Project E-233-3

12-P-E

GEORGIA'S MINERAL RESOURCES:

A Summary of Available Data on Their Past, Present and Future Status

Compiled and Edited by

George I. Whitlatch
Senior Research Scientist

Assisted by

Joseph A. Choquette
Consulting Geologist

John E. Husted
Head, Minerals Engineering Group

Nathan H. Benton
Research Assistant

Industrial Development Branch
Engineering Experiment Station
GEORGIA INSTITUTE OF TECHNOLOGY
June, 1962

TABLE OF CONTENTS

Maps

Tables

Foreword

This report is one of the series of basic studies involved in Georgia Tech's program of auditing and analyzing the State's industrial resources. It is the first of many steps required to expedite the development of the State's mineral resources.

Additional geologic survey work by the Department of Mines, Mining and Geology is one requirement. Full appraisal of those minerals which appear to have economic potential, in order to determine precisely what industries might be developed, will require also laboratory research, including product development programs, plus market research and other technical work required for complete feasibility studies.

Initiation of this project was made possible by the special allocation of $100,000 made to the Industrial Development Division in fiscal 1961 by Governor Ernest Vandiver and the University System Board of Regents. Among the basic studies made possible entirely or in part by this allocation are the "Georgia Manufacturing Atlas," a survey of Georgia's water resources, an analysis of Georgia's chemical potentials and a survey of Georgia's forest products potentials.

Kenneth C. Wagner, Head
Industrial Development Branch
GEORGIA INSTITUTE OF TECHNOLOGY

Preface and Acknowledgments

If the economic and industrial potentials of Georgia are to be fully realized, it is essential that comprehensive factual information on the State's resources and advantages be readily available for the use of industrialists, investors, and the people of Georgia. Such information is basic to the solution of numerous economic problems facing industry and communities throughout the State. Furthermore, an overall view of the State's raw materials, fuels, water supplies, transportation facilities, labor, and similar factors is fundamental to the long-range development of Georgia.

This is the initial report of a planned series that will provide a broad and relatively detailed picture of Georgia's resources and advantages. In the present summary of the State's mineral resources, the guiding tenet has been that "the development of mineral resources is dependent upon our knowledge of them." Thus, it is sought here to summarize the State's various minerals as to location and geologic occurrence, present and past production status, uses, and quantity and quality so that the future outlook of each can be individually and fairly appraised. The information presented is intended primarily to stimulate the industrialist and the investor to investigate further the State's mineral potentials. To the established mineral producer or the prospective miner, this summary has only the limited objective of getting them to go to the Georgia Department of Mines, Mining and Geology, the Georgia Tech Engineering Experiment Station, or related organizations and sit down across the table to discuss their interests and problems with geologists and engineers experienced in the State's geology and mineral resources; or, at least, to consult the many references listed in this report to obtain details on the localities of the various mineral deposits and on the problems they would have to face in mining any specific mineral deposit.

The present compilation is essentially an effort to update a similar report issued in 1926 by the Georgia Geological Survey under the title of Mineral Resources of Georgia. That publication was a revised edition of an even earlier report, issued in 1910, under the title of A Preliminary Report on the Mineral Resources of Georgia. Both reports were authorized by S. W. McCallie, then State Geologist; both editions were identified as Bulletin No. 23 of the State Survey series. In the preparation of the present report, both editions of Bulletin No. 23 have been extensively used.

Prepublication review of the manuscript of the present report was extended to Dr. A. S. Furcron, Chief Geologist of the Georgia Department of Mines, Mining and Geology, and the editor and authors are especially appreciative of Dr. Furcron's constructive suggestions and criticisms. Without such cordial personal assistance and without Dr. Furcron's broad knowledge of Georgia geology, amply evidenced herein by the numerous references to his various publications, the present report would not have been possible. A similar debt of gratitude also is acknowledged to the many other contributors to Georgia geologic information whose works have been consulted and freely used in compiling this summary of the State's mineral resources. A complete list of these sources is presented in the Reference section at the end of this report, and individual citations throughout the report are keyed to this reference list (e.g., B12 refers to the twelfth entry under the second reference classification -- Georgia Geological Survey Bulletins).

INTRODUCTION

Georgia embraces three geologic provinces or areas -- the Folded Paleozoic, Crystalline, and Coastal Plain (see Map 1), with formations ranging in age from pre-Cambrian igneous rocks to sedimentaries of the Tertiary and Quaternary periods.[1/] As a consequence of this wide range in age and variety of its geologic formations, the State has one of the most diversified assemblages of mineral resources in the South.

Altogether, Georgia has more than 30 minerals or mineral products that appear to be economically important. Nevertheless, present production is limited to 18 minerals or mineral products of which two -- clays and stone -- account for about 84% (by value) of the annual output. In 1960, Georgia's mineral production amounted to a total value of $91,203,000 (see Table 1). Georgia's 1960 production of kaolin, marble and crude iron oxide pigments was first in the nation, the fuller's earth output ranked second nationally and, despite the relatively small outputs, barite and mica ranked third nationally and feldspar ranked fourth.

Georgia's position in the production and dollar value of minerals, as compared with five other southeastern states, is shown by the U.S. Bureau of Mines to be as follows for the year 1960 (E9):

State	Production U.S. Rank	Value % of Total U.S.
Alabama	19	1.22
Florida	24	0.99
Tennessee	27	0.80
GEORGIA	30	0.51
North Carolina	40	0.25
South Carolina	41	0.17

These data were based on "Total Minerals" including gas, oil and coal. As Georgia is not a producer of gas and oil at this writing and is a small

1/ The Crystalline area is physiographically divisible into the Piedmont and Highland areas, with the latter including the Blue Ridge and Great Smoky Mountains of north Georgia. It is recognized that within the Crystalline area may occur rocks of Paleozoic age, both igneous and sedimentary. Further, the term Coastal Plain, for sake of convenience, is used to include sediments of Upper Cretaceous or younger ages.

Table 1

MINERAL PRODUCTION IN GEORGIA, 1960

	Short Tons (in thousands)	Value (thousand dollars)
Clays	3,519	$40,160
Coal	4	21
Gem stones	(a)	(b)
Iron ore (usable)	128 long tons	613
Manganese ore	--	--
Mica (sheet), lbs.	10,218	89
Peat	6,904	73
Sand and gravel	3,338	3,047
Stone	14,297	37,033
Talc and soapstone	40,200	88
Value of items that cannot be individually disclosed: barite, bauxite, cement, feldspar, iron oxide pigments, manganiferous ore, scrap mica (c)	--	11,181
Total Georgia (d)		$91,203

(a) Weight not recorded

(b) Less than $1,000

(c) Figures withheld to avoid disclosing individual company confidential data

(d) Total adjusted to eliminate duplicating the values of clays and stone

Source: Minerals Yearbook, U.S. Bureau of Mines, 1960 (preprint).

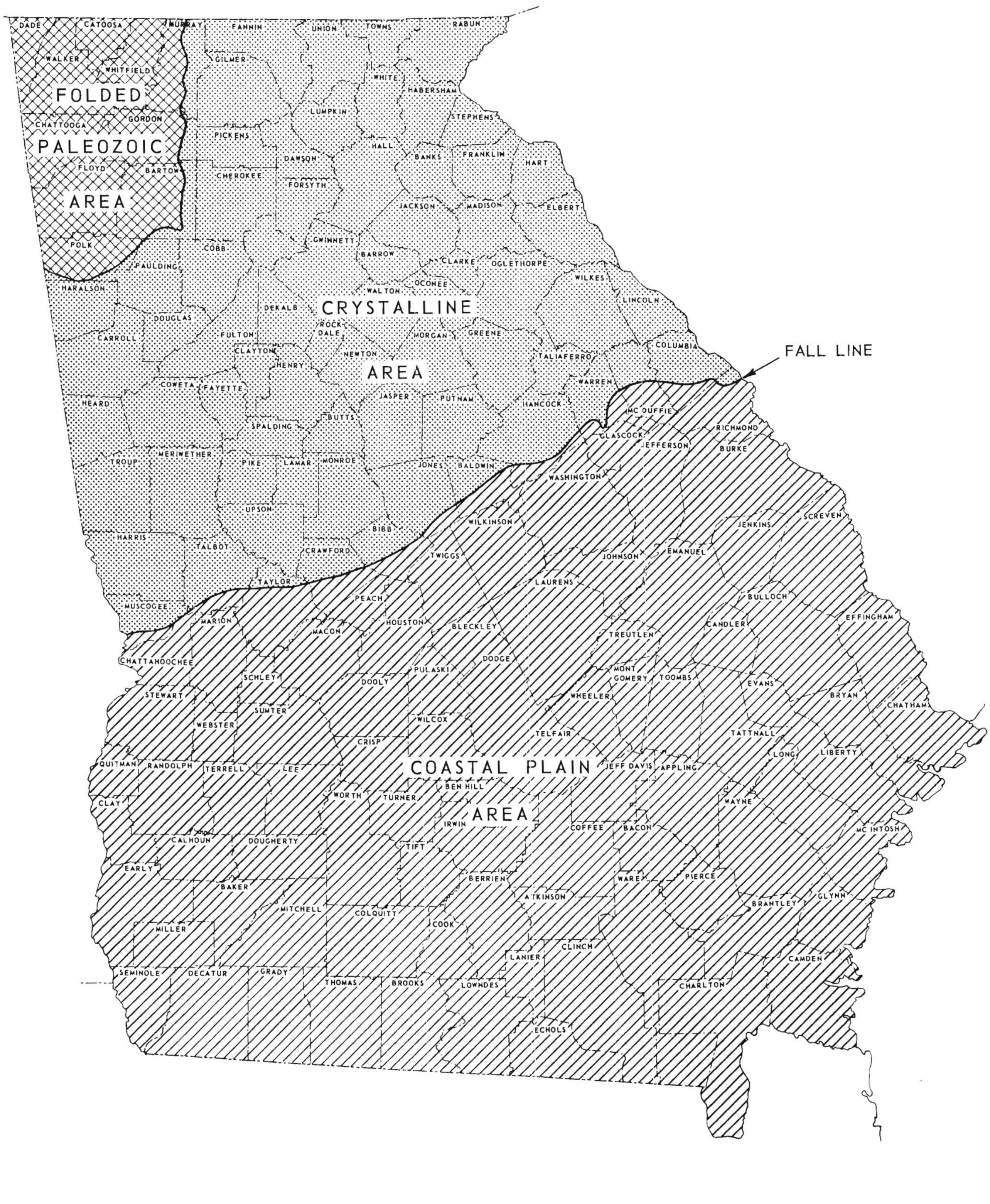
---

producer of coal, it is interesting to note how Georgia would rank nationally in production with these minerals excluded:

Basis	Ranking
Exclusive of gas and oil	21
Exclusive of gas, oil, and coal	19
Non-metallic minerals only	14

Yet, on these same bases, Alabama, Florida, and Tennessee continue to outrank Georgia.

MAP 1
GEOLOGIC AREAS OF GEORGIA



It is particularly noteworthy that since 1958 the State's percentages of national output and value of output have advanced appreciably (see Table 2). Within recent months, there were press reports concerning the establishment of a large-scale mineral-based operation in the State, specifically a steel plant in the western part of Georgia. This or similar developments could do much toward advancing Georgia's position among the nation's mineral producing states. However, if such developments are to materialize and to succeed, there must be much more complete and comprehensive geologic, mineralogic, and economic investigations than have been made to date. To stimulate substantial economic developments of Georgia's minerals requires that much more complete and valid data be made available to answer the inquiries of the entrepreneur.

"Basically, the development of mineral resources is dependent upon our knowledge of them." (D20.) For many years, the State Department of Mines, Mining and Geology and its predecessors have carried on geologic and mineralogic investigations throughout the State and, on the whole, a large body of information on Georgia's mineral resources has been accumulated. However, at best, the financial support given to these investigative efforts by the State legislatures has been relatively limited, and it is to the credit of the designated official agencies that the achieved results are as comprehensive as they are today. Yet, if requests for data on the location, quality, and reserves of mineral deposits are to be answered so definitely as to insure the above-indicated future development of Georgia as a mineral-producing state, then it is essential that the State sufficiently support the Department of Mines, Mining and Geology and related agencies in a greatly amplified program of exploration and research.

It is the purpose of the present report to summarize the present knowledge of Georgia's mineral resources and the status of their production, to appraise the future or potential of each mineral, and to point up the areas of limited and inadequate information. In doing this, full use has been made of the many reports and other publications of the Georgia Department of Mines, Mining and Geology, of the U.S. Bureau of Mines statistics and reports, and applicable articles from numerous scientific and trade journals. By this review, it is hoped that sufficient interest and action can be generated to so advance the investigation and knowledge of the State's mineral potentials that many more minerals can be developed to positions of major economic importance.

Table 2

GEORGIA'S MINERAL GROWTH, 1945-1960

Year	Value Dollars	Rank in Nation	Percent of National Total
1945	$19,988,000	34	0.27
1946	30,449,000	33	0.43
1947	32,009,000	33	0.38
1948	36,103,000	33	0.34
1949	35,408,000	34	0.34
1950	44,157,000	32	0.37
1951	48,509,000	32	0.36
1952	51,450,000	34	0.39
1953	51,395,000	32	0.36
1954	55,828,000	31	0.40
1955	60,417,000	33	0.38
1956	67,912,000	31	0.39
1957	69,799,000	31	0.38
1958	75,106,000	30	0.45
1959	86,262,000	30	0.50
1960	91,203,000	30	0.51

I

MINERALS OF COMMERCIAL AND/OR INDUSTRIAL VALUE

In Production

BARITE

Outlook

While the national consumption of barite is generally upward, the future of barite production in Georgia will depend largely upon successful prospecting to locate new deposits. Urbanization of much of the Cartersville area -- present center of production -- plus the destruction of the ground surface by barite mining create serious problems, since this destruction of landscape and aesthetic values may, in the future, severely curtail the mining in that area. Consequently, the following areas should be explored for economically feasible developments: the Knox limestones near Esom Hill in Polk County, the Waleska deposit of Cherokee County, the Plainville district of Gordon and Floyd counties, the Bass Ferry area of Floyd County, near Ruralvale in Whitfield County, and the Eton district of Murray County.

Production Status

Since the late 1800's, most of Georgia's barite has come from the Cartersville district. Because of the small number of producers, records of annual state output are incomplete and, over the past decade, the figures show only the combined outputs for Georgia, South Carolina and Tennessee. However, in the years immediately preceding 1950, Georgia's indicated production was usually in excess of two-thirds of the combined three-state total and, on this basis, output in 1960 is estimated at 79,000 tons. In 1949, the last year in which Georgia's production was separately totaled, the State output of 50,267 tons ranked fourth in the United States. Total United States' production in 1960 was 1,770,968 tons.

The producers of barite reported from the Cartersville district in 1960 were Thompson-Weinman & Company through their Paga Mining Company operation, the New Riverside Ocher Company, B. R. Cain Mining Company, and T. E. Johnsey (E3).

Location and Occurrence

Barite ($BaSO_4$) or "heavy spar" occurs in the residual clays of the lower Cambrian formations of north Georgia, where it has been mined for over 100 years. The mineral is found in scattered deposits, widely spaced over a belt approximately 75 miles long which has its maximum width of 25 miles near the center. This belt strikes to the northeast through the counties of Polk, Floyd, Bartow, Cherokee, Gordon, Whitfield and Murray. The barite occurs in association with the following formations, in ascending order: Weisner quartzite, Shady limestone, and Rome shales and sandstones. Although the ores are found as veins, replacements, and breccias, the mined ores are in residual and/or alluvial clay deposits derived from these formations.

Only the residual deposits of the Cartersville mining district (Bartow County) and of the Eton district (Murray County) have been of economic importance (B11). The State's production has long centered around Cartersville, and several hundred mines and prospects have been opened there, with only a few proving of major value. However, this general development has led to the discovery of several rich deposits which today produce the bulk of the State's output (A7).

The ore deposits are in lenticular-shaped pockets within the clays that underlie the hill slopes and parts of intervening ridges, and these clays commonly range from 20 feet to, locally, as much as 200 feet in thickness. Mining is by the open-cut or stripping method, using shovels, draglines, bulldozers, and other power equipment. Hydraulic mining was attempted but abandoned, due to the many physical difficulties encountered. Factors essential to successful barite mining are a minimum of 12% ore in a clay bank, favorable topographic and overburden conditions, an adequate water supply, types of clays permitting ready recovery of ore at the washer, and mechanically adjustable equipment to reduce losses in the concentration process.

Uses

The chief use of ground or crushed barite in the United States is as a weighting agent in oil-well drilling mud; this accounts for about 90% of national consumption. Other uses are in the chemical, glass, paper, plastics, paint and rubber industries. Market prices for Georgia crude barite are around $18 per ton, f.o.b. cars, according to recent Engineering & Mining Journal quotations. Because barite is resistant to atomic radiation, its addition to concrete could be advantageous in the building of bomb shelters.

Quality and Quantity

Pure barite, a white mineral with a fibrous texture and specific gravity of 4.3 to 4.6, contains 65.7% BaO and 34.3% SO_3. As Table 3 shows,

Table 3

ANALYSES OF BARITE ORES

	A	B
Paga Mining Company		
Silica (SiO_2)	1.16%	0.43%
Alumina (Al_2O_3)	0.00	0.00
Ferric Oxide (Fe_2O_3)	0.35	1.33
Calcium Oxide (CaO)	0.00	0.00
Moisture	0.06	0.00
Loss on ignition	0.00	0.12
Carbon Monoxide (CO)	0.00	0.00
Titania (TiO_2)	0.00	0.00
Sulphur Trioxide (SO_3)	33.32	34.04
Manganese Oxide (MnO)	trace	0.00
Strontium Oxide (SrO)	1.16	0.00
Barium Oxide (BaO)	63.80	63.86
Barium Carbonate ($BaCO_3$)	0.00	0.00
	99.85%	99.78%
Barium Sulphate ($BaSO_4$)	97.12%	97.90%
Murray County		
Silica (SiO_2)	0.27%	0.34%
Alumina (Al_2O_3)	0.20	0.35
Ferric Oxide (Fe_2O_3)	0.33	0.75
Moisture	0.38	0.32
Barytes ($BaSO_4$)	98.82	98.24
	100.00%	100.00%

A - White granular opaque weathered exterior of selected clean specimen (analysis HU-53).

B - Bluish-white crystalline translucent interior of selected clean specimen (analysis HU-54).

Source: Hull, J. P. D., Barytes Deposits of Georgia, Georgia Geological Survey Bulletin No. 36, 1919.

Georgia barite is of excellent quality. No published estimates of barite reserves in Georgia are known. However, as early as 1949, Kesler indicated a decline in the tenor of the Cartersville deposits.

BAUXITE

Outlook

The short range outlook for Georgia's bauxites continues to be in the chemical, abrasive, and refractory industries.

Advances in technology in the aluminum industry may radically change the outlook for Georgia bauxite and related high-alumina clays, including kaolins. In 1930 bauxite containing 60% alumina was required by that industry; in 1958 ores averaging as little as 50% alumina were being used; processes now under test may permit the use of ores with only 35% alumina. Georgia kaolins and other high-alumina clays associated with bauxite range from the lower 30's up to 50% alumina, and these high-alumina clays are thought to exist in great abundance (see "Quantity and Quality" below and section on Kaolin). However, the production of aluminum from such sources probably will be deterred until there are drilling explorations to determine the quantity and quality of the reserves and until there is a research program to demonstrate the economic feasibility of their use for alumina. Emphasis should be given to research directed toward the combined utilization of the bauxite and associated high-alumina clays, especially in the counties south of the Fall Line for a distance of not more than 75 miles.

Production Status

Bauxite production in Georgia has never been large and, because of its high silica and low iron contents, the ore is used almost entirely in the chemical industry. Cumulative production for the period 1889 to 1948 has been estimated at 936,819 tons, which represents approximately 49% of the entire southeastern states' output over that interval. About 400,000 long tons of that total is estimated to have come from the northwest Georgia area. In 1960, production from both Georgia and Alabama totaled only 66,000 long tons (dry equivalent).

American Cyanamid Company was the only Georgia producer of bauxite in 1960, and the greater part of their output, including kaolins, came from the Lennig and New Holland mines, near Rome (Floyd County). The remainder of their production of bauxite and kaolin was from the Cavender mine (kaolin) in Macon County and the Holloway and Thigpen mines in Sumter

County, all in the Andersonville district. A bauxite drying plant is operated by this company at Halls Station, near Adairsville (Bartow County). (E3).

Location and Occurrence

Bauxite was first identified in the United States in 1883 at a locality in Paleozoic rocks two miles east of Hermitage, near Rome, in Floyd County. This discovery was followed in 1889 by mining of the mineral -- the first U.S. production. In 1958, Floyd County still was the State's chief producing center. Bauxite was discovered south of the Fall Line in the Tertiary formations of Wilkinson County in 1907.

Other occurrences of bauxite in the Paleozoic rocks of northwest Georgia have been found in the following counties: Bartow, Chattooga, Gordon, Polk, and Walker.

The bauxite in these Paleozoic areas occurs in small compact masses resembling inverted cones whose maximum horizontal diameters seldom exceed 100 to 200 feet. The bauxite commonly is enveloped by bauxitic or high-alumina clay with a sharp contact between them. These deposits are associated with the highly soluble magnesian limestones of the Knox group (Cambro-Ordovician) and less commonly with the Shady dolomite (Lower Cambrian). The bauxite deposits probably represent kaolin, transported by streams draining westward from the Crystalline area, which accumulated in sink holes and depressions and was maturely weathered during Eocene time. (A1, G5, G6, H2, H9, H11, H12, H13.)

Quality and Quantity

Analyses of Georgia bauxites range from 57% to 62% alumina; 1% to 8% silica; 0% to 3% iron oxide; and 0% to 6% titania (B12). Most of Georgia's bauxites are within the quality range desired by the chemical industry (52-60% Al_2O_3, up to 13% SiO_2, 2.5% Fe_2O_3 and 3% TiO), yet individual deposits may find use in abrasives, refractories, aluminous cement, filtrants and other industrial products. As much as 90% of the total annual output of the southeastern states has gone to the chemical, abrasive and refractory industries (A1).

Known reserves in the northwest Georgia area are very small and consist mainly of the bauxite left in the bottoms of abandoned mines. There are, however, probably over 300,000 long tons of very low grade siliceous and ferruginous bauxite and bauxitic clay adjacent to old mines and in unworked prospects. It is improbable that commercial deposits totaling over 100,000 long tons remain hidden in the region, although some deposits in the order of 2,000 to 20,000 long tons may well be present and might be found by systematic exploration under geologic guidance (A1).

In the Andersonville district of the south Georgia Coastal Plain, there is an estimated 6,000,000 long tons of bauxite reported to be present; 10% of this tonnage is said to be near enough to the surface for profitable mining. This bauxite runs greater than 51% Al_2O_3 and ranges from 3.0% to 22.5% SiO_2 and 0.3% to 3% Fe_2O_3. A much greater tonnage of the bauxite could be recovered if the large amounts of kaolin and bauxitic clays could be used. This district alone may contain as much as 25,000,000 long tons of kaolin with over 37% alumina and less than 2% quartz sand. Virtually none of this kaolin has been used, but it should be considered as a supplementary reserve of alumina for any process that would permit use of both bauxite and associated clays by mixing and processing them together.

CEMENT (PORTLAND)

Outlook

A recent study (C4) has indicated a cement market sufficient to warrant small plants in the vicinity of both Brunswick and Bainbridge. Limestone would have to be shipped into Brunswick from quarries in southwest Georgia, from elsewhere in the State, or from out-of-state sources. A Bainbridge mill could be supplied rather easily from one of several nearby locations in southwest Georgia.

The impetus for a new plant, particularly in southwest Georgia, may come from an accelerated highway program or other large-scale usage of cement. This is anticipated in the near future. Transportation cost considerations also may dictate construction of one or more plants close to major markets.

Production Status

Annual production figures are not available for the two cement mills in Georgia, but their rated annual capacities are: Marquette, 1,250,000 barrels; Penn-Dixie, 2,300,000 barrels. By 1962, annual capacity of the Penn-Dixie mill will be increased to 2,372,000 barrels. Marquette recently acquired limestone-bearing property in the Albany area to provide for future expansion, and Southern Cement Company, a division of American Marietta Company, Chicago, announced plans in 1961 for a new mill near Atlanta.

Estimated cement consumption in Georgia currently is 6,000,000 barrels, plus or minus 1,000,000 barrels. The additional cement has been shipped into Georgia, mostly from Alabama and Tennessee.

Location and Occurrence

The Portland cement industry began in Georgia in 1903 with the organization of the Southern States Portland Cement Company at Rockmart (Polk County). This company remained in continuous production until its holdings were sold, in January, 1954, to the Marquette Cement Manufacturing Company of Chicago, Illinois. Marquette has continued production and greatly modernized the Rockmart mill. In 1925, the Clinchfield Portland Cement Company began operation at Clinchfield (Houston County). This company was later acquired by the Penn-Dixie Cement Corporation of Nazareth, Pennsylvania. These are the only Portland cement mills presently operating in the State, but at the time of this writing two new cement plants are being projected for locations near Albany and in the Atlanta area.

Marquette's Rockmart mill is in an area of Paleozoic rocks, and the nearby Rockmart Slate (Ordovician) formation supplies its clay needs. Conasuaga (Cambrian) limestone is quarried and trucked to the plant from property owned near Cartersville in Bartow County. The Clinchfield mill uses a soft white limestone and fuller's earth from the Ocala (Eocene) formation and clay from a Cretaceous formation.

Chattooga, Walker and Dade counties in northwest Georgia are known to have suitable cement raw materials in proximity to each other (B10). Limestones of probable cement grade are reported in Washington, Burke and Screven counties in east-central Georgia.

Deposits offering the most promise of utilization in the near future are those in southwest Georgia, both north and south of Albany. The limestone possibilities of this area have been summarized by Furcron and Fortson (D15). (Also see section on Limestone.)

CLAYS, MISCELLANEOUS[1/]

Outlook

The largest users of miscellaneous clays are the heavy wares (brick, tile, sewer pipe, etc.) manufacturers. Most of the present plants are modern installations, with progressive managements. On the whole, they have enjoyed a constant growth, and some plants have multi-state markets. Moreover, the smaller local brick plant is on the decline, as is indicated in Table 4, and today's brickmaking is concentrated in or near the metropolitan areas. Hence, there is lessened need to find additional new deposits of red-firing clays.

Despite this dependence of brickmaking upon the major city markets, it is believed that the State's brick and tile manufacture will continue to flourish in conformity with Georgia and the South's growing economic expansion. On the other hand, the redware and domestic pottery markets are subject to much fluctuation, and their future in the State is difficult to predict.

Production Status

Miscellaneous clays used or sold in Georgia between 1948 and 1952 averaged 1,003,840 tons annually. By 1960, this had increased to 1,305,044 tons, valued at $560,527 (E3).

The industry based on miscellaneous clays has changed greatly over the 32-year period of 1926 to 1959, as shown in Table 4. It is significant that although the number of plants is nearly the same, the production capacity in 1959 was greatly in excess of that in 1926.

Shales are mined at several points in northwest Georgia from the Paleozoic formations. Key-James Brick Company of Chattanooga, Tennessee, ships some of its shale from near Lafayette (Walker County), while the Plainville Brick Company at Plainville (Gordon County) is based on locally mined Conasauga shales. At Rome (Floyd County) the former Rome Brick Company until recently made brick from local shales, and similar deposits near Mount Alto

---

1/ Includes only those red-firing clays used primarily in the manufacture of structural or other heavy clay wares and of cement. Kaolin and fuller's earth are discussed in separate sections of this report. The limited usage of kaolin by heavy ware producers is discussed in the Kaolin section.

Table 4

MISCELLANEOUS CLAY USAGE IN GEORGIA

Type of Plant	1926	1959
Brick, common and face	27	14
Brick, fire and refractory	-	6
Cast stone	-	1
Hollow tile	3	2
Sewer pipe	7	1
Sanitary ware	-	1
Pottery, miscellaneous	8	21

Sources: Mineral Resources of Georgia, Georgia Geological Survey Bulletin No. 23, 1926; Directory of Georgia Mineral Producers, Georgia Department of Mines, Mining and Geology, Geological Survey Circular No. 2, 10th Edition, 1959.

Church supply shale that is being shipped to plants in Atlanta, Columbus and Milledgeville. Brick and other clay products are made at Dalton (Whitfield County) by the Dalton Brick & Tile Company, which also uses Conasauga shale.

The principal clay-working operations in the Fall Line area include Burns Brick Company and Cherokee Brick & Tile Company at Macon (Bibb County); Oconee Clay Products Company at Milledgeville (Baldwin County); Merry Brothers Brick & Tile Company at Augusta (Richmond County); Bickerstaff Company at Columbus (Muscogee County); and Georgia Vitrified Brick & Clay Company at Campania (Columbia County). All of these plants are suppliers to major city markets, as are the Atlanta Brick & Tile Company and the Chattahoochee Brick Company in the Atlanta area. The Arnold Brick Company at Thomasville (Thomas County) uses a sedimentary clay that resembles an altered kaolin or impure fuller's earth from the Alum Bluff or Hawthorn formation (Miocene).

Location and Occurrence

Clays adaptable to heavy wares manufacture occur in all three of the State's major geologic divisions -- the Coastal Plain, the Crystalline and the Paleozoic areas. They occure in (1) bedded deposits, notably as shales and as fire clays in the Paleozoic area of northwest Georgia; (2) alluvial deposits in and along the flood plains of major streams; and (3) residual deposits resulting from the weathering of granites, limestones, shales and other bedrock formations.

Ceramically usable shales occur widely over northwest Georgia, particularly at three Paleozoic horizons. The first of these is the Floyd shale formation (Mississippian) which crops out in the broad valley west of Rome (Floyd County) and north of the Coosa River. Northward into Gordon and Whitfield counties, these shales become sandier and less fissile. A second older series of shales are those of the Rome formation (Cambrian), usually consisting of variegated red, purple, green, yellow and white shales and thin-bedded sandstone, but northeast of Rome the formation is chiefly shales. The longest outcrop band extends northeast from Rome across Gordon County into Whitfield County where it splits into two bands that extend to and beyond the Tennessee line. Another narrow band of the Rome shales extends from southeastern Walker County northeasterly through western Whitfield County and the eastern edge of Catoosa County. Underlying the Rome formation and locally indistinguishable from it is the Conasauga formation (Cambrian). Other phases of the Conasauga range from calcareous or limey shales with thin-bedded to massive layers of limestone to a fine olive clay shale. Broad outcrops of the Conasauga occur in the valleys of the Coosa, Oostanaula and Conasauga rivers. Many of the outcrop areas in Floyd, Bartow, Gordon, Whitfield and Murray counties are comparatively free of limestone and, where weathered, often to 25 to 30 foot depths, the Conasauga shales make excellent heavy clay products material (B17).

Quality and Quantity

The red-firing types of clays are widespread and relatively abundant throughout most of the State. There has never been any systematic exploration of these types of clays, so that any estimate of reserves is impossible. The brick manufacturers of the Fall Line area consider their reserves "adequate," and other usable brick clay deposits could be found elsewhere in the State.

COAL

Outlook

The outlook for the coals of northwest Georgia is that of declining production.

Production Status

Recent coal production in Georgia has been by small trucking mines, essentially for local use. Most of the production has come from Walker County, although Dade County has had limited outputs. Since 1932, annual State output has seldom exceeded 40,000 tons.

Location and Occurrence

Coal in Georgia occurs in the Pottsville (Pennsylvanian) formations which are limited to the extreme northwest part of the State. These coal-bearing strata are mainly in Walker, Chattooga and Dade counties where they form the higher parts of Lookout, Sand and Pigeon mountains. The total coal-bearing area in northwest Georgia is somewhat less than 200 square miles. The coal beds range from a few inches up to several feet in thickness.

Quality and Quantity

All of the Georgia coals are bituminous. In Table 5 are analyses of coals from the Durham No. 4 and No. 5 seams, sampled at mines near Durham in Walker County. The No. 4 seam ranges from 1 2/3 to 3 1/2 feet in thickness; No. 5 is 5 3/4 feet thick. Both are low volatile coals. The coal reserves are not known, but they are not considered large.

Table 5

ANALYSES OF GEORGIA COALS

Content and Quality	Durham No. 4	Durham No. 5
Volatile matter	18.7 - 22.0%	20.4 - 21.9%
Fixed carbon	66.5 - 78.0%	73.0 - 78.1%
Ash	10.4 - 10.9%	3.9 - 4.0%
Calorific value (B.T.U.)	13,210 - 15,510	14,640 - 15,680
Ash softening temperature	2850° F	2470° F

Source: Analyses of Tennessee Coals, Including Georgia, U.S. Bureau of Mines Technical Paper No. 671, 1945, pp. 108-109.

FELDSPAR

Outlook

Feldspar production in Georgia should increase but will always have serious competition from the well-established plants of North Carolina. Georgia's best opportunity will come if and when additional glass or other feldspar-consuming plants are established in the Atlanta or other areas within the State, so that Georgia feldspar would have a transportation-cost advantage.

The high percentage of potassium in the Jasper County feldspar and excellent quality of the finished product should give it an advantage in chemical glassware, high temperature enamels, and similar applications. Sodium-high feldspars or "soda-spar," in large scale production in North Carolina, have a much lower melting point and are usable in most glasses, as well as in lower-temperature enamels.

The various granites of Georgia are potential sources of feldspar, and research has been suggested to determine whether the more feldspathic of these granitic rocks can be broken down to yield commercial feldspar. In some rocks, both soda and potash spars are potentially recoverable (F1).

Production Status

The Jasper County feldspar produced by the Appalachian Minerals Company varies considerably in the chemical analysis, so that blending is always done from two or more dikes. The potash content of the various dikes ranges from 6% to 13% and a 10.25% average is maintained in the finished product (A15).

Appalachian Minerals Company processes its raw material by flotation and then, if required, grinds it to the desired size. The published daily capacity of this plant is 150 tons of minus 20-mesh material; 100 tons of minus 40-mesh; or 70 tons of minus 200-mesh. Five tons of mica are produced daily as a by-product in this operation.

Location and Occurrence

Commercial feldspar is found in Georgia in pegmatite dikes that range from stringers of a few inches width and length up to reported widths of 75 feet and 600 feet lengths. Pegmatites, although essentially the same chemically as members of the granite family, are commonly found in random distribution throughout areas of metamorphic rocks and are sometimes associated closely with granitic-type igneous rocks.

Feldspar is reported from at least 54 counties of the Piedmont and Blue Ridge regions of Georgia but, except for occasional local truckload lots, production has been entirely from Jasper County by the Appalachian Minerals Company. Elbert, Rabun, Putnam and Monroe counties are regarded as the more favorable counties for future prospecting.

The Jasper County deposit currently being worked by the Appalachian Minerals Company, just south of Monticello, is 1 1/2 miles wide by 14 miles long and includes several hundred pegmatite dikes and many small stringers. These dikes, which dip about 60^{o} westerly and vary from 75 feet wide and 600 feet long to four by 10 feet, come to or near the surface and are followed down by open-pit mining. Most of the dikes are graphitic granite, which is highly stratified and can be ripped out. Others high in soda must be drilled and blasted (A15).

Quality and Quantity

The Jasper County feldspar has approximately the analysis shown in Table 6. The quality of the other feldspars in the State varies both in grade and in type (potash, soda, or mixtures).

Estimation of feldspar reserves in Georgia has not been made, and this would be difficult because of the irregular but widespread distribution of feldspar-containing rocks. Present information, however, indicates that additional commercial deposits would be scarce.

Table 6

ANALYSIS OF FELDSPAR, JASPER COUNTY, GEORGIA

Content	Amount
SiO_2	65+% - 66%
Al_2O_3	19+%
Fe_2O_3	0.07%
CaO	0.9%
MgO	Trace
K_2O	10+%
Na_2O	3+%
Loss on ignition	.20%

"+" indicates additional fractional percent.

Two analyses, furnished 18 months apart, by Appalachian Minerals Company were consistent within less than 1%.

FULLER'S EARTH

Outlook

Although treated (activated) bentonites and bauxite have replaced fuller's earth to a large extent in the oil bleaching industry, fuller's earth is rapidly expanding in the fields of absorbents, insecticides and fungicides, rotary drilling muds, and lightweight aggregates. Usage of granulated fuller's earths as an absorbent of oil and chemical splashage in manufacturing operations has increased greatly since World War II.

The fuller's earths of Georgia have not been utilized to any extent in the field of lightweight aggregates. Considering the large amounts of fuller's earth present in the State and the increasing demand for lightweight aggregate, this would appear to be a largely untouched potential field of much promise.

Usage of fuller's earth in fields other than the oil-bleaching industry should continue to increase (A14).

Production Status

Fuller's earth was discovered in Decatur County soon after the initial find in Quincy, Florida, in 1893, but production did not start in this county until 1907 (B14). Georgia and Florida have since alternated in leading the nation in production of this commodity, and the two states together accounted in 1960 for nearly 85% of the total U.S. output of 408,325 short tons, with a price range of $16.30 to $18.00 per short ton (D1, G8). The 1960 value of fuller's earth produced in Georgia totaled $1,777,051 for 93,689 short tons (E1).

There presently are six producers in the State. Four are in southwest Georgia: The Milwhite Company, Inc., and Minerals & Chemicals Philipp Corporation near Attapulgus (Decatur County); Cairo Production Company, Inc., at Cairo (Grady County); and Waverly Petroleum Products Company at Meigs (Thomas County). Farther north are the operations of the Diversey Corporation in Macon (Bibb County) and of the Georgia-Tennessee Mining & Chemical Company at Wrens (Jefferson County). (A6.)

Fuller's earth is mined from pits or open cuts by power shovel and dragline. It is taken to processing plants where it is lightly dried, crushed, and screened to remove sand and foreign matter.

Location and Occurrence

Fuller's earth is an inexact name applied to clays that are naturally highly absorptive. Two types occur and are produced in Georgia. The montmorillonite type is found in the Twiggs clay member of the Barnwell formation (Eocene age), with major deposits lying just south of the Fall Line in Jefferson and Twiggs counties. This type also has been found in Bibb County. The attapulgus type occurs near the Florida border, in Decatur, Grady and Thomas counties, as major deposits which constitute extensive irregular beds of the Hawthorn formation (Miocene age). (B3, D19, D20.)

The fuller's earths occur as sedimentary beds of clay interlayered with sand and other materials. These clays cover a wide range geologically, vary in character within the same deposits, and many represent weathered beds of volcanic ash, yet no evidence has been found of vulcanism at those times and in these areas. The Twiggs clay member consists of yellow to dark blue fuller's earth in massive beds, up to 30 and 40 feet in thickness, that grades into a limestone at its base. Sand overburdens range from 10 to 20 feet. Near Attapulgus (Decatur County), the fuller's earths occur in irregular beds, well laminated with thin partings of fine sand. In Twiggs and Bibb counties, deposits often exceed 50 feet in thickness.

Bentonite, a clay derived from the alternation of volcanic ash, occurs in a bed one to 20 feet thick in the Chickamauga (Ordovician) limestone in the valleys of Lookout and West Chickamauga creeks of northwest Georgia. Outcrops of this bentonite (or "meta-bentonite" of some authorities) have been noted in Dade, Walker and Chattooga counties by Smith (B17). Fuller's earth is associated with this bentonite in a deposit in Walker County near Cassandra (D7).

Uses

The principal use of fuller's earth is in deodorizing or clarifying oils and fats. Its bleaching action is due to its ability to absorb coloring matter selectively when added to the liquid to be decolorized. Absorbent uses in 1958 required over 149,000 short tons of the total U.S. output of 357,883 tons. Other uses were as follows (G8):

	Short Tons
Insecticides and fungicides	85,276
Rotary drilling mud	58,464
Mineral oils and greases	40,074
Lightweight aggregates	7,796
Chemicals	2,003
Other uses (including exports)	14,602

The earths also were used in multi-purpose greases of wide temperature ranges, on specially treated paper which provides multiple copies of business forms without carbon paper, in powdered form as a "floc" agent for purifying water, and as a mineral filler in soap, toilet powder, and some plastics, polishes and paints.

Quality and Quantity

The deposits of fuller's earth are so large in relation to the demand that there has been no reported attempt to determine the full extent of the reserves. Since Georgia's deposits are so extensive, the major economic considerations involve purity, thickness and extent of specific deposits, along with usage tests and market development (G8).

The main reserves of fuller's earth are in Florida, Georgia and Texas. The measured reserve appears to be ample for at least 50 years at the 1958 rate of consumption in the present producing areas. Detailed reserve estimates for Georgia alone are not published, but according to a recent non-numerical estimate, the reserves are very large (D1).

Fuller's earth is characterized by a lack of plasticity, high water content, a high silica to alumina ratio, and a relatively high hydrous silica content. A typical analysis of fuller's earth from Georgia is shown in Table 7.

Fuller's earth from Georgia generally weighs 30 to 40 pounds per cubic foot when processed. Minerals present in fuller's earth include attapulgite, illite, nontronite, and kaolinite, in addition to montmorillonite.

Chemical analyses in general do not reflect as true a picture of the possible usages of fuller's earth as do the various physical properties and usage tests (A14). Results of physical tests on typical fuller's earth from Georgia are listed in Table 8. Details of the physical tests are discussed in the reference cited (A14).

Table 7

TYPICAL ANALYSIS OF FULLER'S EARTH FROM GEORGIA

Content	Amount
SiO_2	53.42%
TiO_2	0.52
Al_2O_3	10.06
Fe_2O_3	3.58
MgO	9.18
CaO	1.29
Na_2O	0.02
K_2O	0.64
P_2O_5	0.12
CO_2	0.05
Cl	0.03
SO_3	0.02
Ignition loss	9.42
Uncombined water	11.83

Source: Rich, A. D., "Bleaching Clay," Industrial Minerals and Rocks, American Institute of Mining Engineers, 1960, pp. 93-102.

Table 8

PHYSICAL TESTS OF GEORGIA FULLER'S EARTH

Data	Fine Grade (Contacting)	Coarse Grade (Percolation)
Volatile matter (%)	16.0	16.5
Density (lb./cu. ft)	31.0	35.0
Acidity (mg KOH per gram)	Neutral	Neutral
Screen test (% through 200-mesh)	95.0	--
Mineral-oil decolorization value (%) (efficiency a = 100%)	100.0	--

IRON ORES

Outlook

The outlook for the iron ore industry of Georgia may be one of change. Two major factors can cause this: the depletion of major high-grade ore bodies in the continental United States, and new techniques of crude iron production that will allow less capital investment to economically handle smaller quantities and to use less favorable quality ores than has been the practice in the past.

The trend in the national iron ore supply is toward manufactured ore feed for blast furnaces. This is done by concentration and pelletization of low-grade ores, such as taconites that exist in large quantities in the iron ore districts of Minnesota. Although the resulting iron pellets are more costly than the natural ores, this cost reportedly is more than offset by economies in the operation of the blast furnace due to the uniformity of grade and size of the ore feed. These manufactured ores would, in fact, probably eliminate the demand for much of the ore as is mined in Georgia, were it not for other factors which enter the picture.

The first of these will be the promptness with which the Birmingham steel furnaces convert to the use of pellet ore to meet the competition of the northern blast furnaces. The second factor is the improved technology in the direct reduction of iron ore. The status of 14 direct reduction processes has been recently summarized (A9), and the D-R processes appear to be of potential interest to Georgia where relatively low-grade ores may be processed with gaseous reducing agents. However, consideration is being given to the use of the "Strategic-Udy" process for the Coastal Plain ores and the "R-N" process for the northwest Georgia ores, although these processes require solid carbon fines or perhaps low-grade fuels for reduction of the ore. The use of direct reduction, it is believed, would allow a lower capital investment and the processing of considerably less volume of ore than has been customary with a blast furnace.

Production Status

Iron ore has been mined in Georgia since about 1840. Until recently, production of the brown ores was largely from northwest Georgia, with the principal mining districts being in the vicinity of Cartersville (Bartow

County) and in the Cedartown area (Polk). (See Tables 9 and 10.) Limited outputs of brown ore have come from Floyd, Cherokee and Gordon counties. The red iron (hematite) ores have been mined in Dade, Walker, Chattooga and Whitfield counties; however, the bulk of production has come from Walker County. Production of the Coastal Plain brown iron ores, principally from Stewart and Webster counties, began in 1956 and current output in that area continues to be mainly from those two counties.

Furnaces for the production of pig iron operated in Georgia off and on from 1840 to about 1910. Since then there have been no such furnace operations in the State, and the ores mined here have been shipped to the iron and steel centers in Birmingham and Gadsden, Alabama.

The 1958 Minerals Yearbook gives, in tabular form, shipments of iron ore in Georgia from 1870 through 1958 (E6). The year of highest production was 1907, with 444,100 long tons, and the second highest output was in 1957, with 442,700 long tons. The low point in production was in 1933, with only 300 long tons. The 1958 tonnage dropped to less than one-half of that of 1957, being only 209,400 long tons. In 1959, the Stewart-Webster counties area accounted for 72% of that year's output of 186,000 long tons (D18). By 1960, the State output was down to 128,000 long tons, still mainly from Stewart and Webster counties. Outputs by counties from 1890 to 1957 are shown in Table 9; the outputs of leading Georgia mines are given in Table 10.

Location and Occurrence

The iron ores of Georgia have four distinct modes of occurrence. These are the lower Paleozoic brown ores and the Clinton (Silurian) siliceous hematite ores of northwest Georgia; the brown ores of Stewart, Webster and Quitman counties in the Coastal Plain sediments of south Georgia; and the titaniferous magnetites scattered throughout the Crystalline area of north Georgia.

The Paleozoic brown iron ores (hydrous Fe_2O_3), associated mainly with the Weisner quartzite, the Knox dolomite, and the Chickamauga limestones of Cambrian and Ordovician ages, occur chiefly in the form of pockets or irregular deposits in clays residual from those formations. The deposits are quite variable in size, ranging from as little as a truckload of ore to, in some instances, enough to extend over five to six acres. The nodules of ore

Table 9

PRODUCTION OF IRON ORE IN GEORGIA, BY COUNTIES, 1890-1957

County	Hematite	Limonite	Total Production (long tons)
Bartow		5,519,082	5,519,082
Chattooga	108,090	334	108,424
Cherokee		229,643	229,643
Dade	111,772		111,772
Fannin		115	115
Floyd	36,165	116,788	152,953
Gilmer	120	27,606	27,726
Gordon		80,690	80,690
Haralson			247
Meriwether		12,013	12,013
Muscogee		2,615	2,615
Polk		5,355,218	5,355,218
Quitman		123	123
Stewart		164,842	164,842
Walker	989,764	7,328	997,092
Webster		5,161	5,161
Whitfield		31	31
Undistributed	684,598	1,271,508	1,956,106
Total	1,930,509	12,793,097	14,723,853

Source: Review of the Southeastern Iron Ores, Exclusive of the Birmingham District, with Emphasis on the Silurian Hard Ores, U.S. Department of Interior, November 1, 1959.

Table 10

PRODUCTION OF LEADING IRON ORE MINES IN GEORGIA

Mine	County	Active Period	Total Production (long tons)
Limonite:			
Bartow	Bartow	1891-	2,233,000
Iron Hill	Bartow	1910-	1,895,000
Woodstock	Polk	1885-1938	1,207,000
Oremont	Polk	1881-	682,000
Grady	Polk	1881-	581,000
Hematite:			
Estelle	Walker	1901-1955	977,000
Rising Fawn	Dade	1902-1940	112,000
Taylors Ridge	Chattooga	1907-1921	56,000
Dirtseller Ridge	Chattooga	1903-1941	52,000

Source: Review of the Southeastern Iron Ores, Exclusive of the Birmingham District, with Emphasis on the Silurian Hard Ores, U.S. Department of Interior, November 1, 1959.

usually have random orientation in the clay, i.e., scattered like raisins in a cake, so that drill prospecting, at best, obtains a statistical average. The quality of the ores can vary considerably. Bartow, Floyd and Polk counties have been the chief mining centers for these brown iron ores.

The Clinton hematite ore (Fe_2O_3), sometimes referred to as "fossil iron" ore, is confined to Dade, Walker, Catoosa, Whitfield and Chattooga counties, in the extreme northwestern part of the State, where, on Taylor Ridge in the last four named counties, ore beds aggregating one to two feet have been mined (A13). These ores, an extension of similar ores mined in the Birmingham, Alabama, steel district, occur in regularly stratified beds that vary from a few inches to several feet in thickness. In Georgia, these ore beds and enclosing Silurian rock are known as the Red Mountain formation. The ore beds frequently dip steeply into the mountains or ridges in which they are found; commonly, several ore beds are present, separated by varying amounts of shale or sandstone, and the beds are not continuous but tend to lense in and out.

The Coastal Plain brown iron ores of Quitman, Stewart and Webster counties have been described as being mainly limonite but containing some hematite (D9, D16). The ores range from small nodules to "hollow" geodes of over one foot in diameter whose interiors contain sand and clay. These ore nodules and geodes tend to occur in beds, or disconnected lenses, ranging from a few inches to several feet in thickness near the base of the Clayton formation. The maximum thickness reported is about five feet.

The magnetite iron ores (Fe_3O_4) are found in the Crystalline rock area of the State as an accessory mineral in igneous and metamorphic rocks and as segregations in veins and irregular small bodies associated with diorite gneiss (D10). None of the magnetite ore has been mined in Georgia to date. Reported occurrences include Cherokee County, two miles southwest of Woodstock; Cobb County, 2 1/2 miles northwest of Blackwell; Gilmer County, on Lot 215, 7th District, 2nd Section; Greene County, 2 1/2 miles north of Robinson; Taliaferro County, one mile north of Robinson; Lumpkin County on Lot 682, 12th District, 1st Section; and Dawson County on Lot 97, 4th District. In Paulding and Haralson counties, magnetite is found associated with pyrite ores. Magnetite in the form of octahedrons with striated faces occurs in Elbert County on the north edge of Elberton and also in the chlorite schist on the dumps of the Little Bob mine, 2 1/2 miles northwest of Hiram (Paulding County).

Quality and Quantity

The north Georgia brown iron ores, presently mined for the Birmingham and Gadsden, Alabama, mills were reported in the early 1900's to contain 42.8 to 55.4% iron and phosphorus ranging from 0.36 to 1.58%; the samples analyzed were taken from six feet to 40 feet below the surface (B12). Ores mined since the 1950's are believed to have been of similar grades.

The "fossil" hematite ores of northwest Georgia vary widely in quality, as shown by the average analyses in Table 11. Because the hematite ore is bedded and, in most instances, dips steeply beneath the mountains of the area, relatively expensive underground mining methods are required. The beds commonly are too thin to permit mining of only the ore and, in consequence, much gangue must be handled also. Output of this ore in recent years has been limited essentially to truck-mine operations on a local scale. The reserves of the "fossil ore" are reported to total approximately three

Table 11

AVERAGE ANALYSES OF HEMATITE ORES OF NORTHWEST GEORGIA

Constituents	Hard	Soft
Hygroscopic water	0.10%	0.65%
Combined water	2.04	3.57
Ferrous oxide, FeO	2.65	none
Ferric oxide, Fe_2O_3	45.29	81.57
Alumina, Al_2O_3	3.14	5.57
Manganous oxide, MnO	0.28	0.43
Lime, CaO	21.41	0.29
Magnesia, MgO	0.44	0.42
Silica, SiO_2	7.28	6.55
Sulphur, S	trace	0.25
Phosphorus pentoxide, P_2O_5	1.17	0.45
Carbon dioxide, CO_2	16.50	none

Source: McCallie, S. W., Mineral Resources of Georgia, Georgia Geological Survey Bulletin No. 23 (Rev. Ed.), 1926, p. 116.

billion long tons in beds of 30 inches minimum thickness for the areas of Sand, Lookout and Pigeon mountains lying in both Georgia and Alabama (A13). An earlier estimate of "available" ores (generally not over 1,000 to 1,200 feet down dip and an ore bed of two-foot minimum thickness) in the northwest Georgia area is given as 19 million long tons. The "potential" ore reserve is given as 1,820,000,000 long tons (A3).

Analyses of the brown iron ores from Stewart and Quitman counties indicate that the better ores range from 54 to 58% metallic iron, with phosphorus and manganese contents being very low (D9). Analyses of Webster County brown iron ores show a range from 47.03 to 56.34% metallic iron, also with relatively low phosphorus and manganese contents (D16). Reserve estimates of these ores for the Southeast have been published (A13) but not for individual states. Private capital recently has been engaged in drill prospecting the southwest Georgia ore areas, but the results of this exploration are unknown.

The scattered magnetite (Fe_3O_4) bodies within the State vary considerably in the content of magnetite and the proportion of associated ilmenite

($FeTiO_3$). Analyses of magnetite ores with a maximum of 69.01% metallic iron are reported (B7). Some of the analyses with considerably lower iron contents run high in TiO_2 -- up to 26.46% in one instance. The published analyses indicate a wide range of magnetites and titaniferous magnetites, which generally occur as lenses and dikes in the crystalline rocks. As Haseltine said in a 1924 report: "No mining of these ores so far has been attempted and but little prospecting has been done. As a matter of fact, with the data now at hand it is not at all certain that these ores really occur in commercial quantities." (B7.) This is still the case.

KAOLIN

Kaolin is Georgia's major mineral resource, both in terms of tonnage and dollar volume. Approximately 75% of the kaolin output of the United States comes from Georgia.

Outlook

The uses of kaolin are traditionally in ceramics and as a filler or coating, particularly for the paper and rubber industries, and these uses should continue to expand with the years. Technological improvements and new processes, such as treating clays with radioactive materials, may change the characteristics and open entirely new fields for kaolin. Considerable new work is being done in the surface chemistry and physics of the clay particle. All of this may lead to improvements, new products and market expansions.

Possible future large-scale usage for kaolin, along with the associated bauxite and bauxitic clays of the kaolin-producing areas, is in the production of alumina for metal manufacture, as already noted under the section on Bauxite.

The excellent supply and relatively low rates of natural gas along the Georgia Fall Line, along with the nearby sources of kaolin, would seem to make south Georgia an ideal location for additional refractory products plants or for whiteware or ceramic tile plants (C2, C3).

Production Status

The sedimentary kaolins of the Coastal Plain of Georgia have been known since Colonial times, at least as early as 1741, and by 1766 were being regularly exported to England where they were used by Wedgewood. Subsequent discovery of English kaolins ended Georgia kaolin mining for over a century, and not until 1876 was the mining in this State revived, at the Morgan property near Augusta in Richmond County (G5, G6).

Georgia, as the leading kaolin producer of the United States, has steadily increased output since 1921, both in terms of the unit price of kaolin and total tonnage volume. Over this span of years, there have been a few periods in which production leveled off or declined slightly. The longest period was during World War II and the second longest was during the depression years of 1930 to 1932.

In 1959, the State's total output was 1,940,279 short tons of kaolin valued at nearly $34,000,000 (E5). This increased in 1960 to 2,121,237 short tons, valued at nearly $38,000,000. In that year, 20 companies mined kaolin in nine counties (E3).

In 1959, six producing companies were reported in the vicinity of Sandersville (Washington County). In the vicinities of McIntyre and Gordon (Wilkinson County), there were three producing companies in each area; while Dry Branch (Bibb County), Huber (Twiggs County), and Stevens Pottery (Baldwin County) each had one producer. There were single producers in Richmond County and at Macon (Bibb County), the latter having a mine in Twiggs County. (A4, A6.) The leading producers in 1960 were Georgia Kaolin Company, Dry Branch; J. M. Huber Corporation, Huber; Minerals & Chemicals Philipp Corporation, McIntyre; and Southern Clays, Inc., Gordon (E3).

Refractory product plants currently operating on Georgia kaolin are: Babcock & Wilcox Company, Augusta; General Refractories Company, Stevens Pottery; and Stevens Firebrick Division, A. P. Green Company, Macon.

Location and Occurrence

Almost all of the kaolin produced in Georgia comes from Upper Cretaceous deposits which are sedimentary in origin and, with one known exception, are all found south of the Fall Line. This exception is the Meriwether County kaolin, found in the Warm Springs-Pine Mountain area, in beds of unknown but possible Upper Cretaceous age.

The chief kaolin-producing counties are Twiggs, Wilkinson and Washington. Some production is usually reported from Richmond, Baldwin and Hancock counties; kaolin also has been reported from and, in some instances, produced from most of the other Fall Line counties, including Columbia, Burke, McDuffie, Jefferson, Glascock, Warren, Jones, Bibb, Houston, Peach, Crawford, Taylor, Macon, Schley, Talbot, Muscogee, Chattahoochee, Sumter, Dooly, Stewart, Webster and Meriwether. Despite these sporadic occurrences of kaolin deposits throughout the Fall Line counties, there are only two areas where the deposits are relatively numerous and of larger than average size -- east of

Macon, in the first three named counties above, and in an area around Augusta that overlaps the state line, with the most productive part in South Carolina, southwest of Aiken (D17).

Kaolin deposits reported from the Crystalline area of Georgia have not, to date, proved economically significant.

The Cretaceous kaolins have had several explanations as to origin, but all explanations allow for transportation of pegmatite and granite-derived materials to an Upper Cretaceous sea. Geologists are not agreed as to whether the feldspars were transported and then weathered in place after Cretaceous deposition or were weathered to kaolin prior to deposition. Very excellent descriptions of the major kaolin areas and their deposits, along with chemical analyses and discussion of the origin of the kaolin, are given by Smith (B16). During World War II, the U.S. Geological Survey made maps of the major kaolin and bauxite deposits in Georgia, and these were placed on open file (H1, H2, H9, H11, H13). Copies of the maps were furnished the Georgia Department of Mines, Mining and Geology. The U.S. Bureau of Mines also selectively drilled certain sites, the results of which are given in their Reports of Investigations (G5, G6).

In their more typical commercial occurrences, Georgia kaolin deposits are in lenses that may range up to several hundred acres in extent or a mile long over the major dimension and 50 feet in thickness (many mined deposits average 20 feet) with sand overburdens ranging up to similar thicknesses (B13, B16, D17). However, kaolin lenses occur to depths of at least 175 feet in the south Georgia Cretaceous and, locally, overburdens up to 100 feet thick have been stripped in mining the kaolins (D17).

Uses

The most important uses of kaolin may be ranked as follows: (1) paper coating; (2) paper filler; (3) rubber filler; (4) firebrick and block; and (5) whiteware. Other filler uses include paint, insecticides, fungicides, etc., and these fillers run to rather high tonnages. Nearly 75% of Georgia's kaolin output in 1958 was sold for filler uses (E6).

Research staffs are maintained by several of the companies in a constant effort to improve present production and to produce new products from the raw kaolin.

Quality and Quantity

Raw kaolin, after it is removed from the ground, must be prepared by processing that may include either air flotation, washing, chemical treatment, or a combination of these. Specifications on such treated products may be best secured from the individual companies, since continuing efforts to improve these products and raw material differences tend to quickly obsolete current specifications on kaolin. Because of this and other facts, many kaolin companies are reluctant to disclose this information for publication. Nevertheless, kaolin currently being produced in filler and coating grades has a range of characteristics as reported in Table 12. The information in this table is based on data from only two companies, and therefore may not be completely comprehensive. The chemical analyses reported in Table 13 have a similar limitation. Analyses of raw kaolin are given in Table 14.

Table 12

PHYSICAL CHARACTERISTICS OF GEORGIA COMMERCIAL KAOLINS

Characteristic	Filler Clays	Coating Clays
G. E. brightness	78.5 - 84	84 - 88
pH range	3.8 - 7.0	4.2 - 7.0
Particle size (%)		
Under 2 microns	64 - 68	72 - 80
Over 5 microns	13 - 19	4 - 9

Table 13

ANALYSES OF PROCESSED GEORGIA KAOLIN

Content	Amount
Silica (SiO_2)	43.7 - 45.50%
Alumina (Al_2O_3)	38.7 - 40.30
Iron Oxide (Fe_2O_3)	0.31 - 0.42
Titania (TiO_2)	1.30 - 1.59
Lime (CaO)	0.33 - 0.56
Magnesia (MgO)	0.00 - 0.28
Sodium Oxide (Na_2O)	0.02 - 0.13
Potassium Oxide (K_2O)	0.01 - 0.02
Loss on Ignition	13.30 - 13.80

Table 14

SUMMARY CHEMICAL ANALYSES OF 115 TYPICAL GEORGIA SEDIMENTARY KAOLINS

Content	Lowest	Highest	Average
Al_2O_3	33.09%	43.50%	38.97%
SiO_2	37.45	46.79	43.03
Hyd. SiO_2	0.01	0.85	0.20
Fe_2O_3	0.47	4.69	1.43
TiO_2	0.54	2.16	1.13
Na_2O	trace	0.85	0.15
K_2O	trace	0.46	0.09
MgO	0.00	0.35	0.04
P_2O_5	0.00	1.33	0.07
SO_3	0.00	2.00	0.13
Loss on ignition	11.48	15.74	13.28

Source: Smith, R. W., Sedimentary Kaolins of the Coastal Plain of Georgia, Geological Survey Bulletin No. 44, 1929.

LIMESTONE

Outlook

Due to the building construction boom in Georgia, notably in the Atlanta metropolitan area, and the increase in highway construction, the State's output of limestone products has increased steadily in volume output and dollar sales over the last several years. This level of activity is expected to continue for the next several years and, as a consequence, Georgia's limestone industry should continue to flourish.

Notable among the limestone products not now made in Georgia are quicklime and hydrated lime. These are shipped in from both Alabama and Tennessee. High-grade magnesium plasterers' lime is shipped from as far away as Virginia. There appears to be a market for lime in the paper plants in southeast Georgia, but an even better market may be found in the use of lime for soil stabilization in road construction. Several states consume large quantities of lime for such road construction purpose.

Production Status

Limestone serves many purposes, but in Georgia its production has been limited largely for making Portland cement, for crushing into road metal and building aggregate, and for grinding into agricultural lime. There is no extensive quarrying of dimension stone, excepting the marbles, and no lime plants are currently in operation.

In 1960, crushed limestone sold or used by producers totaled 1,697,717 short tons, valued at $2,758,086 or an average of $1.62 per ton (E3).

Marquette Cement Manufacturing Company produces Portland cement at Rockmart (Polk County) from limestone of the Conasauga formation quarried near Cartersville (Bartow County). The Penn-Dixie Cement Corporation manufactures Portland cement at Clinchfield (Houston County) from locally quarried Ocala limestone. The company has announced plans to increase their annual capacity from 1.1 million barrels to 2.3 million barrels (E5). The Ocala limestone also is worked for aggregate and agricultural lime in Lee County, near Armena, by the Albany Lime-Rock Corporation. In Mitchell County, the Bridgeboro Stone Company, Inc., works Oligocene limestone for aggregate and aglime. The Ready-Mix Concrete Company, Ledbetter-Johnson, and the Floyd County

Highway Department quarry limestone near Rome for use in concrete, roadstone, and railroad ballast. Analyses of the Floyd (Mississippian) and Conasauga (Cambrian) limestones, are given in Table 15. Similar crushed limestone products are made at the Dave L. Brown quarry near Morganville in Dade County. Crushed marble is produced by the Georgia Marble Company at Marble Hill (Pickens County), at Mineral Bluff (Fannin County), and Holly Springs (Cherokee County). The Georgia Marble Company crushes marble, mined underground, near Whitestone in Gilmer County for terrazzo granules and other uses.

Southern Cement Company, a division of American-Marietta Corporation of Chicago, in 1961 announced plans for a Portland cement plant of 1 1/2 million barrels annual capacity to be built in the Atlanta area. Marble waste from Tate, Georgia, and Conasauga limestone from near Cartersville will be used.

Location and Occurrence

Limestone, one of the principal economic assets of Georgia, occurs in each geologic area. In the Paleozoic area, the chief formations are the Knox (Cambro-Ordovician), the Conasauga (Cambrian), and Floyd and Bangor (Mississippian). Polk, Floyd, Bartow, Chattooga, Gordon, Walker, Dade, Catoosa, Whitfield and Murray counties comprise the area of their occurrence.

In the lower Cambrian, the blue limestone of the Conasauga formation is the most important rock for aggregate, lime, cement, and similar economic uses. The formation is widespread over the southern and eastern third of the exposed Paleozoic area and consists of shale with thin to thick limestone layers or lenses. However, there is an older Cambrian formation, the Shady dolomite, that is poorly exposed and close to the Cartersville fault where, in Bartow County, it is deeply weathered and yields iron ore and ocher in the resultant residuum (D6).

The Knox dolomite of Cambro-Ordovician age also is a very thick and widespread formation. Usually, it is deeply weathered, so that outcrop exposures are limited but, being a quite cherty stone, it can be traced by the high chert content of its soil. This chert and accompanying residual finely siliceous material make an excellent road metal for unpaved roads (D6).

In northwest Georgia, perhaps the best source of limestone is the several gray to bluish gray, coarsely crystalline, thick-bedded limestones generally classified under the Bangor formation (Mississippian). These are best exposed

Table 15

ANALYSES OF GEORGIA LIMESTONES

Content	A	B	C	D	E	F	G
Lime (CaO)	36.76	54.38	53.13	50.84	50.40	53.16	53.78
Magnesia (MgO)	15.24	.25	.60	1.53	2.05	0.57	0.53
Alumina (Al_2O_3) } Ferric Oxide (Fe_2O_3) }	0.84	0.24	1.42	0.96*	1.04*	2.64	1.50
Sulphur Trioxide (SO_3)	0.00	--	--	0.00	0.00	--	--
Phosphorus Pentoxide (P_2O_5)	trace	trace	0.60	trace	0.00	undt.	undt.
Silica (SiO_2)	0.91	1.75	1.82	3.50	2.35	3.76	2.30**
Potash (K_2O)	--	--	--	--	0.12	--	--
Soda (Na_2O)	--	--	--	--	0.09	--	--
Clay Bases	.54	.30	--	0.70	1.51	--	--
Moisture	--	--	--	--	--	0.15	0.04
Undetermined	45.71	43.08	42.43	42.47	42.44	39.98***	41.94**
Total	100.00	100.00	100.00	100.00	100.00	100.26	100.09

*Ferric oxide only; **Insoluble; ***Carbon dioxide (CO_2)

A - Knox dolomite, Ladd Lime Company, lower strata, Cartersville
B - Floyd limestone, Huffaker Lime Quarry, Huffaker, Floyd County
C - Bangor limestone, J. B. Reeves property, west side of Little Sand Mountain, 4 1/2 miles north of Crystal Springs
D - Floyd limestone, 3 1/2 miles north of Rome on U.S. 27, Floyd County
E - Conasauga limestone, northeast Rome near Southern Railway, Floyd County
F - Ocala limestone, R. L. Ferrell estate, eight miles northwest of Albany
G - Oligocene limestone, Bridgeboro Lime & Stone Company quarry, Mitchell County

---

Sources: McCallie, S. W., Mineral Resources of Georgia, Georgia Geological Survey Bulletin No. 23 (Rev. Ed.), 1926, p. 87; Furcron, A. S., "Mineral Resource Survey of Floyd County, Georgia," Georgia Mineral Newsletter, Vol. XI, No. 1, 1958; Furcron, A. S., and Charles W. Fortson, Jr., "Commercial Limestones of the Flint River Basin South of Albany, Georgia," Georgia Mineral Newsletter, Vol. XIII, No. 2, 1960, pp. 53-54.

below the Pennington shales (Mississippian) and Pennsylvania sandstones and shales along the slopes of Lookout Mountain in Dade and Walker counties. The Bangor in this area reportedly reaches a thickness of 900 feet (B10). Nevertheless, there are other Paleozoic limestones, most notably the Floyd (Mississippian) and Newala (Ordovician) limestones, the latter usually being a pure, thick-bedded, blue to blue-gray crystalline stone that crops out in narrow belts, for example, along the sides of Missionary Ridge and north of Aragon in Polk County. Limestone of the Floyd shale formation is well developed in the Rome area where it is a light to dark blue, heavy bedded limestone that reaches 80 feet or more in thickness (D11). Other of the Ordovician limestones that crop out in northwest Georgia, especially around Lookout Mountain in Dade, Catoosa and Walker counties, include the Murfreesboro -- variable but generally blue, compact, locally cherty; Mosheim -- compact, dove-colored, pure, persistent but rather thin; Lenoir -- dark gray, thin bedded, coarsely crystalline, locally cherty and argillaceous; Holston -- often referred to as a marble, which crops out in Whitfield County as a narrow belt east of State Road 71; Louisville -- fairly pure, blue limestone; Moccasin -- argillaceous, often a mud rock; and Trenton -- thin-bedded, blue-gray, coarsely crystalline, very fossiliferous and best seen in Lookout Valley (D6).

In the Crystalline area, limestones of Cambrian and pre-Cambrian ages usually have been recrystallized into white and colored marbles in stratified layers which have had bedding planes obliterated by the pressure to which the rocks of that area have been subjected. Commercially, these are the most important calcium-bearing rocks in Georgia and are used extensively for building and crushed stone (see section on Marble).

The Coastal Plains area has thin-bedded, relatively pure to argillaceous limestones and marls that range in age from the Ripley formation of Upper Cretaceous through the Ocala formation of the Eocene to beds of the Oligocene and Miocene, all of Tertiary age. However, "most of the known commercial deposits of limestone thus far discovered belong to only one of the Tertiary formations," the Ocala limestone of Eocene age (D6).

The Ocala formation crops out in about 20 counties of southwest Georgia, extending from Early and Seminole counties into Twiggs County. A "thick limestone section" is said to underlie the Flint River Basin south of Albany (Dougherty County) (D15), and most reported exposures are generally referred to the Ocala (Eocene) formation which here is usually a white or cream-colored, highly fossiliferous, soft and friable limestone with some sandy beds near its base. Oligocene and Miocene limestones are infrequently exposed here and are light-gray, soft to chalky or dense and recrystallized, with some cherty beds. The Flint River formation (Oligocene), for example, occupies a considerable area in south Georgia, forming a long irregular outcrop belt, just east of the Ocala limestone. Originally consisting of impure limestone and chert, the Flint River is poorly exposed and deeply weathered. There are few outcrops available and no known quarries in this stone at present.

Quality and Uses

Limestone is used for many chemical purposes, including cement, lime, asphalt filler, glass, carbide and paper manufacturing, poultry grit, sugar refining, whiting, acid neutralization, and others. Most of these uses require a stone of more than 95% calcium carbonate ($CaCO_3$) and low contents of magnesium carbonate ($MgCO_2$) and such other impurities as silica, iron oxides, clay and mica. Dolomites, however, have relatively large contents of magnesium carbonate. Some of the physical properties of commercial limestones which determine their economic importance are color, hardness, durability, weathering, permeability to moisture, and specific gravity.

Selected analyses of limestones from north Georgia and from the Coastal Plain area of south Georgia are shown in Table 15.

Both the Floyd and Bangor formations are important sources of limestone aggregate and should be excellent future sources of building stone. The Conasauga limestone has proved suitable for Portland cement manufacture, while the Knox dolomite, high in magnesium carbonate, can be used in plasters and mortars and for agricultural purposes. The Eocene (Ocala) and Oligocene limestones of south Georgia have an excellent potential because of their general purity and abundance. Although presently quarried in but three locations, they are, nevertheless, among the most significant limestone reserves in the State. Commercial deposits of these limestones should be further delimited by planned exploration and drilling. Much of the stone in these formations is suitable for quicklime and also for Portland cement since the magnesium contents are low. By careful selection in the Oligocene formations, sufficiently hard crystalline stone can be obtained for crushing into aggregate, and the softer stone is readily pulverized for aglime, mine rock dust, whiting, fillers, and similar uses.

MANGANESE

Outlook

In 1919 it was stated, "As carried on today, manganese mining is a poor man's business. . ." (B9.) This is essentially true today. The basis for this statement is the lack of known deposits of manganese of sufficient size and quality to attract large investment capital. The pockety nature of the deposits, the uncertainties of ore grade and distribution, and the relatively high costs of prospecting make mining under these conditions a very speculative and often unprofitable business. As stated below, manganese probably will continue to be produced only under subsidy.

Production Status

Manganese production in Georgia has fluctuated greatly over the years since its discovery, owing chiefly to exhaustion, from time to time, of the ore pockets and the delay in finding others. In recent years, production has been only under the stimulus of war and/or subsidy. Even so, the outputs have not been large. Production ceased in 1945 at the close of World War II and did not resume again until 1955 when the federal government subsidized manganese as a part of its mineral stock-piling program. This federal program ceased in August, 1959. Total production during the period from 1955 to 1959 was 3,078 long tons of +34% Mn manganese ore and 7,580 long tons of 10 to 34% Mn ore (F3). In 1959, production was from Bartow County, except for a small tonnage mined in Polk County; in 1960, only Bartow County was producing ore, and this output was solely -35% Mn ore.

Some underground mining of manganese has been done in Georgia, but most recent production has come from open cuts and pits where draglines and other power equipment are used exclusively. In the Cartersville district, the ore bodies occur as pockets and lenticular streaks in the residual clays of the Rome and Shady formations and are located by churn-drill prospecting. These ore bodies may extend to depths of over 200 feet (Dobbins mine), although the average is about 60 feet. Overburdens average 30 to 60 feet.

Location and Occurrence

Manganese was first produced in Georgia in 1866 from the Cartersville (Bartow County) district (H10), and most of the subsequent production has been from that district.

Other areas of notable output have been (1) the Cave Spring district, Floyd and Polk counties; (2) Draketown district, Haralson and Paulding counties; (3) Tunnel Hill district, Whitfield County; and (5) Doogan Mountain district, Murray County. Isolated deposits are reported from the following counties: Fannin, Gilmer, Pickens, Cherokee, Lumpkin, Towns, Habersham, Hart, Lincoln, Greene and Taliaferro. (B9.)

Occurrences of manganese listed by Miser are all oxide ore deposits found in residual clays of the Holston marble (Ordovician), residual clays and chert of the Knox dolomite (Ordovician and Cambrian), weathered beds of the Rome formation (Cambrian), and residual clays of the Shady formation (Cambrian), all in the Paleozoic area and in mica schist of the Crystalline area (A11). The Shady formation, however, has been the principal ore source.

The manganese is commonly found as nodules scattered like raisins in a cake throughout the clay but it may occur as bedded, concretionary, stalactitic and other irregular masses or as pellets or powder (B12). In all instances, as with the closely associated barite deposits, the irregular distribution makes it difficult to predict the extent of ore bodies.

Uses

About 97% of manganese production is used metallurgically, while the remaining 3% is for dry cells and chemicals. Most of Georgia's 1959 output of +34% Mn ore was sold to the federal government. All other ore was shipped to steel companies. (D18.)

Quality and Quantity

Ores from the Cartersville and Cave Spring districts show a range of manganese from 39.6 to 49.3%, iron from 1.7 to 10.5%, silica from 3.7 to 13.0%, and phosphorus from 0.035 to 0.27% (B12). The tenor of the ore sometimes varies widely within the same general area, and in the past Georgia ores have ranged in percentage of Mn from the low 30's to upper 40's. The best grades of ore reportedly have been found in the weathered remnants of the carbonate rocks of Ordovician age in the extreme northern part of the State but, unfortunately, the amounts have been small.

Reserves of manganese have not been determined, but the Cartersville district, followed by the Cave Springs district, will probably prove to be the chief producing areas of the future.

MARBLE

Outlook

Due to modern architectural design trends to lightness and airiness, marble by the end of the 1940's seemed doomed in favor of such man-made materials as metals, glass and concrete. But architects then began to find ways to reconcile marble with modern designs and procedures, and producers, such as Georgia Marble Company, experimented with new forms of the stone, particularly the "thin" marble (technically, "thin" marble is any under two inches in thickness). So today, marble, in the words of Georgia Marble president John W. Dent, ". . . has finally been demonstrated as fitting properly into the demands of modern architectural design." (A8).

As the production of marble is linked closely with the economic fluctuations of the building industry, the demand for Georgia marbles is increasing due to the general prosperity of the nation and resultant rise in new buildings. Although exact production figures are not available, the best estimates place the annual output of Georgia marble at many thousands of tons. Known reserves are adequate at the present rate of production for many years, but new commercial deposits should be located and developed whenever economically practicable. New marble reserves could be located within a few miles of the east side of the Louisville & Nashville Railroad right-of-way between Tate and Ellijay, with the intermediate area between Jasper and Talona being of significant importance.

Production Status

In 1840, the first marble quarry was opened in Georgia near Tate in Pickens County. Since then, marble production has grown to be one of the largest industries in the State. The Georgia Marble Company, which still quarries at Tate, now is considered the largest marble producer in the world, with net sales in 1960 of $17,900,000 (A8). The company also operates mines and quarries at Marble Hill, Mineral Bluff, and Ranger and has dimensional stone plants at Tate and Nelson. Calcium products are ground at its Marble Hill division and dolomitic white marble is mined near Whitestone. The company produces the following marbles: Georgia White, Cherokee, Creole, Mezzotint, Rosepia, Etowah (pink), Grand Antique (black), and Verde Antique (green). About 70,000 cubic feet of top Georgia White was recently supplied for the renovation of the east front of the United States Capitol in Washington, D.C. In addition to dimensional stone for interior and exterior uses and monuments, the Georgia Marble Company crushes stone for many chemical purposes.

The Thompson-Weinman & Company, Inc., at Cartersville (Bartow County), maintains crushing and processing plants that supply crushed and sized marble to industry.

The Marble Products Company of Georgia maintains crushing facilities near Whitestone where it mines dolomitic white marble for industrial use.

Location and Occurrence

The principal marble deposits of Georgia occur in a long syncline of Paleozoic metasedimentary rocks known as the Murphy Marble Belt. This can be observed in the Mineral Bluff area of north Georgia where the belt enters Fannin County from Hewitts, North Carolina. Here the marble lies between the Andrews and Brasstown (Cambrian) formations. Continuing on, the Murphy Marble Belt -- varying from one to three miles in width -- extends southwest about 60 miles through the Crystalline area, passing east of the towns of Ellijay and Talking Rock in Gilmer and Pickens counties, respectively. From Talking Rock, the belt strikes more to the southeast until it passes through Tate and Marble Hill, where one of the most famous commercial deposits in the world is located. Here, the belt attains a width of about three miles, and the marble is said to reach a vertical depth of over 500 feet. Near Nelson, the belt turns back to the southwest, with the quality of the marble depreciating in the vicinity of Ball Ground and Canton in Cherokee County. "In many instances the marbles form the floor of the narrow valleys; but, more frequently, they are exposed along the adjacent hill-slopes where they often form bold cliffs from 40 to 50 feet in height." (B11.)

Marbles of secondary importance occur in the Brevard Schist and are referred to as the Brevard Marble Belt. Again, this is a metasedimentary formation, probably of pre-Cambrian age. The belt enters the State from Oconee, South Carolina, between Habersham and Stephens counties, and strikes to the southwest through the counties of Hall, Gwinnett, Fulton, Cobb, Douglas, Carroll and Heard before entering Alabama. Very little has been done on the stratigraphy of the formation or toward development of the deposits which consist of fine-grained dolomitic marbles, similar in color and composition to those of the Murphy Belt. The counties of Habersham, Stephens and Hall should be carefully explored for economic deposits, since this marble appears suitable for terrazzo chips, roofing granules, agricultural lime, and road metal.

Marbles of lesser importance occur as vari-colored semicrystallines in weathered outcrops among the Paleozoic rocks of northwest Georgia. These outcrops can be located in isolated areas of Murray, Whitfield and Floyd counties. Little is known of the occurrence and extent of these marbles, and much exploratory work would be necessary to determine their value.

Quality and Uses

Georgia marble varies in texture from fine- to coarse-grained and varies in color from white to gray-blue with dark and light gray schistose impurities banding, mottling and clouding it. These impurities add greatly to its beauty. A rose-pink marble of medium grain occurs near Tate. This very decorative marble is somewhat mottled and has green-black vein inclusions. A solid pink also can be obtained here by selective quarrying. Some statuary marble is quarried in Georgia, and it is pure white, free from any contamination, possesses a very fine grain, has a low absorption rate, and is translucent and easily worked.

Physical characteristics of the Murphy Marble, as quarried in the Tate area, are as follows:

Absorption rate - less than 1/10 of 1%
Calcium carbonate ($CaCO_3$) - 95% to 98%
Coefficient of reflection - 86%
Index of refraction - 1.59 (mean)
Crushing strength - 12,000 psi

Chemical analyses of the Murphy Marble, sampled in the Mineral Bluff area of Fannin County, are shown in Table 16.

Table 16

CHEMICAL ANALYSES OF GEORGIA MARBLE

	A	B	C	D	E	F	G	H	I	J	K
MgO	11.19	15.89	5.07	9.42	12.26	15.78	16.37	15.39	4.85	16.96	12.75
CaO	42.64	32.68	48.00	41.62	36.90	33.66	32.70	34.46	47.60	33.10	36.30
Insoluble	1.66	10.70	3.46	7.70	9.43	5.24	4.00	2.50	6.76	6.46	5.72
$MgCO_3$	23.40	33.20	10.61	19.71	25.63	33.00	34.23	32.19	10.15	35.47	26.66
$CaCO_3$	76.11	58.33	85.67	74.28	65.86	60.08	58.36	61.50	84.96	59.10	64.75
Total carbonates	99.51	91.53	96.28	93.99	91.49	93.08	92.59	93.69	95.11	94.57	91.41

A. White, medium-grained marble.
B. White, finely micaceous, dolomitic marble.
C. White, thinly bedded, medium- to fine-grained marble.
D. White, medium- to fine-grained marble.
E. White, coarse-grained marble.
F. Blue and white banded, medium-grained marble containing a few thin streaks of pink marble.
G. White, fine-grained marble.
H. White, fine-grained marble.
I. White, mostly fine-grained marble.
J. White, mostly fine-grained, dolomitic marble.
K. White, fine-grained marble.

Source: Analyses by Dr. L. H. Turner, Chief Chemist, Georgia Geological Survey.

Outlook

The immediate future for Georgia mica cannot be considered too promising. In 1960, the U.S. Bureau of Mines reported that "government inventories of all strategic categories of mica are adequate," and that consumption will probably stay at the 1954-1958 average for a few years (E2). The subsidy for trimmed mica was to end on June 30, 1962, and it would appear that only punch and washer grades of Georgia mica would find ready markets. "Unless new uses develop, demand for lower qualities will continue to decrease." (E2).

Production Status

The United States is the world's largest consumer of mica but produces only 15 to 35% of its sheet mica and less than 2% of its splittings requirements; approximately 90% of scrap and punch mica is produced to meet domestic needs. The major part of strategic sheet mica grades must be imported.

In Georgia, Hart and Upson counties are the principal sources of full-trimmed mica and Cherokee County, of sericite mica for grinding. All hand-cobbed and trimmed mica is sold to the United States government at its Spruce Pine, North Carolina, depot.

The production of sheet mica in Georgia for 1960 decreased 45% in quantity and 26% in value from 1959 to approximately 10,200 pounds and a value of $88,600. This includes 3,150 pounds of full-trimmed sheet mica and 4,546 pounds of punch obtained from 77,772 pounds of hand-cobbed mica. Practically all sheet mica in 1960 came from Hart, Pickens and Upson counties. In the same year, scrap mica decreased 22% in quantity from 1959 but increased 21% in value; ground mica tonnage was 27% under the 1959 output. Scrap mica production figures were withheld as confidential. (E3.)

During 1959, in Cherokee County, the Georgia Talc Company and the Thompson-Weinman & Company mined a sericite mica, about seven miles west of Canton; Arthur W. Moore produced full-trimmed mica near Ball Ground; and Deweese Mining Company was producing hand-cobbed and full-trimmed mica in this county. In Pickens County, Thompson-Weinman & Company was taking sericite mica from the Martin mine, about seven miles southwest of Jasper, for grinding at its Cartersville plant. In Hart County, the Funkhouser Mills Division of the Ruberoid

Company was producing ground mica from a mica-schist located near Hartwell, and Homer Boone was mining sheet mica near Bowersville. Other Hart County operators producing hand-cobbed or full-trimmed mica were Arthur Mining Company, Henry Grindstaff, Payne Brothers, Joe L. Snyder, and E. B. Wood. In Jasper County, full-trimmed mica was being produced by both Mountain Mining Company and Southern Mining Company. Full-trimmed mica was being mined in Elbert County by Joe L. Snyder; in Rabun County near Clayton by T. B. Vance, Jr; in Franklin County by Ernest B. Wood; and in Monroe County by L. D. Gray. Hand-cobbed and full-trimmed mica was being produced in Upson County, in the Thomaston and Yatesville areas, by such major operators as E. L. Clark, Joe L. Snyder, and the Southern Mining Company. (E5.)

Since pegmatites are generally narrow and restricted, sheet mica mining is usually small scale, with most of the recovery obtained from underground mining. In soft material the miner uses pick and shovel, blasting only when the unweathered vein is encountered. The recovered mica is separated from the gangue material by hand, trimmed and sheeted for market. In a good mine, the recovery of sheet mica will run from 3% to 10% of the rock mined. Scrap mica deposits occur in relatively large mineralized sites, and mining is from open cuts with hydraulic equipment, bulldozers, pans, shovels, and trucks. The mined material is carried to a washer where clay, quartz and other substances are removed before it is taken to the grinding plants.

Location and Occurrence

Mica, which comes from the Latin word "micare" meaning "to glitter" or "to shine," occurs as two principal types: muscovite, a light-colored potassium mica, and biotite, a brown to black magnesium-iron mica. The former is most common and appears to be the only variety of commercial value in Georgia.

Mica is always associated with pegmatite or coarse-grained granites which are usually in the form of dikes. Muscovite of commercial value, occurring in crystal blocks or "books," is scattered throughout the dikes or in veins, frequently near their sides. Both dikes and veins are variable in thickness and length, and neither the abundance nor the quality of mica is dependent upon the size of the dike or vein in which it is found. As a rule, however, the better mica is obtained from the pegmatites of coarser crystalline rocks (B11).

Mica is widely distributed throughout the Crystalline area of Georgia, and most counties in this part of the State have one or more prospects. Mica-bearing pegmatites in Rabun, Hart, Elbert, Lumpkin, Union, Cherokee, Towns and Pickens counties intrude the Carolina gneiss and micaceous schist of the pre-Cambrian, one of the oldest formations of the Crystalline area (B4).

While muscovite is the principal mica in metasedimentary rocks, it is also plentiful in some pegmatites associated with the granitic complex. The Jeff Davis formation, in the Thomaston area, is a granite batholith, and here pegmatites bearing mica of economic value have been found in a wide belt around and associated with this structure (B1).

Uses

The industrial value of sheet mica is determined by the following properties: size, color, clearness, a uniform perfect cleavage, good flexibility, a low electric power factor, and freedom from intergrowths with other minerals and from clay, spots and stains (A12). The electric and electronic industries are important users of sheet mica as an insulating material. Mica is employed in nearly all electrical equipment, with the lower grade material utilized in household appliances. Scrap mica is recovered by wet or dry grinding and sold in powdered form. It is obtained from waste, a by-product of the mining of sheet mica and feldspar, recovered from processing kaolin, and found as clay-stained mica in soft weathered pegmatites and micaceous schists. Wet mica is ground in a bath which removes the impurities and produces a higher quality product than dry grinding -- an operation which pulverizes the scrap in a hammer-mill type process. The wet ground mica is used in paints, mineral lubricants, wall-board, tile, paper, rubber and plastics. Dry ground mica is used in concrete, stucco, backing for asphalt roofing, dusting powder for rubber tires, fireproofing material, lubricants, and in molded insulation.

Quality and Quantity

Muscovite, Georgia's only commercial mica, is an orthosilicate of aluminum and potassium. It shows a wide color range of white, gray, yellow, amber, rum, ruby and green. Mica is classified as a strategic mineral by the federal government and has been price-supported for many years. The U.S. Bureau of Mines designates mica as sheet or scrap, and industry uses mica in three forms: sheets trimmed to specifications, films or narrow splittings, and finely ground mica powder. Mica crystals, or "books" as they are called, have been found outside of Georgia in excess of 2,000 pounds. However, most books are very small and produce sheets less than six inches in diameter. Because of perfect basal cleavage, the sheets can be split 1/1000 of an inch thick. Such extremely thin films of mica are called splittings and can be bonded together with a shellac type substance, built up, and heated under pressure to form micanite or mica-board.

In April, 1961, clear sheet mica was bringing from 70¢ to $1.10 per pound, f.o.b. mines, for sheets of 1 1/2 x 2 inches to $4 to $8 for 6 x 8 inch sheets. On other grades the prices were:

punch mica	7¢ to 12¢ per pound
wet ground mica (very fine)	$140 to $155 per ton
dry ground mica	$ 30 to $ 55 per ton
scrap mica	$ 20 to $ 30 per ton

Reserve estimates of Georgia mica have not been published, either for individual areas or for the State as a whole. Estimation of mica reserves would be very uncertain, even with the increased knowledge of its occurrence. Nevertheless, the known economic occurrences are sufficiently numerous to provide satisfactory guidance for any future prospecting, should improved conditions in the industry warrant stimulation of this output. One of the many areas where such prospecting could start is the Bowersville-Canon area, near the Franklin-Hart county line. Other prospects and/or old abandoned mining sites are common throughout north Georgia, particularly in Cobb, Upson, Habersham, Hart, Monroe, Lamar, Elbert, Gwinnett, Rabun, Cherokee and Pickens counties.

Prominent among the earlier prospects and mines were those near Canton in Cherokee County, north of Dahlonega in Lumpkin County near the Union County line, east of Clayton in Rabun County, and near Gainesville in Hall County (B11).

OCHER

Outlook

The outlook for ocher is not promising.

Production Status

From about 1878 until 1950, nine ocher mines had been worked with an aggregate total of about 340,000 short tons being produced (H4). In 1960, the New Riverside Ocher Company at Cartersville was the only producing company and, as a consequence, the U.S. Bureau of Mines reported no tonnage figures of producers, only a 21% decrease in tonnage and a 6% decrease in value as against the 1959 output (E5).

Location and Occurrence

Commercial ocher deposits in Georgia are confined to the Cartersville mining district of Bartow County. The deposits consist of finely intermixed limonite and clay, with smaller and variable proportions of fine-grained quartz, muscovite and, irregularly, some flakes and slabs of specular hematite (H4). Their occurrence is limited mainly to the weathered, surficial part of the Shady formation (Lower Cambrian) where the ocher is thinly bedded in conformable relation with the underlying Weisner rocks. Small amounts of ocher also occur in quartzite of the Weisner formation.

The ocher is believed to be the weathered remains of a specular hematite bed that composes the lowermost part of the Shady formation which, in this district, has a maximum thickness of 30 feet and is exposed for about 18 miles north from Bartow Mountain (H4). In addition, some ocher is thought to be derived from weathered pyrite, particularly where found in fault zones.

Uses

Ocher is used as a pigment.

Quality and Quantity

Refined ocher contains at least 50% Fe_2O_3 and most contain 55 to 60%, and specifications require that 99% of it shall be 325 mesh (H4). Crude ocher mined in recent years has contained from 45 to 56% Fe_2O_3.

There are no published estimates of ocher reserves but Kesler has stated that "it appears probable. . . that most, if not all, of the larger ocher deposits have been found, and that the reserves of better-grade material are probably rather small in proportion to the total amount of ocher already produced." (H4.)

PEAT

Outlook

Utilization of Georgia peat for agricultural and horticultural purposes is expected to decrease slightly, but not significantly. Peat is a Georgia resource that deserves much more attention as to possible new uses. Under certain conditions, it might be suitable as a fuel resource, but exploration for size and quality of reserves is needed to stimulate this or any other new uses. As rivers, such as the Suwannee and St. Marys, become navigable, barge transportation might open new markets.

Production Status

Since 1945, peat production has been reported from Charlton, Lowndes, Pike and Screven counties, with total annual outputs ranging from 2,104 to 4,672 short tons and values from about $45,000 to $51,000 (E8). The 1960 output from Lowndes and Screven counties totaled 6,904 short tons, valued at $89,000 (E3).

Location and Occurrence

Peat, found in bogs or swamps, is partly decomposed plant material whose decomposition has been arrested by the water. Large deposits occur in the southern and southeastern parts of Georgia, especially in the Okefenokee Swamp area (D12, H8). A deposit of peat suitable for fertilizer is reported to extend over about 600 acres to a depth of about five feet near Pineora in Effingham County (H8).

There are extensive peat deposits in the East Flatwood Region of north Florida which includes a number of counties along the Florida-Georgia state border adjacent or near the Okefenokee Swamp. The Georgia counties which border this Flatwood Region are Camden, Charlton, Clinch, Echols, Lowndes and Ware. Brantley County, at the northeast edge of the swamp, also is of potential interest.

Quality and Quantity

At present, Georgia peat is being used exclusively for agricultural and horticultural purposes. Since analyses of the peat from Duval County, Florida, indicate that it is equal to the best peat produced in the Great Lakes states and that it has higher calorific value and lower ash content than much of the New England peat (H8), presumably the peat from the adjacent Georgia counties should be useful as fuel. Analyses of the Georgia peat are not available.

The quantity of peat available in Georgia is unknown, but it is reported that "large amounts" are present, especially in the Okefenokee Swamp area (D12).

SAND AND GRAVEL

Outlook

The economy of the sand and gravel industry depends primarily upon construction and particularly upon highway paving. The upward trend in highway construction is expected to continue for many years. Building construction volume also may be expected to continue to expand during the next decade and, as a result, a continuing steady demand for sand and gravel can be anticipated.

Production Status

Sand and gravel combine to make one of Georgia's most important mineral products. Recently increased building and road construction in the State has served to stimulate production of these basic commodities. A new outlet for glass sand at Atlanta also has improved the output of that material.

Thirty-three companies produced sands and gravels in 22 counties of Georgia during 1960, with Brooks, Crawford, Muscogee, Talbot, Taylor and Thomas being the principal producing counties. The State's leading producers in 1960 were Atlanta Sand and Supply Company (Crawford County), Bannockburn Sand Company (Brooks County), Brown Brothers (Talbot County), Dawes Silica Mining Company (Dougherty, Effingham, Long and Thomas counties), and Howard Sand Company and Taylor Sand Company (Taylor County) (E3). These companies supplied the bulk of the State's commercial sands -- building, filter, abrasive, molding, glass, paving, fill, and others.

Both sand and gravel are mined from open pits which can vary greatly in depth and may extend laterally for many hundred feet; they are mined with sand pumps where water is a barrier. Heavy equipment such as draglines, shovels, and bulldozers are used in the mining process. Frequently, conveyor belts and grab buckets are used to carry the material from the mine to the plant where it is cleaned and graded.

Many communities have unimportant pits yielding material for local purposes only; consequently, these tonnages may not appear in the overall production figures. Of the total sand and gravel produced in Georgia during 1960, sand was 15% higher in tonnage but only 2% greater in value than for the preceding year. (See Table 17.)

Uses

Table 17

SAND AND GRAVEL SOLD OR USED BY PRODUCERS, BY USES
(1959-1960)

	1959			1960		
	Short Tons	Value	Average Per Ton	Short Tons	Value	Average Per Ton
Structural sand	1,981,584	$1,446,211	$0.73	2,405,893	$1,627,290	$0.68
Paving sand	326,981	225,090	0.69	395,768	281,629	0.71
Railroad ballast sand	(a)	(a)	(a)	8,787	6,814	.78
Other sand and gravel (b)	600,505	1,310,416	2.18	527,371	1,131,429	2.15
Total	2,909,070	$2,981,717	1.02	3,337,819	$3,047,162	.91

(a) Figure withheld to avoid disclosing individual company confidential data; included with "Other sand and gravel."
(b) Includes glass, molding, grinding, blast, furnace, engine, filter, railroad ballast, fill, and other sands, and structural and paving gravel.

Source: Minerals Yearbook, U.S. Bureau of Mines, 1960 (preprint).

Location and Occurrence

Both sands and gravels are widely distributed throughout Georgia. They are especially abundant in the northern part of the Coastal Plain area of south Georgia and occur as scattered deposits over much of the Crystalline area. In the latter area, sand and gravel deposits often are residual from the weathering of various formations and may occur as surficial coverings of parent rocks or as stream or bank deposits. Significant locations are along the older rivers and larger creeks where, largely as a result of weathering of the pre-Cambrian crystalline schists and gneisses, a veneer of white to gray sands covers that area.

Along the northern edge of the Coastal Plain, extending about 200 miles east-northeast from Columbus, through Macon, to Augusta, is a sand and gravel belt that marks old shorelines. Most of the State's sand and gravel is produced in the 85 miles over which this belt intermittently crops out across the counties of Muscogee, Talbot, Taylor, Crawford and Bibb. In this belt, ranging up to five miles wide, large commercial deposits occur in the Tuscaloosa formation and, to a lesser extent, in the Cusseta and Providence formations (Upper Cretaceous). The thicker sands, up to 30 feet in depth, occur where the land surfaces have higher elevations and where outcrops appear along natural sand mounds. Notable areas of production are at Columbus in Muscogee County, near Junction City in Talbot County, near Butler and Howard in Taylor County, near Gaillard in Crawford County, and at Tobescofkee Creek near Macon in Bibb County.

Sands and gravels also are mined in six other southern Georgia counties from deposits in the Hawthorn (Tertiary) sediments; these producing centers are in Brooks County, on Little River near Valdosta; along the Ocmulgee and Little Ocmulgee rivers near Lumber City in Telfair County; at Mt. Vernon, in Montgomery County; near Glennville, in Tattnall County; near Daisy in Evans County; and near Thomasville, in Thomas County. It is interesting to note that most sands of the Coastal Plain are confined to the east side of major streams, but in Thomas County they are found on the west side of the Ocklocknee River and on both sides of the Little Ocklocknee River.

In Dougherty County, near Albany, commercial sands are found along the east side of the Flint River in the recent Quaternary deposits and in the Flint River (Tertiary) formation. In Richmond County, near Martinez, the Superior Stone Company mines quartzite for concrete and roadstone from the

Little River (pre-Cambrian) series. In Effingham County, on the east side of the Ogeechee River west of Eden, sands occur in the Upper Pleistocene sediments of the Talbot and Pamlico formations. In Long County, near Ludowici, Dawes Silica Mining Company of Thomasville obtains building sand from the upper Pleistocene sediments of the Penholoway and Talbot formations. In Chatham and Glynn counties, near Savannah and Brunswick, bedded sands occur in the Pamlico formation.

In the Crystalline area, sand and gravel deposits of small lateral extent are common along major streams, in some places representing old terrace deposits. These deposits are of local commercial importance. In Bartow and Whitfield counties such deposits are in stratified beds of considerable lateral extent. In Chattooga County, sand deposits are derived from the weathering of the Knox (Cambrian) formation and are several feet thick along the southern bank of the Chattooga River near the bridge at Trion. Residual chert used in road building is also obtained from the Knox formation.

Quality and Quantity

Ordinary sands for general purposes and sands and gravels suitable for building and paving are the commonest types mined in Georgia and are in plentiful supply. The Columbus Sand & Gravel Company and the J. J. Brown Sand & Gravel Company produce large tonnages of gravel near Columbus (Muscogee County). In nearby Taylor County, Brown Brothers, Inc., at Howard and Butler Sand Company at Butler are producing concrete plaster and foundry sands. These are, in part, good quality white sands (see Table 18), that run 40 feet deep at Brown Brothers No. 1 plant (C1). The Atlanta Sand & Supply Company operates at Galliard, near Roberta (Crawford County), producing sand of several size ranges, some of which might be usable for window and bottle glass (see Table 18). The Libbey Glass Division of Owens-Illinois in Atlanta uses from 300 to 350 tons of glass sand daily, and this is supplied by the Dawes Silica Mining Company from their Thomasville operation (F2). Other potential glass sand deposits are known in the Macon area where preliminary studies indicate that W. D. Scott Company and P. N. Coley are working deposits that might yield sands suitable for green or amber glass or other lesser quality glass products (C1). (See Table 18.) Over a million tons of sand for high quality glasses are estimated as available

Table 18

ANALYSES OF GEORGIA GLASS SAND PROSPECTS

Quantitative Analyses

Compounds	1 (a)*	1 (b)*	1 (c)	2*	3 (a)*	3 (b)**
Metallic Oxides (R_2O_3)	0.20%	0.40%	N.R.	0.71%	1.05%	N.R.
Alumina (Al_2O_3)	0.00	0.29	0.09%	0.63	N.R.	N.R.
Iron Oxide (FeO_3)	0.05	0.11	N.R.	0.08	0.30	0.03-0.09
Silica (SiO_2) (calculated)	00.75	99.60	N.R.	99.29	98.95	N.R.

Compounds	4 (a)	4 (b)*	4 (d)**	5 (a)	5 (b)	6
Metallic Oxides (R_2O_3)	N.R.	N.R.		0.78%	0.15%	N.R.
Alumina (Al_2O_3)	0.10-2.84%	0.47-26.1%		0.64	N.R.	N.R.
Iron Oxide (Fe_2O_3)	0.10-1.04	0.26-0.67	0.01	0.14	0.04	0.15%
Silica (SiO_2) (calculated)	N.R.	N.R.		99.22	98.85	98.5

Dry Screen Analyses

Mesh Size	1 (a)	1 (a)	3 (a)	6	Mesh Size	2 (a)	2 (b)	Mesh Size	4 (c)
30	32.1%	52.5%	44.5%	0.0	30	N.R.	30.0%	5	0.20%
40	25.3	24.5	17.7	0.2%	35-40	35.3%	16.8	+ 5-0	2.01
50	50.0	15.3	14.7	36.2	48-50	25.4	15.4	+ 9	14.20
70	13.3	6.1	14.5	31.6	65-70	31.1	14.9	+ 16- 32	37.90
100	2.8	0.7	5.2	8.6	100	4.6	6.0	+ 32- 60	10.70
Pan	1.3	0.8	3.5	1.9	Pan	3.7	16.5	+ 60-115	0.70
								+115-250	0.70

* Data from Glass Sand Prospecting and Analysis, Charles W. Fortson, Jr., IDB, Georgia Tech Engineering Experiment Station, August, 1959.

** Analyses by MacMillan Laboratories, Atlanta, for E. I. Du Pont de Nemours & Company, Inc., Atlanta (letter report July 13, 1962).

N.R. Not reported.

1. Brown Brothers, Inc., Plant 1, Howard: (a) production sample; (b) pit sample, sand; (c) sample, mechanically washed and screened.

2. Atlanta Sand & Supply Company, Galliard: (a) production sample and (b) pit sample

3. W. C. Scott Company, Macon: (a) production sample and (b) two other unwashed, unscreened samples.

4. P. N. Coley, Macon: (a) Eastern tract, seven samples; (b) Western tract, eight samples; (c) composite sample from 21 wells; and (d) washed and screened sample.

5. Gus Dettlebach, Reedy Creek, two miles north of Matthews: (a) unwashed sample and (b) washed sample.

6. Dawes Silica Mining Company, Eden (Savannah): states "sand probably can be beneficiated for glass use" (company analysis).

near Matthews in Jefferson County. Evidently there is no commercial production of core sand for foundry work in the State, but foundry sand for molding is mined in Effingham and Thomas counties by the Dawes Silica Mining Company; molding sand is produced at the above-mentioned Brown Brothers operation; and unwashed foundry sands are obtained in Chattooga County by the Wolf Creek Sand Company.

There are no general reserve estimates for the State's sands and gravels, except a few limited estimates on glass sand, as mentioned above. However, much more detail on areas and specific deposits is given in Teas' 1921 report (B18).

In the manufacture of glass, sand used must be white, nearly pure silica (SiO_2), and possess a uniformly rounded grain. Accordingly, it must be washed and scrubbed to remove any clay and mineral impurities and iron oxides must be kept low -- below 0.025% for the better grades of glass. A batch usually contains about 72% basic sand, 14% soda ash or alkali, and some limestone and feldspar. In Berrien County, there are deposits in the cypress swamp area where sands have been bleached white by the acid from humus, and some of these sands might prove suitable for glass manufacture purposes. Here also is another white sand worthy of glass testing that lies to depth of five feet beneath a cover of yellow sand along the Withlacoochee River, with depths of five feet or more.

Foundry sand is of two kinds: molding sand for making the mold proper into which the metal is cast, and core sand which occupies the hollow space in the cast object. Bentonite is often added to the sand to make a firm bond for casting. Georgia does not yet supply good core sand, which must have a rounded grain of uniform size which will allow heat to escape from the casting and must have good resistance to fusion at high temperatures.

Filter sand, free from clay and organic matter, is usually a beach or bank sand of uniform mesh with either sharp or rounded grains. Filter gravel is coarse and free from fine-grained sands. Sand used as an abrasive for blast-cleaning must be a clean, sharp quartz sand of medium grain. Engine sand, an ordinary sharp, clean sand which is found throughout most of south Georgia, is used to clean the rail surfaces traveled by locomotives. Railroad ballast is generally a mixture of sand and gravel, which makes a stable road bed and allows for drainage.

STONE

Outlook

The recent increasing volume of stone output in Georgia is expected to continue over the near future, due to the State's strong building boom and highway construction program.

Production Status

During 1960, total stone production continued its steady increase over the previous year (see Table 19). Crushed stone increased in both tonnage and value; dimensional granite, however, decreased in cubic footage while increasing substantially in value. For comparison purposes, the volume and value of crushed and dimension stone sold or used by Georgia producers in 1957 are shown in Table 20.

Dimensional sandstone, used chiefly for flagging and rubble, is quarried near Jasper in Pickens County by Carl Johnson, Hardy Johnson, and the North Georgia Stone Company. Slate, used for slate flour and roofing granules, is quarried from the Conasauga formation near Fairmount in Gordon County by the Funkhouser Mills Division of Ruberoid Company. The Georgia Lightweight Aggregate Company quarries slate near Rockmart in Polk County for use in the manufacture of lightweight aggregate.

The Stone Mountain and Lithonia granites and gneisses are mined for dimensional stone from 22 quarries in five counties. Chief uses are for monumental, architectural, and construction purposes. The leading producers are the Davidson Granite Company, quarrying near Lithonia in DeKalb County; the Coggins Granite Industries, Inc., in Elbert and Madison counties; the Comolli Granite Company in Elbert County; the Hoover Granite Quarries near Lexington in Oglethorpe County; and the Kelley Granite Company, Inc., in Rockdale County.

Crushed granite is produced from 23 quarries in 17 counties of the Crystalline area. Three leading producers are the Stockbridge Stone Division of Vulcan Materials Company, operating at Kennesaw in Cobb County, near Red Oak in Fulton County, and near Stockbridge in Henry County; the Weston & Brooker Company, with plants near Granite Hill in Hancock County, near Gray in Jones County, and near Camak in Warren County; and Consolidated Quarries Division

Table 19

STONE PRODUCTION IN GEORGIA, 1959-1960

Year	Short Tons	Value
1959	13,771,000	$35,973,000
1960	14,297,000	37,033,000

Source: U.S. Bureau of Mines Minerals Yearbook, 1960 (preprint)

Table 20

GEORGIA STONE SOLD OR USED BY PRODUCERS, 1957

Types of Stone	Short Tons	Value
Crushed stone:		
Granite	7,756,520	$10,533,093
Limestone	1,174,628	1,939,392
Marble, sandstone, and quartzite	(a)	(a)
Total (b)	8,931,148	$12,472,485
Dimension stone:		
Granite	126,346	3,321,421
Limestone	6,419	6,780
Marble	(a)	(a)
Sandstone and quartzite	1,182	32,144
Total (c)	133,947	$ 3,360,345
Grand Total (d)	9,065,095	$15,832,830

(a) Figure withheld to avoid disclosing individual company confidential data.
(b) Incomplete total; excludes crushed marble, sandstone, and quartzite.
(c) Incomplete total; excludes dimension marble.
(d) Incomplete total; excludes stone shown under footnotes (b) and (c).

Source: Vallely, James L., and Garland Peyton, "The Mineral Industry of Georgia," Minerals Yearbook, U.S. Bureau of Mines, 1957, p.8.

of the Georgia Marble Company, operating plants near Lithonia in DeKalb County and near Douglasville in Douglas County.

Location and Occurrence

The rocks of Georgia which are used commercially as "stone" (dimension and crushed) occur in all three of the State's geologic areas. In fact, the geology of these areas controls the distribution of the various rock types.

In the Paleozoic area of northwest Georgia occur a thick series of limestones, dolomites, shales and slates, sandstones, and coals, ranging from the Cambrian to Lower Pennsylvania in age. The thickest section is represented by the Cambrian and Cambro-Ordovocian deposits. The rocks of this area have been folded into sharp anticlines and synclines, with much attendant faulting. Differential erosion has subsequently produced the valleys and ridges so characteristic of this area. The more resistant sandstones form the ridges, while the less resistant rocks, such as shales and limestones, have weathered down to form the valley areas. Since limestone predominates, the area is composed largely of valley lands. Limestones and dolomites commercially utilized from this area, as well as from the Coastal Plain area, are discussed in the section on Limestone.

The principal sandstone horizons are the Lookout and Walden formations (Pennsylvania) in the Sand and Lookout mountains of Dade and Walker counties. The formations here attain thicknesses of 500 and 1,000 feet, respectively, and are composed of conglomerates and sandstones, with thin-bedded shales and coals. The massive and conglomeratic sandstones are potential sources of flagging for construction, but they are considered unsuited for aggregate uses.

Slates of economic value also occur in this area. Bartow, Murray and Polk counties have slates of good quality. A slate belt runs southwest from Cartersville (Bartow County) to a point a few miles south of Rockmart (Polk County) where it attains its greatest width. These slates of the Rockmart formation (Mississippian) are dark blue to black and have been the most extensively developed. Commercial production has been limited to the lower part of the Rockmart, due to the remarkable uniformity of that part of the formation. Another slate belt occurs in the vicinity of Cedartown (Polk County) (B12).

The principal sources of commercial stone in the Crystalline areas of north Georgia are the marbles (see section on Marble), granite and gneiss. The latter igneous rocks are exposed in both small and massive outcrops throughout most of the area and consist of three principal types -- the Stone Mountain (biotite-muscovite), the Palmetto (porphyritic granite), and the Lithonia (granite gneiss). The Lithonia may include a porphyritic phase or a diorite injection-gneiss and show strong bandings, possibly due to structural stresses at the time of formation; thus these are referred to as the older granites. The Stone Mountain granites exist as batholiths, stocks and dikes and are younger than the Lithonia (B2). The granites, it should be noted, do not occur at the surface south of the Fall Line.

Granite which occurs on Fort Mountain near Chatsworth (Murray County) has possibilities for lightweight aggregate manufacture because of an unusual "bloating" property. In tests made by the Georgia Tech Engineering Experiment Station in 1958, this granite bloated to a final-to-initial-volume ratio of about 1.6 - 1.8 when fired at about 2500 - 2600° F for three to eight minutes. This is a very satisfactory ratio, but the required temperature is some 200° F higher than usually used in bloating of shale for similar aggregate. Hydrous mica in the granite is believed to be the source of "gas" that causes the bloating (D4). A chemical analysis of the granite is given under "Fort Mountain" in Table 21.

The Coastal Plain area, lying south and east of the Fall Line, is underlain by a series of sands, gravels, clays, marls, sandstones, and limestones. Some of the limestones are used commercially and are described in the section on Limestone.

Quality and Quantity

The granites and other rocks of the Crystalline area afford the greatest supply source of stone in Georgia. The quality of these and other rocks of the State and their uses vary quite widely. Analyses of granites and gneisses are given in Table 21. For additional details, the reader should consult the sections on Limestone and Marble of the present report and Dr. Furcron's article on "The Distribution and Character of Stone for Aggregate in Georgia" in the Georgia Mineral Newsletter (D6).

Table 21

COMPARATIVE ANALYSES OF GEORGIA GRANITES AND GNEISSES
(Percent)

Rock	Locality	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O
Granite gneiss	Conyers	75.45	13.71	0.92	0.18	0.94	3.87	4.30
Granite gneiss	Lithonia	72.96	14.70	1.28	0.07	1.28	4.18	4.74
Granite	Lithonia	75.16	13.74	0.91	0.17	0.91	3.76	5.05
Granite	Stone Mountain	71.66	16.05	0.86	0.17	1.07	4.66	4.92
Granite	Camak	75.64	13.82	1.62	0.01	0.85	4.32	2.31
Granite	Fort Mountain	76.12	13.16	0.17	0.50	1.12	0.04	6.30

Sources: Washington, Henry S., Chemical Analyses of Igneous Rocks Published from 1884 to 1913, Inclusive, U.S. Geological Society Professional Paper No. 99, 1917; analysis of Fort Mountain granite by Law & Company, Atlanta, Georgia.

TALC AND SOAPSTONE

Outlook

Due to the adequate reserve picture, except for block steatite, little time or money is expended on talc research other than for quality control and to expand industrial applications. The deposits of Murray County and others are of the steatite variety, and some research should be initiated to promote usage of this material as block steatite with its higher value instead of grinding it into powdered talc. Further, low-cost beneficiation methods should be developed to permit utilization of the lower grade material now being wasted during mining, screening, and washing processes. The demand for finer grained ground talc should increase, and Georgia producers may find it profitable to do research on this aspect of their business.

Production Status

Current talc production in Georgia centers in Chatsworth (Murray County), where Cohutta Talc Company, Georgia Talc Company, and Southern Talc Company have processing mills and operate mines on Cohutta and Fort mountains about three miles eastward. Here mining operations have been carried on for the past 70 years by open-pit, tunnel, and shaft mines. The talc bodies vary from a few feet up to 150 feet in thickness and reach a mile in length. The bulk of the talc is the massive variety, light to dark green, dense and schiostose in structure. Impurities or "grit" consist of chlorite, magnetite, quartz and pyrite. There are limited amounts of foliated to platy very pure talc. (B6.)

In 1958, Georgia's output of talc and soapstone ranked sixth among the nation's producing states (E6). Output in 1960 totaled 53,692 short tons, essentially all of which was sold as ground talc; total value of the output in that year was $107,000. There is some production of a "fleck" type of talc material similar to granules that is used on the back of composition shingles to keep them from sticking together. Later output data are not available, but it is of interest to note that prior to 1926, the State's annual production was about 6,200 tons; by 1950 this had risen to 58,411 tons. Since then, there has been some evidence of a declining trend.

Location and Occurrence

Talc and soapstone occur as alteration products of peridotitic and pyroxene intrusions into highly metamorphosed magnesium sediments, dolomite or magnesium shale. The whiter and purer talcs are associated with sedimentary magnesium carbonate rocks. Along the contact of the peridotite and pyroxene dikes with enclosing gneisses and schists, a layer of quite pure talc may be developed with a center of massive soapstone. (B8.)

Talc and soapstone have been found at many localities in the Crystalline area of north Georgia, but commercial mining has been done at only a few places. Massive talc, associated with the peridotites, has been found in Habersham, Lumpkin, Murray, Rabun and White counties. It is also found in the pyroxene areas of Cherokee County. (B12.)

Talc deposits derived from the alteration of dolomitic limestone are found in Cherokee, Fannin and Gilmer counties. Limited mining has been done on a massive white talc deposit 3½ miles south of Blue Ridge in Fannin County, while a similarly massive but bluish-gray talc has been prospected on the Dickey property about one-half mile south of Mineral Bluff in the same county. This latter talc occurs in parallel beds about five feet in thickness, enclosed by a quartz schist of sedimentary origin; the talc contains undesirable amounts of pyrite "grit" (B12). In Cherokee County, at the Hawes soapstone mine three miles southwest of Holly Springs, the talc is both massive and foliated along the border of a pyroxene intrusion having a surface area of about 300 x 75 feet. About two miles west of Ball Ground, in the same county, a massive noncrystalline white talc deposit has been prospected.

Uses

The earliest recorded uses of soapstone were for carved ornaments, building stone, and cooking utensils. Talc now has a wide variety of uses, depending largely upon its genesis, and talcs from different deposits are not always interchangeable in industrial application.

As shown in Table 22, the uses of Georgia soapstone follow quite closely the national use-distribution for that material.

Quality and Quantity

The mineral "talc" is a hydrous silicate of magnesium, $3\ MgO.4SiO_2.H_2O$, theoretically containing 63.5% SiO_2, 31.7% MgO, and 4.8% H_2O, but the term

Table 22

AVERAGE DISTRIBUTION OF TALC AND SOAPSTONE USES
(Percent of Total)

Use	U.S. Distribution Talc	U.S. Distribution Soapstone	Soapstone Uses in Georgia (b)
Ceramics	40	2	(a)
Paints	26	3	4
Rubber	5	6	8
Insecticides	4	31	29
Paper	4	2	5
Roofing	4	31	35
Toilet Preparations	2	-	-
Textiles	2	1	2
Asphalt Fillers	1	15	16
Foundry Facings	1	3	-
Refractories	(a)	-	-
Rice Polishing	(a)	-	-
Crayons	(a)	(a)	(a)
Other	11	6	1
Total	100	100	100

(a) Less than 1 percent
(b) Similar breakdown for Georgia talc is not available.

Source: Minerals Yearbook, U.S. Bureau of Mines, 1956 and 1958.

"talc," in a broad sense, covers all gradations from the pure mineral to massive talcose rocks (soapstone) containing as little as 50% of the mineral talc. On the other hand, soapstone actually is a rock rather than a mineral, but the term is often applied to massive talc regardless of purity. "Steatite" originally was a term synonymous with "talc" but in recent years has been used to designate a grade of talc suitable for making electronic insulators.

United States reserves, other than block steatite, are adequate. Block steatite is listed as a strategic and critical material, but phosphate-bonded talc seems to be a satisfactory substitute.

At the current and near-past rates of mining, the known reserves of talc and soapstone in the Murray County district alone should be adequate for at least 30 years. In addition, new mines can be developed from known prospects. (B6.)

II

MINERALS OF COMMERCIAL AND/OR INDUSTRIAL VALUE

Formerly Produced or Undeveloped

ASBESTOS

Outlook

The future of amphibole asbestos in Georgia presently is not regarded with optimism. Any favorable change in the situation will depend on the discovery and development of suitable reserves. So long as the price of asbestos continues to be low relative to the amount of hand labor required to extract the mineral, there is no great incentive to search for new deposits.

Production Status

The United States produces only 4% to 6% of its consumption of all types of asbestos, with the western states and Maine supplying most of it. Since 1949, the U.S. annual output has averaged about 40,000 to 45,000 tons. However, prior to 1930, the top U.S. production was about 1,700 tons, and at that time Georgia's production came from Sall Mountain in White County and from near Hollywood in Habersham County. Production halted in 1921, was resumed from 1923 to 1932, and halted again until 1939. Post World War II production was mostly from the Cornelia mine near Dillard in Rabun County, with a small tonnage from the Gray mine in eastern Meriwether County. Due to the limited number of producers in Georgia specific production figures have not been available in recent years, but certain data indicate outputs of about 300 tons per year until 1958, when production in Georgia again ceased. Currently, no asbestos is being produced in the State.

Location and Occurrence

Georgia is reputed to be "the most consistent producer of amphibole asbestos of any of the states" (G7). This asbestos production has been of the anthophyllite ($7MgO.8SiO_2.H_2O$) variety of amphibole which is associated, in most cases, with peridotite intrusions both in masses and in "cross fiber" and "slip fiber" veins. The peridotites are small in area and usually cut gneisses or mica schist.

"In addition to the masses of short fibered anthophyllite, the asbestos occurs as narrow veins of a long fibered, wood-like type whose fibers, often a foot in length, are either coarse and brittle or soft and 'rotten' and hence of very little value. At Sall Mountain in White County, 12 miles west of Clarkesville, the asbestos occurs as small masses and seems to represent a complete alteration of the original igneous rock. At other localities, the asbestos occurs in veins or masses in partially altered peridotite and is associated with more or less talc, chlorite, and serpentine." (B12.)

Asbestos has usually been mined in the zone of weathering, because the rocks below that zone have been found to be too hard and the fibers too difficult to separate economically.

Counties from which asbestos deposits have been reported are Barrow, Campbell, Carroll, Clayton, Cobb, Coweta, DeKalb, Fulton*, Habersham*, Hall, Hancock, Harris, Jackson, Lumpkin, Meriwether*, Morgan, Paulding, Rabun*, Stephens, Towns, Troup, Walton and White*. The counties identified with asterisks are those with past production, with most, if not all, of the asbestos having been mined from the deposits described by Hopkins (B8).

Uses

The most important use of anthophyllite asbestos is for chemical filtering and certain types of spray paint. In addition, it is used for making plaster cements to cover boilers, pipes and furnaces, as welding rod coatings, as a filter in rubber and battery boxes, and as an admixture in cement and in plastic flooring, acoustical and other wall plasters and stucco. No large and consistent use of amphibole asbestos has been developed, and total U.S. production has seldom exceeded a few hundred tons per year.

Quality and Quantity

The reserves of anthophyllite in Georgia are not known. The higher quality and easier worked materials of all the deposits have been the first to be mined. Consequently, the worked deposits have been depleted, or nearly so, of economic grade asbestos, including many areas the literature describes as having the most promise. Despite continuing explorations of the leading asbestos districts over the years, particularly by W.P.A. projects in the 1930's (F1) and in 1948 by the State Geological Survey in cooperation with TVA (D21), there has been little success in finding new deposits of economic value.

BERYL

Outlook

The outlook for beryl consumption in the United States is more optimistic than it has been in the past. The growing military use of beryllium metal and the increasing uses in high-quality engineering alloys have sparked considerable interest in the metal.

Recent development of a "berylometer" which detects the presence of beryllium in any form should facilitate exploration. At present this instrument is restricted to detection of beryllium to a depth of only a few inches beneath the surface, but research should increase its capabilities. Research is also being done on more economical methods of concentration.

The beryl resources of Georgia may in the future offer greater opportunities than currently, particularly as new demands for beryl are developed and as new exploration and beneficiation techniques are advanced.

Production Status

Sales of beryl from Georgia during the period 1952 through 1957, based on shipments to U.S. depots in North Carolina, are given in Table 23. Beryl is not reported as having been produced in Georgia in 1958, 1959 and 1960.

Location and Occurrence

Beryl, the principal ore of beryllium, is a beryllium aluminum silicate ($Be_3Al_2Si_6O_{18}$). It is found only in the Crystalline area of the State with occurrences reported from 23 or more counties, including Banks, Barrow, Cherokee, Clarke, DeKalb, Elbert, Forsyth, Franklin, Hart, Jackson, Jasper, Jones, Lamar, Meriwether, Morgan, Oconee, Pickens, Rabun, Spalding, Stephens, Troup, Upson and Walton. Of these, only Cherokee, Morgan, Pickens and Troup counties have reported any production in the past.

"Beryl is found. . .in pegmatites, quartz veins and lenses, and in ore against quartz lenses in pegmatites. Wherever there is a mica pegmatite, there is the possibility of beryl and. . .it may be scattered throughout the pegmatite dike, or may occur locally within it.

"Small pockets or segregations of beryl may be found in good sheet mica pegmatites, but if the beryl is well distributed, the sheet mica is usually

Table 23

SALES OF GEORGIA BERYL, 1952-1957

County	Mine(s)	Pounds
Cherokee	Bennett	130
Cherokee	Cochran	4,064
Morgan	Near the bridge at High Shoals	200
Pickens	Denson Mines	1,567
Troup	Foley (Hogg property)	172,401

Source: Furcron, A. S., "Beryl in Georgia," Georgia Mineral Newsletter, Vol. XII, No. 3, 1959.

of poor quality and suitable only for grinding. The mineral also tends to be associated with potash feldspar. . .

"Rather high-temperature quartz solutions pick up beryllium from enclosing rocks. A small lens of quartz several inches thick and about one foot long but containing a relatively large beryl crystal was noted by (Furcron) some years ago in the gneiss along the old incompleted road from Brasstown Bald to Young Harris.

"Gem beryl is common in this state particularly the variety known as aquamarine, which ranges from colorless to clear pale blue, to clear light-green. Yellow beryl or heliodor is less common. Beryl crystals, which are flecked with clear blue patches of aquamarine, are common locally. In all cases the precious variety is found associated with common green beryl and the latter variety is usually much more abundant." (D3.)

Uses

Uses of beryllium are in alloys, particularly with copper, as a hardening and strengthening agent; alloys for certain nonsparking tools; surgical instruments; springs; X-ray tube windows; as a deoxidizing agent in certain molten metals; and as a moderator material in nuclear reactors. In recent years, interest in beryllium has developed in the fields of nuclear energy, supersonic aircraft, missiles, and space vehicles.

Quality and Quantity

The beryl from Georgia, as noted above, is usually of two varieties -- aquamarine, which is relatively common, and yellow beryl, which is less common. Pure beryl contains about 14% BeO, 19% Al_2O_3, and 67% SiO_2, but beryl most commonly contains only 10 to 12% BeO.

Beryl has generally been found as a by-product of mica mining. Drilling or other specific exploration directed toward finding beryl has not been reported upon for Georgia, although some prospect work has been done here by the U.S. Bureau of Mines. Accordingly, the reserves of beryl in Georgia are not known.

COPPER

Outlook

The outlook for copper in the State of Georgia is not bright. Additional drilling and geophysical and geochemical prospecting should be done in the various sulfide zone areas. Techniques using resistivity and self-potential voltage anomalies have been very successful in sulfide ore prospecting. This, coupled with geochemical testing and followed by drilling, could lead to commercial copper production in the State, particularly if sulfuric acid could be produced as a by-product of the sulfide deposits.

Production Status

None of the mines reported to contain copper has been worked since about World War I. Production is not known to be planned for any time in the near future.

Location and Occurrence

"Known copper deposits occur in three rather distinctively definite localities, all within the Crystalline area" of north Georgia (D8). The first of these localities is an extension from the Ducktown, Tennessee copper-producing district into Fannin County. Copper has been mined here in the past from Mine No. 20 and from the Mobile mine, both of which are about three miles south of Copper Hill, Tennessee (B11). The second locality is about two counties wide and extends northeast from Carroll and Haralson counties to Towns and Rabun counties. The northern side of this area is reported to be the most heavily mineralized. Mines worked in the past were the Canton Copper Mine about 1¼ miles south of Canton (Cherokee County), the Waldrop Copper Mine about four miles northwest of Draketown (Haralson County), the Tallapoosa mine about three miles northwest of Draketown, and the Chestatee mine about six miles northeast of Dahlonega (Lumpkin County).

The third locality consists of widely separated veins reported from Lincoln, Wilkes and Greene counties. Here, near the Wilkes-Lincoln county line west-southwest of Lincolnton, were operated the Magruder and Chambers mines and a third mine about five miles north-northeast of Union Point in Greene County (G12).

The Magruder was originally a gold mine but was operated, along with the Chambers Mine, essentially for copper by the Seminole Mining Company from 1897 to 1913. Lead also was produced (see section on Lead and Zinc).

The principal source mineral of copper in all of these localities is chalcopyrite, with common alterations to chalcocite and malachite. The copper ores always occur in veins which vary considerably in all dimensions. The variance in width is so frequent "that they may be spoken of as a series of greatly elongated lenses connected by narrow stringers." (D8.)

The ore bodies are found in three vertical zones: an uppermost zone of weathering; a second "black copper" zone near the water table, containing concentrated oxides or hydroxides of copper; and below this, a zone of unaltered mineralization. The zone of weathering may extend to depths as much as 80 feet but contains so little copper it is of no commercial interest. The "black copper" zone varies in thickness from a few inches to a foot or more.

Quality and Quantity

Two copper mines were drill-prospected by the U.S. Bureau of Mines in post-World War II years. Results of the tests at the Tallapoosa mine (Haralson County) were reported as follows: "The grade of the ore as estimated by the drill-hole samples is 31.1 percent sulfur, 28.7 percent iron, 1.9 percent copper, and 2.9 percent zinc." (G4.)

The Chestatee mine (Lumpkin County) was reported as follows: "Copper assays on early shipments from the mine are reported to have varied little from 1.6 percent. However, copper assays on ore found in the drill cores taken at greater depths indicated average copper content would not be greater than one percent." (G9.)

Reports from early mining indicate copper contents slightly in excess of 3% for these older mines, but it is believed that now the overall or average tenor of the ores would be closer to 1% copper. Reliable estimates of the ore reserves at any of the locations are not available nor is the quality of the ore known at locations other than those drilled by the U.S. Bureau of Mines. However, copper ores of less than 1% copper have been successfully mined where extensive deposits permit large-scale outputs of the ores (A16).

Outlook

Present inactivity in the Georgia gold mining areas does not mean that the ores are depleted. Much of the "easy" gold, it is true, has been mined and while geologists do not believe the ore reserves are equal to those of other, larger producing states, they "do have reason to know that the gold deposits have not been followed down in the best mines and that with assistance the better prospects and mines could be re-opened." (D14.) In brief, there has been recent thinking that, in view of the nation's dwindling gold reserves and their relationship to the United States' position in world trade, perhaps some effort might be made at federal levels to subsidize gold mining to increase production (D14). There is little incentive to mine gold today, in the face of a price pegged at $35 per ounce since 1933, while mining costs probably have tripled since that time.

The Georgia gold-bearing areas have never been systematically drill-prospected, yet explorations of many of the largest veins have shown ore values ranging from $6 to $15 per ton, although these have not been sufficiently exploited to establish such values as an overall average. However, ore of this tenor, if present in quantities sufficient for large-scale operations, would permit profitable mining. Further, exploration of the larger veins at depth might reveal mineable quantities of associated lead, silver, zinc or copper ores. (See sections on Lead and Zinc and Copper.)

Production Status

Gold production in Georgia had become so important by 1838 that the United States government opened a branch mint at Dahlonega in that year, and this continued in operation until 1861. Between 1799 and 1907 Georgia produced $17,519,390 worth of gold at the then existing prices. In 1908, Georgia's annual production was a little over $56,000, and until World War I, the State's annual output ranged between $14,360 and about $35,000. From the end of World War I until the late 30's, the annual production ranged in value from less than $1,000 to as much as $9,500 in 1925. During and since World War II, gold mining in Georgia has been negligible. However, in early 1961, a group of Ohio and Pennsylvania interests leased the John C. Calhoun mine near Dahlonega for the purpose of reopening this well known property.

It was here, in 1939, that the so-called "News of the Day Lode" was struck and attracted widespread attention.

Location and Occurrence

The initial discovery of gold in Georgia is unknown, but some believe that the earliest Spanish explorers mined placers in the State, although the exact locations have not been identified. Following the Spaniards, there is no further record on gold in Georgia until its rediscovery on Dukes Creek (White County) in 1828 or 1829 (exact date unknown). Other accounts place the discovery near Nacoochee (White County) and on the Calhoun property, near Dahlonega (Lumpkin County)(B11). By 1830, some 6,000 to 10,000 persons are estimated to have been engaged in gold mining, and Georgia, prior to the California gold rush of '49, had become the nation's topmost gold-producing state.

Gold has been found in Georgia in several narrow and well-defined belts, although isolated areas near these belts also occur commonly. The Dahlonega belt, about 150 miles long and two to six miles wide, extends from Haralson County at the Alabama line through Paulding County and across the northwest corner of Cobb County and the southeast corner of Bartow County, through Cherokee County and the extreme northwest corner of Forsyth County, and thence through Dawson, Lumpkin, White, Habersham and Rabun counties into North Carolina. The most important gold mining area of the State has been in this belt, centering around Dahlonega in Lumpkin County. The Hall County belt, about 100 miles long, begins in northern Fulton County and extends through the extreme southeast corner of Forsyth County and the northwestern part of Gwinnett County and thence across Hall, Habersham and Rabun counties into North Carolina. The McDuffie County belt, about 30 miles long and two miles wide, begins in northeast Warren County and extends northeast across the northern part of McDuffie County and the extreme southeast corner of Wilkes County, through Lincoln County to the Savannah River. The Carroll County belt, with a length of some 50 miles and a maximum width of two miles, starts in western Carroll County, passes through parts of Douglas, Paulding and Cobb counties, and then joins the Dahlonega belt at the northern edge of Cobb County. The Oglethorpe County belt, about 25 miles long, extends northeast through eastern Oglethorpe County. The Madison County belt, about 10 miles long, is in Madison and Elbert counties approximately between Bowman and Comer.

Minor areas include the Gumlog belt, in the northern parts of Union and Towns counties; the Coosa Creek belt, between the headwaters of Coosa Creek (Union County) and Young Harris (Towns County); and the Hightower Creek belt, extending from the headwaters of Hiawassee River in Towns County to near the North Carolina line.

Three principal types of gold deposits are recognized in Georgia: vein deposits, placer deposits, and auriferous saprolites (or decomposed rock in place) (B12).

While there are several varieties of veins, the predominant type of vein conforms largely to the generally northeast-southwest trend of the inclosing schists and gneisses, and these veins pinch and swell both horizontally and vertically. Thus bodies of ore 15 to 20 feet thick may pinch out in a short distance, at the same level, to a small stringer or seam of quartz. These conditions render mining difficult and preclude accurate estimation of available ores in a deposit.

HEAVY MINERALS

Outlook

In addition to the work already done on Georgia's heavy minerals, extensive prospecting will be necessary to locate and then delineate areas in which economic production may take place. None of the heavy mineral deposits can be mined without consideration of all the heavy minerals present. With adequate geologic and engineering guidance, successful production undoubtedly could be achieved.

Production Status

Georgia has had no heavy mineral production, although significant outputs of titanium, zircon and monazite have been reported from that part of Florida immediately south of the Georgia-Florida border and from the adjacent Aiken, South Carolina, area where the output has been principally monazite.

Location and Occurrence

The term "heavy minerals" refers to those minerals that usually occur as accessories in igneous and metamorphic rocks which, upon weathering and erosion, are transported by the action of wind, water, and gravity to stream bars, deltaic sediments, and ocean beaches, there commonly to be further concentrated by the winnowing action of the wind and coastal storms. Such heavy minerals also are found widely disseminated in the Coastal Plain sediments. Economic concentrations, however, are confined to stream and beach placers, with a substantial concentration in coastal terraces. (G10.)

Individual mineral constituents of heavy mineral suites include such diverse species as: andalusite, anatase, arizonite, brookite, corundum, epidote, garnet, hematite, hornblende, ilmenite, leucoxene, magnetite, monazite, rutile, staurolite, spinel, tourmaline and zircon. As a rule, the specific gravities of the heavy minerals equal or exceed 3.0, so that they readily separate from the more abundant, lighter constituents of the sands, especially quartz and feldspar. (B18.)

Because of the observed concentration of heavy mineral sands along present shore lines, geologists have turned their investigations to ancient shore lines, which are now frequently preserved as "terraces" roughly parallel to and west of the present coast line at distances ranging from 20 up to 100 miles. (G13.)

The commercially significant heavy minerals are (1) the titanium group, (2) zircon, (3) monazite and, to some degree, (4) magnetite. The principal titanium minerals are ilmenite (53% TiO_2) and rutile (100% TiO_2). Zircon is a source of zirconium and hafnium. Monazite, a source of thorium, cerium and other rare earth metals, occurs usually as an occasional by-product of titanium ores. (G14, G15, H7.)

An aerial reconnaissance of the beaches along the Georgia coast, as well as along those of North and South Carolina, has revealed that the "black sand" (i.e., heavy mineral) concentrates are more widespread than has previously been reported (A10). Concentrations of titanium-bearing sands occur along the entire Georgia coast, both in the islands and in terraces west of the present shore. Heavy sands concentrations have been especially noted near the southern ends of St. Simons and Sapelo islands (G10).

As noted above, titanium-bearing sands are common along the Georgia coast. Zircon, as found in the concentrates sampled from Georgia, ranged from 24 to 50%, with a mean value of 33% (H6). Monazite constitutes less than 0.1% of the sediments, except rarely where the deposits have been reworked by waves, rain and wind. In the vicinity of Aiken, South Carolina, however, are large deposits in which monazite reportedly may be the primary mineral, with associated other heavy minerals that are recoverable as by-products (H7).

At a few places along the eastern margin of the Okefenokee Swamp, concentrations of up to 1% of heavy minerals have been found in the topmost several feet of surface sediments. This occurrence may represent an extension of the Trail Ridge deposits of Florida, just to the south. Such percentage is economically significant in view of the practically nonexistent overburden. (H5, H6.)

KYANITE AND SILLIMANITE

Outlook

Kyanite production in the United States has increased at an average annual rate of approximately 10% for the past 10 years and should continue to increase at the same rate (G11).

Among the problems of the industry are the inability to substitute domestic kyanite for imported massive varieties and lack of knowledge on the utilization of lower grade bauxite or other highly aluminous materials. Research directed toward utilization of Georgia's kyanite and sillimanite, in conjunction with the State's high-alumina clays, at a site near low-cost natural gas in the Fall Line area should be investigated.

Production Status

Neither kyanite nor sillimanite is being produced in Georgia. Principal past production has been from Alec Mountain, six miles northwest of Clarkesville (Habersham County), with some placer kyanite mined from a stream a mile northeast of Clarkesville. A prospect near Ball Ground (Cherokee County) reportedly produced one rail carload, and a very small amount was shipped from another prospect on Gumlog Mountain (Towns County).

Late in 1961, the mineral rights to Graves Mountain near Lincolnton (Lincoln County) were acquired by Aluminium Silicates, Inc., of Boston, Massachusetts for the reported purpose of mining kyanite.

Location and Occurrence

Kyanite and sillimanite, different crystal forms of the same chemical compound (Al_2SiO_5) are found in some quantity in Georgia, but andalusite, another mineral variety of this same compound, is not known in the State.

Kyanite has been reported from the following counties: Cherokee, Dawson, Fannin, Fulton, Gilmer, Habersham, Lincoln, Pickens, Pike, Rabun, Talbot, Towns, Union, Upson and Wilkes.

Kyanite has several types of occurrence in Georgia: (1) Kyanite crystals disseminated in mica schist or quartzite is typical of the deposits commercially worked in Virginia, North Carolina and Georgia. (2) Lenses, stringers, and vein-like masses of interlocking bladed blue kyanite crystals, associated with quartz veins and stringers and pegmatites, are the types that were prospected west of Ball Ground (Cherokee County) and by the A. C. Spark Plug Company on Gumlog Mountain (Towns County). Since the deposits are small and local in distribution, they have not been commercially mined thus far. (3) Nodules or segregations, in biotite schist, of dense massive interlocking crystals of blue-gray kyanite occur as masses, ranging up to 800 pounds, in association with pegmatites and intrusive quartz veins. This type of kyanite is similar to that imported from India. (4) Some kyanite showing alteration to sillimanite also has been reported. (B5.)

Several types of sillimanite deposits also have been noted: (1) Sillimanite crystals and bundles of crystals disseminated in schists which have been intruded and recrystallized by granite and pegmatite is the type of deposit that apparently offers most promise for commercial production. Such deposits are described from Hart, Elbert and Madison counties. (2) Stringers and lenses of "fibrolite" or fibrous sillimanite and quartz in schist associated with intrusive pegmatite and granite comprise deposits described from the Davy Mountain-Brasstown Church area of Towns County, as well as from many other isolated areas. These deposits generally are small, and fine grinding is necessary in order to obtain a concentrate. (3) Nodules and segregations of massive sillimanite in schist also have been noted as local occurrences in the Davy Mountain area and in Hart County. (4) Button and flattened pebble-like masses of sillimanite (fibrolite) and quartz in schist, a peculiar "pseudo-conglomeratic" type, occur in the region of the Amicalola River. (5) Sillimanite replacing kyanite also has been found in the Davy Mountain-Brasstown Church belt. (B5.)

Quality and Quantity

The Georgia kyanite deposits range from a few scattered fragments to areas of several acres thickly covered with kyanite. None of the deposits has been prospected, so that it is difficult to estimate available tonnages, but these do seem not to be large at any discovery locality, despite the presence of commercial ore in the soil and subsoil.

Published analyses of Georgia kyanite show an Al_2O_3 content of 57% to 61%. Testing of massive kyanite by the U.S. Bureau of Mines at Norris, Tennessee, indicated that it was superior to other domestic kyanites then being produced but not as good as some imports, especially from India (B5).

In the Hart-Elbert-Madison counties belt, it is estimated that 54,000,000 tons of refined sillimanite could be produced on a 15% average sillimanite content (B5). This belt is east of Bowman and strikes northeast-southwest, being crossed by both the Southern and Seaboard Airline railways. Tonnage estimates are not given for other Georgia locations, but channel samples have varied from 2.5% to 7% sillimanite and selected chip samples, from 8.5% to 21.5%.

Samples of sillimanite from the Hart-Elbert-Madison counties belt, taken 3.5 miles northeast of Bowman, were ground to 28-mesh and concentrated by gravity tabling and flotation, with an 80% recovery. This concentrate, further purified by removal of iron-bearing minerals with a magnetic separator, had the following analysis:

SiO_2	39.69%
Al_2O_3	57.95
TiO_2	0.20
Fe_2O_3	0.99
Total	98.83%

LEAD AND ZINC

Outlook

Since the pyrite and copper deposits in Georgia commonly exhibit little or no surface indications, extensive geochemical and geophysical prospecting, in conjunction with drill exploration, will be necessary for the discovery of future deposits. Further, the gold mines of the State have been abandoned at depths that are relatively shallow compared with those of the majority of the world's gold mines; consequently, explorations in these Georgia mines will have to be extended to much greater depths before the possibility of associated lead and zinc deposits can be discounted. This current lack of knowledge about the possibilities for finding sizable deposits of these ores at depth strongly points up the need for concerted exploration of the metalliferous zones of the State.

Production Status

Currently, Georgia is not a producer of lead or zinc. The only known area where lead and zinc have been produced as other than by-products is the Magruder deposit near Lincolnton. It was first opened as a gold mine but eventual production was mostly copper and lead. When mining was discontinued there in 1940, a total of 50 cars of concentrates had been shipped since the mine opened. The records of the Georgia Copper Company reveal that in 1921 the per-ton mining cost was $13.75 against a smelter return of $40.00, yielding a gross profit of $26.25 per ton. At that time, the ratio of mine ore to concentrates was 3 to 1. (G12.)

Location and Occurrence

Lead and zinc generally occur in Georgia in association with pyrite (FeS), copper, and gold deposits, and such occurrences are discussed in this report under these respective mineral headings since lead and zinc are usually not the dominant economic minerals. Exceptions, however, are the Magruder and Chambers mines described below.

Pyrite and copper occurrences are confined mainly to the Crystalline area of the State, with the principal deposits in Carroll, Cherokee, Cobb, Fannin, Forsyth, Haralson, Lumpkin, Paulding and White counties. Prospects and lesser deposits are known in Banks, Fulton, Floyd, Habersham, Hall, Lincoln, Towns and Wilkes counties. (B3, B15.)

The gold deposits of Georgia are in a belt that extends from near Montgomery, Alabama, to Clayton, Georgia, and includes a number of the above-mentioned counties. Lead and zinc have been reported in association with gold in several of the counties. (G12, H3.)

The most noteworthy occurrence of lead and zinc in the State, insofar as is known, is at the Magruder and Chambers mines which are on the Lincoln-Wilkes County line west southwest of Lincolnton. The ore of this area is siliceous and mineralogically complex, containing gold, silver, copper, lead and zinc. The rock series consists of sericitic, chloritic, and amphibole-pyroxene rocks, all considerably silicified and otherwise altered. Mineralizing solutions attacked and removed considerable amounts of silica, rendering the rock sugary and porous. Pyrite was deposited extensively throughout the leached zone. Chalcopyrite, sphalerite, and galena were later spottily deposited, resulting in the formation of rich stringers and pockets of ore. (G12.)

Quality and Quantity

Published analyses of various ore samples from the Magruder mine range from 1.76 to 41.76% lead and from 0.74 to 41.47% zinc. In 1948-1949 the U.S. Bureau of Mines drilled and sampled the areas of the Magruder and Chambers mines. No estimates of reserves were given, but ore-sample analyses revealed a maximum of 12.0% zinc, 4.95% lead, 0.86% gold, 1.02% silver and 4.28% copper. However, it should be recognized that these analyses were for individual core sections, taken under difficult conditions after the mines had ceased operation. (G12.)

No production data are available for the Chambers mine or for the lead and zinc extracted during the former extensive pyrite, gold and copper operations in the State.

PYRITE

Outlook

The future mining of pyrite in Georgia will depend on the economies of production: the world supply of sulfur and the demand for accessory minerals, such as copper.

Production Status

Pyrite has not been mined in Georgia since about World War I. The most active producing areas in the past were near Villa Rica and at Reid's Mountain on the Central of Georgia Railway two miles southeast of Bremen, both in Carroll County. The Villa Rica property, 2½ miles north of town, was mined continuously from 1899 until 1917 by the Virginia-Carolina Chemical Company. The ores here were in a massive condition, often quite pure, and needed no further treatment. In the period 1904-1908, annual outputs ranged from about 18,000 to 30,000 tons.

In Haralson County, the Smith-McCandless pyrite mine was four miles north of Draketown, near the Haralson-Paulding County line. The ore of the Tallapoosa copper mine, three miles northwest of Draketown in Haralson County, was mainly pyrite; The Waldrop mine, four miles northwest of Draketown, also produced pyrite, although it was originally worked as a copper mine (see section on Copper). The Cobb County deposits are near Acworth. Considerable pyrite mining was done two miles west of Hiram, in Paulding County, at the intersection of the Seaboard and Southern railroads. The most extensive and important Cherokee County deposit is known as the Blake pyrites mine, near the Creighton gold mine, about six miles east of Ball Ground. The pyrite here is reportedly in a finely granular condition. Another excellent prospect is in the immediate vicinity of the Blake mine. The main deposit in Lumpkin County is on the Chestatee River, six miles northeast of Dahlonega. In addition to the above, there are a few other deposits in Fannin and Cherokee counties. (B12.)

Location and Occurrence

Pyrite deposits of possible commercial interest appear to be confined to the Crystalline area. The most important reported localities are in Carroll, Haralson, Paulding, Cobb, Cherokee and Lumpkin counties where all of the deposits are associated with schists and gneiss.

III

MINERALS OF POSSIBLE OR UNCERTAIN VALUE

CHROMITE

Outlook

Chromium is designated as a strategic and critical material in the United States. The trend towards utilization of lower grade ores is favorable to Georgia's apparently low-grade deposits, but any future development here will depend upon the United States being cut off from present foreign sources or some other factor drastically altering the world-wide situation.

Laboratory research on the chromite ore from the Louise area in Troup County has been suggested to determine whether the chromite can be readily separated from the talc with which it occurs and whether this talc could be recovered as a commercial by-product. It is further suggested that systematic sampling of dunites and the less basic peridotites should be done to determine whether they contain recoverable chromite in economic quantities (F1).

Production Status

Chromite has never been commercially produced in Georgia. Since 1958, Montana has been the only producer in the United States.

Location and Occurrence

Chromite, the only commercial mineral of chromium, occurs chiefly in intrusive peridotite, serpentine (alteration products of peridotite), and the peridotite parts of igneous rock complexes (G11). In Georgia, chromite is associated with ultrabasic rocks and is thus restricted to the Crystalline area of north Georgia. There it is found at many points as pebbles scattered about the ground surface.

Chromite deposits have been reported in Harris County, five miles west of Waverly Hall; in Troup County, 1½ miles southeast of Louise; and in Towns County, about five miles southeast of Hiawassee and at the abandoned Hog Creek open-pit corundum mine two miles southwest of Hiawassee (D2).

The Louise chromite deposit, as described in a U.S. Bureau of Mines report of investigations which included core drilling, is largely biotite gneiss in which occur fine grains of magnetite and chrome-magnetites or ilmenite (G2). Also present are some asbestos, corundum, and nickel. This is the only Georgia locality known to have any appreciable amount of chromite. Dr. A. S. Furcron reports that the chromite-bearing areas seen at the two localities near Louise are both "small." (F1.)

Quality and Quantity

The Bureau of Mines, in the above-mentioned investigation of the Louise deposit (G2), analyzed 266 samples of ore. All of this ore was generally within the range specified for the "refractory" grade of chromite, as given in the following (percentages are in terms of dry weight):

Grade	Chemical	Metallurgical	Refractory
Cr_2O_3, minimum	44%	48%	31%
$Cr_2O_3 + Al_2O_3$, minimum	--	--	60
SiO_2	5.0	8.0	5.5

U.S. consumers, it should be noted, are accepting increasing amounts of ores of lower quality than those shown above.

The reserves of Georgia chromite are not known. Since there has been considerable prospecting for asbestos and corundum, with which chromite is commonly associated, it is evident that finds of commercial deposits of chromite will be very limited, if at all.

CORUNDUM

Outlook

The outlook for corundum in Georgia is not favorable. Its future probably is mainly as a source of occasional gems and other specimens for mineral collectors.

Production Status

Corundum is usually classified as "abrasive corundum" and "gem corundum." There is no current United States production of abrasive corundum, the limited needs being supplied through imports. Manufactured carborundum today holds most of the earlier markets for this natural abrasive.

Production of corundum in Georgia during the late 1800's reportedly was good, with the output being used essentially for abrasive purposes. Recent production of corundum has been of the gem varieties, all from Hiawassee (Towns County) and listed by the U.S. Bureau of Mines as having total values of $50 for 1956, $10 for 1957, $100 for 1958 and 1959, and $1 for 1960.

The U.S. Bureau of Mines, during World War II, investigated the Hog Creek and Track Rock mines, but no deposits of commercial significance were found (G1, G3).

Location and Occurrence

The principal sources of corundum (Al_2O_3) in Georgia are small peridotite bodies which usually have a dunite core. Sizable deposits of olivine peridotite surrounded by less basic rocks occur in Rabun, Habersham, Towns and Union counties. Scattered and smaller deposits occur throughout the central and western Georgia Piedmont. The deposits are sources not only for corundum but also for asbestos, chromite, vermiculite and talc. (D5.)

"Corundum is found in the form of individual crystals, large or small, and as massive corundum. There is a great variation in color. . .the mineral may be found. . .at or near contact of the olivine peridotite. . ." (D5.)

Among the notable past producing localities are: (1) a mine on the W. B. Turner farm, Lot 1271, 19th District of southern Cobb County, where a five- to six-foot wide vein in chlorite schists proved to be "exceedingly rich" in corundum of "eminently good" quality; (2) the Alec Mountain prospect, near Clarkesville in Habersham County, the locality at which corundum was discovered in Georgia in 1893 (the specimens found here reportedly were especially beautiful red corundum); (3) at the Laurel Creek mine, on the stream of that name about one mile southwest of Pine Mountain in the southern part of Lot 72, 3rd District, where corundum was first discovered in the early 1870's and, eventually, became "the most famous corundum mine in the country and was worked until 1894" (it is still considered to offer one of the best opportunities in the State for successful mining); (4) the Hog Creek mine, about two miles southwest of Hiawassee in Towns County, which has a vein about four feet wide, in chlorite schists, in which pink corundum was common and some specimens called rubies reportedly were taken (early considered a good prospect, it was further prospected in World War II by the U.S. Bureau of Mines and only a few hand specimens of corundum were obtained); (5) the Bell Creek mine, about four miles north of Hiawassee, Lot 6, 18th District, in Towns County, reportedly an unusually rich small corundum mine with a vein yielding "beautiful pink corundum"; and (6) the Track Rock mine, about 2½ miles west of Young Harris in Union County, which yielded considerable amount of corundum in early mining but failed to reveal more than minor amounts when re-prospected in World War II. (D5.)

In addition to the above-named counties, corundum is reported from Carroll, Cherokee, Douglas, Hart, Heard, Morgan, Paulding, Troup, Upson and Walton counties.

It is difficult to locate corundum deposits from the old reports. These reports mention the names of prospectors and, in some cases, of owners, while one locates the deposits by land lots and districts. There are land lot maps for the various counties and these may be obtained, but most of them were made many years ago before the construction of roads, growth of towns, and development of modern geography.

GEM MINERALS

Outlook

Gem minerals in Georgia contribute little to the overall mineral wealth of the State, and this situation is not expected to alter significantly in the future.

Production Status

The gem minerals of Georgia are mostly collectors' items, and little or no appreciable production has been reported. The 1959 output of gem materials and mineral specimens, centering in the northern part of the State, was valued at less than $1,000 (E4).

Location and Occurrence

A large variety of minerals suitable for gems and cabinet specimens has been found in Georgia, mainly in the Crystalline area of the State. However, a few minerals, such as opal, chalcedony, jasper and agate, occur in the Coastal Plain. (B19.)

Authenticated finds of diamonds have been reported from Hall, White, Lumpkin, Clayton and Twiggs counties in Georgia, and from Lee County, Alabama, only a few miles from Columbus (Muscogee County). Unfortunately, there are few clues as to the source rock of these authenticated diamond finds.

Small rubies have been found in Towns and Habersham counties. Beautiful specimens of blue corundum have been obtained from Rabun, Walton and Paulding counties and red corundum specimens from Paulding, Towns, Hall and Habersham counties.

Excellent specimens of quartz crystals have been obtained from Rabun, Forsyth, Jones, Wilkes, Franklin and Fulton counties; Rabun County also has yielded opalescense rose quartz and amethyst (purple crystalline quartz) of the finest quality.

Smoky quartz suitable for cutting into stones occurs in Elbert, Franklin, Towns and Rabun counties.

Beautiful specimens of coral, replaced by chalcedony, have been found in upper Oligocene strata in Lowndes, Brooks and Thomas counties.

Fire opal has been reported from Washington County.

Emerald, a rich, deep-green variety of beryl, is found in Rabun and Clayton counties, but it is of little value for gems.

Garnet occurs in much of the Piedmont, and almandine garnet of a rich red color has been found in Lumpkin County.

Moonstone, a type of precious feldspar, occurs in Forsyth and Upson counties.

Probably the finest crystals of rutile in the world are those found at Graves Mountain, Lincoln County. Some $20,000 worth of these crystals have been sold. This locality also yields lazulite in fine pale-blue crystals for cabinet specimens.

Good specimens of kyanite have been found in Cobb, Habersham and Upson counties.

Epidote is reported from a number of localities, but nothing of gem value has yet been obtained.

Staurolite in cruciform crystals, forming natural ornaments, were found in Fannin and Cherokee counties.

Beautiful purple crystals of fluorite occur in the Knox dolomite of Catoosa County.

A few valuable pearls have been recovered from the shells of mussels obtained from streams in the northwestern part of the State. Oysters from along the coast have not yielded pearls of much value. (B19.)

Quality and Quantity

The abundant pegmatites that transect the northern part of the State contain many rare and valuable gems but, as a rule, the quantity of gemstone present is insufficient for commercial production. Many excellent articles concerning the gem minerals of Georgia and descriptions of mineral localities have been published in the Georgia Mineral Newsletter, Volumes I-XIII, 1948-1960.

TIN ORE

Outlook

Although commercial deposits of tin are not known in north Georgia, a program of research on placer heavy minerals would be one method of attempting to locate cassiterite-bearing source rocks.

Location and Occurrence

Cassiterite (SnO_2), the principal ore of tin, occurs in cyrstalline rocks and has been found in varying but not large quantities at several points in the eastern United States, including Georgia.

Tin reported from Georgia has been only in small amounts associated with placer gold mined in Lumpkin and White counties. In "old" Gilmer County, there is a long-standing and persistent legend of a tin deposit near the Tennessee line, but this has never been located (D13).

MISCELLANEOUS MINERALS

A few Georgia minerals have had sporadic small production or no production. These include graphite, marl and tungsten, and brief attention is given below to these currently marginal mineral products in the hope that additional exploration or changed demands will increase their potentials.

Graphite

Graphite is usually found in limited quantities interbedded with slate and schists, but it also occurs in irregular veins or small pockets or impregnations in the metamorphic rocks of the Crystalline area (B12). The especially notable occurrences are in Bartow, Cobb and Pickens counties. Deposits in lower Cambrian rocks were worked more or less continuously for several decades in the immediate vicinity of Emerson (Bartow County). Graphite also is found in Cherokee, Douglas, Elbert, Hall, Heard, Madison, Rabun, Habersham, Spalding and other north Georgia counties.

Production generally has been sporadic, with the last known output being just prior to World War II. All of the Georgia graphite was used as a filler for commercial fertilizers.

Marls

Marls are confined to, and widely distributed throughout, the Coastal Plain. They occur in more or less continuous beds associated with the limestones, sands and clays of that region (B12). The most extensive and probably the best variety of marl is the glauconitic or greensand type in the Cretaceous and Eocene formations, although other marls occur in the Oligocene, Miocene and Pliocene formations. Good exposures of marls are to be found along the Chattahoochee, Flint, and Savannah rivers, as well as along the Alapaha River in Echols County, the Big Satilla River in Camden County, and the Altamaha River in Wayne County. In addition exposures are frequently found along some of the small streams.

No production of marls is recorded for Georgia. Marl is chiefly used for fertilizer, due to its lime carbonate content, but "the true agricultural value of the marls of south Georgia has not been thoroughly investigated. . ."

An analysis of Georgia marl, obtained from the bank of the Flint River at Montezuma (Macon County), is as follows (B12):

Lime, CaO	35.54%
Magnesia, MgO	0.10
Alumina, Al_2O_3	2.20
Ferric oxide, Fe_2O_3	2.72
Titanium dioxide, TiO_2	--
Sulphur, S	0.08
Phosphorus pentoxide, P_2O_5	0.64
Silica, SiO_2	25.81
Loss on ignition	32.91
	100.00%

Tungsten

Tungsten is reported to occur in the dumps of old gold mines as follows: the Hamilton and Columbia mines, McDuffie County; Loud Placer, White County; Findley Mine, Lumpkin County; and the Creighton and Cherokee mines, Cherokee County (A5). In almost every instance, scheelite was the tungsten-bearing mineral.

There has been no production in Georgia.

REFERENCES

REFERENCES

A. Books, directories, periodicals and other publications:

1. Bridge, Josiah, "Bauxite Deposits of the Southeastern United States," Symposium on Mineral Resources of the Southeastern United States, University of Tennessee Press, 1950.
2. Cannon, H. B., "Economic Minerals in the Beach Sands of the Southeastern United States," Symposium on Mineral Resources of the Southeastern United States, University of Tennessee Press, 1950, pp. 202-210.
3. Chapman, H. H., The Iron and Steel Industries of the South, University of Alabama Press, 1953.
4. Directory of Georgia Mineral Producers, Georgia Department of Mines, Mining and Geology, Geological Survey Circular No. 2, 10th Edition, 1959.
5. Espenshade, G. A., "Occurrences of Tungsten Minerals in the Southeastern United States," Symposium on Mineral Resources of the Southeastern United States, University of Tennessee Press, 1950, p. 65.
6. Georgia Manufacturing Directory, 1960-1961, Georgia Department of Commerce, 1961.
7. Kesler, Thomas L., "Occurrence and Exploration of Barite Deposits at Cartersville, Georgia," A. I. M. E. Transactions, Mining, Vol. 184, 1949, pp. 371-375.
8. "Marble's Comeback as Building Material," Business Week, September 23, 1961, p. 81.
9. McAneny, Colin C., "Iron -- How is Direct Reduction Doing Commercially?", Engineering and Mining Journal, Vol. 161, No. 12, 1960, pp. 84-99.
10. McKelvey, V. E., and J. R. Balsley, Jr., "Distribution of Coastal Black Sands in North Carolina, South Carolina and Georgia, as Mapped from an Airplane," Economic Geology, Vol. XLIII, No. 6, 1948, pp. 518-524.
11. Miser, Hugh D., "Manganese Deposits of the Southeastern States," Symposium on Mineral Resources of the Southeastern United States, University of Tennessee Press, 1950, pp. 152-169.
12. Olson, J. C., Economic Geology of the Spruce Pine Pegmatite District, North Carolina, North Carolina Department of Conservation and Development, Division of Mineral Resources Bulletin No. 43, 1944.
13. Review of the Southeastern Iron Ores, Exclusive of the Birmingham District, with Emphasis on the Silurian Hard Ores, U. S. Department of Interior, November 1, 1959.
14. Rich, A. D., "Bleaching Clay," Industrial Minerals and Rocks, American Institute of Mining Engineers, 1960, pp. 93-102.
15. Trauffer, Walter E., "No Waste in Georgia Feldspar Plant," Pit and Quarry, Vol. 51, No. 4, October, 1958, pp. 116-119.
16. Whitlatch, George I., "Copper," Industrial Resources of Tennessee -- Copper, Tennessee State Planning Commission, Vol. 2, 1948, pp. 74-75.

B. Georgia Geological Survey Bulletins:

1. Clarke, J. W., Geology and Mineral Resources of the Thomaston Quadrangle, No. 59, 1952, p. 84.
2. Crickmay, G. W., Geology of the Crystalline Rocks of Georgia, No. 58, 1952.
3. Furcron, A. S., Geological Provinces of Georgia and Their Principal Mineral Resources, No. 56, 1950, pp. 10-20.
4. Furcron, A. S., and Kefton H. Teague, Mica-Bearing Pegmatites of Georgia, No. 48, 1943, p. 3.
5. Furcron, A. S., and Kefton H. Teague, Sillimanite and Massive Kyanite in Georgia, No. 51, 1945.
6. Furcron, A. S., and Kefton H. Teague, Talc Deposits of Murray County, Georgia, No. 53, 1947.
7. Haseltine, R. H., Iron Ore Deposits of Georgia, No. 41, 1924.
8. Hopkins, Oliver B., Asbestos, Talc, and Soapstone Deposits of Georgia, No. 29, 1914, pp. 75-189, 199, 217.
9. Hull, J. P. D., L. LaForge, and W. R. Crane, Report on the Manganese Deposits of Georgia, No. 35, 1919.
10. Maynard, T. P., Limestone and Cement Materials of North Georgia, No. 27, 1912, p. 104.
11. McCallie, S. W., Mineral Resources of Georgia, No. 23, 1910, pp. 75-78, 97, 98, 136, 147-150.
12. McCallie, S. W., Mineral Resources of Georgia, No. 23, Revised Edition, 1926, pp. 9-10, 20, 87, 89, 116, 125-128, 144-148.
13. Munyan, Arthur C., Supplement to Bulletin No. 44, No. 44-A, 1938.
14. Shearer, H. K., A Report on the Bauxite and Fuller's Earth of the Coastal Plain of Georgia, No. 31, 1917, pp. 142-143.
15. Shearer, H. K., and J. P. D. Hull, Pyrites Deposits of Georgia, No. 33, 1918, pp. 222-224.
16. Smith, R. W., Sedimentary Kaolins of the Coastal Plain of Georgia, No. 44, 1929.
17. Smith, R. W., Shales and Brick Clays of Georgia, No. 45, 1931, pp. 336-340.
18. Teas, L. P., The Sand and Gravel Deposits of Georgia, No. 37, 1921, pp. 5-6, 39-40, 376-377.
19. Veatch, Otto, "Precious Stones," Mineral Resources of Georgia, No. 23, 1926, pp. 160-170.

C. Georgia Institute of Technology, Engineering Experiment Station, Industrial Development Branch publications:

1. Fortson, Charles W., Jr., Glass Sand Prospecting and Analysis, 1959.
2. Kennon, Walter, and William E. Durrett, Ceramic Floor and Wall Tile, A Manufacturing Opportunity in Georgia, December, 1958.

C. Georgia Institute of Technology, Engineering Experiment Station, Industrial Development Branch publications (continued):

3. Kennon, Walter, and William E. Durrett, Vitreous China Sanitary Ware, A Manufacturing Opportunity in Georgia, July, 1959.
4. White, Lamar, and Vivian Conklin, An Analysis of the Portland Cement Market in and Near Georgia, 1958.

D. Georgia Mineral Newsletter, Georgia Geological Survey:

1. Calver, James L., "Fuller's Earth Industry in the Georgia-Florida District," Vol. IX, No. 2, 1956, pp. 37-44.
2. "A Catalog of Georgia Minerals -- Chromite," Vol. 3, No. 6, 1950, p. 211.
3. Furcron, A. S., "Beryl in Georgia," Vol. XII, No. 3, 1959, pp. 91-95.
4. Furcron, A. S., "Bloating Granites in the Cohutta Mountains of Murray County, Georgia," Vol. VI, No. 1, 1953.
5. Furcron, A. S., "Corundum in Georgia," Vol. XIII, No. 4, 1960, pp. 167-177.
6. Furcron, A. S., "The Distribution and Character of Stone for Aggregate in Georgia," Vol. XII, No. 1, 1959, pp. 1-8.
7. Furcron, A. S., "Fuller's Earth in Georgia," Vol. IV, No. 6, 1951, pp. 207-209.
8. Furcron, A. S., "Georgia's Copper Deposits," Vol. V, No. 5, 1952, pp. 137-139.
9. Furcron, A. S., "Iron Ores of the Clayton Formation in Stewart and Quitman Counties, Georgia," Vol. IX, No. 4, 1956, pp. 116-124.
10. Furcron, A. S., "Magnetite," Vol. III, No. 5, 1950, p. 162.
11. Furcron, A. S., "Mineral Resources Survey of Floyd County, Georgia," Vol. XI, No. 1, 1958, p. 4.
12. Furcron, A. S., "Peat and Peat Muck (in Georgia)," Vol. VI, No. 2, 1953, pp. 31-32.
13. Furcron, A. S., "Some Lost Mineral Localities in Georgia," Vol. XIII, No. 3, 1960, pp. 124-125.
14. Furcron, A. S., "What Can We Do About Gold?", Vol. XIII, No. 4, 1960, p. 162.
15. Furcron, A. S., and Charles W. Fortson, Jr., "Commercial Limestones of the Flint River Basin South of Albany, Georgia," Vol. XIII, No. 2, 1960, pp. 45-47, 53-54.
16. Furcron, A. S., and Donald L. Ray, "Clayton Iron Ores of Webster County, Georgia," Vol. X, No. 3, 1957, pp. 73-76.
17. Kesler, Thomas L., "Environment and Origin of the Cretaceous Kaolin Deposits of Georgia and South Carolina," Vol. X, No. 1, 1957.
18. "The Mineral Industry of Georgia," Vol. XIII, No. 4, 1960, p. 148.
19. "New Fuller's Earth Plant in Thomas County," Vol. IX, No. 2, 1956, p. 44.

D. Georgia Mineral Newsletter, Georgia Geological Survey (continued):

20. Peyton, Garland, "The Industrial Minerals of Georgia," Vol. VII, No. 1, 1954, pp. 1-8.
21. Teague, Kefton H., "Asbestos in Georgia," Vol. IX, No. 1, 1956, pp. 2-7.

E. Minerals Yearbook, U. S. Bureau of Mines:

1. "Clays," 1960 (preprint).
2. "Mica," Vol. 1, 1960, pp. 521-522.
3. "The Mineral Industry of Georgia," 1960 (preprint).
4. "The Mineral Industry of Georgia," Vol. III, 1959, p. 286.
5. "The Mineral Industry of Georgia," 1959 (preprint).
6. "The Mineral Industry of Georgia," 1958 (preprint).
7. "The Mineral Industry of Georgia," Vol. III, 1956.
8. "The Mineral Industry of Georgia," Vol. III, 1952, pp. 54, 57-59.
9. "Statistical Summary of Mineral Production," 1960 (preprint).

F. Personal communications:

1. Furcron, A. S., Chief Geologist, Georgia Department of Mines, Mining and Geology.
2. Moody, O. C., Owens-Illinois Glass Company, Atlanta.
3. U. S. Bureau of Mines, Knoxville, Tennessee office.

G. U. S. Bureau of Mines publications:

1. Ballard, T. J., Exploration of the Hog Creek Corundum Mine, Towns County, Georgia, Report of Investigations 4309, July, 1948.
2. Ballard, T. J., Investigation of Louise Chromite Deposits, Troup County, Georgia, Report of Investigations 4311, July, 1948.
3. Ballard, T. J., Investigation of Track Rock Corundum Mine, Union County, Georgia, Report of Investigations 4309, July, 1948.
4. Ballard, T. J., and F. K. McIntosh, Diamond Drilling at the Tallapoosa Copper Mine, Haralson County, Georgia, Report of Investigations 4316, July, 1948.
5. Beck, William A., Investigation of the Andersonville Bauxite District, Sumter, Macon, and Schley Counties, Georgia, Report of Investigations 4538, 1949.
6. Beck, William A., Investigation of the Springvale Bauxite District, Randolph County, Georgia, Report of Investigation 4555, 1949.
7. Bowles, Oliver, The Asbestos Industry, Bulletin No. 552, 1954, p. 26.
8. de Polo, Taber, Clays, Bulletin No. 585, 1960, pp. 1-13.
9. Kline, M. H., and W. A. Beck, Investigation of Chestatee Copper and Pyrite Deposit, Lumpkin County, Georgia, Report of Investigations 4397, January, 1949.

G. U. S. Bureau of Mines publications (continued):

10. Miller, J. A., Titanium -- A Materials Survey, Information Circular No. 7791, September, 1957.

11. Minerals Facts and Problems, Bulletin No. 585, 1960, pp. 183, 427-428.

12. Peyton, Alexander L., and Harlan E. Cofer, Jr., Magruder and Chambers Copper Deposits, Lincoln and Wilkes Counties, Georgia, Report of Investigations 4665, March, 1950.

13. Spencer, R. V., Titanium Minerals in Trail Ridge, Florida, Report of Investigations 4208, March, 1948, p. 6.

14. Thoenen, J. R., and R. V. Spencer, Drilling Florida Dune Sand, Report of Investigations 4227, April, 1948.

15. Thoenen, J. R., and J. D. Warne, Titanium Minerals in Central and Northeastern Florida, Report of Investigations 4515, September, 1949.

H. U. S. Geological Survey publications and sources:

1. Allen, V. T., and R. M. Thompson, Kaolin Deposits of Twiggs, Washington and Wilkinson Counties, Georgia, open file (released February 18, 1944).

2. Andersonville Bauxite District, Georgia, press release, August 27, 1942.

3. Becker, G. F., Gold Fields of the Southern Appalachians, 16th Annual Report, Part III, 1894, pp. 251-391.

4. Kesler, Thomas L., Geology and Mineral Deposits of the Cartersville District, Georgia, Professional Paper No. 224, 1950.

5. Mertie, J. B., Jr., Monazite Deposits of the Southeastern Atlantic States, Circular No. 237, 1953, p. 6.

6. Mertie, J. B., Jr., Zirconium and Hafnium in the Southeastern Atlantic States, Bulletin No. 1082-A, 1958, p. 13.

7. Overstreet, W. C., N. P. Cuppels, and A. M. White, Monazite in the Southeastern United States, Professional Paper No. 300, 1955, pp. 597-601.

8. Soper, E. K. and C. C. Osbon, The Occurrence and Uses of Peat in the United States, Bulletin No. 728, 1922, pp. 59, 199-201.

9. Warren, W. C., Bauxite Deposits of Wilkinson County, Georgia, open file (released November 29, 1943).

10. Weeks, Joseph D., Manganese, 16th Annual Report, Part III, 1895, pp. 410-412.

11. White, W. S., Geologic Map and Sections of the Warm Springs Bauxite District, Georgia, open file (released May 15, 1943).

12. White, W. S., and N. M. Denson, The Bauxite Deposits of Floyd, Bartow, and Polk Counties, Northwest Georgia, Circular No. 193, 1952.

INDEX OF MINERALS

INDEX OF MINERALS

(Continued)