0.0
		88-94	6	100	2.8
		94-98	4	100	7.0

Note: Low core recoveries, where shown, were due to washing out of soft clays or sands in the indurated clay layers.

TABLE AT-II

MATRIX BENEFICIATION RESULTS

	Feed	+4	-4+8	-8+16	(Flot. feed) -16+150	-16+35	-35+150	(Slime) -150	Concen- trates	Fatty Acid Tailing	Amine Float
HOLE NO. At-1	Surface Elevation = 248 feet (sea level)						Matrix Interval = 85-91 feet				
Total sand footage	6										
Dry density lb/cu ft	91.4										
Percent dry weight	100.0	0.2	1.0	5.0	78.6	30.7	47.9	15.2	8.8	86.9	4.3
Percent BPL	11.7	76.6	73.2	41.6	7.7	10.1	4.8	17.6	60.3	1.3	3.1
Percent acid insol	85.0	7.1	12.9	51.7	91.2	88.4	94.4	69.0	29.5	98.3	96.3
Percent Fe_2O_3	0.59	0.65	0.93	0.37	0.19	0.14	0.24	2.7	0.61	0.13	0.34
Percent Al_2O_3	3.83	1.63	1.42	1.50	1.63	1.06	1.33	16.18*	1.64	1.13	2.06
Percent CaO	6.49	49.6	46.9	24.9	4.11	5.60	2.18	9.55	37.6	0.0	1.12

*This calculated value is unusually high.

BEN HILL COUNTY

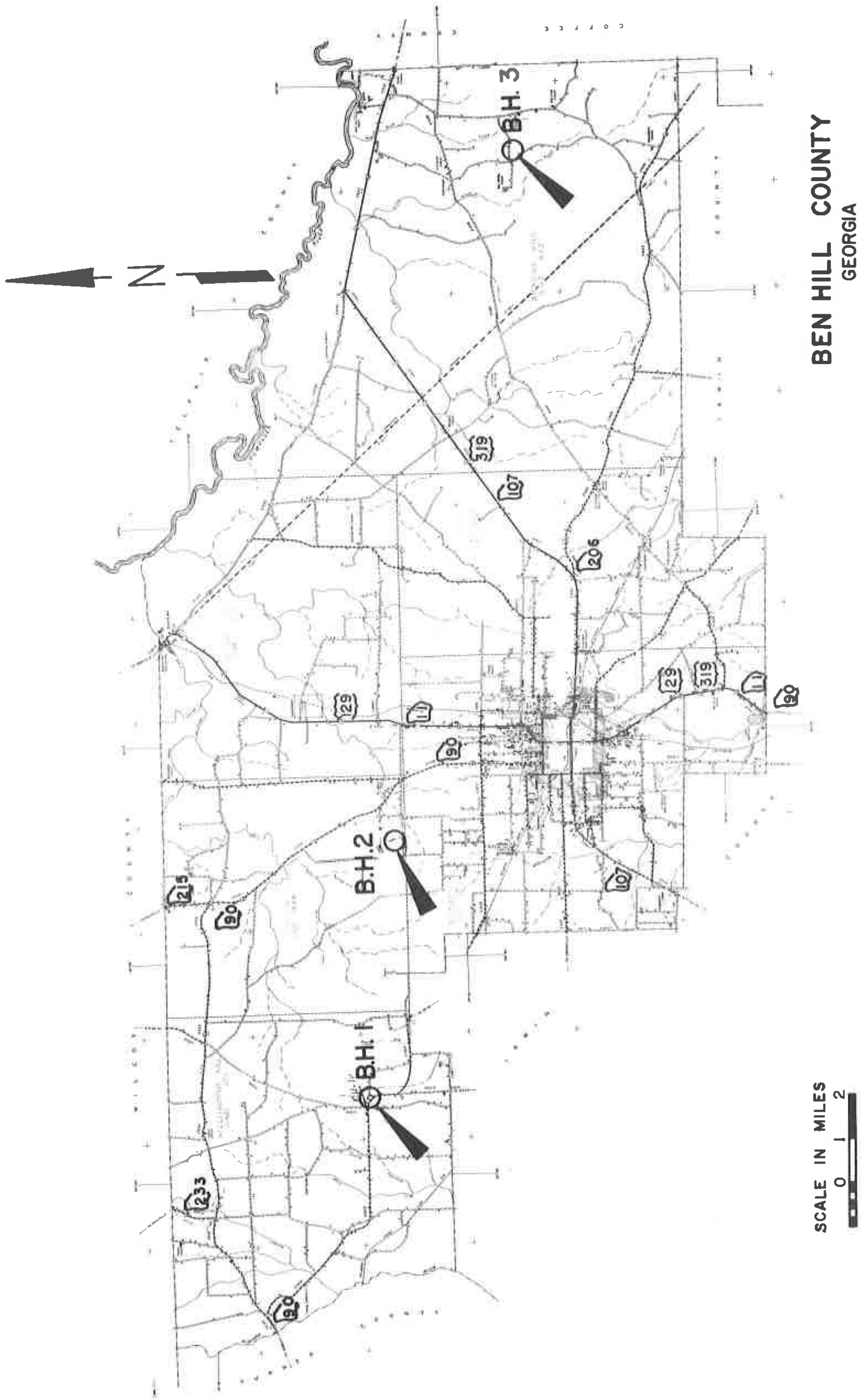


Figure BH-1. Location of Holes - Ben Hill County

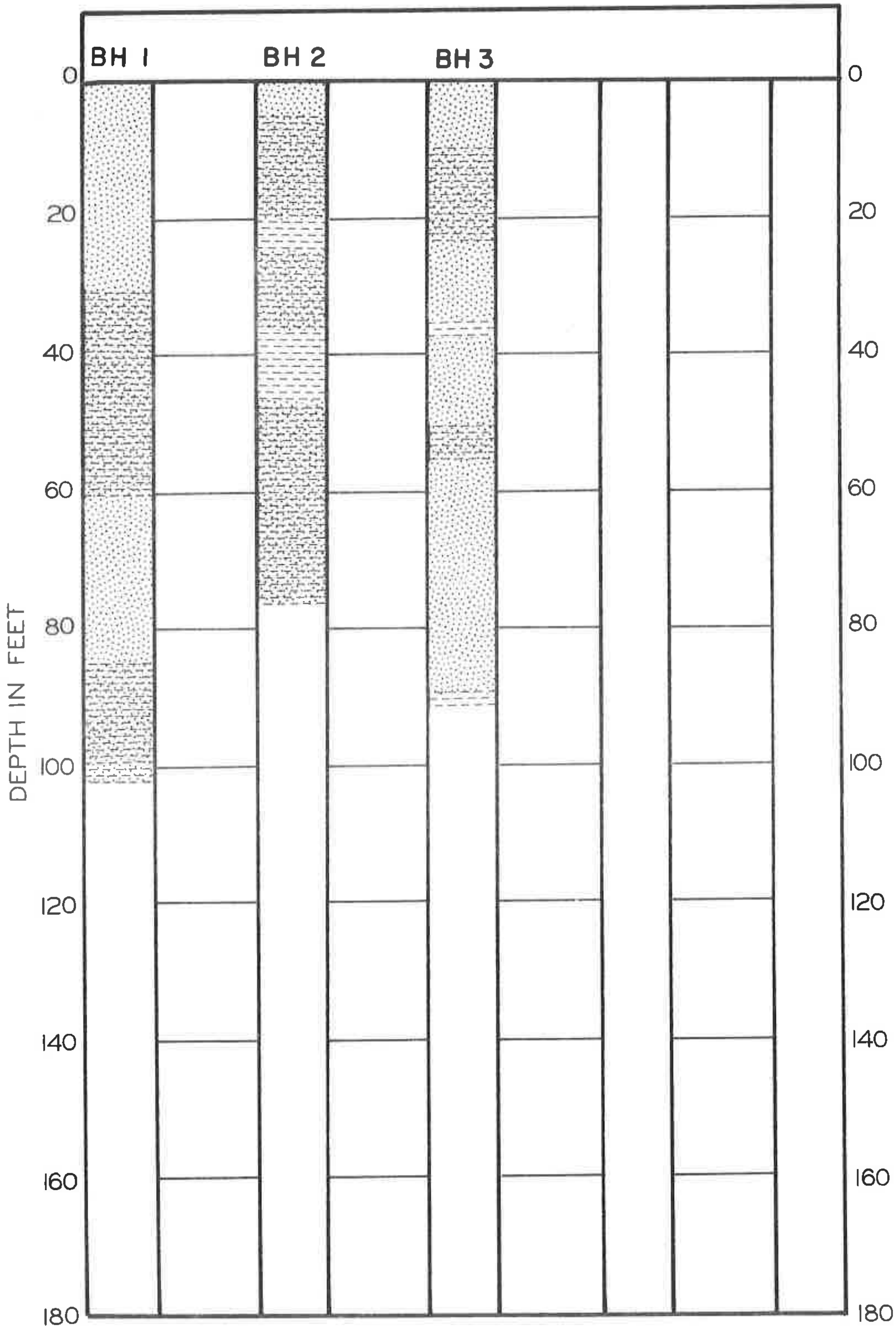


Figure BH-2. Lithologic Logs - Ben Hill County

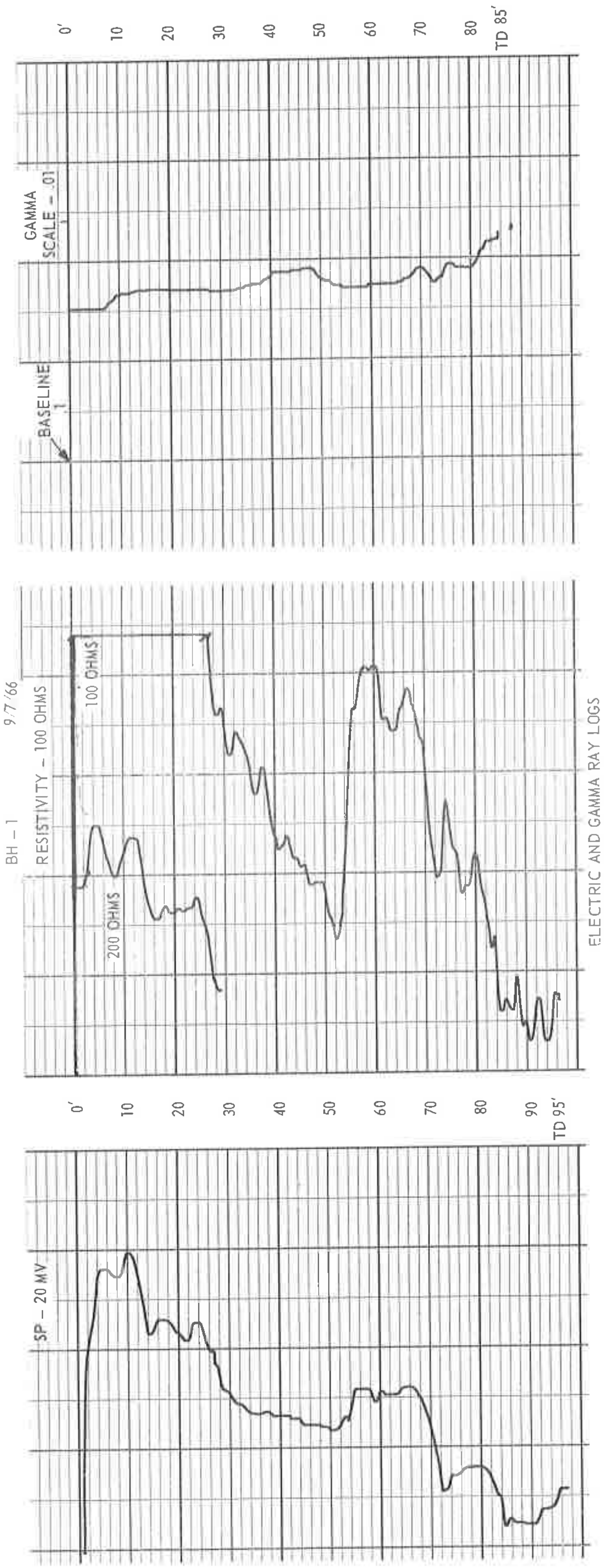


Figure BH-3. Electric and Gamma-Ray Logs - Ben Hill County
Hole BH-1

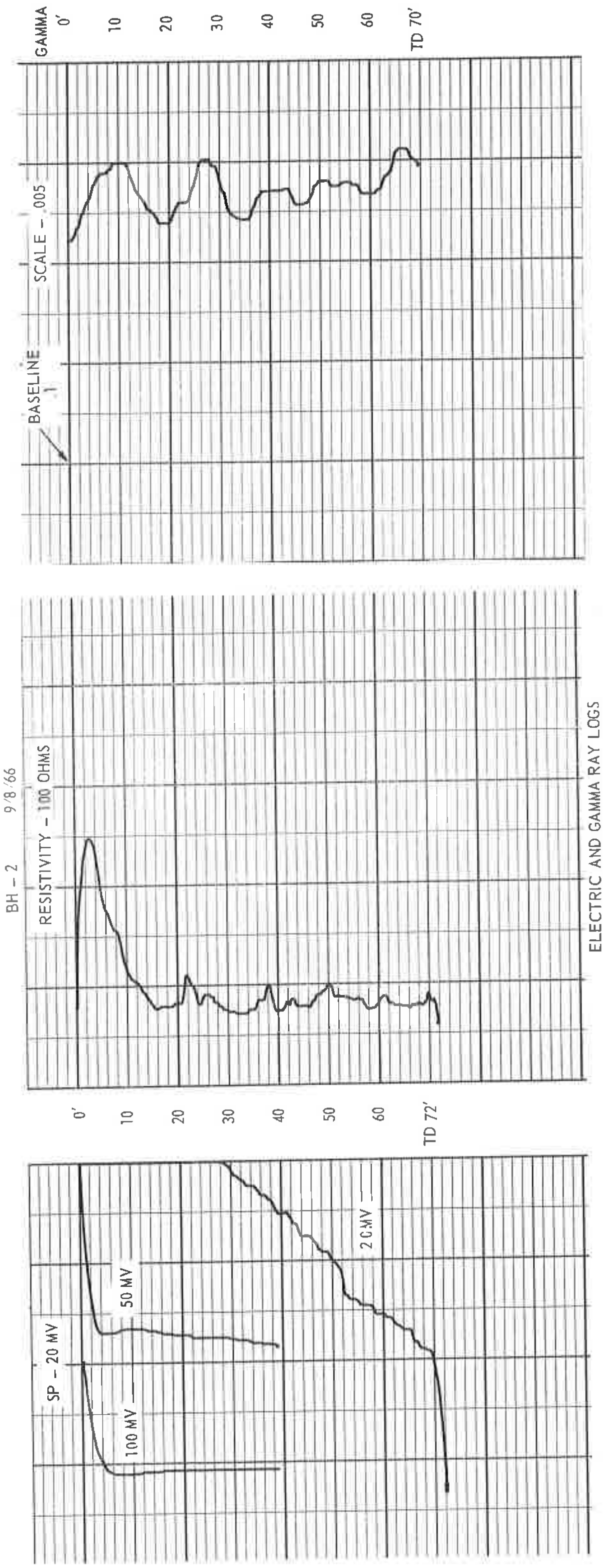


Figure BH-3. Electric and Gamma-Ray Logs - Ben Hill County
Hole BH-2

TABLE BH-I

BPL DETERMINATIONS ON CORES

Ben Hill County

Hole No.	Surface Elevation (Sea Level) Feet	Depth, Feet	Core Recovery Feet	Core Recovery %	BPL %
BH-1	342	0-10	10 W.S.		0.0
		10-18	8	100	0.0
		18-22	3	75	0.0
		22-25	0	0	0.0
		25-33	8	100	0.0
		33-42	4.5	50	0.0
		42-52	4	40	0.0
		52-62	4	40	0.0
		62-72	2.5	25	0.0
		72-87	5	30	0.0
		87-102	6	30	0.0
	Poor recoveries caused by ball check valve failure				
BH-2	302	0-10	10 W.S.		
		10-18	6	80	0.0
		18-28	7	70	0.0
		28-36	6	75	0.0
		36-46	6	60	0.0
		46-56	10	100	0.0
		56-66	10	100	0.0
		66-76	7	70	0.0
		76-81	0	0	
BH-3	268	0-10	10 W.S.		0.0
		10-15	5	100	0.0
		15-40	25	100	0.0
		40-45	3.5	70	0.0
		45-50	3.5	70	0.0
		50-55	5	100	2.0
		55-60	4	80	1.0
		60-70	8	80	0.5
		70-80	9	90	0.0
		80-90	10	100	0.0

BERRIEN COUNTY

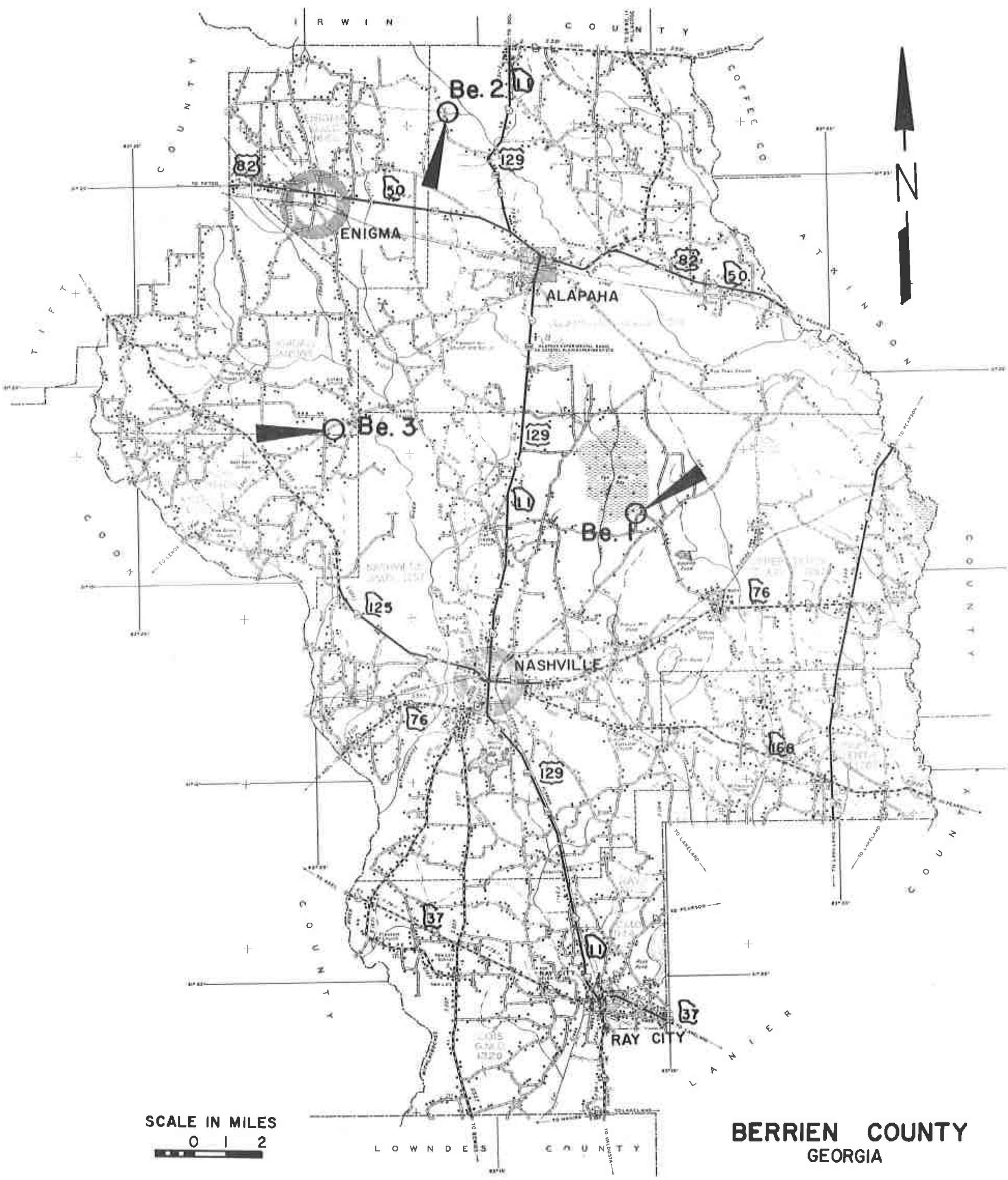


Figure BE-1. Location of Holes - Berrien County

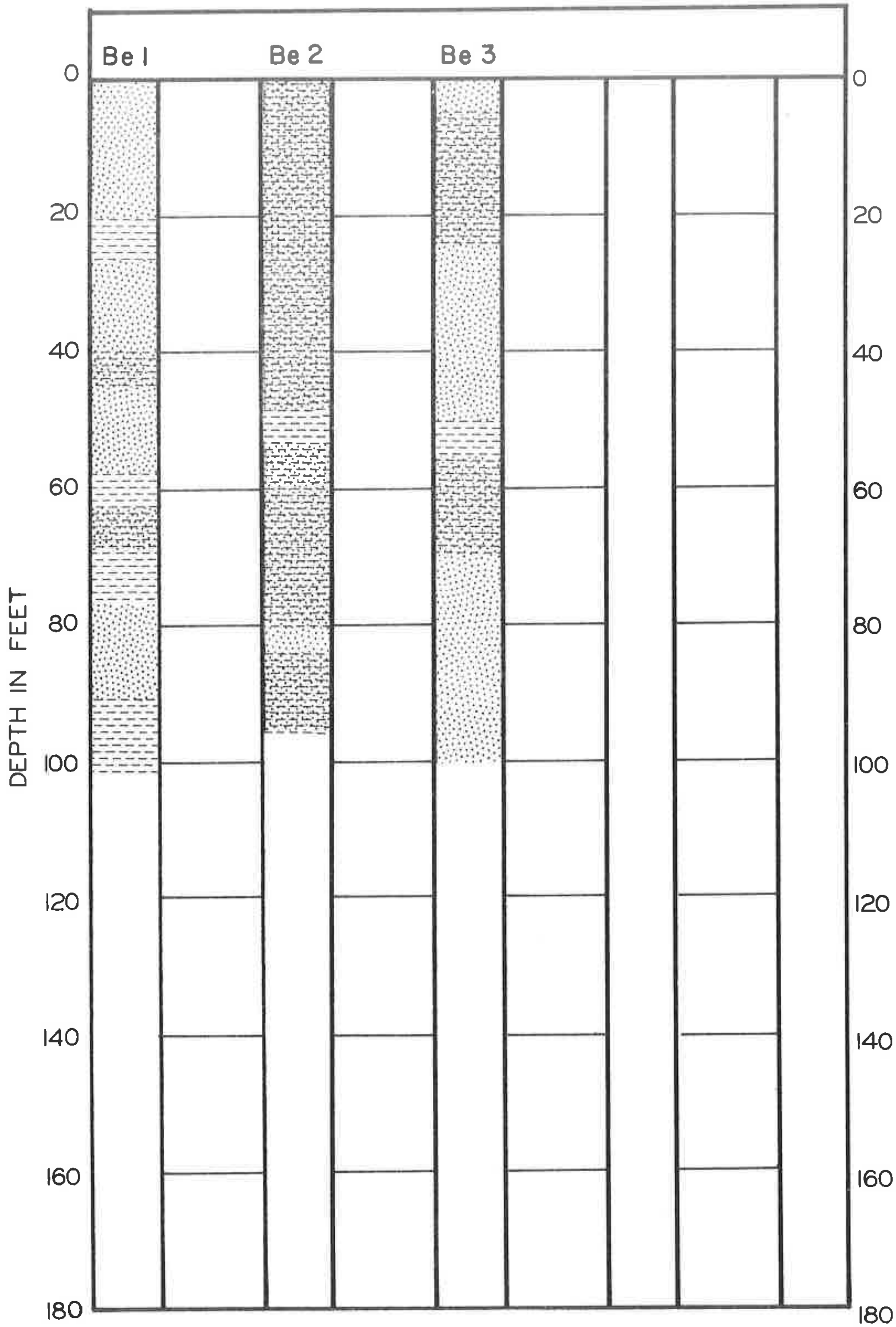


Figure BE-2. Lithologic Logs - Berrien County

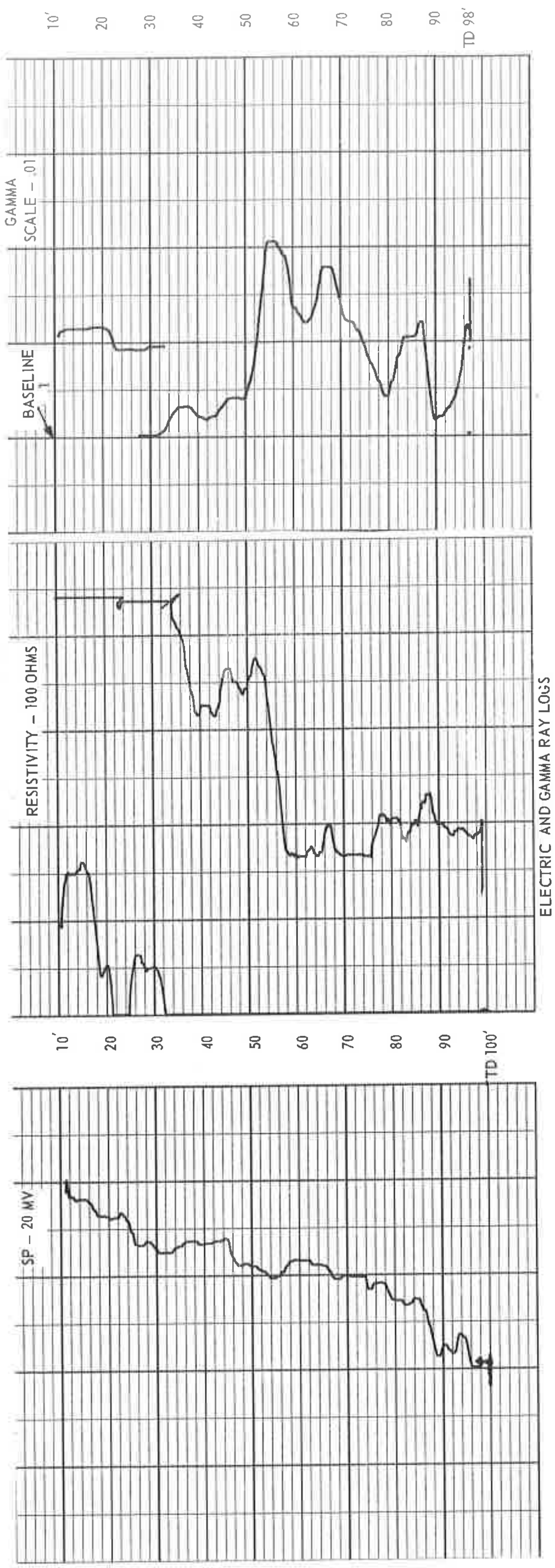


Figure BE-3. Electric and Gamma-Ray Logs - Berrien County
Hole Be-1

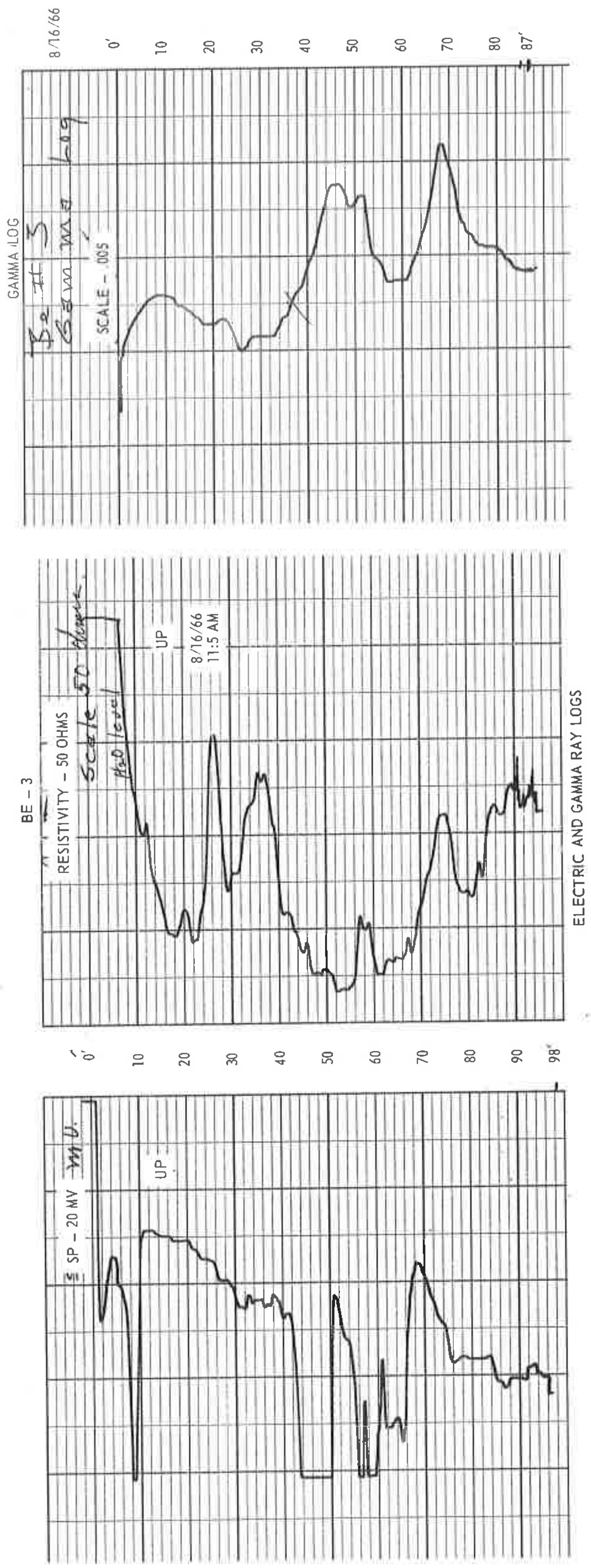


Figure BE-3. Electric and Gamma-Ray Logs - Berrien County
Hole Be-3

TABLE BE-I

BPL DETERMINATIONS ON CORES

Berrien County

Hole No.	Surface Elevation (Sea Level) Feet	Depth, Feet	Core Recovery Feet	Core Recovery %	BPL %
Be-1	241	0-10	8.5 W.S.		0.9
		10-15	4	80	0.0
		15-19	4	100	
		19-22	3	100	
		22-26	0	0	
		26-32	6	100	
		32-42	3	30	0.6
		42-50	8	100	0.7
		50-57	4	57	0.8
		57-62	5	100	0.9
		62-66	4	100	1.8
		66-71	5	100	2.3
		71-77	6	100	6.5
		77-87	7	70	13.3
		87-90	3	100	15.4
		90-95	5	100	4.8
		95-101	6	100	5.6
Be-2	225	0-5	4.5	90	1.4
		5-10	4.5	90	0.0
		10-15	5	100	0.0
		15-19	4	100	0.7
		19-23	4	100	0.7
		23-30	7	100	1.7
		30-37	7	100	4.3
		37-40	3	100	4.7
		40-45	5	100	4.5
		45-50	5	100	1.7
		50-53	2.5	83	3.3
		53-58	3	60	3.4
		58-65	5	71	7.4
		65-75	4	40	4.5
		75-85	6	60	3.8
		85-95	2	20	1.8
		95-101	0	0	
Be-3	331	0-20	0	0	
		20-30	6	60	0.0
		30-35	5	100	0.0
		35-45	8	80	0.0
		45-55	10	100	0.0
		55-65	5	50	
		65-75	10	100	0.9
		75-85	8	80	5.8
		85-95	8	80	11.7
		95-100	5	100	9.7

TABLE BE-II

MATRIX BENEFICIATION RESULTS

HOLE NO. Be-1	Feed	+4	-4+8	-8+16	(Flot. feed) -16+150	-16+35	-35+150	(Slime) -150	Concen- trates	Fatty Acid Tailing	Amine Float
Surface Elevation = 241 feet (sea level) Matrix Interval = 76-90 feet											
Total sand footage	14										
Dry density lb/cu ft	83.5										
Percent dry weight	100.0	.6	1.1	3.8	80.2	22.1	58.1	14.3	9.9	82.9	7.2
Percent BPL	13.0	61.5	70.8	60.4	10.7	16.0	8.1	6.9	72.1	3.8	6.3
Percent acid insol	82.5	28.5	14.0	28.6	88.4	81.3	90.4	71.1	14.9	95.8	92.6
Percent Fe_2O_3	.80	.80	.70	.49	.18	.18	.21	4.36	.08	.40	.61
Percent Al_2O_3	4.25	2.65	2.00	1.89	2.72	1.65	3.34	13.71	1.65	2.39	4.33
Percent CaO	7.30	36.7	43.5	36.1	5.57	9.23	4.34	5.31	41.3	0.59	3.13

(Continued)

TABLE BE-II (Continued)

MATRIX BENEFICIATION RESULTS

	Feed	+4	-4+8	-8+16	(Flot. feed) -16+150	-16+35	-35+150	(Slime) -150	Concen-trates	Fatty Acid Tailing	Amine Float
HOLE NO. Be-3	Surface Elevation = 331 feet (sea level)						Matrix Interval = 85-100 feet				
Total sand footage	15										
Dry density lb/cu ft	73.7										
Percent dry weight	100.0	.3	.7	3.4	81.9	18.1	63.8	13.7	12.3	84.5	3.2
Percent BPL	10.4	73.4	34.9	26.4	8.0*	11.4	7.2	18.0	51.1	1.6	6.0
Percent acid insol	84.1	8.1	51.3	67.5	89.7*	85.5	90.8	58.9	38.1	97.8	92.6
Percent Fe_2O_3	1.13	0.70	2.39	0.41	0.36	0.25	0.19	5.82	0.83	0.12	0.78
Percent Al_2O_3	4.18	1.45	3.57	1.80	3.57	1.54	2.14	8.51	3.34	2.48	5.95
Percent CaO	5.79	48.1	21.8	15.0	4.48	6.52	4.51	9.56	30.9	0.34	4.0

*Average of two values

COFFEE COUNTY

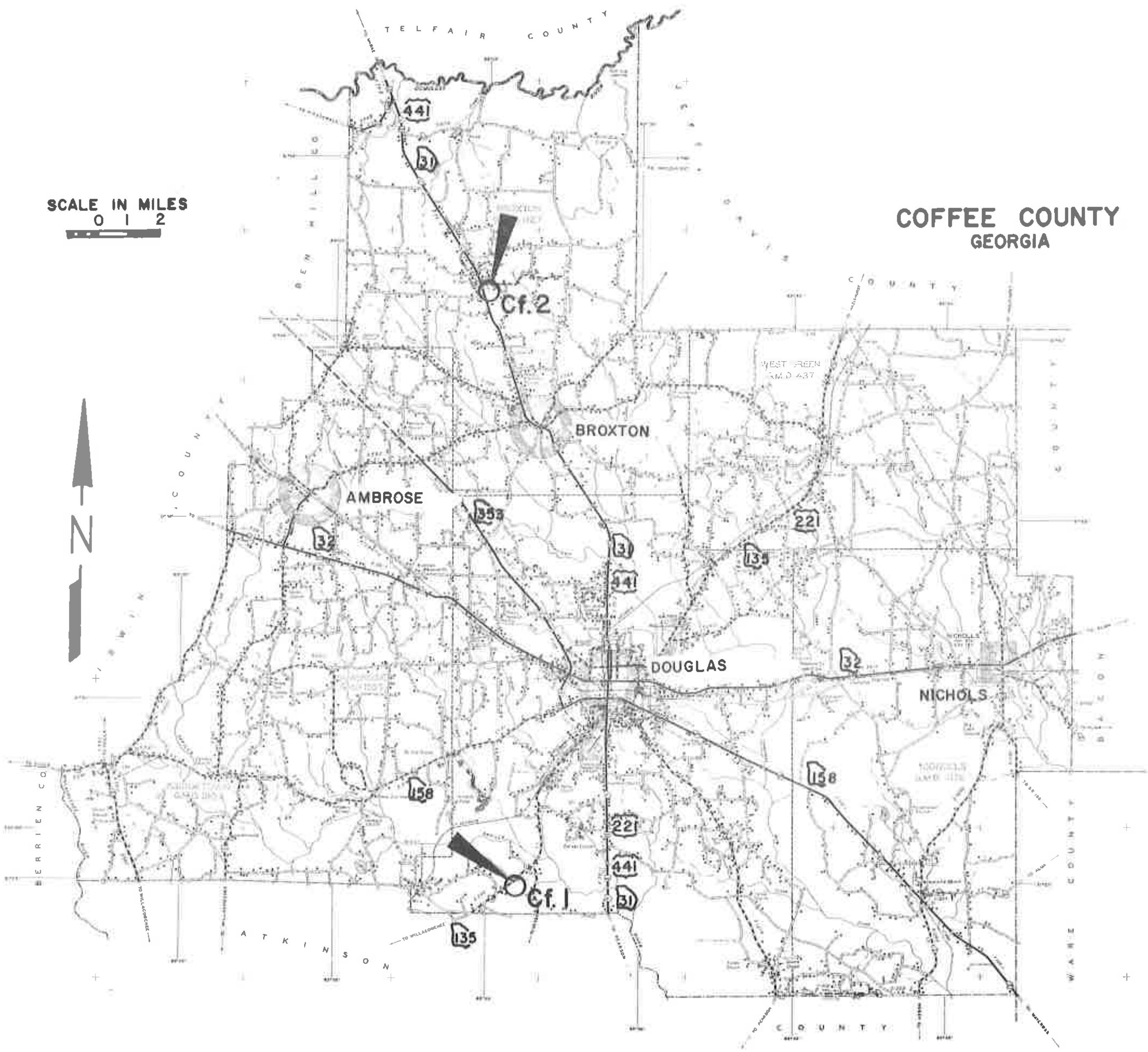


Figure CF-1. Location of Holes - Coffee County

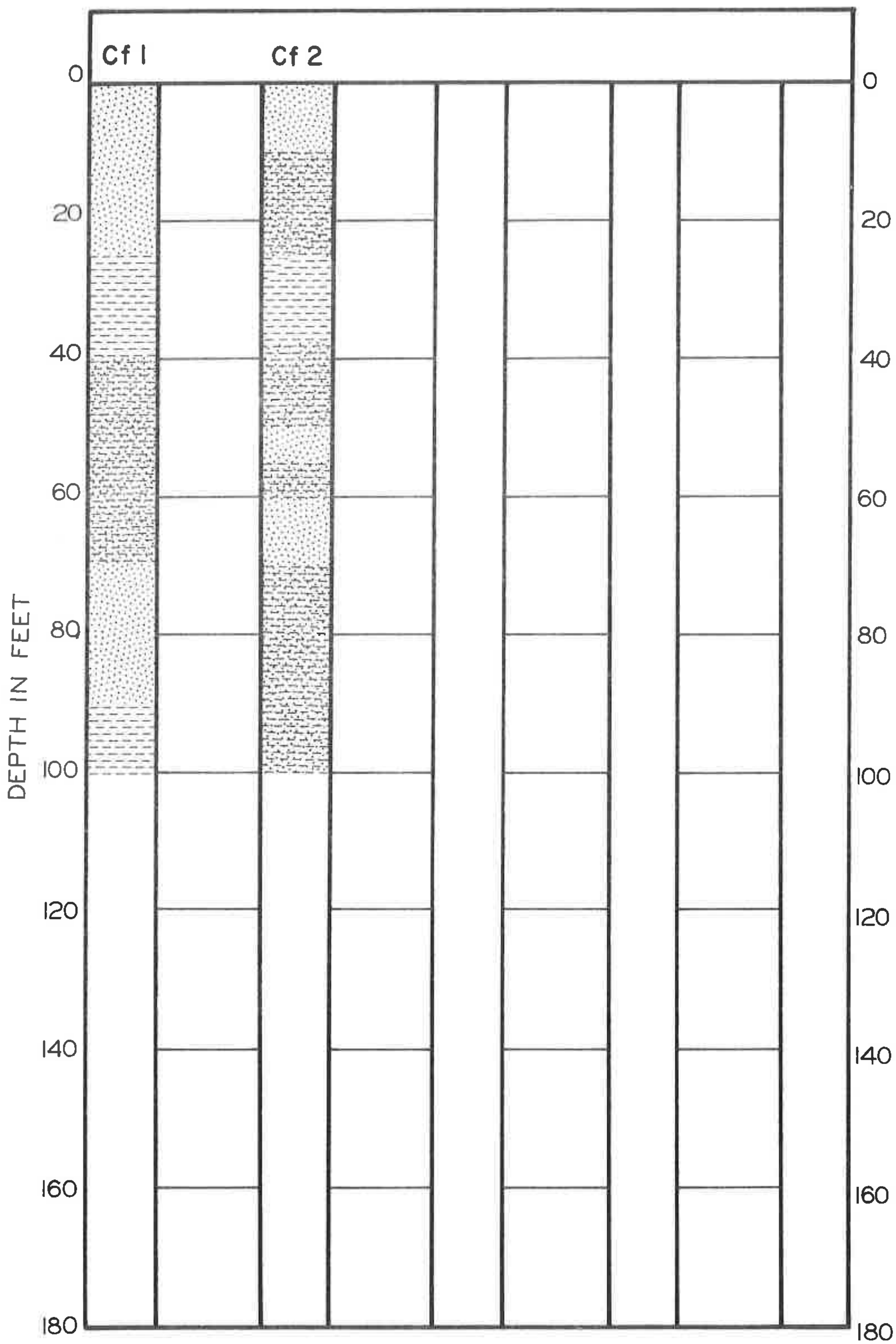


Figure CF-2. Lithologic Logs - Coffee County

TABLE CF-I

BPL DETERMINATIONS ON CORES

Coffee County

Hole No.	Surface Elevation (Sea Level) Feet	Depth, Feet	Core Recovery Feet	Core Recovery %	BPL %
Cf-1	250	0-30	30	100	0.0
		30-40	6	60	0.0
		40-45	1	20	0.0
		45-51	5	83	0.0
		51-56	5	100	0.0
		56-60	2	50	0.0
		60-72	12	100	0.0
		72-82	6	60	0.0
		82-92	8	80	0.0
		90-100	8	80	0.7
Cf-2	267	0-10	10 W.S.		0.0
		10-20	6	60	0.0
		20-30	7	70	0.0
		30-45	15	100	0.0
		45-50	4	80	0.0
		50-55	5	100	0.0
		55-60	4	80	0.0
		60-70	9	90	0.0
		70-80	6	60	0.0
		80-100	20	100	0.0

COOK COUNTY

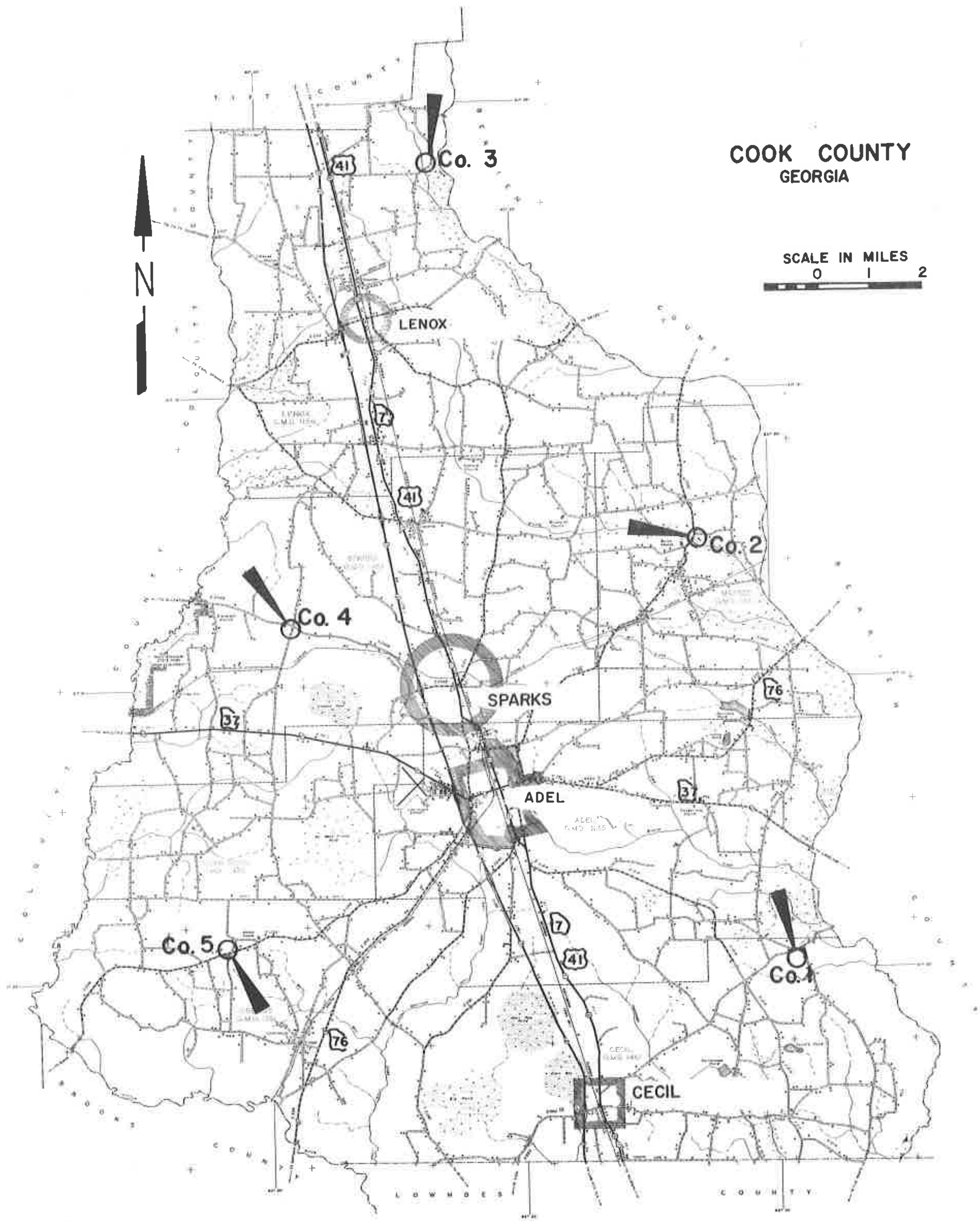


Figure CO-1. Location of Holes - Cook County

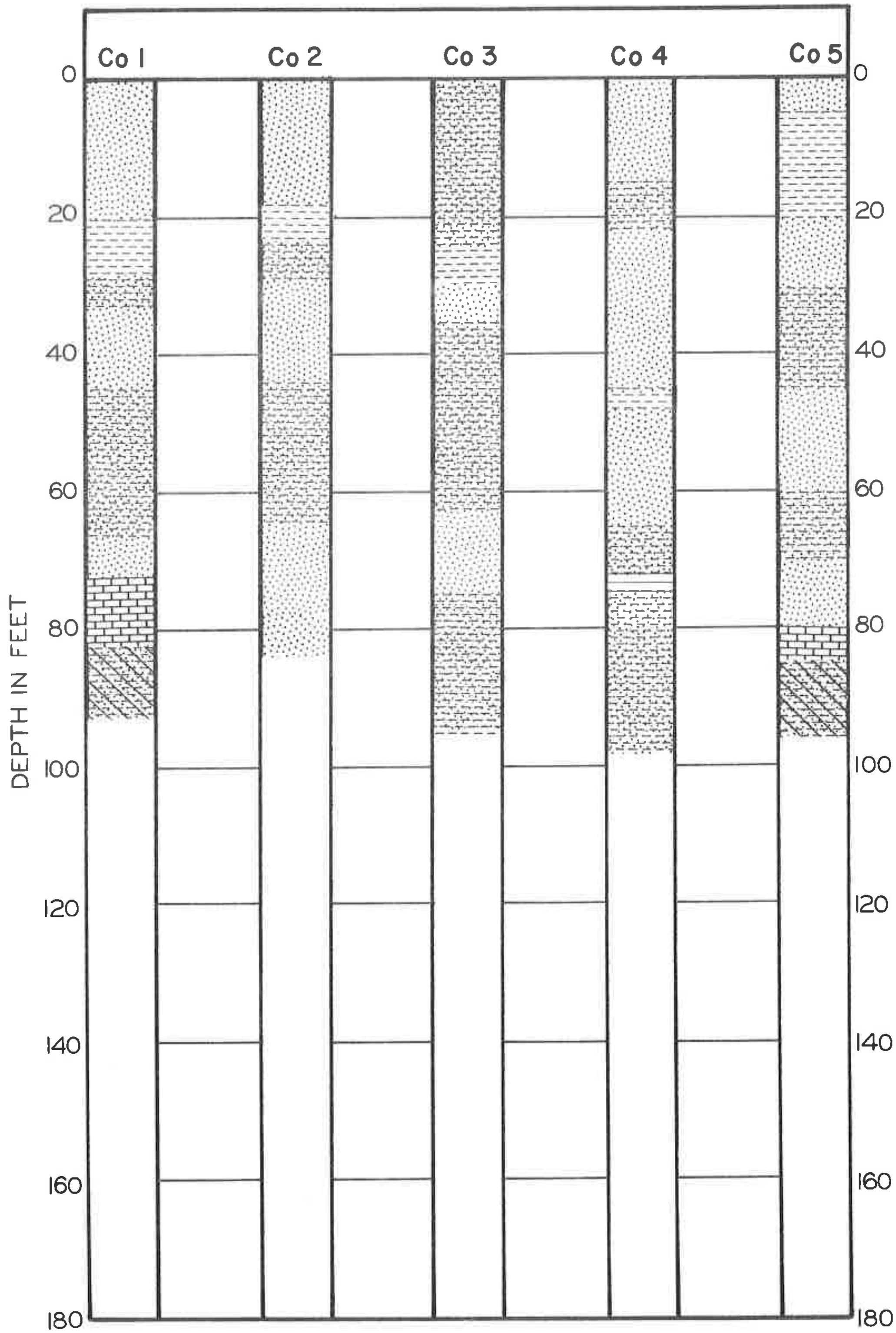


Figure CO-2. Lithologic Logs - Cook County

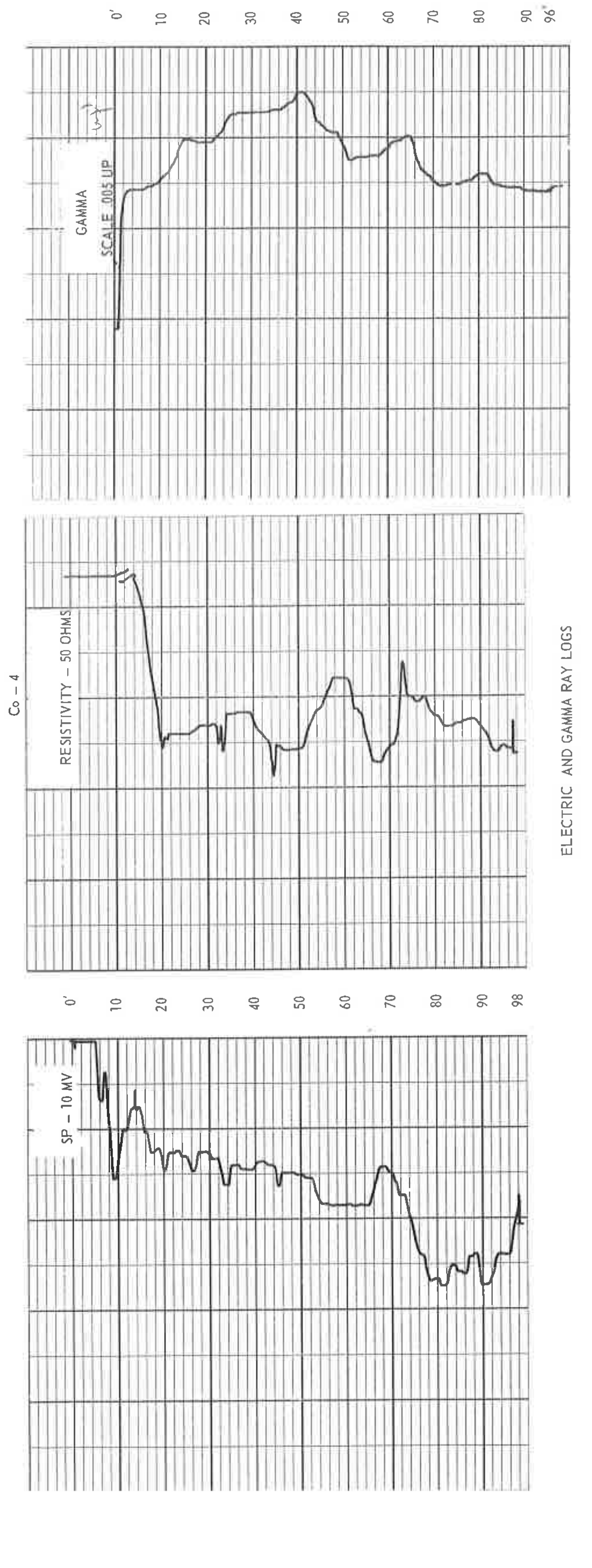


Figure CO-3. Electric and Gamma-Ray Logs - Cook County
Hole Co-4

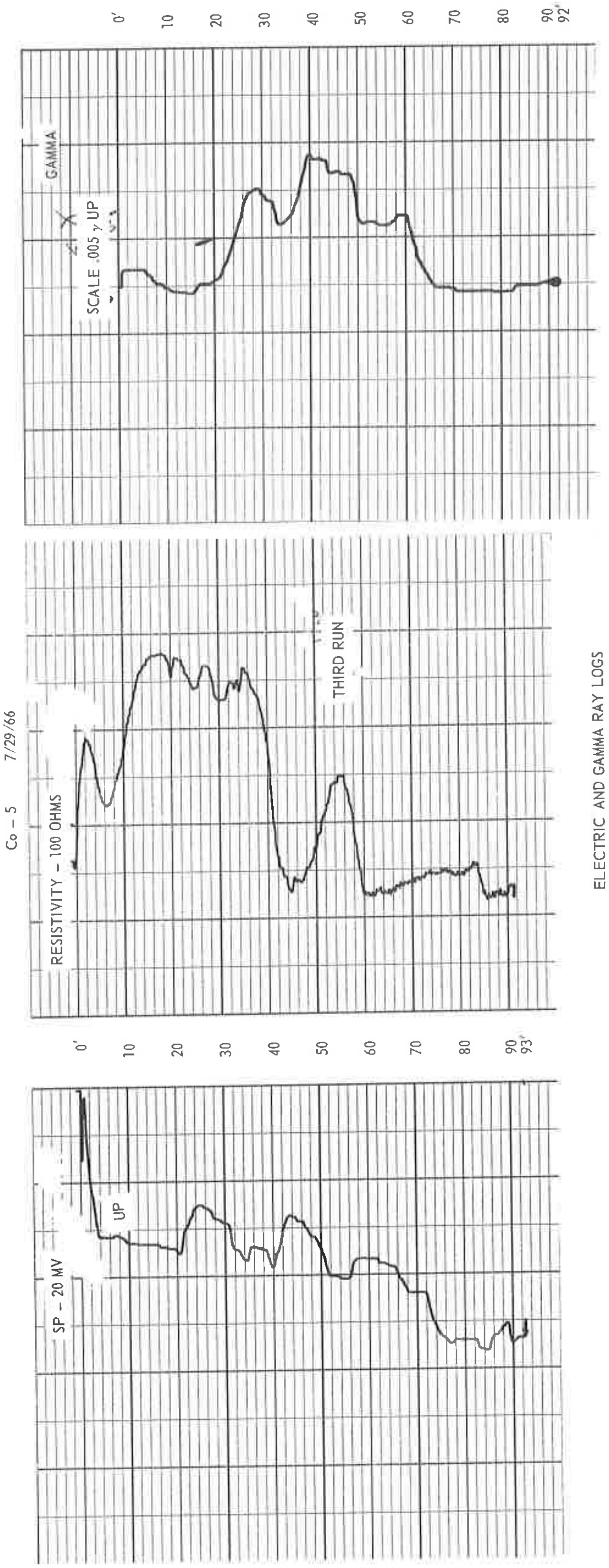


Figure CO-3. Electric and Gamma-Ray Logs - Cook County
Hole Co-5

TABLE CO-I

BPL DETERMINATIONS ON CORES

Cook County

Hole No.	Surface Elevation (Sea Level) Feet	Depth, Feet	Core Recovery Feet	Core Recovery %	BPL %
Co-1	237	0-5	5	100	0.7
		5-10	5	100	0.3
		10-15	5	100	0.5
		15-28	13	100	1.0
		28-33	2.5	50	0.6
		33-38	2	40	0.2
		38-42	1.5	38	0.4
		42-45	1	33	0.4
		45-51	5	83	0.6
		51-56	5	100	0.7
		56-60	2	50	0.3
		60-66	6	100	5.2
		66-72	5.5	92	4.5
		72-82	6	60	1.6
		82-92	8	80	2.1
Co-2	220	0-5	W.S.		1.4
		5-10	W.S.		0.0
		10-13	2	67	0.0
		13-15	2	100	2.1
		15-18	3	100	2.7
		18-21	2	67	1.3
		21-24	1	33	0.9
		24-29	4	80	0.8
		29-34	4	80	0.8
		34-39	4	80	0.8
		39-44	3	60	0.9
		44-49	5	100	1.2
		49-54	5	100	0.9
		54-59	5	100	2.4
		59-64	5	100	5.1
		64-69	1.5	30	3.0
		69-74	4	80	6.7
		74-79	2	40	3.6
		79-84	4	80	3.8
		84-89	0	0	
Co-3	300	0-10	10	100	0.0
		10-15	5	100	1.2
		15-48	33	100	0.0
		48-52	4	100	1.3

(Continued)

TABLE CO-I (Continued)

BPL DETERMINATIONS ON CORES

Cook County

Hole No.	Surface Elevation (Sea Level) Feet	Depth, Feet	Core Recovery Feet	Core Recovery %	BPL %
Co-3 (continued)		52-56	4	100	1.2
		56-66	9.5	95	0.0
		66-70	4	100	0.2
		70-75	3	60	5.4
		75-85	3	30	0.9
		85-95	7	70	0.9
Co-4	250	0-5	W.S.		0.0
		5-10	W.S.		0.7
		10-13	3	100	0.0
		13-15	2	100	0.5
		15-22	7	100	0.0
		22-32	10	100	0.5
		32-40	6	75	0.8
		40-48	7	88	1.6
		48-52	4	100	5.2
		52-60	4.5	75	0.6
		60-70	8.5	85	0.8
		70-78	8	100	1.2
		78-88	7	70	1.5
		88-98	10	100	3.0
Co-5	242	0-5	W.S.		0.5
		5-10	5	100	0.0
		10-20	5	50	0.0
		20-25	3	60	0.0
		25-30	2	40	0.9
		30-40	10	100	0.9
		40-50	8	80	0.9
		50-60	7	70	1.4
		60-70	8	80	4.7
		70-75	5	100	7.6
		75-80	5	100	3.7
		80-85	5	100	1.2
		85-90	4	80	1.4

IRWIN COUNTY

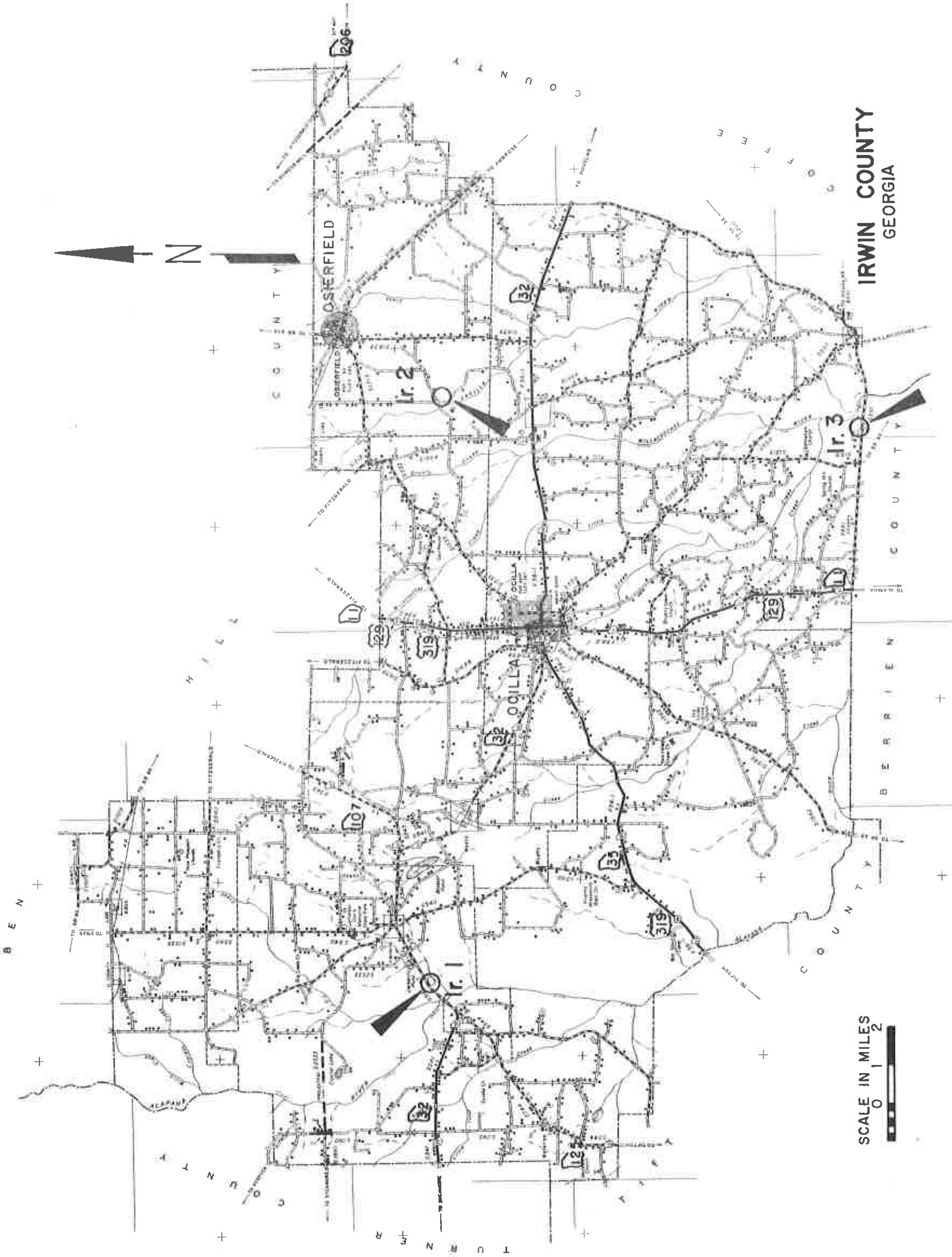


Figure IR-1. Location of Holes - Irwin County

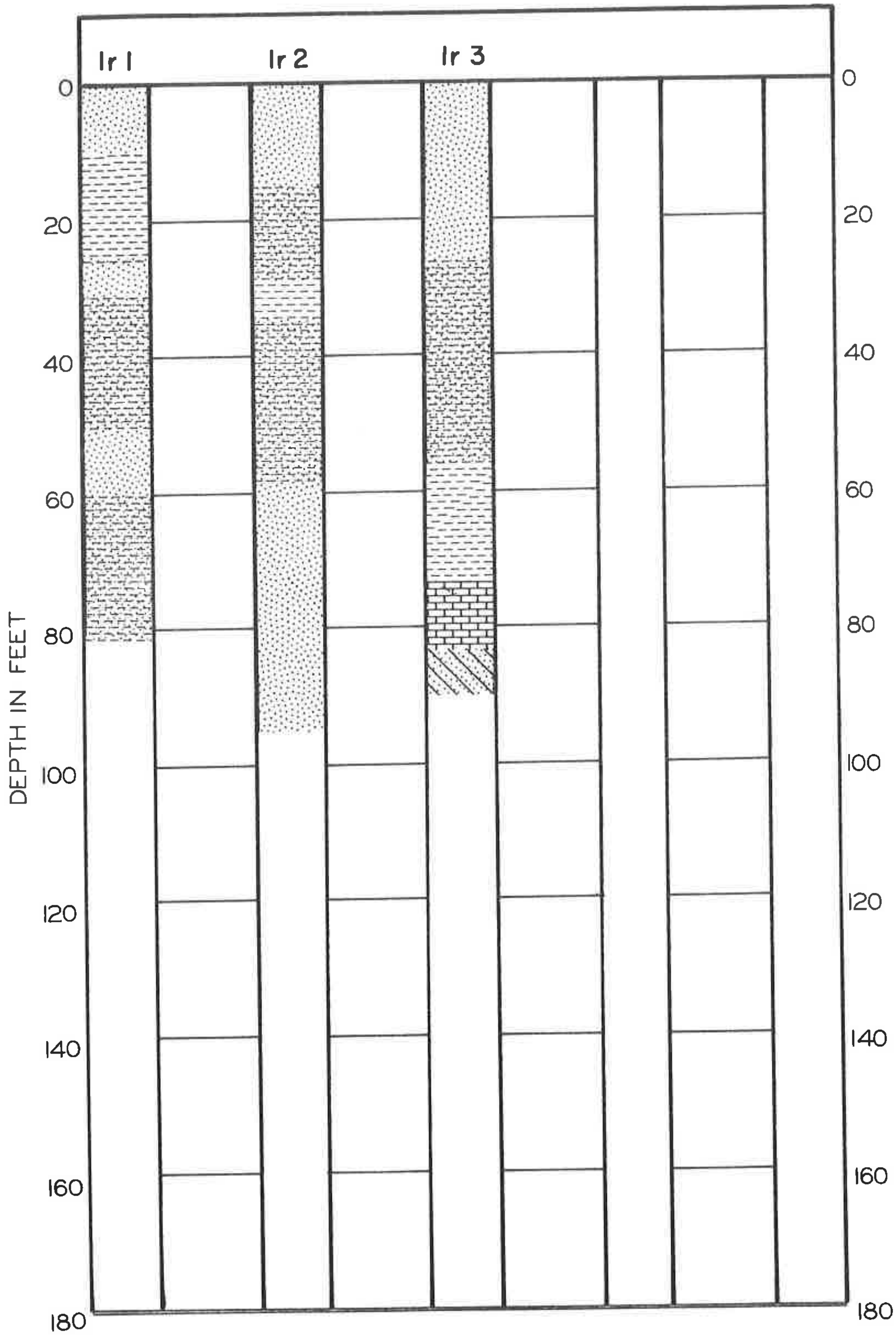


Figure IR-2. Lithologic Logs - Irwin County

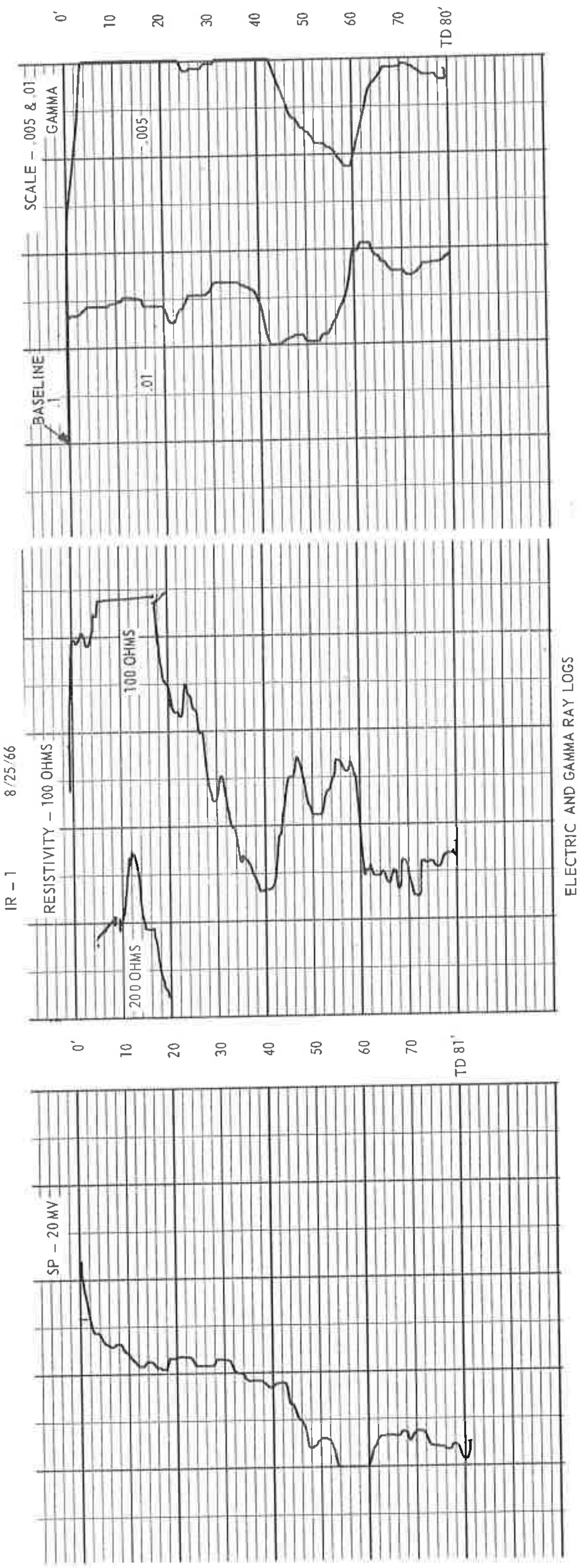


Figure IR-3. Electric and Gamma-Ray Logs - Irwin County
Hole Ir-1

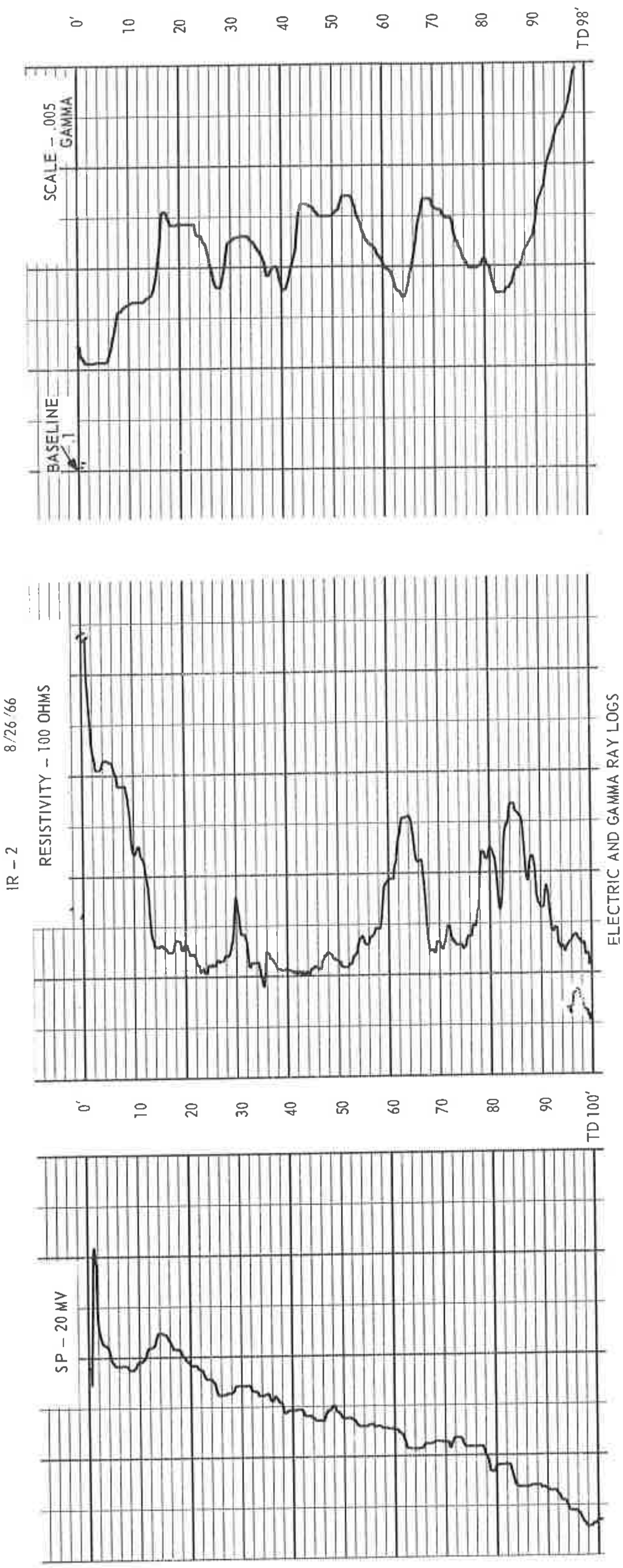


Figure IR-3. Electric and Gamma-Ray Logs - Irwin County
Hole Ir-2

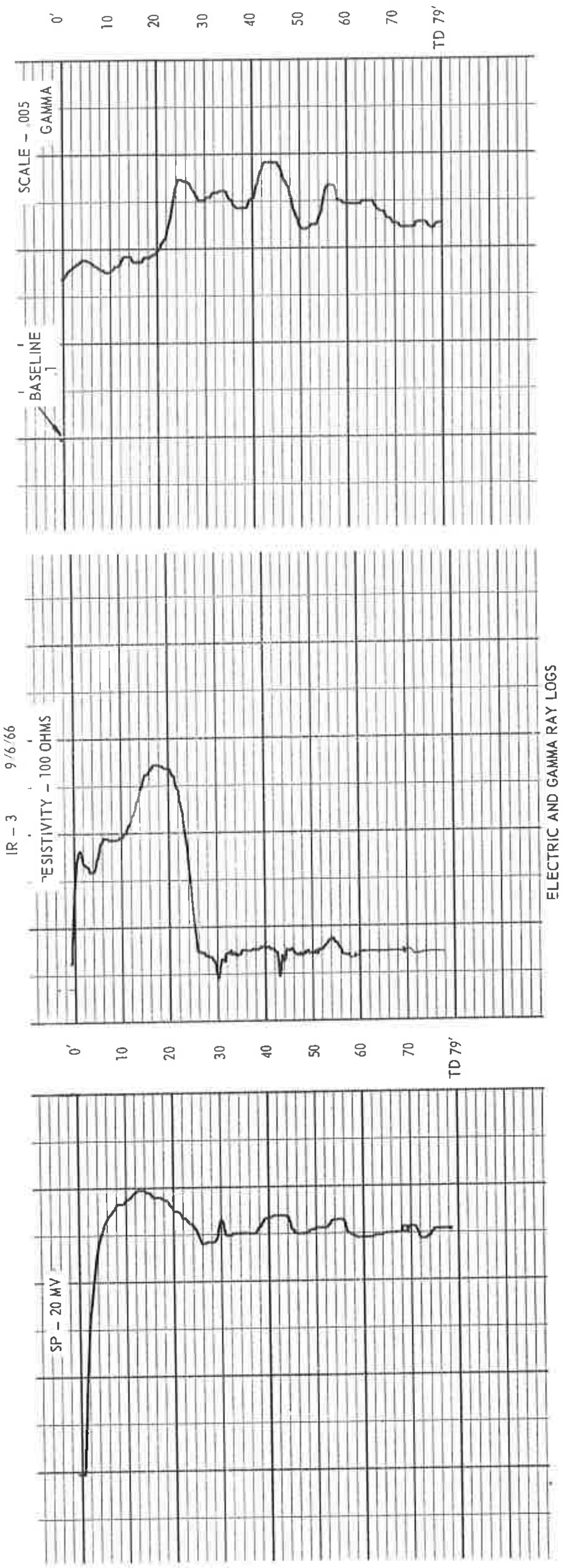


Figure IR-3. Electric and Gamma-Ray Logs - Irwin County
Hole Ir-3

TABLE IR-I

BPL DETERMINATIONS ON CORES

Irwin County

Hole No.	Surface Elevation (Sea Level) Feet	Depth, Feet	Core Recovery Feet	Core Recovery %	BPL %
Ir-1	300	0-10	W.S.		0.0
		10-20	10	100	0.0
		20-25	4.5	90	0.0
		25-55	30	100	0.0
		55-65	7	70	0.0
		65-75	10	100	0.0
		75-85	8	80	0.0
		85-95	10	100	0.0
Ir-2	339	0-10			
		10-15	5	100	0.0
		15-25	6	60	0.0
		25-35	7	70	0.0
		35-45	5	50	0.0
		45-55	10	100	0.1
		55-65	5	50	0.5
		65-75	5	50	0.0
		75-85	5	50	0.0
		85-95	10	100	0.0
Ir-3	289	0-10	W.S.		0.0
		10-16	2	33	0.0
		16-26	6	60	0.0
		26-35	7	78	0.0
		35-43	5	62	0.0
		43-50	5	72	0.0
		50-73	23	100	0.0
		73-83	9	90	0.0
		83-90	7	100	1.1

GLOSSARY 1/

Apatite . . . . Used in this report to mean the mineral carbonate-fluorapatite.

BPL . . . . Bone phosphate of lime ($Ca_3(PO_4)_2$). Equals percent P_2O_5 x 2.185.

Concentrate . . . . . . Fine phosphate product - 1 mm + 0.1 mm in size. Separated from quartz by flotation.

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

Nodule . . . . Rounded, irregular mass of any size. The term may apply to rock fragments, as well as apatite particles.

Overburden . . . . All rock overlying the matrix.

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).

1/Taken from: The Geology and Geochemistry of the Bone Valley Formation and its Phosphate Deposits West Central Florida, by Z. S. Altschuler, J. B. Cathcart, and E. J. Young, Guidebook for Field Trip No. 6, pp. 22-23, Geol. Soc. Amer. Convention, Nov. 1964.

APPENDICES

APPENDIX I

Surface Elevation of Holes Drilled

These data were not included in Project Reports 2 and 3. For determination of trends of geologic layers a uniform reference level is required. From the mean sea level elevation of the ground at the hole site and the reported depths below the surface for the stated layers (lithologic logs), interpretations are facilitated.

For convenience, the surface of all holes drilled and reported to date are presented in a single table.

SURFACE ELEVATIONS AT DRILLING SITES
(Feet above mean sea level)

County	Hole No.	Elevation	County	Hole No.	Elevation
Atkinson	At-1	248	Irwin	Ir-1	300
	At-2	218		Ir-2	339
	At-3	194		Ir-3	289
Ben Hill	BH-1	342	Lanier	La-1	222
	BH-2	302		La-2	177
	BH-3	268		La-3,3a	193
				La-4,4a	214
Berrien	Be-1	241		La-5	230
	Be-2	225		La-6	233
	Be-3	331		La-7	250
Brooks	Br-1	210	Lowndes	Lo-1	185
	Br-2	225		Lo-2	190
				Lo-3	223
Camden	Ca-1	12		Lo-4	247
	Ca-2	22		Lo-5	175
				Lo-6	228
Clinch	Cl-1	223		Lo-7	194
	Cl-2	169			
	Cl-3	163	Thomas	Th-1	183
Coffee	Cf-1	250	Ware	Wa-1	190
	Cf-2	267			
Cook	Co-1	237			
	Co-2	220			
	Co-3	300			
	Co-4	250			
	Co-5	242			
Echols	Ec-1	141			
	Ec-2	125			
	Ec-3	152			
	Ec-4	155			
	Ec-5	122			
	Ec-6	150			
	Ec-7	146			
	Ec-8	135			
	Ec-9	133			
	Ec-10	146			
	Ec-11	143			
	Ec-12	166			
	Ec-13	159			
	Ec-14	144			

APPENDIX II

Supplement Analyses for Project Report 3

Difficulties experienced in certain analyses made it undesirable to report results until full confidence in the data could be obtained. The following table of data fills in gaps in prior reports.

Research had disclosed the sensitivity of P_2O_5 analyses to minor variations in analytical procedures. Accordingly, fresh samples of beneficiated products of cores of highest interest were taken and new analyses made. The new figures, and in comparison with prior reported data, are included in the table.

SUPPLEMENTAL DATA FOR PROJECT REPORT NO. 3
Figures in the body of the table are weight percents of dry samples

La-1 (35-44 ft.)
Reference: Page 45

	BPL		Acid Insol		Al_2O_3 (A)	CaO		Fe_2O_3 (I)	I + A
	prior	new	prior	new	new	prior	new	prior	new
Feed (Crude)	25.6	27.1	65.3	65.4	4.44	15.0	16.3	0.99	5.43
+4	80.4	75.0	2.82	2.93	0.98	51.0	49.7	0.52	1.50
-4+8	79.5	74.7	5.38	5.40	1.10	49.5	49.6	0.52	1.62
-8+16	67.9	70.1	19.8	20.0	1.19	41.6	41.1	0.50	1.69
-16+150 (Flotation Feed)	12.1	10.4	85.2	85.2	1.51	6.7	7.0	0.24	1.75
-16+35	24.8	24.8	69.8	71.9	0.43	14.1	17.6	0.24	0.67
-35+150	8.8	9.3	89.5	90.0	1.64	3.8	5.74	0.21	1.85
-150 (Slimes)*	18.8		58.9		15.20	11.9	15.2	3.47	18.7
Flotation Concentrates	77.3	76.7	8.00	7.8	2.08	48.8	49.7	1.05	3.13
Fatty Acid Tailings	4.6	5.5	94.6	94.5	1.42	1.8	1.9	0.11	1.53
Amine Float	2.6	6.8	97.5	97.5	1.61		1.1	0.18	1.79

*Values determined by difference.

(Continued)

SUPPLEMENTAL DATA FOR PROJECT REPORT NO. 3 (Continued)
Figures in the body of the table are weight percents of dry samples

La-1 (66-77 ft.)
Reference: Page 45

	BPL		Acid Insol		Al_2O_3 (A)	CaO		Fe_2O_3 (I)	I + A
	prior	new	prior	new	new	prior	new	new	new
Feed (Crude)	14.1	14.1	74.6	76.2	6.27		7.50	2.89	9.16
+4	38.4	38.4	38.8	33.8	5.90		18.4	19.9	25.8
-4+8	49.0	60.0	23.6	23.8	2.83		29.9	5.05	7.88
-8+16	48.0	41.6	48.1	49.0	1.72		18.4	1.63	3.35
-16+150 (Flotation Feed)	7.83		91.2						
-16+35	11.6	11.6	87.1	87.0	0.59		3.52	0.71	1.30
-35+150	6.10	5.3	93.2	93.3	1.45		0.95	0.67	2.12
-150 (Slimes)*	2.21		70.0		17.6		7.80	4.90	22.5
Flotation Concentrates									
Fatty Acid Tailings									
Amine Float									

*Values determined by difference.

(Continued)

SUPPLEMENTAL DATA FOR PROJECT REPORT NO. 3 (Continued)
Figures in the body of the table are weight percents of dry samples

La-6 (46-65 ft.)
Reference: Page 46

	BPL		Acid Insol		Al_2O_3 (A)	CaO		Fe_2O_3 (I)	I + A
	prior	new	prior	new	new	prior	new	prior	new
Feed (Crude)	14.1	16.9	78.0 81.8	83.0	3.87	8.05	9.51	0.83	4.70
+4	74.3	76.6	3.66	4.1	1.80	44.5	49.8	1.16	2.96
-4+8	74.6	77.2	5.24	5.7	1.45	42.7	48.4	1.17	2.62
-8+16	53.2	60.0	32.6	31.6	1.06	31.7	35.3	0.42	1.48
-16+150 (Flotation Feed)	12.5	14.6	84.7	84.8	1.28	7.07	7.19	0.24	1.52
-16+35	16.9	19.2	78.9	79.4	0.74	9.74	10.5	0.18	0.92
-35+150	10.7	12.6	86.2	86.4	1.55	9.38	6.38	0.22	1.77
-150 (Slimes)*	16.4		50.4		16.6	9.47	16.9	3.65	20.2
Flotation Concentrates	80.1	78.6	2.82	3.11	1.06	39.9	47.4	0.47	1.53
Fatty Acid Tailings	5.28	6.50	93.8	93.7	1.02	2.79	2.52	0.11	1.13
Amine Float	31.2	35.9	59.1	59.7	1.89	18.3	19.6	0.60	2.49

*Values determined by difference.

(Continued)

SUPPLEMENTAL DATA FOR PROJECT REPORT NO. 3 (Continued)
Figures in the body of the table are weight percents of dry samples

La-6 (65-95 ft.)
Reference: Page 46

	BPL		Acid Insol		Al_2O_3 (A)	CaO		Fe_2O_3 (I)	I + A
	prior	new	prior	new	new	prior	new	prior	new
Feed (Crude)	9.7	10.9	81.8	79.8	6.50	5.58	5.60	2.48	8.98
+4*	46.7	52.0	18.3	19.5	9.05	24.7	8.74**	0.82	9.87
-4+8	57.9	62.1	12.5	14.4	5.08	31.2	14.9**	1.29	6.37
-8+16	44.0	46.9	34.3	35.7	4.84	23.4	14.9**	1.44	6.28
-16+150 (Flotation Feed)	5.92	7.0	91.1	91.5	3.23	3.12	3.08	0.69	3.92
-16+35	21.1	23.0	64.4	67.1	5.57	11.3	11.7	2.60	8.17
-35+150	5.70	6.5	91.6	92.0	3.44	2.98	2.85	0.64	4.08
-150 (Slimes)***	13.2		73.2		9.57	7.84		4.17	13.7
Flotation Concentrates	77.2	77.7	5.70	6.1	1.11	42.7	48.1	0.57	1.68
Fatty Acid Tailings	1.72	2.4	97.9	97.7	2.08	0.79	0.28	0.11	2.19
Amine Float	22.4	24.0	72.4	75.9	3.23	12.3	14.5	1.10	4.33

*A positive borax bead test for cobalt was obtained on the +4 mesh sample.

**Results from a new sample obtained from matrix, since old sample was used up.

***Values determined by difference.

(Continued)

SUPPLEMENTAL DATA FOR PROJECT REPORT NO. 3 (Concluded)
Figures in the body of the table are weight percents of dry samples

La-7 (62-83 ft.)
Reference: Page 47

	BPL		Acid Insol		Al_2O_3 (A)	CaO		Fe_2O_3 (I)	I + A
	prior	new	prior	new	new	prior	new	prior	new
Feed (Crude)	11.7	12.7	82.5	83.2	3.93	6.62	6.66	0.80	4.73
+4	84.5	73.0	2.16	2.8	1.55	43.5	51.6	0.55	2.10
-4+8	79.1	80.0	2.86	2.8	1.53	43.5	51.6	0.55	2.08
-8+16	61.6	65.7	24.4	24.9	1.38	37.1	39.3	0.44	1.82
-16+150 (Flotation Feed)	9.97	11.3	87.7	87.9	1.06	5.45	6.16	0.15	1.21
-16+35	17.0	19.1	79.2	79.3	1.02	9.34	10.4	0.16	1.18
-35+150	8.22	10.2	90.1	90.0	1.28	4.41	4.76	0.15	1.43
-150 (Slimes)*	9.88		71.6		15.9	6.15	2.90	3.47	19.4
Flotation Concentrates	80.4	80.0	3.65	3.7	1.06	42.3	54.6	0.46	1.52
Fatty Acid Tailings	2.6	2.5	97.2	97.3	0.85	1.10	0.70	0.06	0.91
Amine Float	5.60	6.3	93.5	93.7	0.92	2.79	2.66	0.24	1.16

*Values determined by difference.

APPENDIX III

Economic Factors and Figures of Merit for Holes of Interest

Factors, such as the ratio of overburden to matrix, have not been presented in prior reports until more contacts with industry and its applied limits of the factors could be obtained. Different companies employ different break-levels and assign various degrees of importance to the several factors.

In fairness to landowners and others who might not be skilled in the calculations and application of such factors to engineering and economic evaluation, it was decided to indicate a range of levels as reported in the literature, select a mid-point level and present the calculated results for the holes-of-interest, that is, from the cores which showed promise of industrial utilization.

These factors, expressed as numbers, vary widely and can be confusing to the lay public. A Figure of Merit concept was devised whereby the calculated factor would be expressed as a ratio, to the break-point level, in such a way that figures of 1.0 or more would represent economic desirability, or if less than 1.0, economic undesirability. For clarification, typical results for a factor having a maximum economic level and for a factor having a minimum economic level are:

1. Overburden. Current strip mining practice places a maximum of 75 to 100 feet on the overburden which can be removed economically, depending upon the quantity and quality of the deposit beneath the overburden. The midpoint of this range was taken as 88 feet. When expressed in terms of "Economic Factors," Lanier County No. La-1, for the matrix level of 35-45 feet would be "overburden = 35 feet." When expressed as a "Figure of Merit,"

this would appear as (88/35) : 2.5. As this is well above 1.0, the overburden to be removed is well within current practice.

2. Current practice dictates that a matrix bed should be a minimum of 3 feet for mining. For the same hole (La-1) the first matrix encountered had a thickness of 10 feet, and this would be reported as an "Economic Factor." When expressed as a Figure of Merit, it would be 10/3 = 3.3 which indicates economic desirability for this factor.

Note that the ratios for maximums and minimums are inverted, being

$$\frac{\text{Practice}}{\text{Actual}} \text{ for maximum levels of interest}$$

and

$$\frac{\text{Actual}}{\text{Practice}} \text{ for minimum levels of interest.}$$

Economic Factors presented herein, the ranges of each as obtained from industry and publication, and the level of each employed to calculate a Figure of Merit are:

Factor	Unit	Range	Level Used
Overburden Thickness	ft.	75-100 max.	88
Matrix Thickness	ft.	3 min.	3
Matrix BPL	%	10 min.	10
Flotation Concentrate BPL	%	66 min.	66
Rock for Electric Furnace, BPL	%	52 min.	52
Products, BPL	tons/acre-ft.	400 min.	400
Overburden/Matrix	Ratio	1-3 max.	2
Overburden/Products BPL	cu. yd./ton	15-20 max	17.5

(Continued)

Factor	Unit	Range	Level Used
Matrix/Products BPL	cu. yd./ton	5-7 max.	6
$Fe_2O_3 + Al_2O_3$ in Products	%	4-5 max.	4.5
SiO_2/CaO (For Electric Furnace)	Ratio	0.8-1.0 min.	0.9
Products Recovery*	%	58-68 min.	63

Certain assumptions, and average values and factors, were made to expedite caluclations:

Density of overburden or matrix	=	90 lb./cu. ft.
Feet thickness x 1613	=	cu. yd./acre
Cubic yards x 1.215	=	Tons (2,000 lb.)
Feet thickness x 1960	=	Tons/acre

*Total BPL recoverable from "pebbles" and flotation concentrates divided by total BPL in matrix.

ECONOMIC FACTORS - FIGURES OF MERIT

Item	Unit	Ec-4	Ec-5	Ec-11	La-1 First Matrix	La-1 Second Matrix	La-1 Combined	La-6 First Matrix	La-6 Second Matrix	La-6 Combined	La-7	At-1	Be-1 (Note 1)	Be-3 (Note 2)
	M=1000's													
ECONOMIC FACTORS*														
* Overburden	Ft.	49	25	100	35	22	57	46	0	46	62	85	76	85
	MT/Ac	96.0	49.0	196.0	68.6	43.1	111.7	90.2	0	90.2	121.5	166.6	149.0	166.6
* Matrix (M)	Ft	20	30	5	10	10	20	19	30	49	21	6	14	15
	MT/Ac	39.2	58.8	9.8	19.6	19.6	39.2	37.2	58.8	96.0	41.2	11.8	27.4	29.4
* , BPL	%	10.0	16.3	18.5	25.6	14.1	19.9	14.2	9.7	11.5	11.7	11.7	13.0	10.4
	MT/Ac	3.92	9.58	1.81	5.02	2.76	7.80	5.29	5.70	10.99	4.82	1.38	3.57	3.06
* Overburden/Matrix	Ratio	2.5	0.8	20.0	3.5	2.2	3.0	2.4	0.0	0.9	2.0	14.1	5.4	5.7
Matrix: Wash-Screen Products														
+16 Mesh	MT/Ac	.43	1.00		3.90	3.98	7.88	.78	.06	.84	1.28	.73	1.51	1.29
-16+150 Mesh	MT/Ac	32.4	47.1		11.47	9.90	21.3	30.1	28.5	58.6	31.9	9.24	22.0	24.1
-150 Mesh (Loss)	MT/Ac	6.35	10.7		4.29	5.72	10.0	.63	30.3	30.9	7.94	1.79	3.92	4.03
BPL Recovery														
+16 Mesh	MT/Ac	.14	.52		2.83	1.86	4.69	.46	.03	.48	.85	.35	.94	.40
* -16+150 Mesh (Flotation Concentrate)	% BPL	41.7	73.2		77.3			80.1	77.2	78.3	80.4	60.3	72.1	51.1
	MT/Ac	.61	3.03		.76			1.21	.31	1.52	2.13	.49	1.57	1.51
-150 Mesh (Loss)	MT/Ac	.04	.53		.18	.04	.21	.2	2.05	2.07	.15	.05	.04	.10
* Total Useful	MT/Ac	.75	3.56		3.59	1.86	5.44	1.66	.34	2.00	2.98	.84	2.52	1.92
* Product Recovery	%	19.1	37.2		71.5	67.4	70.0	31.4	6.0	18.2	61.8	61.0	70.6	62.7
* Overburden/BPL Product	Cu Yd/T	105	11.3		15.7	19.1	16.9	44.7		37.1	33.6	163	48.6	71.4
* Matrix/BPL Product	Cu Yd/T	43.0	13.6		4.5	8.7	5.9	18.5	142	39.5	11.4	11.5	9.0	12.6
* I&A (Fe_2O_3 + Al_2O_3), Flo. Con.	%	3.2	2.4		3.1			1.6	1.7	1.6	1.6	2.2	1.7	4.1
FIGURES OF MERIT	Level													
Overburden Thickness	88 max	1.8	3.5	0.9	2.5	4.0	1.5	1.9		1.9	1.4	1.0	1.2	1.0
Matrix Thickness	3 min	6.7	10.0		3.3	3.3	6.7	6.3	10.0	16.3	7.0	2.0	4.7	5.0
Matrix BPL %	10 min	1.0	1.6	1.8	2.6	1.4	1.9	1.4	1.0	1.2	1.2	1.2	1.3	1.0
Flotation Concentrate BPL %	66 min	0.6	1.1		1.2			1.2	1.2	1.2	1.2	0.9	1.1	0.8
Flotation Concentrate BPL % (Electric Furnace)	52 min	0.8			1.5			1.5	1.5	1.5	1.5	1.2	1.4	1.0
Overburden/Matrix	2 max	0.8	2.5	0.1	0.6	0.9	0.7	0.8		2.1	0.7	0.1	0.4	0.4
Cu Yd Overburden/T Products	17.5 max	0.2	1.5		1.1	0.9	1.0	0.4		0.5	0.5	0.1	0.4	0.2
I&A, %	5 max	1.4	1.9		1.5			2.8	2.6	2.8	2.8	2.0	2.6	1.1
Product Recovery, T/Ac-ft	400 min	0.1	0.3		0.9	0.5	0.7	0.2	0.03	0.1	0.4	0.4	0.5	0.3
Product Recovery, %	63 min	0.3	0.6		1.1	1.1	1.1	0.5	0.1	0.3	1.0	1.0	1.1	1.0
Cu Yd Matrix/T Product	6 max	0.1	0.4		1.3	0.7	1.0	0.3	0.04	0.2	0.5	0.5	0.7	0.5

Note 1: There is an additional 10 feet of matrix with 5.3% BPL immediately below.

Note 2: 10 feet @ 5.8% BPL immediately above.

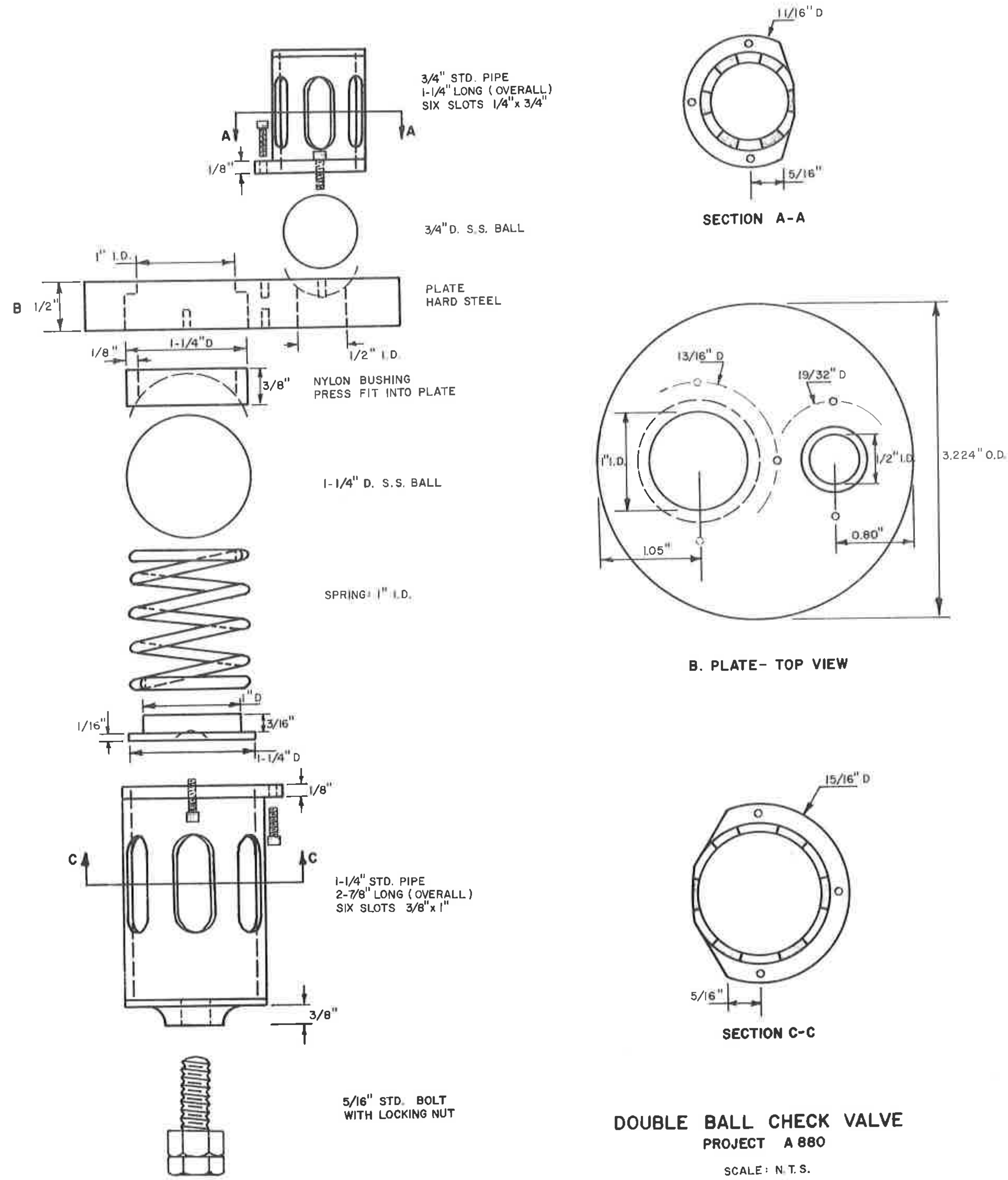
APPENDIX IV

Double Ball Check-Valve for Core Barrel

A commercial double ball check-valve for the core barrel gave unsatisfactory life through excessive erosion of a seat and ball. Various modifications were tried with but partial success.

The attached sketch is a redesign of a double ball check-valve that has been found more satisfactory. The combination of a hard steel ball (ball bearing) relatively free to rotate and a nylon bushing to form the seat has demonstrated better sealing characteristics than steel-to-steel. The strength of the spring required is only that to withstand about 30 feet of water. Automobile valve lifter springs can be used.

Current practice by the drilling crew is to use a 10-foot core barrel with this valve, even when taking 5-foot cores.



Double Ball Check Valve