# Project Report No. 1
# South Georgia Minerals Program

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

A. S. Furcron, Director

By

Mr. John E. Husted, Project Director and Head, Minerals Engineering Group
Georgia Institute of Technology.

Dr. A. S. Furcron, Director, State Department of Mines, Mining and Geology.

Dr. Frederick Bellinger, Chief, Chemical Sciences and Materials Division,
Georgia Institute of Technology.

January 1966


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

# Project Report No. 1
# South Georgia Minerals Program

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

A. S. Furcron, Director

By

Mr. John E. Husted, Project Director and Head, Minerals Engineering Group
Georgia Institute of Technology.

Dr. A. S. Furcron, Director, State Department of Mines, Mining and Geology.

Dr. Frederick Bellinger, Chief, Chemical Sciences and Materials Division,
Georgia Institute of Technology.

January 1966


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

## X-RAY FLUORESCENCE-ANALYSIS UNIT

**The unit above can automatically analyze eight samples in a few seconds per sample. This is typical of the modern instrumentation necessary to handle the thousands of samples of earth being taken for the South Georgia Minerals Program.**

The cabinet on the right contains the high voltage power unit to generate the x-rays in a controlled manner.

The central feature is the x-ray fluorescent unit which exposes the samples to bombardment by the x-ray beams. Elements are distinguished because each fluoresces distinctively and in relation to the amount present.

The recorder on the left selects and records the elements according to the variety and intensity of their fluorescence. This strip recorder makes a chart showing the per cent of each element in the samples, including phosphorous, silicon, magnesium, calcium, aluminum, iron and others which may be present.

TABLE OF CONTENTS

# SOUTH GEORGIA MINERALS PROGRAM

## INTRODUCTION

"The future prosperity of South Georgia will depend largely upon the economic industrial utilization of its mineral resources." This statement is borne out from a review of the lag in industrialization of South Georgia by comparison with other parts of Georgia, the Southeast, and the Nation, and from an overall review of South Georgia's natural resources. The *existence* of minerals throughout South Georgia such as fuller's earth in southwest Georgia, kaolins in south-central Georgia, and iron ore in western-central Georgia is well known; but all too little is known of the quality and quantity of these and other mineral deposits and their potential to attract industry to the State. Heavy minerals which contain titanium are mined near Folkston close to the Florida border and should be widespread in this section of the state.

The benefits to Florida from its phosphate industry are well known. Florida produces 70-75 percent of the phosphate used in U. S. industry, primarily for fertilizers and export. The demand for phosphates has increased by an almost staggering rate since 1932; and Florida's marketable phosphate production of 188,000,000 tons in 1964 was nearly double that of 1958 which was valued at about $116,000,000. According to *Chemical Week* of November 13, 1965, Florida's "best rock at the established mines in central Florida - is running out," and, "The Hunt Is On for new higher-grade rock" (phosphate). The discovery of massive high grade deposits in North Carolina, resulting in a $45,000,000 production facility raised the question: If good phosphates exist in Florida and in North Carolina, why not in Georgia and South Carolina? In the past year or so, many industrial firms have been highly active in prospecting-drilling in northern Florida, Georgia, South Carolina and North Carolina. The South Georgia Minerals Program was started in July 1965, and with all this activity by industry and the state, it is no wonder that the people of south and east Georgia are "Feeling Phosphate Fever," which is the title of the *Chemical Week* article.

The present production of phosphate in the world is about 65 million tons a year. However, this increased production has not kept up with demands during the past 2 or 3 years. A statistical analysis in the December 1965 Mining Engineering, in which the consideration of phosphate is a vital one, shows that the rate of world growth in fertilizer use since 1962-63 is greater than ever recorded before. A conclusion is that rapidly accelerated demand and the long period required to explore and produce from mineral properties, means that a continuing stream of investment decisions must be made regarding this mineral; also, an aggressive approach to investigation of deposits is necessary in the present and immediate future.

## PURPOSE

This Special Report is published to acquaint people of Georgia with this "Phosphate Program," which is being carried out with State funds by Georgia Tech in cooperation with the State Department of Mines, Mining and Geology.

## SCOPE

The entire Coastal Plain, about 25,000 square miles, is to be checked for mineral resources of suitable quality, amount, and other economic factors which could attract industry to make intensive studies necessary as a basis for locating in the State; also, to give our citizens information to guide them in leasing, selling, or starting up their own industries. It is hoped that industry will construct production plants in Georgia—not simply mine and ship the product out-of-state for processing, or lease lands for future reserves. PHOSPHATES, HEAVY MINERALS, CLAYS, and SANDS will receive primary consideration, but other minerals, if they exist in promising quality and amounts, will not be overlooked. Hence, the program is a South Georgia Minerals Program and not simply a "Phosphate Program."

## INITIATION OF THE PROGRAM

Recognizing the need for knowing more of South Georgia's minerals resources, and the extensive exploration effort by industries for phosphates in other states, and desiring data to guide its citizens, the 1965 General Assembly, in its collective wisdom, appropriated a sum of $225,000 to the State Department of Mines, Mining and Geology for a two-year effort entitled "Accelerated Phosphate Exploration Program." Funds were to become available on July 1, 1965. Explicitly included in the budget documents were funds for the purchase of one (or more) drilling rigs, and statements that the study would include phosphates, fuller's earth (a clay), and heavy minerals (ilmenite, rutile, leucoxene, zircon, monazite and others); also, sands for construction and glass.

It was obvious that a special staff of geologists, engineers, mineralogists, chemists, and mineral economists would be required to carry out this broad program. The field staff of the State Department of Mines, Mining and Geology was being built up at that time. The laboratory facilities of the Department were insufficient to handle the large number of samples to be examined and analyzed. After many discussions with Georgia Tech and others, it was determined that Tech (the engineering institute of the state) had the key personnel on hand to carry out the scientific, engineering, and economic phases of this industrially-oriented program. Tech's Engineering Experiment Station had the laboratory facilities, a long history of accomplishments in undertaking such programs under contract, and could acquire additional personnel as needed. Accordingly, with the approval of State government officials, a contract was negotiated and signed on July 19, 1965, wherein Georgia Tech assumed the responsibility for carrying out the exploration program within the approved budget. Because of its interest and the ongoing program of development in its Minerals Engineering Group, Tech agreed to contribute $18,320 to enhance the first year's effort.

## THE PROGRAM

### *Background*

#### *Information Needed*

There are *many* factors involved in an evaluation of the potential commercial use of a mineral deposit. These include: quantity of mineral available, thickness and type of overburden to be removed above the ore, material (matrix) with which the mineral is intermixed, ease with which the mineral can be separated from the mineral-matrix mixture, "quality" of the mineral, suitability for use in existing production plant processes, present and future demand, availability and cost of utilities and personnel, transportation (roads, railroads and rivers), other products which could be produced simultaneously, living conditions for personnel, State and local tax considerations and regulations concerning waste products (water and air pollution), cost of production vs. sales price considerations, competition in the area, and impact of new producing plants in relation to the future demand. For example, when the tons of overburden to be removed plus the tons of matrix (materials in which the phosphate rock is mixed) reaches or exceeds three times the tons of phosphates being obtained, Florida industries move on to new and better mines. Such rules-of-thumb are based upon years of experience and are followed quite closely.

These are all technical and economic factors. The really big problem facing the program was where to start - with the vast area of the Coastal Plain and the specified limits of funds and time - it was essential to determine, upon the best total information available, which minerals and which area had the most promise of success, and which exploratory techniques and methods of analyses should be used to get the most results from the dollars spent.

#### *Available Information and Mapping*

Conferences were held with the State Department of Mines, Mining and Geology, with the U. S. Geological Survey both in Georgia and in Washington, the Geology Departments of the railroads, with engineers and scientists in industry, with consultants, and with drillers; a review was made quickly of published information on the Coastal Plain.

Topographic maps, prepared by the U. S. Geological Survey, if available, usually are first studied by a geologist-engineer as a guide to planning. Unfortunately, only about 30 percent of the State and 10 percent of the Coastal Plain has been mapped. (This is really a critical gap which should be filled as soon as possible.) The State Department of Mines has cooperated for years with the Federal Government in making these maps, and in July 1965 suggested a 5-year program for complete State coverage on the desirable scale.

The best comprehensive published guide was in the work of Dr. S. M. Herrick of the U. S. Geological Survey, who, working in cooperation with the State Department of

Mines, Mining and Geology, over a period of more than ten years, has compiled and summarized results from an examination of some 350 "logs" of wells drilled in the Coastal Plain. (See Bulletin No. 70, Georgia Geological Survey, 1961.) These logs consist of mineralogical and paleontological descriptions of the earth's layers at various depths beneath the surface. For example: "Overburden 0-50 ft. sand-clay, phosphatic," and "90-105 ft. Upper Miocene, phosphatic, finely disseminated grains abundant." So, these logs are invaluable as clues to the geologic structure of the Coastal Plain, and the *existence* of minerals; but do not supply data as to the quantity or quality of the minerals.

Fine cooperation from the railroads who are drilling, particularly in South Georgia, and from Dr. Charles E. Weaver of Tech, who is studying clays in the South Georgia counties along the Florida border, and from the State Highway Department are giving a more complete picture of overall possibilities in the Coastal Plain than could be made from any single source.

It was obvious that traditional wet-chemical methods of analyses could not meet demands for handling the large number of samples. Modern equipment for fast analyses were on hand at Tech and needed only slight modifications for this project. Some analyses still are best carried out by wet chemistry, so a special chemical laboratory was needed also. Visits to the advanced laboratories of the U. S. Geological Survey in Washington and to several commercial laboratories in Florida assisted greatly in planning and equipping for the special purposes of the study. The chemical laboratory of the State Department of Mines, Mining and Geology also makes phosphate analyses.

Although, the program is planned to investigate potential industrial use of *mineral* resources, the recent intense interest in phosphate dictated that highest priority be given to phosphates. Requirements for phosphates used in agricultural fertilizers *are steadily increasing annually* with the world-wide expansion of population. As an example, the Japanese, using six times more fertilizer per acre than the United States, feed 93 million people from an area smaller than West Virginia.

### *Methods of Exploration*

There are a number of different methods of exploration used by geologists-geophysicists, each with specific applications and limitations. Some work had been done on magnetic, gravity and seismic mapping of the State, but the data are, so far, inadequate for this study.

Geochemistry is a relatively rapid and inexpensive method of early prospecting. Through very sensitive chemical analyses, the very small amounts of minerals in plants and shrubs may offer clues to undiscovered elements. Also, surface soil samples are commonly used in geochemical prospecting. From Herrick's report, the *existence* of min-

erals is known, and layers containing pebble or rock phosphate are noted at rather uneconomical depths beneath the surface in a number of areas throughout the Coastal Plain. Accordingly, as so little new data of real value would be gained, geochemical exploratory methods are, for the time, not given continued consideration.

ELECTRICAL LOGGING (earth resistivity) and GAMMA-RAY (x-ray) LOGGING are useful tools in the hands of specially trained geologists. As these instruments are lowered down a well, *already drilled,* a "line" is drawn on a chart at the surface. As the unit passes from one layer to another, the "line" takes a rise or dip, and these changes at the recorded depth are revealing. The gamma-ray log, in particular, "jumps" when it starts into a bed containing phosphates. A similar "jump" also is caused by a couple of minerals other than phosphates; hence, the need for a specially trained operator with knowledge of the "probable" geologic structure. This method is being used upon our drilled wells.

It was decided to use the method of prospecting preferred by industry when the existence of a mineral is considered likely. This method is "core drilling" which is like "plugging a watermelon" to "look inside" and see the quality. A hollow pipe is drilled into the ground and a *plug* or a sample of earth *as it exists* is pulled out of the earth. In other words, if you drill down, say, 100 feet, usually in 10 foot sections, the core can be laid out on the ground and examined; then the exact distance beneath the surface where layers occur can be seen and noted, and the entire 100 foot-long "sample" shipped back to a laboratory for analysis. When an area is considered worthwhile investigating, the usual industrial method is to core drill at 2 to 5 mile intervals, then go back to the better areas and take more cores in between. Finally, to determine the best plant location and to plan mining operations, industrial people will take about 1 core per acre.

A modified drilling operation called "wash sampling" washes up to the surface a sample of earth at, usually, 5 foot intervals. This is quicker than coring, but gives information only on the "average" sample of that 5 foot layer. This "wash sampling" and/or drive pipe sampling is suitable for heavy minerals prospecting, but is not desirable for phosphate-at-depth prospecting.

*Industrial Requirements*

Information on the quality of phosphate material of *use* by industry is summarized in Table 1.

QUALITY OF PHOSPHATE

| Product | Minimum % BPL (1) or % $P_2O_5$ (2) | | Maximum % Iron + Aluminum | Other |
|---|---|---|---|---|
| Superphosphate fertilizer | 68 | 31 | 4 | |
| Triple superphosphate | 72 | 32 | | |
| Phosphoric acid (wet method) | 66 | 30 | 4.5 | |
| Phosphorous (elemental) (electric furnace method) | 55 | 25 | | $\frac{SiO_2}{CaO}$=0.8 to 1.0(3) |

1. BPL = Bone Phosphate of Lime = Tricalcium Phosphate, $Ca_3(PO_4)_2$
2. $P_2O_5$ = Phosphorous Pentoxide ($P_2O_5$ x 2.185 = BPL)
3. Iron oxide, if present, forms ferro-phosphorous which is difficult to sell at a profit.

TABLE 1.

The "quality" of the phosphate material has a market effect on the price. Florida's production in 1964 called for a price of $5.84 per long ton of 66 to 68% BPL, and $9.30 per long ton for 76 to 77% BPL material.

Another economic factor is that present industrial processes cannot use phosphatic material if it is finer than about 150 mesh in size. Hence, it has been necessary to obtain core samples, examine them, wash and screen them, and then analyze them for size, for % BPL (or$P_2O_5$), and for iron, aluminum, sand ($SiO_2$), calcium, and other minerals. Also, present industrial practice is confined to recovery of phosphates not more than about 85 feet beneath the surface.

*Procedures Being Followed*

Exploratory drilling is restricted to public-owned lands, such as state highways and county road rights-of-way and core drilling, as the most satisfactory exploratory method. Specifications for a state-owned drilling rig, which consists of a truck-mounted drill and a truck to carry the water-mud equipment, were carefully prepared and submitted to the State Purchasing Agent for bids. Delivery of the drill rig units is anticipated during February, 1966. Knowing of the time-delay in buying such heavy, complex equipment, and that operation of one drilling rig could not give core samples as soon as the people of Georgia desired, it was decided to speed-up operations by contracting with commerical drillers. There are many drillers in Georgia; however, only a few were known to have the rugged equipment needed for exploratory phosphate core drilling to depths of

300 feet. About seven drillers from Georgia, Florida, and Texas supplied detailed information as to their drilling rigs, experience, and approximate drilling charges.

*Drilling Methods*

As drilling is done on public road rights-of-way, approval by County Commissioners and the State Highway Board is needed. In each case, complete cooperation has been received.

Drilling, under contract, has been carried out in Echols County and in December moved to other areas. Each driller is allowed two holes to show his capability to recover the required minimum of 85% of the core. When qualified, he is eligible to bid on other programs, usually a 10-hole program. Every driller must meet State Purchasing Department bonding, insurance, and other requirements. To date, three drillers have shown competence, and a fine degree of interest in the program as a whole.

A Tech field geologist is on hand at the drill with authority to modify the operation as necessary; he examines the cores with a microscope, logs the results and drilling speeds, and runs the electrical and gamma-ray logs; he also ships the labeled cores back to the Tech laboratories, and insures that all information gained is held in confidence until sufficient data are ready for release by the State Department of Mines, Mining and Geology. A State truck has been equipped specifically for logging operations and will be used on wells, as drilled, *and* on wells already drilled, in order to obtain additional information.

Drilling is continued, in general, until identifiable strata such as the Tampa Limestone are reached. In Echols County, this formation has been about 130 feet below the surface. As this basic geologic feature is found to rise or fall, one obtains additional guidance upon geologic structures which may direct continued well drilling.

*Cutting of Cores and Sampling*

At the laboratories, the cores are cut lengthwise in half, one half retained for reference, and the other half used for numerous tests and analyses. Representative samples of each homogeneous layer of interest are taken. One sample is crushed, placed in a heavy liquid (tetrabromo-ethane) and the part that sinks is examined first by a special microscope for heavy mineral identification, size, shape, and rough percentage of each mineral in the precipitate. Another sample is screened to remove coarse (pebble) phosphate larger than 16 mesh, and to remove slimes - or tailings (finer than 150 mesh). The concentrates (middle size) are "beneficiated" by an industrial type flotation process to upgrade the quality of the phosphate.

*Analytical Methods*

If the heavy mineral fraction shows a good minerals content, the rough microscopic analyses are confirmed. The feeds, concentrates and fines of the other sample are analyzed (if desirable) for phosphate, iron and aluminum, acid insoluble material, and calcium and magnesium. If samples are taken of, say, 5-foot intervals from a 150 foot hole, it is easy to see that very many tests and analyses are required. Determinations are made by several different techniques in order to obtain the data with a minimum of time and effort: conventional chemical wet-analysis, X-ray fluorescence, and atomic absorption techniques are used - each to determine specific materials.

*Interpretation and Results*

All the data obtained in the field and in the laboratory are compiled, and rules-of-thumb factors calculated. The data from each hole is then studied in relation to other holes in that area, the information reviewed by one of the nation's top consultants in the phosphate industry; *finally, a comprehensive report will be prepared for release to the public. The reports will be on units, or certain areas, rather than piecemeal on each individual hole, which could be misleading.* These reports will go to all state officials, members of the General Assembly, and to property owners, or those interested in development.

The reports will vary due to the minerals of interest, the amount of drilling in each area, and previous usable work.

## ACCOMPLISHMENTS TO DATE AND PROGRESS REPORTS

Consistent with the allowable budget, studies of available information have been made, laboratories have been set up, logging equipment has been bought, a drilling rig has been ordered, specially trained personnel has been employed, and a drilling program under contract is underway.

Data available at the start of the program indicated that best prospects seemed to be: fuller's earth and clays in southwest Geo:gia, heavy minerals along the coastal counties, phosphate from Echols County northeastward into the Effingham County region.

Under this program, drilling in Echols County has been completed. *A report, including data from prior work by railroads, should be submitted about the middle of January, 1966.* Other progress reports will be issued at later dates to keep the public aware of new discoveries and advancements in prospecting.

In addition, many conferences have been held with local leaders to clarify the program to them — its background, its urgency, the vast area to be covered, and the program underway and operated by funds available. An enhanced program, permissible only if additional funds are made available, would result in greater activity simultaneously in several areas within the Coastal Plain, and much additional data through full-time use of a geologist on electric and gamma-ray logging.

It is expected that exploration for heavy minerals will be carried out in the near future, together with continuation of the phosphate-oriented program. Geologists of the Department of Mines, Mining and Geology are now doing exploratory work in advance of drilling. Considerable recent data on the clay of southwest Georgia have just become available and a study of these data will be made in the near future.

## SUMMARY

The program is being carried out by Georgia Tech under contract with, and in conjunction with, the State Department of Mines, Mining and Geology. Public funds are being spent, drilling-sampling is confined to public roadways (or public lands), and all detailed information will be issued by the State Department of Mines, Mining and Geology to the public-at-large.

The area to be covered is vast (25,000 square miles) and the funds are limited. The work, while of an exploratory reconnaissance nature, also has the objective of attracting industry to engage in its own detailed programs and establish new mineral industry facilities within the Coastal Plain. Private companies have already begun prospecting. It is reported that industries are active and are doing exploration and drilling in the following counties: Bulloch, Effingham, Bryan, Chatham, Liberty, Long, Wayne, McIntosh, Ware, Pierce, Brantley, Glynn, Camden, Charlton, Clinch, Atkinson, Berrien, Cook, Lanier, Echols, Lowndes, Brooks, Thomas, and Grady. Active leasing is reported in Lanier, Lowndes, Echols, Clinch, and Effingham Counties.