

STATE OF FLORIDA  
DEPARTMENT OF NATURAL RESOURCES

Elton J. Gissendanner, *Executive Director*

DIVISION OF RESOURCE MANAGEMENT

Casey J. Gluckman, *Director*

BUREAU OF GEOLOGY

Charles W. Hendry, Jr., *Chief*

SPECIAL PUBLICATION NO. 26

THE FLORIDA BUREAU OF GEOLOGY  
PAST, PRESENT, AND FUTURE

By

Ronald W. Hoenstine, Jr. and Sheila Weissinger



75th ANNIVERSARY  
FLORIDA BUREAU OF GEOLOGY

Prepared by the  
BUREAU OF GEOLOGY  
DIVISION OF RESOURCE MANAGEMENT  
FLORIDA DEPARTMENT OF NATURAL RESOURCES

TALLAHASSEE

1983

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## LETTER OF TRANSMITTAL



Bureau of Geology  
Tallahassee  
March 17, 1983

Governor Bob Graham, Chairman  
Florida Department of Natural Resources  
Tallahassee, Florida 32301

Dear Governor Graham:

The Bureau of Geology, Division of Resource Management, Department of Natural Resources, is publishing as its Special Publication No. 26, "Florida Bureau of Geology, Past, Present, and Future," prepared by Ronald Hoenstine and Sheila Weissinger.

Respectfully yours,

Charles W. Hendry, Jr.  
Chief  
Bureau of Geology

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### PREFACE

#### 1907 ACT ESTABLISHING THE FLORIDA GEOLOGICAL SURVEY

The State Geological Survey was authorized by the General Assembly of 1907. The act establishing the Survey reads as follows:

AN ACT establishing a Geological Survey for the State of Florida,

to provide for the appointment of a State Geologist, to define his duties, and to provide for the maintenance of the survey.

*Be it Enacted by the Legislature of the State of Florida:*

Section 1. That the Governor of the State shall appoint a suitable person to conduct a geological survey of the State; such person shall be known as the State Geologist, and shall have his office at the Capitol.

Section 2. The State Geologist shall appoint subject to the approval of the Governor such assistance as he may find necessary to enable him to successfully, and with reasonable dispatch, accomplish the object of the survey, and such assistance shall be entirely under the control of the State Geologist.

Section 3. The State Geologist shall make to the Governor annually a report of the progress of his surveys and explorations of the minerals, water supply and other natural resources of the State, and he shall include in such report full description of such surveys and explorations, occurrence and location of mineral and other deposits of value, surface and subterranean water supply and power and mineral waters and the best and most economical methods of development, together with analysis of soils, minerals and mineral waters, with maps, charts and drawings of the same; and it shall be the duty of the State Geologist and his assistants, when they discover any mineral deposits or other substance of value, to notify the owner of the land upon which such deposits occur. Failure of the said Geologist to notify the owner of such deposit before disclosing to any other

## BUREAU OF GEOLOGY

person or persons, shall subject said Geologist to a fine of one thousand dollars and six months imprisonment.

Section 4. It shall be the duty of the State Geologist to make collections of specimens illustrating the geological and mineral features of the State; one suit of which shall be deposited in the office of the State Geologist, at Tallahassee, and duplicate suits in the libraries of each of the State Colleges; each suit to be correctly labeled for convenient use and study.

Section 5. That for the purpose of expeditiously and thoroughly carrying out the provisions of this act, there shall be appropriated out of any moneys in the Treasury not otherwise appropriated the sum of seven thousand five hundred dollars per annum. The Comptroller shall, upon the requisition of the State Geologist, when approved by the Governor, draw his warrant on the Treasurer for the amount so appropriated in such sums as may be needed from time to time for the purpose of said survey as herein set forth; and for all such expenditures made under the provisions of this act except for the payment of the salary of the State Geologist, as herein provided, the consent and approval of the Governor shall be obtained, and the vouchers for all such expenditures made from this fund shall be filed with the Comptroller; and a statement of his receipts and expenditures shall be printed in such annual report of the State Geologist. Of the amount annually appropriated, there shall be expended: First, for the salary of the State Geologist, two thousand five hundred dollars per annum, which salary is hereby fixed at that sum. Second, for the contingent expenses of the survey, including compensation of all temporary and permanent assistance; traveling expenses of the geological corps; purchase of materials or other necessary expenses for outfit; expenses incurred in providing for the transportation, arrangement and proper exhibition of the geological and other collections made under the provisions of this act; for

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postage, stationery and printing, and the printing and engraving of maps and sections to illustrate the annual reports, five thousand dollars, or so much thereof as may be necessary.

Section 6. All chemical, analytical or assay work shall be performed by the State Chemist and his assistants, at the direction of the Governor, upon request of the State Geologist.

Section 7. All laws and parts of laws inconsistent herewith are hereby repealed.

Section 8. This act shall take effect upon its passage and approval by the Governor, or upon its becoming a law without such approval.

Approved June 3, 1907.

### INTRODUCTION

During fiscal year 1982-83, the Florida Bureau of Geology celebrates its 75th year of service. The Bureau is an organizational unit within the Florida Department of Natural Resources. One of the Bureau's primary objectives is to study Florida's geological resources and to make the data and interpretations derived from these investigations available to other governmental agencies, the general public and the scientific community. This information is essential to the formulation and evaluation of effective policies dealing with the management, utilization and conservation of Florida's valuable resources. In addition the Bureau is responsible for regulating various phases of exploration and production of hydrocarbons and to regulate the reclamation of certain mined lands.

Between 1852 and 1907, this organization twice lost its struggle for existence. Even after existence was assured in 1907, the Bureau experienced three reorganizations and several name changes. These changes reflect in part Florida's response to the expanding demand for efficient utilization of its mineral resources, and increased concern for the environment.

## BUREAU OF GEOLOGY

The Bureau's early beginnings date back to the mid-nineteenth century. Florida, as well as other states throughout the young nation, was struggling to establish funding for its governmental activities. Consequently, during this period the discovery and development of mineral resource deposits on public lands was of special interest. This concern continues today, as Florida's future remains dependent upon the identification and wise use of its limited natural resources. Necessary to the effective management of these resources is cooperation among such agencies as the Florida Bureau of Geology, the legislature, city and county planners, and the general public.

The way in which Florida, a state once thought to have "no geology", came to discover and use its mineral potential is closely interwoven with the history of Florida's geological survey. The occasion of the Bureau's 75th anniversary presents an opportunity to review both past and present accomplishments and look ahead to future needs and concerns.

### HISTORY

The beginnings of the Florida Bureau of Geology can be traced to the year 1852 when the office of State Engineer and Geologist was authorized by the legislature. The man chosen to head this new office was "General" Francis L. Dancy, a former militia officer and mayor of St. Augustine. Although he lacked a geological background, Dancy's extensive experience in engineering and construction was useful since his responsibilities included overseeing the drainage of lowland areas for agricultural development. Unfortunately, funding proved a problem. When, in November of 1855, he requested \$500 to enable him to test soils in various parts of the state, the post was abolished.

It wasn't until 1880 when the Alabama State Geologist, Eugene A. Smith, reported the presence of phosphoric acid in a sample of Florida building stone that the potential economic value of Florida's mineral

resources began to be recognized. Since phosphoric acid is an essential substance which is easily depleted from the soil by intensive cultivation, the possibility of commercially valuable phosphate in the state represented a windfall. Not only was phosphate valuable as a fertilizer, but increased mining activities would attract northern capital, provide employment opportunities, encourage construction of railroads, harbor facilities, and in other ways "open up" the state for further development.

Because of the phosphate and the possible existence of other valuable minerals, Governor E. A. Perry appointed Dr. John Kost, a medical doctor and amateur geologist, as State Geologist in 1886. Upon assuming his post, Kost initiated studies of phosphate and other minerals in the state, of which a report was completed in 1887. The report began:

"To His Excellency, E. A. Perry,  
Governor of the State of Florida. Sir:  
I have the honor to report that I  
proceeded immediately to the work of  
the State Geological Survey, after  
receiving my commission, and that I  
have improved (sic) all my time in the  
work of the survey that my other  
professional duties permit...I am ready  
now to state that the results of my  
observations will fully justify the  
Legislature this spring to provide for  
a two year's work in a regular  
geological survey of the State...."

However, Dr. Kost's recommendations suffered a fate similar to General Dancy's and his request for funding to extend the survey was rejected. As a result, during the following two decades, the study of Florida's geology was principally conducted by the United States Geological Survey, mining companies and other private industries.

## BUREAU OF GEOLOGY

Legislative action to provide a full-fledged state geological survey was initiated in 1903 by freshman Senator E. S. Crill of Palatka and Representative DeWitt Webb of St. Johns County. This legislation, which was finally passed in 1907, provided for an autonomous permanent geological survey and an office of State Geologist who, with his staff, would conduct a geological survey of Florida. This new organization was called the Florida Geological Survey.

This law was exemplary in that the state was willing to subsidize a geological survey which would be permitted latitude in its choice of studies and research (Act creating the Survey, see Preface). The law remained unchanged until 1933, at which time the Survey was placed under the newly-formed State Board of Conservation. This organization was comprised of the Florida Geological Survey, the Department of Game and Fresh Water Fish, and the Office of Shell Fish Commissioner. Though the administrative structure was altered, the Geological Survey remained essentially autonomous in function, as it had been since 1907. The 1907 Florida Geological Survey organization and the present organization are shown in Figure 1.



BUREAU OF GEOLOGY  
STATE GEOLOGISTS



Elias Sellards  
1907-1919

Since passage of the 1907 law, there have been four state geologists. The first was Dr. Elias Sellards who was appointed by Governor Napoleon B. Broward. Sellards, who for two years was assistant paleontologist with the Kansas Geological Survey, received his B.A. and M.A. degrees from the University of Kansas and his Ph.D. from Yale University. He taught geology and mineralogy at Rutgers University then, in 1904, became an instructor at the University of Florida.

While at the University of Florida, Sellards devoted a considerable amount of time to the study of Florida's underground water resources, a subject of special concern to the state's agricultural interests.

ly, water resource studies became a primary the early work done by the survey staff. rly investigations, which included the id water supply of central Florida and a road materials, were directed toward serving economic needs. In later years the emphasis ore academic, and expanded to include gy and general Florida geology.

Sellards' guidance, the Geological Survey as a permanent department of state s, and notably without political co. After Sellards' resignation in April of joined the Bureau of Economic Geology of the Texas. His former student and staff, Herman Gunter, assumed the position of ologist following Sellards' resignation.



Herman Gunter  
1919-1958

## BUREAU OF GEOLOGY

Herman Gunter's association with the Florida Geological Survey spanned almost 52 years - a length of service unmatched by any other state geologist. Gunter graduated from the University of Florida with a B.S. degree in 1907 and in that same year joined the Survey staff. His advancement to director in 1919 ensured that the position was staffed by someone well-versed in Florida geology.

As the Geological Survey's second director, he changed the survey's emphasis somewhat by making its reports more diverse and less academic in outlook, and by more closely relating the Geological Survey's work to the needs of state government. In his role as administrator, Gunter encouraged cooperation with the state's public schools, enlarged the Geological Survey's museum and library, and thereby acted on his belief that a primary purpose of the Florida Geological Survey was to serve as a highly accessible source of information on Florida geology.

Under Gunter's direction the Florida Geological Survey initiated a conservation campaign aimed at exposing the gross damage being done to the state's underground and surface water supplies by careless drilling practices and misuse of water. In response to this campaign, a bill was introduced in 1937 to protect the state's water resources; however, it failed to pass the legislature.

His interest in the preservation of the water resources of Florida propelled him to the forefront as an opponent of the Cross Florida Barge Canal (originally conceived as a sea level ship canal across Florida). Also under Gunter, work was begun on investigating Florida's mineral resources. He sought and obtained funding for a cooperative venture with the U.S. Geological Survey to complete topographic mapping of the state.

His contributions to geologic research were formally recognized by the University of Florida when, in 1944, he was awarded an honorary Doctorate of Science. His accomplishments were varied and distinguished and laid a firm foundation for the future. When he retired in 1958, Herman Gunter had

most 52 years with the Florida Geological Survey. In recognition of his service, the building which houses the Florida Bureau of Geology is named the Gunter Building.



Robert O. Vernon  
1958-1971

After Gunter's death, his successor was Robert O. Vernon, who served the Survey as an assistant state geologist. Vernon received his B.S. from Birmingham College, his M.S. from the University of Alabama, and his Ph.D. from Louisiana State University. During his geologic research, Vernon conducted or participated in a large number of investigations on hydrogeology. Part of this emphasis resulted in the establishment of the Florida Geological Survey - U.S. Geological Survey cooperative program in water

## BUREAU OF GEOLOGY

resource investigations.

Recognizing the need for conservation of Florida's limited water resources, much of his time was spent informing the public about Florida geology and hydrology through numerous publications, public forums, and presentations to schools and civic organizations. The Florida statutes relating to conservation of water resources are principally the direct result of Vernon's efforts.

It was also largely through his efforts that the legislature authorized and funded the construction of a geologic center comprised of the Florida State University's Department of Geology and the Florida Bureau of Geology. The proximity of these entities, which are housed next to each other on the campus of Florida State University, has provided for a cooperative use of scientific equipment and library facilities, and has encouraged an open and stimulating exchange of ideas between the university and the survey over the years. It also has enhanced opportunities for student employment at the Florida Bureau of Geology and has benefited the survey staff by supplying skilled, knowledgeable graduate students to assist in areas involving practical geological research.

In November of 1971, Vernon resigned as Bureau Chief and accepted the position of Director of the Division of Interior Resources in the Department of Natural Resources. Robert Vernon is remembered as a dedicated professional, who devoted many years of thought and energy to Florida geology.



Charles W. Hendry, Jr.  
1971-Present

Upon Vernon's resignation in 1971, Charles W. "Bud" Hendry, Jr., assumed the post of State Geologist and Chief of the Bureau of Geology. An employee of the Florida Geological Survey since 1949, Hendry has held a number of positions including draftsman, stratigrapher, director of water resource investigations, and assistant state geologist. In addition to earning his B.S. from Florida State University, Hendry had the distinction of receiving the first M.S. degree in geology awarded by Florida State University.

Aware of a growing population and its increasing impact on Florida's environment, Hendry has recognized the importance of the role of the Bureau of Geology in providing the geological data necessary to evaluate and mitigate these impacts. Consequently, under Hendry's direction the primary focus of the programs of the Bureau has been on "applied geology." This approach directs the efforts of the Bureau to seek answers to questions and problems concerning man's impact on the state's geologic environment. In the process of pursuing this objective, the Bureau has

## BUREAU OF GEOLOGY

significantly increased its geologic data base. These data and their interpretation are provided to other governmental agencies and the general public through publications, seminars and service as geologic consultants. A prime example of the type of geological data offered the public is the recently completed statewide Environmental Geology Map Series, which were designed to present geologic data and their interpretation in a manner easily understood by the general public.

## A SURVEY OF FLORIDA'S MINERAL RESOURCES

Florida is more than just the Sunshine State, for below its surface lie valuable minerals which add significantly to the State's economy. The value of these commodities, illustrated in Table 1, contributes in excess of \$3 billion annually to the state in the form of sales, salaries, and taxes. The mining industry employs thousands of workers, with the phosphate industry alone employing more than 14,000 (1981 data, Florida Phosphate Council). Florida's importance as a mineral producer in the United States is presented in Table 2. The locations of Florida's major mineral deposits are illustrated in Figure 2.

## Phosphate

Phosphate represents the most important mineral in Florida in terms of both sales and production (Figure 3). Florida is the largest producer of phosphate rock in the world, accounting for over 80 percent of total U.S. production, and one-third of world production (Table 3). Florida's estimated reserves are enormous, totaling more than 4 billion tons.

Although pebble phosphate was mined from the Peace River in central Florida as early as 1881, it wasn't until the late 1880's that land surface mining began in Florida. The production of phosphate, which totaled several thousand tons in 1888, increased to

BUREAU OF GEOLOGY

TABLE 1 - PRELIMINARY DATA, MINERAL PRODUCTION IN FLORIDA, 1982<sup>1,5</sup>

| Mineral                                                                                                                                                                                                            | 1982                |                              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------------------|
|                                                                                                                                                                                                                    | Quantity            | Value<br>Thousand<br>Dollars |
| Cement, masonry...thousand short tons.....                                                                                                                                                                         | 235                 | 17,200                       |
| Cement, portland...thousand short tons.....                                                                                                                                                                        | 2,600               | 149,800                      |
| Clays.....do.....                                                                                                                                                                                                  | 680                 | 31,915 <sup>2</sup>          |
| Lime.....do.....                                                                                                                                                                                                   | 150                 | 9,354                        |
| Peat.....thousand short tons.....                                                                                                                                                                                  | 160                 | 2,937                        |
| Sand and gravel...thousand short tons.....                                                                                                                                                                         | 11,110              | 27,800                       |
| Stone (crushed).....do.....                                                                                                                                                                                        | 52,400 <sup>3</sup> | 173,400 <sup>3</sup>         |
| Combined value of kaolin, magnesium<br>compounds, phosphate rock, rare-earth<br>concentrates, staurolite, stone<br>(dimension), titanium concentrates<br>(ilmenite and rutile), and zirconium<br>concentrates..... | XX                  | 845,808                      |
| TOTAL.....                                                                                                                                                                                                         | XX                  | 1,263,219 <sup>4</sup>       |

XX Not applicable

<sup>1</sup>Production is measured by mine shipments, sales, or marketable production (including consumption by producers).

<sup>2</sup>Excludes value of kaolin; value included in "Combined value" figure.

<sup>3</sup>Excludes dimension stone; value included in "Combined value" figure.

<sup>4</sup>Incomplete total; excludes value of natural gas, natural gas liquids, and petroleum (oil and gas production shown in Figure 7).

<sup>5</sup>1982 Preliminary Data, James Boyle, U.S. Bureau of Mines (Personal Communication).

TABLE 2 - FLORIDA'S ROLE IN U.S. NONFUEL MINERAL SUPPLY IN 1981<sup>2</sup>

| Major Commodity                   | Share of<br>U.S. Output,<br>Percent | Rank in<br>Nation | Reserves |
|-----------------------------------|-------------------------------------|-------------------|----------|
| Fuller's earth.....               | 31                                  | 2                 | Moderate |
| Phosphate rock <sup>1</sup> ..... | 86                                  | 1                 | Moderate |
| Staurolite.....                   | 100                                 | 1                 | Small    |
| Stone (crushed).....              | 7                                   | 2                 | Large    |
| Titanium minerals.....            | W                                   | 1                 | Moderate |
| Zircon.....                       | 100                                 | 1                 | Small    |

W Withheld to avoid disclosing individual company confidential data.

<sup>1</sup>Includes North Carolina.

<sup>2</sup>United States Bureau of Mines.

three million tons by 1920 and by 1981 Florida's annual production was over 46 million metric tons of phosphate rock. Today, as in the early days, most phosphate is mined using the open-pit method. Previous mining utilized such equipment as hydraulic pumps, steam shovels and dredges to remove the overburden and expose the matrix (ore body). However, in 1929, this extractive machinery was replaced by the more efficient dragline, which increased the tonnage of ore mined.

Phosphorus is important to both domestic and world-wide agriculture since it is essential to plant growth. Almost 90 percent of the phosphate produced in Florida in 1981 was used in making fertilizer. Although the primary use for phosphate is for agriculture, other uses include animal feed supplements, cleaning compounds, leavening agents, food preservatives, and insecticides.

World demand for phosphate is expected to increase dramatically in the coming years. Using present technology and known reserves, Florida has enough remaining phosphate to meet projected demand for the next 200 years (Florida Phosphate Council, 1982).

# BUREAU OF GEOLOGY

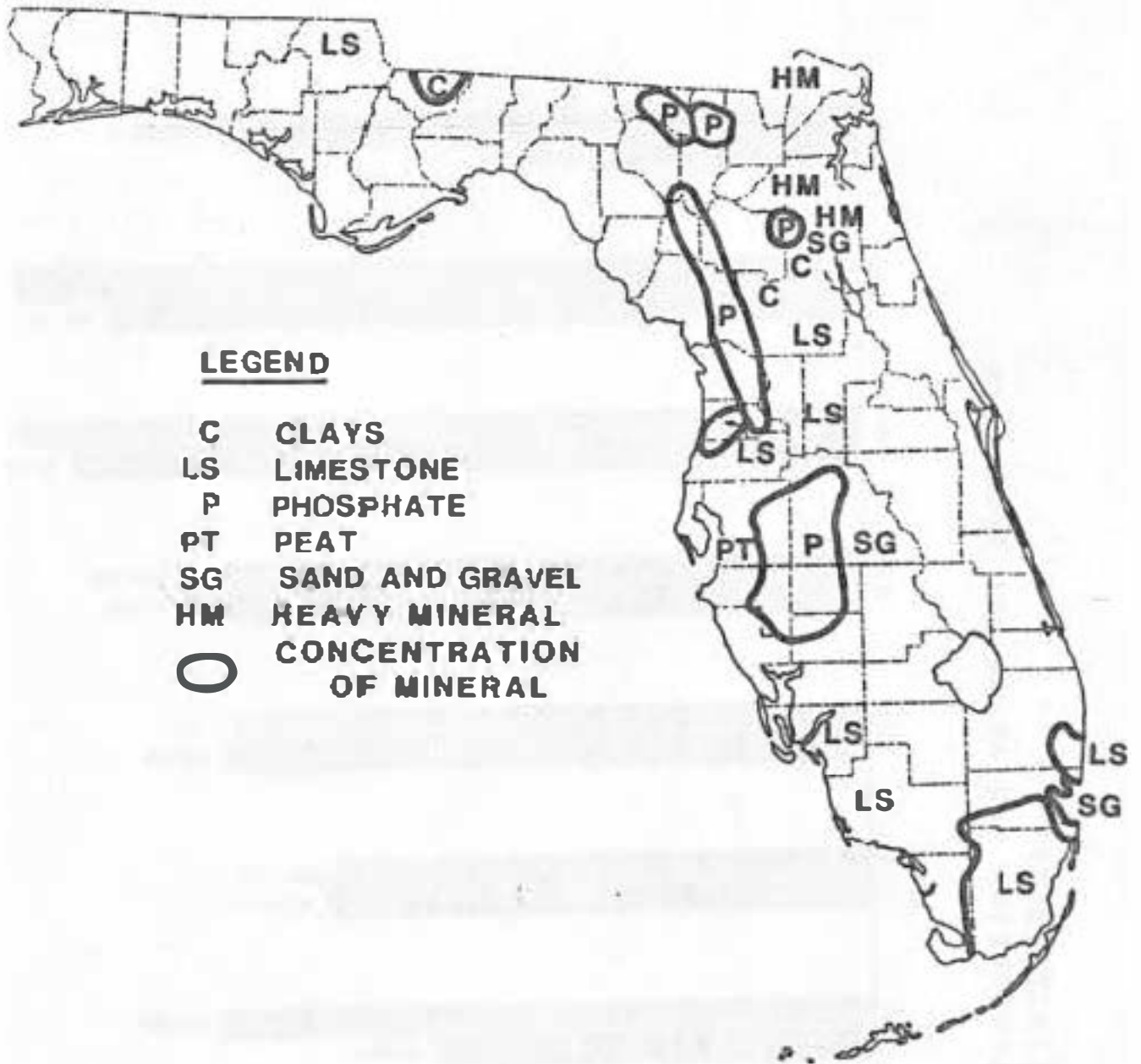


Figure 2. Location of major known solid mineral deposits.

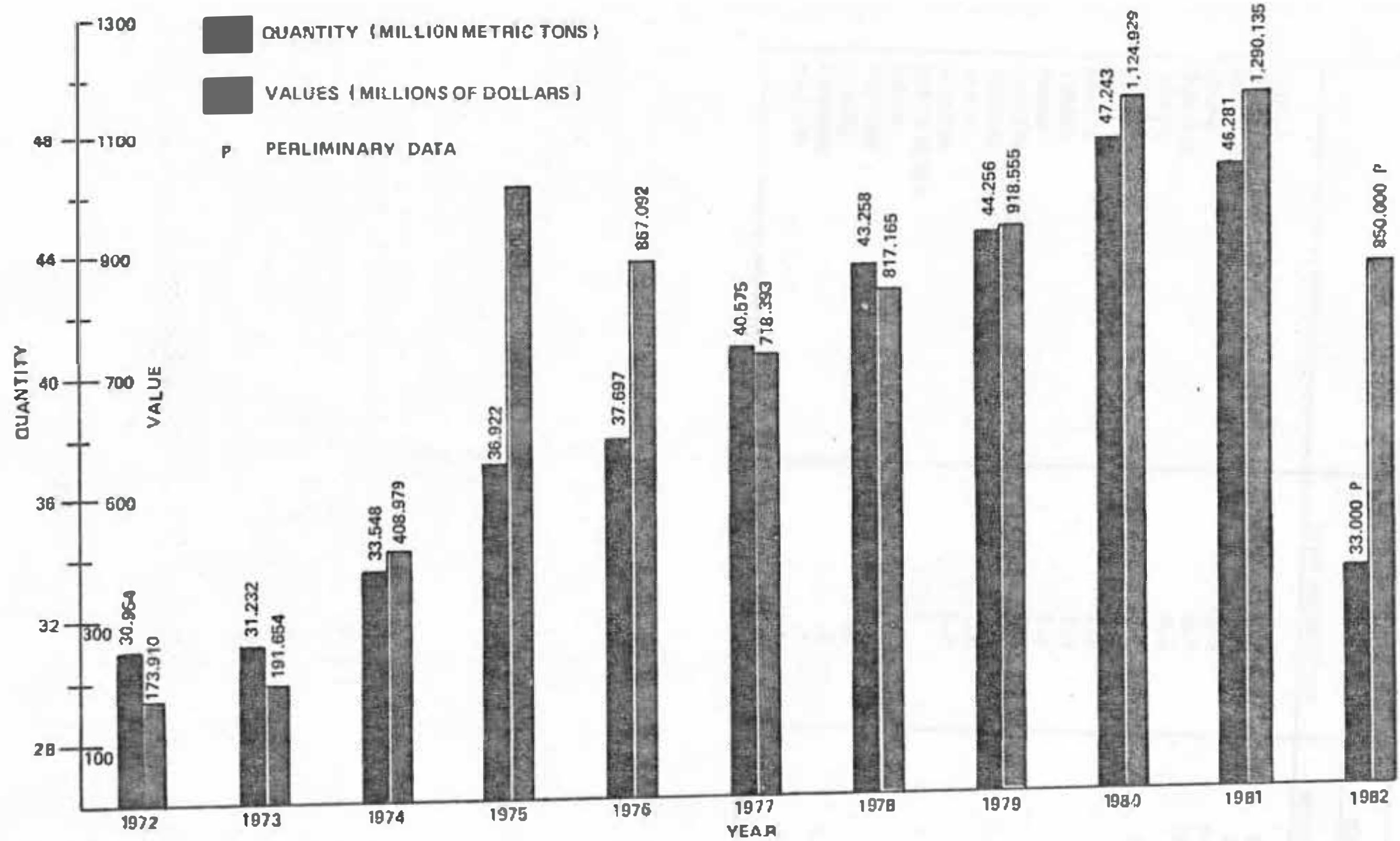


Figure 3.

Production and value for phosphate  
(1972-1982).

# BUREAU OF GEOLOGY

TABLE 3 - LEADING PRODUCERS of phosphate rock (in the world) are listed in millions of metric tons. The reserve base is phosphate rock that could be mined under existing economic conditions (after Sheldon, 1982).

|                  | MILLION METRIC TONS |              |
|------------------|---------------------|--------------|
|                  | 1980 PRODUCTION     | RESERVE BASE |
| U.S.             | 54.4                | 8,000        |
| U.S.S.R.         | 26.1                | 8,300        |
| MOROCCO-SAHARA   | 16.8                | 44,000       |
| CHINA            | 6.7                 | 10,000       |
| TUNISIA          | 4.6                 | 500          |
| JORDAN           | 4.2                 | 1,100        |
| SOUTH AFRICA     | 3.3                 | 700          |
| TOGO             | 2.9                 | 110          |
| BRAZIL           | 2.9                 | 800          |
| ISRAEL           | 2.6                 | 150          |
| NAURU            | 2.1                 | 20           |
| CHRISTMAS ISLAND | 1.7                 | 62           |
| SENEGAL          | 1.4                 | 75           |
| SYRIA            | 1.3                 | 833          |
| ALGERIA          | 1                   | 1,000        |
| NORTH KOREA      | .5                  | 90           |
| INDIA            | .4                  | 108          |
| VIETNAM          | .4                  | 100          |
| MEXICO           | .3                  | 1,034        |
| ZIMBABWE         | .1                  | 50           |
| FINLAND          | .1                  | 565          |

## Limestone and Dolomite

Coquina, a variety of limestone, was the first of Florida's mineral resources to be utilized by early European settlers. It was used in the construction of forts and missions; one of which, the Castillo de San Marcos in St. Augustine, is a National Park. Florida is underlain by sedimentary rock, predominantly limestone and dolomite, to depths ranging from 3,500 feet in the north to over 20,000 feet in the Keys.

A major producer, Florida ranked second in the nation in the production of limestone and dolomite in 1980, producing over 66,000 tons with a value of more than \$215 million (U.S. Bureau of Mines, 1980). Figure 4 shows total production and value for crushed limestone in Florida for the period 1972-82. This production of limestone and dolomite is by open-pit mining, with the highest concentration of quarries located in Broward, Dade, and Marion counties.

The growth of this industry is clearly illustrated by comparing 1907 production, which totaled 6,000 tons, to 1980 production of 66,000 tons. This rapid development over the past 50 years can be attributed to a number of factors including a marked increase in highway construction, the building construction industry, and a significant expansion in the metallurgical, chemical and processing industries in which limestone is an important ingredient.

The principal uses of limestone in Florida are for portland cement, concrete aggregate, and road base material which account for over 80 percent of the limestone produced. Smaller but significant amounts of limestone and lime are used in agriculture.

Although subject to fluctuations caused by changes in the economy, certain trends may be projected. Road base and concrete aggregate usage in highway construction is expected to show a moderate increase due to the construction of new roads and rehabilitation and resurfacing of existing roads. In addition, the use of limestone for agricultural needs

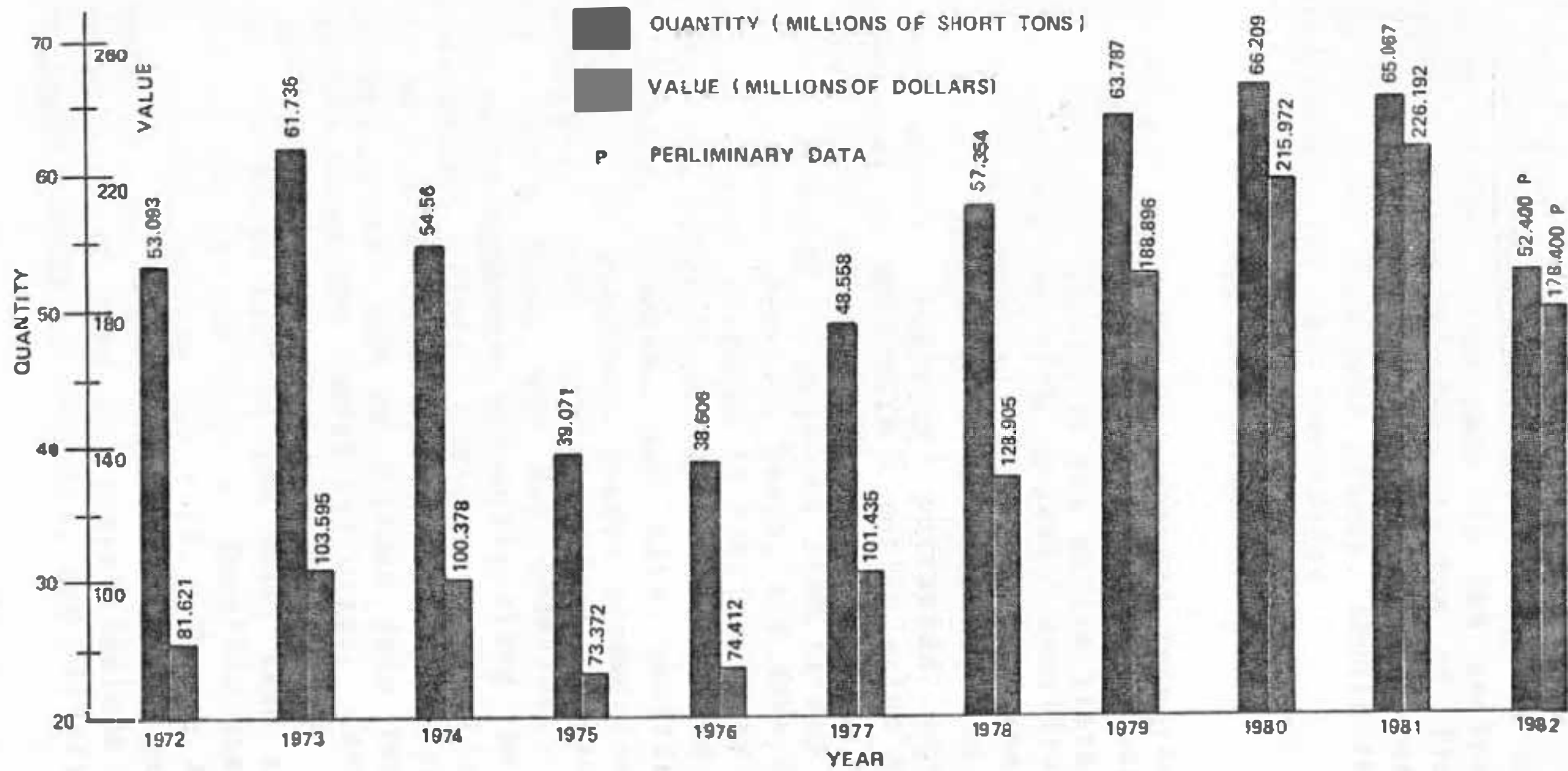


Figure 4. Production and value for crushed limestone (1972-1982).

should experience substantial growth due to the world's expanding population and consequent need for higher crop yields. New uses in the environmental field which include desulphurization of flue gas, neutralization of acid mine drainage, and use as a substrate in waste treatment plants, should result in increasing demand for this commodity.

### Sand and Gravel

One of our most abundant natural resources, sand represents more to Florida than just an attraction for tourists. Covering virtually the entire state, quartz sand, in conjunction with gravel, constitutes the largest non-fuel mineral industry in the United States. Mined extensively in Florida, the state's sand and gravel industry extracted more than 11,000,000 tons in 1982 with a dollar value exceeding \$27 million (U.S. Bureau of Mines, 1982).

Sand in Florida is produced from stream alluvial deposits, terraces, fluvial, beach, and dune deposits. All sand and gravel produced in Florida is by open-pit mining with the largest sand quarries located in Polk, Putnam, Hendry, Broward, and Lake counties. In contrast, most of Florida's gravel production is from the panhandle, with concentrations occurring in Escambia, Santa Rosa, and Bay counties. Present mining is being conducted primarily along the Escambia and Apalachicola rivers. Sand and gravel and their products have a multiplicity of uses. The production of sand and gravel can be divided into two groups: construction usage and industrial usage. Construction sand and gravel, the largest usage by far, now accounts for 95 percent of the total sand and gravel produced in the United States. Specific uses include mortar, plaster, paving and fill. Though accounting for only 4 to 5 percent of total production, industrial uses of sand and gravel include glass and foundry sands, abrasive products, and filtering media.

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TABLE 4 - ESTIMATED ACRES DISTURBED BY MINING

| Commodity      | (Based on<br>State Data<br>Acreage<br>Thru 1981 | (Based on<br>State Data)<br>Acres Mined<br>Annually |
|----------------|-------------------------------------------------|-----------------------------------------------------|
| Phosphate      | 187,000                                         | 7,000                                               |
| Stone**        | 31,500*                                         | 500                                                 |
| Sand/Gravel**  | 11,100*                                         | 300                                                 |
| Clay           | 2,450                                           | 100                                                 |
| Heavy Minerals | 8,750                                           | 400                                                 |
| Peat**         | 1,050*                                          | 50                                                  |
| TOTAL          | 241,850                                         | 8,350                                               |

\* (Based on State Data Acreage through 1978 plus annual estimates for period 1979-81).

\*\* Not subject to mandatory reclamation.

Source: DNR and U. S. Department of Agriculture, Soil Conservation Service, The Status of Lands Disturbed by Surface Mining in the United States.

Figure 5 shows total production and value of sand and gravel in Florida for the period 1972-1982. The data show fluctuations in production which, in general, can be attributed to changes in the economy, especially as reflected in the construction industry. From a 1976 base, total national demand for sand and gravel is forecast to increase at an annual rate of 1.6 percent (U.S. Bureau of Mines, 1979), thus demonstrating a need for continued industry expansion in Florida.

## Heavy Minerals and Rare-Earth Minerals

An important producer of heavy minerals (accessory minerals that are a product of weathering of parent rocks and distinguished by their high

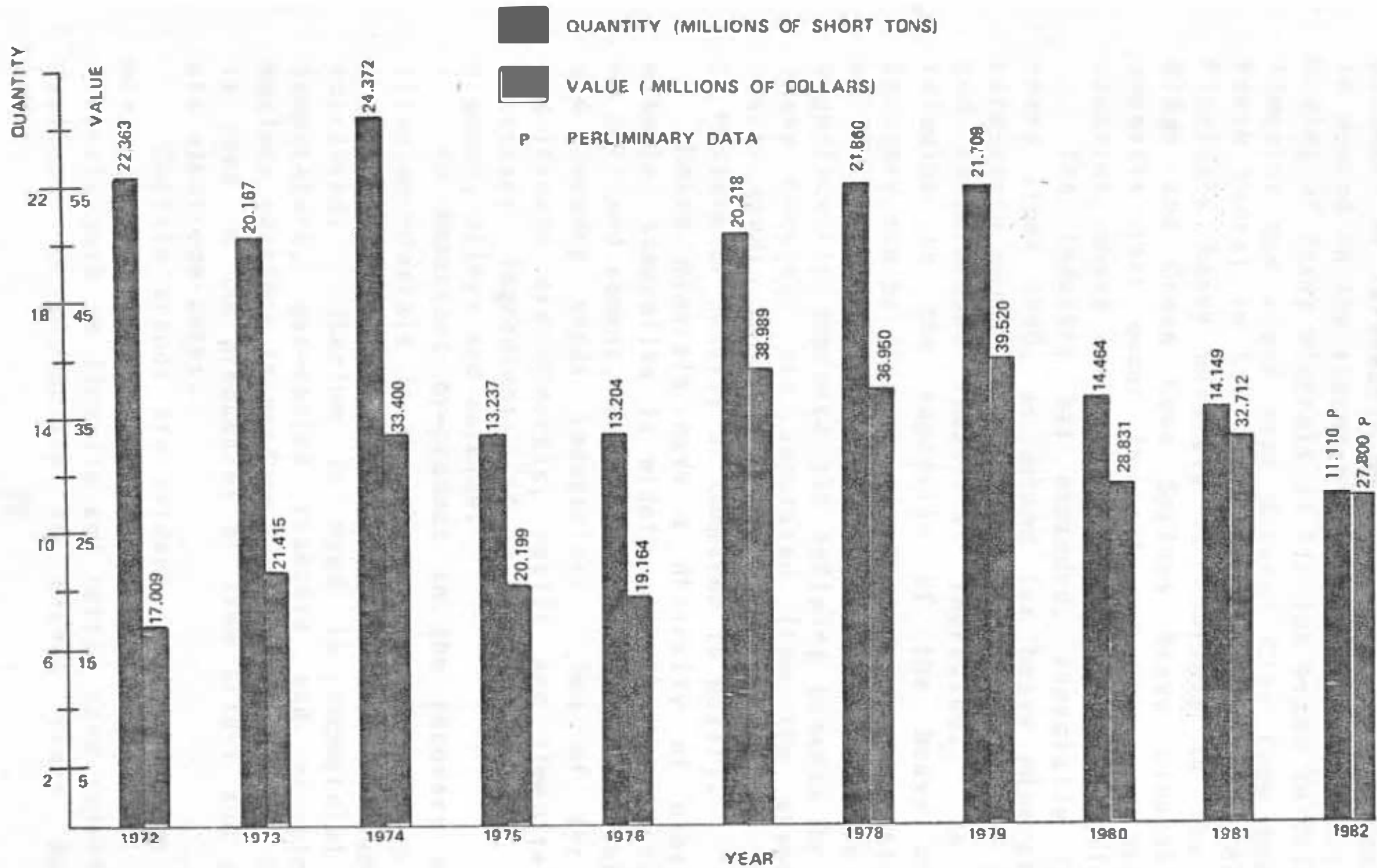


Figure 5. Production and value for sand and gravel (1972-1982).

## BUREAU OF GEOLOGY

specific gravity), Florida not only ranks first in the nation in the production of titanium but is also the only producer of zircon and staurolite in the United States (Table 2). In addition, Florida is a major producer of rare-earth metals, which are increasingly in demand in the electronics and aerospace industries. Mining of heavy minerals in Florida began in 1916 when ilmenite was mined near Mineral City (now known as Ponte Vedra) in St. Johns County. Today, mining of Florida's heavy minerals is confined to the Trail Ridge and Green Cove Springs heavy mineral sand deposits that occur in parts of Clay and Bradford counties, where some 400 acres are mined annually.

The industry has expanded, especially in the years since 1940, as demand for heavy minerals and rare-earth metals in the aeronautics, nuclear power, and construction industries increased. An added stimulus to the expansion of the heavy mineral industry can be directly attributed to the development of the Humphreys Spiral Concentrator, a device which significantly improved the refining process by which heavy minerals are separated from the associated quartz sands, based on their higher specific gravity (a measure of density as compared to water).

Heavy minerals have a diversity of uses; for example, staurolite is widely used in the manufacture of portland cement, and zircon is used in the ceramics and foundry sands industries. Two of the most significant ore minerals, rutile and ilmenite, are necessary ingredients of titanium dioxide paint pigment, alloys and carbide.

An important by-product in the recovery of the titanium minerals is the mineral monazite, from which the rare-earth elements cerium and thorium are extracted. Thorium is used in commercial high temperature, gas-cooled reactors and experimental nuclear reactors to produce fissionable U-233. Cerium is used in the production of iron alloys and carbon arc electrode cores.

Certain trends are evident based on known heavy mineral reserves. Specifically, important heavy minerals such as ilmenite and rutile have experienced declines in production in recent years due to

diminishing reserves. Although demand for rare-earth concentrates is expected to increase, Florida's known reserves are small and production has correspondingly decreased. However, the production of zircon and staurolite should increase in the coming years in response to a growing demand and moderate remaining reserves.

### Clay

An abundant natural resource, clay deposits are widely distributed throughout much of Florida. This fine grained material is mined in Florida by the open pit method.

Compositional differences as well as the presence of impurities such as silica, iron oxides, and calcium magnesium carbonates accounts for a wide variation in the properties of each clay deposit. These differences in turn effect their usage. As a result, clays mined in Florida may be classified into four types: adsorptive clay, white firing clay, expanding clay, and common clay.

Florida's production of fuller's earth (clays which are naturally highly adsorptive) ranked second in the nation in 1981. The mining of fuller's earth in Florida is concentrated in Gadsden, Brevard, and Marion counties. These clays are principally used as fillers, pesticide carriers, drilling mud, filters aids, absorbents and animal litters. Other clays mined in Florida are used in the manufacture of building brick, pottery, tile, cement, and light weight aggregate.

### Peat

Producing more than 154,000 tons, Florida ranked second nationally in the production of peat in 1980 (Table 2). Florida's known peat reserves, totaling more than 6.7 billion tons, are the fourth largest in the U.S., and are estimated to contain the equivalent of 82 quadrillion BTU's of power, enough energy to satisfy Florida's energy needs for 38 years (AAPG

## BUREAU OF GEOLOGY

Explorer, June 1982). Although the largest peat reserves are located in the Florida Everglades, primary production occurs in Hillsborough, Polk, Lake, and Putnam counties.

Most of the peat mined in Florida is used for potting soils and general soil improvement; however, the vast peat deposits in the Everglades are utilized in farming, and represent some of the most productive farmland in the United States. Presently, studies are being conducted to determine the feasibility of using peat as a primary fuel for a proposed 400 megawatt power plant in Florida.

Factors such as peat's estimated slow rate of accumulation (9.1 centimeters per 100 years, Kuehn, 1980) and loss of peat to urban expansion point out the need for conservation and wise utilization of this valuable resource. Demand is expected to continue to increase at a moderate rate for present uses, but may increase significantly if peat is used in the future as a primary energy source.

### Oil and Gas

Although not generally perceived as an oil producing state, the most recent data (Florida Department of Natural Resources Annual Production Report, 1982) shows Florida produced more than 25 million barrels of oil in 1982. This same report shows that Florida's total oil production over the years has amounted to more than 440 million barrels. Past, present and projected oil and gas production in Florida is shown in Figure 6.

Prospecting for oil and gas in Florida began as early as 1892, but it wasn't until 1943 that the first successful well was drilled. This well, located in Collier County, was drilled to a depth of 11,626 feet and ultimately produced 20,550 barrels of oil. Since 1943, 15 fields have been discovered and, to date, more than 400 million barrels of oil and more than 400 billion cubic feet of natural gas have been produced.

Today there are 12 producing oil fields located

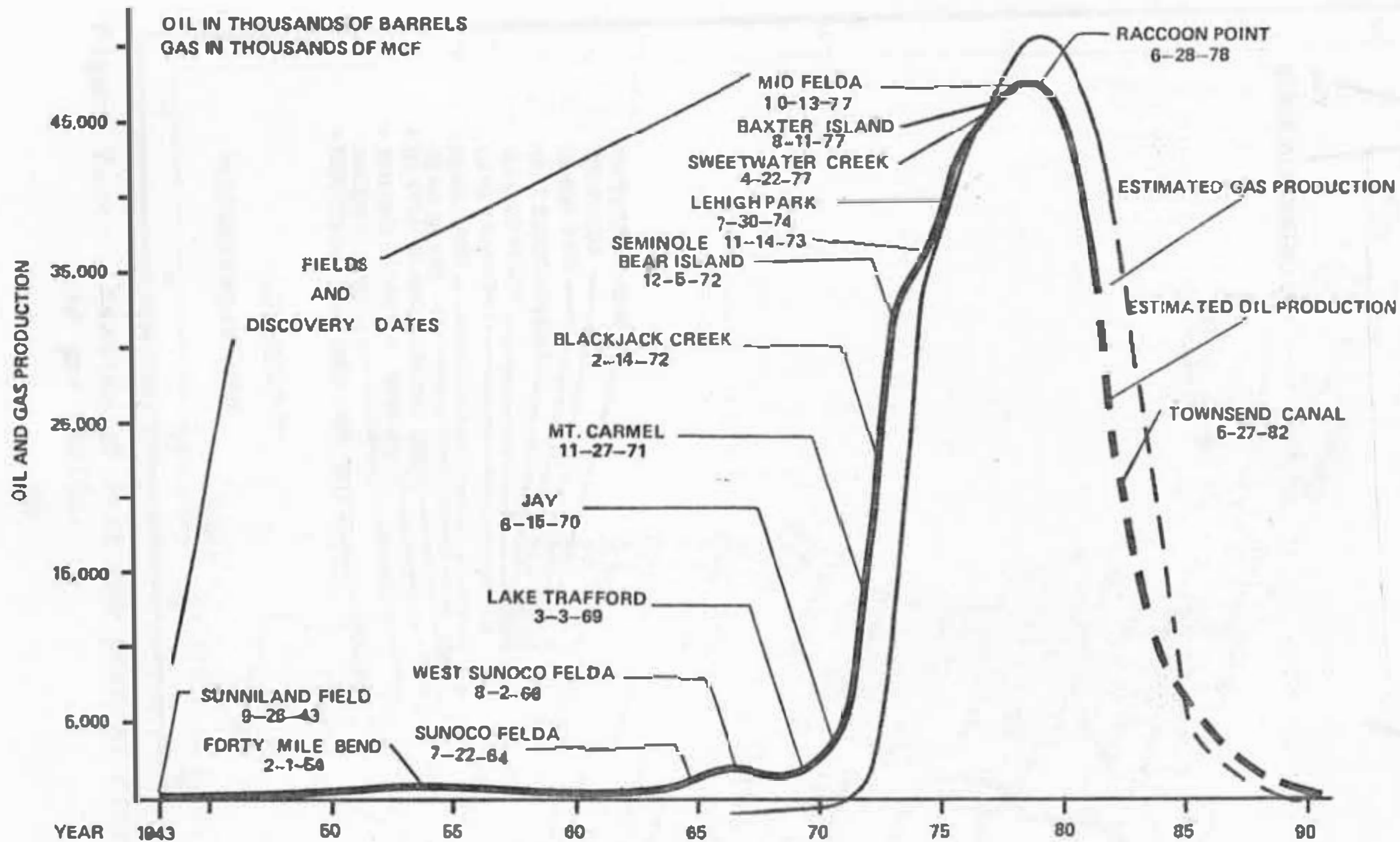


Figure 6.

Past, present, and projected oil and gas  
production in Florida for years  
1943-1990.

# BUREAU OF GEOLOGY

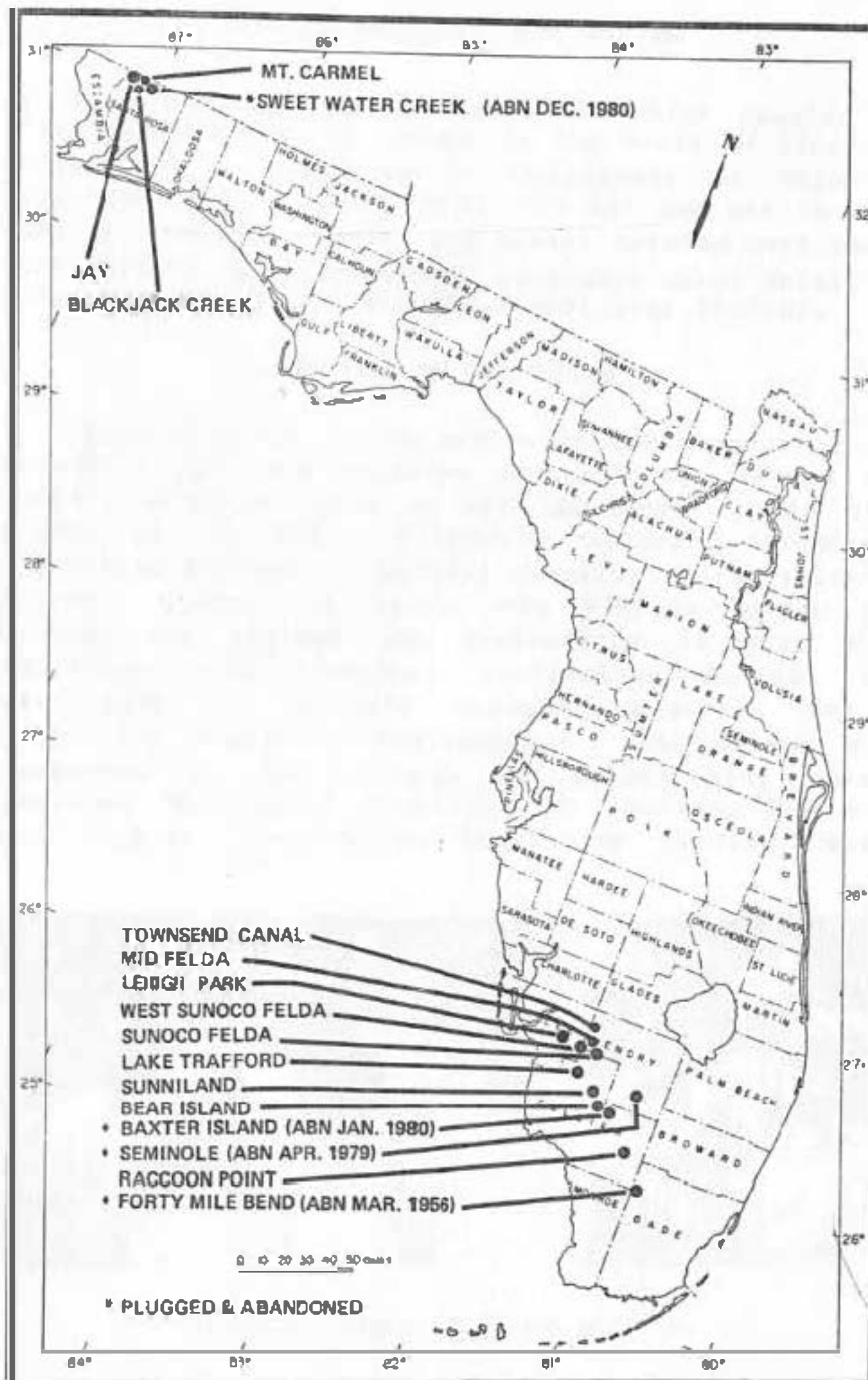
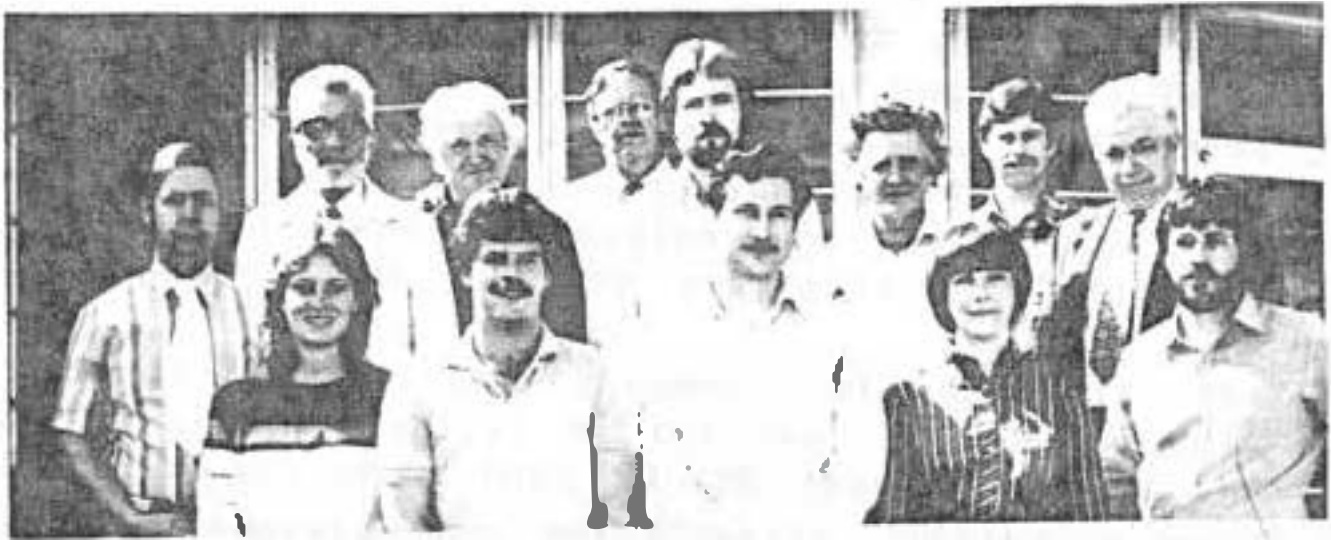


Figure 7. Location of past and present Florida oil and gas fields.

In south Florida and the panhandle which provide a significant source of income to the State of Florida (Figure 7). According to Department of Natural Resources data, revenues from this oil and gas in the form of royalties, taxes, and leases totaled more than \$2.6 million, with additional severance taxes totaling more than \$78 million for the fiscal year 1981-82.

### FUNCTIONS OF THE BUREAU

Ranking first in the nation in the production of phosphate rock and titanium concentrates, second in fullers earth and peat as well as number 10 in oil production in 1982, Florida's natural resources contribute billions of dollars annually to the state's economy. Over the years, the Florida Bureau of Geology has evolved and diversified to meet the challenges and sometimes conflicting demands of developing the state's mineral resources while protecting Florida's environment. The Bureau has responded to these needs by establishing three sections (Geological Investigation Section, Oil and Gas Section, Reclamation Regulation Section) with



### GEOLOGIC INVESTIGATIONS SECTION

First row *left to right* Kelly Frierson, Tom Allen, Walt Schmidt, Paulette Bond, Ken Campbell. Second row *left to right* Ron Hoenstine, Ernest Bishop, Justin Hodges, Steve Windham, Tom Scott, Albert Phillips, Steve Spencer, and Al Applegate.

## BUREAU OF GEOLOGY

specific responsibilities of evaluating and determining the extent of Florida's mineral resources, as well as monitoring the reclamation of certain mined mineral lands. A short discussion of each section is included here.

### Geologic Investigations Section Geologic Data Base

The function of investigating the geology of the state is carried out by the Geologic Investigations Section of the Bureau of Geology. The ability of this section to carry out this function is highly dependent on the Bureau's substantial data base. Collected over decades, these data include over 4,500 geophysical logs, more than 15,000 sets of well cuttings, and approximately 300 cores, in addition to core chips representing hundreds of thousands of feet of sediments from exploratory oil and gas test wells. These samples, which have been collected from locations throughout the state, are essential to the study of Florida's geology.

The majority of these samples are well cuttings, which upon receipt at the Bureau are washed, dried, catalogued, and stored for future reference. Detailed lithologic descriptions of these well cuttings, as well as cores, are prepared by Bureau geologists who then enter coded descriptions into a computer. These data are accessible to Bureau staff, government agencies, industry, and the general public. The well cuttings and core collection are stored in the Bureau's warehouse and are available for study by visiting scientists.

Another significant source of data is the Bureau's paleontological collection. Included in this collection are more than 20,000 labeled slides and specimens representing microfossils, including many holotypes (original type specimens), invertebrate macrofossils, thin sections, and sediment samples. This collection, which is used by scientists from around the world, serves as a valuable source of information in the study of Florida's stratigraphy and past environment.

## Stratigraphy

Stratigraphy is the study of the formation, composition, sequence and correlation of rock layers in the earth's crust. Florida has minor topographic relief, yet Florida's relatively featureless surface masks a complicated subsurface containing faults and extensive cavernous zones as well as sands, clays, and carbonates overlying igneous and metamorphic basement rocks.

With few surface outcrops, the study of Florida's stratigraphy is especially dependent on the availability of subsurface data which are used to identify and quantify Florida's substantial mineral resources. Just as a road map shows the location of surface features such as roads and towns, Bureau geologists construct geologic maps that depict subsurface formations and prominent structural features, which are based on information obtained from limited surface outcrops supplemented by cores and well cuttings. Continually being updated, these maps serve as valuable tools useful in locating mineral deposits, oil, and water supplies hidden below Florida's land and water surface.

## Applied Geology

In the past, geologists emphasized pure research relating to the structure and composition of the earth. However, as in many other fields, the pure science of yesterday has become the applied science of today.

As part of this process, the Bureau of Geology continues to lay the groundwork of basic geological investigations, while placing increasing emphasis on the practical application of this accumulated knowledge. For example, due to the rapid urbanization and development of Florida, geologic processes that were in the past relatively unnoticed, such as natural drainage and sinkhole development, have taken on added importance where increased building due to urban expansion has significantly altered the natural

## BUREAU OF GEOLOGY

environment and the processes operating on it. Specifically, in many Florida communities increased building construction and paving have reduced the area available for water infiltration. This has resulted in additional runoff, increased erosion and water pollution, as well as a greater frequency of flooding than would occur under more natural conditions. As a result of the urgent nature of these and other problems state and local governments are frequently called upon to make decisions on the basis of data that are incomplete and sometimes apparently conflicting. For this and other reasons, a broad understanding of an area's geology is essential to the formulation of effective land use planning policies. To meet these needs, the Bureau's continuing core-drilling program has enabled Bureau geologists to provide more complete geologic information to various city and county planning departments. Such information is essential in the development of plans to minimize adverse impacts on the environment, while permitting growth.

Of increasing concern to the general public is the occurrence of sinkholes, which in recent years have emerged as a significant problem, causing considerable damage and economic loss. Sinkholes are especially prevalent in Florida because of abundant rainfall and a terrain underlain by thick sequences of limestone. To address this concern, the Geologic Investigations Section has devoted increased effort toward identifying probable areas of sinkhole development as well as providing technical expertise to state and local governments on existing sinkholes.

Another important role of the Geologic Investigations Section involves locating and identifying areas of economically valuable mineral deposits. This function is wide-ranging and includes gathering and interpreting data from geological field reconnaissance and examination of cores and well cuttings.

To summarize, the Bureau's role in the areas of land use planning, studies of sinkhole development and location of potential mineral deposits represents a valuable contribution to Florida's present and future



## BUREAU OF GEOLOGY

economic well-being. This ever-evolving role is, however, dependent on the continued acquisition of basic geologic data.

### Publications

Since the Florida Geological Survey was formed in 1907, a primary goal has been the publication of the results of its geologic investigations. Numbering more than 400, these publications contain information and data gathered and compiled by Bureau staff and others and are published in the form of Bulletins, Reports of Investigations, Information Circulars, Special Publications, and a Map Series. To date these various publications include specific detailed geologic studies of 12 counties, hydrogeologic water resource studies of 35 counties, as well as regional and county mineral resource studies (Figure 8).

Designed to address varying needs, these publications are used by both the public and private sectors. For example, county geologic bulletins are used by various county agencies as guides in developing long range plans related to zoning and protection of areas of natural recharge to underground aquifers. Other reports on general stratigraphy and paleontology are used by industry as an aid in locating mineral resources, as well as by the scientific community in the study of Florida's geology and natural resources.

A very popular group of publications, the Bureau's Special Publications series is intended for the general public as a source of information on specific subjects. Much requested, these publications, such as Special Publication No. 8, "Guide to Rocks and Minerals of Florida," are frequently used as reference material by schools, clubs, and interested individuals.

A publication with a different format, the extensive Map Series, depicts various aspects of geohydrology, physiography, and mineral resources. Included in this group is the recently completed Environmental Geology Series which describes the

near-surface geology and other environmental characteristics of areas throughout the state in a manner designed to be understood and useful to the general public, as well as the scientific community.

These publications are distributed to schools and libraries throughout the United States and several foreign countries. A listing of all the Bureau of Geology's publications, with instructions for ordering, is available on request.



#### OIL AND GAS SECTION

*Left to right* David Curry, Gwen Manning and Charles Tootle.

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## Oil and Gas Section

in 1945, the legislature mandated the regulation of oil and gas drilling and producing operations in Florida. The responsibility for enforcing these regulations was placed with the Bureau of Geology. This law, which was revised in 1981, requires that the Bureau, through its Oil and Gas Section, make systematic inspections of oil drilling rigs, production and service wells, and other production facilities. The Bureau's field office personnel, located in Ft. Myers, in Lee County, and Jay, in Santa Rosa County, conduct predrilling site inspections prior to permitting and monitor all drilling, cementing and plugging operations. In addition, they monitor all testing, completion and production operations and conduct final site restoration inspections at the conclusion of drilling. These inspections are made in order to evaluate and effect necessary changes to mitigate possible damage to the environment as a result of the operations.

In addition to these responsibilities, the Oil and Gas Section maintains permanent oil and gas records and samples. These core samples and well logs, which are examined by geologists from all over the United States, are a significant aid in the search for oil and gas in Florida.

Figure 7 illustrates the estimated decline of Florida's known oil and gas reserves. This decline points out the importance of the Oil and Gas Section as a depository for existing geologic data. The evaluation of such data is basic to the exploration for and location of additional oil fields.

## Reclamation Regulation Section

Increased public awareness and concern for preserving Florida's environment resulted in the passage of a tax bill by the 1971 legislature which encouraged, through fiscal incentives, the reclamation of certain mined lands. This law has been strengthened by legislation over the years so that today all lands which are subject to the tax are



### RECLAMATION REGULATION SECTION

First row left to right Randy Musgrove, Amber Mchaffey, Joan Ragland, Jacqueline Lloyd. Second row left to right Susie Coleman, Lee Edmiston, Zoe Kulakowski, Lee Sherwood, Greg Daugherty, Jack Merriam. Third row left to right Ross McWilliams, Bill Yon, and Bruce Greenwood.

subject to mandatory reclamation and restoration. In 1978, another law incorporating fiscal incentive-based provisions was enacted to provide for the reclamation of non-mandatory phosphate lands, which total more than 149,000 acres.

The Reclamation Regulation Section is charged with the responsibility of overseeing and monitoring approved reclamation and restoration programs. The primary goal is to ensure that lands disturbed by surface mining will be reclaimed and restored. The Bureau's responsibility also includes the development and enforcement of rules and regulations pertaining to the reclamation and restoration of lands mined for solid minerals which are subject to the severance tax (primarily phosphate, heavy minerals, clays). Considerations include the physical and chemical quality of surface bodies of water, vegetation, soil stabilization, elimination of health and safety hazards, and the time schedule for completion of the

# BUREAU OF GEOLOGY

TABLE 4 -- ESTIMATED ACRES DISTURBED BY MINING

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| Phosphate      | 187,000                                         | 7,000                                               |
| Stone**        | 31,500*                                         | 500                                                 |
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\* (Based on State Data Acreage through 1978 plus annual estimates for period 1979-81).

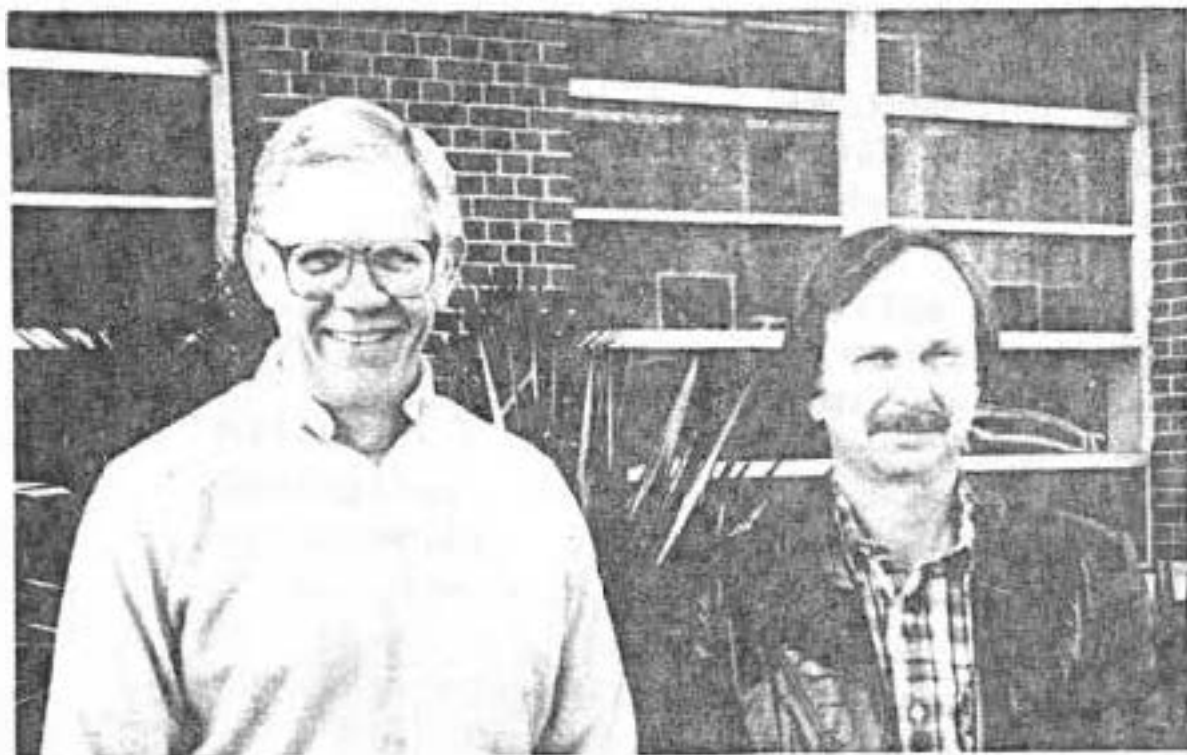
\*\* Not subject to mandatory reclamation.

Source: DNR and U. S. Department of Agriculture, Soil Conservation Service, The Status of Lands Disturbed by Surface Mining in the United States.

various phases of the program. Conceptual and detailed reclamation and restoration plans must be submitted to the Bureau's Reclamation Regulation Section for review and must be approved by the Executive Board of the Department of Natural Resources (made up of the Governor and Cabinet) prior to disturbing an area. The reclamation and restoration efforts, based on the approved plans, are monitored by staff geologists at regular intervals until completion.

Phosphate and heavy minerals are the primary solid minerals affected by this program. As Table 4 shows, phosphate is the major mineral commodity subject to mandatory reclamation and restoration with approximately 165,000 acres of land having been mined or disturbed prior to 1978 and 5,000 acres being mined annually. Although only 28 percent of this disturbed land acreage has been reclaimed, approximately 149,000 acres are not subject to mandatory reclamation and restoration.

A 10 percent severance tax is imposed on solid minerals mined and exported by the phosphate and heavy mineral industries. A 5 percent tax is imposed on all other mineral industries. This severance tax generated more than \$77 million for the fiscal year 1981-82 (Florida Department of Revenue, 1982), with 75 percent going into the General Revenue Fund, 20 percent going into the Non-Mandatory and Mandatory Trust Funds, and 5 percent going into the Phosphate Research Trust Fund.



#### OFFICE OF RECLAMATION RESEARCH

*Left to right Bill Yon and Monnie Beach*

#### Office of Reclamation Research

A related reclamation function of the Bureau involves studies of present reclamation techniques as well as new and proposed reclamation procedures. These investigations are conducted by the Bureau's Office of Reclamation Research and provide important data ultimately used in the formulation of

## BUREAU OF GEOLOGY

recommendations by the Reclamation Regulation Section. In addition, this research group offers assistance in the form of information and recommendations to the regulated companies. Such advisory assistance is directed primarily toward evaluating the impact of proposed mining and reclamation on the environment.

Other objectives of the Office include promotion of reclamation research aimed at enhancing and accelerating the process of reclamation, and determining what can be realistically accomplished by reclamation of lands disturbed by surface mining. Future programs include the utilization of computers to assist in the retrieval and analysis of reclamation data.

### SERVICES TO GOVERNMENTAL AGENCIES, INDUSTRY AND THE PUBLIC Cooperative Studies

Since 1907 the Florida Geological Survey has consistently pursued a policy of cooperation with various state and federal agencies such as the National Geological Survey (now the United States Geological Survey), the Florida Department of Agriculture, and other state geological surveys. Today, the scope of cooperative programs has expanded in terms of both magnitude and applicability and involves many other state, local and federal agencies.

For example, a study with the U.S. Bureau of Mines was recently completed which investigated the phosphate-bearing sediments of the Hawthorn Formation in peninsular Florida. This study not only enhanced our understanding of this complex formation, but may serve as a catalyst for further exploration and eventual mining of the formation's associated phosphate. In the area of water resources, the Bureau provides extensive geological data to individual Water Management Districts concerning the geological parameters of Florida's aquifers (water-bearing sedimentary rocks). This information is essential to an evaluation and understanding of Florida's water resources, especially in such critical areas of

concern as saltwater intrusion and groundwater contamination. Recently, the Bureau of Geology provided assistance to municipalities in central Florida in evaluating probability and extent of sinkhole development in the area. Upon request, information is provided to the general public regarding the potential for mineral resource development on private lands.

These cooperative programs are of continuing scientific and economic value to the state. As a result, the Bureau's role in sharing both data and expertise provides benefits to the public as well as to the scientific community.

### Educational Services

Since 1908, when the first Annual Report was published by the Florida Geological Survey, continuing emphasis has been placed on the importance of disseminating information on Florida geology to the general public, other government agencies and the scientific community. For this reason, members of the Bureau frequently give talks and slide presentations to various groups including schools, civic organizations, and scientific gatherings. These talks serve to increase public awareness, understanding, and appreciation of Florida's valuable natural resources and the geologic processes operating on the environment.

The Bureau's numerous publications are distributed worldwide to public and university libraries. Publications are continually being generated by the staff and vary in scope from highly technical bulletins to generalized special publications and leaflets. Inprint publications can be ordered for a small postage and handling fee. Out-of-print publications are on file in the Bureau's library and are available through interlibrary loan to public, academic, or company libraries.

Containing approximately 1,000 volumes in 1908, the Bureau's library has experienced growth in both size and scope over the years. Today, the library contains more than 24,000 volumes and provides

## BUREAU OF GEOLOGY

Immediate access to basic research materials including books, state and federal documents, maps, and periodicals. These publications deal with a variety of geologic subjects, including general geology, mining and mineral resources, petroleum engineering and production, climatological data, and water resources. In addition to the material available at the Bureau, the library participates in a nationwide interlibrary loan network through which Bureau staff have access to other library collections.

In addition to these educational services, the Bureau offers geology graduate students part-time employment. This work provides students with valuable experience in data gathering and its interpretation, while providing important assistance to Bureau geologists in their geologic investigations.



### TECHNICAL SUPPORT

First row *left to right* Jim Jones, Mary Ann Cleveland, Dorothy Janson, Pauline Hurst, Albert Phillips. Second row *left to right* Steve Spencer, Richard Howard, Ed Lane, and Justin Hodges.

### LOOKING AHEAD

The pressures of population growth and accompanying urban development will increasingly

Involve Florida in facing important public policy issues of technical and scientific content. Examples of these issues include the problems of sinkholes, hazardous waste disposal, and reclamation of mined lands, areas of concern which require a balance between the need for development and growth and the necessity of ensuring a high quality environment for all of Florida's citizens. A diversity of interests, which include the public, industrial and agricultural sectors, are competing for Florida's substantial yet limited natural resources. It is therefore imperative that state and local governments have sufficient geologic data to formulate responsible policies concerning the allocation of these resources. Accordingly, the role of the Bureau in the future is expected to acquire added significance in providing much of this essential information.

One of the major issues facing Florida is the wise management of its fresh water resources. Basic to this process is a knowledge of such geologic parameters as the depths, distribution, permeabilities and porosities associated with the rocks comprising Florida's aquifers. Such specialized geologic information is vital to the formulation of effective policies concerning this major source of the state's fresh water supply.

An additional area of concern is the need for the location of suitable sites for hazardous waste disposal. Disposal methods include both deep well injection for liquid wastes and burial of solid wastes. An extensive knowledge of the subsurface geology of the state is required in order to project possible adverse effects associated with waste disposal. Such a knowledge requires the continual acquisition and assessment of geologic data by the Bureau.

The Florida Resource and Management Act was enacted by the 1974 state legislature to establish and maintain a comprehensive solid waste management and resource recovery program. This act recognized the vast quantity and variety of solid wastes being

## BUREAU OF GEOLOGY

Generated throughout the state by an ever-expanding population. The safe disposal of these wastes takes on added importance in Florida in light of the state's heavy dependence on groundwater. Once an aquifer is contaminated, it is extremely difficult and time consuming to return it to its former purity. In order to implement an effective solid waste program, a comprehensive understanding of the state's geology is essential. This underscores the Bureau's present and continuing role in providing assistance in the form of basic geological information and its interpretation to appropriate government agencies, information which will enable these agencies to make sound and responsible decisions.

Another highly visible problem is that of sinkholes which pose a hazard to life and property. In order to aid in effective planning for construction and urban development in potential sinkhole areas, a thorough knowledge and evaluation of the local geology is required.

In this day of diminishing mineral reserves, it is of increasing importance to develop a knowledge of the state's mineral resources. Because of the rapid encroachment of Florida's land surface by subdivisions, industry and recreation, unmined resource reserves need to be considered. Likewise, a knowledge of the mineral resources underlying state-owned lands is essential in determining fair market value, assuring the state an equitable return on the sale or lease of these lands. To aid in this, an inventory which includes the identification and evaluation of state mineral reserves is expected to be an important objective of the Bureau in the coming years.

To help meet these and other needs, Bureau geologists must have access to the latest geologic studies and data. This access to current geological studies is significantly enhanced through the use of computers. As a result, one projected area of expansion is the computerization of the Bureau's library services, including on-line data base

## SPECIAL PUBLICATION NO. 26

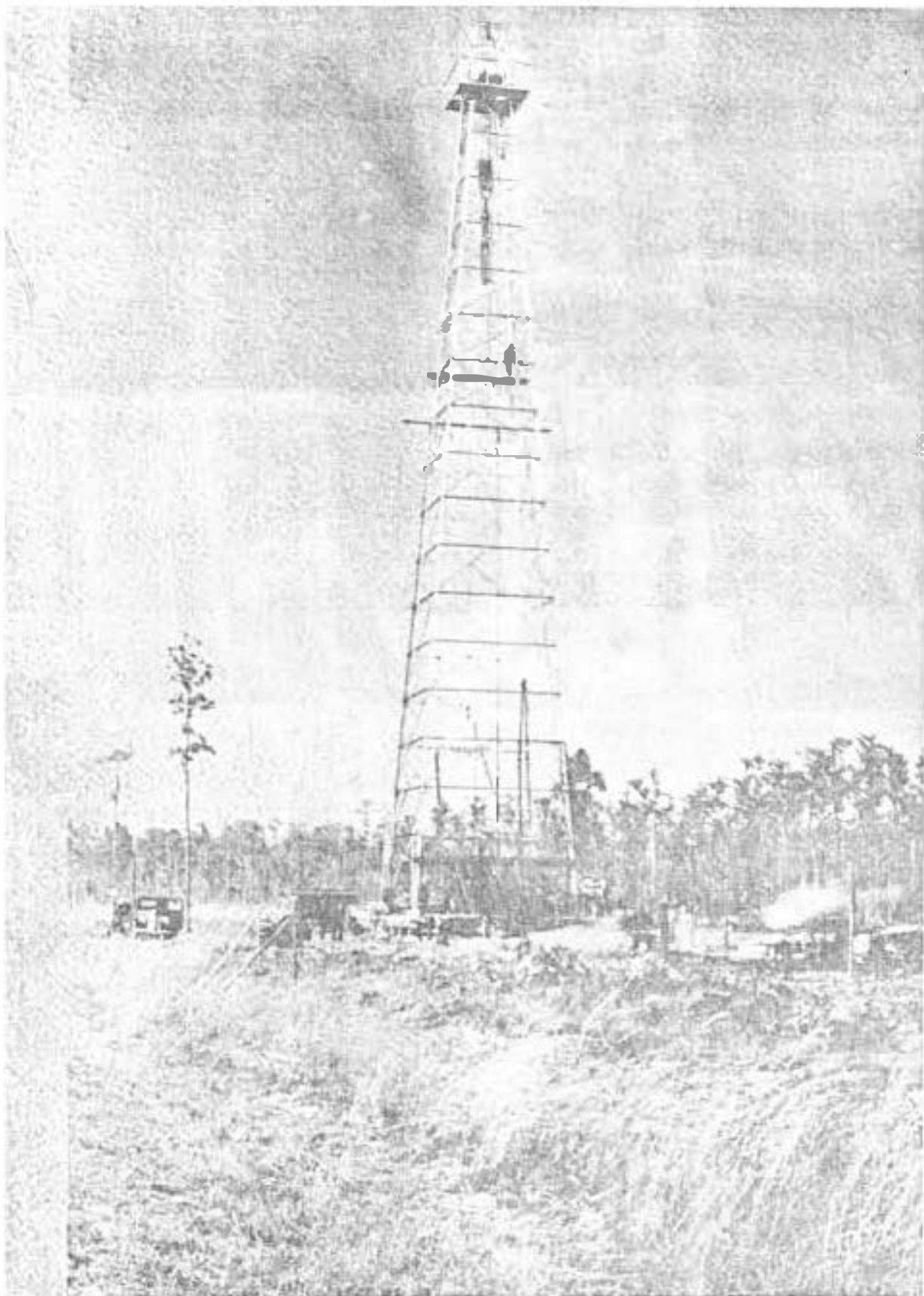
searching, computerized card catalogue access and document retrieval. One response in dealing with an ever-expanding data base is a continuing program of placing lithologic descriptions in computer storage. This program has significant potential for future expansion as a tool for permitting the staff to generate computer models of cross-sections, geologic unit thickness maps, and structure maps based on this stored information.

In summary, the Bureau in its 75 year history has contributed in great measure to Florida's economic well being and environmental integrity. This contribution, assessed in terms of providing geologic data and expert advice to state and local governments, water management districts, and regulatory agencies, cannot be overestimated. Its impact today as well as in the future should be significant in preserving the environment and aiding in an enlightened utilization of Florida's natural resources.

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Steel derrick of the Oil Development company of Florida. "South Lake Well" on Florida State Highway #2 about 14 miles south of Groveland, Lake County. Spudded in February 26, 1935.



This large sinkhole, which developed May 8-9 in Winter Park, Florida, measures about 115x100m. In this photo, taken May 13, the water level was about 13m below the land surface. (Photo by Rich Deuerling.)

DEPARTMENT OF NATURAL RESOURCES  
BUREAU OF GEOLOGY

This public document was promulgated at a total cost of \$88.65 or a per copy cost of \$0.18 for the purpose of disseminating geologic data.